FOR CONTRACT NO.: 07-138204

INFORMATION HANDOUT

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PERMIT NO. 5-10-030

UNITED STATES ARMY CORPS OF ENGINEERS NATIONWIDE PERMIT AUTHORIZATION
PERMIT NO. SPL-2010-00186-PHT

UNITED STATES COAST GUARD BRIDGE PERMIT
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PERMIT NO. HDP-10-014

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FILE NO. G.10-07-021
GENERAL ORDER 88-B REQUEST FOR AUTHORITY TO MODIFY THE NEW DOCK ST AT-GRADE HIGHWAY-RAIL CROSSING
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HARBOR DEVELOPMENT PERMIT (RAILROAD GUIDELINES SECTION)

RAILROAD SPECIAL PROVISIONS

PORT OF LONG BEACH/PORT OF LOS ANGELES
INSURANCE REQUIREMENTS FOR JOINT REVOCABLE PERMIT'JOINT TEMPORARY ENTRY AND USE LICENSE

ROUTE: 07-LA-47, 103-3.5/4.6, 0.0/1.1

CALIFORNIA COASTAL COMMISSION
South Coast Area Office
200 Oceangate, Suite 1000
Long Beach, CA 90802-4302
(562) 590-5071

Date: June 1, 2010
Permit No: 5-10-030

COASTAL DEVELOPMENT PERMIT

On **April 16, 2010**, the California Coastal Commission granted to **Department of Transportation, District #7** Coastal Development Permit **5-10-030**, subject to the attached Standard and Special Conditions, for development consisting of:

Construct new, approximately 96 foot wide, 4-12 foot wide bridge approach road with 4 12-foot wide lanes and shoulders varying from 2 feet to 10 feet, bridge approach road by realigning the existing approximately 80 foot wide road (Route 47) to the east. The realigned road will overlap portions of the existing roadway and the new roadway will be partly elevated and extend approximately 1,800 feet in length from the City of Los Angeles boundary line, located approximately 240 feet north of the Cerritos Channel to approximately the Pier A West crossing. The new road is part of the proposed Schuyler Heim bridge replacement project which is in the Port of Long Beach's permit jurisdiction. More specifically described in the application file in the Commission offices.

The development is within the coastal zone in Los Angeles County at **State Route 47 (from Ocean Blvd. to Henry Ford Avenue, SR-47 Right-of-Way).**

Issued on behalf of the California Coastal Commission on June 1, 2010.

PETER DOUGLAS
Executive Director

By:
Title: Coastal Program Analyst

ACKNOWLEDGMENT

The undersigned permittee acknowledges receipt of this permit and agrees to abide by all terms and conditions thereof.

The undersigned permittee acknowledges that Government Code Section 818.4 which states in pertinent part, that: "A public entity is not liable for injury caused by the issuance . . . of any permit . . ." applies to the issuance of this permit.

IMPORTANT: THIS PERMIT IS NOT VALID UNLESS AND UNTIL A COPY OF THE PERMIT WITH THE SIGNED ACKNOWLEDGMENT HAS BEEN RETURNED TO THE COMMISSION OFFICE. 14 CAL. ADMIN. CODE SECTION 13158(a).

7/8/10
Date

Karl Price
Signature of Permittee

Please sign and return one copy of this form to the Commission office at the above address.

STANDARD CONDITIONS

1. **Notice of Receipt and Acknowledgment.** The permit is not valid and development shall not commence until a copy of the permit, signed by the permittee or authorized agent, acknowledging receipt of the permit and acceptance of the terms and conditions, is returned to the Commission office.

2. **Expiration.** If development has not commenced, the permit will expire two years from the date on which the Commission voted on the application. Development shall be pursued in a diligent manner and completed in a reasonable period of time. Application for extension of the permit must be made prior to the expiration date.

3. **Interpretation.** Any questions of intent or interpretation of any condition will be resolved by the Executive Director or the Commission.

4. **Assignment.** The permit may be assigned to any qualified person, provided assignee files with the Commission an affidavit accepting all terms and conditions of the permit.

5. **Terms and Conditions Run with the Land.** These terms and conditions shall be perpetual, and it is the intention of the Commission and the permittee to bind all future owners and possessors of the subject property to the terms and conditions.

SPECIAL CONDITIONS:

1. **Landscape Plan**

A. Prior to issuance of the coastal development permit, the applicant shall submit, for review and approval of the Executive Director, a landscaping plan. The plan shall be prepared by a licensed landscape architect. To minimize the need for irrigation and to minimize encroachment of non-native plant species into adjacent areas, all landscaping shall consist of native and/or drought tolerant non-invasive plant species. No plant species listed as problematic and/or invasive by the California Native Plant Society, the California Invasive Plant Council (formerly known as the California Exotic Pest Plant Council), or as may be identified from time to time by the State of California shall be utilized on the property. No plant species listed as a 'noxious weed' by the State of California or the U.S. Federal Government shall be utilized within the property. All plants employed on the site shall be drought tolerant (low water use) plants identified by U. C Davis and the State Water Resources Control Board.

B. The permittee shall undertake development in accordance with the final plans approved by the Executive Director pursuant to this condition. Any proposed changes to the approved plans shall be reported to the Executive Director in order to determine if the proposed change shall require a permit amendment pursuant to the requirements of the Coastal Act and the California Code of Regulations.

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 30, 2010

REPLY TO
ATTENTION OF:

Regulatory Division

DEPARTMENT OF THE ARMY NATIONWIDE PERMIT AUTHORIZATION

Karl Price, District 7
California Department of Transportation
c/o Lenny Malo, URS Corporation
2020 East First Street, Suite 400
Santa Ana, California 92705

Dear Mr. Price:

This is in reply to your application (File No. SPL-2010-00186-PHT), dated January 7, 2010, for a Department of the Army Permit to discharge fill into waters of the U.S., in association with the Schuyler Heim Bridge Replacement Project. The proposed work would take place in Cerritos Channel, in the Cities of Long Beach and Los Angeles, Los Angeles County, California. Please refer to the enclosed map.

Based on the information you have provided, the Corps of Engineers has determined that your proposed activity complies with the enclosed terms and conditions of Nationwide Permit No. 14 for Linear Transportation Projects, as described in enclosure 1.

Specifically, as shown on the enclosed plans, you are authorized to:

1. Temporarily grade 0.15 acre on the south side of Cerritos Channel and temporarily grade 0.01 acre on the north side of Cerritos Channel for temporary construction access;
2. Construct eight cast-in-drilled hole piles to support the east side of the new bridge, permanently impacting 0.021 acre;
3. Temporarily place two 140-foot-long by 80-foot-wide coffer dams around Piers 27 and 28 and two 140-foot-long by 51-foot-wide coffer dams around Piers 26 and 29 of the existing bridge, temporarily impacting 0.488 acre of Cerritos Channel;
4. Construct eight cast-in-drilled hole piles to support the west side of the new bridge, permanently impacting 0.021 acre; and
5. Place rock over areas where an existing concrete retaining wall around Pier 29 would be removed and where two columns for Pier 26 would be removed, permanently impacting 0.28 acre of Cerritos Channel.

Furthermore, you must comply with the following non-discretionary Special Conditions:

1. The permitted activity shall not interfere with the right of the public to free navigation on all navigable waters of the United States as defined by 33 C.F.R. Part 329.

2. The Permittee shall discharge only clean construction materials suitable for use in the oceanic environment. The Permittee shall ensure no debris, soil, silt, sand, sawdust, rubbish, cement or concrete washings thereof, oil or petroleum products, from construction shall be allowed to enter into or placed where it may be washed by rainfall or runoff into waters of the United States. Upon completion of the project authorized herein, any and all excess material or debris shall be completely removed from the work area and disposed of in an appropriate upland site.

3. The Permittee shall notify the Corps Regulatory Division of the date of commencement of operations not less than 14 calendar days prior to commencing work, and shall notify the Corps of the date of completion of operations at least five calendar days prior to such completion.

4. To ensure navigational safety, the Permittee shall provide appropriate notifications to the U.S. Coast Guard as described below:

Commander, 11th Coast Guard District (dpw)
TEL: (510) 437-2980
E-mail: d11LNM@uscg.mil
Website: http://www.uscg.mil/dp/lnmrequest.asp

U.S. Coast Guard, Sector LA-LB (COTP)
TEL: (310) 521-3860
E-mail: john.p.hennigan@uscg.mil

A) The Permittee shall notify the U.S. Coast Guard, Commander, 11th Coast Guard District (dpw) and the U.S. Coast Guard, Sector LA-LB (COTP) (contact information shown above), not less than 14 calendar days prior to commencing work and as project information changes. The notification shall be provided by e-mail with at least the following information, transmitted as an attached Word or PDF file:

1) Project description including the type of operation (i.e. dredging, diving, construction, etc).
2) Location of operation, including Latitude / Longitude (NAD 83).
3) Work start and completion dates and the expected duration of operations. The Coast Guard needs to be notified if these dates change.
4) Vessels involved in the operation (name, size and type).
5) VHF-FM radio frequencies monitored by vessels on scene.
6) Point of contact and 24 -hour phone number.

7) Potential hazards to navigation.
8) Chart number for the area of operation.
9) Recommend the following language be used in the LNM: "Mariners are urged to transit at their slowest safe speed to minimize wake, and proceed with caution after passing arrangements have been made."

B) The Permittee and its contractor(s) shall not remove, relocate, obstruct, willfully damage, make fast to, or interfere with any aids to navigation defined at 33 C.F.R. chapter I, subchapter C, part 66. The Permittee shall ensure its contractor notifies the Eleventh Coast Guard District in writing, with a copy to the Corps Regulatory Division, not less than 30 calendar days in advance of operating any equipment adjacent to any aids to navigation that requires relocation or removal. Should any federal aids to navigation be affected by this project, the Permittee shall submit a request, in writing, to the Corps Regulatory Division as well as the U.S. Coast Guard, Aids to Navigation office (contact information provided above). The Permittee and its contractor are prohibited from relocating or removing any aids to navigation until authorized to do so by the Corps Regulatory Division and the U.S. Coast Guard.

C) Should the Permittee determine the work requires the temporary placement and use of private aids to navigation in navigable waters of the U.S., the Permittee shall submit a request in writing to the Corps Regulatory Division as well as the U.S. Coast Guard, Aids to Navigation office (contact information provided above). The Permittee is prohibited from establishing private aids to navigation in navigable waters of the U.S. until authorized to do so by the Corps Regulatory Division and the U.S. Coast Guard.

D) The COTP may modify the deployment of marine construction equipment or mooring systems to safeguard navigation during project construction. The Permittee shall direct questions concerning lighting, equipment placement, and mooring to the appropriate COTP.

5. Within 30 calendar days of completion of the project authorized by this permit, the Permittee shall conduct a post-project survey indicating changes to structures and other features in navigable waters. The Permittee shall forward a copy of the survey to the Corps Regulatory Division and to the National Oceanic and Atmospheric Service for chart updating: Gerald E Wheaton, NOAA, Regional Manager, West Coast and Pacific Ocean, DOD Center Monterey Bay, Room 5082, Seaside, CA 93955-6711.

6. The Permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the Permittee will be required, upon due notice from the Corps of Engineers Regulatory Division, to remove, relocate, or

alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

7. The Permittee shall ensure that the natural course of all drainages impacted are restored to pre-project contours or gradients and conditions to the maximum extent possible upon project completion to provide optimal habitat for fish and other aquatic wildlife.

8. This Corps permit does not authorize you to take any threatened or endangered species, in particular the California least tern (*Sternula antillarum browni*) or adversely modify its designated critical habitat. In order to legally take a listed species, you must have separate authorization under the Endangered Species Act (ESA) (e.g. ESA Section 10 permit, or a Biological Opinion (BO) under ESA Section 7, with "incidental take" provisions with which you must comply). Pursuant to the FWS correspondence dated July 24, 2009, including the required avoidance and minimization measures, the Corps Regulatory Division has determined and the FWS has concurred that your activity is not likely to adversely affect the above species. Your authorization under this Corps permit is conditional upon your compliance with all of the required avoidance and minimization measures, which are incorporated by reference in this permit. Failure to comply with the required avoidance and minimization measures would constitute non-compliance with your Corps permit. The FWS is the appropriate authority to determine compliance with the terms and conditions of its BO and with the ESA.

9. The Permittee shall adhere to the "Memorandum of Agreement between the California Department of Transportation and the California State Historic Preservation Officer Regarding the State Route 47 Expressway and the Schuyler Heim Bridge Replacement Project, Cities of Long Beach and Los Angeles, Los Angeles County, California," executed on February 5, 2008.

10. The Permittee shall implement all conservation measures proposed in its "Schuyler Heim Bridge Replacement Project Essential Fish Habitat Assessment," dated January 2010.

11. The Permittee shall abide by the terms and conditions of Clean Water Act Section 401 Certification 10-005, issued by Los Angeles Regional Water Quality Control Board.

12. The Permittee shall abide by the terms and conditions of Coastal Development Permit 5-10-030, issued by California Coastal Commission South Coast Area Office.

13. The Permittee shall abide by the terms and conditions of Harbor Development Permit 10-014, issued by Port of Long Beach.

This verification is valid until the NWP is modified, reissued, or revoked. All of the existing NWPs are scheduled to be modified, reissued, or revoked prior to March 18, 2012. It is incumbent upon you to remain informed of changes to the NWPs. We will issue a public notice

when the NWPs are reissued. Furthermore, if you commence or are under contract to commence this activity before the date that the relevant nationwide permit is modified or revoked, you will have twelve (12) months from the date of the modification or revocation of the NWP to complete the activity under the present terms and conditions of this nationwide permit.

A nationwide permit does not grant any property rights or exclusive privileges. Also, it does not authorize any injury to the property or rights of others or authorize interference with any existing or proposed Federal project. Furthermore, it does not obviate the need to obtain other Federal, state, or local authorizations required by law.

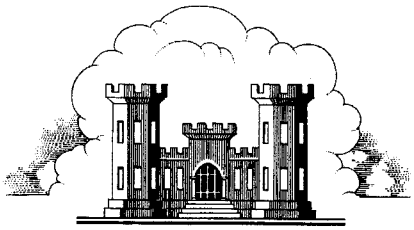
Thank you for participating in our regulatory program. If you have any questions, please contact Phuong Trinh of my staff at 213.452.3372 or via e-mail at Phuong.H.Trinh@usace.army.mil.

Please be advised that you can now comment on your experience with Regulatory Division by accessing the Corps web-based customer survey form at: http://per2.nwp.usace.army.mil/survey.html.

Sincerely,

Mark D. Cohen
Deputy Chief, Regulatory Division

Enclosures



LOS ANGELES DISTRICT
U.S. ARMY CORPS OF ENGINEERS

CERTIFICATION OF COMPLIANCE WITH
DEPARTMENT OF THE ARMY NATIONWIDE PERMIT

Permit Number: *SPL-2010-00186-PHT*

Name of Permittee: *Karl Price, District 7, California Department of Transportation*

Date of Issuance: *July 30, 2010*

Upon completion of the activity authorized by this permit and any mitigation required by the permit, sign this certification and return it to the following address:

U.S Army Corps of Engineers
Regulatory Division
ATTN: CESPL-RG-SPL-2010-00186-PHT
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

Please note that your permitted activity is subject to a compliance inspection by an Army Corps of Engineers representative. If you fail to comply with this nationwide permit you may be subject to permit suspension, modification, or revocation procedures as contained in 33 CFR 330.5 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5.

I hereby certify that the work authorized by the above referenced permit has been completed in accordance with the terms and conditions of the said permit, and required mitigation was completed in accordance with the permit condition(s).

_____ _____

Signature of Permittee Date

U.S. Department of Homeland Security
United States Coast Guard

BRIDGE PERMIT

(3-10-11) AUG 2 4 2010

WHEREAS by Title V of an act of Congress approved August 2, 1946, entitled "General Bridge Act of 1946," as amended (33 U.S.C. 525-533), the consent of Congress was granted for the construction, maintenance and operation of bridges and approaches thereto over the navigable waters of the United States;

AND WHEREAS the Secretary of Homeland Security has delegated the authority of Section 502(b) of that act to the Commandant, U. S. Coast Guard by Department of Homeland Security Delegation Number: 0170.1;

AND WHEREAS before construction is commenced, the Commandant must approve the location and plans of any such bridge and may impose any specific conditions relating to the construction, maintenance and operation of the structure deemed necessary in the interest of public navigation, such conditions to have the force of law;

AND WHEREAS the - **STATE OF CALIFORNIA** - has submitted for approval the location and plans of a bridge to be constructed across the Cerritos Channel at the Ports of Los Angeles and Long Beach, California;

NOW THEREFORE, This is to certify that the location and plans revised 11 August 2010 are hereby approved by the Commandant, subject to the following conditions:

1. No deviation from the approved plans may be made either before or after completion of the structure unless the modification of said plans has previously been submitted to and received the approval of the Commandant.

2. The construction of falsework, cofferdams or other obstructions, if required, shall be in accordance with plans submitted to and approved by the Commander, Eleventh Coast Guard District, prior to construction of the bridge. All work shall be so conducted that the free navigation of the waterway is not unreasonably interfered with and the present navigable depths are not impaired. Timely notice of any and all events that may affect navigation shall be given to the District Commander during construction of the bridge. The channel or channels through the structure shall be promptly cleared of all obstructions placed therein or caused by the construction of the bridge to the satisfaction of the District Commander, when in the judgment of the District Commander the construction work has reached a point where such action should be taken, but in no case later than 90 days after the bridge has been opened to traffic.

3. Issuance of this permit does not relieve the permittee of the obligation or responsibility for compliance with the provisions of any other law or regulation as may be under the jurisdiction of the U. S. Army Corps of Engineers, Los Angeles District; U. S. Department of the Interior, Fish and Wildlife Service; U. S. Department of Commerce, National Marine Fisheries Service; State of California, State Historic Preservation Office, or any other federal, state or local authority having cognizance of any aspect of the location, construction or maintenance of said bridge.

4. A bridge fendering system of non-sparking material shall be installed and maintained in good condition by and at the expense of the owner of the bridge as shown on the approved plan sheets 2, 3 and 4 (of 4) revised 11 August 2010. Said installation and maintenance shall be for the safety of navigation and be in accordance with plans submitted to and approved by the District Commander prior to its construction.

5. Clearance gauges shall be installed and maintained in a good and legible condition by and at the expense of the owner of the bridge. The type of gauges and the locations in which they are to be installed will be submitted to the District Commander for approval.

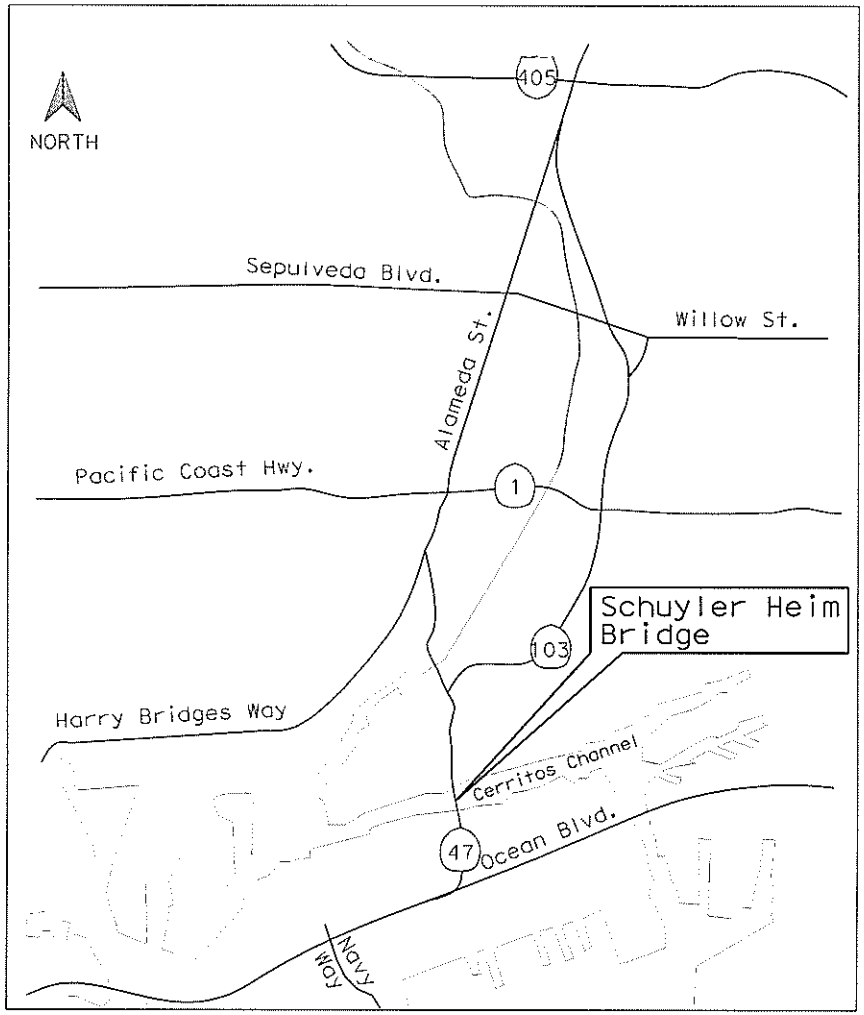
6. All parts of the existing to-be-replaced Schuyler Heim Bridge across the Cerritos Channel, mile 4.9, not utilized in the new bridge shall be removed down to or below elevation 53 feet below Mean Sea Level within the navigation channel and down to or below elevation 18 feet below Mean Sea Level outside of the navigation channel. All other parts shall be removed down to a minimum of one foot below the natural ground line. The waterway shall be cleared to the satisfaction of the District Commander. A period of one year subsequent to the opening to traffic of the new bridge, mile 4.9, will be allowed for such removal and clearance.

7. When the proposed bridge is no longer used for transportation purposes, it shall be removed in its entirety or to an elevation deemed appropriate by the District Commander and the waterway cleared to the satisfaction of the District Commander. Such removal and clearance shall be completed by and at the expense of the owner of the bridge upon due notice from the District Commander.

8. The approval hereby granted shall cease and be null and void unless construction of the bridge is commenced within three years and completed within five years after the date of this permit.

Hala Elgaaly

HALA ELGAALY, P.E.
Administrator, Bridge Program
U. S. Coast Guard
By direction of the Commandant



Project Location

CHIEF ENGINEER

BRIDGE ENGINEER

MARCH 16, 2010

STATE OF
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

CERRITOS CHANNEL BRIDGE REPLACEMENT
LOS ANGELES COUNTY

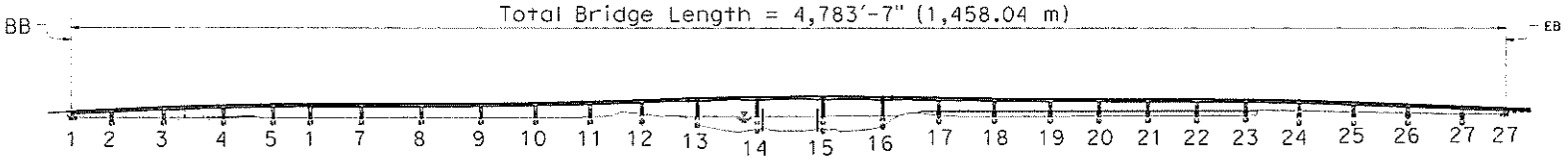
SCHUYLER HEIM BRIDGE (REPLACE)
CERRITOS CHANNEL MILE 4.9 (7.89 KM)

VICINITY MAP

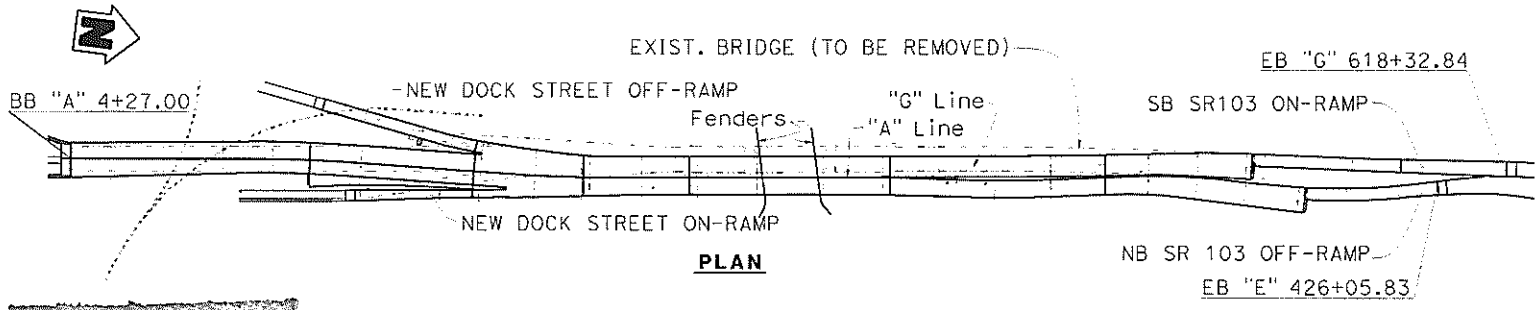
SHEET	OF
1	4

Revised: August 11, 2010 ACTA

APPROVED
AUG 24 2010
(3-10-11)
U.S.
COAST GUARD



ELEVATION



PLAN

APPROVED
AUG 24 2010
4-3-10-11
U.S.
COAST GUARD

CHIEF ENGINEER

BRIDGE ENGINEER

0 200 400 600 800 1000 2000 FT

MARCH 16, 2010

STATE OF
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

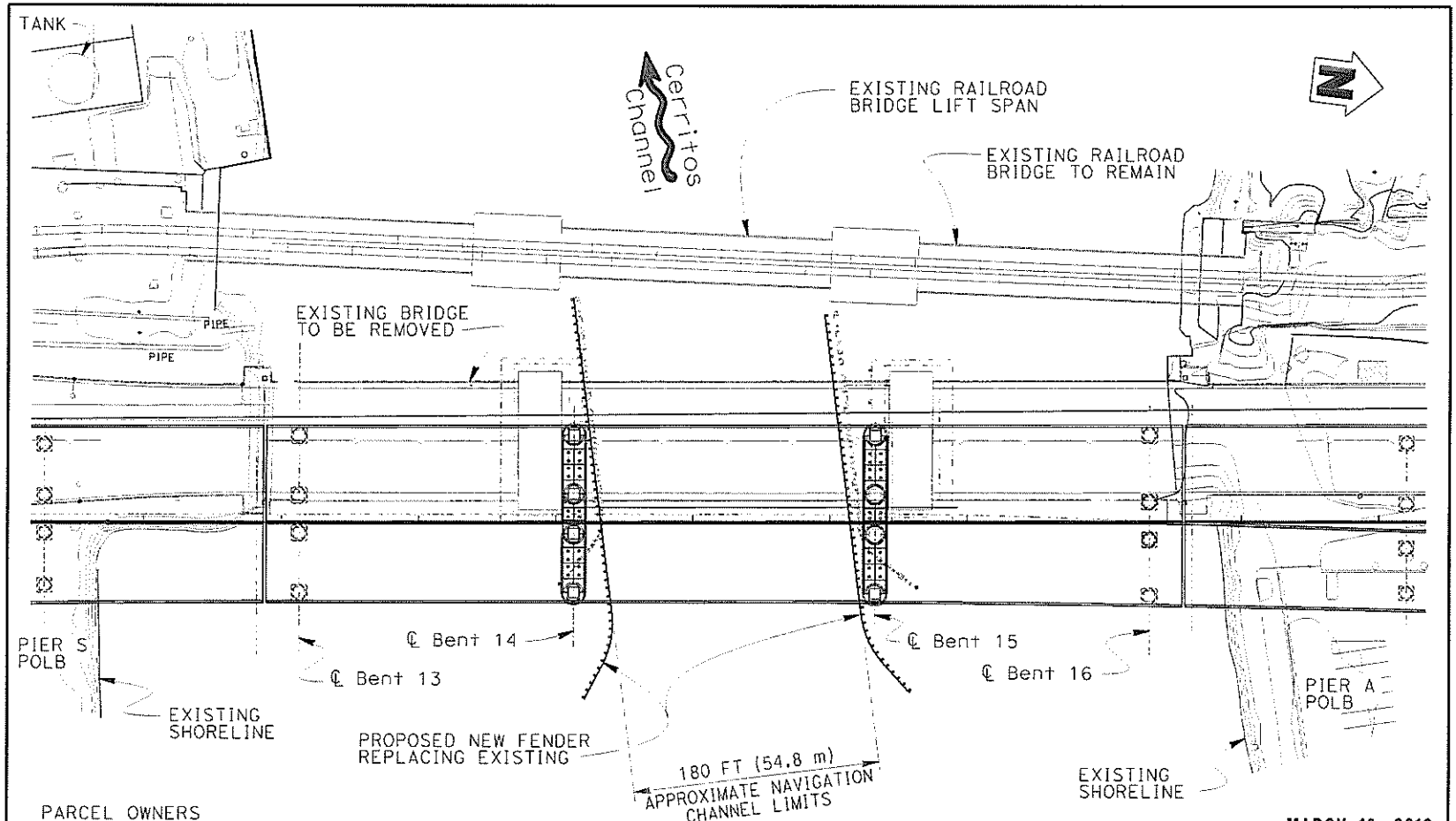
CERRITOS CHANNEL BRIDGE REPLACEMENT
LOS ANGELES COUNTY

SCHUYLER HEIM BRIDGE (REPLACE)
CERRITOS CHANNEL MILE 4.9 (7.89 KM)

GENERAL PLAN

SHEET	OF
2	4

ACTA
Revised: August 11, 2010



MARCH 16, 2010

PARCEL OWNERS

1. Alameda Corridor Transit Authority
2. Port of Long Beach (Pier S)
3. Port of Long Beach (Pier A)

NOTES:

1. Datum - NAVD 88
2. MLW = -0.38, MHW = + 4.33

0 50 100 150 200 400 FT

PLAN

CHIEF ENGINEER

BRIDGE ENGINEER

APPROVED
AUG 24 2010
PC3-10-11
U.S.
COAST GUARD

STATE OF
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

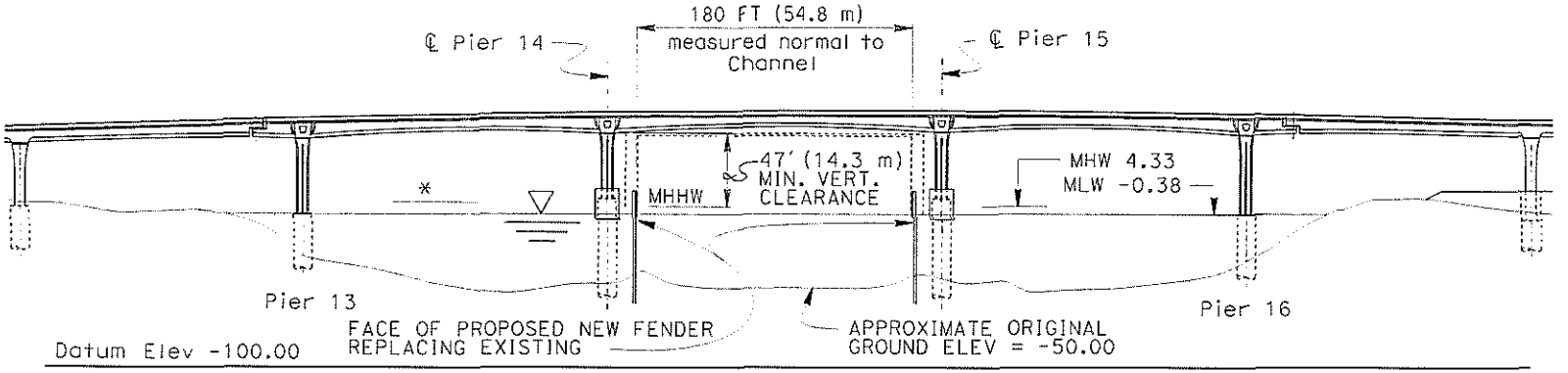
CERRITOS CHANNEL BRIDGE REPLACEMENT
LOS ANGELES COUNTY

SCHUYLER HEIM BRIDGE (REPLACE)
CERRITOS CHANNEL MILE 4.9 (7.89 KM)

KEY PLAN

SHEET	OF
3	4

ACTA
Revised: August 11, 2010

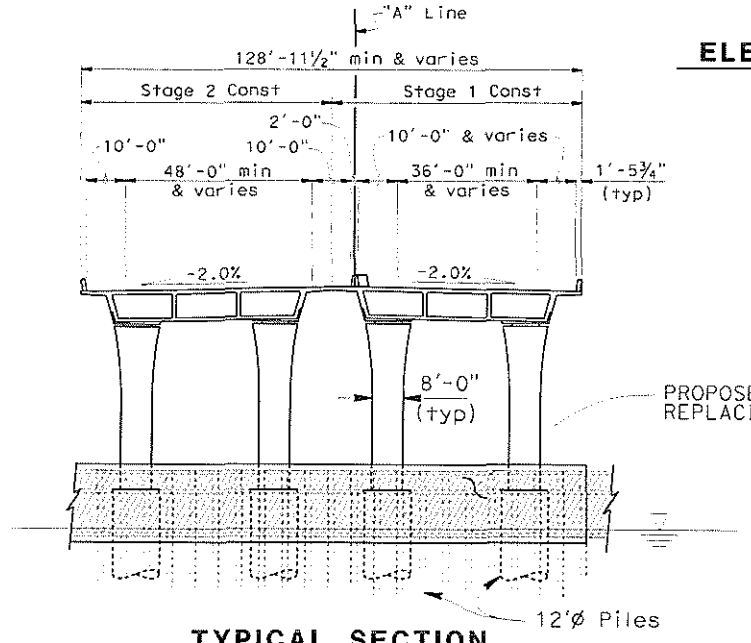


ELEVATION

* – 100 YEAR FLOOD ELEV = 8.00
NET PERMANENT FILL = -0.47 acres

NOTE: Datum - NAVD 88

0 50 100 150 200 400 FT



TYPICAL SECTION

0 20 40 60 80 100

CHIEF ENGINEER

BRIDGE ENGINEER

MARCH 16, 2010

STATE OF
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

CERRITOS CHANNEL BRIDGE REPLACEMENT
LOS ANGELES COUNTY

SCHUYLER HEIM BRIDGE (REPLACE)
CERRITOS CHANNEL MILE 4.9 (7.89 KM)

KEY ELEVATION

SHEET	OF
4	4

ACTA
Revised: August 11, 2010

APPROVED
AUG 24 2010
U.S. COAST GUARD

The Port of LONG BEACH

HARBOR DEVELOPMENT PERMIT

925 HARBOR PLAZA LONG BEACH. CALIFORNIA 90802
TELEPHONES (562)590-4160 (562)437-0041 FAX:(562)901-1728

1. PERMIT NUMBER	2. ISSUE DATE	3. EXPIRATION DATE	NOTE
HDP-10-014	07/19/2010	07/19/2012	

4. TYPE OF ACTION:

X PURSUANT TO CALIFORNIA COASTAL ACT OF 1976 AND CERTIFIED PORT MASTER PLAN
X PURSUANT TO SECTION 1215 OF THE LONG BEACH CITY CHARTER
LEVEL III COASTAL DEVELOPMENT PERMIT
X APPEALABLE UNDER COASTAL ACT SECTION 30715

5. PERMITTEE: CALTRANS

6. LEGAL INTEREST: Permittee

7. PERMITTEE ADDRESS
100 S. Main Street
Los Angeles, CA **ZIP** 90012

8. PERMITTEE PHONE: (213) 897-0120

9. CONTACT PERSON: Karl Price

10. TITLE/AFFILIATION:
Senior Environmental Planner

11. PHONE: 213-897-1839

12. DESCRIPTION OF APPROVED WORK:
Replacement of the Shuyler Heim Bridge, including modifications to the bridge approaches.

13. LOCATION OF APPROVED WORK:
SR-47 from Ocean Boulevard to SR-103/Henry Ford Avenue, Long Beach, CA

14. DRAWINGS: SEE ATTACHED DESCRIPTION

15. CALIFORNIA ENVIRONMENTAL QUALITY ACT DETERMINATION:

_ CATEGORICALLY EXEMPT _____ [CLASS]
_ NEGATIVE DECLARATION, ADOPTED _____ [DATE]
X ENVIRONMENTAL IMPACT REPORT, CERTIFIED BY Board of Harbor Commissioners [LEAD AGENCY] 07/19/2010 [DATE]

16. MANDATORY FINDINGS:

X THE PROJECT CONFORMS WITH THE CERTIFIED PORT MASTER PLAN
X THE PROJECT CONFORMS WITH THE POLICIES OF THE COASTAL ACT
X THE PROJECT CONFORMS WITH THE ESTABLISHED POLICIES OF THE Various HARBOR PLANNING DISTRICT
X THE PROJECT X WILL _ WILL NOT HAVE ANY SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACTS
_ PUBLIC HEARING NOT REQUIRED PURSUANT TO THE PROVISIONS OF THE CERTIFIED PORT MASTER PLAN
_ THE EXECUTIVE DIRECTOR AUTHORIZED ISSUANCE OF THIS PERMIT ON _____
X A PUBLIC HEARING WAS HELD ON 07/19/2010 AT Port of Long Beach Admin Bdg
X THE BOARD OF HARBOR COMMISSIONERS AUTHORIZED ISSUANCE OF THIS PERMIT ON 07/19/2010
BY A 5 TO 0 VOTE
_ _____
_ _____

17. THIS PERMIT IS ISSUED SUBJECT TO PERMITTEE OBTAINING THE FOLLOWING APPROVALS, AS NECESSARY, AND COMPLYING WITH STATED PERMIT TERMS AND CONDITIONS

X L.B. DEPARTMENT OF PLANNING AND BUILDING
X L.B. BUREAU OF FIRE PREVENTION
X REGIONAL WATER QUALITY CONTROL BOARD
X AIR QUALITY MANAGEMENT DISTRICT
X U.S. ARMY CORPS OF ENGINEERS
X OTHER Hot Work, Dig Alert, Various permits
X THOSE **STANDARD CONDITIONS** SHOWN ON THE ATTACHED **PAGE** OF THIS PERMIT.
X THOSE **SPECIAL CONDITIONS** SHOWN ON THE ATTACHED **PAGE[S]** OF THIS PERMIT.

18. ACKNOWLEDGEMENTS

DIRECTOR OF PLANNING — 07/21/2010 DATE

I, KARL PRICE **[PERMITTEE/AGENT] HEREBY ACKNOWLEDGE RECEIPT OF** HDP-10-014 **AND HAVE ACCEPTED ITS CONTENTS AND CONDITIONS.**

Karl Price — SIGNATURE OF PERMITTEE/AGENT — 7/23/10 DATE

APPLICANT COPY

The Port of LONG BEACH

HARBOR DEVELOPMENT PERMIT

925 HARBOR PLAZA LONG BEACH, CALIFORNIA 90802
TELEPHONES (562)590-4160 (562)437-0041 FAX:(562)901-1728

1. PERMIT NUMBER	2. ISSUE DATE	3. EXPIRATION DATE	NOTE
HDP-10-014	07/19/2010	07/19/2012	

STANDARD CONDITIONS:

1 Effective Date: This permit shall not become effective until the ORIGINAL has been returned to the Environmental Planning Division, fully signed by the permittee or agent(s) authorized in the permit application. Failure to return the original within thirty (30) days of approval shall render the permit invalid. Other conditions notwithstanding, if the project is appealable the permit shall not become until after the tenth (10th) working day following notification of approval, unless an appeal has been filed with the California Coastal Commission within that time. By executing this permit, permittee or its agent(s) acknowledge that they have received a copy of the fully-signed permit for its use and post said copy conspicuously at the project site.

2 Non-Waiver Condition and Assignment: Nothing in this permit shall be deemed or construed as a waiver of any term or condition contained in permittee lease, preferential assignment, permit, or other agreement with the Long Beach Harbor Commission. This permit shall not be assigned except as provided in the Board of Harbor Commissioners Port Master Plan Implementation Guidelines and in Section 13170 of Title 14 of the California Administrative code, to the extent applicable.

3 Permit Expiration: Work authorized by this permit must commence within two years of the effective date of this permit unless otherwise specified. If work has not commenced, this permit will expire two (2) years from its effective date. Any application for an extension of said commencement date must be made at least thirty (30) days prior to the expiration of this permit.

4 Compliance With Laws and Regulations: Permittee shall comply with all laws, statutes, rules, regulations, and orders of all governmental agencies having jurisdiction over the permittee's project. Permittee, at its own expense, shall obtain all requisite permits, approvals, and consents from the appropriate agencies, including but not limited to the City of Long Beach (COLB) Harbor Department, the COLB Development Services, COLB Fire Department, the South Coast Air Quality Management District, the California Department of Health Services, and the Regional Water Quality Control Board, and shall comply with any such permit, approval or consent. Copies of all requisite permits shall be available for inspection at the project site.

5 Construction Drawings: Final plans and specifications for construction, incorporating any modifications made by the Harbor Department, shall be submitted to the Environmental Planning Division for review and approval prior to commencement of any portion of the development.

6 Notification: Permittee shall notify the Chief Harbor Engineer, in writing, of the anticipated start date of any construction at least ten (10) days in advance.

7 Permission from Property Owner: Permittee shall coordinate with all facilities which may be affected by the permitted project. Permittee shall not interfere with any facility operations. Permittee may contact the Harbor Department Terminal Services Section at 562-590-4180 for assistance with notifications.

8 Subsurface Construction: Permittee shall consult with the Surveys and Mappings Section of the Harbor Department and Underground Service Alert of Southern California (Dig-Alert) regarding possible interference to underground utilities for all work involving excavation, a minimum of 48 hours in advance. Permittee shall conduct all subsurface work in accordance with Section 5 of the latest edition of Standard Specifications for Public Works Constructions (The "Green Book"). Permittee shall be responsible for all damage to underground structures and utility lines occurring as a result of project construction and shall restore all ground surfaces disturbed by excavation to original conditions, unless otherwise provided for by the permitted project design. This includes, but is not limited to, irrigation lines, water main lines, underground conduit, and surface landscaping. The alignment of any underground utilities that must be relocated as a result of the permitted project must be approved by the Director of Environmental Planning and the utility owner. Permittee, except as otherwise provided for or agreed to, is responsible for any costs associated with repairing, replacing, or relocating underground or surface utilities or landscaping disturbed or destroyed during the permitted project.

9 Conduct of Work: Permittee shall perform all work in strict accordance with the plans and specifications approved by the Harbor Department Environmental Planning Division. Permittee shall conduct project site preparation and construction activities in a manner that minimizes dust and releases of materials into harbor waters. Distribution and/or removal of surplus materials (fills, dirt, broken asphalt, etc.) generated by the construction activities on property under the jurisdiction of the Harbor Commission must have prior approval of the Chief Harbor Engineer.

10 As-built: As-built drawings for construction within the Harbor District shall be submitted to the Construction Management Division (562-590-4172) of the Harbor Department within thirty (30) days of the completion of work. Except in the case of underground work, final construction drawings may serve as as-builts provided a set of such drawings are submitted and stamped "as-built". For underground work, permittee shall submit to the Construction Mangement Division, within thirty (30) days of completion of the work, two (2) sets of as-built drawings and survey notes, signed by a licensed surveyor who shall certify to the accuracy of the horizontal and vertical alignment. All of said drawings shall be drawn to a scale of no more than one hundred (100) feet to the inch, shall show the accurate alignments by centerline traverses, shall be referenced to all intersections of street property lines and survey points furnished by the Harbor Department, and shall show the elevations of the tops of the pipelines and facilities. All surveys work shall be to the latest third order of accuracy as established by the National Oceanic and Atmospheric Administration surveys.

11 Traffic Management: For all projects that impact Harbor Department roads, Permittee shall submit for approval by the Director of Environmental Planning a Traffic Management Plan. Permittee shall comply with all traffic warning and control devices, signs, and plans described in the Work Area Traffic Control Handbook or the Manual on Uniform Traffic Control Devices (MUTCD) 2003 California Supplement.

12 Non-Compliance Penalties: Violation of any provision or condition in this permit shall constitute grounds for revocation of this permit and shall render the permittee liable for civil penalties of up to $10,000.00. Any person who willfully and knowingly conducts work in the Harbor District in violation of the Port Master Plan Guidelines shall be liable for civil penalties of $5,000.00 per violation per day.

13 Hazardous Material: If during the course of the permitted project permittee shall discover or have reason to believe that material being excavated at the project site contains extremely hazardous wastes or hazardous wastes as those terms are or have been defined by the administrator of the Environmental Protection Agency, the California Department of Toxic Substances Control, or any other person or agency having jurisdiction over the management of hazardous materials, permittee, at its cost, shall: (i) promptly notify the Director of Environmental Planning of the permittees discovery or belief; (ii) at the request of the Director of Environmental Planning, initiate chemical and or physical characterization of the material; (iii) promptly submit all laboratory and test results to the Director of Environmental Planning on receipt thereof; (iv) develop and submit for approval to the Director of Environmental Planning a remediation plan providing for the appropriate disposal and or treatment of the contaminated material; (v) implement that plan in accordance with the regulations and orders of the governmental agencies having jurisdiction; (vi) if material is

ACKNOWLEDGEMENTS

DIRECTOR OF PLANNING	DATE	SIGNATURE OF PERMITTEE/AGENT	DATE
	07/21/2010	Karl Puls	7/23/10

APPLICANT COPY

The Port of LONG BEACH

HARBOR DEVELOPMENT PERMIT

925 HARBOR PLAZA LONG BEACH. CALIFORNIA 90802
TELEPHONES (562)590-4160 (562)437-0041 FAX:(562)901-1728

1. PERMIT NUMBER	2. ISSUE DATE	3. EXPIRATION DATE	NOTE
HDP-10-014	07/19/2010	07/19/2012	

removed, replace all such material with clean fill material that is structurally suitable for the project, and cause the excavation to be backfilled and compacted; and (vii) promptly submit copies of all waste manifests to the Director of Environmental Planning.

14 Indemnity: Permittee shall indemnify the Harbor Department from and against any and all actions, suits, proceedings, claims, demands, damages, losses, liens, costs, expenses, or liabilities of any kind and nature whatsoever ("claims") which may be brought, made, filed against, imposed upon, or sustained by the Harbor Department, arising from, attributable to, caused by, in connection with, or pertaining to the activities described in this permit, except to the extent such claims are caused by the negligence or willful misconduct of the Harbor Department.

DRAWINGS :

3 unnumbered drawings, L-1 through L-6, X-1 through X-8, PS-1 through PS-18, G-1 through G-6, U-1 through U-33, D-1 through D-6, DP-1 through DP-5, DD-1 throgh DD-10, DQ-1 through DQ-7, WPC-1 through WPC-6, PP-1 through PP-6, IP-1 through IP-6, Structure Plan 1 through Structure Plan 9, General Plan 1 and 2

SPECIAL CONDITIONS:

1 Permittee shall submit a Railroad Work Plan to the Port of Long Beach Environmental Planning Division (562-590-4160) for work within 10-feet of the track centerline no less than 14 calendar days prior to starting work and be responsible for the cost of a flag person, provided by Pacific Harbor Line (310-834-4594), to work within 20-feet of the track centerline.

2 Permittee shall provide Port of Long Beach Inspections (562-590-4172) with as-built coordinates of all exposed, new or abandoned underground utilities or structures in NAD '83 epoch 1991.35 feet coordinates and elevations in NGVD '29 Mean Lower Low Water feet.

3 Permittee shall coordinate with all facilities which may be affected by the permitted project, including but not limited to SSAT, TTI, and the Port of Long Beach Trade Relations, Engineering, and Real Estate divisions. Permittee shall not interfere with any facility operations. Permittee may contact POLB Terminal Services at 562-590-4180 for assistance with notifications.

4 Permittee shall contact the Port of Long Beach Inspection Division at (562) 590-4172 at least 2 working days prior to backfilling any exposed or new underground utilities or structures to allow for as-built surveys.

5 Permittee shall install peregrine falcon nesting platforms on the Badger Avenue Bridge at least 1 month prior to the start of construction on the Project. Permittee shall conduct monitoring of the falcons' use of the Badger Avenue Bridge nesting platforms commencing at least 1 month prior to, and monthly thereafter, for each nesting season occurring during construction of the Project. Permittee shall have a qualified biologist conduct the monitoring. If after the first nesting season falcon nesting was not observed on the Badger Avenue Bridge, Permittee shall install falcon nesting platforms on the new Schuyler Heim Bridge, at least
1 month prior to the start of the next nesting season. Permittee shall submit annual reports on the falcon nesting status to the Director of Environmental Planning (562) 590-4160.

6 Permittee shall be responsible for designing and building a structure northerly of the Cerritos Channel, including foundations and soil improvements, that accommodates fill under the proposed bridge to an elevation that approximately matches adjacent grades (approximately 15 feet above sea level).

7 Permittee shall handle all stormwater runoff from the Project without discharging into the Port of Long Beach's stormwater drainage facilities. If an independent Caltrans drainage system is not feasible, Permittee shall treat all stormwater to meet current and future regulatory requirements (including TMDLs) prior to the stormwater entering the Port of Long Beach's drainage system. Final drainage improvements shall be agreed to by both the Permittee and the Port of Long Beach. Permittee shall be responsible for the costs of drainage improvements, including but not limited to treatment installations, drainage-related fill, and modifications to existing facilities. Permittee shall prepare a Standard Urban Stormwater Mitigation Plan (SUSMP) and submit it to the Port of Long Beach Director of Environmental Planning (562-590-4160) for review and approval prior to project commencement.

8 Permittee shall construct a heavy construction pier per the guidelines in the American Railway Engineering and Maintenance of Way Association Manual of Recommended Practices (Chapter 8, Part 2, Section 2.1.5.1) which requires piers within 25 feet of a future track be heavy construction or protected by a pier protection (crash) wall. The Project must meet these criteria and not interfere with planned upgrades to the Pier S Railyard.

10 Permittee shall implement all mitigation measures identified in the FEIS/FEIR that apply to the Project

ACKNOWLEDGEMENTS

DIRECTOR OF PLANNING	DATE	SIGNATURE OF PERMITTEE/AGENT	DATE
	07/21/2010	Karl Price	7/23/10

APPLICANT COPY

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

FEB 12 2010

Karl Price
California Department of Transportation
District 7 – Division of Environmental Planning
100 Main Street, Suite 100
Los Angeles, California 90012-3606

Dear Mr. Price:

NOAA's National Marine Fisheries Service (NMFS) has reviewed the Essential Fish Habitat (EFH) Assessment and Final Environmental Impact Assessment/Environmental Impact Report (EIS/EIR), for the demolition and replacement of the Commodore Schuyler Heim Bridge (Br. No. 53-2618) in the Ports of Long Beach and Los Angeles, Los Angeles County, California. NMFS offers the following comments pursuant to section 305(b)(4)(A) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and the Marine Mammal Protection Act (MMPA).

Proposed Project

The proposed project will replace the existing bridge with a fixed-span seismically sound bridge just east of the current alignment. Both the northerly and southerly approaches to the bridge will be replaced as well. Total permanent and temporary disturbance is expected to be approximately 92 acres which includes the 250 foot (ft) buffer along the bridge footprint, used to accommodate temporary structures necessary for bridge construction. The bridge will be 36.6 meters (m) wide and will span 1,463 m over the Cerritos Channel. The bridge will be constructed 14.3 m above mean high water and no changes will be made to the navigational width of the channel. Project implementation is expected to take 2 to 3 years beginning in the winter of 2010.

Magnuson-Stevens Fishery Conservation and Management Act Comments

Action Area

The proposed project occurs in EFH for various federally managed fish species within the Pacific Groundfish and Coastal Pelagics Fishery Management Plans (FMPs). Additionally, the project occurs within estuarine habitat, which is a designated habitat area of particular concern (HAPC) for various federally managed fish species within the Pacific Groundfish FMP. HAPC are described in the regulations as subsets of EFH which are rare, particularly susceptible to human-induced degradation, especially

ecologically important, or located in an environmentally stressed area (50 CFR 600.815(a)(8)). Designated HAPCs are not afforded any additional regulatory protection under MSA; however, federal projects with potential adverse impacts to HAPC will be more carefully analyzed during the consultation process.

Effects of the Action

The proposed bridge will increase the overwater footprint and will have adverse impacts to the underwater light environment through increased shading. The underwater light environment is a naturally light-reduced ecosystem due to light refraction from the waters surface. Light drives the photosynthetic process controlling plant growth and survival and is the most important factor affecting plants. Shading from overwater structures can reduce the complexity of the habitat by reducing the abundance of aquatic vegetation and phytoplankton. The overall morphology of the shadow cast by a structure is dependent on the height, width, material, and polar orientation of the structure. Structure height above aquatic vegetation has been determined to be the most important attribute affecting underwater light penetration and seagrass bed quality. Given the relatively depauperate underwater plant community within the action area and overall height of the proposed bridge, adverse impacts to EFH from shading are expected to be minimal.

Fishes rely on visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. Juvenile and larval fish are primarily visual feeders with starvation being the major cause of larval mortality in marine fish populations. Early life history stages are likely critical determining factors for recruitment and survival, with survival linked to the ability to locate and capture prey and to avoid predation. The reduced-light conditions found under an overwater structure limit the ability of fishes, especially juveniles and larvae, to perform these essential activities. The shadow cast by an overwater structure may increase predation on federally managed species by creating a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility). As coastal development and overwater structure expansion continues, the underwater light environment will continue to degrade resulting in adverse effects to EFH and nearshore ecosystems. In this case, however, NMFS expects the adverse impacts to EFH be minimal given the overall bridge height and polar orientation.

With the proposed pile installation, removal activities, and large areas of dewatered coffer dams, there may be a change in the benthic community. Piles impact the substrate into which they are driven, depending on the size and spacing of the pilings these impacts may be significant. While permanent piles will be placed within the dewatered coffer dams, the temporary pile driving will occur in-water using vibratory and impact hammers, which can generate intense underwater sound pressure waves. These sound pressures have been linked to fish kills and internal fish injury. The primary effect of pile removal is the resuspension of sediments, which may result in increased turbidity levels, as well as release of contaminants contained within the pile and associated substrate.

EFH Conclusion

As described in the above effects analysis, NMFS has determined that the proposed action would adversely affect EFH for various federally managed fish species within the Coastal Pelagics and Pacific Groundfish FMPs. However, Chapters 5 and 2 of the proposed action contain adequate measures to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH. Additionally construction activities will adhere to all applicable laws, regulations, and Best Management Procedures (BMPs) - including, but not limited to, requirements mandated by the United States Army Corps of Engineers, California Coastal Commission, California Department of Fish and Game, Regional Water Quality Control Board and other appropriate regulatory agencies. Therefore, NMFS has no additional EFH Conservation Recommendations to provide. We thank you for your continued consultation.

Marine Mammal Protection Act Comments

The proposed action may result in effects to the following non Endangered Species Act-listed marine mammal species: Pacific harbor seal (*Phoca vitulina richardii*) and the California sea lion (*Zalophus californianus*). Sounds introduced into the sea by man-made devices could have a deleterious effect on marine mammals by causing stress or injury, interfering with communication and predator/prey detection, and changing behavior. Acoustic exposure to loud sounds, may result in a temporary or permanent loss of hearing (termed a temporary or permanent threshold shift) depending upon the location of the marine mammal in relation to the source of the sound. NMFS is currently in the process of determining safety criteria (*i.e.*, guidelines) for marine species exposed to underwater sound. However, pending adoption of these guidelines, we have preliminarily determined, based on past projects, consultations with experts, and published studies, that 180 dB re 1μPa_{RMS} (190 dB re 1μPa_{RMS} for pinnipeds) is the impulse sound pressure level that can be received by marine mammals without injury. Marine mammals have shown behavioral changes when exposed to impulse sound pressure levels of 160 dB re 1μPa_{RMS} and when exposed to continuous sound levels of 120 re 1μPa_{RMS}.

The principal mechanism of potential effects to marine mammals from the proposed project is exposure to underwater sound generated by pile driving and vessel traffic. The EIS/EIR states that injuries to pinnipeds in the Cerritos Channel may occur up to and between 55 m (181 ft) to 95 m (312 ft) from the source of the pile driving. By providing attenuation from pile driving (*i.e.*, air bubble curtain), injuries to pinnipeds may be reduced to a distance of up to and between 20 m (66 ft) to 55 m (181 ft) from the source. Behavioral harassment to pinnipeds may occur up to and between 230 m (755 ft) to 1,000 m (3,281 ft) from the source of the pile driving even with attenuation methods. In addition, the estimated distances from the pile driving source in the Dominguez Channel/Consolidated Slip may cause injuries to pinnipeds at 10 m (33 ft), if unattenuated or at 2 m (7 ft) using the air bubble curtain. Similar to the Cerritos Channel, behavioral harassment to pinnipeds may occur up to 1,000 m (3,281 ft) from the source

of pile driving even with attenuation methods. The EIS/EIR also states that pinnipeds in the project area would be expected to either move away from or avoid the immediate vicinity until the pile driving stops. Avoidance is not considered a mitigation measure. While the estimated distances for potential impacts to marine mammals were addressed in the EIS/EIR, it is not clear what the sound pressure levels are at those distances. In addition, the sound generated in the Channels and Consolidated Slip from project activities could potentially impact a marine mammal's ability to transit through the area. Please provide minimization or mitigation measures to NMFS as they relate to transiting marine mammals through the project area. It is also not clear how the structure of the Cerritos Channel, for example, with a width of 183 m (600 ft), could potentially affect the zone of acoustic influence on marine mammals and the estimated distance measurements for injury and behavioral harassment reported in the EIS/EIR. NMFS requests a map depicting the estimated sound pressure levels and associated distances, as they relate to injury and behavioral harassment within the Cerritos Channel and Dominguez Channel/Consolidated Slip.

Vessel traffic coming in and going out of the area (*e.g.,* barges, tugs, work vessels) related to the proposed construction of the project would be transiting to and from offshore waters where California sea lion, Pacific harbor seal, and other marine mammals occur. Work vessels transiting to and from the project area could collide with marine mammals. Please describe the impact that vessel traffic may have on marine mammals and any applicable mitigation or minimization measures. Further, in the event of a watercraft collision with a marine mammal, officials must immediately contact the NMFS Stranding Coordinator, Mr. Joseph Cordaro at (562) 980-4017.

Seals and sea lions are protected under the MMPA. Under the MMPA, with the exception for military readiness, it is illegal to "take" a marine mammal without prior authorization from NMFS. "Take" is defined as harassing, hunting, capturing, or killing, or attempting to harass, hunt, capture, or kill any marine mammal. "Harassment" is defined as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal in the wild, or has the potential to disturb a marine mammal in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. Based on the information provided in the EIS/EIR, NMFS recommends applying for a permit to take marine mammals under section 101(a)(5) of the MMPA.

NMFS would like to acknowledge the decision to use a biological monitor during construction activities in order to minimize the potential impacts of the project on marine mammals and we look forward to reviewing the marine mammal monitoring plan mentioned in the EIS/EIR.

Thank you for consideration of our comments. Please contact Barak Shemai at 562-980-4044 or Barak.Shemai@noaa.gov if you have any questions related to our EFH comments. Please contact Monica DeAngelis at 562-980-3232 or Monica.DeAngelis@noaa.gov if you have any questions concerning our MMPA comments.

Sincerely,

for Robert S. Hoffman
Assistant Regional Administrator
for Habitat Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE
OFFICE OF LAW ENFORCEMENT
2800 COTTAGE WAY, ROOM W2928
SACRAMENTO, CA 95825

June 5, 2009

To Whom It May Concern:

The Migratory Bird Treaty Act (MBTA) prohibits the taking of migratory birds except when specifically authorized by the Department of the Interior (16 USC 703). Most native songbirds, wading birds, waterfowl and birds of prey are protected under the MBTA, and the Government need not prove that a taking was intentional to substantiate a violation. Authorization by the Department of Interior would consist of a permit, and neither the MBTA nor its implementing regulations (50 CFR 21) provide for the issuance of permits authorizing the "incidental take" of migratory birds that may be killed or injured by otherwise lawful activities.

The act of destroying *active* nests constructed by any protected migratory bird listed under 50 CFR 10.13 would constitute a violation of the MBTA; specifically, Title 16 USC 703, which states, in part: it shall be unlawful at anytime, by any means or in any manner, to take any migratory bird, or any part, nest or egg thereof. Upon conviction, this violation may be punishable up to $15,000 and/or imprisonment for not more than 6 months.

Notwithstanding the MBTA, and other applicable laws (i.e. Endangered Species Act, Bald and Golden Eagle Protection Act), an individual may legally destroy (i.e. wash down, knock down) a nest if the nest is deemed inactive – such as when birds, eggs or fledglings are no longer present. However, please note that if an individual destroys a nest that was mistakenly deemed inactive, and in turn was active, regardless of intent, they may be found responsible under the provisions of the MBTA, as described above.

Additional information may be conveniently researched under the U.S. Fish and Wildlife Service website http://www.fws.gov.

Further inquiries regarding this matter may be directed to the U.S. Fish and Wildlife Service, Sacramento Office of Law Enforcement at (916)414-6660, or the Migratory Bird Permit Office for permit inquiries at (916)414-6600.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Carlsbad Fish and Wildlife Office
6010 Hidden Valley Road, Suite 101
Carlsbad, California 92011

In Reply Refer To:
FWS-LA-09B0313-09I0914

JUL 24 2009

Karl Price
Senior Environmental Planner
California Department of Transportation
District 7
Environmental Planning
100 South Main Street
Los Angeles, California 90012-3606

Subject: Informal Section 7 Consultation for the Schuyler Heim Bridge Replacement and SR-47 Expressway Project, Alternative 1, Los Angeles County, California

Dear Mr. Price:

This document is in response to your letter dated May 21, 2009, requesting our concurrence with your determination that the proposed Schuyler Heim Bridge Replacement and SR-47 Expressway Project is not likely to adversely affect the federally threatened western snowy plover (*Charadrius alexandrinus nivosus*) and the federally endangered brown pelican (*Pelecanus occidentalis*) and California least tern (*Sternula* (*Sterna*) *antillarum browni*) in accordance with section 7 of the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*). The project is receiving Federal funding through the Federal Highway Administration (FHWA), and Caltrans has assumed FHWA's responsibilities under the Act for this consultation in accordance with Section 6005 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) 2005, as described in the National Environmental Policy Act (NEPA) Delegation Pilot Program Memorandum of Understanding between FHWA and Caltrans (effective July 1, 2007) and codified in 23USC327(a)(2)(A). We initiated consultation on the date we received your request and additional information was provided on the proposed project on July 23, 2009.

While the Natural Environmental Study for the proposed project includes several alternatives, consultation has been requested for Alternative 1. Implementation of Alternative 1 will result in the replacement of the Schuyler Heim Bridge in order to meet the state mandate that bridges must sustain a major earthquake without collapsing. The existing steel vertical lift bridge will be removed and replaced with a new fixed-span bridge. The project includes the construction of the proposed SR-47 Expressway located north of the Schuyler Heim Bridge and extending to

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Alameda Street, at the intersection with Pacific Coast Highway, a distance of 2.7 kilometers (km) (1.5 miles [mi]). The four-lane, limited-access expressway eliminates at-grade rail crossings and signalized intersections along its length and includes a new bridge structure across the Consolidated Slip / Dominguez Channel near the Henry Ford Avenue Bridge. In addition, an Ocean Boulevard / SR-47 Flyover would be constructed on Terminal Island to divert traffic bound for northbound SR-47 directly onto the new bridge from eastbound Ocean Boulevard.

Construction of the new bridge footings in the Cerritos Channel and Consolidated Slip / Dominguez Channel will require disturbance of channel bottom sediments that are contaminated with copper, lead, zinc, mercury, total dichloro-diphenyl-trichloroethane (DDT) compounds, total polychlorinated biphenyl (PCB) compounds, and polycyclic aromatic hydrocarbon (PAH) compounds which may adversely affect water quality in the channels for a few days. This may result in acute toxicity to invertebrates or fish but is not expected to result in chronic bioaccumulation or food-chain effects. In addition, bridge demolition may affect channel water quality through the release of lead compounds in the bridge's paint.

Habitat within the Biological Study Area (BSA) for the proposed project is largely industrial and commercial, interspersed with bare ground and asphalt. A small amount of terrestrial vegetation is present comprising approximately 15 percent of the project site, and of this vegetated area approximately 7 percent is composed of native vegetation with the remainder consisting of non-native weeds and ornamental landscaping. The federally listed western snowy plover, brown pelican, and California least tern have been observed in or near the project impact areas utilizing the marine environment. These species are not expected to nest within the project impact area but may forage or rest in the area.

In addition, a nesting pair of American peregrine falcons (*Falco peregrinus anatum*) occupies the south tower of the Schuyler Heim Bridge. If these falcons are displaced by the project there is some potential that they may relocate closer to the breeding colony of California least terns at Pier T and begin foraging on the terns. However, this is unlikely given abundant other prey sources in the area and the presence of another pair of territorial American peregrine falcons at the Koch Carbon facility near Pier T.

The following measures have been incorporated into the project design to avoid impacts to federally listed species:

1) Best Management Practices will be utilized during construction to limit the spread of resuspended sediment. These may include cofferdams, blasting mats, silt curtains, and or turbidity curtains which would contain resuspended sediment onsite until it settles.

2) Best Management Practices will be utilized during bridge demolition to limit the spread of lead paint. These may include the use of shrouds, nets or tarps suspended around working areas and below bridges, and use of barges and booms below bridges, and use of vacuum or suction shrouds on blast heads to capture grit and old paint.

3) Preconstruction surveys of potential California least tern breeding sites (which may include any area of bare ground in the vicinity of the proposed project) will be conducted within 456 meters (m) (1,500 feet [ft]) of construction activities. If breeding special-status birds are present then construction activities within 456 meters (m) (1,500 feet [ft]) of the nest sites will be delayed until after the February to July breeding season.

4) A new peregrine falcon nest site will be established for the resident pair of falcons in close proximity to the project area by placing a nesting box on a tower of the Badger Avenue Bridge or another elevated structure. The local peregrine falcon population will be monitored to determine whether the resident pair nests in the new nesting box.

5) To avoid and minimize vehicle caused bird mortality, a fence will be incorporated on both sides of the new Schuyler Heim Bridge with a height of 4.27 m (14 ft).

Because the above avoidance measures have been incorporated into the project, we concur with your determination that the proposed project is not likely to adversely affect the western snowy plover, brown pelican, and California least tern. Therefore, the interagency consultation requirements of section 7 of the Act have been satisfied. Although our concurrence ends informal consultation, obligations under section 7 of the Act shall be reconsidered if new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered or this action is subsequently modified in a manner that was not considered in this assessment.

This document does not authorize take under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712) (MBTA). In order to avoid violation of the MBTA, Caltrans will avoid take of active nests, including an American peregrine falcon nest, by excluding all nests from the bridge structure prior to the nesting period. An onsite biological monitor will coordinate during construction activities in the nesting season to ensure that active nests are not taken.

Thank you for your coordination on this project. If you have any questions regarding this letter, please contact Sally Brown of my staff at (760) 431-9440 x278.

Sincerely,

for Karen A. Goebel
Assistant Field Supervisor

California Regional Water Quality Control Board

Los Angeles Region

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

Arnold Schwarzenegger
Governor

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Karl Price
California Department of Transportation
100 S. Main Street
Los Angeles, CA 90012

WATER QUALITY CERTIFICATION FOR PROPOSED SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT (Corps' Project No. 2010-186-PHT), DOMINGUEZ CHANNEL, CITY OF LOS ANGELES, LOS ANGELES COUNTY (File No. 10-005)

Dear Mr. Price:

Board staff has reviewed your request on behalf of California Department of Transportation (Applicant) for a Clean Water Act Section 401 Water Quality Certification for the above-referenced project. Your application was deemed complete July 14, 2010

I hereby issue an order certifying that any discharge from the referenced project will comply with the applicable provisions of sections 301 (Effluent Limitations), 302 (Water Quality Related Effluent Limitations), 303 (Water Quality Standards and Implementation Plans), 306 (National Standards of Performance), and 307 (Toxic and Pretreatment Effluent Standards) of the Clean Water Act, and with other applicable requirements of State law. This discharge is also regulated under State Water Resources Control Board Order No. 2003 - 0017 - DWQ, "General Waste Discharge Requirements for Dredge and Fill Discharges that have received State Water Quality Certification" which requires compliance with all conditions of this Water Quality Certification.

The Applicant shall be liable civilly for any violations of this Certification in accordance with the California Water Code. This Certification does not eliminate the Applicant's responsibility to comply with any other applicable laws, requirements and/or permits.

Should you have questions concerning this Certification action, please contact Dana Cole, Section 401 Program, at (213) 576-5733.

Samuel Unger
Interim Executive Officer

July 21, 2010
Date

DISTRIBUTION LIST

Lenny Malo
URS Corporation
2020 East First Street, Suite 400
Santa Ana, CA 92705

Bill Orme (via electronic copy)
State Water Resources Control Board
Division of Water Quality
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Betty Courtney
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Eric Raffini (via electronic copy)
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Jim Bartel
U.S. Fish and Wildlife Service
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Carlsbad, CA 92009

ATTACHMENT A

Project Information
File No. 10-005

1. Applicant:

Karl Price
California Department of Transportation
100 S. Main Street
Los Angeles, CA 90012

Phone: (213) 897-1839 Fax: (213) 897-0685

2. Applicant's Agent:

Lenny Malo
URS Corporation
2020 East First Street, Suite 400
Santa Ana, CA 92705

Phone: (714) 648-2762 Fax: (714) 433-7701

3. Project Name: Schuyler Heim Bridge Replacement Project

4. Project Location: Long Beach/Los Angeles, Los Angeles County

Latitude	Longitude
33.7650	118.2404
33.7660	118.2407
33.7674	118.2386
33.7649	118.2383
33.7660	118.2405
33.7671	118.2396
33.7663	118.2385
33.7648	118.2393

5. Type of Project: Bridge replacement

6. Project Purpose: The proposed project (Project) will provide a seismically safe structural connection for vehicle traffic to Terminal Island that can sustain a major earthquake, as well as improve operational and safety design features that meet current design standards.

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7. Project Description:

The Project will replace the existing Schuyler Heim Bridge (Bridge) with a fixed-span bridge east of the existing bridge alignment. Currently the Bridge has substandard lane widths, bridge rails, and shoulder widths, or no shoulder. Standard lane widths can accommodate heavy trucks and larger vehicles, as well as a shoulder in each direction for disabled vehicles.

A fixed-span bridge will replace the existing structure, and will eliminate the raising and lowering that impedes vehicular traffic. The estimated total temporary and permanent disturbance area associated is approximately 92 acres, which includes the permanent disturbance footprint as well as a 250-foot buffer to accommodate temporary structures (trestles, piers, lay down areas, and access and egress routes).

Construction of the Project is expected to take approximately two to three years with multiple crews working over the course of a two-shift workday. The construction schedule for replacement of the Schuyler Heim Bridge involves demolition, grading or excavation, foundation and bridge abutment and column construction, and bridge construction.

The proposed fixed-span structure will be approximately 4,800 feet long and with an average width of 120 feet. The proposed bridge is 43 feet wider than the existing lift bridge due to a new southbound auxiliary lane, standard 12-foot wide lanes, and standard Caltrans shoulders. In the northbound direction, the replacement bridge will include three 12-foot wide through traffic lanes, 10-foot shoulders. In the southbound direction, the replacement bridge will include three 12-foot wide traffic lanes, one 12-foot auxiliary lane, and 10-foot shoulders. The proposed alignment for the new fixed-span bridge is located primarily within, and partially east of the existing bridge's right-of-way.

The footprint of the proposed fixed-span bridge is located east of the existing bridge footprint to avoid impacts to the Alameda Corridor Transportation Authority tracks - located on the Badger Bridge immediately west of the existing Schuyler Heim Bridge, and to accommodate construction sequencing and maintain traffic flows during Project construction and demolition activities.

The vertical clearance of the proposed fixed-span bridge will be 47

feet over the Cerritos Channel mean high water line of 4.7 feet. This profile will accommodate a 45-foot fireboat. The width of the navigable channel (distance between bridge-support columns and fenders) will be 180 feet, the same as the existing width. The bridge replacement will retain access to a southbound off-ramp and northbound on-ramp at New Dock Street on Terminal Island, as well as a northbound off-ramp and southbound on-ramp at Henry Ford Avenue on the mainland (north) side of the bridge. The New Dock Street southbound off-ramp will be elevated to clear the existing industry tracks that join the Badger Bridge rail alignment from east of State Route (SR)-47. The new alignment of the off-ramp will eliminate one of the two at-grade rail crossings at SR-47 and New Dock Street. New Dock Street will be realigned to accommodate the realigned on-ramp and off-ramp.

Construction of the Project will require temporary structures, or "falsework" that will be built to support the new bridge and then be removed once construction is complete. The falsework required to construct the new bridge within the channel will temporarily restrict the available horizontal clearance and the vertical clearance to 13-foot wide openings required for U.S. Coast Guard emergency and security vessels. The Cerritos Channel clearance restrictions are projected for a period of 12 to 24 months during construction of the eastern deck sections of the new bridge, demolition of the existing steel lift bridge and construction of the western deck sections of the new bridge. The channel will be closed completely to large marine vessels for a period of approximately one year to erect the new bridge and remove the mid-span truss of the old lift bridge. With the exception of these periods of restriction and closure, the channel will be open for navigation during bridge construction.

The Project involves utilizing shafts that are cast-in-drilled-hole (CIDH) over land and cast-in-steel-shell (CISS) in the water depending on soil conditions. Most of the shafts will be of CIDH construction, as CIDH shafts can carry vertical and lateral loads through the deep, liquefiable soil layers. Also, the CIDH shafts do not require footings and, therefore, minimize right-of-way takes and utility relocations and have less effect on biological resources compared to the CISS shafts. The CISS shafts which require footings will be constructed where soil conditions require additional support.

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The Project will demolish the existing Schuyler Heim Bridge by first removing the lift span and then removing the remaining steel structure. The first phase constructs the easterly portion of the new fixed-span bridge east of the existing bridge. Once built, traffic from the existing bridge approaches will be routed onto the recently constructed bridge. In the second phase, the existing Schuyler Heim Bridge will be demolished. The final phase constructs the westerly portion of the new fixed-span bridge over the footprint of the recently demolished bridge.

The eastern side of the new fixed-span bridge will be constructed east of the existing lift bridge. The south ends of the new bridge approach will connect to Ocean Boulevard. On the north, the new bridge will connect to the existing SR-103 and Henry Ford Avenue. The connection to Ocean Boulevard and SR-103 are expected to occur at night without closing the SR-47 to traffic. Traffic on the existing bridge will be diverted to the eastern side of the new bridge, and the existing bridge will be demolished.

Construction of the portion of the new bridge that is directly over the Cerritos Channel will require access from both sides of the channel. Pier S and Pier A West will serve as local construction staging and materials storage areas. The contractor will either employ material delivery and crane work with the use of barges, or temporary trestles. The temporary pier would be required to dock the construction barges that supply construction materials, falsework, equipment and workers from the Pier S staging area.

If multiple barges are used a temporary pier composed of individual concrete column footings spaced every 20 feet, timber posts, cross tie beams and a wooden deck would be constructed from Pier S. The temporary pier will extend approximately 150 feet beyond the Pier S channel embankment to allow barges to dock. The temporary pier would be approximately 40 feet wide to accommodate a haul truck or front loader. The temporary pier would also be utilized in constructing the eastern half of the new bridge, demolishing of the existing Schuyler Heim Bridge and constructing the western half of the new bridge. Upon completion of this work, the temporary pier would be completely removed from the channel. The pier will have an estimated temporary in-channel impact of 0.0023 acres, based on 26 column footings that are approximately four feet square each. Barge access to the contractor's construction staging area within

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Pier A West will not require a temporary pier be erected in the Cerritos Channel. Due to the amount of goods movement activity on Pier A East and the fully developed Anchorage marina, construction materials, falsework, equipment and workers from Pier will be transported to an existing barge dock on the northern shore of the Dominguez Channel, west of Henry Ford Avenue. As result, the construction barges will travel about a mile southwest on the Dominguez Channel before intersecting the Cerritos Channel and traveling east to access the construction site.

The contractor could also elect to build a temporary trestle bridge to construct the Project. This approach would require a timber trestle erected on concrete column footings, or short steel driven piles spaced every 20 feet to span the entire channel. The temporary structure would be placed just east of the eastern half of the new bridge to load and unload construction materials, falsework, equipment and workers from the Pier A and Pier S construction staging areas. The temporary structure would be approximately 780 feet long and 40 feet wide. The trestle bridge will have a temporary in-channel impact of 0.0110 acres, based on 120 column footings that are approximately four feet square each.

Openings within the temporary trestle to accommodate U.S. Coast Guard emergency and security vessels will be provided by the contractor. Once the eastern half of the new bridge is completed, the temporary trestle would be removed. After demolition of the existing Schuyler Heim Bridge, another temporary trestle would be constructed just west of the second half of the new bridge to supply construction materials, falsework, also be approximately 780 feet long and 40 feet wide. Once the western half of the new bridge is completed, the temporary trestle would be removed. The trestle bridge will have a temporary in-channel impact of 0.0110 acres, based on 120 column footings that are approximately four square feet each.

The new eastern half of the bridge will require the contractor to install two footings at each of the four bents within the Cerritos Channel for a total of eight CISS piles. After demolition of the existing Schuyler Heim Bridge, the contractor will install the remaining eight piers for a grand total of 16 CISS piles constructed within the Cerritos Channel. All CISS piles within the channel that support the new Schuyler Heim Bridge have a 12-foot diameter.

Drilling for the 16 CIS S piles will produce 2,513 cubic yards of excavated material to be removed from the channel, and the same volume of concrete and steel reinforcing bars will be placed into the channel to permanently fill the drilled CISS piles.

In order to provide a dry workspace to join the bridge's columns to the steel reinforcing bars in the CISS piles, the contractor will construct a watertight coffer dam at each bent. Dewatering will occur once steel piles along with interlocking corrugated metal sheets are driven around the bridge bents to form a dry workspace. Water removed from the dams will be analyzed to identify if it is contaminated, classified, and treated if required before it is disposed in the approved manner. The area within the coffer dam will be utilized to construct the bridge's CISS piles and later the bridge columns. Four coffer dams, each 90 feet long and 40 feet wide, will be utilized to construct the eastern section of the new bridge's footings. Construction materials, equipment, and laborers will be supplied by barge or trestle.

All excavated material will be analyzed to identify if it is contaminated, and will either be used for fill in upland areas within Project limits or transported to a legal point of disposal. Once the first half of the bridge's columns has been constructed, the coffer dams will be removed. After the existing bridge has been demolished, the next four coffer dams will be erected to construct the second set of CISS piers and bridge columns. The four additional coffer dams will be removed after the new bridge's columns have been completed. The eight coffer dams will have a temporary in-channel impact 5.7 acres.

Falsework for the new Schuyler Heim Bridge will require driven steel pipe columns, 23.6 inches in diameter, to be installed at 20 feet center-to-center spacing for additional temporary support. The driven steel pipe columns will have a temporary impact of 0.127 acres, based on 440 driven steel pipes. Once the steel pipes are in place, wooden timber posts with cross-bracing lumber ties will support structural steel "I" beams to form a temporary heavy timber deck. The temporary deck will be employed for constructing the cast-in-place and post tensioned girders as well as the final concrete deck between spans. During erection and dismantling of the bridge falsework, marine traffic will not be allowed to pass.

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During the anticipated two- to three-year construction period, marine traffic in Cerritos Channel will be limited, as temporary navigation openings will be a maximum 75 feet wide and 43 feet high. In addition, the channel could be closed for periods up to 30 days for falsework erection, girder casting, lift bridge span demolition and falsework dismantling. During periods when the channel will be open, marine traffic would be directed through temporary openings.

Bridge construction will occur in phases. The construction schedule balances speed of construction with maintaining traffic on SR-47 and also minimizes bridge closures during construction. During construction, security fencing will be installed; followed by rough grading. Grading will occur on the north and south sides of the Cerritos Channel within the right-of-way to build the access ramps and approaches for the new higher bridge. It is expected that cut and fill will be balanced for this activity. The grading phase is estimated to require approximately one month to complete.

Pile casting will be completed after the column's reinforcing steel bar cages have been installed, the vertical column forms have been erected, and the structural concrete has been poured. Concrete will be brought on site in ready-mix trucks and pumped into the forms. After the specified curing period, the column forms will be removed. The columns will be spaced approximately 154 feet to 246 feet apart to support the fixed-span bridge. Each column will be approximately seven to nine feet in diameter. This phase will require an estimated 24 months to complete. A total of 120 columns will be installed and will have a permanent impact of 0.078 acres.

The existing fender piles (a mooring structure designed to absorb the impact energy of berthing vessels that avoids damage to the vessel or pier structure) in the channel will be pulled out with a crane. A total of 144 fender piles will be removed, each having a diameter of 1.2 feet for a total area of 0.0013 acres. A pile-driver will be used to install the new fender piles in the channel. The fender piles for this Project will be approximately 24-inches in diameter, and approximately 80 piles will be required. The permanent impact of new fender piles is estimated to be 0.018 acres. Fender piles are likely to be driven with a hydraulic impact hammer, with total energy per strike up to 370,000 foot-pounds of force. During this period, actual striking time is approximately 45

minutes, with a strike occurring between every one to two seconds, excluding adjustments or to check the pile tip elevation. A total of approximately 1,350 to 1,800 strikes or more may be required to drive each pile for duration of approximately 2 hours.

After column installation is complete in the channel, wood forms supported by steel and wood falsework will be erected at each pair of columns. During this phase, warning signs and night lighting will be utilized on the falsework as necessary to alert marine traffic of the presence of construction structures. This phase will require an estimated 17 months to complete.

When the falsework for the approach span is completed, installation will begin by constructing the bridge support structure with steel and reinforced concrete. Overhead bridge deck forms will be placed, and concrete will be poured and cured. The forms will be removed as the final step. This phase will require an estimated 13 months to complete.

With a substantial portion of the falsework in place, installation of the main-span superstructure will begin. This will consist of connecting pairs of columns, and subsequently the bridge support structure. Overhead forms will be installed around each section of the superstructure. Concrete will be poured, cured, and forms will be removed. This phase will complete of the structural section of the main span. This phase will require an estimated 25 months to complete.

The existing bridge superstructure and piers will also need to be removed. The pile caps will remain, except for a small portion of the existing main-span footing, which will be removed to allow placement of several CISS piles in the channel. The existing pile caps, footings, and piles will be cut two feet below the channel invert (per a 2005 agreement with the U.S. Coast Guard), and the hard-bottom substrate will revert back to native earth bottom. Prior to existing substructure removal, four coffer dams will be erected to provide dry workspaces. The two coffer dam in the center of the channel will be approximately 140 feet in length while the outside coffer dams by the shore will be 80 feet in width and the other two will be approximately 140 feet in length and 51 feet in width. The four coffer dams will have a temporary in-channel impact of 0.488 acres. If the bridge is not sold for reuse in an alternate location, the

port will leave the existing bridge pile caps in place, provided they are cut off and appropriately marked. The superstructure will be sent to a scrap metal exporting terminal. While there is no steel recycling mill operating in the Port of Long Beach (POLB) or Port of Los Angeles (POLA), there are several scrap metal exporting terminals at both ports. Because lead paint is likely to be encountered on the old superstructure, special measures will be employed during demolition to prevent lead contamination. A lead-based paint and asbestos survey will be conducted. If lead or asbestos were encountered at levels higher than the mandated thresholds, these materials will be removed from the steel for disposal prior to recycling. This demolition phase will require an estimated 17 months to complete.

Once the approach and main-span decks have been completed, construction of the deck barriers and joints will begin. The deck barriers will consist of forms and reinforced concrete to provide vehicle protection along both the outside portions of the structure and the center divider. Joints will consist of forms and reinforced concrete to tie together each segment of the bridge and expressway structure, and allow for expansion and contraction of the road surface. This phase will require an estimated 18 months to complete.

At the close of construction, the bridge surface will be striped for the prescribed number of traffic lanes, lighting fixtures and signage will be installed, and a fence will be incorporated on both sides of the new bridge with a height of 14 feet. This phase will require an estimated 12 months to complete. Overall, the Project will have a temporary in channel impact of 6.36 acres. Although the Project will require the permanent placement of 0.02 acres of CISS piles within the Cerritos Channel, the Project will remove 0.49 acres of existing piles and footings which will result in a net gain in open water habitat of 0.47 acres.

Dewatering activities will include coffer dams or similar structures within the Cerritos Channel. Barge mounted vibratory pile drivers will be used to vibrate sheet piles for the coffer dams into the ground. The coffer dams will be equipped with pumps for dewatering. Water that enters the coffer dams will be removed by pump and placed in a baker storage tank for testing and treatment. Pumped water will be allowed to settle in the baker tanks. If foreign

material enters the water it will be disposed of according the requirements of the Clean Water Act Section 402 National Pollution Discharge Elimination System Permit, Industrial Water Permit, or taken to a legal point of disposal. Clean water will be returned to the Cerritos Channel.

Sediments from the baker tanks will be placed on a barge and taken to shore for processing or to a legal point of disposal. Water will remain flowing during construction around the coffer dams within the Cerritos Channel. The coffer dams will be removed using the barge mounted vibratory pile drivers upon completion of construction.

The Project will not disrupt the tidally influenced hydrological regime within the Cerritos Channel. The channel will maintain its tidally-influenced hydrologic regime during Project construction to avoid or minimize adverse impacts to fish or other biological resources and localized water chemistry.

8. Federal Agency/Permit:

U.S. Army Corps of Engineers
NWP No. 14 Linear Transportation Projects (Permit No. 2010-186-PHT)

9. Other Required Regulatory Approvals:

California Coastal Commission
Coastal Development Permit

10. California Environmental Quality Act Compliance:

The California Department of Transportation approved the Project's Final Environmental Impact Report (FHWA-CA-EIS-2007-07-01F, State Clearinghouse (SCH) No. 2002021009) on May 12, 2009. A notice of Determination was filed with the SCH on August 17, 2009.

A Final Environmental Impact Statement / Environmental Impact Report (FEIS/FEIR) was prepared for the Schuyler Heim Bridge Replacement and SR-47 Expressway Project (Caltrans 2009). The FEIS/FEIR identified six proposed project alternatives. *Alternative 1 (Bridge Replacement and SR-47 Expressway)* was selected as the preferred alternative. Alternative 1 combined the Schuyler Heim Bridge Replacement Project and the Alameda Corridor Expressway

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Project to create a grade-separated expressway that will be a high-capacity alternate route between Terminal Island and Alameda Street at Pacific Coast Highway. This alternative involved replacement of the Schuyler Heim Bridge; construction of a limited-access expressway that begins at Ocean Boulevard, crosses the Cerritos Channel, and extends northward for a distance of approximately 1.7 miles; and construction of the proposed 5,084 feet flyover (a connector ramp from the eastbound Ocean Blvd which is planned as a later phase of the project around the year of 2020.)

Alternative 1 could not be completely funded at this time. As a consequence, only a portion of Alternative 1, construction of a replacement Schuyler Heim Bridge and demolition of the existing bridge, will be completed at this time by Caltrans. The Project does not include adverse impacts to common or special status species or other biological resources associated with the construction of the SR-47 Expressway Project.

11. Receiving Water:	Receiving water from Dominguez Channel Hydrologic Unit No. 405.12)
12. Designated Beneficial Uses:	MUN*, REC-1, REC-2, WARM, WILD, RARE *Conditional beneficial use
13. Impacted Waters of the United States:	Ocean/Estuary/Bay: 6.36 temporary and 0.116 permanent acres
14. Dredge Volume:	None
15. Related Projects Implemented/to be Implemented by the Applicant:	Two projects are to be completed within the next 5 years that are related to the Schuyler Heim Bridge Replacement Project and include: SR-47 Expressway and the Ocean Boulevard Connector Ramp. Neither of these projects will impact the Cerritos Channel.

16. Avoidance/ Minimization Activities:

The Applicant has proposed to implement Best Management Practices, including, but not limited to, the following:

- Preconstruction surveys of potential California least tern breeding sites (which may include any area of bare ground in the vicinity of the Project) will be conducted within 1,500 feet of construction activities.
- If breeding special status birds are present, then construction activities within 1,500 feet of the nest sites will be delayed until after the February to July breeding season.
- A new peregrine falcon nest site will be established for the resident pair of falcons in close proximity to the Project by placing a nesting box on, a tower of the Badger Avenue Bridge or another elevated locale.
- The local peregrine falcon population will be monitored to determine whether the resident pair nests in the new nesting box.
- A falcon relocation plan, detailing the relocation means and methods will be approved by the resource agencies and implemented prior to Project construction.
- To avoid or minimize vehicle caused bird mortality, a fence will be incorporated on both sides of the new Schuyler Heim Bridge with a height of 14 feet.
- Limiting the area of Project activities
- Pile driving volume will be developed as well by use of a contained air bubble curtain on larger pile installations and dewatering casings for smaller piles.
- Performance criteria for sound attenuation will be developed to achieve maximum practicable reductions in underwater sound levels.
- A hydro-acoustic monitoring plan will be developed and submitted to this Regional Board before work begins, and will include appropriate sampling point locations, frequency, and methods to be implemented during pile driving.

- The results of the hydro-acoustic monitoring will be analyzed as occurring to identify appropriate safety isopleths and monitoring zones for sensitive biological resources.

- Channel bank work will include bank protection (riprap, concrete walls) to eliminate the possibility of enhanced bank erosion.

- Sediment suspension will be minimized by adherence to the CIDH, CISS, or similar material designed for all in-water piles (the outer shell will act as a coffer dam during construction and contain suspended sediment onsite until removed prior to concrete pile installation).

- Cofferdams and sand blasting mats will be used during sand blasting operations.

- The contractor will construct a watertight coffer dam at each bent. Dewatering will occur once steel piles along with interlocking corrugated metal sheets are driven around the bridge bents to form a dry workspace.

- Water removed from the coffer dams will be analyzed to identify if it is contaminated, classified, and treated if required before it is disposed of to a legal point of disposal.

- Nets and tarps will be suspended below bridges to catch debris from removal of old paint where wind conditions permit.

- Vacuum or suction shrouds will be used on blast heads to capture grit and old paint.

- Booms will be used to capture fugitive floating paint chips and debris.

- Perform lead-based paint removal.

- Turbidity curtains that are constructed of a permeable material allowing water to flow through the membrane while trapping suspended sediment will be used.

- Use of these permeable membranes allows the barrier to extend

from the water surface to the bottom, providing effective containment and filtering of suspended sediments.

- Tires on construction equipment will be washed before the equipment enters and leaves the Project.
- Construction equipment will be cleaned as necessary to minimize the volume of decontamination wash water and prevent transport of contaminants from the Project.
- Designated locations will be provided for servicing, washing, and refueling equipment, away from temporary channels or swales that will quickly convey runoff to the drainage system and into the Cerritos Channel.
- Hazardous material will be kept at a safe from an entry into a receiving water body.
- Temporary barriers and containers will be used to confine any contaminated materials.
- Upon completion of construction, all contaminated material on the proposed project will be removed and disposed of in accordance with federal, regional, and local regulations.
- A temporary spill containment system will be installed and maintained within Project limits during construction.
- Entrances and exits will be stabilized.
- non-paved surfaces will be wetted,
- Paved surfaces will be swept and vacuumed.
- Silt fences at the toe of excavation and embankment slopes will be installed.
- Sand or gravel bag berms along the top of slopes will be installed.
- Slope protection and erosion control blankets will be installed

ATTACHMENT A

Project Information
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- Storm drain inlets will be protected by gravel sand bag berms.

- Monitor and report BMP performance and conditions before and immediately after the completion of work, in accordance with SWPPP specifications.

- Before the first week of work water quality testing will be conducted to establish a baseline for monitoring purposes in order to establish compliance. Analyses must be performed using approved US Environmental Protection Agency methods, where applicable. Monitoring will be required for:

  - pH
  - temperature
  - dissolved oxygen
  - turbidity
  - total suspended solids

- The plan describing the monitoring above shall be submitted prior to any project work as described herein for approval by this Regional Board.

- After a water quality baseline is established, testing will occur only when the bottom is impacted, or when heavy machinery is operating in the water.

- If impacts to water quality are detected, these constituents shall be measured on a daily basis during the first week of detection and then on a weekly basis thereafter until the detection ceases.

- Results of the analyses shall be submitted to this Regional Board by the 15th day of each subsequent sampling month. A map or drawing indicating the locations of sampling points shall be included with each submittal. Activities shall not result in the degradation of beneficial uses or exceedance of water quality objectives of the receiving waters. Any such violations may result in corrective and/or enforcement actions, including increased monitoring and sample collection.

- No testing will be required for hand work or above-water work items such as assembling the bridge or using tools, installing pipes, pulling wires, or similar hand work if the work does not

cause water quality impacts.

- The contractor and Caltrans will monitor for turbidity plumes, hydrocarbons, floating debris, or heavy items which fall in the water. If there are any visual or monitoring indications during the out of water work portion of the project, then testing will be implemented to determine the water quality impact.

- Additionally, the Contractor will:

  - Deploy hydrocarbon and trash booms as required by the permit conditions and the Engineer's specifications.

  - Recover all the items which fall into the water including those that require a diver to retrieve.

17. Proposed Compensatory Mitigation:	None
18. Required Compensatory Mitigation:	The Applicant shall restore 6.26 acres of temporary impacts, and provide 0.348 acres of mitigation (3:1) for permanent impacts to Ocean/Estuary/Bay waters of the U.S. See *Attachment B, Conditions of Certifications, Additional Conditions* for modifications and additions to the above proposed compensatory mitigation.

ATTACHMENT B

Conditions of Certification
File No. 10-005

STANDARD CONDITIONS

Pursuant to §3860 of Title 23 of the California Code of Regulations (23 CCR), the following three standard conditions shall apply to this project:

1. This Certification action is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to §13330 of the California Water Code and Article 6 (commencing with 23 CCR §3867).

2. This Certification action is not intended and shall not be construed to apply to any activity involving a hydroelectric facility and requiring a Federal Energy Regulatory Commission (FERC) license or an amendment to a FERC license unless the pertinent Certification application was filed pursuant to 23 CCR Subsection 3855(b) and the application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought.

3. Certification is conditioned upon total payment of any fee required pursuant to 23 CCR Chapter 28 and owed by the Applicant.

ADDITIONAL CONDITIONS

Pursuant to 23 CCR §3859(a), the Applicant shall comply with the following additional conditions:

1. The Applicant shall submit to this Regional Board copies of any other final permits and agreements required for this project, including, but not limited to, the U.S. Army Corps of Engineers' (ACOE) Section 404 Permit and the California Coastal Commission (CCC) Coastal Development Permit. **These documents shall be submitted prior to any discharge to waters of the State.**

2. The Applicant shall adhere to the most stringent conditions indicated with either this Certification, the CCC's Coastal Development Permit, or the ACOE Section 404 Permit.

3. The Applicant shall comply with all water quality objectives, prohibitions, and policies set forth in the *Water Quality Control Plan, Los Angeles Region (1994),* as amended.

4. The Avoidance/Minimization activities proposed by the Applicant as described in **Attachment A, No. 16**, are incorporated as additional conditions herein.

5. The Applicant and all contractors employed by the Applicant shall have copies of this Certification, the approved *Design Drawings, Plans and Specifications* as submitted with the 401 Application (January 13, 2010) and all other regulatory approvals for this project on site at all times and shall be familiar with all conditions set forth.

6. Fueling, lubrication, maintenance, operation, and storage of vehicles and equipment shall not result in a discharge or a threatened discharge to waters of the State. At no time shall the Applicant use any vehicle or equipment which leaks any substance that may impact water quality. Staging and storage areas for vehicles and equipment shall be located outside of waters of the State.

7. All excavation, construction, or maintenance activities shall follow best management practices to minimize impacts to water quality and beneficial uses. Dust control activities shall be conducted in such a manner that will not produce downstream runoff.

8. No construction material, spoils, debris, or any other substances associated with this project that may adversely impact water quality standards, shall be located in a manner which may result in a discharge or a threatened discharge to waters of the State. Designated spoil and waste areas shall be visually marked prior to any excavation and/or construction activity, and storage of the materials shall be confined to these areas.

9. All waste and/or dredged material removed shall be relocated to a legal point of disposal if applicable. A legal point of disposal is defined as one for which Waste Discharge Requirements have been established by a California Regional Water Quality Control Board, and is in full compliance therewith. Please contact Rodney Nelson, Land Disposal Unit, at (213) 620-6119 for further information.

10. The Applicant shall implement all necessary control measures to prevent the degradation of water quality from the proposed project in order to maintain compliance with the Basin Plan. The discharge shall meet all effluent limitations and toxic and effluent standards established to comply with the applicable water quality standards and other appropriate requirements, including the provisions of Sections 301, 302, 303, 306, and 307 of the Clean Water Act. This Certification does not authorize the discharge by the applicant for any other activity than specifically described in the 404 Permit.

11. The discharge shall not: a) degrade surface water communities and populations including vertebrate, invertebrate, and plant species; b) promote the breeding of mosquitoes, gnats, black flies, midges, or other pests; c) alter the color, create visual contrast with the natural appearance, nor cause aesthetically undesirable discoloration of the receiving waters; d) cause formation of sludge deposits; or e) adversely affect any designated beneficial uses.

12. The Applicant shall allow the Regional Board and its authorized representative entry to the premises, including all mitigation sites, to inspect and undertake any activity to determine compliance with this Certification, or as otherwise authorized by the California Water Code.

ATTACHMENT B

Conditions of Certification
File No. 10-005

13. The Applicant shall not conduct any construction activities within waters of the State during a rainfall event. The Applicant shall maintain **a five-day (5-day) clear weather forecast** before conducting any operations within waters of the State.

14. If rain is predicted after operations have begun, grading activities must cease immediately and the site must be stabilized to prevent impacts to water quality, and minimize erosion and runoff from the site.

15. Sediment removal at each phase shall not go beyond the extent as defined in the application packet.

16. The grading, stabilization and re-vegetation will be phased to limit the exposed or working face such that the graded area can be stabilized within 24 hours after the first prediction of rain during the 5-day forecast or within 24 hours after final grading of the phased area.

17. No activities shall involve wet excavations (i.e., no excavations shall occur below the seasonal high water table). A minimum **5-foot** buffer zone shall be maintained above the existing groundwater level. If construction or groundwater dewatering is proposed or anticipated, the Applicant shall file a **Report of Waste Discharge** to this Regional Board and obtain any necessary NPDES permits/Waste Discharge Requirements prior to discharging waste. Sufficient time should be allowed to obtain any such permits (generally 180 days). If groundwater is encountered without the benefit of appropriate permits, the Applicant shall cease all activities in the areas where groundwater is present, file a Report of Waste Discharge to this Regional Board, and obtain any necessary permits prior to discharging waste.

18. All project or construction activities not included in this Certification, and which may require a permit, must be reported to the Regional Board for appropriate permitting. Bank stabilization and grading, as well as any other ground disturbances, are subject to restoration and revegetation requirements, and may require additional Certification action.

19. The Applicant shall restore the proposed **6.36 acres** of TEMPORARY IMPACTS to waters of the United States and all other areas of temporary disturbance which could result in a discharge or a threatened discharge to waters of the State. Restoration shall include grading of disturbed areas to pre-project contours. The Applicant shall implement all necessary Best Management Practices to control erosion and runoff from areas associated with this project.

20. The Applicant shall also provide Compensatory Mitigation for the proposed permanent impacts **to 0.116 acres** of Ocean/Estuary/Bay waters of the United States/Federal jurisdictional wetlands by creating or restoring riparian habitat/Federal jurisdictional wetland habitat at a minimum **3:1** area replacement ratio **(0.348 acres)**.

21. If the Applicant proposes funding or a combination of funding and onsite mitigation to a third-party organization for habitat within waters of the United States/Federal jurisdictional wetlands, then funding shall apply to mitigation acreage only, exclusive of administrative costs. The mitigation site shall be located within the Dominguez Channel Watershed unless otherwise approved by this Regional Board. The Applicant shall submit a **Proposed Mitigation Report** which shall include:

    (a) Documentation from the third party indicating that funds have been used for mitigation acreage only, which do not include administrative costs.
    (b) The boundary of the mitigation site shall be clearly identified on a map of suitable resolution and quality and shall also be defined by latitude and longitude.
    (c) The type(s) of mitigation shall be described (e.g., removal of exotics and/or replanting with native species, etc.)
    (d) Success criteria shall be established.

    This information shall be submitted to this Regional Board for approval before project completion and shall include copies of all agreements made between the Applicant and a third party organization regarding compensatory mitigation efforts.

22. All open space and mitigation areas shall be placed within a conservation easement to ensure preservation in perpetuity. Documentation of proper easement placement shall be submitted to the Regional Board within one year.

23. The Applicant shall submit to this Regional Board **Annual Mitigation Monitoring Reports** (Annual Reports) by **January 1st** of each year for a minimum period of **five (5) years** following this issuance of 401 Certification or until mitigation has been achieved and documented. The Annual Reports shall describe in detail all of the project/construction activities performed during the previous year and all restoration and mitigation efforts; including percent survival by plant species and percent cover. The Annual Reports shall describe the status of other agreements (e.g., mitigation banking) or any delays in the mitigation process. At a minimum the Annual Reports shall include the following documentation and answered appropriately whether or not mitigation has been performed:

    (e) Color photo documentation of the pre- and post-project and mitigation site conditions;

    (f) Geographical Positioning System (GPS) coordinates in decimal-degrees format outlining the boundary of the project and mitigation areas;

    (g) The overall status of project including a detailed schedule of work;

    (h) Copies of all permits revised as required in Additional Condition 1;

(i) Water quality monitoring results for each reach (as required) compiled in an easy to interpret format;

(j) A certified Statement of "no net loss" of wetlands associated with this project;

(k) Discussion of any monitoring activities and exotic plant control efforts; and

(l) A certified Statement from the permittee or his/her representative that all conditions of this Certification have been met.

24. All applications, reports, or information submitted to the Regional Board shall be signed:

(a) For corporations, by a principal executive officer at least of the level of vice president or his duly authorized representative, if such representative is responsible for the overall operation of the facility from which discharge originates.

(b) For a partnership, by a general partner.

(c) For a sole proprietorship, by the proprietor.

(d) For a municipal, State, or other public facility, by either a principal executive officer, ranking elected official, or other duly authorized employee.

25. Each and any report submitted in accordance with this Certification shall contain the following completed declaration:

"I declare under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system or those directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Executed on the _____ day of _____ at _____.

_____ (Signature)
_____ (Title)"

26. All communications regarding this project and submitted to this Regional Board shall identify the Project File Number **10-005**. Submittals shall be sent to the attention of the 401 Certification Unit.

27. Any modifications of the proposed project may require submittal of a new Clean Water Act Section 401 Water Quality Certification application and appropriate filing fee.

28. The project shall comply with the local regulations associated with the Regional Board's **Municipal Stormwater Permit** issued to the Department of Transportation (Caltrans) under NPDES No. CAS000003 and Waste Discharge Requirements Order No. 99 - 06 - DWQ. This includes the Standard Urban Storm Water Mitigation Plan (SUSMP) and all related implementing local ordinances and regulations for the control of stormwater pollution from new development and redevelopment.

29. The project shall comply with all requirements of the National Pollutant Discharge Elimination System (NPDES) **General Permit** for Storm Water Discharges Associated with Construction Activity, Order No. 99-08-DWQ. All stormwater treatment systems shall be located outside of any water of the State and shall not be used as a wetland or riparian mitigation credit.

30. Coverage under this Certification may be transferred to the extent the underlying federal permit may legally be transferred and further provided that the Applicant notifies the Executive Officer at least 30 days before the proposed transfer date, and the notice includes a written agreement between the existing and new Applicants containing a specific date of coverage, responsibility for compliance with this Certification, and liability between them.

31. The Applicant or their agents shall report any noncompliance. Any such information shall be provided verbally to the Executive Officer within 24 hours from the time the Applicant becomes aware of the circumstances. A written submission shall also be provided within five days of the time the Applicant becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected; the anticipated time it is expected to continue and steps taken or planned to reduce, eliminate and prevent recurrence of the noncompliance. The Executive Officer, or an authorized representative, may waive the written report on a case-by-case basis if the oral report has been received within 24 hours.

32. *Enforcement:*

    (a) In the event of any violation or threatened violation of the conditions of this Certification, the violation or threatened violation shall be subject to any remedies, penalties, process or sanctions as provided for under State law. For purposes of section 401(d) of the Clean Water Act, the applicability of any State law authorizing remedies, penalties, process or sanctions for the violation or threatened violation constitutes a limitation necessary to assure compliance with the water quality standards and other pertinent requirements incorporated into this Certification.

(b) In response to a suspected violation of any condition of this Certification, the State Water Resources Control Board (SWRCB) or Regional Water Quality Control Board (RWQCB) may require the holder of any permit or license subject to this Certification to furnish, under penalty of perjury, any technical or monitoring reports the SWRCB deems appropriate, provided that the burden, including costs, of the reports shall be a reasonable relationship to the need for the reports and the benefits to be obtained from the reports.

(c) In response to any violation of the conditions of this Certification, the SWRCB or RWQCB may add to or modify the conditions of this Certification as appropriate to ensure compliance.

33. This Certification shall expire **five (5) years** from date of this Certification. The Applicant shall submit a complete application prior to termination of this Certification if renewal is requested.

M e m o r a n d u m

Flex your power!
Be energy efficient!

To: Hamid Toossi, STE
Office of Design D

Attn: Hector Bedolla
Project Engineer

Date: July 2, 2010

File: 07-LA-47
PM 2.8/4.3
Schuyler Heim Bridge
Replacement Project
Bridge # 53-2618

EA: 07-333-138201

From: **DEPARTMENT OF TRANSPORTATION**
OEECS- HAZARDOUS WASTE BRANCH, SOUTH REGION, MS 16

Subject: *Conditional Approval of Site Investigation Work Plan for the Commodore Schuyler F. Heim Bridge Replacement Project, Long Beach, California*

The Department of Transportation (Caltrans) has reviewed the revised Limited Subsurface Investigation Work Plan, Commodore Schuyler F. Heim Bridge Replacement Project, Long Beach, California (Work Plan), dated June 24, 2010, prepared by Ninyo and Moore, submitted by ACTA.

The revised Work Plan did not adequately address all of the comments provided by Caltrans on June 16, 2010. However, due to the tight time schedule, Caltrans will provide ACTA with approval of the Work Plan subject to the conditions listed below. ACTA Project Manager and environmental staff must be made aware of the conditions prior to commencement of field activities. A final/signed Work Plan addressing all of the conditions will be available at the site during all field activities. The conditions of approval are as follows:

1. Objectives need to be expanded to include determination of the type, distribution, and extent of surface and subsurface contamination, identification of the groundwater conditions, determination of water quality, and assessment of impacts to environment. The objectives are important and ensure the data collected is of the type and quality for the intended purpose.
2. Increase the number of grab groundwater samples to meet the objective of determining water quality across the project area both laterally and vertically in locations where a structure or utility will be constructed at or below the groundwater table. The Work Plan proposes to collect groundwater samples from one to two borehole locations (an inconsistency in the number of groundwater samples appears in the Work Plan).
    a. In addition, include collection of ground water at depth intervals to the pile tip depth to meet objective of evaluating groundwater for disposal options or if dewatering is required.
3. Tubing used in collection of groundwater samples shall be disposed after one time use. Tubing will not be reused or require decontamination.

4. Classification of Investigation Derived Waste (IDW) is to be based on the analytical results. The statement that IDW is non-hazardous waste is unfounded as presented in the Work Plan. Guidance on the classification of IDW may be found in the U.S. EPA document entitled: Management of Investigation-Derived Waste During Site Investigations, May 1990, EPA/540/G-91/009.
5. Samples collected for aerially deposited lead (ADL) need to include the following depths: 0 ft, 1 ft, 2 ft, 3 ft and 5 ft.
6. ACTA field staff that will direct the analytical laboratory to analyze samples must have an understanding of the conditions of the DTSC issued variance (July 2009) for reuse of ADL contaminated soil within Caltrans right of way. The following clarifications to the Work Plan are as follows:
    a. The variance issued by DTSC applies to lead and not any other metals;
    b. Ten percent of randomly selected samples are to be analyzed using the TCLP method;
    c. Ten percent of all samples analyzed for total lead are to be analyzed by the standard WET method using citric acid as the extractant;
    d. Ten to 30 percent of all samples analyzed for total lead are to be analyzed by a modified WET method using de-ionized water as the extractant;
    e. Ten percent of all samples analyzed for total lead, with a minimum of four samples are to be analyzed for pH.
    f. Samples collected from boreholes advanced using a hand auger, shall be collect using a sampler attached to a slide hammer. The sampler shall contain brass or stainless steel liners. This is necessary for stratigraphic control of the sample, to ensure that a representative sample of the depth interval is collected, and to avoid collection of slough material.
7. The holding time for soil matrix samples to be analyzed for hexavalent chromium is 30 days.
8. Field quality control is to include a travel blank to accompany each set of samples submitted to the laboratory for VOC analysis.
9. Duplicate samples are to be collected at a rate of ten percent or one field duplicate sample for every 10 primary field samples or fraction thereof for each sample matrix. This includes groundwater samples.
10. Decontamination of all reusable equipment is to include the brass or stainless steel sampler liners.
11. Global Positioning System (GPS) Requirements
    a. Provide borehole locations within 6 inches accuracy in North American Datum
    b. Submit GPS data in Decimal Degree format in digital format CD-ROM along with the final hard copy in the final investigation report
    c. A Microsoft Access 2000 database is attached for your input of the GPS data point of the samples/boreholes.
12. Provide Appendix D, ATL's Quality Assurance Program Plan. In addition to the method blank, duplicate, spike samples, listed in the Work Plan, the Laboratory QA/QC needs to include

instrument calibration standards, laboratory control samples, internal standards and surrogate spikes.

13. Site Investigation Report contents shall include the following:
    a. Executive Summary
    b. Project Description
    c. Investigative Methods
    d. Investigative Results and Field Observations
    e. Maps, figures, tables
    f. Data Evaluation and Discussion
    g. For ADL, Statistical evaluation, tables, and graphs, including histograms of the original data and transformations, and showing the mean, median, standard deviation with 80 percent (two-tail)/90 percent (one-tail) and 95 percent confidence levels
    h. Conclusions and Recommendations
    i. References
    j. Laboratory Analytical Reports and Chain of Custody Forms
14. The detection limits for each analyte must be below any screening level or standard.
15. Methods to prevent bridging upon backfilling of boreholes with hydrated bentonite are to be utilized.
16. Provide Caltrans with the location selected for storage of drums containing IDW before the start of field activities. The secured area must be in a location that will not receive runoff, and away from storm drains or surface water. The drums will be properly labeled with the Consultant's name, contact information, date, and borehole identification.
17. The revised Health and Safety Plan (HaSP) was not submitted with the revision of the Work Plan. Therefore, a revised Health and Safety Plan must be prepared and include all of the comments provided to ACTA by Caltrans on June 16, 2010.

Prior to start of field activities, submit a final/signed Work Plan to our office and Caltrans Permit office for record retention. Any condition that is not met during implementation of the Work Plan may require additional work to be performed prior to acceptance of the Site Investigation Report.

If you have any question or need additional clarification, I can be reached at steve.chan@dot.ca.gov 213-897-3646 or contact Penny Nakashima of my staff at penny.nakashima@dot.ca.gov 213- 897-4058.

Steve Chan

Steve Chan, P.E., STE
District Hazardous Waste Branch, South Region
Office of Environmental Engineering and Corridor Studies

cc: File
Karen Fong, Office of Design D

Christine Song, Office of Permit
Sam Alameddine, OEECS, Planning
Ron Kosinski, Environmental Planning

Attachments: GPS MS Access-Database Template

PRE-DEMOLITION ASBESTOS
AND
LEAD PAINT SURVEY REPORT

Commodore Schuyler Heim Bridge
Long Beach, CA

DATE OF SURVEY: FEBRUARY 23-25, 2010

PREPARED FOR:
Alameda Corridor Transportation Authority
One Civic Plaza, Suite 600
Carson, California 90745

PREPARED BY:
Tetra Tech, Inc.
3475 East Foothill Blvd.
Pasadena, California 91107

_____
Christopher Surdzial, CAC
Principal Scientist

_____
Heather Benfield, P.E.
Project Manager

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List of Acronyms

ACBM	Asbestos Containing Building Material
ACCM	Asbestos Containing Construction Material
ACM	Asbestos Containing Material
AHERA	Asbestos Hazard Emergency Response Act
CAA	Clean Air Act
CAC	Certified Asbestos Consultant
CalEPA	California Environmental Protection Agency
CAL/OSHA	California Occupational Safety and Health Administration
CCR	California Code of Regulations
CFR	Code of Federal Regulations
CPSC	Consumer Products Safety Commission
CSLB	Contractors State Licensing Board
Cl. I NF	Class I Non-Friable Material
Cl. II NF	Class II Non-Friable Material
DOSH	Division of Occupational Safety and Health
DPH	Department of Public Health
DTSC	Department of Toxic Substances Control
ELLAP	Environmental Lead Laboratory Accreditation Program
EPA	United States Environmental Protection Agency
Flame AAS	Flame Atomic Absorption Stectroscopy
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
HM	Homogeneous material
HUD	Housing and Urban Development
LBP	Lead Based Paint
LCP	Lead Containing Paint
mg/cm^2	milligrams per centimeter squared
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
NESHAP	National Emission Standards for Hazardous Air Pollutants
NLLAP	National Lead Laboratory Accreditation Program
NVLAP	National Voluntary Laboratory Accreditation Program
OSHA	Occupational Safety and Health Act
%/wt	Percent by Weight
PEL	Permissible Exposure Limit
PLM	Polarized Light Microscopy
PPE	Personal Protective Equipment
ppm	parts per million
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
SCAQMD	South Coast Air Quality Management District
SST	Site Surveillance Technician
STLC	Soluble Threshold Limit Concentration
TCLP	Toxic Characteristic Leachate Potential
TSCA	Toxic Substances Control Act
TSI	Thermal Systems Insulation
TTLC	Total Threshold Limit Concentration
TWA	Time Weighted Average
WET	Waste Extraction Test
XRF	X-Ray Fluorescence
Ug/m	micrograms per meters cubed

EXECUTIVE SUMMARY

Tetra Tech, Inc. was retained by the Alameda Corridor Transportation Authority (ACTA) to perform a pre-demolition asbestos and lead-based paint survey for the Commodore Schuyler Heim Bridge (the "Bridge") located in Long Beach, California. This Bridge is a lift span bridge that crosses the Cerritos Channel from Terminal Island to mainland Long Beach. ACTA is working together with the California Department of Transportation (Caltrans) to prepare the design and specifications which includes the demolition in an overall effort to replace the lift span bridge with a fixed span bridge structure. An asbestos survey is required by South Coast Air Quality Management District (SCAQMD) Rule 1403 and Federal National Emission Standard for Hazardous Air Pollutants (NESHAP) regulations prior to demolition or major renovation activities. A lead based paint survey is required to determine the level of worker protection to be utilized during demolition and to guide the waste disposal of construction materials from the demolition process.

Tetra Tech, Inc. conducted an asbestos and lead paint survey at the Bridge February 23 through 25, 2010. The following is a summary report of that survey.

Asbestos

Bulk samples of suspect asbestos-containing materials were collected and submitted for laboratory analysis. The following materials were identified as having an asbestos content greater than 0.1 percent, and are thus regulated in California.

Exterior:

- Roof penetration mastic (5% Chrysotile asbestos) on roof penetration points and flashings of control rooms and maintenance switch room/storage room. Approximately 5 square foot of material.

Interior:

- 12" square (white crackle pattern) floor tile (5% Chrysotile asbestos) in north control room, approximately 64 square feet of material.
- Gray Masonite wallboard panels (20% Chrysotile asbestos) in north control room walls and ceilings and maintenance switch room/storage room divider walls, approximately 1,600 square feet of material.

Samples were collected of all accessible interior and exterior suspect building materials at the Bridge and analyzed for asbestos content. Since this is a pre-demolition survey, limited destructive sampling techniques were utilized to attempt to locate all suspect materials. A total of 21 samples (32 separate samples when multi layer samples were accounted for) were collected of suspect building materials from 7 distinct homogeneous materials (HM), including the following (highlighted rows denote homogenous materials that were found to be asbestos containing):

Homogeneous Material List

HM #	Type	Homogeneous Material	Location/Comments
HM1	Flooring	12"square (white crackle pattern) floor tiles	Single layer, north control room
HM1M	Flooring	Mastic applied to HM1	North control room
HM2	Flooring	12" square (beige squares pattern) floor tiles	North control room
HM2M	Flooring	Mastic applied to HM2	North control room
HM3	Miscellaneous	Masonite wallboard panels	North control room walls and ceiling and maintenance switch room/storage room divider walls
HM4	Roofing	Roofing sealant	North/South tower roof panels
HM5	Roofing	Multi layer roofing sample (roofing and tar)	Maintenance switch room/storage area roof
HM6	Roofing	Roof penetration mastic	Control room and maintenance switch room/storage area roofs
HM7	Roofing	Multi layer roofing sample (roofing and tar)	Control room roof

Three duplicate samples were collected as a quality assurance and quality control (QA/QC) measure. These samples were collected from the same material and location as the parent sample. The results were then compared to the parent sample as a test of the technical proficiency of the analysis laboratory. The samples were given sample identification numbers after the original samples and were given fictitious sampling times and descriptions. These samples are listed below.

HM #	Type	Homogeneous Material	Parent Sample Association
HM8-1	Miscellaneous	Gray Masonite wallboard panels	Duplicate sample of HM3-4
HM9-1	Roofing	Roof penetration mastic	Duplicate sample of HM6-3
HM10-1	Flooring	12" square (white crackle pattern) floor tile	Duplicate sample of HM1-1
HM10-1M	Flooring	Mastic applied to HM10	Duplicate sample of HM1-1M

All materials that were found to contain asbestos in the Bridge were classified as Asbestos Containing Building Materials (ACBM), with no Asbestos Containing Construction Materials (ACCM) found. Further, the ACBM found was all non-friable materials, which pose much less of a hazard in their removal than do friable materials. The proposed demolition work will disturb the ACBM, so these materials must be removed prior to commencement of the demolition process. This removal must be conducted in conformance with all applicable Federal, State, and Local regulations by appropriately trained and certified personnel and contractors. The abatement contractor must be registered with California De3partment of Occupational Safety and Health Division of Occupational Safety and Health (DOSH) and have an ASB-certification on their contractor's license issued by the Contractors State Licensing Board (CSLB). All abatement contractor workers must have certified training and be registered with DOSH. A trained and DOSH certified supervisor must be on site at all times while abatement activities are being conducted. SCAQMD and California Department of Occupational Safety and Health (CalOSHA) must be notified of the abatement activity using the proper forms at the required interval prior to the start of work.

The material removed must be handled, labeled, stored and transported in accordance with Local, State and Federal requirements. The ACBM must be segregated after removal and be disposed of separately from other construction debris at a landfill authorized to accept asbestos. Failure to properly segregate

ACBM from other construction debris can result in the entire waste stream to be disposed of as ACBM. This can result in much higher disposal costs.

Lead Paint

A total of 98 paint chip samples (89 samples and 9 duplicate samples) were collected from the various paints applied to the structure and analyzed for lead content. There are two regulatory thresholds for lead content in paint:

- Lead-Based Paint (LBP): Paint or other surface coating that contains lead in excess of 1.0 milligrams per centimeter squared or 0.5 percent by weight. Lead-Based Paint removal and disposal must be performed in accordance with California Department of Public Health (DPH) Regulations as well as OSHA requirements.
- Lead-Containing Paint (LCP): painted material or surfaces containing any [primarily >600 parts per million (ppm) or 0.06 percent by weight] detectable level of lead. Lead-Containing Paint removal and disposal must be performed in accordance with OSHA regulations.

The following table summarizes the samples collected. Dark shaded table rows indicate paint that was contained lead levels at or above the LBP threshold and are therefore considered LBP. Light shaded table rows indicate paint which was found at levels below the LBP threshold but above the LCP threshold and are therefore considered as LCP. Unshaded rows indicate paint which contained lead below either threshold level and are not considered LBP or LCP.

Lead Paint Chip Samples

PC #	No of Samples	Description	Max Lead Content (% by wt.)	Location/Comments
PC1	30	Green exterior structural paint	17.0	All exterior structural coatings
PC2	16	Yellowish-grey guard rail exterior Structural Paint	1.8	All exterior structural coatings
PC3	8	White guard rail exterior structural paint	1.1	All exterior structural coatings
PC4	1	Yellow traffic arm exterior paint	14.0	Yellow caution area at traffic arm
PC5	1	Grayish-tan traffic arm exterior paint	0.91	Traffic arm support structure
PC6	1	Green interior stairway structural paint	8.6	All interior structural coatings
PC7	1	Green interior stairway handrail paint	4.6	All interior structural coatings
PC8	1	Green exterior door paint	9.6	All exterior structural coatings
PC9	1	Green interior stair landing	0.15	All interior structural coatings
PC10	1	Grey wood utility cabinet paint	3.6	Under Bridge near parking area
PC11	1	Grey support pillar/column paint	0.36	Under Bridge near parking area
PC12	1	White traffic arm paint	0.027	Traffic arm
PC13	1	Red traffic arm paint	0.023	Traffic arm
PC14	3	Center exterior guard rail paint	10.0	All exterior structural coatings
PC15	1	Yellow traffic lane paint	0.47	Exterior traffic lane
PC16	1	Green exterior hatch paint	0.11	All exterior structural coatings
PC17	2	Yellow pop-ups paint	6.8	Traffic barricade pop-ups

PC #	No of Samples	Description	Max Lead Content (% by wt.)	Location/Comments
PC18	4	Silver interior paint	24.0	All interior structural coatings
PC19	2	Yellow machine cover paint	7.5	Tower machinery room
PC20	2	Grey w/orange base interior floor paint	16.0	Tower machinery room
PC21	1	Grey machinery paint	8.4	Tower machinery room
PC22	2	Green roof covering	0.11	Exterior hatch at tower machinery room
PC23	2	White machinery paint	0.26	Tower machinery room
PC24	1	Cream elevator paint	0.011	Interior elevator
PC25	2	Yellow interior hand rail paint	3.4	All interior structural coatings
PC26	1	Grey interior door paint	0.012	Maintenance area
PC27	1	Grey interior wall paint	1.5	Maintenance area

Nine duplicate samples were collected as a quality control and quality assurance measure. These samples were collected from the same material and location as the parent sample. The results were then compared to the parent sample as a test of the technical proficiency of the analysis laboratory. The samples were given sample identification numbers after the original samples and were given fictitious sampling times and descriptions. These samples are as follows:

Duplicate Paint Chip Samples

PC #	Description	Location/Comments	Parent Sample Association
PC28-1	Green exterior structural paint	All exterior structural coatings	Duplicate sample of PC1-28
PC29-1	Green roof covering	Exterior hatch at tower machinery room	Duplicate sample of PC22-1
PC30-1	Silver interior paint	All interior structural coatings	Duplicate sample of PC18-3
PC31-1	Green interior stairway handrail paint	All interior structural coatings	Duplicate sample of PC7-1
PC32-1	Center exterior guard rail paint	All exterior structural coatings	Duplicate sample of PC14-1
PC33-1	Green exterior structural paint	All exterior structural coatings	Duplicate sample of PC1-8
PC34-1	White guard rail exterior structural paint	All exterior structural coatings	Duplicate sample of PC3-3
PC35-1	Yellow pop-ups paint	Traffic barricade pop-ups	Duplicate sample of PC17-2
PC36-1	Grey support pillar/column paint	Under Bridge near parking area	Duplicate sample of PC11-1

Seventeen of the paint types (77 samples total) contained lead exceeding the regulatory 0.5% threshold and are therefore considered to be LBP. Some of this paint was in poor shape and was flaking and chipping off of the structures.

The majority of the paint on the Bridge is either LBP or LCP; therefore special procedures are required to ensure that the health and safety of the demolition workers is protected and to prevent contamination of the surrounding environment. CalOSHA considers both LCP and LBP to pose a hazard to workers who will disturb the paint while conducting the demolition activities. By CalOSHA standard, any paint that is at or higher than 0.06% by weight in lead content is considered lead containing paint and worker protection measures including monitoring, proper Personal Protective Equipment (PPE), specific work practices, dust control measures such as containment, and worker and contractor training and registration must be implemented if the paint is to be disturbed through renovation or demolition activities. All

removal and stabilization must be conducted by certified lead abatement contractors. Monitoring should be implemented while demolition is being done to ensure that workers are not being exposed above regulatory Permissible Exposure Limit (PEL).

Prior to demolition activities, at a minimum, all peeling and chipping paint must be removed and the paint chips disposed of as hazardous waste prior to building demolition. Measures such as paint stabilization must be taken to ensure that the paint will not continue to peel or chip off as the demolition is conducted and efforts should be taken to protect the surrounding ground surfaces and the Cerritos Channel below the Bridge from any paint that may come off in the demolition process. Removal of all paint prior to demolition would be the most conservative approach. However, full removal may not be necessary because, once peeling paint has been removed and remaining paint stabilized, the demolition waste may not exceed California waste thresholds. Full removal of paint may be necessary from some areas so that the demolition can be conducted where otherwise the presence of the paint may prevent the demolition process or the demolition activity might cause the paint to and spread into the surrounding environment.

Due to the condition of the painted components/surfaces at this site, there is a potential for surface contamination (soils, grounds, and water) at the base of the piers, below the viaduct structures, and below the bridge area over both solid ground and the Cerritos Channel. Special procedures will be required to ensure that paint chips and flakes are captured to protect the Cerritos Channel or onto the ground below. This issue must be addressed when remediation/demolition activities are planned at the facility and abatement plans and specifications should contain these measures.

Waste stream testing must be conducted to ensure proper disposal. In California, for waste purposes, regardless of the classification of the paint as LCP or LBP, it is considered as a California hazardous waste at a level of 0.1% (1,000 ppm) and must be disposed of as such if the composite samples exceed this level. Demolition waste should be segregated into three groups, construction debris, debris with lead containing paint (at or above 0.06 %/wt lead content), and debris with Resource Conservation and Recovery Act (RCRA) lead-based paint (at or above 0.50 %/wt lead content). Composite samples of the demolition waste should be collected and analyzed for lead content as discussed previously is Section 4.2 by Total Threshold Limit Concentration (TTLC), then Soluble Threshold Limit Concentration (STLC), and finally Toxic Characteristic Leachate potential (TCLP) methods to characterize it for disposal. By segregating the waste prior to characterization for disposal, contamination of clean construction debris is avoided.

Since a large majority of the bridge structure is constructed of steel, this material is potentially recyclable as a scrap metal. Even though the steel is coated with LBP or LCP, and may be classified as a California or Federal RCRA hazardous material, there are Federal and State regulations that provide exemptions from waste disposal restrictions for recycled materials. These exclusions are defined in 40 CFR Sections 261.1, 261.4 and 261.6 and Title 22 CCR Sections 66260.10 and 66261.6. These exclusions allow the steel to be recycled and the paint will not be considered to be a hazardous waste. Until the point of recycling, however, procedures remain the same. The same work procedures, monitoring, PPE, and training and contractor certifications still apply during demolition. The painted structural elements still need to be stabilized or have paint removed to ensure that paint will not continue to fall off while the steel elements are being transported for recycling. The recycler may accept these materials due to the exemptions, but they are in no way mandated by these regulations to accept the LBP or LCP coated scrap metal for recycling and it is at their discretion if they choose to do so. The intended recycler will need to be contacted and notified that the steel is coated with LBP and LCP paint prior to shipping. The recycler may also have special packaging or transportation procedures to ship these materials to them for recycling.

1.0 PROJECT BACKGROUND

Tetra Tech, Inc. was retained by the Alameda Corridor Transportation Authority (ACTA) to perform a pre-demolition asbestos and lead-based paint survey for the Commodore Schuyler Heim Bridge (the "Bridge") and approach viaducts located in Long Beach, California. This Bridge is a lift span bridge that crosses the Cerritos Channel from Terminal Island to mainland Long Beach. ACTA is working together with the California Department of Transportation (Caltrans) to prepare the design and specifications which includes the demolition in an overall effort to replace the lift span bridge with a fixed span bridge structure. An asbestos survey is required by South Coast Air Quality Management District (SCAQMD) Rule 1403 and Federal National Emission Standard for Hazardous Air Pollutants (NESHAP) regulations prior to demolition or major renovation activities. A lead based paint survey is required to determine the level of worker protection to be utilized during demolition and to guide the waste disposal of construction materials from the demolition process.

This survey report includes site and structure descriptions, analytical methods and limitations, summary of findings, and recommendations for all identified Asbestos Containing Building Materials (ACBM), Lead-Based Paint (LBP), and Lead Containing Paint (LCP) at the facility. A glossary of asbestos and lead-based paint related technical terms is contained in Appendix A. Appendix B contains copies of the analysis laboratory's accreditation certificates and the certification and registration credentials for the samplers who conducted the surveys. A table listing the asbestos sample details is presented in Appendix C, and the sample laboratory analysis reports for both lead and asbestos are presented in Appendix D. Site drawings created in the field, which show floor plans of the structures, sample locations and any other pertinent field notes are contained in Appendix E. Appendix F contains site photographs collected while conducting the surveys.

2.0 SITE DESCRIPTION

The Bridge is a motor vehicle bridge that serves to connect Terminal Island with Long Beach by crossing the Cerritos Channel on the north side of the island. The structure consists of one metal-decked six lane lift bridge and the two viaduct connectors and associated off and on ramp structures leading to and from the Bridge. The Bridge was constructed in 1948 by the U.S. Navy.

The Bridge is supported by four concrete footing foundation piers that are each keyed into the subsurface at below water level depths. The outer two support piers (Piers 26 and 29) rise to the traffic level and serve only as supports for the roadway. The inner two piers (Piers 27 and 28) serve to support the roadway structure as well as support the approximately four story metal lift tower structures that facilitate the lifting action of the Bridge. With the exception of the lift span, the roadway surface for both the Bridge and the two viaducts are concrete supported by metal lattice underpinnings and concrete support columns. The lift span is all metal with a metal grated roadway deck.

The two lift towers each contain a control room at just above the traffic deck level. Only the south control room is currently used. A machine room is located in the top of each tower structure. These machine rooms house the equipment used to hoist the lift deck of the Bridge when needed. A switchgear and mechanical storage room structure spans the width of the south tower.

The roof of the two lift tower structures is a metal clad raised seam roof while the roof of the control rooms and switchgear/storage room is a single layer of built up composite roofing and roofing tar. All roofing is in good shape. Interior walls and ceilings of the switchgear/storage room and the north control room are Masonite panels. Exterior walls and many of the other interior walls are clad in corrugated sheet metal.

The south control room was previously remodeled and expanded and the Masonite panels were removed and replaced with plywood. The flooring in the south control room was also replaced with rubber sheet flooring. The north control room flooring is 12-inch vinyl floor tiles. Insulation in the walls of the control room and other rooms, where placed, is fiberglass.

The paint history of the structure appears to be uniform. The locations of all paint samples showed a layer of primer paint applied to the substrate for applications on metal with a uniform layer of top coat paint applied on top. Paint applied to non-metal substrates appeared to have just a top coat application or the use of a primer coat of similar color to the top coat. Any repainting appears to have been done on a touch-up basis. The exterior of the metal structural components of the Bridge are covered by a green paint which appears to be uniformly applied throughout. The interior structural areas are coated in a silver paint, and the control rooms and mechanical storage and switchgear rooms are painted gray. Much of the paint on the structure is in poor shape and is peeling and separating due to corrosion.

3.0 BACKGROUND

3.1 Asbestos Background

The term asbestos describes six naturally occurring fibrous minerals found in certain types of rock formations. The minerals chrysotile, amosite, and crocidolite have been most commonly used in building products such as floor tile, pipe insulation, boiler insulation, and plasters. The minerals anthophyllite, actinolite, and tremolite are not frequently found in ACBM.

Intact and undisturbed ACBM do not pose a health risk. They may, however, become a health hazard if they are damaged, disturbed, or deteriorate over time and release fibers into the air. If released into the air, asbestos fibers may be inhaled. After prolonged or intense exposure, inhaled asbestos fibers may cause various types of lung disease. The health risks associated with asbestos exposure are greater for those who smoke.

3.2 Lead Paint Background

Elemental lead is a heavy, soft, easily worked, bluish metal. Lead deposits are often found in the form of galena, a lead sulfide mineral associated with zinc sulfides and silver. In historic times, lead was recovered as a result of smelting silver. Lead has been mined, smelted, and made into products for thousands of years. The oldest known lead object is an 8,500 year old statue that was excavated in Turkey.

After the industrial age began in the 1800s, the use of lead increased, and with it the potential for occupational exposure. Lead's versatility, as well as its favorable physical and chemical properties, accounted for its popularity. Lead compounds (chemicals consisting of lead in combination with other elements such as oxygen or chromium), such as white lead and lead chromate, have been widely used as pigments in paint. Lead was primarily added to paint as a pigment, to add durability, and as a drying agent. Although the use of lead-based paint, in particular on interior surfaces, has declined over the years, most housing units built before 1980 contain some lead based paint.

Lead dust is generated when paint deteriorates or is disturbed. This dust can be ingested by children or workers. This dust or paint chips can contaminate soils which poses a hazard to children or adults who may come into contact with the contaminated soil.

4.0 REGULATORY BACKGROUND

4.1 Federal Regulations

Asbestos

The United States Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and delegated states are responsible for regulating environmental exposure and protecting workers from asbestos exposure. OSHA is responsible for the health and safety of workers who may be exposed to asbestos in connection with their jobs [Occupational Exposure to Asbestos; Title 29, Code of Federal Regulations (CFR) Parts 1910.1001 and 1926.1101]. The EPA and state regulators are responsible for developing and enforcing regulations necessary to protect the general public from exposure to airborne contaminants that are known to be hazardous to human health.

In 1979, EPA began an asbestos technical assistance program for building owners, environmental groups, contractors, and industry. In May 1982, EPA issued the first regulation intended to control asbestos in schools under the authority of the Toxic Substances Control Act (TSCA); this regulation is known as the Asbestos-in-Schools Rule.

Two EPA regulations govern asbestos: the Asbestos Hazard Emergency Response Act (AHERA) and NESHAP.

AHERA

In 1986, Congress enacted AHERA (Title 40, CFR Part 763) which mandated a regulatory program to address the asbestos hazards in schools. A part of AHERA deals with the mandatory training and accreditation of persons who perform certain types of asbestos-related work in schools. Subsequently, in 1990 Congress amended AHERA to extend some of the training and accreditation requirements to persons performing such work in public and commercial buildings.

AHERA requires surveys of school buildings to determine the conditions of ACBM and preparation of management plans which recommend the best way to reduce the asbestos hazards. The industry standard is to utilize AHERA protocols for all asbestos surveys and to choose control methods for management of asbestos. The methods may include removal, encapsulation, enclosure, repair, and operations and maintenance to protect human health and the environment from ACBM.

NESHAP

The Clean Air Act (CAA) of 1970 required EPA to develop and enforce regulations to protect the general public from exposure to airborne contaminants that are known to be hazardous to human health; therefore, EPA promulgated NESHAP (Title 40, CFR Part 61) on April 6, 1973.

NESHAP is intended to minimize the release of asbestos fibers during certain activities (i.e., renovations, demolition, and installations). It specifies work practices to be followed during renovations of buildings (except apartment buildings that have no more than four dwelling units) which contain a specific amount of friable asbestos. NESHAP requires that buildings be inspected for ACBM prior to renovation/demolition projects.

NESHAP also requires owners and operators subject to the asbestos rules to notify delegated state and local agencies and/or the regional EPA offices before demolition or renovation activities begin. In addition, NESHAP requires the removal of all friable ACBM prior to demolition.

OSHA

OSHA began regulating workplace asbestos exposure in 1970, adopting a permissible exposure limit (PEL) to regulate worker exposure. The original asbestos standard has been revised several times to better protect workers. On August 10, 1994, OSHA issued a revised final standard regulating asbestos exposure in all industries. The newly revised standard for the construction industry lowers the PEL. The revised standard also establishes a new classification system for asbestos construction work, which clearly spells out mandatory work practices to follow to reduce worker exposures (see Occupational Exposure to Asbestos, Title 29, CFR 1926.1101).

Lead Paint

The Residential Lead-Based Paint Hazard Act of 1992, also called Title X, required the EPA and the U.S. Department of Housing and Urban Development (HUD) to develop regulations for disclosing lead-based paint hazards in homes built before 1978 that are offered for sale or lease. On March 6, 1996, these new regulations went into effect. They are known as 24 CFR Part 35 and 40 CFR Part 745, "Lead; Requirements for Disclosure of Known Lead-Based Paint and/or Lead-Based Paint Hazards in Housing; Final Rule". The law put in place by these regulations went into effect on September 6, 1996, for owners of buildings with more than four units, and December 6, 1996, for owners of buildings with four or fewer units (including single family homes).

Under this law, before finalizing a contract for the sale or lease of housing built before 1978:

- Sellers, landlords or their agents must disclose known information regarding lead-based paint hazards in the housing including copies of any survey reports;
- Sellers, landlords or their agents must provide purchasers and renters with an EPA pamphlet entitled "Protect Your Family from Lead in Your Home" which may be found at this website http://www.epa.gov/opptintr/lead/leadpbed.htm#Brochures;
- Purchasers have ten days to inspect or test for lead hazards. This time period may be shortened or lengthened by mutual agreement; and
- Sales contracts and leasing agreements must contain disclosure statements. Signed copies must be kept for a minimum of three years.

The Federal OSHA have enacted a construction industry lead standard in 29 CFR 1926.62, which was adopted by California Occupational Safety and Health Administration (Cal/OSHA) as 8 California Code of Regulations (CCR) 1532.1. The purpose of both standards is to protect workers from exposure to lead. OSHA is primarily concerned with activities that disturb paints with any amount of lead. Lead was used in most paints until the mid 1950's and was banned in amounts in excess of 0.06% by weight [600 parts per million (ppm)] in 1978 for most non-industrial paints by the Consumer Product Safety Commission (CPSC).

These standards require contractors and employers who perform paint removal activities to monitor their employees to determine whether they are being exposed in excess of the action level of 30 micrograms per cubic meter of air ($\mu g/m^3$) over an eight-hour time weighted average (TWA) or the PEL of 50 $\mu g/m^3$ TWA. Monitoring is performed by personal air sampling.

Even when concentrations are below the action level, an employer must provide employees with High Efficiency Particulate Air (HEPA) filtered vacuums, wetting agents and hand-washing facilities. If the exposure exceeds the action level or the PEL, other procedures such as containing the area, local exhaust

ventilation, respiratory and worker protection, worker training, decontamination facilities and medical monitoring are required.

OSHA has identified several work practices that pose varying levels of lead exposure to laborers disturbing lead-containing paint. Estimated exposure levels of lead are founded on the activity itself, rather than the concentrations of lead present in paint. As an example, paint that contains 0.5% versus 15% of lead by weight or 0.8 milligrams per centimeter squared (mg/cm^2) versus 3.5 mg/cm^2 of lead in paint could pose the same exposure levels to workers depending on the activities that cause the disturbance and the administrative and engineering controls that are followed.

The following is a summary of work activities that disturb paint, the expected exposure and the respiratory protection requirements that result as outlined in the OSHA standards:

Activities	**Potential Exposure**	**Minimum Respiratory Protection**
Class I activities include: Manual demolition, manual scraping, manual sanding, heat gun applications, general cleanup, power tool cleaning with dust collection systems and spray painting activities	50 $\mu g/m^3$ to 500 $\mu g/m^3$	Half mask air purifying respirator equipped with HEPA filters having a protection factor of 10
Class II activities include: Using lead-containing mortars, lead burning, lead riveting, rivet busting, power tool cleaning without dust collection systems, cleanup of dry expendable abrasives and abrasive blasting	500 $\mu g/m^3$ to 2,500 $\mu g/m^3$	Full face powered air purifying respirators equipped with HEPA filters having a protection factor of 100
Class III activities include: Abrasive blasting, welding, cutting and torch burning on steel structures	Greater than 2,500 $\mu g/m^3$	Full face supplied air respirator operated in pressure demand mode or other positive pressure mode (type "C")

The Resource Conservation and Recovery Act (RCRA) applies to lead abatement work whenever lead containing waste is generated. Under RCRA, waste samples must be analyzed by the Toxic Characteristic Leachate potential (TCLP) analysis method. The TCLP analysis method determines the solubility of the lead in the waste material. A sample of the waste material is placed in one of two extraction fluids (determined by the alkalinity of the waste sample) and then this mixture is tumbled for a 18 hour period. The fluid is then decanted and analyzed for lead content. The threshold lead level to be considered a RCRA hazardous waste is 5 milligrams per liter (mg/l). If samples of waste exceed this level then the waste must be identified, handled, stored, transported, treated, and disposed of as hazardous waste.

4.2 State Regulations

Asbestos

Adopted state regulations are similar to the Federal regulations. In many instances, state asbestos regulations are more stringent; therefore, it is recommended that the applicable state asbestos regulation(s) be reviewed before the start of any renovation/demolition projects.

Most state asbestos regulations include requirements for licensing and certification of personnel who will perform asbestos-related work activities. All personnel who engage in asbestos-related activities must comply with the state licensing/certification requirements as well as with all Federal requirements. In California, the agency governing licensing and certification of all asbestos professionals is the Cal/OSHA Division of Occupation Safety and Health (DOSH). All sampling and asbestos consulting services must be done by properly trained and licensed personnel. Sampling and monitoring must be performed by either a Certified Asbestos Consultant (CAC) or Site Surveillance Technician (SST) under the direct supervision of a CAC. Any remedial activities must be done by a contractor registered with DOSH to perform asbestos removal and all workers must be trained at the worker level. At least one individual trained at supervisor level must be present at all asbestos removal jobs. Asbestos abatement contractors must also have their company registered with the Contractors State Licensing Board (CSLB) as a Contractor with an asbestos abatement certification (ASB–Certification). Obtaining an ASB-Certification requires the passing of an exam administered by the CSLB. More specific information regarding the regulatory requirements for asbestos work in California is contained in Title 8 CCR Section 1529 and the California Business and Professions Code, Division 3, Chapter 9, Article 4, Section 7058.5.

In California, the enforcement of NESHAP is done by the Air Quality Management Districts. In the Los Angeles Basin, where this project is located, this falls under the SCAQMD. The requirements for conducting a pre-demolition survey and for managing any asbestos containing building materials found in this survey are covered by SCAQMD Rule 1403. This rule refers back to the Federal NESHAP regulations but also contains several unique provisions. These provisions include California specific items such as using DOSH certified individuals and removal firms as well as notification requirements. Detailed information is contained in Rule 1403.

Disposal of asbestos containing materials is governed by the California Department of Toxic Substances Control (DTSC). There are two categories of asbestos waste, friable asbestos waste and non-friable asbestos waste. Friable asbestos waste includes waste that contains asbestos in quantities greater than 1%, as determined by polarized light microscopy (PLM), and can be crumbled, pulverized, or reduced to a powder by hand pressure. Friable asbestos waste is regulated as a hazardous waste (Title 22 CCR, Division 4.5, Chapter 11, Article 3, Section 66261.24) and must be transported by a licensed hazardous waste hauler and disposed of in a landfill approved for friable asbestos waste disposal. Non-friable asbestos waste includes waste materials that contain asbestos in quantities greater than 1%, as determined by PLM, that cannot be crumbled, pulverized, or reduced to a powder through hand pressure. Non-friable asbestos waste is not designated as a hazardous material; however, the disposal of these materials is still regulated and they cannot be disposed of as normal waste or construction debris. These materials must be disposed of at a waste facility approved to accept non-friable asbestos wastes.

In California, Cal/OSHA has a lower threshold for asbestos containing materials as they relate to worker protection measures. Asbestos Containing Construction Materials (ACCM) is defined as a construction material which contains less than 1% but greater than 0.1% asbestos content as determined by PLM. These materials must be treated the same as for ACBM in regards to abatement procedures, worker training, and contractor certification; however, once removed ACCM waste may be disposed of as regular construction debris at any landfill that accepts construction waste. More information on these requirements may be found at Title 8 CCR Section 341.

Lead Paint

The Cal/OSHA construction industry lead standard (Title 8 CCR 1532.1) is almost the same as the federal standard with the four following differences:

- The California standard requires employers to notify Cal/OSHA before employees conduct a trigger task that will disturb more than 100 square feet or linear feet of lead paint containing more than 5,000 ppm of lead. Trigger tasks include manual demolition, scraping, sanding, using HEPA-attached equipment, using heat guns to remove lead paint, and using other more aggressive techniques.
- The California standard defines lead containing paint at the CPSC level of 0.06% by weight or 600 ppm for non-trigger tasks. Common maintenance and construction tasks such as drilling and cutting into painted materials are probably not trigger tasks. However both the California and federal standards require training, personal protective equipment, and specific work practices whenever paint with any quantity of lead will be disturbed (including less than 600 ppm) because this disturbance may result in airborne exposures over the action limit or PEL.
- The California standard requires Department of Public Health (DPH) certified lead training for any workers and training and DPH certification for any supervisors, inspectors, project monitors or project designers of lead projects (in public and commercial buildings) who may be exposed at or above the PEL.
- The California standard uses the term "regulated area" Cal/OSHA requires the supervisor to establish a regulated work area whenever workers may be exposed to airborne lead over the PEL or if they will perform trigger tasks.

The California Environmental Protection Agency (CalEPA) is the state agency responsible for determining when lead paint waste is a hazardous waste and how the waste must be disposed. In general, the CalEPA testing requirements are substantively more stringent than the federal requirements. Procedures for identification, management, transport, record keeping, and disposal of all types of hazardous waste are set forth in Title 22 CCR Sections 66260.1 through 66263.12 and 66268.1 through 66268.124, and the California Health and Safety Code Section 25163, subdivision (c).

Three different tests to determine waste disposal methods may be required to comply with California waste characterization requirements. First, waste materials must by analyzed using the Total Threshold Limit Concentration (TTLC) analysis. If the TTLC analysis result is less than 50 milligrams per kilogram (mg/kg) (equivalent to ppm), the waste can be disposed as non-hazardous construction debris. If the results of this analysis are above 1,000 mg/kg (ppm), then the waste is considered a California hazardous waste and must be disposed per CA Health & Safety Code Section 25157.8. However, additional analysis is needed to determine if the waste is required to be disposed of according to RCRA requirements.

If the TTLC result is between 50 and 1,000 mg/kg (ppm), a Soluble Threshold Limit Concentration (STLC) analysis must be conducted to determine the solubility of the lead in the waste per Title 22 CCR. The STLC method first places a sample of the waste in a sodium citrate solution, resulting in a dilution factor of 10:1. After tumbling for 48 hours, the liquid solution is drained and analyzed to determine the lead content. If the STLC results are more than 5.0 mg/l (ppm) of lead, then the waste must be disposed as a non-RCRA hazardous waste in California. Note that the TTLC threshold for disposal as a non-hazardous waste (<50 mg/kg [ppm]) is derived from multiplying the STLC threshold of <5.0 mg/l (ppm) by ten to account for the 10:1 dilution factor in the STLC test.

If the TTLC result is higher than 100 mg/kg (ppm), then a Toxicity Characteristic Leaching Potential (TCLP) analysis must be performed in addition to the STLC analysis to determine if the waste material is a Federal RCRA waste. As previously described in Section 4.1, if the TCLP results are >5.0 mg/l (ppm), then the waste is considered RCRA hazardous waste. The 100 mg/kg (ppm) screening threshold is a result of twenty times the TCLP threshold due to the 20:1 dilution factor of the TCLP analysis.

5.0 ANALYTICAL METHODS AND LIMITATIONS

5.1 Asbestos Bulk Sampling Protocol

EPA defines ACBM in the AHERA (40 CFR Part 763) as any material which contains greater than 1 percent asbestos. OSHA defines Asbestos Containing Materials (ACM) in its asbestos in construction standards (29 CFR Parts 1910.1001 and 1910.1101) as any material which contains greater than 1 percent asbestos. The term ACM is used for any asbestos containing material while ACBM is used for building materials that may contain asbestos. Since this survey is concerned with determining the asbestos content of building materials the term ACBM is being used. However, in regards to the EPA or OSHA law and regulatory applicability, for the purpose of this report the two terms are to be considered synonymous. The definition of ACBM as mandated by Cal/OSHA and its applicability was previously discussed in Section 4.2.

The ACBM survey and bulk sampling were performed in accordance with the methods outlined in the EPA guidance document titled *Guidance for Controlling Asbestos-Containing Materials in Buildings* (Document No. 560/5-85/024). In addition, bulk sampling of asbestos was performed in accordance with 40 CFR Part 763, AHERA requirements for number of samples and types of ACBM to be sampled. According to these requirements, materials are classified as either surfacing (e.g., ceiling plaster, wall plaster, spray-applied fireproofing), thermal system insulation (e.g., pipe insulation, pipe fitting insulation, boiler insulation), or miscellaneous materials (e.g., floor tile, ceiling tile, wallboard). Materials are further grouped as homogeneous materials and then the appropriate amount of samples per each homogeneous material are collected as discussed below.

As floor tile is a distinct unit of miscellaneous material that is very commonly encountered, for the purpose of this survey, floor tile is classified as a separate category. However, the management of floor tile typically follows the regulatory guidelines for miscellaneous materials.

The number of samples collected from each homogeneous material varies based on the classification of the material and increases as the potential for a non-uniform mixture of asbestos in the material increases. Typically, regulations require a minimum number of samples to be collected from the different classifications of suspect ACBM, as follows:

- Surfacing Material
  - Three samples from homogeneous areas up to 1,000 square feet
  - Five samples from homogeneous areas between 1,000 and 5,000 square feet
  - Seven samples from homogeneous areas over 5,000 square feet;
- Thermal System Insulation (TSI)
  - Minimum of three samples per homogeneous area or material; and
- Miscellaneous Material
  - Minimum of one samples per homogeneous area or material, but must be sufficient to determine asbestos content. Typically, three samples are collected to maintain statistical validity.

5.2 Lead Paint Chip Sampling Protocol

Two types of lead paint surveys are in use today. The first, a risk based paint identification survey tests every painted surface in a structure and determines the lead content of the paint. This survey is performed using a portable x-ray fluorescence (XRF) meter to determine the paint's lead content. This type of survey is mandated by the HUD and DPH in cases where it is necessary to determine the health risks posed by lead based paint to occupants in a structure due to their continued presence. Since this survey is not being conducted to determine the occupational safety of bridge employees, this type of survey is not called for.

The second type of survey performed is a paint chip sample survey. This survey is conducted by collecting physical samples of the representative types of paint in a structure. These samples are then sent to an analytical laboratory for analysis. This type of survey is mandated by both the Cal/OSHA and the DTSC for facilities that will be undergoing demolition or renovation. DTSC requires this type of survey be performed before any painted material can be disposed of following a renovation or demolition project. Cal/OSHA requires this type of survey be performed prior to a renovation or demolition activity so that worker safety issues may be addressed during the renovation/demolition activity.

As the proposed plans for this structure include demolition, sampling for lead paint by paint chip sampling was the method used to determine lead content in paint at the site. For each area within the Bridge structure and approach viaducts, the various different paint schemes were recorded. Samples were collected of each different paint that was used. The historic paint scheme of the structure was determined by scraping off paint until the building material substrate was reached so that the number of paint layers and colors of the various paint layers could be revealed. Once both current and historic paint schemes were determined, representative samples of each paint were collected. Samples of paint in different structural elements with like paint schemes were collected to help determine if the same paint was used.

5.3 Sample Collection/Analytical Procedures

Samples for asbestos were collected by Chris Surdzial, an EPA-certified and State-licensed inspector (Certified Asbestos Consultant # 03-3435) and DPH certified Lead Paint Inspector/Risk Assessor and Project Monitor (DPH certification number 14751). Samples for lead paint analysis were collected by either Mr. Surdzial or Dorothy Knowlton, a California DPH certified Lead Paint Sampling Technician (DPH certification number 19550) under the supervision of Mr. Surdzial. Proper safety measures such as wetting the material before sampling, cleaning up the area by wet-wiping any resulting residual debris, and wearing proper personal protective equipment, were employed. Coring tools, razor blades, and knives were utilized to be certain of sampling the entire thickness of a material. Paint chip samples were collected using a heat gun to soften and lift the paint from the building material it is applied to, followed by scraping with a razor blade. If multiple layers of paint were present, sometimes re-application of heat, followed by razor scraping were needed until all paint was removed to the substrate material level.

Asbestos samples were each labeled as follows. Each sample is given a distinct sample identification number yet keyed to the structure and the homogeneous material within that structure. Each sample label began with "HM" for Homogeneous Material followed by a number designating the homogeneous material. A dash separates the first part of the sample identification label followed by another number which denotes the individual sample number within the homogeneous material. The individual sample numbers started sequentially at one for each different homogeneous material. Finally, the laboratory performing sample analysis sometimes adds a follower label to the end of the field assigned sample labels. This occurs when multiple layers are encountered such as a floor tile (T) and mastic (M) or joint

compound (JC) and drywall (DW) submitted in the same sample. The lab analyzes each layer separately even though it is not possible to separate each layer in the field.

Each lead paint chip samples each sample is given the prefix "PC" which stands for "paint chip" to separate these samples from asbestos samples submitted to the same lab. Next a numerical number follows the PC and denotes the sampling area from which the sample was collected. Sampling areas have the same general paint theme. If multiple samples of the same paint are required a dash follows this and then another numeral which denotes the paint sample in that sampling area. The color of the paint sampled and any other comments such as multiple lower paint layers were recorded so that the paint samples can be representative of an entire paint application layer. Additionally, each sample (both asbestos and lead paint) was labeled with the date and time of collection, sampler's name, company name, and project name and number.

All samples were placed in appropriately labeled airtight containers for shipment to the laboratory. All samples were analyzed by a laboratory certified in the National Voluntary Laboratory Accreditation Program (NVLAP) for asbestos and in the National Lead Laboratory Accreditation Program (NLLAP) for lead through the California Environmental Lead Laboratory Accreditation Program (ELLAP). Copies of the sampler and laboratory certification forms are provided in Appendix B.

All asbestos bulk and lead paint chip samples were analyzed by the following laboratory:

Laboratory	**Accreditation**
LA Testing 158 Pasadena Avenue South Pasadena, California 91030 (800) 303 - 0047	NVLAP #200232-0 ELLAP # 102814

ACBM are defined as suspect materials which have at least one sample containing an asbestos content of more than one percent from a homogeneous area set of samples. Bulk samples from a homogeneous area must be found to contain less than one percent of asbestos to be classified as non-asbestos-containing. However, as discussed in Section 4.2, CalOSHA has a lower percent threshold of one tenth of a percent (0.1%) asbestos and refers to materials that contain greater than 0.1% but less than 1% asbestos as ACCM.

Asbestos bulk samples were analyzed by PLM. PLM analysis has a lower quantification limit of approximately 1 percent asbestos content. PLM analysis can detect levels of asbestos lower than one percent but the amount can not be accurately quantified. Samples that are greater than 0.1% asbestos content yet less than 1% asbestos content are defined by the laboratory as "trace" samples. Samples which initially were found to contain trace quantities of asbestos by PLM method can be re-analyzed by point count method. Point counting can quantify mineral content below one percent. This is utilized to verify that the sample content is below the regulatory threshold of one percent.

Lead paint chip samples were analyzed for total lead concentration by method SW-846, EPA method 7420. The samples were analyzed by flame atomic absorption spectrometry (Flame AAS). Results are reported in units of percent by weight. Anything at or above 0.06 percent by weight (%/wt) is considered a LCP in California and any samples at or above 0.50 %/wt are considered to be LBP.

Additionally, duplicate samples were collected for both asbestos and lead paint samples at an approximate frequency of 10% of the samples collected. These samples were given a unique sample identification number and were submitted to the laboratory with the other samples for analysis. The results were compared with those of the parent sample/homogeneous material. This is done as a Quality Assurance

and Quality Control (QA/QC) measure to check the accuracy and precision of the sample analysis by the laboratory.

6.0 SUMMARY OF FINDINGS

6.1 Survey Limitations

All accessible areas within the facility were inspected, including access panels to chases, tower mechanical rooms, areas above suspended ceilings, and crawl spaces. As this is a pre-demolition survey, limited destructive sampling methods were utilized to try to evaluate and locate all suspect materials.

Any areas not inspected are listed below:

- Areas within or below the concrete slab foundation;
- No below water investigations were conducted;
- No subterranean investigation was conducted; and
- Any hidden utility chases or spaces between walls and ceiling

Tetra Tech is committed to providing quality consulting services. However, asbestos and lead paint survey work is not an exact science. The possibility of field and general conditions, beyond Tetra Tech's control, that affect our work or that present a concern for the safety of our employees, our consultants, building occupants and the public at the site, and insurance constraints, requires that we qualify the services we provide with the following limitations.

The findings of this survey, opinions rendered, recommendations and conclusions provided in this survey report are only valid for a period of up to one year from the date of this survey report.

Reasonable effort is made by Tetra Tech's personnel to locate and sample all suspect materials. However, for any facility the existence of unique or concealed asbestos-containing materials and debris is a possibility. In addition, sampling and laboratory analysis constraints typically hinder the investigation. Tetra Tech does not warrant, guarantee or profess to have the ability to locate or identify all asbestos-containing materials or to have sampled all paint in a facility.

Confined spaces, and areas determined by Tetra Tech personnel as unsafe to access, are excluded from the scope of work.

Tetra Tech does not employ professional cost estimators. Statements of probable construction cost or cost estimates prepared by Tetra Tech represent Tetra Tech's professional opinion of probable costs based upon current industry information. Actual costs may fluctuate due to several variables including, but not limited to, the time the work is performed, phasing, labor availability, quantity of work performed, product availability, specification requirements, and unforeseeable changes in the economy and asbestos regulations.

Tetra Tech is not, and has no responsibility as a generator, operator, treater, storer, transporter, or disposer of hazardous materials or waste found or identified as a result of Tetra Tech 's work.

Tetra Tech does not guarantee or warrant that the facility or workplace is safe, nor does Tetra Tech's involvement in this property relieve the Client, building owner/operator or tenant of any continuing responsibility of providing a safe facility or workplace.

This report was based on those conditions observed on the day(s) the field evaluation was accomplished. In the event that changes in the nature of the property have occurred, or additional relevant information about the property is subsequently discovered, the findings and recommendations contained in this report may not be valid unless these changes and additional relevant information are reviewed and the conclusion of this report is modified and verified in writing.

This report does not cover any assessment of water damage and any biological growth conditions in or around the surveyed structures.

6.2 Non-Asbestos-Containing Building Materials

The following materials are not sampled (per EPA) because they are not considered suspect asbestos-containing materials:

- Brick materials (except bricks found within boilers);
- Ceramic tiles;
- Cinderblock and marble;
- Fiberglass insulating materials (yellow and pink colored);
- Plastic and glass materials;
- Rubber and synthetic materials including Styrofoam; and
- Wood materials.

The sampled materials classified as non-asbestos-containing materials based on bulk sampling and analytical results are listed in Table 1.

Table 1. Non-Asbestos-Containing Building Materials

HM #	Type	Homogeneous Material	Location/Comments
HM1M	Miscellaneous	Floor tile mastic under HM1	North control room (Duplicate HM10M)
HM2FT	Flooring	12” square (beige squares pattern) floor tile	North control room
HM2M	Miscellaneous	Floor tile mastic under HM2	North control room
HM4	Roofing	Roofing sealant	On raised seam metal roofing on both tower roofs
HM5	Roofing	Multi layer roofing	On roof of switchgear and mechanical room structure
HM7	Roofing	Multi layer roofing	On control room roof

6.3 Asbestos-Containing Building Materials

All suspect building materials were sampled and analyzed for asbestos (see Appendices C and D for asbestos sample detail tables and laboratory analysis reports).

For this report, ACBM is classified as either friable or non-friable. The following are the general definitions of each:

Friable Material: Any material which, when dry, may be easily crumbled, pulverized, or reduced to a powder by hand pressure. It includes previously non-friable material after it becomes damaged to the extent that when dry, it may be crumbled, pulverized, or reduced to a powder by hand pressure.

Non-Friable Material: Any material which, when dry, may not be easily crumbled, pulverized, or reduced to a powder by hand pressure.

Non-friable materials are further broken down into the NESHAP designations of Class I and Class II non-friable materials. Class I non-friable items consist of non-friable asbestos containing materials such as asphalt roofing products, resilient floor coverings, packings, and gaskets. (In general, all non-friable, non-cementitious materials are considered Class I.) Class II non-friable items consist of materials which are non-friable asbestos containing materials that are not Class I materials. (In general, this is limited to cementitious materials such as transite, stucco, etc.)

The locations, types, quantities, and friability of ACBM and presumed ACBM identified at the facility are listed in Tables 2 and 3. Field drawings showing sampling locations are presented in Appendix E and photographs of asbestos containing materials are presented in Appendix F.

Table 2. Asbestos-Containing Building Materials

HM #	Type	Homogeneous Material	Location/Comments	Quantity	Friability
HM1 (Dup HM10-1FT)	Flooring	12" square (white crackle pattern) floor tile	North control room	64 sq. ft.	Cl. I NF
HM3 (Dup HM8-1)	Miscellaneous	Masonite wall panel boards	On north control room and switchgear/storage room walls and ceiling	1,600 sq. ft.	Cl. II NF
HM8 (Dup HM9-1)	Roofing	Roof penetration mastic	On control room and switchgear/storage room roofs	5 sq. ft.	Cl. I NF

Note: Friability
F = Friable
Cl.1 NF = Class I Non-Friable
Cl. II NF= Class II Non-Friable

Lead Based Paint Analysis Results

The following table describes the results of all paint chips sampled. Shaded table rows indicate samples which were detected above the regulatory threshold and are therefore considered lead-based paint (dark shading) or lead containing paint (light shading). The quantity of only the LBP and LCP were estimated and listed in the table if they could be estimated. Due to the complex nature and size of the structure certain painted areas such as the exterior and interior structural paints could not have their quantity determined, and are marked as such in the table. Copies of the analytical laboratory results are presented

in Appendix D. Field drawings showing sampling locations are presented in Appendix E. Representative photographs of the lead containing paint are presented in Appendix F.

Table 3: Summary of Paint Chip Sample Analysis Results for Lead Content

(Refer to Appendix D for laboratory analysis results and individual sample results)

Sample Number	Description	Location	Condition	Analytical Results (% by wt)	Approximate Quantity (Only LBP or LCP)
PC1-1	Green exterior structural paint	Under east side span 0-1	Intact	0.81 (LBP)	Could not be estimated
PC1-2	Green exterior structural paint	Under west side span 5-6	Peeling	0.26 (LCP)	Could not be estimated
PC1-3	Green exterior structural paint	Under east side span 7-8	Peeling	0.51 (LBP)	Could not be estimated
PC1-4	Green exterior structural paint	Under west side span 9-10	Peeling	0.31 (LCP)	Could not be estimated
PC1-5	Green exterior structural paint	Under east side span 13-14	Peeling	0.38 (LCP)	Could not be estimated
PC1-6	Green exterior structural paint	On ramp under west across span 13	Peeling	0.11 (LCP)	Could not be estimated
PC1-7	Green exterior structural paint	On ramp under east across span 15	Peeling	0.37 (LCP)	Could not be estimated
PC1-8 Dup PC33-1	Green exterior structural paint	Under west side span 15-16	Peeling	0.20 (LCP) 0.24 (LCP)	Could not be estimated
PC1-9	Green exterior structural paint	Off ramp under east across span 15-16	Peeling	0.032	N/A
PC1-10	Green exterior structural paint	Off ramp under west across span 18	Peeling	3.3 (LBP)	Could not be estimated
PC1-11	Green exterior structural paint	Under west side span 23-24	Peeling	0.0290	N/A
PC1-12	Green exterior structural paint	Upper structure	Peeling	0.19 (LCP)	Could not be estimated
PC1-13	Green exterior structural paint	Upper structure	Peeling	3.3 (LBP)	Could not be estimated
PC1-14	Green exterior structural paint	Under span 31-32	Peeling	16 (LBP)	Could not be estimated
PC1-15	Green exterior structural paint	Under span 29-30	Peeling	2.8 (LBP)	Could not be estimated
PC1-16	Green exterior structural paint	Under span 34-35	Peeling	5.1 (LBP)	Could not be estimated
PC1-17	Green exterior structural paint	Under span 38-39	Peeling	6.0 (LBP)	Could not be estimated
PC1-18	Green exterior structural paint	Under span 43-44	Peeling	17 (LBP)	Could not be estimated
PC1-19	Green exterior structural paint	Upper structure span 27-28	Peeling	9.3 (LBP)	Could not be estimated
PC1-20	Green exterior structural paint	Catwalk span 27-28	Peeling	8.0 (LBP)	Could not be estimated
PC1-21	Green exterior structural paint	Catwalk span 27-28	Peeling	2.9 (LBP)	Could not be estimated
PC1-22	Green exterior structural paint	Catwalk span 27-28	Peeling	0.42 (LCP)	Could not be estimated
PC1-23	Green exterior structural paint	Catwalk north side	Peeling	0.076 (LCP)	Could not be estimated
PC1-24	Green exterior structural paint	Catwalk south side	Peeling	3.2 (LBP)	Could not be estimated
PC1-25	Green exterior structural paint	Catwalk south side	Peeling	0.96 (LBP)	Could not be estimated

Sample Number	Description	Location	Condition	Analytical Results (% by wt)	Approximate Quantity (Only LBP or LCP)
PC1-26	Green exterior structural paint	Catwalk south side	Peeling	0.067 (LCP)	Could not be estimated
PC1-27	Green exterior structural paint	Upper structure	Peeling	2.4 (LBP)	Could not be estimated
PC1-28 Dup PC28-1	Green exterior structural paint	Upper structure	Peeling	0.44 (LCP) 0.42 (LCP)	Could not be estimated
PC1-29	Green exterior structural paint	Upper structure	Peeling	1.2 (LBP)	Could not be estimated
PC1-30	Green exterior structural paint	Upper structure	Peeling	8.6 (LBP)	Could not be estimated
PC2-1	Gold guardrail paint	East side span 0-1	Intact	0.38 (LCP)	Could not be estimated
PC2-2	Gold guardrail paint	West side span 5-6	Intact	0.71 (LBP)	Could not be estimated
PC2-3	Gold guardrail paint	East side span 7-8	Intact	0.36 (LCP)	Could not be estimated
PC2-4	Gold guardrail paint	West side span 9-10	Intact	0.32 (LCP)	Could not be estimated
PC2-5	Gold guardrail paint	East side span 13-14	Intact	0.35 (LCP)	Could not be estimated
PC2-6	Gold guardrail paint	On ramp west across span 13	Intact	0.30 (LCP)	Could not be estimated
PC2-7	Gold guardrail paint	On ramp east across span 15	Intact	0.23 (LCP)	Could not be estimated
PC2-8	Gold guardrail paint	West side span 15-16	Intact	0.22 (LCP)	Could not be estimated
PC2-9	Gold guardrail paint	Off ramp east across span 15-16	Intact	0.22 (LCP)	Could not be estimated
PC2-10	Gold guardrail paint	Off ramp west across span 18	Intact	0.40 (LCP)	Could not be estimated
PC2-11	Gold guardrail paint	West side span 23-24	Intact	0.45 (LCP)	Could not be estimated
PC2-12	Gold guardrail paint	Under span 31-32	Intact	0.19 (LCP)	Could not be estimated
PC2-13	Gold guardrail paint	Under span 29-30	Intact	1.3 (LBP)	Could not be estimated
PC2-14	Gold guardrail paint	Under span 34-35	Intact	1.8 (LBP)	Could not be estimated
PC2-15	Gold guardrail paint	Under span 38-39	Intact	0.54 (LBP)	Could not be estimated
PC2-16	Gold guardrail paint	Under span 43-44	Intact	1.4 (LBP)	Could not be estimated
PC3-1	White guardrail paint	Traffic guard arm Span 25	Intact	1.1 (LBP)	Could not be estimated
PC3-2	White guardrail paint	Near span 25 stairway	Intact	1.1 (LBP)	Could not be estimated
PC3-3 Dup PC34-1	White guardrail paint	Near span 25 stairway	Peeling	0.22 (LCP) 0.20 (LCP)	9,000 sq. ft. total
PC3-4	White guardrail paint	Near span 25 stairway	Peeling	0.18 (LCP)	9,000 sq. ft. total
PC3-5	White guardrail paint	Near span 25	Peeling	0.39 (LCP)	9,000 sq. ft. total
PC3-6	White guardrail paint	Near span 29	Peeling	0.16 (LCP)	9,000 sq. ft. total
PC3-7	White guardrail paint	Near span 29	Peeling	0.29 (LCP)	9,000 sq. ft. total

Sample Number	Description	Location	Condition	Analytical Results (% by wt)	Approximate Quantity (Only LBP or LCP)
PC3-8	White guardrail paint	Near span 29	Peeling	0.77 (LBP)	9,000 sq. ft. total
PC4-1	Yellow traffic arm	West side span 25	Intact	14.0 (LBP)	10 sq. ft.
PC5-1	Tan traffic arm box	West side span 25	Intact	0.91 (LBP)	75 sq. ft.
PC6-1	Green stairway hatch	Near span 25	Peeling	8.6 (LBP	40 sq. ft.
PC7-1 Dup PC31-1	Green stairway handrails	Span 25 stairwell	Mostly intact	4.6 (LBP) 3.7 (LBP)	100 sq. ft.
PC8-1	Green stairwell entry door	Span 25 stairwell	Intact	9.6 (LBP)	50 sq. ft.
PC9-1	Green stair landing	Span 25 stairwell exterior landing	Intact	0.15 (LCP)	200 sq. ft.
PC10-1	Gray wood utility cabinet paint	Span 25 under concrete footing	Peeling	3.6 (LBP)	100 sq. ft.
PC11-1 Dup PC36-1	Gray paint on support column	Applied to span 24 pillar over graffiti	Intact	0.34 (LCP) 0.36 (LCP)	50 sq. ft. at this location Could not estimate total use
PC12-1	White paint	Traffic control arm	Intact	0.027	N/A
PC13-1	Red paint	Traffic control arm	Intact	0.023	N/A
PC14-1 Dup PC32-1	White center guardrail paint	Main bridge section	Peeling	6.6 (LBP) 6.6 (LBP)	5,000 sq. ft total
PC14-2	White center guardrail paint	Main bridge section	Peeling	6.5 (LBP)	5,000 sq. ft total
PC14-3	White center guardrail paint	Main bridge section	Peeling	10.0 (LBP)	5,000 sq. ft total
PC15-1	Yellow traffic marking paint	On road bed dividing lanes	Intact	0.47 (LCP)	Could not be estimated
PC16-1	Green north stairwell door paint	North pier stairwell hatch door near span 29	Intact	0.11 (LCP)	75 sq. ft.
PC17-1	Yellow paint on pop ups	North traffic barricade pop ups- span 27-28	Intact	6.8 (LBP)	1,000 sq. ft total
PC17-2 Dup PC35-1	Yellow paint on pop ups	South traffic barricade pop ups- span 26-27	Intact	4.8 (LBP) 3.4 (LBP)	1,000 sq. ft total
PC18-1	Silver interior structure paint	North tower span 27-28	Peeling	0.11 (LCP)	Could not be estimated
PC18-2	Silver interior structure paint	North tower near control room	Intact	0.086 (LCP)	Could not be estimated
PC18-3 Dup PC30-1	Silver interior structure paint	North tower top mechanical room	Peeling	24.0 (LBP) 22.0 (LBP)	Could not be estimated
PC18-4	Silver interior structure paint	South tower top mechanical room	Peeling	10.0 (LBP)	Could not be estimated
PC19-1	Yellow machine guard paint	North tower machinery guards	Intact	7.5 (LBP)	500 sq. ft. (North tower only)
PC19-2	Yellow machine guard paint	South tower machinery guards	Intact	0.039	N/A
PC20-1	Gray floor paint	North tower top machinery room	Intact	16.0 (LBP)	6,000 sq. ft total
PC20-2	Gray floor paint	South tower top machinery room	Intact	5.4 (LBP)	6,000 sq. ft total
PC21-1	Gray machinery paint	North top mechanical room	Intact	8.4 (LBP)	1,000 sq. ft.
PC22-1 Dup PC29-1	Green roof paint	North tower metal roof	Intact	<0.010 0.012	N/A
PC22-2	Green roof paint	South tower metal roof	Intact	0.11 (LCP)	6,000 sq. ft. total
PC23-1	White machinery paint	North tower top mechanical room	Peeling	<0.010	N/A

Sample Number	Description	Location	Condition	Analytical Results (% by wt)	Approximate Quantity (Only LBP or LCP)
PC23-2	White machinery paint	South tower top mechanical room	Peeling	0.26 (LCP)	1,000 sq. ft.
PC24-1	Cream elevator interior paint	North tower elevator	Intact	0.011	N/A
PC25-1	Yellow handrail paint	North tower	Intact	3.4 (LBP)	300 sq. ft total
PC25-2	Yellow handrail paint	South tower	Intact	0.78 (LBP)	300 sq. ft total
PC26-1	Gray door paint	Switchgear and maintenance storage rooms	Intact	0.012	N/A
PC27-1	Gray wall paint	Switchgear and maintenance storage rooms	Intact	1.5 (LBP)	5,000 sq. ft.

Notes:
LBP = Lead Based Paint >0.5 % by weight
LCP = Lead Containing Paint >0.06% by weight
Dup = duplicate quality assurance/ quality control (QA/QC) sample
PC = Paint chip
N/A = Not applicable
Sq. ft. = Square feet
% by wt = percent by weight

Painted areas were determined homogeneous through visual inspection and multiple samples of these areas were collected across the whole structure to give a representative sampling of the paint applied to the entire surveyed structure. Although the lead levels on some samples varied, the determination of whether the paint is considered as LBP or LCP must use the maximum lead level observed for that paint.

7.0 CONCLUSION/RECOMMENDATIONS

Asbestos

All materials that were found to contain asbestos in the Bridge were classified as ACBM, with no ACCM found. Further, the ACBM found was all non-friable materials, which pose much less of a hazard in their removal than do friable materials. The proposed demolition work will disturb the ACBM, so these materials must be removed prior to commencement of the demolition process. This removal must be conducted in conformance with all applicable Federal, State, and Local regulations by appropriately trained and certified personnel and contractors. The abatement contractor must be registered with DOSH and have an ASB-certification on their contractor's license issued by CSLB. All abatement contractor workers must have certified training and be registered with DOSH. A trained and DOSH certified supervisor must be on site at all times while abatement activities are being conducted. SCAQMD and CalOSHA must be notified of the abatement activity using the proper forms at the required interval prior to the start of work.

The material removed must be handled, labeled, stored and transported in accordance with Local, State and Federal requirements. The ACBM must be segregated after removal and be disposed of separately from other construction debris at a landfill authorized to accept asbestos. Failure to properly segregate ACBM from other construction debris can result in the entire waste stream to be disposed of as ACBM. This can result in much higher disposal costs.

Lead Paint

The majority of the paint on the Bridge is either LBP or LCP; therefore special procedures are required to ensure that the health and safety of the demolition workers is protected and to prevent contamination of

the surrounding environment. CalOSHA considers both LCP and LBP to pose a hazard to workers who will disturb the paint while conducting the demolition activities. By CalOSHA standard, any paint that is at or higher than 0.06% by weight in lead content is considered lead containing paint and worker protection measures including monitoring, proper PPE, specific work practices, dust control measures such as containment, and worker and contractor training and registration must be implemented if the paint is to be disturbed through renovation or demolition activities. All removal and stabilization must be conducted by certified lead abatement contractors. Monitoring should be implemented while demolition is being done to ensure that workers are not being exposed above regulatory PEL.

Prior to demolition activities, at a minimum, all peeling and chipping paint must be removed and the paint chips disposed of as hazardous waste prior to building demolition. Measures such as paint stabilization must be taken to ensure that the paint will not continue to peel or chip off as the demolition is conducted and efforts should be taken to protect the surrounding ground surfaces and the Cerritos Channel below the Bridge from any paint that may come off in the demolition process. Removal of all paint prior to demolition would be the most conservative approach. However, full removal may not be necessary because, once peeling paint has been removed and remaining paint stabilized, the demolition waste may not exceed California waste thresholds. Full removal of paint may be necessary from some areas so that the demolition can be conducted where otherwise the presence of the paint may prevent the demolition process or the demolition activity might cause the paint to and spread into the surrounding environment.

Due to the condition of the painted components/surfaces at this site, there is a potential for surface contamination (soils, grounds, and water) at the base of the piers, below the viaduct structures, and below the bridge area over both solid ground and the Cerritos Channel. Special procedures will be required to ensure that paint chips and flakes are captured to protect the Cerritos Channel or onto the ground below. This issue must be addressed when remediation/demolition activities are planned at the facility and abatement plans and specifications should contain these measures.

Waste stream testing must be conducted to ensure proper disposal. In California, for waste purposes, regardless of the classification of the paint as LCP or LBP, it is considered as a California hazardous waste at a level of 0.1% (1,000 ppm) and must be disposed of as such if the composite samples exceed this level. Demolition waste should be segregated into three groups, construction debris, debris with lead containing paint (at or above 0.06 %/wt lead content), and debris with RCRA lead-based paint (at or above 0.50 %/wt lead content). Composite samples of the demolition waste should be collected and analyzed for lead content as discussed previously is Section 4.2 by TTLC, then STLC, and finally TCLP methods to characterize it for disposal. By segregating the waste prior to characterization for disposal, contamination of clean construction debris is avoided.

Since a large majority of the bridge structure is constructed of steel, this material is potentially recyclable as a scrap metal. Even though the steel is coated with LBP or LCP, and may be classified as a California or Federal RCRA hazardous material, there are Federal and State regulations that provide exemptions from waste disposal restrictions for recycled materials. These exclusions are defined in 40 CFR Sections 261.1, 261.4 and 261.6 and Title 22 CCR Sections 66260.10 and 66261.6. These exclusions allow the steel to be recycled and the paint will not be considered to be a hazardous waste. Until the point of recycling, however, procedures remain the same. The same work procedures, monitoring, PPE, and training and contractor certifications still apply during demolition. The painted structural elements still need to be stabilized or have paint removed to ensure that paint will not continue to fall off while the steel elements are being transported for recycling. The recycler may accept these materials due to the exemptions, but they are in no way mandated by these regulations to accept the LBP or LCP coated scrap metal for recycling and it is at their discretion if they choose to do so. The intended recycler will need to be contacted and notified that the steel is coated with LBP and LCP paint prior to shipping. The recycler

may also have special packaging or transportation procedures to ship these materials to them for recycling.

APPENDIX A

GLOSSARY

GLOSSARY

AIHA: American Industrial Hygiene Association.

Air Monitoring: The process of measuring the airborne fiber content of a known volume of air collected during a specific period of time. The acceptable procedure for airborne asbestos measurement by Phase Contrast Microscopy (PCM) is the OSHA reference method specified in Appendix A of 29, CFR 1926.1101. The acceptable procedure for airborne asbestos measurement by transmission electron microscopy (TEM) is the method specified in *Electron Microscope Measurement of Airborne Asbestos Concentrations* (EPA Report 500/2-77-178 (Rev. 1978) and EPA Contract No. 68-02-3266 (1984)).

Asbestos: Any hydrated mineral silicate separable into commercially usable fibers, including, but not limited to, chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

Asbestos Abatement: Procedures to control fiber release from asbestos-containing materials, including removal, encapsulation, enclosure, repair, demolition, and renovation activities.

Asbestos Abatement Contractor: An individual and/or business properly licensed and certified to perform asbestos abatement. The contractor is responsible for the proper completion of project activities in accordance with Federal, state, and local regulations.

Asbestos-Containing Building Material (ACBM): Material composed of asbestos of any type in an amount greater than 1 percent by weight, either alone or mixed with other fibrous or non-fibrous materials. For the purposes of this document the terms ACM (asbestos-containing material) and ACBM are used interchangeably.

Asbestos-Containing Material (ACM): Any material containing more than 1 percent asbestos. For the purposes of this document the terms ACBM (asbestos-containing building material) and ACM are used interchangeably.

Asbestos Hazard Emergency Response Act (AHERA): An EPA regulation published in the October 30, 1987, *Federal Register* covering asbestos-containing materials in schools.

Asbestos Survey: The survey of a building or portion of a building for the determination of the location of all ACBM present. An asbestos survey usually includes the collection of bulk samples for analysis by a laboratory.

Bulk Material Sample: A representative sample of a material collected by an inspector for asbestos analysis.

Condition Assessment: The determination of a material's overall condition and potential risk. The following information is typically included in an assessment: a description of any physical damage, water damage, delamination, etc.; degree of accessibility of the material; degree of activity near the material; and location in or near an air plenum or other HVAC (heating, ventilation, and air conditioning) equipment.

Demolition: The tearing down, wrecking, or removal of portions or all of a facility.

Destructive Surveying: The limited exploratory demolition of chases, walls, ceiling cavities, etc., for the purposes of identifying all previously hidden and inaccessible ACBM in an area.

Deterioration: The condition of ACBM in which the integrity of the material worsens. Deterioration includes physical damage, water damage, air erosion, and delamination of a material.

ELAP: Environmental Laboratory Approval Program.

EPA: United States Environmental Protection Agency.

EPA Green Book: *Managing Asbestos in Place, A Building Owner's Guide to Operations and Maintenance Programs for Asbestos-Containing Materials*; the latest EPA guidance on asbestos, issued in July 1990.

EPA Pink Book: *Asbestos in Buildings: Simplified Sampling Scheme for Friable Surfacing Materials*; available on the Postal Service's internal environmental web site.

EPA Purple Book: *Guidance for Controlling Asbestos-Containing Materials in Buildings*; available on the Postal Service's internal environmental web site.

Exploratory Demolition: The limited demolition of walls, chases, building components, etc., for the purposes of inspecting an area which was previously inaccessible. Demolition is usually limited to the extent necessary to provide an opening for visual survey.

Friable Asbestos: ACBM that, when dry, may be easily crumbled, pulverized, or reduced to powder by hand pressure; includes previously non-friable material after it becomes damaged to the extent that when dry, it may be crumbled, pulverized, or reduced to powder by hand pressure.

Functional Area: The basic unit used to describe locations within a facility where assessment data is collected. A functional area may be a room, crawl space, hallway, or other location within a facility.

Hazard Rank: a method of ranking hazards from most to least hazardous.

HEPA Filter: A high-efficiency particulate air (HEPA) filter capable of removing particles 0.3 micron or larger in diameter with 99.97 percent efficiency.

HEPA Vacuum: A vacuum system equipped with HEPA filtration.

Homogeneous Materials: Material types which are uniform in texture, color, and function and which appear to be identical in all other respects. A homogeneous material may span several functional areas.

Heating, Ventilating, and Air Conditioning Systems (HVAC): Any equipment, ducts, pipes, chillers, boilers, heaters, fans, or air conditioners used to condition or filter air in a building.

Inaccessible Areas: All areas that cannot be reached without first removing major components, including walls, ceilings, and flooring, to access the ACBM located in those areas.

Miscellaneous Material: Any suspect asbestos-containing material on structural components, structural members, or fixtures, such as floor and ceiling tiles, mastics, transite, etc.; does not include surfacing material or thermal system insulation.

NIST: National Institute of Standards and Technology.

Non-Friable Asbestos: ACBM that, when dry, may not be crumbled, pulverized, or reduced to powder by hand pressure.

NOB: Non-Friable Organically Bound material such as floor tile, mastics, roofing materials, etc.

NVLAP: National Voluntary Laboratory Accreditation Program.

OSHA: Occupational Safety and Health Administration, U.S. Department of Labor.

Personal Protective Equipment (PPE): Includes items such as HEPA filtered respirators, disposable protective clothing, gloves, boots, etc.

Phase Contrast Microscopy (**PCM):** Optical analytical method for determining fiber concentrations in air. Does not distinguish among asbestos and other fibers.

Plenum: A building space utilized to transport air commonly found below ground or above drop ceilings.

Polarized Light Microscopy (PLM): An optical method used to analyze bulk or wipe samples that utilizes polarized light and dispersion staining.

Quantification: A means of estimating the amounts of ACBM in an area, and usually reported as square feet, linear feet, or number of units. Quantification is typically performed in the field, but in some cases can be performed by estimating from scaled drawings (e.g., quantities of floor covering can be estimated readily from scaled drawings where certain pipe fittings and insulation are more readily estimated in the field).

Renovation: Altering in any way one or more facility components.

Substrate Material: Refers to the underlying material or component to which the ACBM is attached (e.g., metal doors, concrete floors, steel beams).

Surfacing Material: Any material that is sprayed-on, trowelled-on, or otherwise applied to surfaces for acoustical, fireproofing, decorative, or other purposes.

Suspect Asbestos-Containing Material: Any material which is suspect for containing asbestos and which must be sampled to determine asbestos content, if any. Appendix G of the EPA Guidance Document 20T-2003 (“Green Book”) contains a partial list of all suspect ACBM. Some common materials which are suspect ACBM include plaster, pipe insulation, floor tile, etc. Materials which are not considered suspect include fiberglass, wood, plastic, etc.

Thermal System Insulation (TSI): Any material applied to pipes, fittings, boilers, breeching, tanks, ducts, or other interior structural components to prevent heat loss or gain, or water condensation, or for other purposes.

Transmission Electron Microscopy (TEM): Analytical method using an electron microscope for the purposes of identifying and analyzing the concentration of airborne or bulk asbestos fibers and structures, if any. The TEM method distinguishes among asbestos and other materials and can detect smaller asbestos fibers than does the PCM or PLM method.

Type: The term "Type" is used to define the type of suspect asbestos-containing building material where S=Surfacing, T=Thermal Systems Insulation, M=Miscellaneous, and F=Flooring.

Visible Suspect ACBM Debris: Any debris which contains either asbestos-containing or suspect ACBM material that is visually detectable without the aid of instruments.

X-Ray Diffraction (XRD): Analytical method which analyzes the dispersive spectrum of the various asbestos mineral forms. It is a useful analytical method or bulk sample analyses. The minimum detection limit for this technique is approximately 1%. XRD is unable to separate out fibrous portions from non-fibrous portions. TEM should be used when discrete analysis is required.

APPENDIX B

SAMPLER AND LAB CERTIFICATION FORMS

APPENDIX C

ASBESTOS BULK SAMPLE DETAILS

BULK SAMPLE RESULTS SUMMARY

(See laboratory bulk sample analysis results in Appendix C for individual sample results)

Sample Number	Type	Homogeneous Material	Location	Tested	Peak %	Type	Test Method	Comments
HM1FT-1,2,3 HM10FT-1(Dup of HM1FT-1)	Flooring	12” White crackle pattern floor tile	North control room	T	5	Chrysotile	PLM	
HM1M-1,2,3 HM10M-1(Dup of HM1M-1)	Flooring	Floor tile mastic under HM1	North Control Room	T	N/D	None	PLM	
HM2FT-1	Flooring	12” beige squares pattern floor tile	North control room	T	N/D	None	PLM	
HM2M-1	Flooring	Floor tile mastic under HM2	North Control Room	T	N/D	None	PLM	
HM3-1,2,3,4,5,6 HM8-1 (Dup of HM3-4)	Miscellaneous	Masonite wall board panels	North control room walls and ceiling and switchgear and mechanical storage room wall dividers	T	20	Chrysotile	PLM	
HM4-1,2,3	Roofing	Roofing sealant	North and South tower metal roof sealant	T	N/D	None	PLM	
HM5Roofing-1,2,3	Roofing	Multi layer roofing	Mechanical storage and switchgear roof	T	N/D	None	PLM	
HM5Tar- 1,2,3	Roofing	Multi layer roofing	Mechanical storage and switchgear roof	T	N/D	None	PLM	
HM6-1,2,3 HM9-1 (Dup of HM6-3)	Roofing	Roof Penetration Mastic	Control room and switchgear/storage room roofs	T	5	Chrysotile	PLM	
HM7-1,2,3	Roofing	Multi layer roofing	Control room roof	T	N/D	None	PLM	

Notes:
HM(in sample number)= Homogeneous Material
M(in sample number)= Mastic
N/A = Not Applicable
N/D = Not Detected
NT = Not Tested
PLM = Polarized Light Microscopy
T (in sample number) = Floor Tile
T = Tested

APPENDIX D

LABORATORY SAMPLE ANALYSIS REPORTS

APPENDIX D1
ASBESTOS BULK SAMPLE LABORATORY ANALYSIS RESULTS

APPENDIX D2
LEAD PAINT CHIP SAMPLE LABORATORY ANALYSIS RESULTS

APPENDIX E

SITE DRAWINGS

APPENDIX F

SITE PHOTOGRAPHS

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
07	LA	47, 103	3.5/4.6, 0.0/1.1		

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RICHARD F. NORTON
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Exp. 12/31/11
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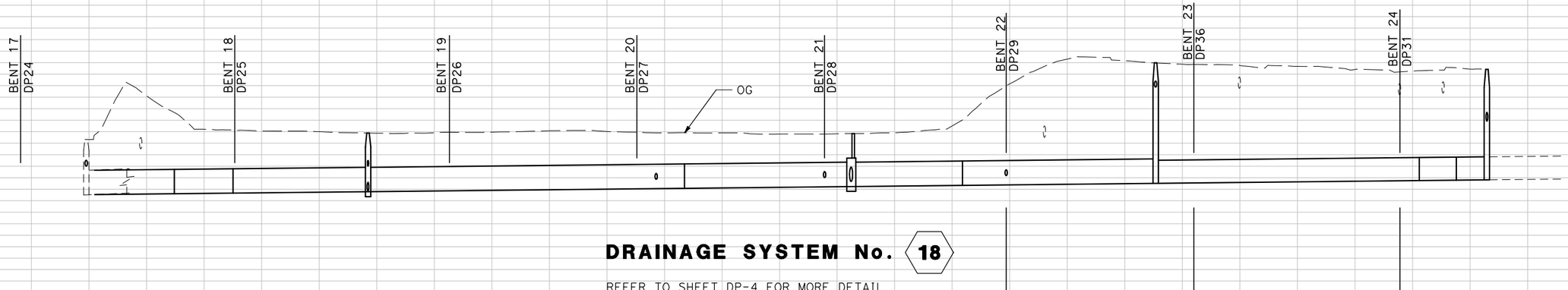
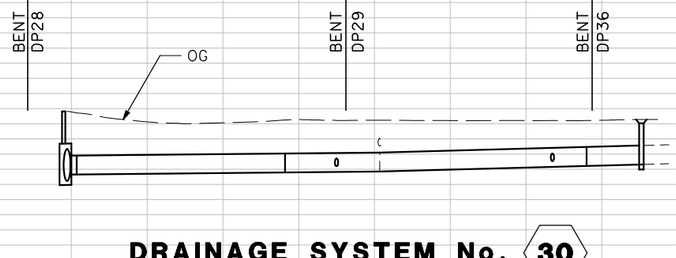


DRAINAGE SYSTEM No. 18

REFER TO SHEET DP-4 FOR MORE DETAIL



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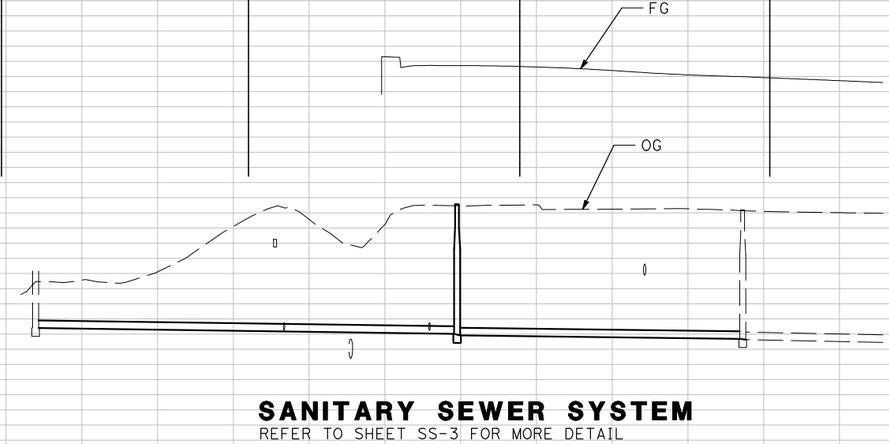

SANITARY SEWER SYSTEM

REFER TO SHEET SS-3 FOR MORE DETAIL

NOTES:
SEE HAZARDOUS CONTAMINATION DETAIL SHEET FOR POLLUTANT TABLE.

HAZARDOUS CONTAMINATION PROFILE

SCALE: Horiz 1" = 50'
Vert 1" = 10'

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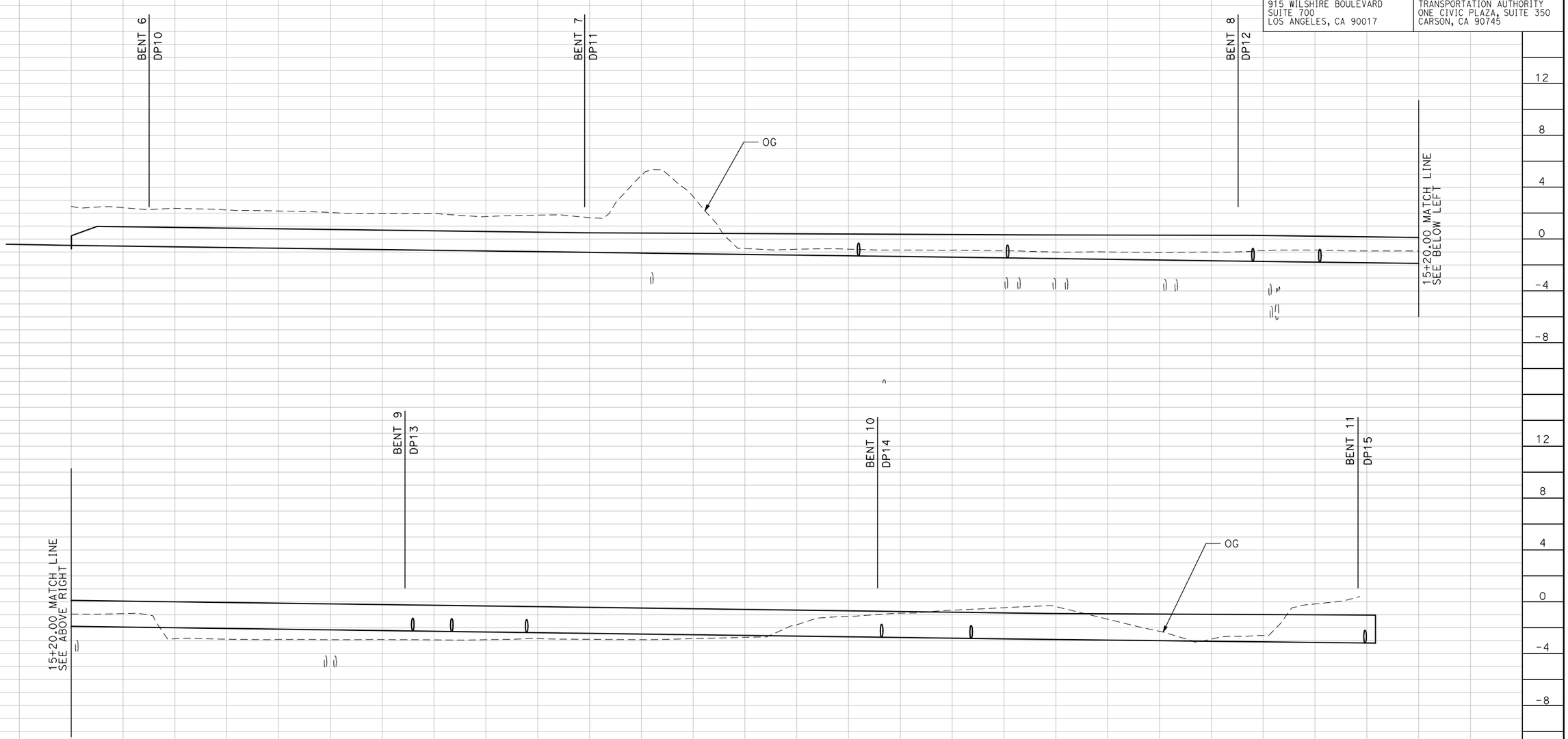

NOTES:
SEE HAZARDOUS CONTAMINATION DETAIL SHEET FOR POLLUTANT TABLE.

DRAINAGE SYSTEM No. 7

REFER TO SHEET DP-3 FOR MORE DETAIL

HAZARDOUS CONTAMINATION PROFILE

Scale: Horiz 1" = 20'
Vert 1" = 4'

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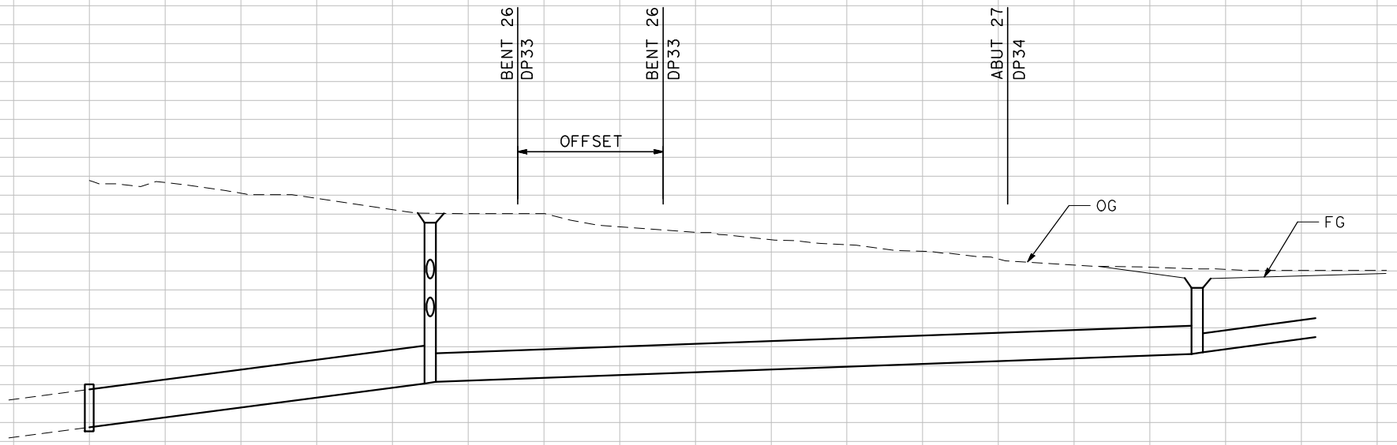

DRAINAGE SYSTEM No. 36

REFER TO SHEET DP-5 FOR MORE DETAIL

NOTES:
SEE HAZARDOUS CONTAMINATION DETAIL SHEET FOR POLLUTANT TABLE.

HAZARDOUS CONTAMINATION PROFILE

Scale: Horiz 1" = 20'
Vert 1" = 4'

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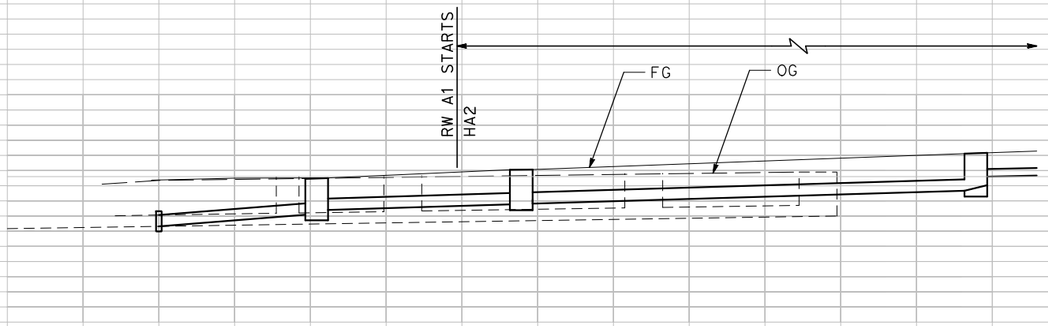

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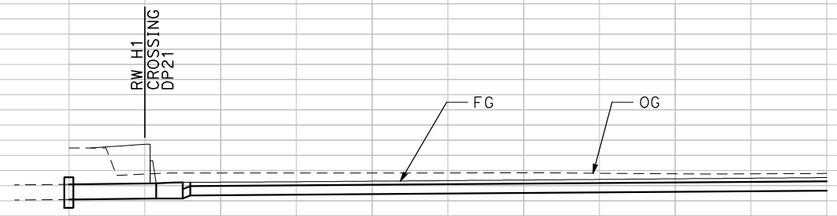
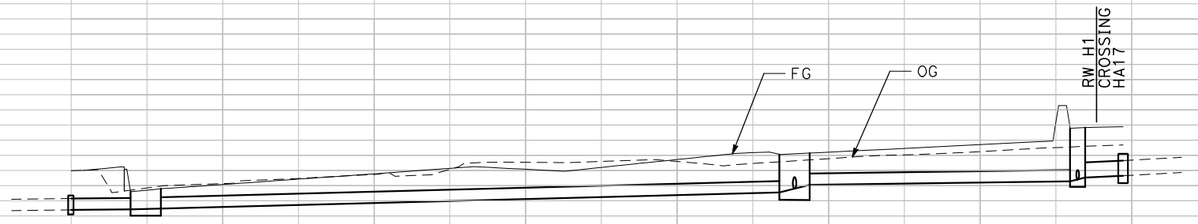
REFER TO SHEET DP-1 FOR MORE DETAIL



DRAINAGE SYSTEM No. 41

REFER TO SHEET DP-6 FOR MORE DETAIL



DRAINAGE SYSTEM No. 40

REFER TO SHEET DP-6 FOR MORE DETAIL

NOTES:
SEE HAZARDOUS CONTAMINATION DETAIL SHEET FOR POLLUTANT TABLE.

HAZARDOUS CONTAMINATION PROFILE

SCALE: Horiz 1"=10'
Vert 1"=10'

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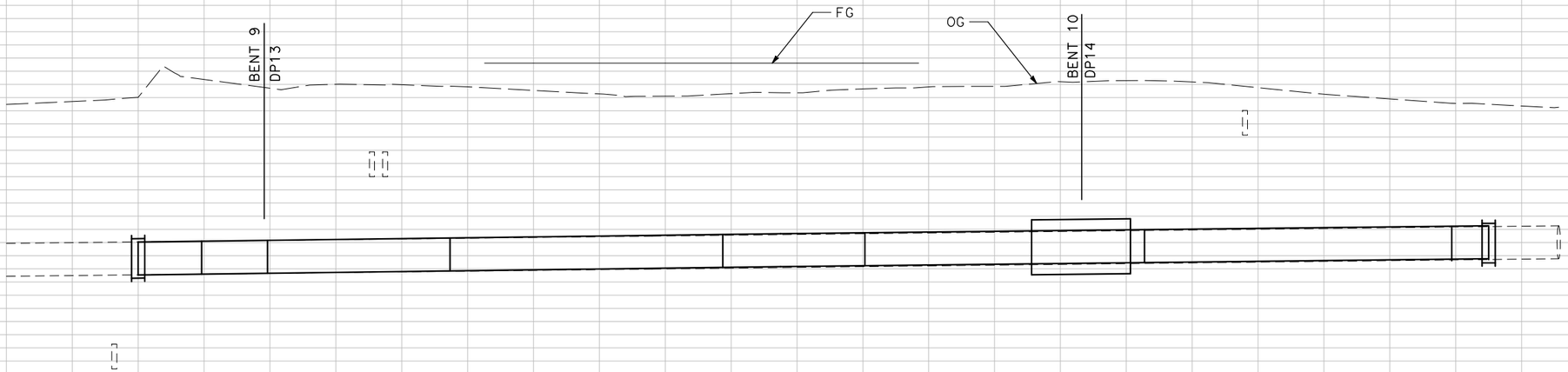
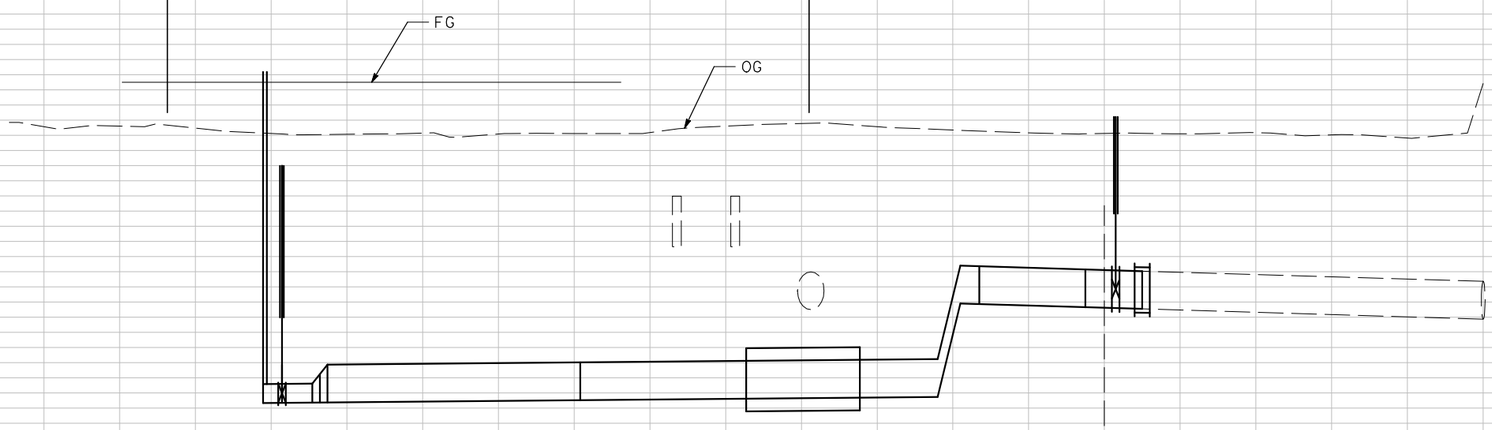


WATER SYSTEM
REFER TO SHEET U-16 FOR MORE DETAIL



WATER SYSTEM
REFER TO SHEET U-16 FOR MORE DETAIL

NOTES:
SEE HAZARDOUS CONTAMINATION DETAIL SHEET FOR POLLUTANT TABLE.

HAZARDOUS CONTAMINATION PROFILE

SCALE: Horiz 1" = 50'
Vert 1" = 10'

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SR47: Soils Profiles at Excavation Locations

Location	Pothole No.	Depth (ft.)	Pollutant	Soil Type	Excavation Limits WxLxD	Note	Soil Handling Criteria
All	*All*	*0' - 1'*	*Dispose off site in permitted Class 1 landfill (95% UCL for lead STLC=13.66)*	*Haz*	*Depth = 0' - 1'*		*Type Z-2*
All except DP23	*All except DP23*	*1' - 20'*	*LEAD ONLY ŦSee Bent, Abutment and Borehole locations for depth of other contaminants precluding reuse of soil. 95% UCL: TTLC=19.42 mg/kg STLC = 2.0 mg/L may require removal if exceeds other POLB acceptance criteria'*	*non-haz, reuse if ≤ POLB criteria (50 mg/kg lead and 1000 mg/kg TPH) or RWQCB criteria (DRO=100 mg/kg, ORO=1000mg/kg)*	*Depth = 1' - 20'*		*see below for contaminated interval*
Abut 1	DP2	1' - 3.5'	Diesel Range Organics (DRO) & Oil Range Organics (ORO)	non-haz/recycle	18'x70'x5' (allows 1' cover)	SR47	**Type DC**
		3.5'+	Reuse onsite	non-haz			**Type A**
Bent 2	DP6	1'+	Reuse onsite	non-haz	4 columns 10' dia. x 100' ***	SR47	**Type A**
Bent 3	DP7	1' +	Reuse onsite	non-haz	4 columns 10' dia. x 100' ***	SR47	**Type A**
Bent 4	DP8	1' +	Reuse onsite	non-haz	4 columns 10' dia. x 100' ***	SR47	**Type A**
Bent 5	DP9	1' - 2.5'	DRO & ORO	non-haz/recycle	4 columns 10' dia. x 100' ***	SR47	**Type DC**
Bent 6	DP10	1' - 4.5'	DRO and ORO	non-haz/recycle	5 columns 10' dia. x 100' ***	SR47	**Type DC**
Bent 7	DP11	1' -3'	DRO and ORO	non-haz/recycle	5 columns 10' dia. x 100' ***	SR47	**Type DC**
Bent 8	DP12	1' - 2'	DRO and ORO	non-haz/recycle	4 columns 10' dia. x 100' ***	SR47	**Type DC**
Bent 9	DP13	1' +	Reuse onsite	non-haz	6 columns 10' dia. x 100' ***	SR47	**Type A**
Bent 10	DP14	1' - 4.5'	DRO and ORO	non-haz/recycle	6 columns 10' dia. x 100' ***	SR47	**Type DC**
Bent 11	DP15	1' - 6'	DRO and ORO	non-haz/recycle	4 columns 10' dia. x 100' ***	SR47	**Type DC**
Bent 12	DP16	1' - 2.5'	DRO and ORO	non-haz/recycle	4 columns 10' dia. x 100' ***	SR47	**Type DC**
		2.5'- 6.5'	Reuse onsite	non-haz			**Type A**
Abut 3	HA8	1' - 2'	DRO and ORO	non-haz/recycle	20'x41'x5' (allows 1' cover)	New Dock off-ramp	**Type DC**
Bent 4	DP5	1' +	Reuse onsite	non-haz	1 column 10' dia. x 100' ***	New Dock off-ramp	**Type A**
Bent 5	DP4	1' +	Reuse onsite	non-haz	1 column 10' dia. x 100' ***	New Dock off-ramp	**Type A**
Bent 6	DP4	1' +	Reuse onsite	non-haz	1 column 10' dia. x 100' ***	New Dock off-ramp	**Type A**
Bent 7	HA9	1' +	Reuse onsite	non-haz	2 columns 10' dia. x 100' ***	New Dock off-ramp	**Type A**
Bent 8	HA9	1' +	Reuse onsite	non-haz	1 column 10' dia. x 100' ***	Bent 8 close to 2 borings	**Type A**
Bent 8	DP13	1' +	Reuse onsite	non-haz	1 column 10' dia. x 100' ***	New Dock off-ramp	**Type A**
Abut 6	DP3	1' +	Reuse onsite	non-haz	19'x39.5'x5' (allows 1' cover)	New Dock on-ramp	**Type A**
Bent 7	HA6	1' +	Reuse onsite	non-haz	1 column 10' dia. x 100' ***	New Dock on-ramp	**Type A**
Bent 8	DP12	1' - 2'	DRO and ORO	non-haz/recycle	1 column 10' dia. x 100' ***	New Dock on-ramp	**Type DC**
Bent 8	DP40	1' - 5'	DRO and ORO	non-haz/recycle	1 column 10' dia. x 100' ***	Bent 8 close to 2 borings	**Type DC**
Pier 13		0' - 10'	*In Cerritos Channel - no information available*	disposal			**Type SC**
Pier 14		0' - 10'	*In Cerritos Channel - no information available*	disposal			**Type SC**
Pier 15		0' - 10'	*In Cerritos Channel - no information available*	disposal			**Type SC**
Pier 16		0' - 10'	*In Cerritos Channel - no information available*	disposal			**Type SC**
Bent 17	DP24	1' +	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	SR47	**Type A**
Bent 18	DP25	1' +	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	SR47	**Type A**
Bent 19	DP26	1' +	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	SR47	**Type A**
Bent 20	DP27	1' +	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	SR47	**Type A**
Bent 21	DP28	1' +	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	SR47	**Type A**
Bent 22	DP29	1' - 2.5'	DRO and ORO	non-haz/recycle	4 columns 12' dia. x 100' ***	SR47	**Type DC**
		2.5'-5.5'	Reuse onsite	non-haz			**Type A**
Bent 23	DP30	1' - 4.5'	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	SR47	**Type A**
		4.5' - 5.5'	DRO and ORO	non-haz/recycle			**Type DC**
Bent 23	DP36	1' - 4.5'	Reuse onsite	non-haz			**Type A**
Bent 23	DP36	4.5' - 5.5'	DRO and ORO	non-haz/recycle	4 columns 12' dia. x 100' ***	SR47	**Type DC**
Bent 24	DP31	1' +	Reuse onsite	non-haz	2 columns 12' dia. x 100' ***	Bent 24 SB103, DP31	**Type A**
Bent 25	DP35	1' - 9'	Reuse onsite	non-haz			**Type A**
Bent 25	DP35	9' - 15'	DRO & ORO	non-haz/recycle	4 columns 12' dia. x 100' ***	Bent 24 SR47, DP35	**Type DC**
Bent 25	DP32	1' - 2'	DRO & ORO	non-haz/recycle			**Type DC**
Bent 25	DP32	2' +	Reuse onsite	non-haz	4 columns 12' dia. x 100' ***	2 columns for SB103 2 columns for NB103	**Type A**
Bent 26	DP33	1' - 7'	Reuse onsite	non-haz			**Type A**
Bent 26	DP33	7' - 9'	SVOCs	non-haz/off-site disposal	4 columns 12' dia. x 100' ***	2 columns for SB103 2 columns for NB103	**Type SC**
Bent 27	DP34	1' +	Reuse onsite	non-haz	2 columns 12' dia. x 100' ***	SB103	**Type A**
Abut 27	DP23	1' - 6'	Lead (soluble 44 mg/l), VOCs	Haz	24'x70'x5' (allows 1' cover)	Abut 27 close to 2 borings	**Type Z-2**
		6' - 17.5'	Reuse onsite	non-haz			**Type A**
Abut 27	DP34	1' +	Reuse onsite	non-haz		NB103	**Type A**
Abut 28	HA13	1' +	Reuse onsite	non-haz	24'x52'x5' (allows 1' cover)	SB103	**Type A**
RW A1	HA1	1' - 2'	DRO & ORO	non-haz/recycle			**Type DC**
RW A1	HA2	1' +	Reuse onsite	non-haz	2'x186'x2' (allows 1' cover)		**Type A**
RW A1	HA3	1' +	Reuse onsite	non-haz			**Type A**
RW C1	DP3	1' +	Reuse onsite	non-haz	2'x134'x2' (allows 1' cover)		**Type A**
RW C1	HA7	1' +	Reuse onsite	non-haz			**Type A**
RW E1	DP34	1' +	Reuse onsite	non-haz	2'x216'x2' (allows 1' cover)		**Type A**
RW E1	HA13	1' +	Reuse onsite	non-haz			**Type A**
RW E2	DP22	1' - 3.5'	DRO	non-haz/recycle	2'x453'x2' (allows 1' cover)		**Type DC**
RW E2	DP23	1' - 6'	Lead (soluble 44 mg/l), VOCs	Haz			**Type Z-2**
RW E2	DP23	6' - 17.5'	Reuse onsite	non-haz			**Type A**
RW E2	HA16	1' - 2.5'	DRO & ORO	non-haz/recycle			**Type DC**
		2.5'-5.5'	Reuse onsite	non-haz			**Type A**
RW G1	HA12	1' - 2'	DRO	non-haz/recycle			**Type DC**
RW G1	HA12	2' +	Reuse onsite	non-haz			**Type A**
RW G1	HA10	1' +	Reuse onsite	non-haz			**Type A**
RW G1	HA11	1' +	Reuse onsite	non-haz	2'x388'x2' (allows 1' cover)		**Type A**
RW G1	DP17	2.5' - 7.5'	Reuse onsite	non-haz			**Type A**
RW G1	DP17	7.5' - 12.5'	DRO & ORO	non-haz/recycle			**Type DC**
RW G2	HA14	1' +	Reuse onsite	non-haz			**Type A**
RW G2	HA15	1' - 2.5'	SVOCs	non-haz/off-site disposal	2'x256'x2' (allows 1' cover)		**Type SC**
RW G2	HA15	2.5' - 4'	Reuse onsite	non-haz			**Type A**
RW G2	HA15	4' - 6'	DRO & ORO	non-haz/recycle			**Type DC**
RW G2	DP19	1' +	Reuse onsite	non-haz			**Type A**
RW G2	DP20	1' - 2'	SVOCs	non-haz/off-site disposal			**Type SC**
RW G2	DP20	2' +	Reuse onsite	non-haz			**Type A**
RW H1	HA17	1' - 3'	DRO & ORO	non-haz/recycle	10'x432'x3' (allows 1' cover)		**Type DC**
RW H1	DP21	1' - 2.5'	DRO & ORO	non-haz/recycle			**Type DC**

HA = Hand Auger Boring
DP = Direct Push Boring
RW = Retaining Wall
Abut = Abutment
haz = Hazardous Material
non-haz = Non-Hazardous Material
0' - equivalent to surface level

*** On average spaced about 10' apart on center
1 - DP Sampling at 0', 5', 10', and 15' and HA Sampling at 0', 1', 2', 3' and 5'
DRO = Diesel Range Organic Compounds
ORO = Oil Range Organic Compounds
SVOCs = Semi-volatile organic compounds
Ŧ See Bent, Abutment and Borehole locations for depth of other contaminants precluding reuse of soil.
Type DC - non-hazardous soil contaminated with TPH (DRO and ORO) that must be sent to a recycling facility
Type SC - soil contaminated with semi-volatile organic compounds that must be disposed off-site at an appropriate Class 2 or 3 landfill in California
Type A - non-hazardous soil that meets POLB acceptance criteria and may be reused on site.

HAZARDOUS CONTAMINATION DETAIL

NOT TO SCALE

REVISED BY	DATE REVISED
YOUNG YOON	JERRY GANTNY
CALCULATED-DESIGNED BY	CHECKED BY
CONSULTANT FUNCTIONAL SUPERVISOR	SHAHRAM VAHDAT

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION — Caltrans

LAST REVISION 00-00-00 | DATE PLOTTED => 9/27/2010 | TIME PLOTTED => 8:18:45 AM

BORDER LAST REVISED 4/11/2008

RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

USERNAME => Shruti_Shah
DGN FILE => ...\HZ Contamination Profile-TABLE.dgn

CU 07271

EA 138201

SUBSURFACE INVESTIGATION
SOIL PORTION
COMMODORE SCHUYLER F. HEIM BRIDGE REPLACEMENT PROJECT
LONG BEACH, CALIFORNIA

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PREPARED FOR:
Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
475 Goddard, Suite 200
Irvine, California 92618

July 30, 2010
Project No. 207940001

July 30, 2010
Project No. 207940001

Ms. Elaine Silvestro
Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Subject: Limited Subsurface Investigation
Soil Portion
Commodore Schuyler F. Heim Bridge Replacement Project
Long Beach, California

DRAFT

Dear Ms. Silvestro:

Ninyo & Moore is pleased to provide the report for the soil portion of the limited subsurface investigation (LSI) report for the above referenced site. A draft report for the grab groundwater and channel water portion of this limited LSI will be provided under separate cover. The two reports will be combined into one final limited SI report. The attached report presents our methodology, findings, conclusions, and recommendations regarding the environmental conditions at the site.

We appreciate the opportunity to be of service to you on this project.

Respectfully submitted,
NINYO & MOORE

Javier Perez
Senior Staff Environmental Scientist

John Jay Roberts, P.G., C.E.G.
Senior Geologist

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Principal Environmental Geologist

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Distribution: (2) Addressee

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EXECUTIVE SUMMARY

The Alameda Corridor Transportation Authority (ACTA) authorized Ninyo & Moore to conduct a limited subsurface investigation (LSI) for the Commodore Schuyler F. Heim Bridge Replacement Project. The site is an approximate 6,000-foot long section of SR-47 that begins at West Ocean Boulevard on the south and extends to SR-103 on the north. The site includes the Schuyler Heim Bridge and its northern and southern approaches. The portion of the site south of the Cerritos Channel, including the Schuyler Heim Bridge and its northern approaches, is in the city of Long Beach, Los Angeles County, California. The portion of the site north of the Cerritos Channel, including the southern approaches of the Schuyler Heim Bridge, is in the city of Los Angeles, Los Angeles County, California. The site has been developed with the existing SR-47 and the Schuyler Heim Bridge beginning with construction in approximately 1947 until present day. Prior to the construction of the Schuyler Heim Bridge and SR-47, the site was primarily a road (Henry Ford Avenue). Based on this information there is a high likelihood that soil underlying the existing SR-47 and right of way (ROW) areas along SR-47 have been impacted with aerially deposited lead (ADL). Additionally the painted lines, markings, and pavement legends are likely to contain elevated concentrations of lead and hexavalent chromium. The historic presence of railroad tracks adjacent to the site presents a potential for lead, arsenic, and chromium contamination in the soil. Based on the condition of the bridge and approaches, there is also a potential for soil contamination from lead based paint (LBP) on the bridge and approaches.

The portion of the site north of the Cerritos Channel and east of the Schuyler Heim Bridge approach was developed as the Ford Motor Company's Long Beach assembly plant (Pier A) from prior to 1949 to some time prior to 1969, at which time it was replaced as a port terminal. Based on the site uses and the listings on the database report for this property, there is a likelihood that soil and groundwater located in the portion of the site north of the Cerritos Channel and east of the SR-47 may be impacted with solvents and petroleum hydrocarbons historically used in the automobile manufacturing industry.

The site vicinity has been used primarily for industrial and manufacturing purposes, and largely for oil field activities. The site vicinity has several oil and gas wells adjacent to the project area.

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Based on this information, there is a high likelihood that soil underlying and adjacent to the site is impacted with petroleum hydrocarbons.

Two plugged and abandoned oil wells appear to be within the project area, on the portion of the site south of the Cerritos Channel and east of the bridge approach. The existence of abandoned or active oil wells with piping is considered an environmental concern. A large diameter gasoline pipeline was observed aboveground running along the southwestern portion of the site between the railroad tracks and the Schuyler Heim Bridge approaches.

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The objectives of the LSI as described in the ACTA-approved LSI Work Plan, dated July 9, 2010 and prepared by Ninyo & Moore are to evaluate health and safety concerns and waste management options through the collection of soil, surface water, and groundwater samples. This draft report discusses the results of the soil sampling; groundwater sampling results is discussed in a separate draft report and the two reports will be combined when finalized.

In accordance with the approved LSI work plan, soil samples were collected from 39 direct-push borings and 18 hand-augered borings for a total of 57 borings. The direct-push borings were advanced at the base of the mechanically stabilized earth (MSE) walls, accessible bridge bents, areas of utility relocations, backfill areas, railroad track relocations, and new off ramp areas. The hand-augered borings were used to obtain soil samples from areas inaccessible to a direct-push drill rig, including: the middle section of the MSE walls, sloped areas with MSE walls, and areas adjacent to the current off ramp. Depth to groundwater was approximately 3 to 4 feet below ground surface (bgs) at level ground adjacent to the northern and southern bridge approaches and approximately 5.5 to 20 feet bgs along SR-47 north of the Cerritos Channel.

The field sampling for the LSI was conducted on July 7, 9, and 12 through 16, 2010, by Ninyo & Moore in general accordance with the ACTA-approved LSI Work Plan dated July 9, 2010, and included boring mark out and advancing and sampling a total of 57 soil borings.

The boreholes were advanced and sampled by CoreProbe International, Inc. (CoreProbe), of Rosemead, California, and StrongArm Environmental Field Services (StrongArm), of Norwalk,

California using a hand-auger and slide hammer for the first 5 feet bgs, followed by hydraulic direct-push methods from 5 feet bgs to total depths of up to approximately 21 feet bgs.

This LSI evaluated the presence of possible contaminants that might exceed acceptable regulatory levels the Regional Water Quality Control Board (RWQCB) uses to determine the threat to groundwater from nonhalogenated hydrocarbons, the United States Environmental Protection Agency (EPA) Regional Screening Level for industrial properties (RSLi), California Human Health Screening Levels (CHHSLs) for commercial/industrial use (CHHSLi), and hazardous waste levels for disposal at landfills.

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The following presents a summary of the findings and conclusions of the LSI:

- Depth to groundwater was approximately 3 to 4 feet bgs at level ground adjacent to the northern and southern bridge approaches and approximately 5.5 to 20 feet bgs along SR-47 north of the Cerritos Channel.

- A total of 177 soil samples were collected and analyzed from 57 borings. Of these 177 soil samples (including 15 duplicate samples), 149 samples were analyzed for total petroleum hydrocarbons as gasoline (TPHg), total petroleum hydrocarbons as diesel and oil (TPHd) and total petroleum hydrocarbons as oil (TPHo), semi-volatile organic compounds (SVOCs), CAM 17 Metals, and pH in general accordance with EPA Methods, 8015M/5035, 8015M, 8270C, 6010B/7471, and 9045, respectively. Eighty-three (including three duplicate samples) of the 177 soil samples were analyzed for volatile organic compounds (VOCs) plus oxygenates by EPA Method 8260B/5035. Twenty-eight of the 177 samples were analyzed for total lead by EPA Method 6010B.

- Detectable concentrations of VOCs were not reported in the samples analyzed at the site, with the exception of chloromethane in the duplicate sample collected from boring D23 at 5 feet bgs.

- Of the 177 soil samples analyzed for lead, 15 samples were analyzed for soluble lead in general accordance with the Waste Extraction Test (WET) method using both citric acid and deionized (DI) water as the extractant. The same 15 samples were also analyzed in accordance with the Toxicity Characteristic Leaching Procedure (TCLP).

- Three soil samples analyzed for chromium were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. [2 results pending]

- One primary and one duplicate soil sample were collected from boring DP24 due to its close proximity to a bank of transformers and analyzed for polychlorinated biphenyls (PCBs) by

EPA Method 8082. Detectable concentrations of PCBs were not reported either of the two samples analyzed

- Detectable concentrations of TPHg (C_4-C_{12}) were not reported in the samples analyzed. Concentrations above the maximum soil screening levels (MSSL) of 100 milligrams per kilogram (mg/kg) of TPHd (C_{13}-C_{22}) for soils less than 20 feet above groundwater were reported in 51 samples collected from 33 borings at the site. Concentrations above the MSSL were detected primarily at the surface (0-6 inches bgs). In addition to TPHd concentrations detected in the surface samples, TPHd concentrations were reported at depths ranging from 2.5 to 14.5 feet bgs in ten borings ranging from 170 to 5,600 mg/kg. Seven of the ten borings are located north of the Cerritos Channel and all were located either on State Route 47 or Pier A Plaza with the exception of DP36 which was located immediately adjacent to an asphalt road leading out of the Port of Long Beach (POLB), Pier A easement onto Pier A Plaza. The highest concentration of 5,600 mg/kg was reported from boring DP17 at 10 feet bgs. Three borings were located beneath the bridge approach north of New Dock Street and south of the Cerritos Channel. Concentrations of TPHd in these three borings ranged from 150 to 320 mg/kg.

- Concentrations above the MSSL of 1,000 mg/kg of TPHo (C_{23}-C_{32}) for soils less than 20 feet above groundwater were reported in 35 samples collected from 27 soil borings at the site. Concentrations above the MSSL were detected primarily at the surface (0-6 inches bgs) or directly below asphalt or concrete cover. In addition to TPHo concentrations detected in the surface samples, TPHo concentrations were reported at depths ranging from 1.5 to 14.5 feet bgs in five borings ranging from 1,300 to 13,000 mg/kg. The five borings are either directly on SR-47 or the associated on and off ramps with the exception of boring HA5 which is located on the northbound Ocean Avenue on ramp. The highest concentration of 13,000 mg/kg was reported from boring DP17 at 10 feet bgs.

- Detectable concentrations of SVOCs were reported in samples DP20-1, DP33-8, HA13-0, and HA15-0. The four samples exceeded both the CHHSLi and RSLi of 130 and 210 micrograms per kilogram (µg/kg), respectively, for benzo(a)pyrene. Sample DP33-8 had reported concentrations of benzo(a)anthracene (17,000 µ/kg), benzo(b)fluoranthene (41,000 µg/kg), dibenz(a,h)anthracene (5,900 µg/kg), and indeno(1,2,3,cd)pyrene (17,000 µg/kg) that exceeded their respective RSLi. The four samples had reported concentrations of pyrene ranging from 440 to 14,000 µg/kg. One sample, HA13-0, had a reported concentration of 610 µg/kg of phenanthrene. Three samples DP20-1, DP33-8, and HA15-0 had reported concentrations of benzo(g,h,i)perylene ranging from 380 to 41,000 µg/kg. None of these three analytes have an established CHHSLi or RSLi. The four borings were located north of the Cerritos Channel along SR-47.

- Detectable concentrations of CAM 17 Metals above their respective CHHSLi or RSLi were not reported for the CAM 17 analytes, with the exception of arsenic, cadmium, and lead. Concentrations of arsenic ranged from less than 1 to 19 mg/kg. Arsenic concentrations in 125 of the 148 samples analyzed exceeded the CHHSLi and 121 exceeded the RSLi. How-

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ever, the Department of Toxic Substance Control (DTSC) provides an upper bound estimate of 12 mg/kg in southern California native soils. Arsenic concentrations in one sample, DP24-2.5 (19 mg/kg) exceeded this upper bound estimate of 12 mg/kg. The other samples are considered within background. One sample, DP23-20, with a reported concentration of 7.8 mg/kg of cadmium exceeded the CHHSLi of 7.5 mg/kg. However, this sample was several orders of magnitude below the RSLi for cadmium of 800 mg/kg.

- Two samples, DP8-0 and DP23-20, had lead concentrations above the CHHSLi of 320 mg/kg but were below the RSLi of 800 mg/kg. Sample DP8-0 is located beneath the bridge approach south of the Cerritos Channel adjacent to ACTA railroad tracks. Soil collected from this same boring at 2.5 feet bgs had lead concentrations of 16 mg/kg, well below the CHHSLi. Sample DP23-20 is located on SR-47 north of the Cerritos Channel and is a duplicate of primary sample DP23-5. The primary soil sample and soil samples collected from this same boring at the surface and at 10 feet bgs had lead concentrations well below the CHHSLi of 320 mg/kg.

- Thirteen soil samples analyzed for lead had reported concentrations ten times above the soluble threshold limit concentration (STLC). The samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant. Eight soil samples, DP3-0, DP3-20, DP4-0, DP6-6.5, DP8-0, DP23-20, HA7-0, and HA7-1, contained greater than or equal to 5.0 mg/l soluble leads, which exceeds the STLC. The thirteen samples were analyzed using the toxicity characteristic leaching procedure (TCLP). None of the samples contained soluble lead concentration in excess of 5 mg/l so would not be considered Resource Conservation and Recovery Act (RCRA) hazardous waste. Soil from borings DP3, DP4, DP6, DP8, DP23, and HA7 if excavated would be considered California regulated hazardous waste.

- The eight samples exceeding the STLC using citric acid as the extractant were analyzed for soluble lead in general accordance with the WET method using deionized (DI) water as the extractant. The reported concentrations in the eight samples were below the DTSC issued California Department of Transportation (Caltrans) DTSC variance for lead of 1.5 mg/l. Additionally pH levels for the eight samples were above 5.5. The eight samples are located along Caltrans ROW with the exception of samples collected from borings DP8 and DP6 which are located on POLB property south of New Dock Street. Soil from the Caltrans ROW is classified as Y1 soil and the Caltrans DTSC variance applies.

- Additionally, seven randomly selected soil samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant and TCLP. Four of the seven soil samples were analyzed for soluble lead in general accordance with the WET method using DI water as the extractant. None of the samples had reported concentrations soluble lead equal to or above the STLC of 5 mg/l, the TCLP of 5 mg/l or the STLC-DI of 1.5 mg/l.

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- Chromium was detected in three samples at concentrations greater than or equal to ten times the STLC for chromium of 5 mg/l. The three samples, DP15-20 (70 mg/kg), DP23-20 (100 mg/kg), and DP25-0 (60 mg/kg), were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. Detectable concentrations of soluble chromium were not reported in sample DP23-20. Therefore soil from boring DP23 is considered non-hazardous with respect to chromium. Analytical results for samples DP15-20 and DP25-0 are still pending.

- One-hundred forty-eight soil samples (including 15 duplicate samples) were collected from 56 boring locations and analyzed for pH. pH levels in the 83 soil samples analyzed north of the Cerritos Channel ranged from 7.2 to 11. pH levels in the 65 soil samples analyzed south of the Cerritos Channel ranged from 7.1 to 11 pH. pH levels at the project area range from 7.1 to 11 pH.

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Based on the results of this LSI, Ninyo & Moore provides the following recommendations:

- Soil from borings DP3, DP4, DP6, DP8, DP23, and HA7 is considered California regulated hazardous waste due to its concentration of soluble lead and should be disposed of accordingly. Based on the STLC WET-citric, STLC WET-DI, TCLP, and pH analytical results, soil from the boring locations within the Caltrans ROW could be on the Caltrans ROW in accordance with the DTSC issued Caltrans lead variance. However, based on restrictions applied by the POLB, the soil may need to be removed.

- Soil at the site that is impacted with TPHs above the MSSLs should be removed and disposed as a petroleum contaminated non-hazardous waste.

- Soil in the vicinity of boring D24 at 2.5 feet contains elevated arsenic and should be removed as a non-hazardous waste.

- Personnel performing subsurface work, including geotechnical investigations, utility installations, or other construction, should be provided with the analytical data from this LSI so that they can be used in developing an applicable health and safety program. The personnel should be notified that elevated concentrations of lead may be present in on-site soil.

1. INTRODUCTION

The Alameda Corridor Transportation Authority (ACTA) authorized Ninyo & Moore to conduct a limited subsurface investigation (LSI) for the Commodore Schuyler F. Heim Bridge Replacement Project. The site is an approximate 6,000-foot long section of SR-47 that begins at West Ocean Boulevard on the south and extends to SR-103 on the north. The site includes the Schuyler Heim Bridge and its northern and southern approaches. The portion of the site south of the Cerritos Channel, including the Schuyler Heim Bridge and its northern approaches, is in the city of Long Beach, Los Angeles County, California. The portion of the site north of the Cerritos Channel, including the southern approaches of the Schuyler Heim Bridge, is in the city of Los Angeles, Los Angeles County, California. The site has been developed with the existing SR-47 and the Schuyler Heim Bridge beginning with construction in approximately 1947 until present day. Prior to the construction of the Schuyler Heim Bridge and SR-47, the site was primarily a road (Henry Ford Avenue). Based on this information there is a high likelihood that soil underlying the existing SR-47 and ROW areas along SR-47 have been impacted with aerially deposited lead (ADL). Additionally the painted lines, markings, and pavement legends are likely to contain elevated concentrations of lead and hexavalent chromium. The historic presence of railroad tracks adjacent to the site presents a potential for lead, arsenic, and chromium contamination in the soil. Based on the condition of the bridge and approaches, there is also a potential for soil contamination from lead based paint (LBP) on the bridge and approaches.

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The portion of the site north of the Cerritos Channel and east of the Schuyler Heim Bridge approach was developed as the Ford Motor Company's Long Beach assembly plant (Pier A) from prior to 1949 to some time prior to 1969, at which time it was replaced as a port terminal. Based on the site uses and the listings on the database report for this property, there is a likelihood that soil and groundwater located in the portion of the site north of the Cerritos Channel and east of the SR-47 may be impacted with solvents and petroleum hydrocarbons historically used in the automobile manufacturing industry.

The site vicinity has been used primarily for industrial and manufacturing purposes, and largely for oil field activities. The site vicinity has several oil and gas wells adjacent to the project area.

Based on this information, there is a high likelihood that soil underlying and adjacent to the site is impacted with petroleum hydrocarbons.

Two plugged and abandoned oil wells appear to be within the project area, on the portion of the site south of the Cerritos Channel and east of the bridge approach. The existence of abandoned or active oil wells with piping is considered an environmental concern. A large diameter gasoline pipeline was observed aboveground running along the southwestern portion of the site between the railroad tracks and the Schuyler Heim Bridge approaches.

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The objectives of the LSI are to evaluate health and safety concerns and waste management options through the collection of soil, surface water, and groundwater samples.

In accordance with the approved LSI work plan, soil samples were collected from 39 direct-push borings and 18 hand-augered borings for a total of 57 borings. The direct-push borings were advanced at the base of the mechanically stabilized earth (MSE) walls, accessible bridge bents, areas of utility relocations, backfill areas, railroad track relocations, and new off ramp areas. The hand-augered borings were used to obtain soil samples from areas inaccessible to a direct-push drill rig, including: the middle section of the MSE walls, sloped areas with MSE walls, and areas adjacent to the current off ramp. Depth to groundwater was approximately 3 to 4 feet below ground surface (bgs) at level ground adjacent to the northern and southern bridge approaches and approximately 5.5 to 20 feet bgs along SR-47 north of the Cerritos Channel.

The following sections discuss the items of work conducted for this LSI and any exceptions to the activities.

1.1. Scope of Work

The following is a general outline of the approved scope of work for this LSI as described in the LSI Work Plan, dated July 9, 2010 prepared by Ninyo & Moore. Exceptions to this scope of work are discussed in Section 1.2.

- Prepare a Health and Safety Plan (HSP).

- Clear subsurface utilities by notification to Underground Service Alert (USA).
- Advance a total of 59 soil borings at the site .
- Locate the horizontal coordinates of the soil borings using a Global Positioning System (GPS). This data is located in Appendix A.
- Analyze selected soil samples for suspected chemical constituents.
- Prepare this report.

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1.2. Exceptions to Scope of Work

This LSI was completed in general accordance with the ACTA-approved LSI work plan prepared by Ninyo & Moore dated July 9, 2010, with the following exceptions:

- Two proposed direct-push soil borings were eliminated due to safety concerns; one related to underground utilities (DP1), and the other due to traffic hazards (DP18).
- Direct-push soil boring DP14 was moved approximately 280 feet south of the originally proposed location due to refusal encountered in the original location resulting from encountering the underlying gravel road base.
- Direct-push soil boring DP41 was moved approximately 15 feet west of the originally proposed location due to refusal encountered in the original location resulting from encountering the underlying gravel road base.
- Direct-push soil boring DP15 was moved approximately 25 feet northwest of the originally proposed location due to underground utilities.
- The location of hand-auger soil boring HA9 was switched with the location of direct-push soil boring DP4 due to access restrictions encountered in the field.
- Direct-push soil boring DP5 was moved approximately 40 feet east upslope to the top of the New Dock Street off ramp due to underground utilities, railroad track, and gravel and boulders located around the originally proposed location.
- Direct-push soil boring DP35 was moved approximately 15 feet west due to refusal encountered at the originally proposed location (possible underground utility).

A total of 39 of the 41 planned direct-push soil boring locations were advanced, and a total of 177 soil samples (including 15 duplicate samples) were collected during the LSI (29 of which were only analyzed for lead).

The 18 planned hand-auger soil borings were advanced, and a total of 54 soil samples (including 4 duplicate samples) were collected during the LSI. However, six of the 18 planned hand-auger soil borings were advanced with a direct-push rig.

2. PROJECT DESCRIPTION

It is our understanding that the project includes replacement of the Schuyler Heim Bridge. A Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) was prepared for the Schuyler Heim Bridge Replacement and SR-47 Expressway Project. The EIS/EIR identified six proposed project alternatives. "Alternative 1 (Bridge Replacement and SR-47 Expressway)" was selected as the preferred alternative. Alternative 1 combined the Schuyler Heim Bridge Replacement Project and the Alameda Corridor Expressway Project to create a grade-separated expressway that will be a high-capacity alternate route between Terminal Island and Alameda Street/Pacific Coast Highway. This alternative involved replacement of the Schuyler Heim Bridge; construction of a limited-access expressway that begins at Ocean Boulevard, crosses the Cerritos Channel, and extends northward for a distance of approximately 1.7 miles (2.7 kilometers); and construction of the proposed 5,084-foot (1,550-meter) flyover (see Figure 2-1 within the EIS/EIR). However, Alternative 1 could not be completely funded at this time. As a consequence, only a portion of Alternative 1 (the construction of a replacement Schuyler Heim Bridge and demolition of the existing bridge) will be completed at this time by Caltrans. Complete implementation of the SR-47 Expressway portion of Alternative 1 may be constructed following the project, depending upon the availability of funding. The remaining SR-47 Expressway portion of Alternative 1 will obtain separate discretionary approvals, as necessary, prior to implementation.

The project is intended to provide a structurally sound vehicular connection between Terminal Island and the mainland that complies with the State of California's current bridge seismic design criteria. The Schuyler Heim Bridge was built by the United States Navy in 1946 per federal bridge design standards of that time. The existing bridge does not meet current seismic design criteria. In the event of a major earthquake, the bridge is projected to be severely damaged and non-operable. The project will conform to current seismic criteria by replacing the existing

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Schuyler Heim Bridge with a fixed-span bridge along and east of the existing bridge alignment. The project will also reconstruct the northerly and southerly approaches to the bridge and maintain connectivity to SR-103 and Ocean Boulevard. In addition, existing connections to Henry Ford Avenue and New Dock Street will be maintained.

This LSI evaluated the presence of possible contaminants that might exceed acceptable regulatory levels the Regional Water Quality Control Board (RWQCB) uses to determine the threat to groundwater from nonhalogenated hydrocarbons, the United States Environmental Protection Agency (EPA) Regional Screening Level for industrial properties (RSLi), California Human Health Screening Levels (CHHSLs) for commercial/industrial use (CHHSLi), and hazardous waste levels for disposal at landfills. The EPA Regional Screening Levels for residential properties (RSLr) are listed in the attached tables for reference. However, the RSLi were used to evaluate the presence of possible contaminants that might exceed acceptable regulatory levels.

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3. REGIONAL SITE GEOLOGY

Based on our review of the United States Geological Survey (USGS) Topographic Map, Long Beach, California 7.5 minute Quadrangle, dated 1964 and photo-revised in 1981, the properties on both sides of the site are relatively flat, and have an elevation of approximately 5 feet above mean sea level (MSL). The northern and southern bridge approaches are elevated to match the existing grade of the Schuyler Heim Bridge.

The project lies at the southern edge of the Los Angeles Basin within the Dominguez Gap. The site is underlain with approximately 20 to 40 feet of fill soils, believed to be derived from dredging operations in nearby channels or imported from similar sources. The soils consist of sandy clay and silty very fine sand. Dredge fill is underlain by approximately 70 feet of Quaternary-age silt and clay with interbedded layers of loose to medium dense, fine sand. These deposits overlie approximately 15,000 feet of Tertiary Age basin sedimentary deposits generally composed of dense to very dense sand and silty sand.

The project is located within the southern portion of the West Coast Groundwater basin which is bound on the north by the Ballona Escarpment, on the east by the Newport-Inglewood fault zone, on the south and west by the Pacific Ocean and consolidated rocks of the Palos Verdes Hills (DWR, 1999). Based on data from the California State Water Resources Control Board's (SWRCB) GeoTracker website database, depth to groundwater in the site vicinity ranges from approximately 5 to 17 feet bgs. Groundwater was encountered at the site at depths ranging from 3 to 21 feet bgs. Groundwater in the site vicinity is expected to flow towards the east. It should be noted that groundwater levels are influenced by seasonal variations in precipitation, irrigation, soil types, tidal influences, groundwater pumping, and other factors and are, therefore, subject to variation.

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Surface water runoff in the project area generally follows surface topography toward the south.

The following bodies of water are located within or adjacent to the project area: the Cerritos Channel bisects the project area, the Dominquez Channel is located approximately 900 feet north of the northern boundary of the project area, and the Pacific Ocean is located approximately 3 miles south of the southern boundary of the project area.

4. INVESTIGATION METHODS

On July 7, 9, and 12 through 16, 2010, Ninyo & Moore conducted boring mark out and a subsurface investigation in general accordance with the ACTA-approved LSI Work Plan dated July 9, 2010, except as noted in Section 1.2. The subsurface investigation included advancing 57 soil borings at 57 locations (Figures 2 through 7). The boreholes were advanced and sampled by CoreProbe International, Inc. (CoreProbe), of Rosemead, California, and StrongArm Environmental Field Services (StrongArm), of Norwalk, California using a hand-auger and slide hammer for the first 5 feet bgs, followed by hydraulic direct-push methods from 5 feet bgs to total depths of up to approximately 21 feet bgs. The following sections document the activities conducted prior to the fieldwork, field sampling, and laboratory analysis conducted during the investigation.

4.1. Work Plan and Health and Safety Plan

Ninyo & Moore previously prepared and submitted an LSI work plan which was approved by ACTA and California Department of Transportation (Caltrans) and was issued as a final document on July 9, 2010. As part of the scope of services for this LSI, Ninyo & Moore prepared and submitted a site-specific Health and Safety Plan to ACTA in the LSI work plan which was approved by ACTA and Caltrans. A copy of the Health and Safety Plan is included in Appendix B.

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4.2. Physical Conditions

At the time of the field investigation, the weather was generally clear and sunny with temperatures ranging from approximately 75 to 90 degrees Fahrenheit.

4.3. Utility Clearance

The boring locations were evaluated with regard to subsurface utilities by notification to USA. The boring locations were marked in white paint, and USA was notified at least 48 hours prior to conducting the soil sampling. USA marked the public utilities they were aware of that cross the site or were in the vicinity of the boring locations.

In addition, utility plans and utility pothole location maps were provided to Ninyo & Moore by ACTA to verify subsurface utilities not identified by USA.

4.4. Soil Boring Locations

Soil borings locations were selected by Ninyo & Moore and ACTA personnel prior to field mobilization. The boring locations were verified and adjusted in the field based on field conditions, access, and location of underground utilities.

The geographic coordinates of the soil borings were surveyed by GPS. The coordinates, provided in North American Datum (NAD) 1983, are provided in Appendix A. The boring locations are shown on Figures 2 through 7.

4.5. Soil Classification

Soils encountered in the borings consisted primarily of sand, silty sand, and sandy clay. The soil samples were visually logged and classified in general accordance with the Unified Soil Classification System (USCS). Logs of borings are presented in Appendix C.

4.6. Soil Sampling

Soil samples from direct-push boring locations were collected from immediately below the surface at 0, 5, 10, and 15 feet bgs or approximately 6 inches above first encountered groundwater. Soil samples from hand-auger boring locations were collected from 0, 1, 2, 3, and 5 feet bgs or approximately 6 inches above first encountered groundwater. Soil samples collected from 0 to 5.5 feet bgs were collected in stainless steel sleeves advanced using a slide-hammer. Soil samples collected at depth greater than 5.5 feet bgs were collected in acetate sleeves.

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Samples were collected using EPA Method 5035 sample preservation for volatile organic compoiunds (VOCs) and total petroleum hydrocarbons as gasoline (TPHg) analysis. These samples were collected directly from the undisturbed soil sample within the stainless steel or acetate sleeve. A plastic syringe was used to collect three samples of approximately 5 grams of soil from the sample sleeve. Two of the 5-gram soil samples were ejected into two pre-weighed, laboratory supplied, 40-milliliter (ml) volatile organic analysis (VOA) vials containing sodium bisulfate. The third 5-gram soil sample was ejected into one pre-weighed, laboratory supplied, 40-ml VOA vial containing methanol. A new syringe was used for each sampling interval. Field procedures from the LSI work plan are outlined in Appendix D.

Soil samples were capped with Teflon® sheets and PVC end caps, labeled, placed in zip-lock plastic bags, and placed in an ice chest cooled to approximately 4 degrees Celsius.

The samples were delivered to Advanced Technology Laboratories (ATL) of Signal Hill, California, a state-certified hazardous materials testing laboratory, for chemical analysis. Samples were transported under chemical of concern (COC) protocol to the laboratory the same day of collection with the exception of samples collected on July 12, 2010 which were

delivered the following day of collection due to laboratory sample receiving hours. The laboratory reports are included in Appendix E.

Prior to leaving the site, the boreholes were carefully backfilled with hydrated bentonite to prevent bridging and the ground surface was repaired to match the pre-existing surface conditions. Waste materials, such as drill cuttings generated by the sampling activities, were containerized in 16-gallon, Department of Transportation (DOT)-approved drums.

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4.7. Groundwater Sampling

Grab groundwater and channel water sampling and analytical results in accordance the LSI work plan are discussed in a draft LSI report under separate cover. The soil and water reports will be combined when the documents are finalized.

4.8. Sample Analyses

The soil samples collected from the site were analyzed for VOCs plus oxygenates, TPHg, total petroleum hydrocarbons as diesel (TPHd), total petroleum hydrocarbons as oil (TPHo), semi-volatile organic compounds (SVOCs), CAM 17 Metals, and pH in general accordance with EPA Methods 8260B/5035, 8015M/5035, 8015M, 8270C, 6010B/7471, and 9045, respectively. Additionally, the soil samples collected from soil boring DP24 near the transformers located beneath the bridge approach north of the Cerritos Channel were analyzed for polychlorinated biphenyls (PCBs) in general accordance with EPA Method 8082.

5. INVESTIGATION RESULTS

The following sections discuss the laboratory results presented in Tables 1 through 7.

5.1. Site Sample Analyses

A total of 177 soil samples were collected and analyzed from 57 borings locations. Of these 177 soil samples (including 15 duplicate samples), 149 samples were analyzed for TPHg, TPHd and TPHo, SVOCs, CAM 17 Metals, and pH in general accordance with EPA

Methods, 8015M/5035, 8015M, 8270C, 6010B/7471, and 9045, respectively. Eighty-three (including three duplicate samples) of the 177 soil samples were analyzed for VOCs plus oxygenates by EPA Method 8260B/5035. Twenty-eight of the 177 samples were analyzed for total lead by EPA Method 6010B.

Of the 177 soil samples analyzed for lead, 15 samples were analyzed for soluble lead in general accordance with the Waste Extraction Test (WET) method using both citric acid (WET-citric) and de-ionized (WET-DI) water as the extractant. The same 15 samples were also analyzed in accordance with the Toxicity Characteristic Leaching Procedure (TCLP).

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Three soil samples analyzed for chromium were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. [2 results pending]

One primary and one duplicate soil sample were analyzed for PCBs by EPA Method 8082.

TPH, as reported by the analytical laboratory, are divided into carbon chain ranges. The following is a list of carbon chain ranges (e.g., C_4-C_{12}) reported by the laboratory and common substances typically found within those ranges:

- C_4-C_{12} (Gasoline; Mineral Spirits; Stoddard Solvent) TPHg
- C_{13}-C_{22} (Diesel Fuel; Brake Fluid; Transmission Fluid) TPHd
- C_{23}-C_{32} (Motor Oil; Hydraulic Oil; Brake Fluid; Transmission Fluid) TPHo

Analytical results are shown on Tables 1 through 7. A discussion of the investigative results in this LSI is as follows.

5.2. Analytical Results

5.2.1. Organic Compounds

A total of 83 soil samples (including three duplicate samples) were collected from 54 boring locations and analyzed for VOCs. Detectable concentrations of VOCs were not reported in the samples analyzed at the site, with the exception of chloromethane in the duplicate sample collected from boring D23 at 5 feet bgs.

A total of 149 soil samples (including 15 duplicate samples) were collected from 57 borings locations and analyzed for TPHg, TPHd and TPHo, SVOCs, CAM 17 metals, and pH. Detectable concentrations of TPHg (C_4-C_{12}) were not reported in the 149 samples analyzed. Concentrations of TPHd (C_{13}-C_{22}) ranged from less than 1 to 5,600 milligrams per kilogram (mg/kg). Fifty-one soil samples collected from 33 soil boring locations exceeded the maximum soil screening levels (MSSL) of 100 mg/kg of TPHd (C_{13}-C_{22}) for soils less than 20 feet above groundwater. Concentrations of TPHo (C_{23}-C_{32}) ranged from less than 1 13,000 mg/kg. Thirty-five soil samples collected from 27 soil boring locations exceeded the MSSL of 1,000 mg/kg of TPHo (C_{23}-C_{32}) for soil less than 20 feet above groundwater. Groundwater throughout the site was generally encountered at depths less than 20 feet bgs.

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Detectable concentrations of SVOCs were reported in four of the 148 samples analyzed. Concentrations of benzo(a)anthracene ranged from 420 to 17,000 micrograms per kilogram (µg/kg). None of the samples exceeded the RSLi for benzo(a)anthracene of 21,000 µg/kg. Concentrations of benzo(a)pyrene ranged from 460 to 29,000 µg/kg. The four samples (DP20-1, DP33-8, HA13-0, and HA15-0) exceeded both the CHHSLi of 130 µg/kg and the RSLi of 210 µg/kg for benzo(a)pyrene. Concentrations of benzo(b)fluoranthene ranged from 650 to 41,000 µg/kg. One sample (DP33-8) exceeded the RSLi for benzo(b)fluoranthene of 2,100 µg/kg. Concentrations of benzo(g,h,i)perylene ranged from less than 330 to 21,000 µg/kg. Neither a CHHSLi nor a RSLi has been established for benzo(g,h,i)perylene. Concentrations of benzo(k)fluoranthene ranged from less than 330 to 12,000 µg/kg. None of the samples exceeded the RSLi for benzo(k)fluoranthene of 21,000 µg/kg. Concentrations of chrysene ranged from 480 µg/kg to 21,000 µg/kg. None of the samples exceeded the RSLi for chrysene of 210,000 µg/kg. Concentration of dibenz(a,h)anthracene was reported in one sample (DP33-8) at 5,900 µg/kg which exceeds the RSLi of 210 µg/kg. Concentrations of fluoranthene ranged from 390 to 12,000 µg/kg. None of the samples exceeded the RSLi for fluoranthene of 22,000 µg/kg. Concentrations of indeno(1,2,3-cd)pyrene ranged from less than 330 to 17,000 µg/kg. One sample (DP33-8) exceeded the RSLi

for indeno(1,2,3-cd)pyrene of 2,100 µg/kg. Concentration of phenanthrene was reported in one sample (HA13-0) at 610 µg/kg. Concentrations of pryrene ranged from 440 to 14,000 µg/kg. Neither a CHHSLi nor RSLi have been established for phenanthrene or pyrene.

One primary and one duplicate soil sample were collected from one boring location and analyzed for PCBs. Detectable concentrations of PCBs were not reported either of the two samples analyzed.

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5.2.2. CAM 17 Metals

Detectable concentrations of CAM 17 Metals above their respective CHHSLi or RSLi were not reported for the CAM 17 analytes, with the exception of arsenic, cadmium, and lead. Concentrations of arsenic ranged from less than 1 to 19 mg/kg. Arsenic concentrations in 125 of the 148 samples analyzed exceeded the CHHSLi for arsenic of 0.24 mg/kg. Arsenic concentrations in 121 of the 148 samples analyzed exceeded the RSLi for arsenic of 1.6 mg/kg. However, only one sample, DP24-2.5 with a reported concentration of 19 mg/kg exceeded the DTSC upper bound limit for arsenic of 12 mg/kg which is considered acceptable by the DTSC for school sites. Concentrations of cadmium ranged from less than 1 mg/kg to 7.8 mg/kg. One sample, DP23-20 with a reported concentration of 7.8 mg/kg exceeded the CHHSLi for cadmium of 7.5 mg/kg. However, this sample was several orders of magnitude below the RSLi for cadmium of 800 mg/kg. Concentrations of lead ranged from 1.5 mg/kg to 610 mg/kg. Two samples, DP8-0 with a reported concentration of 360 mg/kg and DP23-20 with a reported concentration of 610 mg/kg, exceeded the CHHSLi of 320 mg/kg. However, none of the samples analyzed exceeded the RSLi for lead of 800 mg/kg.

Additionally 28 of the 177 samples were analyzed for total lead. Concentrations of lead ranged from less than 5 to 65 mg/kg. None of the samples analyzed for total lead exceeded either the CHHSLi for lead of 320 or the RSLi for lead of 800 mg/kg.

Concentrations of lead ten times above the STLC were reported in 13 of the 177 samples analyzed. The 13 samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant. Eight soil samples, DP3-0, DP3-20, DP4-0, DP6-6.5, DP8-0, DP23-20, HA7-0 and HA7-1, contained greater than or equal to 5.0 milligrams per liter (mg/l) soluble lead using citric acid as the extractant, which exceeds the STLC that defines California hazardous waste (Title 22 CCR, Section 66261.24). The 13 samples were analyzed using the TCLP. None of the samples analyzed contained soluble lead concentrations in excess of 5 mg/l so would not be classified as an RCRA regulated hazardous wastte.

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The eight samples that exceeded the STLC for California hazardous waste were analyzed for soluble lead in general accordance with the WET method using de-ionized (DI) water as the extractant. Reported concentrations in the eight samples were below the Caltrans DTSC variance for lead of 1.5 mg/l. In addition, pH levels for each of the samples were above 5.5. Therefore, soil from these locations that are within the Caltrans ROW would be classified as Y1 soil and the Caltrans variance applies.

Additionally, seven randomly selected soil samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant and TCLP. Four of the seven soil samples were analyzed for soluble lead in general accordance with the WET method using DI water as the extractant. None of the samples had reported concentrations soluble lead equal to or above the STLC of 5 mg/l, the TCLP of 5 mg/l or the STLC-DI of 1.5 mg/l.

Three samples analyzed for chromium were reported at concentrations ten times above the STLC. The three samples, DP15-20, DP23-20, and DP25-0, were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. Detectable concentrations of soluble chromium using citric acid as the extractant were not reported in sample DP23-20. Analytical results for samples DP15-20 and DP25-0 are pending.

A total of 148 soil samples (including 15 duplicate samples) were collected from 57 boring locations and analyzed for pH. pH in the 83 soil samples analyzed north of the Cerritos Channel ranged from 7.2 to 11. pH in the 65 soil samples analyzed south of the Cerritos Channel ranged from 7.1 to 11.

5.3. Quality Assurance/Quality Control (QA/QC)

QA/QC procedures were performed in general accordance with the LSI work plan. Field QA/QC procedures included decontamination of field sampling equipment as described in Appendix D and collection of equipment blanks. In order to reduce the likelihood of cross-contamination, sampling equipment was decontaminated between borings. Equipment was washed in a solution of non-phosphate detergent, rinsed in clear water, rinsed in distilled water, and dried. To evaluate the effectiveness of the decontamination procedures, one equipment rinsate blank was collected at a rate of one per day per sampling method. Equipment blanks were obtained by passing water through or over the decontaminated sampling devices. Detectable concentrations of analytes were not reported in the equipment blanks.

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Trip blanks were prepared by ATL and shipped with the soil samples. The trip blanks were analyzed for VOCs. Detectable concentrations of VOCs were not reported in the trip blanks.

The equipment and trip blank results will be presented in the tables in the water LSI.

In addition, duplicate samples were collected in the field and submitted to the laboratory for analysis. The LSI work plan specified that field duplicate samples would be collected at the rate of approximately 10 percent of the sample set. Fifteen duplicate soil samples were collected for the 162 primary samples collected. The duplicate samples were analyzed for the same constituents for which the primary samples were analyzed. Relative percent differences in analytical results reported between the primary sample and its duplicate are due to sample heterogeneity and is not anticipated to affect data quality or the results of the sampling. The duplicate sample results are considered acceptable.

Soil samples were delivered to ATL within 24 hours of collection, and analyses were performed within respective method holding times. ATL conducted laboratory QA/QC in general accordance with the LSI work plan. QA/QC procedures included analyzing method blanks and spiked samples. ATL also conducted the following QA/QC with respect to EPA Method 8260: a Continuing Calibration Verification (CCV) and 4-bromofluorobenzene (BFB) Tune Check were performed at least every 12-hour shift. This CCV is an indicator whether or not the Initial Calibration Curve (ICC) is still valid. Whenever the CCV did not pass all method criteria and/or performance of significant instrument maintenance, a new ICC was run.

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5.4. Decontamination and Disposal

Sampling equipment was decontaminated between each sample collected as specified in the LSI work plan. Sampling equipment was decontaminated prior to initiation of each boring. Equipment was washed in a solution of non-phosphate detergent and clear water, rinsed in clear water and rinsed again in distilled water, and air-dried. Decontamination water and soil cuttings generated during the LSI were collected four 16-gallon DOT-approved metal drums and stored within locked gates in the Port of Long Beach (POLB) easement located beneath the bridge approach north of the Cerritos Channel (Pier A). The decontamination water and soil cuttings are pending disposal to a licensed soil recycling facility. Based on the analytical results soil cuttings are expected to be classified as California hazardous waste.

6. DATA EVALUATION AND DISCUSSION

The LSI included advancing soil borings and collecting samples at the site to assess whether impacted soil was present due to current and historical land uses and to evaluate health and safety concerns and waste management options for future project construction work.

A total of 149 soil samples were collected from the areas of concern at the site and selectively analyzed for VOCs, TPH, SVOCs, CAM 17 Metals, PCBs, and pH. An additional 28 soil samples were analyzed for total lead.

A total of 83 soil samples (including three duplicate samples) from 54 borings were collected and analyzed for VOCs. A total of 149 soil samples (including 15 duplicate samples) were collected from 57 borings and analyzed for TPHg, TPHd and TPHo, SVOCs, CAM 17 Metals, and pH. An additional 28 samples were analyzed for total lead. One primary and one duplicate soil sample from one boring location was analyzed for PCBs. Results are discussed below.

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6.1. VOCs

Detectable concentrations of VOCs were not reported in the samples analyzed for the site, with the exception of chloromethane in the duplicate sample collected from boring DP23 at 5 feet bgs.

6.2. TPH

Detectable concentrations of TPHg (C4-C_{12}) were not reported in the samples analyzed.

Concentrations of TPHd (C_{13}-C_{22}) above the MSSL of 100 mg/kg for soils less than 20 feet above groundwater were reported in 51 samples collected from 33 borings at the site. Concentrations above the MSSL were detected primarily at the surface (0-6 inches bgs). In addition to TPHd concentrations detected in the surface sample TPHd concentrations were reported at depths ranging from 2.5 to 14.5 feet bgs in borings: DP10 (3.5 feet bgs), DP14 (3.5 feet bgs), DP17 (10 feet bgs), DP23 (5 feet bgs), DP30 (15 feet bgs), DP35 (10 and 14.5 feet bgs), DP36 (5 feet bgs), DP40 (4.5 feet bgs), HA15 (5 feet bgs), and HA17 (2 feet bgs). Concentrations of TPHd in these ten boring locations ranged from 170 to 5,600 mg/kg. Seven of the ten borings are located north of the Cerritos Channel and all were located either on State Route 47 or Pier A Plaza with the exception of DP36 which was located adjacent to an asphalt road leading out of the POLB, Pier A easement onto Pier A Plaza. The highest concentration of 5,600 mg/kg was reported for DP17 at 10 feet bgs. Three borings were located beneath the bridge approach north of New Dock Street and south of the Cerritos Channel. Concentrations of TPHd in these three borings ranged from 150 to 320 mg/kg.

Concentrations of TPHo (C_{23}-C_{32}) above the MSSL of 1,000 mg/kg for soils less than 20 feet above groundwater were reported in 35 samples collected from 27 soil borings at the site. Concentrations above the MSSL were detected primarily at the surface (0-6 inches bgs) or directly below asphalt or concrete cover. In addition to TPHo concentrations detected in the surface sample, TPHo concentrations were reported at depths ranging from 1.5 to 14.5 feet bgs in borings: DP17 (10 feet bgs), DP23 (5 feet bgs), DP35 (10 and 14.5 feet bgs), HA5 (1.5 feet bgs), and HA17 (2 feet bgs). Concentrations of TPHo in these five boring locations ranged from 1,300 to 13,000 mg/kg. The five borings are located either directly on SR-47 or the associated on and off ramps with the exception of HA5 which is located on the northbound Ocean Avenue on ramp. The highest concentration of 13,000 mg/kg was reported for DP17 at 10 feet bgs.

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6.3. SVOCs

Detectable concentrations of SVOCs were reported in samples DP20-1, DP33-8, HA13-0, and HA15-0. The four borings were located north of the Cerritos Channel along SR-47. The four samples exceeded both the CHHSLi and RSLi of 130 and 210 µg/kg, respectively for benzo(a)pyrene. Sample DP33-8 had reported concentrations of benzo(a)anthracene (17,000 µ/kg), benzo(b)fluoranthene (41,000 µg/kg), dibenz(a,h)anthracene (5,900 µg/kg), and indeno(1,2,3,cd)pyrene (17,000 µg/kg) that exceeded their respective RSLi.

The four samples had reported concentrations of pyrene ranging from 440 to 14,000 µg/kg. One sample, HA13-0 had a reported concentration of 610 µg/kg of phenanthrene. Three samples DP20-1, DP33-8, and HA15-0 had reported concentrations of benzo(g,h,i)perylene ranging from 380 to 41,000 µg/kg. None of these three analytes have an established CHHSLi or RSLi.

6.4. CAM 17 Metals

Detectable concentrations cof CAM 17 Metals above their respective CHHSLi or RSLi were not reported for the CAM 17 analytes, with the exception of arsenic, cadmium, and lead. Concentrations of arsenic ranged from less than 1 to 19 mg/kg. Arsenic concentrations in

125 of the 148 samples analyzed exceeded the CHHSLi and 121 exceeded the RSLi. However, arsenic is a naturally occurring substance, which concentrations should be compared to background concentrations. The "Determination of a Southern California Regional Background Arsenic Concentration in Soil" published by the DTSC, describes an upper bound estimate of 12 mg/kg in southern California in native soils. Arsenic concentrations in one sample, DP24-2.5 (19 mg/kg) exceed this upper bound estimate of 12 mg/kg. The other samples are considered within background.

One sample, DP23-20 with a reported concentration of 7.8 mg/kg of cadmium,exceeded the CHHSLi of 7.5 mg/kg. However, this sample was several orders of magnitude below the RSLi for cadmium of 800 mg/kg.

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Two samples, DP8-0 and DP23-20 had lead concentrations above the CHHSLi of 320 mg/kg but were below the RSLi of 800 mg/kg. Sample DP8-0 is located beneath the bridge approach south of the Cerritos Channel adjacent to ACTA railroad tracks. Soil sample collected from this same boring at 2.5 feet bgs had lead concentrations of 16 mg/kg, well below the CHHSLi. Sample DP23-20 is located on SR-47 north of the Cerritos Channel and is a duplicate of primary sample DP23-5. The primary soil sample and soil samples collected from this same boring at the surface and at 10 feet bgs had lead concentrations well below the CHHSLi of 320 mg/kg.

Thirteen soil samples analyzed for lead had reported concentrations ten times above the STLC. The samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant. Eight soil samples, DP3-0, DP3-20, DP4-0, DP6-6.5, DP8-0, DP23-20, HA7-0, and HA7-1, contained greater than or equal to 5.0 mg/l soluble lead which exceeds the STLC. The thirteen samples were analyzed for soluble lead using the TCLP. None of the samples contained soluble lead in excess of 5 mg/l, so would not be classified as a RCRA hazardous waste. Soil from borings DP3, DP4, DP6, DP8, DP23, and HA7 if excavated would be considered California hazardous waste.

The eight samples exceeding the STLC using citric acid as the extractant were analyzed for soluble lead in general accordance with the WET method using DI water as the extractant. The reported concentrations in the eight samples were below the DTSC issued Caltrans variance for lead of 1.5 mg/l. Additionally pH levels for each of the eight samples were above 5.5. The eight samples are located along Caltrans ROW with the exception of samples collected from borings DP8 and DP6 which are located on POLB property south of New Dock Street. Soil from the Caltrans ROW locations could be classified as Y1 soil if the Caltrans DTSC variance applies.

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Additionally, seven randomly selected soil samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant and TCLP. Four of the seven soil samples were analyzed for soluble lead in general accordance with the WET method using DI water as the extractant. None of the samples had reported concentrations soluble lead equal to or above the STLC of 5 mg/L, the TCLP of 5 mg/l or the STLC-DI.

Chromium was detected in three samples at concentrations greater than or equal to the STLC for chromium of 5 mg/l (50 mg/kg). The three samples, DP15-20 (70 mg/kg), DP23-20 (100 mg/kg), and DP25-0 (60 mg/kg), were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. Detectable concentrations of soluble chromium were not reported in sample DP23-20. Therefore soil from boring DP23 is considered non-hazardous with respect to chromium. Analytical results for samples DP15-20 and DP25-0 are still pending.

6.5. pH

One-hundred forty-eight soil samples (including 15 duplicate samples) were collected from 56 boring locations and analyzed for pH. pH in the 83 soil samples analyzed north of the Cerritos Channel ranged from 7.2 to 11. pH in the 65 soil samples analyzed south of the Cerritos Channel ranged from 7.1 to 11 pH. pH levels at the project area range from 7.1 to 11.

6.6. PCBs

One primary sample and one duplicate soil sample were collected and analyzed for PCBs from boring DP-24 due to its close proximity to a bank of transformers. Detectable concentrations of PCBs were not reported either of the two samples analyzed.

6.7. Statistical Evaluation for Lead

Because of the site sampling, no obvious sample groups can be identified. Samples were collected from embankments shoulders, medians, beneath the existing bridge, etc., and the ADL depositional history will be different in each area. Additionally, it is not possible to correlate vertical layers between these different sampling areas. For those reasons statistal analyses of the data were not performed.

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Soil from the following locations is considered hazardous but can be reused in accordance with the Variance. Thee areas had samples containing soluble lead concentrations greater than or equal to 5 mg/l as analyzed using the WET method using citric acid as the extractant, but containing soluble lead concentrations less than 1.5 mg/l as analyzed using the WET method using deionized water as the extractant.

- Boring DP3 at surface which is associated with retaining wall C1 at the New Dock Street on ramp.
- Boring DP4 at surface which is associated with the New Dock Street off ramp.
- Boring DP6 at 6.5 feet which is associated with the northbound SR-47 between stations 5+00 and 6+00.
- Boring DP8 at surface which is associated with SR-47 between stations 9+00 and 10+00.
- Boring DP23 at 20 feet which is associated with the MSE wall E2.
- Boring HA7 at surface and 1 foot which is associated with retaining wall C1.

Soil disturbed in these areas is considered Type Y1 soil and may be used as fill in the Caltrans ROW provided the soil is placed a minimum of 5 feet above the maximum level of the water table and covered with at least 1 foot of non-hazardous soil.

7. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This LSI evaluated the presence of possible contaminants that might exceed acceptable regulatory levels the RWQCB uses to determine the threat to groundwater from nonhalogenated hydrocarbons, the EPA RSLi, CHHSLi, and hazardous waste levels for disposal at landfills. Findings and conclusions follow:

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7.1. Findings and Conclusions

- Depth to groundwater was approximately 3 to 4 feet bgs at level ground adjacent to the northern and southern bridge approaches and approximately 5.5 to 20 feet bgs along SR-47 north of the Cerritos Channel.

- A total of 177 soil samples were collected and analyzed from 57 borings. Of these 177 soil samples (including 15 duplicate samples), 149 samples were analyzed for total petroleum hydrocarbons as gasoline (TPHg), total petroleum hydrocarbons as diesel and oil (TPHd) and total petroleum hydrocarbons as oil (TPHo), semi-volatile organic compounds (SVOCs), CAM 17 Metals, and pH in general accordance with EPA Methods, 8015M/5035, 8015M, 8270C, 6010B/7471, and 9045, respectively. Eighty-three (including three duplicate samples) of the 177 soil samples were analyzed for volatile organic compounds (VOCs) plus oxygenates by EPA Method 8260B/5035. Twenty-eight of the 177 samples were analyzed for total lead by EPA Method 6010B.

- Detectable concentrations of VOCs were not reported in the samples analyzed at the site, with the exception of chloromethane in the duplicate sample collected from boring D23 at 5 feet bgs.

- Of the 177 soil samples analyzed for lead, 15 samples were analyzed for soluble lead in general accordance with the Waste Extraction Test (WET) method using both citric acid and de-ionized (DI) water as the extractant. The same 15 samples were also analyzed in accordance with the Toxicity Characteristic Leaching Procedure (TCLP).

- Three soil samples analyzed for chromium were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. [2 results pending]

- One primary and one duplicate soil sample were collected from boring DP24 due to its close proximity to a bank of transformers and analyzed for polychlorinated biphenyls (PCBs) by EPA Method 8082. Detectable concentrations of PCBs were not reported either of the two samples analyzed

- Detectable concentrations of TPHg (C_4-C_{12}) were not reported in the samples analyzed. Concentrations above the maximum soil screening levels (MSSL) of 100 milligrams per kilogram (mg/kg) of TPHd (C_{13}-C_{22}) for soils less than 20 feet above groundwater were reported in 51 samples collected from 33 borings at the site. Concentrations above the MSSL were detected primarily at the surface (0-6 inches bgs). In addition to TPHd concentrations detected in the surface samples, TPHd concentrations were reported at depths ranging from 2.5 to 14.5 feet bgs in ten borings ranging from 170 to 5,600 mg/kg. Seven of the ten borings are located north of the Cerritos Channel and all were located either on State Route 47 or Pier A Plaza with the exception of DP36 which was located immediately adjacent to an asphalt road leading out of the Port of Long Beach (POLB), Pier A easement onto Pier A Plaza. The highest concentration of 5,600 mg/kg was reported from boring DP17 at 10 feet bgs. Three borings were located beneath the bridge approach north of New Dock Street and south of the Cerritos Channel. Concentrations of TPHd in these three borings ranged from 150 to 320 mg/kg.

- Concentrations above the MSSL of 1,000 mg/kg of TPHo (C_{23}-C_{32}) for soils less than 20 feet above groundwater were reported in 35 samples collected from 27 soil borings atthe site. Concentrations above the MSSL were detected primarily at the surface (0-6 inches bgs) or directly below asphalt or concrete cover. In addition to TPHo concentrations detected in the surface samples, TPHo concentrations were reported at depths ranging from 1.5 to 14.5 feet bgs in five borings ranging from 1,300 to 13,000 mg/kg. The five borings are either directly on SR-47 or the associated on and off ramps with the exception of boring HA5 which is located on the northbound Ocean Avenue on ramp. The highest concentration of 13,000 mg/kg was reported from boring DP17 at 10 feet bgs.

- Detectable concentrations of SVOCs were reported in samples DP20-1, DP33-8, HA13-0, and HA15-0. The four samples exceeded both the CHHSLi and RSLi of 130 and 210 micrograms per kilogram (µg/kg), respectively, for benzo(a)pyrene. Sample DP33-8 had reported concentrations of benzo(a)anthracene (17,000 µ/kg), benzo(b)fluoranthene (41,000 µg/kg), dibenz(a,h)anthracene (5,900 µg/kg), and indeno(1,2,3,cd)pyrene (17,000 µg/kg) that exceeded their respective RSLi. The four samples had reported concentrations of pyrene ranging from 440 to 14,000 µg/kg. One sample, HA13-0, had a reported concentration of 610 µg/kg of phenanthrene. Three samples DP20-1, DP33-8, and HA15-0 had reported concentrations of benzo(g,h,i)perylene ranging from 380 to 41,000 µg/kg. None of these three analytes have an established CHHSLi or RSLi. The four borings were located north of the Cerritos Channel along SR-47.

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- Detectable concentrations of CAM 17 Metals above their respective CHHSLi or RSLi were not reported for the CAM 17 analytes, with the exception of arsenic, cadmium, and lead. Concentrations of arsenic ranged from less than 1 to 19 mg/kg. Arsenic concentrations in 125 of the 148 samples analyzed exceeded the CHHSLi and 121 exceeded the RSLi. However, the Department of Toxic Substance Control (DTSC) provides an upper bound estimate of 12 mg/kg in southern California native soils. Arsenic concentrations in one sample, DP24-2.5 (19 mg/kg) exceeded this upper bound estimate of 12 mg/kg. The other samples are considered within background. One sample, DP23-20, with a reported concentration of 7.8 mg/kg of cadmium exceeded the CHHSLi of 7.5 mg/kg. However, this sample was several orders of magnitude below the RSLi for cadmium of 800 mg/kg.

- Two samples, DP8-0 and DP23-20, had lead concentrations above the CHHSLi of 320 mg/kg but were below the RSLi of 800 mg/kg. Sample DP8-0 is located beneath the bridge approach south of the Cerritos Channel adjacent to ACTA railroad tracks. Soil collected from this same boring at 2.5 feet bgs had lead concentrations of 16 mg/kg, well below the CHHSLi. Sample DP23-20 is located on SR-47 north of the Cerritos Channel and is a duplicate of primary sample DP23-5. The primary soil sample and soil samples collected from this same boring at the surface and at 10 feet bgs had lead concentrations well below the CHHSLi of 320 mg/kg.

- Thirteen soil samples analyzed for lead had reported concentrations ten times above the soluble threshold limit concentration (STLC). The samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant. Eight soil samples, DP3-0, DP3-20, DP4-0, DP6-6.5, DP8-0, DP23-20, HA7-0, and HA7-1, contained greater than or equal to 5.0 mg/l soluble leads, which exceeds the STLC. The thirteen samples were analyzed using the toxicity characteristic leaching procedure (TCLP). None of the samples contained soluble lead concentration in excess of 5 mg/l so would not be considered Resource Conservation and Recovery Act (RCRA) hazardous waste. Soil from borings DP3, DP4, DP6, DP8, DP23, and HA7 if excavated would be considered California regulated hazardous waste.

- The eight samples exceeding the STLC using citric acid as the extractant were analyzed for soluble lead in general accordance with the WET method using deionized (DI) water as the extractant. The reported concentrations in the eight samples were below the DTSC issued California Department of Transportation (Caltrans) DTSC variance for lead of 1.5 mg/l. Additionally pH levels for the eight samples were above 5.5. The eight samples are located along Caltrans ROW with the exception of samples collected from borings DP8 and DP6 which are located on POLB property south of New Dock Street. Soil from the Caltrans ROW is classified as Y1 soil and the Caltrans DTSC variance applies.

- Additionally, seven randomly selected soil samples were analyzed for soluble lead in general accordance with the WET method using citric acid as the extractant and TCLP.

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Four of the seven soil samples were analyzed for soluble lead in general accordance with the WET method using DI water as the extractant. None of the samples had reported concentrations soluble lead equal to or above the STLC of 5 mg/l, the TCLP of 5 mg/l or the STLC-DI of 1.5 mg/l.

- Chromium was detected in three samples at concentrations greater than or equal to ten times the STLC for chromium of 5 mg/l. The three samples, DP15-20 (70 mg/kg), DP23-20 (100 mg/kg), and DP25-0 (60 mg/kg), were analyzed for soluble chromium in general accordance with the WET method using citric acid as the extractant. Detectable concentrations of soluble chromium were not reported in sample DP23-20. Therefore soil from boring DP23 is considered non-hazardous with respect to chromium. Analytical results for samples DP15-20 and DP25-0 are still pending.

- One-hundred forty-eight soil samples (including 15 duplicate samples) were collected from 56 boring locations and analyzed for pH. pH levels in the 83 soil samples analyzed north of the Cerritos Channel ranged from 7.2 to 11. pH levels in the 65 soil samples analyzed south of the Cerritos Channel ranged from 7.1 to 11 pH. pH levels at the project area range from 7.1 to 11 pH.

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7.2. Recommendations

Based on the results of this LSI, Ninyo & Moore provides the following recommendations:

- Soil from borings DP3, DP4, DP6, DP8, DP23, and HA7 is considered California regulated hazardous waste due to its concentration of soluble lead and should be disposed of accordingly. Based on the STLC WET-citric, STLC WET-DI, TCLP, and pH analytical results, soil from the boring locations within the Caltrans ROW could be on the Caltrans ROW in accordance with the DTSC issued Caltrans lead variance. However, based on restrictions applied by the POLB, the soil may need to be removed.

- Soil at the site that is impacted with TPHs above the MSSLs should be removed and disposed as a petroleum contaminated non-hazardous waste.

- Soil in the vicinity of boring D24 at 2.5 feet contains elevated arsenic and should be removed as a non-hazardous waste.

- Personnel performing subsurface work, including geotechnical investigations, utility installations, or other construction, should be provided with the analytical data from this LSI so that they can be used in developing an applicable health and safety program. The personnel should be notified that elevated concentrations of lead may be present in on-site soil.

8. LIMITATIONS AND EXCEPTIONS OF ASSESSMENT

The environmental services described in this report have been conducted in general accordance with current regulatory guidelines and the standard-of-care exercised by environmental consultants performing similar work in the project area. Please note that this study did not include an evaluation of geotechnical conditions or potential geologic hazards.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires any additional information or has questions regarding the content, interpretations presented, or completeness of this document.

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Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions and the referenced literature. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

TABLE 1 - SOIL SAMPLE ANALYTICAL TEST RESULTS - VOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8260B (mg/kg)																												
			1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloroprop	1,2-Dibromoethane	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane	1,4-Dichlorobenzene	2,2-Dichloropropane	2-Chlorotoluene	4-Chlorotoluene	4-Isopropyltoluene	Benzene	Bromobenzene	Bromodichloromethane	Bromoform	Bromomethane
DP2-5	5	7/14/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 11	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4
DP2-10	10	7/14/2010	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 10	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2
DP2-15	15	7/14/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 9.3	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7
DP3-5	5	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP3-10	10	7/13/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 9.6	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8
DP3-15	15	7/13/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP4-5	5	7/13/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP4-10	10	7/13/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP4-15	15	7/13/2010	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 9.8	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9
DP5-5	5	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP5-10	10	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP5-15	15	7/13/2010	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 8.7	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3
DP6-6.5	6.5	7/15/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 7.7	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9
DP7-4.5	4.5	7/15/2010	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 5.2	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6
DP8-2.5	2.5	7/15/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 8.3	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1
DP9-2.5	2.5	7/15/2010	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 6.2	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1
DP10-3.5	3.5	7/14/2010	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 10	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2
DP11-2	2	7/13/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 7.8	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9
DP12-2.5	2.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP13-2	2	7/13/2010	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 7.6	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8
DP14-3.5	3.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP15-5	5	7/16/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.4	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP15-6.5	6.5	7/16/2010	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 16	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2
DP16-5	5	7/13/2010	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 12	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1
DP16-6.5	6.5	7/13/2010	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 8.1	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4
DP17-5	5	7/12/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 11	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4
DP17-10	10	7/12/2010	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 5.1	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5
DP17-15	15	7/12/2010	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 13	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6
DP19-5	5	7/15/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP20-1	1	7/15/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.1	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP22-3	3	7/16/2010	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 11	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3
DP23-5	5	7/16/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 11	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9.1	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP23-10	10	7/16/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP23-15	15	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP23-17	17	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9.1	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP24-2.5	2.5	7/12/2010	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 6.5	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2
DP25-2	2	7/12/2010	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 7.1	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6
DP26-4.5	4.5	7/12/2010	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 8.6	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3
DP27-2	2	7/16/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 9.4	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7
DP27-20 (Duplicate of DP27-2)	2	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 8.9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP28-2.5	2.5	7/12/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 8.2	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1
DP29-5	5	7/12/2010	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 6.7	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4
DP30-5	5	7/12/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.4	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP30-10	10	7/12/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.3	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP30-15	15	7/12/2010	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 8	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4
DP31-5	5	7/15/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 8.2	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1
DP31-10	10	7/15/2010	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 15	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5
DP31-15	15	7/15/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP32-5	5	7/15/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 7.8	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9
DP32-13.5	13.5	7/15/2010	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 36	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18
DP33-5	5	7/15/2010	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 6.9	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5
DP33-8	8	7/15/2010	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 12	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9

Notes:
mg/kg – milligrams per kilogram
EPA – United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
PQL - Practical Quantitation Limit
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 1 - SOIL SAMPLE ANALYTICAL TEST RESULTS - VOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8260B (mg/kg)																										
			Carbon_tetrachloride	Chlorobenzene	Chloroethane	Chloroform	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromochloromethane	Dibromomethane	Dichlorodifluoromethane	Di-isopropyl_ether	Ethyl_Tert-butyl_ether	Ethylbenzene	Hexachlorobutadiene	Isopropylbenzene	m,p-Xylene	Methylene_chloride	MTBE	Naphthalene	n-Butylbenzene	n-Propylbenzene	o-Xylene	sec-Butylbenzene	Styrene	Tert-amyl_methyl_ether	Tert-Butanol	tert-Butylbenzene
DP2-5	5	7/14/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 11	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 110	ND< 5.4
DP2-10	10	7/14/2010	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 10	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 100	ND< 5.2
DP2-15	15	7/14/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 9.3	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 93	ND< 4.7
DP3-5	5	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 100	ND< 5.1
DP3-10	10	7/13/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 9.6	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 96	ND< 4.8
DP3-15	15	7/13/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 92	ND< 4.6
DP4-5	5	7/13/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 110	ND< 5.6
DP4-10	10	7/13/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 110	ND< 5.6
DP4-15	15	7/13/2010	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 9.8	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 98	ND< 4.9
DP5-5	5	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 100	ND< 5.1
DP5-10	10	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 100	ND< 5.1
DP5-15	15	7/13/2010	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 8.7	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 87	ND< 4.3
DP6-6.5	6.5	7/15/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 7.7	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 77	ND< 3.9
DP7-4.5	4.5	7/15/2010	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 5.2	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 52	ND< 2.6
DP8-2.5	2.5	7/15/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 8.3	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 83	ND< 4.1
DP9-2.5	2.5	7/15/2010	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 6.2	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 62	ND< 3.1
DP10-3.5	3.5	7/14/2010	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 10	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 100	ND< 5.2
DP11-2	2	7/13/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 7.8	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 78	ND< 3.9
DP12-2.5	2.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 100	ND< 5
DP13-2	2	7/13/2010	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 7.6	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 76	ND< 3.8
DP14-3.5	3.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 100	ND< 5
DP15-5	5	7/16/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.4	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 84	ND< 4.2
DP15-6.5	6.5	7/16/2010	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 16	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 160	ND< 8.2
DP16-5	5	7/13/2010	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 12	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 120	ND< 6.1
DP16-6.5	6.5	7/13/2010	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 8.1	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 81	ND< 4
DP17-5	5	7/12/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 11	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 110	ND< 5.4
DP17-10	10	7/12/2010	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 5.1	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 51	ND< 2.5
DP17-15	15	7/12/2010	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 13	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 130	ND< 6.6
DP19-5	5	7/15/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 100	ND< 5.1
DP20-1	1	7/15/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.1	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 91	ND< 4.6
DP22-3	3	7/16/2010	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 11	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 110	ND< 5.3
DP23-5	5	7/16/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 11	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 110	ND< 5.4
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9.1	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 91	ND< 4.5
DP23-10	10	7/16/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 92	ND< 4.6
DP23-15	15	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 90	ND< 4.5
DP23-17	17	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9.1	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 91	ND< 4.5
DP24-2.5	2.5	7/12/2010	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 6.5	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 65	ND< 3.2
DP25-2	2	7/12/2010	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 7.1	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 71	ND< 3.6
DP26-4.5	4.5	7/12/2010	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 8.6	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 86	ND< 4.3
DP27-2	2	7/16/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 9.4	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 94	ND< 4.7
DP27-20 (Duplicate of DP27-2)	2	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 8.9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 89	ND< 4.5
DP28-2.5	2.5	7/12/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 8.2	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 82	ND< 4.1
DP29-5	5	7/12/2010	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 6.7	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 67	ND< 3.4
DP30-5	5	7/12/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.4	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 84	ND< 4.2
DP30-10	10	7/12/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.3	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 83	ND< 4.2
DP30-15	15	7/12/2010	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 8	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 80	ND< 4
DP31-5	5	7/15/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 8.2	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 82	ND< 4.1
DP31-10	10	7/15/2010	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 15	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 150	ND< 7.5
DP31-15	15	7/15/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 110	ND< 5.6
DP32-5	5	7/15/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 7.8	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 78	ND< 3.9
DP32-13.5	13.5	7/15/2010	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 36	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 360	ND< 18
DP33-5	5	7/15/2010	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 6.9	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 69	ND< 3.5
DP33-8	8	7/15/2010	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 12	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 120	ND< 5.9

Notes:
mg/kg – milligrams per kilogram
EPA – United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND -- not detected above the Practical Quantitation Limit
NE – non established
PQL - Practical Quantitation Limit
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 1 - SOIL SAMPLE ANALYTICAL TEST RESULTS - VOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8260B (mg/kg)					
			Tetrachloroethene	Toluene	trans-1,2-Dichloroethene	Trichloroethene	Trichlorofluoromethane	Vinyl_chloride
DP2-5	5	7/14/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4
DP2-10	10	7/14/2010	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2
DP2-15	15	7/14/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7
DP3-5	5	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP3-10	10	7/13/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8
DP3-15	15	7/13/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP4-5	5	7/13/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP4-10	10	7/13/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP4-15	15	7/13/2010	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9	ND< 4.9
DP5-5	5	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP5-10	10	7/13/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP5-15	15	7/13/2010	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3
DP6-6.5	6.5	7/15/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9
DP7-4.5	4.5	7/15/2010	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6	ND< 2.6
DP8-2.5	2.5	7/15/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1
DP9-2.5	2.5	7/15/2010	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1	ND< 3.1
DP10-3.5	3.5	7/14/2010	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2	ND< 5.2
DP11-2	2	7/13/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9
DP12-2.5	2.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP13-2	2	7/13/2010	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8	ND< 3.8
DP14-3.5	3.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP15-5	5	7/16/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP15-6.5	6.5	7/16/2010	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2	ND< 8.2
DP16-5	5	7/13/2010	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1
DP16-6.5	6.5	7/13/2010	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4
DP17-5	5	7/12/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4
DP17-10	10	7/12/2010	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5	ND< 2.5
DP17-15	15	7/12/2010	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6	ND< 6.6
DP19-5	5	7/15/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP20-1	1	7/15/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP22-3	3	7/16/2010	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3
DP23-5	5	7/16/2010	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4	ND< 5.4
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP23-10	10	7/16/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP23-15	15	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP23-17	17	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP24-2.5	2.5	7/12/2010	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2	ND< 3.2
DP25-2	2	7/12/2010	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6	ND< 3.6
DP26-4.5	4.5	7/12/2010	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3	ND< 4.3
DP27-2	2	7/16/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7
DP27-20 (Duplicate of DP27-2)	2	7/16/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP28-2.5	2.5	7/12/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1
DP29-5	5	7/12/2010	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4	ND< 3.4
DP30-5	5	7/12/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP30-10	10	7/12/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP30-15	15	7/12/2010	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4	ND< 4
DP31-5	5	7/15/2010	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1	ND< 4.1
DP31-10	10	7/15/2010	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5	ND< 7.5
DP31-15	15	7/15/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP32-5	5	7/15/2010	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9	ND< 3.9
DP32-13.5	13.5	7/15/2010	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18	ND< 18
DP33-5	5	7/15/2010	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5	ND< 3.5
DP33-8	8	7/15/2010	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9	ND< 5.9

Notes:
mg/kg – milligrams per kilogram
EPA – United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
PQL - Practical Quantitation Limit
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TABLE 1 - SOIL SAMPLE ANALYTICAL TEST RESULTS - VOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8260B (mg/kg)																													
			1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropa	1,2-Dibromoethane	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane	1,4-Dichlorobenzene	2,2-Dichloropropane	2-Chlorotoluene	4-Chlorotoluene	4-Isopropyltoluene	Benzene	Bromobenzene	Bromodichloromethane	Bromoform	Bromomethane
DP34-5	5	7/15/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.5	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP35-5	5	7/16/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.3	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP35-10	10	7/16/2010	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 11	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3
DP35-14.5	14.5	7/16/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP35-20B	20	7/16/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 9.6	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8
DP36-5	5	7/12/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP36-10	10	7/12/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP37-4.5	4.5	7/12/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.3	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP38-5	5	7/12/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP39-5	5	7/12/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP40-4.5	4.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP41-0	0	7/14/2010	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 11	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5
HA1-2	2	7/14/2010	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 6.1	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3
HA2-1.5	1.5	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.1	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
HA3-3	3	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
HA4-5	5	7/14/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.3	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
HA5-1.5	1.5	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.1	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
HA6-5	5	7/13/2010	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 14	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8
HA7-3	3	7/13/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
HA7-5	5	7/13/2010	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 12	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8
HA8-0	0	7/15/2010	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 8.9	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4
HA10-5	5	7/12/2010	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 11	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5
HA11-0	0	7/15/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
HA12-2	2	7/15/2010	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 13	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5
HA13-1	1	7/15/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 9.4	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7
HA14-1	1	7/15/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 9.6	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8
HA15-5	5	7/15/2010	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 14	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7
HA16-5	5	7/16/2010	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 12	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1
HA16-20 (Duplicate of HA16-5)	5	7/16/2010	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 13	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5
HA17-2	2	7/16/2010	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 11	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7
Regulatory Screening Level *																																
CHHSLi																																
RSLi																																

Notes:
mg/kg – milligrams per kilogram
EPA – United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
PQL - Practical Quantitation Limit
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 1 - SOIL SAMPLE ANALYTICAL TEST RESULTS - VOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8260B (mg/kg)																												
			Carbon_tetrachloride	Chlorobenzene	Chloroethane	Chloroform	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromochloromethane	Dibromomethane	Dichlorodifluoromethane	Di-isopropyl_ether	Ethyl_Tert-butyl_ether	Ethylbenzene	Hexachlorobutadiene	Isopropylbenzene	m,p-Xylene	Methylene_chloride	MTBE	Naphthalene	n-Butylbenzene	n-Propylbenzene	o-Xylene	sec-Butylbenzene	Styrene	Tert-amyl_methyl_ether	Tert-Butanol	tert-Butylbenzene
DP34-5	5	7/15/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.5	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 85	ND< 4.2
DP35-5	5	7/16/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.3	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 93	ND< 4.6
DP35-10	10	7/16/2010	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 11	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 110	ND< 5.3
DP35-14.5	14.5	7/16/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 11	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 110	ND< 5.6
DP35-20B	20	7/16/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 9.6	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 96	ND< 4.8
DP36-5	5	7/12/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 100	ND< 5.1
DP36-10	10	7/12/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 9	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 90	ND< 4.5
DP37-4.5	4.5	7/12/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.3	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 93	ND< 4.6
DP38-5	5	7/12/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 92	ND< 4.6
DP39-5	5	7/12/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 100	ND< 5
DP40-4.5	4.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 100	ND< 5
DP41-0	0	7/14/2010	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 11	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 110	ND< 5.5
HA1-2	2	7/14/2010	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 6.1	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 61	ND< 3
HA2-1.5	1.5	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.1	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 91	ND< 4.6
HA3-3	3	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.2	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 92	ND< 4.6
HA4-5	5	7/14/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 8.3	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 83	ND< 4.2
HA5-1.5	1.5	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 9.1	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 91	ND< 4.6
HA6-5	5	7/13/2010	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 14	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 140	ND< 6.8
HA7-3	3	7/13/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 10	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 100	ND< 5
HA7-5	5	7/13/2010	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 12	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 120	ND< 5.8
HA8-0	0	7/15/2010	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 8.9	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 89	ND< 4.4
HA10-5	5	7/12/2010	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 11	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 110	ND< 5.5
HA11-0	0	7/15/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 10	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 100	ND< 5.1
HA12-2	2	7/15/2010	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 13	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 130	ND< 6.5
HA13-1	1	7/15/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 9.4	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 94	ND< 4.7
HA14-1	1	7/15/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 9.6	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 96	ND< 4.8
HA15-5	5	7/15/2010	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 14	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 140	ND< 7
HA16-5	5	7/16/2010	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 12	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 120	ND< 6.1
HA16-20 (Duplicate of HA16-5)	5	7/16/2010	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 13	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 130	ND< 6.5
HA17-2	2	7/16/2010	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 11	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 110	ND< 5.7
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Notes:
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ND – not detected above the Practical Quantitation Limit
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CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 1 - SOIL SAMPLE ANALYTICAL TEST RESULTS - VOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8260B (mg/kg)					
			Tetrachloroethene	Toluene	trans-1,2-Dichloroethene	Trichloroethene	Trichlorofluoromethane	Vinyl_chloride
DP34-5	5	7/15/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
DP35-5	5	7/16/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP35-10	10	7/16/2010	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3	ND< 5.3
DP35-14.5	14.5	7/16/2010	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6	ND< 5.6
DP35-20B	20	7/16/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8
DP36-5	5	7/12/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
DP36-10	10	7/12/2010	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5	ND< 4.5
DP37-4.5	4.5	7/12/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP38-5	5	7/12/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
DP39-5	5	7/12/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP40-4.5	4.5	7/14/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
DP41-0	0	7/14/2010	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5
HA1-2	2	7/14/2010	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3	ND< 3
HA2-1.5	1.5	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
HA3-3	3	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
HA4-5	5	7/14/2010	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2	ND< 4.2
HA5-1.5	1.5	7/14/2010	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6	ND< 4.6
HA6-5	5	7/13/2010	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8	ND< 6.8
HA7-3	3	7/13/2010	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5	ND< 5
HA7-5	5	7/13/2010	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8	ND< 5.8
HA8-0	0	7/15/2010	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4	ND< 4.4
HA10-5	5	7/12/2010	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5	ND< 5.5
HA11-0	0	7/15/2010	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1	ND< 5.1
HA12-2	2	7/15/2010	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5
HA13-1	1	7/15/2010	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7	ND< 4.7
HA14-1	1	7/15/2010	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8	ND< 4.8
HA15-5	5	7/15/2010	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7	ND< 7
HA16-5	5	7/16/2010	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1	ND< 6.1
HA16-20 (Duplicate of HA16-5)	5	7/16/2010	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5	ND< 6.5
HA17-2	2	7/16/2010	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7	ND< 5.7
Regulatory Screening Level *								
CHHSLi								
RSLi								

Notes:
mg/kg – milligrams per kilogram
EPA – United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
PQL - Practical Quantitation Limit
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																		
			1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-Methylphenol	2-Nitroaniline	2-Nitrophenol	3,3	3-Nitroaniline	4,6-Dinitro-2-methylphenol
DP2-2	2	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 9,900	ND< 25,000	ND< 25,000
DP2-5	5	7/14/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP2-10	10	7/14/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP2-15	15	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP3-0	0	7/13/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP3-20 (Duplicate of DP3-0)	0	7/13/2010	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 33,000	ND< 6,600	ND< 33,000	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 33,000	ND< 6,600	ND< 13,000	ND< 33,000	ND< 33,000
DP3-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP3-10	10	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP3-15	15	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP4-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP4-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP4-10	10	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP4-15	15	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP5-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP5-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP5-10	10	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP5-15	15	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP6-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP6-6.5	6.5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP7-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP7-20 (Duplicate of DP7-0)	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP7-4.5	4.5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP8-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP8-2.5	2.5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP9-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP9-2.5	2.5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP10-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 9,900	ND< 25,000	ND< 25,000
DP10-3.5	3.5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP11-0	0	7/13/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 33,000	ND< 82,000	ND< 82,000
DP11-2	2	7/13/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 33,000	ND< 82,000	ND< 82,000
DP12-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 9,900	ND< 25,000	ND< 25,000
DP12-2.5	2.5	7/14/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 1,600	ND< 4,100	ND< 4,100
DP13-0	0	7/13/2010	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 66,000	ND< 160,000	ND< 160,000
DP13-2	2	7/13/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP14-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 9,900	ND< 25,000	ND< 25,000
DP14-3.5	3.5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP15-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP15-5	5	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP15-20 (Duplicate of DP15-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP15-6.5	6.5	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP16-0	0	7/13/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 33,000	ND< 82,000	ND< 82,000
DP16-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP16-6.5	6.5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP17-0	0	7/12/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 33,000	ND< 82,000	ND< 82,000
DP17-5	5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP17-10	10	7/12/2010	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 66,000	ND< 13,000	ND< 66,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 66,000	ND< 13,000	ND< 26,000	ND< 66,000	ND< 66,000
DP17-15	15	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP19-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP19-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP20-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP20-1	1	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP21-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																					
			4-Bromophenyl-phenylether	4-Chloro-3-methylphenol	4-Chloroaniline	4-Chlorophenyl-phenylether	4-Methylphenol	4-Nitroaniline	4-Nitrophenol	Acenaphthene	Acenaphthylene	Anthracene	Benzidine__M_	Benzo_a_anthracene	Benzo_a_pyrene	Benzo_b_fluoranthene	Benzo_g,h,i_perylene	Benzo_k_fluoranthene	Benzoic_acid	Benzyl_alcohol	Bis_2-chloroethoxy_methane	Bis_2-chloroethyl_ether	Bis_2-chloroisopropyl_ether	Bis_2-ethylhexyl_phthalate	Butylbenzylphthalate	Chrysene
DP2-2	2	7/14/2010	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 25,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000
DP2-5	5	7/14/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP2-10	10	7/14/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP2-15	15	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP3-0	0	7/13/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP3-20 (Duplicate of DP3-0)	0	7/13/2010	ND< 6,600	ND< 13,000	ND< 13,000	ND< 6,600	ND< 6,600	ND< 33,000	ND< 33,000	ND< 6,600	ND< 6,600	ND< 6,600	ND< 33,000	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 33,000	ND< 13,000	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600
DP3-5	5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP3-10	10	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP3-15	15	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP4-0	0	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP4-5	5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP4-10	10	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP4-15	15	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP5-0	0	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP5-5	5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP5-10	10	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP5-15	15	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP6-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP6-6.5	6.5	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP7-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP7-20 (Duplicate of DP7-0)	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP7-4.5	4.5	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP8-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP8-2.5	2.5	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP9-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP9-2.5	2.5	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP10-0	0	7/14/2010	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 25,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000
DP10-3.5	3.5	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP11-0	0	7/13/2010	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000
DP11-2	2	7/13/2010	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000
DP12-0	0	7/14/2010	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 25,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000
DP12-2.5	2.5	7/14/2010	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 4,100	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820
DP13-0	0	7/13/2010	ND< 33,000	ND< 66,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000
DP13-2	2	7/13/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP14-0	0	7/14/2010	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 25,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000
DP14-3.5	3.5	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP15-0	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP15-5	5	7/16/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP15-20 (Duplicate of DP15-0)	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP15-6.5	6.5	7/16/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP16-0	0	7/13/2010	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000
DP16-5	5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP16-6.5	6.5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP17-0	0	7/12/2010	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000
DP17-5	5	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP17-10	10	7/12/2010	ND< 13,000	ND< 26,000	ND< 26,000	ND< 13,000	ND< 13,000	ND< 66,000	ND< 66,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 66,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 66,000	ND< 26,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000
DP17-15	15	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP19-0	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP19-5	5	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP20-0	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP20-1	1	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	420	620	880	380	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	510
DP21-0	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (ug/kg)																					
			Dibenz_a,h_anthracene	Dibenzofuran	Diethylphthalate	Dimethylphthalate	Di-n-butylphthalate	Di-n-octylphthalate	Fluoranthene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachlorocyclopentadiene	Hexachloroethane	Indeno_1,2,3-cd_pyrene	Isophorone	Naphthalene	Nitrobenzene	N-Nitrosodi-n-propylamine	N-Nitrosodiphenylamine	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
DP2-2	2	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000
DP2-5	5	7/14/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP2-10	10	7/14/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP2-15	15	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP3-0	0	7/13/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP3-20 (Duplicate of DP3-0)	0	7/13/2010	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 13,000	ND< 13,000	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 6,600	ND< 33,000	ND< 6,600	ND< 6,600	ND< 6,600
DP3-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP3-10	10	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP3-15	15	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP4-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP4-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP4-10	10	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP4-15	15	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP5-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP5-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP5-10	10	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP5-15	15	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP6-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP6-6.5	6.5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP7-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP7-20 (Duplicate of DP7-0)	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP7-4.5	4.5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP8-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP8-2.5	2.5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP9-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP9-2.5	2.5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP10-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000
DP10-3.5	3.5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP11-0	0	7/13/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000
DP11-2	2	7/13/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000
DP12-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000
DP12-2.5	2.5	7/14/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820
DP13-0	0	7/13/2010	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 66,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000
DP13-2	2	7/13/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP14-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000
DP14-3.5	3.5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP15-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP15-5	5	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP15-20 (Duplicate of DP15-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP15-6.5	6.5	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP16-0	0	7/13/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000
DP16-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP16-6.5	6.5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP17-0	0	7/12/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000
DP17-5	5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP17-10	10	7/12/2010	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 26,000	ND< 26,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 13,000	ND< 66,000	ND< 13,000	ND< 13,000	ND< 13,000
DP17-15	15	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP19-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP19-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP20-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP20-1	1	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	390	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	440
DP21-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																		
			1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-Methylphenol	2-Nitroaniline	2-Nitrophenol	3,3	3-Nitroaniline	4,6-Dinitro-2-methylphenol
DP21-20 (Duplicate of DP21-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP22-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP22-3	3	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP22-20 (Duplicate of DP22-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
DP23-0	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP23-5	5	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP23-10	10	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP23-15	15	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP23-17	17	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP24-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP24-20 (Duplicate of DP24-0)	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP24-2.5	2.5	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP25-0	0	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP25-2	2	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP26-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP26-4.5	4.5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP27-0	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP27-2	2	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP27-20 (Duplicate of DP27-2	2	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP28-0	0	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP28-2.5	2.5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP29-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP29-5	5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP30-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP30-5	5	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP30-10	10	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP30-15	15	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP31-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP31-5	5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP31-10	10	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP31-15	15	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP32-0	0	7/15/2010	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 99,000	ND< 20,000	ND< 99,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 99,000	ND< 20,000	ND< 40,000	ND< 99,000	ND< 99,000
DP32-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP32-13.5	13.5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP33-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP33-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP33-8	8	7/15/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP34-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP34-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP34-20 (Duplicate of DP34-0)	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP35-0	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP35-20 (Duplicate of DP35-0)	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP35-5	5	7/16/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 1,600	ND< 4,100	ND< 4,100
DP35-10	10	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP35-14.5	14.5	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP35-20B	20	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP36-0	0	7/12/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																						
			4-Bromophenyl-phenylether	4-Chloro-3-methylphenol	4-Chloroaniline	4-Chlorophenyl-phenylether	4-Methylphenol	4-Nitroaniline	4-Nitrophenol	Acenaphthene	Acenaphthylene	Anthracene	Benzidine__M_	Benzo_a_anthracene	Benzo_a_pyrene	Benzo_b_fluoranthene	Benzo_g,h,i_perylene	Benzo_k_fluoranthene	Benzoic_acid	Benzyl_alcohol	Bis_2-chloroethoxy_methane	Bis_2-chloroethyl_ether	Bis_2-chloroisopropyl_ether	Bis_2-ethylhexyl_phthalate	Butylbenzylphthalate	Chrysene
DP21-20 (Duplicate of DP21-0)	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP22-0	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP22-3	3	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP22-20 (Duplicate of DP22-0)	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
DP23-0	0	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP23-5	5	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP23-10	10	7/16/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP23-15	15	7/16/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP23-17	17	7/16/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP24-0	0	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP24-20 (Duplicate of DP24-0)	0	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP24-2.5	2.5	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP25-0	0	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP25-2	2	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP26-0	0	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	16,000 16,000	ND< 3,300
DP26-4.5	4.5	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP27-0	0	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP27-2	2	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP27-20 (Duplicate of DP27-2	2	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP28-0	0	7/12/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP28-2.5	2.5	7/12/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP29-0	0	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP29-5	5	7/12/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP30-0	0	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP30-5	5	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP30-10	10	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP30-15	15	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP31-0	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP31-5	5	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP31-10	10	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP31-15	15	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP32-0	0	7/15/2010	ND< 20,000	ND< 40,000	ND< 40,000	ND< 20,000	ND< 20,000	ND< 99,000	ND< 99,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 99,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 99,000	ND< 40,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000
DP32-5	5	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP32-13.5	13.5	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP33-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP33-5	5	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP33-8	8	7/15/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	17,000	29,000	41,000	21,000	12,000	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	21,000
DP34-0	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP34-5	5	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP34-20 (Duplicate of DP34-0)	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP35-0	0	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP35-20 (Duplicate of DP35-0)	0	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP35-5	5	7/16/2010	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 4,100	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820
DP35-10	10	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP35-14.5	14.5	7/16/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP35-20B	20	7/16/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP36-0	0	7/12/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																				
			Dibenz_a,h_anthracene	Dibenzofuran	Diethylphthalate	Dimethylphthalate	Di-n-butylphthalate	Di-n-octylphthalate	Fluorantheene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachlorocyclopentadiene	Hexachloroethane	Indeno_1,2,3-cd_pyrene	Isophorone	Naphthalene	Nitrobenzene	N-Nitrosodi-n-propylamine	N-Nitrosodiphenylamine	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
DP21-20 (Duplicate of DP21-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP22-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP22-3	3	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP22-20 (Duplicate of DP22-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
DP23-0	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP23-5	5	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP23-10	10	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP23-15	15	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP23-17	17	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP24-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP24-20 (Duplicate of DP24-0)	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP24-2.5	2.5	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP25-0	0	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP25-2	2	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP26-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP26-4.5	4.5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP27-0	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP27-2	2	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP27-20 (Duplicate of DP27-2	2	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP28-0	0	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP28-2.5	2.5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP29-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP29-5	5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP30-0	0	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP30-5	5	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP30-10	10	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP30-15	15	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP31-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP31-5	5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP31-10	10	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP31-15	15	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP32-0	0	7/15/2010	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 40,000	ND< 40,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 20,000	ND< 99,000	ND< 20,000	ND< 20,000	ND< 20,000
DP32-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP32-13.5	13.5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP33-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP33-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP33-8	8	7/15/2010	5,900	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	12,000	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	17,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	14,000
DP34-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP34-5	5	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP34-20 (Duplicate of DP34-0)	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP35-0	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP35-20 (Duplicate of DP35-0)	0	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP35-5	5	7/16/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820
DP35-10	10	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP35-14.5	14.5	7/16/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP35-20B	20	7/16/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP36-0	0	7/12/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																		
			1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-Methylphenol	2-Nitroaniline	2-Nitrophenol	3,3	3-Nitroaniline	4,6-Dinitro-2-methylphenol
DP36-5	5	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP36-10	10	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
DP37-0	0	7/12/2010	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 66,000	ND< 160,000	ND< 160,000
DP37-4.5	4.5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP38-0	0	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP38-5	5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
DP39-0	0	7/12/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 33,000	ND< 82,000	ND< 82,000
DP39-5	5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP39-20 (Duplicate of DP39-0)	0	7/12/2010	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 66,000	ND< 160,000	ND< 160,000
DP40-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 9,900	ND< 25,000	ND< 25,000
DP40-4.5	4.5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
DP41-0	0	7/14/2010	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 41,000	ND< 8,200	ND< 41,000	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 41,000	ND< 8,200	ND< 16,000	ND< 41,000	ND< 41,000
HA1-0	0	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
HA1-20 (Duplicate of HA1-0)	0	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
HA1-2	2	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
HA2-0	0	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA2-1.5	1.5	7/14/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 1,600	ND< 4,100	ND< 4,100
HA3-0	0	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA3-3	3	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA4-0	0	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA4-5	5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA5-0	0	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
HA5-1.5	1.5	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 6,600	ND< 16,000	ND< 16,000
HA6-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA6-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA7-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA7-3	3	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA7-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA8-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA9-0	0	7/13/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA9-20 (Duplicate of HA9-0)	0	7/13/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA10-0	0	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA10-5	5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA11-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA12-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA12-2	2	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA13-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA13-1	1	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA14-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA14-1	1	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA15-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 660	ND< 1,600	ND< 1,600
HA15-5	5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 3,300	ND< 8,200	ND< 8,200
HA16-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
HA16-5	5	7/16/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 1,600	ND< 4,100	ND< 4,100
HA16-20 (Duplicate of HA16-5)	0	7/16/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 1,600	ND< 4,100	ND< 4,100
HA17-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
HA17-2	2	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
HA17-20 (Duplicate of HA17-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 20,000	ND< 50,000	ND< 50,000
Regulatory Screening Levels*																						
CHHSLr																						
CHHSLi																						
RSLr																						
RSLi																						

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (µg/kg)																					
			4-Bromophenyl-phenylether	4-Chloro-3-methylphenol	4-Chloroaniline	4-Chlorophenyl-phenylether	4-Methylphenol	4-Nitroaniline	4-Nitrophenol	Acenaphthene	Acenaphthylene	Anthracene	Benzidine__M_	Benzo_a_anthracene	Benzo_a_pyrene	Benzo_b_fluoranthene	Benzo_ghi_perylene	Benzo_k_fluoranthene	Benzoic_acid	Benzyl_alcohol	Bis_2-chloroethoxy_methane	Bis_2-chloroethyl_ether	Bis_2-chloroisopropyl_ether	Bis_2-ethylhexyl_phthalate	Butylbenzylphthalate	Chrysene
DP36-5	5	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP36-10	10	7/12/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
DP37-0	0	7/12/2010	ND< 33,000	ND< 66,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000
DP37-4.5	4.5	7/12/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP38-0	0	7/12/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP38-5	5	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
DP39-0	0	7/12/2010	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000
DP39-5	5	7/12/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP39-20 (Duplicate of DP39-0)	0	7/12/2010	ND< 33,000	ND< 66,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000
DP40-0	0	7/14/2010	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 25,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000
DP40-4.5	4.5	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
DP41-0	0	7/14/2010	ND< 8,200	ND< 16,000	ND< 16,000	ND< 8,200	ND< 8,200	ND< 41,000	ND< 41,000	ND< 8,200	ND< 8,200	ND< 8,200	ND< 41,000	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 41,000	ND< 16,000	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200
HA1-0	0	7/14/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
HA1-20 (Duplicate of HA1-0)	0	7/14/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
HA1-2	2	7/14/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
HA2-0	0	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA2-1.5	1.5	7/14/2010	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 4,100	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820
HA3-0	0	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA3-3	3	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA4-0	0	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA4-5	5	7/14/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA5-0	0	7/14/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
HA5-1.5	1.5	7/14/2010	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 16,000	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300
HA6-0	0	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA6-5	5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA7-0	0	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA7-3	3	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA7-5	5	7/13/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA8-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA9-0	0	7/13/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA9-20 (Duplicate of HA9-0)	0	7/13/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA10-0	0	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA10-5	5	7/12/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA11-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA12-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA12-2	2	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA13-0	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	470	460	650	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	480
HA13-1	1	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA14-0	0	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA14-1	1	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330
HA15-0	0	7/15/2010	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 1,600	ND< 1,600	ND< 330	ND< 330	ND< 330	ND< 1,600	660	1,100	1,500	690	540	ND< 1,600	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	890
HA15-5	5	7/15/2010	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 8,200	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600
HA16-0	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
HA16-5	5	7/16/2010	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 4,100	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820
HA16-20 (Duplicate of HA16-5)	0	7/16/2010	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 4,100	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820
HA17-0	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
HA17-2	2	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
HA17-20 (Duplicate of HA17-0)	0	7/16/2010	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 50,000	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900
Regulatory Screening Levels*																									
CHHSLr													NE	38	NE	NE	NE								NE
CHHSLi													NE	130	NE	NE	NE								NE
RSLr													150	15	150	NE	1,500								15,000
RSLi													21,000	210	2,100	NE	21,000								210,000

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 2 - SOIL SAMPLE ANALYTICAL TEST RESULTS - SVOCs

Sample ID	Sample Depth	Date Sampled	EPA Method 8270C (ug/kg)																					
			Dibenz_a,h_anthracene	Dibenzofuran	Diethylphthalate	Dimethylphthalate	Di-n-butylphthalate	Di-n-octylphthalate	Fluoranthene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachlorocyclopentadiene	Hexachloroethane	Indeno_1,2,3-cd_pyrene	Isophorone	Naphthalene	Nitrobenzene	N-Nitrosodi-n-propylamine	N-Nitrosodiphenylamine	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
DP36-5	5	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP36-10	10	7/12/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
DP37-0	0	7/12/2010	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 66,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000
DP37-4.5	4.5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP38-0	0	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP38-5	5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
DP39-0	0	7/12/2010	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 33,000	ND< 33,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 16,000	ND< 82,000	ND< 16,000	ND< 16,000	ND< 16,000
DP39-5	5	7/12/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP39-20 (Duplicate of DP39-0)	0	7/12/2010	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 66,000	ND< 66,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 33,000	ND< 160,000	ND< 33,000	ND< 33,000	ND< 33,000
DP40-0	0	7/14/2010	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 9,900	ND< 9,900	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 5,000	ND< 25,000	ND< 5,000	ND< 5,000	ND< 5,000
DP40-4.5	4.5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
DP41-0	0	7/14/2010	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 16,000	ND< 16,000	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 8,200	ND< 41,000	ND< 8,200	ND< 8,200	ND< 8,200
HA1-0	0	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
HA1-20 (Duplicate of HA1-0)	0	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
HA1-2	2	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
HA2-0	0	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA2-1.5	1.5	7/14/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820
HA3-0	0	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA3-3	3	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA4-0	0	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA4-5	5	7/14/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA5-0	0	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
HA5-1.5	1.5	7/14/2010	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 6,600	ND< 6,600	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 3,300	ND< 16,000	ND< 3,300	ND< 3,300	ND< 3,300
HA6-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA6-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA7-0	0	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA7-3	3	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA7-5	5	7/13/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA8-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA9-0	0	7/13/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA9-20 (Duplicate of HA9-0)	0	7/13/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA10-0	0	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA10-5	5	7/12/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA11-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA12-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA12-2	2	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA13-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	940	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	610	ND< 330	830
HA13-1	1	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA14-0	0	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA14-1	1	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	ND< 330
HA15-0	0	7/15/2010	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	560	ND< 330	ND< 330	ND< 660	ND< 660	ND< 330	570	ND< 330	ND< 330	ND< 330	ND< 330	ND< 330	ND< 1,600	ND< 330	ND< 330	630
HA15-5	5	7/15/2010	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 3,300	ND< 3,300	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 1,600	ND< 8,200	ND< 1,600	ND< 1,600	ND< 1,600
HA16-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
HA16-5	5	7/16/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820
HA16-20 (Duplicate of HA16-5)	0	7/16/2010	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 1,600	ND< 1,600	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 820	ND< 4,100	ND< 820	ND< 820	ND< 820
HA17-0	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
HA17-2	2	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
HA17-20 (Duplicate of HA17-0)	0	7/16/2010	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 20,000	ND< 20,000	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 9,900	ND< 50,000	ND< 9,900	ND< 9,900	ND< 9,900
Regulatory Screening Levels*																								
CHHSLr			NE						NE						NE							NE		NE
CHHSLi			NE						NE						NE							NE		NE
RSLr			15						2,300						150							NE		NE
RSLi			210						22,000						2,100							NE		NE

Notes:
mg/kg – micrograms per kilogram
EPA – United States Environmental Protection Agency
PQL – Practical Quantitation Limit
ND – not detected above the Practical Quantitation Limit
NE – non established
NA – not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr – California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 3 – SOIL SAMPLE ANALYTICAL TEST RESULTS – CAM 17 METALS AND PH

Sample ID	Sample Depth	Date Sampled	EPA Methods 6010B/7471A mg/kg															9045C pH Units
			Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Mercury	pH
DP2-2	2	7/14/2010	ND< 2	5.1	86	ND< 1	ND< 1	13	5.2	26	14	ND< 1	11	ND< 1	1	ND< 1	24	47	ND< 0.1	9
DP2-3	3	7/14/2010									9.5									
DP2-4	4	7/14/2010									15									
DP2-5	5	7/14/2010	ND< 2	2.1	96	ND< 1	ND< 1	8.9	3.6	9.2	8.7	ND< 1	5.3	ND< 1	ND< 1	ND< 1	20	37	ND< 0.1	8.6
DP2-10	10	7/14/2010	ND< 2	3.9	63	ND< 1	ND< 1	10	3.7	7.6	4.8	ND< 1	7.2	ND< 1	ND< 1	ND< 1	19	29	ND< 0.1	7.9
DP2-15	15	7/14/2010	ND< 2	3.8	71	ND< 1	ND< 1	14	5.1	8.6	6	ND< 1	9	ND< 1	ND< 1	ND< 1	23	37	0.14	7.7
DP3-0	0	7/13/2010	2.8	5.3	220	ND< 1	2.7	43	6.9	170	190	1.4	36	ND< 1	ND< 1	ND< 1	27	930	0.45	8.3
DP3-20 (Duplicate of DP3-0)	0	7/13/2010	3.1	5	220	ND< 1	2.2	46	6.5	120	200	2.8	53	1.9	2.1	ND< 1	26	950	0.45	8
DP3-1	1	7/13/2010									12									
DP3-2	2	7/13/2010									65									
DP3-3	3	7/13/2010									48									
DP3-5	5	7/13/2010	ND< 2	4	57	ND< 1	ND< 1	10	4.5	6.1	2.3	ND< 1	7.5	ND< 1	ND< 1	ND< 1	18	32	ND< 0.1	8.6
DP3-10	10	7/13/2010	ND< 2	2.9	29	ND< 1	ND< 1	6.5	2.4	3.7	1.9	ND< 1	4.2	ND< 1	ND< 1	ND< 1	12	17	ND< 0.1	8.3
DP3-15	15	7/13/2010	ND< 2	2.6	59	ND< 1	ND< 1	8.3	2.9	8.4	5.6	ND< 1	5.8	ND< 1	ND< 1	ND< 1	14	26	ND< 0.1	8
DP4-0	0	7/13/2010	ND< 2	4.9	110	ND< 1	ND< 1	22	5.5	39	260	ND< 1	18	ND< 1	ND< 1	ND< 1	34	170	ND< 0.1	8.2
DP4-5	5	7/13/2010	ND< 2	1.5	56	ND< 1	ND< 1	7.1	2.7	5.8	6.4	ND< 1	4.2	ND< 1	ND< 1	ND< 1	14	26	ND< 0.1	8.5
DP4-10	10	7/13/2010	ND< 2	3.7	65	ND< 1	ND< 1	11	4.2	7.9	11	ND< 1	8	ND< 1	ND< 1	ND< 1	19	41	ND< 0.1	8.4
DP4-15	15	7/13/2010	ND< 2	2.9	47	ND< 1	ND< 1	8.9	3.5	5.9	3.2	ND< 1	6.4	ND< 1	ND< 1	ND< 1	16	25	ND< 0.1	7.8
DP5-0	0	7/13/2010	ND< 2	3.3	82	ND< 1	ND< 1	12	4.2	12	9.7	ND< 1	11	ND< 1	ND< 1	ND< 1	23	43	ND< 0.1	8.3
DP5-1	1	7/13/2010									11									
DP5-2	2	7/13/2010									9.2									
DP5-3	3	7/13/2010									11									
DP5-5	5	7/13/2010	ND< 2	1.3	83	ND< 1	ND< 1	6.5	3.2	6.7	6.2	ND< 1	4.6	ND< 1	ND< 1	ND< 1	15	30	ND< 0.1	8.6
DP5-10	10	7/13/2010	ND< 2	2.8	38	ND< 1	ND< 1	7.8	3.1	5.5	5.5	ND< 1	5.6	ND< 1	ND< 1	ND< 1	15	23	ND< 0.1	8.6
DP5-15	15	7/13/2010	ND< 2	2	32	ND< 1	ND< 1	6	2.3	4.1	3.6	ND< 1	4	ND< 1	ND< 1	ND< 1	12	18	ND< 0.1	8.1
DP6-0	0	7/15/2010	ND< 2	4.6	120	ND< 1	ND< 1	20	7.5	18	9.7	ND< 1	13	ND< 1	ND< 1	ND< 1	40	51	ND< 0.1	8.2
DP6-6.5	6.5	7/15/2010	ND< 2	3.2	67	ND< 1	ND< 1	21	7.7	21	160	ND< 1	23	ND< 1	ND< 1	ND< 1	38	140	ND< 0.1	8.2
DP7-0	0	7/15/2010	ND< 2	4.9	170	ND< 1	ND< 1	25	9	18	6.7	ND< 1	17	ND< 1	ND< 1	ND< 1	40	60	ND< 0.1	8.2
DP7-20 (Duplicate of DP7-0)	0	7/15/2010	ND< 2	7.2	130	ND< 1	ND< 1	26	8.6	30	31	ND< 1	18	ND< 1	ND< 1	ND< 1	40	96	ND< 0.1	8.3
DP7-4.5	4.5	7/15/2010	ND< 2	4.4	44	ND< 1	ND< 1	13	3.7	7.3	6.9	ND< 1	6.9	ND< 1	ND< 1	ND< 1	38	26	ND< 0.1	8.4
DP8-0	0	7/15/2010	ND< 2	5.7	130	ND< 1	ND< 1	19	6.3	37	360	ND< 1	16	ND< 1	ND< 1	ND< 1	35	250	ND< 0.1	8.4
DP8-2.5	2.5	7/15/2010	ND< 2	6.3	86	ND< 1	ND< 1	14	6.1	19	16	ND< 1	11	ND< 1	ND< 1	ND< 1	28	49	ND< 0.1	7.9
DP9-0	0	7/15/2010	ND< 2	4.6	160	ND< 1	ND< 1	14	5.8	26	17	ND< 1	12	ND< 1	1.4	ND< 1	32	54	0.11	11
DP9-2.5	2.5	7/15/2010	ND< 2	5.4	88	ND< 1	ND< 1	22	6.2	14	29	ND< 1	13	ND< 1	ND< 1	ND< 1	30	51	ND< 0.1	8.2
DP10-0	0	7/14/2010	ND< 2	4.8	160	ND< 1	ND< 1	18	4.1	53	17	ND< 1	12	ND< 1	ND< 1	ND< 1	25	110	ND< 0.1	7.5
DP10-3.5	3.5	7/14/2010	ND< 2	6.8	270	ND< 1	ND< 1	19	6.7	19	15	ND< 1	14	ND< 1	ND< 1	ND< 1	35	84	ND< 0.1	8
DP11-0	0	7/13/2010	ND< 2	4.4	150	ND< 1	ND< 1	13	4.8	15	11	ND< 1	9.4	ND< 1	ND< 1	ND< 1	28	47	ND< 0.1	9.8
DP11-2	2	7/13/2010	ND< 2	5	100	ND< 1	ND< 1	17	4.2	18	22	ND< 1	12	ND< 1	ND< 1	ND< 1	24	57	0.11	9.1
DP12-0	0	7/14/2010	ND< 2	4.2	82	ND< 1	ND< 1	17	4	14	8.4	ND< 1	11	ND< 1	ND< 1	ND< 1	23	41	ND< 0.1	11
DP12-2.5	2.5	7/14/2010	ND< 2	3	83	ND< 1	ND< 1	13	4.8	12	12	ND< 1	8.7	ND< 1	ND< 1	ND< 1	26	38	ND< 0.1	8.1
DP13-0	0	7/13/2010	ND< 2	6.1	76	ND< 1	ND< 1	12	4.1	13	18	ND< 1	10	ND< 1	ND< 1	ND< 1	23	52	ND< 0.1	10
DP13-2	2	7/13/2010	ND< 2	5.5	70	ND< 1	ND< 1	12	5.6	12	4.4	ND< 1	10	ND< 1	ND< 1	ND< 1	25	38	ND< 0.1	8
DP14-0	0	7/14/2010	ND< 2	4.5	180	ND< 1	ND< 1	18	4.9	17	19	ND< 1	11	ND< 1	ND< 1	ND< 1	26	63	ND< 0.1	8.5
DP14-3.5	3.5	7/14/2010	ND< 2	5.8	110	ND< 1	ND< 1	17	7.3	18	8	ND< 1	14	ND< 1	ND< 1	ND< 1	32	55	ND< 0.1	8.3
DP15-0	0	7/16/2010	ND< 2	6.5	160	ND< 1	ND< 1	38	5	21	32	ND< 1	100	ND< 1	ND< 1	ND< 1	25	56	0.15	9.7
DP15-20 (Duplicate of DP15-0)	0	7/16/2010	ND< 2	5.2	120	ND< 1	ND< 1	70	5.4	23	64	ND< 1	38	ND< 1	ND< 1	ND< 1	26	64	0.15	9.1
DP15-5	5	7/16/2010	ND< 2	3.6	81	ND< 1	ND< 1	10	3.7	7	3.9	ND< 1	6.7	ND< 1	ND< 1	ND< 1	20	29	ND< 0.1	8.9
DP15-6.5	6.5	7/16/2010	ND< 2	8.9	280	ND< 1	ND< 1	18	4.8	9.5	4.2	ND< 1	12	ND< 1	ND< 1	ND< 1	33	30	ND< 0.1	8.5
DP16-0	0	7/13/2010	ND< 2	4.3	80	ND< 1	ND< 1	11	4.3	18	27	ND< 1	12	ND< 1	ND< 1	ND< 1	26	57	ND< 0.1	7.7
DP16-5	50	7/13/2010	ND< 2	2.6	18	ND< 1	ND< 1	5.6	2	3.2	1.5	ND< 1	4	ND< 1	ND< 1	ND< 1	10	14	ND< 0.1	8.8
DP16-6.5	6.5	7/13/2010	ND< 2	2.3	21	ND< 1	ND< 1	5.4	2.1	3.3	1.8	ND< 1	3.8	ND< 1	ND< 1	ND< 1	9.9	13	ND< 0.1	8.1
DP17-0	0	7/12/2010	ND< 2	3.5	68	ND< 1	ND< 1	10	4.7	22	5.5	ND< 1	15	ND< 1	6.9	ND< 1	21	34	ND< 0.1	9.1
DP17-5	5	7/12/2010	ND< 2	1.3	54	ND< 1	ND< 1	5.9	2.5	5.2	4.7	ND< 1	3.6	ND< 1	ND< 1	ND< 1	12	23	ND< 0.1	8.4
DP17-10	10	7/12/2010	ND< 2	2.8	81	ND< 1	ND< 1	16	4.7	16	16	ND< 1	12	ND< 1	2	ND< 1	29	41	ND< 0.1	8.7

TABLE 3 – SOIL SAMPLE ANALYTICAL TEST RESULTS – CAM 17 METALS AND PH

Sample ID	Sample Depth	Date Sampled	EPA Methods 6010B/7471A mg/kg																9045C pH Units
			Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Mercury	pH
DP17-15	15	7/12/2010	ND< 2	6.9	110	ND< 1	ND< 1	20	8.5	23	5.7	ND< 1	15	ND< 1	ND< 1	ND< 1	38	52	ND< 0.1	8.4
DP19-0	0	7/15/2010	ND< 2	1.7	130	ND< 1	ND< 1	7.5	65	21	1.6	ND< 1	15	ND< 1	ND< 1	ND< 1	11	31	ND< 0.1	7.7
DP19-5	5	7/15/2010	ND< 2	ND< 1	110	ND< 1	ND< 1	13	6.7	11	4.7	ND< 1	9	ND< 1	ND< 1	ND< 1	24	37	ND< 0.1	8.6
DP20-0	0	7/15/2010	ND< 2	1.9	55	ND< 1	ND< 1	8.4	4.8	7.1	3.9	ND< 1	7.2	ND< 1	ND< 1	ND< 1	23	21	ND< 0.1	8.4
DP20-1	1	7/15/2010	ND< 2	ND< 1	40	ND< 1	ND< 1	7.7	4	3.9	3.3	ND< 1	5.4	ND< 1	ND< 1	ND< 1	14	21	ND< 0.1	8.5
DP21-0	0	7/16/2010	ND< 2	1.4	120	ND< 1	ND< 1	14	5.2	31	10	1.1	14	ND< 1	2.6	ND< 1	25	45	0.22	10
DP21-20 (Duplicate of DP21-0)	0	7/16/2010	ND< 2	ND< 1	110	ND< 1	ND< 1	11	4.7	17	8.1	ND< 1	13	ND< 1	2.6	ND< 1	22	38	0.34	10
DP22-0	0	7/16/2010	ND< 2	1.1	86	ND< 1	ND< 1	14	6.1	20	16	1.1	14	ND< 1	ND< 1	ND< 1	26	43	ND< 0.1	11
DP22-20 (Duplicate of DP22-0)	0	7/16/2010	ND< 2	1.3	160	ND< 1	ND< 1	21	8.4	23	13	ND< 1	17	ND< 1	ND< 1	ND< 1	31	54	ND< 0.1	10
DP22-3	3	7/16/2010	ND< 2	ND< 1	83	ND< 1	ND< 1	12	5.2	16	16	ND< 1	12	ND< 1	ND< 1	ND< 1	23	39	ND< 0.1	10
DP23-0	0	7/16/2010	ND< 2	6.8	120	ND< 1	ND< 1	19	8	19	7	ND< 1	15	ND< 1	ND< 1	1.9	37	55	ND< 0.1	7.8
DP23-5	5	7/16/2010	ND< 2	5.1	85	ND< 1	1.1	14	4.8	21	20	ND< 1	13	ND< 1	ND< 1	ND< 1	25	64	ND< 0.1	7.5
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	4.7	12	260	ND< 1	7.8	100	8.7	240	610	4.4	58	ND< 1	2.1	ND< 1	39	770	0.66	7.8
DP23-10	10	7/16/2010	ND< 2	6.7	100	ND< 1	ND< 1	19	8.1	17	4.2	ND< 1	15	ND< 1	ND< 1	2.1	36	49	ND< 0.1	7.7
DP23-15	15	7/16/2010	ND< 2	18	120	ND< 1	ND< 1	27	10	32	9	ND< 1	19	ND< 1	ND< 1	2	48	63	0.13	8.3
DP23-17	17	7/16/2010	ND< 2	11	69	ND< 1	ND< 1	21	7.5	18	5.2	2.1	15	ND< 1	ND< 1	1.7	40	50	ND< 0.1	8.9
DP24-0	0	7/12/2010	ND< 2	4.6	81	ND< 1	ND< 1	13	5.2	14	14	ND< 1	9.9	ND< 1	ND< 1	ND< 1	22	63	ND< 0.1	8.2
DP24-20 (Duplicate of DP24-0)	0	7/12/2010	ND< 2	8.3	67	ND< 1	ND< 1	26	8	22	31	ND< 1	20	ND< 1	ND< 1	ND< 1	26	240	ND< 0.1	8.3
DP24-2.5	2.5	7/12/2010	ND< 2	19	97	ND< 1	ND< 1	21	6.3	19	9.2	ND< 1	15	ND< 1	ND< 1	ND< 1	36	63	ND< 0.1	8.3
DP25-0	0	7/12/2010	2.3	10	53	ND< 1	1.2	60	12	20	21	ND< 1	34	ND< 1	ND< 1	ND< 1	30	270	0.24	9.4
DP25-2	2	7/12/2010	ND< 2	4.5	54	ND< 1	ND< 1	14	5.5	9.8	6.8	ND< 1	11	ND< 1	ND< 1	ND< 1	22	65	ND< 0.1	8.4
DP26-0	0	7/12/2010	ND< 2	5.4	140	ND< 1	ND< 1	21	5.9	23	16	ND< 1	15	ND< 1	ND< 1	ND< 1	27	84	ND< 0.1	7.9
DP26-4.5	4.5	7/12/2010	ND< 2	2.7	53	ND< 1	ND< 1	9.4	4.7	8.3	2.2	ND< 1	7.5	ND< 1	ND< 1	ND< 1	19	28	ND< 0.1	8.3
DP27-0	0	7/16/2010	ND< 2	3.5	57	ND< 1	ND< 1	11	4.6	8.7	3.1	ND< 1	8.1	ND< 1	ND< 1	1.2	22	36	ND< 0.1	8.1
DP27-2	2	7/16/2010	ND< 2	5.6	64	ND< 1	ND< 1	15	5.5	15	5	ND< 1	11	ND< 1	ND< 1	1.2	25	50	ND< 0.1	8
DP27-20 (Duplicate of DP27-2)	2	7/16/2010	ND< 2	3.5	40	ND< 1	ND< 1	8.1	3.2	6.3	2.2	ND< 1	5.8	ND< 1	ND< 1	ND< 1	15	22	0.11	7.9
DP28-0	0	7/12/2010	ND< 2	4.1	78	ND< 1	ND< 1	12	4.6	12	10	ND< 1	8.5	ND< 1	ND< 1	ND< 1	20	82	0.12	8
DP28-2.5	2.5	7/12/2010	ND< 2	4.1	58	ND< 1	ND< 1	12	5.4	14	4.1	ND< 1	9.4	ND< 1	ND< 1	ND< 1	23	41	ND< 0.1	8
DP29-0	0	7/12/2010	ND< 2	3.7	92	ND< 1	ND< 1	17	15	16	18	ND< 1	11	ND< 1	ND< 1	ND< 1	23	50	ND< 0.1	8
DP29-5	5	7/12/2010	ND< 2	3.5	86	ND< 1	ND< 1	12	5.1	15	11	ND< 1	9.1	ND< 1	ND< 1	ND< 1	26	45	ND< 0.1	7.8
DP30-0	0	7/12/2010	ND< 2	4.6	170	ND< 1	ND< 1	13	4.4	16	22	ND< 1	11	ND< 1	ND< 1	ND< 1	22	63	0.1	8.9
DP30-5	5	7/12/2010	ND< 2	5.6	210	ND< 1	ND< 1	16	5.5	20	13	ND< 1	12	ND< 1	ND< 1	ND< 1	28	52	ND< 0.1	8.1
DP30-10	10	7/12/2010	ND< 2	3.9	160	ND< 1	ND< 1	12	4.5	14	15	ND< 1	9.3	ND< 1	ND< 1	ND< 1	22	47	ND< 0.1	8.9
DP30-15	15	7/12/2010	ND< 2	2.5	51	ND< 1	ND< 1	11	4.2	10	8.5	ND< 1	9.3	ND< 1	ND< 1	ND< 1	17	36	ND< 0.1	8.4
DP31-0	0	7/15/2010	ND< 2	4	51	ND< 1	ND< 1	11	5.6	11	4.4	ND< 1	6.9	ND< 1	ND< 1	ND< 1	30	27	ND< 0.1	8.3
DP31-5	5	7/15/2010	ND< 2	3.8	53	ND< 1	ND< 1	11	4.4	11	8	ND< 1	7.5	ND< 1	ND< 1	ND< 1	19	42	0.14	8.3
DP31-10	10	7/15/2010	ND< 2	ND< 1	38	ND< 1	ND< 1	8.4	3.9	4.2	5	ND< 1	5.6	ND< 1	ND< 1	ND< 1	13	26	ND< 0.1	7.8
DP31-15	15	7/15/2010	ND< 2	ND< 1	50	ND< 1	ND< 1	6.3	2.5	2.8	2.1	ND< 1	3.8	ND< 1	ND< 1	ND< 1	10	14	ND< 0.1	7.8
DP32-0	0	7/15/2010	ND< 2	2.3	56	ND< 1	ND< 1	16	8.1	26	2.7	ND< 1	13	ND< 1	1.1	ND< 1	29	27	ND< 0.1	8
DP32-5	5	7/15/2010	ND< 2	ND< 1	45	ND< 1	ND< 1	8.7	4.2	23	2.8	ND< 1	6	ND< 1	ND< 1	ND< 1	15	22	ND< 0.1	8.2
DP32-13.5	13.5	7/15/2010	ND< 2	ND< 1	22	ND< 1	ND< 1	5.7	2.5	2.4	2.7	ND< 1	3.5	ND< 1	ND< 1	ND< 1	9.4	16	ND< 0.1	7.7
DP33-0	0	7/15/2010	ND< 2	ND< 1	100	ND< 1	ND< 1	9.9	6.6	28	13	ND< 1	9.4	ND< 1	2.6	ND< 1	18	39	ND< 0.1	8.6
DP33-5	5	7/15/2010	ND< 2	ND< 1	31	ND< 1	ND< 1	7	3.2	3.3	4.1	ND< 1	4.7	ND< 1	ND< 1	ND< 1	12	21	ND< 0.1	8.8
DP33-8	8	7/15/2010	ND< 2	ND< 1	30	ND< 1	ND< 1	6.9	3.1	3.3	4.8	ND< 1	4.3	ND< 1	ND< 1	ND< 1	11	21	0.54	8.4
DP34-0	0	7/15/2010	ND< 2	ND< 1	52	ND< 1	ND< 1	8.3	4.2	5.5	92	ND< 1	6	ND< 1	ND< 1	ND< 1	14	24	ND< 0.1	8.4
DP34-20 (Duplicate of DP34-0)	0	7/15/2010	ND< 2	ND< 1	60	ND< 1	ND< 1	9.9	4.9	5.9	4.3	ND< 1	7.2	ND< 1	ND< 1	ND< 1	17	28	ND< 0.1	8.3
DP34-5	5	7/15/2010	ND< 2	ND< 1	65	ND< 1	ND< 1	11	5.7	7.1	6.4	ND< 1	8.2	ND< 1	ND< 1	ND< 1	20	33	ND< 0.1	8.4
DP35-0	0	7/16/2010	ND< 2	5.9	210	ND< 1	ND< 1	20	6.5	32	25	ND< 1	15	ND< 1	ND< 1	1.1	34	110	0.1	8.1
DP35-20 (Duplicate of DP35-0)	0	7/16/2010	ND< 2	6.3	190	ND< 1	ND< 1	20	6.5	34	20	ND< 1	15	ND< 1	ND< 1	1.1	39	110	0.15	8.6
DP35-5	5	7/16/2010	ND< 2	3.9	110	ND< 1	ND< 1	15	4.2	14	22	ND< 1	9.8	ND< 1	ND< 1	ND< 1	21	51	ND< 0.1	8.5

TABLE 3 – SOIL SAMPLE ANALYTICAL TEST RESULTS – CAM 17 METALS AND PH

Sample ID	Sample Depth	Date Sampled	EPA Methods 6010B/7471A mg/kg															9045C pH Units
			Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Mercury	pH
DP35-10	10	7/16/2010	ND< 2	5.3	230	ND< 1	ND< 1	18	6.7	20	15	ND< 1	15	ND< 1	ND< 1	ND< 1	33	59	ND< 0.1	9.7
DP35-14.5	14.5	7/16/2010	ND< 2	6.5	100	ND< 1	ND< 1	16	4.7	15	14	ND< 1	12	ND< 1	ND< 1	ND< 1	26	66	ND< 0.1	9.4
DP35-20B	20	7/16/2010	ND< 2	4.8	86	ND< 1	ND< 1	15	6.6	12	2.6	ND< 1	12	ND< 1	ND< 1	1.7	28	42	ND< 0.1	8.5
DP36-0	0	7/12/2010	ND< 2	5.6	190	ND< 1	ND< 1	15	5.1	17	15	ND< 1	12	ND< 1	ND< 1	ND< 1	26	53	ND< 0.1	7.9
DP36-5	5	7/12/2010	ND< 2	4.8	160	ND< 1	1.3	19	5.1	40	34	4	15	ND< 1	ND< 1	ND< 1	23	120	ND< 0.1	8
DP36-10	10	7/12/2010	ND< 2	5	170	ND< 1	ND< 1	17	5.7	24	19	ND< 1	14	ND< 1	ND< 1	ND< 1	27	71	ND< 0.1	8
DP37-0	0	7/12/2010	ND< 2	4	100	ND< 1	ND< 1	13	4.6	21	15	ND< 1	14	ND< 1	ND< 1	ND< 1	29	51	ND< 0.1	8.4
DP37-4.5	4.5	7/12/2010	ND< 2	5.8	140	ND< 1	ND< 1	21	5	31	18	ND< 1	17	ND< 1	ND< 1	ND< 1	27	64	0.17	7.8
DP38-0	0	7/12/2010	ND< 2	5.5	180	ND< 1	ND< 1	21	5.9	22	14	ND< 1	14	ND< 1	ND< 1	ND< 1	27	59	ND< 0.1	7.2
DP38-5	5	7/12/2010	ND< 2	2.5	39	ND< 1	ND< 1	6.9	3.6	7.1	1.8	ND< 1	5.7	ND< 1	ND< 1	ND< 1	14	21	ND< 0.1	7.2
DP39-0	0	7/12/2010	ND< 2	3.1	57	ND< 1	ND< 1	7.5	4.4	18	5	ND< 1	13	ND< 1	2	ND< 1	20	56	ND< 0.1	8.3
DP39-20 (Duplicate of DP39-0)	0	7/12/2010	ND< 2	2.4	58	ND< 1	ND< 1	7.8	4.1	19	5.8	ND< 1	14	ND< 1	ND< 1	ND< 1	21	65	ND< 0.1	8
DP39-5	5	7/12/2010	ND< 2	7.7	110	ND< 1	ND< 1	17	7.1	27	5.8	ND< 1	13	ND< 1	ND< 1	ND< 1	31	46	ND< 0.1	7.8
DP40-0	0	7/14/2010	ND< 2	5.5	120	ND< 1	ND< 1	12	3.7	15	15	ND< 1	9.9	ND< 1	ND< 1	ND< 1	22	49	ND< 0.1	9.9
DP40-4.5	4.5	7/14/2010	ND< 2	6.2	450	ND< 1	ND< 1	25	6.3	29	45	ND< 1	17	ND< 1	ND< 1	ND< 1	31	120	0.12	7.7
DP41-0	0	7/14/2010	ND< 2	3.9	71	ND< 1	ND< 1	8.8	3.7	14	11	ND< 1	10	ND< 1	ND< 1	ND< 1	23	44	ND< 0.1	10
HA1-0	0	7/14/2010	ND< 2	5.9	310	ND< 1	ND< 1	18	5.3	21	25	ND< 1	13	ND< 1	ND< 1	ND< 1	30	110	ND< 0.1	8.6
HA1-20 (Duplicate of HA1-0)	0	7/14/2010	ND< 2	5	260	ND< 1	ND< 1	15	4.9	20	24	ND< 1	11	ND< 1	ND< 1	ND< 1	27	98	ND< 0.1	8.9
HA1-2	2	7/14/2010	ND< 2	4.8	260	ND< 1	ND< 1	19	5.2	19	70	ND< 1	11	ND< 1	ND< 1	ND< 1	27	78	0.14	8.4
HA2-0	0	7/14/2010	ND< 2	5.7	130	ND< 1	ND< 1	11	3.9	18	14	ND< 1	8.1	ND< 1	ND< 1	ND< 1	23	77	ND< 0.1	7.1
HA2-1.5	1.5	7/14/2010	ND< 2	5.7	120	ND< 1	ND< 1	11	3.8	15	12	ND< 1	7.8	ND< 1	ND< 1	ND< 1	23	63	ND< 0.1	7.4
HA3-0	0	7/14/2010	ND< 2	4.3	140	ND< 1	ND< 1	16	4.8	18	16	ND< 1	11	ND< 1	ND< 1	ND< 1	27	59	ND< 0.1	8
HA3-1	1	7/14/2010									13									
HA3-2	2	7/14/2010									7									
HA3-3	3	7/14/2010	ND< 2	3.3	100	ND< 1	ND< 1	13	3.7	19	14	ND< 1	8.6	ND< 1	ND< 1	ND< 1	21	49	ND< 0.1	8.4
HA4-0	0	7/14/2010	ND< 2	4.7	110	ND< 1	ND< 1	9.2	3.3	12	13	ND< 1	6.4	ND< 1	ND< 1	ND< 1	20	60	ND< 0.1	8.1
HA4-1	1	7/14/2010									ND< 5									
HA4-2	2	7/14/2010									9.7									
HA4-3	3	7/14/2010									26									
HA4-5	5	7/14/2010	ND< 2	5	120	ND< 1	ND< 1	11	3.8	12	11	ND< 1	7.7	ND< 1	ND< 1	ND< 1	23	43	ND< 0.1	8.4
HA5-0	0	7/14/2010	ND< 2	5.2	150	ND< 1	ND< 1	14	4.4	15	16	ND< 1	10	ND< 1	ND< 1	ND< 1	26	70	ND< 0.1	8.2
HA5-1	1	7/14/2010									12									
HA5-1.5	1.5	7/14/2010	ND< 2	5.1	75	ND< 1	ND< 1	18	2.7	11	11	ND< 1	9.9	ND< 1	ND< 1	ND< 1	22	34	ND< 0.1	11
HA6-0	0	7/13/2010	ND< 2	3.7	47	ND< 1	ND< 1	9.3	3.9	8.4	7.4	ND< 1	7.2	ND< 1	ND< 1	ND< 1	17	29	ND< 0.1	7.9
HA6-1	1	7/13/2010									10									
HA6-2	2	7/13/2010									14									
HA6-3	3	7/13/2010									ND< 5									
HA6-5	5	7/13/2010	ND< 2	3.3	62	ND< 1	ND< 1	9.9	4.1	7.5	6.9	ND< 1	7.4	ND< 1	ND< 1	ND< 1	19	29	ND< 0.1	8.4
HA7-0	0	7/13/2010	ND< 2	4	100	ND< 1	ND< 1	40	4.1	39	210	ND< 1	16	ND< 1	ND< 1	ND< 1	21	180	0.23	7.8
HA7-1	1	7/13/2010									61									
HA7-2	2	7/13/2010									26									
HA7-3	3	7/13/2010	ND< 2	4.5	58	ND< 1	ND< 1	11	4.5	16	26	ND< 1	8	ND< 1	ND< 1	1.6	20	44	ND< 0.1	8.5
HA7-5	5	7/13/2010	ND< 2	3.7	88	ND< 1	ND< 1	13	4.3	12	29	ND< 1	9.5	ND< 1	ND< 1	ND< 1	19	76	ND< 0.1	8.4
HA8-0	0	7/15/2010	ND< 2	4.1	120	ND< 1	ND< 1	14	4.9	17	21	ND< 1	13	ND< 1	ND< 1	ND< 1	26	69	ND< 0.1	8.4
HA9-0	0	7/13/2010	ND< 2	4.8	200	ND< 1	ND< 1	27	5.3	20	40	ND< 1	15	ND< 1	ND< 1	ND< 1	28	110	0.13	7.2
HA9-20 (Duplicate of HA9-0)	0	7/13/2010	ND< 2	4.9	220	ND< 1	ND< 1	28	5.5	19	40	ND< 1	15	ND< 1	ND< 1	ND< 1	28	100	0.15	7.7
HA10-0	10	7/12/2010	ND< 2	3.9	110	ND< 1	ND< 1	13	7.7	11	5.6	ND< 1	8.8	ND< 1	ND< 1	ND< 1	27	29	ND< 0.1	8.5
HA10-1	1	7/12/2010									10									
HA10-2	2	7/12/2010									ND< 5									
HA10-3	3	7/12/2010									16									
HA10-5	5	7/12/2010	ND< 2	2.7	64	ND< 1	ND< 1	22	7.5	29	30	ND< 1	13	ND< 1	ND< 1	ND< 1	23	85	ND< 0.1	8.6
HA11-0	0	7/15/2010	ND< 2	6.2	120	ND< 1	ND< 1	16	6.2	25	51	ND< 1	12	ND< 1	ND< 1	ND< 1	32	140	ND< 0.1	8.2
HA12-0	0	7/15/2010	ND< 2	3.8	100	ND< 1	ND< 1	9.7	4.5	21	26	ND< 1	8.1	ND< 1	ND< 1	ND< 1	27	240	ND< 0.1	7.9
HA12-2	2	7/15/2010	ND< 2	6.9	93	ND< 1	ND< 1	12	5.6	17	24	ND< 1	11	ND< 1	ND< 1	ND< 1	29	110	0.11	8.4

TABLE 3 – SOIL SAMPLE ANALYTICAL TEST RESULTS – CAM 17 METALS AND PH

Sample ID	Sample Depth	Date Sampled	EPA Methods 6010B/7471A mg/kg															9045C pH Units
			Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Mercury	pH
HA13-0	0	7/15/2010	ND< 2	ND< 1	41	ND< 1	ND< 1	7.9	4	4.5	5.1	ND< 1	5.8	ND< 1	ND< 1	ND< 1	14	24	ND< 0.1	8
HA13-1	1	7/15/2010	ND< 2	ND< 1	44	ND< 1	ND< 1	8	6.4	6.8	6.6	ND< 1	5.8	ND< 1	ND< 1	ND< 1	15	24	ND< 0.1	8.5
HA14-0	0	7/15/2010	ND< 2	ND< 1	140	ND< 1	ND< 1	17	8	15	9.4	ND< 1	14	ND< 1	ND< 1	ND< 1	30	40	ND< 0.1	8.4
HA14-1	1	7/15/2010	ND< 2	2.5	49	ND< 1	ND< 1	11	9.6	11	3.2	ND< 1	6.8	ND< 1	ND< 1	ND< 1	29	28	ND< 0.1	8.2
HA15-0	0	7/15/2010	ND< 2	ND< 1	56	ND< 1	ND< 1	9.3	4.8	6.5	5	ND< 1	6.5	ND< 1	ND< 1	ND< 1	17	27	ND< 0.1	8.1
HA15-1	1	7/15/2010									9.7									
HA15-2	2	7/15/2010									9									
HA15-3	3	7/15/2010									6.8									
HA15-5	5	7/15/2010	ND< 2	ND< 1	110	ND< 1	ND< 1	20	10	17	5.1	ND< 1	17	ND< 1	ND< 1	ND< 1	36	39	ND< 0.1	8.1
HA16-0	0	7/16/2010	ND< 2	6.1	100	ND< 1	ND< 1	13	4.9	20	35	ND< 1	13	ND< 1	1.3	ND< 1	29	52	ND< 0.1	11
HA16-1	1	7/16/2010									9.5									
HA16-2	2	7/16/2010									ND< 5									
HA16-3	3	7/16/2010						0			6.6									
HA16-5	5	7/16/2010	ND< 2	ND< 1	83	ND< 1	ND< 1	13	7	10	5.8	ND< 1	11	ND< 1	ND< 1	ND< 1	22	37	ND< 0.1	9.4
HA16-20 (Duplicate of HA16-5)	5	7/16/2010	ND< 2	ND< 1	96	ND< 1	ND< 1	17	8.7	11	2.7	ND< 1	13	ND< 1	ND< 1	ND< 1	28	42	ND< 0.1	8.9
HA17-0	0	7/16/2010	ND< 2	ND< 1	93	ND< 1	ND< 1	13	5.6	20	14	1	15	ND< 1	ND< 1	ND< 1	24	41	ND< 0.1	10
HA17-20 (Duplicate of HA17-0)	0	7/16/2010	ND< 2	1.3	94	ND< 1	ND< 1	10	4.1	13	20	ND< 1	8.8	ND< 1	ND< 1	ND< 1	20	41	ND< 0.1	10
HA17-1	1	7/16/2010									22									
HA17-2	2	7/16/2010	ND< 2	ND< 1	91	ND< 1	ND< 1	12	4.8	14	17	ND< 1	11	ND< 1	ND< 1	ND< 1	23	42	ND< 0.1	9.7
Regulatory Screening Levels*																				
CHHSLr			30	0.07	5,200	16	1.7	100,000	660	3,000	80	380	1,600	380	380	5.0	530	23,000	18	NE
CHHSLi			380	0.24	63,000	190	7.5	100,000	3,000	38,000	320	4,800	16,000	4,800	4,800	63	6,700	100,000	180	NE
RSLr			31	0.39	15,000	160	70	120,000	23	3,100	400	390	1,500	390	390	NE	390	23,000	5.6	NE
RSLi			410	1.6	190,000	2,000	800	1,200,000	300	41,000	800	5,100	20,000	5,100	5,100	NE	5,200	310,000	34	NE

Notes:
mg/kg – milligrams per kilogram
EPA – United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND – not detected above the PQL
NE – non established
NA – not applicable
TTLC – State of California Total Threshold Limit Concentration
STLC – State of California Soluble Threshold Limit Concentration
TCLP – Federal Toxicity Characteristic Leaching Procedure
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr - California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr – EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi – EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 4 – SOIL SAMPLE ANALYTICAL TEST RESULTS – TPHs

Sample ID	Sample Depth	Date Sampled	EPA Method 8015B mg/kg		
			TPHg	TPHd	TPHo
DP2-2	2	7/14/2010	ND< 1	430	1,800
DP2-5	5	7/14/2010	ND< 1.1	ND< 1	3
DP2-10	10	7/14/2010	ND< 1	52	160
DP2-15	15	7/14/2010	ND< 0.95	4	12
DP3-0	0	7/13/2010	ND< 1.2	200	610
DP3-20 (Duplicate of DP3-0)	0	7/13/2010	ND< 1.1	210	560
DP3-5	5	7/13/2010	ND< 1.2	6	18
DP3-10	10	7/13/2010	ND< 1	2	7
DP3-15	15	7/13/2010	ND< 0.96	26	61
DP4-0	0	7/13/2010	ND< 1.1	6	24
DP4-5	5	7/13/2010	ND< 1.1	ND	1
DP4-10	10	7/13/2010	ND< 1.2	12	35
DP4-15	15	7/13/2010	ND< 0.95	1	5
DP5-0	0	7/13/2010	ND< 0.92	12	39
DP5-5	5	7/13/2010	ND< 1.1	7	21
DP5-10	10	7/13/2010	ND< 1	3	8
DP5-15	15	7/13/2010	ND< 1.2	3	10
DP6-0	0	7/15/2010	ND< 0.83	5	33
DP6-6.5	6.5	7/15/2010	ND< 0.75	17	60
DP7-0	0	7/15/2010	ND< 1	59	320
DP7-20 (Duplicate of DP7-0)	0	7/15/2010	ND< 0.64	12	78
DP7-4.5	4.5	7/15/2010	ND< 0.54	11	55
DP8-0	0	7/15/2010	ND< 0.75	57	280
DP8-2.5	2.5	7/15/2010	ND< 0.59	2	9
DP9-0	0	7/15/2010	ND< 0.94	290	1,800
DP9-2.5	2.5	7/15/2010	ND< 1.1	30	100
DP10-0	0	7/14/2010	ND< 0.78	270	1,100
DP10-3.5	3.5	7/14/2010	ND< 0.82	320	910
DP11-0	0	7/13/2010	ND< 0.9	420	1,900
DP11-2	2	7/13/2010	ND< 0.73	170	580
DP12-0	0	7/14/2010	ND< 1.2	390	1,800
DP12-2.5	2.5	7/14/2010	ND< 0.82	44	120
DP13-0	0	7/13/2010	ND< 0.86	170	590
DP13-2	2	7/13/2010	ND< 0.78	31	93
DP14-0	0	7/14/2010	ND< 0.85	460	1,600
DP14-3.5	3.5	7/14/2010	ND< 0.97	170	170
DP15-0	0	7/16/2010	ND< 0.96	870	5,200
DP15-20 (Duplicate of DP15-0)	0	7/16/2010	ND< 0.95	800	4,600
DP15-5	5	7/16/2010	ND< 1.1	110	560
DP15-6.5	6.5	7/16/2010	ND< 1.3	ND< 1	ND< 1
DP16-0	0	7/13/2010	ND< 0.99	570	2,300
DP16-5	5	7/13/2010	ND< 0.88	6	27

TABLE 4 – SOIL SAMPLE ANALYTICAL TEST RESULTS – TPHs

Sample ID	Sample Depth	Date Sampled	EPA Method 8015B mg/kg		
			TPHg	TPHd	TPHo
DP16-6.5	6.5	7/13/2010	ND< 0.8	ND< 1	ND< 1
DP17-0	0	7/12/2010	ND< 0.86	1,400	4,800
DP17-5	5	7/12/2010	ND< 0.73	ND< 1	2
DP17-10	10	7/12/2010	ND< 0.89	5,600	13,000
DP17-15	15	7/12/2010	ND< 0.76	ND< 1	ND< 1
DP19-0	0	7/15/2010	ND< 0.87	ND< 1	6
DP19-5	5	7/15/2010	ND< 0.97	ND< 1	7
DP20-0	0	7/15/2010	ND< 0.63	ND< 1	4
DP20-1	1	7/15/2010	ND< 0.73	2	12
DP21-0	0	7/16/2010	ND< 1.5	450	2,800
DP21-20 (Duplicate of DP21-0)	0	7/16/2010	ND< 1.1	700	4,500
DP22-0	0	7/16/2010	ND< 1.3	1,200	6,600
DP22-20 (Duplicate of DP22-0)	0	7/16/2010	ND< 1.3	970	5,500
DP22-3	3	7/16/2010	ND< 1.4	210	1,500
DP23-0	0	7/16/2010	ND< 0.87	30	370
DP23-5	5	7/16/2010	ND< 1.1	290	1,600
DP23-20 (Duplicate of DP23-5)	5	7/16/2010	ND< 1	110	630
DP23-10	10	7/16/2010	ND< 1.2	ND< 1	ND< 1
DP23-15	15	7/16/2010	ND< 0.95	ND< 1	1
DP23-17	14	7/16/2010	ND< 0.93	ND< 1	ND< 1
DP24-0	0	7/12/2010	ND< 0.7	32	220
DP24-20 (Duplicate of DP24-0)	0	7/12/2010	ND< 3	65	450
DP24-2.5	2.5	7/12/2010	ND< 0.77	6	30
DP25-0	0	7/12/2010	ND< 0.56	10	48
DP25-2	2	7/12/2010	ND< 0.67	4	14
DP26-0	0	7/12/2010	ND< 0.62	300	1,400
DP26-4.5	4.5	7/12/2010	ND< 0.86	ND< 1	ND< 1
DP27-0	0	7/16/2010	ND< 0.91	36	490
DP27-2	2	7/16/2010	ND< 1.1	43	350
DP27-20 (Duplicate of DP27-2)	2	7/16/2010	ND< 0.9	15	100
DP28-0	0	7/12/2010	ND< 1.2	5	22
DP28-2.5	2.5	7/12/2010	ND< 0.74	11	48
DP29-0	0	7/12/2010	ND< 0.87	330	1,400
DP29-5	5	7/12/2010	ND< 0.66	30	160
DP30-0	0	7/12/2010	ND< 0.98	62	330
DP30-5	5	7/12/2010	ND< 0.9	82	310
DP30-10	10	7/12/2010	ND< 0.72	73	260
DP30-15	15	7/12/2010	ND< 0.83	160	800
DP31-0	0	7/15/2010	ND< 0.65	ND< 1	2
DP31-5	5	7/15/2010	ND< 0.98	8	49

TABLE 4 – SOIL SAMPLE ANALYTICAL TEST RESULTS – TPHs

Sample ID	Sample Depth	Date Sampled	EPA Method 8015B mg/kg		
			TPHg	TPHd	TPHo
DP31-10	10	7/15/2010	ND< 2.5	83	330
DP31-15	15	7/15/2010	ND< 0.94	9	50
DP32-0	0	7/15/2010	ND< 0.83	1,200	12,000
DP32-5	5	7/15/2010	ND< 0.74	ND< 1	4
DP32-13.5	13.5	7/15/2010	ND< 0.79	1	12
DP33-0	0	7/15/2010	ND< 0.64	24	210
DP33-5	5	7/15/2010	ND< 0.85	3	19
DP33-8	8	7/15/2010	ND< 0.8	6	28
DP34-0	0	7/15/2010	ND< 0.8	4	19
DP34-20 (Duplicate of DP34-0)	0	7/15/2010	ND< 1.1	3	13
DP34-5	5	7/15/2010	ND< 0.98	30	93
DP35-0	0	7/16/2010	ND< 1	61	510
DP35-20 (Duplicate of DP35-0)	0	7/16/2010	ND< 1.1	100	710
DP35-5	5	7/16/2010	ND< 1	41	220
DP35-10	10	7/16/2010	ND< 1	480	2,500
DP35-14.5	14.5	7/16/2010	ND< 0.97	360	3,500
DP35-20B	20	7/16/2010	ND< 0.87	ND< 1	1
DP36-0	0	7/12/2010	ND< 1.1	43	160
DP36-5	5	7/12/2010	ND< 1.2	230	850
DP36-10	10	7/12/2010	ND< 0.91	10	47
DP37-0	0	7/12/2010	ND< 0.96	86	400
DP37-4.5	4.5	7/12/2010	ND< 0.86	20	44
DP38-0	0	7/12/2010	ND< 0.95	110	440
DP38-5	5	7/12/2010	ND< 0.85	ND< 1	ND< 1
DP39-0	0	7/12/2010	ND< 0.98	750	7,000
DP39-20 (Duplicate of DP39-0)	0	7/12/2010	ND< 1	1,000	8,600
DP39-5	5	7/12/2010	ND< 0.88	16	58
DP40-0	0	7/14/2010	ND< 0.99	330	1,500
DP40-4.5	4.5	7/14/2010	ND< 0.81	150	540
DP41-0	0	7/14/2010	ND< 1	1,400	6,200
HA1-0	0	7/14/2010	ND< 0.76	150	640
HA1-20 (Duplicate of HA1-0)	0	7/14/2010	ND< 1.3	330	1,800
HA1-2	2	7/14/2010	ND< 0.71	130	540
HA2-0	0	7/14/2010	ND< 0.82	40	150
HA2-1.5	1.5	7/14/2010	ND< 1	67	270
HA3-0	0	7/14/2010	ND< 1.2	170	540
HA3-3	3	7/14/2010	ND< 0.9	64	320
HA4-0	0	7/14/2010	ND< 0.85	21	96
HA4-5	5	7/14/2010	ND< 1	34	130
HA5-0	0	7/14/2010	ND< 0.91	230	1,200
HA5-1.5	1.5	7/14/2010	ND< 0.92	260	1,300

TABLE 4 – SOIL SAMPLE ANALYTICAL TEST RESULTS – TPHs

Sample ID	Sample Depth	Date Sampled	EPA Method 8015B mg/kg		
			TPHg	TPHd	TPHo
HA6-0	0	7/13/2010	ND< 0.87	6	22
HA6-5	5	7/13/2010	ND< 1.4	ND< 1	3
HA7-0	0	7/13/2010	ND< 0.99	17	52
HA7-3	3	7/13/2010	ND< 1	3	19
HA7-5	5	7/13/2010	ND< 1.2	5	18
HA8-0	0	7/15/2010	ND< 0.78	210	1,500
HA9-0	0	7/13/2010	ND< 0.97	88	290
HA9-20 (Duplicate of HA9-0)	0	7/13/2010	ND< 0.94	96	300
HA10-0	0	7/12/2010	ND< 4.1	3	8
HA10-5	5	7/12/2010	ND< 1.2	27	110
HA11-0	0	7/15/2010	ND< 1	23	110
HA12-0	0	7/15/2010	ND< 1.4	240	1,200
HA12-2	2	7/15/2010	ND< 0.93	38	250
HA13-0	0	7/15/2010	ND< 0.94	2	14
HA13-1	1	7/15/2010	ND< 0.75	7	32
HA14-0	0	7/15/2010	ND< 0.96	540	1,800
HA14-1	1	7/15/2010	ND< 1.4	ND< 1	2
HA15-0	0	7/15/2010	ND< 1.2	39	140
HA15-5	5	7/15/2010	ND< 0.99	250	690
HA16-0	0	7/16/2010	ND< 1.3	740	4,200
HA16-5	5	7/16/2010	ND< 0.88	58	290
HA16-20 (Duplicate of HA16-5)	5	7/16/2010	ND< 0.98	17	97
HA17-0	0	7/16/2010	ND< 1	1,200	6,500
HA17-20 (Duplicate of HA17-0)	0	7/16/2010	ND< 0.87	660	3,600
HA17-2	2	7/16/2010	ND< 1.2	560	3,300
Regulatory Screening Levels					
MSSLs <20 feet bgs			100	100	1,000

Notes:
mg/kg − milligrams per kilogram
EPA − United States Environmental Protection Agency
CRWQCB - California Regional Water Quality Control Board
bgs - belowground surface
PQL - Practical Quantitation Limit
ND − not detected above the Practical Quantitation Limit
MSSL - RWQCBs Maximum Soil Screening Level above drinking aquifer less than 20 feet bgs.

TABLE 5 – SOIL SAMPLE ANALYTICAL TEST RESULTS – PCBs

Sample ID	Sample Depth	Date Sampled	EPA Method 8082 µg/kg								
			Aroclor_1016	**Aroclor_1221**	**Aroclor_1232**	**Aroclor_1242**	**Aroclor_1248**	**Aroclor_1254**	**Aroclor_1260**	**Aroclor_1262**	**Aroclor_1268**
DP24-0	0	7/12/2010	ND< 16	ND< 33	ND< 16	ND< 16	ND< 16	ND< 16	ND< 16	ND< 16	ND< 16
DP24-20 (Duplicate of DP24-20)	0	7/12/2010	ND< 16	ND< 33	ND< 16	ND< 16	ND< 16	ND< 16	ND< 16	ND< 16	ND< 16
Regulatory Screening Levels*											
CHHSLr			0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
CHHSLi			0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
RSLr			3,900	140	140	220	220	220	220	NE	NE
RSLi			21,000	540	540	740	740	740	740	NE	NE

Notes:
mg/kg − milligrams per kilogram
mg/kg − micrograms per kilogram
EPA − United States Environmental Protection Agency
PQL - Practical Quantitation Limit
ND − not detected above the PQL
NE − non established
NA − not applicable
* - regulatory screening levels only noted for those analytes with reported concentrations above the PQL
CHHSLr - California Human Health Screening Levels for residential land use, (1/2005)
CHHSLi - California Human Health Screening Levels for industrial land use, (1/2005)
RSLr − EPA Region 9, Regional Screening Levels for residential Properties (5/2010)
RSLi − EPA Region 9, Regional Screening Levels for Industrial Properties (5/2010)

TABLE 6 – SOIL SAMPLE ANALYTICAL TEST RESULTS – Total and Soluble Lead and Chromium

Sample ID	Sample Depth	Date Sampled	Test Type	Units	Analyte	
					Chromium	Lead
DP3-0	0	7/13/2010	Total	mg/kg	43	190
			STLC	mg/l		13
			STLC-DI	mg/l		ND
			TCLP	mg/l		0.31
DP3-20 (Duplicate of DP3-0)	0	7/13/2010	Total	mg/kg	46	200
			STLC	mg/l		13
			STLC-DI	mg/l		0.27
			TCLP	mg/l		0.33
DP3-2	2	7/13/2010	Total	mg/kg		65
			STLC	mg/l		4.0
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP3-3	3	7/13/2010	Total	mg/kg		48
			STLC	mg/l		1.9
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP4-0	0	7/13/2010	Total	mg/kg	22	260
			STLC	mg/l		19
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP6-6.5	6.5	7/15/2010	Total	mg/kg	21	160
			STLC	mg/l		19
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP8-0	0	7/15/2010	Total	mg/kg	19	360
			STLC	mg/l		6.4
			STLC-DI	mg/l		ND
			TCLP	mg/l		0.31
DP15-20	20	7/16/2010	Total	mg/kg	70	64
			STLC	mg/l		3.2
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP23-20	20	7/16/2010	Total	mg/kg	100	610
			STLC	mg/l		44
			STLC-DI	mg/l	ND	0.27
			TCLP	mg/l		1.1

TABLE 2 – SOIL SAMPLE ANALYTICAL TEST RESULTS – Total and Soluble Lead and Chromium

Sample ID	Sample Depth	Date Sampled	Test Type	Units	Analyte	
					Chromium	Lead
DP24-20 (Duplicate of DP24-0)	0	7/12/2010	Total	mg/kg	26	31
			STLC	mg/l		0.78
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP25-0	0	7/12/2010	Total	mg/kg	60	21
			STLC-DI	mg/l		
DP34-0	0	7/15/2010	Total	mg/kg	8.3	92
			STLC	mg/l		ND
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
DP36-5	5	7/12/2010	Total	mg/kg	19	34
			STLC	mg/l		3
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
HA1-2	2	7/14/2010	Total	mg/kg	19	70
			STLC	mg/l		1.3
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
HA7-0	0	7/13/2010	Total	mg/kg	40	**210**
			STLC	mg/l		**5**
			STLC-DI	mg/l		ND
			TCLP	mg/l		0.33
HA7-1	1	7/13/2010	Total	mg/kg		**61**
			STLC	mg/l		**5**
			STLC-DI	mg/l		ND
			TCLP	mg/l		0.33
HA9-0	0	7/13/2010	Total	mg/kg	27	40
			STLC	mg/l		1.8
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND
HA9-20 (Duplicate of HA9-0)	0	7/13/2010	Total	mg/kg	28	40
			STLC	mg/l		1.8
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND

TABLE 2 – SOIL SAMPLE ANALYTICAL TEST RESULTS – Total and Soluble Lead and Chromium

Sample ID	Sample Depth	Date Sampled	Test Type	Units	Analyte	
					Chromium	Lead
HA10-1	1	7/12/2010	Total	mg/kg		10
			STLC	mg/l		0.49
			TCLP	mg/l		ND
HA10-2	2	7/12/2010	Total	mg/kg		ND
			STLC	mg/l		ND
			TCLP	mg/l		ND
HA10-3	3	7/12/2010	Total	mg/kg		16
			STLC	mg/l		0.94
			TCLP	mg/l		ND
HA11-0	0	7/15/2010	Total	mg/kg	16	**51**
			STLC	mg/l		2.1
			STLC-DI	mg/l		ND
			TCLP	mg/l		ND

Notes:
mg/kg – milligrams per kilogram
mg/l – milligrams per liter
TTLC – total lead for comparison to the Total Threshold Limit Concentration
STLC – soluble chromium or lead by the Waste Extraction Test (WET) using citric acid for comparison to the Soluble Threshold Limit Concentration
STLC-DI – soluble chromium or lead by WET using deionized water
TCLP – soluble lead by the Toxicity Characteristic Leaching Procedure
ND − not detected above reporting limits presented in Appendix A

DRAFT

APPENDIX A

GIS DATABASE EXCEL SPREADSHEET DELIVERABLE

(Will be included in final report)

DRAFT

APPENDIX B

HEALTH AND SAFETY PLAN

[COPY FROM WORKPLAN]

DRAFT

APPENDIX C

BORING LOGS

DRAFT

APPENDIX D

FIELD PROCEDURES AND LABORATORY QA/QC PLAN

[COPY FROM WORKPLAN]

DRAFT

APPENDIX E

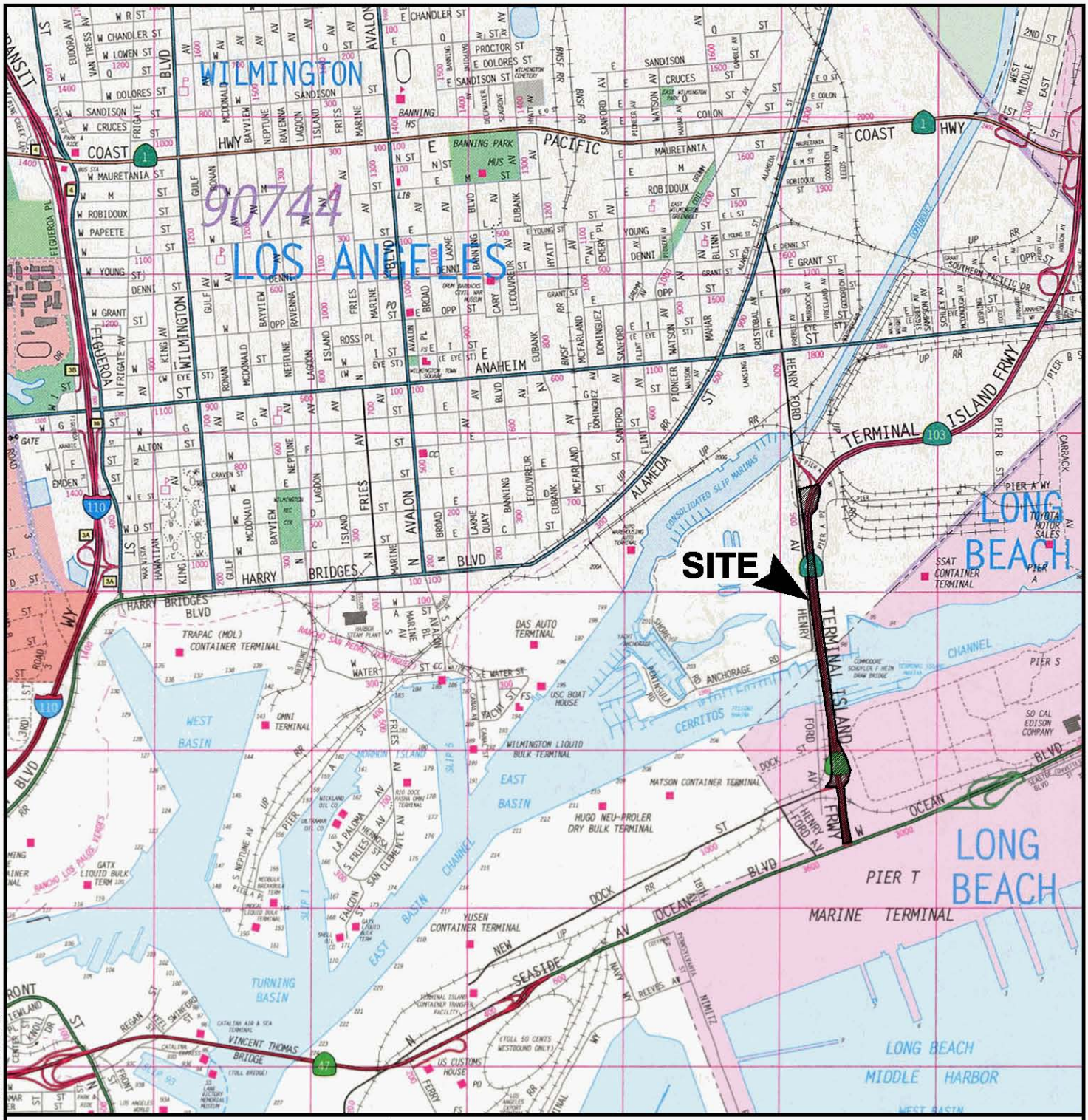
LABORATORY REPORTS

DRAFT

APPENDIX F

WASTE MANIFEST

[PENDING]



207940_A1.DWG

REFERENCE: 2007 THOMAS GUIDE FOR LOS ANGELES/ORANGE COUNTIES, STREET GUIDE AND DIRECTORY

APPROXIMATE SCALE IN FEET

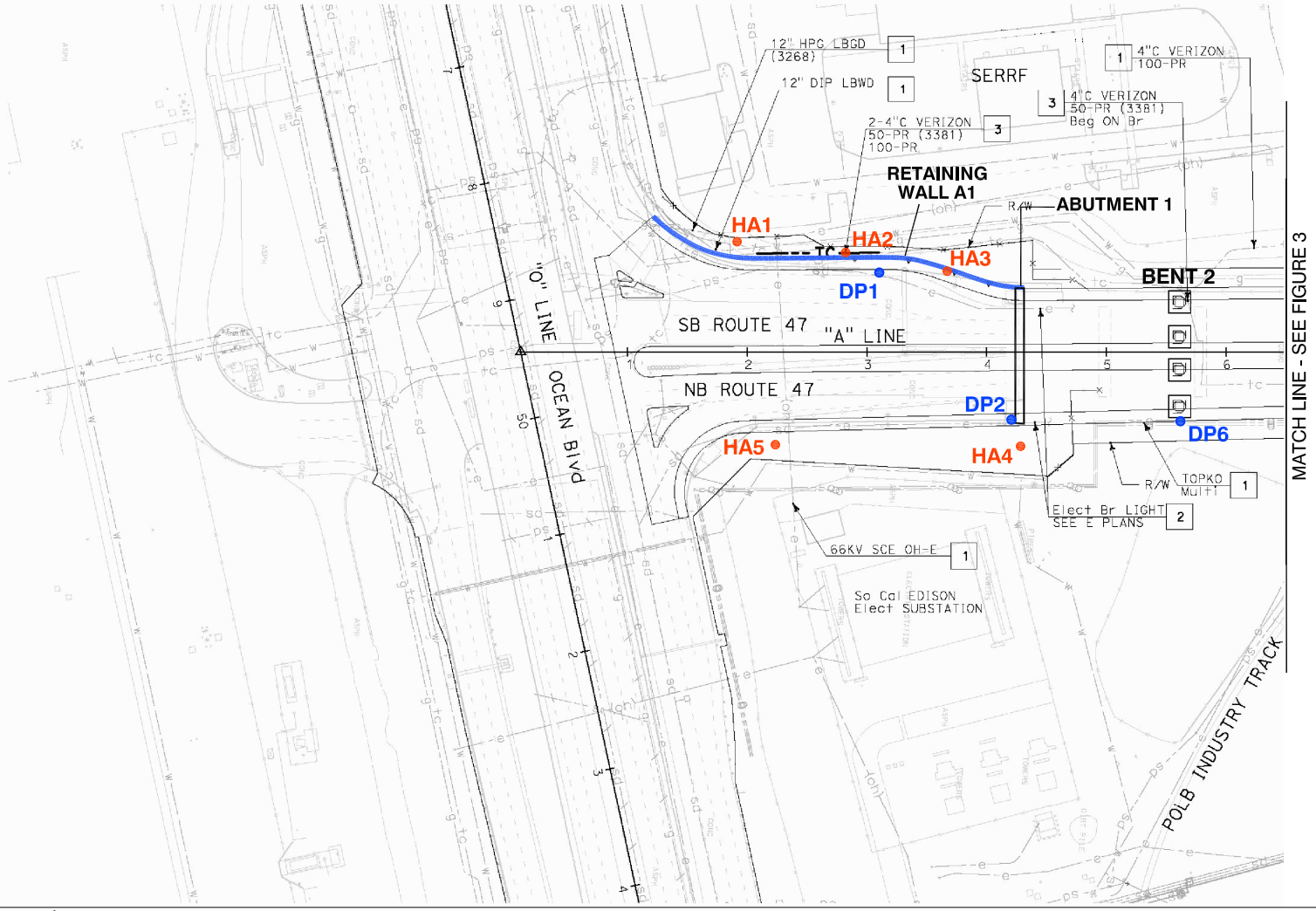
0 2400 4800

N

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Map © Rand McNally, R.L.07-S-129

Ninyo & Moore	SITE LOCATION MAP	FIGURE
PROJECT NO.	DATE	SCHUYLER HEIM BRIDGE LONG BEACH, CALIFORNIA	1
207940001	7/10	



REFERENCE: PLAN PROVIDED BY CALTRANS, 9/11/2008.

LEGEND	
●	DIRECT PUSH BORING TO 15' BGS
●	HAND AUGER BORING TO 5' BGS
BGS	BELOW GROUND SURFACE

N

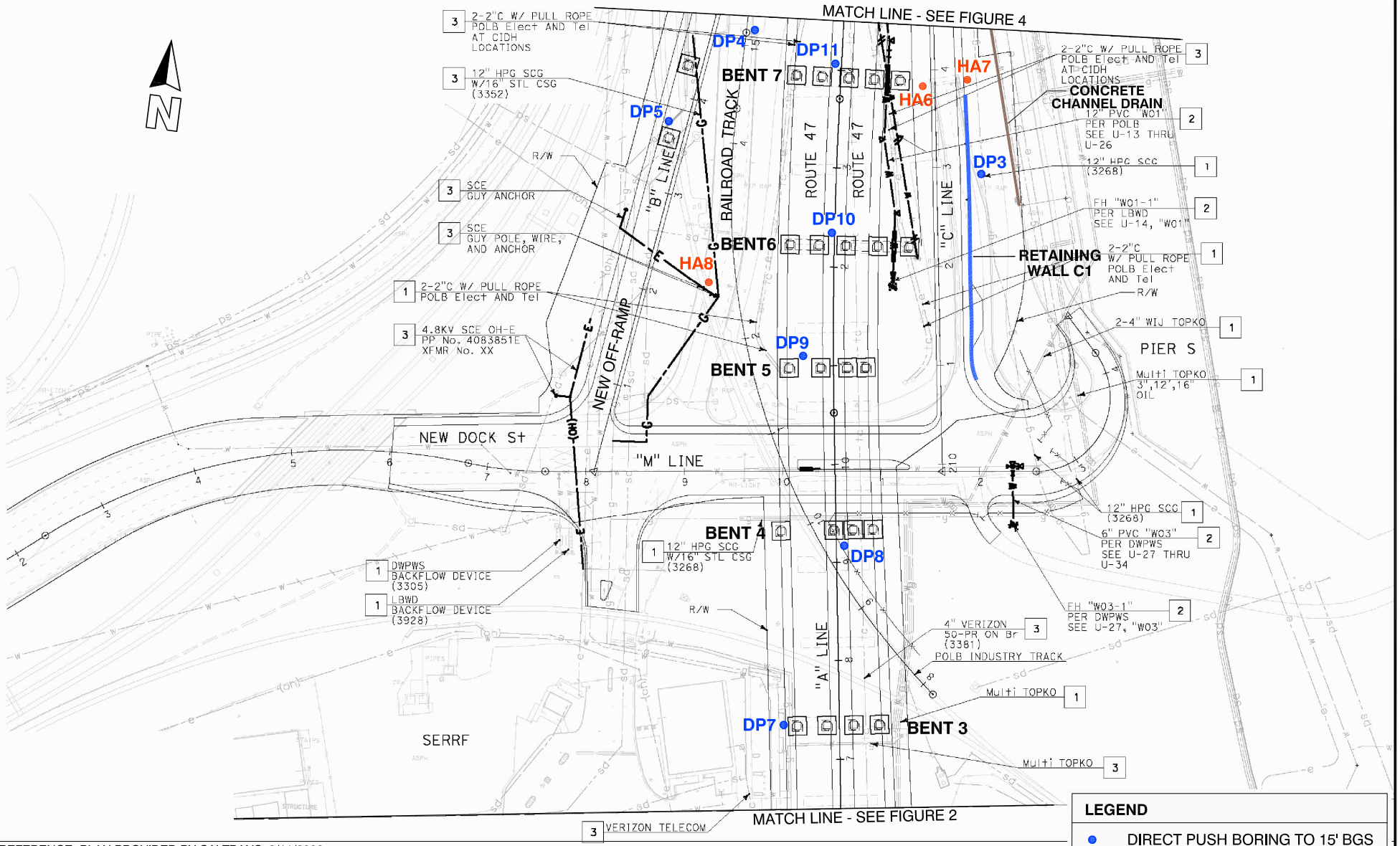
APPROXIMATE SCALE IN FEET

0 140 280

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Ninyo & Moore	PROPOSED BORING LOCATION MAP	FIGURE
PROJECT NO. 207940001 / DATE 7/10	SCHUYLER HEIM BRIDGE PORT OF LONG BEACH, CALIFORNIA	2

207940_A13.DWG



REFERENCE: PLAN PROVIDED BY CALTRANS, 9/11/2008.

LEGEND

- DIRECT PUSH BORING TO 15' BGS
- HAND AUGER BORING TO 5' BGS

BGS BELOW GROUND SURFACE

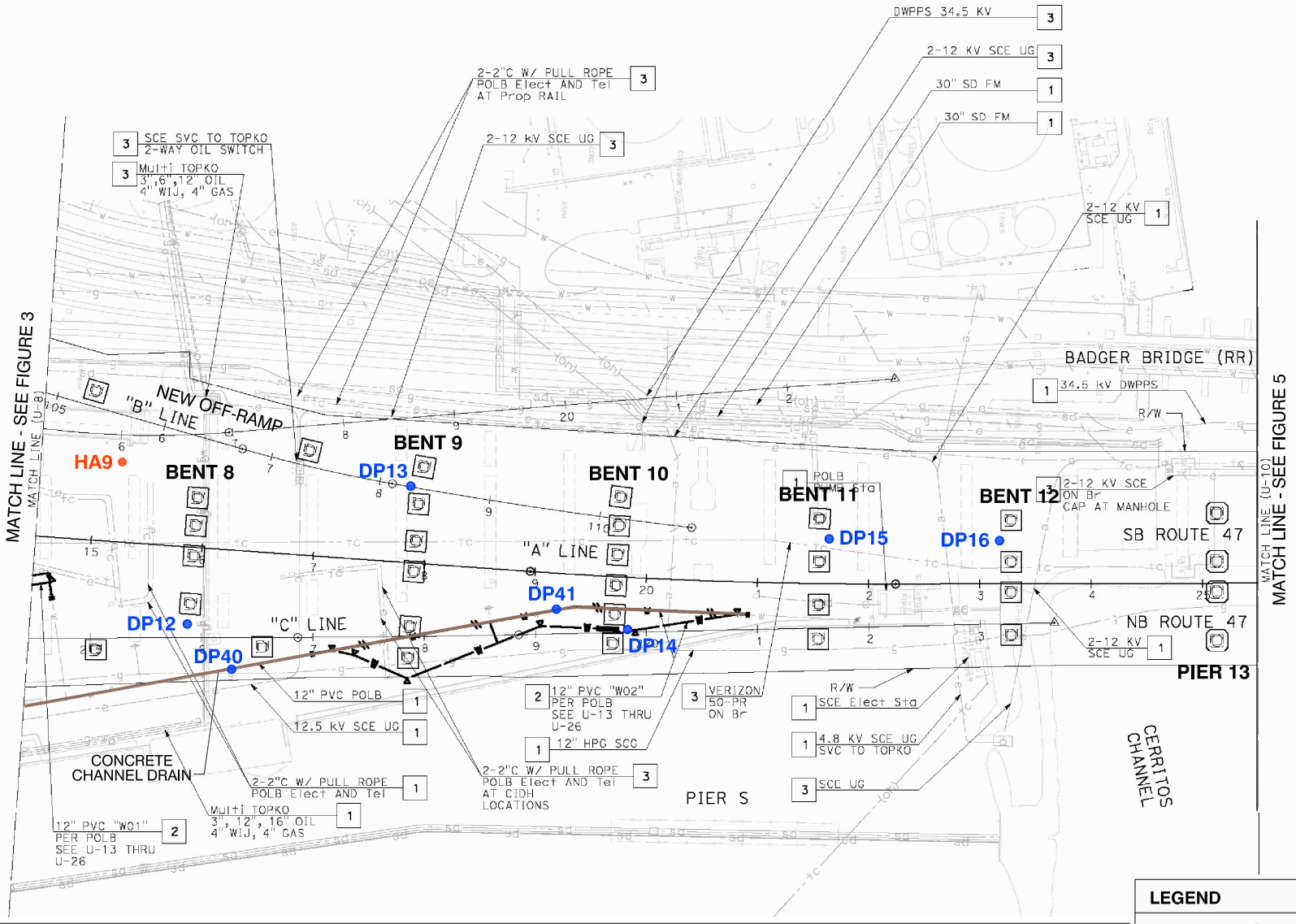
APPROXIMATE SCALE IN FEET

0 140 280

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Ninyo & Moore	PROPOSED BORING LOCATION MAP	FIGURE
PROJECT NO. 207940001 / DATE 7/10	SCHUYLER HEIM BRIDGE PORT OF LONG BEACH, CALIFORNIA	3

207940_A14.DWG



LEGEND

- DIRECT PUSH BORING TO 15' BGS
- HAND AUGER BORING TO 5' BGS

BGS BELOW GROUND SURFACE

N

APPROXIMATE SCALE IN FEET

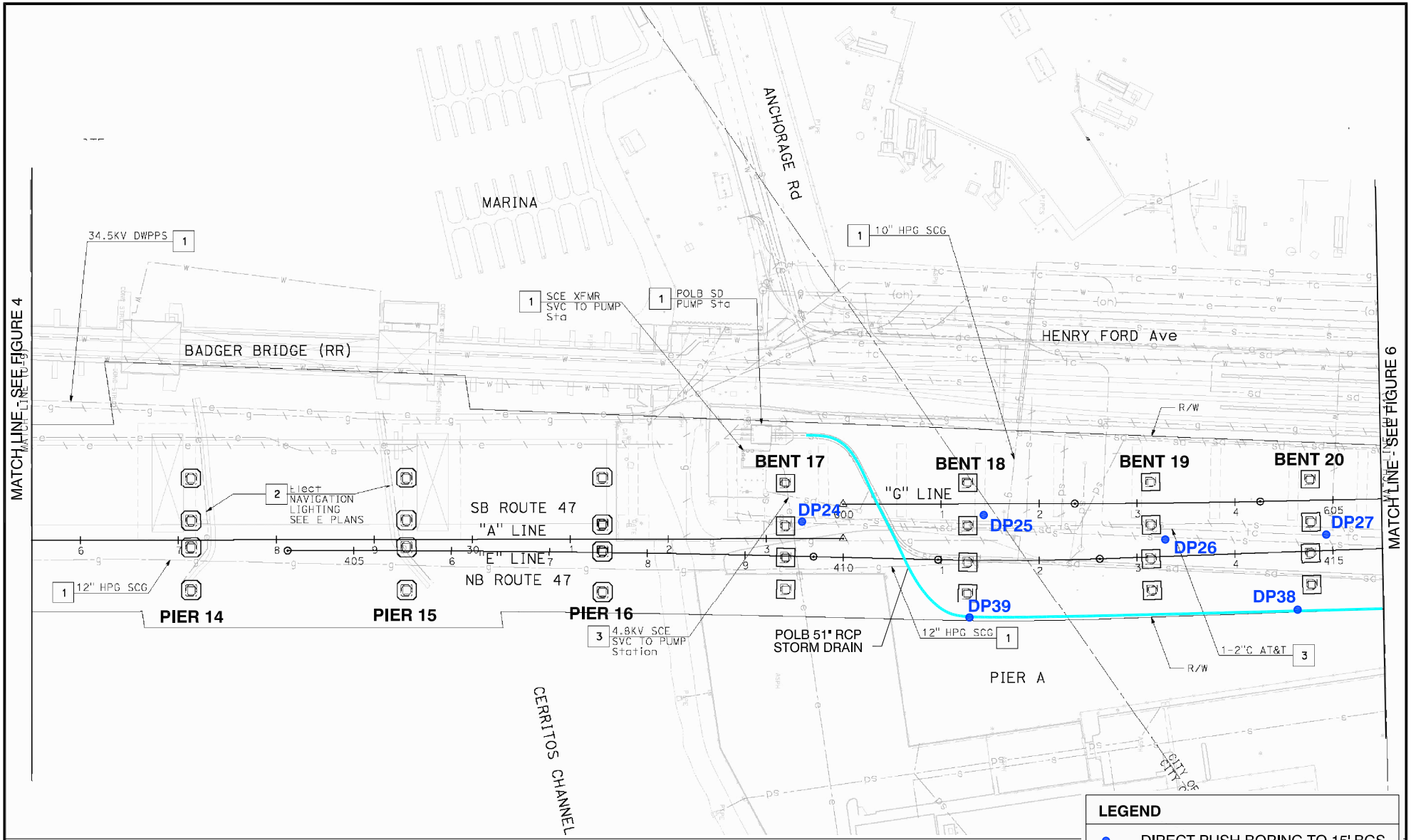
0 140 280

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: PLAN PROVIDED BY CALTRANS, 9/11/2008.

207940_A15.DWG

Ninyo & Moore	PROPOSED BORING LOCATION MAP	FIGURE
PROJECT NO. 207940001 / DATE 7/10	SCHUYLER HEIM BRIDGE PORT OF LONG BEACH, CALIFORNIA	4



LEGEND

●	DIRECT PUSH BORING TO 15' BGS
BGS	BELOW GROUND SURFACE
POLB	PORT OF LONG BEACH

207940_A16.DWG

N

APPROXIMATE SCALE IN FEET

0 140 280

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: PLAN PROVIDED BY CALTRANS, 9/11/2008.

Ninyo & Moore

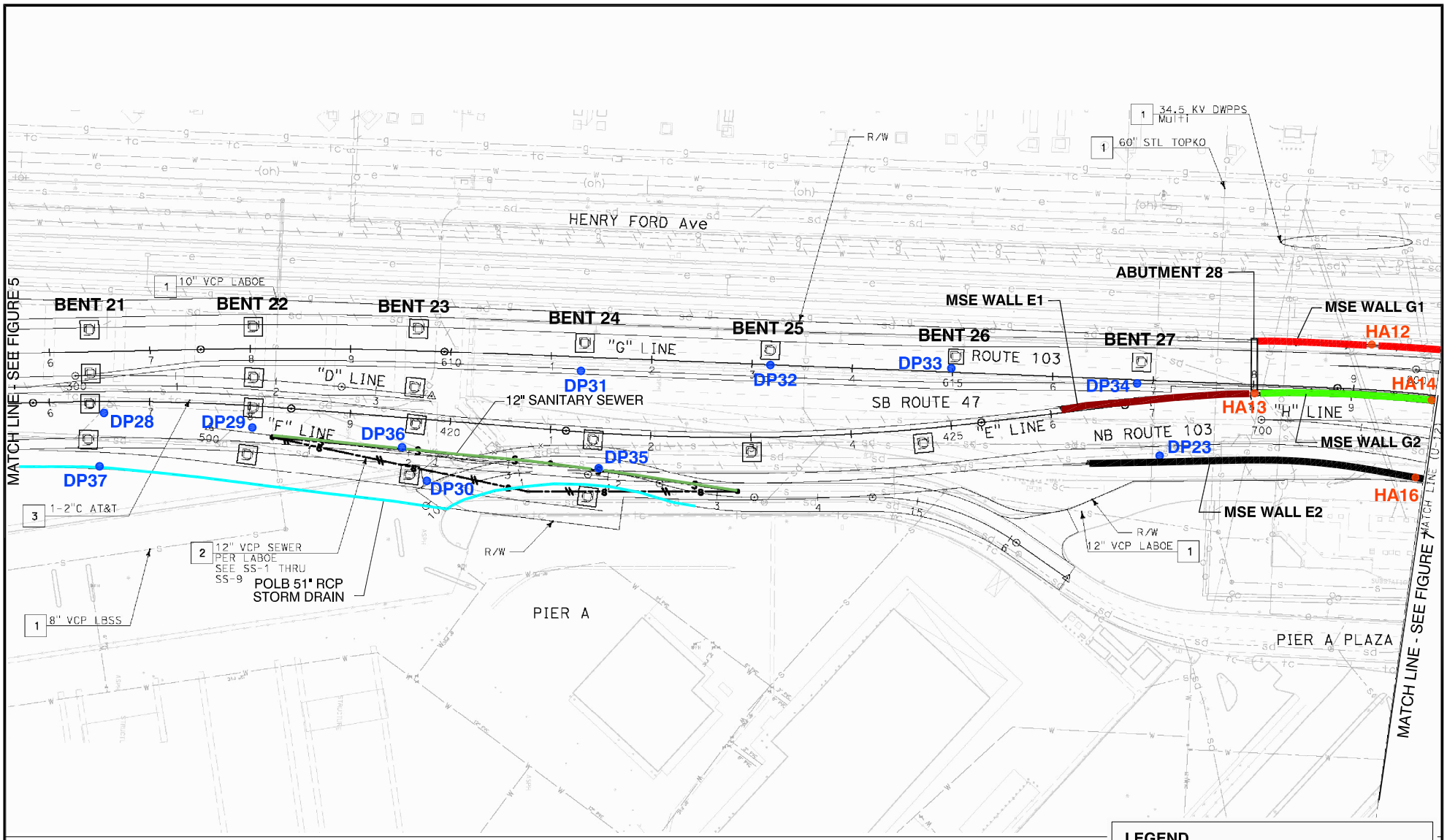
PROJECT NO.	DATE
207940001	7/10

PROPOSED BORING LOCATION MAP

SCHUYLER HEIM BRIDGE
PORT OF LONG BEACH, CALIFORNIA

FIGURE

5



LEGEND	
●	DIRECT PUSH BORING TO 15' BGS
●	HAND AUGER BORING TO 5' BGS
BGS	BELOW GROUND SURFACE

N

APPROXIMATE SCALE IN FEET

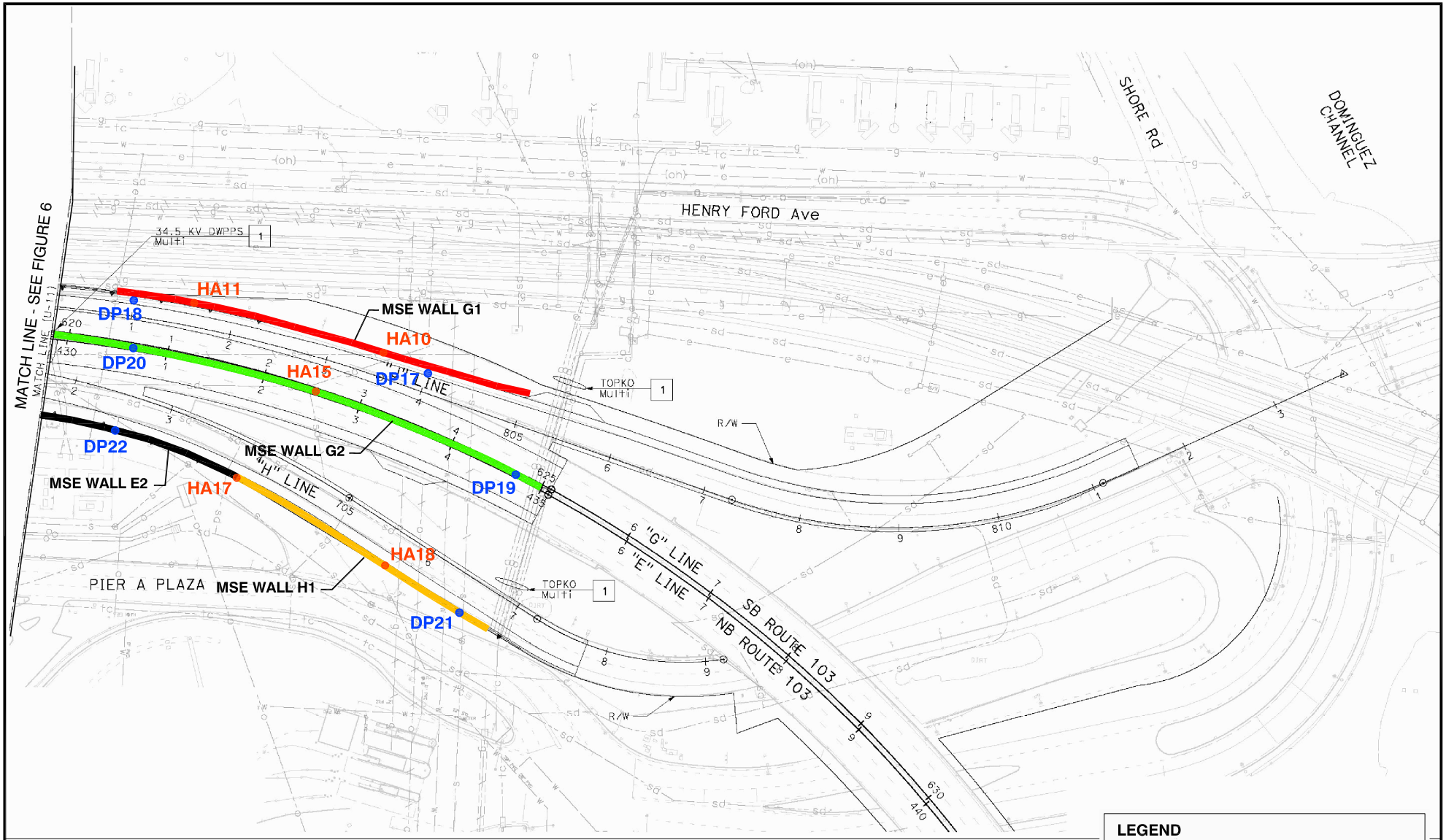
0 140 280

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: PLAN PROVIDED BY CALTRANS, 9/11/2008.

Ninyo & Moore	PROPOSED BORING LOCATION MAP	FIGURE
PROJECT NO. 207940001 / DATE 7/10	SCHUYLER HEIM BRIDGE PORT OF LONG BEACH, CALIFORNIA	6

207940_A17.DWG



207940_A18.DWG

LEGEND

- DIRECT PUSH BORING TO 15' BGS
- HAND AUGER BORING TO 5' BGS

BGS BELOW GROUND SURFACE

N

APPROXIMATE SCALE IN FEET

0 140 280

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: PLAN PROVIDED BY CALTRANS, 9/11/2008.

Ninyo & Moore	PROPOSED BORING LOCATION MAP	FIGURE
PROJECT NO. 207940001 / DATE 7/10	SCHUYLER HEIM BRIDGE PORT OF LONG BEACH, CALIFORNIA	7

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 7, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, NB SR 103 Off-Ramp, Bridge No. 53-3034K Los Angeles County, California, (7-LA-47, PM 0.01, EA 238501)***

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject bridge. This report presents the results of our analyses and recommendations for design and construction of the bridge foundation for the subject bridge replacement.

The Foundation Report for the subject bridge, dated February 8, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on March 23, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on April 20, 2010. OGDS-1 review comments and EMI responses are included in Appendix I. The responses to these review comments have been incorporated into this Final Foundation Report.

We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

REGISTERED PROFESSIONAL ENGINEER
ERIC BROWN
NO. GE 2806
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(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
NB SR 103 OFF-RAMP, BRIDGE NO. 53-3034K
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.01, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 7, 2010

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End of Text – Log-of-Test-Borings (LOTB) Sheets and As-Built LOTB

APPENDICES

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1.0 INTRODUCTION

1.1 Purpose and Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed State Route-103 Off-Ramp in Los Angeles County, California (Bridge No. 53-3034K). The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analysis and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the replacement of the SR-103 Off-Ramp structure (Figure 2).

The proposed SR-103 Street Off-Ramp is a three-span Cast-in-Place (CIP) prestressed concrete box girder bridge supported on a single seat type abutment and two single-column bents. The south end of the structure terminates at an expansion joint where the SR-103 Off-Ramp abuts the mainline structure approximately 25 ft north of Bent 24 of the mainline. The bridge deck varies in width up to about 42 ft and is approximately 443 ft long.

The typical bridge bent has a single column with each column supported on a single 12 ft diameter Type II cast-in-drilled-hole (CIDH) pile. The abutments are supported on 2.5-foot diameter CIDH piles.

1.3 Existing Bridge Information

The existing Schuyler Heim Bridge is a 45-span structure, is approximately 3,975 feet long and varies from about 80 to 130 feet in width. SR-47 connects to SR-103 via at-grade ramps to the north of the existing northern bridge abutment (Abutment 45) so there are currently no SR-103 connector ramp bridges. Abutment 45 of the existing Schuyler Heim Bridge is located about 275 ft south of the southern most bent (Bent 25) of the proposed SR-103 Off-Ramp bridge.

Based on the as-built plans, the existing bridge is supported on a combination of timber piles and 14BP73 driven steel piles. Steel piles with a design loading of 40 tons are used at the abutments and timber piles with a design loading of 22 tons are used at the bents.

Copies of selected sheets from the as-built drawings for the existing Schuyler Heim Bridge relevant to the SR-103 Off-Ramp are provided in Appendix A.

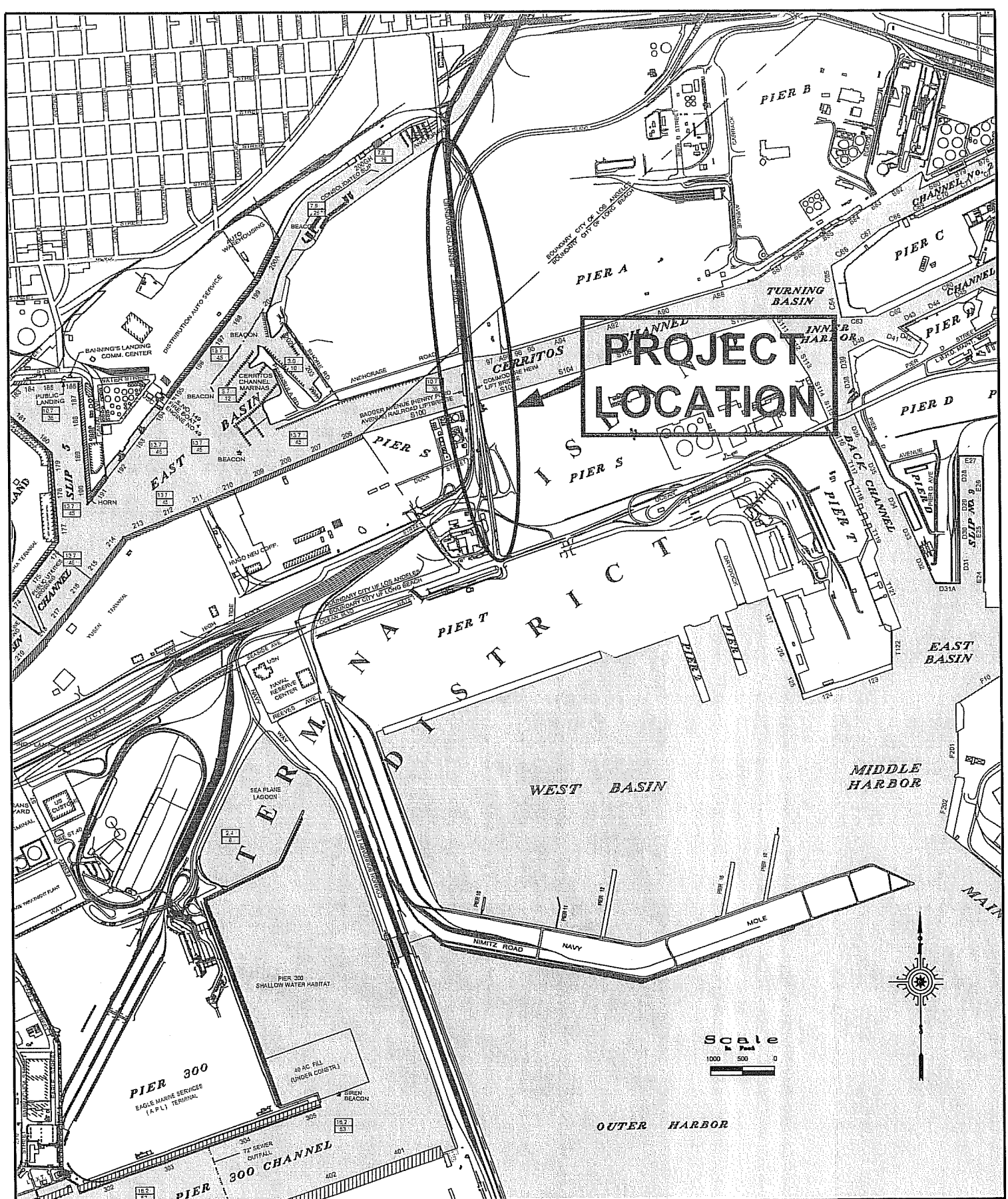
1.4 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed SR-103 Off-Ramp bridge. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



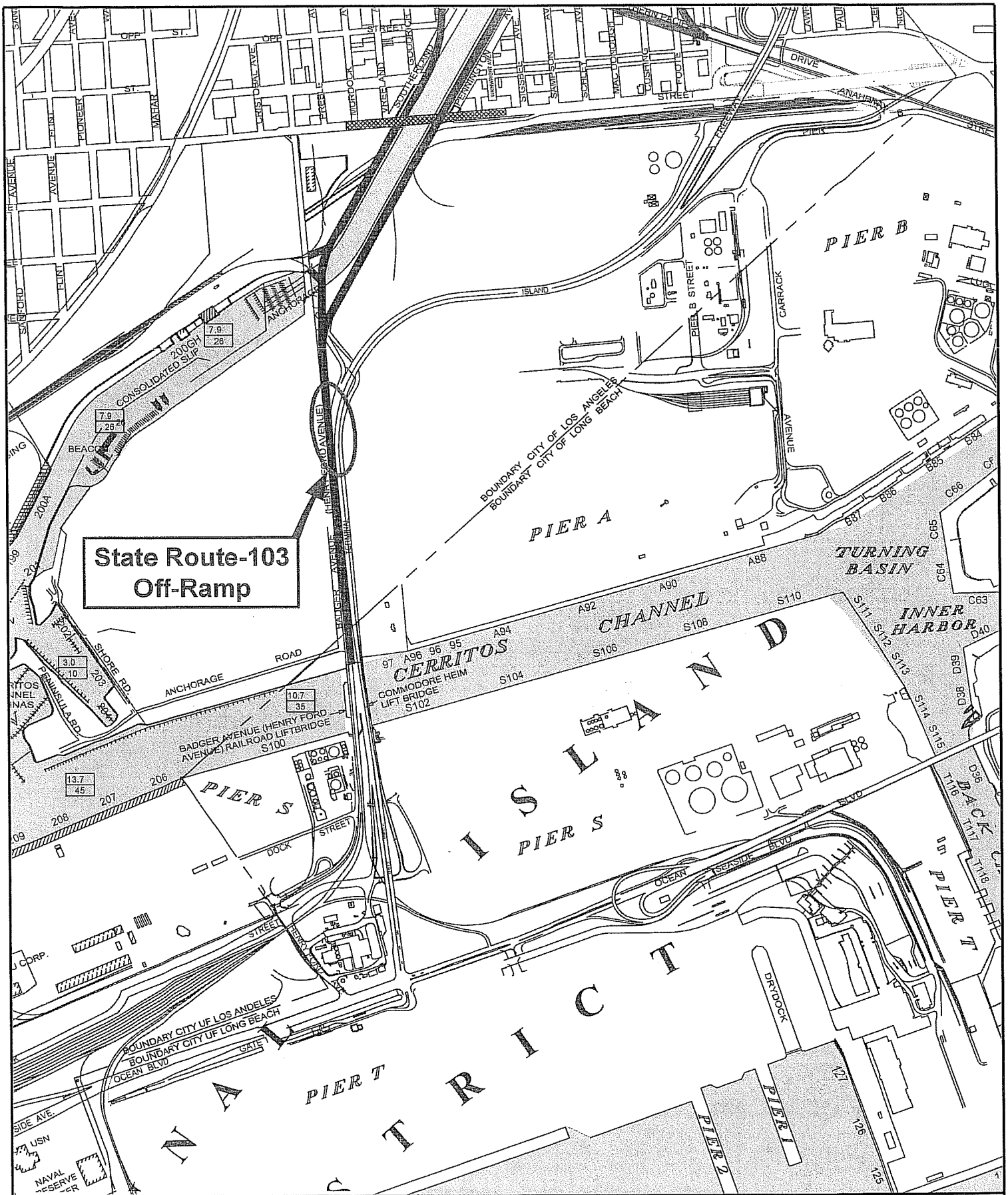
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123 | Date: 5-07-10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-07-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of the SR-103 Off-Ramp were those shown on the on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and borings, the nearest exploration to the proposed bridge is a CPT that was performed approximately 300 ft south of the southern most bent (Bent 25). That CPT sounding penetrated to a depth of 100 ft below existing grade with a deepest penetration to an elevation of -102 ft.

Copies of the LOTB sheets prepared by LKR for the seismic retrofit study are provided in Appendix B.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, three rotary wash borings were performed in the vicinity of the SR-103 Off-Ramp. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed bridge supports. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

All three of the borings surrounding the proposed bridge were performed at grade on the shoulder of the existing northbound SR-103/SR47 ramp. The deepest boring penetrated down to about elevation -148 ft, approximately 155 ft below ground surface.

The borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4

inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal. A copy of the ES report is provided in Appendix C.

Boring geophysical measurements were also collected by GeoVision (GeoVision 2009) under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix D.

Table 1. Soil Exploration Information

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-030[2]	"E" Line	423+04.5	11.8 Rt	+6.8	-11.7	-149.2	RW
R-09-032[2]		424+79.5	2.3 Lt	+4.1	-9.9	-146.4	RW
R-09-033[1]		425+87.5	84.7 Rt	+6.1	-9.9	-94.9	RW

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3. GWE = Groundwater Elevation.
4. GSE = Ground Surface Elevation (estimated from topographic plans).
5. Top of Boring Elevation Based on NAVD88.
6. RW = Rotary Wash, CPT = Cone Penetration Test.

2.3 Laboratory Testing

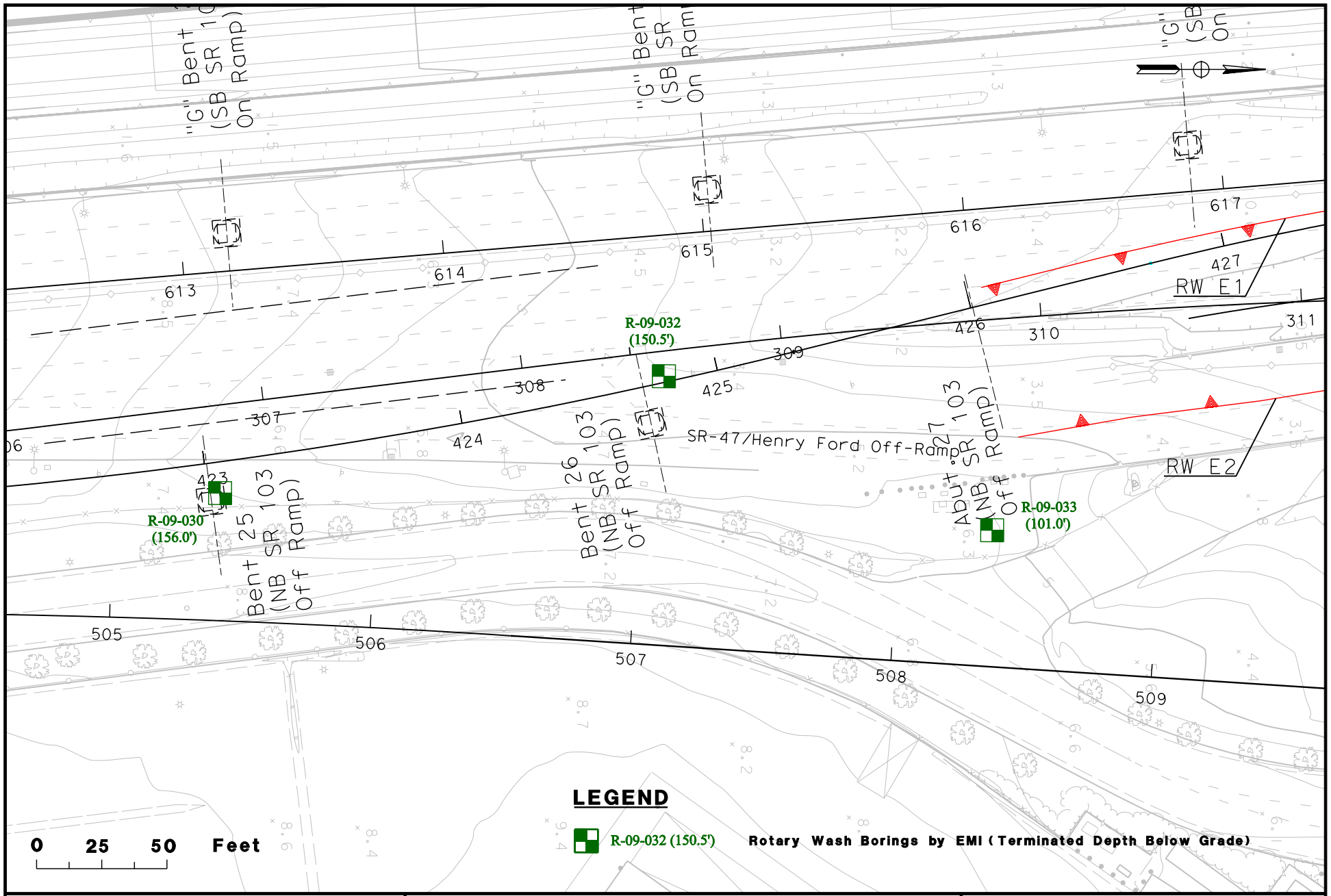
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of soils that exist at the site. Selected soil samples were tested to determine soil classification and physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. Test results are shown on the LOTB sheet at the end of the report and in tables in Appendix E.

Table 2. Explanation of Laboratory Tests Performed

Type of Test	Applicable Test Method	Purpose	Test Results Location
Dry Density	ASTM[1] D 2937	Estimate in-situ soil density	Appendix E
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content	Appendix E
No. 200 Wash	ASTM D 1140	Determine the percentage of fine grained particles of soil	Appendix E
Sieve & Hydrometer	ASTM D 422	Determine particle size distribution of soil	Appendix E
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil	Appendix E
Specific Gravity	ASTM D 854	Determine degree of saturation	Appendix E
Consolidation	ASTM D 2435	Determine compressibility of soil	Appendix E
UU Triaxial Test	ASTM D 2850	Estimate strength parameters of soil	Appendix E
Direct Shear	ASTM D 3080	Estimate strength parameters of soil	Appendix E
Soil pH	CT 532/643	Determine corrosion potential of soil	Appendix E
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil	Appendix E
Sulfate Content	CT 417	Determine corrosion potential of soil	Appendix E
Chloride Content	CT 422	Determine corrosion potential of soil	Appendix E

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Boring/CPT Sounding Location Map
	Project No. 06-123 / Date: 05-07-10	Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland

and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

Table 3. Stratigraphy and Correlation Chart, Long Beach Area

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	California Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks

rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

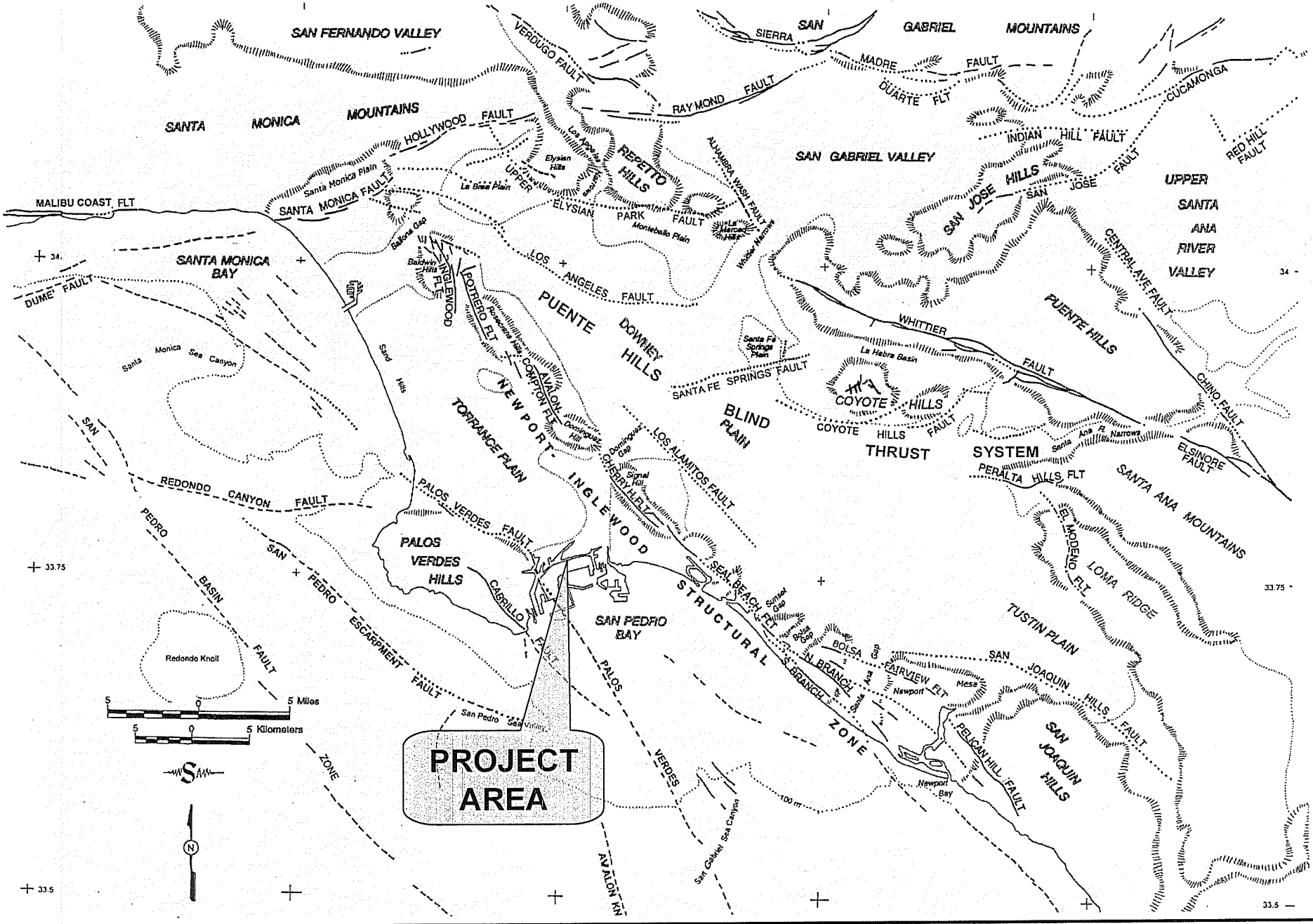
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

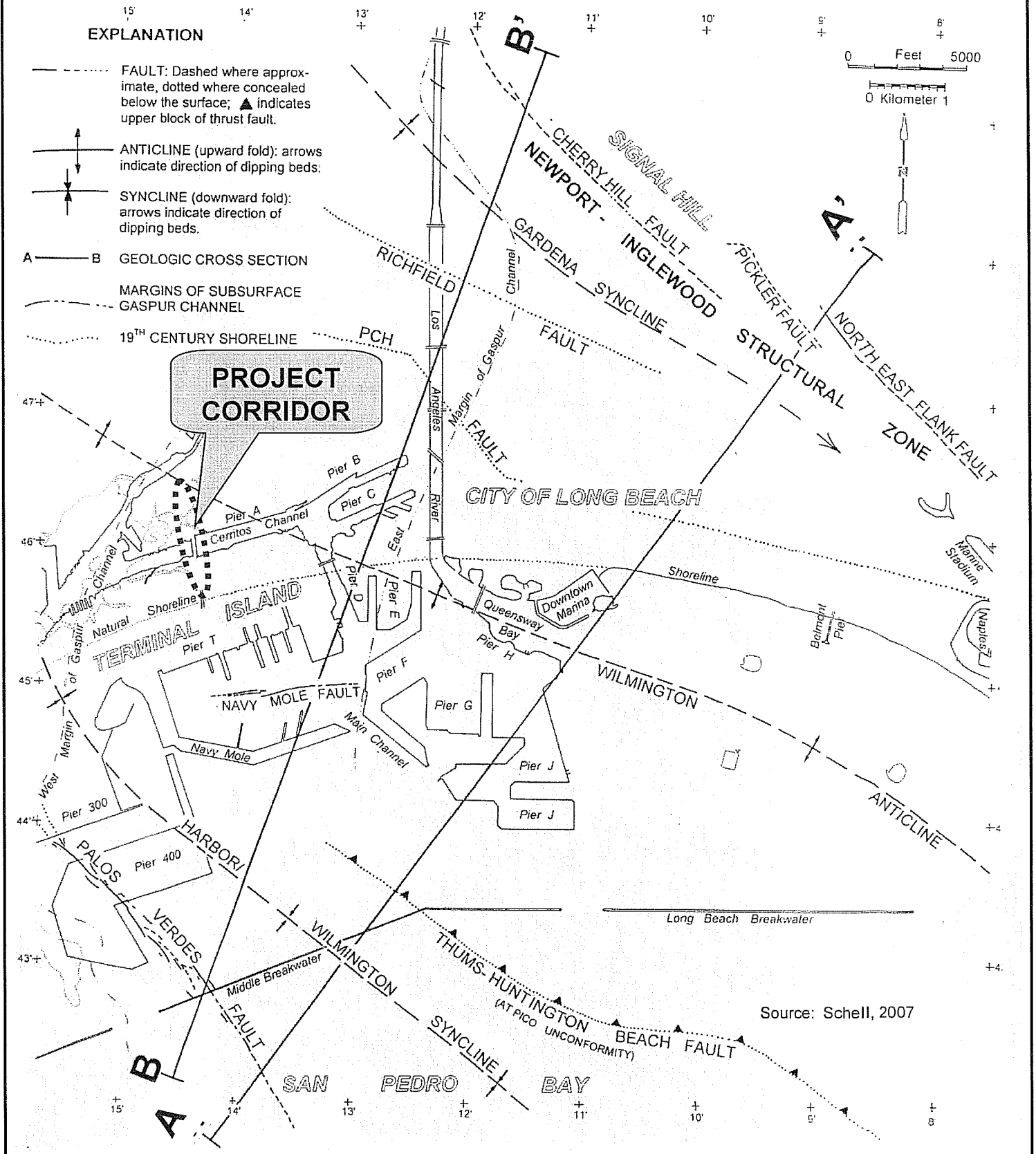
Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 5-07-10	Figure 4



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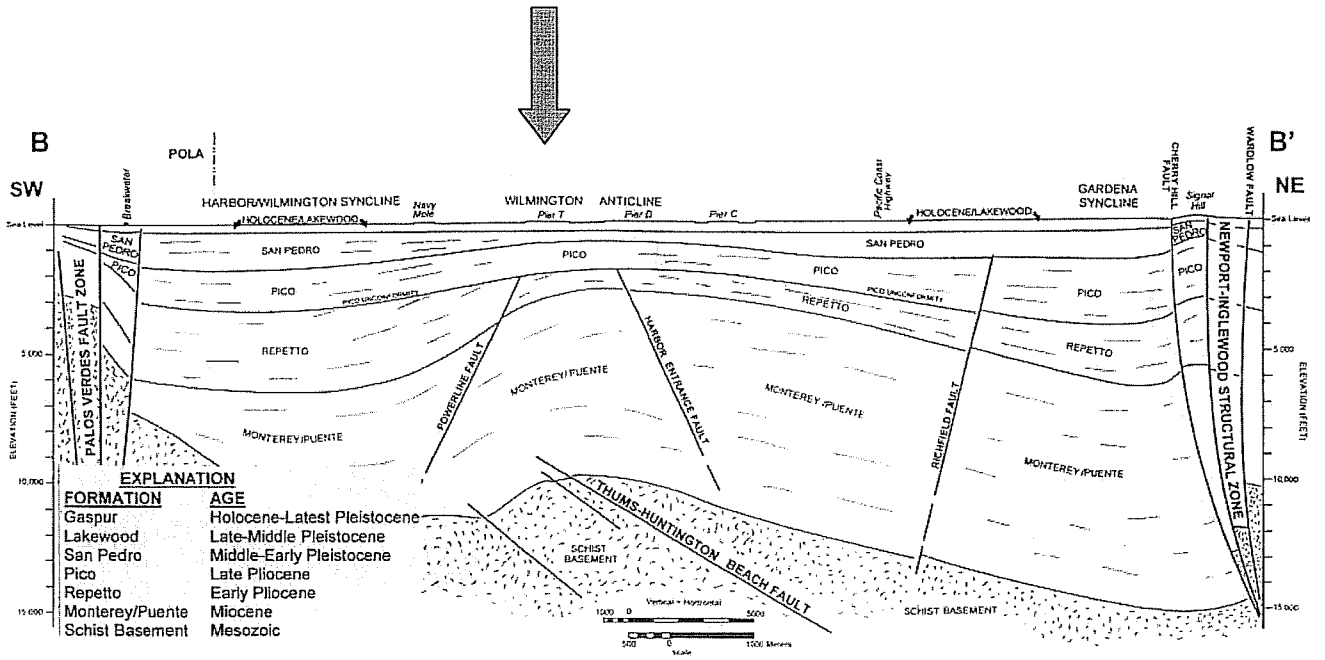
Structural Geology Map, Long Beach Harbor

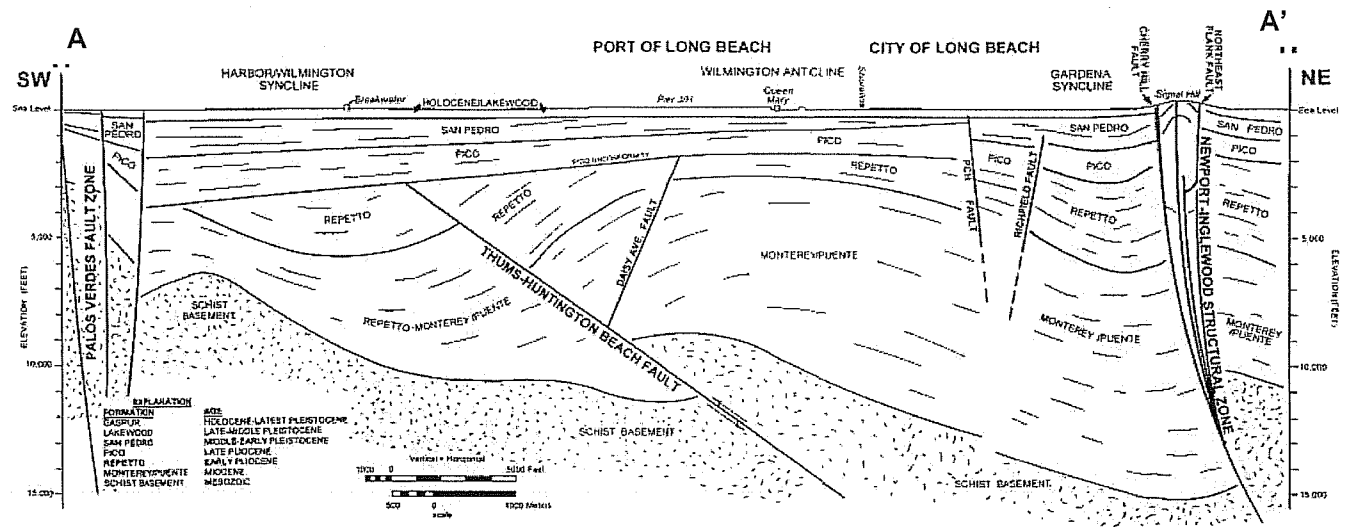
Figure 5

Project No. 06-123	Date: 5-07-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

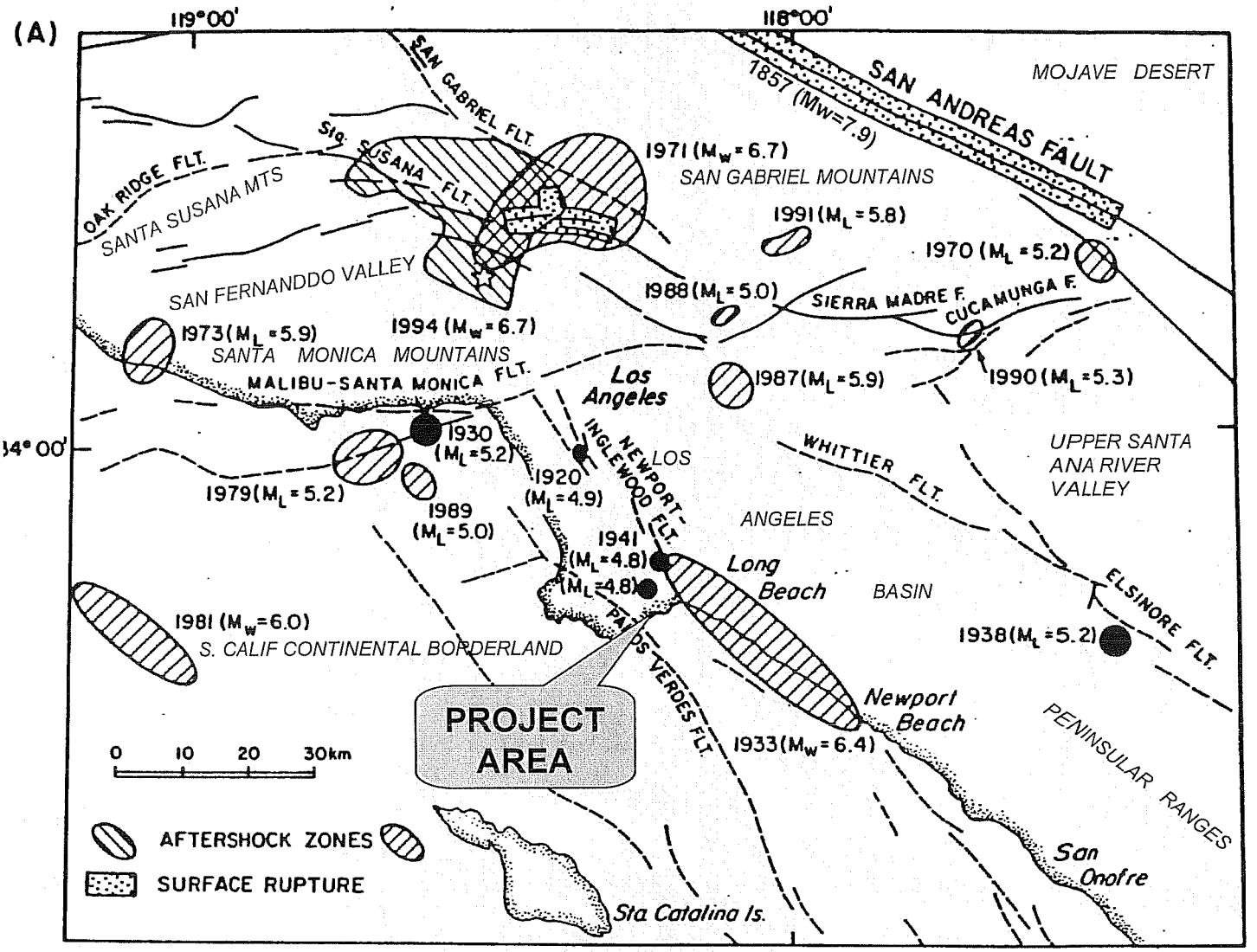


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

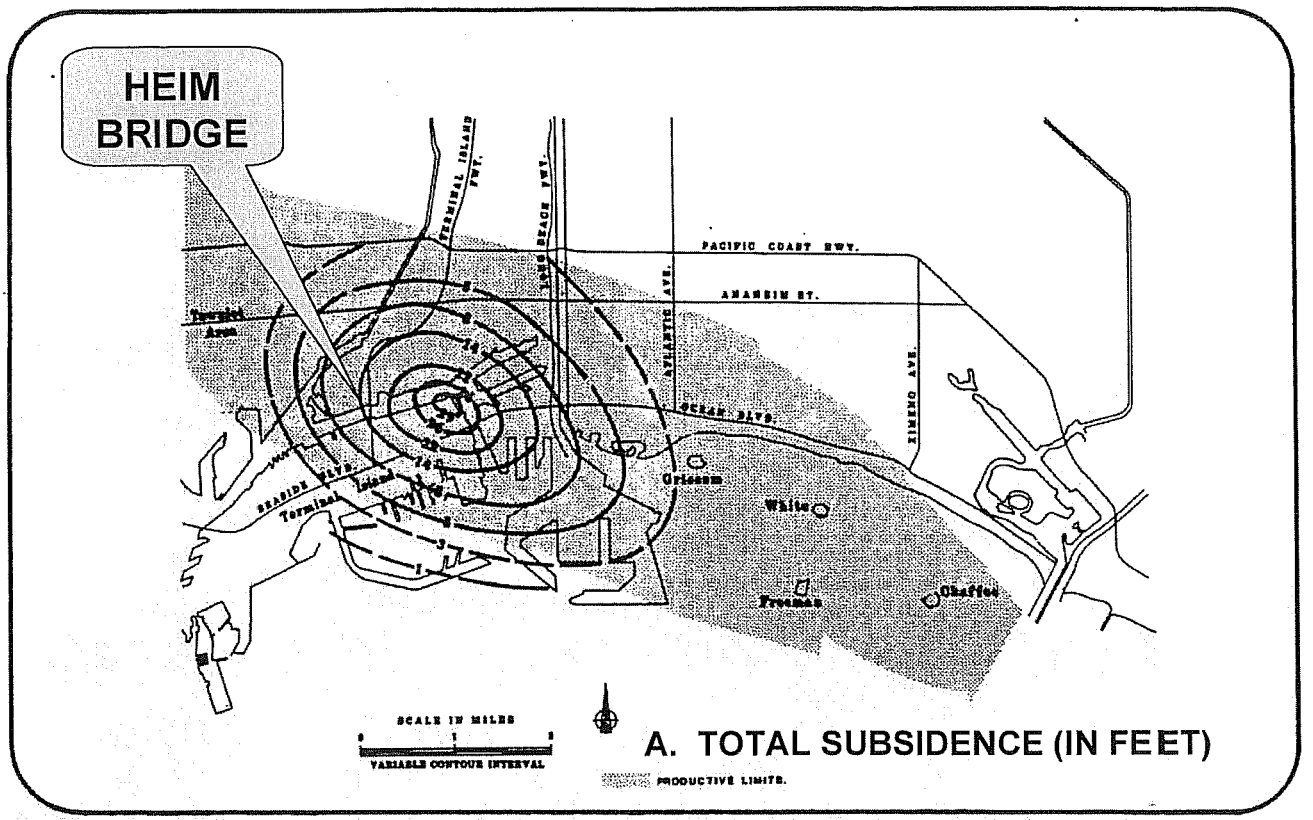
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-07-10	Geologic Cross-Sections, LA Harbor Figure 6

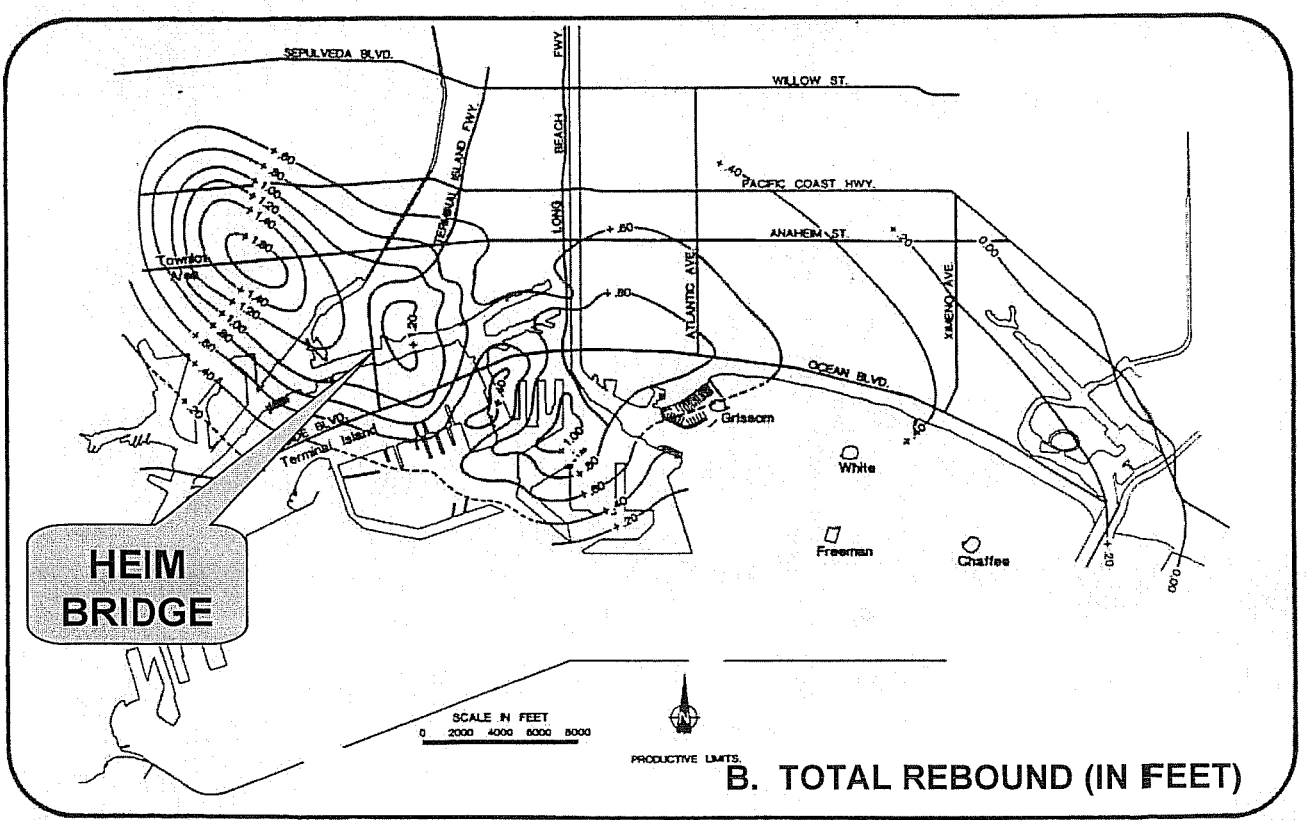


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-07-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

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Project No. 06-123	Date: 5-07-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT sounding (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -148 ft), the subsurface profile consists of about 50 to 60 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject bridge site, natural grade lies at an elevation of about zero, with a few feet of import fill for the existing northern approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +8 ft near SR-103 Off-Ramp Bent 25. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -4 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -60 ft. Below elevation -60 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in all five of the borings performed near the proposed structure between elevation -9.5 ft and -11.9 feet. The elevation that groundwater was encountered at in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. Due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

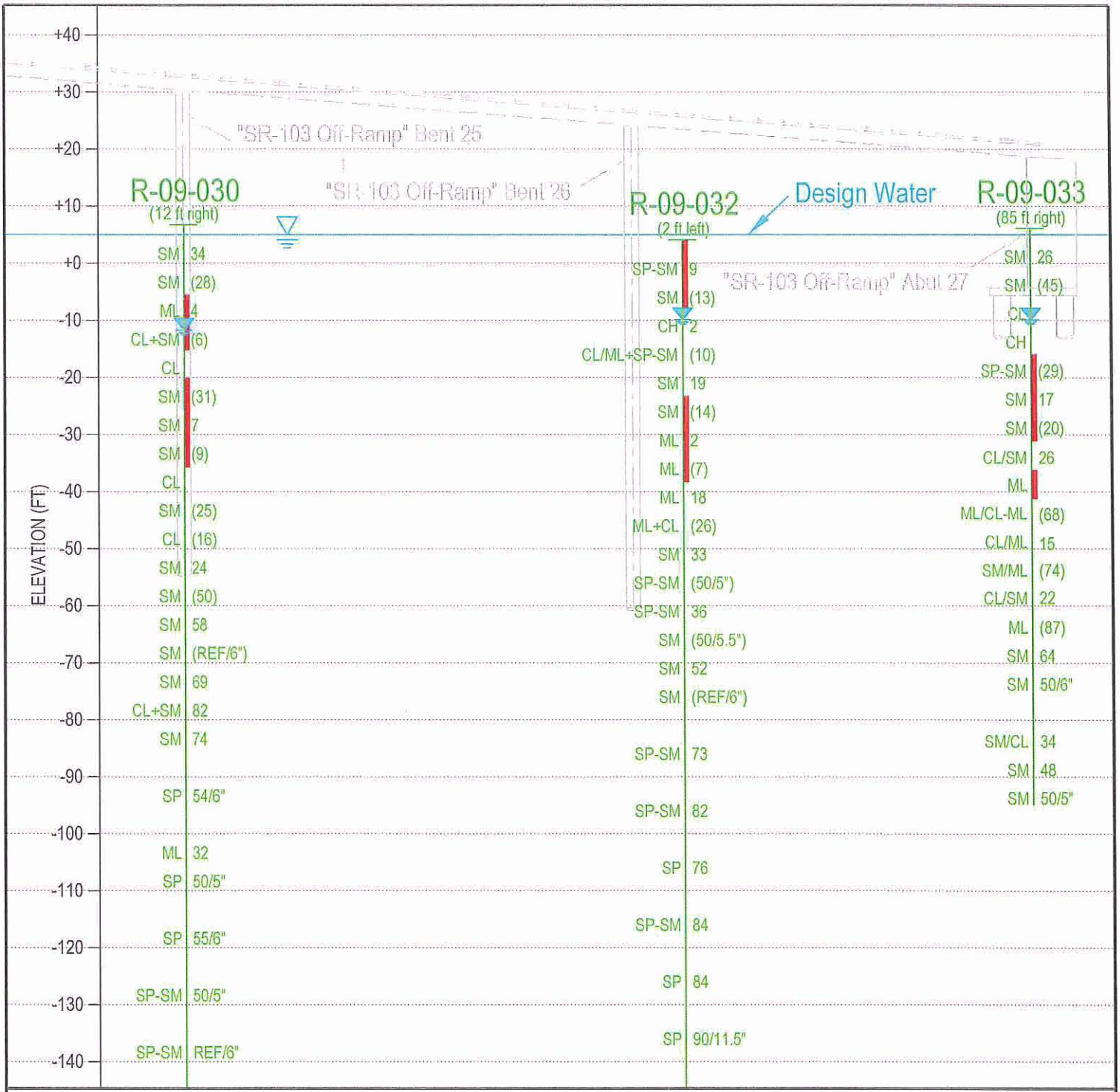
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

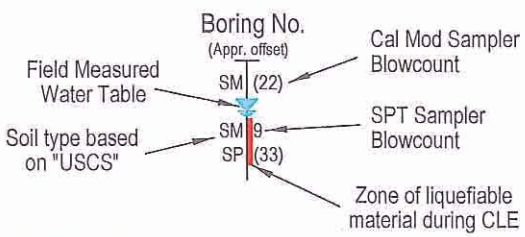
Based on information collected from borings R-09-030, R-09-032 and R-09-033 an idealized soil profile for foundation analysis and design was developed along the proposed bridge alignment. The subsurface profile beneath the proposed structure is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

Table 4. Idealized Soil Profile and Parameters

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+7.0 to -5.0	Sand with Silt / Silty Sand	120	0	33
-5.0 to -15.0	Silty Sand / Sandy Silt / Clay	120	0	30
-15.0 to -25.0	Silty Sand / Sandy Silt / Clay	120	700	0
-25.0 to -50.0	Silty Sand / Sandy Silt / Sand with Silt	120	0	32
-50.0 to -60.0	Silty Sand / Sand with Silt	125	0	34
-60.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Project No. 06-123 | Date: 5-07-10 | Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Study

A preliminary seismic evaluation was performed by EMI in 2006 and included in the Preliminary Foundation Report (EMI, 2006) based on the 2006 Seismic Design Criteria (SDC) (Caltrans, 2006d).

Using the 2006 SDC, the PBA was determined based on Caltrans Seismic Hazard Map (Mualchin, 1996a) and the attenuation relationship by Sadigh et al. (1997), as required by Caltrans (2006a). The controlling fault was found to be the Palos Verdes fault which is a strike-slip fault capable of generating a Maximum Credible Earthquake (MCE) of magnitude 7.0 and a PBA of 0.60g at the bridge site.

The standard ARS curve published in the 2006 SDC (Caltrans, 2006d) for this bridge site is shown on Figure B.8 for Soil Profile D (M = 7.25±0.25) and 0.6g. The standard ARS curve was modified to account for near-fault effects (a 20% increase of spectral accelerations for periods greater than 1 sec., no increase for periods less than 0.5 sec., and linear interpolation between 0.5 and 1 sec) per SDC Section 6.1.2.1

Figure 10 shows the recommended modified design ARS curve with coordinates as provided in the PFR (EMI, 2006).

During bridge type selection, Caltrans commented based on the PFR that due to the length of the proposed structure, a site specific ARS curve should be developed following completion of the project geotechnical investigation. It is our understanding that following approval of bridge type selection, preliminary design of the bridge proceeded using the preliminary ARS curve in anticipation that the site specific ARS curve would be completed in the early stages of final design.

As part of the EMI field investigation described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings for the entire project along the mainline bridge alignment. Using the results of shear wave velocity measurements, a site specific ground motion study was performed.

Results of the geotechnical field investigation and site specific ground motion study, following the procedures outlined in the latest Caltrans SDC (Caltrans, 2009) indicate that the preliminary ARS curve shown in Figure 10 plots well above the site specific ARS curve. Consequently, previously conducted analyses and design based on the preliminary seismic evaluation ARS curve are considered conservative and suitable for final design. The peak ground acceleration for the site was revised to 0.5 g based on the latest Caltrans SDC. The details of the ground motion study and the site specific ARS curve are summarized in a memorandum prepared by EMI and are included in Appendix F.

Ground Rupture. No known active faults traverse the surface of the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Liquefaction Potential and Seismically Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -60 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. Locations of potentially liquefiable material during the design earthquake are also identified in the subsurface profile shown in Figure 9.

Table 5. Liquefaction and Seismic Settlement Analysis Results

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-030	-5 to -15	3.6	7.7
	-20 to -35	4.1	
R-09-032	+4 to -10	2.2	7.5
	-22 to -38	5.3	
R-09-033	-16 to -31	3.1	3.2
	-37 to -42	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Five soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. In the performed tests, the pH varied from about 8.1 to 8.9, the minimum resistivity varied from about 330 to 630 ohm-cm, the soluble chloride content varied from about 605 to 1500 parts per million (ppm) and the soluble sulfate content varied from about 180 to 1900 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on these test results, the on-site soils are considered to be corrosive.

5.4 Scour

This site is located within an area that is generally flat and there are no rivers, creeks or channels that cross beneath the structure; therefore, scour is not considered a design issue.

5.5 Foundation Type

Due to presence of the weak near-surface soils and the potential for seismically induced settlement throughout the site, spread footings are not considered feasible for support of the proposed structure.

Site soils are conducive to either a driven or drilled pile foundation. Due to the presence of deep liquefiable layers, large diameter Cast-In-Drilled-Hole (CIDH) piles are better suited to resist the large lateral foundation demands than small diameter piles and large diameter piles are needed at bent locations to support the large axial pile demands. Based on the foundation loads provided by the designers, 12 ft diameter CIDH piles are recommended for support at the proposed structure bents and 2.5 ft diameter CIDH piles are recommended at the abutment. At the bent locations, a permanent steel casing from finished grade to a depth between 33 and 36 ft is also proposed.

5.5.1 Axial Pile Capacity

Per Caltrans policy, LRFD method is used for bent piles and WSD is used for abutment piles. The foundation design data sheet and factored foundation loads were estimated by the designers following the latest Caltrans Memo to Designers 3-1 (Caltrans, 2008), and are shown in Tables 6 and 7, respectively.

Table 6. Foundation Design Data Sheet

Location	Design Method	Pile Type	Finished Grade El. (ft)	Pile Cut-off El. (ft)	Pile Cap Size (ft)		Permissible Settlement under Service Load (in)	No. of Piles per Support
					B	L		
Bent 25	LRFD	12 ft CIDH	+7.0	0.0	NA	NA	1	2
Bent 26	LRFD	12 ft CIDH	+5.0	-3.0	NA	NA	1	2
Abut 27	WSD	2.5 ft CIDH	+1.0	-4.8	24	62.5	1	23

Axial CIDH pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). Axial driven steel shell capacities were calculated according to recommendations by Tomlinson (1987) and API (2000). The calculated factored axial geotechnical capacities and pile tip elevations for each 30-inch CIDH pile at the abutment and 12-ft CIDH pile at the interior bents are presented in Tables 8 and 9, respectively. For the extreme event limit case, negative skin friction due to seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The depth to the bottom of the liquefiable layer at each support was determined based upon the nearest boring information. The Pile Data Table is provided in Table 10. For bent piles, a resistance factor of 0.7 was applied per Caltrans LRFD guidelines.

Table 7. Foundation Design Loads

Location	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)			
	Total Load		Perm Load	Compression		Tension		Compression		Tension	
	Per Support	Max Per Pile	Per Support	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile
Bent 25	3,278	3,278	2,460	4,545	4,545	0	0	2,460	2,460	0	0
Bent 26	2,550	2,550	1,905	3,566	3,566	0	0	1,905	1,905	0	0
Abut 27	5,290	230	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes: 1. For bents with more than one support, the highest support/pile demand is listed in the table, as provided by the designer.

The maximum pile-head settlement due to the nominal resistance is estimated to be less than 1-inch at all supports. For axial loading, pile group effects can be neglected if the on-center spacing is equal to or greater than 4 times the pile diameter. A group reduction factor of 0.65 is applied for on-center spacing of 2.5 times the pile diameter. Based on interpolation over this range, an average group reduction factor of 0.87 was applied at the abutment.

Table 8. Foundation Recommendations for Abutments

Location	Pile Type	Cut-off El. (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip El. (ft)	Specified Tip El. (ft)
			Total	Permanent				
Abut 27	2.5 ft CIDH	-4.8	5,290	NA	230	460	-74 (a) -56 (c) -49 (d)	-74

Notes: 1. Design tip elevations are controlled by: (a) Compression, (b) Tension, (c) Settlement, (d) Lateral Load.
2. The specified tip elevation shall not be raised.

Table 9. Foundation Recommendations for Bents

Location	Pile Type	Cut-off El. (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				Design Tip El. (ft)	Specified Tip El (ft)	Steel Casing Specified Tip El. (ft)	Steel Casing Nominal Driving Resistance Required ((kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 25	12 ft CIDH	0.0	3,278	1	4,545	0	2,460	0	-117 (a-I) -95 (a-II) -70 (c) -80 (d)	-117	-25	520
Bent 26	12 ft CIDH	-3.0	2,550	1	3,566	0	1,905	0	-102 (a-I) -95 (a-II) -77 (c) -83 (d)	-102	-28	510

Notes: 1. Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (a-II) Compression (Extreme Event Limit), (b) Tension, (c) Settlement, (d) Lateral Load.

2. The specified tip elevation shall not be raised.

Table 10. Pile Data Table

Support	Pile Type	Nominal Resistance (kip)		Nominal Resistance (Driven Steel Shell) (kip)		Steel Casing Specified Tip Elevation (ft)	CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Comp	Tens	Comp	Tens				
Bent 25	12 ft CIDH	6490	0	520	0	-25	-117 (a) -70 (c) -80 (d)	-117	520
Bent 26	12 ft CIDH	5090	0	510	0	-28	-102 (a) -77 (c) -83 (d)	-102	510
Abut 27	2.5 ft CIDH	460	0	NA	NA	NA	-74 (a) -56 (c) -49 (d)	-74	NA

Notes: 1. Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

2. The specified tip elevation shall not be raised.

5.5.2 Lateral Pile Capacity

Abutments. Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a fixed-head connection with the pile cap are provided in Tables 11 and 12 for the Service Limit State and the Extreme Event Limit State, respectively. The design tip elevations for lateral loading are given in Table 10.

Lateral pile analyses were performed using the computer program LPILE (Ensoft 2007). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000). The internally generated p-y curves for stiff fine-grained soils were estimated using the method proposed by Reese (Reese et al., 1975), and the internally generated p-y curves for soft fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.75 was used in the analysis based on the pile layout provided by the designers and the procedures outlined in the Ensoft Group 7.0 software Technical Manual (Ensoft 2006). Under seismic conditions, liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008).

The solutions presented are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and other connection details.

Table 11. Abutment 27, 30-in CIDH Pile "Fixed" Head Solution: Service Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	164	7,206

Notes: 1. Group effects considered with a reduction factor of 0.75 on "p."
2. Static strength parameters used in all soil layers.
3. A cracked section modulus of 80% of EI was used in the analysis.

Bents. The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time that included a general description of the subsurface conditions beneath the proposed structure and eight idealized soil profiles along the proposed alignment. It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared.

Table 12. Abutment 27, 30-in CIDH Pile "Fixed" Head Solution: Extreme Event Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	40	2,653
0.5	71	4,735
1.0	115	8,202
3.0	193	17,728

Notes: 1. Group effects considered with a reduction factor of 0.75 on "p."

2. Liquefied strength parameters used in liquefiable soil layers.

3. A cracked section modulus of 50% of EI was used in the analysis.

Based on the current geotechnical investigation and updated soil profile, an additional project specific lateral pile analysis was also performed. Results from that analysis indicate that the p-y curves generated from the soil profiles presented in the PFR are suitable for use in the final design. The current results either generate a more conservative lateral pile response than the p-y curves developed by Caltrans based on the PFR, or a lateral pile response that is within an acceptable design tolerance. Details of the lateral pile analysis and a comparison between the preliminary and updated p-y curves are included in a memorandum prepared by EMI. The memorandum is included in Appendix G. The preliminary p-y curves generated from the soil profiles in the PFR which were determined to be suitable for use in final design for Bent 24 to Bent 27 are provided in Appendix H.

5.6 Bridge Abutment Walls

5.6.1 Earth Pressures

An active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf are recommended for a level abutment backfill. If abutment walls are free to move laterally at the top, a static active lateral earth pressure of 36 psf per ft of depth is recommended for a level backfill. If lateral movement at the top of abutment walls is restrained, the lateral pressure distribution has a trapezoidal shape with a maximum lateral pressure of 28.8H psf between 0.2H from the top and bottom of the wall, where H is the wall height in feet. A traffic surcharge equivalent to a vertical pressure produced by at least 2 ft of earth should be added to the above lateral earth pressure values. Other design requirements are specified in Section 3.20 of the Caltrans Bridge Design Specifications (Caltrans, 2004).

5.6.2 Passive Resistance

Under seismic loading, an ultimate passive earth pressure of 5 ksf may be used for the approach backfill and abutment backwalls with a height equal to or greater than 5.5 ft. For abutment backwalls with heights less than 5.5 ft, the maximum passive pressure may be calculated proportionally (e.g., for a 4 ft high backwall, the maximum passive pressure is [4/5.5]x5 ksf = 3.6 ksf). The horizontal movement at which the maximum passive pressure is expected to be

fully mobilized can be determined following the procedure outlined in Section 7.8.1 of the Caltrans SDC (2006d).

5.7 Approach Embankments

Up to about 20 ft of fill will be placed near the SR-103 Off-Ramp Abutment 27 in order to raise existing grade to proposed grade. The abutment end slope will be graded at an inclination of 1.5:1 (Horizontal:Vertical) with full slope paving. The bridge approach embankment will be a mechanically stabilized embankment (MSE) retained by Retaining Wall E1 along the western roadway edge and Retaining Wall E2 along the eastern roadway edge. Recommendations for Retaining Wall E1 and E2 are provided in a separate foundation report prepared by EMI (EMI, 2010).

5.7.1 Static Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed embankment approximately 25 ft behind the bridge abutment. Based on cross-sections provided by URS Corporation, the existing embankment at "E" Line Sta. 426+25 will be approximately 60 ft wide at roadway level and the embankment height is approximately 20 feet. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 4 inches. The settlement period is estimated to be about 13 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 5 weeks. For a 7-ft embankment surcharge, the settlement period is reduced to about 4 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

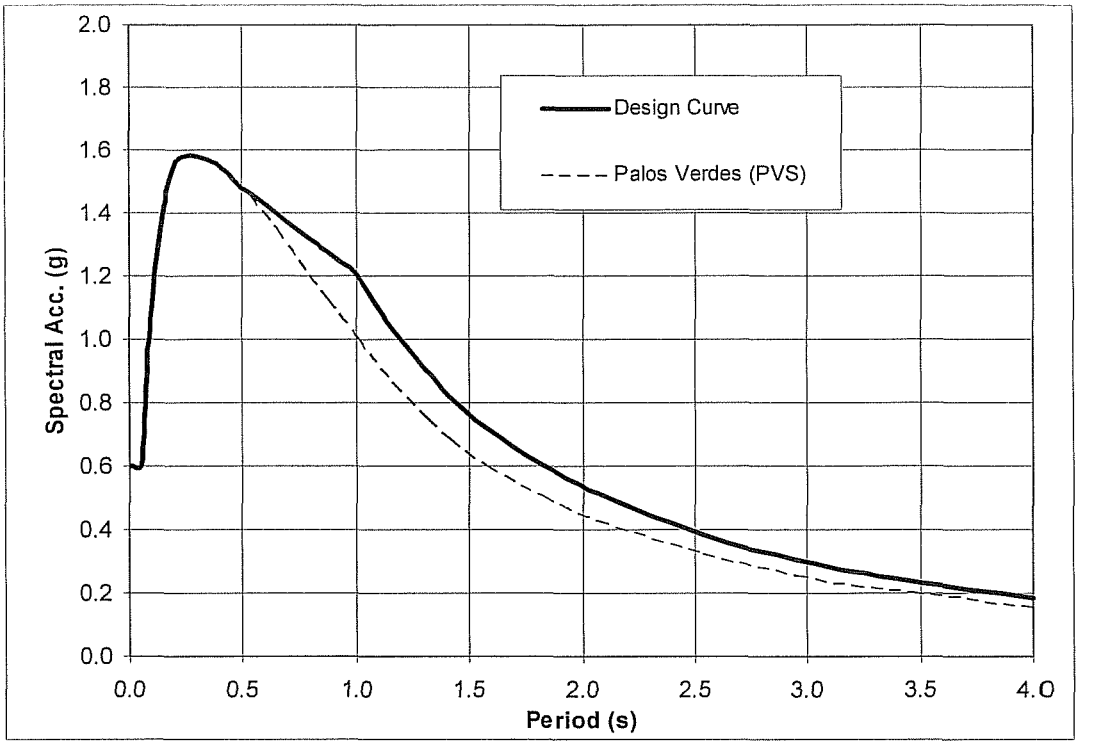
Settlement of the embankment fill should be verified by the Engineer prior to installation of abutment piles to prevent a reduction in axial pile capacity due to downdrag loads being applied to the piles.

5.7.2 Bridge Abutment Slope Stability

The global stability analysis of Retaining Wall E1 and E2 is provided in a separate report prepared by EMI (EMI, 2010).

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).



Fault Name	Fault Type	M_w	Dist, km	PBA, g
Palos Verdes (PVS)	ST	7.25	2.7	0.6

Period	Acc (g)	Period	Acc (g)	Period	Acc (g)	Period	Acc (g)
0.010	0.600	0.500	1.479	2.954	0.304		
0.050	0.600	0.533	1.461	3.203	0.266		
0.079	0.938	0.650	1.398	3.463	0.239		
0.099	1.127	0.787	1.323	4.000	0.186		
0.124	1.283	0.868	1.279				
0.154	1.419	0.998	1.209				
0.177	1.507	1.000	1.208				
0.208	1.564	1.162	1.031				
0.236	1.578	1.307	0.906				
0.271	1.584	1.411	0.822				
0.309	1.580	1.575	0.723				
0.355	1.570	1.819	0.605				
0.386	1.557	2.068	0.513				
0.442	1.525	2.537	0.383				

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned or dried to near optimum moisture, and compacted in place to a minimum 95 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts or excavations necessary to achieve finish grades. However, temporary cuts may be required in areas where drainage improvements and footings are proposed. Temporary excavations, including temporary shoring, necessary to construct the bridge abutment footings or culverts will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all three of the borings performed for the proposed bridge foundation between Elevation -9.9 and -11.7 ft. The proposed footing bottom elevation at Abutment 27 is -6.0 ft. Due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

Groundwater was encountered between elevation -9.9 and -11.7 feet in October and November 2009. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff and other man-made conditions. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled

with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.3 Backdrain and Backfill Requirements for Abutment Walls

Materials behind the abutment and wing walls should be low-expansive soil with an Expansion Index (EI) less than 50 and Sand Equivalent (SE) of more than 20 as shown in Figure 11. The low-expansive material requirement should not supersede the structure backfill and pervious backfill requirements as described in Caltrans Standard Plans, Bridge Detail 3-1 (2006b), and Caltrans Standard Specifications (2006c) under Sections 19-3.06 and 19-3.065, respectively.

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the abutment walls in order to avoid damaging the walls due to large lateral earth pressures.

Backdrains should be installed behind abutment walls to relieve hydrostatic pressure. The backdrains should be constructed in accordance with Bridge Detail 3-1 per Caltrans Standard Plans (2006b).

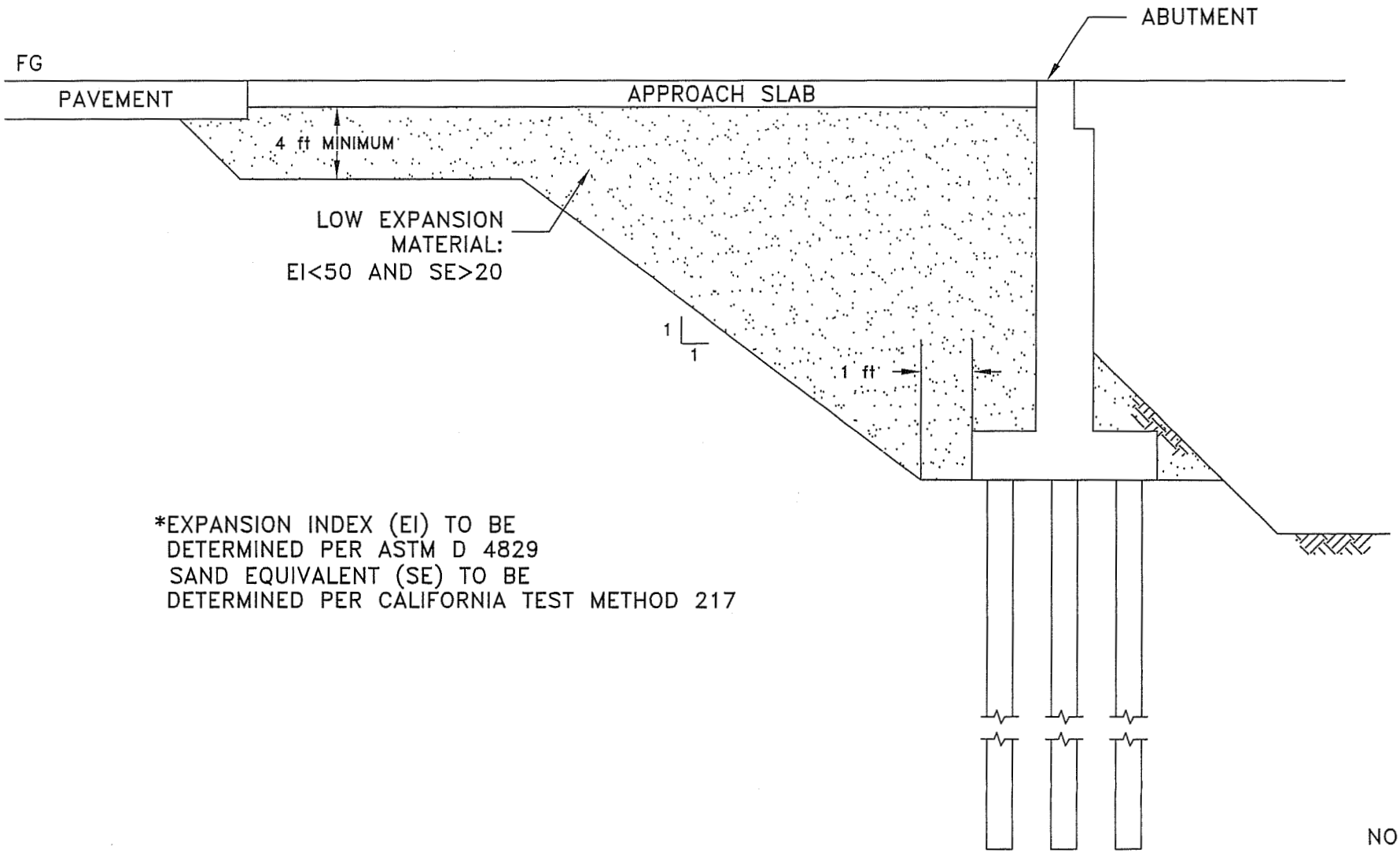
6.4 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations presented in this report may require modification or additional recommendations may be necessary based on the final design.

6.5 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of bridge abutment walls.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.



*EXPANSION INDEX (EI) TO BE DETERMINED PER ASTM D 4829
SAND EQUIVALENT (SE) TO BE DETERMINED PER CALIFORNIA TEST METHOD 217

NO SCALE

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 5-07-10

Low Expansion Material at Bridge Abutments

Figure 11

7.0 REFERENCES

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BENCHMARKS:

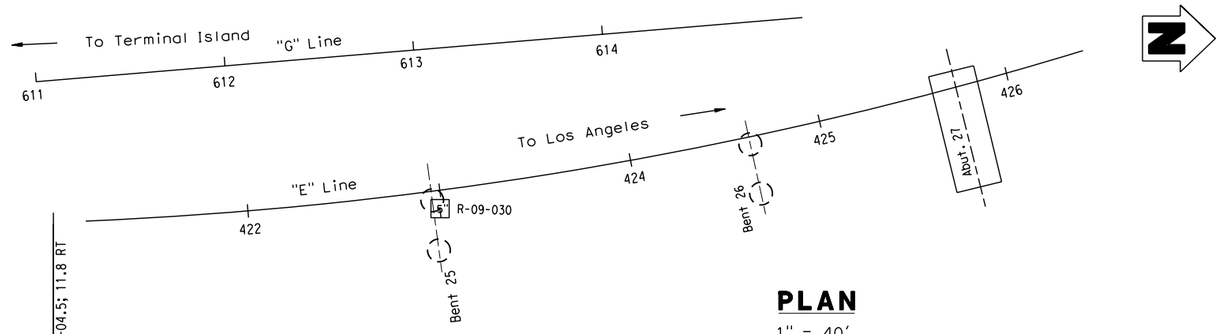
PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671′ Lt ℄ "G"Line	28.517′ Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40′

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

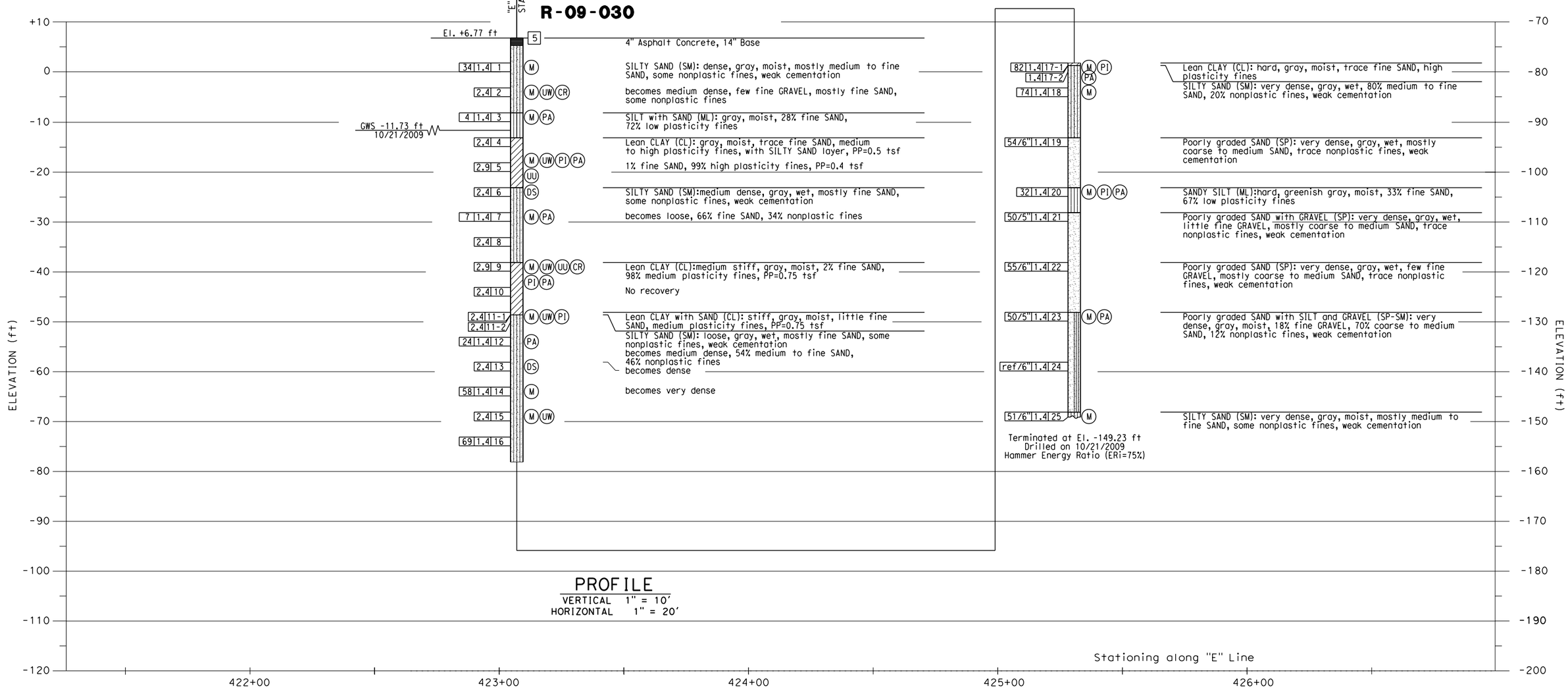
REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

R-09-030



PROFILE

VERTICAL 1" = 10′
HORIZONTAL 1" = 20′

Stationing along "E" Line
422+00
423+00
424+00
425+00
426+00

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53-3034K	NB SR-103 OFF-RAMP
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.01	LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
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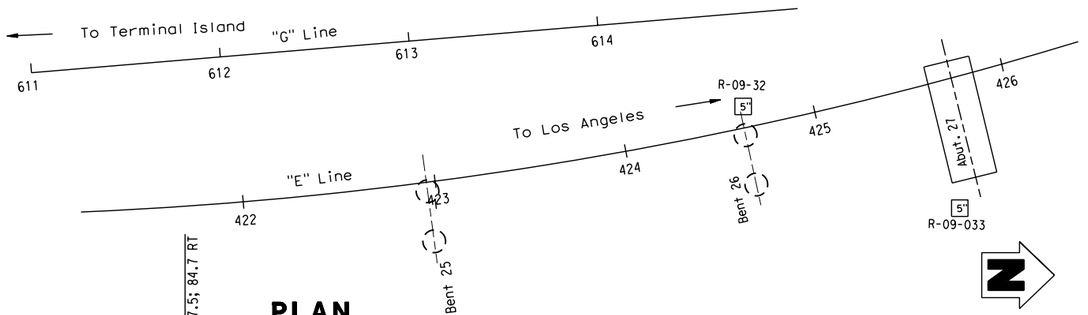

PLAN

1" = 40'

PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

R-09-032

"E" Line
STA 424+79.5; 2.3 LT

El. +4.12 ft

5" 10" Asphalt Concrete, 9" Base

9|1.4| 1 (M) Poorly graded SAND with SILT (SP-SM): medium dense, olive-brown, moist, mostly coarse to medium SAND, trace nonplastic fines, weak cementation

2.4| 2 (PA)(DS) SILTY SAND (SM): medium dense, gray, wet, 77% fine SAND, 23% nonplastic fines, weak cementation

GWS -9.88 ft 10/12/2009

2|1.4| 3 (M)(PA)(PI)(CR) Fat CLAY (CH): dark gray, moist, 12% fine SAND, 88% high plasticity fines

2.4| 4 (M)(UW) SILTY CLAY (CL-ML): dark gray, moist, trace fine SAND, low plasticity fines, PP=0.25 tsf

19|1.4| 5 SILTY SAND (SM): medium dense, gray, wet, mostly fine SAND, some nonplastic fines, weak cementation

2.4| 6 (M)(UW)(PA)(DS) becomes loose, 76% fine SAND, 24% nonplastic fines

2|1.4| 7 (M)(PI) SILT with SAND (ML): dark gray, moist, little fine SAND, low plasticity fines

2.4| 8 (M)(UW) SANDY SILT (ML): stiff, dark gray, moist, some fine SAND, low plasticity fines, PP=1.25 tsf

18|1.4| 9 (CR)(PA) 2% fine GRAVEL, 46% fine SAND, 52% low plasticity fines

2.4|10 (M)(UW)(PA)(PI) Lean CLAY (CL): very stiff, dark gray, moist, 4% fine SAND, 96% medium plasticity fines

33|1.4|11 (PA) SILTY SAND (SM): dense, dark gray, moist, 82% fine SAND, 18% nonplastic fines, weak cementation

2.4|12 (M)(UW) Poorly graded SAND with SILT (SP-SM): very dense, gray, moist, mostly medium to fine SAND, few nonplastic fines, weak cementation

36|1.4|13 (PA) becomes dense, 91% medium to fine SAND, 9% nonplastic fines

2.4|14 (M)(UW) becomes very dense

R-09-033

"E" Line
STA 425+87.5; 84.7 RT

El. +6.13 ft

5" Asphalt, gravel up to 0.5" dia

26|1.4| 1 (M) SILTY SAND (SM): medium dense, light brown, moist, trace fine GRAVEL, mostly medium to fine SAND, some nonplastic fines, weak cementation

2.4| 2 (M)(UW)(PA) SILTY SAND with GRAVEL (SM): dense, olive brown, moist, little fine GRAVEL, mostly coarse to fine SAND, little nonplatic fines, trace shell fragment

2.9| 3 (M)(UW)(C)(CR) Lean CLAY with SAND (CL): dark gray, moist, little fine SAND, mostly medium plasticity fines, trace shell fragments at top

2.9| 4 (M)(UW)(UU)(SG)(PI)(PA) Fat CLAY (CH): dark gray, moist, 3% fine SAND, 97% high plasticity fines, PP=0.5 tsf

2.4| 5 (PA) Poorly graded SAND with SILT (SP-SM): medium dense, gray, moist, 89% fine SAND, 11% nonplastic fines, weak cementation

17|1.4| 6 Slow drilling at 27' to 29' depth in gravel layer few mica, trace shell fragments

2.4| 7 (M)(DS) SILTY SAND with GRAVEL (SM): medium dense, dark gray, moist, little fine GRAVEL, mostly fine SAND, little nonplastic fines, weak cementation

18|1.4|8-1 (M)(PI)(PA) Lean CLAY (CL): very stiff, gray, moist, 13% fine SAND, 87% medium plasticity fines, thin SILTY SAND layer in middle

1.4|8-2

2.9| 9 (M)(UW)(UU)(SG)(PI)(PA) SILTY SAND (SM): medium dense, gray, moist, trace fine GRAVEL, mostly fine SAND, little nonplastic fines, few shell fragments

2.4|10-1 SANDY SILT (ML): stiff, dark gray, moist, 30% fine SAND, 70% low plasticity fines, micaceous, more sand and shell fragment at bottom, PP=1.75tsf

2.4|10-2 (M)(UW)(C)

15|1.4|11-1 (M)(PI) becomes hard, 44% fine SAND, 56% nonplastic fines

1.4|11-2 (M)(PI) Lean CLAY with SAND (CL): very stiff, dark gray, moist, little fine SAND, mostly low plasticity fines

2.4|12-1 (M)(UW)(PA) SILT with SAND (ML): very stiff, dark gray, moist, little fine SAND, mostly low plasticity fines

2.4|12-2

22|1.4|13-1 (M)(PI)(PA) SILTY SAND (SM): dense, gray, moist, 57% fine SAND, 43% nonplastic fines, weak cementation

1.4|13-2 Lean CLAY (CL): very stiff, dark gray, moist, 6% fine SAND, 94% medium plasticity fines

2.4|14 SILTY SAND (SM): medium dense, dark gray, moist, mostly fine SAND, some nonplastic fines, weak cementation

64|1.4|15 becomes very dense, gray

50/6"|1.4|16 (M)(PA) becomes mostly medium to fine SAND, little nonplasticity fines

83% medium to fine SAND, 17% nonplasticity fines

34|1.4|17-1 dense, mostly fine SAND, some nonplastic fines

1.4|17-2 (M)(PI)(PA) Lean CLAY (CL): hard, dark gray, moist, 3% fine SAND, 97% medium plasticity fines

48|1.4|18 SILTY SAND (SM): very dense, gray, moist, mostly fine SAND, little nonplastic fines, weak cementation

50/5"|1.4|19 (M)(PA) light gray, 6% fine GRAVEL, 79% fine SAND, 15% nonplastic fines

Terminated at El. -94.87 ft
Drilled on 11/6/2009
Hammer Energy Ratio (ERi=75%)

52|1.4|15 (M) SILTY SAND (SM): very dense, gray, wet, mostly fine SAND, little nonplastic fines, weak cementation

2.4|16 (M)(UW)

73|1.4|17 Poorly graded SAND with SILT (SP-SM): very dense, gray, moist, few fine GRAVEL, mostly coarse to fine SAND, few nonplastic fines, weak cementation

82|1.4|18 (M)

76|1.4|19 Poorly graded SAND (SP): very dense, gray, moist, mostly coarse to fine SAND, trace nonplastic fines, weak cementation

84|1.4|20 (M)(PA) Poorly graded SAND with SILT (SP-SM): very dense, gray, moist, 90% coarse to fine SAND, 10% nonplastic fines, weak cementation

84|1.4|21 Poorly graded SAND (SP): very dense, gray, moist, few fine GRAVEL, mostly coarse to fine SAND, trace nonplastic fines, weak cementation

90/11.5"|1.4|22 (M) Poorly graded SAND with GRAVEL (SP): very dense, gray, moist, little fine GRAVEL, mostly coarse to fine SAND, trace nonplastic fines, weak cementation

ref/6"|1.4|23 (M)(PA) Poorly graded SAND with SILT and GRAVEL (SP-SM): very dense, gray, moist, 40% coarse to fine GRAVEL, 50% coarse to fine SAND, 10% nonplastic fines, weak cementation

Terminated at El. -146.38 ft
Drilled on 10/12/2009
Hammer Energy Ratio (ERi=75%)

ELEVATION (ft): +10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120

ELEVATION (ft): -70, -80, -90, -100, -110, -120, -130, -140, -150, -160, -170, -180, -190, -200

Stationing along "E" Line

424+00 425+00 426+00 427+00 428+00 429+00

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER ERIC BROWN NO. GE-2806 EXP. 06-30-2010 GEOTECHNICAL STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY: J. Fang
CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
E. Brown

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53-3034K
POST MILE 0.01

NB SR-103 OFF-RAMP

LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER · ERIC BROWN · NO. GE-2806 EXP. 06-30-2010 · GEOTECHNICAL · STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

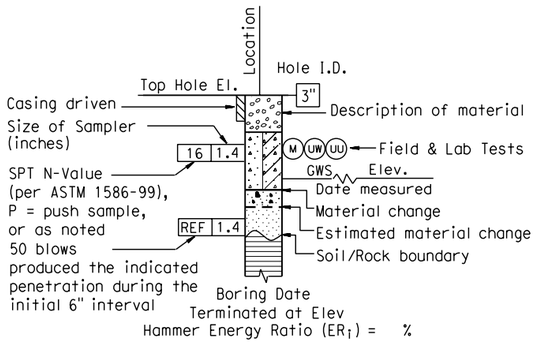
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

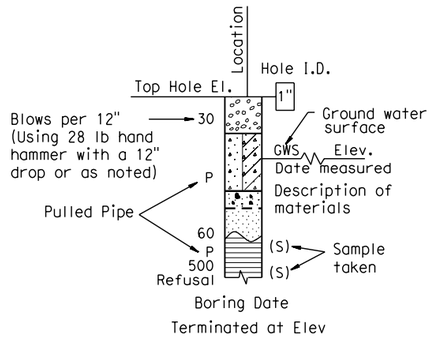
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

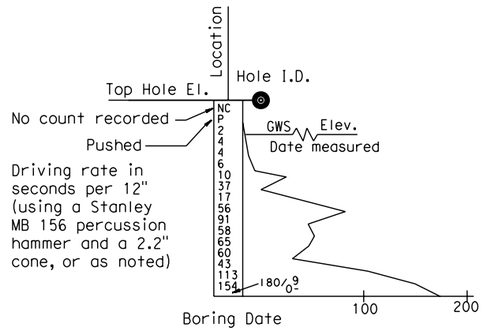
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



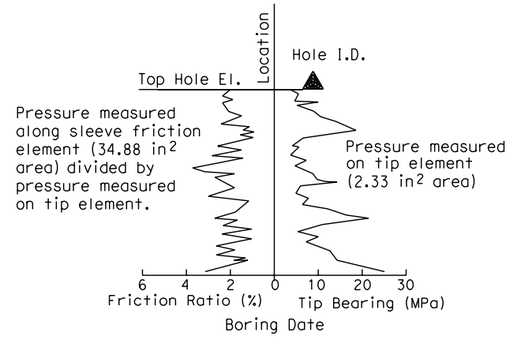
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53-3034K POST MILE 0.01	NB SR-103 OFF-RAMP LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
02/08/10	03/24/10								X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53-3034K
POST MILE 0.01

NB SR-103 OFF-RAMP

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

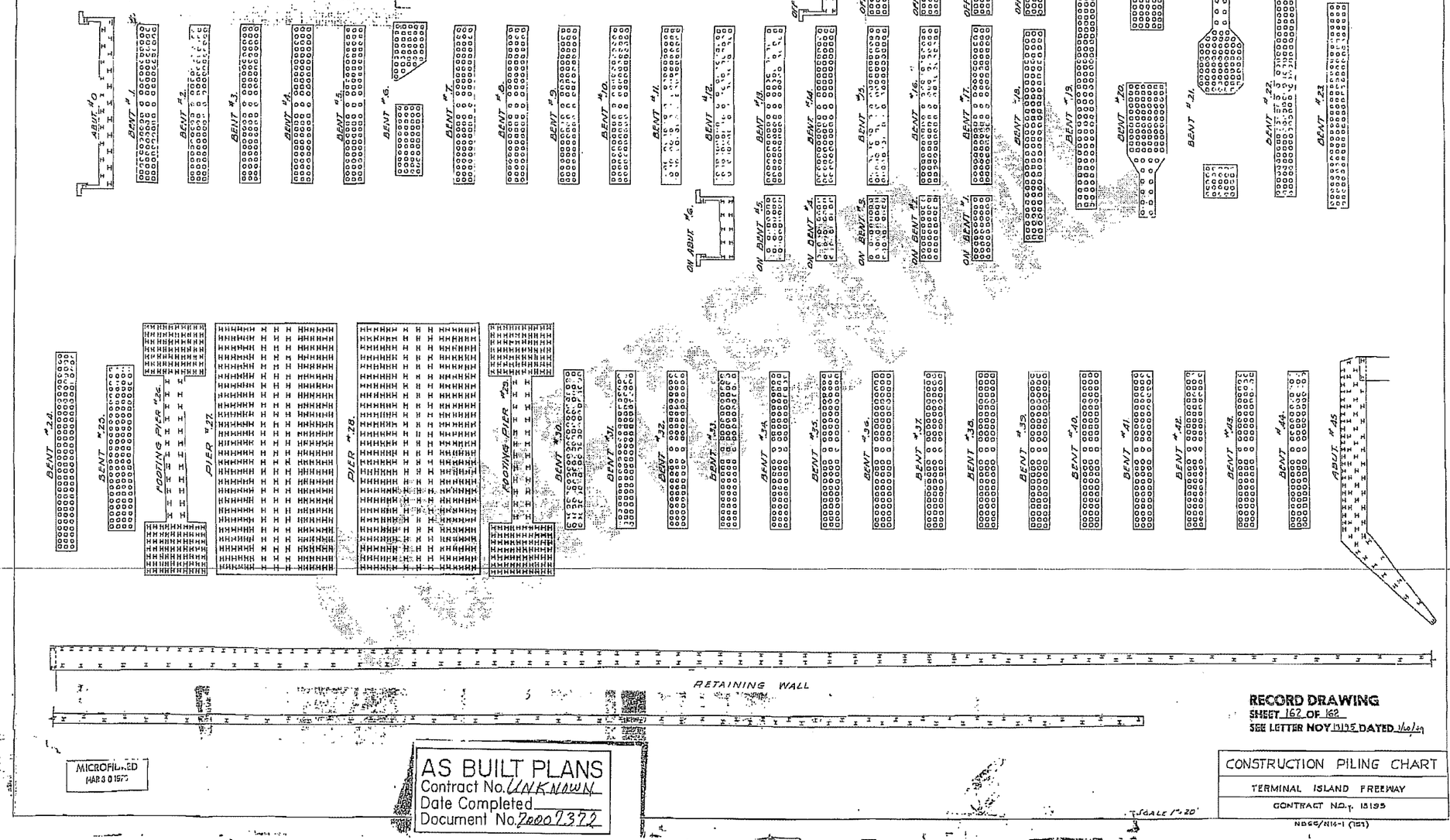
REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10, 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

Appendix A. Selected As-Built Plan Sheets for Schuyler Heim Bridge



MICROFILMED
MAR 3 0 1979

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

RECORD DRAWING
SHEET 162 OF 162
SEE LETTER NOY 15195 DATED 1/10/79

CONSTRUCTION PILING CHART

TERMINAL ISLAND FREEWAY

CONTRACT NO. 15195

ND66/N14-1 (157)

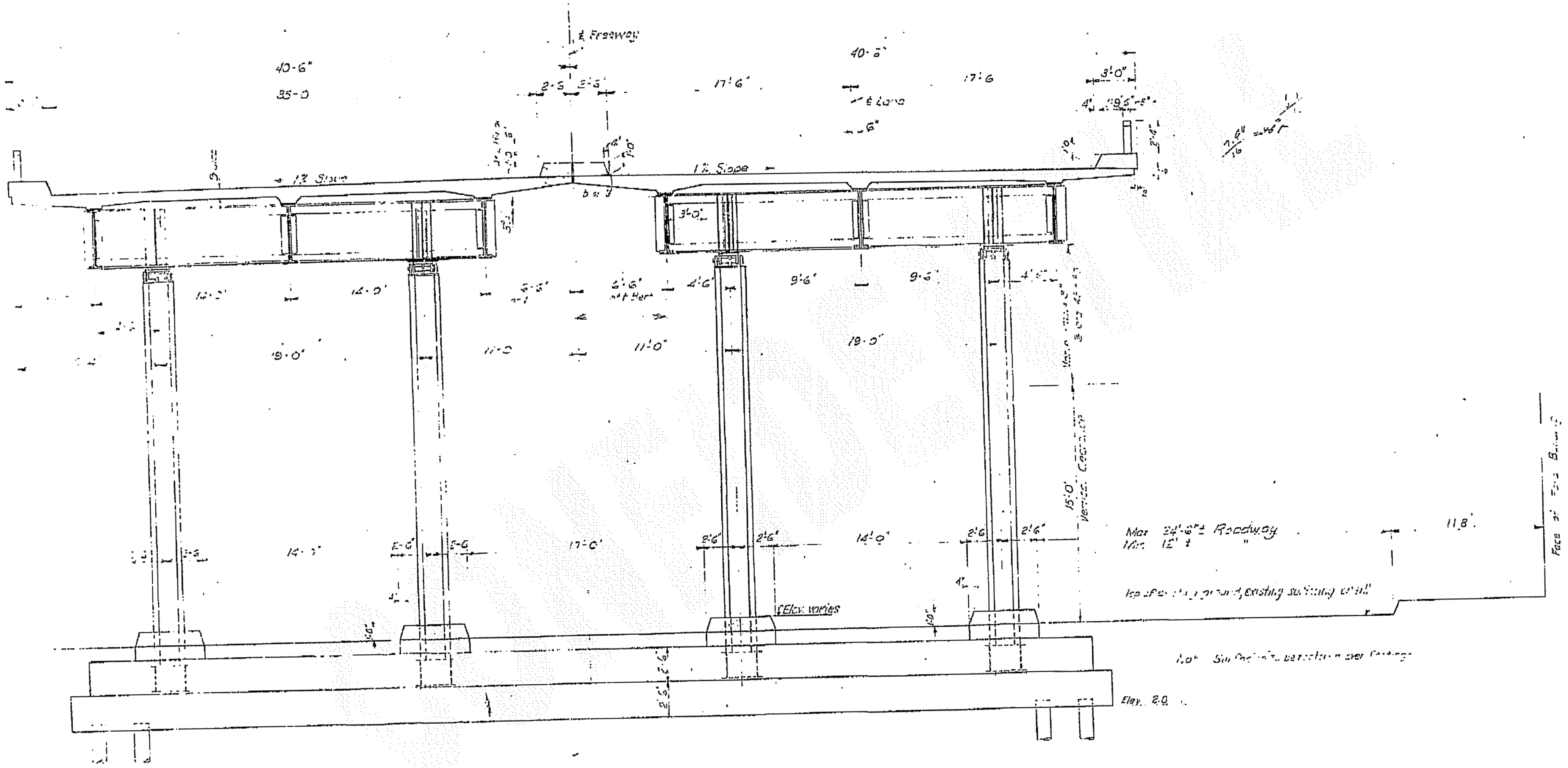
I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THE DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 3/30/79

CamPDF - www.fastio.com

BRIDGE DEPARTMENT

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL				



TYPICAL BENT

Sta 25 to 28

416,894	NAVAL OPERATING BASE
NB66/h14-1 (133) 133 / 146	APPROVED 1943

BRIDGE ACROSS CERRITOS CHANNEL

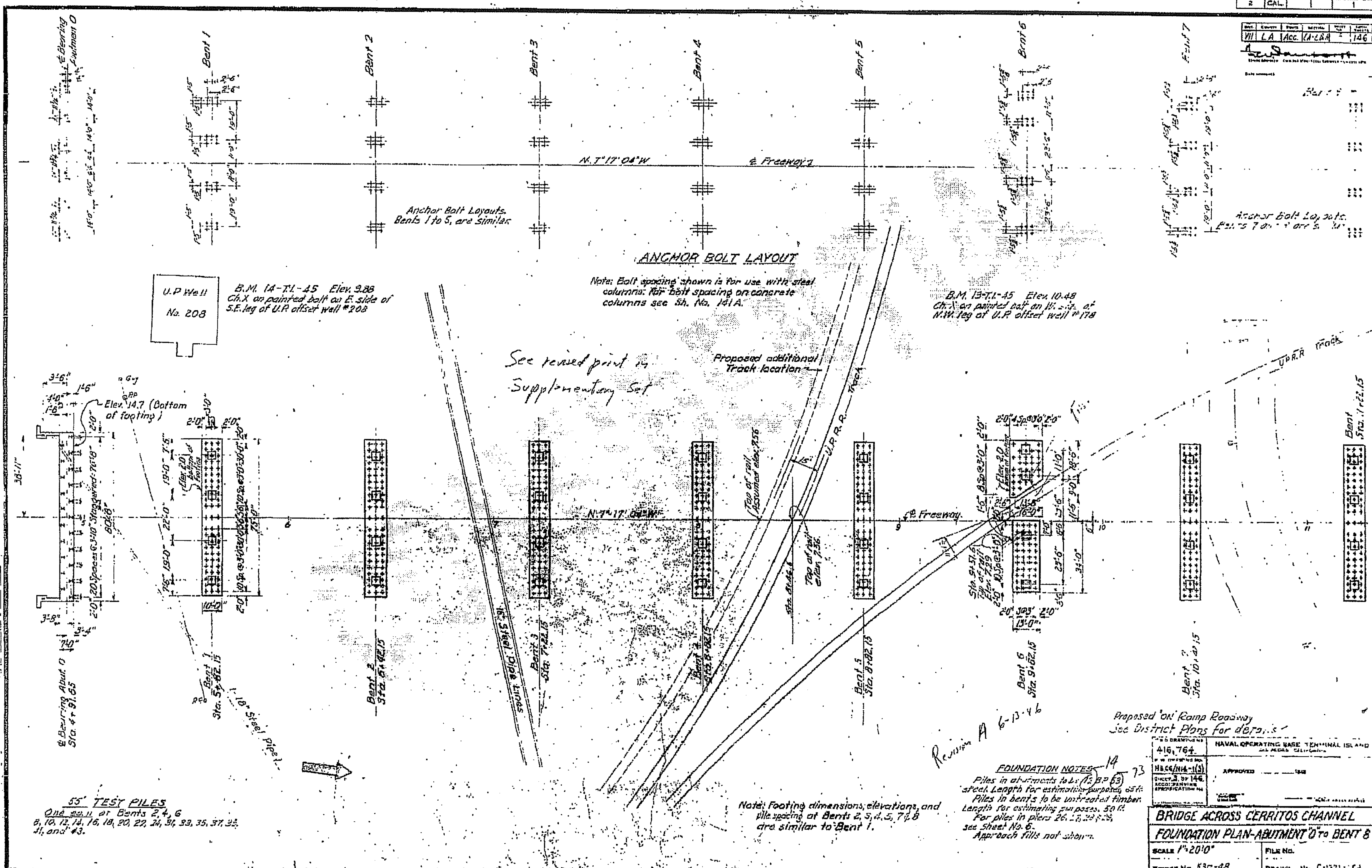
TYPICAL BENT

SCALE 1/4" = 1'-0"

FILE No.

BRIDGE No. 53C-48

DRAWING No. C-1321-332


ANCHOR BOLT LAYOUT
Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.
Anchor Bolt Layouts. Bents 1 to 5, are similar.
N. 7°17'04"W
℄ Freeway
U.P. Well No. 208
B.M. 14-T.I.-45 Elev. 9.88 Ch.X on painted bolt on E. side of S.E. leg of U.P. offset well #208
B.M. 13-T.I.-45 Elev. 10.48
See revised print in Supplementary Set
Proposed additional Track location
U.P.R.R. Track
Elev. 14.7 (Bottom of footing)
℄ Bearing Abut. 0 Sta. 4+91.65
Bent 1 Sta. 5+82.15
Bent 2 Sta. 6+62.15
Bent 3 Sta. 7+42.15
Bent 4 Sta. 8+02.15
Bent 5 Sta. 8+82.15
Bent 6 Sta. 9+62.15
Bent 7 Sta. 10+42.15
Bent 8 Sta. 11+22.15
16" Steel Pipe Lines
18" Steel Pipe
Proposed 'ON' Ramp Roadway See District Plans for details
Revision A 6-13-46
55' TEST PILES
One each at Bents 2, 4, 6
8, 10, 12, 14, 16, 18, 20, 22, 24, 31, 33, 35, 37, 39, 41, and 43.
Note: Footing dimensions, elevations, and pile spacing at Bents 2, 3, 4, 5, 7 & 8 are similar to Bent 1.
FOUNDATION NOTES
Piles in abutments to be 12 BP 53 steel. Length for estimating purposes 65 ft.
Piles in bents to be untreated timber. Length for estimating purposes 50 ft.
For piles in piers see Sheet No. 6.
Approach fills not shown.
BRIDGE DEPARTMENT
NAVAL OPERATING BASE TERMINAL ISLAND
BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLAN-ABUTMENT 0 TO BENT 8
SCALE 1"=20'0"
BRIDGE No. 53C-48
VII LA Acc. 146

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	LA	Acc.	LA-1-R/V	4	146

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

℄ Bent

℄ Bearings

℄ Eastbound

N 7°17'27" W

BENTS 9-16 INCL.

℄ OFF Ramp

"OFF" ABUTMENT 5

"OFF" BENTS 1-4 INCL.

℄ ON Ramp

"ON" ABUTMENT 6

"ON" BENTS 1-5 INCL.

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141 A.

Note: Footing dimensions, elevation, and pile spacing for Bents 10, 11, 12, 13, 15, & 16 are similar to Bent 9.
Footing dimensions and pile spacing for "OFF" Abutment 5 are similar to "ON" Abutment 6.
Footing dimensions, elevation, and pile spacing for "ON" Bents 2, 3 & 4 and "OFF" Bents 3 & 4 are similar to ON Bent 5 except as noted.

One Row of 14 Batter Piles at 3:12 on Bents 4 & 2 of "ON" Ramp
One Row of Batter Piles at 3:12 on Bent 3 of "OFF" Ramp.
Alternate Batter Piles along Freeway.

EXIST. 12" 20° OILED T.I. FREEWAY

SERVICE ROAD PLAN
SEE PLAN SHEET 60

Grade to join existing roads, average fill slopes 4 feet, 1½:1

Bit. Surf. Treath shall conform to Sec. 39 of Calif. Std. Specifications. Base shall be Class A as specified in Sec. 26 of said specifications. Base shall be certified.

"OFF" RAMP

N 3°32'04" W

Elev. 15.5 Bottom of footing 2 ea. Bent

Off Bent 4 Sta. 11+72.64

Junction of tanks

Const. Service Road See Plan Above

Bent 3 Sta. 19+93.01

Bent 10 Sta. 12+82.15

Bent 11 Sta. 13+62.15

Bent 12 Sta. 14+42.15

Bent 13 Sta. 15+22.15

Bent 14 Sta. 16+02.15

Bent 15 Sta. 16+82.15

Bent 16 Sta. 17+64.15

Elev. 2.0 (Bottom of Footing) Bent 9 Sta. 12+02.15

79.990 79.990 79.990 79.990 79.983 79.983 79.984 79.993

℄ Freeway

N 7°17'04" W

Drainage Ditch

Orient Road

"ON" RAMP

Batter 3:12

Elev. 2.0 (Bottom of footing)

Elev. 1.4 (Bottom of footing)

"ON" Bent 5 Sta. 21+22.65

MICROFILMED MAR 3 0 1976

RECORD DRAWING
SHEET 4 OF 162
SEE LETTER NOV 5 1965 DATED 7/8/66

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 3/30/76 SIGNED

416,765	NAVAL OPERATING BASE TERMINAL ISLAND SAN PEDRO, CALIFORNIA		
BRIDGE No. 53C-68	APPROVED 1943		

7-19-46 MEAS SPAN LENGTH AS OF 7-19-46 (T)
6-24-41 Change Size of Pile Abut. W
REV. DATES 1-29-41 Service Road Added SHEETS

BRIDGE ALIGNMENTS

FOUNDATION PLAN - BENT 9

SCALE 1"=10'-0" FILE NO.

BRIDGE No. 53C-68 DRAWING No. 20 (141)

FED. ROAD DIST. NO.	STATE			SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	KILOPOST	SHEET NO.	TOTAL SHEETS
VII-1	SD	5	24.1/25.3	2	146

BRIDGE DEPARTMENT

± OFF Bent 2 ± OFF Bent 1 ± Bent 17 ± O.V. Bent 1 ± Bent 18 ± Bent 19 ± Bent 20 ± Bent 21 ± Bent 22 ± Bent 23 ± End of 24

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns; for bolt spacing at concrete columns see Sh No. 141.4.

RECORD DRAWING
SHEET 5 OF 162
SEE LETTER NOV 13/95 DATED 4/10/49

OFF Bent 2 Sta 10+12.90

OFF Bent 1 Sta 9+33.78

Bent 17 Sta 13+42.15

Bent 18 Sta 15+79.15

Bent 19 Sta 18+83.15

Bent 20 Sta 20+53.15

Bent 21 Sta 21+93.15

Bent 22 Sta 23+33.15

Bent 23 Sta 24+73.15

Throw track 1" ± Existing Railroad Tracks

± Relocation of Railroad tracks

Throw track 6" to be left in place, Elev. 10.0

Elev. 2.0 (Bottom of Footing)

Elev. 4.0 (Bottom of Footing)

Elev. 8.0 (Bottom of Footing)

Elev. 10.0 (Bottom of Footing)

60.000 70.990 79.984 80.000 84.000 93.000

N 3°32'04"W ℄ OFF RAMP

N 7°17'04"W ℄ OF FREEWAY

℄ ON RAMP

N 15°32'04"W

Off Ramp Sta 5+34.55 = Freeway Sta 81+60.10 = On Ramp Sta 0+00

U.P. Offset Wall No 99

BM: II-T.L.25 Elev. 11.02

Ch. X on painted bolt on W side of S.W. leg of U.P. wall #99.

5.M. 10-T.L-45 Elev. 10.45

Ch. X on painted bolt on S.W. side of S.W. leg of U.P. offset wall #81.

Note: Concrete Columns only To Be Skewed 30° From ℄ Bent 6 Following locations: Column 1, Bent 19; 1 & 3, " 20; 1 & 3, " 21; 1, " 22

F.A.P. DRAWING NO.	6161796	NAVAL OPERATING BASE TRIANNAL ISLAND SAN DIEGO, CALIFORNIA
STR. DRAWING NO.	165ENTR-1(6)	
UNIT 5 OF 146		APPROVED 1948

BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLANS - BENTS 17 TO 25

SCALE 1" = 20'	FILE NO.
BRIDGE NO. 53C-48	DRAWING NO. C-1321-2042

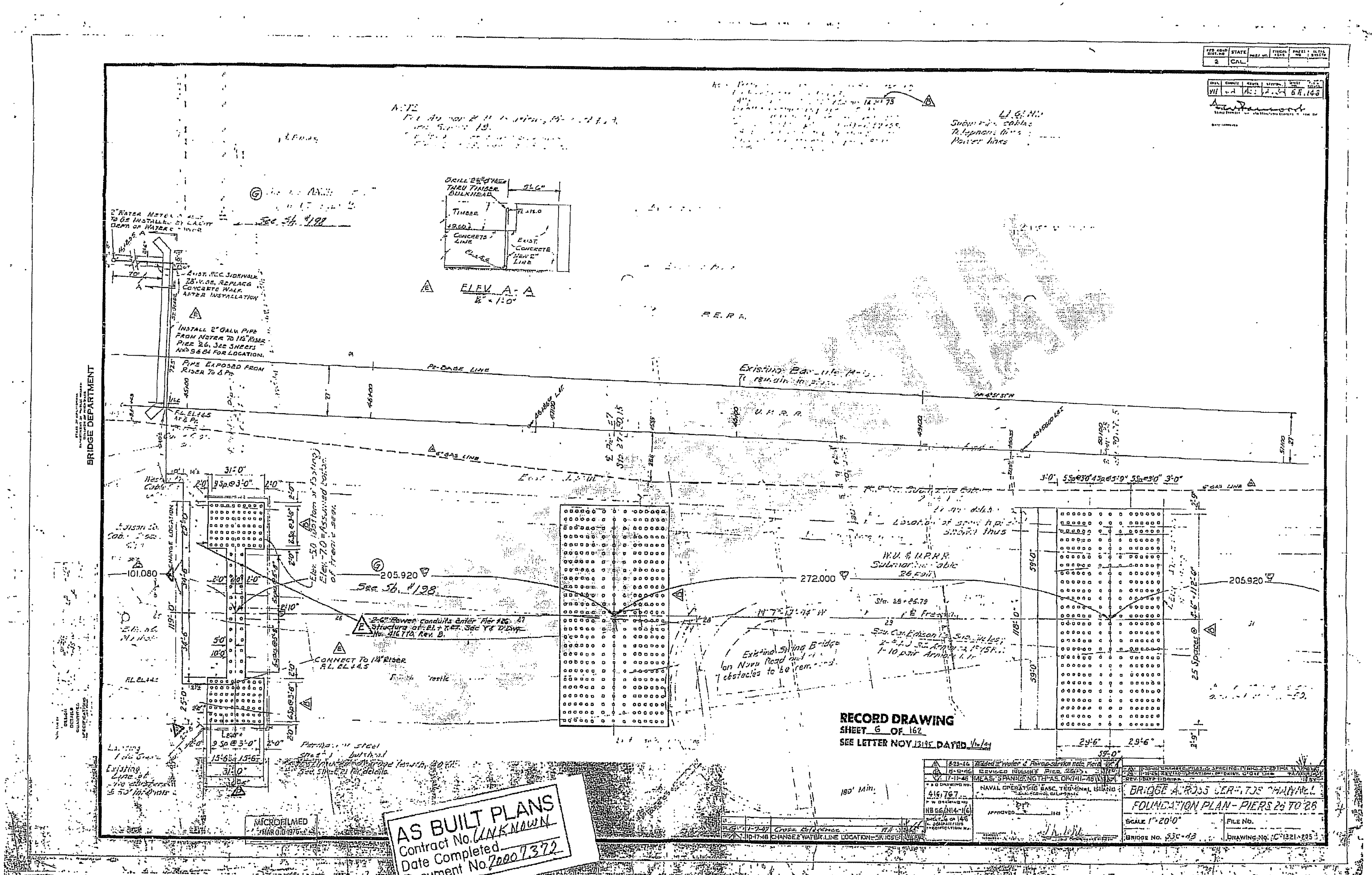
AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

MICROFILMED MAR 3 0 1979

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/96

ClibPDF - www.fastio.com



I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

Dist.	County	Route	Section	Proj. No.	Total Sheets
VII	L.A.	ACC. I-I-Rd.	7A	146	

BRIDGE DEPARTMENT

Fr. Junction of Truss Bearing Lines Sta. [illegible] Ahd. ℄

℄ Bearing P.I. = 29

N 7° 17' 04" W

Sta. 35+02.7 ± B.C.

℄ Bent 30 · ℄ Bent 31 · ℄ Bent 32 · ℄ Bent 33 · ℄ Bent 34 · ℄ Bent 35

Ahead Rail Lines, Bents 32 & 33 C.L. to be same.

See Sh # 198

ANCHOR BOLT LAYOUT

Note: Bolt spacing & details for use with steel columns. For bolt spacing on concrete columns see Sh. No. 147-A

GENERAL PETROLEUM OIL LINE 6"

EXIST NORTH ABUTMENT OF BASCULE BRIDGE

"PD" - BASE LINE - N 7° 17' 04" W

HENRY FORD AVENUE

LOS ANGELES LONG BEACH CITY BOUNDARY

R/W Line

U.P.R.R.

RR Block Signal

2-37 KV. CABLES (EXIST.)

Exist. Bulkhead

205.920

See Sh. # 198

101.080

93.000 · 80.000 · 80.000 · 80.000 · 80.000 · 80.000

℄ of FREEWAY

Sta. 35+76.84

Remove Exist. M.H. Cover and Ring in Navy Road and Install in New Junction Chamber at Left Hereon

Exist. 24" Storm Drain Abandon

Cut Hole in Exist. C.B. for New 12" Pipe & Brace Rods

Elev. Outlet Invt. for this ℄

Remove exist. M.H. and Salvage Flusher

Abandon exist 12" Sewer

Construct M.H. Verify location and depth in field.

Invt. 20 (Bottom of Fr. -11.73)

Construct 18" Storm Drain

Exist 12" Sewer

Exist C.B. to be Reconstructed

Flow

NAVY ROAD

R/W

Location of Steel H Piles Shown Thus (See Note Sheet No. 6)

Encase 16Ø See Profile

Rock Fill

For Profile and Details See Y.&D. Dwg. 417012

FORD MOTOR COMPANY PLANT

PLAN

RECORD DRAWING
SHEET 17 OF 162
SEE LETTER NOV 1966 DATED

MICROFILMED 13 Q 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 70007372

1	V2-9 Cross Reference	MA
2	8-66 Revised Bulkhead Pier 29	MA
3	7-25-66 Sewer M.H. Relocation	MA
4	11-4-66 Abd. Stn Length as of 7-11-66	MA
5	9-12-67 Revised Outline A, Pier 29	MA
6	11-1-68 Relocated Front Fender and Dolphin	MA
7	5-7-71 Changed Piles & Cracking, Piers 32 & 33	MA
8	11-8-72 Revised Location of Exist. Gas Line	MA
REV.	DATE	BY

Δ = 2° 25' 00"
R = 15.000'
T = 316.99'
L = 632.68'

416.768
NBAS/NI4-1(7)
7 = 146

BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLAN - PIER 29, BENTS 30-35

SCALE 1" = 20' | FILE NO. [illegible]

BRIDGE NO. 53C-48 | DRAWING NO. C-1321-296.4

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/96 SIGNATURE [illegible] TITLE Principal Engineer

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Appendix B. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501 Project No.:96-1005

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity

N.S.R= No sample recovery

OVM6606 Gas Readings

PLAN

SCALE: 1"=40' NORTH

BENT 37, BENT 38, BENT 39, BENT 40, BENT 41, BENT 42, BENT 43, BENT 44, ABUT. 45

CPT-18, CPT-19, CPT-20, CPT-21, CPT-22

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

STA. 40+76.50 ELEV.= -2.30 CPT-19 08-20-96

STA. 42+18.50 ELEV.= -2.15 CPT-20 08-20-96

50' Rt. STA. 43+58.00 ELEV.= -2.42 CPT-21 08-19-96

67' Rt. STA. 43+68.00 ELEV.= -2.17 B-5 GWS ELEV.=-12.0 08-26-96 B-6 08-29-96

22' Rt. STA. 44+44.00 ELEV.= -1.88 CPT-22 08-20-96

3"-7" of AC
FILL-(SP)Brown coarse SAND w/GRAVEL
Grades to fine w/mica & SILT
NATIVE-(ML)Dark gray SANDY SILT, very soft
(SM)Dark gray fine SILTY SAND
(SP)Gray fine SILTY SAND, compact
(ML)Dark gray SANDY SILT, soft, traces of SILT
(SM/SP)Gray fine SILTY SAND, dense
(ML)Dark gray SANDY SILT, soft
very stiff
(CL)Gray SILTY CLAY
(SM/ML)Gray fine SILTY SAND/SANDY SILT w/mica, dense
(ML)Gray SANDY SILT
hard
(SM/ML)Gray fine SILTY SAND/SANDY SILT w/mica
very dense
very dense
(SP)Gray fine to medium SAND w/mica
(ML/CL)Gray CLAYEY SILT/SANDY SILT, very hard
(ML)Gray SANDY SILT w/mica
(SM)Gray fine SILTY SAND w/mica, very dense

LEGEND OF EARTH MATERIALS
GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS
According to the Standard Penetration Test

	Penetration Index (Blows/ft)	
Granular	0-4	Very loose
	5-9	Loose
	10-19	Slightly compact
	20-34	Compact
	35-69	Dense
	>70	Very dense
Cohesive		Very soft
		Soft
		Stiff
		Very stiff
		Hard
		Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

DESIGN OVERNIGHT
Date Off Date

DRAWN BY NL
CHECKED BY MR

CS-LN-MC
FIELD INVESTIGATOR
DATE 06-18-96

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

BRIDGE NO. 53-2618
POST MILE 3.58

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO.6

SHEET 14 OF 148

C:\CADDD\VG\JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

Appendix C. EarthSpectives SPT Hammer Energy Measurement Report

EARTHSPECTIVES
250 Goddard
Irvine, California 92618
Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

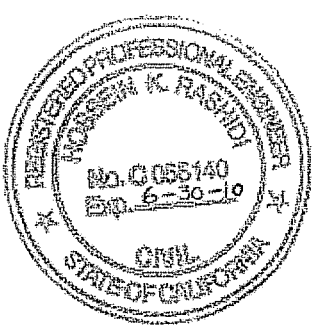
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

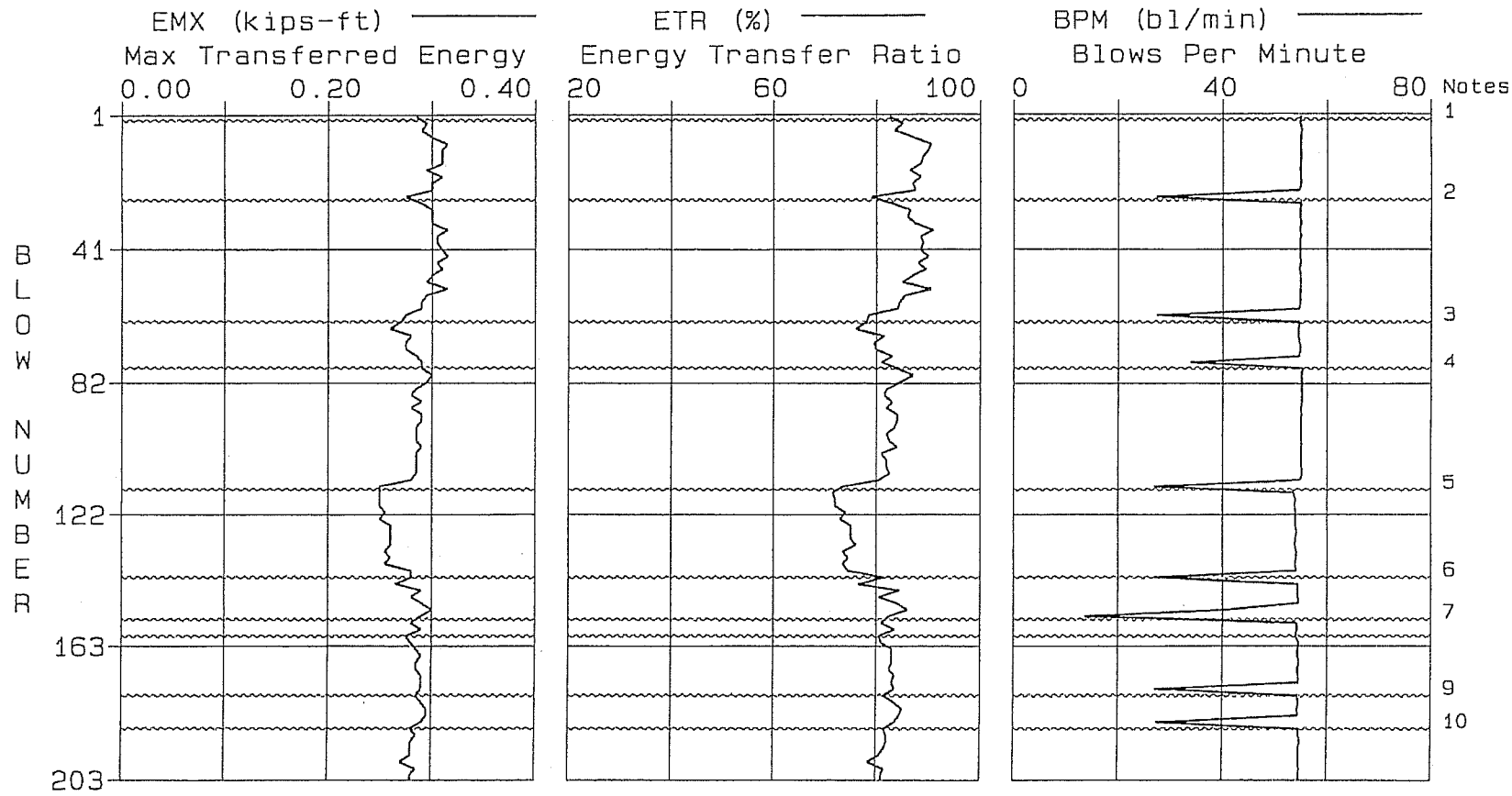
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

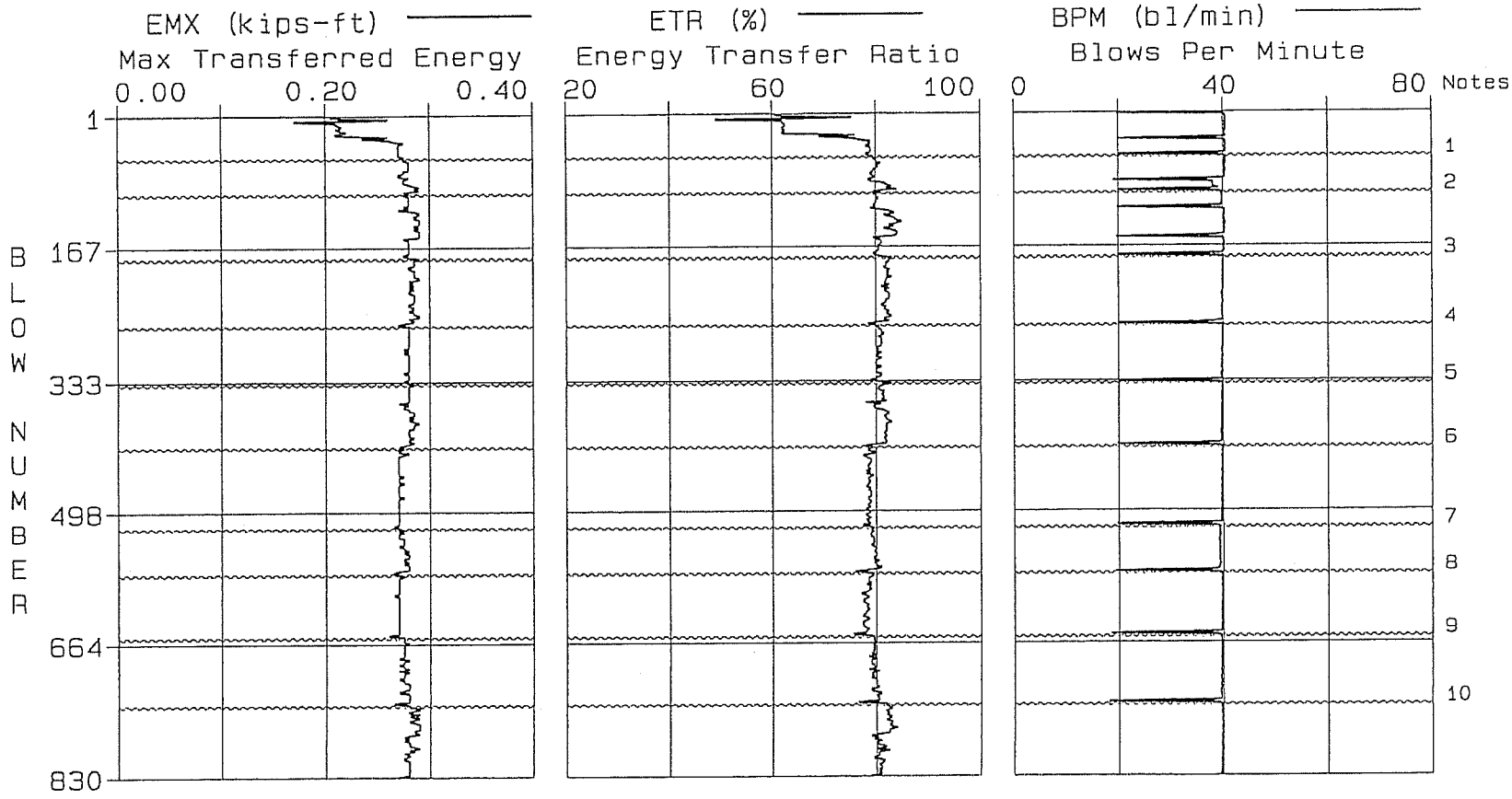
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

Info: MUD ROTARY

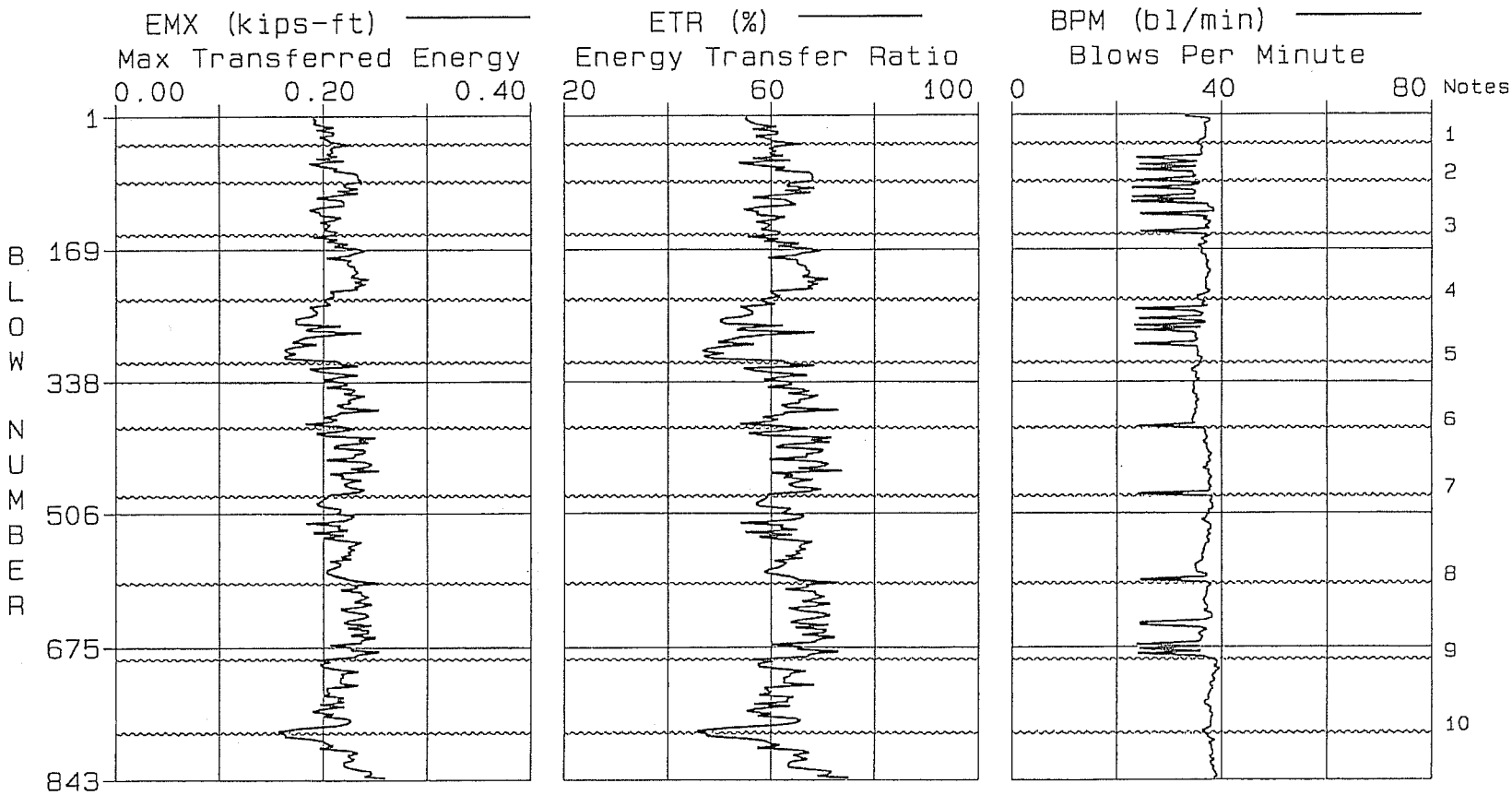
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

Appendix D. GeoVision Geophysical Investigation Report

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

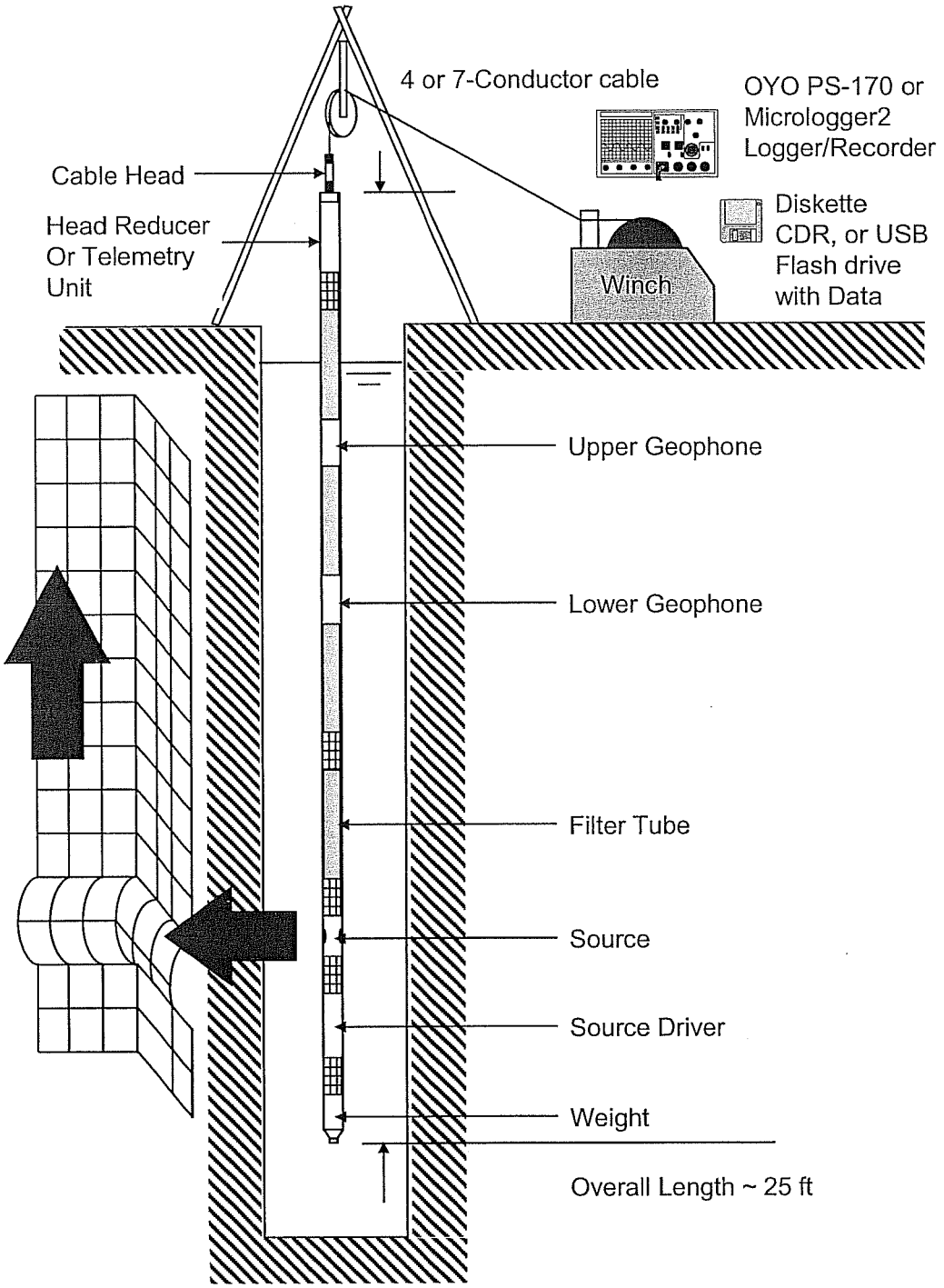


Figure 1: Concept illustration of P-S logging system

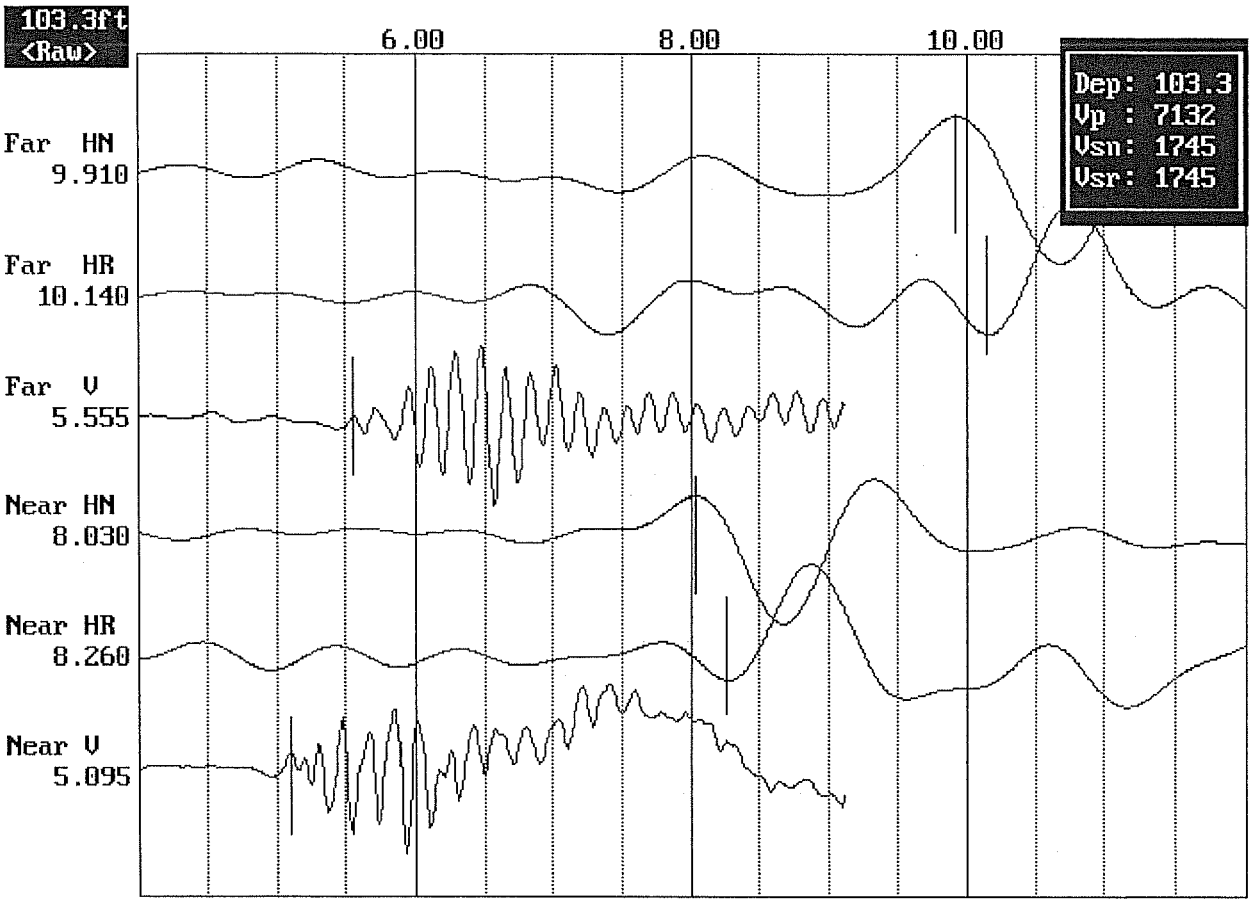


Figure 2: Example of filtered (1400 Hz lowpass) record

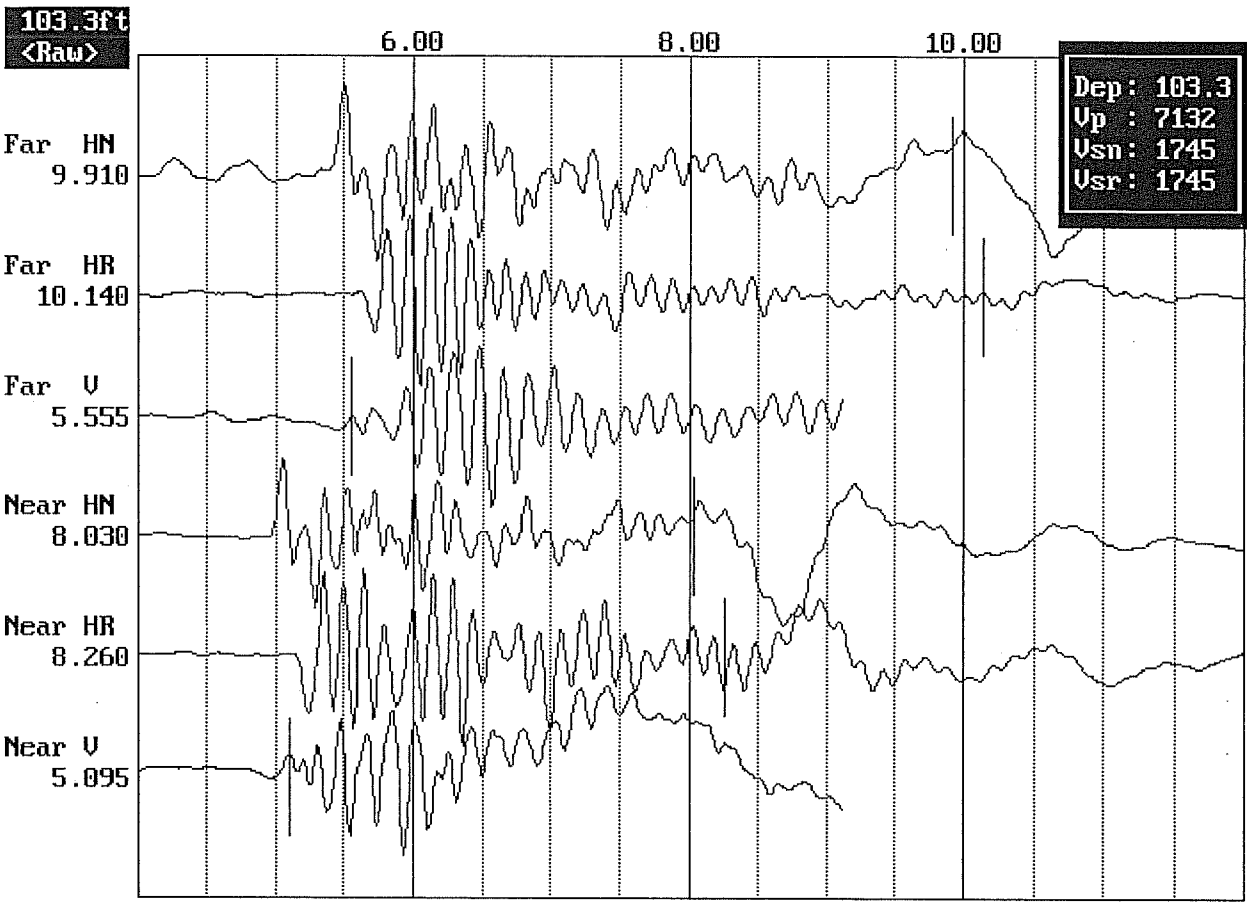


Figure 3. Example of unfiltered record

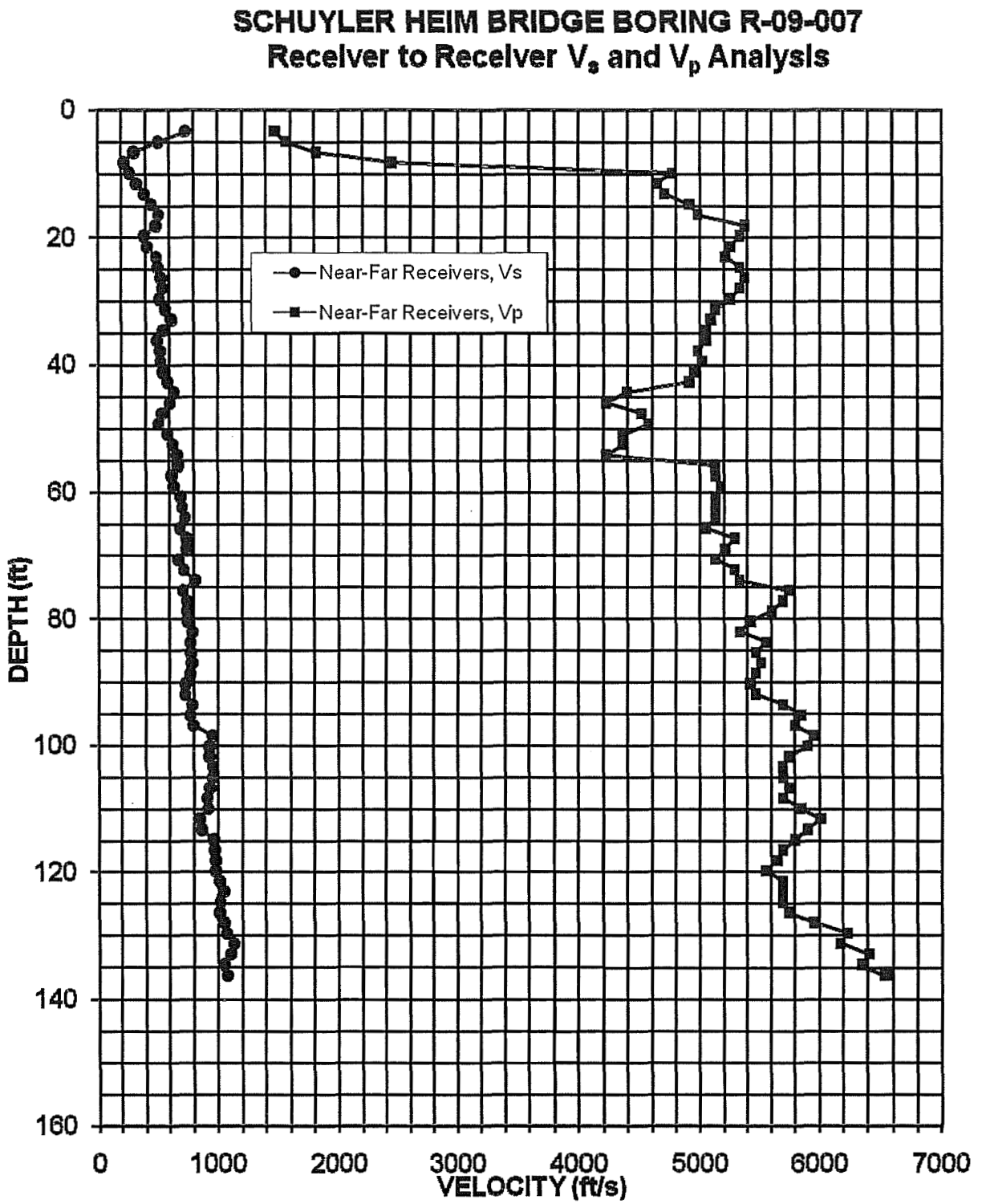


Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

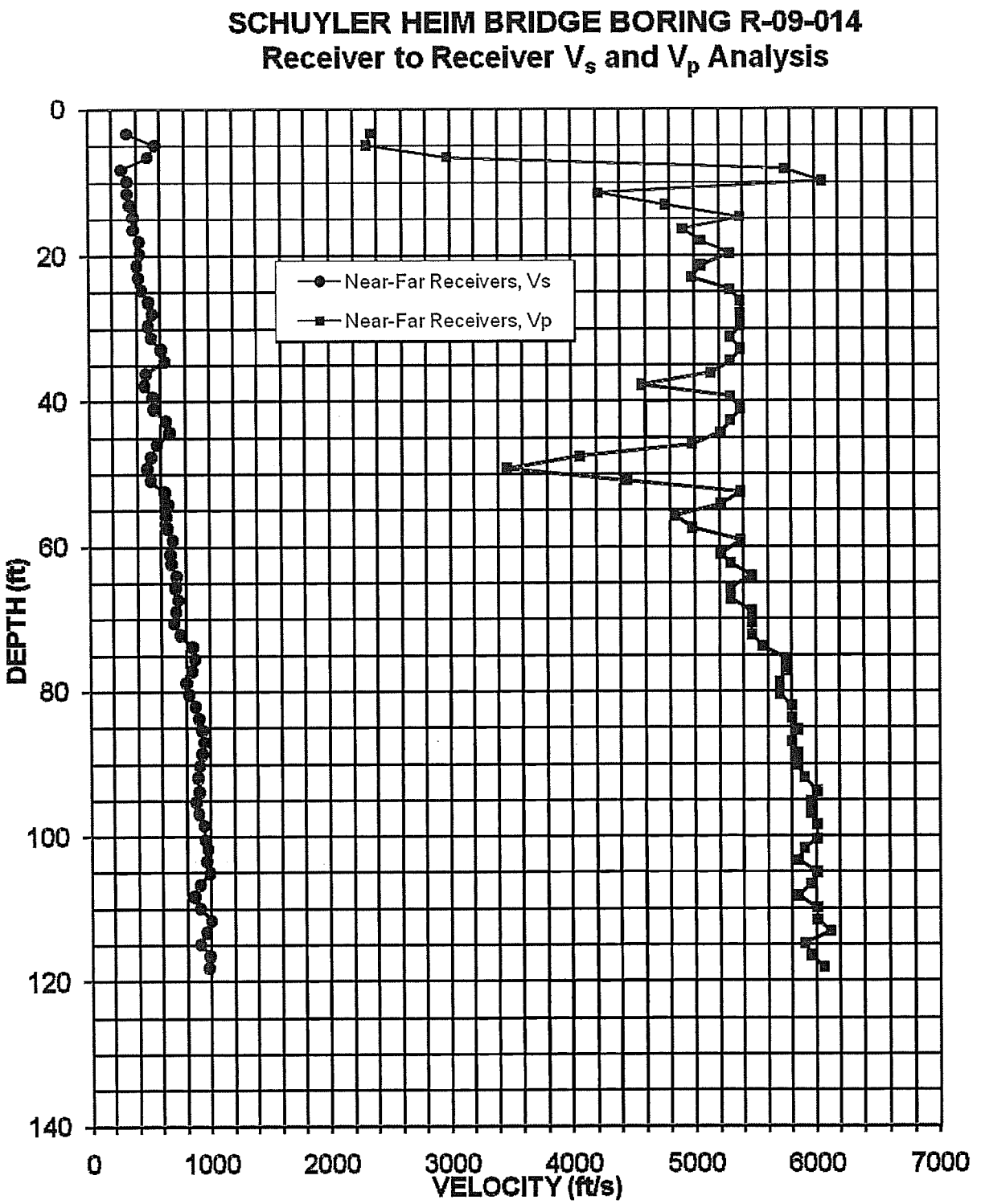


Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

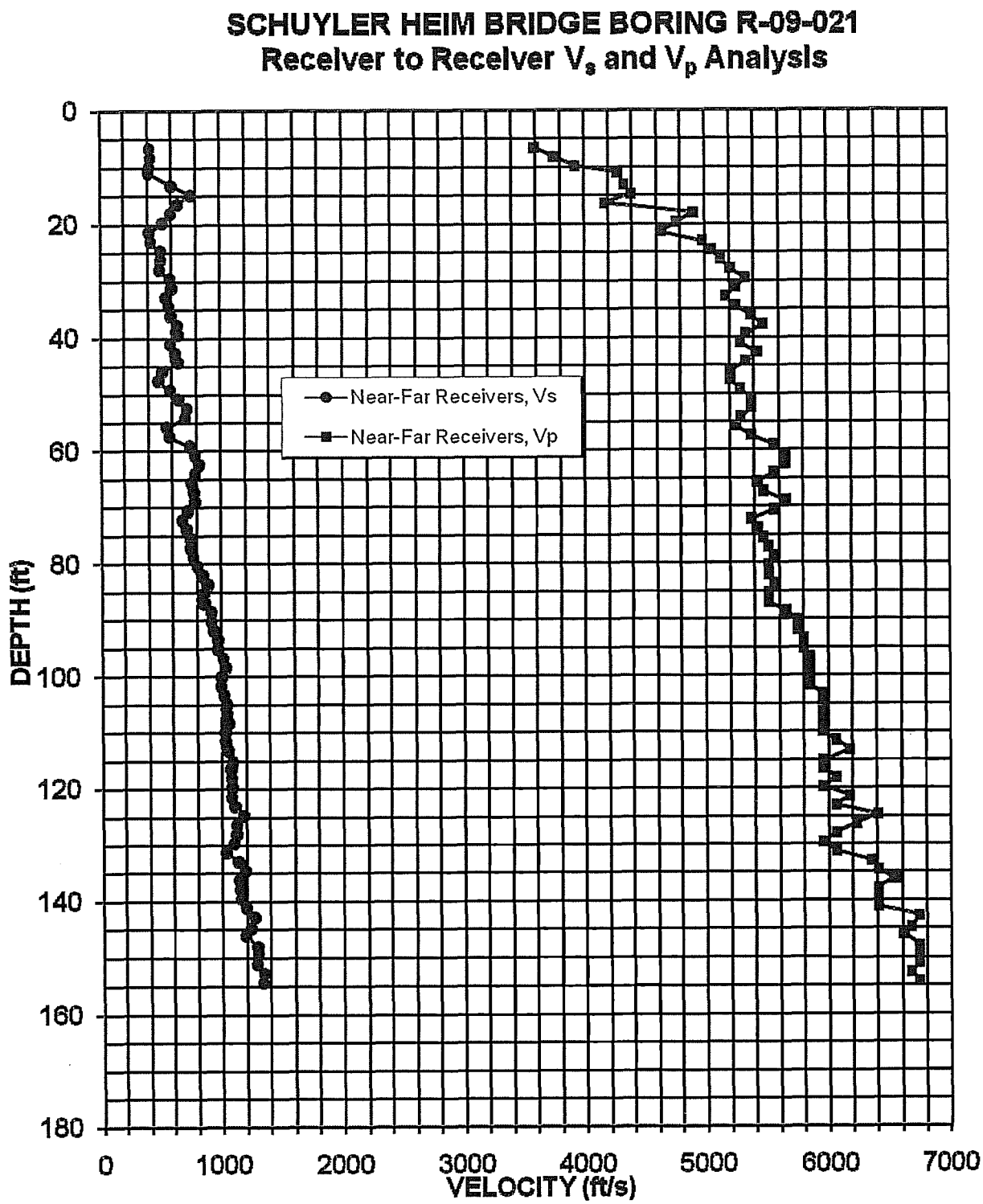


Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

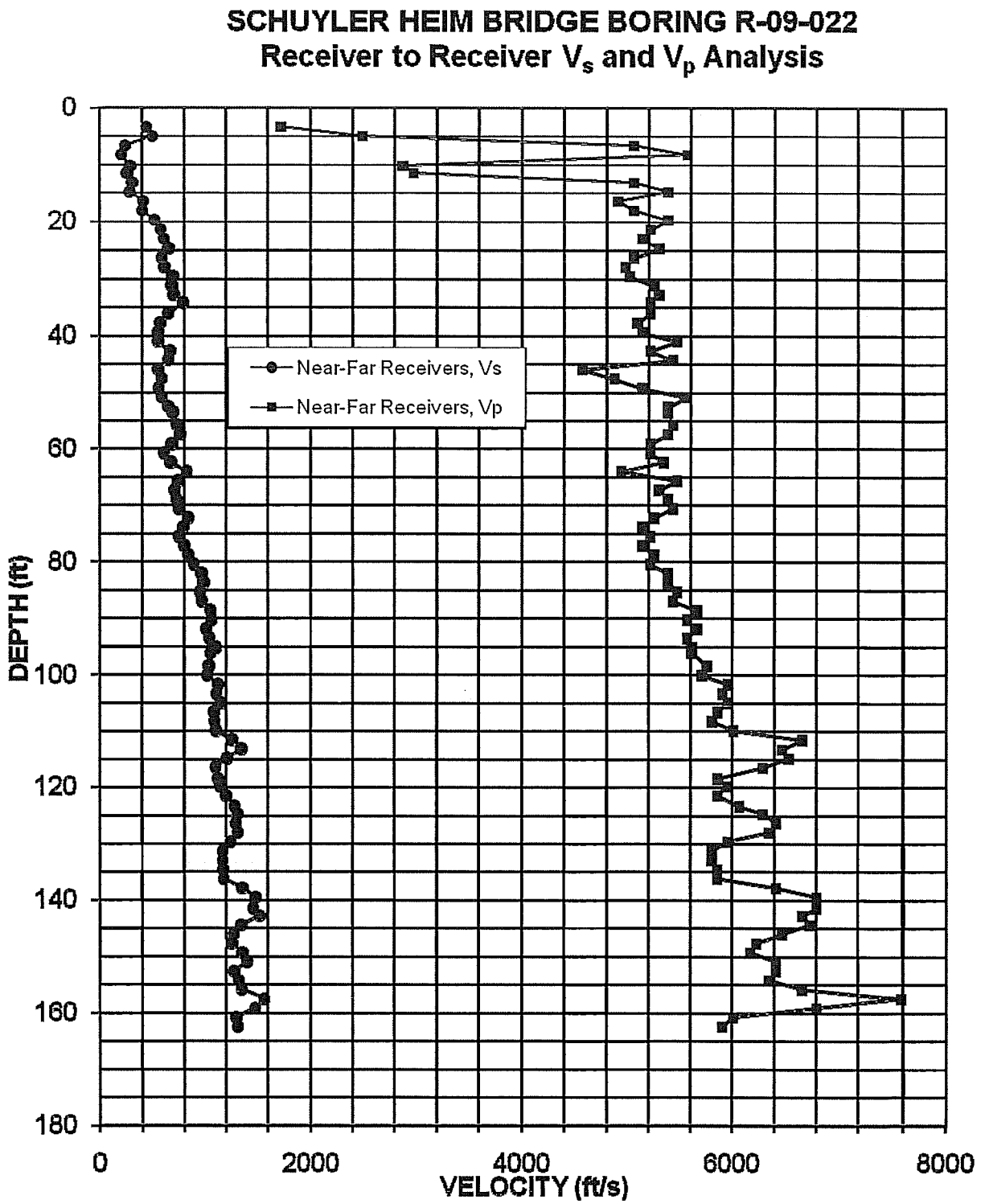


Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

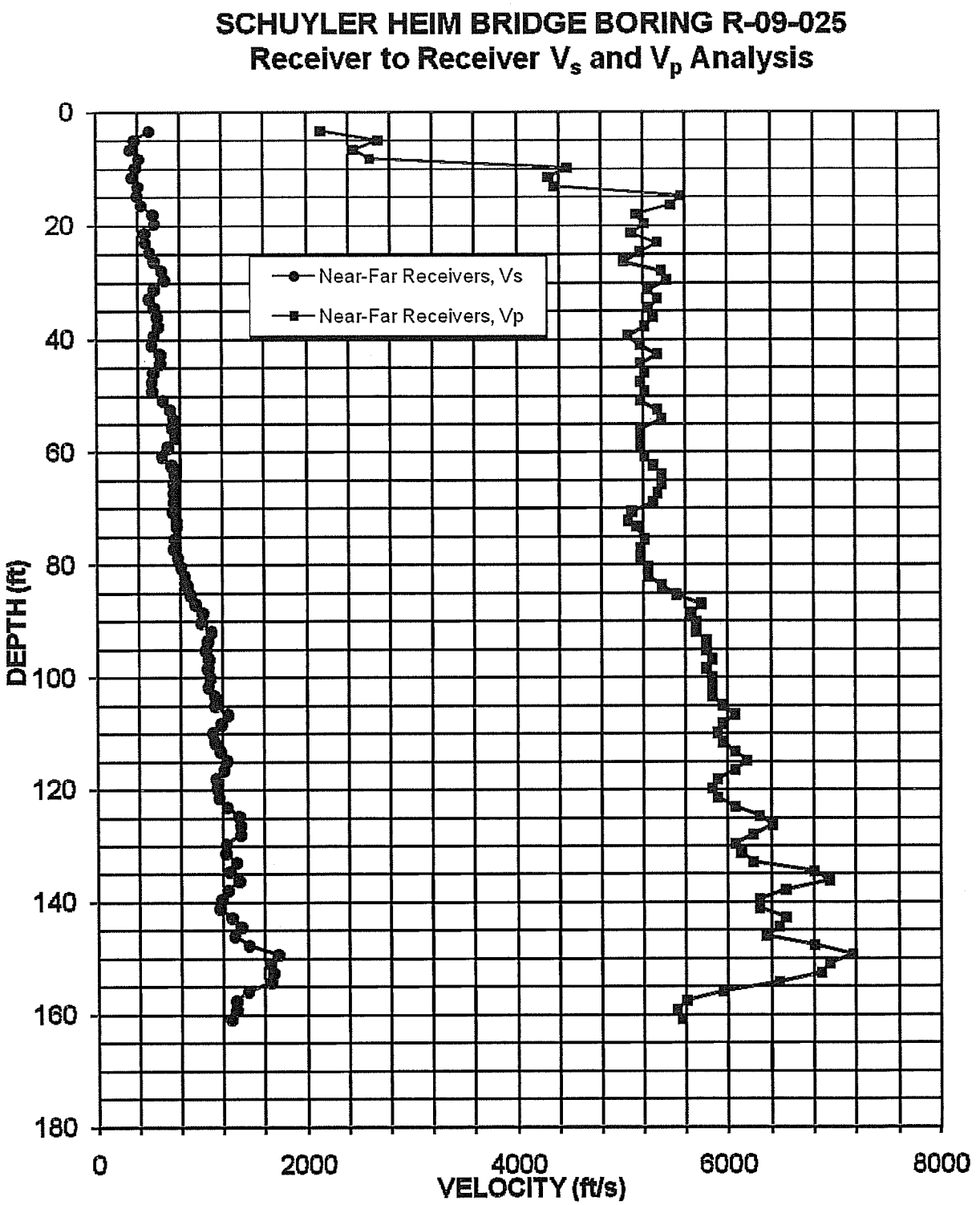


Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

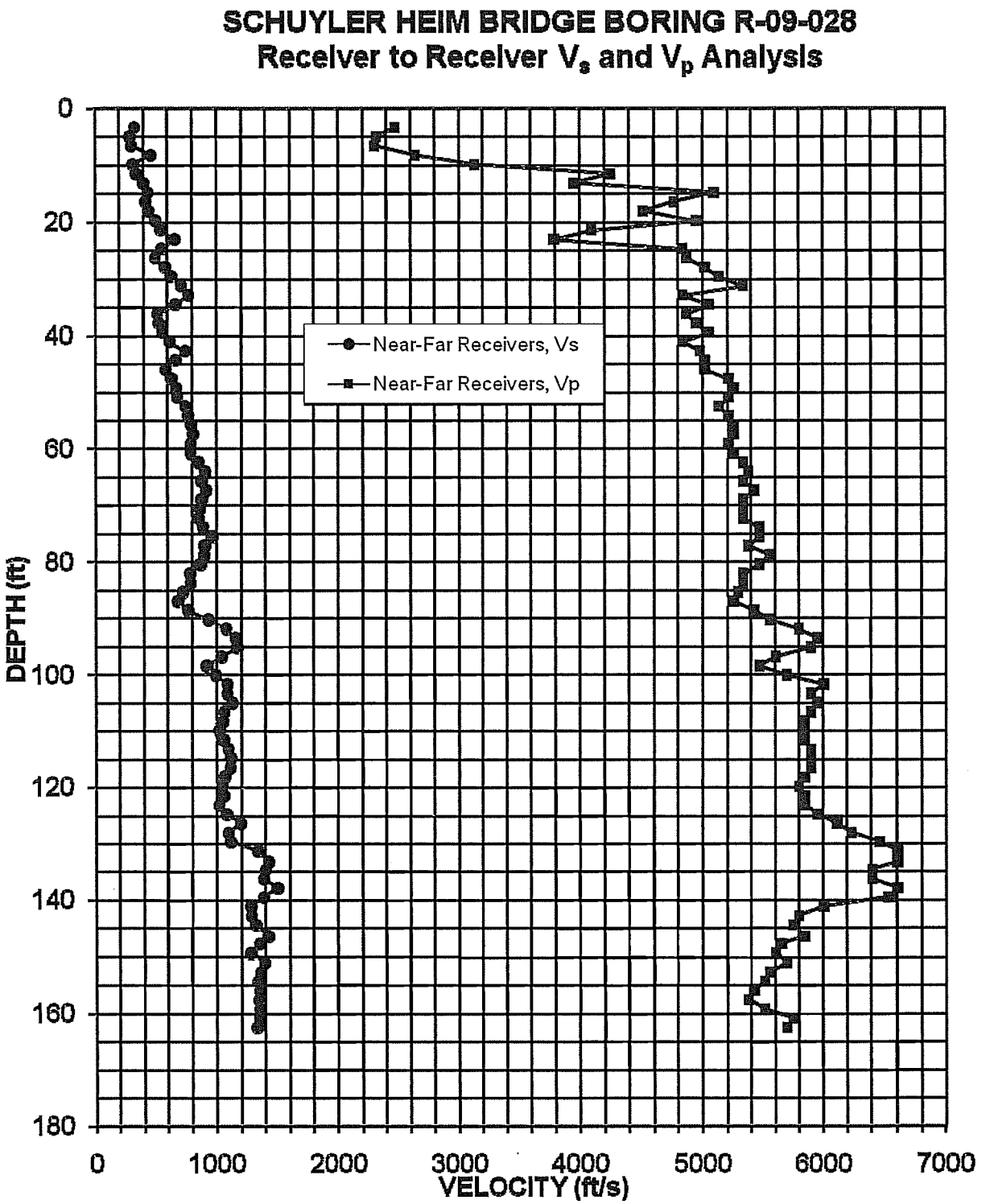


Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

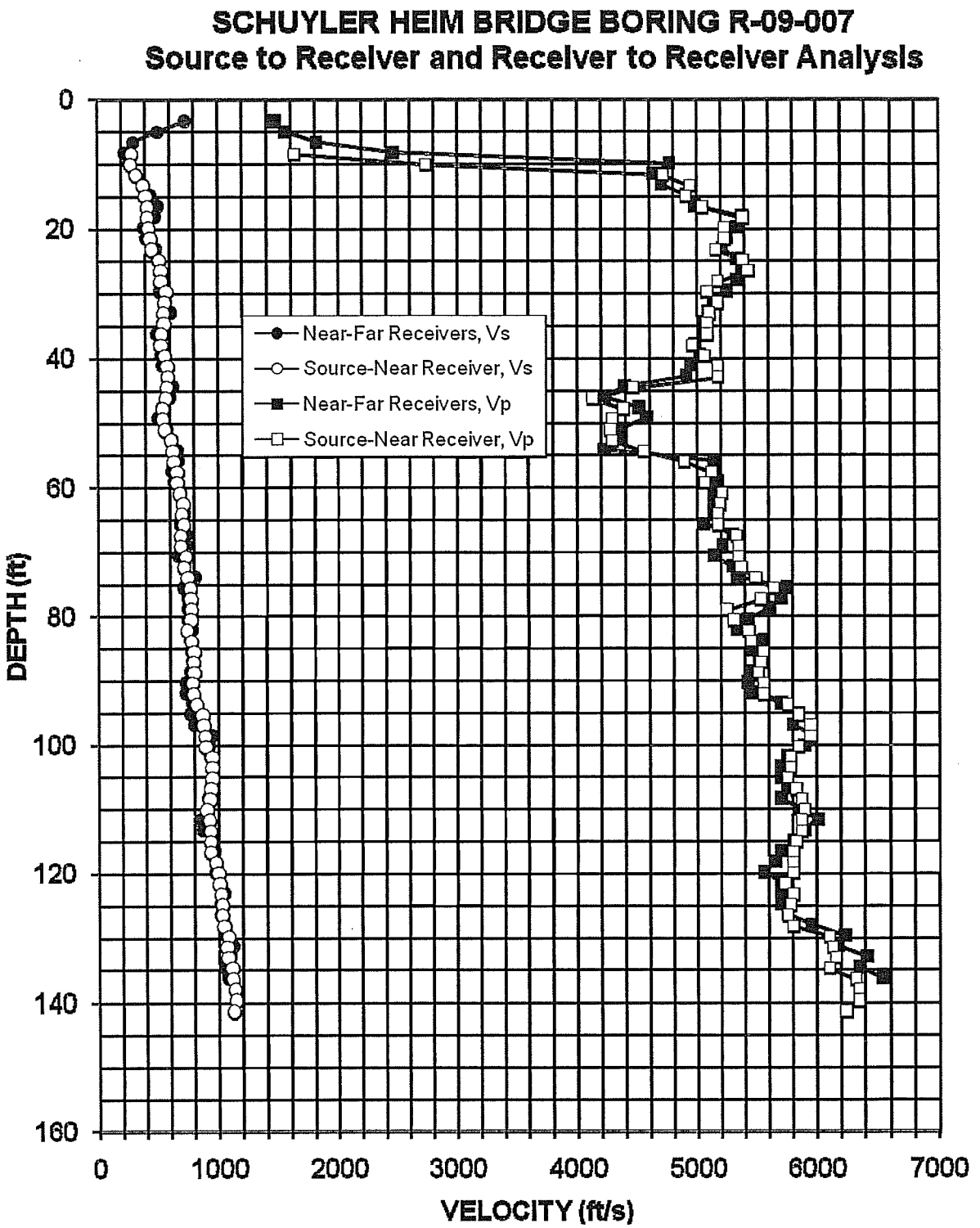


Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

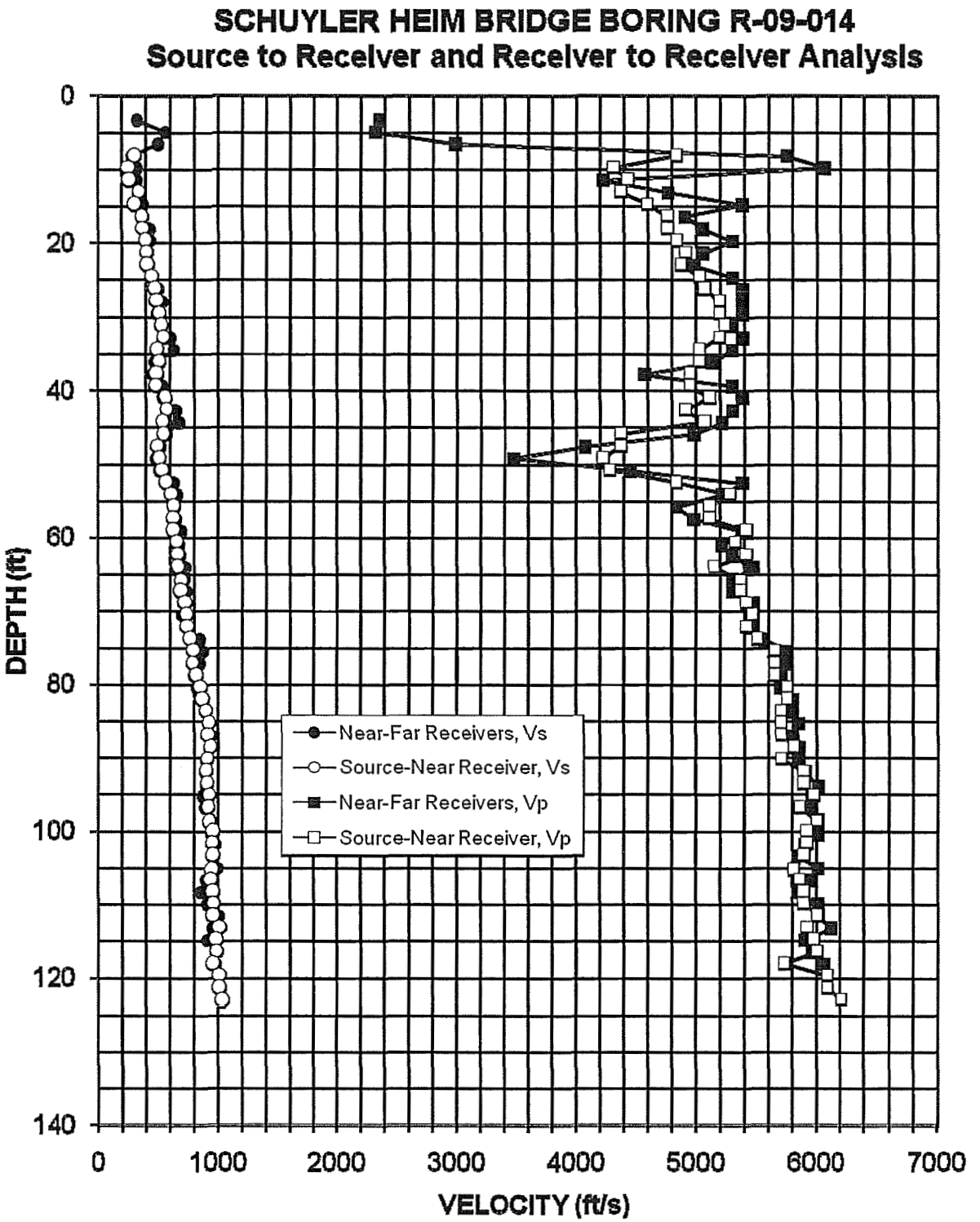


Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

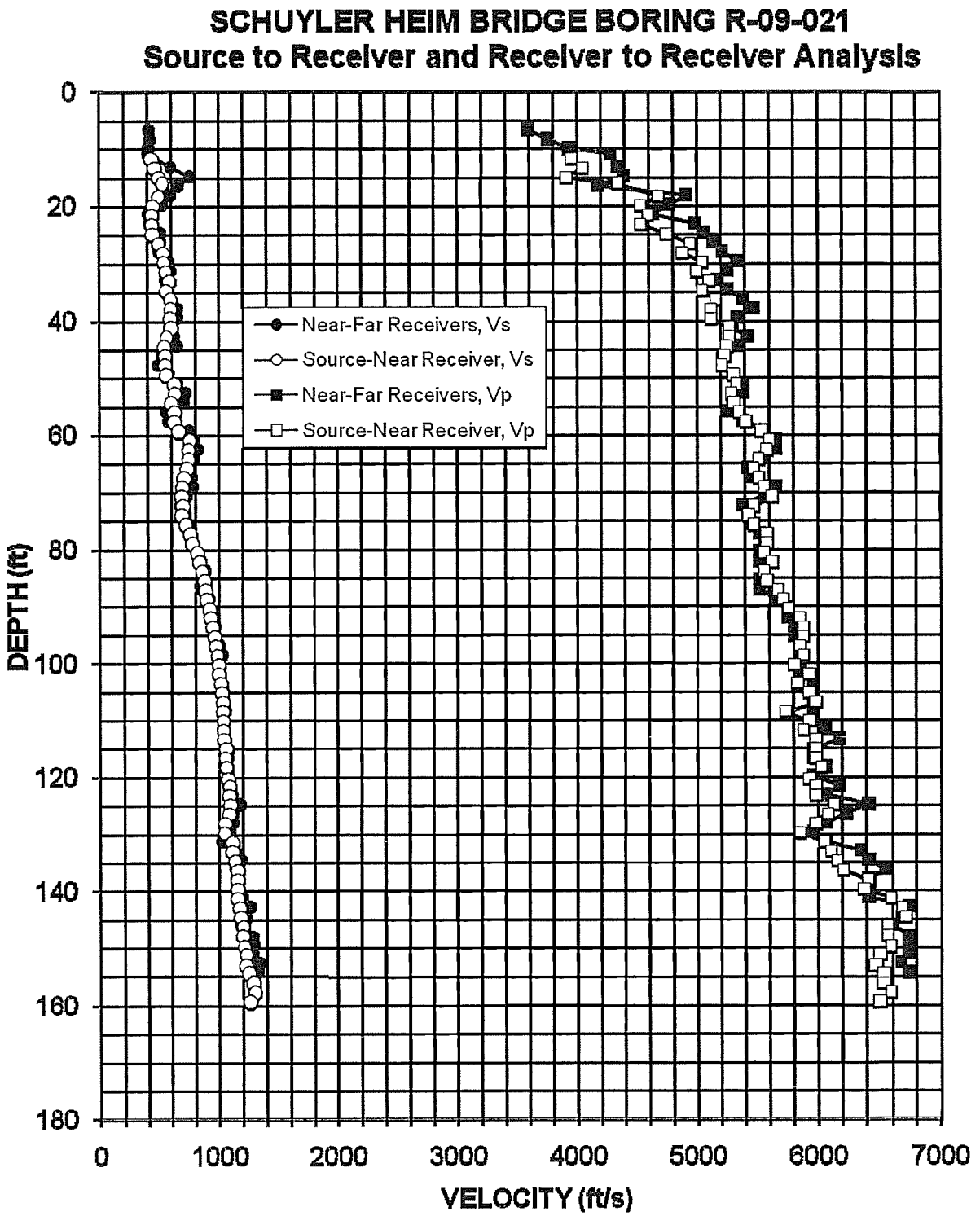


Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

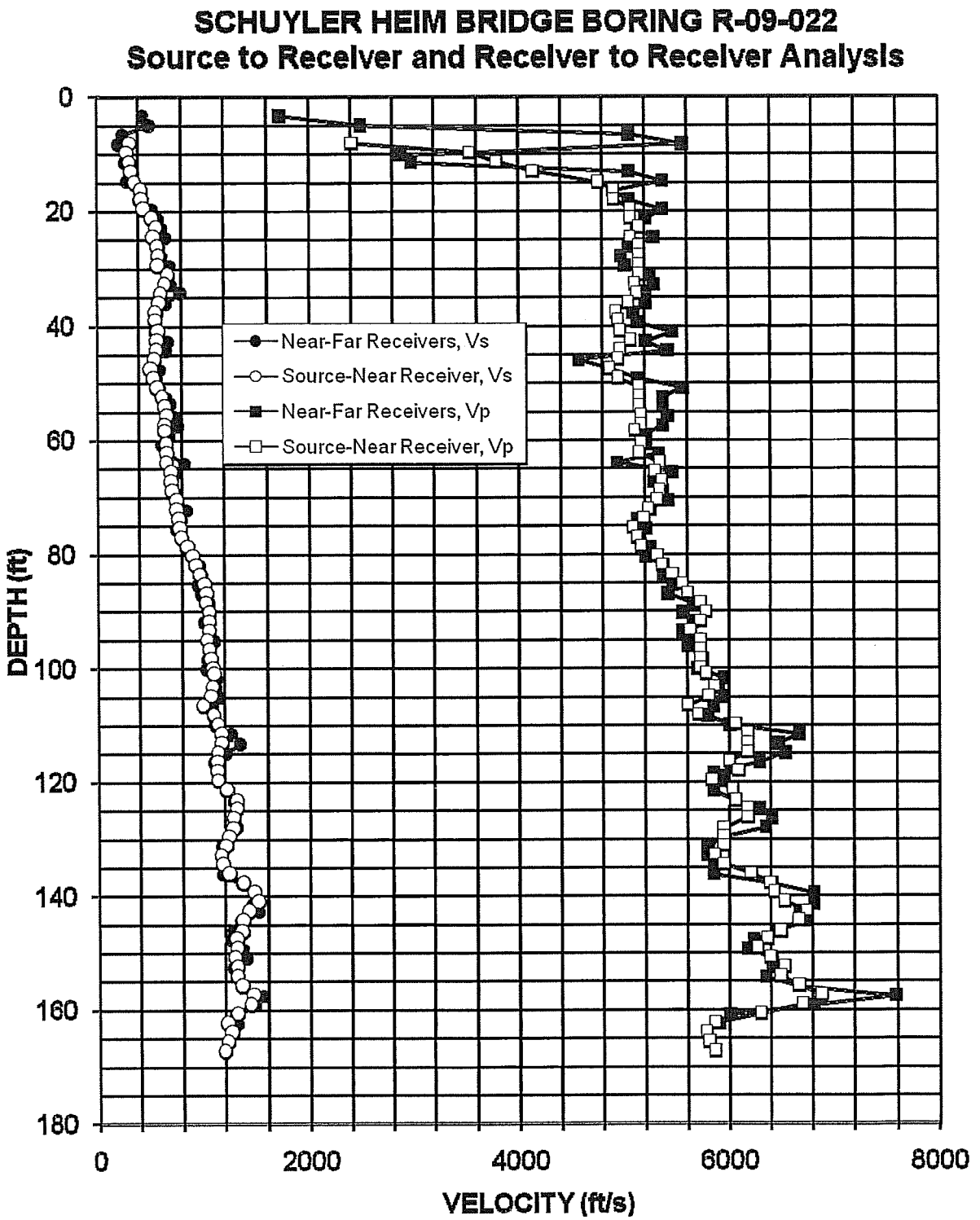


Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

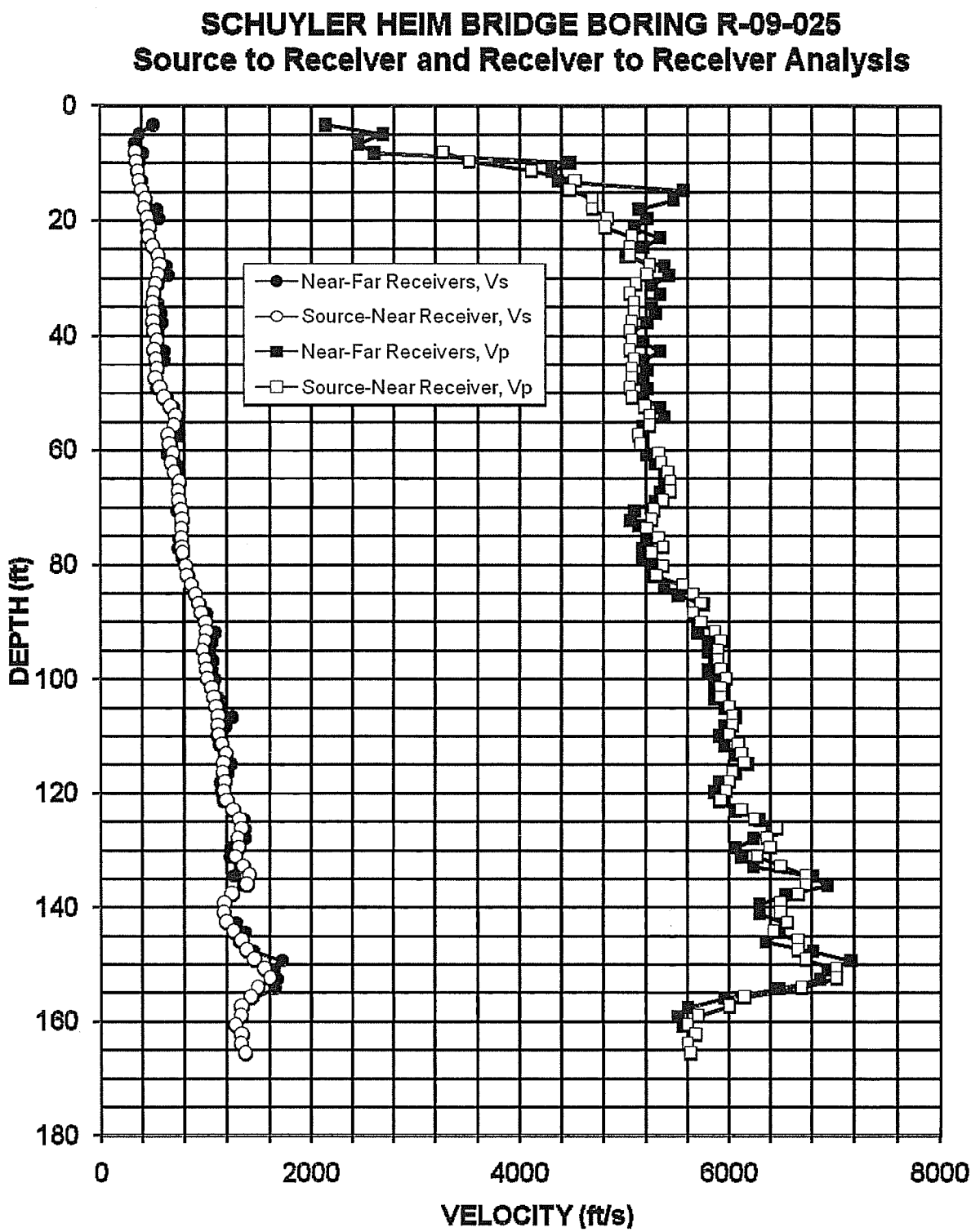


Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

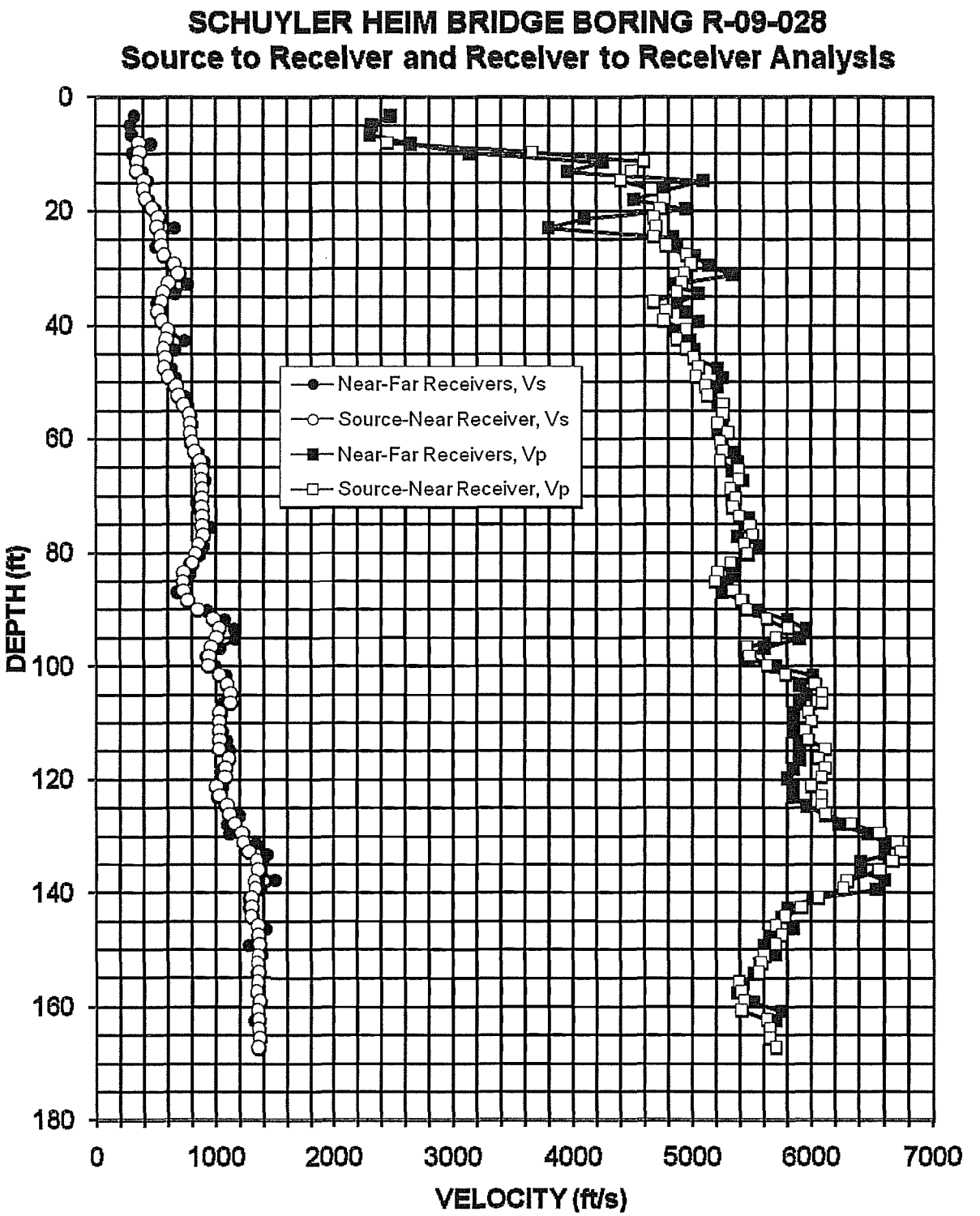


Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠ Calibration Report

TEST NUMBER 573794

A SOUTHERN CALIFORNIA EDISON® Company

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CXB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

MudCats CPM: Version 2.2.2 (Professional)
Src DUI: {9548AF3D-C74D-4C9F-AEEF-21EF560BC451} (c)
Doc DUI: {AB10F47E-4C5F-4650-91CB-A05A72E361C1} (o)

ATTACHMENT 2
Page 2 of 2

Customer

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11% As left -0.11%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠ Calibration Report

A SOUTHERN CALIFORNIA EDISON® Company

TEST NUMBER 573795

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

MudCats CPM: Version 2.2.2 (Professional)
Src DUI: {9548AF3D-C74D-4C9F-AEEF-21EF560BC451} (c)
Doc DUI: {1269C0B2-3A13-416A-81BF-409D9887DDDA} (o)

ATTACHMENT 2
Page 2 of 2

Customer

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

Appendix E. Laboratory Soil Test Results

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-030	S-01	5.0	21.6			
R-09-030	D-02	10.0	11.2	120.0		
R-09-030	S-03	15.0	42.9		72.3	
R-09-030	U-05	25.0				43,25,18
R-09-030	S-07	35.0	30.5		34.3	
R-09-030	U-09	45.0				45,25,20
R-09-030	D-11-1	55.0	35.3	82.9		35,20,15
R-09-030	S-12	60.0			46.2	
R-09-030	S-14	70.0	27.4			
R-09-030	D-15	75.0	27.5	95.4		
R-09-030	S-17-1	85.0	41.3			48,26,22
R-09-030	S-17-2	85.5			20.2	
R-09-030	S-18	90.0	25.2			
R-09-030	S-20	110.0	31.4			27,23,4
R-09-030	S-23	135.0	12.5			
R-09-030	S-25	155.0	23.9			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-030	D-02	10	8.17	1085	0.19	340
R-09-030	U-09	45	8.86	1500	0.054	330

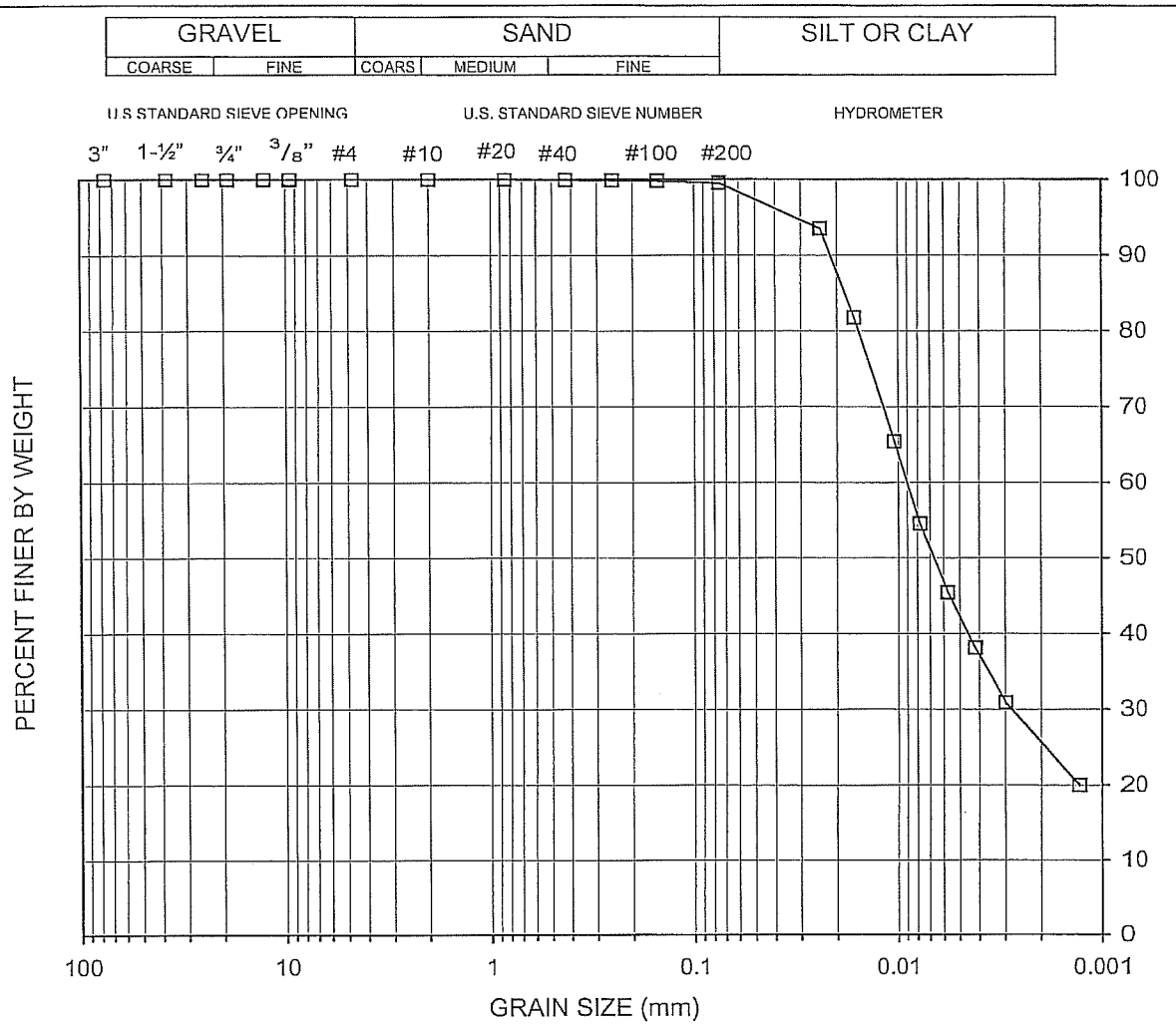
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-030	U-05	25	2.764
R-09-030	U-09	45	2.745



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-030	U-05	25	Shelby Tube	CL	43	18

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

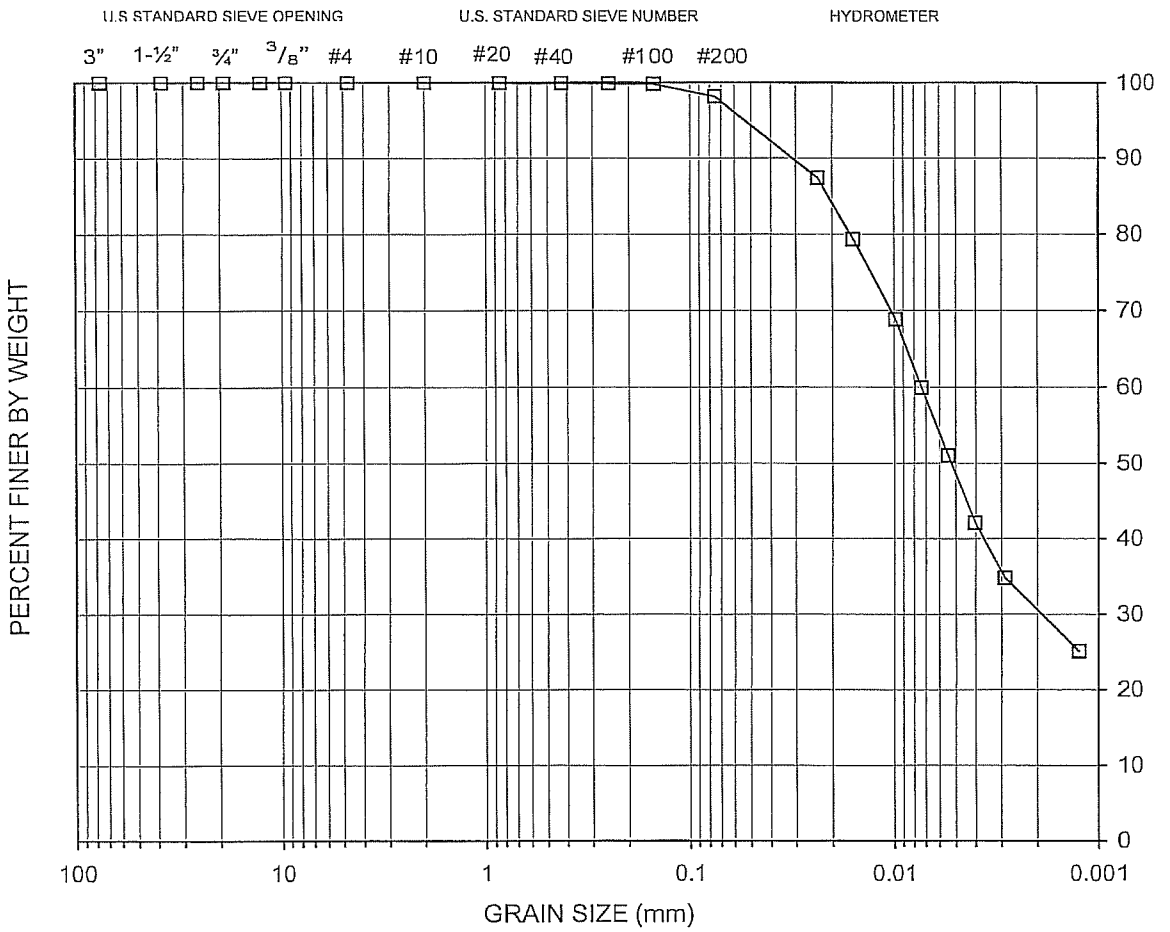
Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-030	U-09	45	Shelby Tube	CL	45	20

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

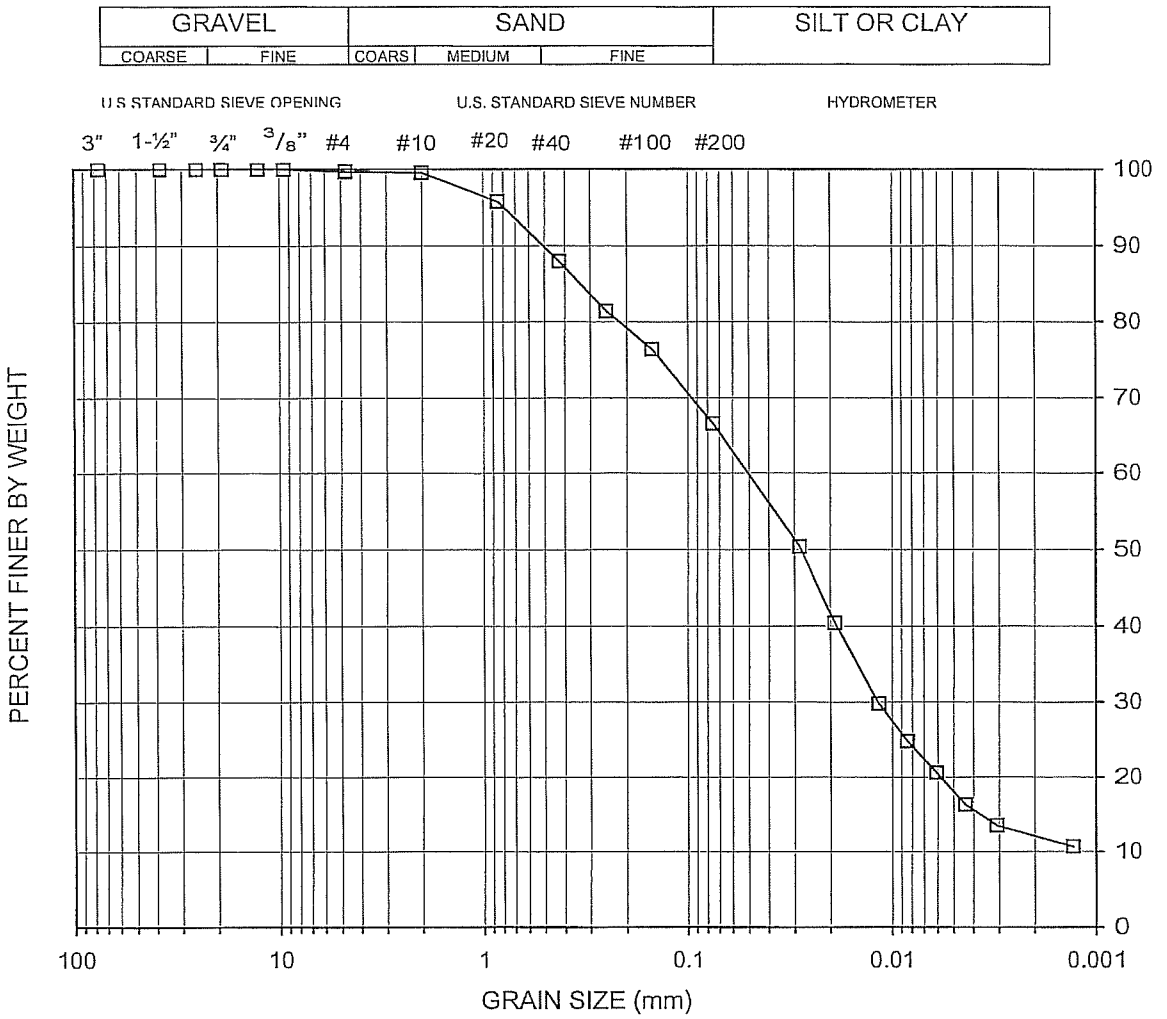
Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-030	S-20	110	BAG	ML	27	4

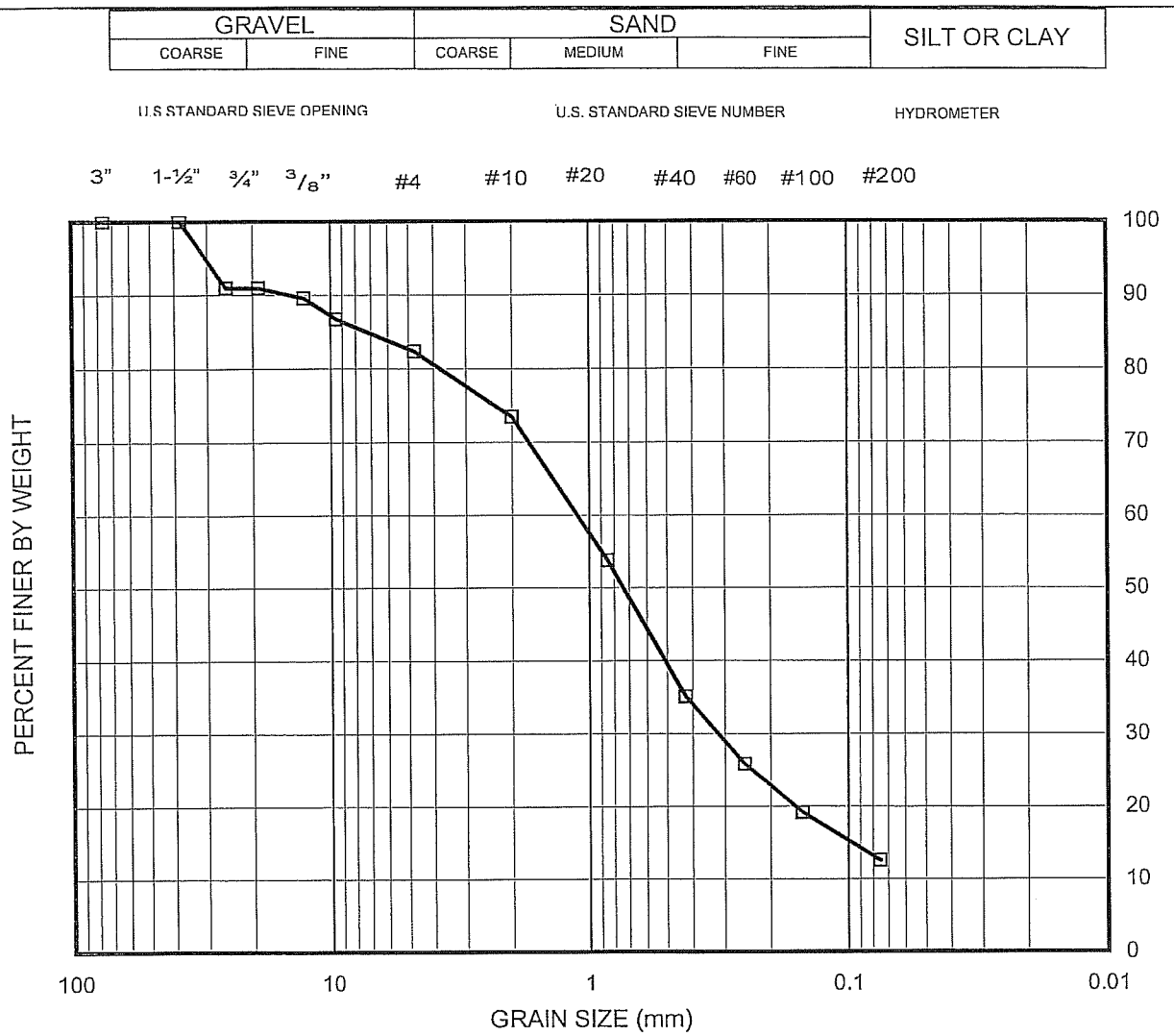
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



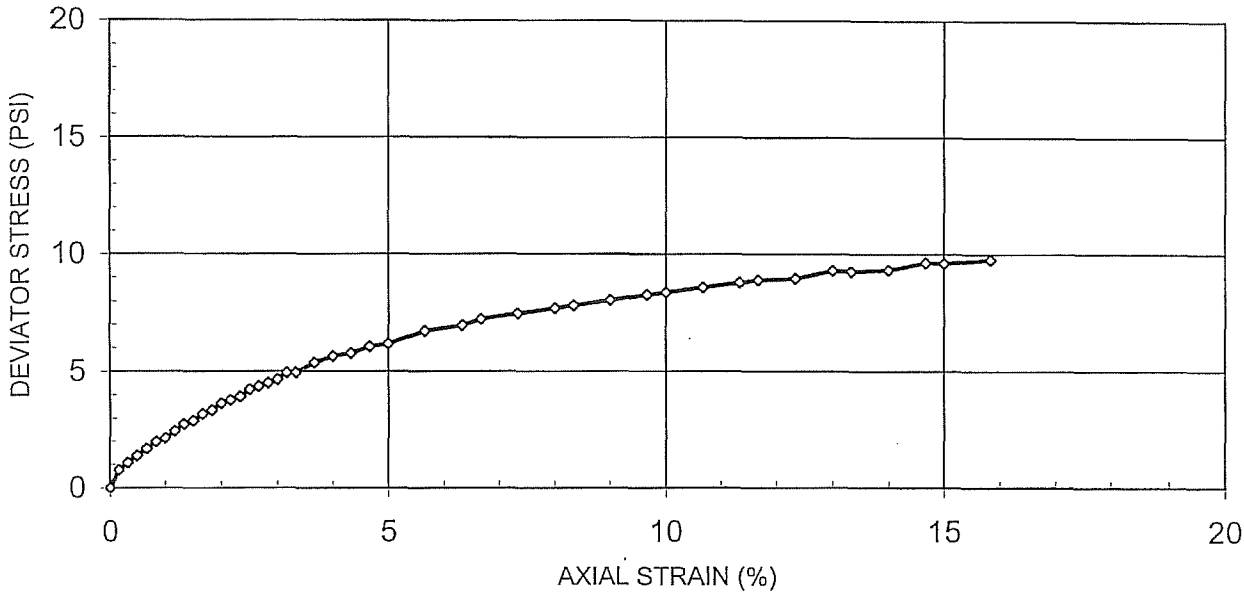
SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-030	S-23	135	Bag	SM	N/A	N/A

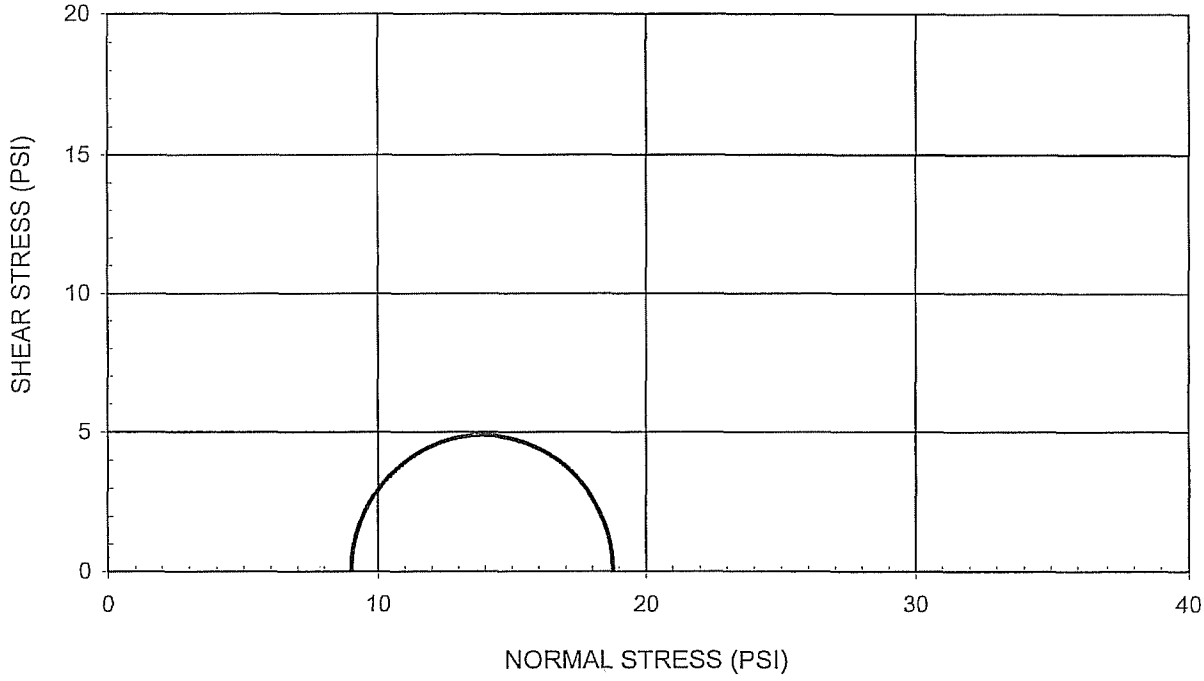
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-030	25	U-05	CL	Shelby Tube	46.30	75.3	9.0	9.8	0.06	101.1

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

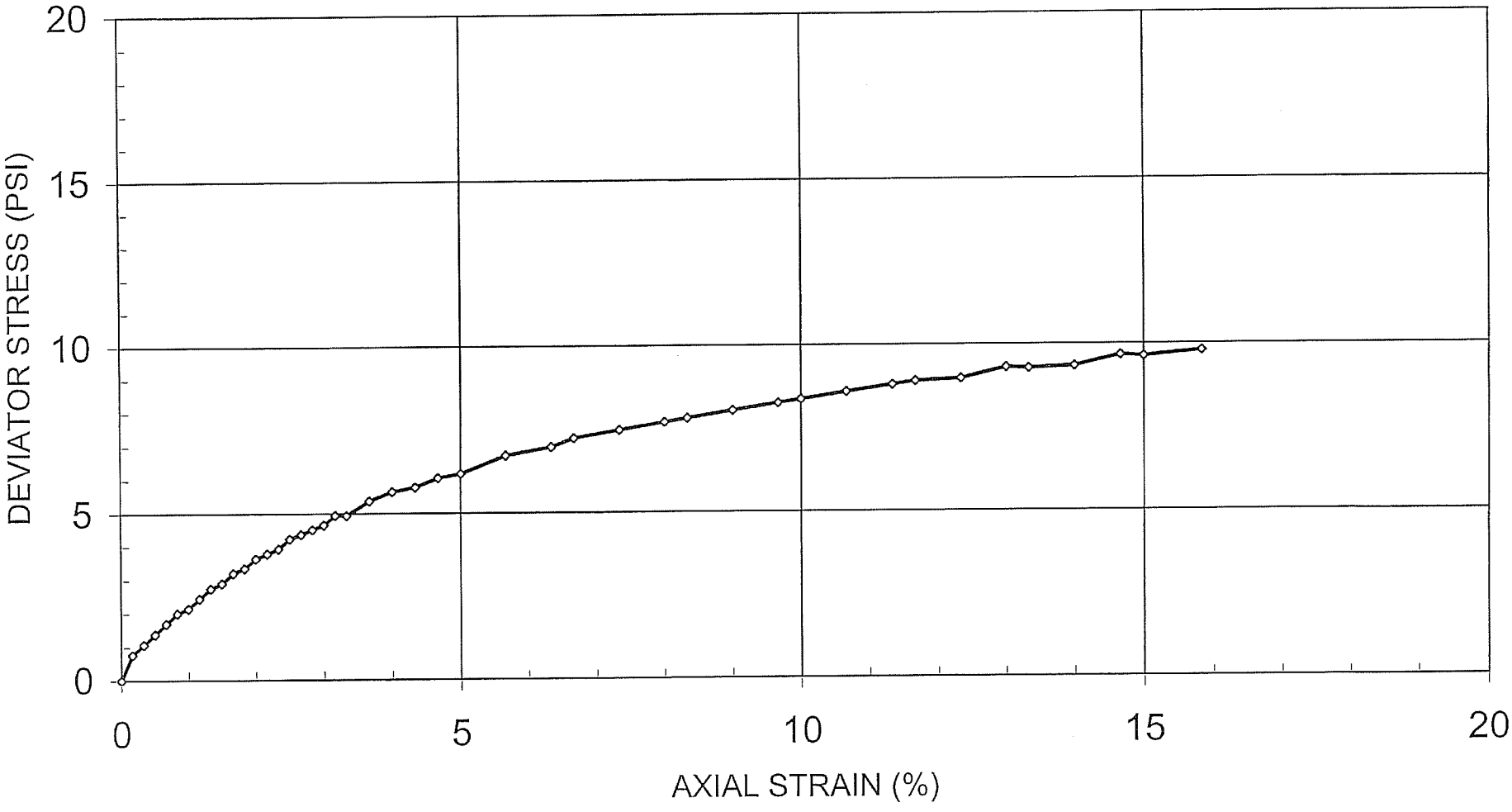
(ASTM D2850)

11/29/09

Figure

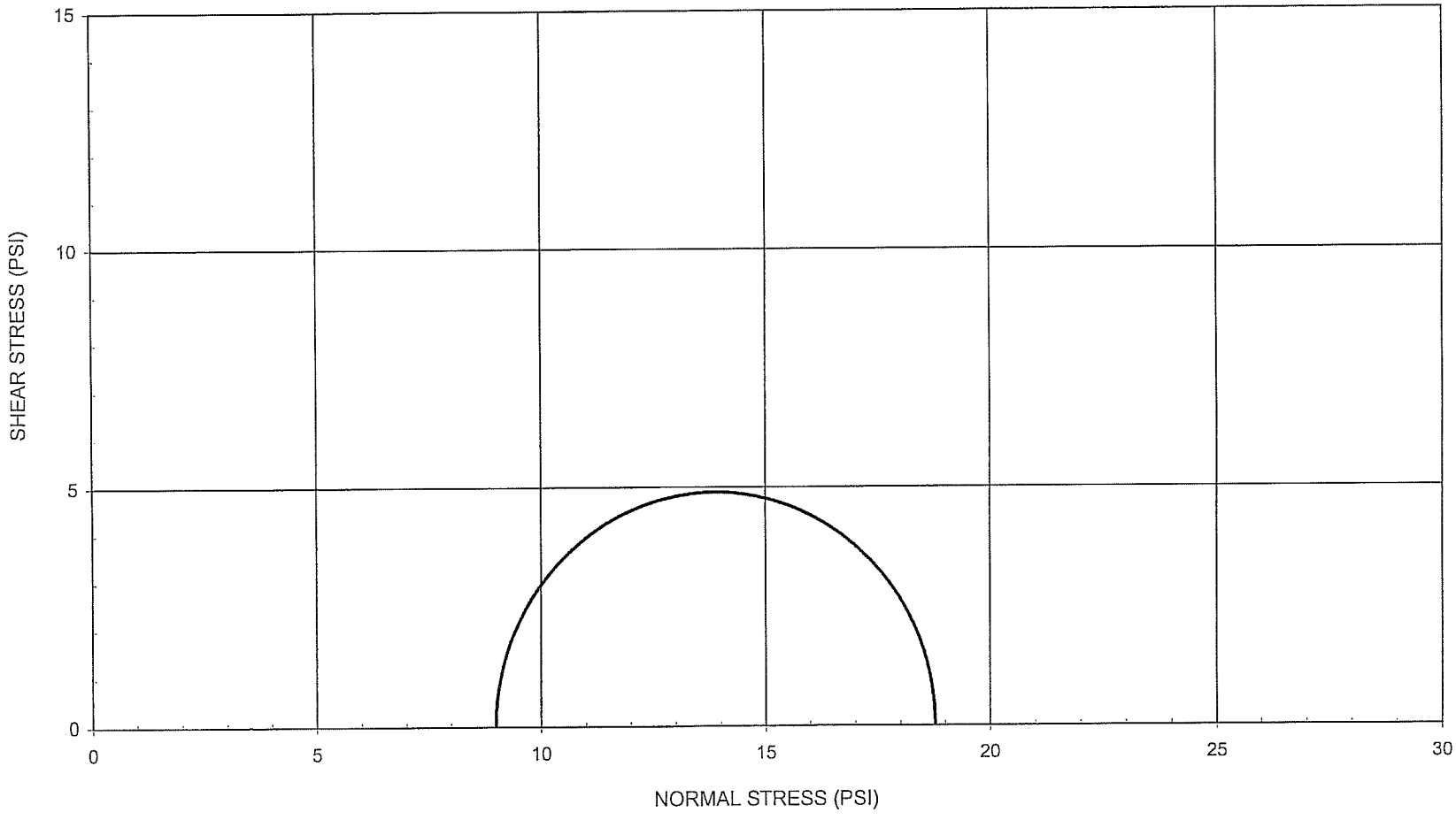
Project Name: ACTA Heim Bridge Replacement

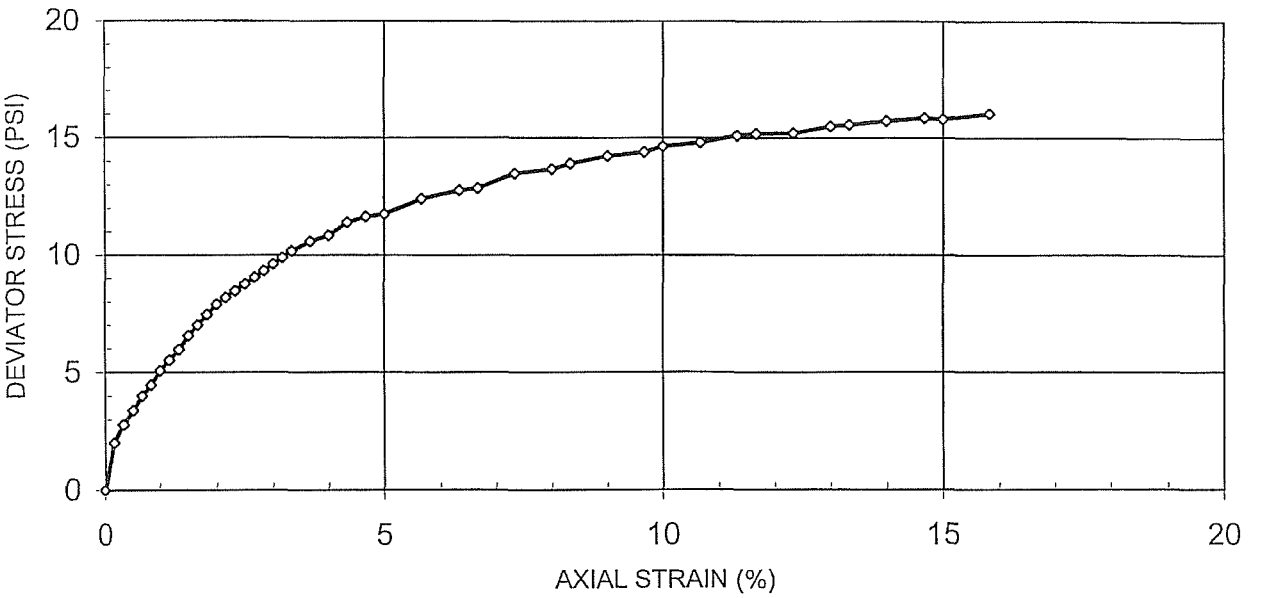
Boring: R-09-030 Sample ID: U-05 Depth (ft): 25

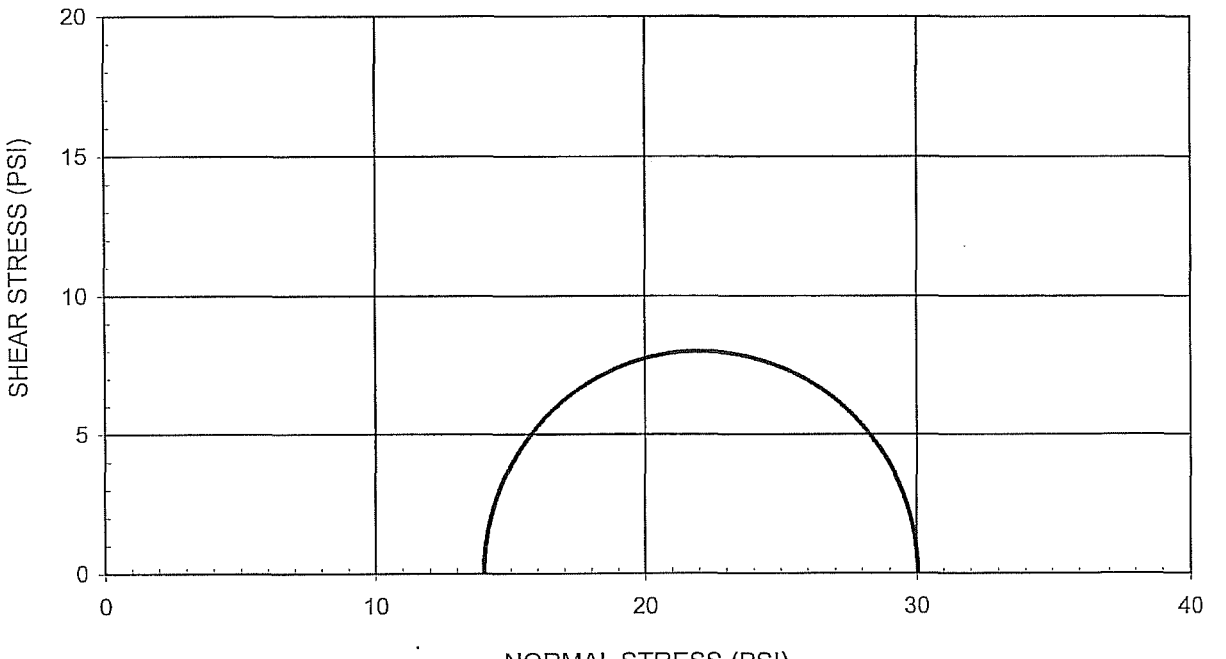


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-030 Sample ID: U-05 Depth (ft): 25







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-030	45	U-09	CL	Shelby Tube	43.34	78.1	14.0	16.0	0.06	101.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

UNCONSOLIDATED UNDRAINED

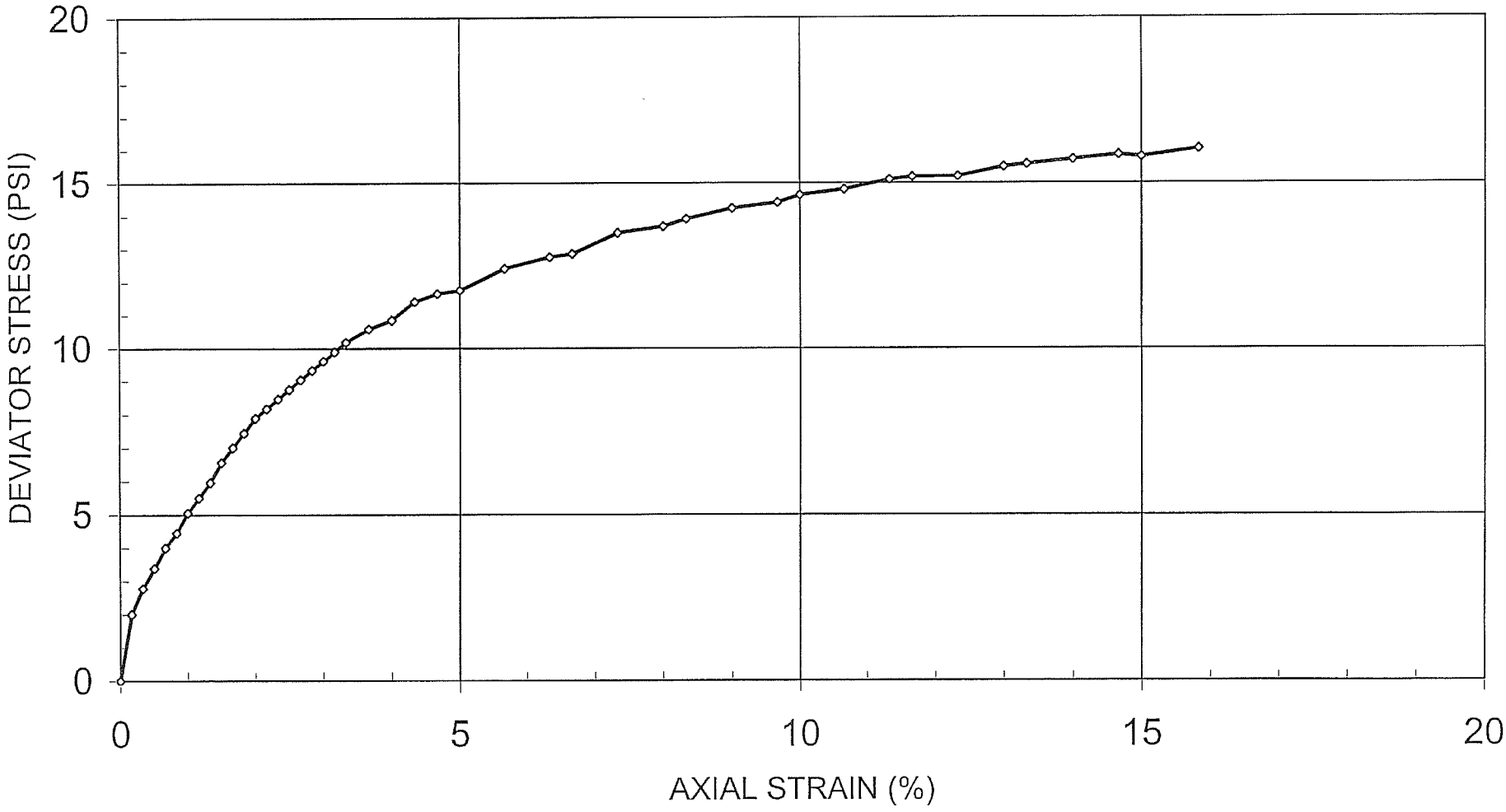
(ASTM D2850)

11/29/09

Figure

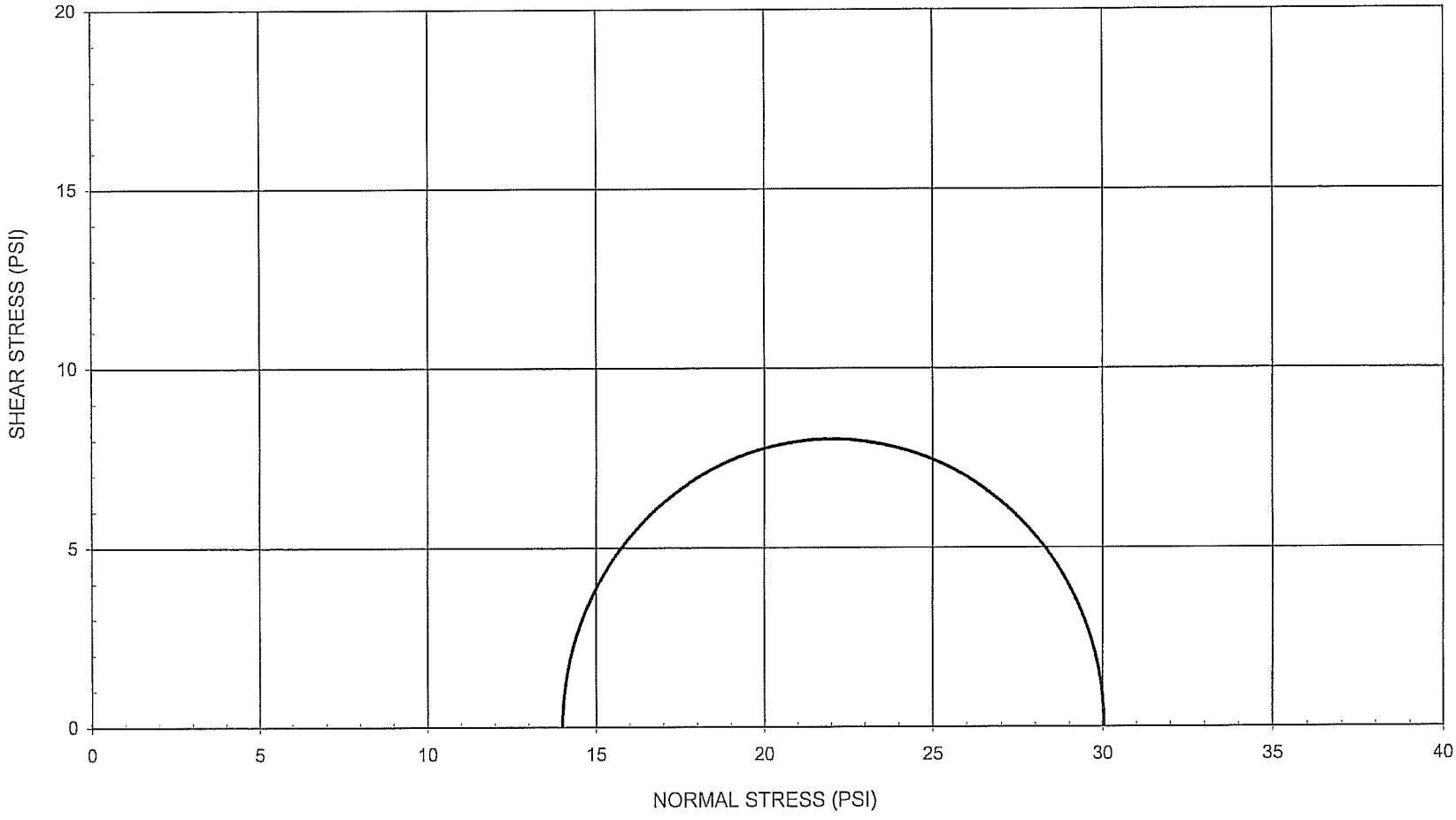
Project Name: ACTA Heim Bridge Replacement

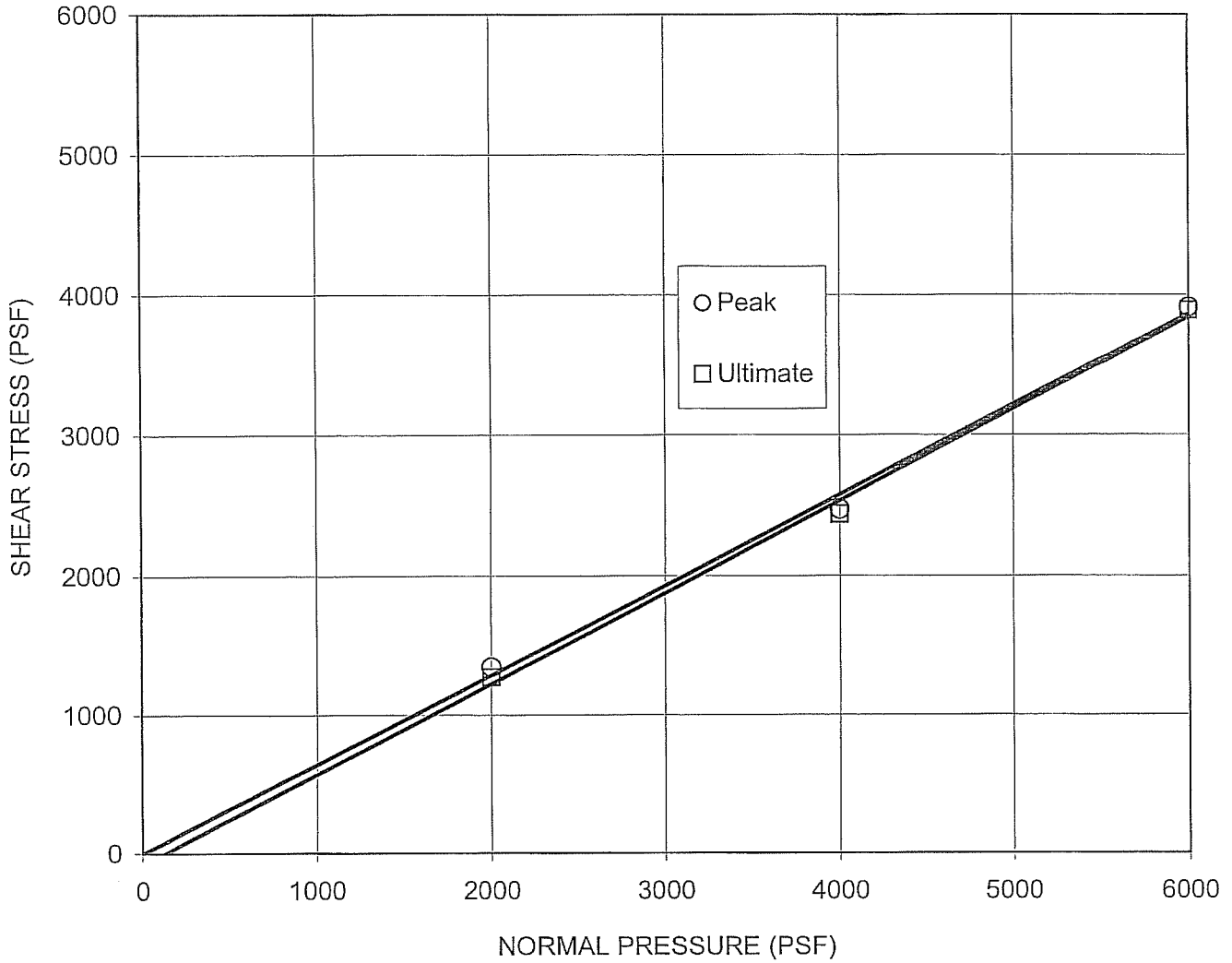
Boring: R-09-030 Sample ID: U-09 Depth (ft): 45



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-030 Sample ID: U-09 Depth (ft): 45





Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-030	D-06	30	Ring	SM	○	10	33
					□	0	32

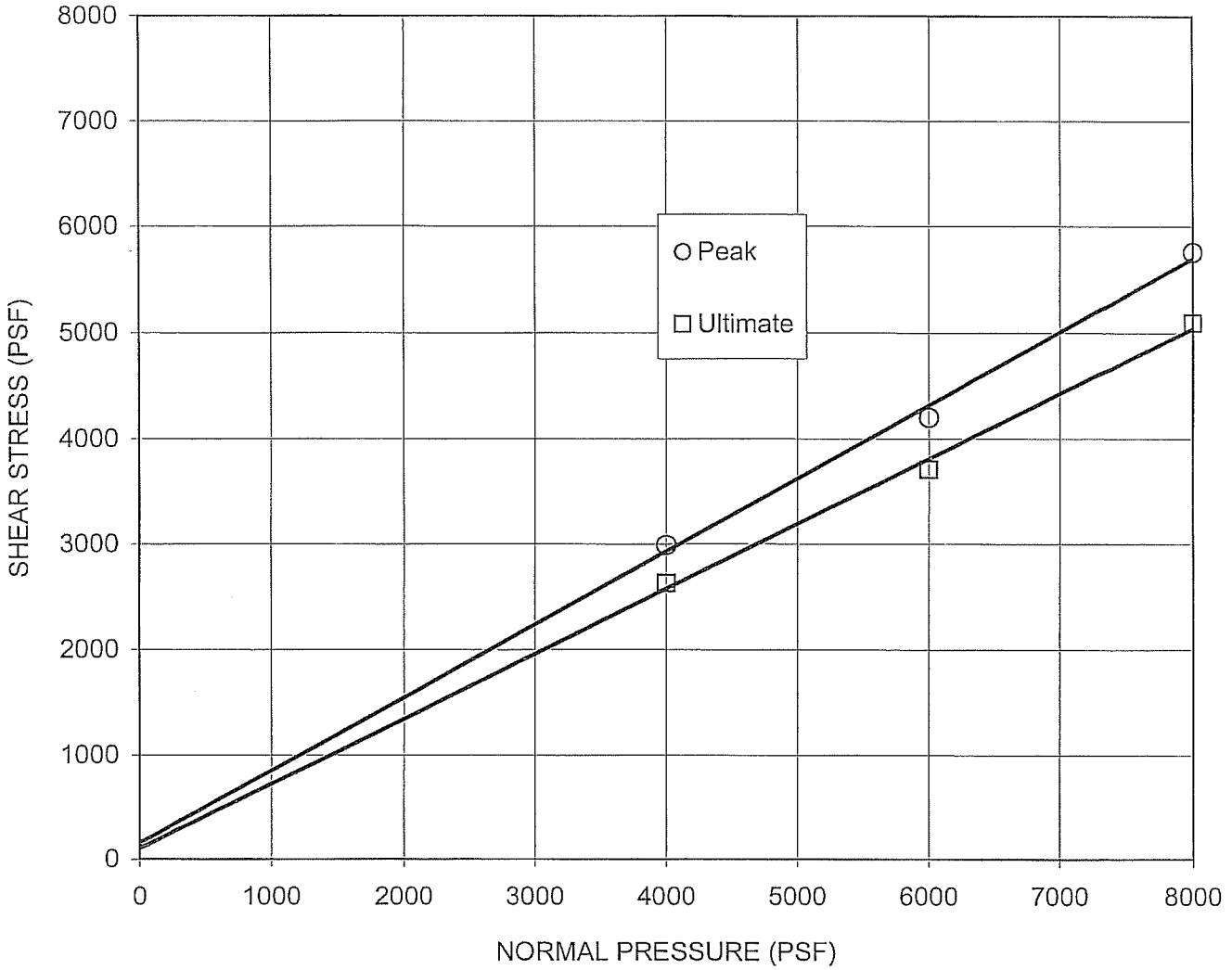
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2000	24.9	33.0
4000	24.9	30.7
6000	24.9	29.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-030	D-13	65	Ring	SM	○	160	35
					□	109	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	26.1	29.1
6000	26.1	27.2
8000	26.1	26.6

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

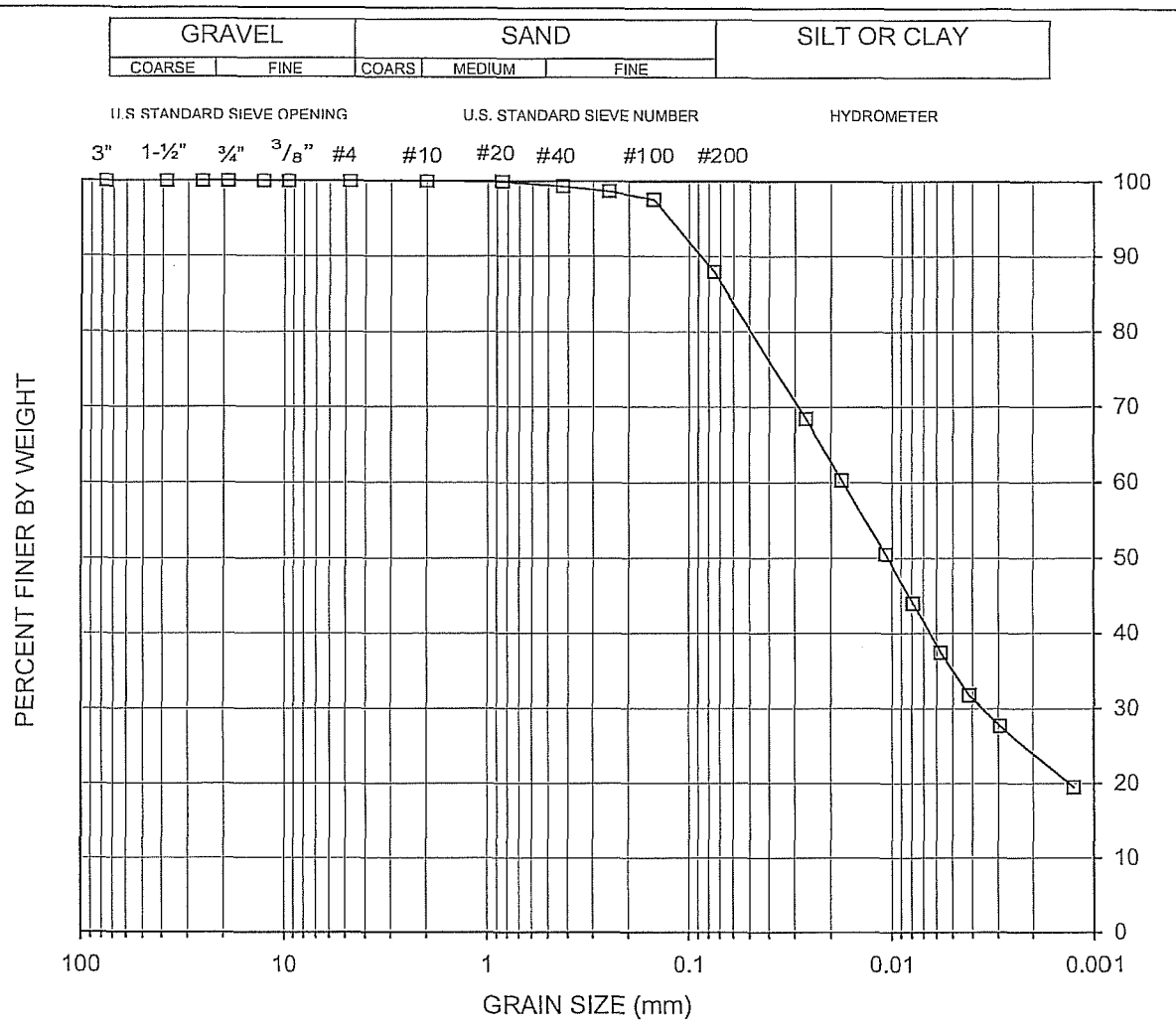
BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-032	S-01	5.0	19.6			
R-09-032	D-02	10.0			23.5	
R-09-032	S-03	15.0	64.8			55,26,29
R-09-032	D-04	20.0	42.0	82.1		
R-09-032	S-05	25.0				
R-09-032	D-06	30.0	28.9	96.5	24.2	
R-09-032	S-07	35.0	39.0			28,23,5
R-09-032	D-08	40.0	34.4	89.3		
R-09-032	S-09	45.0			52.0	
R-09-032	D-10	50.0	38.2	83.4		40,22,18
R-09-032	S-11	55.0			18.1	
R-09-032	D-12	60.0	24.6	101.9		
R-09-032	S-13	65.0			9.2	
R-09-032	D-14	70.0	25.7	99.4		
R-09-032	S-15	75.0	25.8			
R-09-032	D-16	80.0	23.3	104.8		
R-09-032	S-18	100.0	17.9			
R-09-032	S-20	120.0	20.5			
R-09-032	S-22	140.0	10.0			
R-09-032	S-23	150.0	13.1			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-032	S-03	15	8.09	1280	0.093	360
R-09-032	S-09	45	8.79	635	0.054	520



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-032	S-03	15	BAG	CH	55	29

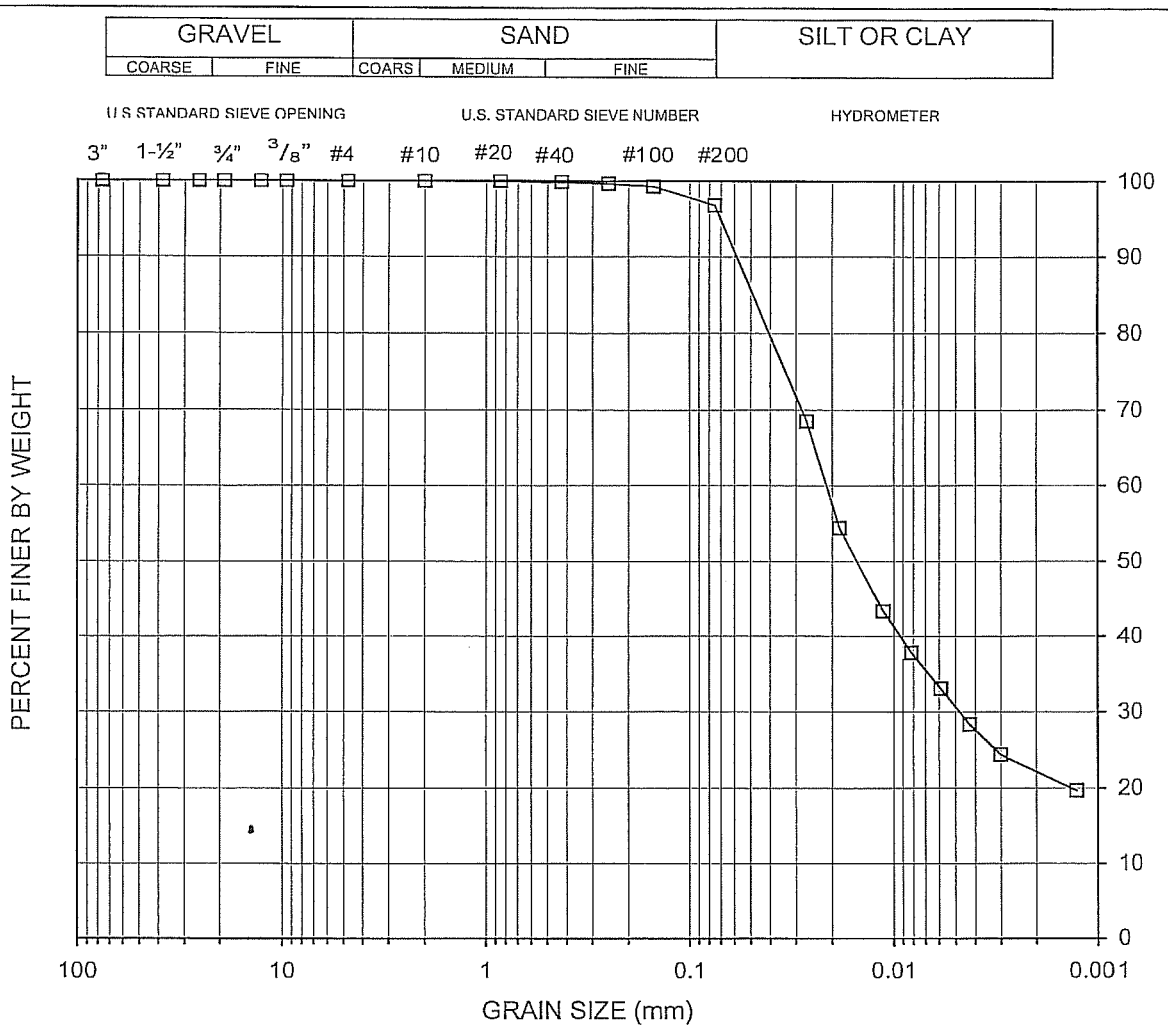
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-032	D-10	50	RING	CL	40	18

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.

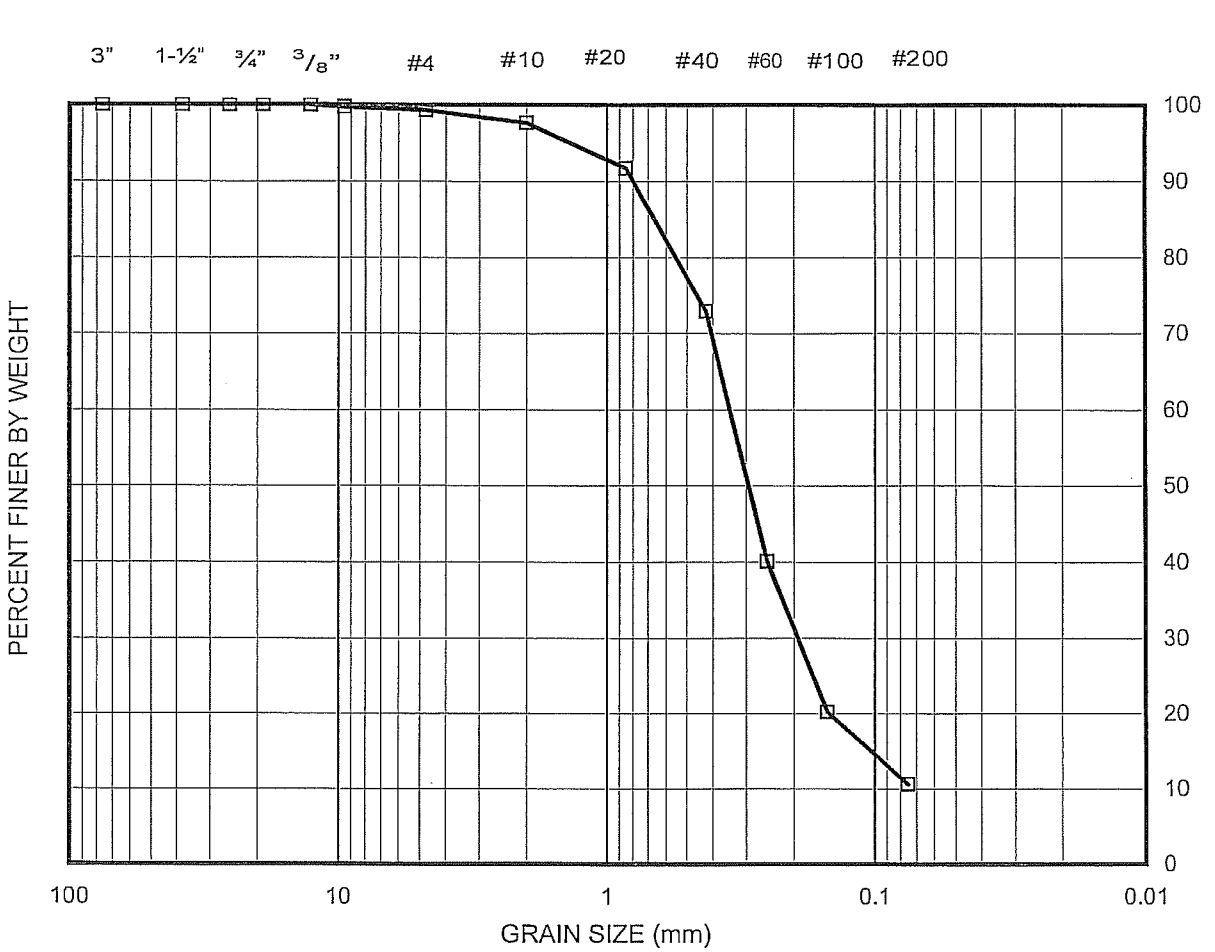
Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-032	S-20	120	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

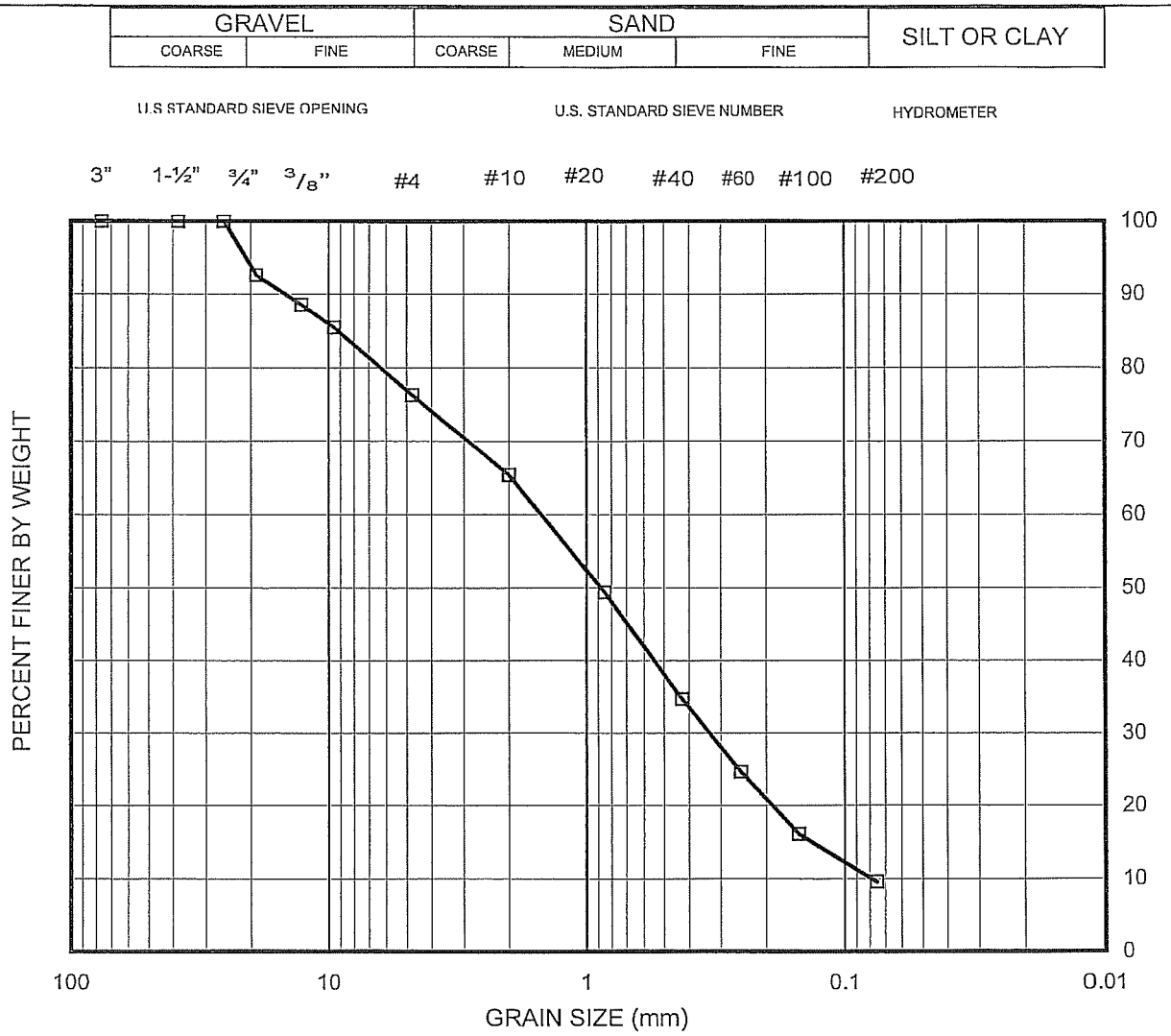
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE



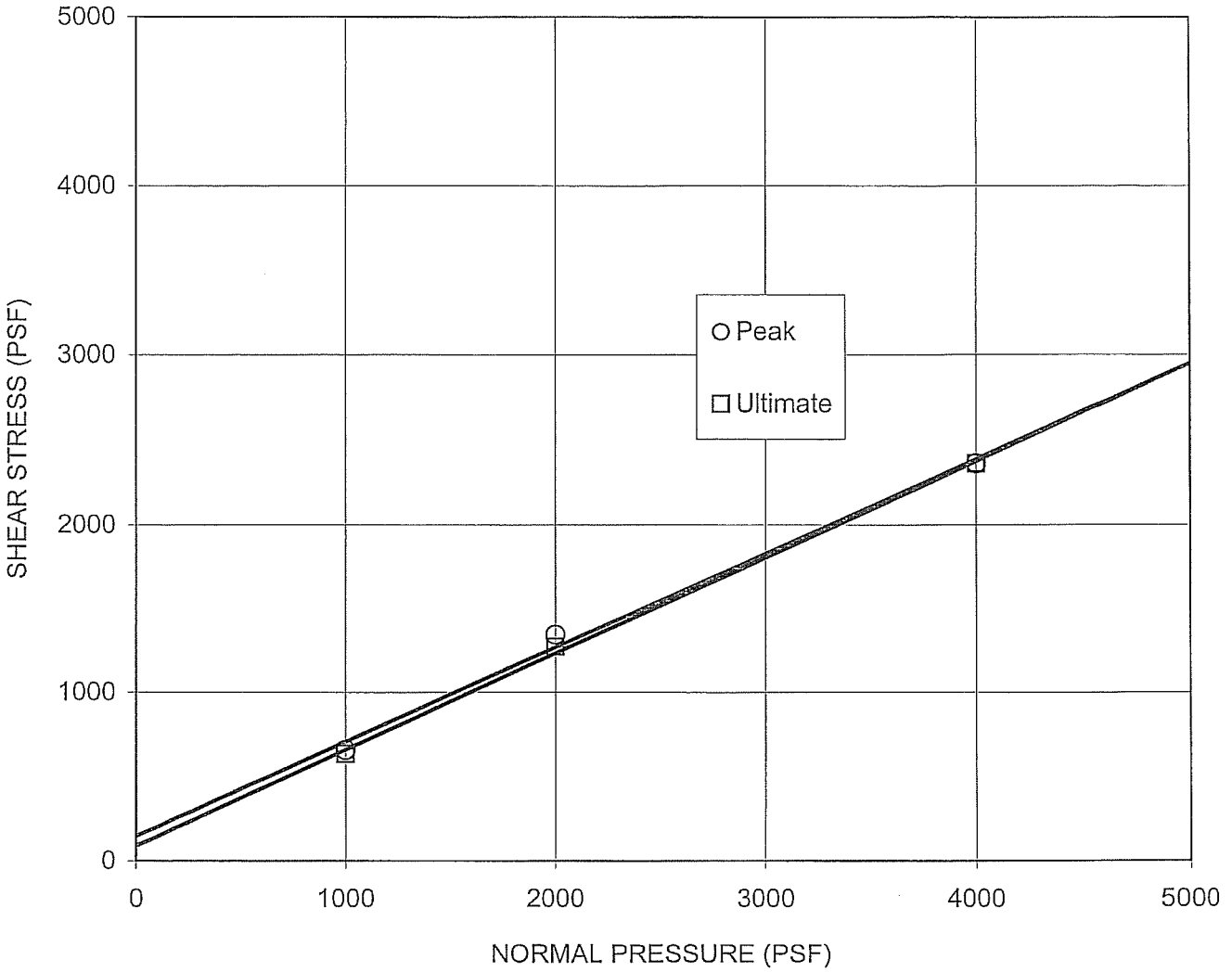
SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-032	S-23	150	Bag	SW-SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-032	D-02	10	Ring	SM	○	150	29
					□	90	30

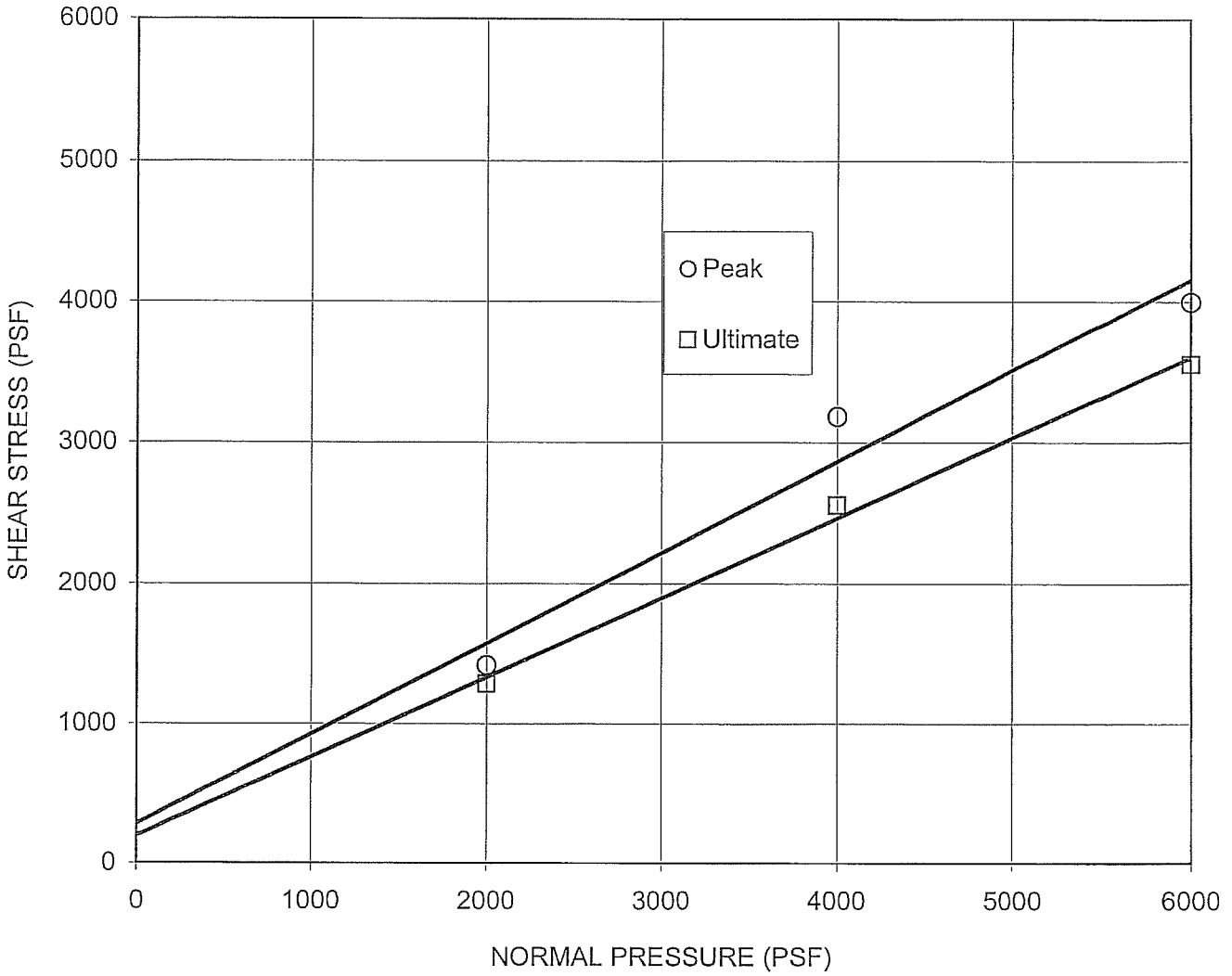
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	29.6	36.8
2000	29.6	36.0
4000	29.6	35.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-032	D-06	30	Ring	SM	○	284	33
					□	196	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2000	28.9	32.9
4000	28.9	28.4
6000	28.9	25.9

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

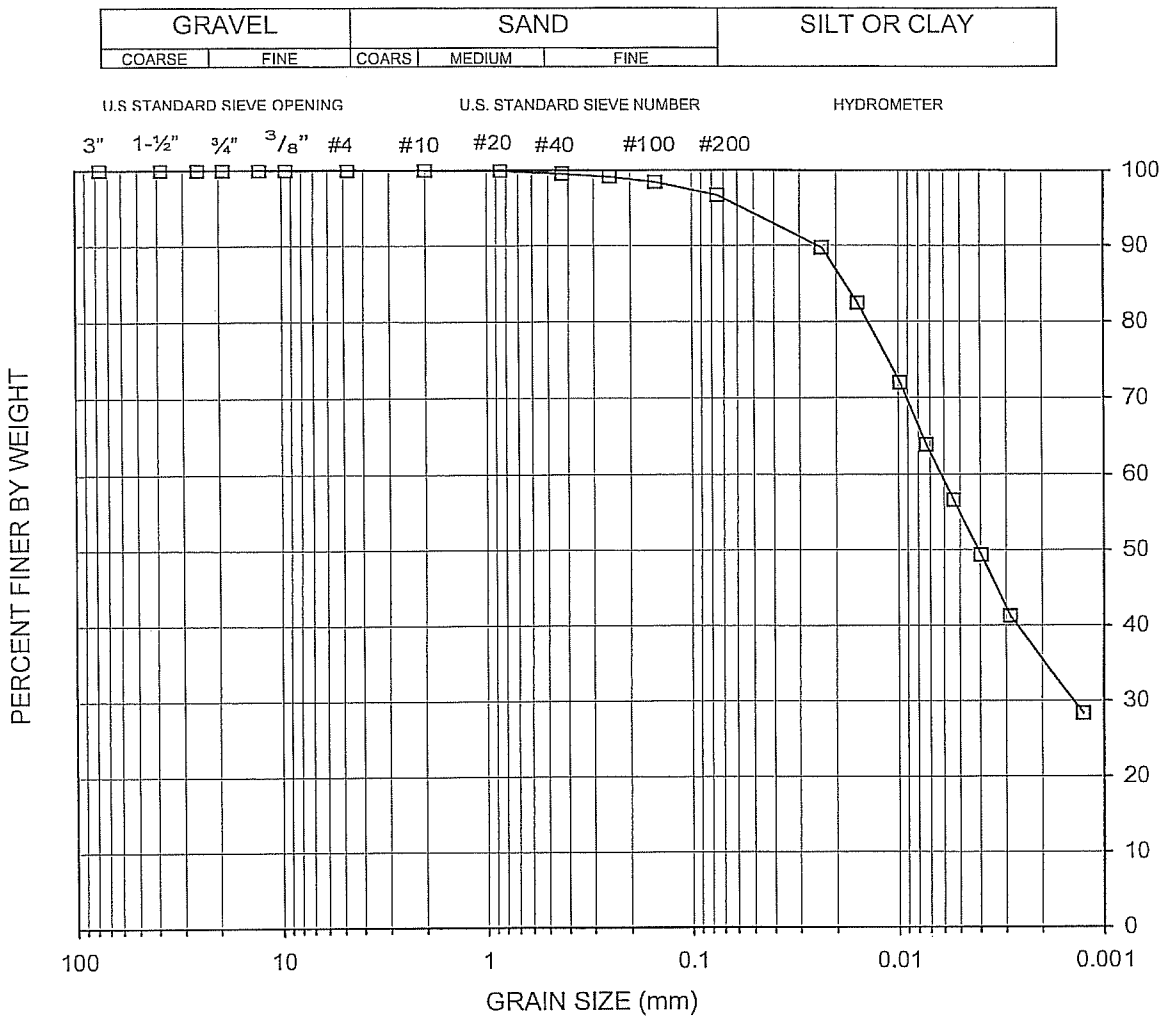
CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-033	S-01	5.0	12.7			
R-09-033	D-02	10.0	12.7	104.6	21.4	
R-09-033	U-04	20.0				61,26,35
R-09-033	D-05	25.0			10.9	
R-09-033	S-08-1	40.0	47.8			41,23,18
R-09-033	U-09	45.0				25,24,1
R-09-033	D-10-1	50.0			55.5	
R-09-033	S-11-1	55.0	31.9			29,28,1
R-09-033	S-11-2	55.8	30.5			24,23,1
R-09-033	D-12-1	60.0	25.5	100.4		
R-09-033	S-13-1	65.0	38.6			38,24,14
R-09-033	S-16	80.0	20.7			
R-09-033	S-17-2	90.6	35.5			33,22,11
R-09-033	S-19	100.0	14.2			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	U-04	20	Shelby Tube	CH	61	35

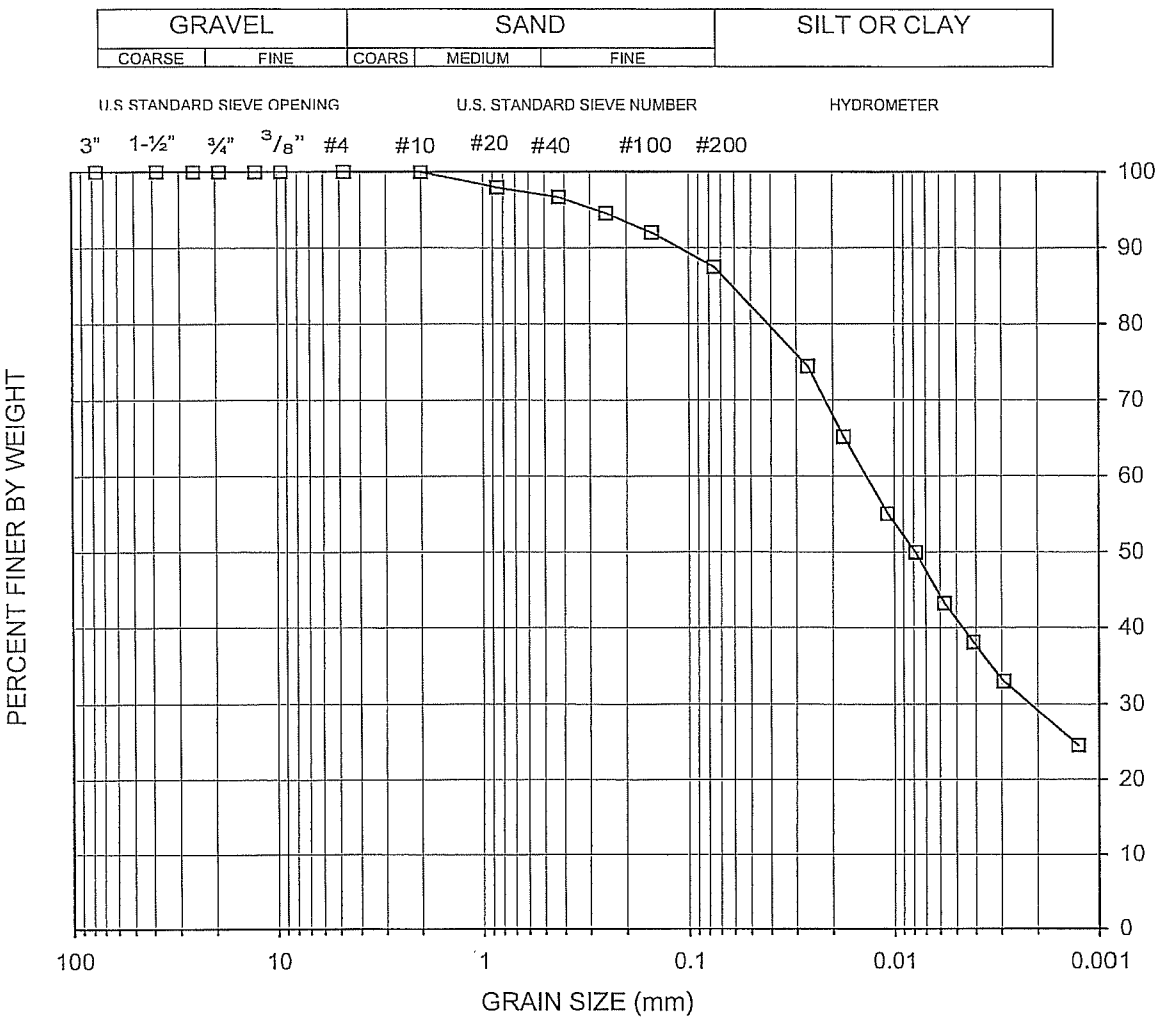
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-08-1	40	Bag	CL	41	18

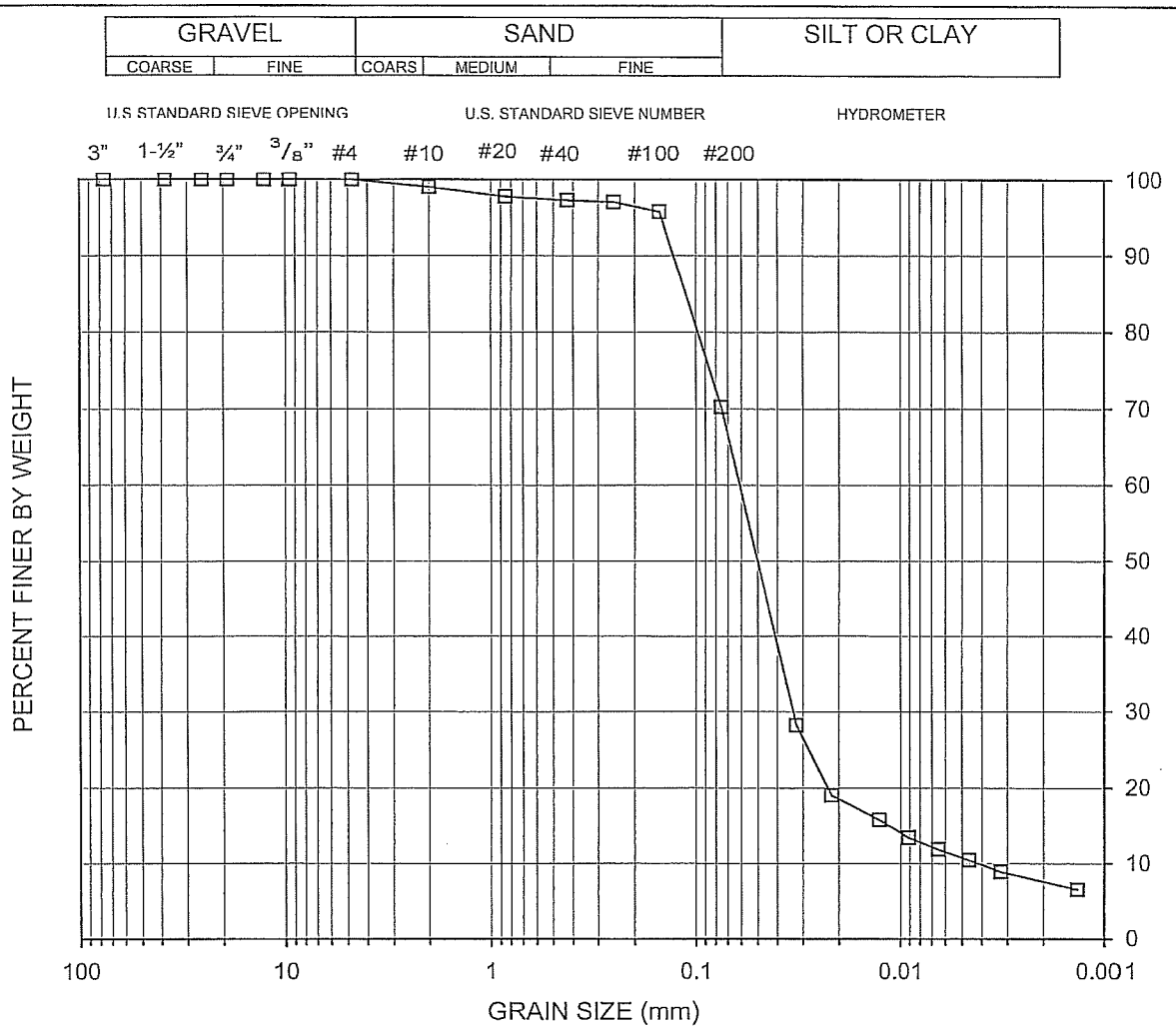
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	U-09	45	Shelby Tube	ML	24	1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

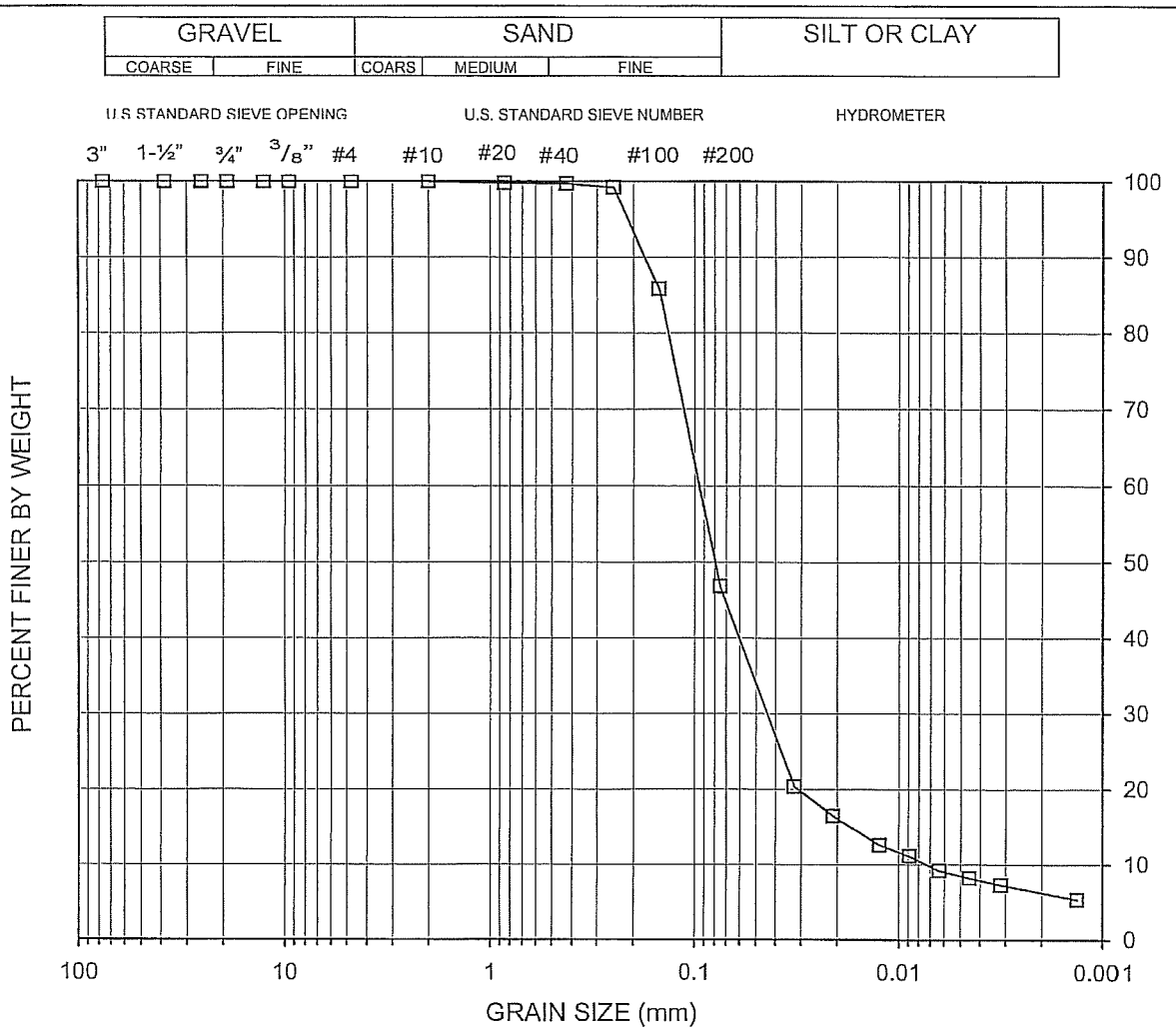
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/22/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	D-12-1	60	Ring	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement

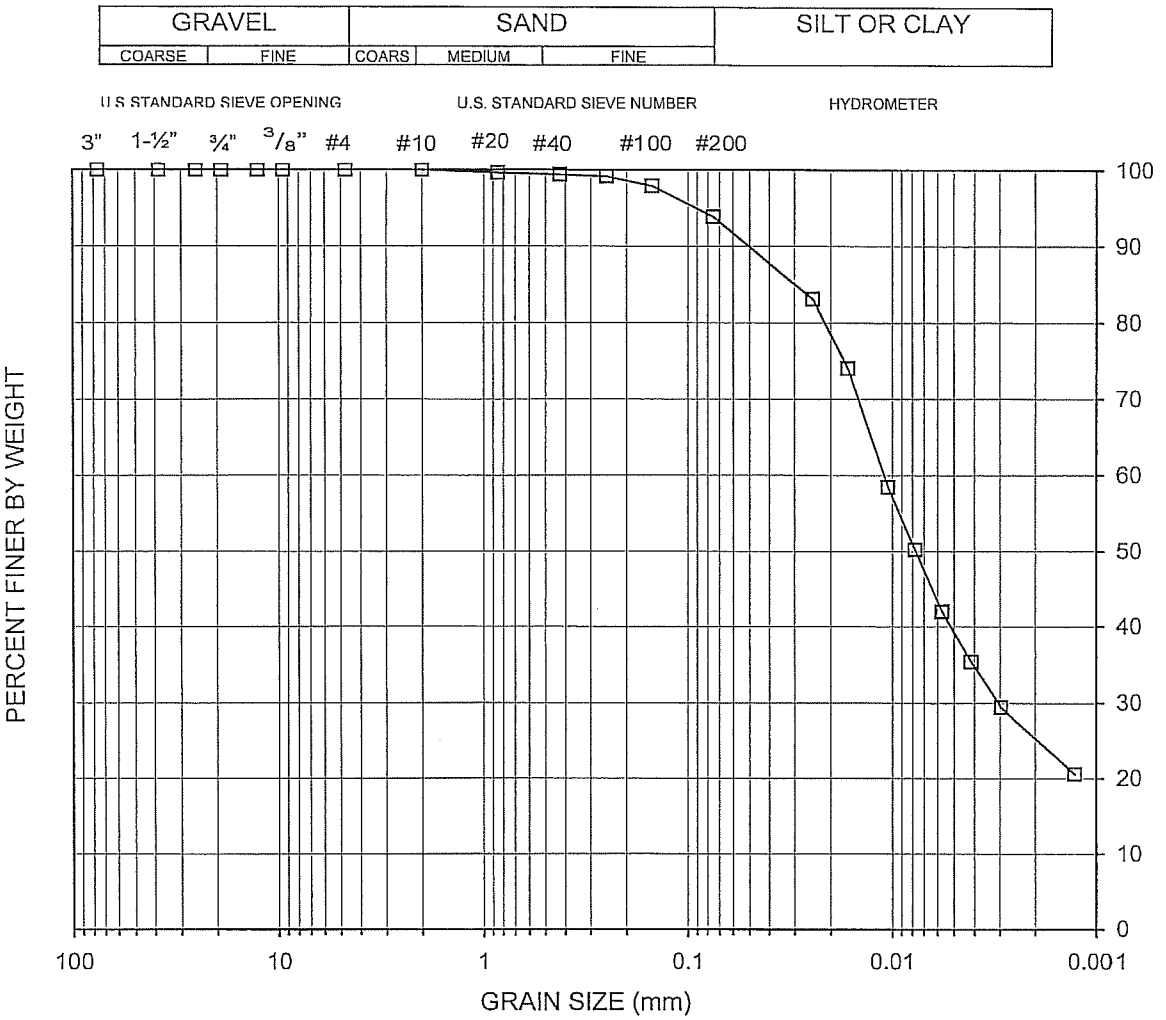
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-13-1	65	Bag	CL	38	14

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

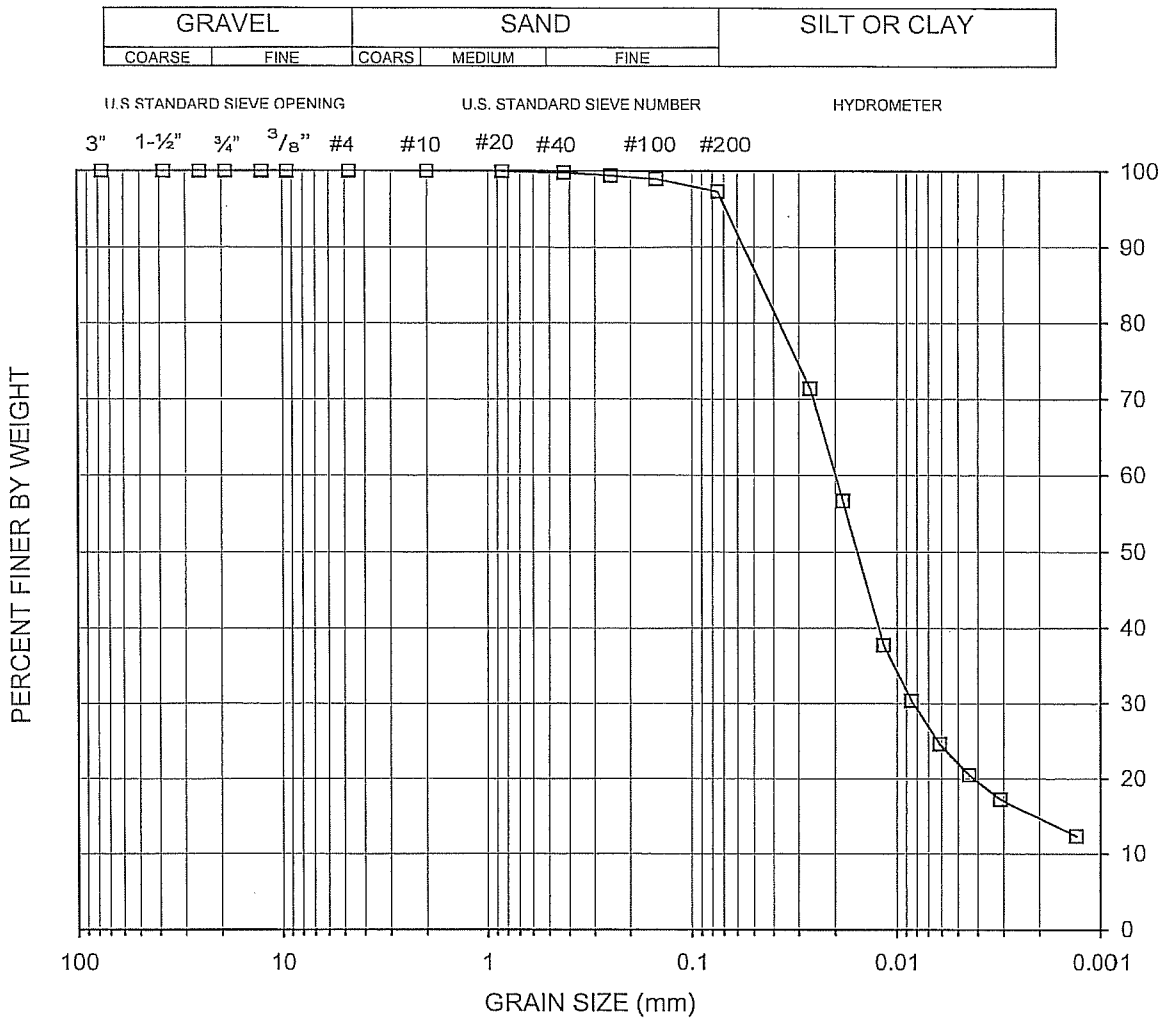
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-17-2	90.6	Bag	CL	33	11

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

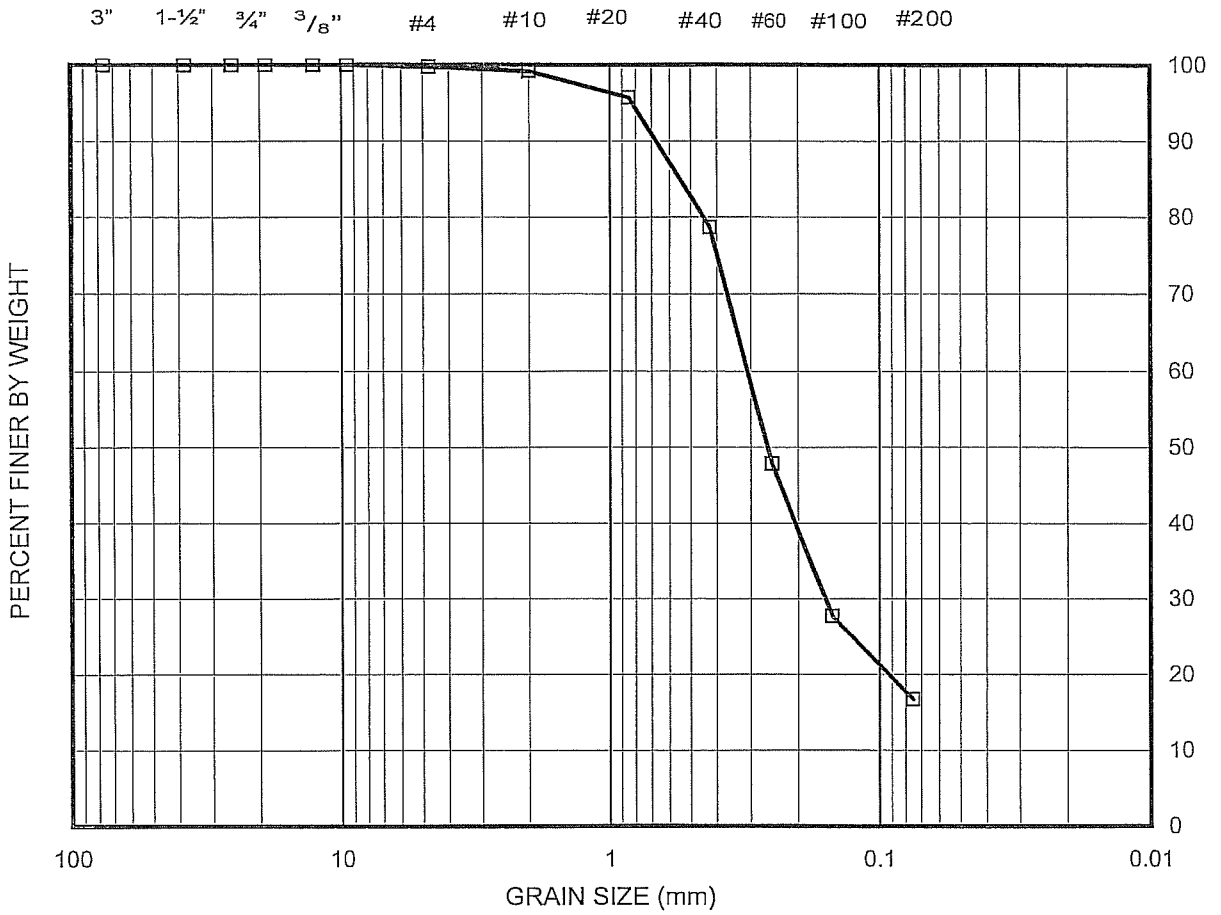
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-033	S-16	80	Bag	SM	N/A	N/A

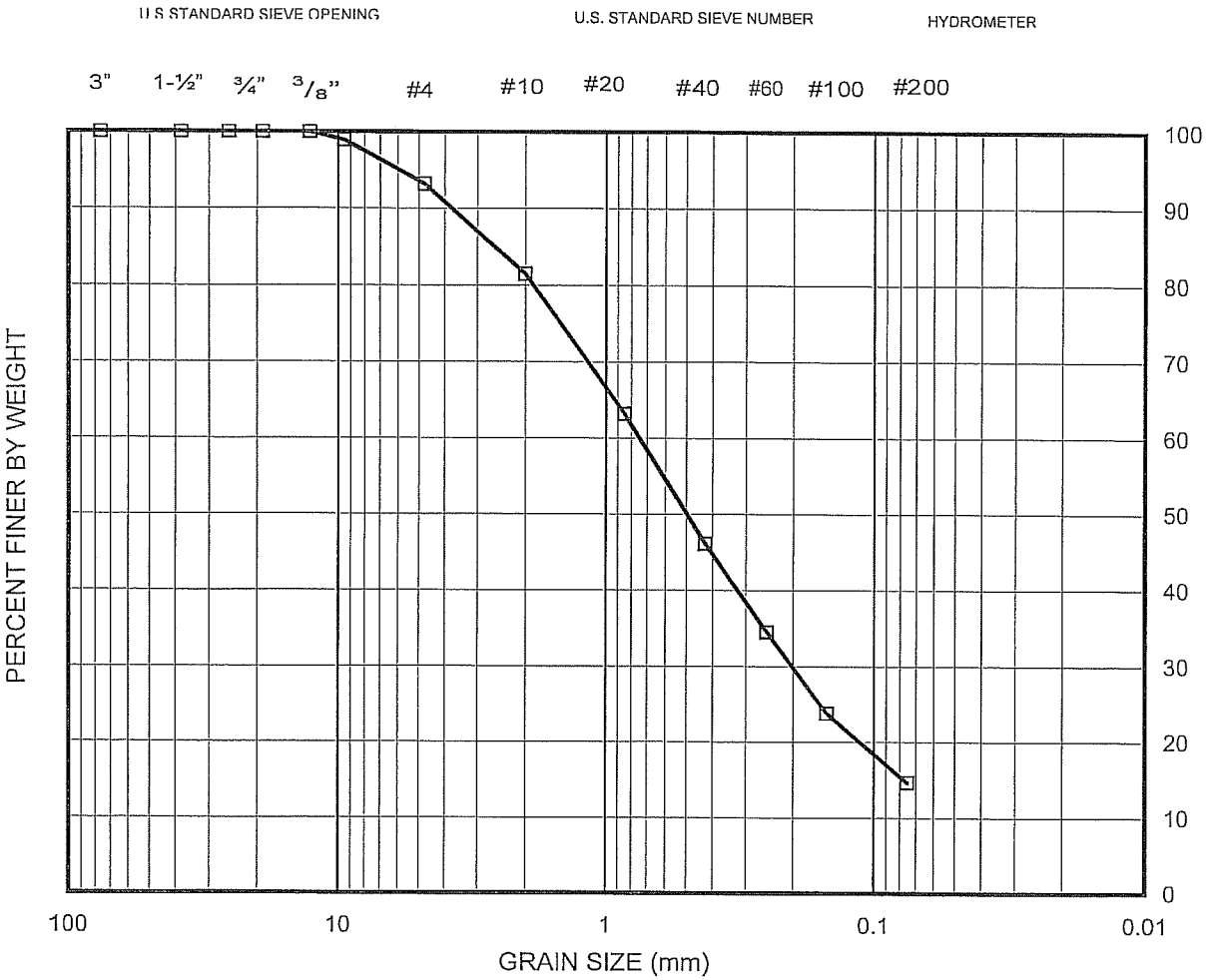
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-033	S-19	100	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008A
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	12/18/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-033	U-03	15	8.40	605	0.018	630

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
R-09-033	U-04	20	0.5
R-09-033	U-09	45	1.75

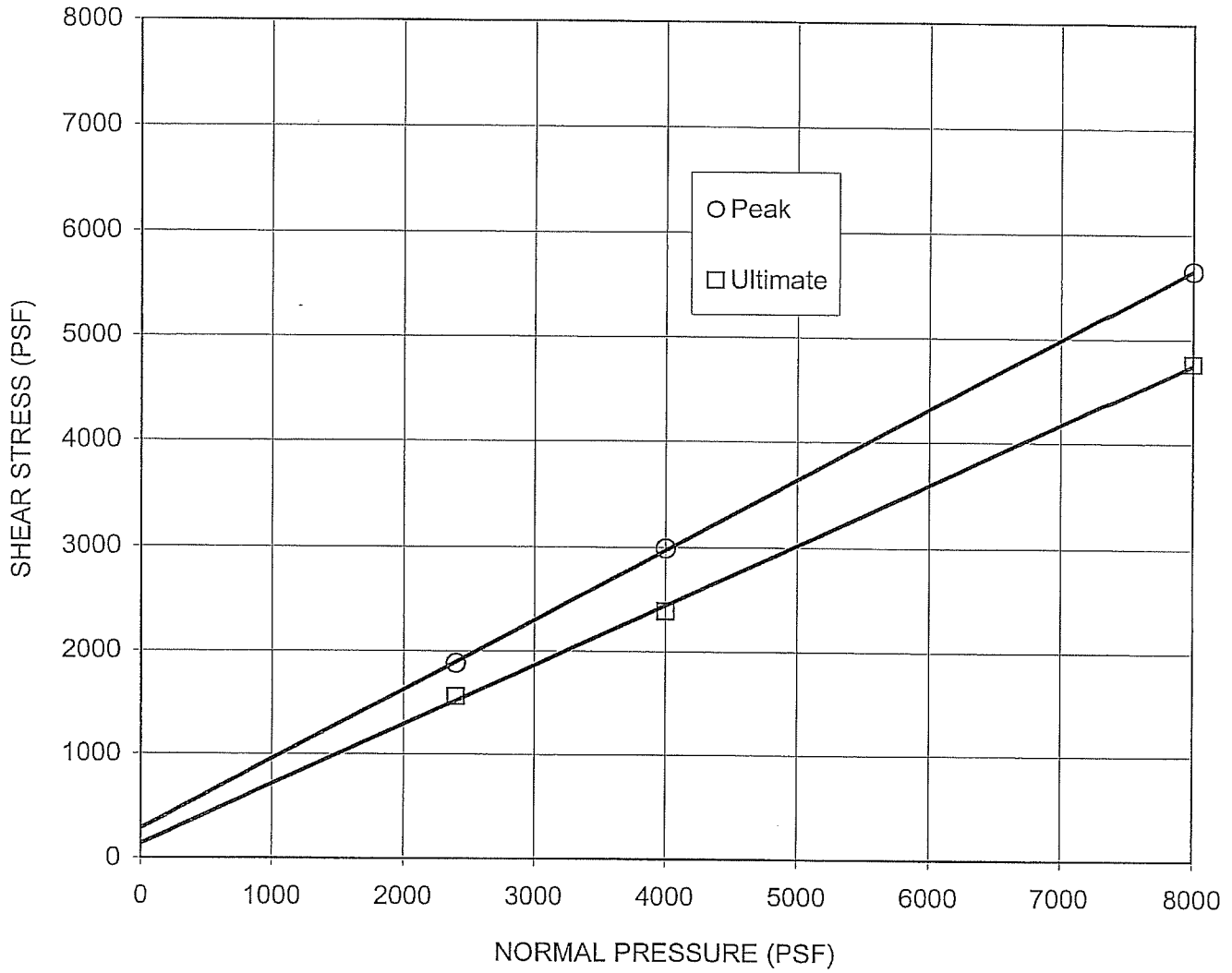
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-033	U-04	20	2.697
R-09-033	U-09	45	2.746



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-033	D-07	35	Ring	SP-SM	○	286	34
					□	138	30

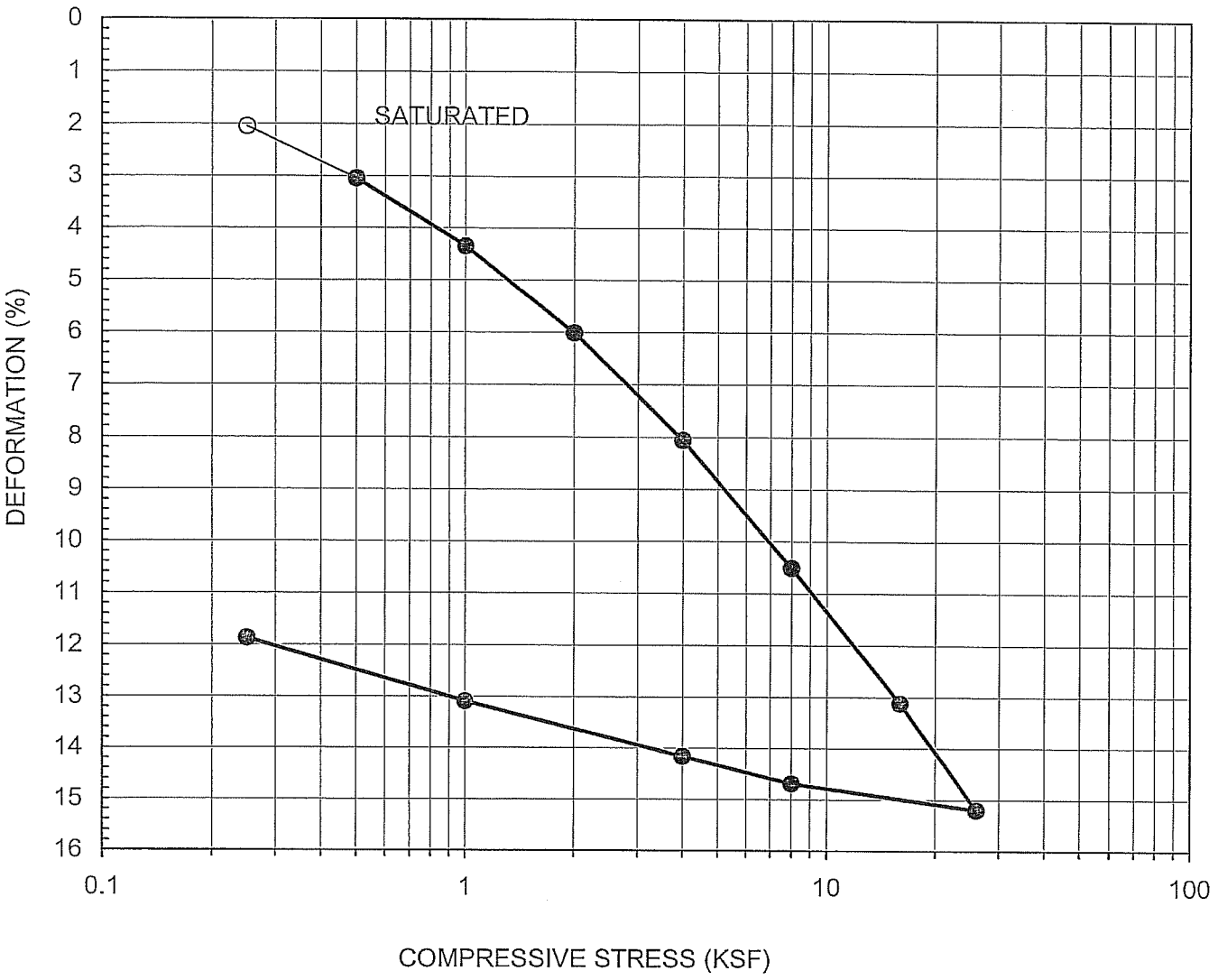
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2400	21.4	26.4
4000	21.4	25.8
8000	21.4	25.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



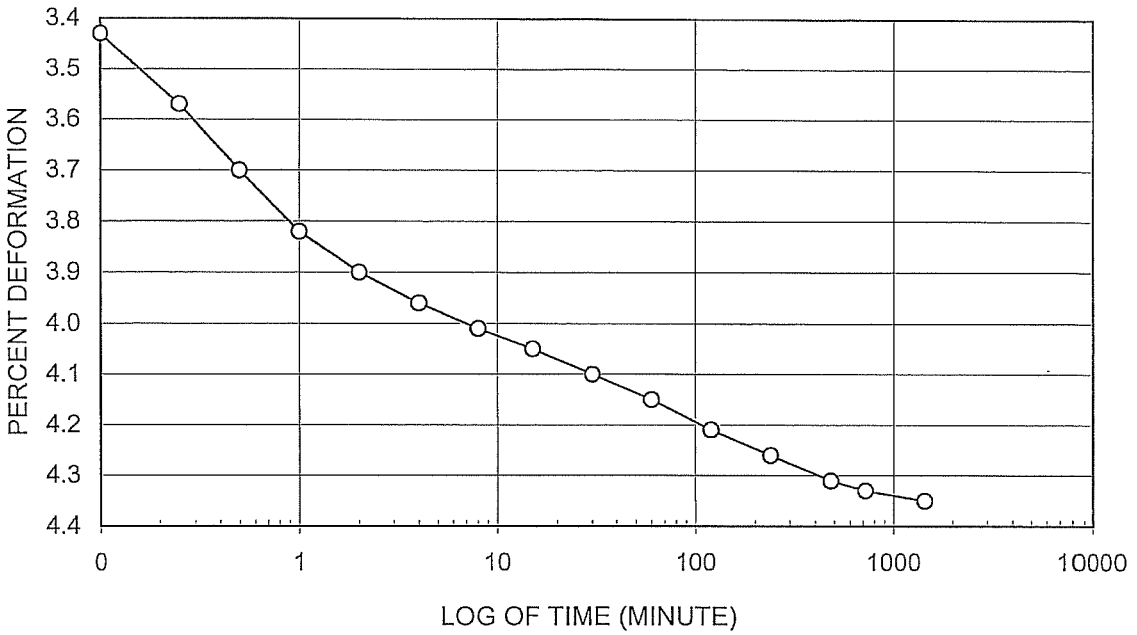
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-033	U-03	15.0	CL-ML	47.8	77.3	1.179

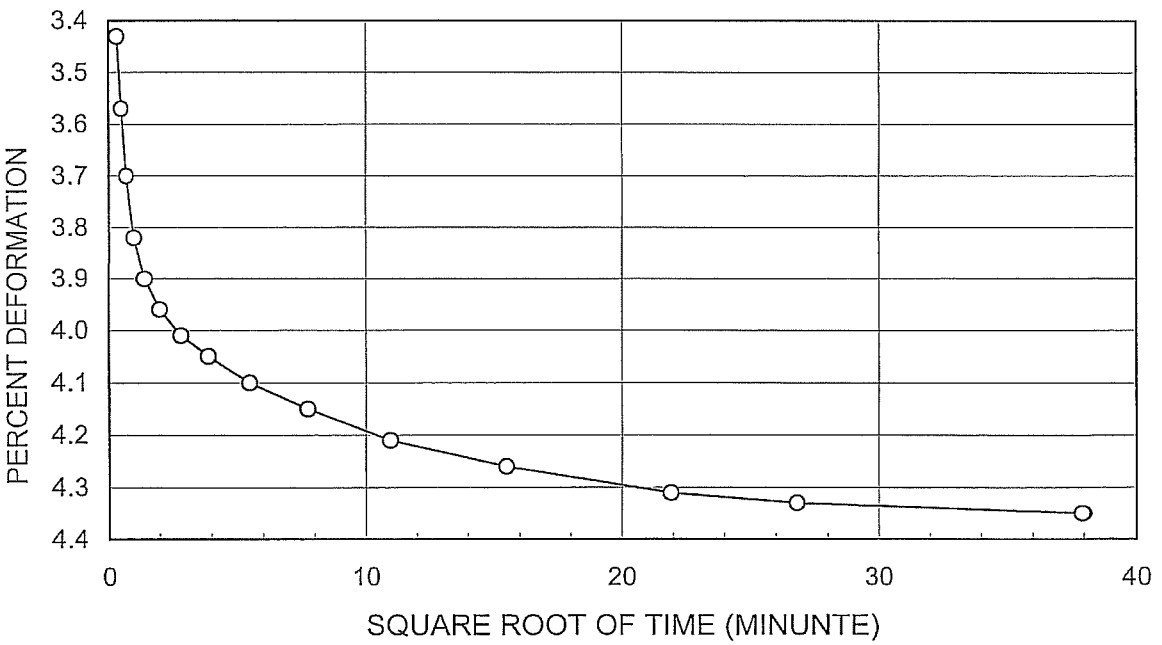
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





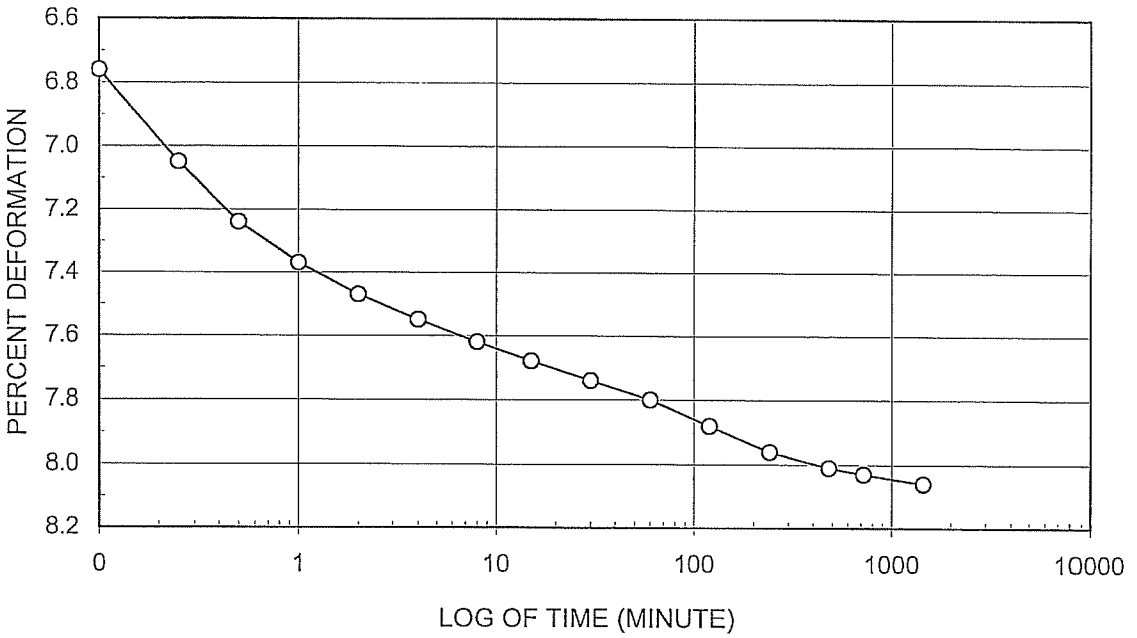
Boring No: R-09-033
Sample No: U-03
Depth (ft): 15
Soil Type: CL-ML
Normal Stress: 1.0 ksf

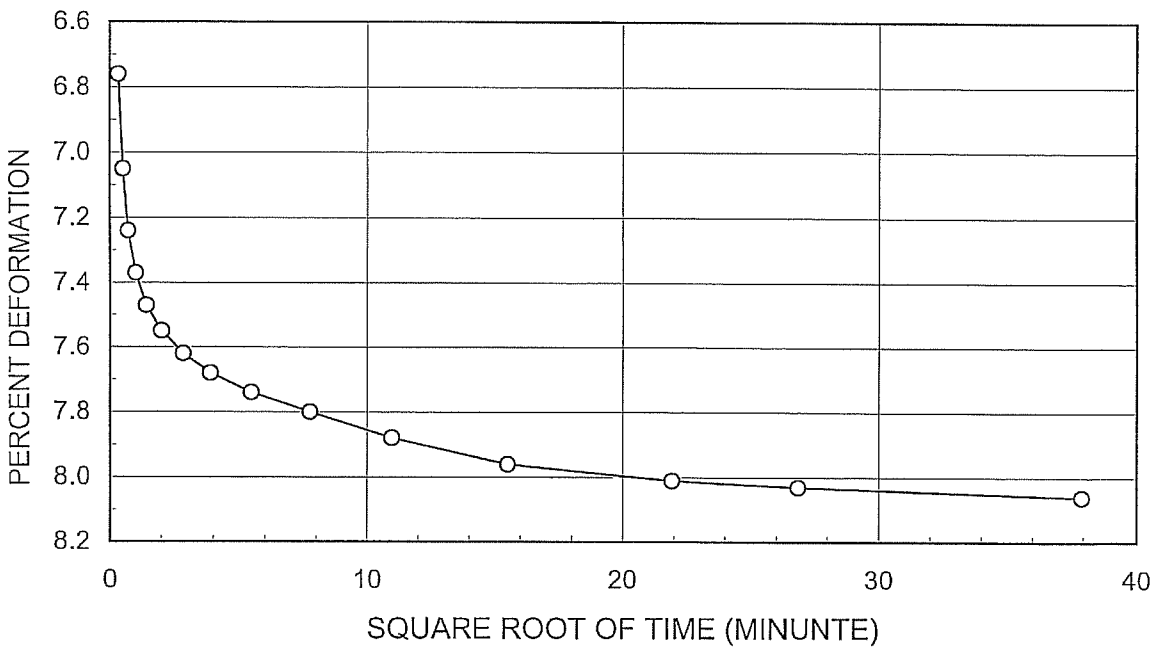
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





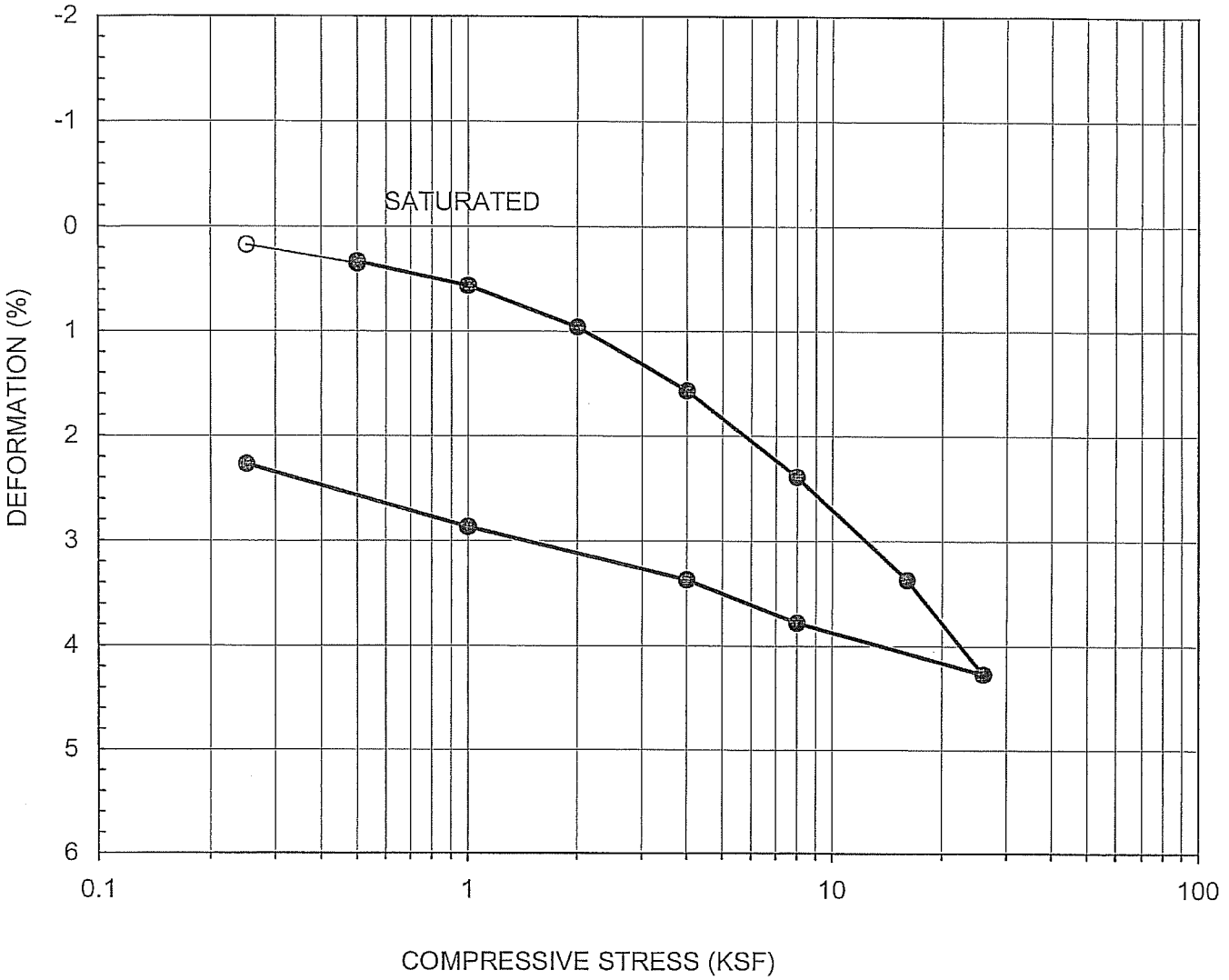
Boring No: R-09-033
Sample No: U-03
Depth (ft): 15
Soil Type: CL-ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



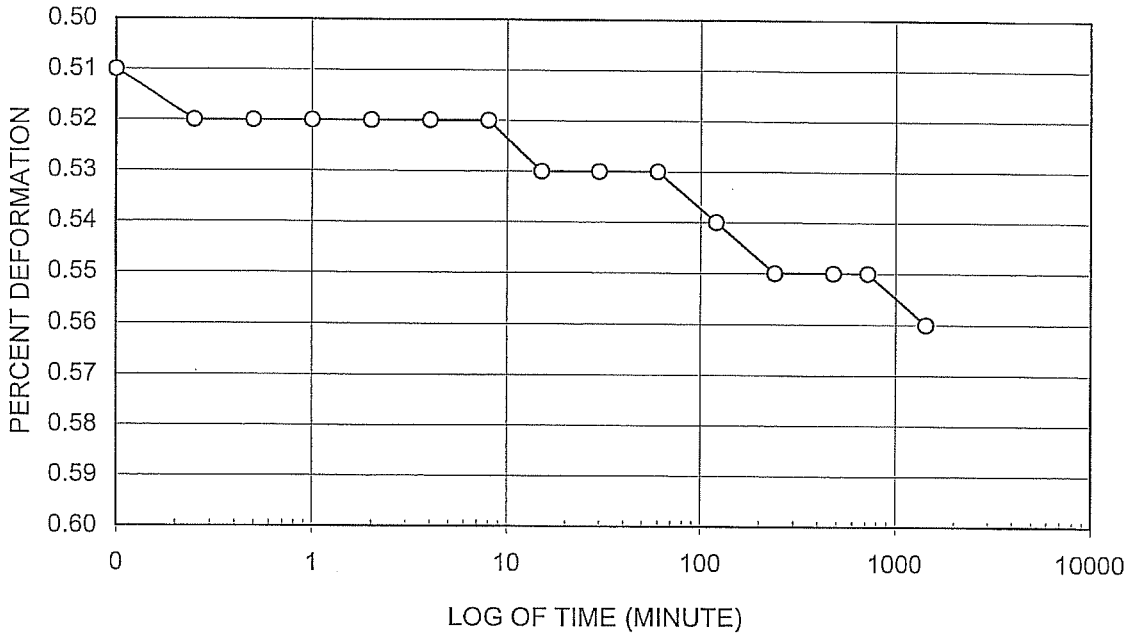
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-033	D-10-2	50.5	ML	27.1	95.7	0.761

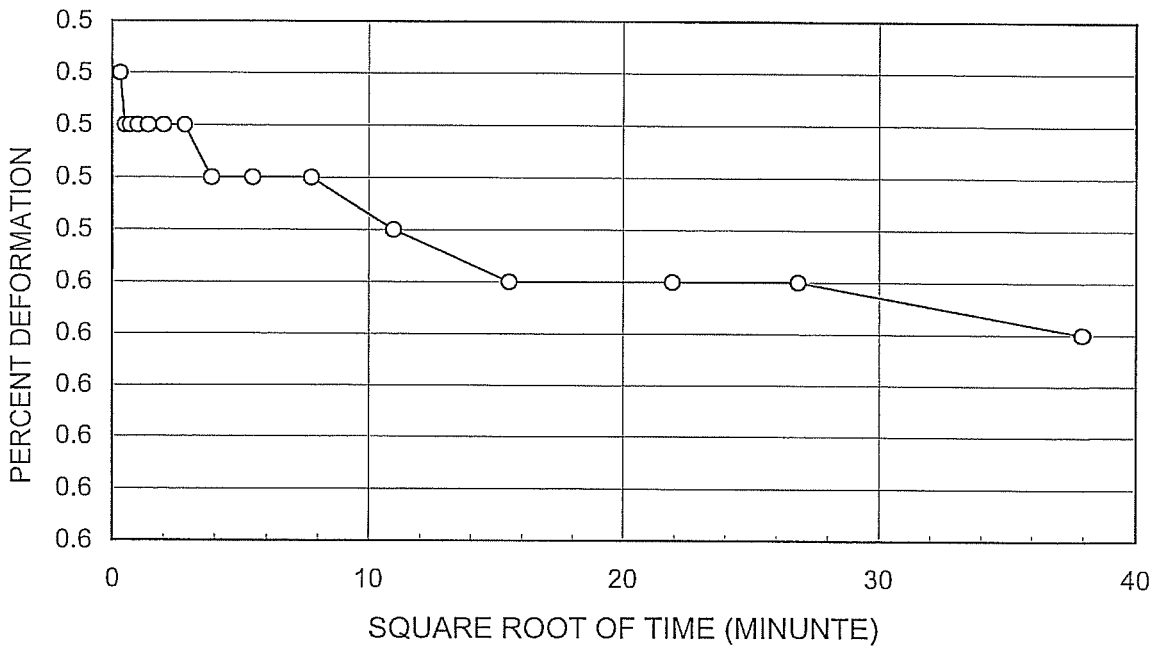
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





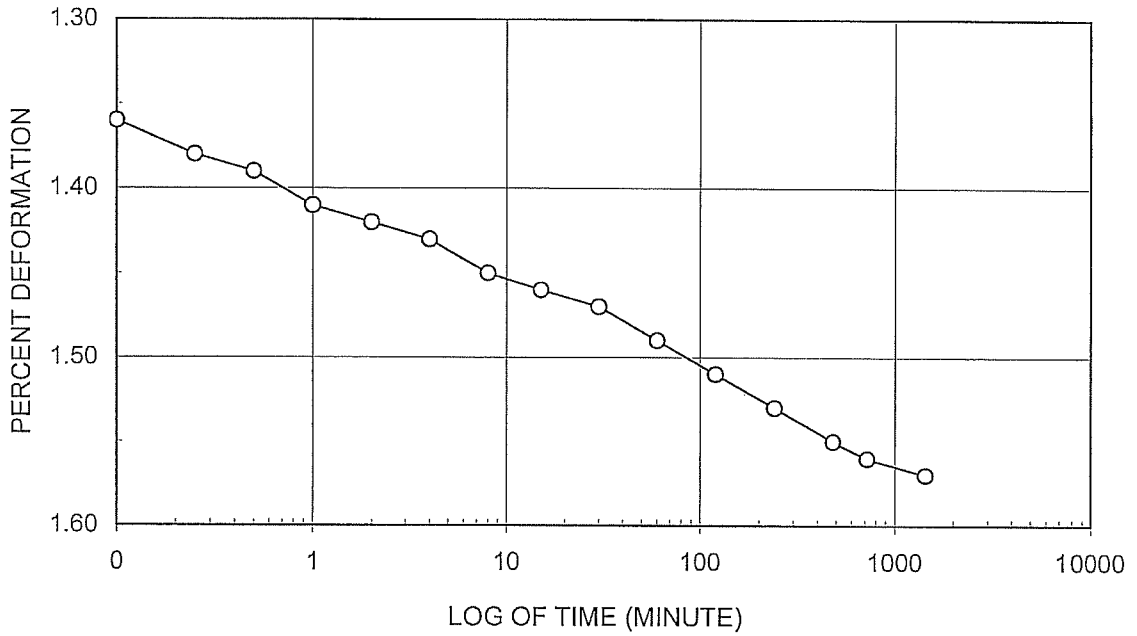
Boring No: R-09-033
Sample No: D-10-2
Depth (ft): 50.5
Soil Type: ML
Normal Stress: 1.0 ksf

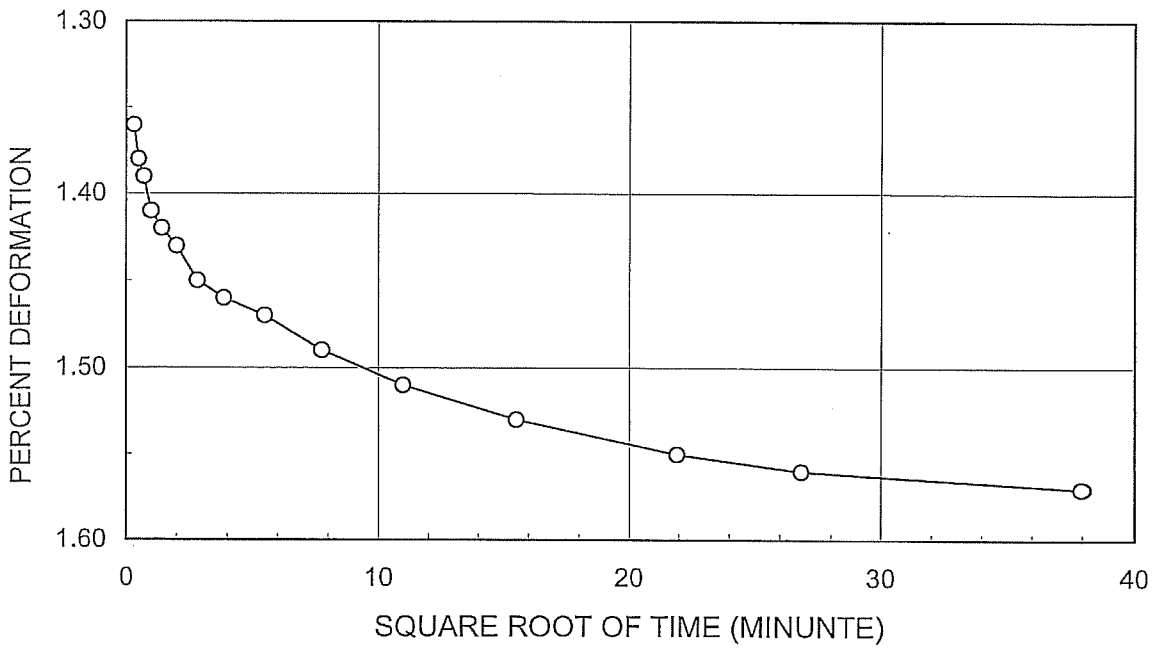
Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





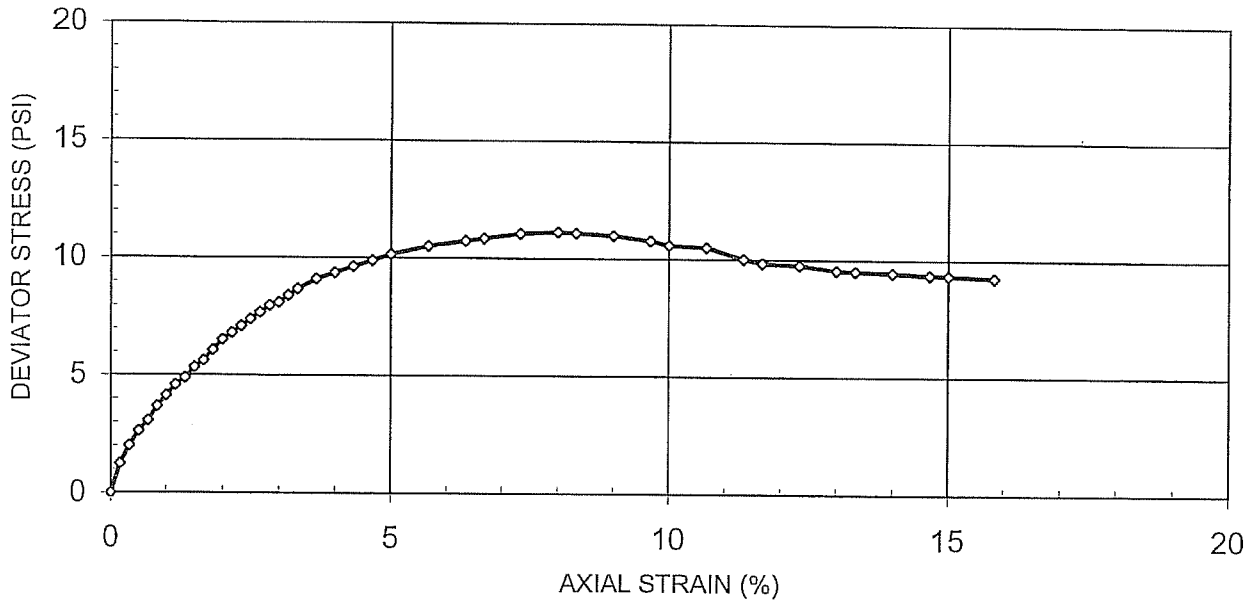
Boring No: R-09-033
Sample No: D-10-2
Depth (ft): 50.5
Soil Type: ML
Normal Stress: 4.0 ksf

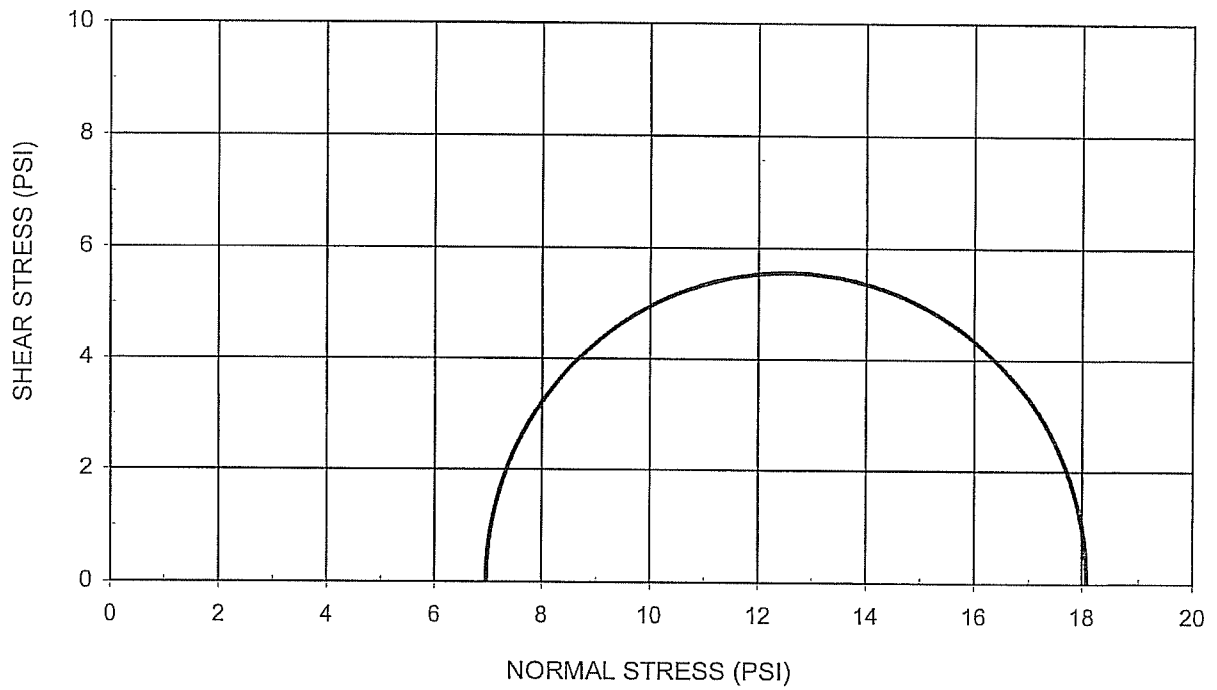
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-033	20	U-04	CH	Shelby Tube	59.44	64.1	7.0	11.1	0.06	98.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

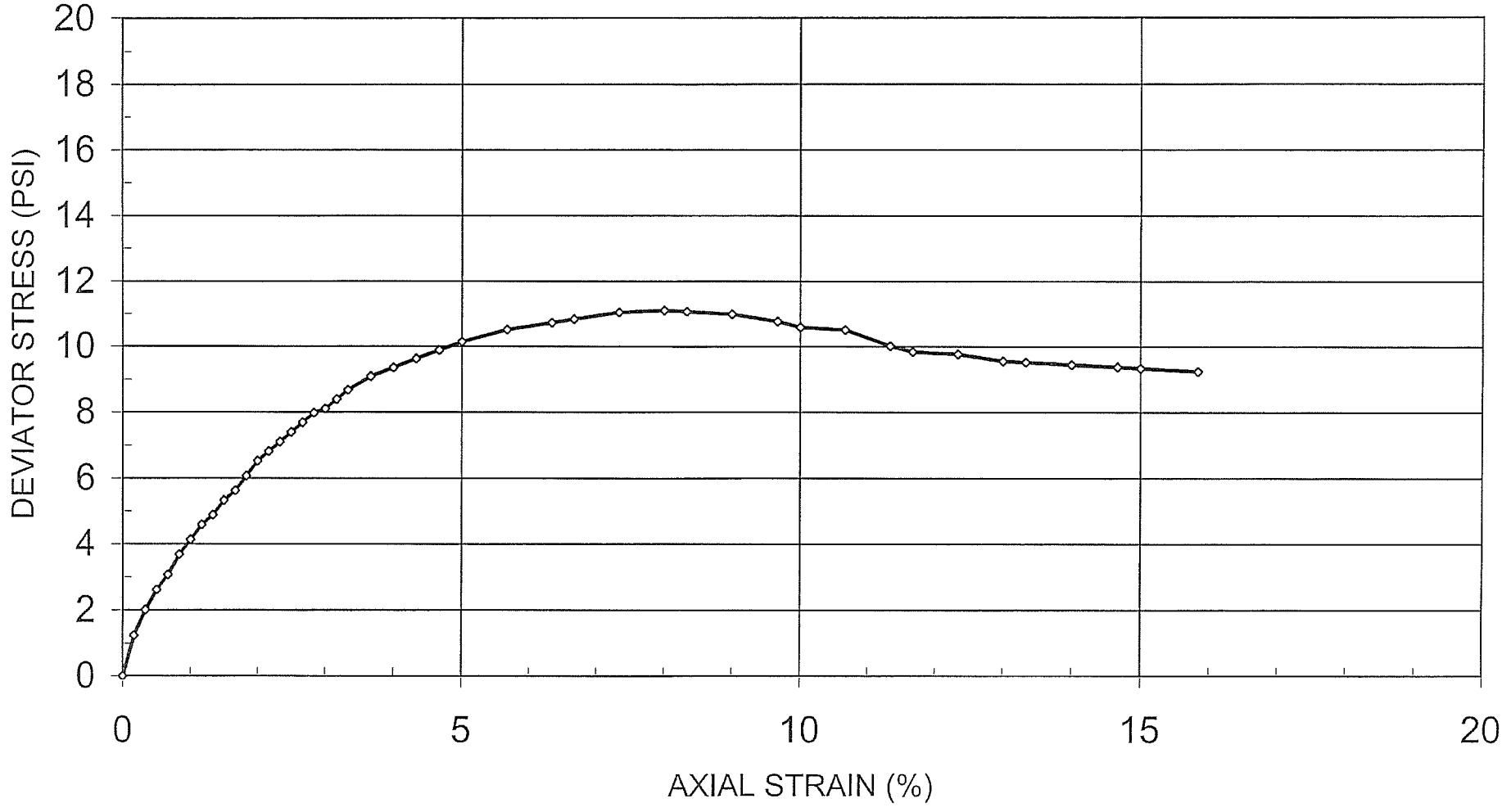
(ASTM D2850)

12/21/09

Figure

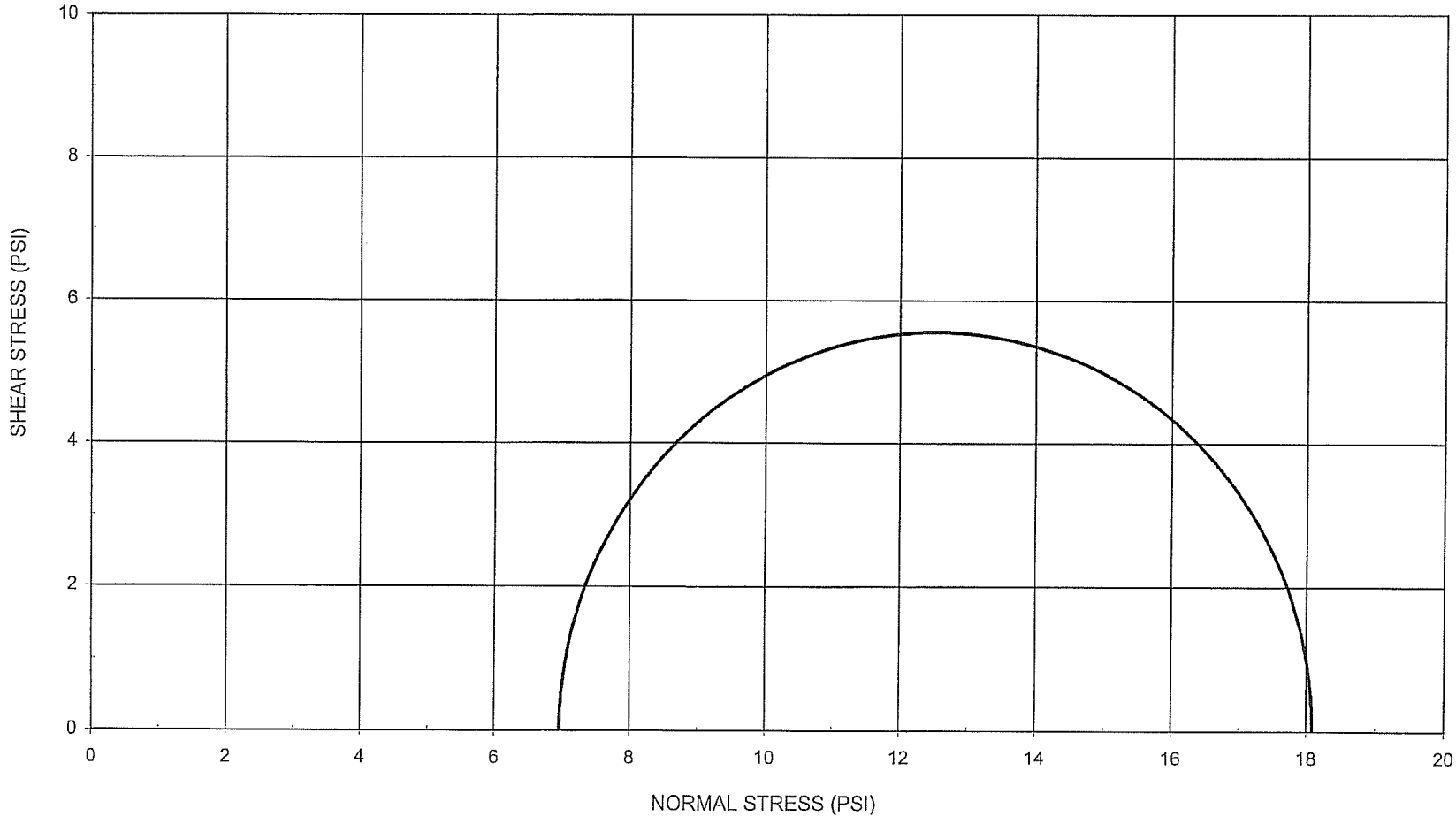
Project Name: ACTA Heim Bridge Replacement

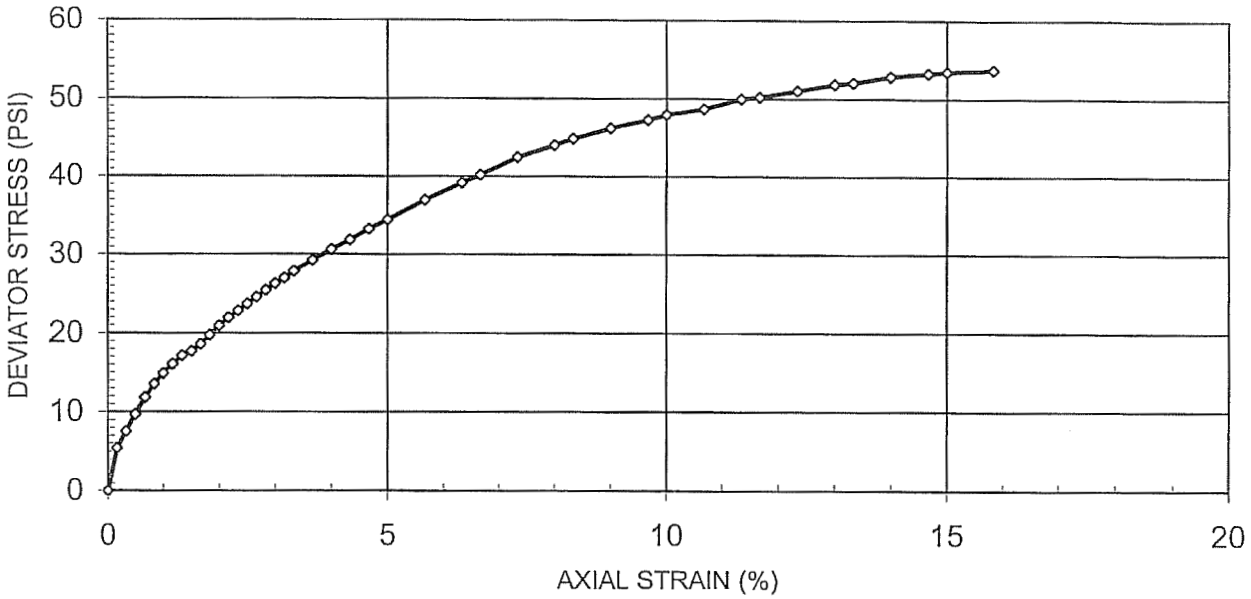
Boring: R-09-033 Sample ID: U-04 Depth (ft): 20

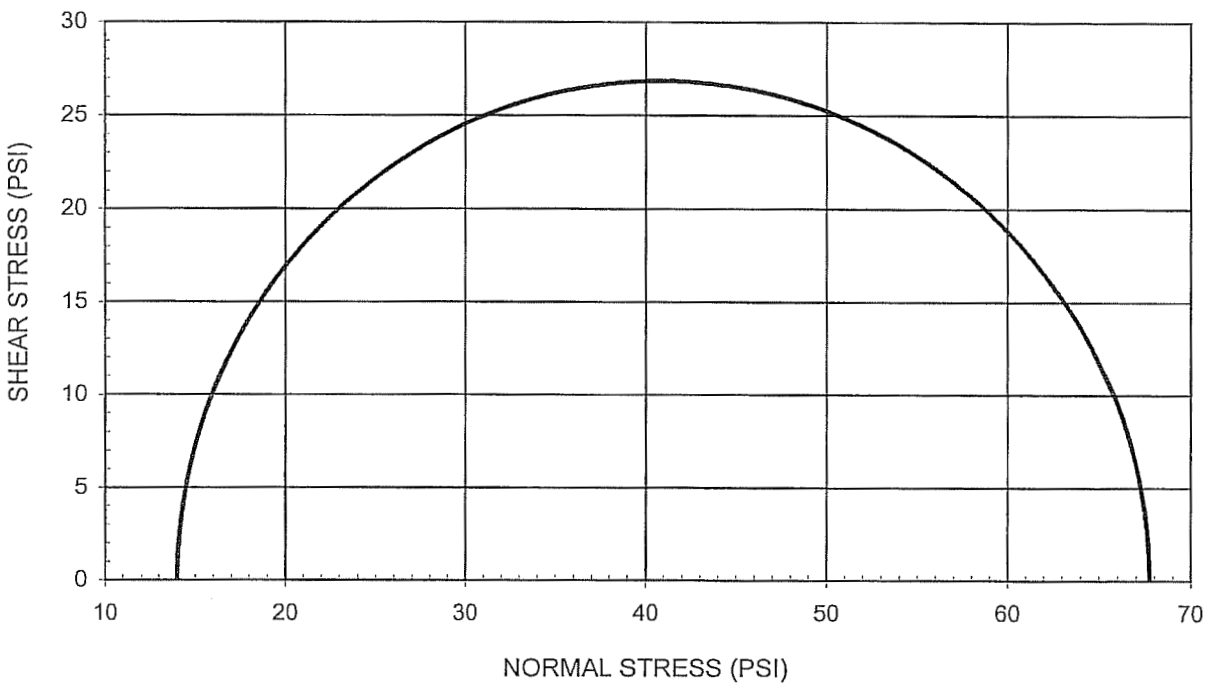


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-04 Depth (ft): 20







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-033	45	U-09	ML	Shelby Tube	30.47	92.2	14.0	53.7	0.06	99.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

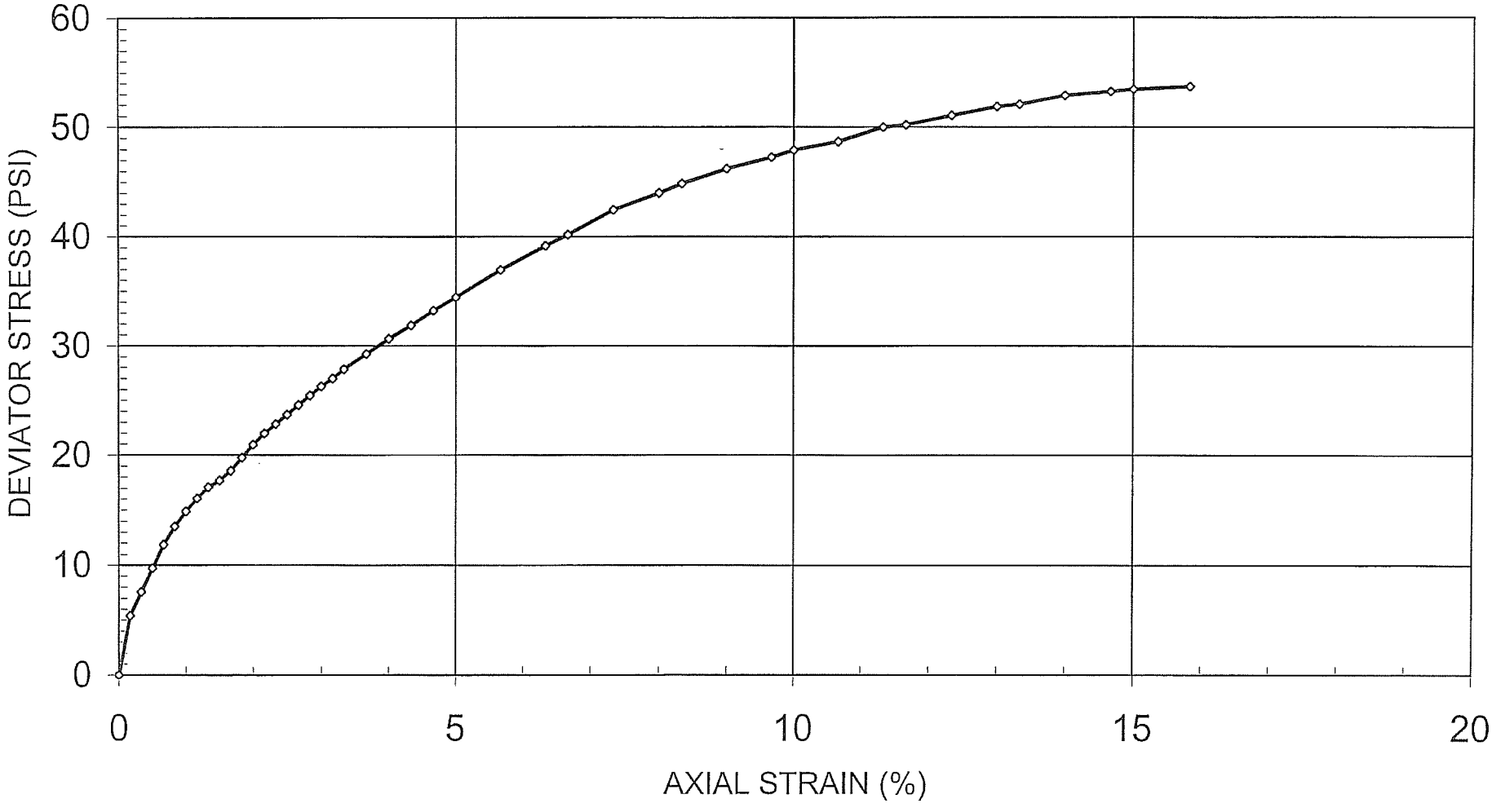
(ASTM D2850)

12/21/09

Figure

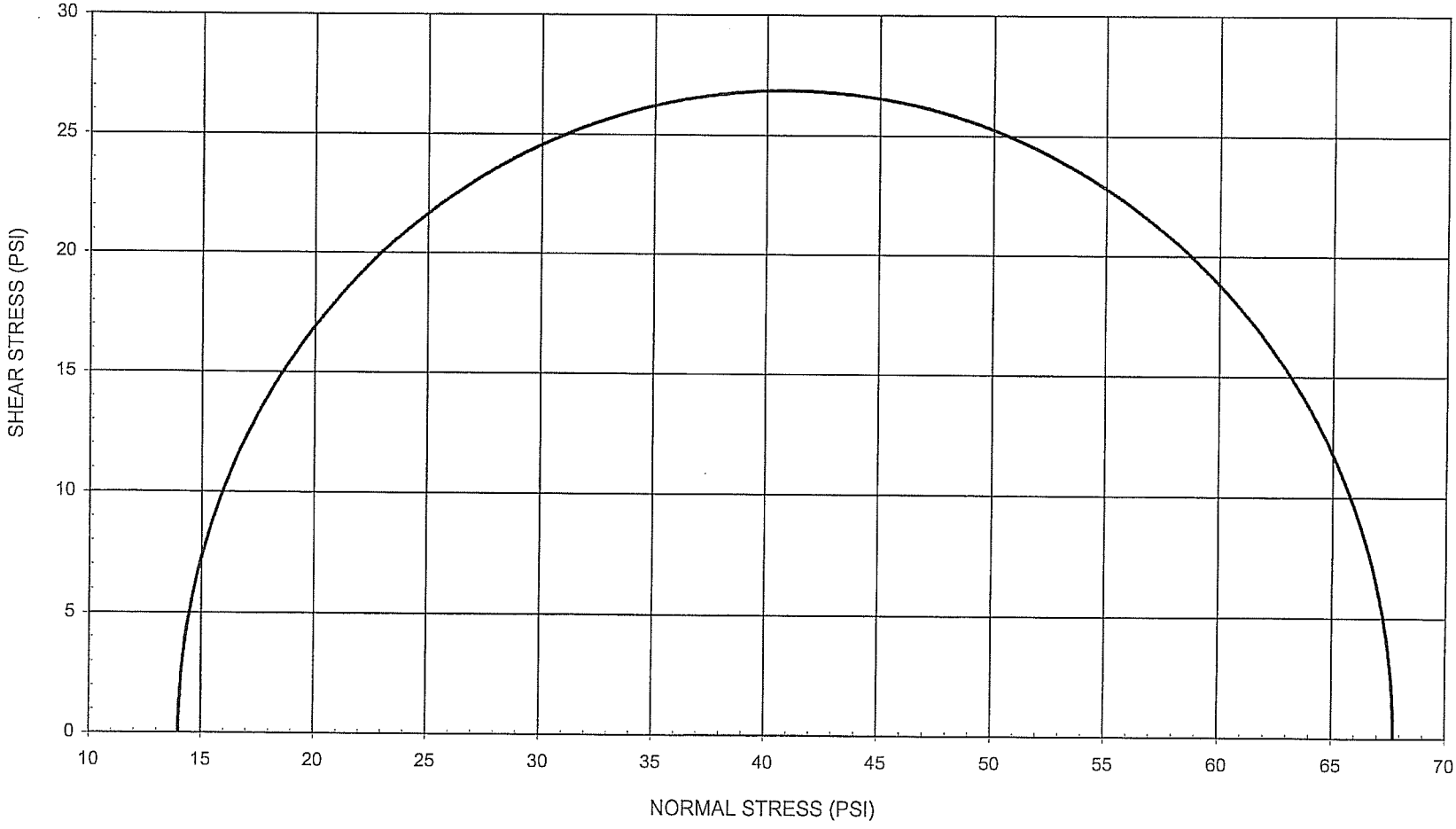
Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-09 Depth (ft): 45



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-09 Depth (ft): 45



Appendix F. Site-Specific Ground Motion Study Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

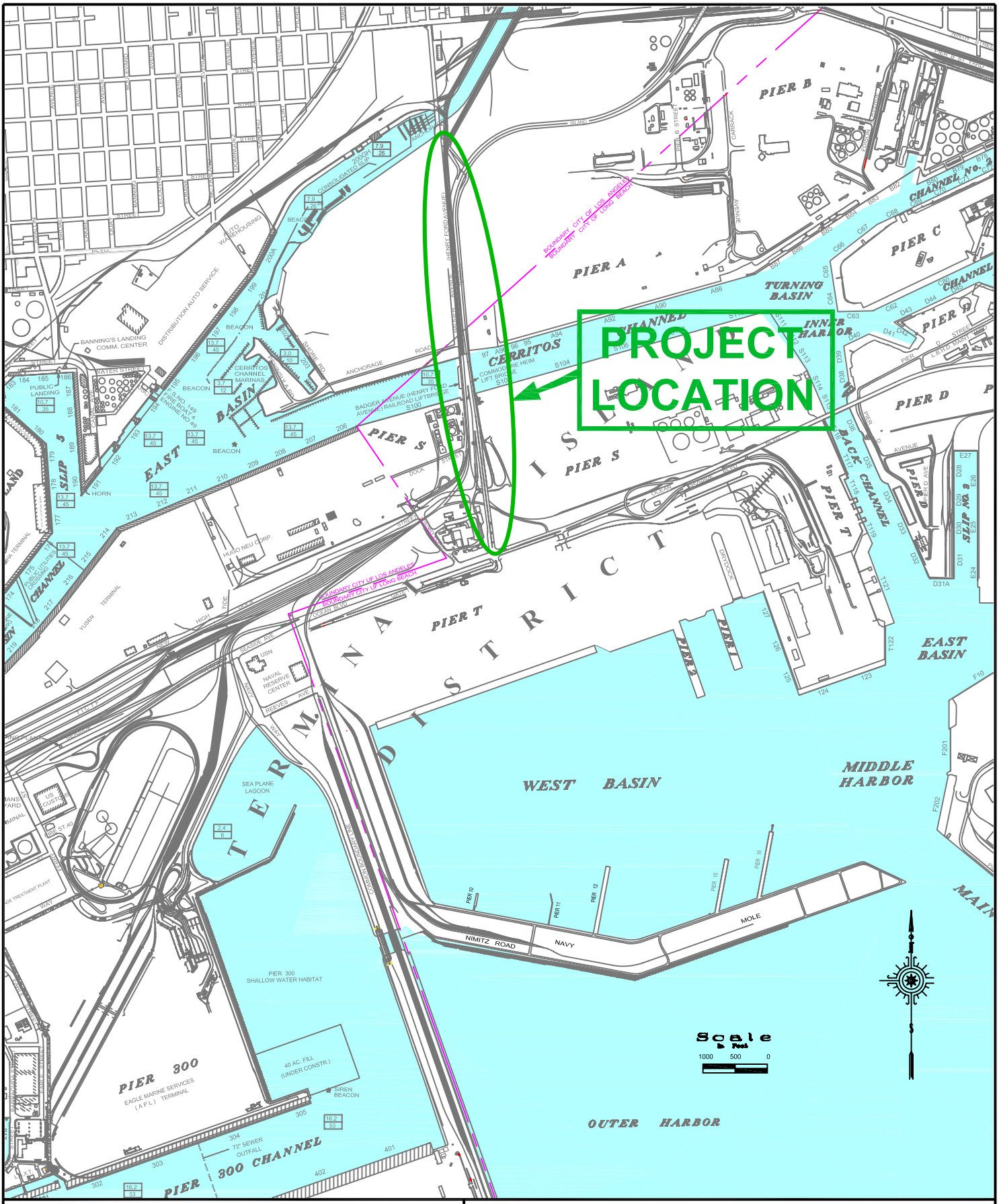
California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

Earth Mechanics, Inc., 2006a, "Preliminary Foundation Report, ACTA Schuyler Heim Bridge (Replace), Los Angeles, California," Report Prepared for Alameda Corridor Transportation Authority, EMI Project No. 06-123, June 23.

——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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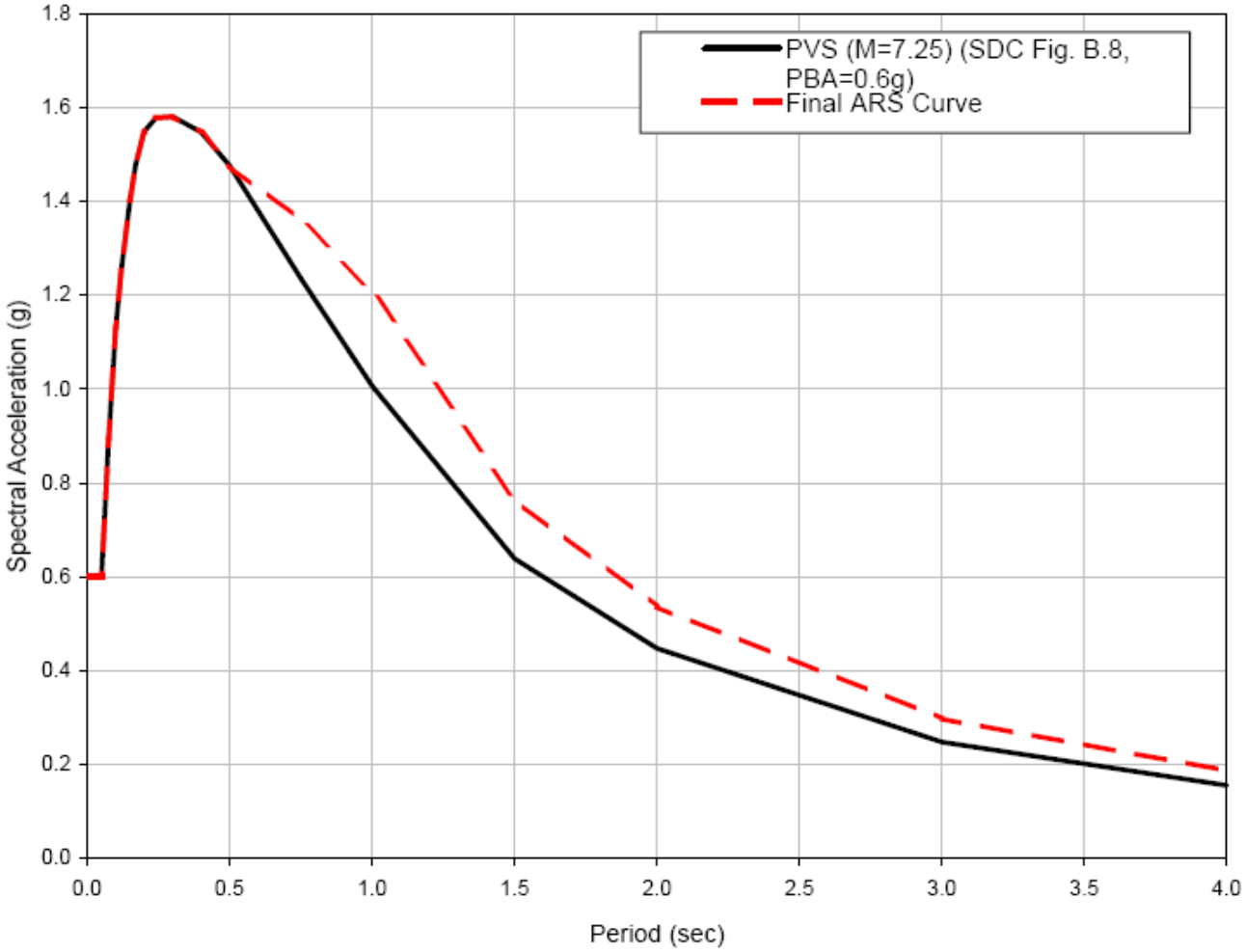
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

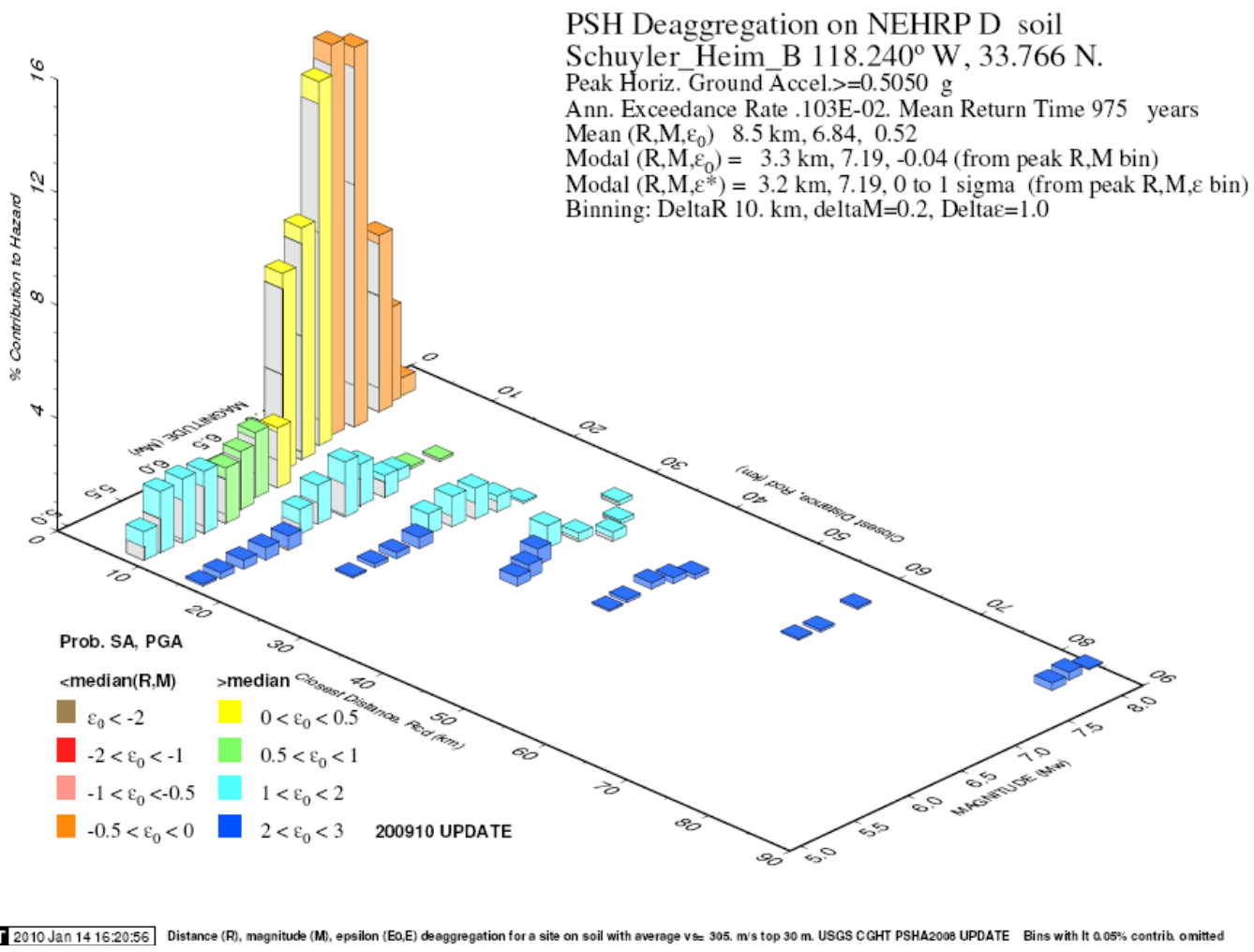


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

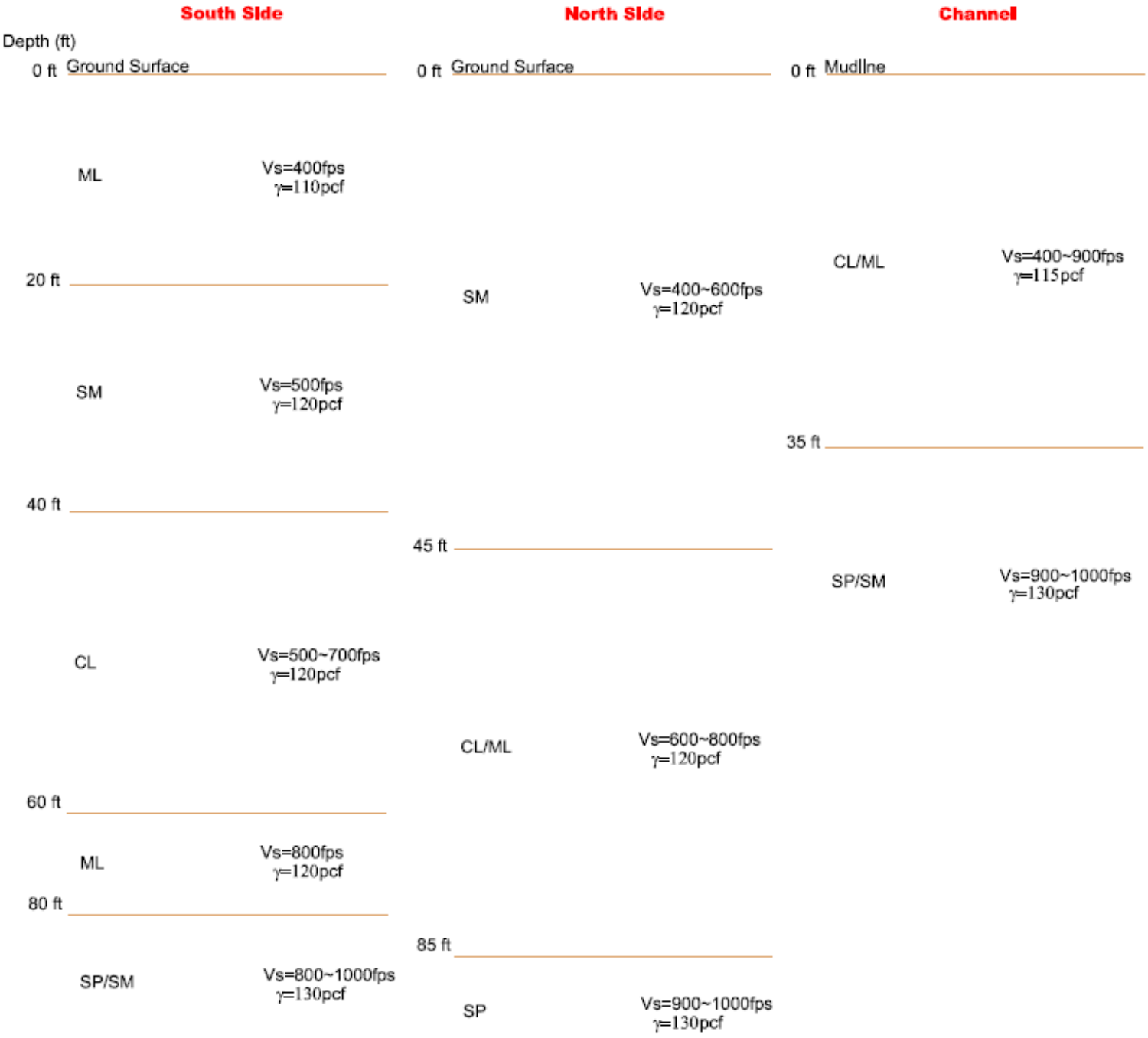
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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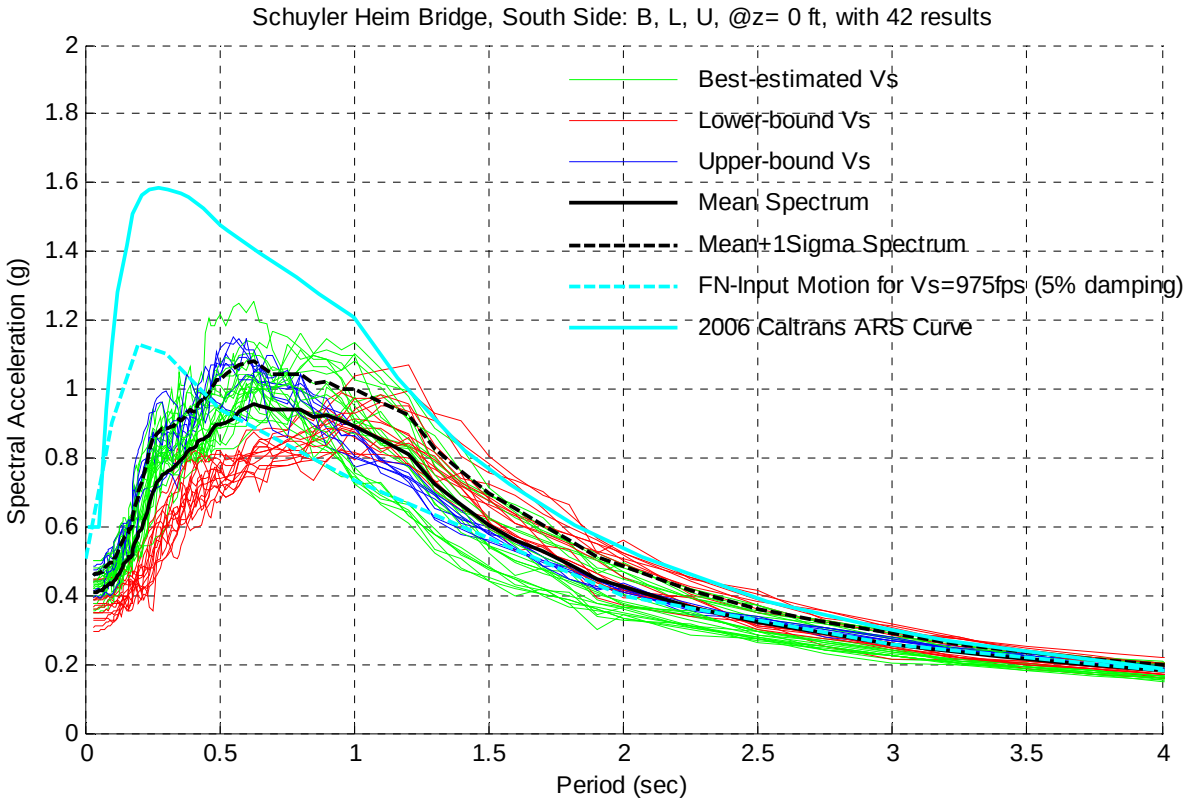
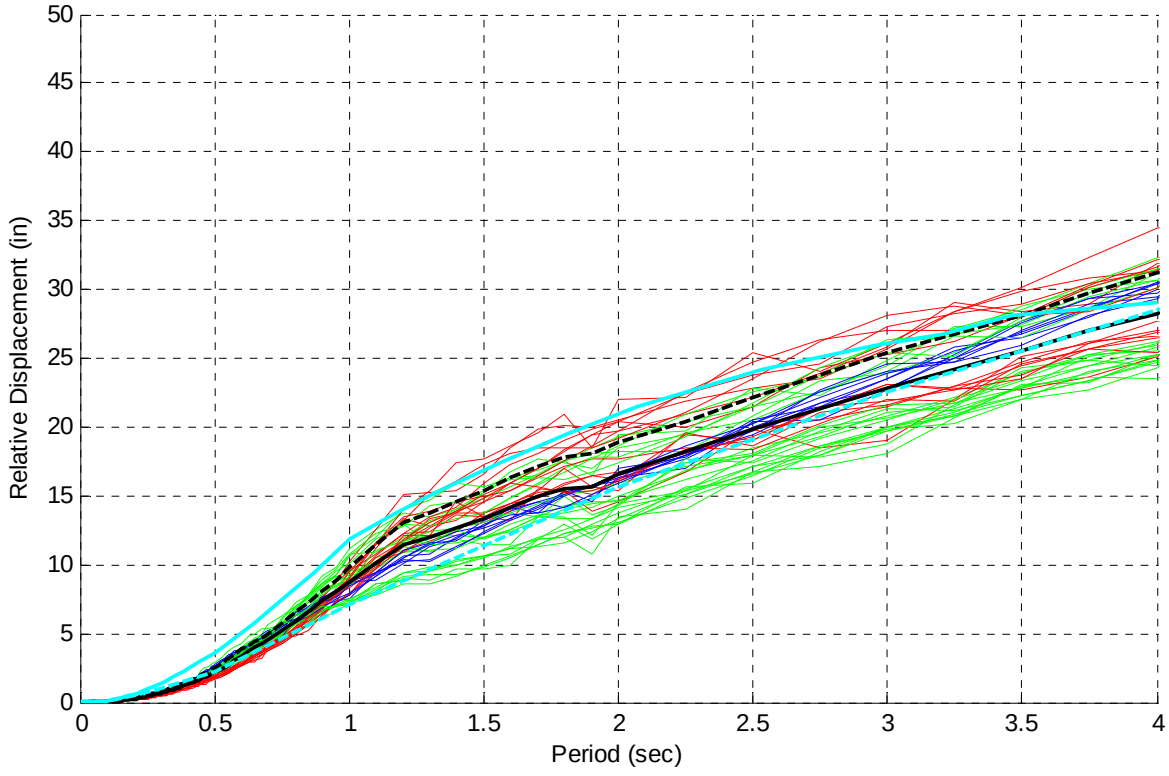
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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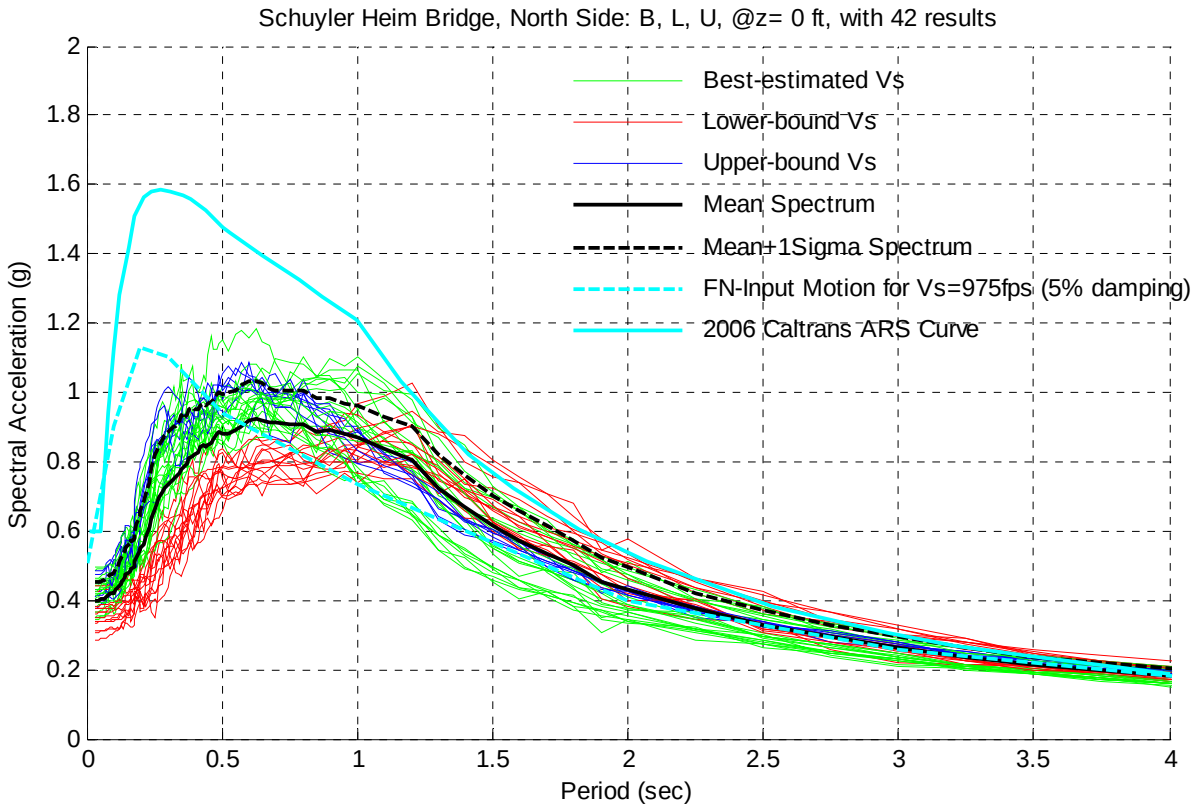
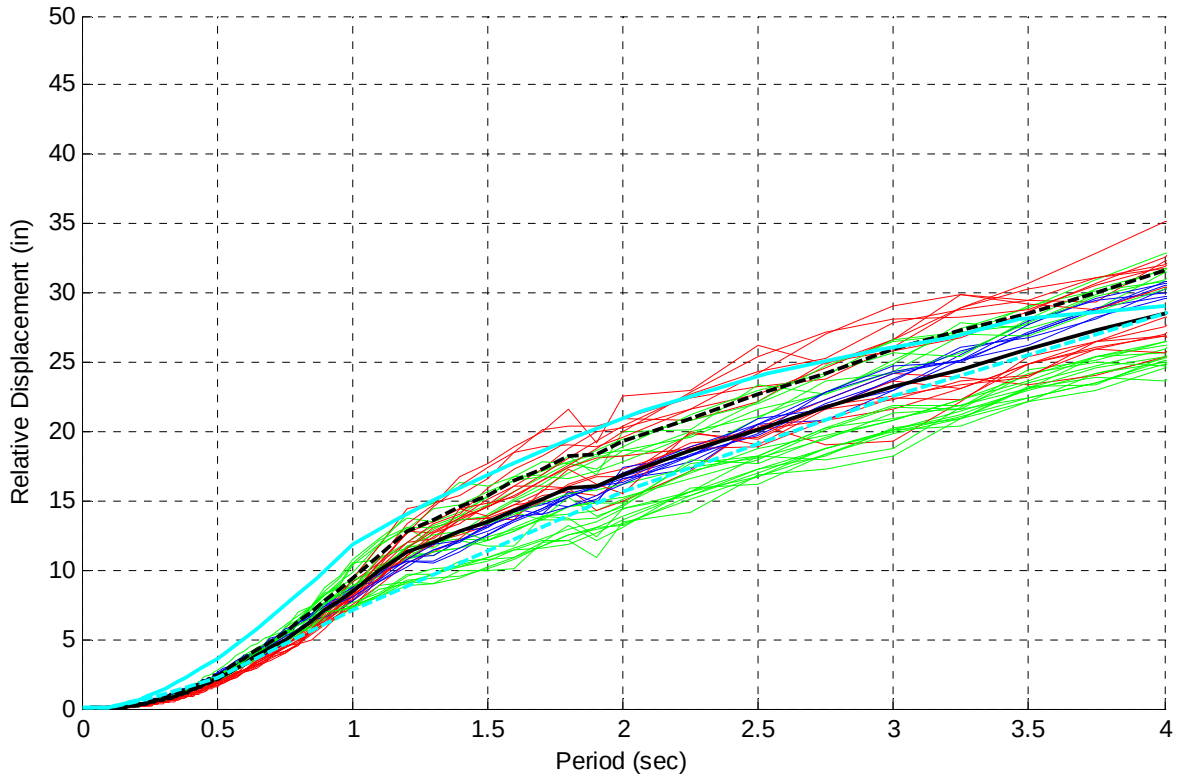
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





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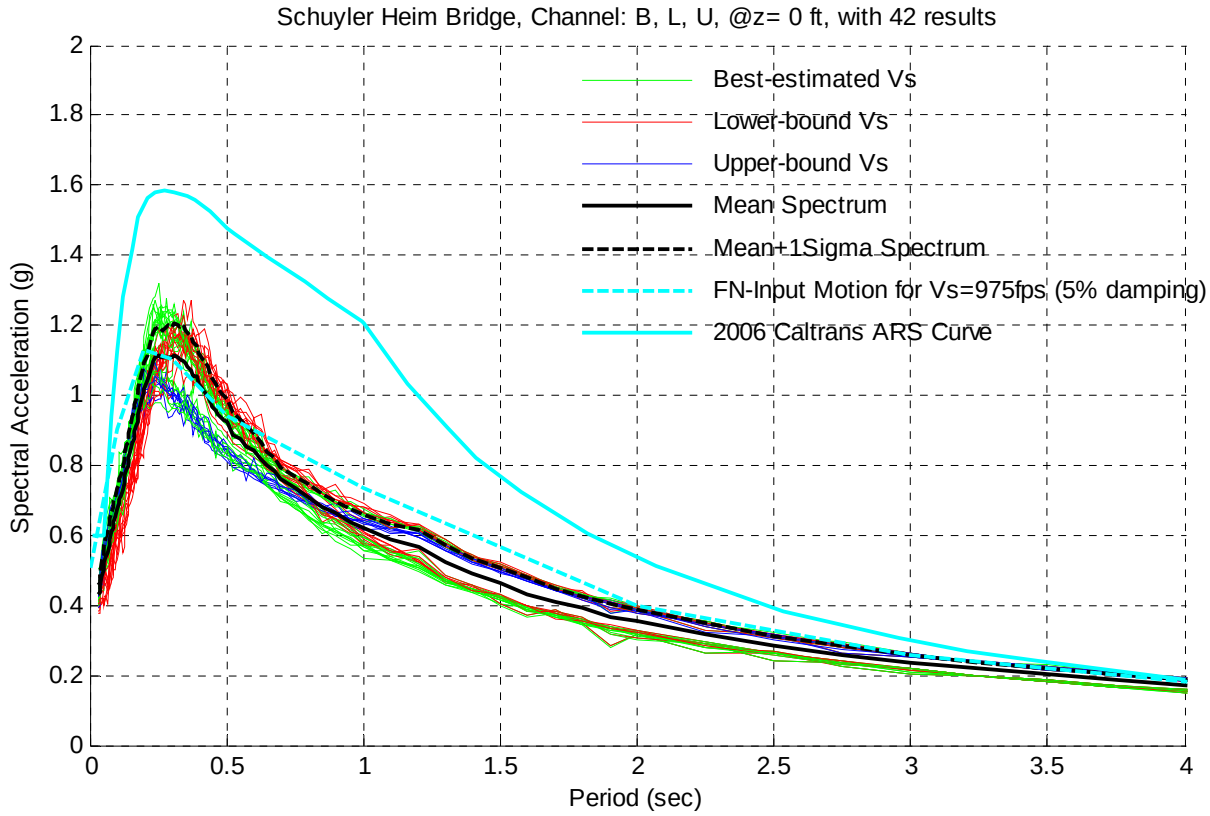
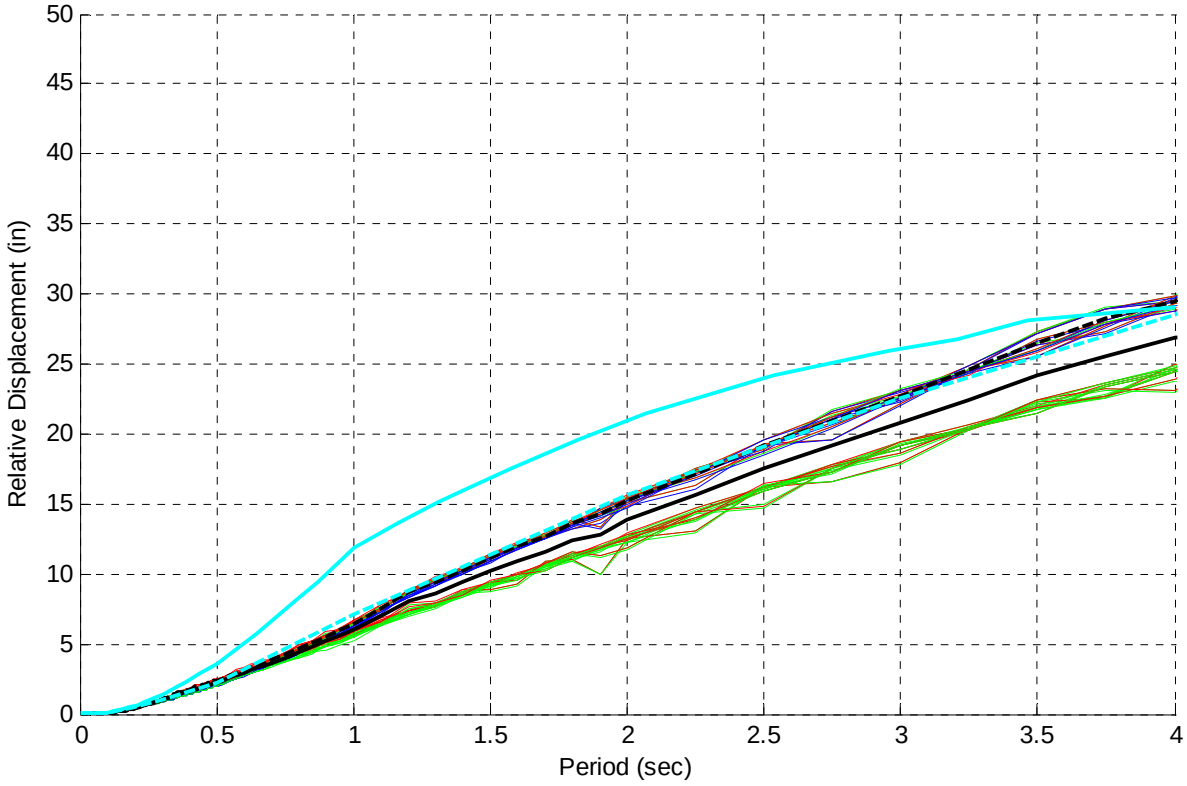
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





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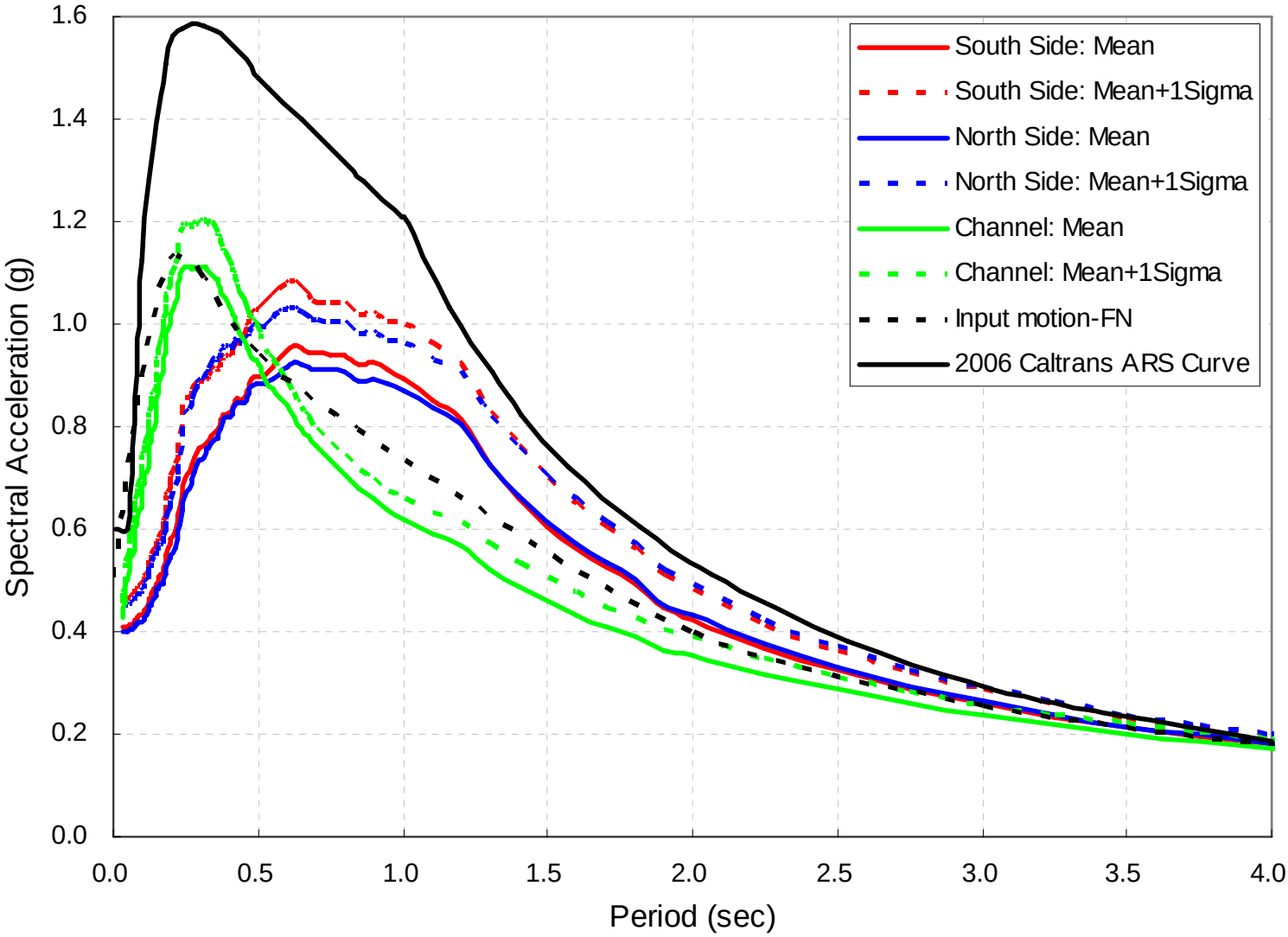
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

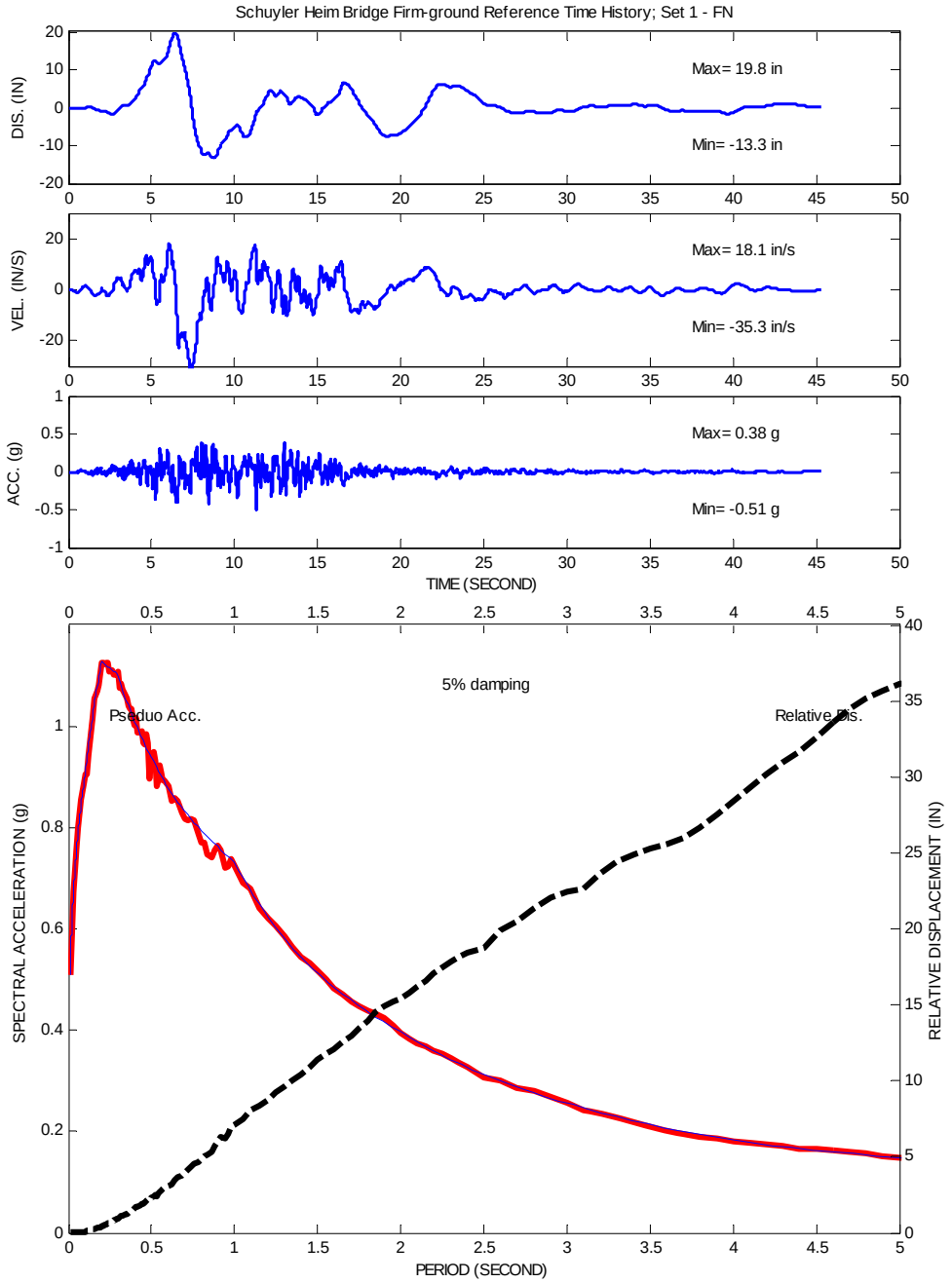

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

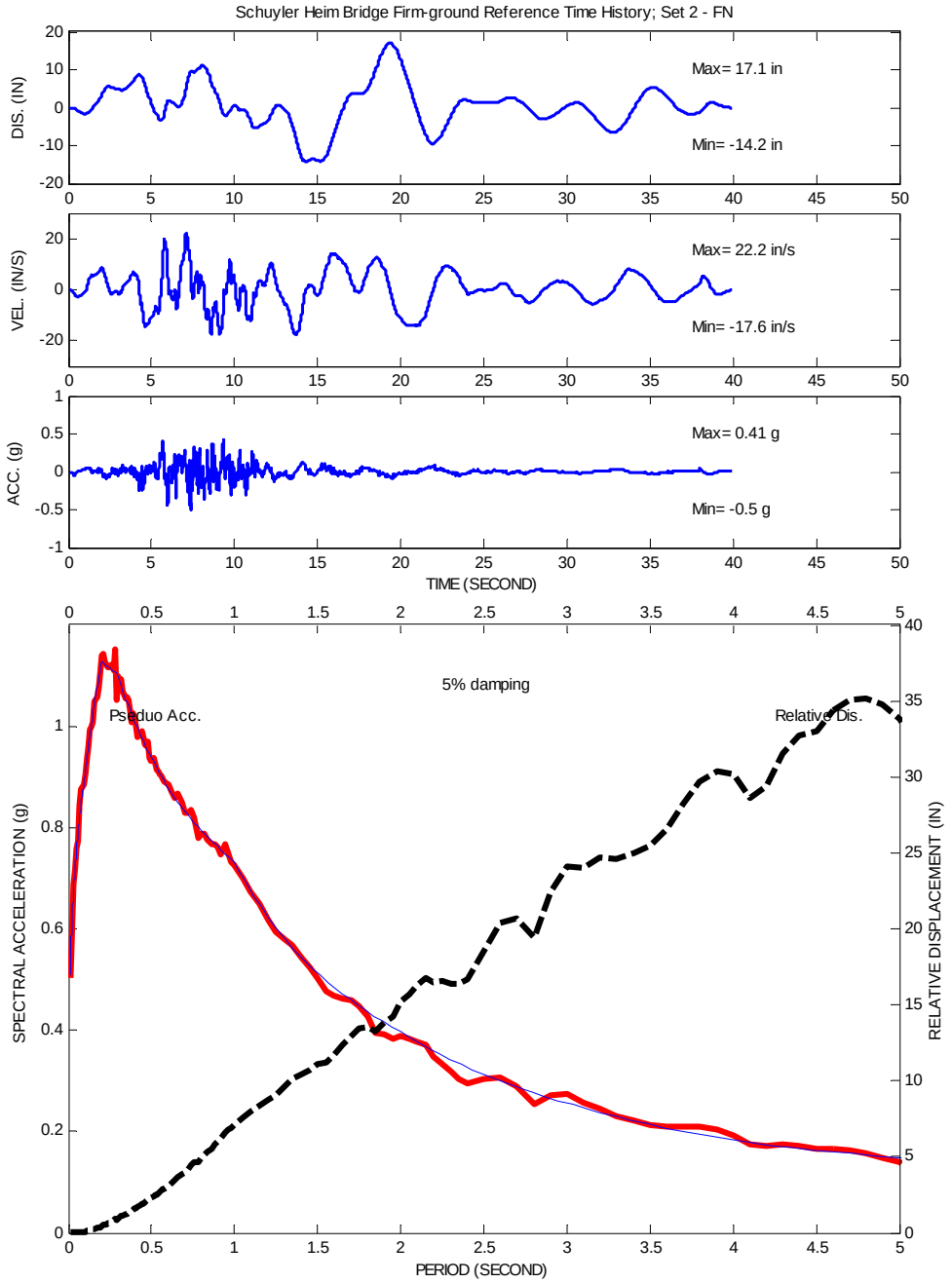

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

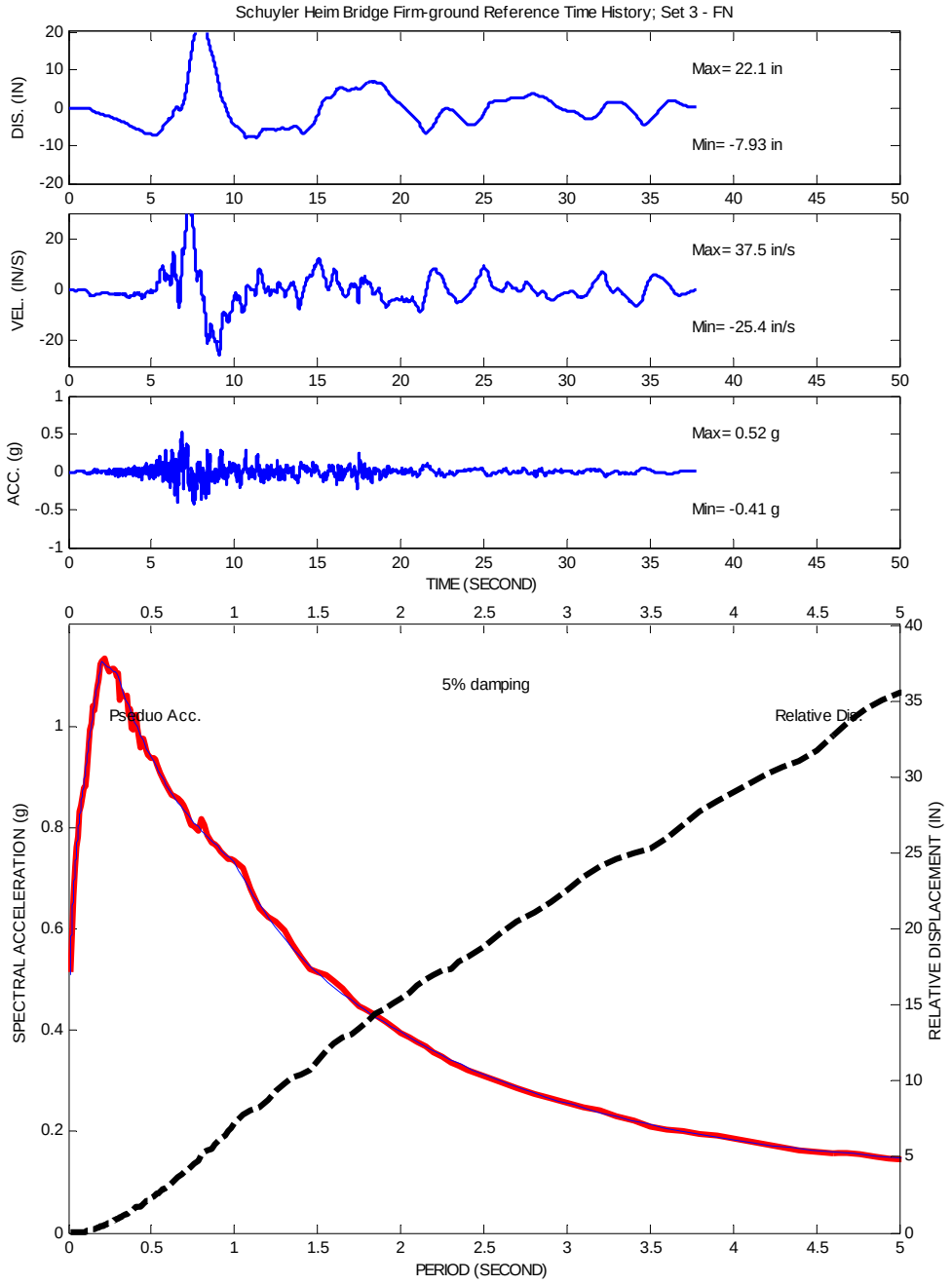

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

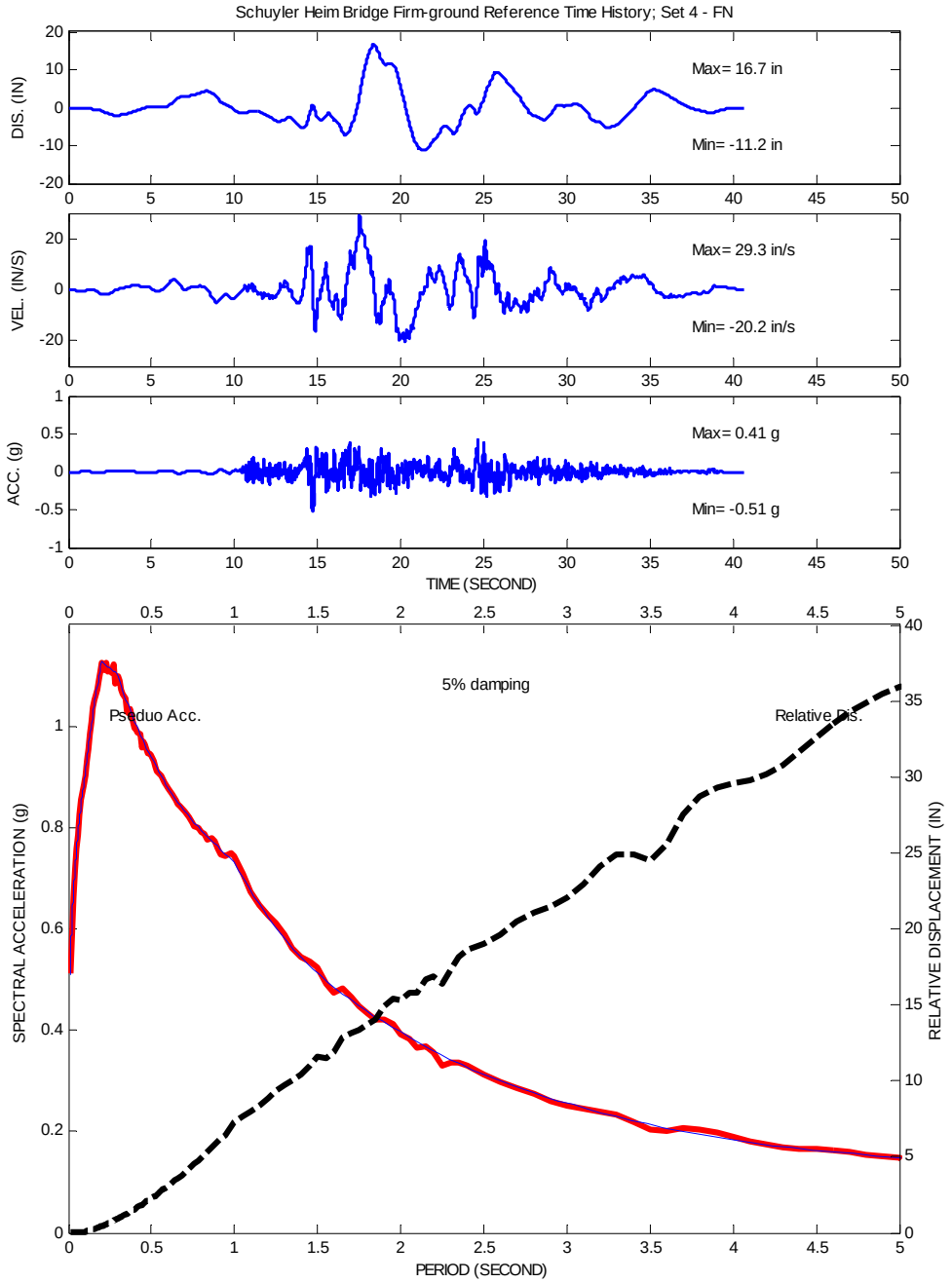

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

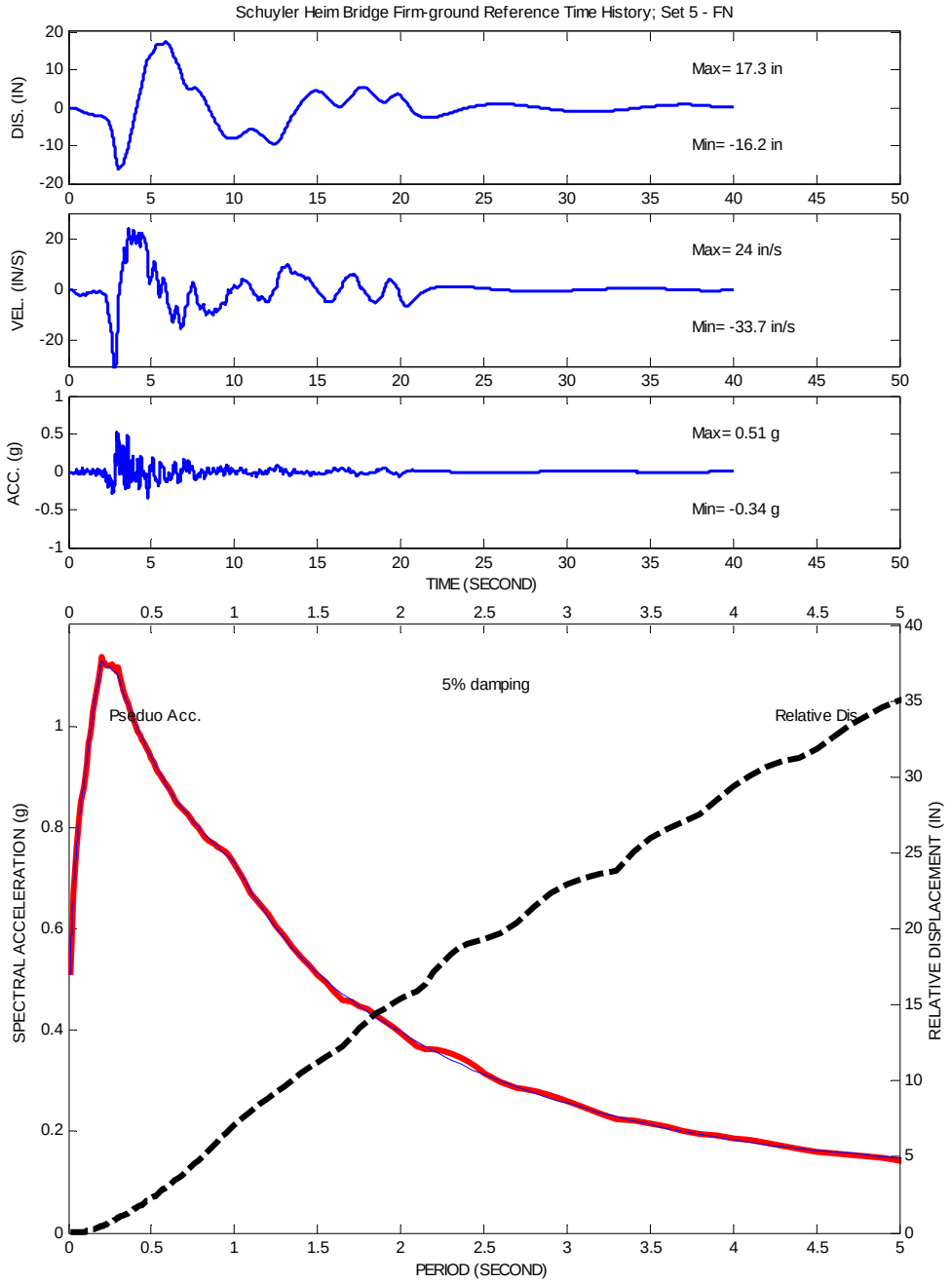

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

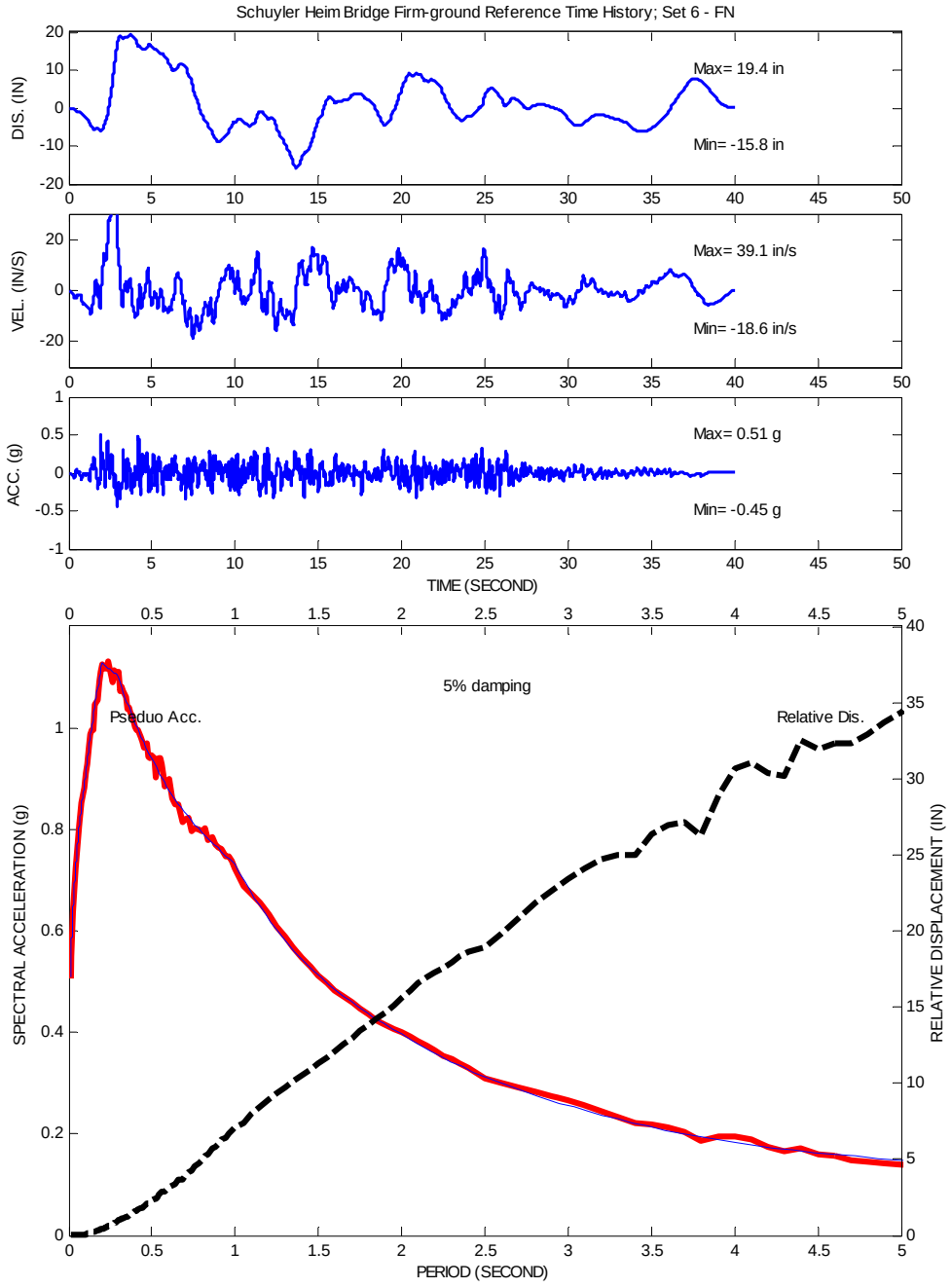

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

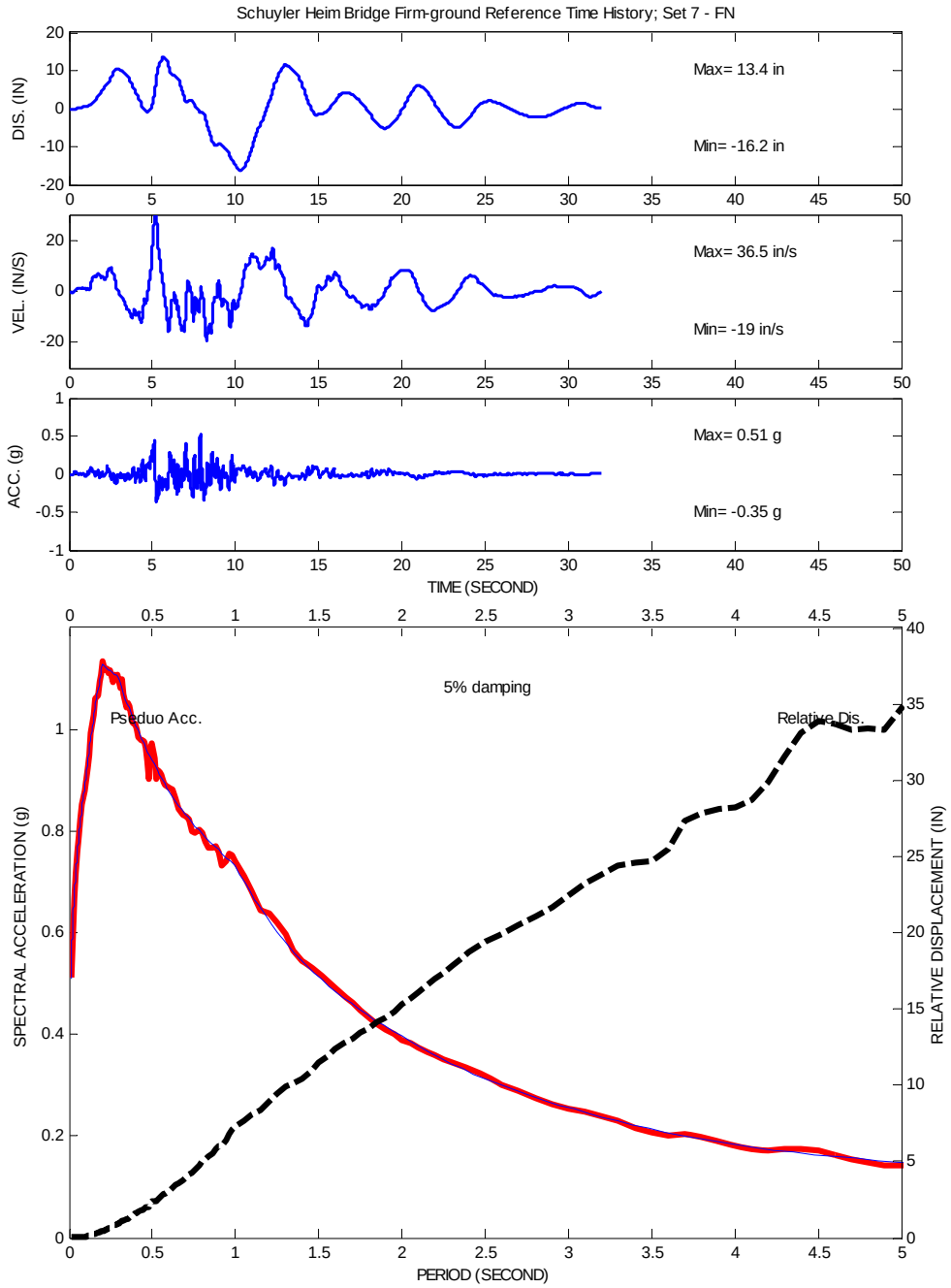

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

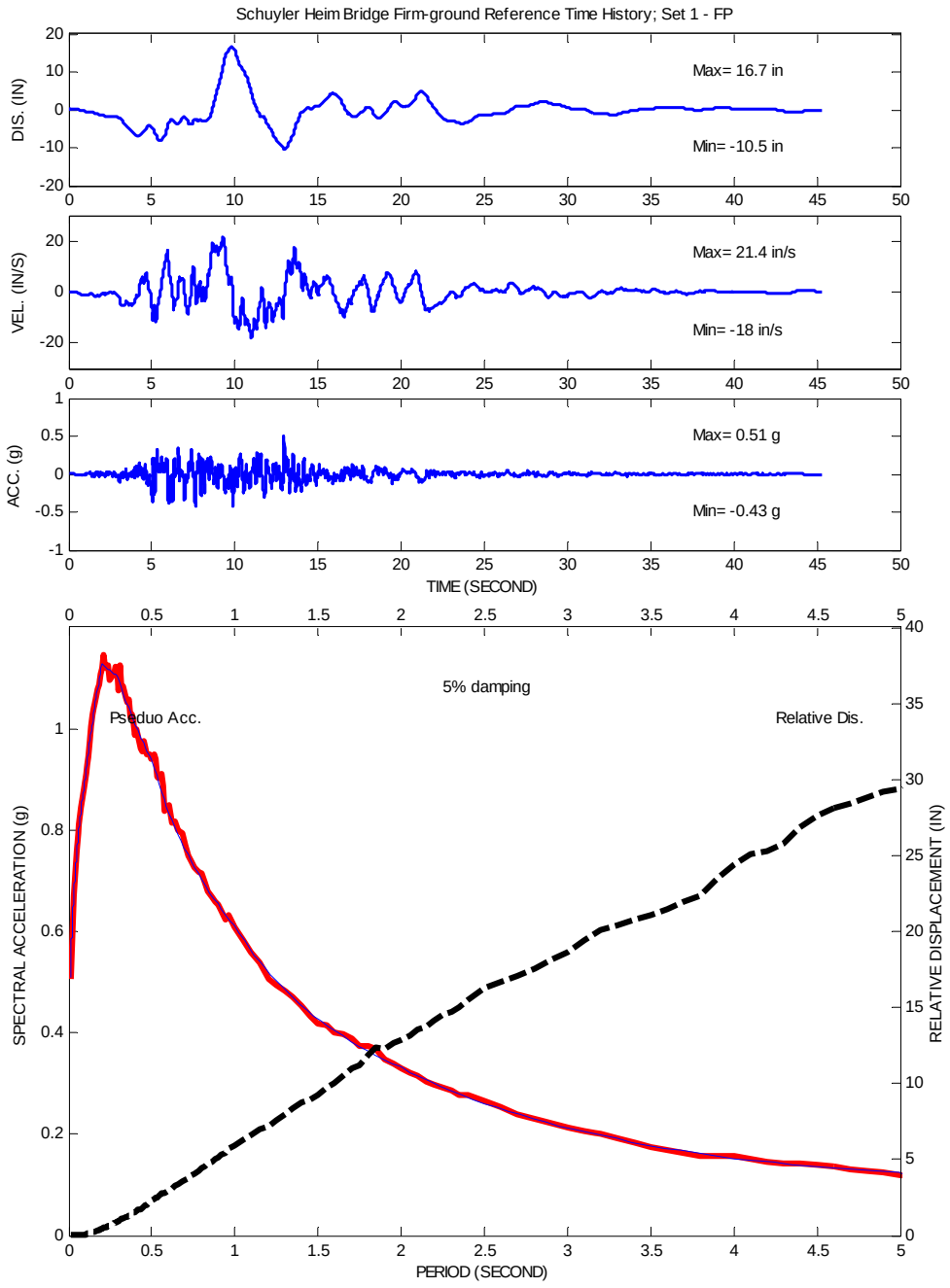

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

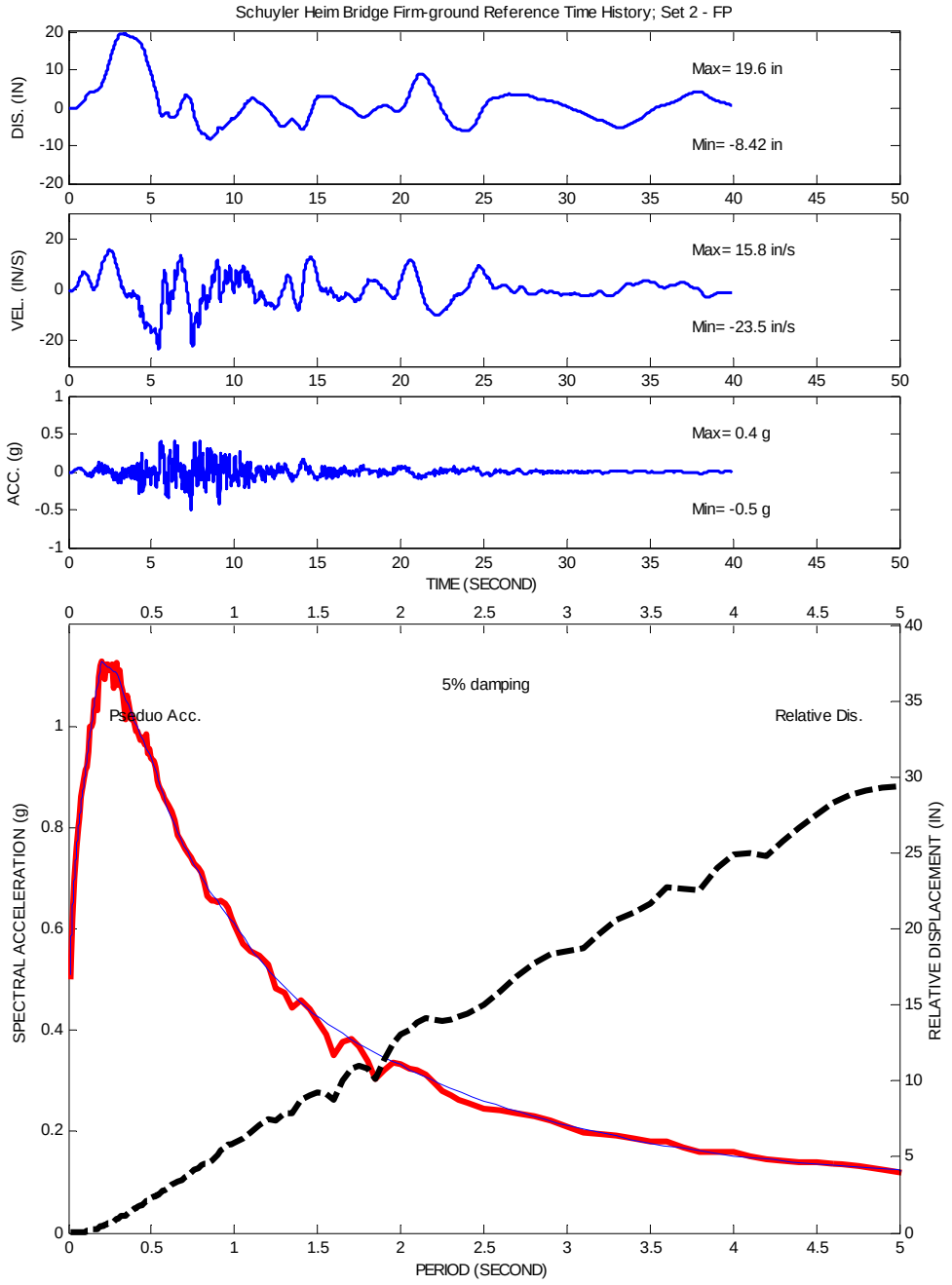

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

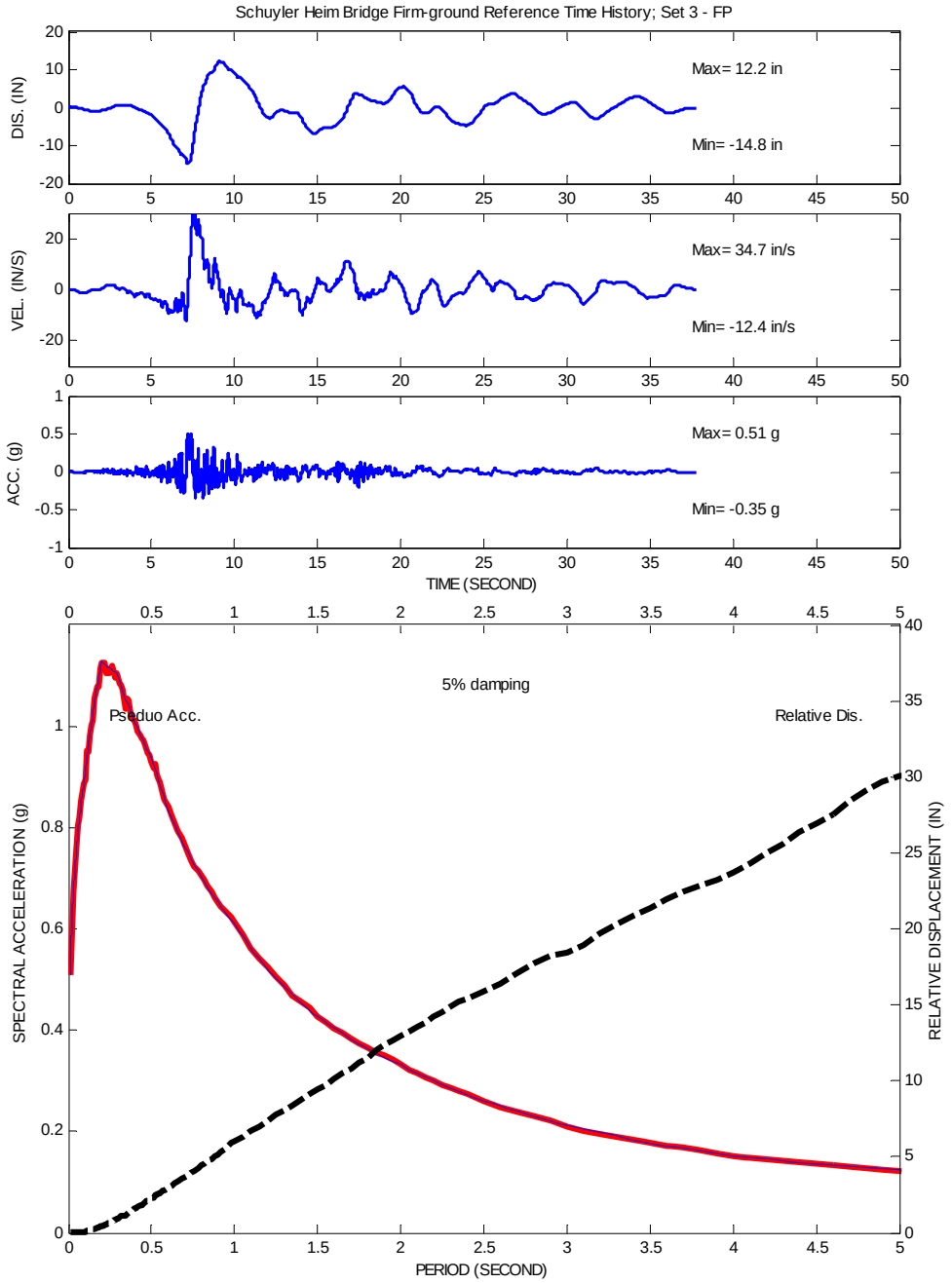

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

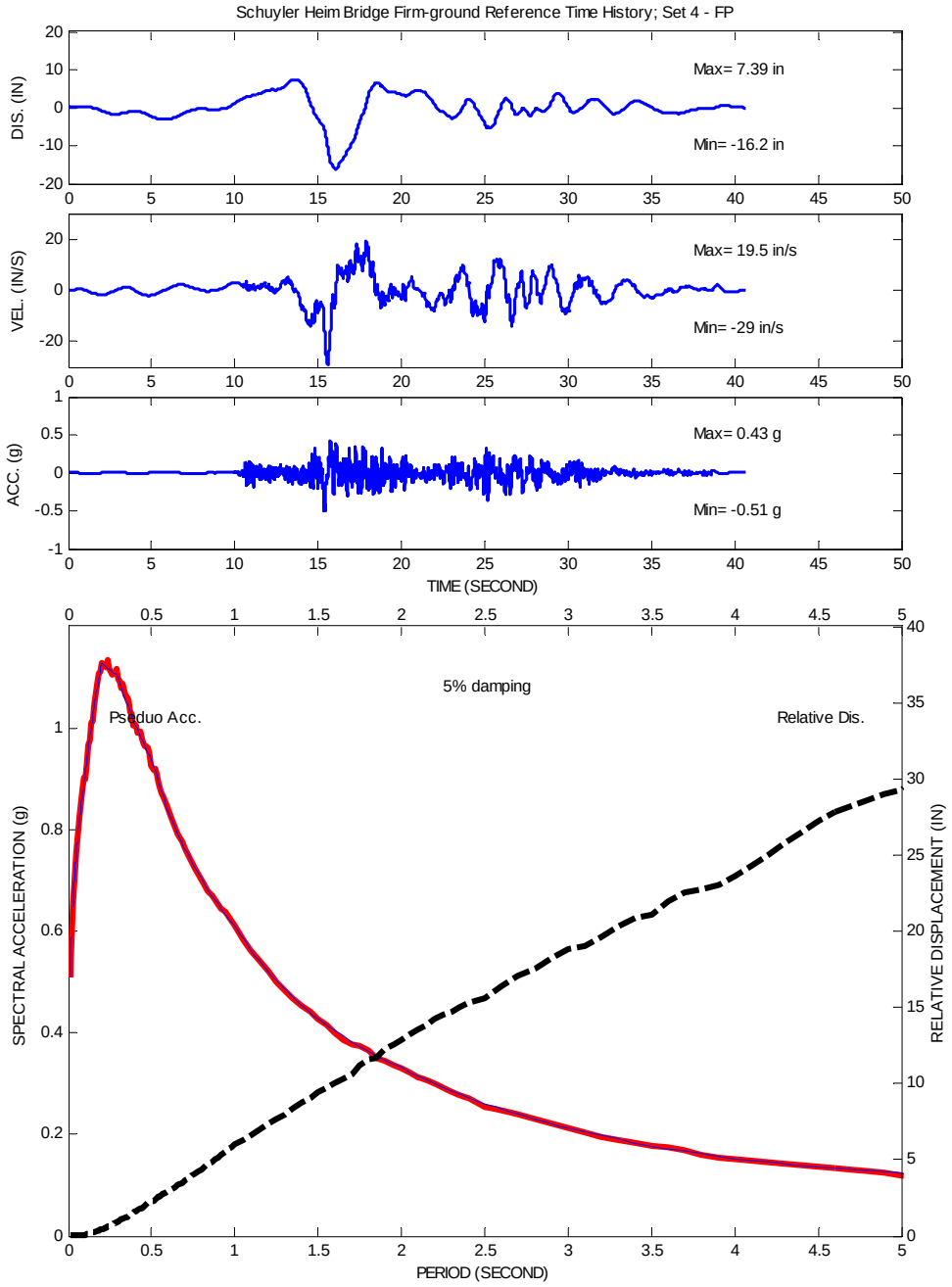

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

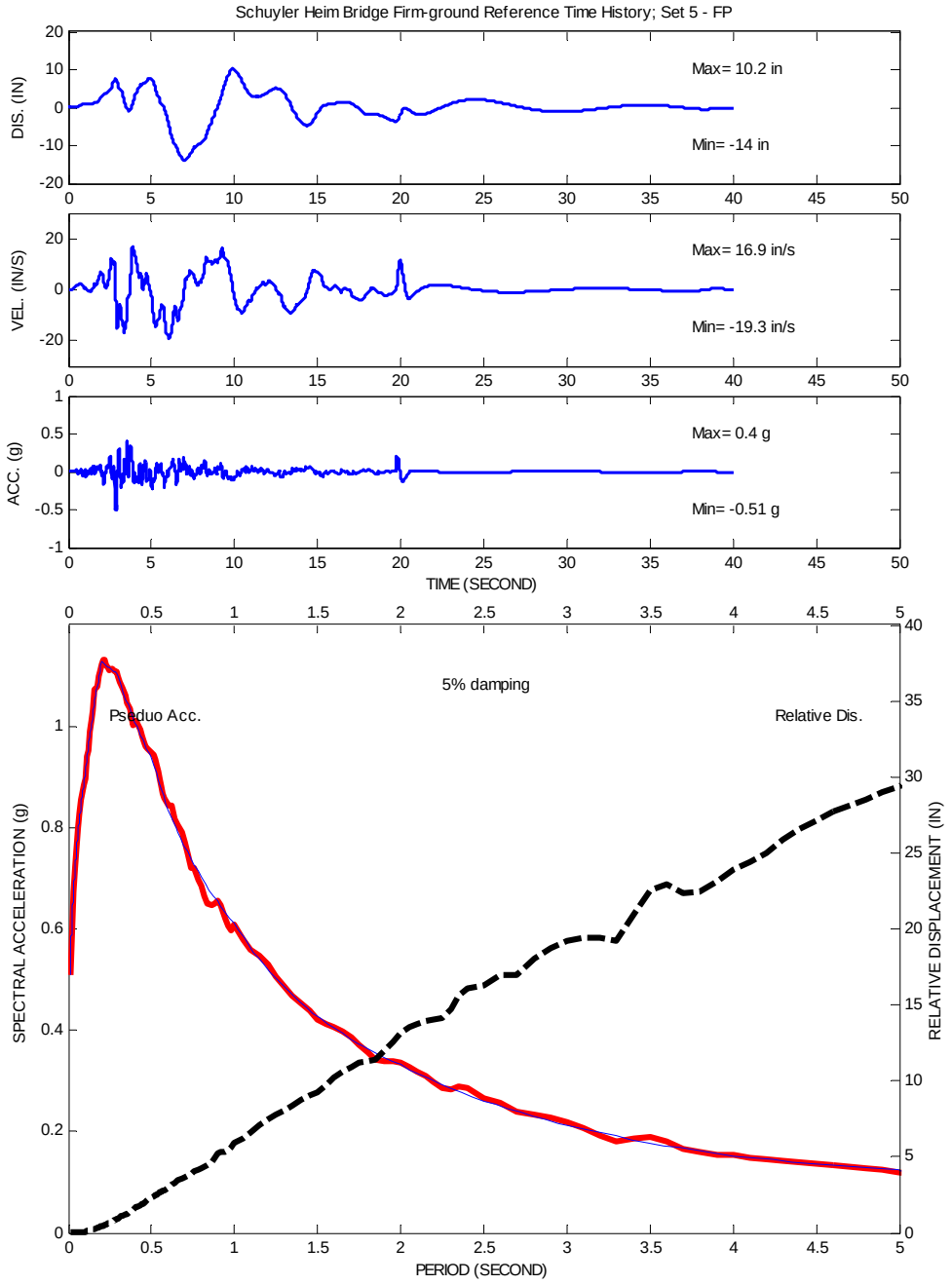

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

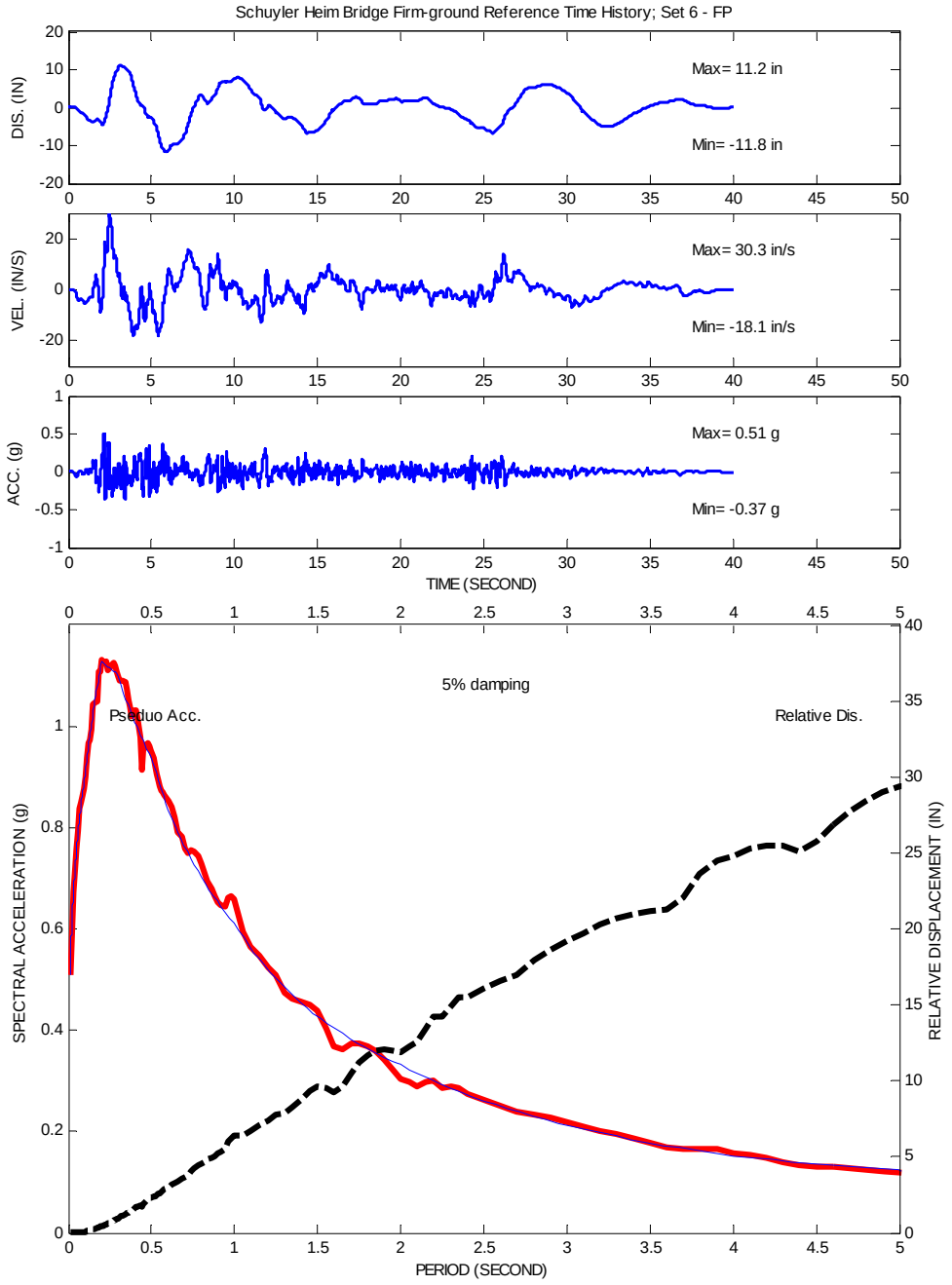

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

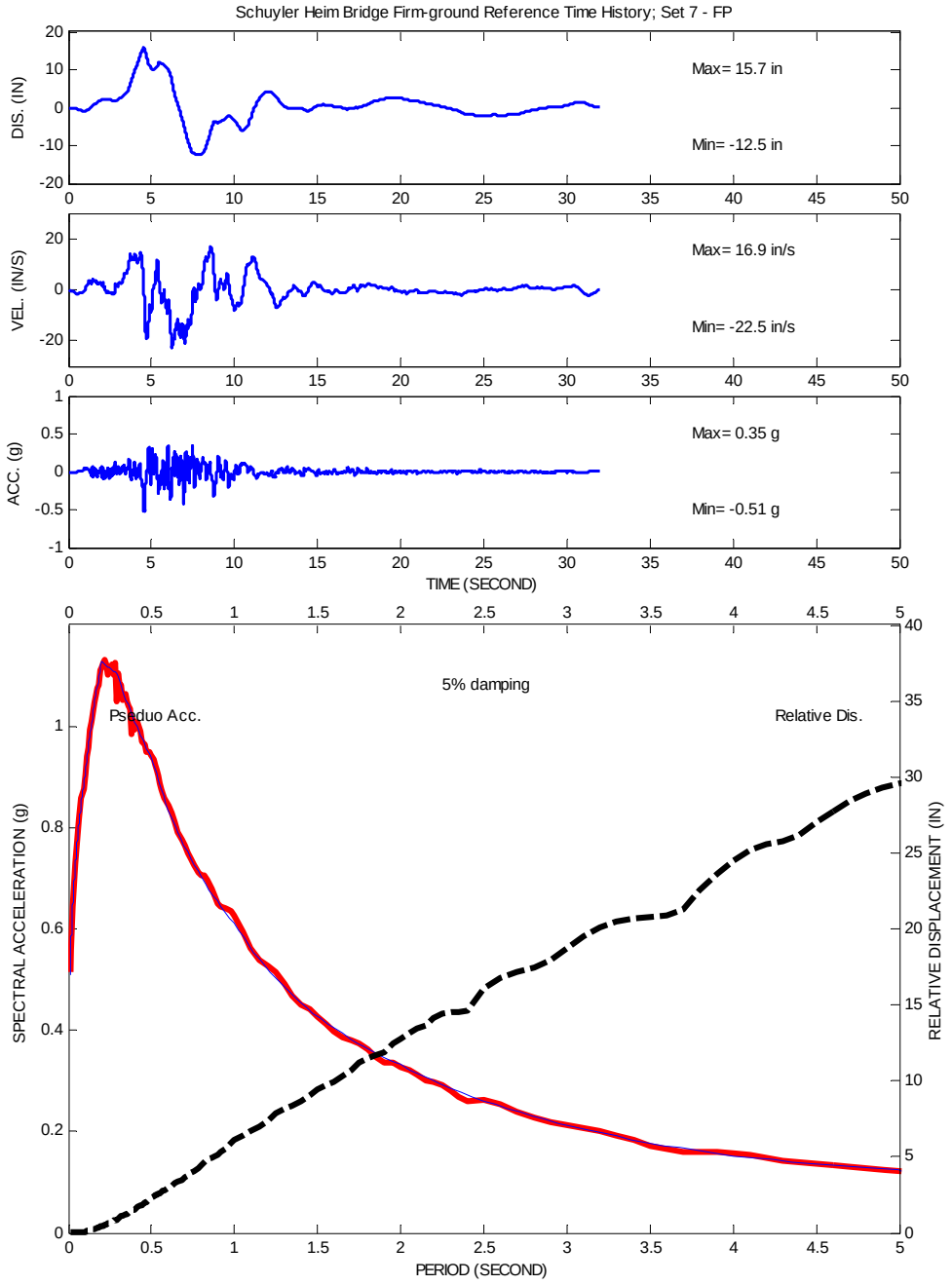

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

Appendix G. p-y Curve Comparison Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 2, 2010 **EMI PROJECT NO:** 06-123-03

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SUBJECT: ACTA Schuyler Heim Bridge (Replace)
Los Angeles and Long Beach, CA
Bent Foundation Lateral Pile Analysis (p-y Curve Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge (Replace) and associated ramp structures (New Dock Street On-Ramp, New Dock Street Off-Ramp, State Route-103 On-Ramp and State Route-103 Off-Ramp) in the cities of Los Angeles and Long Beach, California.

This memorandum summarizes the results of our lateral pile analysis following completion of the recent field investigation and laboratory testing program and is intended to verify that p-y curves developed during the preliminary design phase are suitable and conservative for use in final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California. The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and W. Ocean Boulevard on the south side.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge and the new alignment shifts east along the existing alignment. The proposed fixed bridge will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge will also include southbound exit ramps and northbound entrance ramps at New Dock Street and State Route (SR) 103.

The typical bridge bent will have either multiple columns (mainline) or single columns (ramp structures) supported on Type II cast-in-drilled-hole (CIDH) piles. South of Cerritos Channel, the CIDH piles are 10 ft diameter while the spans across Cerritos Channel and north of Cerritos Channel are supported on 11 to 12 ft diameter CIDH piles. The abutments for the mainline and the ramp structures are expected to be supported on 2.5-foot diameter CIDH piles; however the subject memorandum only pertains to the bent pile analysis.

Project Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time and was intended to be used for bridge type selection and preliminary design. The PFR included a general description of the subsurface conditions including eight idealized soil profiles along the proposed structure alignment with each idealized soil profile typically spanning across multiple bents. The idealized soil profile was used by EMI to develop pile lengths for cost estimating purposes based upon preliminary design loads provided by the designers. Each idealized soil profile included stratigraphy and idealized soil strength parameters (unit weight, friction angle and undrained shear strength) including post-liquefaction "residual" shear strengths for the layers identified as being potentially liquefiable based on a liquefaction analysis performed on the existing soil borings.

It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared. A set of p-y curves was generated at each bent of the mainline and ramp structures for a single 10-ft diameter CIDH pile and included reduced soil strengths for the layers identified in the PFR as potentially liquefiable. Since the project specific geotechnical field investigation could not be initiated until late during the project timeline, the preliminary p-y curves were used by the Caltrans bridge designers in final design. Based upon our conversations with the bridge designers, the only modifications that were made to the preliminary p-y curves was the application of a p-multiplier of 1.2 to curves where the CIDH pile diameter was increased to 12 ft.

In September 2009, EMI was requested by the Alameda Corridor Transportation Agency (ACTA) to perform the project-specific geotechnical field investigation which when completed consisted of 42 rotary wash borings, 33 cone penetration test (CPT) soundings and 8 hollow-stem auger borings along the proposed bridge and ramp alignment; including at least one boring performed near each support of the proposed structure. After completion of the geotechnical field investigation and laboratory testing program, a complete liquefaction analysis was conducted using the new boring information and the idealized soil profile along the proposed bridge alignment was revised.

Because the geotechnical field investigation was not able to be initiated until late during the project timeline, re-analyzing the structure based upon p-y curves generated using the updated soil profile was not feasible given project deadlines. Therefore, EMI performed a set of lateral pile analyses at selected bent locations representing the entire bridge alignment to compare the

preliminary p-y curves (referred to as Design Curves in this memorandum) generated from the idealized soil profiles in the PFR to the p-y curves developed using the updated soil profile (referred to as Revised Profile Curves in this memorandum) to verify that the preliminary curves are suitable and conservative for use in final design.

Method of Analysis

As described above, the Design Curves were generated from eight different soil profiles provided in the PFR (EMI, 2006). For comparison purposes, five bent locations were selected where the individual p-y curves and the overall pile behavior (pile head shear resistance and maximum pile moment versus pile-top deflection) could be compared. The bents selected for comparison were at locations where five of the eight different soil profiles generated during preliminary design could be analyzed. The bent locations selected consisted of two bents south of Cerritos Channel (Bent 2 and Bent 11), one of the bents inside the Cerritos Channel (Bent 14) and two bents north of Cerritos Channel (Bent 18 and Bent 24). The five different idealized soil profiles are shown in Figures 1 to 5.

A review of the Design Curves indicated that coarse-grained soils appear to have been developed using the method proposed by Reese et al. (1974) and fine-grained soils appear to have been developed using the method proposed by Reese and Cox (1975) for stiff clay in the presence of free water. The Revised Profile Curves generated by EMI were developed using API criteria (2000) for coarse grained soils, Matlock's soft clay criteria (Matlock, 1970) for clays with undrained shear strength less than 1 ksf and Reese's method (Reese and Cox, 1975) for stiff clay in the presence of free water for clays with an undrained shear strength greater than 1 ksf.

For comparison of the individual p-y curves, the design curves were provided by the designers. The Revised Profile Curves were generated using LPILE (Ensoft, 2004) based upon the revised idealized soil profile developed at the different bent locations. For the comparison of overall pile behavior (pile head shear resistance and pile moment versus pile-top deflection), the Design Curves were input into LPILE using the "user input p-y curves" option. Based upon our conversations with the designers, a "cracked" section modulus (EI) equal to 75% of the gross EI was used for both models.

Liquefiable Soil. As described above, the Design Curves were generated from soil profiles that indicated the presence of potentially liquefiable material. Based upon a review of the Design Curves, liquefied strengths were generated by applying a p-reduction factor varying between 0.15 and 0.20 for potentially liquefiable layers.

The Revised Profile Curves were generated based upon an updated liquefaction analysis performed on the borings completed in the EMI field investigation. Liquefied soil strengths for layers identified to be potentially liquefiable were modeled using a p-reduction factor based upon the values provided in Ashford et al. (2008). The p-reduction factors are correlated to an average normalized clean sand SPT blowcount $(N1)_{60\text{-}CS}$ for the liquefiable layer with discrete values provided for a range of $(N1)_{60\text{-}CS}$. An approximate trend line was drawn through the ranges proposed by Ashford and used in the analysis as shown in Figure 6.

Group Effects. It is our understanding that the Design Curves were generated prior to Caltrans implementation of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2007) which required p-reduction factors to p-y curves to account for group effects. P-reduction factors to account for group effects for the Revised Profile Curves followed the recommendations for pile group efficiency reduction factors provided in Caltrans Amendments to AASHTO LRFD BDS (Caltrans, 2008) and were based upon the CIDH pile on-center spacing in the bridge transverse direction at the individual bent locations. Since each bent consists of a single row of piles, the bridge transverse direction controls the pile design as it has a greater group reduction than the longitudinal direction. The pile spacing and p-reduction factors used in the analysis for each bent are listed in Table 1.

Table 1. Group Reduction Factors for Revised Profile Curves

Bent Location	Pile Diameter (ft)	Average Spacing in Transverse Direction (ft)	P-Reduction Factor for Group Effects
Bent 2	10	30 = 3.0 x D	0.53
Bent 11	10	36 = 3.6 x D	0.61
Bent 14	12	33 = 2.9 x D	0.48
Bent 18	12	35 = 3.0 x D	0.53
Bent 24	12	45 = 4.0 x D	0.67
Note: Group reduction effects were not accounted for in development of Design Curves.			

Groundwater. The design groundwater elevation for the Revised Profile Curves was placed at an elevation of +5 ft MLLW or the ground surface in locations where proposed grade is indicated on the plans as being below elevation +5 ft MLLW.

Results

The revised soil profiles resulting from the information gathered during the recent investigation are generally consistent with those provided in the PFR that were used to develop the Design Curves. Site soils can be characterized by alluvial deposits consisting of loose to medium dense fine-grained silty sand and sandy silt with abundant silty clay and clayey silt layers between the ground surface and about 50 to 70 ft below grade. The near surface alluvium is underlain by dense to very dense coarse-grained Gaspur Formation sand. The coarse grained portions of the alluvium is generally liquefiable with some pockets and lenses with medium dense to dense consistency that are not considered susceptible to liquefaction.

Since lateral pile behavior is primarily dictated by the soil profile within the upper portion of the pile (within about 5 to 7 pile diameters from the pile top), the lateral pile stiffness throughout the project is dominated by soft to stiff fine-grained material and liquefiable sand. In generating the revised soil profiles, the recent soil borings and laboratory test results justify using more appropriate p-reduction factors to account for liquefaction throughout the profile and higher undrained shear strengths in some of the fine-grained material. Though the Design Curves were generated during early stages of the project without considering group effects, when the more appropriate p-reduction factors for liquefiable soils and increased undrained shear strengths for the appropriate fine-grained soils are used in conjunction with the group reduction factors, the Revised Profile Curves are generally comparable to the Design Curves. Figures 7 to 11 show the

Design Curves plotted along side the Revised Profile Curves at each bent location for the top 100 ft of pile length.

Due to some revisions in the idealized soil profile stratigraphy based upon the new soil information, there are some depths that the Revised Profile Curves model a layer or a portion of a layer as softer than the Design Curves; therefore, it isn't necessarily clear upon initial inspection which set of p-y curves generates a more conservative soil model. Based upon our conversations with the designers, performing a pile pushover analysis using a free-head pile, the curves that generate a pile response where a smaller pile-head shear is required to produce a prescribed lateral pile displacement is considered to be more conservative. In addition, since earthquake loading on a bridge is force based (i.e., mass times the spectral acceleration), the curve that predicts more moment in the pile for a given pile-head shear would also be an indication of a more conservative analysis.

For the five different bents considered, the lateral pile head shear and maximum moment are plotted against lateral pile-top displacement in Figures 12 to 16 using the analysis methods described above. Figures 12, 15 and 16 show that for Bent 2, Bent 18 and Bent 24, respectively, the Design Curves produce a more conservative lateral pile response than the analysis using the Revised Profile Curves. For Bent 11 and Bent 14 shown in Figures 13 and 14, respectively, the lateral pile head shear to produce the same lateral pile deflection is about 15 percent less for the Revised Profile Curves than that for the Design Curves. These differences are considered small and acceptable. In addition, as shown in Figures 12 through 16, the maximum moments for given pile-head shear values predicted using the Design Curves are approximately equal to or greater those predicted using the Revised Profile Curves.

Conclusions

Based upon the results of the above described analysis and our discussions with the designers, we conclude that the Design Curves are appropriate for use in the bridge final design as they typically generate a more conservative lateral pile response than the response predicted by the Revised Curves.

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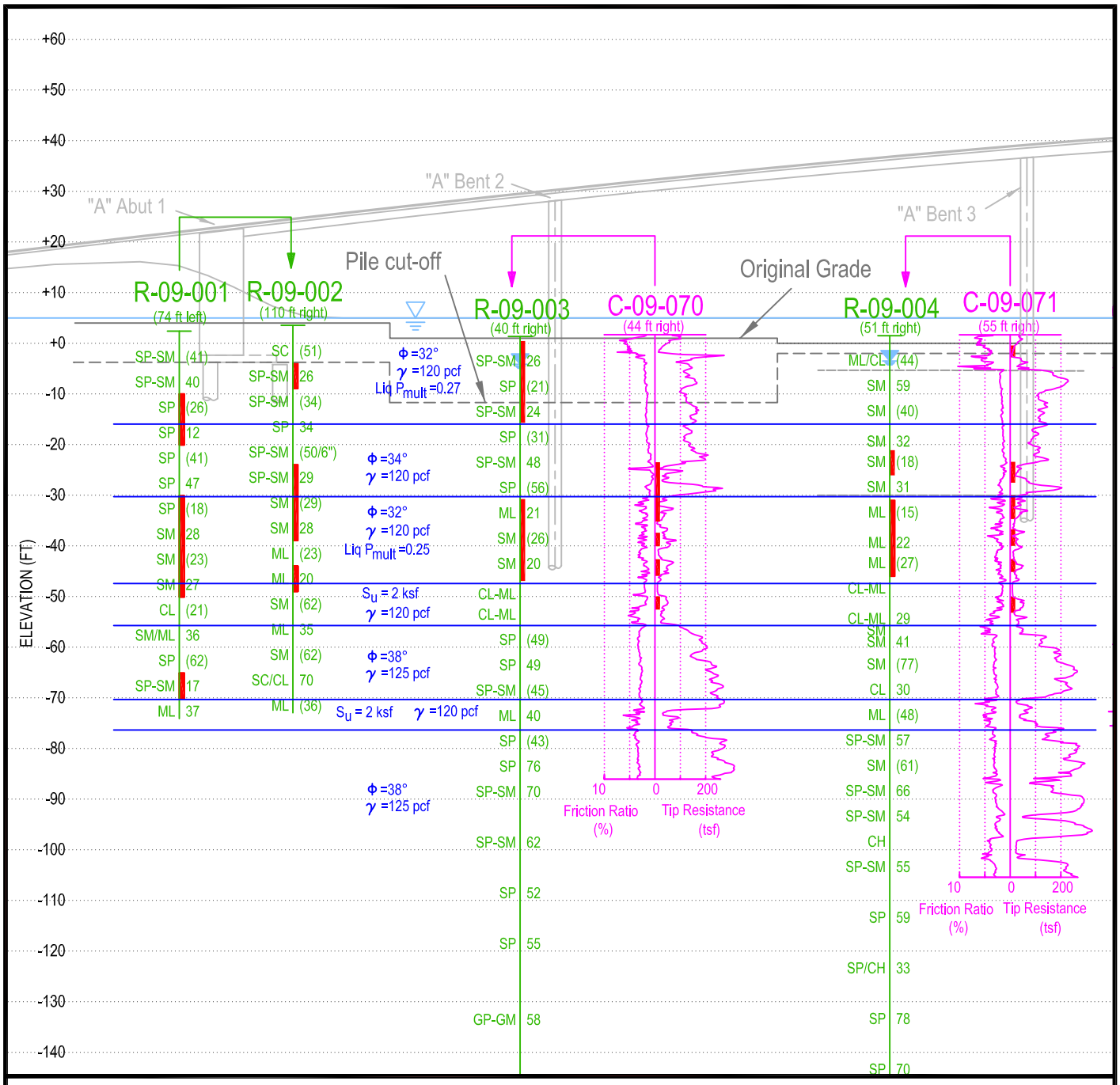

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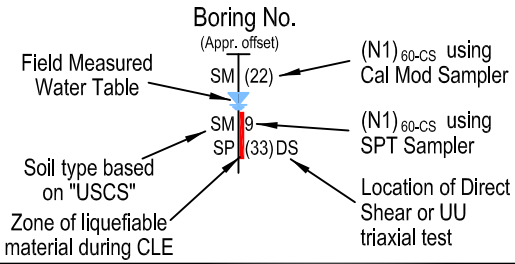
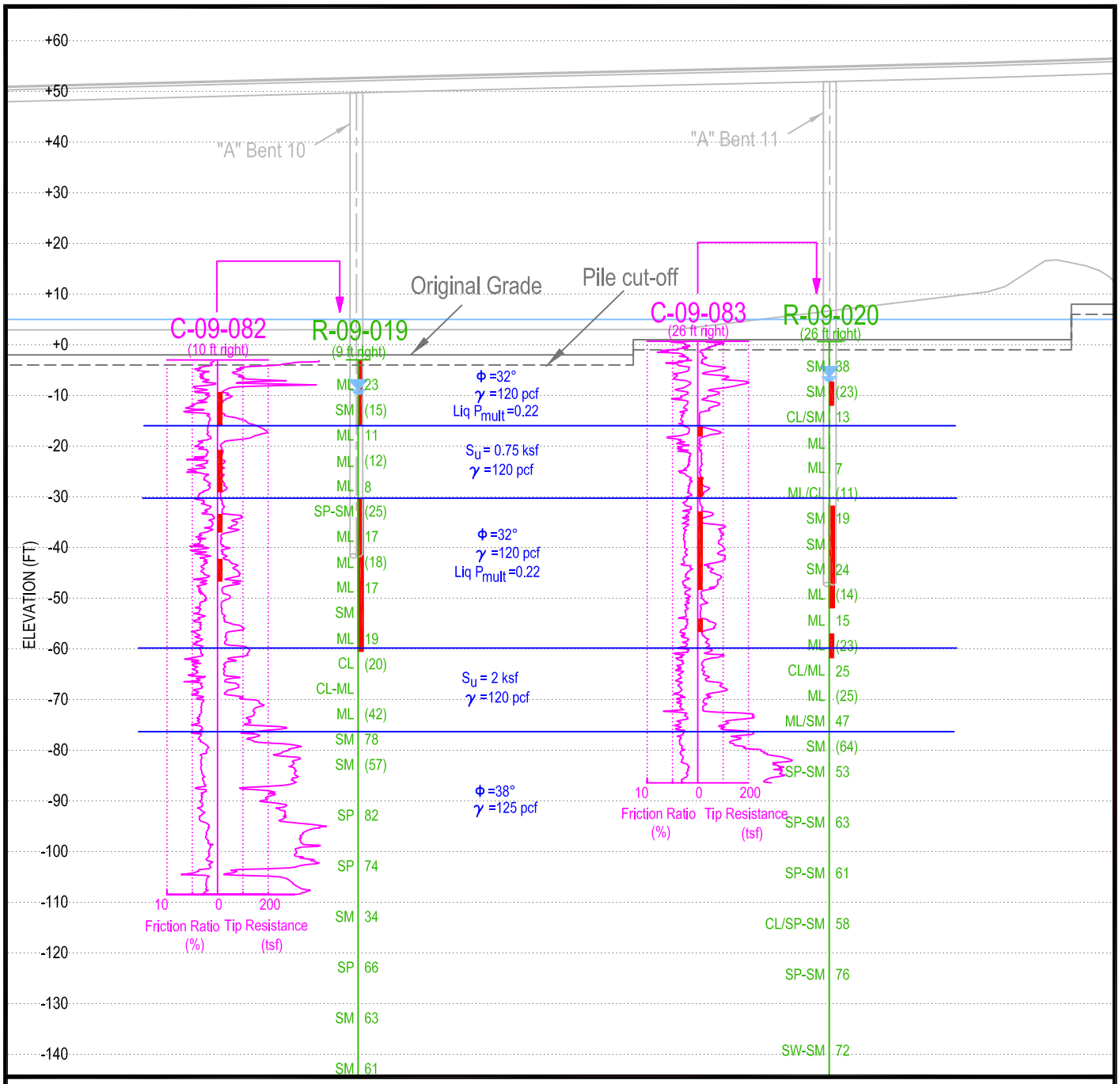


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 2 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 1



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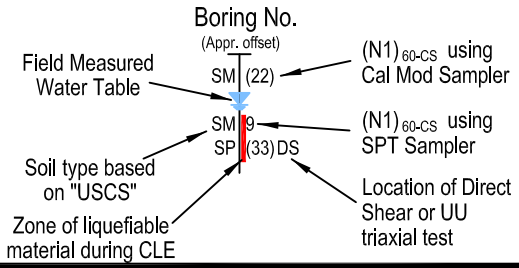

Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Idealized Soil Profile
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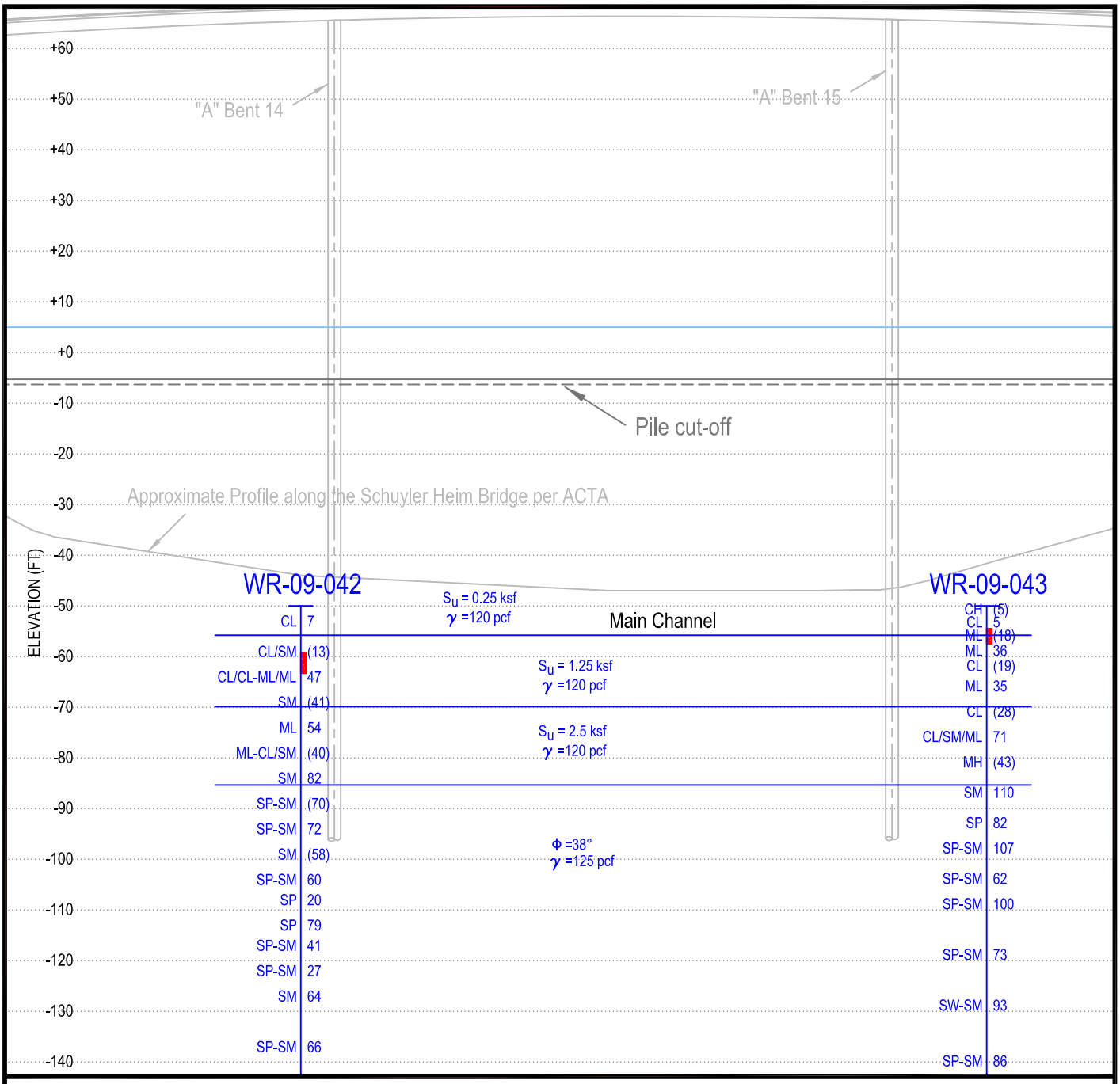

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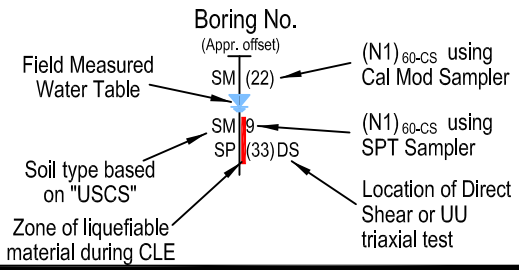
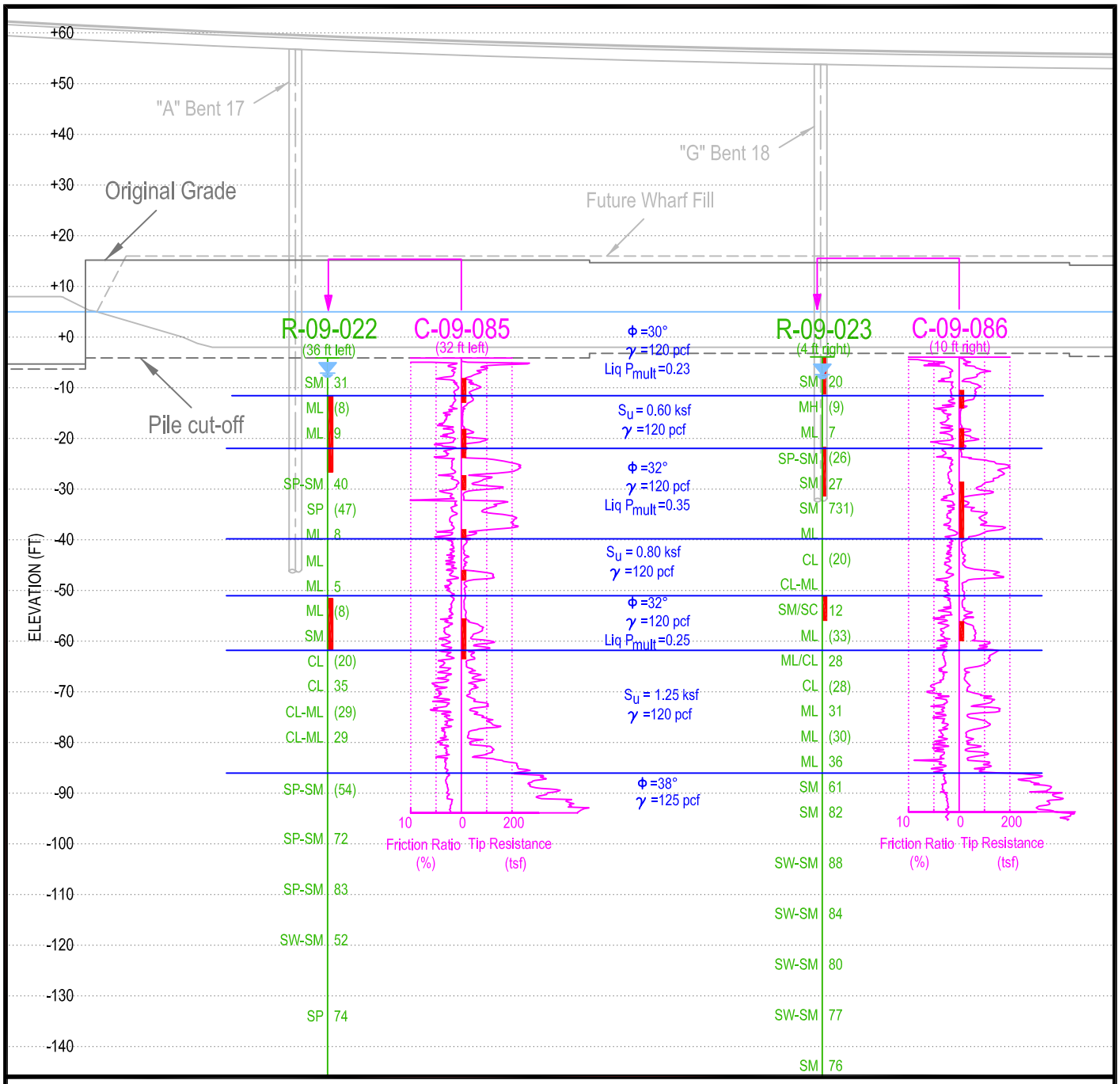


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 3



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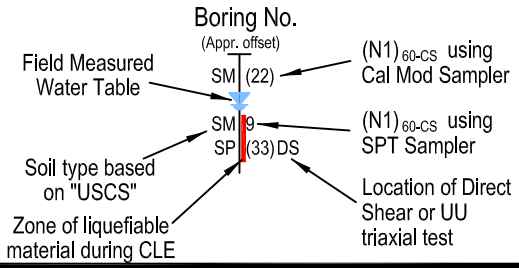
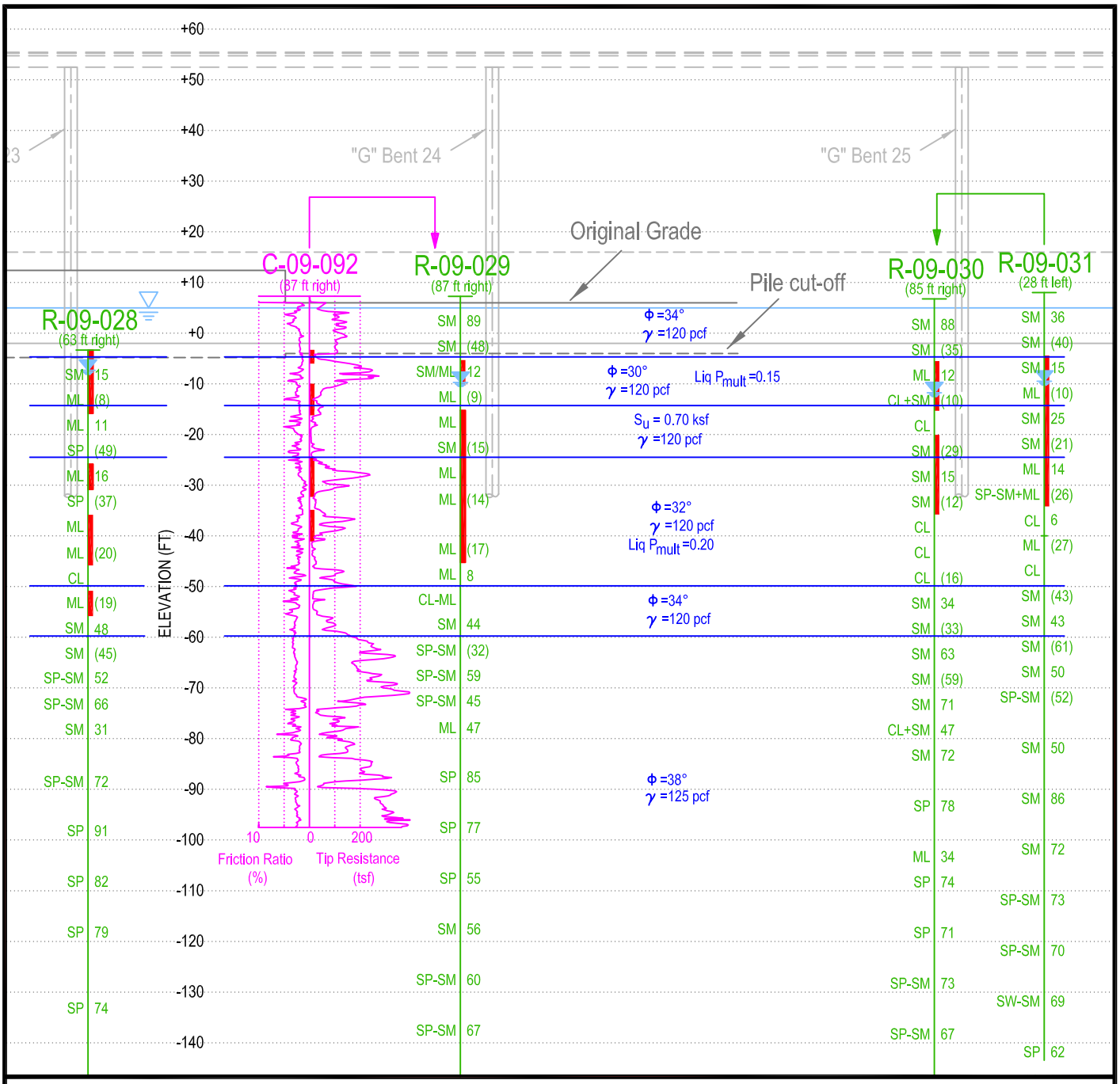


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 4



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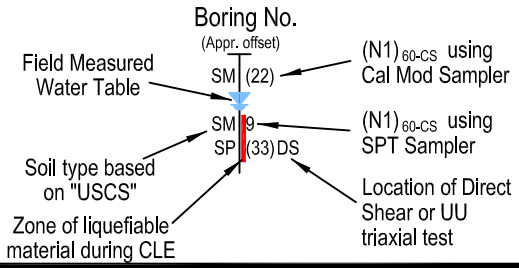


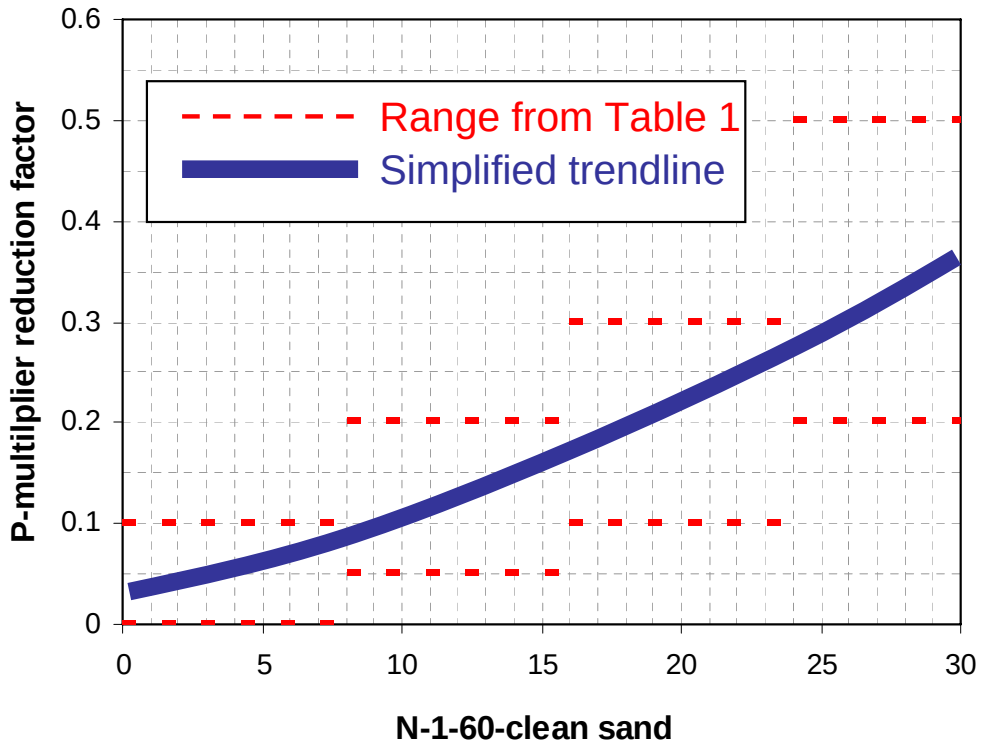
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 24 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 5

Recommended values (after Ashford et al. 2008)

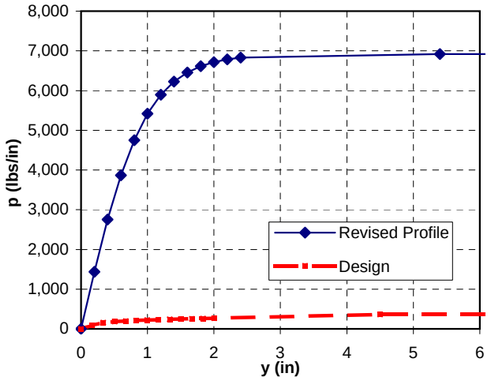
Table 1. p-multipliers, m_p, to account for liquefaction

$(N_1)_{60\text{-}CS}$	m_p
<8	0.0 to 0.1
8-16	0.05 to 0.2
16-24	0.1 to 0.3
>24	0.2 to 0.5

Chart for selecting p-multiplier based on $(N1)60_{cs}$

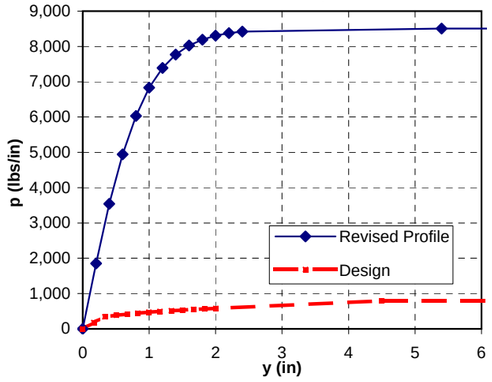


5 ft depth



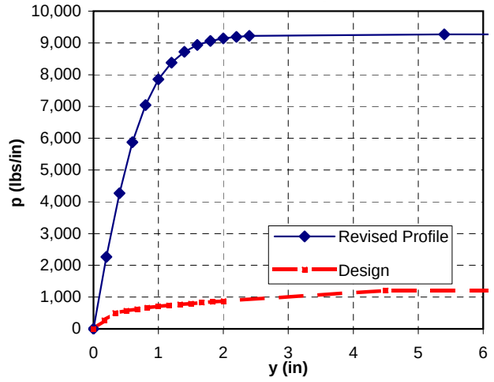
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	1,436
0.34	162	0.40	2,753
0.50	182	0.60	3,869
0.67	197	0.80	4,753
0.83	210	1.00	5,416
1.00	221	1.20	5,894
1.16	231	1.40	6,228
1.33	240	1.60	6,457
1.50	248	1.80	6,611
1.67	256	2.00	6,715
1.84	263	2.20	6,783
2.00	269	2.40	6,829
4.50	365	5.40	6,916
124.50	365	149.40	6,916

10 ft depth



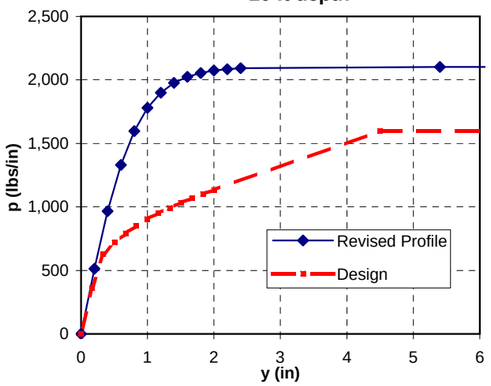
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	1,853
0.34	341	0.40	3,538
0.50	384	0.60	4,943
0.67	418	0.80	6,032
0.83	447	1.00	6,829
1.00	472	1.20	7,389
1.16	494	1.40	7,771
1.33	514	1.60	8,025
1.50	532	1.80	8,193
1.67	549	2.00	8,303
1.84	565	2.20	8,374
2.00	579	2.40	8,420
4.50	794	5.40	8,503
124.50	794	149.40	8,503

15 ft depth



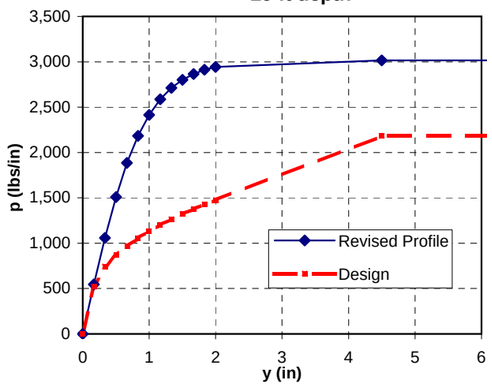
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.20	2,263
0.34	502	0.40	4,271
0.50	569	0.60	5,873
0.67	622	0.80	7,046
0.83	666	1.00	7,852
1.00	705	1.20	8,381
1.16	739	1.40	8,719
1.33	770	1.60	8,931
1.50	799	1.80	9,062
1.67	825	2.00	9,143
1.84	850	2.20	9,192
2.00	873	2.40	9,222
4.50	1,210	5.40	9,269
124.50	1,210	149.40	9,269

20 ft depth



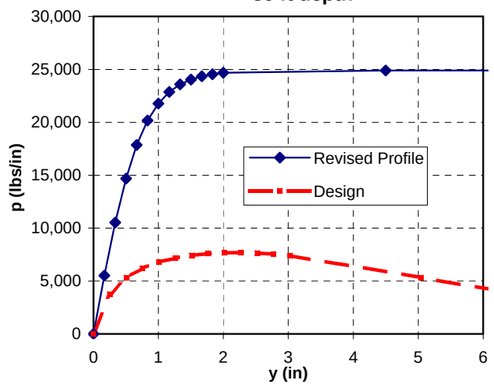
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	360	0.20	512
0.34	631	0.40	967
0.50	720	0.60	1,330
0.67	792	0.80	1,597
0.83	852	1.00	1,780
1.00	904	1.20	1,900
1.16	951	1.40	1,977
1.33	993	1.60	2,026
1.50	1,032	1.80	2,055
1.67	1,069	2.00	2,074
1.84	1,103	2.20	2,085
2.00	1,134	2.40	2,092
4.50	1,599	5.40	2,103
124.50	1,599	149.40	2,103

29 ft depth



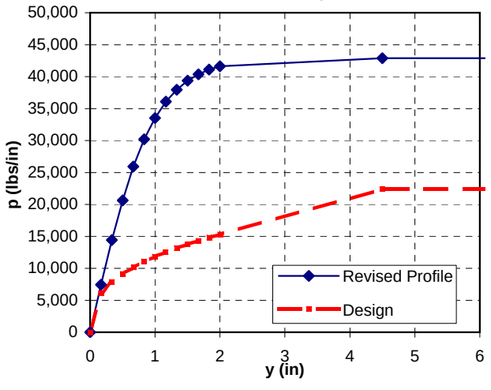
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	522	0.17	547
0.34	744	0.33	1,058
0.50	868	0.50	1,509
0.67	970	0.67	1,885
0.83	1,056	0.83	2,184
1.00	1,132	1.00	2,414
1.16	1,201	1.17	2,586
1.33	1,264	1.33	2,711
1.50	1,322	1.50	2,802
1.67	1,377	1.67	2,866
1.84	1,428	1.83	2,911
2.00	1,476	2.00	2,943
4.50	2,182	4.50	3,016
124.50	2,182	124.50	3,017

50 ft depth



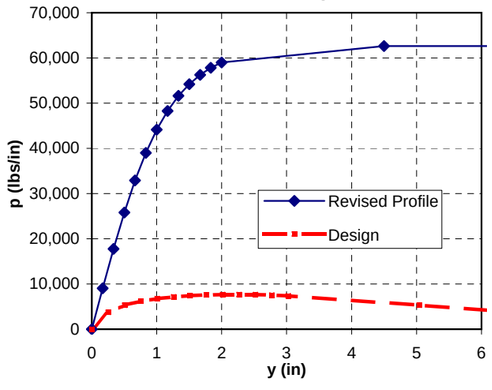
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	5,521
0.50	5,325	0.33	10,523
0.76	6,204	0.50	14,668
1.01	6,775	0.67	17,855
1.26	7,164	0.83	20,166
1.51	7,425	1.00	21,774
1.76	7,585	1.17	22,858
2.02	7,664	1.33	23,576
2.27	7,676	1.50	24,045
2.52	7,629	1.67	24,348
2.77	7,532	1.83	24,543
3.02	7,390	2.00	24,668
5.04	5,330	4.50	24,888
7.06	3,268	124.50	24,889

71 ft depth



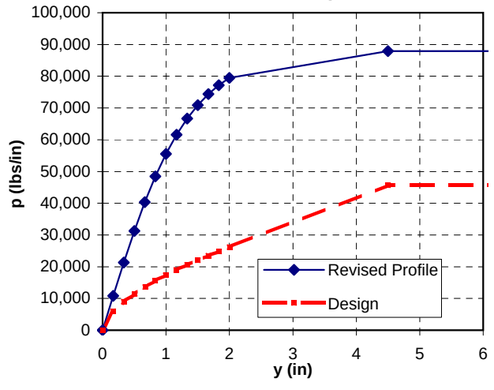
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	6,081	0.17	7,430
0.34	7,867	0.33	14,426
0.50	9,145	0.50	20,652
0.67	10,176	0.67	25,918
0.83	11,056	0.83	30,186
1.00	11,830	1.00	33,525
1.16	12,527	1.17	36,068
1.33	13,164	1.33	37,963
1.50	13,753	1.50	39,354
1.67	14,302	1.67	40,363
1.84	14,817	1.83	41,089
2.00	15,303	2.00	41,609
4.50	22,408	4.50	42,867
124.50	22,408	124.50	42,874

85 ft depth



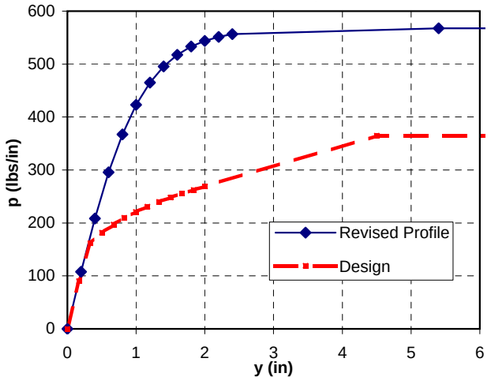
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	9,074
0.50	5,325	0.33	17,775
0.76	6,204	0.50	25,790
1.01	6,775	0.67	32,904
1.26	7,164	0.83	39,014
1.51	7,425	1.00	44,113
1.76	7,585	1.17	48,270
2.02	7,664	1.33	51,593
2.27	7,676	1.50	54,208
2.52	7,629	1.67	56,241
2.77	7,532	1.83	57,807
3.02	7,390	2.00	59,004
5.04	5,330	4.50	62,636
7.06	3,268	124.50	62,684

100 ft depth



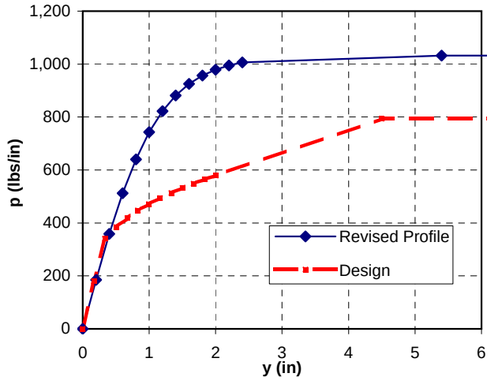
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	5,976	0.17	10,832
0.34	9,023	0.33	21,341
0.50	11,483	0.50	31,242
0.67	13,624	0.67	40,316
0.83	15,557	0.83	48,423
1.00	17,338	1.00	55,503
1.16	19,001	1.17	61,565
1.33	20,571	1.33	66,668
1.50	22,063	1.50	70,902
1.67	23,489	1.67	74,373
1.84	24,858	1.83	77,191
2.00	26,177	2.00	79,461
4.50	45,628	4.50	87,868
124.50	45,628	124.50	88,090

5 ft depth



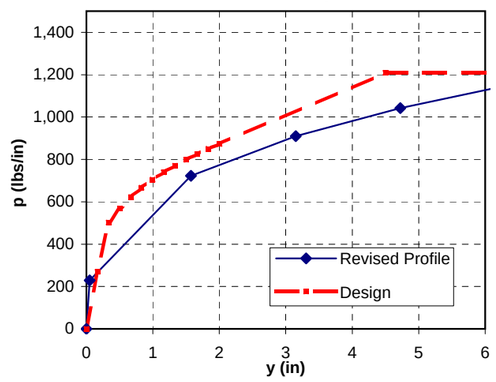
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	108
0.34	162	0.40	208
0.50	182	0.60	295
0.67	197	0.80	367
0.83	210	1.00	423
1.00	221	1.20	465
1.16	231	1.40	496
1.33	240	1.60	518
1.50	248	1.80	533
1.67	256	2.00	544
1.84	263	2.20	551
2.00	269	2.40	556
4.50	365	5.40	567
124.50	365	149.40	568

10 ft depth



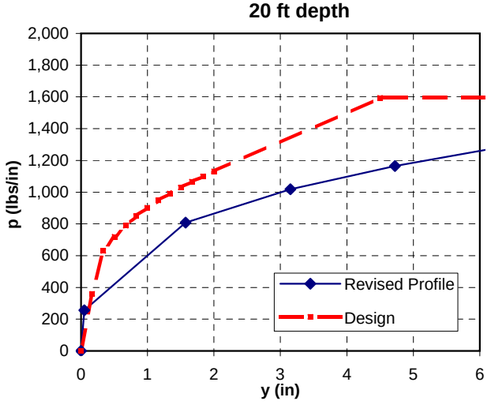
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	185
0.34	341	0.40	359
0.50	384	0.60	512
0.67	418	0.80	640
0.83	447	1.00	743
1.00	472	1.20	822
1.16	494	1.40	881
1.33	514	1.60	925
1.50	532	1.80	956
1.67	549	2.00	979
1.84	565	2.20	995
2.00	579	2.40	1,006
4.50	794	5.40	1,032
124.50	794	149.40	1,033

15 ft depth



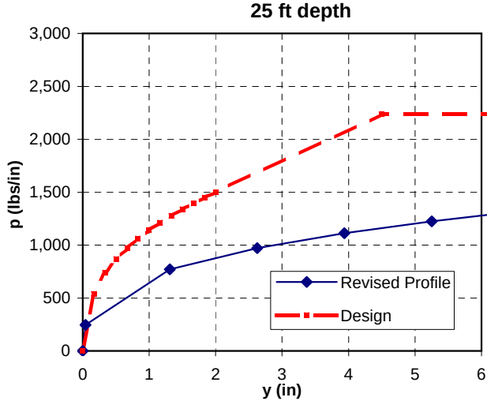
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.05	229
0.34	502	1.58	723
0.50	569	3.15	910
0.67	622	4.73	1,042
0.83	666	6.30	1,147
1.00	705	7.88	1,235
1.16	739	9.45	1,313
1.33	770	11.03	1,382
1.50	799	12.60	1,445
1.67	825	14.18	1,503
1.84	850	15.75	1,557
2.00	873	17.33	1,607
4.50	1,210	18.90	1,654
124.50	1,210	50.40	2,294

20 ft depth



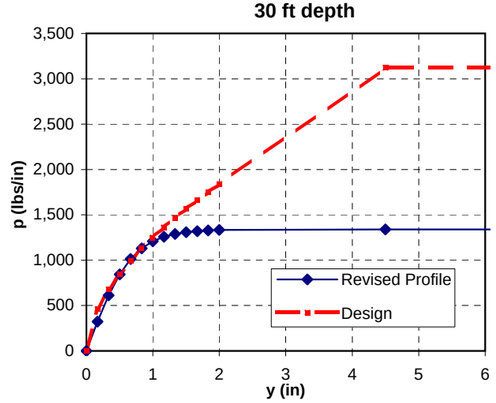
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	359	0.05	256
0.34	629	1.58	808
0.50	719	3.15	1,018
0.67	790	4.73	1,165
0.83	850	6.30	1,282
1.00	902	7.88	1,381
1.16	949	9.45	1,468
1.33	991	11.03	1,545
1.50	1,030	12.60	1,616
1.67	1,066	14.18	1,680
1.84	1,100	15.75	1,740
2.00	1,132	17.33	1,797
4.50	1,594	18.90	1,849
124.50	1,594	50.40	2,565

25 ft depth



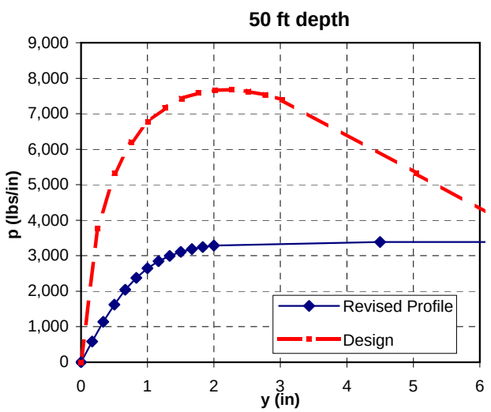
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	539	0.04	245
0.34	740	1.31	771
0.50	869	2.63	972
0.67	973	3.94	1,112
0.83	1,062	5.25	1,224
1.00	1,141	6.56	1,319
1.16	1,212	7.88	1,402
1.33	1,278	9.19	1,475
1.50	1,338	10.50	1,543
1.67	1,395	11.81	1,604
1.84	1,448	13.13	1,662
2.00	1,499	14.44	1,715
4.50	2,236	15.75	1,766
124.50	2,236	42.00	2,449

30 ft depth



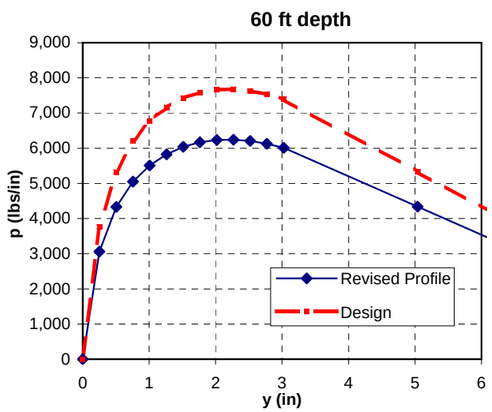
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	461	0.17	324
0.34	678	0.33	612
0.50	850	0.50	843
0.67	998	0.67	1,012
0.83	1,130	0.83	1,130
1.00	1,251	1.00	1,208
1.16	1,363	1.17	1,257
1.33	1,468	1.33	1,289
1.50	1,567	1.50	1,308
1.67	1,662	1.67	1,320
1.84	1,753	1.83	1,328
2.00	1,840	2.00	1,332
4.50	3,121	4.50	1,340
124.50	3,121	124.50	1,340

50 ft depth



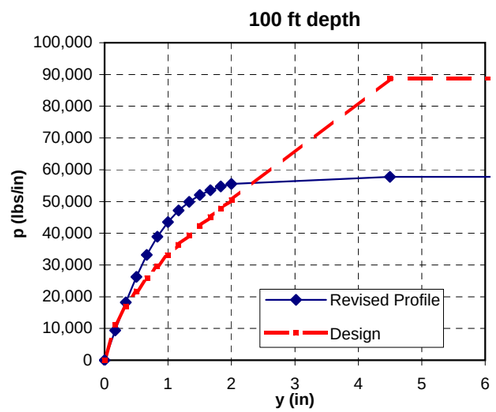
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	584
0.50	5,325	0.33	1,135
0.76	6,204	0.50	1,626
1.01	6,775	0.67	2,041
1.26	7,164	0.83	2,379
1.51	7,425	1.00	2,643
1.76	7,585	1.17	2,845
2.02	7,664	1.33	2,996
2.27	7,676	1.50	3,107
2.52	7,629	1.67	3,188
2.77	7,532	1.83	3,246
3.02	7,390	2.00	3,288
5.04	5,330	4.50	3,389
7.06	3,268	124.50	3,390

60 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.25	3,063
0.50	5,325	0.50	4,332
0.76	6,204	0.76	5,047
1.01	6,775	1.01	5,511
1.26	7,164	1.26	5,828
1.51	7,425	1.51	6,040
1.76	7,585	1.76	6,170
2.02	7,664	2.02	6,235
2.27	7,676	2.27	6,244
2.52	7,629	2.52	6,206
2.77	7,532	2.77	6,127
3.02	7,390	3.02	6,011
5.04	5,330	5.04	4,336
7.06	3,268	7.06	2,658

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	11,128	0.17	9,360
0.34	16,961	0.33	18,242
0.50	21,702	0.50	26,260
0.67	25,850	0.67	33,178
0.83	29,606	0.83	38,920
1.00	33,077	1.00	43,533
1.16	36,327	1.17	47,142
1.33	39,400	1.33	49,910
1.50	42,325	1.50	51,998
1.67	45,125	1.67	53,555
1.84	47,817	1.83	54,706
2.00	50,414	2.00	55,551
4.50	88,729	4.50	57,780
124.50	88,729	124.50	57,797

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

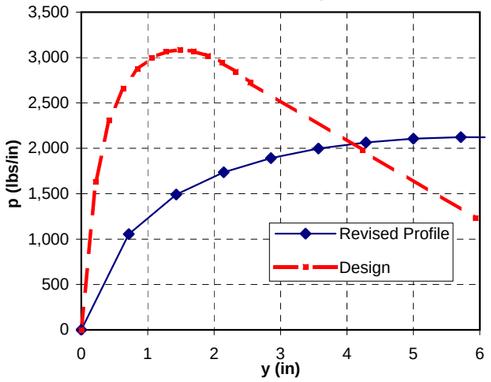
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 11

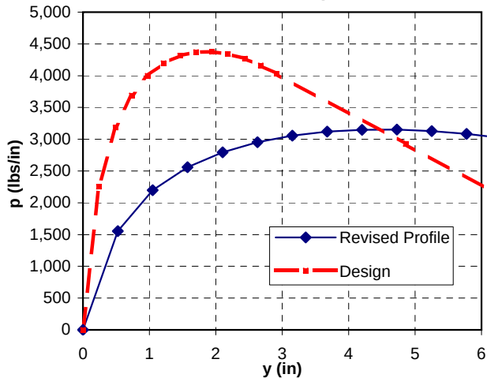
Figure 8

55 ft depth



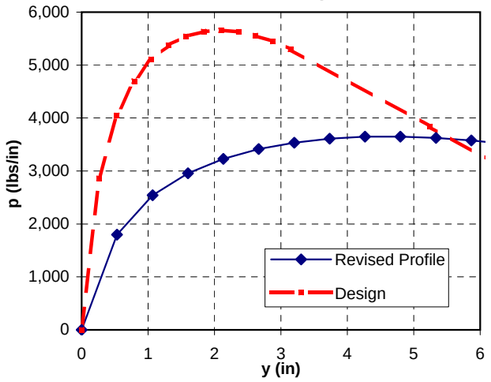
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	1,631	0.71	1,055
0.42	2,306	1.43	1,491
0.64	2,660	2.14	1,735
0.85	2,870	2.86	1,891
1.06	2,997	3.57	1,996
1.27	3,064	4.29	2,065
1.49	3,085	5.00	2,105
1.69	3,068	5.71	2,122
1.91	3,019	6.43	2,121
2.12	2,944	7.14	2,102
2.33	2,844	7.86	2,069
2.54	2,724	8.57	2,024
4.24	1,978	14.29	1,463
5.94	1,230	20.00	902

60 ft depth



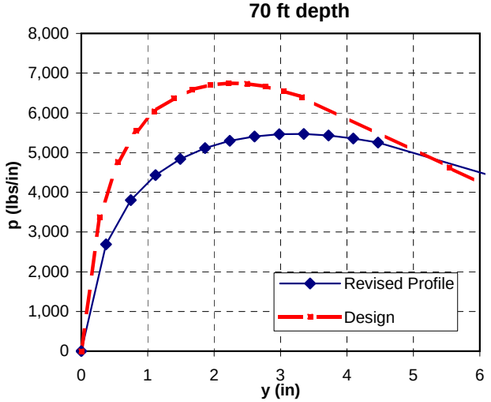
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.24	2,252	0.53	1,555
0.49	3,185	1.05	2,200
0.73	3,688	1.58	2,561
0.97	3,999	2.10	2,794
1.21	4,198	2.63	2,952
1.46	4,316	3.15	3,057
1.70	4,372	3.68	3,120
1.94	4,378	4.20	3,149
2.18	4,341	4.73	3,150
2.44	4,268	5.25	3,127
2.68	4,163	5.78	3,083
2.92	4,032	6.30	3,021
4.86	2,926	10.50	2,181
6.80	1,820	14.71	1,341

65 ft depth



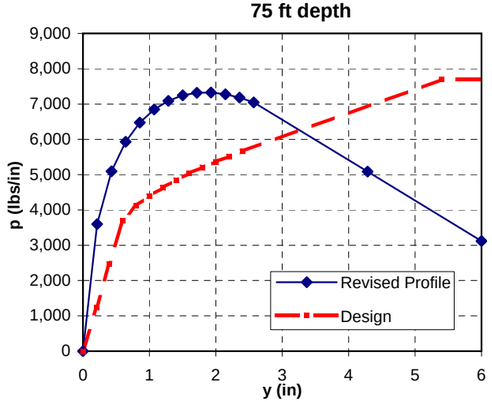
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.26	2,862	0.53	1,796
0.53	4,047	1.07	2,540
0.79	4,697	1.60	2,958
1.04	5,106	2.13	3,229
1.31	5,375	2.67	3,414
1.57	5,542	3.20	3,536
1.84	5,631	3.73	3,611
2.10	5,657	4.27	3,647
2.36	5,630	4.80	3,651
2.62	5,558	5.33	3,627
2.88	5,445	5.87	3,578
3.14	5,300	6.40	3,510
5.24	3,841	10.67	2,532
7.34	2,382	14.93	1,554

70 ft depth



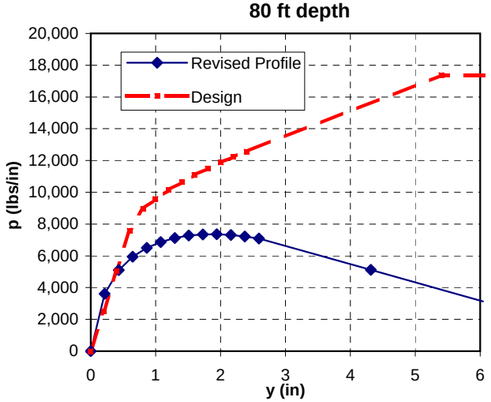
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.28	3,375	0.37	2,691
0.55	4,773	0.74	3,805
0.83	5,547	1.12	4,432
1.10	6,041	1.49	4,837
1.39	6,371	1.86	5,113
1.67	6,583	2.23	5,296
1.94	6,703	2.61	5,408
2.22	6,750	2.98	5,461
2.50	6,735	3.35	5,466
2.77	6,667	3.72	5,429
3.05	6,553	4.10	5,356
3.32	6,400	4.47	5,251
5.54	4,631	7.45	3,790
7.76	2,861	10.43	2,327

75 ft depth



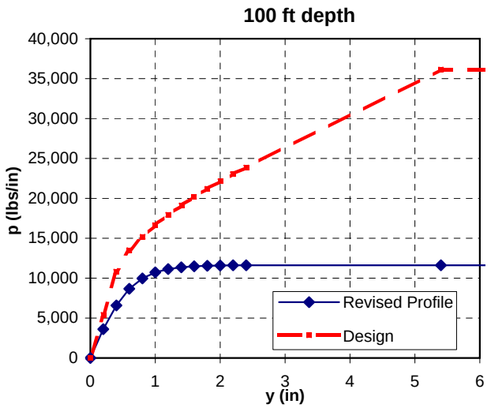
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	1,234	0.21	3,600
0.40	2,467	0.43	5,092
0.60	3,701	0.64	5,931
0.80	4,120	0.86	6,475
1.00	4,395	1.07	6,846
1.20	4,632	1.29	7,093
1.40	4,843	1.50	7,244
1.60	5,033	1.71	7,317
1.80	5,208	1.93	7,326
2.00	5,368	2.14	7,279
2.20	5,518	2.36	7,183
2.40	5,659	2.57	7,044
5.40	7,701	4.29	5,083
149.40	7,701	6.00	3,119

80 ft depth



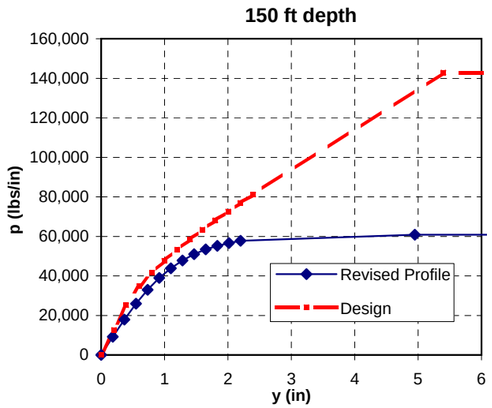
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	2,530	0.22	3,613
0.40	5,059	0.43	5,110
0.60	7,589	0.65	5,953
0.80	8,955	0.86	6,500
1.00	9,591	1.08	6,874
1.20	10,144	1.29	7,123
1.40	10,637	1.51	7,277
1.60	11,083	1.73	7,353
1.80	11,491	1.94	7,364
2.00	11,870	2.16	7,319
2.20	12,223	2.37	7,225
2.40	12,555	2.59	7,088
5.40	17,381	4.32	5,113
149.40	17,381	6.04	3,135

100 ft depth



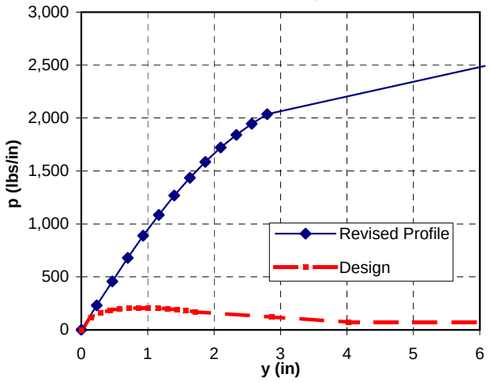
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	5,410	0.20	3,604
0.40	10,819	0.40	6,576
0.60	13,502	0.60	8,661
0.80	15,196	0.80	9,964
1.00	16,655	1.00	10,720
1.20	17,951	1.20	11,140
1.40	19,125	1.40	11,368
1.60	20,203	1.60	11,490
1.80	21,205	1.80	11,554
2.00	22,143	2.00	11,588
2.20	23,028	2.20	11,607
2.40	23,866	2.40	11,616
5.40	36,124	5.40	11,627
149.40	36,124	149.40	11,627

150 ft depth



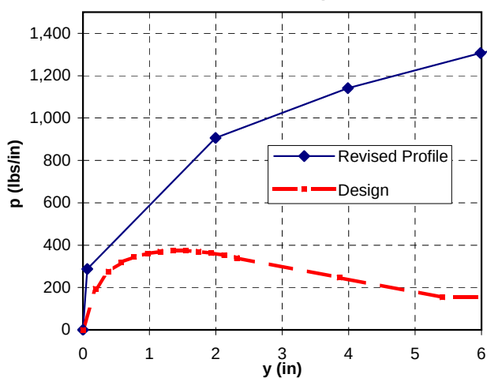
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	12,610	0.18	9,154
0.40	25,219	0.37	17,902
0.60	34,932	0.55	25,909
0.80	41,608	0.73	32,951
1.00	47,654	0.92	38,933
1.20	53,241	1.10	43,863
1.40	58,472	1.28	47,829
1.60	63,417	1.47	50,956
1.80	68,125	1.65	53,382
2.00	72,632	1.83	55,243
2.20	76,965	2.02	56,657
2.40	81,146	2.20	57,723
5.40	142,818	4.95	60,806
149.40	142,818	136.95	60,840

5 ft depth



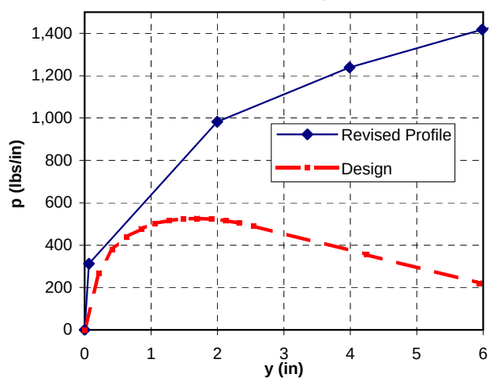
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	231
0.29	162	0.47	459
0.43	186	0.70	679
0.58	199	0.93	889
0.72	206	1.17	1,086
0.86	209	1.40	1,269
1.01	208	1.63	1,436
1.15	204	1.87	1,586
1.30	198	2.10	1,721
1.44	190	2.33	1,841
1.57	180	2.57	1,946
1.72	169	2.80	2,037
2.87	122	6.30	2,522
4.02	74	174.30	2,560
100.00	74	342.30	2,560

10 ft depth



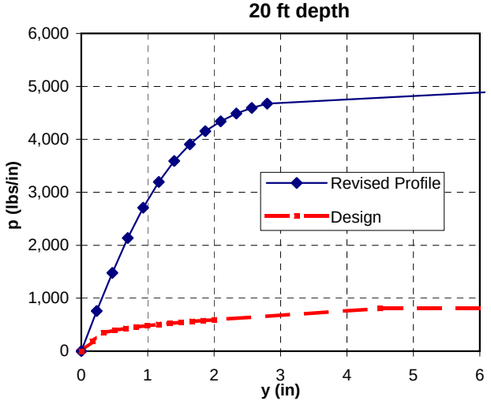
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.06	288
0.38	275	2.00	906
0.58	318	3.99	1,142
0.77	344	5.99	1,307
0.97	361	7.98	1,438
1.16	370	9.98	1,549
1.36	374	11.97	1,646
1.55	374	13.97	1,733
1.74	370	15.96	1,812
1.93	363	17.96	1,885
2.12	353	19.95	1,952
2.32	340	21.95	2,015
3.86	247	23.94	2,074
5.41	154	63.84	2,877
100.00	154	119.70	2,877

15 ft depth



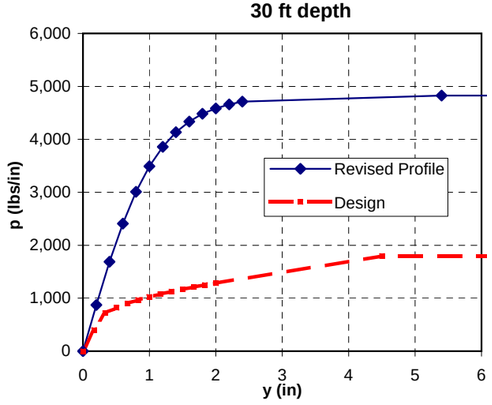
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	312
0.42	379	2.00	983
0.64	439	3.99	1,239
0.85	477	5.99	1,418
1.06	502	7.98	1,560
1.27	517	9.98	1,681
1.49	524	11.97	1,786
1.69	526	13.97	1,880
1.91	523	15.96	1,966
2.12	515	17.96	2,045
2.33	504	19.95	2,118
2.54	490	21.95	2,186
4.25	355	23.94	2,251
5.94	221	63.84	3,121
100.00	221	119.70	3,121

20 ft depth



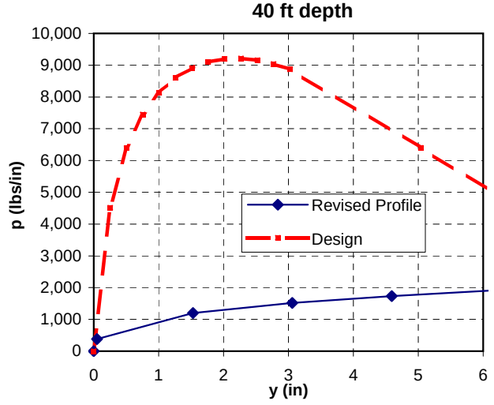
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	186	0.23	757
0.34	350	0.47	1,479
0.50	395	0.70	2,136
0.67	429	0.93	2,711
0.83	458	1.17	3,195
1.00	483	1.40	3,591
1.16	505	1.63	3,907
1.33	526	1.87	4,153
1.50	544	2.10	4,342
1.67	561	2.33	4,486
1.84	577	2.57	4,594
2.00	592	2.80	4,675
4.50	808	6.30	4,902
124.50	808	174.30	4,904

30 ft depth



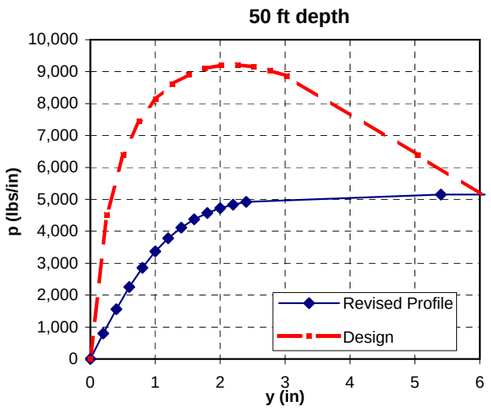
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	402	0.20	872
0.34	722	0.40	1,690
0.50	822	0.60	2,410
0.67	902	0.80	3,011
0.83	969	1.00	3,490
1.00	1,027	1.20	3,859
1.16	1,080	1.40	4,134
1.33	1,127	1.60	4,336
1.50	1,171	1.80	4,481
1.67	1,211	2.00	4,585
1.84	1,249	2.20	4,658
2.00	1,284	2.40	4,710
4.50	1,800	5.40	4,829
124.50	1,800	149.40	4,829

40 ft depth



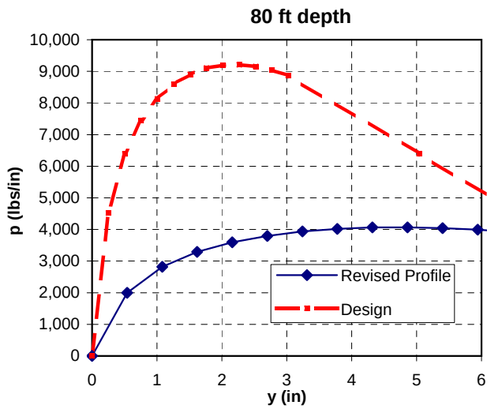
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.05	382
0.50	6,390	1.53	1,203
0.76	7,445	3.06	1,516
1.01	8,129	4.59	1,735
1.26	8,597	6.12	1,910
1.51	8,910	7.65	2,057
1.76	9,102	9.18	2,186
2.02	9,197	10.71	2,301
2.27	9,211	12.24	2,406
2.52	9,155	13.77	2,502
2.77	9,038	15.30	2,592
3.02	8,868	16.83	2,675
5.04	6,396	18.36	2,754
7.06	3,922	48.96	3,819

50 ft depth



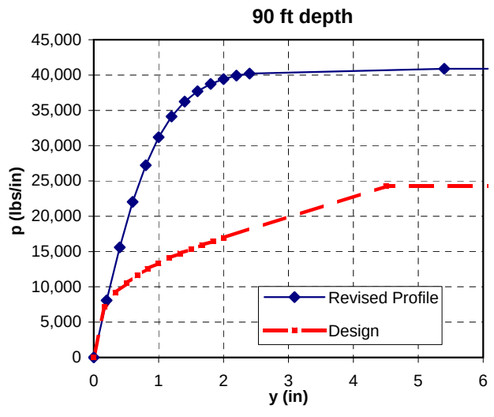
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	798
0.50	6,390	0.40	1,559
0.76	7,445	0.60	2,252
1.01	8,129	0.80	2,857
1.26	8,597	1.00	3,367
1.51	8,910	1.20	3,782
1.76	9,102	1.40	4,113
2.02	9,197	1.60	4,371
2.27	9,211	1.80	4,569
2.52	9,155	2.00	4,720
2.77	9,038	2.20	4,833
3.02	8,868	2.40	4,917
5.04	6,396	5.40	5,152
7.06	3,922	149.40	5,154

80 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.54	1,996
0.50	6,390	1.08	2,822
0.76	7,445	1.62	3,288
1.01	8,129	2.16	3,590
1.26	8,597	2.70	3,797
1.51	8,910	3.24	3,935
1.76	9,102	3.78	4,020
2.02	9,197	4.32	4,062
2.27	9,211	4.86	4,068
2.52	9,155	5.40	4,044
2.77	9,038	5.94	3,992
3.02	8,868	6.48	3,917
5.04	6,396	10.80	2,825
7.06	3,922	15.12	1,732

90 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	7,207	0.20	8,099
0.34	9,150	0.40	15,587
0.50	10,522	0.60	22,023
0.67	11,618	0.80	27,217
0.83	12,546	1.00	31,200
1.00	13,360	1.20	34,137
1.16	14,088	1.40	36,240
1.33	14,751	1.60	37,715
1.50	15,362	1.80	38,734
1.67	15,930	2.00	39,430
1.84	16,462	2.20	39,903
2.00	16,963	2.40	40,223
4.50	24,267	5.40	40,876
124.50	24,267	149.40	40,878

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

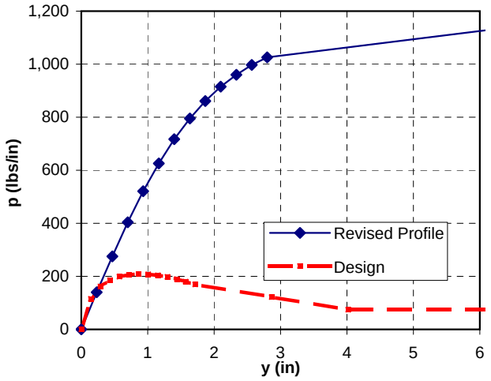
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 18

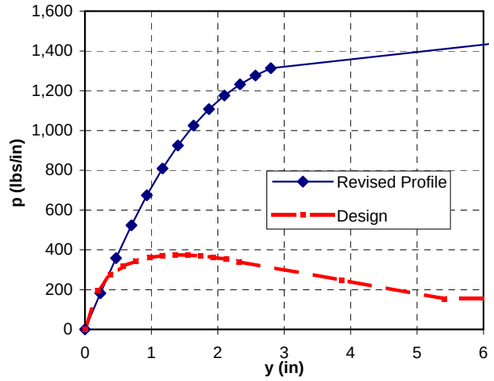
Figure 10

5 ft depth



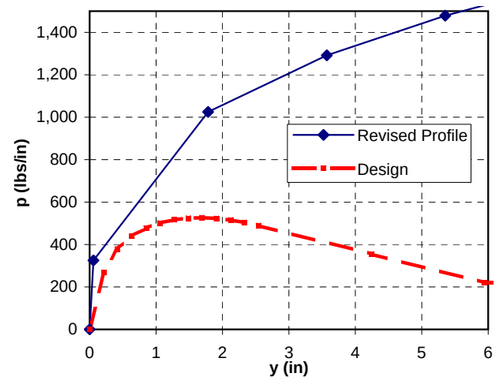
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	140
0.29	162	0.47	276
0.43	186	0.70	404
0.58	199	0.93	521
0.72	206	1.17	625
0.86	209	1.40	717
1.01	208	1.63	795
1.15	204	1.87	861
1.30	198	2.10	916
1.44	190	2.33	960
1.57	180	2.57	997
1.72	169	2.80	1,026
2.87	122	6.30	1,134
4.02	74	174.30	1,137
100.00	74	342.30	1,137

10 ft depth



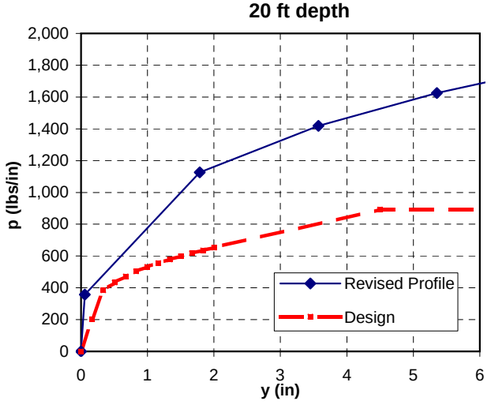
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.23	182
0.38	275	0.47	358
0.58	318	0.70	523
0.77	344	0.93	674
0.97	361	1.17	808
1.16	370	1.40	925
1.36	374	1.63	1,024
1.55	374	1.87	1,107
1.74	370	2.10	1,176
1.93	363	2.33	1,232
2.12	353	2.57	1,277
2.32	340	2.80	1,313
3.86	247	6.30	1,443
5.41	154	174.30	1,446
100.00	154	342.30	1,446

15 ft depth



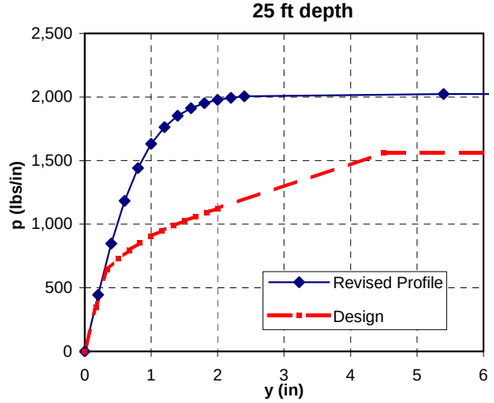
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	325
0.42	379	1.79	1,025
0.64	439	3.57	1,291
0.85	477	5.36	1,478
1.06	502	7.14	1,627
1.27	517	8.93	1,753
1.49	524	10.71	1,862
1.69	526	12.50	1,961
1.91	523	14.28	2,050
2.12	515	16.07	2,132
2.33	504	17.85	2,208
2.54	490	19.64	2,279
4.25	355	21.42	2,347
5.94	221	57.12	3,254
100.00	221	107.10	3,254

20 ft depth



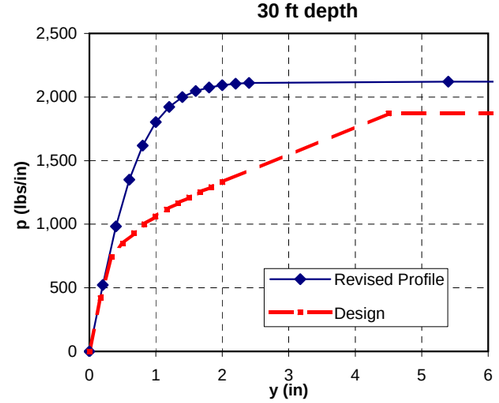
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	204	0.06	358
0.34	385	1.79	1,127
0.50	434	3.57	1,419
0.67	472	5.36	1,625
0.83	504	7.14	1,788
1.00	532	8.93	1,926
1.16	557	10.71	2,047
1.33	579	12.50	2,155
1.50	599	14.28	2,253
1.67	618	16.07	2,343
1.84	636	17.85	2,427
2.00	652	19.64	2,505
4.50	892	21.42	2,579
124.50	892	57.12	3,577

25 ft depth



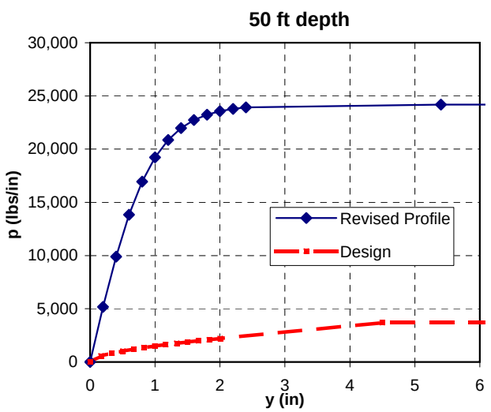
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	348	0.20	444
0.34	642	0.40	848
0.50	729	0.60	1,183
0.67	797	0.80	1,443
0.83	855	1.00	1,631
1.00	905	1.20	1,764
1.16	949	1.40	1,853
1.33	990	1.60	1,913
1.50	1,027	1.80	1,952
1.67	1,061	2.00	1,978
1.84	1,093	2.20	1,994
2.00	1,123	2.40	2,005
4.50	1,561	5.40	2,024
124.50	1,561	149.40	2,024

30 ft depth



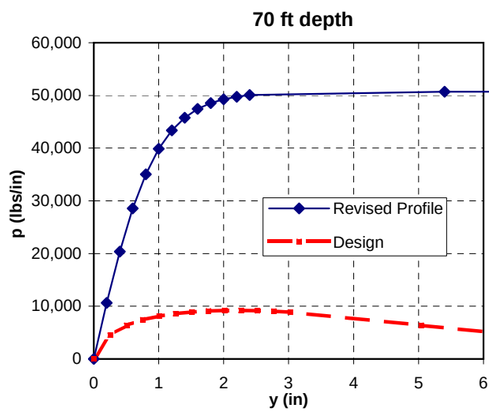
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	420	0.20	521
0.34	743	0.40	983
0.50	848	0.60	1,351
0.67	931	0.80	1,619
0.83	1,001	1.00	1,802
1.00	1,062	1.20	1,922
1.16	1,116	1.40	1,999
1.33	1,166	1.60	2,046
1.50	1,211	1.80	2,076
1.67	1,254	2.00	2,094
1.84	1,293	2.20	2,105
2.00	1,330	2.40	2,111
4.50	1,871	5.40	2,122
124.50	1,871	149.40	2,122

50 ft depth



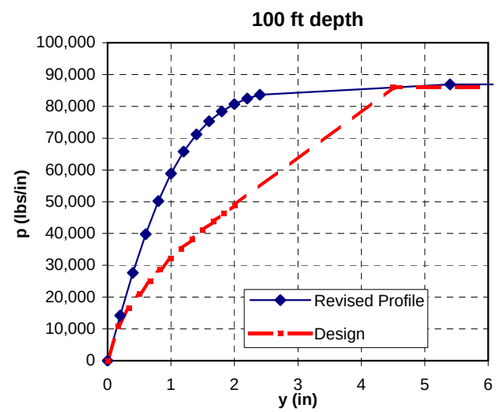
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	565	0.20	5,169
0.34	826	0.40	9,886
0.50	1,030	0.60	13,846
0.67	1,205	0.80	16,941
0.83	1,361	1.00	19,231
1.00	1,504	1.20	20,855
1.16	1,636	1.40	21,973
1.33	1,760	1.60	22,728
1.50	1,877	1.80	23,230
1.67	1,988	2.00	23,561
1.84	2,094	2.20	23,778
2.00	2,196	2.40	23,920
4.50	3,694	5.40	24,182
124.50	3,694	149.40	24,182

70 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	10,619
0.50	6,390	0.40	20,345
0.76	7,445	0.60	28,563
1.01	8,129	0.80	35,046
1.26	8,597	1.00	39,889
1.51	8,910	1.20	43,362
1.76	9,102	1.40	45,780
2.02	9,197	1.60	47,429
2.27	9,211	1.80	48,537
2.52	9,155	2.00	49,275
2.77	9,038	2.20	49,764
3.02	8,868	2.40	50,086
5.04	6,396	5.40	50,698
7.06	3,922	149.40	50,699

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	10,788	0.20	14,188
0.34	16,443	0.40	27,639
0.50	21,040	0.60	39,764
0.67	25,061	0.80	50,205
0.83	28,702	1.00	58,848
1.00	32,067	1.20	65,771
1.16	35,218	1.40	71,173
1.33	38,197	1.60	75,301
1.50	41,032	1.80	78,408
1.67	43,747	2.00	80,717
1.84	46,357	2.20	82,418
2.00	48,875	2.40	83,664
4.50	86,020	5.40	86,920
124.50	86,020	149.40	86,943

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

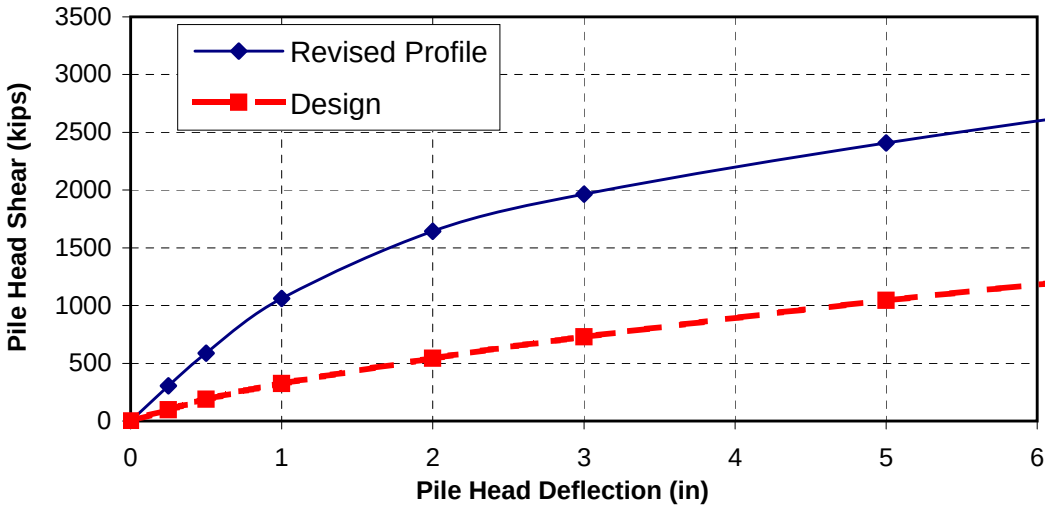
ACTA Schuyler Heim Bridge (Replace)

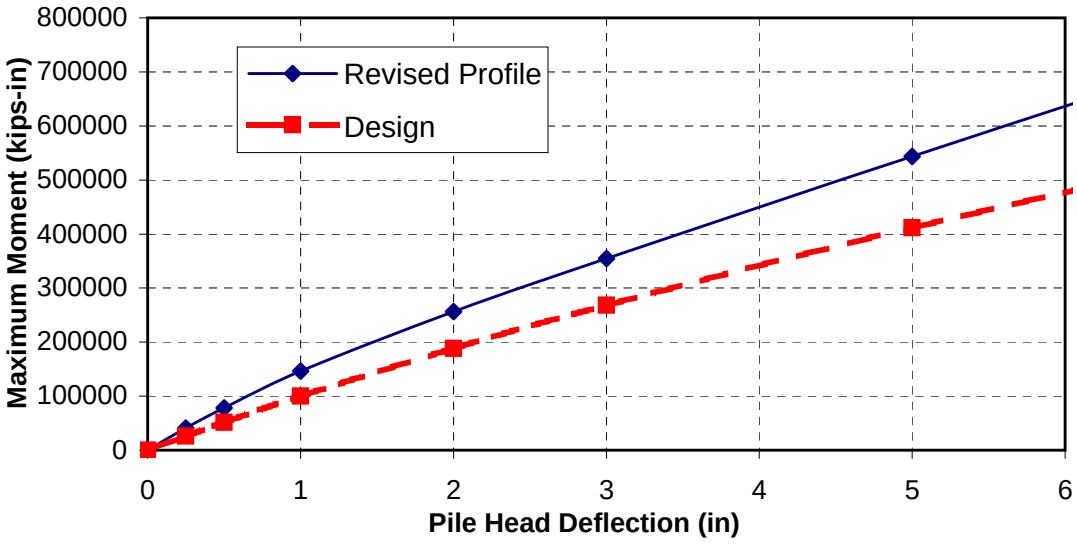
Project Number: 06-123

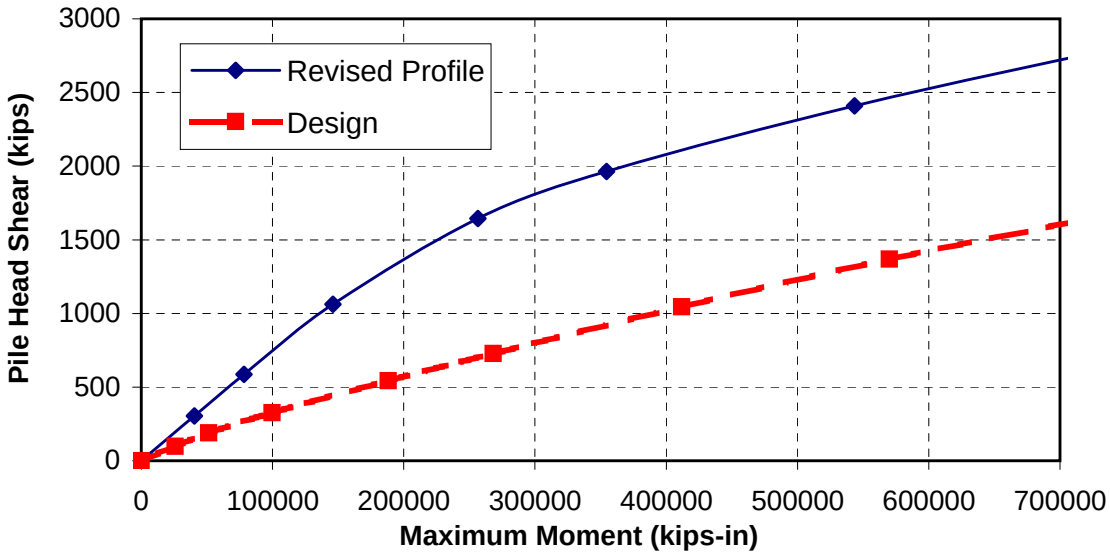
Date: 1/20/2010

p-y Curve Comparison for Bent 24

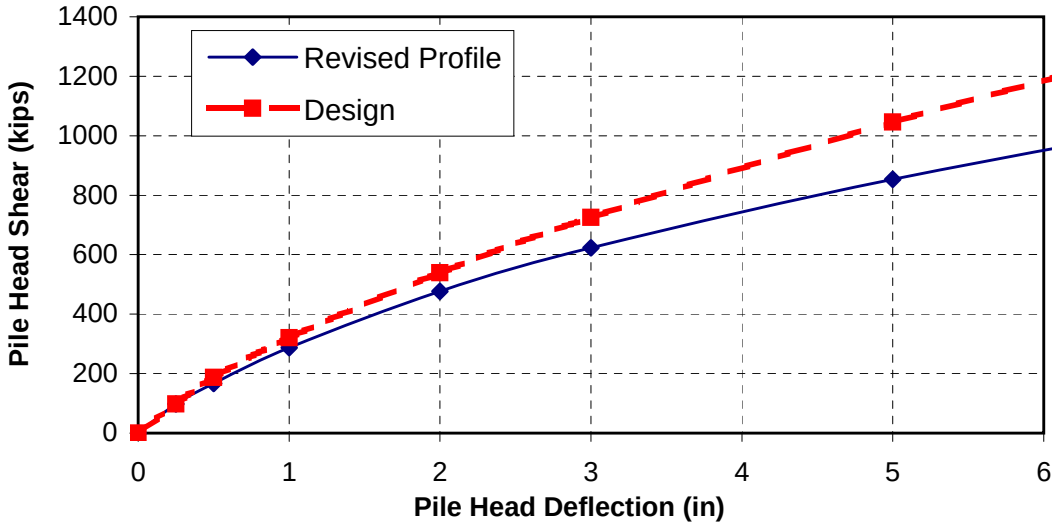
Figure 11

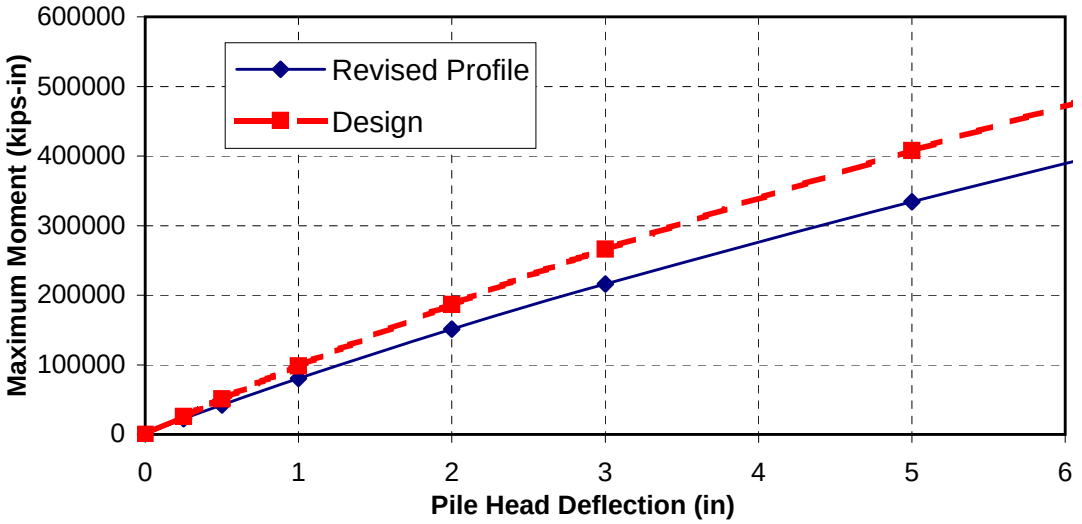


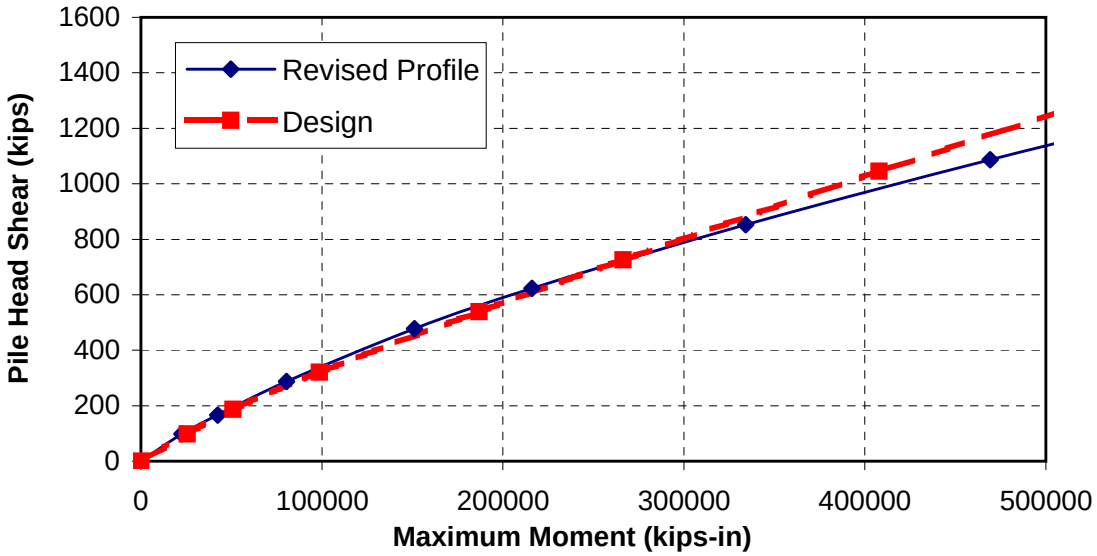




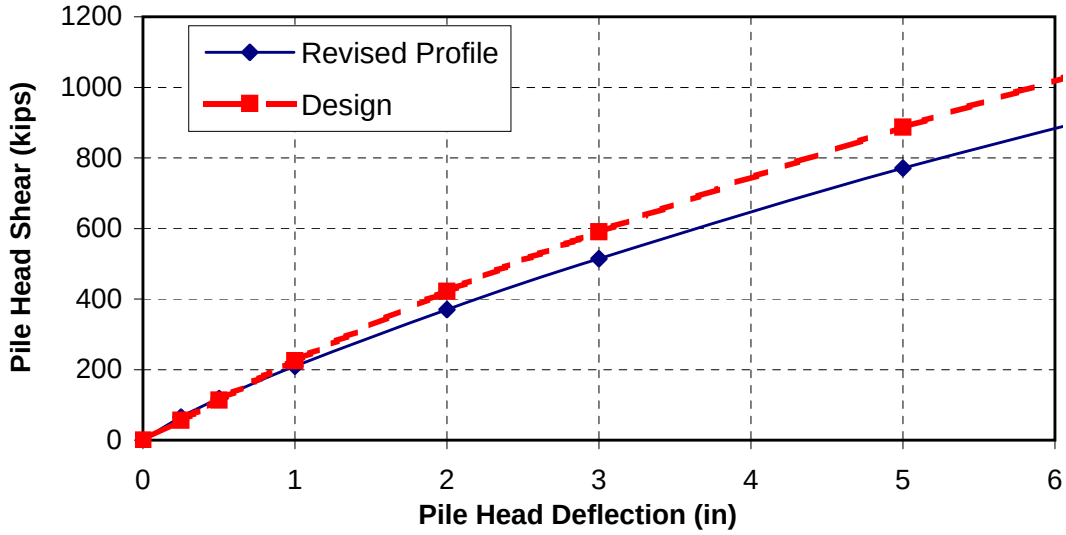
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 2 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 12

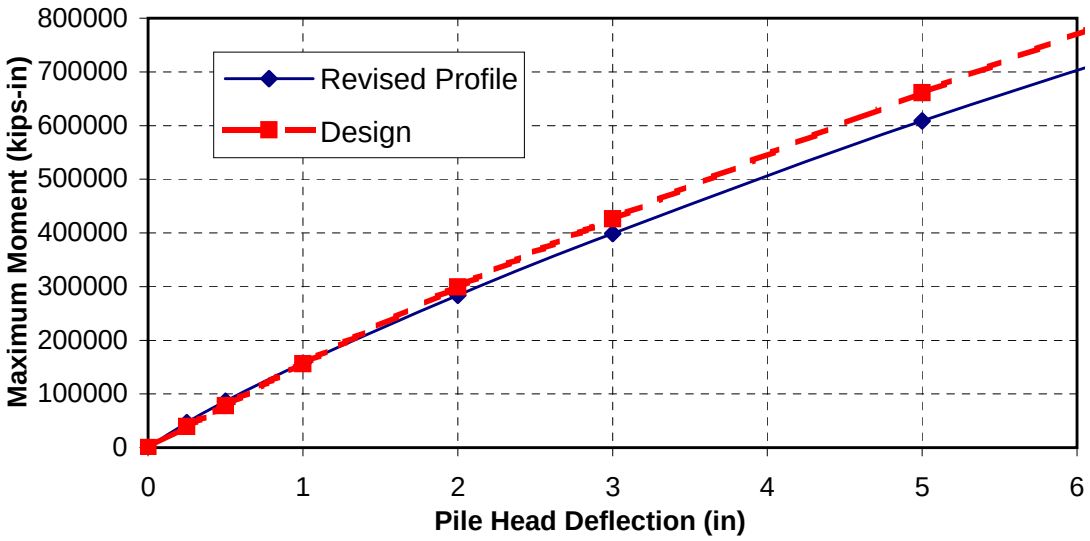


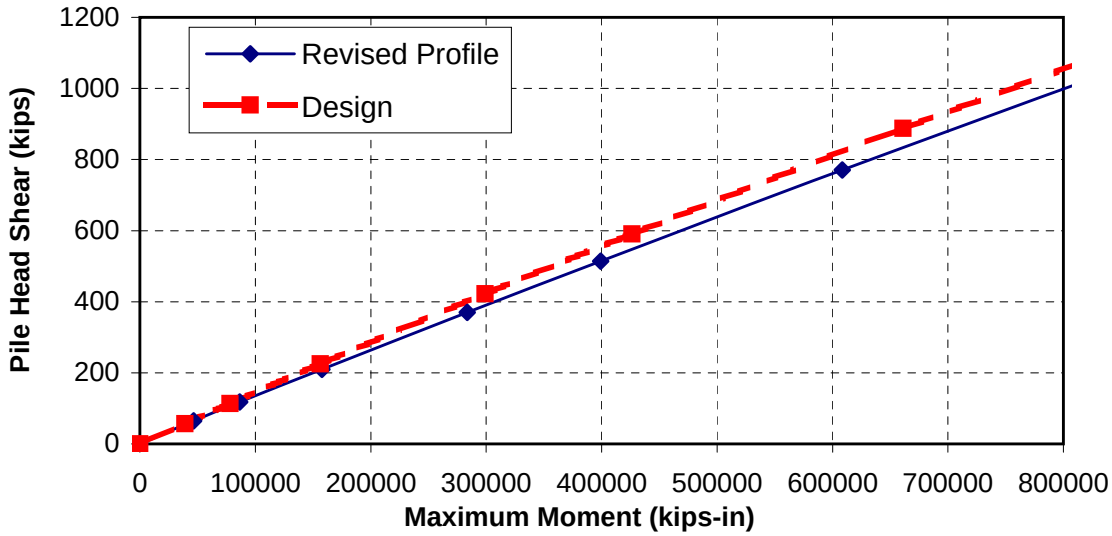




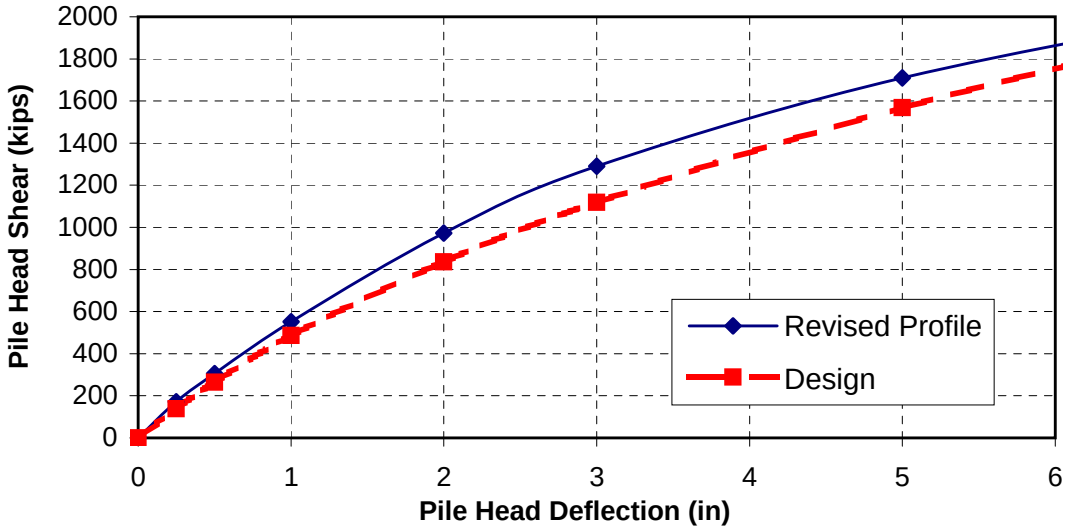
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 13

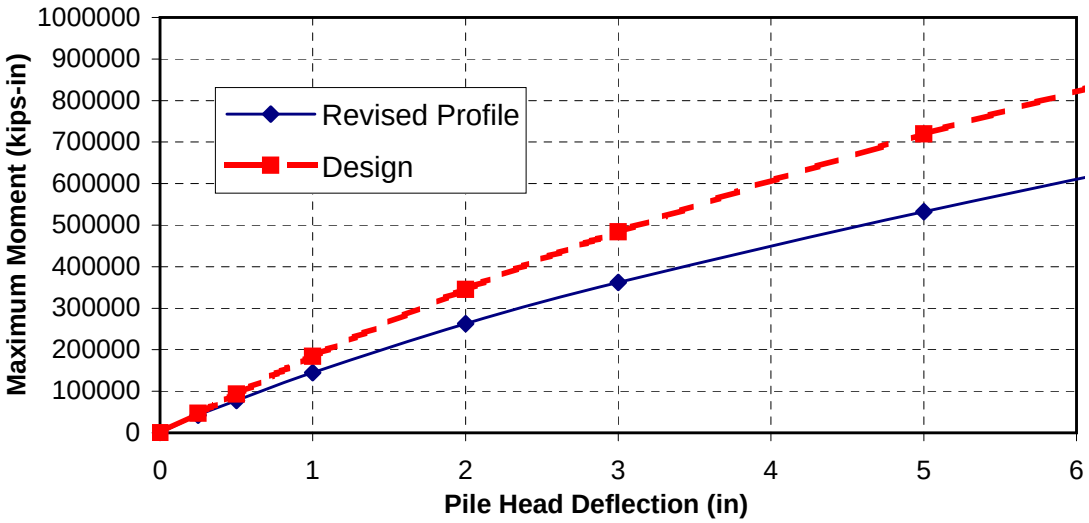


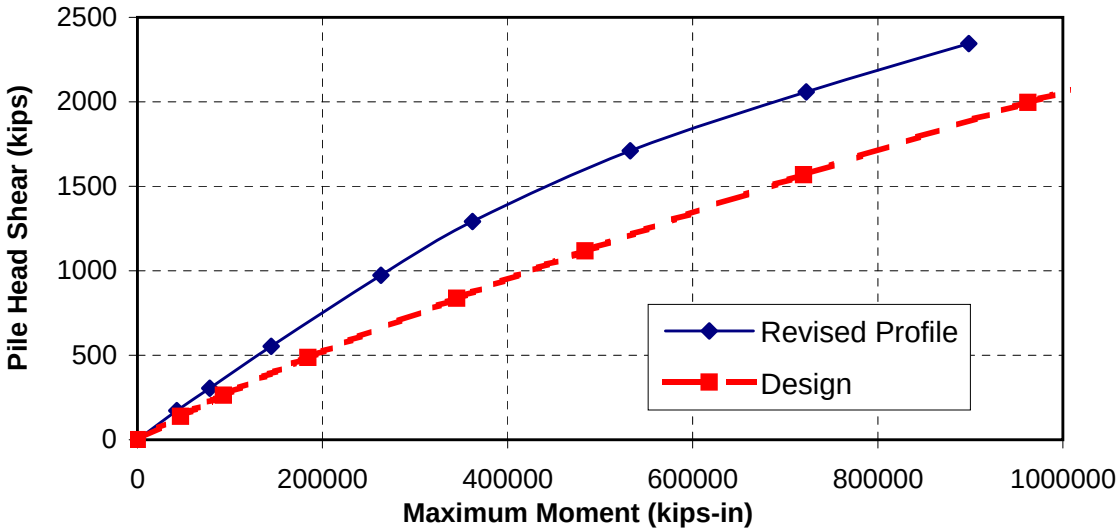




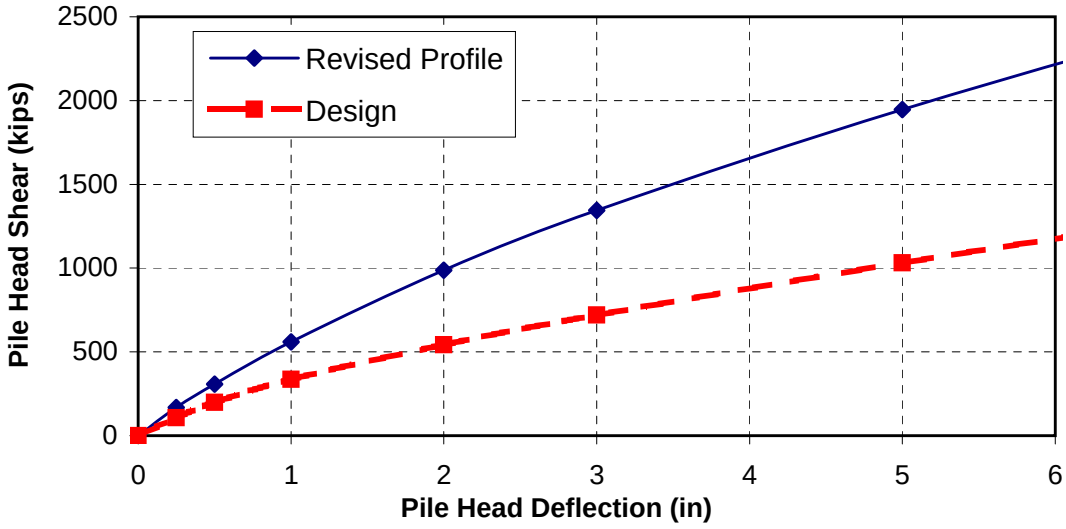
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Pile Head Shear and Max Moment versus Deflection Figure 14
	Project Number: 06-123	Date: 1/20/2010	

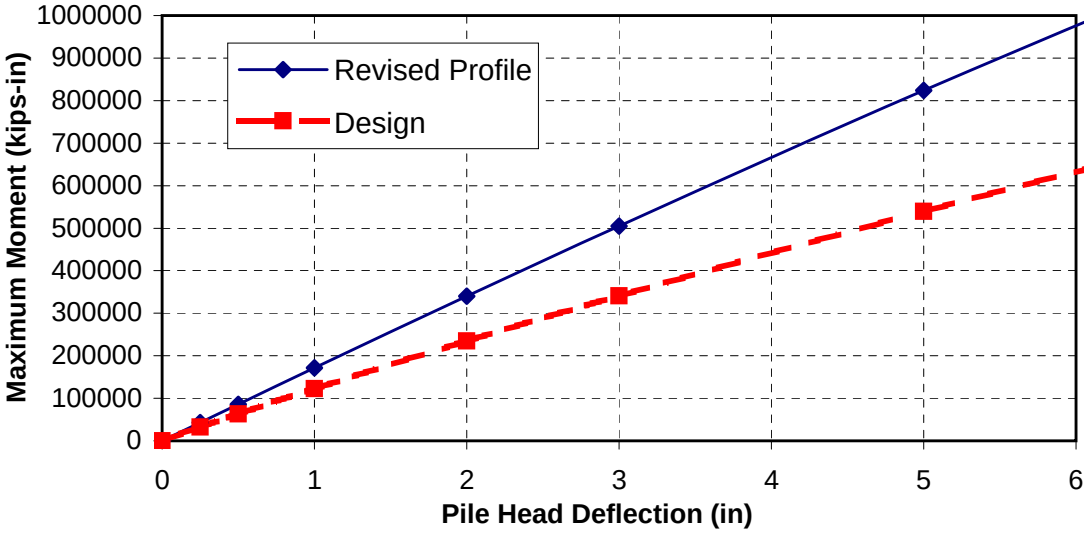


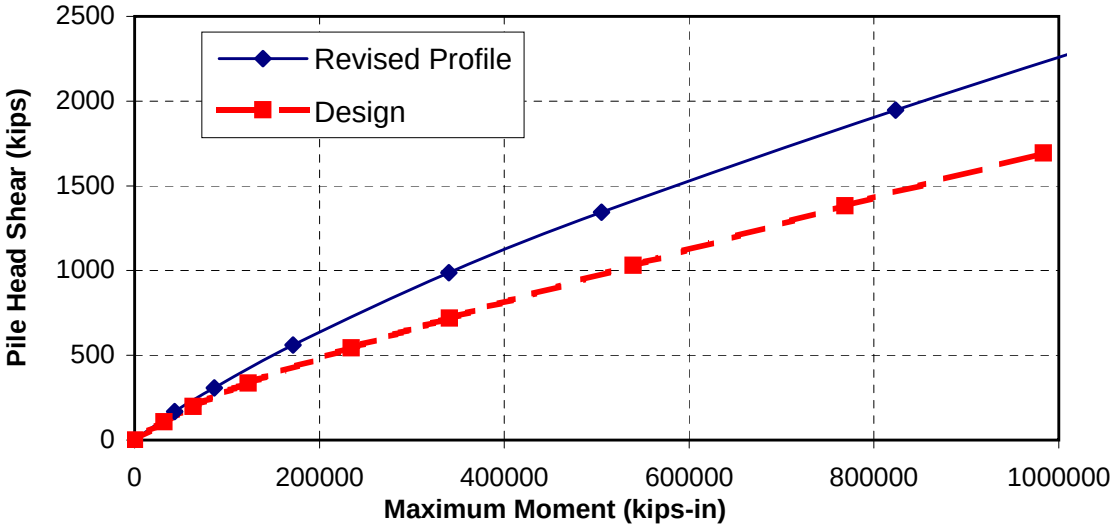




Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 15







Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 24 Pile Head Shear and Max Moment versus Deflection Figure 16
	Project Number: 06-123	Date: 1/20/2010	

Appendix H. Design p-y Curves for Bent Lateral Pile Analysis

Table H-1. NB SR 103 Off-Ramp Bent 25 and Bent 26
p-y Curves for 10' Diameter CIDH Piles

3 ft depth		10 ft depth		17 ft depth		25 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	150	0.05	194	0.01	402	0.17	115	0.17	145
0.33	300	1.50	610	0.38	1,267	0.33	230	0.33	290
0.50	450	3.00	769	0.75	1,597	0.50	346	0.50	436
0.67	600	4.50	880	1.13	1,828	0.67	461	0.67	581
0.83	640	6.00	969	1.50	2,012	0.83	576	0.83	726
1.00	672	7.50	1,044	1.88	2,167	1.00	691	1.00	871
1.17	701	9.00	1,109	2.25	2,303	1.17	798	1.17	941
1.33	727	10.50	1,168	2.63	2,424	1.33	833	1.33	984
1.50	751	12.00	1,221	3.00	2,535	1.50	865	1.50	1,025
1.67	773	13.50	1,270	3.38	2,636	1.67	895	1.67	1,062
1.83	793	15.00	1,315	3.75	2,730	1.83	923	1.83	1,097
2.00	812	16.50	1,357	4.13	2,818	2.00	950	2.00	1,130
4.50	1,089	18.00	1,397	4.50	2,901	4.50	1,335	4.50	1,612
124.50	1,089	48.00	1,938	12.00	4,023	124.50	1,335	124.50	1,612
244.50	1,089	90.00	1,938	22.50	4,023	244.50	1,335	244.50	1,612
364.50	1,089	120.00	1,938	30.00	4,023	364.50	1,335	364.50	1,612

40 ft depth		55 ft depth		70 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	205	0.17	579	0.17	7,172	0.17	16,746	0.17	33,477
0.33	410	0.33	861	0.33	10,932	0.33	25,523	0.33	63,412
0.50	616	0.50	1,085	0.50	13,988	0.50	32,659	0.50	81,140
0.67	821	0.67	1,280	0.67	16,661	0.67	38,901	0.67	96,650
0.83	967	0.83	1,454	0.83	19,082	0.83	44,554	0.83	110,693
1.00	1,050	1.00	1,614	1.00	21,319	1.00	49,777	1.00	123,670
1.17	1,126	1.17	1,763	1.17	23,414	1.17	54,668	1.17	135,821
1.33	1,196	1.33	1,903	1.33	25,394	1.33	59,291	1.33	147,308
1.50	1,261	1.50	2,035	1.50	27,279	1.50	63,693	1.50	158,244
1.67	1,323	1.67	2,162	1.67	29,084	1.67	67,907	1.67	168,712
1.83	1,381	1.83	2,283	1.83	30,819	1.83	71,958	1.83	178,778
2.00	1,436	2.00	2,399	2.00	32,494	2.00	75,867	2.00	188,490
4.50	2,248	4.50	4,116	4.50	57,189	4.50	133,527	4.50	331,743
124.50	2,248	124.50	4,116	124.50	57,189	124.50	133,527	124.50	331,743
244.50	2,248	244.50	4,116	244.50	57,189	244.50	133,527	244.50	331,743
364.50	2,248	364.50	4,116	364.50	57,189	364.50	133,527	364.50	331,743

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

Appendix I. Caltrans Review Comments and EMI Response

Subject: Review Comments for Foundation Reports for BR53-3031, BR53-3033, BR53-3034K, BR53-3035S.
From: Haitao Liu <haitao_liu@dot.ca.gov>
Date: Tue, 23 Mar 2010 17:17:30 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Hector Bedolla <hector_bedolla@dot.ca.gov>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>, Hamid R Toossi <hamid_r_toossi@dot.ca.gov>, Foued Zayati <foued_zayati@dot.ca.gov>, Bojan Misic <bojan_misic@dot.ca.gov>, Ranjan Gunaranjan <ranjan@earthmech.com>, Eric Brown <e.brown@earthmech.com>, Seungwoon Han <seungwoon_han@dot.ca.gov>

Dear Arul,

Below are our review comments for the subject bridges:

New Dock Street Off-Ramp, Bridge No. 53-3031:

1) Table 5 (Page 28 of Foundation Report).
Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings

2) Section 5.6.1 (Page 34 of the Report).
Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.

3) Section 5.6.2 (Page 34 of the Report).
Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.

4) Log of Test Borings.
I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.

5) Appendix E.Lab Test Results
Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.

6) Axial Capacity (Calculation Volume)
Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.

7) Axial Capacity for Abut 3 (Calculation Volume)
Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.

8) Axial Capacity for Abut 3 (Calculation Volume)
The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.

9) Axial Capacity for all bents (Calculation Volume)
According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.

10) Axial Capacity for Bent 4 (Calculation Volume)
For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.

11) Axial Capacity for Bent 5 (Calculation Volume)
For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.

12) Lateral Pile Capacity for Abut 3 (Calculation Volume)
Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.

13) Static Settlement
Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.

14) Static Settlement
The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.

SR 103 Off-Ramp, Bridge No. 53-3034K:

All applicable review comments from New Dock Street Off-Ramp, plus:

1) Axial Pile Capacity for Abutment 27 (Calculation Volume)
Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.

2) Axial Pile Capacity (Calculation Volume)
The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with

blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.

New Dock Street On-Ramp, Bridge No. 53-3033 and SR 103 On-Ramp, Bridge No. 53-3035S

All applicable review comments from BR 53-3031 and BR 3034K.

Should you have any question, please contact me or Mr. Seungwoon Han at (916) 227-4533.

Thank you.

Haitao Liu, P.E.

Transportation Engineer - Civil
Office of Geotechnical Design South - 1
Division of Engineering Services
Department of Transportation, California

5900 Folsom Blvd.
Sacramento, CA 95819
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Cell phone: (916) 704-6519

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New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			1) Table 5 (Page 28 of Foundation Report). Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA)	A	Will comply. Supplemental laboratory tests performed on the sample indicate a Plasticity Index (PI) of 12; therefore, based upon the Boulanger and Idriss (2006) criteria, this layer is determined to be non-liquefiable. Lab test results are attached.	4/20/2010	
2			2) Section 5.6.1 (Page 34 of the Report). Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.	PW / EB / KA	A	Will comply. Tthe recommendations for seismic lateral earth pressure on nonyielding bridge abutments have been revised to be consistent with the recommendations shown in Section A11.1.1.3 of AASHTO LRFD BDS.	4/20/2010	
3			3) Section 5.6.2 (Page 34 of the Report). Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.	PW / EB / KA	A	Will comply. We agree that the recommended edit will be more clear for the reader and the text has been revised per your suggestion.	4/20/2010	
4			4) Log of Test Borings. I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.	PW / EB / KA	A / C	I. Will comply. LOTB's have been revised to only show SPT blowcounts (attached). II. Silty Clay is listed as a soil-type descriptor in Figure 3-3 (page 42) of the Caltrans SRLPCM for material with a PI between 4 and 7. All of the instances where a material is described as Silty Clay on the LOTBs, plasticity test results indicate a PI between 4 and 7.	4/20/2010	
5			5) Appendix E.Lab Test Results Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			6) Axial Capacity (Calculation Volume) Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.	PW / EB / KA	A	Will comply. All six borings/CPTs were used to generate the idealized soil profile used in the pile analysis. We agree that the downdrag elevation for determining the seismic-controlled (extreme event) design pile tip elevation should be based on the nearest soil boring or CPT sounding. Different bottom of liquefiable layer elevations were used at each support. As shown in the calculation volume, the elevation to the bottom of the liquefiable layer was based on R-09-010 for abutment 3 and bent 4, CPT-09-064 for bent 5, R-09-012 for bent 6, R-09-013 for bent 7, and R-09-015 for bent 8. This appears to comply with your comment.	4/20/2010	
7			7) Axial Capacity for Abut 3 (Calculation Volume) Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.	PW / EB / KA	A	Will comply. Per our discussions with the designer, 1 pile will be added at this abutment. We have revised our axial pile capacity calculations to include an average pile group reduction factor of 0.93 at Abutment 3. The evaluation of the group reduction factor and revised axial pile capacity calculations for Abutment 3 are attached.	4/20/2010	
8			8) Axial Capacity for Abut 3 (Calculation Volume) The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.	PW / EB / KA	A	Will comply. Revised axial pile capacity calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
9			9) Axial Capacity for all bents (Calculation Volume) According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.	PW / EB / KA	D	As a result of design development and discussions with the designers, the CMP permanent casing has been replaced with driven permanent steel casing. The driving resistance of the permanent steel casing will be specified in the Pile Data Table; therefore, the skin friction along the length of the permanent casing (based upon API methodology) has been included in the design. The axial pile capacity calculations for the controlling limit case (Strength Limit State) for the bents have been revised. A sample revised calcuation for Bent 4 and the revised pile data table are attached.	4/20/2010	
10			10) Axial Capacity for Bent 4 (Calculation Volume) For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
11			11) Axial Capacity for Bent 5 (Calculation Volume) For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
12			12) Lateral Pile Capacity for Abut 3 (Calculation Volume) Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.	PW / EB / KA	A	I. The apparent discrepancy arises from the facts that the LPile program does not allow the bottom of a soil layer to be above the pile cut-off, and the water table is not directly entered (it is accounted for by inputting the correct effective unit weight and subgrade modulus values based on saturated/dry conditions). At abutment 3, the top of the embankment is at about elevation +20 ft. Finished grade is at about elevation +7 ft. Taking the average of the top of the embankment and finished grade gives +13.5 ft. The design water table is conservatively located at elevation +5 ft. Pile cut-off is at +1 ft. So the overburden can be estimated by including 4 ft of buoyant soil unit weight plus 8.5 ft of dry soil unit weight, which is about 1260 psf. Due to the LPile soil layering constraints mentioned above, we modeled the overburden using a 19 ft layer, with buoyant unit weight, which gives an overburden of about 1140 psf, which is slightly below the estimate above (conservative). II. Will comply. The revised lateral pile analysis includes a "cracked" EI value equal to 80% of the gross EI for the pile for service and strength limit state (0.25" lateral pile top deflection) and 50% of the gross EI for the extreme event limit state (greater than 0.25" lateral pile top deflection). Revised lateral pile capacity calculations are attached. III. Based upon our conversations with the bridge designers, the pile reinforcing has been designed to have sufficient capacity to handle the moment demands.	4/20/2010 4/20/2010	
13			13) Static Settlement Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.	PW / EB / KA	A	Will comply. The settlement calculations have been revised to account for the compressible layer between elevation -5 and -10 ft. The revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
14			14) Static Settlement The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.	PW / EB / KA	A	Yes this is correct. Because the two bridges are located close to one another, based upon the subsurface exploration, the same idealized soil profile was originally used for both locations. However, based on comment #13, the settlement calculations for New Dock Street Off-Ramp have been revised to account for the clay layer encountered in Boring R-09-010 between elevation -5 and 10 ft. The revised settlement calculations are attached.	4/20/2010	
15			1) Axial Pile Capacity for Abutment 27 (Calculation Volume) Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
16			2) Axial Pile Capacity (Calculation Volume) The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.	PW / EB / KA	A	Will comply. Axial pile capacity calculations have been revised to incorporate a reduced load transfer in soil layers with blowcounts less than 15 blows per foot, where applicable. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 7, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, New Dock Street Off-Ramp, Bridge No. 53-3031 Los Angeles County, California, (7-LA-47, PM 3.74, EA 238501)***

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject bridge. This report presents the results of our analyses and recommendations for design and construction of the bridge foundation for the subject bridge replacement.

The Foundation Report for the subject bridge, dated February 8, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on March 23, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on April 20, 2010. OGDS-1 review comments and EMI responses are included in Appendix I. The responses to these review comments have been incorporated into this Final Foundation Report.

We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

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FINAL FOUNDATION REPORT
NEW DOCK STREET OFF-RAMP, BRIDGE NO. 53-3031
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 3.74, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 7, 2010

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Appendix B. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)
Appendix C. EarthSpectives SPT Hammer Energy Measurement Report
Appendix D. GeoVision Geophysical Investigation Report
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Appendix I. Caltrans Review Comments and EMI Response

1.0 INTRODUCTION

1.1 Purpose and Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed New Dock Street Off-Ramp (Replace) in Los Angeles County, California (Bridge No. 53-3031). The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analysis and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the replacement of the New Dock Street Off-Ramp structure (Figure 2).

The proposed New Dock Street Off-Ramp is a six-span Cast-in-Place (CIP) prestressed concrete box girder bridge supported on a single seat type abutment, four single-column bents and one two-column bent. The north end of the structure terminates at an expansion joint where the New Dock Street Off-Ramp abuts the mainline structure approximately 25 ft south of Bent 9 of the mainline. The bridge deck is about 39 ft in width and is approximately 529 ft long.

The typical bridge bent has either one or two columns with each column supported on a single 10 ft diameter Type II cast-in-drilled-hole (CIDH) pile. The abutments are supported on 2.5-foot diameter CIDH piles.

1.3 Existing Bridge Information

The existing Schuyler Heim Bridge is a 45-span structure and is approximately 3,975 feet long and varies from about 80 to 130 feet wide. On the as-built drawings, the New Dock Street Off-Ramp is shown as part of the mainline structure with five spans and is identified between "Off Bent No. 1" and "Off Abutment No. 5" with an approximate length of about 310 ft and deck width of about 30 ft.

Based on the as-built plans, the existing bridge is supported on a combination of timber piles and 14BP73 driven steel piles. Steel piles with a design loading of 40 tons are used at the abutments and timber piles with a design loading of 22 tons are used at the bents.

Copies of selected sheets from the as-built drawings for the existing Schuyler Heim Bridge relevant to the New Dock Street Off-Ramp are provided in Appendix A.

1.4 Limitations

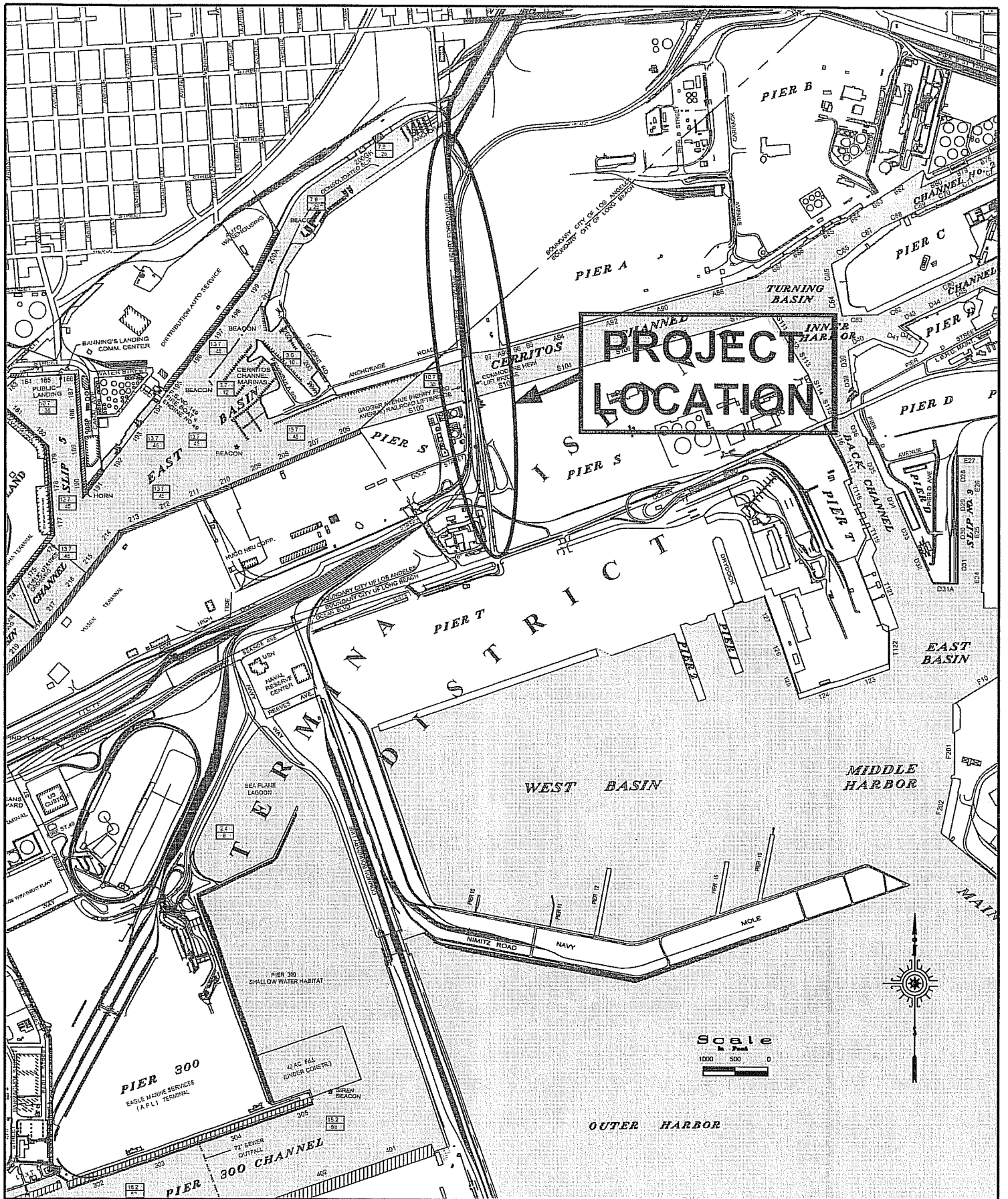
This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed New Dock Street Off-Ramp (Replace). This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

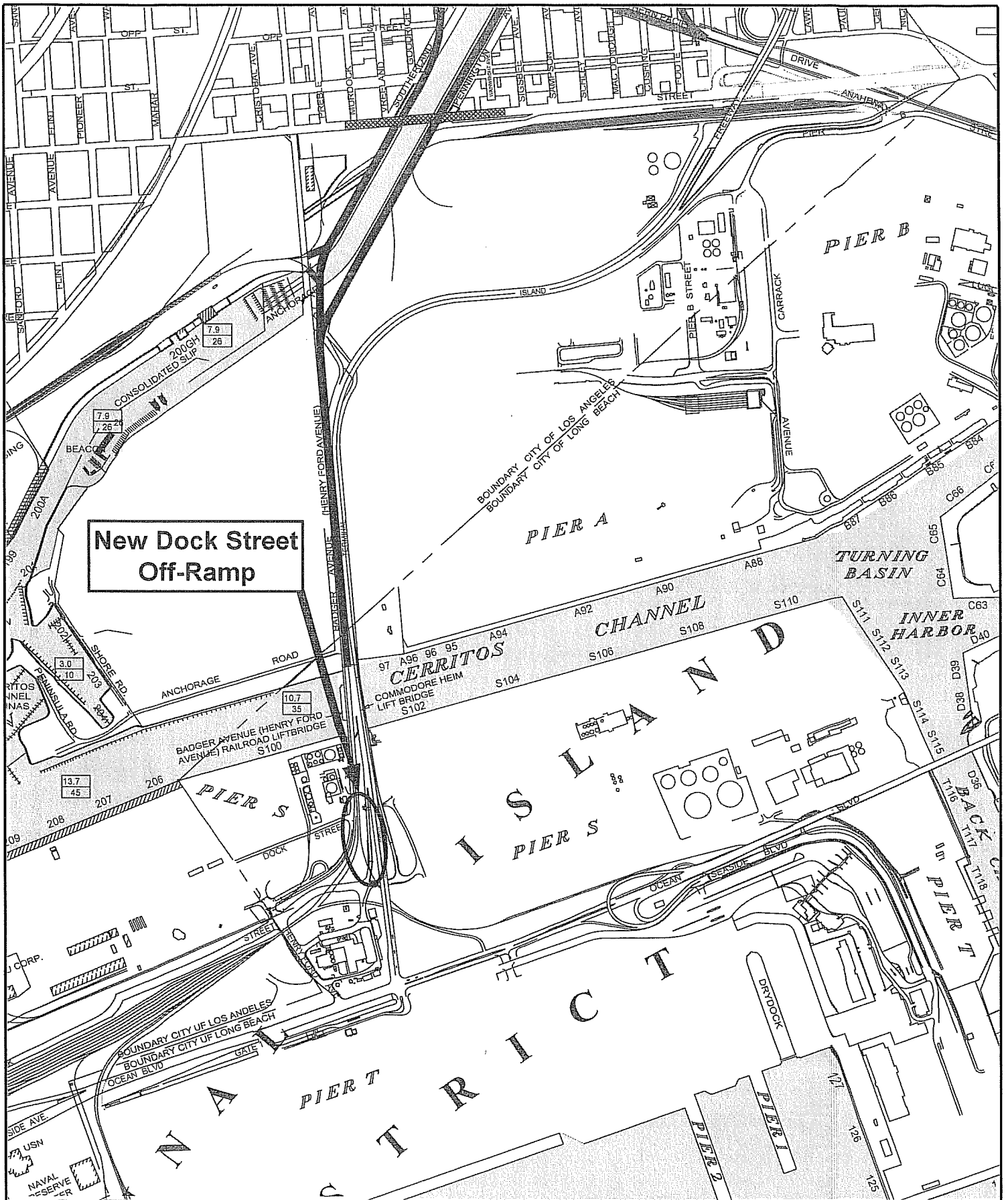
EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality

under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-07-10	Project Location Map — Figure 1



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-07-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of the New Dock Street on-Ramp were those shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and borings, four CPTs and one auger boring were performed near the subject bridge site. The auger boring penetrated to a depth of 157 ft and a tip elevation of -159 ft. The CPT soundings penetrated to depths between 100 and 138 ft below existing grade with a deepest penetration to an elevation of -140 ft.

Copies of the LOTB sheets prepared by LKR for the seismic retrofit study are provided in Appendix B.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, four rotary wash borings and two CPT soundings were performed in the vicinity of the New Dock Street Off-Ramp. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed bridge supports. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings surrounding the proposed bridge were performed at grade in the undeveloped area beneath the existing New Dock Street Off-Ramp bridge, west of the mainline structure through the existing New Dock Street Off-Ramp approach embankment. The deepest boring penetrated down to about elevation -165 ft, approximately 165 ft below ground surface.

The borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test

(SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal. A copy of the ES report is provided in Appendix C.

Boring geophysical measurements were also collected by GeoVision (GeoVision 2009) under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix D.

Table 1. Soil Exploration Information

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-010[2]	"B" Line	103+54.3	39.7 Rt	+4.4	-5.1	-147.1	RW
R-09-012[1]		105+35.4	8.9 Rt	+13.3	-8.7	-142.2	RW
R-09-013[2]		106+29.2	25.1 Rt	+0.2	-4.3	-165.8	RW
R-09-015[1]		107+42.6	4.5 Lt	-2.7	-10.7	-148.0	RW
CPT-09-064		104+35.0	24.8 Rt	+7.6	NR	-103.1	CPT
CPT-09-078		106+27.8	18.7 Rt	+0.3	NR	-97.1	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3. GWE = Groundwater Elevation.
4. GSE = Ground Surface Elevation (estimated from topographic plans).
5. Top of Boring Elevation Based on NAVD88.
6. RW = Rotary Wash, CPT = Cone Penetration Test.
7. NR = Not Recorded

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -102.5 ft, approximately 110.1 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI. The CPT sounding was performed using an

electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in^2 (10 cm^2) and a cylindrical friction sleeve with a surface area of 23.25 in^2 (150 cm^2). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

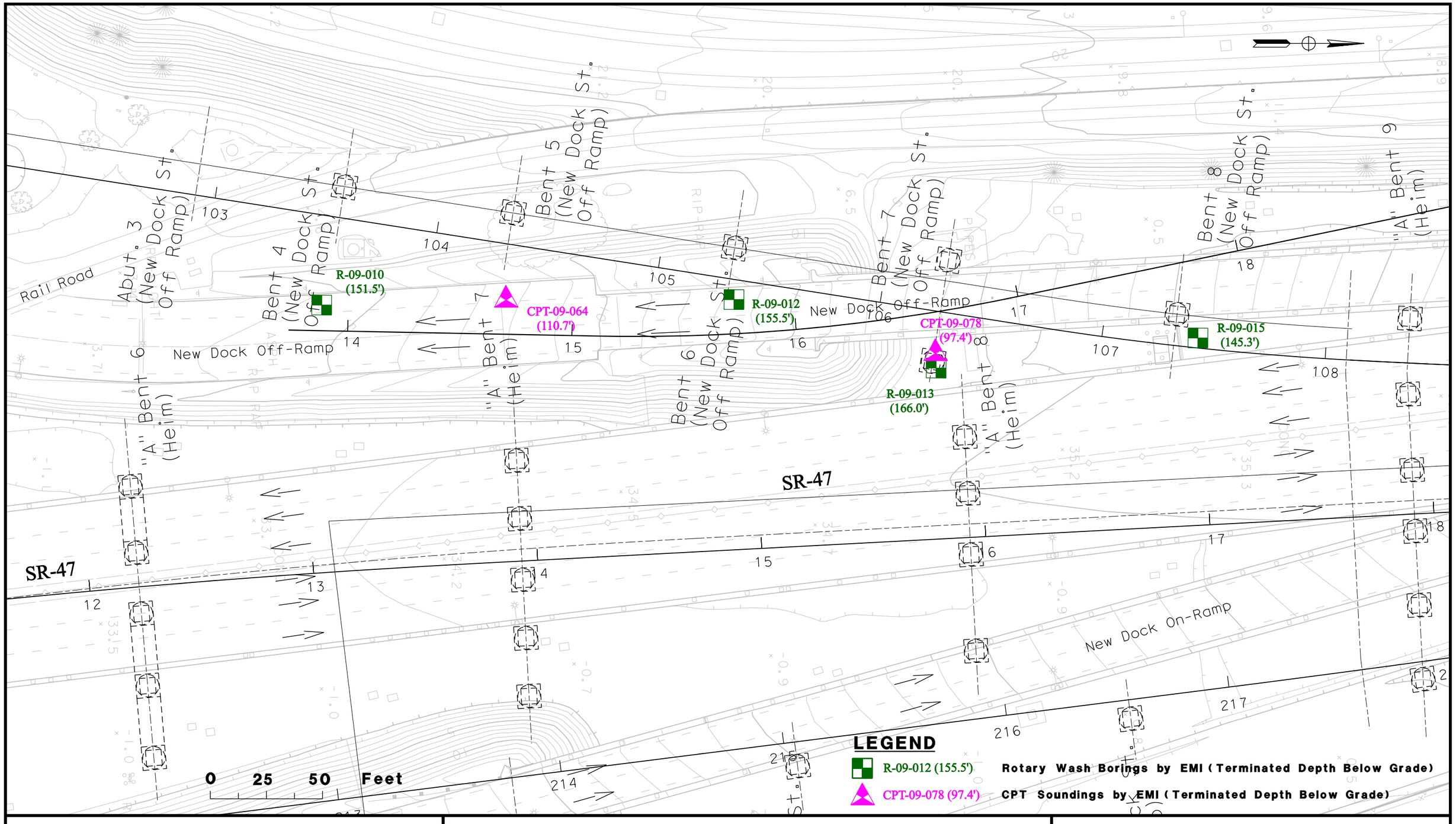
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of soils that exist at the site. Selected soil samples were tested to determine soil classification and physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. Test results are shown on the LOTB sheet at the end of the report and in tables in Appendix E.

Table 2. Explanation of Laboratory Tests Performed

Type of Test	Applicable Test Method	Purpose	Test Results Location
Dry Density	ASTM[1] D 2937	Estimate in-situ soil density	Appendix E
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content	Appendix E
No. 200 Wash	ASTM D 1140	Determine the percentage of fine grained particles of soil	Appendix E
Sieve & Hydrometer	ASTM D 422	Determine particle size distribution of soil	Appendix E
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil	Appendix E
Specific Gravity	ASTM D 854	Determine degree of saturation	Appendix E
Consolidation	ASTM D 2435	Determine compressibility of soil	Appendix E
UU Triaxial Test	ASTM D 2850	Estimate strength parameters of soil	Appendix E
Direct Shear	ASTM D 3080	Estimate strength parameters of soil	Appendix E
Soil pH	CT[1] 532/643	Determine corrosion potential of soil	Appendix E
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil	Appendix E
Sulfate Content	CT 417	Determine corrosion potential of soil	Appendix E
Chloride Content	CT 422	Determine corrosion potential of soil	Appendix E

Note: 1. ASTM = American Society for Testing and Material; CT = California Test Method.



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-07-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland

and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

Table 3. Stratigraphy and Correlation Chart, Long Beach Area

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	California Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks

rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

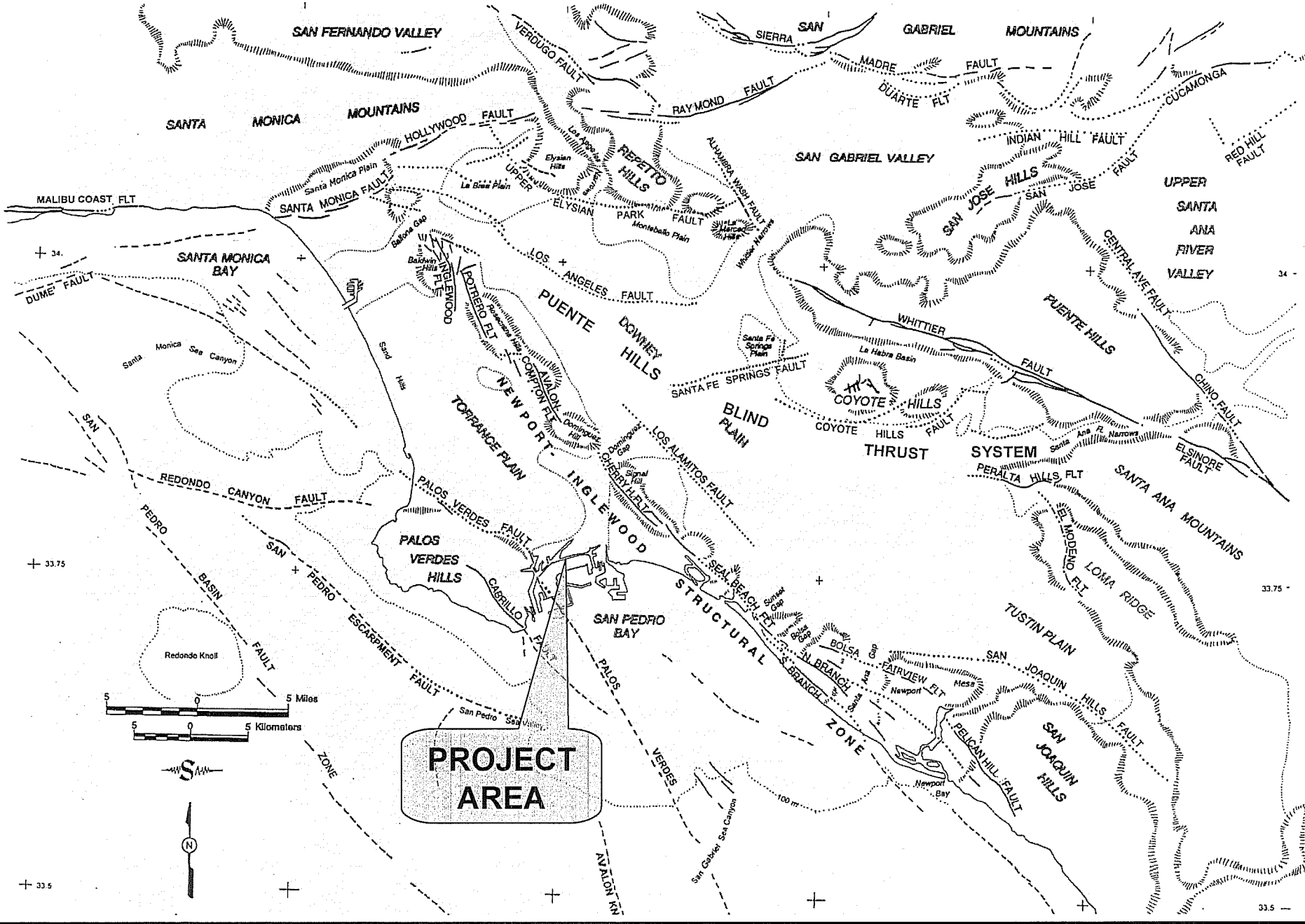
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

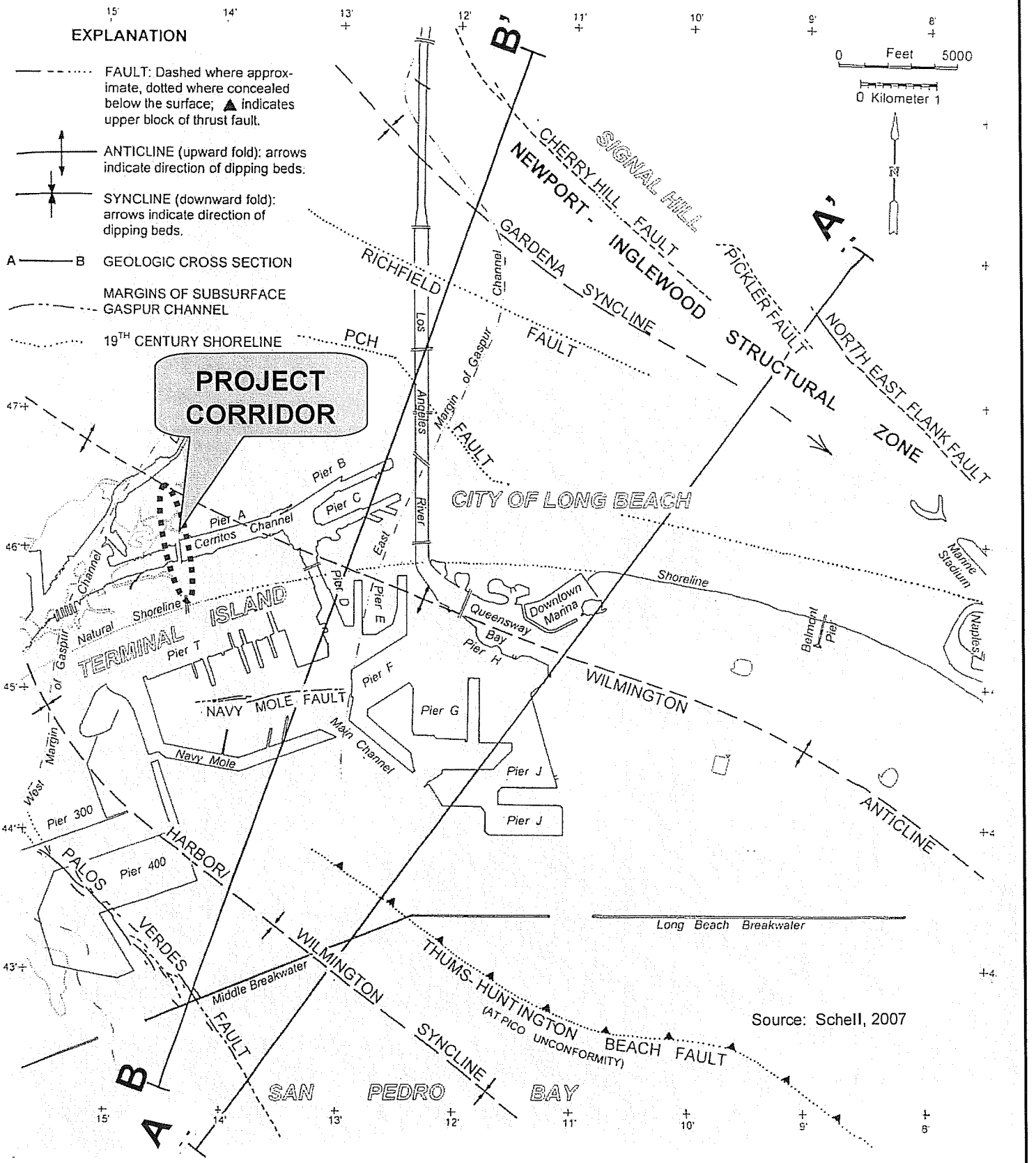
Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 5-07-10	Figure 4



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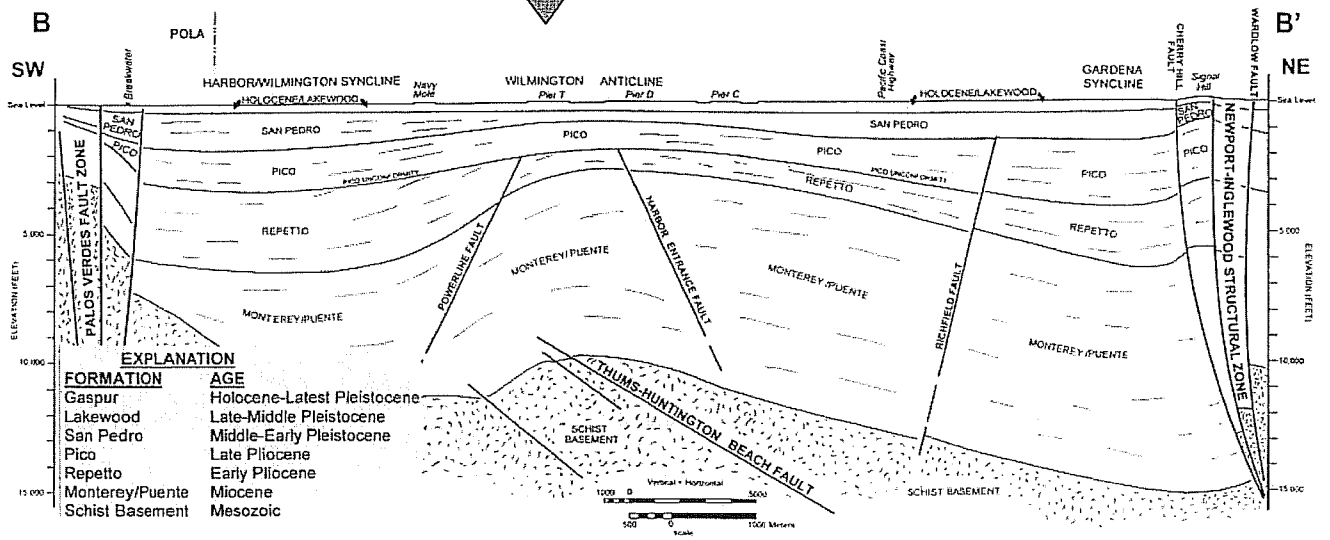
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structural Geology Map, Long Beach Harbor

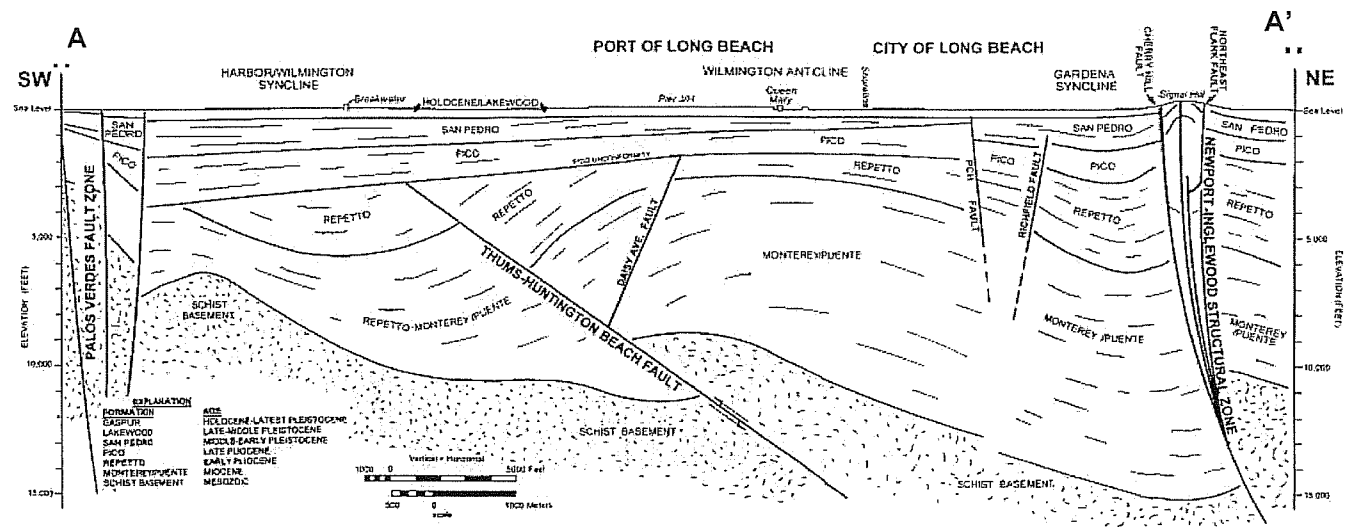
Figure 5

Project No. 06-123	Date: 5-07-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

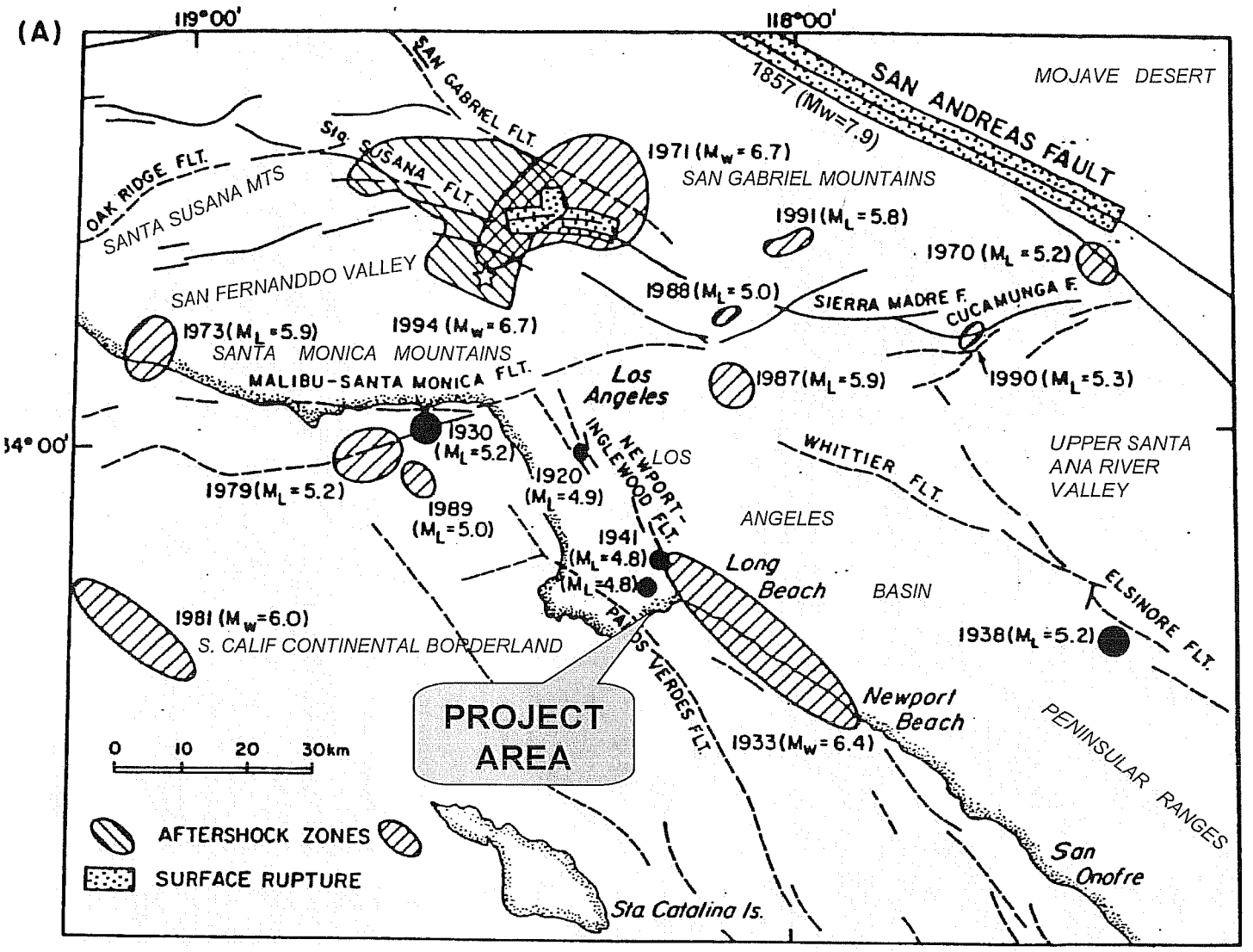


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

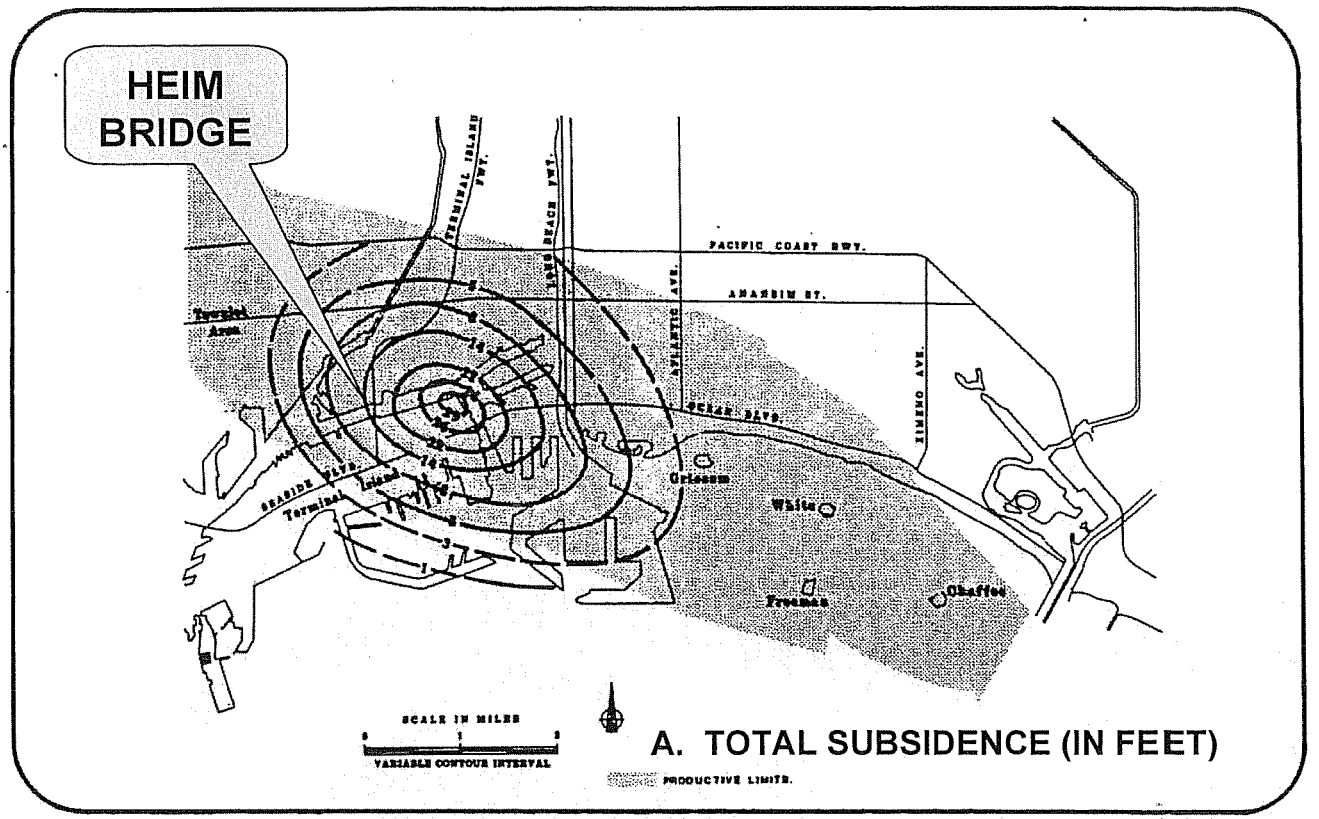
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	
Project No. 06-123 | Date: 5-07-10	Geologic Cross-Sections, LA Harbor	Figure 6

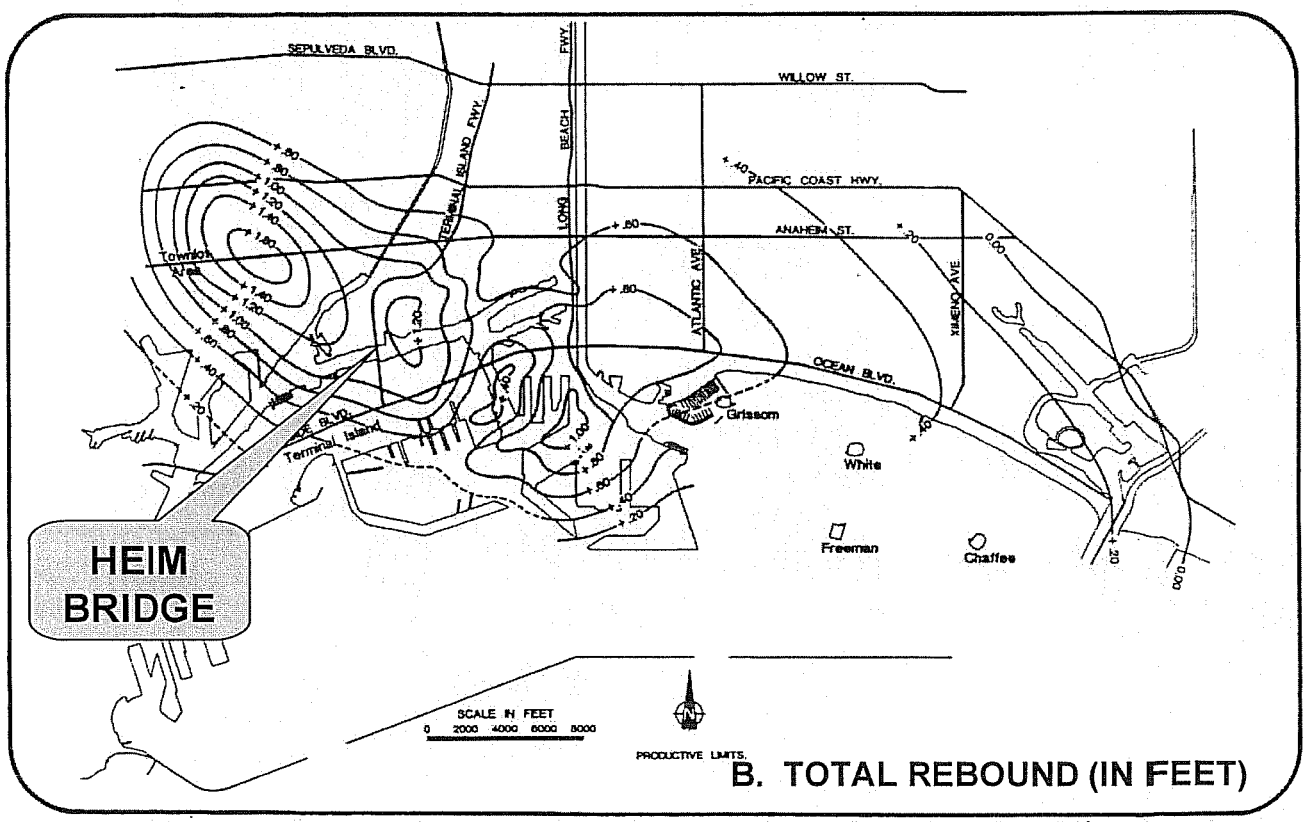


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-07-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-07-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -164.8 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject bridge site, natural grade lies at an elevation of about zero, with the approach embankment for the existing New Dock Street On-Ramp consisting of import fill extending to a maximum elevation of about +15 ft. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -25 ft. The near surface deposits are underlain by a thick strata of inter-layered soft to stiff silt, sandy silt, clay, and loose to medium dense silty sand down to about elevation -75 ft. Below elevation -75 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

Groundwater was recorded at elevation -5.5 ft in the auger boring performed in 1996 for the Geotechnical Investigation by LKR (LKR, 1998). During the EMI investigation in 2009, groundwater was recorded in all four of the borings performed near the proposed structure between elevation -4.3 ft and -10.7 feet. The elevation that groundwater was encountered at in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. Due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

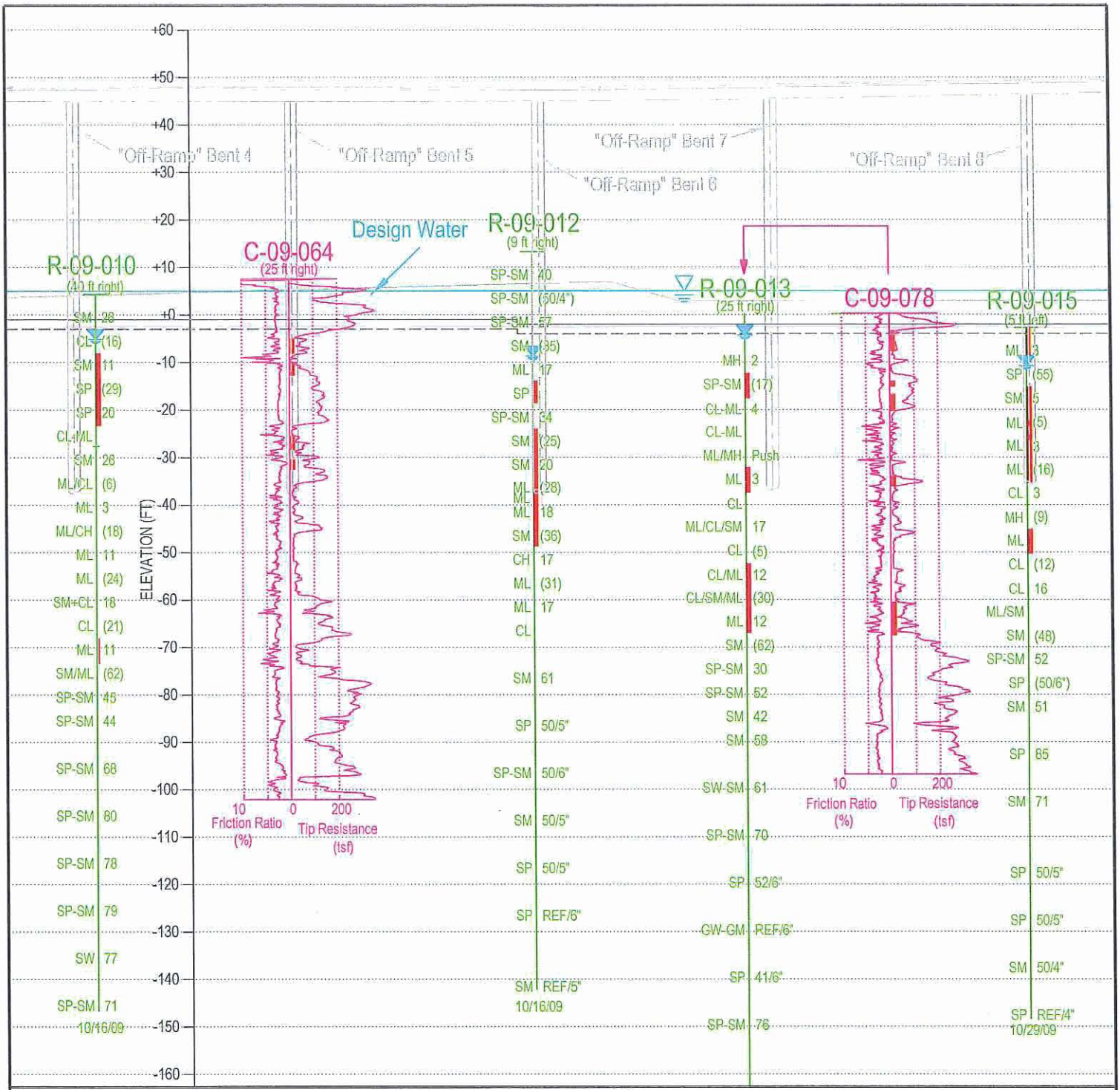
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

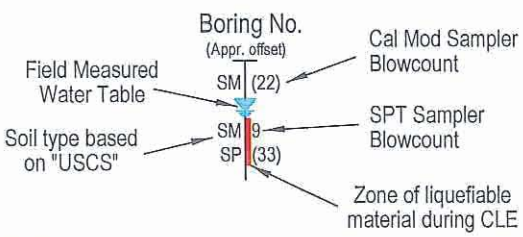
Based on information collected from borings R-09-010, R-09-012, R-09-013, R-09-015, and CPT soundings CPT-09-064 and CPT-09-078 an idealized soil profile for foundation analysis and design was developed along the proposed bridge alignment. The subsurface profile beneath the proposed structure is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

Table 4. Idealized Soil Profile and Parameters

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20.0 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -8.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-8.0 to -25.0	Silty Sand / Sand / Sand with Silt	120	0	32
-25.0 to -47.0	Silty Sand Sandy Silt / Silty Clay	120	1,000	0
-47.0 to -62.0	Clayey Silt / Sandy Silt / Clay with Sand	120	2,000	0
-62.0 to -75.0	Clayey Silt / Silt with Sand / Silt with Clay	120	1,500	0
-75.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Figure 9

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5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Study

A preliminary seismic evaluation was performed by EMI in 2006 and included in the Preliminary Foundation Report (EMI, 2006) based on the 2006 Seismic Design Criteria (SDC) (Caltrans, 2006d).

Using the 2006 SDC, the PBA was determined based on Caltrans Seismic Hazard Map (Mualchin, 1996a) and the attenuation relationship by Sadigh et al. (1997), as required by Caltrans (2006a). The controlling fault was found to be the Palos Verdes fault which is a strike-slip fault capable of generating a Maximum Credible Earthquake (MCE) of magnitude 7.0 and a PBA of 0.60g at the bridge site.

The standard ARS curve published in the 2006 SDC (Caltrans, 2006d) for this bridge site is shown on Figure B.8 for Soil Profile D (M = 7.25±0.25) and 0.6g. The standard ARS curve was modified to account for near-fault effects (a 20% increase of spectral accelerations for periods greater than 1 sec., no increase for periods less than 0.5 sec., and linear interpolation between 0.5 and 1 sec) per SDC Section 6.1.2.1

Figure 10 shows the recommended modified design ARS curve with coordinates as provided in the PFR (EMI, 2006).

During bridge type selection, Caltrans commented based on the PFR that due to the length of the proposed structure, a site specific ARS curve should be developed following completion of the project geotechnical investigation. It is our understanding that following approval of bridge type selection, preliminary design of the bridge proceeded using the preliminary ARS curve in anticipation that the site specific ARS curve would be completed in the early stages of final design.

As part of the EMI field investigation described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings for the entire project along the mainline bridge alignment. Using the results of shear wave velocity measurements, a site specific ground motion study was performed.

Results of the geotechnical field investigation and site specific ground motion study, following the procedures outlined in the latest Caltrans SDC (Caltrans, 2009) indicate that the preliminary ARS curve shown in Figure 10 plots well above the site specific ARS curve. Consequently, previously conducted analyses and design based on the preliminary seismic evaluation ARS curve are considered conservative and suitable for final design. The peak ground acceleration for the site was revised to 0.5 g based on the latest Caltrans SDC. The details of the ground motion study and the site specific ARS curve are summarized in a memorandum prepared by EMI and are included in Appendix F.

Ground Rupture. No known active faults traverse the surface of the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Liquefaction Potential and Seismically Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -75 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. Locations of potentially liquefiable material during the design earthquake are also identified in the subsurface profile shown in Figure 9.

Table 5. Liquefaction and Seismic Settlement Analysis Results

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-010	-8 to -23	2.2	3.3
	-67to -72	1.1	
R-09-012	-23 to -48	5.7	5.7
R-09-013	-13 to -18	1.0	5.1
	-33 to -38	1.6	
	-53 to -68	2.5	
R-09-015	-2 to -9	1.5	7.3
	-15 to -35	5.7	
	-45 to -50	0.1	
C-09-064	-5.0 to -8.0	0.1	0.8
	-10.0 to -12.6	0.2	
	-25.5 to -28.3	0.3	
	-30.5 to -32.4	0.2	
C-09-078	-3.4 to -7.5	0.4	1.7
	-14.3 to -15.3	0.1	
	-16.8 to –20.1	0.2	
	-34.0 to -36.0	0.5	
	-60.6 to -67.4	0.5	

Note: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Five soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to range between 7.0 and 8.8, the minimum resistivity varied from 90 to 470 ohm-cm, soluble chloride contents were between 540 and 17,602 parts per million (ppm) and soluble sulfate contents were between 292 and 1,322 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

5.4 Scour

This site is located within an area that is generally flat and there are no rivers, creeks or channels that cross beneath the structure; therefore, scour is not considered a design issue.

5.5 Foundation Type

Due to presence of the weak near-surface soils and the potential for seismically induced settlement throughout the site, spread footings are not considered feasible for support of the proposed structure.

Site soils are conducive to either a driven or drilled pile foundation. Due to the presence of deep liquefiable layers, large diameter Cast-In-Drilled-Hole (CIDH) piles are better suited to resist the large lateral foundation demands than small diameter piles and large diameter piles are needed at bent locations to support the large axial pile demands. Based on the foundation loads provided by the designers, 10 ft diameter CIDH piles are recommended for support at the proposed structure bents and 2.5 ft diameter CIDH piles are recommended at the abutment. At the bent locations, a permanent steel casing from finished grade to a depth between 31 ft to 38 ft is also proposed.

5.5.1 Axial Pile Capacity

Per Caltrans policy, LRFD method is used for bent piles and WSD is used for abutment piles. The foundation design data sheet and factored foundation loads were estimated by the designers following the latest Caltrans Memo to Designers 3-1 (Caltrans, 2008), and are shown in Tables 6 and 7, respectively.

Axial CIDH pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). Axial driven steel shell capacities were calculated according to recommendations by Tomlinson (1987) and API (2000). The calculated factored axial geotechnical capacities and pile tip elevations for each 30-inch CIDH pile at the abutment and 10-ft CIDH pile at the interior bents are presented in Tables 8 and 9, respectively. For the extreme event limit case, negative skin friction due to seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The depth to the bottom of the

liquefiable layer at each support was determined based upon the nearest boring information. The Pile Data Table is provided in Table 10. For bent piles, a resistance factor of 0.7 was applied per Caltrans LRFD guidelines.

Table 6. Foundation Design Data Sheet

Location	Design Method	Pile Type	Finished Grade El. (ft)	Pile Cut-off El. (ft)	Pile Cap Size (ft)		Permissible Settlement under Service Load (in)	No. of Piles per Support
					B	L		
Abut 3	WSD	2.5 ft CIDH	+7	-1.8	20.0	42.33	1	12
Bent 4	LRFD	10 ft CIDH	+5	-10.0	NA	NA	1	1
Bent 5	LRFD	10 ft CIDH	+4	-10.0	NA	NA	1	1
Bent 6	LRFD	10 ft CIDH	+4	-5.0	NA	NA	1	1
Bent 7	LRFD	10 ft CIDH	+2	-3.0	NA	NA	1	1
Bent 8	LRFD	10 ft CIDH	+0	-4.0	NA	NA	1	1

Table 7. Foundation Design Loads

Location	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)			
	Total Load		Perm Load	Compression		Tension		Compression		Tension	
	Per Support	Max Per Pile	Per Support	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile
Abut 3	2,330	200	2,110	NA	NA	NA	NA	NA	NA	NA	NA
Bent 4	1,630	1,630	1,340	2,360	2,360	0	0	1,340	1,340	0	0
Bent 5	1,950	1,950	1,490	2,660	2,660	0	0	1,490	1,490	0	0
Bent 6	2,070	2,070	1,580	2,840	2,840	0	0	1,580	1,580	0	0
Bent 7	1,830	1,830	1,400	2,590	2,590	0	0	1,400	1,400	0	0
Bent 8	2,150	2,150	1,700	2,980	2,980	0	0	1,700	1,700	0	0

Notes: 1. For bents with more than one support, the highest support/pile demand is listed in the table, as provided by the designer.

The maximum pile-head settlement due to the nominal resistance is estimated to be less than 1-inch at all supports. For axial loading, pile group effects can be neglected if the on-center spacing is equal to or greater than 4 times the pile diameter. A group reduction factor of 0.65 is applied for on-center spacing of 2.5 times the pile diameter. Based on interpolation over this range, an average group reduction factor of 0.93 was applied at the abutment.

Table 8. Foundation Recommendations for Abutments

Location	Pile Type	Cut-off El. (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip El. (ft)	Specified Tip El. (ft)
			Total	Permanent				
Abut 3	2.5 ft CIDH	-1.8	2,330	2,110	200	400	-71 (a) -43 (c) -47 (d)	-71

Notes: 1. Design tip elevations are controlled by: (a) Compression, (b) Tension, (c) Settlement, (d) Lateral Load.
2. The specified tip elevation shall not be raised.

Table 9. Foundation Recommendations for Bents

Location	Pile Type	Cut-off El. (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				Design Tip El. (ft)	Specified Tip El (ft)	Steel Casing Specified Tip El. (ft)	Steel Casing Nominal Driving Resistance Required ((kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 4	10 ft CIDH	-10.0	1,630	1	2,360	0	1,340	0	-106 (a-I) -86 (a-II) -73 (c) -95 (d)	-106	-35	420
Bent 5	10 ft CIDH	-10.0	1,950	1	2,660	0	1,490	0	-114 (a-I) -96 (a-II) -82 (c) -95 (d)	-114	-35	230
Bent 6	10 ft CIDH	-5.0	2,070	1	2,840	0	1,580	0	-113 (a-I) -102 (a-II) -68 (c) -90 (d)	-113	-30	430
Bent 7	10 ft CIDH	-3.0	1,830	1	2,590	0	1,400	0	-111 (a-I) -88 (a-II) -65 (c) -88 (d)	-111	-28	320
Bent 8	10 ft CIDH	-4.0	2,150	1	2,980	0	1,700	0	-118 (a-I) -93 (a-II) -76 (c) -89 (d)	-118	-29	150

Notes: 1. Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (a-II) Compression (Extreme Event Limit), (b) Tension, (c) Settlement, (d) Lateral Load.
2. The specified tip elevation shall not be raised.

Table 10. Pile Data Table

Support	Pile Type	Nominal Resistance (kip)		Nominal Resistance (Driven Steel Shell) (kip)		Steel Casing Specified Tip Elevation (ft)	CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Comp	Tens	Comp	Tens				
Abut 3	2.5 ft CIDH	400	0	NA	NA	NA	-71 (a) -43 (c) -47 (d)	-71	NA
Bent 4	10 ft CIDH	3,380	0	420	0	-35	-106 (a) -73 (c) -95 (d)	-106	420
Bent 5	10 ft CIDH	3,800	0	230	0	-35	-114 (a) -82 (c) -95 (d)	-114	230
Bent 6	10 ft CIDH	4,060	0	430	0	-30	-113 (a) -68 (c) -90 (d)	-113	430
Bent 7	10 ft CIDH	3,700	0	320	0	-28	-111 (a) -65 (c) -88 (d)	-111	320
Bent 8	10 ft CIDH	4,260	0	150	0	-29	-118 (a) -76 (c) -89 (d)	-118	150

Notes: 1. Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

2. The specified tip elevation shall not be raised.

5.5.2 Lateral Pile Capacity

Abutments. Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a fixed-head connection with the pile cap are provided in Tables 11 and 12 for the Service Limit State and the Extreme Event Limit State, respectively. The design tip elevations for lateral loading are given in Table 10.

Lateral pile analyses were performed using the computer program LPILE (Ensoft 2007). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000). The internally generated p-y curves for stiff fine-grained soils were estimated using the method proposed by Reese (Reese et al., 1975), and the internally generated p-y curves for soft fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.8 was used in the analysis based on the pile layout provided by the designers and the procedures outlined in the Ensoft Group 7.0 software Technical Manual

(Ensoft 2006). Under seismic conditions, liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008).

The solutions presented are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and other connection details.

Table 11. Abutment 3, 30-in CIDH Pile "Fixed" Head Solution: Service Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	155	7,507

Notes: 1. Group effects considered with a reduction factor of 0.8 on "p."
2. Static strength parameters used in all soil layers.
3. A cracked section modulus of 80% of EI was used in the analysis.

Table 12. Abutment 3, 30-in CIDH Pile "Fixed" Head Solution: Extreme Event Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	41	2,789
0.5	78	5,443
1.0	134	10,153
3.0	251	23,420

Notes: 1. Group effects considered with a reduction factor of 0.8 on "p."
2. Liquefied strength parameters used in liquefiable soil layers.
3. A cracked section modulus of 50% of EI was used in the analysis.

Bents. The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time that included a general description of the subsurface conditions beneath the proposed structure and eight idealized soil profiles along the proposed alignment. It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared.

Based on the current geotechnical investigation and updated soil profile, an additional project specific lateral pile analysis was performed. Results from that analysis indicate that the p-y curves generated from the soil profiles presented in the PFR are suitable for use in the final design. The current results either generate a more conservative lateral pile response than the p-y curves developed by Caltrans based on the PFR, or a lateral pile response that is within an

acceptable design tolerance. Details of the lateral pile analysis and a comparison between the preliminary and updated p-y curves are included in a memorandum prepared by EMI. The memorandum is included in Appendix G. The preliminary p-y curves generated from the soil profiles in the PFR which were determined to be suitable for use in final design for Bent 4 to Bent 8 are provided in Appendix H.

5.6 Bridge Abutment Walls

5.6.1 Earth Pressures

An active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf are recommended for a level abutment backfill. If abutment walls are free to move laterally at the top, a static active lateral earth pressure of 36 psf per ft of depth is recommended for a level backfill. If lateral movement at the top of abutment walls is restrained, the lateral pressure distribution has a trapezoidal shape with a maximum lateral pressure of 28.8H psf between 0.2H from the top and bottom of the wall, where H is the wall height in feet. A traffic surcharge equivalent to a vertical pressure produced by at least 2 ft of earth should be added to the above lateral earth pressure values. Other design requirements are specified in Section 3.20 of the Caltrans Bridge Design Specifications (Caltrans, 2004).

5.6.2 Passive Resistance

Under seismic loading, an ultimate passive earth pressure of 5 ksf may be used for the approach backfill and abutment backwalls with a height equal to or greater than 5.5 ft. For abutment backwalls with heights less than 5.5 ft, the maximum passive pressure may be calculated proportionally (e.g., for a 4 ft high backwall, the maximum passive pressure is [4/5.5]x5 ksf = 3.6 ksf). The horizontal movement at which the maximum passive pressure is expected to be fully mobilized can be determined following the procedure outlined in Section 7.8.1 of the Caltrans SDC (2006d).

5.7 Approach Embankments

The alignment of the proposed New Dock Street Off-Ramp (Replace) will be shifted slightly to the west from the existing alignment with a slightly elevated roadway profile. Due to the alignment shift, up to 18 ft of fill will be placed in order to raise existing grade to proposed grade. The abutment end slope will be graded at an inclination of 1.5:1 (Horizontal:Vertical) with full slope paving and the side slopes of the embankment will be graded at an inclination of about 4:1 (Horizontal:Vertical).

5.7.1 Static Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in

this case occurs during grading or shortly thereafter while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed embankment approximately 25 ft behind the bridge abutment. Based on cross-sections provided by URS Corporation, the existing embankment at "B" Line Sta. 102+60 will be approximately 40 feet at the crest and the embankment height is approximately 16 feet. Based on our calculations, the maximum settlement will occur beneath the center of the proposed embankment and is estimated to be about 4 inches. The settlement period is estimated to be about 13 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 5 weeks. For a 7-ft embankment surcharge, the settlement periods is reduced to about 4 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

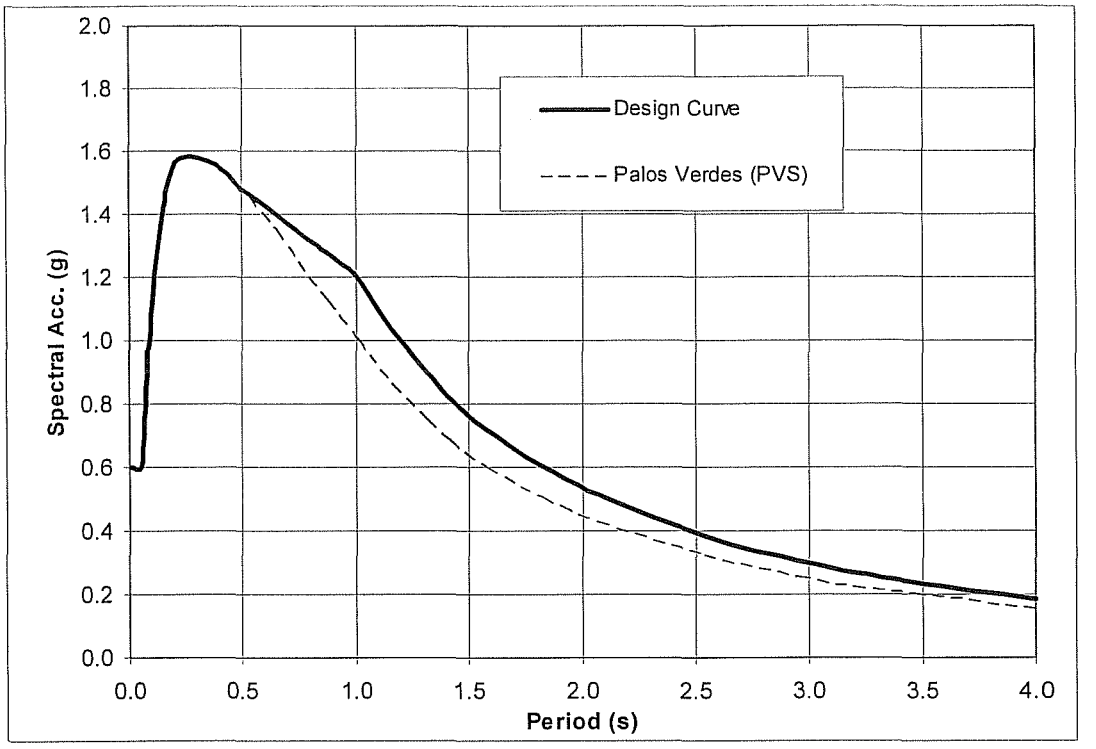
Settlement of the embankment fill should be verified by the Engineer prior to installation of abutment piles to prevent a reduction in axial pile capacity due to downdrag loads being applied to the piles.

5.7.2 Bridge Abutment Slope Stability

The "global" stability of the embankment side slopes was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).



Fault Name	Fault Type	M_w	Dist, km	PBA, g
Palos Verdes (PVS)	ST	7.25	2.7	0.6

Period	Acc (g)	Period	Acc (g)	Period	Acc (g)	Period	Acc (g)
0.010	0.600	0.500	1.479	2.954	0.304		
0.050	0.600	0.533	1.461	3.203	0.266		
0.079	0.938	0.650	1.398	3.463	0.239		
0.099	1.127	0.787	1.323	4.000	0.186		
0.124	1.283	0.868	1.279				
0.154	1.419	0.998	1.209				
0.177	1.507	1.000	1.208				
0.208	1.564	1.162	1.031				
0.236	1.578	1.307	0.906				
0.271	1.584	1.411	0.822				
0.309	1.580	1.575	0.723				
0.355	1.570	1.819	0.605				
0.386	1.557	2.068	0.513				
0.442	1.525	2.537	0.383				

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned or dried to near optimum moisture, and compacted in place to a minimum 95 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts or excavations necessary to achieve finish grades. However, temporary cuts may be required in areas where drainage improvements and footings are proposed. Temporary excavations, including temporary shoring, necessary to construct the bridge abutment footings or culverts will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all four of the borings performed for the proposed bridge foundation between Elevation -4.3 and -10.7 ft. The proposed footing bottom elevation at Abutment 3 is +1.0 ft. Due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

Groundwater was encountered between elevation -4.3 and -10.7 feet in October 2009. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff and other man-made conditions. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled

with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.3 Backdrain and Backfill Requirements for Abutment Walls

Materials behind the abutment and wing walls should be low-expansive soil with an Expansion Index (EI) less than 50 and Sand Equivalent (SE) of more than 20 as shown in Figure 11. The low-expansive material requirement should not supersede the structure backfill and pervious backfill requirements as described in Caltrans Standard Plans, Bridge Detail 3-1 (2006b), and Caltrans Standard Specifications (2006c) under Sections 19-3.06 and 19-3.065, respectively.

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the abutment walls in order to avoid damaging the walls due to large lateral earth pressures.

Backdrains should be installed behind abutment walls to relieve hydrostatic pressure. The backdrains should be constructed in accordance with Bridge Detail 3-1 per Caltrans Standard Plans (2006b).

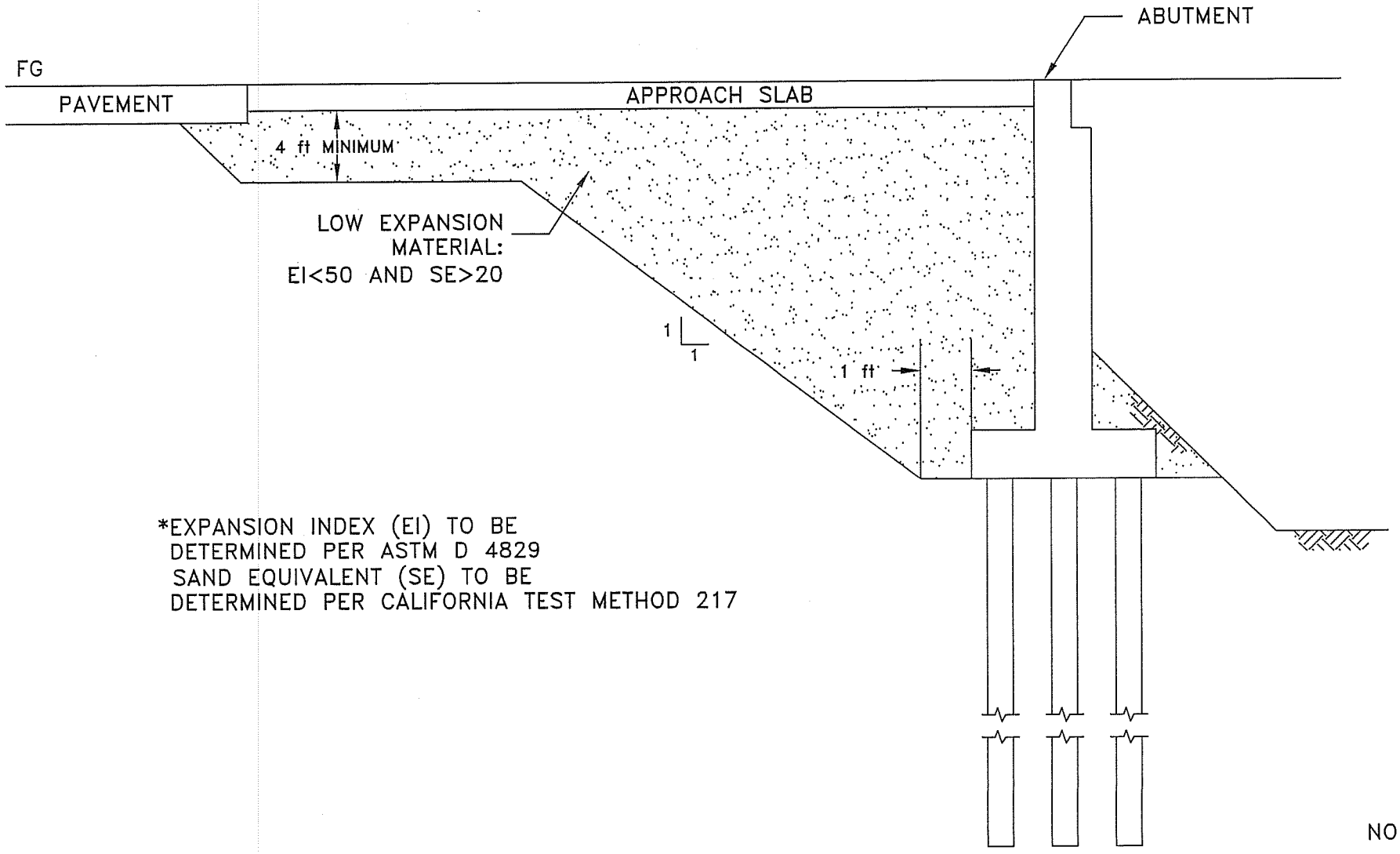
6.4 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations presented in this report may require modification or additional recommendations may be necessary based on the final design.

6.5 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of bridge abutment walls.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.



*EXPANSION INDEX (EI) TO BE DETERMINED PER ASTM D 4829
SAND EQUIVALENT (SE) TO BE DETERMINED PER CALIFORNIA TEST METHOD 217

NO SCALE

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 5-07-10

Low Expansion Material at Bridge Abutments

Figure 11

7.0 REFERENCES

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PT-524	PT-525
SET REBAR	SET + VLT
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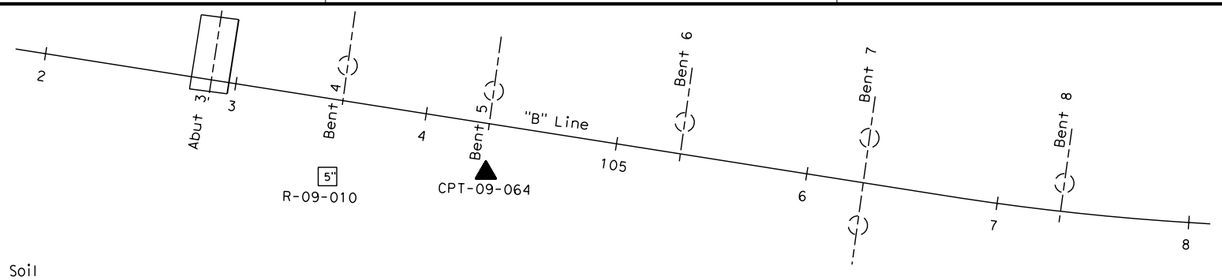
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



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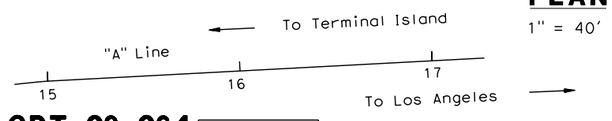

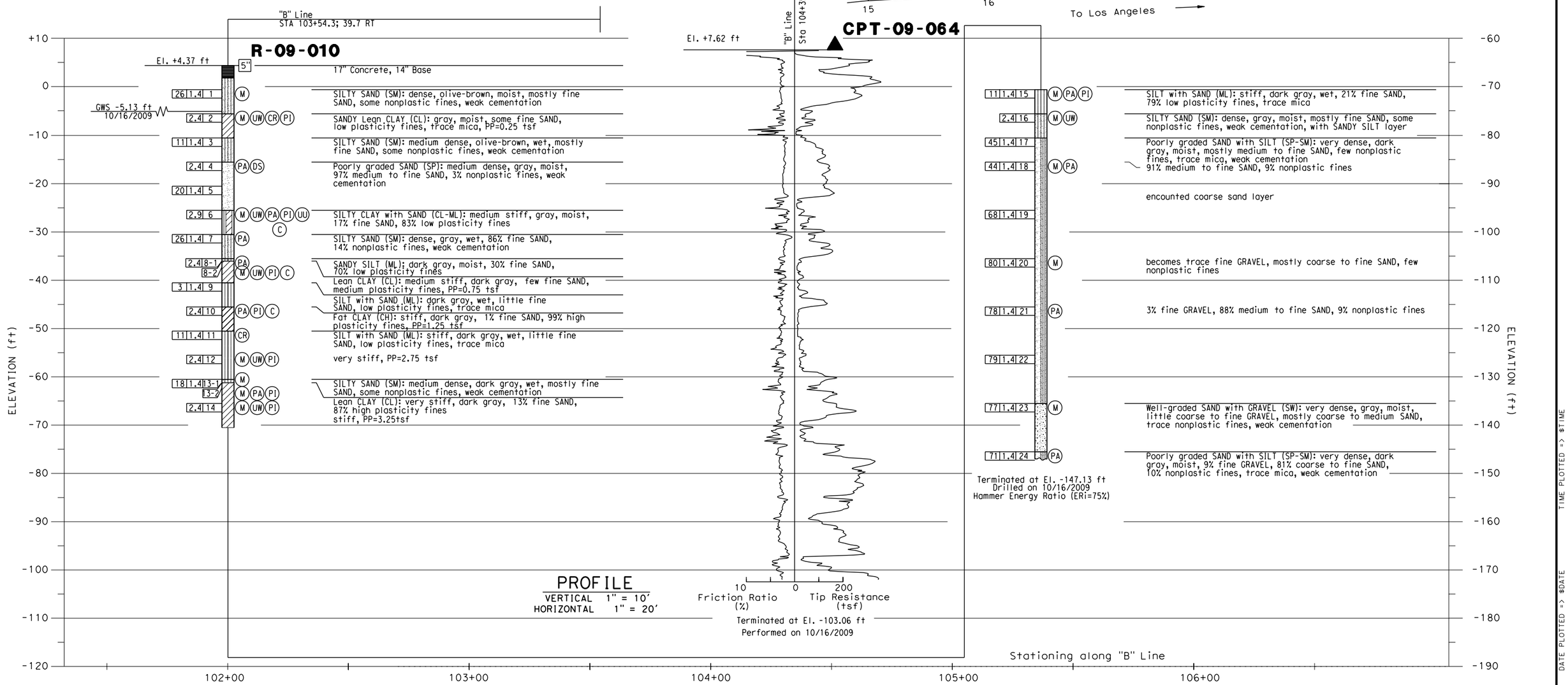

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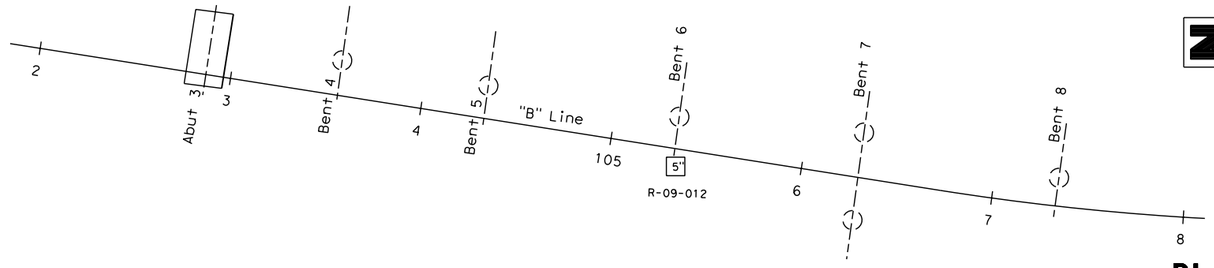

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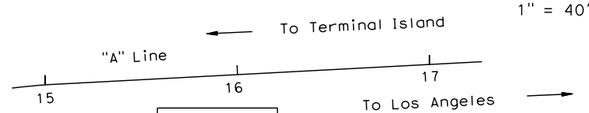

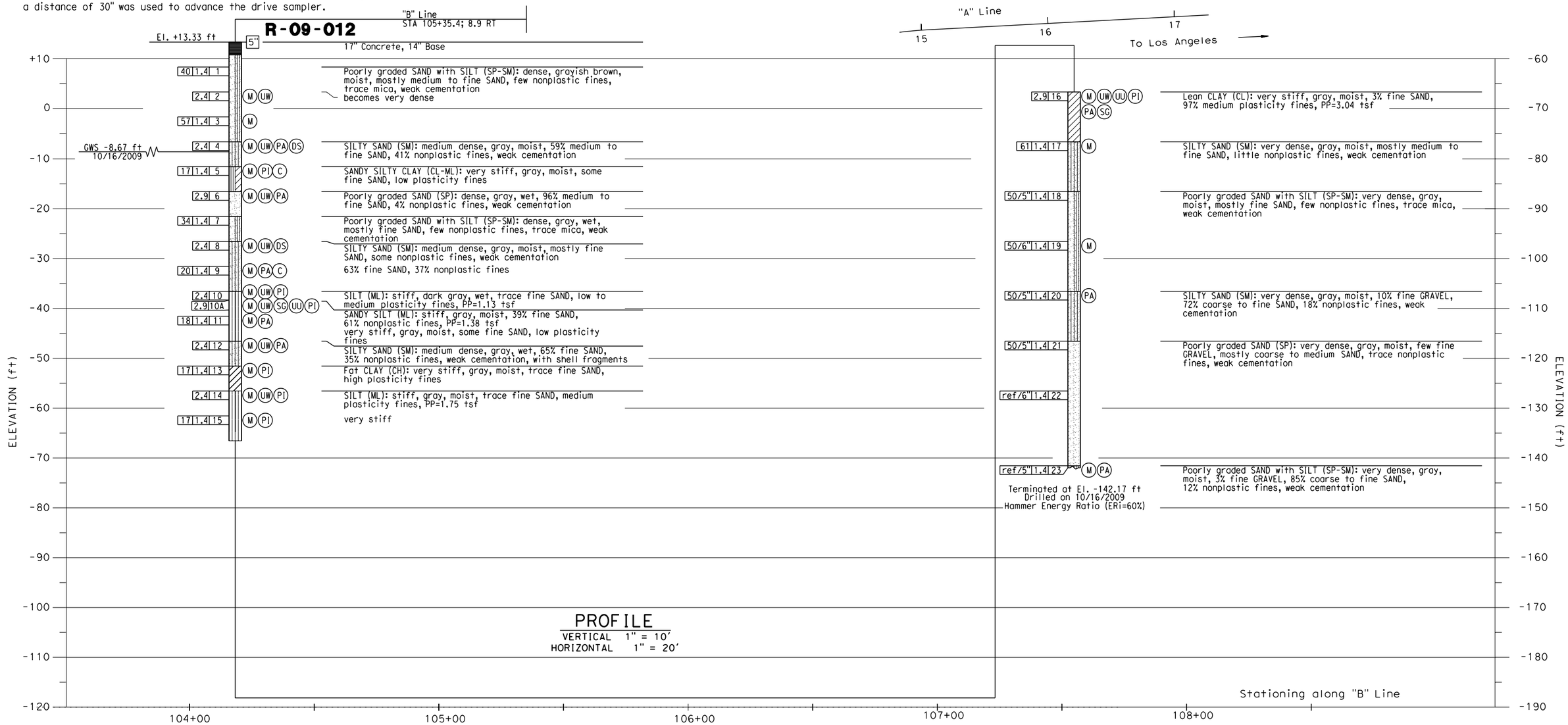

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HORIZONTAL 1" = 20'

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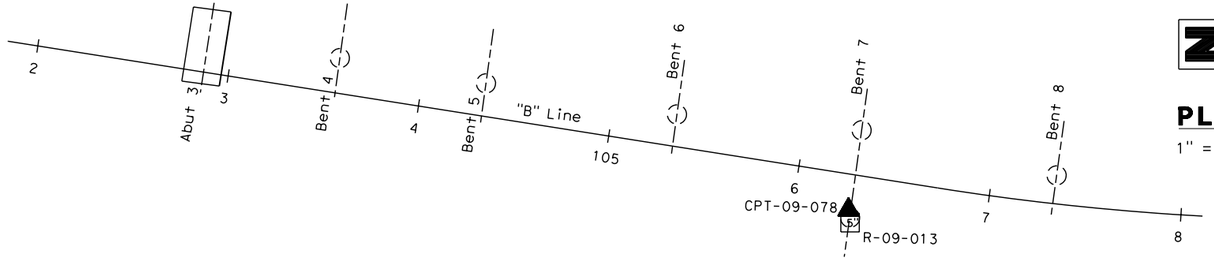

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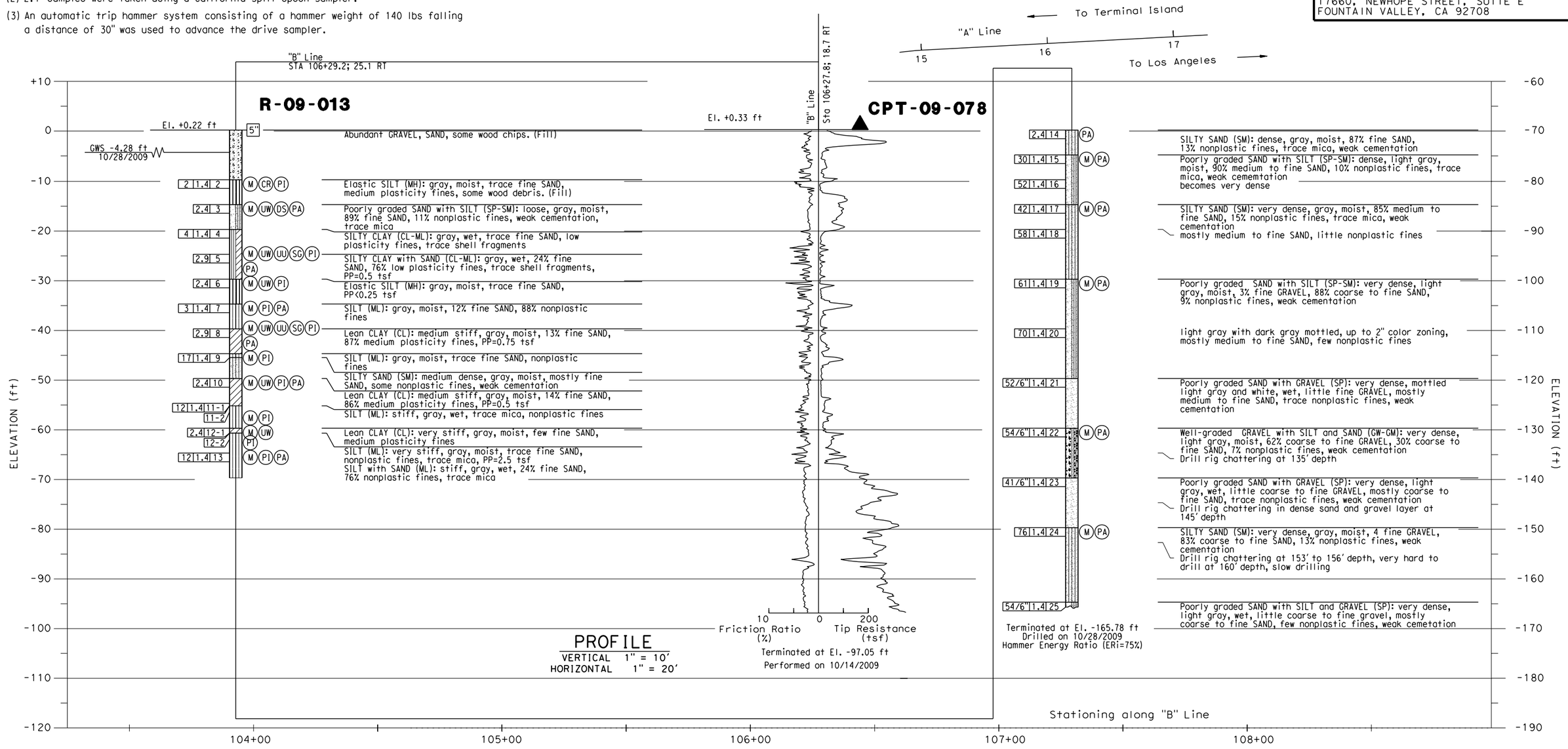

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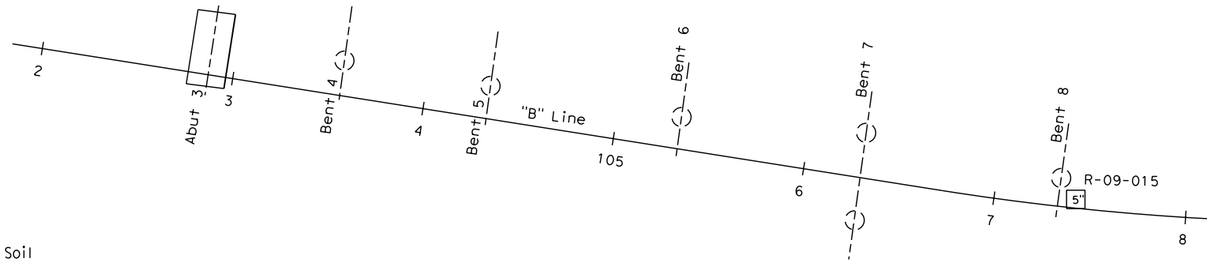

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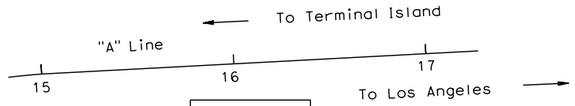
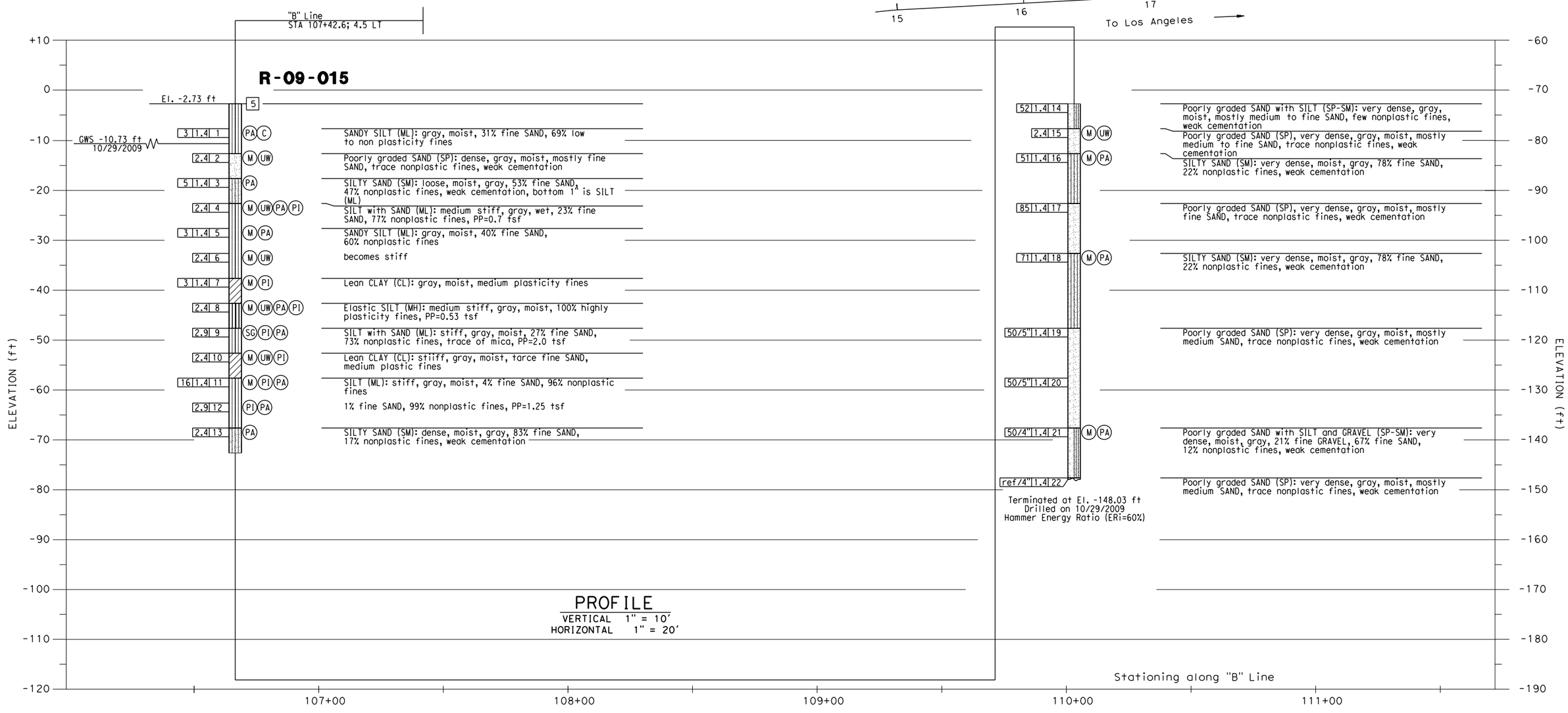
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708





PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53-3031 / POST MILE 3.74
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			

NEW DOCK STREET OFF-RAMP
LOG OF TEST BORINGS NO. 4 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10, 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

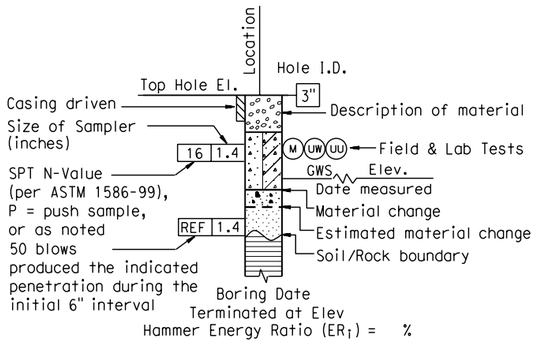
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

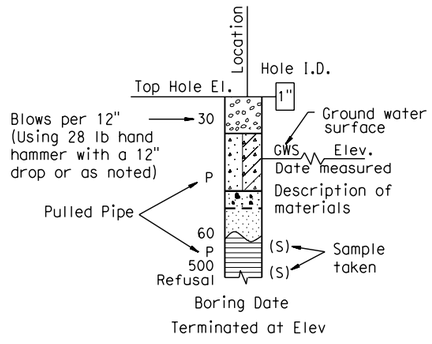
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

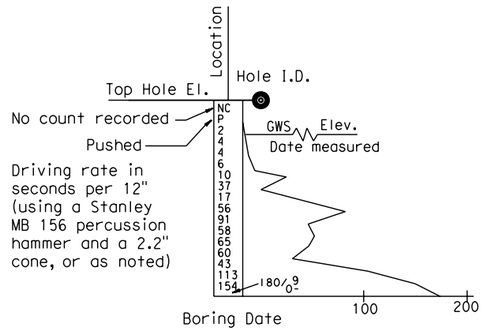
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



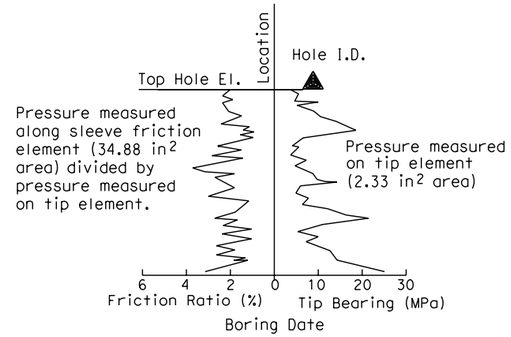
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53-3031 POST MILE 3.74

NEW DOCK STREET OFF-RAMP

LOG OF TEST BORINGS NO. 5 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53-3031
POST MILE 3.74

NEW DOCK STREET OFF-RAMP
LOG OF TEST BORINGS NO. 6 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 235801

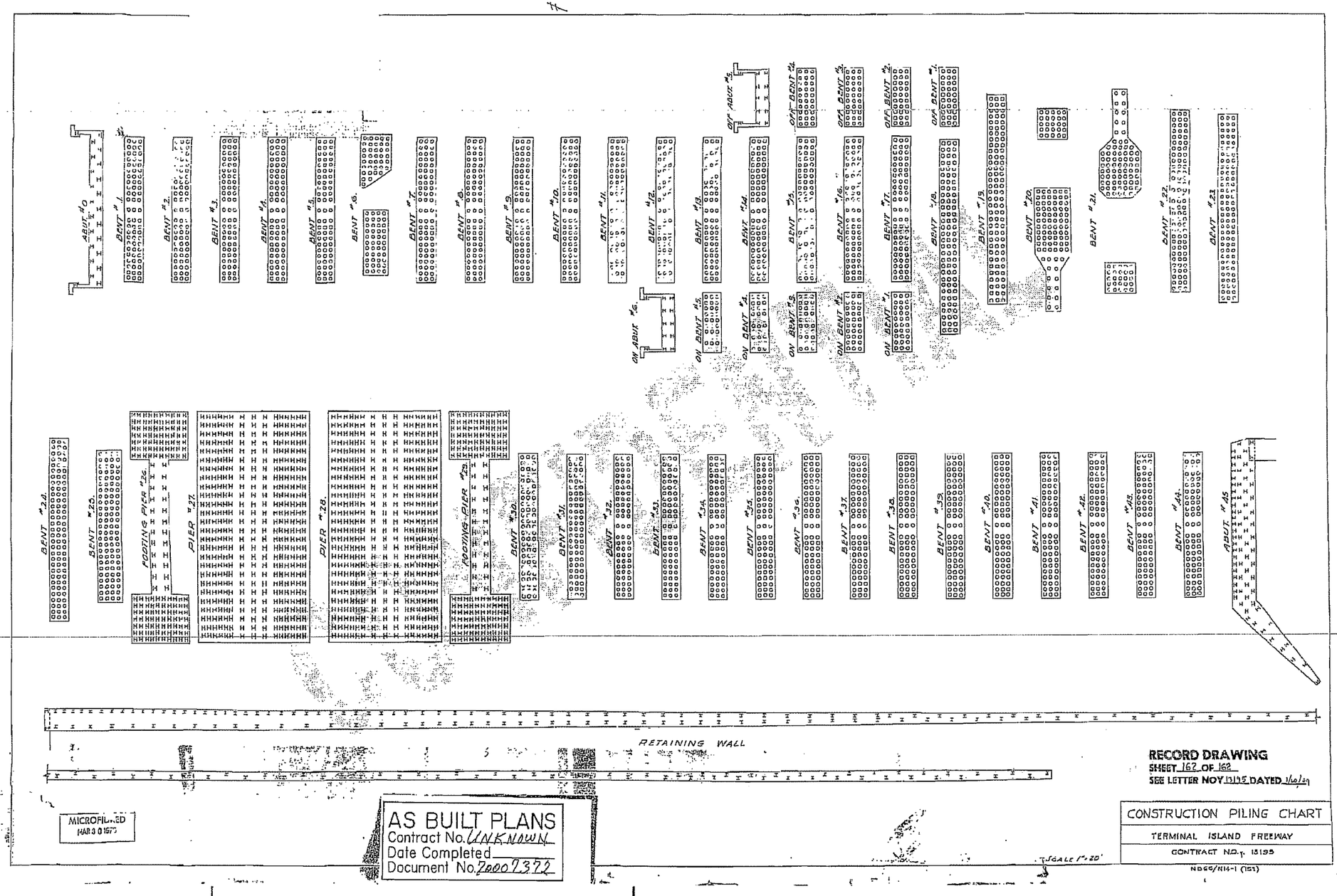
DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

Appendix A. Selected As-Built Plan Sheets for Schuyler Heim Bridge



MICROFILMED
MAR 3 0 1979

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

RECORD DRAWING
SHEET 162 OF 162
SEE LETTER NOY 13195 DATED 1/10/79

CONSTRUCTION PILING CHART

TERMINAL ISLAND FREEWAY

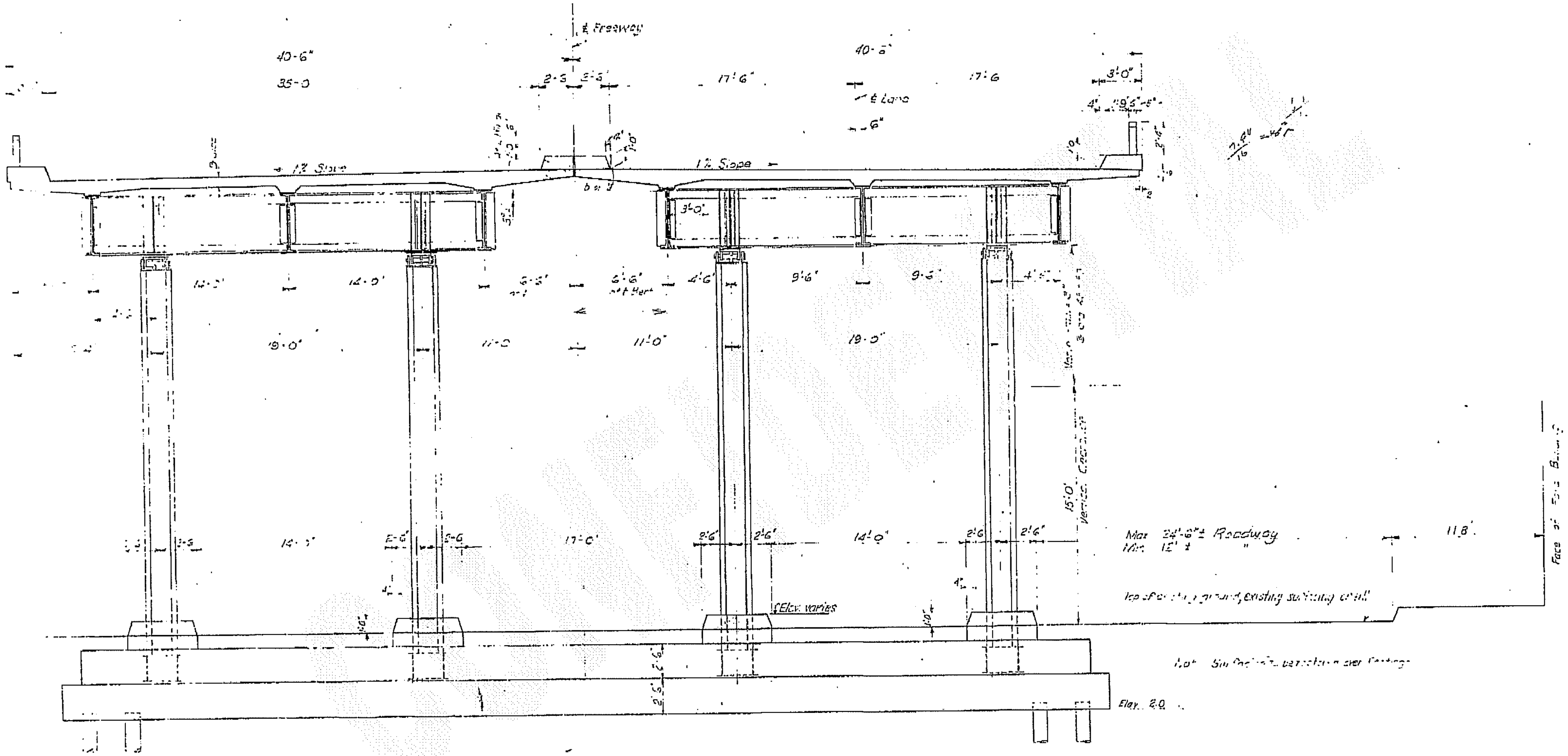
CONTRACT NO. 13195

NDSG/R14-1 (151)

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THE DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/14 SIGNATURE

CutePDF - www.funbio.com



TYPICAL BENT

Sta 25 to 39

DIST	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	L.A.	Access			146

414,894

NAVAL OPERATING BASE

APPROVED

BRIDGE ACROSS CERRITOS CHANNEL

TYPICAL BENT

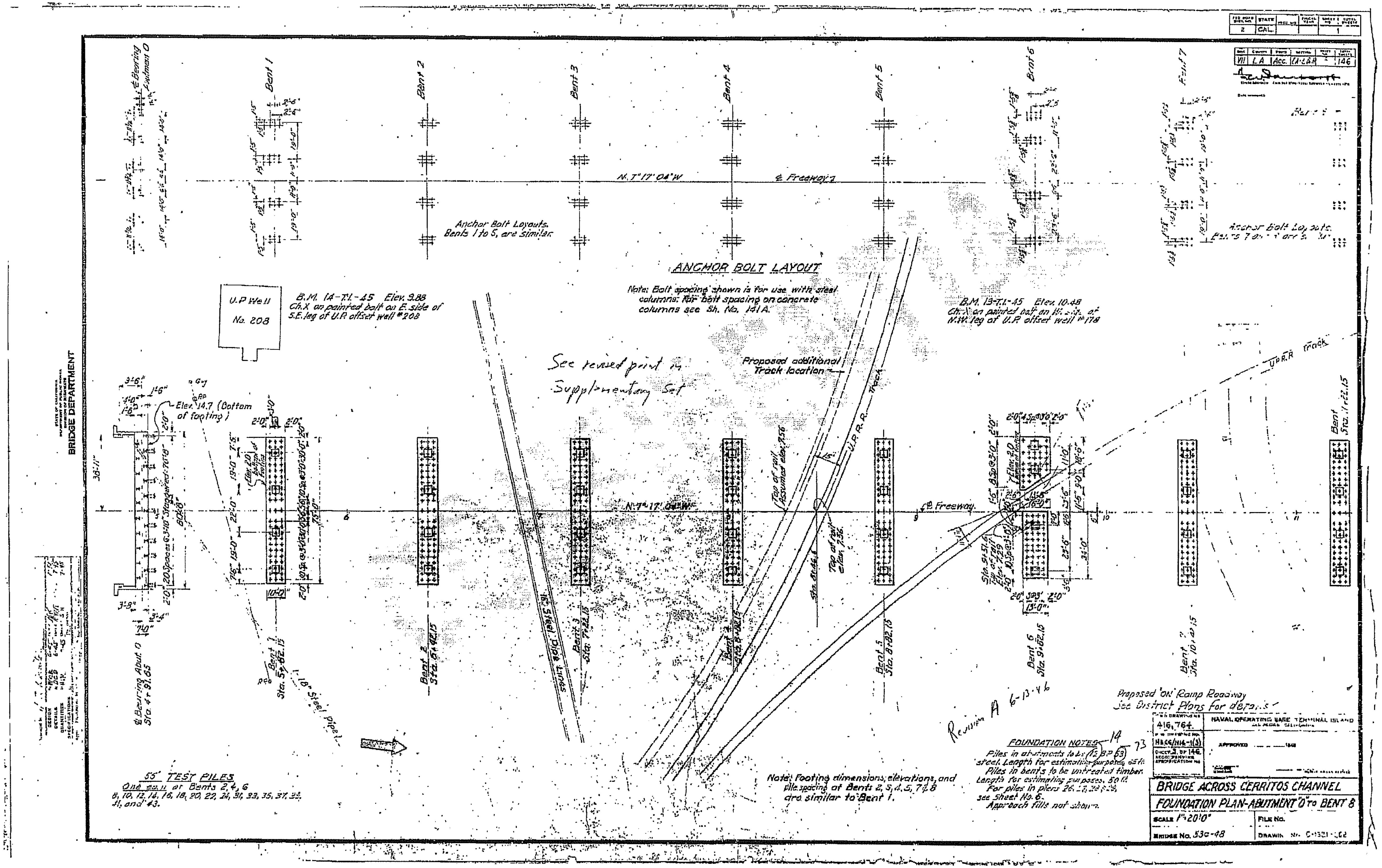
SCALE 1/4" = 1'-0"

FILE No.

BRIDGE No. 53C-48

DRAWING No. C-1531-332

BRIDGE DEPARTMENT



Bent 1
Bent 2
Bent 3
Bent 4
Bent 5
Bent 6
N. 7°17' 04" W
℄ Freeway
Anchor Bolt Layouts. Bents 1 to 5, are similar.
ANCHOR BOLT LAYOUT
Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.
U.P. Well No. 208
B.M. 14-T.I.-45 Elev. 9.88
Ch. X on painted bolt on E. side of S.E. leg of U.P. offset well #208
B.M. 13-T.I.-45 Elev. 10.48
See revised print in Supplementary Set
Proposed additional Track location
U.P.R.R. Track
Elev. 14.7 (Bottom of footing)
20 Spaces @ 3'-10" Staggered = 76'-8"
℄ Bearing Abut. 0 Sta. 4+91.65
Bent 1 Sta. 5+62.15
Bent 2 Sta. 6+42.15
Bent 3 Sta. 7+22.15
Bent 4 Sta. 8+02.15
Bent 5 Sta. 8+82.15
Bent 6 Sta. 9+62.15
16" Steel pipe
55' TEST PILES
One each at Bents 2, 4, 6
8, 10, 12, 14, 16, 18, 20, 22, 24, 31, 33, 35, 37, 39, 41, and 43.
Note: Footing dimensions, elevations, and pile spacing at Bents 2, 3, 4, 5, 7 & 8 are similar to Bent 1.
FOUNDATION NOTES
Piles in abutments to be 12 BP 53 steel. Length for estimating purposes 65 ft.
Piles in bents to be untreated timber. Length for estimating purposes, 50 ft.
For piles in piers 26, 27, 28 & 29, see Sheet No. 6.
Approach fills not shown.
Revision A 6-13-46
Proposed 'ON' Ramp Roadway
See District Plans for details
BRIDGE DEPARTMENT
416,764
NBGS/N14-1(3)
Sheet 3 of 146
NAVAL OPERATING BASE TERMINAL ISLAND
APPROVED
BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLAN-ABUTMENT "0" TO BENT 8
SCALE 1" = 20'-0"
FILE NO.
BRIDGE No. 53c-48
VII LA Acc. 146

FED. ROAD DIST. NO.	STATE	ROUTE NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	SECTION	SHEET	TOTAL SHEETS
VII	LA	Acc. LA-LBK		# 1146	

BRIDGE DEPARTMENT

"OFF" ABUTMENT 5

"OFF" BENTS 1-4 INCL.

BENTS 9-16 INCL.

"ON" ABUTMENT 6

"ON" BENTS 1-5 INCL.

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.

SERVICE ROAD PLAN
SCALE 1"=50'

"OFF" RAMP

"ON" RAMP

Drainage Ditch

Note: Footing dimensions, elevation, and pile spacing for Bents 10, 11, 12, 13, 15, & 16 are similar to Bent 9.
Footing dimensions and pile spacing for OFF Abutment 5 are similar to ON Abutment 6.
Footing dimensions, elevation, and pile spacing for ON Bents 2, 3 & 4 and OFF Bents 3 & 4 are similar to ON Bent 5 except as noted.

"OFF" PILES
One row in lieu of 2 of ON Ramp
Two rows in lieu of OFF Ramp
Piles along Freeway

7-6-46	MEAS SPAN LENGTH AS OF 7-19-46
6-24-46	CHANGE SIZE OF PILE ABUT. W
6-17-46	SERVICE ROAD ADDED
REV. DATE	DRIFF

NAVAL OPERATING BASE TERMINAL ISLAND
SAN PEDRO, CALIFORNIA

FOUNDATION PLAN-BENTS 9, 10 & 16

SCALE 1"=10'-0" | FILE No.

BRIDGE No. 530-48 | DRAWING No.

RECORD DRAWING
SHEET 1 OF 122
SEE LETTER NOV DATED 7-18

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20001372

MICROFILMED
MAR 3 0 1976

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATED 5/20/16 SIGNED

FED. ROAD DIST. NO.	STATE	ROUTE	SHEET NO.	TOTAL SHEETS
2	CAL.			

DIST.	COUNTY	ROUTE	POST MILES	SHEET NO.	TOTAL SHEETS
271	SD	14	24.55	5	162

± OFF Bent 2 ± OFF Bent 1 ± Bent 17 ± Bent 18 ± Bent 19 ± Bent 20 ± Bent 21 ± Bent 22 ± Bent 23

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing of concrete columns see Sh. No. 1414.

RECORD DRAWING
SHEET 5 OF 162
SEE LETTER NOV 13 1951 DATED 11/10/49

BRIDGE DEPARTMENT

Throw track 1" ± Existing Railroad Tracks

± Relocation of Railroad tracks

Throw tracks to top of rail Elev.

Off Ramp Sta. 5+24.55 = Freeway Sta. 22+03.10
L On Ramp Sta. 0+00

℄ OFF RAMP

℄ OF FREEWAY

℄ ON RAMP

N 3°32 04" W

N 7°17'04"W

S.M. 10-71-45
Elev. 10.45
Ch. X on painted bolt on S.W. side of S.Wly leg of U.P. offset well #81.

BM. 11-71-45
Elevation 8.02
Ch. X on painted bolt on W. side of S.W. leg of U.P. well #99.

U.P. Offset Well No 99

Note: Concrete Columns only to be skewed 50° from ℄ Bent 6 following locations:
Column 1, Bent 19
" 2, " 20
" 3, " 21
" 4, " 22

U.S. DRAWING NO.	NAVAL OPERATING BASE, TREASURE ISLAND, SAN FRANCISCO, CALIFORNIA
416,766	
1855/N14-1(5)	APPROVED Apr 7 1942
SHEETS 5 OF 146	

Power L.P.	□
Telephone L.P.	○
Power O.H. Line	

BRIDGE ACROSS CERRITOS CHANNEL	
FOUNDATION PLANS - BENTS 17 to 25	
SCALE 1" = 20'	FILE NO.
BRIDGE NO. 53C-48	DRAWING NO. C-1321-2042

MICROFILMED MAR 3 0 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 7000 7372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/96

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FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	STATION	SHEET NO.	TOTAL SHEETS
VII	SD	[illegible]	[illegible]	6A	162

BRIDGE DEPARTMENT

NOTE
[illegible]

U.G. H.C.
Storm drain cables
Telephone lines
Power lines

DRILL 24" ø HOLES THRU TIMBER BULKHEAD

ELEV A-A
1/2" = 1'-0"

2" WATER METER & ASSY TO BE INSTALLED BY LALIT DEPT OF WATER & POWER

See Sh. #198

EXIST. SCC SIDEWALK 28'-0" L.F., REPLACE CONCRETE WALK AFTER INSTALLATION

INSTALL 2" GALV. PIPE FROM METER TO 12" RISER PIER 26, SEE SHEETS Nos 9 & 84 FOR LOCATION.

PIPE EXPOSED FROM RISER TO 8" Ø

P.E.R.R.

Existing Bar [illegible]

RE-BASE LINE

N 89°51'51" W

U.P.R.R.

8" GAS LINE

East [illegible]

Sta. 27 + 30.15 ℄ Pier 27

Sta. 25+65.79 ℄ Pier 25

Elson Co. Cab.

Elev. -5.0 Bottom of Casing
Elev. -7.0 Assumed bottom of trench sect.

205.920

See Sh. #198

101.080

272.000

205.920

2-8" Rawen conduits enter Pier 26. See Structural Plan & Elev. Sht. Y & Detail No. 41 ETTA Rev. 8.

CONNECT TO 12" RISER EL. EL. 4.5

Existing Swing Bridge on Navy Road [illegible] obstacles to be removed.

W.U. & U.P.R.R. Submarine Cable 26 Feet

Sta. 25+65.79 ℄ Pier 25

Sta. Cor. Erikson [illegible]

2-2'-0 Sq. Anchor Bolts 1'-10 per Anchor

Existing Timber Fender System

Permanent steel bulkhead

See Sheet 91 for details

180' Min.

RECORD DRAWING
SHEET 6 OF 162
SEE LETTER NOV 13195 DATED 1/10/44

8-23-46	Added 2" Water & Fence-strike note, Revised		
18-9-46	REVISED TIDELAND'S PIER 26&27		
17-19-46	MEAS. SPANS ON TH "AS OR" 11-48		
P.W.D. DRAWING NO.	416 767	NAVAL OPERATING BASE, TERMINAL ISLAND	
P.W. ENGINEER	NB 66 (A14-16)	APPROVED [illegible]	
SHEET 6 OF 162 SHEETS			
1-2-47 Cross Ch Distance			
10-17-46 CHANGE 2 WATER LINE LOCATION-SK 105			

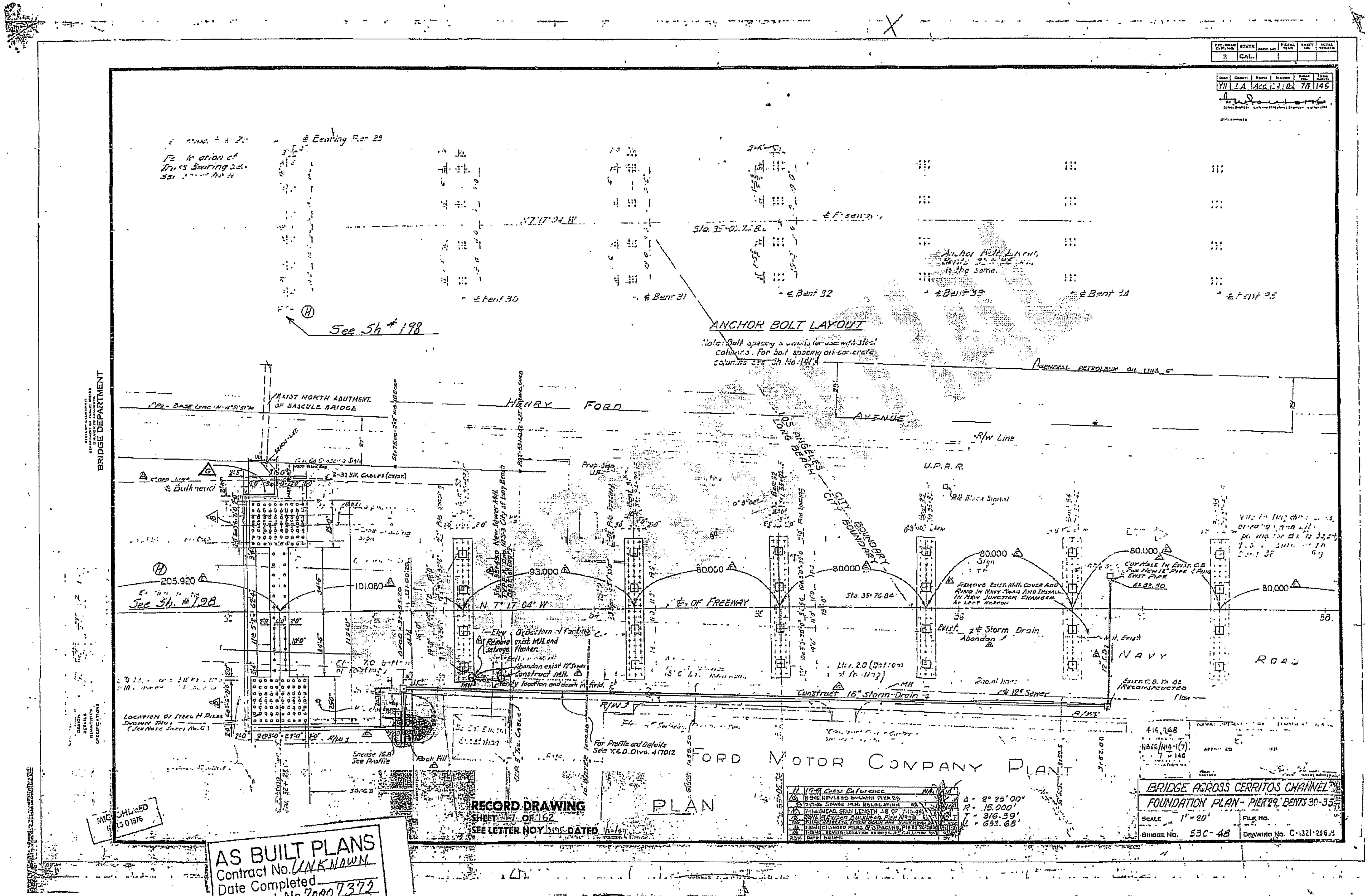
BRIDGE ACROSS LEARY'S CHANNEL
FOUNDATION PLAN - PIERS 25 TO 28
SCALE 1" = 20'-0" | FILE No.
BRIDGE NO. 53C-43 | DRAWING NO. C-13211-E95

MICROFILMED
MAR 01 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THE DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 3/30/76 [illegible]



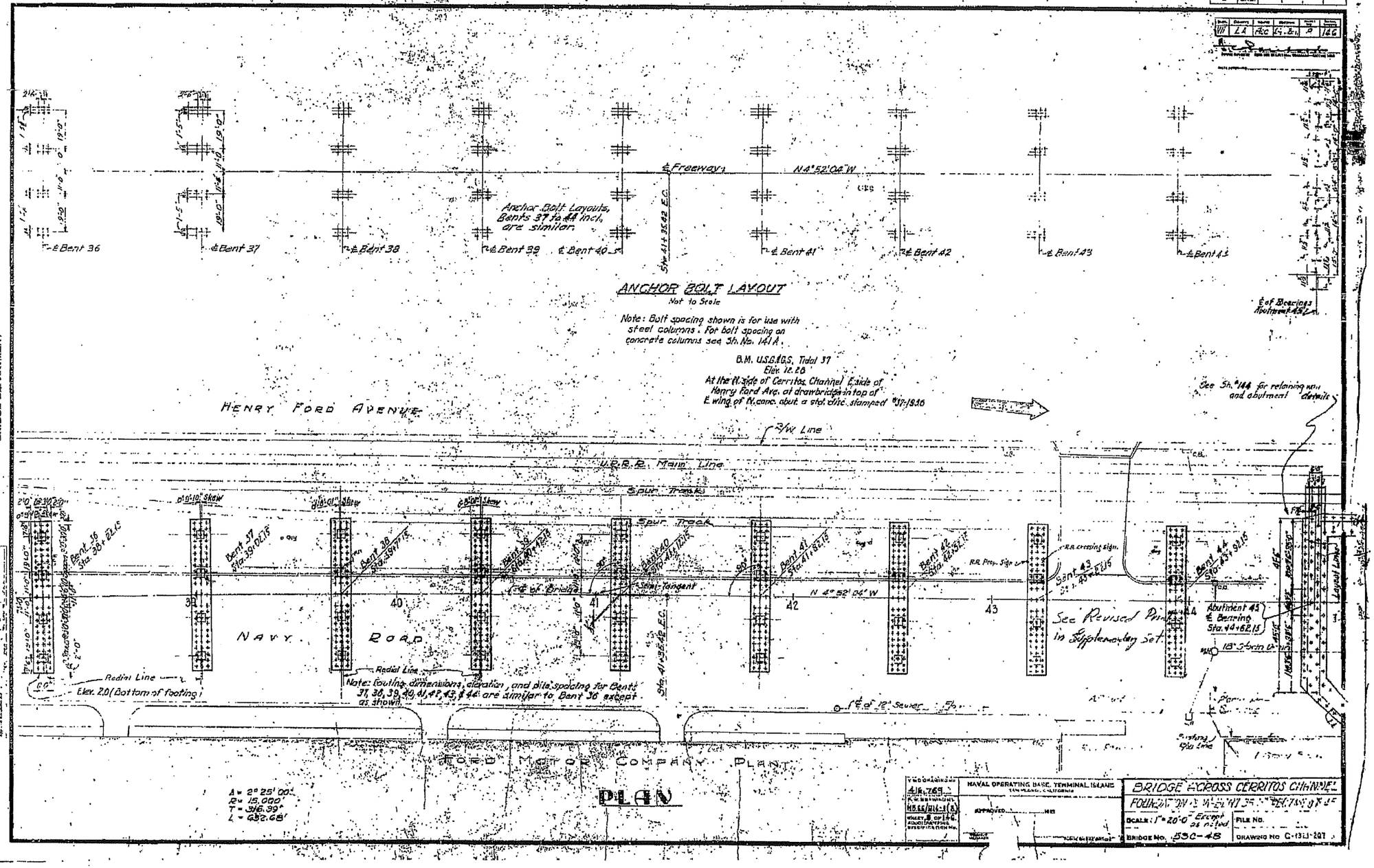
I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

5/30/16

CutePDF - www.fineprint.com

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
BRIDGE DEPARTMENT

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	LA	Acc	14.8-A	9	166



DESIGN DETAILS CHECKED APPROVED	46-769	NAVAL OPERATING BASE, TERMINAL ISLAND, SAN PEDRO, CALIFORNIA
	46.66/214-1(8)	APPROVED ..... MS
	SHEET 8 OF 166 SHEETS DRAWING SPECIFICATION NO.	

BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLAN, PILE LAYOUT & DETAILS
SCALE: 1" = 20'-0" Except as noted
FILE NO.
BRIDGE NO. 53C-48
DRAWING NO. C-1321-207

CHIPDF - www.fastio.com

Appendix B. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No.: 96-1005

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (ME) Minimum Resistivity

N.S.R.= No sample recovery
OVM580S Gas Readings

PLAN
SCALE: 1"=40'

NORTH

BENT 9, CPT-5, BENT 11, CPT-6, BENT 12, "OFF" RAMP 5, B-2, CPT-7, "OFF" BENT 4, "OFF" BENT 3, CPT-8, "OFF" BENT 2, "OFF" BENT 1, BENT 18

BENT 10, "ON" RAMP 6, "ON" RAMP 5, "ON" BENT 4, "ON" BENT 3, "ON" BENT 2, "ON" BENT 1

PROFILE
HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

45° LT. STA. 12+82.50 — ELEV.= -0.68 — CPT-5 — 08-15-96

STA. 14+05.00 — ELEV.= -1.78 — CPT-6 — 08-15-96

STA. 15+63.50 — ELEV.= -1.66 — CPT-7 — 08-15-96

5° LT. STA. 15+51.50 — ELEV.= -1.54 — B-2 — GWS ELEV.= -5.54' 08-23-96 — 08-21-96

STA. 17+23.00 — ELEV.= -0.02 — CPT-8 — 08-15-96

N [blows/foot]

Vs (ft/s)

FILL-(SM)Brown fine SILTY SAND w/GRAVEL & shell fragments
(ML)Dark gray CLAYEY SILT w/roots, very soft
NATIVE-(SP)Gray fine SAND w/mica, slightly compact
(ML)Gray SILT w/traces of SAND, stiff
grades to SANDY, very soft
grades to w/SAND and shells
grades to SANDY
Increasing shells, stiff
grades to CLAYEY w/traces of mica
Decreasing in CLAY, soft
grades to CLAYEY w/mica
Decreasing in mica, very stiff
stiff
w/traces of SAND
interbedded w/ SANDY SILT
(SP)Gray fine SAND, dense
(ML/SM)Gray SANDY SILT
(SP)Gray fine SAND w/traces of SILT
grades to w/mica, decreasing in SILT, very dense
traces of SILT
traces of GRAVEL, 0.5" dia.
w/o GRAVEL
grades to fine to medium
grades to fine to medium w/traces of GRAVEL
grades to w/traces of SILT
(ML)Gray SANDY SILT
(SP)Gray fine SAND, very dense
grades to medium to coarse w/GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND, 3/8" max. dia.
(SP)Gray fine SAND w/GRAVEL
Decreasing in GRAVEL
(ML)Dark gray SILT w/decomposed wood & mica
(SP)Gray fine to medium SAND w/1.5" GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND
(ML)Dark gray SILT w/SAND
(SM)Dark gray fine to medium SILTY SAND w/traces of CLAY
(ML)Gray SILT w/SAND

PENETROMETER TEST — ELECTRONIC CONE
PENETRATION BORING — 2½" CONE
ROTARY SAMPLE BORING (WET)
SAMPLE BORING (DRY)

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SEDIMENTARY ROCK, METAMORPHIC ROCK, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS according to the Standard Penetration Test

Penetration Index (Blows/ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
70	Very dense	Very hard

NOTE: Classification of earth materials as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERNIGHT	DRAWN BY	NL	08-LN-MC	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	
	CHECKED BY	MR	FIELD INVESTIGATOR		PROJECT ENGINEER
BACK OFF DATE			DATE 09-15-96		

BRIDGE NO.	53-2618
POST MILE	9.58

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO.2

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY) 4/16/97 9/23/97

SHEET 142 OF 148

C:\CADDV\GV\JOB\LKR\LTBBDR 9-15-96 11:45:15 am EST

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

PLAN

SCALE: 1"=40' NORTH

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity
- N.S.R.= No sample recovery
- OVM5608 Gas Reading

"ON" BENT 1, BENT 17, "OFF" BENT 1, BENT 18, BENT 19, CPT-10, BENT 20, BENT 21, BENT 22, B-3, CPT-11, BENT 23, BENT 24, CPT-12, BENT 25, CPT-15, BENT 26

CPT-9

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

STA. 18+85.00, ELEV.= -1.77, CPT-9, 08-19-96
70' Lt. STA. 20+24.00, ELEV.= -1.10, CPT-10, 08-15-96
13' Rt. STA. 22+25.00, ELEV.= 1.89, CPT-11, 08-16-96
STA. 22+25.00, ELEV.= 1.89, GWS ELEV.= -5.61, 08-26-96, B-3, 08-19-96
8' Lt. STA. 23+98.00, ELEV.= 8.42, CPT-12, 08-19-96

N [blows/foot] Vs (ft/s)

2" of AC
FILL: (SP)Brown fine SAND w/SILT
(SM)Gray fine SILTY SAND w/mica, wood fragments
(ML)Dark brown CLAYEY SILT w/wood fragments, soft petroleum odor, very soft, traces of SILTY SAND & mica
(SP)Dark gray fine SAND w/traces of wood & mica, SILT
NATIVE: (ML)Dark gray SANDY SILT w/traces of shell & mica, soft
Grades to CLAYEY, decreasing of shell
(SM)Dark gray fine SILTY SAND, w/mica
compact
(ML)Dark gray SANDY SILT w/CLAY, mica, & shell
grades to CLAYEY
Grades to SILT w/SAND & mica
stiff
decreasing of SAND
Grades to SANDY, very stiff
Grades to CLAYEY
(SP)Gray fine SAND w/SILT, dense
(ML)Gray SANDY SILT
(SM)Gray fine SILTY SAND, dense
(SP)Gray fine SAND
(ML)Gray SILT w/traces of SAND, hard
(SP)Gray fine SAND, very dense
grades to fine to medium
(ML)Gray CLAYEY SILT, very hard
(SP)Gray fine SAND, very dense
Traces of GRAVEL & sea shell
Grades to medium to coarse
traces of SILT
increasing of shell
(GP)Dark gray SANDY GRAVEL, 1.5" max. dia.
(ML)Gray SANDY SILT, very hard
(SP)Gray fine SAND w/SILT, very dense

PENETRATION BORING
2 1/2" CONE PENETRATION BORING
ELECTRONIC CONE PENETROMETER TEST
ROTARY SAMPLE BORING (WET)
SAMPLE BORING (DRY)

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS

Penetration (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Slightly stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
170	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERSIGHT	DRAWN BY	NL	CS-LN-MC	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	BRIDGE NO. 53-2618
BEM DPF DATE	CHECKED BY	MR	FIELD INVESTIGATOR DATE 09-15-93	PROJECT ENGINEER	POST MILE 3.58

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.3

DISREGARD PRINTS BEARING EARLIER REVISION DATES →
REVISION DATES (PRELIMINARY STAGE ONLY) 9/24/96

SHEET 14 OF 3148

CADDDWGS\TERN\KRNLTRBDR 8-15-96 1145:15 am EST

Appendix C. EarthSpectives SPT Hammer Energy Measurement Report

EARTHSPECTIVES
250 Goddard
Irvine, California 92618
Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

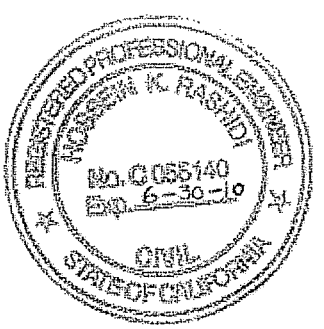
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

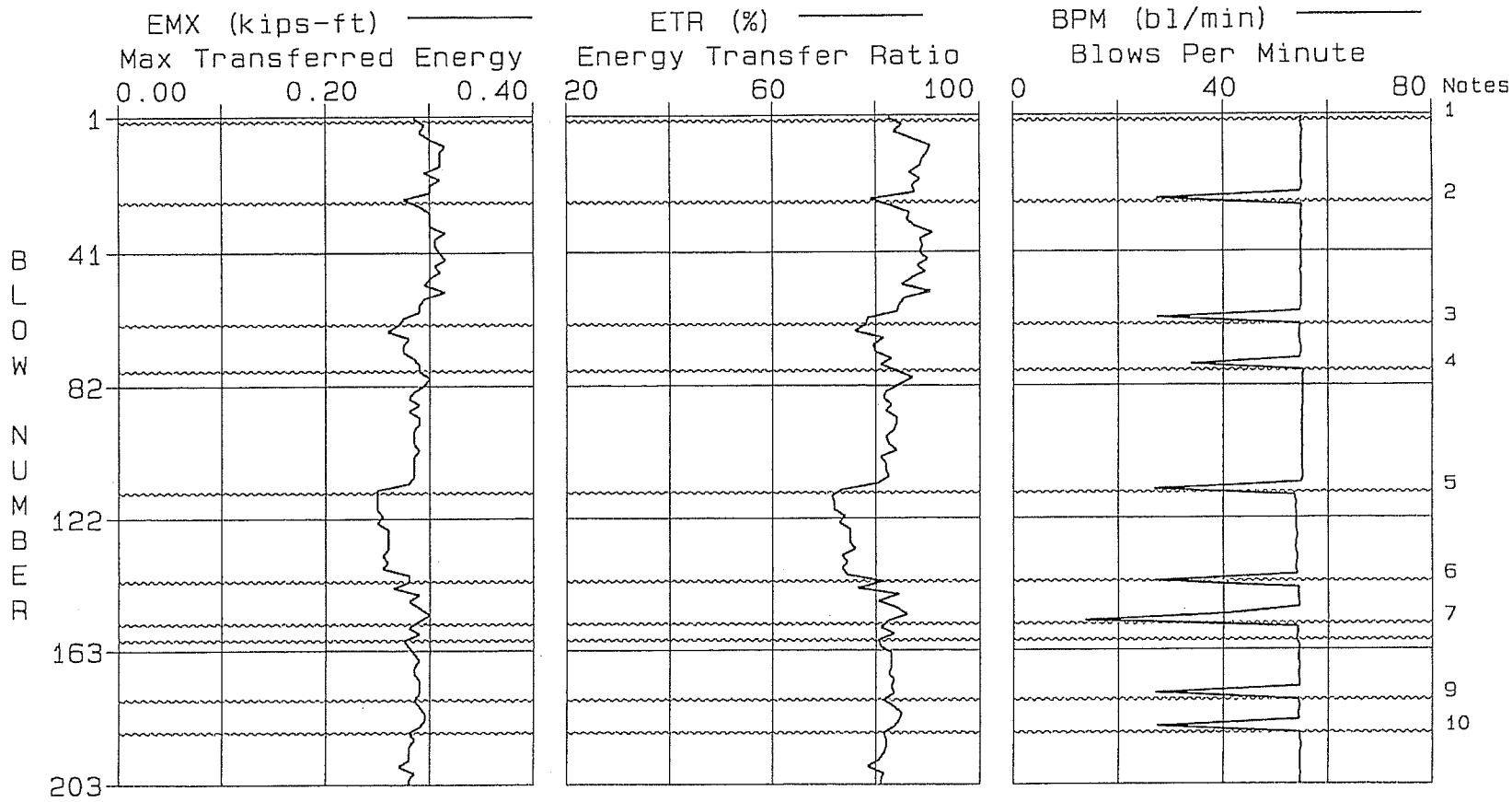
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

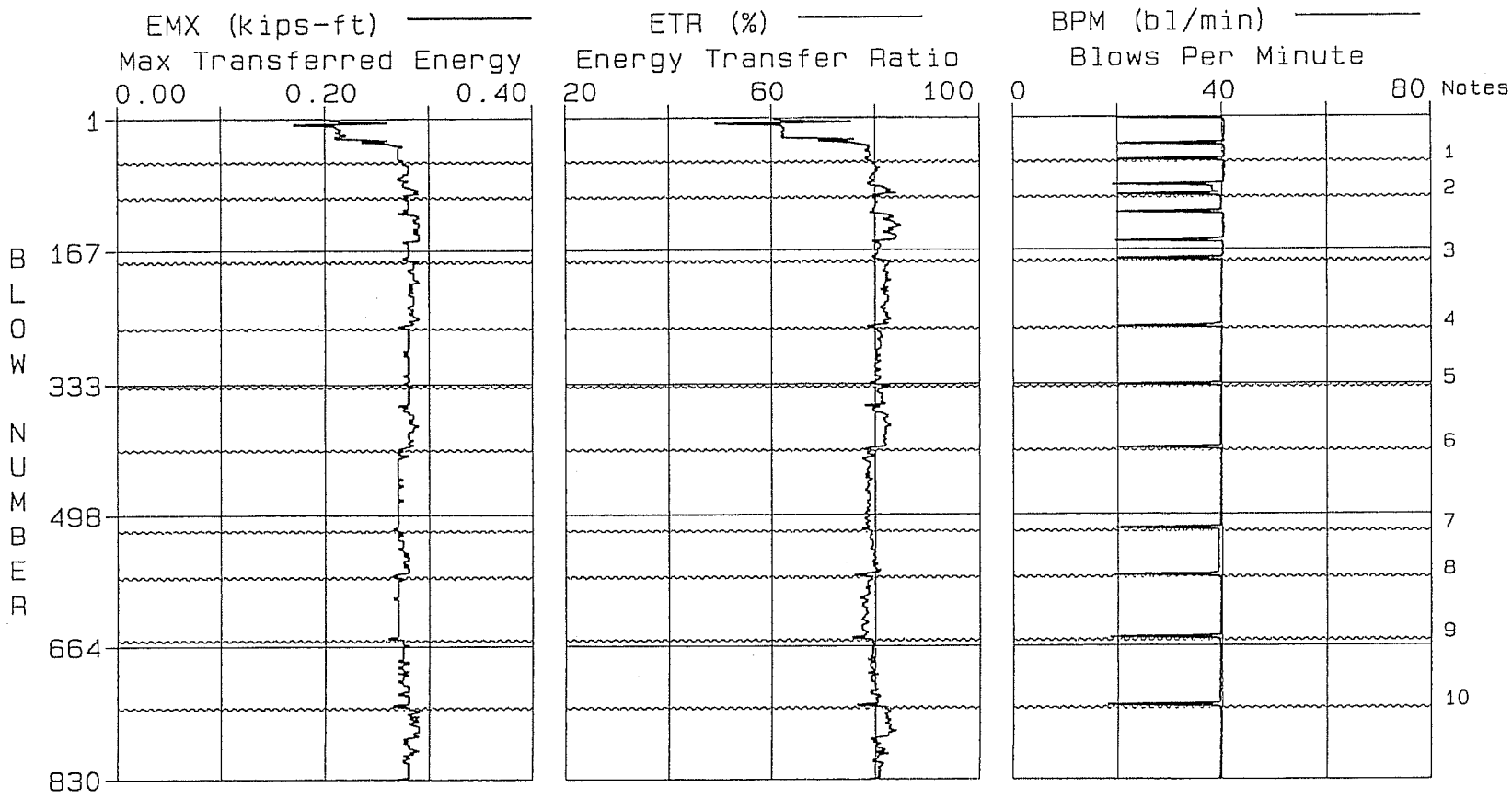
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

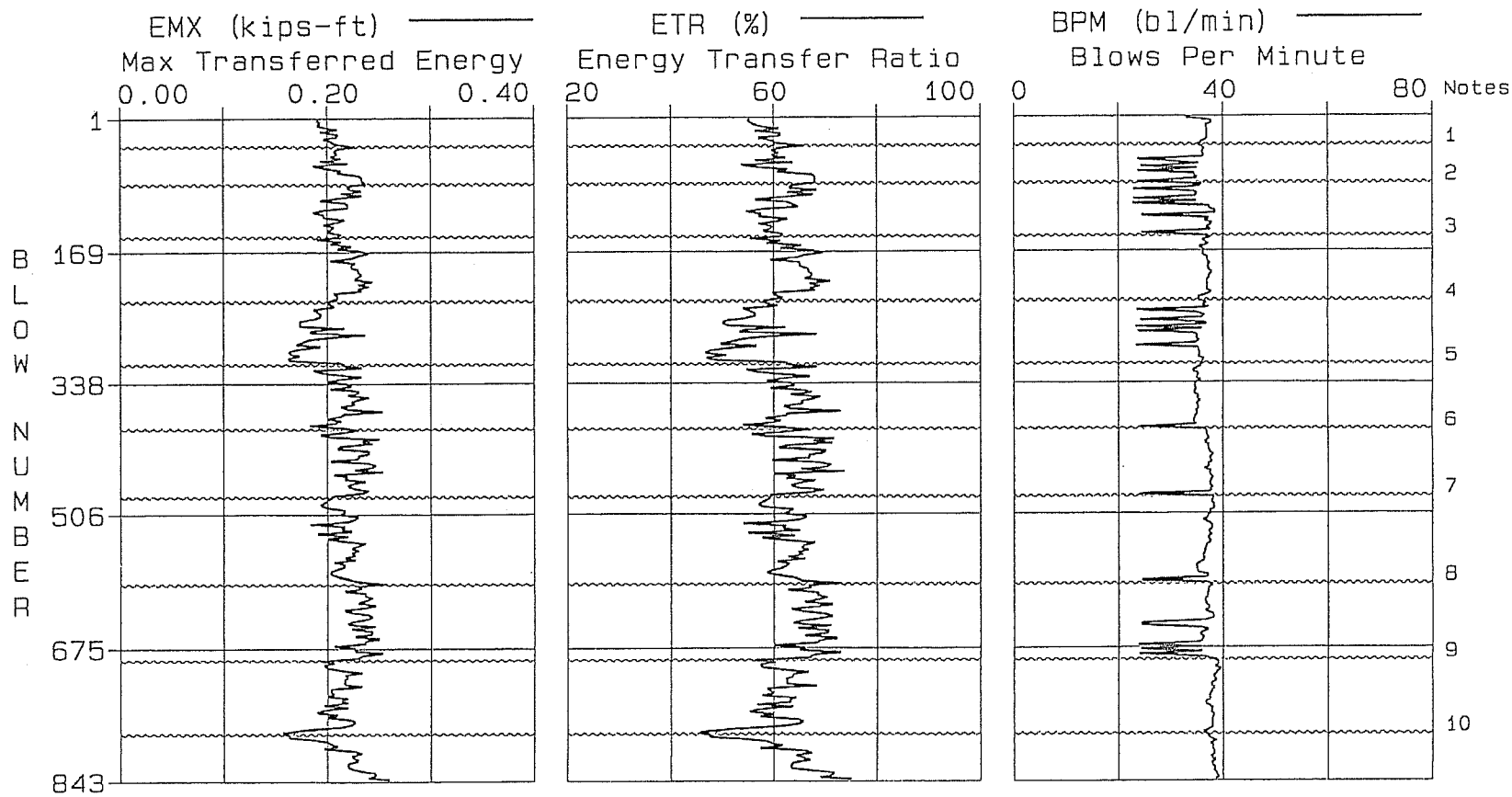
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009 Proj: ACTA HEIM BRIDGE PROJECT
Info: MUD ROTARY- rope and cathead SP: 0.492 k/ft^3
AR: 1.4 in^2 WS: 16808 ft/s
LE: 165.0 ft EM: 30000 KSI

EMX: Max Transferred Energy BPM: Blows Per Minute
ETR: Energy Transfer Ratio CSX: Max Measured C-Stress
E2F: UNDEFINED CSI: Max F1 or F2 C-Stress
EF2: Energy by F^2 Method TSX: Max Computed T-Stress
EV2: UNDEFINED

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

Appendix D. GeoVision Geophysical Investigation Report

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

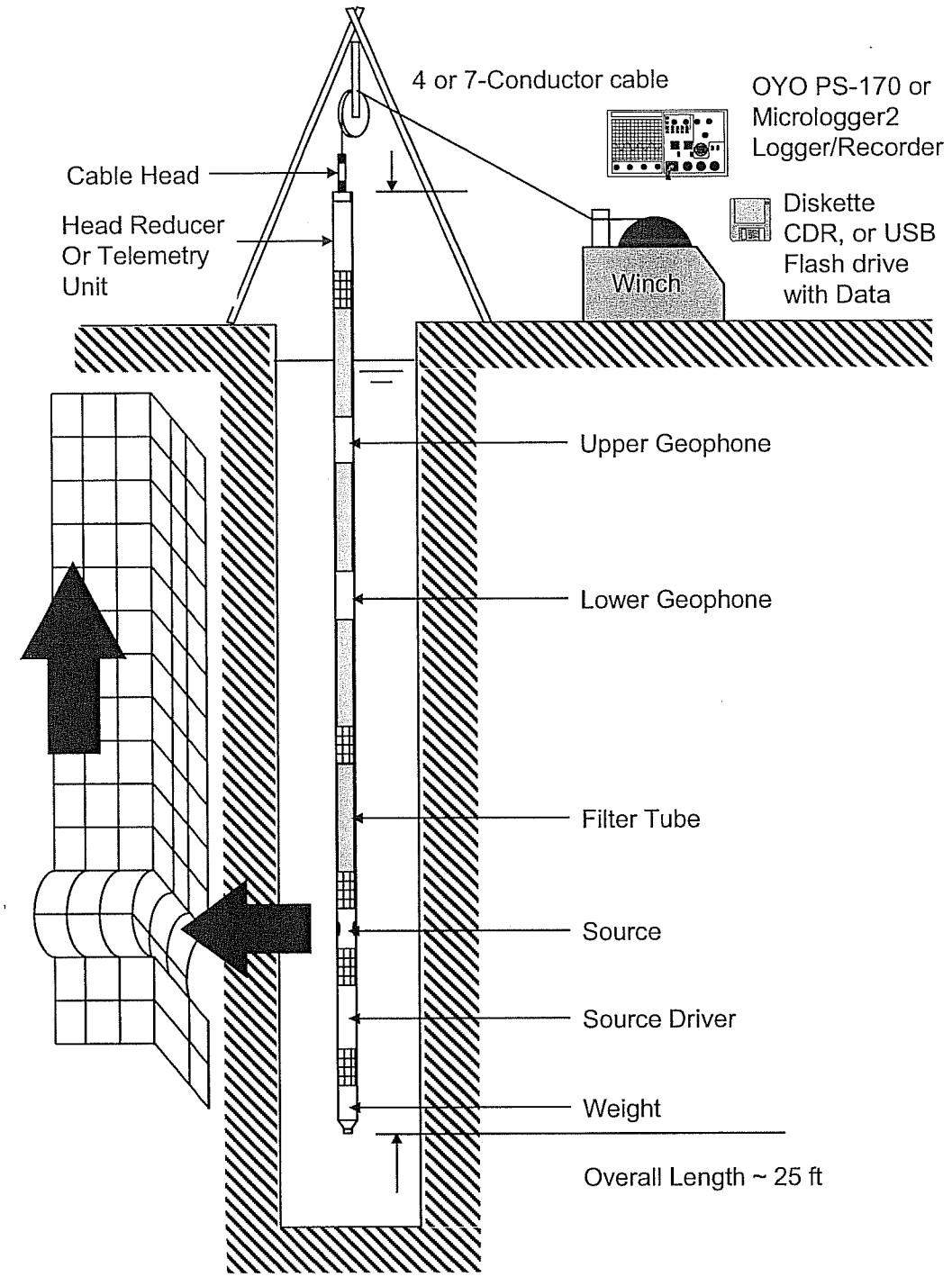

Figure 1: Concept illustration of P-S logging system

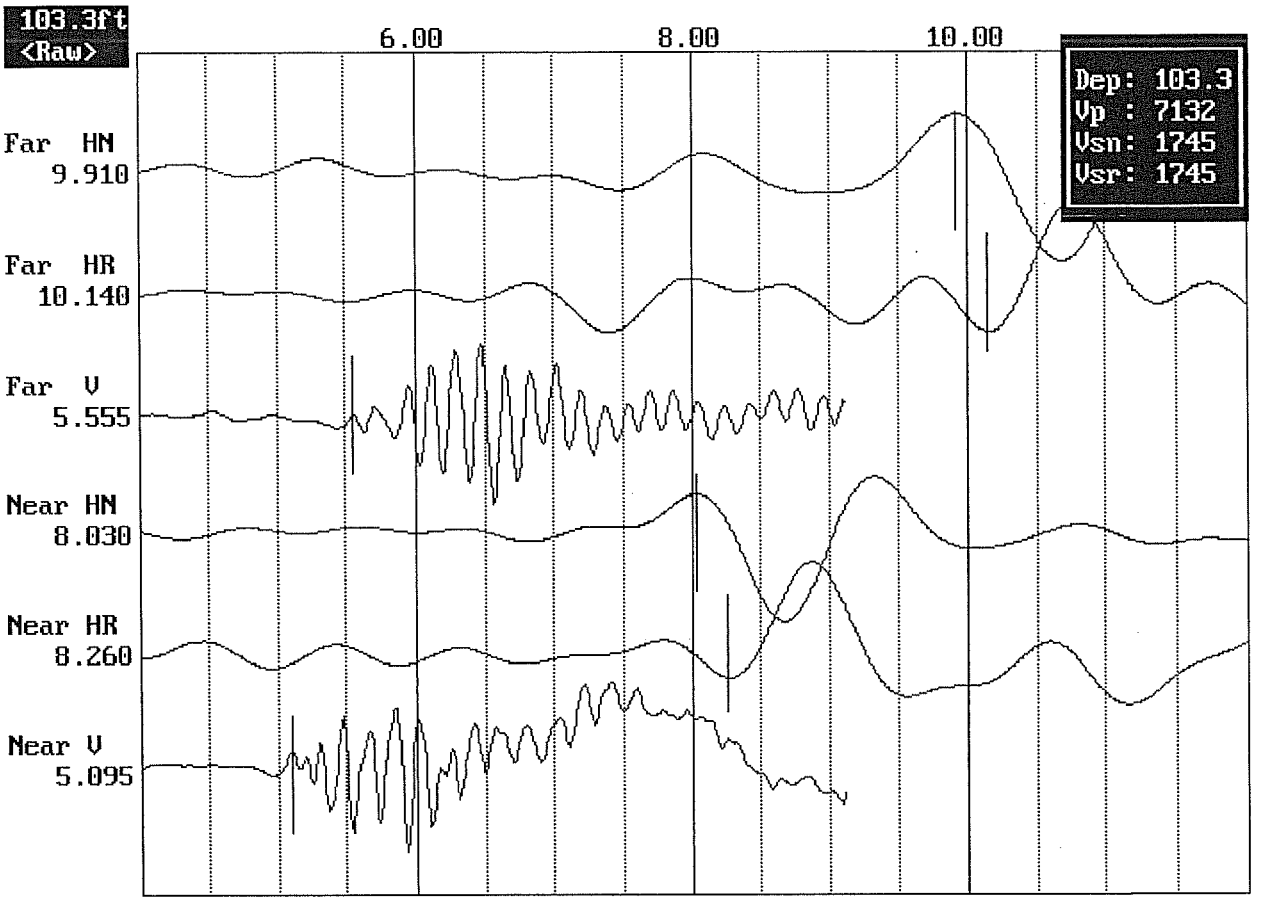

Figure 2: Example of filtered (1400 Hz lowpass) record

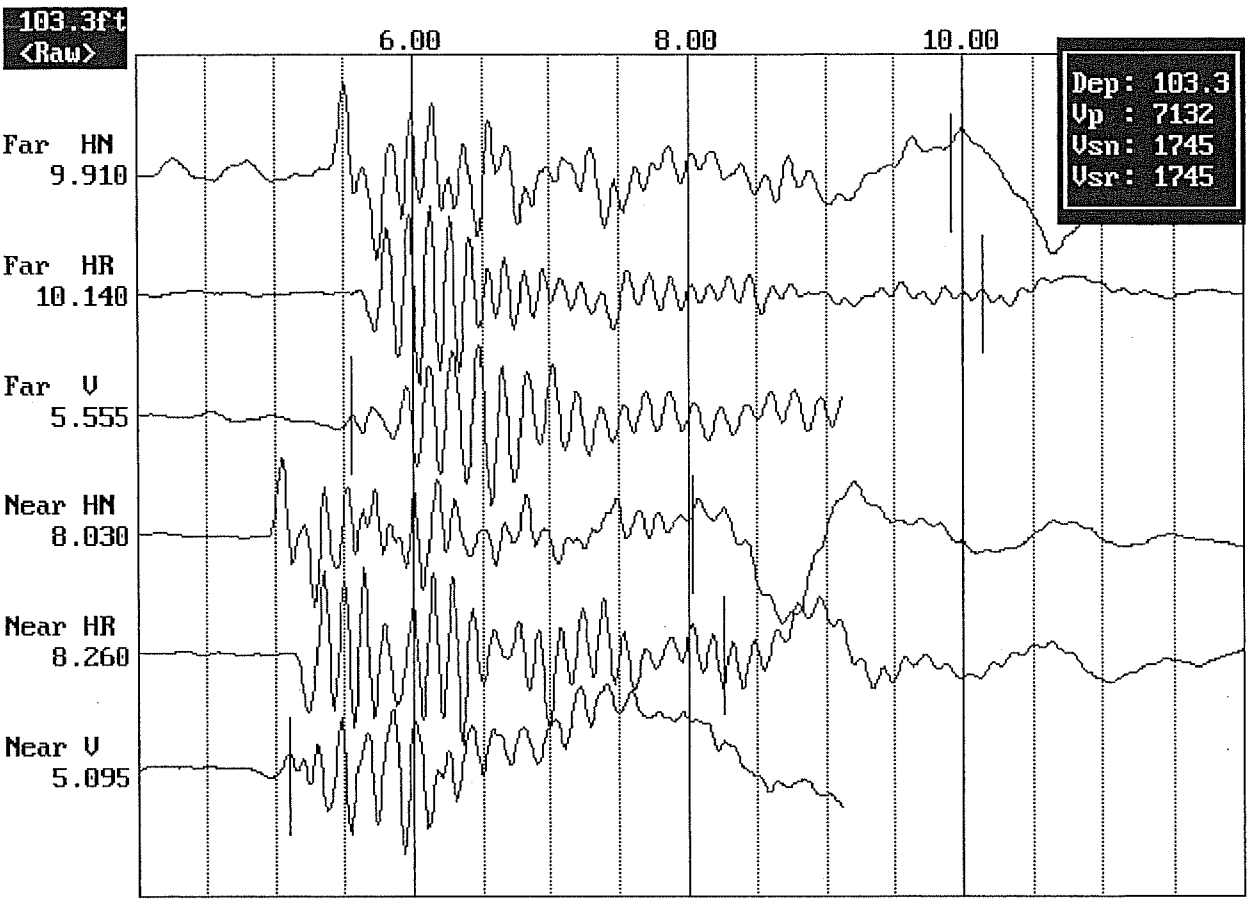

Figure 3. Example of unfiltered record

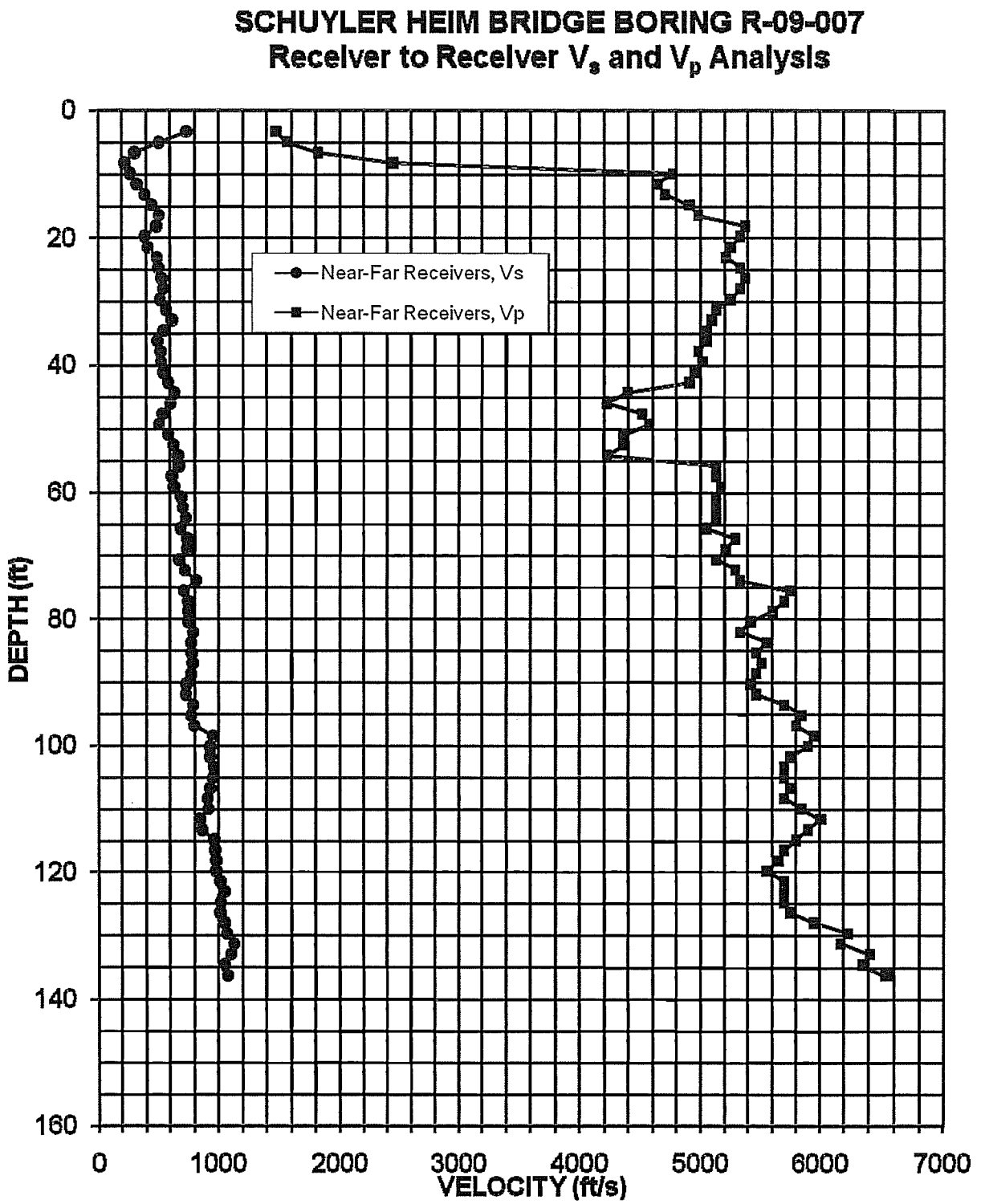

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

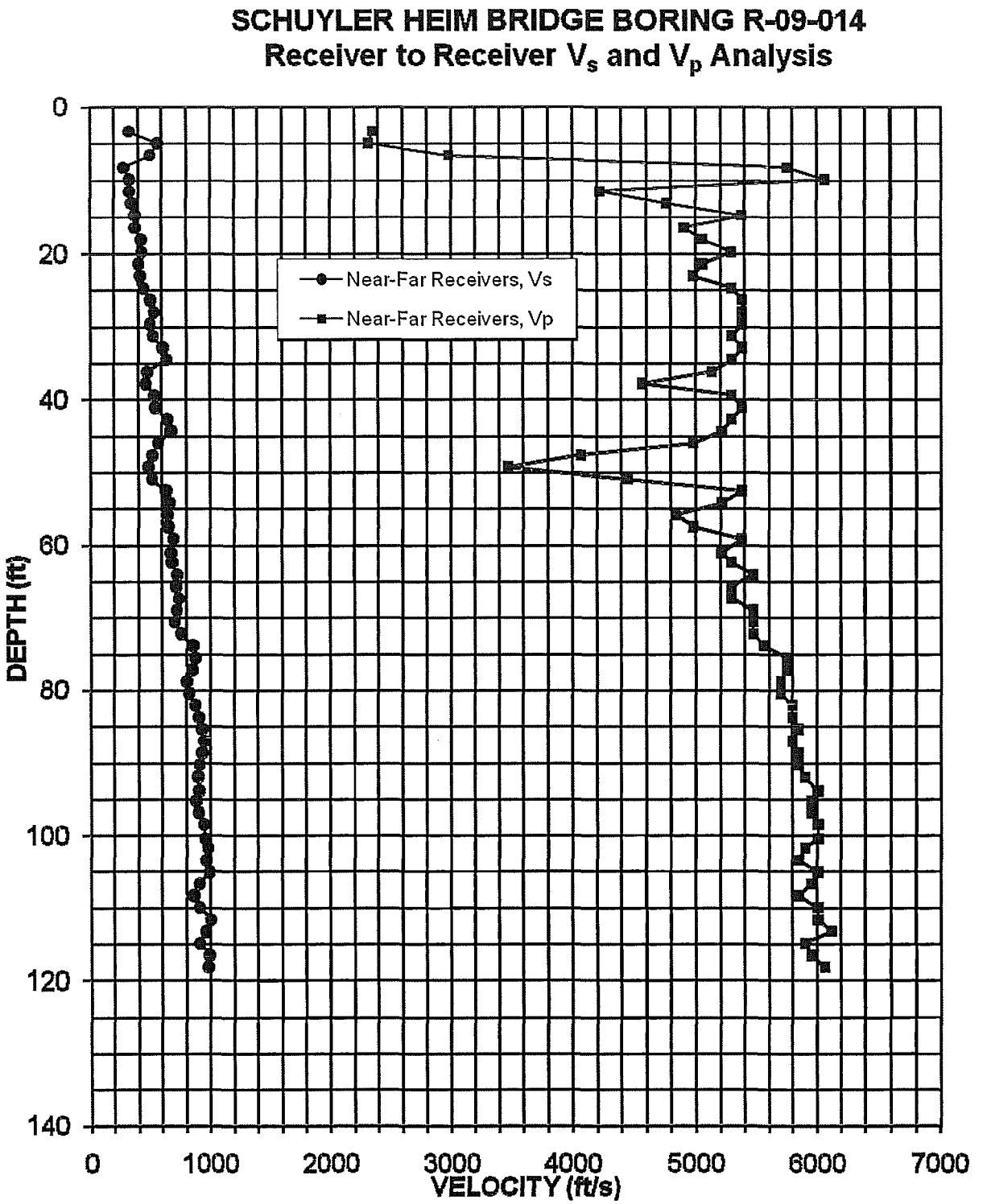

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

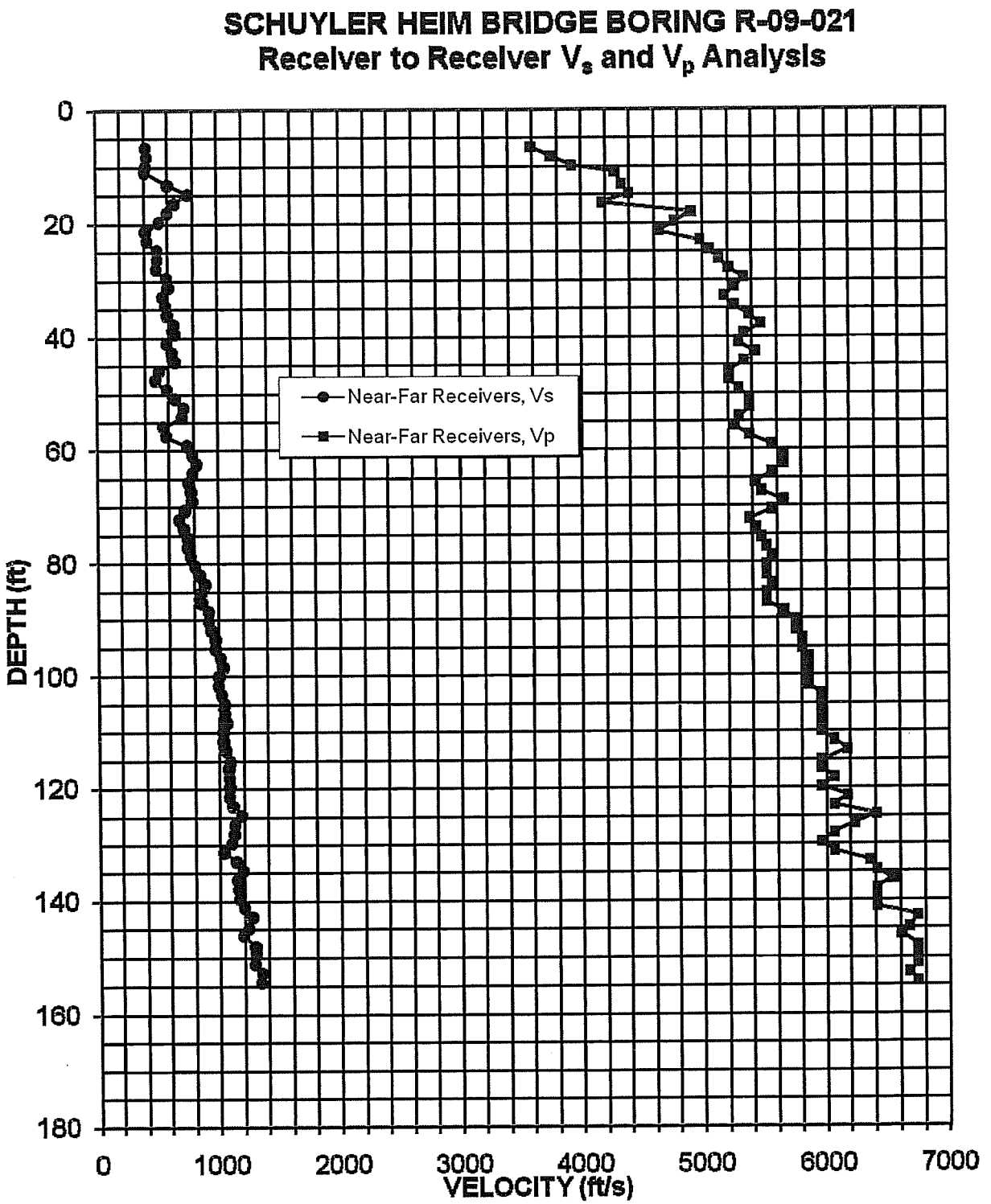

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

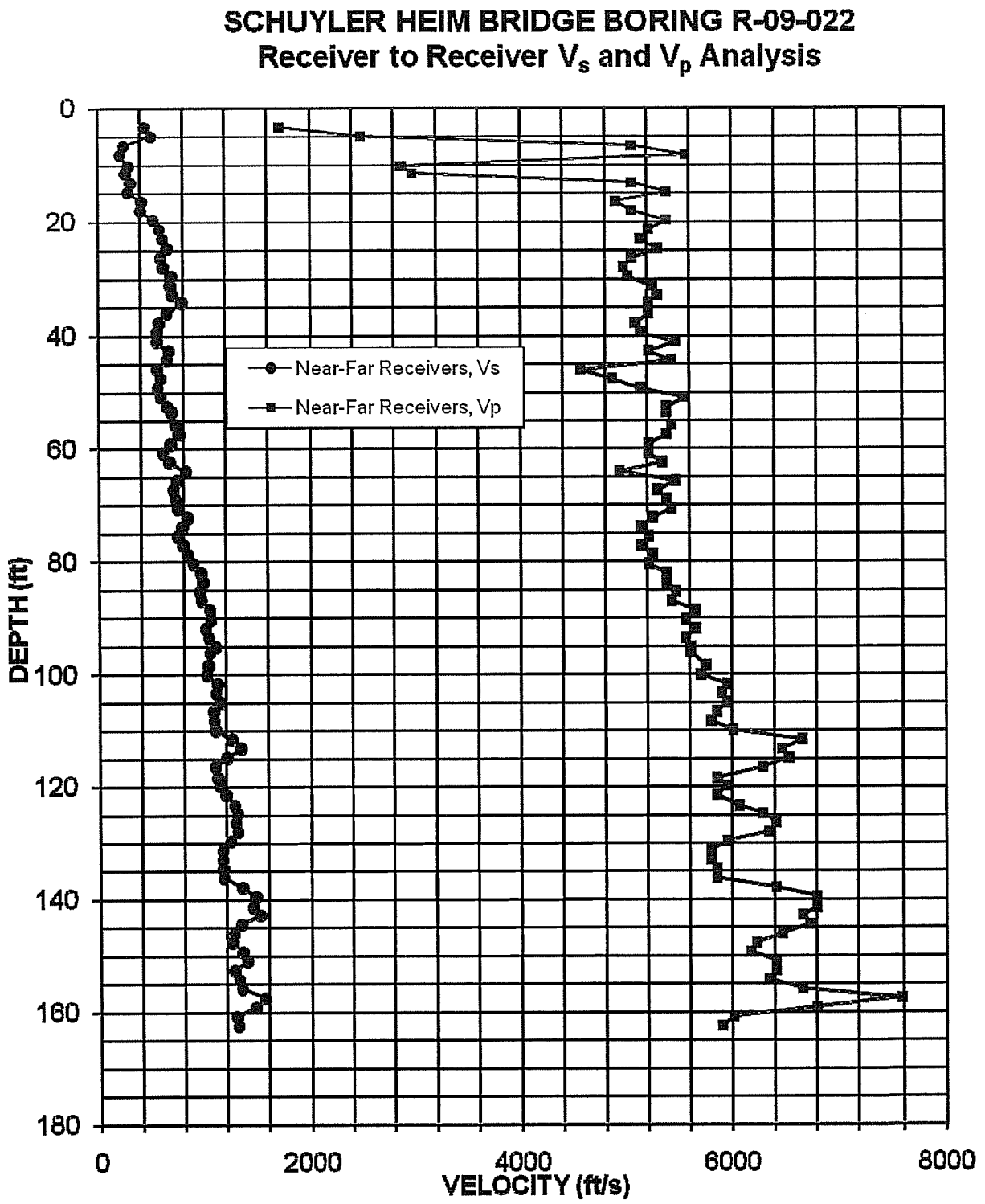

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

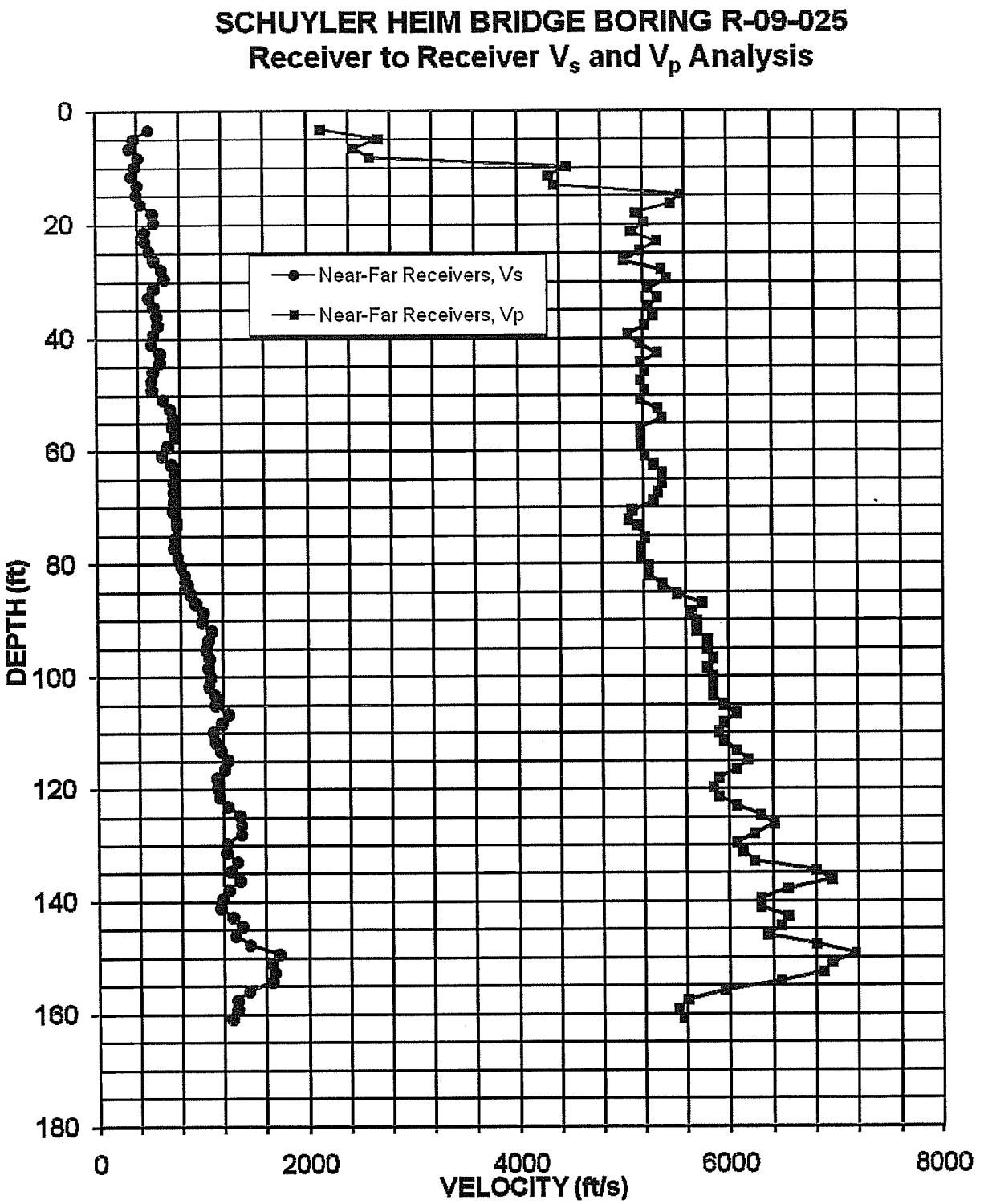

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

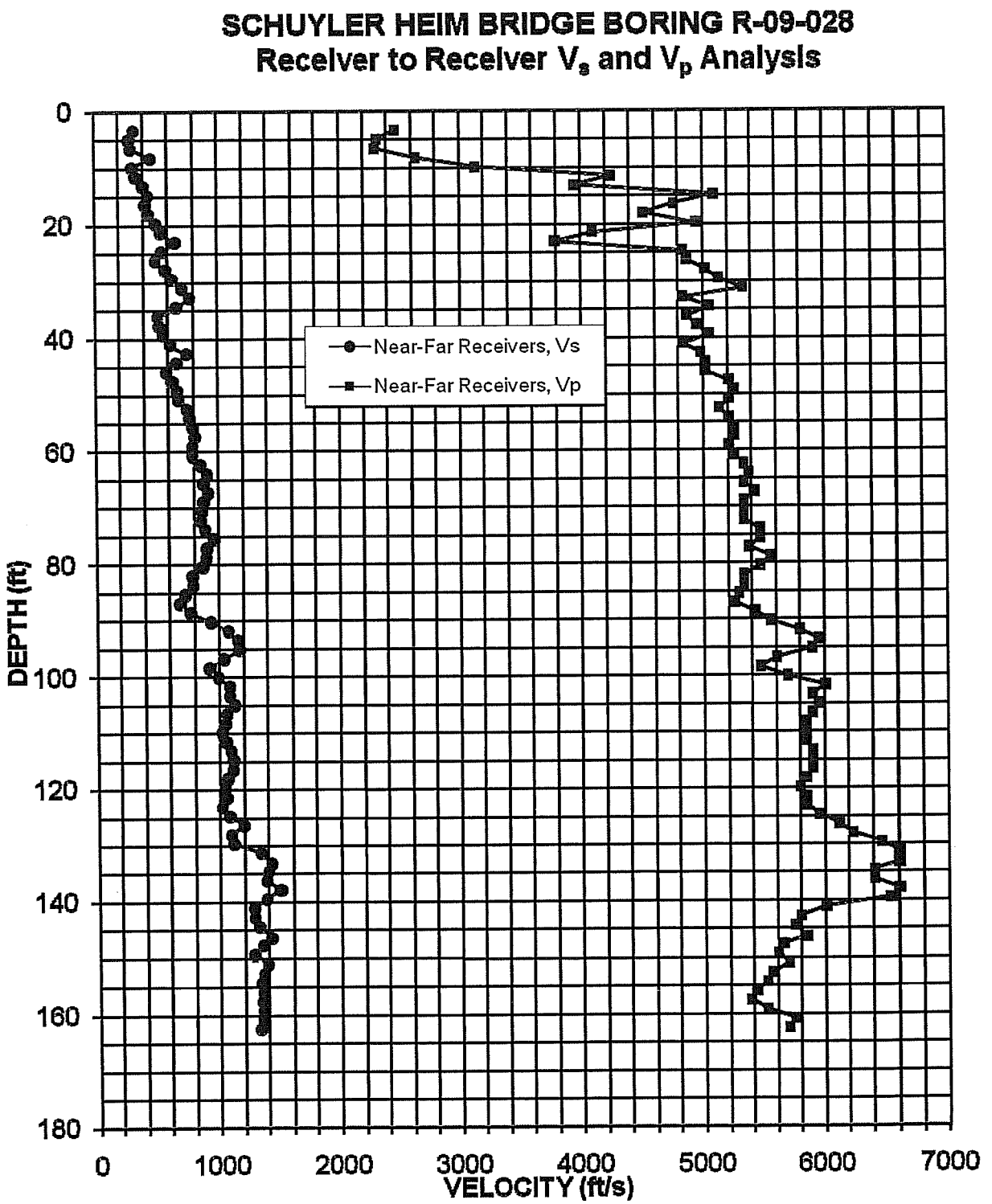

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

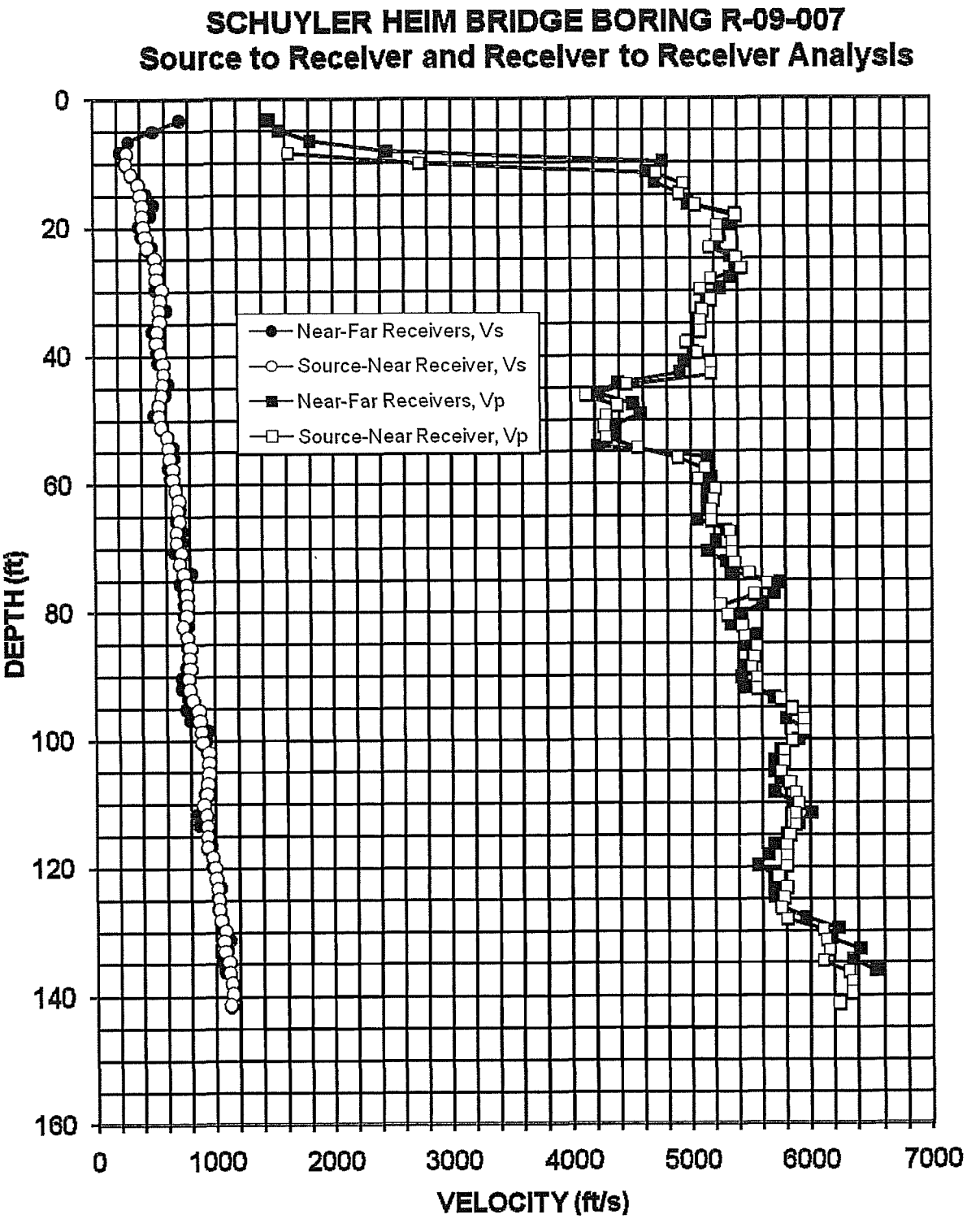

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

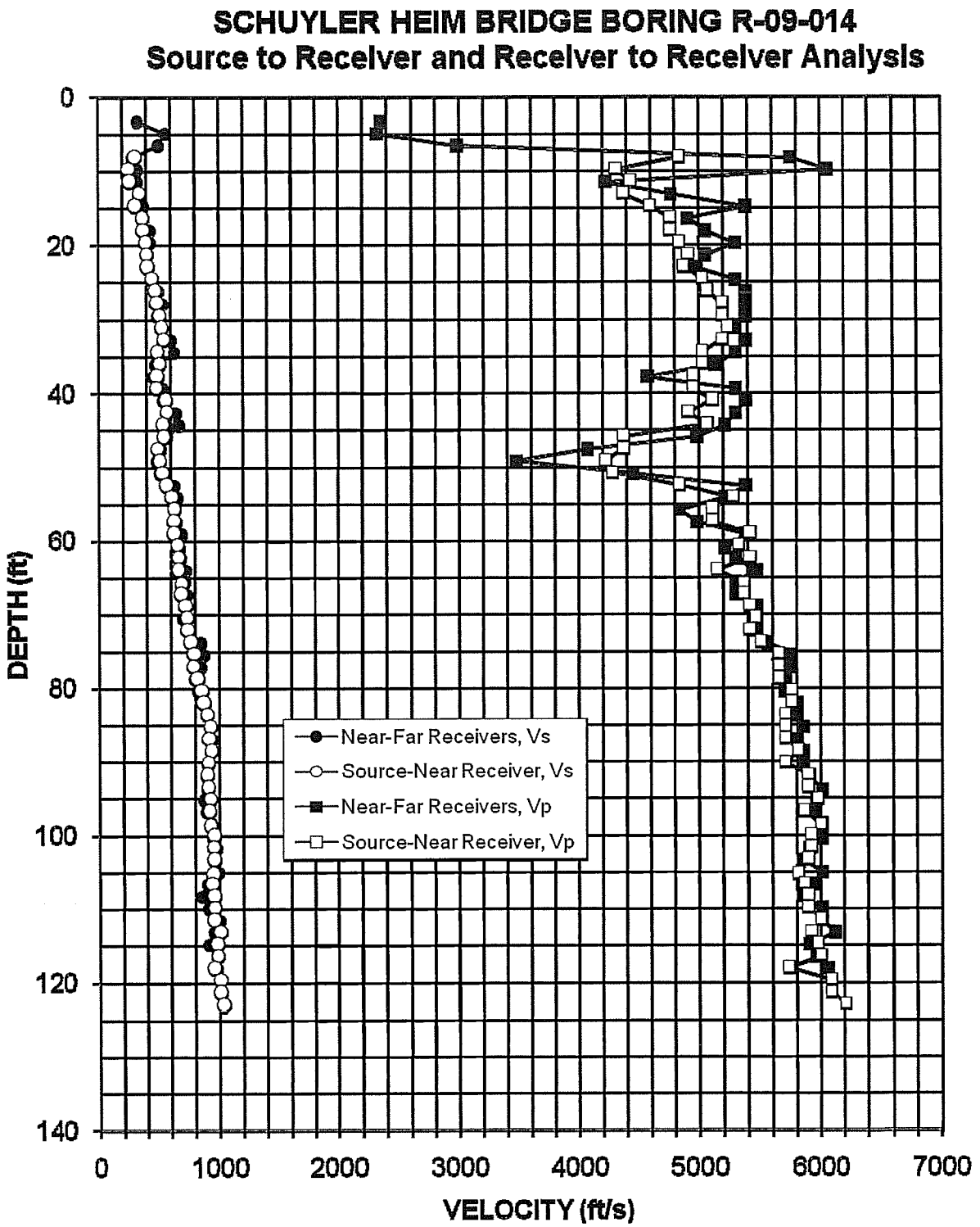

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

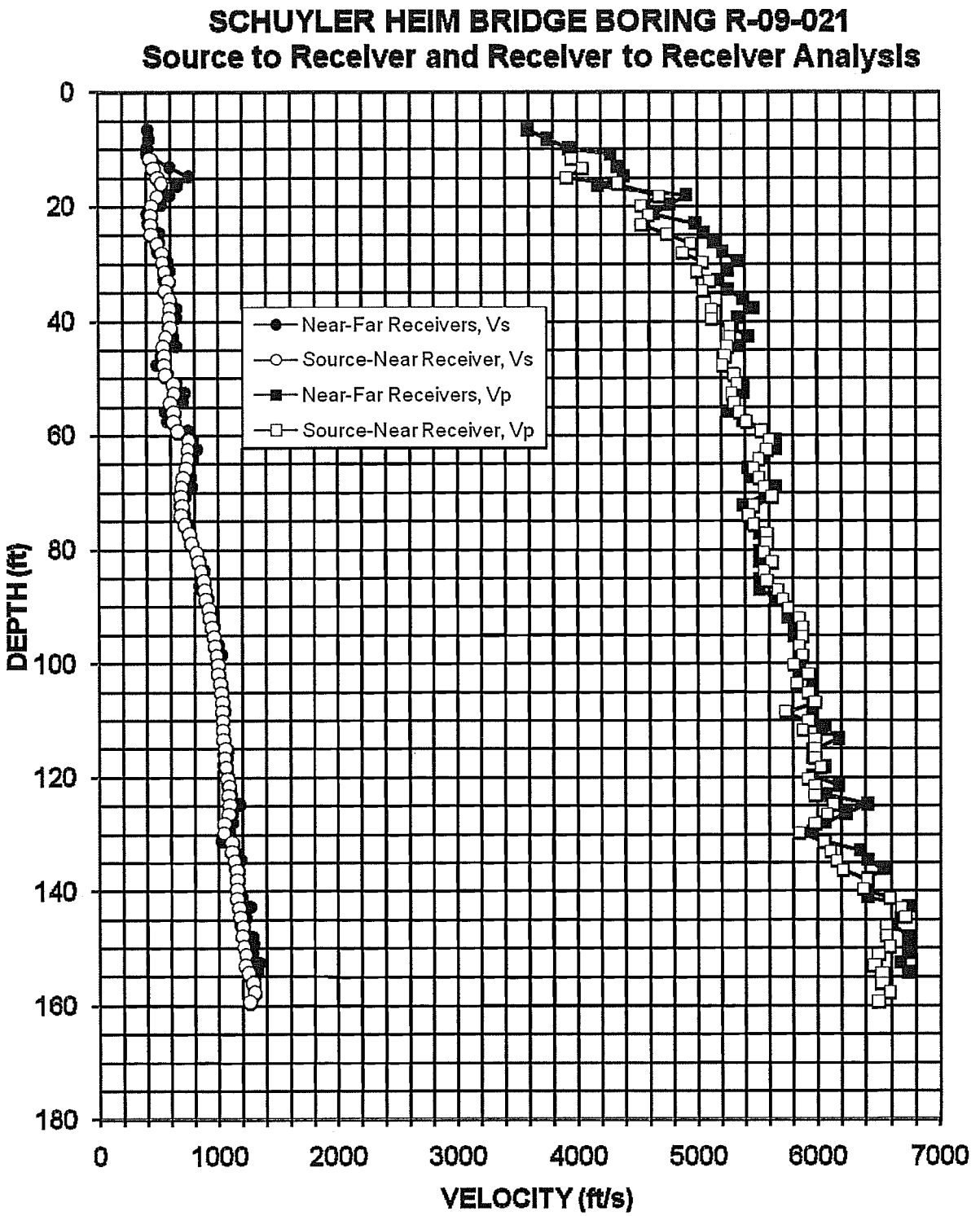

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

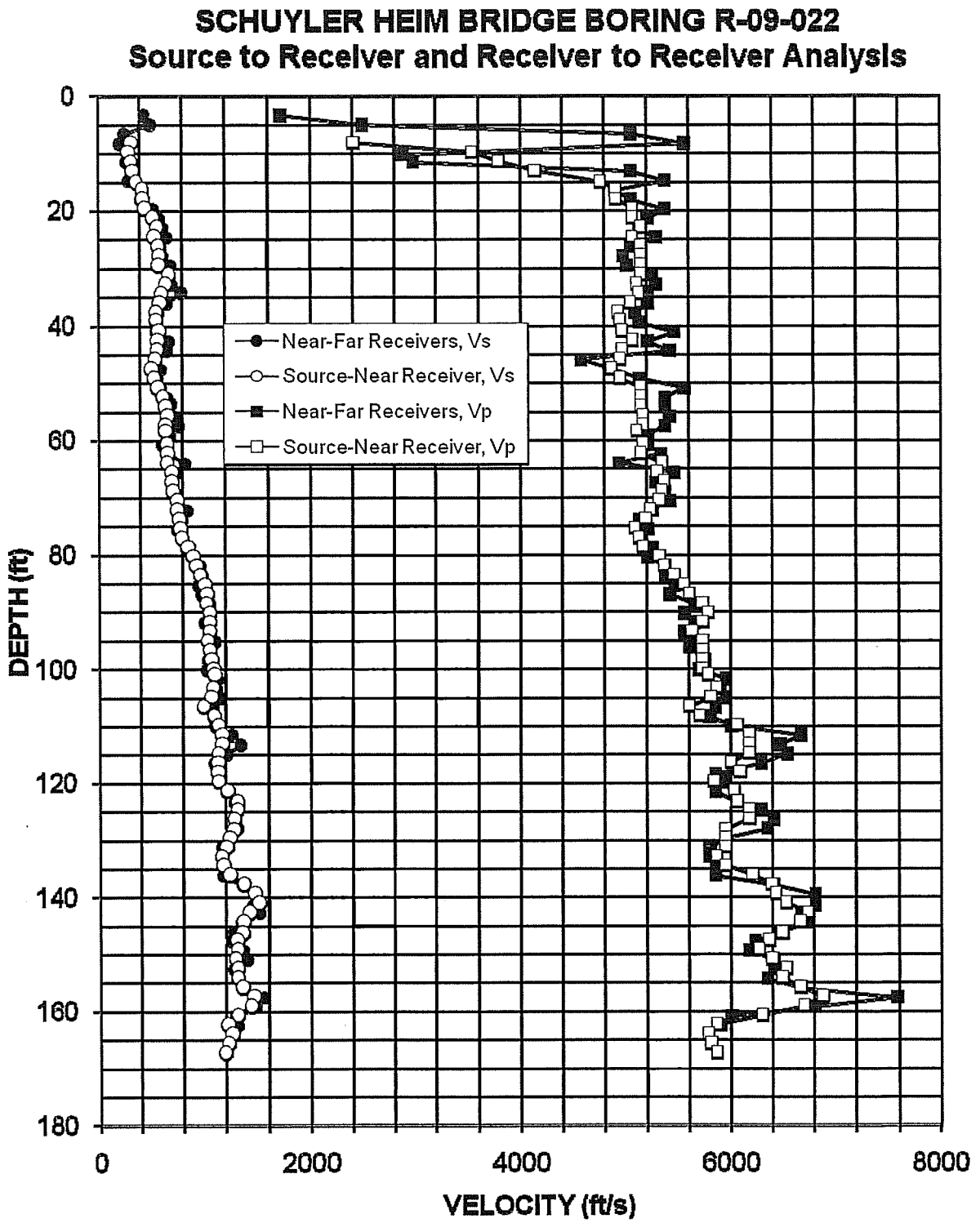

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

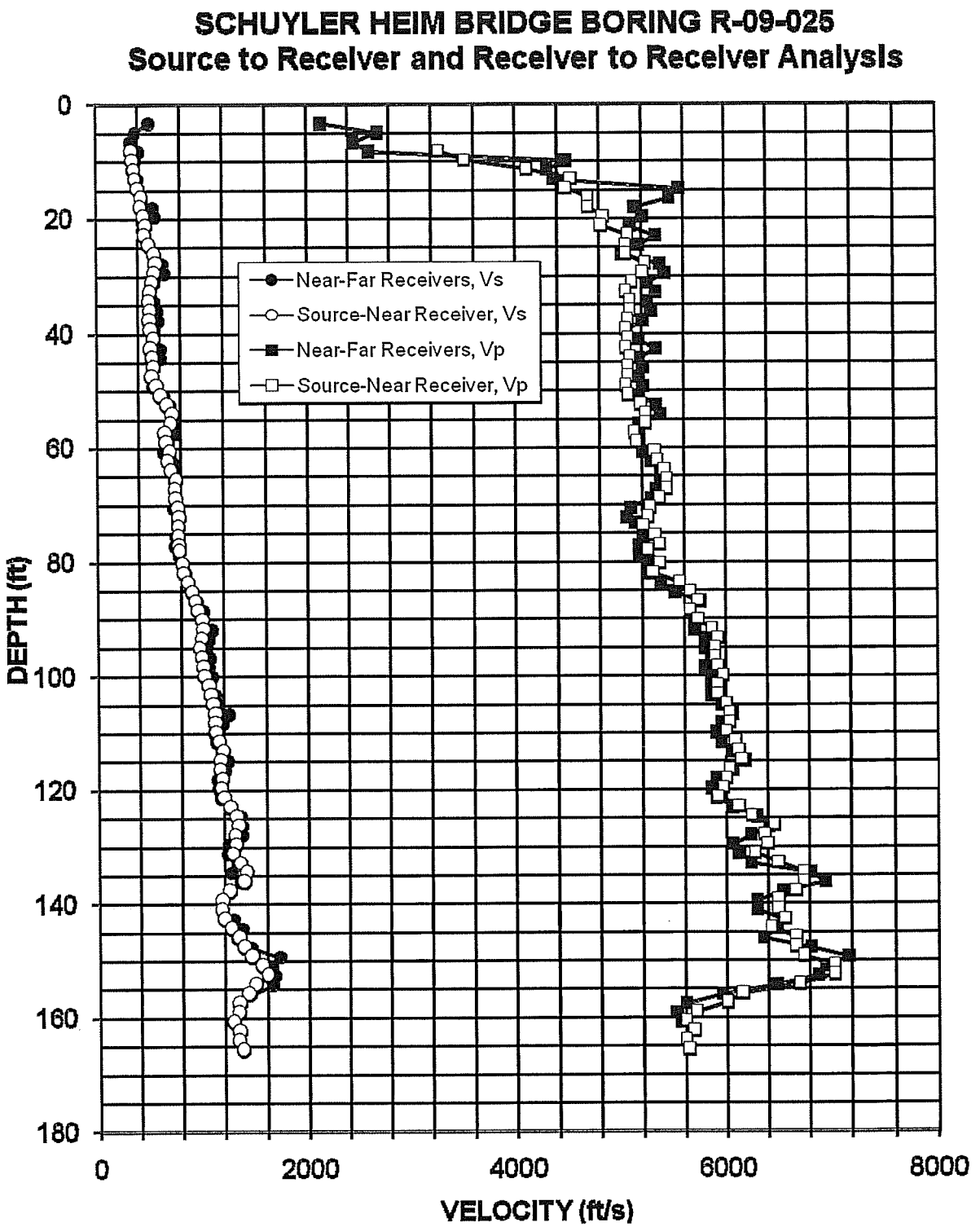

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

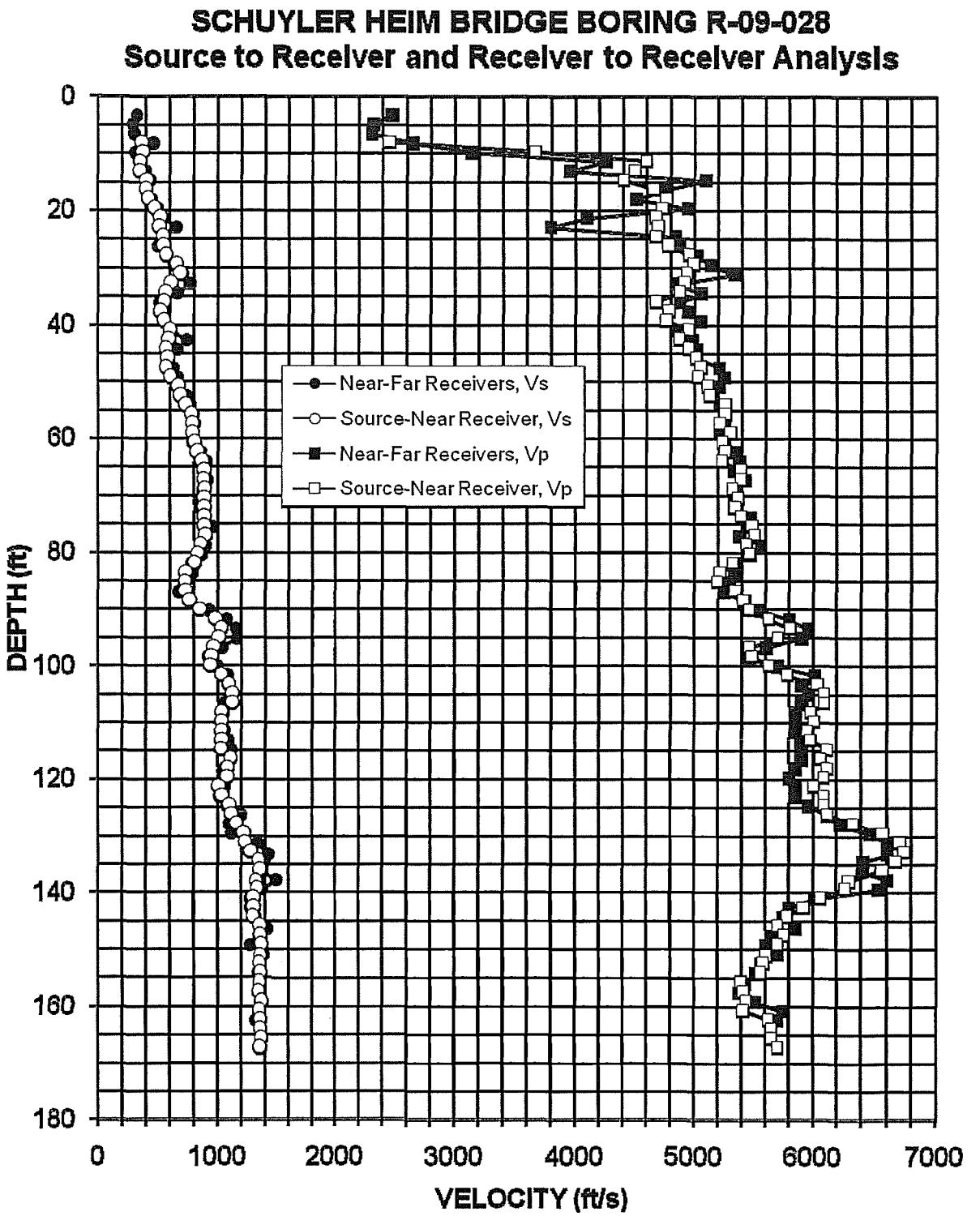

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠ Calibration Report

A SOUTHERN CALIFORNIA EDISON® Company

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson	
	Name	Date	Signature	
Witnessed by:	Robert Steller	7/17/2009		
	Name	Date	Signature	

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠ **Calibration Report**

TEST NUMBER 573795

A SOUTHERN CALIFORNIA EDISON® Company

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP *under the specific scope of accreditation for lab* code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160824 ~~160024~~ 573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

Appendix E. Laboratory Soil Test Results

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-010	S-01	5.0	25.9			
R-09-010	D-02	10.0	26.7	107.3		26,14,12
R-09-010	D-04	20.0			3.3	
R-09-010	U-06	30.0				29,23,6
R-09-010	S-07	35.0			14.1	
R-09-010	D-8-1	40.0			66.9	
R-09-010	D-8-2	40.5	39.5	82.7		40,23,17
R-09-010	D-10	50.0				51,27,24
R-09-010	D-12	60.0	30.4	93.2		33,26,7
R-09-010	S-13-1	65.0	21.9			
R-09-010	S13-2	65.7	34.1			35,20,15
R-09-010	D-14	70.0	32.4	90.4		31,22,9
R-09-010	S-15	75.0	34.0		79.3	26,23,3
R-09-010	D-16	80.0	30.1	93.8		
R-09-010	S-18	90.0	25.8		8.9	
R-09-010	S-20	110.0	18.7			
R-09-010	S-23	140.0	12.4			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-010	D-02	10	8.55	2790	0.05	170
R-09-010	S-11	55	8.77	820	0.045	470

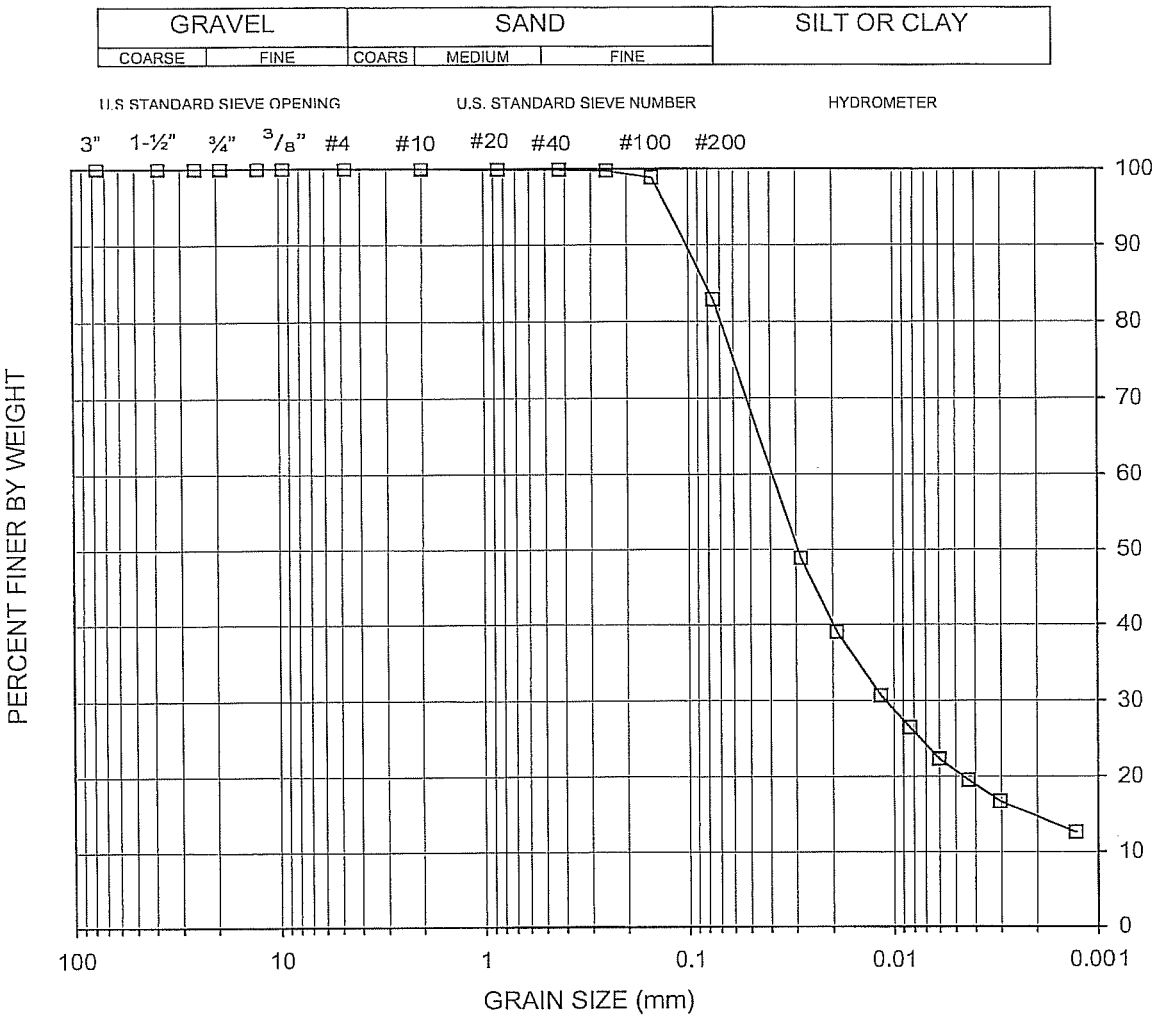
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-010	U-06	30	2.769



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-010	U-06	30	Shelby Tube	ML	29	6

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

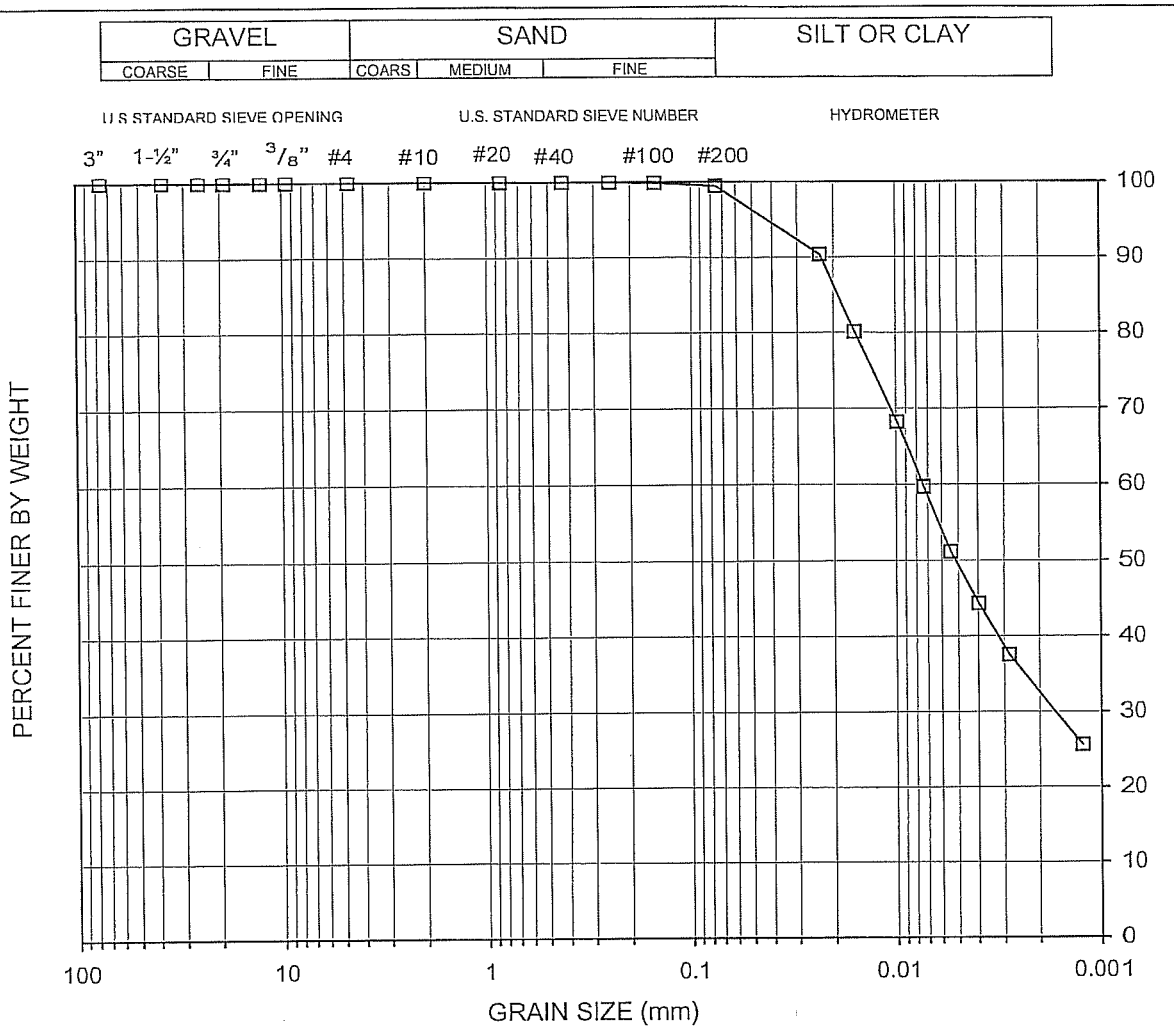
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-010	D-10	50	RING	CH	51	24

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

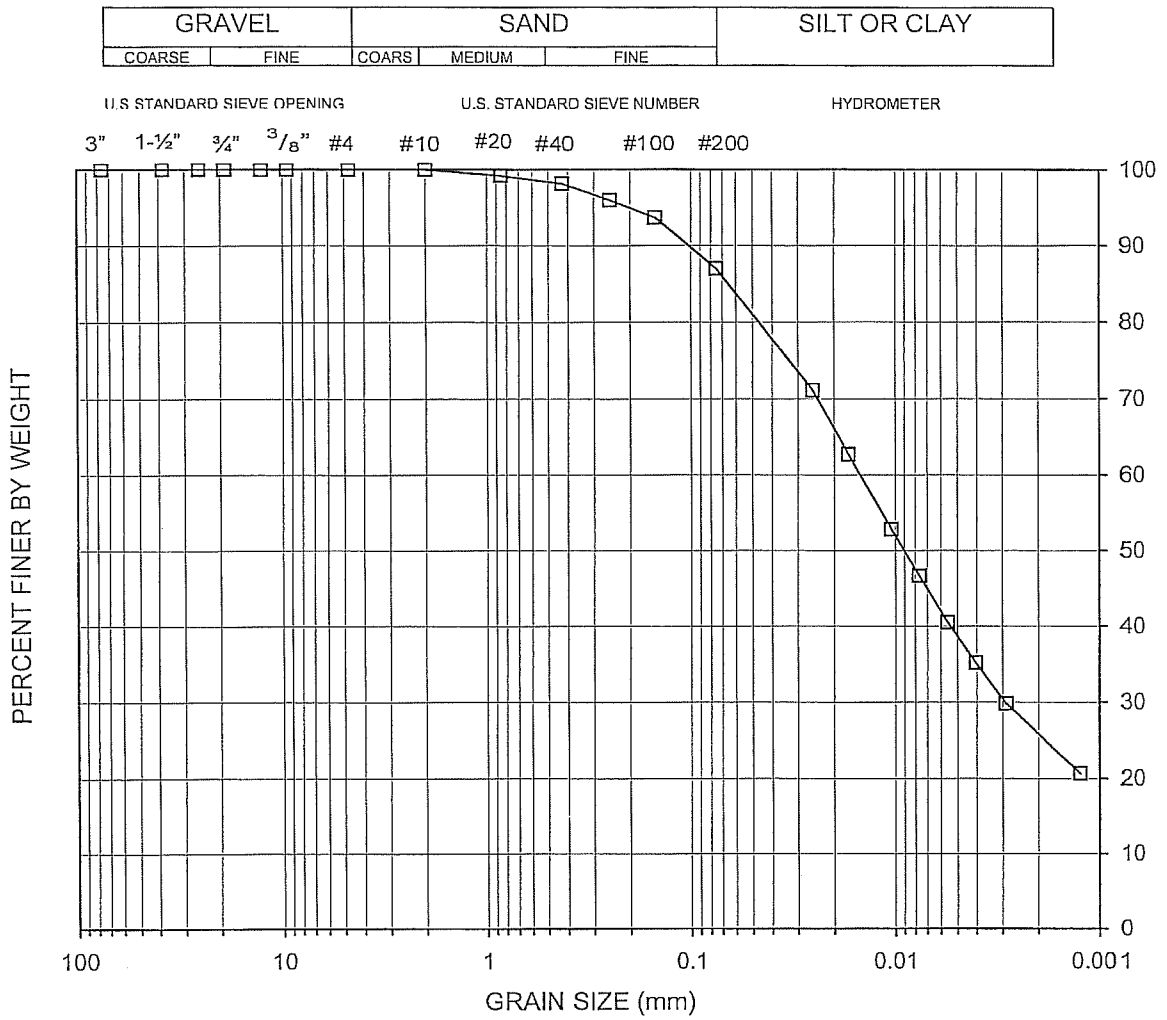
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-010	S-13-2	65.7	BAG	CL	35	15

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

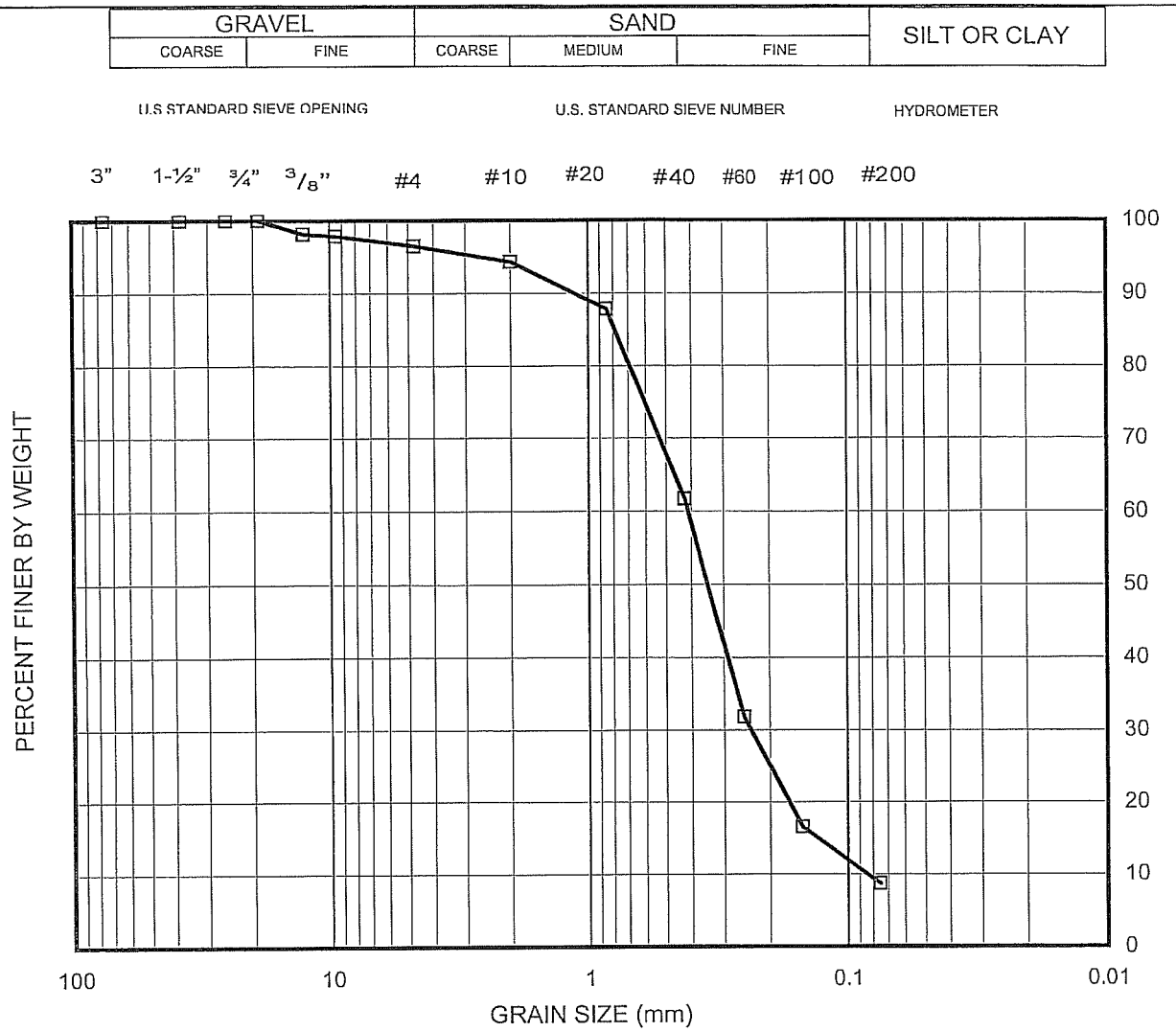
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE



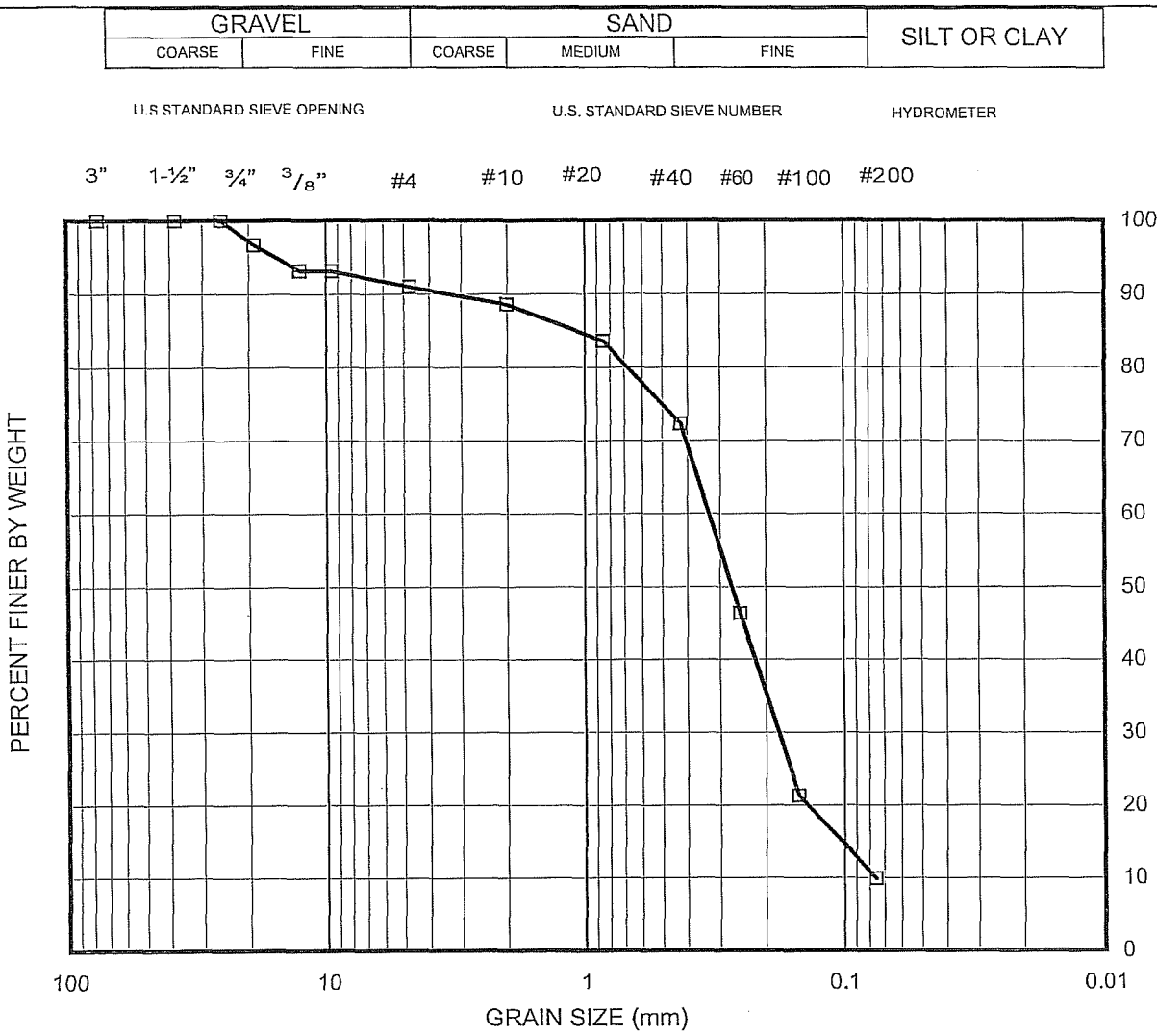
SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-010	S-21	120	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-010	S-24	150	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

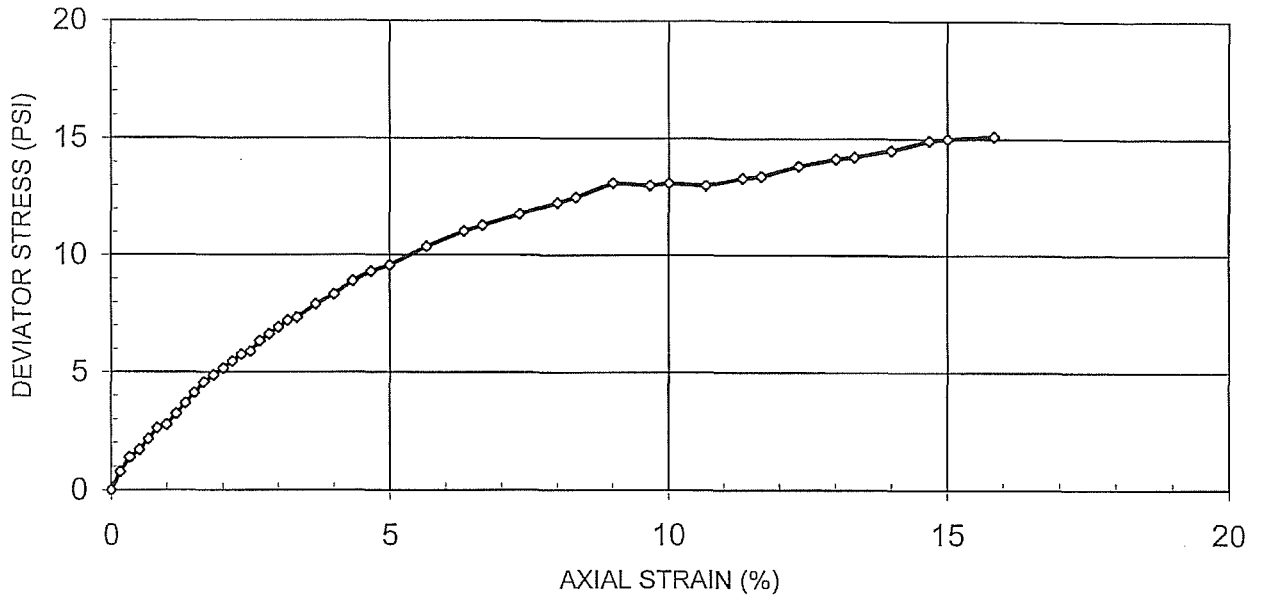
Client Job No.: 06-123-03

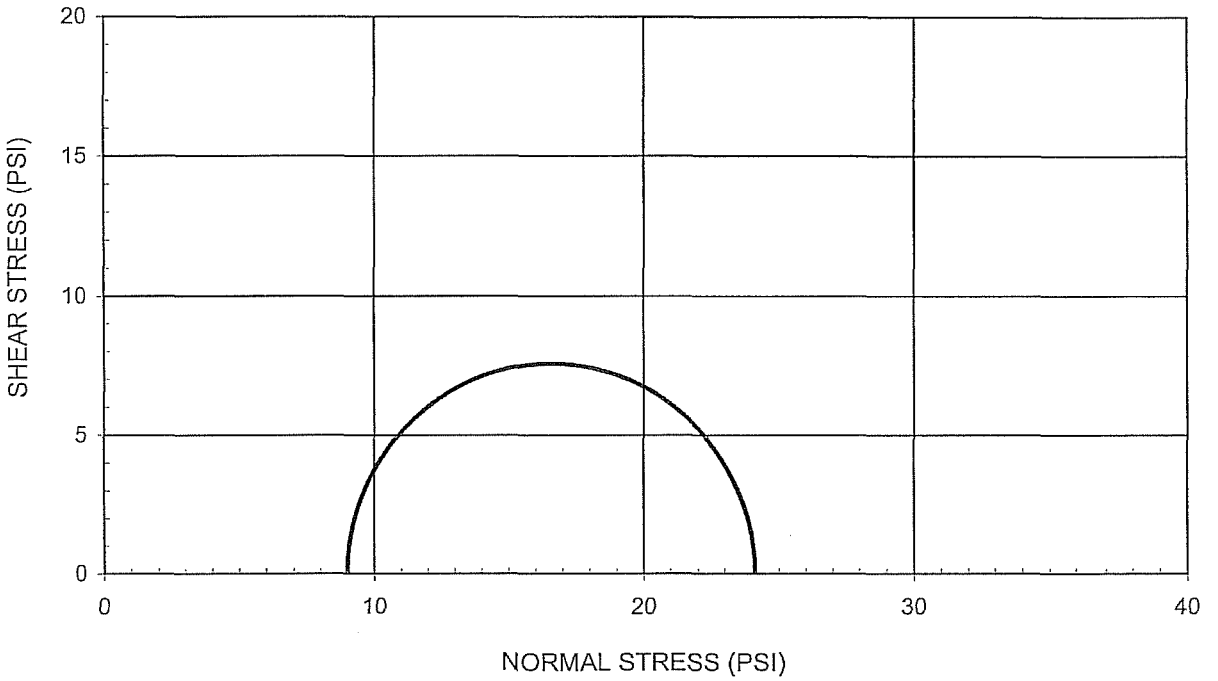
Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-010	30	U-06	ML	Shelby Tube	32.09	90.5	9.0	15.1	0.06	100.5

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

UNCONSOLIDATED UNDRAINED

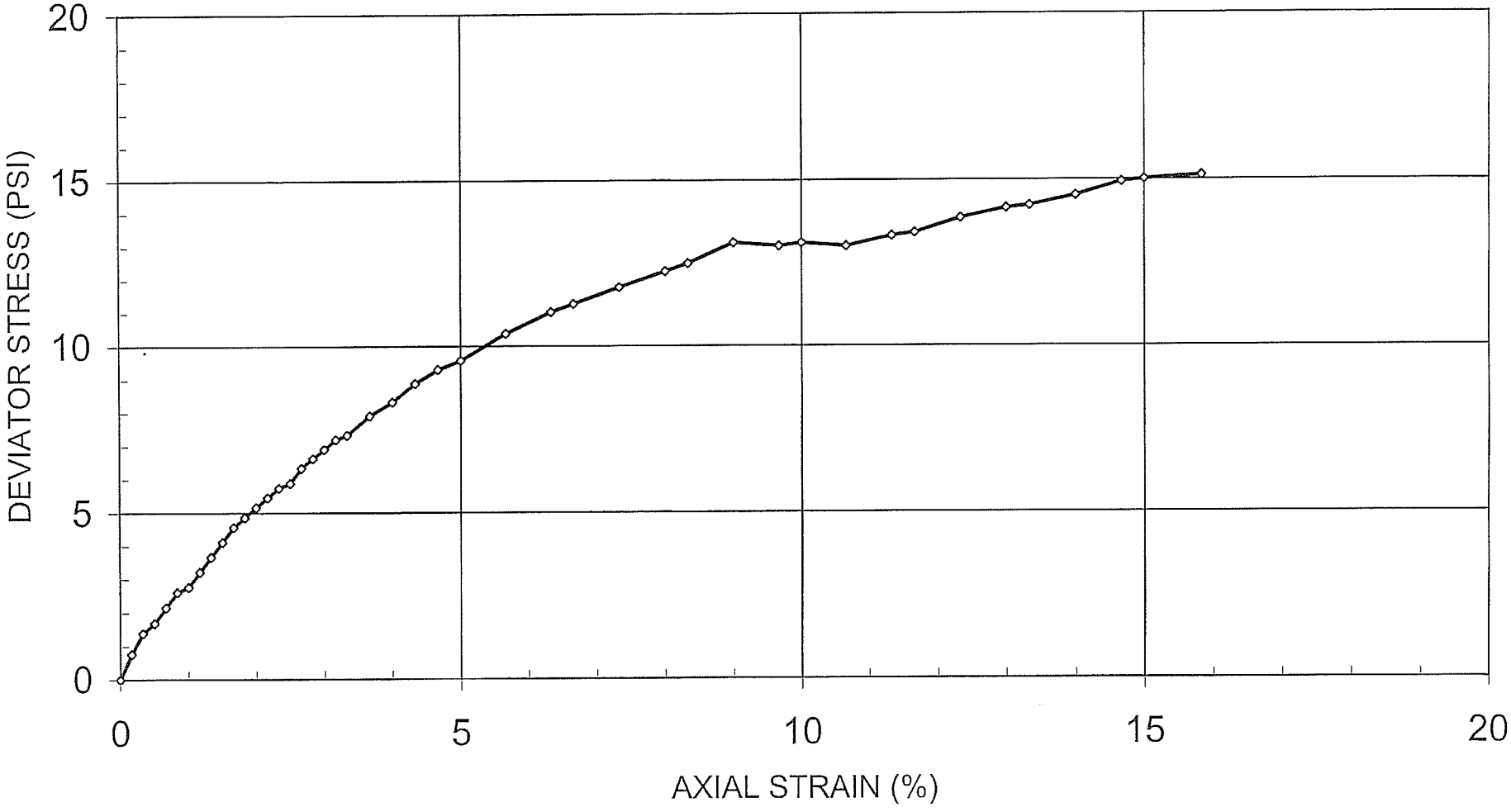
(ASTM D2850)

11/29/09

Figure

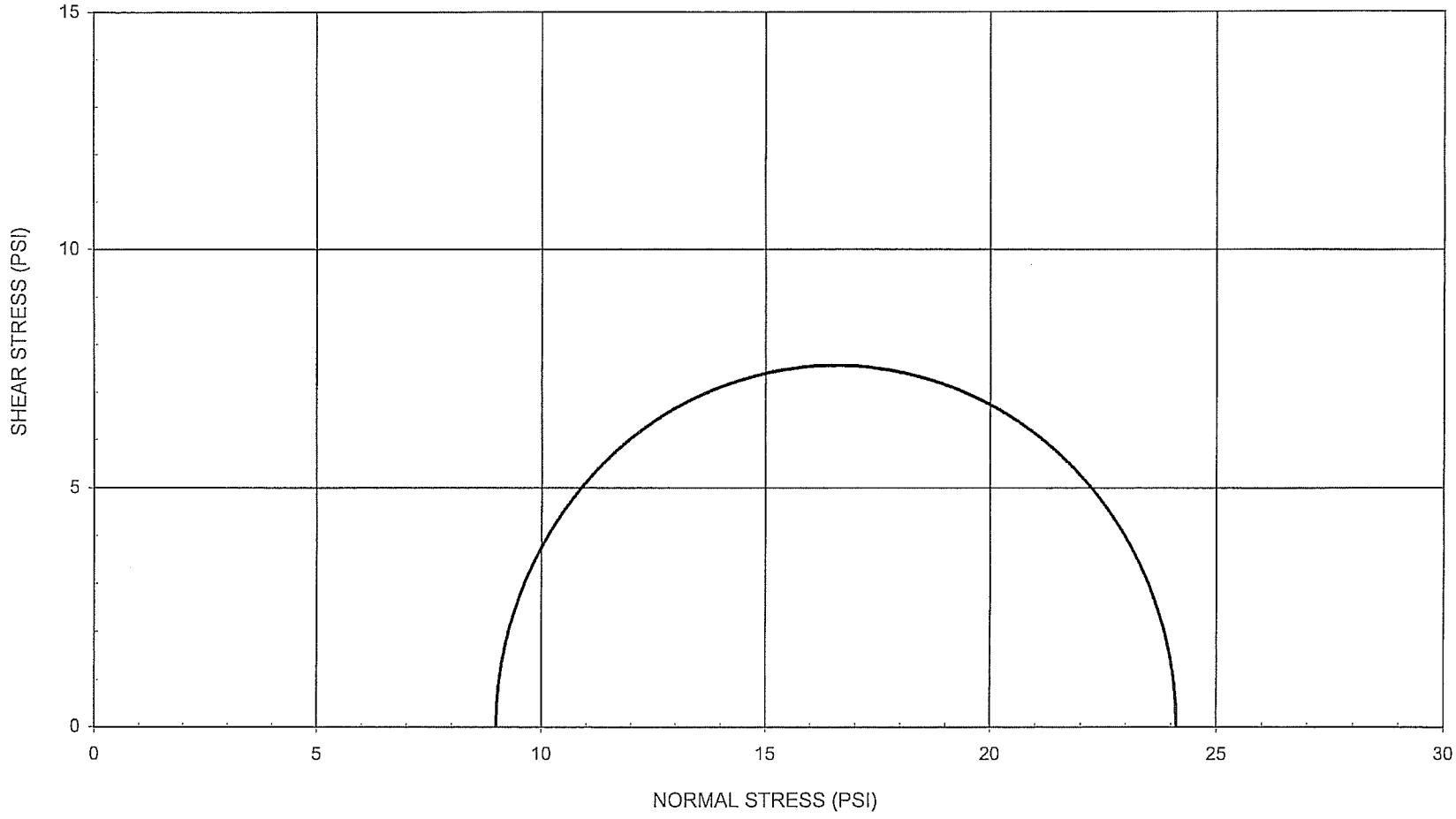
Project Name: ACTA Heim Bridge Replacement

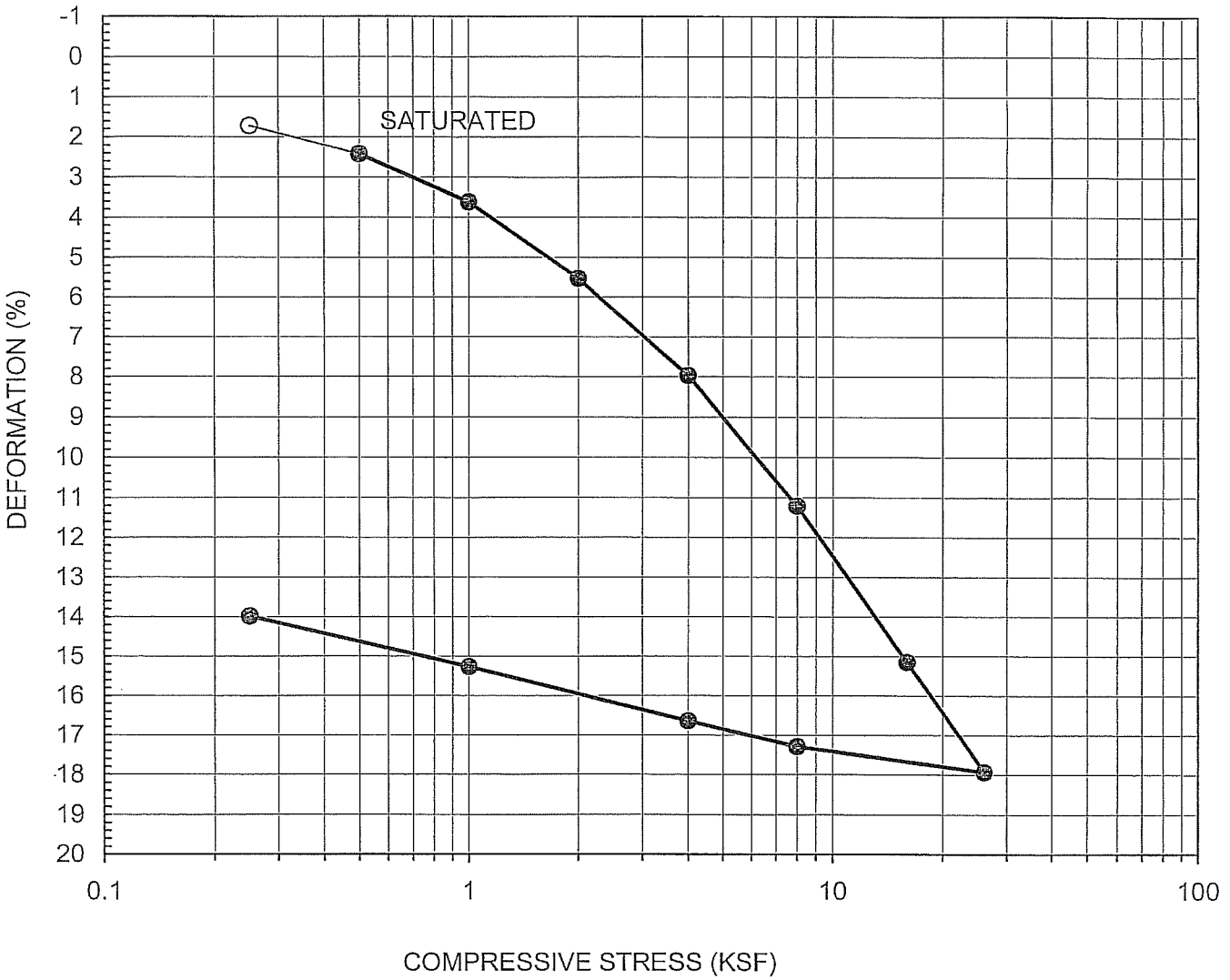
Boring: R-09-010 Sample ID: U-06 Depth (ft): 30



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-010 Sample ID: U-06 Depth (ft): 30





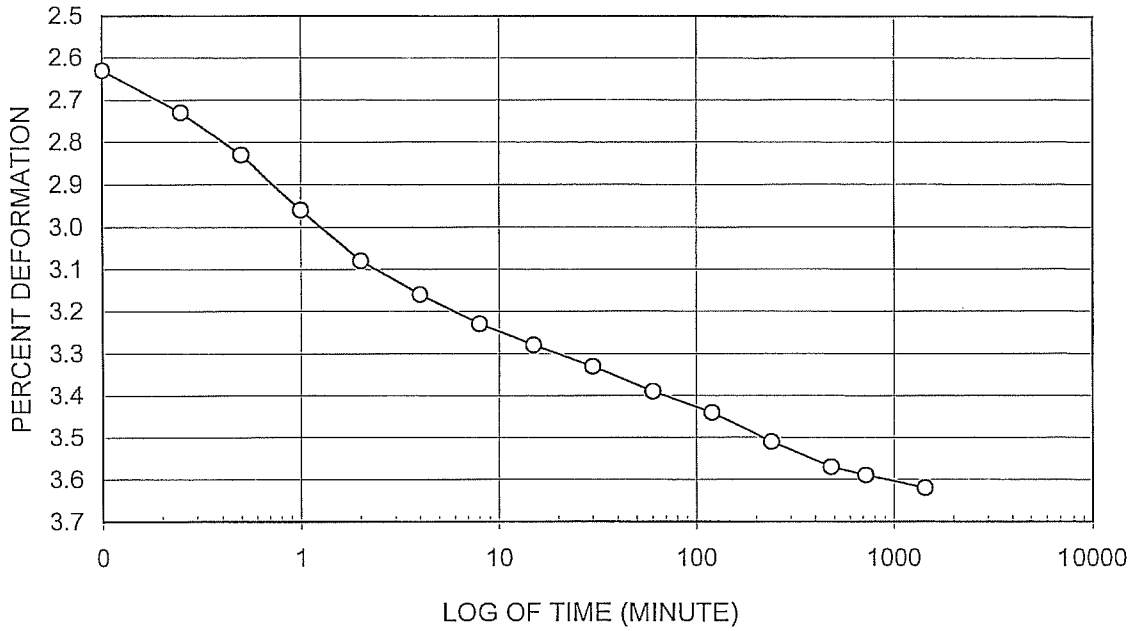
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-010	U-06	30.0	ML	34.8	84.9	0.984

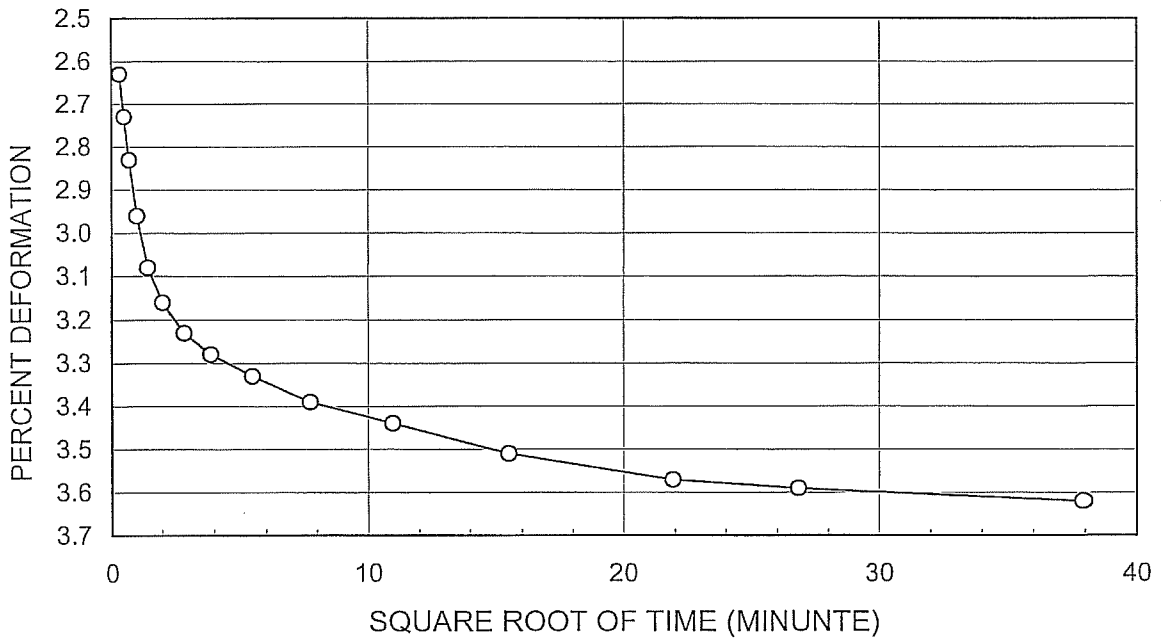
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





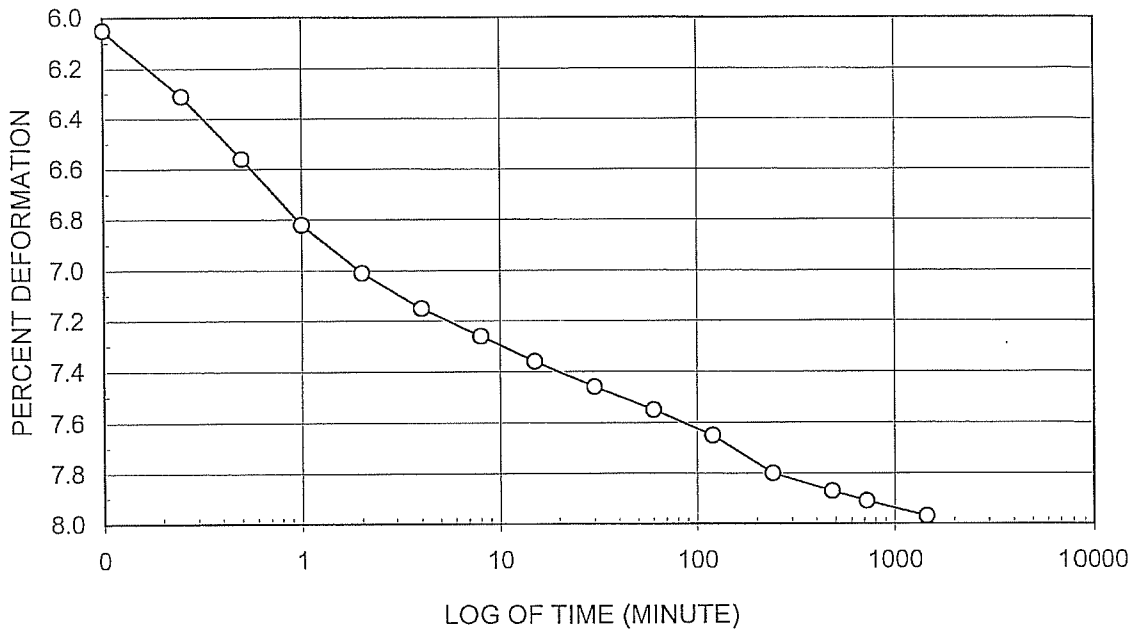
Boring No: R-09-010
Sample No: U-06
Depth (ft): 30
Soil Type: ML
Normal Stress: 1.0 ksf

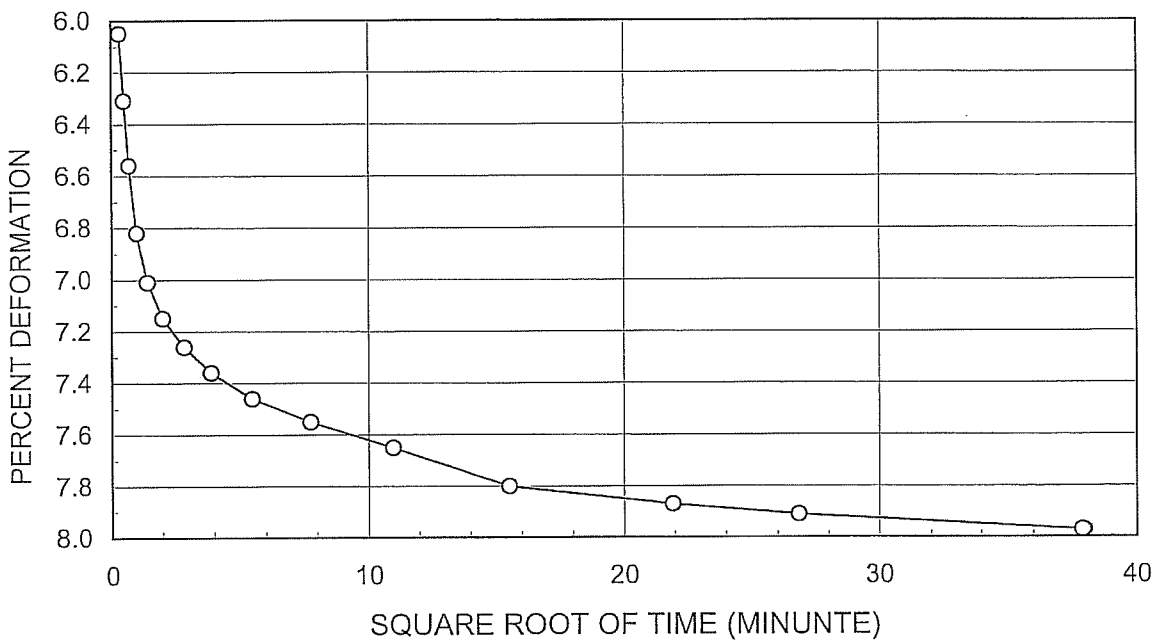
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





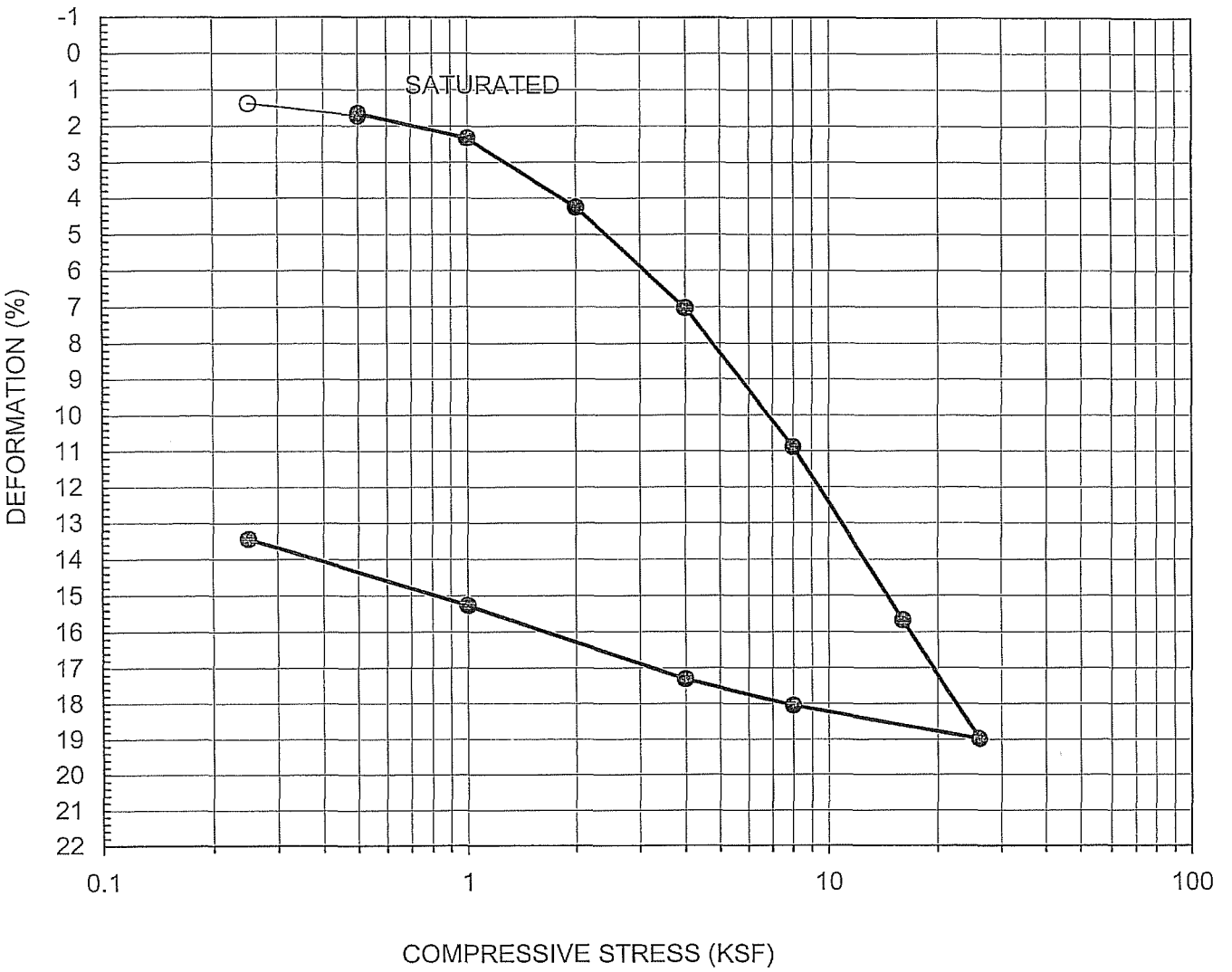
Boring No: R-09-010
Sample No: U-06
Depth (ft): 30
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



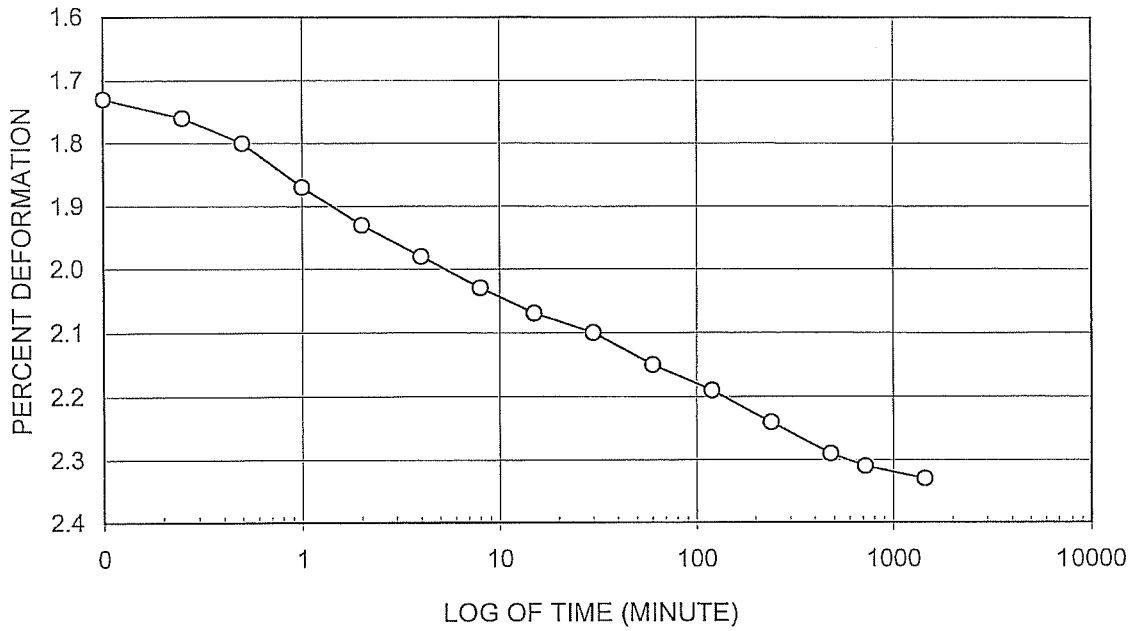
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-010	D-08-2	40.5	CL	39.5	81.7	1.063

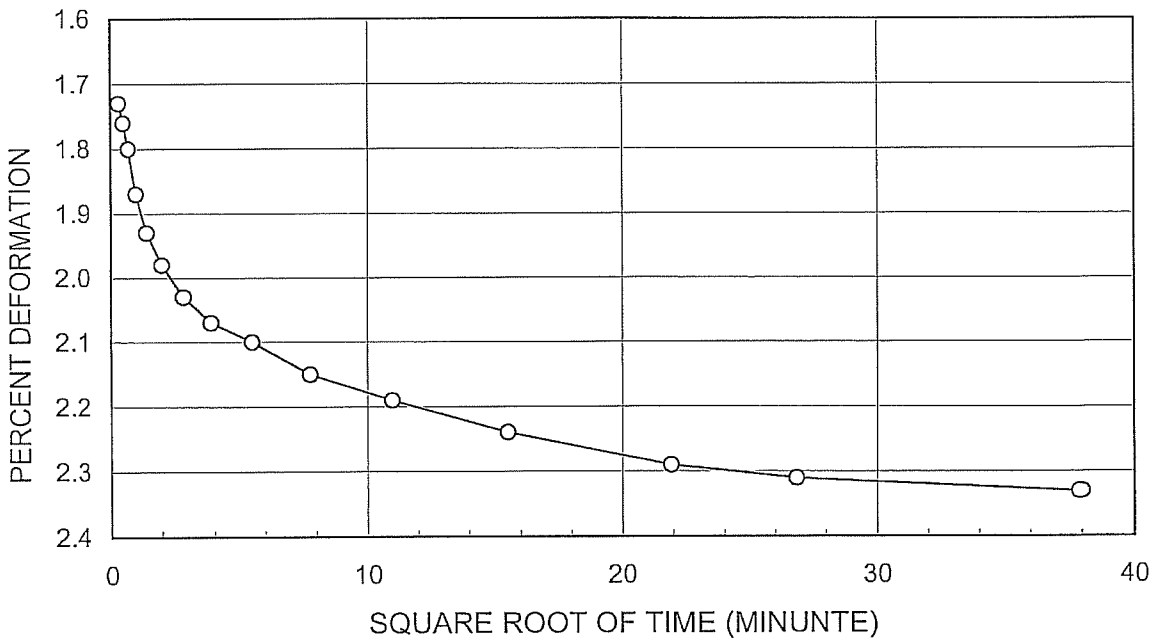
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





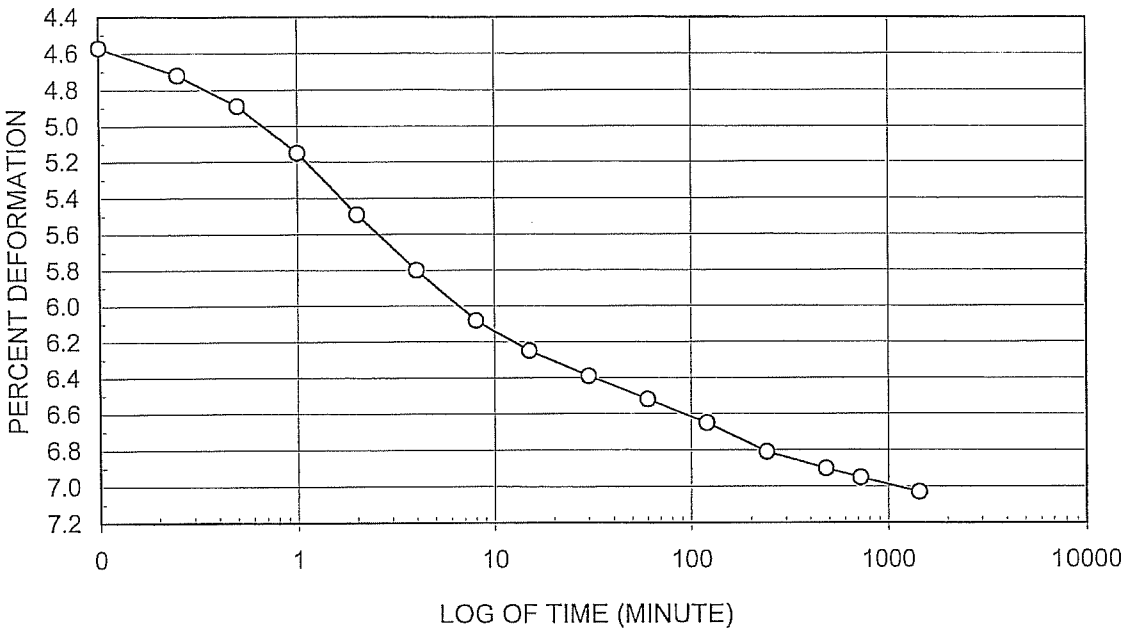
Boring No: R-09-010
Sample No: D-08-2
Depth (ft): 40.5
Soil Type: CL
Normal Stress: 1.0 ksf

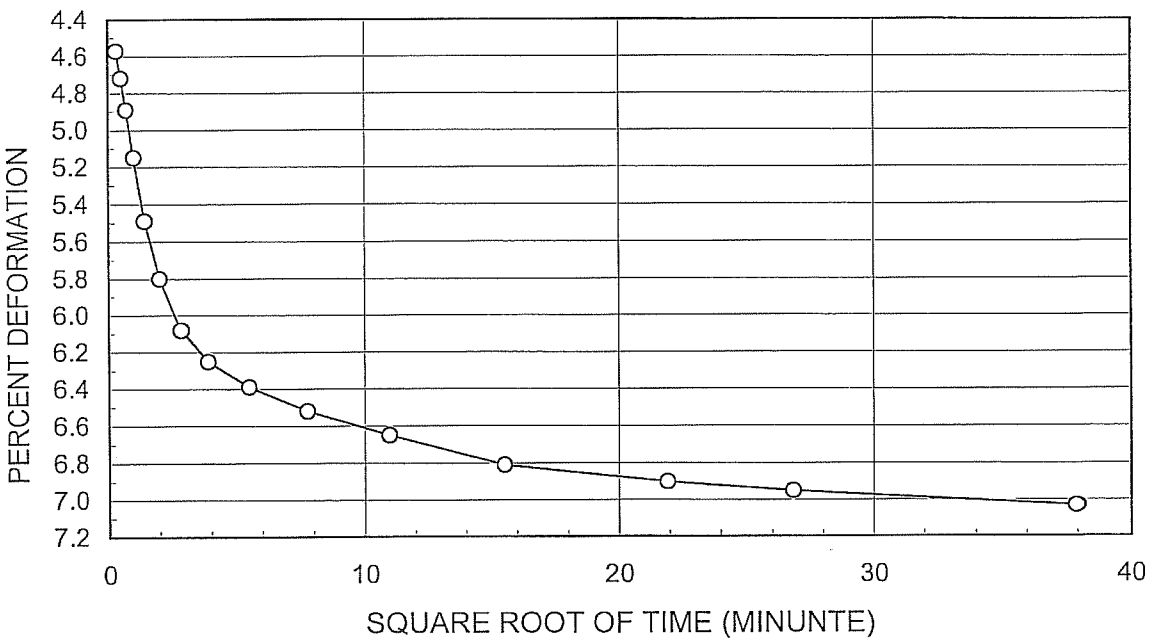
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





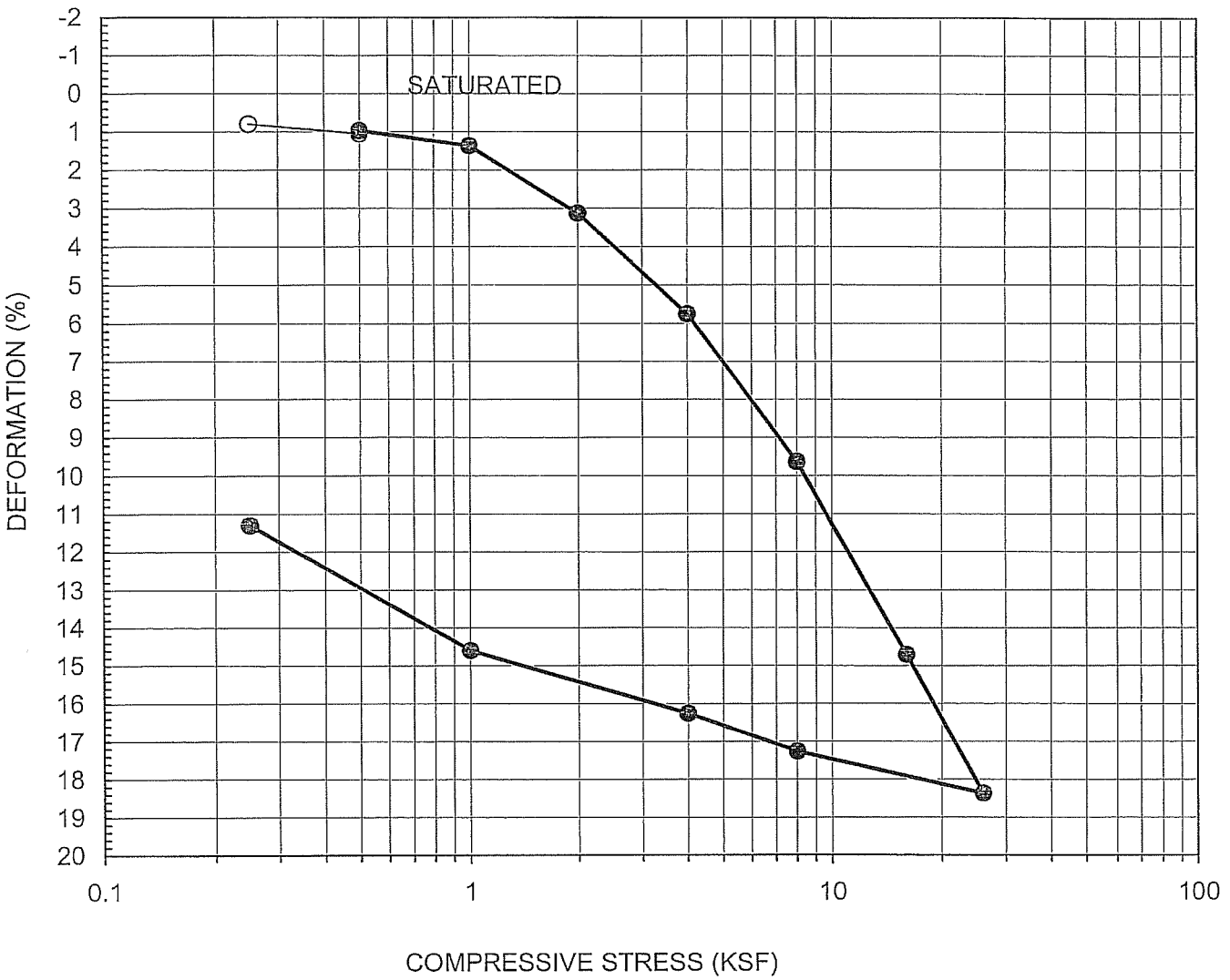
Boring No: R-09-010
Sample No: D-08-2
Depth (ft): 40.5
Soil Type: CL
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



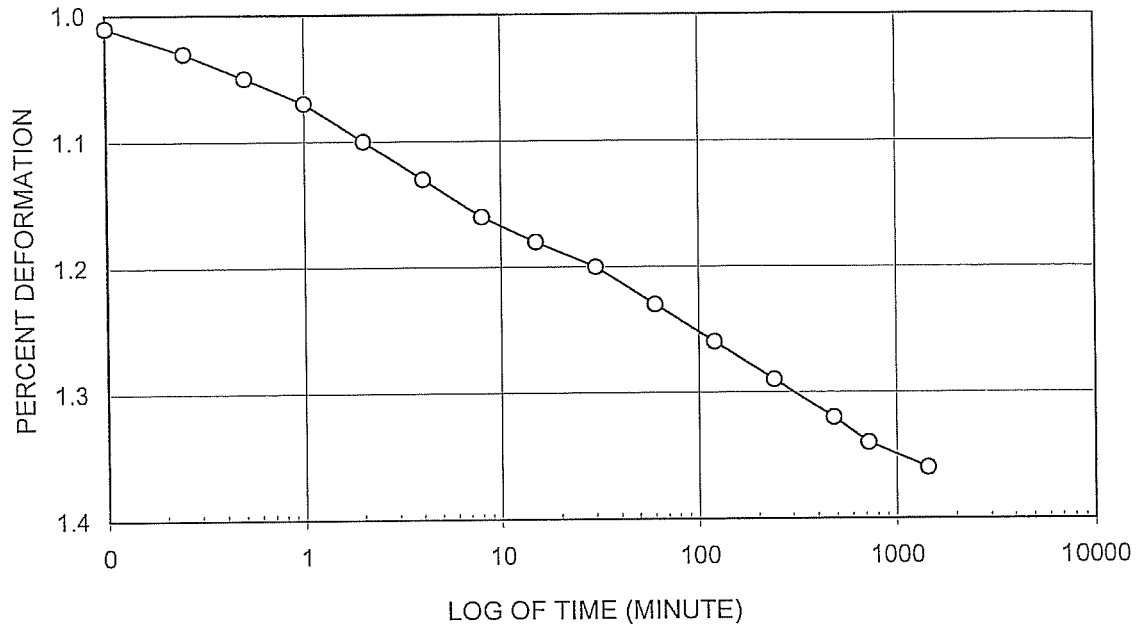
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-010	D-10	50.0	CH	44.1	76.1	1.215

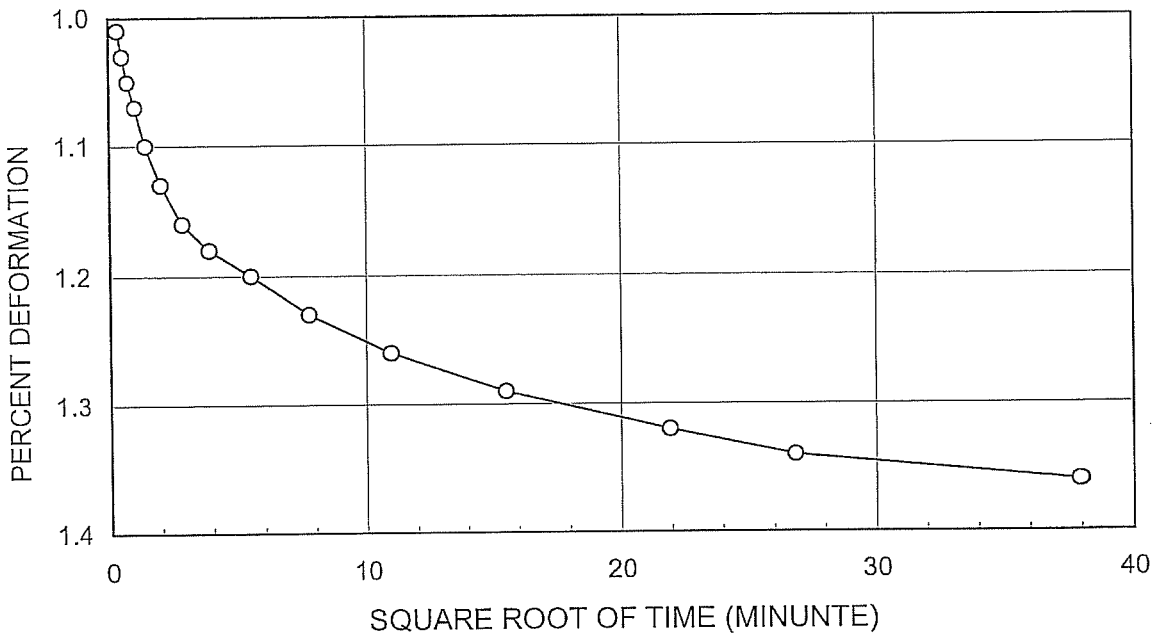
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





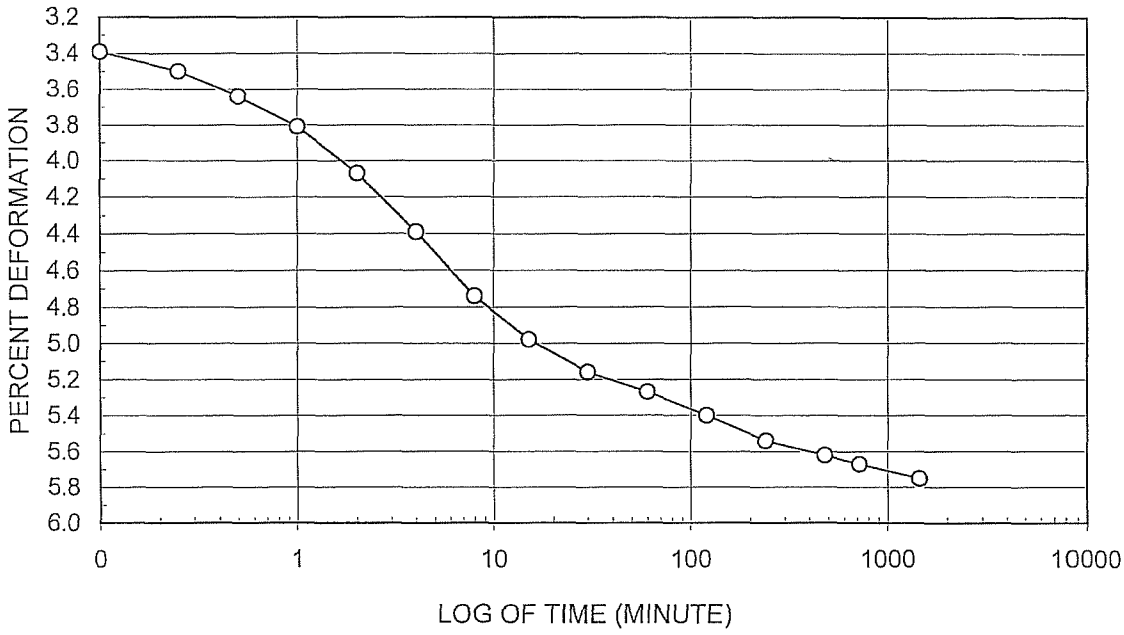
Boring No: R-09-010
Sample No: D-10
Depth (ft): 50
Soil Type: CH
Normal Stress: 1.0 ksf

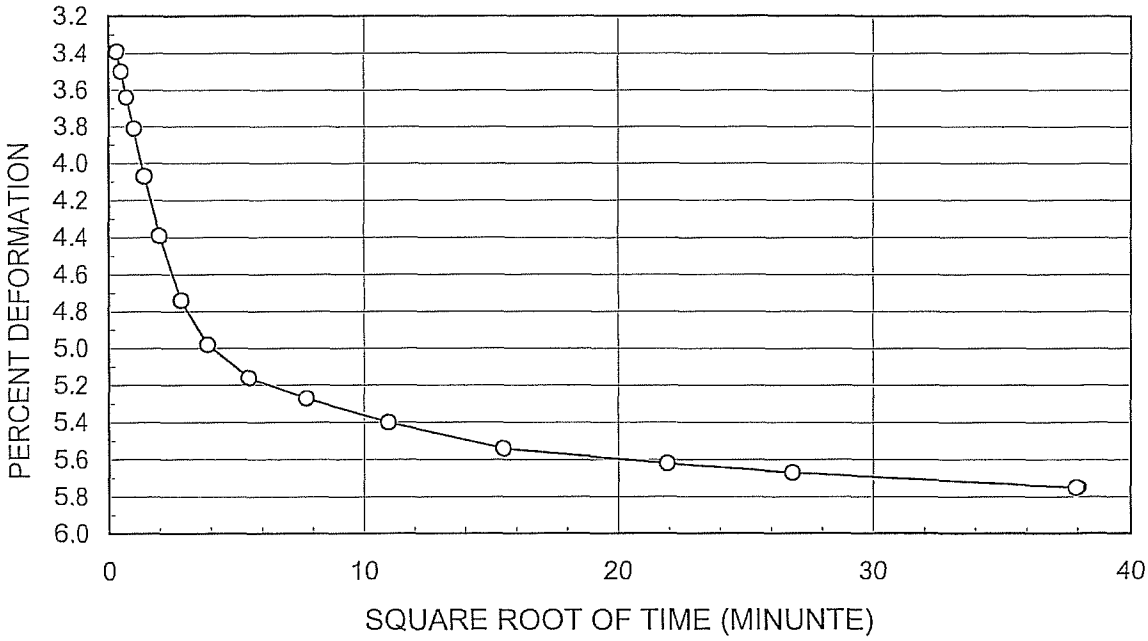
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





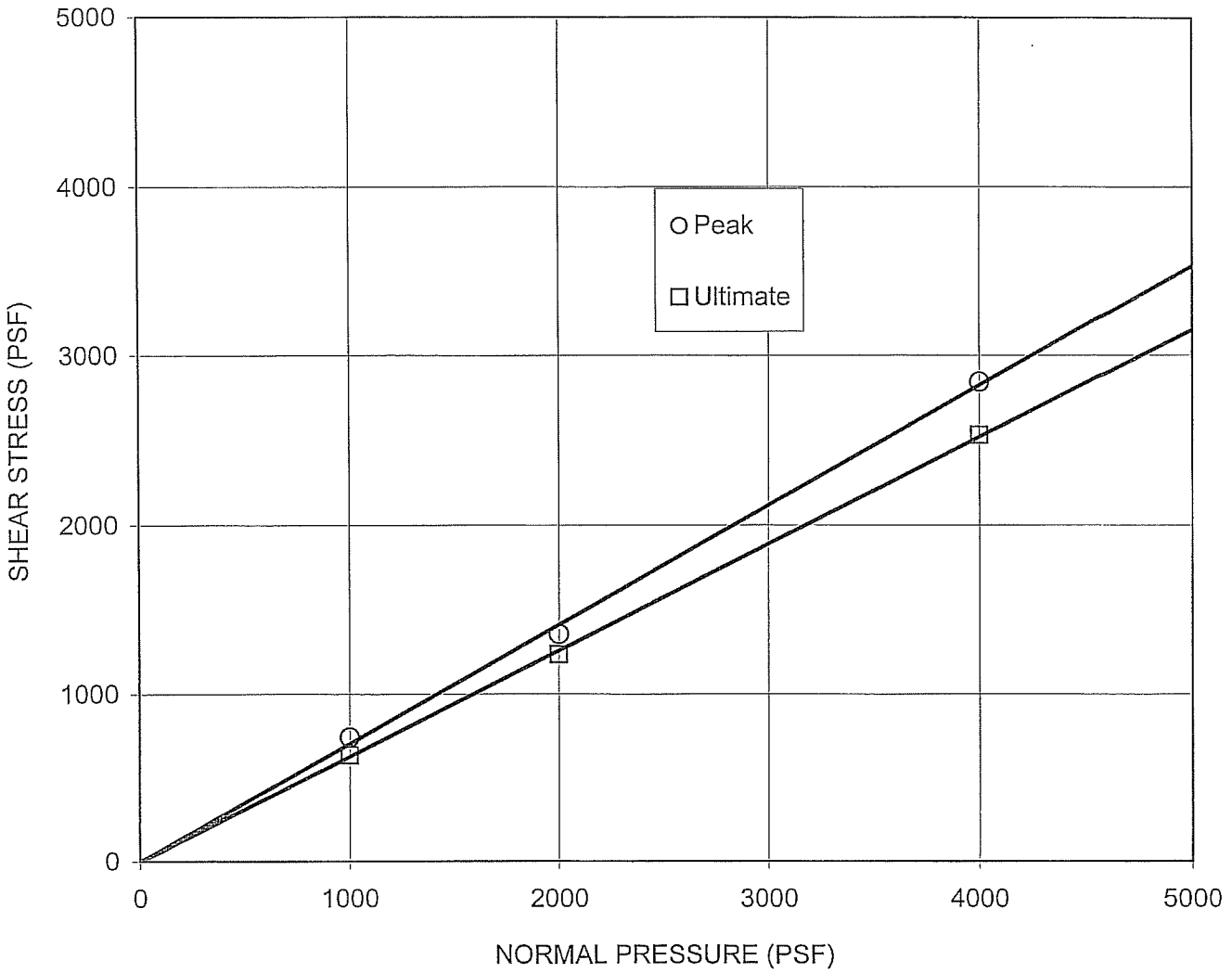
Boring No: R-09-010
Sample No: D-10
Depth (ft): 50
Soil Type: CH
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-010	D-04	20	Ring	SM	○	0	35
					□	0	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	31.2	35.7
2000	31.2	34.8
4000	31.2	34.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/16/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-012	D-02	10	14.1	97.7
R-09-012	S-03	15	23.7	NA
R-09-012	S-05	25	44.5	NA
R-09-012	U-06	30	36.6	85.0
R-09-012	D-08	40	29.2	94.6
R-09-012	S-09	45	28.4	NA
R-09-012	D-10	50	38.3	86.2
R-09-012	S-11	55	32.0	NA
R-09-012	D-12	60	31.6	89.8
R-09-012	S-13	65	48.0	NA
R-09-012	D-14	70	35.0	87.9
R-09-012	S-15	75	39.1	NA
R-09-012	S-17	90	39.3	NA
R-09-012	S-19	110	17.3	NA
R-09-012	S-22	140	18.8	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-012	D-10	50	1.13
R-09-012	U-10A	51.5	1.38
R-09-012	D-14	70	1.75
R-09-012	U-16	80	3.04

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/16/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-012	D-04	20	40.74
R-09-012	U-06	30	4.18
R-09-012	S-09	45	36.91
R-09-012	D-12	60	35.36

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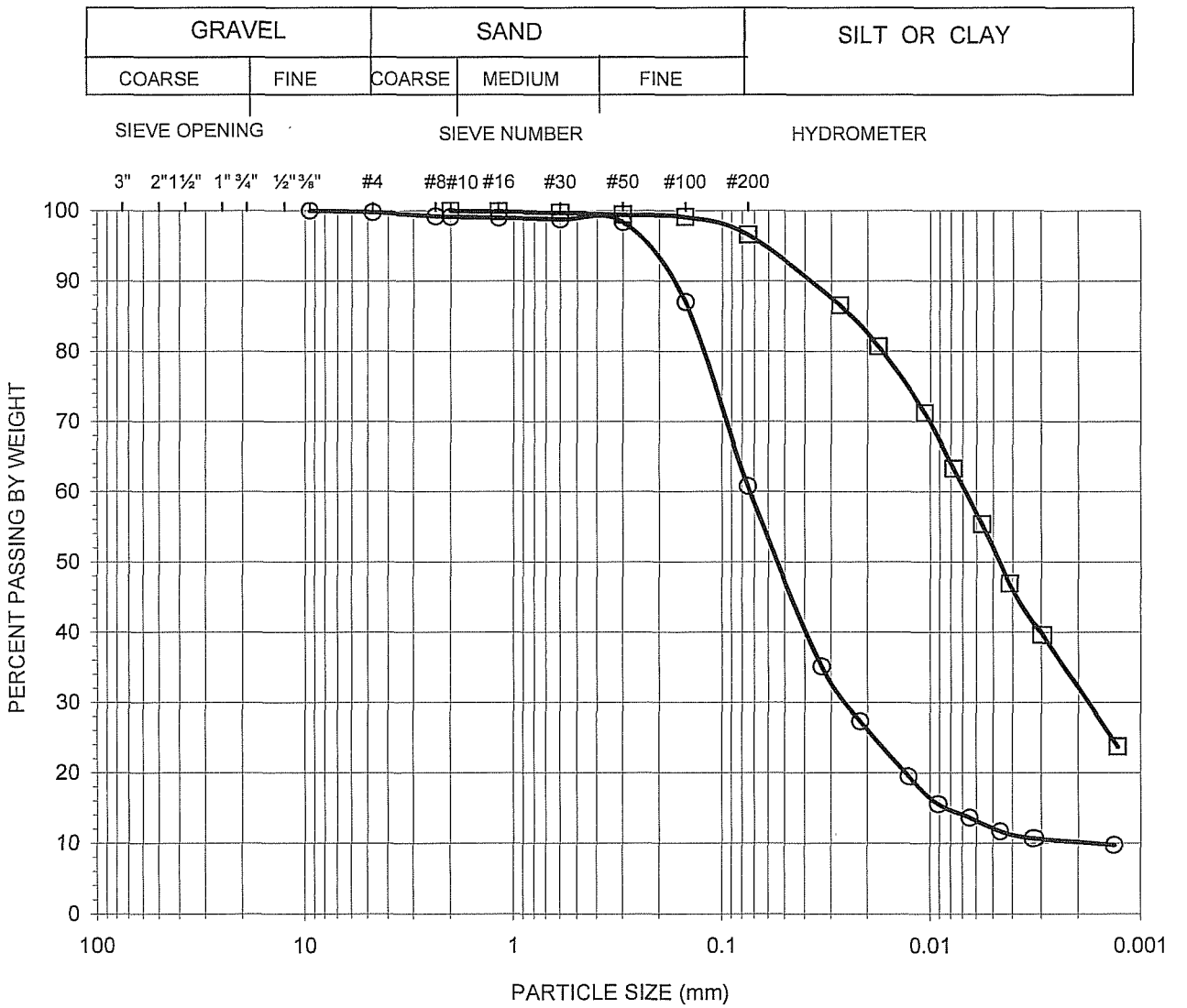
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

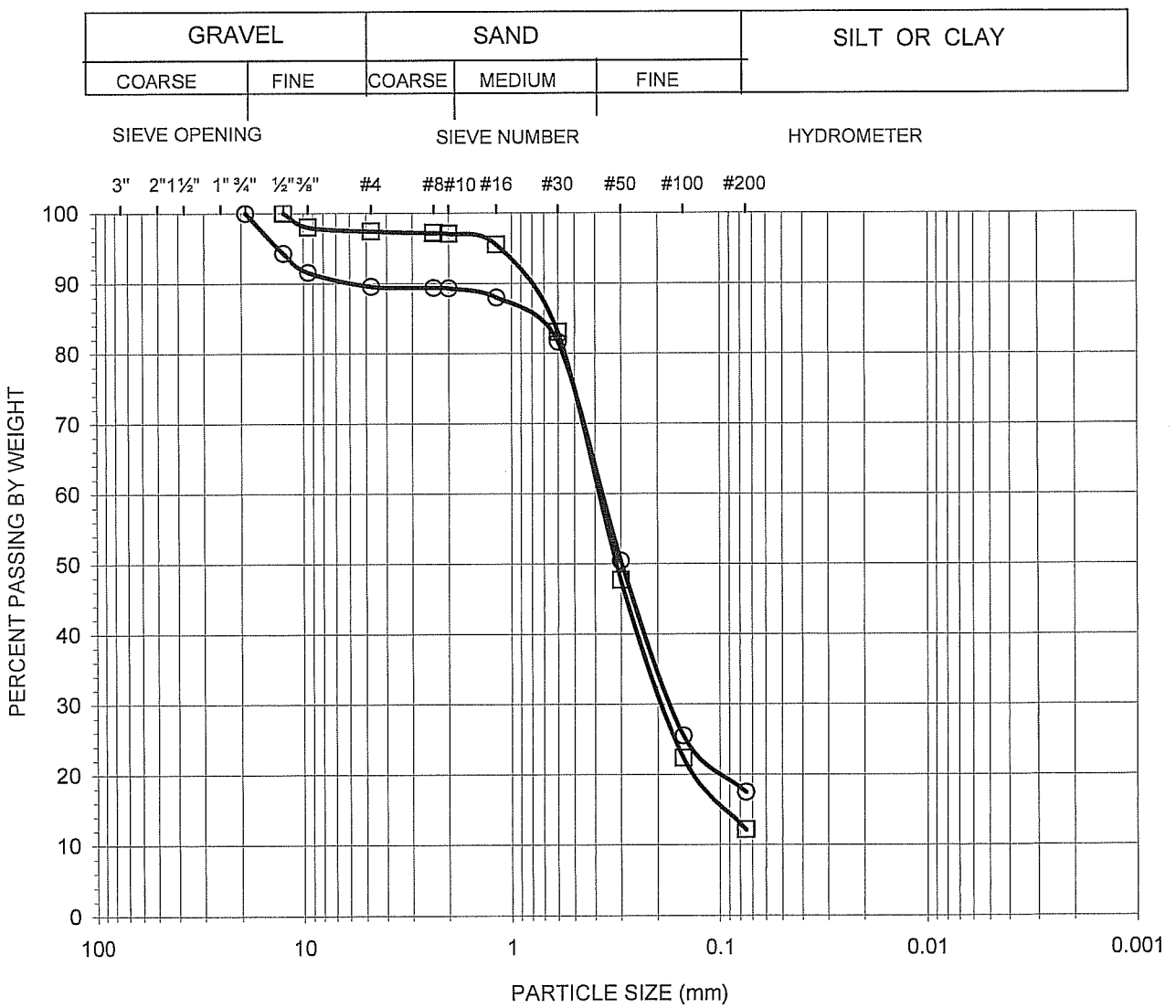


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-012	U-10A	51.5	0.25	38.93	60.82	N/P	ML
□	R-09-012	U-16	80	0.00	3.46	96.54	35:23:12	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



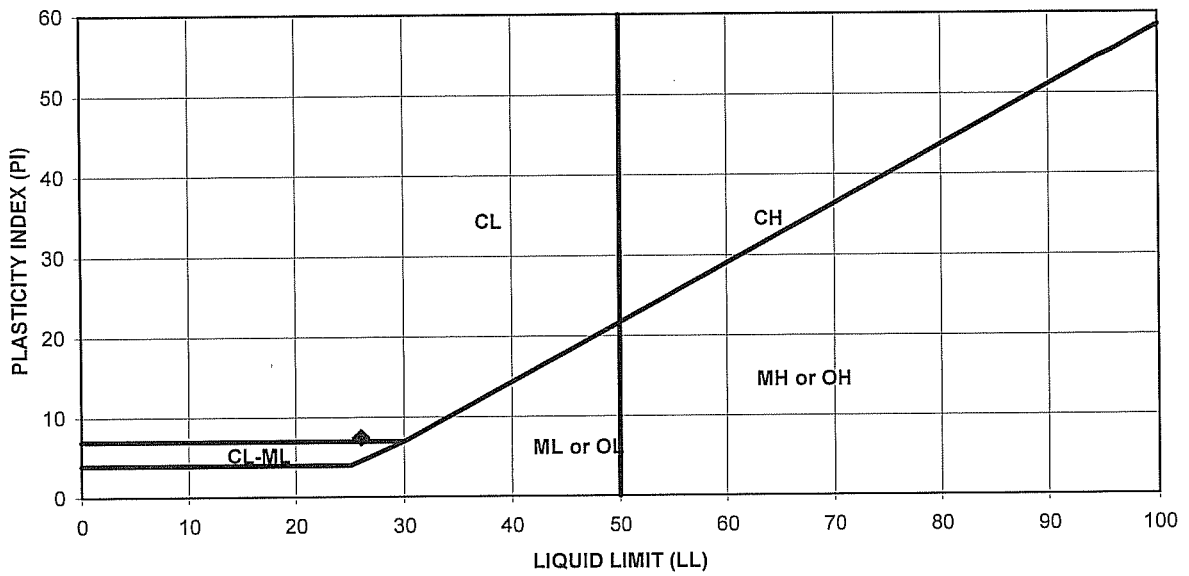
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-012	S-20	120	10.40	72.09	17.51	N/A	SM
□	R-09-012	S-23	155	2.59	85.23	12.18	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

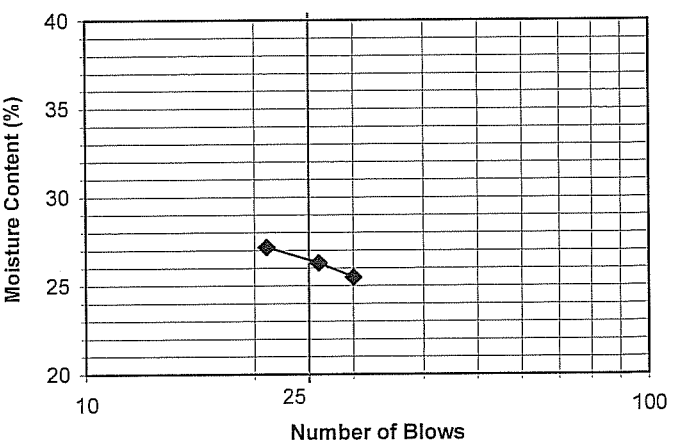
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



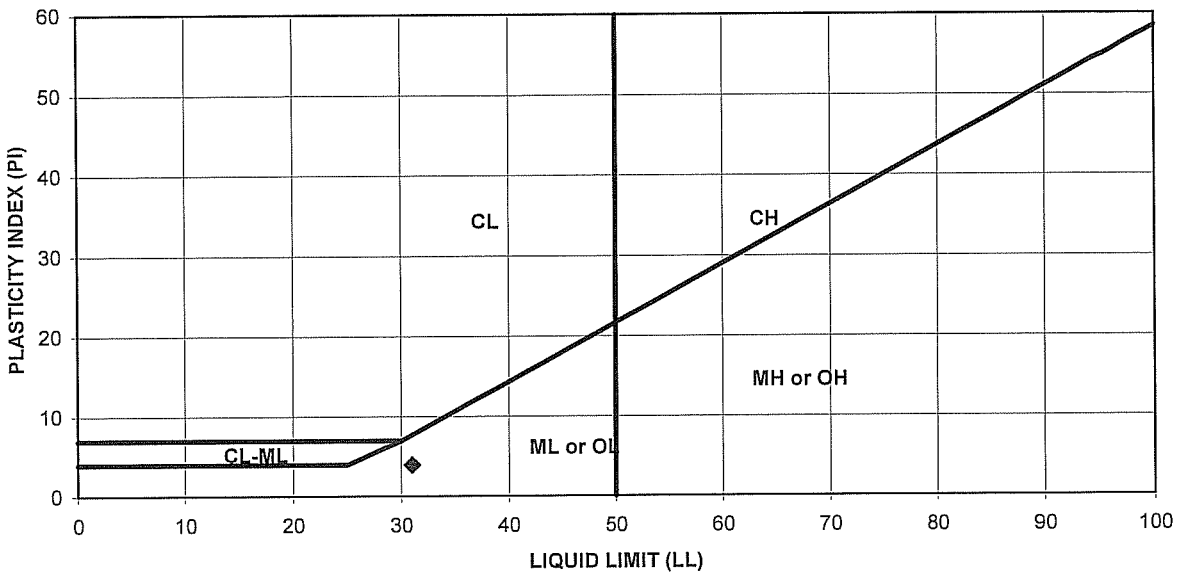
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-012	S-05	25	26	19	7	CL-ML

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

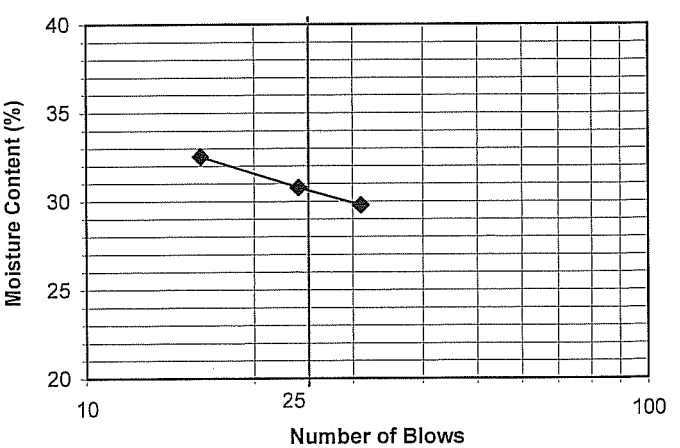
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 01/06/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-012	D-10	50	31	27	4	ML

* NP denotes "non-plastic"

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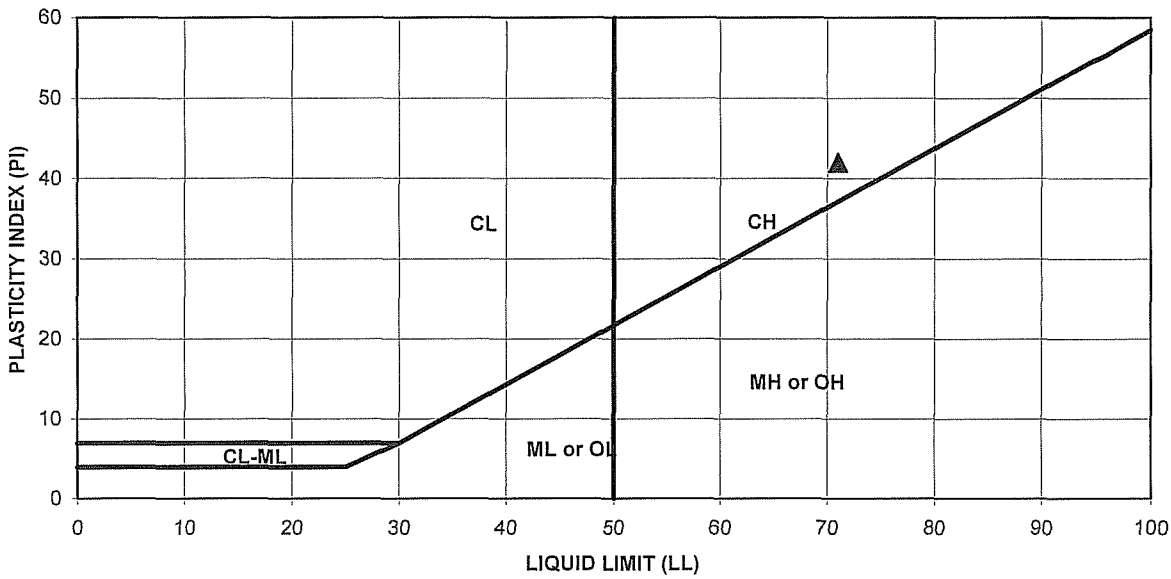
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

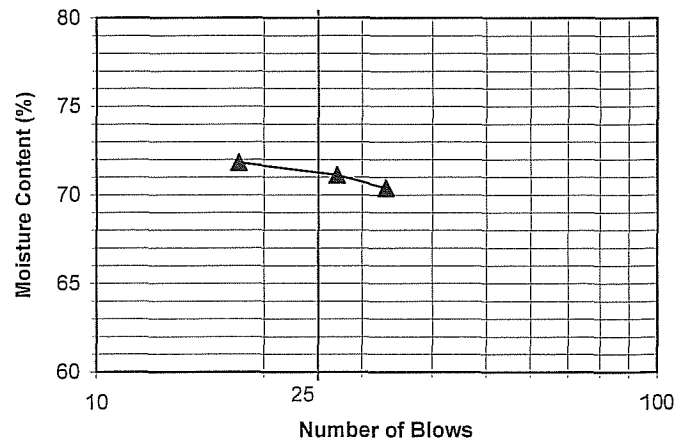
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



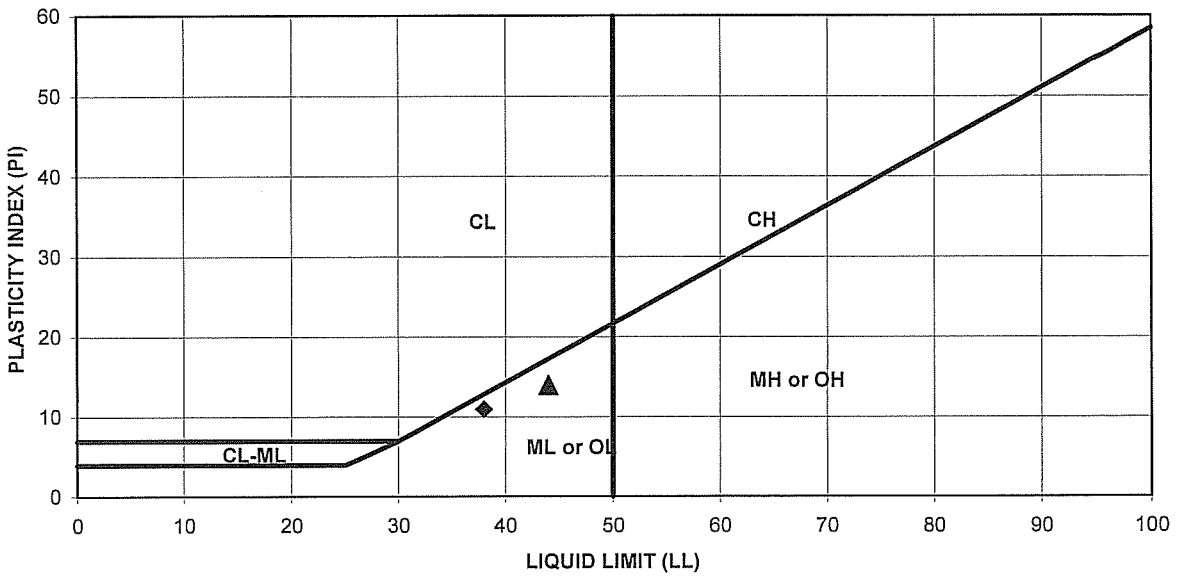
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-012	U-10A	51.5	NP	NP	NP	
▲	R-09-012	S-13	65	71	29	42	CH

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

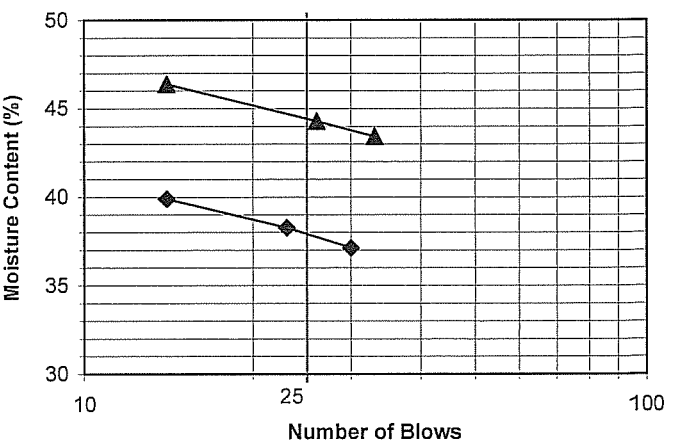
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



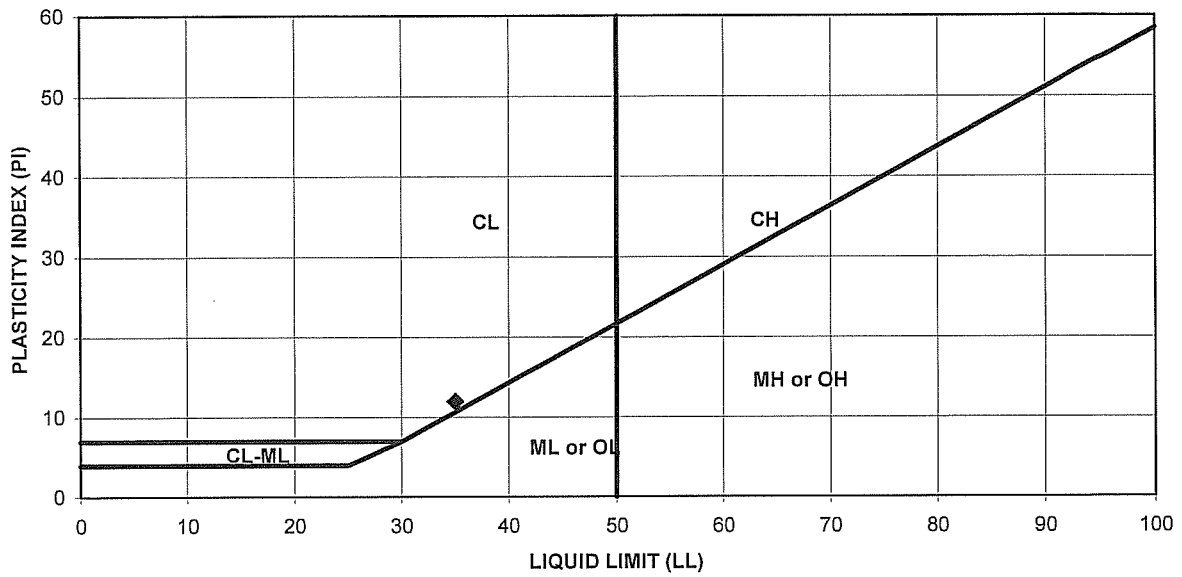
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-012	D-14	70	38	27	11	ML
▲	R-09-012	S-15	75	44	30	14	ML

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

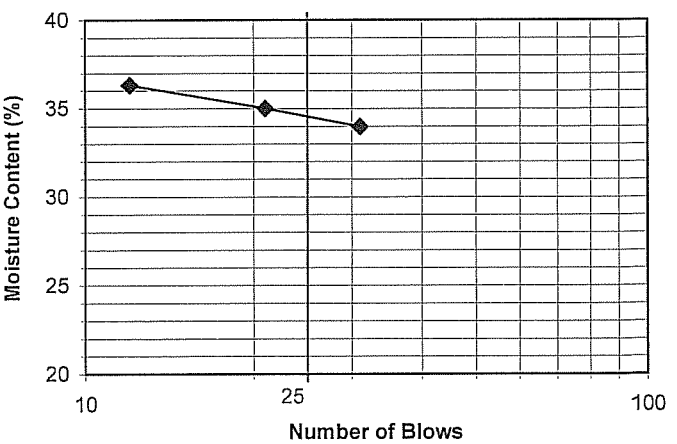
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-012	U-16	80	35	23	12	CL

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/16/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-012	S-05	25	ML	180	8.0	499	540
R-09-012	S-09	45	SM	90	8.1	1322	17602

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-012	R-09-012				
SAMPLE NUMBER	U-10A	U-16				
DEPTH (FT)	51.5	80				
SOIL CLASSIFICATION	Sandy Silt	Lean Clay				
METHOD (A OR B)	B	B				
FLASK NUMBER	2	3				
WT. FLASK+WATER+SOIL, g	381.43	361.17				
TEMPERATURE, °C	20.1	20.8				
CORRECTION FACTOR	1.0000	0.9998				
WT. DRY SOIL, g	68.10	36.28				
WT. FLASK + WATER, g	249.30	249.23				
% RETAINED #4	0.00	0.00				
% PASSING #4	100.00	100.00				
MATERIAL EXCLUDED	None	None				
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.67**	**2.79**				

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AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-012	R-09-012				
SAMPLE NUMBER	U-10A	U-16				
DEPTH (FT)	51.5	80				
SOIL CLASSIFICATION	Sandy Silt	Lean Clay				
METHOD (A OR B)	B	B				
FLASK NUMBER	2	3				
WT. FLASK+WATER+SOIL, g	381.43	361.17				
TEMPERATURE, °C	20.1	20.8				
CORRECTION FACTOR	1.0000	0.9998				
WT. DRY SOIL, g	68.10	36.28				
WT. FLASK + WATER, g	249.30	249.23				
% RETAINED #4	0.00	0.00				
% PASSING #4	100.00	100.00				
MATERIAL EXCLUDED	None	None				
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.67**	**2.79**				

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AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/17/09

Boring No.: R-09-012 Checked By: AP Date: 12/01/09

Sample No.: D-04 Depth (ft): 20

Description: Gray Silty Sand, fine grained sand w/shell

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	563.46
Total Ring Weight (g)	135.25
Wet Density (pcf)	118.70
Dry Density (pcf)	94.56

Moisture Determination	Before Test	After Test
Cont. Weight (g)	179.29	103.53
Wet Soil+Cont. (g)	472.01	520.28
Dry Soil+Cont. (g)	412.48	428.54
Moisture Content (%)	25.5	28.2
Degree Saturation	88.1	96.5

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

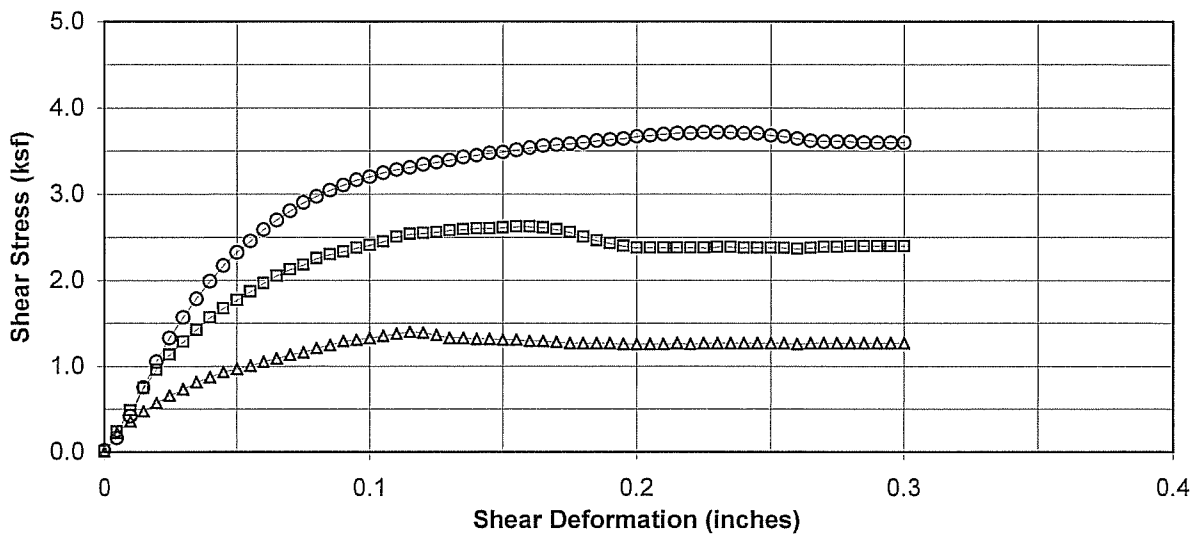
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

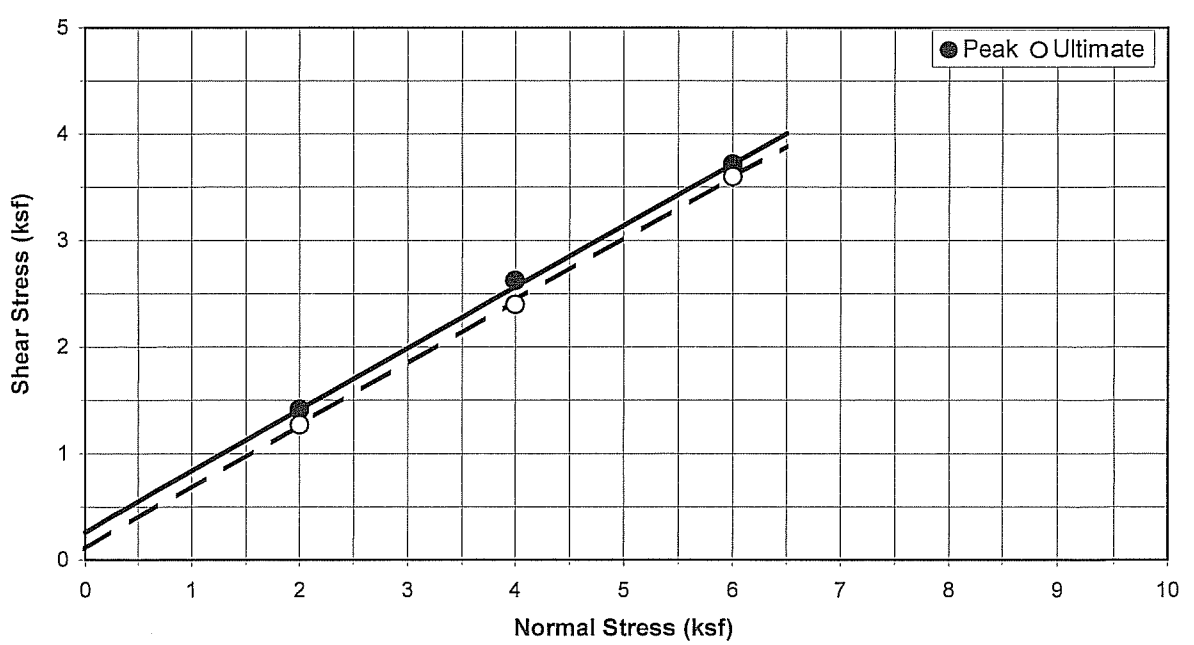
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**187.83**	**44.65**	**2.0**	**1416**	**1272**	
2	**189.87**	**45.43**	**4.0**	**2624**	**2398**	
3	**185.76**	**45.17**	**6.0**	**3720**	**3600**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.6	pcf
Boring No.:	R-09-012	Moisture Content (before):	25.5	%
Sample No.:	D-04	Moisture Content (after):	28.2	%
Depth (ft):	20			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand, fine grained sand w/shell			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	100
Friction Angle:	30 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/17/09

Boring No.: R-09-012 Checked By: AP Date: 12/01/09

Sample No.: D-08 Depth (ft): 40

Description: Gray Silty Sand, fine grained

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	575.87
Total Ring Weight (g)	134.10
Wet Density (pcf)	122.46
Dry Density (pcf)	94.82

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.38	104.09
Wet Soil+Cont. (g)	192.08	525.74
Dry Soil+Cont. (g)	160.09	430.27
Moisture Content (%)	29.2	29.3
Degree Saturation	101.2	100.7

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

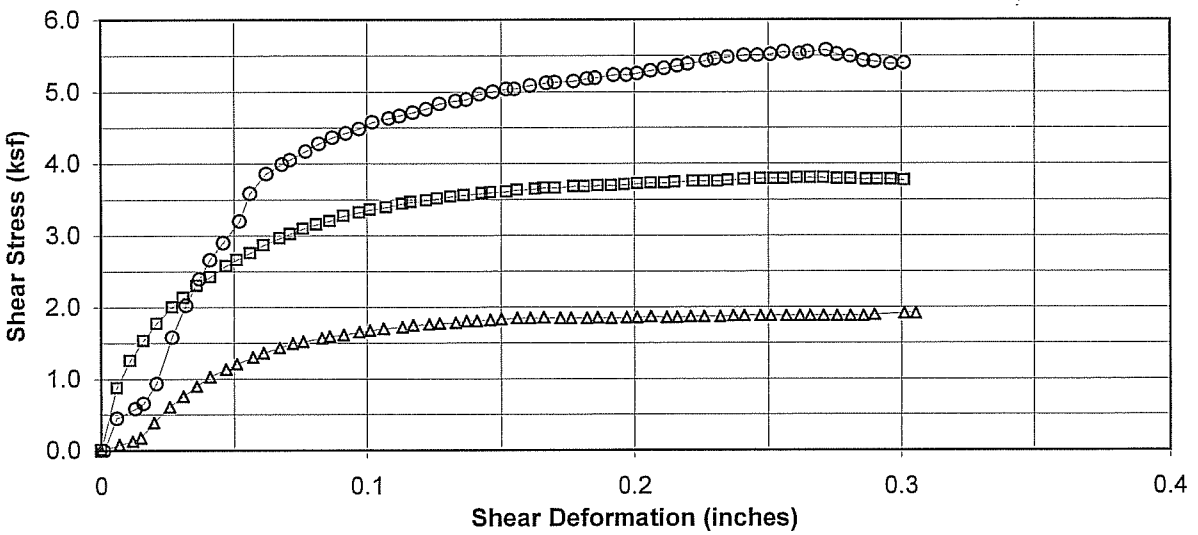
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

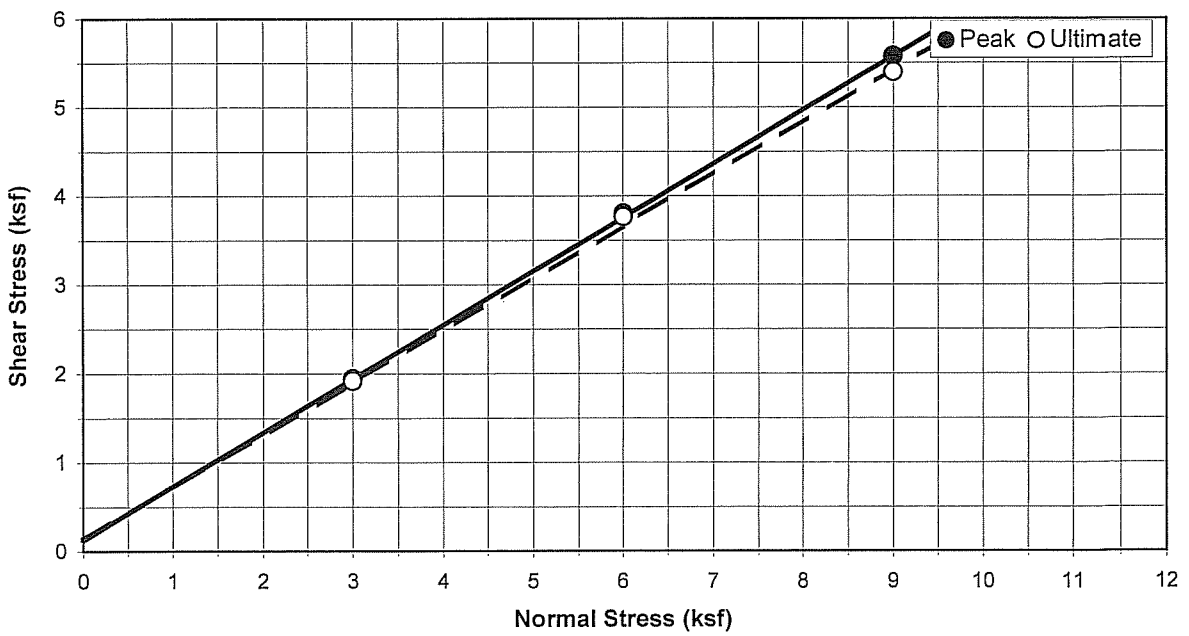
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**194.23**	**44.66**	**3.0**	**1944**	**1920**	
2	**191.00**	**44.74**	**6.0**	**3804**	**3768**	
3	**190.64**	**44.70**	**9.0**	**5579**	**5400**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.8	pcf
Boring No.:	R-09-012	Moisture Content (before):	29.2	%
Sample No.:	D-08	Moisture Content (after):	29.3	%
Depth (ft):	40			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand, fine grained			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	150
Friction Angle:	31 °	30 °

AP Engineering & Testing, Inc.

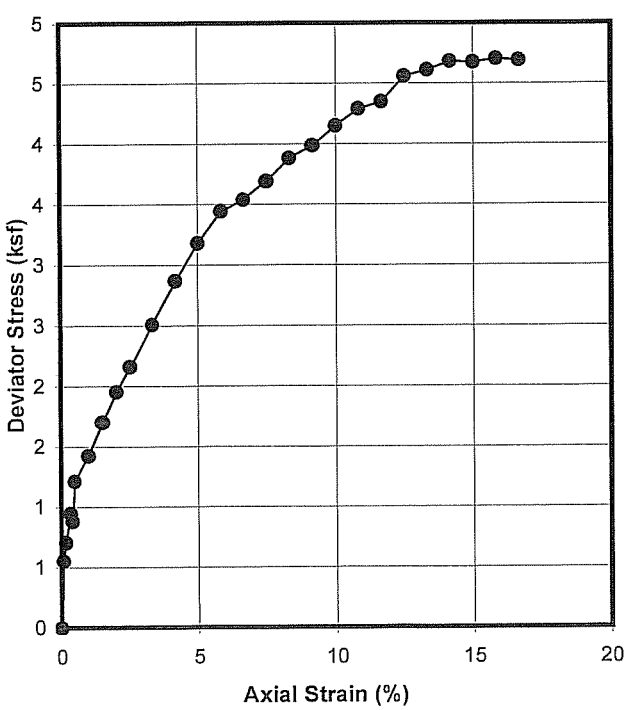
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-012		
Sample No.:	U-10A Depth (feet): 51.5		
Soil Description	Gray Sandy Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	123.5
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	96.9
Sample Weight (gms):	1263.87	Moisture Content (%):	27.5
Wt. Wet Soil+Container(gms)	1451.08	Void Ratio for Gs=2.7:	0.74
Wt. Dry Soil+Container(gms)	1179.72	% Saturation:	100.4
Wt. Container (gms)	191.91		

TEST DATA

Cell Pressure (ksf):	2.59
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.59
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.7
Ultimate Deviator Stress (ksf):	4.7
Ultimate Undrained Shear Strength (ksf):	2.3
Axial Strain @ Maximum Stress (%)	15.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
25	0.005	6.50	0.55	0.08
32	0.010	6.50	0.71	0.17
43	0.020	6.51	0.95	0.33
40	0.025	6.52	0.88	0.42
55	0.030	6.52	1.21	0.50
65	0.060	6.56	1.43	1.00
78	0.090	6.59	1.70	1.50
90	0.120	6.62	1.96	2.00
100	0.150	6.66	2.16	2.50
117	0.200	6.72	2.51	3.33
135	0.250	6.77	2.87	4.17
151	0.300	6.83	3.18	5.00
165	0.350	6.89	3.45	5.83
171	0.400	6.96	3.54	6.67
180	0.450	7.02	3.69	7.50
191	0.500	7.08	3.88	8.33
198	0.550	7.15	3.99	9.17
208	0.600	7.21	4.15	10.00
217	0.650	7.28	4.29	10.83
222	0.700	7.35	4.35	11.67
235	0.750	7.42	4.56	12.50
240	0.800	7.49	4.61	13.33
246	0.850	7.56	4.68	14.17
248	0.900	7.64	4.68	15.00
252	0.950	7.71	4.70	15.83
254	1.000	7.79	4.70	16.67

AP Engineering & Testing, Inc.

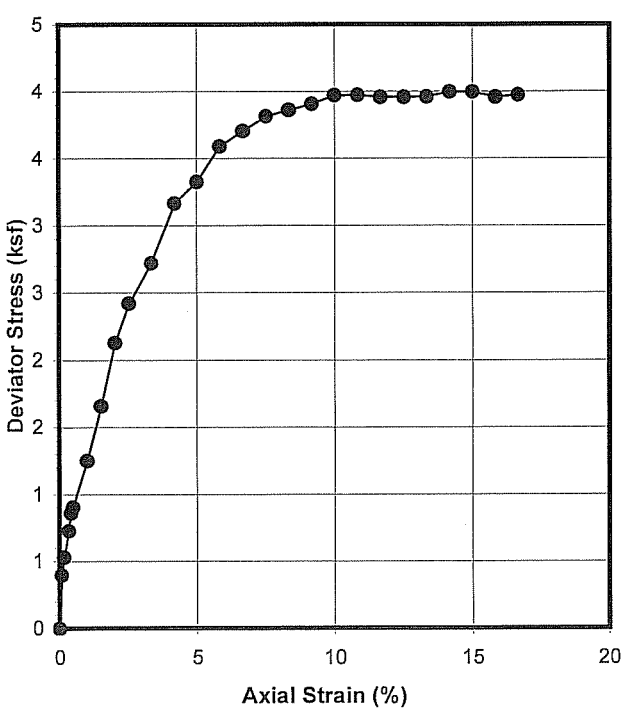
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-012		
Sample No.:	U-16 Depth (feet): 80		
Soil Description	Gray Lean Clay	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	116.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	85.1
Sample Weight (gms):	1190.00	Moisture Content (%):	36.6
Wt. Wet Soil+Container(gms)	1396.63	Void Ratio for Gs=2.7:	0.98
Wt. Dry Soil+Container(gms)	1075.08	% Saturation:	101.0
Wt. Container (gms)	196.61		

TEST DATA

Cell Pressure (ksf):	3.60
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	3.60
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.0
Ultimate Deviator Stress (ksf):	4.0
Ultimate Undrained Shear Strength (ksf):	2.0
Axial Strain @ Maximum Stress (%)	14.17



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
18	0.005	6.50	0.40	0.08
24	0.010	6.50	0.53	0.17
33	0.020	6.51	0.73	0.33
39	0.025	6.52	0.86	0.42
41	0.030	6.52	0.90	0.50
57	0.060	6.56	1.25	1.00
76	0.090	6.59	1.66	1.50
98	0.120	6.62	2.13	2.00
112	0.150	6.66	2.42	2.50
127	0.200	6.72	2.72	3.33
149	0.250	6.77	3.17	4.17
158	0.300	6.83	3.33	5.00
172	0.350	6.89	3.59	5.83
179	0.400	6.96	3.71	6.67
186	0.450	7.02	3.82	7.50
190	0.500	7.08	3.86	8.33
194	0.550	7.15	3.91	9.17
199	0.600	7.21	3.97	10.00
201	0.650	7.28	3.98	10.83
202	0.700	7.35	3.96	11.67
204	0.750	7.42	3.96	12.50
206	0.800	7.49	3.96	13.33
210	0.850	7.56	4.00	14.17
212	0.900	7.64	4.00	15.00
212	0.950	7.71	3.96	15.83
215	1.000	7.79	3.97	16.67

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/01/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-013	D-02	10	73.7	NA
R-09-013	D-03	15	30.2	93.4
R-09-013	D-06	30	52.7	70.1
R-09-013	S-07	35	36.2	NA
R-09-013	S-09-1	45	41.9	NA
R-09-013	D-10	50	39.4	79.7
R-09-013	S-11-2	55.5	35.5	NA
R-09-013	D-12	60	32.8	88.2
R-09-013	S-13	65	33.9	NA
R-09-013	S-15	75	24.5	NA
R-09-013	S-17	85	24.9	NA
R-09-013	S-19	100	18.3	NA
R-09-013	S-22	130	5.9	NA
R-09-013	S-24	150	18.7	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-013	U-15	25	0.50
R-09-013	U-08	40	0.75
R-09-013	D-10	50	0.50

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	12/09/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-013	D-03	15	10.68
R-09-013	D-14	70	12.69

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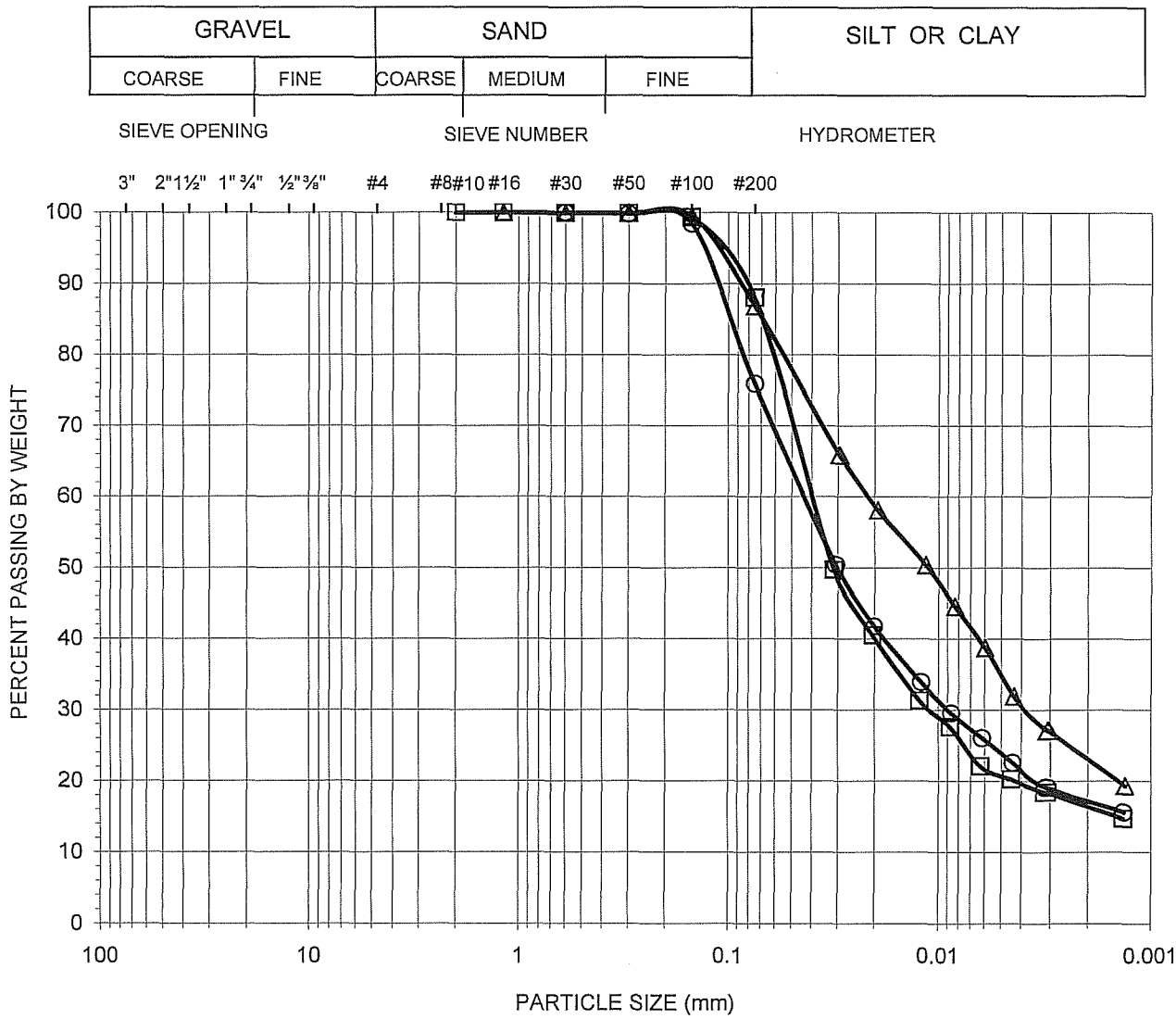
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

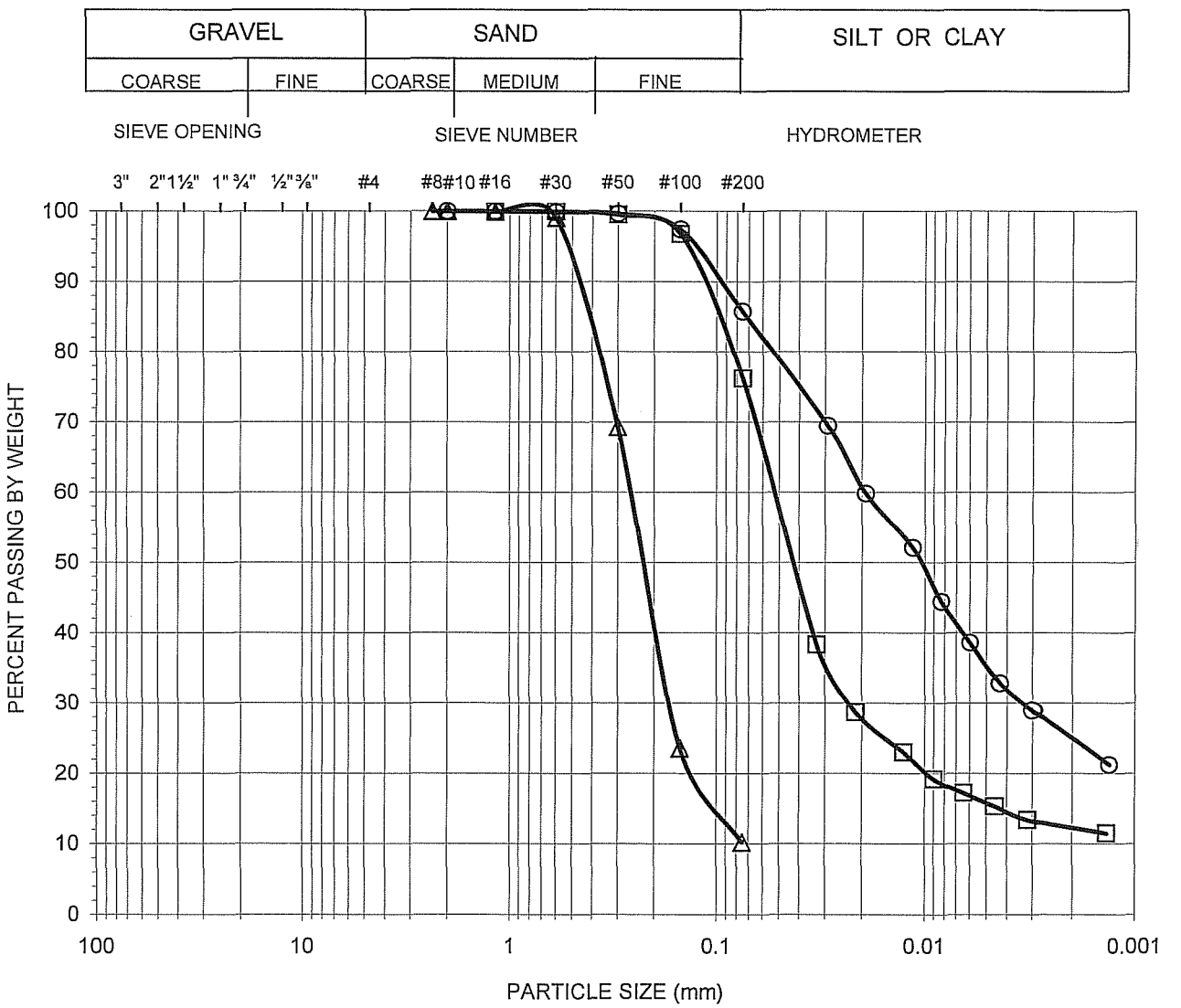


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	U-05	25	0.00	24.03	75.97	30:23:7	CL-ML
□	R-09-013	S-07	35	0.00	11.97	88.03	N/P	ML
△	R-09-013	U-08	40	0.00	13.09	86.91	36:24:12	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

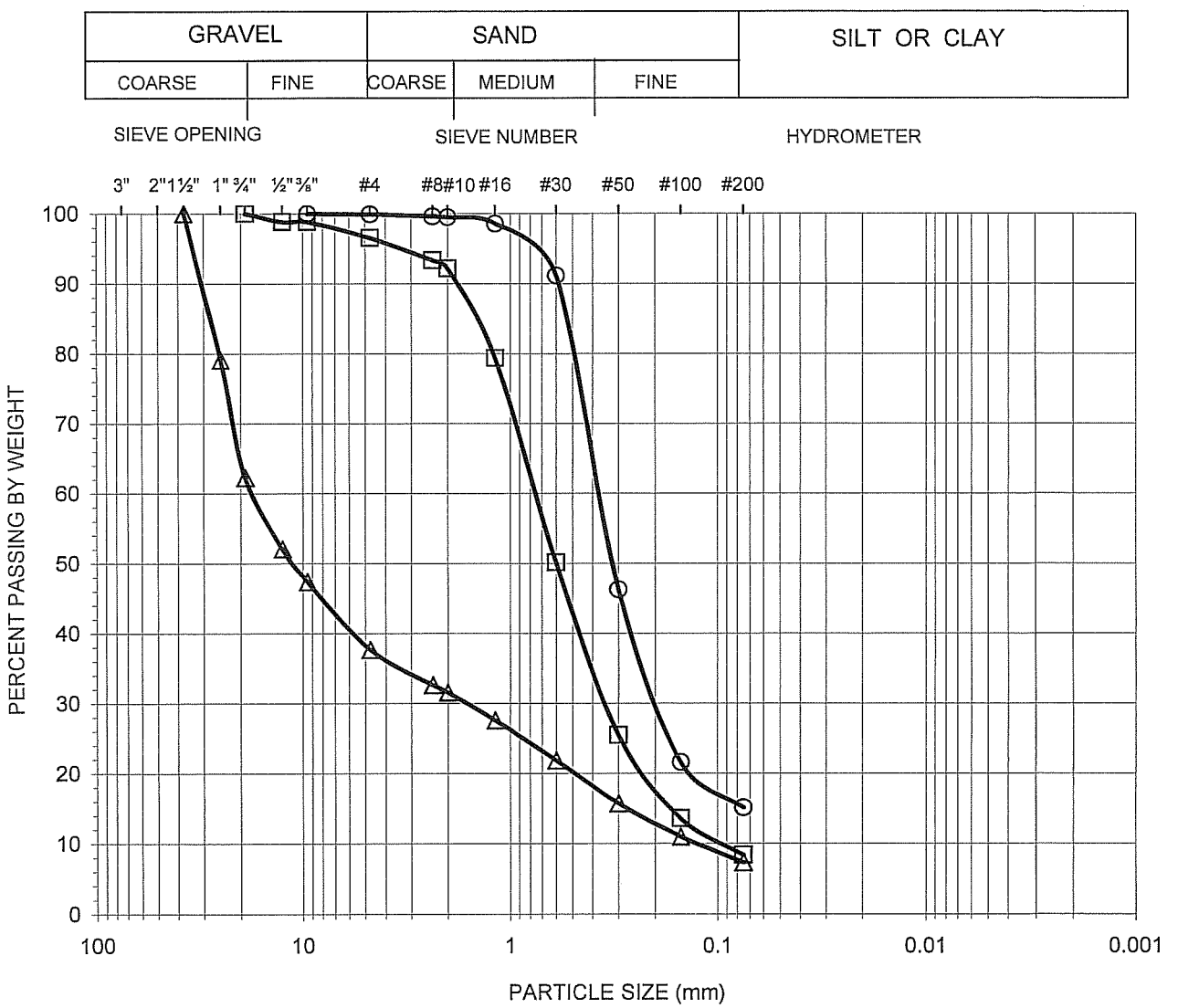


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	D-10	50	0.00	14.25	85.75	38:25:13	CL
□	R-09-013	S-13	65	0.00	23.80	76.20	N/P	ML
△	R-09-013	S-15	75	0.00	89.76	10.24	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

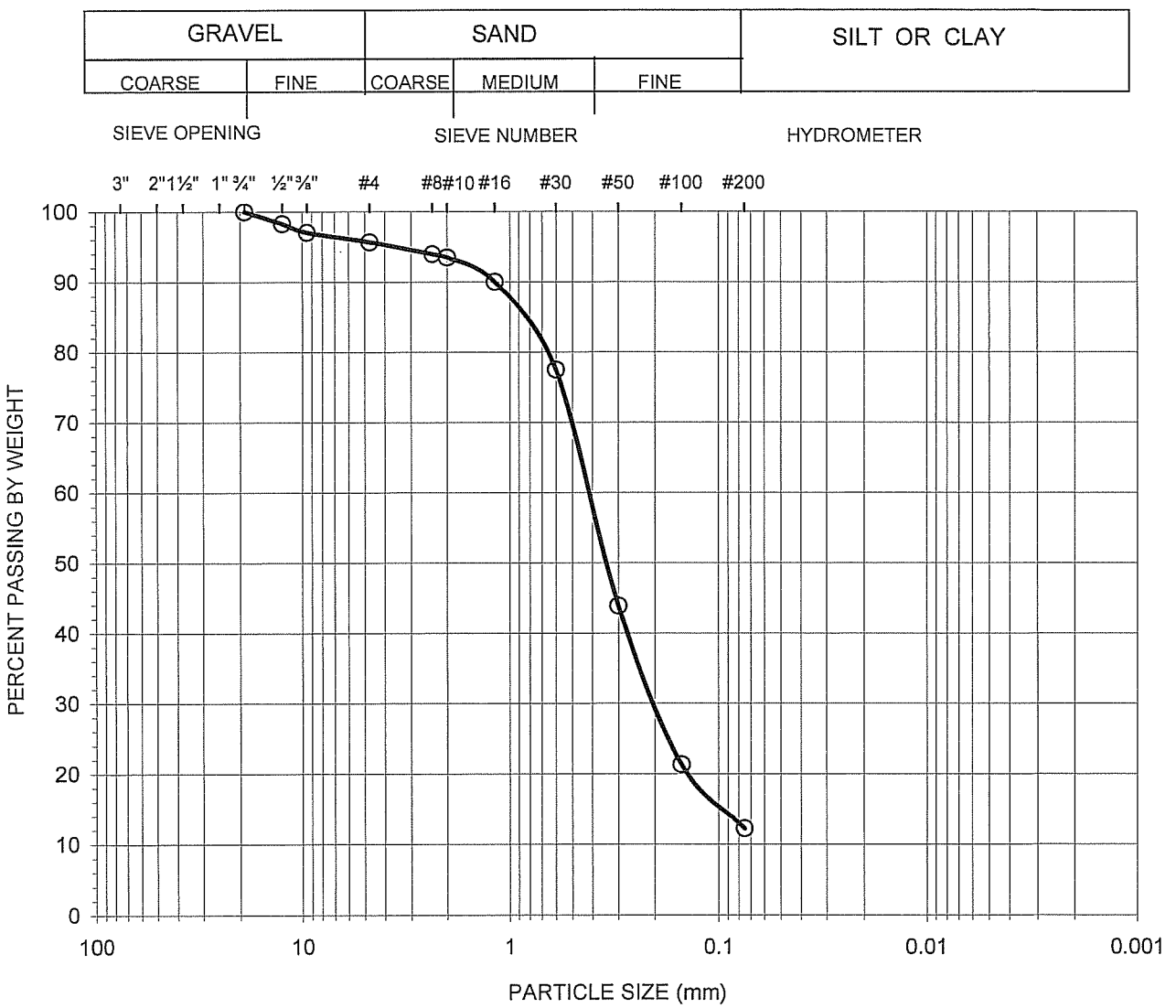


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	S-17	85	0.06	84.77	15.17	N/A	SM
□	R-09-013	S-19	100	3.49	88.11	8.40	N/A	SW-SM
△	R-09-013	S-22	130	62.32	30.32	7.36	N/A	GW-GM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



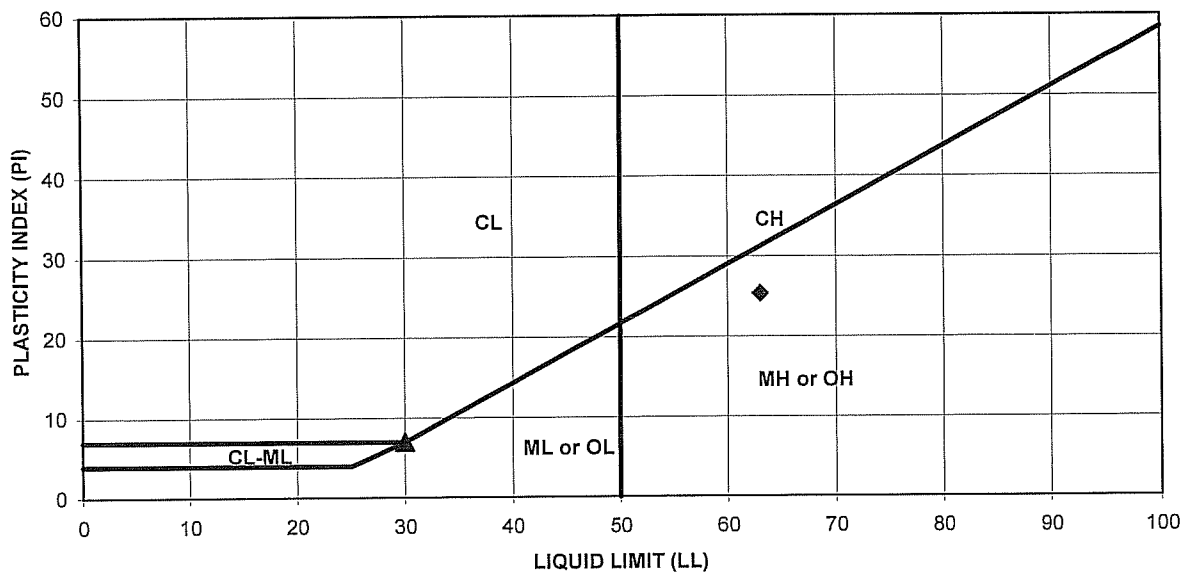
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	S-24	150	4.31	83.40	12.29	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

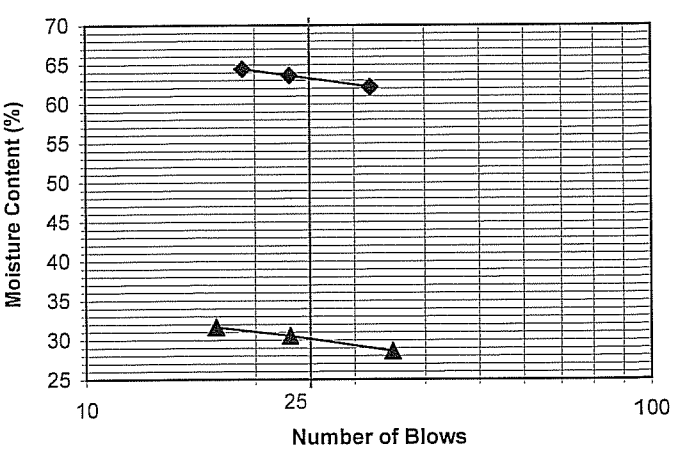
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



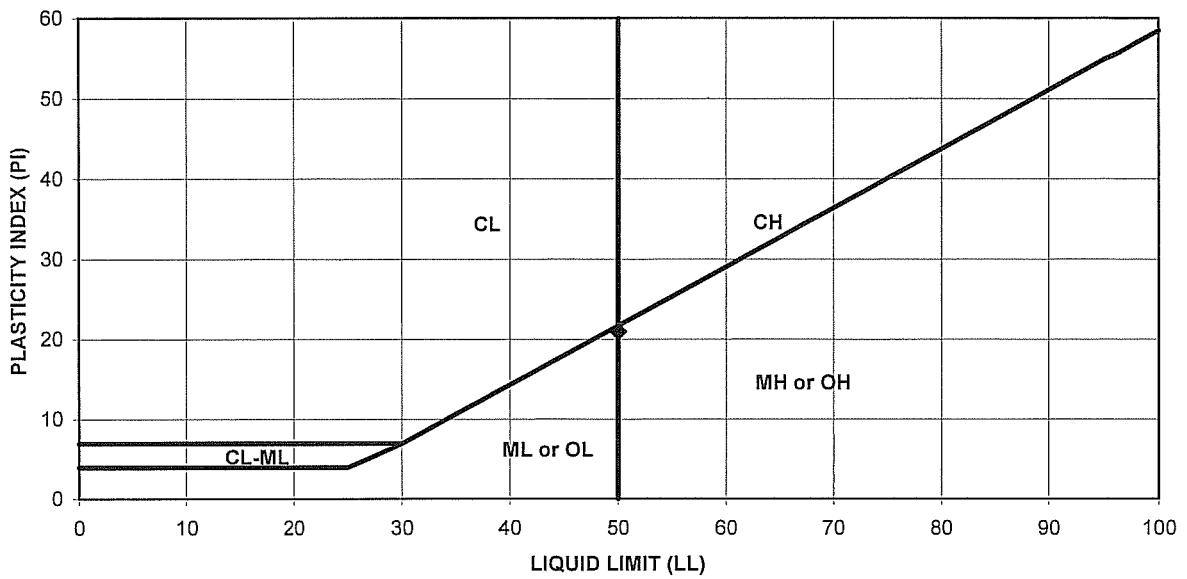
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-013	S-02	10	63	38	25	MH
▲	R-09-013	U-05	25	30	23	7	CL-ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

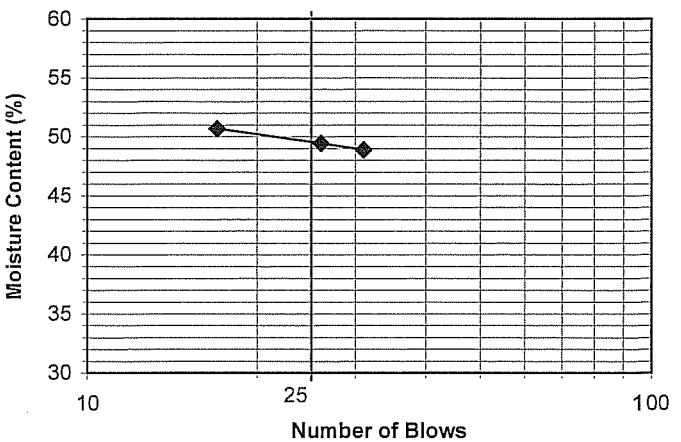
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



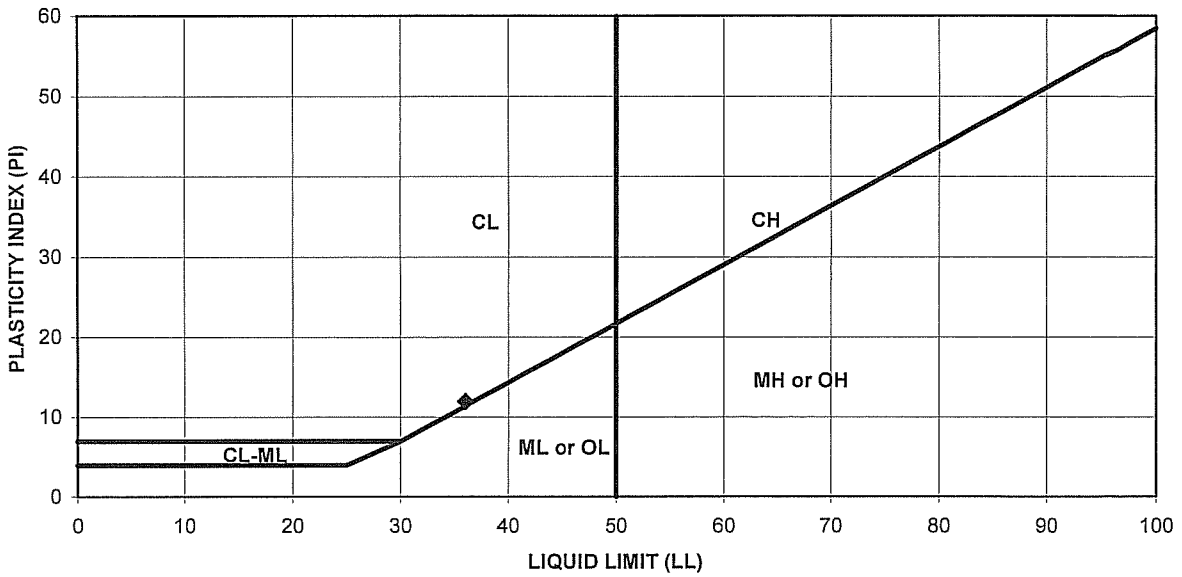
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-013	D-06	30	50	29	21	ML-MH
	R-09-013	S-07	35	NP	NP	NP	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

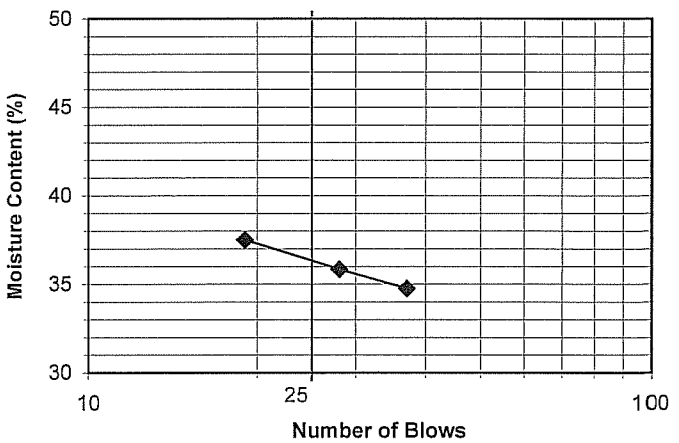
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-013	U-08	40	36	24	12	CL
	R-09-013	S-09-1	45	NP	NP	NP	

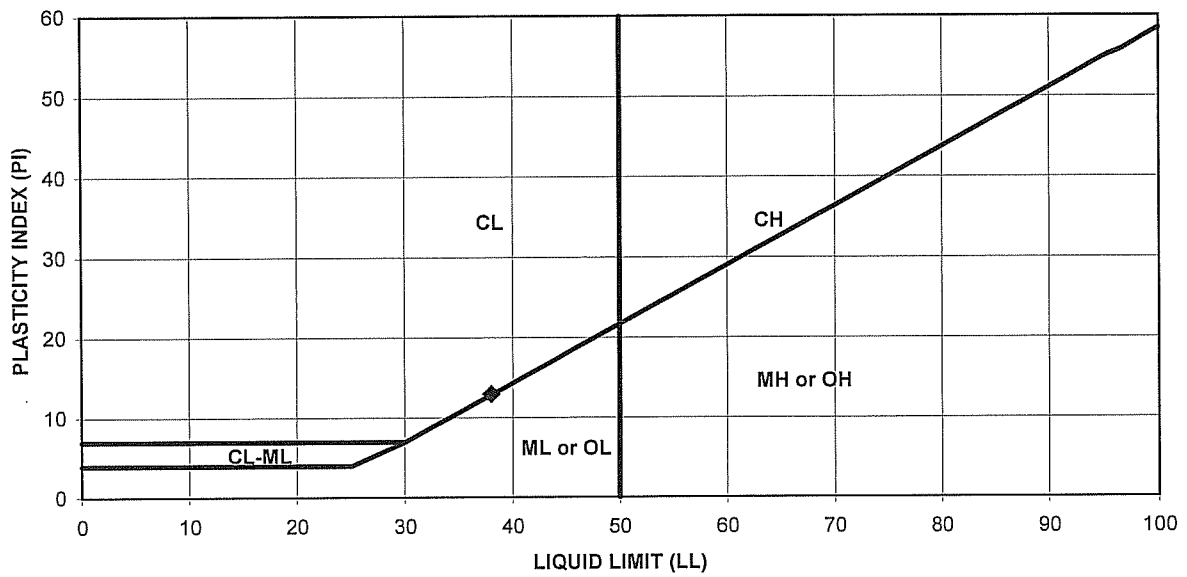
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

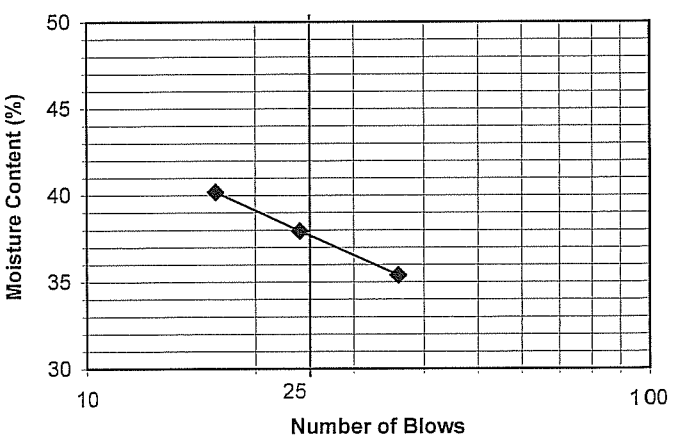
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



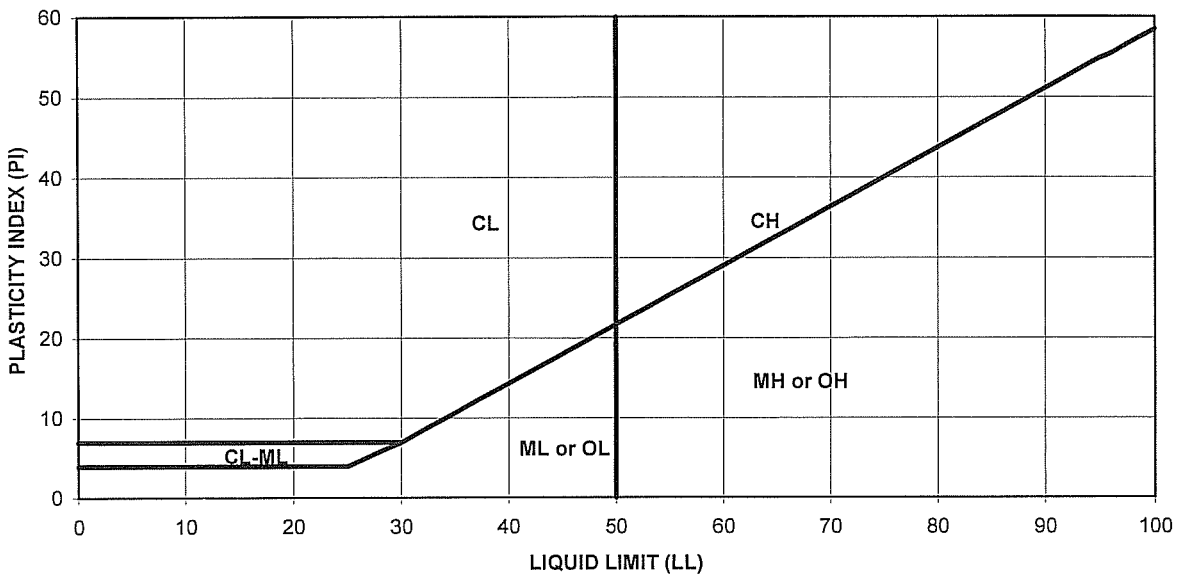
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-013	D-10	50	38	25	13	CL
	R-09-013	S-11-2	55.5	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

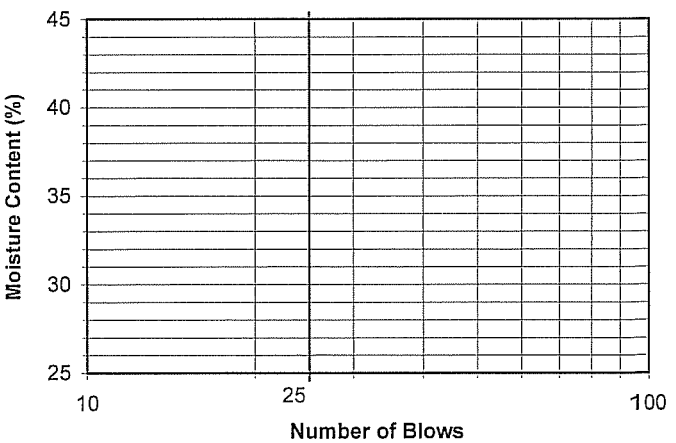
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-013	D-12	60	NP	NP	NP	ML
	R-09-013	S-13	65	NP	NP	NP	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/11/09

Project No. : 06-123-03 Checked By: AP Date: 12/11/09

BORING NUMBER	R-09-013	R-09-013				
SAMPLE NUMBER	U-5	U-8				
DEPTH (FT)	25	40				
SOIL CLASSIFICATION	Silty Clay with sand	Lean Clay with sand				
METHOD (A OR B)	B	B				
FLASK NUMBER	3	1				
WT. FLASK+WATER+SOIL, g	363.61	387.73				
TEMPERATURE, °C	19.0	19.4				
CORRECTION FACTOR	1.0002	1.0001				
WT. DRY SOIL, g	40.59	40.88				
WT. FLASK + WATER, g	249.23	249.36				
% RETAINED #4	0.00	0.00				
% PASSING #4	100.00	100.00				
MATERIAL EXCLUDED	None	None				
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.71**	**2.69**				

2607 Pomona Boulevard. Pomona, California 91768
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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 12/07/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-013	S-02	10	MH	110	7.0	292	1598

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KK Date: 12/08/09

Boring No.: R-09-013 Checked By: AP Date: 12/11/09

Sample No.: D-03 Depth (ft): 15

Description: Gray Sand with Silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	571.84
Total Ring Weight (g)	131.61
Wet Density (pcf)	122.04
Dry Density (pcf)	93.74

Moisture Determination	Before Test	After Test
Cont. Weight (g)	179.76	156.56
Wet Soil+Cont. (g)	391.41	579.16
Dry Soil+Cont. (g)	342.33	480.75
Moisture Content (%)	30.2	30.4
Degree Saturation	97.7	100.4

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

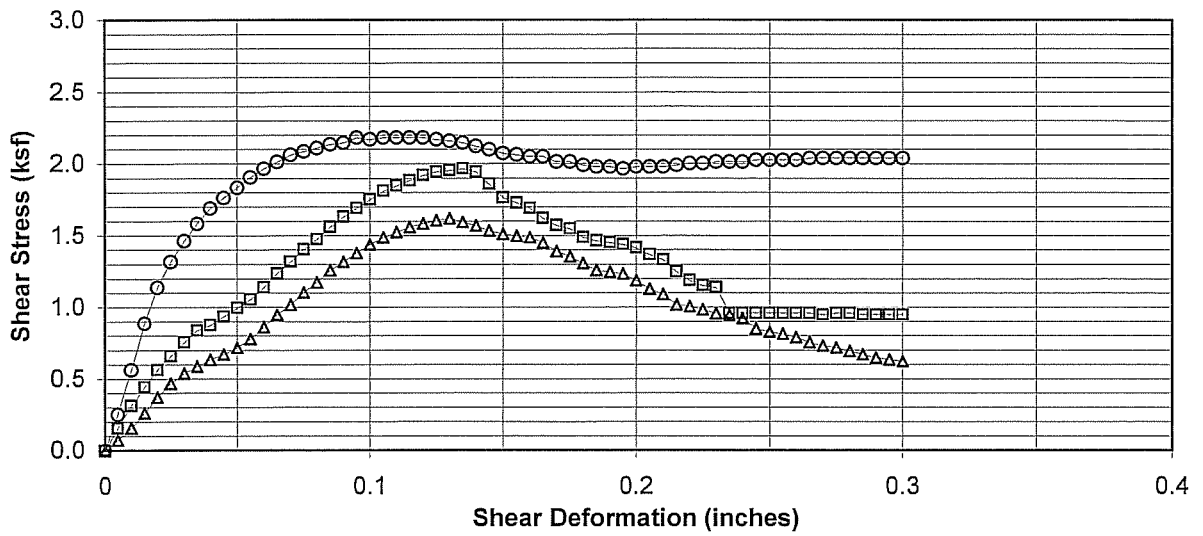
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

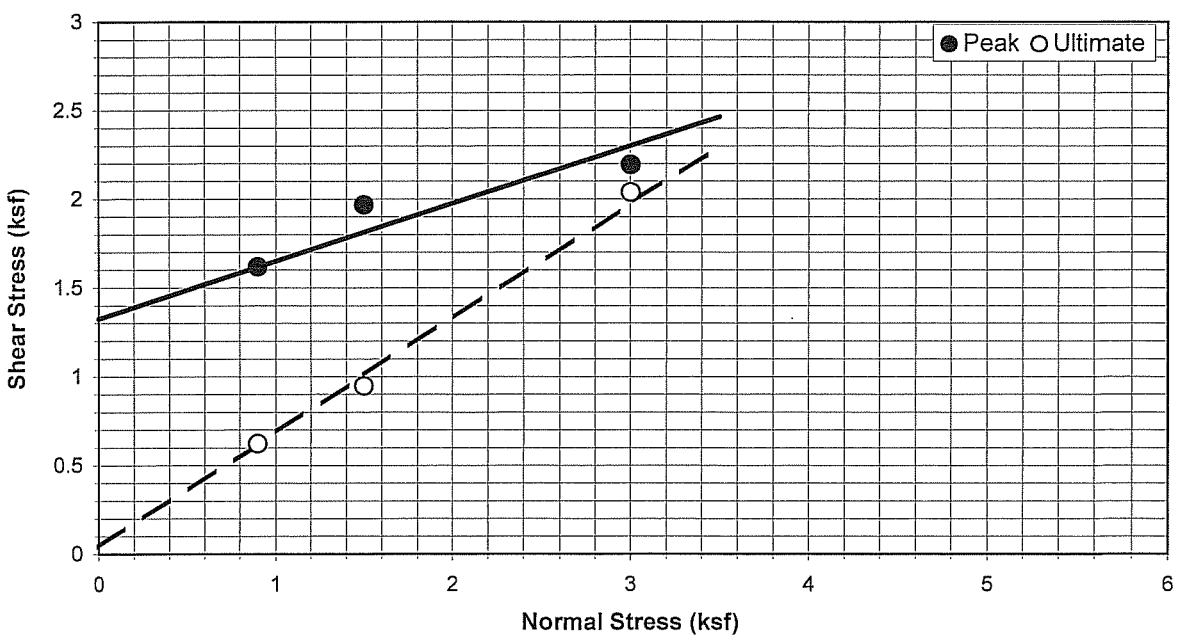
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**191.71**	**43.31**	**0.9**	**1620**	**624**	
2	**189.60**	**44.87**	**1.5**	**1968**	**948**	
3	**190.53**	**43.43**	**3.0**	**2196**	**2040**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.7	pcf
Boring No.:	R-09-013	Moisture Content (before):	30.2	%
Sample No.:	D-03	Moisture Content (after):	30.4	%
Depth (ft):	15			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sand with Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	1350	50
Friction Angle:	18 °	33 °

AP Engineering & Testing, Inc.

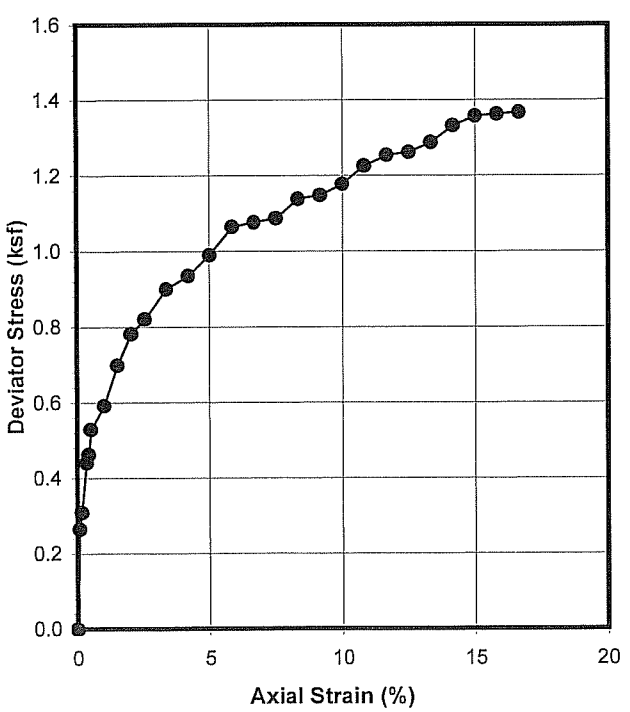
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/12/09
Project No.:	06-123-03		
Boring No.:	R-09-013		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silty Clay with sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	110.8
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	77.7
Sample Weight (gms):	1133.95	Moisture Content (%):	42.7
Wt. Wet Soil+Container(gms)	1238.93	Void Ratio for Gs=2.7:	1.17
Wt. Dry Soil+Container(gms)	899.10	% Saturation:	98.6
Wt. Container (gms)	103.89		

TEST DATA

Cell Pressure (ksf):	1.01
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.01
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.4
Ultimate Deviator Stress (ksf):	1.3
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
14	0.010	6.50	0.31	0.17
20	0.020	6.51	0.44	0.33
21	0.025	6.52	0.46	0.42
24	0.030	6.52	0.53	0.50
27	0.060	6.56	0.59	1.00
32	0.090	6.59	0.70	1.50
36	0.120	6.62	0.78	2.00
38	0.150	6.66	0.82	2.50
42	0.200	6.72	0.90	3.33
44	0.250	6.77	0.94	4.17
47	0.300	6.83	0.99	5.00
51	0.350	6.89	1.07	5.83
52	0.400	6.96	1.08	6.67
53	0.450	7.02	1.09	7.50
56	0.500	7.08	1.14	8.33
57	0.550	7.15	1.15	9.17
59	0.600	7.21	1.18	10.00
62	0.650	7.28	1.23	10.83
64	0.700	7.35	1.25	11.67
65	0.750	7.42	1.26	12.50
67	0.800	7.49	1.29	13.33
70	0.850	7.56	1.33	14.17
72	0.900	7.64	1.36	15.00
73	0.950	7.71	1.36	15.83
74	1.000	7.79	1.37	16.67

AP Engineering & Testing, Inc.

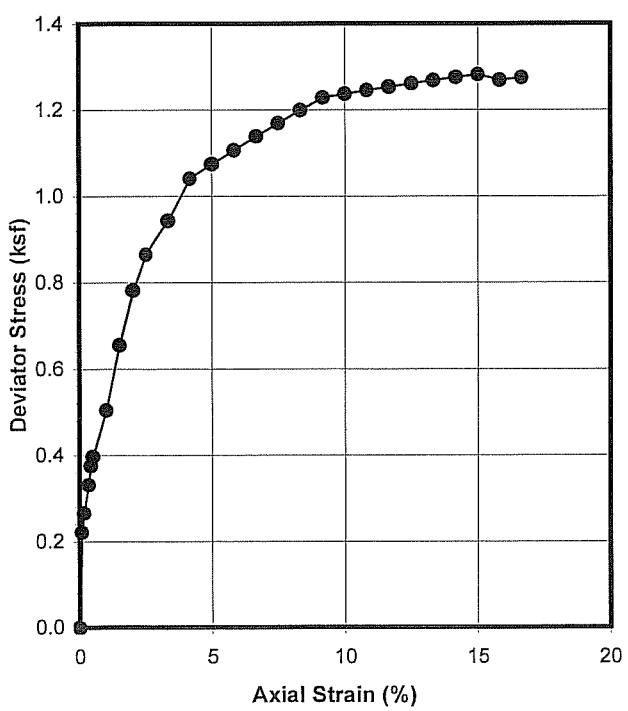
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-013				
Sample No.:	U-08	Depth (feet): 25			
Soil Description	Gray Lean Clay with sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	114.5
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	81.1
Sample Weight (gms):	1171.80	Moisture Content (%):	41.3
Wt. Wet Soil+Container(gms)	1327.70	Void Ratio for Gs=2.7:	1.08
Wt. Dry Soil+Container(gms)	984.72	% Saturation:	103.4
Wt. Container (gms)	154.45		

TEST DATA

Cell Pressure (ksf):	1.58
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.58
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.3
Ultimate Deviator Stress (ksf):	1.3
Ultimate Undrained Shear Strength (ksf):	0.6
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
10	0.005	6.50	0.22	0.08
12	0.010	6.50	0.27	0.17
15	0.020	6.51	0.33	0.33
17	0.025	6.52	0.38	0.42
18	0.030	6.52	0.40	0.50
23	0.060	6.56	0.51	1.00
30	0.090	6.59	0.66	1.50
36	0.120	6.62	0.78	2.00
40	0.150	6.66	0.87	2.50
44	0.200	6.72	0.94	3.33
49	0.250	6.77	1.04	4.17
51	0.300	6.83	1.07	5.00
53	0.350	6.89	1.11	5.83
55	0.400	6.96	1.14	6.67
57	0.450	7.02	1.17	7.50
59	0.500	7.08	1.20	8.33
61	0.550	7.15	1.23	9.17
62	0.600	7.21	1.24	10.00
63	0.650	7.28	1.25	10.83
64	0.700	7.35	1.25	11.67
65	0.750	7.42	1.26	12.50
66	0.800	7.49	1.27	13.33
67	0.850	7.56	1.28	14.17
68	0.900	7.64	1.28	15.00
68	0.950	7.71	1.27	15.83
69	1.000	7.79	1.28	16.67

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/07/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-015	D-02	10	25.6	98.3
R-09-015	D-04	20	42.9	79.4
R-09-015	S-05	25	36.5	NA
R-09-015	D-06	30	34.8	84.9
R-09-015	S-07	35	51.0	NA
R-09-015	D-08	40	62.8	62.4
R-09-015	D-10	50	35.3	82.8
R-09-015	S-11	55	37.2	NA
R-09-015	D-15	75	27.0	98.0
R-09-015	S-16	80	24.7	NA
R-09-015	S-18	100	17.5	NA
R-09-015	S-21	135	13.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-015	D-04	20	0.70
R-09-015	D-08	40	0.53
R-09-015	U-09	45	2.00
R-09-015	U-12	60	1.25

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	12/07/09
Project Number:	06-123-03		

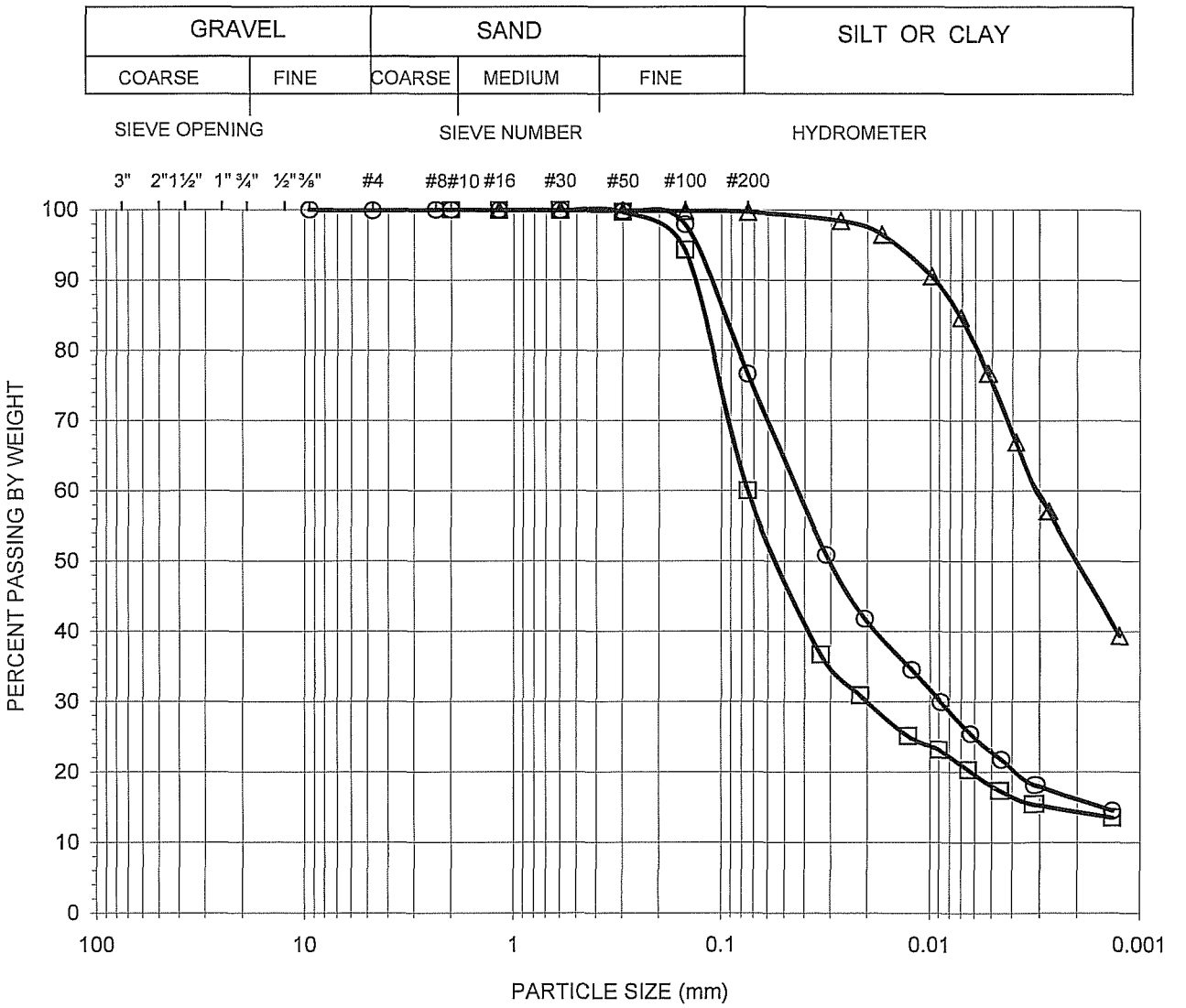
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-015	S-01	5	69.40
R-09-015	S-03	15	47.28
R-09-015	D-13	65	16.69

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

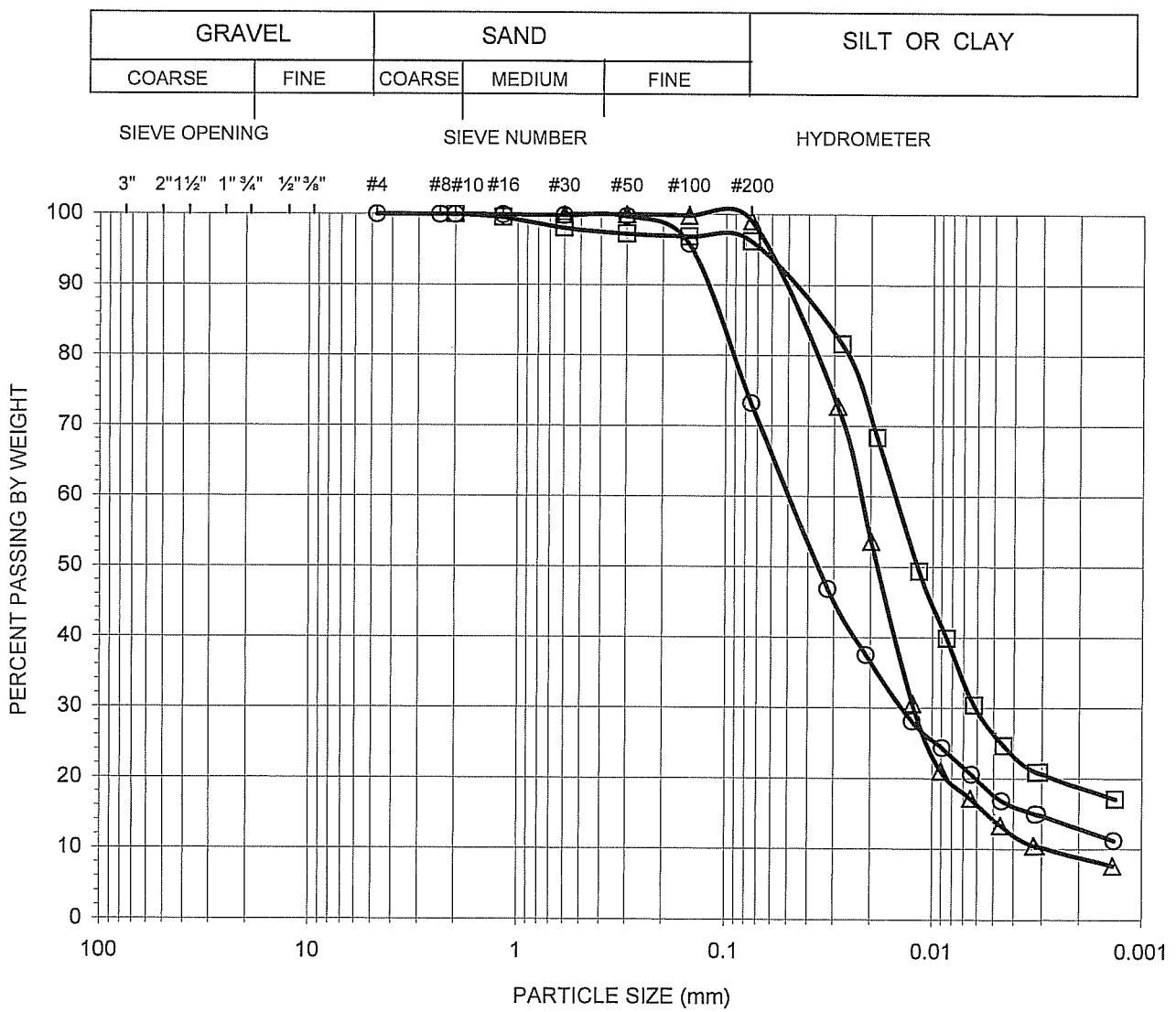


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-015	D-04	20	0.10	23.22	76.68	N/P	ML
□	R-09-015	S-05	25	0.00	40.02	59.98	N/A	ML
△	R-09-015	D-08	40	0.00	0.32	99.68	71:37:34	MH

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

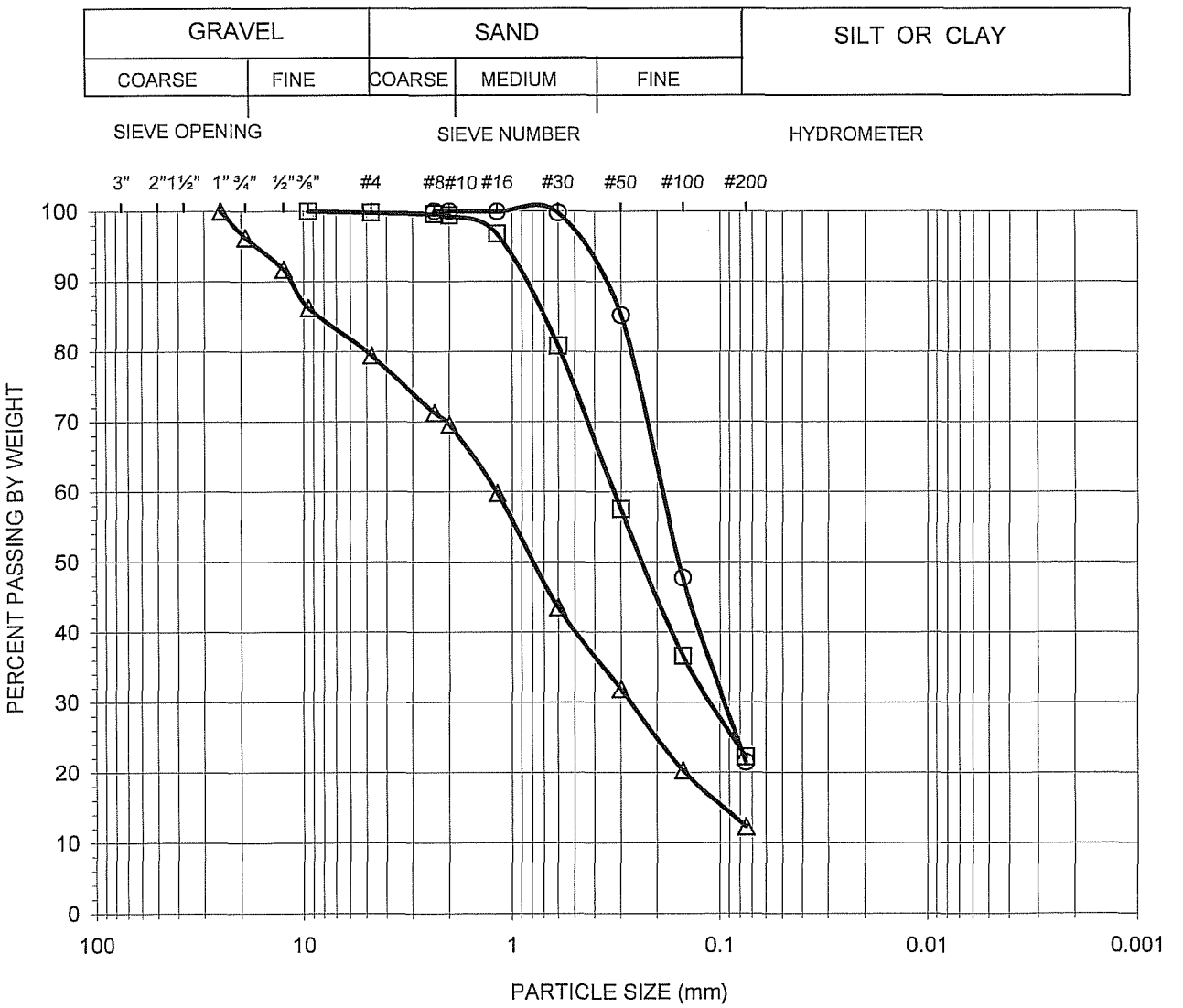


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-015	U-09	45	0.00	26.74	73.26	N/P	ML
□	R-09-015	S-11	55	0.00	3.82	96.18	38:26:12	ML
△	R-09-015	U-12	60	0.00	0.93	99.07	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09



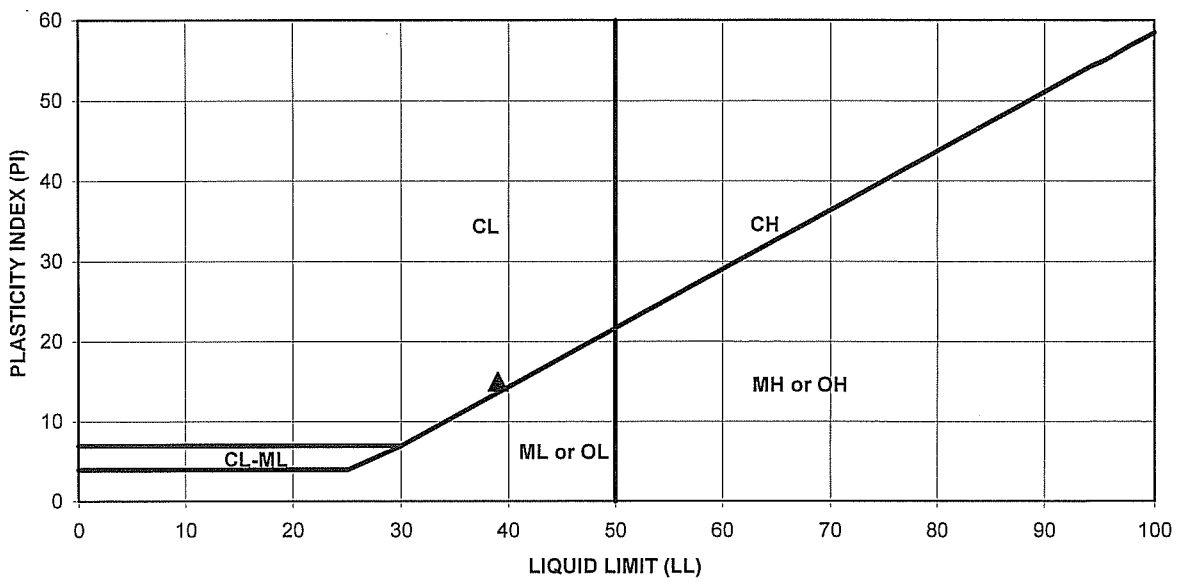
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-015	S-16	80	0.00	78.48	21.52	N/A	SM
□	R-09-015	S-18	100	0.22	77.57	22.21	N/A	SM
△	R-09-015	S-21	135	20.52	67.10	12.38	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

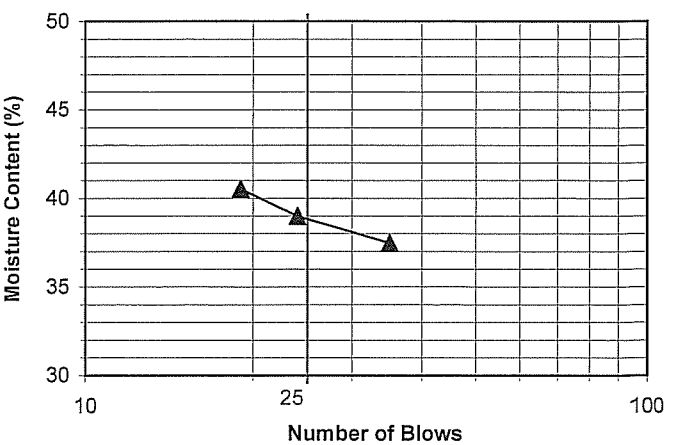
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 12/07/09
Checked By: AP Date: 12/20/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-015	D-04	20	NP	NP	NP	
▲	R-09-015	S-07	35	39	24	15	CL

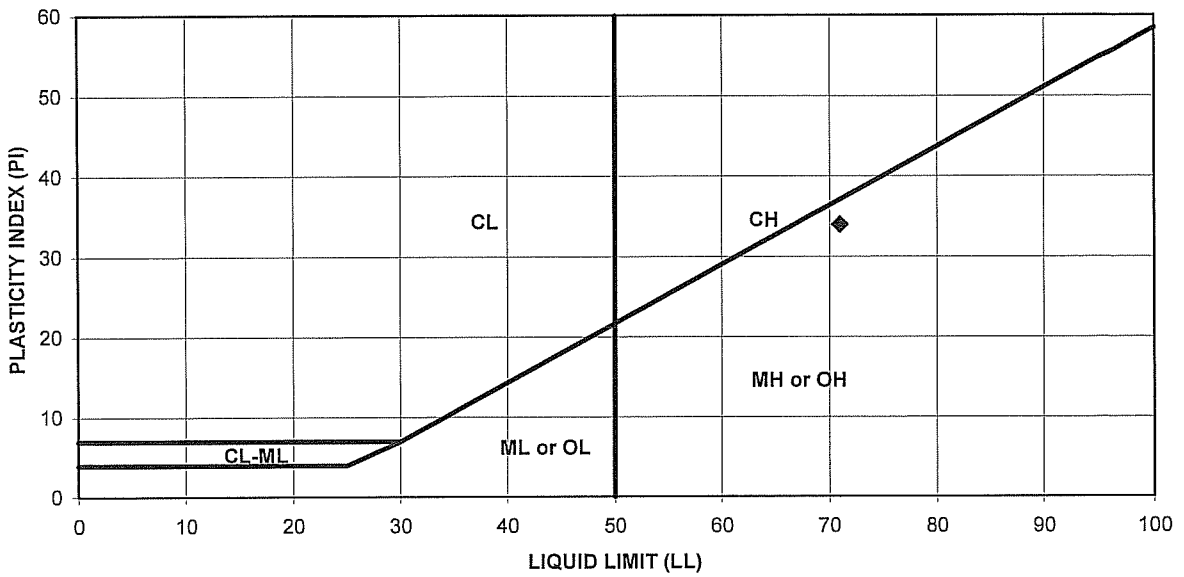
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

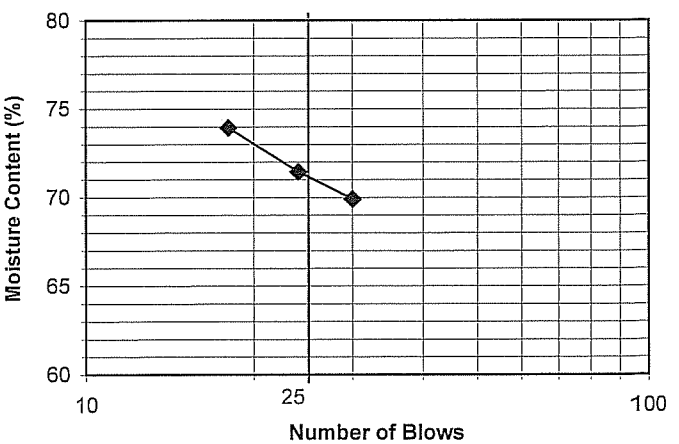
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 12/07/09
Checked By: AP Date: 12/20/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-015	D-08	40	71	37	34	MH
	R-09-015	U-09	45	NP	NP	NP	

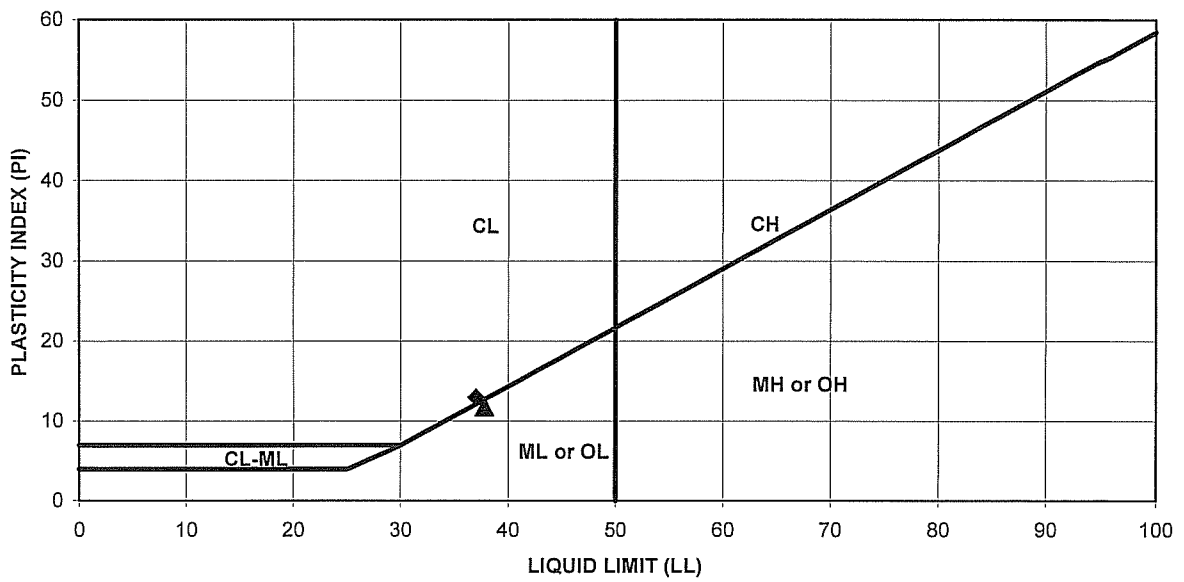
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

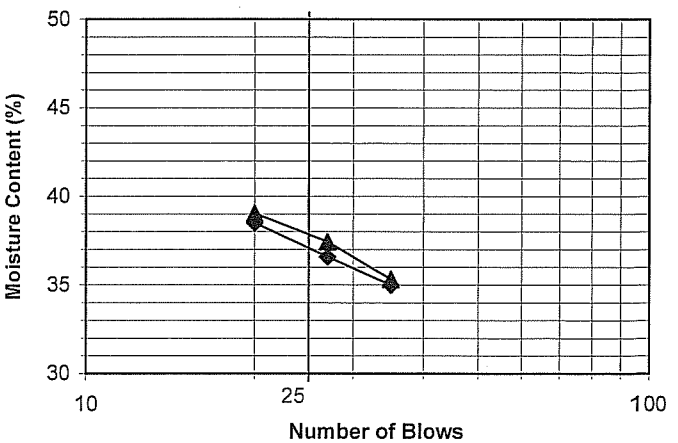
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 12/07/09
Checked By: AP Date: 12/20/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-015	D-10	50	37	24	13	CL
▲	R-09-015	S-11	55	38	26	12	ML

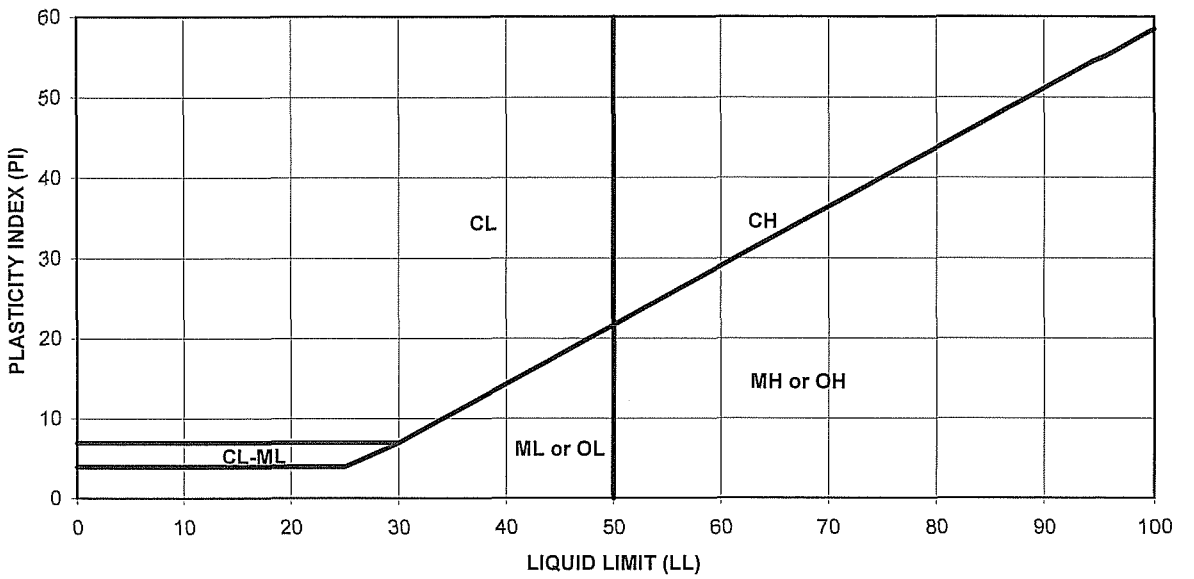
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

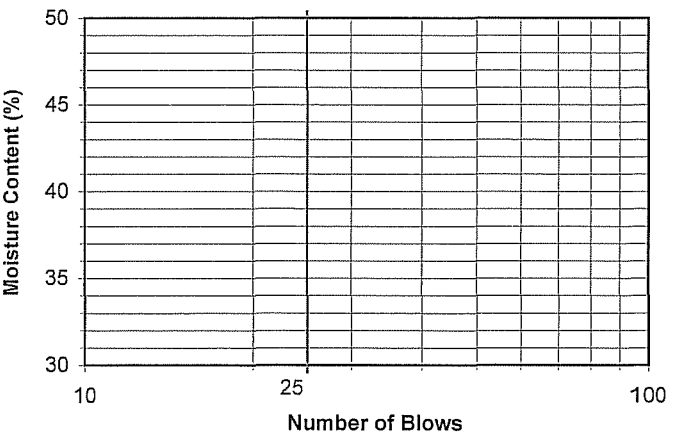
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 12/07/09
Checked By: AP Date: 12/20/09



PROCEDURE USED

- ☐ Wet Preparation
- ☒ Dry Preparation
- ☒ Procedure A Multipoint Test
- ☐ Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-015	U-12	60	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/28/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/20/09

Project No. : 06-123-03 Checked By: AP Date: 12/20/09

BORING NUMBER	R-09-015					
SAMPLE NUMBER	U-09					
DEPTH (FT)	45					
SOIL CLASSIFICATION	Silt with sand					
METHOD (A OR B)	B					
FLASK NUMBER	3					
WT. FLASK+WATER+SOIL, g	363.53					
TEMPERATURE, °C	19.2					
CORRECTION FACTOR	1.0002					
WT. DRY SOIL, g	40.17					
WT. FLASK + WATER, g	249.23					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.75**					

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

Appendix F. Site-Specific Ground Motion Study Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

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——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

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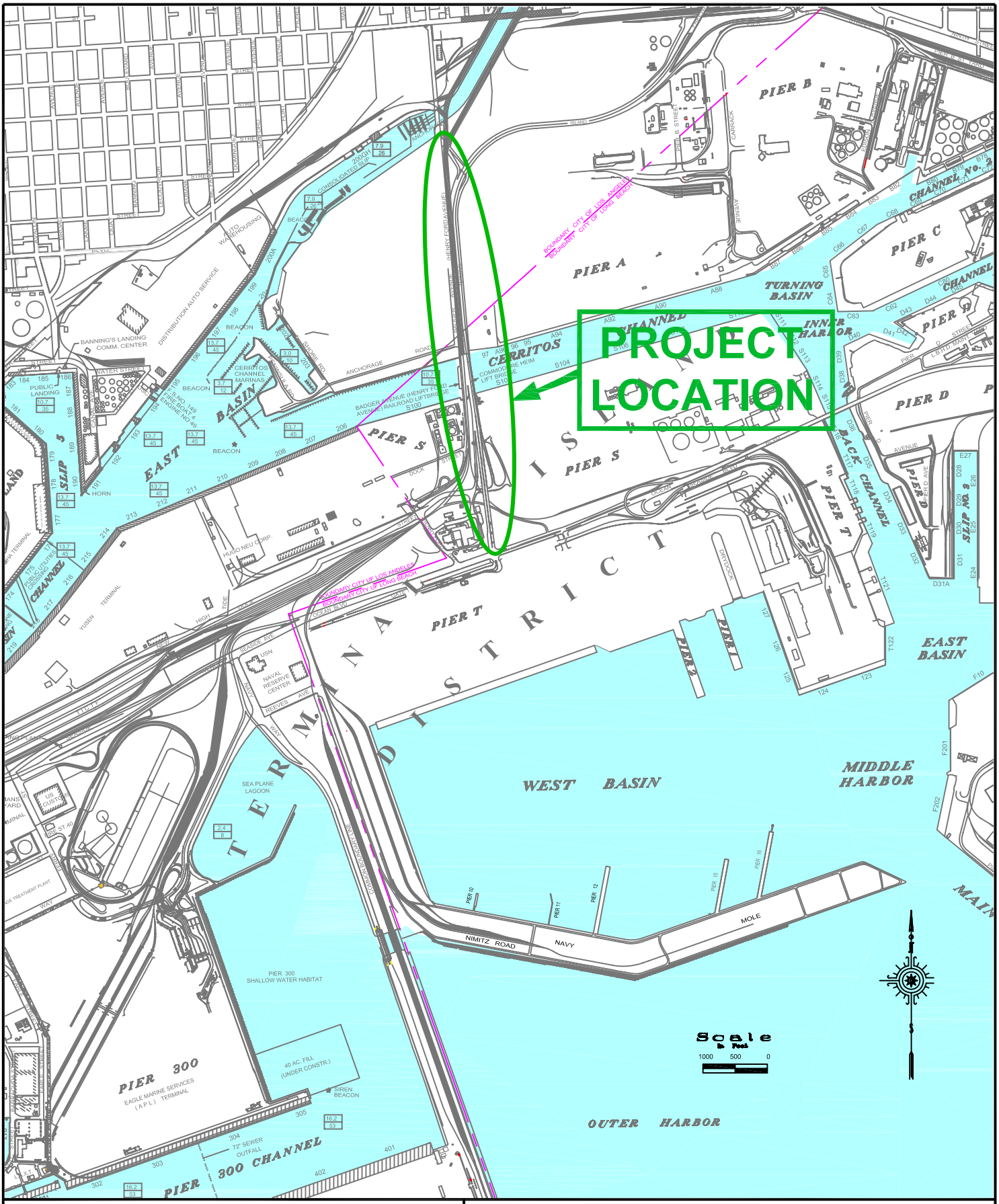
——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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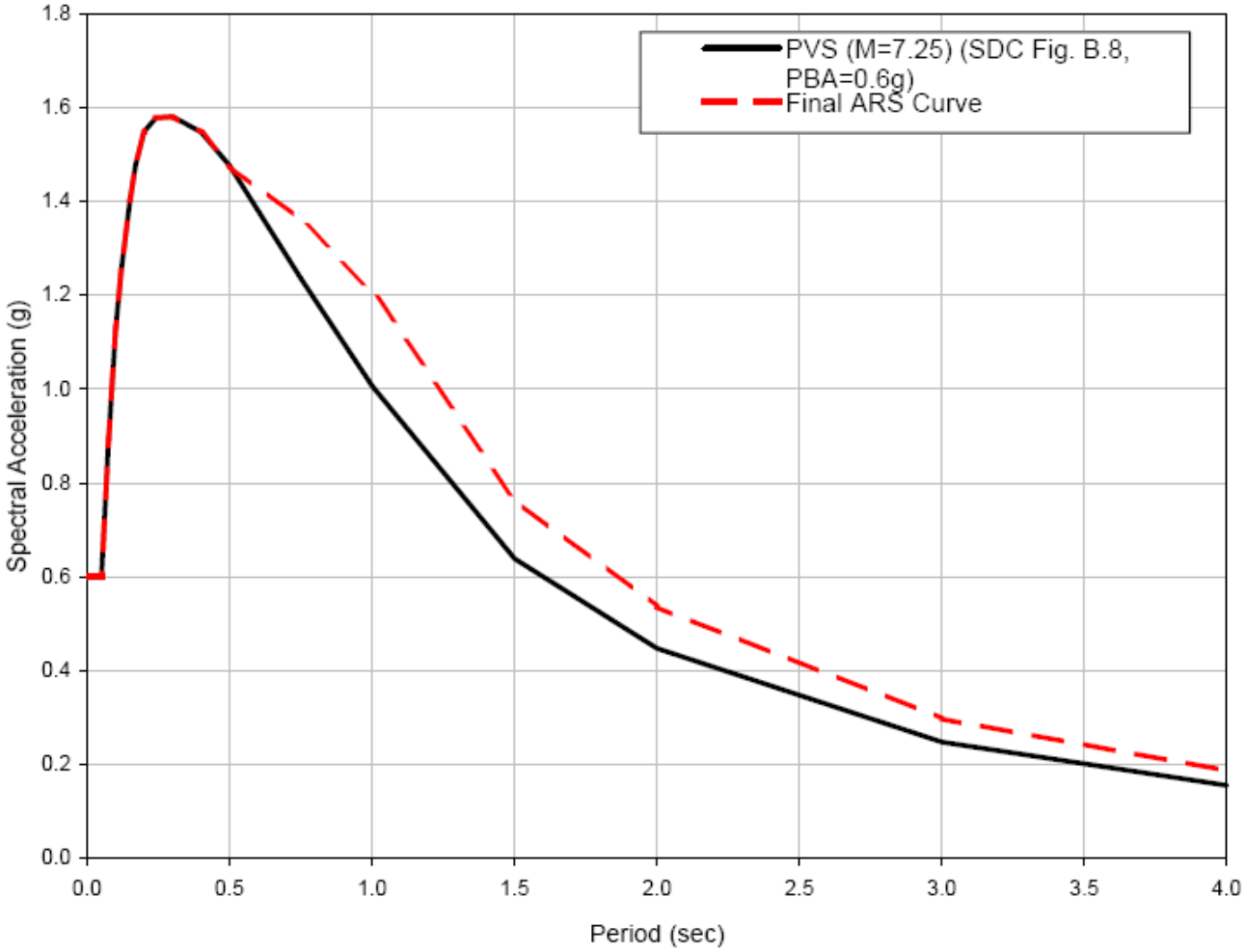
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

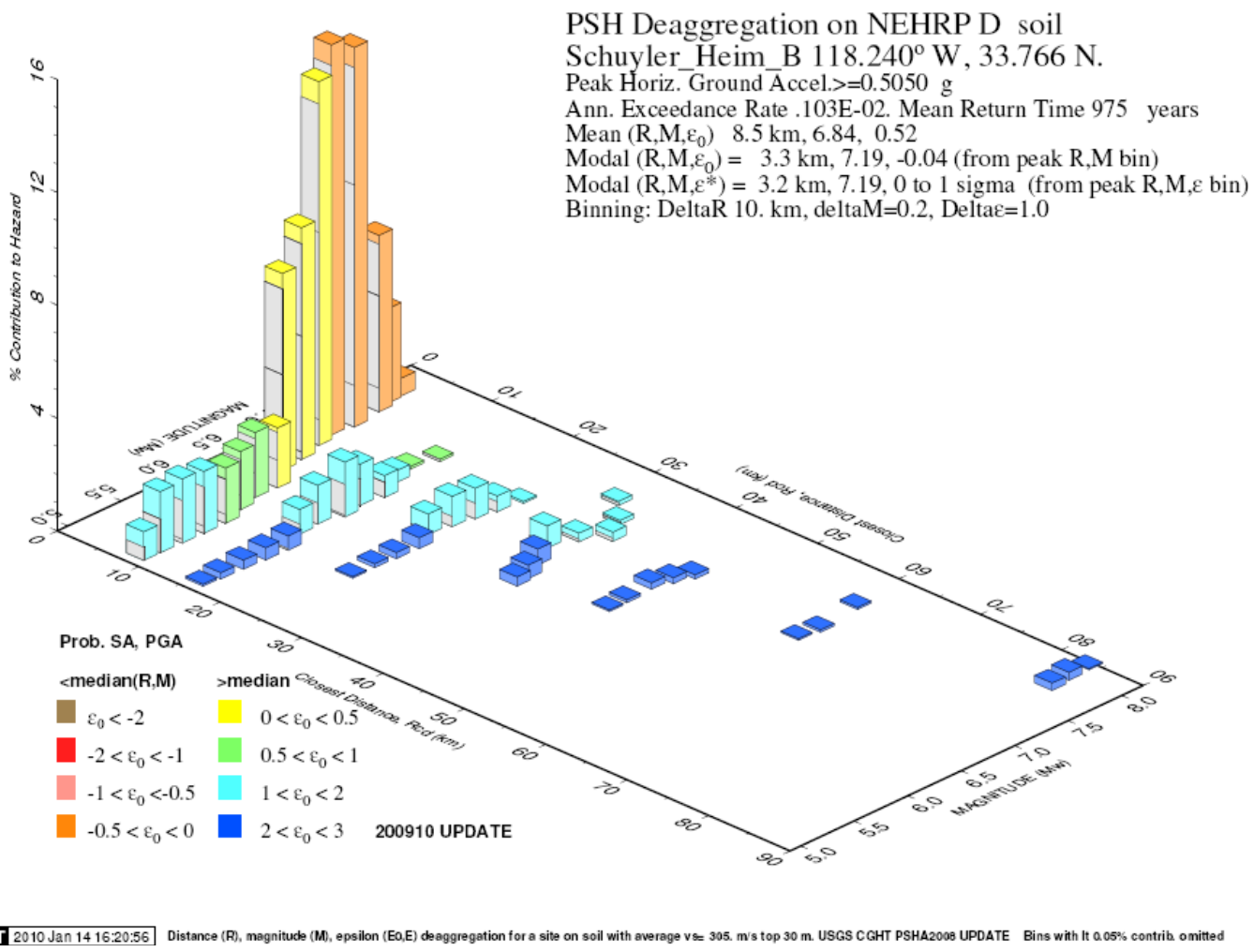


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

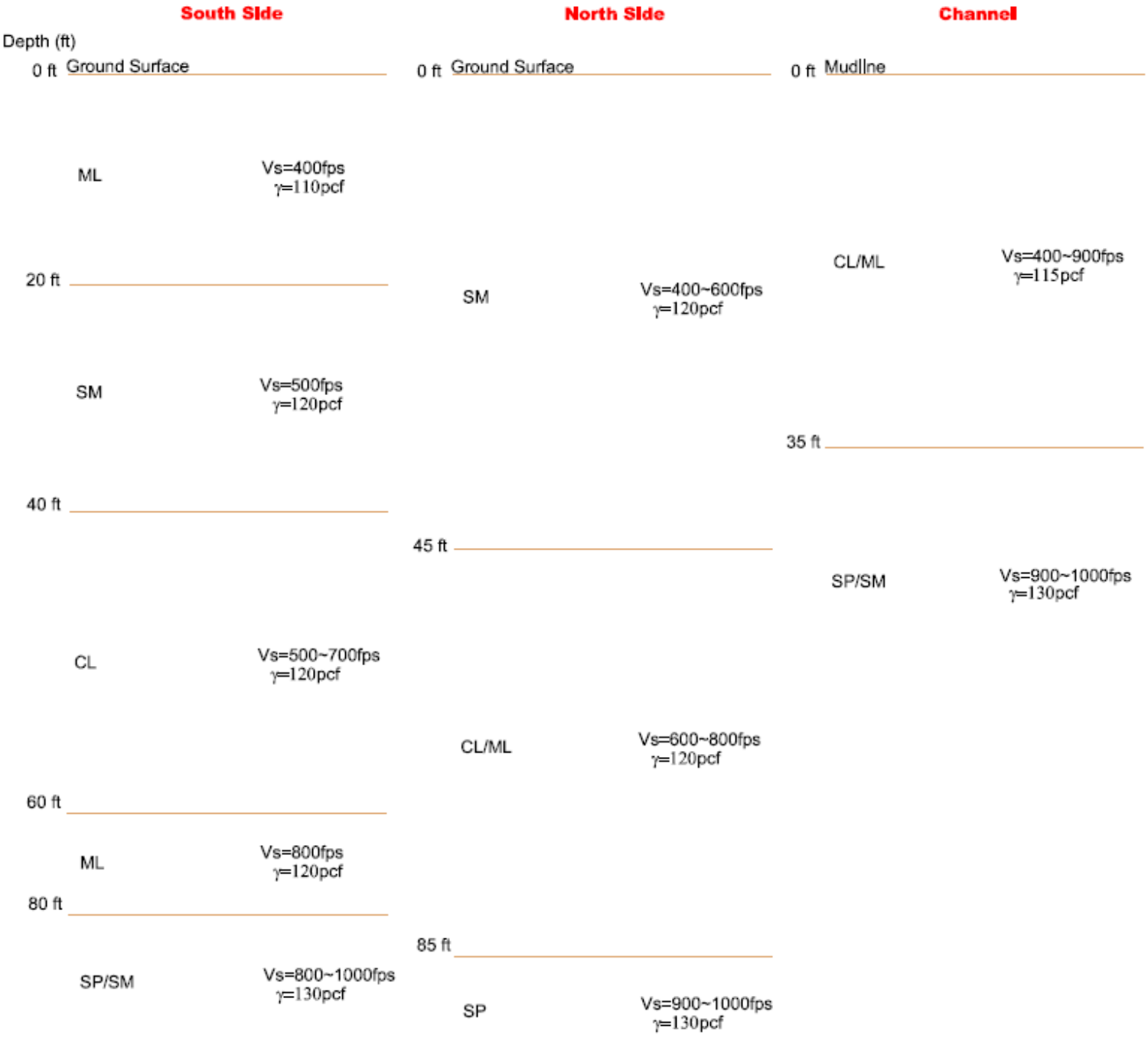
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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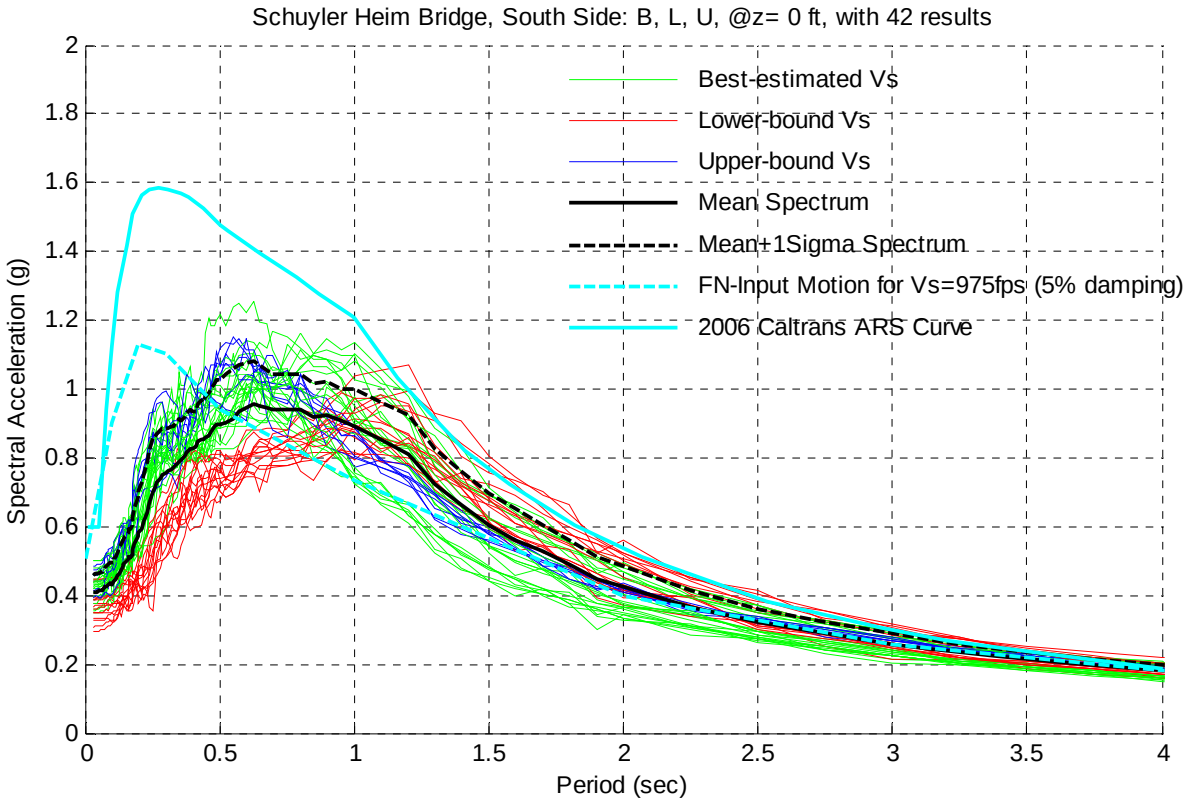
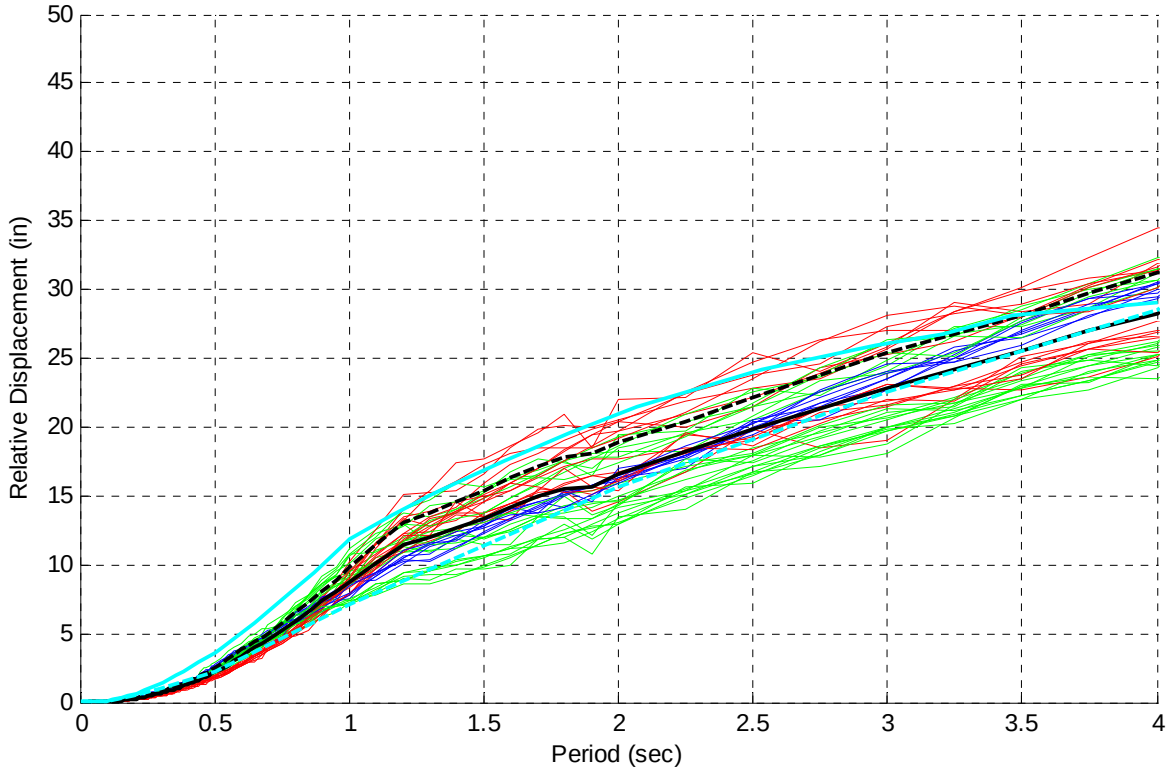
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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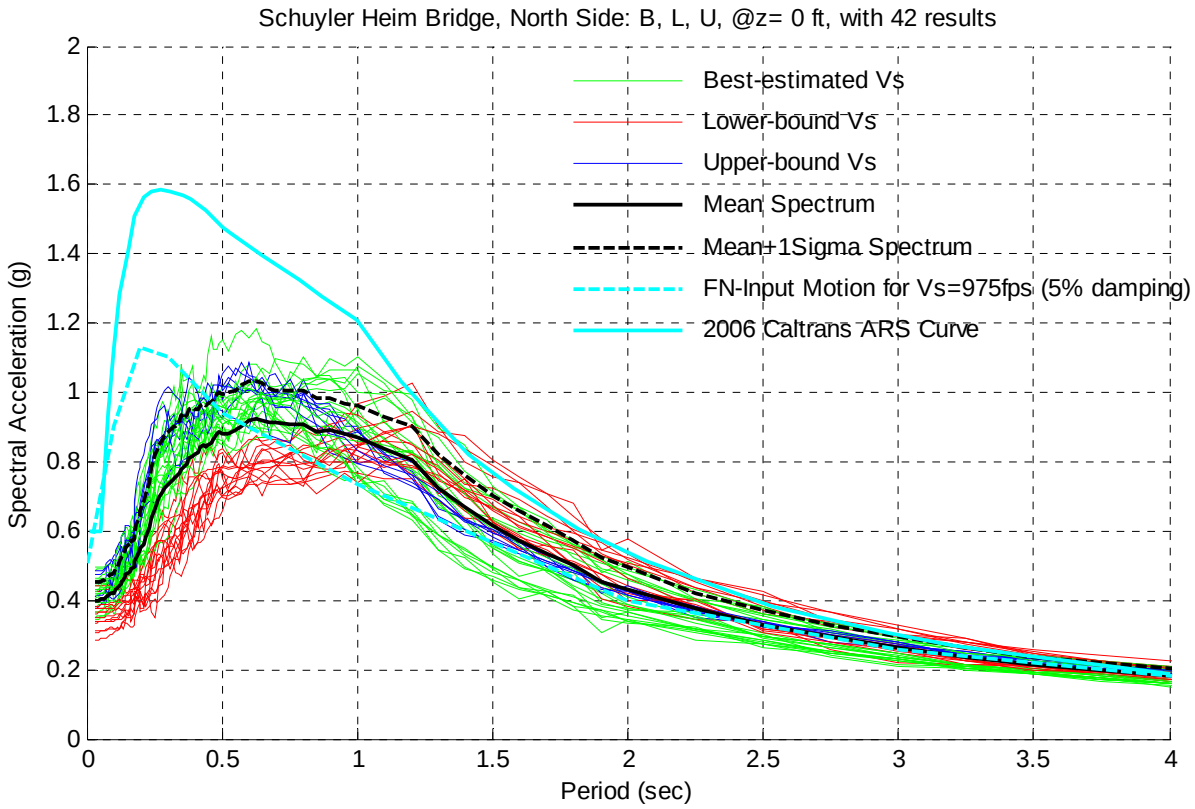
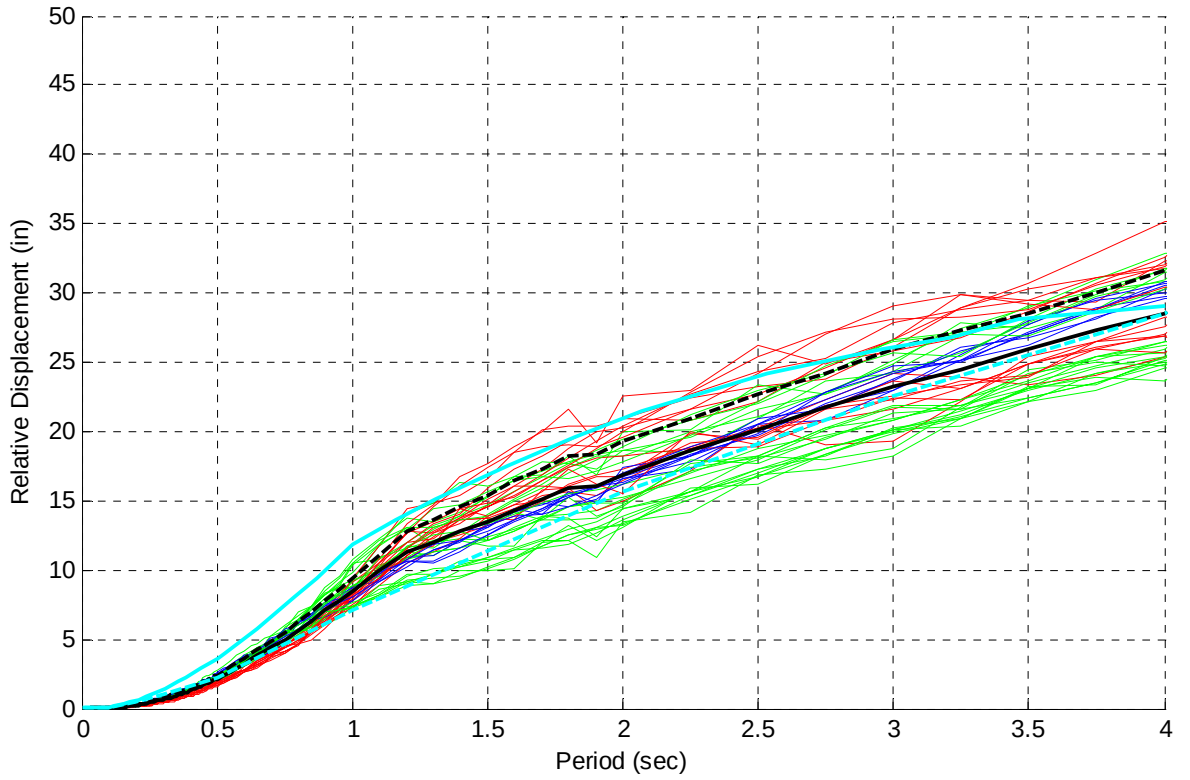
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





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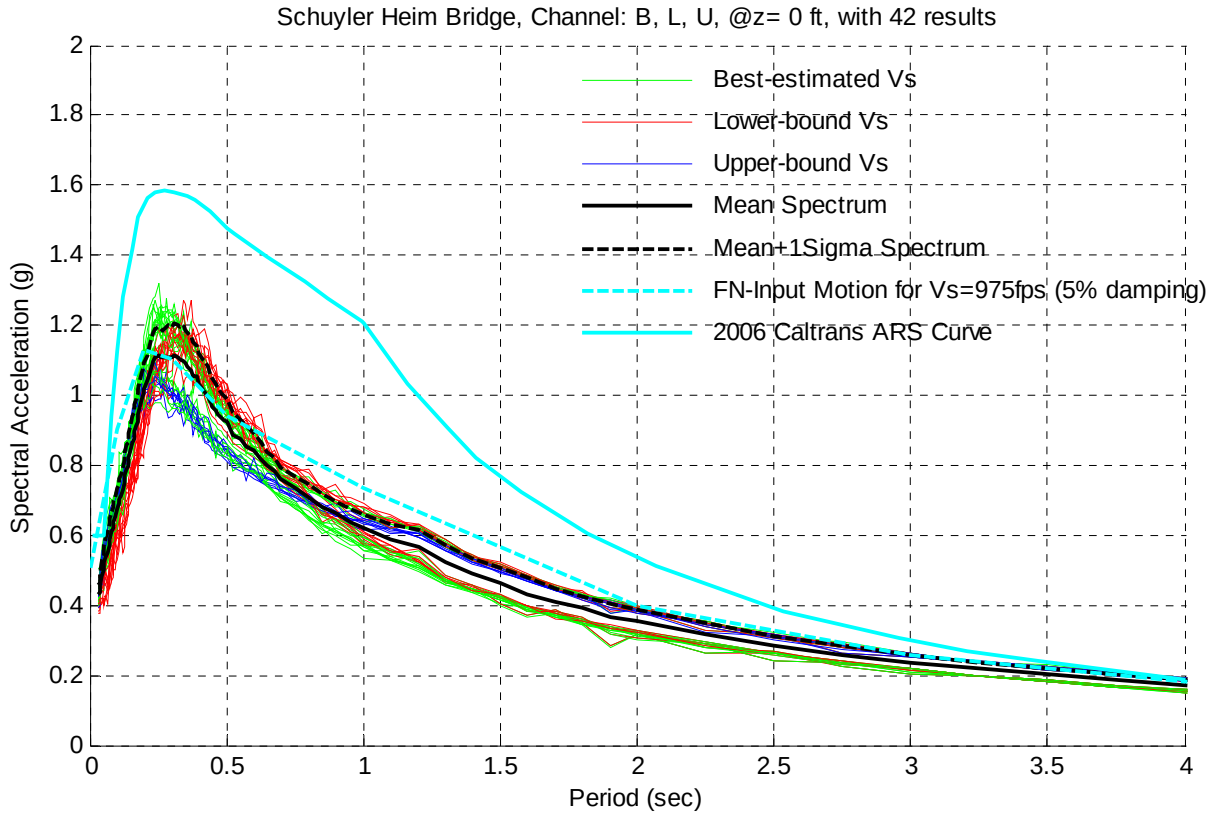
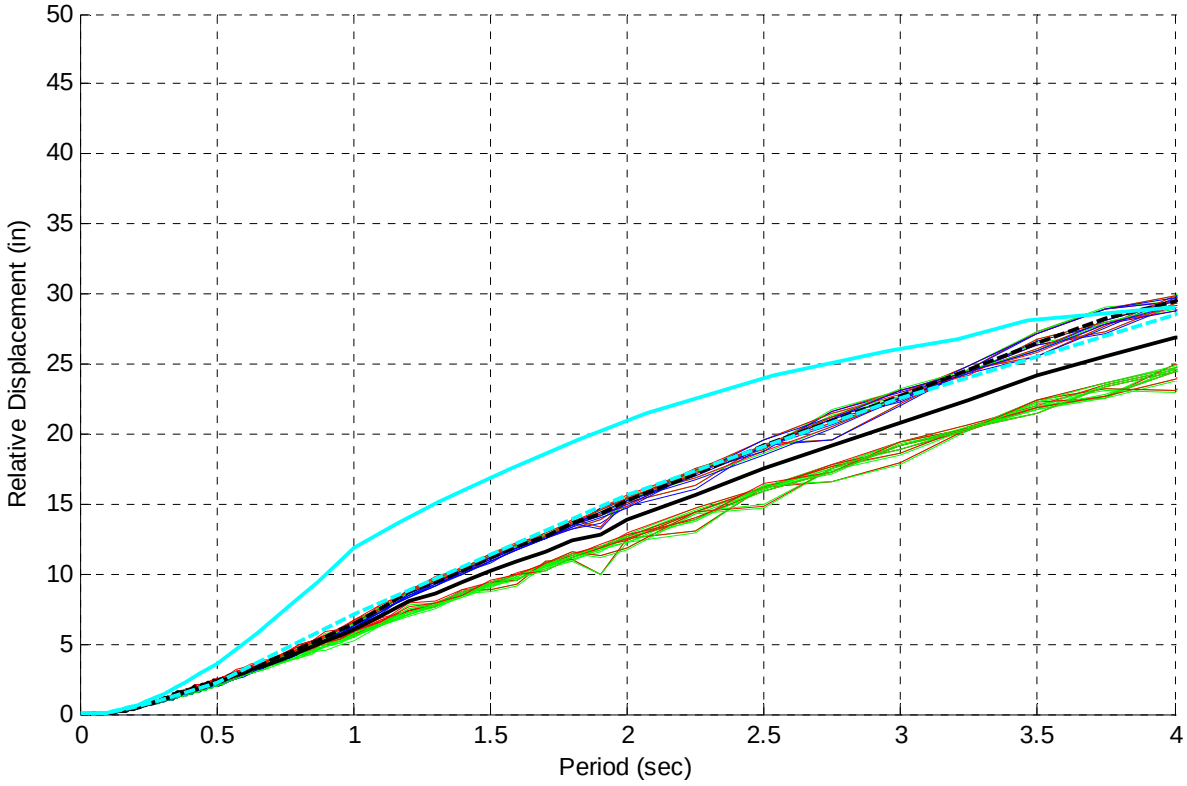
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





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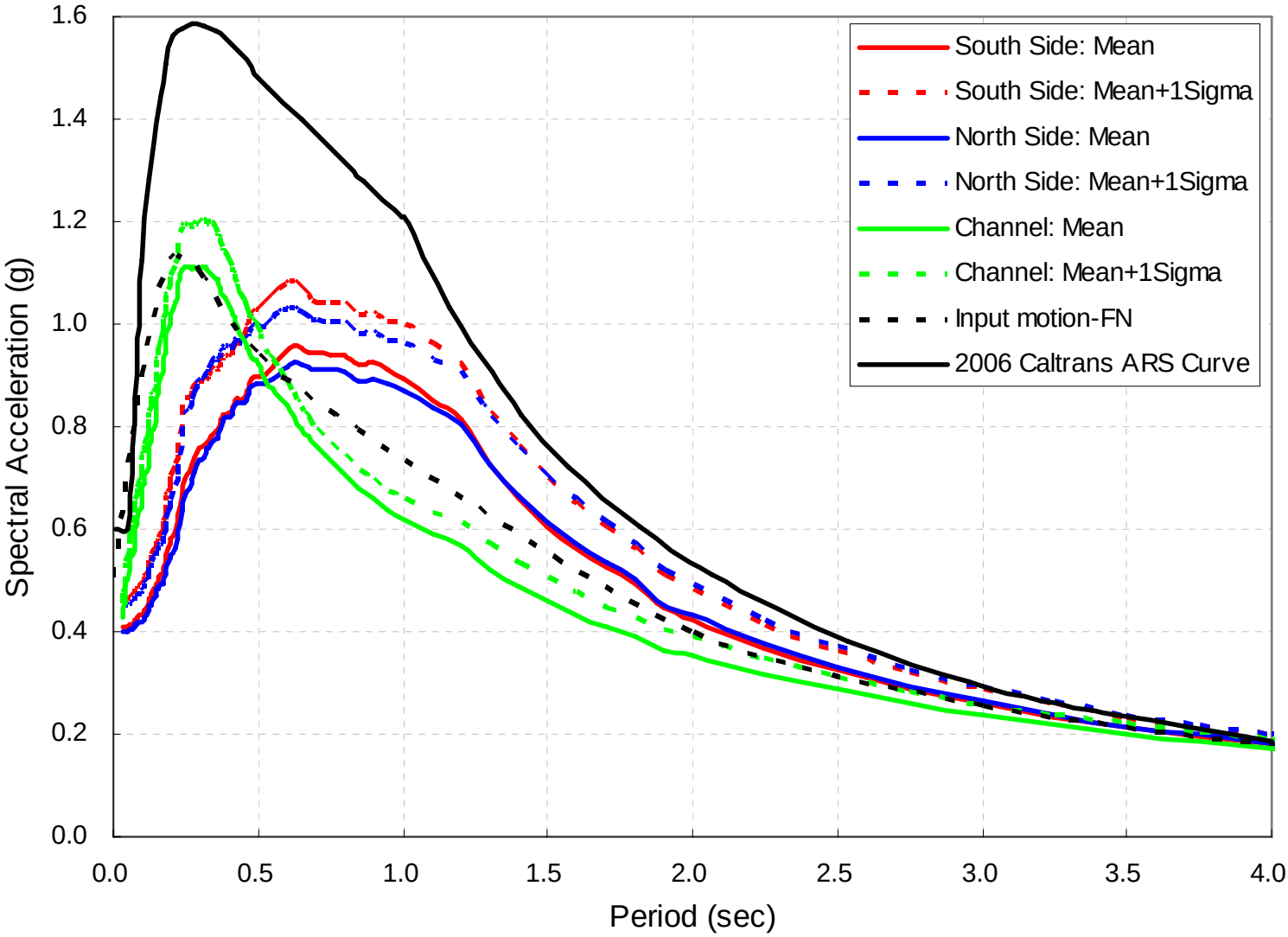
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

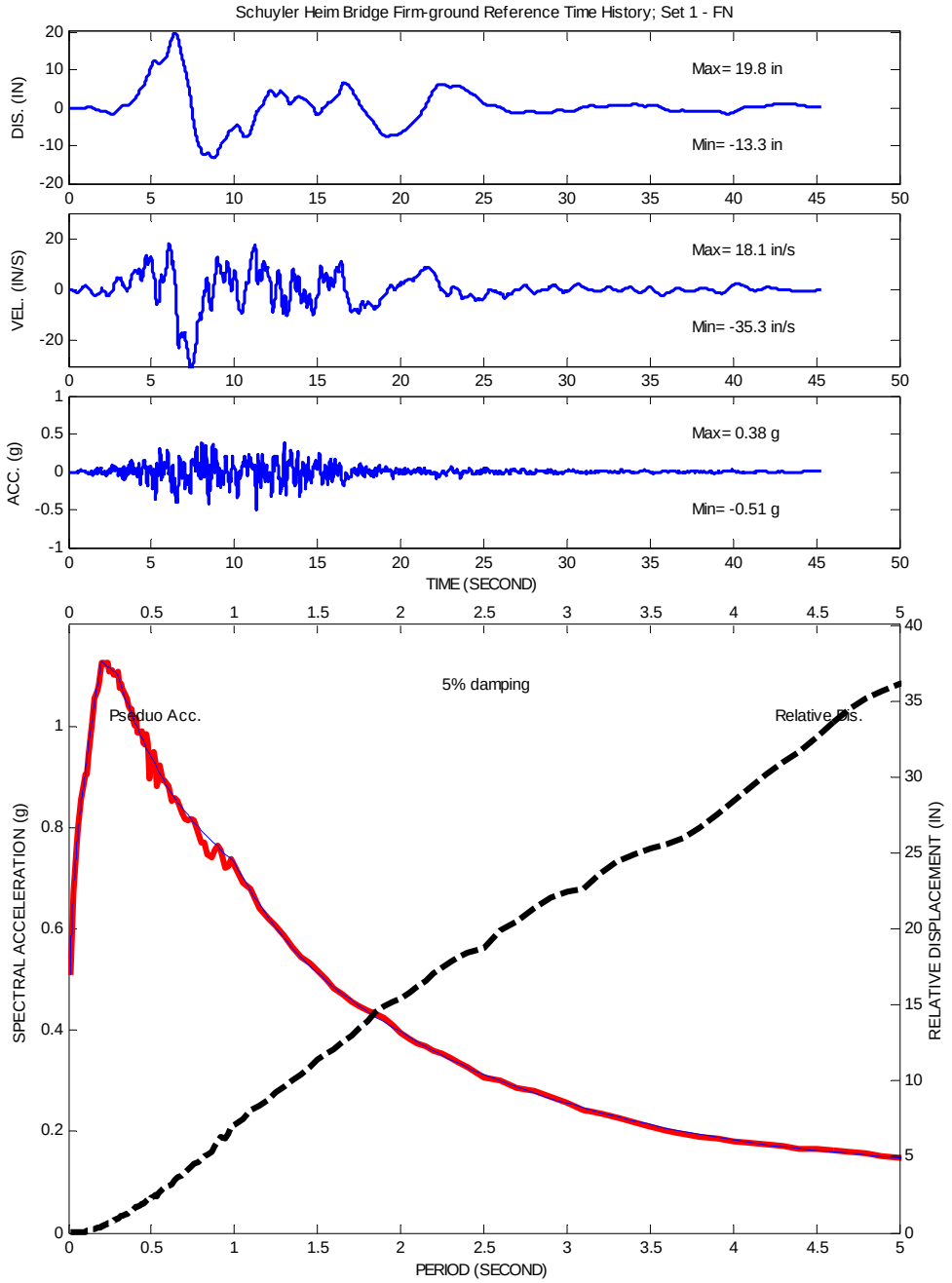

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

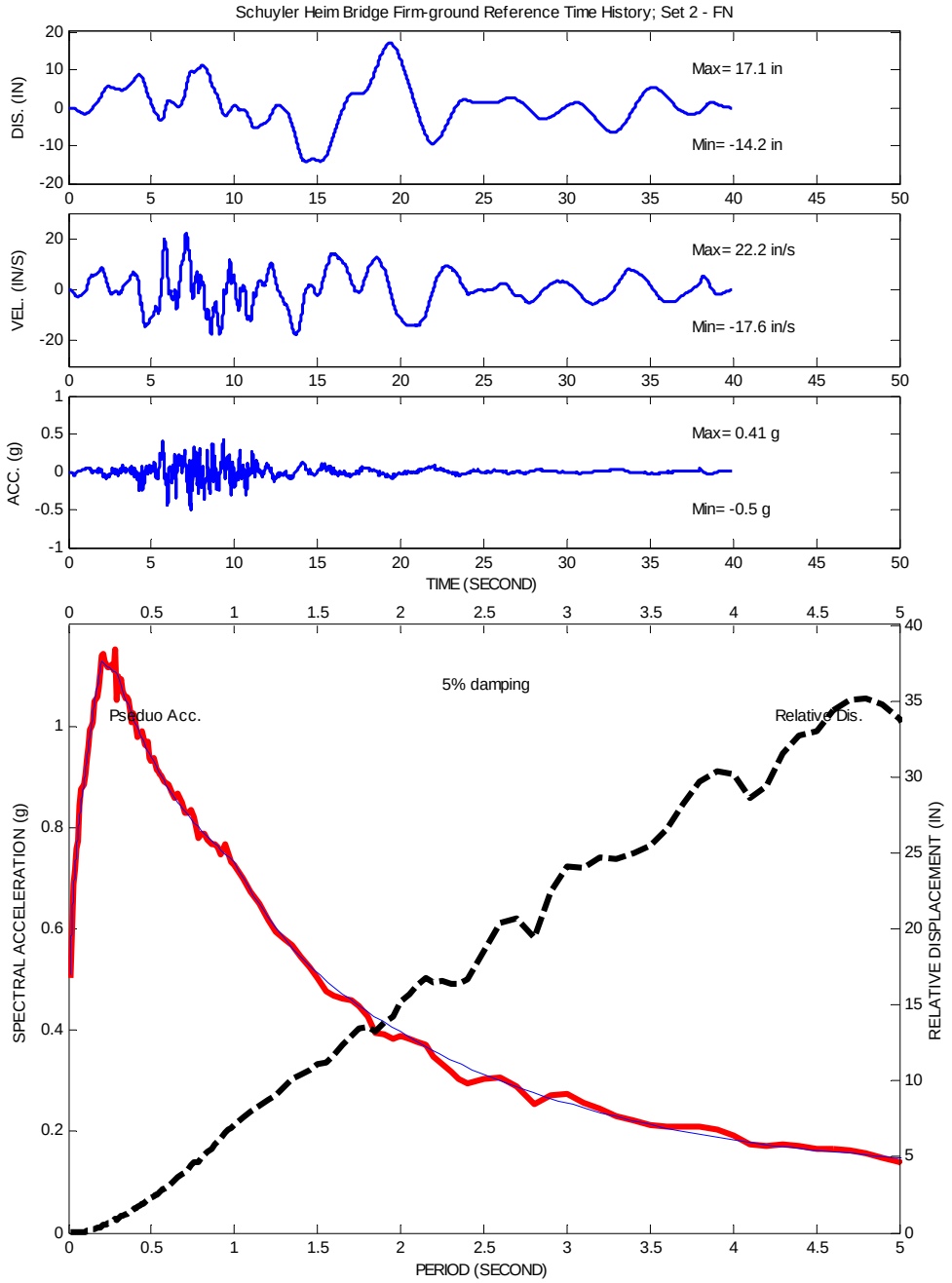

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

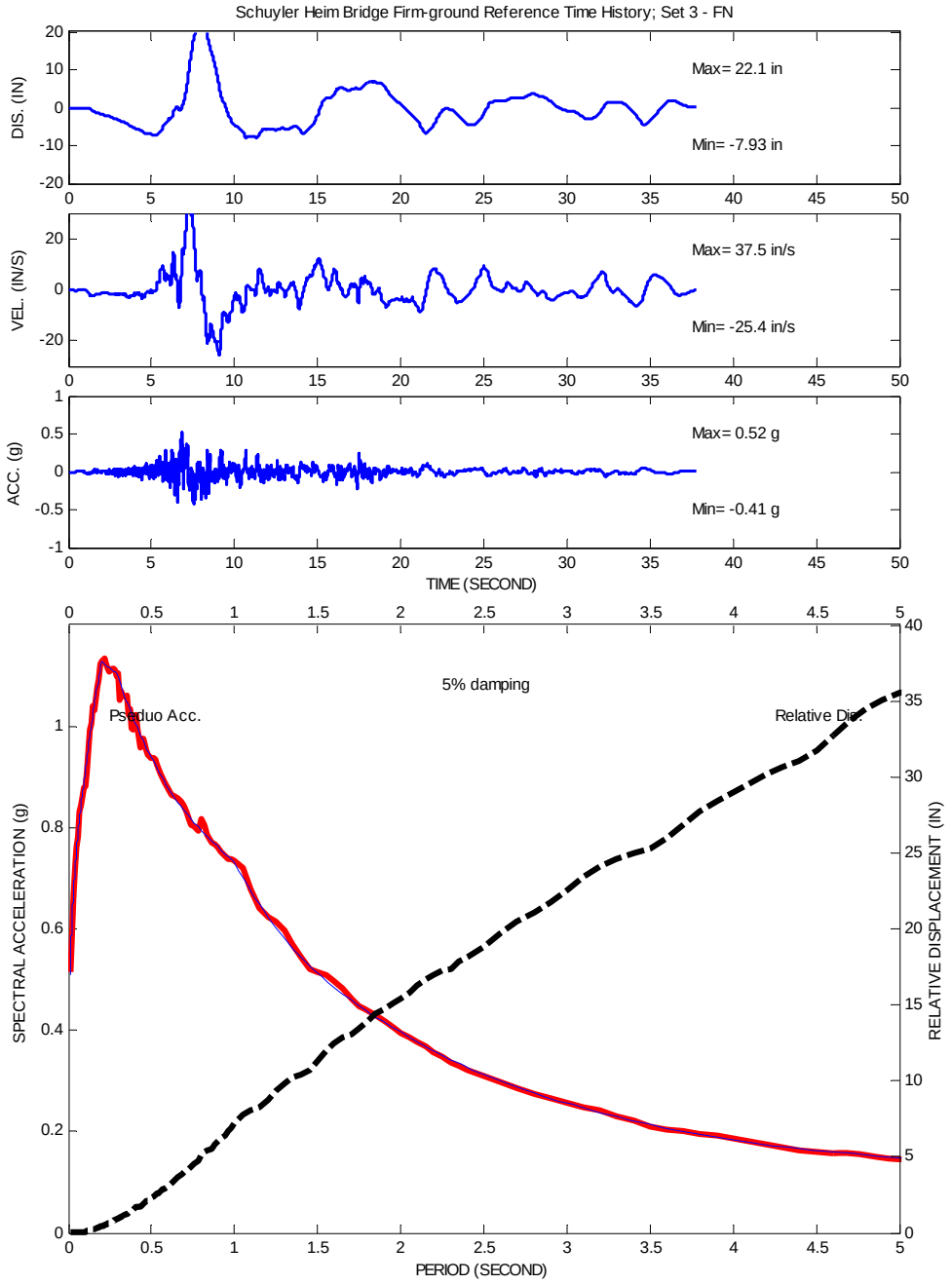

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

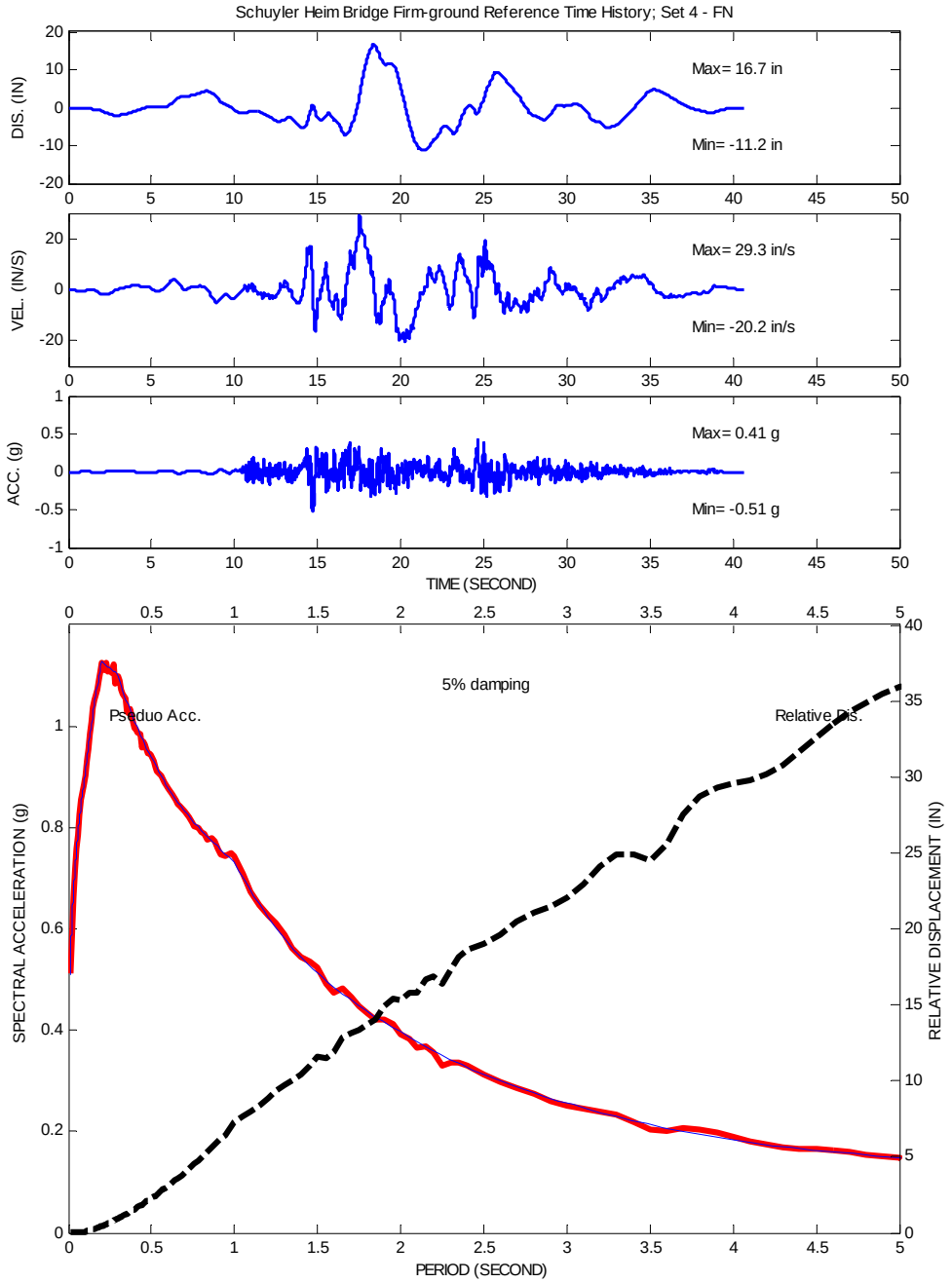

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

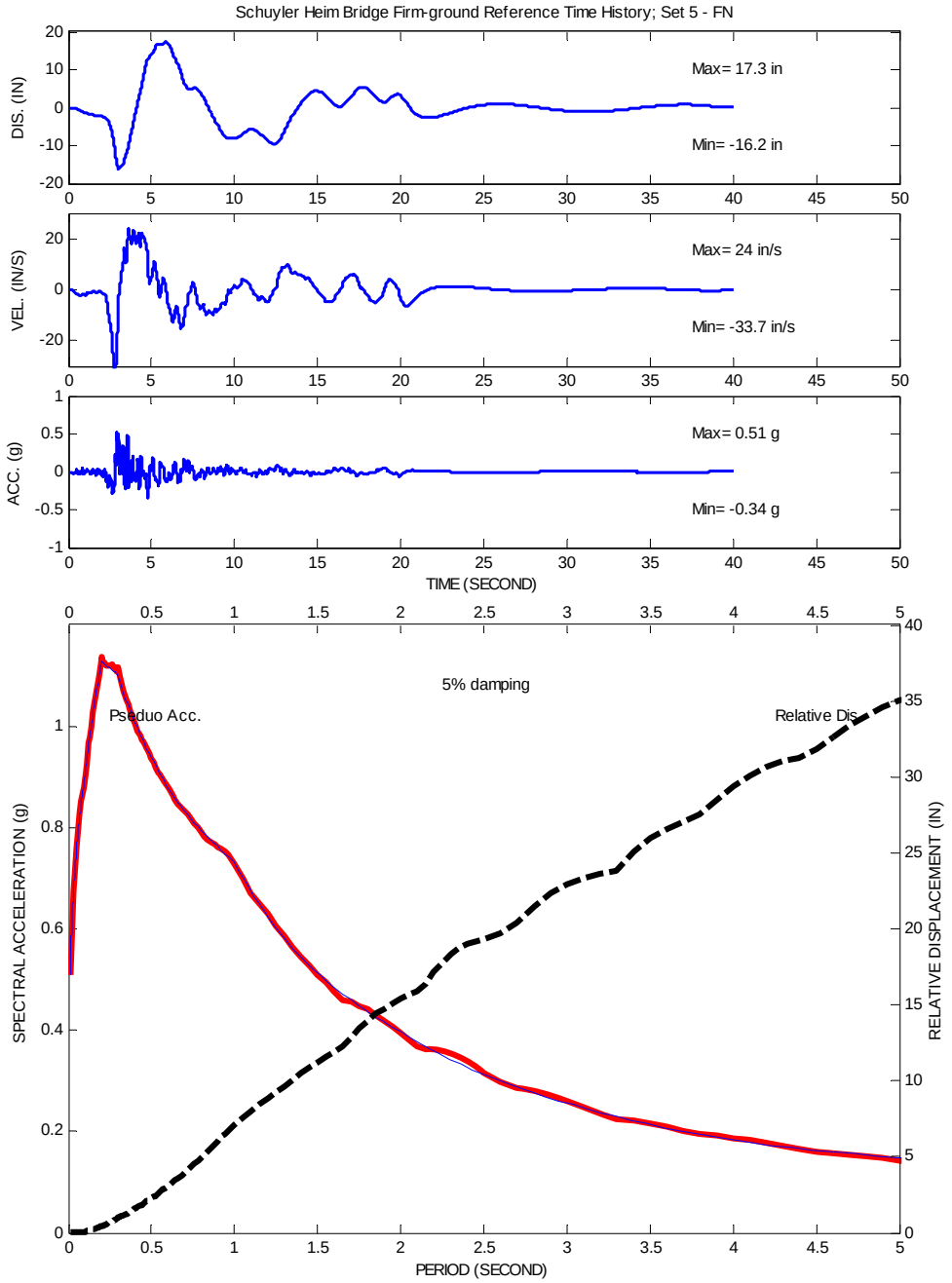

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

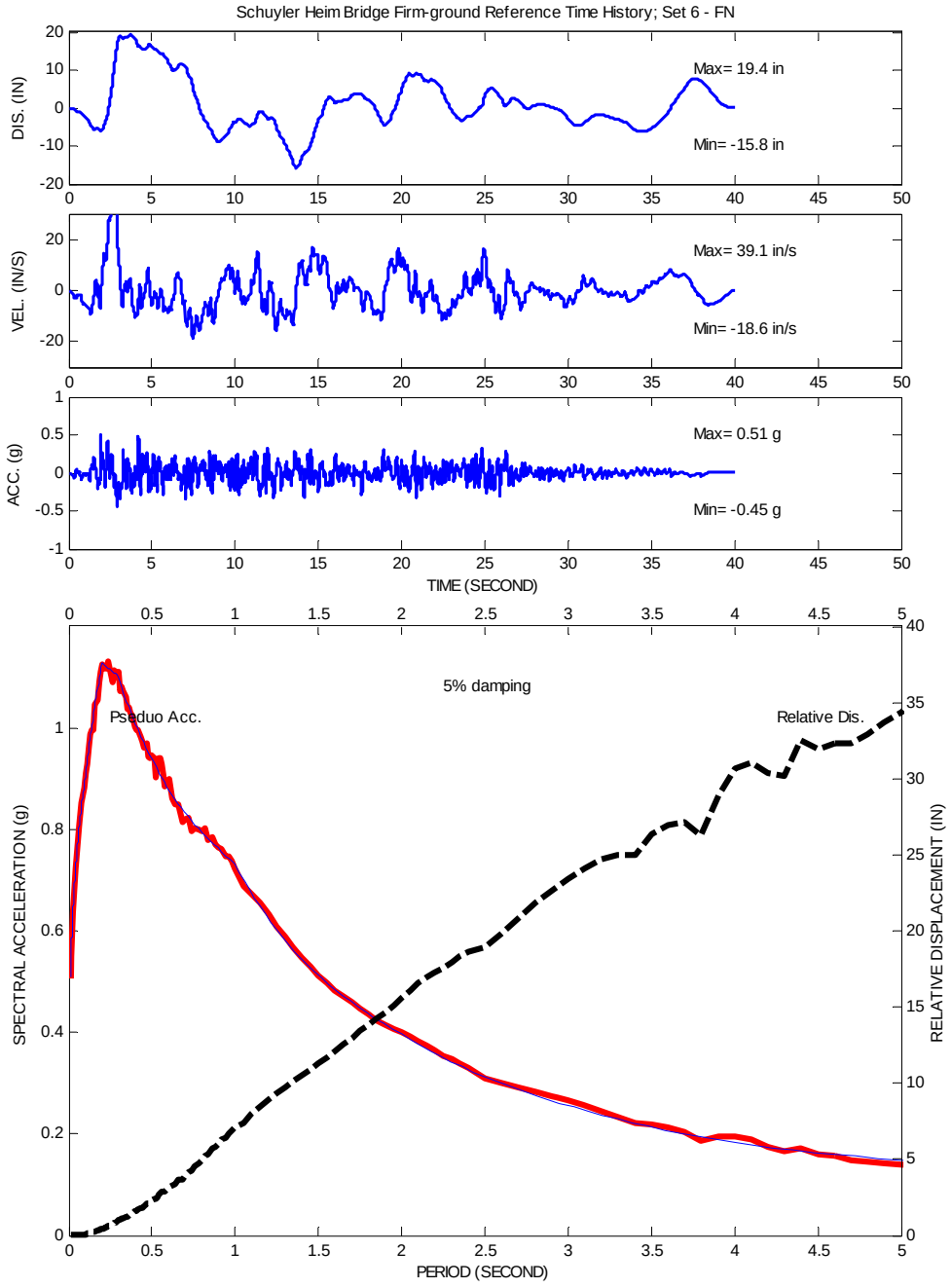

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

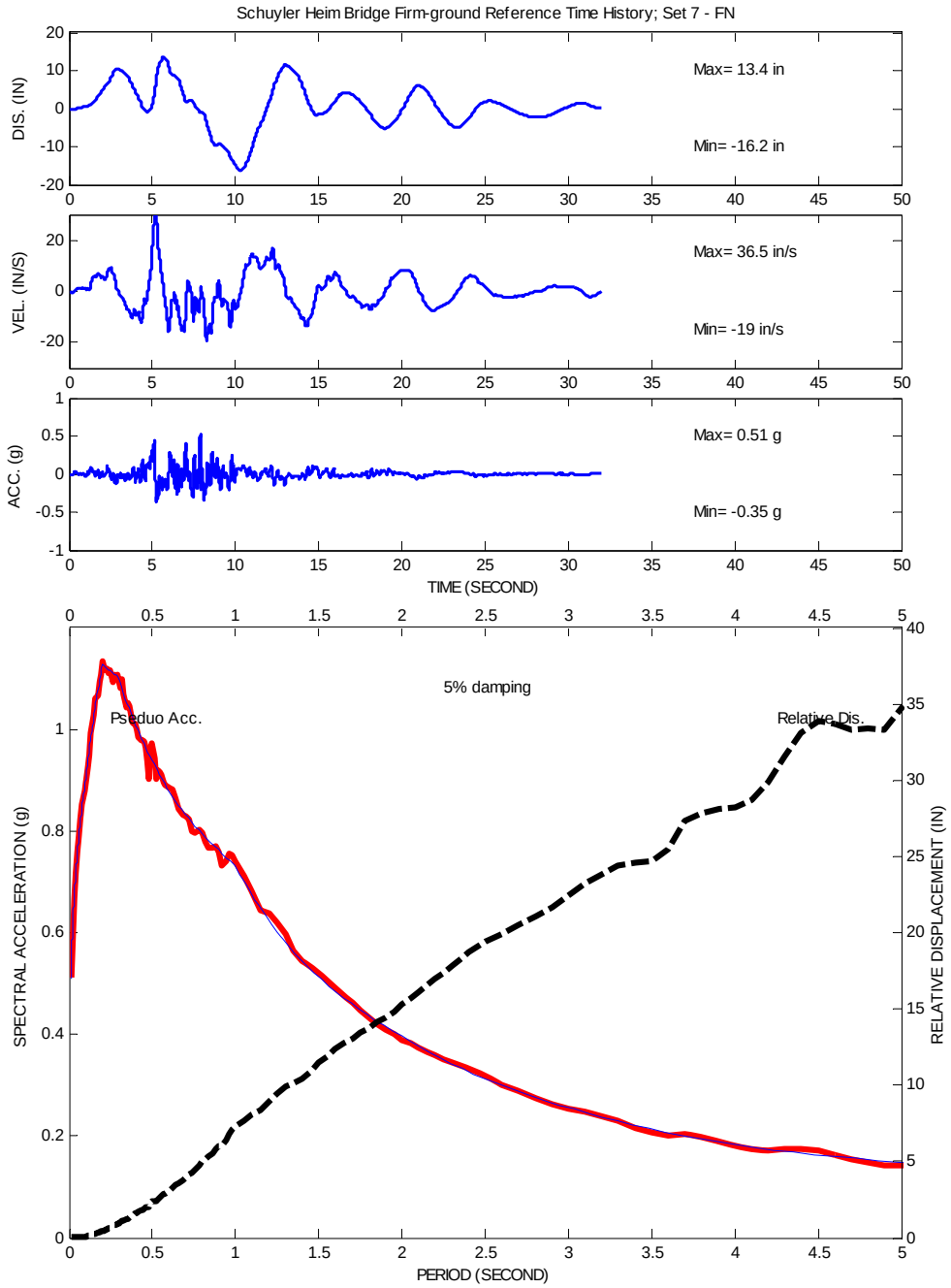

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

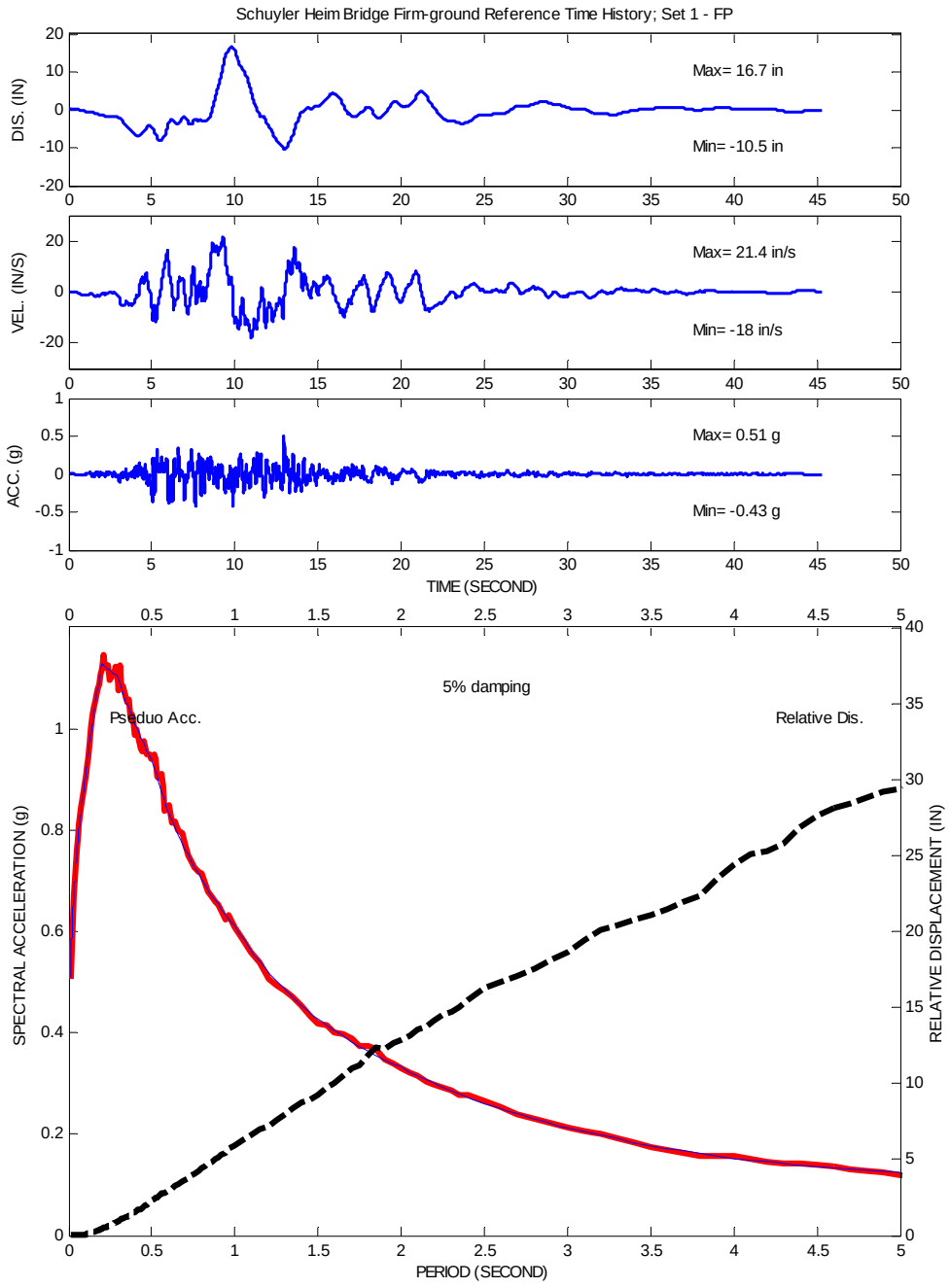

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

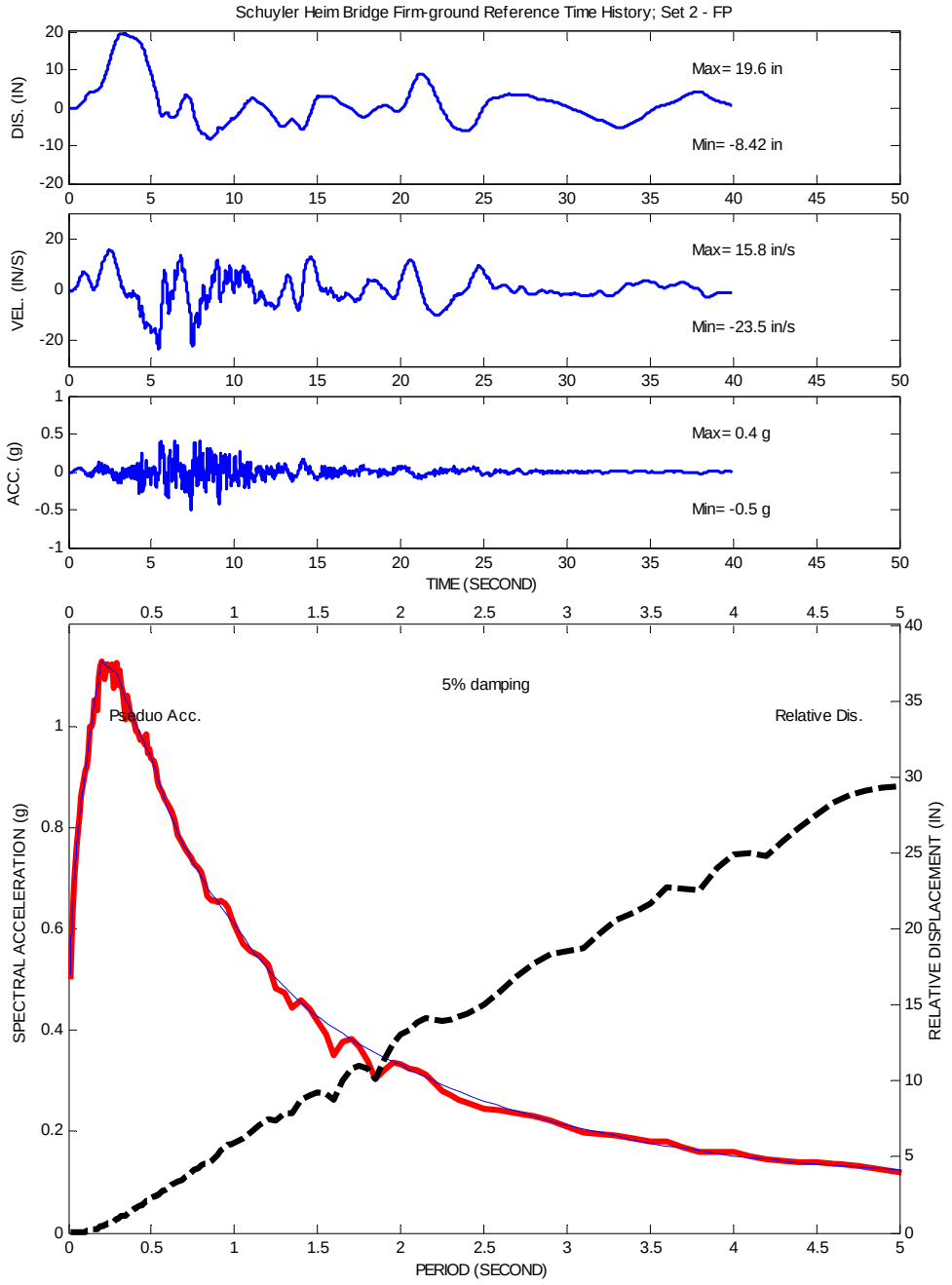

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

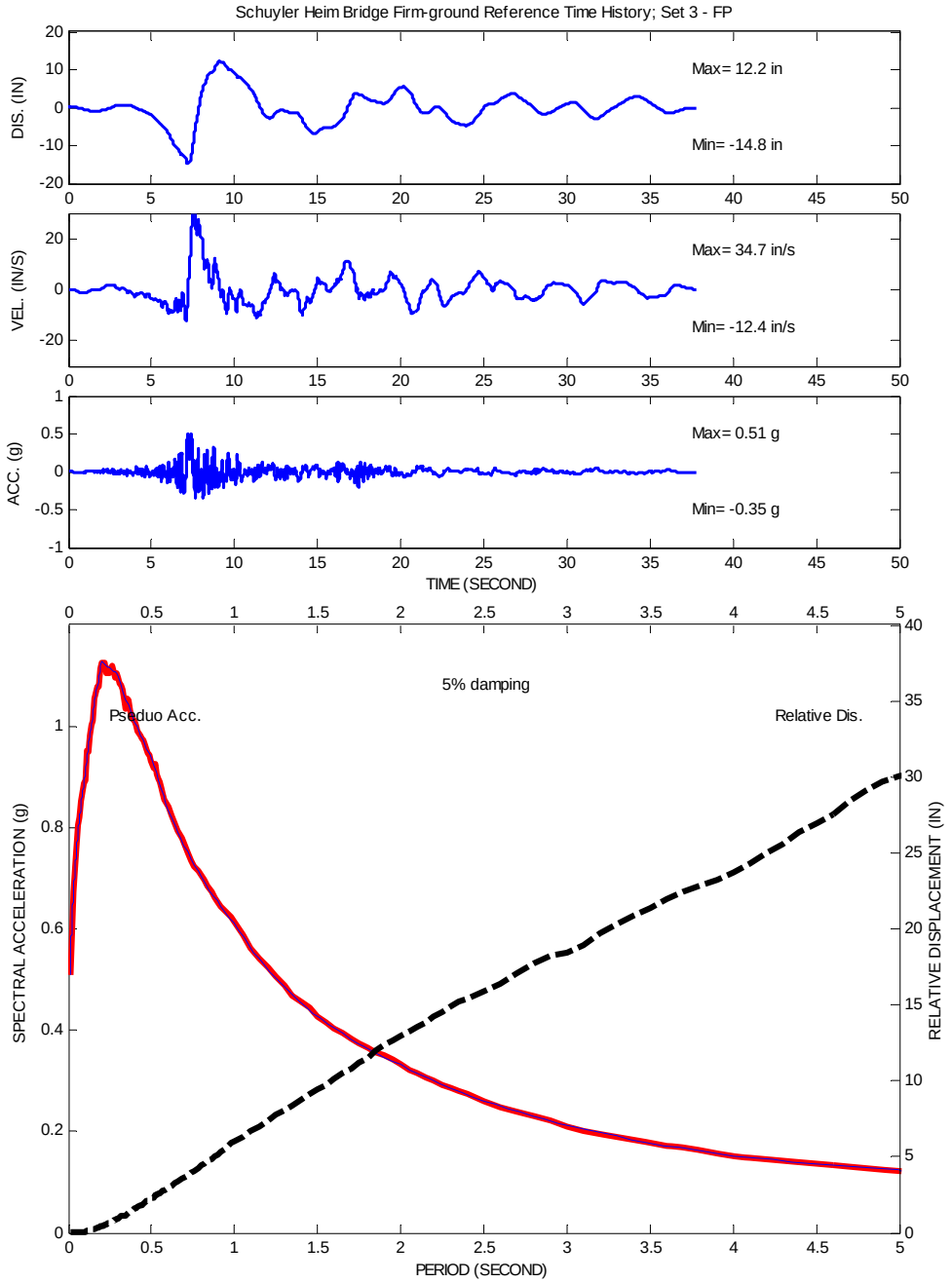

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

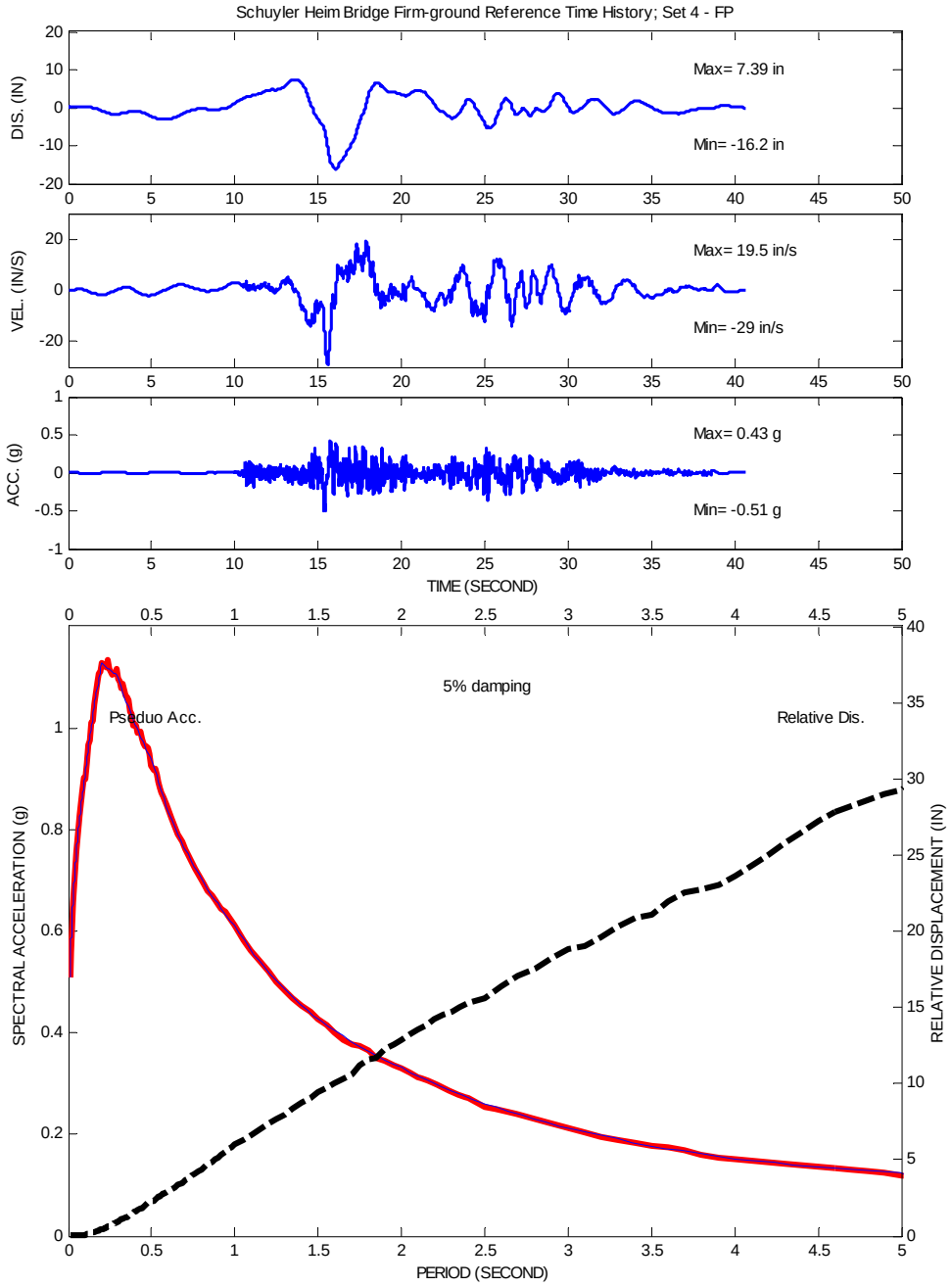

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

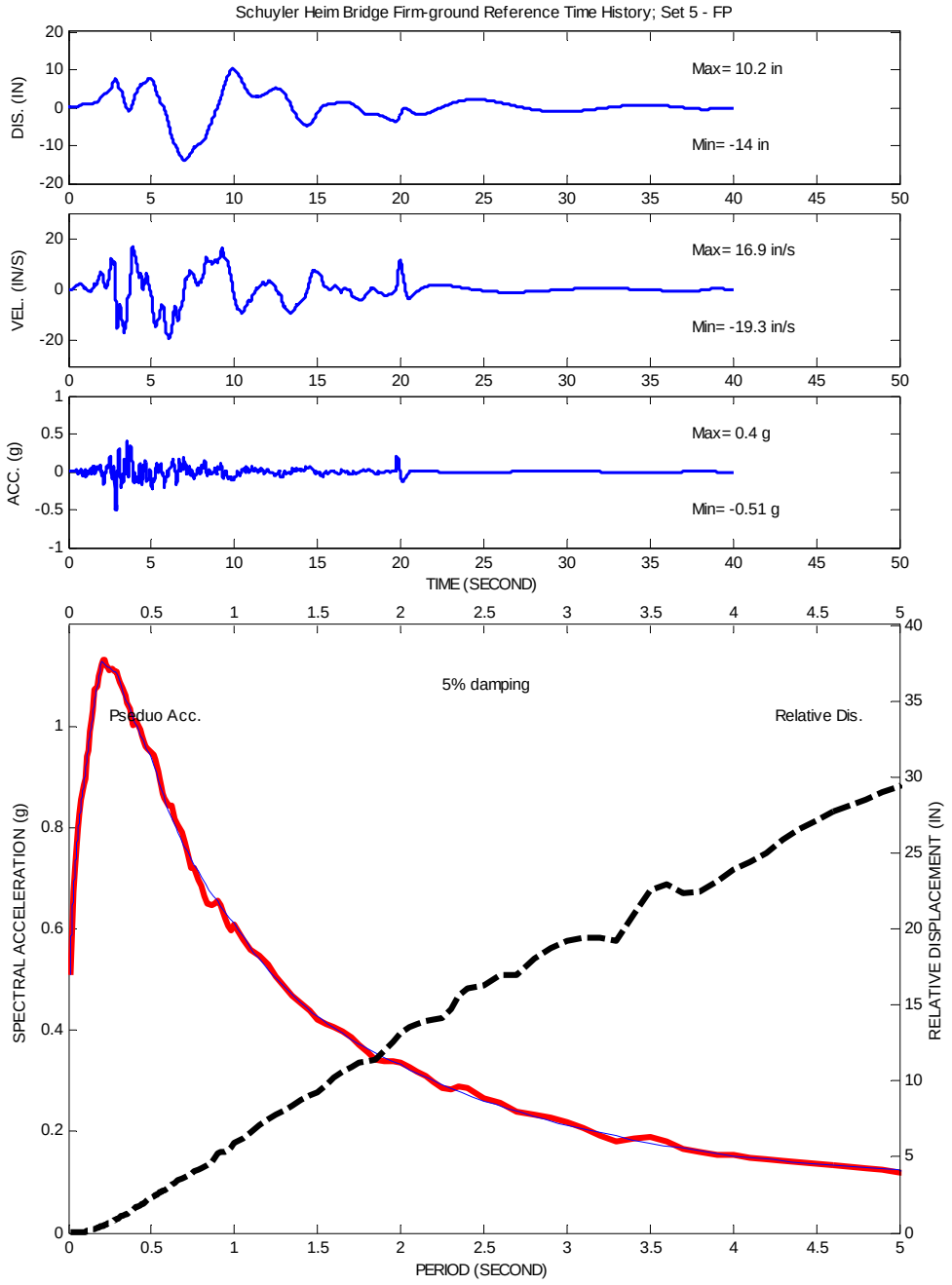

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

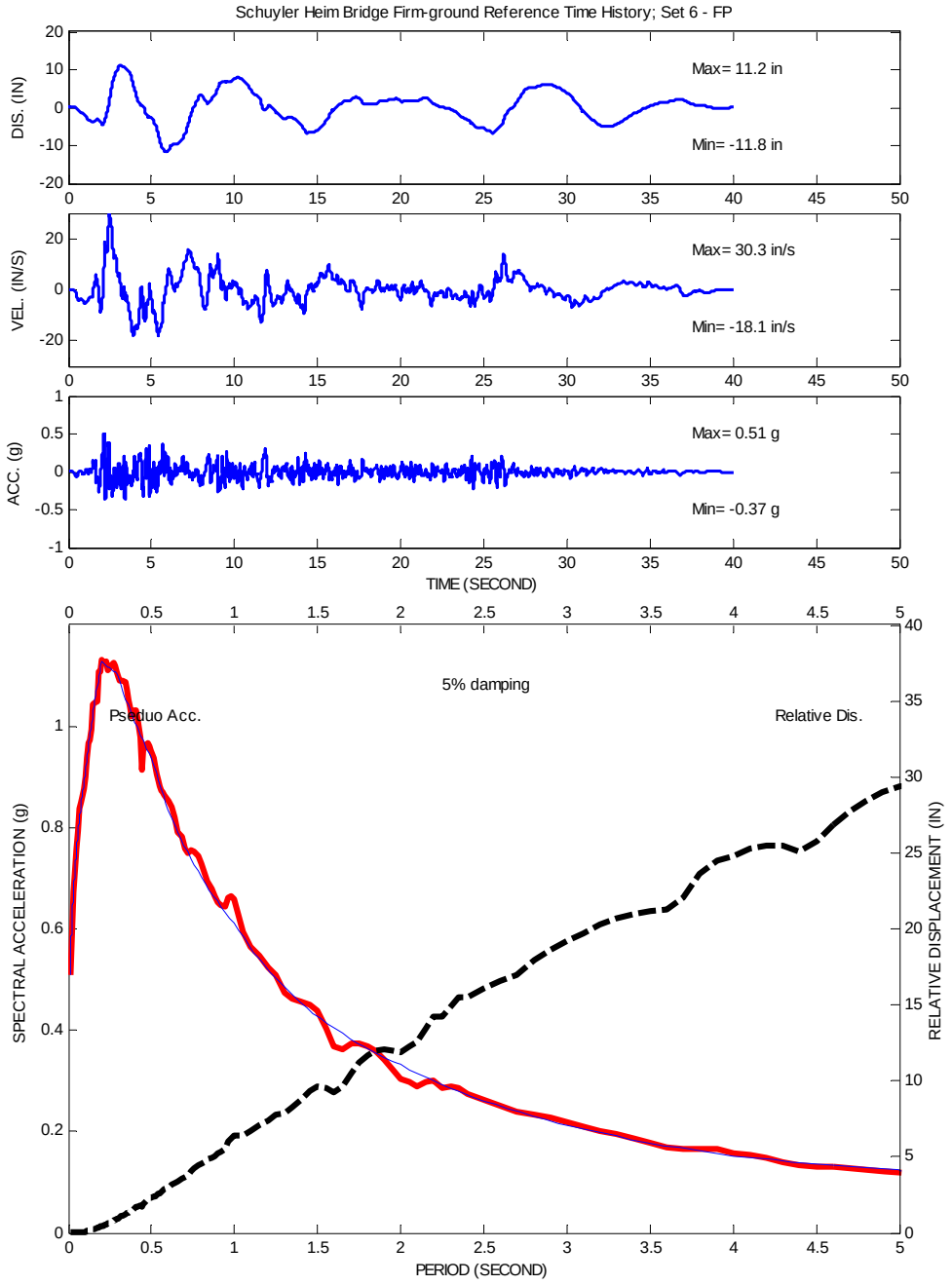

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

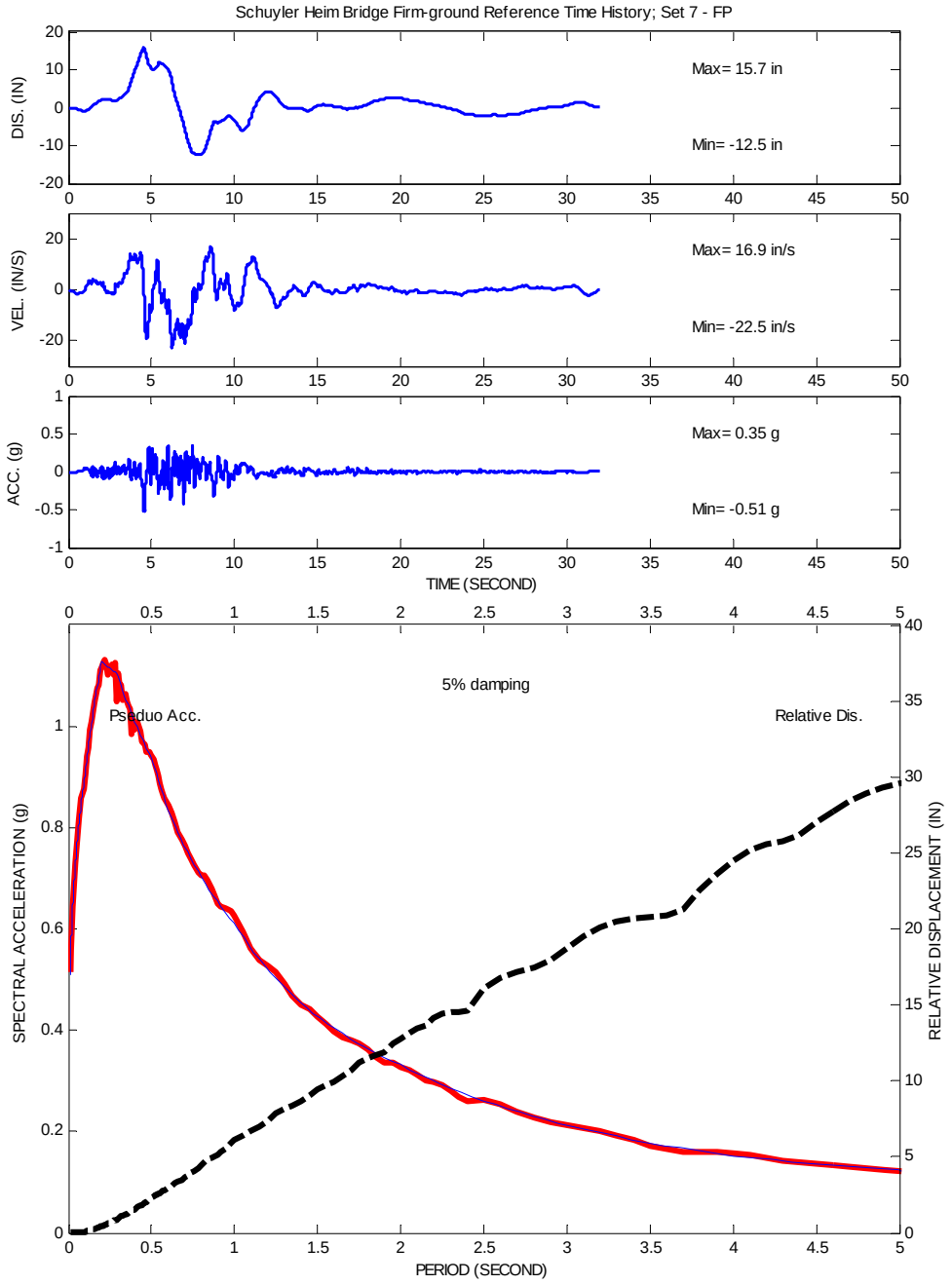

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

Appendix G. p-y Curve Comparison Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 2, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul K. Arulmoli, Eric Brown & Patrick Wilson / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge (Replace)
Los Angeles and Long Beach, CA
Bent Foundation Lateral Pile Analysis (p-y Curve Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge (Replace) and associated ramp structures (New Dock Street On-Ramp, New Dock Street Off-Ramp, State Route-103 On-Ramp and State Route-103 Off-Ramp) in the cities of Los Angeles and Long Beach, California.

This memorandum summarizes the results of our lateral pile analysis following completion of the recent field investigation and laboratory testing program and is intended to verify that p-y curves developed during the preliminary design phase are suitable and conservative for use in final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California. The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and W. Ocean Boulevard on the south side.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge and the new alignment shifts east along the existing alignment. The proposed fixed bridge will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge will also include southbound exit ramps and northbound entrance ramps at New Dock Street and State Route (SR) 103.

The typical bridge bent will have either multiple columns (mainline) or single columns (ramp structures) supported on Type II cast-in-drilled-hole (CIDH) piles. South of Cerritos Channel, the CIDH piles are 10 ft diameter while the spans across Cerritos Channel and north of Cerritos Channel are supported on 11 to 12 ft diameter CIDH piles. The abutments for the mainline and the ramp structures are expected to be supported on 2.5-foot diameter CIDH piles; however the subject memorandum only pertains to the bent pile analysis.

Project Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time and was intended to be used for bridge type selection and preliminary design. The PFR included a general description of the subsurface conditions including eight idealized soil profiles along the proposed structure alignment with each idealized soil profile typically spanning across multiple bents. The idealized soil profile was used by EMI to develop pile lengths for cost estimating purposes based upon preliminary design loads provided by the designers. Each idealized soil profile included stratigraphy and idealized soil strength parameters (unit weight, friction angle and undrained shear strength) including post-liquefaction "residual" shear strengths for the layers identified as being potentially liquefiable based on a liquefaction analysis performed on the existing soil borings.

It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared. A set of p-y curves was generated at each bent of the mainline and ramp structures for a single 10-ft diameter CIDH pile and included reduced soil strengths for the layers identified in the PFR as potentially liquefiable. Since the project specific geotechnical field investigation could not be initiated until late during the project timeline, the preliminary p-y curves were used by the Caltrans bridge designers in final design. Based upon our conversations with the bridge designers, the only modifications that were made to the preliminary p-y curves was the application of a p-multiplier of 1.2 to curves where the CIDH pile diameter was increased to 12 ft.

In September 2009, EMI was requested by the Alameda Corridor Transportation Agency (ACTA) to perform the project-specific geotechnical field investigation which when completed consisted of 42 rotary wash borings, 33 cone penetration test (CPT) soundings and 8 hollow-stem auger borings along the proposed bridge and ramp alignment; including at least one boring performed near each support of the proposed structure. After completion of the geotechnical field investigation and laboratory testing program, a complete liquefaction analysis was conducted using the new boring information and the idealized soil profile along the proposed bridge alignment was revised.

Because the geotechnical field investigation was not able to be initiated until late during the project timeline, re-analyzing the structure based upon p-y curves generated using the updated soil profile was not feasible given project deadlines. Therefore, EMI performed a set of lateral pile analyses at selected bent locations representing the entire bridge alignment to compare the

preliminary p-y curves (referred to as Design Curves in this memorandum) generated from the idealized soil profiles in the PFR to the p-y curves developed using the updated soil profile (referred to as Revised Profile Curves in this memorandum) to verify that the preliminary curves are suitable and conservative for use in final design.

Method of Analysis

As described above, the Design Curves were generated from eight different soil profiles provided in the PFR (EMI, 2006). For comparison purposes, five bent locations were selected where the individual p-y curves and the overall pile behavior (pile head shear resistance and maximum pile moment versus pile-top deflection) could be compared. The bents selected for comparison were at locations where five of the eight different soil profiles generated during preliminary design could be analyzed. The bent locations selected consisted of two bents south of Cerritos Channel (Bent 2 and Bent 11), one of the bents inside the Cerritos Channel (Bent 14) and two bents north of Cerritos Channel (Bent 18 and Bent 24). The five different idealized soil profiles are shown in Figures 1 to 5.

A review of the Design Curves indicated that coarse-grained soils appear to have been developed using the method proposed by Reese et al. (1974) and fine-grained soils appear to have been developed using the method proposed by Reese and Cox (1975) for stiff clay in the presence of free water. The Revised Profile Curves generated by EMI were developed using API criteria (2000) for coarse grained soils, Matlock's soft clay criteria (Matlock, 1970) for clays with undrained shear strength less than 1 ksf and Reese's method (Reese and Cox, 1975) for stiff clay in the presence of free water for clays with an undrained shear strength greater than 1 ksf.

For comparison of the individual p-y curves, the design curves were provided by the designers. The Revised Profile Curves were generated using LPILE (Ensoft, 2004) based upon the revised idealized soil profile developed at the different bent locations. For the comparison of overall pile behavior (pile head shear resistance and pile moment versus pile-top deflection), the Design Curves were input into LPILE using the "user input p-y curves" option. Based upon our conversations with the designers, a "cracked" section modulus (EI) equal to 75% of the gross EI was used for both models.

Liquefiable Soil. As described above, the Design Curves were generated from soil profiles that indicated the presence of potentially liquefiable material. Based upon a review of the Design Curves, liquefied strengths were generated by applying a p-reduction factor varying between 0.15 and 0.20 for potentially liquefiable layers.

The Revised Profile Curves were generated based upon an updated liquefaction analysis performed on the borings completed in the EMI field investigation. Liquefied soil strengths for layers identified to be potentially liquefiable were modeled using a p-reduction factor based upon the values provided in Ashford et al. (2008). The p-reduction factors are correlated to an average normalized clean sand SPT blowcount $(N1)_{60\text{-}CS}$ for the liquefiable layer with discrete values provided for a range of $(N1)_{60\text{-}CS}$. An approximate trend line was drawn through the ranges proposed by Ashford and used in the analysis as shown in Figure 6.

Group Effects. It is our understanding that the Design Curves were generated prior to Caltrans implementation of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2007) which required p-reduction factors to p-y curves to account for group effects. P-reduction factors to account for group effects for the Revised Profile Curves followed the recommendations for pile group efficiency reduction factors provided in Caltrans Amendments to AASHTO LRFD BDS (Caltrans, 2008) and were based upon the CIDH pile on-center spacing in the bridge transverse direction at the individual bent locations. Since each bent consists of a single row of piles, the bridge transverse direction controls the pile design as it has a greater group reduction than the longitudinal direction. The pile spacing and p-reduction factors used in the analysis for each bent are listed in Table 1.

Table 1. Group Reduction Factors for Revised Profile Curves

Bent Location	Pile Diameter (ft)	Average Spacing in Transverse Direction (ft)	P-Reduction Factor for Group Effects
Bent 2	10	30 = 3.0 x D	0.53
Bent 11	10	36 = 3.6 x D	0.61
Bent 14	12	33 = 2.9 x D	0.48
Bent 18	12	35 = 3.0 x D	0.53
Bent 24	12	45 = 4.0 x D	0.67
Note: Group reduction effects were not accounted for in development of Design Curves.			

Groundwater. The design groundwater elevation for the Revised Profile Curves was placed at an elevation of +5 ft MLLW or the ground surface in locations where proposed grade is indicated on the plans as being below elevation +5 ft MLLW.

Results

The revised soil profiles resulting from the information gathered during the recent investigation are generally consistent with those provided in the PFR that were used to develop the Design Curves. Site soils can be characterized by alluvial deposits consisting of loose to medium dense fine-grained silty sand and sandy silt with abundant silty clay and clayey silt layers between the ground surface and about 50 to 70 ft below grade. The near surface alluvium is underlain by dense to very dense coarse-grained Gaspur Formation sand. The coarse grained portions of the alluvium is generally liquefiable with some pockets and lenses with medium dense to dense consistency that are not considered susceptible to liquefaction.

Since lateral pile behavior is primarily dictated by the soil profile within the upper portion of the pile (within about 5 to 7 pile diameters from the pile top), the lateral pile stiffness throughout the project is dominated by soft to stiff fine-grained material and liquefiable sand. In generating the revised soil profiles, the recent soil borings and laboratory test results justify using more appropriate p-reduction factors to account for liquefaction throughout the profile and higher undrained shear strengths in some of the fine-grained material. Though the Design Curves were generated during early stages of the project without considering group effects, when the more appropriate p-reduction factors for liquefiable soils and increased undrained shear strengths for the appropriate fine-grained soils are used in conjunction with the group reduction factors, the Revised Profile Curves are generally comparable to the Design Curves. Figures 7 to 11 show the

Design Curves plotted along side the Revised Profile Curves at each bent location for the top 100 ft of pile length.

Due to some revisions in the idealized soil profile stratigraphy based upon the new soil information, there are some depths that the Revised Profile Curves model a layer or a portion of a layer as softer than the Design Curves; therefore, it isn't necessarily clear upon initial inspection which set of p-y curves generates a more conservative soil model. Based upon our conversations with the designers, performing a pile pushover analysis using a free-head pile, the curves that generate a pile response where a smaller pile-head shear is required to produce a prescribed lateral pile displacement is considered to be more conservative. In addition, since earthquake loading on a bridge is force based (i.e., mass times the spectral acceleration), the curve that predicts more moment in the pile for a given pile-head shear would also be an indication of a more conservative analysis.

For the five different bents considered, the lateral pile head shear and maximum moment are plotted against lateral pile-top displacement in Figures 12 to 16 using the analysis methods described above. Figures 12, 15 and 16 show that for Bent 2, Bent 18 and Bent 24, respectively, the Design Curves produce a more conservative lateral pile response than the analysis using the Revised Profile Curves. For Bent 11 and Bent 14 shown in Figures 13 and 14, respectively, the lateral pile head shear to produce the same lateral pile deflection is about 15 percent less for the Revised Profile Curves than that for the Design Curves. These differences are considered small and acceptable. In addition, as shown in Figures 12 through 16, the maximum moments for given pile-head shear values predicted using the Design Curves are approximately equal to or greater those predicted using the Revised Profile Curves.

Conclusions

Based upon the results of the above described analysis and our discussions with the designers, we conclude that the Design Curves are appropriate for use in the bridge final design as they typically generate a more conservative lateral pile response than the response predicted by the Revised Curves.

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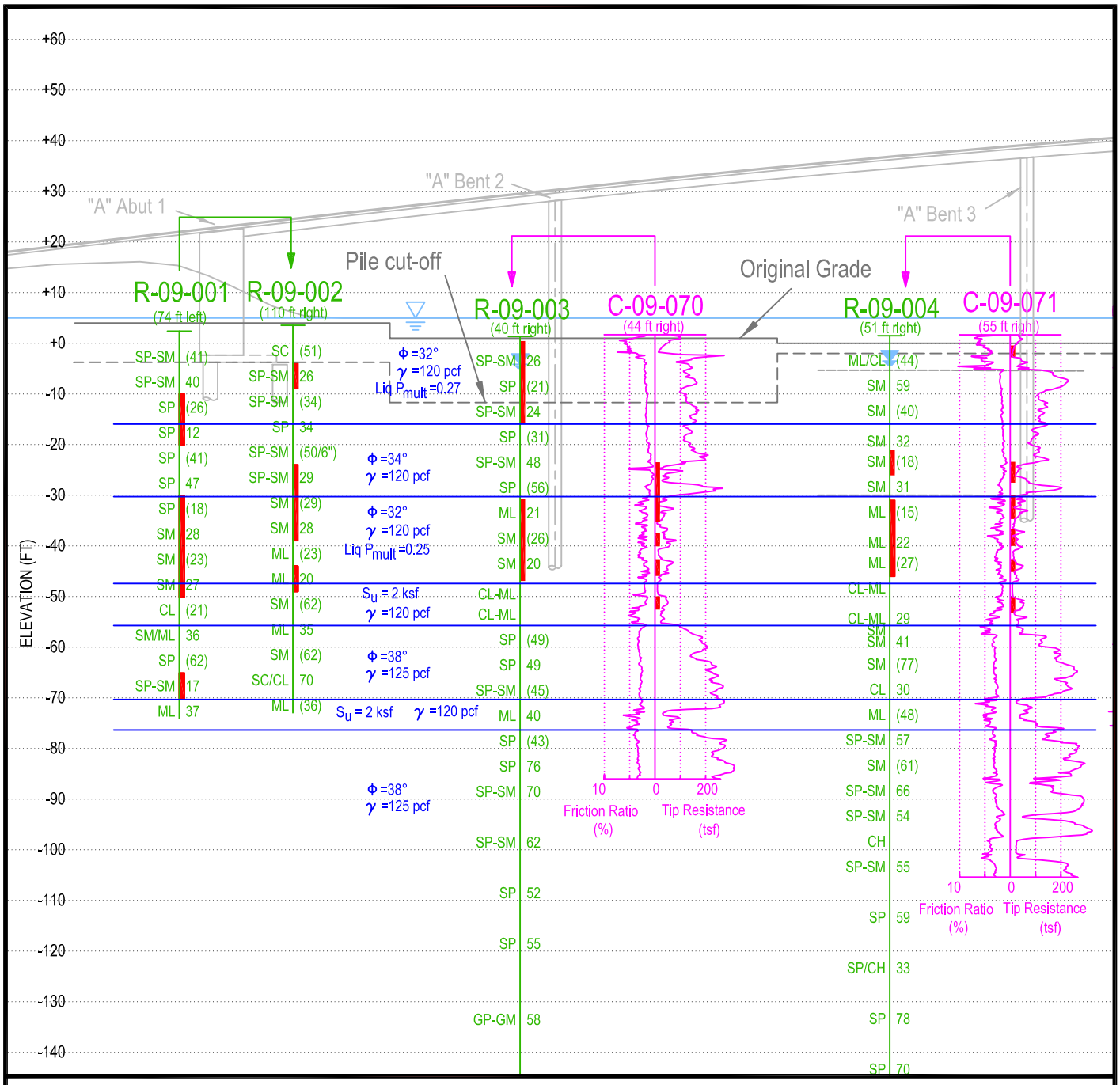

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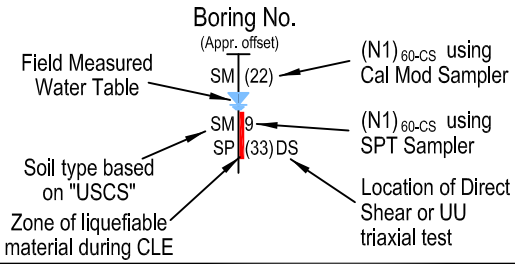
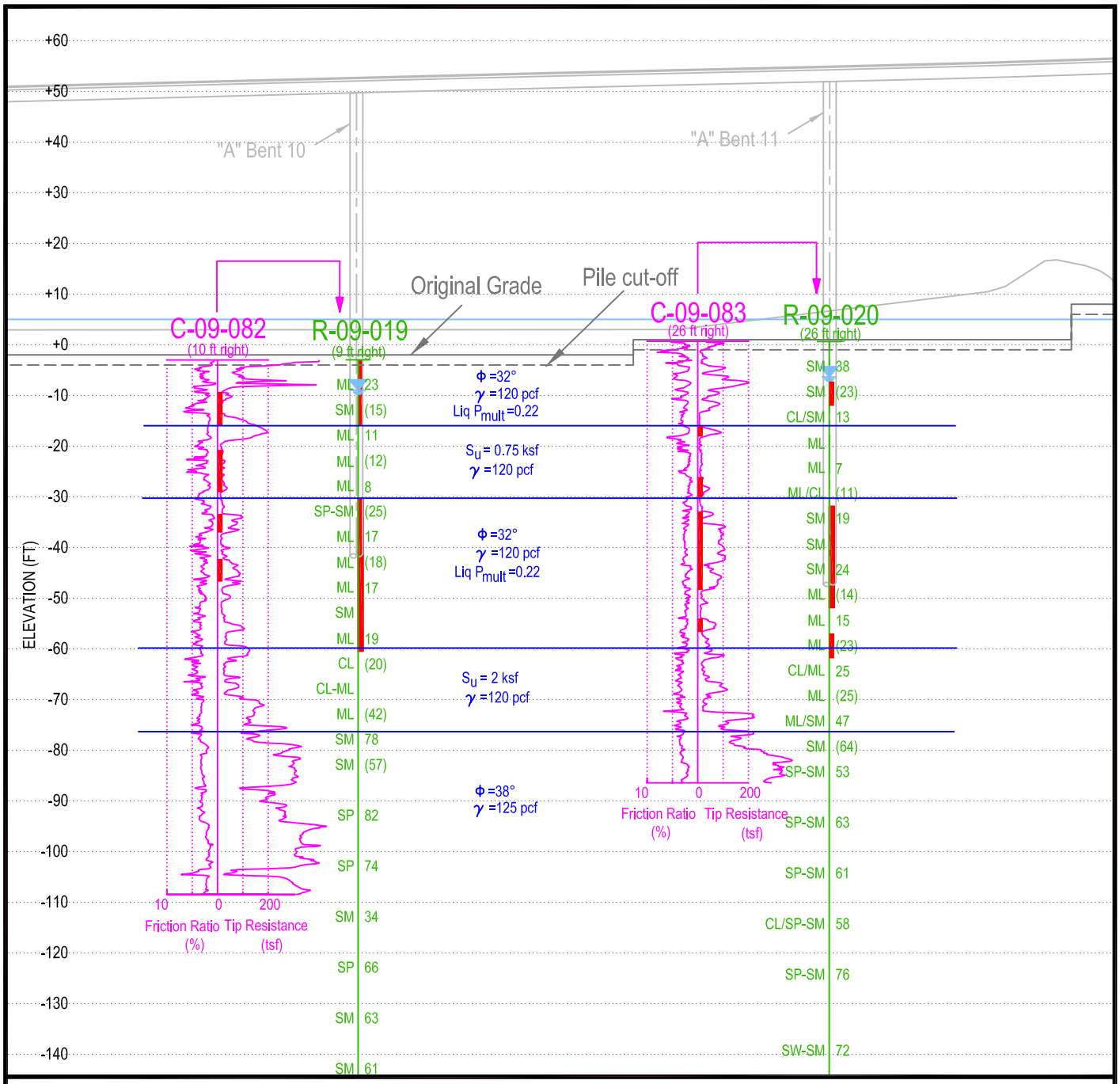


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 2 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 1



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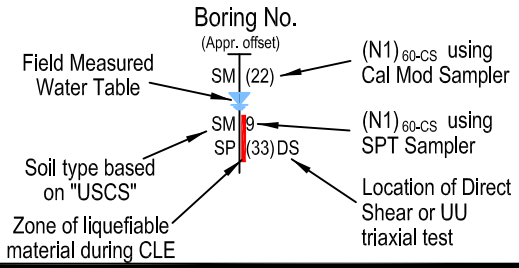
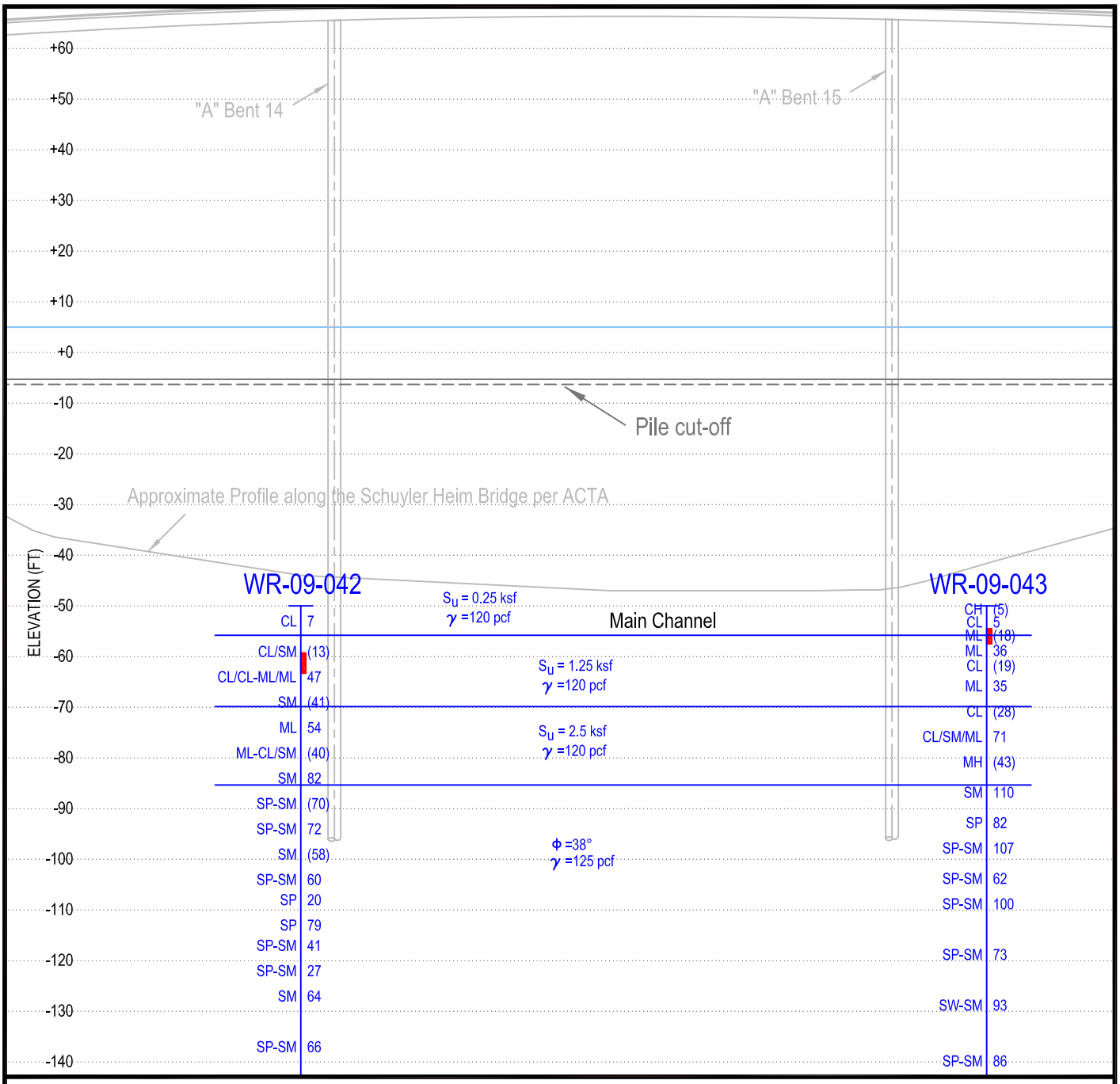


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 2



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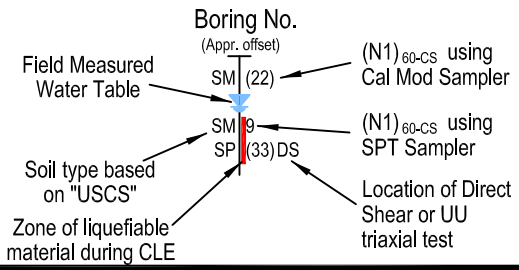
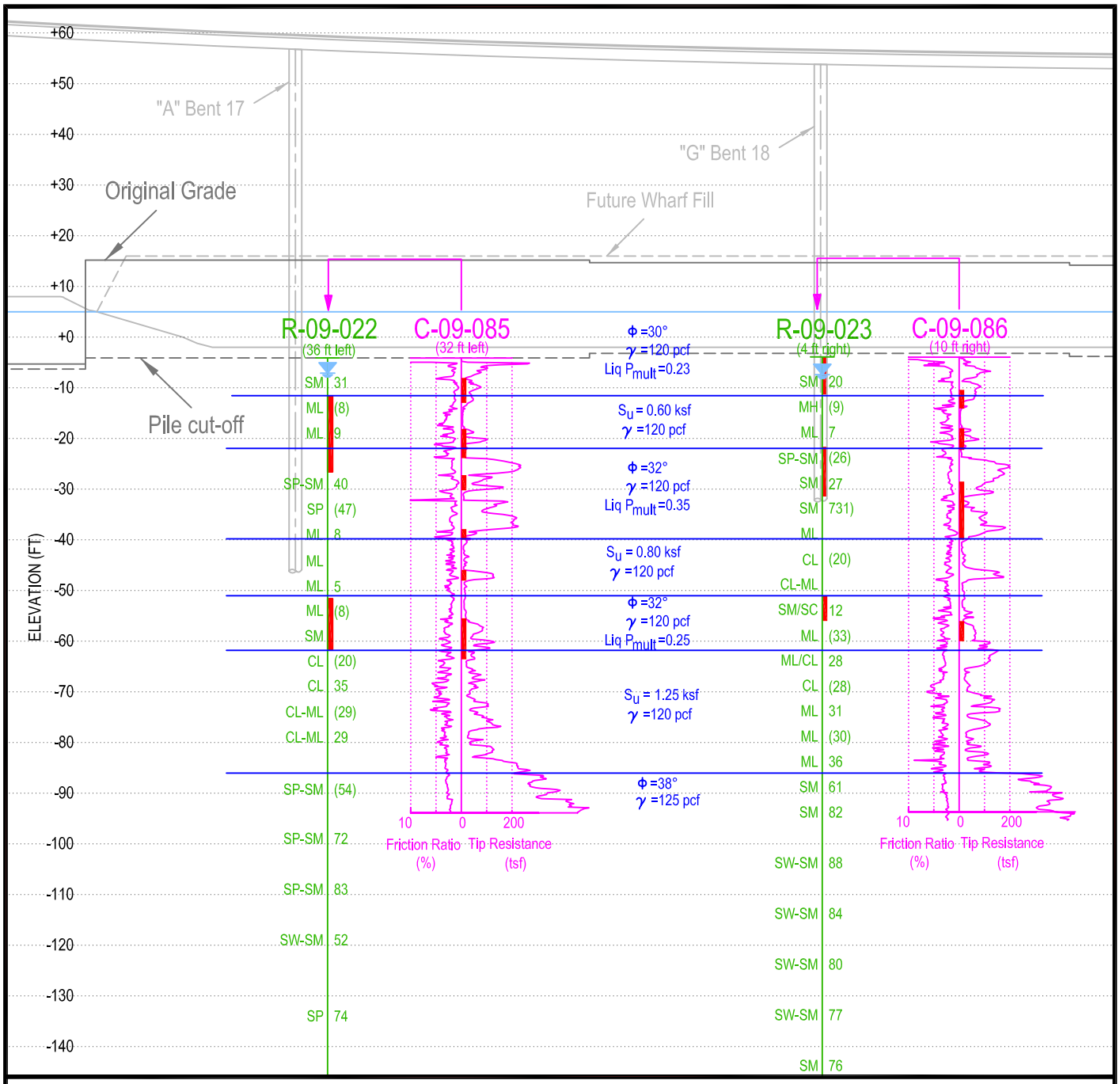


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 3



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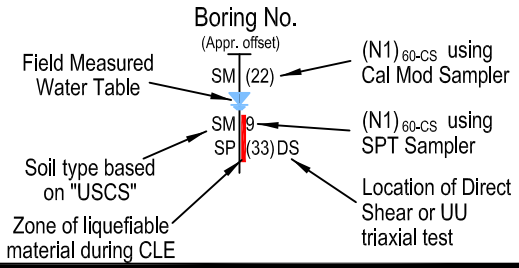
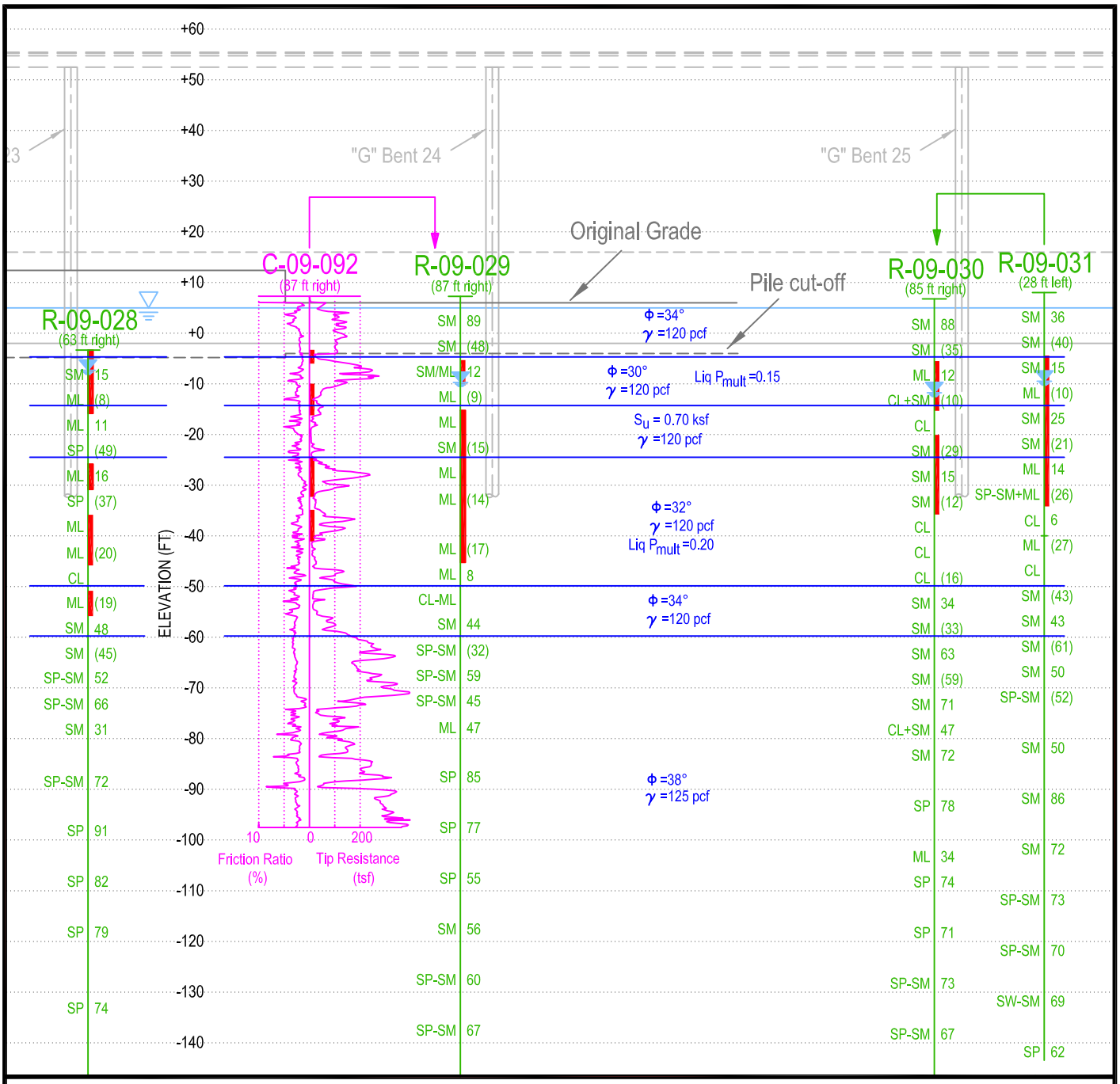


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 4



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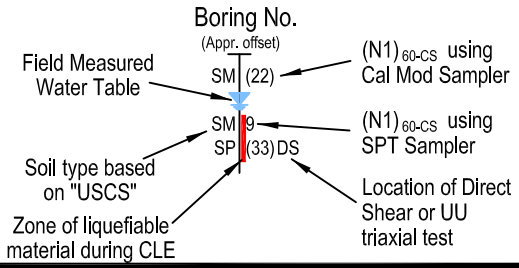


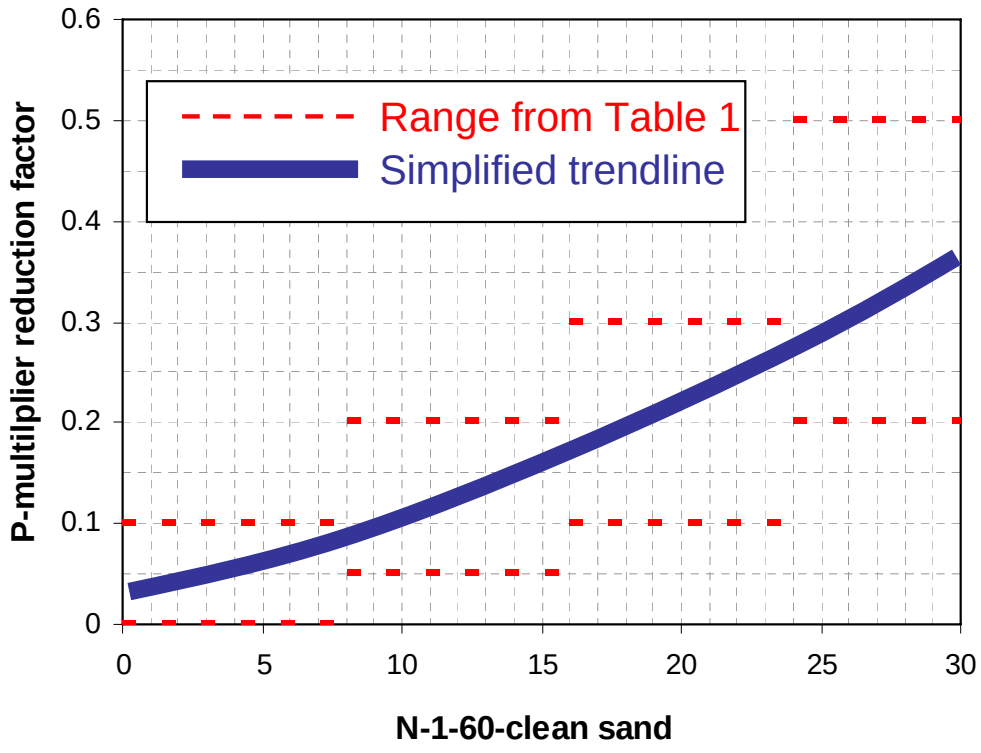
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 24 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 5

Recommended values (after Ashford et al. 2008)

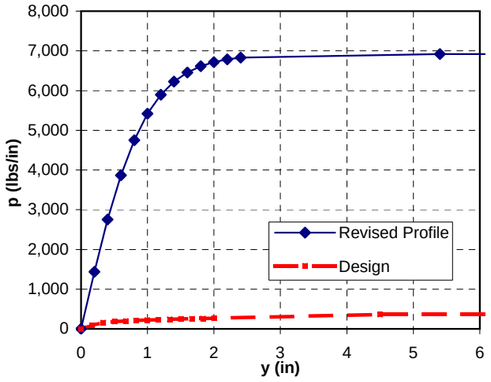
Table 1. p-multipliers, m_p, to account for liquefaction

$(N_1)_{60\text{-}CS}$	m_p
<8	0.0 to 0.1
8-16	0.05 to 0.2
16-24	0.1 to 0.3
>24	0.2 to 0.5

Chart for selecting p-multiplier based on $(N1)60_{cs}$

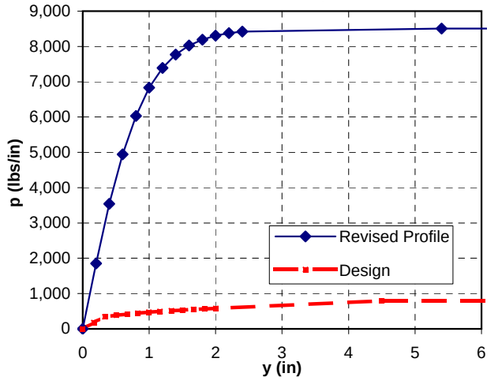


5 ft depth



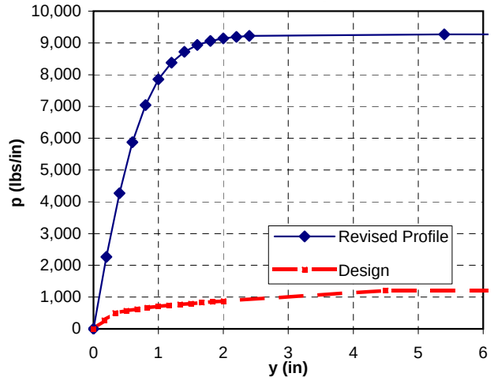
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	1,436
0.34	162	0.40	2,753
0.50	182	0.60	3,869
0.67	197	0.80	4,753
0.83	210	1.00	5,416
1.00	221	1.20	5,894
1.16	231	1.40	6,228
1.33	240	1.60	6,457
1.50	248	1.80	6,611
1.67	256	2.00	6,715
1.84	263	2.20	6,783
2.00	269	2.40	6,829
4.50	365	5.40	6,916
124.50	365	149.40	6,916

10 ft depth



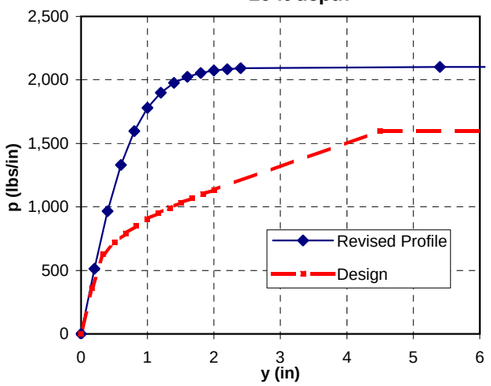
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	1,853
0.34	341	0.40	3,538
0.50	384	0.60	4,943
0.67	418	0.80	6,032
0.83	447	1.00	6,829
1.00	472	1.20	7,389
1.16	494	1.40	7,771
1.33	514	1.60	8,025
1.50	532	1.80	8,193
1.67	549	2.00	8,303
1.84	565	2.20	8,374
2.00	579	2.40	8,420
4.50	794	5.40	8,503
124.50	794	149.40	8,503

15 ft depth



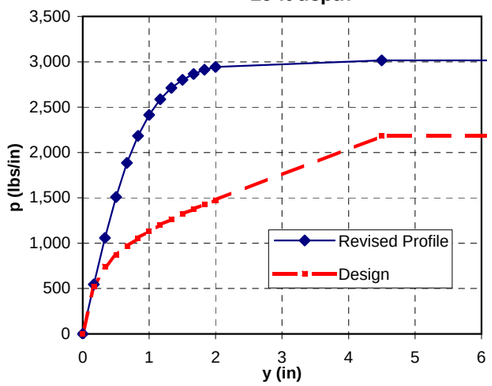
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.20	2,263
0.34	502	0.40	4,271
0.50	569	0.60	5,873
0.67	622	0.80	7,046
0.83	666	1.00	7,852
1.00	705	1.20	8,381
1.16	739	1.40	8,719
1.33	770	1.60	8,931
1.50	799	1.80	9,062
1.67	825	2.00	9,143
1.84	850	2.20	9,192
2.00	873	2.40	9,222
4.50	1,210	5.40	9,269
124.50	1,210	149.40	9,269

20 ft depth



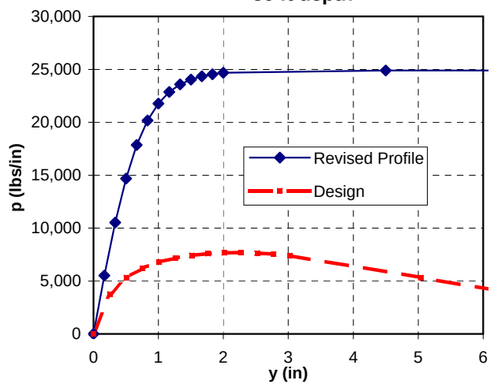
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	360	0.20	512
0.34	631	0.40	967
0.50	720	0.60	1,330
0.67	792	0.80	1,597
0.83	852	1.00	1,780
1.00	904	1.20	1,900
1.16	951	1.40	1,977
1.33	993	1.60	2,026
1.50	1,032	1.80	2,055
1.67	1,069	2.00	2,074
1.84	1,103	2.20	2,085
2.00	1,134	2.40	2,092
4.50	1,599	5.40	2,103
124.50	1,599	149.40	2,103

29 ft depth



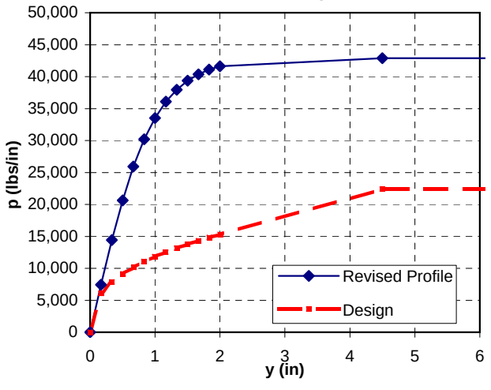
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	522	0.17	547
0.34	744	0.33	1,058
0.50	868	0.50	1,509
0.67	970	0.67	1,885
0.83	1,056	0.83	2,184
1.00	1,132	1.00	2,414
1.16	1,201	1.17	2,586
1.33	1,264	1.33	2,711
1.50	1,322	1.50	2,802
1.67	1,377	1.67	2,866
1.84	1,428	1.83	2,911
2.00	1,476	2.00	2,943
4.50	2,182	4.50	3,016
124.50	2,182	124.50	3,017

50 ft depth



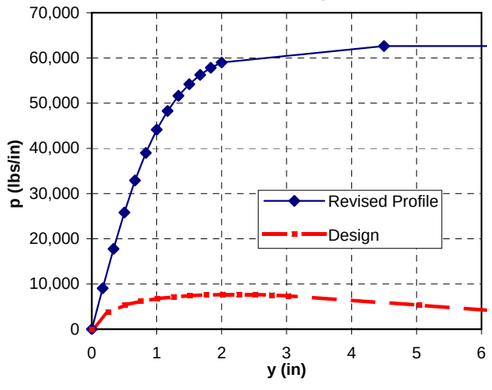
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	5,521
0.50	5,325	0.33	10,523
0.76	6,204	0.50	14,668
1.01	6,775	0.67	17,855
1.26	7,164	0.83	20,166
1.51	7,425	1.00	21,774
1.76	7,585	1.17	22,858
2.02	7,664	1.33	23,576
2.27	7,676	1.50	24,045
2.52	7,629	1.67	24,348
2.77	7,532	1.83	24,543
3.02	7,390	2.00	24,668
5.04	5,330	4.50	24,888
7.06	3,268	124.50	24,889

71 ft depth



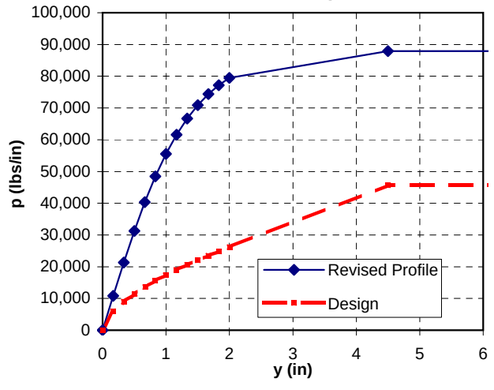
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	6,081	0.17	7,430
0.34	7,867	0.33	14,426
0.50	9,145	0.50	20,652
0.67	10,176	0.67	25,918
0.83	11,056	0.83	30,186
1.00	11,830	1.00	33,525
1.16	12,527	1.17	36,068
1.33	13,164	1.33	37,963
1.50	13,753	1.50	39,354
1.67	14,302	1.67	40,363
1.84	14,817	1.83	41,089
2.00	15,303	2.00	41,609
4.50	22,408	4.50	42,867
124.50	22,408	124.50	42,874

85 ft depth



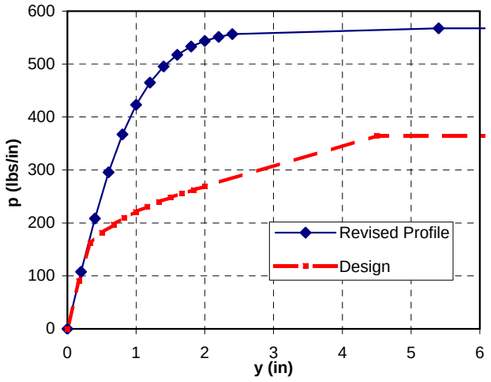
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	9,074
0.50	5,325	0.33	17,775
0.76	6,204	0.50	25,790
1.01	6,775	0.67	32,904
1.26	7,164	0.83	39,014
1.51	7,425	1.00	44,113
1.76	7,585	1.17	48,270
2.02	7,664	1.33	51,593
2.27	7,676	1.50	54,208
2.52	7,629	1.67	56,241
2.77	7,532	1.83	57,807
3.02	7,390	2.00	59,004
5.04	5,330	4.50	62,636
7.06	3,268	124.50	62,684

100 ft depth



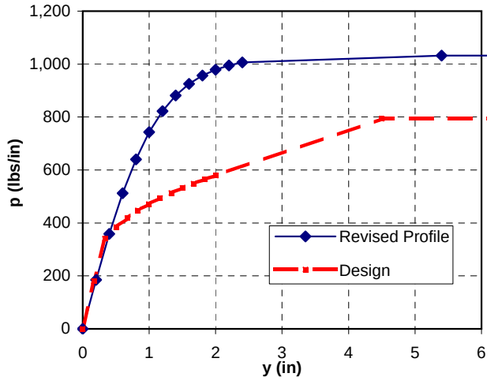
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	5,976	0.17	10,832
0.34	9,023	0.33	21,341
0.50	11,483	0.50	31,242
0.67	13,624	0.67	40,316
0.83	15,557	0.83	48,423
1.00	17,338	1.00	55,503
1.16	19,001	1.17	61,565
1.33	20,571	1.33	66,668
1.50	22,063	1.50	70,902
1.67	23,489	1.67	74,373
1.84	24,858	1.83	77,191
2.00	26,177	2.00	79,461
4.50	45,628	4.50	87,868
124.50	45,628	124.50	88,090

5 ft depth



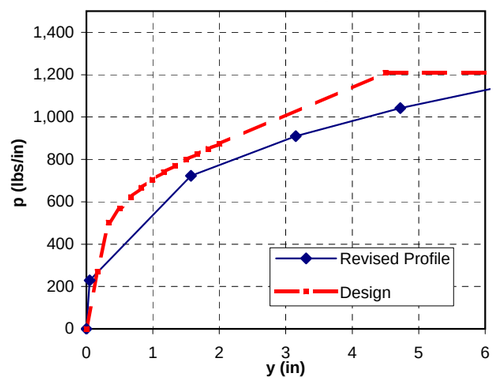
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	108
0.34	162	0.40	208
0.50	182	0.60	295
0.67	197	0.80	367
0.83	210	1.00	423
1.00	221	1.20	465
1.16	231	1.40	496
1.33	240	1.60	518
1.50	248	1.80	533
1.67	256	2.00	544
1.84	263	2.20	551
2.00	269	2.40	556
4.50	365	5.40	567
124.50	365	149.40	568

10 ft depth



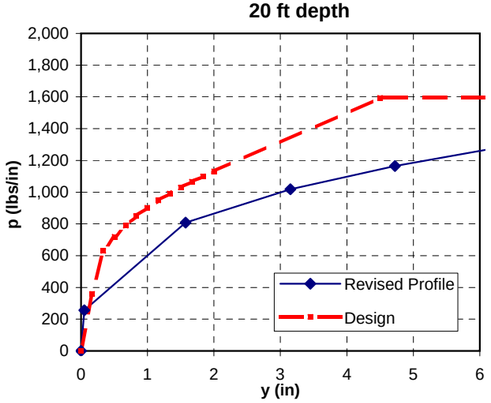
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	185
0.34	341	0.40	359
0.50	384	0.60	512
0.67	418	0.80	640
0.83	447	1.00	743
1.00	472	1.20	822
1.16	494	1.40	881
1.33	514	1.60	925
1.50	532	1.80	956
1.67	549	2.00	979
1.84	565	2.20	995
2.00	579	2.40	1,006
4.50	794	5.40	1,032
124.50	794	149.40	1,033

15 ft depth



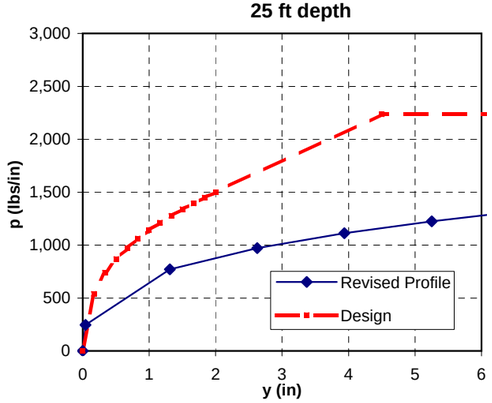
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.05	229
0.34	502	1.58	723
0.50	569	3.15	910
0.67	622	4.73	1,042
0.83	666	6.30	1,147
1.00	705	7.88	1,235
1.16	739	9.45	1,313
1.33	770	11.03	1,382
1.50	799	12.60	1,445
1.67	825	14.18	1,503
1.84	850	15.75	1,557
2.00	873	17.33	1,607
4.50	1,210	18.90	1,654
124.50	1,210	50.40	2,294

20 ft depth



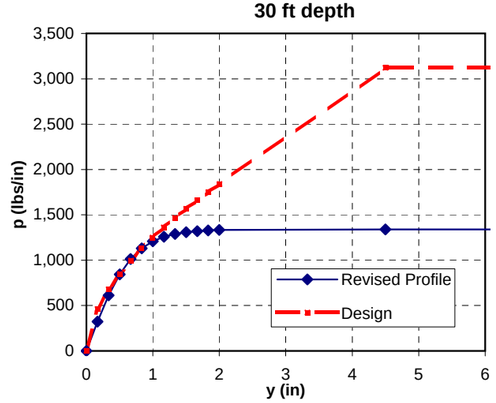
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	359	0.05	256
0.34	629	1.58	808
0.50	719	3.15	1,018
0.67	790	4.73	1,165
0.83	850	6.30	1,282
1.00	902	7.88	1,381
1.16	949	9.45	1,468
1.33	991	11.03	1,545
1.50	1,030	12.60	1,616
1.67	1,066	14.18	1,680
1.84	1,100	15.75	1,740
2.00	1,132	17.33	1,797
4.50	1,594	18.90	1,849
124.50	1,594	50.40	2,565

25 ft depth



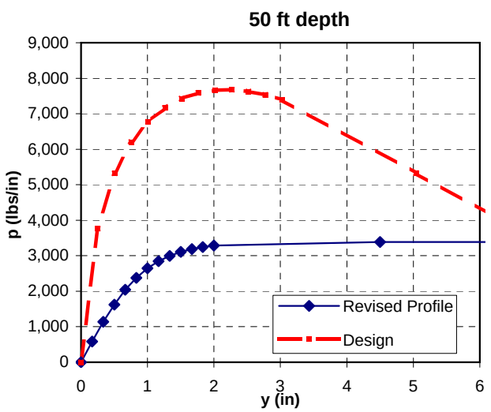
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	539	0.04	245
0.34	740	1.31	771
0.50	869	2.63	972
0.67	973	3.94	1,112
0.83	1,062	5.25	1,224
1.00	1,141	6.56	1,319
1.16	1,212	7.88	1,402
1.33	1,278	9.19	1,475
1.50	1,338	10.50	1,543
1.67	1,395	11.81	1,604
1.84	1,448	13.13	1,662
2.00	1,499	14.44	1,715
4.50	2,236	15.75	1,766
124.50	2,236	42.00	2,449

30 ft depth



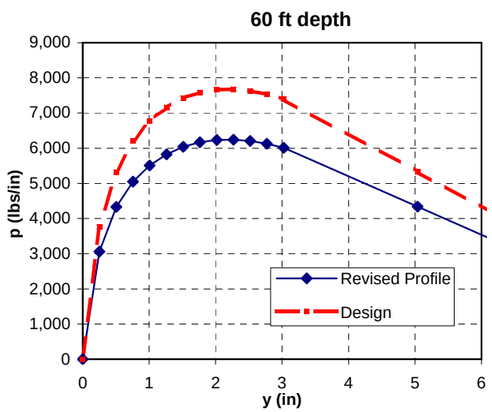
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	461	0.17	324
0.34	678	0.33	612
0.50	850	0.50	843
0.67	998	0.67	1,012
0.83	1,130	0.83	1,130
1.00	1,251	1.00	1,208
1.16	1,363	1.17	1,257
1.33	1,468	1.33	1,289
1.50	1,567	1.50	1,308
1.67	1,662	1.67	1,320
1.84	1,753	1.83	1,328
2.00	1,840	2.00	1,332
4.50	3,121	4.50	1,340
124.50	3,121	124.50	1,340

50 ft depth



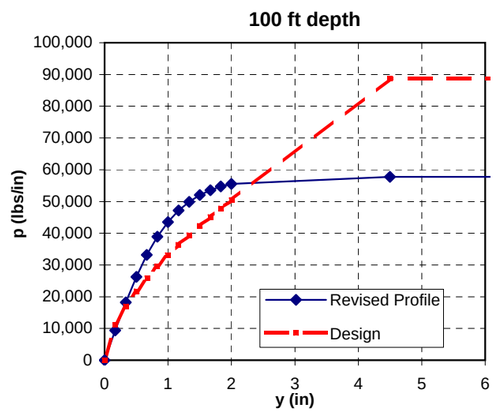
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	584
0.50	5,325	0.33	1,135
0.76	6,204	0.50	1,626
1.01	6,775	0.67	2,041
1.26	7,164	0.83	2,379
1.51	7,425	1.00	2,643
1.76	7,585	1.17	2,845
2.02	7,664	1.33	2,996
2.27	7,676	1.50	3,107
2.52	7,629	1.67	3,188
2.77	7,532	1.83	3,246
3.02	7,390	2.00	3,288
5.04	5,330	4.50	3,389
7.06	3,268	124.50	3,390

60 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.25	3,063
0.50	5,325	0.50	4,332
0.76	6,204	0.76	5,047
1.01	6,775	1.01	5,511
1.26	7,164	1.26	5,828
1.51	7,425	1.51	6,040
1.76	7,585	1.76	6,170
2.02	7,664	2.02	6,235
2.27	7,676	2.27	6,244
2.52	7,629	2.52	6,206
2.77	7,532	2.77	6,127
3.02	7,390	3.02	6,011
5.04	5,330	5.04	4,336
7.06	3,268	7.06	2,658

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	11,128	0.17	9,360
0.34	16,961	0.33	18,242
0.50	21,702	0.50	26,260
0.67	25,850	0.67	33,178
0.83	29,606	0.83	38,920
1.00	33,077	1.00	43,533
1.16	36,327	1.17	47,142
1.33	39,400	1.33	49,910
1.50	42,325	1.50	51,998
1.67	45,125	1.67	53,555
1.84	47,817	1.83	54,706
2.00	50,414	2.00	55,551
4.50	88,729	4.50	57,780
124.50	88,729	124.50	57,797

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

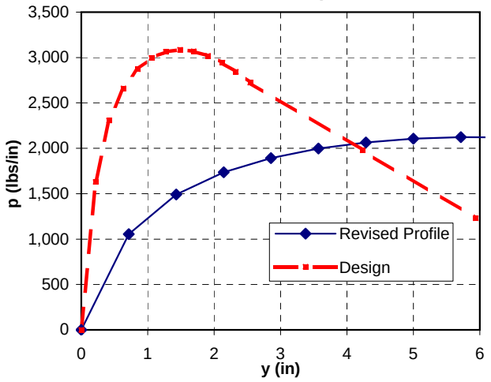
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 11

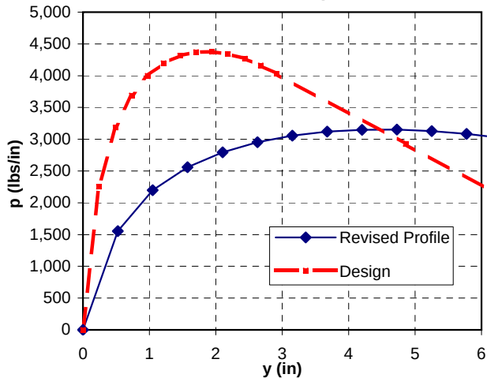
Figure 8

55 ft depth



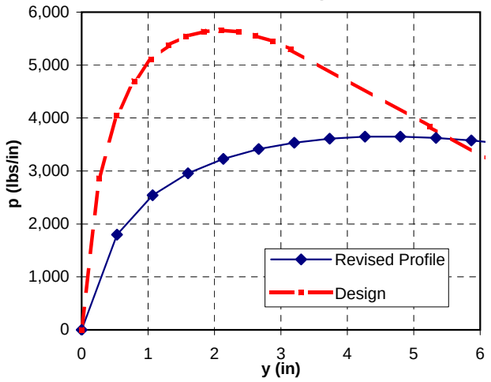
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	1,631	0.71	1,055
0.42	2,306	1.43	1,491
0.64	2,660	2.14	1,735
0.85	2,870	2.86	1,891
1.06	2,997	3.57	1,996
1.27	3,064	4.29	2,065
1.49	3,085	5.00	2,105
1.69	3,068	5.71	2,122
1.91	3,019	6.43	2,121
2.12	2,944	7.14	2,102
2.33	2,844	7.86	2,069
2.54	2,724	8.57	2,024
4.24	1,978	14.29	1,463
5.94	1,230	20.00	902

60 ft depth



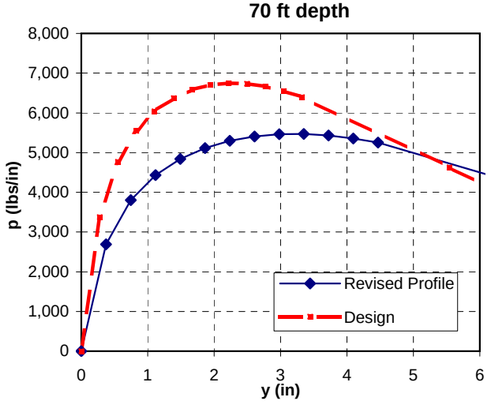
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.24	2,252	0.53	1,555
0.49	3,185	1.05	2,200
0.73	3,688	1.58	2,561
0.97	3,999	2.10	2,794
1.21	4,198	2.63	2,952
1.46	4,316	3.15	3,057
1.70	4,372	3.68	3,120
1.94	4,378	4.20	3,149
2.18	4,341	4.73	3,150
2.44	4,268	5.25	3,127
2.68	4,163	5.78	3,083
2.92	4,032	6.30	3,021
4.86	2,926	10.50	2,181
6.80	1,820	14.71	1,341

65 ft depth



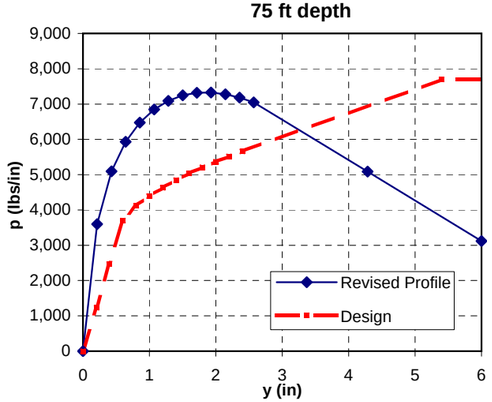
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.26	2,862	0.53	1,796
0.53	4,047	1.07	2,540
0.79	4,697	1.60	2,958
1.04	5,106	2.13	3,229
1.31	5,375	2.67	3,414
1.57	5,542	3.20	3,536
1.84	5,631	3.73	3,611
2.10	5,657	4.27	3,647
2.36	5,630	4.80	3,651
2.62	5,558	5.33	3,627
2.88	5,445	5.87	3,578
3.14	5,300	6.40	3,510
5.24	3,841	10.67	2,532
7.34	2,382	14.93	1,554

70 ft depth



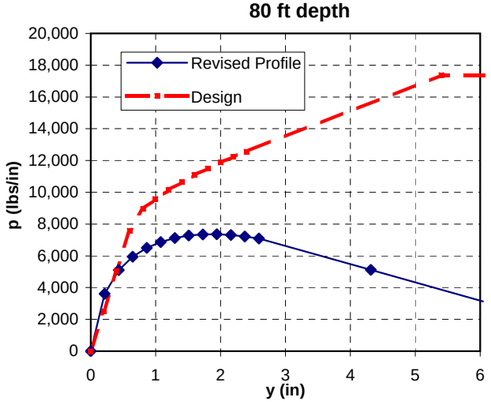
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.28	3,375	0.37	2,691
0.55	4,773	0.74	3,805
0.83	5,547	1.12	4,432
1.10	6,041	1.49	4,837
1.39	6,371	1.86	5,113
1.67	6,583	2.23	5,296
1.94	6,703	2.61	5,408
2.22	6,750	2.98	5,461
2.50	6,735	3.35	5,466
2.77	6,667	3.72	5,429
3.05	6,553	4.10	5,356
3.32	6,400	4.47	5,251
5.54	4,631	7.45	3,790
7.76	2,861	10.43	2,327

75 ft depth



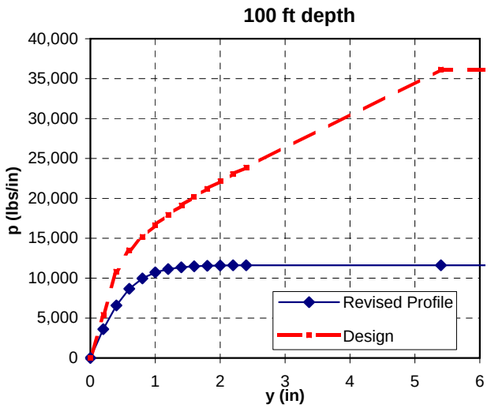
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	1,234	0.21	3,600
0.40	2,467	0.43	5,092
0.60	3,701	0.64	5,931
0.80	4,120	0.86	6,475
1.00	4,395	1.07	6,846
1.20	4,632	1.29	7,093
1.40	4,843	1.50	7,244
1.60	5,033	1.71	7,317
1.80	5,208	1.93	7,326
2.00	5,368	2.14	7,279
2.20	5,518	2.36	7,183
2.40	5,659	2.57	7,044
5.40	7,701	4.29	5,083
149.40	7,701	6.00	3,119

80 ft depth



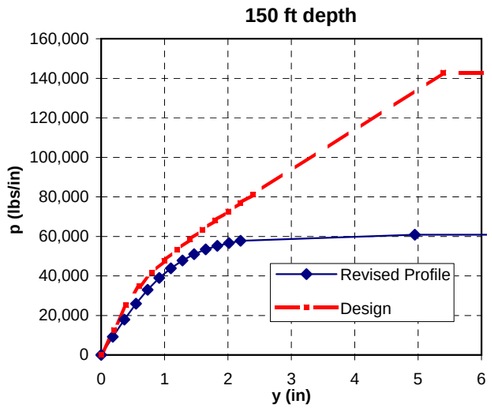
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	2,530	0.22	3,613
0.40	5,059	0.43	5,110
0.60	7,589	0.65	5,953
0.80	8,955	0.86	6,500
1.00	9,591	1.08	6,874
1.20	10,144	1.29	7,123
1.40	10,637	1.51	7,277
1.60	11,083	1.73	7,353
1.80	11,491	1.94	7,364
2.00	11,870	2.16	7,319
2.20	12,223	2.37	7,225
2.40	12,555	2.59	7,088
5.40	17,381	4.32	5,113
149.40	17,381	6.04	3,135

100 ft depth



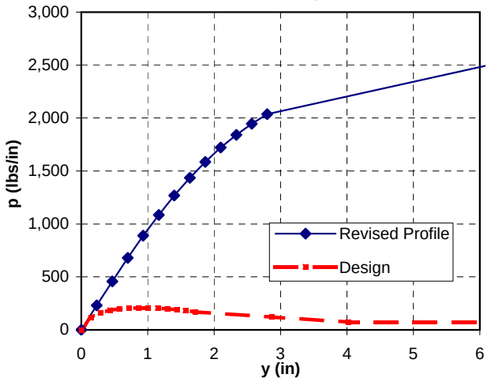
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	5,410	0.20	3,604
0.40	10,819	0.40	6,576
0.60	13,502	0.60	8,661
0.80	15,196	0.80	9,964
1.00	16,655	1.00	10,720
1.20	17,951	1.20	11,140
1.40	19,125	1.40	11,368
1.60	20,203	1.60	11,490
1.80	21,205	1.80	11,554
2.00	22,143	2.00	11,588
2.20	23,028	2.20	11,607
2.40	23,866	2.40	11,616
5.40	36,124	5.40	11,627
149.40	36,124	149.40	11,627

150 ft depth



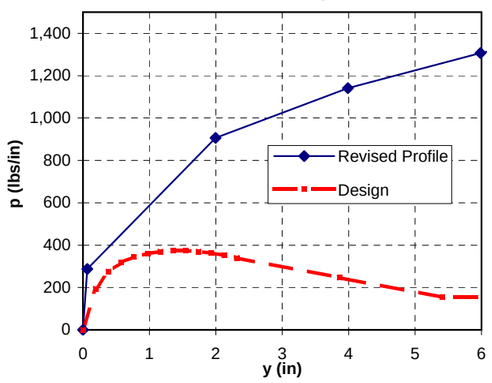
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	12,610	0.18	9,154
0.40	25,219	0.37	17,902
0.60	34,932	0.55	25,909
0.80	41,608	0.73	32,951
1.00	47,654	0.92	38,933
1.20	53,241	1.10	43,863
1.40	58,472	1.28	47,829
1.60	63,417	1.47	50,956
1.80	68,125	1.65	53,382
2.00	72,632	1.83	55,243
2.20	76,965	2.02	56,657
2.40	81,146	2.20	57,723
5.40	142,818	4.95	60,806
149.40	142,818	136.95	60,840

5 ft depth



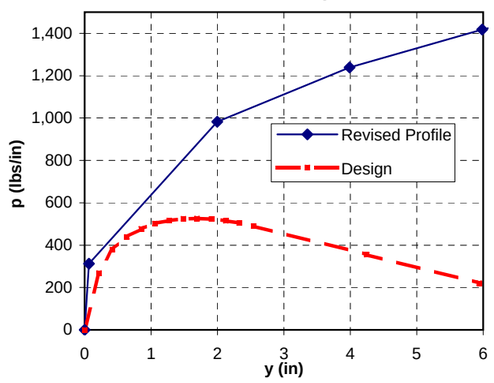
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	231
0.29	162	0.47	459
0.43	186	0.70	679
0.58	199	0.93	889
0.72	206	1.17	1,086
0.86	209	1.40	1,269
1.01	208	1.63	1,436
1.15	204	1.87	1,586
1.30	198	2.10	1,721
1.44	190	2.33	1,841
1.57	180	2.57	1,946
1.72	169	2.80	2,037
2.87	122	6.30	2,522
4.02	74	174.30	2,560
100.00	74	342.30	2,560

10 ft depth



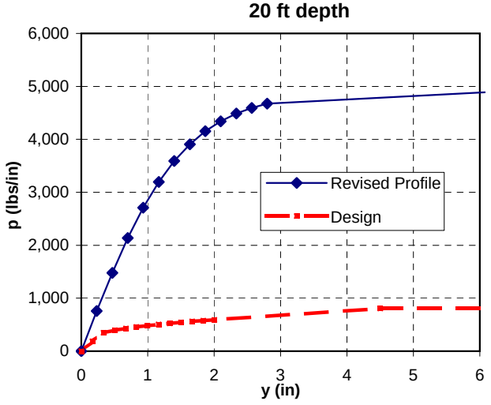
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.06	288
0.38	275	2.00	906
0.58	318	3.99	1,142
0.77	344	5.99	1,307
0.97	361	7.98	1,438
1.16	370	9.98	1,549
1.36	374	11.97	1,646
1.55	374	13.97	1,733
1.74	370	15.96	1,812
1.93	363	17.96	1,885
2.12	353	19.95	1,952
2.32	340	21.95	2,015
3.86	247	23.94	2,074
5.41	154	63.84	2,877
100.00	154	119.70	2,877

15 ft depth



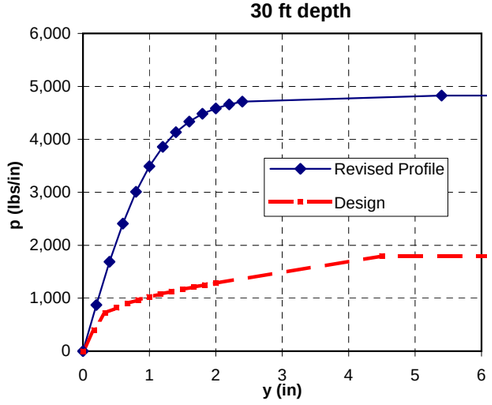
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	312
0.42	379	2.00	983
0.64	439	3.99	1,239
0.85	477	5.99	1,418
1.06	502	7.98	1,560
1.27	517	9.98	1,681
1.49	524	11.97	1,786
1.69	526	13.97	1,880
1.91	523	15.96	1,966
2.12	515	17.96	2,045
2.33	504	19.95	2,118
2.54	490	21.95	2,186
4.25	355	23.94	2,251
5.94	221	63.84	3,121
100.00	221	119.70	3,121

20 ft depth



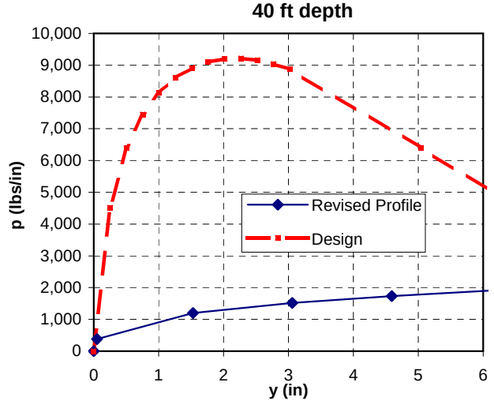
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	186	0.23	757
0.34	350	0.47	1,479
0.50	395	0.70	2,136
0.67	429	0.93	2,711
0.83	458	1.17	3,195
1.00	483	1.40	3,591
1.16	505	1.63	3,907
1.33	526	1.87	4,153
1.50	544	2.10	4,342
1.67	561	2.33	4,486
1.84	577	2.57	4,594
2.00	592	2.80	4,675
4.50	808	6.30	4,902
124.50	808	174.30	4,904

30 ft depth



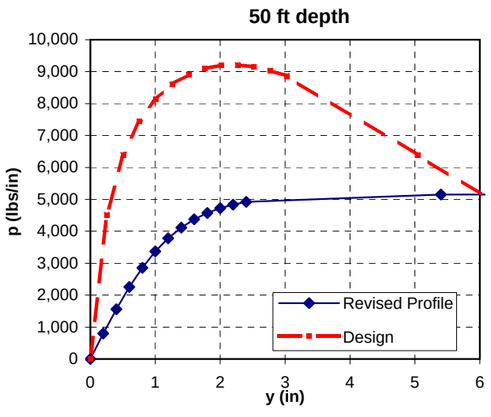
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	402	0.20	872
0.34	722	0.40	1,690
0.50	822	0.60	2,410
0.67	902	0.80	3,011
0.83	969	1.00	3,490
1.00	1,027	1.20	3,859
1.16	1,080	1.40	4,134
1.33	1,127	1.60	4,336
1.50	1,171	1.80	4,481
1.67	1,211	2.00	4,585
1.84	1,249	2.20	4,658
2.00	1,284	2.40	4,710
4.50	1,800	5.40	4,829
124.50	1,800	149.40	4,829

40 ft depth



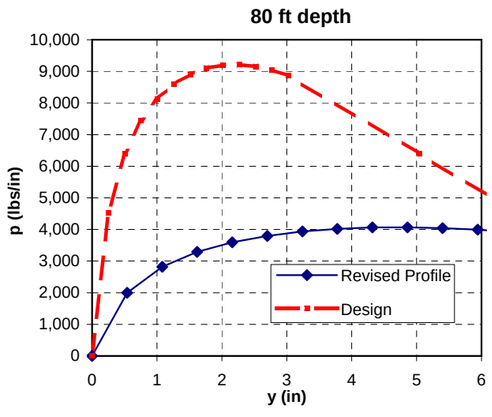
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.05	382
0.50	6,390	1.53	1,203
0.76	7,445	3.06	1,516
1.01	8,129	4.59	1,735
1.26	8,597	6.12	1,910
1.51	8,910	7.65	2,057
1.76	9,102	9.18	2,186
2.02	9,197	10.71	2,301
2.27	9,211	12.24	2,406
2.52	9,155	13.77	2,502
2.77	9,038	15.30	2,592
3.02	8,868	16.83	2,675
5.04	6,396	18.36	2,754
7.06	3,922	48.96	3,819

50 ft depth



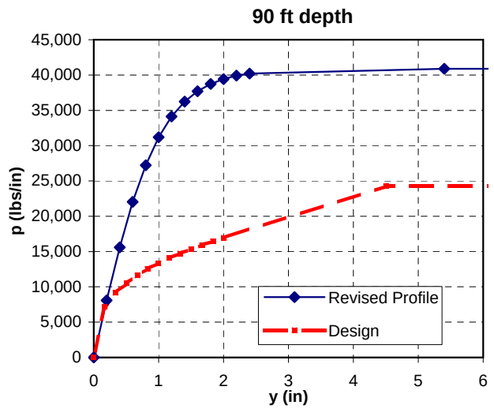
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	798
0.50	6,390	0.40	1,559
0.76	7,445	0.60	2,252
1.01	8,129	0.80	2,857
1.26	8,597	1.00	3,367
1.51	8,910	1.20	3,782
1.76	9,102	1.40	4,113
2.02	9,197	1.60	4,371
2.27	9,211	1.80	4,569
2.52	9,155	2.00	4,720
2.77	9,038	2.20	4,833
3.02	8,868	2.40	4,917
5.04	6,396	5.40	5,152
7.06	3,922	149.40	5,154

80 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.54	1,996
0.50	6,390	1.08	2,822
0.76	7,445	1.62	3,288
1.01	8,129	2.16	3,590
1.26	8,597	2.70	3,797
1.51	8,910	3.24	3,935
1.76	9,102	3.78	4,020
2.02	9,197	4.32	4,062
2.27	9,211	4.86	4,068
2.52	9,155	5.40	4,044
2.77	9,038	5.94	3,992
3.02	8,868	6.48	3,917
5.04	6,396	10.80	2,825
7.06	3,922	15.12	1,732

90 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	7,207	0.20	8,099
0.34	9,150	0.40	15,587
0.50	10,522	0.60	22,023
0.67	11,618	0.80	27,217
0.83	12,546	1.00	31,200
1.00	13,360	1.20	34,137
1.16	14,088	1.40	36,240
1.33	14,751	1.60	37,715
1.50	15,362	1.80	38,734
1.67	15,930	2.00	39,430
1.84	16,462	2.20	39,903
2.00	16,963	2.40	40,223
4.50	24,267	5.40	40,876
124.50	24,267	149.40	40,878

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

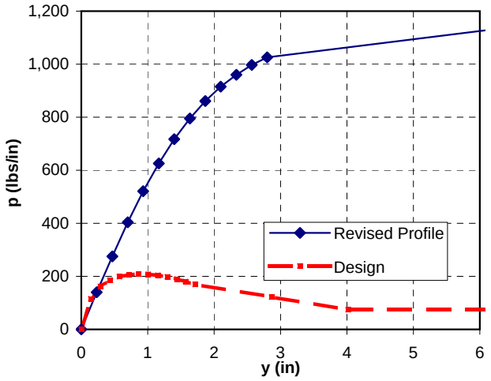
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 18

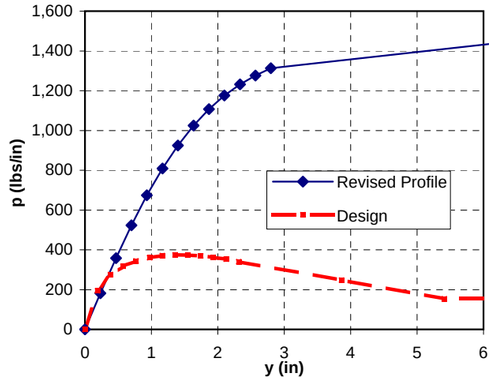
Figure 10

5 ft depth



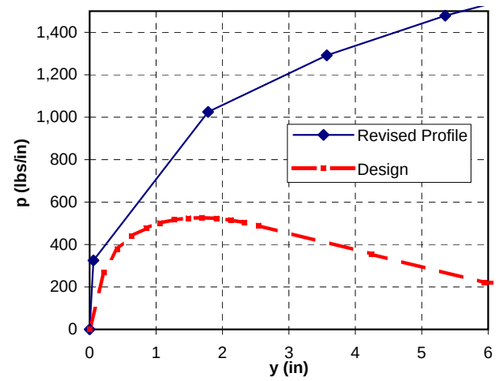
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	140
0.29	162	0.47	276
0.43	186	0.70	404
0.58	199	0.93	521
0.72	206	1.17	625
0.86	209	1.40	717
1.01	208	1.63	795
1.15	204	1.87	861
1.30	198	2.10	916
1.44	190	2.33	960
1.57	180	2.57	997
1.72	169	2.80	1,026
2.87	122	6.30	1,134
4.02	74	174.30	1,137
100.00	74	342.30	1,137

10 ft depth



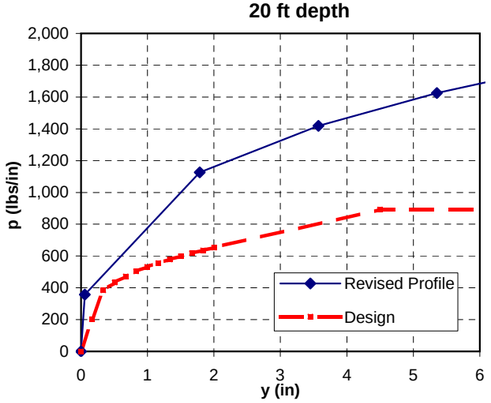
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.23	182
0.38	275	0.47	358
0.58	318	0.70	523
0.77	344	0.93	674
0.97	361	1.17	808
1.16	370	1.40	925
1.36	374	1.63	1,024
1.55	374	1.87	1,107
1.74	370	2.10	1,176
1.93	363	2.33	1,232
2.12	353	2.57	1,277
2.32	340	2.80	1,313
3.86	247	6.30	1,443
5.41	154	174.30	1,446
100.00	154	342.30	1,446

15 ft depth



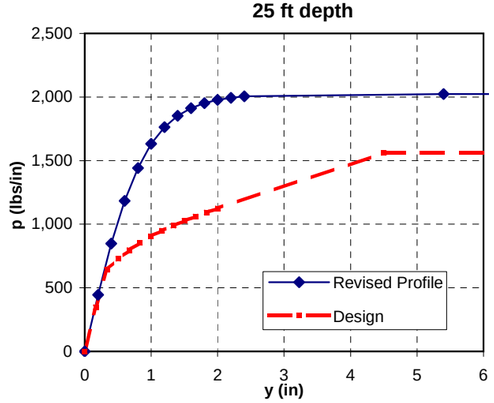
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	325
0.42	379	1.79	1,025
0.64	439	3.57	1,291
0.85	477	5.36	1,478
1.06	502	7.14	1,627
1.27	517	8.93	1,753
1.49	524	10.71	1,862
1.69	526	12.50	1,961
1.91	523	14.28	2,050
2.12	515	16.07	2,132
2.33	504	17.85	2,208
2.54	490	19.64	2,279
4.25	355	21.42	2,347
5.94	221	57.12	3,254
100.00	221	107.10	3,254

20 ft depth



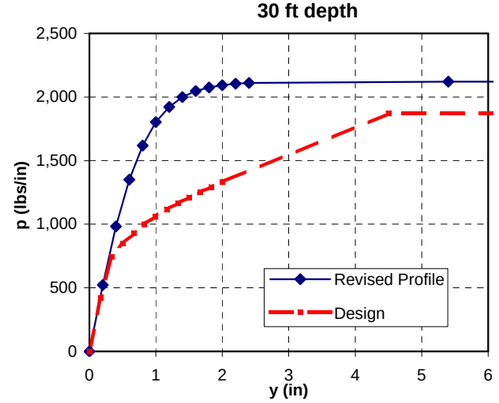
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	204	0.06	358
0.34	385	1.79	1,127
0.50	434	3.57	1,419
0.67	472	5.36	1,625
0.83	504	7.14	1,788
1.00	532	8.93	1,926
1.16	557	10.71	2,047
1.33	579	12.50	2,155
1.50	599	14.28	2,253
1.67	618	16.07	2,343
1.84	636	17.85	2,427
2.00	652	19.64	2,505
4.50	892	21.42	2,579
124.50	892	57.12	3,577

25 ft depth



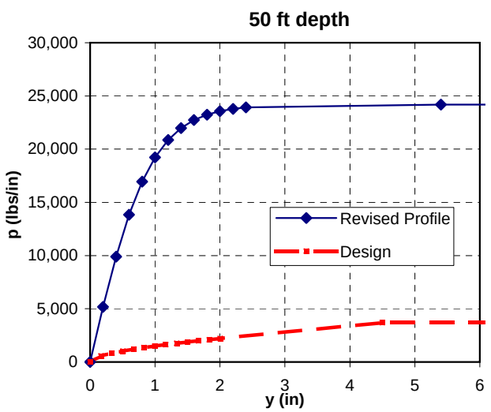
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	348	0.20	444
0.34	642	0.40	848
0.50	729	0.60	1,183
0.67	797	0.80	1,443
0.83	855	1.00	1,631
1.00	905	1.20	1,764
1.16	949	1.40	1,853
1.33	990	1.60	1,913
1.50	1,027	1.80	1,952
1.67	1,061	2.00	1,978
1.84	1,093	2.20	1,994
2.00	1,123	2.40	2,005
4.50	1,561	5.40	2,024
124.50	1,561	149.40	2,024

30 ft depth



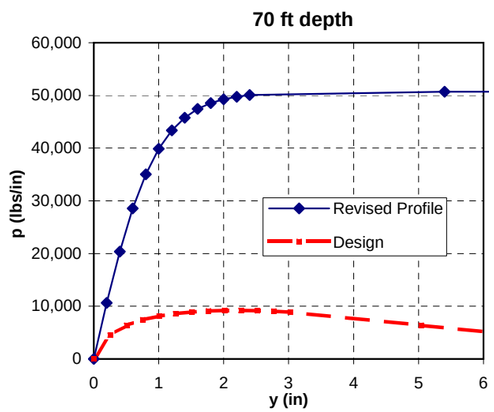
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	420	0.20	521
0.34	743	0.40	983
0.50	848	0.60	1,351
0.67	931	0.80	1,619
0.83	1,001	1.00	1,802
1.00	1,062	1.20	1,922
1.16	1,116	1.40	1,999
1.33	1,166	1.60	2,046
1.50	1,211	1.80	2,076
1.67	1,254	2.00	2,094
1.84	1,293	2.20	2,105
2.00	1,330	2.40	2,111
4.50	1,871	5.40	2,122
124.50	1,871	149.40	2,122

50 ft depth



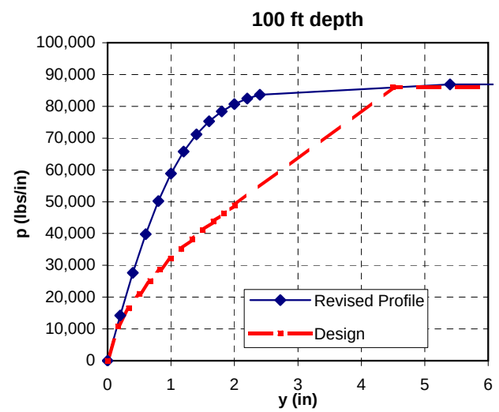
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	565	0.20	5,169
0.34	826	0.40	9,886
0.50	1,030	0.60	13,846
0.67	1,205	0.80	16,941
0.83	1,361	1.00	19,231
1.00	1,504	1.20	20,855
1.16	1,636	1.40	21,973
1.33	1,760	1.60	22,728
1.50	1,877	1.80	23,230
1.67	1,988	2.00	23,561
1.84	2,094	2.20	23,778
2.00	2,196	2.40	23,920
4.50	3,694	5.40	24,182
124.50	3,694	149.40	24,182

70 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	10,619
0.50	6,390	0.40	20,345
0.76	7,445	0.60	28,563
1.01	8,129	0.80	35,046
1.26	8,597	1.00	39,889
1.51	8,910	1.20	43,362
1.76	9,102	1.40	45,780
2.02	9,197	1.60	47,429
2.27	9,211	1.80	48,537
2.52	9,155	2.00	49,275
2.77	9,038	2.20	49,764
3.02	8,868	2.40	50,086
5.04	6,396	5.40	50,698
7.06	3,922	149.40	50,699

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	10,788	0.20	14,188
0.34	16,443	0.40	27,639
0.50	21,040	0.60	39,764
0.67	25,061	0.80	50,205
0.83	28,702	1.00	58,848
1.00	32,067	1.20	65,771
1.16	35,218	1.40	71,173
1.33	38,197	1.60	75,301
1.50	41,032	1.80	78,408
1.67	43,747	2.00	80,717
1.84	46,357	2.20	82,418
2.00	48,875	2.40	83,664
4.50	86,020	5.40	86,920
124.50	86,020	149.40	86,943

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

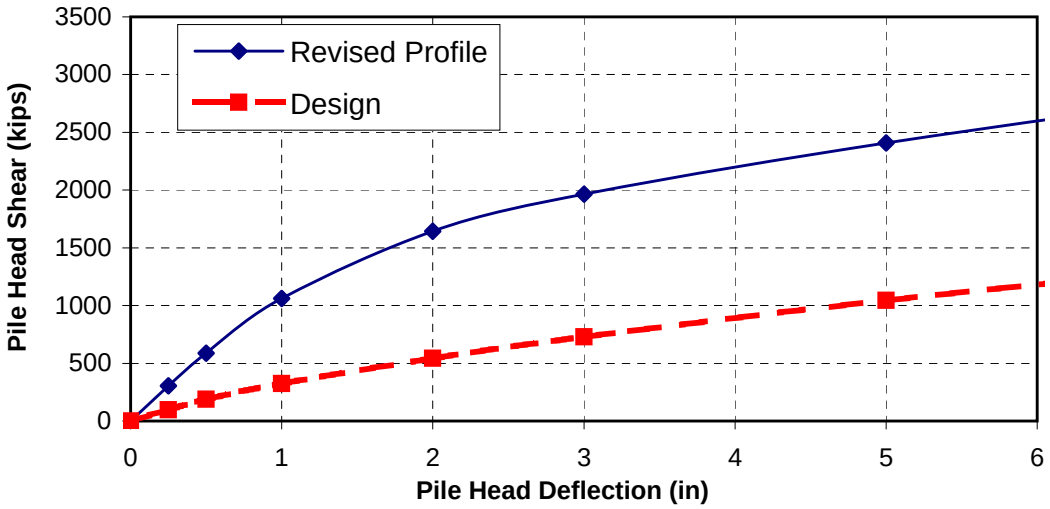
ACTA Schuyler Heim Bridge (Replace)

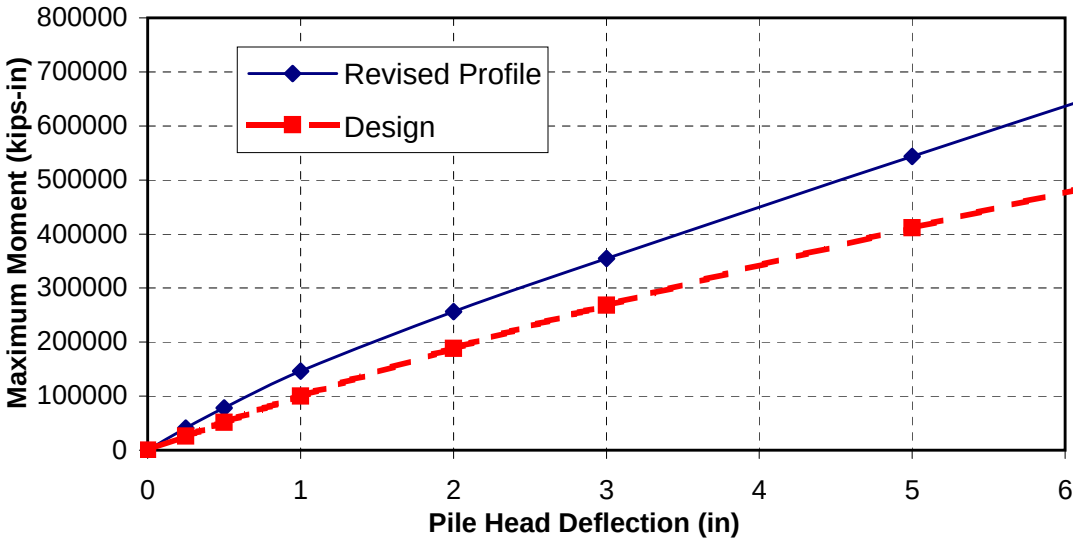
Project Number: 06-123

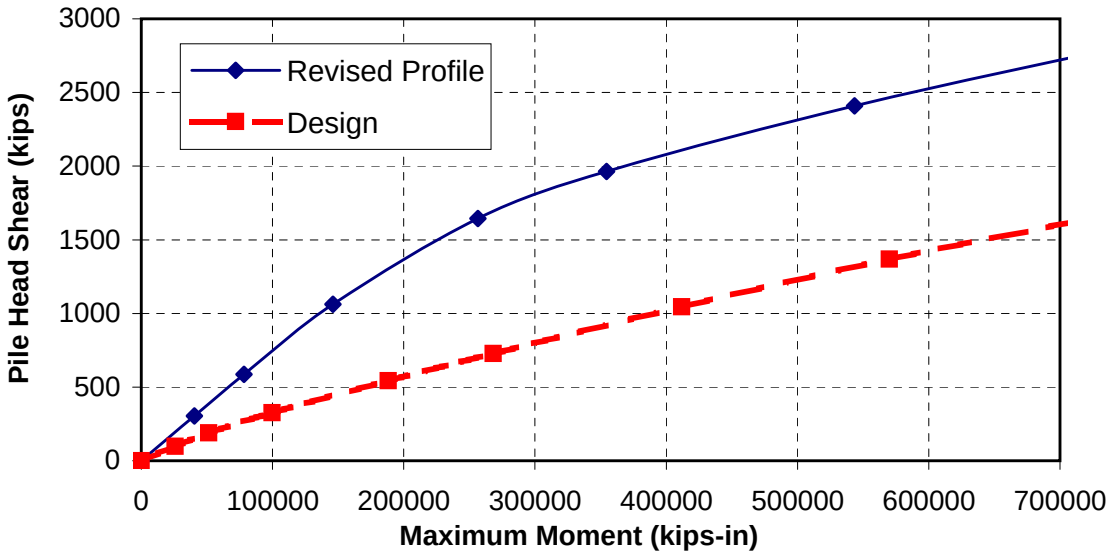
Date: 1/20/2010

p-y Curve Comparison for Bent 24

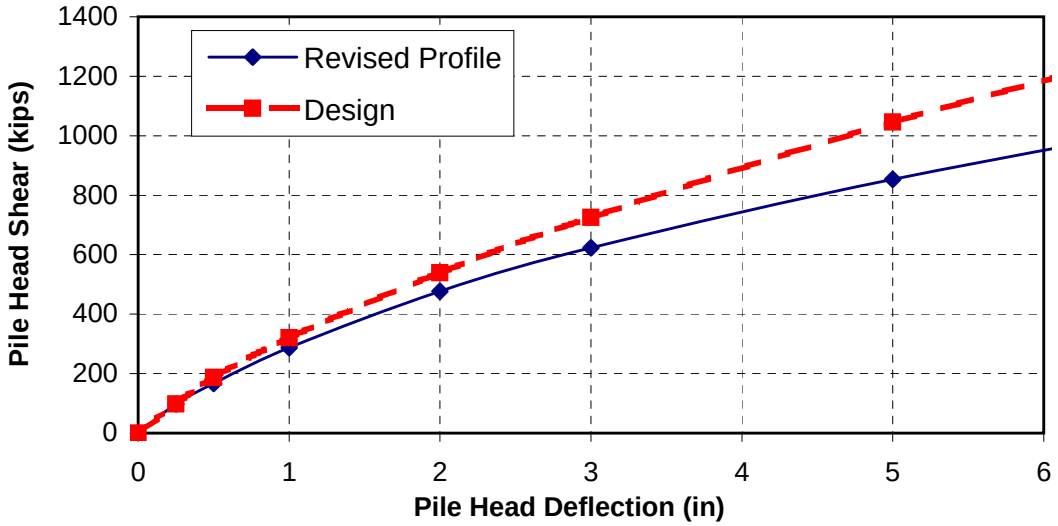
Figure 11

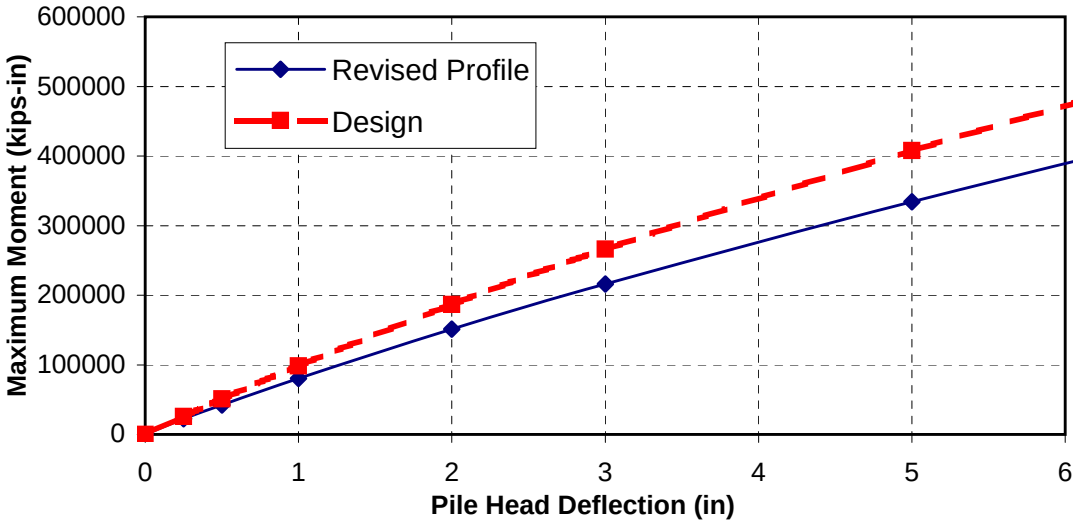


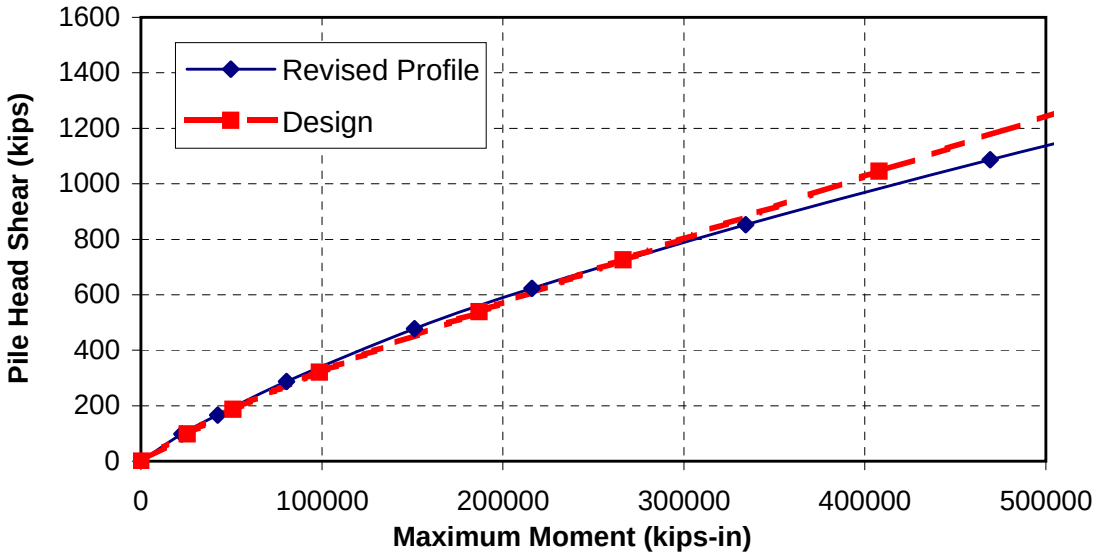




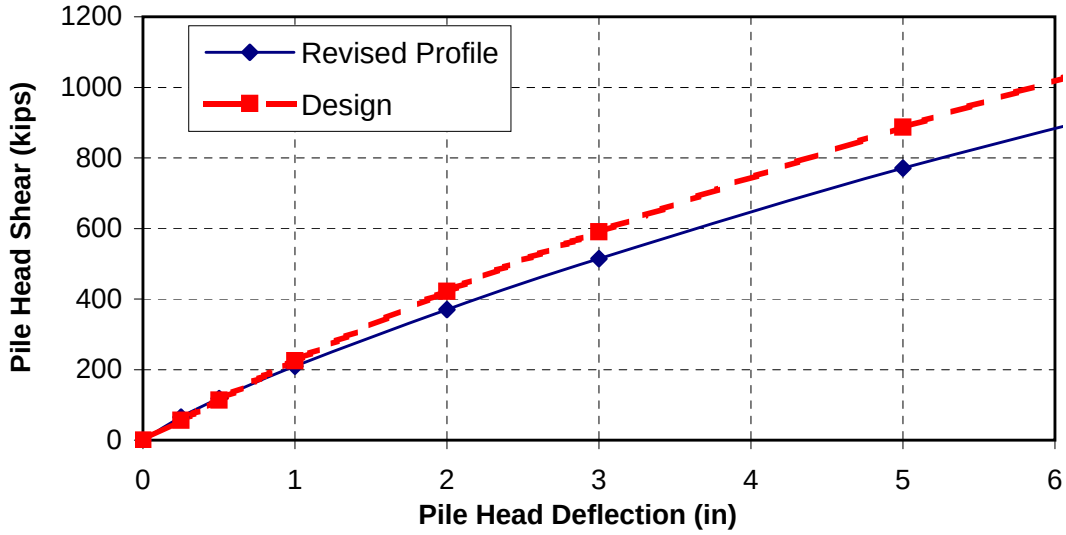
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 2 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 12

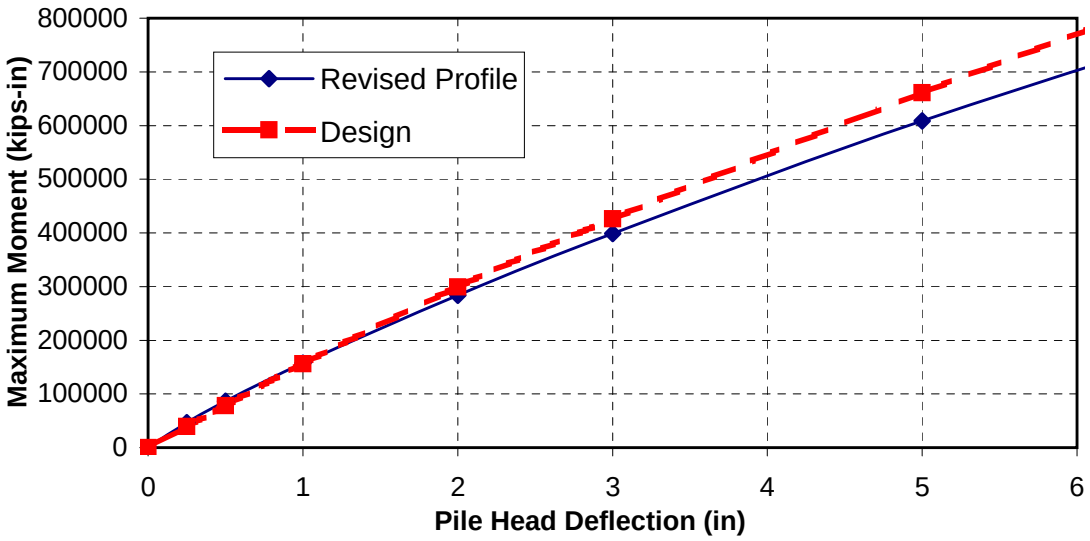


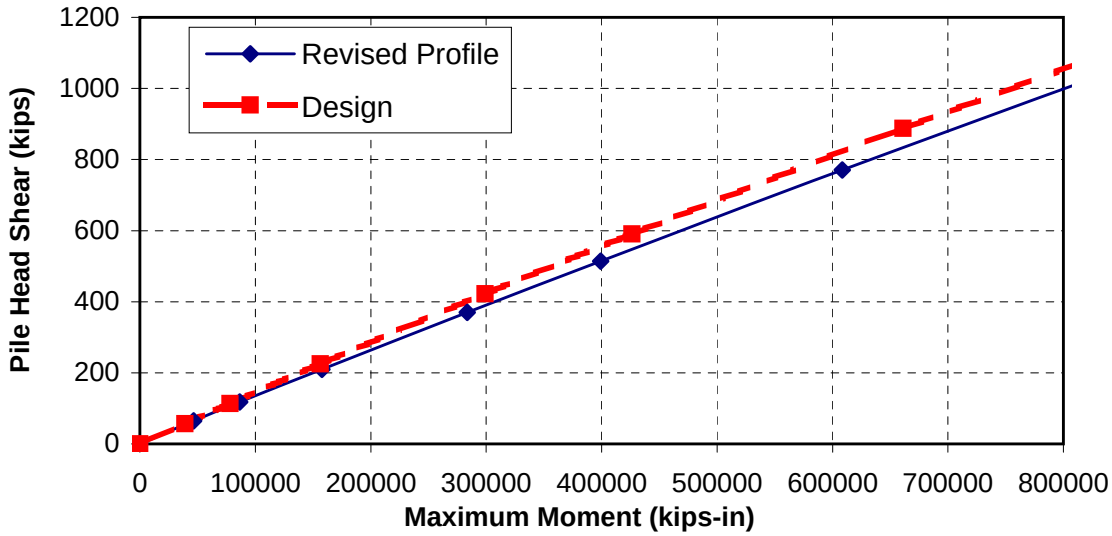




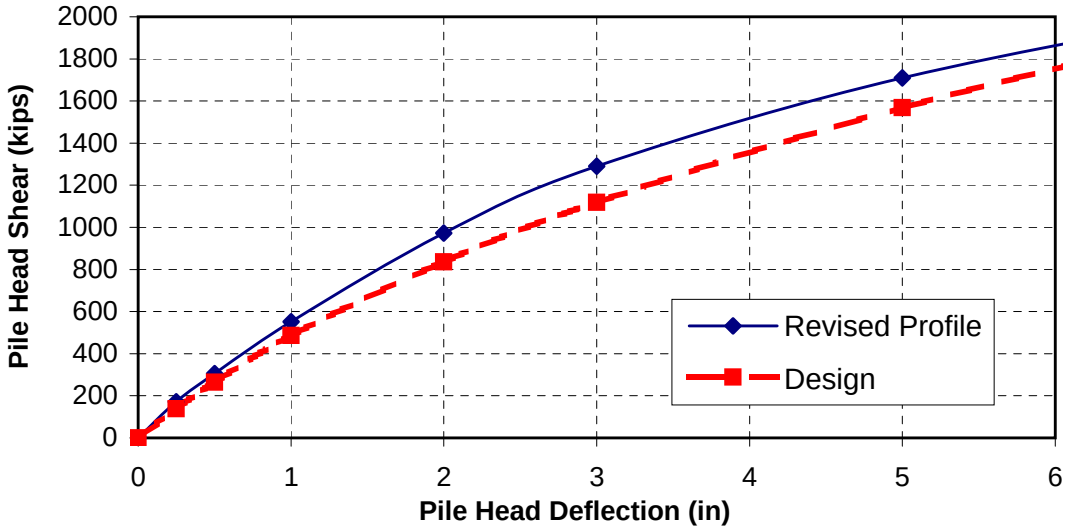
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 13

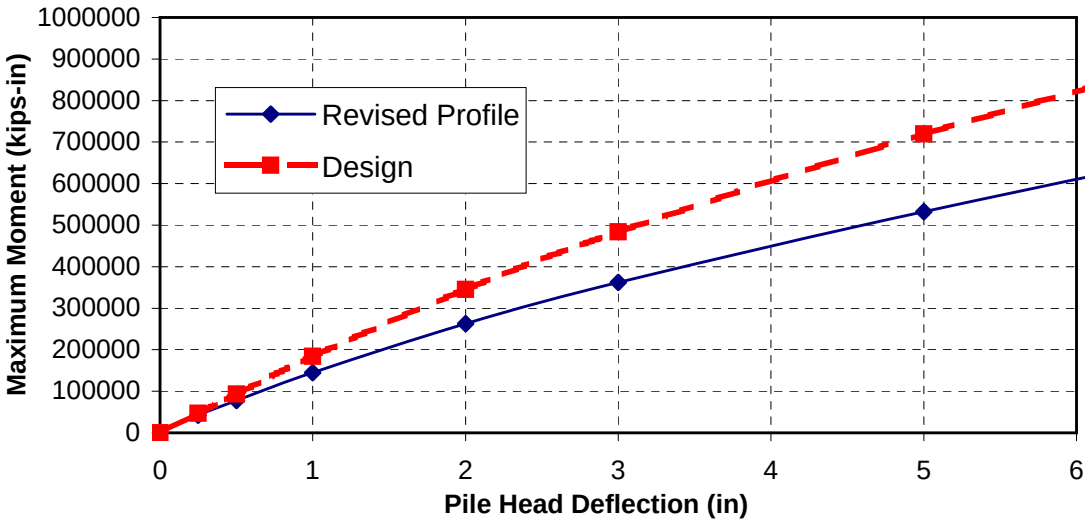


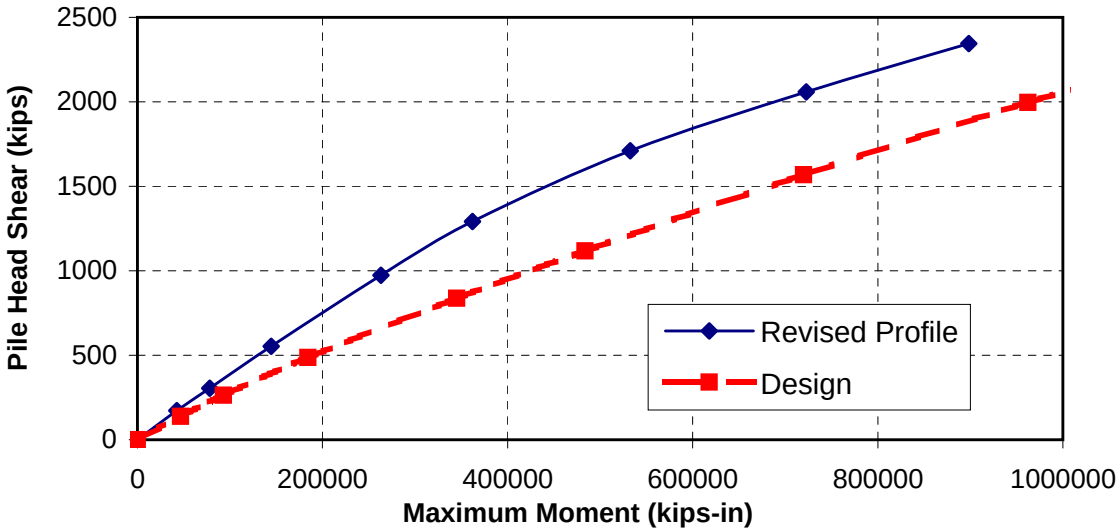




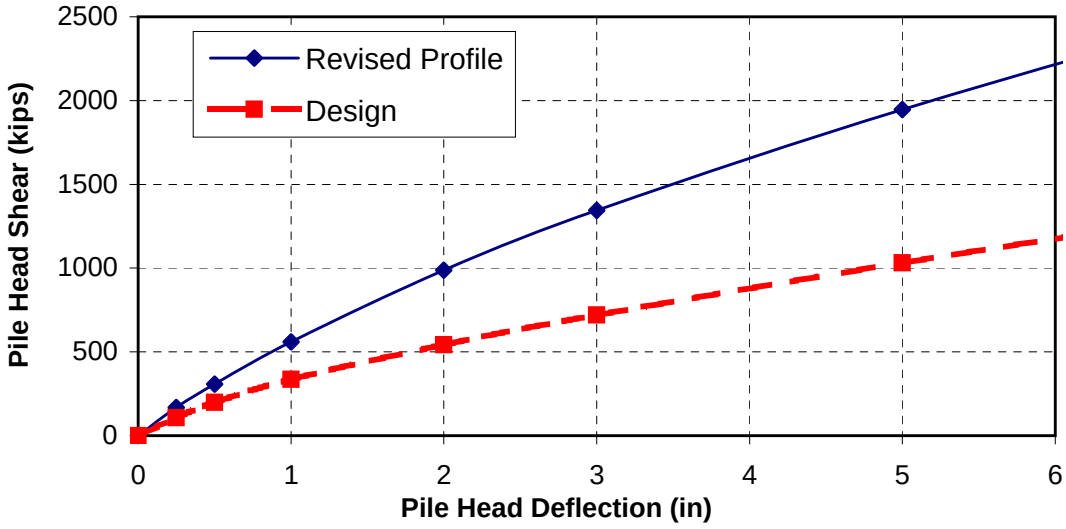
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Pile Head Shear and Max Moment versus Deflection Figure 14
	Project Number: 06-123	Date: 1/20/2010	

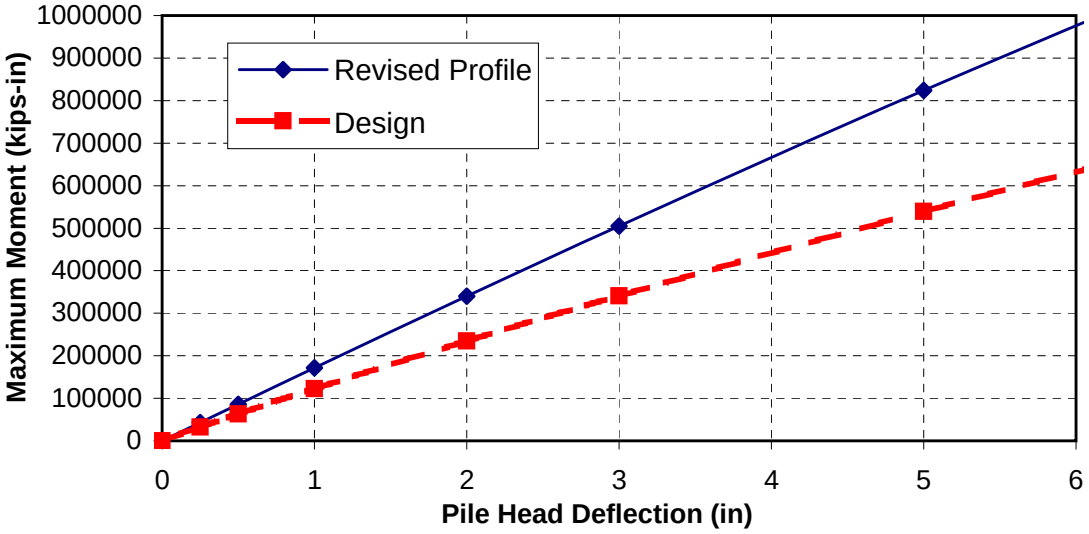


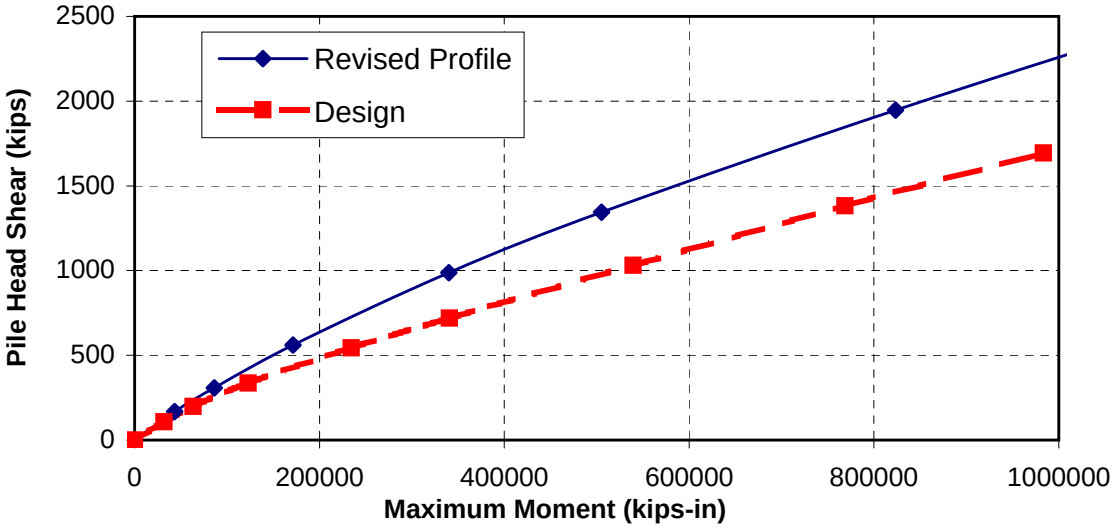




Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 15







Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 24 Pile Head Shear and Max Moment versus Deflection Figure 16
	Project Number: 06-123	Date: 1/20/2010	

Appendix H. Design p-y Curves for Bent Lateral Pile Analysis

Table H-1. New Dock Street Off-Ramp Bent 4 to Bent 8
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	90	0.17	180	0.17	270	0.17	360	0.25	3,765
0.33	162	0.33	341	0.33	502	0.33	631	0.50	5,325
0.50	181	0.50	384	0.50	569	0.50	720	0.76	6,204
0.67	197	0.67	418	0.67	622	0.67	791	1.01	6,775
0.83	210	0.83	447	0.83	666	0.83	852	1.26	7,164
1.00	221	1.00	472	1.00	705	1.00	904	1.51	7,425
1.17	231	1.17	494	1.17	739	1.17	951	1.76	7,585
1.33	240	1.33	514	1.33	770	1.33	993	2.02	7,664
1.50	248	1.50	532	1.50	799	1.50	1,032	2.27	7,676
1.67	255	1.67	549	1.67	825	1.67	1,069	2.52	7,629
1.83	262	1.83	564	1.83	850	1.83	1,102	2.77	7,532
2.00	269	2.00	579	2.00	873	2.00	1,134	3.02	7,390
4.50	365	4.50	794	4.50	1,209	4.50	1,599	5.04	5,330
124.50	365	124.50	794	124.50	1,209	124.50	1,599	7.06	3,268
244.50	365	244.50	794	244.50	1,209	244.50	1,599	9.07	1,206
364.50	365	364.50	794	364.50	1,209	364.50	1,599	100.80	1,206

40 ft depth		60 ft depth		80 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,765	0.25	3,765	0.17	5,033	0.17	8,287	0.17	27,207
0.50	5,325	0.50	5,325	0.33	7,286	0.33	12,631	0.33	41,512
0.76	6,204	0.76	6,204	0.50	9,046	0.50	16,162	0.50	53,118
1.01	6,775	1.01	6,775	0.67	10,548	0.67	19,251	0.67	63,270
1.26	7,164	1.26	7,164	0.83	11,882	0.83	22,048	0.83	72,464
1.51	7,425	1.51	7,425	1.00	13,096	1.00	24,633	1.00	80,959
1.76	7,585	1.76	7,585	1.17	14,219	1.17	27,053	1.17	88,914
2.02	7,664	2.02	7,664	1.33	15,269	1.33	29,341	1.33	96,433
2.27	7,676	2.27	7,676	1.50	16,260	1.50	31,519	1.50	103,592
2.52	7,629	2.52	7,629	1.67	17,201	1.67	33,605	1.67	110,446
2.77	7,532	2.77	7,532	1.83	18,098	1.83	35,609	1.83	117,035
3.02	7,390	3.02	7,390	2.00	18,959	2.00	37,544	2.00	123,393
5.04	5,330	5.04	5,330	4.50	31,607	4.50	66,077	4.50	217,172
7.06	3,268	7.06	3,268	124.50	31,607	124.50	66,077	124.50	217,172
9.07	1,206	9.07	1,206	244.50	31,607	244.50	66,077	244.50	217,172
100.80	1,206	100.80	1,206	364.50	31,607	364.50	66,077	364.50	217,172

Appendix I. Caltrans Review Comments and EMI Response

Subject: Review Comments for Foundation Reports for BR53-3031, BR53-3033, BR53-3034K, BR53-3035S.
From: Haitao Liu <haitao_liu@dot.ca.gov>
Date: Tue, 23 Mar 2010 17:17:30 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Hector Bedolla <hector_bedolla@dot.ca.gov>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>, Hamid R Toossi <hamid_r_toossi@dot.ca.gov>, Foued Zayati <foued_zayati@dot.ca.gov>, Bojan Misic <bojan_misic@dot.ca.gov>, Ranjan Gunaranjan <ranjan@earthmech.com>, Eric Brown <e.brown@earthmech.com>, Seungwoon Han <seungwoon_han@dot.ca.gov>

Dear Arul,

Below are our review comments for the subject bridges:

New Dock Street Off-Ramp, Bridge No. 53-3031:

1) Table 5 (Page 28 of Foundation Report).
Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings

2) Section 5.6.1 (Page 34 of the Report).
Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.

3) Section 5.6.2 (Page 34 of the Report).
Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.

4) Log of Test Borings.
I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.

5) Appendix E.Lab Test Results
Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.

6) Axial Capacity (Calculation Volume)
Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.

7) Axial Capacity for Abut 3 (Calculation Volume)
Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.

8) Axial Capacity for Abut 3 (Calculation Volume)
The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.

9) Axial Capacity for all bents (Calculation Volume)
According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.

10) Axial Capacity for Bent 4 (Calculation Volume)
For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.

11) Axial Capacity for Bent 5 (Calculation Volume)
For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.

12) Lateral Pile Capacity for Abut 3 (Calculation Volume)
Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.

13) Static Settlement
Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.

14) Static Settlement
The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.

SR 103 Off-Ramp, Bridge No. 53-3034K:

All applicable review comments from New Dock Street Off-Ramp, plus:

1) Axial Pile Capacity for Abutment 27 (Calculation Volume)
Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.

2) Axial Pile Capacity (Calculation Volume)
The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with

blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.

New Dock Street On-Ramp, Bridge No. 53-3033 and SR 103 On-Ramp, Bridge No. 53-3035S

All applicable review comments from BR 53-3031 and BR 3034K.

Should you have any question, please contact me or Mr. Seungwoon Han at (916) 227-4533.

Thank you.

Haitao Liu, P.E.

Transportation Engineer - Civil
Office of Geotechnical Design South - 1
Division of Engineering Services
Department of Transportation, California

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New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			1) Table 5 (Page 28 of Foundation Report). Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA)	A	Will comply. Supplemental laboratory tests performed on the sample indicate a Plasticity Index (PI) of 12; therefore, based upon the Boulanger and Idriss (2006) criteria, this layer is determined to be non-liquefiable. Lab test results are attached.	4/20/2010	
2			2) Section 5.6.1 (Page 34 of the Report). Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.	PW / EB / KA	A	Will comply. Tthe recommendations for seismic lateral earth pressure on nonyielding bridge abutments have been revised to be consistent with the recommendations shown in Section A11.1.1.3 of AASHTO LRFD BDS.	4/20/2010	
3			3) Section 5.6.2 (Page 34 of the Report). Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.	PW / EB / KA	A	Will comply. We agree that the recommended edit will be more clear for the reader and the text has been revised per your suggestion.	4/20/2010	
4			4) Log of Test Borings. I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.	PW / EB / KA	A / C	I. Will comply. LOTB's have been revised to only show SPT blowcounts (attached). II. Silty Clay is listed as a soil-type descriptor in Figure 3-3 (page 42) of the Caltrans SRLPCM for material with a PI between 4 and 7. All of the instances where a material is described as Silty Clay on the LOTBs, plasticity test results indicate a PI between 4 and 7.	4/20/2010	
5			5) Appendix E.Lab Test Results Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			6) Axial Capacity (Calculation Volume) Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.	PW / EB / KA	A	Will comply. All six borings/CPTs were used to generate the idealized soil profile used in the pile analysis. We agree that the downdrag elevation for determining the seismic-controlled (extreme event) design pile tip elevation should be based on the nearest soil boring or CPT sounding. Different bottom of liquefiable layer elevations were used at each support. As shown in the calculation volume, the elevation to the bottom of the liquefiable layer was based on R-09-010 for abutment 3 and bent 4, CPT-09-064 for bent 5, R-09-012 for bent 6, R-09-013 for bent 7, and R-09-015 for bent 8. This appears to comply with your comment.	4/20/2010	
7			7) Axial Capacity for Abut 3 (Calculation Volume) Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.	PW / EB / KA	A	Will comply. Per our discussions with the designer, 1 pile will be added at this abutment. We have revised our axial pile capacity calculations to include an average pile group reduction factor of 0.93 at Abutment 3. The evaluation of the group reduction factor and revised axial pile capacity calculations for Abutment 3 are attached.	4/20/2010	
8			8) Axial Capacity for Abut 3 (Calculation Volume) The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.	PW / EB / KA	A	Will comply. Revised axial pile capacity calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
9			9) Axial Capacity for all bents (Calculation Volume) According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.	PW / EB / KA	D	As a result of design development and discussions with the designers, the CMP permanent casing has been replaced with driven permanent steel casing. The driving resistance of the permanent steel casing will be specified in the Pile Data Table; therefore, the skin friction along the length of the permanent casing (based upon API methodology) has been included in the design. The axial pile capacity calculations for the controlling limit case (Strength Limit State) for the bents have been revised. A sample revised calcuation for Bent 4 and the revised pile data table are attached.	4/20/2010	
10			10) Axial Capacity for Bent 4 (Calculation Volume) For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
11			11) Axial Capacity for Bent 5 (Calculation Volume) For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
12			12) Lateral Pile Capacity for Abut 3 (Calculation Volume) Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.	PW / EB / KA	A	I. The apparent discrepancy arises from the facts that the LPile program does not allow the bottom of a soil layer to be above the pile cut-off, and the water table is not directly entered (it is accounted for by inputting the correct effective unit weight and subgrade modulus values based on saturated/dry conditions). At abutment 3, the top of the embankment is at about elevation +20 ft. Finished grade is at about elevation +7 ft. Taking the average of the top of the embankment and finished grade gives +13.5 ft. The design water table is conservatively located at elevation +5 ft. Pile cut-off is at +1 ft. So the overburden can be estimated by including 4 ft of buoyant soil unit weight plus 8.5 ft of dry soil unit weight, which is about 1260 psf. Due to the LPile soil layering constraints mentioned above, we modeled the overburden using a 19 ft layer, with buoyant unit weight, which gives an overburden of about 1140 psf, which is slightly below the estimate above (conservative). II. Will comply. The revised lateral pile analysis includes a "cracked" EI value equal to 80% of the gross EI for the pile for service and strength limit state (0.25" lateral pile top deflection) and 50% of the gross EI for the extreme event limit state (greater than 0.25" lateral pile top deflection). Revised lateral pile capacity calculations are attached. III. Based upon our conversations with the bridge designers, the pile reinforcing has been designed to have sufficient capacity to handle the moment demands.	4/20/2010 4/20/2010	
13			13) Static Settlement Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.	PW / EB / KA	A	Will comply. The settlement calculations have been revised to account for the compressible layer between elevation -5 and -10 ft. The revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
14			14) Static Settlement The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.	PW / EB / KA	A	Yes this is correct. Because the two bridges are located close to one another, based upon the subsurface exploration, the same idealized soil profile was originally used for both locations. However, based on comment #13, the settlement calculations for New Dock Street Off-Ramp have been revised to account for the clay layer encountered in Boring R-09-010 between elevation -5 and 10 ft. The revised settlement calculations are attached.	4/20/2010	
15			1) Axial Pile Capacity for Abutment 27 (Calculation Volume) Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
16			2) Axial Pile Capacity (Calculation Volume) The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.	PW / EB / KA	A	Will comply. Axial pile capacity calculations have been revised to incorporate a reduced load transfer in soil layers with blowcounts less than 15 blows per foot, where applicable. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 7, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, New Dock Street On-Ramp, Bridge No. 53-3033 Los Angeles County, California, (7-LA-47, PM 3.74, EA 238501)***

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject bridge. This report presents the results of our analyses and recommendations for design and construction of the bridge foundation for the subject bridge replacement.

The Foundation Report for the subject bridge, dated February 8, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on March 23, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on April 20, 2010. OGDS-1 review comments and EMI responses are included in Appendix I. The responses to these review comments have been incorporated into this Final Foundation Report.

We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
NEW DOCK STREET ON-RAMP, BRIDGE NO. 53-3033
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 3.74, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 7, 2010

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APPENDICES

Appendix A. Selected As-Built Plan Sheets for Schuyler Heim Bridge
Appendix B. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)
Appendix C. EarthSpectives SPT Hammer Energy Measurement Report
Appendix D. GeoVision Geophysical Investigation Report
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Appendix I. Caltrans Review Comments and EMI Response

1.0 INTRODUCTION

1.1 Purpose and Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed New Dock Street On-Ramp (Replace) in Los Angeles County, California (Bridge No. 53-3033). The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analysis and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the replacement of the New Dock Street On-Ramp structure (Figure 2).

The proposed New Dock Street On-Ramp is a three-span Cast-in-Place (CIP) prestressed concrete box girder bridge supported on a single seat type abutment and two single-column bents. The north end of the structure terminates at an expansion joint where the New Dock Street On-Ramp abuts the mainline structure approximately 25 ft south of Bent 9 of the mainline. The bridge deck varies in width up to about 37 ft and is approximately 394 ft long.

The typical bridge bent has a single column with each column supported on a single 10 ft diameter Type II cast-in-drilled-hole (CIDH) pile. The abutments are supported on 2.5-foot diameter CIDH piles.

1.3 Existing Bridge Information

The existing Schuyler Heim Bridge is a 45-span structure and is approximately 3,975 feet long and varies from about 80 to 130 feet wide. On the as-built drawings, the New Dock Street On-Ramp is shown as part of the mainline structure with six spans and is identified between "On Bent No. 1" and "On Abutment No. 6" with an approximate length of about 585 ft and deck width of about 30 ft.

Based on the as-built plans, the existing bridge is supported on a combination of timber piles and 14BP73 driven steel piles. Steel piles with a design loading of 40 tons are used at the abutments and timber piles with a design loading of 22 tons are used at the bents.

Copies of selected sheets from the as-built drawings for the existing Schuyler Heim Bridge relevant to the New Dock Street On-Ramp are provided in Appendix A.

1.4 Limitations

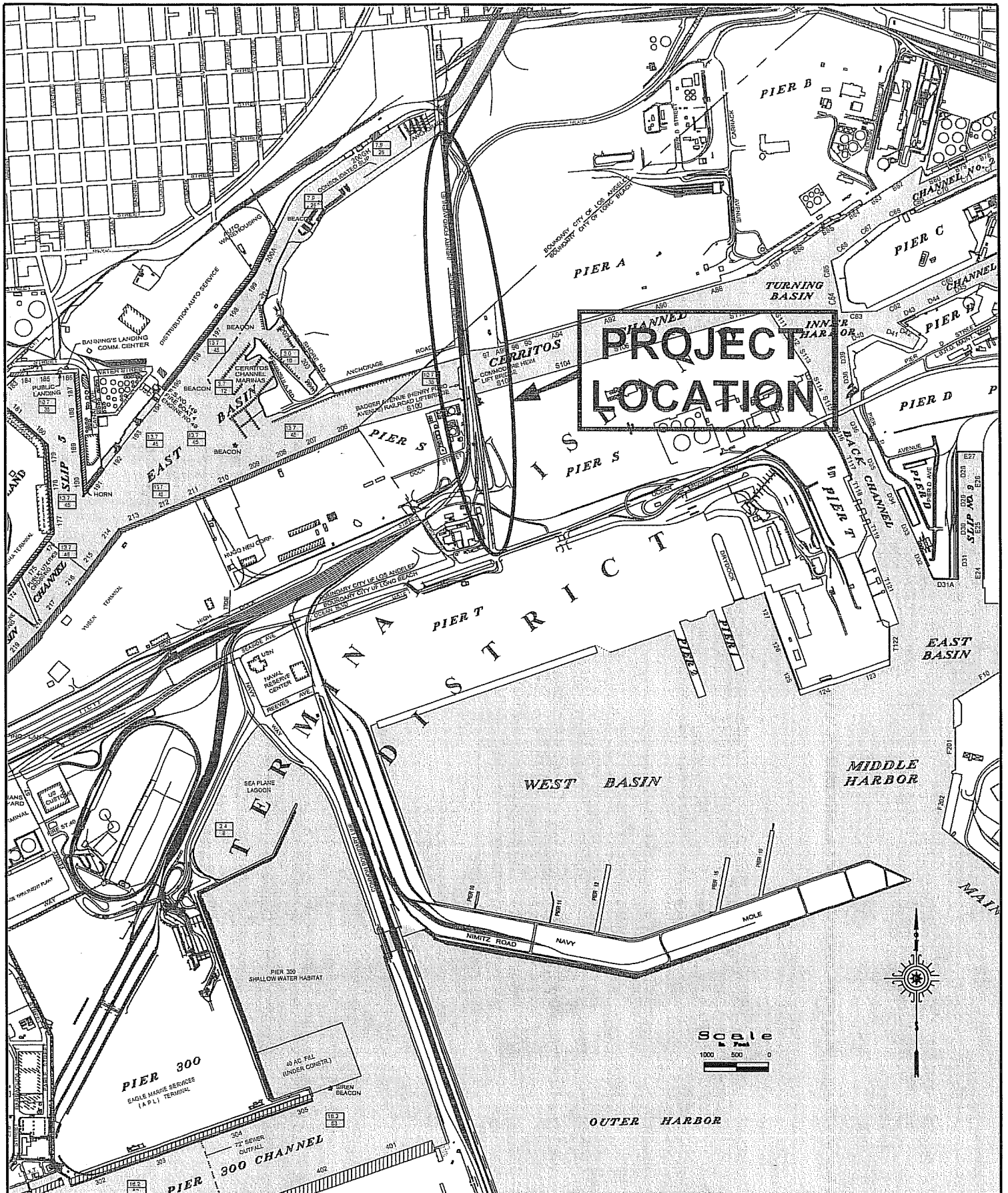
This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed New Dock Street On-Ramp (Replace). This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality

under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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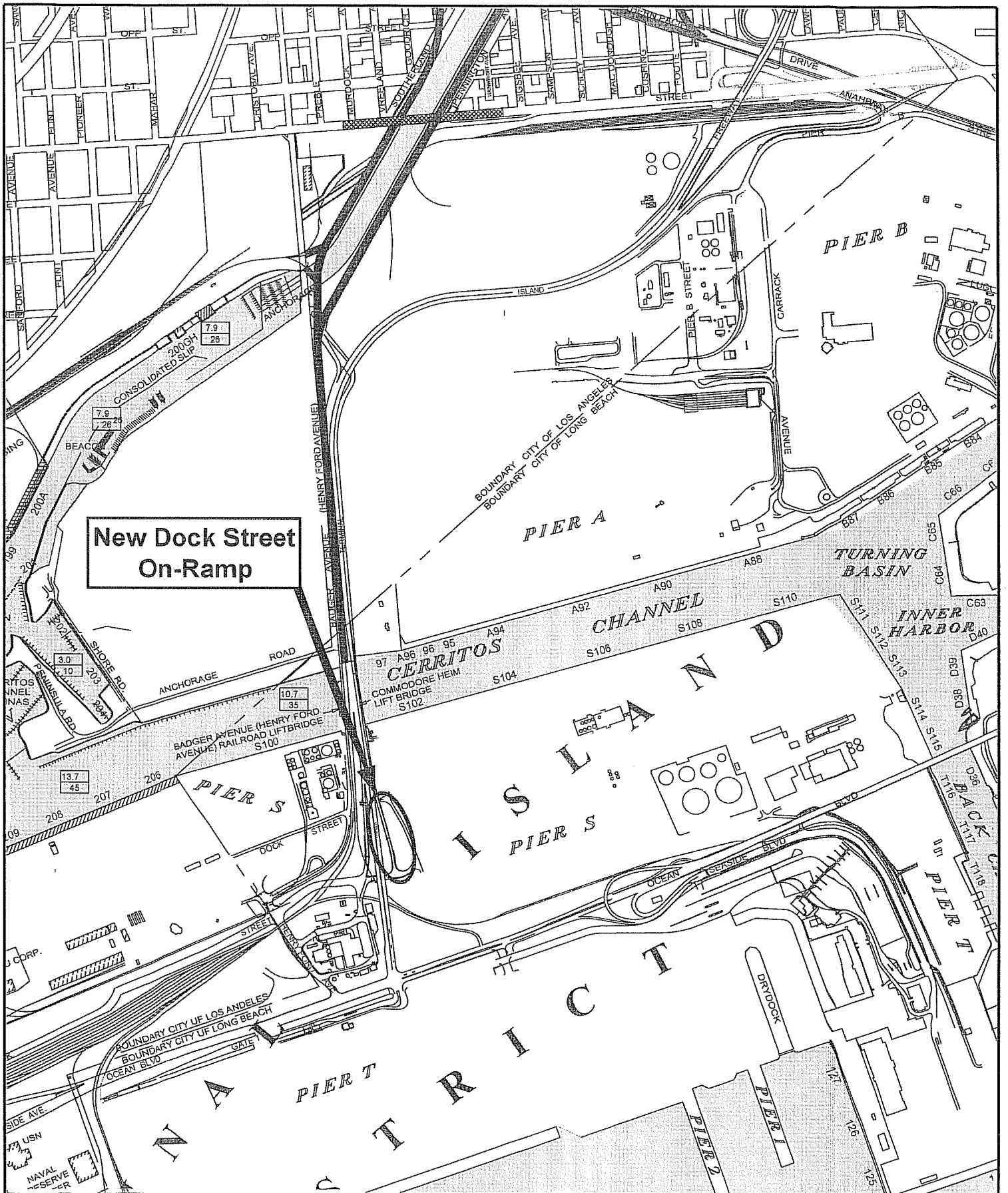
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 5-07-10



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Project No. 06-123 | Date: 5-07-10

Structure Location Map

Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of the New Dock Street On-Ramp were those shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and borings, four CPTs and one auger boring were performed near the subject bridge site. The auger boring penetrated to a depth of 157 ft and a tip elevation of -159 ft. The CPT soundings penetrated to depths between 100 and 138 ft below existing grade with a deepest penetration to an elevation of -140 ft.

Copies of the LOTB sheets prepared by LKR for the seismic retrofit study are provided in Appendix B.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, three rotary wash borings and three CPT soundings were performed in the vicinity of the New Dock Street On-Ramp. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed bridge supports. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

All of the borings surrounding the proposed bridge were performed at grade in the undeveloped area near or beneath the existing New Dock Street On-Ramp bridge, east of the mainline structure. The deepest boring penetrated down to about elevation -166 ft, approximately 165 ft below ground surface.

The borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small

disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal. A copy of the ES report is provided in Appendix C.

Boring geophysical measurements were also collected by GeoVision (GeoVision 2009) under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix D.

Table 1. Soil Exploration Information

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-011[1]	"C" Line	213+81.5	61.5 Lt	-1.0	-10.0	-151.3	RW
R-09-014[2]		215+76.1	61.3 Lt	-1.3	-5.3	-167.8	RW
R-09-016[1]		216+68.2	8.6 Rt	-0.8	-7.8	-151.3	RW
CPT-09-065		215+17.8	8.3 Lt	-0.8	NR	-91.4	CPT
CPT-09-077		213+86.4	61.3 Lt	-0.8	NR	-103.2	CPT
CPT-09-079		215+81.1	61.0 Lt	-1.3	NR	-98.9	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3. GWE = Groundwater Elevation.
4. GSE = Ground Surface Elevation (estimated from topographic plans).
5. Top of Boring Elevation Based on NAVD88.
6. RW = Rotary Wash, CPT = Cone Penetration Test.
7. NR = Not Recorded.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -102.7 ft, approximately 103.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI. The CPT sounding was performed using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM

D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

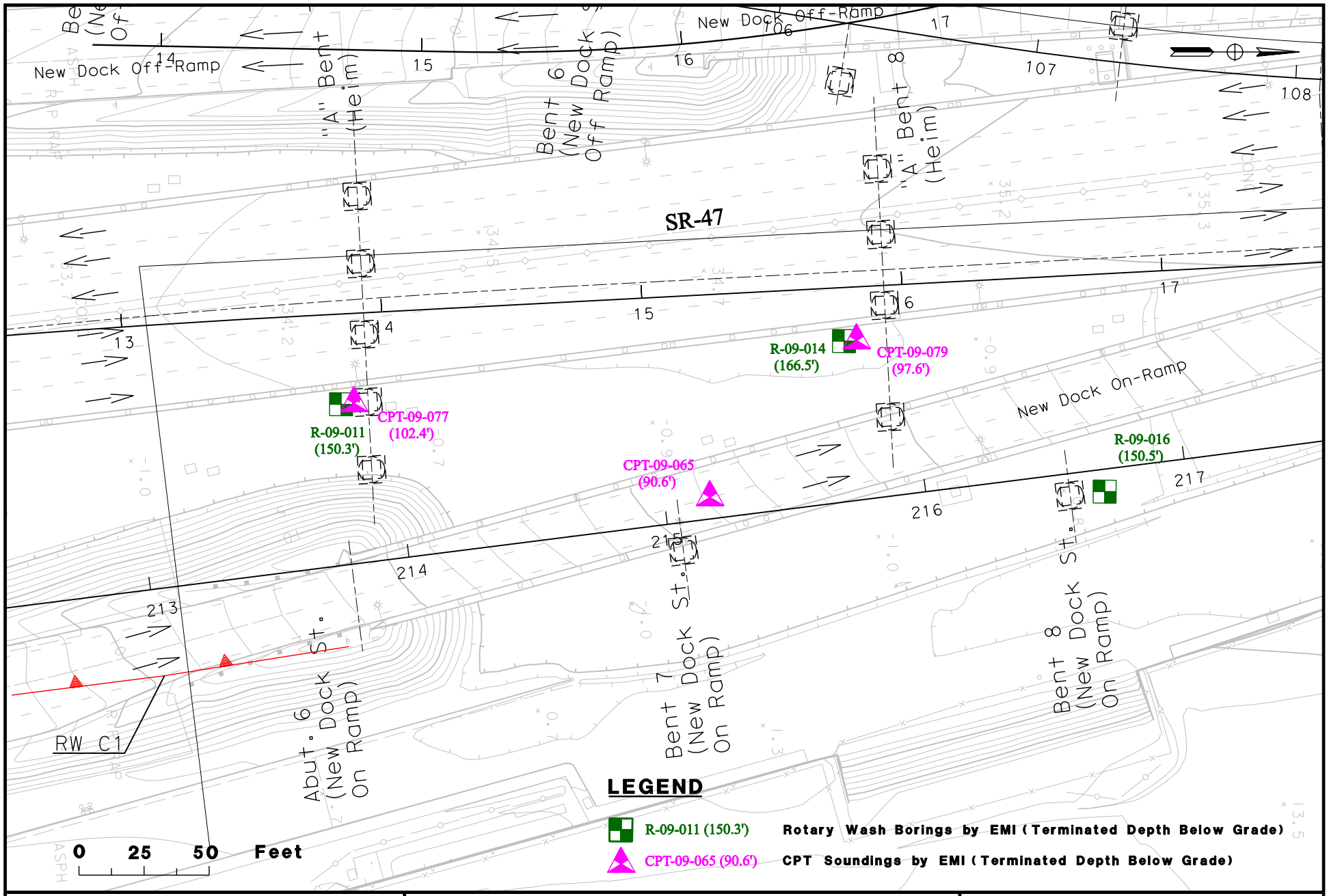
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of soils that exist at the site. Selected soil samples were tested to determine soil classification and physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. Test results are shown on the LOTB sheet at the end of the report and in tables in Appendix E.

Table 2. Explanation of Laboratory Tests Performed

Type of Test	Applicable Test Method	Purpose	Test Results Location
Dry Density	ASTM[1] D 2937	Estimate in-situ soil density	Appendix E
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content	Appendix E
No. 200 Wash	ASTM D 1140	Determine the percentage of fine grained particles of soil	Appendix E
Sieve & Hydrometer	ASTM D 422	Determine particle size distribution of soil	Appendix E
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil	Appendix E
Specific Gravity	ASTM D 854	Determine degree of saturation	Appendix E
Consolidation	ASTM D 2435	Determine compressibility of soil	Appendix E
UU Triaxial Test	ASTM D 2850	Estimate strength parameters of soil	Appendix E
Direct Shear	ASTM D 3080	Estimate strength parameters of soil	Appendix E
Soil pH	CT[1] 532/643	Determine corrosion potential of soil	Appendix E
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil	Appendix E
Sulfate Content	CT 417	Determine corrosion potential of soil	Appendix E
Chloride Content	CT 422	Determine corrosion potential of soil	Appendix E

Note: 1. ASTM = American Society for Testing and Materials; CT = California Test Method.



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-07-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland

and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

Table 3. Stratigraphy and Correlation Chart, Long Beach Area

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	California Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks

rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

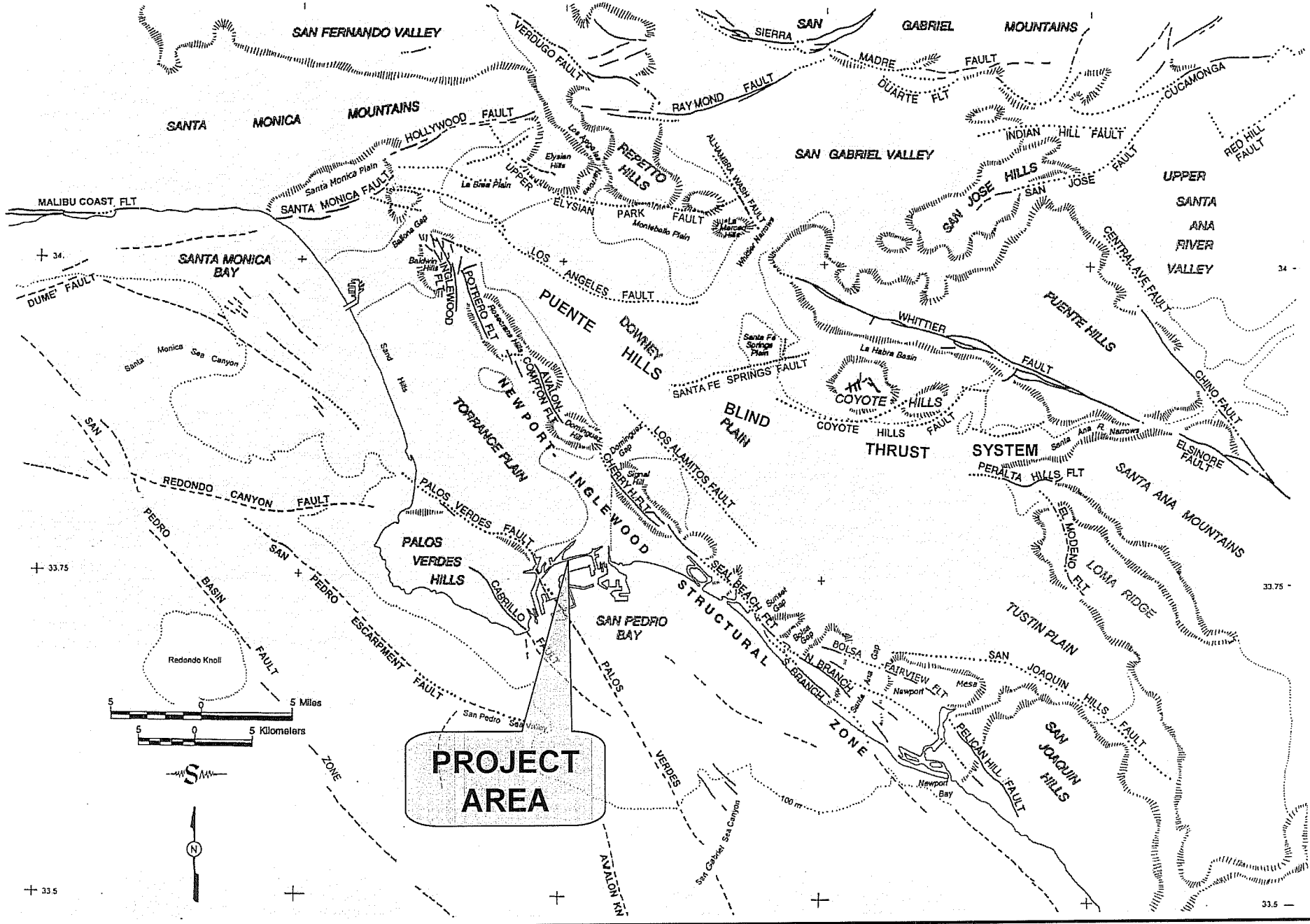
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



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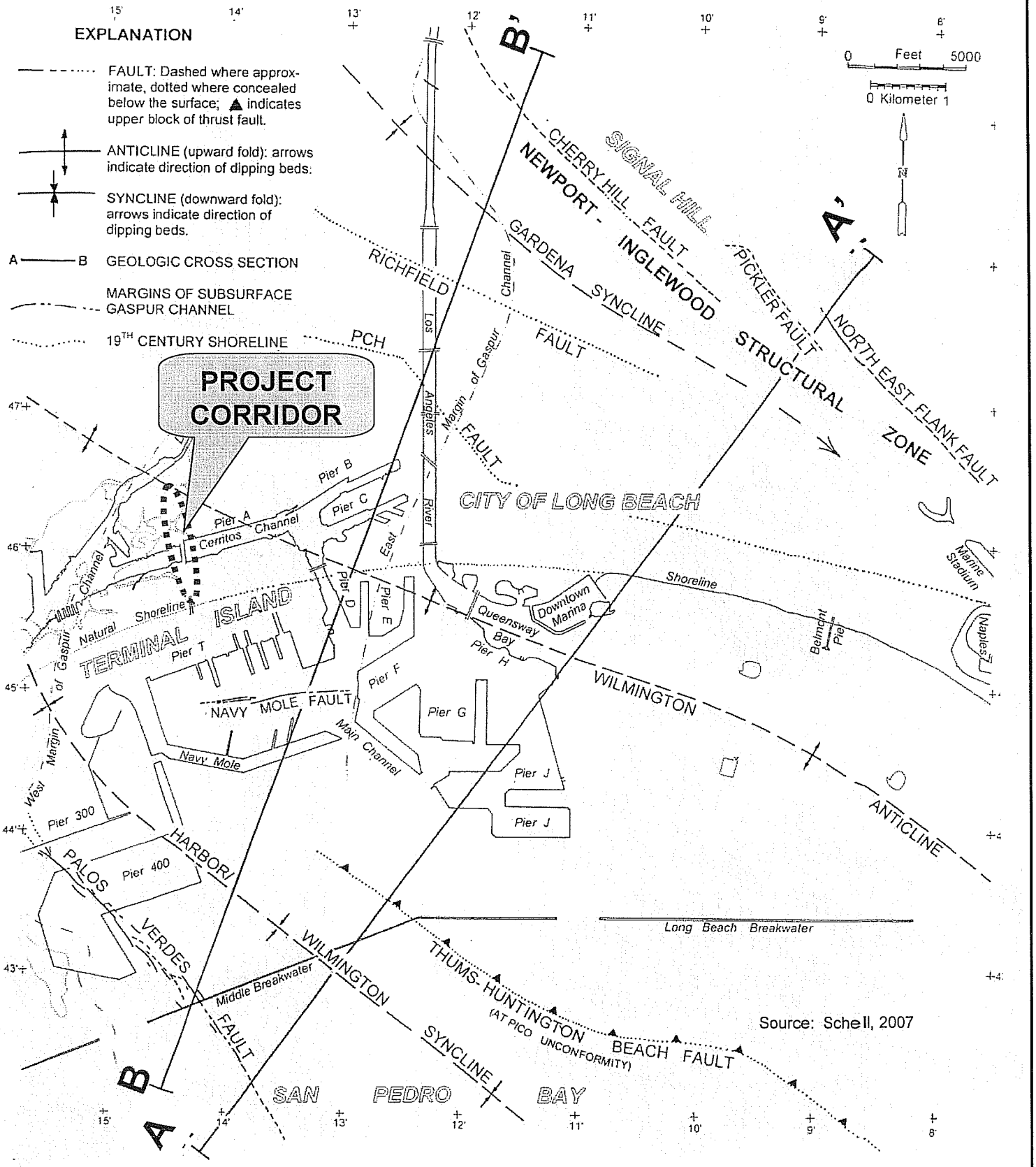
Map of Active Faults and Physiography, LA Basin

Figure 4



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Structural Geology Map, Long Beach Harbor

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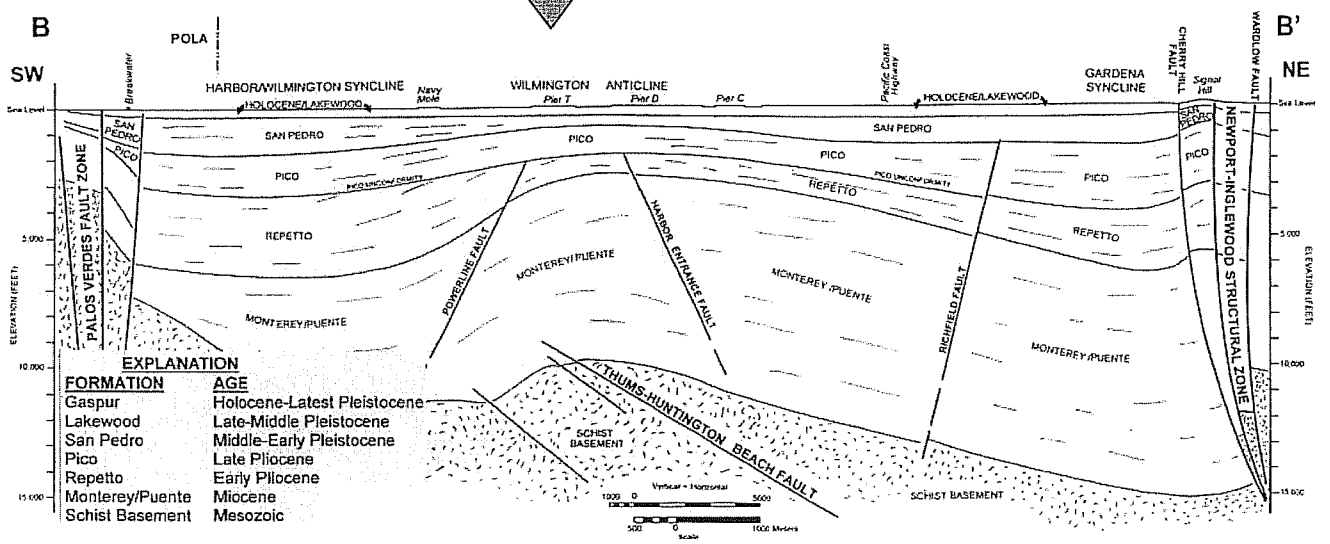
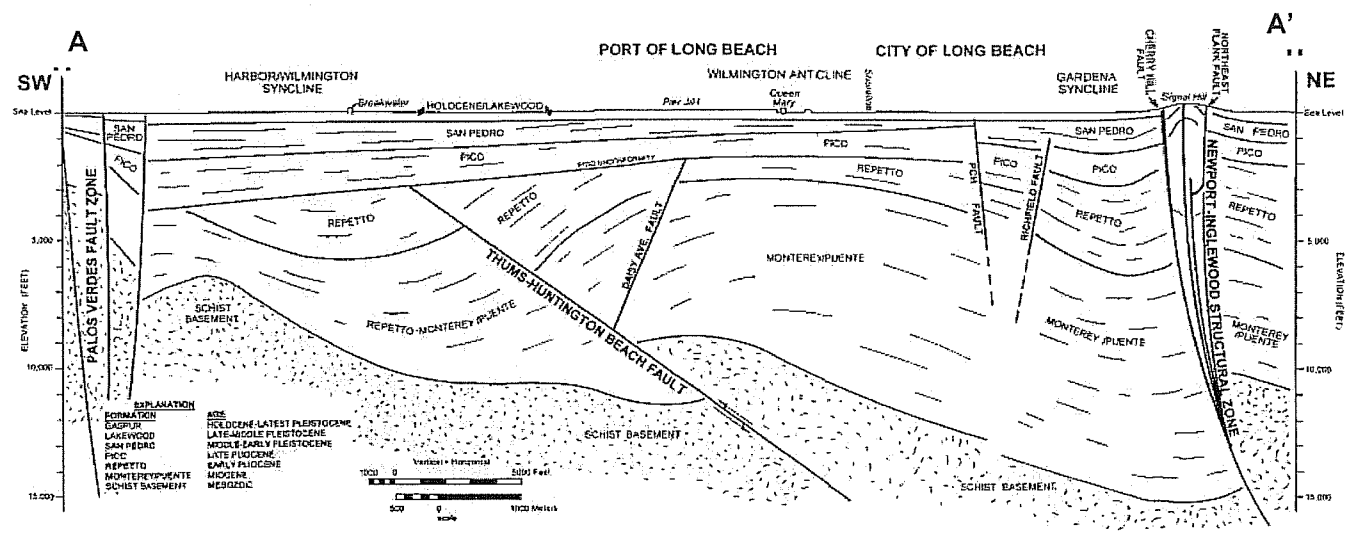
Figure 5

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH



A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

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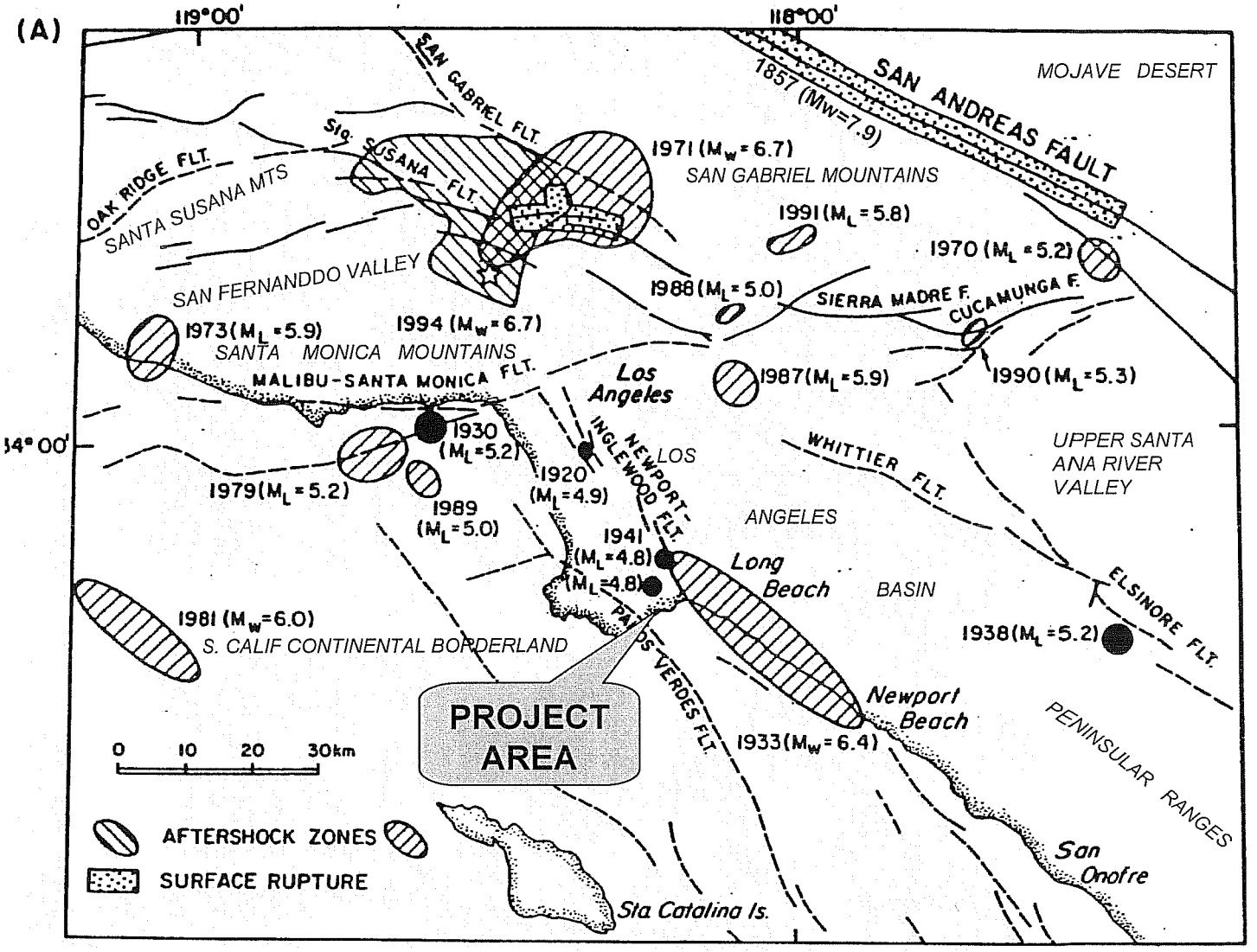
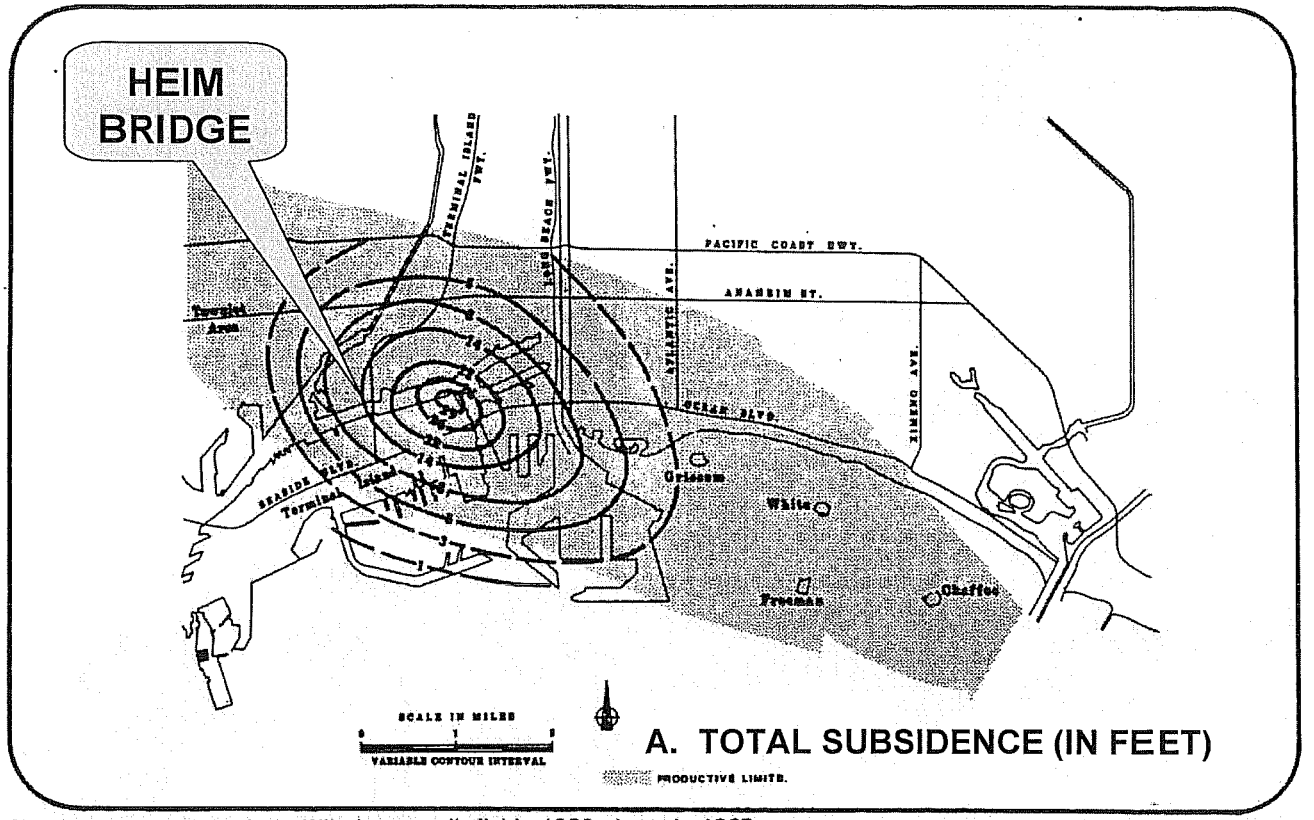
Project No. 06-123 Date: 5-07-10	Geologic Cross-Sections, LA Harbor Figure 6

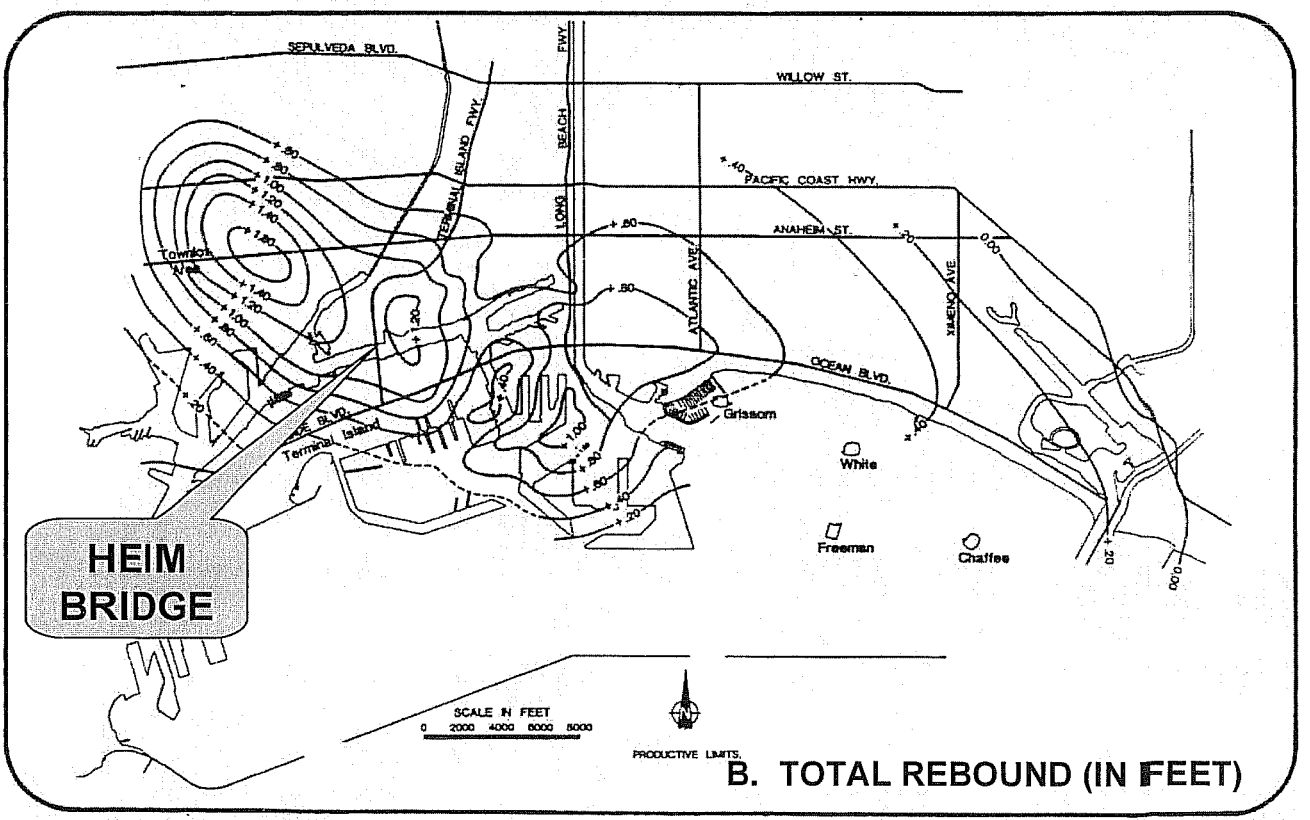


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-07-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-07-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -166.3 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject bridge site, natural grade lies at an elevation of about zero, with the approach embankment for the existing New Dock Street On-Ramp consisting of import fill extending to a maximum elevation of about +15 ft. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -25 ft. The near surface deposits are underlain by a thick strata of inter-layered soft to stiff silt, sandy silt, clay, and loose to medium dense silty sand down to about elevation -75 ft. Below elevation -75 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

Groundwater was recorded at elevation -5.5 ft in the auger boring performed in 1996 for the Geotechnical Investigation by LKR (LKR, 1998). During the EMI investigation in 2009, groundwater was recorded in all three of the borings performed near the proposed structure between elevation -5.3 ft and -10 feet. The elevation that groundwater was encountered at in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. Due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

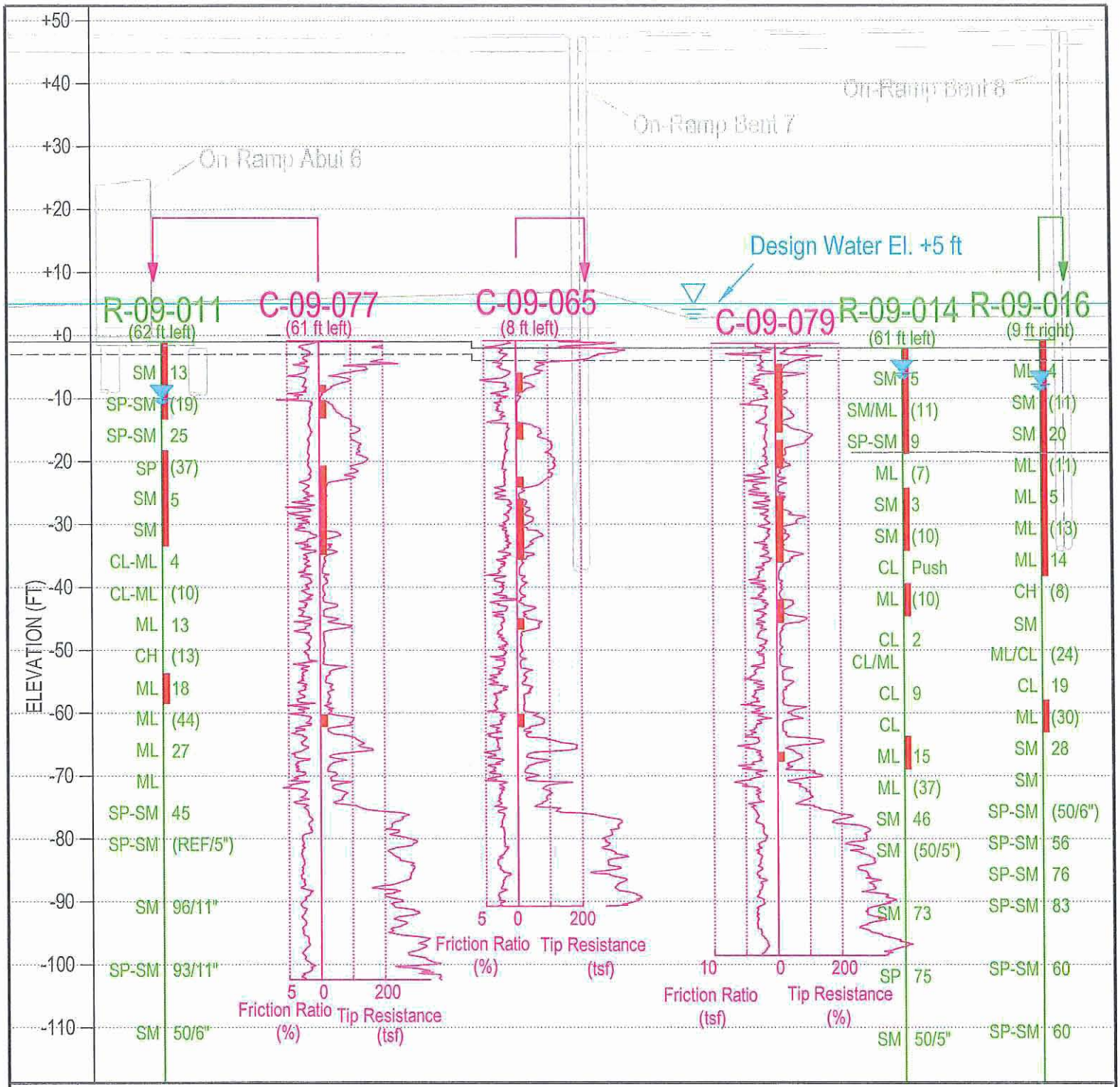
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

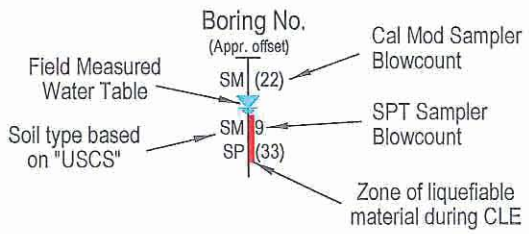
Based on information collected from borings R-09-011, R-09-014, R-09-016, and CPT soundings CPT-09-065, CPT-09-077, and CPT-09-079 two idealized soil profiles for foundation analysis and design were developed along the proposed bridge alignment. The subsurface profile beneath the proposed structure is shown in Figure 9. The soil profiles and design strength parameters are presented below in Table 4.

Table 4. Idealized Soil Profile and Parameters

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
	Bents 7 and 8			
Grade to -8.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-8.0 to -25.0	Silty Sand / Sandy Silt	120	0	32
-25.0 to -47.0	Sandy Silt / Silty Clay / Lean Clay	120	1,000	0
-47.0 to -62.0	Clayey Silt / Clay with Silt / Clay with Sand	120	2,000	0
-62.0 to -75.0	Clayey Silt / Silt with Sand / Silt with Clay	120	1,500	0
-75.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38
	Abutment 6			
+23.0 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -8.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-8.0 to -25.0	Silty Sand / Sandy Silt	120	0	32
-25.0 to -47.0	Sandy Silt / Silty Clay / Lean Clay	120	1,000	0
-47.0 to -62.0	Clayey Silt / Clay with Silt / Clay with Sand	120	2,000	0
-62.0 to -75.0	Clayey Silt / Silt with Sand / Silt with Clay	120	3,000	0
-75.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Project No. 06-123 | Date: 5-07-10 | Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Study

A preliminary seismic evaluation was performed by EMI in 2006 and included in the Preliminary Foundation Report (EMI, 2006) based on the 2006 Seismic Design Criteria (SDC) (Caltrans, 2006d).

Using the 2006 SDC, the PBA was determined based on Caltrans Seismic Hazard Map (Mualchin, 1996a) and the attenuation relationship by Sadigh et al. (1997), as required by Caltrans (2006a). The controlling fault was found to be the Palos Verdes fault which is a strike-slip fault capable of generating a Maximum Credible Earthquake (MCE) of magnitude 7.0 and a PBA of 0.60g at the bridge site.

The standard ARS curve published in the 2006 SDC (Caltrans, 2006d) for this bridge site is shown on Figure B.8 for Soil Profile D (M = 7.25±0.25) and 0.6g. The standard ARS curve was modified to account for near-fault effects (a 20% increase of spectral accelerations for periods greater than 1 sec., no increase for periods less than 0.5 sec., and linear interpolation between 0.5 and 1 sec) per SDC Section 6.1.2.1

Figure 10 shows the recommended modified design ARS curve with coordinates as provided in the PFR (EMI, 2006).

During bridge type selection, Caltrans commented based on the PFR that due to the length of the proposed structure, a site specific ARS curve should be developed following completion of the project geotechnical investigation. It is our understanding that following approval of bridge type selection, preliminary design of the bridge proceeded using the preliminary ARS curve in anticipation that the site specific ARS curve would be completed in the early stages of final design.

As part of the EMI field investigation described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings for the entire project along the mainline bridge alignment. Using the results of shear wave velocity measurements, a site specific ground motion study was performed.

Results of the geotechnical field investigation and site specific ground motion study, following the procedures outlined in the latest Caltrans SDC (Caltrans, 2009) indicate that the preliminary ARS curve shown in Figure 10 plots well above the site specific ARS curve. Consequently, previously conducted analyses and design based on the preliminary seismic evaluation ARS curve are considered conservative and suitable for final design. The peak ground acceleration for the site was revised to 0.5 g based on the latest Caltrans SDC. The details of the ground motion study and the site specific ARS curve are summarized in a memorandum prepared by EMI and are included in Appendix F.

Ground Rupture. No known active faults traverse the surface of the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Liquefaction Potential and Seismically Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -75 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. Locations of potentially liquefiable material during the design earthquake are also identified in the subsurface profile shown in Figure 9.

Table 5. Liquefaction and Seismic Settlement Analysis Results

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-011	-1 to -14	2.0	6.5
	-18 to -30	3.7	
	-53 to -58	0.8	
R-09-014	-1 to -18	3.4	8.8
	-23 to -33	3.2	
	-38 to -43	1.3	
	-63 to -68	0.9	
R-09-016	-1 to -38	9.7	9.7
CPT-09-065	-6.0 to -9.0	0.2	2.0
	-13.9 to -16.4	0.1	
	-22.5 to -24.0	0.1	
	-26.0 to -35.5	1.4	
	-45.0 to -46.6	0.1	
	-60.0 to -62.0	0.1	

Table 5. Continued on Following Page

Table 5 (Continued). Liquefaction and Seismic Settlement Analysis Results

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
CPT-09-077	-7.9 to -8.9	0.1	3.2
	-10.3 to -13.0	0.1	
	-20.7 to -34.7	2.9	
	-60.3 to -62.1	0.1	
CPT-09-079	-4.6 to -15.3	0.6	3.2
	-16.7 to -21.0	0.6	
	-25.5 to -36.0	1.5	
	-42.0 to -45.6	0.4	
	-66.3 to -67.6	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Three soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to range between 7.5 and 8.0, the minimum resistivity varied from 100 to 910 ohm-cm, soluble chloride contents were between 568 and 13,807 parts per million (ppm) and soluble sulfate contents were between 353 and 999 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

5.4 Scour

This site is located within an area that is generally flat and there are no rivers, creeks or channels that cross that cross beneath the structure; therefore, scour is not considered a design issue.

5.5 Foundation Type

Due to presence of the weak near-surface soils and the potential for seismically induced settlement throughout the site, spread footings are not considered feasible for support of the proposed structure.

Site soils are conducive to either a driven or drilled pile foundation. Due to the presence of deep liquefiable layers, large diameter Cast-In-Drilled-Hole (CIDH) piles are better suited to resist the large lateral foundation demands than small diameter piles and large diameter piles are needed at bent locations to support the large axial pile demands. Based on the foundation loads provided by the designers, 10 ft diameter CIDH piles are recommended for support at the proposed structure bents and 2.5 ft diameter CIDH piles are recommended at the abutment. At the bent locations, a permanent steel casing from finished grade to a depth between 33 and 38 ft is also proposed.

5.5.1 Axial Pile Capacity

Per Caltrans policy, LRFD method is used for bent piles and WSD is used for abutment piles. The foundation design data sheet and factored foundation loads were estimated by the designers following the latest Caltrans Memo to Designers 3-1 (Caltrans, 2008), and are shown in Tables 6 and 7, respectively.

Table 6. Foundation Design Data Sheet

Location	Design Method	Pile Type	Finished Grade El. (ft)	Pile Cut-off El. (ft)	Pile Cap Size (ft)		Permissible Settlement under Service Load (in)	No. of Piles per Support
					B	L		
Abut 6	WSD	2.5 ft CIDH	+8.5	-2.8	20.0	42.33	1	12
Bent 7	LRFD	10 ft CIDH	-2.6	-10.0	NA	NA	1	1
Bent 8	LRFD	10 ft CIDH	-1.6	-4.0	NA	NA	1	1

Table 7. Foundation Design Loads

Location	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)			
	Total Load		Perm Load	Compression		Tension		Compression		Tension	
	Per Support	Max Per Pile	Per Support	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile
Abut 6	2,830	240	2,590	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bent 7	2,790	2,790	2,250	3,960	3,960	0	0	2,250	2,250	0	0
Bent 8	2,690	2,690	2,120	3,720	3,720	0	0	2,250	2,250	0	0

Axial CIDH pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). Axial driven steel shell capacities were calculated according to recommendations by Tomlinson (1987) and API (2000). Axial pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). The calculated factored axial geotechnical capacities and pile tip elevations for each 30-inch CIDH pile at the abutment and 10-ft CIDH pile at the interior

bents are presented in Tables 8 and 9, respectively. For the extreme event limit case, negative skin friction due to seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The depth to the bottom of the liquefiable layer at each support was determined based upon the nearest boring information. The Pile Data Table is provided in Table 10. For bent piles, a resistance factor of 0.7 was applied per Caltrans LRFD guidelines.

The maximum pile-head settlement due to the nominal resistance is estimated to be less than 1-inch at all supports. For axial loading, pile group effects can be neglected if the on-center spacing is equal to or greater than 4 times the pile diameter. A group reduction factor of 0.65 is applied for on-center spacing of 2.5 times the pile diameter. Based on interpolation over this range, an average group reduction factor of 0.93 was applied at the abutment.

Table 8. Foundation Recommendations for Abutments

Location	Pile Type	Cut-off El. (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip El. (ft)	Specified Tip El. (ft)
			Total	Permanent				
Abut 6	2.5 ft CIDH	-2.8	2,830	2,590	240	480	-71 (a) -46 (c) -43 (d)	-71

Notes: 1. Design tip elevations are controlled by: (a) Compression, (b) Tension, (c) Settlement, (d) Lateral Load.
2. The specified tip elevation shall not be raised.

Table 9. Foundation Recommendations for Bents

Location	Pile Type	Cut-off El. (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				Design Tip El. (ft)	Specified Tip El (ft)	Steel Casing Specified Tip El. (ft)	Steel Casing Nominal Driving Resistance Required ((kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 7	10 ft CIDH	-10.0	2,790	1	3,960	0	2,250	0	-137 (a-I) -124 (a-II) -88 (c) -95 (d)	-137	-35	250
Bent 8	10 ft CIDH	-4.0	2,690	1	3,720	0	2,250	0	-133 (a-I) -112 (a-II) -72 (c) -89 (d)	-133	-29	190

Notes: 1. Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (a-II) Compression (Extreme Event Limit), (b) Tension, (c) Settlement, (d) Lateral Load.

2. The specified tip elevation shall not be raised.

Table 10. Pile Data Table

Support	Pile Type	Nominal Resistance (kip)		Nominal Resistance (Driven Steel Shell) (kip)		Steel Casing Specified Tip Elevation (ft)	CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Comp	Tens	Comp	Tens				
Abut 6	2.5 ft CIDH	480	0	NA	NA	NA	-71 (a) -46 (c) -48 (d)	-71	NA
Bent 7	10 ft CIDH	5,660	0	250	0	-35	-137 (a) -88 (c) -95 (d)	-137	250
Bent 8	10 ft CIDH	5,310	0	190	0	-29	-133 (a) -72 (c) -89 (d)	-133	190

Notes: 1. Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

2. The specified tip elevation shall not be raised.

5.5.2 Lateral Pile Capacity

Abutments. Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a fixed-head connection with the pile cap are provided in Tables 11 and 12 for the Service Limit State and the Extreme Event Limit State, respectively. The design tip elevations for lateral loading are given in Table 10.

Lateral pile analyses were performed using the computer program LPILE (Ensoft 2007). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000). The internally generated p-y curves for stiff fine-grained soils were estimated using the method proposed by Reese (Reese et al., 1975), and the internally generated p-y curves for soft fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.8 was used in the analysis based on the pile layout provided by the designers and the procedures outlined in the Ensoft Group 7.0 software Technical Manual (Ensoft 2006). Under seismic conditions, liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008).

The solutions presented are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and other connection details.

Bents. The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time that included a general description of the subsurface conditions beneath the proposed structure and eight idealized soil profiles along the proposed alignment. It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared.

Based on the current geotechnical investigation and updated soil profile, an additional project specific lateral pile analysis was also performed. Results from that analysis indicate that the p-y curves generated from the soil profiles presented in the PFR are suitable for use in the final design. The current results either generate a more conservative lateral pile response than the p-y curves developed by Caltrans based on the PFR, or a lateral pile response that is within an acceptable design tolerance. Details of the lateral pile analysis and a comparison between the preliminary and updated p-y curves are included in a memorandum prepared by EMI. The memorandum is included in Appendix G. The preliminary p-y curves generated from the soil profiles in the PFR which were determined to be suitable for use in final design for Bent 7 and Bent 8 are provided in Appendix H.

Table 11. Abutment 6, 30-in CIDH Pile "Fixed" Head Solution: Service Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	140	6,961

Notes: 1. Group effects considered with a reduction factor of 0.8 on "p."
2. Static strength parameters used in all soil layers.
3. A cracked section modulus of 80% of EI was used in the analysis.

Table 12. Abutment 6, 30-in CIDH Pile "Fixed" Head Solution: Extreme Event Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	38	2,608
0.5	72	5,083
1.0	122	9,472
3.0	230	22,123

Notes: 1. Group effects considered with a reduction factor of 0.8 on "p."
2. Liquefied strength parameters used in liquefiable soil layers.
3. A cracked section modulus of 50% of EI was used in the analysis.

5.6 Bridge Abutment Walls

5.6.1 Earth Pressures

An active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf are recommended for a level abutment backfill. If abutment walls are free to move laterally at the top, a static active lateral earth pressure of 36 psf per ft of depth is recommended for a level backfill. If lateral movement at the top of abutment walls is restrained, the lateral pressure distribution has a trapezoidal shape with a maximum lateral pressure of 28.8H psf between 0.2H from the top and bottom of the wall, where H is the wall height in feet. A traffic surcharge equivalent to a vertical pressure produced by at least 2 ft of earth should be added to the above lateral earth pressure values. Other design requirements are specified in Section 3.20 of the Caltrans Bridge Design Specifications (Caltrans, 2004).

5.6.2 Passive Resistance

Under seismic loading, an ultimate passive earth pressure of 5 ksf may be used for the approach backfill and abutment backwalls with a height equal to or greater than 5.5 ft. For abutment backwalls with heights less than 5.5 ft, the maximum passive pressure may be calculated

proportionally (e.g., for a 4 ft high backwall, the maximum passive pressure is [4/5.5]x5 ksf = 3.6 ksf). The horizontal movement at which the maximum passive pressure is expected to be fully mobilized can be determined following the procedure outlined in Section 7.8.1 of the Caltrans SDC (2006d).

5.7 Approach Embankments

The proposed New Dock Street On-Ramp (Replace) will generally have the same alignment as the existing structure with a slightly elevated roadway profile. Up to 8 ft of fill will be placed atop the existing approach embankment in order to raise existing grade to proposed grade. The abutment end slope will be graded at an inclination of 1.5:1 (Horizontal:Vertical) with full slope paving and the western slope of the embankment will be graded at an inclination of 2:1 (Horizontal:Vertical). At the eastern roadway edge, the embankment fill that will be placed as part of the project will be retained by an MSE wall (Retaining Wall C1) that will be constructed on top of the existing approach embankment with grade descending down and away from the wall toe at an inclination of 4:1 (Horizontal:Vertical). Recommendations for Retaining Wall C1 wall are provided in a separate foundation report prepared by EMI (EMI, 2010).

5.7.1 Static Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed embankment approximately 25 ft behind the bridge abutment. Based on cross-sections provided by URS Corporation, the existing embankment at "C" Line Sta. 213+50 will be widened approximately 5 feet at the crest and the total embankment height is approximately 19 feet. Based on our calculations, settlement of soils underlying the proposed retaining wall is estimated to be about 2 inches. The maximum settlement beneath the center of the embankment is estimated to be about 3.5 inches. The settlement period is estimated to be about 22 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 11 weeks. For a 7-ft embankment surcharge, the settlement periods is reduced to about 8 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

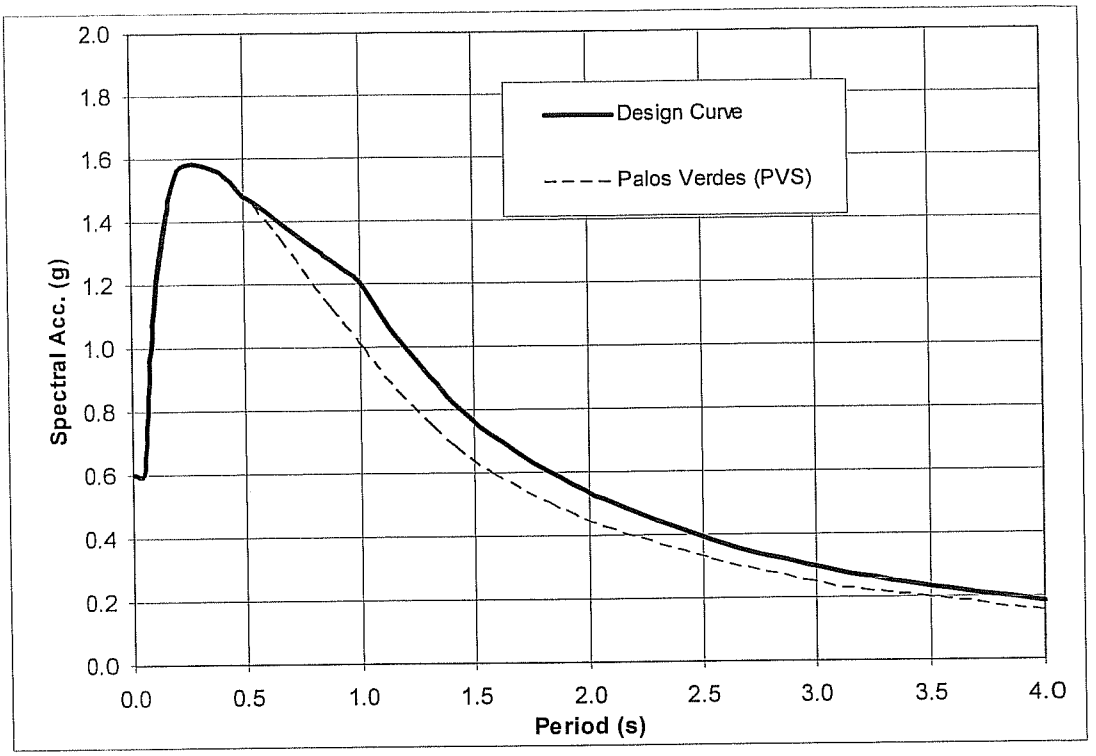
Settlement of the embankment fill should be verified by the Engineer prior to installation of abutment piles to prevent a reduction in axial pile capacity due to downdrag loads being applied to the piles.

5.7.2 Bridge Abutment Slope Stability

The "global" stability of the western embankment side slope was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The global stability analysis of the eastern embankment slope and Retaining Wall C1 is provided in a separate report prepared by EMI (EMI, 2010).

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).



Fault Name	Fault Type	M_w	Dist, km	PBA, g
Palos Verdes (PVS)	ST	7.25	2.7	0.6

Period	Acc (g)	Period	Acc (g)	Period	Acc (g)	Period	Acc (g)
0.010	0.600	0.500	1.479	2.954	0.304		
0.050	0.600	0.533	1.461	3.203	0.266		
0.079	0.938	0.650	1.398	3.463	0.239		
0.099	1.127	0.787	1.323	4.000	0.186		
0.124	1.283	0.868	1.279				
0.154	1.419	0.998	1.209				
0.177	1.507	1.000	1.208				
0.208	1.564	1.162	1.031				
0.236	1.578	1.307	0.906				
0.271	1.584	1.411	0.822				
0.309	1.580	1.575	0.723				
0.355	1.570	1.819	0.605				
0.386	1.557	2.068	0.513				
0.442	1.525	2.537	0.383				

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Design Acceleration Response Spectrum

Figure 10

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6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned or dried to near optimum moisture, and compacted in place to a minimum 95 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts or excavations necessary to achieve finish grades. However, temporary cuts may be required in areas where drainage improvements and footings are proposed. Temporary excavations, including temporary shoring, necessary to construct the bridge abutment footings or culverts will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all three of the borings performed for the proposed bridge foundation between Elevation -5.3 and -10.0 ft. The proposed footing bottom elevation at Abutment 6 is -1.4 ft. Due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

Groundwater was encountered between elevation -5.3 and -10.0 feet in October 2009. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff and other man-made conditions. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled

with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.3 Backdrain and Backfill Requirements for Abutment Walls

Materials behind the abutment and wing walls should be low-expansive soil with an Expansion Index (EI) less than 50 and Sand Equivalent (SE) of more than 20 as shown in Figure 11. The low-expansive material requirement should not supersede the structure backfill and pervious backfill requirements as described in Caltrans Standard Plans, Bridge Detail 3-1 (2006b), and Caltrans Standard Specifications (2006c) under Sections 19-3.06 and 19-3.065, respectively.

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the abutment walls in order to avoid damaging the walls due to large lateral earth pressures.

Backdrains should be installed behind abutment walls to relieve hydrostatic pressure. The backdrains should be constructed in accordance with Bridge Detail 3-1 per Caltrans Standard Plans (2006b).

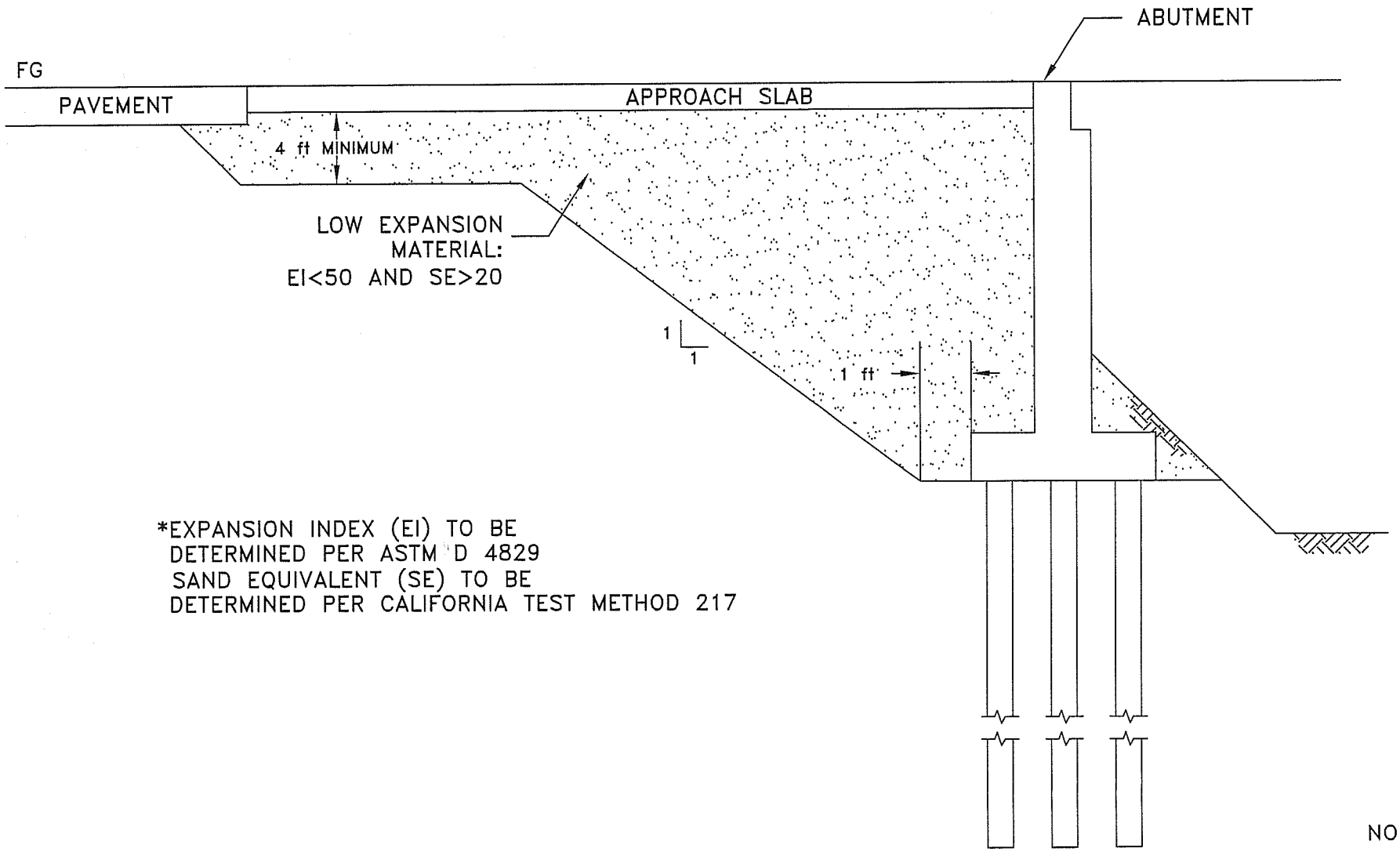
6.4 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations presented in this report may require modification or additional recommendations may be necessary based on the final design.

6.5 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of bridge abutment walls.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.



*EXPANSION INDEX (EI) TO BE DETERMINED PER ASTM D 4829
SAND EQUIVALENT (SE) TO BE DETERMINED PER CALIFORNIA TEST METHOD 217

NO SCALE

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Low Expansion Material at Bridge Abutments

Figure 11

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BENCHMARKS:

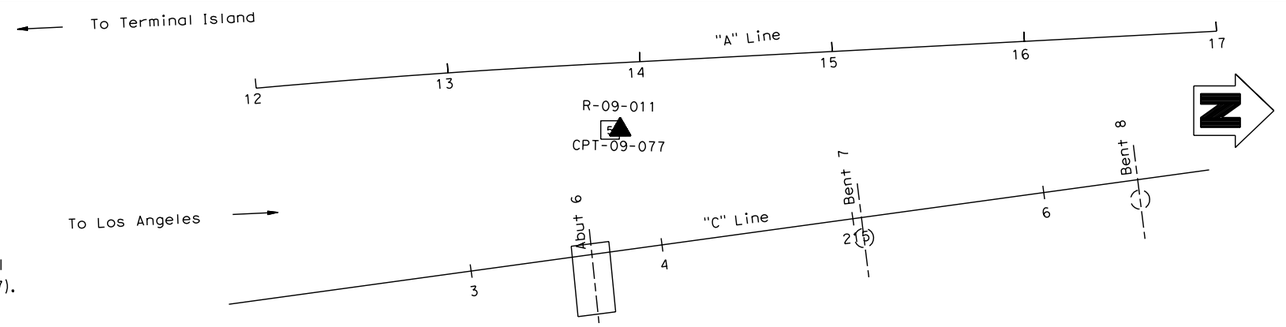
PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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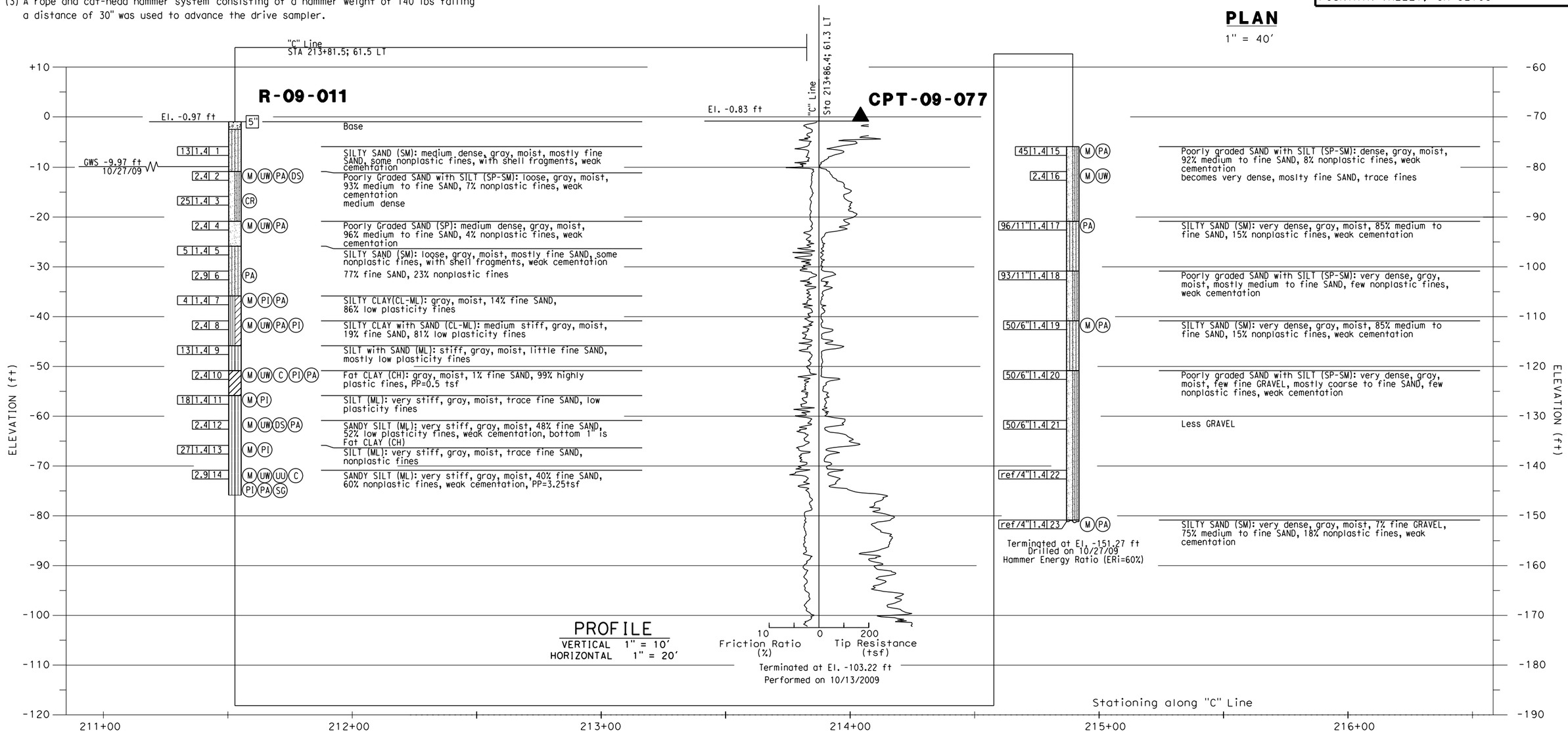
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

PLAN

1" = 40'



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53-3033
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 3.74

NEW DOCK STREET ON-RAMP

LOG OF TEST BORINGS NO. 1 OF 5

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

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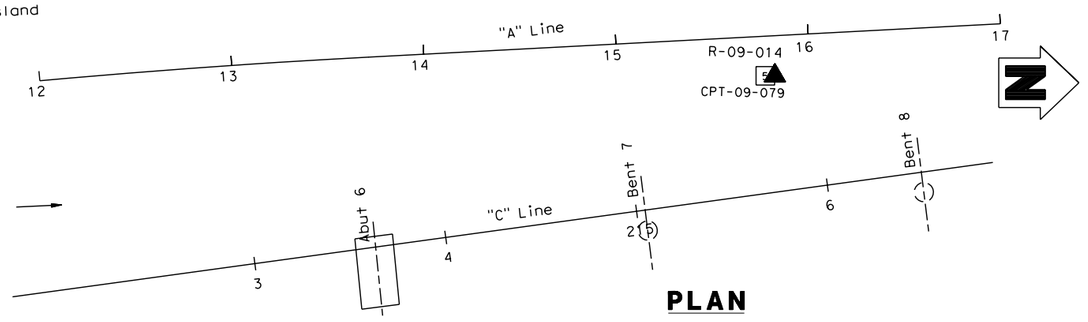
(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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EARTH MECHANICS, INC.
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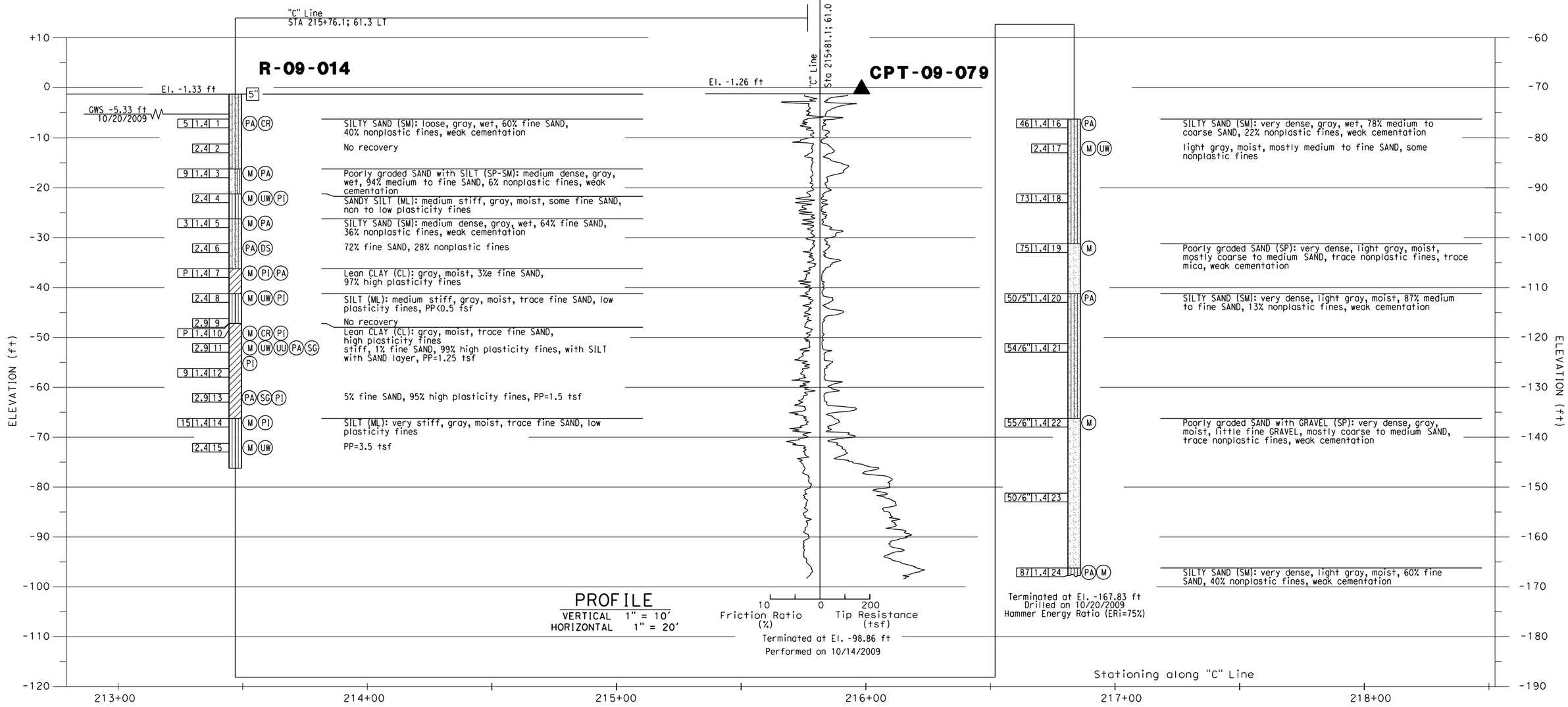
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53-3033 / POST MILE 3.74
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			

NEW DOCK STREET ON-RAMP

LOG OF TEST BORINGS NO. 2 OF 5

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-524	PT-525
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19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
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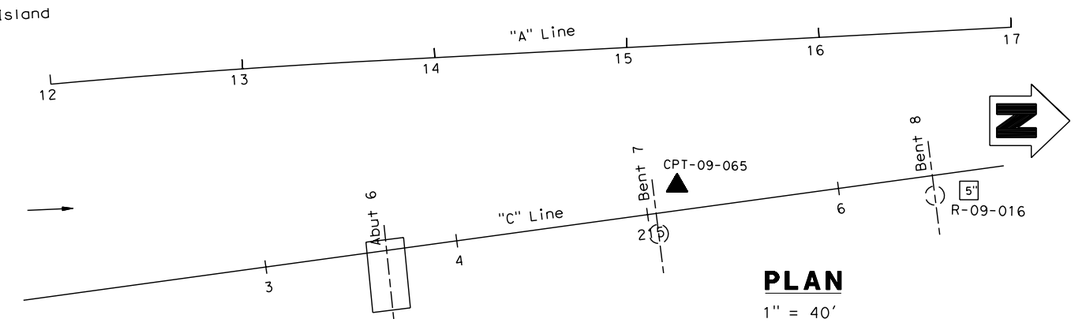

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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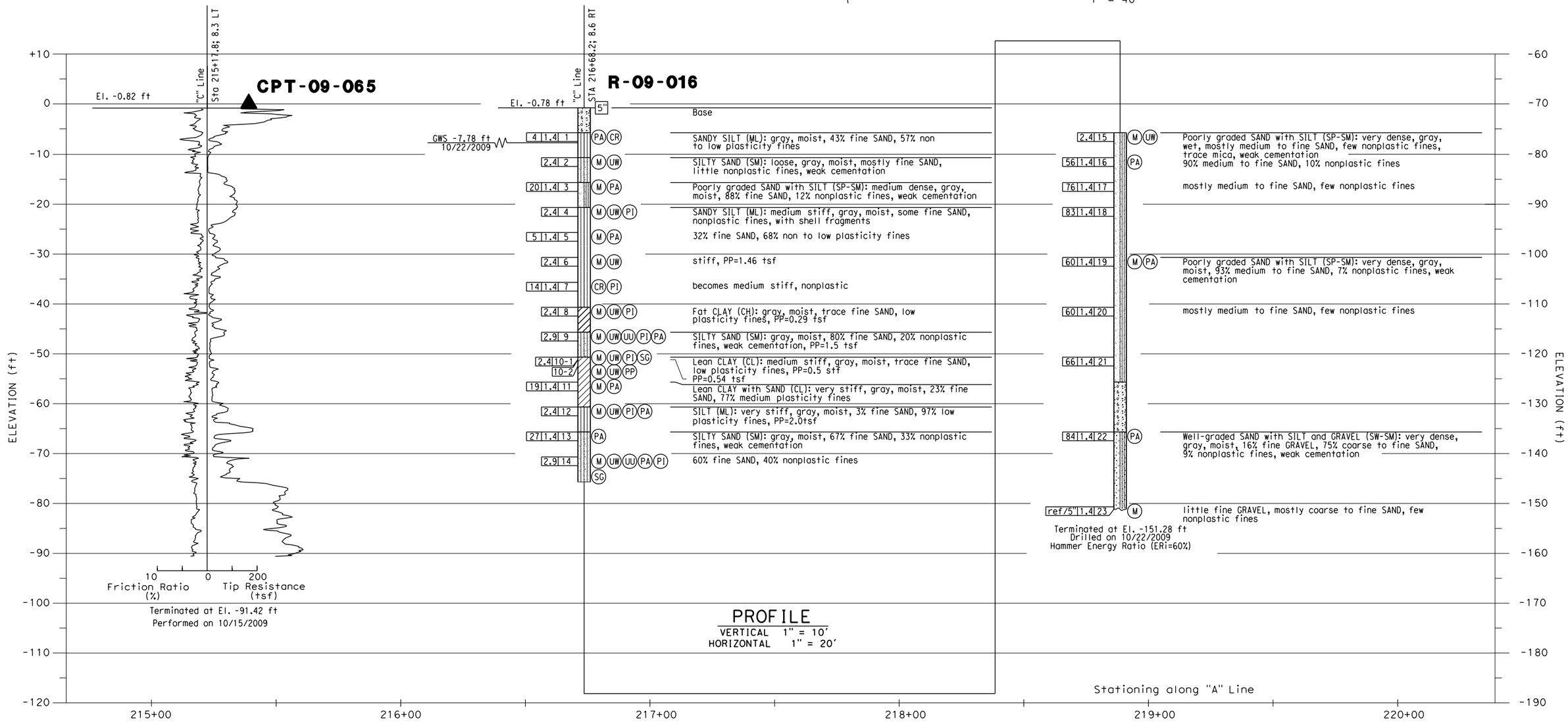

DESIGN OVERSIGHT / SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53-3033 POST MILE 3.74

NEW DOCK STREET ON-RAMP

LOG OF TEST BORINGS NO. 3 OF 5

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R	Rotary drilled boring
	P	Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

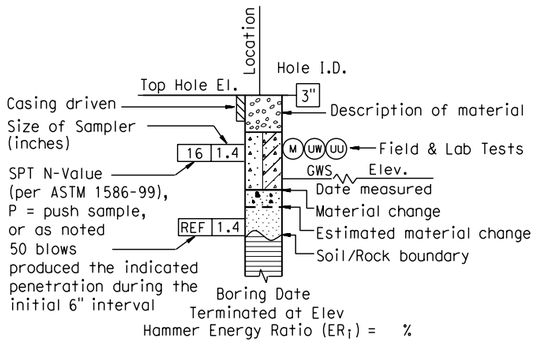
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

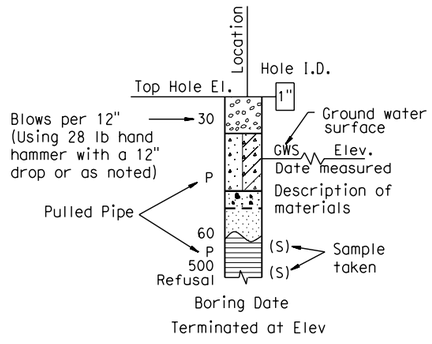
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

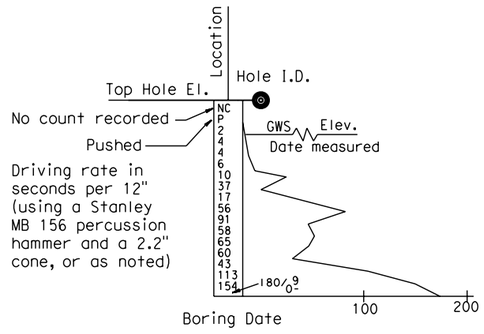
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



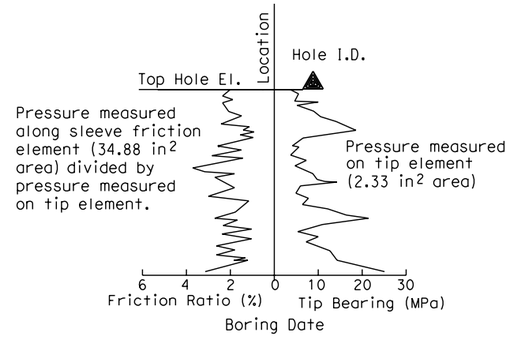
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53-3033	NEW DOCK STREET ON-RAMP
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 3.74	LOG OF TEST BORINGS NO. 4 OF 5

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
02/08/10	03/24/10								X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53-3033
POST MILE 3.74

NEW DOCK STREET ON-RAMP
LOG OF TEST BORINGS NO. 5 OF 5

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

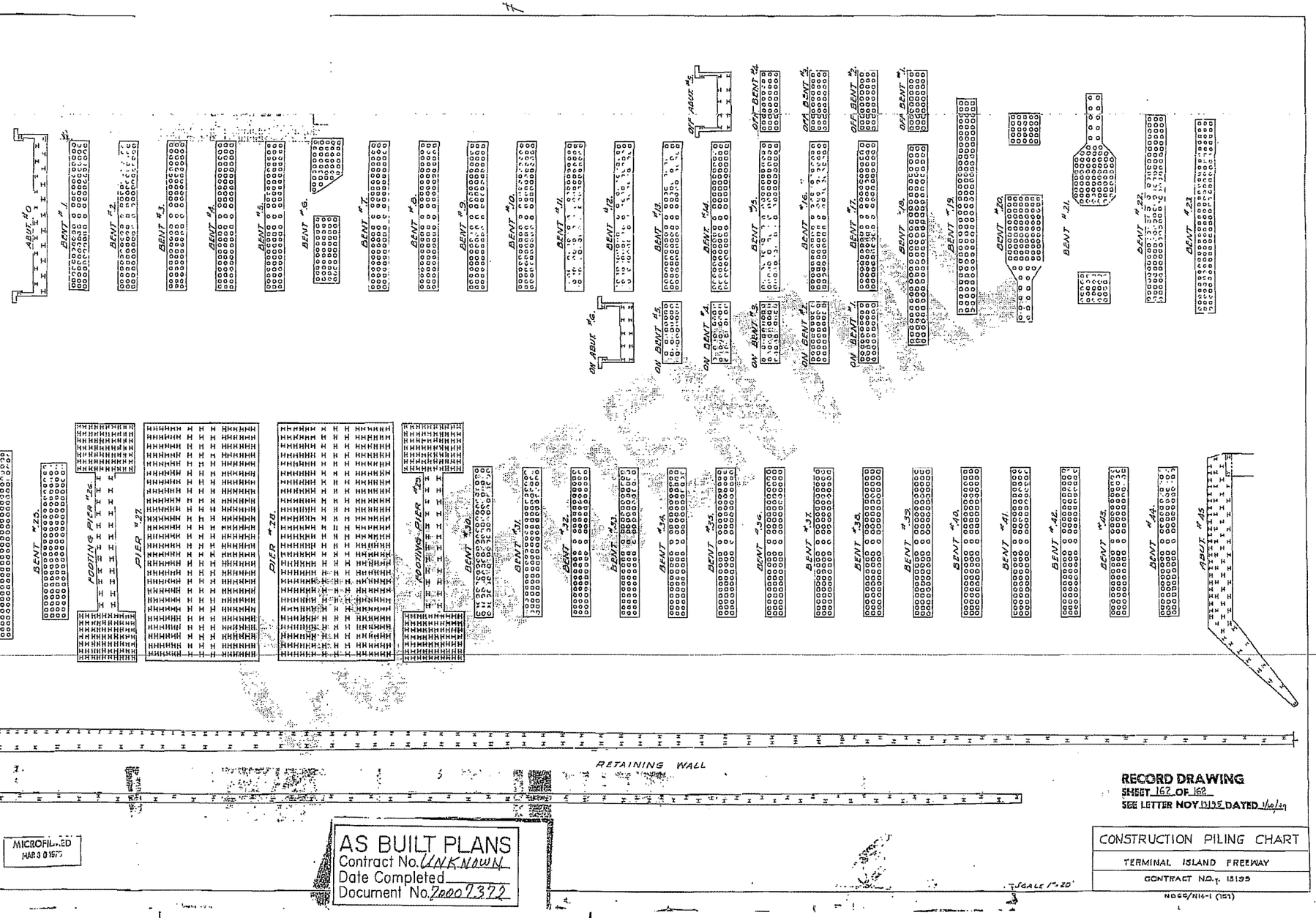
REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

Appendix A. Selected As-Built Plan Sheets for Schuyler Heim Bridge



MICROFILMED
MAR 3 0 1979

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

RECORD DRAWING
SHEET 162 OF 162
SEE LETTER NOY 13135 DATED 11/6/79

CONSTRUCTION PILING CHART
TERMINAL ISLAND FREEWAY
CONTRACT NO. 13135

NO SCALE 1"=20'

NDSS/NH-1 (151)

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THE DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

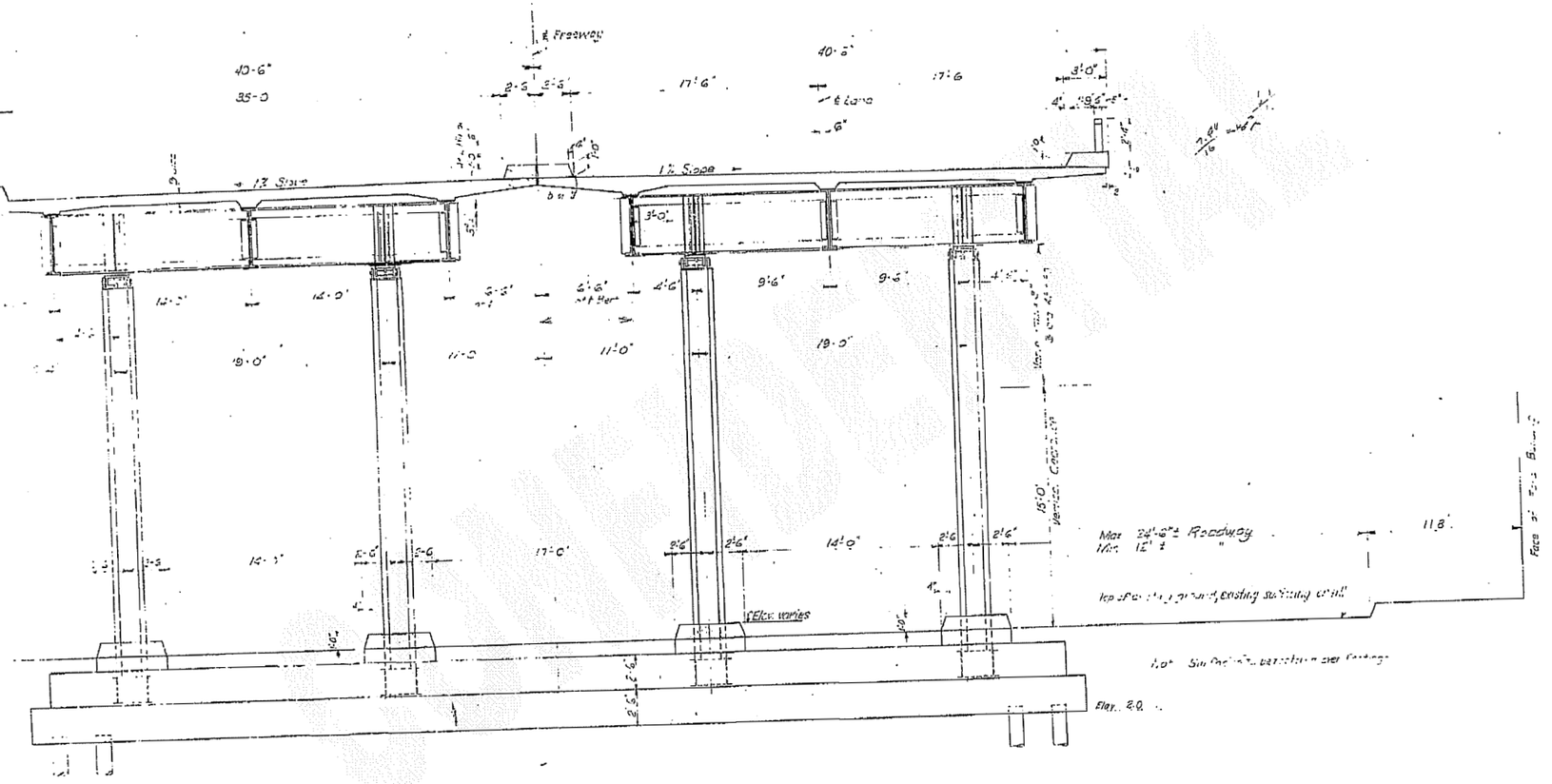
DATE 5/30/14 SIGNED

ClibPDF - www.fastio.com

FED. ROAD DIST. NO.	STATE	PROJ. NO.	F. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	L.A.	Access to Pier		1	1146

BRIDGE DEPARTMENT



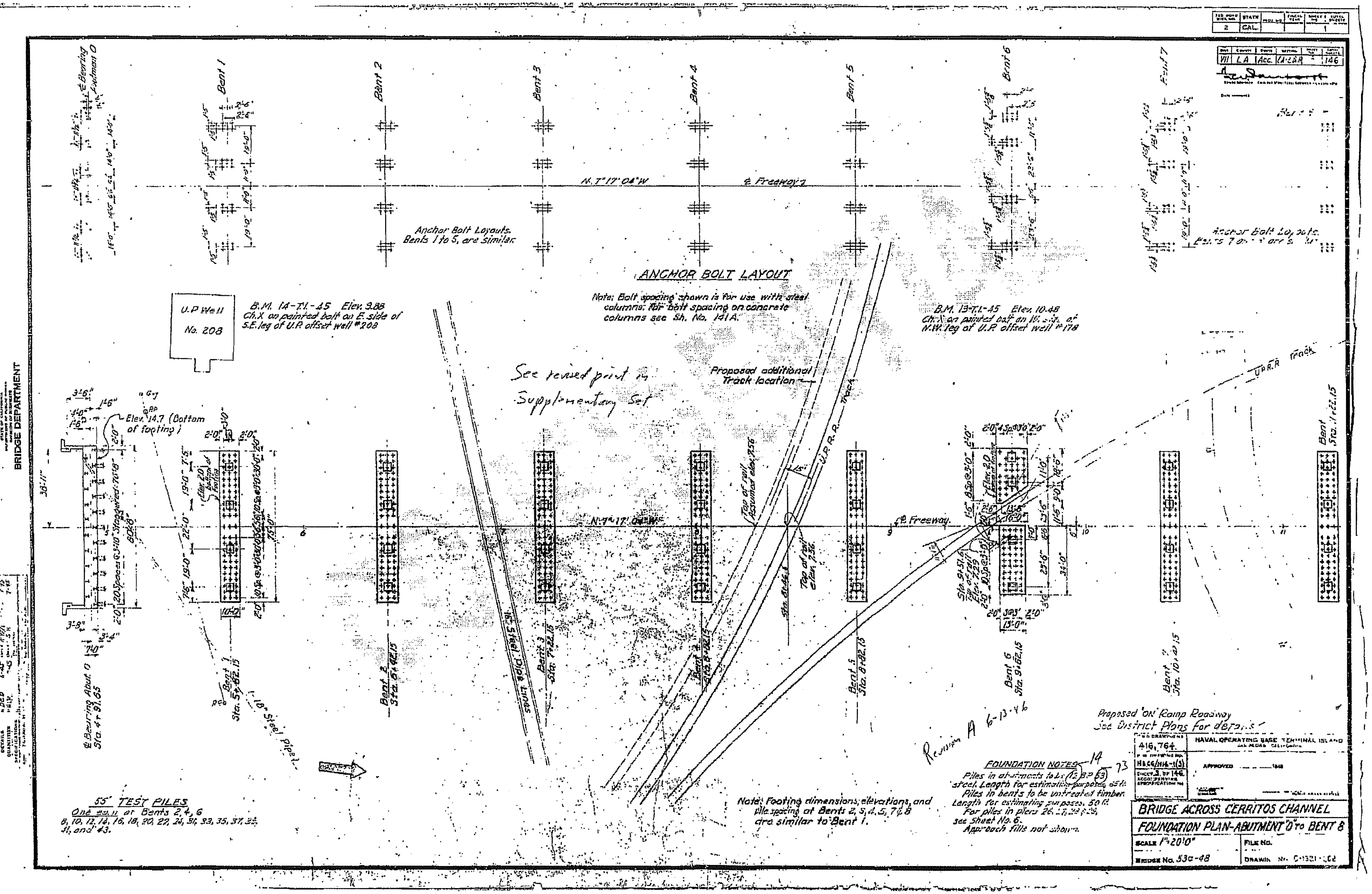
TYPICAL BENT
Scale 1/2" = 1'-0"

414,894	NAVAL OPERATIONAL BASE
NBSS/N14-1 (335) 133 1146	APPROVED

BRIDGE ACROSS CERRITOS CHANNEL
TYPICAL BENT

SCALE 1/2" = 1'-0"	FILE NO.
BRIDGE NO. 53C-48	DRAWING NO C-1521-332

CutePDF - www.fastio.com


ANCHOR BOLT LAYOUT
Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.
Anchor Bolt Layouts. Bents 1 to 5, are similar.
N. 7°17'04"W
℄ Freeway
B.M. 14-T.I.-45 Elev. 3.88
Ch.X on painted bolt on E. side of S.E. leg of U.P. offset well #208
U.P Well No. 208
B.M. 13-T.I.-45 Elev. 10.48
Proposed additional Track location
U.P.R.R. Track
See revised print in Supplementary Set
55' TEST PILES
One each at Bents 2, 4, 6
8, 10, 12, 14, 16, 18, 20, 27, 29, 31, 33, 35, 37, 39, 41, and 43.
Note: Footing dimensions, elevations, and pile spacing at Bents 2, 3, 4, 5, 7 & 8 are similar to Bent 1.
FOUNDATION NOTES
Proposed 'ON' Ramp Roadway
See District Plans for details
Revision A 6-13-46
℄ Bearing Abut. 0 Sta. 4+91.65
Bent 1 Sta. 5+62.15
Bent 2 Sta. 6+42.15
Bent 3 Sta. 7+22.15
Bent 4 Sta. 8+02.15
Bent 5 Sta. 8+82.15
Bent 6 Sta. 9+62.15
Bent 8 Sta. 11+22.15
16" Steel Pipe Lines
BRIDGE DEPARTMENT
NAVAL OPERATING BASE TERMINAL ISLAND
BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLAN-ABUTMENT 0 TO BENT 8
SCALE 1"=20'0"
BRIDGE No. 53c-48
416,764
CAL.
VII LA Acc. 146

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
BRIDGE DEPARTMENT

CO. ROAD NO.	STATE	ROAD NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	LOCATION	SHEET NO.	TOTAL SHEETS
VII	LA	Acc.	LA-Lab. #	146	

BENTS 9-16 INCL.

"OFF" ABUTMENT 5

"ON" ABUTMENT 6

"OFF" BENTS 1-4 INCL.

"ON" BENTS 1-5 INCL.

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.

Note: Footing dimensions, elevation, and pile spacing for Bents 10, 11, 12, 13, 15, & 16 are similar to Bent 9.
Footing dimensions and pile spacing for "OFF" Abutment 5 are similar to "ON" Abutment 6.
Footing dimensions, elevation, and pile spacing for "ON" Bents 2, 3 & 4 and "OFF" Bents 3 & 4 are similar to ON Bent 5 except as noted.

INSTALL 97 PILES
One Bent in Bents 4 & 2 of "ON" Ramp
One in Bents of "OFF" Ramp
Sheet Piles along Freeway

MICROFILMED
MAR 3 0 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

RECORD DRAWING
SHEET 1 OF 122
SEE LETTER NOV 1995 DATED 1/3/96

REV. BY	DATE	DESCRIPTION
	7-19-46	MEAS SPAN LENGTH AS OF 7-19-46
	6-7-46	CHANGE SIZE OF PILE ABUT.
	10-8-46	SERVICE ROAD ADDED

BRIEF

F.A.D. DRAWING NO.	NAVAL OPERATING BASE, TERMINAL ISLAND, SAN PEDRO, CALIFORNIA
416,765	
N.O.B.C./NAVY DWG. NO.	APPROVED

BRIDGE ACROSS DRAINAGE DITCH
FOUNDATION PLAN - BENTS 9, 10, 11, 12, 13, 14, 15, 16

SCALE 1"=10'-0" | FILE No.

BRIDGE No. 936-48 | DRAWING No. 121,206

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 3/30/96 SIGNED

BRIDGE DEPARTMENT

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing of concrete columns see Sh No. 14-4.

RECORD DRAWING
SHEET 5 OF 162
SEE LETTER NOY 13195 DATED 4/10/44

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

MICROFILMED

BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLANS - BENTS 17 TO 25

NAVAL OPERATING BASE TERMINAL ISLAND
SAN PEDRO, CALIFORNIA

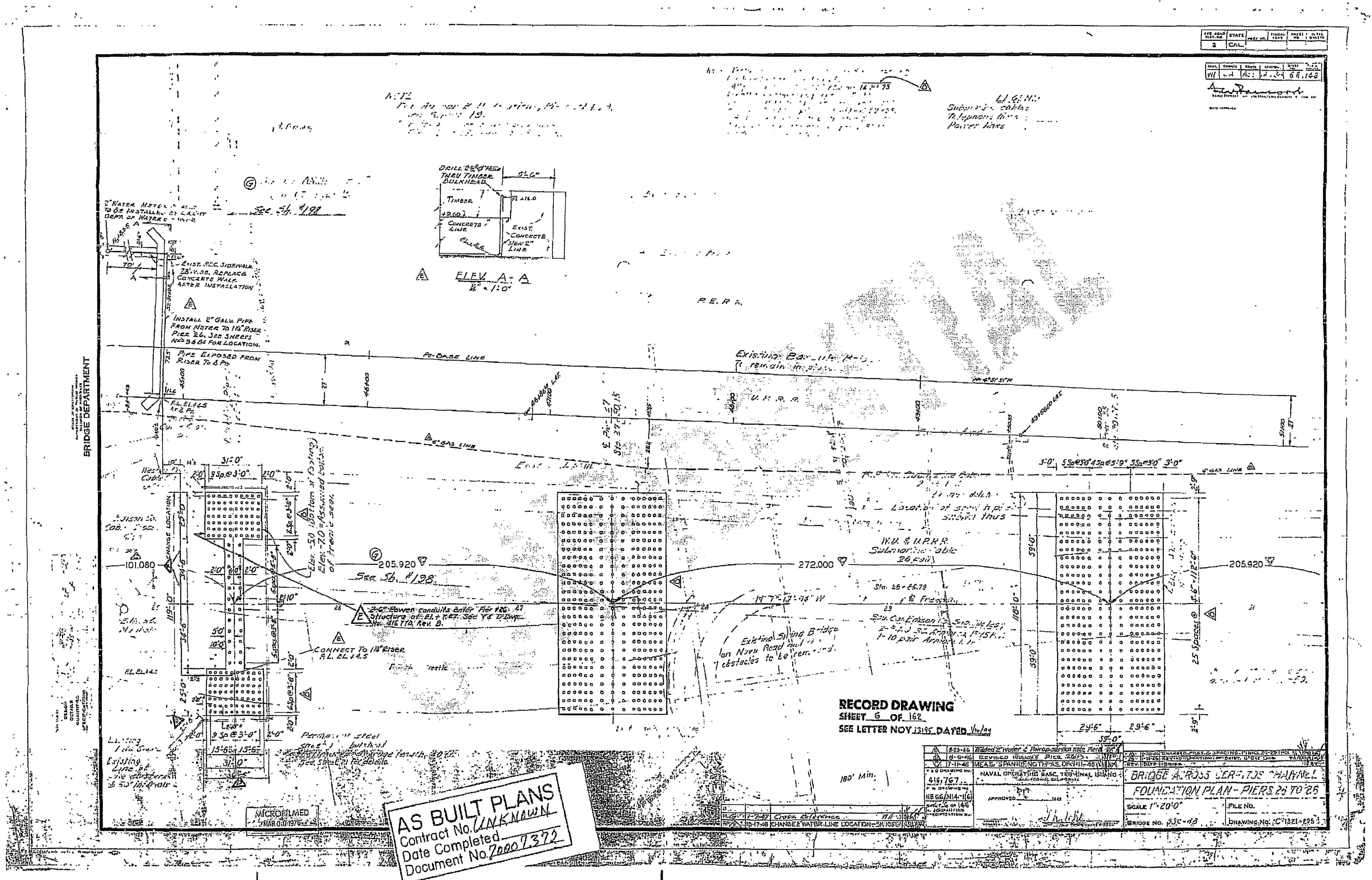
SCALE 1" = 20'
FILE NO.
BRIDGE NO. 53C-48
DRAWING NO. C-1321-2041

APPROVED 1943

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

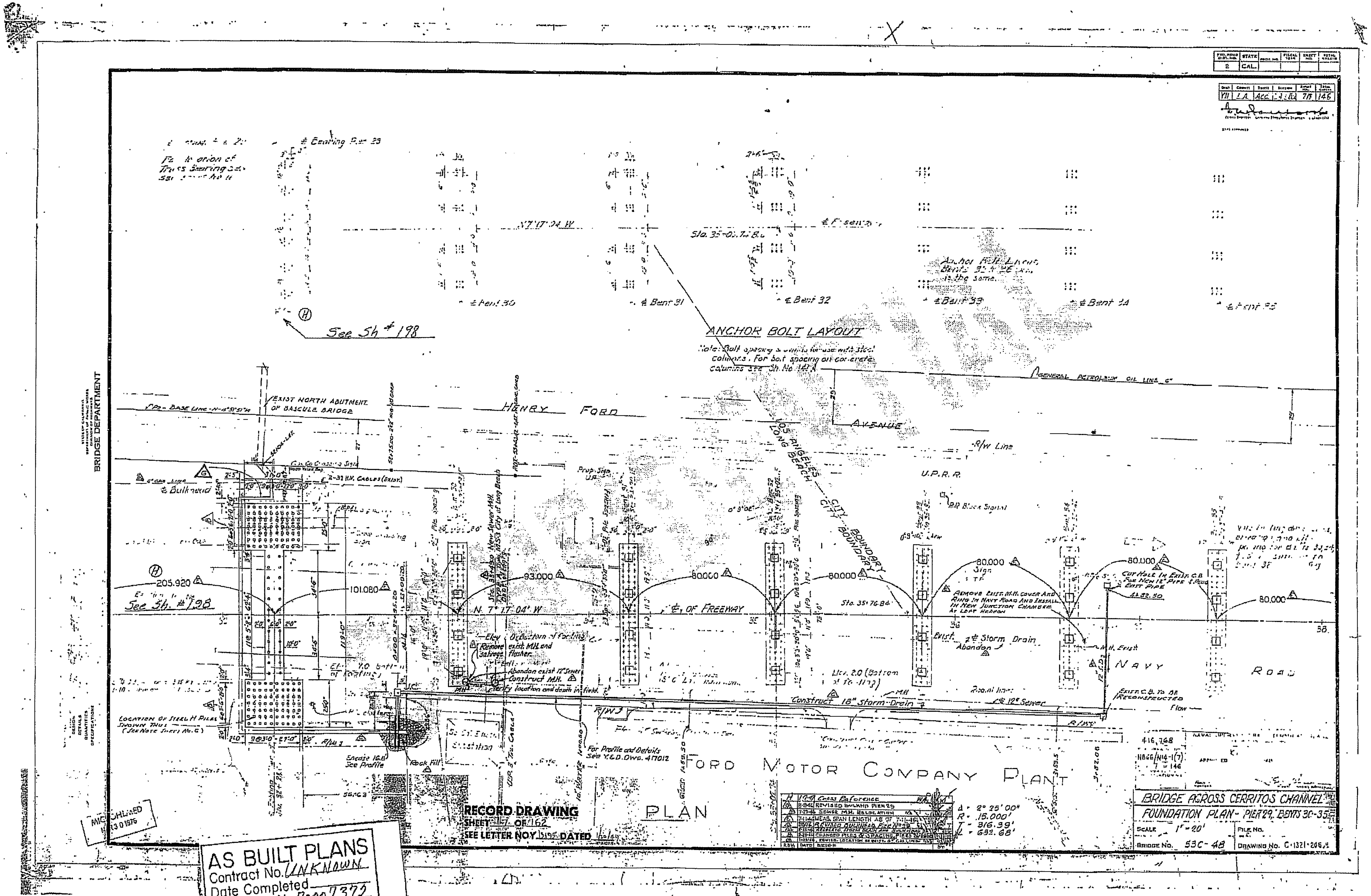
5/30/96

ClibPDF - www.fastio.com



I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THE DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

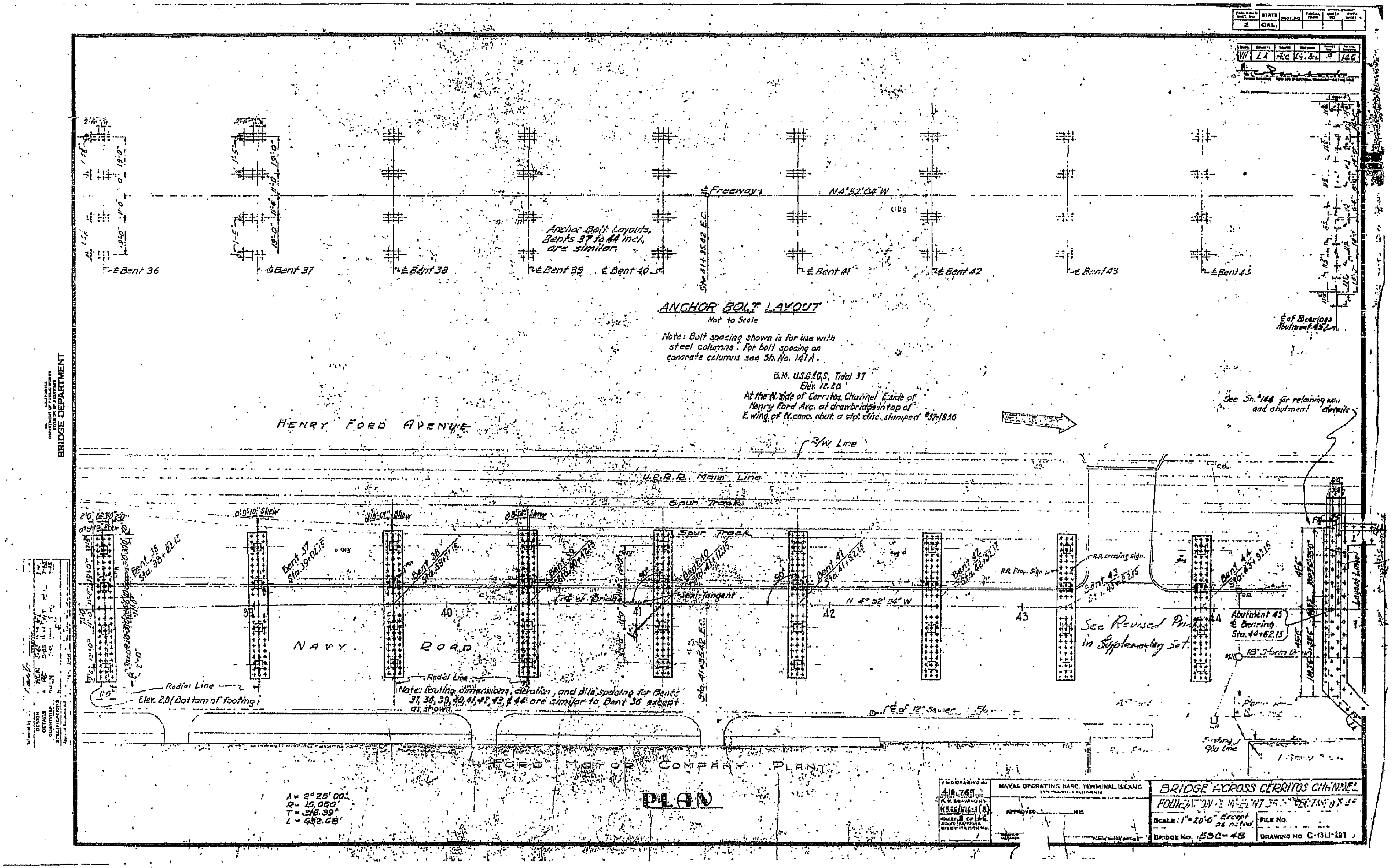
3/30/00



AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 70007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

5/30/96



ANCHOR BOLT LAYOUT
Not to Scale
Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.
Anchor Bolt Layouts, Bents 37 to 44 incl. are similar.
℄ Freeway
N 4°52'04" W
℄ Bent 36
℄ Bent 37
℄ Bent 38
℄ Bent 39
℄ Bent 40
℄ Bent 41
℄ Bent 42
℄ Bent 43
℄ Bent 44
B.M. U.S.C.&G.S. Tidal 37
Elev. 12.08
At the N. side of Cerritos Channel E. side of Henry Ford Ave. at drawbridge in top of E. wing of N. conc. abut. a std. disc. stamped "37-1936"
See Sh. #144 for retaining wall and abutment details
HENRY FORD AVENUE
R/W Line
U.P.R.R. Main Line
Spur Tracks
Spur Track
NAVY ROAD
Radial Line
Elev. 2.0 (Bottom of footing)
Note: Footing dimensions, elevation, and pile spacing for Bents 37, 38, 39, 40, 41, 42, 43, & 44 are similar to Bent 36 except as shown.
℄ of 12" Sewer
See Revised Plan in Supplementary Set
Abutment 45 ℄ Bearing Sta. 44+62.15
18" Storm Drain
FORD MOTOR COMPANY PLANT
Δ = 2°25'00"
R = 15,000'
T = 316.39'
L = 632.68'
PLAN
BRIDGE DEPARTMENT
Y&D DRAWING NO. 416,769
NAVAL OPERATING BASE, TERMINAL ISLAND
APPROVED
BRIDGE ACROSS CERRITOS CHANNEL
SCALE: 1" = 20'-0" Except as noted
FILE NO.
BRIDGE NO. 53C-48
DRAWING NO. C-1321-207
CAL.

Appendix B. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity

N.S.R.= No sample recovery
OVM5608 Gas Reading

PLAN
SCALE: 1"=40'

NORTH

BENT 9, CPT-5, BENT 11, BENT 12, OFF RAMP 6, OFF RAMP 5, B-2, CPT-7, OFF BENT 4, OFF BENT 3, OFF BENT 2, OFF BENT 1, BENT 18
ON BENT 4, ON BENT 3, ON BENT 2, ON BENT 1, FOAT BENT 5, BENT 10, BENT 13, BENT 14, BENT 15, BENT 16, BENT 17, CPT-6, CPT-8
2, 12, 13, 14, 15, 16, 17, 18, 19

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE
HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

45' Lt. STA. 12+82.50 — ELEV.= -0.68 — CPT-5 — 08-15-96
STA. 14+05.00 — ELEV.= -1.78 — CPT-6 — 08-15-96
STA. 15+63.50 — ELEV.= -1.66 — CPT-7 — 08-15-96
5' Lt. STA. 15+51.50 — ELEV.= -1.54 — B-2 — GWS ELEV.= -5.54' 08-23-96 — 08-21-96
STA. 17+23.00 — ELEV.= -0.02 — CPT-8 — 08-15-96

FILL:(SM)Brown fine SILTY SAND w/GRAVEL & shell fragments
(ML)Dark gray CLAYEY SILT w/roots, very soft
NATIVE:(SP)Gray fine SAND w/mica, slightly compact
(ML)Gray SILT w/traces of SAND, stiff
grades to SANDY, very soft
grades to w/SAND and shells
grades to SANDY
increasing shells, stiff
grades to CLAYEY w/traces of mica
Decreasing in CLAY, soft
grades to CLAYEY w/mica
Decreasing in mica, very stiff
stiff
w/traces of SAND
interbedded w/ SANDY SILT
(SP)Gray fine SAND, dense
(ML/SM)Gray SANDY SILT
(SP)Gray fine SAND w/traces of SILT
grades to w/mica, decreasing in SILT, very dense
traces of SILT
traces of GRAVEL, 0.5" dia.
w/o GRAVEL
grades to fine to medium
grades to fine to medium w/traces of GRAVEL
grades to w/traces of SILT
(ML)Gray SANDY SILT
(SP)Gray fine SAND, very dense
grades to medium to coarse w/GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND, 3/8" max. dia.
(SP)Gray fine SAND w/GRAVEL
Decreasing in GRAVEL
(ML)Dark gray SILT w/decomposed wood & mica
(SP)Gray fine to medium SAND w/1.5" GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND
(ML)Dark gray SILT w/SAND
(SM)Dark gray fine to medium SILTY SAND w/traces of CLAY
(ML)Gray SILT w/SAND

ELEVATION

PENETRATION BORING: 2½" CONE PENETROMETER TEST; 2½" CONE PENETRATION BORING; ROTARY SAMPLE BORING (WET); ROTARY SAMPLE BORING (DRY); AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; JET BORING; ELECTRONIC CONE PENETROMETER

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS According to the Standard Penetration Test

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
170	Very dense	Very hard

NOTE: Classification of earth material as shown on the sheet is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERSIGHT	DRAWN BY	NL	CS-LN-MC	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	PROJECT ENGINEER
SIGN OFF DATE	CHECKED BY	MR	FIELD INVESTIGATOR DATE 09-18-96		

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

BRIDGE NO. 53-2618
POST MILE 3.58

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO.2

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY) 4/16 9/23

SHEET 142 OF 148

C:\CADDD\VGN\JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

PLAN

SCALE: 1"=40'

NORTH

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (MR) Minimum Resistivity
- N&Re N3 sample recovery
- OVM5808 Gas Readings

BENT 17 "OFF" BENT 1 "ON" BENT
BENT 18
BENT 19
CPT-10
BENT 20
BENT 21
BENT 22
B-3
CPT-11
BENT 23
BENT 24
CPT-12
BENT 25
CPT-13
BENT 26
CPT-9
18 19 20 21 22 23 24 25

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

STA. 18+85.00 — ELEV.= -1.77 — CPT-9 — 08-19-96
70' Lt. STA. 20+24.00 — ELEV.= -1.10 — CPT-10 — 08-15-96
13' Rt. STA. 22+25.00 — ELEV.= 1.89 — CPT-11 — 08-16-96
STA. 22+25.00 — ELEV.= 1.89 — GWS ELEV.= -5.61 — 08-26-96 — B-3 — 08-19-96
8' Lt. STA. 23+98.00 — ELEV.= 8.42 — CPT-12 — 08-19-96

N [blows/foot] 10 20 30 40 50

Vs (ft/s) 1400 1200 1000 800 600 400 200

2" of AC
FILL: (SP)Brown fine SAND w/SILT
(SM)Gray fine SILTY SAND w/mica, wood fragments
(ML)Dark brown CLAYEY SILT w/wood fragments, soft petroleum odor, very soft, traces of SILTY SAND & mica
(SP)Dark gray fine SAND w/traces of wood & mica, SILT
NATIVE-(ML)Dark gray SANDY SILT w/traces of shell & mica, soft
Grades to CLAYEY, decreasing of shell
(SM)Dark gray fine SILTY SAND, w/mica
compact
(ML)Dark gray SANDY SILT w/CLAY, mica, & shell
grades to CLAYEY
Grades to SILT w/SAND & mica
stiff
decreasing of SAND
Grades to SANDY, very stiff
Grades to CLAYEY
(SP)Gray fine SAND w/SILT, dense
(ML)Gray SANDY SILT
(SM)Gray fine SILTY SAND, dense
(SP)Gray fine SAND
(ML)Gray SILT w/traces of SAND, hard
(SP)Gray fine SAND, very dense
grades to fine to medium
(ML)Gray CLAYEY SILT, very hard
(SP)Gray fine SAND, very dense
Traces of GRAVEL & sea shell
Grades to medium to coarse
traces of SILT
increasing of shell
(GP)Dark gray SANDY GRAVEL, 1.5" max. dia.
(ML)Gray SANDY SILT, very hard
(SP)Gray fine SAND w/SILT, very dense

18 19 20 21 22 23 24 25

Boring Data: ELECTRONIC CONE PENETROMETER TEST; 2 1/2" CONE PENETRATION BORING; ROTARY SAMPLE BORING (WET); DRIVE SAMPLE BORING (DRY)

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, BEDROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY, CLASSIFICATION FOR SOILS

Penetration Index (Blows/Ft)	Granular	Cohesive
0-4	Very loose	Very soft
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10-18	Slightly compact	Stiff
20-34	Compact	Very stiff
36-69	Dense	Hard
170	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

DESIGN OVERNIGHT	DRAWN BY	NL	CB-LN-MC	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	BRIDGE NO. 53-2618
DESIGN OFF DATE	CHECKED BY	MR	FIELD INVESTIGATION DATE 09-15-93	PROJECT ENGINEER	POST MILE 3.58

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO.3

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 143 OF 148

C:\CADD\WORK\HEIM\KRV\TBR08 8-15-96 11:45:15 am EST

Appendix C. EarthSpectives SPT Hammer Energy Measurement Report

EARTHSPECTIVES
250 Goddard
Irvine, California 92618
Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

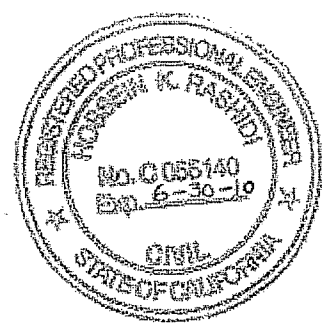
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

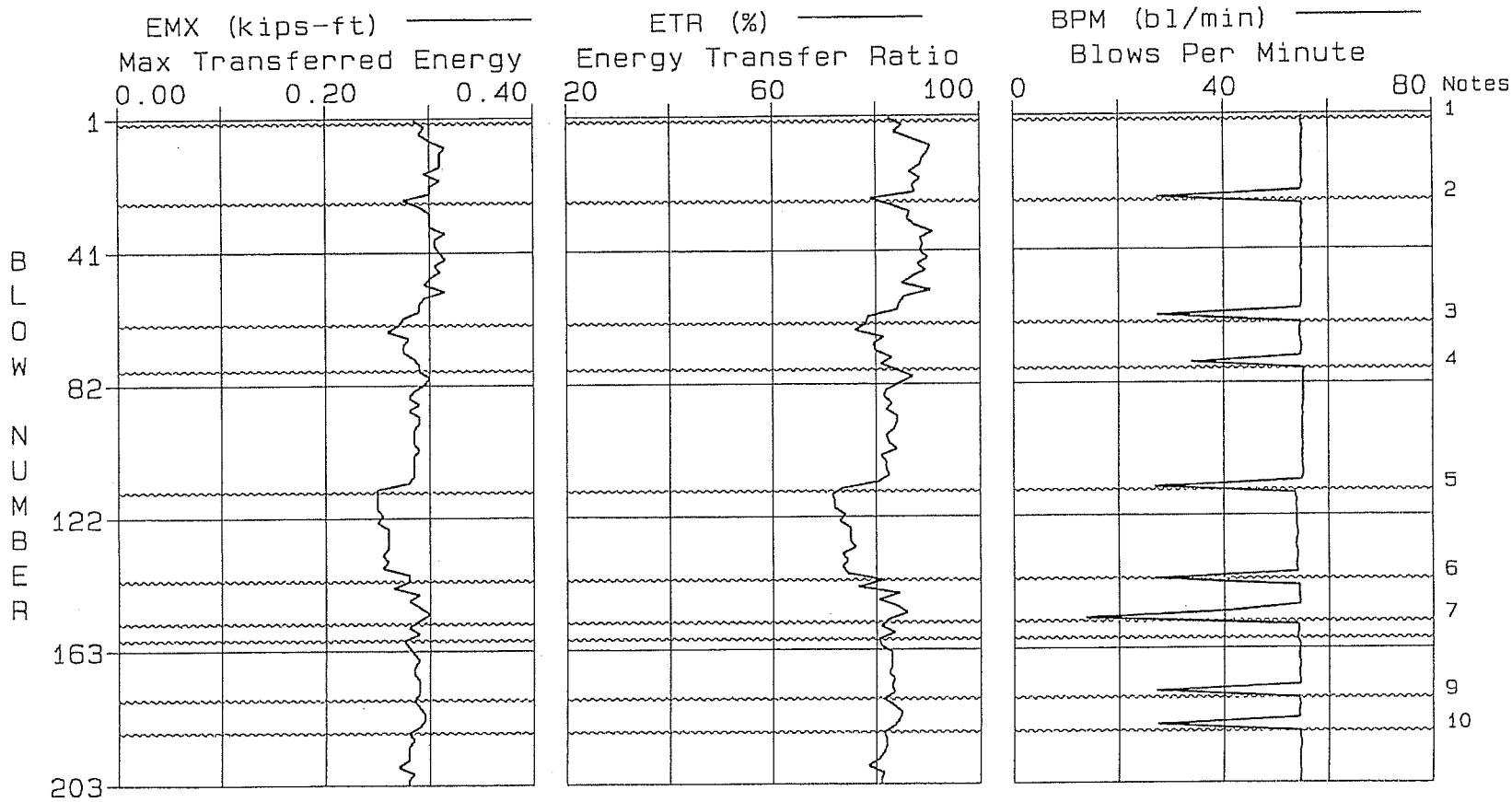
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

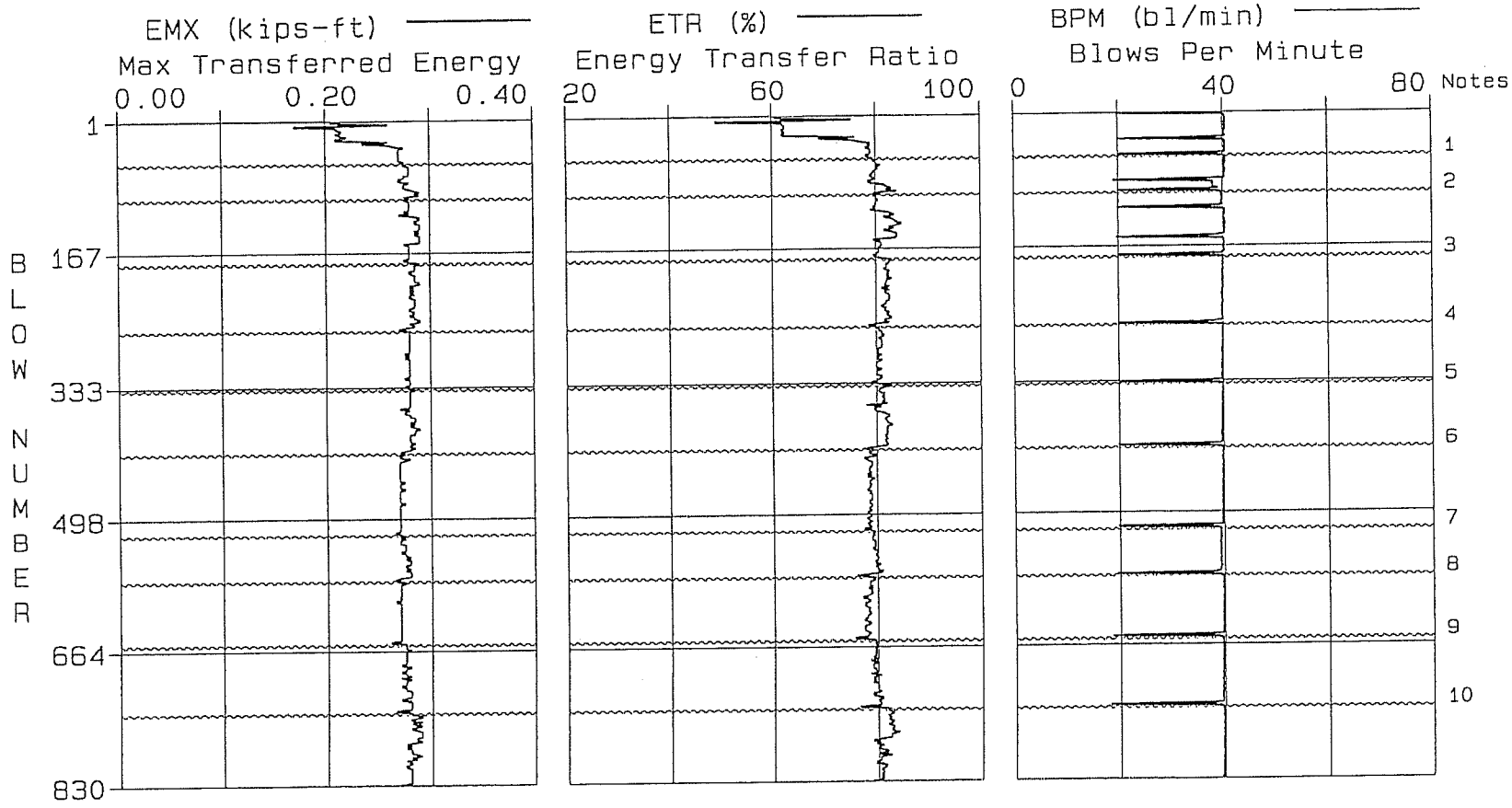
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004 Proj: ACTA HEIM BRIDGE PROJECT Pg1
Info: MUD ROTARY SP: 0.492 k/ft^3
AR: 1.4 in^2 WS: 16808 ft/s
LE: 163.0 ft EM: 30000 KSI

EMX: Max Transferred Energy BPM: Blows Per Minute
ETR: Energy Transfer Ratio CSX: Max Measured C-Stress
E2F: UNDEFINED CSI: Max F1 or F2 C-Stress
EF2: Energy by F^2 Method TSX: Max Computed T-Stress
EV2: UNDEFINED

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

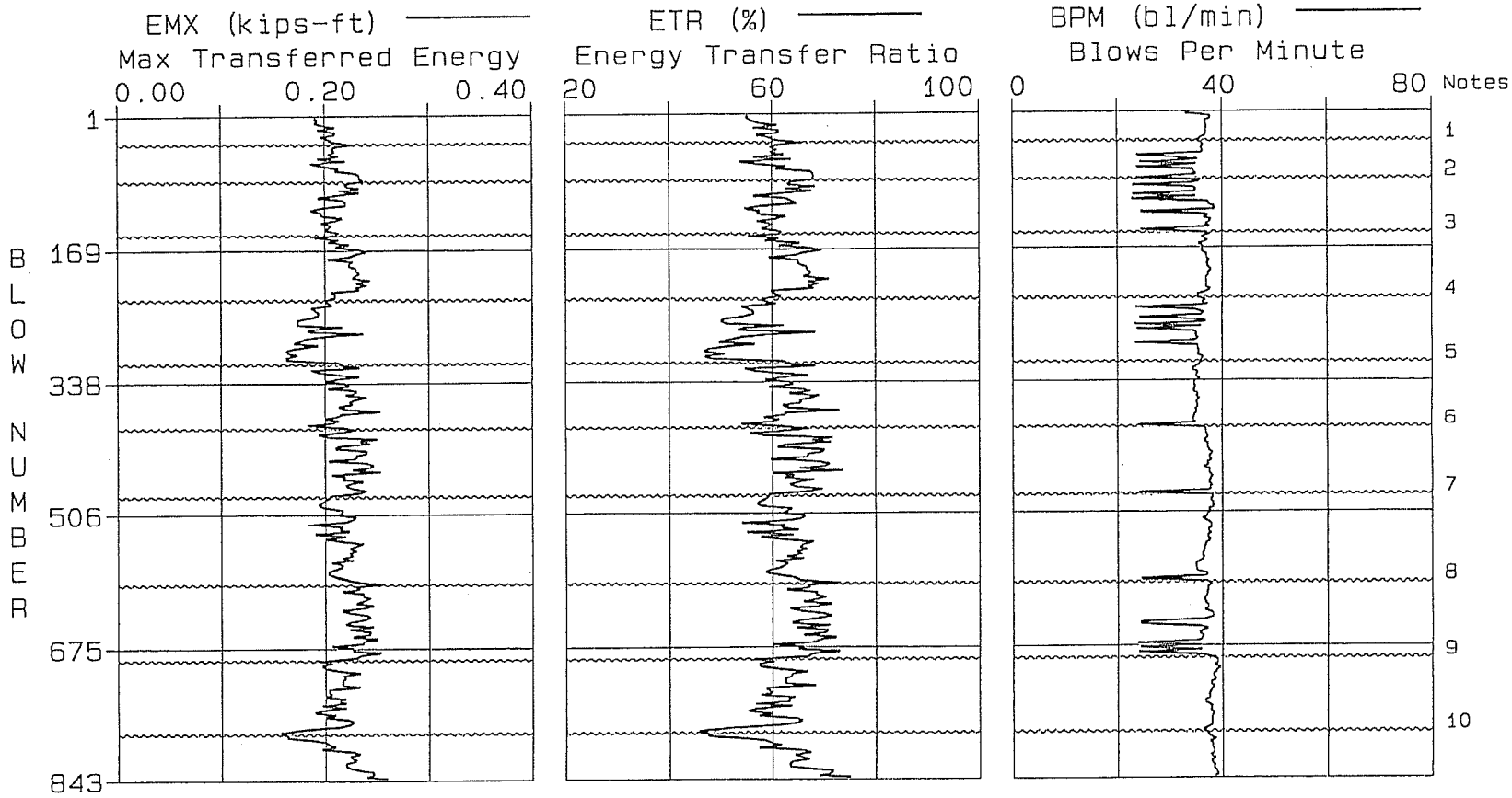
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009 Proj: ACTA HEIM BRIDGE PROJECT Pg1
Info: MUD ROTARY- rope and cathead SP: 0.492 k/ft^3
AR: 1.4 in^2 WS: 16808 ft/s
LE: 165.0 ft EM: 30000 KSI

EMX: Max Transferred Energy BPM: Blows Per Minute
ETR: Energy Transfer Ratio CSX: Max Measured C-Stress
E2F: UNDEFINED CSI: Max F1 or F2 C-Stress
EF2: Energy by F^2 Method TSX: Max Computed T-Stress
EV2: UNDEFINED

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

Appendix D. GeoVision Geophysical Investigation Report

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

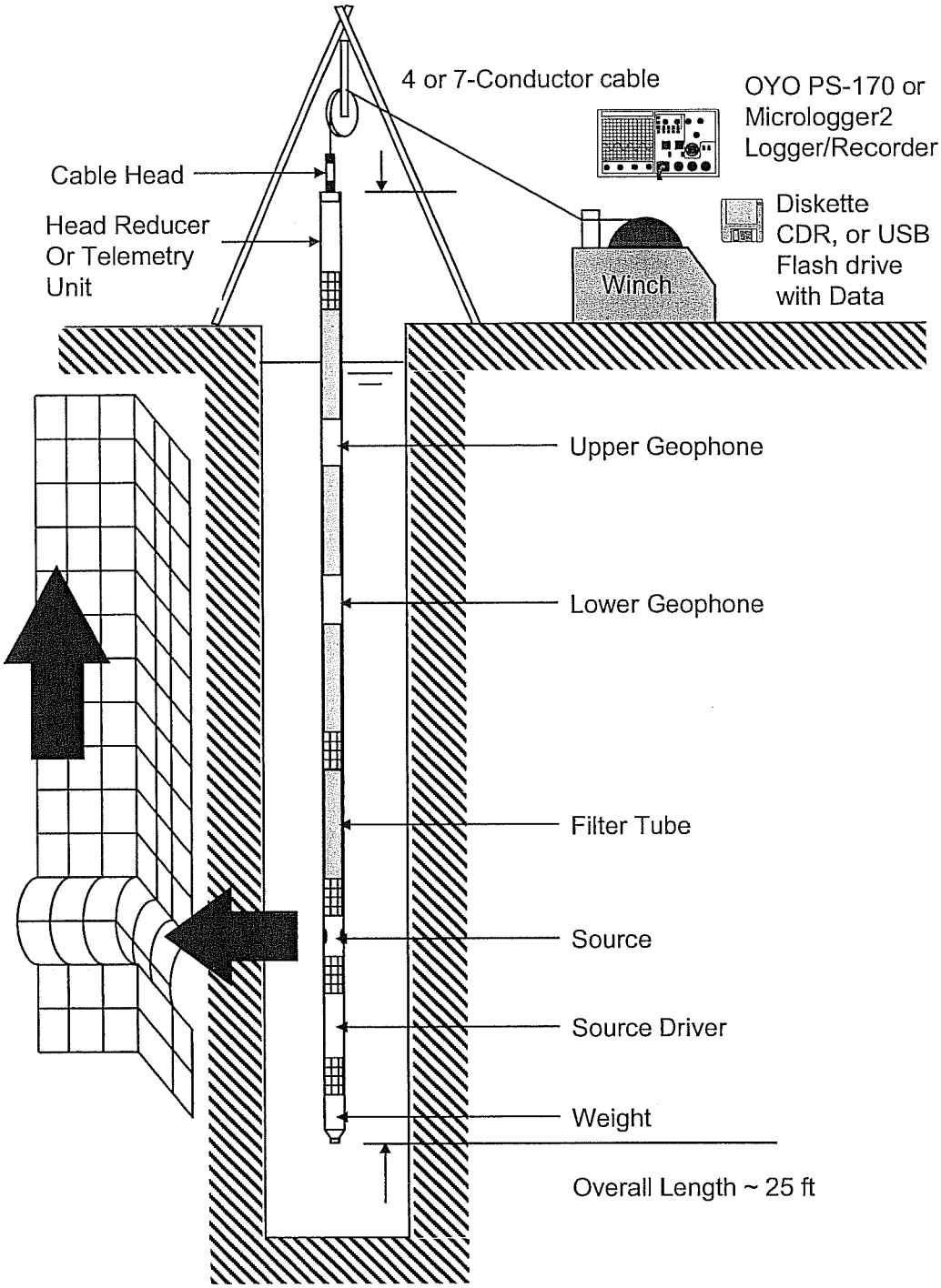

Figure 1: Concept illustration of P-S logging system

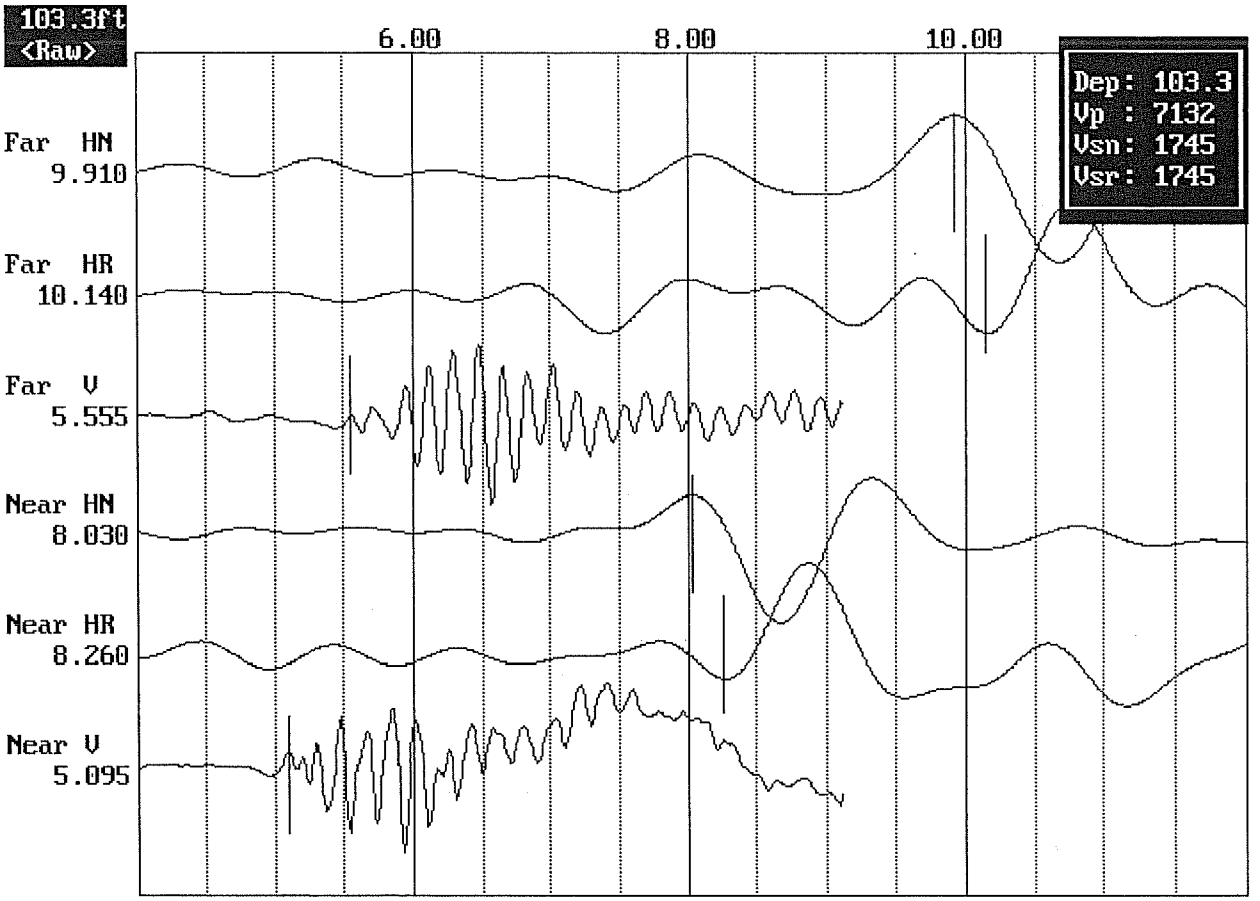

Figure 2: Example of filtered (1400 Hz lowpass) record

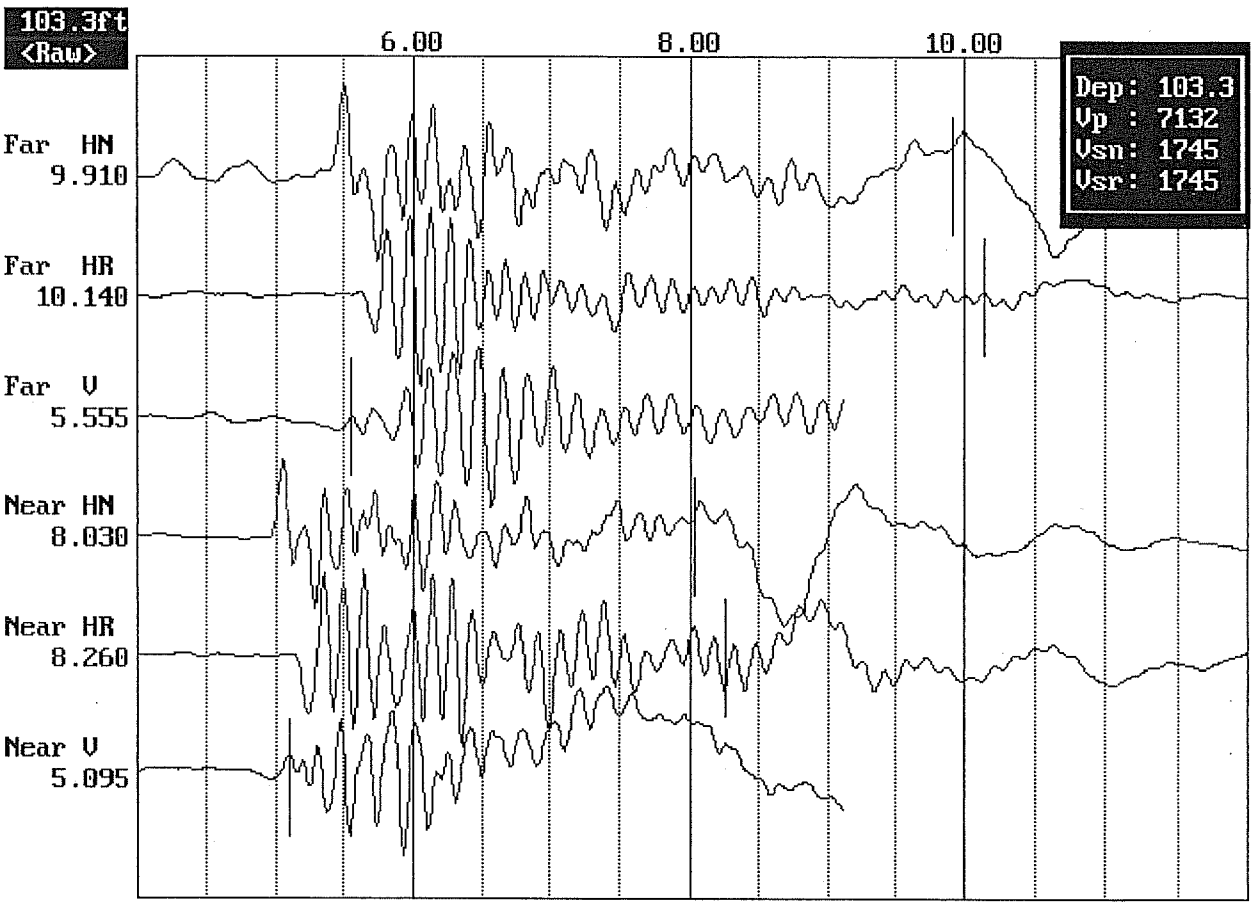

Figure 3. Example of unfiltered record

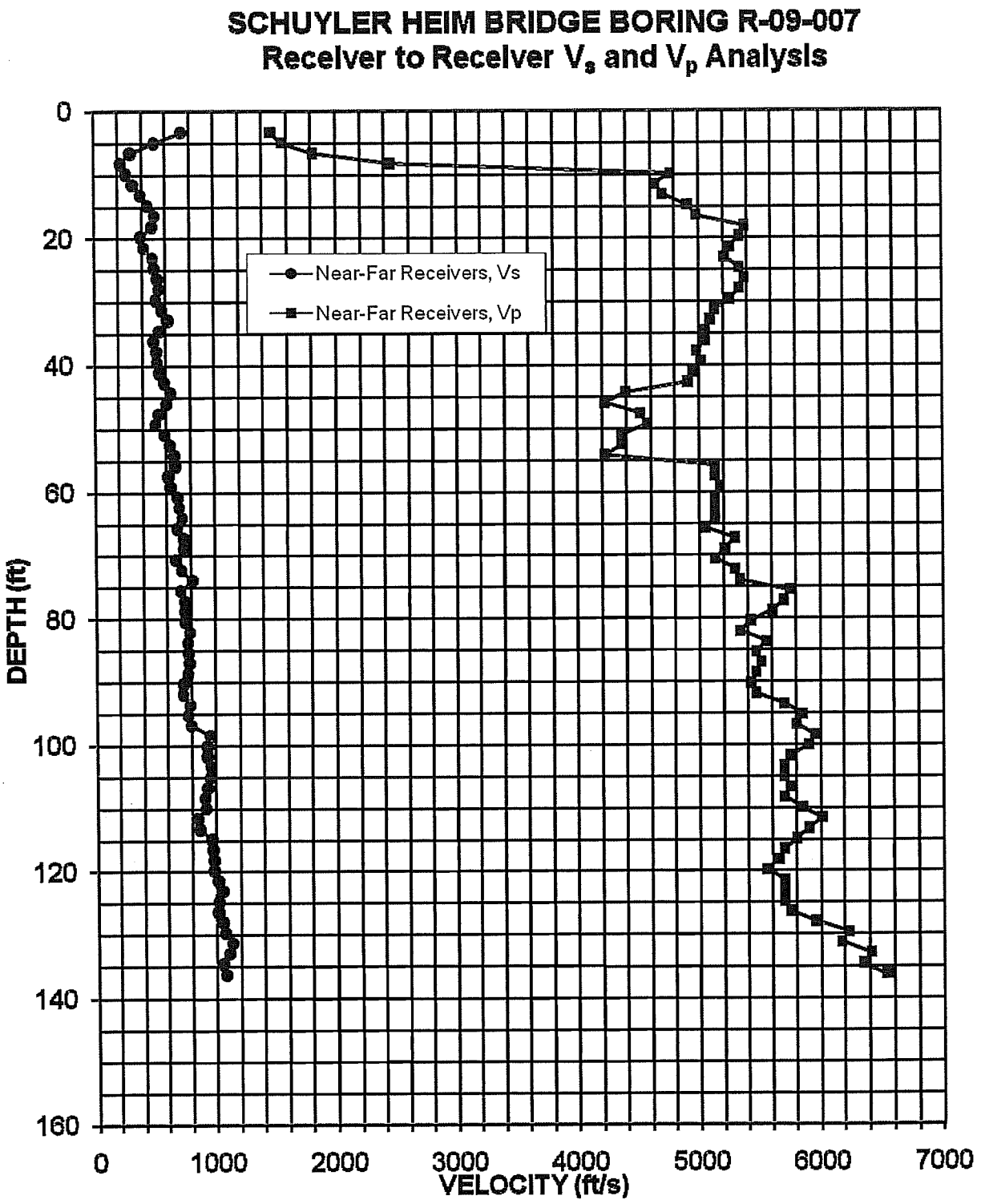

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

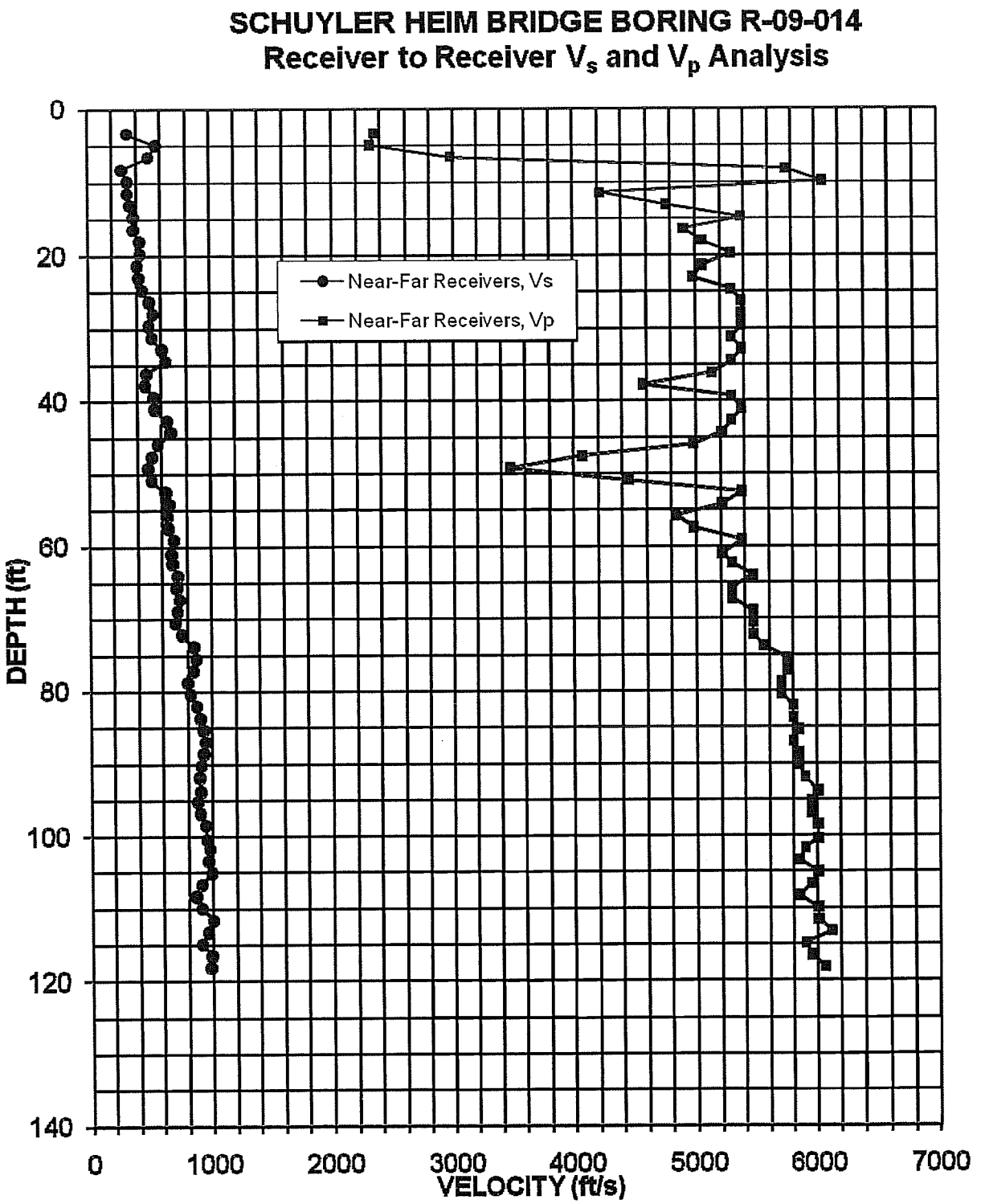

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

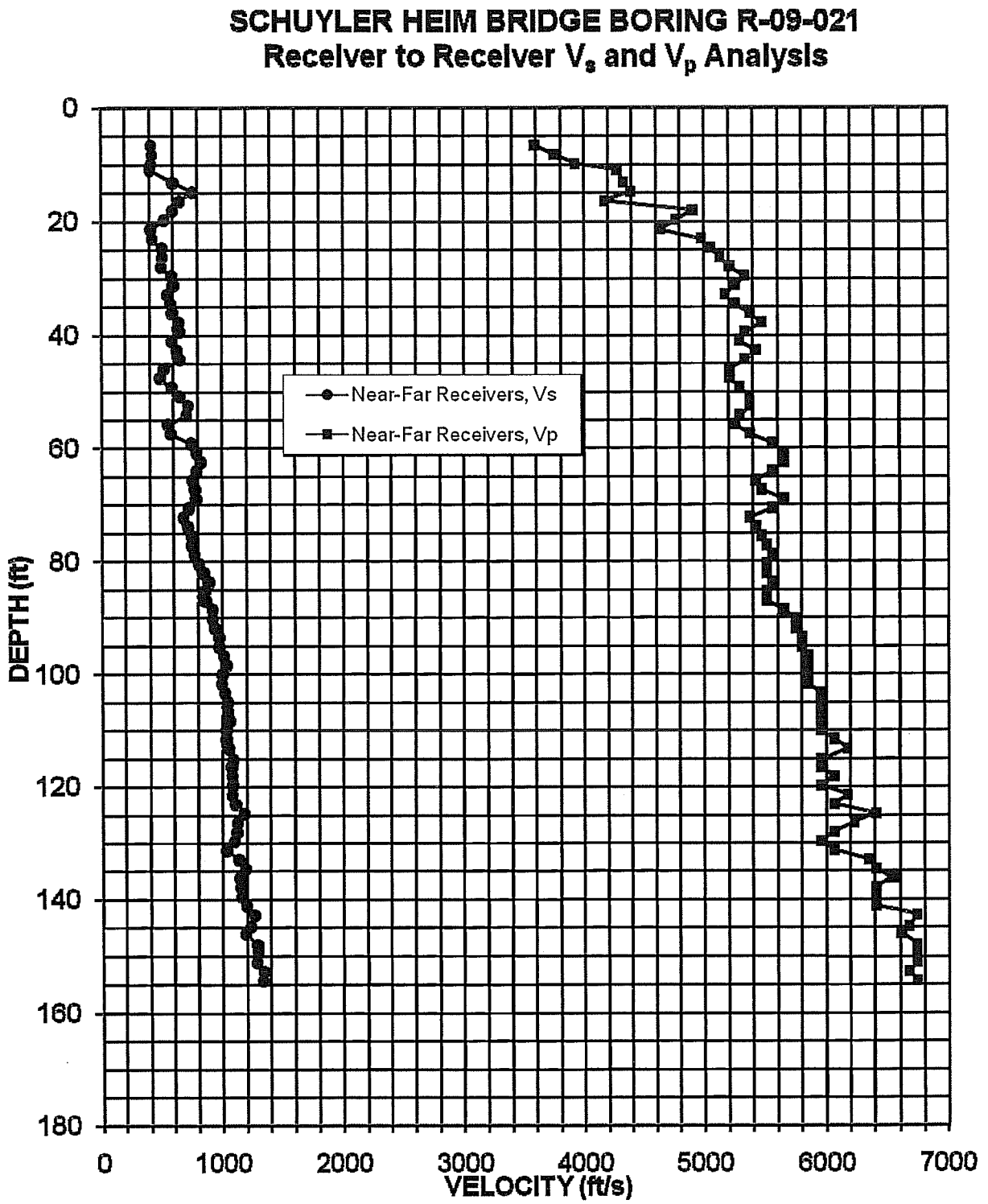

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

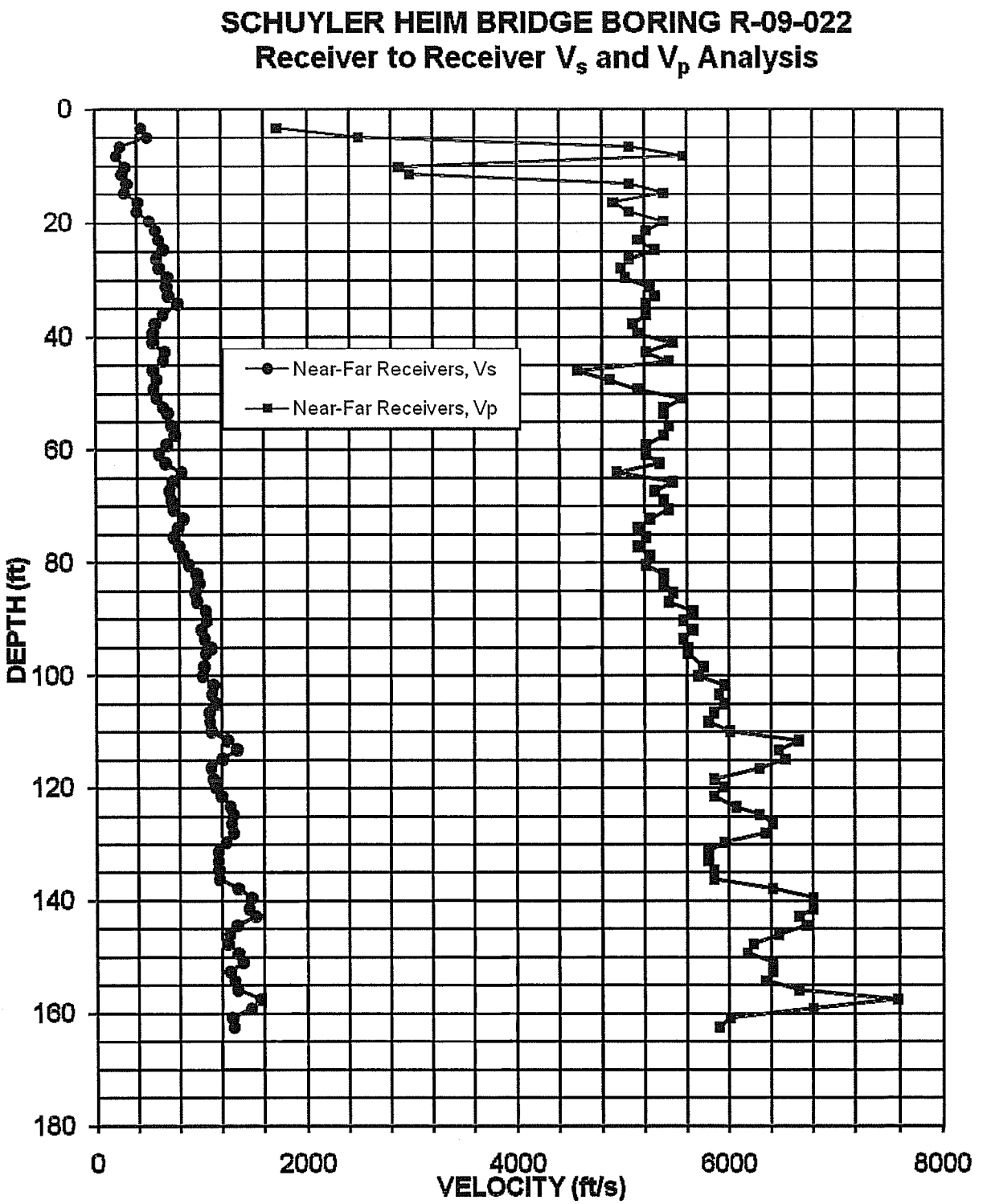

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

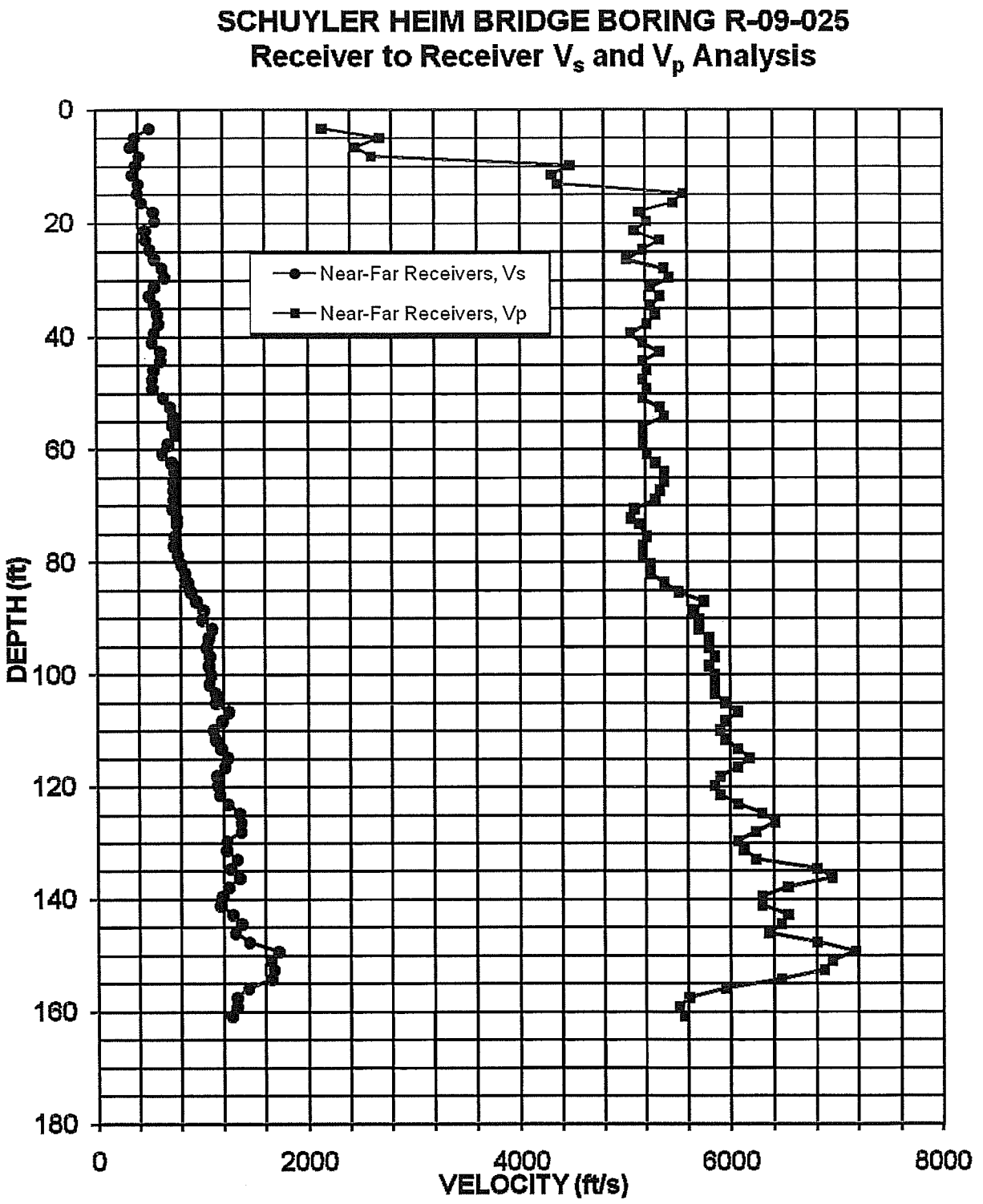

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

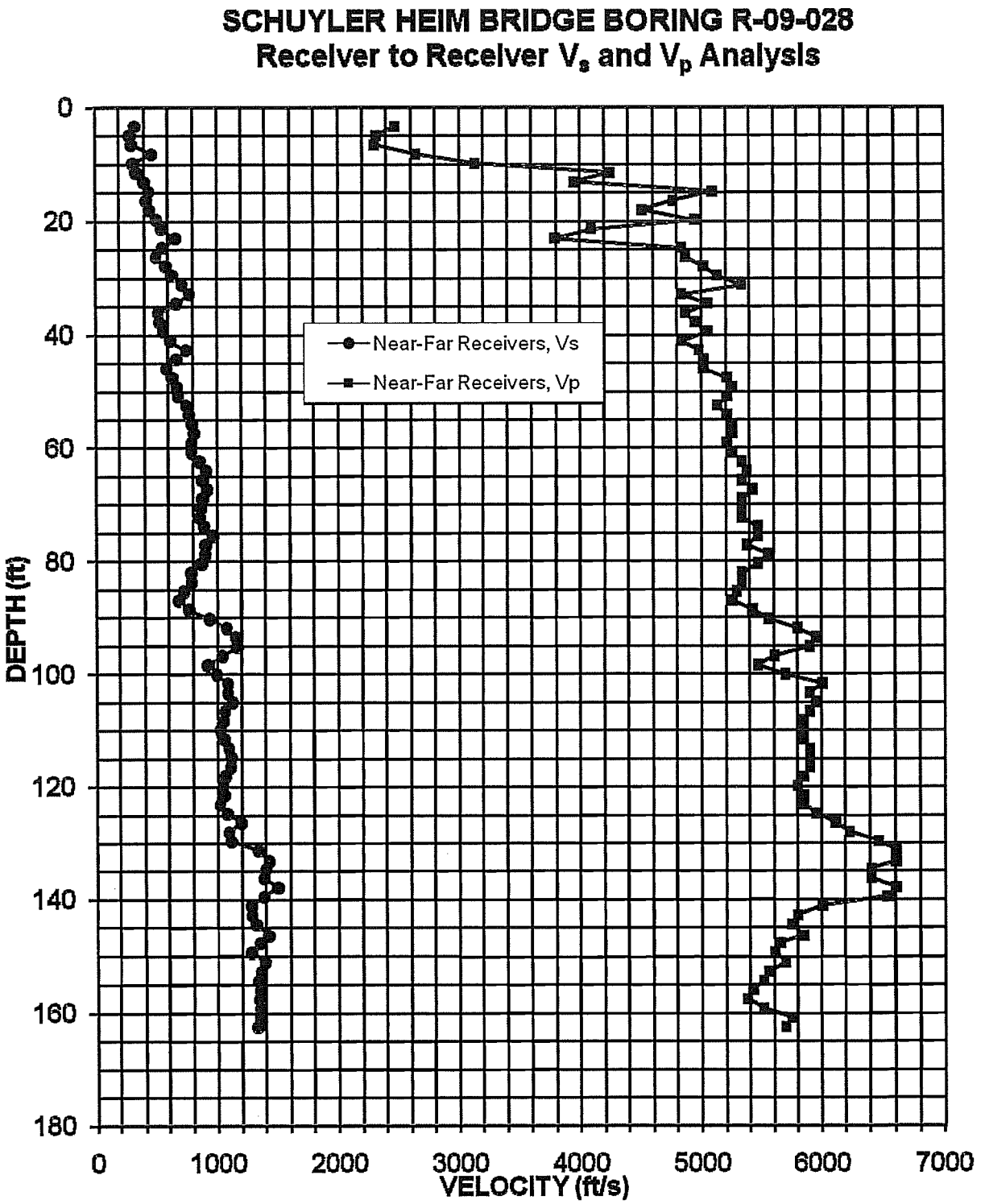

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

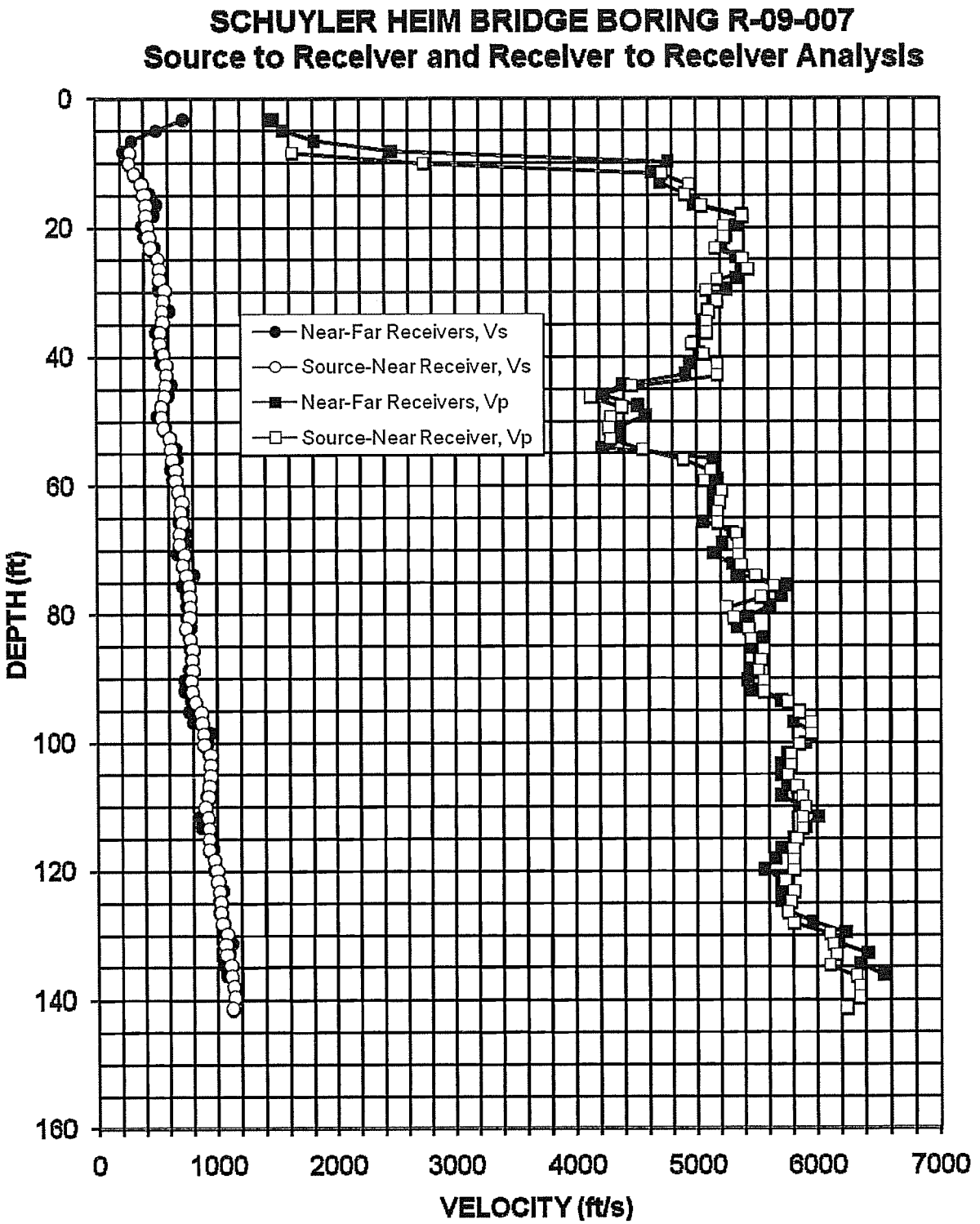

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

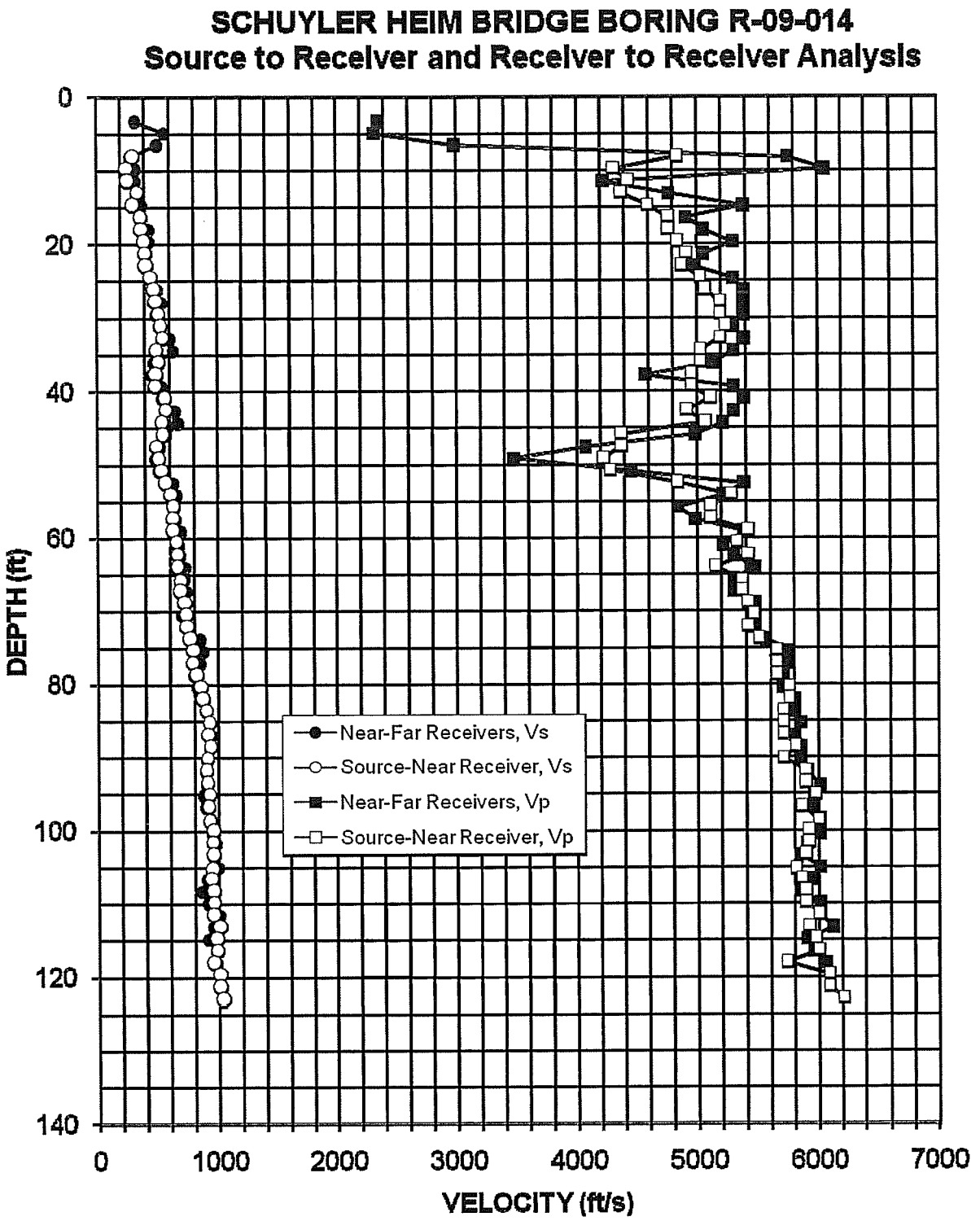

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

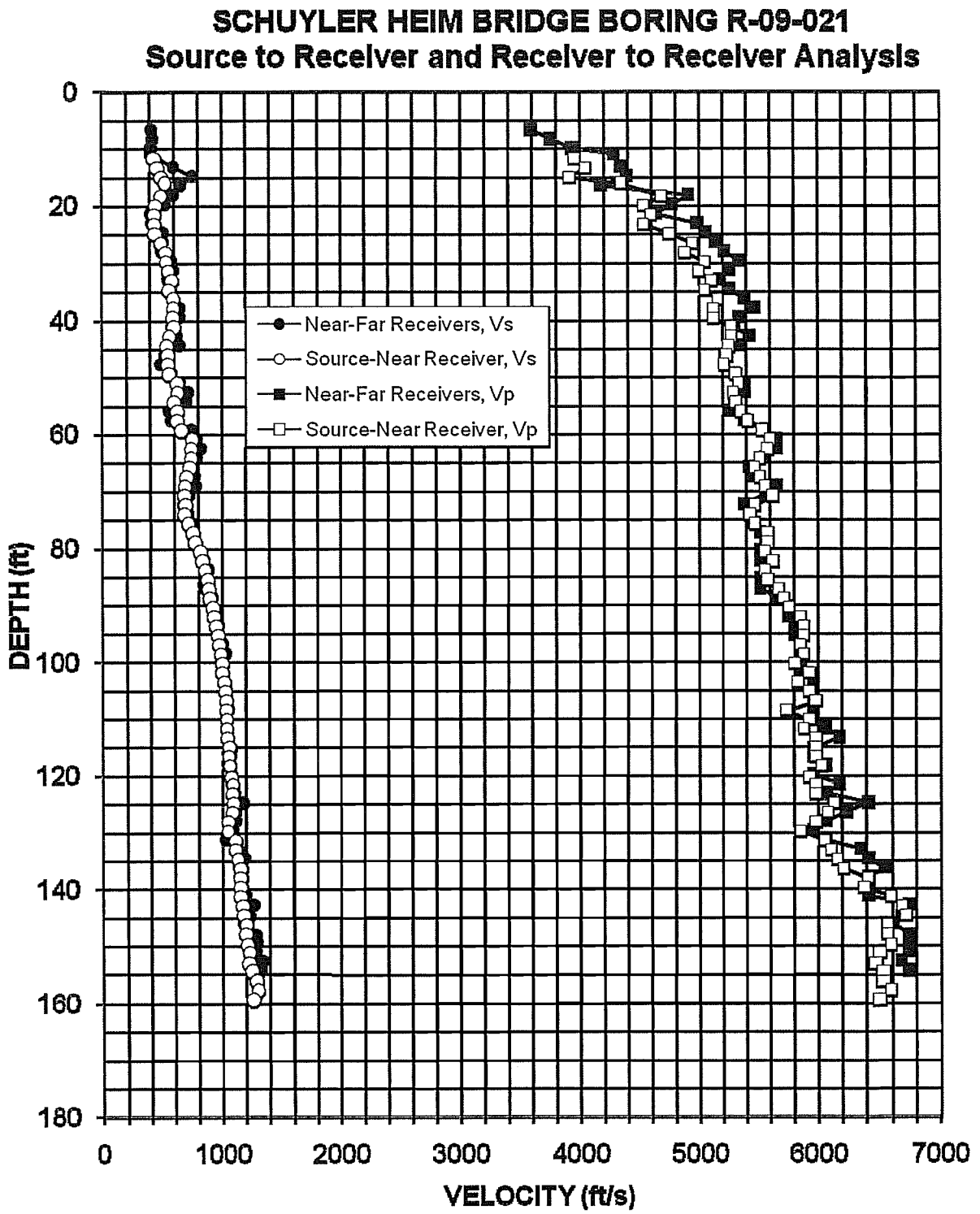

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

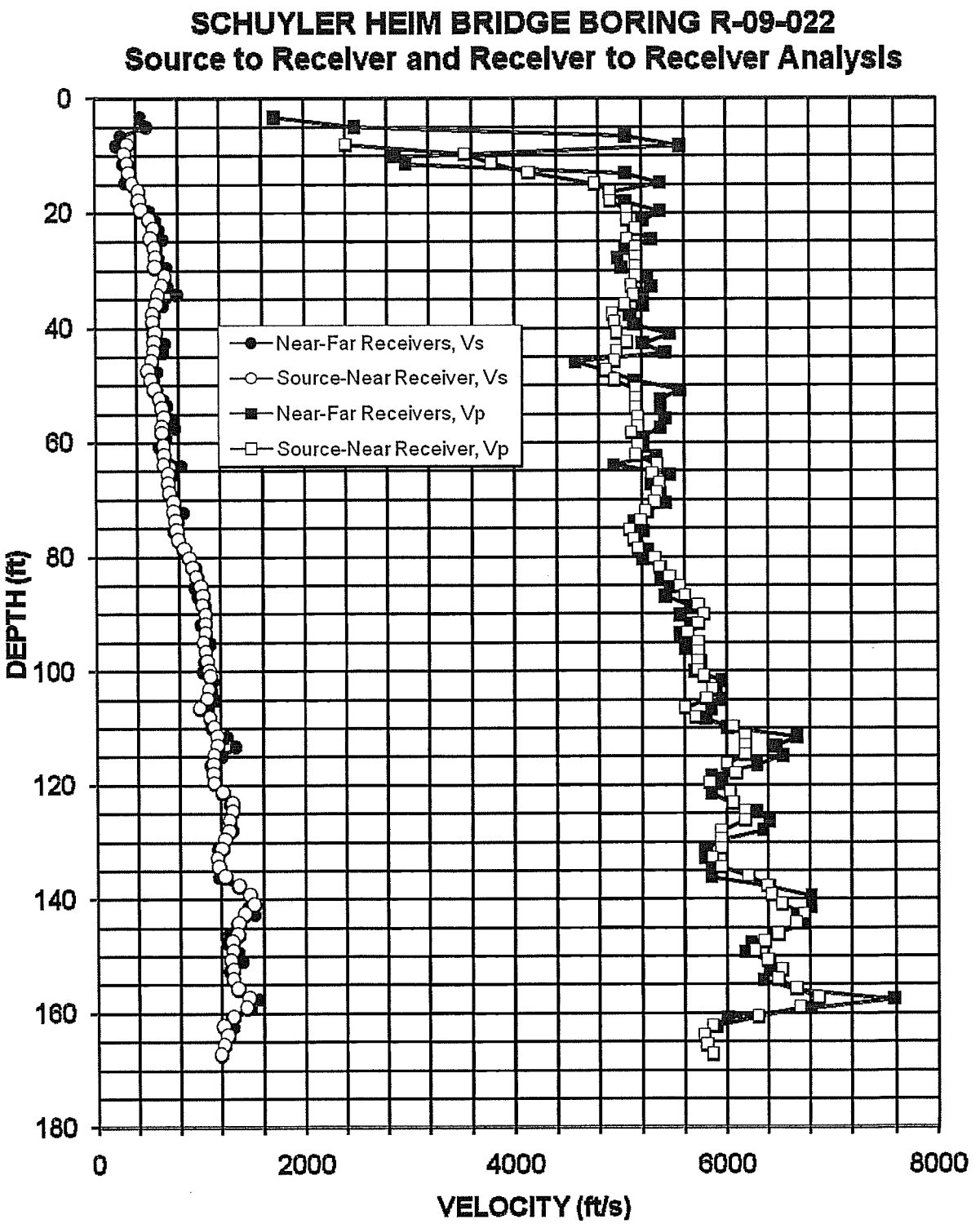

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

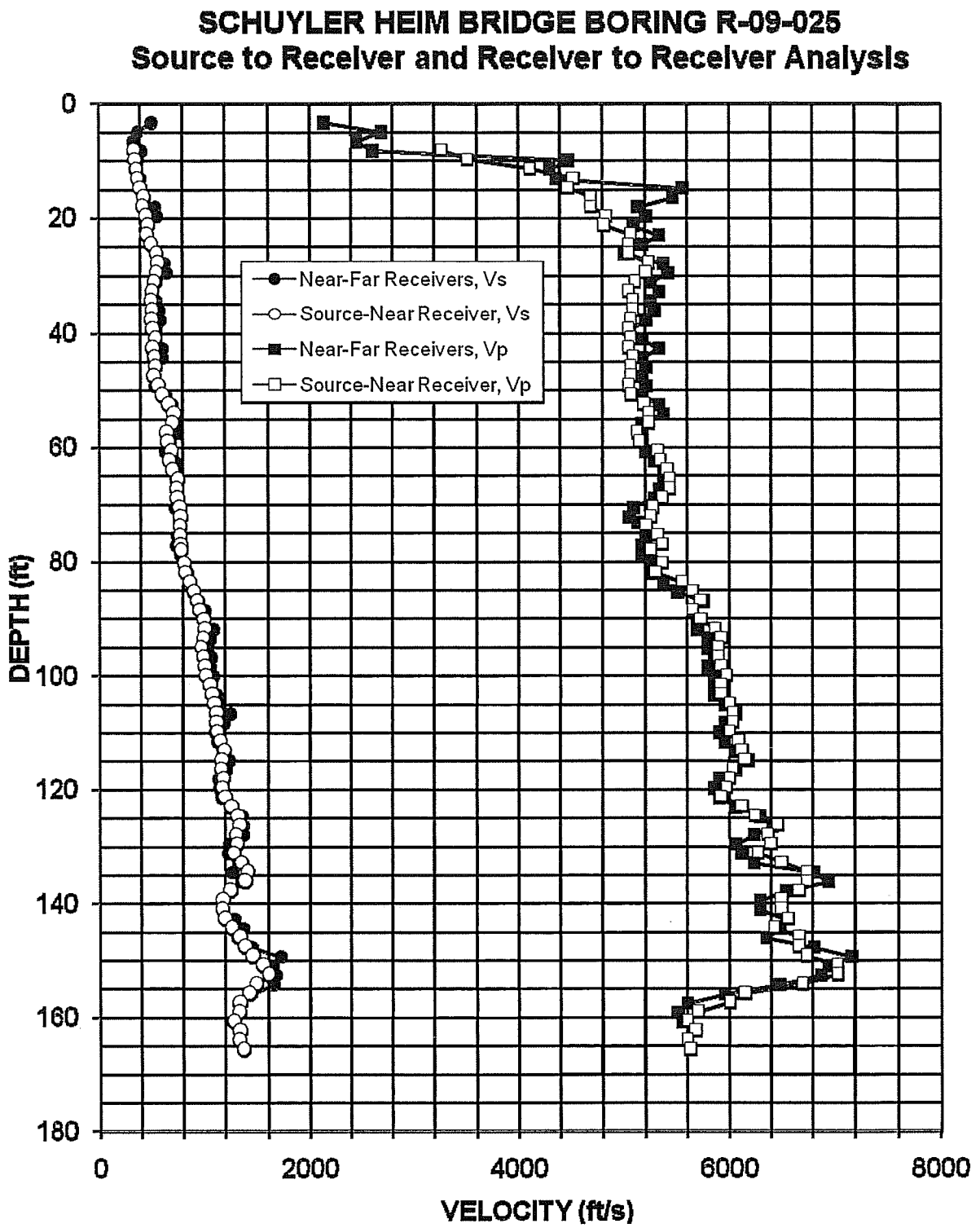

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

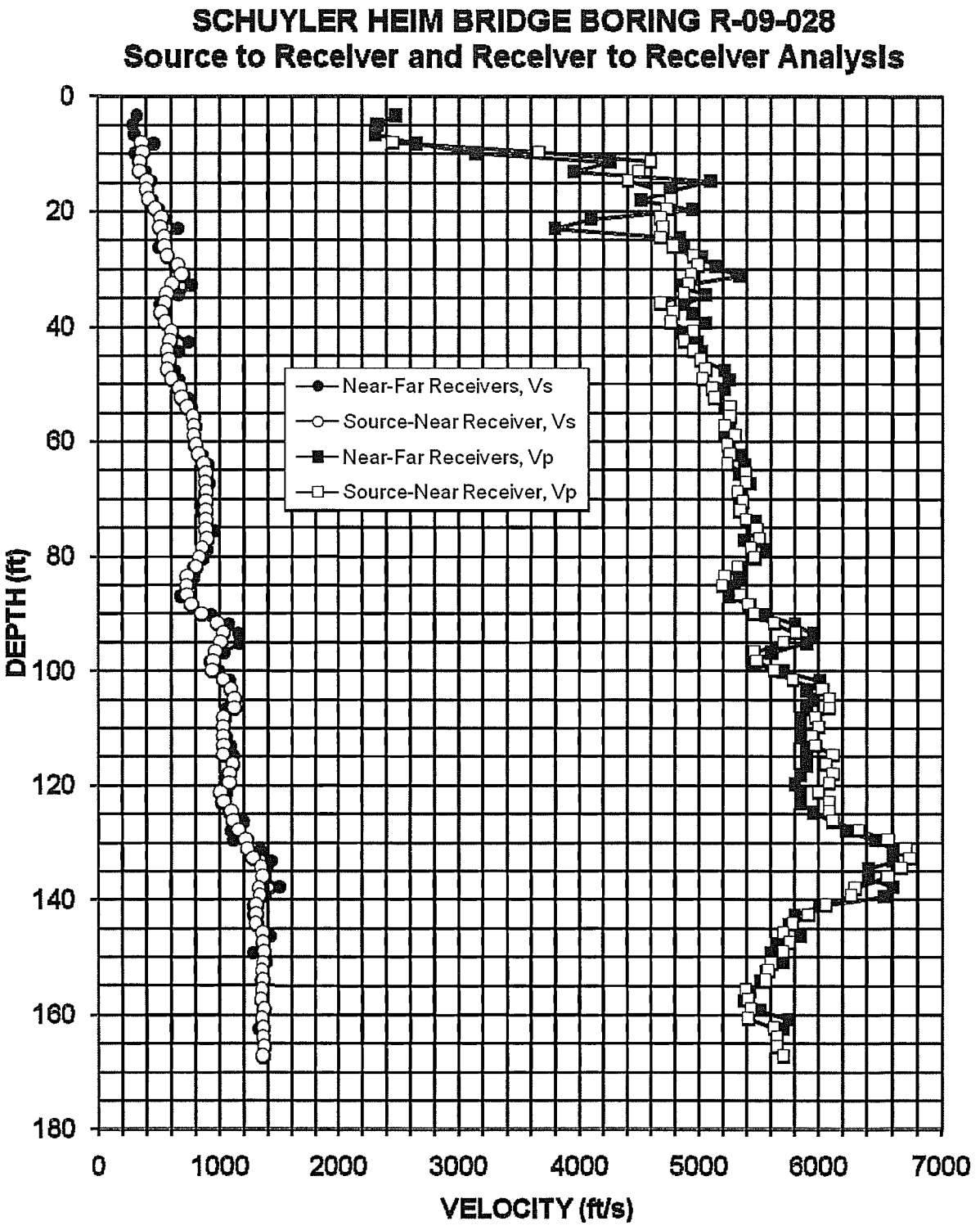

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver (ft)	Velocity V_s (ft/s)	Velocity V_p (ft/s)	Poisson's Ratio
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver (m)	Velocity V_s (m/s)	Velocity V_p (m/s)	Poisson's Ratio
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®

Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:

The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CXB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson	
	Name	Date		Signature
Witnessed by:	Robert Steller	7/17/2009		
	Name	Date		Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

MudCats CPM: Version 2.2.2 (Professional)
Src DUI: {9548AF3D-C74D-4C9F-AEEF-21EF560BC451} (c)
Doc DUI: {1269C0B2-3A13-416A-81BF-409D9887DDDA} (o)

ATTACHMENT 2
Page 1 of 2

Customer

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160824 Project Number 06-123 3-17 CA-3

~~160024~~

573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

Appendix E. Laboratory Soil Test Results

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/01/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-011	D-02	10	27.2	91.4
R-09-011	D-04	20	26.6	97.2
R-09-011	S-07	35	39.1	NA
R-09-011	D-08	40	35.1	87.9
R-09-011	D-10	50	39.8	78.5
R-09-011	S-11	55	38.8	NA
R-09-011	S-13	65	32.2	NA
R-09-011	S-15	75	21.8	NA
R-09-011	D-16	80	28.9	97.1
R-09-011	S-19	110	22.1	NA
R-09-011	S-23	150	18.7	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-011	D-10	50	0.50
R-09-011	U-14	70	3.25

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	12/04/09
Project Number:	06-123-03		

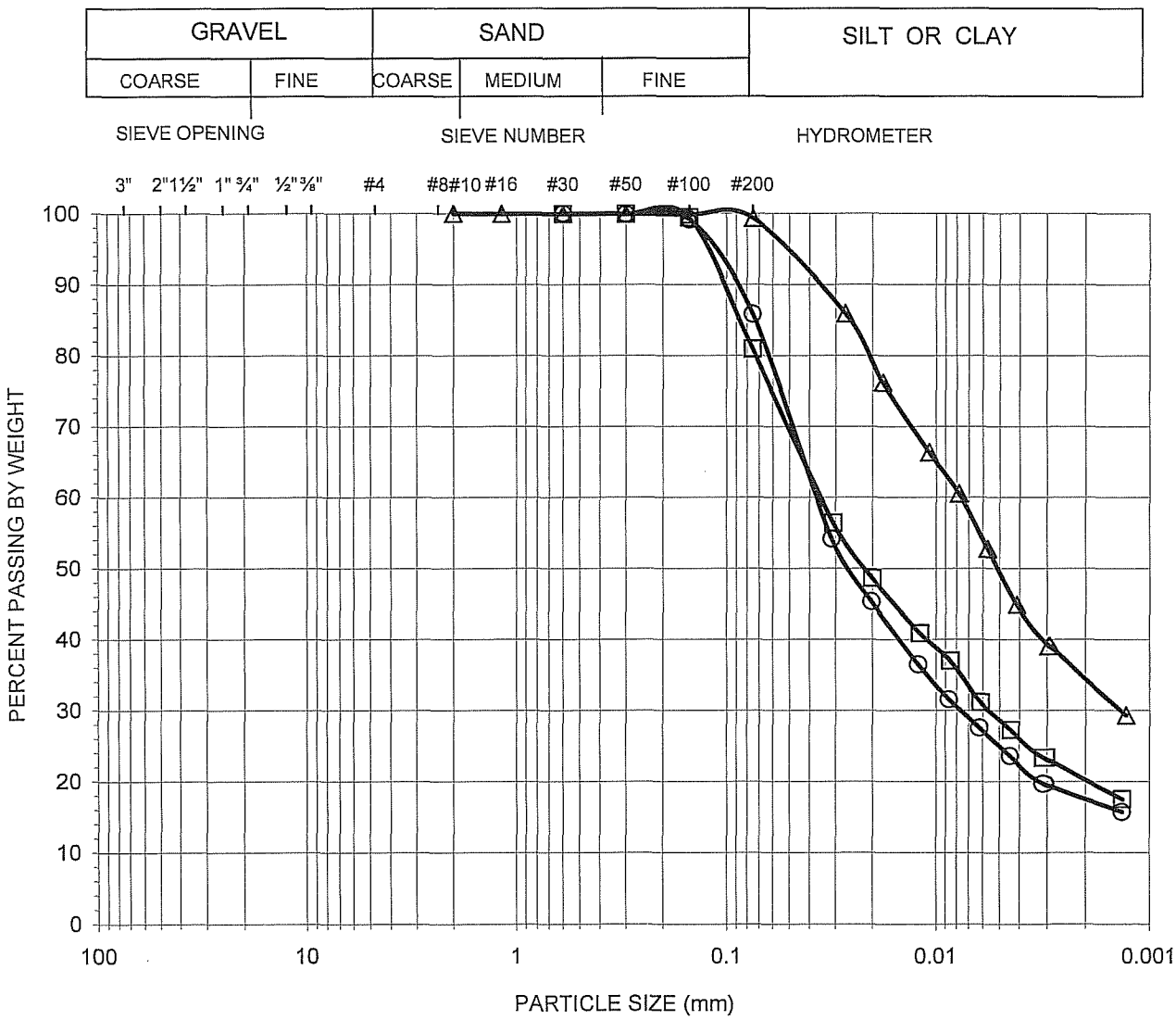
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-011	D-02	10	6.60
R-09-011	D-04	20	4.17
R-09-011	U-06	30	23.02

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

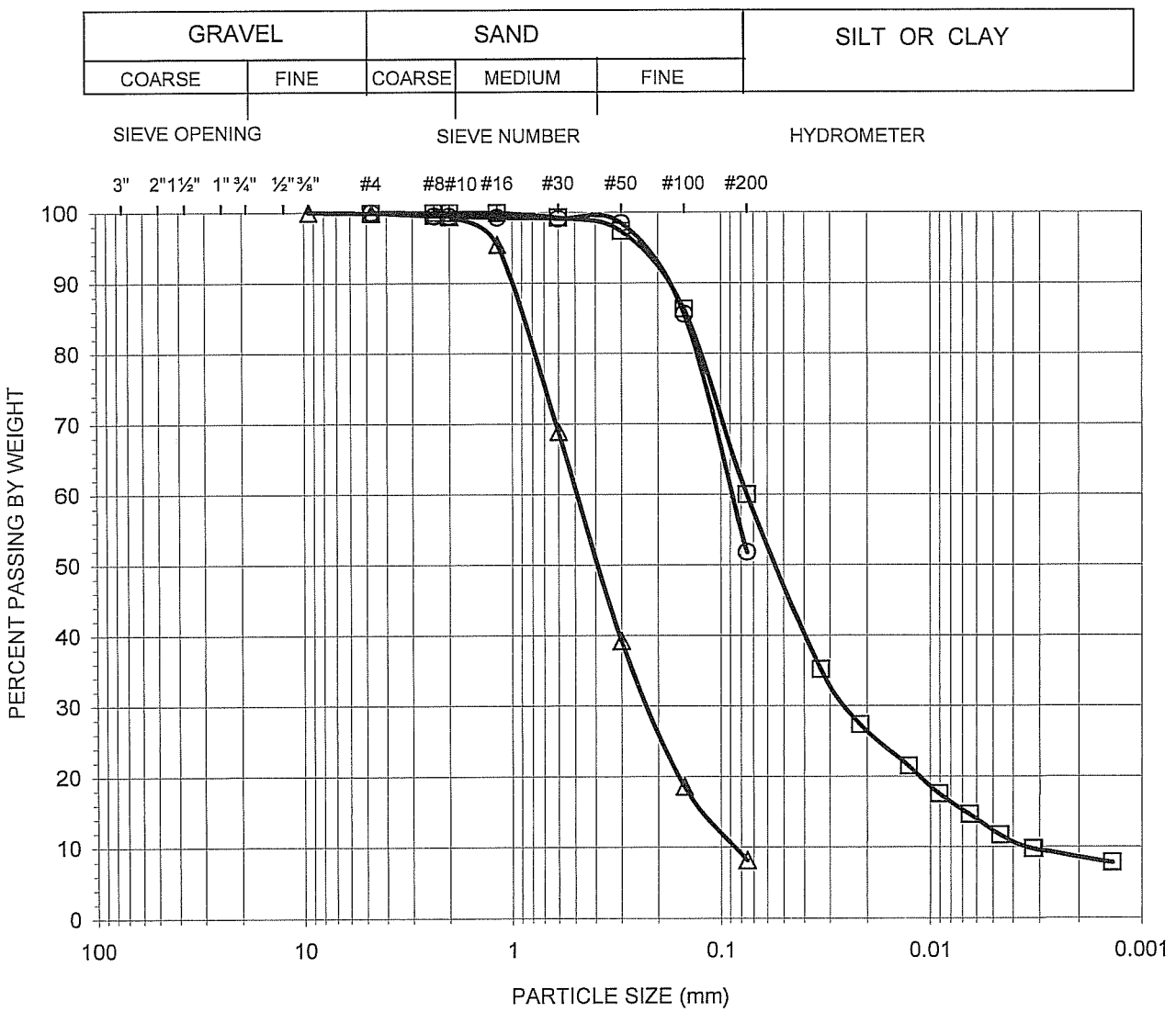


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-07	35	0.00	14.12	85.88	29:23:6	CL-ML
□	R-09-011	D-08	40	0.00	19.09	80.91	29:22:7	CL-ML
△	R-09-011	D-10	50	0.00	0.65	99.35	51:23:28	CH

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

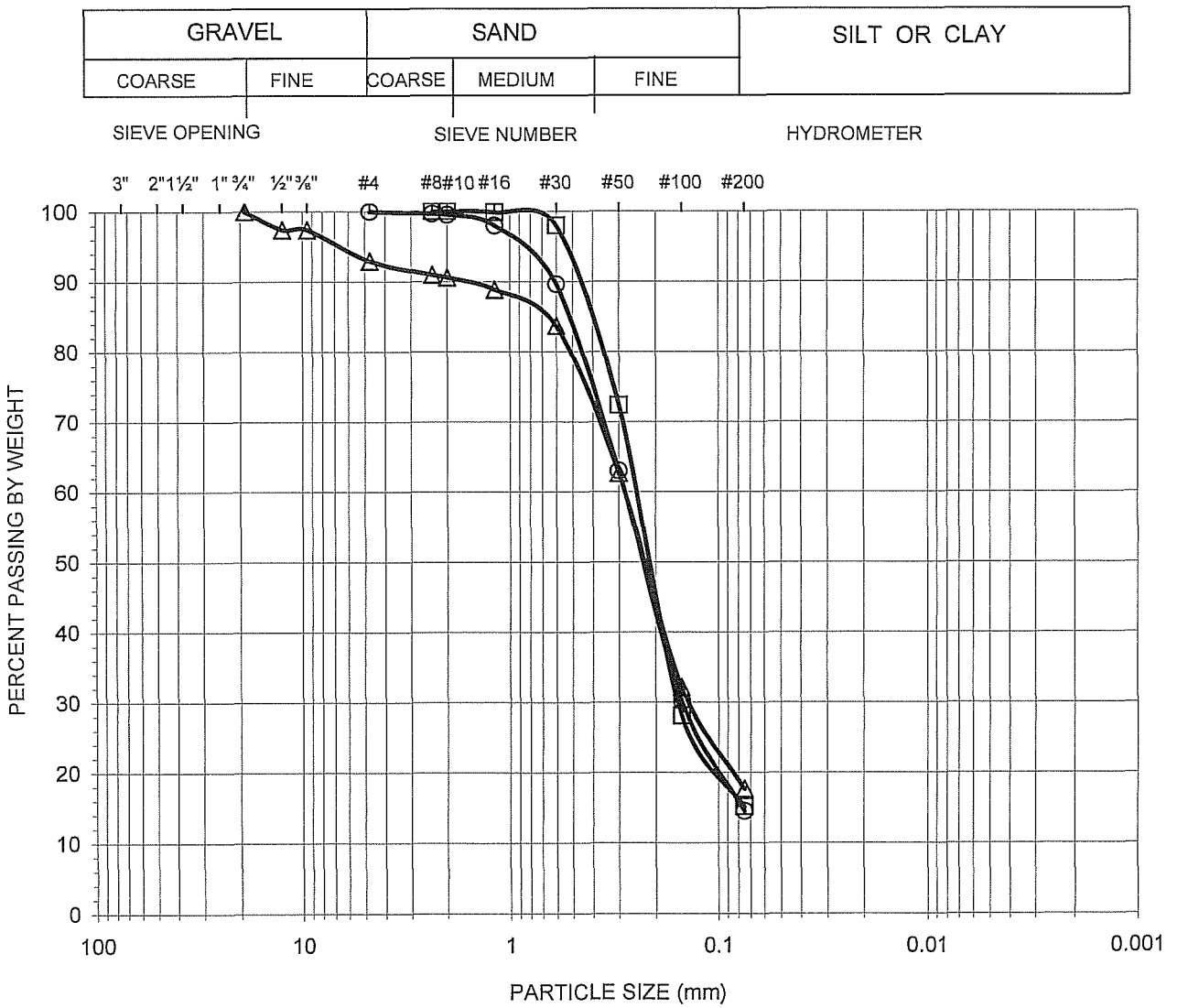


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	D-12	60	0.00	48.16	51.84	N/A	ML
□	R-09-011	U-14	70	0.00	40.02	59.98	N/P	ML
△	R-09-011	S-15	75	0.07	91.69	8.24	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



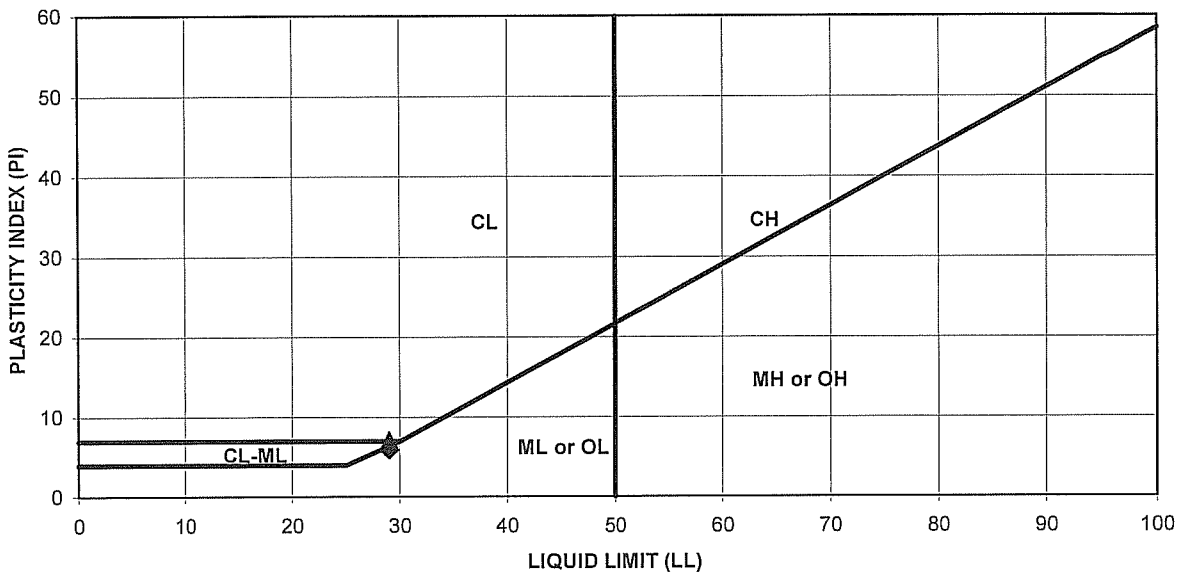
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-17	90	0.00	85.42	14.58	N/A	SM
□	R-09-011	S-19	110	0.00	84.84	15.16	N/A	SM
△	R-09-011	S-23	150	7.02	75.27	17.71	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

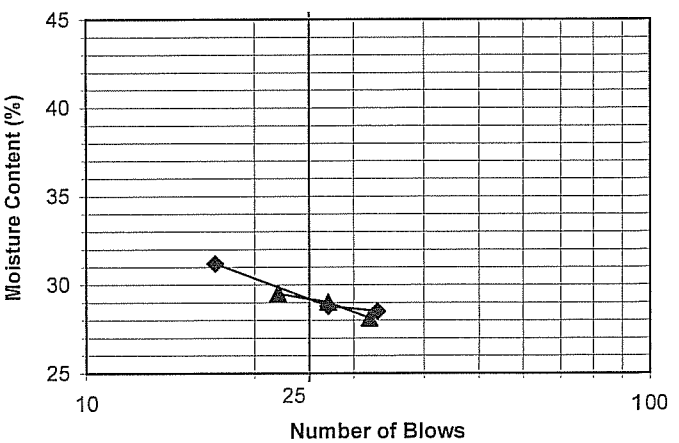
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



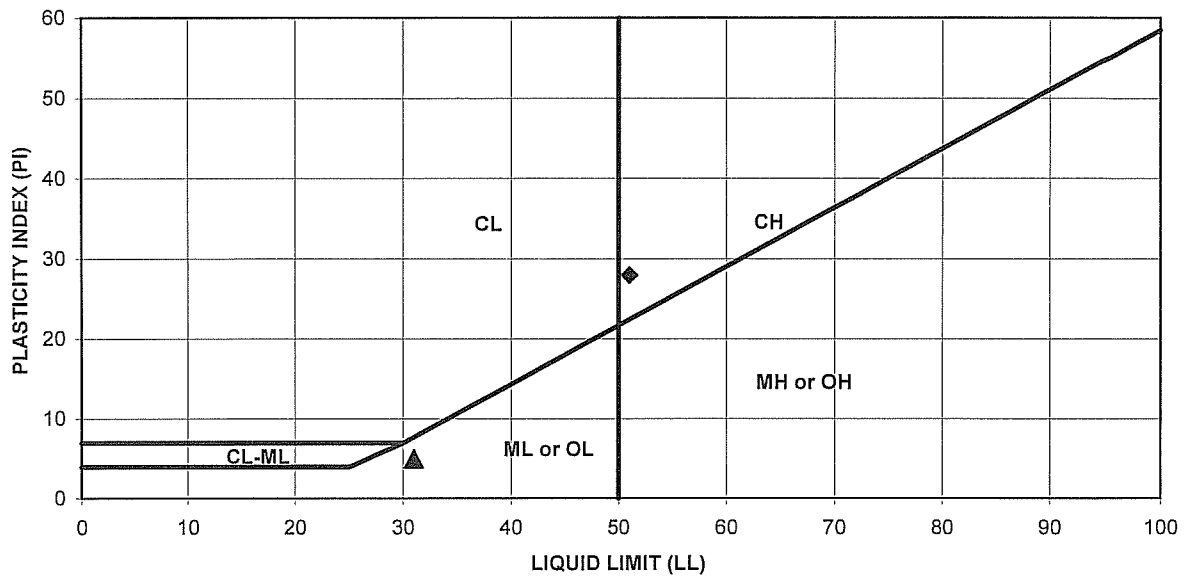
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-011	S-07	35	29	23	6	CL-ML
▲	R-09-011	D-08	40	29	22	7	CL-ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

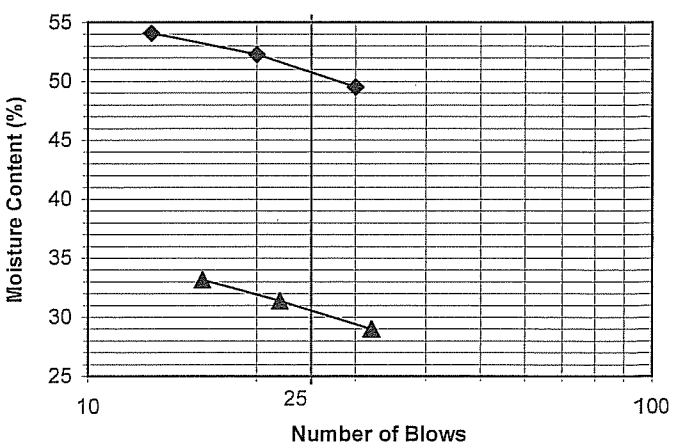
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



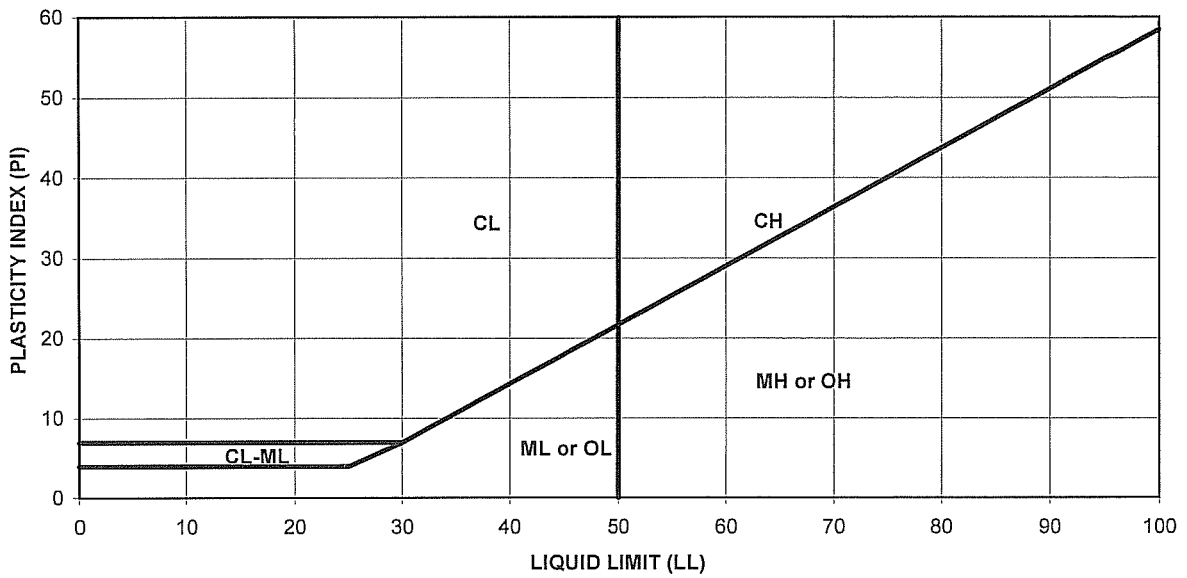
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-011	D-10	50	51	23	28	CH
▲	R-09-011	S-11	55	31	26	5	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

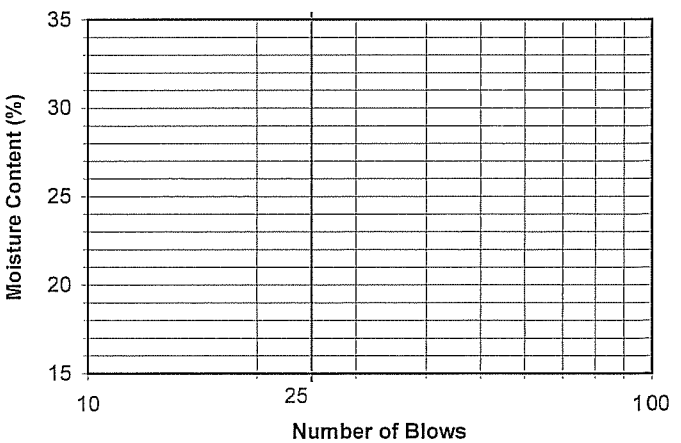
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-011	S-13	65	NP	NP	NP	
	R-09-011	U-14	70	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/30/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-011	S-03	15	SP-SM	200	7.5	514	568

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/11/09

Project No. : 06-123-03 Checked By: AP Date: 12/11/09

BORING NUMBER	R-09-011					
SAMPLE NUMBER	U-14					
DEPTH (FT)	70					
SOIL CLASSIFICATION	Sandy Silt					
METHOD (A OR B)	B					
FLASK NUMBER	2					
WT. FLASK+WATER+SOIL, g	368.25					
TEMPERATURE, °C	19.8					
CORRECTION FACTOR	1.0000					
WT. DRY SOIL, g	46.78					
WT. FLASK + WATER, g	249.30					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.69**					

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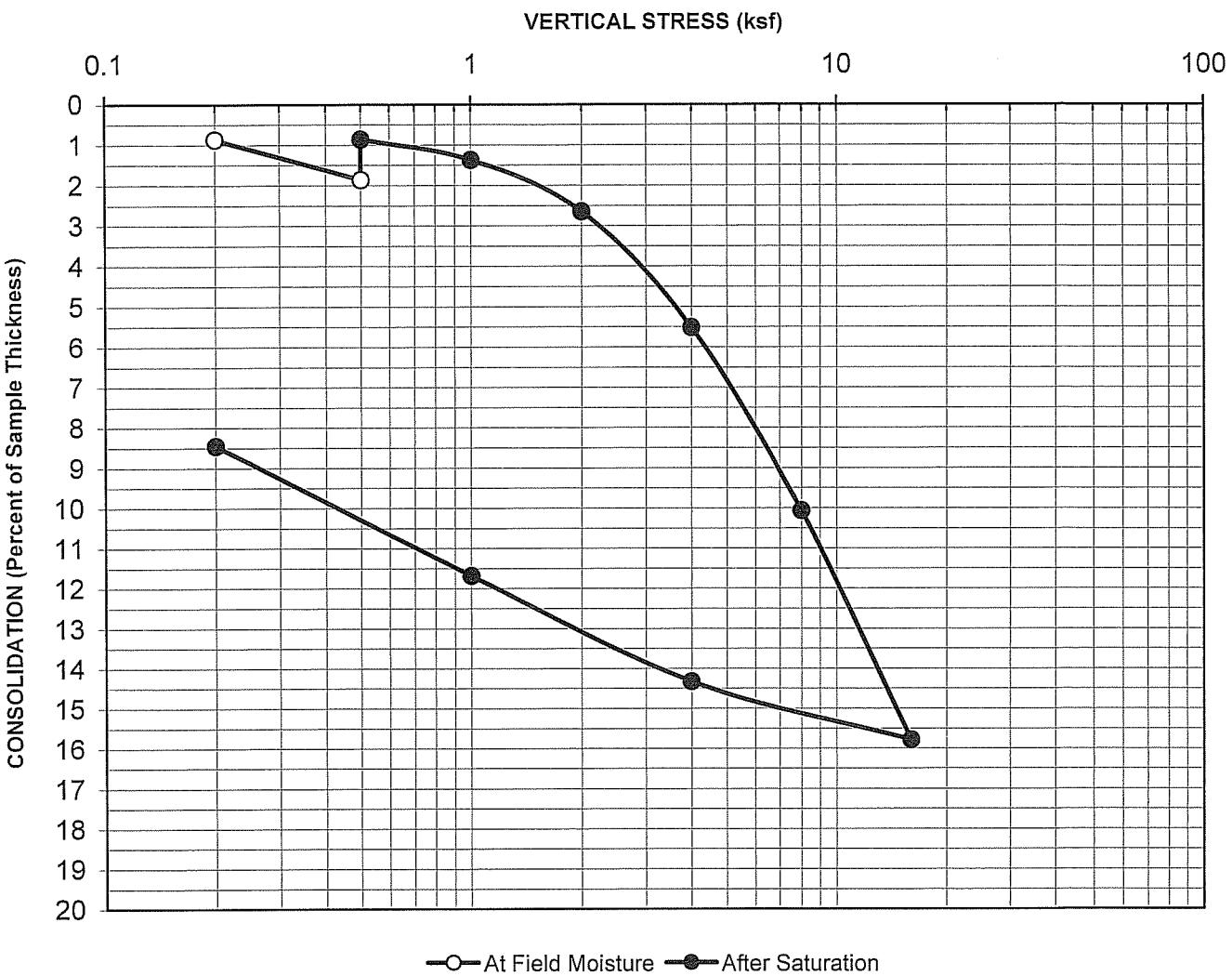
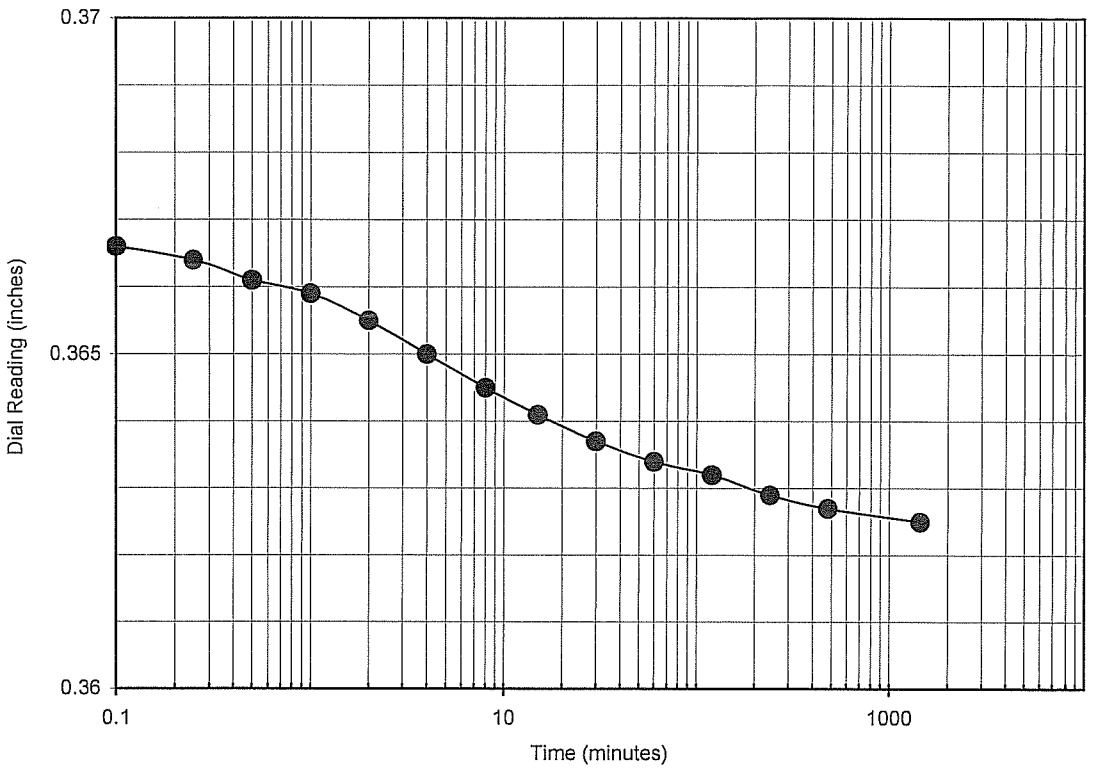
AP Engineering & Testing, Inc.



Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	77.3
Sample No.:	D-10	Initial Moisture Content (%):	39.8
Depth (feet):	50	Final Moisture Content (%):	39.1
Sample Type:	Mod. Cal.	Assumed Specific Gravity:	2.7
Soil Description:	Fat Clay	Initial Void Ratio:	1.18
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

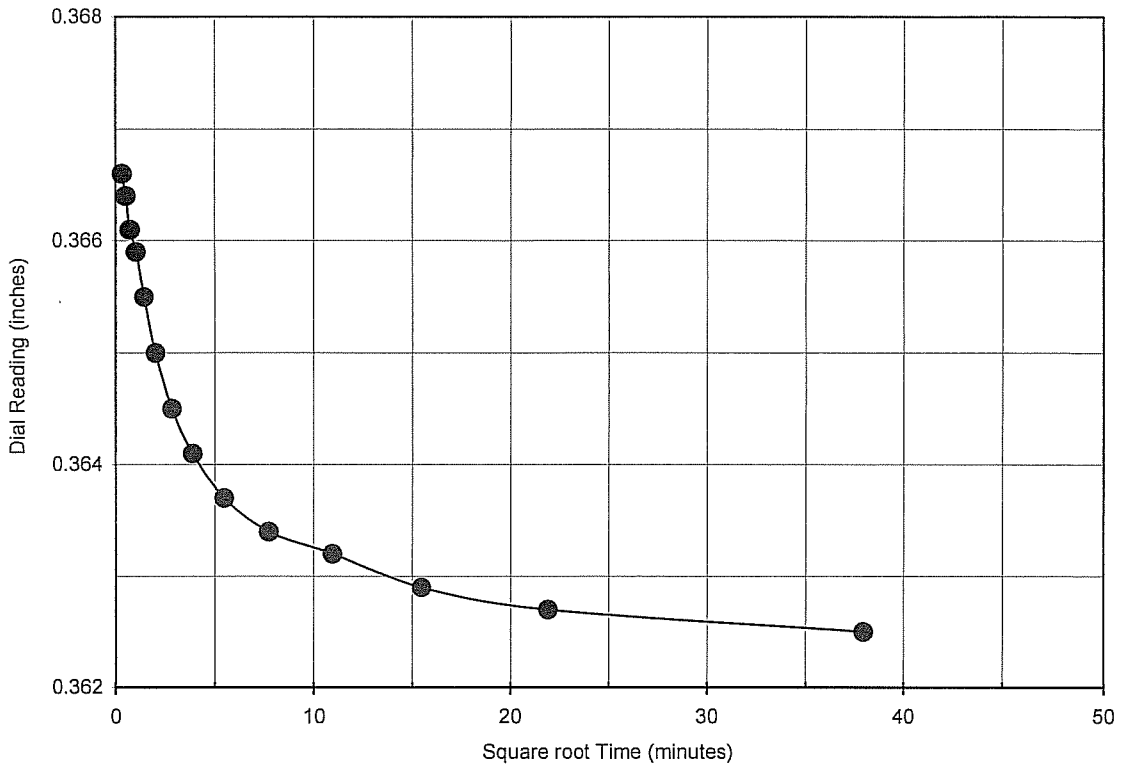


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3666
0.25	0.3664
0.5	0.3661
1	0.3659
2	0.3655
4	0.365
8	0.3645
15	0.3641
30	0.3637
60	0.3634
120	0.3632
240	0.3629
480	0.3627
1440	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

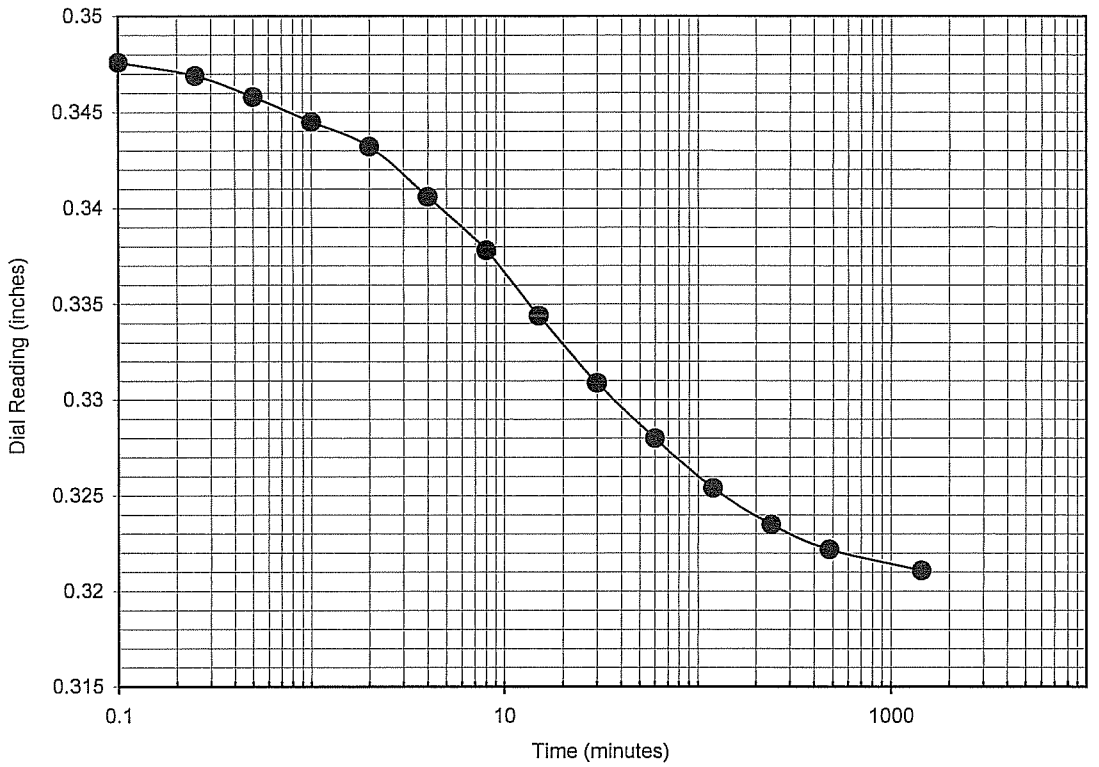


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3666
0.5000	0.3664
0.7071	0.3661
1.0000	0.3659
1.4142	0.3655
2.0000	0.3650
2.8284	0.3645
3.8730	0.3641
5.4772	0.3637
7.7460	0.3634
10.9545	0.3632
15.4919	0.3629
21.9089	0.3627
37.9473	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

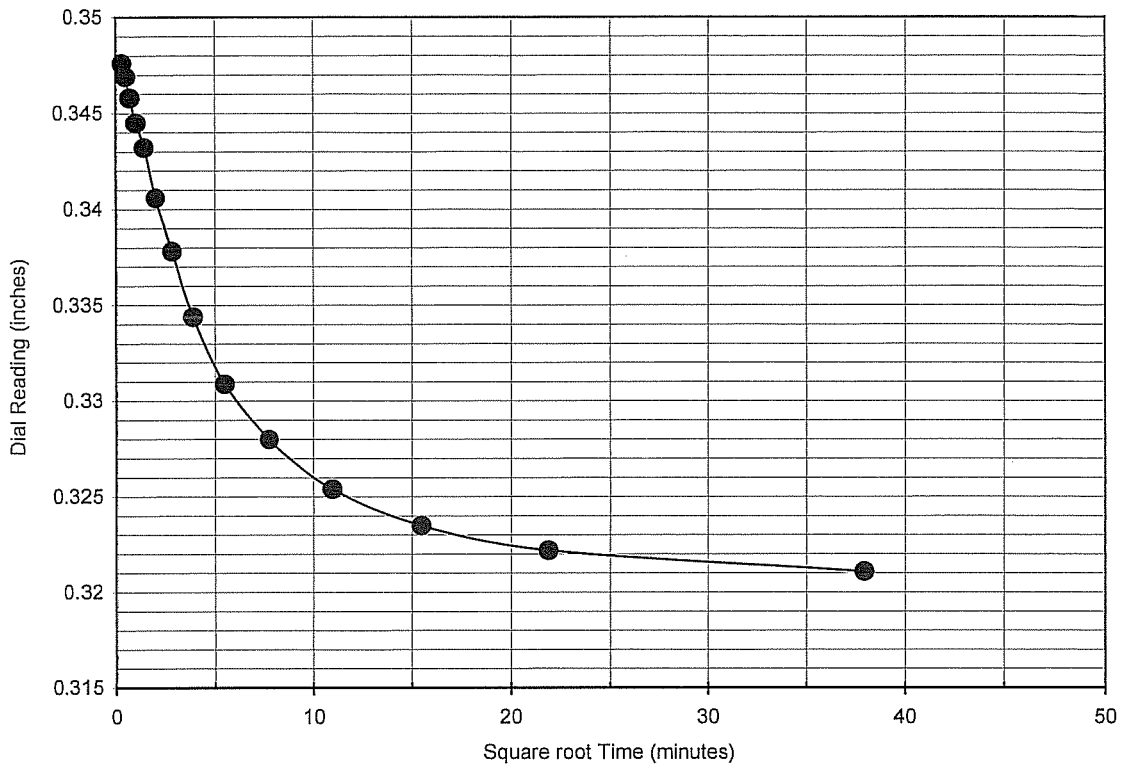


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3476
0.25	0.3469
0.5	0.3458
1	0.3445
2	0.3432
4	0.3406
8	0.3378
15	0.3344
30	0.3309
60	0.328
120	0.3254
240	0.3235
480	0.3222
1440	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3476
0.5000	0.3469
0.7071	0.3458
1.0000	0.3445
1.4142	0.3432
2.0000	0.3406
2.8284	0.3378
3.8730	0.3344
5.4772	0.3309
7.7460	0.3280
10.9545	0.3254
15.4919	0.3235
21.9089	0.3222
37.9473	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/01/09

Boring No.: R-09-011 Checked By: AP Date: 12/11/09

Sample No.: D-02 Depth (ft): 10

Description: Gray Poorly-Graded Sand w/ silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	554.38
Total Ring Weight (g)	126.64
Wet Density (pcf)	118.57
Dry Density (pcf)	93.24

Moisture Determination	Before Test	After Test
Cont. Weight (g)	194.13	104.46
Wet Soil+Cont. (g)	478.24	511.68
Dry Soil+Cont. (g)	417.54	416.03
Moisture Content (%)	27.2	30.7
Degree Saturation	87.0	100.3

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

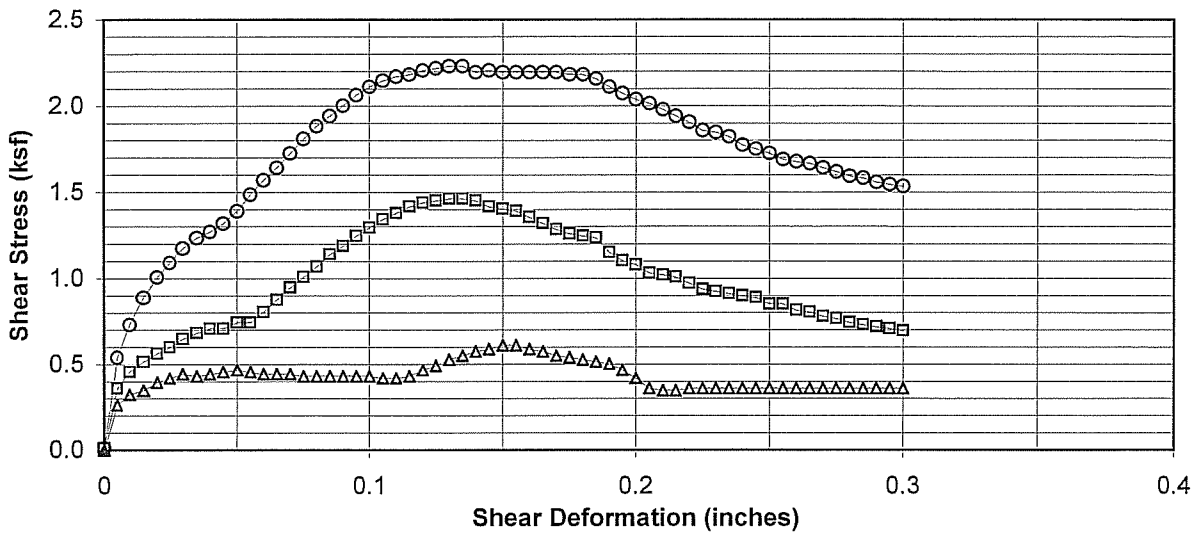
Shear Distance (in): **0.3**

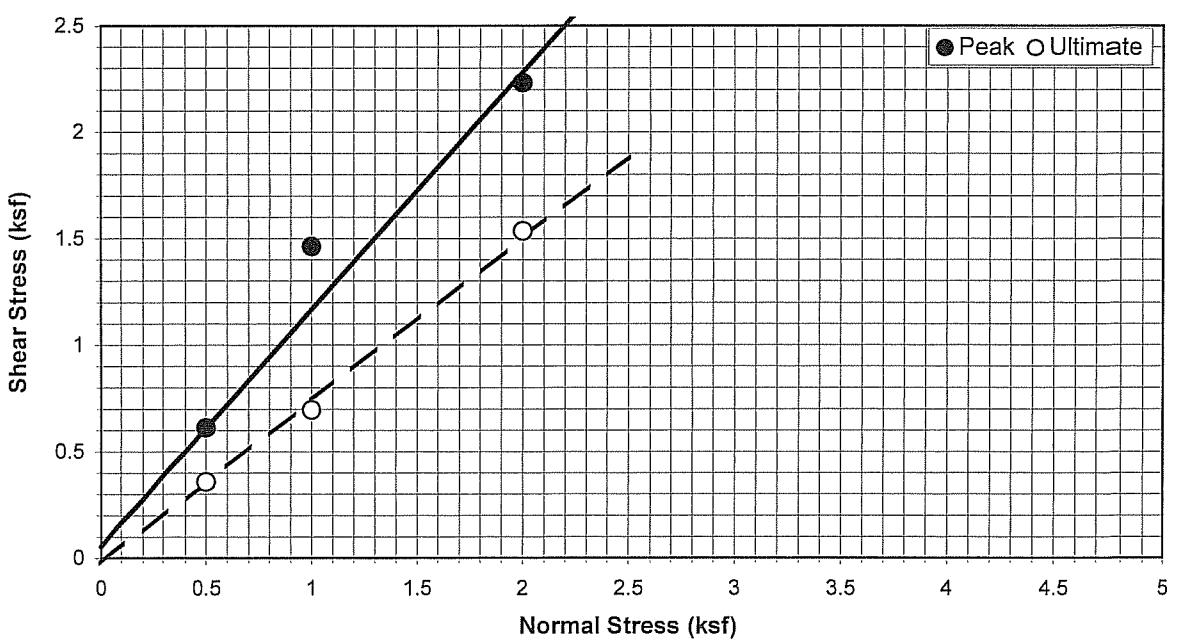
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**187.49**	**42.13**	**0.5**	**612**	**360**	
2	**184.75**	**42.70**	**1.0**	**1464**	**696**	
3	**182.14**	**41.81**	**2.0**	**2232**	**1536**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.2	pcf
Boring No.:	R-09-011	Moisture Content (before):	27.2	%
Sample No.:	D-02	Moisture Content (after):	30.7	%
Depth (ft):	10			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/ silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	48 °	37 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/01/09

Boring No.: R-09-011 Checked By: AP Date: 12/11/09

Sample No.: D-12 Depth (ft): 60

Description: Gray Sandy Silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	586.40
Total Ring Weight (g)	131.26
Wet Density (pcf)	126.17
Dry Density (pcf)	97.30

Moisture Determination	Before Test	After Test
Cont. Weight (g)	198.19	104.12
Wet Soil+Cont. (g)	480.64	542.99
Dry Soil+Cont. (g)	416.01	448.93
Moisture Content (%)	29.7	27.3
Degree Saturation	104.3	100.6

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

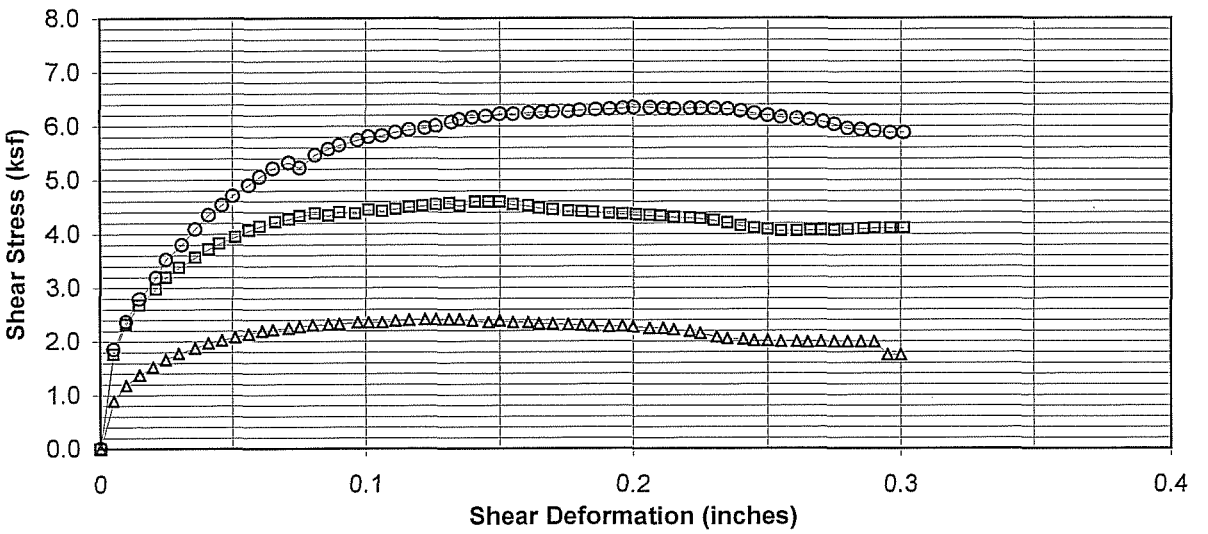
Shear Distance (in): **0.3**

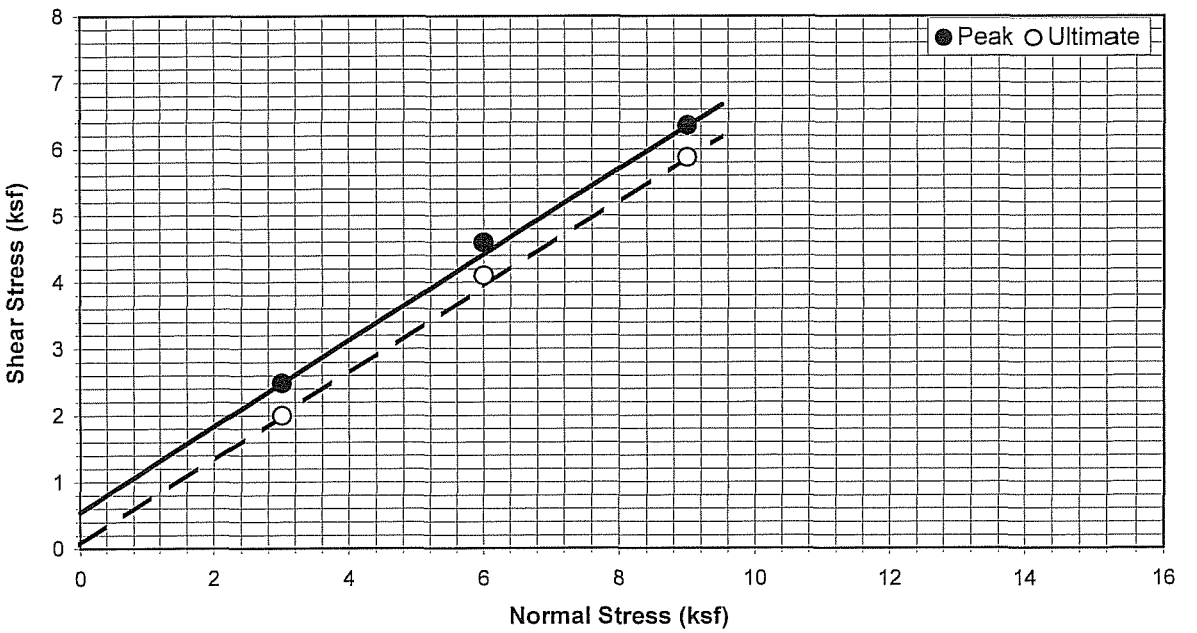
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**197.56**	**43.02**	**3.0**	**2487**	**2003**	
2	**196.67**	**44.97**	**6.0**	**4596**	**4104**	
3	**192.17**	**43.27**	**9.0**	**6359**	**5879**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

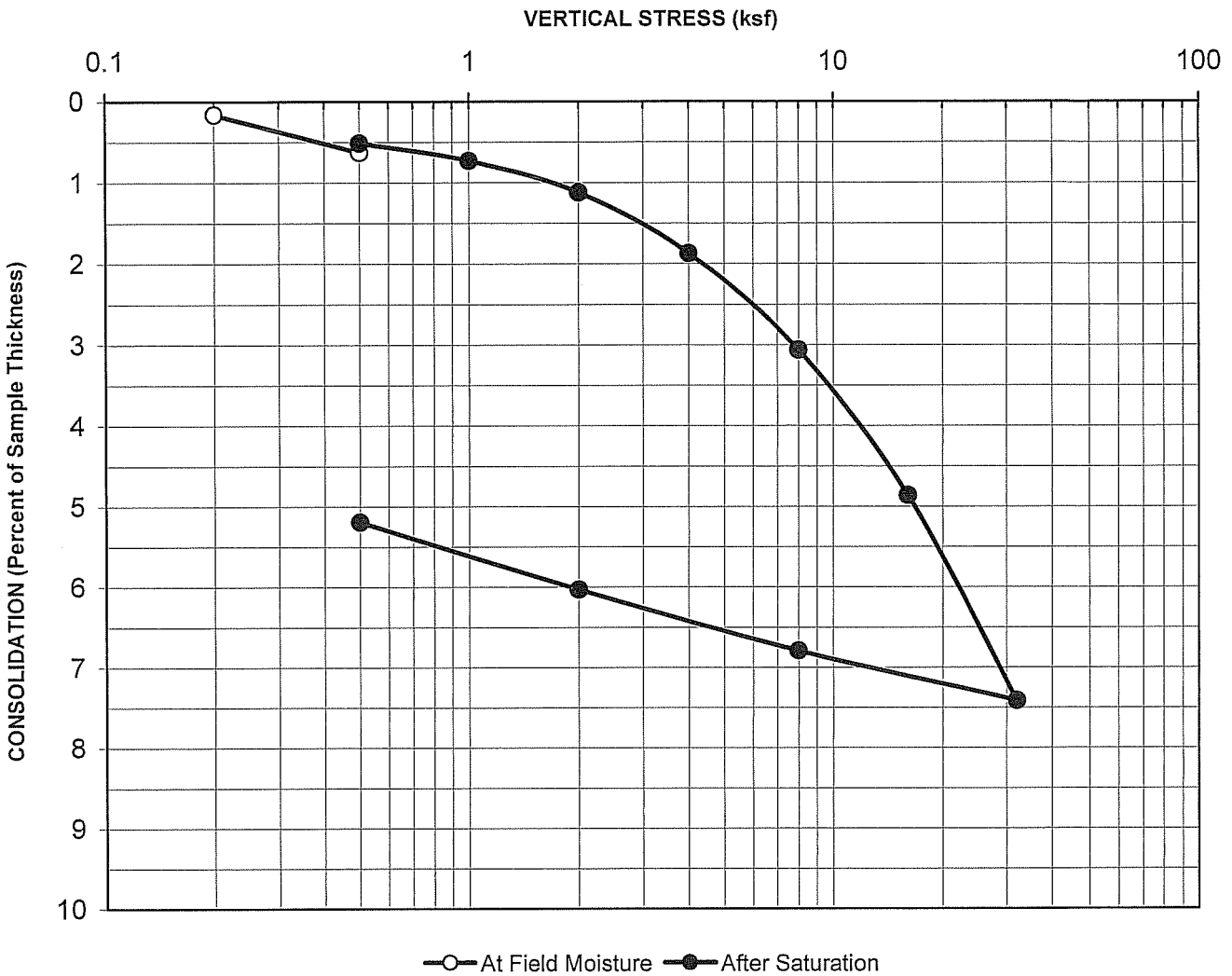
Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	97.3	pcf
Boring No.:	R-09-011	Moisture Content (before):	29.7	%
Sample No.:	D-12	Moisture Content (after):	27.3	%
Depth (ft):	60			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	550	50
Friction Angle:	33 °	33 °

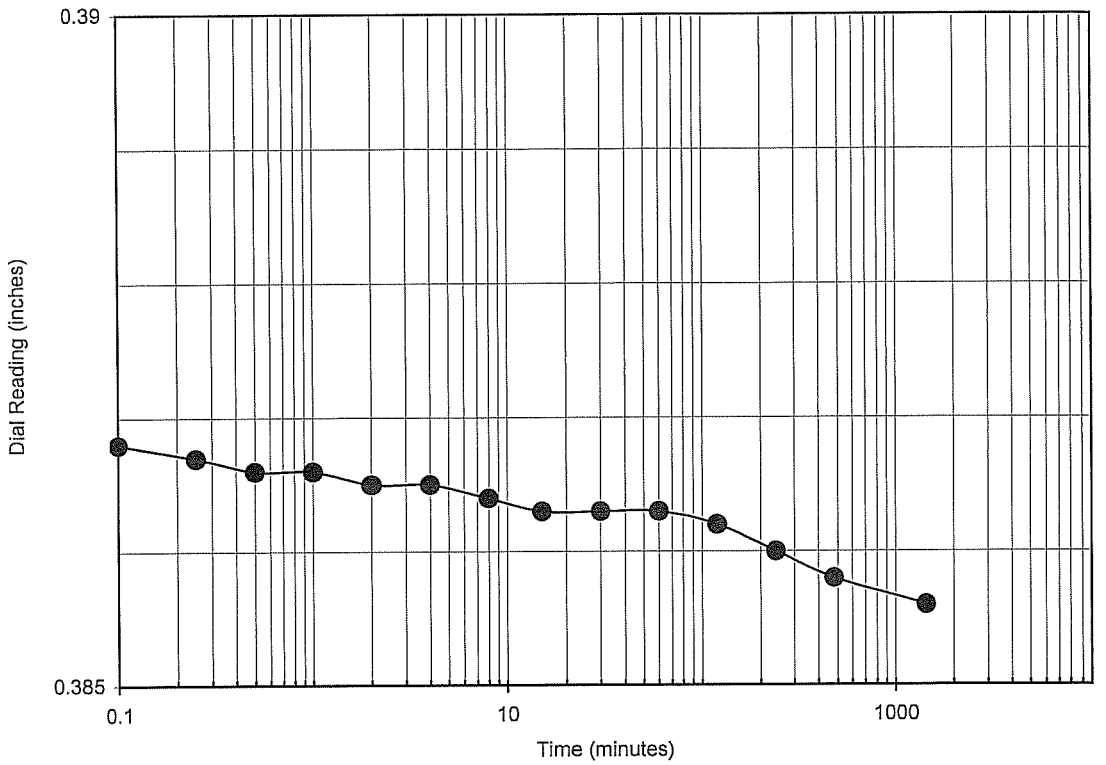
AP Engineering & Testing, Inc.



Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	104.2
Sample No.:	U-14	Initial Moisture Content (%):	22.0
Depth (feet):	70	Final Moisture Content (%):	20.4
Sample Type:	Shelby	Assumed Specific Gravity:	2.7
Soil Description:	Sandy Silt	Initial Void Ratio:	0.62
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

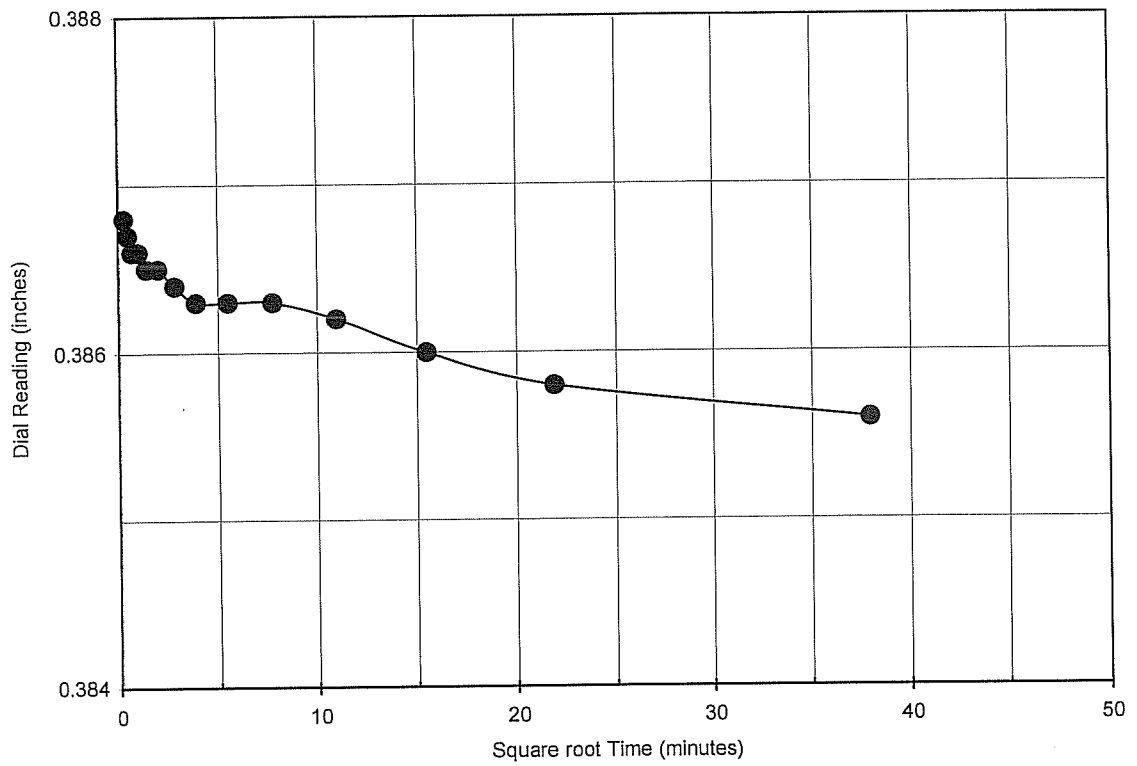


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3868
0.25	0.3867
0.5	0.3866
1	0.3866
2	0.3865
4	0.3865
8	0.3864
15	0.3863
30	0.3863
60	0.3863
120	0.3862
240	0.386
480	0.3858
1440	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

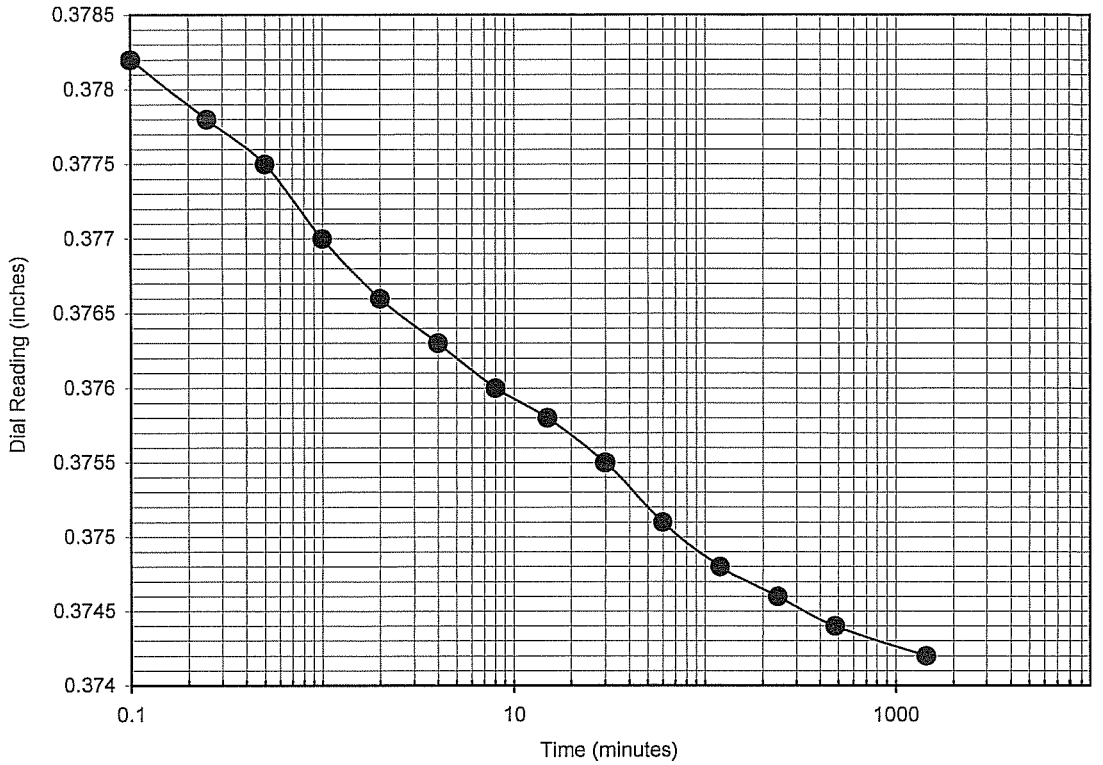


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3868
0.5000	0.3867
0.7071	0.3866
1.0000	0.3866
1.4142	0.3865
2.0000	0.3865
2.8284	0.3864
3.8730	0.3863
5.4772	0.3863
7.7460	0.3863
10.9545	0.3862
15.4919	0.3860
21.9089	0.3858
37.9473	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

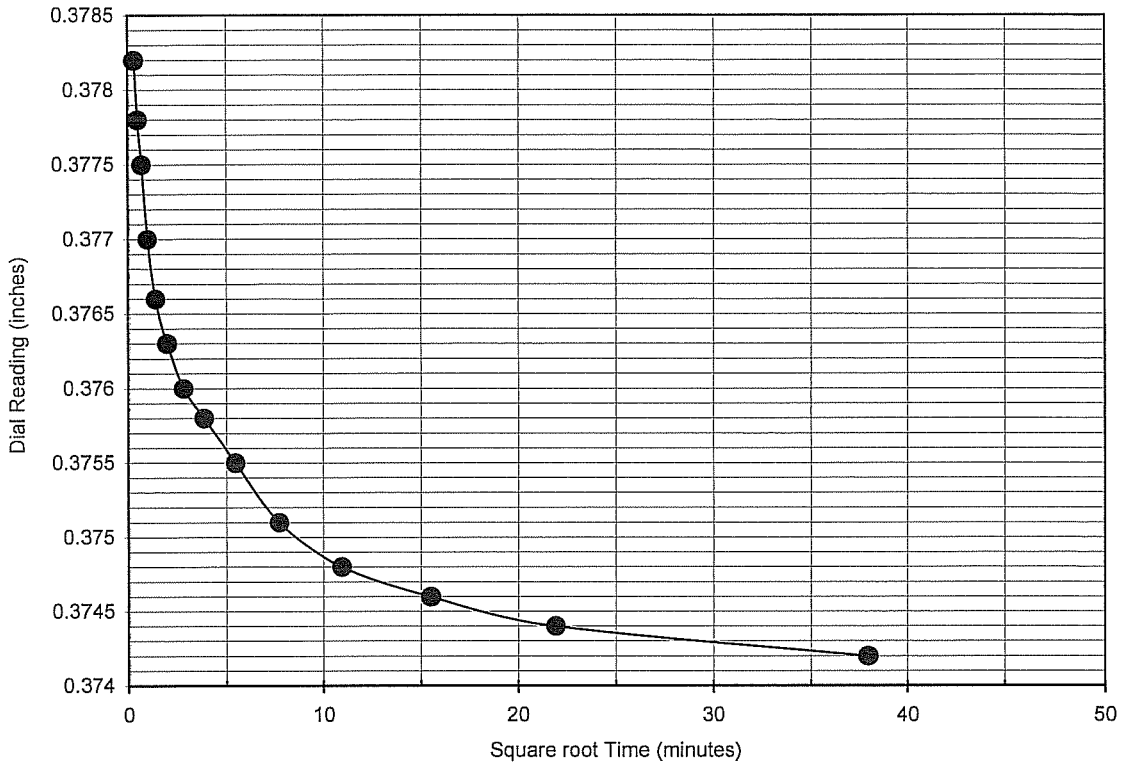


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3782
0.25	0.3778
0.5	0.3775
1	0.377
2	0.3766
4	0.3763
8	0.376
15	0.3758
30	0.3755
60	0.3751
120	0.3748
240	0.3746
480	0.3744
1440	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3782
0.5000	0.3778
0.7071	0.3775
1.0000	0.3770
1.4142	0.3766
2.0000	0.3763
2.8284	0.3760
3.8730	0.3758
5.4772	0.3755
7.7460	0.3751
10.9545	0.3748
15.4919	0.3746
21.9089	0.3744
37.9473	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

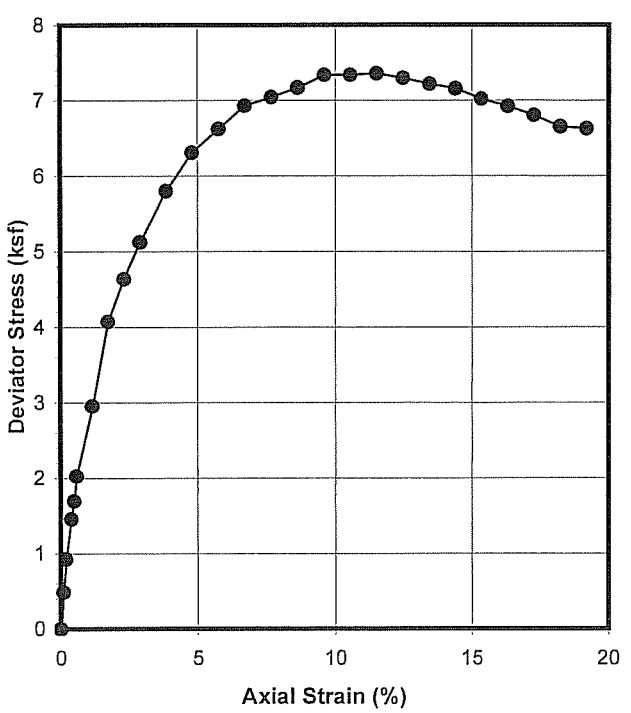
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-011				
Sample No.:	U-14	Depth (feet): 70			
Soil Description	Gray Sandy Silt		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	129.4
Sample Hieght (inch):	5.2	Dry Unit Weight (pcf):	106.1
Sample Weight (gms):	1149.87	Moisture Content (%):	22.0
Wt. Wet Soil+Container(gms)	1310.19	Void Ratio for Gs=2.7:	0.59
Wt. Dry Soil+Container(gms)	1101.86	% Saturation:	101.0
Wt. Container (gms)	154.83		

TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	7.4
Ultimate Deviator Stress (ksf):	6.9
Ultimate Undrained Shear Strength (ksf):	3.5
Axial Strain @ Maximum Stress (%)	11.52



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
22	0.005	6.50	0.49	0.10
42	0.010	6.50	0.93	0.19
66	0.020	6.52	1.46	0.38
77	0.025	6.52	1.70	0.48
92	0.030	6.53	2.03	0.58
135	0.060	6.57	2.96	1.15
187	0.090	6.61	4.08	1.73
214	0.120	6.64	4.64	2.30
238	0.150	6.68	5.13	2.88
272	0.200	6.75	5.80	3.84
299	0.250	6.82	6.31	4.80
317	0.300	6.89	6.63	5.76
335	0.350	6.96	6.93	6.72
344	0.400	7.03	7.04	7.68
354	0.450	7.11	7.17	8.64
366	0.500	7.18	7.34	9.60
370	0.550	7.26	7.34	10.56
375	0.600	7.34	7.36	11.52
376	0.650	7.42	7.30	12.48
376	0.700	7.50	7.22	13.44
377	0.750	7.58	7.16	14.40
374	0.800	7.67	7.02	15.36
373	0.850	7.76	6.92	16.31
371	0.900	7.85	6.81	17.27
367	0.950	7.94	6.66	18.23
370	1.000	8.03	6.63	19.19

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-014	S-01	5.0			39.6	
R-09-014	S-03	15.0	30.0		5.6	
R-09-014	D-04	20.0	38.0	86.9		34,24,10
R-09-014	S-05	25.0	30.6		35.5	
R-09-014	D-06	30.0			28.3	
R-09-014	S-07	35.0	53.2			49,24,25
R-09-014	D-08	40.0	33.4	90.6		26,24,2
R-09-014	S-10	46.0	48.2			45,22,23
R-09-014	U-11	50.0	46.5	75.1		49,24,25
R-09-014	U-13	60.0				43,24,19
R-09-014	S-14	65.0	36.7			28,25,3
R-09-014	D-15	70.0	20.1	109.1		
R-09-014	S-16	75.0			21.9	
R-09-014	D-17	80.0	25.6	103.1		
R-09-014	S-19	100.0	19.2			
R-09-014	S-22	135.0	16.0			
R-09-014	S-24	165.0	25.3			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-014	S-01	5	8.03	2310	0.067	220
R-09-014	S-10	46	8.63	1490	0.144	360

SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

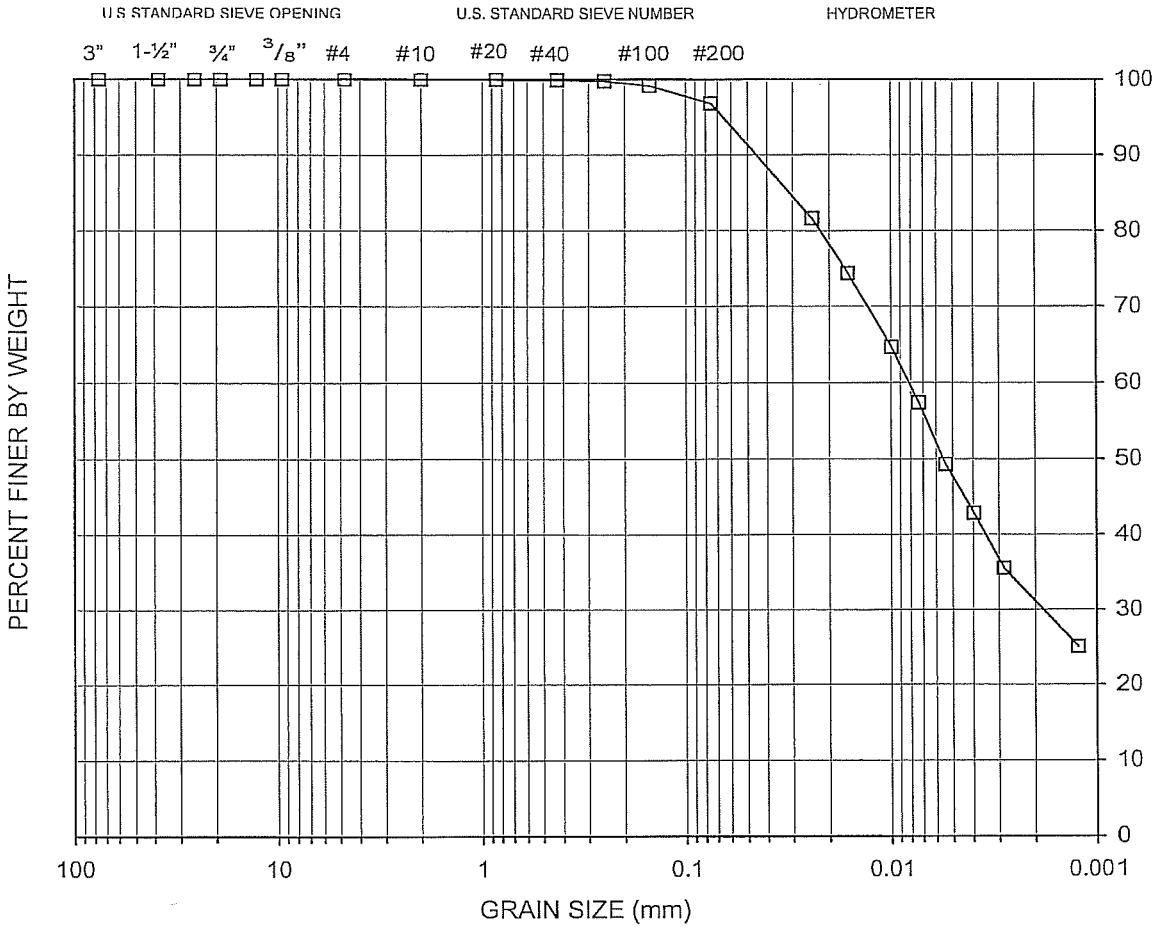
PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-014	U-11	50	2.751
R-09-014	U-13	60	2.771

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-014	S-07	35	BAG	CL	49	25

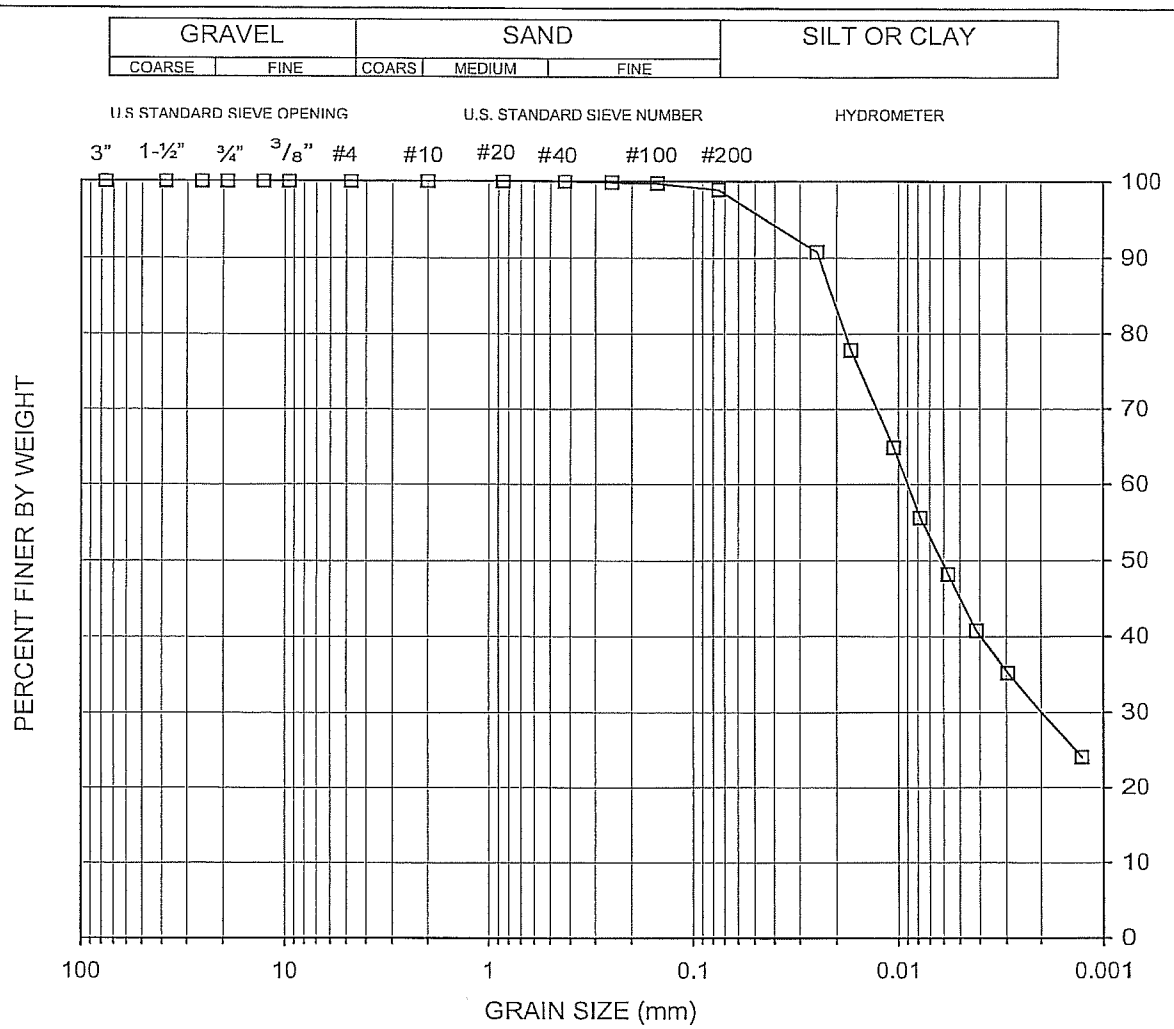
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-014	U-11	50	Shelby Tube	CL	49	25

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement

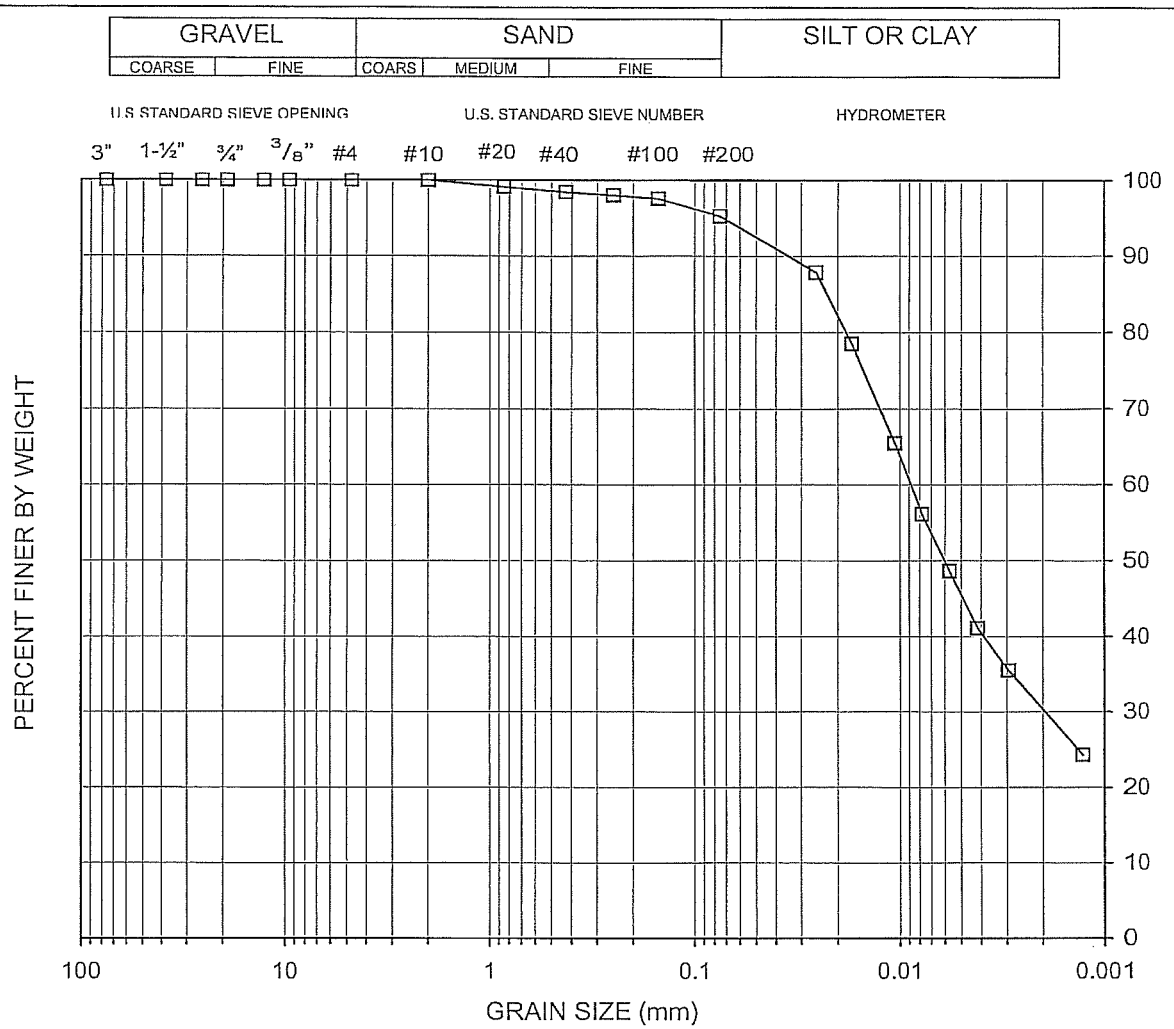
Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-014	U-13	60	Shelby Tube	CL	43	19

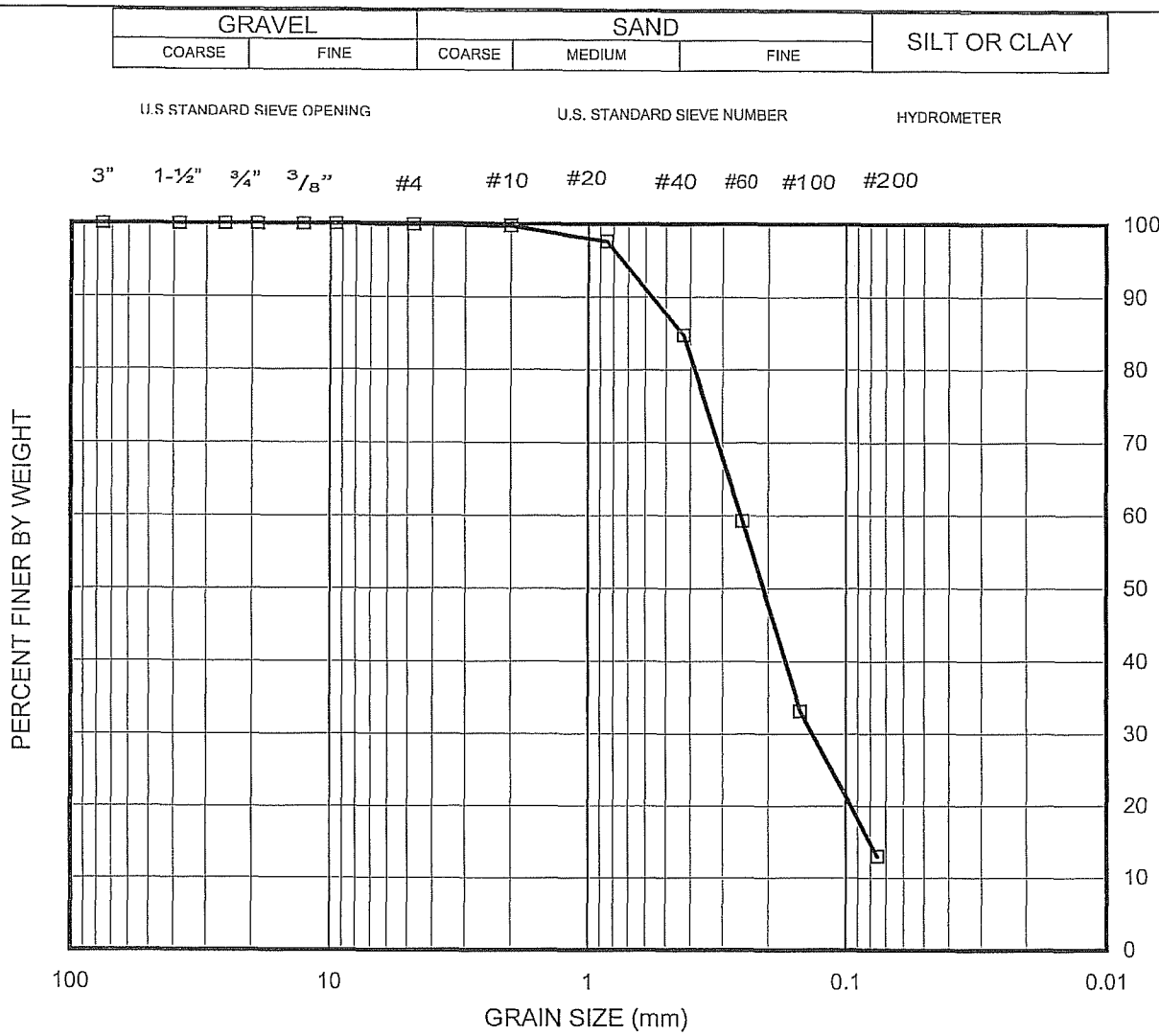
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-014	S-20	110	Bag	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

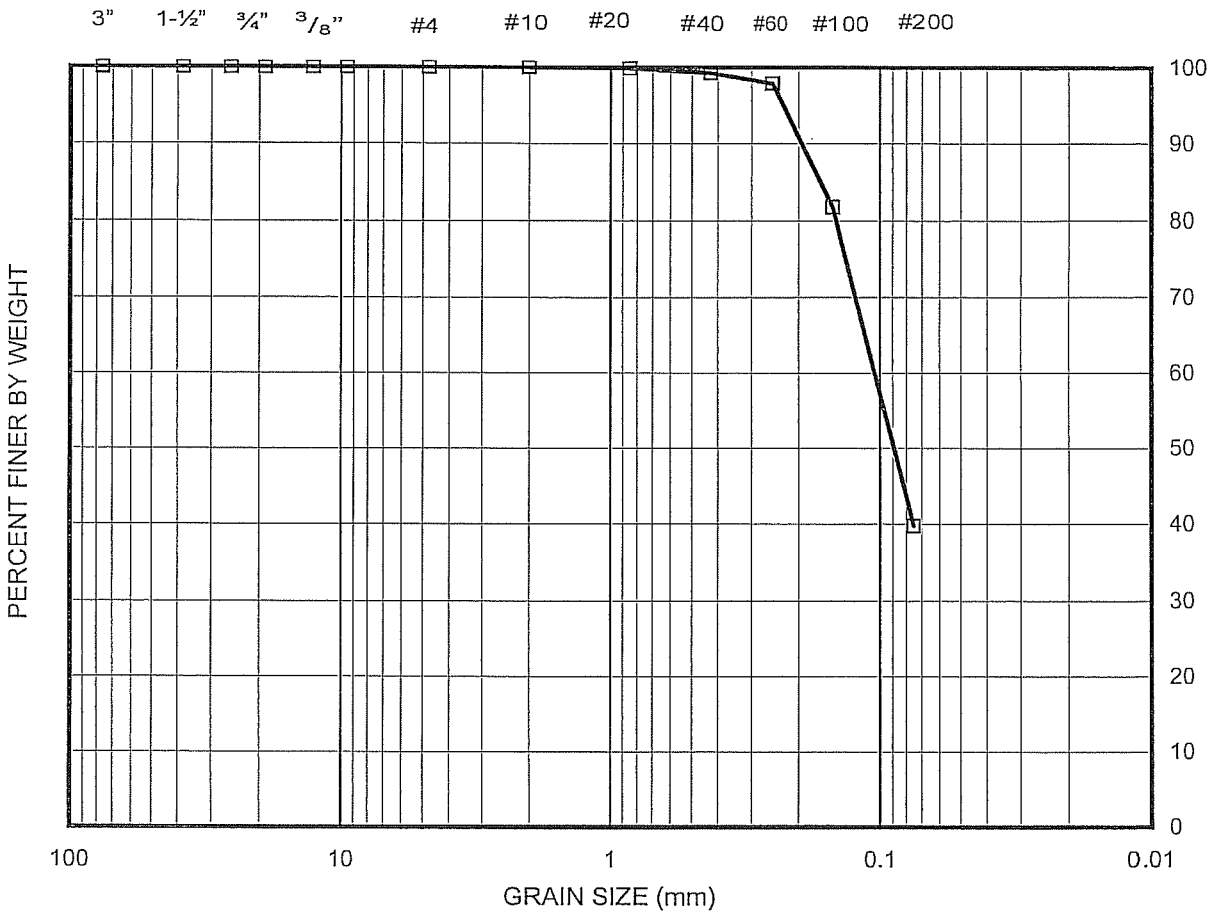
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-014	S-24	165	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

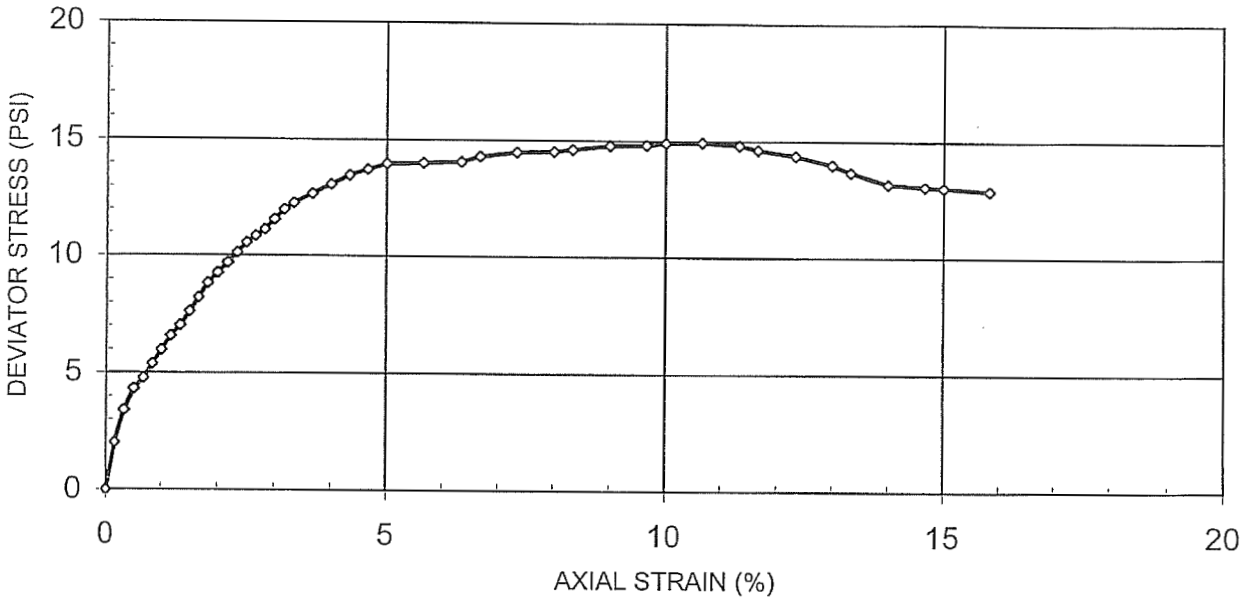
Client Job No.: 06-123-03

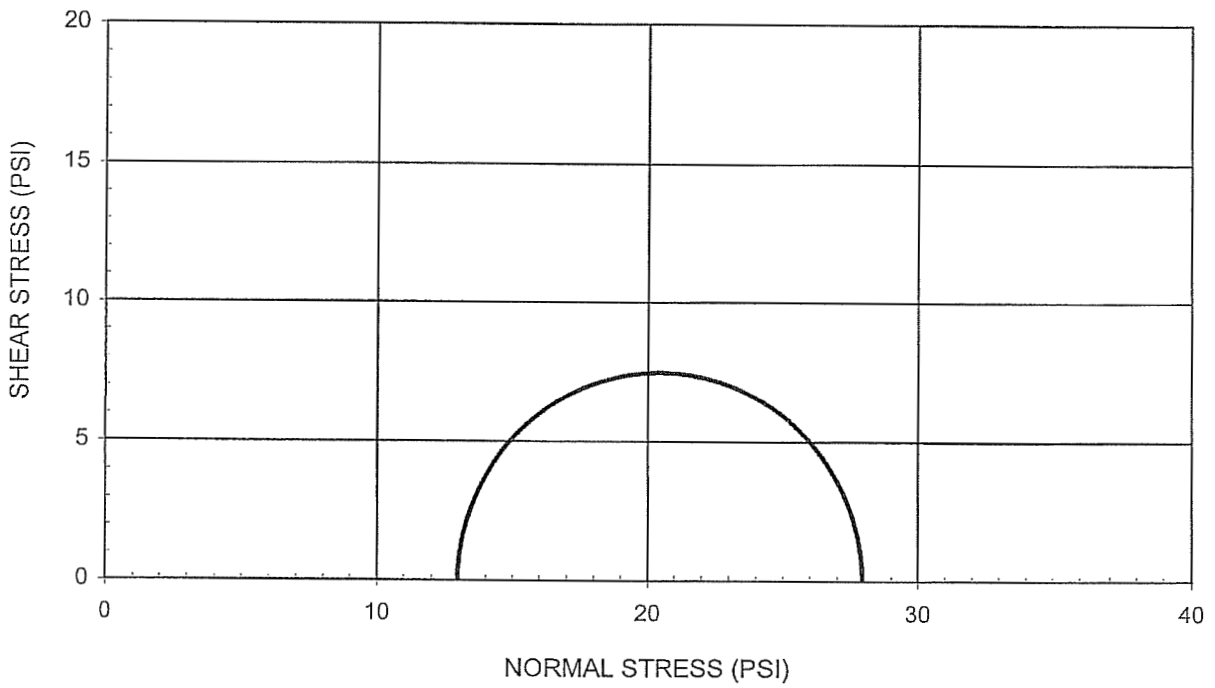
Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-014	50	U-11	CL	Shelby Tube	46.54	75.1	13.0	14.9	0.06	101.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

UNCONSOLIDATED UNDRAINED

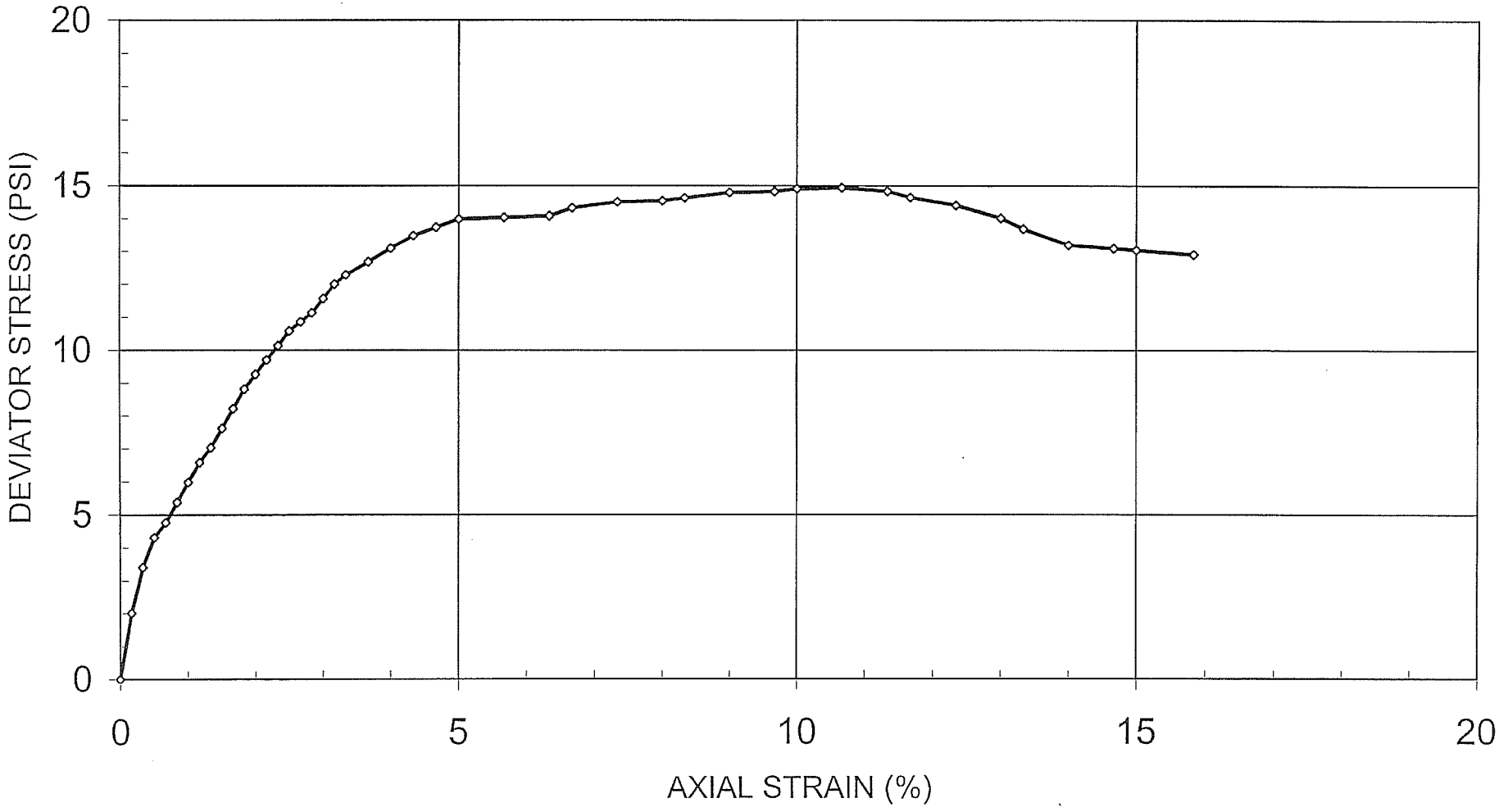
(ASTM D2850)

11/30/09

Figure

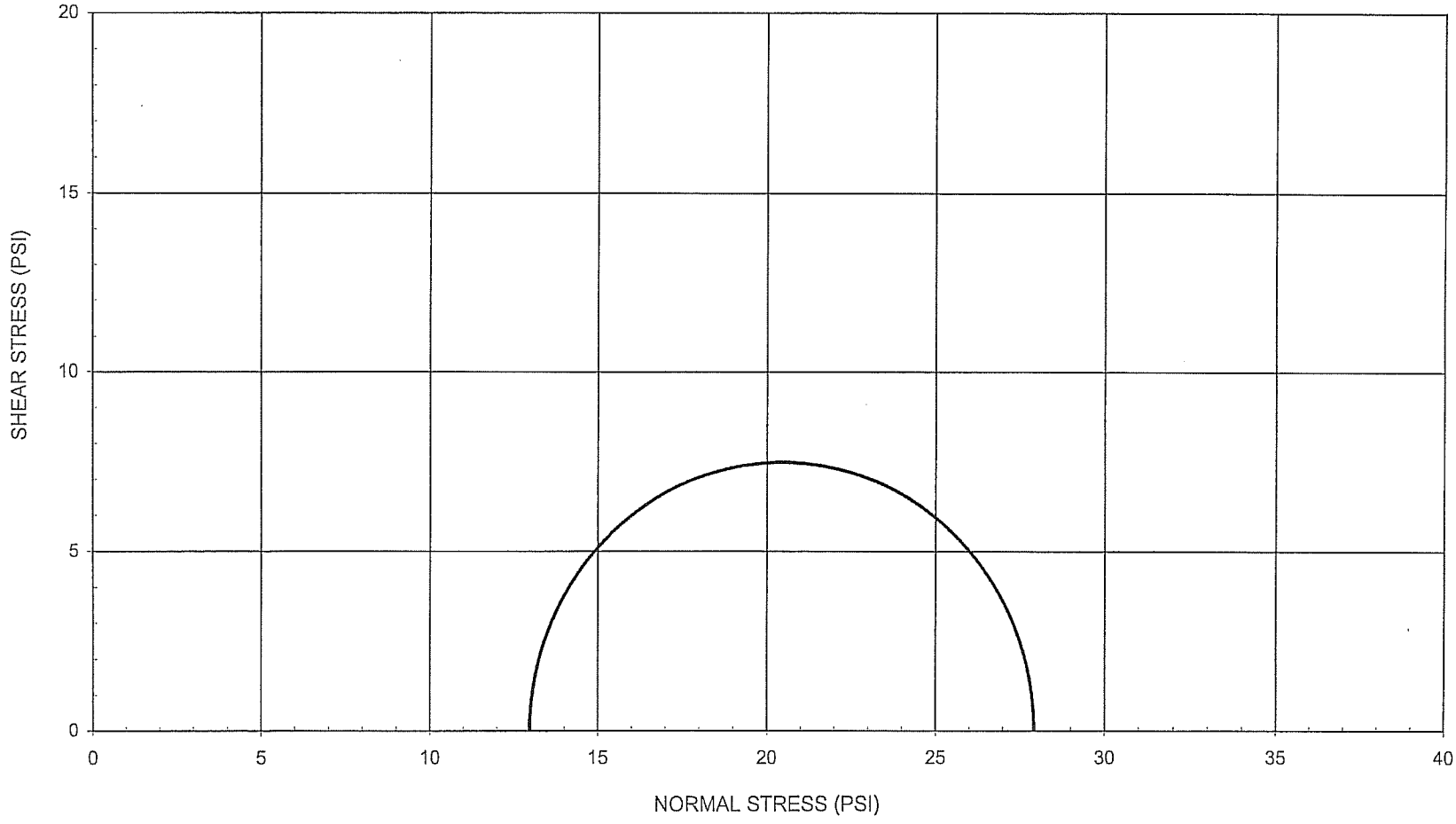
Project Name: ACTA Heim Bridge Replacement

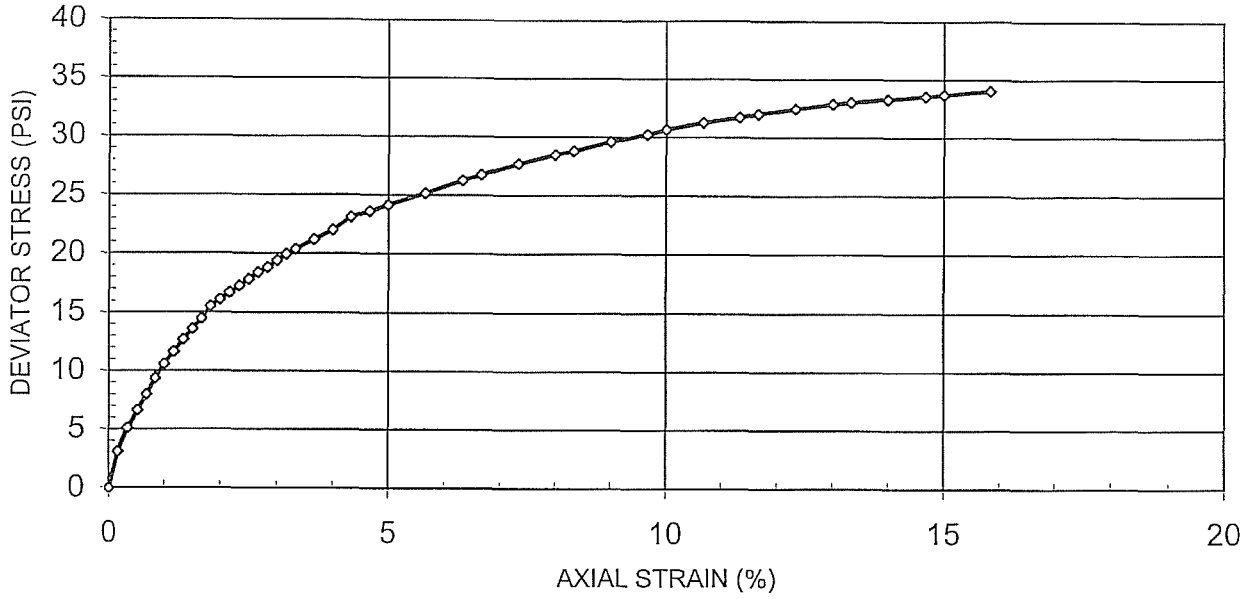
Boring: R-09-014 Sample ID: U-11 Depth (ft): 50

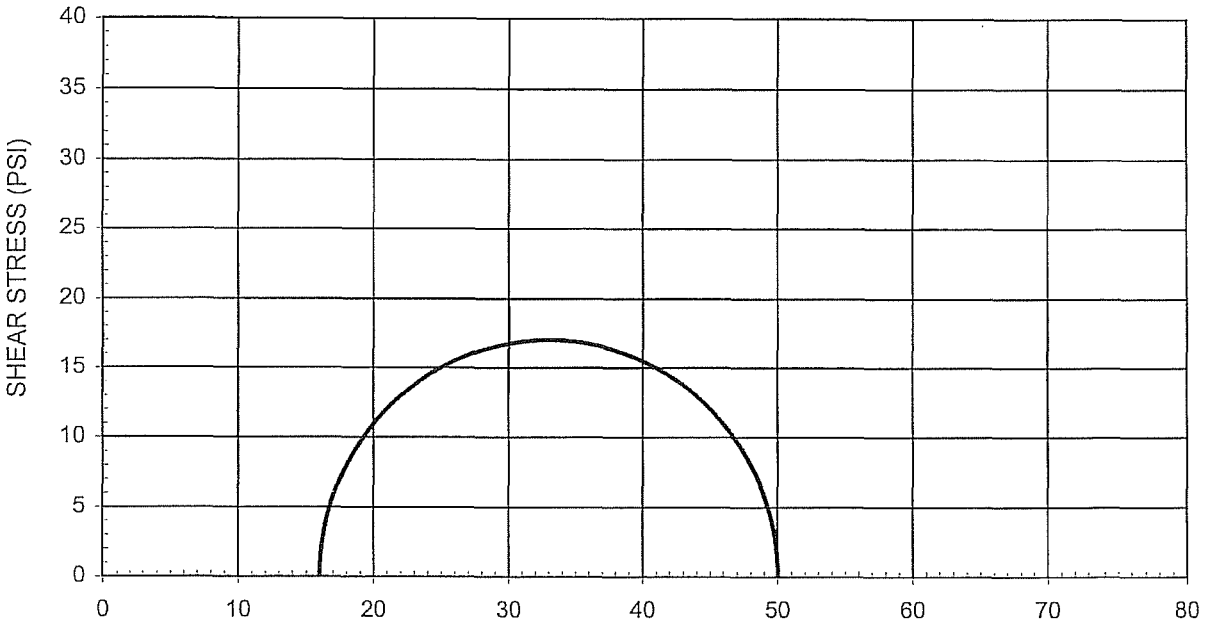


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-014 Sample ID: U-11 Depth (ft): 50







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-014	60	U-13	CL	Shelby Tube	36.13	86.2	16.0	34.0	0.06	102.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

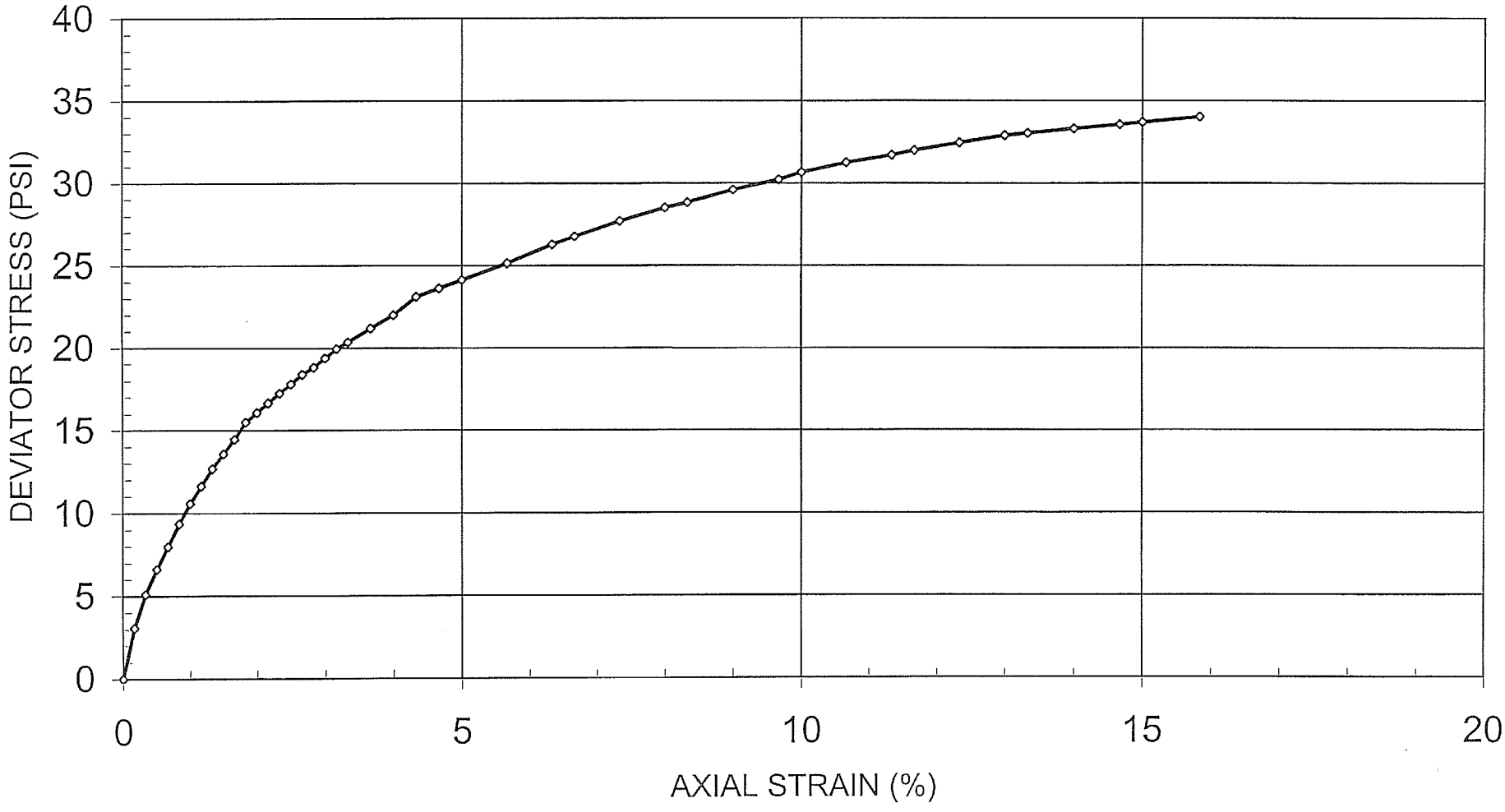
(ASTM D2850)

11/29/09

Figure

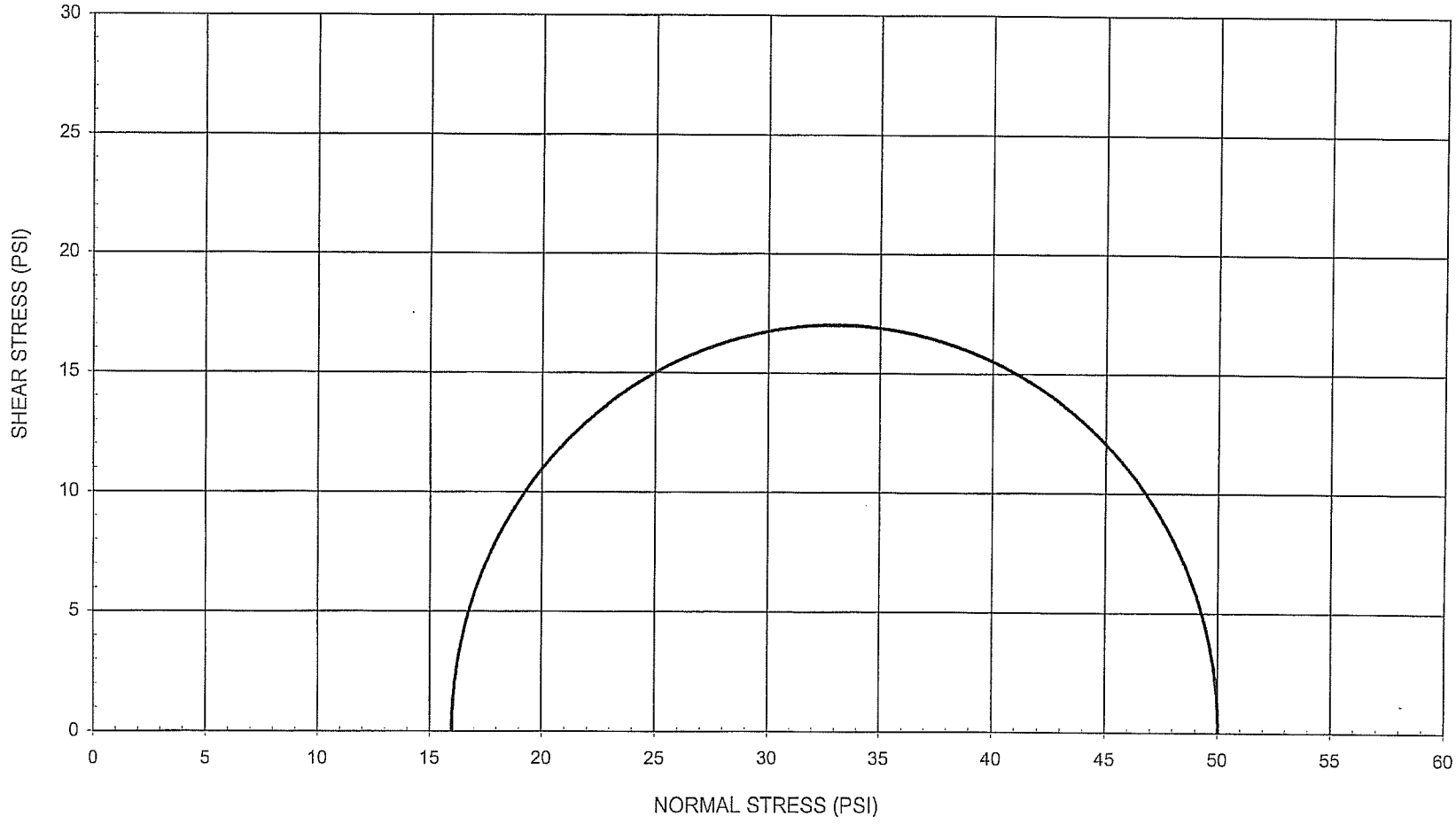
Project Name: ACTA Heim Bridge Replacement

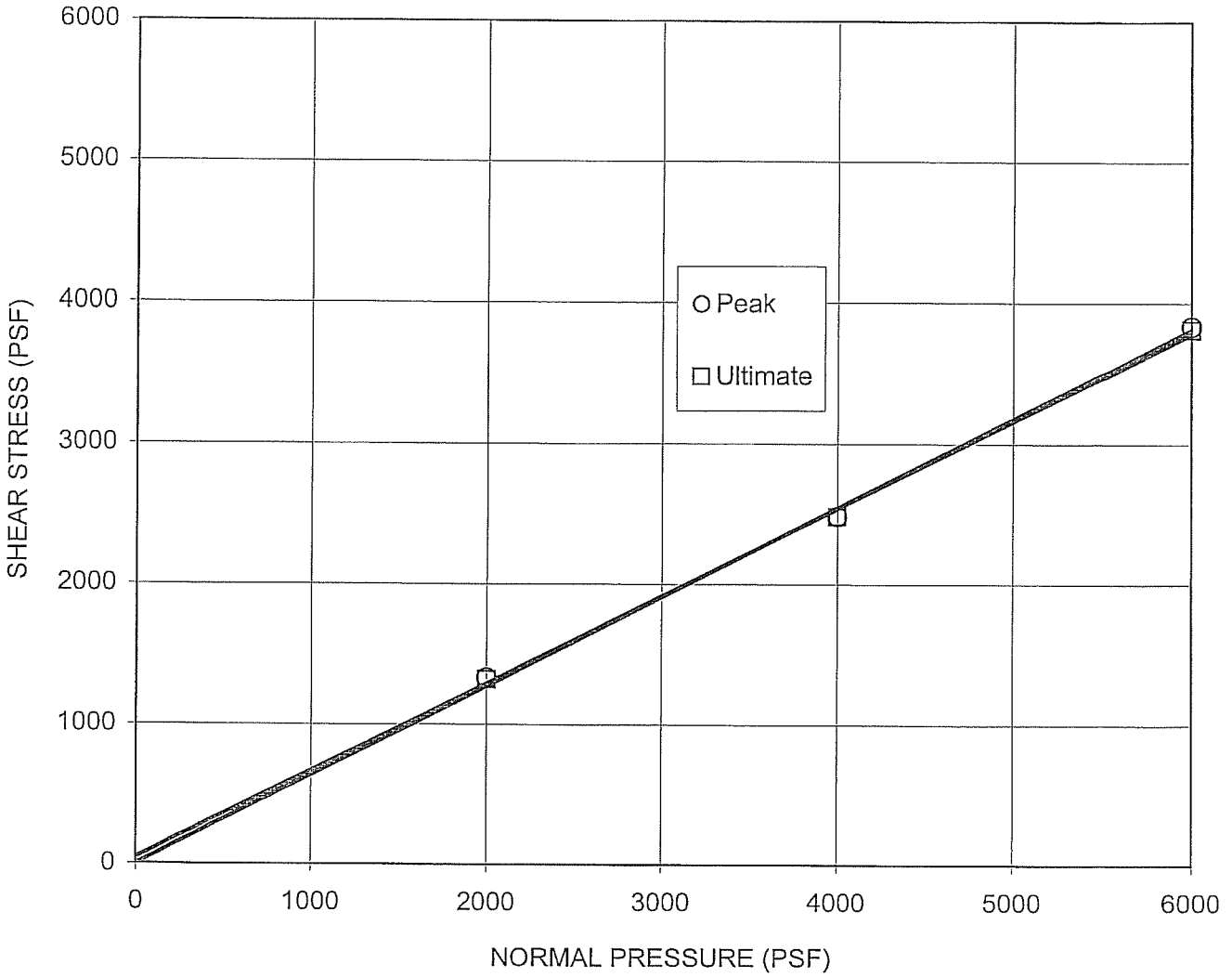
Boring: R-09-014 Sample ID: U-13 Depth (ft): 60



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-014 Sample ID: U-13 Depth (ft): 60





Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-014	D-06	30	Ring	SM	O	47	32
					□	47	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2000	31.6	32.6
4000	31.6	31.1
6000	31.6	30.6

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/16/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-016	D-02	10	20.2	108.7
R-09-016	S-03	15	28.8	NA
R-09-016	D-04	20	29.2	93.9
R-09-016	S-05	25	45.0	NA
R-09-016	D-06	30	31.9	86.7
R-09-016	D-08	40	56.2	65.9
R-09-016	D-10-1	50	36.2	79.6
R-09-016	D-10-2	50.5	41.8	78.1
R-09-016	S-11	55	35.8	NA
R-09-016	D-12-1	60	33.7	88.3
R-09-016	D-15	75	24.3	100.3
R-09-016	S-19	100	19.3	NA
R-09-016	S-23	150	10.7	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-016	D-06	30	1.46
R-09-016	D-08	40	0.29
R-09-016	U-09	45	1.50
R-09-016	D-10-1	50	0.50
R-09-016	D-10-2	50.5	0.54
R-09-016	D-12-1	60	2.01

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/17/09
Project Number:	06-123-03		

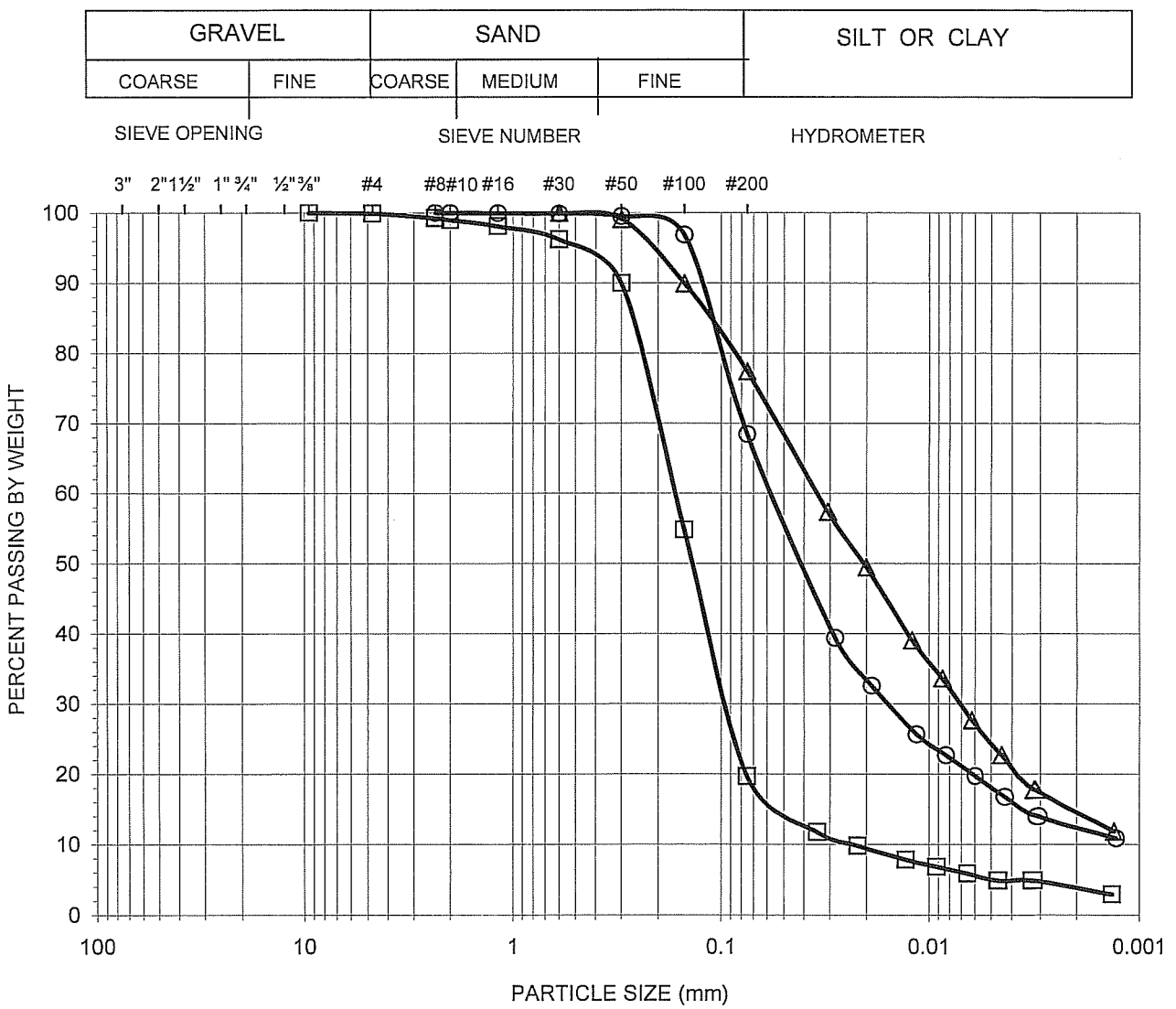
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-016	S-01	5	56.60
R-09-016	S-03	15	12.41
R-09-016	S-13	65	32.94
R-09-016	U-14	70	40.05
R-09-016	S-16	80	9.89

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

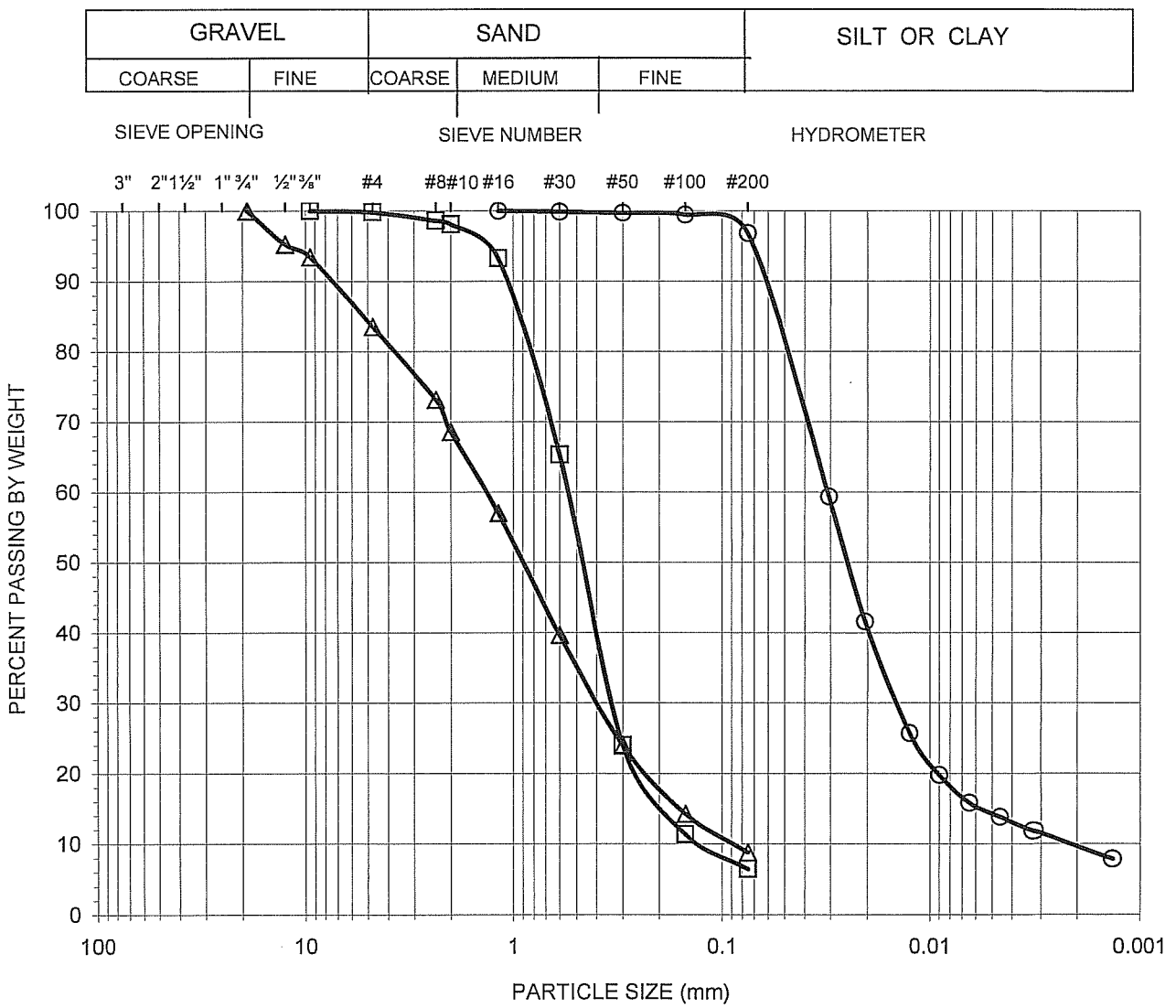


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-016	S-05	25	0.00	31.51	68.49	N/A	ML
□	R-09-016	U-09	45	0.13	80.18	19.69	N/P	SM
△	R-09-016	S-11	55	0.00	22.55	77.45	N/A	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-016	D-12-2	60.5	0.00	3.14	96.86	N/A	ML
□	R-09-016	S-19	100	0.19	93.34	6.47	N/A	SP-SM
△	R-09-016	S-22	135	16.45	74.72	8.83	N/A	SW-SM

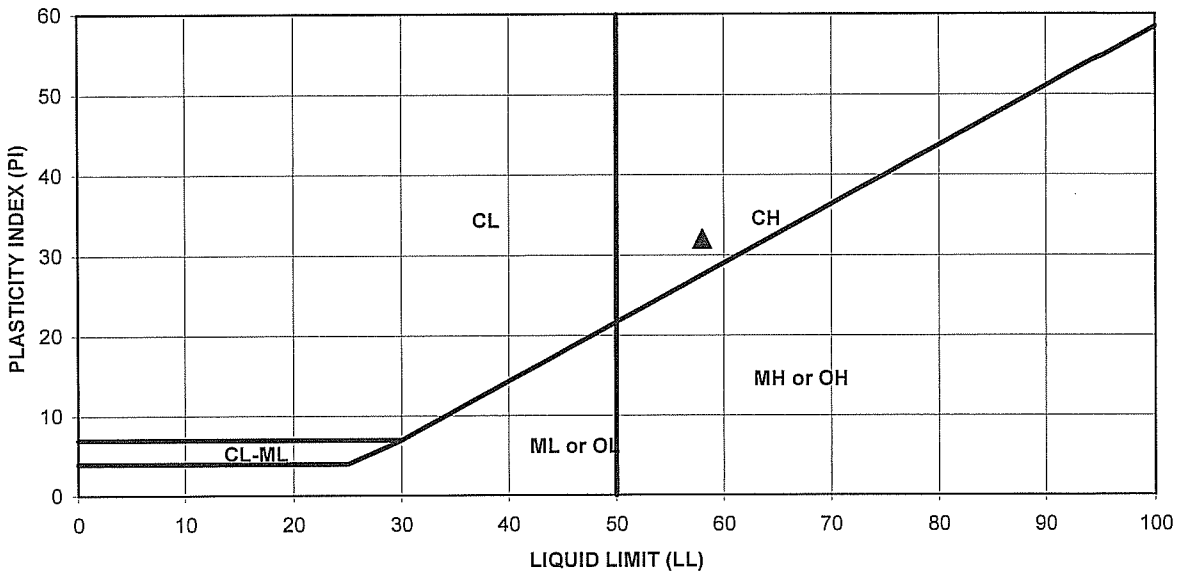
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

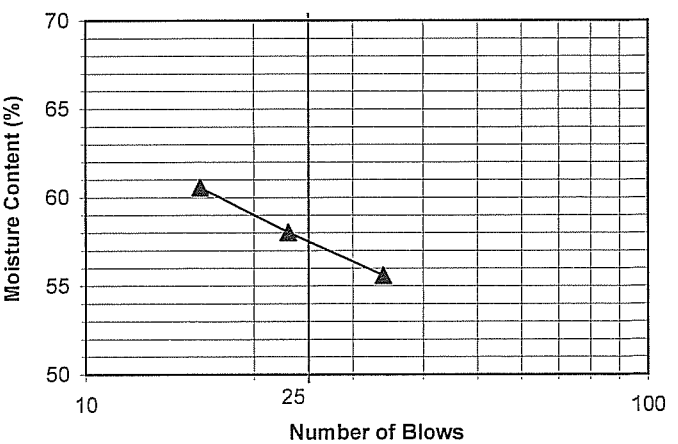
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



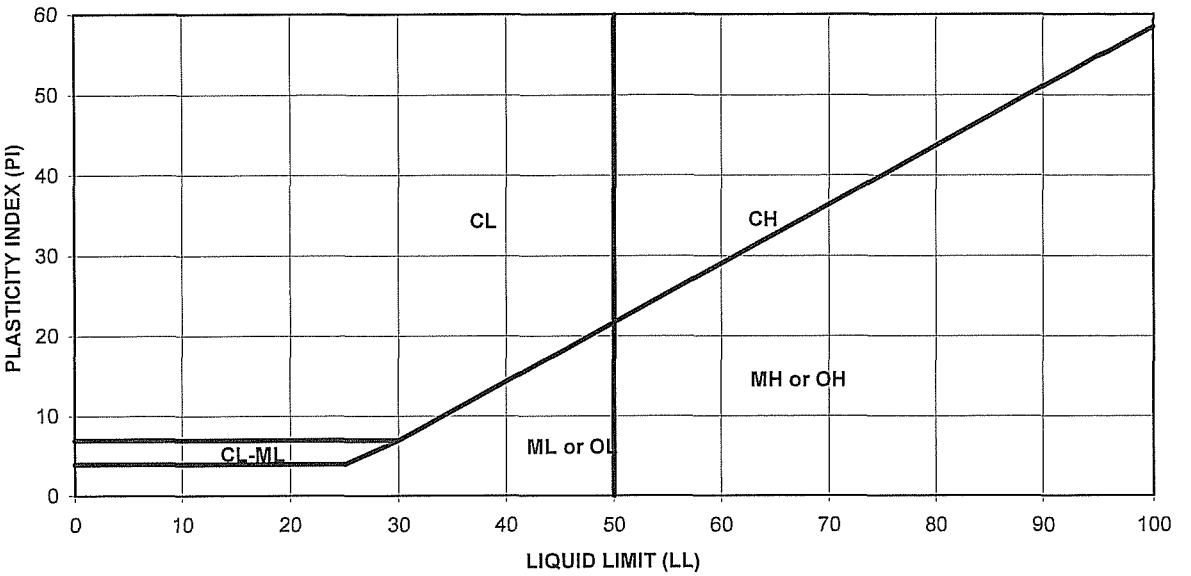
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-016	D-04	20	NP	NP	NP	
▲	R-09-016	D-08	40	58	26	32	CH

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

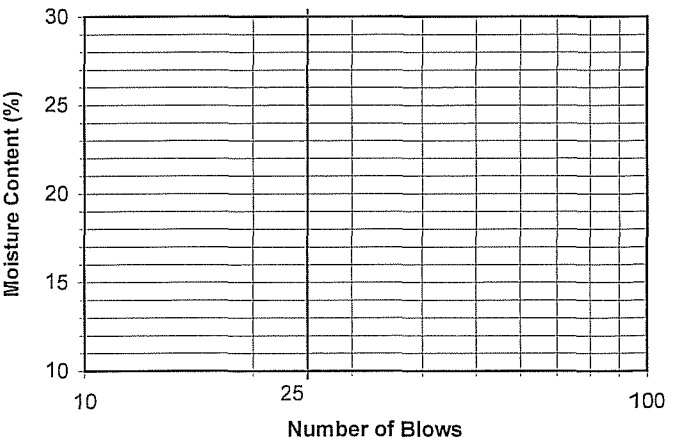
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/07/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



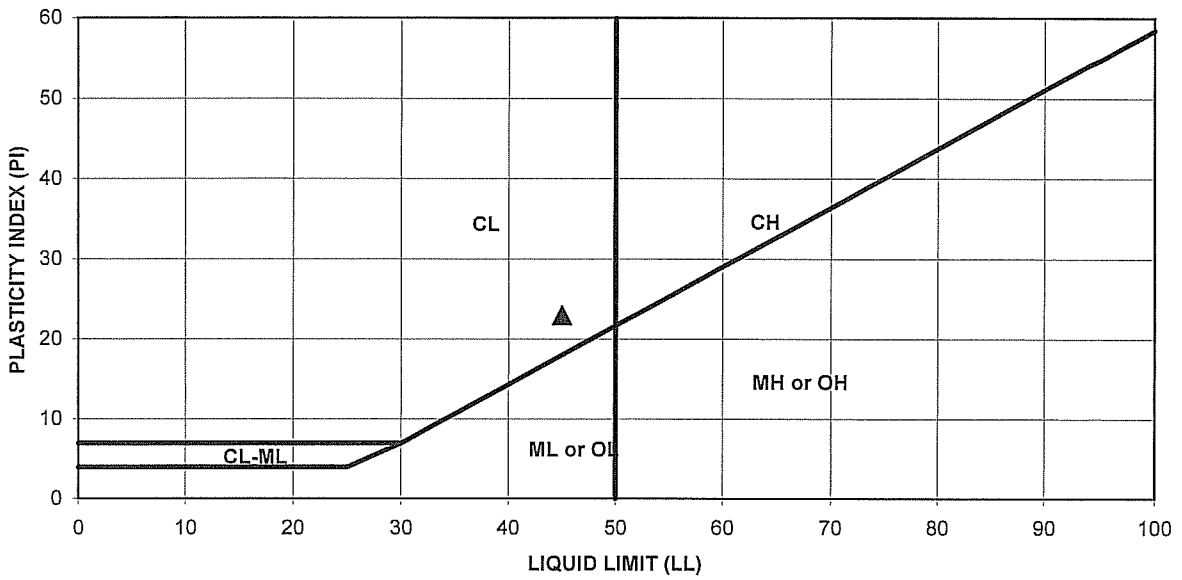
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-016	S-07	35	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

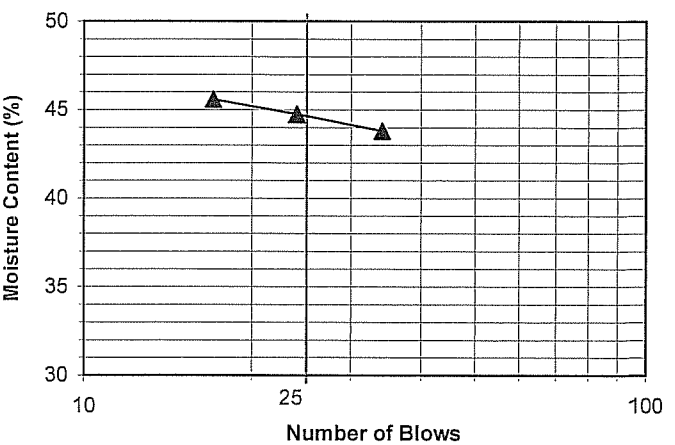
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-016	U-09	45	NP	NP	NP	
▲	R-09-016	D-10-1	50	45	22	23	CL

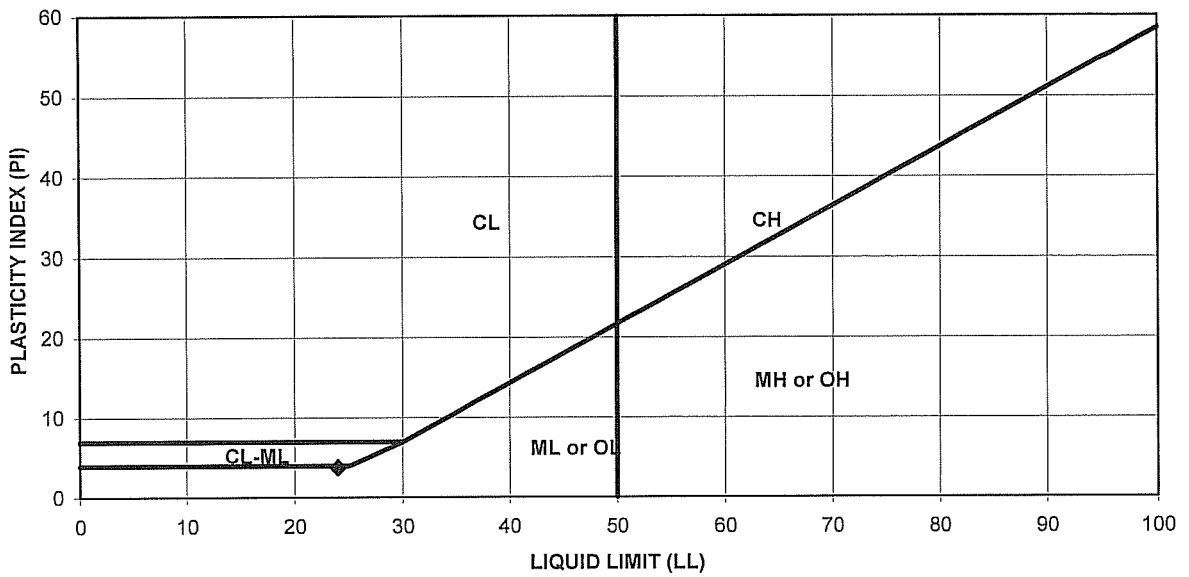
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

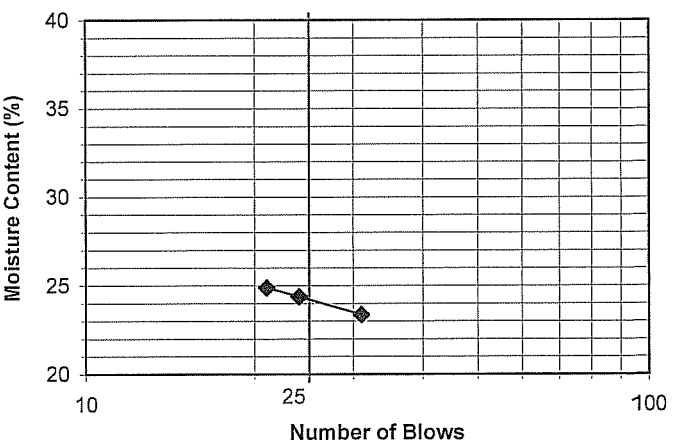
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/11/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-017	S-09	45	24	20	4	CL-ML

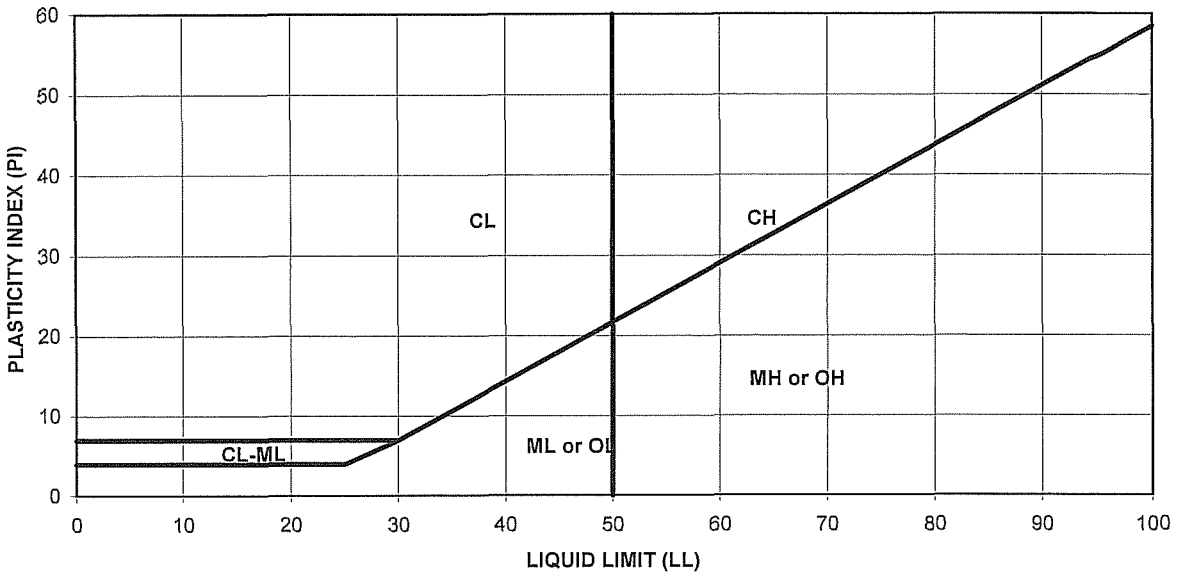
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

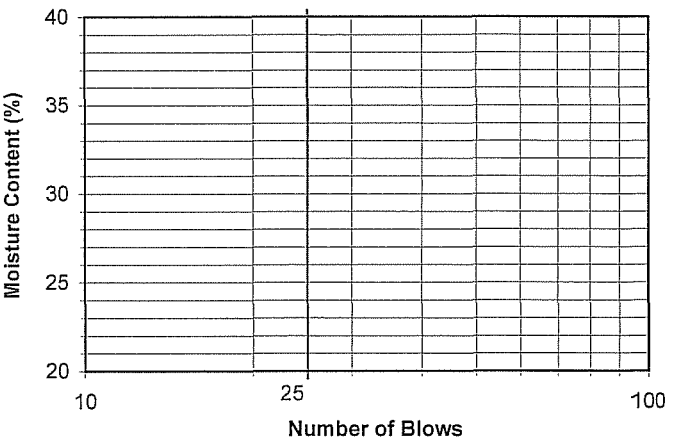
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-016	D-12-1	60	NP	NP	NP	
	R-09-016	U-14	70	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/25/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-016	R-09-016				
SAMPLE NUMBER	U-09	U-14				
DEPTH (FT)	45	70				
SOIL CLASSIFICATION	Silty Sand	Silty Sand				
METHOD (A OR B)	B	B				
FLASK NUMBER	1	2				
WT. FLASK+WATER+SOIL, g	391.72	365.12				
TEMPERATURE, °C	18.4	18.4				
CORRECTION FACTOR	1.0003	1.0003				
WT. DRY SOIL, g	46.75	41.11				
WT. FLASK + WATER, g	249.36	249.30				
% RETAINED #4	0.00	0.00				
% PASSING #4	100.00	100.00				
MATERIAL EXCLUDED	None	None				
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.73**	**2.75**				

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/20/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-016	S-01	5	ML	910	8.0	353	1240
R-09-016	S-07	35	SM	100	8.0	999	13807

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
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AP Engineering & Testing, Inc.

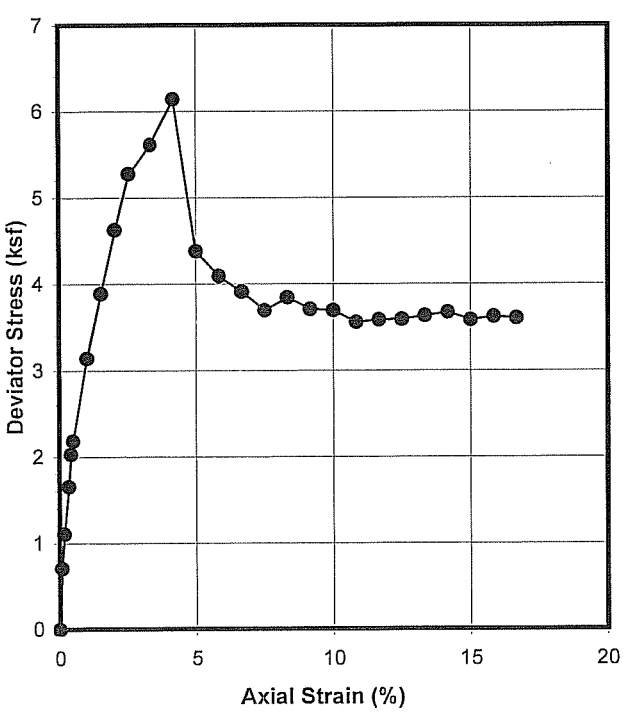
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-016				
Sample No.:	U-09	Depth (feet): 45			
Soil Description	Gray Silty Sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	121.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	96.0
Sample Weight (gms):	1241.34	Moisture Content (%):	26.4
Wt. Wet Soil+Container(gms)	1448.54	Void Ratio for Gs=2.7:	0.76
Wt. Dry Soil+Container(gms)	1186.41	% Saturation:	94.4
Wt. Container (gms)	194.62		

TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	6.1
Ultimate Deviator Stress (ksf):	3.7
Ultimate Undrained Shear Strength (ksf):	1.8
Axial Strain @ Maximum Stress (%)	4.17



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
32	0.005	6.50	0.71	0.08
50	0.010	6.50	1.11	0.17
75	0.020	6.51	1.66	0.33
92	0.025	6.52	2.03	0.42
99	0.030	6.52	2.19	0.50
143	0.060	6.56	3.14	1.00
178	0.090	6.59	3.89	1.50
213	0.120	6.62	4.63	2.00
244	0.150	6.66	5.28	2.50
262	0.200	6.72	5.62	3.33
289	0.250	6.77	6.14	4.17
208	0.300	6.83	4.38	5.00
196	0.350	6.89	4.09	5.83
189	0.400	6.96	3.91	6.67
180	0.450	7.02	3.69	7.50
189	0.500	7.08	3.84	8.33
184	0.550	7.15	3.71	9.17
185	0.600	7.21	3.69	10.00
180	0.650	7.28	3.56	10.83
183	0.700	7.35	3.59	11.67
185	0.750	7.42	3.59	12.50
189	0.800	7.49	3.63	13.33
193	0.850	7.56	3.67	14.17
190	0.900	7.64	3.58	15.00
194	0.950	7.71	3.62	15.83
195	1.000	7.79	3.60	16.67

AP Engineering & Testing, Inc.

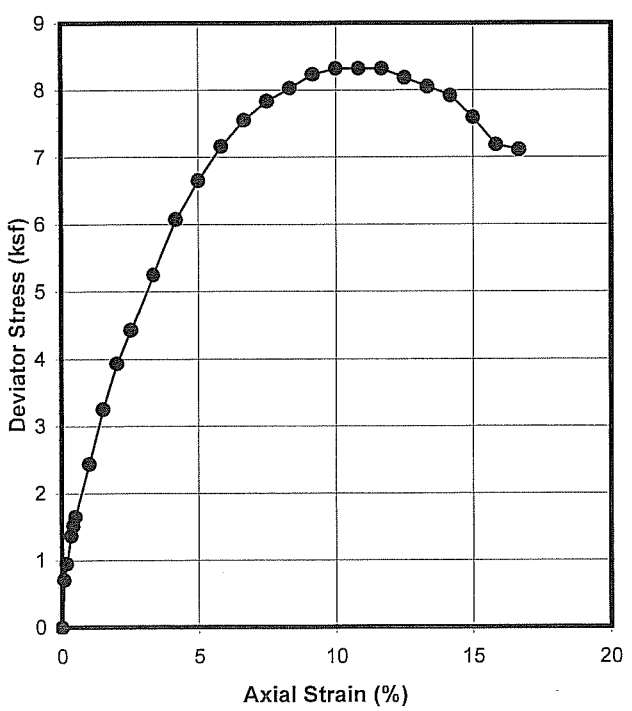
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-016		
Sample No.:	U-14 Depth (feet): 70		
Soil Description	Gray Silty Sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	127.4
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	102.8
Sample Weight (gms):	1303.38	Moisture Content (%):	24.0
Wt. Wet Soil+Container(gms)	1419.78	Void Ratio for Gs=2.7:	0.64
Wt. Dry Soil+Container(gms)	1165.60	% Saturation:	101.2
Wt. Container (gms)	104.45		

TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	8.3
Ultimate Deviator Stress (ksf):	7.9
Ultimate Undrained Shear Strength (ksf):	4.0
Axial Strain @ Maximum Stress (%)	11.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
32	0.005	6.50	0.71	0.08
43	0.010	6.50	0.95	0.17
62	0.020	6.51	1.37	0.33
69	0.025	6.52	1.52	0.42
75	0.030	6.52	1.66	0.50
111	0.060	6.56	2.44	1.00
149	0.090	6.59	3.26	1.50
181	0.120	6.62	3.93	2.00
205	0.150	6.66	4.43	2.50
245	0.200	6.72	5.25	3.33
286	0.250	6.77	6.08	4.17
316	0.300	6.83	6.66	5.00
343	0.350	6.89	7.16	5.83
365	0.400	6.96	7.56	6.67
382	0.450	7.02	7.84	7.50
395	0.500	7.08	8.03	8.33
409	0.550	7.15	8.24	9.17
417	0.600	7.21	8.32	10.00
421	0.650	7.28	8.33	10.83
425	0.700	7.35	8.33	11.67
422	0.750	7.42	8.19	12.50
419	0.800	7.49	8.05	13.33
416	0.850	7.56	7.92	14.17
403	0.900	7.64	7.60	15.00
385	0.950	7.71	7.19	15.83
385	1.000	7.79	7.12	16.67

Appendix F. Site-Specific Ground Motion Study Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

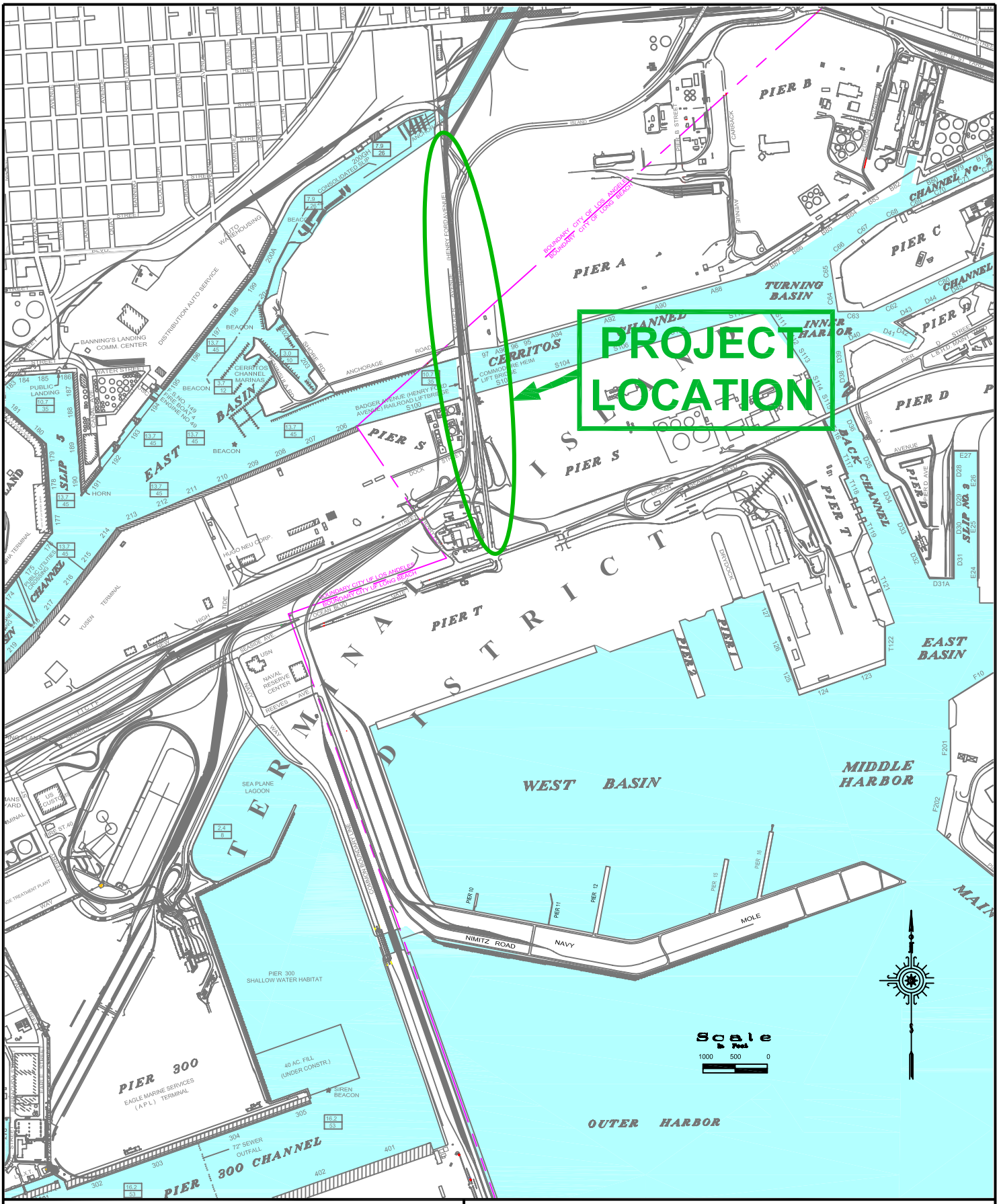
California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

Earth Mechanics, Inc., 2006a, "Preliminary Foundation Report, ACTA Schuyler Heim Bridge (Replace), Los Angeles, California," Report Prepared for Alameda Corridor Transportation Authority, EMI Project No. 06-123, June 23.

——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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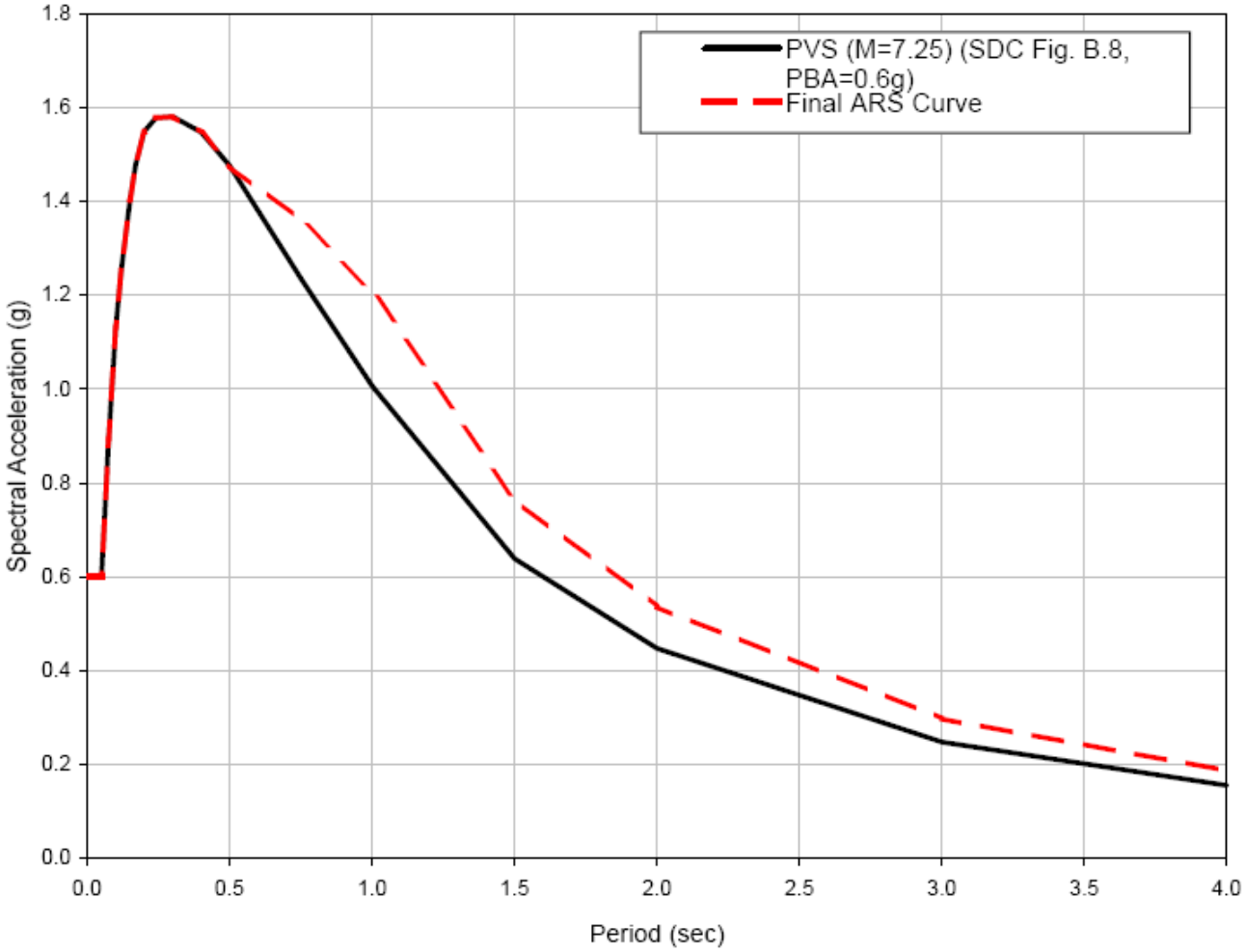
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

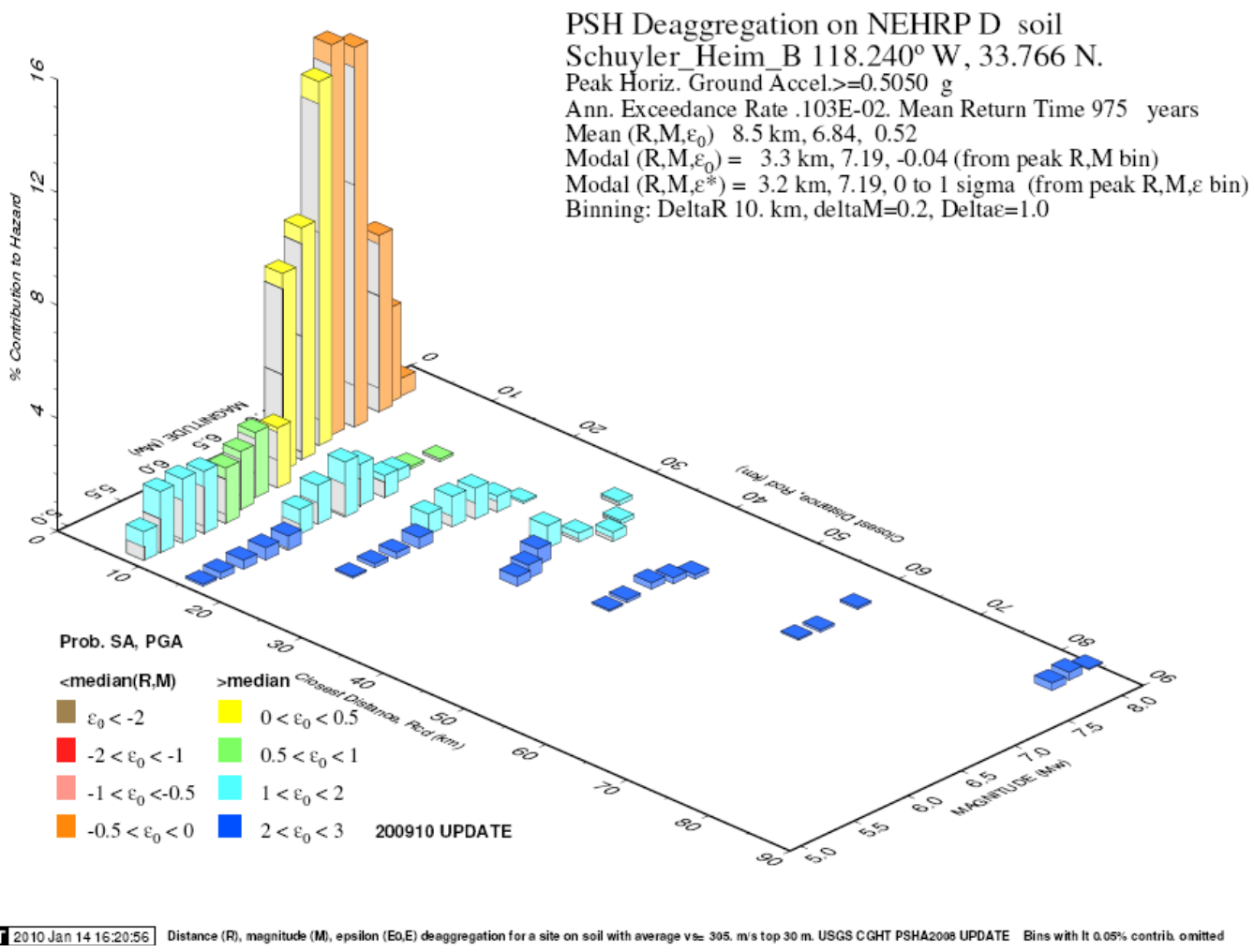


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

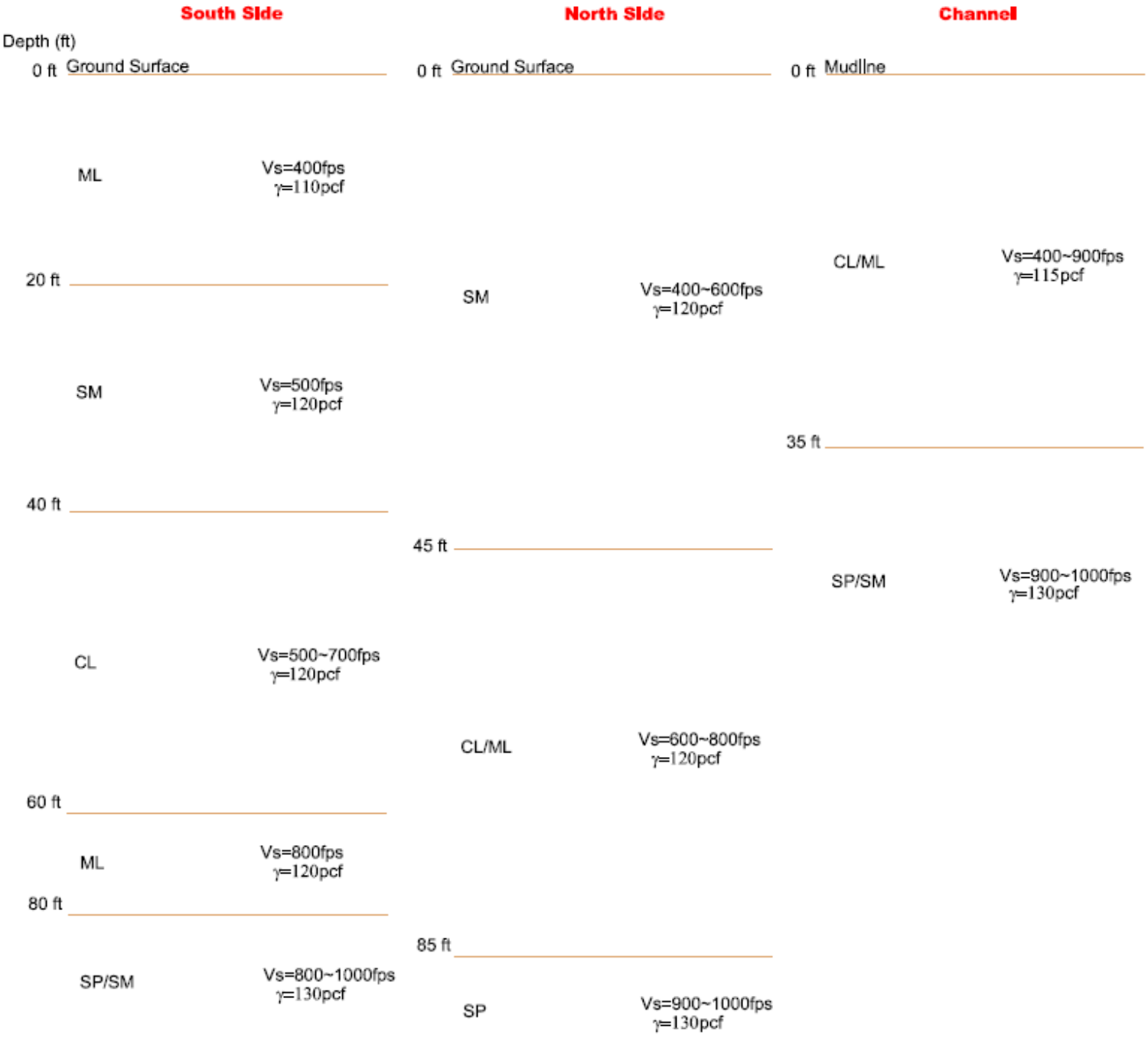
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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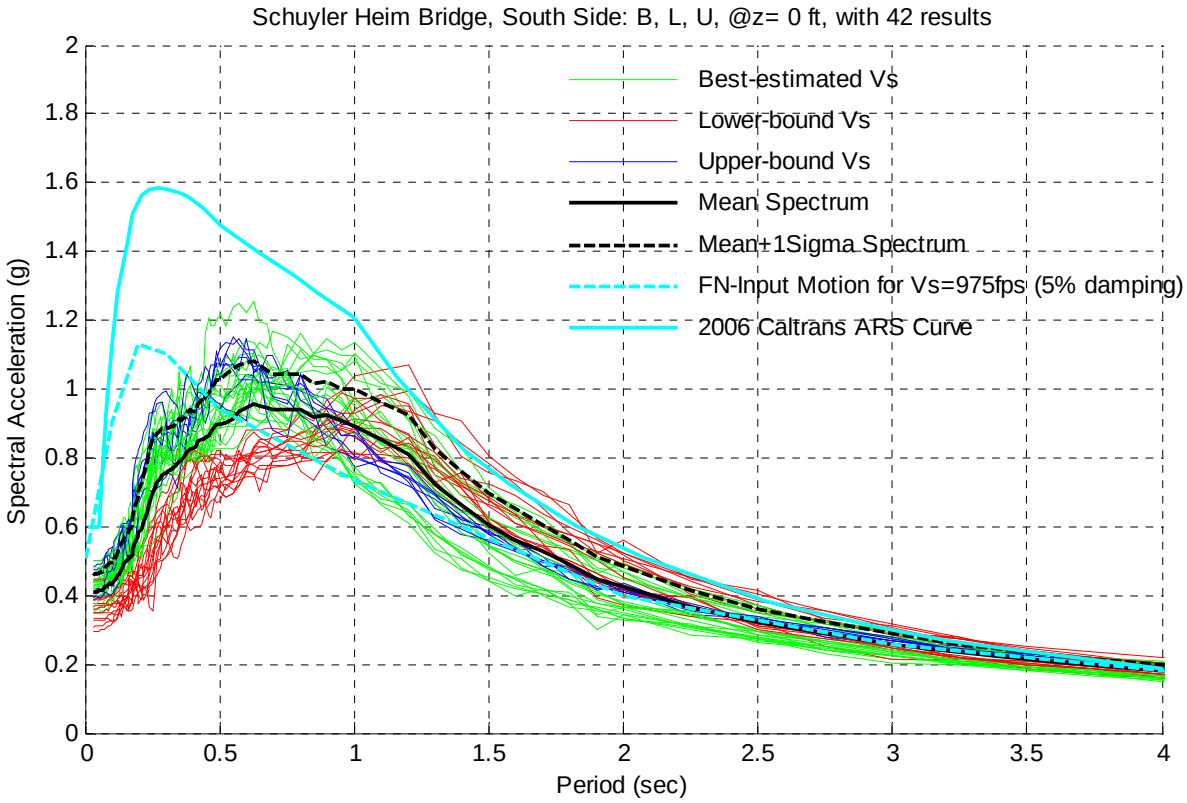
Geotechnical and Earthquake Engineering

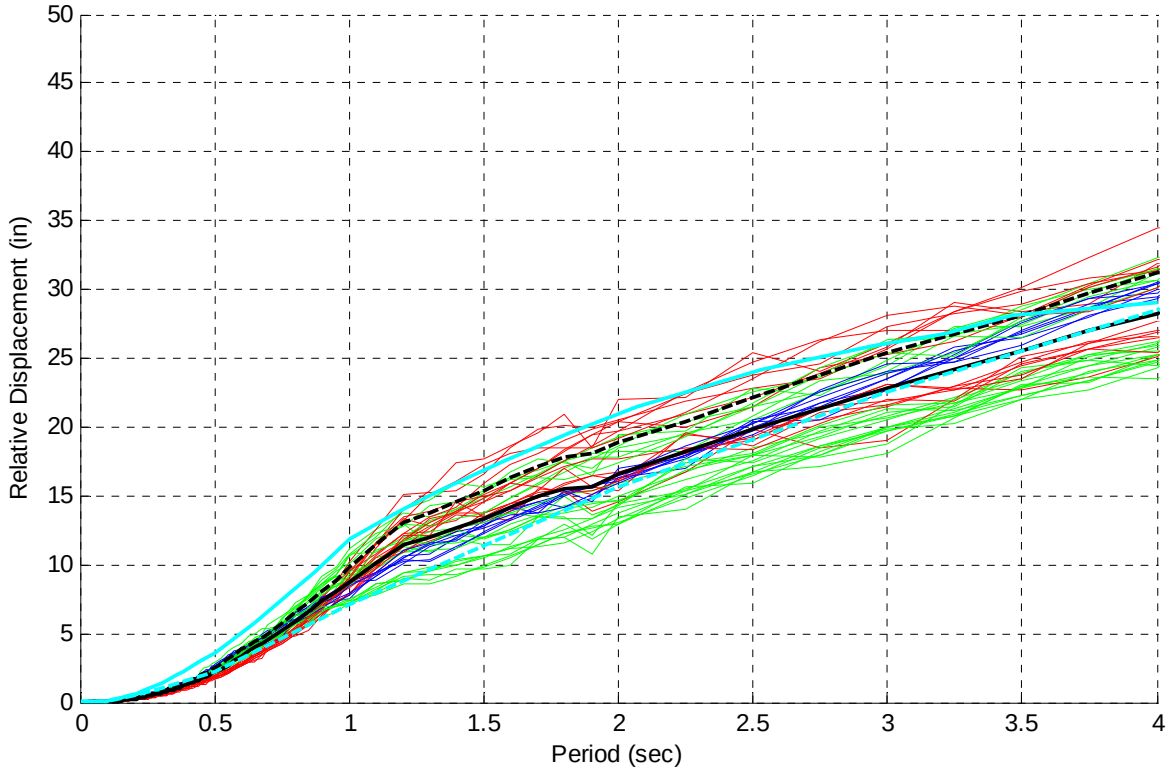
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





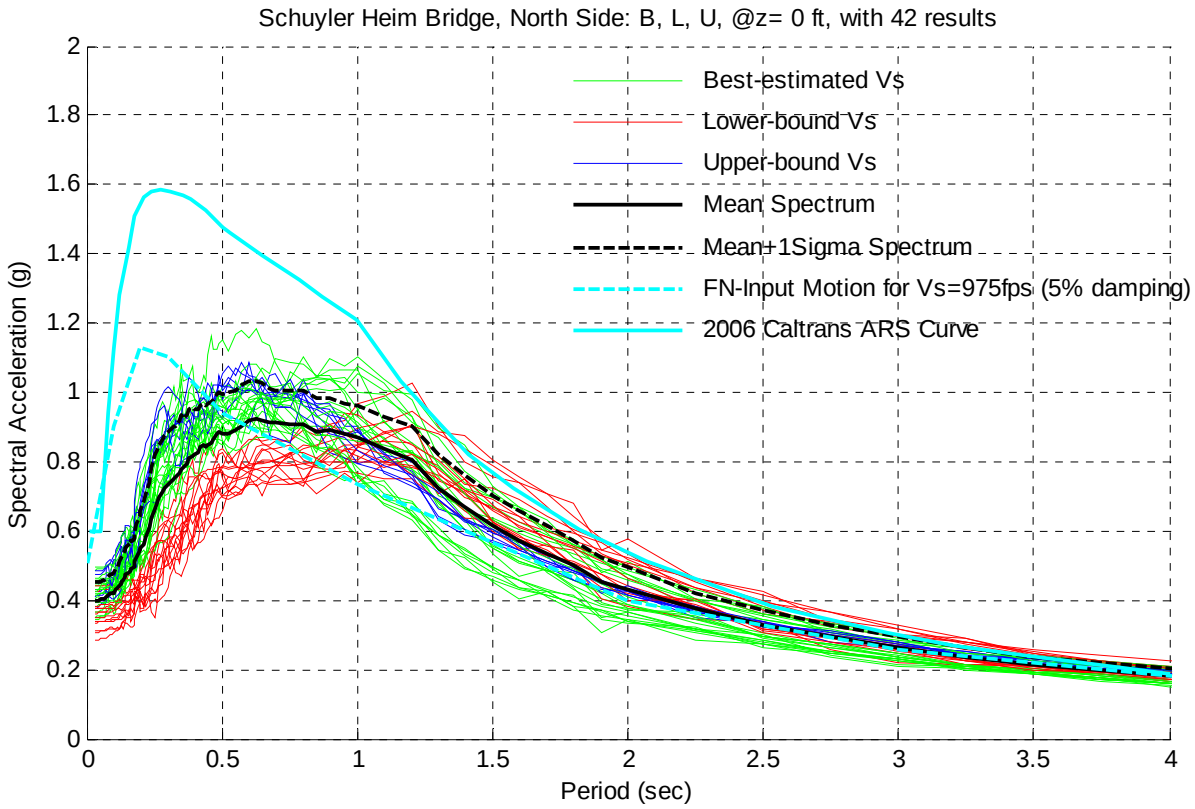
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

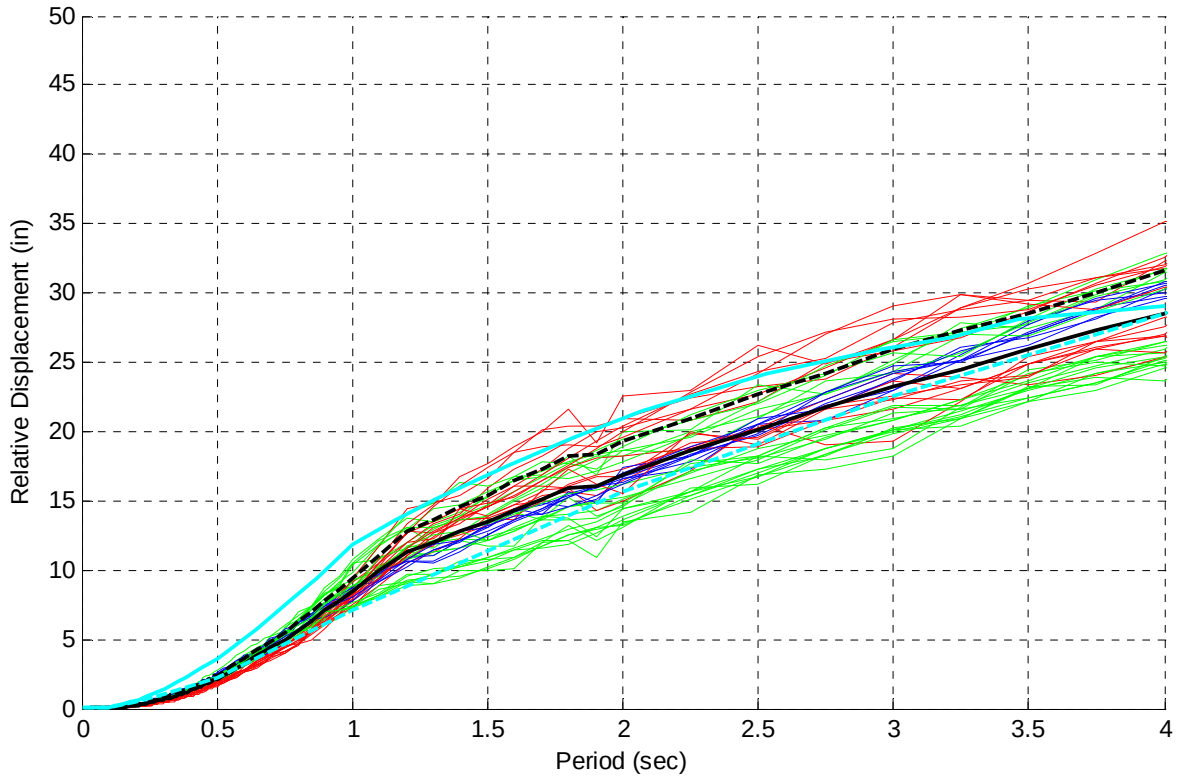
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





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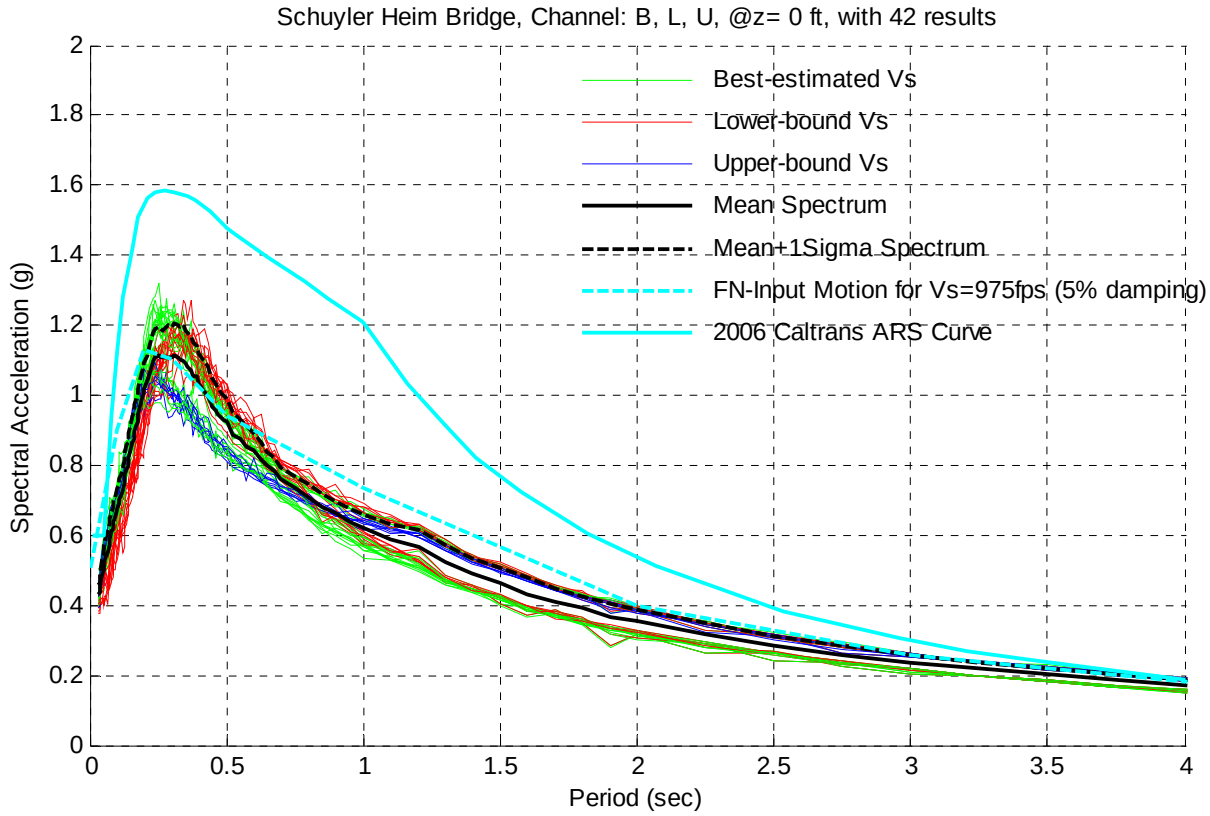
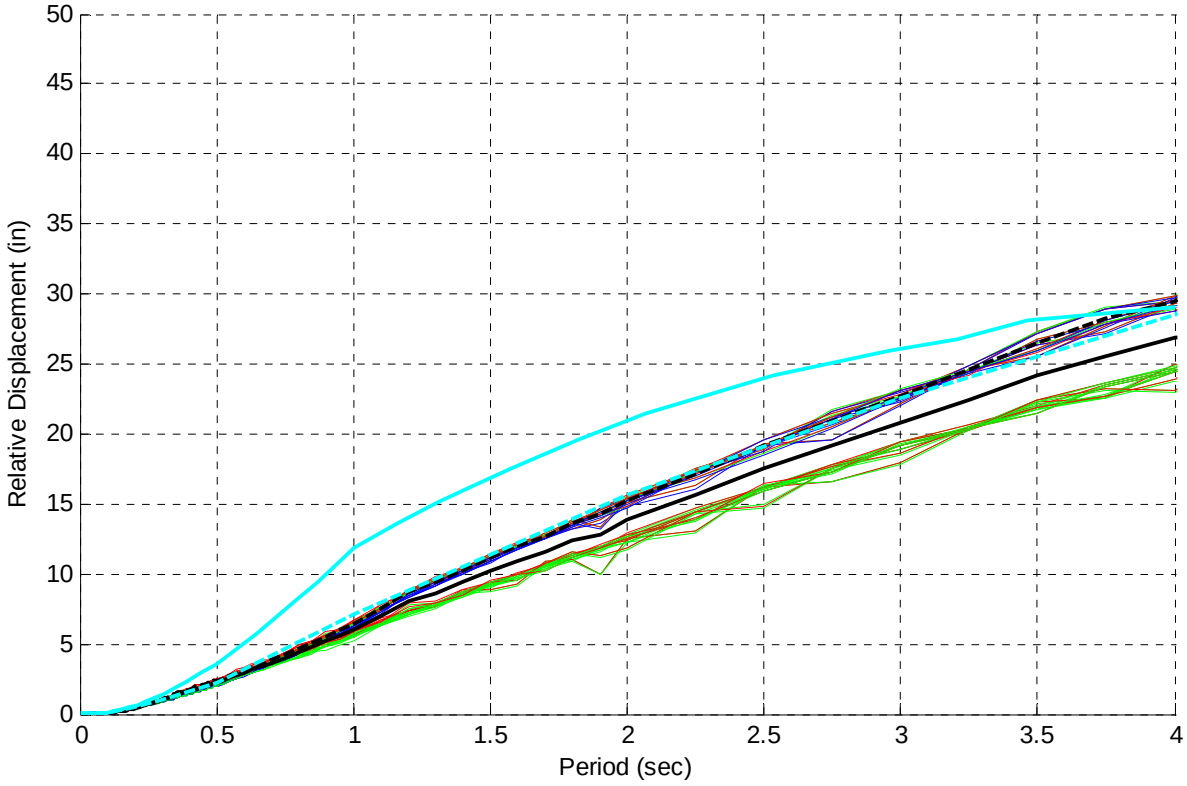
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





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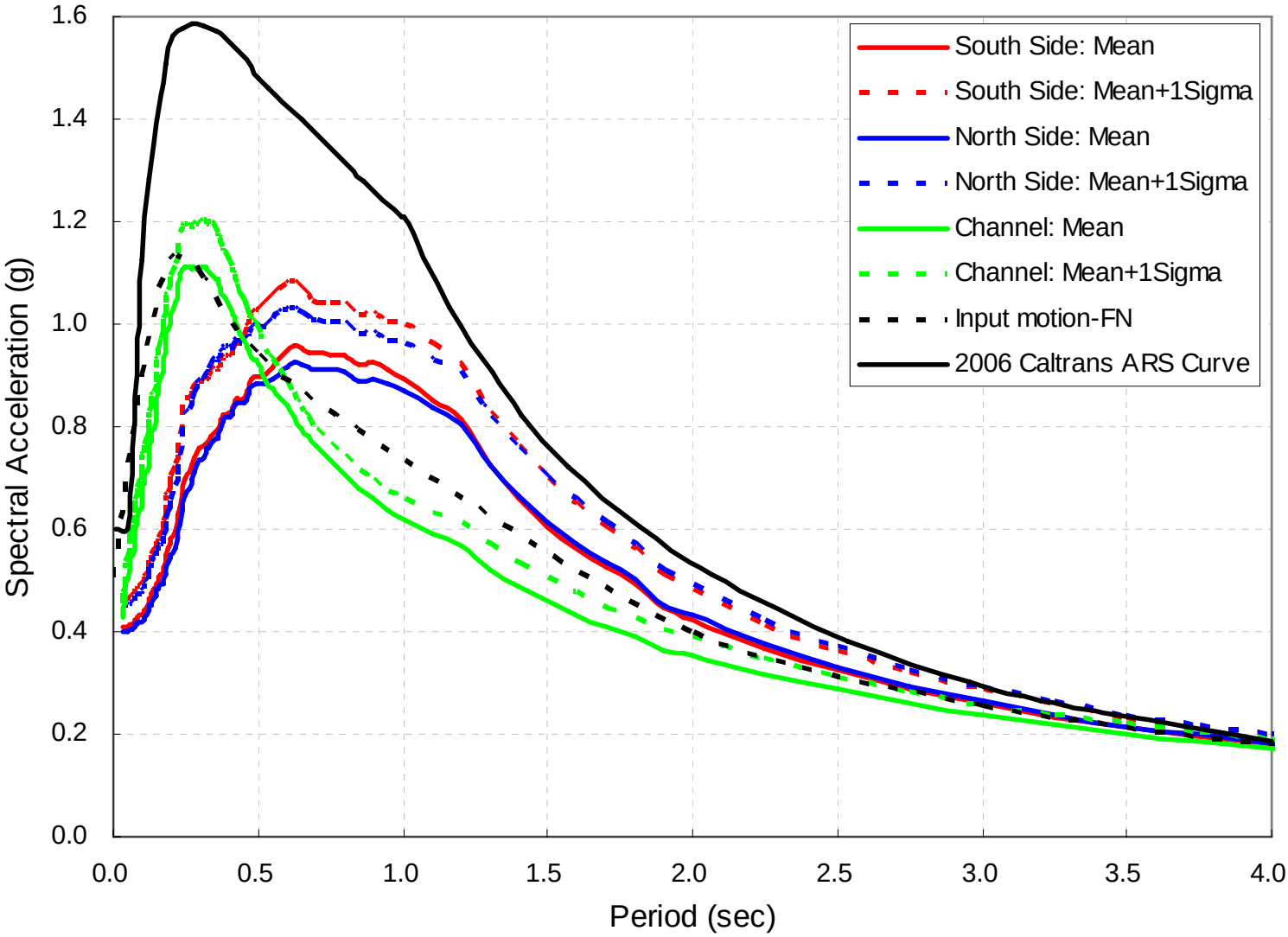
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

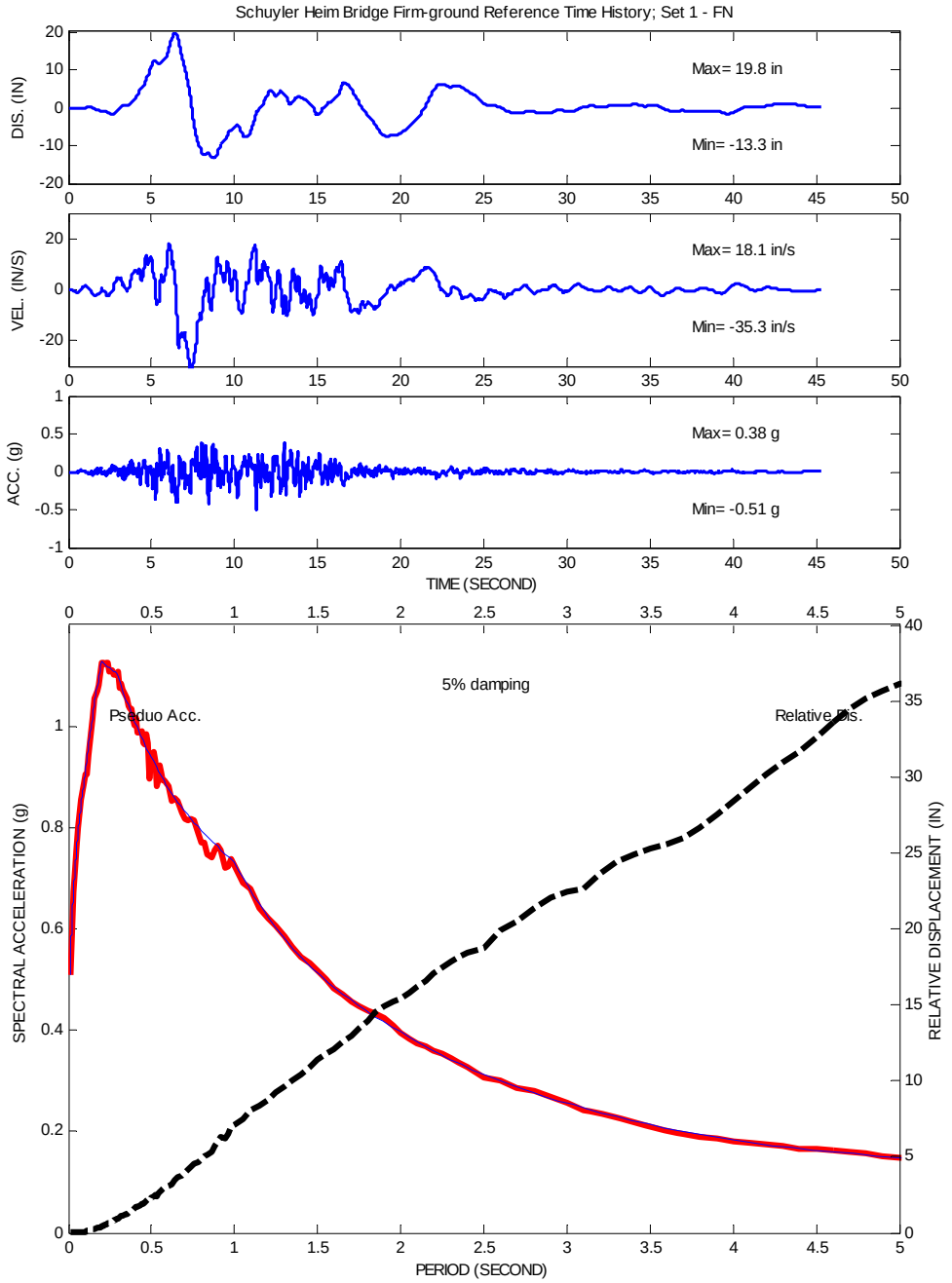

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

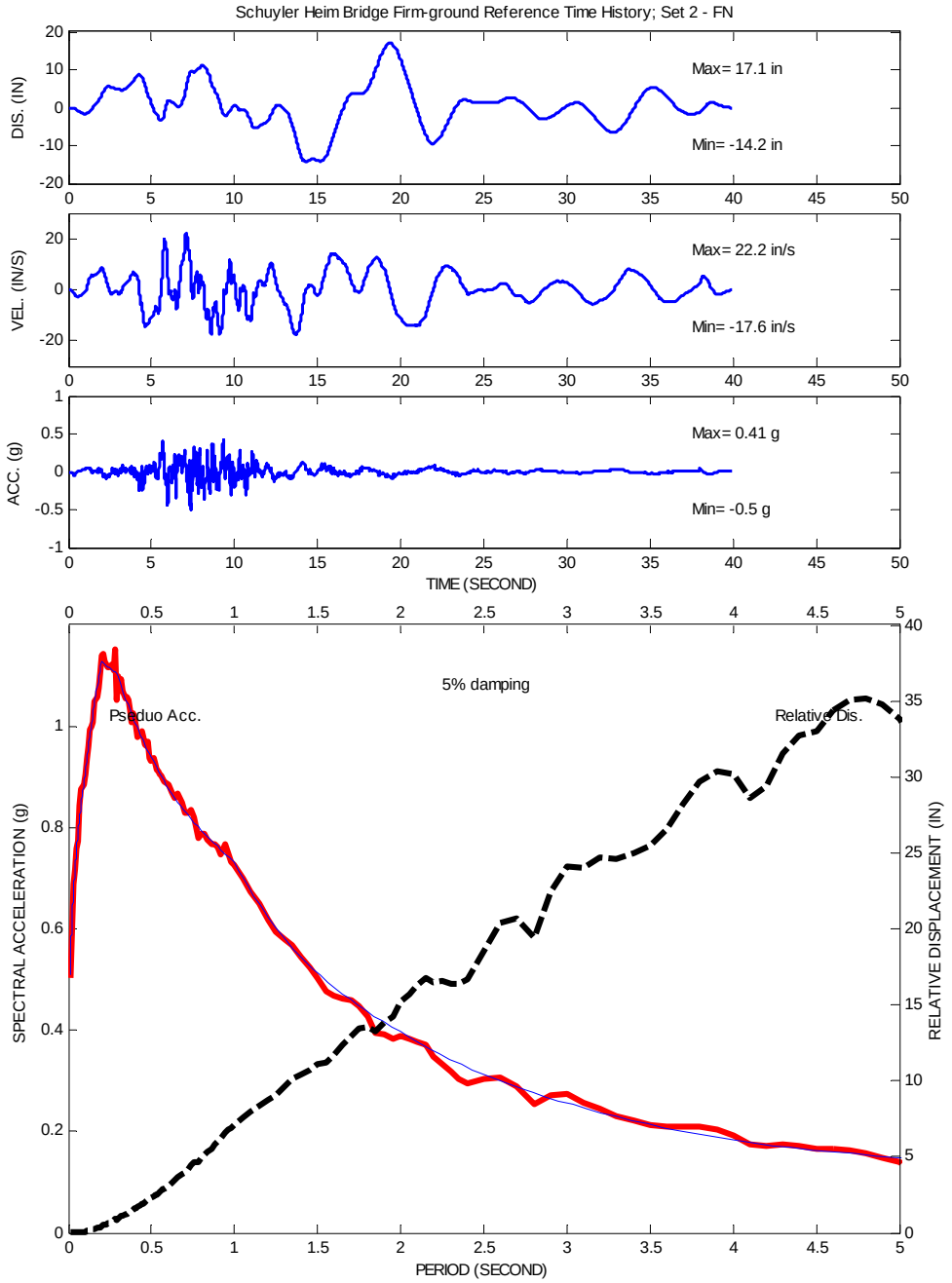

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

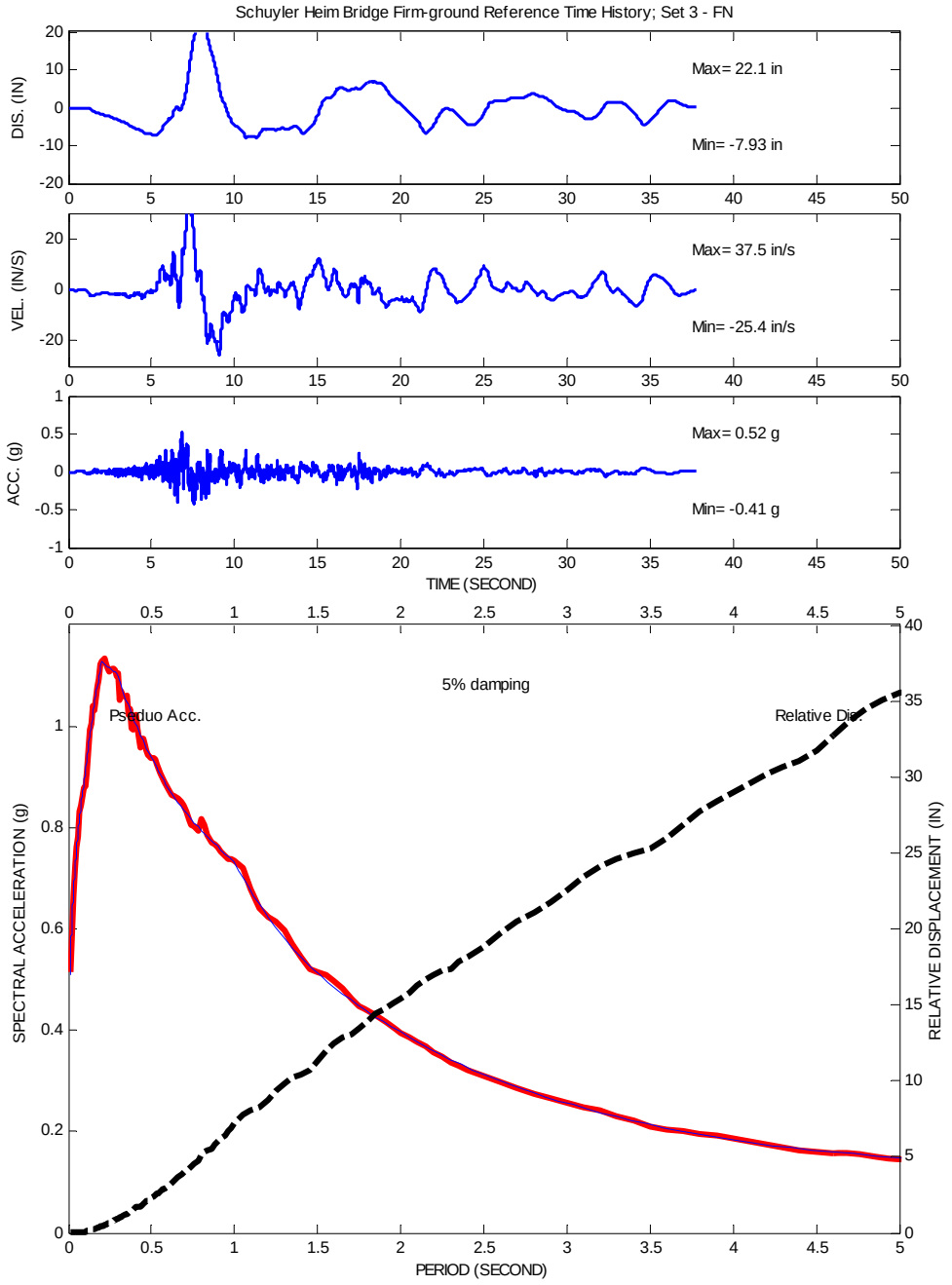

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

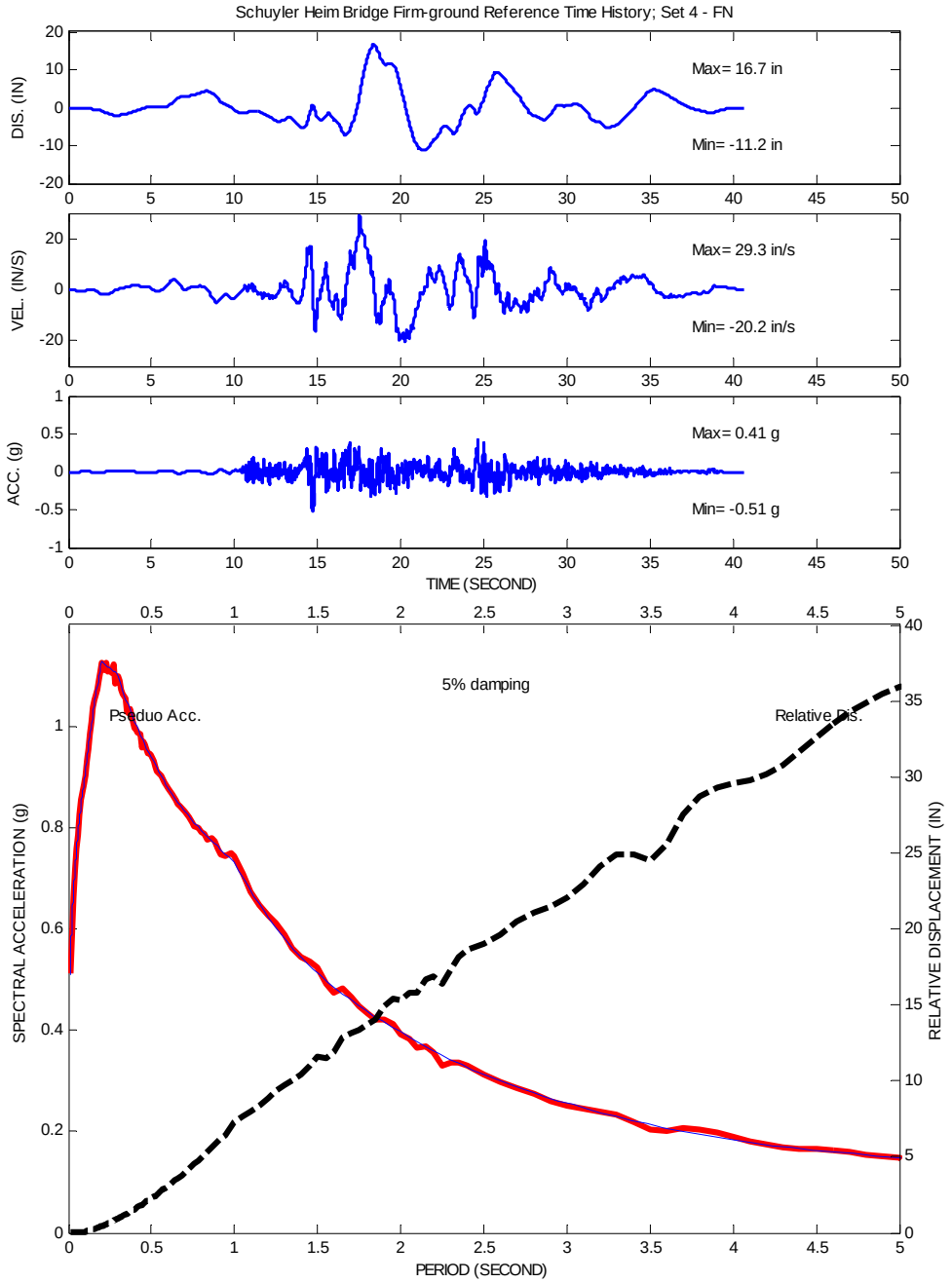

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

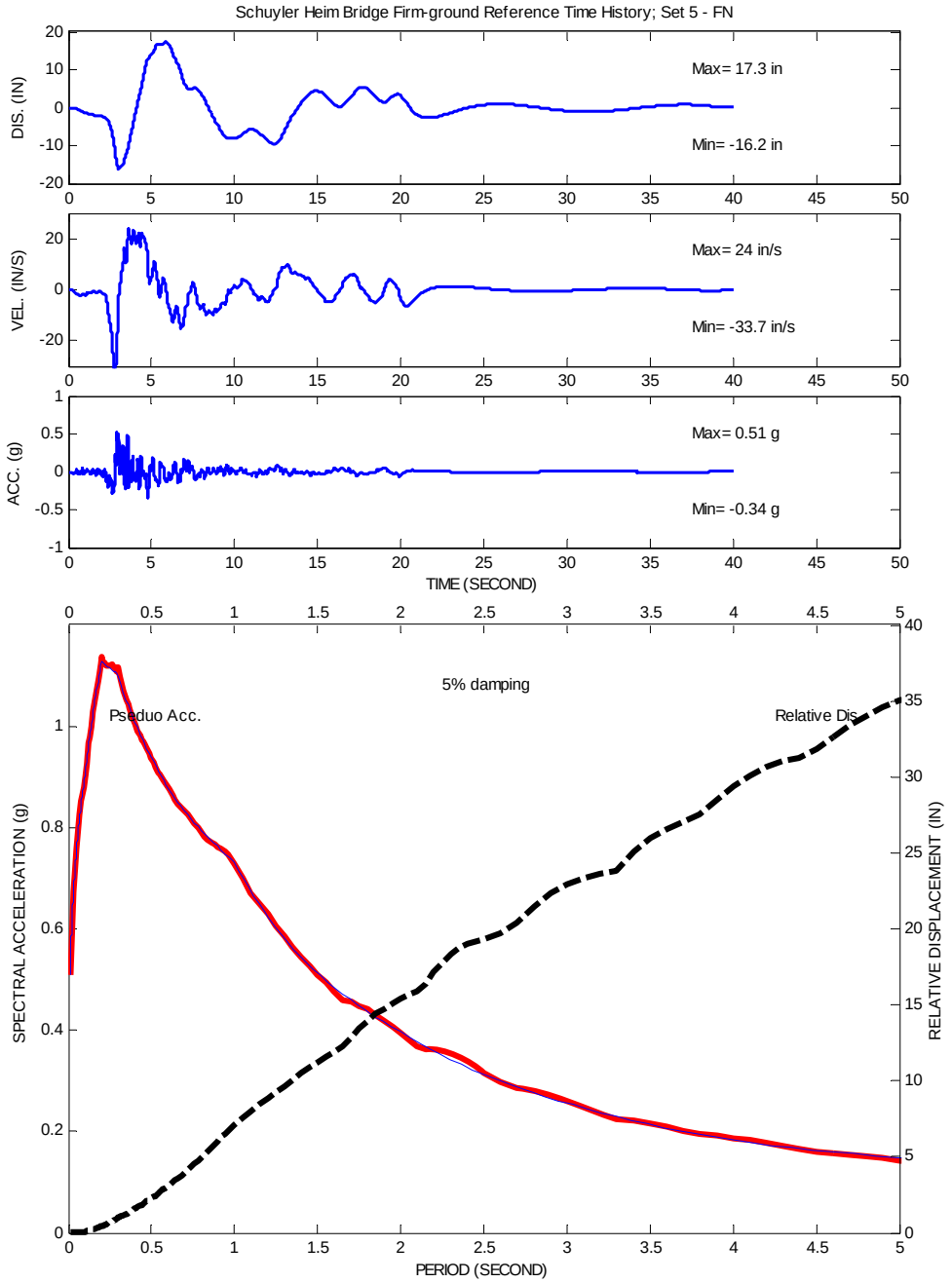

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

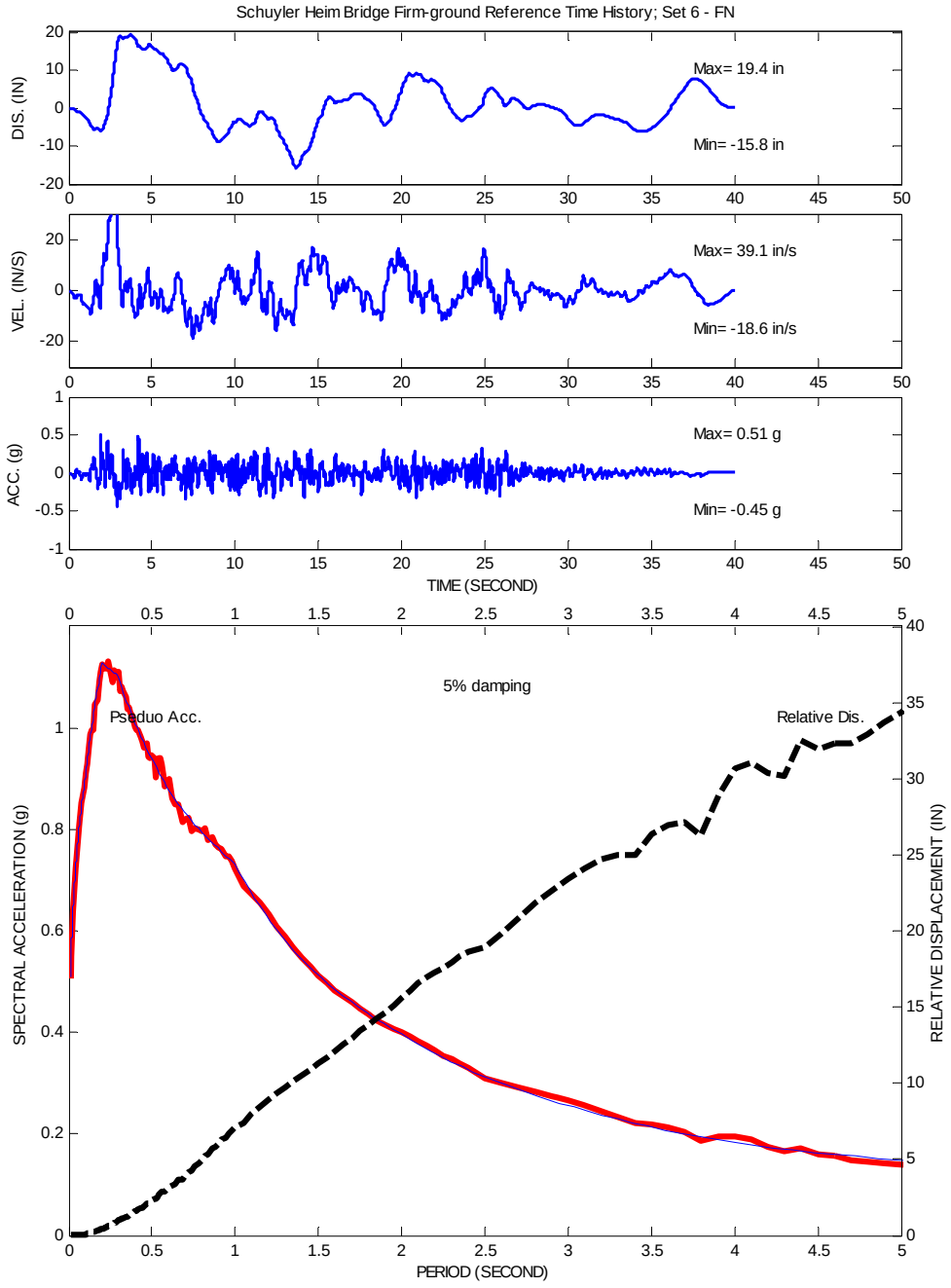

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

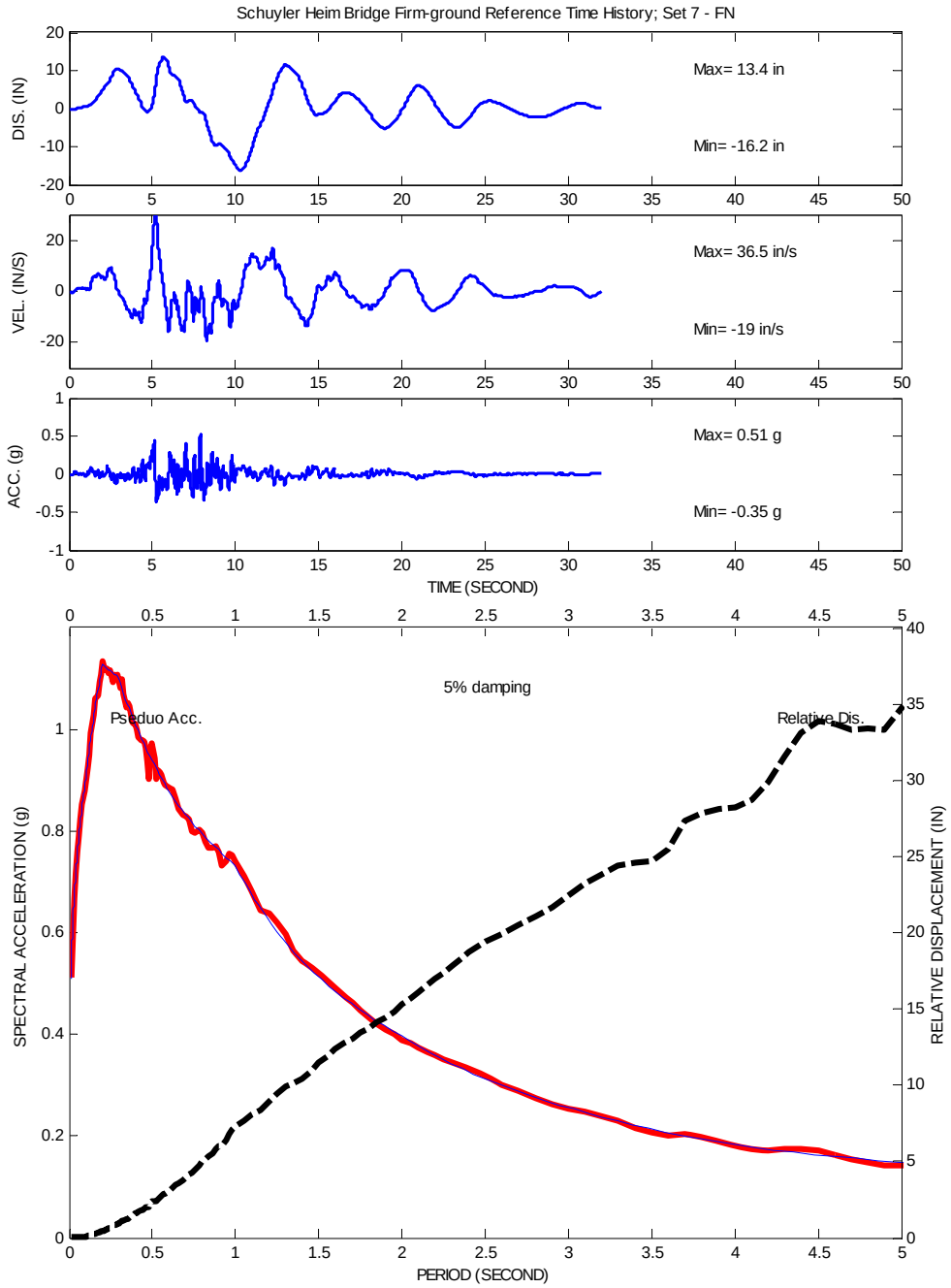

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

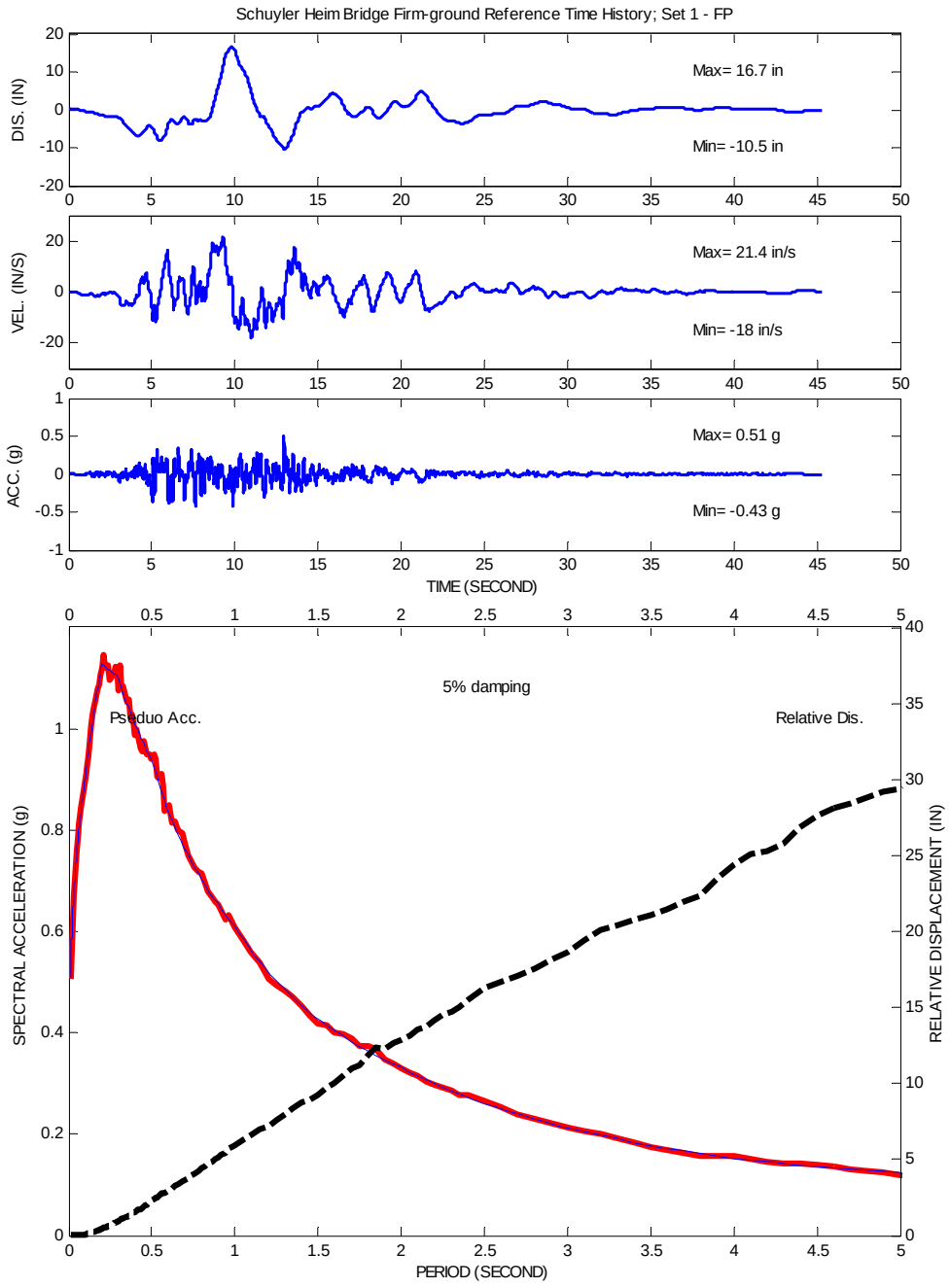

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

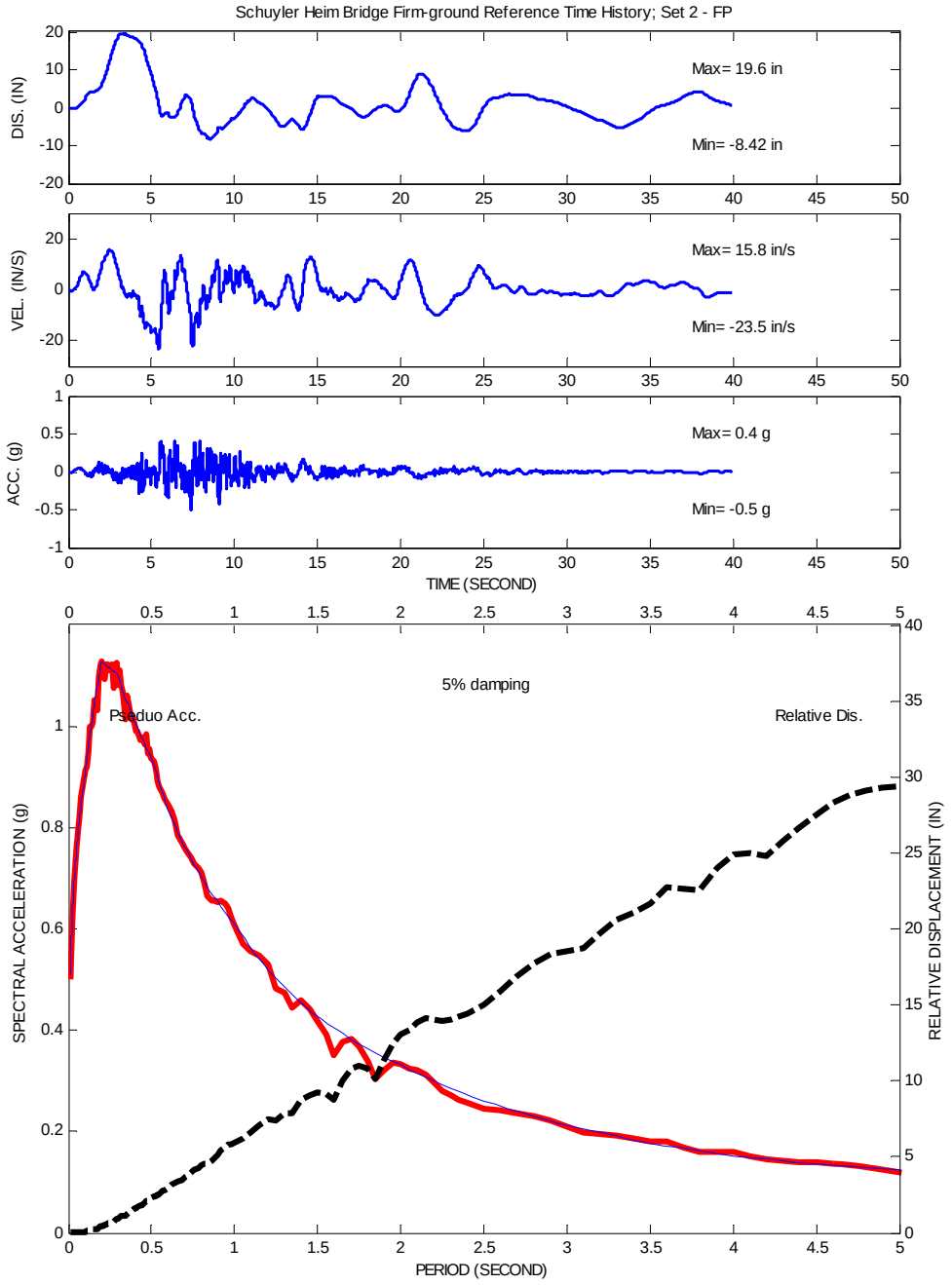

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

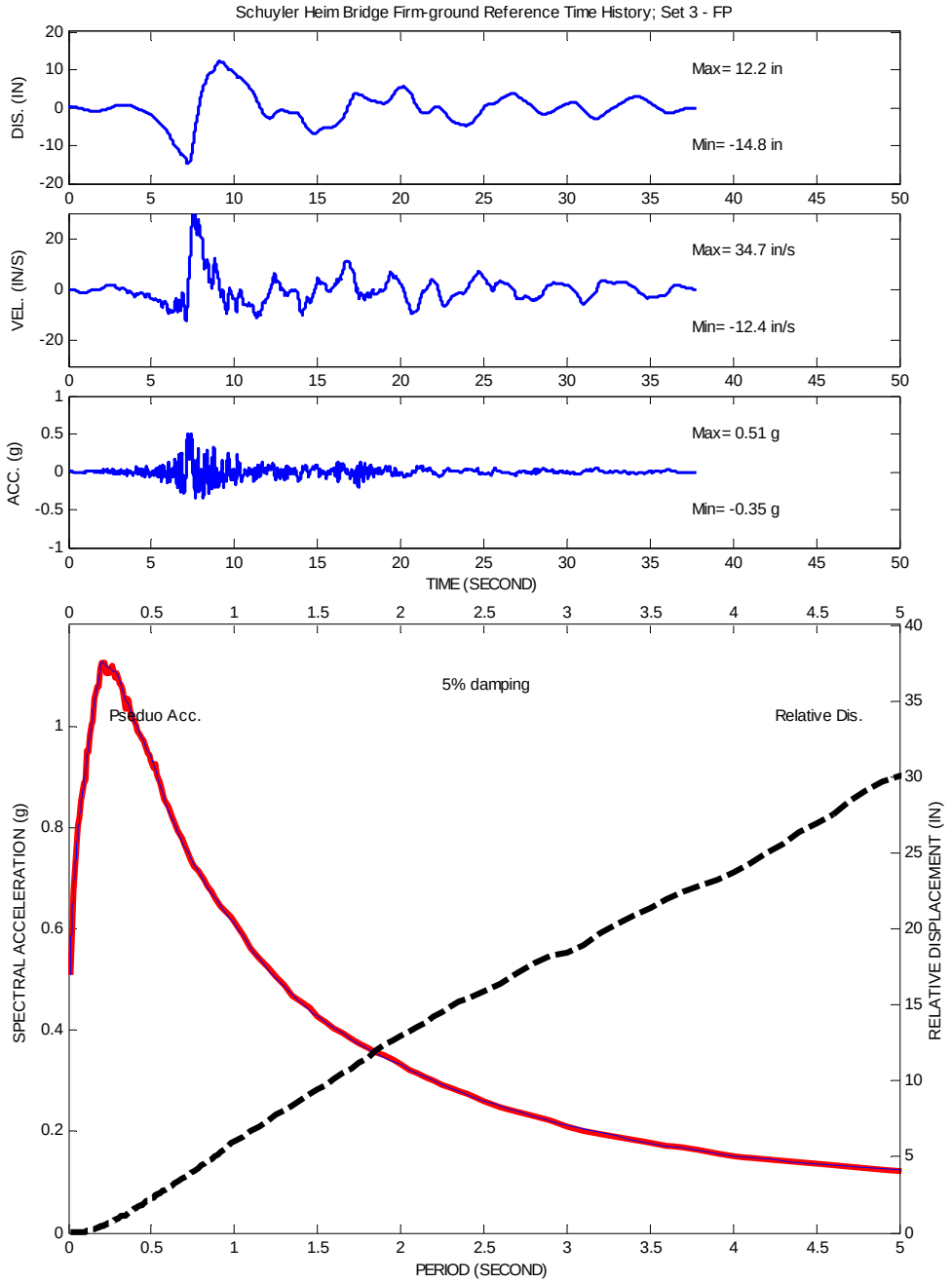

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

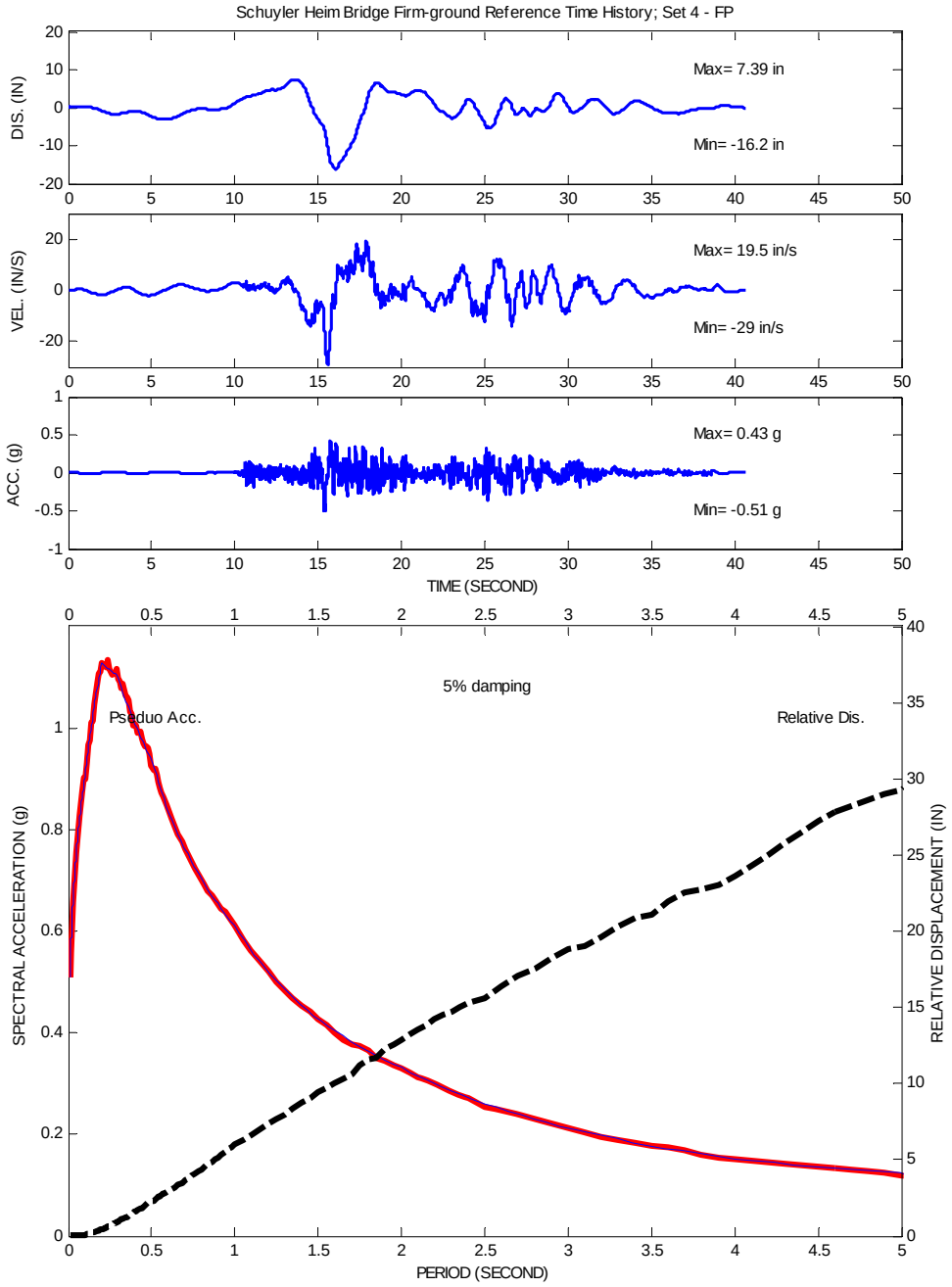

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

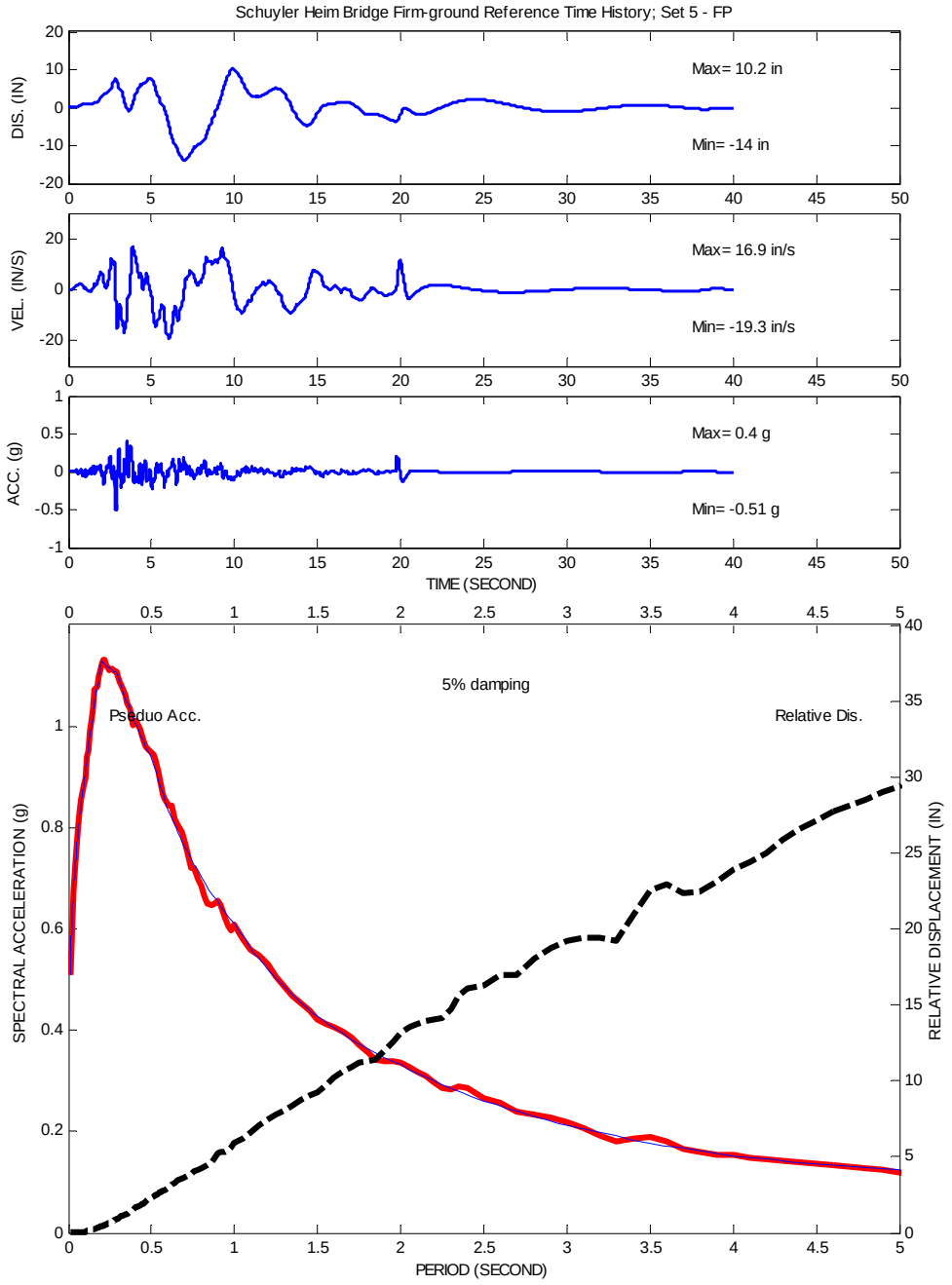

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

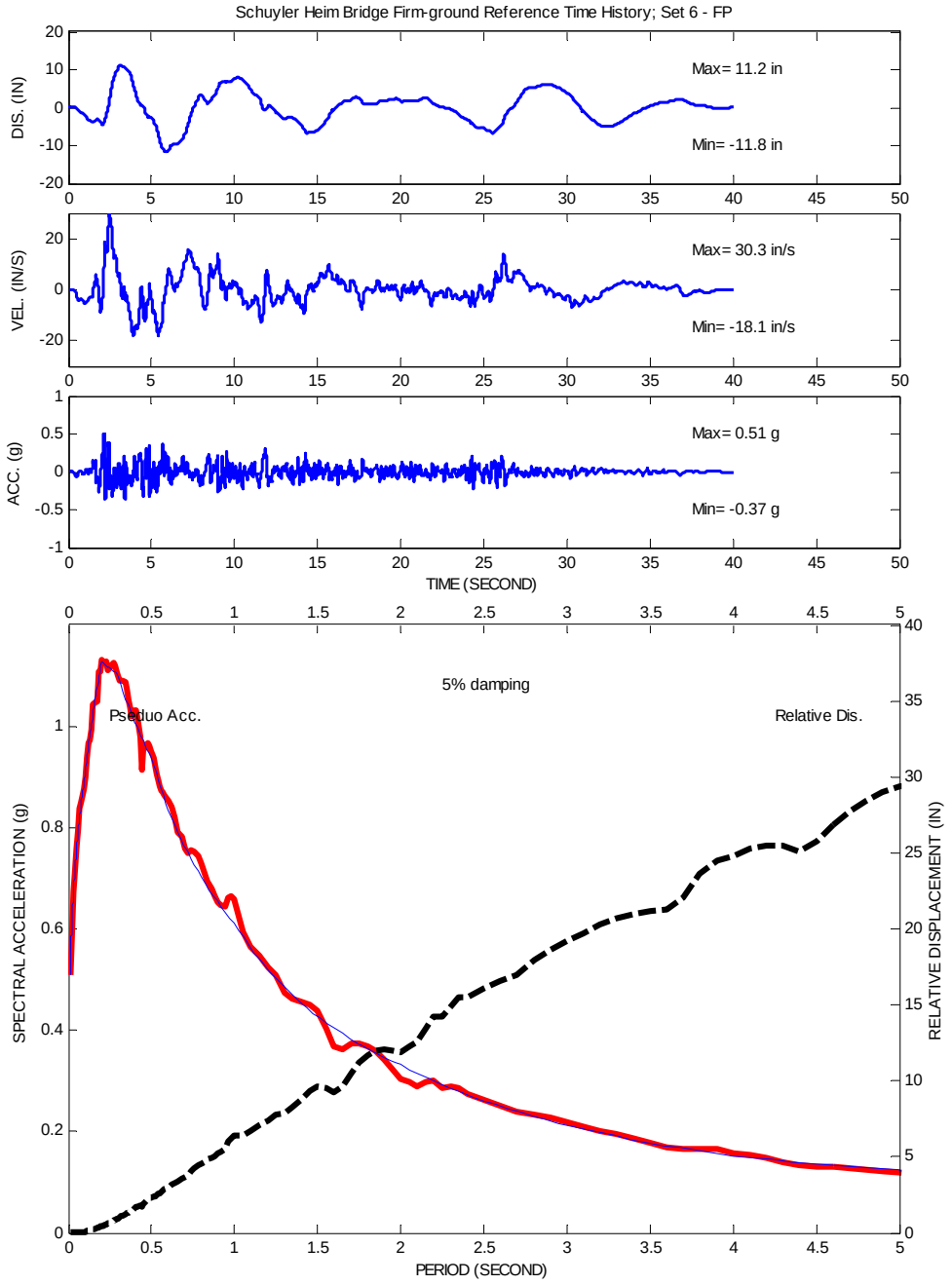

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

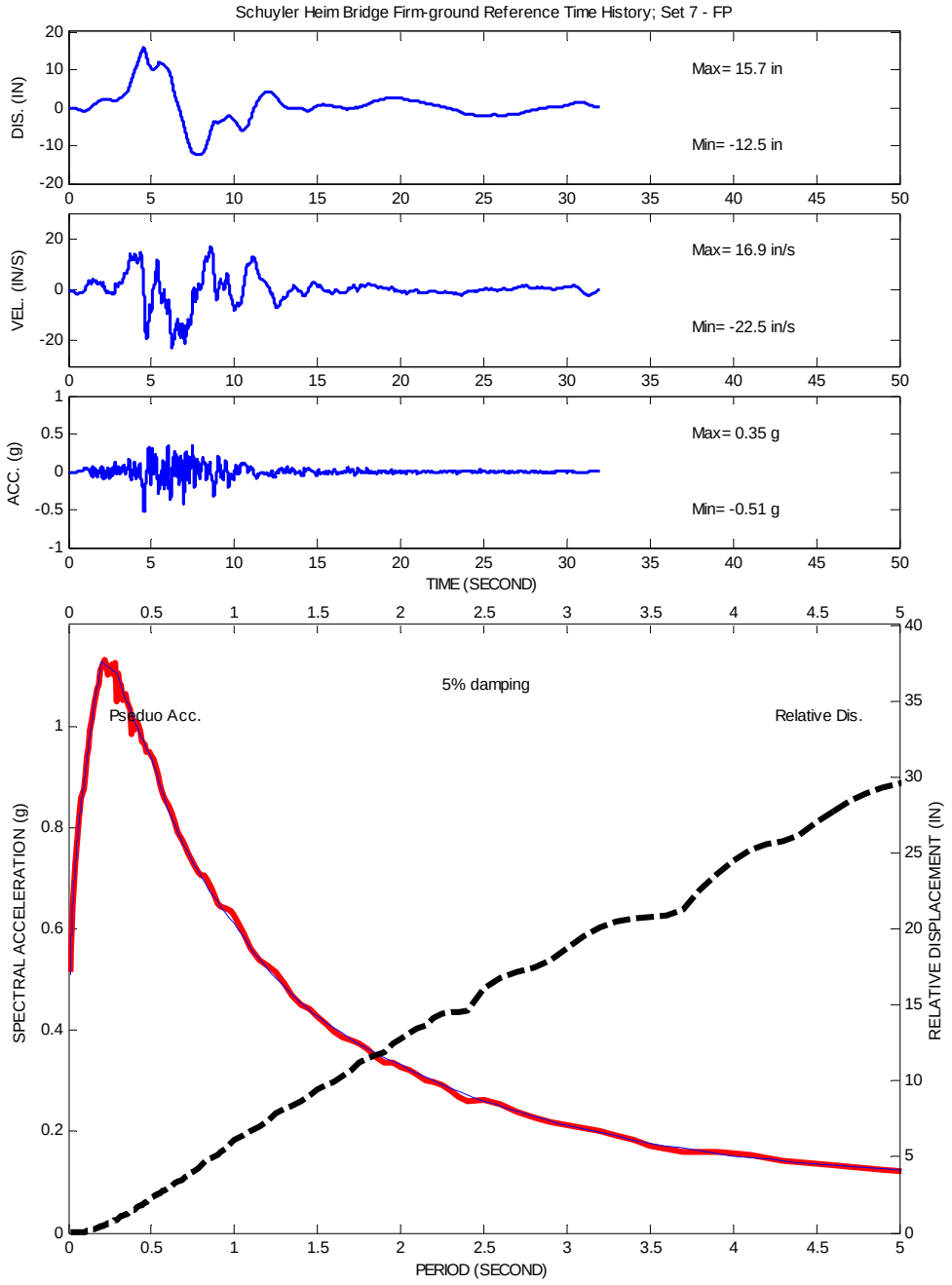

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

Appendix G. p-y Curve Comparison Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 2, 2010 **EMI PROJECT NO:** 06-123-03

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Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul K. Arulmoli, Eric Brown & Patrick Wilson / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge (Replace)
Los Angeles and Long Beach, CA
Bent Foundation Lateral Pile Analysis (p-y Curve Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge (Replace) and associated ramp structures (New Dock Street On-Ramp, New Dock Street Off-Ramp, State Route-103 On-Ramp and State Route-103 Off-Ramp) in the cities of Los Angeles and Long Beach, California.

This memorandum summarizes the results of our lateral pile analysis following completion of the recent field investigation and laboratory testing program and is intended to verify that p-y curves developed during the preliminary design phase are suitable and conservative for use in final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California. The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and W. Ocean Boulevard on the south side.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge and the new alignment shifts east along the existing alignment. The proposed fixed bridge will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge will also include southbound exit ramps and northbound entrance ramps at New Dock Street and State Route (SR) 103.

The typical bridge bent will have either multiple columns (mainline) or single columns (ramp structures) supported on Type II cast-in-drilled-hole (CIDH) piles. South of Cerritos Channel, the CIDH piles are 10 ft diameter while the spans across Cerritos Channel and north of Cerritos Channel are supported on 11 to 12 ft diameter CIDH piles. The abutments for the mainline and the ramp structures are expected to be supported on 2.5-foot diameter CIDH piles; however the subject memorandum only pertains to the bent pile analysis.

Project Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time and was intended to be used for bridge type selection and preliminary design. The PFR included a general description of the subsurface conditions including eight idealized soil profiles along the proposed structure alignment with each idealized soil profile typically spanning across multiple bents. The idealized soil profile was used by EMI to develop pile lengths for cost estimating purposes based upon preliminary design loads provided by the designers. Each idealized soil profile included stratigraphy and idealized soil strength parameters (unit weight, friction angle and undrained shear strength) including post-liquefaction "residual" shear strengths for the layers identified as being potentially liquefiable based on a liquefaction analysis performed on the existing soil borings.

It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared. A set of p-y curves was generated at each bent of the mainline and ramp structures for a single 10-ft diameter CIDH pile and included reduced soil strengths for the layers identified in the PFR as potentially liquefiable. Since the project specific geotechnical field investigation could not be initiated until late during the project timeline, the preliminary p-y curves were used by the Caltrans bridge designers in final design. Based upon our conversations with the bridge designers, the only modifications that were made to the preliminary p-y curves was the application of a p-multiplier of 1.2 to curves where the CIDH pile diameter was increased to 12 ft.

In September 2009, EMI was requested by the Alameda Corridor Transportation Agency (ACTA) to perform the project-specific geotechnical field investigation which when completed consisted of 42 rotary wash borings, 33 cone penetration test (CPT) soundings and 8 hollow-stem auger borings along the proposed bridge and ramp alignment; including at least one boring performed near each support of the proposed structure. After completion of the geotechnical field investigation and laboratory testing program, a complete liquefaction analysis was conducted using the new boring information and the idealized soil profile along the proposed bridge alignment was revised.

Because the geotechnical field investigation was not able to be initiated until late during the project timeline, re-analyzing the structure based upon p-y curves generated using the updated soil profile was not feasible given project deadlines. Therefore, EMI performed a set of lateral pile analyses at selected bent locations representing the entire bridge alignment to compare the

preliminary p-y curves (referred to as Design Curves in this memorandum) generated from the idealized soil profiles in the PFR to the p-y curves developed using the updated soil profile (referred to as Revised Profile Curves in this memorandum) to verify that the preliminary curves are suitable and conservative for use in final design.

Method of Analysis

As described above, the Design Curves were generated from eight different soil profiles provided in the PFR (EMI, 2006). For comparison purposes, five bent locations were selected where the individual p-y curves and the overall pile behavior (pile head shear resistance and maximum pile moment versus pile-top deflection) could be compared. The bents selected for comparison were at locations where five of the eight different soil profiles generated during preliminary design could be analyzed. The bent locations selected consisted of two bents south of Cerritos Channel (Bent 2 and Bent 11), one of the bents inside the Cerritos Channel (Bent 14) and two bents north of Cerritos Channel (Bent 18 and Bent 24). The five different idealized soil profiles are shown in Figures 1 to 5.

A review of the Design Curves indicated that coarse-grained soils appear to have been developed using the method proposed by Reese et al. (1974) and fine-grained soils appear to have been developed using the method proposed by Reese and Cox (1975) for stiff clay in the presence of free water. The Revised Profile Curves generated by EMI were developed using API criteria (2000) for coarse grained soils, Matlock's soft clay criteria (Matlock, 1970) for clays with undrained shear strength less than 1 ksf and Reese's method (Reese and Cox, 1975) for stiff clay in the presence of free water for clays with an undrained shear strength greater than 1 ksf.

For comparison of the individual p-y curves, the design curves were provided by the designers. The Revised Profile Curves were generated using LPILE (Ensoft, 2004) based upon the revised idealized soil profile developed at the different bent locations. For the comparison of overall pile behavior (pile head shear resistance and pile moment versus pile-top deflection), the Design Curves were input into LPILE using the "user input p-y curves" option. Based upon our conversations with the designers, a "cracked" section modulus (EI) equal to 75% of the gross EI was used for both models.

Liquefiable Soil. As described above, the Design Curves were generated from soil profiles that indicated the presence of potentially liquefiable material. Based upon a review of the Design Curves, liquefied strengths were generated by applying a p-reduction factor varying between 0.15 and 0.20 for potentially liquefiable layers.

The Revised Profile Curves were generated based upon an updated liquefaction analysis performed on the borings completed in the EMI field investigation. Liquefied soil strengths for layers identified to be potentially liquefiable were modeled using a p-reduction factor based upon the values provided in Ashford et al. (2008). The p-reduction factors are correlated to an average normalized clean sand SPT blowcount $(N1)_{60\text{-}CS}$ for the liquefiable layer with discrete values provided for a range of $(N1)_{60\text{-}CS}$. An approximate trend line was drawn through the ranges proposed by Ashford and used in the analysis as shown in Figure 6.

Group Effects. It is our understanding that the Design Curves were generated prior to Caltrans implementation of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2007) which required p-reduction factors to p-y curves to account for group effects. P-reduction factors to account for group effects for the Revised Profile Curves followed the recommendations for pile group efficiency reduction factors provided in Caltrans Amendments to AASHTO LRFD BDS (Caltrans, 2008) and were based upon the CIDH pile on-center spacing in the bridge transverse direction at the individual bent locations. Since each bent consists of a single row of piles, the bridge transverse direction controls the pile design as it has a greater group reduction than the longitudinal direction. The pile spacing and p-reduction factors used in the analysis for each bent are listed in Table 1.

Table 1. Group Reduction Factors for Revised Profile Curves

Bent Location	Pile Diameter (ft)	Average Spacing in Transverse Direction (ft)	P-Reduction Factor for Group Effects
Bent 2	10	30 = 3.0 x D	0.53
Bent 11	10	36 = 3.6 x D	0.61
Bent 14	12	33 = 2.9 x D	0.48
Bent 18	12	35 = 3.0 x D	0.53
Bent 24	12	45 = 4.0 x D	0.67
Note: Group reduction effects were not accounted for in development of Design Curves.			

Groundwater. The design groundwater elevation for the Revised Profile Curves was placed at an elevation of +5 ft MLLW or the ground surface in locations where proposed grade is indicated on the plans as being below elevation +5 ft MLLW.

Results

The revised soil profiles resulting from the information gathered during the recent investigation are generally consistent with those provided in the PFR that were used to develop the Design Curves. Site soils can be characterized by alluvial deposits consisting of loose to medium dense fine-grained silty sand and sandy silt with abundant silty clay and clayey silt layers between the ground surface and about 50 to 70 ft below grade. The near surface alluvium is underlain by dense to very dense coarse-grained Gaspur Formation sand. The coarse grained portions of the alluvium is generally liquefiable with some pockets and lenses with medium dense to dense consistency that are not considered susceptible to liquefaction.

Since lateral pile behavior is primarily dictated by the soil profile within the upper portion of the pile (within about 5 to 7 pile diameters from the pile top), the lateral pile stiffness throughout the project is dominated by soft to stiff fine-grained material and liquefiable sand. In generating the revised soil profiles, the recent soil borings and laboratory test results justify using more appropriate p-reduction factors to account for liquefaction throughout the profile and higher undrained shear strengths in some of the fine-grained material. Though the Design Curves were generated during early stages of the project without considering group effects, when the more appropriate p-reduction factors for liquefiable soils and increased undrained shear strengths for the appropriate fine-grained soils are used in conjunction with the group reduction factors, the Revised Profile Curves are generally comparable to the Design Curves. Figures 7 to 11 show the

Design Curves plotted along side the Revised Profile Curves at each bent location for the top 100 ft of pile length.

Due to some revisions in the idealized soil profile stratigraphy based upon the new soil information, there are some depths that the Revised Profile Curves model a layer or a portion of a layer as softer than the Design Curves; therefore, it isn't necessarily clear upon initial inspection which set of p-y curves generates a more conservative soil model. Based upon our conversations with the designers, performing a pile pushover analysis using a free-head pile, the curves that generate a pile response where a smaller pile-head shear is required to produce a prescribed lateral pile displacement is considered to be more conservative. In addition, since earthquake loading on a bridge is force based (i.e., mass times the spectral acceleration), the curve that predicts more moment in the pile for a given pile-head shear would also be an indication of a more conservative analysis.

For the five different bents considered, the lateral pile head shear and maximum moment are plotted against lateral pile-top displacement in Figures 12 to 16 using the analysis methods described above. Figures 12, 15 and 16 show that for Bent 2, Bent 18 and Bent 24, respectively, the Design Curves produce a more conservative lateral pile response than the analysis using the Revised Profile Curves. For Bent 11 and Bent 14 shown in Figures 13 and 14, respectively, the lateral pile head shear to produce the same lateral pile deflection is about 15 percent less for the Revised Profile Curves than that for the Design Curves. These differences are considered small and acceptable. In addition, as shown in Figures 12 through 16, the maximum moments for given pile-head shear values predicted using the Design Curves are approximately equal to or greater those predicted using the Revised Profile Curves.

Conclusions

Based upon the results of the above described analysis and our discussions with the designers, we conclude that the Design Curves are appropriate for use in the bridge final design as they typically generate a more conservative lateral pile response than the response predicted by the Revised Curves.

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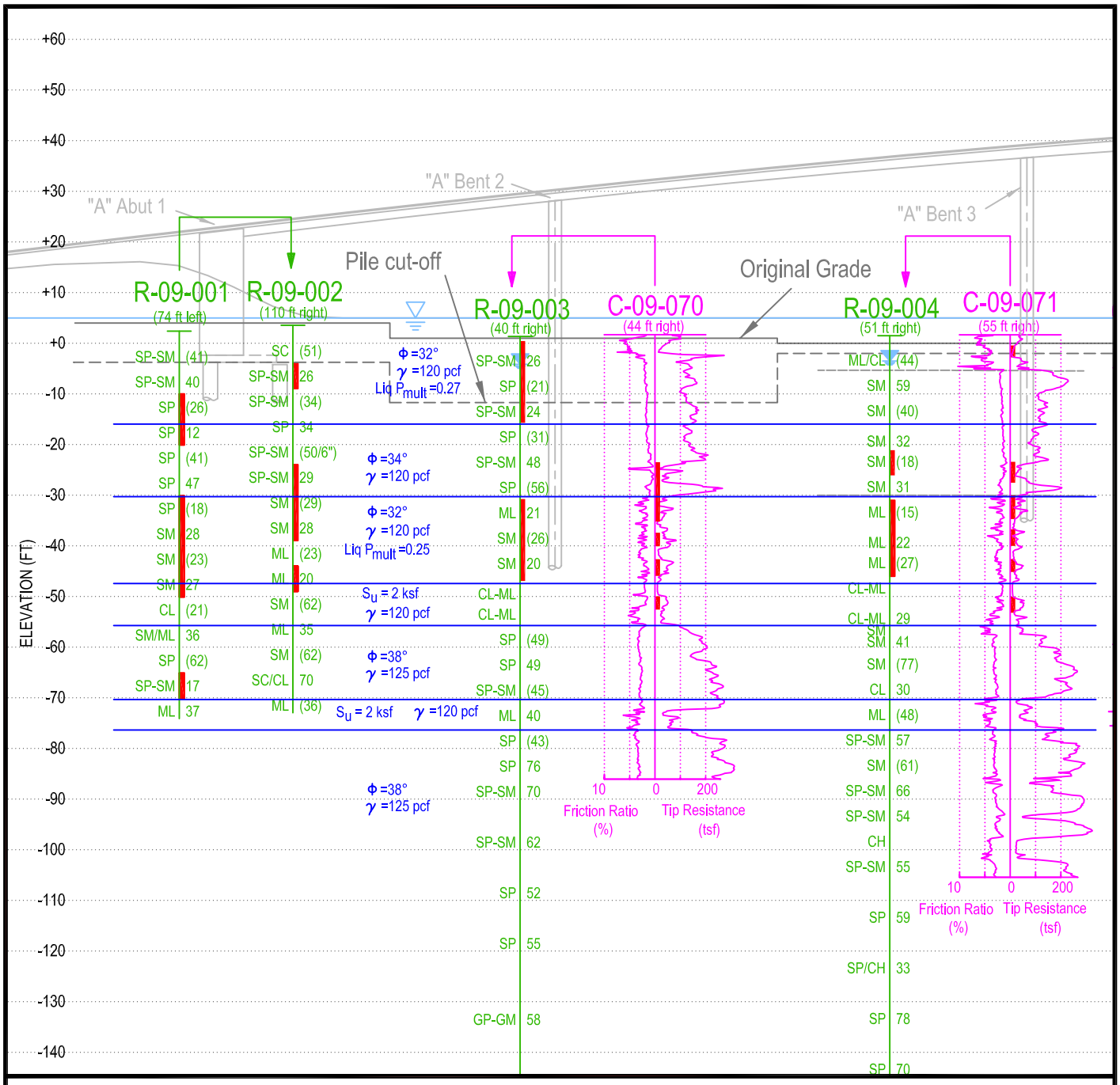

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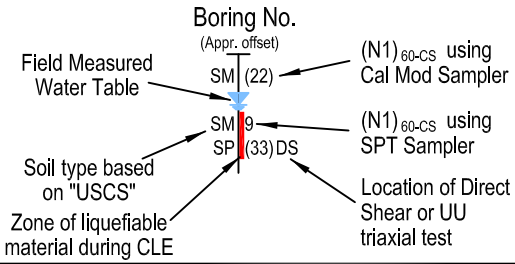
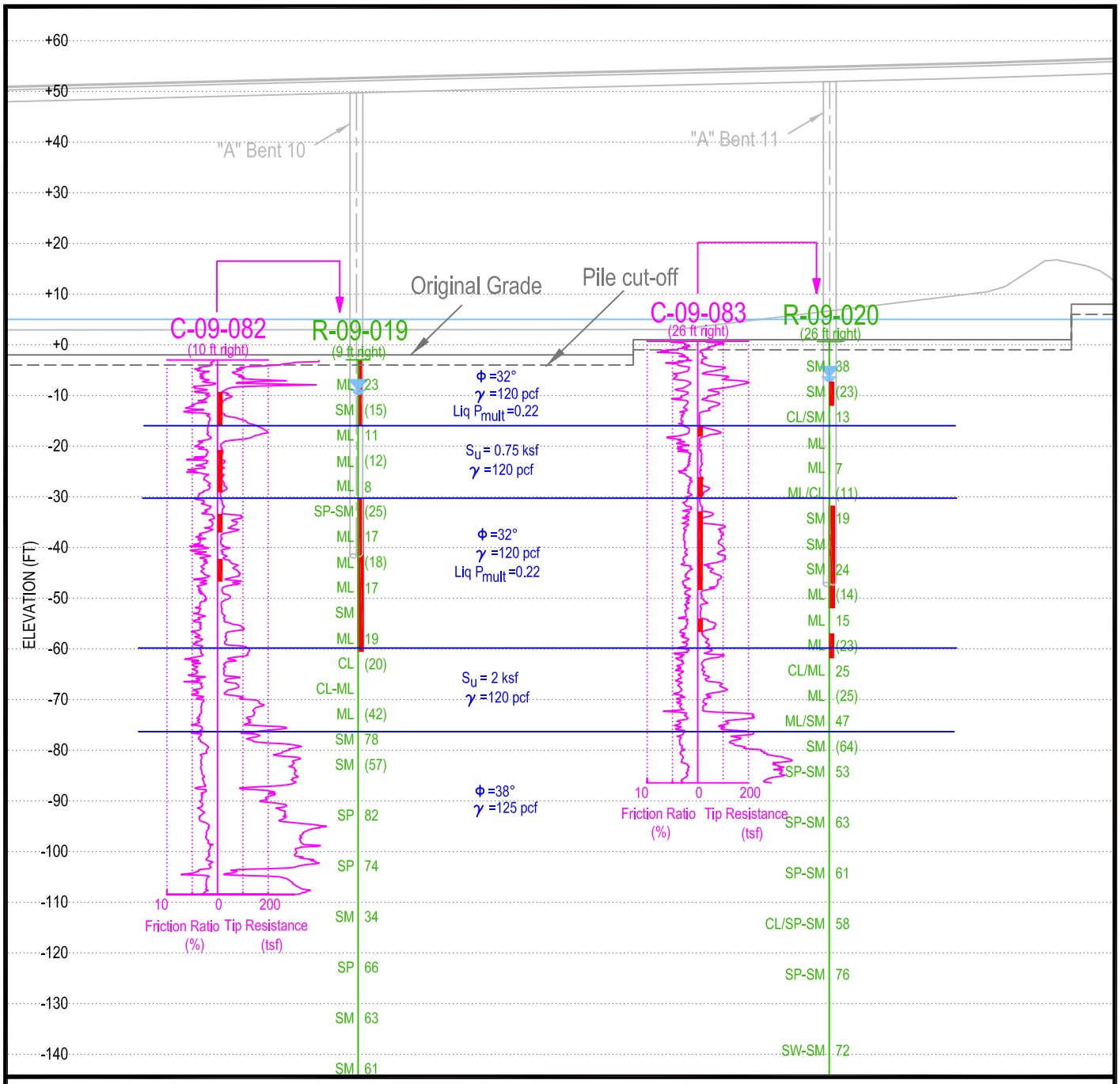


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 2 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 1



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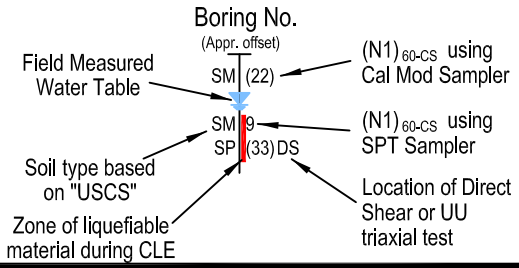
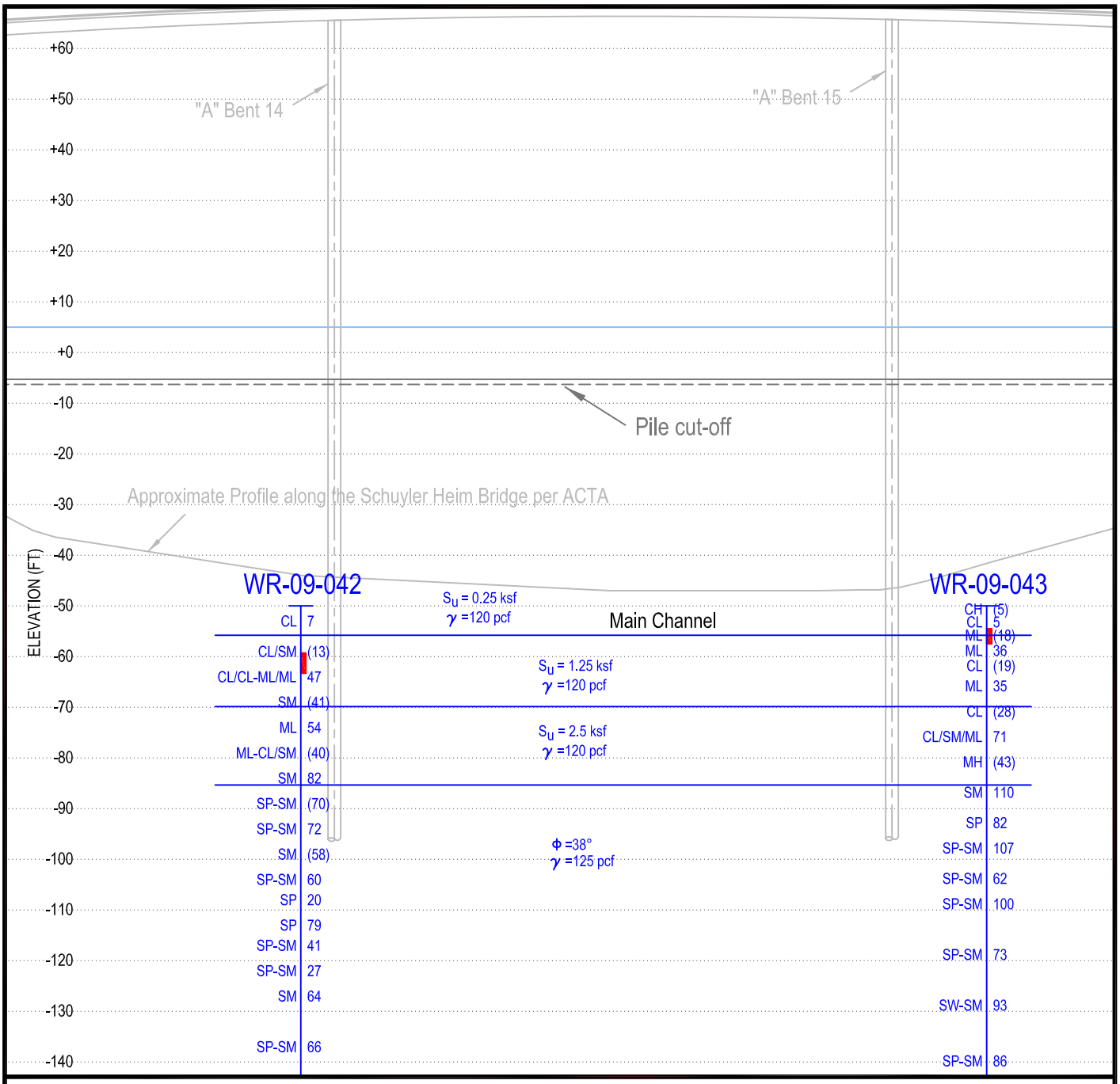


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 2



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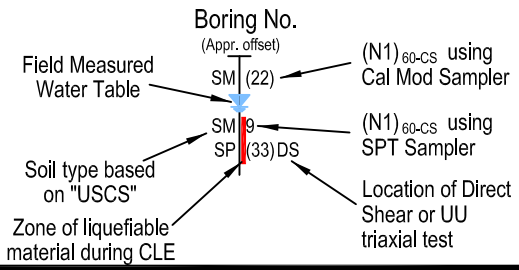
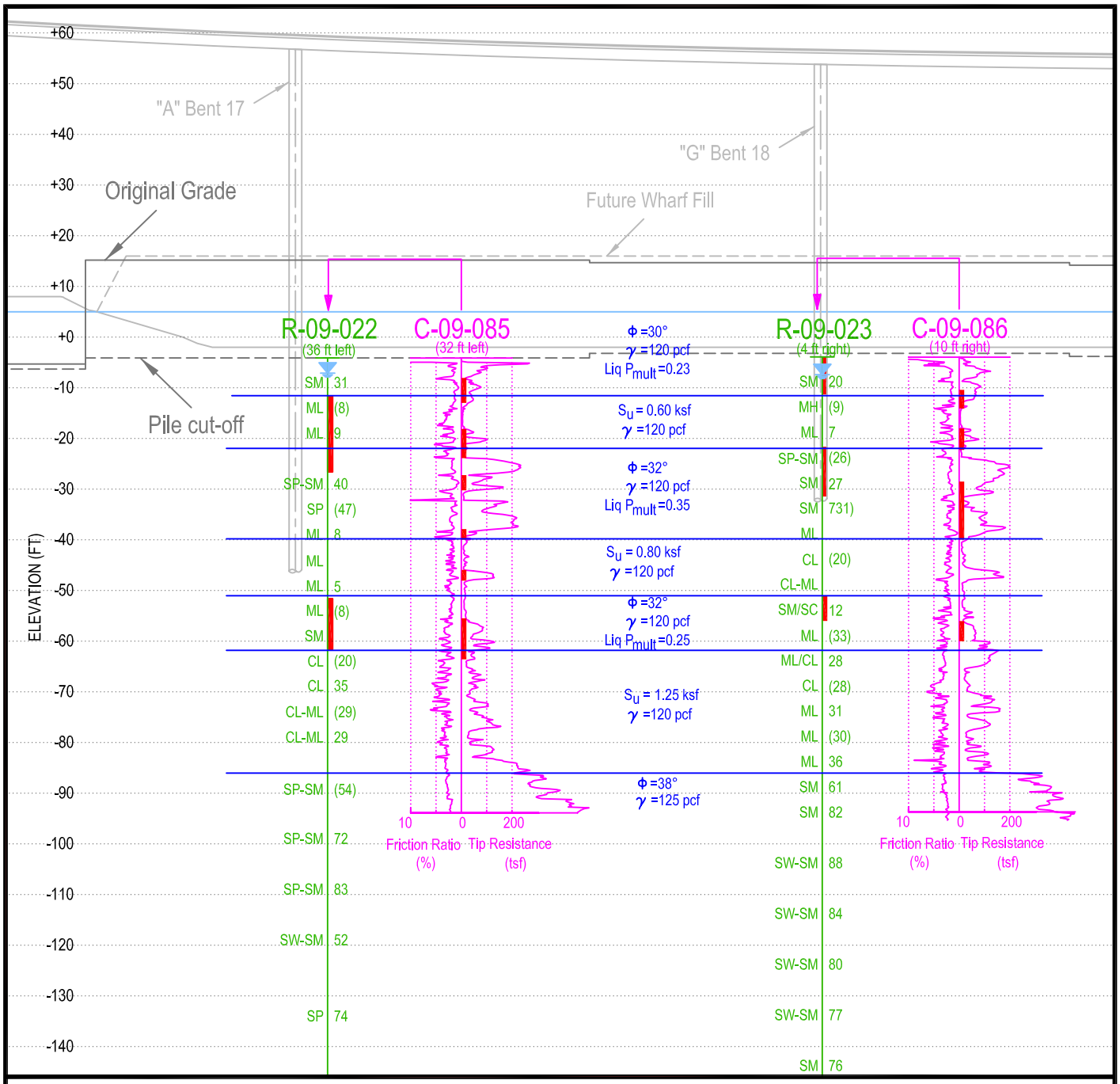


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 3



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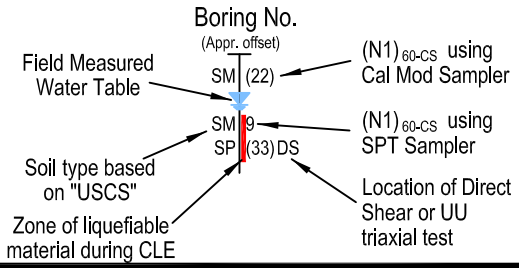
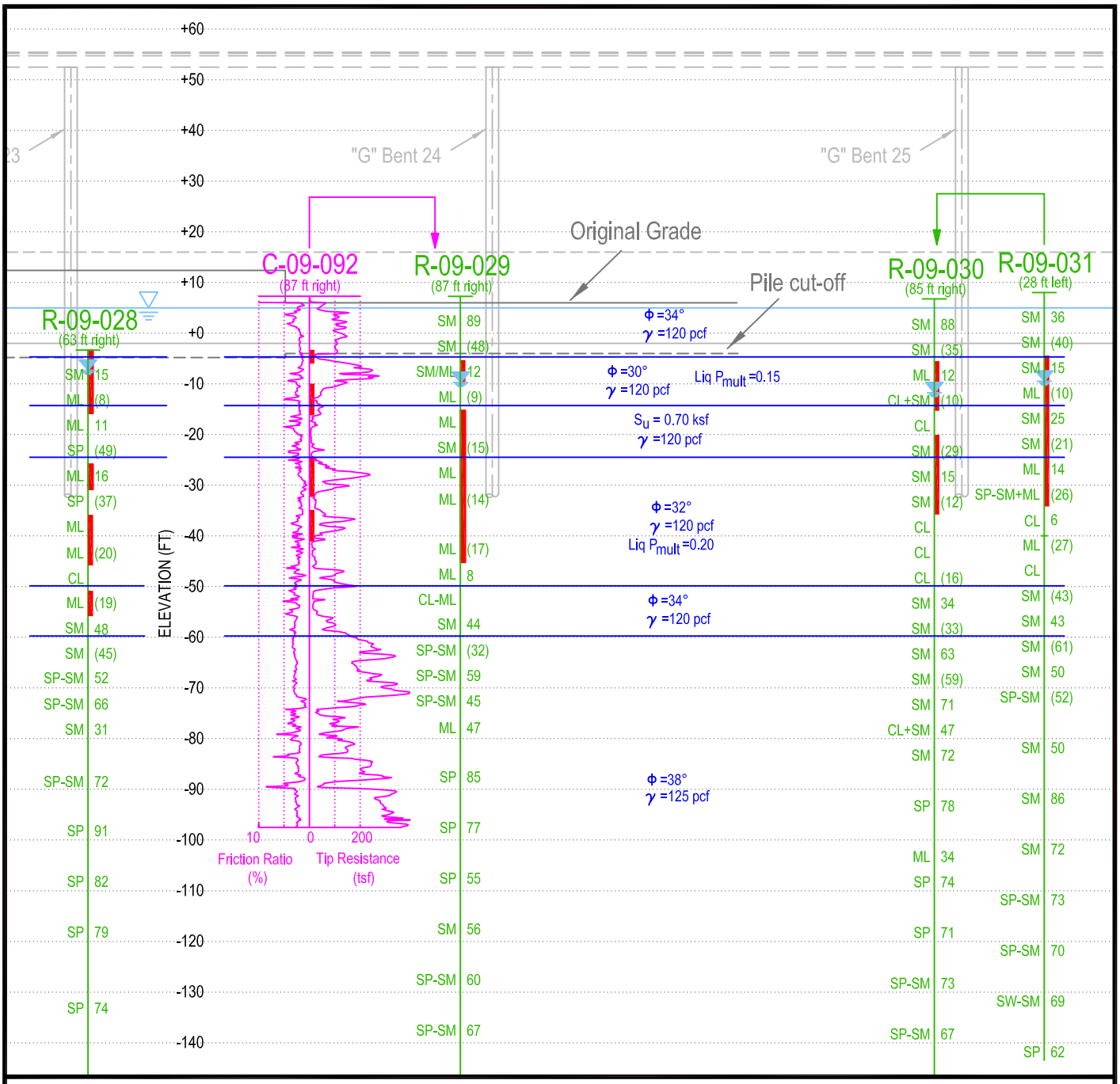
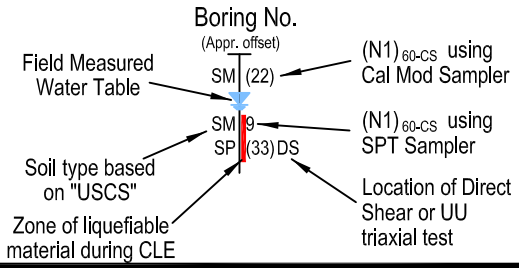


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 4



Boring Log Legend



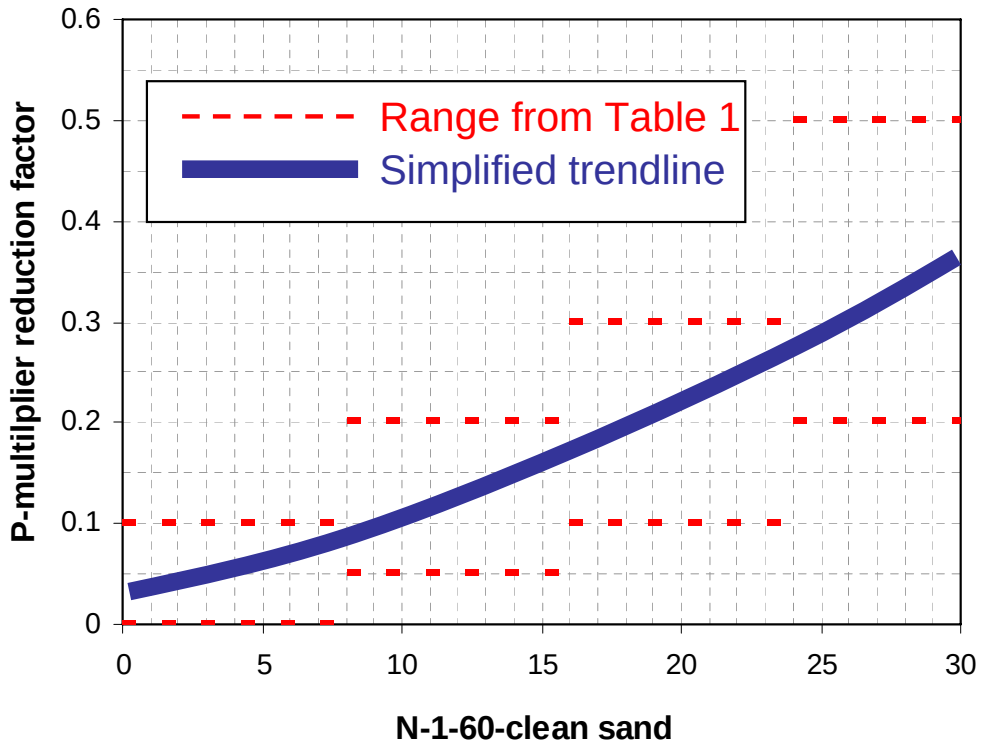
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 24 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 5

Recommended values (after Ashford et al. 2008)

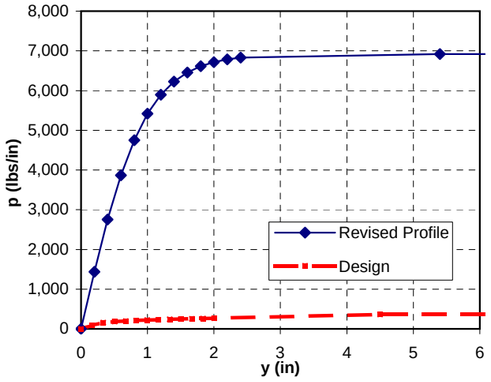
Table 1. p-multipliers, m_p, to account for liquefaction

$(N_1)_{60\text{-}CS}$	m_p
<8	0.0 to 0.1
8-16	0.05 to 0.2
16-24	0.1 to 0.3
>24	0.2 to 0.5

Chart for selecting p-multiplier based on $(N1)60_{cs}$

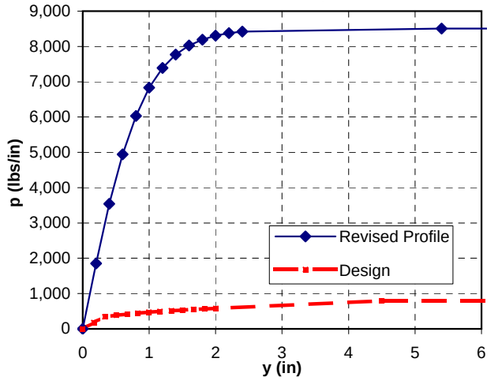


5 ft depth



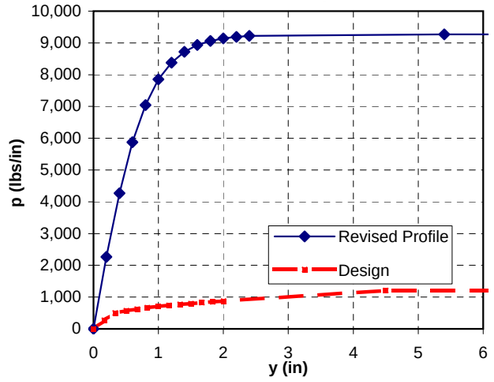
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	1,436
0.34	162	0.40	2,753
0.50	182	0.60	3,869
0.67	197	0.80	4,753
0.83	210	1.00	5,416
1.00	221	1.20	5,894
1.16	231	1.40	6,228
1.33	240	1.60	6,457
1.50	248	1.80	6,611
1.67	256	2.00	6,715
1.84	263	2.20	6,783
2.00	269	2.40	6,829
4.50	365	5.40	6,916
124.50	365	149.40	6,916

10 ft depth



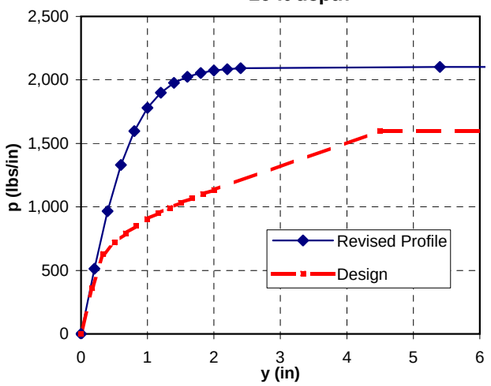
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	1,853
0.34	341	0.40	3,538
0.50	384	0.60	4,943
0.67	418	0.80	6,032
0.83	447	1.00	6,829
1.00	472	1.20	7,389
1.16	494	1.40	7,771
1.33	514	1.60	8,025
1.50	532	1.80	8,193
1.67	549	2.00	8,303
1.84	565	2.20	8,374
2.00	579	2.40	8,420
4.50	794	5.40	8,503
124.50	794	149.40	8,503

15 ft depth



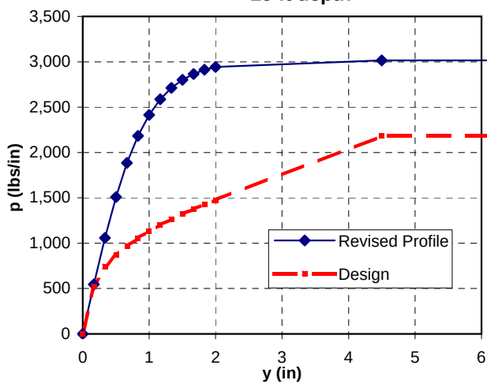
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.20	2,263
0.34	502	0.40	4,271
0.50	569	0.60	5,873
0.67	622	0.80	7,046
0.83	666	1.00	7,852
1.00	705	1.20	8,381
1.16	739	1.40	8,719
1.33	770	1.60	8,931
1.50	799	1.80	9,062
1.67	825	2.00	9,143
1.84	850	2.20	9,192
2.00	873	2.40	9,222
4.50	1,210	5.40	9,269
124.50	1,210	149.40	9,269

20 ft depth



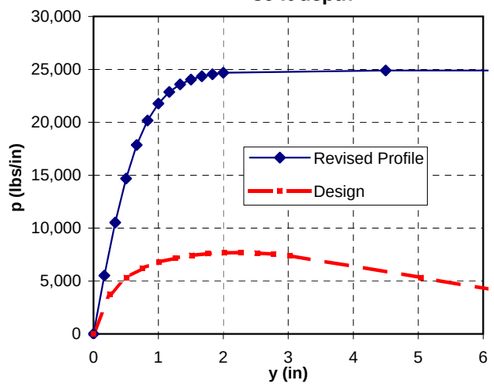
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	360	0.20	512
0.34	631	0.40	967
0.50	720	0.60	1,330
0.67	792	0.80	1,597
0.83	852	1.00	1,780
1.00	904	1.20	1,900
1.16	951	1.40	1,977
1.33	993	1.60	2,026
1.50	1,032	1.80	2,055
1.67	1,069	2.00	2,074
1.84	1,103	2.20	2,085
2.00	1,134	2.40	2,092
4.50	1,599	5.40	2,103
124.50	1,599	149.40	2,103

29 ft depth



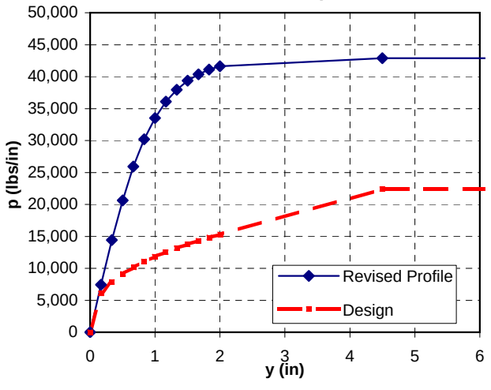
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	522	0.17	547
0.34	744	0.33	1,058
0.50	868	0.50	1,509
0.67	970	0.67	1,885
0.83	1,056	0.83	2,184
1.00	1,132	1.00	2,414
1.16	1,201	1.17	2,586
1.33	1,264	1.33	2,711
1.50	1,322	1.50	2,802
1.67	1,377	1.67	2,866
1.84	1,428	1.83	2,911
2.00	1,476	2.00	2,943
4.50	2,182	4.50	3,016
124.50	2,182	124.50	3,017

50 ft depth



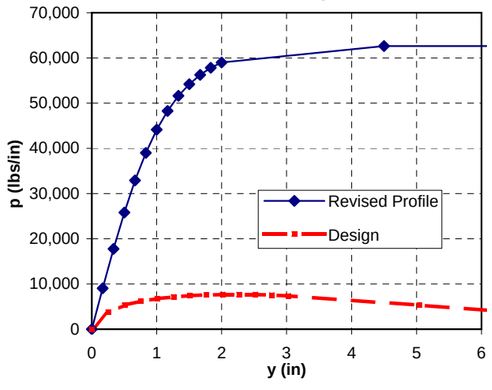
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	5,521
0.50	5,325	0.33	10,523
0.76	6,204	0.50	14,668
1.01	6,775	0.67	17,855
1.26	7,164	0.83	20,166
1.51	7,425	1.00	21,774
1.76	7,585	1.17	22,858
2.02	7,664	1.33	23,576
2.27	7,676	1.50	24,045
2.52	7,629	1.67	24,348
2.77	7,532	1.83	24,543
3.02	7,390	2.00	24,668
5.04	5,330	4.50	24,888
7.06	3,268	124.50	24,889

71 ft depth



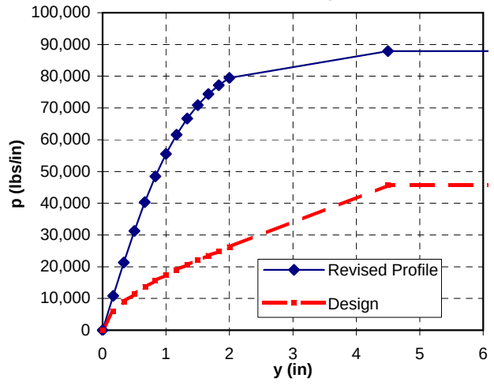
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	6,081	0.17	7,430
0.34	7,867	0.33	14,426
0.50	9,145	0.50	20,652
0.67	10,176	0.67	25,918
0.83	11,056	0.83	30,186
1.00	11,830	1.00	33,525
1.16	12,527	1.17	36,068
1.33	13,164	1.33	37,963
1.50	13,753	1.50	39,354
1.67	14,302	1.67	40,363
1.84	14,817	1.83	41,089
2.00	15,303	2.00	41,609
4.50	22,408	4.50	42,867
124.50	22,408	124.50	42,874

85 ft depth



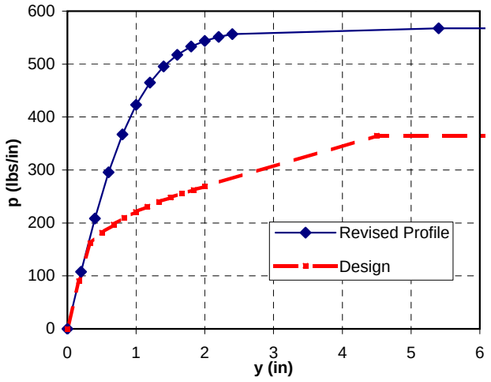
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	9,074
0.50	5,325	0.33	17,775
0.76	6,204	0.50	25,790
1.01	6,775	0.67	32,904
1.26	7,164	0.83	39,014
1.51	7,425	1.00	44,113
1.76	7,585	1.17	48,270
2.02	7,664	1.33	51,593
2.27	7,676	1.50	54,208
2.52	7,629	1.67	56,241
2.77	7,532	1.83	57,807
3.02	7,390	2.00	59,004
5.04	5,330	4.50	62,636
7.06	3,268	124.50	62,684

100 ft depth



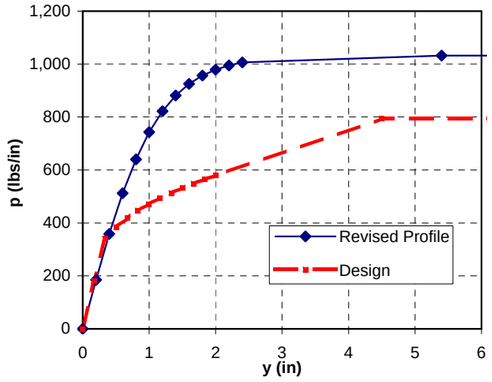
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	5,976	0.17	10,832
0.34	9,023	0.33	21,341
0.50	11,483	0.50	31,242
0.67	13,624	0.67	40,316
0.83	15,557	0.83	48,423
1.00	17,338	1.00	55,503
1.16	19,001	1.17	61,565
1.33	20,571	1.33	66,668
1.50	22,063	1.50	70,902
1.67	23,489	1.67	74,373
1.84	24,858	1.83	77,191
2.00	26,177	2.00	79,461
4.50	45,628	4.50	87,868
124.50	45,628	124.50	88,090

5 ft depth



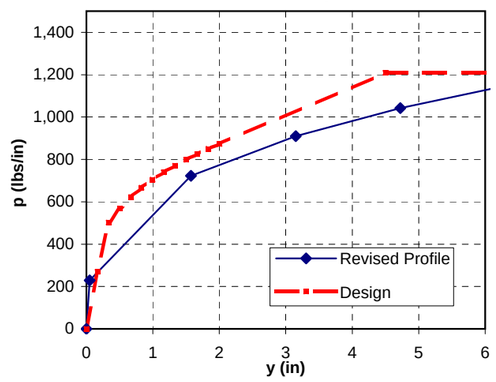
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	108
0.34	162	0.40	208
0.50	182	0.60	295
0.67	197	0.80	367
0.83	210	1.00	423
1.00	221	1.20	465
1.16	231	1.40	496
1.33	240	1.60	518
1.50	248	1.80	533
1.67	256	2.00	544
1.84	263	2.20	551
2.00	269	2.40	556
4.50	365	5.40	567
124.50	365	149.40	568

10 ft depth



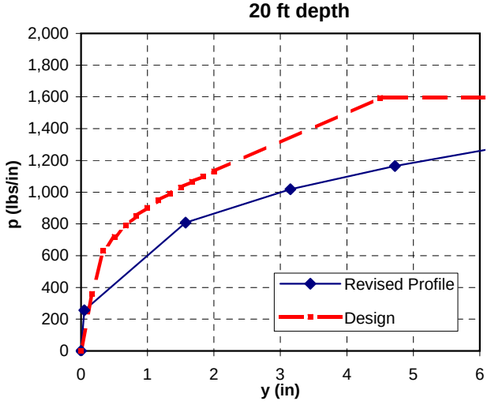
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	185
0.34	341	0.40	359
0.50	384	0.60	512
0.67	418	0.80	640
0.83	447	1.00	743
1.00	472	1.20	822
1.16	494	1.40	881
1.33	514	1.60	925
1.50	532	1.80	956
1.67	549	2.00	979
1.84	565	2.20	995
2.00	579	2.40	1,006
4.50	794	5.40	1,032
124.50	794	149.40	1,033

15 ft depth



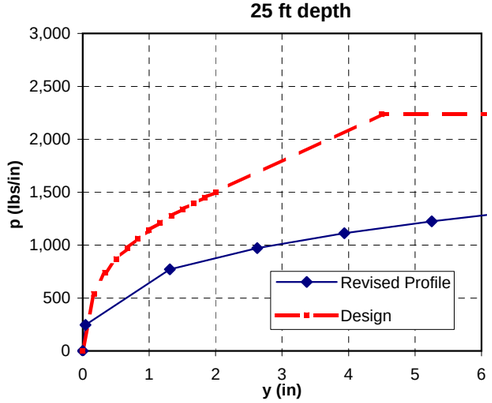
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.05	229
0.34	502	1.58	723
0.50	569	3.15	910
0.67	622	4.73	1,042
0.83	666	6.30	1,147
1.00	705	7.88	1,235
1.16	739	9.45	1,313
1.33	770	11.03	1,382
1.50	799	12.60	1,445
1.67	825	14.18	1,503
1.84	850	15.75	1,557
2.00	873	17.33	1,607
4.50	1,210	18.90	1,654
124.50	1,210	50.40	2,294

20 ft depth



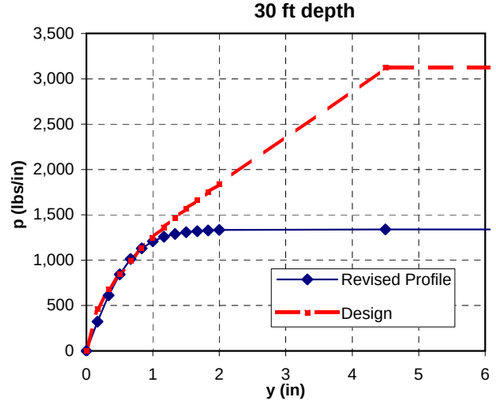
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	359	0.05	256
0.34	629	1.58	808
0.50	719	3.15	1,018
0.67	790	4.73	1,165
0.83	850	6.30	1,282
1.00	902	7.88	1,381
1.16	949	9.45	1,468
1.33	991	11.03	1,545
1.50	1,030	12.60	1,616
1.67	1,066	14.18	1,680
1.84	1,100	15.75	1,740
2.00	1,132	17.33	1,797
4.50	1,594	18.90	1,849
124.50	1,594	50.40	2,565

25 ft depth



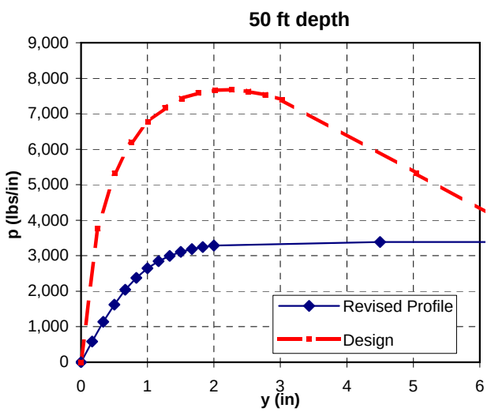
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	539	0.04	245
0.34	740	1.31	771
0.50	869	2.63	972
0.67	973	3.94	1,112
0.83	1,062	5.25	1,224
1.00	1,141	6.56	1,319
1.16	1,212	7.88	1,402
1.33	1,278	9.19	1,475
1.50	1,338	10.50	1,543
1.67	1,395	11.81	1,604
1.84	1,448	13.13	1,662
2.00	1,499	14.44	1,715
4.50	2,236	15.75	1,766
124.50	2,236	42.00	2,449

30 ft depth



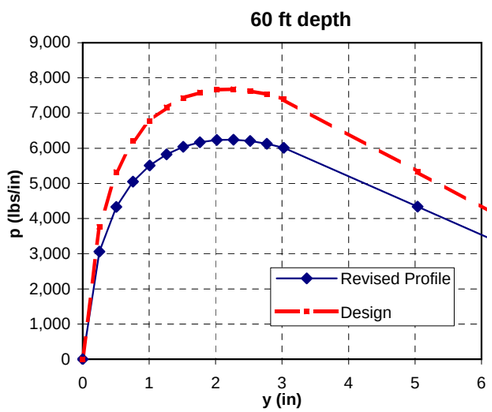
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	461	0.17	324
0.34	678	0.33	612
0.50	850	0.50	843
0.67	998	0.67	1,012
0.83	1,130	0.83	1,130
1.00	1,251	1.00	1,208
1.16	1,363	1.17	1,257
1.33	1,468	1.33	1,289
1.50	1,567	1.50	1,308
1.67	1,662	1.67	1,320
1.84	1,753	1.83	1,328
2.00	1,840	2.00	1,332
4.50	3,121	4.50	1,340
124.50	3,121	124.50	1,340

50 ft depth



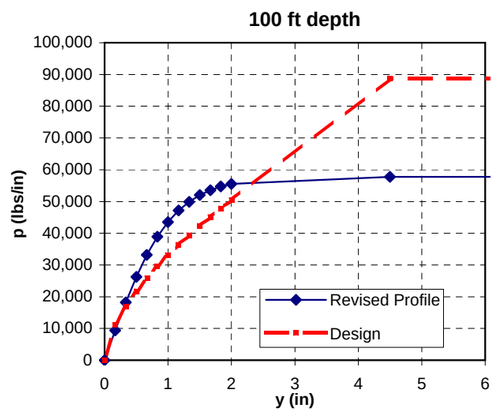
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	584
0.50	5,325	0.33	1,135
0.76	6,204	0.50	1,626
1.01	6,775	0.67	2,041
1.26	7,164	0.83	2,379
1.51	7,425	1.00	2,643
1.76	7,585	1.17	2,845
2.02	7,664	1.33	2,996
2.27	7,676	1.50	3,107
2.52	7,629	1.67	3,188
2.77	7,532	1.83	3,246
3.02	7,390	2.00	3,288
5.04	5,330	4.50	3,389
7.06	3,268	124.50	3,390

60 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.25	3,063
0.50	5,325	0.50	4,332
0.76	6,204	0.76	5,047
1.01	6,775	1.01	5,511
1.26	7,164	1.26	5,828
1.51	7,425	1.51	6,040
1.76	7,585	1.76	6,170
2.02	7,664	2.02	6,235
2.27	7,676	2.27	6,244
2.52	7,629	2.52	6,206
2.77	7,532	2.77	6,127
3.02	7,390	3.02	6,011
5.04	5,330	5.04	4,336
7.06	3,268	7.06	2,658

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	11,128	0.17	9,360
0.34	16,961	0.33	18,242
0.50	21,702	0.50	26,260
0.67	25,850	0.67	33,178
0.83	29,606	0.83	38,920
1.00	33,077	1.00	43,533
1.16	36,327	1.17	47,142
1.33	39,400	1.33	49,910
1.50	42,325	1.50	51,998
1.67	45,125	1.67	53,555
1.84	47,817	1.83	54,706
2.00	50,414	2.00	55,551
4.50	88,729	4.50	57,780
124.50	88,729	124.50	57,797

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

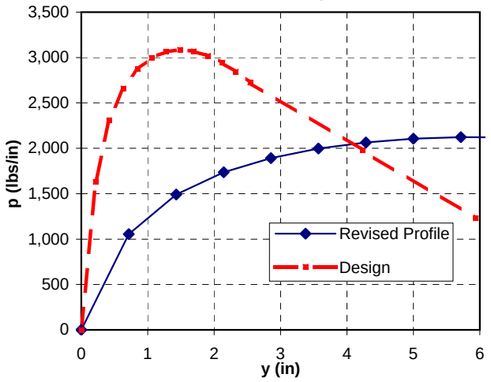
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 11

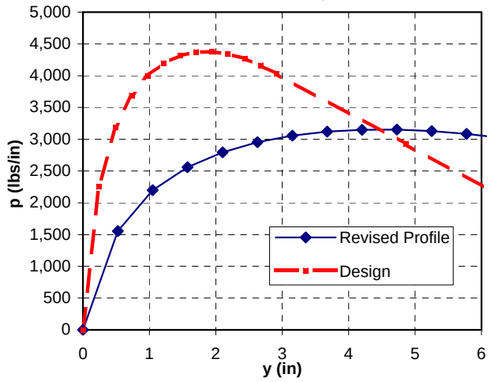
Figure 8

55 ft depth



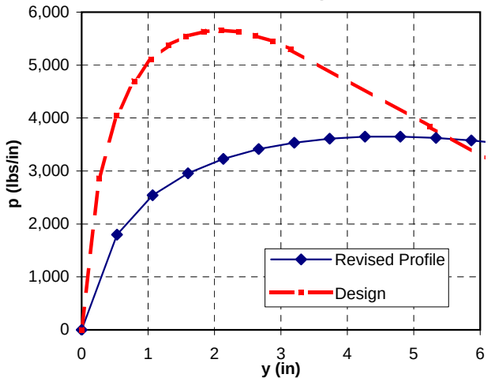
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	1,631	0.71	1,055
0.42	2,306	1.43	1,491
0.64	2,660	2.14	1,735
0.85	2,870	2.86	1,891
1.06	2,997	3.57	1,996
1.27	3,064	4.29	2,065
1.49	3,085	5.00	2,105
1.69	3,068	5.71	2,122
1.91	3,019	6.43	2,121
2.12	2,944	7.14	2,102
2.33	2,844	7.86	2,069
2.54	2,724	8.57	2,024
4.24	1,978	14.29	1,463
5.94	1,230	20.00	902

60 ft depth



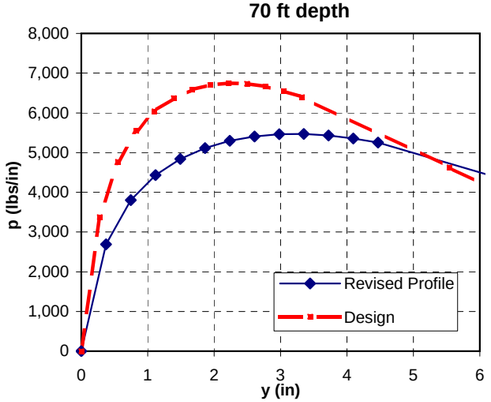
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.24	2,252	0.53	1,555
0.49	3,185	1.05	2,200
0.73	3,688	1.58	2,561
0.97	3,999	2.10	2,794
1.21	4,198	2.63	2,952
1.46	4,316	3.15	3,057
1.70	4,372	3.68	3,120
1.94	4,378	4.20	3,149
2.18	4,341	4.73	3,150
2.44	4,268	5.25	3,127
2.68	4,163	5.78	3,083
2.92	4,032	6.30	3,021
4.86	2,926	10.50	2,181
6.80	1,820	14.71	1,341

65 ft depth



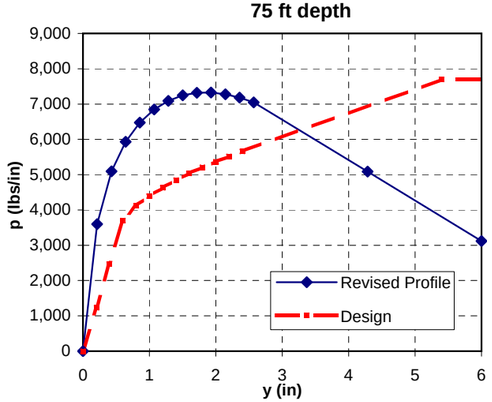
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.26	2,862	0.53	1,796
0.53	4,047	1.07	2,540
0.79	4,697	1.60	2,958
1.04	5,106	2.13	3,229
1.31	5,375	2.67	3,414
1.57	5,542	3.20	3,536
1.84	5,631	3.73	3,611
2.10	5,657	4.27	3,647
2.36	5,630	4.80	3,651
2.62	5,558	5.33	3,627
2.88	5,445	5.87	3,578
3.14	5,300	6.40	3,510
5.24	3,841	10.67	2,532
7.34	2,382	14.93	1,554

70 ft depth



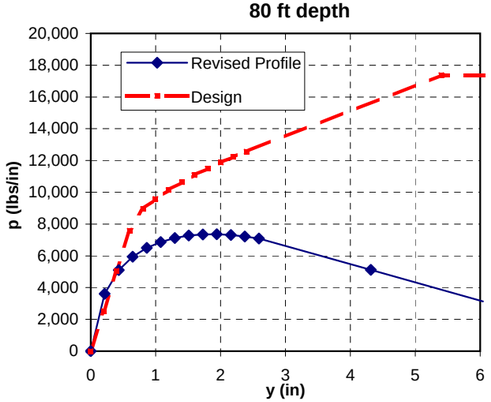
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.28	3,375	0.37	2,691
0.55	4,773	0.74	3,805
0.83	5,547	1.12	4,432
1.10	6,041	1.49	4,837
1.39	6,371	1.86	5,113
1.67	6,583	2.23	5,296
1.94	6,703	2.61	5,408
2.22	6,750	2.98	5,461
2.50	6,735	3.35	5,466
2.77	6,667	3.72	5,429
3.05	6,553	4.10	5,356
3.32	6,400	4.47	5,251
5.54	4,631	7.45	3,790
7.76	2,861	10.43	2,327

75 ft depth



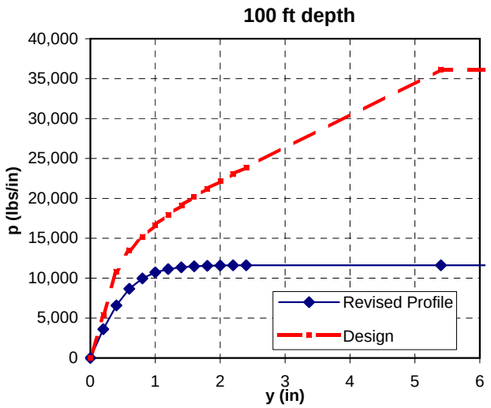
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	1,234	0.21	3,600
0.40	2,467	0.43	5,092
0.60	3,701	0.64	5,931
0.80	4,120	0.86	6,475
1.00	4,395	1.07	6,846
1.20	4,632	1.29	7,093
1.40	4,843	1.50	7,244
1.60	5,033	1.71	7,317
1.80	5,208	1.93	7,326
2.00	5,368	2.14	7,279
2.20	5,518	2.36	7,183
2.40	5,659	2.57	7,044
5.40	7,701	4.29	5,083
149.40	7,701	6.00	3,119

80 ft depth



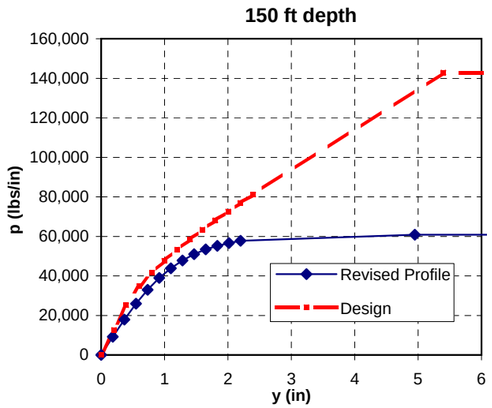
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	2,530	0.22	3,613
0.40	5,059	0.43	5,110
0.60	7,589	0.65	5,953
0.80	8,955	0.86	6,500
1.00	9,591	1.08	6,874
1.20	10,144	1.29	7,123
1.40	10,637	1.51	7,277
1.60	11,083	1.73	7,353
1.80	11,491	1.94	7,364
2.00	11,870	2.16	7,319
2.20	12,223	2.37	7,225
2.40	12,555	2.59	7,088
5.40	17,381	4.32	5,113
149.40	17,381	6.04	3,135

100 ft depth



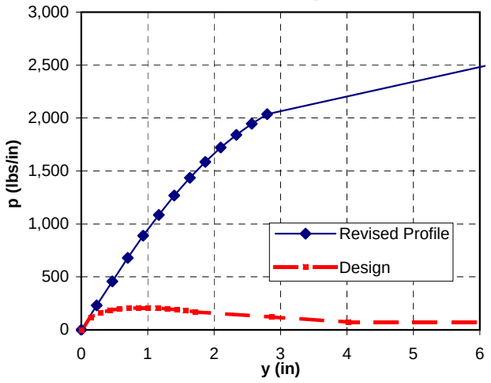
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	5,410	0.20	3,604
0.40	10,819	0.40	6,576
0.60	13,502	0.60	8,661
0.80	15,196	0.80	9,964
1.00	16,655	1.00	10,720
1.20	17,951	1.20	11,140
1.40	19,125	1.40	11,368
1.60	20,203	1.60	11,490
1.80	21,205	1.80	11,554
2.00	22,143	2.00	11,588
2.20	23,028	2.20	11,607
2.40	23,866	2.40	11,616
5.40	36,124	5.40	11,627
149.40	36,124	149.40	11,627

150 ft depth



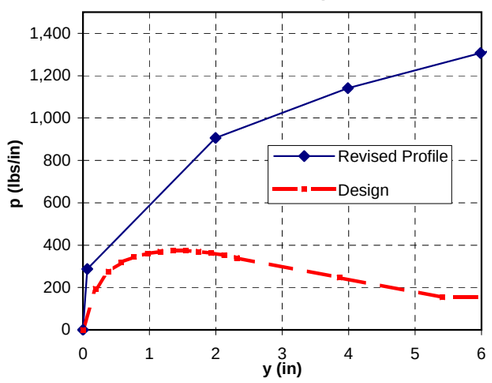
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	12,610	0.18	9,154
0.40	25,219	0.37	17,902
0.60	34,932	0.55	25,909
0.80	41,608	0.73	32,951
1.00	47,654	0.92	38,933
1.20	53,241	1.10	43,863
1.40	58,472	1.28	47,829
1.60	63,417	1.47	50,956
1.80	68,125	1.65	53,382
2.00	72,632	1.83	55,243
2.20	76,965	2.02	56,657
2.40	81,146	2.20	57,723
5.40	142,818	4.95	60,806
149.40	142,818	136.95	60,840

5 ft depth



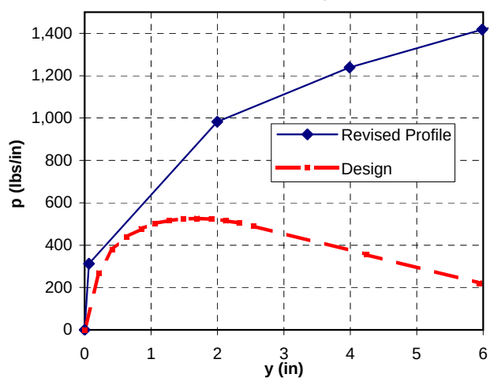
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	231
0.29	162	0.47	459
0.43	186	0.70	679
0.58	199	0.93	889
0.72	206	1.17	1,086
0.86	209	1.40	1,269
1.01	208	1.63	1,436
1.15	204	1.87	1,586
1.30	198	2.10	1,721
1.44	190	2.33	1,841
1.57	180	2.57	1,946
1.72	169	2.80	2,037
2.87	122	6.30	2,522
4.02	74	174.30	2,560
100.00	74	342.30	2,560

10 ft depth



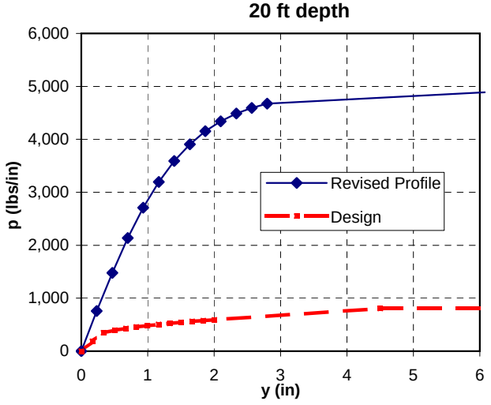
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.06	288
0.38	275	2.00	906
0.58	318	3.99	1,142
0.77	344	5.99	1,307
0.97	361	7.98	1,438
1.16	370	9.98	1,549
1.36	374	11.97	1,646
1.55	374	13.97	1,733
1.74	370	15.96	1,812
1.93	363	17.96	1,885
2.12	353	19.95	1,952
2.32	340	21.95	2,015
3.86	247	23.94	2,074
5.41	154	63.84	2,877
100.00	154	119.70	2,877

15 ft depth



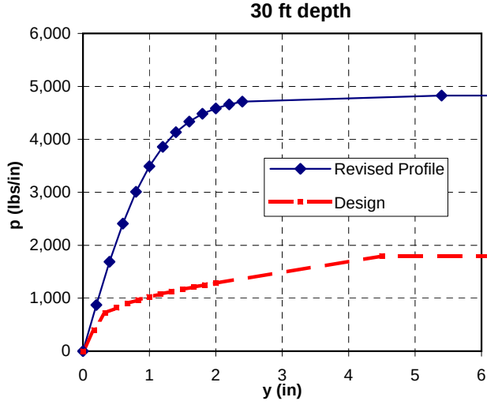
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	312
0.42	379	2.00	983
0.64	439	3.99	1,239
0.85	477	5.99	1,418
1.06	502	7.98	1,560
1.27	517	9.98	1,681
1.49	524	11.97	1,786
1.69	526	13.97	1,880
1.91	523	15.96	1,966
2.12	515	17.96	2,045
2.33	504	19.95	2,118
2.54	490	21.95	2,186
4.25	355	23.94	2,251
5.94	221	63.84	3,121
100.00	221	119.70	3,121

20 ft depth



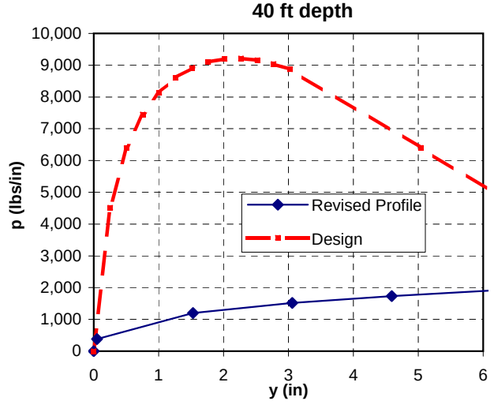
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	186	0.23	757
0.34	350	0.47	1,479
0.50	395	0.70	2,136
0.67	429	0.93	2,711
0.83	458	1.17	3,195
1.00	483	1.40	3,591
1.16	505	1.63	3,907
1.33	526	1.87	4,153
1.50	544	2.10	4,342
1.67	561	2.33	4,486
1.84	577	2.57	4,594
2.00	592	2.80	4,675
4.50	808	6.30	4,902
124.50	808	174.30	4,904

30 ft depth



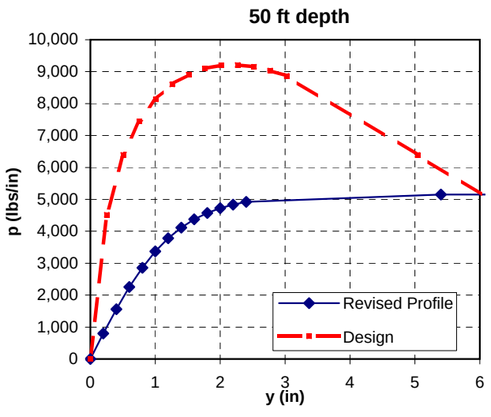
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	402	0.20	872
0.34	722	0.40	1,690
0.50	822	0.60	2,410
0.67	902	0.80	3,011
0.83	969	1.00	3,490
1.00	1,027	1.20	3,859
1.16	1,080	1.40	4,134
1.33	1,127	1.60	4,336
1.50	1,171	1.80	4,481
1.67	1,211	2.00	4,585
1.84	1,249	2.20	4,658
2.00	1,284	2.40	4,710
4.50	1,800	5.40	4,829
124.50	1,800	149.40	4,829

40 ft depth



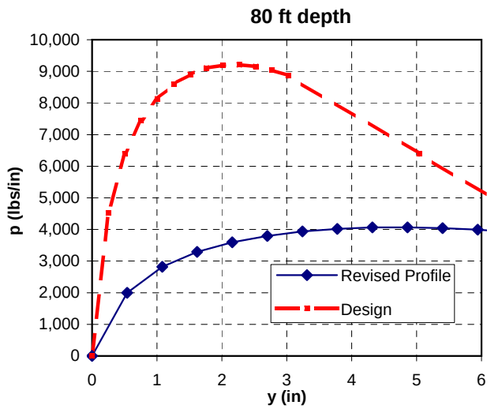
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.05	382
0.50	6,390	1.53	1,203
0.76	7,445	3.06	1,516
1.01	8,129	4.59	1,735
1.26	8,597	6.12	1,910
1.51	8,910	7.65	2,057
1.76	9,102	9.18	2,186
2.02	9,197	10.71	2,301
2.27	9,211	12.24	2,406
2.52	9,155	13.77	2,502
2.77	9,038	15.30	2,592
3.02	8,868	16.83	2,675
5.04	6,396	18.36	2,754
7.06	3,922	48.96	3,819

50 ft depth



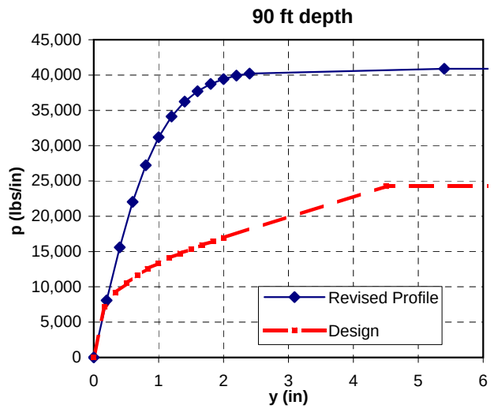
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	798
0.50	6,390	0.40	1,559
0.76	7,445	0.60	2,252
1.01	8,129	0.80	2,857
1.26	8,597	1.00	3,367
1.51	8,910	1.20	3,782
1.76	9,102	1.40	4,113
2.02	9,197	1.60	4,371
2.27	9,211	1.80	4,569
2.52	9,155	2.00	4,720
2.77	9,038	2.20	4,833
3.02	8,868	2.40	4,917
5.04	6,396	5.40	5,152
7.06	3,922	149.40	5,154

80 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.54	1,996
0.50	6,390	1.08	2,822
0.76	7,445	1.62	3,288
1.01	8,129	2.16	3,590
1.26	8,597	2.70	3,797
1.51	8,910	3.24	3,935
1.76	9,102	3.78	4,020
2.02	9,197	4.32	4,062
2.27	9,211	4.86	4,068
2.52	9,155	5.40	4,044
2.77	9,038	5.94	3,992
3.02	8,868	6.48	3,917
5.04	6,396	10.80	2,825
7.06	3,922	15.12	1,732

90 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	7,207	0.20	8,099
0.34	9,150	0.40	15,587
0.50	10,522	0.60	22,023
0.67	11,618	0.80	27,217
0.83	12,546	1.00	31,200
1.00	13,360	1.20	34,137
1.16	14,088	1.40	36,240
1.33	14,751	1.60	37,715
1.50	15,362	1.80	38,734
1.67	15,930	2.00	39,430
1.84	16,462	2.20	39,903
2.00	16,963	2.40	40,223
4.50	24,267	5.40	40,876
124.50	24,267	149.40	40,878

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

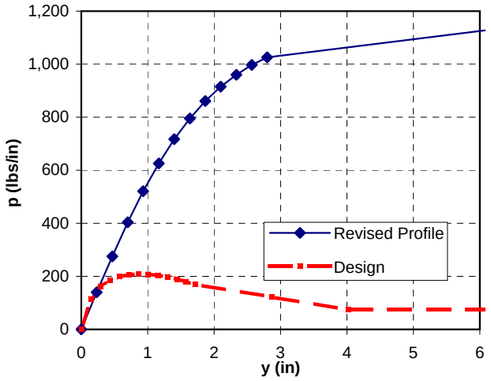
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 18

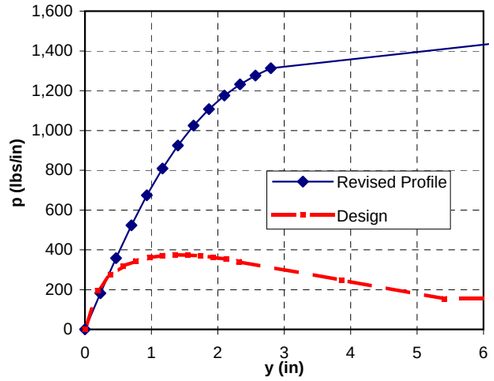
Figure 10

5 ft depth



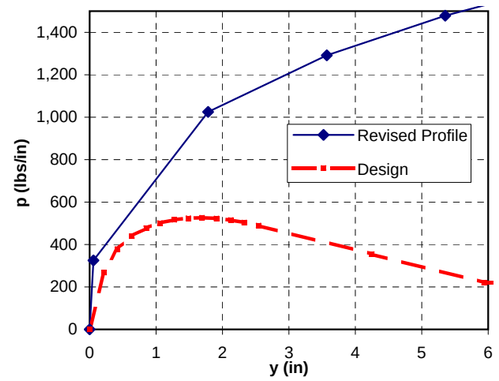
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	140
0.29	162	0.47	276
0.43	186	0.70	404
0.58	199	0.93	521
0.72	206	1.17	625
0.86	209	1.40	717
1.01	208	1.63	795
1.15	204	1.87	861
1.30	198	2.10	916
1.44	190	2.33	960
1.57	180	2.57	997
1.72	169	2.80	1,026
2.87	122	6.30	1,134
4.02	74	174.30	1,137
100.00	74	342.30	1,137

10 ft depth



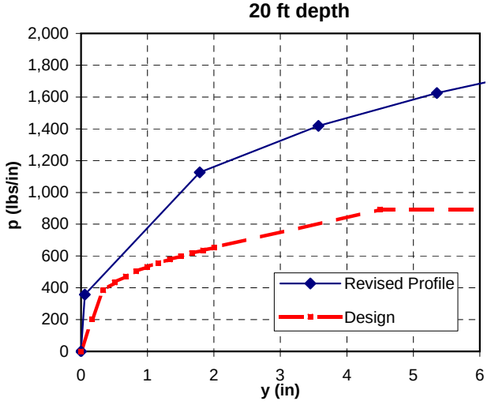
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.23	182
0.38	275	0.47	358
0.58	318	0.70	523
0.77	344	0.93	674
0.97	361	1.17	808
1.16	370	1.40	925
1.36	374	1.63	1,024
1.55	374	1.87	1,107
1.74	370	2.10	1,176
1.93	363	2.33	1,232
2.12	353	2.57	1,277
2.32	340	2.80	1,313
3.86	247	6.30	1,443
5.41	154	174.30	1,446
100.00	154	342.30	1,446

15 ft depth



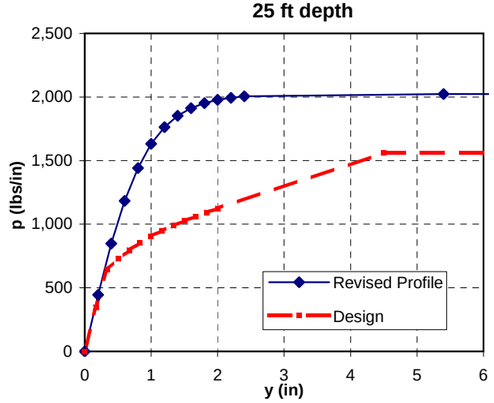
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	325
0.42	379	1.79	1,025
0.64	439	3.57	1,291
0.85	477	5.36	1,478
1.06	502	7.14	1,627
1.27	517	8.93	1,753
1.49	524	10.71	1,862
1.69	526	12.50	1,961
1.91	523	14.28	2,050
2.12	515	16.07	2,132
2.33	504	17.85	2,208
2.54	490	19.64	2,279
4.25	355	21.42	2,347
5.94	221	57.12	3,254
100.00	221	107.10	3,254

20 ft depth



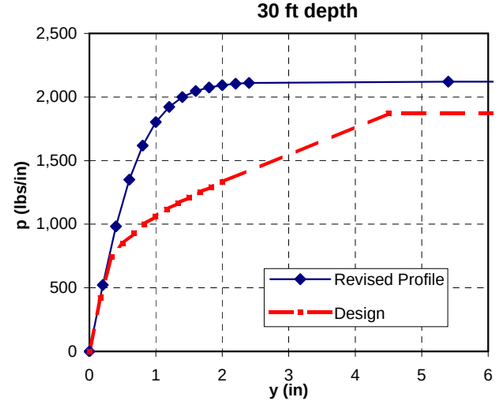
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	204	0.06	358
0.34	385	1.79	1,127
0.50	434	3.57	1,419
0.67	472	5.36	1,625
0.83	504	7.14	1,788
1.00	532	8.93	1,926
1.16	557	10.71	2,047
1.33	579	12.50	2,155
1.50	599	14.28	2,253
1.67	618	16.07	2,343
1.84	636	17.85	2,427
2.00	652	19.64	2,505
4.50	892	21.42	2,579
124.50	892	57.12	3,577

25 ft depth



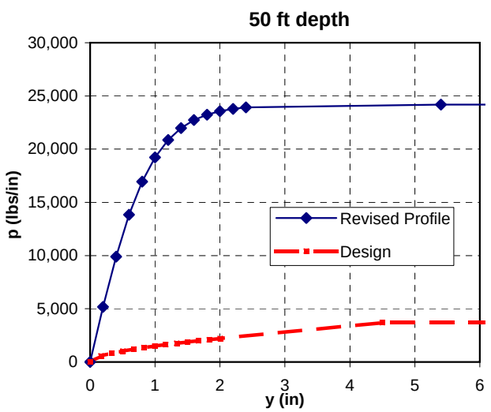
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	348	0.20	444
0.34	642	0.40	848
0.50	729	0.60	1,183
0.67	797	0.80	1,443
0.83	855	1.00	1,631
1.00	905	1.20	1,764
1.16	949	1.40	1,853
1.33	990	1.60	1,913
1.50	1,027	1.80	1,952
1.67	1,061	2.00	1,978
1.84	1,093	2.20	1,994
2.00	1,123	2.40	2,005
4.50	1,561	5.40	2,024
124.50	1,561	149.40	2,024

30 ft depth



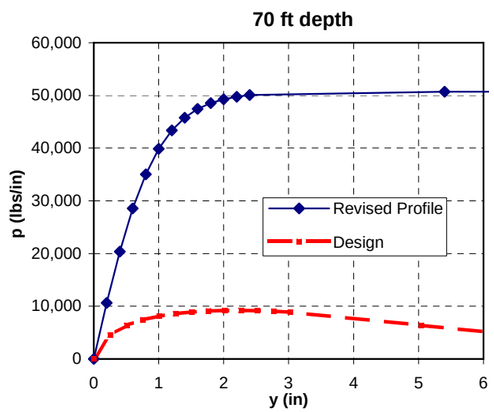
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	420	0.20	521
0.34	743	0.40	983
0.50	848	0.60	1,351
0.67	931	0.80	1,619
0.83	1,001	1.00	1,802
1.00	1,062	1.20	1,922
1.16	1,116	1.40	1,999
1.33	1,166	1.60	2,046
1.50	1,211	1.80	2,076
1.67	1,254	2.00	2,094
1.84	1,293	2.20	2,105
2.00	1,330	2.40	2,111
4.50	1,871	5.40	2,122
124.50	1,871	149.40	2,122

50 ft depth



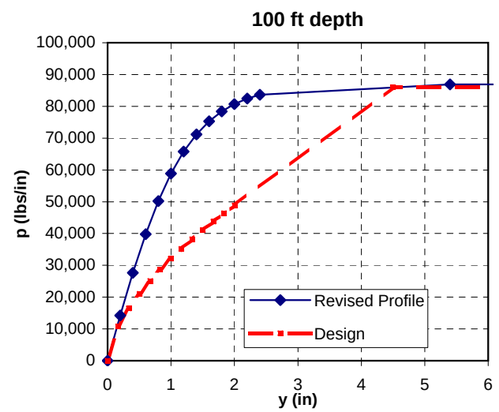
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	565	0.20	5,169
0.34	826	0.40	9,886
0.50	1,030	0.60	13,846
0.67	1,205	0.80	16,941
0.83	1,361	1.00	19,231
1.00	1,504	1.20	20,855
1.16	1,636	1.40	21,973
1.33	1,760	1.60	22,728
1.50	1,877	1.80	23,230
1.67	1,988	2.00	23,561
1.84	2,094	2.20	23,778
2.00	2,196	2.40	23,920
4.50	3,694	5.40	24,182
124.50	3,694	149.40	24,182

70 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	10,619
0.50	6,390	0.40	20,345
0.76	7,445	0.60	28,563
1.01	8,129	0.80	35,046
1.26	8,597	1.00	39,889
1.51	8,910	1.20	43,362
1.76	9,102	1.40	45,780
2.02	9,197	1.60	47,429
2.27	9,211	1.80	48,537
2.52	9,155	2.00	49,275
2.77	9,038	2.20	49,764
3.02	8,868	2.40	50,086
5.04	6,396	5.40	50,698
7.06	3,922	149.40	50,699

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	10,788	0.20	14,188
0.34	16,443	0.40	27,639
0.50	21,040	0.60	39,764
0.67	25,061	0.80	50,205
0.83	28,702	1.00	58,848
1.00	32,067	1.20	65,771
1.16	35,218	1.40	71,173
1.33	38,197	1.60	75,301
1.50	41,032	1.80	78,408
1.67	43,747	2.00	80,717
1.84	46,357	2.20	82,418
2.00	48,875	2.40	83,664
4.50	86,020	5.40	86,920
124.50	86,020	149.40	86,943

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

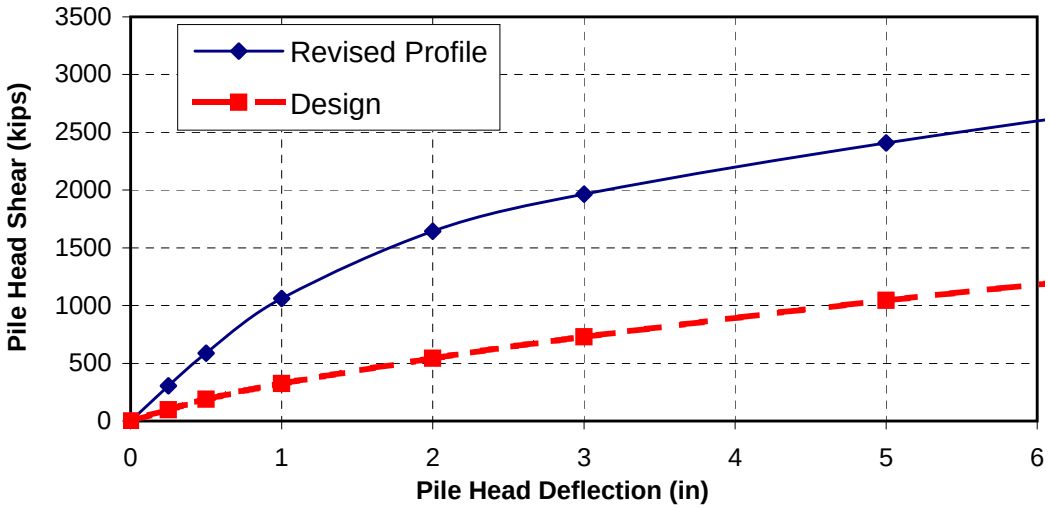
ACTA Schuyler Heim Bridge (Replace)

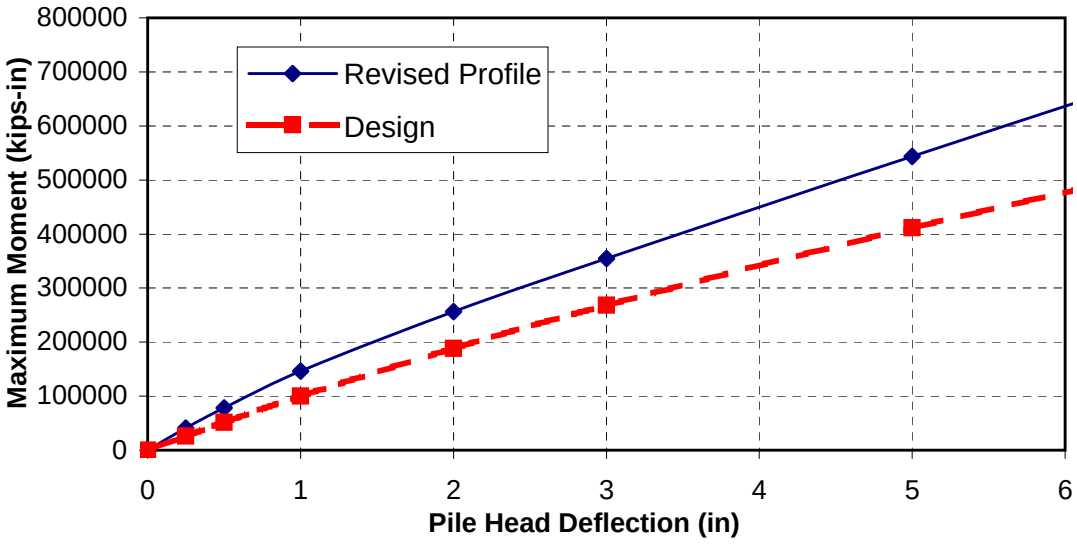
Project Number: 06-123

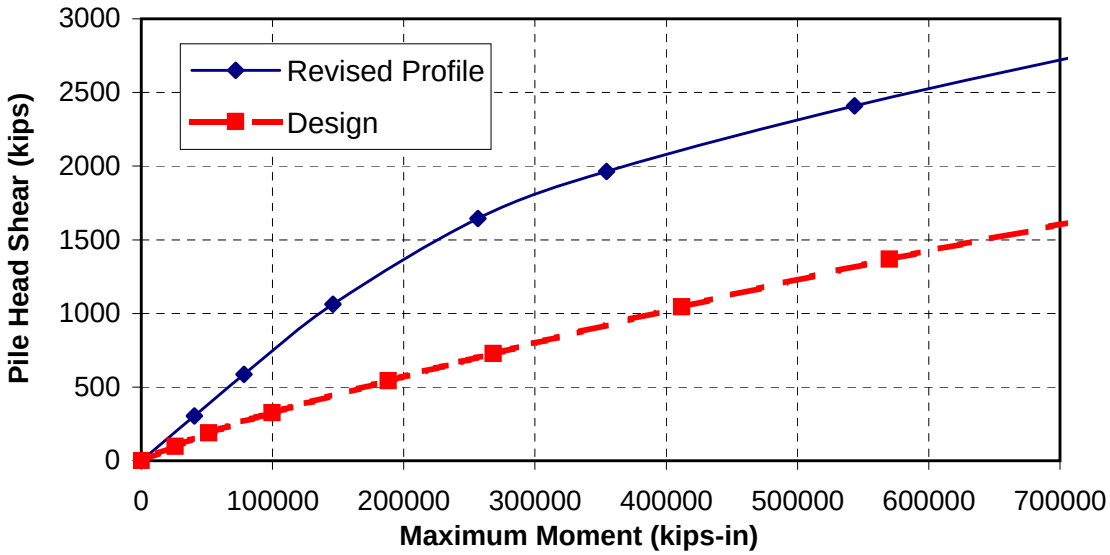
Date: 1/20/2010

p-y Curve Comparison for Bent 24

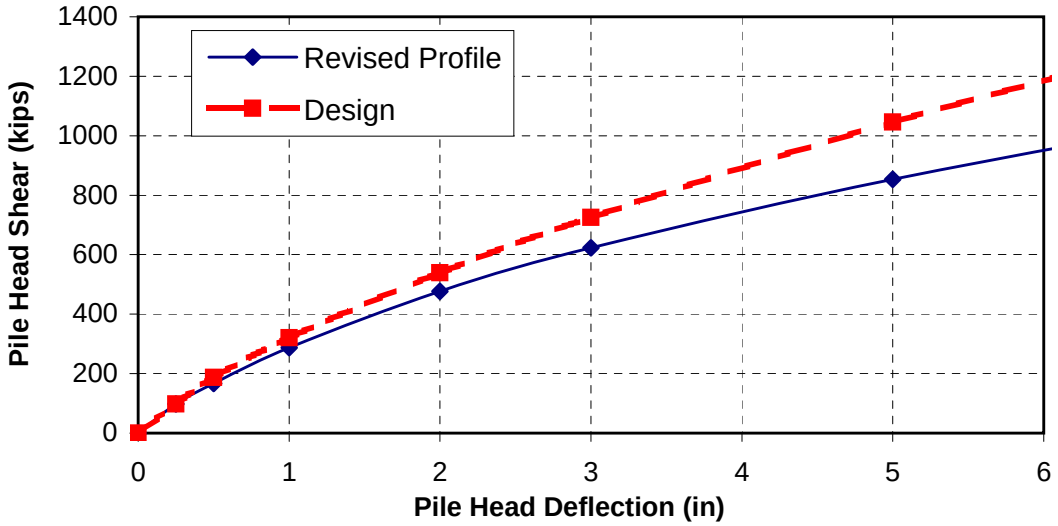
Figure 11

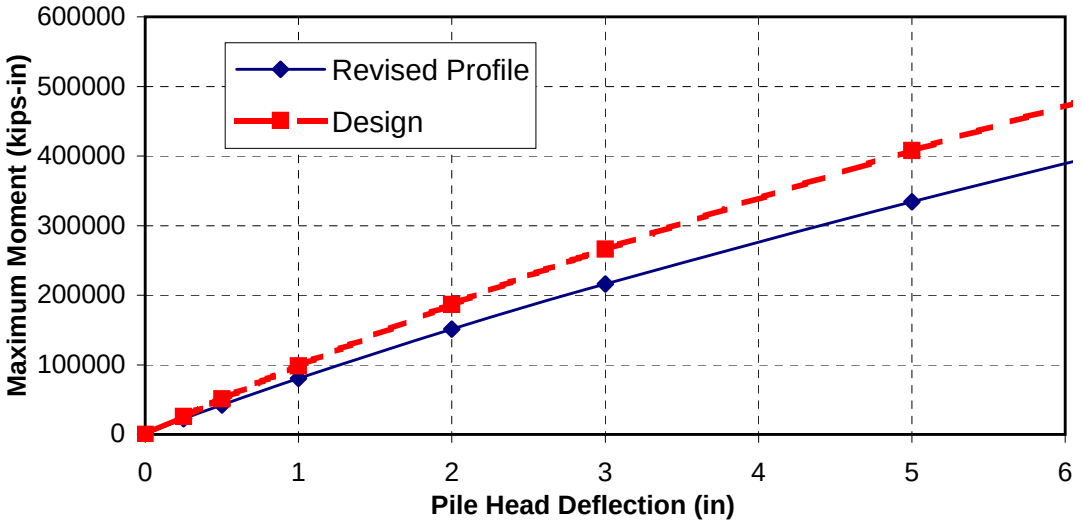


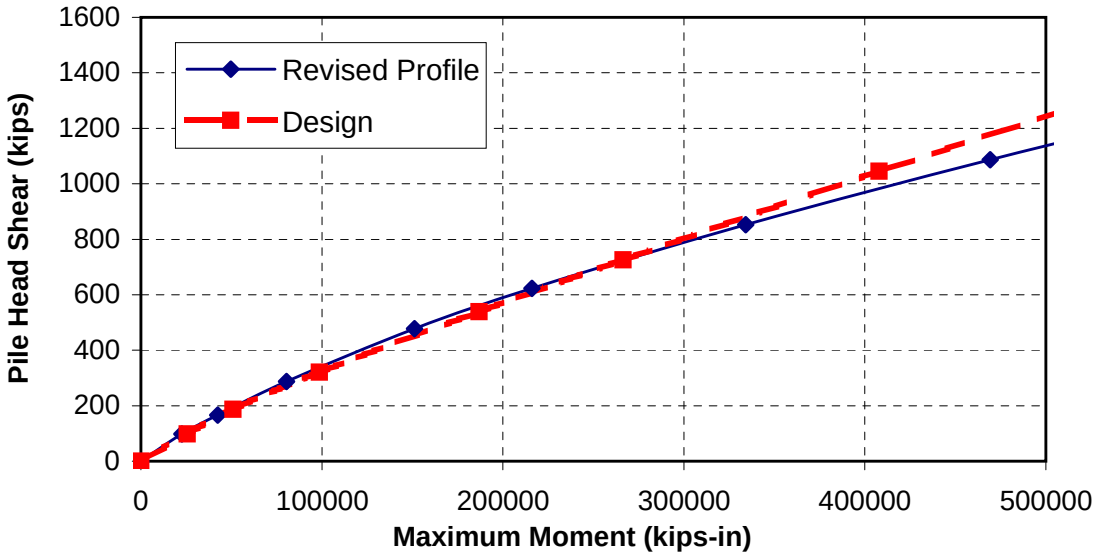




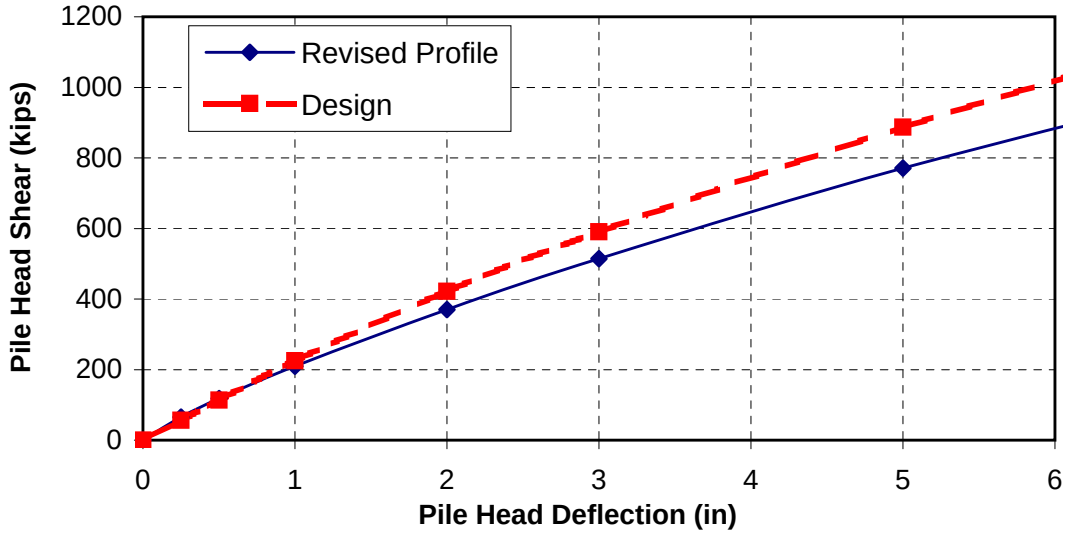
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 2 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 12

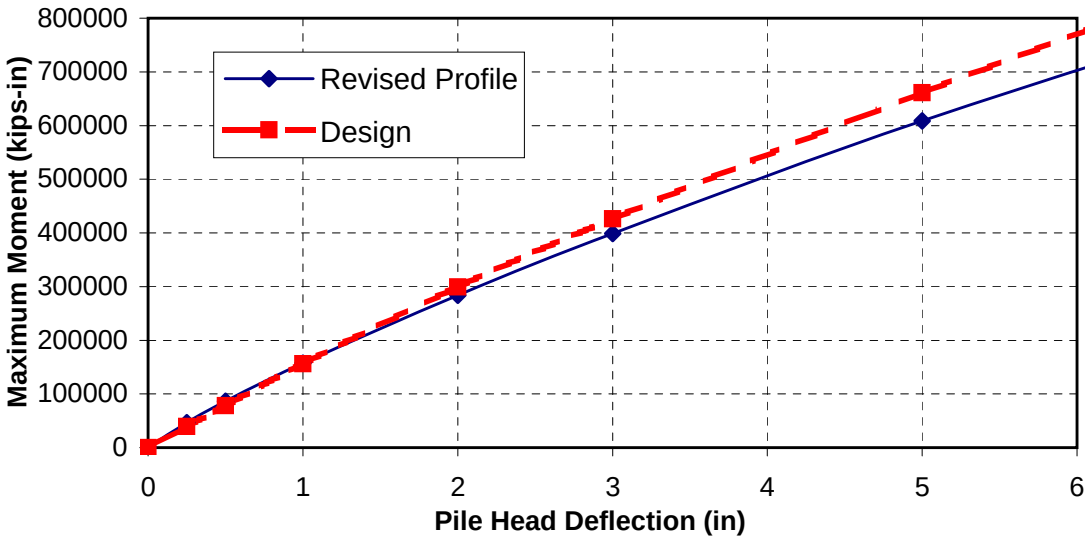


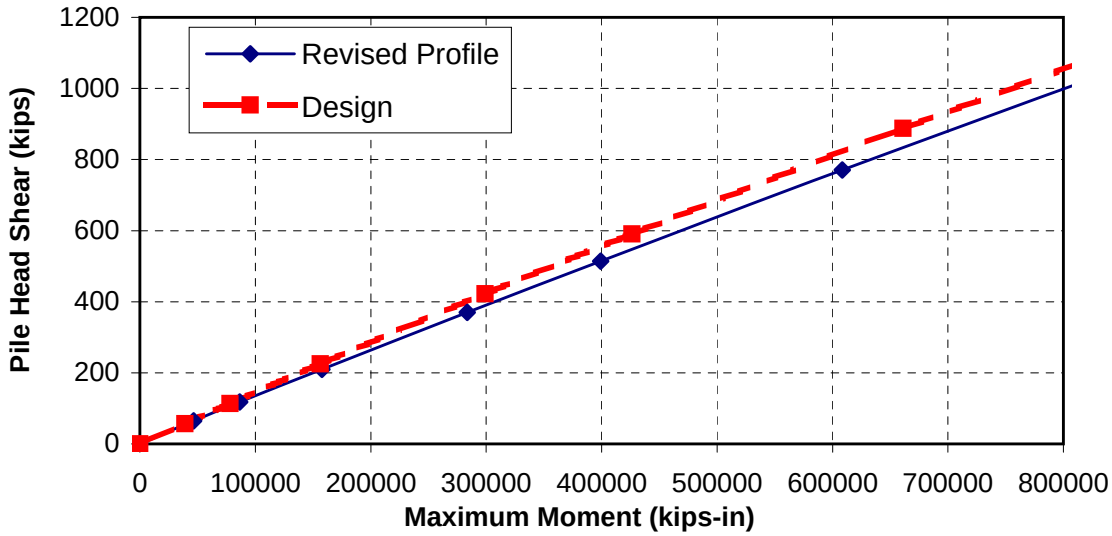




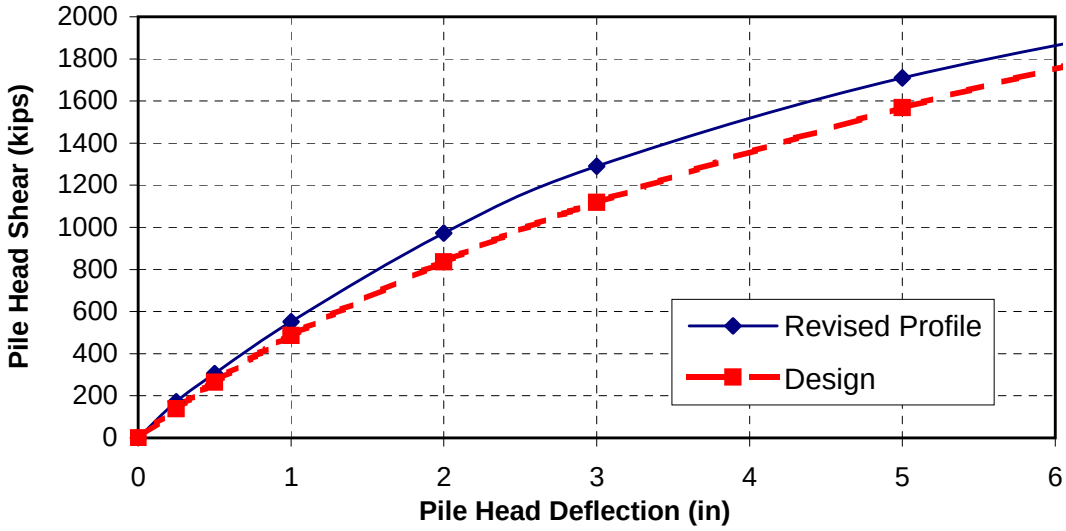
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 13

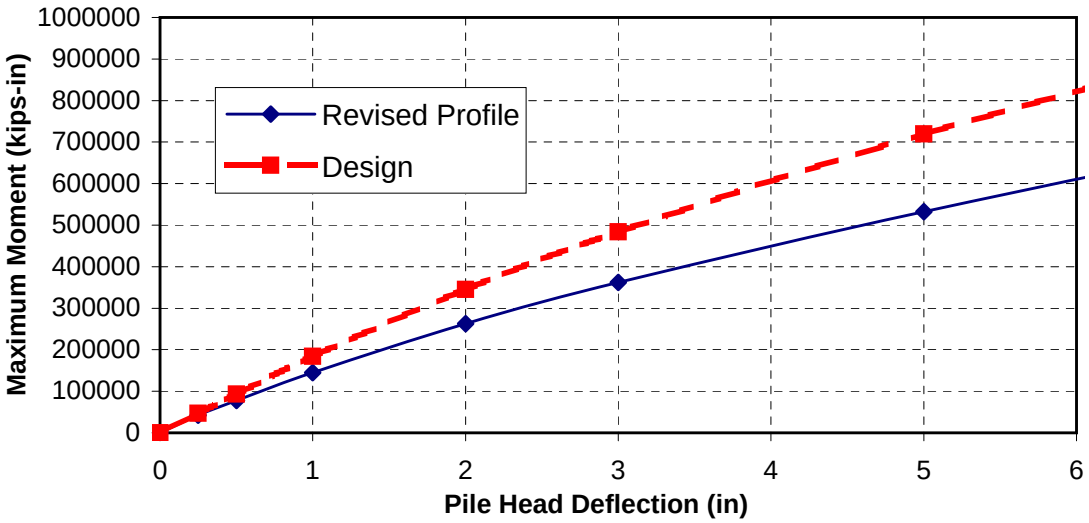


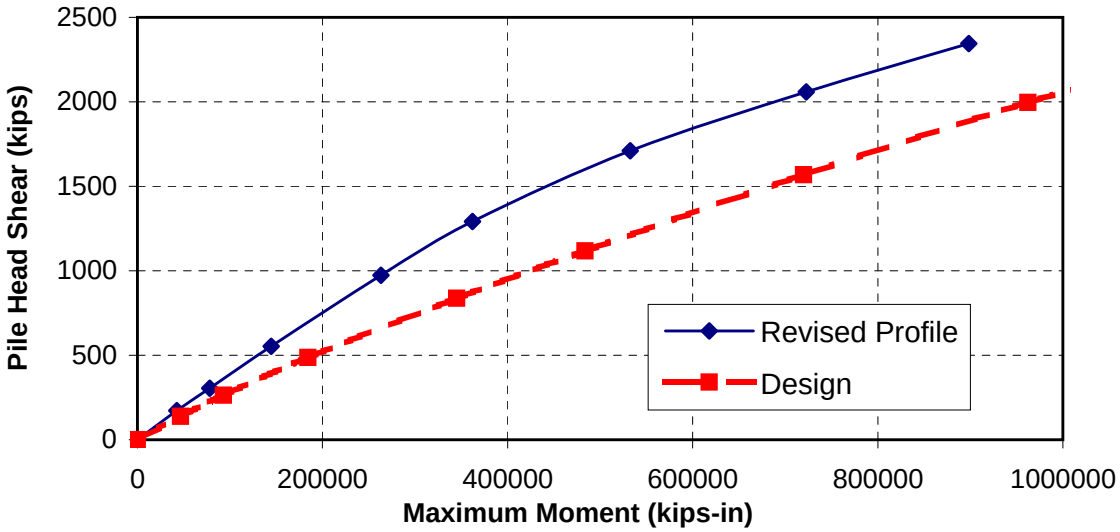




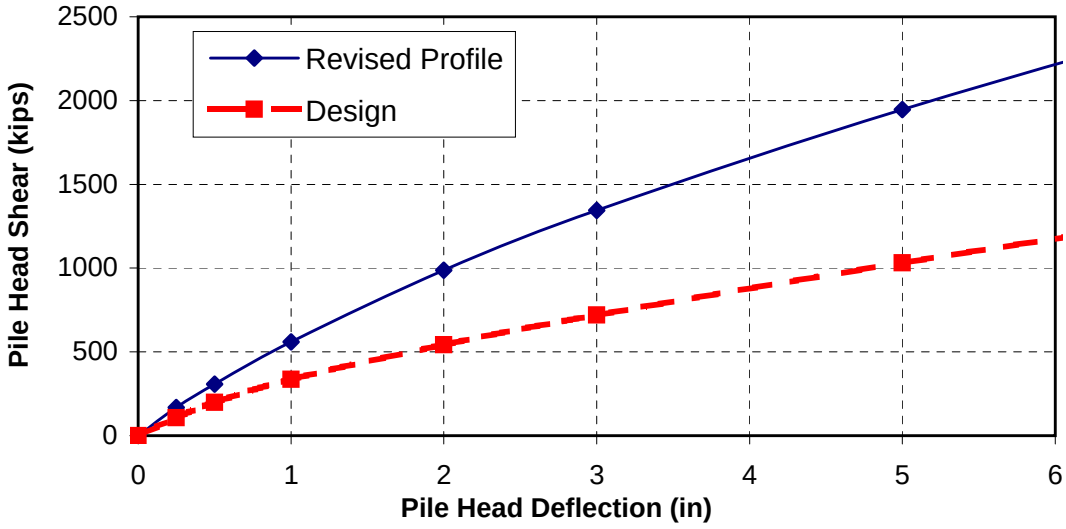
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Pile Head Shear and Max Moment versus Deflection Figure 14
	Project Number: 06-123	Date: 1/20/2010	

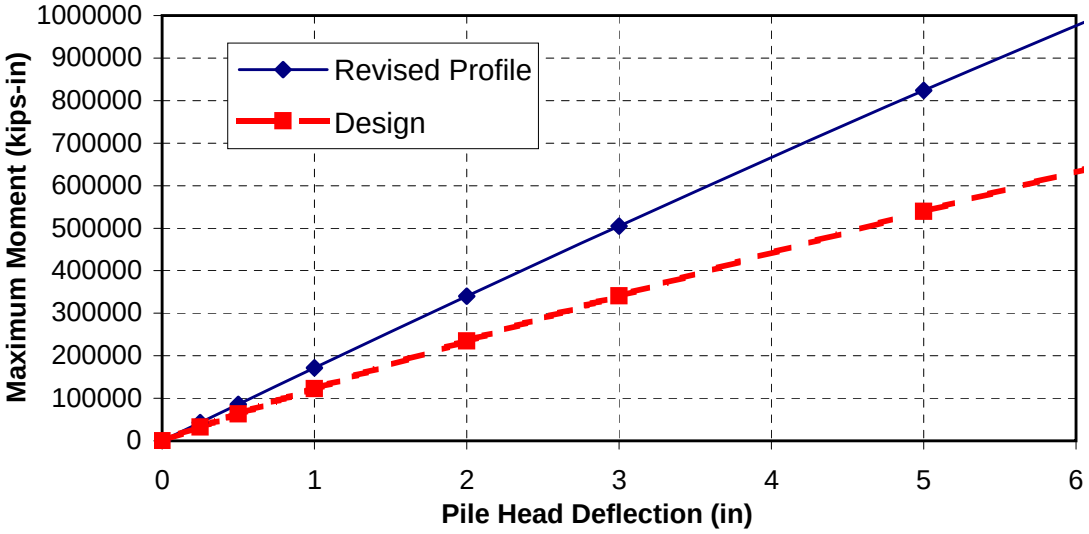


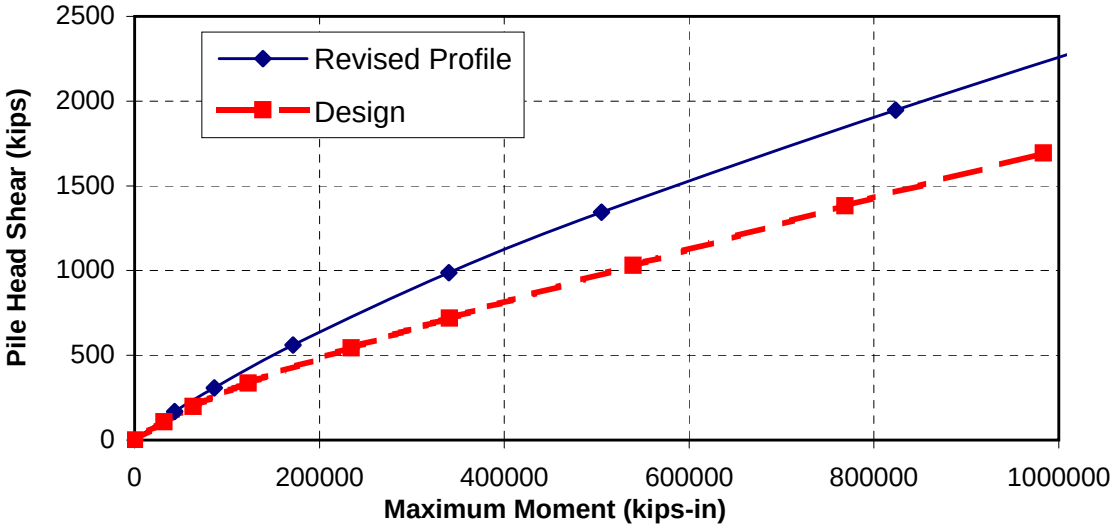




Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 15







Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 24 Pile Head Shear and Max Moment versus Deflection Figure 16
	Project Number: 06-123	Date: 1/20/2010	

Appendix H. Design p-y Curves for Bent Lateral Pile Analysis

Table H-1. New Dock Street On-Ramp Bent 7 and Bent 8
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	90	0.17	180	0.17	270	0.17	360	0.25	3,765
0.33	162	0.33	341	0.33	502	0.33	631	0.50	5,325
0.50	181	0.50	384	0.50	569	0.50	720	0.76	6,204
0.67	197	0.67	418	0.67	622	0.67	791	1.01	6,775
0.83	210	0.83	447	0.83	666	0.83	852	1.26	7,164
1.00	221	1.00	472	1.00	705	1.00	904	1.51	7,425
1.17	231	1.17	494	1.17	739	1.17	951	1.76	7,585
1.33	240	1.33	514	1.33	770	1.33	993	2.02	7,664
1.50	248	1.50	532	1.50	799	1.50	1,032	2.27	7,676
1.67	255	1.67	549	1.67	825	1.67	1,069	2.52	7,629
1.83	262	1.83	564	1.83	850	1.83	1,102	2.77	7,532
2.00	269	2.00	579	2.00	873	2.00	1,134	3.02	7,390
4.50	365	4.50	794	4.50	1,209	4.50	1,599	5.04	5,330
124.50	365	124.50	794	124.50	1,209	124.50	1,599	7.06	3,268
244.50	365	244.50	794	244.50	1,209	244.50	1,599	9.07	1,206
364.50	365	364.50	794	364.50	1,209	364.50	1,599	100.80	1,206

40 ft depth		60 ft depth		80 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,765	0.25	3,765	0.17	5,033	0.17	8,287	0.17	27,207
0.50	5,325	0.50	5,325	0.33	7,286	0.33	12,631	0.33	41,512
0.76	6,204	0.76	6,204	0.50	9,046	0.50	16,162	0.50	53,118
1.01	6,775	1.01	6,775	0.67	10,548	0.67	19,251	0.67	63,270
1.26	7,164	1.26	7,164	0.83	11,882	0.83	22,048	0.83	72,464
1.51	7,425	1.51	7,425	1.00	13,096	1.00	24,633	1.00	80,959
1.76	7,585	1.76	7,585	1.17	14,219	1.17	27,053	1.17	88,914
2.02	7,664	2.02	7,664	1.33	15,269	1.33	29,341	1.33	96,433
2.27	7,676	2.27	7,676	1.50	16,260	1.50	31,519	1.50	103,592
2.52	7,629	2.52	7,629	1.67	17,201	1.67	33,605	1.67	110,446
2.77	7,532	2.77	7,532	1.83	18,098	1.83	35,609	1.83	117,035
3.02	7,390	3.02	7,390	2.00	18,959	2.00	37,544	2.00	123,393
5.04	5,330	5.04	5,330	4.50	31,607	4.50	66,077	4.50	217,172
7.06	3,268	7.06	3,268	124.50	31,607	124.50	66,077	124.50	217,172
9.07	1,206	9.07	1,206	244.50	31,607	244.50	66,077	244.50	217,172
100.80	1,206	100.80	1,206	364.50	31,607	364.50	66,077	364.50	217,172

Appendix I. Caltrans Review Comments and EMI Response

Subject: Review Comments for Foundation Reports for BR53-3031, BR53-3033, BR53-3034K, BR53-3035S.
From: Haitao Liu <haitao_liu@dot.ca.gov>
Date: Tue, 23 Mar 2010 17:17:30 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Hector Bedolla <hector_bedolla@dot.ca.gov>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>, Hamid R Toossi <hamid_r_toossi@dot.ca.gov>, Foued Zayati <foued_zayati@dot.ca.gov>, Bojan Misic <bojan_misic@dot.ca.gov>, Ranjan Gunaranjan <ranjan@earthmech.com>, Eric Brown <e.brown@earthmech.com>, Seungwoon Han <seungwoon_han@dot.ca.gov>

Dear Arul,

Below are our review comments for the subject bridges:

New Dock Street Off-Ramp, Bridge No. 53-3031:

1) Table 5 (Page 28 of Foundation Report).
Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings

2) Section 5.6.1 (Page 34 of the Report).
Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.

3) Section 5.6.2 (Page 34 of the Report).
Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.

4) Log of Test Borings.
I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.

5) Appendix E.Lab Test Results
Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.

6) Axial Capacity (Calculation Volume)
Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.

7) Axial Capacity for Abut 3 (Calculation Volume)
Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.

8) Axial Capacity for Abut 3 (Calculation Volume)
The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.

9) Axial Capacity for all bents (Calculation Volume)
According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.

10) Axial Capacity for Bent 4 (Calculation Volume)
For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.

11) Axial Capacity for Bent 5 (Calculation Volume)
For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.

12) Lateral Pile Capacity for Abut 3 (Calculation Volume)
Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.

13) Static Settlement
Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.

14) Static Settlement
The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.

SR 103 Off-Ramp, Bridge No. 53-3034K:

All applicable review comments from New Dock Street Off-Ramp, plus:

1) Axial Pile Capacity for Abutment 27 (Calculation Volume)
Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.

2) Axial Pile Capacity (Calculation Volume)
The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with

blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.

New Dock Street On-Ramp, Bridge No. 53-3033 and SR 103 On-Ramp, Bridge No. 53-3035S

All applicable review comments from BR 53-3031 and BR 3034K.

Should you have any question, please contact me or Mr. Seungwoon Han at (916) 227-4533.

Thank you.

Haitao Liu, P.E.

Transportation Engineer - Civil
Office of Geotechnical Design South - 1
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New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			1) Table 5 (Page 28 of Foundation Report). Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA)	A	Will comply. Supplemental laboratory tests performed on the sample indicate a Plasticity Index (PI) of 12; therefore, based upon the Boulanger and Idriss (2006) criteria, this layer is determined to be non-liquefiable. Lab test results are attached.	4/20/2010	
2			2) Section 5.6.1 (Page 34 of the Report). Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.	PW / EB / KA	A	Will comply. Tthe recommendations for seismic lateral earth pressure on nonyielding bridge abutments have been revised to be consistent with the recommendations shown in Section A11.1.1.3 of AASHTO LRFD BDS.	4/20/2010	
3			3) Section 5.6.2 (Page 34 of the Report). Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.	PW / EB / KA	A	Will comply. We agree that the recommended edit will be more clear for the reader and the text has been revised per your suggestion.	4/20/2010	
4			4) Log of Test Borings. I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.	PW / EB / KA	A / C	I. Will comply. LOTB's have been revised to only show SPT blowcounts (attached). II. Silty Clay is listed as a soil-type descriptor in Figure 3-3 (page 42) of the Caltrans SRLPCM for material with a PI between 4 and 7. All of the instances where a material is described as Silty Clay on the LOTBs, plasticity test results indicate a PI between 4 and 7.	4/20/2010	
5			5) Appendix E.Lab Test Results Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			6) Axial Capacity (Calculation Volume) Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.	PW / EB / KA	A	Will comply. All six borings/CPTs were used to generate the idealized soil profile used in the pile analysis. We agree that the downdrag elevation for determining the seismic-controlled (extreme event) design pile tip elevation should be based on the nearest soil boring or CPT sounding. Different bottom of liquefiable layer elevations were used at each support. As shown in the calculation volume, the elevation to the bottom of the liquefiable layer was based on R-09-010 for abutment 3 and bent 4, CPT-09-064 for bent 5, R-09-012 for bent 6, R-09-013 for bent 7, and R-09-015 for bent 8. This appears to comply with your comment.	4/20/2010	
7			7) Axial Capacity for Abut 3 (Calculation Volume) Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.	PW / EB / KA	A	Will comply. Per our discussions with the designer, 1 pile will be added at this abutment. We have revised our axial pile capacity calculations to include an average pile group reduction factor of 0.93 at Abutment 3. The evaluation of the group reduction factor and revised axial pile capacity calculations for Abutment 3 are attached.	4/20/2010	
8			8) Axial Capacity for Abut 3 (Calculation Volume) The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.	PW / EB / KA	A	Will comply. Revised axial pile capacity calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
9			9) Axial Capacity for all bents (Calculation Volume) According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.	PW / EB / KA	D	As a result of design development and discussions with the designers, the CMP permanent casing has been replaced with driven permanent steel casing. The driving resistance of the permanent steel casing will be specified in the Pile Data Table; therefore, the skin friction along the length of the permanent casing (based upon API methodology) has been included in the design. The axial pile capacity calculations for the controlling limit case (Strength Limit State) for the bents have been revised. A sample revised calcuation for Bent 4 and the revised pile data table are attached.	4/20/2010	
10			10) Axial Capacity for Bent 4 (Calculation Volume) For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
11			11) Axial Capacity for Bent 5 (Calculation Volume) For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
12			12) Lateral Pile Capacity for Abut 3 (Calculation Volume) Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.	PW / EB / KA	A	I. The apparent discrepancy arises from the facts that the LPile program does not allow the bottom of a soil layer to be above the pile cut-off, and the water table is not directly entered (it is accounted for by inputting the correct effective unit weight and subgrade modulus values based on saturated/dry conditions). At abutment 3, the top of the embankment is at about elevation +20 ft. Finished grade is at about elevation +7 ft. Taking the average of the top of the embankment and finished grade gives +13.5 ft. The design water table is conservatively located at elevation +5 ft. Pile cut-off is at +1 ft. So the overburden can be estimated by including 4 ft of buoyant soil unit weight plus 8.5 ft of dry soil unit weight, which is about 1260 psf. Due to the LPile soil layering constraints mentioned above, we modeled the overburden using a 19 ft layer, with buoyant unit weight, which gives an overburden of about 1140 psf, which is slightly below the estimate above (conservative). II. Will comply. The revised lateral pile analysis includes a "cracked" EI value equal to 80% of the gross EI for the pile for service and strength limit state (0.25" lateral pile top deflection) and 50% of the gross EI for the extreme event limit state (greater than 0.25" lateral pile top deflection). Revised lateral pile capacity calculations are attached. III. Based upon our conversations with the bridge designers, the pile reinforcing has been designed to have sufficient capacity to handle the moment demands.	4/20/2010 4/20/2010	
13			13) Static Settlement Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.	PW / EB / KA	A	Will comply. The settlement calculations have been revised to account for the compressible layer between elevation -5 and -10 ft. The revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
14			14) Static Settlement The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.	PW / EB / KA	A	Yes this is correct. Because the two bridges are located close to one another, based upon the subsurface exploration, the same idealized soil profile was originally used for both locations. However, based on comment #13, the settlement calculations for New Dock Street Off-Ramp have been revised to account for the clay layer encountered in Boring R-09-010 between elevation -5 and 10 ft. The revised settlement calculations are attached.	4/20/2010	
15			1) Axial Pile Capacity for Abutment 27 (Calculation Volume) Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
16			2) Axial Pile Capacity (Calculation Volume) The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.	PW / EB / KA	A	Will comply. Axial pile capacity calculations have been revised to incorporate a reduced load transfer in soil layers with blowcounts less than 15 blows per foot, where applicable. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 7, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, SB SR 103 On-Ramp, Bridge No. 53-3035S Los Angeles County, California,* (7-LA-47, PM 0.01, EA 238501)**

Dear Mr. Hersh:

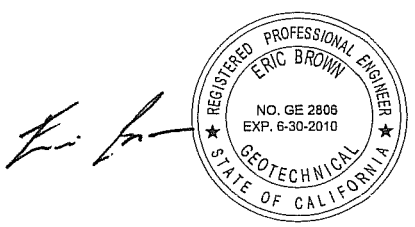
Attached is our Final Foundation Report for the subject bridge. This report presents the results of our analyses and recommendations for design and construction of the bridge foundation for the subject bridge replacement.

The Foundation Report for the subject bridge, dated February 8, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on March 23, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on April 20, 2010. OGDS-1 review comments and EMI responses are included in Appendix I. The responses to these review comments have been incorporated into this Final Foundation Report.

We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer



Eric Brown, GE
Senior Engineer

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
SB SR 103 ON-RAMP, BRIDGE NO. 53-3035S
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.01, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 7, 2010

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APPENDICES

Appendix A. Selected As-Built Plan Sheets for Schuyler Heim Bridge
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Appendix D. GeoVision Geophysical Investigation Report
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1.0 INTRODUCTION

1.1 Purpose and Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed State Route-103 On-Ramp in Los Angeles County, California (Bridge No. 53-3035S). The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analysis and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the replacement of the SR-103 On-Ramp structure (Figure 2).

The proposed SR-103 Street On-Ramp is a five-span Cast-in-Place (CIP) prestressed concrete box girder bridge supported on a single seat type abutment and four single-column bents. The south end of the structure terminates at an expansion joint where the SR-103 On-Ramp abuts the mainline structure approximately 15 ft north of Bent 23 of the mainline. The bridge deck varies in width up to about 42 ft and is approximately 847 ft long.

The typical bridge bent has a single column with each column supported on a single 12 ft diameter Type II cast-in-drilled-hole (CIDH) pile. The abutments are supported on 2.5-foot diameter CIDH piles.

1.3 Existing Bridge Information

The existing Schuyler Heim Bridge is a 45-span structure, is approximately 3,975 feet long and varies from about 80 to 130 feet in width. SR-47 connects to SR-103 via at-grade ramps to the north of the existing northern bridge abutment (Abutment 45) so there are currently no SR-103 connector ramp bridges. Abutment 45 of the existing Schuyler Heim Bridge is located about 100 ft south of the southern most bent (Bent 24) of the proposed SR-103 On-Ramp bridge.

Based on the as-built plans, the existing bridge is supported on a combination of timber piles and 14BP73 driven steel piles. Steel piles with a design loading of 40 tons are used at the abutments and timber piles with a design loading of 22 tons are used at the bents.

Copies of selected sheets from the as-built drawings for the existing Schuyler Heim Bridge relevant to the SR-103 On-Ramp are provided in Appendix A.

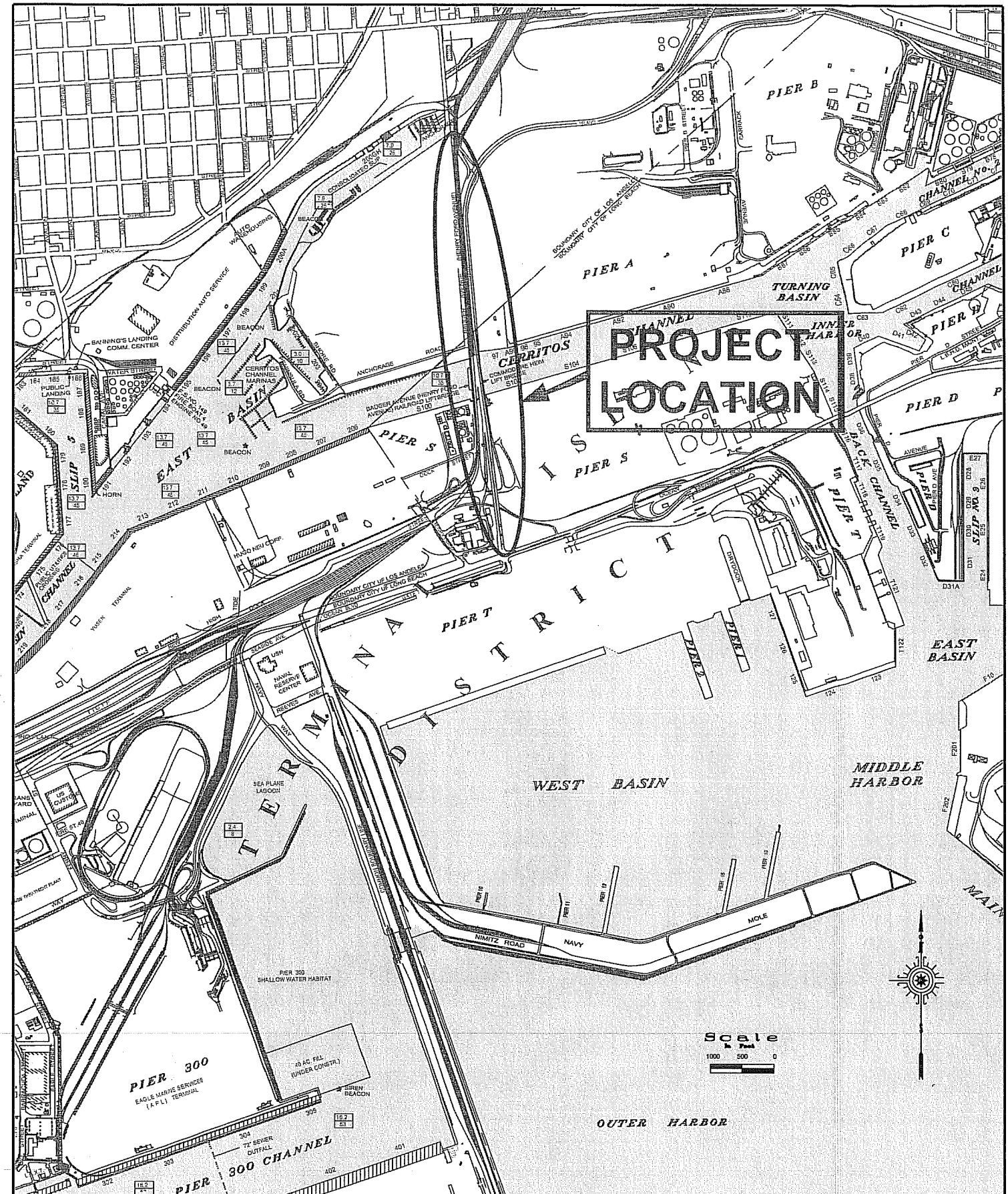
1.4 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed SR-103 On-Ramp bridge. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.


PROJECT LOCATION
PIER B
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PIER T
TURNING BASIN
INNER HARBOR
CERRITOS CHANNEL
EAST BASIN
WEST BASIN
MIDDLE HARBOR
OUTER HARBOR
TERMINAL ISLAND
PIER 300
PIER 300 CHANNEL
NIMITZ ROAD
NAVY
MOLE
SEASIDE AVE
REEVES AVE
BANNING'S LANDING COMM. CENTER
PUBLIC LANDING
DISTRIBUTION AUTO SERVICE
AUTO WAREHOUSING
CONSOLIDATED SLIP
BACK CHANNEL
SLIP 5
SLIP 9
SLIP 10
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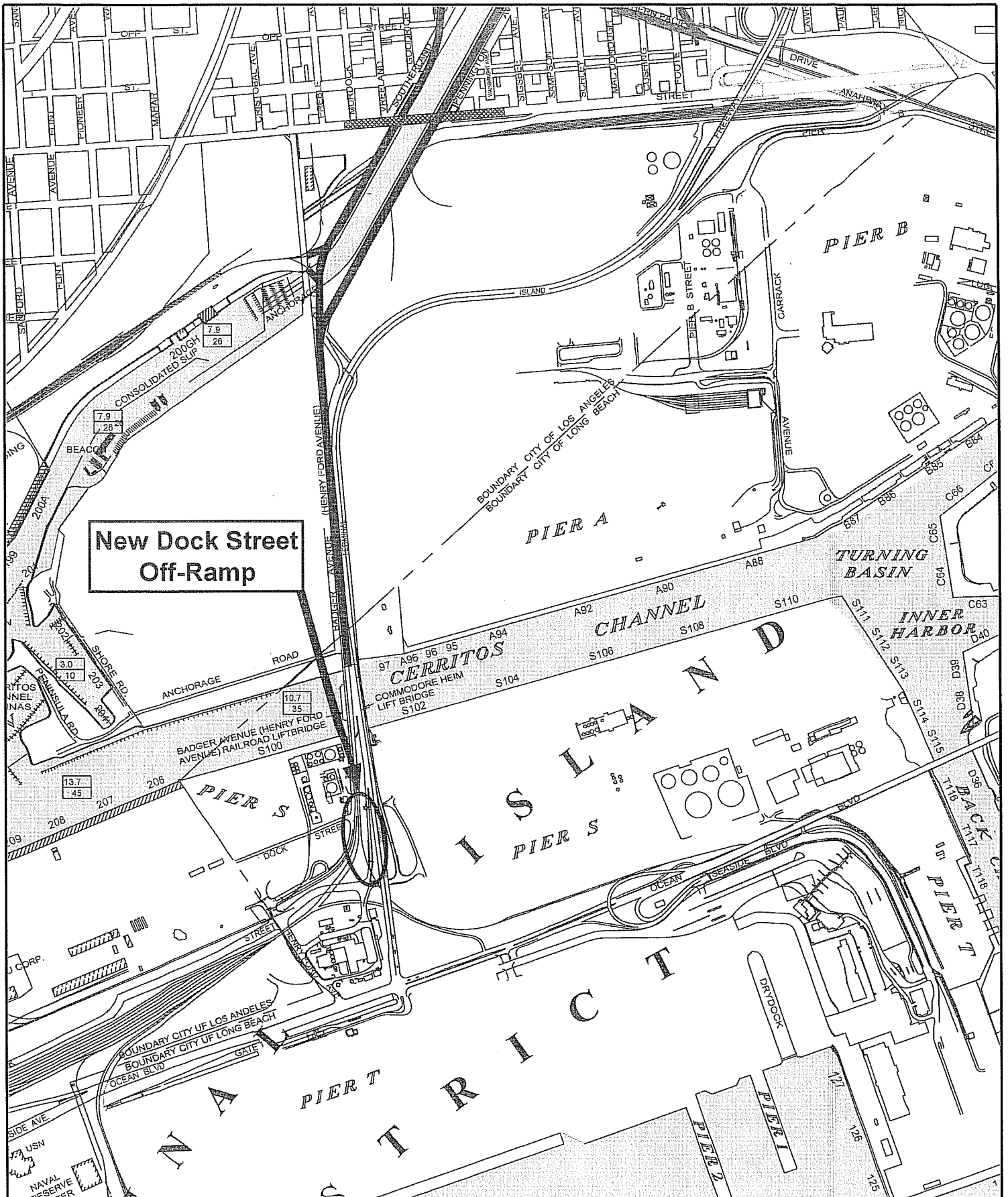


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-07-10	Structure Location Map Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of the SR-103 On-Ramp were those shown on the on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and borings, only one CPT was performed near the subject bridge site. That CPT sounding penetrated to a depth of 100 ft below existing grade with a deepest penetration to an elevation of -102 ft.

Copies of the LOTB sheets prepared by LKR for the seismic retrofit study are provided in Appendix B.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, five rotary wash borings and one CPT sounding were performed in the vicinity of the SR-103 On-Ramp. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed bridge supports. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

All of the borings surrounding the proposed bridge were performed at grade on the shoulders of the existing SR-103/SR47 ramps. The deepest boring penetrated down to about elevation -153 ft, approximately 160 ft below ground surface.

The borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4

inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal. A copy of the ES report is provided in Appendix C.

Boring geophysical measurements were also collected by GeoVision (GeoVision 2009) under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix D.

Table 1. Soil Exploration Information

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-029[2]	"G" Line	611+19.7	86.7 Rt	7.3	-9.7	-154.2	RW
R-09-031[2]		613+07.9	28.4 Lt	8.0	-9.5	-143.5	RW
R-09-032[2]		614+80.3	54.0 Rt	4.1	-9.9	-146.4	RW
R-09-034[1]		616+64.1	28.7 Lt	1.3	-9.7	-149.0	RW
R-09-035[2]		618+39.2	28.5 Lt	2.1	-11.9	-74.4	RW
CPT-09-092		611+10.4	87.2 Rt	7.3	NR	-96.8	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3. GWE = Groundwater Elevation.
4. GSE = Ground Surface Elevation (estimated from topographic plans).
5. Top of Boring Elevation Based on NAVD88.
6. RW = Rotary Wash, CPT = Cone Penetration Test.

2.2.2 CPT Soundings

The CPT sounding was also performed at grade on the shoulder of the existing SR-103/SR47 ramp. The sounding was advanced down to elevation -97.9 ft, approximately 105 ft below ground surface.

Cone Penetration Test (CPT) sounding was performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI. The CPT sounding was performed using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior

of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

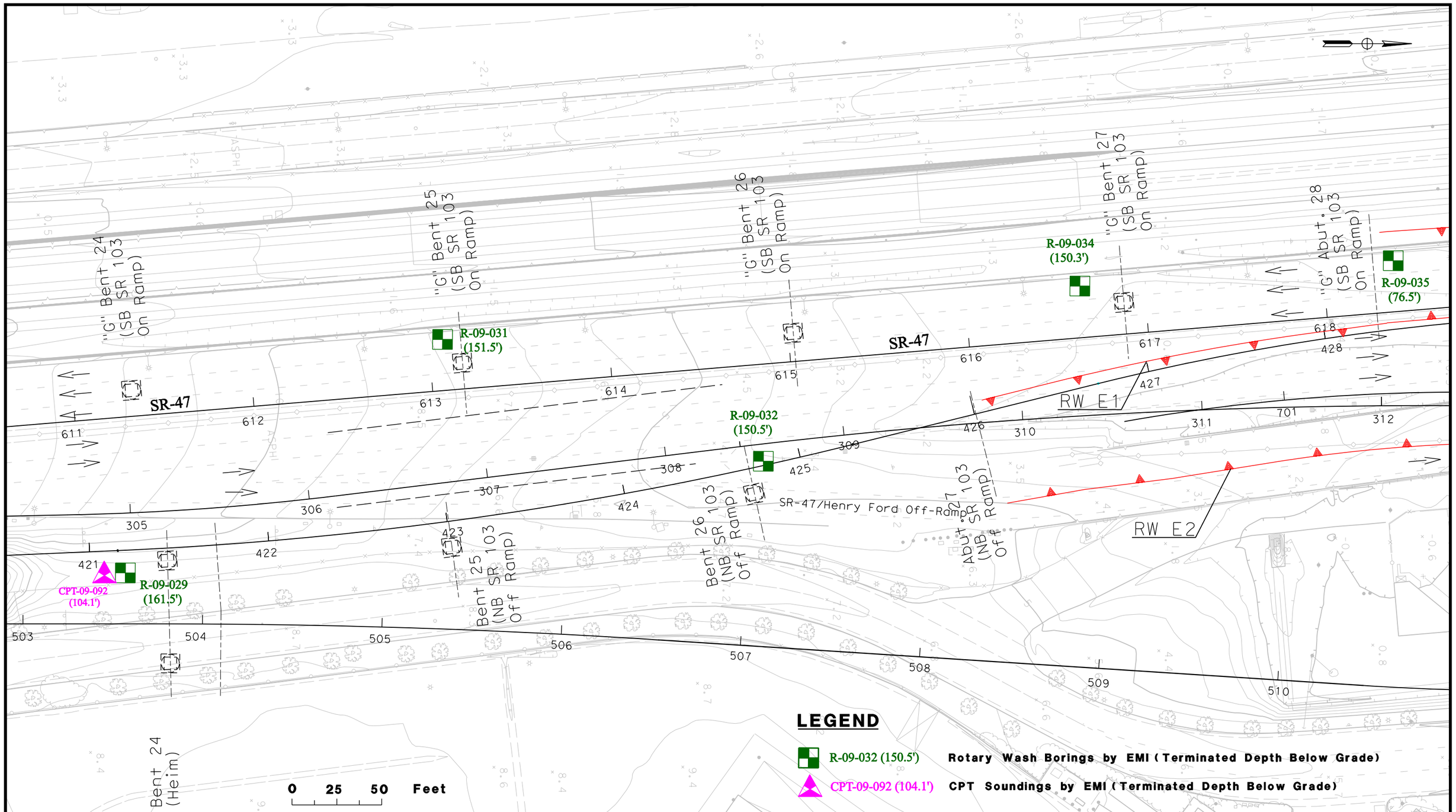
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of soils that exist at the site. Selected soil samples were tested to determine soil classification and physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. Test results are shown on the LOTB sheet at the end of the report and in tables in Appendix E.

Table 2. Explanation of Laboratory Tests Performed

Type of Test	Applicable Test Method	Purpose	Test Results Location
Dry Density	ASTM[1] D 2937	Estimate in-situ soil density	Appendix E
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content	Appendix E
No. 200 Wash	ASTM D 1140	Determine the percentage of fine grained particles of soil	Appendix E
Sieve & Hydrometer	ASTM D 422	Determine particle size distribution of soil	Appendix E
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil	Appendix E
Specific Gravity	ASTM D 854	Determine degree of saturation	Appendix E
Consolidation	ASTM D 2435	Determine compressibility of soil	Appendix E
UU Triaxial Test	ASTM D 2850	Estimate strength parameters of soil	Appendix E
Direct Shear	ASTM D 3080	Estimate strength parameters of soil	Appendix E
Soil pH	CT 532/643	Determine corrosion potential of soil	Appendix E
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil	Appendix E
Sulfate Content	CT 417	Determine corrosion potential of soil	Appendix E
Chloride Content	CT 422	Determine corrosion potential of soil	Appendix E

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-07-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland

and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

Table 3. Stratigraphy and Correlation Chart, Long Beach Area

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	California Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks

rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

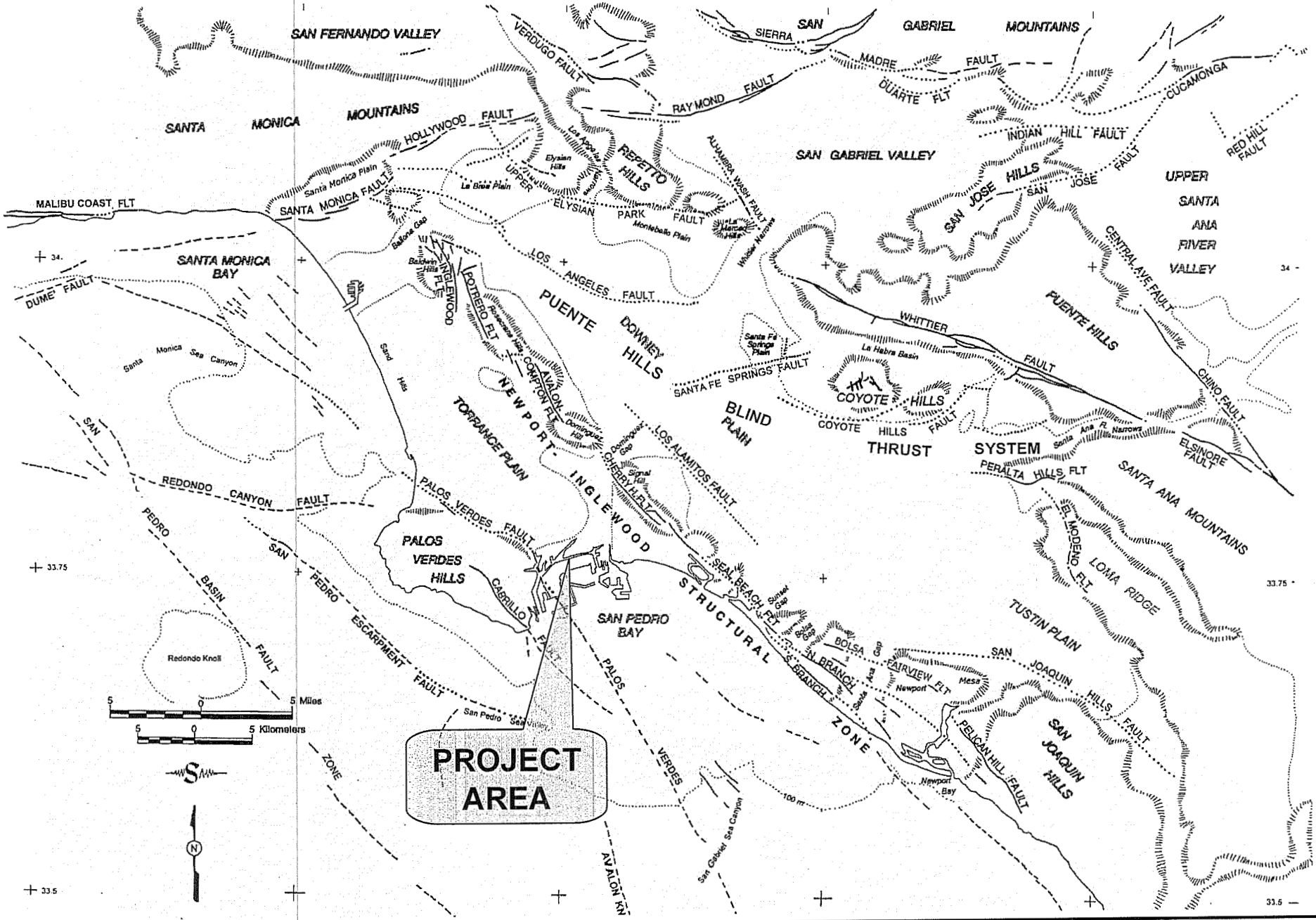
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



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Project No. 06-123

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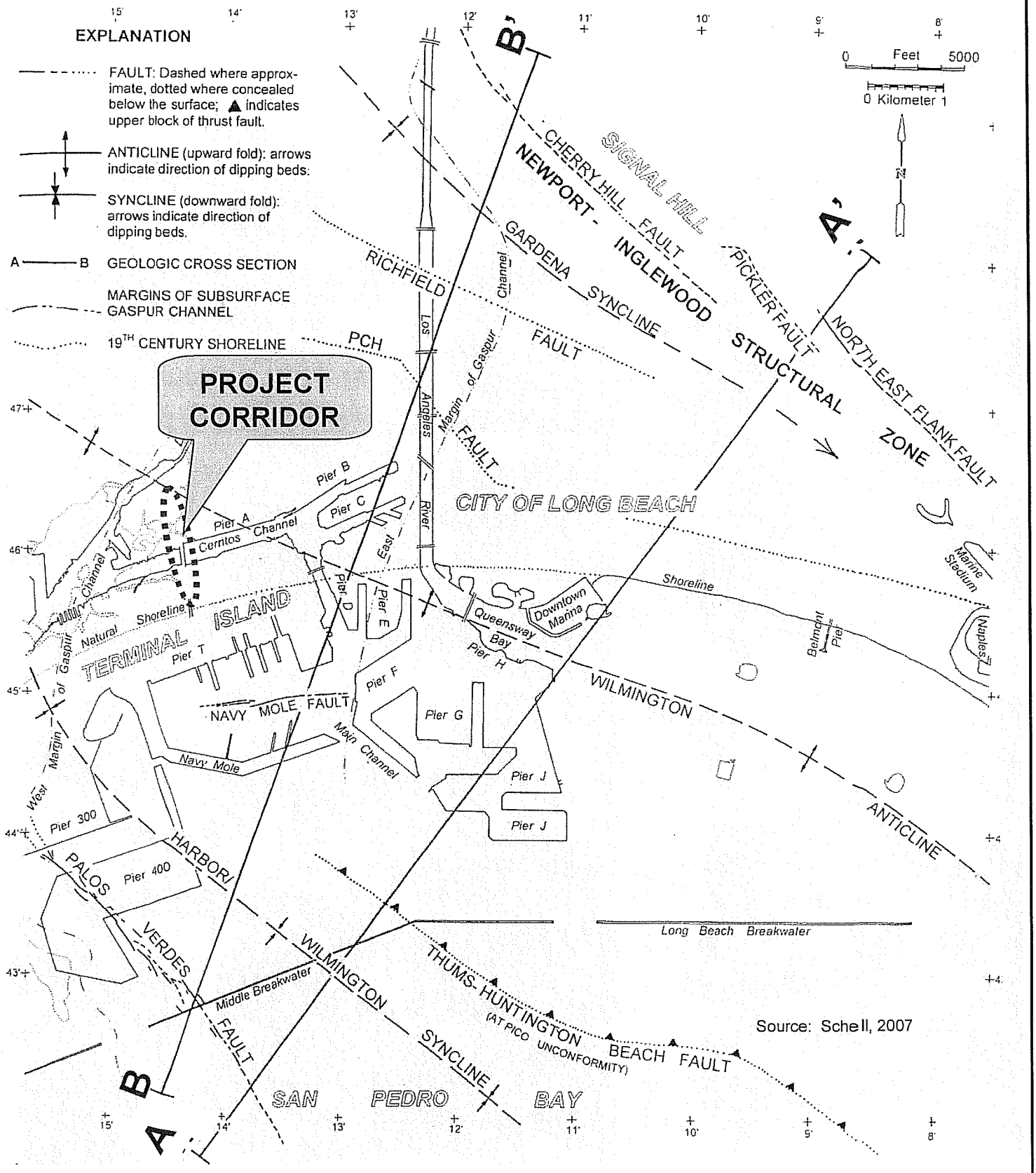
Map of Active Faults and Physiography, LA Basin

Figure 4



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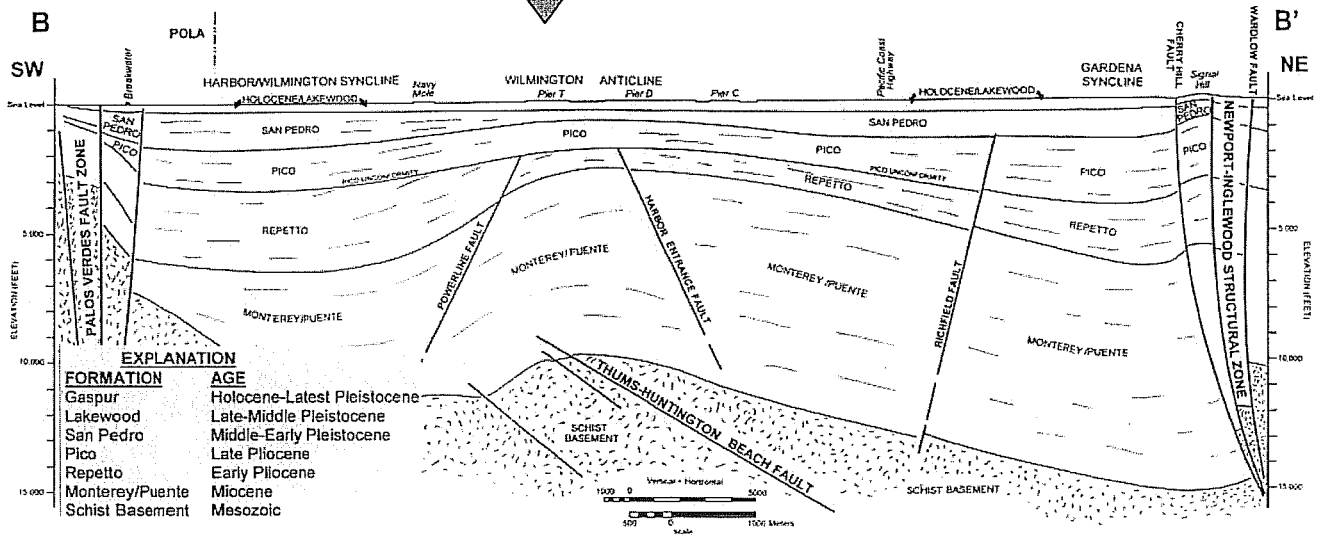
Structural Geology Map, Long Beach Harbor

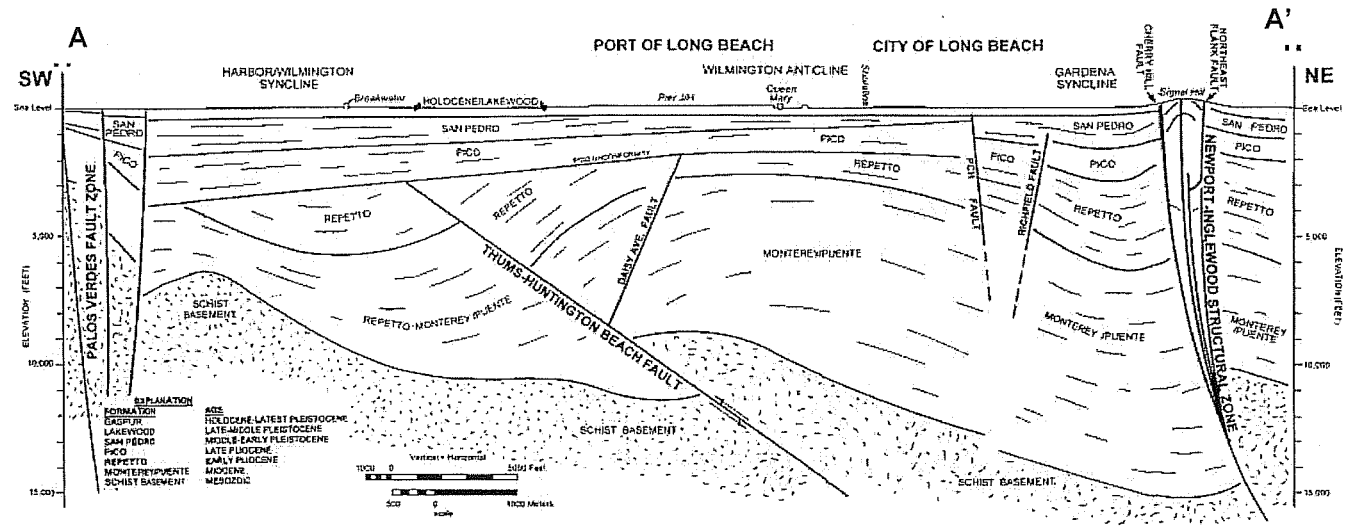
Figure 5

Project No. 06-123 | Date: 5-07-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH



A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

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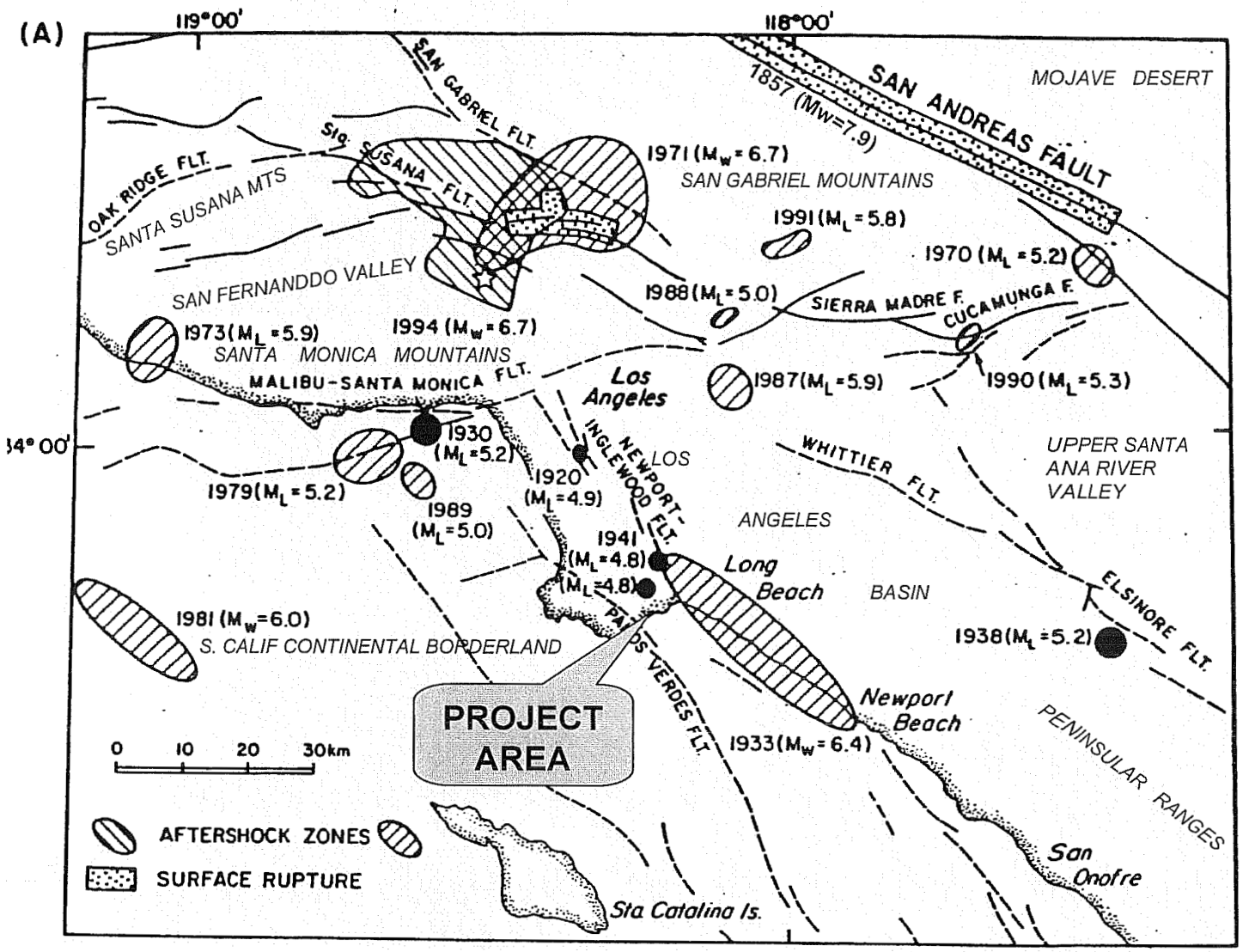
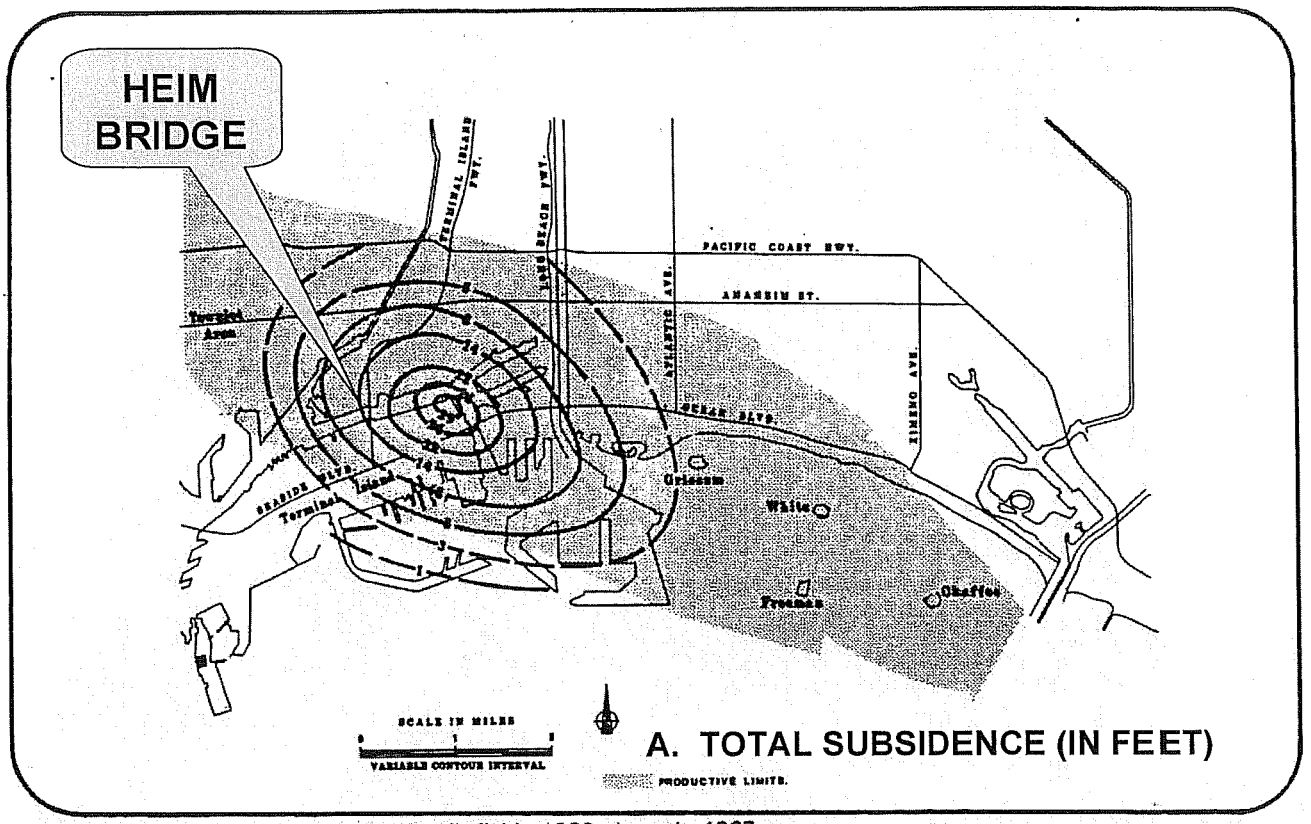
	Geologic Cross-Sections, LA Harbor	
Project No. 06-123	Date: 5-07-10	Figure 6

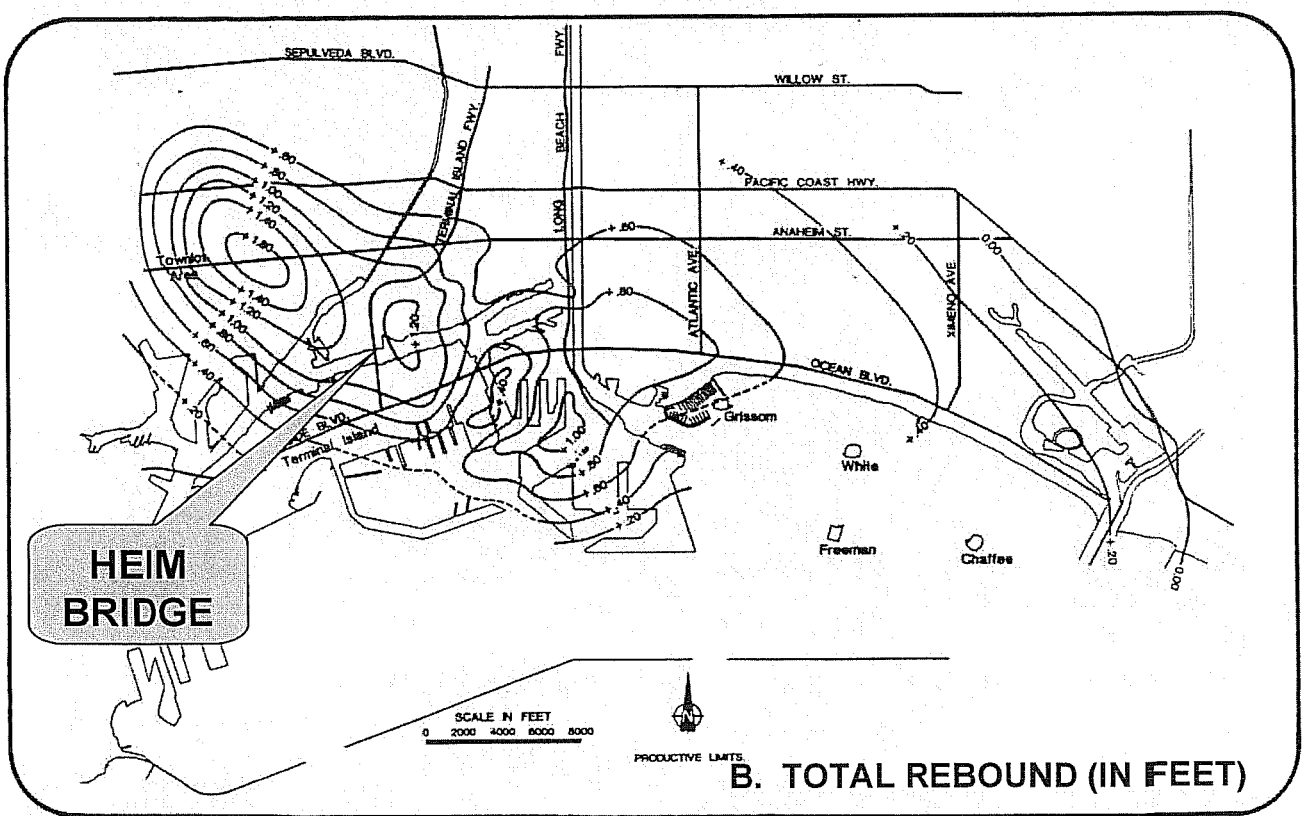


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-07-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

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Project No. 06-123	Date: 5-07-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT sounding (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -153 ft), the subsurface profile consists of about 50 to 60 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject bridge site, natural grade lies at an elevation of about zero, with a few feet of import fill for the existing northern approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +12 ft near SR-103 On-Ramp Bent 24. The near surface deposits consist of silty sand and sand with silt between natural grade and about elevation -4 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -50 ft. Below elevation -50 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in all five of the borings performed near the proposed structure between elevation -9.5 ft and -11.9 feet. The elevation that groundwater was encountered at in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. Due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

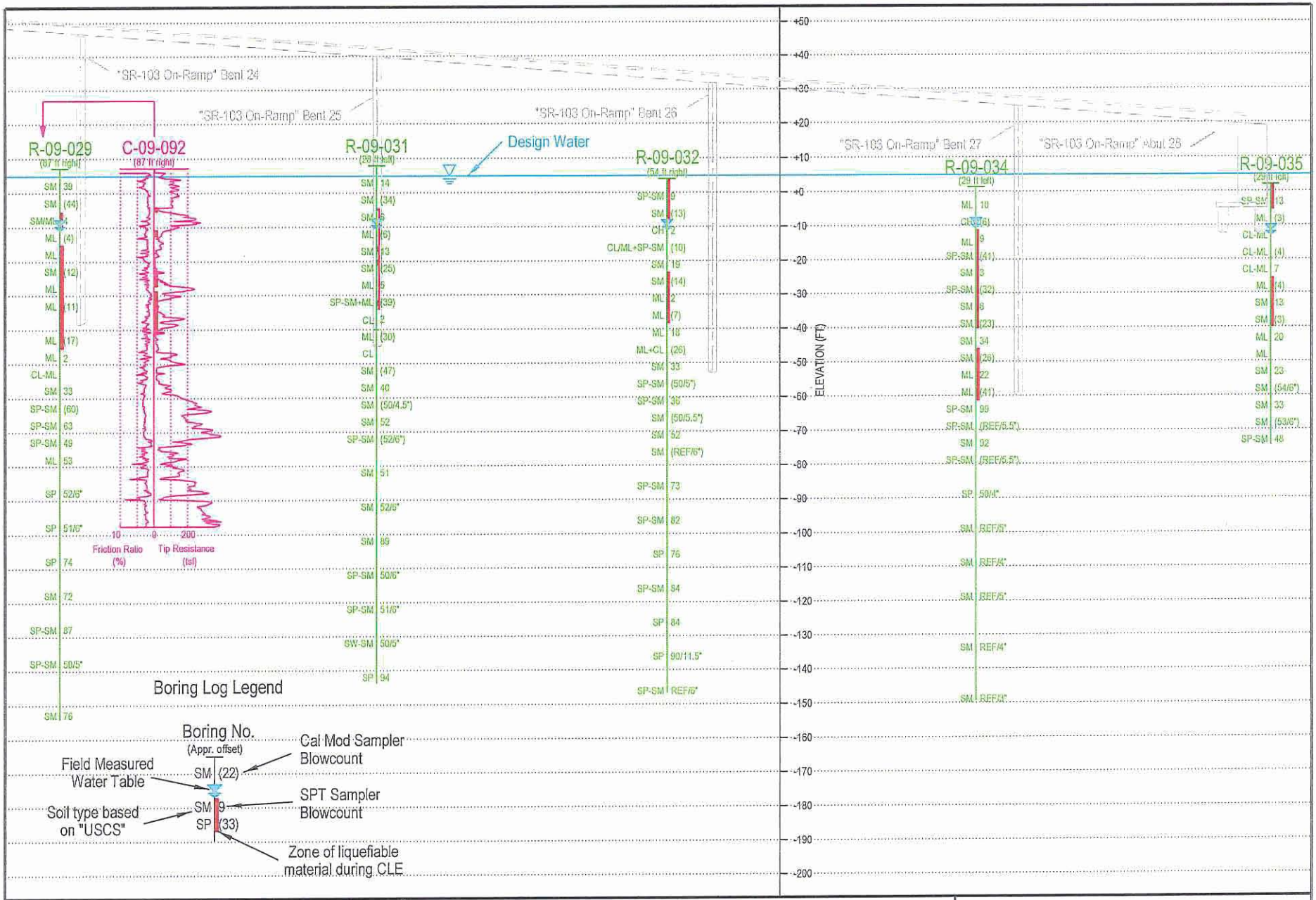
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

Based on information collected from borings R-09-029, R-09-031, R-09-032, R-09-034 and R-09-035 and CPT sounding CPT-09-092 two idealized soil profiles for foundation analysis and design was developed along the proposed bridge alignment. The subsurface profile beneath the proposed structure is shown in Figure 9. The soil profiles and design strength parameters are presented below in Table 4.

Table 4. Idealized Soil Profile and Parameters

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
	Bent 24 to Bent 27			
+12.0 to -4.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	33
-4.0 to -23.0	Silty Sand / Sandy Silt / Clayey Silt	120	750	0
-23.0 to -50.0	Silty Sand / Sandy Silt / Sand with Silt	120	0	32
-50.0 to -60.0	Silty Sand / Sand with Silt	125	0	34
-60.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38
	Abutment 28			
+21.0 to +8.0	Silty Sand (assumed embankment fill)	120	200	32
+8.0 to -4.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	33
-4.0 to -23.0	Silty Sand / Sandy Silt / Clayey Silt	120	750	0
-23.0 to -41.0	Silty Sand / Sandy Silt / Sand with Silt	120	0	30
-41.0 to -56.0	Clayey Silt / Clay with Silt / Sandy Silt	120	2,500	0
-56.0 to -65.0	Silty Sand / Sand with Silt	125	0	34
-65.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Subsurface Profile

Project No. 06-123

Date: 5-07-10

Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Study

A preliminary seismic evaluation was performed by EMI in 2006 and included in the Preliminary Foundation Report (EMI, 2006) based on the 2006 Seismic Design Criteria (SDC) (Caltrans, 2006d).

Using the 2006 SDC, the PBA was determined based on Caltrans Seismic Hazard Map (Mualchin, 1996a) and the attenuation relationship by Sadigh et al. (1997), as required by Caltrans (2006a). The controlling fault was found to be the Palos Verdes fault which is a strike-slip fault capable of generating a Maximum Credible Earthquake (MCE) of magnitude 7.0 and a PBA of 0.60g at the bridge site.

The standard ARS curve published in the 2006 SDC (Caltrans, 2006d) for this bridge site is shown on Figure B.8 for Soil Profile D (M = 7.25±0.25) and 0.6g. The standard ARS curve was modified to account for near-fault effects (a 20% increase of spectral accelerations for periods greater than 1 sec., no increase for periods less than 0.5 sec., and linear interpolation between 0.5 and 1 sec) per SDC Section 6.1.2.1

Figure 10 shows the recommended modified design ARS curve with coordinates as provided in the PFR (EMI, 2006).

During bridge type selection, Caltrans commented based on the PFR that due to the length of the proposed structure, a site specific ARS curve should be developed following completion of the project geotechnical investigation. It is our understanding that following approval of bridge type selection, preliminary design of the bridge proceeded using the preliminary ARS curve in anticipation that the site specific ARS curve would be completed in the early stages of final design.

As part of the EMI field investigation described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings for the entire project along the mainline bridge alignment. Using the results of shear wave velocity measurements, a site specific ground motion study was performed.

Results of the geotechnical field investigation and site specific ground motion study, following the procedures outlined in the latest Caltrans SDC (Caltrans, 2009) indicate that the preliminary ARS curve shown in Figure 10 plots well above the site specific ARS curve. Consequently, previously conducted analyses and design based on the preliminary seismic evaluation ARS curve are considered conservative and suitable for final design. The peak ground acceleration for the site was revised to 0.5 g based on the latest Caltrans SDC. The details of the ground motion study and the site specific ARS curve are summarized in a memorandum prepared by EMI and are included in Appendix F.

Ground Rupture. No known active faults traverse the surface of the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Liquefaction Potential and Seismically Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -60 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. Locations of potentially liquefiable material during the design earthquake are also identified in the subsurface profile shown in Figure 9.

Table 5. Liquefaction and Seismic Settlement Analysis Results

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-029	-5 to -10	1.9	9.3
	-20 to -45	7.4	
R-09-031	-4 to -34	7.1	7.1
R-09-032	+4 to -10	2.2	7.5
	-22 to -38	5.3	
R-09-034	-10 to -40	7.7	9.5
	-45 to -55	1.8	
R-09-035	+2 to -5	0.7	6.3
	-25 to -40	5.6	
CPT-09-092	-4.0 to -5.2	0.2	2.4
	-10.7 to -12.4	0.1	
	-22.5 to -27.2	0.1	
	-28.7 to -41.0	2.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Eight

soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH varied between 7.7 and 8.8, the minimum resistivity varied from 140 to 620 ohm-cm, soluble chloride contents were between 465 and 6,316 parts per million (ppm) and soluble sulfate contents were between 107 and 1,330 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

5.4 Scour

This site is located within an area that is generally flat and there are no rivers, creeks or channels that cross beneath the structure; therefore, scour is not considered a design issue.

5.5 Foundation Type

Due to presence of the weak near-surface soils and the potential for seismically induced settlement throughout the site, spread footings are not considered feasible for support of the proposed structure.

Site soils are conducive to either a driven or drilled pile foundation. Due to the presence of deep liquefiable layers, large diameter Cast-In-Drilled-Hole (CIDH) piles are better suited to resist the large lateral foundation demands than small diameter piles and large diameter piles are needed at bent locations to support the large axial pile demands. Based on the foundation loads provided by the designers, 12 ft diameter CIDH piles are recommended for support at the proposed structure bents and 2.5 ft diameter CIDH piles are recommended at the abutment. At the bent locations, a permanent steel casing from finished grade to a depth between 29 and 38 ft is also proposed.

5.5.1 Axial Pile Capacity

Per Caltrans policy, LRFD method is used for bent piles and WSD is used for abutment piles. The foundation design data sheet and factored foundation loads were estimated by the designers following the latest Caltrans Memo to Designers 3-1 (Caltrans, 2008), and are shown in Tables 6 and 7, respectively.

Table 6. Foundation Design Data Sheet

Location	Design Method	Pile Type	Finished Grade El. (ft)	Pile Cut-off El. (ft)	Pile Cap Size (ft)		Permissible Settlement under Service Load (in)	No. of Piles per Support
					B	L		
Bent 24	LRFD	12 ft CIDH	+12.0	-5.5	NA	NA	1	2
Bent 25	LRFD	12 ft CIDH	+8.0	-9.5	NA	NA	1	2
Bent 26	LRFD	12 ft CIDH	+4.0	-15.5	NA	NA	1	2
Bent 27	LRFD	12 ft CIDH	+2.0	-18.3	NA	NA	1	2
Abut 28	WSD	2.5 ft CIDH	+2.0	-4.8	24	56	1	21

Table 7. Foundation Design Loads

Location	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)			
	Total Load		Perm Load	Compression		Tension		Compression		Tension	
	Per Support	Max Per Pile	Per Support	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile	Per Support	Max Per Pile
Bent 24	4,092	4,092	3,107	5,650	5,650	0	0	3,107	3,107	0	0
Bent 25	2,915	2,915	2,189	4,049	4,049	0	0	2,189	2,189	0	0
Bent 26	2,882	2,882	2,189	3,991	3,991	0	0	2,189	2,189	0	0
Bent 27	2,823	2,823	2,088	3,959	3,959	0	0	2,088	2,088	0	0
Abut 28	4,620	220	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes: 1. For bents with more than one support, the highest support/pile demand is listed in the table, as provided by the designer.

Axial CIDH pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). Axial driven steel shell capacities were calculated according to recommendations by Tomlinson (1987) and API (2000). The calculated factored axial geotechnical capacities and pile tip elevations for each 30-inch CIDH pile at the abutment and 12-ft CIDH pile at the interior bents are presented in Tables 8 and 9, respectively. For the extreme event limit case, negative skin friction due to seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The depth to the bottom of the liquefiable layer at each support was determined based upon the nearest boring information. The Pile Data Table is provided in Table 10. For bent piles, a resistance factor of 0.7 was applied per Caltrans LRFD guidelines.

Table 8. Foundation Recommendations for Abutments

Location	Pile Type	Cut-off El. (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip El. (ft)	Specified Tip El. (ft)
			Total	Permanent				
Abut 28	2.5 ft CIDH	-4.8	4,620	NA	220	440	-65 (a) -45 (c) -47 (d)	-65

Notes: 1. Design tip elevations are controlled by: (a) Compression, (b) Tension, (c) Settlement, (d) Lateral Load.
2. The specified tip elevation shall not be raised.

The maximum pile-head settlement due to the nominal resistance is estimated to be less than 1-inch at all supports. For axial loading, pile group effects can be neglected if the on-center spacing is equal to or greater than 4 times the pile diameter. A group reduction factor of 0.65 is applied for on-center spacing of 2.5 times the pile diameter. Based on interpolation over this range, an average group reduction factor of 0.87 was applied at the abutment.

Table 9. Foundation Recommendations for Bents

Location	Pile Type	Cut-off El. (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				Design Tip El. (ft)	Specified Tip El (ft)	Steel Casing Specified Tip El. (ft)	Steel Casing Nominal Driving Resistance Required ((kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 24	12 ft CIDH	-5.5	4,092	1	5,650	0	3,107	0	-135 (a-I) -110 (a-II) -85 (c) -86 (d)	-135	-31	690
Bent 25	12 ft CIDH	-9.5	2,915	1	4,049	0	2,189	0	-113 (a-I) -103 (a-II) -93 (c) -90 (d)	-113	-35	660
Bent 26	12 ft CIDH	-15.5	2,882	1	3,991	0	2,189	0	-112 (a-I) -106 (a-II) -109 (c) -96 (d)	-112	-41	640
Bent 27	12 ft CIDH	-18.3	2,823	1	3,959	0	2,088	0	-111 (a-I) -107 (a-II) -101 (c) -98 (d)	-111	-44	620

Notes: 1. Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (a-II) Compression (Extreme Event Limit), (b) Tension, (c) Settlement, (d) Lateral Load.

2. The specified tip elevation shall not be raised.

Table 10. Pile Data Table

Support	Pile Type	Nominal Resistance (kip)		Nominal Resistance (Driven Steel Shell) (kip)		Steel Casing Specified Tip Elevation (ft)	CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Comp	Tens	Comp	Tens				
Bent 24	12 ft CIDH	8,070	0	690	0	-31	-135 (a) -85 (c) -86 (d)	-135	690
Bent 25	12 ft CIDH	5,780	0	660	0	-35	-113(a) -93 (c) -90 (d)	-113	660
Bent 26	12 ft CIDH	5,700	0	640	0	-41	-112 (a) -109 (c) -96 (d)	-112	640
Bent 27	12 ft CIDH	5,660	0	620	0	-44	-111 (a) -101 (c) -98 (d)	-111	620
Abut 28	2.5 ft CIDH	440	0	NA	NA	NA	-65 (a) -45 (c) -47 (d)	-65	NA

Notes: 1. Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

2. The specified tip elevation shall not be raised.

5.5.2 Lateral Pile Capacity

Abutments. Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a fixed-head connection with the pile cap are provided in Tables 11 and 12 for the Service Limit State and the Extreme Event Limit State, respectively. The design tip elevations for lateral loading are given in Table 10.

Lateral pile analyses were performed using the computer program LPILE (Ensoft 2007). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000). The internally generated p-y curves for stiff fine-grained soils were estimated using the method proposed by Reese (Reese et al., 1975), and the internally generated p-y curves for soft fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.75 was used in the analysis based on the pile layout provided by the designers and the procedures outlined in the Ensoft Group 7.0 software Technical Manual (Ensoft 2006). Under seismic conditions, liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008).

The solutions presented are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and other connection details.

Table 11. Abutment 28, 30-in CIDH Pile "Fixed" Head Solution: Service Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	50	3,596

Notes: 1. Group effects considered with a reduction factor of 0.75 on "p."
2. Static strength parameters used in all soil layers.
3. A cracked section modulus of 80% of EI was used in the analysis.

Table 12. Abutment 28, 30-in CIDH Pile "Fixed" Head Solution: Extreme Event Limit State

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	45	2,852
0.5	63	4,434
1.0	88	6,989
3.0	158	15,149

Notes: 1. Group effects considered with a reduction factor of 0.75 on "p."
2. Liquefied strength parameters used in liquefiable soil layers.
3. A cracked section modulus of 50% of EI was used in the analysis.

Bents. The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time that included a general description of the subsurface conditions beneath the proposed structure and eight idealized soil profiles along the proposed alignment. It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared.

Based on the current geotechnical investigation and updated soil profile, an additional project specific lateral pile analysis was also performed. Results from that analysis indicate that the p-y curves generated from the soil profiles presented in the PFR are suitable for use in the final design. The current results either generate a more conservative lateral pile response than the p-y curves developed by Caltrans based on the PFR, or a lateral pile response that is within an acceptable design tolerance. Details of the lateral pile analysis and a comparison between the preliminary and updated p-y curves are included in a memorandum prepared by EMI. The memorandum is included in Appendix G. The preliminary p-y curves generated from the soil

profiles in the PFR which were determined to be suitable for use in final design for Bent 24 to Bent 27 are provided in Appendix H.

5.6 Bridge Abutment Walls

5.6.1 Earth Pressures

An active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf are recommended for a level abutment backfill. If abutment walls are free to move laterally at the top, a static active lateral earth pressure of 36 psf per ft of depth is recommended for a level backfill. If lateral movement at the top of abutment walls is restrained, the lateral pressure distribution has a trapezoidal shape with a maximum lateral pressure of 28.8H psf between 0.2H from the top and bottom of the wall, where H is the wall height in feet. A traffic surcharge equivalent to a vertical pressure produced by at least 2 ft of earth should be added to the above lateral earth pressure values. Other design requirements are specified in Section 3.20 of the Caltrans Bridge Design Specifications (Caltrans, 2004).

5.6.2 Passive Resistance

Under seismic loading, an ultimate passive earth pressure of 5 ksf may be used for the approach backfill and abutment backwalls with a height equal to or greater than 5.5 ft. For abutment backwalls with heights less than 5.5 ft, the maximum passive pressure may be calculated proportionally (e.g., for a 4 ft high backwall, the maximum passive pressure is [4/5.5]x5 ksf = 3.6 ksf). The horizontal movement at which the maximum passive pressure is expected to be fully mobilized can be determined following the procedure outlined in Section 7.8.1 of the Caltrans SDC (2006d).

5.7 Approach Embankments

Up to about 18 ft of fill will be placed near the SR-103 On-Ramp Abutment 28 in order to raise existing grade to proposed grade. The abutment end slope will be graded at an inclination of 1.5:1 (Horizontal:Vertical) with full slope paving. The western portion of the bridge approach embankment will be a mechanically stabilized embankment (MSE) retained by Retaining Wall G1 along the western roadway edge. The eastern portion of the embankment will consist of import fill retained by a Caltrans standard Type 1 retaining wall (Retaining Wall G2) founded on a spread footing. Recommendations for Retaining Wall G1 and G2 are provided in a separate foundation report prepared by EMI (EMI, 2010).

5.7.1 Static Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed embankment approximately 25 ft behind the bridge abutment. Based on cross-sections provided by URS Corporation, the existing embankment at "G" Line Sta. 618+75 will be approximately 50 ft wide at roadway level and the embankment height is approximately 16 feet. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 7.5 inches. The settlement period is estimated to be about 24 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 15 weeks. For a 7-ft embankment surcharge, the settlement periods is reduced to about 13 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

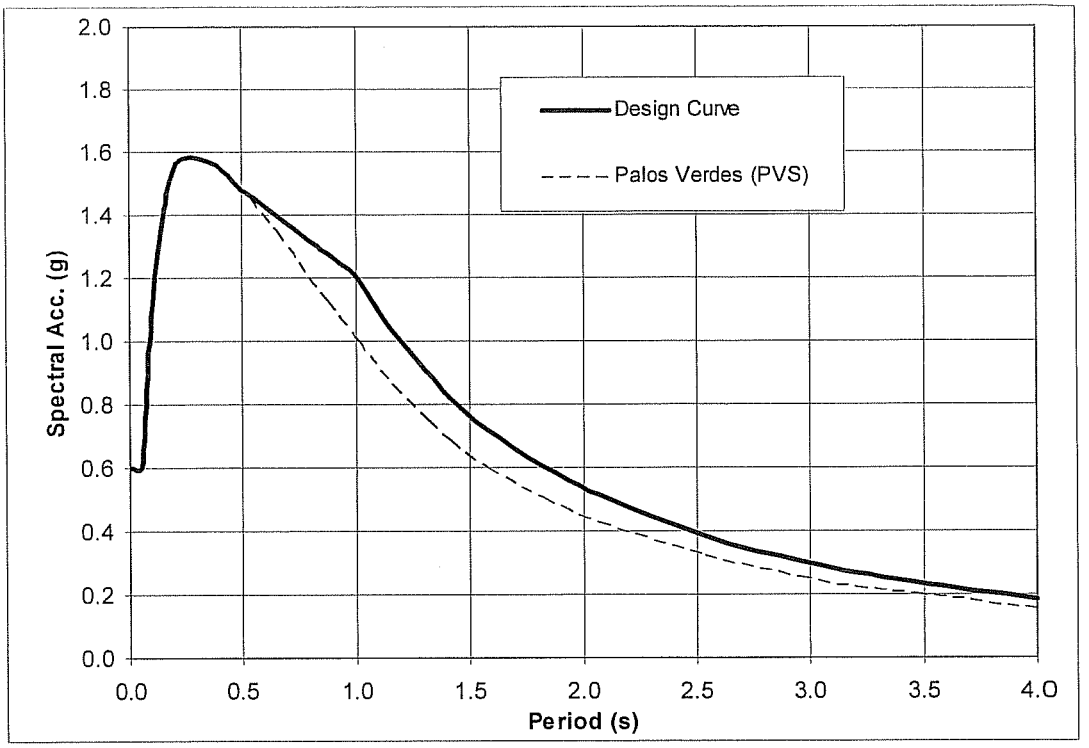
Settlement of the embankment fill should be verified by the Engineer prior to installation of abutment piles to prevent a reduction in axial pile capacity due to downdrag loads being applied to the piles.

5.7.2 Bridge Abutment Slope Stability

The global stability analysis of Retaining Wall G1 and G2 is provided in a separate report prepared by EMI (EMI, 2010).

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).



Fault Name	Fault Type	M_w	Dist, km	PBA, g
Palos Verdes (PVS)	ST	7.25	2.7	0.6

Period	Acc (g)	Period	Acc (g)	Period	Acc (g)	Period	Acc (g)
0.010	0.600	0.500	1.479	2.954	0.304		
0.050	0.600	0.533	1.461	3.203	0.266		
0.079	0.938	0.650	1.398	3.463	0.239		
0.099	1.127	0.787	1.323	4.000	0.186		
0.124	1.283	0.868	1.279				
0.154	1.419	0.998	1.209				
0.177	1.507	1.000	1.208				
0.208	1.564	1.162	1.031				
0.236	1.578	1.307	0.906				
0.271	1.584	1.411	0.822				
0.309	1.580	1.575	0.723				
0.355	1.570	1.819	0.605				
0.386	1.557	2.068	0.513				
0.442	1.525	2.537	0.383				

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned or dried to near optimum moisture, and compacted in place to a minimum 95 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts or excavations necessary to achieve finish grades. However, temporary cuts may be required in areas where drainage improvements and footings are proposed. Temporary excavations, including temporary shoring, necessary to construct the bridge abutment footings or culverts will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all four of the borings performed for the proposed bridge foundation between Elevation -9.5 and -11.9 ft. The proposed footing bottom elevation at Abutment 28 is -5.0 ft. Due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

Groundwater was encountered between elevation -9.5 and -11.9 feet in October and November 2009. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff and other man-made conditions. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled

with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.3 Backdrain and Backfill Requirements for Abutment Walls

Materials behind the abutment and wing walls should be low-expansive soil with an Expansion Index (EI) less than 50 and Sand Equivalent (SE) of more than 20 as shown in Figure 11. The low-expansive material requirement should not supersede the structure backfill and pervious backfill requirements as described in Caltrans Standard Plans, Bridge Detail 3-1 (2006b), and Caltrans Standard Specifications (2006c) under Sections 19-3.06 and 19-3.065, respectively.

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the abutment walls in order to avoid damaging the walls due to large lateral earth pressures.

Backdrains should be installed behind abutment walls to relieve hydrostatic pressure. The backdrains should be constructed in accordance with Bridge Detail 3-1 per Caltrans Standard Plans (2006b).

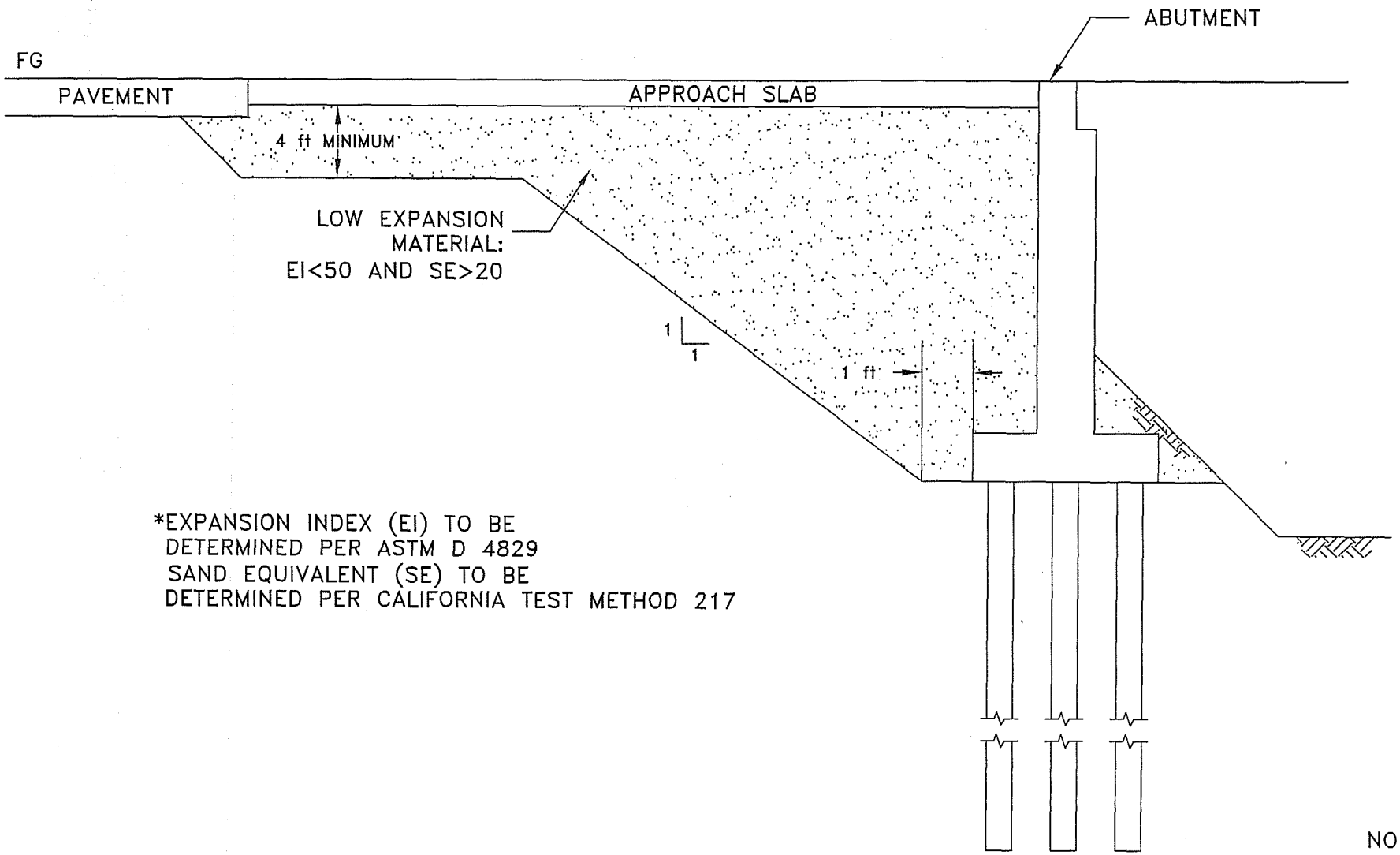
6.4 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations presented in this report may require modification or additional recommendations may be necessary based on the final design.

6.5 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of bridge abutment walls.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.



*EXPANSION INDEX (EI) TO BE DETERMINED PER ASTM D 4829
SAND EQUIVALENT (SE) TO BE DETERMINED PER CALIFORNIA TEST METHOD 217

NO SCALE

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 5-07-10

Low Expansion Material at Bridge Abutments

Figure 11

7.0 REFERENCES

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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

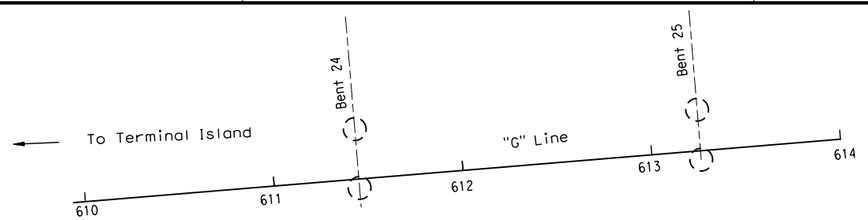
PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

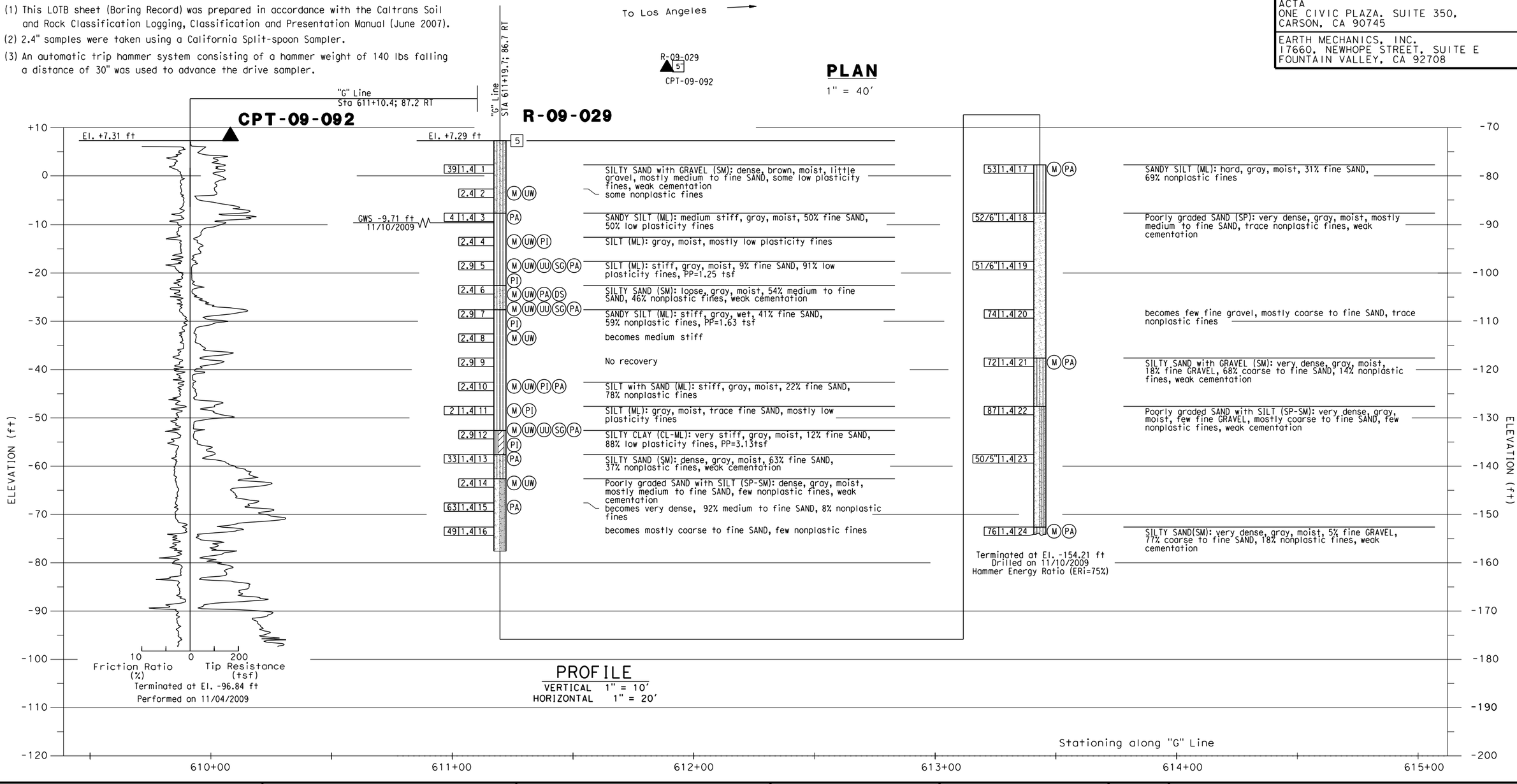
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.





PLAN

1" = 40'

PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53-3035S	SB SR-103 ON-RAMP
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.01	LOG OF TEST BORINGS NO. 1 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

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DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/04/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

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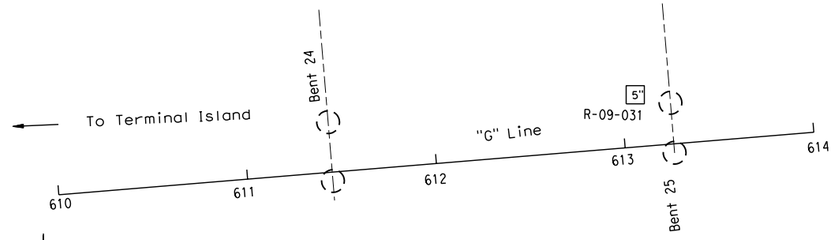

PLAN

1" = 40′

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

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PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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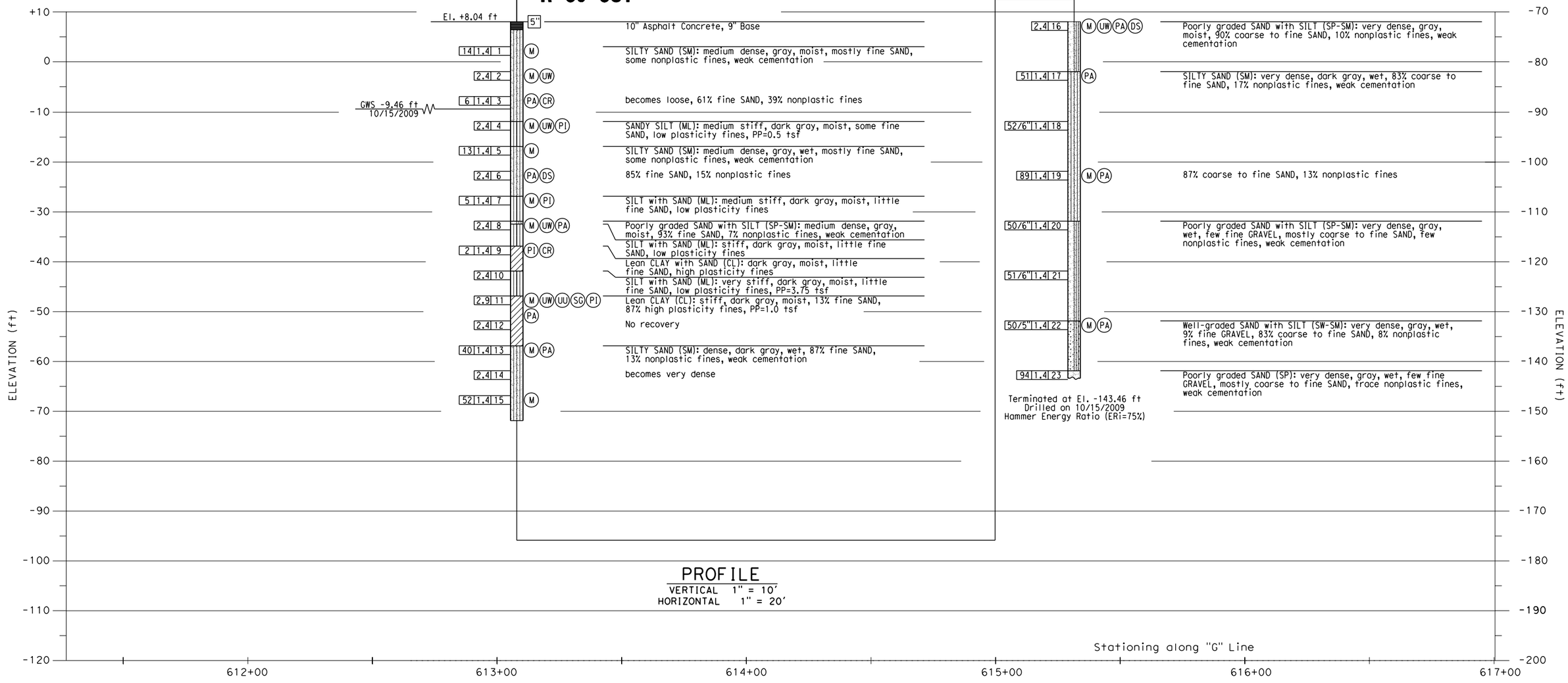
R-09-031



PROFILE

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			SB SR-103 ON-RAMP
					LOG OF TEST BORINGS NO. 2 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

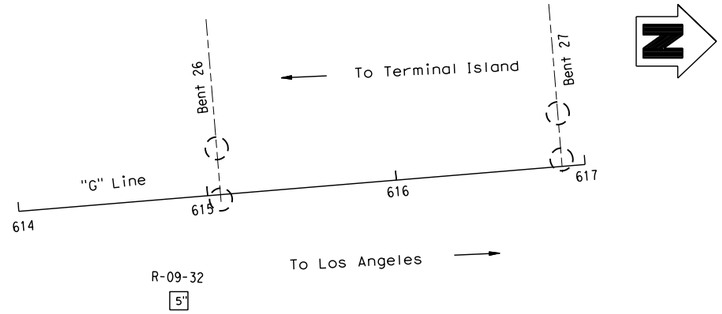
PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

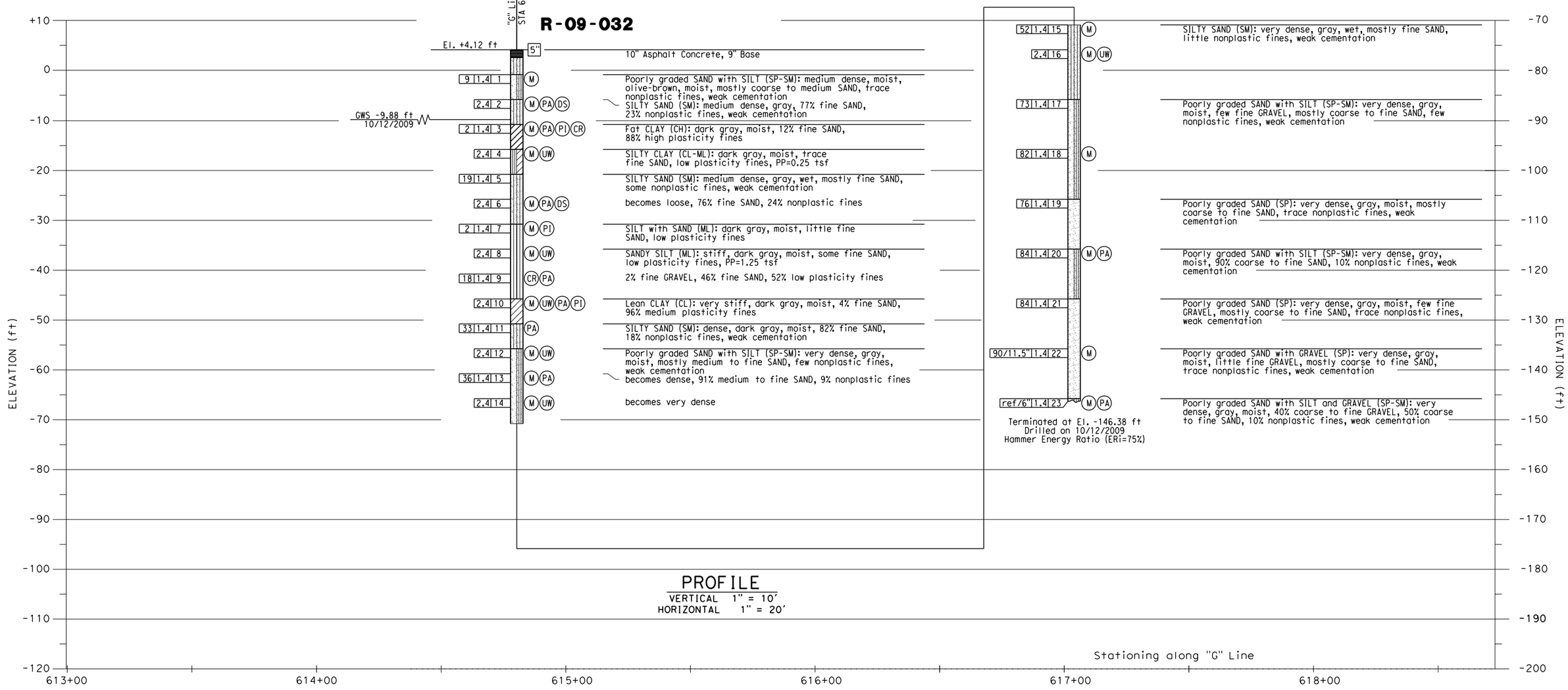
(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53-3035S; POST MILE 0.01
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			SB SR-103 ON-RAMP
					LOG OF TEST BORINGS NO. 3 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

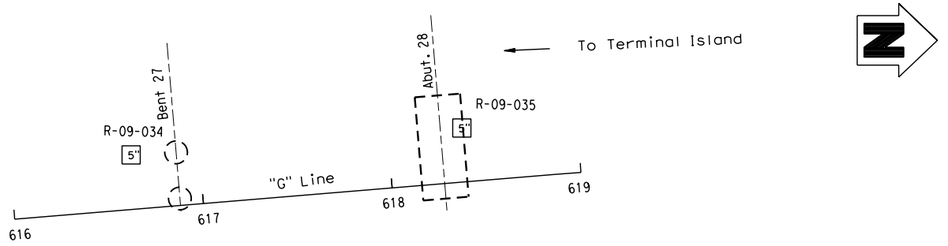
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

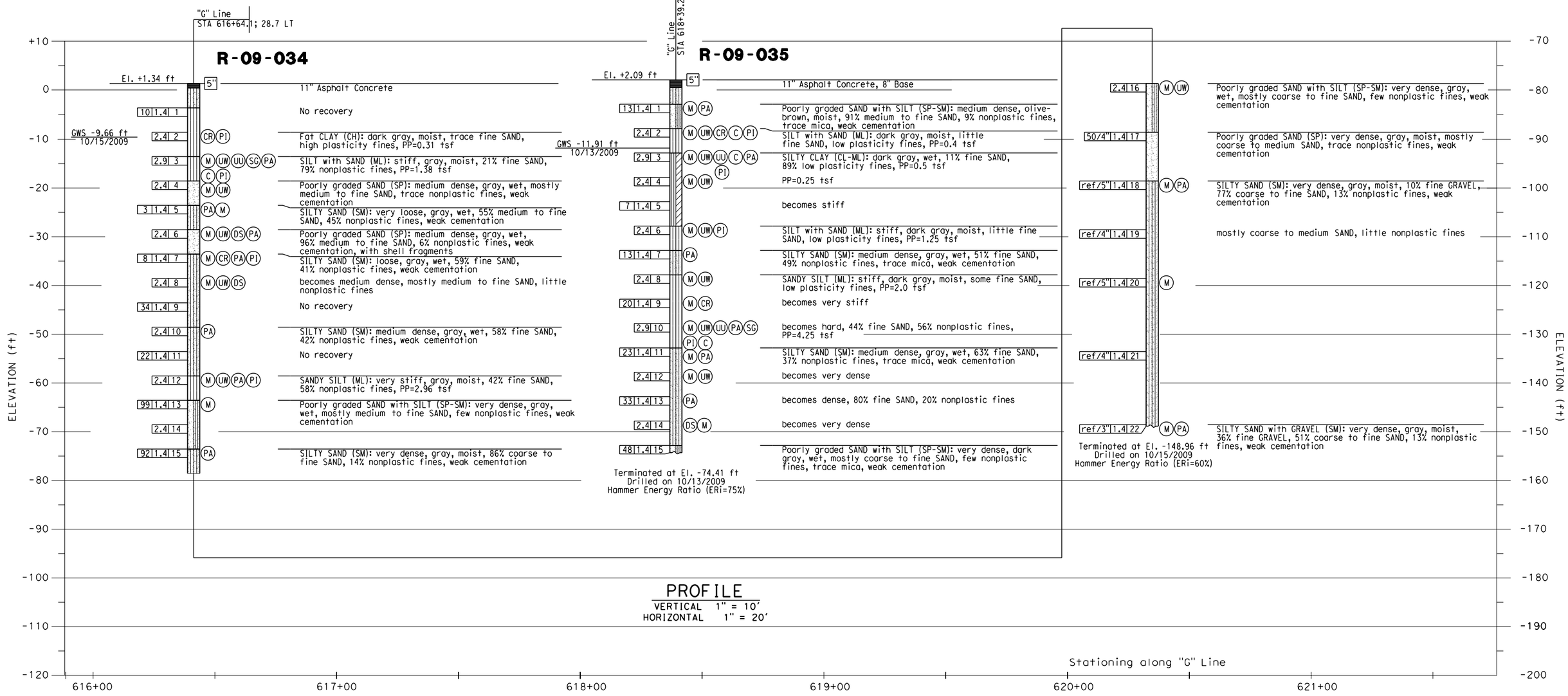
(3) For R-09-034, a rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) For R-09-035, an automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER ERIC BROWN NO. GE-2806 EXP. 06-30-2010 GEOTECHNICAL STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53-3035S
POST MILE 0.01

SB SR-103 ON-RAMP

LOG OF TEST BORINGS NO. 4 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER · ERIC BROWN · NO. GE-2806 EXP. 06-30-2010 · GEOTECHNICAL · STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R	Rotary drilled boring
	P	Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

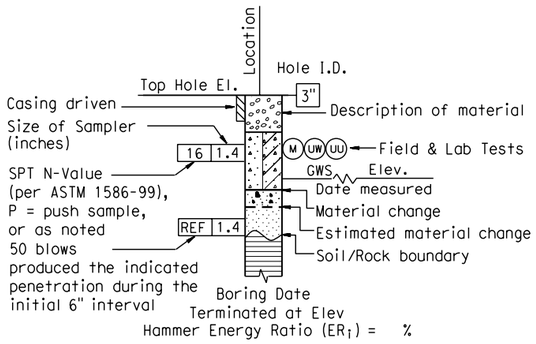
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

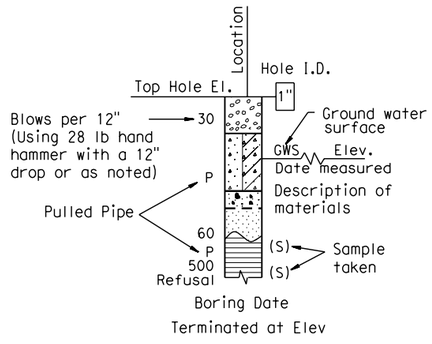
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

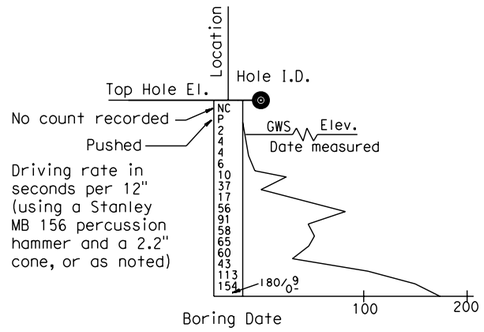
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



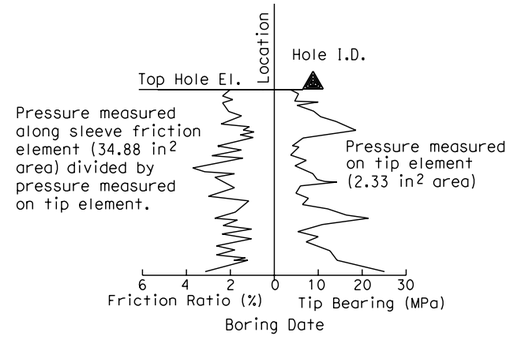
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown	BRIDGE NO. 53-3035S	SB SR-103 ON-RAMP
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown		PROJECT ENGINEER	POST MILE 0.01	LOG OF TEST BORINGS NO. 5 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
02/08/10	03/24/10								X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53-3035S
POST MILE 0.01

SB SR-103 ON-RAMP

LOG OF TEST BORINGS NO. 6 OF 6

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

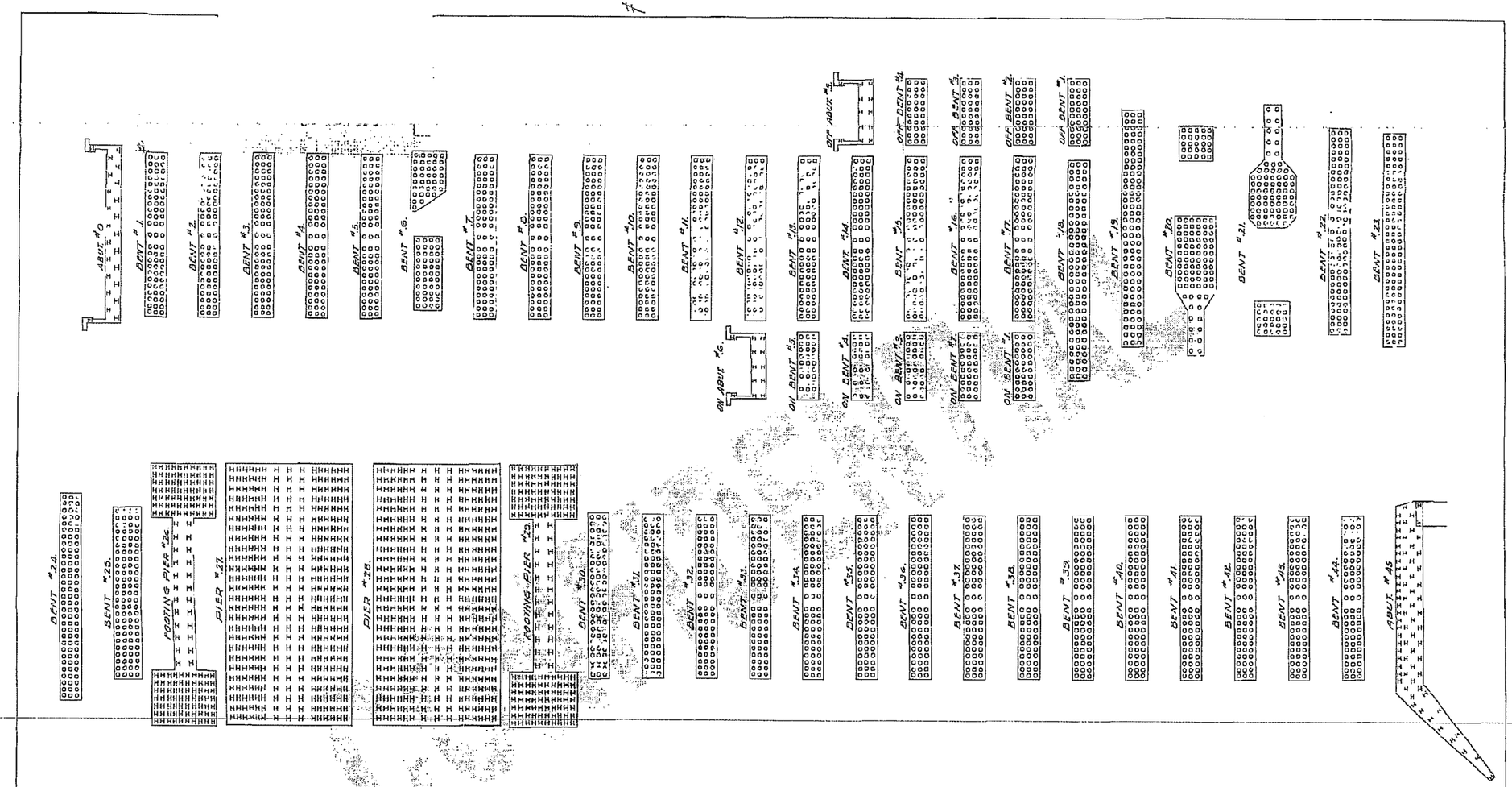
REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

Appendix A. Selected As-Built Plan Sheets for Schuyler Heim Bridge



MICROFILMED
MAR 3 0 1973

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 2372

RECORD DRAWING
SHEET 162 OF 162
SEE LETTER NOV 13195 DATED 1/10/29

CONSTRUCTION PILING CHART

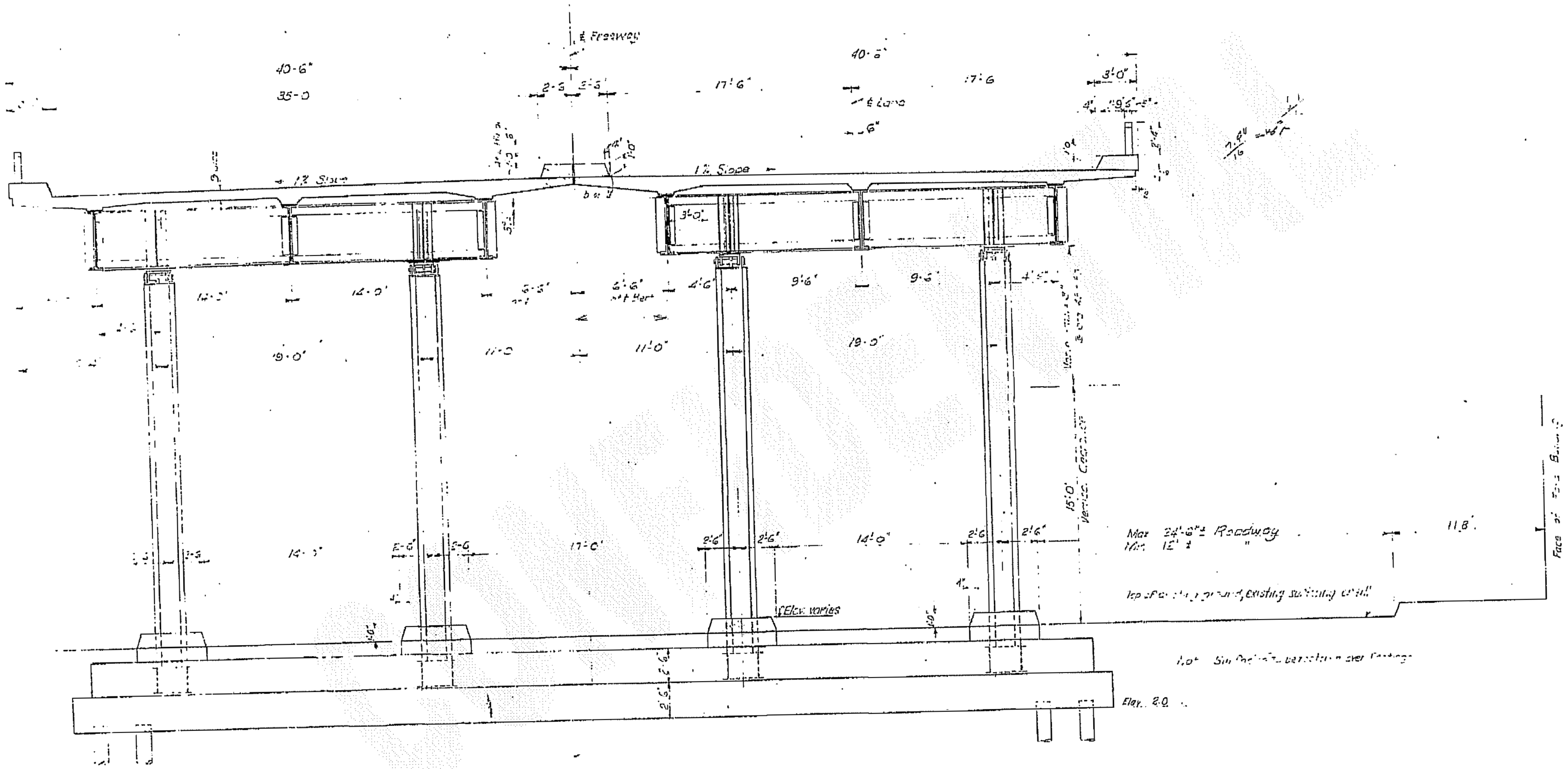
TERMINAL ISLAND FREEWAY

CONTRACT NO. 13195

NDGG/RIH-1 (151)

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THE DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

ClibPDF - www.fnobo.com



TYPICAL BENT

Sta 25 to 28

BRIDGE DEPARTMENT

416,894	NAVAL OPERATING BASE
NB66/N14-1 (133)	APPROVED 1943
133 / 146	

BRIDGE ACROSS CERRITOS CHANNEL

TYPICAL BENT

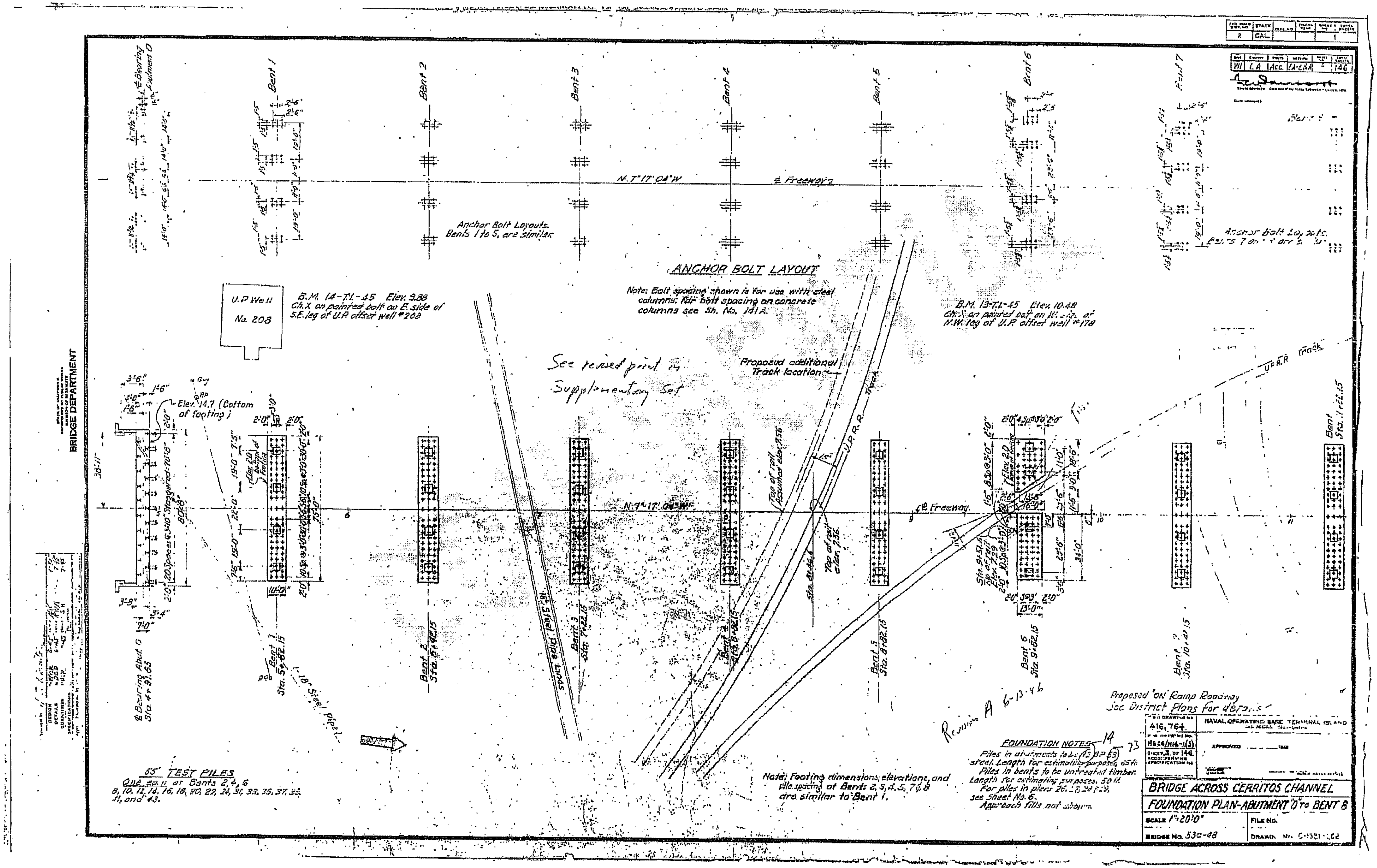
SCALE 1/8" = 1'-0"

FILE No.

BRIDGE No. 53C-48

DRAWING No. C-1341-332

ClibPDF - www.fastio.com


BRIDGE DEPARTMENT
Bent 1
Bent 2
Bent 3
Bent 4
Bent 5
Bent 6
Anchor Bolt Layouts. Bents 1 to 5, are similar.
N.7°17'04"W
℄ Freeway
ANCHOR BOLT LAYOUT
Note: Bolt spacing shown is for use with steel columns: for bolt spacing on concrete columns see Sh. No. 141A.
U.P. Well No. 208
B.M. 14-T.I.-45 Elev. 9.88
Ch.X on painted bolt on E. side of S.E. leg of U.P. offset well #208
B.M. 13-T.I.-45 Elev. 10.48
Ch.X on painted bolt on W. side of N.W. leg of U.P. offset well #178
See revised print in Supplementary Set
Proposed additional Track location
U.P.R.R. Track
Elev. 14.7 (Bottom of footing)
℄ Freeway
℄ Bearing Abut. 0 Sta. 4+91.65
Bent 1 Sta. 5+62.15
Bent 2 Sta. 6+42.15
Bent 3 Sta. 7+22.15
Bent 5 Sta. 8+82.15
Bent 6 Sta. 9+62.15
Bent Sta. 11+22.15
18" Steel pipe
16" Steel pipe Lines
Revision A 6-13-46
55' TEST PILES
One each at Bents 2, 4, 6
8, 10, 12, 14, 16, 18, 20, 22, 24, 31, 33, 35, 37, 39, 41, and 43.
Note: Footing dimensions, elevations, and pile spacing at Bents 2, 3, 4, 5, 7 & 8 are similar to Bent 1.
Proposed 'ON' Ramp Roadway
See District Plans for details
FOUNDATION NOTES
Piles in abutments to be 12 BP 53 steel. Length for estimating purposes 45 ft.
Piles in bents to be untreated timber. Length for estimating purposes 50 ft.
For piles in piers 26, 27, 28 & 29, see Sheet No. 6.
Approach fills not shown.
416,764
NAVAL OPERATING BASE TERMINAL ISLAND
APPROVED
SHEET 3 OF 146
BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLAN-ABUTMENT "0" TO BENT 8
SCALE 1"=20'0"
FILE No.
BRIDGE No. 53C-48
2 CAL.
VII LA 146

BRIDGE DEPARTMENT

"OFF" ABUTMENT 5

"ON" ABUTMENT 5

BENTS 9-16 INCL.

"OFF" BENTS 1-4 INCL.

"ON" BENTS 1-5 INCL.

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141 A.

Note: Footing dimensions, elevation, and pile spacing for Bents 10, 11, 12, 13, 15, & 16 are similar to Bent 9.
Footing dimensions and pile spacing for "OFF" Abutment 5 are similar to "ON" Abutment 6.
Footing dimensions, elevation, and pile spacing for "ON" Bents 2, 3 & 4 and "OFF" Bents 3 & 4 are similar to "ON" Bent 5 except as noted.

STEEL PILES
Horizontal Batter 3:12 at Bent 1 of "OFF" Ramp
Horizontal Batter 3:12 at "OFF" Ramp
Steel Piles along Freeway

RECORD DRAWING
SHEET ___ OF ___
SEE LETTER NO(V) ___ DATED ___

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed ___
Document No. 7000 7372

MICROFILMED
MAR 3 0 1976

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

Date 3/30/76 Signed [illegible]

CO. ROAD SECT. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	LA	Acc.	LA-Lab # 146		

NAVAL OPERATING BASE, TERMINAL ISLAND
SAN PEDRO, CALIFORNIA
APPROVED 1943

F-G-R MEAS SPAN LENGTH AS OF 7-19-46
G-R-M CHANGE SIZE OF PILE
SERVICE ROAD ADDED
REVISIONS BRIEF

BRIDGE LAID OUT AND DRAWN BY
FOUNDATION PLAN - BENTS 9 TO 16
SCALE 1"=10'-0" FILE No.
BRIDGE No. 53C-48 DRAWING No. 141

FED. ROAD DIST. NO.	STATE		FISCAL YEAR	SHEET NO.	TOTAL SHEETS
9	CAL.				

11-SF-4	14.2/R4.2	2	166		

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
BRIDGE DEPARTMENT

± Bent 17 ± Bent 18 ± Bent 19 ± Bent 20 ± Bent 21 ± Bent 22 ± Bent 23 ± Bent 24

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing of concrete columns see Sh. No. 141-4.

RECORD DRAWING
SHEET 5 OF 162
SEE LETTER NO. V-13105 DATED 4/20/49

Off Ramp Sta. 5+24.25
= Freeway Sta. 82+03.10
= On Ramp Sta. 0+00

Throw track 7" ±
Existing Railroad Tracks
Relocation of railroad tracks
Throw track 6" ±
Elev. 2.0 (Bottom of Footing)
Elev. 2.0 (Bottom of Paving)
Elev. 2.0 (Bottom of Paving)
Elev. 2.0 (Bottom of Paving)

℄ ON RAMP
℄ OF FREEWAY
℄ OFF RAMP

U.P. Offset Well No. 99

B.M. 11-T.L.25
Elev. 11.02
Ch. X on painted bolt on W. side of S.W. leg of U.P. well #99.

S.M. 10-T.L.45
Elev. 10.45
Ch. X on painted bolt on S.W. side of S.W. leg of U.P. offset well #81.

Note: Concrete Columns only to be skewed 50° Rt. ℄ Bent 18 following locations:
Column 1, Bent 19
" 2, " 20
" 3, " 21
" 4, " 22

U.S.N. DRAWING NO.	416,746	NAVAL OPERATING BASE, TERMINAL ISLAND, SAN PEDRO, CALIFORNIA	
PUBLIC WORKS OFFICE NO.	NBSE/N14-1(5)	APPROVED ... 1948	
SHEET 5 OF 146 SHEETS			
ACCEPTANCE OR CONSTRUCTION NO.			

BRIDGE ACROSS CERRITOS CHANNEL	
FOUNDATION PLANS - BENTS 17 TO 25	
SCALE 1" = 20'	FILE NO.
BRIDGE NO. 53C-48	DRAWING NO. C-1321-2041

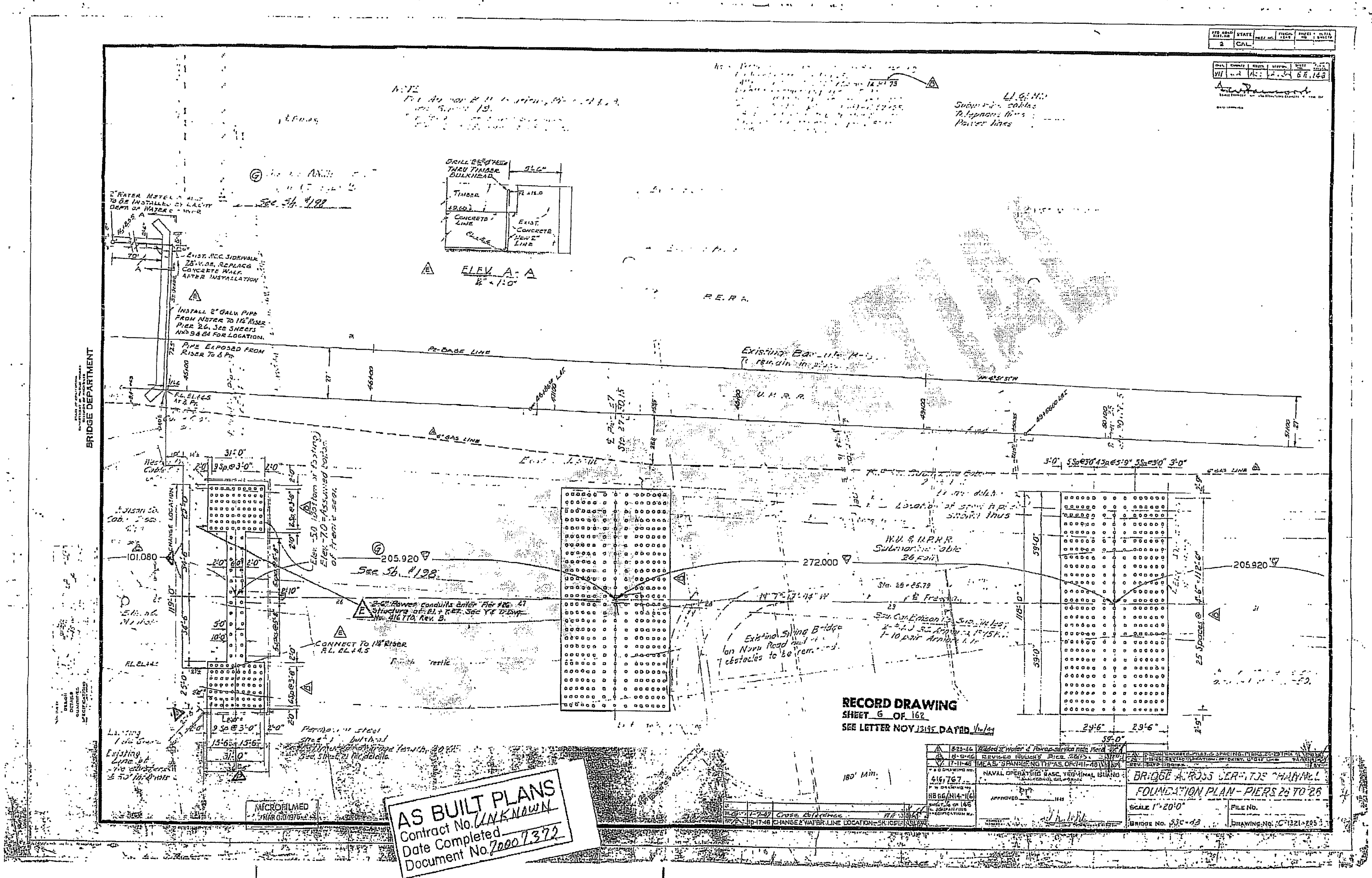
AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

MICROFILMED MAR 3 0 1979

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

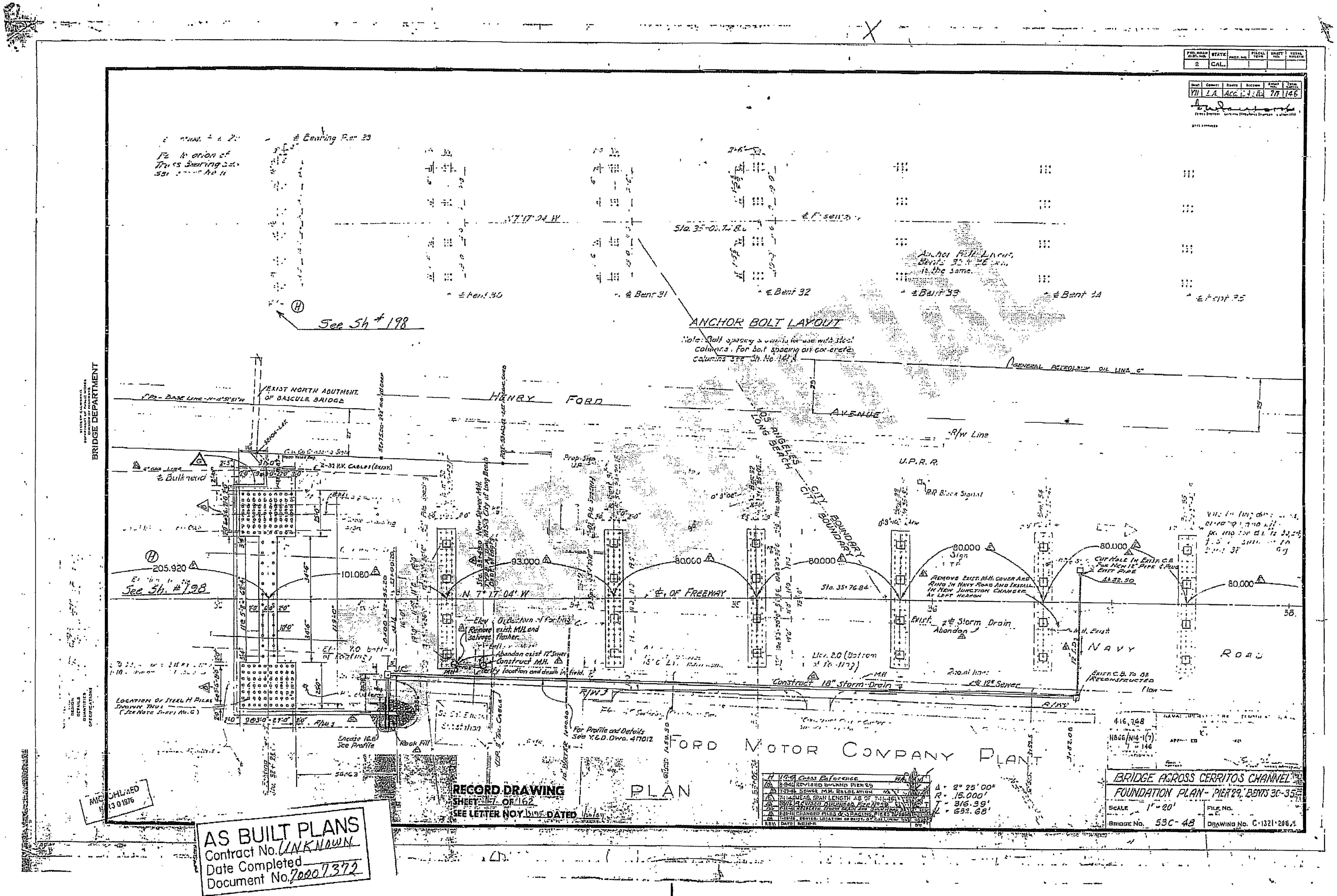
DATE 5/30/06 SIGNED

ClibPDF - www.fastio.com



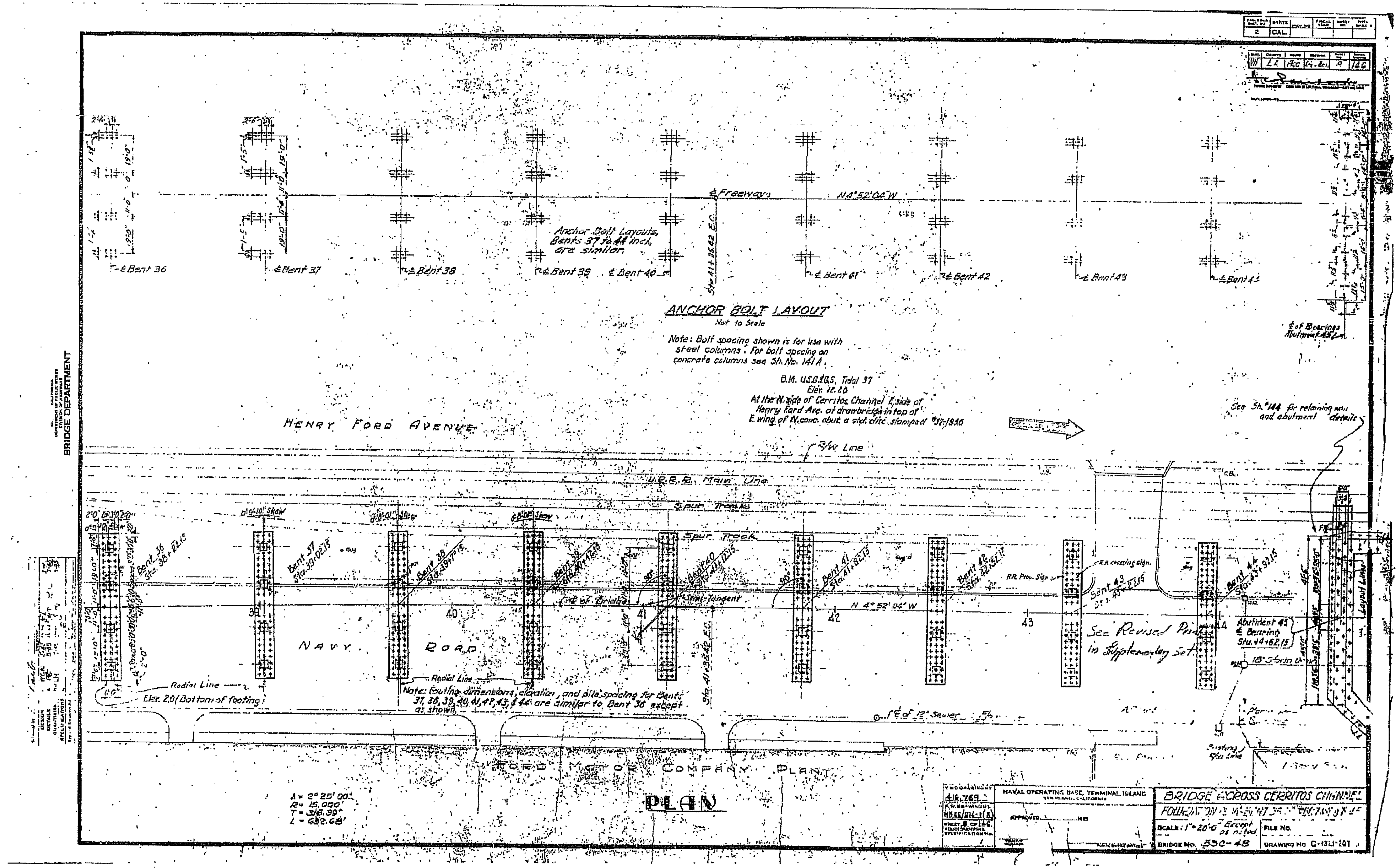
I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

5/30/86



I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

CutePDF - www.fastio.com


BRIDGE DEPARTMENT
ANCHOR BOLT LAYOUT
Not to Scale
Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141 A.
Anchor Bolt Layouts, Bents 37 to 44 incl. are similar.
℄ Freeway
N 4°52'04" W
℄ Bent 36
℄ Bent 37
℄ Bent 38
℄ Bent 39
℄ Bent 40
℄ Bent 41
℄ Bent 42
℄ Bent 43
℄ Bent 44
℄ of Bearings Abutment 45
B.M. U.S.C.&G.S. Tidal 37
Elev. 12.28
At the N. side of Cerritos Channel E. side of Henry Ford Ave. at drawbridge in top of E. wing of N. conc. abut. a std. disc. stamped "37-1936"
See Sh. 144 for retaining wall and abutment details
HENRY FORD AVENUE
R/W Line
U.P.R.R. Main Line
Spur Tracks
Spur Track
NAVY ROAD
℄ of Bridge
Semi-Tangent
N 4°52'04" W
Radial Line
Elev. 2.0 (Bottom of footing)
Note: Footing dimensions, elevation, and pile spacing for Bents 37, 38, 39, 40, 41, 42, 43, & 44 are similar to Bent 36 except as shown.
R.R. crossing sign
R.R. Prop. Sign
Abutment 45
℄ Bearing
Sta. 44+62.15
See Revised Print in Supplementary Set
Layout Line
18" Storm Dr.
℄ of 12" Sewer
FORD MOTOR COMPANY PLANT
PLAN
Δ = 2° 25' 00"
R = 15,000'
T = 316.39'
L = 632.68'
NAVAL OPERATING BASE, TERMINAL ISLAND
BRIDGE ACROSS CERRITOS CHANNEL
SCALE: 1" = 20'-0" Except as noted
BRIDGE No. 53C-48
FILE NO.
DRAWING NO. C-1313-207
APPROVED
CAL.
VII LA 146

Appendix B. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reeder
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Reelability

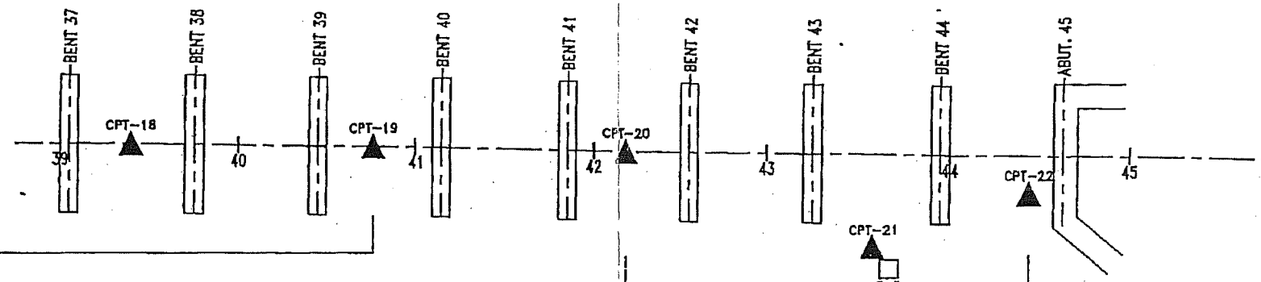
N.S.R= No sample recovery

- OVM5008 Gas Readings

PLAN

SCALE: 1"=40'

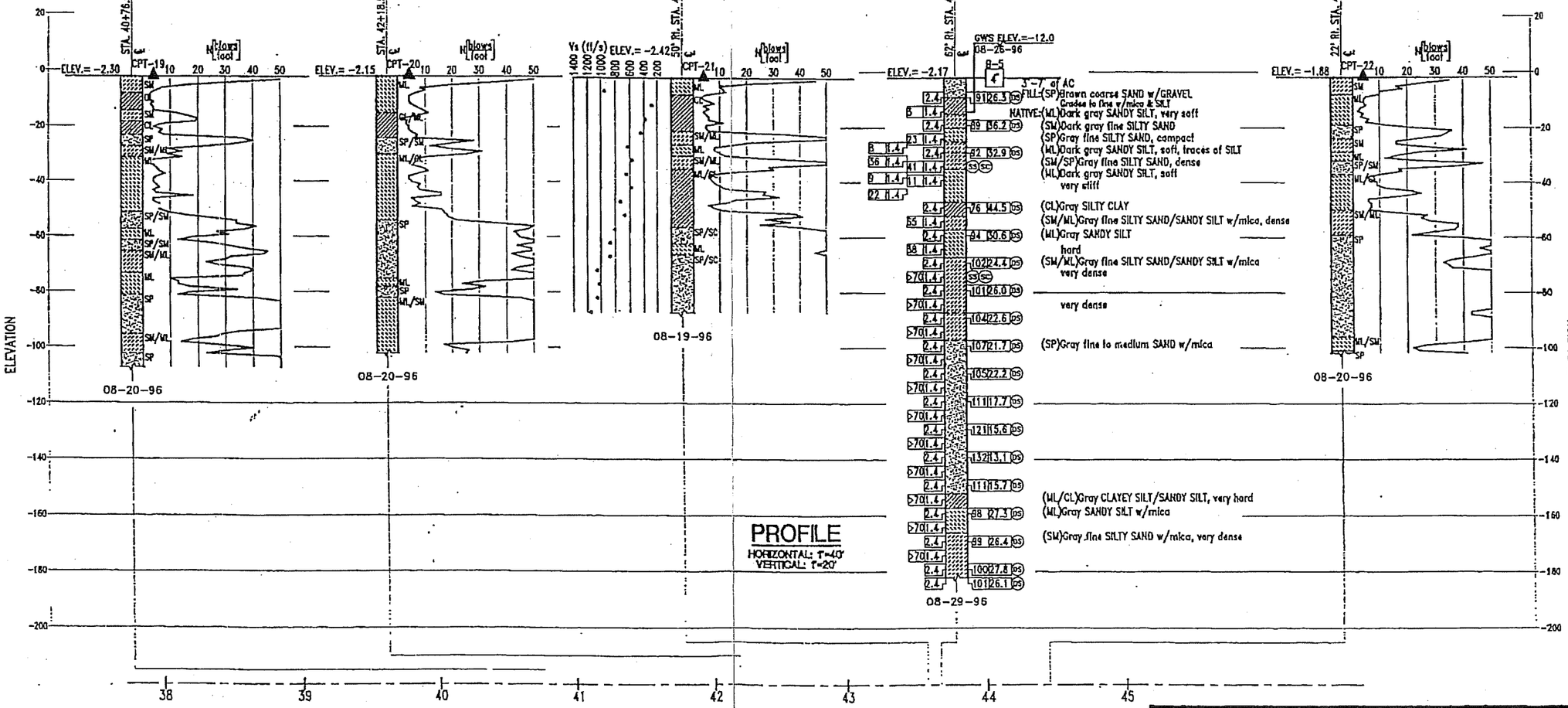
NORTH



Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'



SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO.6

DESIGN OVERNIGHT	DRAWN BY	ML	CS-LN-MC
	CHECKED BY	MR	FIELD INVESTIGATOR
BRK OFF DATE			DATE 08-15-96

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

BRIDGE NO.	53-2618
POST MILE	3.58

CU 07
EA 136201

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 14 OF 148

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
170	Very dense	Very hard

Assumes 1 in. Standard Penetration Tool

2½" CONE PENETROMETER
SAMPLE BORING (DRY)
SAMPLE BORING (WET)
AUGER BORING (DRY)
TEST PIT
DIAMOND CORE BORING
JET BORING
ELECTRONIC CONE PENETROMETER

PENETROMETER TEST
ELECTRONIC CONE
2½" Vf. CONE
PENETRATION BORING
ROTARY SAMPLE BORING (WET)
BORING (DRY)

CA\CADDDWG\JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

Appendix C. EarthSpectives SPT Hammer Energy Measurement Report

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

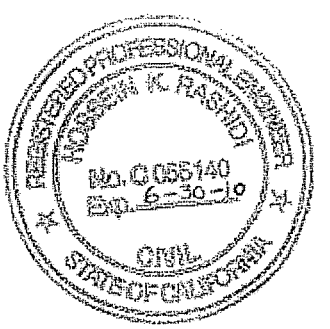
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

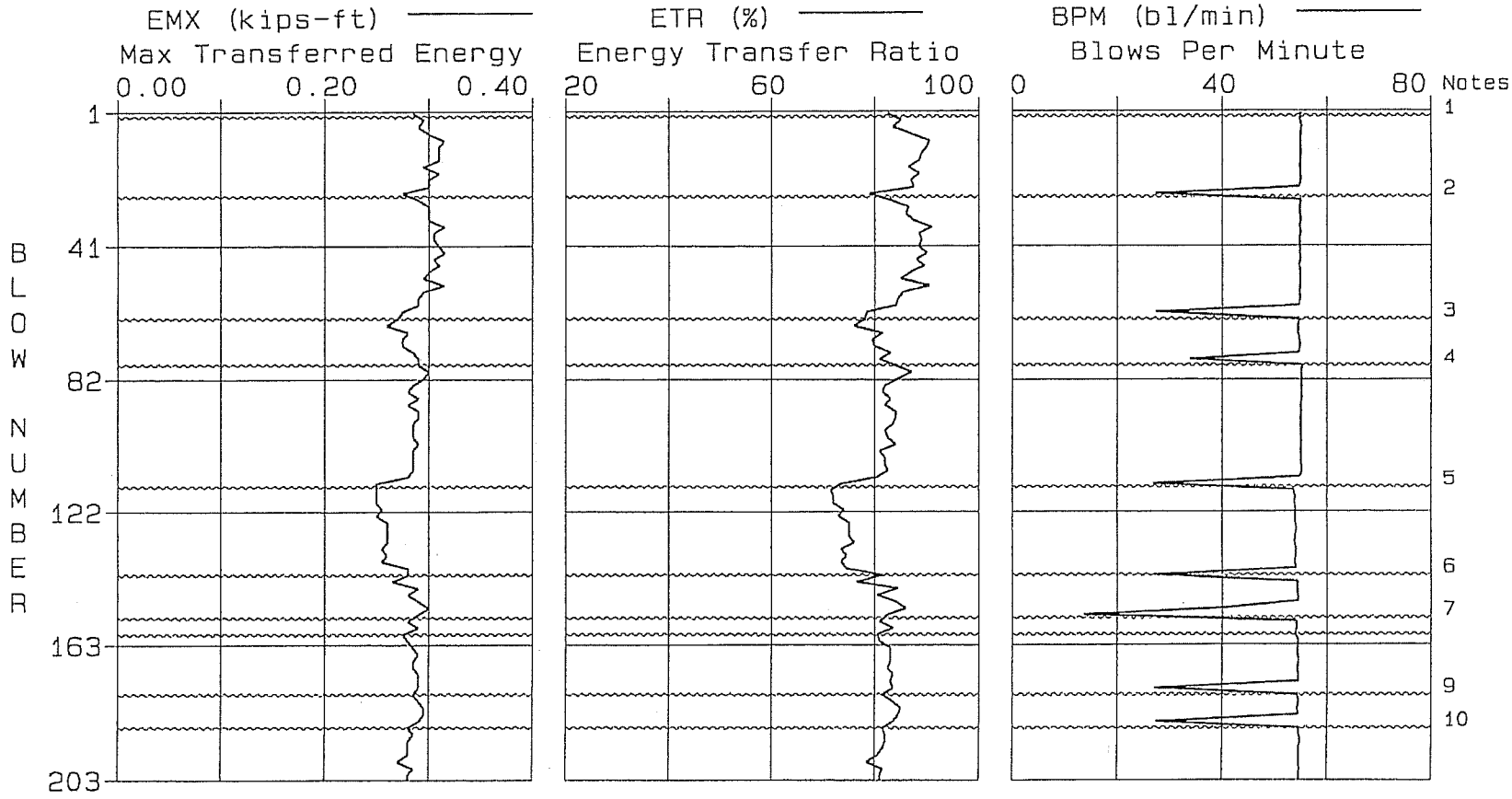
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

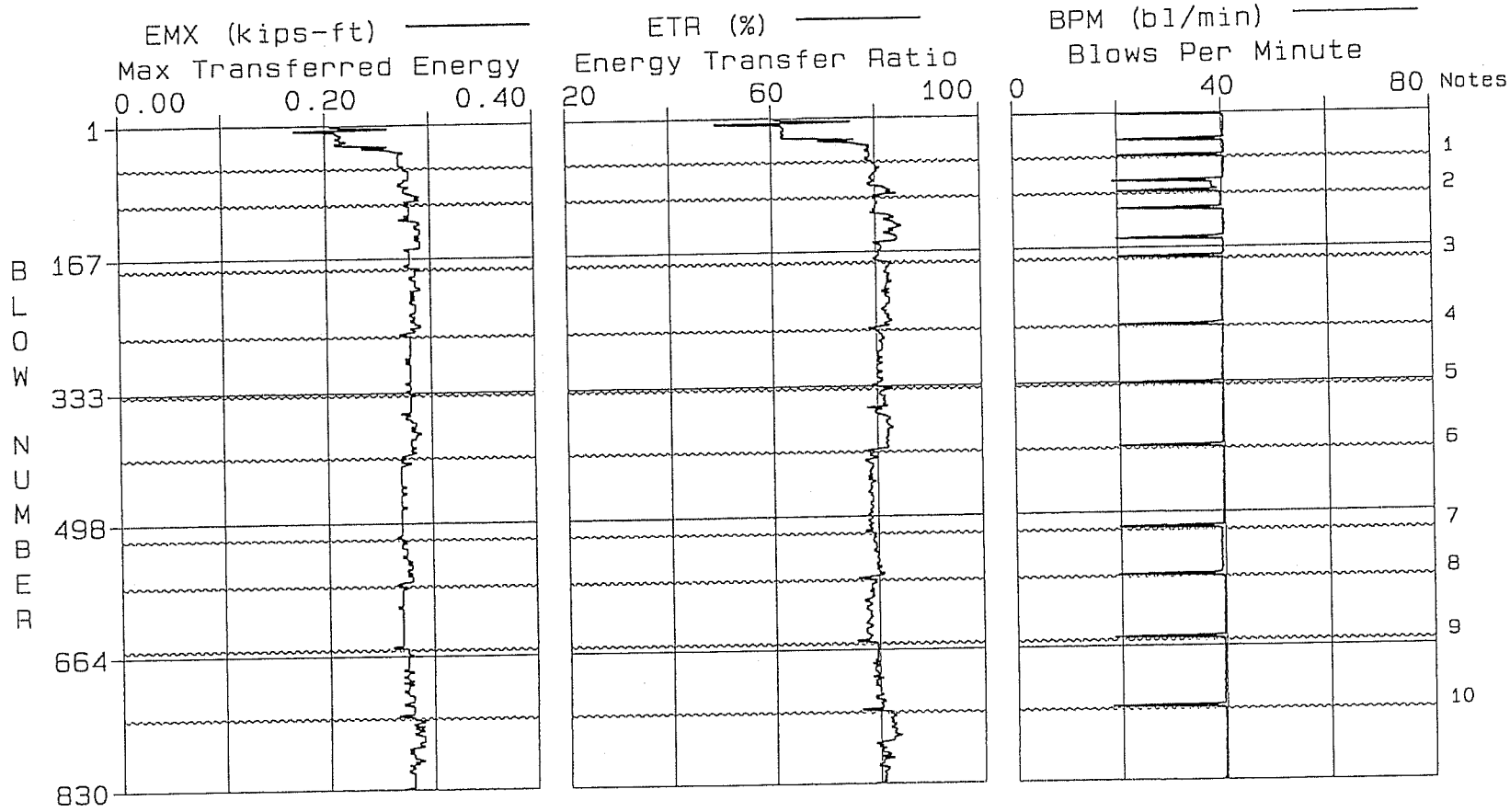
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

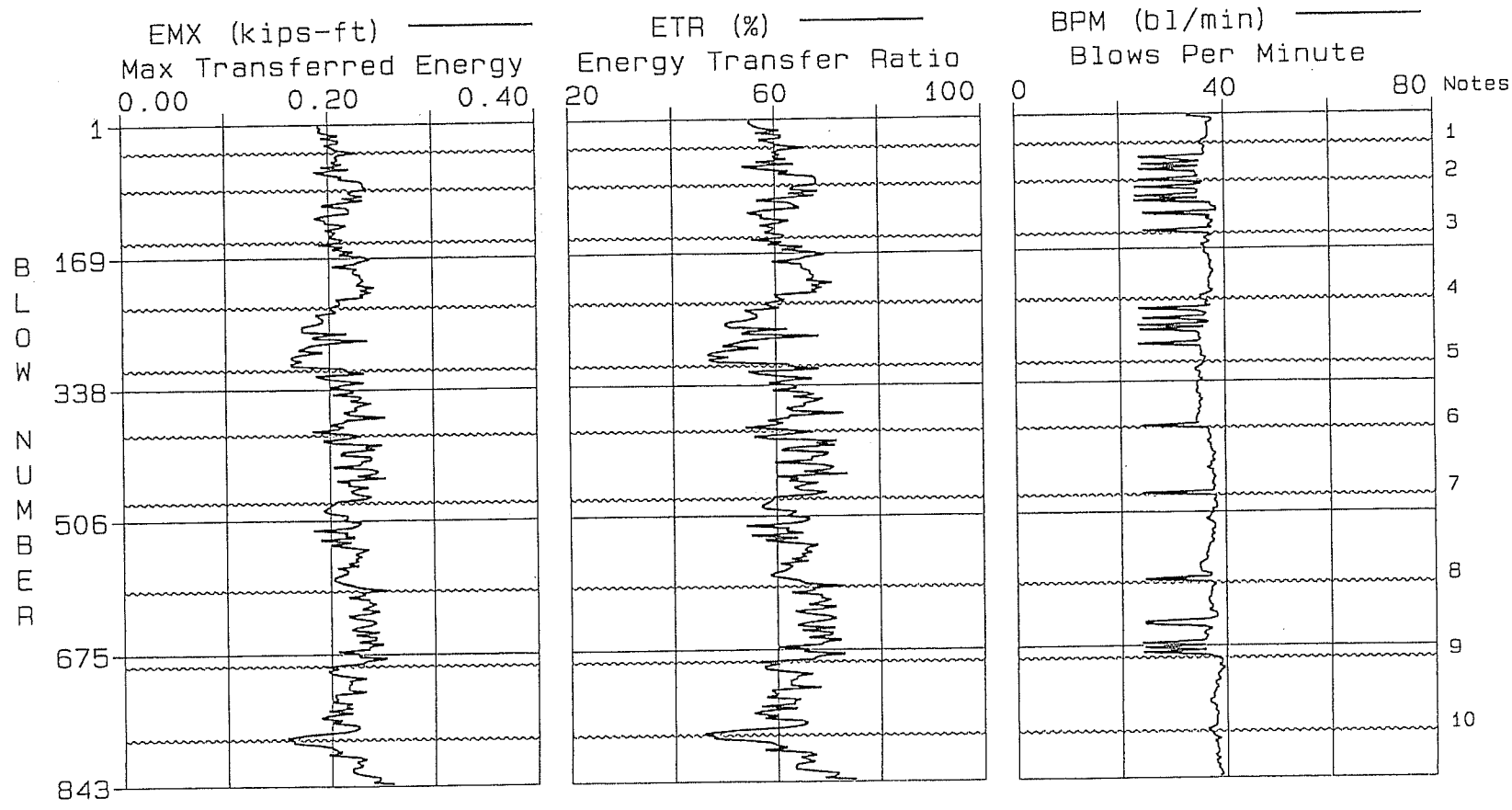
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

Appendix D. GeoVision Geophysical Investigation Report

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

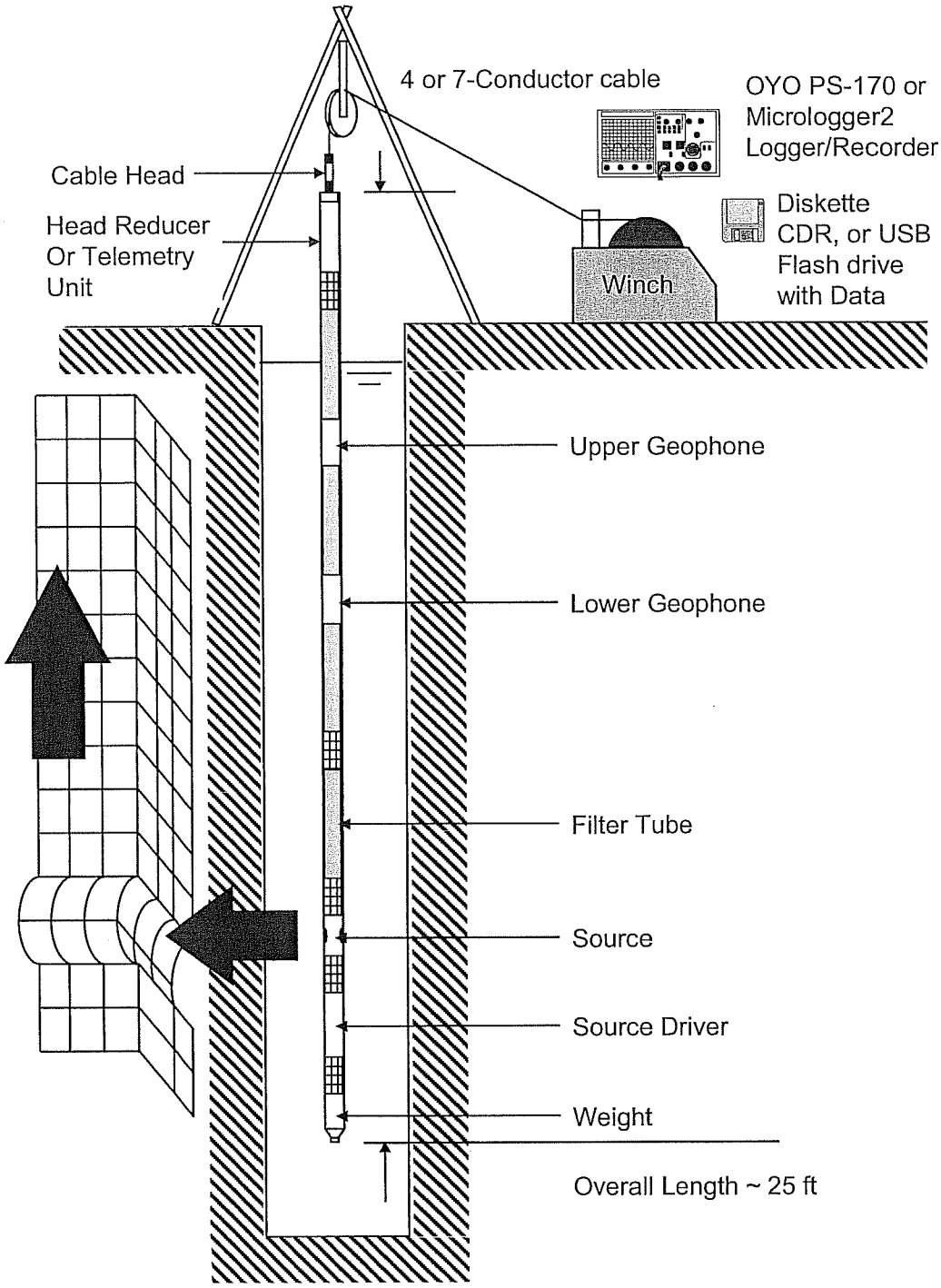

Figure 1: Concept illustration of P-S logging system

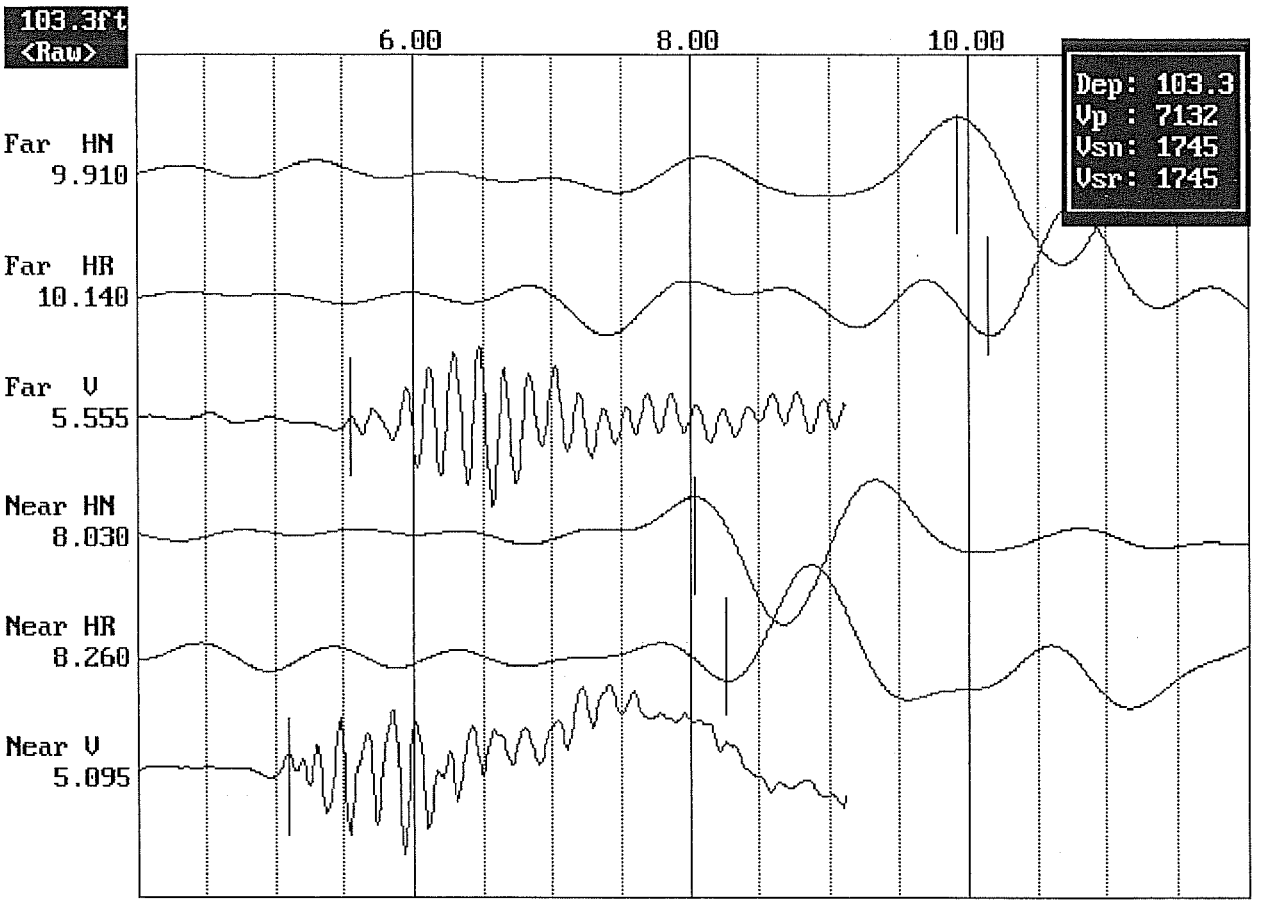

Figure 2: Example of filtered (1400 Hz lowpass) record

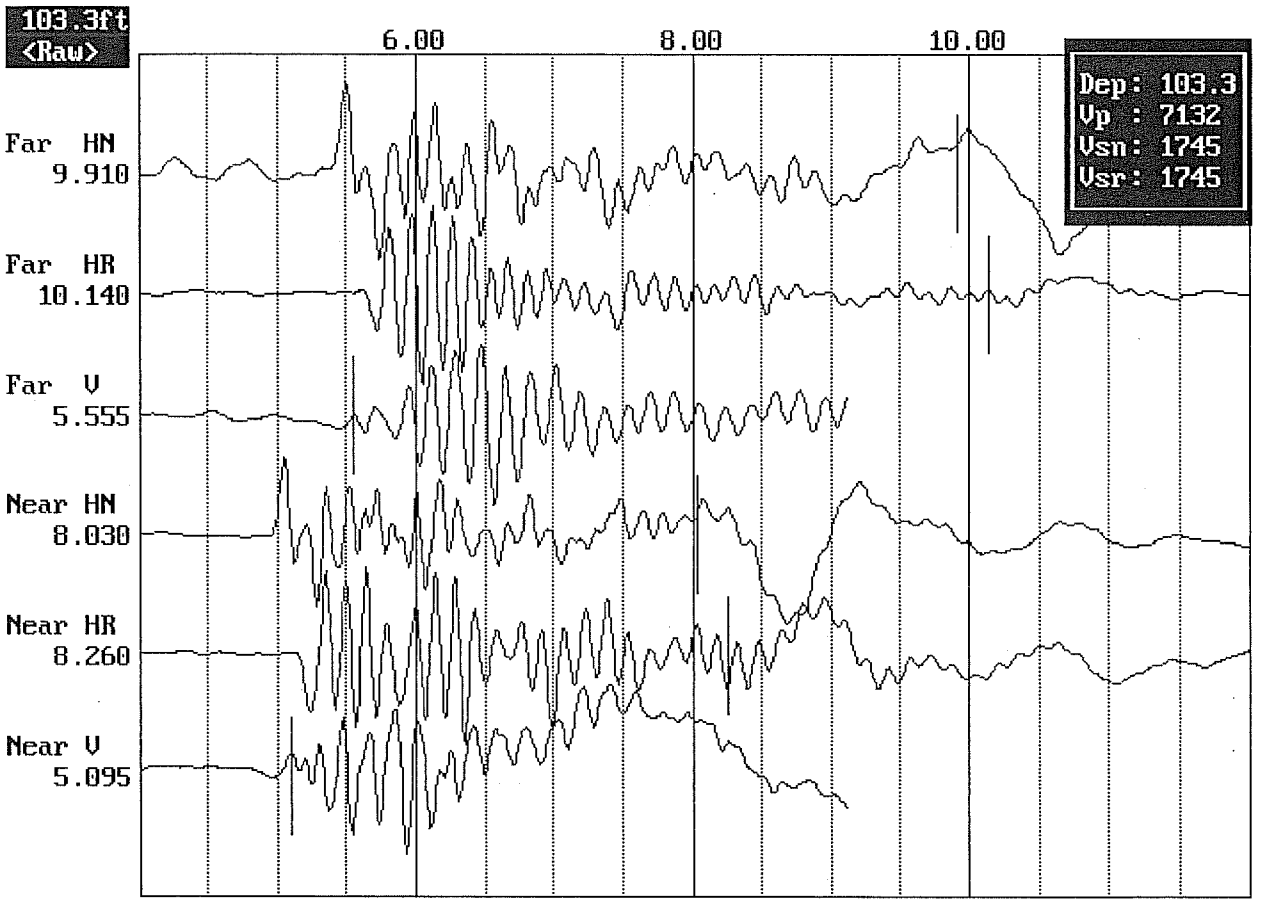

Figure 3. Example of unfiltered record

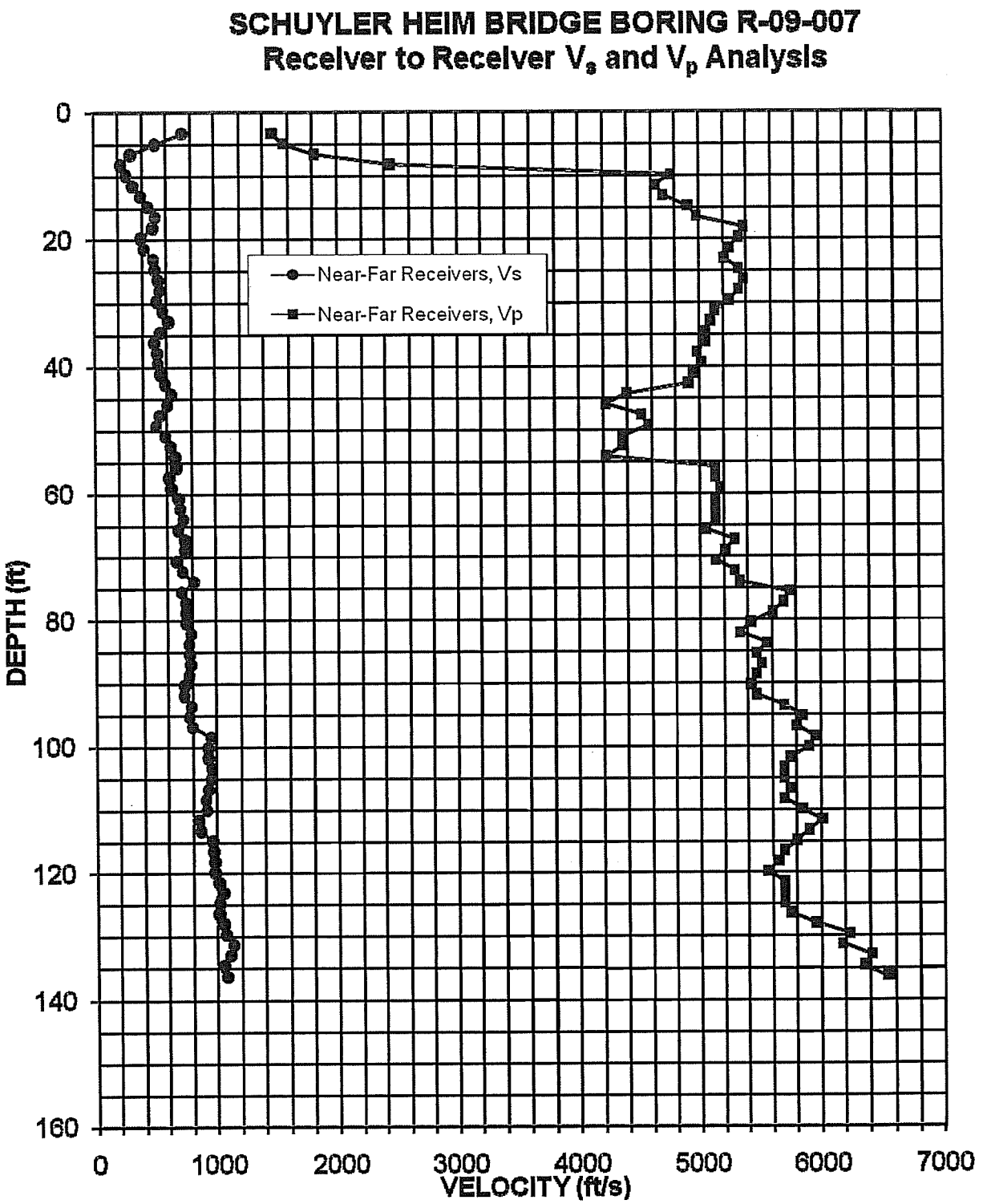

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

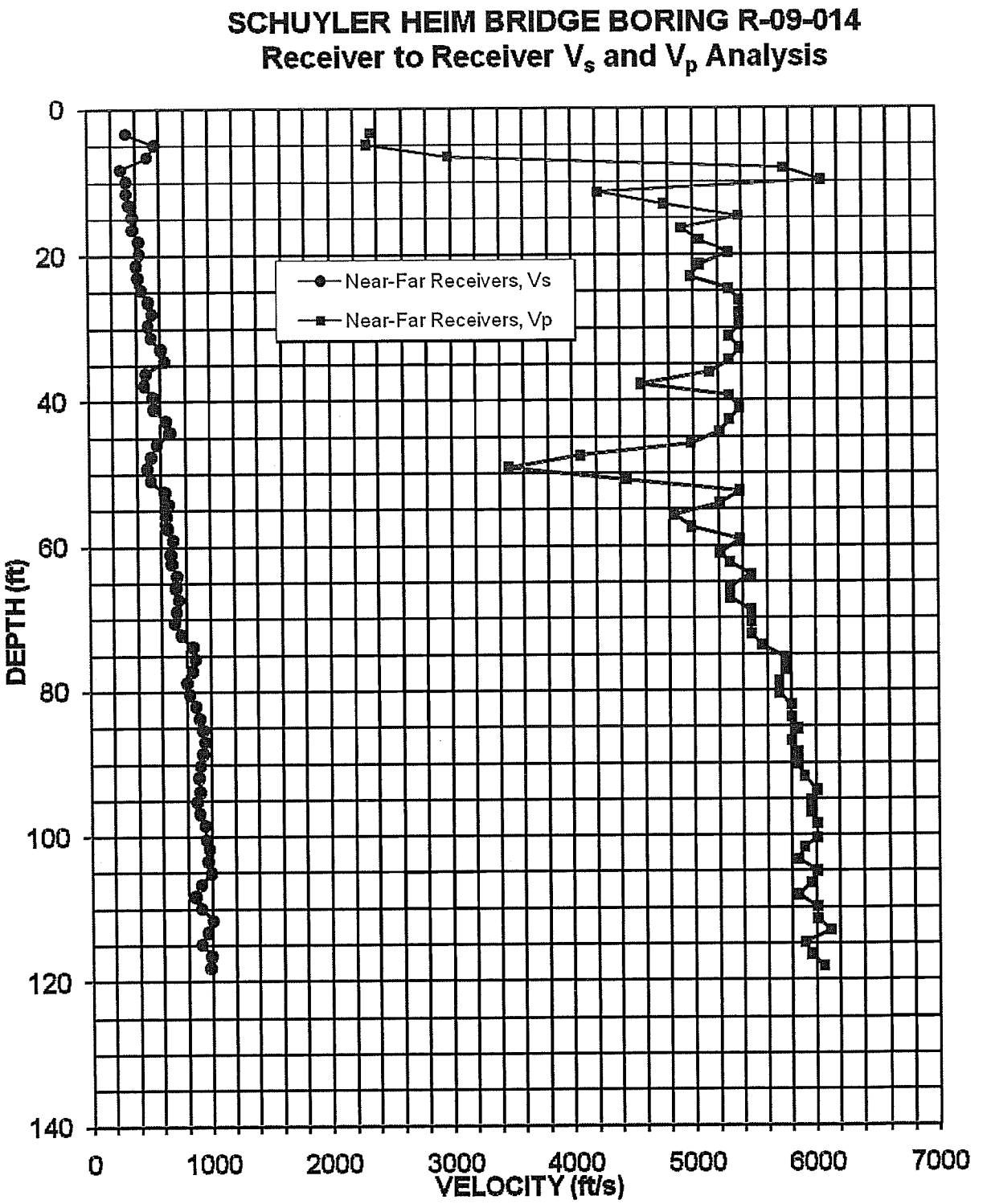

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

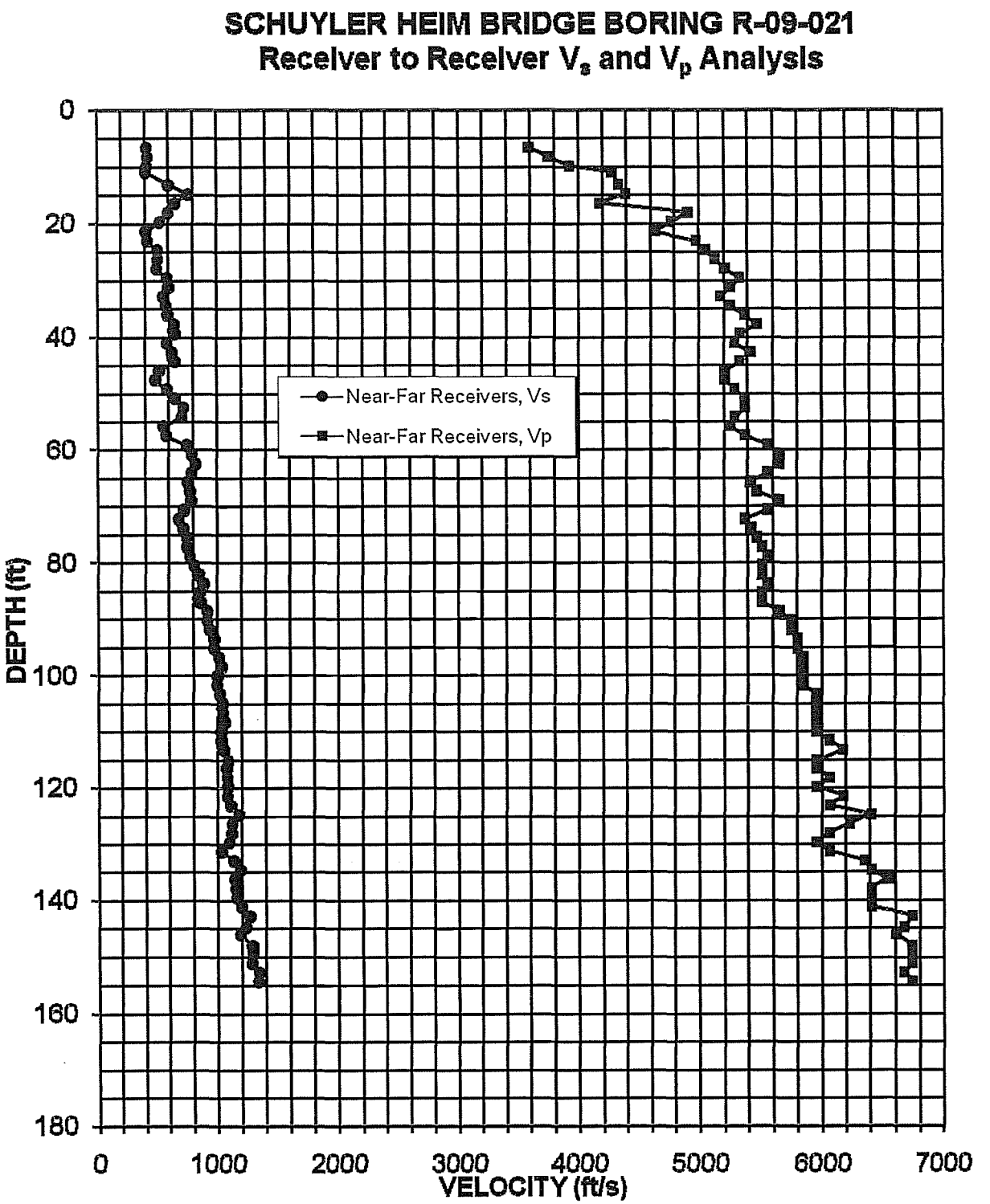

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

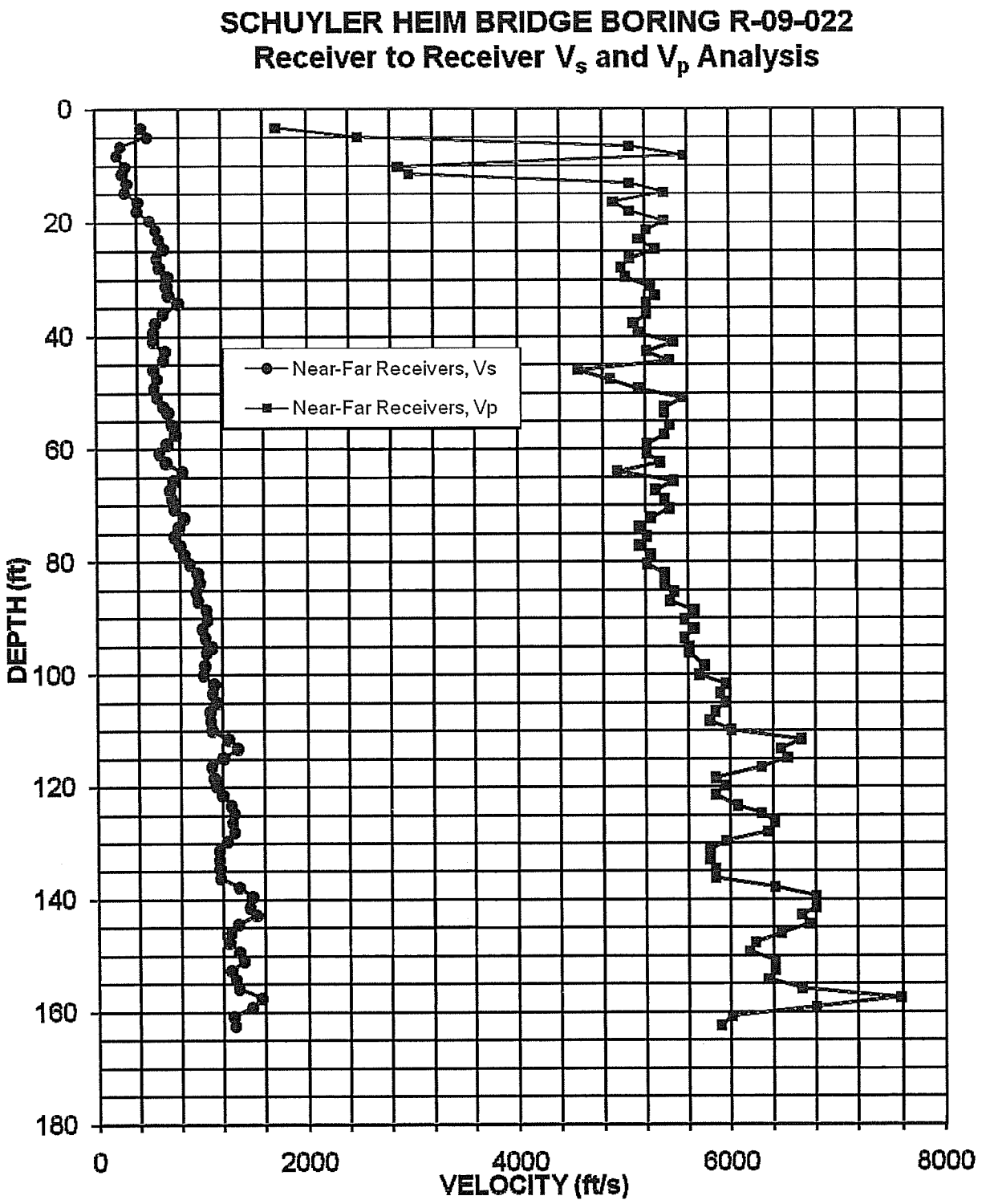

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

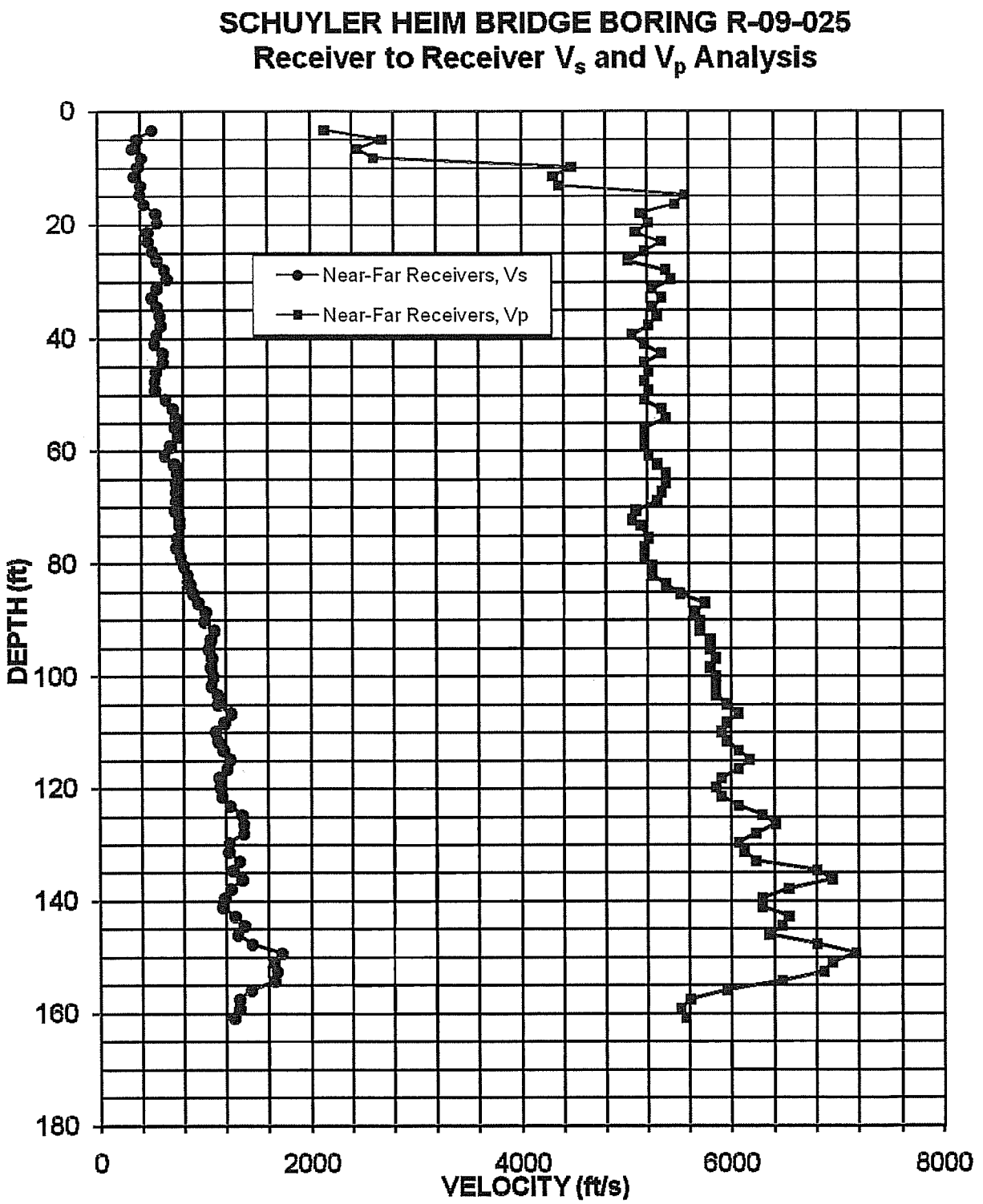

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

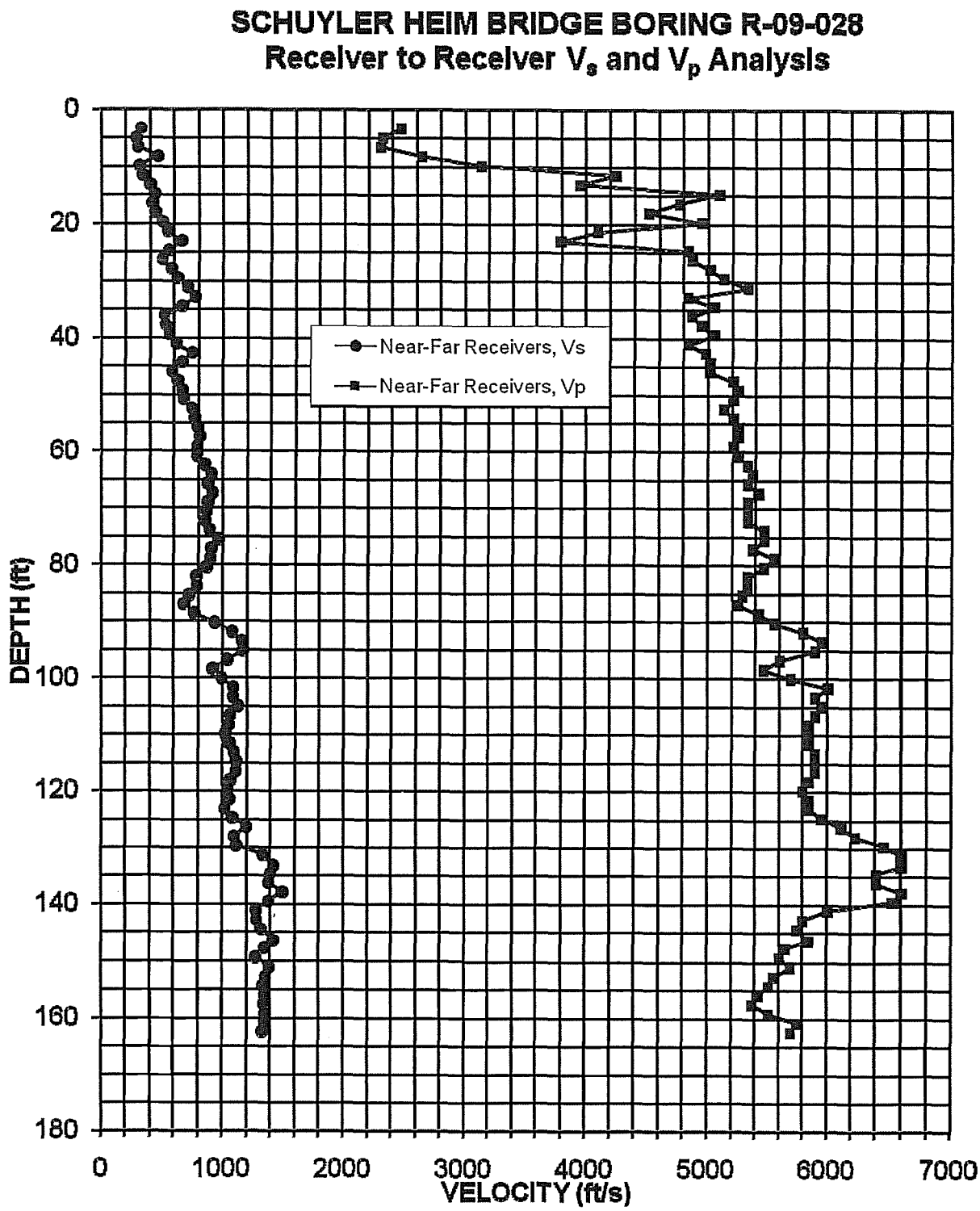

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

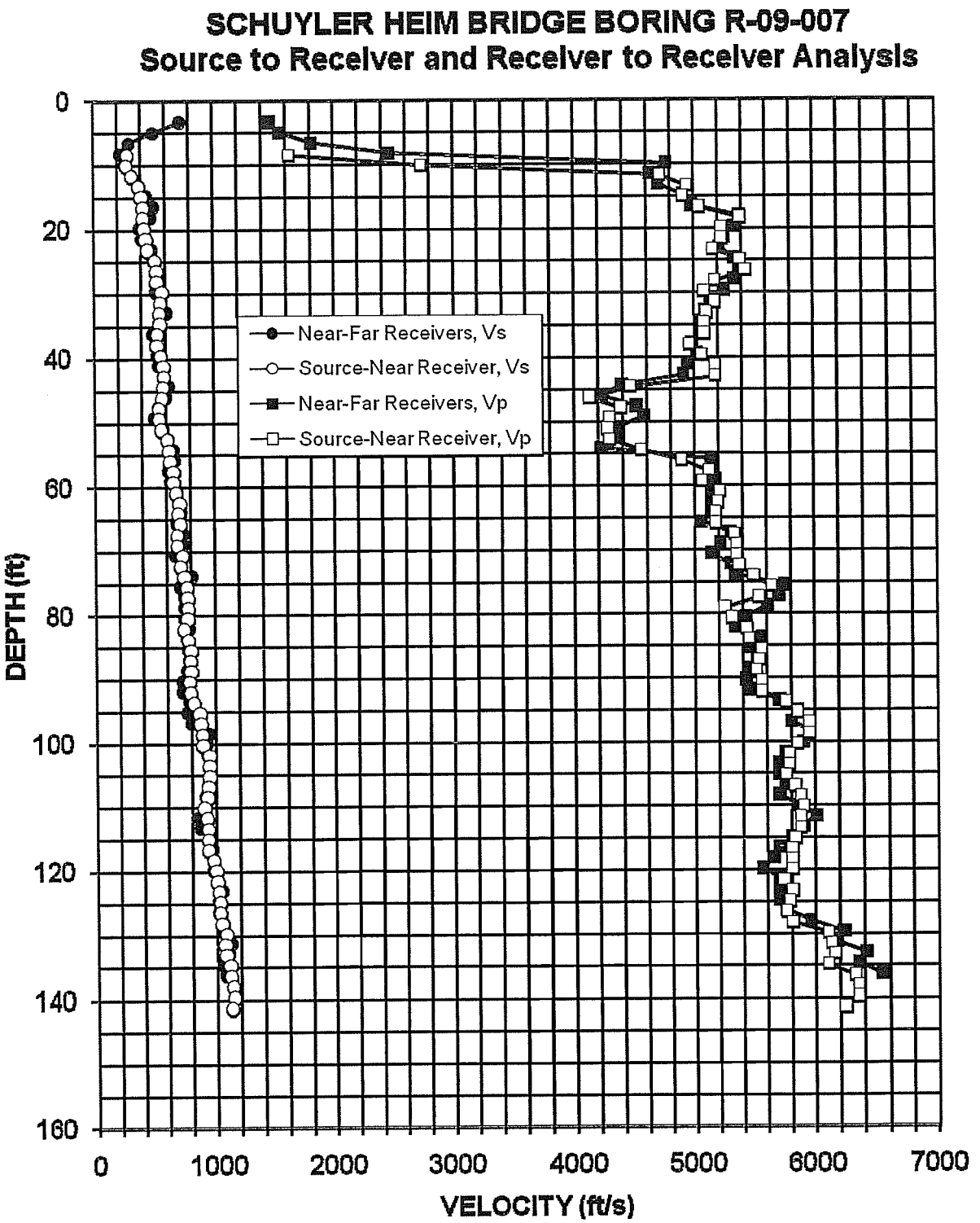

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

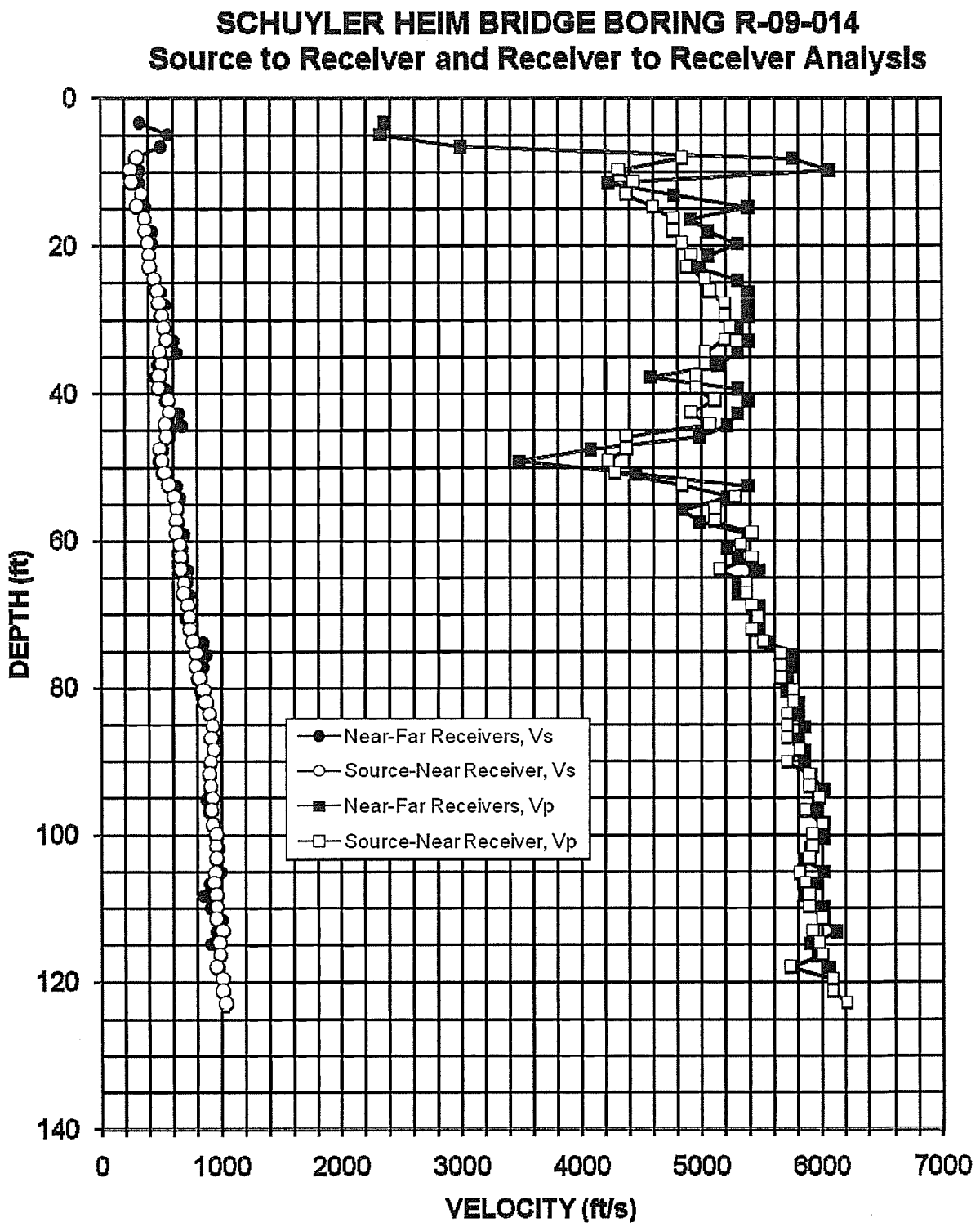

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

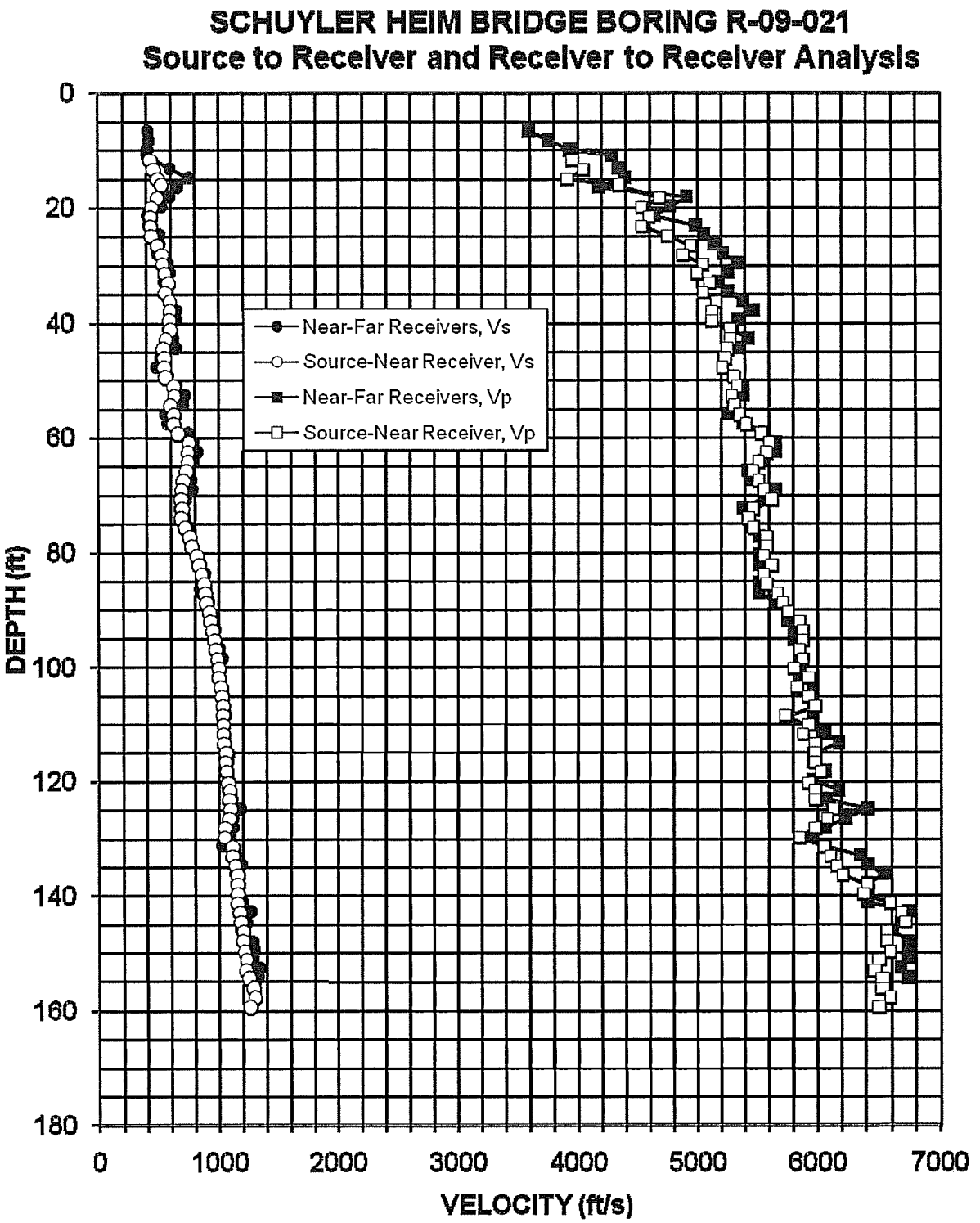

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

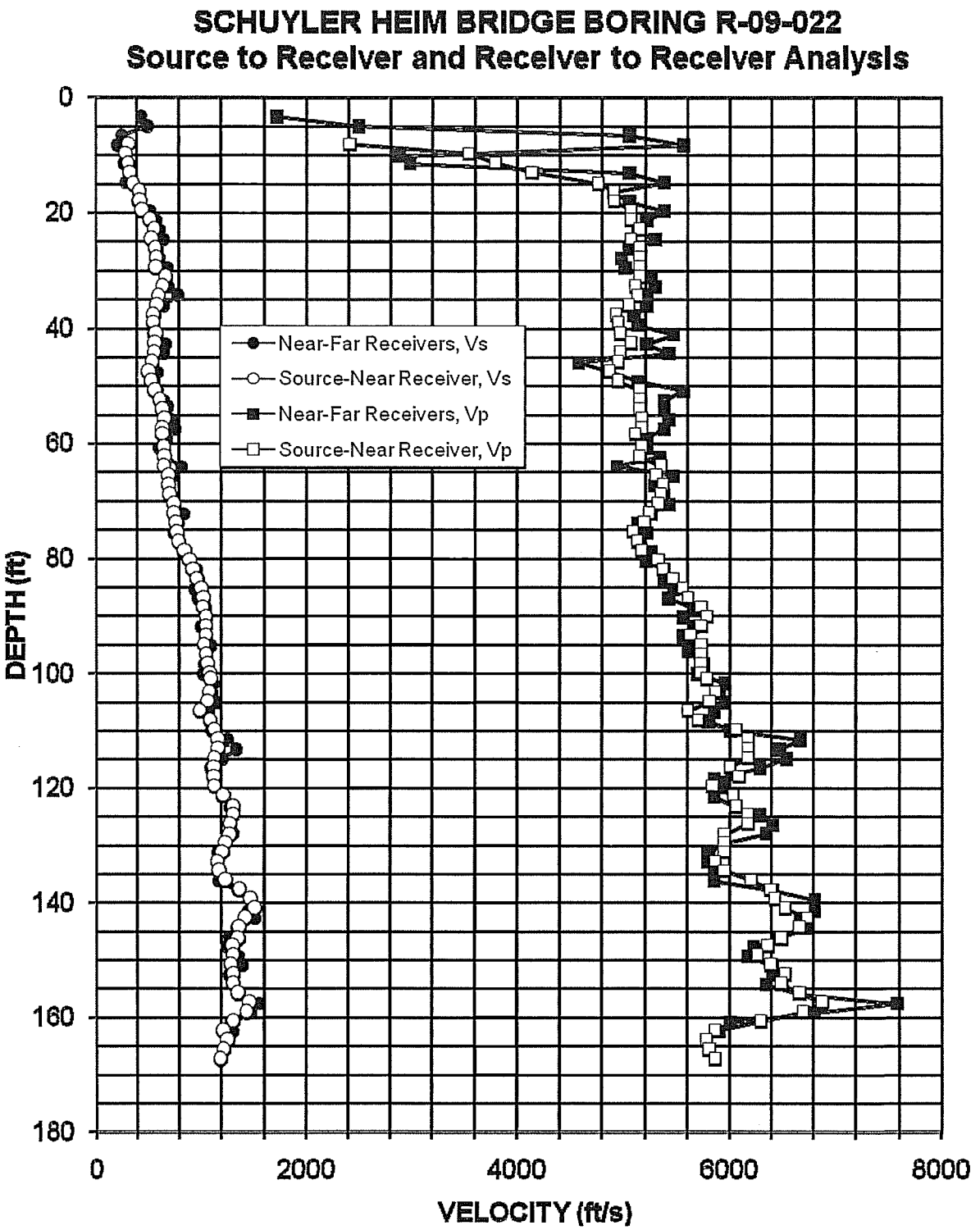

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

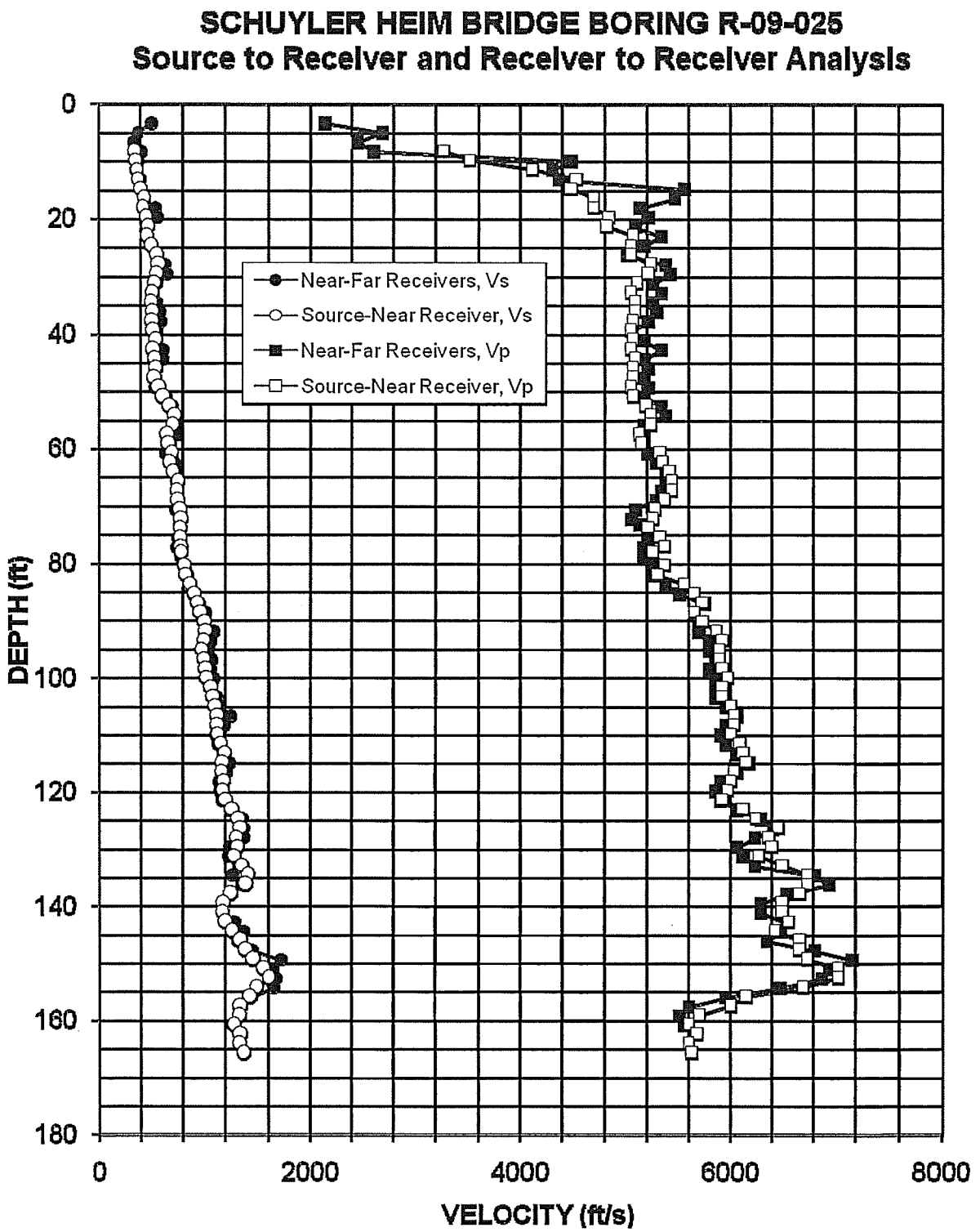

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

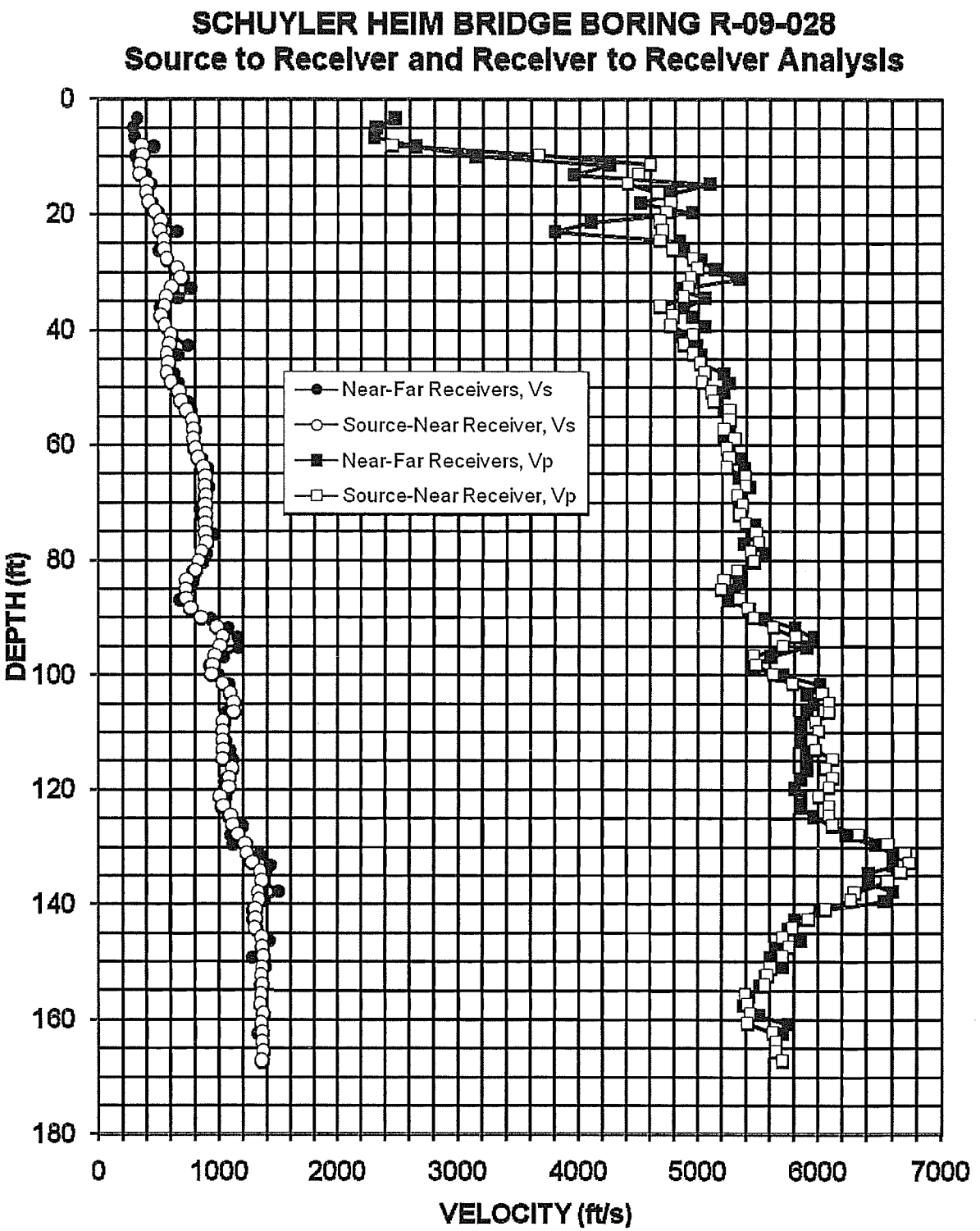

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠ Calibration Report

A SOUTHERN CALIFORNIA EDISON® Company

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
		2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson	
	Name	Date		Signature
Witnessed by:	Robert Steller	7/17/2009		
	Name	Date		Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠ Calibration Report

A SOUTHERN CALIFORNIA EDISON® Company

TEST NUMBER 573795

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

MudCats CPM: Version 2.2.2 (Professional)
Src DUI: {9548AF3D-C74D-4C9F-AEEF-21EF560BC451} (c)
Doc DUI: {1269C0B2-3A13-416A-81BF-409D9887DDDA} (o)

ATTACHMENT 2
Page 1 of 2

Customer

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

Project Number 06-123

160824 ~~160024~~ 573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

Appendix E. Laboratory Soil Test Results

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/16/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-029	D-02	10	41.6	76.8
R-09-029	D-04	20	43.9	76.7
R-09-029	D-08	40	29.3	92.4
R-09-029	D-10	50	32.1	90.3
R-09-029	S-11	55	37.2	NA
R-09-029	D-14	70	19.7	102.8
R-09-029	S-17	85	30.7	NA
R-09-029	S-21	125	16.5	NA
R-09-029	S-24	160	27.8	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/09/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-029	U-05	25	1.25
R-09-029	U-07	35	1.63
R-09-029	U-12	60	3.13

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03
Laboratory No.: 29-1121
Date: 12/17/09

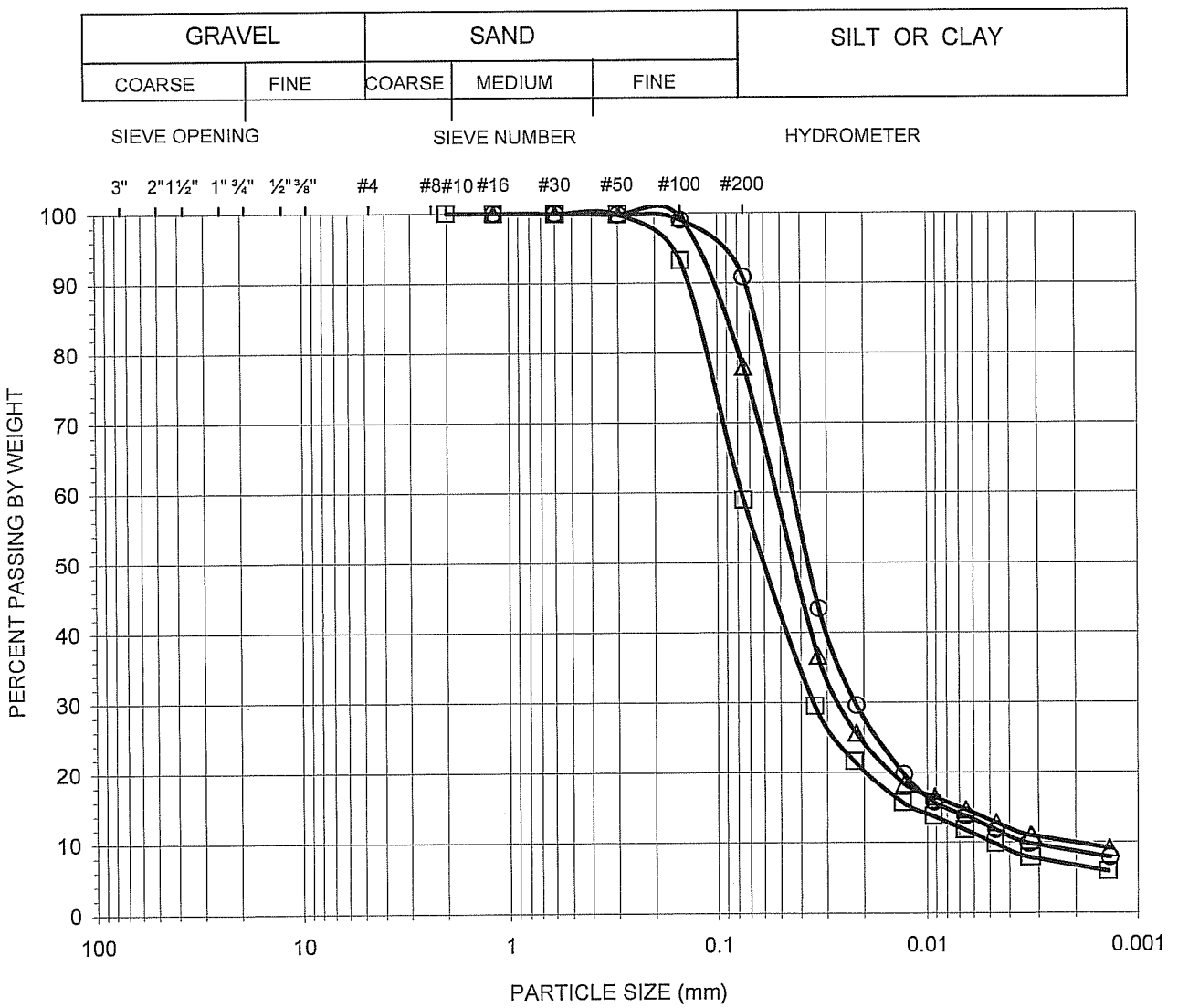
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-029	S-03	15	50.05
R-09-029	D-06	30	46.18
R-09-029	S-13	65	36.93
R-09-029	S-15	75	8.01

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

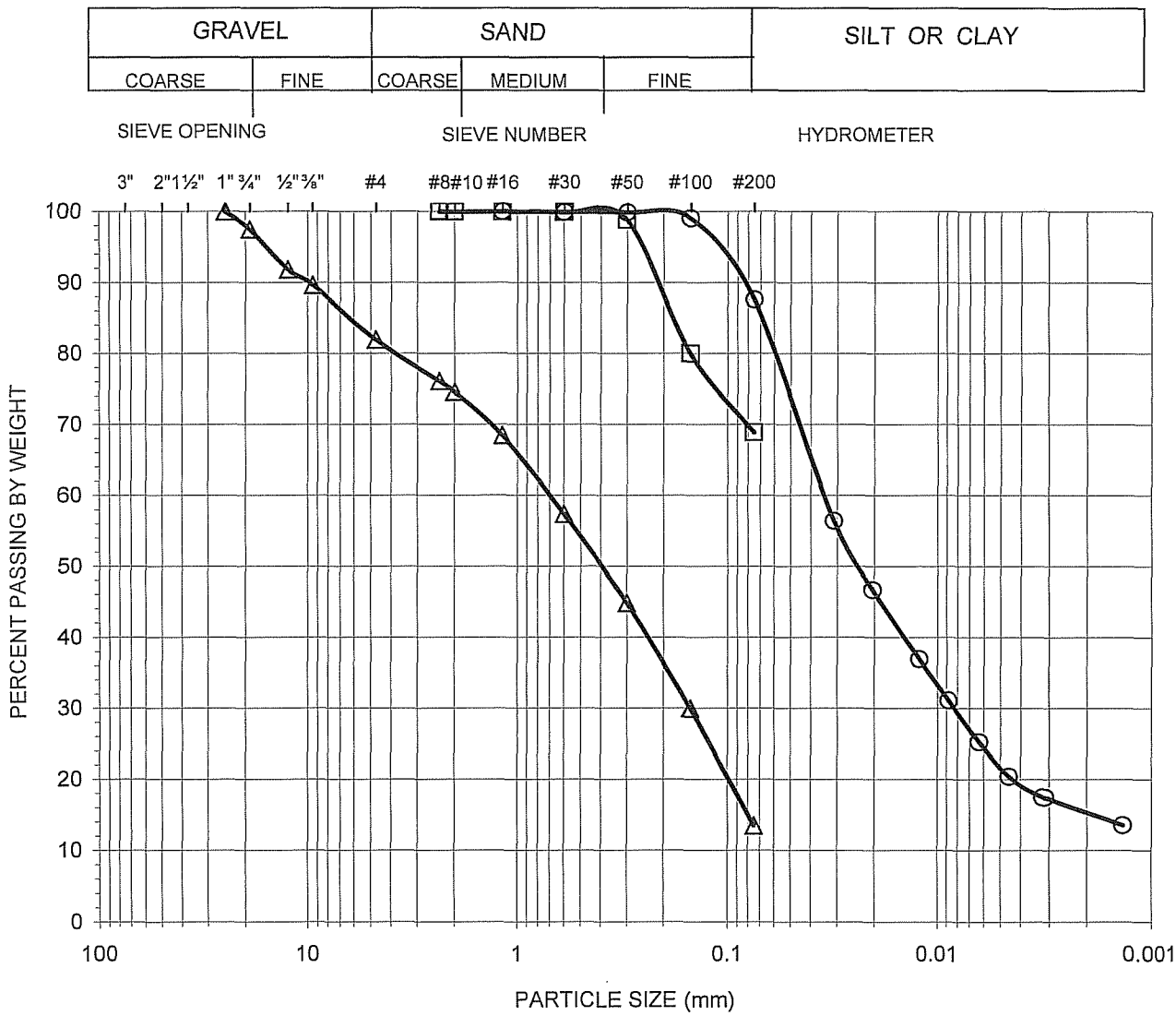


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-029	U-05	25	0.00	9.13	90.87	N/P	ML
□	R-09-029	U-07	35	0.00	41.03	58.97	N/A	ML
△	R-09-029	D-10	50	0.00	21.98	78.02	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

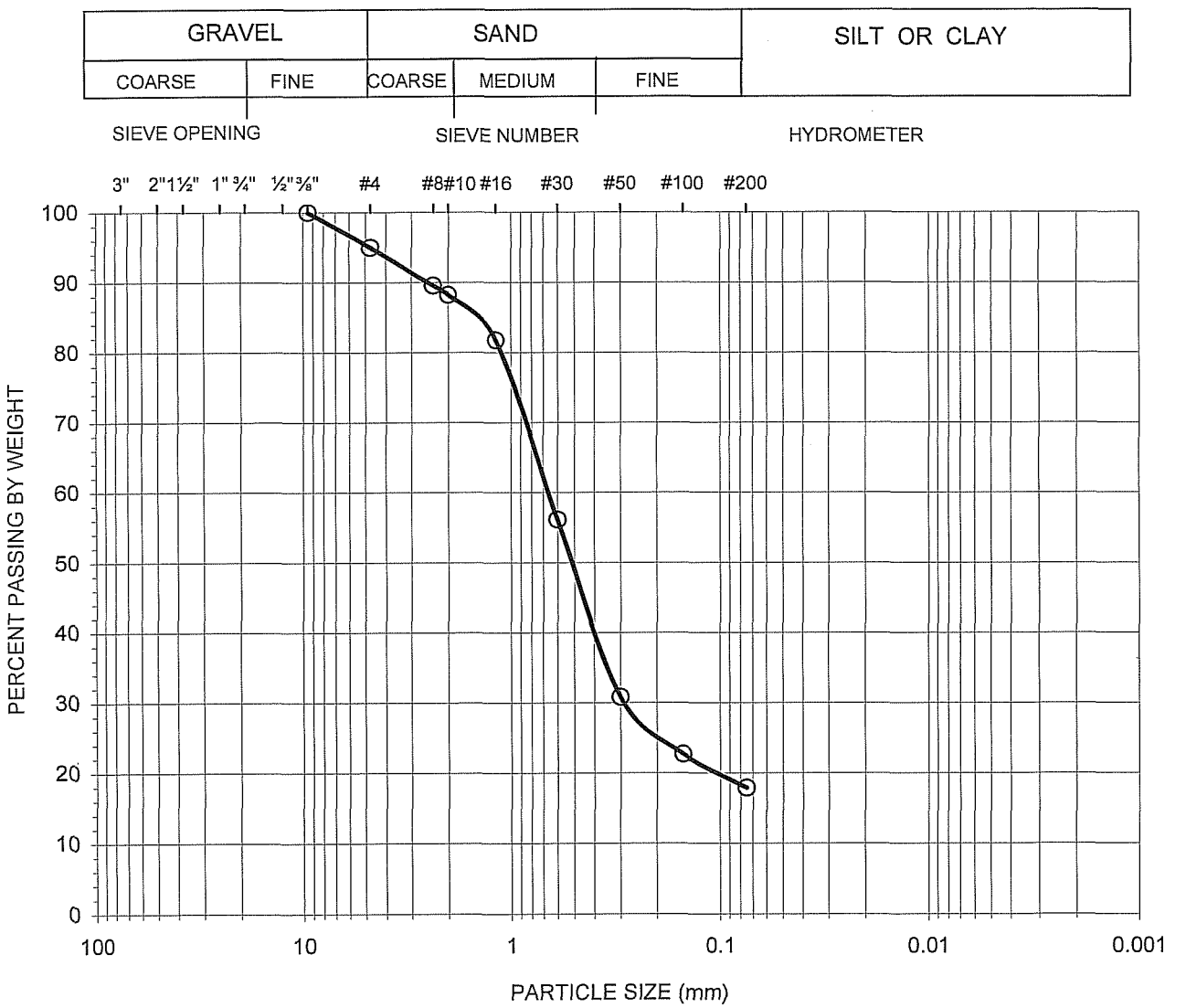


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-029	U-12	60	0.00	12.36	87.64	27:22:5	ML
□	R-09-029	S-17	85	0.00	31.14	68.86	N/A	ML
△	R-09-029	S-21	125	18.02	68.46	13.52	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09



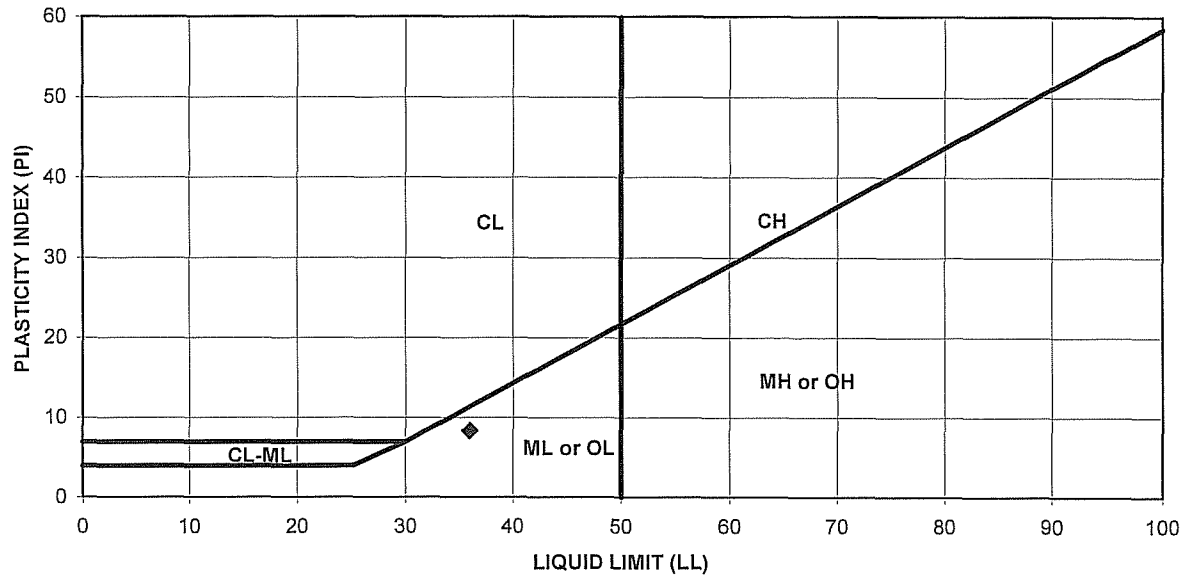
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-029	S-24	160	5.00	77.08	17.92	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

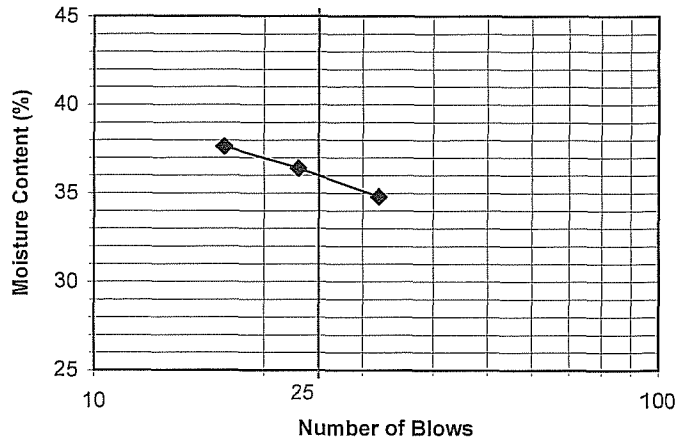
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 12/18/09
Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-029	D-04	20	36	28	8	ML
	R-09-029	U-05	25	NP	NP	NP	

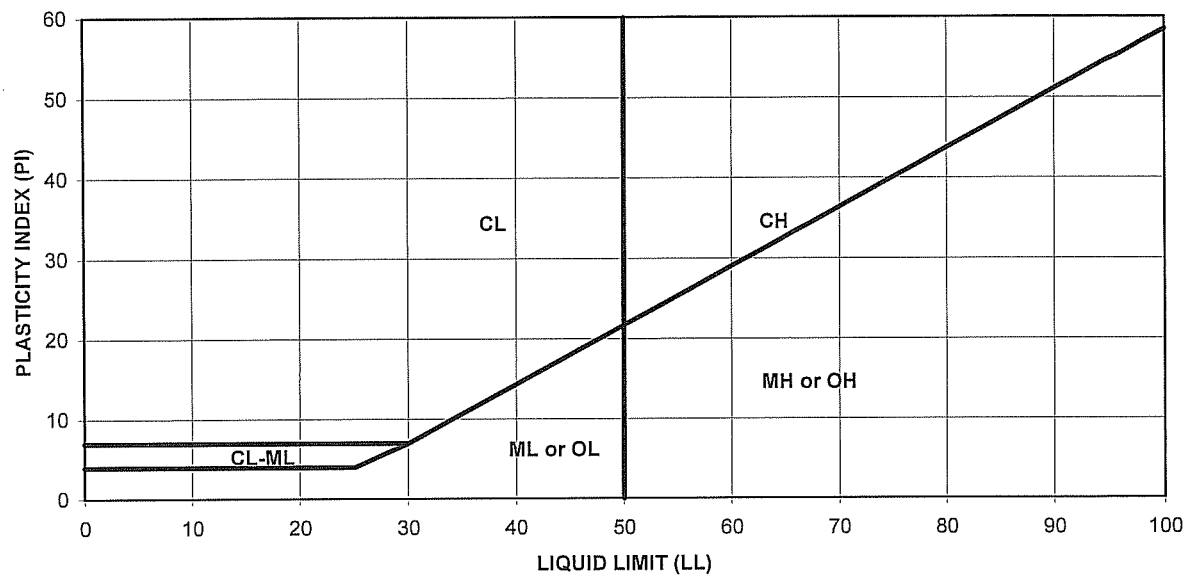
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

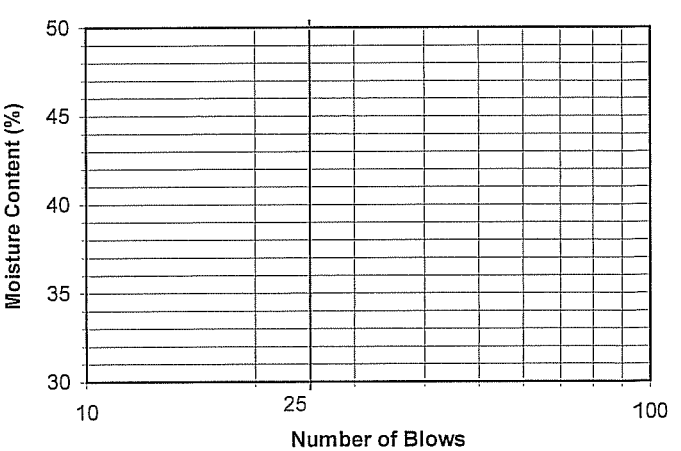
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 12/18/09
Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-029	U-07	35	NP	NP	NP	
	R-09-029	D-10	50	NP	NP	NP	

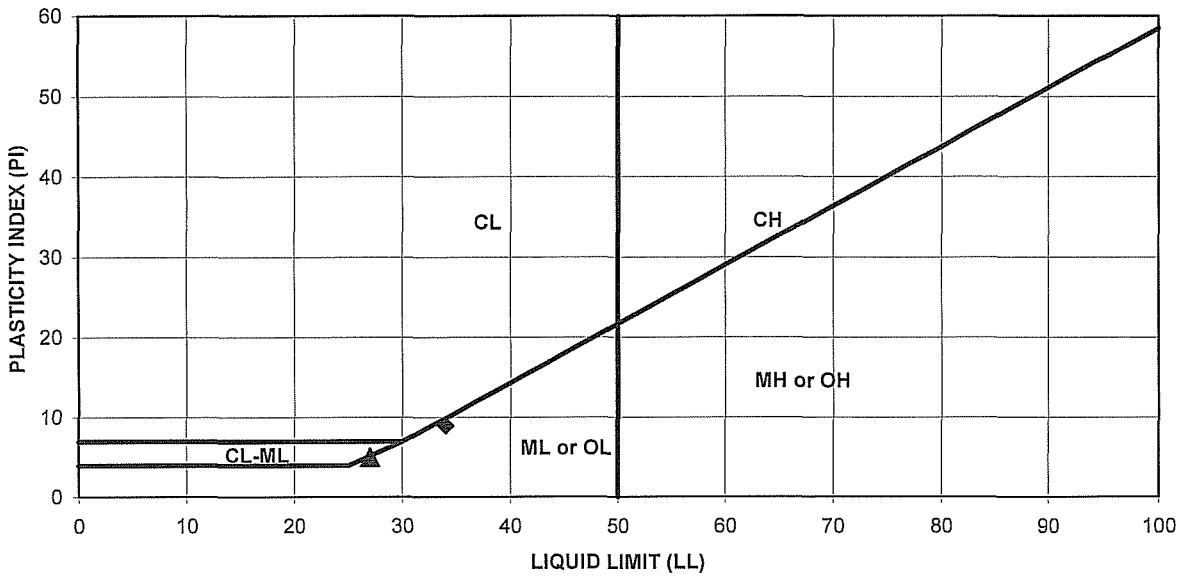
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

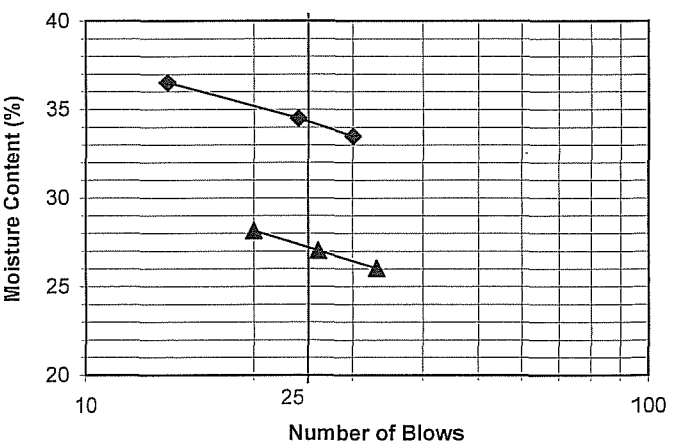
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 12/18/09
Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-029	S-11	55	34	25	9	ML
▲	R-09-029	U-12	60	27	22	5	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 12/22/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/26/09

Project No. : 06-123-03 Checked By: AP Date: 12/26/09

BORING NUMBER	R-09-029	R-09-029	R-09-029			
SAMPLE NUMBER	U-05	U-07	U-12			
DEPTH (FT)	25	35	60			
SOIL CLASSIFICATION	Silt (ML)	Sandy Silt (ML)	Silt w/ sand (ML)			
METHOD (A OR B)	B	B	B			
FLASK NUMBER	2	2	1			
WT. FLASK+WATER+SOIL, g	367.95	368.28	388.20			
TEMPERATURE, °C	18.5	18.9	19.8			
CORRECTION FACTOR	1.0003	1.0002	1.0000			
WT. DRY SOIL, g	44.97	45.37	40.66			
WT. FLASK + WATER, g	249.30	249.30	249.36			
% RETAINED #4	0.00	0.00	0.00			
% PASSING #4	100.00	100.00	100.00			
MATERIAL EXCLUDED	None	None	None			
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.82**	**2.83**	**2.81**			

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AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/18/09

Boring No.: R-09-029 Checked By: AP Date: 12/28/09

Sample No.: D-06 Depth (ft): 30

Description: Gray Sandy Silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	570.00
Total Ring Weight (g)	130.43
Wet Density (pcf)	121.85
Dry Density (pcf)	92.55

Moisture Determination	Before Test	After Test
Cont. Weight (g)	148.94	187.72
Wet Soil+Cont. (g)	438.13	619.95
Dry Soil+Cont. (g)	368.59	518.09
Moisture Content (%)	31.7	30.8
Degree Saturation	99.7	99.2

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

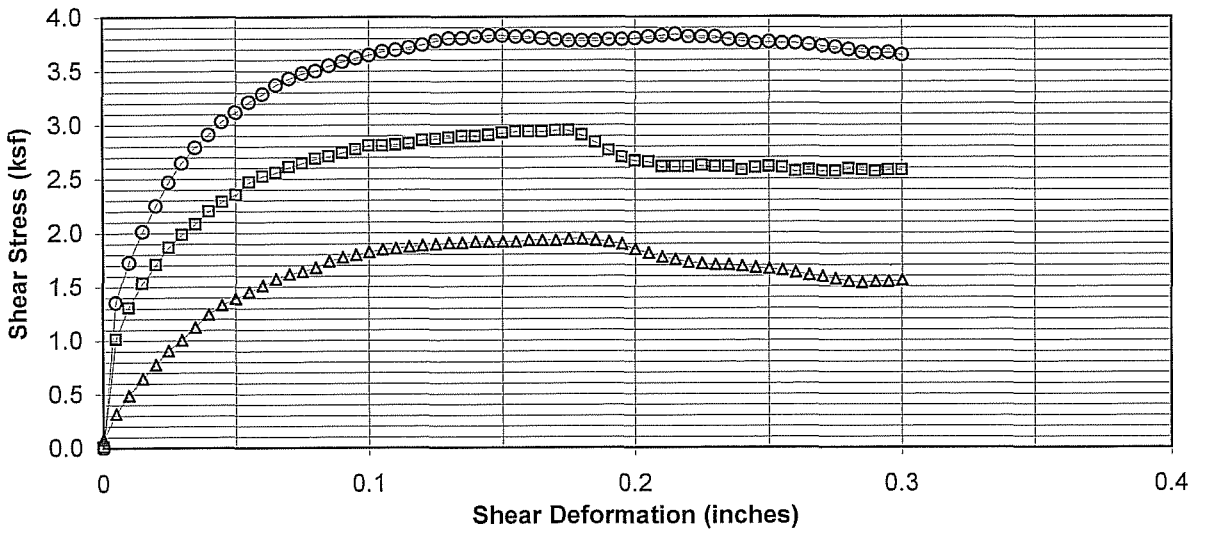
Shear Distance (in): **0.3**

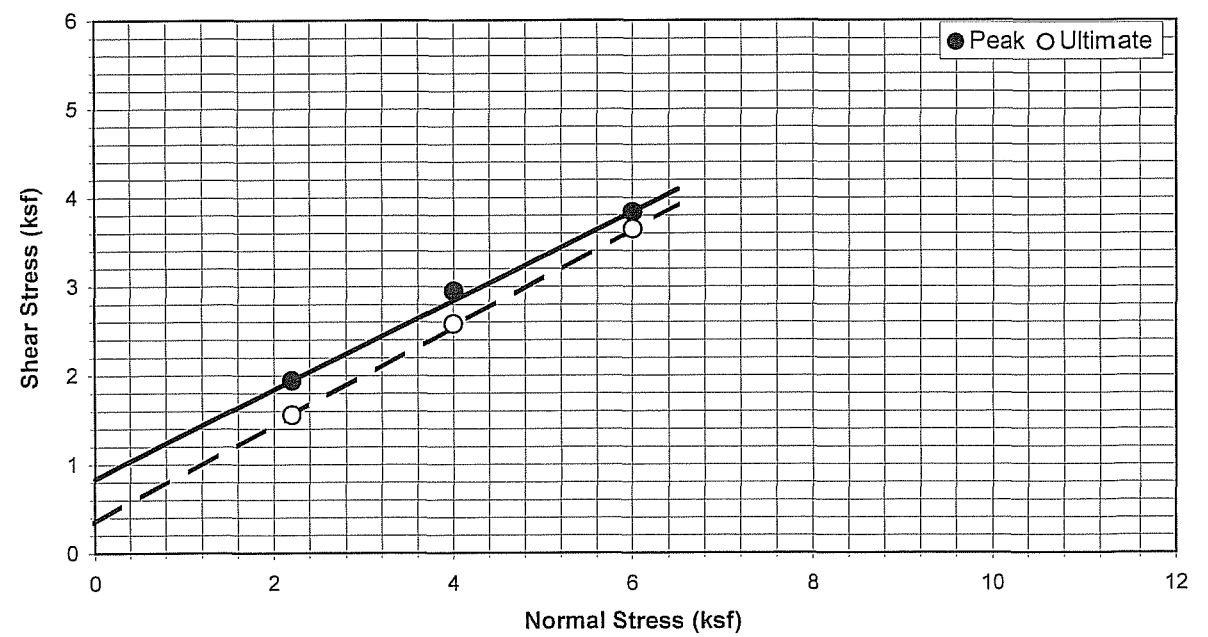
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**192.04**	**43.35**	**2.2**	**1944**	**1560**	
2	**190.15**	**43.19**	**4.0**	**2948**	**2581**	
3	**187.81**	**43.89**	**6.0**	**3840**	**3648**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	92.6	pcf
Boring No.:	R-09-029	Moisture Content (before):	31.7	%
Sample No.:	D-06	Moisture Content (after):	30.8	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	850	350
Friction Angle:	27 °	29 °

AP Engineering & Testing, Inc.

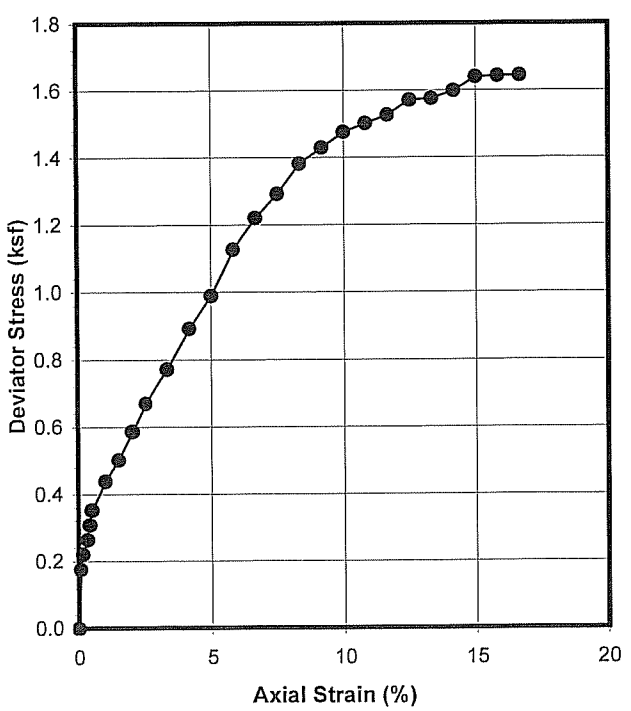
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/31/09
Project No.:	06-123-03		
Boring No.:	R-09-029		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	116.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	83.2
Sample Weight (gms):	1190.00	Moisture Content (%):	39.8
Wt. Wet Soil+Container(gms)	1339.05	Void Ratio for Gs=2.7:	1.03
Wt. Dry Soil+Container(gms)	1000.29	% Saturation:	104.9
Wt. Container (gms)	149.61		

TEST DATA

Cell Pressure (ksf):	1.30
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.30
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.6
Ultimate Deviator Stress (ksf):	1.6
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
8	0.005	6.50	0.18	0.08
10	0.010	6.50	0.22	0.17
12	0.020	6.51	0.27	0.33
14	0.025	6.52	0.31	0.42
16	0.030	6.52	0.35	0.50
20	0.060	6.56	0.44	1.00
23	0.090	6.59	0.50	1.50
27	0.120	6.62	0.59	2.00
31	0.150	6.66	0.67	2.50
36	0.200	6.72	0.77	3.33
42	0.250	6.77	0.89	4.17
47	0.300	6.83	0.99	5.00
54	0.350	6.89	1.13	5.83
59	0.400	6.96	1.22	6.67
63	0.450	7.02	1.29	7.50
68	0.500	7.08	1.38	8.33
71	0.550	7.15	1.43	9.17
74	0.600	7.21	1.48	10.00
76	0.650	7.28	1.50	10.83
77.98352	0.700	7.35	1.53	11.67
81	0.750	7.42	1.57	12.50
82	0.800	7.49	1.58	13.33
84	0.850	7.56	1.60	14.17
87	0.900	7.64	1.64	15.00
88	0.950	7.71	1.64	15.83
89	1.000	7.79	1.65	16.67

AP Engineering & Testing, Inc.

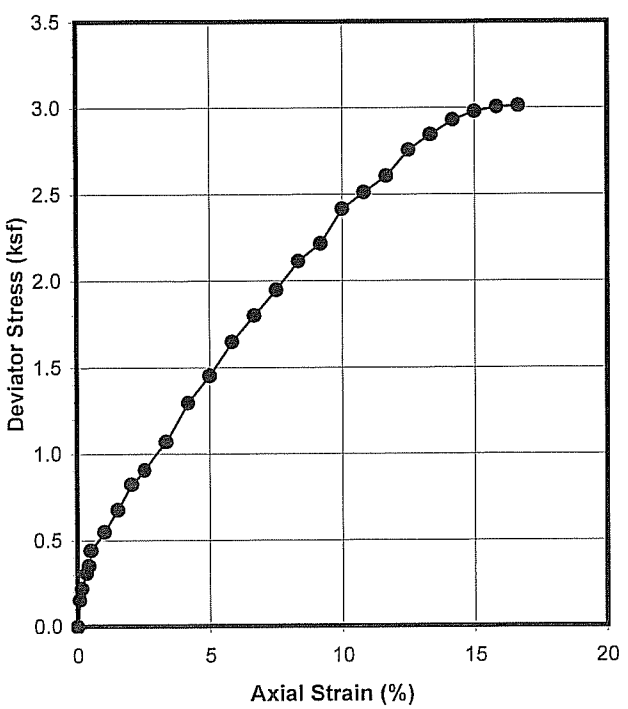
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/31/09
Project No.:	06-123-03		
Boring No.:	R-09-029		
Sample No.:	U-07 Depth (feet): 35		
Soil Description	Gray Sandy Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	122.8
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	93.0
Sample Weight (gms):	1255.86	Moisture Content (%):	32.0
Wt. Wet Soil+Container(gms)	1361.96	Void Ratio for Gs=2.7:	0.81
Wt. Dry Soil+Container(gms)	1057.14	% Saturation:	106.5
Wt. Container (gms)	105.05		

TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	3.0
Ultimate Deviator Stress (ksf):	2.9
Ultimate Undrained Shear Strength (ksf):	1.5
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
7	0.005	6.50	0.16	0.08
10	0.010	6.50	0.22	0.17
14	0.020	6.51	0.31	0.33
16	0.025	6.52	0.35	0.42
20	0.030	6.52	0.44	0.50
25	0.060	6.56	0.55	1.00
31	0.090	6.59	0.68	1.50
38	0.120	6.62	0.83	2.00
42	0.150	6.66	0.91	2.50
50	0.200	6.72	1.07	3.33
61	0.250	6.77	1.30	4.17
69	0.300	6.83	1.45	5.00
79	0.350	6.89	1.65	5.83
87	0.400	6.96	1.80	6.67
95	0.450	7.02	1.95	7.50
104	0.500	7.08	2.11	8.33
110	0.550	7.15	2.22	9.17
121	0.600	7.21	2.42	10.00
127	0.650	7.28	2.51	10.83
133	0.700	7.35	2.61	11.67
142	0.750	7.42	2.76	12.50
148	0.800	7.49	2.85	13.33
154	0.850	7.56	2.93	14.17
158	0.900	7.64	2.98	15.00
161	0.950	7.71	3.01	15.83
163	1.000	7.79	3.01	16.67

AP Engineering & Testing, Inc.

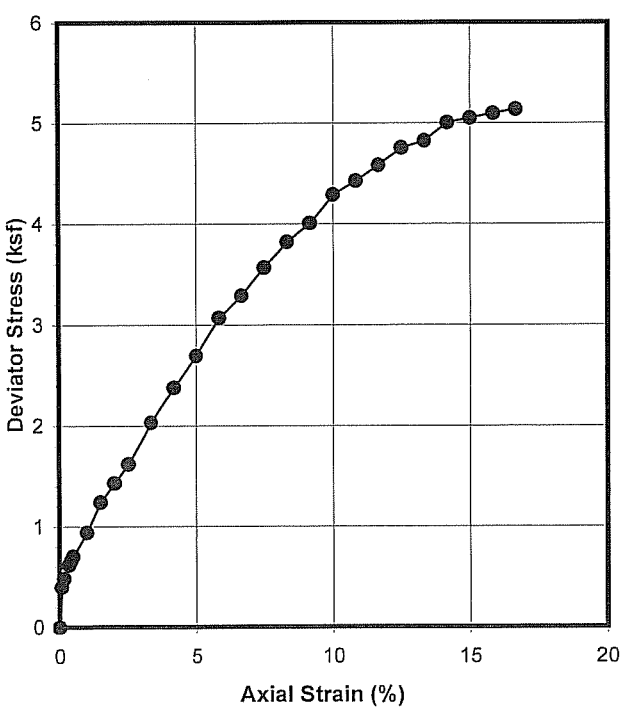
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/31/09
Project No.:	06-123-03		
Boring No.:	R-09-029		
Sample No.:	U-12 Depth (feet): 60		
Soil Description	Gray Silt with sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	127.6
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	101.1
Sample Weight (gms):	1305.57	Moisture Content (%):	26.3
Wt. Wet Soil+Container(gms)	1505.68	Void Ratio for Gs=2.7:	0.67
Wt. Dry Soil+Container(gms)	1233.50	% Saturation:	106.3
Wt. Container (gms)	196.95		

TEST DATA

Cell Pressure (ksf):	2.59
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.59
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	5.1
Ultimate Deviator Stress (ksf):	5.0
Ultimate Undrained Shear Strength (ksf):	2.5
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
18	0.005	6.50	0.40	0.08
22	0.010	6.50	0.49	0.17
28	0.020	6.51	0.62	0.33
30	0.025	6.52	0.66	0.42
32	0.030	6.52	0.71	0.50
43	0.060	6.56	0.94	1.00
57	0.090	6.59	1.25	1.50
66	0.120	6.62	1.43	2.00
75	0.150	6.66	1.62	2.50
95	0.200	6.72	2.04	3.33
112	0.250	6.77	2.38	4.17
128	0.300	6.83	2.70	5.00
147	0.350	6.89	3.07	5.83
159	0.400	6.96	3.29	6.67
174	0.450	7.02	3.57	7.50
188	0.500	7.08	3.82	8.33
199	0.550	7.15	4.01	9.17
215	0.600	7.21	4.29	10.00
224	0.650	7.28	4.43	10.83
234	0.700	7.35	4.58	11.67
245	0.750	7.42	4.76	12.50
251	0.800	7.49	4.83	13.33
263	0.850	7.56	5.01	14.17
268	0.900	7.64	5.05	15.00
273	0.950	7.71	5.10	15.83
278	1.000	7.79	5.14	16.67

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-031	S-01	5.0	24.8			
R-09-031	D-02	10.0	10.3	97.4		
R-09-031	S-03	15.0			38.8	
R-09-031	D-04	20.0	35.7	84.3		27,24,3
R-09-031	S-05	25.0	29.3			
R-09-031	D-06	30.0			14.9	
R-09-031	S-07	35.0	33.9			24,23,1
R-09-031	D-08	40.0	23.7	98.9	7.0	
R-09-031	S-09	45.0				49,25,24
R-09-031	U-11	55.0				45,22,23
R-09-031	S-13	65.0	28.6		12.8	
R-09-031	S-15	75.0	28.2			
R-09-031	D-16	80.0	26.8	98.0		
R-09-031	S-17	90.0			16.6	
R-09-031	S-19	110.0	21.7			
R-09-031	S-22	140.0	14.0			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-031	S-03	15	8.43	1790	0.014	250
R-09-031	S-09	45	8.15	4090	0.133	140

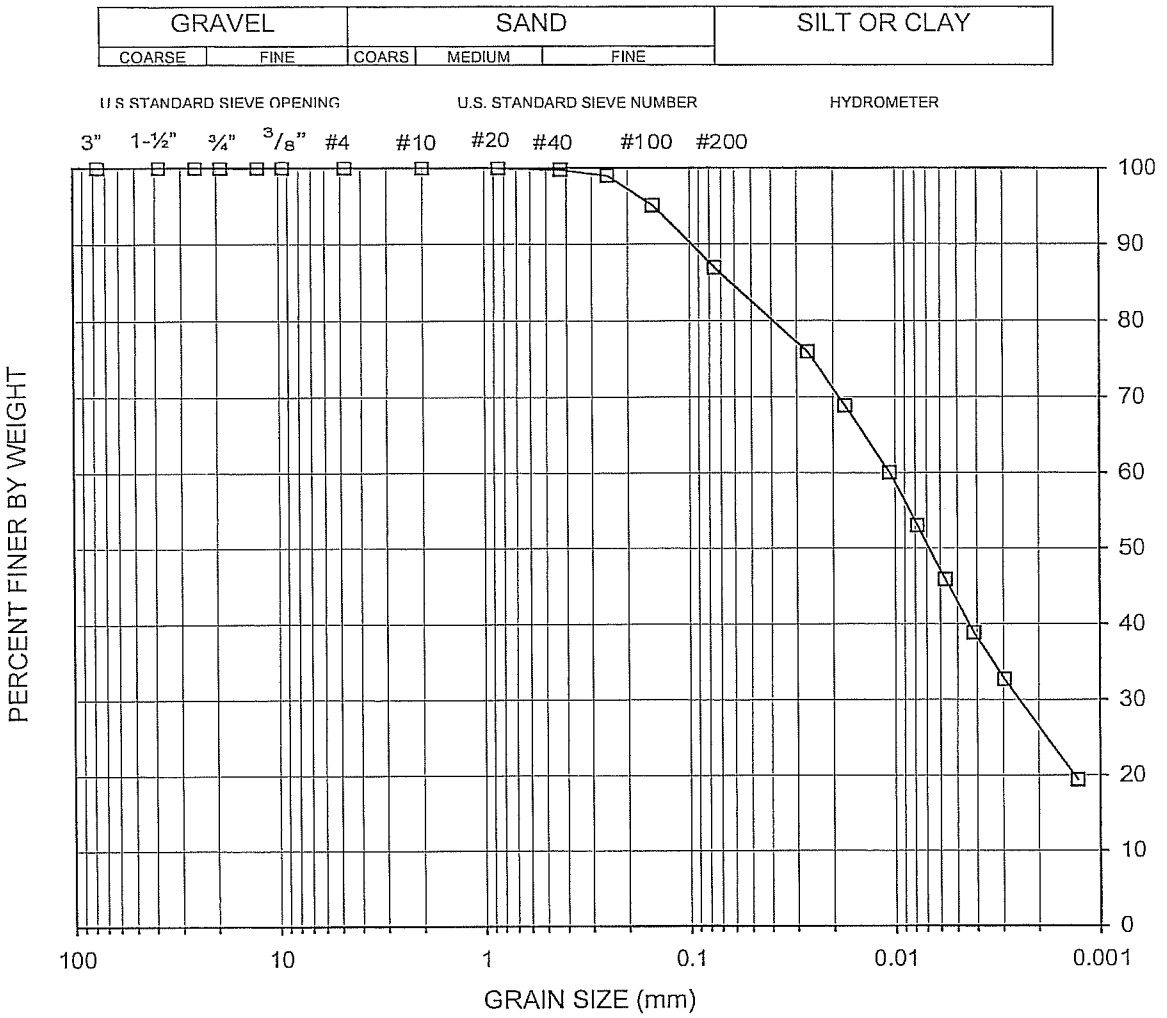
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-031	U-11	55	2.729



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-031	U-11	55	Shelby Tube	CL	45	23

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

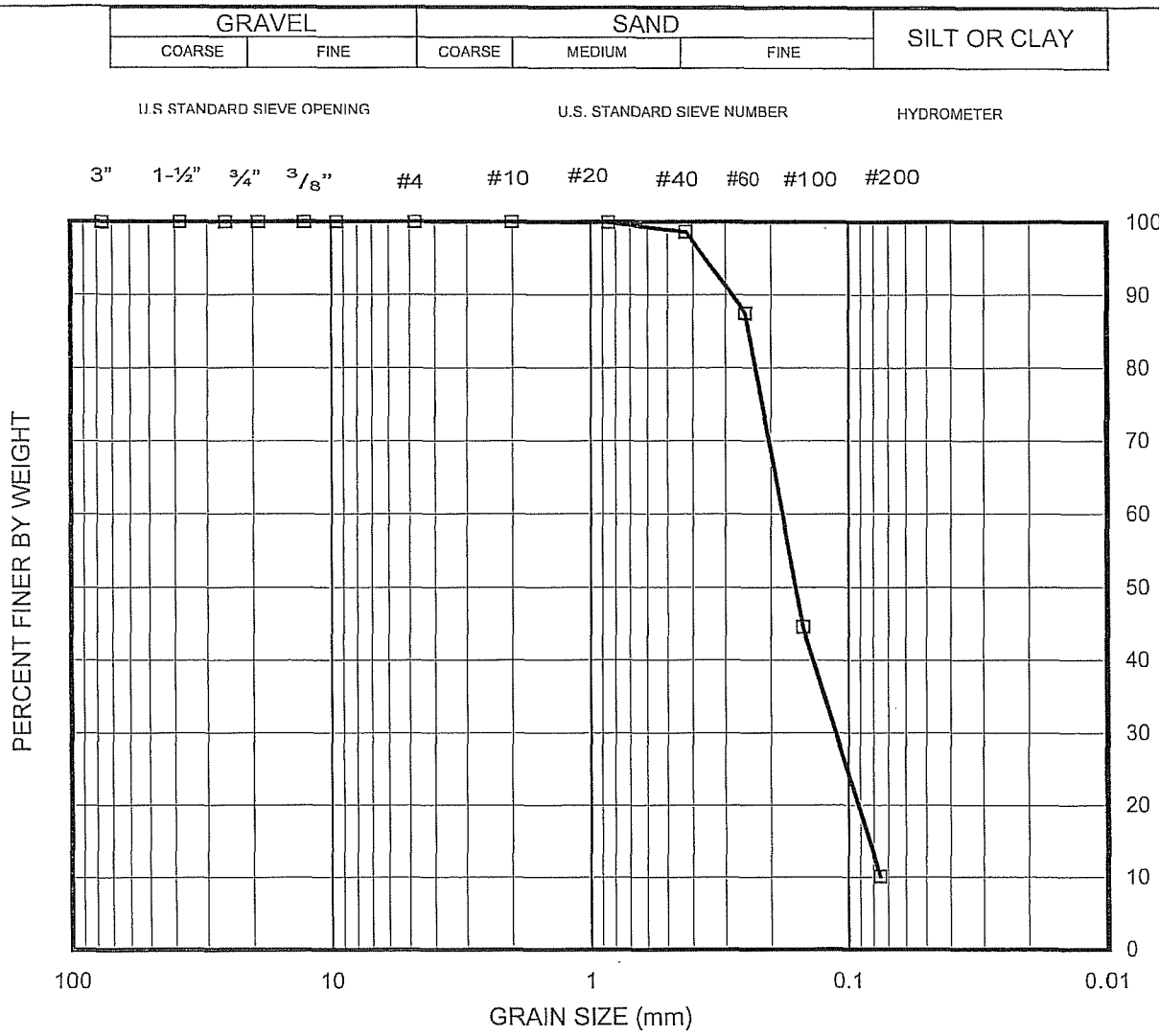
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-031	D-16	80	Ring	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

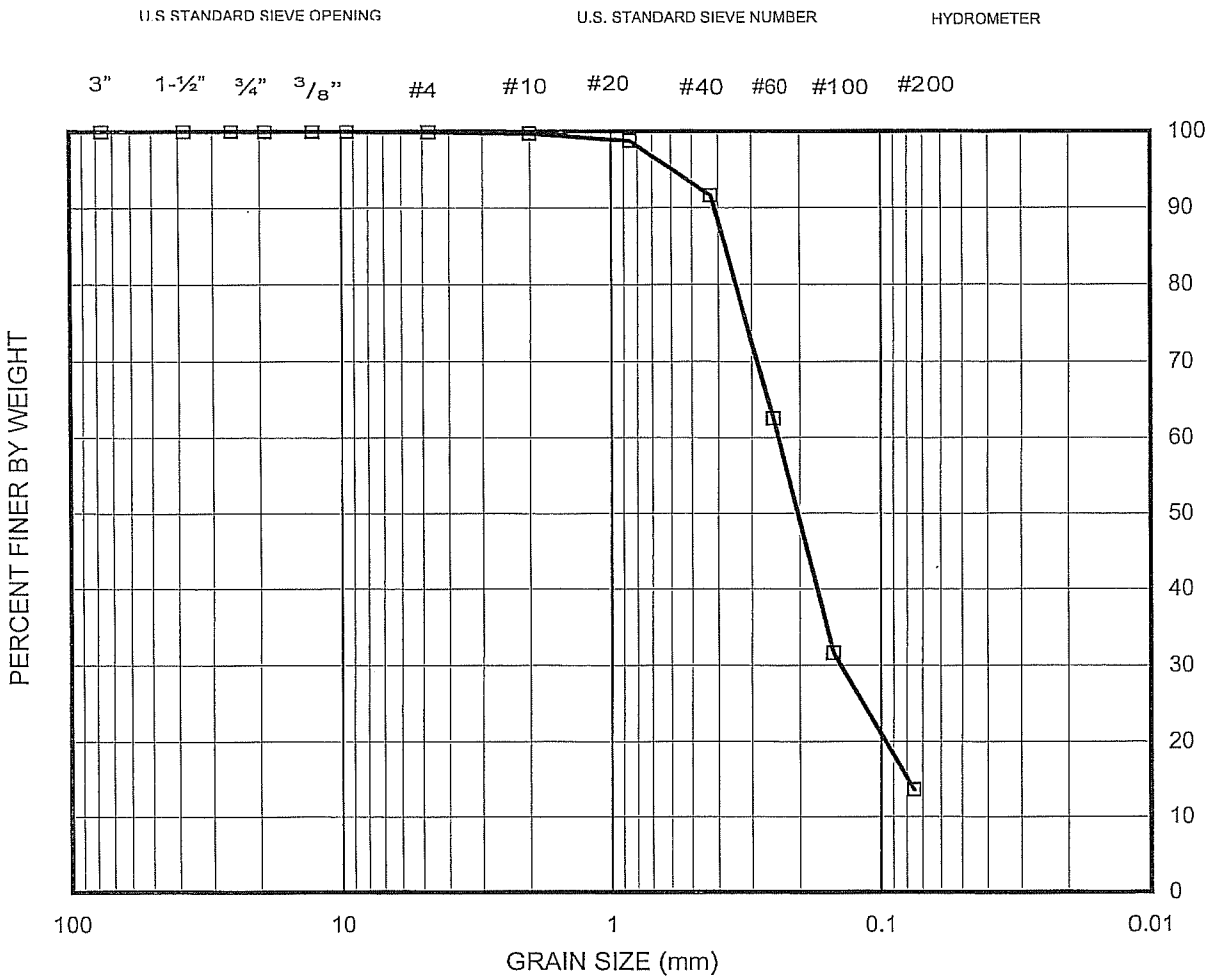
Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-031	S-19	110	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

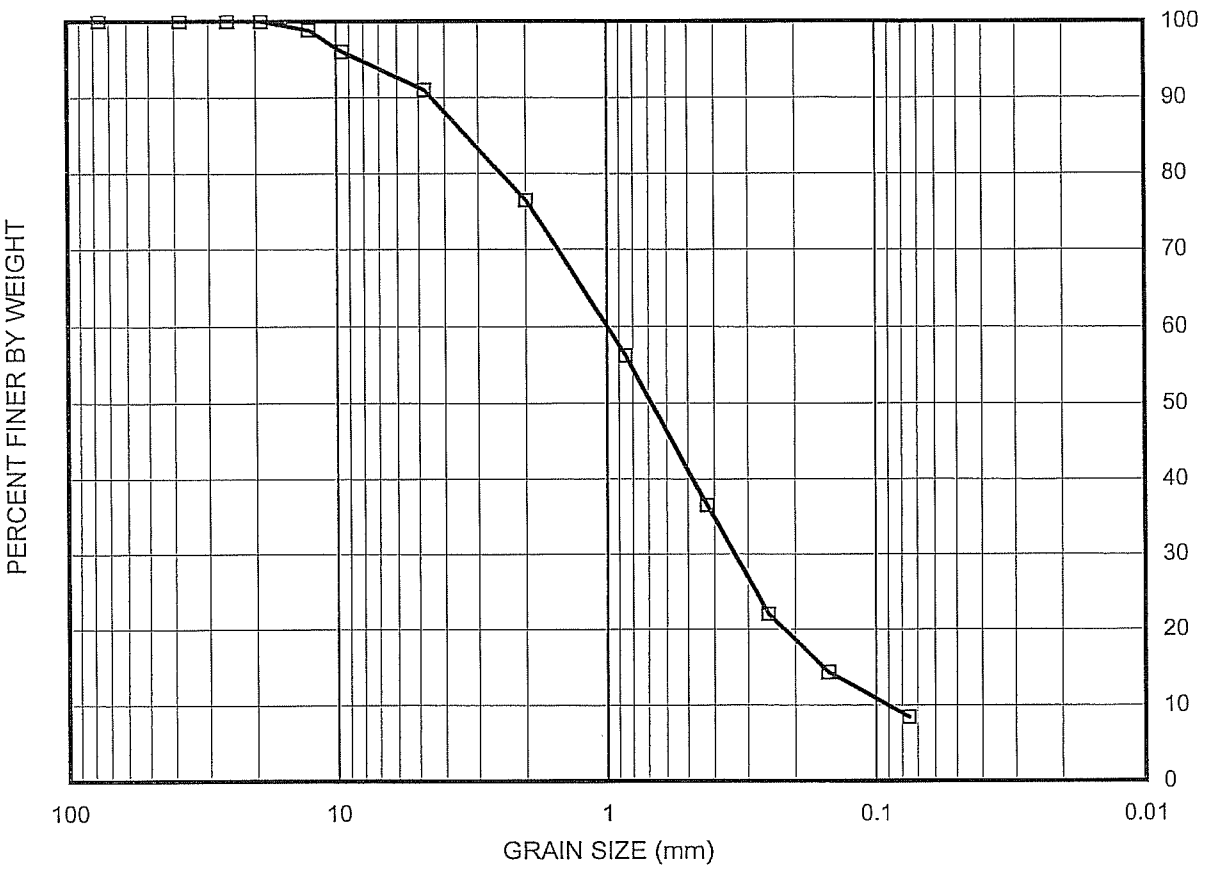
GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER

3" 1-½" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200



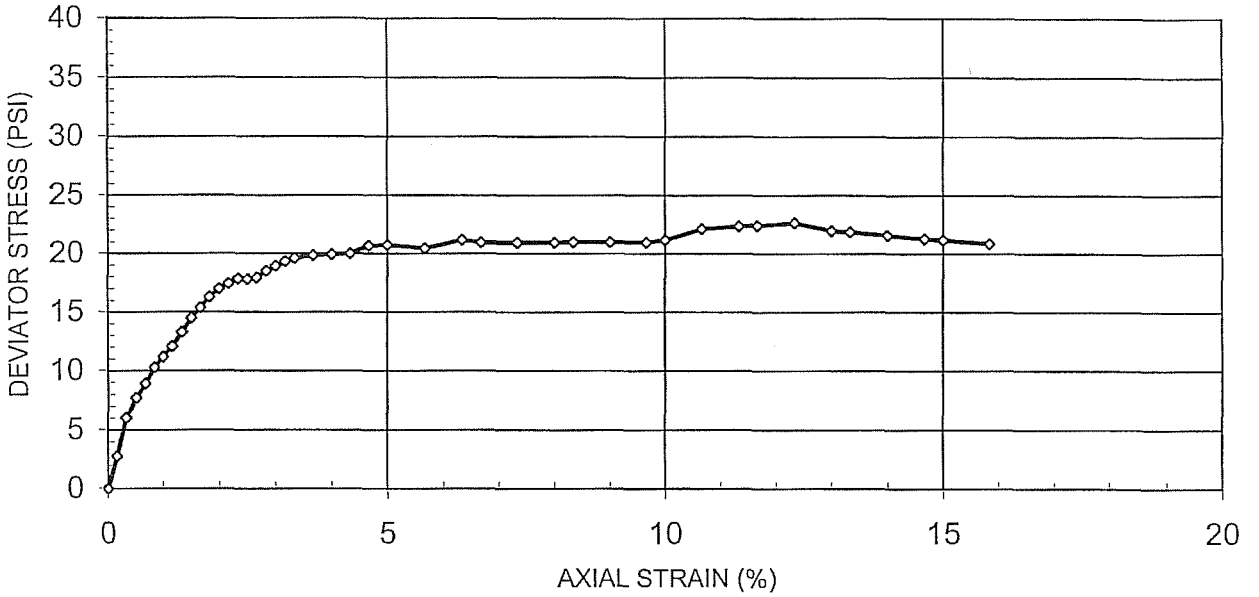
SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-031	S-22	140	Bag	SW-SM	N/A	N/A

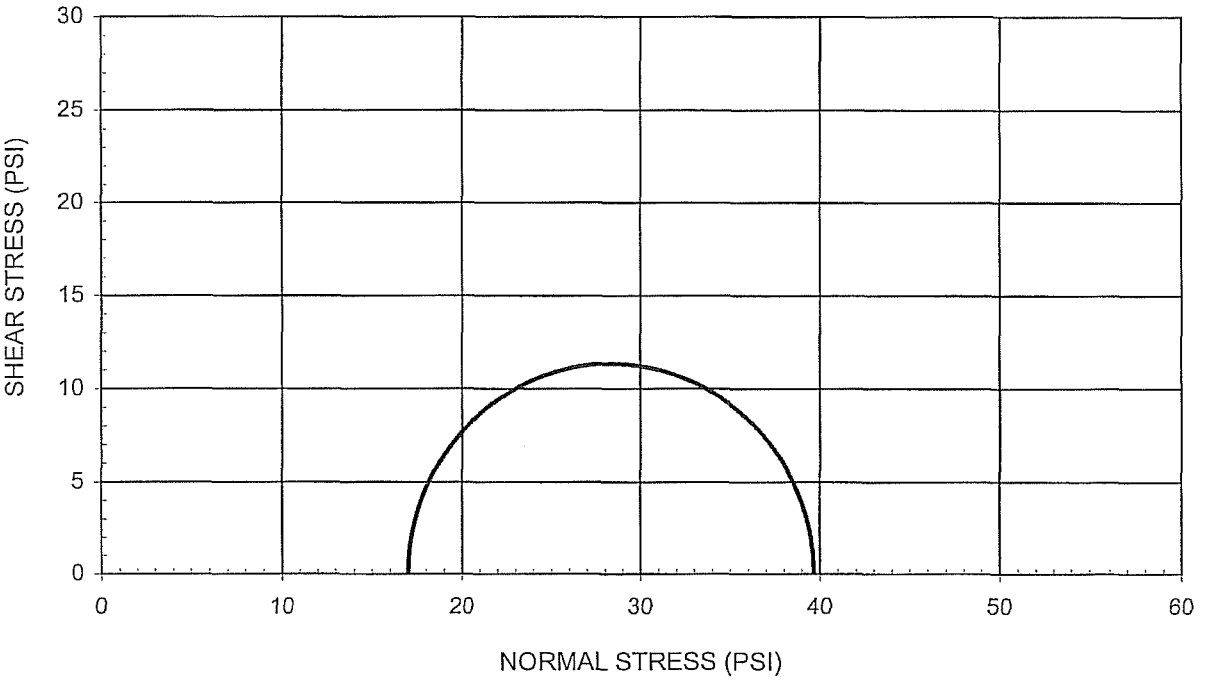
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-031	55	U-11	CL	Shelby Tube	42.81	78.4	17.0	22.7	0.06	100.7

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

UNCONSOLIDATED UNDRAINED

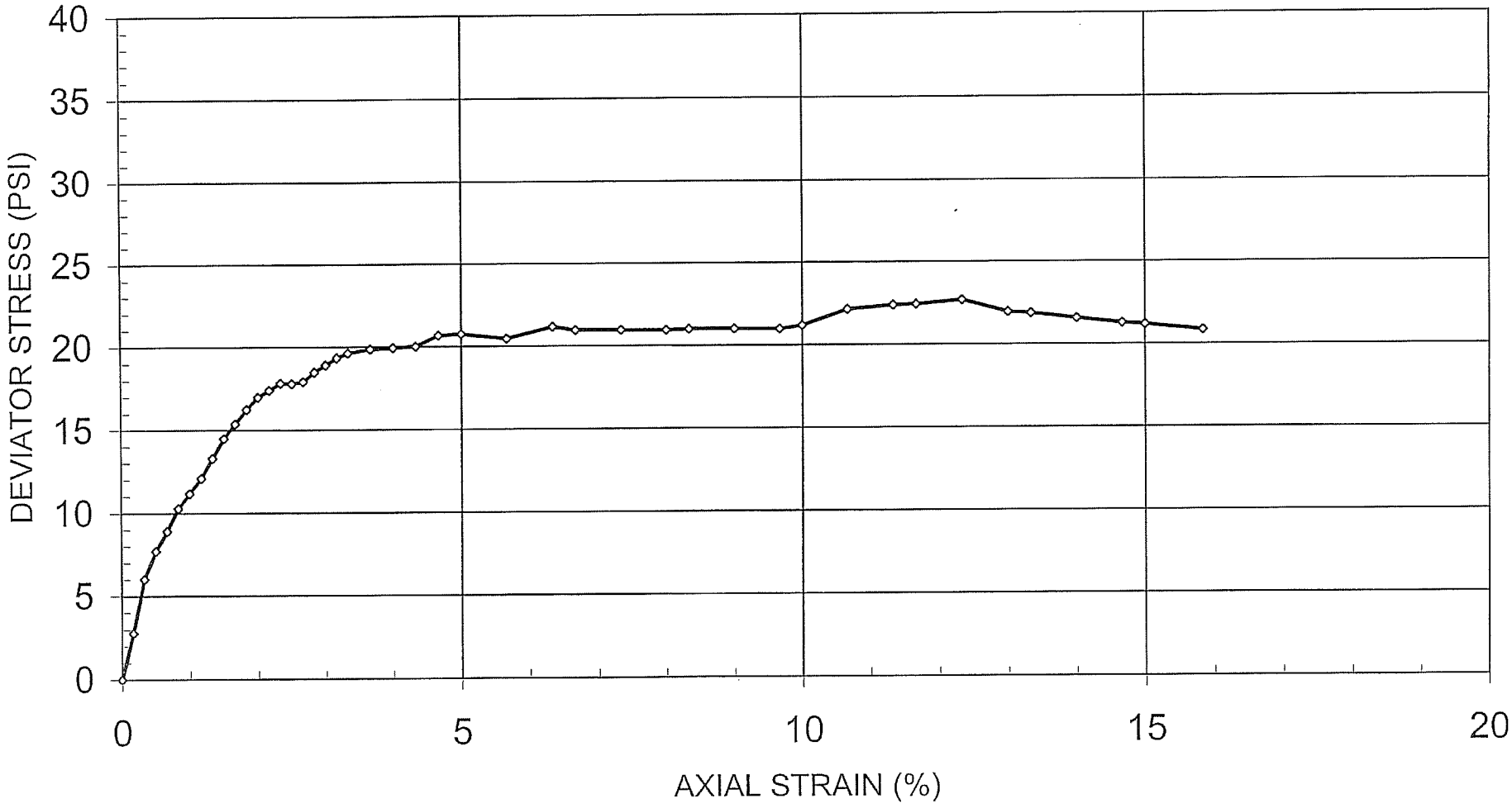
(ASTM D2850)

11/30/09

Figure

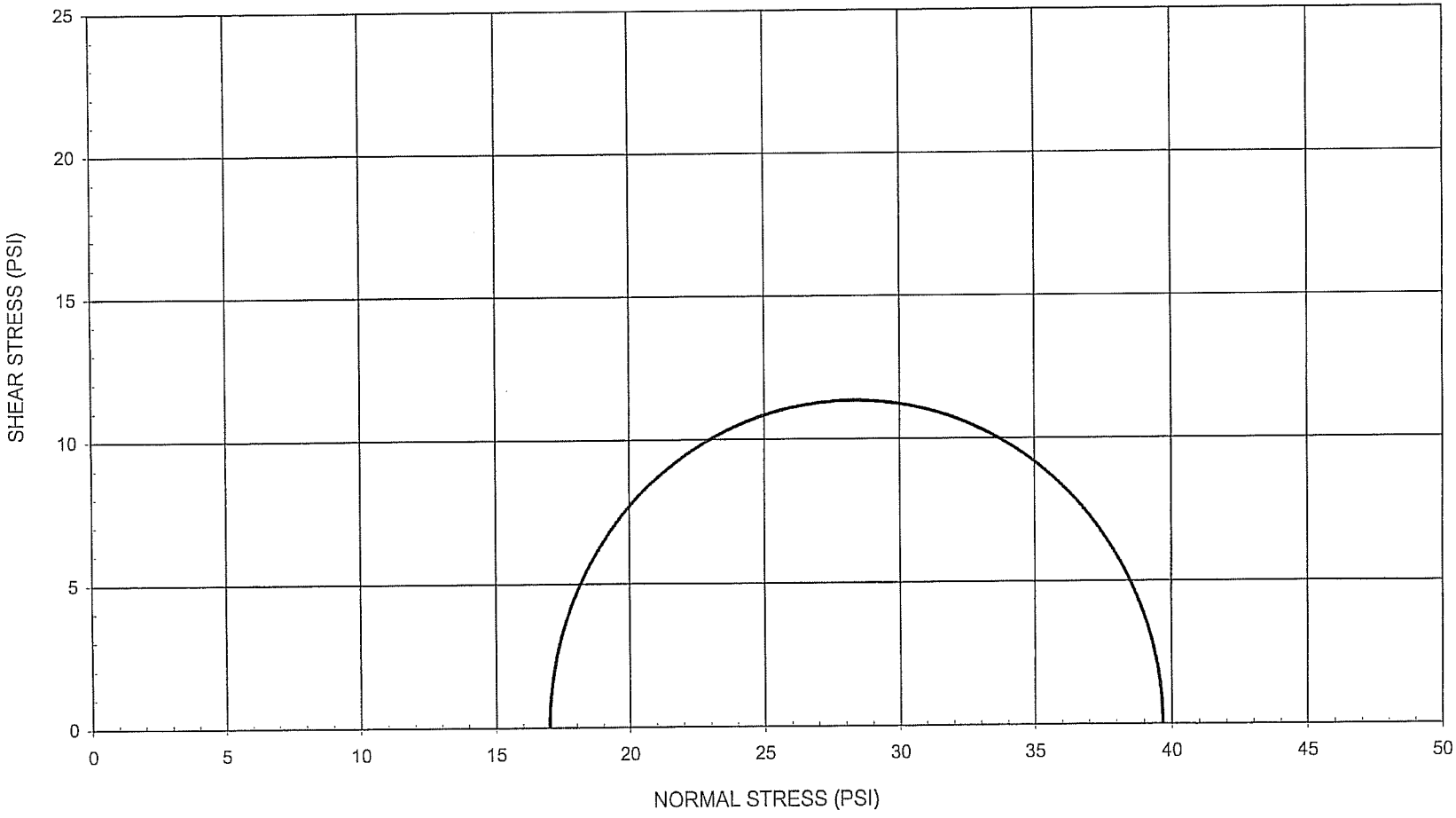
Project Name: ACTA Heim Bridge Replacement

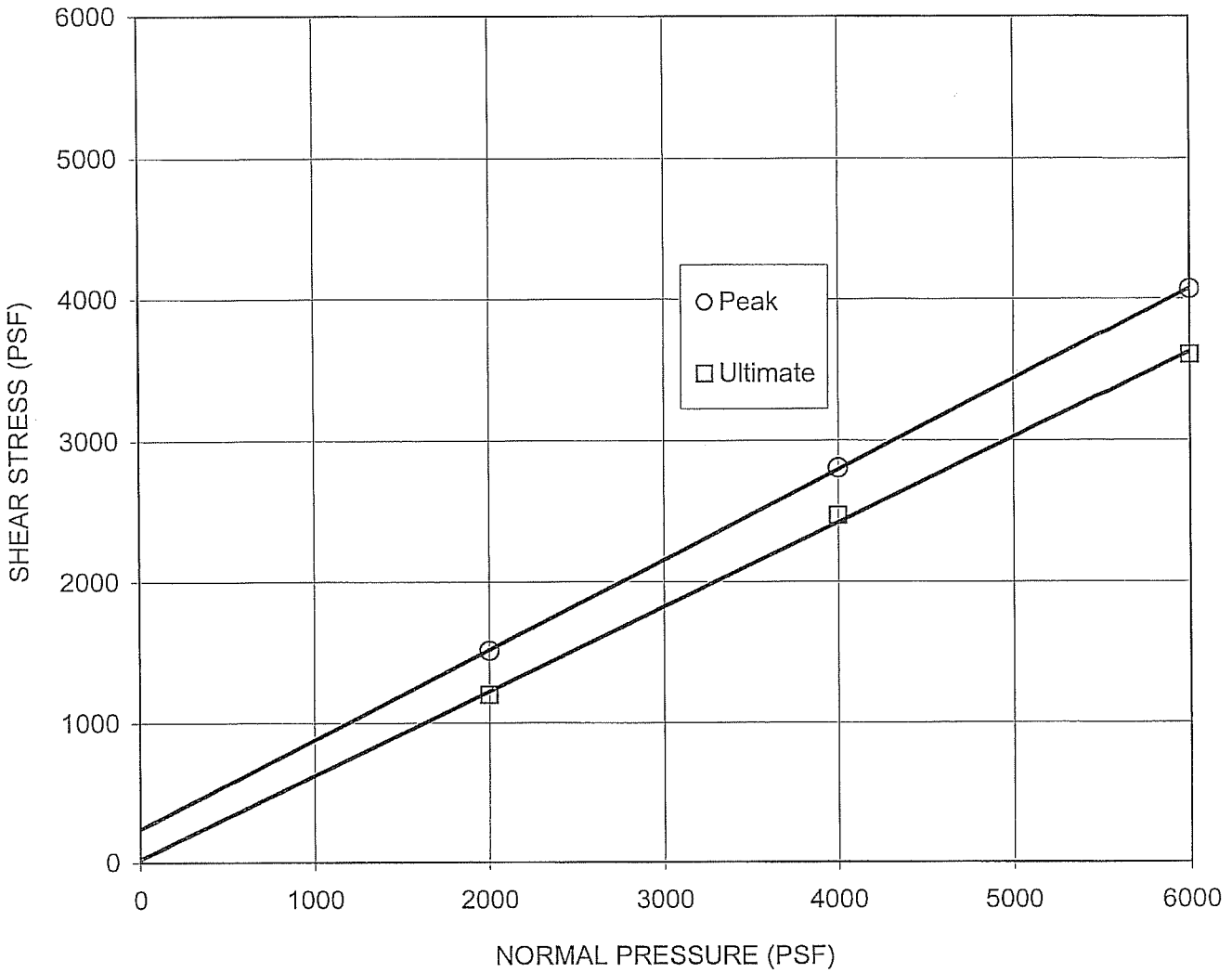
Boring: R-09-031 Sample ID: U-11 Depth (ft): 55



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-031 Sample ID: U-11 Depth (ft): 55





Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-031	D-06	30	Ring	SM	○	240	33
					□	25	31

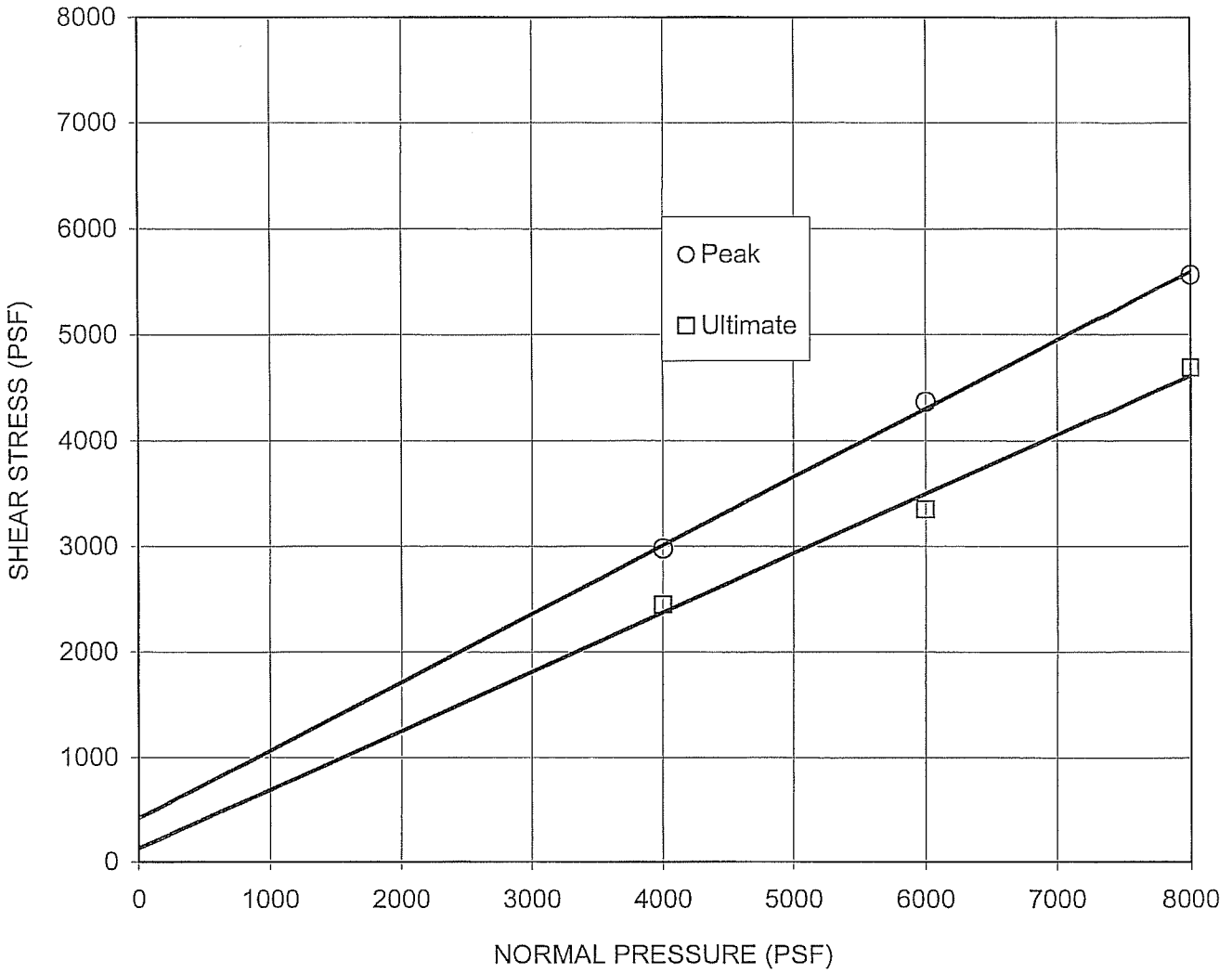
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2000	24.9	28.1
4000	24.9	28.0
6000	24.9	27.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-031	D-16	80	Ring	SP-SM	O	418	33
					□	130	29

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	26.8	32.0
6000	26.8	31.5
8000	26.8	30.9

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

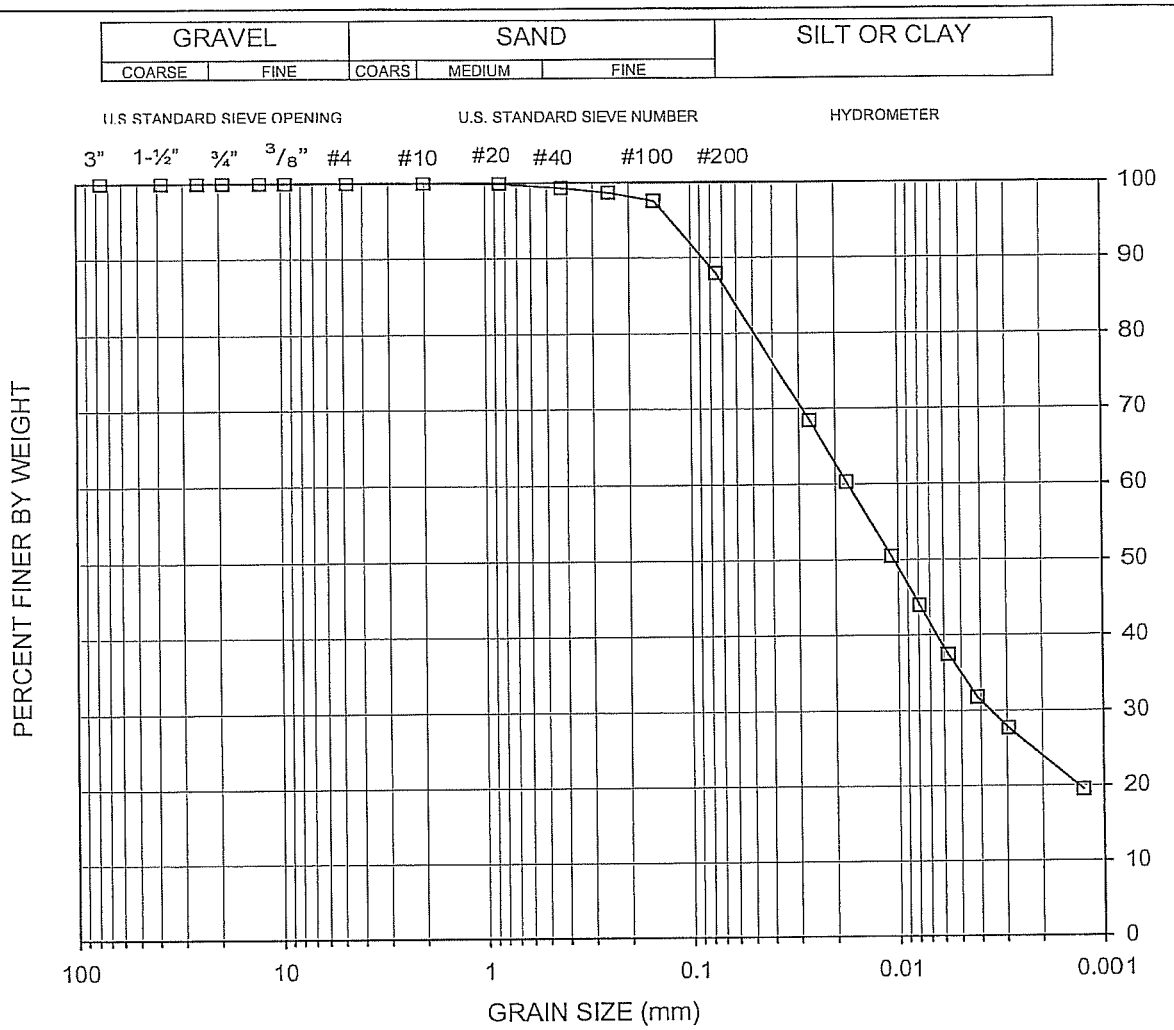
BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-032	S-01	5.0	19.6			
R-09-032	D-02	10.0			23.5	
R-09-032	S-03	15.0	64.8			55,26,29
R-09-032	D-04	20.0	42.0	82.1		
R-09-032	S-05	25.0				
R-09-032	D-06	30.0	28.9	96.5	24.2	
R-09-032	S-07	35.0	39.0			28,23,5
R-09-032	D-08	40.0	34.4	89.3		
R-09-032	S-09	45.0			52.0	
R-09-032	D-10	50.0	38.2	83.4		40,22,18
R-09-032	S-11	55.0			18.1	
R-09-032	D-12	60.0	24.6	101.9		
R-09-032	S-13	65.0			9.2	
R-09-032	D-14	70.0	25.7	99.4		
R-09-032	S-15	75.0	25.8			
R-09-032	D-16	80.0	23.3	104.8		
R-09-032	S-18	100.0	17.9			
R-09-032	S-20	120.0	20.5			
R-09-032	S-22	140.0	10.0			
R-09-032	S-23	150.0	13.1			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-032	S-03	15	8.09	1280	0.093	360
R-09-032	S-09	45	8.79	635	0.054	520



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-032	S-03	15	BAG	CH	55	29

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

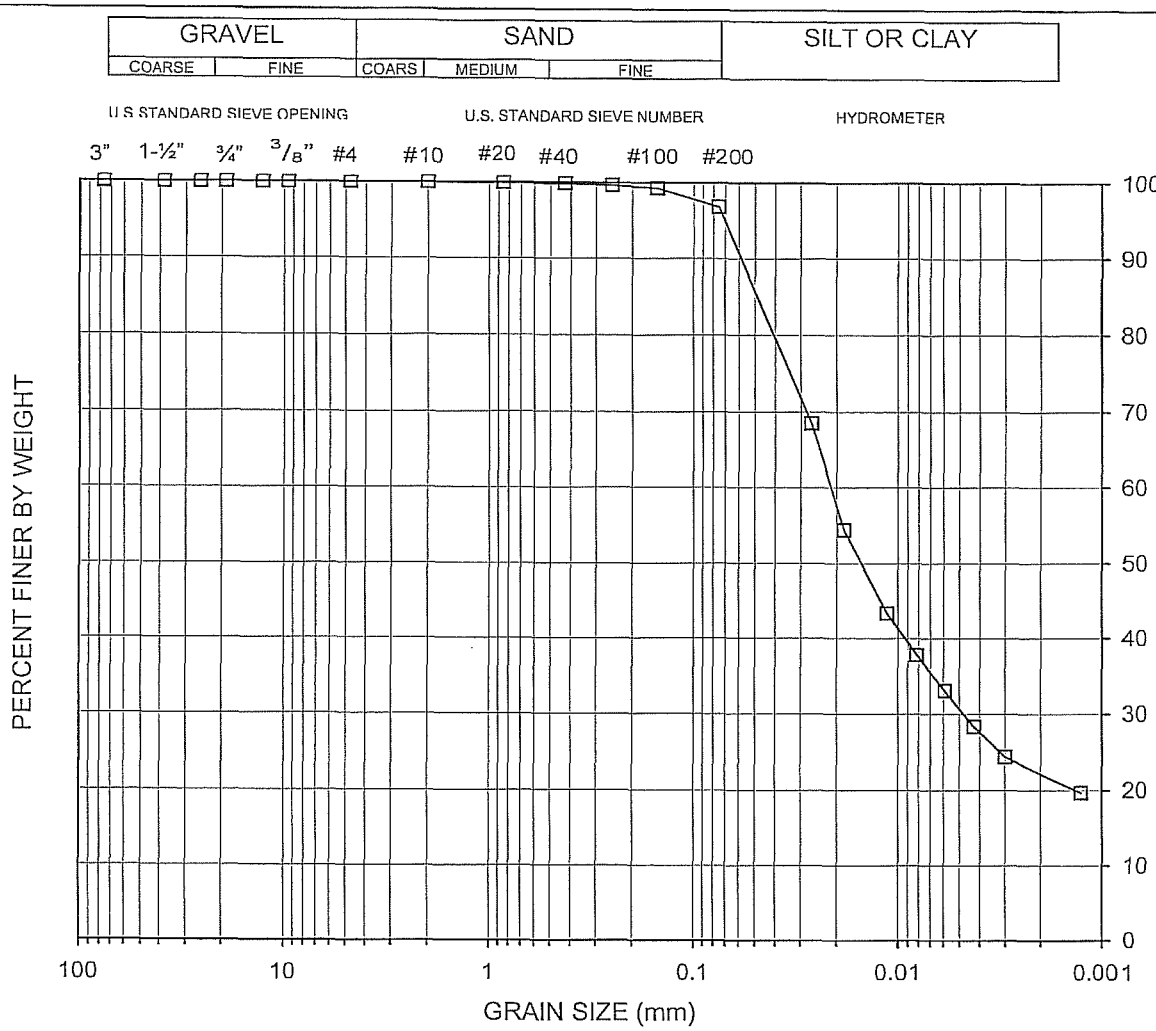
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-032	D-10	50	RING	CL	40	18

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

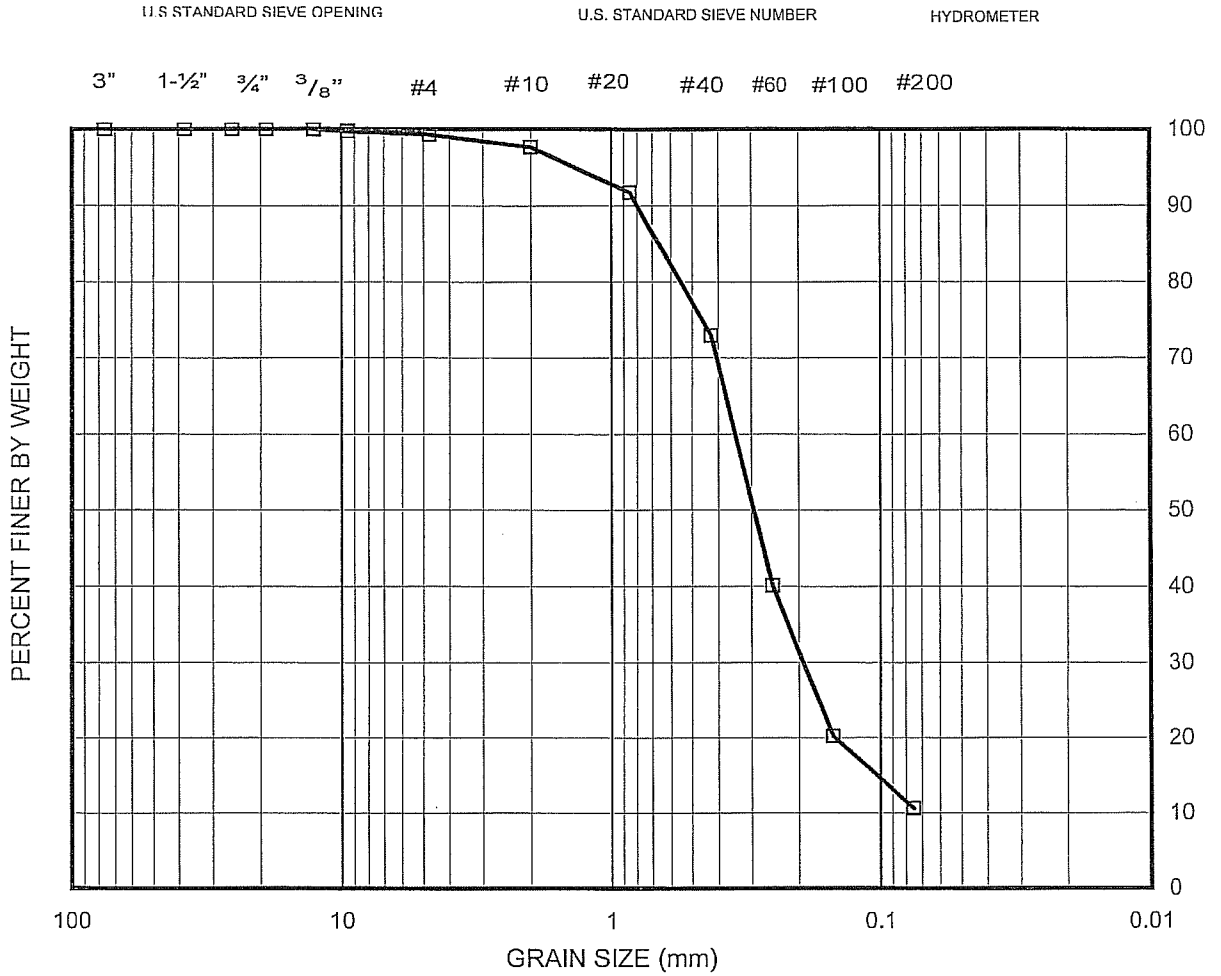
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-032	S-20	120	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

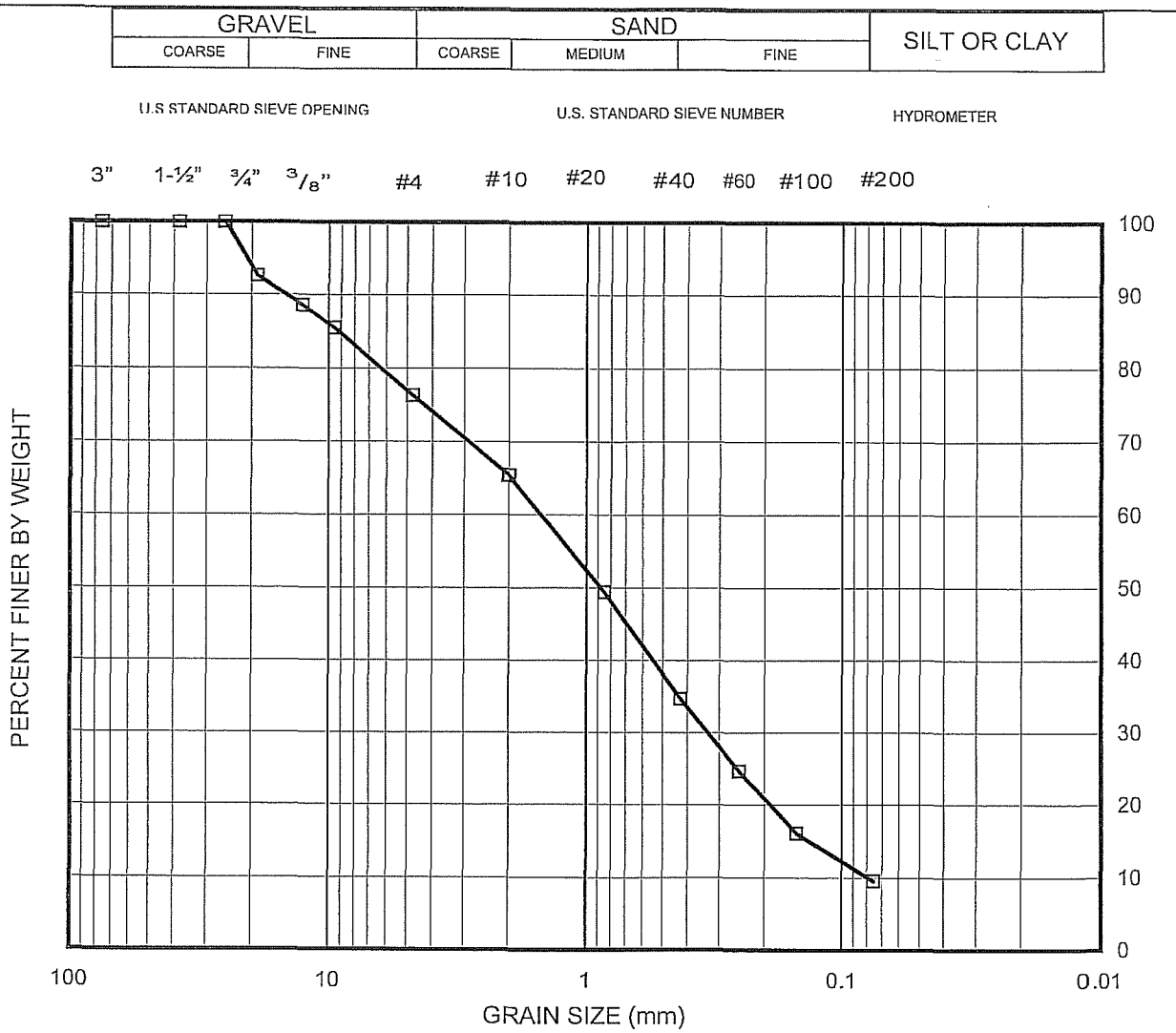
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE



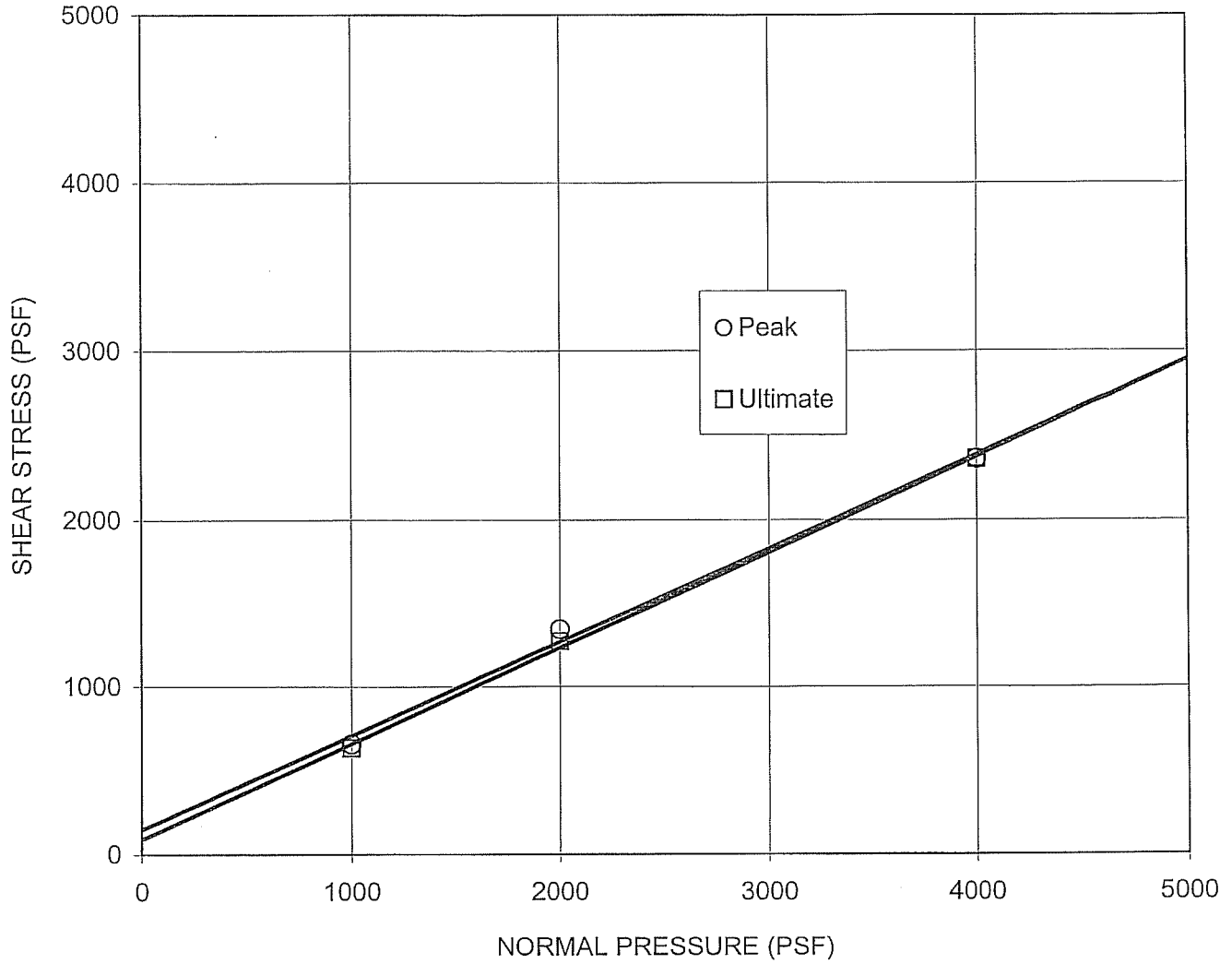
SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-032	S-23	150	Bag	SW-SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-032	D-02	10	Ring	SM	○	150	29
					□	90	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	29.6	36.8
2000	29.6	36.0
4000	29.6	35.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

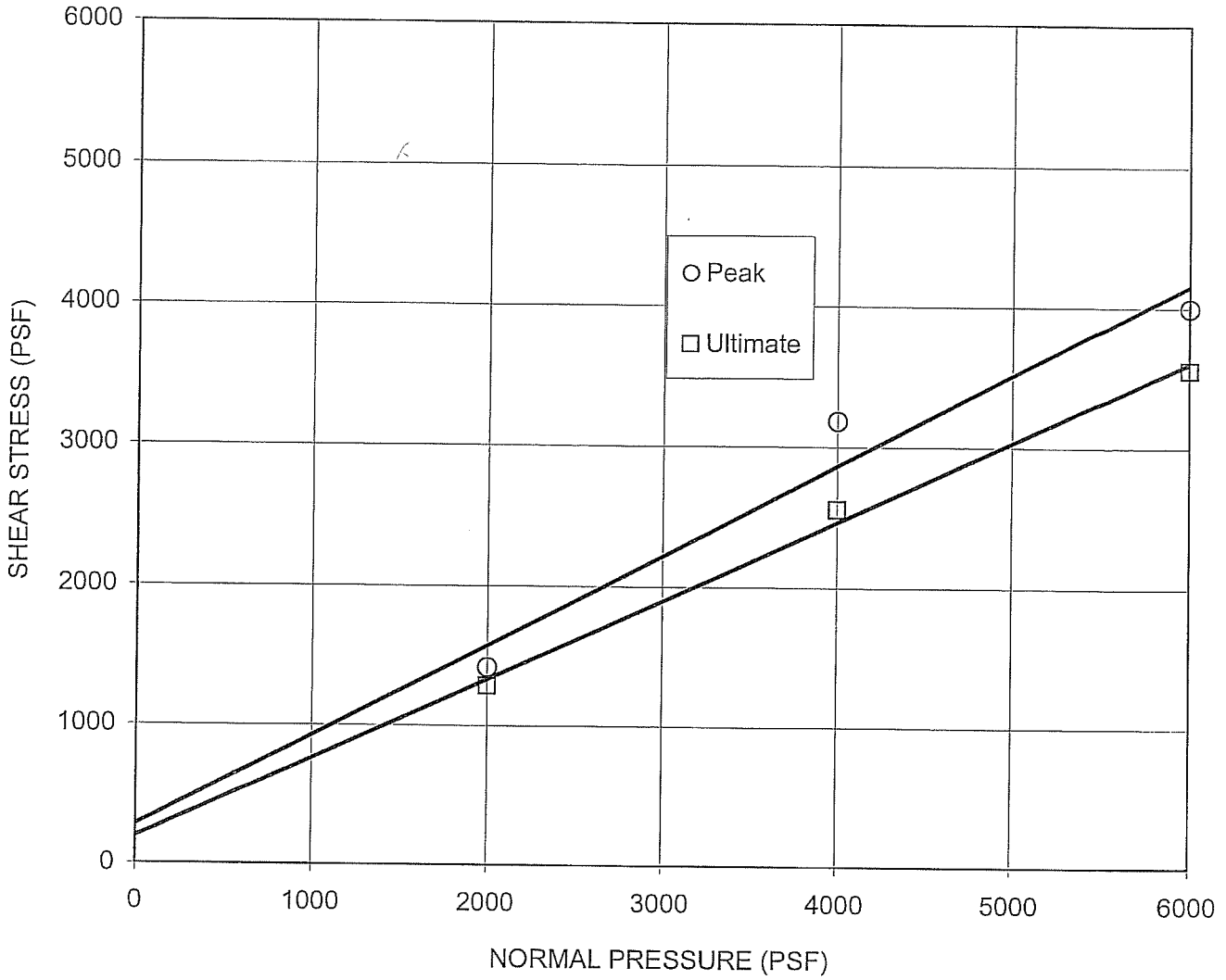
Client: Earth Mechanics, Inc.

Project No: 06-123-03

EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-032	D-06	30	Ring	SM	○	284	33
					□	196	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2000	28.9	32.9
4000	28.9	28.4
6000	28.9	25.9

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-034	D-04	20	24.1	98.5
R-09-034	S-05	25	26.6	NA
R-09-034	S-07	35	33.5	NA
R-09-034	D-12	60	26.7	117.8
R-09-034	S-13	65	26.6	NA
R-09-034	D-16	80	21.1	98.3
R-09-034	S-18	100	34.9	NA
R-09-034	S-20	120	13.3	NA
R-09-034	S-22	150	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-034	D-02	10	0.31
R-09-034	U-03	16	1.38
R-09-034	D-12	60	2.96

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-034	S-05	25	45.21
R-09-034	D-06	30	5.96
R-09-034	S-07	35	41.20
R-09-034	D-10	50	42.15
R-09-034	D-12	60	58.30
R-09-034	S-15	75	13.73

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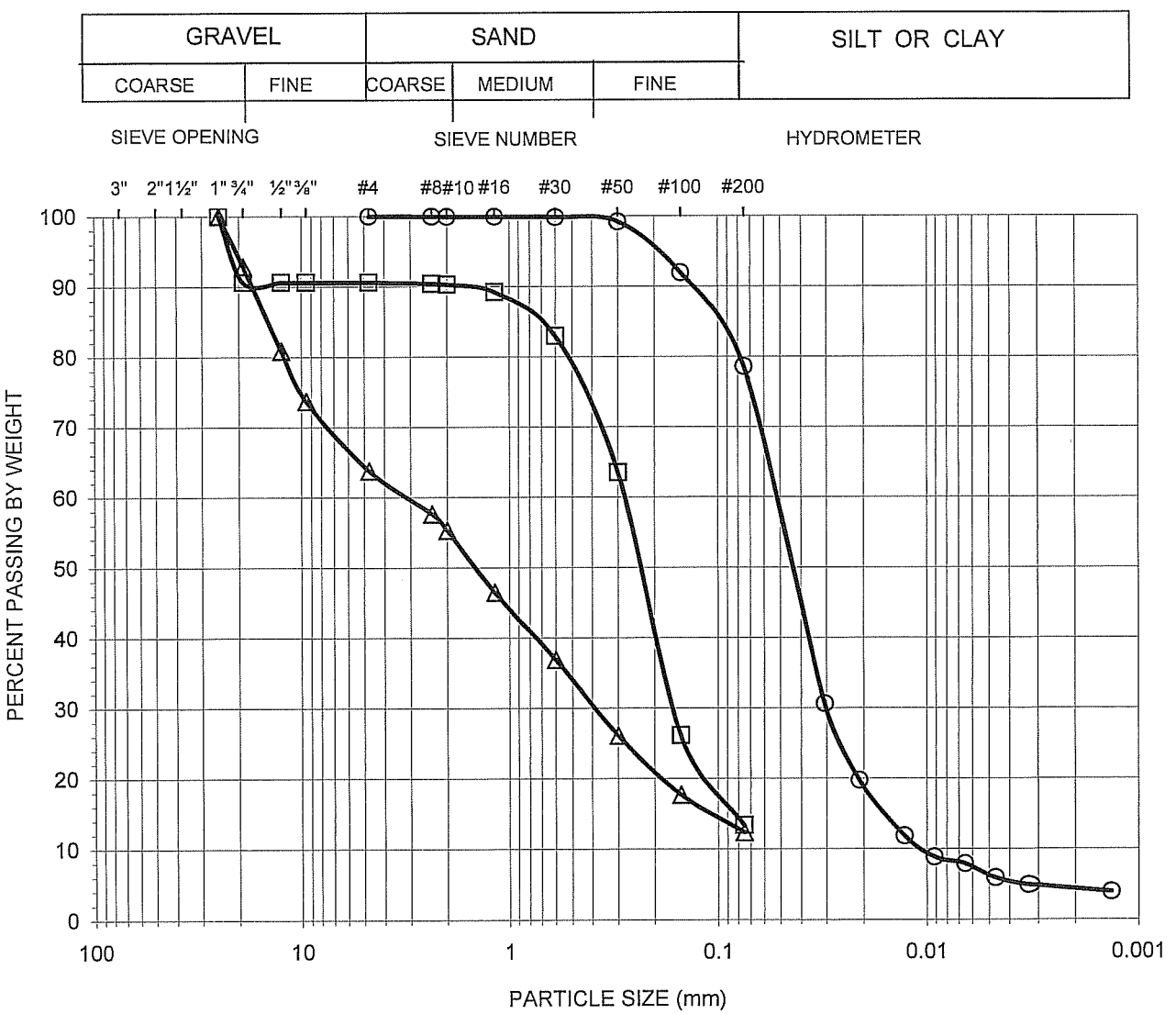
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



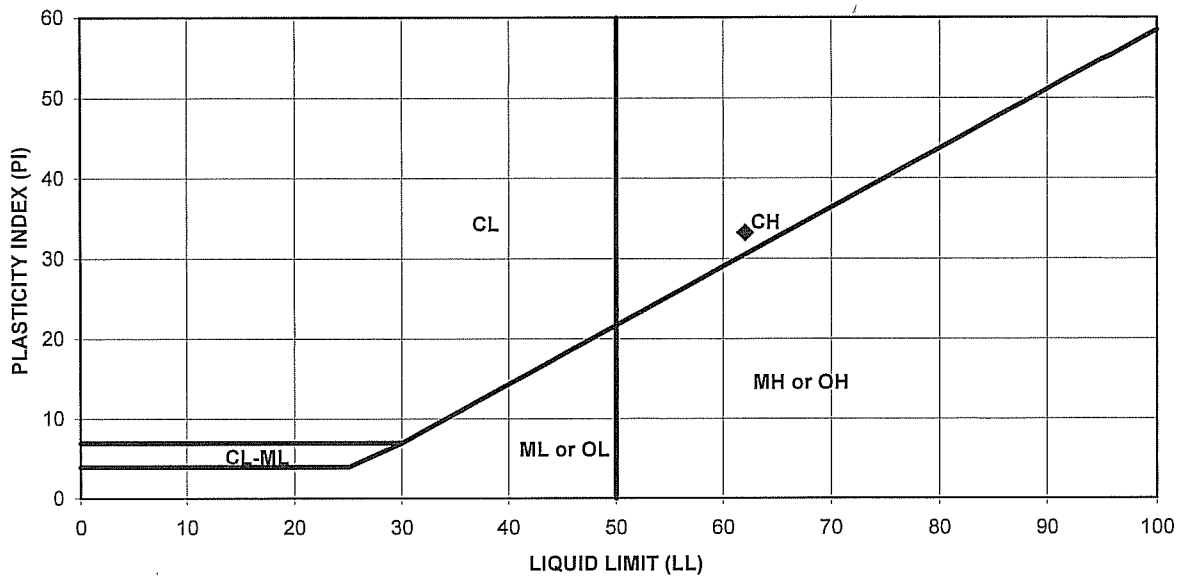
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-034	U-03	16	0.00	21.36	78.64	N/P	ML
□	R-09-034	S-18	100	9.40	77.23	13.37	N/A	SM
△	R-09-034	S-22	150	36.20	51.38	12.42	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

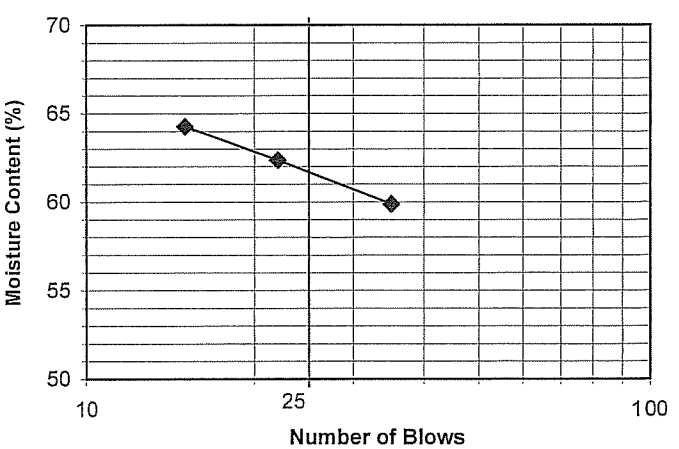
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-034	D-02	10	62	29	33	CH
	R-09-034	U-03	16	NP	NP	NP	

* NP denotes "non-plastic"

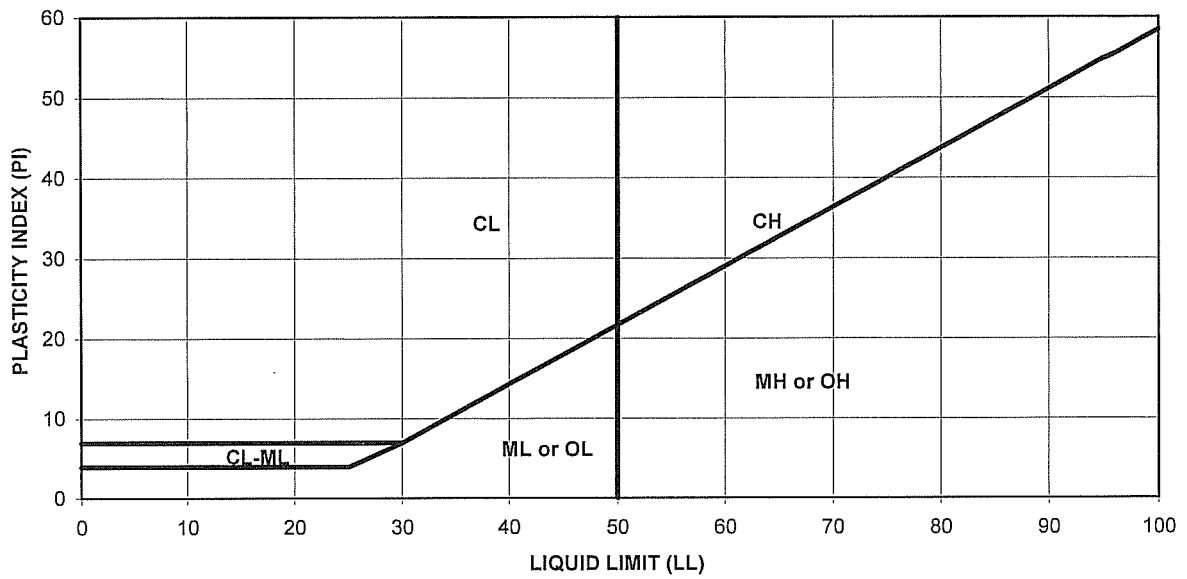
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

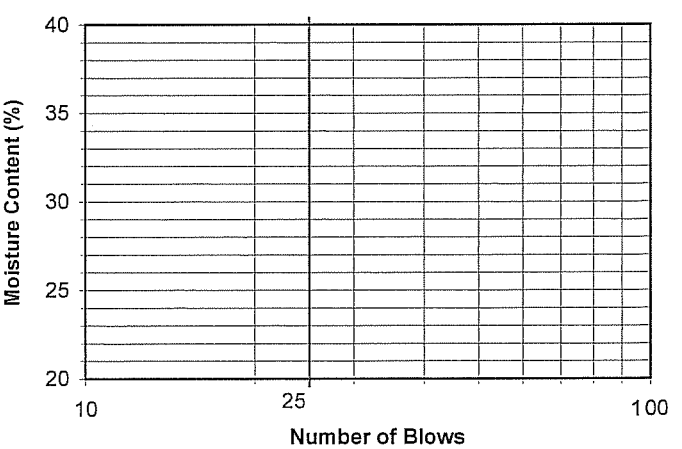
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/01/09



PROCEDURE USED

- ☐ Wet Preparation
- ☒ Dry Preparation
- ☒ Procedure A Multipoint Test
- ☐ Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-034	S-07	35	NP	NP	NP	

* NP denotes "non-plastic"

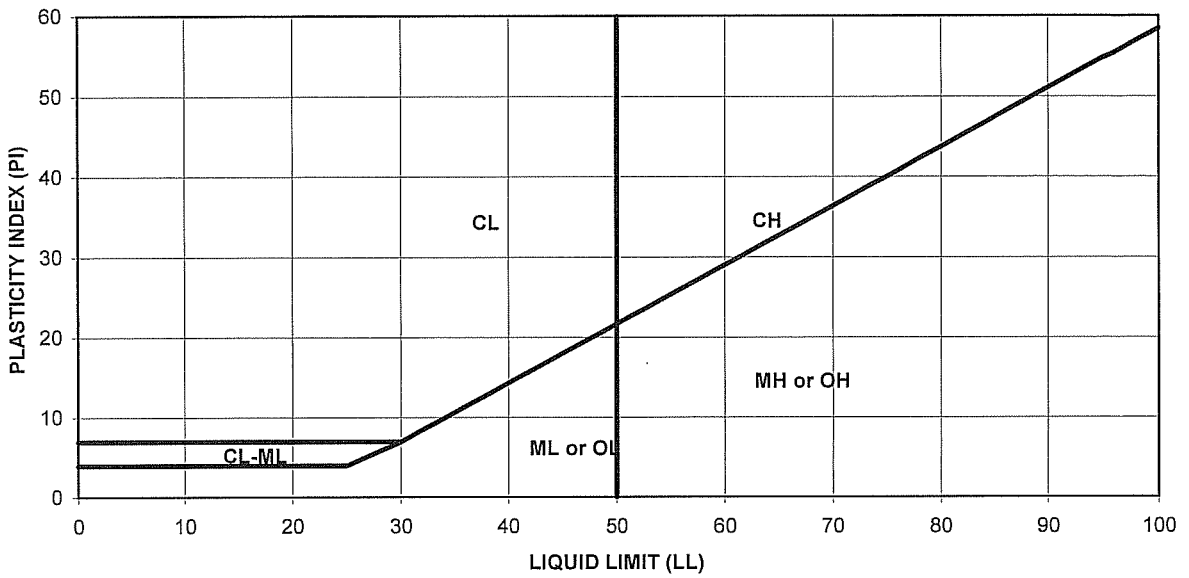
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

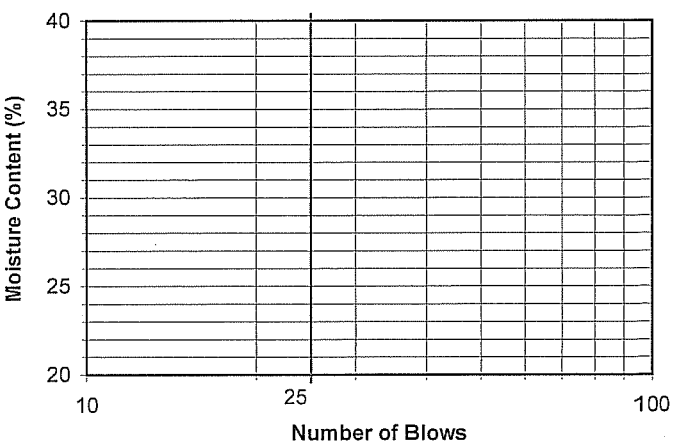
Tested By: WJO
Checked By: AP

Date: 01/06/10
Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-034	D-12	60	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/25/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-034					
SAMPLE NUMBER	U-03					
DEPTH (FT)	16					
SOIL CLASSIFICATION	Silt with sand					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	388.13					
TEMPERATURE, °C	20.0					
CORRECTION FACTOR	1.0000					
WT. DRY SOIL, g	41.27					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.72**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/16/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-034	D-02	10	CH	470	7.7	107	1281
R-09-034	S-07	35	SM	620	7.7	915	6316

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/19/09

Boring No.: R-09-034 Checked By: AP Date: 12/01/09

Sample No.: D-06 Depth (ft): 30

Description: Gray Poorly-Graded Sand w/silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	586.70
Total Ring Weight (g)	139.93
Wet Density (pcf)	123.85
Dry Density (pcf)	99.64

Moisture Determination	Before Test	After Test
Cont. Weight (g)	179.16	104.26
Wet Soil+Cont. (g)	346.93	532.23
Dry Soil+Cont. (g)	314.13	439.98
Moisture Content (%)	24.3	27.5
Degree Saturation	94.8	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

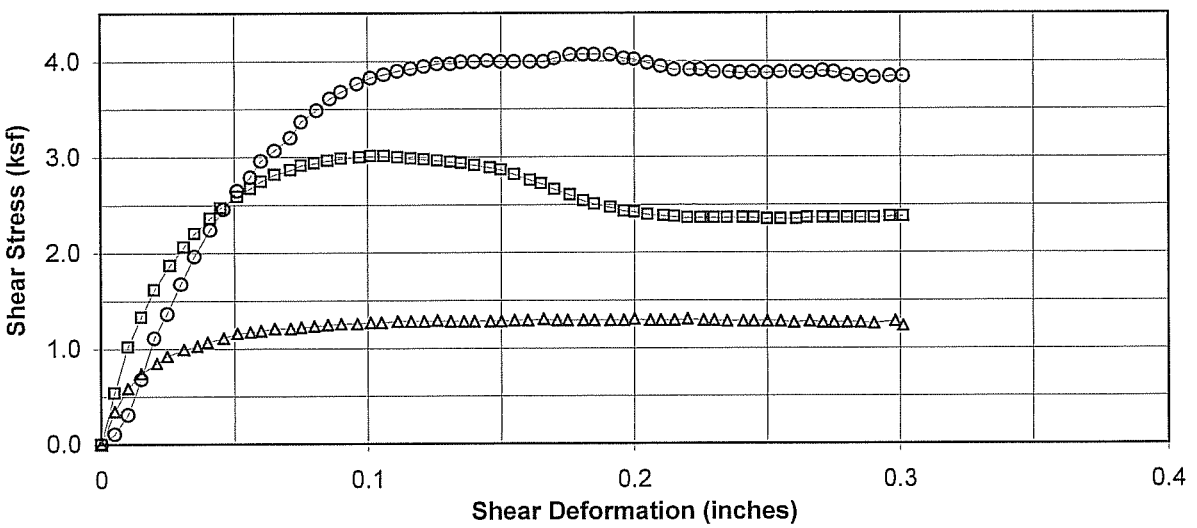
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

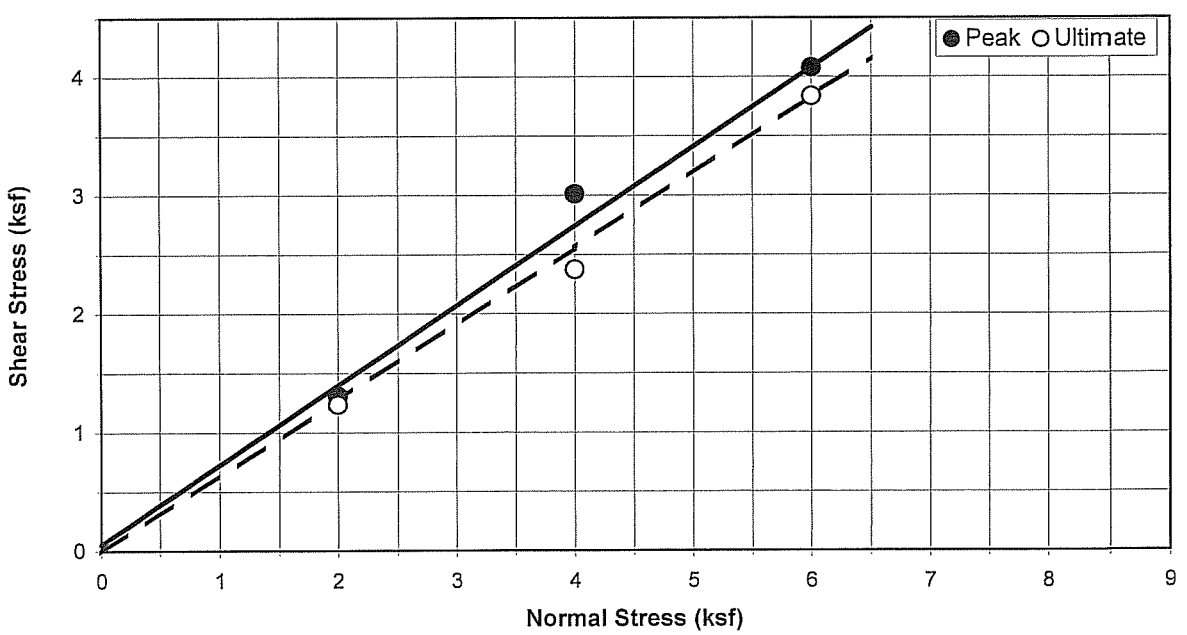
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**196.74**	**47.59**	**2.0**	**1308**	**1236**	
2	**194.81**	**46.29**	**4.0**	**3012**	**2376**	
3	**195.15**	**46.05**	**6.0**	**4080**	**3840**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	99.6	pcf
Boring No.:	R-09-034	Moisture Content (before):	24.3	%
Sample No.:	D-06	Moisture Content (after):	27.5	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	34 °	33 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/19/09

Boring No.: R-09-034 Checked By: AP Date: 12/01/09

Sample No.: D-08 Depth (ft): 40

Description: Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	576.23
Total Ring Weight (g)	133.93
Wet Density (pcf)	122.61
Dry Density (pcf)	94.17

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.44	104.78
Wet Soil+Cont. (g)	201.97	530.31
Dry Soil+Cont. (g)	166.82	431.86
Moisture Content (%)	30.2	30.1
Degree Saturation	98.8	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

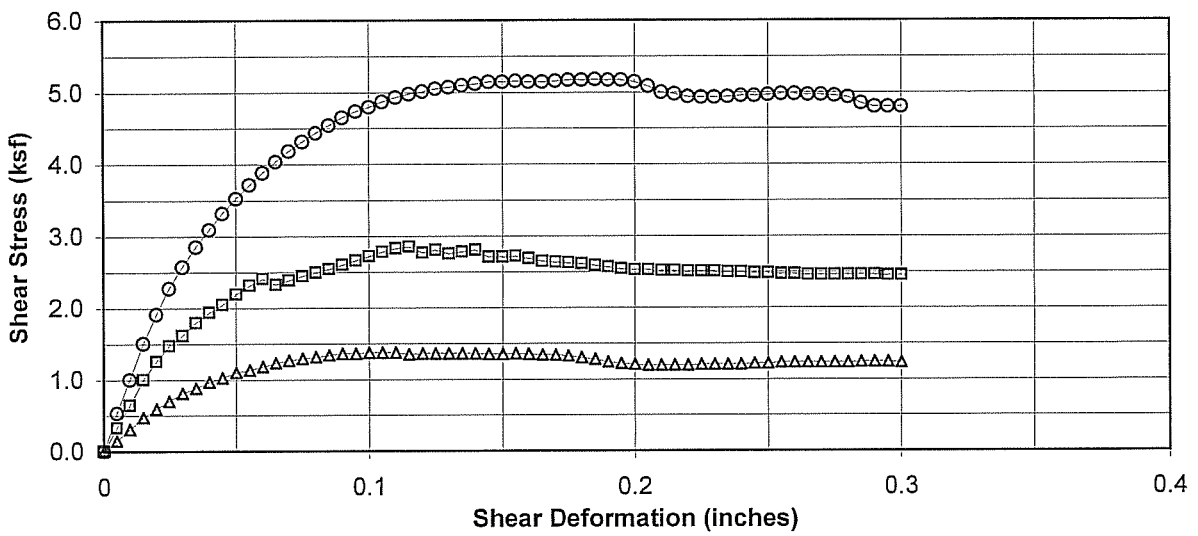
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

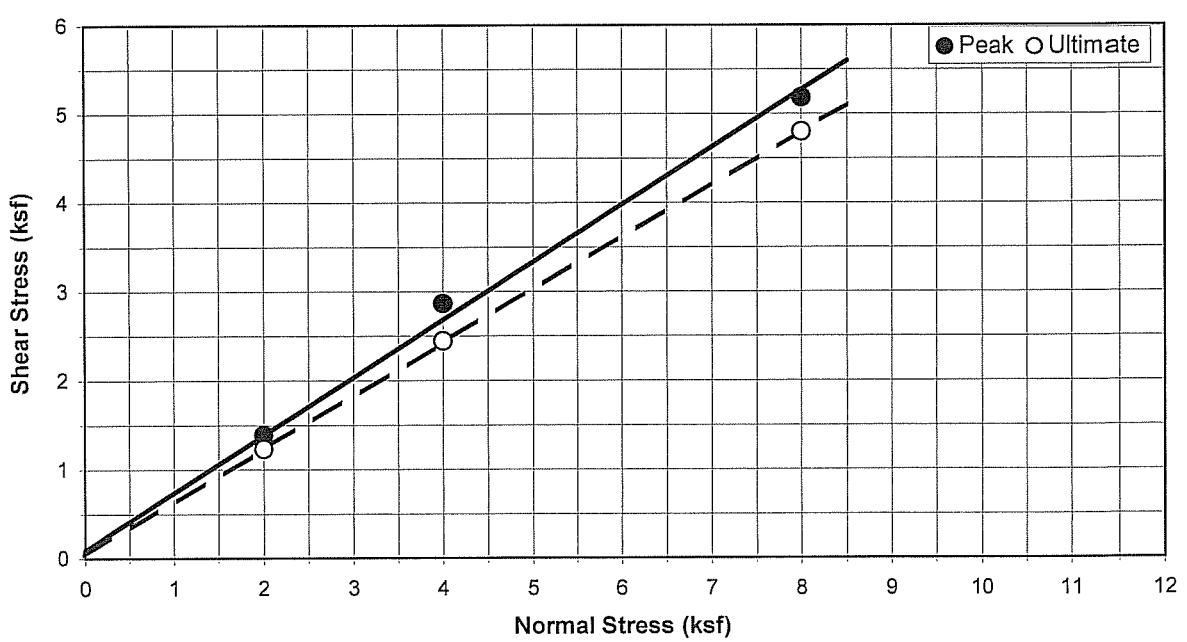
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**192.96**	**43.62**	**2.0**	**1392**	**1236**	
2	**193.96**	**46.65**	**4.0**	**2868**	**2448**	
3	**189.31**	**43.66**	**8.0**	**5184**	**4800**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.2	pcf
Boring No.:	R-09-034	Moisture Content (before):	30.2	%
Sample No.:	D-08	Moisture Content (after):	30.1	%
Depth (ft):	40			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	100	50
Friction Angle:	33 °	31 °

AP Engineering & Testing, Inc.

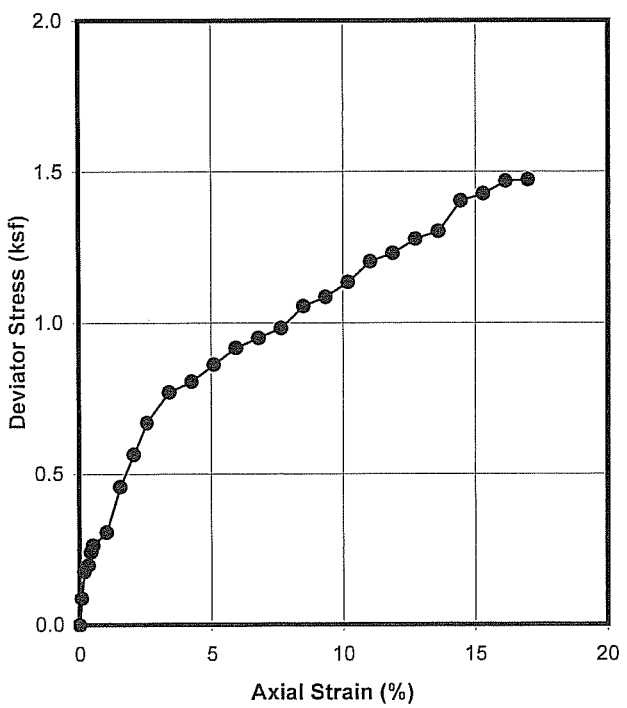
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-034		
Sample No.:	U-03 Depth (feet): 16		
Soil Description	Gray Silt with sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	117.9
Sample Hieght (inch):	5.9	Dry Unit Weight (pcf):	87.7
Sample Weight (gms):	1182.02	Moisture Content (%):	34.4
Wt. Wet Soil+Container(gms)	1373.35	Void Ratio for Gs=2.7:	0.92
Wt. Dry Soil+Container(gms)	1071.47	% Saturation:	100.9
Wt. Container (gms)	194.37		

TEST DATA

Cell Pressure (ksf):	0.72
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	0.72
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.5
Ultimate Deviator Stress (ksf):	1.4
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	17.01



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
4	0.005	6.50	0.09	0.09
8	0.010	6.50	0.18	0.17
9	0.020	6.51	0.20	0.34
11	0.025	6.52	0.24	0.43
12	0.030	6.53	0.26	0.51
14	0.060	6.56	0.31	1.02
21	0.090	6.59	0.46	1.53
26	0.120	6.63	0.56	2.04
31	0.150	6.66	0.67	2.55
36	0.200	6.72	0.77	3.40
38	0.250	6.78	0.81	4.25
41	0.300	6.84	0.86	5.10
44	0.350	6.90	0.92	5.95
46	0.400	6.97	0.95	6.80
48	0.450	7.03	0.98	7.65
52	0.500	7.10	1.06	8.50
54	0.550	7.16	1.09	9.35
57	0.600	7.23	1.14	10.20
61	0.650	7.30	1.20	11.05
63	0.700	7.37	1.23	11.90
66	0.750	7.44	1.28	12.76
68	0.800	7.51	1.30	13.61
74	0.850	7.59	1.40	14.46
76	0.900	7.67	1.43	15.31
79	0.950	7.74	1.47	16.16
80	1.000	7.82	1.47	17.01

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-035	S-01	5.0	25.4		9.3	
R-09-035	D-02	10.0				38,29,10
R-09-035	U-03	15.0				28,23,5
R-09-035	D-04	20.0	43.1	80.0		
R-09-035	D-06	30.0	33.3	90.2		24,22,2
R-09-035	S-07	35.0			48.8	
R-09-035	D-08	40.0	31.1	92.7		
R-09-035	S-09	45.0	39.7			
R-09-035	U-10	50.0				NP
R-09-035	S-11	55.0	33.4		37.0	
R-09-035	D-12	60.0	21.9	105.4		
R-09-035	S-13	65.0			19.9	
R-09-035	D-14	70.0	27.0	98.7		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-035	D-02	10	7.88	465	0.051	610
R-09-035	S-09	45	8.65	2215	0.056	230

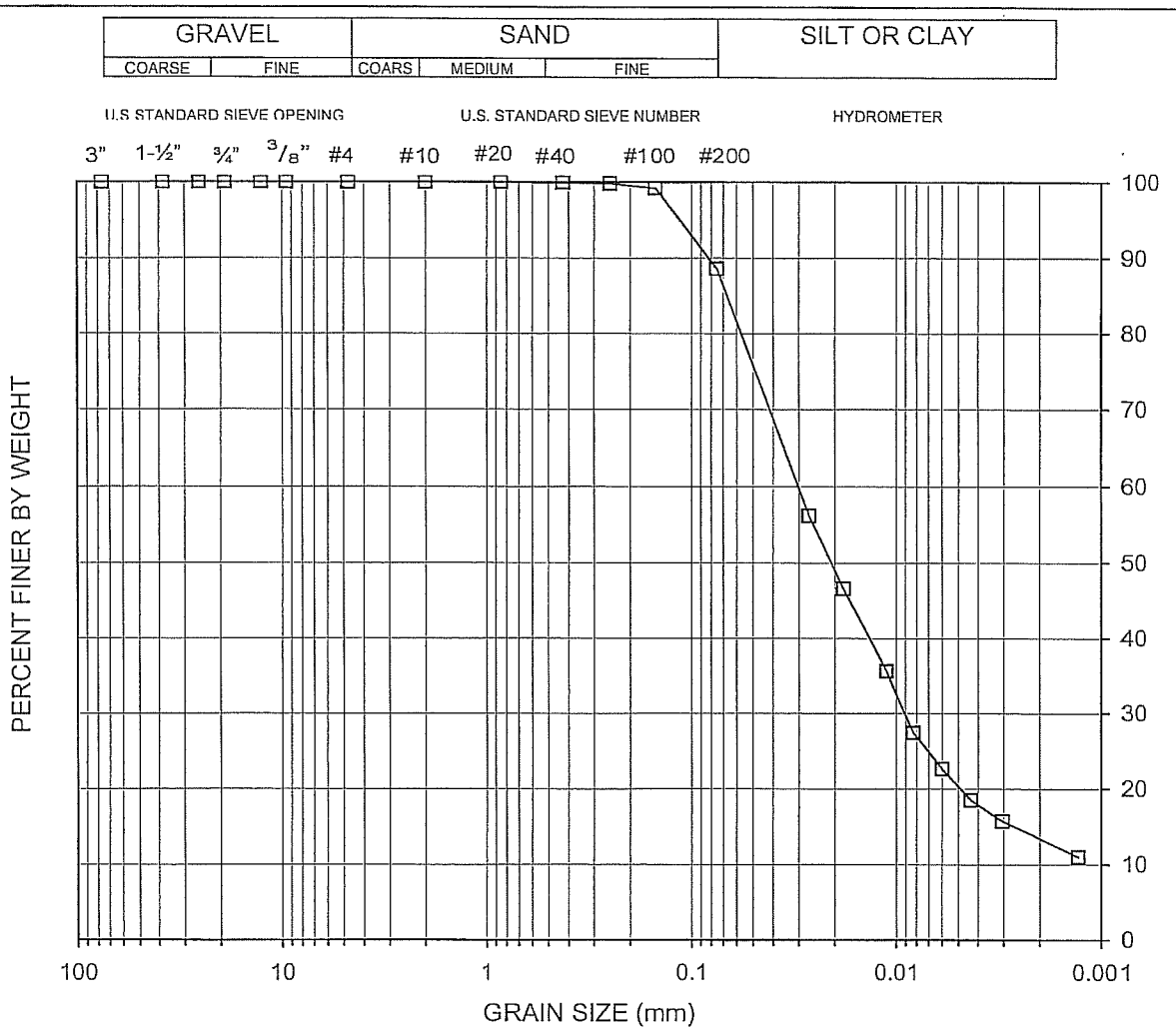
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-035	U-03	15	2.763
R-09-035	U-10	50	2.742



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-03	15	Shelby Tube	ML	28	5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

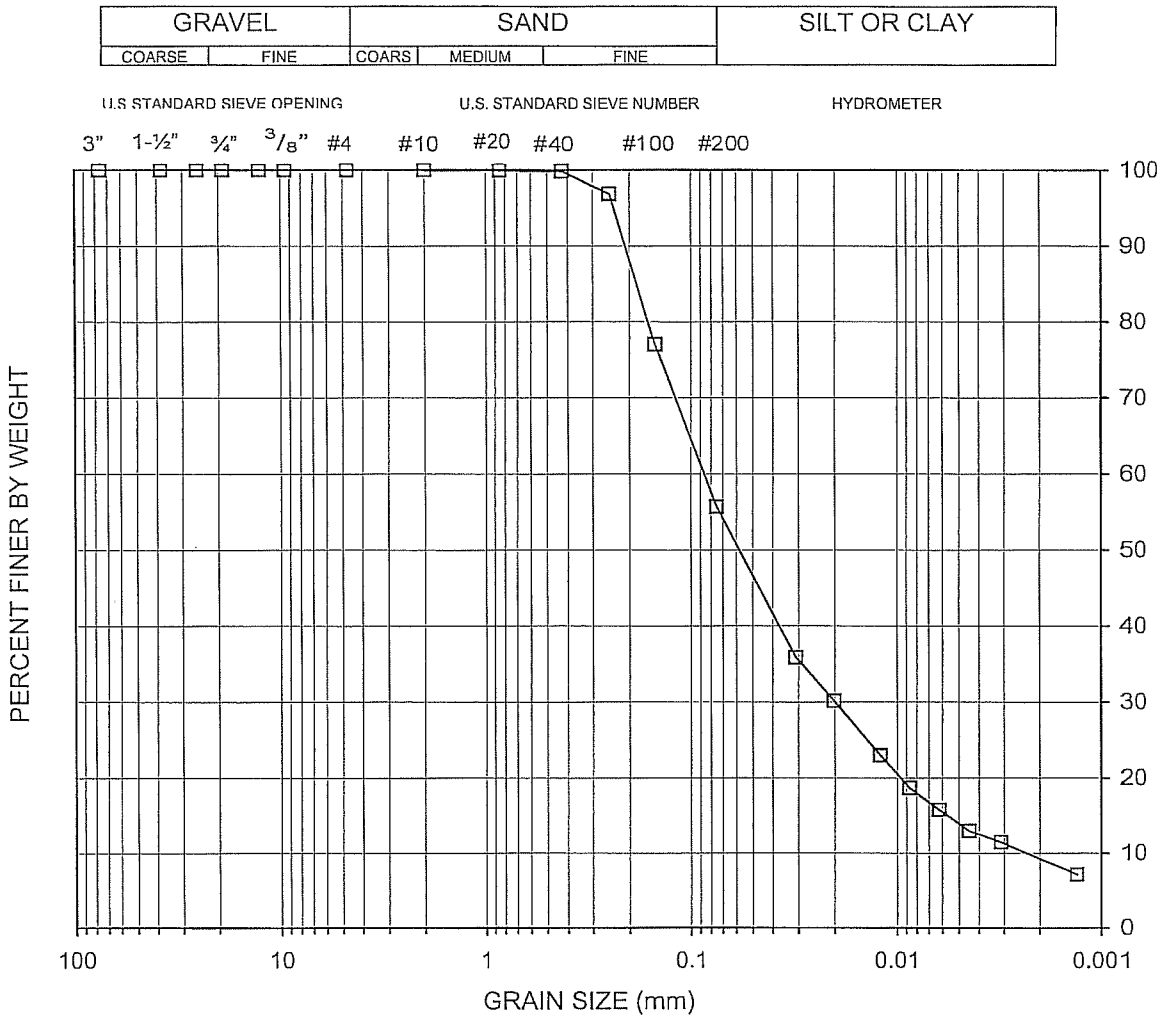
Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-10	50	Shelby Tube	ML	NP	N/A

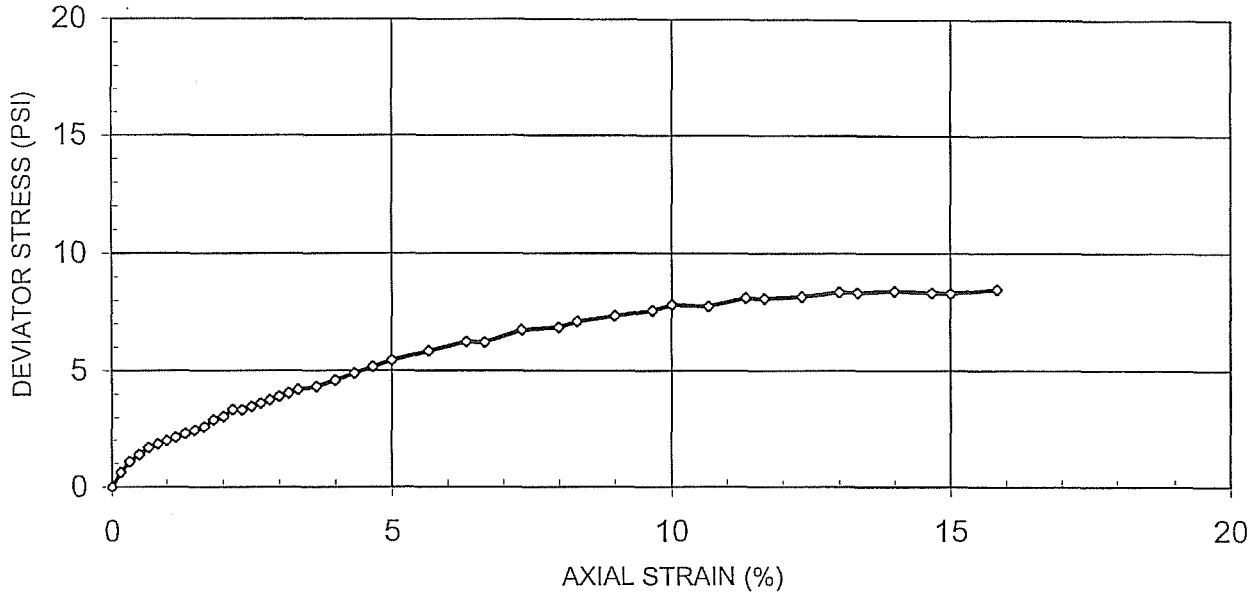
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

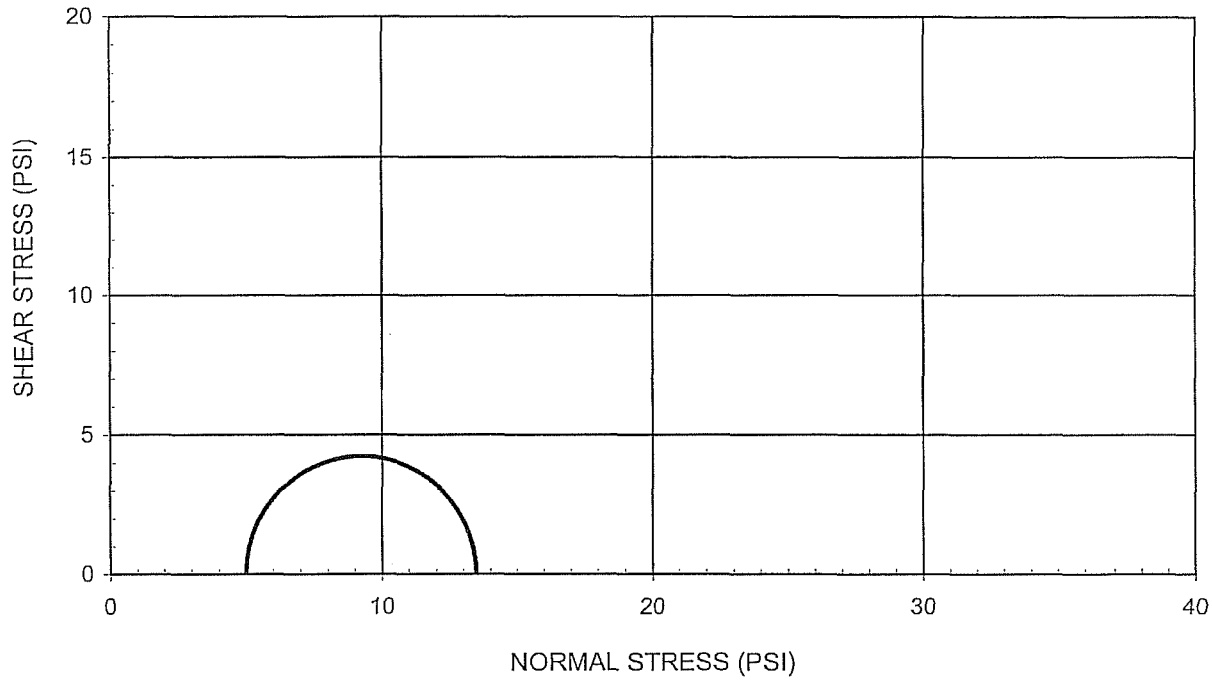
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	15	U-03	ML	Shelby Tube	41.01	80.0	5.0	8.5	0.06	100.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

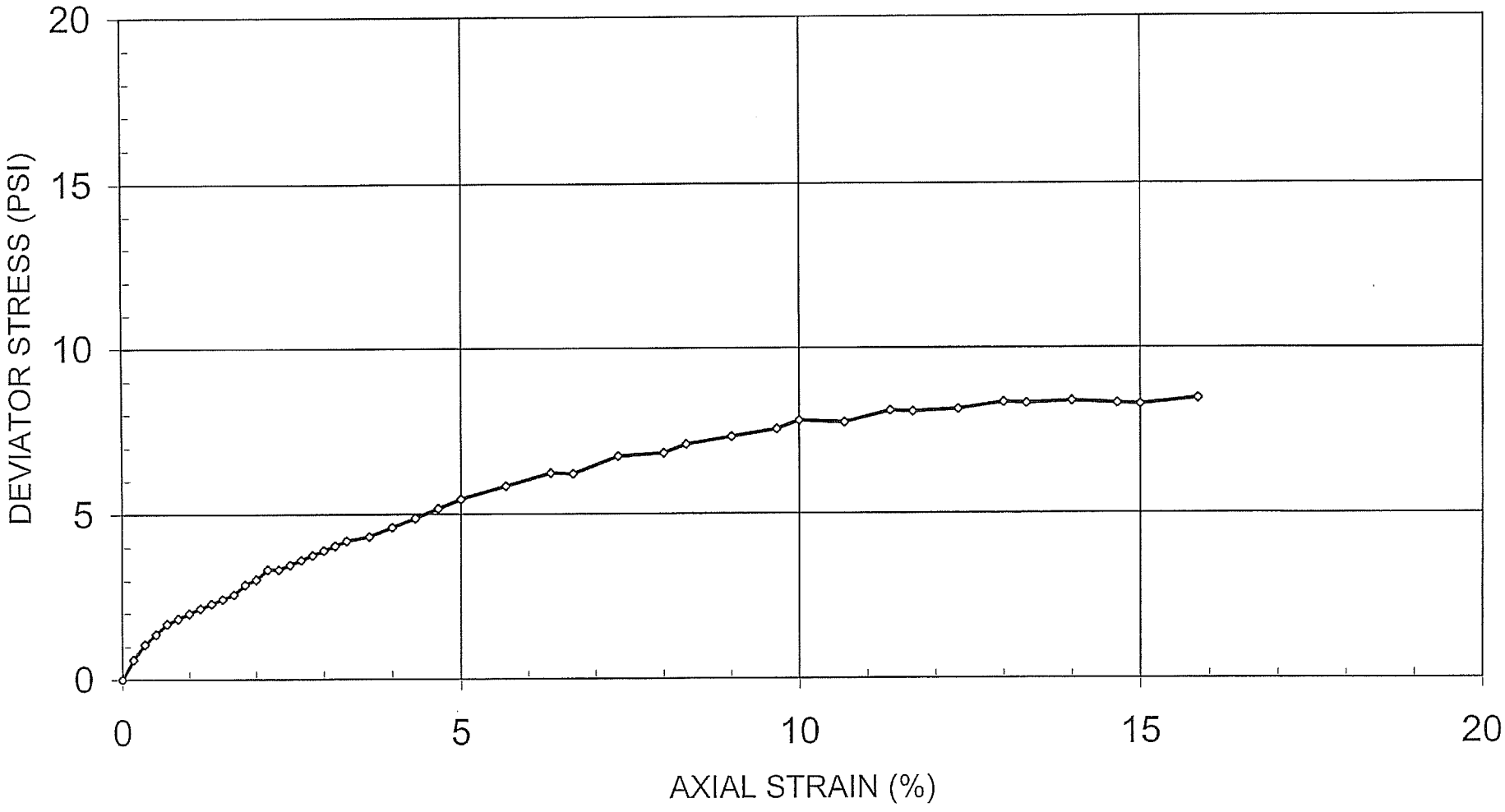
(ASTM D2850)

11/29/09

Figure

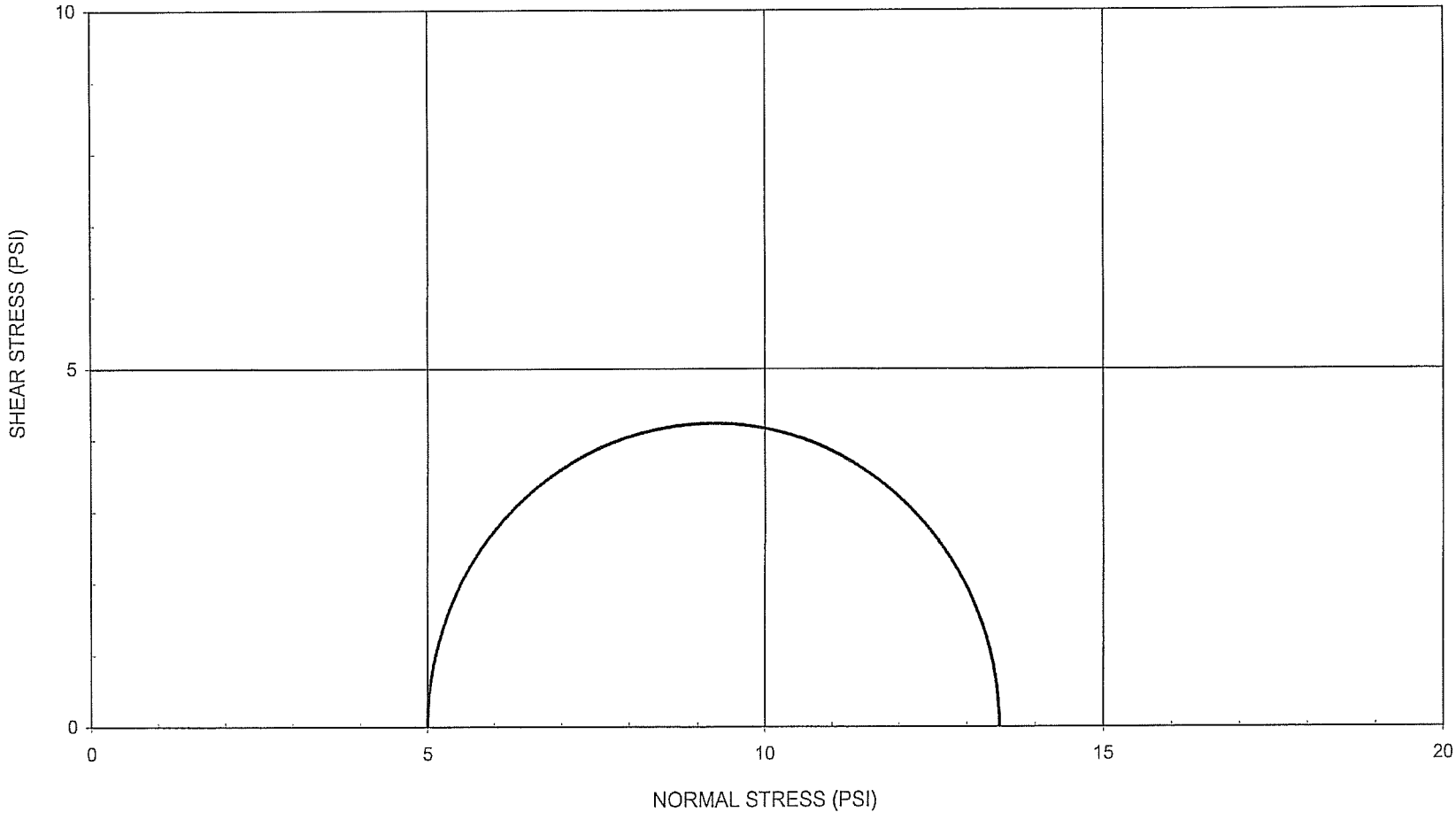
Project Name: ACTA Heim Bridge Replacement

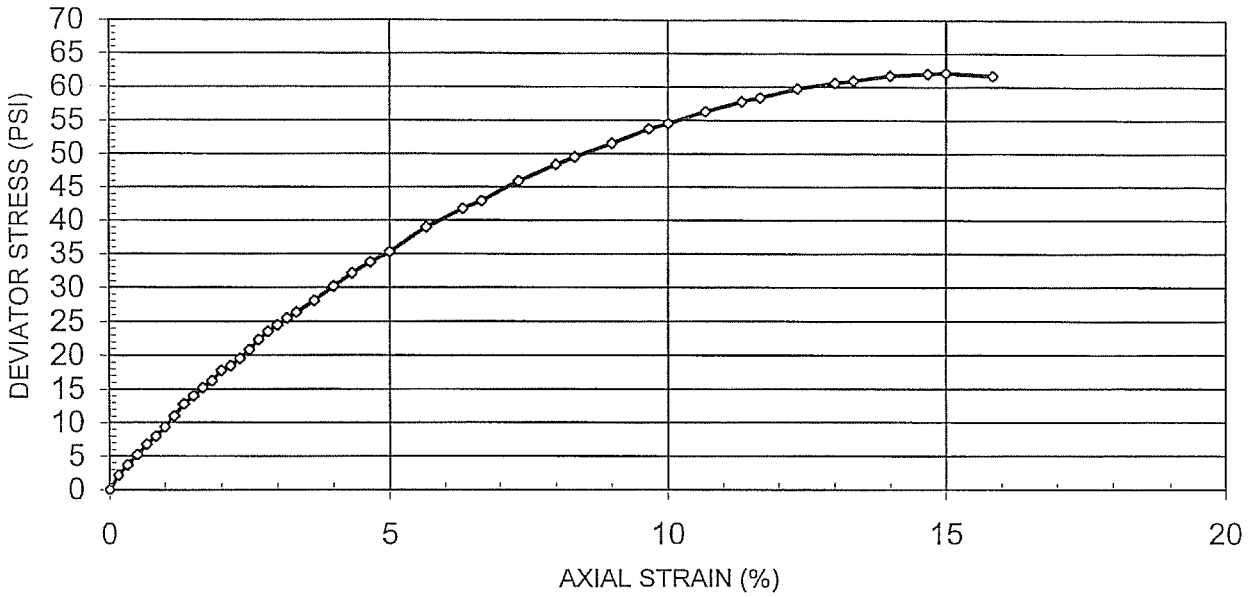
Boring: R-09-035 Sample ID: U-03 Depth (ft): 15

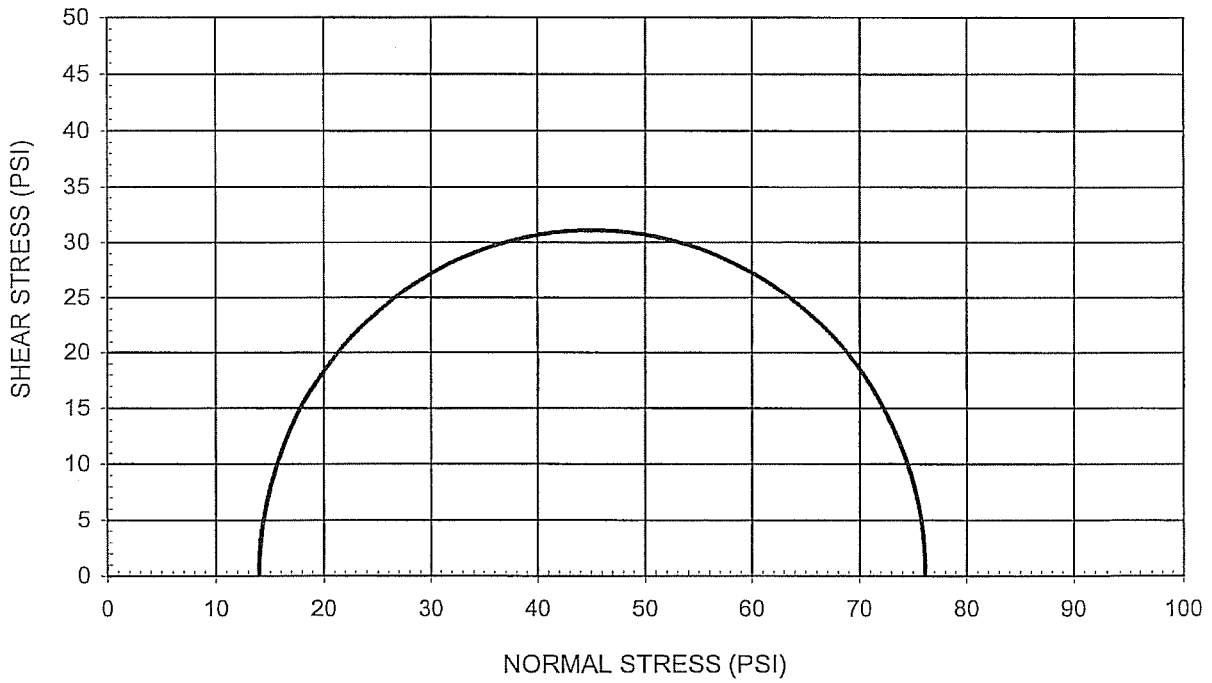


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-03 Depth (ft): 15







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	50	U-10	ML	Shelby Tube	22.25	106.6	14.0	62.1	0.06	103.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

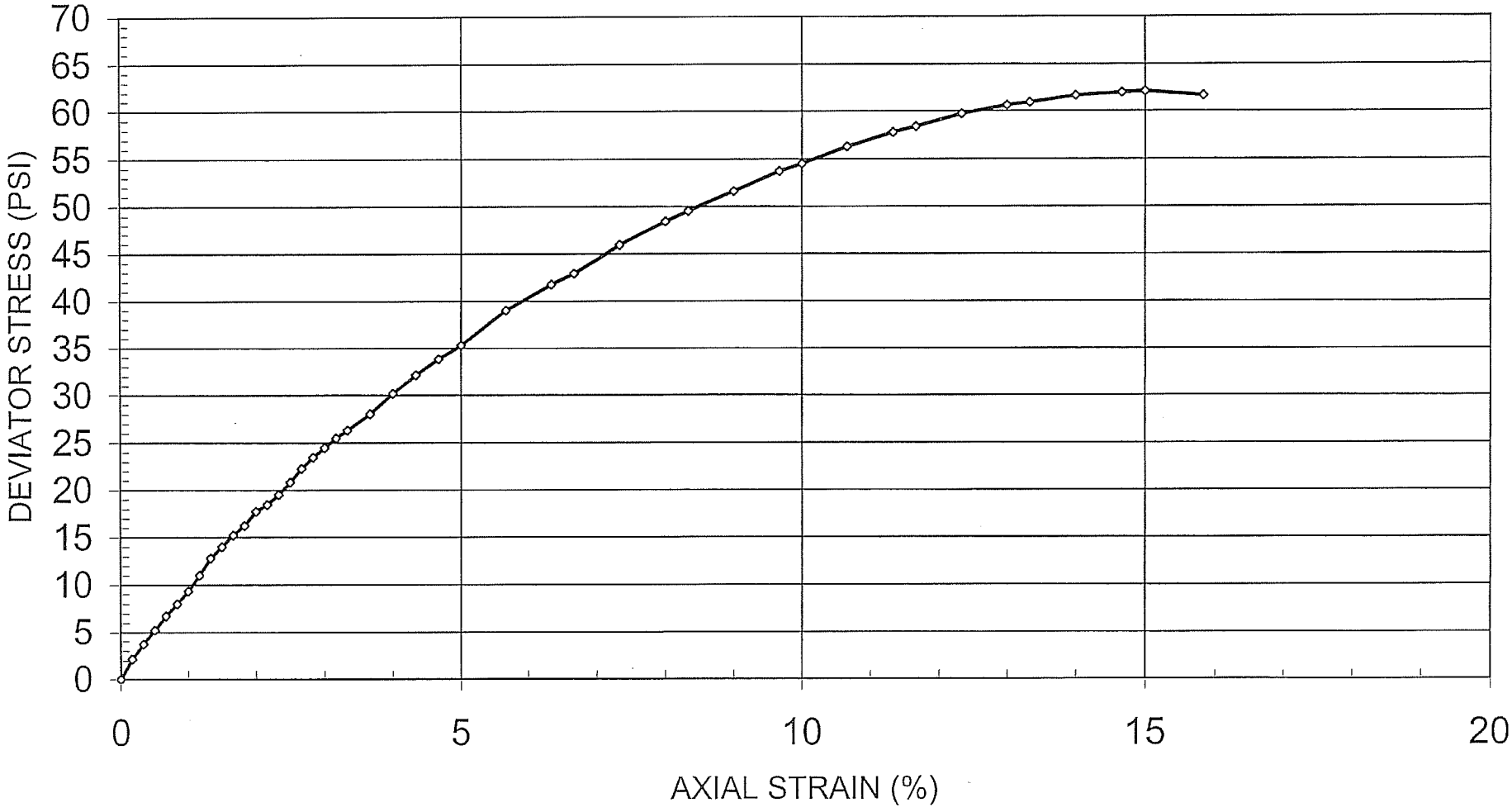
(ASTM D2850)

11/29/09

Figure

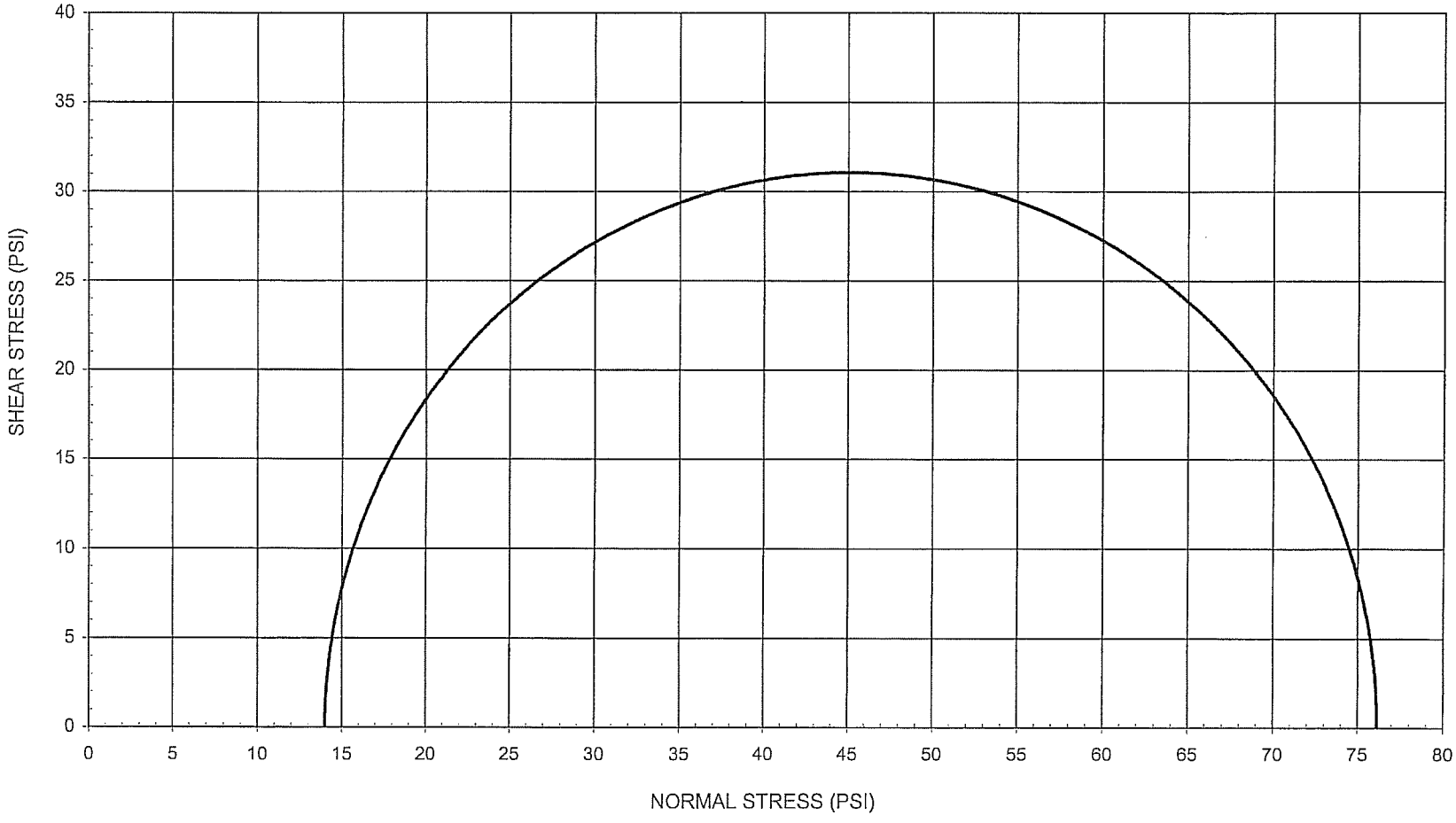
Project Name: ACTA Heim Bridge Replacement

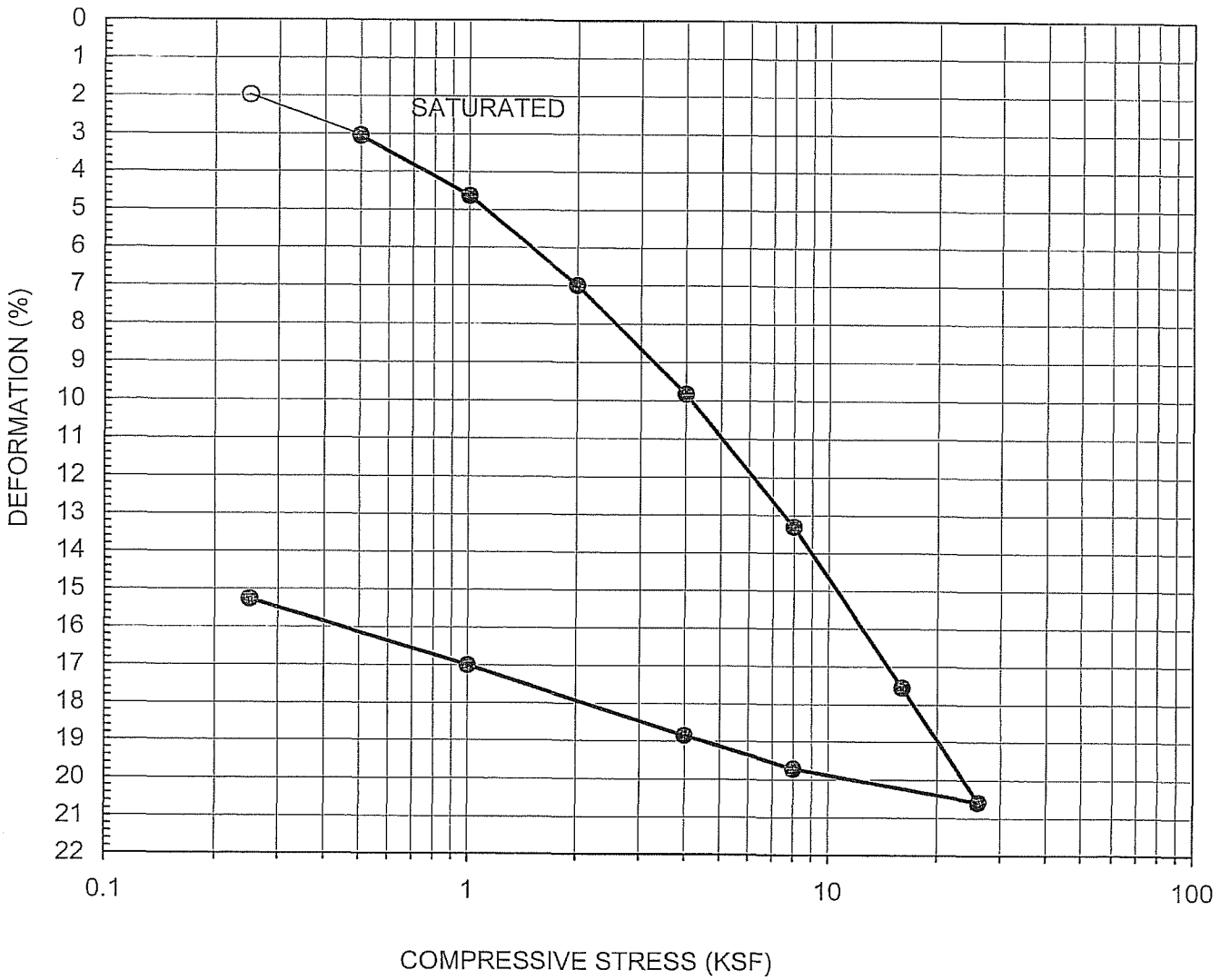
Boring: R-09-035 Sample ID: U-10 Depth (ft): 50



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-10 Depth (ft): 50





Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	D-02	10.0	ML	48.0	73.9	1.279

ENVIRONMENTAL
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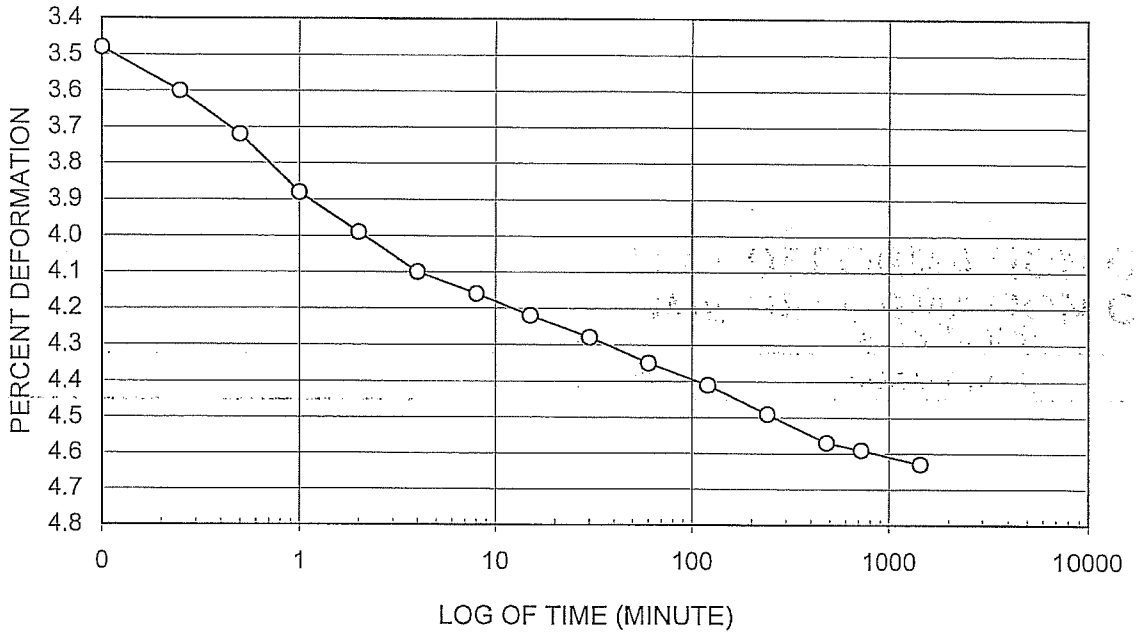
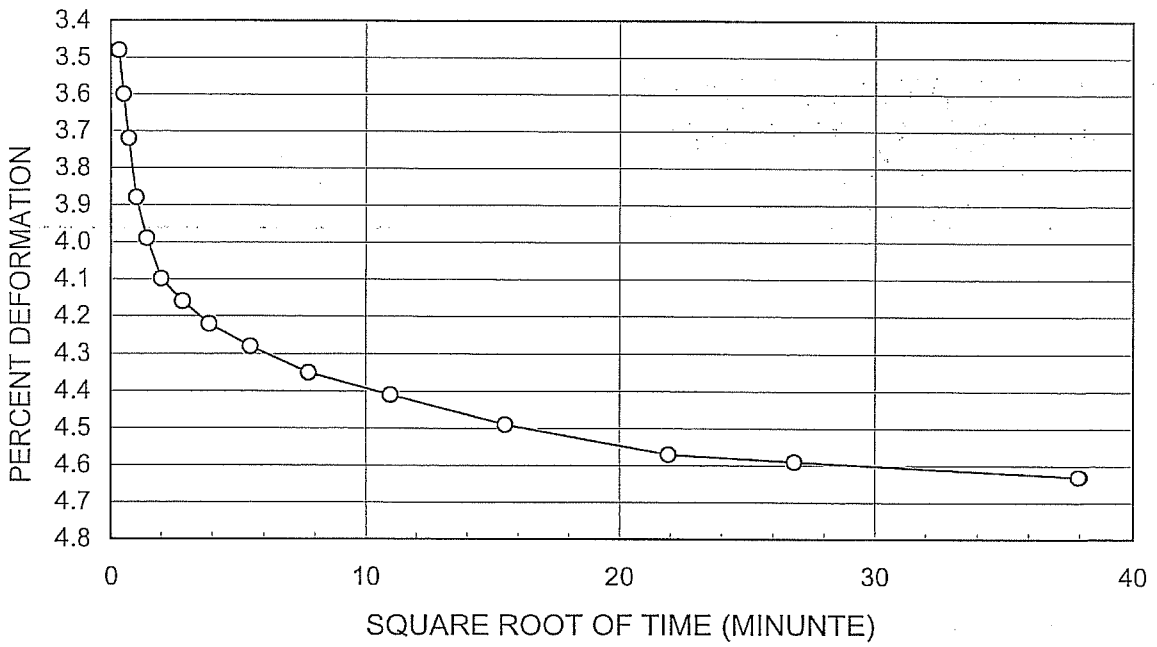
Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





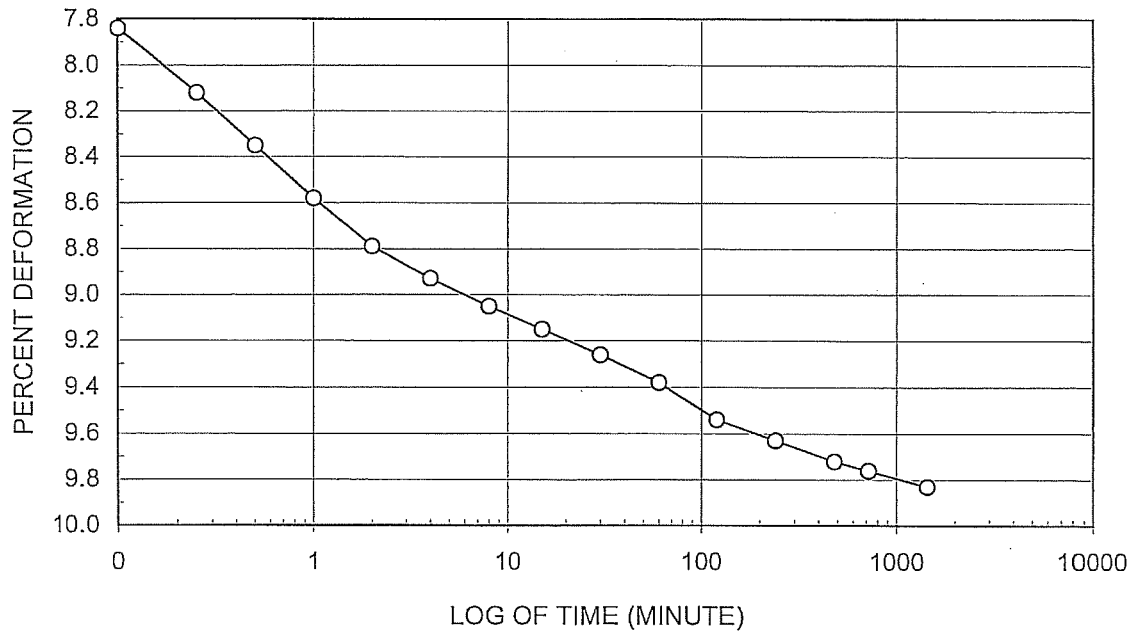
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 1.0 ksf

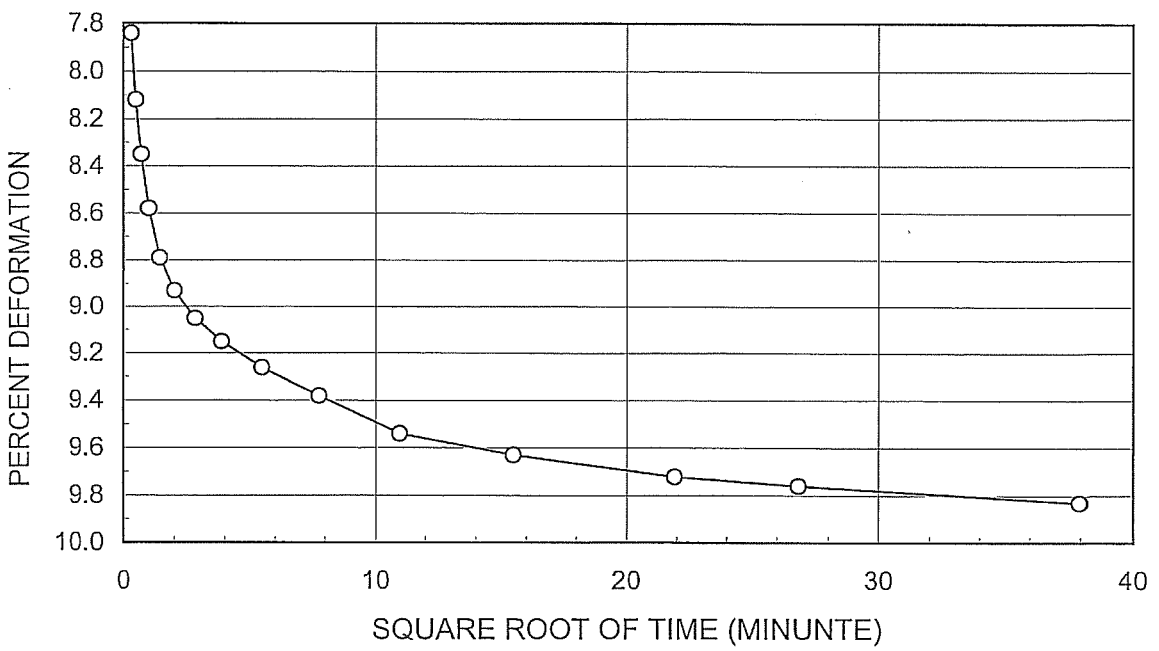
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





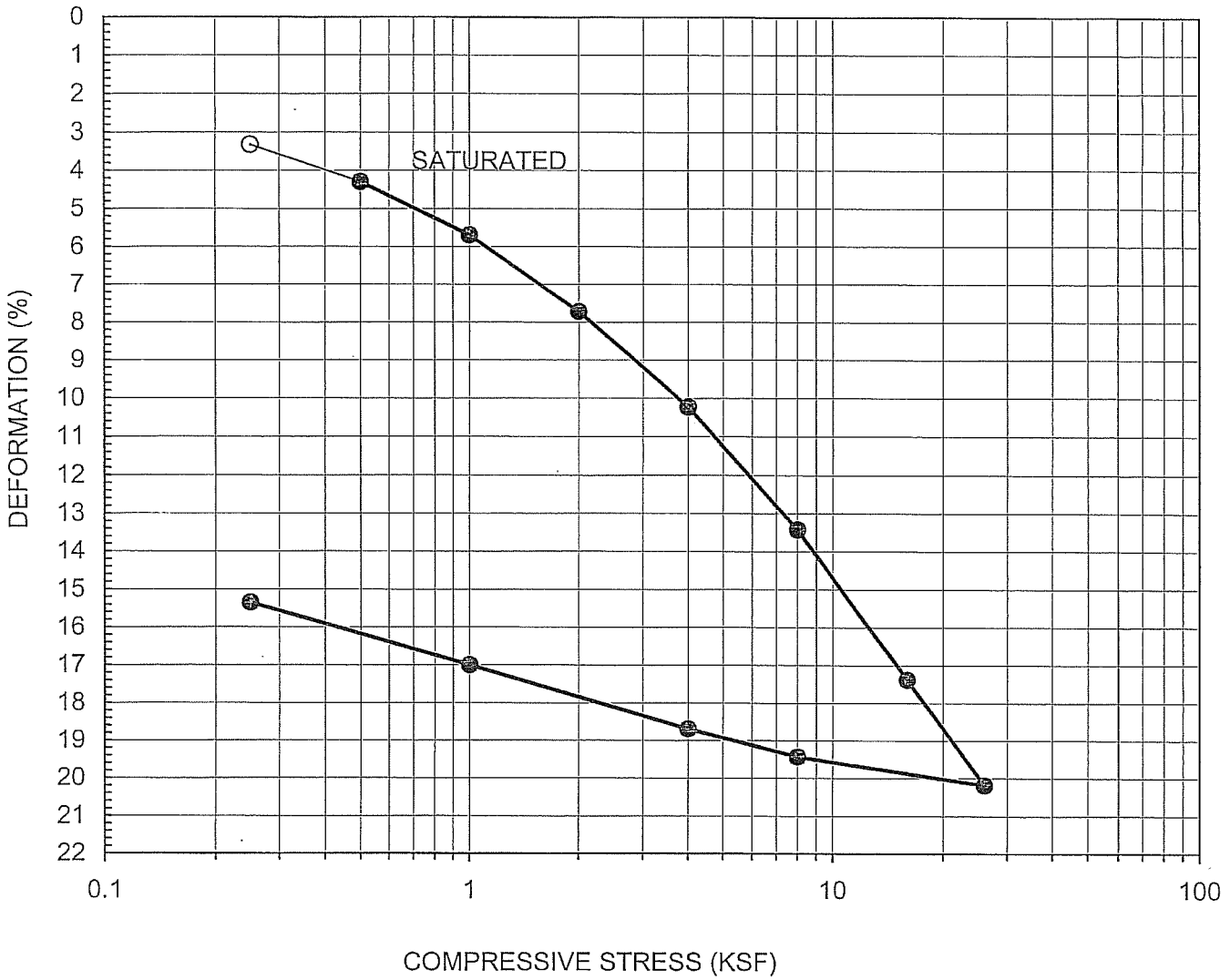
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-03	15.0	ML	40.8	78.1	1.157

ENVIRONMENTAL
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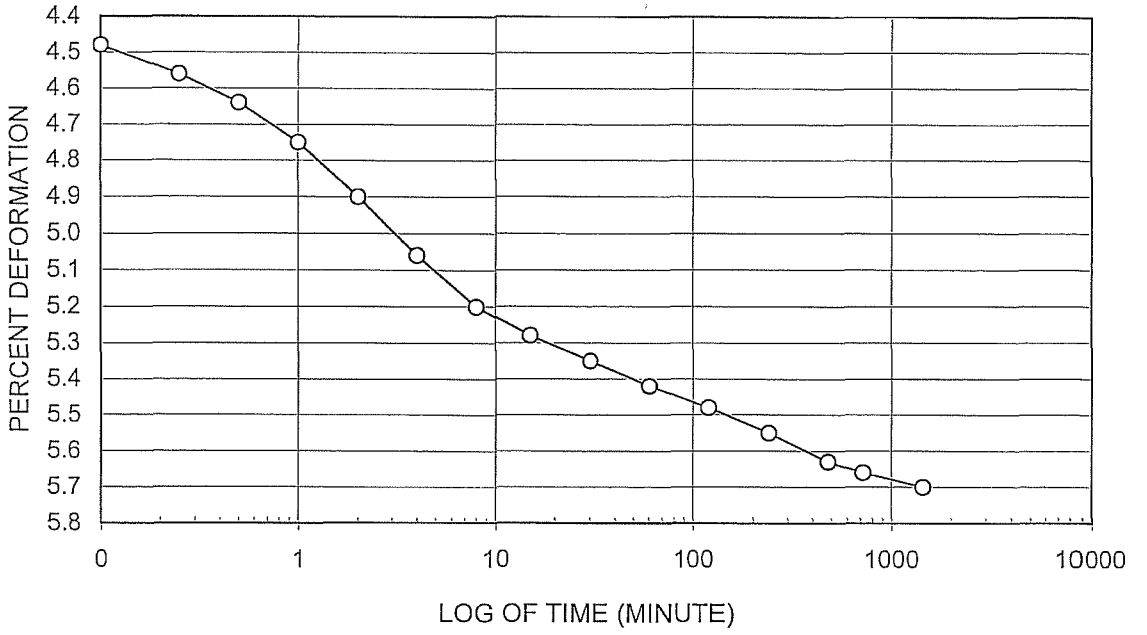
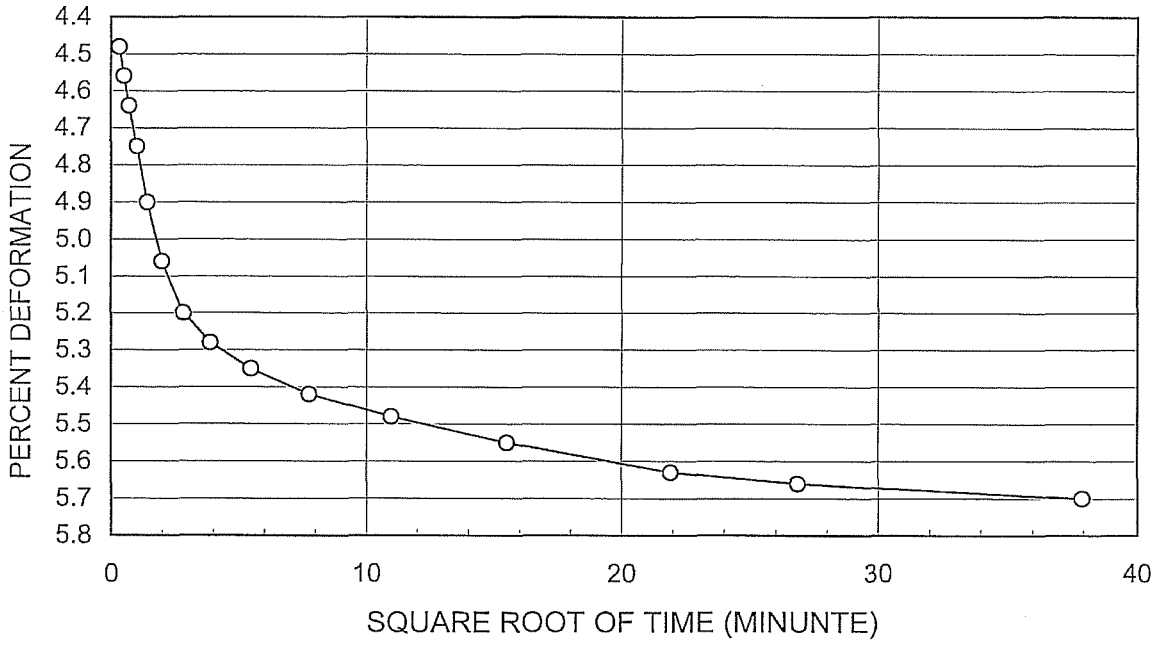
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





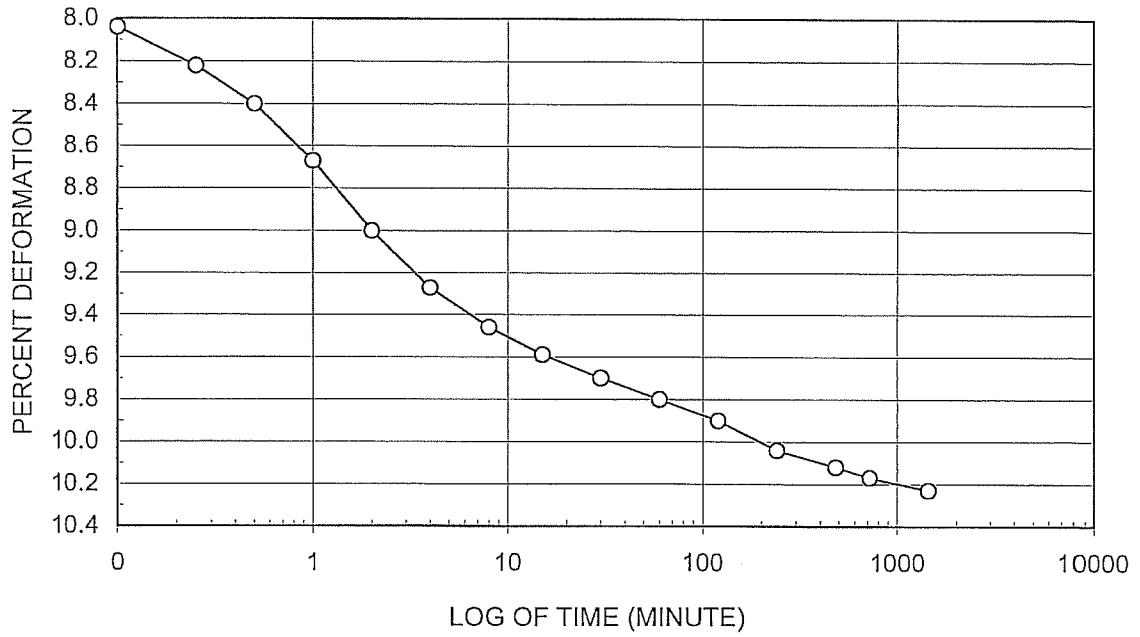
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 1.0 ksf

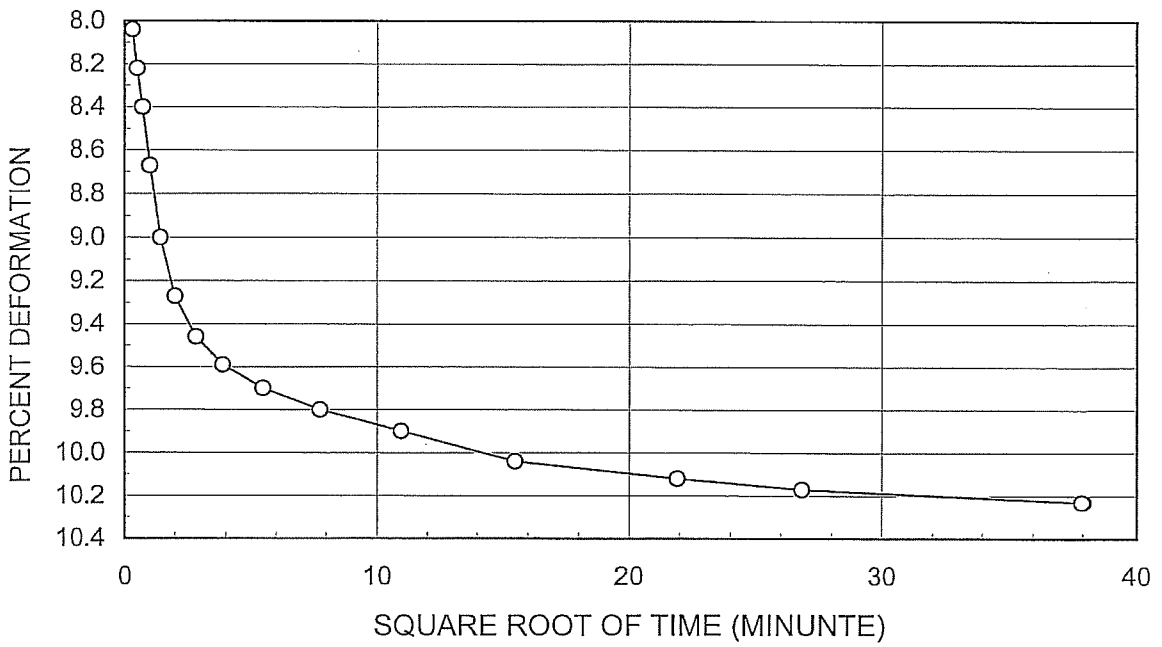
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





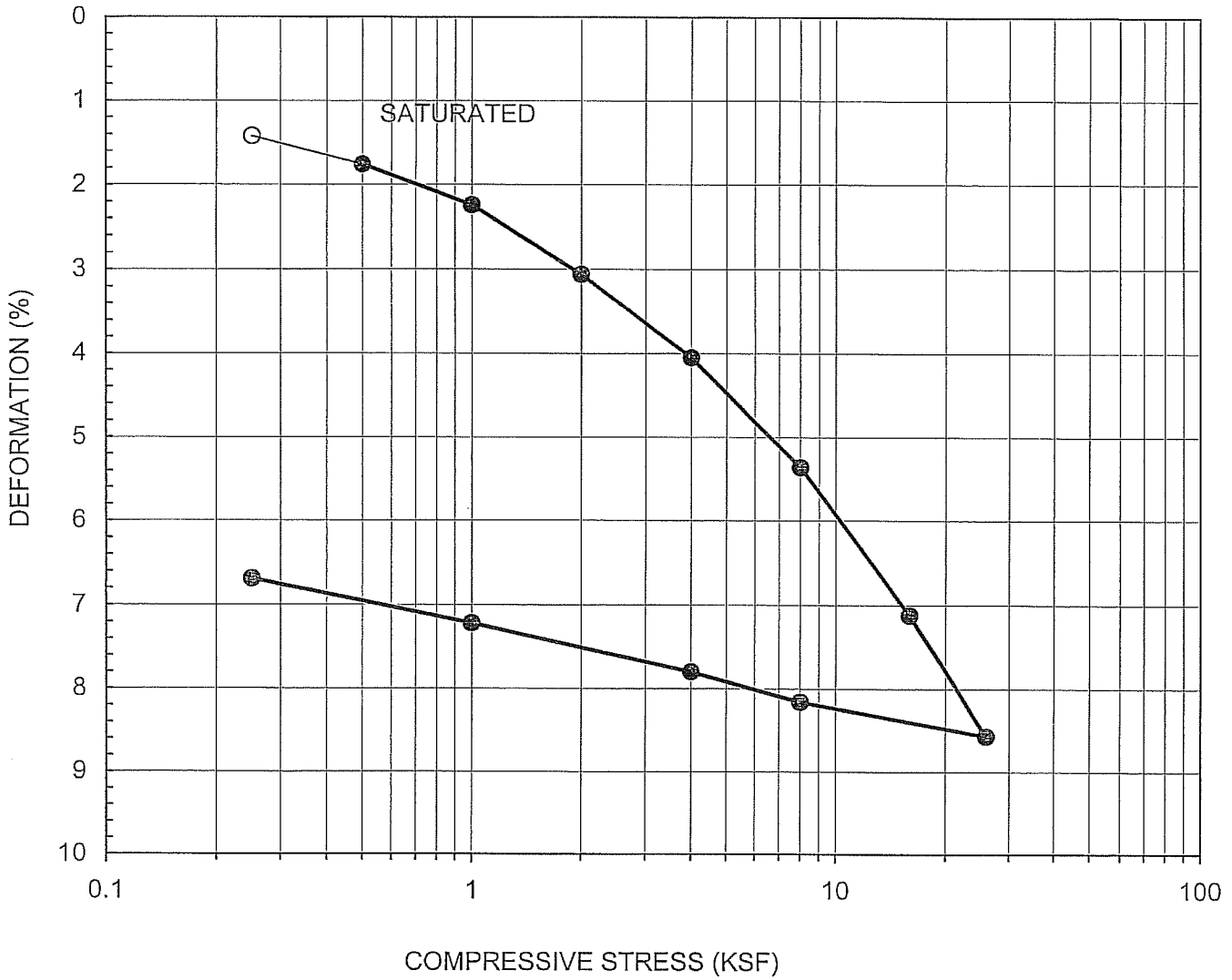
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-10	50.0	ML	21.6	109.1	0.544

ENVIRONMENTAL
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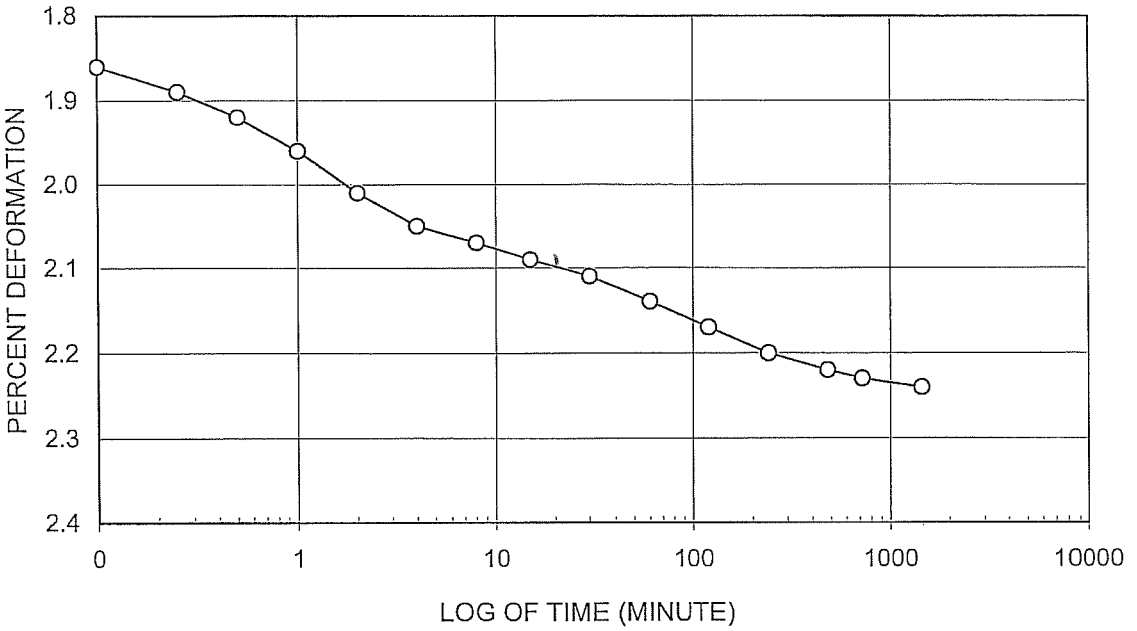
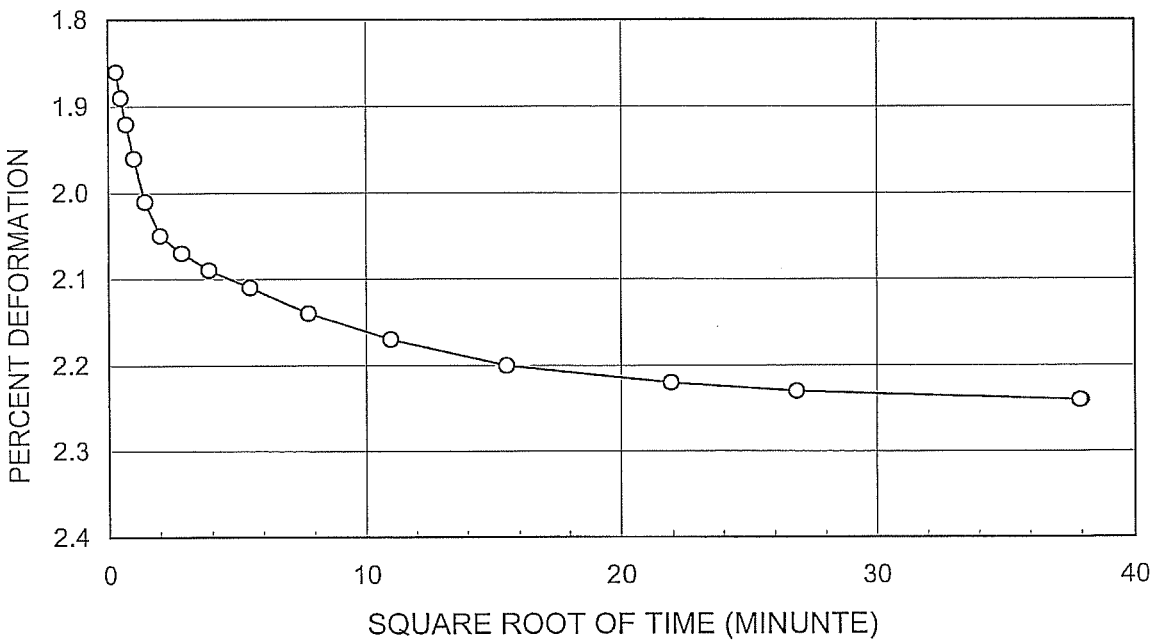
Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





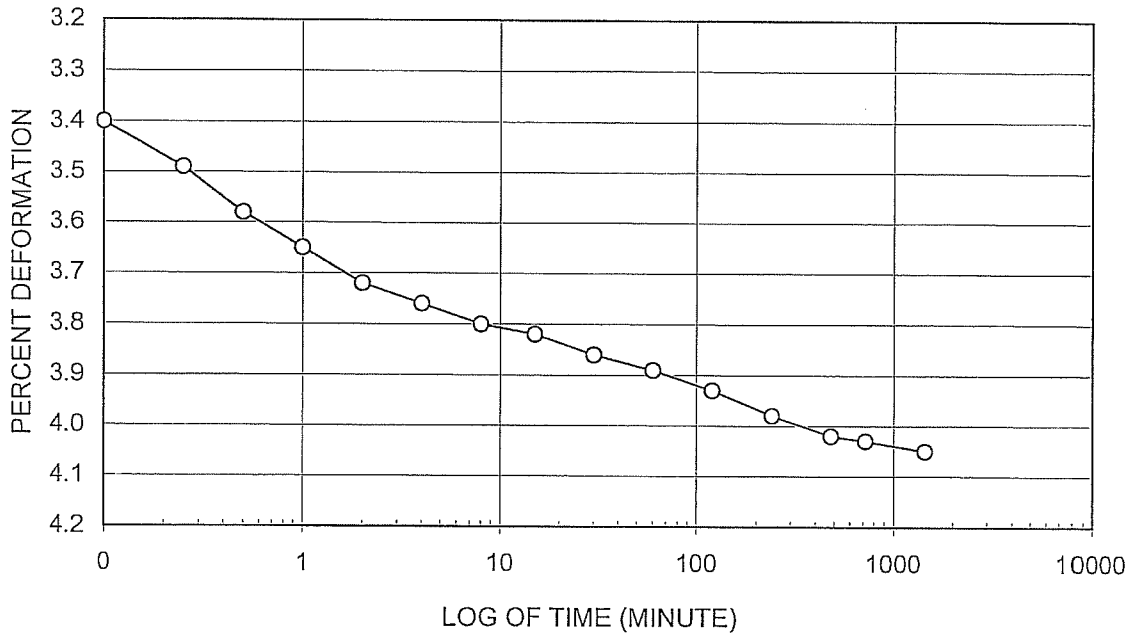
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 1.0 ksf

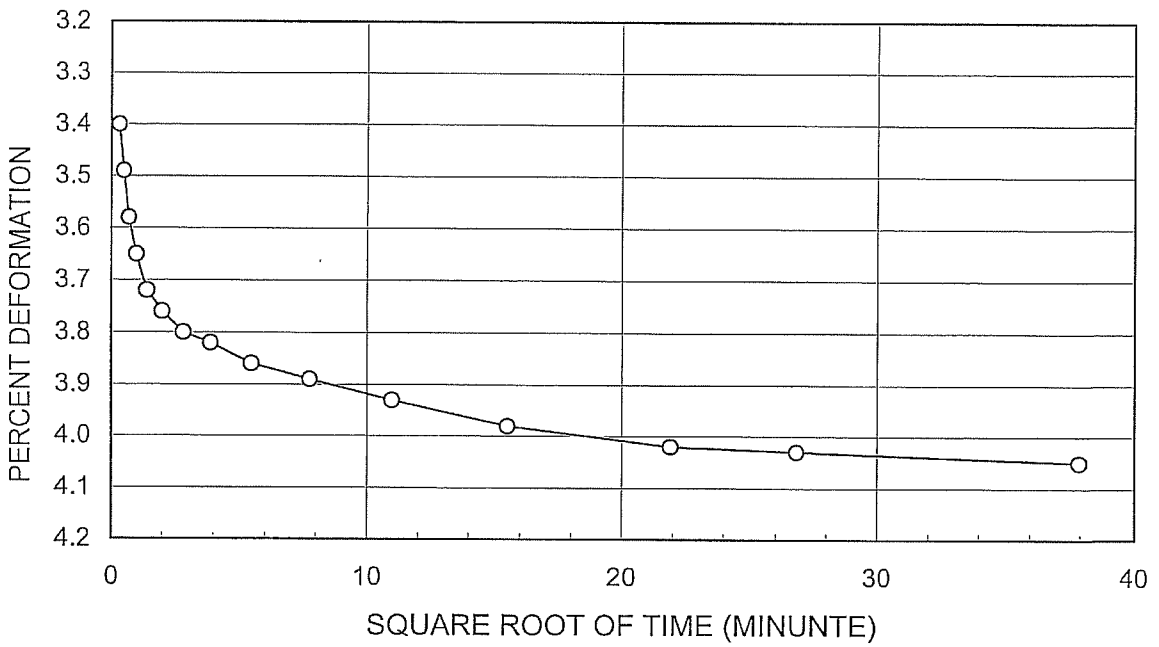
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





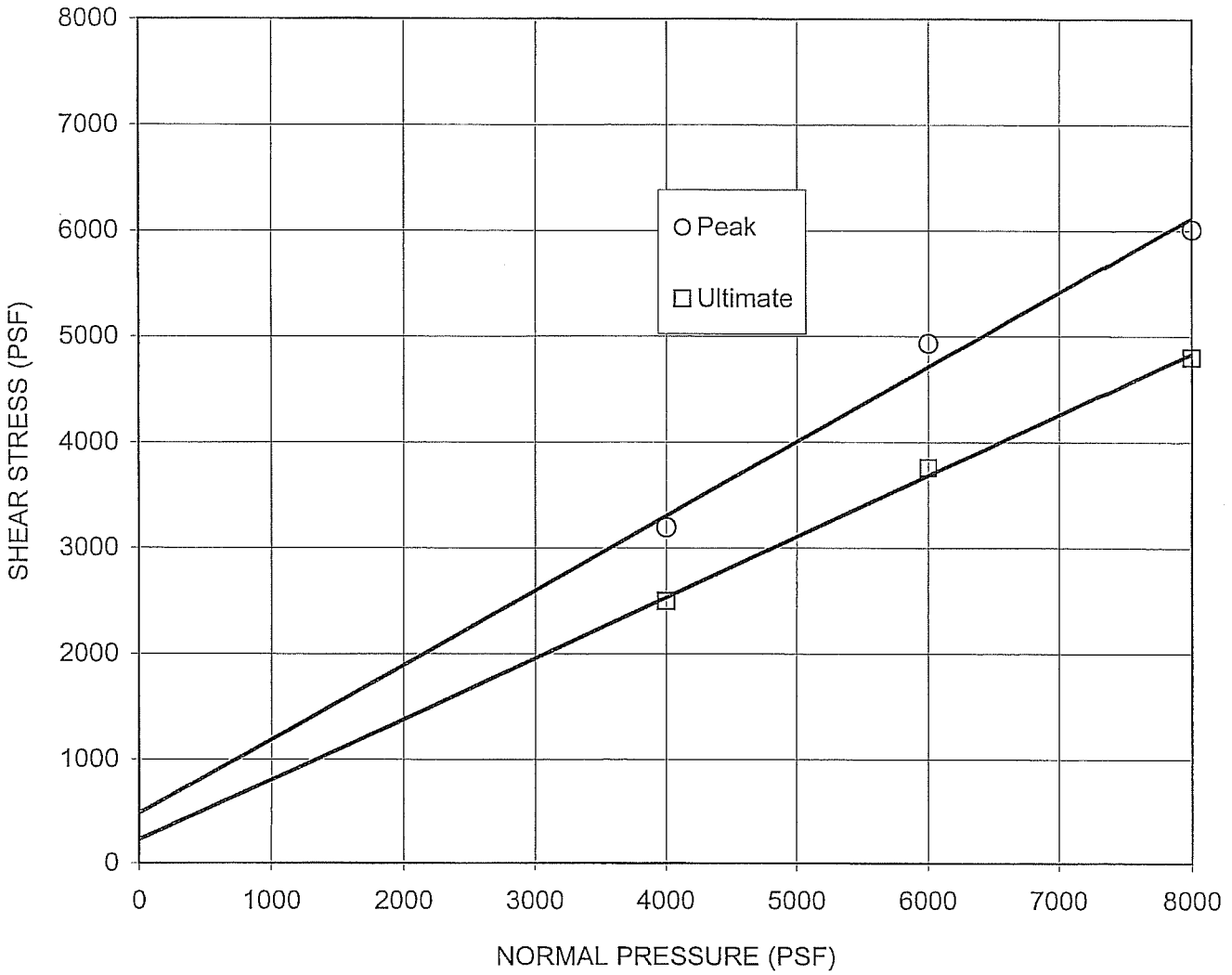
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-035	D-14	70	Ring	SM	○	484	35
					□	228	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	27.0	30.7
6000	27.0	29.3
8000	27.0	29.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

Appendix F. Site-Specific Ground Motion Study Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

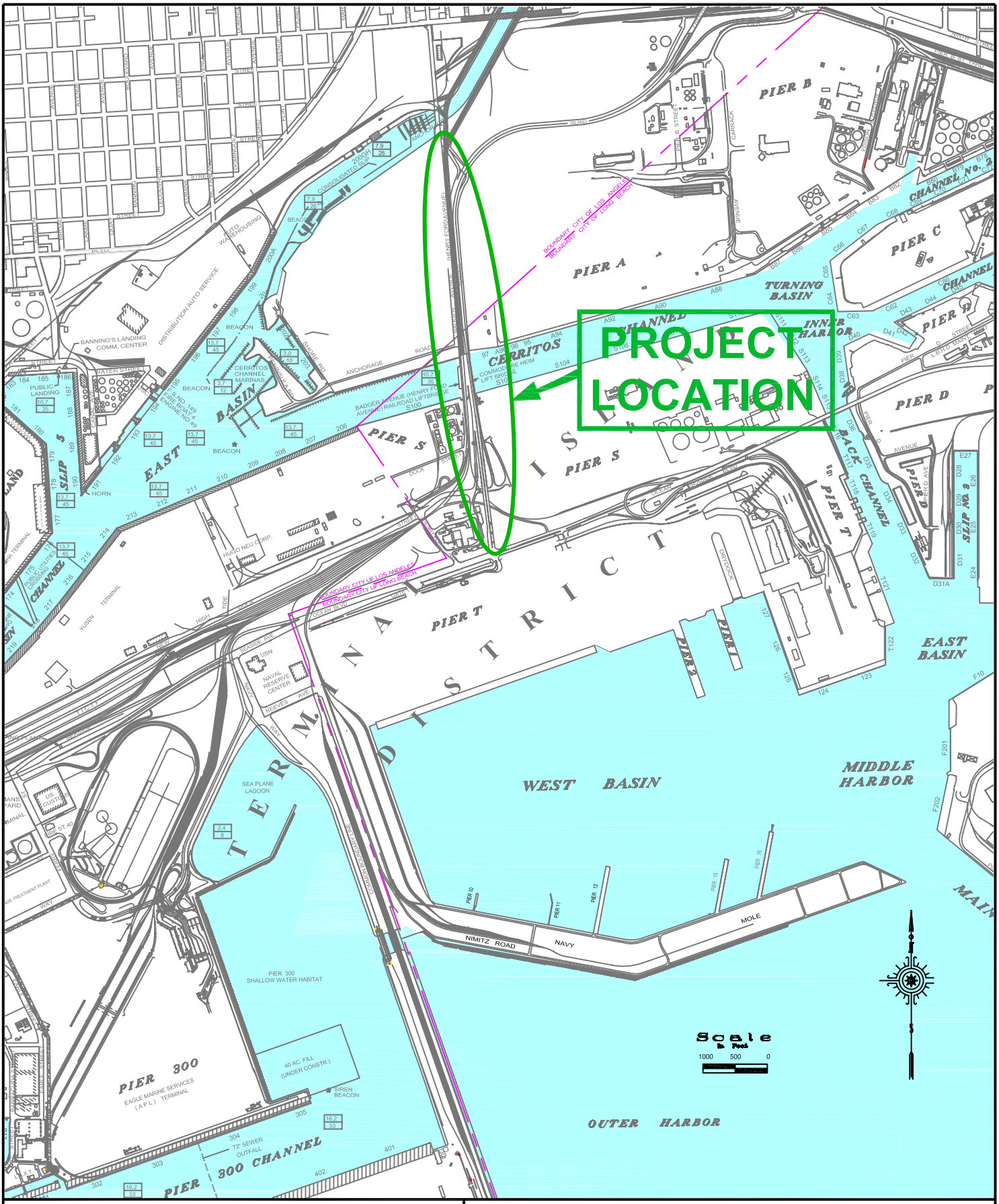
California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

Earth Mechanics, Inc., 2006a, "Preliminary Foundation Report, ACTA Schuyler Heim Bridge (Replace), Los Angeles, California," Report Prepared for Alameda Corridor Transportation Authority, EMI Project No. 06-123, June 23.

——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



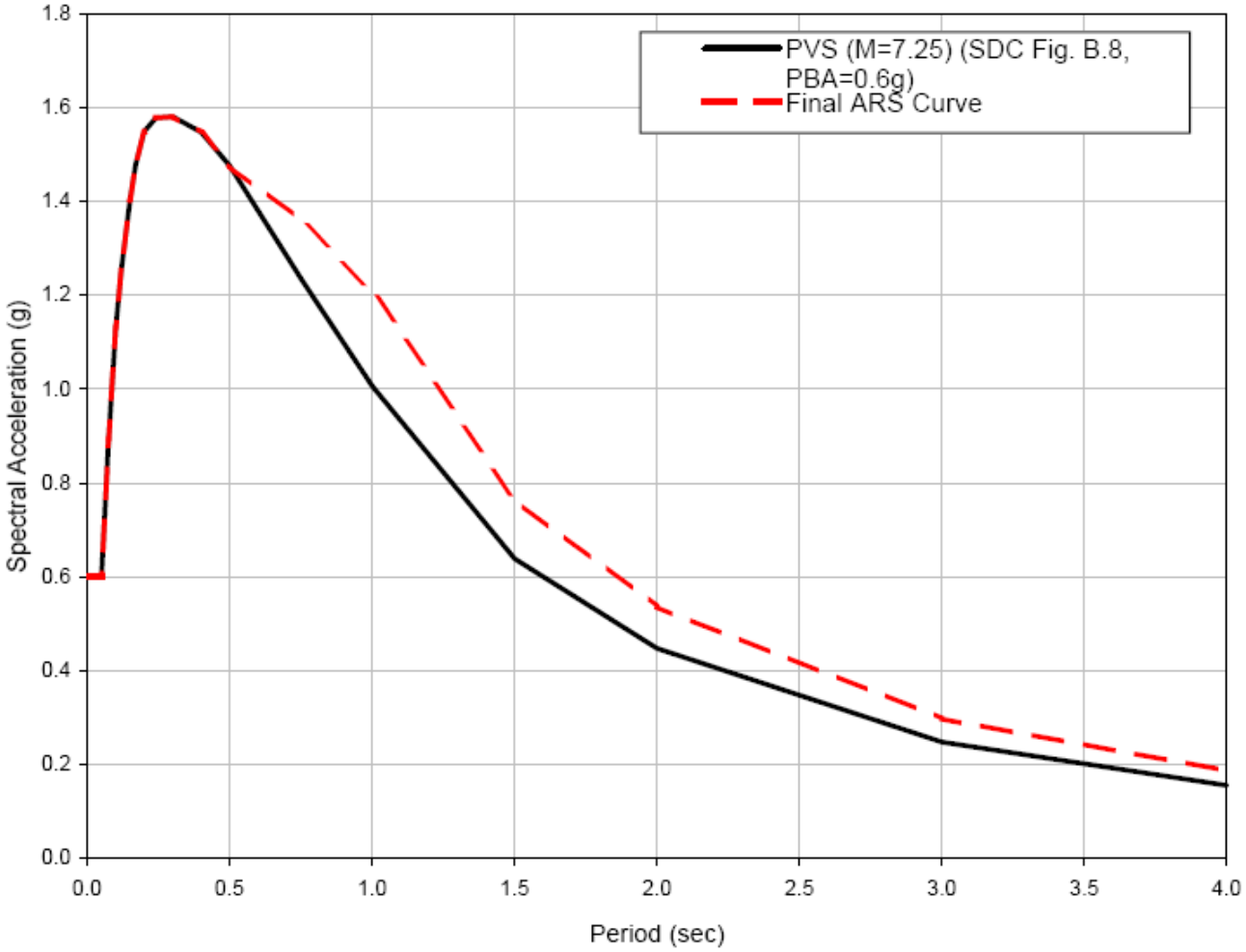
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

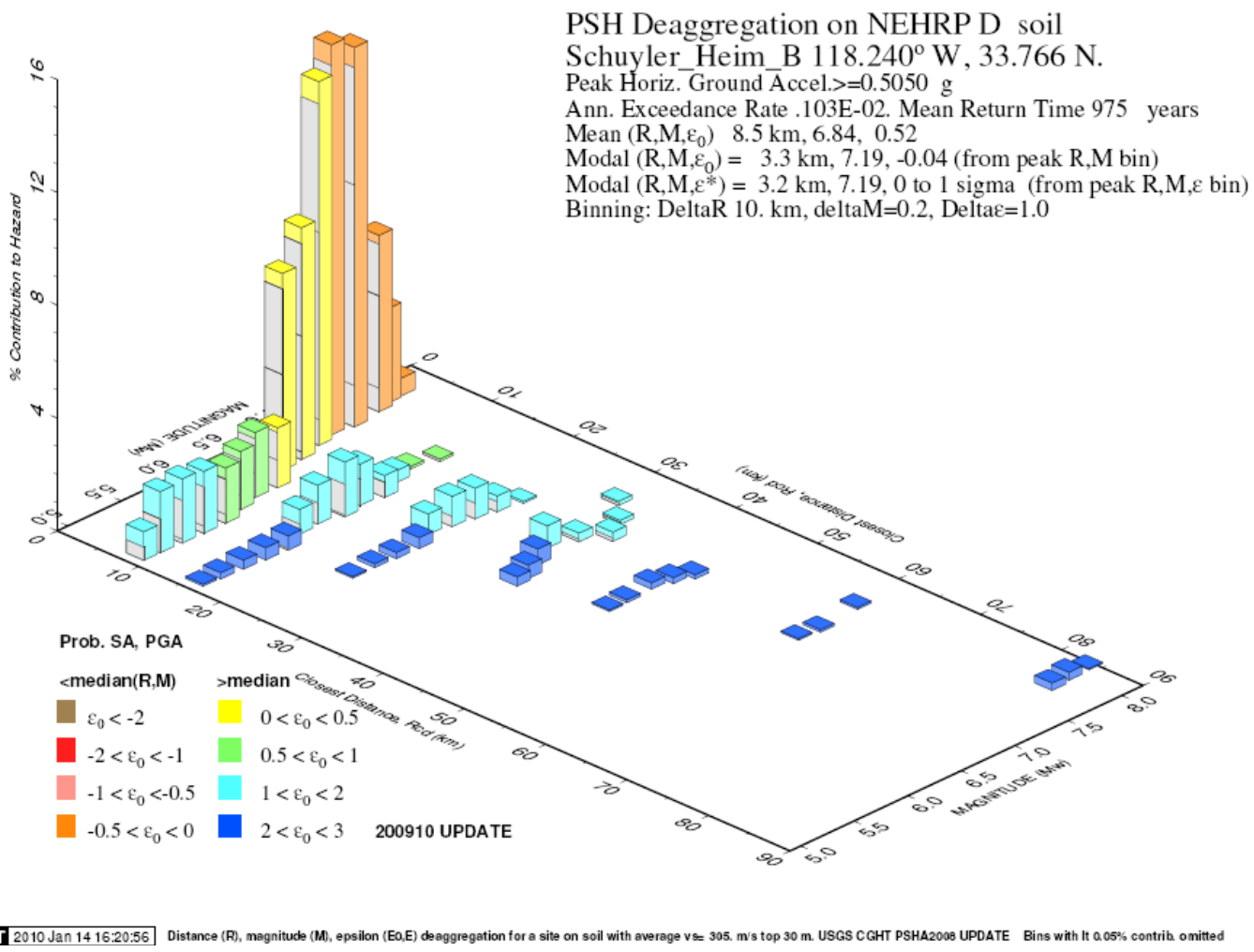


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

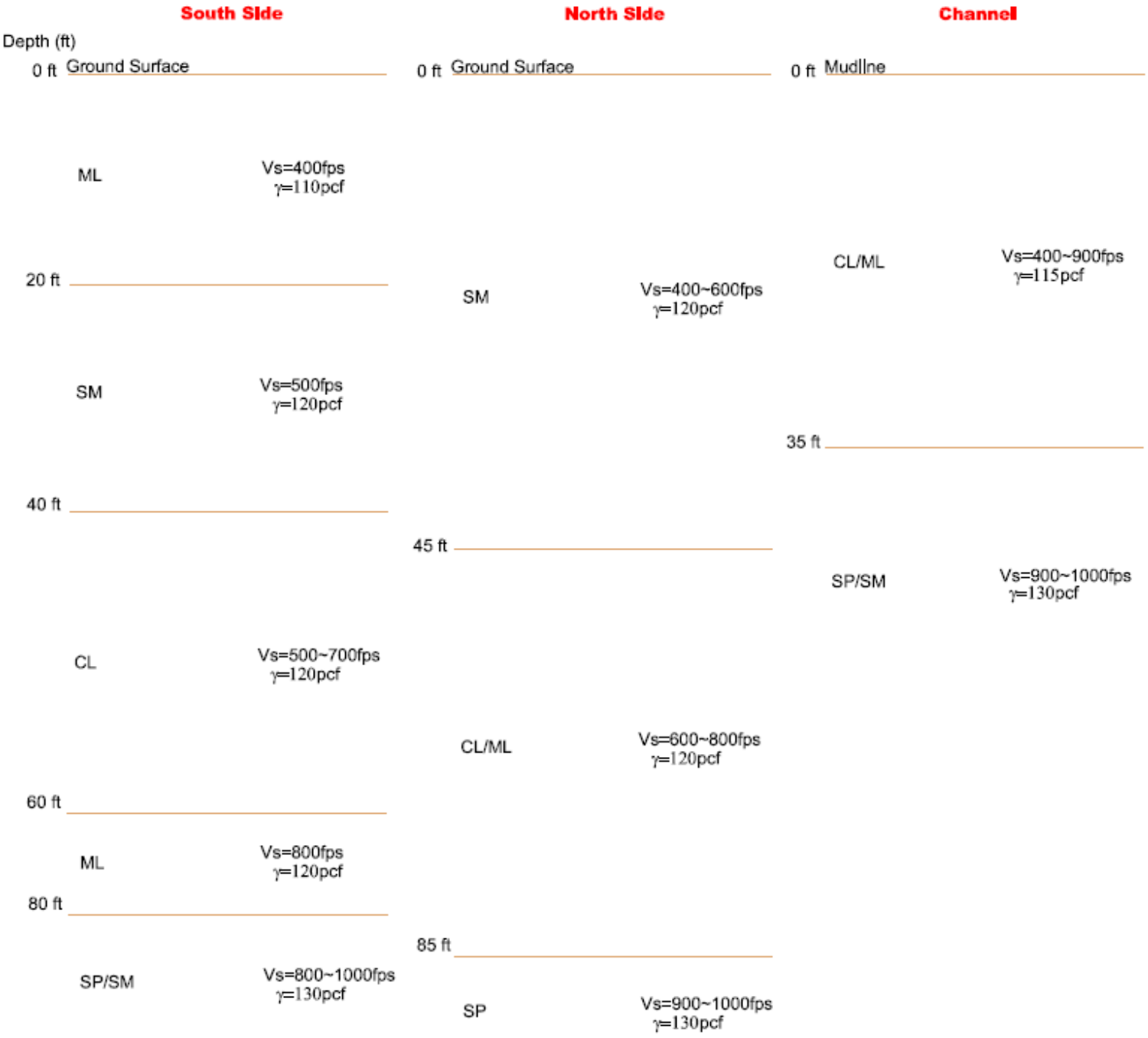
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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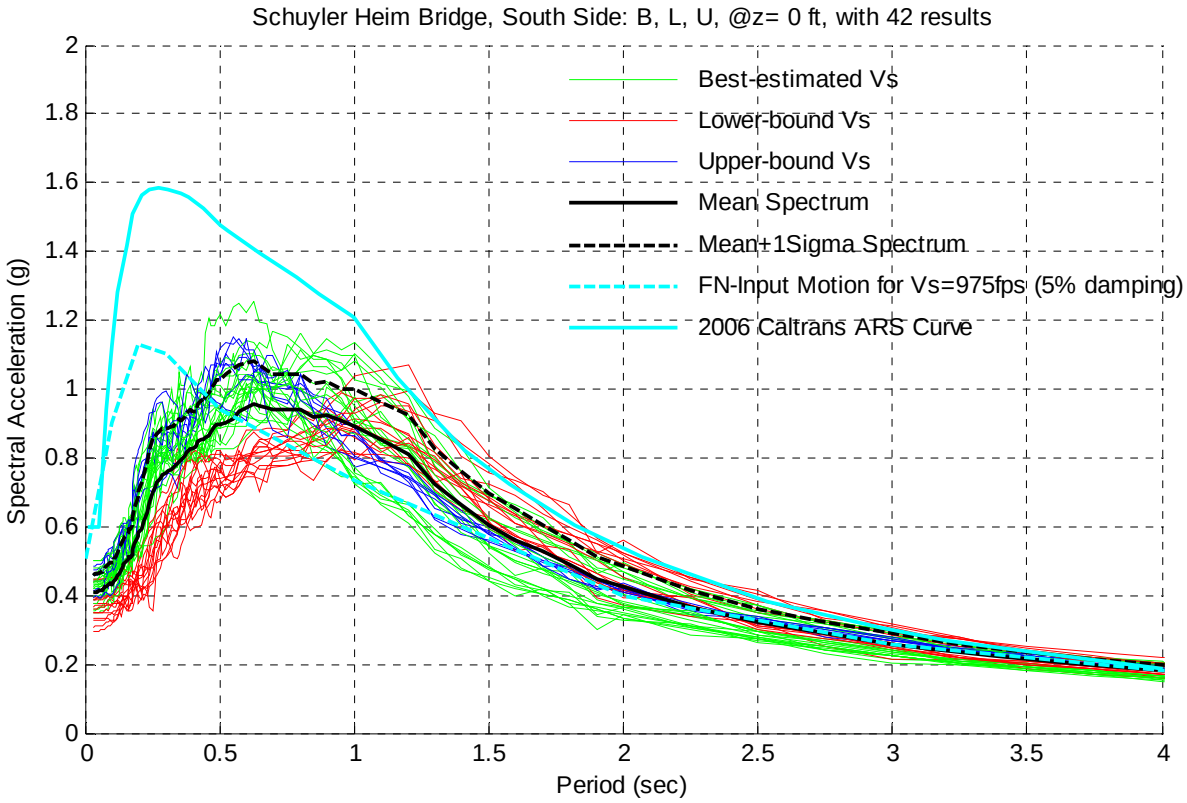
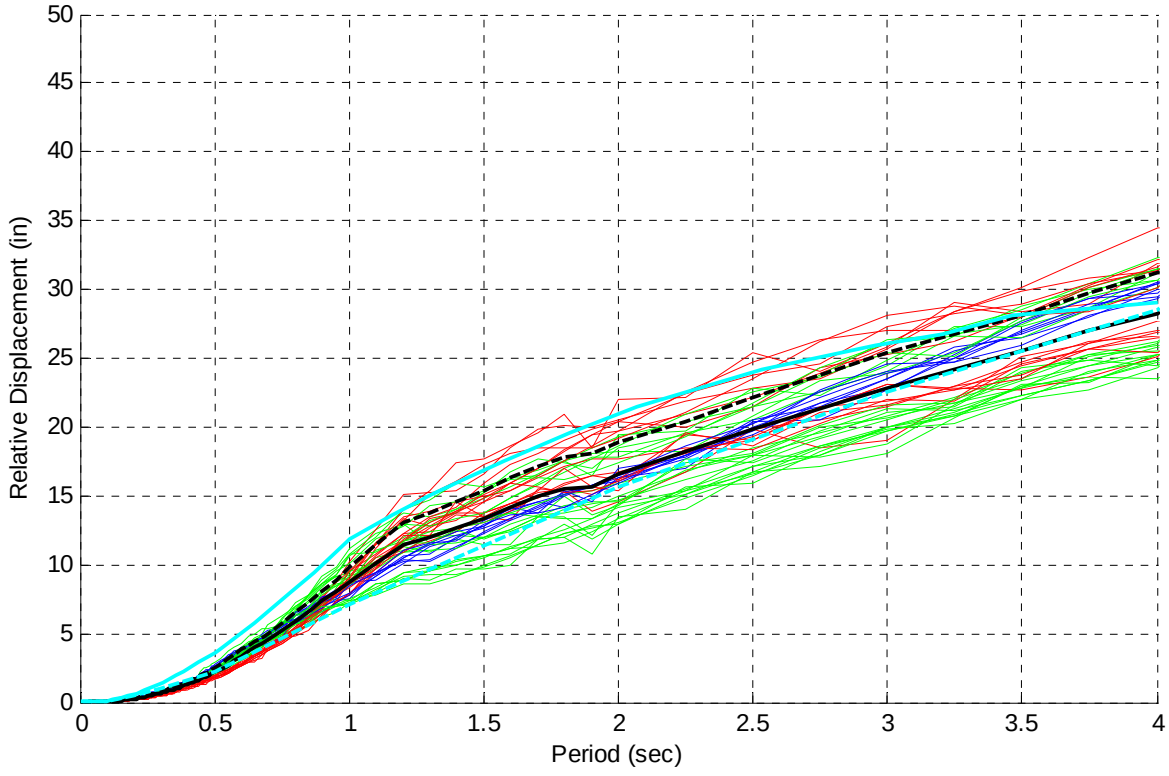
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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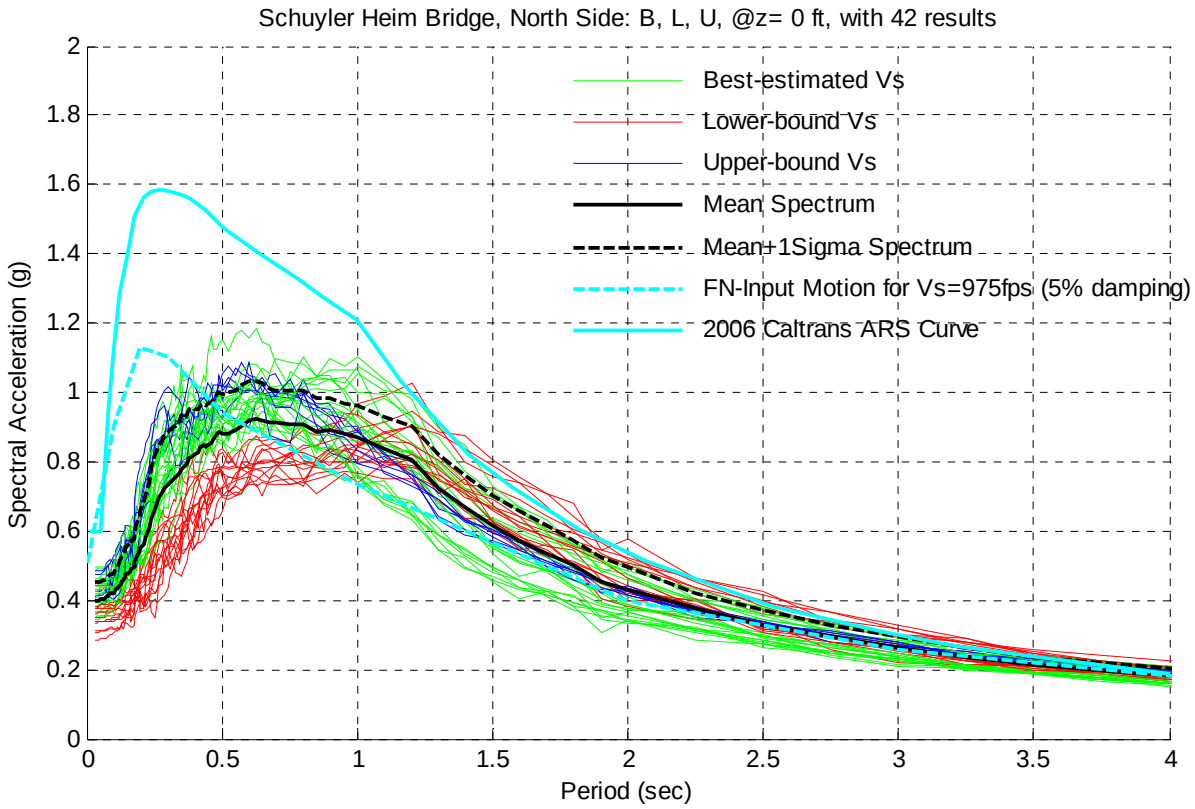
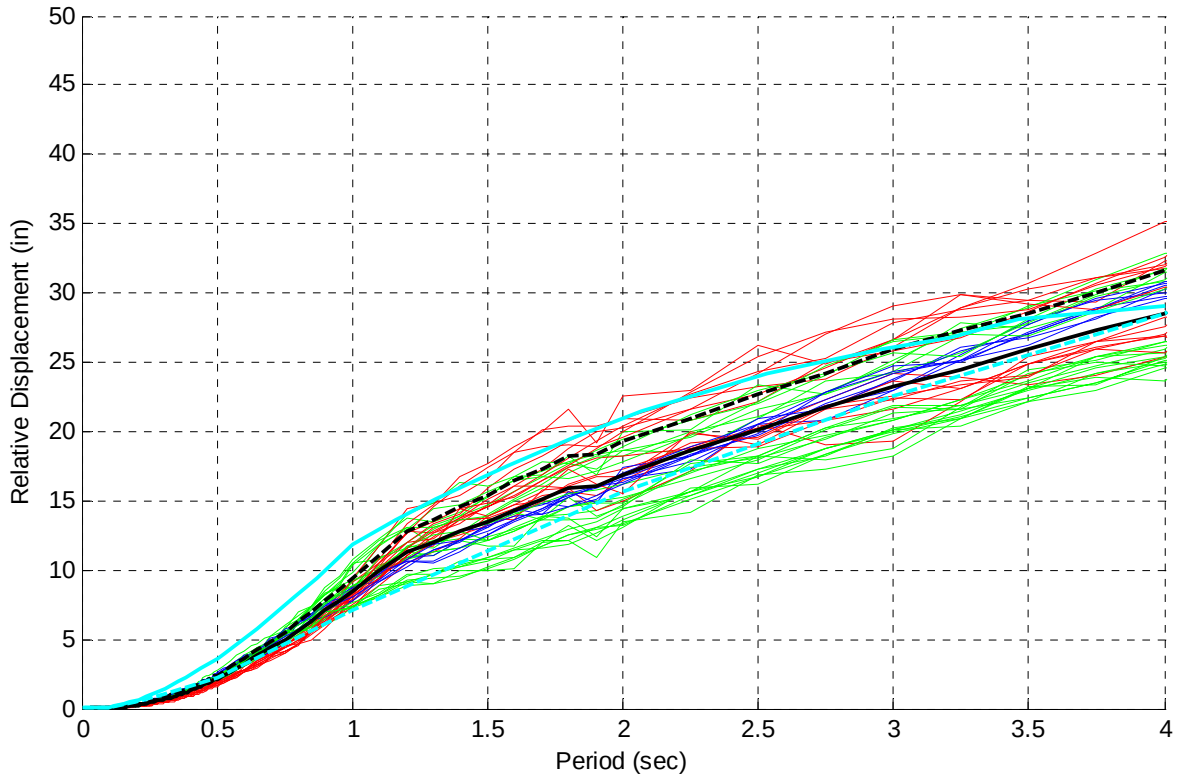
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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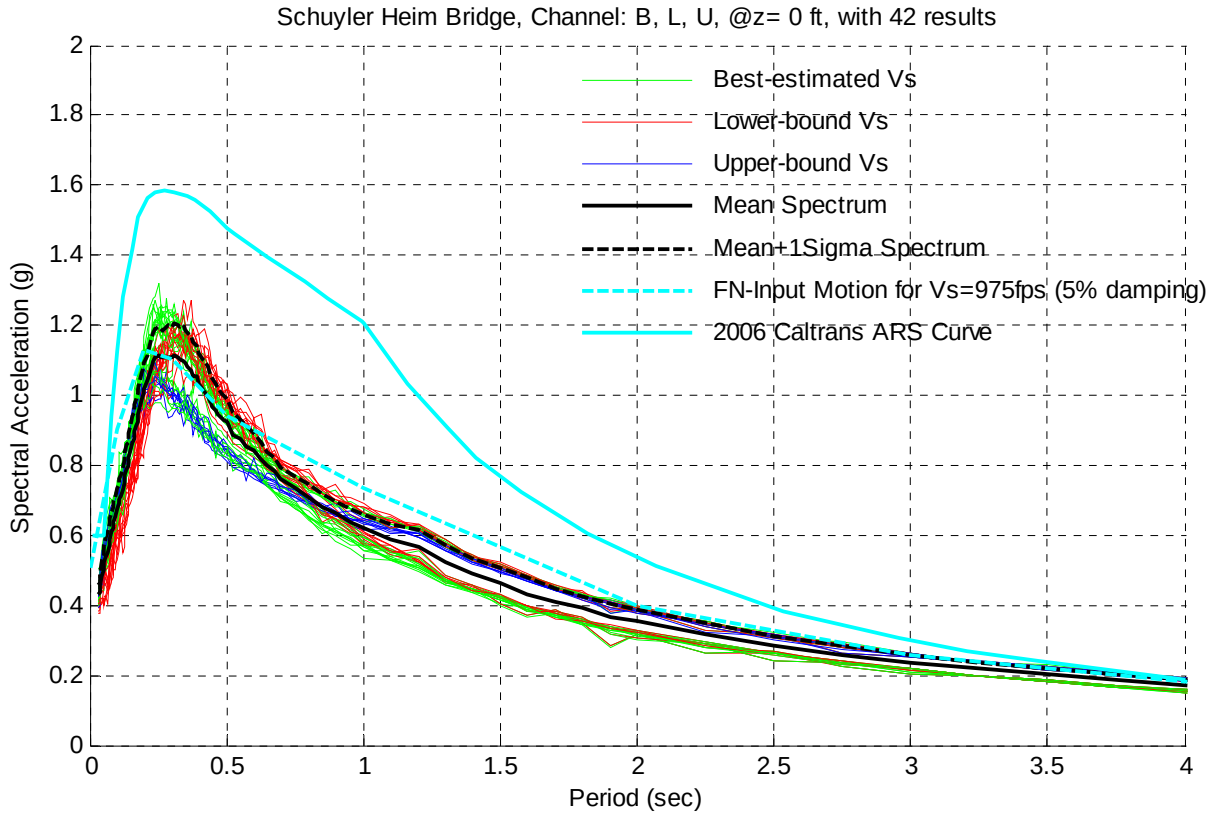
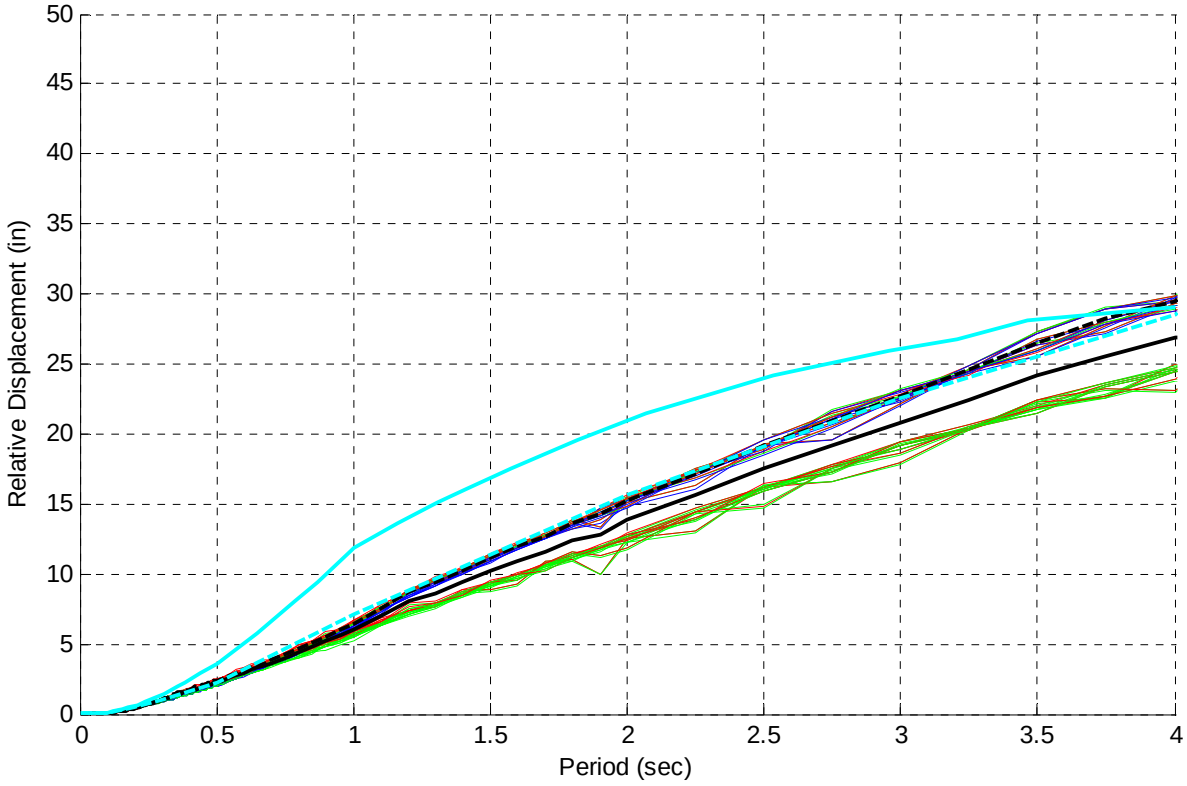
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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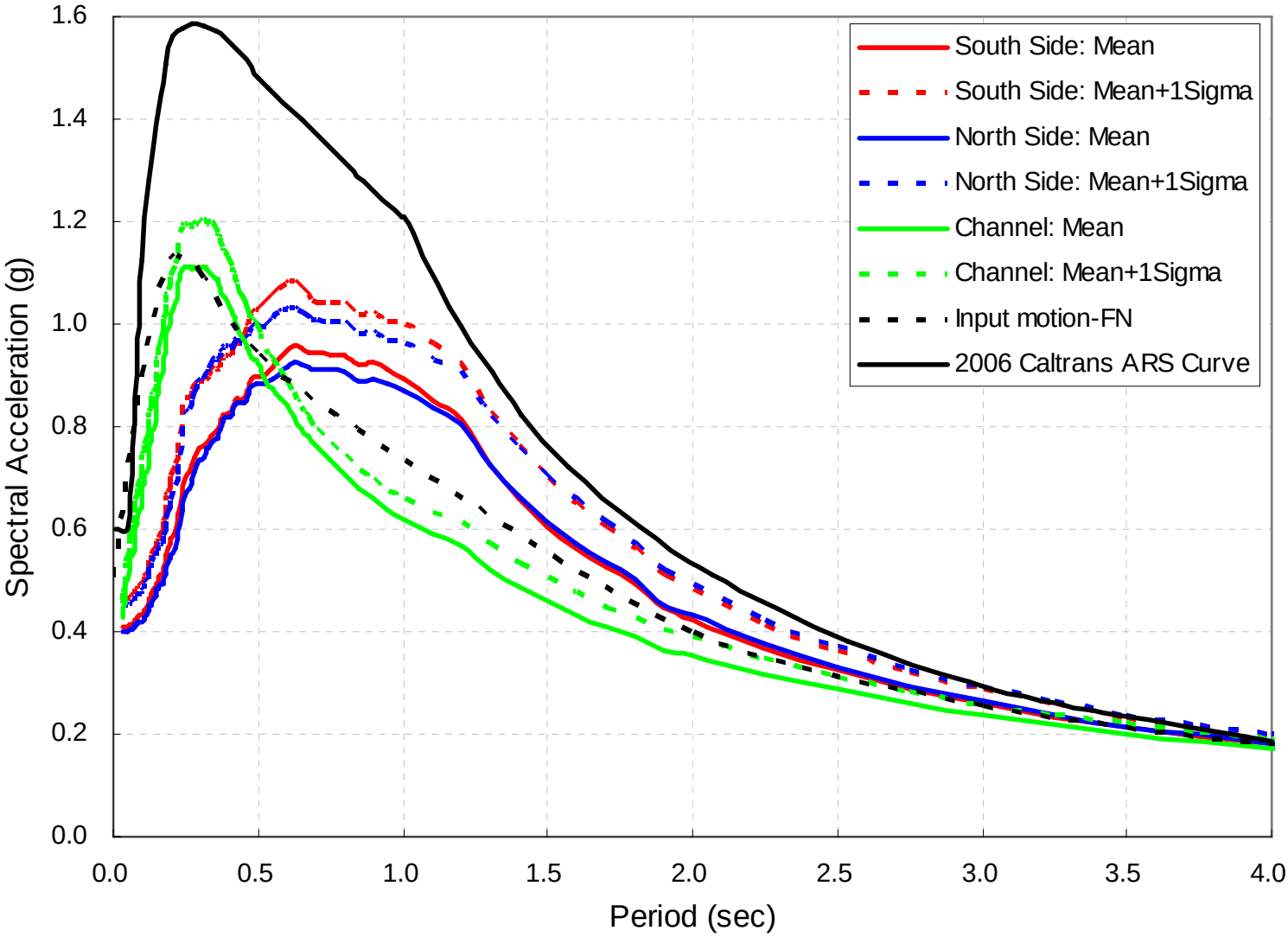
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

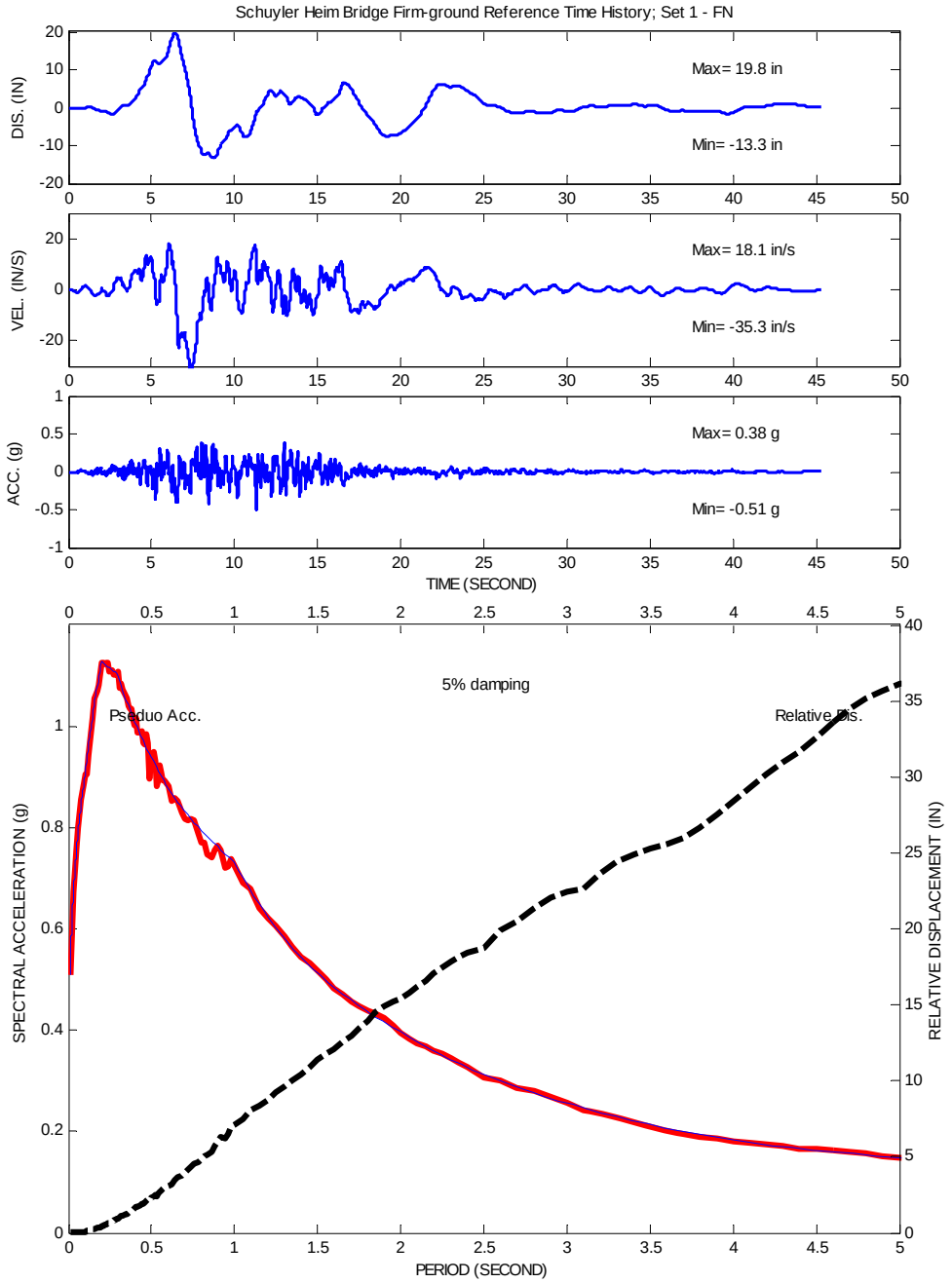

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

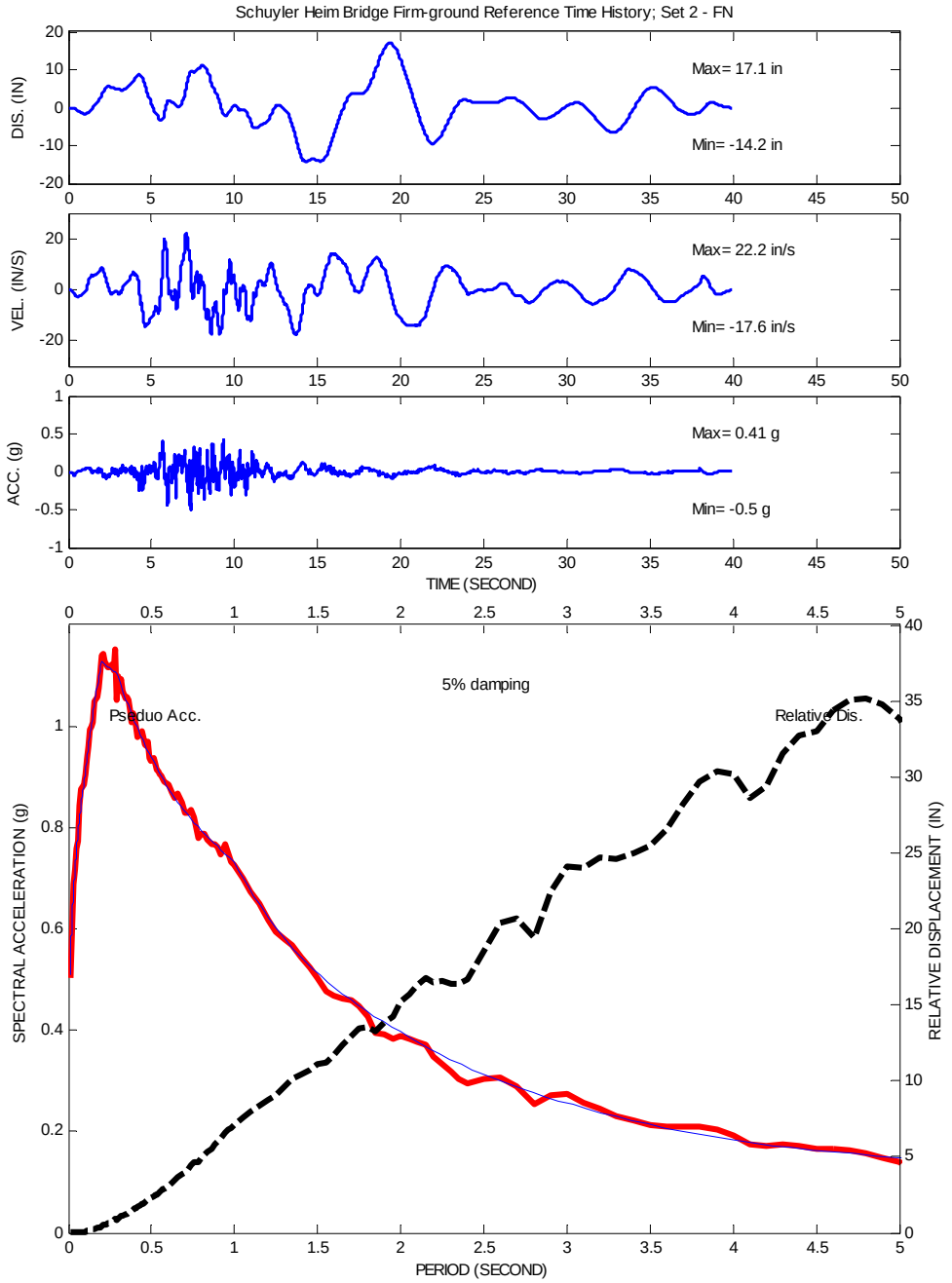

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

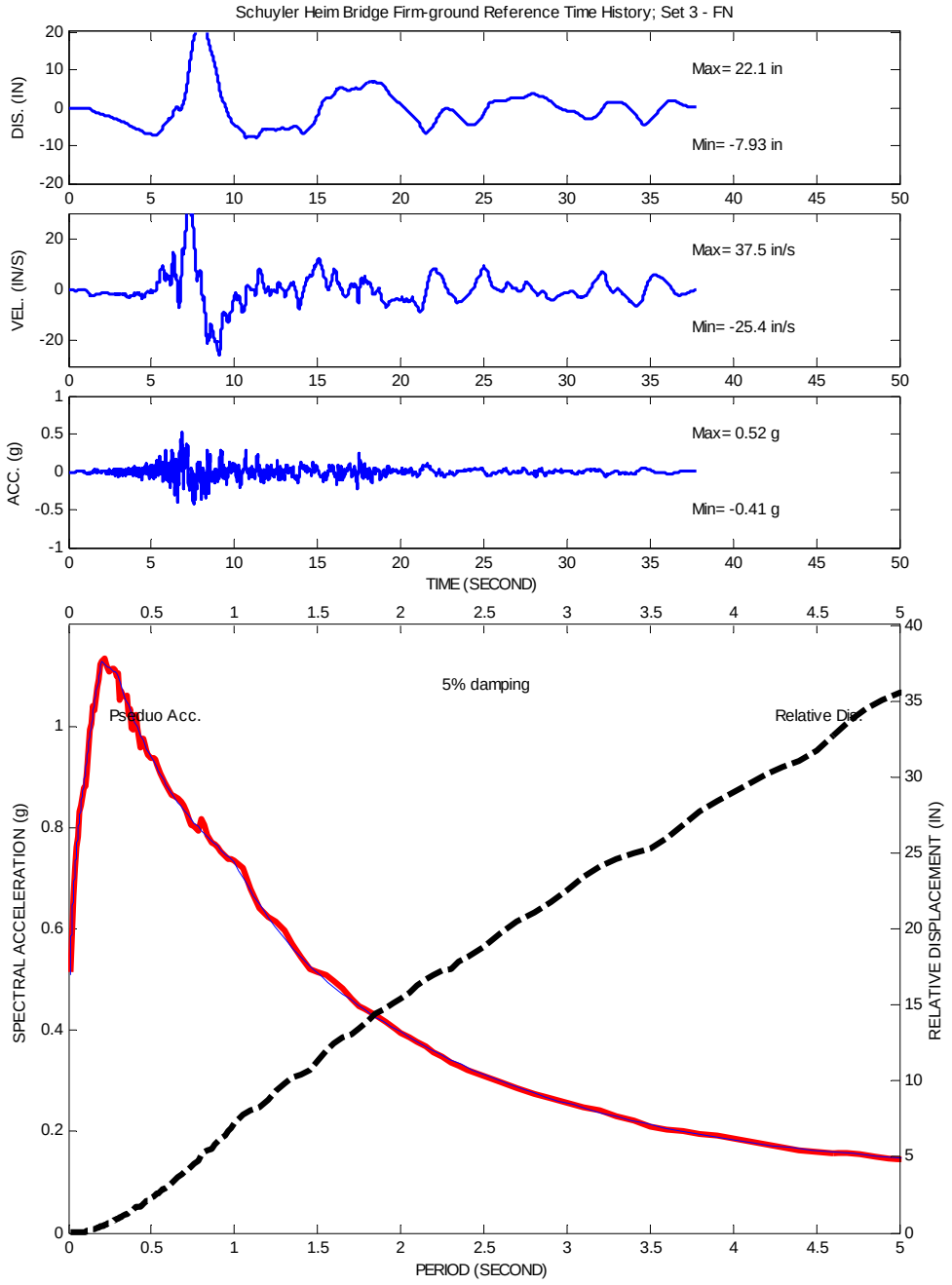

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

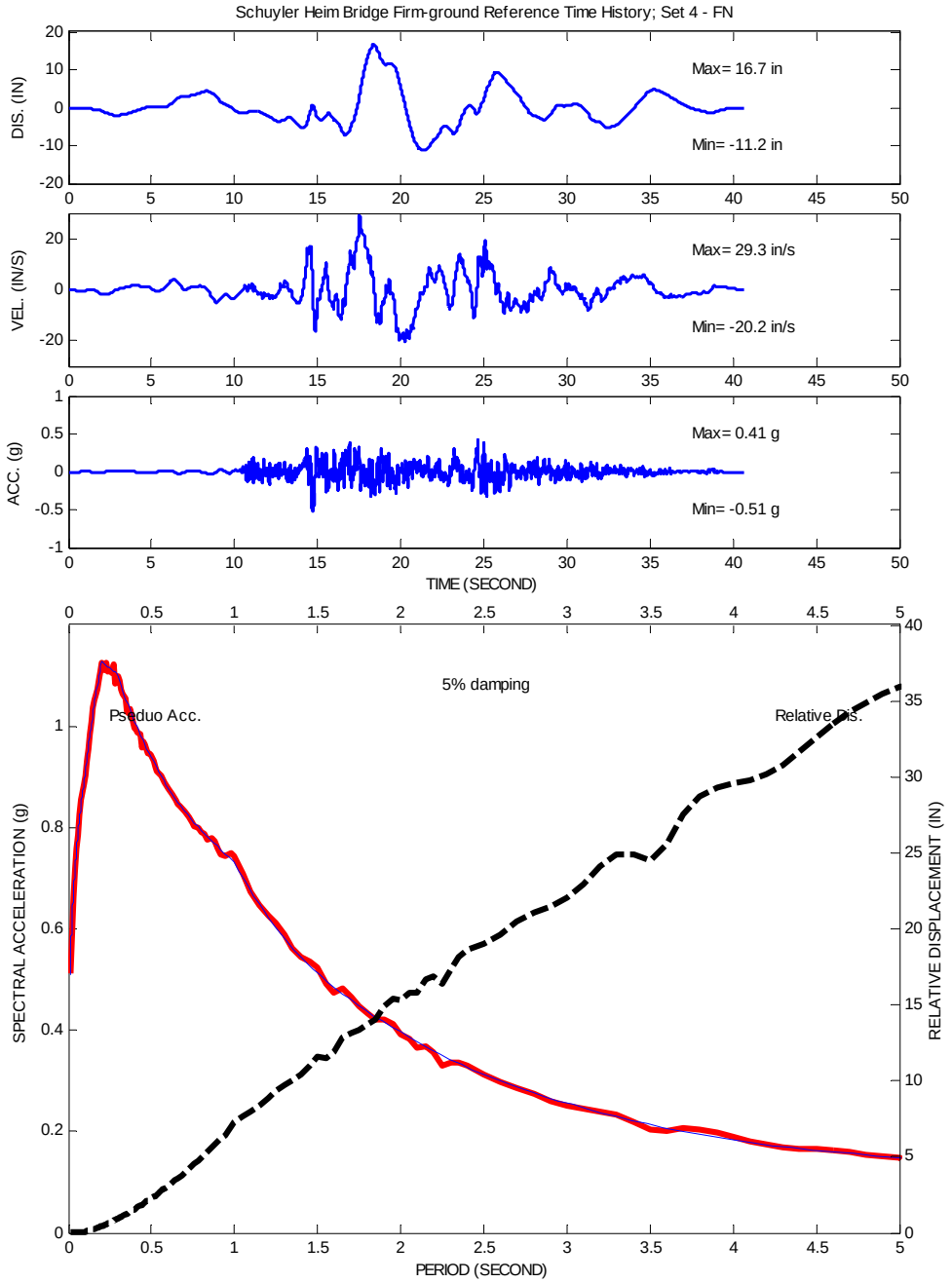

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

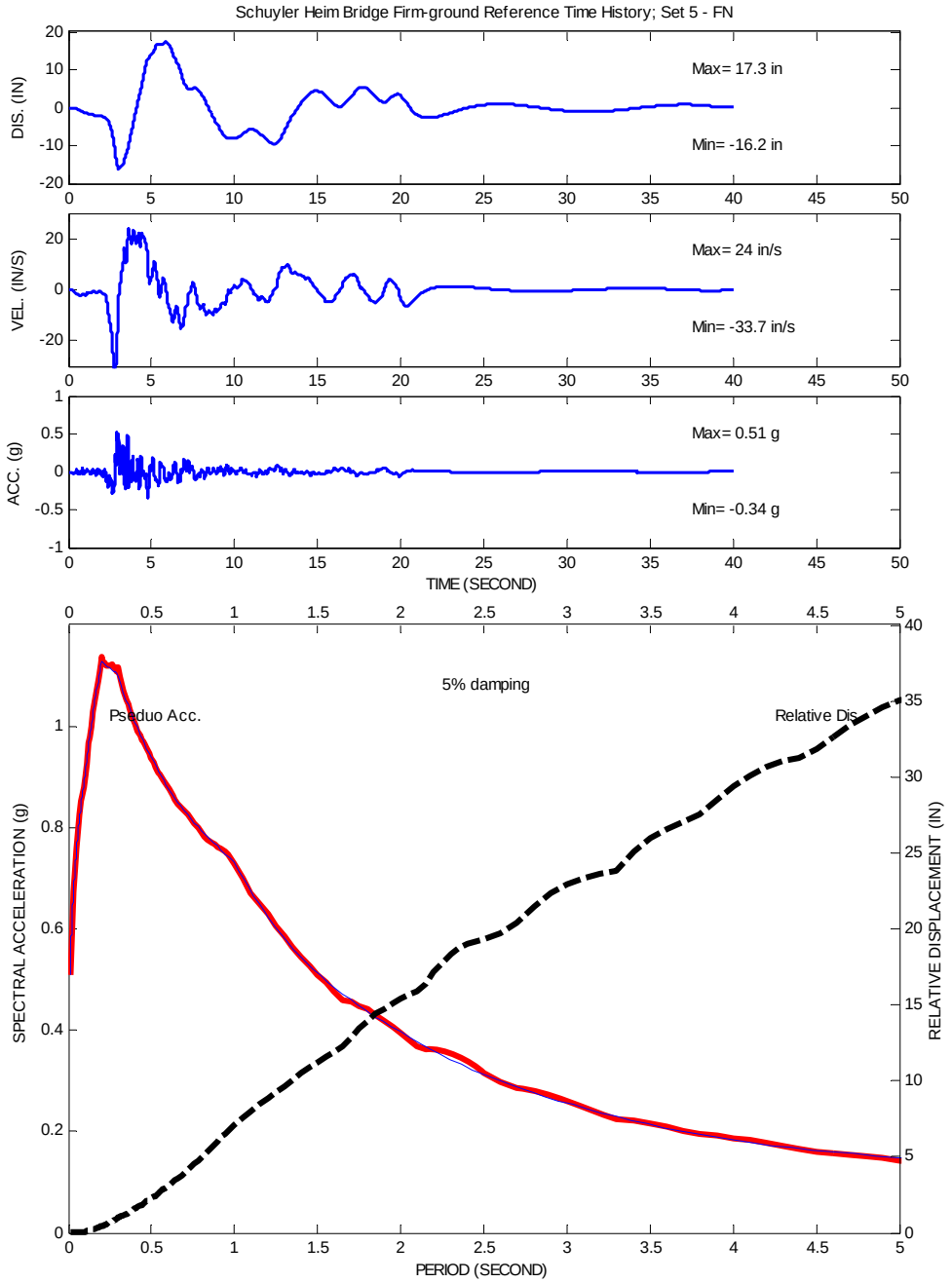

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

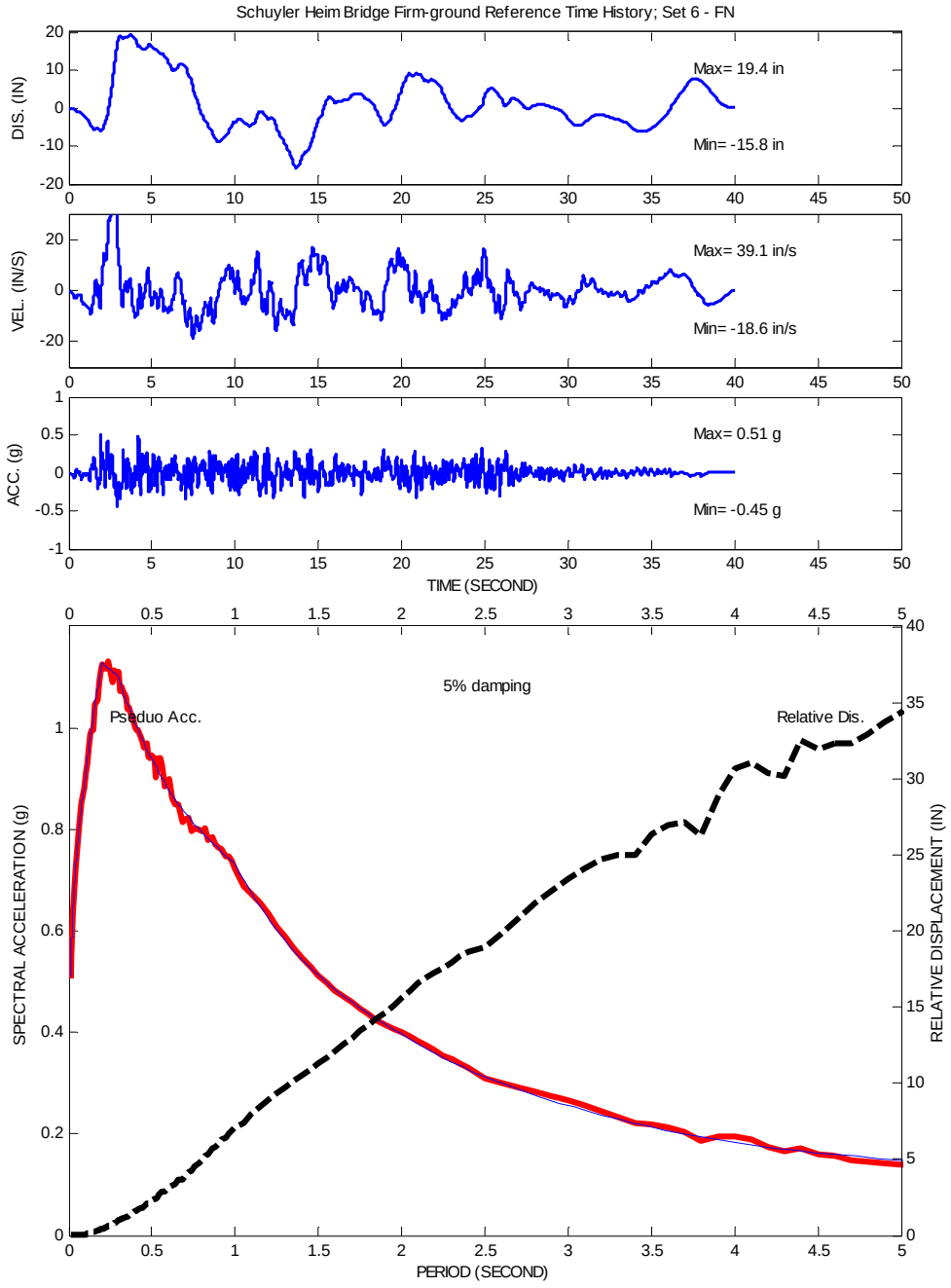

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

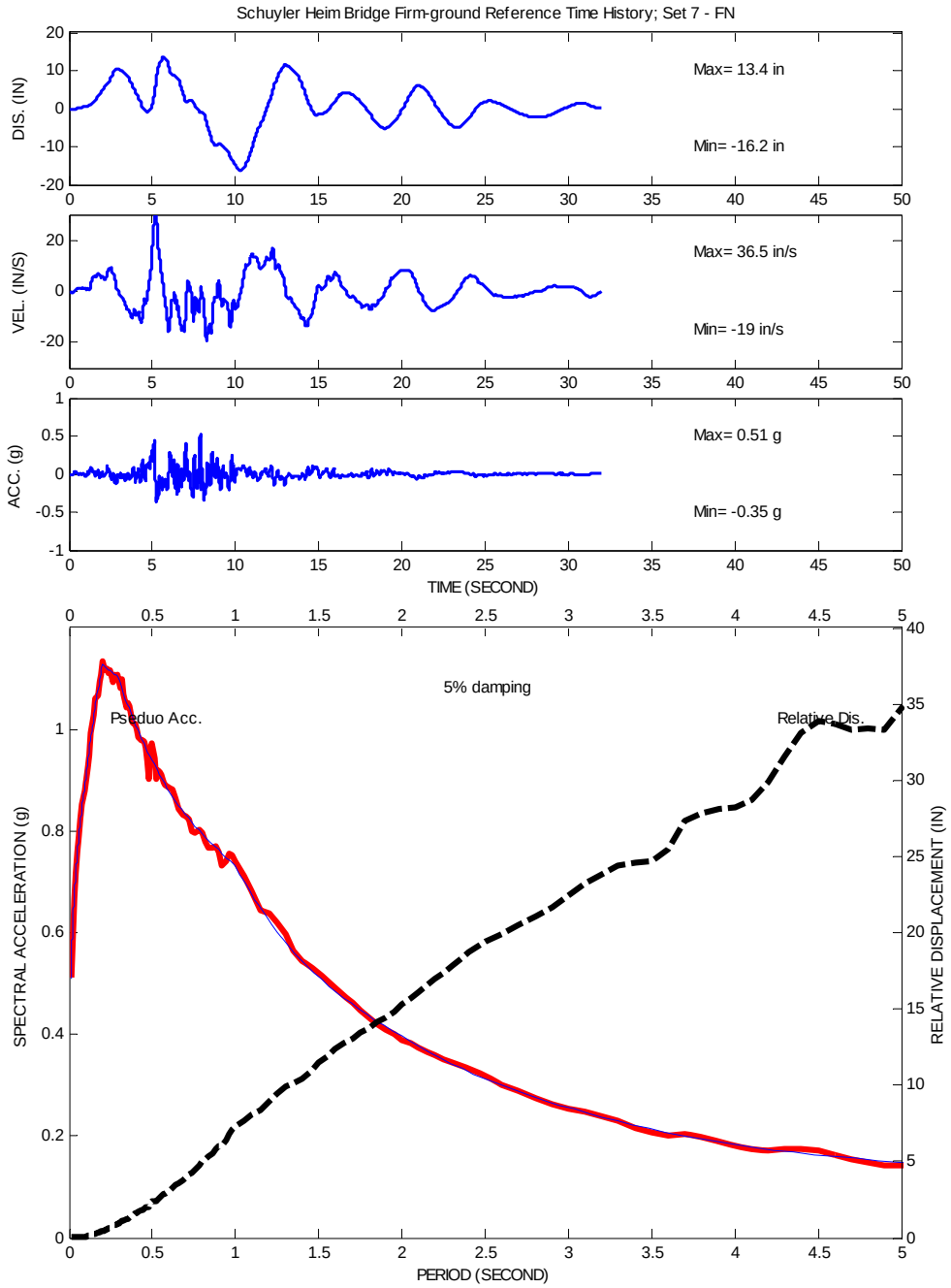

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

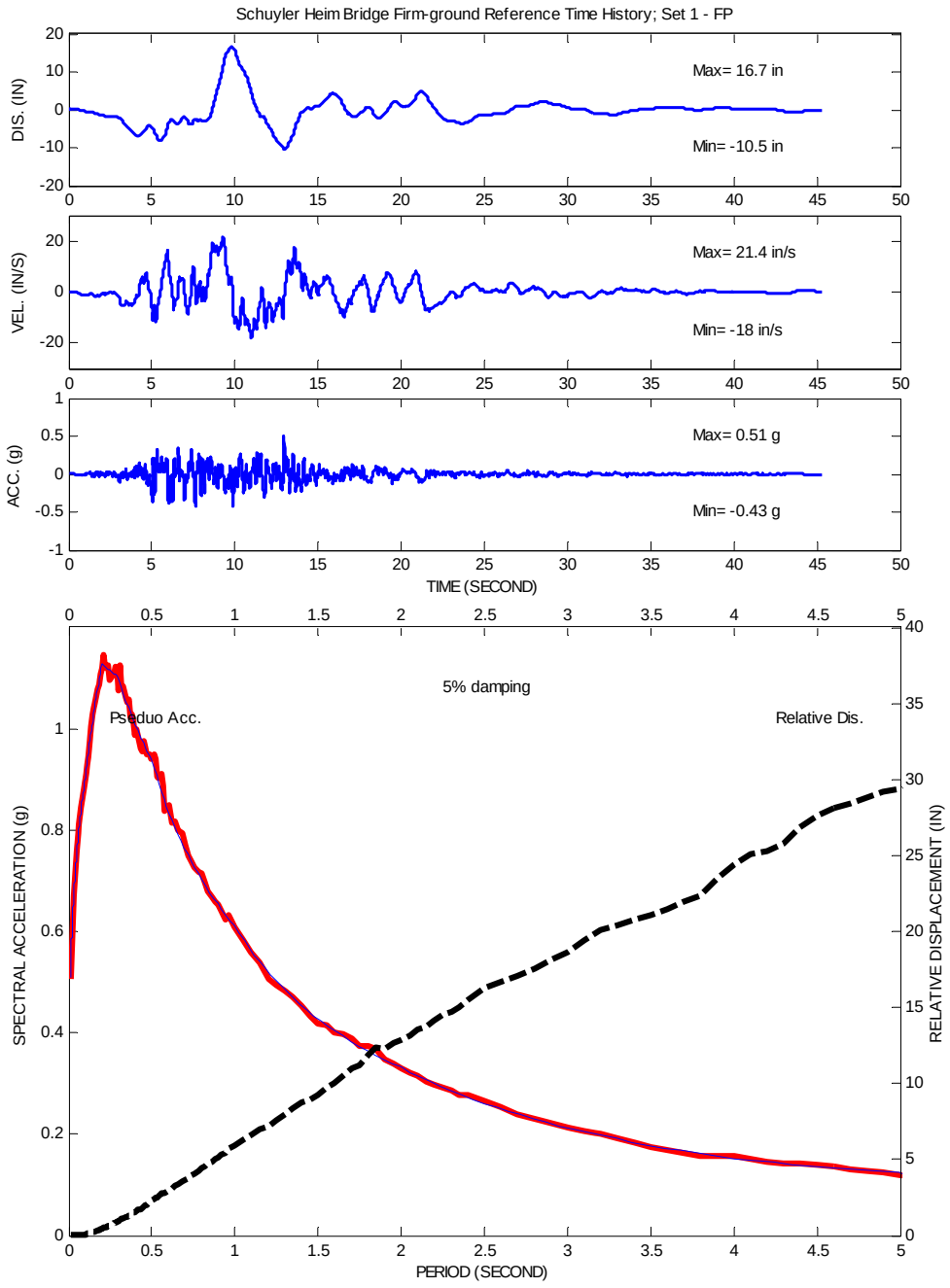

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

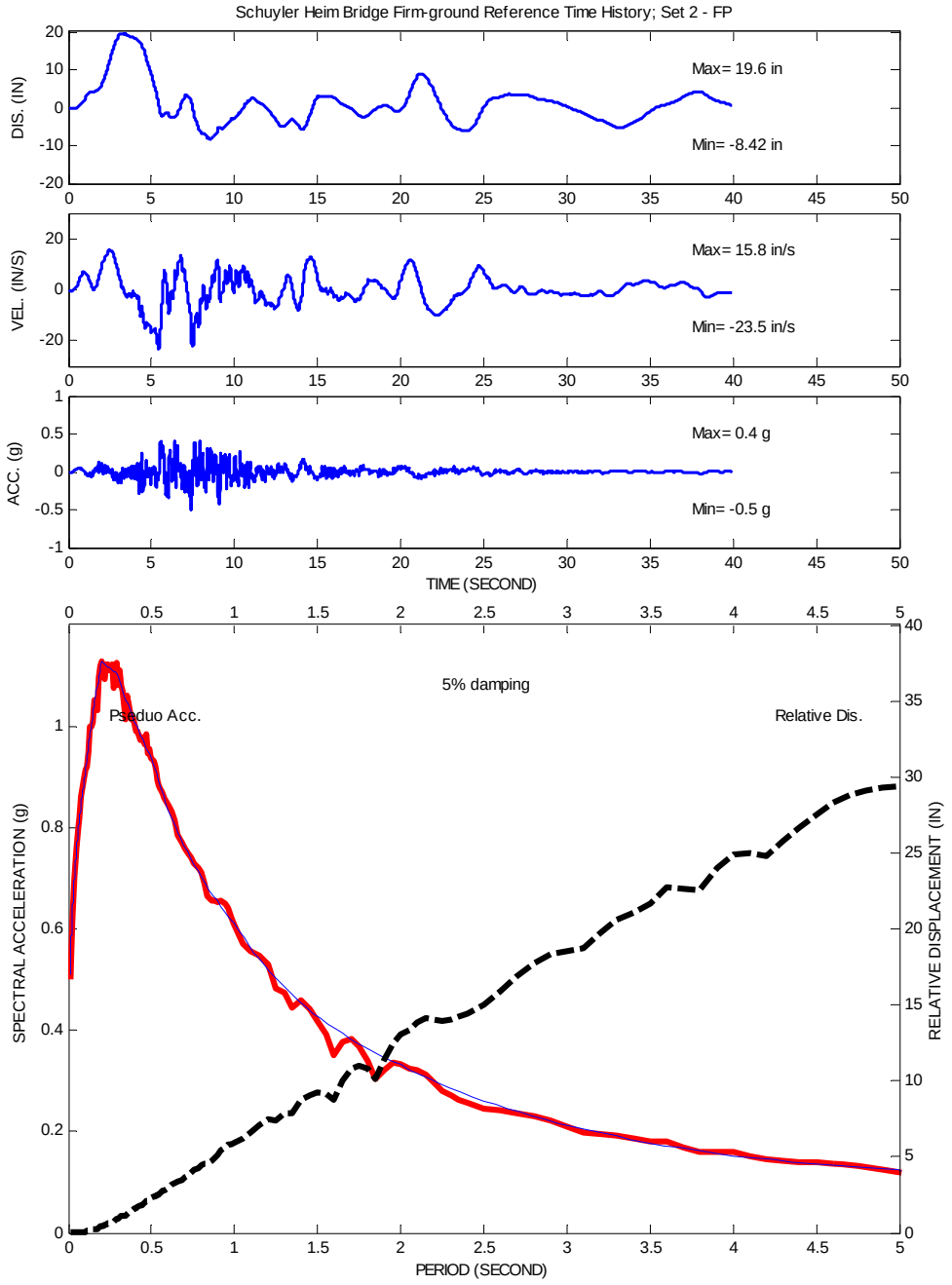

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

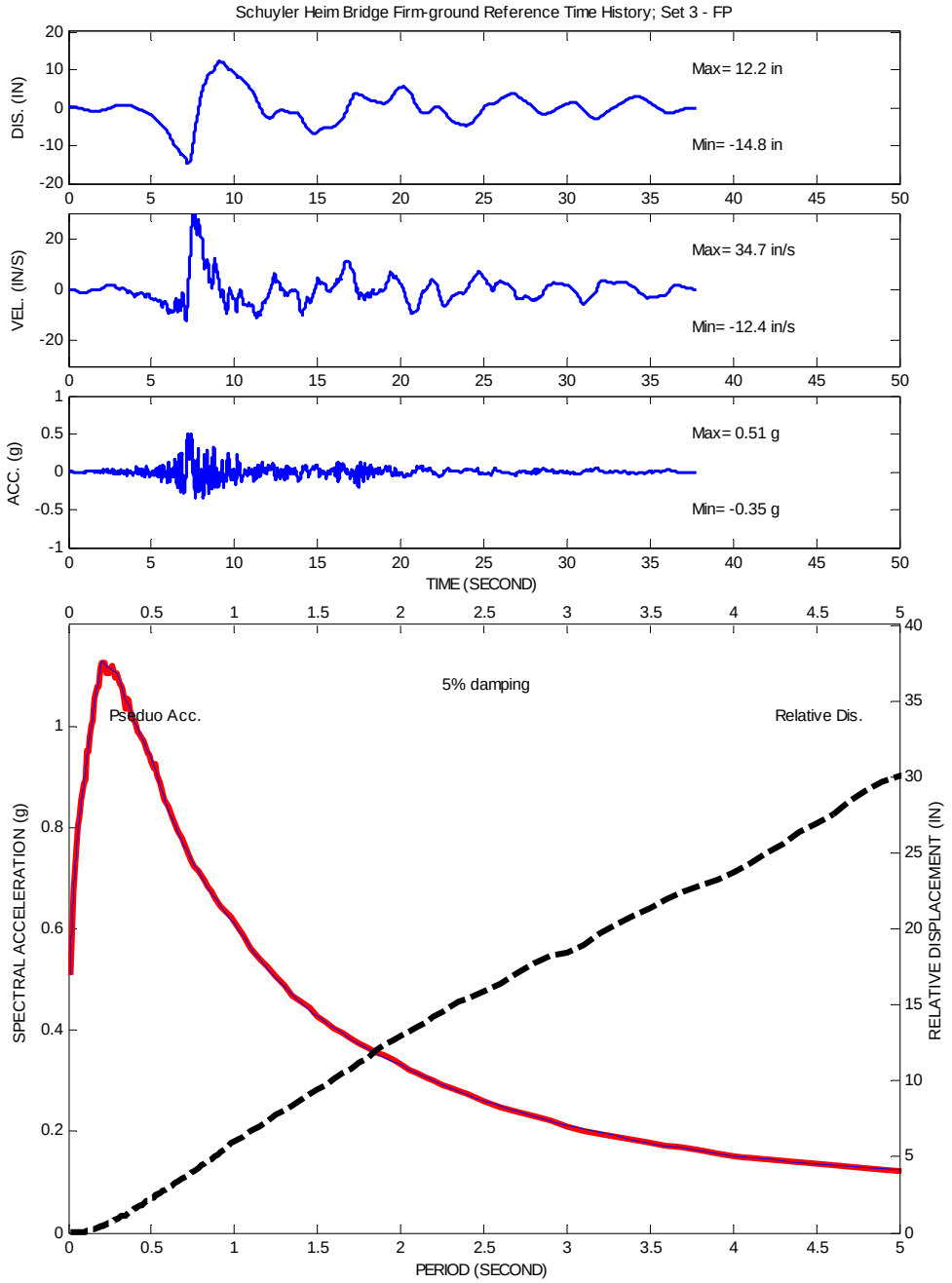

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

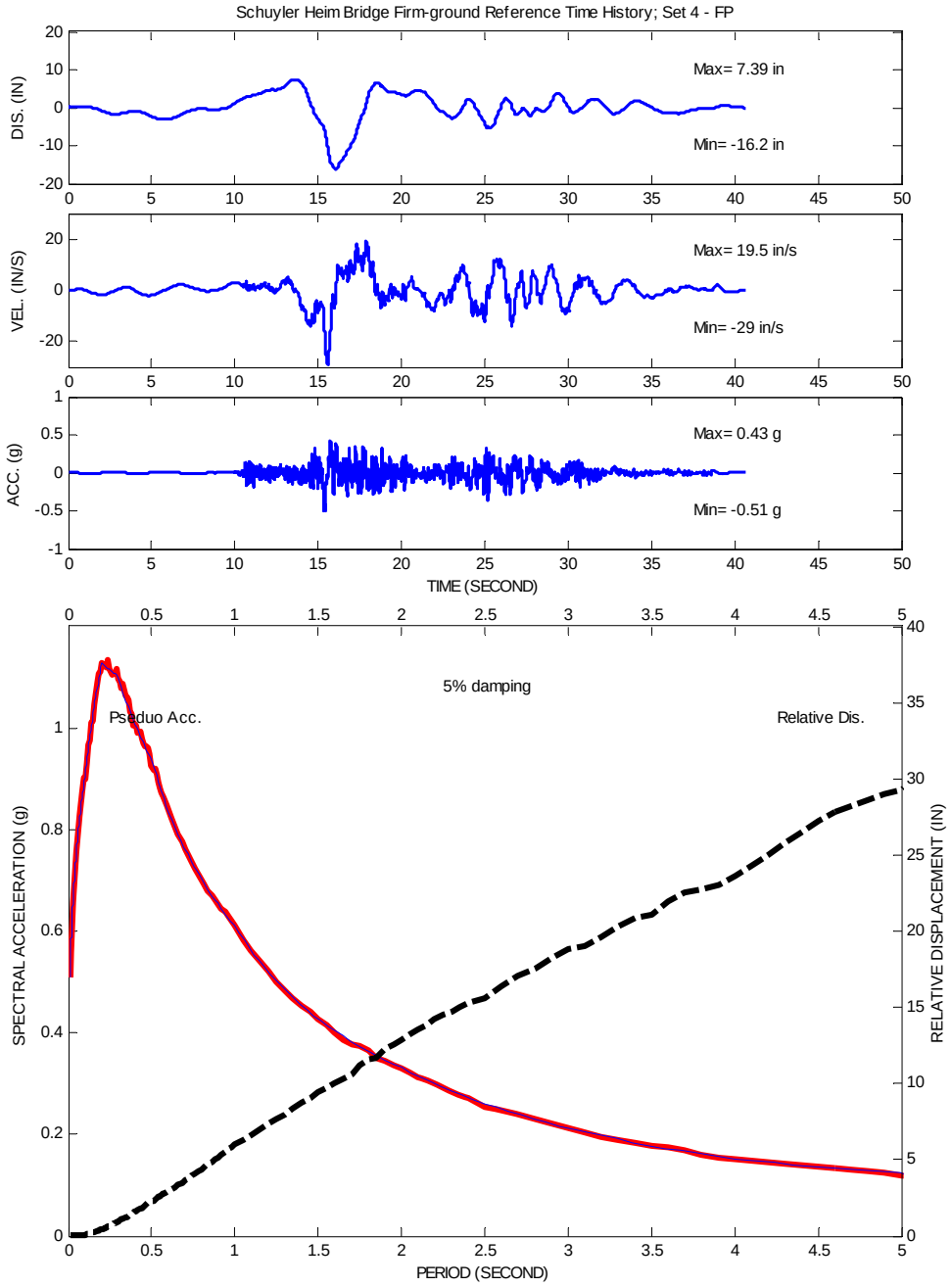

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

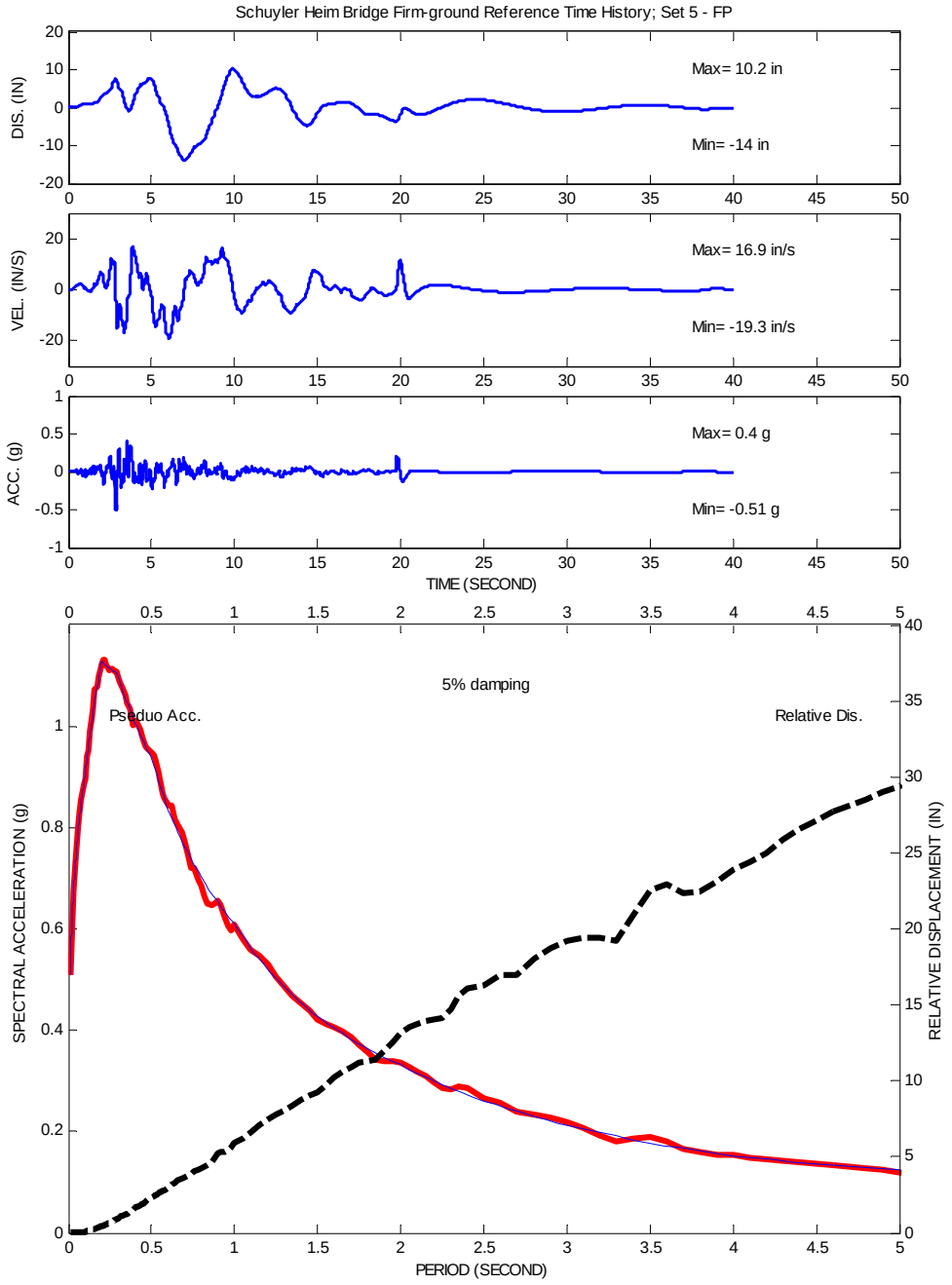

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

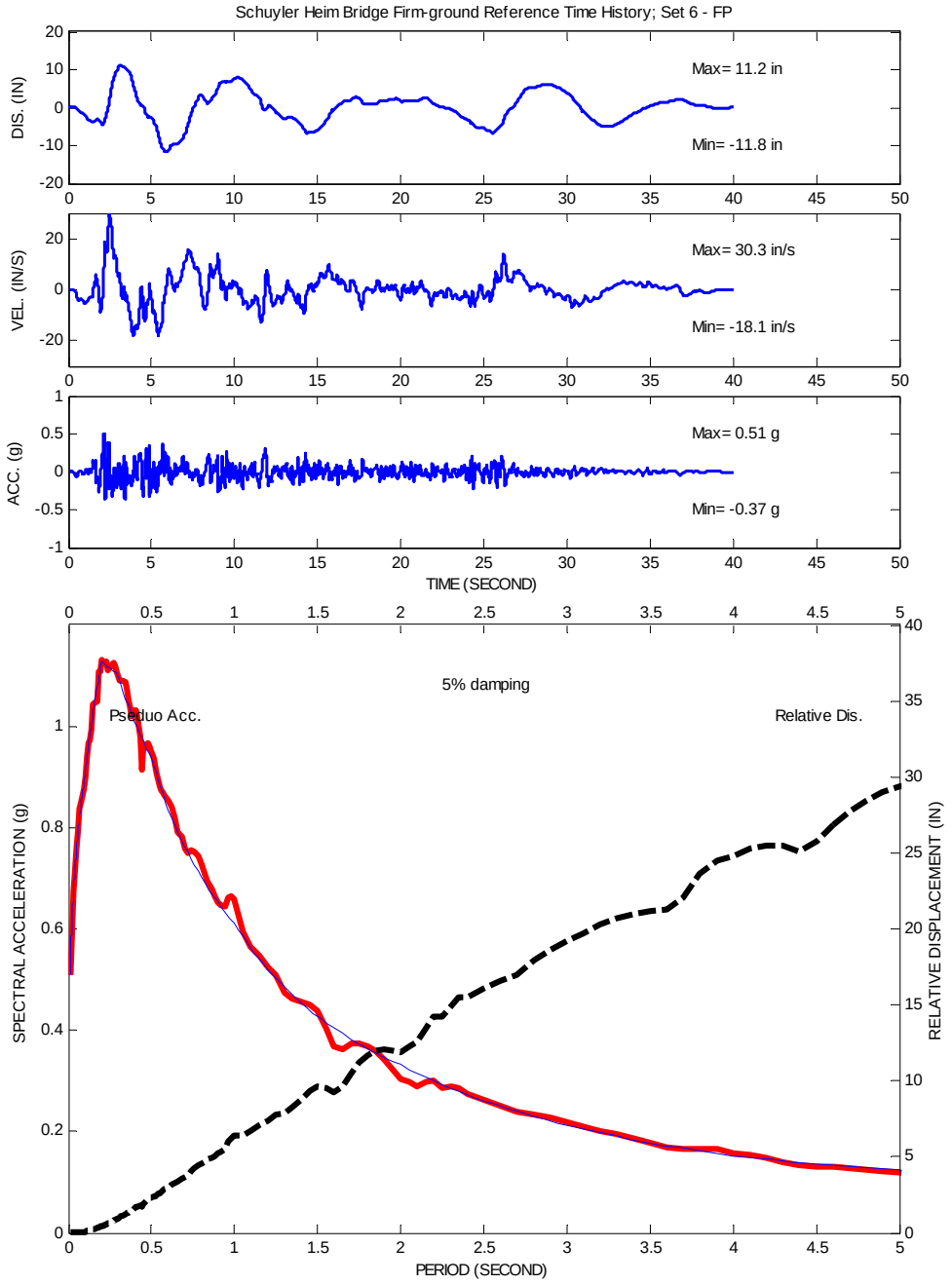

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

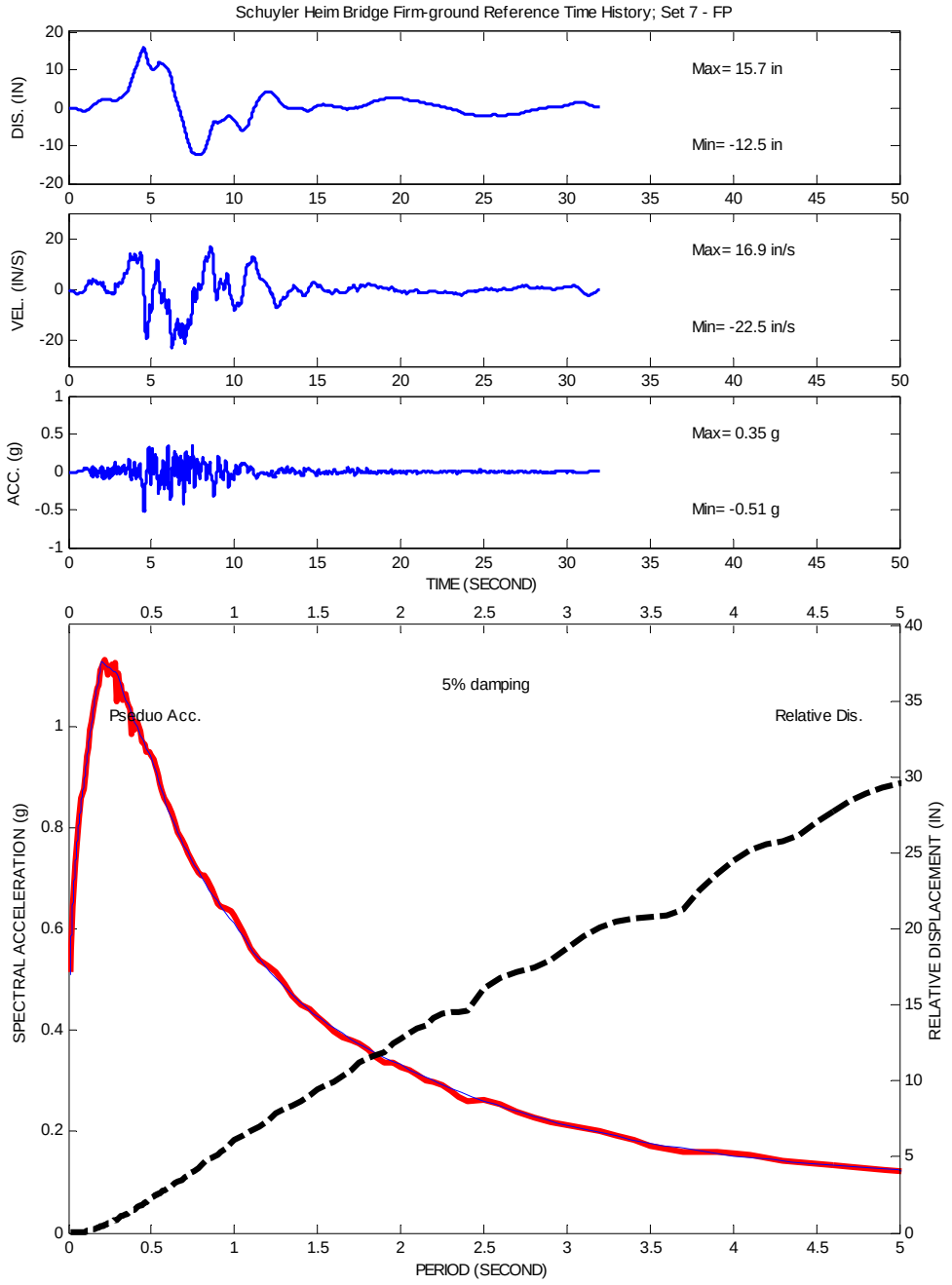

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

Appendix G. p-y Curve Comparison Memorandum

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 2, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul K. Arulmoli, Eric Brown & Patrick Wilson / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge (Replace)
Los Angeles and Long Beach, CA
Bent Foundation Lateral Pile Analysis (p-y Curve Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge (Replace) and associated ramp structures (New Dock Street On-Ramp, New Dock Street Off-Ramp, State Route-103 On-Ramp and State Route-103 Off-Ramp) in the cities of Los Angeles and Long Beach, California.

This memorandum summarizes the results of our lateral pile analysis following completion of the recent field investigation and laboratory testing program and is intended to verify that p-y curves developed during the preliminary design phase are suitable and conservative for use in final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California. The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and W. Ocean Boulevard on the south side.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge and the new alignment shifts east along the existing alignment. The proposed fixed bridge will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge will also include southbound exit ramps and northbound entrance ramps at New Dock Street and State Route (SR) 103.

The typical bridge bent will have either multiple columns (mainline) or single columns (ramp structures) supported on Type II cast-in-drilled-hole (CIDH) piles. South of Cerritos Channel, the CIDH piles are 10 ft diameter while the spans across Cerritos Channel and north of Cerritos Channel are supported on 11 to 12 ft diameter CIDH piles. The abutments for the mainline and the ramp structures are expected to be supported on 2.5-foot diameter CIDH piles; however the subject memorandum only pertains to the bent pile analysis.

Project Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time and was intended to be used for bridge type selection and preliminary design. The PFR included a general description of the subsurface conditions including eight idealized soil profiles along the proposed structure alignment with each idealized soil profile typically spanning across multiple bents. The idealized soil profile was used by EMI to develop pile lengths for cost estimating purposes based upon preliminary design loads provided by the designers. Each idealized soil profile included stratigraphy and idealized soil strength parameters (unit weight, friction angle and undrained shear strength) including post-liquefaction "residual" shear strengths for the layers identified as being potentially liquefiable based on a liquefaction analysis performed on the existing soil borings.

It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared. A set of p-y curves was generated at each bent of the mainline and ramp structures for a single 10-ft diameter CIDH pile and included reduced soil strengths for the layers identified in the PFR as potentially liquefiable. Since the project specific geotechnical field investigation could not be initiated until late during the project timeline, the preliminary p-y curves were used by the Caltrans bridge designers in final design. Based upon our conversations with the bridge designers, the only modifications that were made to the preliminary p-y curves was the application of a p-multiplier of 1.2 to curves where the CIDH pile diameter was increased to 12 ft.

In September 2009, EMI was requested by the Alameda Corridor Transportation Agency (ACTA) to perform the project-specific geotechnical field investigation which when completed consisted of 42 rotary wash borings, 33 cone penetration test (CPT) soundings and 8 hollow-stem auger borings along the proposed bridge and ramp alignment; including at least one boring performed near each support of the proposed structure. After completion of the geotechnical field investigation and laboratory testing program, a complete liquefaction analysis was conducted using the new boring information and the idealized soil profile along the proposed bridge alignment was revised.

Because the geotechnical field investigation was not able to be initiated until late during the project timeline, re-analyzing the structure based upon p-y curves generated using the updated soil profile was not feasible given project deadlines. Therefore, EMI performed a set of lateral pile analyses at selected bent locations representing the entire bridge alignment to compare the

preliminary p-y curves (referred to as Design Curves in this memorandum) generated from the idealized soil profiles in the PFR to the p-y curves developed using the updated soil profile (referred to as Revised Profile Curves in this memorandum) to verify that the preliminary curves are suitable and conservative for use in final design.

Method of Analysis

As described above, the Design Curves were generated from eight different soil profiles provided in the PFR (EMI, 2006). For comparison purposes, five bent locations were selected where the individual p-y curves and the overall pile behavior (pile head shear resistance and maximum pile moment versus pile-top deflection) could be compared. The bents selected for comparison were at locations where five of the eight different soil profiles generated during preliminary design could be analyzed. The bent locations selected consisted of two bents south of Cerritos Channel (Bent 2 and Bent 11), one of the bents inside the Cerritos Channel (Bent 14) and two bents north of Cerritos Channel (Bent 18 and Bent 24). The five different idealized soil profiles are shown in Figures 1 to 5.

A review of the Design Curves indicated that coarse-grained soils appear to have been developed using the method proposed by Reese et al. (1974) and fine-grained soils appear to have been developed using the method proposed by Reese and Cox (1975) for stiff clay in the presence of free water. The Revised Profile Curves generated by EMI were developed using API criteria (2000) for coarse grained soils, Matlock's soft clay criteria (Matlock, 1970) for clays with undrained shear strength less than 1 ksf and Reese's method (Reese and Cox, 1975) for stiff clay in the presence of free water for clays with an undrained shear strength greater than 1 ksf.

For comparison of the individual p-y curves, the design curves were provided by the designers. The Revised Profile Curves were generated using LPILE (Ensoft, 2004) based upon the revised idealized soil profile developed at the different bent locations. For the comparison of overall pile behavior (pile head shear resistance and pile moment versus pile-top deflection), the Design Curves were input into LPILE using the "user input p-y curves" option. Based upon our conversations with the designers, a "cracked" section modulus (EI) equal to 75% of the gross EI was used for both models.

Liquefiable Soil. As described above, the Design Curves were generated from soil profiles that indicated the presence of potentially liquefiable material. Based upon a review of the Design Curves, liquefied strengths were generated by applying a p-reduction factor varying between 0.15 and 0.20 for potentially liquefiable layers.

The Revised Profile Curves were generated based upon an updated liquefaction analysis performed on the borings completed in the EMI field investigation. Liquefied soil strengths for layers identified to be potentially liquefiable were modeled using a p-reduction factor based upon the values provided in Ashford et al. (2008). The p-reduction factors are correlated to an average normalized clean sand SPT blowcount $(N1)_{60\text{-}CS}$ for the liquefiable layer with discrete values provided for a range of $(N1)_{60\text{-}CS}$. An approximate trend line was drawn through the ranges proposed by Ashford and used in the analysis as shown in Figure 6.

Group Effects. It is our understanding that the Design Curves were generated prior to Caltrans implementation of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2007) which required p-reduction factors to p-y curves to account for group effects. P-reduction factors to account for group effects for the Revised Profile Curves followed the recommendations for pile group efficiency reduction factors provided in Caltrans Amendments to AASHTO LRFD BDS (Caltrans, 2008) and were based upon the CIDH pile on-center spacing in the bridge transverse direction at the individual bent locations. Since each bent consists of a single row of piles, the bridge transverse direction controls the pile design as it has a greater group reduction than the longitudinal direction. The pile spacing and p-reduction factors used in the analysis for each bent are listed in Table 1.

Table 1. Group Reduction Factors for Revised Profile Curves

Bent Location	Pile Diameter (ft)	Average Spacing in Transverse Direction (ft)	P-Reduction Factor for Group Effects
Bent 2	10	30 = 3.0 x D	0.53
Bent 11	10	36 = 3.6 x D	0.61
Bent 14	12	33 = 2.9 x D	0.48
Bent 18	12	35 = 3.0 x D	0.53
Bent 24	12	45 = 4.0 x D	0.67
Note: Group reduction effects were not accounted for in development of Design Curves.			

Groundwater. The design groundwater elevation for the Revised Profile Curves was placed at an elevation of +5 ft MLLW or the ground surface in locations where proposed grade is indicated on the plans as being below elevation +5 ft MLLW.

Results

The revised soil profiles resulting from the information gathered during the recent investigation are generally consistent with those provided in the PFR that were used to develop the Design Curves. Site soils can be characterized by alluvial deposits consisting of loose to medium dense fine-grained silty sand and sandy silt with abundant silty clay and clayey silt layers between the ground surface and about 50 to 70 ft below grade. The near surface alluvium is underlain by dense to very dense coarse-grained Gaspur Formation sand. The coarse grained portions of the alluvium is generally liquefiable with some pockets and lenses with medium dense to dense consistency that are not considered susceptible to liquefaction.

Since lateral pile behavior is primarily dictated by the soil profile within the upper portion of the pile (within about 5 to 7 pile diameters from the pile top), the lateral pile stiffness throughout the project is dominated by soft to stiff fine-grained material and liquefiable sand. In generating the revised soil profiles, the recent soil borings and laboratory test results justify using more appropriate p-reduction factors to account for liquefaction throughout the profile and higher undrained shear strengths in some of the fine-grained material. Though the Design Curves were generated during early stages of the project without considering group effects, when the more appropriate p-reduction factors for liquefiable soils and increased undrained shear strengths for the appropriate fine-grained soils are used in conjunction with the group reduction factors, the Revised Profile Curves are generally comparable to the Design Curves. Figures 7 to 11 show the

Design Curves plotted along side the Revised Profile Curves at each bent location for the top 100 ft of pile length.

Due to some revisions in the idealized soil profile stratigraphy based upon the new soil information, there are some depths that the Revised Profile Curves model a layer or a portion of a layer as softer than the Design Curves; therefore, it isn't necessarily clear upon initial inspection which set of p-y curves generates a more conservative soil model. Based upon our conversations with the designers, performing a pile pushover analysis using a free-head pile, the curves that generate a pile response where a smaller pile-head shear is required to produce a prescribed lateral pile displacement is considered to be more conservative. In addition, since earthquake loading on a bridge is force based (i.e., mass times the spectral acceleration), the curve that predicts more moment in the pile for a given pile-head shear would also be an indication of a more conservative analysis.

For the five different bents considered, the lateral pile head shear and maximum moment are plotted against lateral pile-top displacement in Figures 12 to 16 using the analysis methods described above. Figures 12, 15 and 16 show that for Bent 2, Bent 18 and Bent 24, respectively, the Design Curves produce a more conservative lateral pile response than the analysis using the Revised Profile Curves. For Bent 11 and Bent 14 shown in Figures 13 and 14, respectively, the lateral pile head shear to produce the same lateral pile deflection is about 15 percent less for the Revised Profile Curves than that for the Design Curves. These differences are considered small and acceptable. In addition, as shown in Figures 12 through 16, the maximum moments for given pile-head shear values predicted using the Design Curves are approximately equal to or greater those predicted using the Revised Profile Curves.

Conclusions

Based upon the results of the above described analysis and our discussions with the designers, we conclude that the Design Curves are appropriate for use in the bridge final design as they typically generate a more conservative lateral pile response than the response predicted by the Revised Curves.

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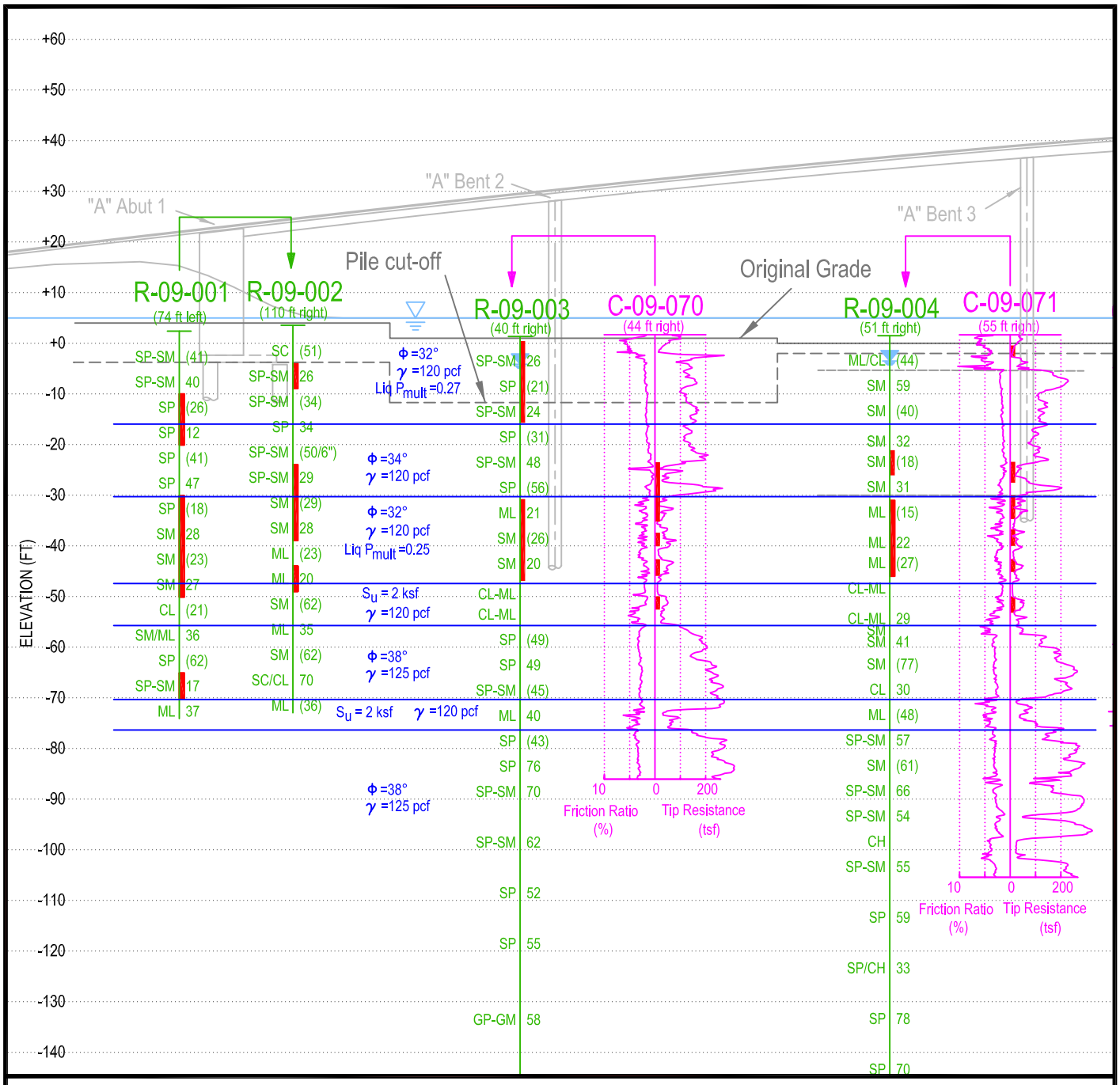
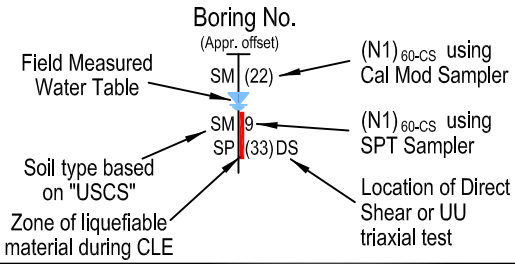
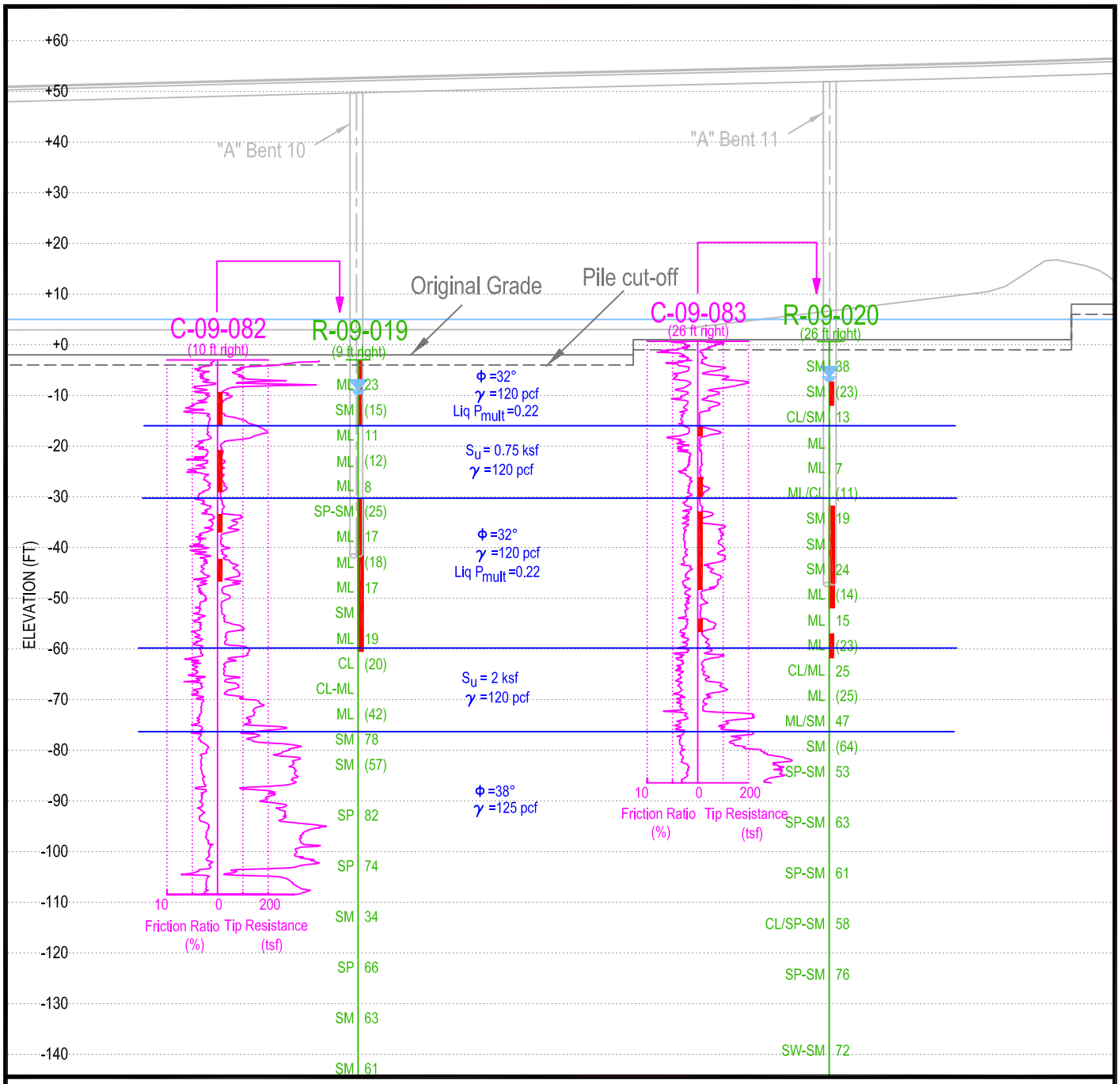
Reese, L.C., and W.R. Cox, 1975, "Field Testing and Analysis of Laterally Loaded Piles in Stiff Clay," Proceedings, Offshore Technology Conference, Houston, Texas, Vol. II, Paper No. 2312, pp. 671-690.



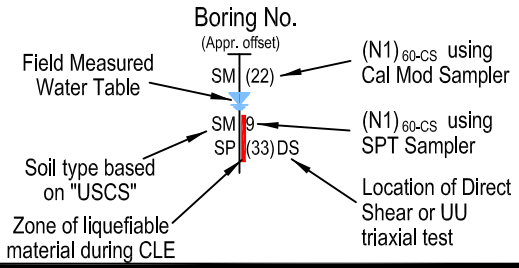
Boring Log Legend



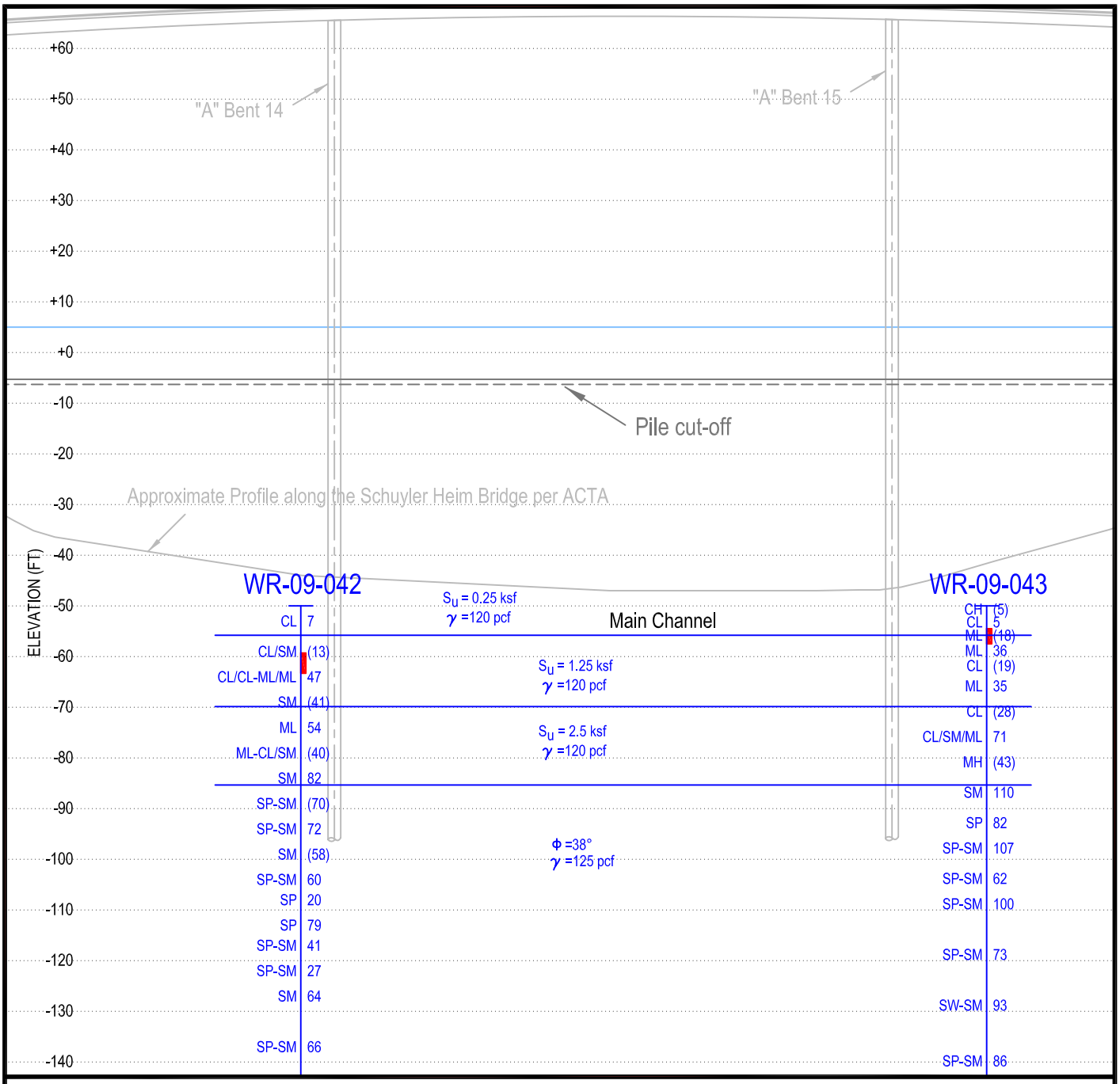
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 2 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 1



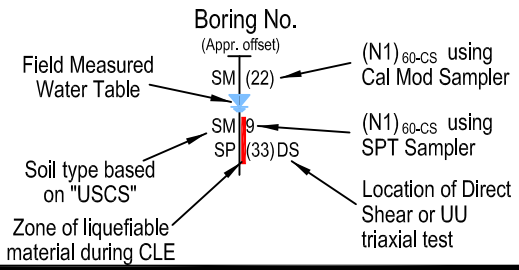
Boring Log Legend



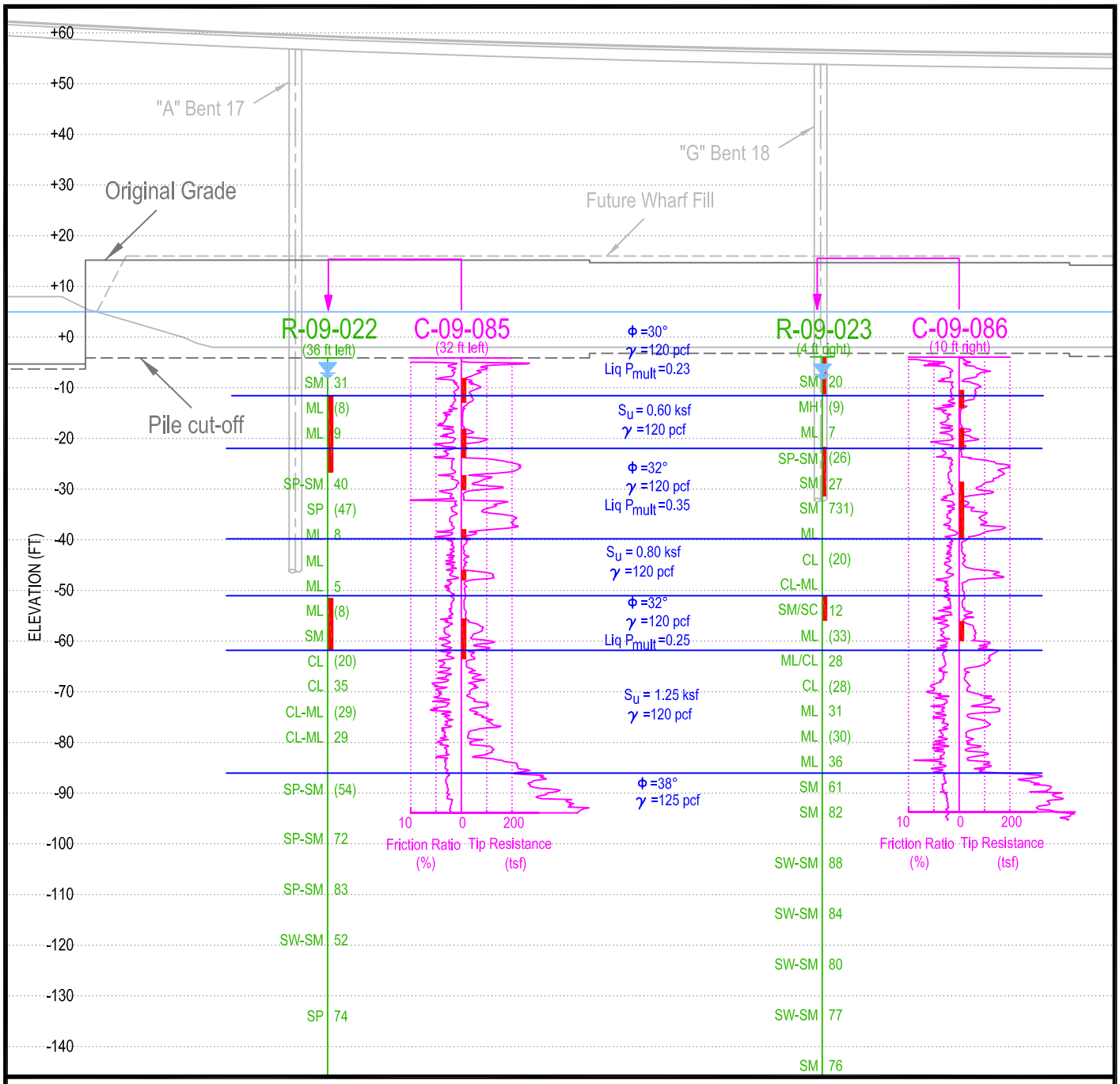
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 2



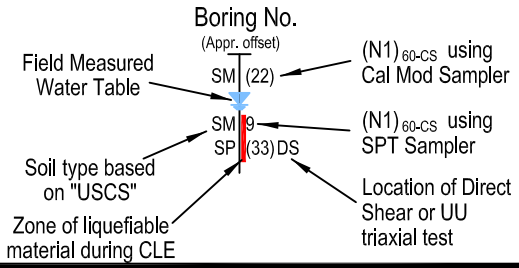
Boring Log Legend



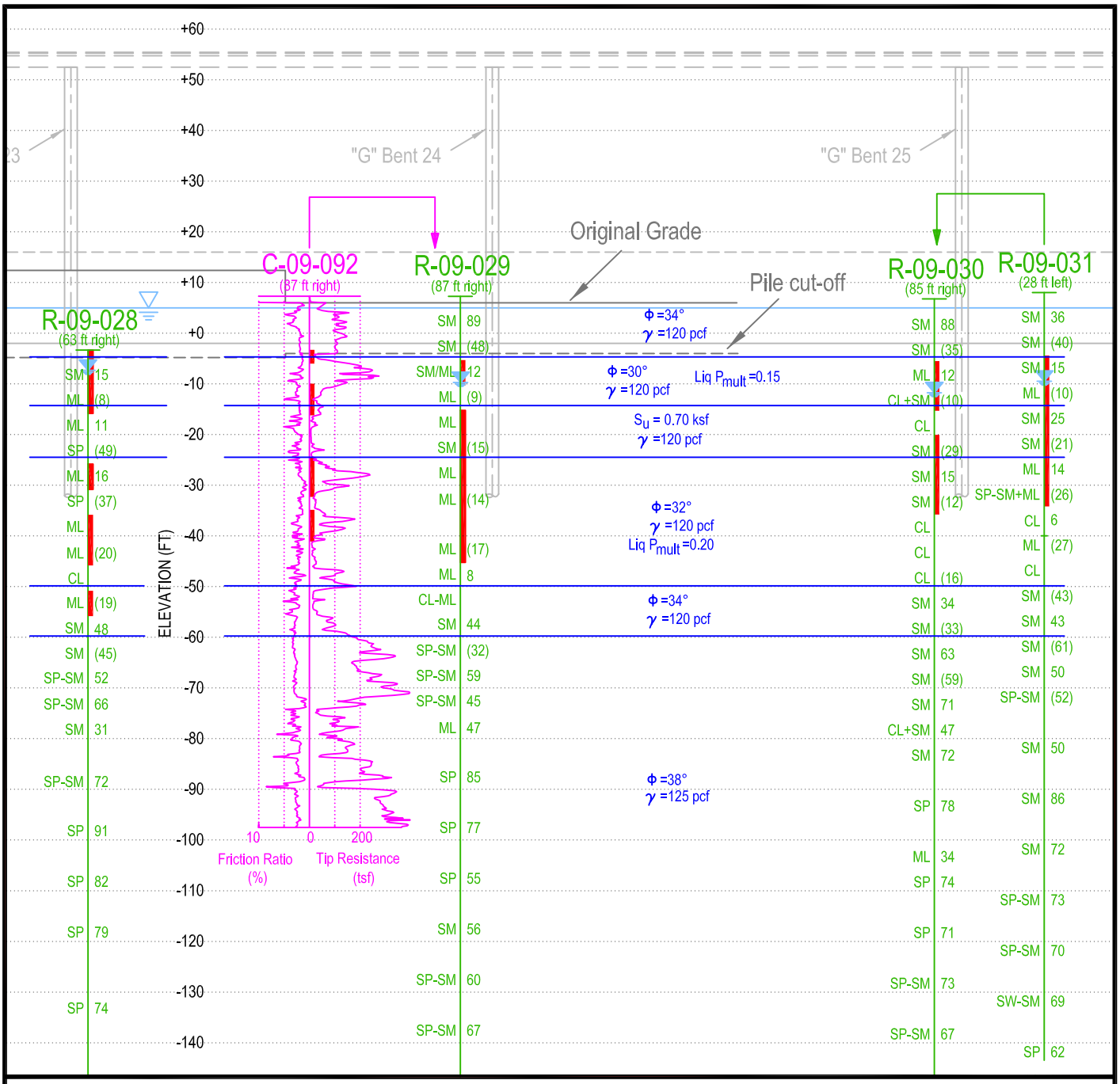
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 3



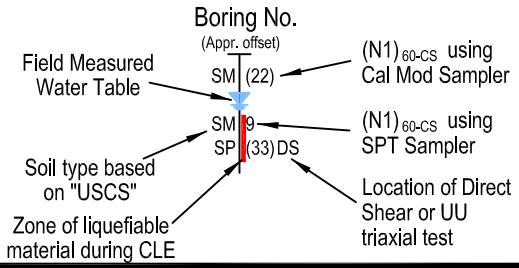
Boring Log Legend



Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 4



Boring Log Legend



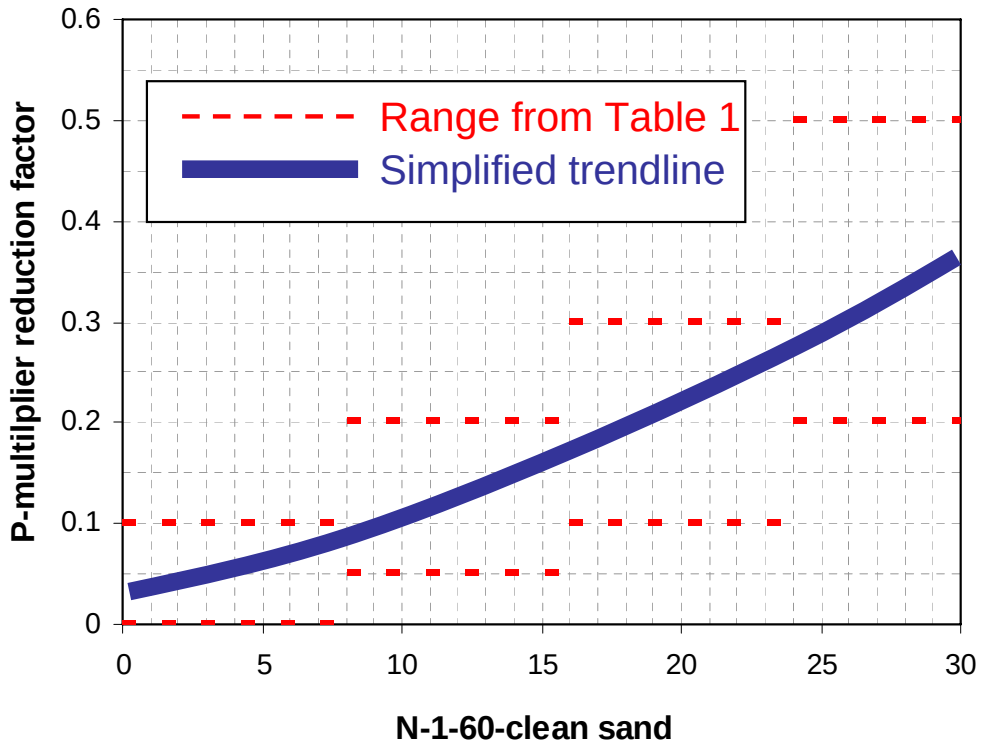
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 24 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 5

Recommended values (after Ashford et al. 2008)

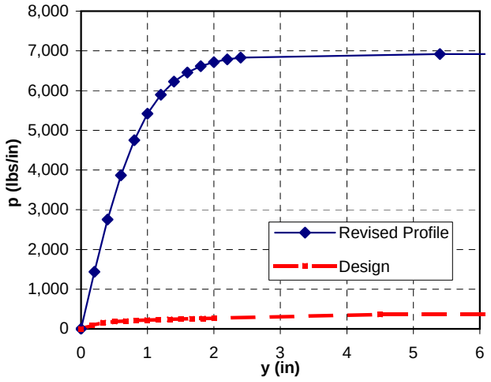
Table 1. p-multipliers, m_p, to account for liquefaction

$(N_1)_{60\text{-}CS}$	m_p
<8	0.0 to 0.1
8-16	0.05 to 0.2
16-24	0.1 to 0.3
>24	0.2 to 0.5

Chart for selecting p-multiplier based on $(N1)60_{cs}$

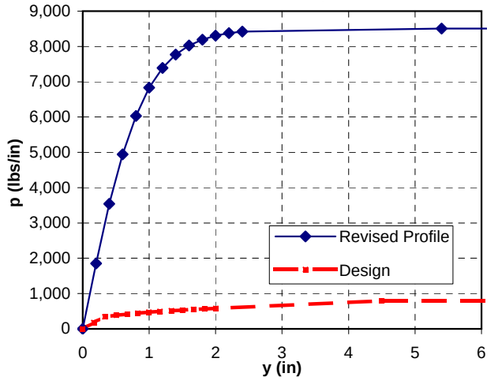


5 ft depth



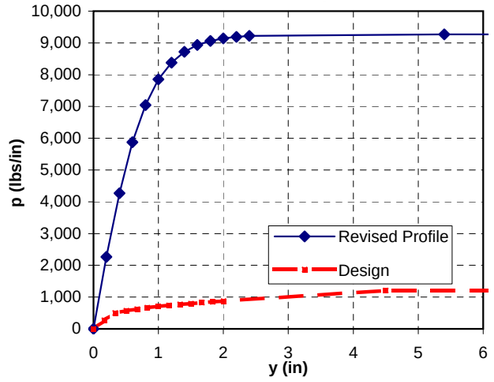
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	1,436
0.34	162	0.40	2,753
0.50	182	0.60	3,869
0.67	197	0.80	4,753
0.83	210	1.00	5,416
1.00	221	1.20	5,894
1.16	231	1.40	6,228
1.33	240	1.60	6,457
1.50	248	1.80	6,611
1.67	256	2.00	6,715
1.84	263	2.20	6,783
2.00	269	2.40	6,829
4.50	365	5.40	6,916
124.50	365	149.40	6,916

10 ft depth



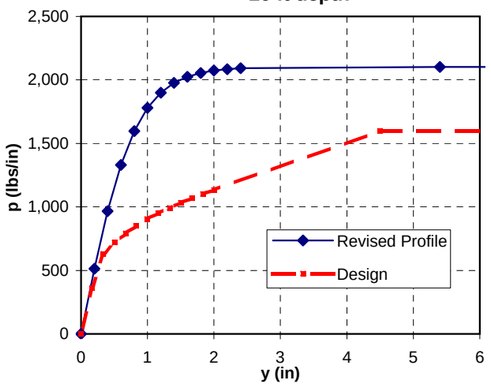
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	1,853
0.34	341	0.40	3,538
0.50	384	0.60	4,943
0.67	418	0.80	6,032
0.83	447	1.00	6,829
1.00	472	1.20	7,389
1.16	494	1.40	7,771
1.33	514	1.60	8,025
1.50	532	1.80	8,193
1.67	549	2.00	8,303
1.84	565	2.20	8,374
2.00	579	2.40	8,420
4.50	794	5.40	8,503
124.50	794	149.40	8,503

15 ft depth



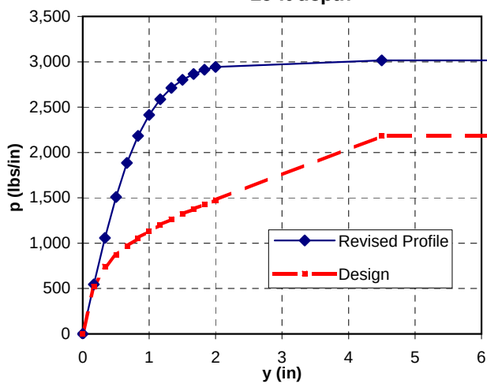
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.20	2,263
0.34	502	0.40	4,271
0.50	569	0.60	5,873
0.67	622	0.80	7,046
0.83	666	1.00	7,852
1.00	705	1.20	8,381
1.16	739	1.40	8,719
1.33	770	1.60	8,931
1.50	799	1.80	9,062
1.67	825	2.00	9,143
1.84	850	2.20	9,192
2.00	873	2.40	9,222
4.50	1,210	5.40	9,269
124.50	1,210	149.40	9,269

20 ft depth



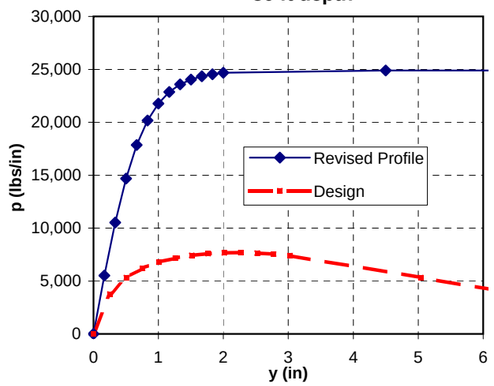
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	360	0.20	512
0.34	631	0.40	967
0.50	720	0.60	1,330
0.67	792	0.80	1,597
0.83	852	1.00	1,780
1.00	904	1.20	1,900
1.16	951	1.40	1,977
1.33	993	1.60	2,026
1.50	1,032	1.80	2,055
1.67	1,069	2.00	2,074
1.84	1,103	2.20	2,085
2.00	1,134	2.40	2,092
4.50	1,599	5.40	2,103
124.50	1,599	149.40	2,103

29 ft depth



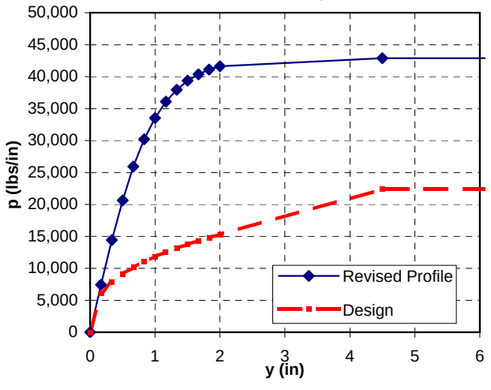
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	522	0.17	547
0.34	744	0.33	1,058
0.50	868	0.50	1,509
0.67	970	0.67	1,885
0.83	1,056	0.83	2,184
1.00	1,132	1.00	2,414
1.16	1,201	1.17	2,586
1.33	1,264	1.33	2,711
1.50	1,322	1.50	2,802
1.67	1,377	1.67	2,866
1.84	1,428	1.83	2,911
2.00	1,476	2.00	2,943
4.50	2,182	4.50	3,016
124.50	2,182	124.50	3,017

50 ft depth



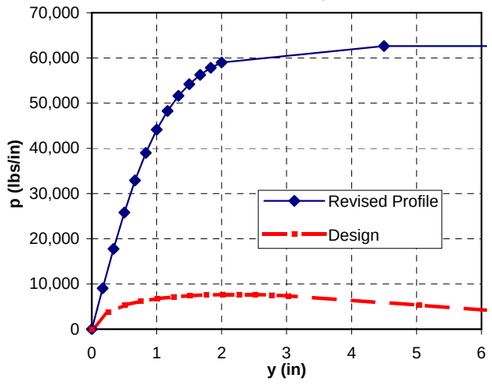
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	5,521
0.50	5,325	0.33	10,523
0.76	6,204	0.50	14,668
1.01	6,775	0.67	17,855
1.26	7,164	0.83	20,166
1.51	7,425	1.00	21,774
1.76	7,585	1.17	22,858
2.02	7,664	1.33	23,576
2.27	7,676	1.50	24,045
2.52	7,629	1.67	24,348
2.77	7,532	1.83	24,543
3.02	7,390	2.00	24,668
5.04	5,330	4.50	24,888
7.06	3,268	124.50	24,889

71 ft depth



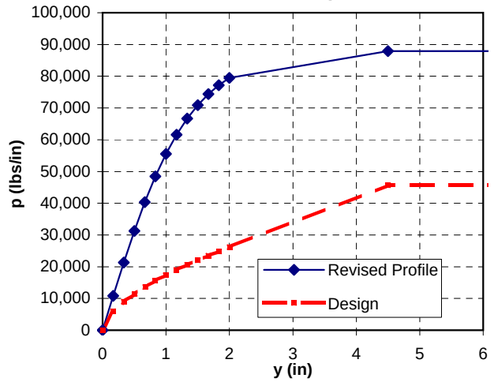
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	6,081	0.17	7,430
0.34	7,867	0.33	14,426
0.50	9,145	0.50	20,652
0.67	10,176	0.67	25,918
0.83	11,056	0.83	30,186
1.00	11,830	1.00	33,525
1.16	12,527	1.17	36,068
1.33	13,164	1.33	37,963
1.50	13,753	1.50	39,354
1.67	14,302	1.67	40,363
1.84	14,817	1.83	41,089
2.00	15,303	2.00	41,609
4.50	22,408	4.50	42,867
124.50	22,408	124.50	42,874

85 ft depth



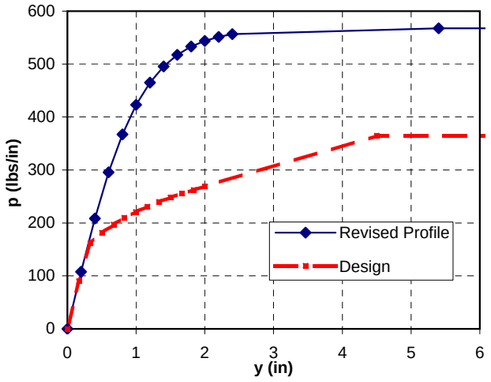
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	9,074
0.50	5,325	0.33	17,775
0.76	6,204	0.50	25,790
1.01	6,775	0.67	32,904
1.26	7,164	0.83	39,014
1.51	7,425	1.00	44,113
1.76	7,585	1.17	48,270
2.02	7,664	1.33	51,593
2.27	7,676	1.50	54,208
2.52	7,629	1.67	56,241
2.77	7,532	1.83	57,807
3.02	7,390	2.00	59,004
5.04	5,330	4.50	62,636
7.06	3,268	124.50	62,684

100 ft depth



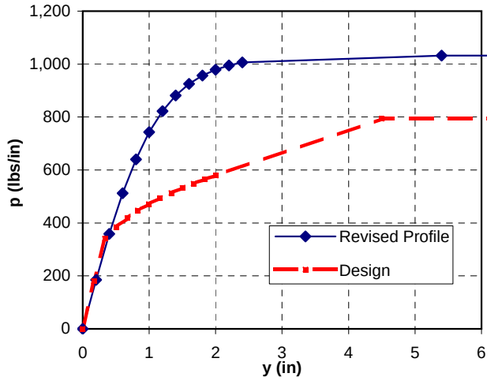
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	5,976	0.17	10,832
0.34	9,023	0.33	21,341
0.50	11,483	0.50	31,242
0.67	13,624	0.67	40,316
0.83	15,557	0.83	48,423
1.00	17,338	1.00	55,503
1.16	19,001	1.17	61,565
1.33	20,571	1.33	66,668
1.50	22,063	1.50	70,902
1.67	23,489	1.67	74,373
1.84	24,858	1.83	77,191
2.00	26,177	2.00	79,461
4.50	45,628	4.50	87,868
124.50	45,628	124.50	88,090

5 ft depth



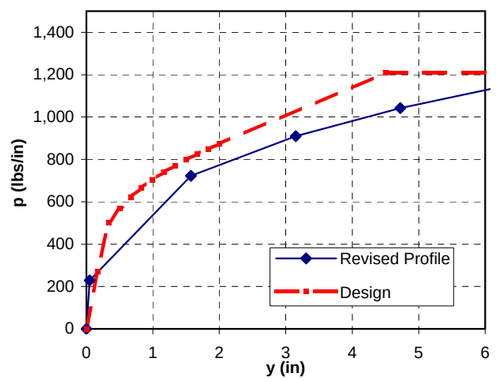
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	108
0.34	162	0.40	208
0.50	182	0.60	295
0.67	197	0.80	367
0.83	210	1.00	423
1.00	221	1.20	465
1.16	231	1.40	496
1.33	240	1.60	518
1.50	248	1.80	533
1.67	256	2.00	544
1.84	263	2.20	551
2.00	269	2.40	556
4.50	365	5.40	567
124.50	365	149.40	568

10 ft depth



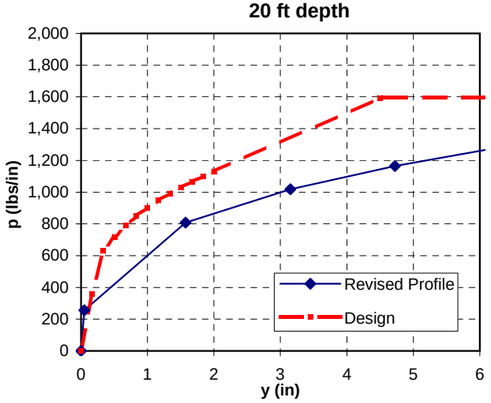
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	185
0.34	341	0.40	359
0.50	384	0.60	512
0.67	418	0.80	640
0.83	447	1.00	743
1.00	472	1.20	822
1.16	494	1.40	881
1.33	514	1.60	925
1.50	532	1.80	956
1.67	549	2.00	979
1.84	565	2.20	995
2.00	579	2.40	1,006
4.50	794	5.40	1,032
124.50	794	149.40	1,033

15 ft depth



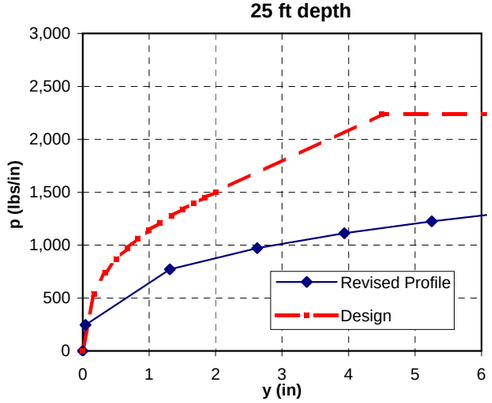
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.05	229
0.34	502	1.58	723
0.50	569	3.15	910
0.67	622	4.73	1,042
0.83	666	6.30	1,147
1.00	705	7.88	1,235
1.16	739	9.45	1,313
1.33	770	11.03	1,382
1.50	799	12.60	1,445
1.67	825	14.18	1,503
1.84	850	15.75	1,557
2.00	873	17.33	1,607
4.50	1,210	18.90	1,654
124.50	1,210	50.40	2,294

20 ft depth



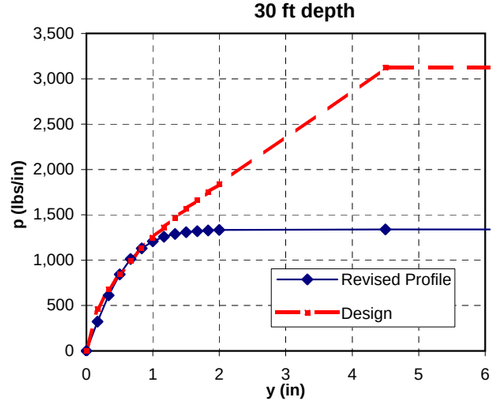
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	359	0.05	256
0.34	629	1.58	808
0.50	719	3.15	1,018
0.67	790	4.73	1,165
0.83	850	6.30	1,282
1.00	902	7.88	1,381
1.16	949	9.45	1,468
1.33	991	11.03	1,545
1.50	1,030	12.60	1,616
1.67	1,066	14.18	1,680
1.84	1,100	15.75	1,740
2.00	1,132	17.33	1,797
4.50	1,594	18.90	1,849
124.50	1,594	50.40	2,565

25 ft depth



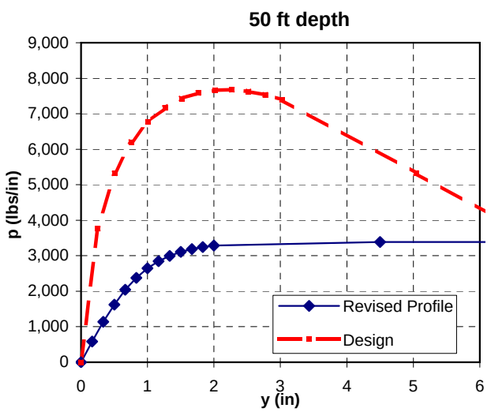
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	539	0.04	245
0.34	740	1.31	771
0.50	869	2.63	972
0.67	973	3.94	1,112
0.83	1,062	5.25	1,224
1.00	1,141	6.56	1,319
1.16	1,212	7.88	1,402
1.33	1,278	9.19	1,475
1.50	1,338	10.50	1,543
1.67	1,395	11.81	1,604
1.84	1,448	13.13	1,662
2.00	1,499	14.44	1,715
4.50	2,236	15.75	1,766
124.50	2,236	42.00	2,449

30 ft depth



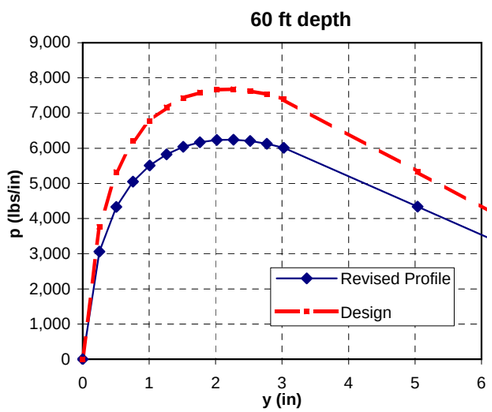
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	461	0.17	324
0.34	678	0.33	612
0.50	850	0.50	843
0.67	998	0.67	1,012
0.83	1,130	0.83	1,130
1.00	1,251	1.00	1,208
1.16	1,363	1.17	1,257
1.33	1,468	1.33	1,289
1.50	1,567	1.50	1,308
1.67	1,662	1.67	1,320
1.84	1,753	1.83	1,328
2.00	1,840	2.00	1,332
4.50	3,121	4.50	1,340
124.50	3,121	124.50	1,340

50 ft depth



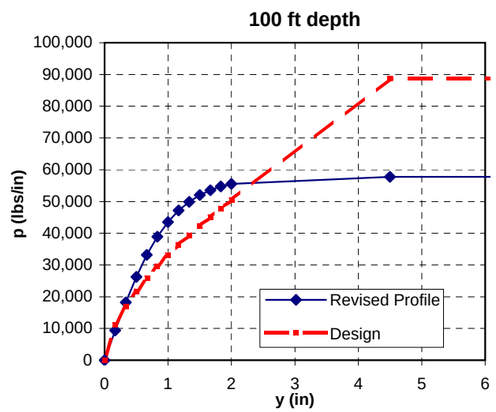
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	584
0.50	5,325	0.33	1,135
0.76	6,204	0.50	1,626
1.01	6,775	0.67	2,041
1.26	7,164	0.83	2,379
1.51	7,425	1.00	2,643
1.76	7,585	1.17	2,845
2.02	7,664	1.33	2,996
2.27	7,676	1.50	3,107
2.52	7,629	1.67	3,188
2.77	7,532	1.83	3,246
3.02	7,390	2.00	3,288
5.04	5,330	4.50	3,389
7.06	3,268	124.50	3,390

60 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.25	3,063
0.50	5,325	0.50	4,332
0.76	6,204	0.76	5,047
1.01	6,775	1.01	5,511
1.26	7,164	1.26	5,828
1.51	7,425	1.51	6,040
1.76	7,585	1.76	6,170
2.02	7,664	2.02	6,235
2.27	7,676	2.27	6,244
2.52	7,629	2.52	6,206
2.77	7,532	2.77	6,127
3.02	7,390	3.02	6,011
5.04	5,330	5.04	4,336
7.06	3,268	7.06	2,658

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	11,128	0.17	9,360
0.34	16,961	0.33	18,242
0.50	21,702	0.50	26,260
0.67	25,850	0.67	33,178
0.83	29,606	0.83	38,920
1.00	33,077	1.00	43,533
1.16	36,327	1.17	47,142
1.33	39,400	1.33	49,910
1.50	42,325	1.50	51,998
1.67	45,125	1.67	53,555
1.84	47,817	1.83	54,706
2.00	50,414	2.00	55,551
4.50	88,729	4.50	57,780
124.50	88,729	124.50	57,797

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

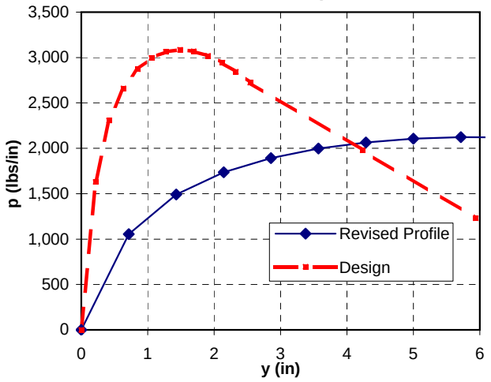
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 11

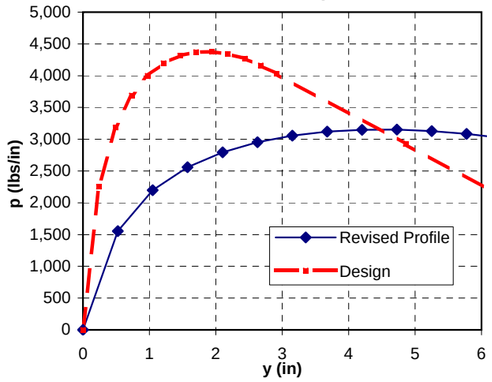
Figure 8

55 ft depth



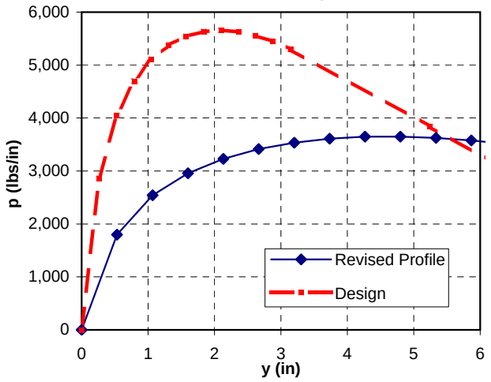
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	1,631	0.71	1,055
0.42	2,306	1.43	1,491
0.64	2,660	2.14	1,735
0.85	2,870	2.86	1,891
1.06	2,997	3.57	1,996
1.27	3,064	4.29	2,065
1.49	3,085	5.00	2,105
1.69	3,068	5.71	2,122
1.91	3,019	6.43	2,121
2.12	2,944	7.14	2,102
2.33	2,844	7.86	2,069
2.54	2,724	8.57	2,024
4.24	1,978	14.29	1,463
5.94	1,230	20.00	902

60 ft depth



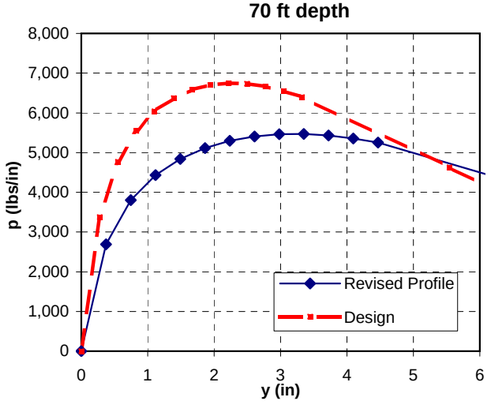
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.24	2,252	0.53	1,555
0.49	3,185	1.05	2,200
0.73	3,688	1.58	2,561
0.97	3,999	2.10	2,794
1.21	4,198	2.63	2,952
1.46	4,316	3.15	3,057
1.70	4,372	3.68	3,120
1.94	4,378	4.20	3,149
2.18	4,341	4.73	3,150
2.44	4,268	5.25	3,127
2.68	4,163	5.78	3,083
2.92	4,032	6.30	3,021
4.86	2,926	10.50	2,181
6.80	1,820	14.71	1,341

65 ft depth



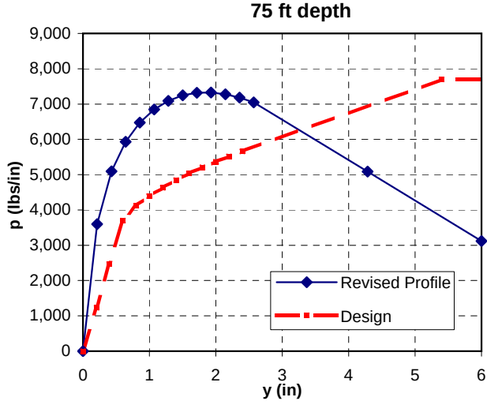
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.26	2,862	0.53	1,796
0.53	4,047	1.07	2,540
0.79	4,697	1.60	2,958
1.04	5,106	2.13	3,229
1.31	5,375	2.67	3,414
1.57	5,542	3.20	3,536
1.84	5,631	3.73	3,611
2.10	5,657	4.27	3,647
2.36	5,630	4.80	3,651
2.62	5,558	5.33	3,627
2.88	5,445	5.87	3,578
3.14	5,300	6.40	3,510
5.24	3,841	10.67	2,532
7.34	2,382	14.93	1,554

70 ft depth



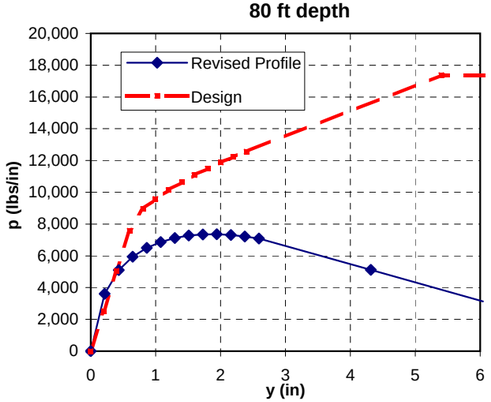
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.28	3,375	0.37	2,691
0.55	4,773	0.74	3,805
0.83	5,547	1.12	4,432
1.10	6,041	1.49	4,837
1.39	6,371	1.86	5,113
1.67	6,583	2.23	5,296
1.94	6,703	2.61	5,408
2.22	6,750	2.98	5,461
2.50	6,735	3.35	5,466
2.77	6,667	3.72	5,429
3.05	6,553	4.10	5,356
3.32	6,400	4.47	5,251
5.54	4,631	7.45	3,790
7.76	2,861	10.43	2,327

75 ft depth



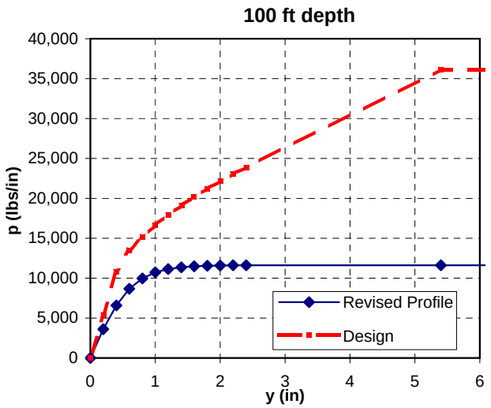
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	1,234	0.21	3,600
0.40	2,467	0.43	5,092
0.60	3,701	0.64	5,931
0.80	4,120	0.86	6,475
1.00	4,395	1.07	6,846
1.20	4,632	1.29	7,093
1.40	4,843	1.50	7,244
1.60	5,033	1.71	7,317
1.80	5,208	1.93	7,326
2.00	5,368	2.14	7,279
2.20	5,518	2.36	7,183
2.40	5,659	2.57	7,044
5.40	7,701	4.29	5,083
149.40	7,701	6.00	3,119

80 ft depth



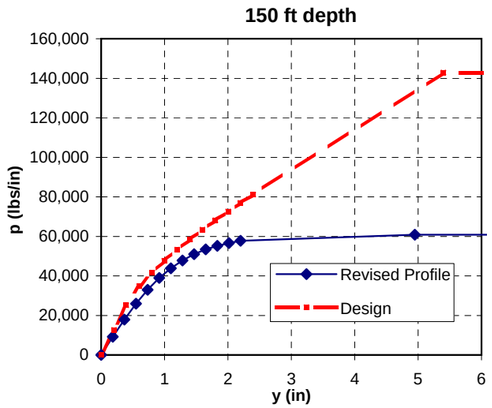
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	2,530	0.22	3,613
0.40	5,059	0.43	5,110
0.60	7,589	0.65	5,953
0.80	8,955	0.86	6,500
1.00	9,591	1.08	6,874
1.20	10,144	1.29	7,123
1.40	10,637	1.51	7,277
1.60	11,083	1.73	7,353
1.80	11,491	1.94	7,364
2.00	11,870	2.16	7,319
2.20	12,223	2.37	7,225
2.40	12,555	2.59	7,088
5.40	17,381	4.32	5,113
149.40	17,381	6.04	3,135

100 ft depth



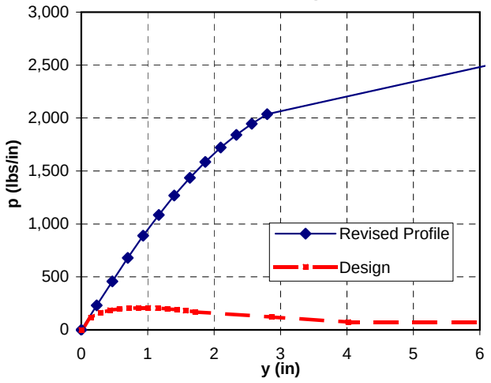
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	5,410	0.20	3,604
0.40	10,819	0.40	6,576
0.60	13,502	0.60	8,661
0.80	15,196	0.80	9,964
1.00	16,655	1.00	10,720
1.20	17,951	1.20	11,140
1.40	19,125	1.40	11,368
1.60	20,203	1.60	11,490
1.80	21,205	1.80	11,554
2.00	22,143	2.00	11,588
2.20	23,028	2.20	11,607
2.40	23,866	2.40	11,616
5.40	36,124	5.40	11,627
149.40	36,124	149.40	11,627

150 ft depth



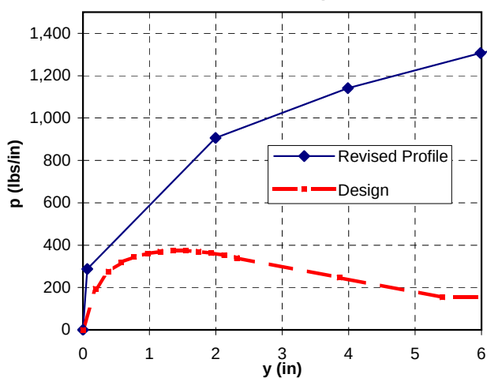
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	12,610	0.18	9,154
0.40	25,219	0.37	17,902
0.60	34,932	0.55	25,909
0.80	41,608	0.73	32,951
1.00	47,654	0.92	38,933
1.20	53,241	1.10	43,863
1.40	58,472	1.28	47,829
1.60	63,417	1.47	50,956
1.80	68,125	1.65	53,382
2.00	72,632	1.83	55,243
2.20	76,965	2.02	56,657
2.40	81,146	2.20	57,723
5.40	142,818	4.95	60,806
149.40	142,818	136.95	60,840

5 ft depth



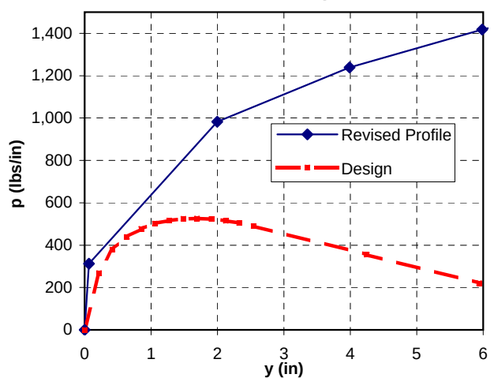
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	231
0.29	162	0.47	459
0.43	186	0.70	679
0.58	199	0.93	889
0.72	206	1.17	1,086
0.86	209	1.40	1,269
1.01	208	1.63	1,436
1.15	204	1.87	1,586
1.30	198	2.10	1,721
1.44	190	2.33	1,841
1.57	180	2.57	1,946
1.72	169	2.80	2,037
2.87	122	6.30	2,522
4.02	74	174.30	2,560
100.00	74	342.30	2,560

10 ft depth



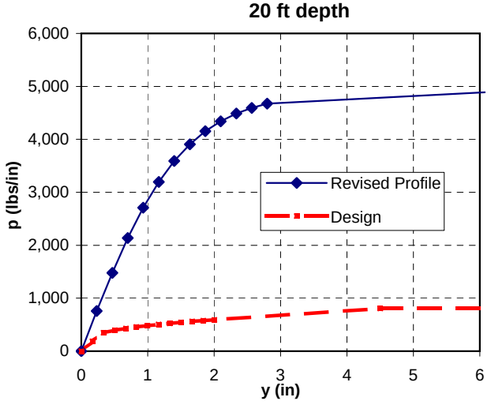
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.06	288
0.38	275	2.00	906
0.58	318	3.99	1,142
0.77	344	5.99	1,307
0.97	361	7.98	1,438
1.16	370	9.98	1,549
1.36	374	11.97	1,646
1.55	374	13.97	1,733
1.74	370	15.96	1,812
1.93	363	17.96	1,885
2.12	353	19.95	1,952
2.32	340	21.95	2,015
3.86	247	23.94	2,074
5.41	154	63.84	2,877
100.00	154	119.70	2,877

15 ft depth



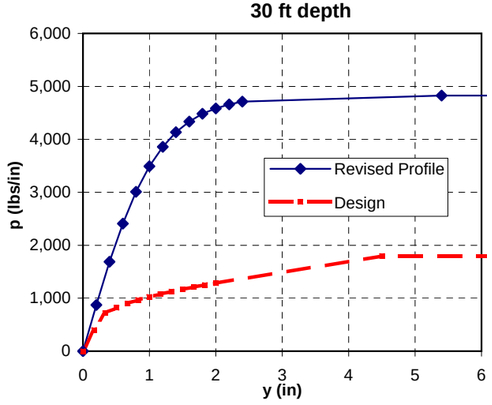
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	312
0.42	379	2.00	983
0.64	439	3.99	1,239
0.85	477	5.99	1,418
1.06	502	7.98	1,560
1.27	517	9.98	1,681
1.49	524	11.97	1,786
1.69	526	13.97	1,880
1.91	523	15.96	1,966
2.12	515	17.96	2,045
2.33	504	19.95	2,118
2.54	490	21.95	2,186
4.25	355	23.94	2,251
5.94	221	63.84	3,121
100.00	221	119.70	3,121

20 ft depth



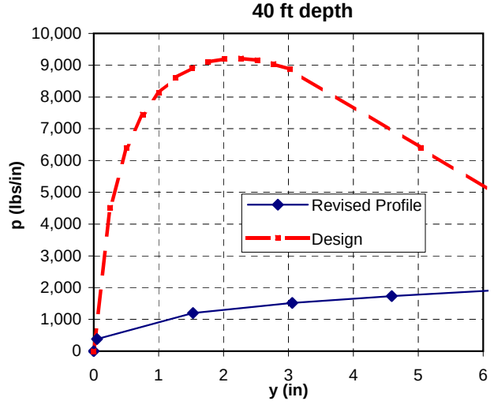
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	186	0.23	757
0.34	350	0.47	1,479
0.50	395	0.70	2,136
0.67	429	0.93	2,711
0.83	458	1.17	3,195
1.00	483	1.40	3,591
1.16	505	1.63	3,907
1.33	526	1.87	4,153
1.50	544	2.10	4,342
1.67	561	2.33	4,486
1.84	577	2.57	4,594
2.00	592	2.80	4,675
4.50	808	6.30	4,902
124.50	808	174.30	4,904

30 ft depth



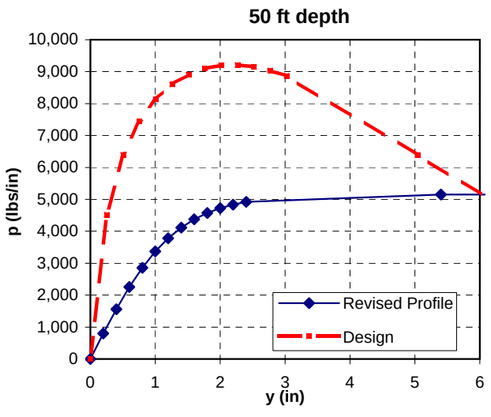
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	402	0.20	872
0.34	722	0.40	1,690
0.50	822	0.60	2,410
0.67	902	0.80	3,011
0.83	969	1.00	3,490
1.00	1,027	1.20	3,859
1.16	1,080	1.40	4,134
1.33	1,127	1.60	4,336
1.50	1,171	1.80	4,481
1.67	1,211	2.00	4,585
1.84	1,249	2.20	4,658
2.00	1,284	2.40	4,710
4.50	1,800	5.40	4,829
124.50	1,800	149.40	4,829

40 ft depth



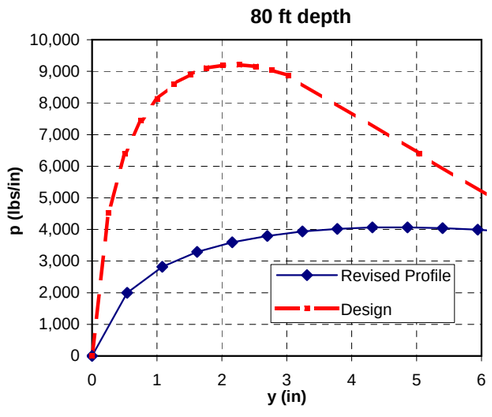
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.05	382
0.50	6,390	1.53	1,203
0.76	7,445	3.06	1,516
1.01	8,129	4.59	1,735
1.26	8,597	6.12	1,910
1.51	8,910	7.65	2,057
1.76	9,102	9.18	2,186
2.02	9,197	10.71	2,301
2.27	9,211	12.24	2,406
2.52	9,155	13.77	2,502
2.77	9,038	15.30	2,592
3.02	8,868	16.83	2,675
5.04	6,396	18.36	2,754
7.06	3,922	48.96	3,819

50 ft depth



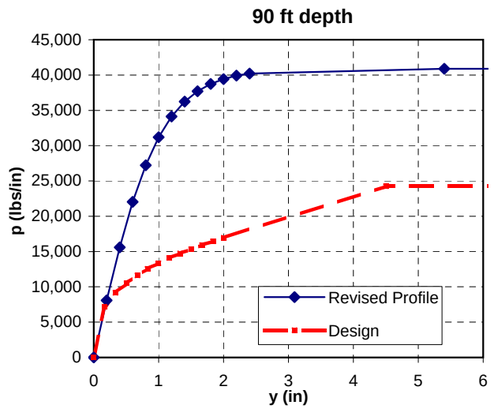
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	798
0.50	6,390	0.40	1,559
0.76	7,445	0.60	2,252
1.01	8,129	0.80	2,857
1.26	8,597	1.00	3,367
1.51	8,910	1.20	3,782
1.76	9,102	1.40	4,113
2.02	9,197	1.60	4,371
2.27	9,211	1.80	4,569
2.52	9,155	2.00	4,720
2.77	9,038	2.20	4,833
3.02	8,868	2.40	4,917
5.04	6,396	5.40	5,152
7.06	3,922	149.40	5,154

80 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.54	1,996
0.50	6,390	1.08	2,822
0.76	7,445	1.62	3,288
1.01	8,129	2.16	3,590
1.26	8,597	2.70	3,797
1.51	8,910	3.24	3,935
1.76	9,102	3.78	4,020
2.02	9,197	4.32	4,062
2.27	9,211	4.86	4,068
2.52	9,155	5.40	4,044
2.77	9,038	5.94	3,992
3.02	8,868	6.48	3,917
5.04	6,396	10.80	2,825
7.06	3,922	15.12	1,732

90 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	7,207	0.20	8,099
0.34	9,150	0.40	15,587
0.50	10,522	0.60	22,023
0.67	11,618	0.80	27,217
0.83	12,546	1.00	31,200
1.00	13,360	1.20	34,137
1.16	14,088	1.40	36,240
1.33	14,751	1.60	37,715
1.50	15,362	1.80	38,734
1.67	15,930	2.00	39,430
1.84	16,462	2.20	39,903
2.00	16,963	2.40	40,223
4.50	24,267	5.40	40,876
124.50	24,267	149.40	40,878

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

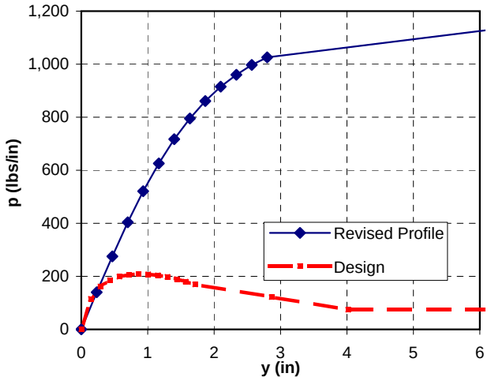
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 18

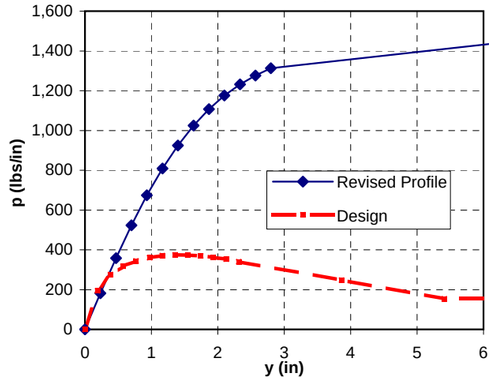
Figure 10

5 ft depth



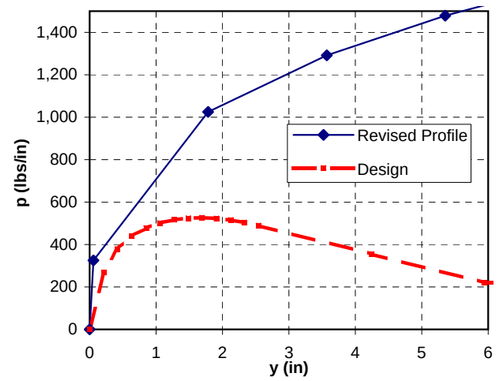
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	140
0.29	162	0.47	276
0.43	186	0.70	404
0.58	199	0.93	521
0.72	206	1.17	625
0.86	209	1.40	717
1.01	208	1.63	795
1.15	204	1.87	861
1.30	198	2.10	916
1.44	190	2.33	960
1.57	180	2.57	997
1.72	169	2.80	1,026
2.87	122	6.30	1,134
4.02	74	174.30	1,137
100.00	74	342.30	1,137

10 ft depth



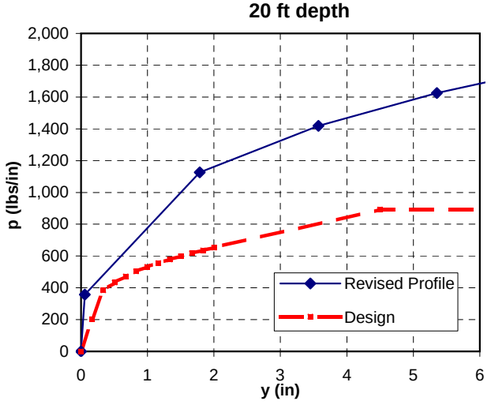
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.23	182
0.38	275	0.47	358
0.58	318	0.70	523
0.77	344	0.93	674
0.97	361	1.17	808
1.16	370	1.40	925
1.36	374	1.63	1,024
1.55	374	1.87	1,107
1.74	370	2.10	1,176
1.93	363	2.33	1,232
2.12	353	2.57	1,277
2.32	340	2.80	1,313
3.86	247	6.30	1,443
5.41	154	174.30	1,446
100.00	154	342.30	1,446

15 ft depth



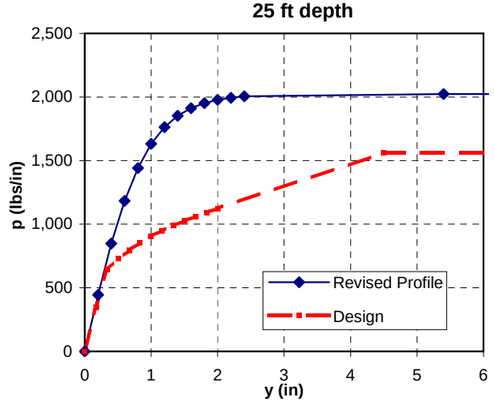
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	325
0.42	379	1.79	1,025
0.64	439	3.57	1,291
0.85	477	5.36	1,478
1.06	502	7.14	1,627
1.27	517	8.93	1,753
1.49	524	10.71	1,862
1.69	526	12.50	1,961
1.91	523	14.28	2,050
2.12	515	16.07	2,132
2.33	504	17.85	2,208
2.54	490	19.64	2,279
4.25	355	21.42	2,347
5.94	221	57.12	3,254
100.00	221	107.10	3,254

20 ft depth



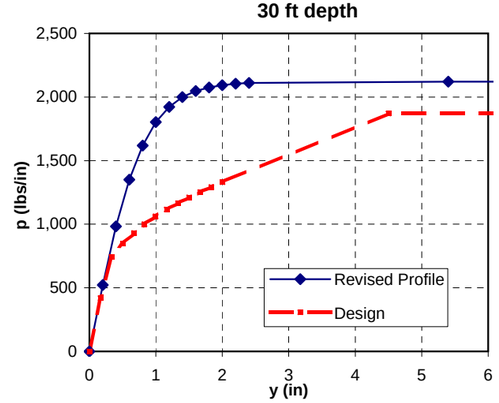
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	204	0.06	358
0.34	385	1.79	1,127
0.50	434	3.57	1,419
0.67	472	5.36	1,625
0.83	504	7.14	1,788
1.00	532	8.93	1,926
1.16	557	10.71	2,047
1.33	579	12.50	2,155
1.50	599	14.28	2,253
1.67	618	16.07	2,343
1.84	636	17.85	2,427
2.00	652	19.64	2,505
4.50	892	21.42	2,579
124.50	892	57.12	3,577

25 ft depth



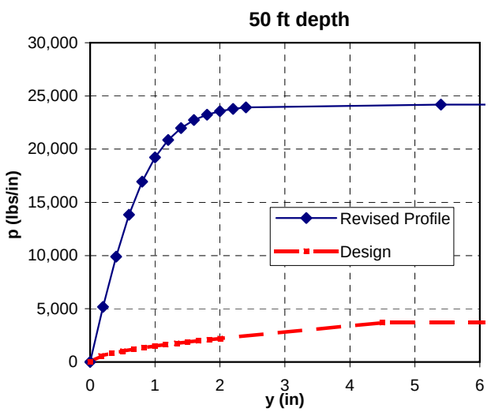
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	348	0.20	444
0.34	642	0.40	848
0.50	729	0.60	1,183
0.67	797	0.80	1,443
0.83	855	1.00	1,631
1.00	905	1.20	1,764
1.16	949	1.40	1,853
1.33	990	1.60	1,913
1.50	1,027	1.80	1,952
1.67	1,061	2.00	1,978
1.84	1,093	2.20	1,994
2.00	1,123	2.40	2,005
4.50	1,561	5.40	2,024
124.50	1,561	149.40	2,024

30 ft depth



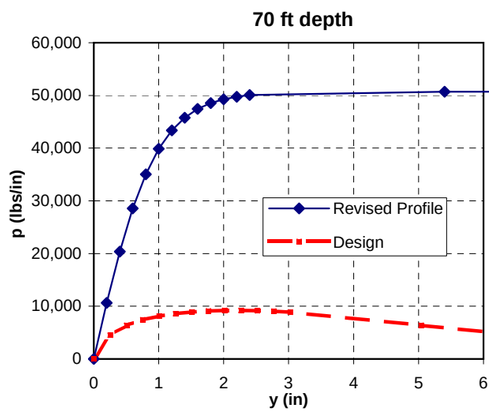
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	420	0.20	521
0.34	743	0.40	983
0.50	848	0.60	1,351
0.67	931	0.80	1,619
0.83	1,001	1.00	1,802
1.00	1,062	1.20	1,922
1.16	1,116	1.40	1,999
1.33	1,166	1.60	2,046
1.50	1,211	1.80	2,076
1.67	1,254	2.00	2,094
1.84	1,293	2.20	2,105
2.00	1,330	2.40	2,111
4.50	1,871	5.40	2,122
124.50	1,871	149.40	2,122

50 ft depth



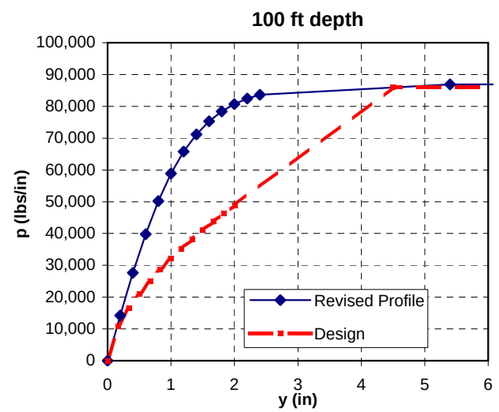
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	565	0.20	5,169
0.34	826	0.40	9,886
0.50	1,030	0.60	13,846
0.67	1,205	0.80	16,941
0.83	1,361	1.00	19,231
1.00	1,504	1.20	20,855
1.16	1,636	1.40	21,973
1.33	1,760	1.60	22,728
1.50	1,877	1.80	23,230
1.67	1,988	2.00	23,561
1.84	2,094	2.20	23,778
2.00	2,196	2.40	23,920
4.50	3,694	5.40	24,182
124.50	3,694	149.40	24,182

70 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	10,619
0.50	6,390	0.40	20,345
0.76	7,445	0.60	28,563
1.01	8,129	0.80	35,046
1.26	8,597	1.00	39,889
1.51	8,910	1.20	43,362
1.76	9,102	1.40	45,780
2.02	9,197	1.60	47,429
2.27	9,211	1.80	48,537
2.52	9,155	2.00	49,275
2.77	9,038	2.20	49,764
3.02	8,868	2.40	50,086
5.04	6,396	5.40	50,698
7.06	3,922	149.40	50,699

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	10,788	0.20	14,188
0.34	16,443	0.40	27,639
0.50	21,040	0.60	39,764
0.67	25,061	0.80	50,205
0.83	28,702	1.00	58,848
1.00	32,067	1.20	65,771
1.16	35,218	1.40	71,173
1.33	38,197	1.60	75,301
1.50	41,032	1.80	78,408
1.67	43,747	2.00	80,717
1.84	46,357	2.20	82,418
2.00	48,875	2.40	83,664
4.50	86,020	5.40	86,920
124.50	86,020	149.40	86,943

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

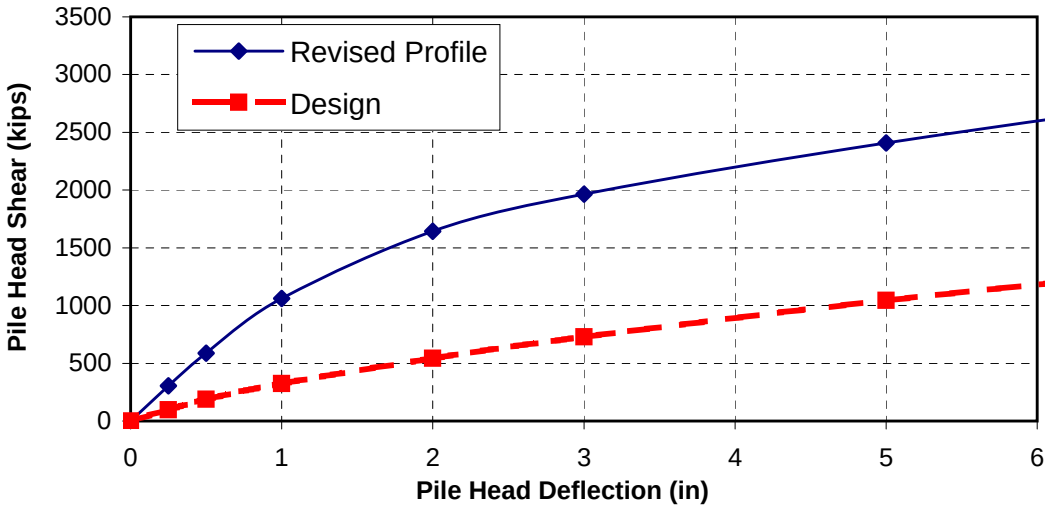
ACTA Schuyler Heim Bridge (Replace)

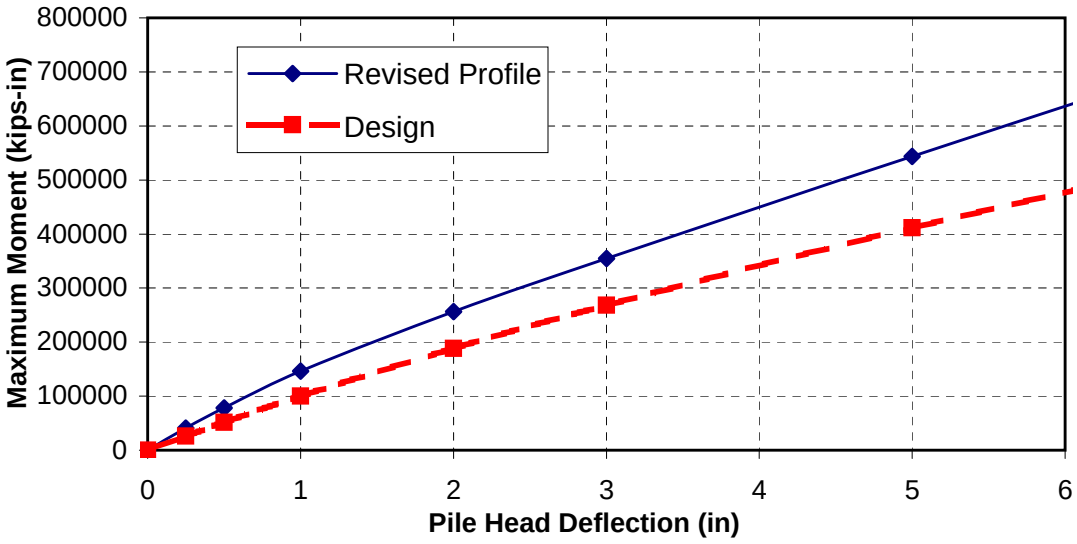
Project Number: 06-123

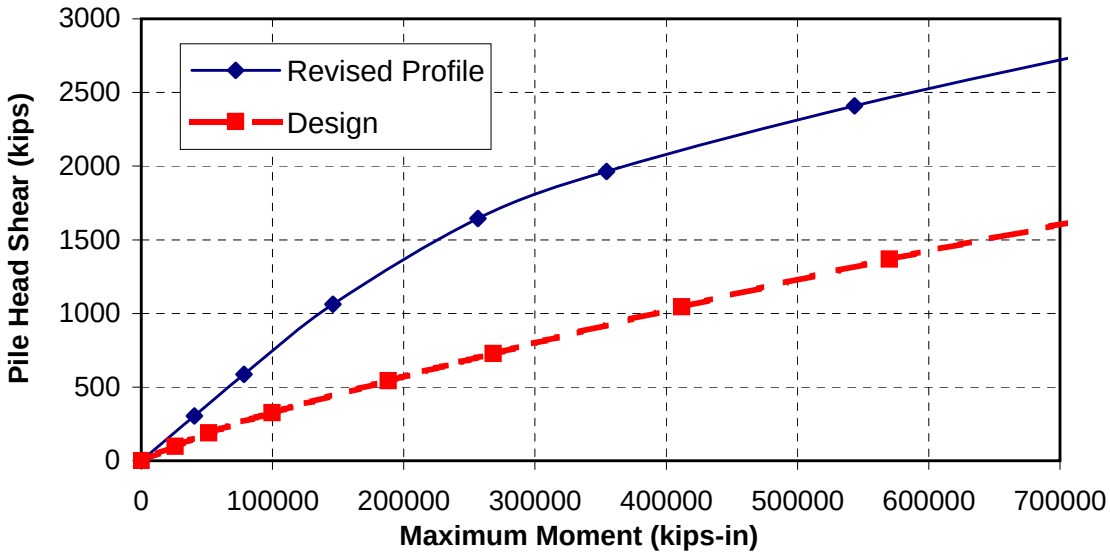
Date: 1/20/2010

p-y Curve Comparison for Bent 24

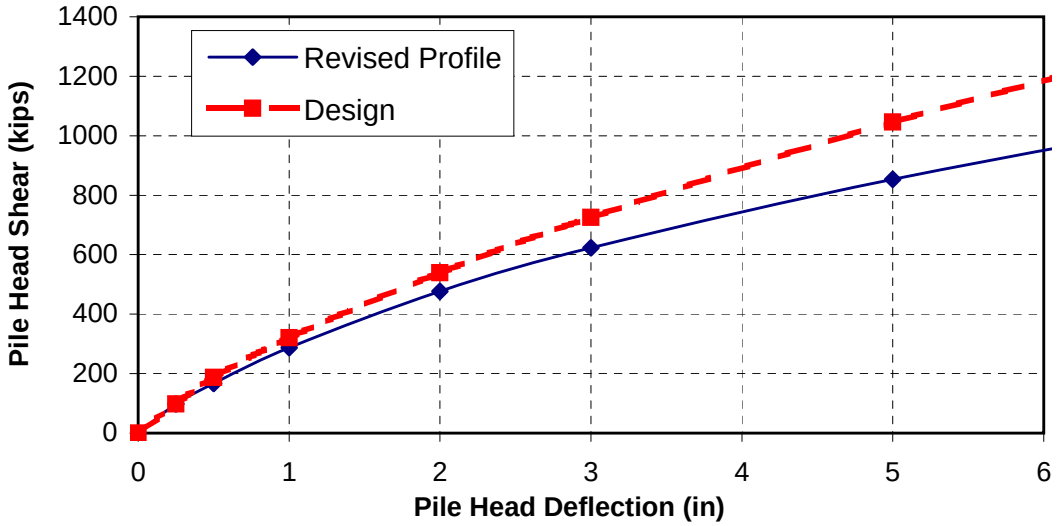
Figure 11

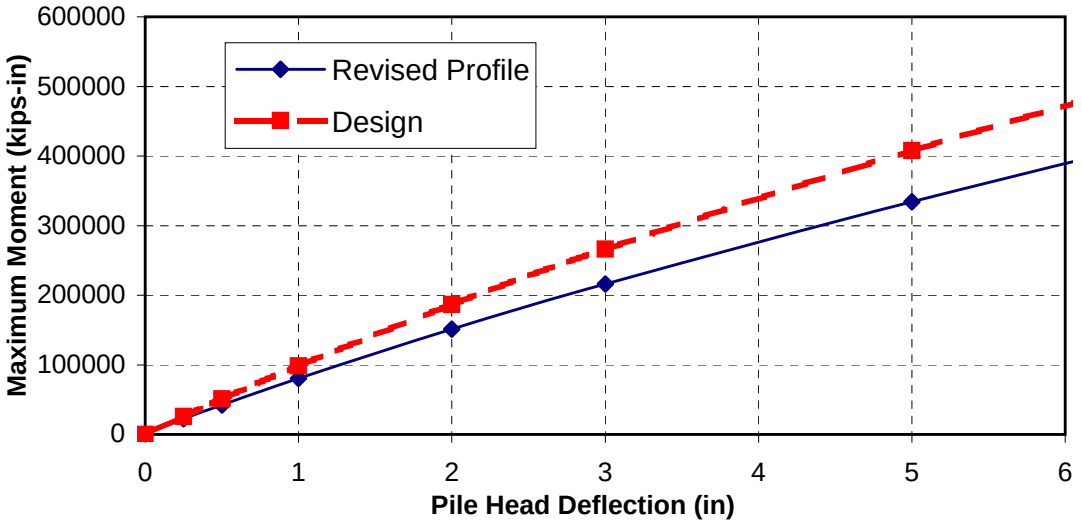


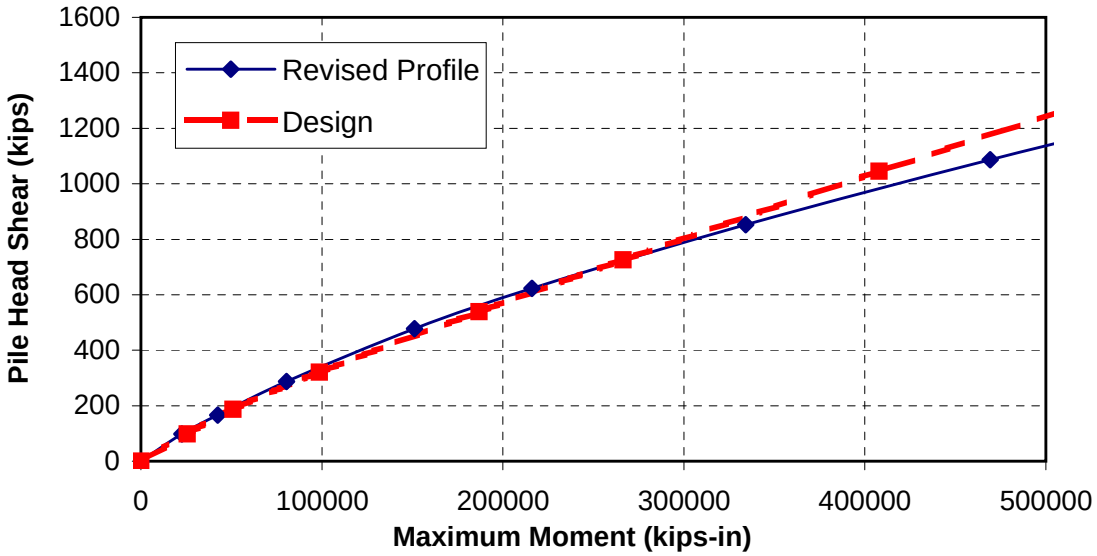




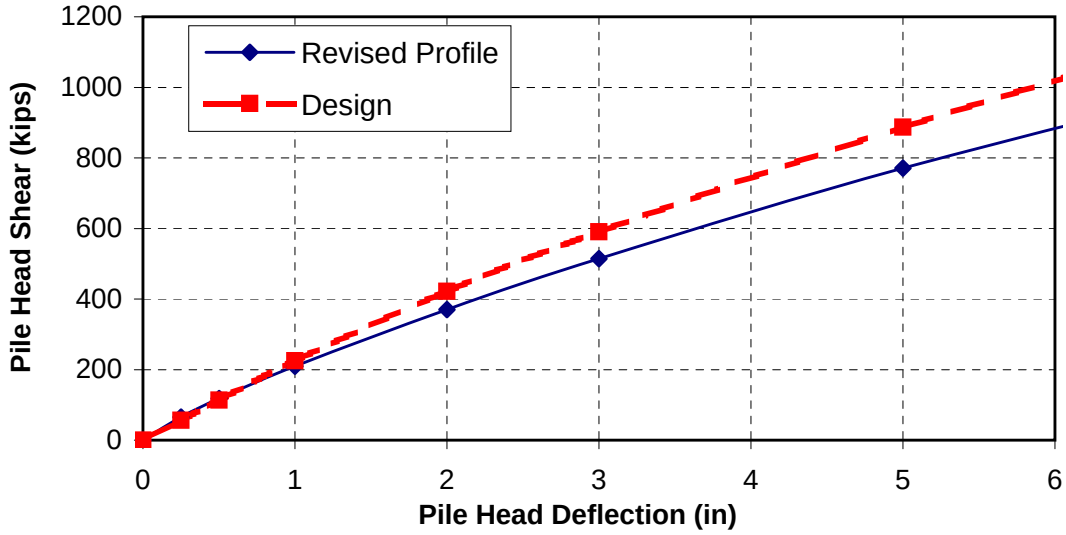
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 2 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 12

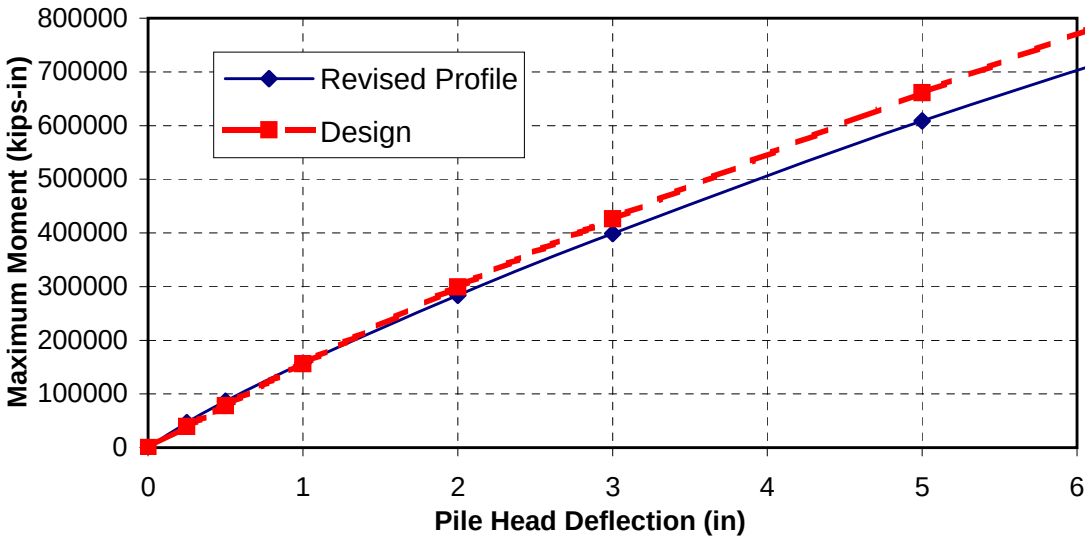


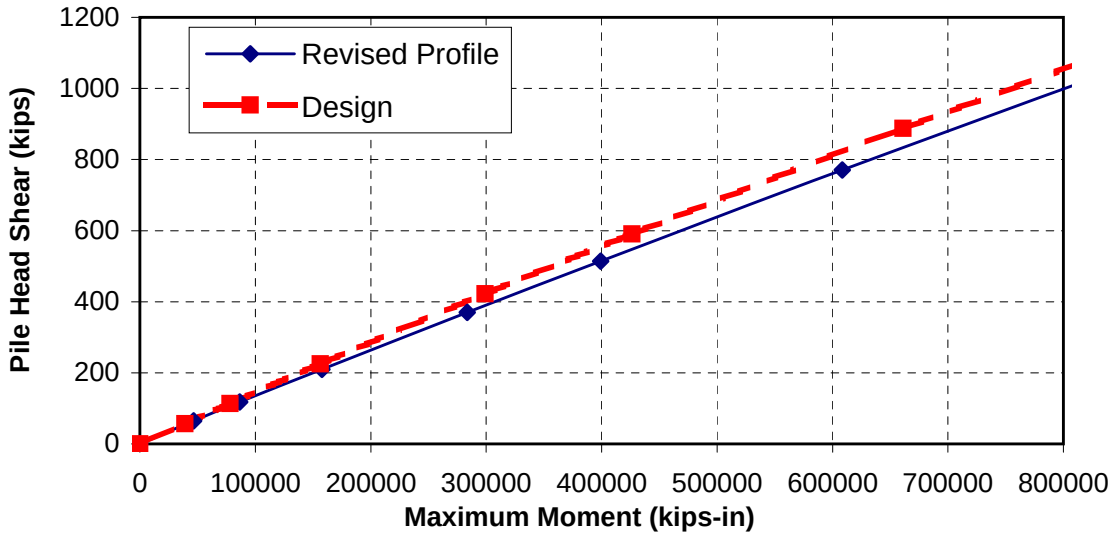




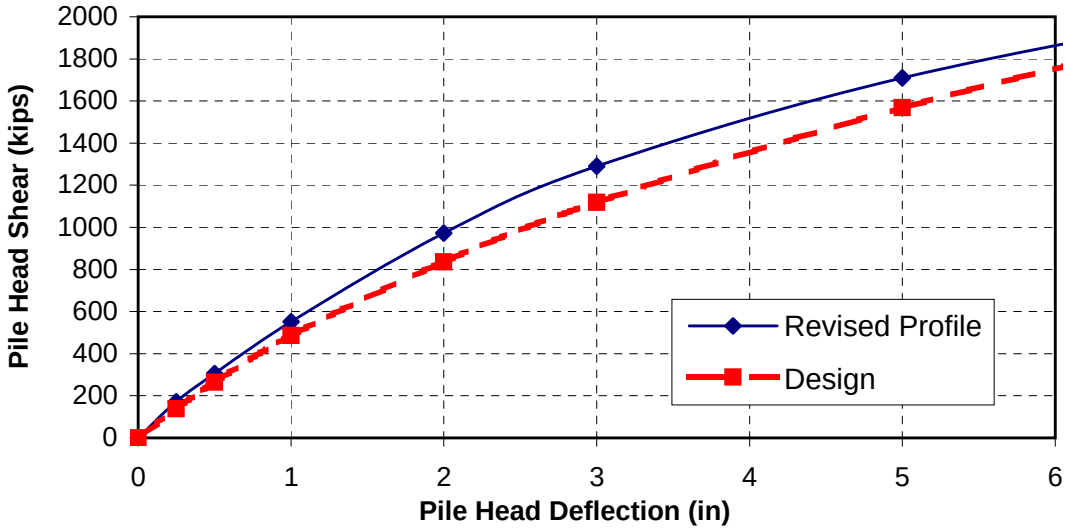
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 13

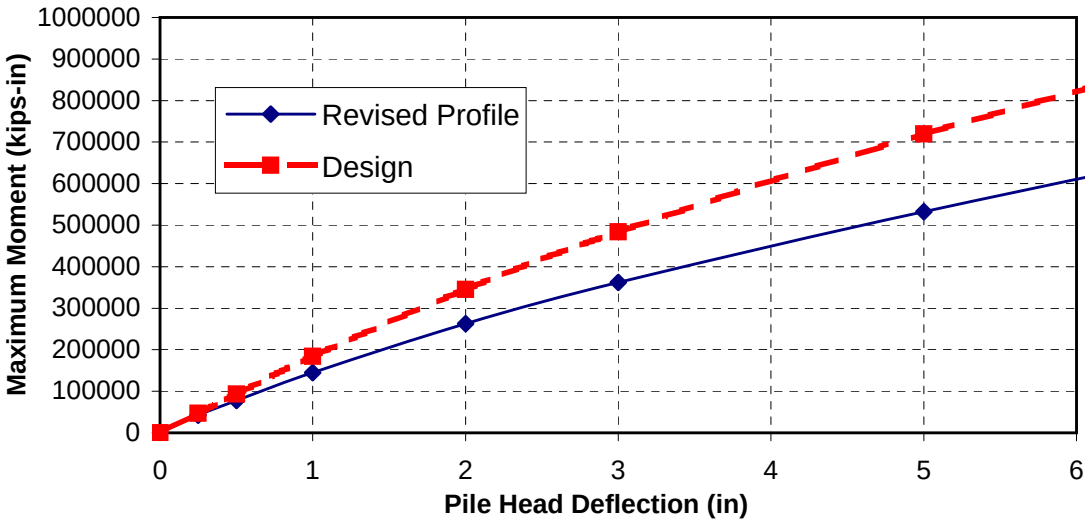


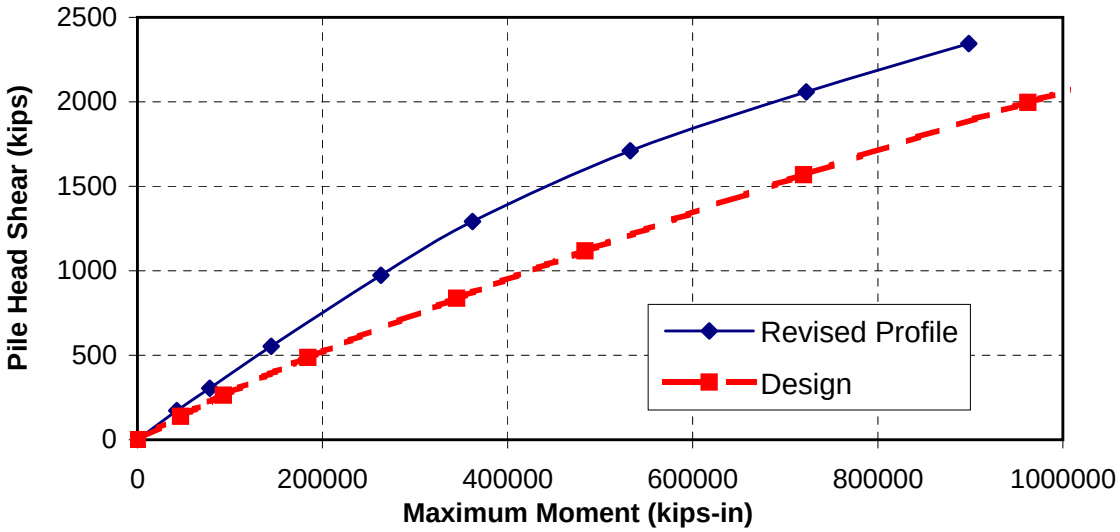




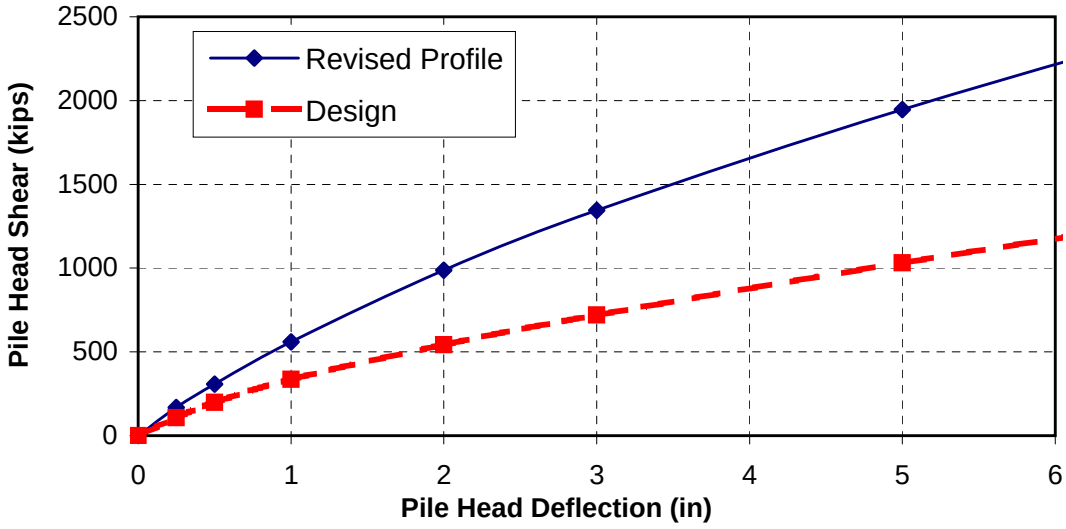
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Pile Head Shear and Max Moment versus Deflection Figure 14
	Project Number: 06-123	Date: 1/20/2010	

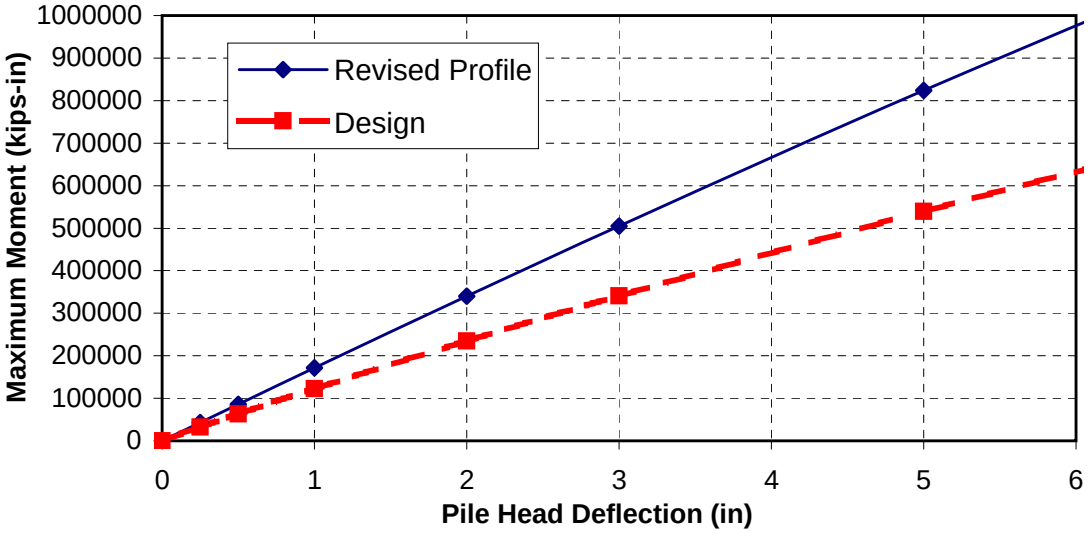


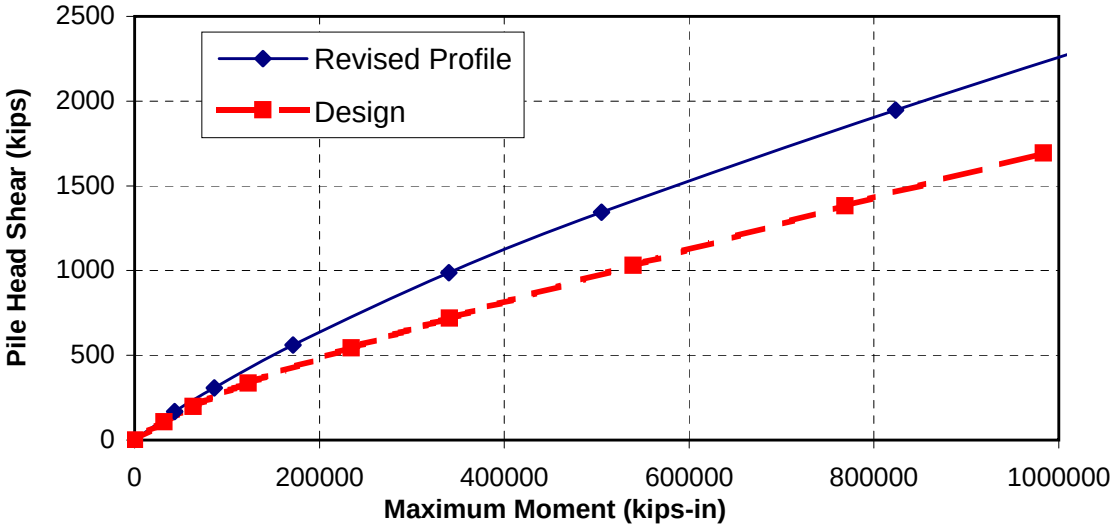




Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 15







Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 24 Pile Head Shear and Max Moment versus Deflection Figure 16
	Project Number: 06-123	Date: 1/20/2010	

Appendix H. Design p-y Curves for Bent Lateral Pile Analysis

Table H-1. SB SR 103 On-Ramp Bent 24 to Bent 27
p-y Curves for 10' Diameter CIDH Piles

3 ft depth		10 ft depth		17 ft depth		25 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	150	0.05	194	0.01	402	0.17	115	0.17	145
0.33	300	1.50	610	0.38	1,267	0.33	230	0.33	290
0.50	450	3.00	769	0.75	1,597	0.50	346	0.50	436
0.67	600	4.50	880	1.13	1,828	0.67	461	0.67	581
0.83	640	6.00	969	1.50	2,012	0.83	576	0.83	726
1.00	672	7.50	1,044	1.88	2,167	1.00	691	1.00	871
1.17	701	9.00	1,109	2.25	2,303	1.17	798	1.17	941
1.33	727	10.50	1,168	2.63	2,424	1.33	833	1.33	984
1.50	751	12.00	1,221	3.00	2,535	1.50	865	1.50	1,025
1.67	773	13.50	1,270	3.38	2,636	1.67	895	1.67	1,062
1.83	793	15.00	1,315	3.75	2,730	1.83	923	1.83	1,097
2.00	812	16.50	1,357	4.13	2,818	2.00	950	2.00	1,130
4.50	1,089	18.00	1,397	4.50	2,901	4.50	1,335	4.50	1,612
124.50	1,089	48.00	1,938	12.00	4,023	124.50	1,335	124.50	1,612
244.50	1,089	90.00	1,938	22.50	4,023	244.50	1,335	244.50	1,612
364.50	1,089	120.00	1,938	30.00	4,023	364.50	1,335	364.50	1,612

40 ft depth		55 ft depth		70 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	205	0.17	579	0.17	7,172	0.17	16,746	0.17	33,477
0.33	410	0.33	861	0.33	10,932	0.33	25,523	0.33	63,412
0.50	616	0.50	1,085	0.50	13,988	0.50	32,659	0.50	81,140
0.67	821	0.67	1,280	0.67	16,661	0.67	38,901	0.67	96,650
0.83	967	0.83	1,454	0.83	19,082	0.83	44,554	0.83	110,693
1.00	1,050	1.00	1,614	1.00	21,319	1.00	49,777	1.00	123,670
1.17	1,126	1.17	1,763	1.17	23,414	1.17	54,668	1.17	135,821
1.33	1,196	1.33	1,903	1.33	25,394	1.33	59,291	1.33	147,308
1.50	1,261	1.50	2,035	1.50	27,279	1.50	63,693	1.50	158,244
1.67	1,323	1.67	2,162	1.67	29,084	1.67	67,907	1.67	168,712
1.83	1,381	1.83	2,283	1.83	30,819	1.83	71,958	1.83	178,778
2.00	1,436	2.00	2,399	2.00	32,494	2.00	75,867	2.00	188,490
4.50	2,248	4.50	4,116	4.50	57,189	4.50	133,527	4.50	331,743
124.50	2,248	124.50	4,116	124.50	57,189	124.50	133,527	124.50	331,743
244.50	2,248	244.50	4,116	244.50	57,189	244.50	133,527	244.50	331,743
364.50	2,248	364.50	4,116	364.50	57,189	364.50	133,527	364.50	331,743

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

Appendix I. Caltrans Review Comments and EMI Response

Subject: Review Comments for Foundation Reports for BR53-3031, BR53-3033, BR53-3034K, BR53-3035S.
From: Haitao Liu <haitao_liu@dot.ca.gov>
Date: Tue, 23 Mar 2010 17:17:30 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Hector Bedolla <hector_bedolla@dot.ca.gov>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>, Hamid R Toossi <hamid_r_toossi@dot.ca.gov>, Foued Zayati <foued_zayati@dot.ca.gov>, Bojan Misic <bojan_misic@dot.ca.gov>, Ranjan Gunaranjan <ranjan@earthmech.com>, Eric Brown <e.brown@earthmech.com>, Seungwoon Han <seungwoon_han@dot.ca.gov>

Dear Arul,

Below are our review comments for the subject bridges:

New Dock Street Off-Ramp, Bridge No. 53-3031:

1) Table 5 (Page 28 of Foundation Report).
Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings

2) Section 5.6.1 (Page 34 of the Report).
Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.

3) Section 5.6.2 (Page 34 of the Report).
Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.

4) Log of Test Borings.
I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.

5) Appendix E.Lab Test Results
Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.

6) Axial Capacity (Calculation Volume)
Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.

7) Axial Capacity for Abut 3 (Calculation Volume)
Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.

8) Axial Capacity for Abut 3 (Calculation Volume)
The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.

9) Axial Capacity for all bents (Calculation Volume)
According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.

10) Axial Capacity for Bent 4 (Calculation Volume)
For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.

11) Axial Capacity for Bent 5 (Calculation Volume)
For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.

12) Lateral Pile Capacity for Abut 3 (Calculation Volume)
Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.

13) Static Settlement
Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.

14) Static Settlement
The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.

SR 103 Off-Ramp, Bridge No. 53-3034K:

All applicable review comments from New Dock Street Off-Ramp, plus:

1) Axial Pile Capacity for Abutment 27 (Calculation Volume)
Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.

2) Axial Pile Capacity (Calculation Volume)
The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with

blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.

New Dock Street On-Ramp, Bridge No. 53-3033 and SR 103 On-Ramp, Bridge No. 53-3035S

All applicable review comments from BR 53-3031 and BR 3034K.

Should you have any question, please contact me or Mr. Seungwoon Han at (916) 227-4533.

Thank you.

Haitao Liu, P.E.

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Office of Geotechnical Design South - 1
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New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			1) Table 5 (Page 28 of Foundation Report). Boring No. R-09-010: Please verify the liquefaction potential and seismic-induced settlement for the soils from El. -40' to -45' (Silt with sand under the blowcounts of 3), and evaluate its impact on the CIDH pile design in Abut 3. Comment eliminated based on your recent findings.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA)	A	Will comply. Supplemental laboratory tests performed on the sample indicate a Plasticity Index (PI) of 12; therefore, based upon the Boulanger and Idriss (2006) criteria, this layer is determined to be non-liquefiable. Lab test results are attached.	4/20/2010	
2			2) Section 5.6.1 (Page 34 of the Report). Please refer to Section A11.1.1.3 of AASHTO LRFD BDS for the estimation of seismic lateral earth pressure on nonyielding bridge abutment, as Yong's method (1985) may not be an acceptable approach for the seismic earth pressure estimation.	PW / EB / KA	A	Will comply. Tthe recommendations for seismic lateral earth pressure on nonyielding bridge abutments have been revised to be consistent with the recommendations shown in Section A11.1.1.3 of AASHTO LRFD BDS.	4/20/2010	
3			3) Section 5.6.2 (Page 34 of the Report). Please change the word "abutment wall" into "abutment backwall". For the seat abutment in this bridge, it is the backwall portion of the abutment wall that is designed to break off under longitudinal thrust from the box girder in order to engage the passive earth pressure. The soil spring behind the stemwall portion of the abutment wall will not be included for the bridge seismic analysis in longitudinal direction.	PW / EB / KA	A	Will comply. We agree that the recommended edit will be more clear for the reader and the text has been revised per your suggestion.	4/20/2010	
4			4) Log of Test Borings. I. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs; II. Silty clay is not a standard group name for fine-grained soils in Caltrans Soil and Rock Logging Manual, please revise them.	PW / EB / KA	A / C	I. Will comply. LOTB's have been revised to only show SPT blowcounts (attached). II. Silty Clay is listed as a soil-type descriptor in Figure 3-3 (page 42) of the Caltrans SRLPCM for material with a PI between 4 and 7. All of the instances where a material is described as Silty Clay on the LOTBs, plasticity test results indicate a PI between 4 and 7.	4/20/2010	
5			5) Appendix E.Lab Test Results Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			6) Axial Capacity (Calculation Volume) Boring No. R-09-010 was used as the reference boring for the analysis of axial pile capacity at all bridge support locations. This practice will generate relatively conservative results for the determination of pile tip under strength and service limit states. However, under the extreme event, the dragload produced by the soils above the bottom of liquefaction layer in locations other than R-09-010 could be higher than those presented in the analysis. The downdrag effect due to soil liquefaction could make what is conservative for the strength and service limit states more aggressive for extreme event in axial pile analysis. Different load/resistance combination may be needed for the seismic-controlled design pile tip.	PW / EB / KA	A	Will comply. All six borings/CPTs were used to generate the idealized soil profile used in the pile analysis. We agree that the downdrag elevation for determining the seismic-controlled (extreme event) design pile tip elevation should be based on the nearest soil boring or CPT sounding. Different bottom of liquefiable layer elevations were used at each support. As shown in the calculation volume, the elevation to the bottom of the liquefiable layer was based on R-09-010 for abutment 3 and bent 4, CPT-09-064 for bent 5, R-09-012 for bent 6, R-09-013 for bent 7, and R-09-015 for bent 8. This appears to comply with your comment.	4/20/2010	
7			7) Axial Capacity for Abut 3 (Calculation Volume) Based on Abutment 3 Details No.1, the closest pile center-to-center spacing is three times of pile diameter, group reduction factor may be needed in determining design pile tip elevations.	PW / EB / KA	A	Will comply. Per our discussions with the designer, 1 pile will be added at this abutment. We have revised our axial pile capacity calculations to include an average pile group reduction factor of 0.93 at Abutment 3. The evaluation of the group reduction factor and revised axial pile capacity calculations for Abutment 3 are attached.	4/20/2010	
8			8) Axial Capacity for Abut 3 (Calculation Volume) The current design pile tips will stop at cohesive soil layers. Based on Section 10.8.3.5.1 of AASHTO LRFD BDS, the contribution to total pile side resistance from the bottom one diameter of pile embedment should be ignored due to the potential tensile crack in that area. Please extend the pile tip by one time pile diameter to reflect the above design consideration.	PW / EB / KA	A	Will comply. Revised axial pile capacity calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
9			9) Axial Capacity for all bents (Calculation Volume) According to CIDH Pile Details No. 2, the permanent steel casing will be used within 26 feet below the top of the shaft to facilitate the installation of the column rebar cage to be embedded into the shaft and subsequent concrete pour under the dry condition. It is recommended that shaft frictional resistance be neglected within the vertical limits of the proposed permanent casing. Please revise the shaft axial capacity analysis and design pile tips for all bents accordingly.	PW / EB / KA	D	As a result of design development and discussions with the designers, the CMP permanent casing has been replaced with driven permanent steel casing. The driving resistance of the permanent steel casing will be specified in the Pile Data Table; therefore, the skin friction along the length of the permanent casing (based upon API methodology) has been included in the design. The axial pile capacity calculations for the controlling limit case (Strength Limit State) for the bents have been revised. A sample revised calcuation for Bent 4 and the revised pile data table are attached.	4/20/2010	
10			10) Axial Capacity for Bent 4 (Calculation Volume) For extreme event, the depth to the bottom of soil liquefaction and downdrag should be 30 feet (El.+5 ft minus El.-25 ft) below finished grade, instead of 37 ft.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
11			11) Axial Capacity for Bent 5 (Calculation Volume) For all limit states, the depth to the shaft cut-off should be taken as 10 feet below finished grade (El.+4 ft minus El.-6 ft), instead of 4 feet.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
12			12) Lateral Pile Capacity for Abut 3 (Calculation Volume) Please consider following point in pile lateral analysis. I. Reduce the overburden that is 19 ft above the pile cut-off, and create a more conservative soil spring value. II. Reduce the value of moment of inertia ("I" value) for the CIDH piles, and create a more conservative pile stiffness to reflect the cracked condition; or use nonlinear EI in L-Pile analysis, based on pile reinforcement information from the contract plans. III. Try to limit the maximum bending moment of the piles to the plastic moment in the analysis, and revise the boundary condition of the pile, if necessary.	PW / EB / KA	A	I. The apparent discrepancy arises from the facts that the LPile program does not allow the bottom of a soil layer to be above the pile cut-off, and the water table is not directly entered (it is accounted for by inputting the correct effective unit weight and subgrade modulus values based on saturated/dry conditions). At abutment 3, the top of the embankment is at about elevation +20 ft. Finished grade is at about elevation +7 ft. Taking the average of the top of the embankment and finished grade gives +13.5 ft. The design water table is conservatively located at elevation +5 ft. Pile cut-off is at +1 ft. So the overburden can be estimated by including 4 ft of buoyant soil unit weight plus 8.5 ft of dry soil unit weight, which is about 1260 psf. Due to the LPile soil layering constraints mentioned above, we modeled the overburden using a 19 ft layer, with buoyant unit weight, which gives an overburden of about 1140 psf, which is slightly below the estimate above (conservative). II. Will comply. The revised lateral pile analysis includes a "cracked" EI value equal to 80% of the gross EI for the pile for service and strength limit state (0.25" lateral pile top deflection) and 50% of the gross EI for the extreme event limit state (greater than 0.25" lateral pile top deflection). Revised lateral pile capacity calculations are attached. III. Based upon our conversations with the bridge designers, the pile reinforcing has been designed to have sufficient capacity to handle the moment demands.	4/20/2010 4/20/2010	
13			13) Static Settlement Based on LOTBs, sandy lean clay layer was encountered from El. -5 ft to El.-10 ft, with PP value of 0.25 tsf. However the settlement contribution from the above layer has not been addressed in the consolidation analysis. Please include them in your future submittal if necessary.	PW / EB / KA	A	Will comply. The settlement calculations have been revised to account for the compressible layer between elevation -5 and -10 ft. The revised settlement calculations are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

New Dock St. On Ramp (Bridge No. 53-3033), New Dock St. Off Ramp (Bridge No. 53-3031), SB SR 103 On Ramp (Bridge No. 53-3035S) and NB SR 103 Off Ramp (Bridge No. 53-3034K) Bridges
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District-Co-Rte-PM:	07-LA-47-PM 3.74	Reviewing Agency:	Caltrans
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Milestone:	65% PS&E	Review Date:	March 23, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 20, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
14			14) Static Settlement The soil profile for New Dock Street On-Ramp Abutment 6 was used for the settlement analysis of the Off-Ramp Abutment 3.	PW / EB / KA	A	Yes this is correct. Because the two bridges are located close to one another, based upon the subsurface exploration, the same idealized soil profile was originally used for both locations. However, based on comment #13, the settlement calculations for New Dock Street Off-Ramp have been revised to account for the clay layer encountered in Boring R-09-010 between elevation -5 and 10 ft. The revised settlement calculations are attached.	4/20/2010	
15			1) Axial Pile Capacity for Abutment 27 (Calculation Volume) Please limit the end bearing to less than 20% of total required nominal resistance in determining design pile tip, regardless of what limit state we are looking at. This will reduce the additional settlement (or the additional stress on structural member under such settlement) associated with the end bearing mobilization.	PW / EB / KA	A	Will comply. The revised axial capacity calculations and pile data table are attached.	4/20/2010	
16			2) Axial Pile Capacity (Calculation Volume) The average energy corrected blowcounts are all assumed to be 18 for soils from El.-25 ft to El.-50 ft in axial pile analysis for all bridge support locations. However, the LOTBs at Bents 25 and 26 shows that soils with blowcounts significantly less than 15 were encountered from El.-30 ft to El.-40 ft, which requires that the reduction factor for the load transfer coefficient be included in axial pile analysis per Reese-O'Neil (1999). Please adjust the number of blowcounts in axial analysis based on LOTBs for Bents 25 and 26.	PW / EB / KA	A	Will comply. Axial pile capacity calculations have been revised to incorporate a reduced load transfer in soil layers with blowcounts less than 15 blows per foot, where applicable. The revised axial capacity calculations and pile data table are attached.	4/20/2010	

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Schuyler Heim Bridge (Replace), Bridge No. 53-3032 Los Angeles County, California, (7-LA-47, PM 3.58, EA 238501)***

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject bridge. This report presents the results of our analyses and recommendations for design and construction of the bridge foundation for the subject bridge replacement.

The Foundation Report for the subject bridge, dated February 11, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 7, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on April 27, 2010. OGDS-1 review comments and EMI responses are included in Appendix I. The responses to these review comments have been incorporated into this Final Foundation Report.

We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

(Ranjan) G.J. Gunaranjan, PE 71758
Senior Staff Engineer

(Arul) K. Arulmoli, PhD, GE 2090
Project Manager

GJG/KA

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
SCHUYLER HEIM BRIDGE (REPLACE)
BRIDGE NO. 53-3032 (7-LA-47, PM 3.58, EA 238501)
LOS ANGELES COUNTY, CALIFORNIA

Prepared For:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared By:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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1.0 INTRODUCTION

1.1 Purpose and Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Schuyler Heim Bridge (Replace) in Los Angeles County, California (Bridge No. 53-3032). The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analysis and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging twenty nine land and four overwater exploratory borings and twenty five Cone Penetration Test (CPT) soundings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the replacement of the Schuyler Heim Bridge structure (Figure 2).

The proposed Schuyler Heim Bridge (Bridge No. 53-3032) is a twenty three-span Cast-in-Place (CIP) prestressed concrete box girder bridge supported on a single seat type abutment at the south end (Abutment 1), a two-column bent at the north end (Bent 24); and eighteen four-column bents (Bents 2 through 5, 8, and 11 through 23), two five-column bents (Bents 6 and 7),

and two six-column bents (Bents 9 and 10). The bridge deck varies in width up to about 129 ft and is approximately 4,122 ft long. The proposed Schuyler Heim Bridge spans about 750 ft long over the Cerritos Channel between Bents 13 through 16. Per channel section provided by URS, the existing slope of Cerritos Channel at south side is approximately 2H:1V above approximate El. -26 ft and changes to 5H:1V below this elevation. The existing slopes of Cerritos Channel at north side are approximately 2H:1V and 10H:1V at above and below El. -40 ft, respectively. The top of the slopes at south and north sides are at about El. +2 ft and El. +10 ft, respectively. The channel bottom exists between approximate El. -40 ft and -50 ft. Based on the topographic map provided, an area extending from the crest of the north slope to about 225 ft north has an approximate finished grade at El. + 10 ft. This area is located on the east side of the existing Schuyler Heim Bridge.

The proposed eastern column of Bent 11 is located behind an existing MSE wall that has an approximate finished at El. +16 ft.

The typical bridge bents on the south side of the channel (Bents 2 through 12) have each column supported on a single 10-ft diameter cast-in-drilled-hole (CIDH) pile whereas the bents within the channel (Bents 13 through 16) will be supported on 11-ft diameter CIDH piles, and on the north side of the channel (Bents 17 through 24) will be supported on 12-ft diameter CIDH piles. All bent piles are Type II shafts. The southern abutment (Abutment 1) will be supported on 2.5-ft diameter CIDH piles.

The proposed Schuyler Heim Bridge (Replace) will generally have the same alignment as the existing structure at the southern end and is proposed to be realigned northwards slightly to the east of the existing structure (Bridge No. 53-2618). The southern bridge approach embankment at Abutment 1 will be constructed with a Mechanically Stabilized Embankment wall (MSE Wall No. A1) of about 185-ft long and 20-ft maximum high on the west side. The east side of the approach embankment will have an earthen embankment with 2H:1V finish slopes. Recommendations for the MSE wall and the earthen embankment are addressed in a separate foundation report prepared by EMI (EMI, 2010e).

The north end of the mainline structure terminates at an expansion joint where the east side of the mainline abuts northbound SR-103 Off-Ramp structure (Bridge No. 53-3034K) approximately 26.5 ft north of Bent 24 of the mainline while the west side of the mainline abuts southbound SR-103 On-Ramp structure (Bridge No. 53-3035S) approximately 25 ft north of Bent 23 of the mainline. Recommendations for these SR-103 Off- and On-Ramp structures are addressed in separate foundation reports prepared by EMI (EMI, 2010a and EMI, 2010b). The subject mainline bridge also includes bridge structures along the southbound off-ramp (Bridge No. 53-3031) and northbound on-ramp (Bridge No. 53-3033) at New Dock Street. Recommendations for these New Dock Street Off- and On-Ramp structures are also addressed in separate foundation reports prepared by EMI (EMI, 2010c and EMI, 2010d).

As described earlier, the proposed Schuyler Heim Bridge (Replace) is a portion of the overall SR-47 Expressway Project which includes extension of the structure north of Bent 24 planned for the future (SR-103 Expressway). The SR-47 Expressway Project includes the SR-47 Expressway Ramps that will eventually abut the subject Schuyler Heim Bridge adjacent to the

SR-103 On- and Off-Ramp structures. The SR-47 Expressway Ramps are proposed as part of a separate project. At the two hinge points where the subject Schuyler Heim Bridge will abut the SR-47 Expressway Ramps, the deck of the subject bridge will have a row of tie-down anchors that will simulate the weight of the SR-47 Expressway Ramps until they are constructed at a later date. Each anchor is anticipated to be approximately 6-inches in diameter and 75 ft in length with a service capacity of 175 kips.

Based on latest plans provided by the designers, four proposed RCP lines with diameters of 18, 24, 30, and 51 inches and one proposed 12-inch diameter VCP line are located on the north side of the Cerritos channel. In addition, an existing 12-inch diameter high pressure gas line is located about 33 ft west of Abutment 1. Toward the south, this gas line is located about 5 to 10 ft west of Retaining Wall A1.

It is our understanding that the Port of Long Beach (POLB) may raise the grade in the future at north side of Cerritos Channel from Bents 17 through 23 as part of the potential future Pier A improvements. If this improvement occurs, appropriate measures need to be taken to mitigate the downdrag effect on piles at Bents 17 through 23 and kinematic loading effect on piles at Bent 17 due to the fill placement.

1.3 Existing Bridge Information

The existing Schuyler Heim Bridge (Bridge No. 53-2618) is a 45-span structure and is approximately 3,975 ft long and varies from about 80 to 130 ft wide. The typical span between piers is about 70 ft with the exception of the three spans between Piers 26 through 29 which crosses the Cerritos Channel and collectively spans about 685 ft. The center of these three spans between Piers 27 and 28 is the lifting span of the structure and is approximately 272 ft long.

Based on the as-built plans, the existing bridge is supported on a combination of timber piles and 14BP73 driven steel piles. Steel piles with a design loading of 40 tons are used at the abutments and Piers 26 through 29. Timber piles with a design loading of 22 tons are used at all other supports.

Copies of selected sheets from the as-built drawings for the existing Schuyler Heim Bridge are provided in Appendix A.

1.4 Limitations

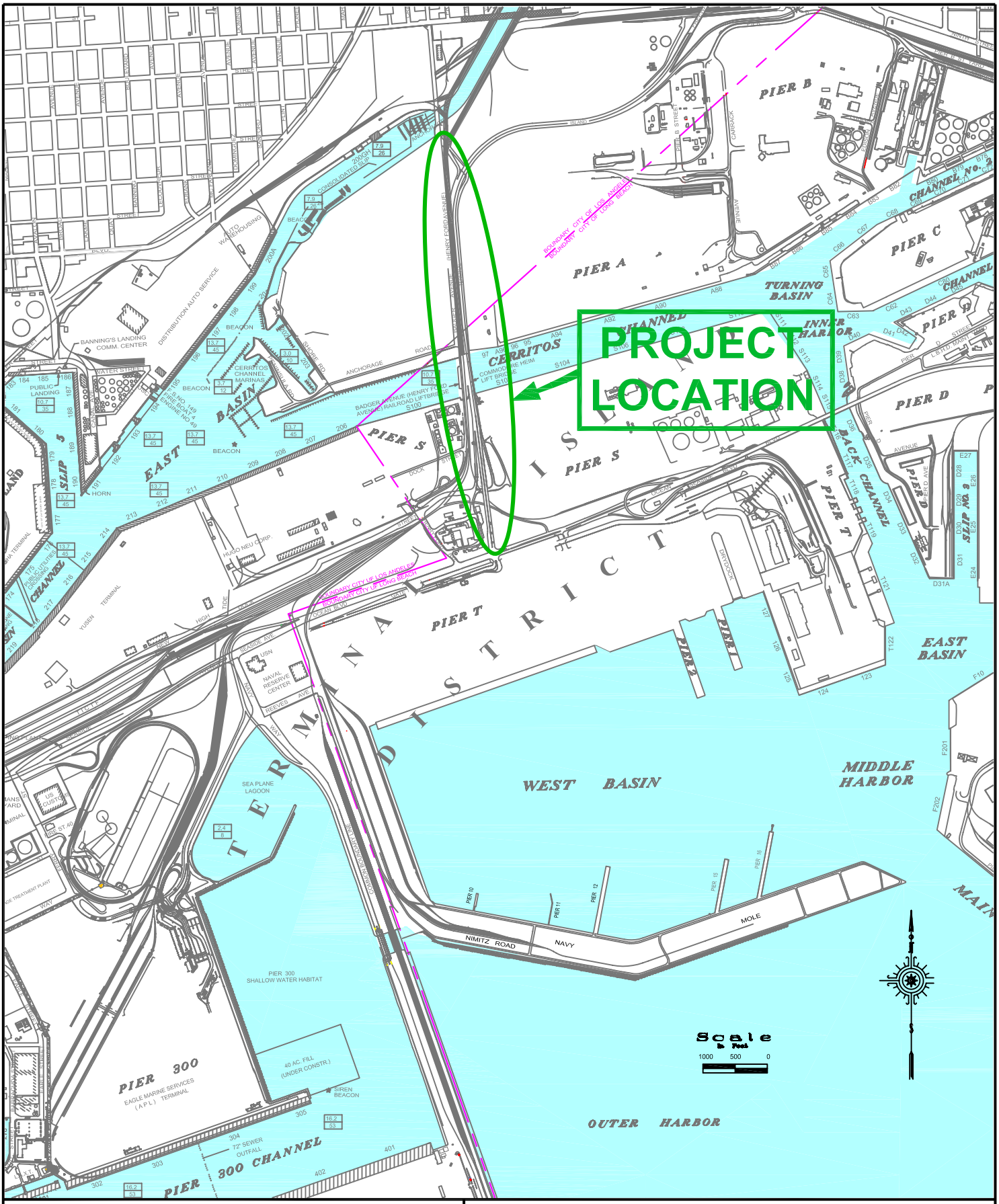
This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Schuyler Heim Bridge (Replace). This report is based on the project as described herein and the information obtained from the exploratory borings and Cone Penetration Testing (CPT) soundings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings and CPT

soundings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



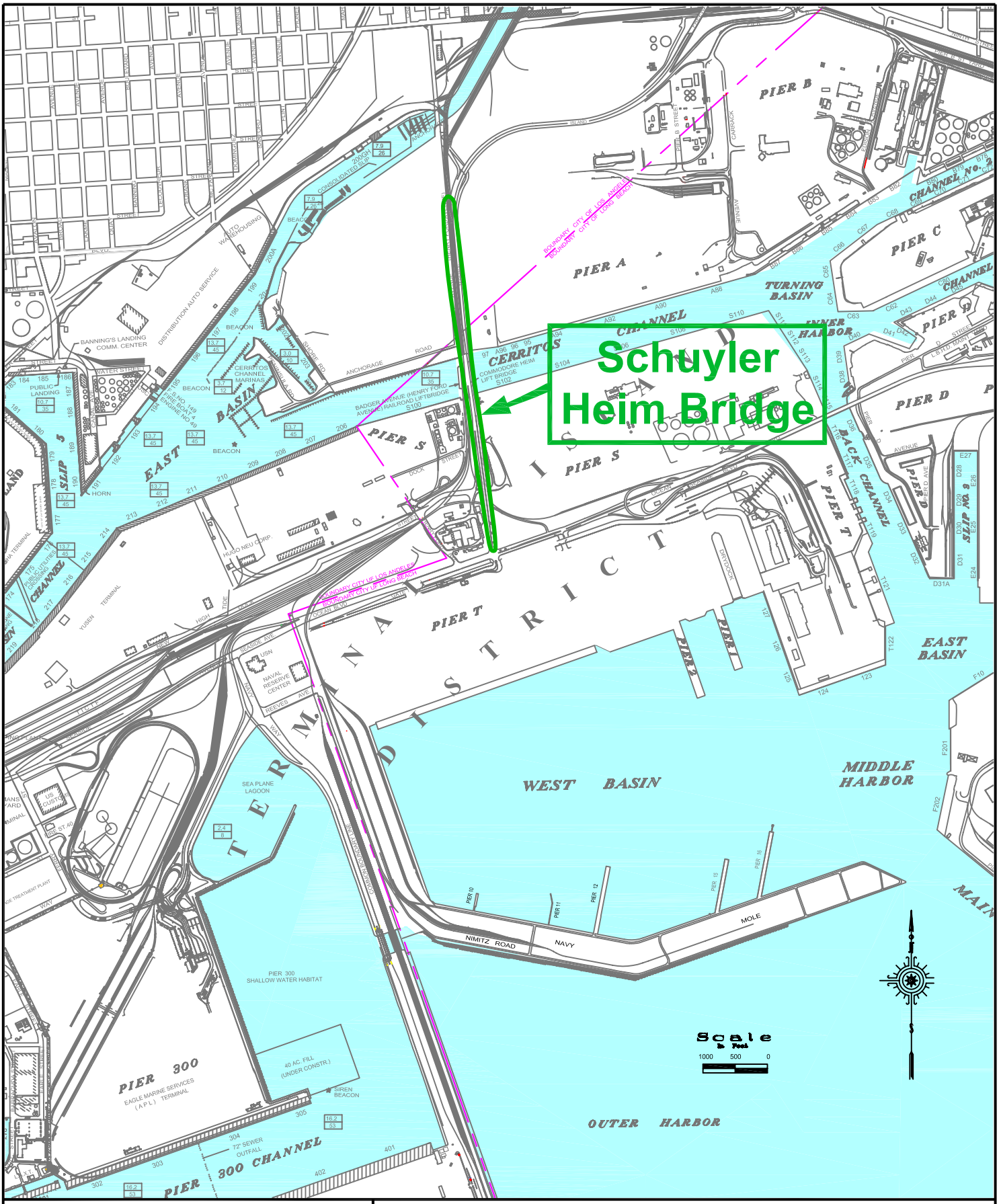
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	
Project No. 06-123	Date: 2-08-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

The as-built Logs-of-Test-Borings (LOTBs) and available logs of soil borings and CPT soundings for existing Schuyler Heim Bridge (Bridge No. 53-2618) were reviewed as part of the preparation of this report. Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, copies of LOTB sheets and logs of soil borings and CPT soundings are provided in Appendix B.

2.2 Supplement Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, forty two rotary wash borings and thirty four CPT soundings. Of that exploration program, twenty nine land rotary wash borings, four over water rotary wash borings, and twenty five land CPT soundings were performed in the vicinity of the Schuyler Heim Bridge. The purpose of the exploration was to log subsurface conditions and collect soil samples from locations near the proposed bridge supports. Soil boring and CPT sounding information are summarized in Table 1 and Table 2, respectively. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI using CA State Plane, NAD 83 and NAVD 1988 coordinate system to establish the offsets and elevations. All NAD83 values were obtained from the Caltrans District 7 Survey Request 94-156 whereas all NAVD 1988 values were either obtained from the Caltrans District 7 Survey Request 94-156 or the National Geodetic Survey Benchmark Database. Approximate locations of borings and CPT soundings performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of the text.

TABLE 1. SOIL BORING INFORMATION

Boring No.	Sta. Line	Station (ft)	Offset (ft) ( ) Right (-) Left	GSE (ft)	GWE (ft)	Approx. Bottom Elevation (ft)	Date Performed	Exploration Method
R-09-001		04+56.78	-73.62	+2.39	NR	-74.1	10/23/2009	RW
R-09-002		04+57.38	110.03	+3.55	NR	-73.0	10/12/2009	RW
R-09-003		05+47.32	39.77	+1.34	-4.2	-149.2	10/19/2009	RW
R-09-004		06+93.23	51.29	+1.51	-3.5	-155.0	10/22/2009	RW
R-09-005		09+25.22	-60.29	-0.16	-6.2	-160.7	10/21/2009	RW
R-09-006		09+17.14	70.18	+0.30	-3.7	-161.2	10/27/2009	RW
R-09-007		10+92.62	-43.21	-0.79	-4.8	-151.8	10/19/2009	RW
R-09-008		11+11.14	46.06	-0.74	-5.2	-151.0	10/26/2009	RW
R-09-009		12+16.84	44.46	-0.89	-4.9	-156.3	10/28/2009	RW
R-09-010		13+11.45	-119.05	+4.37	-5.1	-147.1	10/16/2009	RW
R-09-011	"A"	13+82.57	34.61	-0.97	-10.0	-151.3	10/27/2009	RW
R-09-012		14+93.50	-111.36	+13.33	-8.7	-142.2	10/16/2009	RW
R-09-013		15+81.86	-76.17	+0.22	-4.3	-165.8	10/28/2009	RW
R-09-014		15+76.68	20.55	-1.33	-5.3	-167.8	10/20/2009	RW
R-09-015		16+99.10	-83.4	-2.73	-10.7	-148.0	10/29/2009	RW
R-09-016		16+73.56	83.56	-0.78	-7.8	-151.3	10/22/2009	RW
R-09-017		17+88.21	-83.82	-2.78	-8.3	-183.3	10/20/2009	RW
R-09-018		18+06.82	49.2	-2.81	-5.8	-164.3	10/26/2009	RW
R-09-019		19+74.02	9.09	-2.98	-9.0	-154.5	10/30/2009	RW
R-09-020		21+60.02	25.71	+0.62	-6.4	-185.9	10/29/2009	RW
R-09-021		23+31.57	-7.78	+7.31	+2.3	-163.2	10/21/2009	RW
R-09-022		33+32.76	-36.28	-4.11	-7.1	-165.6	11/02/2009	RW
R-09-023		601+27.94	3.51	-4.49	-8.0	-155.0	10/30/2009	RW
R-09-024		603+15.67	25.4	-3.99	-8.0	-154.5	11/04/2009	RW
R-09-025		604+68.11	34.99	-3.90	-7.9	-165.4	11/05/2009	RW
R-09-026	"G"	606+31.07	45.14	-3.87	-9.9	-149.2	11/09/2009	RW
R-09-027		607+93.94	50.2	-3.80	-12.3	-155.3	11/05/2009	RW
R-09-028		609+73.16	62.76	-3.32	-7.3	-164.3	11/06/2009	RW
R-09-029		611+19.73	86.74	+7.29	-9.7	-154.2	11/10/2009	RW
WR-09-041		25+13.20	125.60	-37.0	-	-222.8	11/09-10/2009	RW
WR-09-042	"A"	27+00.60	107.80	-50.0	-	-231.5	11/05/2009	RW
WR-09-043		29+85.30	108.00	-50.0	-	-233.3	11/05/2009	RW
WR-09-044		31+14.30	109.50	-44.0	-	-236.5	11/05/2009	RW

Notes: 1. Exploration locations were field surveyed using CA State Plane NAD 83 and NAVD 1988 coordinate systems.

2. GSE = Ground Surface Elevation; GWE = Groundwater Elevation; NR = Not Recorded; RW = Rotary Wash; R-09-0xx = Land Boring; and WR-09-04x = Over Water Boring.

TABLE 2. CPT SOUNDING INFORMATION

CPT No.	Sta. Line	Station (ft)	Offset (ft) ( ) Right (-) Left	GSE (ft)	GWE (ft)	Approx. Bottom Elevation (ft)	Date Performed	Exploration Method
CPT-09-064	"A"	13+91.97	-116.59	+7.62	NR	-103.1	10/16/2009	CPT
CPT-09-065		15+22.34	77.67	-0.82	NR	-91.4	10/15/2009	CPT
CPT-09-070		05+44.00	44.30	+1.70	NR	-86.7	10/12/2009	CPT
CPT-09-071		06+99.46	55.17	+1.68	NR	-105.9	10/12/2009	CPT
CPT-09-072		09+31.57	-59.57	-0.32	NR	-95.1	10/12/2009	CPT
CPT-09-073		09+08.37	73.38	+0.26	NR	-104.5	10/12/2009	CPT
CPT-09-074		10+86.36	-44.13	-0.82	NR	-86.7	10/13/2009	CPT
CPT-09-075		11+16.10	47.57	-0.95	NR	-93.0	10/13/2009	CPT
CPT-09-076		12+22.42	45.23	-0.89	NR	-92.1	10/13/2009	CPT
CPT-09-077		13+87.48	34.47	-0.83	NR	-103.2	10/13/2009	CPT
CPT-09-078		15+81.86	-82.69	+0.33	NR	-97.1	10/14/2009	CPT
CPT-09-079		15+81.62	20.56	-1.26	NR	-98.9	10/14/2009	CPT
CPT-09-080		17+95.23	-85.09	-2.78	NR	-97.3	10/14/2009	CPT
CPT-09-081		18+01.50	49.96	-2.66	NR	-108.5	10/15/2009	CPT
CPT-09-082		19+67.67	10.25	-2.99	NR	-109.1	10/15/2009	CPT
CPT-09-083		21+55.46	26.42	+0.67	NR	-86.7	10/15/2009	CPT
CPT-09-084		23+30.52	-19.62	+7.64	NR	-101.3	10/15/2009	CPT
CPT-09-085		33+33.31	-31.60	-4.14	NR	-94.2	10/14/2009	CPT
CPT-09-086	"G"	601+26.28	10.61	-3.95	NR	-95.6	10/14/2009	CPT
CPT-09-087		603+16.58	13.03	-4.00	NR	-95.7	11/02/2009	CPT
CPT-09-088		604+68.56	24.33	-3.83	NR	-103.1	11/02/2009	CPT
CPT-09-089		606+36.97	38.64	-3.91	NR	-97.6	11/02/2009	CPT
CPT-09-090		607+91.76	41.24	-3.97	NR	-80.3	11/02/2009	CPT
CPT-09-091		609+69.98	54.65	-3.40	NR	-84.3	11/02/2009	CPT
CPT-09-092		611+10.35	87.15	+7.31	NR	-96.8	11/04/2009	CPT

Notes: 1. Exploration locations were field surveyed using CA State Plane NAD 83 and NAVD 1988 coordinate systems.

2. GSE = Ground Surface Elevation; GWE = Groundwater Elevation; NR = Not Recorded; CPT = Cone Penetration Test.

2.2.1 Soil Borings

The soil borings were conducted on both land and water sides. The land borings surrounding the proposed bridge were performed at grade in the undeveloped area near or beneath the existing Schuyler Heim bridge structure. The over water borings were performed in the Cerritos channel, east of the existing mainline structure. The deepest land boring penetrated down to about elevation -186 ft, approximately 186 ft below ground surface. The deepest overwater boring penetrated down to about elevation -236 ft, approximately 192 ft below mudline.

2.2.1.1 Land Borings

The borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs. Soil samples were visually classified and logged in the field by EMI personnel.

2.2.1.2 Overwater Borings

The overwater borings were performed by Gregg Drilling & Testing, Inc. (Gregg) under subcontract with EMI to supplement the available geotechnical information. The overwater borings were drilled from a small drill ship "Quin Delta" operated by Gregg. The Quin Delta drill ship, 110 ft long and 28 ft wide, is a self propelled ocean-going vessel. It was specially engineered and designed with 80-ft spuds that can be used for stable anchoring in waters up to 70-ft deep. The drilling vessel was maneuvered to the position over the testing location by using Digital Global Positioning System (DGPS).

Borings were drilled to tip elevations ranging from about -222 ft to -236 ft using Mobile B-80/22 mud rotary drill rig equipped with a 5.5 inches rotary wash bit. At each soil borings, soil samples were collected generally at 5 ft vertical intervals by means of split-spoon drive samplers; the SPT sampler and the MCD sampler were used to collect small disturbed and relatively undisturbed samples, respectively. Sampling intervals were increased as it advanced to deeper depths. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.0 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs. Soil samples were visually classified and logged in the field by EMI personnel.

2.2.2 SPT Hammer Energy Measurements

As part of the field investigation, energy measurements were performed for the SPT hammers used in various drill rigs during land and over water exploration at the subject site. The energy measurements at two land boring locations (designated as R-09-004 and R-09-009) were performed by EarthSpectives (ES) under a subcontract with EMI while at one overwater boring location (designated as WR-09-041) energy measurements were made by Gregg. Based on those measurements, the average hammer efficiencies were about 62 percent and 79 percent in the land borings performed C&L with rope and cat-head hammer and SoCal with automatic trip hammer, respectively. The average hammer efficiency of about 85 percent was measured at the over water boring performed by Gregg with automatic trip hammer. A copy of these ES and Gregg reports are provided in Appendix C.

2.2.3 Boring Geophysical Measurements

Boring geophysical measurements were also collected by GeoVision Geophysical Services (GeoVision) under a subcontract with EMI in six uncased borings (designated as R-09-007, R-09-014, R-09-021, R-09-022, R-09-025, and R-09-028); to a maximum depth of about 160 ft. The purpose of the study was to supplement stratigraphic information obtained during soil investigation program and acquire compression (P) and shear (S) wave velocities as a function of depth. A copy of the GeoVision report is provided in Appendix D.

2.2.4 CPT Soundings

CPT soundings were also performed at grade in the undeveloped area near or beneath the existing the existing Schuyler Heim bridge structure. The deepest sounding was advanced down to approximate elevation -109 ft, approximately 106 ft below ground surface.

The CPT soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under subcontract with EMI. The CPT sounding was performed using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

Laboratory tests were performed to determine relevant physical characteristics and engineering properties of soils that exist at the site. Selected soil samples were tested to determine soil classification and physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 3.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. Test results are shown on the LOTB sheet at the end of the text and included in Appendix E.

TABLE 3. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
Specific Gravity	ASTM D 854	Determine degree of saturation
UU Triaxial Test	ASTM D 2850	Estimate strength parameters of fine-grained soil
Direct Shear	ASTM D 3080	Estimate strength parameters of coarse-grained soil
Soil pH	CT 532/643	Determine corrosion potential of soil
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil
Sulfate Content	CT 417	Determine corrosion potential of soil
Chloride Content	CT 422	Determine corrosion potential of soil

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.

"A" Abut 1 (Heim)

"A" Bent 2 (Heim)

"A" Bent 3 (Heim)

"A" Bent 4 (Heim)

RW A1

R-09-001 (76.5')

R-09-002 (76.5')

R-09-003 (150.5')

CPT-09-070 (88.4')

R-09-004 (156.5')

CPT-09-071 (107.6')

R-09-005 (160.5')

CPT-09-072 (94.8')

CPT-09-073 (104.8')

R-09-006 (161.5')

SR-47

Rail Road

Approximate Match Line (See Sheet 2)

0 25 50 Feet

LEGEND

R-09-003 (150.5')	Rotary Wash Borings by EMI (Terminated Depth Below Grade)
WR-09-041 (185.8')	Over Water Borings by EMI (Terminated Depth Below Mudline)
CPT-09-070 (88.4')	CPT Soundings by EMI (Terminated Depth Below Grade)

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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

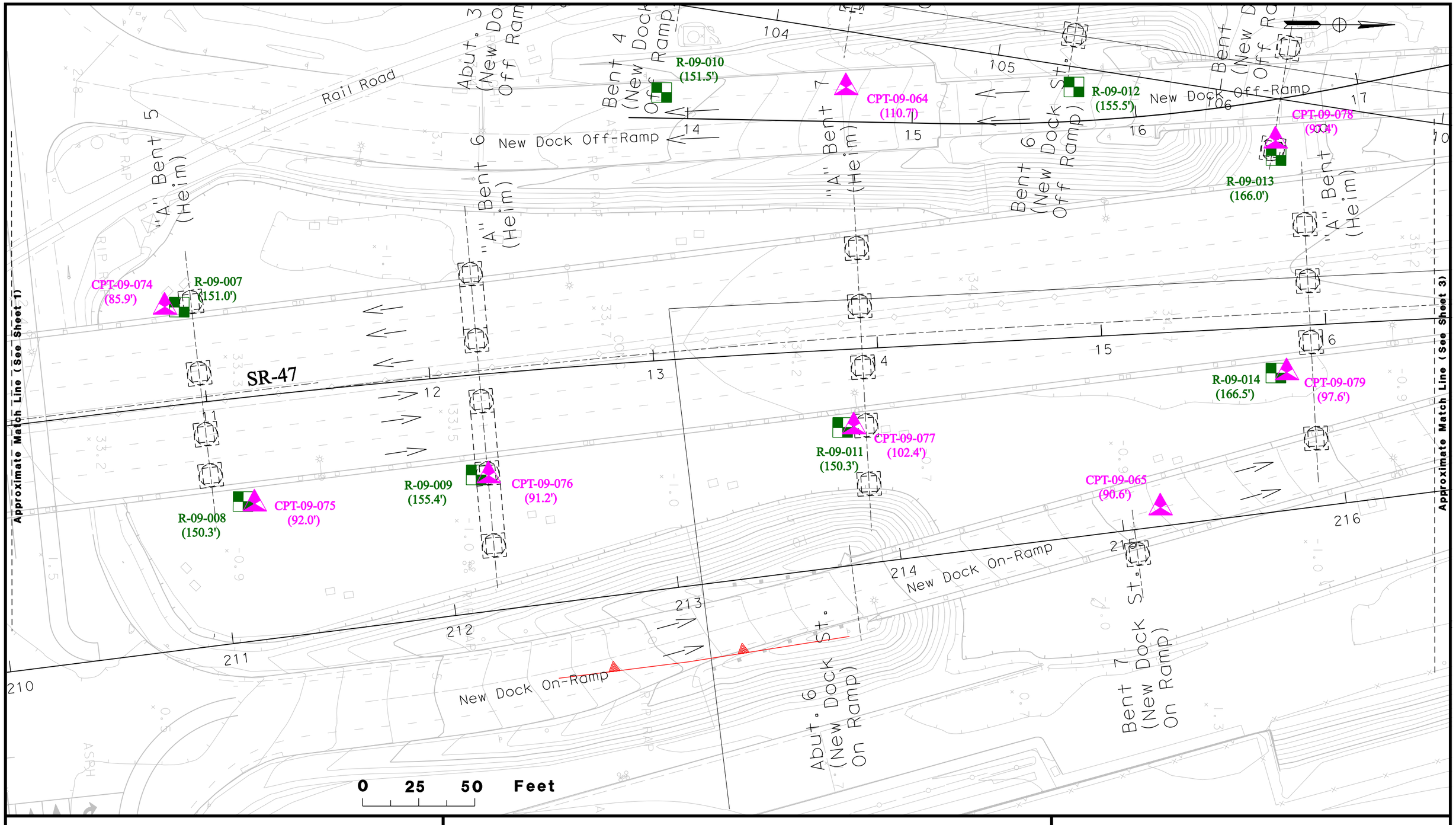
Project No. 06-123

Date: 2-08-10

Boring/CPT Sounding Location Map

(Sheet 1 of 7)

Figure 3



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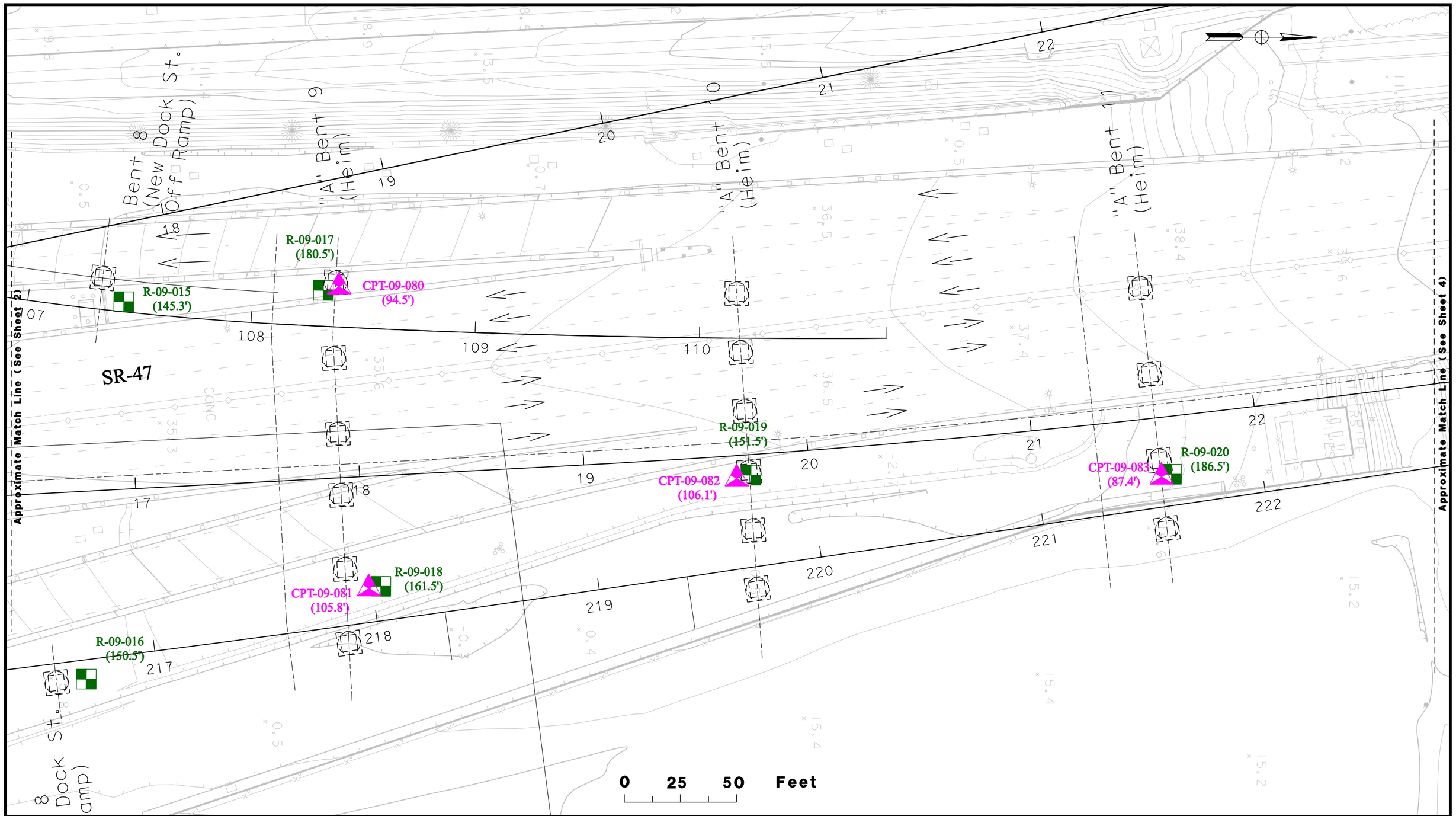
Project No. 06-123

Date: 2-08-10

Boring/CPT Sounding Location Map

(Sheet 2 of 7)

Figure 3



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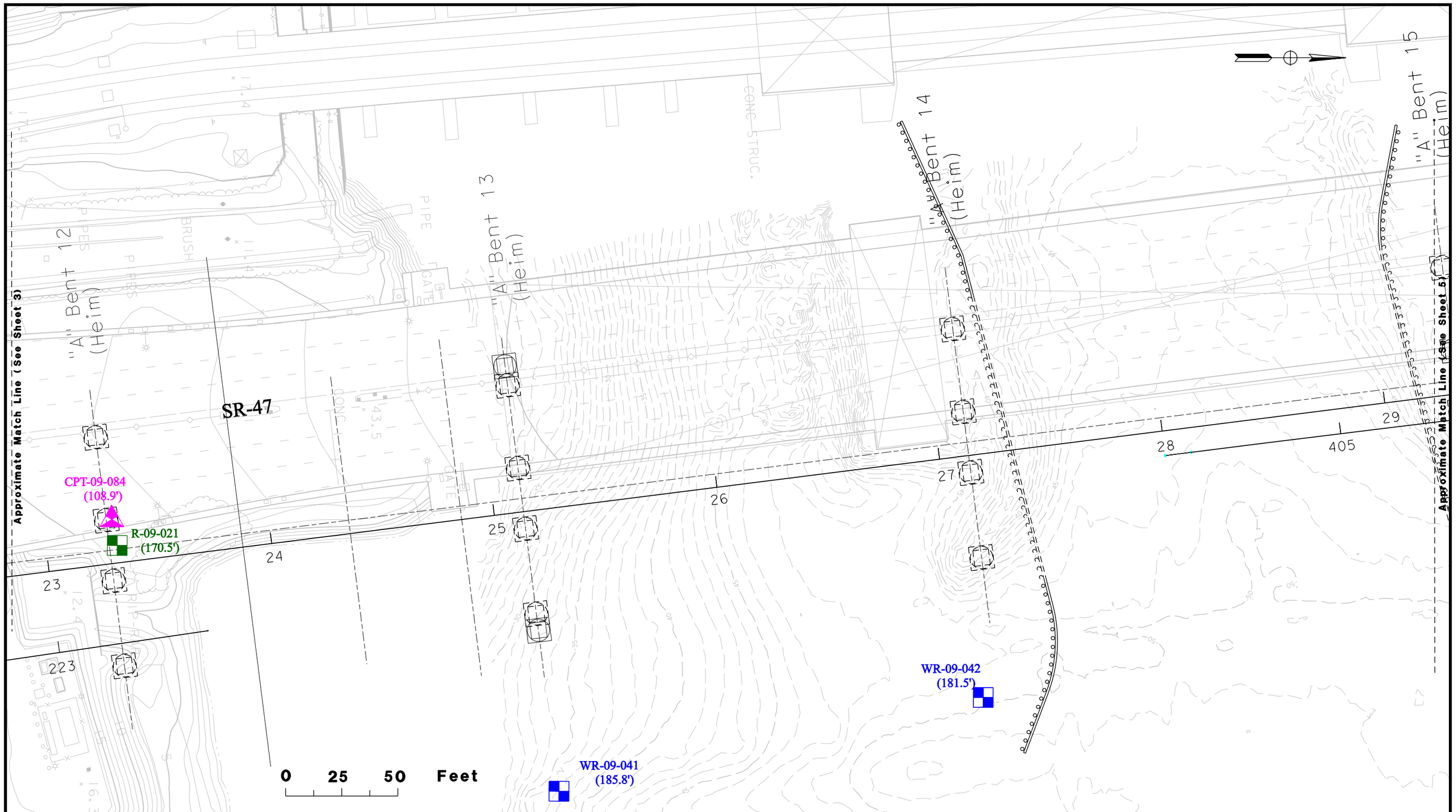
Boring/CPT Sounding Location Map

(Sheet 3 of 7)

Figure 3



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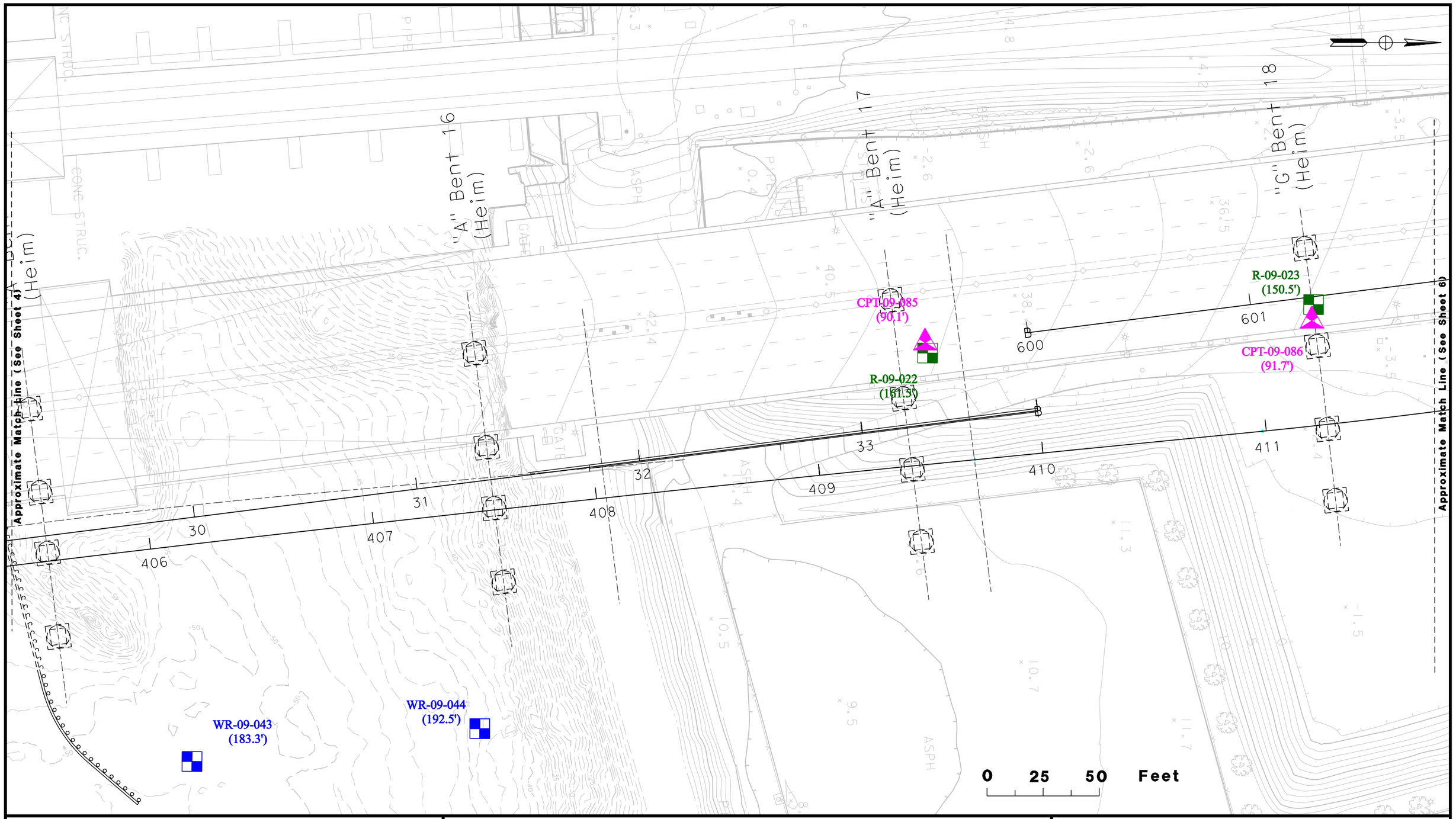
Boring/CPT Sounding Location Map

(Sheet 4 of 7)

Figure 3



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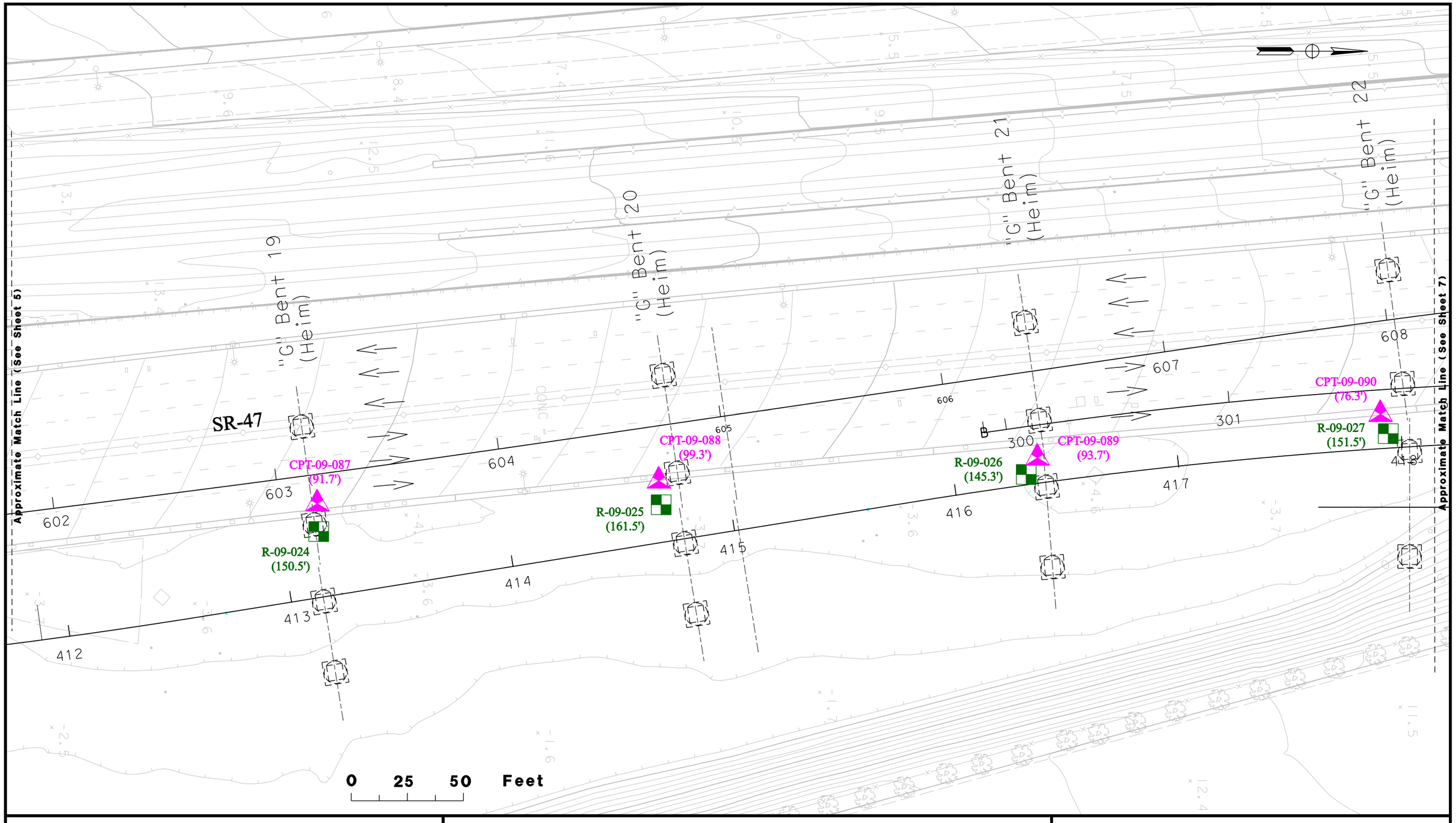
Boring/CPT Sounding Location Map

(Sheet 5 of 7)

Figure 3



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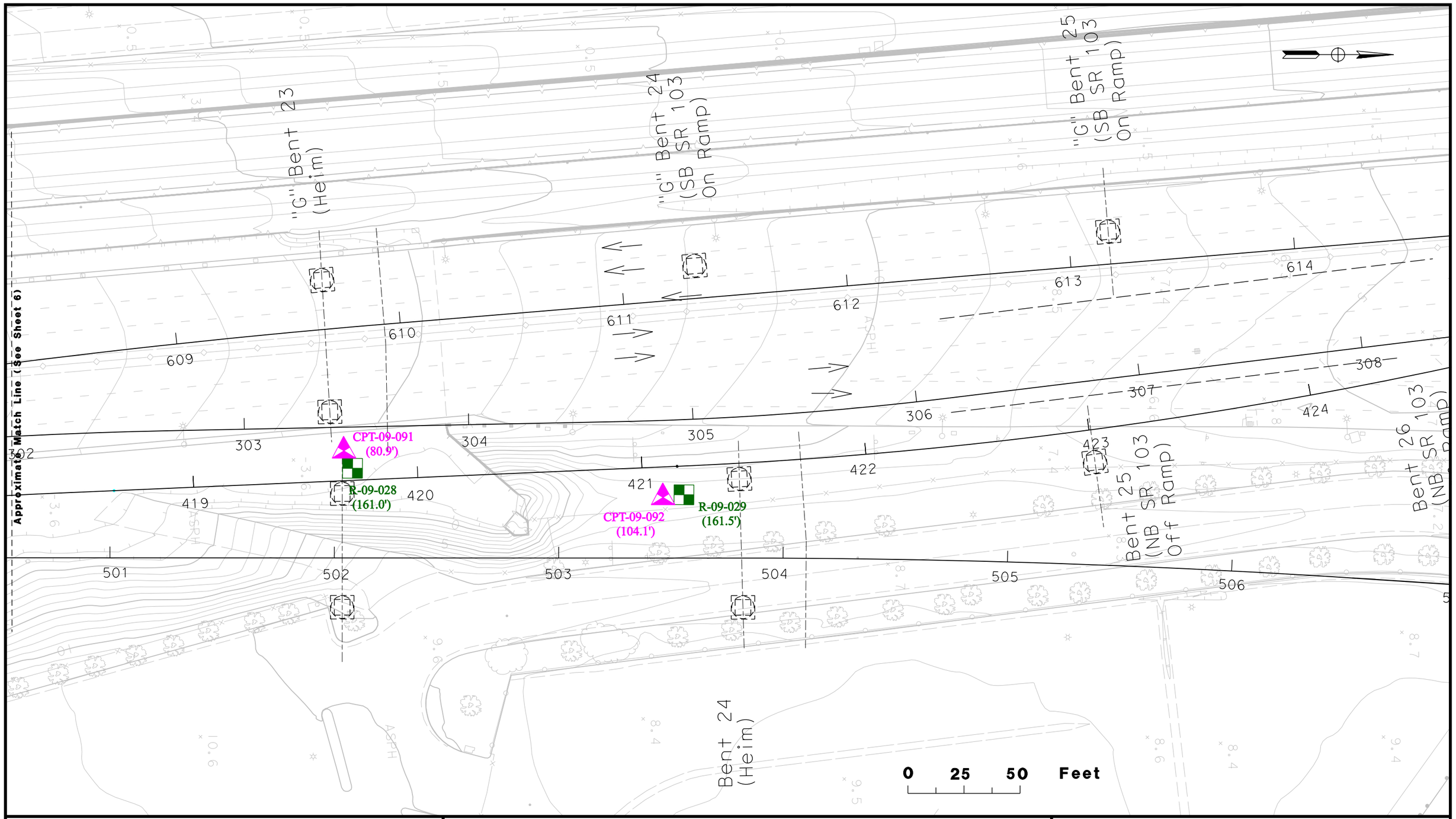
Project No. 06-123 | Date: 2-08-10

Boring/CPT Sounding Location Map
(Sheet 6 of 7)

Figure 3



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Boring/CPT Sounding Location Map

(Sheet 7 of 7)

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the

NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 5 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.

2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.

3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.

5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figure 5 and Figure 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figure 5 and Figure 6).

TABLE 4. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	California Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic

measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figure 4 through Figure 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area

to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (Long Beach Gas and Oil Department, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

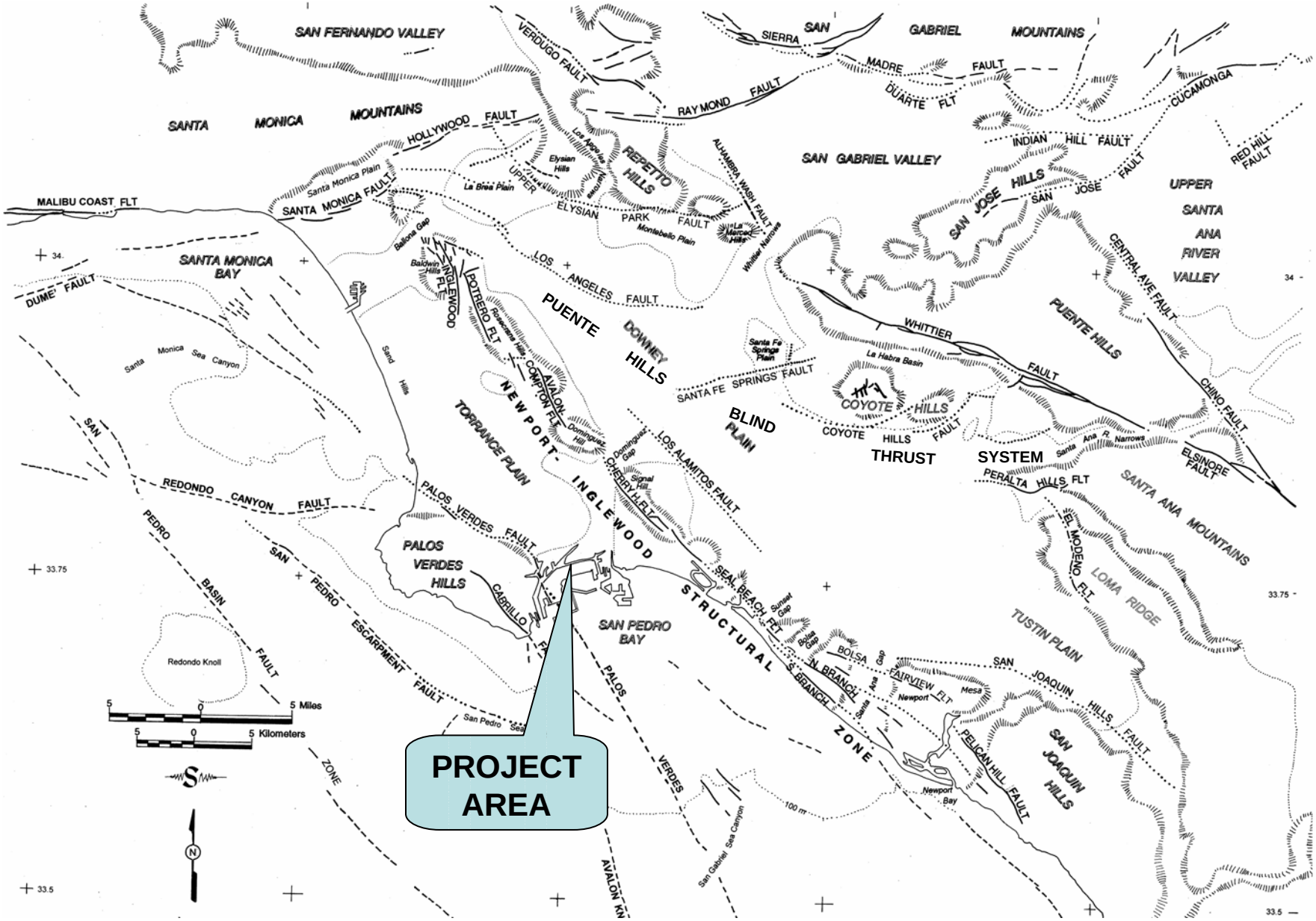
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

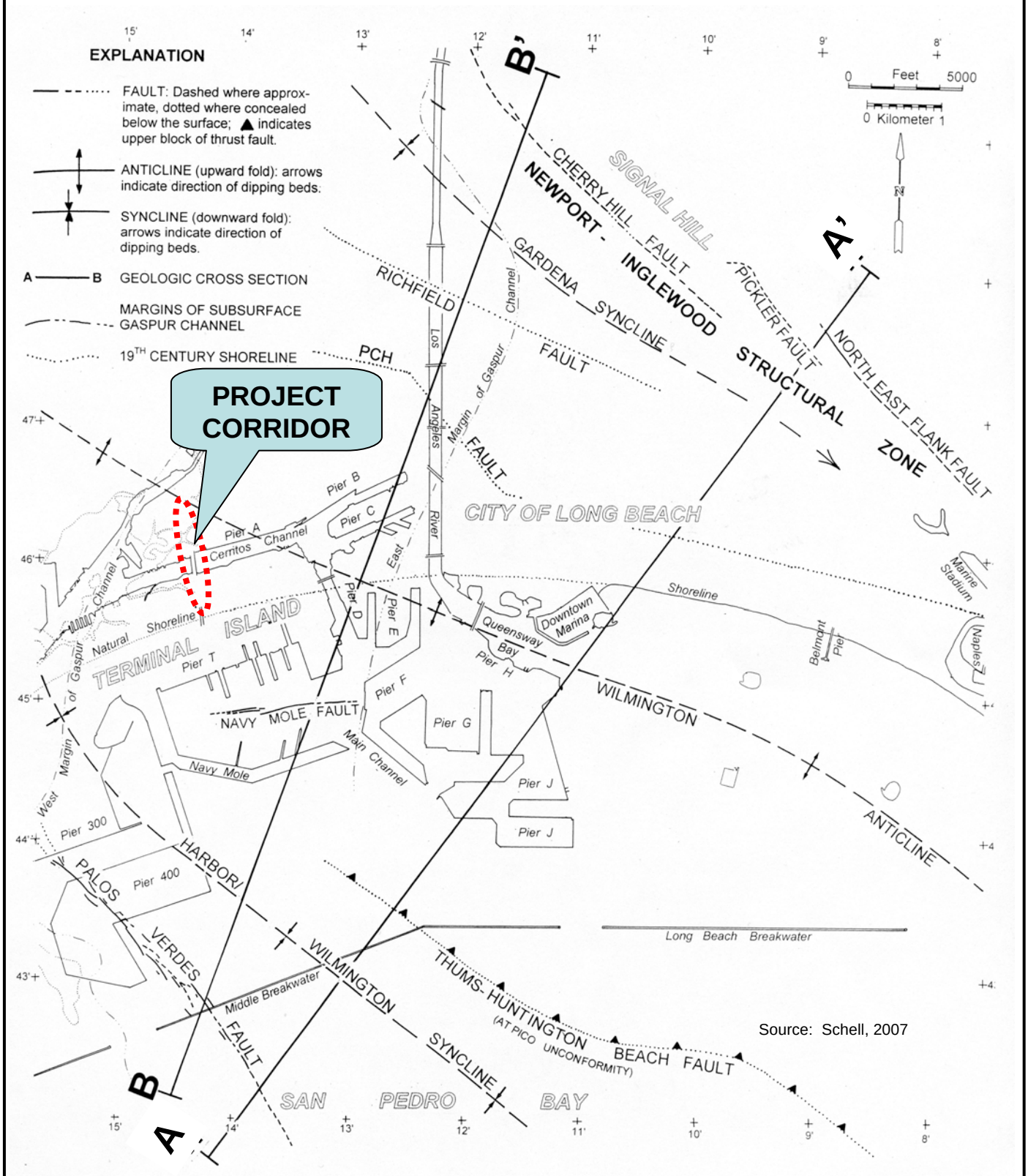
Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 2-08-10	Figure 4



Source: Schell, 2007

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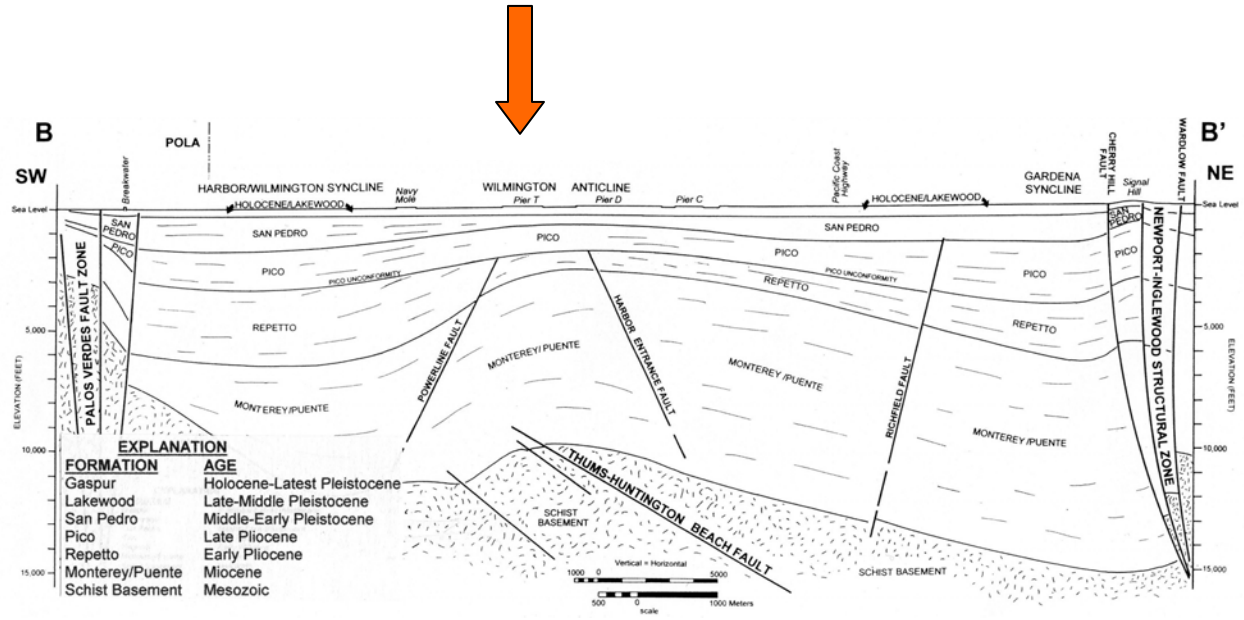
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structural Geology Map, Long Beach Harbor

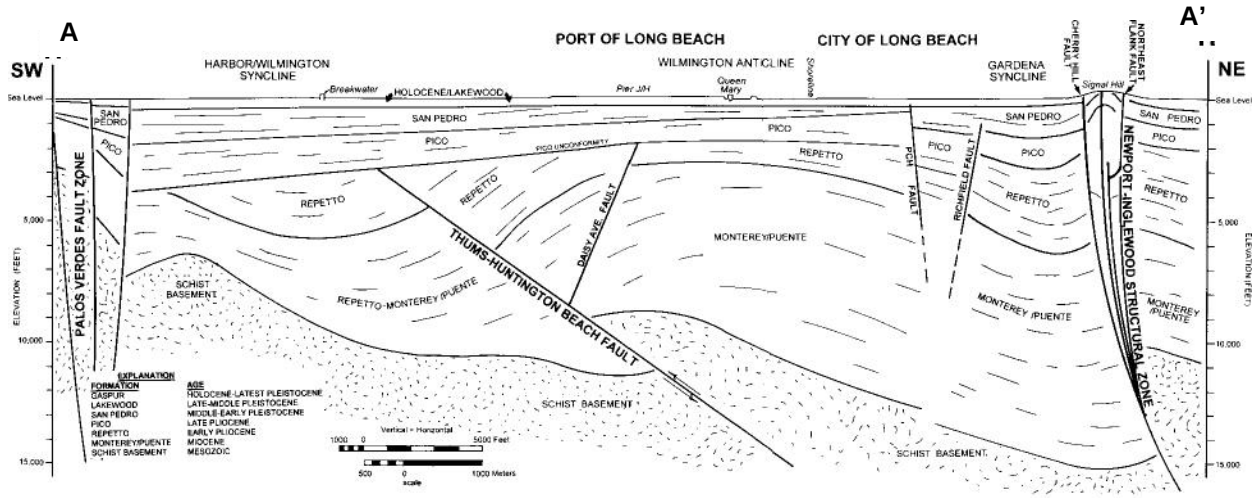
Figure 5

Project No. 06-123 | Date: 2-08-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

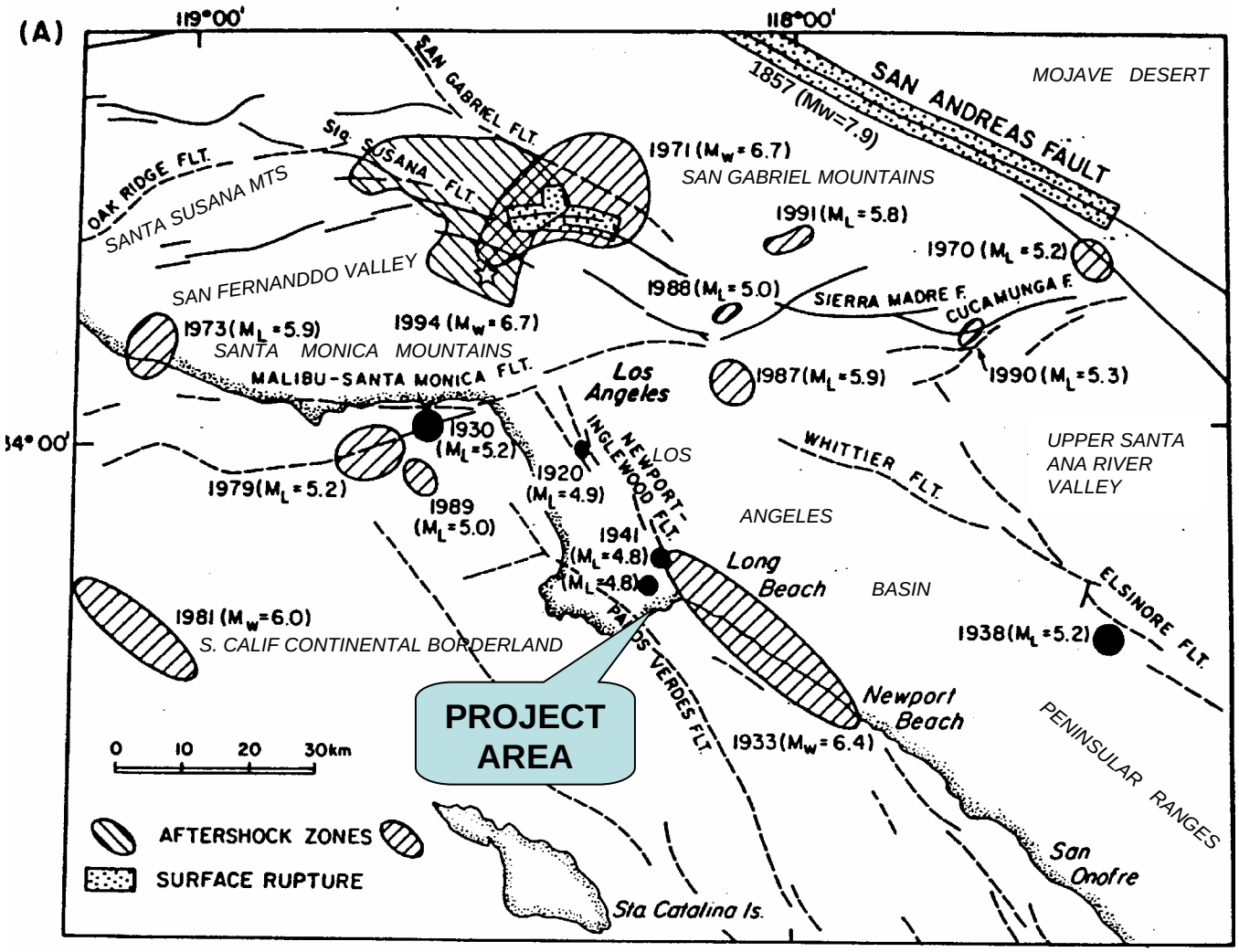


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	
Project No. 06-123	Date: 2-08-10	Geologic Cross-Sections, LA Harbor Figure 6



Source: Modified from Hauksson, 1995

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Map of Notable Earthquakes, LA Region

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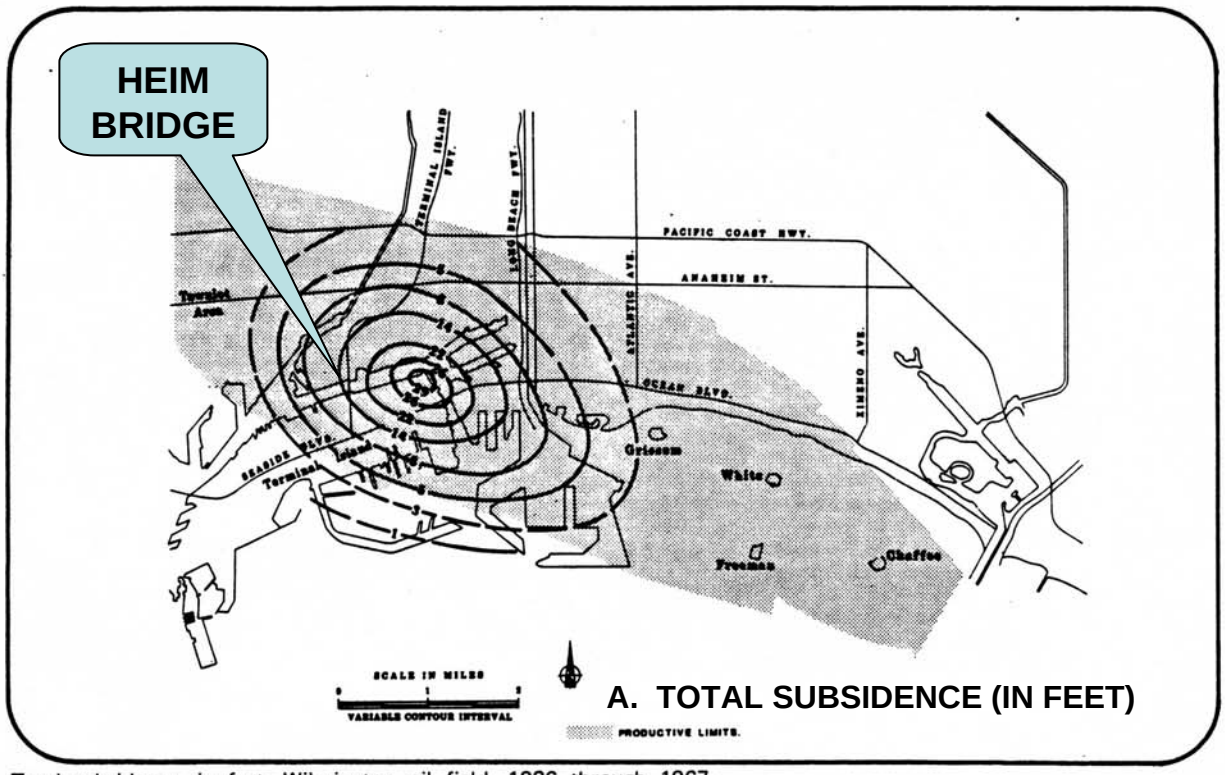
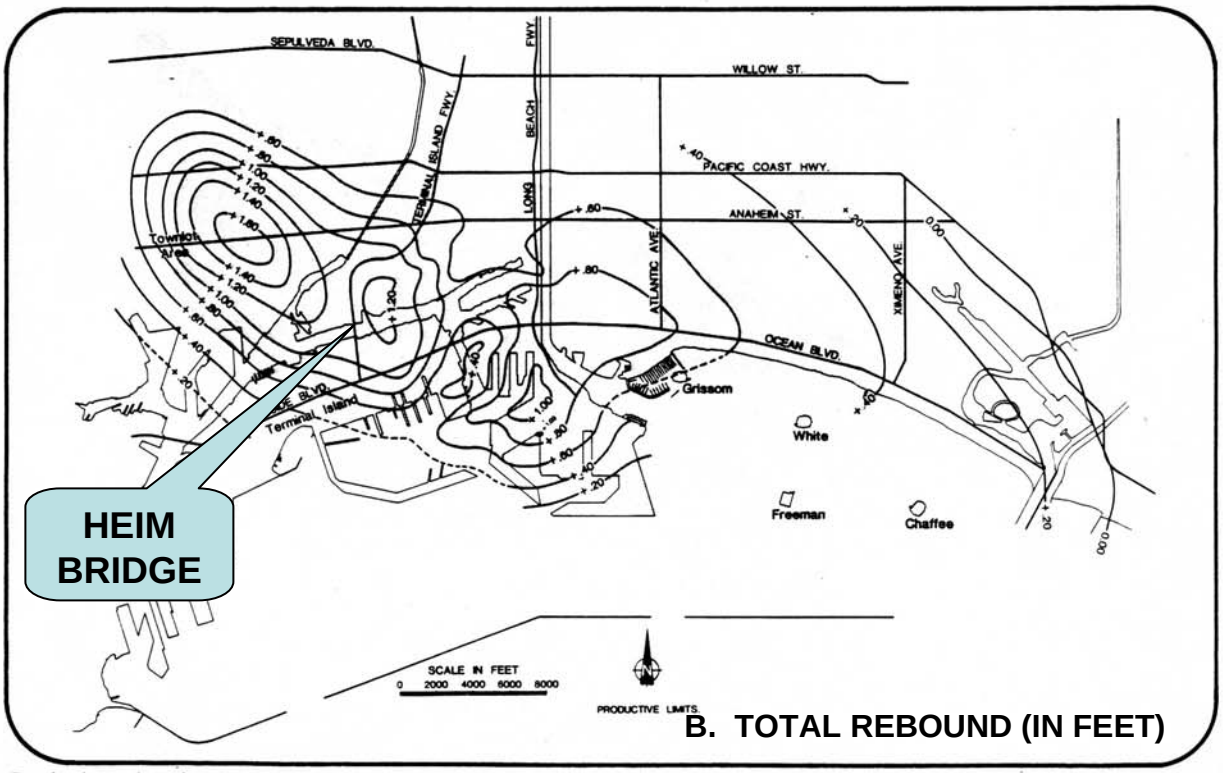
Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

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Map of Subsidence and Rebound, Long Beach Harbor

Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soil information and the site-specific exploratory borings and CPT soundings, described in Section 2, performed under the supervision of EMI for the subject project. Within the depths explored (between approximate El. +13 ft and El. -236 ft), the subsurface profile consists of about 75 ft to 85 ft thick interlayered alluvial deposits overlying Gaspur Formation sand.

Along the subject bridge site, natural grade varies between approximate El. 0 ft and -4 ft, with approach embankments for existing New Dock Street On- and Off-Ramps consisting of import fill extending to a maximum elevation of about +15 ft. The near surface deposits generally consist of loose to medium silty sand to poorly graded sand with few interbedded fine-grained layers between natural grade and about elevation -25 ft to -35 ft. The near surface deposits are underlain by a thick strata of interbedded layers of soft to very stiff sandy silt, silt, silty clay, and clay materials and loose to dense silty sand to poorly graded sand with silt down to about elevation -75 ft to -85 ft. Below elevation -75 ft to -85 ft, lies the Gaspur Formation which consists of dense to very dense poorly graded sand to silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each boring and CPT sounding location, refer to the LOTB sheet at the end of the text.

4.2 Groundwater Conditions

During the investigation by LKR (LKR, 1998) in 1996, Groundwater was recorded between El. -4 and -6 ft in borings. During the EMI investigations in 2009, groundwater was recorded between El. +2.3 ft and El. -12.3 ft in twenty seven of the twenty nine site-specific borings performed along the proposed bridge alignment. The elevation that groundwater was encountered at in each boring is listed in Table 1 and also on LOTB sheets at the end of the text. However, due to the close proximity to the ocean, the ground water table at the project site is directly related to tidal fluctuations.

Based on the above information and the observed high water groundwater elevation at the Cerritos Channel, the design groundwater was placed conservatively at El. +5 ft or the ground surface in locations where finished grade is proposed to be below El. +5 ft.

4.3 Idealized Soil Profile

Based on information collected from thirty three site-specific soil borings and twenty nine CPT soundings listed in Table 1 and Table 2, an idealized soil profile for foundation analysis and design was developed along the proposed bridge alignment. The soil profile and design strength parameters are presented in Table 5 and shown graphically in Figure 9. The cohesion values for

clayey soils and shear strength parameters for sandy soils were estimated using laboratory test data, correlation between field blow count and shear strength, and interpretation of CPT sounding tip resistance.

TABLE 5. IDEALIZED SOIL PROFILES AND STRENGTH PARAMETERS

Approximate Elevation (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
Abutment 1 (R-09-001 and R-09-002)				
Grade to -20	SP, SP-SM, SC	120	100	32
-20 to -30	SP, SP-SM	120	100	34
-30 to -50	SM, ML	120	100	33
-50 to -68	SP, SM, SC, ML	120	100	36
-68 to -75	ML	120	3,000	0
Below -75	SP, SP-SM, SM, GP-GM	125	0	38
Bent 2 (R-09-003 & CPT-09-070)				
Grade to -15	SP, SP-SM	120	100	32
-15 to -30	SP, SP-SM	120	100	34
-30 to -48	SM, ML	120	100	32
-48 to -55	CL-ML	120	2,250	0
-55 to -72	SP, SP-SM	120	100	36
-72 to -75	ML	120	3,000	0
Below -75	SP, SP-SM, SM, GP-GM	125	0	38
Bent 3 (R-09-004 & CPT-09-071)				
Grade to -30	SM	120	100	32
-30 to -47	ML	120	100	30
-47 to -57	CL-ML	120	2,000	0
-57 to -68	SM	120	0	36
-68 to -75	CL, ML	120	2,500	0
Below -75	SP, SP-SM, SM	125	0	38

TABLE 5. IDEALIZED SOIL PROFILES AND STRENGTH PARAMETERS (CONT.)

Approximate Elevation (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
Bent 4 (R-09-005 & R-09-006 and CPT-09-072 & CPT-09-073)				
Grade to -32	SM, SP-SM, SP	120	100	30
-32 to -42	ML, CL-ML	120	750	0
-42 to -62	SM, ML	120	100	32
-62 to -75	ML, CL	120	2,000	0
Below -75	SP, SP-SM, SW-SM, SM	125	0	38
Bent 5 (R-09-007 & R-09-008 and CPT-09-074 & CPT-09-075)				
Grade to -42	SP, SM, ML	120	100	32
-42 to -53	CL, ML	120	1,000	0
-53 to -63	SM, ML	120	100	32
-63 to -75	CL, ML	120	3,000	0
Below -75	SP, SP-SM, SM	125	0	38
Bent 6 (R-09-009 & CPT-09-076)				
Grade to -29	SM, SP-SM, SP	120	100	32
-29 to -44	ML, CL-ML, CH	120	1,500	0
-44 to -58	CL, CL-ML	120	1,000	0
-58 to -75	ML, CL-ML	120	3,000	0
Below -75	SP, SP-SM, SM	125	0	38
Bent 7 (R-09-011 and CPT-09-064 & CPT-09-077)				
Grade to -13	SM, SP-SM	120	100	32
-13 to -19	SP-SM	120	100	33
-19 to -34	SM, SP	120	100	30
-34 to -59	CL-ML, ML, CH	120	1,000	0
-59 to -75	ML	120	3,000	0
Below -75	SP-SM, SM	125	0	38

TABLE 5. IDEALIZED SOIL PROFILES AND STRENGTH PARAMETERS (CONT.)

Approximate Elevation (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
Bent 8 (R-09-013 & R-09-014 and CPT-09-078 & CPT-09-079)				
Grade to -34	SM, ML	120	100	30
-34 to -52	CL, ML	120	650	0
-52 to -68	ML, SM, CL	120	100	32
-68 to -75	SP-SM, SM	120	100	36
Below -75	SP, SP-SM, SW-SM, SM, GW-GM	125	0	38
Bent 9 (R-09-017 & R-09-018 and CPT-09-080 & CPT-09-081)				
Grade to -20	SP, SM	120	100	30
-20 to -30	SM, CL-ML	120	100	30
-30 to -36	ML, MH	120	1,200	0
-36 to -50	SM, ML	120	100	32
-50 to -60	ML, CH	120	2,250	0
-60 to -75	SM, SP-SM	120	100	36
Below -75	SP, SP-SM, SM, GW-GM	125	0	38
Bent 10 (R-09-019 & CPT-09-082)				
Grade to -16	SM, ML	120	100	30
-16 to -30	ML	120	500	0
-30 to -60	ML, SM	120	100	32
-60 to -75	CL-ML, CL, ML	120	1,850	0
Below -75	SP, SM	125	0	38
Bent 11 (R-09-020 & CPT-09-083)				
Grade to -12	SM	120	100	32
-12 to -32	ML, CL	120	500	0
-32 to -52	SM, ML	120	100	32
-52 to -75	ML	120	2,000	0
Below -75	SP, SP-SM, SM	125	0	38

TABLE 5. IDEALIZED SOIL PROFILES AND STRENGTH PARAMETERS (CONT.)

Approximate Elevation (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
Bent 12 (R-09-021 & CPT-09-084)				
Grade to -10	SM	120	100	30
-10 to -16	CH	120	950	0
-16 to -31	SM	120	100	32
-31 to -41	ML, CH	120	1,250	0
-41 to -50	ML, CL	120	1,250	0
-50 to -56	SM	120	100	36
-56 to -75	CL, ML	120	3,000	0
Below -75	SP, SP-SM, SM	125	0	38
Bent 13 (WR-09-041)				
Mudline to -45	CL, ML	120	250	0
-45 to -55	CL, ML	120	1,250	0
-55 to -75	ML, CL-ML, CL	120	2,500	0
Below -75	SP, SP-SM, SW-SM, SM	125	0	38
Bents 14 through Bent 16 (WR-09-042 through WR-09-044)				
Mudline to -55	CL, ML, CH	120	250	0
-55 to -70	CL, ML	120	1,250	0
-70 to -85	ML, CL, MH	120	2,500	0
Below -85	SP, SP-SM, SM, GW-GM, GP, GW	125	0	38
Bent 17 (R-09-022 & CPT-09-085)				
Grade to -9	SM	120	100	32
-9 to -21	ML	120	100	30
-21 to -38	SP-SM, SP	120	100	33
-38 to -48	ML	120	800 [1] & 1,000 [2]	0
-48 to -56	ML	120	1,000 [1] & 1,250 [2]	0
-56 to -85	CL, CL-ML	120	3,000	0
Below -85	SP, SP-SM, SW-SM	125	0	38

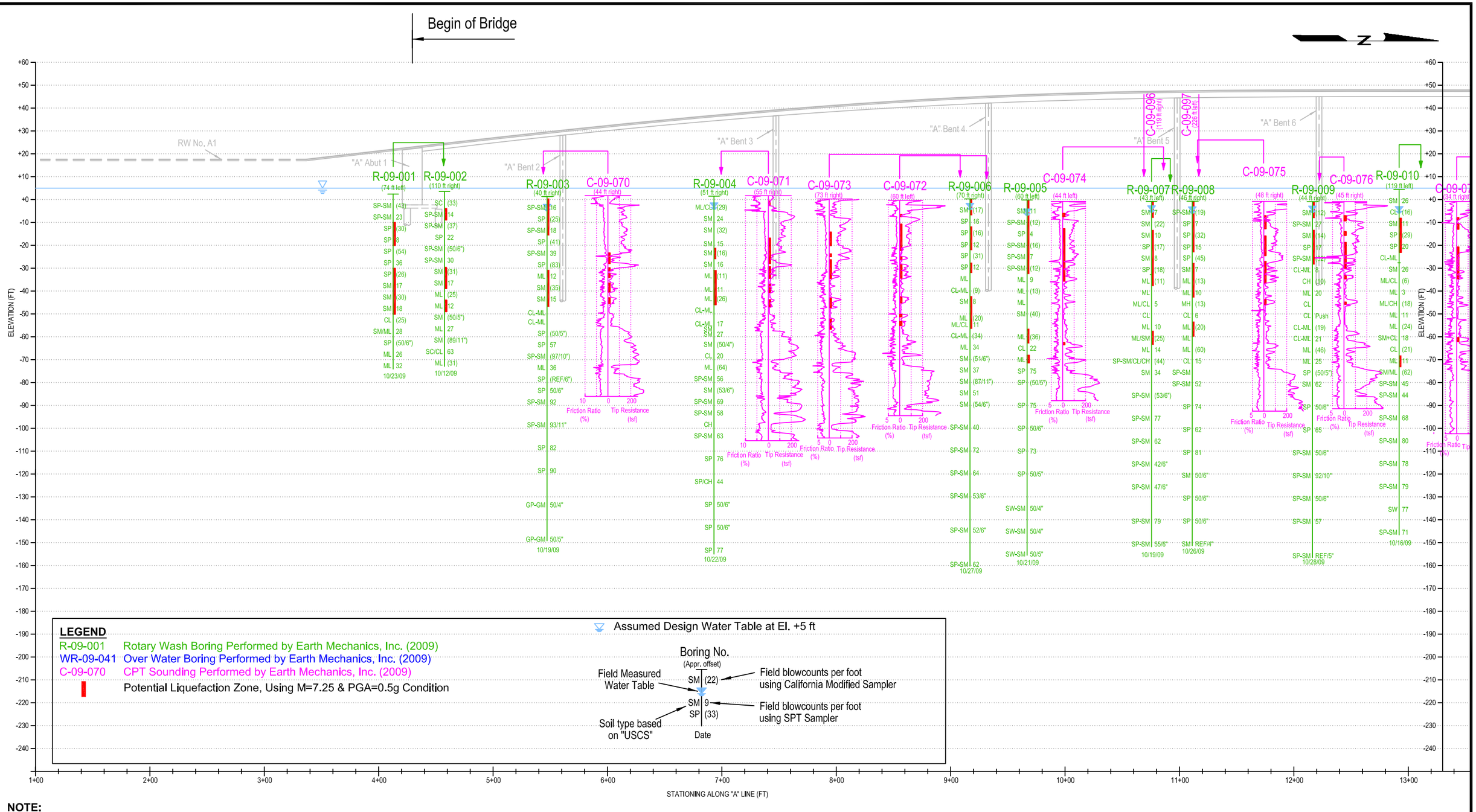
[1] *At west side of Bent 17;* [2] *At east side of Bent 17.*

TABLE 5. IDEALIZED SOIL PROFILES AND STRENGTH PARAMETERS (CONT.)

Approximate Elevation (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
Bent 18 (R-09-023 & CPT-09-086)				
Grade to -11	SM	120	100	30
-11 to -21	ML, MH	120	300	0
-21 to -40	SM, SP-SM	120	100	32
-40 to -51	CL, CL-ML	120	800	0
-51 to -58	SM, SC	120	100	30
-58 to -85	ML, CL	125	3,000	0
Below -85	SM, SW-SM	125	0	38
Bent 19 (R-09-024 & CPT-09-087)				
Grade to -20	SM, ML	120	100	30
-20 to -31	SM, ML	120	100	30
-31 to -37	ML	120	650	0
-37 to -47	ML	120	100	30
-47 to -57	CL	120	800	0
-57 to -62	SM, ML	120	100	33
-62 to -85	ML, CL	120	3,000	0
Below -85	SP-SM, SW-SM	125	0	38
Bent 20 (R-09-025 & CPT-09-088)				
Grade to -17	SM, ML	120	100	30
-17 to -31	SM, ML	120	100	32
-31 to -37	SP-SM	120	100	34
-37 to -56	ML, SM	120	100	32
-56 to -85	ML, CL	120	3,000	0
Below -85	SW-SM	125	0	38

TABLE 5. IDEALIZED SOIL PROFILES AND STRENGTH PARAMETERS (CONT.)

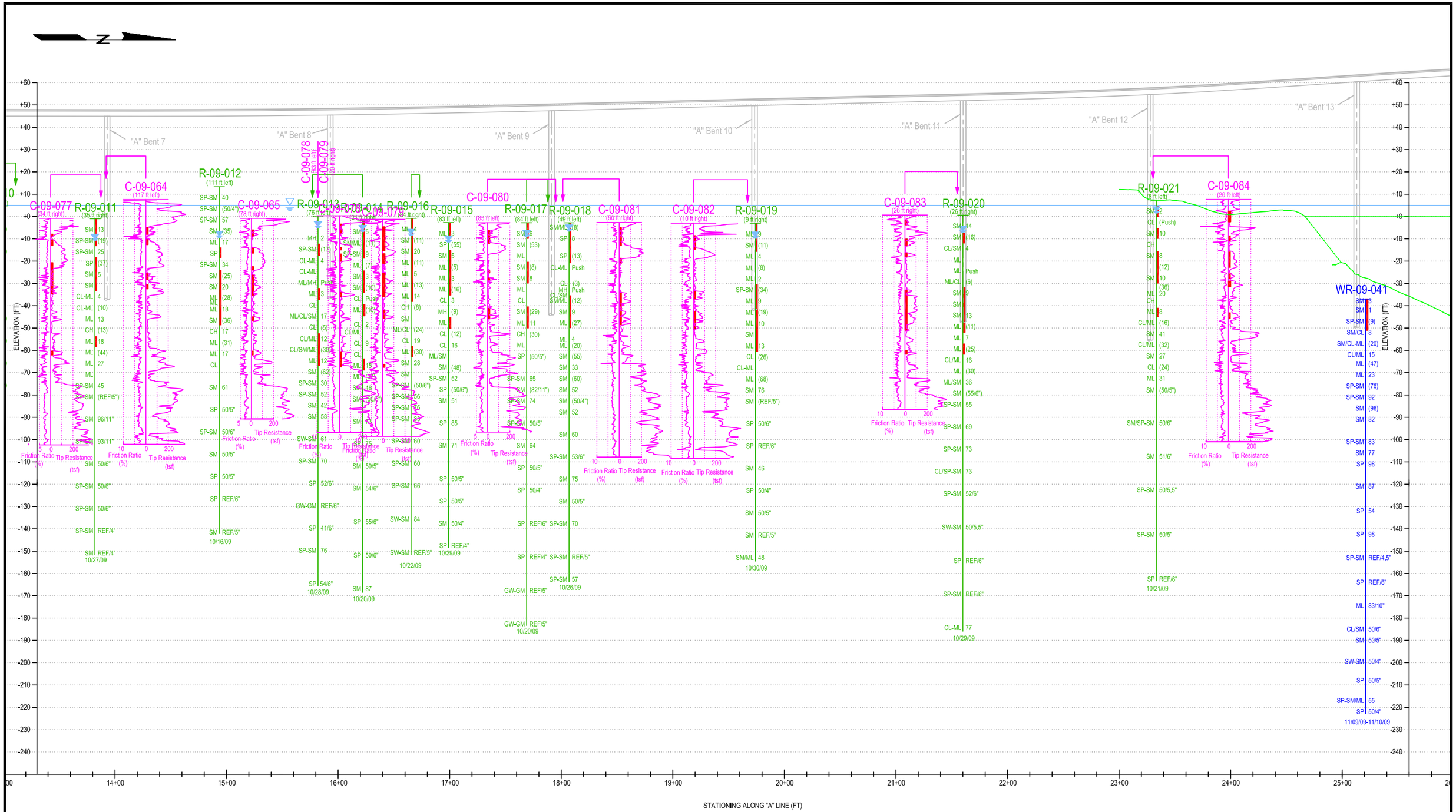
Approximate Elevation (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
Bent 21 (R-09-026 & CPT-09-089)				
Grade to -17	SM, ML	120	100	30
-17 to -26	ML	120	500	0
-26 to -52	ML	120	1,250	0
-52 to -68	SM	120	100	36
-68 to -85	ML, CL	120	3,000	0
Below -85	SW-SM, SP	125	0	38
Bent 22 (R-09-027 & CPT-09-090)				
Grade to -18	SM, CL	120	100	30
-18 to -32	SM	120	100	32
-32 to -40	SM, SP-SM	120	100	36
-40 to -57	CL, ML, CH	120	1,000	0
-57 to -85	SM	120	100	36
Below -85	SM, SW-SM	125	0	38
Bent 23 (R-09-028 & CPT-09-091)				
Grade to -16	SM, ML	120	100	30
-16 to -22	ML	120	400	0
-22 to -26	SP	120	100	34
-26 to -30	ML	120	100	30
-30 to -36	SP	120	100	34
-36 to -56	ML, CL	120	100	32
-56 to -85	SM, SP-SM	120	100	36
Below -85	SP, SP-SM	125	0	38
Bent 24 (R-09-029 & CPT-09-092)				
Grade to -4	SM, CL	120	100	34
-4 to -16	ML, SM	120	100	30
-16 to -46	ML, SM	120	100	30
-46 to -57	CL, CL-ML	120	1,500	0
-57 to -85	SP-SM, SM	120	100	36
Below -85	SM, SP-SM, SM	125	0	38



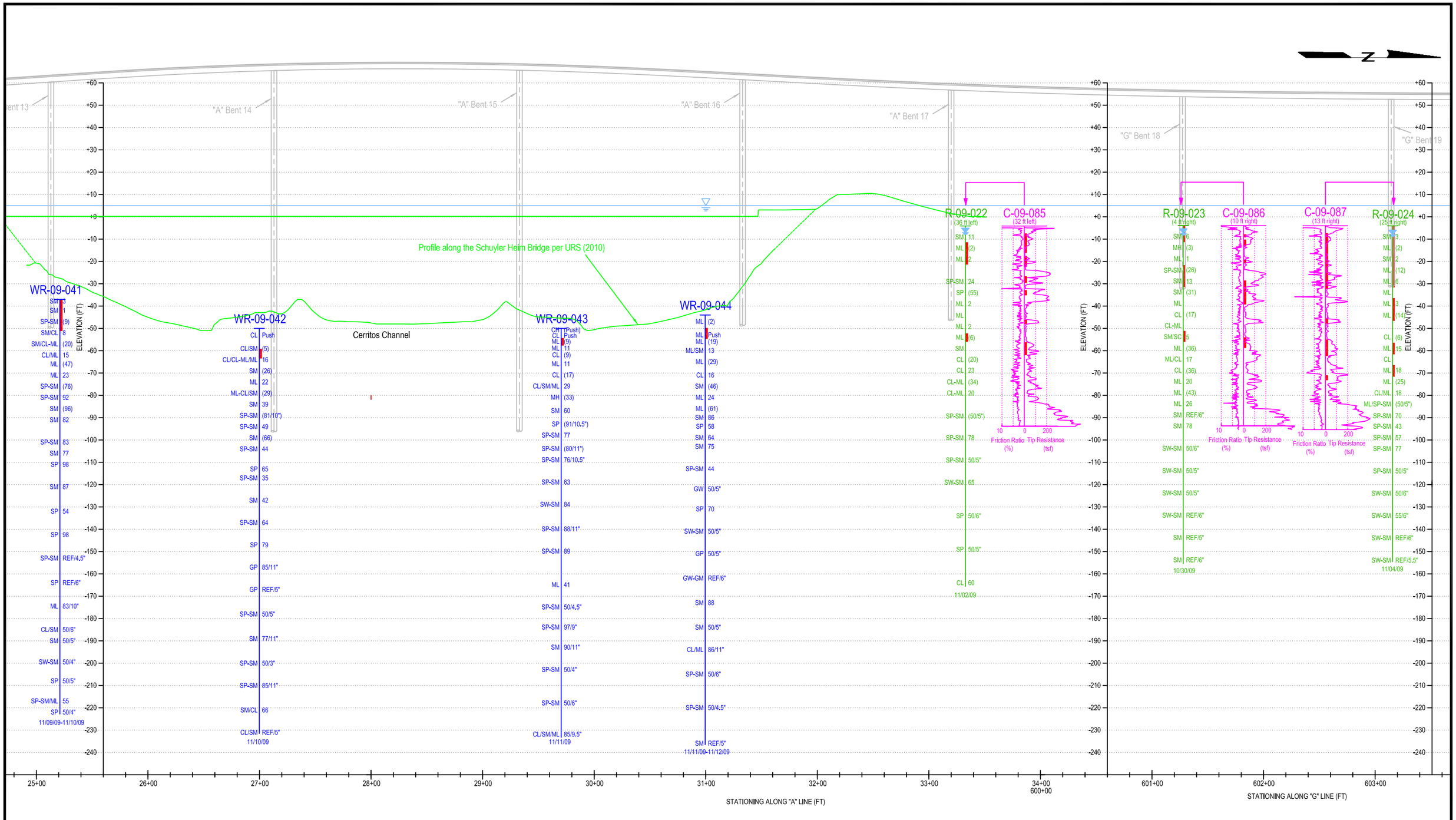
NOTE:

1. Locations of explorations shown are approximate.
2. Locations of proposed abutments and bents shown are approximate.

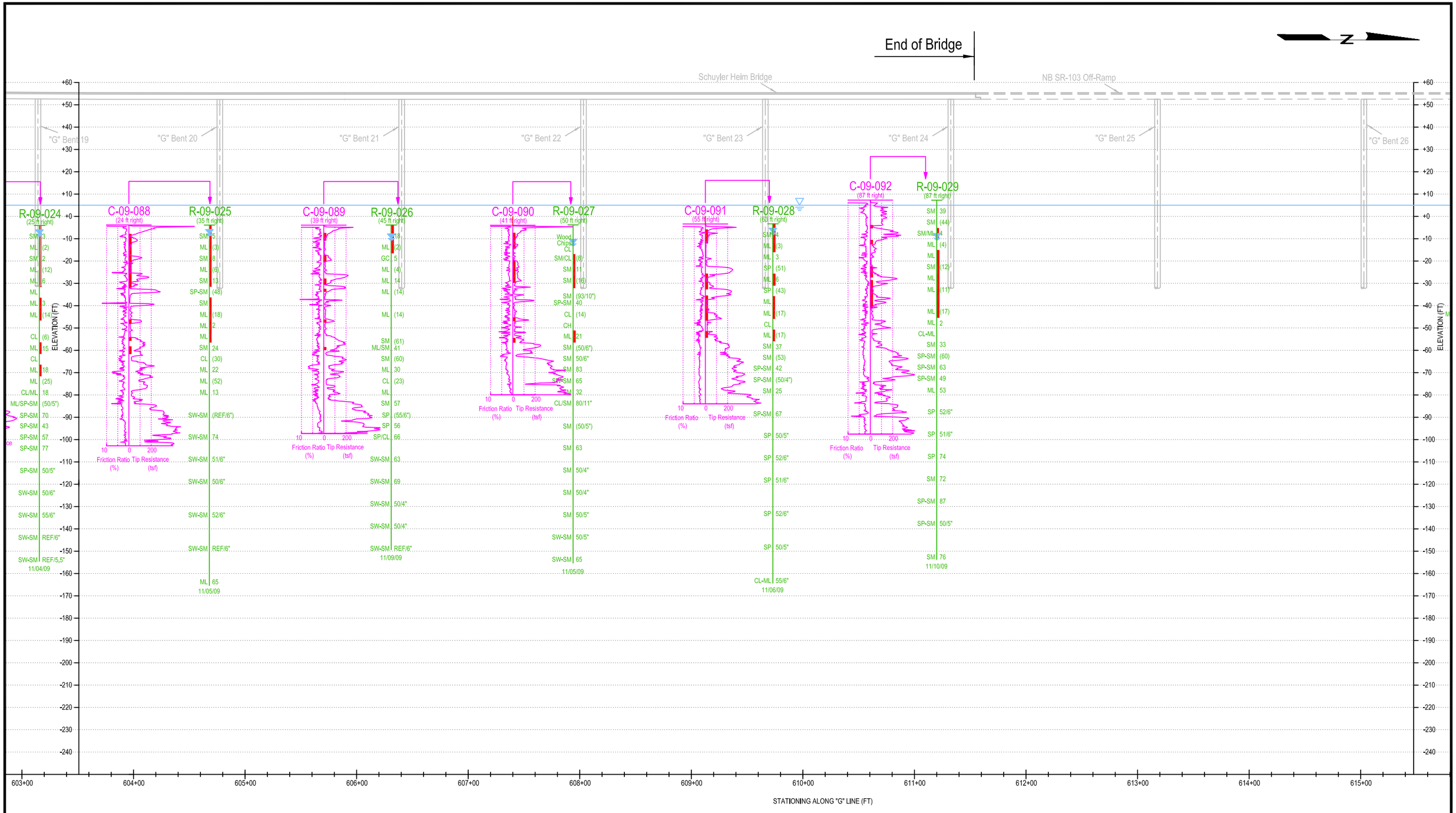
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Subsurface Profile Along Schuyler Heim Bridge (Sheet 1 of 4)
	EMI Project No. 06-123 / Date: 2-08-2010	Figure 9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Subsurface Profile Along Schuyler Heim Bridge (Sheet 2 of 4)
	EMI Project No. 06-123 / Date: 2-08-2010	Figure 9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Subsurface Profile Along Schuyler Heim Bridge (Sheet 3 of 4)
	EMI Project No. 06-123 / Date: 2-08-2010	Figure 9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Subsurface Profile Along Schuyler Heim Bridge (Sheet 4 of 4)
	EMI Project No. 06-123 / Date: 2-08-2010	Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Study

A preliminary seismic evaluation was performed by EMI in 2006 and included in the Preliminary Foundation Report (PFR) (EMI, 2006) based on the 2006 Seismic Design Criteria (SDC) (Caltrans, 2006d).

Using the 2006 SDC, the PBA was determined based on Caltrans Seismic Hazard Map (Mualchin, 1996a) and the attenuation relationship by Sadigh et al., (1997), as required by Caltrans (2006a). The controlling fault was found to be the Palos Verdes fault which is a strike-slip fault capable of generating a Maximum Credible Earthquake (MCE) of magnitude 7.0 and a PBA of 0.60g at the bridge site.

The standard ARS curve published in the 2006 SDC (Caltrans, 2006d) for this bridge site is shown on Figure B.8 for Soil Profile D (M = 7.25±0.25) and 0.6g. The standard ARS curve was modified to account for near-fault effects (a 20% increase of spectral accelerations for periods greater than 1 sec., no increase for periods less than 0.5 sec., and linear interpolation between 0.5 and 1 sec) per SDC Section 6.1.2.1.

Figure 10 shows the recommended modified design ARS curve with coordinates as provided in the PFR (EMI, 2006).

During bridge type selection, Caltrans commented based on the PFR that due to the length of the proposed structure, a site specific ARS curve should be developed following completion of the project geotechnical investigation. It is our understanding that following approval of bridge type selection, preliminary design of the bridge proceeded using the preliminary ARS curve in anticipation that the site specific ARS curve would be completed in the early stages of final design.

As part of the EMI field investigation described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings for the entire project along the mainline bridge alignment. Using the results of shear wave velocity measurements, a site specific ground motion study was performed.

Results of the geotechnical field investigation and site specific ground motion study, following the procedures outlined in the latest Caltrans SDC (Caltrans, 2009) indicate that the preliminary ARS curve shown in Figure 10 plots well above the site specific ARS curve. Consequently, previously conducted analyses and design based on the preliminary seismic evaluation ARS curve are considered conservative and suitable for final design. The peak ground acceleration for the site was revised to 0.5 g based on the latest Caltrans SDC. The details of the ground motion study and the site specific ARS curve are summarized in a memorandum prepared by EMI and are included in Appendix F.

Ground Rupture: No known active faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al., (1983) and updated by NCEER (1997) and Youd et al., (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction analyses.

Layers, pockets, and, lenses of saturated coarse-grained alluvial deposits above the dense to very dense Gaspur Formation (located below approximate El. -75 ft) are expected to be susceptible to liquefaction. Seismically-induced settlements up to 12 inches are anticipated around the project area. The summary of liquefiable potential and the corresponding anticipated seismic settlements using current soil borings and CPT soundings are shown in Table 6 and Table 7, respectively. Locations of potentially liquefiable material during the design earthquake are also identified in the subsurface profile shown in Figure 9.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Thirty six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to range between 7.1 and 8.8, minimum resistivities varied from 59 to 1,400 ohm-cm, soluble chloride contents were between 135 and 13,130 parts per million (ppm), and soluble sulfate contents were between 57 and 1,440 ppm. Results of all corrosion tests are provided in Table 8.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the minimum resistivity is 1,000 ohm-cm or less, or the chloride concentration is 500 ppm or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive to concrete and bare metals. Appropriate corrosion measures should be taken for any concrete elements that will be in contact with site soils.

TABLE 6. SUMMARY OF LIQUEFACTION ANALYSES USING CURRENT SOIL BORINGS

Boring No.	Approximate Elevations of Liquefiable Zones (ft MLLW)	Approximate Total Seismically-Induced Settlement (inches)
R-09-001	-10 to -20 -30 to -50	5.5
R-09-002	-5 to -10 -29 to -39 -44 to -47	3.4
R-09-003	1 to -15 -31 to -47	5.5
R-09-004	-21 to -26 -30 to -45	4.1
R-09-005	0 to -32 -55 to -62 -67 to -72	11.5
R-09-006	0 to -7 -12 to -22 -27 to -32 -43 to -55	6.6
R-09-007	-1 to -8 -13 to -38 -57 to -62	7.3
R-09-008	-1 to -22 -27 to -42 -52 to -60	9.5
R-09-009	-1 to -8 -13 to -28	3.7
R-09-010	-8 to -23 -67to -72	3.3
R-09-011	-1 to -30 -18 to -30 -53 to -58	6.5
R-09-012	-23 to -48	5.7
R-09-013	-13 to -18 -33 to -38 -53 to -68	5.1
R-09-014	-1 to -18 -23 to -33 -38 to -43 -63 to -68	8.8
R-09-015	-2 to -9 -15 to -35 -45 to -50	7.3

Boring No.	Approximate Elevations of Liquefiable Zones (ft MLLW)	Approximate Total Seismically-Induced Settlement (inches)
R-09-016	-1 to -38	9.7
R-09-017	-3 to -8 -18 to -30 -39 to -44	7.5
R-09-018	-3 to -21 -35 to -50	7.3
R-09-019	-3 to -17 -30 to -60	8.8
R-09-020	-6 to -11 -32 to -52 -57 to -62	6.3
R-09-021	+5 to 0 -5 to -10 -15 to -30 -40 to -45	7.8
R-09-022	-12 to -23 -52 to -57	7.6
R-09-023	-5 to -12 -22 to -32 -52 to -57	4.4
R-09-024	-4 to -31 -37 to -47 -57 to -62 -67 to -72	14.9
R-09-025	-4 to -30 -41 to -56	10.9
R-09-026	-10 to -15	1.8
R-09-027	-17 to -32 -50 to -55	5.2
R-09-028	-3 to -15 -25 to -30 -36 to -56	7.2
R-09-029	-5 to -10 -20 to -45	9.3
WR-09-041	-40 to -50	4.9
WR-09-042	-56 to -62	1.5
WR-09-043	-54 to -58	0.7
WR-09-044	-50 to -55	2.4

TABLE 7. SUMMARY OF LIQUEFACTION ANALYSES USING CURRENT CPT SOUNDINGS

CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)	Approximate Total Seismically-Induced Settlement (inches)
CPT-09-064	-5.0 to -8.0 -10.0 to -12.6 -25.5 to -28.3 -30.5 to -32.4	0.8
CPT-09-065	-6.0 to -9.0 -13.9 to -16.4 -22.5 to -24.0 -26.0 to -35.5 -45.0 to -46.6 -60.0 to -62.0	2.0
CPT-09-070	-23.3 to -28.0 -29.8 to -31.2 -32.3 to -34.1 -36.5 to -40.5 -42.9 to -45.5	1.8
CPT-09-071	-1.0 to -2.0 -16.8 to -28.0 -29.3 to -34.5 -37.0 to -40.6 -43.8 to -47.0	2.8
CPT-09-072	-6.5 to -7.5 -10.7 to -22.3 -25.0 to -29.2 -28.4 to -34.4 -42.5 to -45.2 -50.2 to -51.3 -53.3 to -55.1	1.8
CPT-09-073	-14.2 to -20.2 -23.7 to -25.0 -26.3 to -34.5 -43.0 to -47.3 -52.2 to -56.7	1.9
CPT-09-074	-6.0 to -7.5 -12.7 to -35.7 -62.5 to -63.5	0.9
CPT-09-075	-7.0 to -12.8 -15.9 to -24.5 -27.0 to -36.6 -43.7 to -46.0	1.4

CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)	Approximate Total Seismically-Induced Settlement (inches)
CPT-09-076	-7.0 to -9.3 -14.0 to -15.7 -18.7 to -30.1 -33.2 to -34.7 -44.8 to -45.8	1.0
CPT-09-077	-7.9 to -8.9 -10.3 to -13.0 -20.7 to -34.7 -60.3 to -62.1	3.2
CPT-09-078	-3.4 to -7.5 -14.3 to -15.3 -16.8 to –20.1 -34.0 to -36.0 -60.6 to -67.4	1.7
CPT-09-079	-4.6 to -15.3 -16.7 to -21.0 -25.5 to -36.0 -42.0 to -45.6 -66.3 to -67.6	3.2
CPT-09-080	-6.3 to -12.0 -24.3 to -25.3 -27.5 to -28.5 -41.1 to -45.8	1.4
CPT-09-081	-5.2 to -13.0 -18.7 to -21.0 -34.0 to -48.5 -56.4 to -61.8	3.4
CPT-09-082	-8.6 to -14.7 -33.5 to -37.0 -42.5 to -50.6	1.9
CPT-09-083	-1.6 to -3.8 -10.1 to -13.2 -16.2 to -18.0 -33.0 to -51.0 -60.1 to -61.7	1.2
CPT-09-084	+2.4 to -2.4 -8.5 to -11.0 -15.7 to -23.0 -25.5 to -28.0 -29.0 to -36.5 -43.0 to -46.0	3.8

CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)	Approximate Total Seismically-Induced Settlement (inches)
CPT-09-085	-7.6 to -16.0 -17.7 to -22.2 -26.8 to -29.4 -33.0 to -35.0 -46.3 to -47.8 -56.4 to -61.8	1.9
CPT-09-086	-8.0 to -9.0 -10.4 to -13.0 -19.4 to -20.4 -28.7 to -39.1 -54.2 to -58.6	1.2
CPT-09-087	-7.5 to -32.1 -45.7 to -47.7 -55.2 to -62.2 -71.2 to -73.0	3.5
CPT-09-088	-8.0 to -32.0 -46.3 to -48.0 -54.3 to -55.6 -58.4 to -61.5	3.6
CPT-09-089	-7.6 to -10.7 -17.5 to -20.2 -28.0 to -30.4 -32.6 to -33.6 -46.4 to -47.4 -58.7 to -59.7	1.0
CPT-09-090	-7.5 to -14.4 -19.8 to -29.6 -45.4 to -46.8 -54.6 to -56.4	2.2
CPT-09-091	-6.0 to -12.0 -25.8 to -32.5 -35.6 to -46.5 -51.6 to -54.2	3.5
CPT-09-092	-4.0 to -5.2 -10.7 to -12.4 -22.5 to -27.2 -28.7 to -41.0	2.4

TABLE 8. SUMMARY OF CORROSION TEST RESULTS

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-001	S-02	10.0	SP-SM	1,400	7.4	158	407
R-09-002	S-02	10.0	SP-SM	1,100	7.7	325	267
R-09-003	S-03	15.0	SP-SM	1,300	7.7	222	328
R-09-003	S-09	45.0	SM	780	7.9	406	621
R-09-004	S-02	10.0	SM	1,300	8.6	190	190
R-09-005	S-01	5.0	SM	900	7.8	475	326
R-09-005	S-07	35.0	ML	150	8.3	57	9,543
R-09-007	S-01	5.0	SM	1,080	8.6	380	270
R-09-007	S-09	45.0	ML/CL	260	8.6	720	1,660
R-09-010	D-02	10.0	ML	170	8.6	500	2,790
R-09-010	S-11	55.0	ML	470	8.8	450	820
R-09-014	S-01	5.0	SM	220	8.0	670	2,310
R-09-014	S-10	46.0	CL	360	8.6	1,440	1,490
R-09-015	S-01	5.0	ML	230	7.4	466	412
R-09-016	S-01	5.0	ML	910	8.0	353	1,240
R-09-016	S-07	35.0	SM	100	8.0	999	13,807
R-09-017	D-02	10.0	SM	150	7.4	305	7,778
R-09-017	S-09	45.0	ML	200	8.2	647	9,813
R-09-018	S-04	20.0	CL	86	7.4	717	864
R-09-019	S-03	15.0	CL	59	7.1	786	10,029
R-09-020	S-03-1	15.0	ML	88	7.4	198	9,087
R-09-021	D-02	10.0	CL	960	7.6	650	135
R-09-021	U-10	45.0	CH	74	8.5	1,040	13,130
R-09-022	S-03	15.0	ML	78	7.4	426	5,582
R-09-022	S-03	15.0	ML	78	7.4	426	5,582
R-09-023	S-03	15.0	ML	72	7.6	538	7,547
R-09-024	S-01	5.0	SM	140	7.5	200	4,036
R-09-025	D-04	20.0	ML	72	7.3	417	5,237
R-09-026	D-02	20.0	ML	64	7.5	426	5,561
R-09-027	D-02-2	15.5	SM	72	8.1	1,060	10,655
R-09-028	D-03	15.0	CL	70	7.2	285	5,644
R-09-029	D-04	20.0	CL-ML	72	7.2	183	6,418
WR-09-041	S-06-2	25.4	ML	98	8.2	360	7,929
WR-09-042	D-06	29.0	SM	130	7.6	300	6,417
WR-09-043	D-05-1	12.0	ML	87	7.5	390	9,074
WR-09-044	D-03-2	12.5	ML	88	7.6	310	8,416

R-09-0xx - Land Boring; and WR-09-0xx - Over Water Boring

5.4 Scour

The proposed Schuyler Heim Bridge crosses the Cerritos Channel between Bents 13 through 16. The Cerritos Channel at the subject site is a tidally influenced body of water that received a limited amount of stormwater runoff from Dominguez Channel. Based on the conclusions of Hydraulics and Scour Analyses in a Preliminary Report provided by URS (URS, 2010), a scour depth of 10 ft is recommended in the Cerritos Channel. Therefore, scour is expected to be a design issue; the recommended scour depths of 10 ft and 5 ft were considered in axial pile capacity evaluations under strength and extreme limit conditions, respectively.

5.5 Foundation Type

Due to presence of the weak near-surface soils and the potential for seismically-induced settlement throughout the site, spread footings are not considered feasible for support of the proposed structure.

Site soils are conducive to either a driven or drilled pile foundation. Due to the presence of deep liquefiable layers, large diameter Cast-In-Drilled-Hole (CIDH) piles are better suited to resist the large lateral foundation demands than small diameter piles, and large diameter piles are needed at bent locations to support the large axial pile demands. Based on the foundation loads provided by the designers, 10-ft diameter CIDH piles are recommended for bents located at the south side of the channel (Bents 2 through 12); 11-ft diameter CIDH piles are recommended for bents located within the channel (Bents 13 through 16); and 12-ft diameter CIDH piles are recommended for bents located at the north side of the channel (Bents 17 through 24). At Abutment 1, 2.5-ft diameter CIDH piles are recommended.

Approximately 25-ft long permanent driven steel casings with 11-ft inside diameter (ID) and 13-ft ID are proposed from the pile cut-off at bents located south and north sides of the channel, respectively. For the channel bents (Bents 13 through 16), 12-ft ID permanent driven steel casings are proposed down to elevations between -65 ft and -95 ft.

For the proposed bridge fender system at Bents 14 and 15, 18-inch diameter steel pipe piles (Galvanized NPS Schedule 80) are recommended.

5.5.1 Axial Pile Capacity

Per Caltrans policy, the Load and Resistant Factor Design (LRFD) method is used for bent piles and the Working Stress Design (WSD) is used for abutment piles. The foundation design data sheet and factored foundation loads were estimated by the designers following the latest Caltrans Memo To Designers 3-1 (Caltrans, 2008), and are shown in Table 9 and Table 10, respectively.

Axial capacity of a single CIDH pile is estimated using the computer program SHAFT Version 6.0 (Ensoft, 2007b). Axial capacities of permanent driven steel casings were calculated according to recommendations by Tomlinson (1987) and API (2000). The calculated factored axial geotechnical capacities and pile tip elevations for each 30-inch diameter CIDH pile at the abutment and 10-ft, 11-ft, and 12-ft diameter CIDH piles at the bents are presented in Table 11 and Table 12, respectively. For the extreme event limit case, negative skin friction due to

seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The depth to the bottom of the liquefiable layer at each support was determined based upon the nearest boring and CPT sounding information. The Pile Data Table is provided in Table 13. For bent piles, a resistance factor of 0.7 was applied under strength limit condition per Caltrans LRFD guidelines.

TABLE 9. FOUNDATION DESIGN DATA SHEET

Location	Design Method	Pile Type	Finished Grade El. (ft)	Pile Cut-off El. (ft)	Pile Cap Size (ft)		Permissible Settlement under Service Load (in)	Number of Piles per Support
					B	L		
Abut 1	WSD	2.5 ft CIDH	+4.0	-1.75	120.5	24.0	0.5	39
Bent 2	LRFD	10 ft CIDH	+1.0	-12.5	N/A	N/A	1	4
Bent 3	LRFD	10 ft CIDH	0.0	-2.0	N/A	N/A	1	4
Bent 4	LRFD	10 ft CIDH	0.0	-2.0	N/A	N/A	1	4
Bent 5	LRFD	10 ft CIDH	0.0	-2.0	N/A	N/A	1	4
Bent 6	LRFD	10 ft CIDH	-1.0	-3.0	N/A	N/A	1	5
Bent 7	LRFD	10 ft CIDH	-1.0	-3.0	N/A	N/A	1	5
Bent 8	LRFD	10 ft CIDH	-2.0	-4.0	N/A	N/A	1	4
Bent 9	LRFD	10 ft CIDH	-2.0	-4.0	N/A	N/A	1	6
Bent 10	LRFD	10 ft CIDH	-2.0	-4.0	N/A	N/A	1	6
Bent 11	LRFD	10 ft CIDH	-1.0 *	-1.0	N/A	N/A	1	4
Bent 12	LRFD	10 ft CIDH	+8.0	+6.0	N/A	N/A	1	4
Bent 13	LRFD	11 ft CIDH	-33.0	-1.0	N/A	N/A	1	4
Bent 14	LRFD	11 ft CIDH	-44.0	+10.0	N/A	N/A	1	4
Bent 15	LRFD	11 ft CIDH	-48.0	+10.0	N/A	N/A	1	4
Bent 16	LRFD	11 ft CIDH	-39.0	-1.0	N/A	N/A	1	4
Bent 17	LRFD	12 ft CIDH	-4.1 *	-5.5	N/A	N/A	1	4
Bent 18	LRFD	12 ft CIDH	-3.2	-5.5	N/A	N/A	1	4
Bent 19	LRFD	12 ft CIDH	-3.8	-5.5	N/A	N/A	1	4
Bent 20	LRFD	12 ft CIDH	-3.4	-5.5	N/A	N/A	1	4
Bent 21	LRFD	12 ft CIDH	-3.7	-5.5	N/A	N/A	1	4
Bent 22	LRFD	12 ft CIDH	-3.7 *	-5.5	N/A	N/A	1	4
Bent 23	LRFD	12 ft CIDH	-4.8 *	-5.5	N/A	N/A	1	4
Bent 24	LRFD	12 ft CIDH	-4.0 *	-5.5	N/A	N/A	1	2

** Grade elevation varies within each support from -1.0 ft to about +16.0 ft at Bent 11; from -4.1 ft to about +10.0 ft at Bent 17; from -3.7 ft to about +1.0 ft at Bent 22; from -4.8 ft to about +10.0 ft at Bent 23; and from -4.0 ft to about +9.0 ft at Bent 24.*

TABLE 10. FOUNDATION DESIGN LOADS

Location	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)			
	Total Load		Permanent Loads	Compression		Tension		Compression		Tension	
	Per Column	Max. Per Pile	Per Column / Pile	Per Column	Max. Per Pile	Per Column	Max. Per Pile	Per Column	Max. Per Pile	Per Column	Max. Per Pile
Abut 1	9,240	278	257	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bent 2	2,787	N/A	2,296	3,972	3,972	0	0	2,296	2,296	0	0
Bent 3	3,141	N/A	2,604	4,393	4,393	0	0	2,604	2,604	0	0
Bent 4	3,303	N/A	2,845	4,597	4,597	0	0	2,845	2,845	0	0
Bent 5	2,747	N/A	2,271	3,910	3,910	0	0	2,271	2,271	0	0
Bent 6	2,973	N/A	2,508	4,175	4,175	0	0	2,508	2,508	0	0
Bent 7	3,193	N/A	2,674	4,472	4,472	0	0	2,674	2,674	0	0
Bent 8	3,955	N/A	3,382	5,353	5,353	0	0	3,382	3,382	0	0
Bent 9	3,399	N/A	2,872	4,632	4,632	0	0	2,872	2,872	0	0
Bent 10	3,180	N/A	2,706	4,458	4,458	0	0	2,706	2,706	0	0
Bent 11	3,836	N/A	3,309	5,281	5,281	0	0	3,309	3,309	0	0
Bent 12	3,341	N/A	2,810	4,617	4,617	0	0	2,810	2,810	0	0
Bent 13	4,906	N/A	4,366	6,460	6,460	0	0	4,366	4,366	0	0
Bent 14	5,264	N/A	4,661	6,953	6,953	0	0	4,661	4,661	0	0
Bent 15	5,489	N/A	4,876	7,240	7,240	0	0	4,876	4,876	0	0
Bent 16	4,868	N/A	4,356	6,397	6,397	0	0	4,356	4,356	0	0
Bent 17	3,945	N/A	3,397	5,364	5,364	0	0	3,397	3,397	0	0
Bent 18	3,804	N/A	3,239	5,165	5,165	0	0	3,239	3,239	0	0
Bent 19	3,483	N/A	2,923	4,760	4,760	0	0	2,923	2,923	0	0
Bent 20	3,706	N/A	3,190	5,047	5,047	0	0	3,190	3,190	0	0
Bent 21	3,387	N/A	2,967	4,628	4,628	0	0	2,967	2,967	0	0
Bent 22	3,416	N/A	2,950	4,688	4,688	0	0	2,950	2,950	0	0
Bent 23	4,242	N/A	3,735	5,614	5,614	0	0	3,735	3,735	0	0
Bent 24	4,200	N/A	3,718	5,735	5,735	0	0	3,718	3,718	0	0

Note: For bents with more than one column, the highest column/pile demand is listed in the table, as provided by the designers.

Since piles are tipped into the dense sandy soil layer, the maximum pile-head settlement under Service-I Limit State loads is estimated to be less than ½-inch at Abutment 1 and 1-inch at all bent supports. For axial loading, pile group effects can be neglected for a group of piles if the on-center spacing is equal to or greater than 4 times the pile width. At Abutment 1, where the on-center spacing is approximately 3.3 diameters in the transverse direction and 4 diameters in the longitudinal direction, an average group effect reduction factor of 0.9 was included in determining the tip elevations shown in Table 11 and Table 13. For bents, since there are only single rows of piles and their spacings varied between 2.5 and 5.0 diameters, group effect was not considered in determining the tip elevations.

TABLE 11. FOUNDATION RECOMMENDATIONS FOR ABUTMENT

Location	Pile Type	Cut-off Elevation (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip Elevation (ft)	Specified Tip Elevation (ft)
			Total	Permanent				
Abut 1	2.5 ft CIDH	-1.75	9,240	8,350	278	560	-77 (a), -47 (c), -49 (d)	-77

Notes:

(1) Design tip elevations are controlled by: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

TABLE 12. FOUNDATION RECOMMENDATIONS FOR BENTS

Location	Pile Type	Cut-off Elevation (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance (kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 2	10 ft CIDH	-12.5	2,787	1	3,972	0	2,296	0	-127 (a-I), -82 (a-II), -71 (c), -98 (d)	-127	-38	360
Bent 3	10 ft CIDH	-2.0	3,141	1	4,393	0	2,604	0	-136 (a-I), -91 (a-II), -82 (c), -87 (d)	-136	-27	210
Bent 4	10 ft CIDH	-2.0	3,303	1	4,597	0	2,845	0	-149 (a-I), -107 (a-II), -91 (c), -87 (d)	-149	-27	190
Bent 5	10 ft CIDH	-2.0	2,747	1	3,910	0	2,271	0	-131 (a-I), -88 (a-II), -74 (c), -87 (d)	-131	-27	210
Bent 6	10 ft CIDH	-3.0	2,973	1	4,175	0	2,508	0	-136 (a-I), -72 (a-II), -87 (c), -88 (d)	-136	-28	210
Bent 7	10 ft CIDH	-3.0	3,193	1	4,472	0	2,674	0	-145 (a-I), -75 (a-II), -88 (c), -88 (d)	-145	-28	200

Notes:

(1) Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (b-I) Tension (Strength Limit), (a-II) Compression (Extreme Event), (b-II) Tension (Extreme Event), (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

TABLE 12. FOUNDATION RECOMMENDATIONS FOR BENTS (CONT.)

Location	Pile Type	Cut-off Elevation (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance (kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 8	10 ft CIDH	-4.0	3,955	1	5,353	0	3,382	0	-161 (a-I), -119 (a-II), -110 (c), -89 (d)	-161	-29	190
Bent 9	10 ft CIDH	-4.0	3,399	1	4,632	0	2,872	0	-143 (a-I), -90 (a-II), -89 (c), -89 (d)	-143	-29	190
Bent 10	10 ft CIDH	-4.0	3,180	1	4,458	0	2,706	0	-144 (a-I), -100 (a-II), -92 (c), -89 (d)	-144	-29	280
Bent 11	10 ft CIDH	-1.0	3,836	1	5,281	0	3,309	0	-156 (a-I), -107 (a-II), -110 (c), -86 (d)	-156	-26	280
Bent 12	10 ft CIDH	+6.0	3,341	1	4,617	0	2,810	0	-133 (a-I), -69 (a-II), -81 (c), -79 (d)	-133	-19	310
Bent 13	11 ft CIDH	-1.0	4,906	1	6,460	0	4,366	0	-181 (a-I), -103 (a-II), -151 (c), -127 (d)	-181	-76	810

Notes:

(1) Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (b-I) Tension (Strength Limit), (a-II) Compression (Extreme Event), (b-II) Tension (Extreme Event), (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

TABLE 12. FOUNDATION RECOMMENDATIONS FOR BENTS (CONT.)

Location	Pile Type	Cut-off Elevation (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance (kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 14	11 ft CIDH	+10.0	5,264	1	6,953	0	4,661	0	-200 (a-I), -119 (a-II), -165 (c), -138 (d)	-200	-95	1,460
Bent 15	11 ft CIDH	+10.0	5,489	1	7,240	0	4,876	0	-206 (a-I), 123 (a-II), -168 (c), -142 (d)	-206	-95	1,390
Bent 16	11 ft CIDH	-1.0	4,868	1	6,397	0	4,356	0	-189 (a-I), -114 (a-II), -154 (c), -133 (d)	-189	-86	760
Bent 17	12 ft CIDH	-5.5	3,945	1	5,364	0	3,397	0	-143 (a-I), -64 (a-II), -96 (c), -84 (d)	-143	-31	210
Bent 18	12 ft CIDH	-5.5	3,804	1	5,165	0	3,239	0	-140 (a-I), -99 (a-II), -95 (c), -83 (d)	-140	-31	250
Bent 19	12 ft CIDH	-5.5	3,483	1	4,760	0	2,923	0	-138 (a-I), -92 (a-II), -91 (c), -84 (d)	-138	-31	200

Notes:

(1) Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (b-I) Tension (Strength Limit), (a-II) Compression (Extreme Event), (b-II) Tension (Extreme Event), (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

TABLE 12. FOUNDATION RECOMMENDATIONS FOR BENTS (CONT.)

Location	Pile Type	Cut-off Elevation (ft)	Service-I Limit State Load (kips) per Column	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance (kips)
					Strength Limit		Extreme Event					
					Comp (φ= 0.7)	Tension (φ= 0.7)	Comp (φ= 1.0)	Tension (φ= 1.0)				
Bent 20	12 ft CIDH	-5.5	3,706	1	5,047	0	3,190	0	-137 (a-I), -95 (a-II), -84 (c), -83 (d)	-137	-31	210
Bent 21	12 ft CIDH	-5.5	3,387	1	4,628	0	2,967	0	-129 (a-I), -64 (a-II), -94 (c), -84 (d)	-129	-31	330
Bent 22	12 ft CIDH	-5.5	3,416	1	4,688	0	2,950	0	-134 (a-I), -75 (a-II), -94 (c), -84 (d)	-134	-31	210
Bent 23	12 ft CIDH	-5.5	4,242	1	5,614	0	3,735	0	-142 (a-I), -104 (a-II), -103 (c), -85 (d)	-142	-31	250
Bent 24	12 ft CIDH	-5.5	4,200	1	5,735	0	3,718	0	-148 (a-I), -90 (a-II), -101 (c), -84 (d)	-148	-31	200

Notes:

(1) Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (b-I) Tension (Strength Limit), (a-II) Compression (Extreme Event), (b-II) Tension (Extreme Event), (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

TABLE 13. PILE DATA TABLE

Location	Pile Type	Nominal Resistance (kips)		Nominal Resistance (Driven Steel Casing) (kips)		Driven Steel Casing Specified Tip Elevation (ft)	CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Compr.	Tension	Compr.	Tension				
Abut 1	2.5 ft CIDH	560	0	N/A	N/A	N/A	-77 (a), -47 (c), & -49 (d)	-77	N/A
Bent 2	10 ft CIDH	5,680	0	360	0	-38	-127 (a), -71 (c), & -98 (d)	-127	360
Bent 3	10 ft CIDH	6,280	0	210	0	-27	-136 (a), -82 (c), & -87 (d)	-136	210
Bent 4	10 ft CIDH	6,570	0	190	0	-27	-149 (a), -91 (c), & -87 (d)	-149	190
Bent 5	10 ft CIDH	5,590	0	210	0	-27	-131 (a), -74 (c), & -87 (d)	-131	210
Bent 6	10 ft CIDH	5,970	0	210	0	-28	-136 (a), -87 (c), & -88 (d)	-136	210
Bent 7	10 ft CIDH	6,390	0	200	0	-28	-145 (a), -88 (c), & -88 (d)	-145	200
Bent 8	10 ft CIDH	7,650	0	190	0	-29	-161 (a), -110 (c), & -89 (d)	-161	190
Bent 9	10 ft CIDH	6,620	0	190	0	-29	-143 (a), -89 (c), & -89 (d)	-143	190
Bent 10	10 ft CIDH	6,370	0	280	0	-29	-144 (a), -92 (c), & -89 (d)	-144	280
Bent 11	10 ft CIDH	7,550	0	280	0	-26	-156 (a), -110 (c), & -86 (d)	-156	280
Bent 12	10 ft CIDH	6,600	0	320	0	-19	-133 (a), -81 (c), & -79 (d)	-133	320
Bent 13	11 ft CIDH	9,230	0	810	0	-76	-181 (a), -151 (c), & -127 (d)	-181	810
Bent 14	11 ft CIDH	9,940	0	1,460	0	-95	-200 (a), -165 (c), & -138 (d)	-200	1,460

Notes:

(1) Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

TABLE 13. PILE DATA TABLE (CONT.)

Location	Pile Type	Nominal Resistance (kips)		Nominal Resistance (Driven Steel Casing) (kips)		Driven Steel Casing Specified Tip Elevation (ft)	CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Compr.	Tension	Compr.	Tension				
Bent 15	11 ft CIDH	10,350	0	1,390	0	-95	-206 (a), -168 (c), & -142 (d)	-206	1,390
Bent 16	11 ft CIDH	9,140	0	760	0	-86	-189 (a), -154 (c), & -133 (d)	-189	760
Bent 17	12 ft CIDH	7,670	0	210	0	-31	-143 (a), -96 (c), & -84 (d)	-143	210
Bent 18	12 ft CIDH	7,380	0	250	0	-31	-140 (a), -95 (c), & -83 (d)	-140	250
Bent 19	12 ft CIDH	6,800	0	200	0	-31	-138 (a), -91 (c), & -84 (d)	-138	200
Bent 20	12 ft CIDH	7,210	0	210	0	-31	-137 (a), -84 (c), & -83 (d)	-137	210
Bent 21	12 ft CIDH	6,620	0	330	0	-31	-129 (a), -94 (c), & -84 (d)	-129	330
Bent 22	12 ft CIDH	6,700	0	210	0	-31	-134 (a), -94 (c), & -84 (d)	-134	210
Bent 23	12 ft CIDH	8,020	0	250	0	-31	-142 (a), -103 (c), & -85 (d)	-142	250
Bent 24	12 ft CIDH	8,200	0	200	0	-31	-148 (a), -101 (c), & -84 (d)	-148	200

Notes:

(1) Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

Fender Piles: Based on the information provided by Caltrans designers, steel pipe piles (Galvanized NPS Schedule 80) with a diameter of 18-inch and a wall thickness of 0.9375-inch are recommended for the proposed bridge fender system at Bents 14 and 15. Piles will be spaced at 8-ft on center. Service axial demand of 14 kips was estimated for the fender piles by the designers. Pile embedment of 20 diameters (i.e. 30 ft long piles) is recommended to provide the minimum embedment during lateral loading.

5.5.1.1 Pile Load Test

Based on the current soil investigations, the Gaspur Formation which consists of dense to very dense poorly graded sand to silty sand exists below approximate elevations of -75 ft to -85 ft

throughout the project site. Much of the axial pile capacity is derived from the Gaspur Formation. We believe that the axial pile capacity evaluations are conservative since maximum end bearing contribution is limited to be about 20 percent of the nominal resistance. Due to the large axial pile demands, the proposed piles are very long. The total length of the large diameter CIDH piles proposed for the Heim Bridge is estimated to be more than 14,000 linear feet and the foundation system represents significant cost of the bridge. Therefore, it would be beneficial to perform one pile load test for the project and use data from the test to the design tip elevations to optimize pile lengths. In addition, the pile load test would also help to identify and minimize constructability related issues during pile installation.

Based on our discussions with Caltrans Foundation Testing Branch, we understand that the pile load test frame that is owned by Caltrans is capable of testing piles to an axial load of up to 8,000 kips. We recommend that an axial static compression pile load test be performed by Caltrans on a 10-ft diameter CIDH pile, at a non-production location before installation of any production piles, within the Stage 1 footprint. The approximate location and configuration of the pile load test pile group are shown in Figure 11 and Figure 12, respectively. The maximum compression load during the pile load test should be equal to 6,000 kips, the Nominal Resistance shown in the Pile Data Table (Table 14). However, the test pile should be loaded up to the maximum frame capacity of about 8,000 kips or pile failure, whichever occurs first. In order to provide adequate tension capacity, the tip elevation for the 8-ft diameter anchor piles is estimated to be El. -129 ft. A conservative resistance factor of 0.6 was used in estimating the tension capacity of anchor piles.

TABLE 14. PILE DATA TABLE FOR PILE LOAD TEST

Location	Pile Type	Nominal Resistance (kips)		CIDH Design Tip Elevation (ft)	CIDH Specified Tip Elevation (ft)	Driven Steel Casing Specified Tip Elevation (ft)	Steel Casing Nominal Driving Resistance Required (kips)
		Compression	Tension				
Load Test Pile	10 ft CIDH	6,000	0	-136 (a)	-136	-28	210
Anchor Piles	8 ft CIDH	0	2,250	-129 (b)	-129	N/A	N/A

Notes:

(1) Design Tip Elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement, and (d) Lateral Load.

(2) The specified tip elevation shall not be raised.

(3) The test pile should be loaded up to 8,000 kips or failure, whichever occurs first.

Based on the results of the pile load test, specified tip elevations should be revised. However, if the pile load recommendations cannot be used to modify pile lengths during construction, we do not recommend performing the pile load test as the value added by the test would not justify the cost and time needed to perform the test.

5.5.1.2 Potential Future Improvements by POLB

As mentioned earlier in Section 1.2, POLB may raise the grade to El. +14.5 ft at north side of Cerritos Channel from Bents 17 through 23 for potential future Pier A improvements. If and when this improvement is implemented, the compressible fine-grained soil layers that are present at the site are expected to undergo consolidation settlement, thus inducing downdrag force on piles approximately down to the depths of the compressible layers. The depths of the compressible fine-grained soil layers at each support vary and based on our preliminary analyses, piles at Bents 17 through 23 would have to be extended during current design by about 50 ft to 70 ft longer in order to accommodate the anticipated downdrag forces. In addition to the vertical downdrag forces, additional lateral loading is also anticipated on piles at Bent 17 due to lateral movement of soils during a design earthquake, as discussed in Section 5.6.3. This effect also needs to be mitigated.

Based on our preliminary cost estimates, improving the subsurface soils around the piles prior to placement of fill may be a more cost-effective option to mitigate the downdrag effects than extending the piles by about 50 ft to 70 ft. A suitable ground improvement method is discussed in as follows.

Deep Soil Mixing

The deep mixing method is an in situ soil mixing technology that mixes existing soil with cementitious materials using mixing shafts consisting of auger cutting heads, discontinuous auger flights and mixing paddles. The soil-cement (or other binders) columns produced have a higher strength, less compressibility, and lower permeability than native soils. Two types of deep soil mixing methods are considered.

1. Wet Soil Mixing: Wet soil mixing is the mechanical blending of the in situ soil with grout slurry using hollow stem paddle mixer. A revolving hollow shaft with mixing paddles is advanced into the soil. As the mixing tool is advanced, the cement grout is pumped through the hollow stem of the revolving shaft and discharged laterally along the lower mixing paddle where it is mixed with native soil. The primary goal is to mix the soil and the cement grout. The kneading action of the mixing tool blends the cement grout and the soil. When the design depth is reached, the tool is withdrawn maintaining the rotational speed of the mixing tool. The resulting soil-cement column will gain high strength with curing. Rebar can be installed if high bending or tensional capacities are required. Depending on the soil type, spoils generated may range from 20 to 40 percent of the improved volume.

2. Dry Soil Mixing: Dry soil mixing is a similar process as of wet soil mixing except, instead of cement grout slurry, dry binder agents are injected directly into, and mixed

with the soil. The advantage of dry soil mix is that minimum or no spoils are generated during the process.

Depending on the cost, schedule, amount of spoils generated, one of the deep soil mixing methods can be chosen. A preliminary sketch of a ground improvement scheme around the pile using deep soil mixing method is shown in Figure 13. Detailed soil investigation, laboratory testing, and engineering analyses with deep soil mixing method should be performed to finalize the dimension of the area and depth required to be improved. If the proposed deep soil mixing is performed, kinematic loading effect due to the slope movement on piles at Bent 17, as discussed in Section 5.6.3, is expected to be minimized.

5.5.2 Lateral Pile Capacity

Abutment: Lateral pile capacity analyses were performed using the computer program LPILE (Ensoft, 2007a). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000) whereas the p-y curves for fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.82 was used in the analysis based on the pile layout provided by the designers and the procedures outlined in the Ensoft Group 7.0 software Technical Manual (Ensoft, 2006). Under seismic conditions, liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008). Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a fixed-head connection with the pile cap are provided in Table 15 and Table 16 for the Service Limit State and the Extreme Event Limit State, respectively. The design tip elevations for lateral loading are given in Table 13.

The solutions presented in Table 15 and Table 16 for the abutment are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by structural capacity of the piles and other connection details.

Bents: The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time that included a general description of the subsurface conditions beneath the proposed structure and eight idealized soil profiles along the proposed alignment. It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared.

Based on the current geotechnical investigation and updated soil profile, an additional project specific lateral pile analysis was also performed. Results from that analysis indicate that the p-y curves generated from the soil profiles presented in the PFR are suitable for use in the final design. The current results either generate a more conservative lateral pile response than the p-y curves developed by Caltrans based on the PFR, or a lateral pile response that is within an acceptable design tolerance. Details of the lateral pile analysis and a comparison between the preliminary and updated p-y curves are included in a memorandum prepared by EMI. The memorandum is included in Appendix G. The preliminary p-y curves generated from the soil

profiles in the PFR which were determined to be suitable for use in final design for the Bents are provided in Appendix H.

TABLE 15. ABUTMENT 1, 30-IN CIDH PILE "FIXED" HEAD SOLUTION: SERVICE LIMIT STATE

Pile Head Deflection (in)	Pile Head Shear (kips)	Maximum Moment (kips-in)
0.25	106	6,079

1) Group effects considered with a reduction factor of 0.82 on "p" using Group 7.0.
2) Static strength parameters used in all soil layers.
3) A cracked section modulus of 80% of EI was used in the analysis.

TABLE 16. ABUTMENT 1, 30-IN CIDH PILE "FIXED" HEAD SOLUTION: EXTREME EVENT LIMIT STATE

Pile Head Deflection (in)	Pile Head Shear (kips)	Maximum Moment (kips-in)
0.25	41	2,442
0.5	63	4,467
1.0	94	7,951
3.0	185	19,866

1) Group effects considered with a reduction factor of 0.82 on "p" using Group 7.0.
2) Liquefied strength parameters used in liquefiable soil layers.
3) A cracked section modulus of 50% of EI was used in the analysis.

5.6 Slope Stability Analyses of Cerritos Channel under Existing Conditions

It is important to evaluate the loading on the piles from earthquake induced lateral movement of Cerritos Channel slopes. The stability evaluations of the existing channel slopes were performed for both static and pseudo-static conditions using the computer program SLIDE 5.0 (Rocscience, 2006). A section along the Cerritos channel was provided by the designers to evaluate the stability of existing channel slopes at both south and north sides. The existing slopes of Cerritos Channel at south side are approximately 2H:1V at the top 30 ft and 5H:1V at the bottom. The existing north side slope is approximately 2H:1V, except the bottom portion of the slope which is about 10H:1V below El. -40 ft. As described in Section 1.2, on the north side of Cerritos Channel near Bent 17, ground elevation varies in transverse (east-west) direction. On the west side, ground elevation is about -4 ft while on the east side, ground elevation is about +10 ft. Using the topographic map provided, an additional section at the east end of the north slope was developed along this elevated area for stability evaluations. The static soil parameters used in the analyses are provided in Table 5. Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990).

Slope stability analyses were conducted for the static and seismic conditions. In accordance with Caltrans Guidelines (Caltrans, 2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.167; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, all the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition. However, slopes do not meet the minimum required factor-of-safety of 1.1 for the seismic condition per Caltrans guidelines (Caltrans, 2006e). Therefore, lateral spreading/slope deformation analyses were performed as discussed in the following section.

5.6.1 Lateral Spreading/Slope Deformation during Seismic Event

The seismically-induced lateral slope displacements were determined from the Newmark sliding block procedure using the yield acceleration estimated from the pseudo-static analyses. In order to determine yield acceleration in pseudo-static analyses, an equivalent horizontal force is applied to the soil mass to represent earthquake-induced forces.

Newmark displacements curves based on site-specific peak ground acceleration of 0.5 and a conservative peak ground velocity of 60Kmax for Western United Soil (WUS) condition was obtained from TRB (2008). Using the curves and estimated critical yield acceleration from the pseudo-static analyses, lateral movements of the liquefied layers are estimated to be up to 8 inches, 20 inches, and 36 inches for south slope, west end of north slope, and east end of north slope, respectively, under the design earthquake event (Table 17).

5.6.2 Lateral Loading on Piles during Seismic Event

Based on the slope stability analyses, the lateral slope movements are expected to impose loadings on the piles that are located within and near the channel slopes. The lateral loading conditions induce maximum moments in the lower regions of the piles.

In order to determine the pile behavior under lateral soil loading conditions, lateral loading due to anticipated soil movement was imposed on the pile by pushing it with the soil springs (p-y curves). Based on the column-to-superstructure connection details, the maximum pile moments within the affected piles were estimated using both "hinge" and "cantilever" conditions at the column top; it is recommended that the average of the results from these conditions are used in design. The pushover analyses results are provided in Table 17. The distribution of moment and shear within the piles were provided to the structural designers for further evaluation.

TABLE 17. SUMMARY OF LATERAL SOIL LOADING ANALYSES

Support	Location	Approximate Lateral Movement (inches)	Column Top Condition	Approximate Maximum Moment (kips-ft)	Approximate Elevation of Maximum Moment (ft)
Bent 12	South Side of Southern Slope	8	Hinged	5,937	-8
			Cantilever	15,292	-50
			Average of Hinged and Cantilever (Recommended)	10,614	-
Bent 13	On Southern Slope	8	Hinged	85	-47
			Cantilever	137	-45
			Average of Hinged and Cantilever (Recommended)	111	-
Bent 16	On Northern Slope	Negligible	-	-	-
Bent 17-West End	North Side of Northern Slope	20	Hinged	1,661	-47
			Cantilever	3,067	-40
			Average of Hinged and Cantilever (Recommended)	2,364	-
Bent 17-East End	North Side of Northern Slope	36	Hinged	18,875	-36
			Cantilever	41,398	-32
			Average of Hinged and Cantilever (Recommended)	30,136	-

Note: Hinged condition (Moment = 0 & Deflection = 0) and cantilever condition (Moment = 0 & Shear = 0) were used at column top.

5.6.3 Impact on Piles due to Potential Future Improvements by POLB

As mentioned in Section 1.2, the existing grade at north side of Cerritos Channel from Bents 17 through 23 may be raised to El. +14.5 ft for potential Pier A future improvements by POLB. Based on our preliminary slope stability analyses and lateral deformation estimates, during a design earthquake, soils around piles at Bent 17 are expected to impose significant loads on the piles for the future raised grade condition. The anticipated maximum pile moments at Bent 17 could be on the order of the nominal pile capacity under these conditions. Additional ground improvement measures may be needed near Bent 17 to minimize the impact of lateral soil loading on piles, if the potential Pier A future improvement is implemented. An area of

subsurface soils, with the dimensions of about 200-ft long in transverse direction and about 20-ft wide in longitudinal direction, extending to a depth of about 60 ft may need to be improved using deep soil mixing. Detailed soil investigation, laboratory testing, and engineering analyses should be performed to develop a final soil improvement configuration.

It should be noted that this ground improvement would be necessary only if the piles are lengthened by about 50 to 70 ft, as discussed in Section 5.5.1.2, to accommodate the anticipated downdrag forces due to potential future grade increase.

5.7 Bridge Abutment Wall

5.7.1 Earth Pressures

An active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf are recommended for a level backfill. For cantilever retaining walls, a static active lateral earth pressure of 36 psf per ft of depth is recommended for a level backfill. If lateral movement at the top of abutment walls is restrained, the lateral pressure distribution has a trapezoidal shape with a maximum lateral pressure of 28.8H psf between 0.2H from the top and bottom of the wall, where H is the wall height in feet. An additional lateral uniform pressure of 72 psf due to a traffic surcharge equivalent to a vertical pressure of 240 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied at H/3 ft above the bottom of the wall (H is the wall height in ft). Other design requirements are specified in Section 3.20 of the Caltrans Bridge Design Specifications (Caltrans, 2004).

5.7.2 Passive Resistance

Under seismic loading, an ultimate passive earth pressure of 5 ksf may be used for the approach backfill and abutment walls with a height equal to or greater than 5.5 ft. For abutment walls with heights less than 5.5 ft, the maximum passive pressure may be calculated proportionally (e.g., for a 4 ft high wall, the maximum passive pressure is [4/5.5]x5 ksf = 3.6 ksf). The horizontal movement at which the maximum passive pressure is expected to be fully mobilized can be determined following the procedure outlined in Section 7.8.1 of the Caltrans SDC (Caltrans, 2006d).

5.8 Approach Embankments

The proposed Schuyler Heim Bridge (Replace) will generally have the same alignment as the existing structure at the southern end and is proposed to be realigned northwards slightly to the east of the existing structure (Bridge No. 55-0333L). The southern approach embankment at Abutment 1 will be slightly elevated (i.e., up to 2 ft) and the crest of the existing embankment will be widened by about 13 ft eastwards. Up to 5 ft of fill atop the existing approach embankment will be placed at the crest of the proposed embankment. The abutment end slope will be graded at an inclination of 1.5H:1V with full slope paving. The western face of the southern approach embankment will be retained by a MSE wall (Retaining Wall No. A1) and the eastern slope of the embankment will be graded at an inclination of 2:1 side slope.

Recommendations for the Retaining Wall No. A1 and the southern approach embankment are addressed in a separate foundation report prepared by EMI (EMI, 2010e).

As mentioned in Section 1.2, the north end of the subject structure abuts northbound SR-103 Off-Ramp structure (Bridge No. 53-3034K) and southbound SR-103 On-Ramp structure (Bridge No. 53-3035S) on the east and west sides, respectively. Therefore, no embankment fill will be placed at north end of the subject structure. Recommendations for these SR-103 Off- and On-Ramp structures are addressed in separate foundation reports prepared by EMI (EMI, 2010a and EMI, 2010b).

5.8.1 Static Settlement

Standard procedures were used to evaluate ground settlement due to the proposed fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading, or shortly thereafter and consolidation settlement occurs over varying time periods. Immediate settlement, which is estimated to be negligible in this case, while consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers.

A cross-section near the southern abutment (Abutment 1) at Sta. 4+27 ("A" Line) was selected to evaluate potential settlement beneath the proposed embankment. Based on cross-sections provided by URS, the future roadway profile is slightly elevated by about 2 ft and the width of the proposed embankment varies approximately between 120 ft and 150 ft. Since compressible fine-grained soil layers were not encountered near Abutment 1 during the current field investigation program, the soil profile developed at further south of Abutment 1, which consists of compressible fine-grained soil layers, is conservatively used for the settlement calculations near Abutment 1. Based on the existing approach embankment configuration and the proposed final embankment configuration, the total settlement of soils induced by the new embankment fill near Abutment is expected to be about 1.5 inches and will require a settlement period of about 6 weeks to reduce the long-term post-construction settlement to be less than ½-inch.

Utilities: As discussed in Section 1.2, four proposed RCP lines with diameters ranging from 18 to 51 inches and one proposed 12-inch diameter VCP line are located on the north side of the Cerritos channel according to latest plans provided by the designers. If and when POLB raises the grade to El. +14.5 ft at north side of Cerritos Channel for potential future Pier A improvements, the compressible fine-grained soil layers that are present down to approximate El. -85 ft at the site are expected to undergo consolidation settlement. Settlement below the utility line is not anticipated in the area where no future fill will be placed. Details of the settlement estimates and possible mitigation measures are provided in a separate memorandum.

In addition, an existing 12-inch diameter high pressure gas line is located about 33 ft west of Abutment 1. The maximum settlement below the gas line is estimated to be less than 0.25 inch due to the proposed embankment fill. However, toward the south, this gas line is located to about 5 to 10 ft west of Retaining Wall A1. The settlement recommendations for the southern portion of this gas line are addressed in the foundation report prepared Retaining Wall No. A1 (EMI, 2010e).

Settlement Monitoring Recommendations: Based on our past experience, calculated settlements and settlement periods are usually approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of deposits, it is recommended that settlement monitoring be conducted at the abutment. Surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent, should be placed near the proposed abutment location and two other points selected by the Engineer. The settlement monuments should be installed in a timely manner upon completion of embankment construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. Settlement of the embankment fill should be verified by the Engineer prior to installation of abutment piles to prevent a reduction in axial pile capacity due to downdrag loads being applied to the piles. The installation of abutment pile should not begin until the long-term residual settlement becomes ½-inch or less.

5.8.2 Bridge Abutment Global Stability

The "global" stability of the proposed approach embankment for the subject bridge (Bridge No. 55-3032) Abutment 1 was evaluated for both static and pseudo-static conditions using the computer program SLIDE 5.0 (Rocscience, 2006). A cross-section near Abutment 1 at Sta. 4+26 ("A" Line) was selected to evaluate global slope stability of the proposed embankment. The stability of the end slope at Abutment 1 was also analyzed. The global stability of the southernmost part of the proposed embankment is addressed in a separate foundation report prepared by EMI (EMI, 2010e). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf.

Slope stability analyses were conducted for both static and seismic conditions. In the analyses, traffic loading was considered for only static condition by including a 2 ft soil surcharge. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.167; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans guidelines (Caltrans, 2006e).

5.9 Tie-Down Anchors

As mentioned in Section 1.2, at the two hinge points where the proposed Schuyler Heim Bridge will abut the SR-47 Expressway Ramps, the deck of the subject bridge will have a row of tie-down anchors that will simulate the weight of the SR-47 Expressway Ramps until they are constructed in future. Each anchor is anticipated to be approximately 6-inches in diameter and 75 ft in length with a service capacity of 175 kips. Per FHWA (1999), presumptive ultimate transfer loads for gravity-grouted anchors were used in the capacity calculations.

5.9.1 Un-Bonded Length

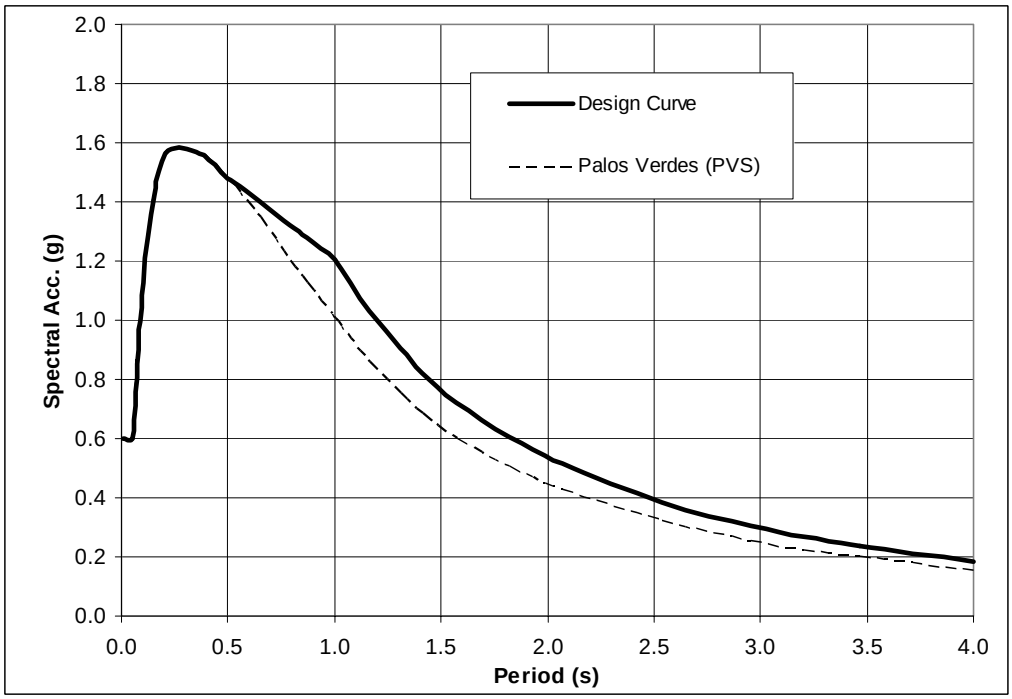
The un-bonded length (or "free length") of the anchor is the portion of the anchor which is not grouted. The un-bonded portion of the anchor should have a minimum length of 15 ft. In addition, the bonded portion of anchors should be set below any adjacent footings a minimum distance of 6 ft or 5 times the diameter of the concrete anchors, whichever is greater.

5.9.2 Bonded Length

The bonded length of anchors is the portion which is grouted and provides the tensile resistance due to friction between the soil and concrete. The maximum allowable anchor load is computed by multiplying the surface area of the grouted anchor (along the bonded length) by the ultimate transfer load and dividing by a factor of safety. The contractor is responsible for determining the bonded length of the anchors; however, the bonded length of the anchors should not be less than 30 ft. For the purposes of preliminary design of small diameter, straight shaft, gravity-grouted anchors in loose sand and low plasticity silt and clay, an ultimate unit bond strength of 4.0 and 2.0 kips/ft, respectively between the grouted anchor and soil may be used (FHWA, 1999). A minimum factor of safety of 2.0 for determining allowable load is recommended (FHWA, 1999).

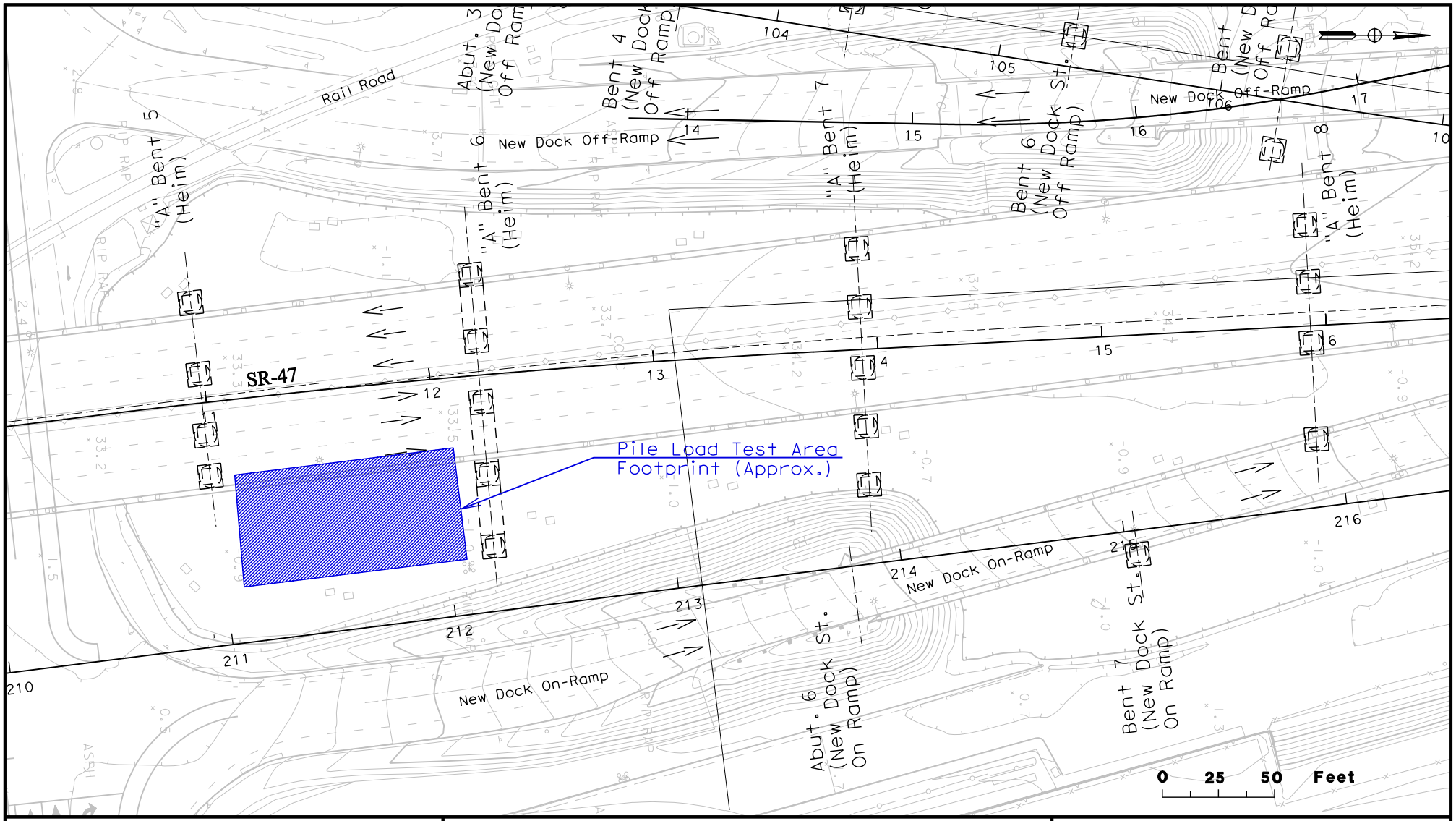
5.9.3 Anchor Spacing

Tieback anchors should not be spaced closer than three diameters of the bonded zone. The anchors should be located to maximize their distance from the proposed bridge piles.



Fault Name	Fault Type	M_w	Dist, km	PBA, g
Palos Verdes (PVS)	ST	7.25	2.7	0.6

Period	Acc (g)	Period	Acc (g)	Period	Acc (g)	Period	Acc (g)
0.010	0.600	0.500	1.479	2.954	0.304		
0.050	0.600	0.533	1.461	3.203	0.266		
0.079	0.938	0.650	1.398	3.463	0.239		
0.099	1.127	0.787	1.323	4.000	0.186		
0.124	1.283	0.868	1.279				
0.154	1.419	0.998	1.209				
0.177	1.507	1.000	1.208				
0.208	1.564	1.162	1.031				
0.236	1.578	1.307	0.906				
0.271	1.584	1.411	0.822				
0.309	1.580	1.575	0.723				
0.355	1.570	1.819	0.605				
0.386	1.557	2.068	0.513				
0.442	1.525	2.537	0.383				



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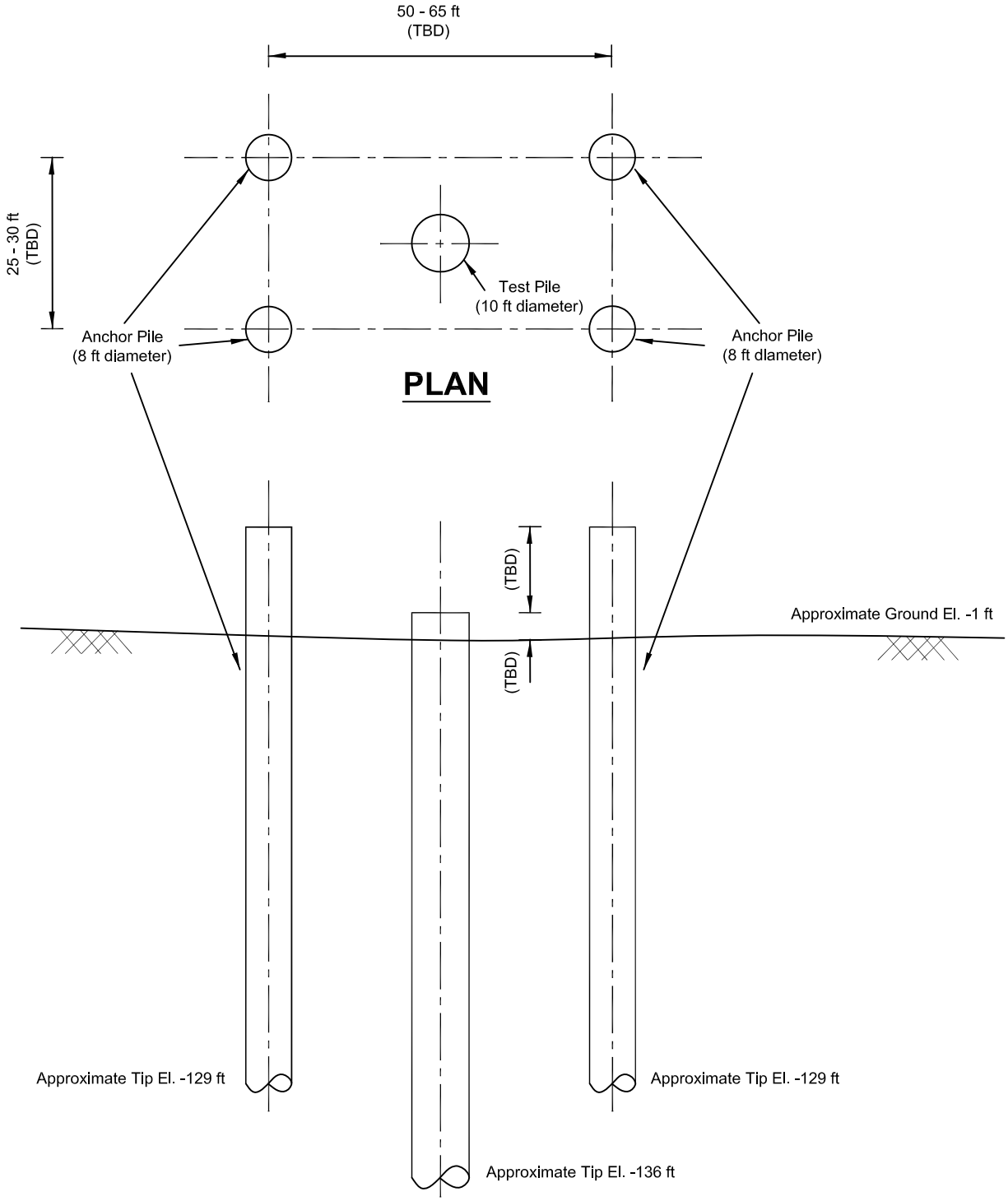
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 5-10-10

Location Map of Proposed Pile Load Test Area

Figure 11

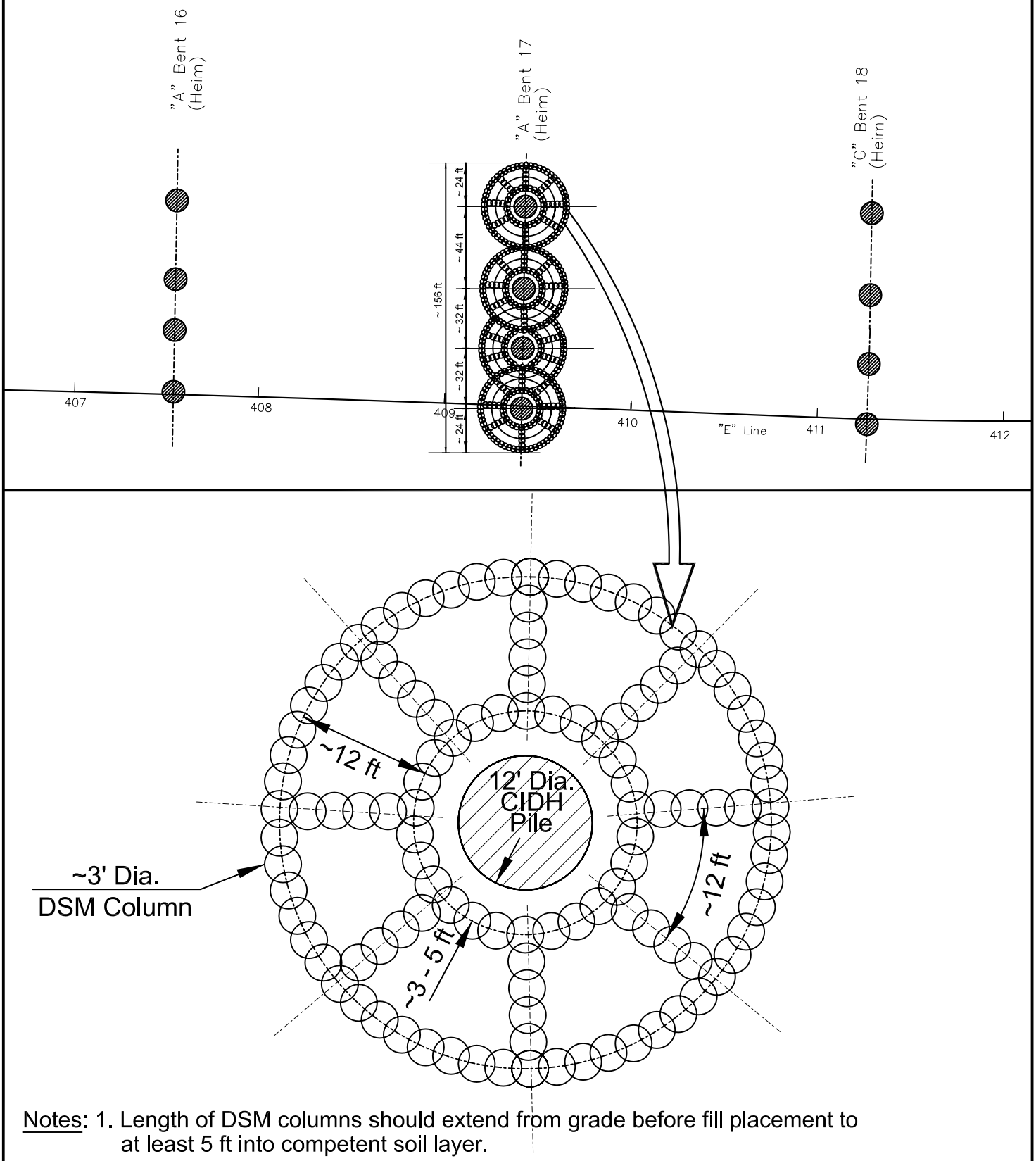


ELEVATION

Notes: 1. Pile load test is proposed to be performed within the footprint of Stage 1 construction between Bents 5 and 6 (See Figure 11).

2. TBD - To Be Decided.

SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Preliminary Configuration of Load Test Piles
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Figure 12
Project No. 06-123	Date: 5-10-10



Notes: 1. Length of DSM columns should extend from grade before fill placement to at least 5 ft into competent soil layer.

2. Similar improvement would be needed around all piles at Bents 18 through 23.

SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

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Schematic Showing Preliminary Configuration of Deep Soil Mixing (DSM) Around Piles at a Support

Figure 13

Project No. 06-123

Date: 2-08-10

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture, and compacted in place to a minimum 95 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts or excavations necessary to achieve finish grades. However, temporary cuts may be required in areas where drainage improvements and footings are proposed. Temporary excavations, including temporary shoring, necessary to

construct the bridge abutment footings or culverts will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

During the LKR investigations in 1996, groundwater was recorded between El. -4 ft and El. -6 ft in borings. During the EMI investigations in 2009, groundwater was recorded between El. +2.3 ft and El. -12.3 ft in twenty seven of the twenty nine site-specific borings performed along the proposed bridge alignment. The proposed footing bottom elevation at Abutment 1 is -1.75 ft. Due to the close proximity to the ocean where the ground water table at the project site is directly related to tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (Caltrans, 2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

During the EMI investigations in 2009, groundwater was recorded between El. +2.3 ft and El. -12.3 ft in the site-specific borings performed along the proposed bridge alignment. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff, and other man-made conditions. In addition, due to the close proximity to the ocean where the ground water table at the project site is directly related to tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a

temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.2.1 Permanent Steel Casing Installation

As a result of recent design development, approximately 25-ft long permanent driven steel casings with 11-ft inside diameter (ID) and 13-ft ID are proposed from the pile cut-off at bents located south and north sides of the channel, respectively. For the channel bents (Bents 13 through 16), 12-ft ID permanent driven steel casings are proposed down to elevations between -76 ft and -95 ft. The specified tip elevations of permanent steel casings for the bents are included in Table 13. These steel casings should be driven using impact hammers. Center Relief driving method is allowed, to a depth of no deeper than 5 ft above the final tip elevation of the casings, for installation of these steel casings.

6.2.2 Bent 11 East Pile Installation

As mentioned in Section 1.2, the proposed eastern pile at Bent 11 is located behind an existing MSE wall that has an approximate finished grade at El. +16 ft. Appropriate measures need to be taken by the contractor both to prevent any damages on the wall facings due to the driving of pile isolation casings and to strengthen the existing MSE wall, if necessary. Based on the information provided by the designers, we understand that the top layer of the wall strap will need to be exposed by excavating from the top of the wall before driving the pile isolation casings since it may pull the wall facing at the top. Below the top strap, the pile isolation casing is expected to be able to cut through the remaining straps without damaging the wall facing. Due to the presence of the pile isolation casing around the column, additional loading from the column on the existing MSE wall is expected to be negligible.

6.3 Backdrain and Backfill Requirements for Abutment Walls

Materials behind the abutment and wing walls should be low-expansive soil with an Expansion Index (EI) less than 50 and Sand Equivalent (SE) of more than 20 as shown in Figure 14. The low-expansive material requirement should not supersede the structure backfill and pervious backfill requirements as described in Caltrans Standard Plans (Caltrans, 2006b) and Caltrans Standard Specifications (Caltrans, 2006c) under Sections 19-3.06 and 19-3.065, respectively.

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (Caltrans, 2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test 216. Jetting or flooding to compact backfill is

not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the abutment walls in order to avoid damaging the walls due to large lateral earth pressures.

Backdrains should be installed behind abutment walls to relieve hydrostatic pressure. The backdrains should be constructed in accordance Caltrans Standard Plans (Caltrans, 2006b).

6.4 Tie-Anchor Installation

Drilled excavations for anchors are expected to be small in diameter (less than 12 inches) and should not be left open overnight. Excavation, anchor installation, and initial grouting of anchors should be performed within the same work-shift. Excavations for anchors are susceptible to collapse; therefore, holes may require casing.

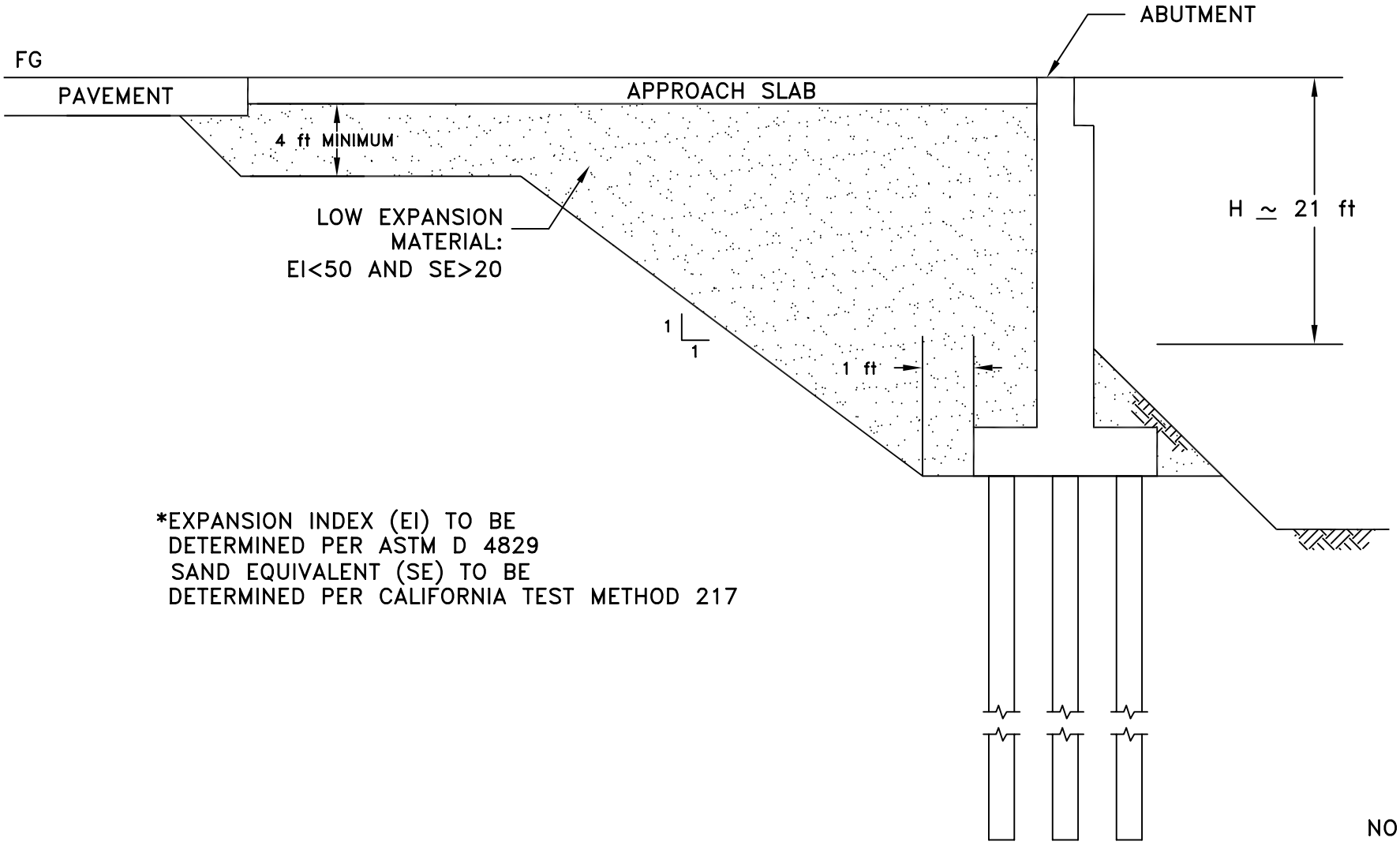
6.5 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations presented in this report may require modification or additional recommendations may be necessary based on the final design.

6.6 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of bridge abutment walls.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 2-08-10

Low Expansion Material at Bridge Abutment

Figure 14

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BENCHMARKS:

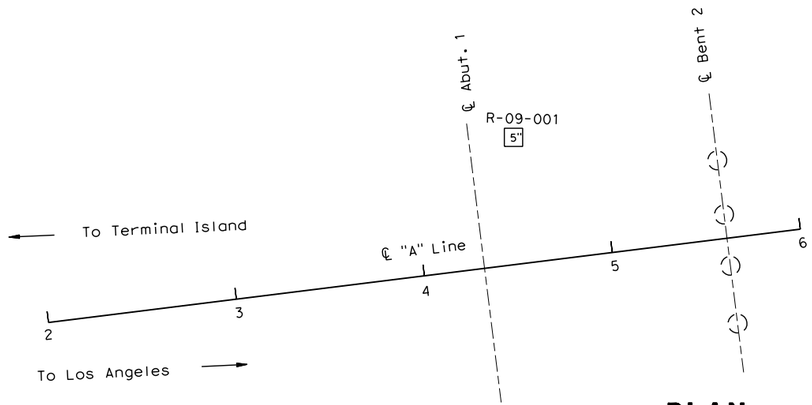
PT-503	PT-531065
REBAR	PK NAIL IN LEAD
18.51'Lt ℄ "A" Line	53.55'Lt ℄ "A" Line
Sta. 8+8.66	Sta. 4+24.53
N 1735350.13	N 1734960.02
E 6489075.70	E 6489051.67
Elev. = -0.53	Elev. = 17.75

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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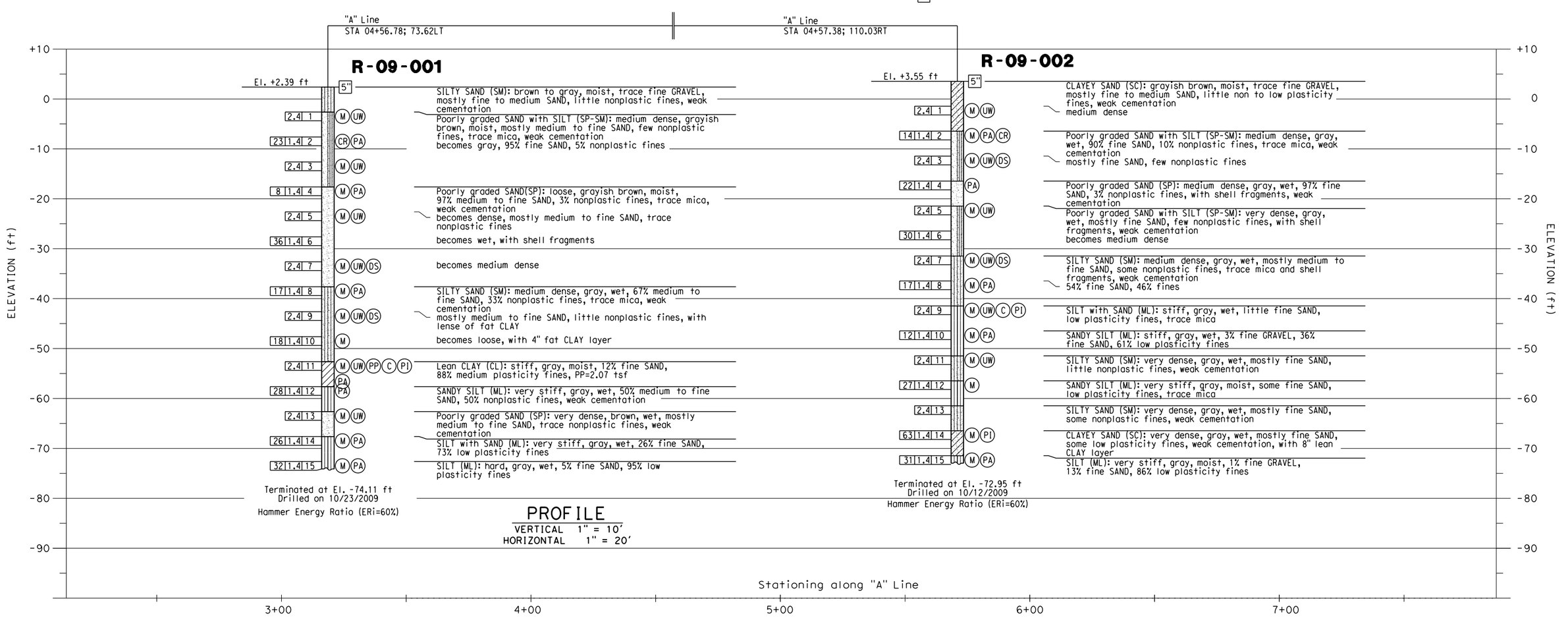
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 1 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

Monument: 1A-144-04

PT-503	PT-531065
REBAR	PK NAIL IN LEAD
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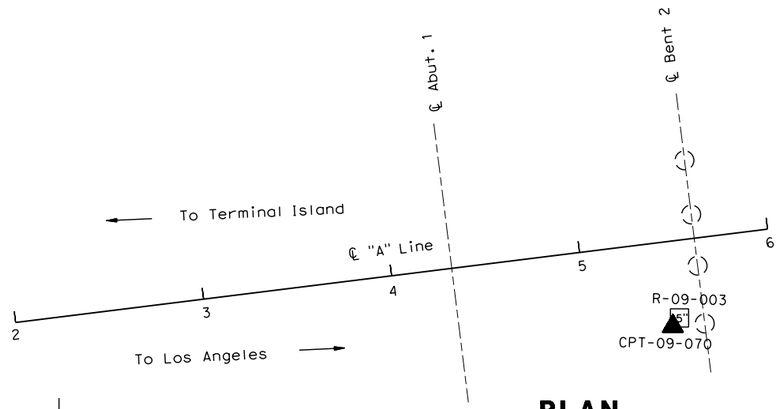
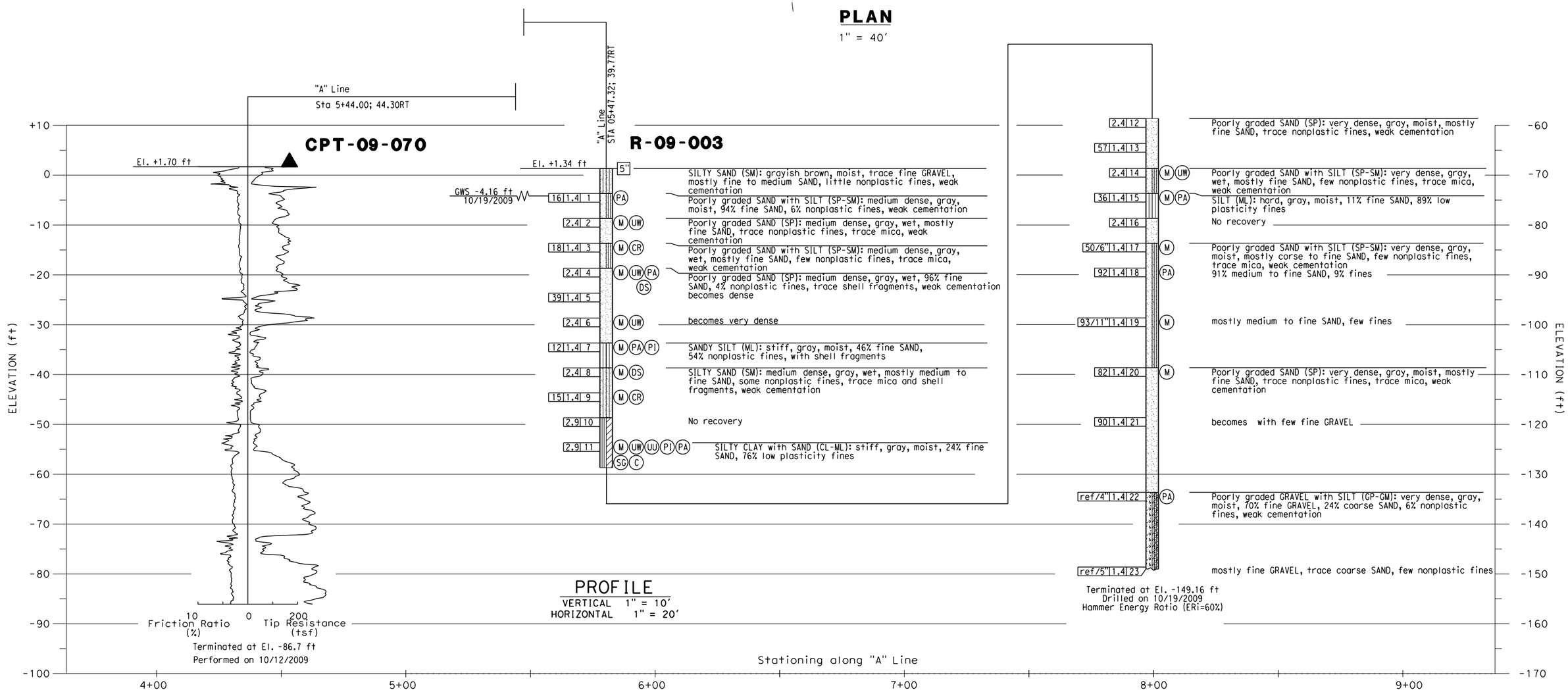


PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032 / POST MILE 3.58
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		CU 07 EA 238501	SCHUYLER HEIM BRIDGE (REPLACE) / LOG OF TEST BORINGS NO. 2 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

BENCHMARKS:

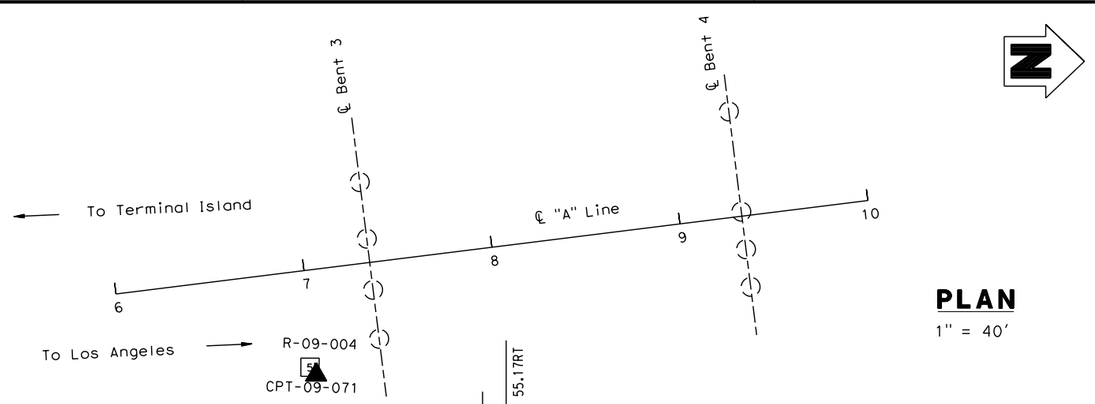
PT-503	PT-531065
REBAR	PK NAIL IN LEAD
18.51'Lt ℄ "A" Line	53.55'Lt ℄ "A" Line
Sta. 8+8.66	Sta. 4+24.53
N 1735350.13	N 1734960.02
E 6489075.70	E 6489051.67
Elev. = -0.53	Elev. = 17.75

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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ACTA
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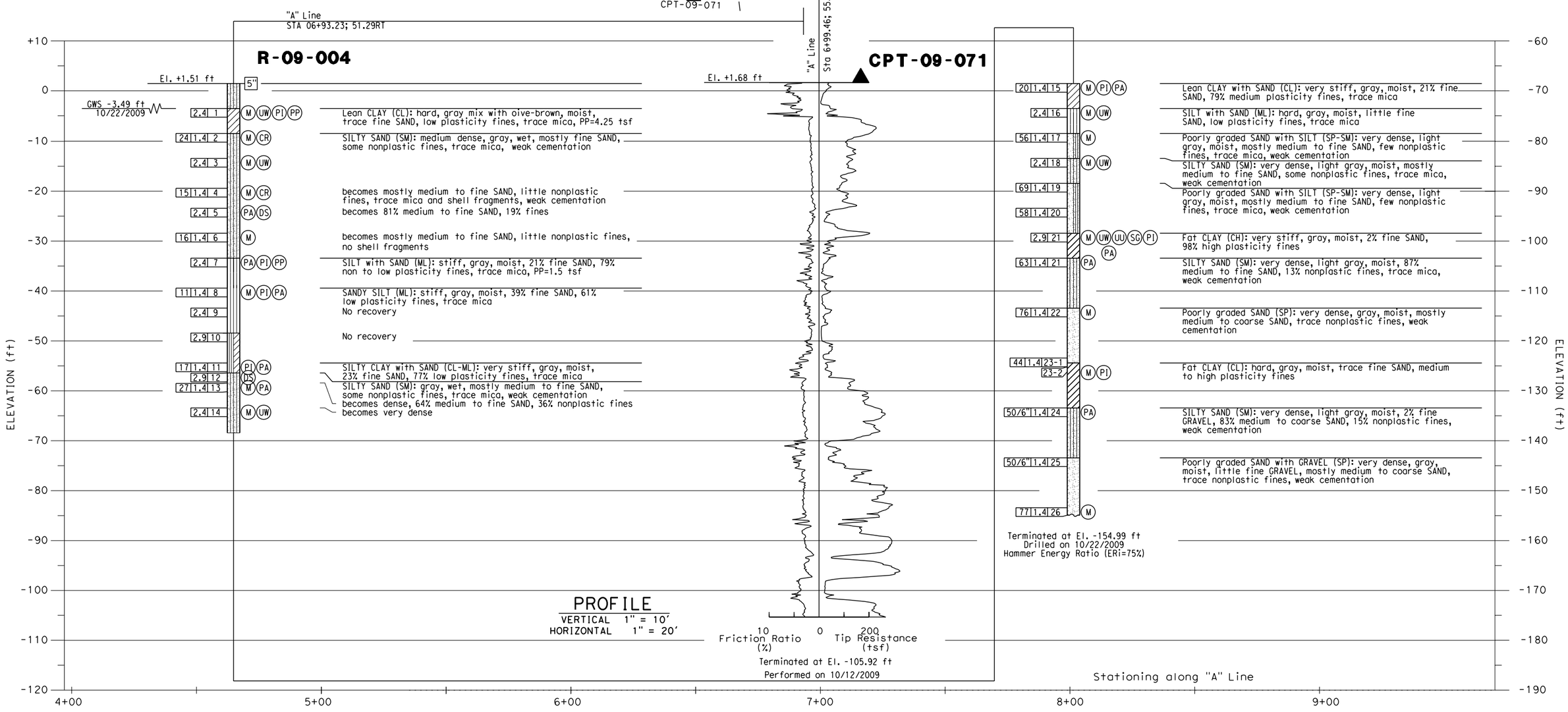
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 3 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

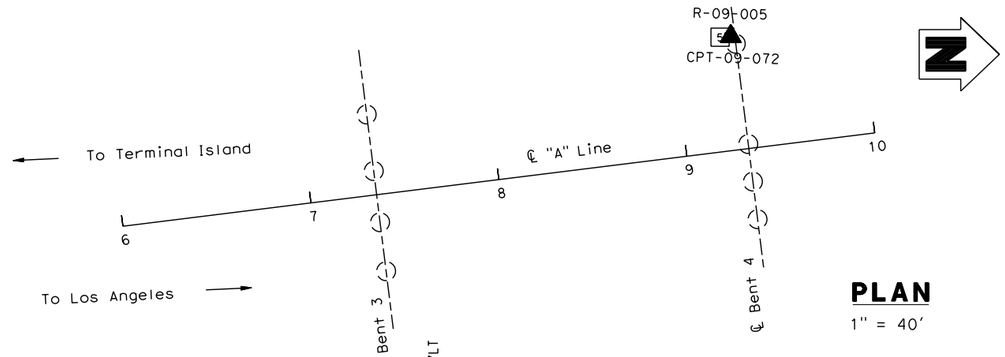
PT-501	PT-15001
SET + FOOTING 23.25'Rt ℄ "A" Line	STK601061 MAG NAIL IN LEAD CUT 113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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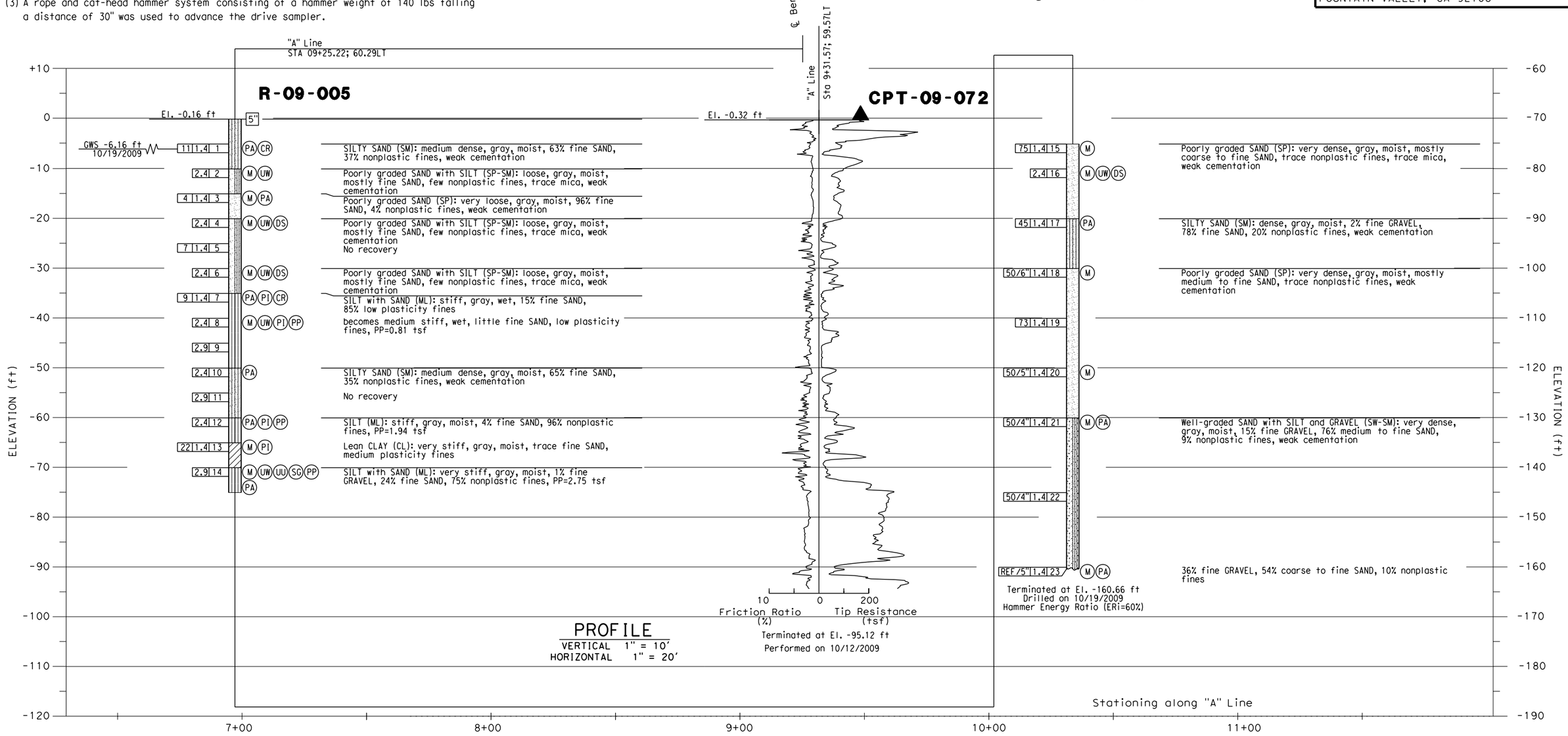
ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 4 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

BENCHMARKS:

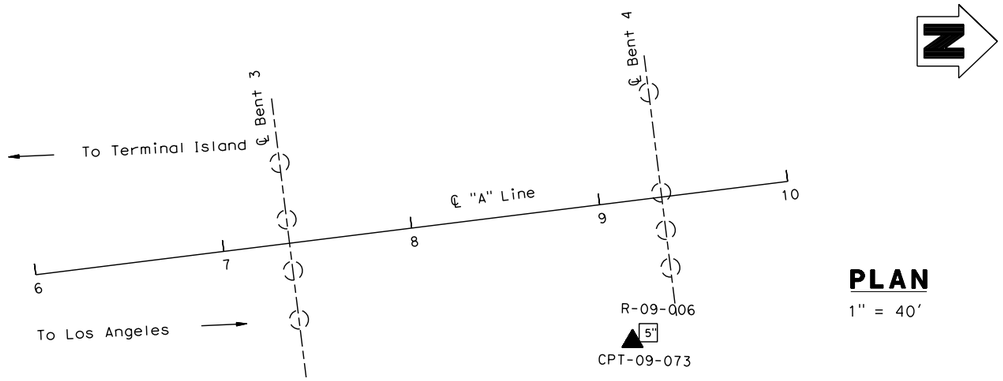
PT-501	PT-15001
SET + FOOTING	STK601061 MAG NAIL IN LEAD CUT
23.25'Rt ℄ "A" Line	113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.10 04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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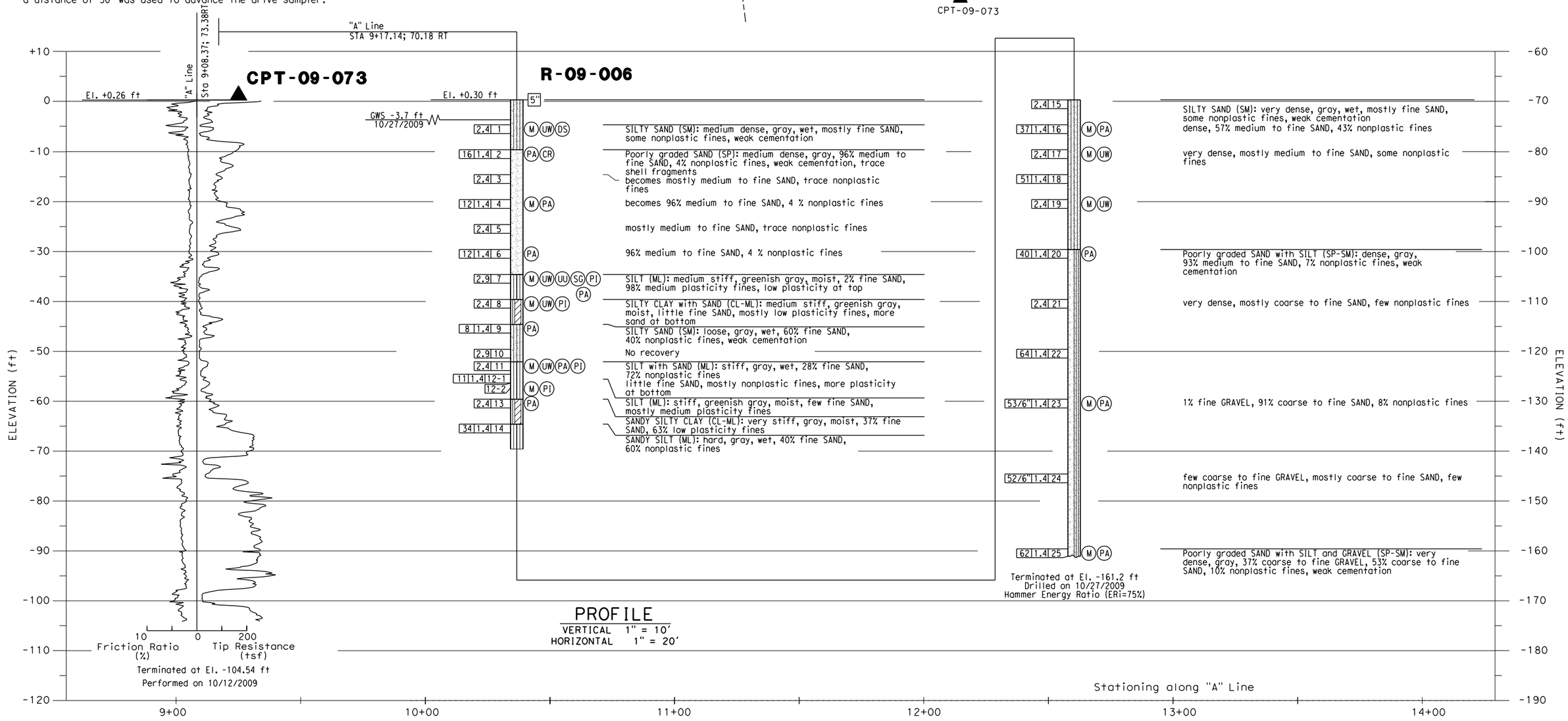
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant			POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 5 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/04/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-501	PT-15001
SET + FOOTING	STK601061 MAG NAIL IN LEAD CUT
23.25'Rt ℄ "A" Line	113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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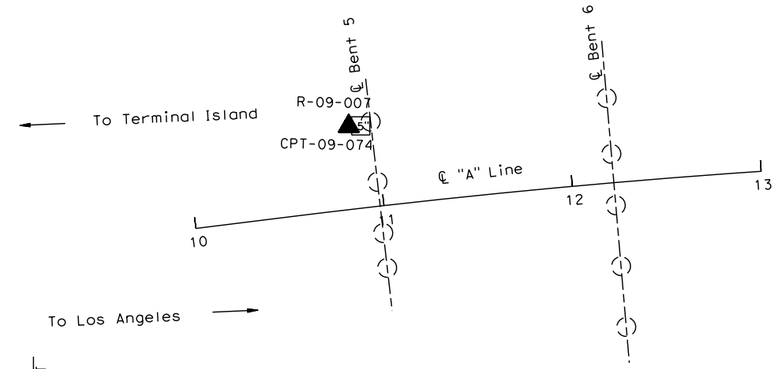
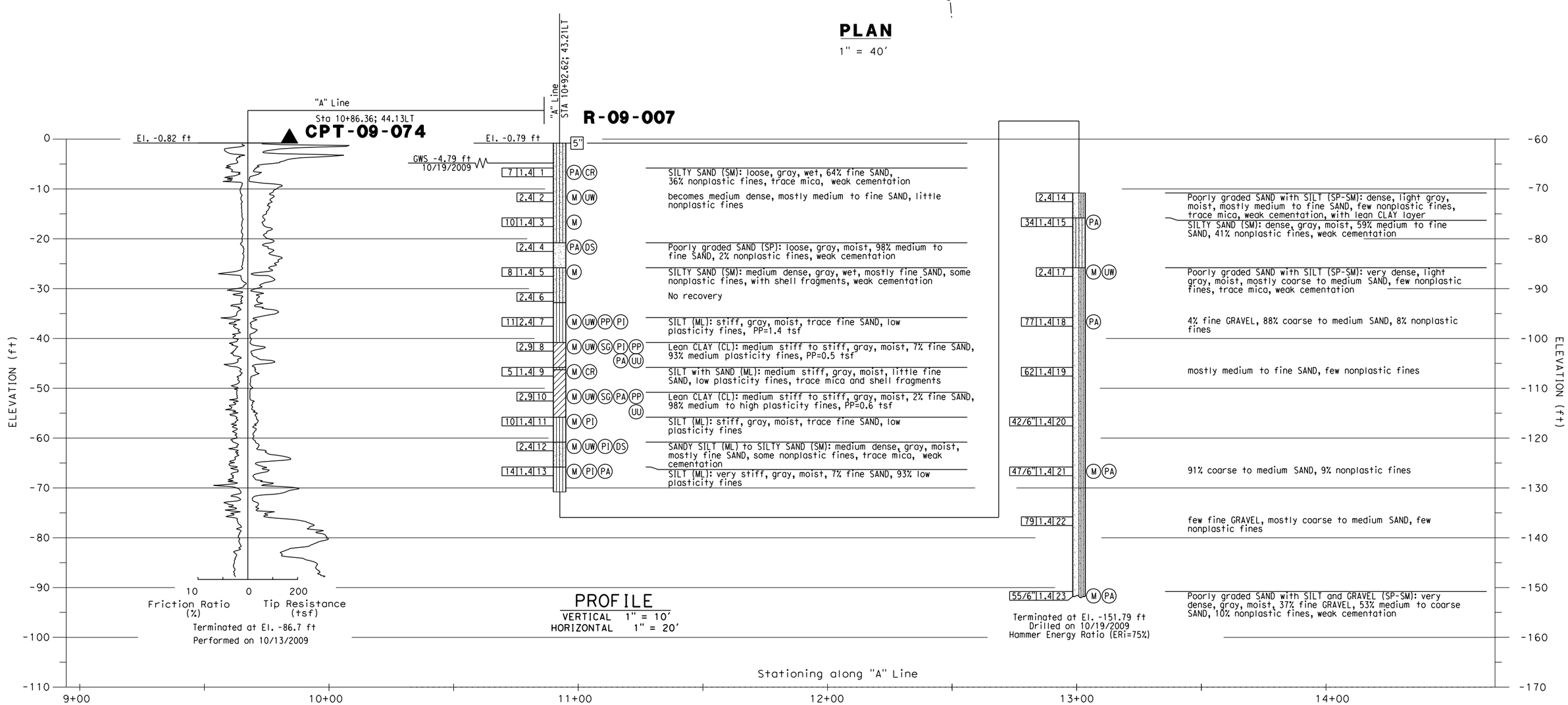
REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 6 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

BENCHMARKS:

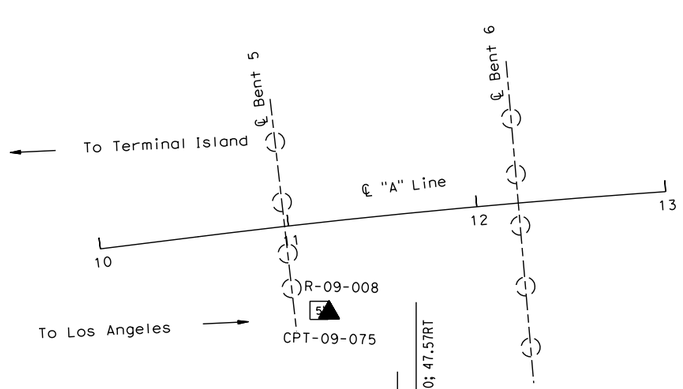
PT-501	PT-15001
SET + FOOTING	STK601061 MAG NAIL IN LEAD CUT
23.25'Rt ℄ "A" Line	113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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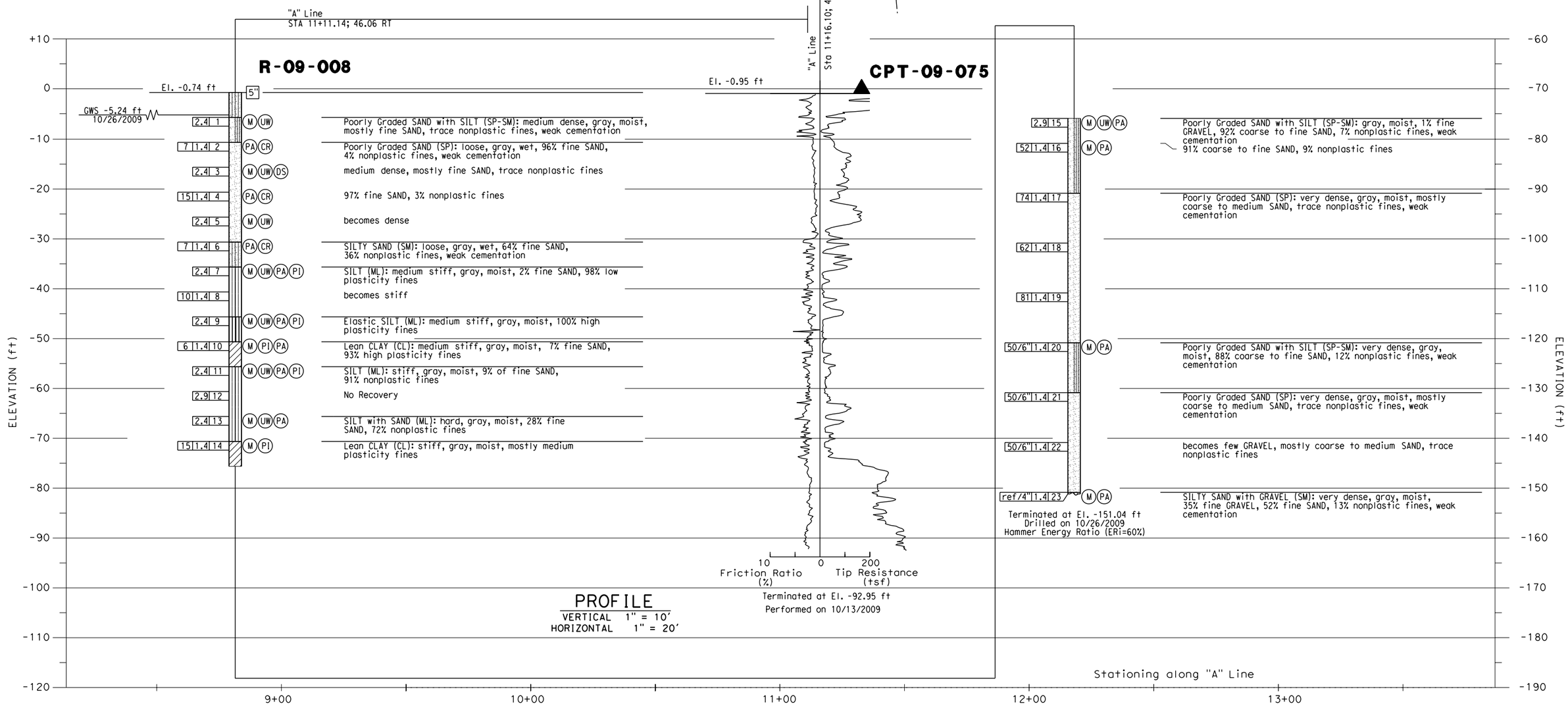
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 7 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

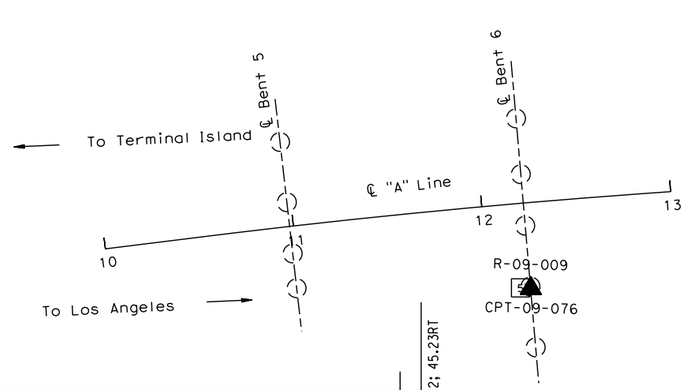
PT-501	PT-15001
SET + FOOTING	STK601061 MAG NAIL IN LEAD CUT
23.25'Rt ℄ "A" Line	113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.8 — REGISTERED CIVIL ENGINEER — 04/19/10 DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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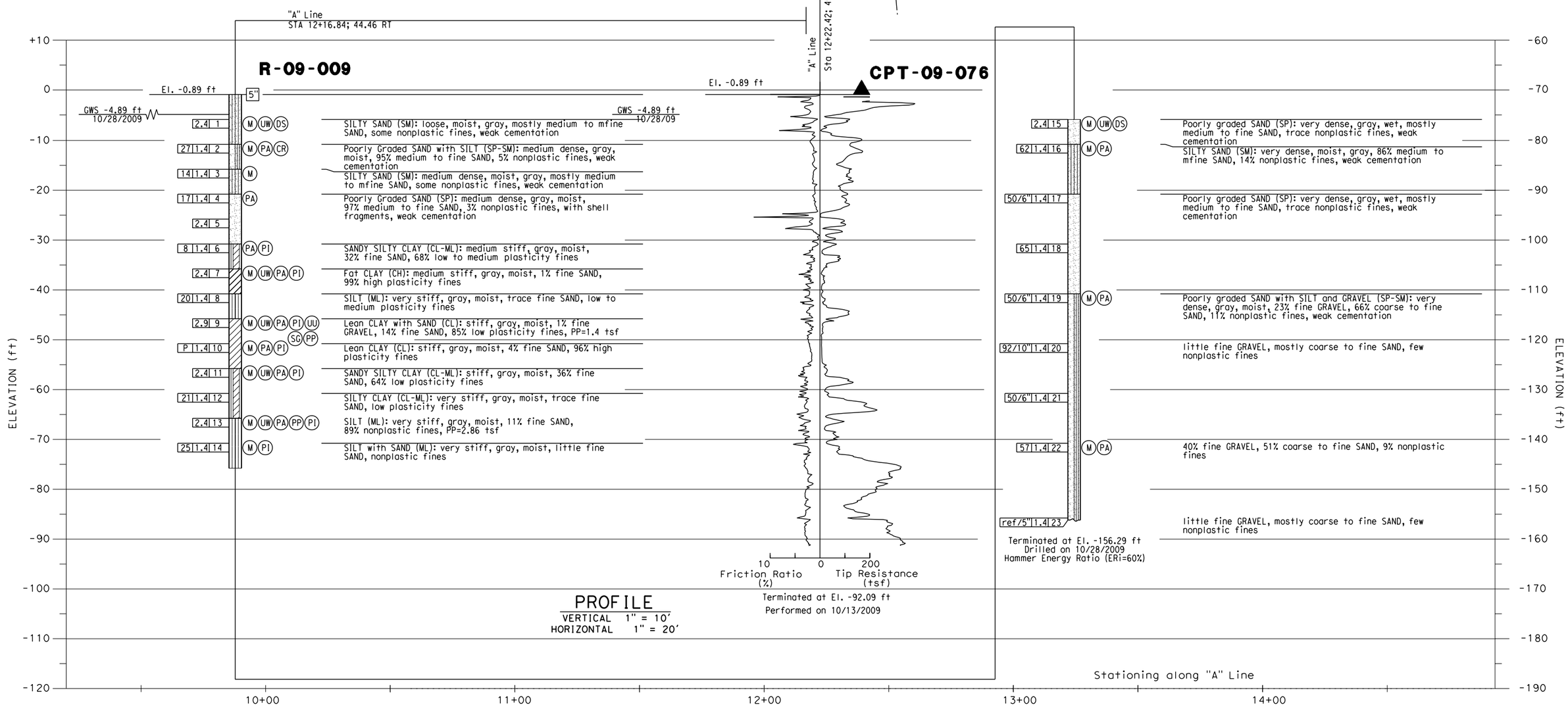
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.58	LOG OF TEST BORINGS NO. 8 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/04/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

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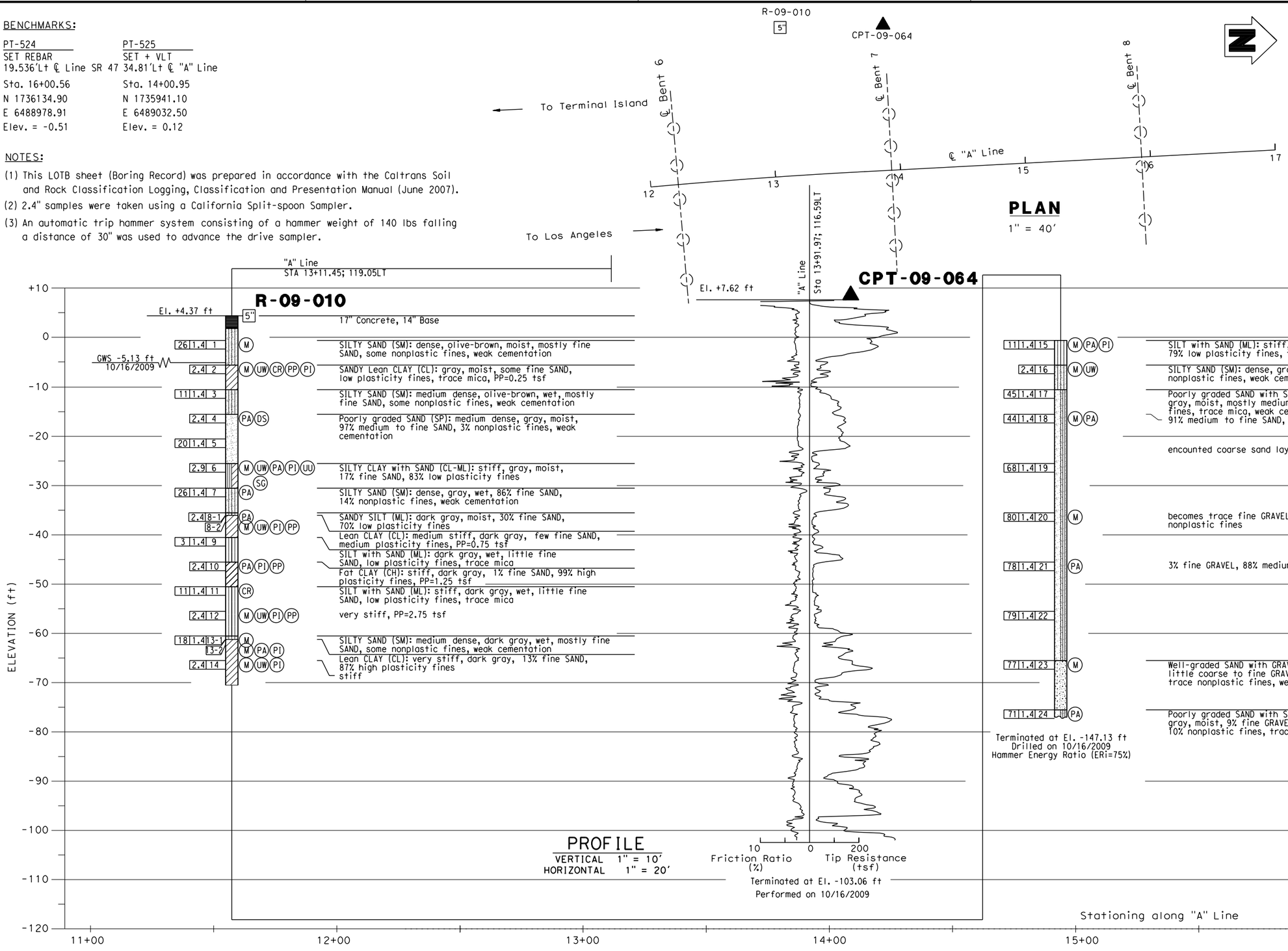

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	**PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION**	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 9 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
02/08/10	03/24/10								X	X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

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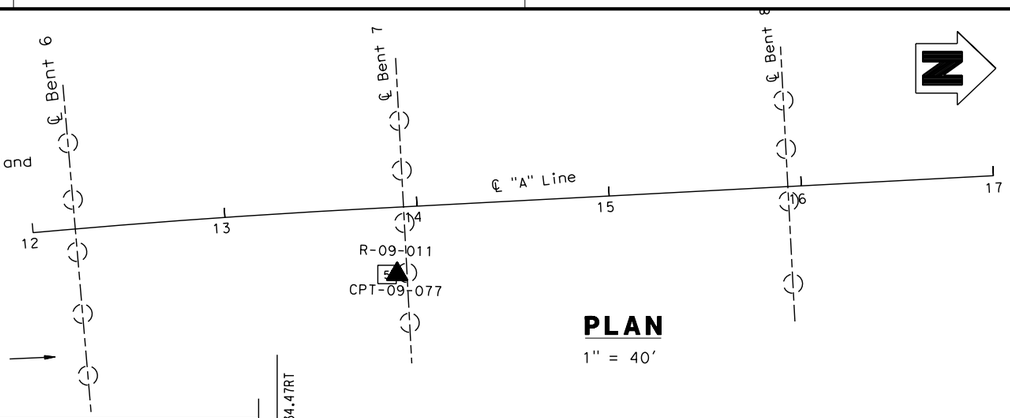

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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CARSON, CA 90745

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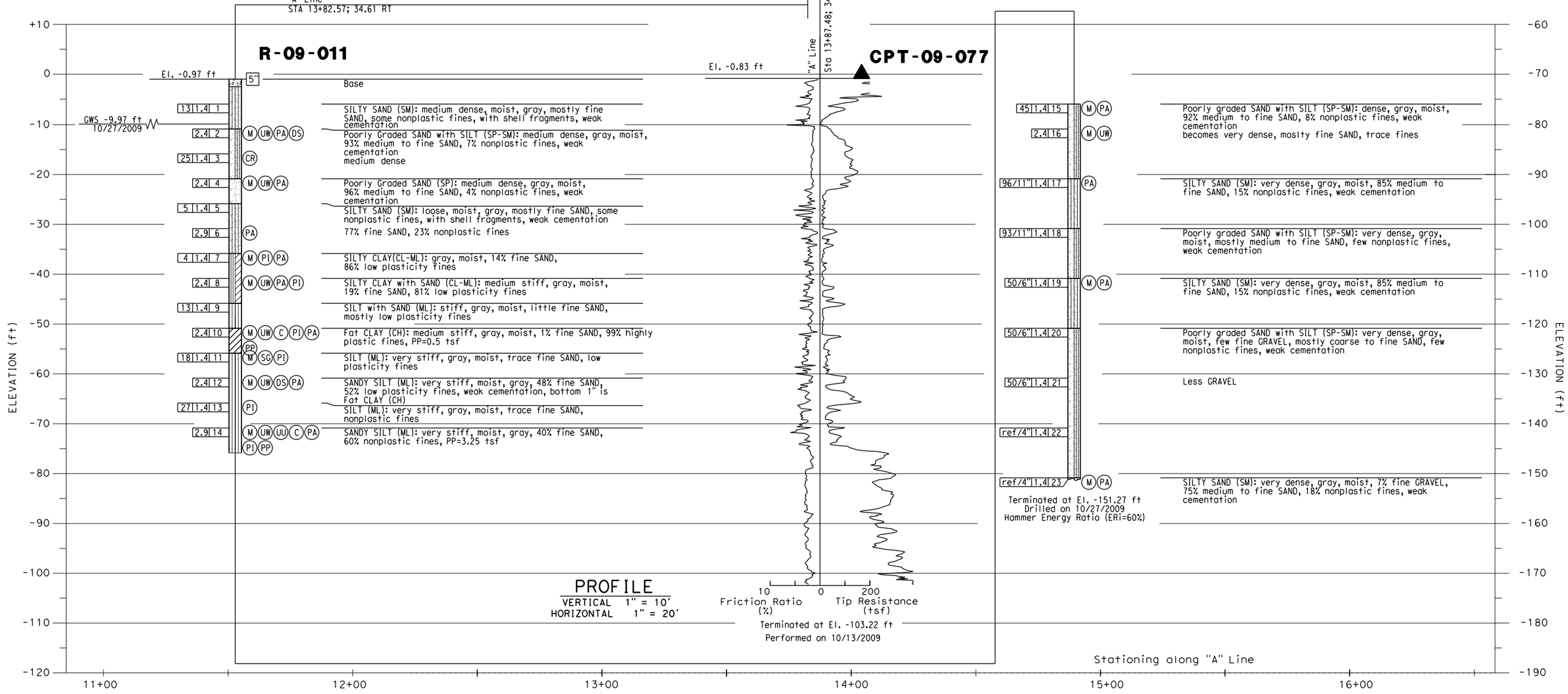
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 10 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

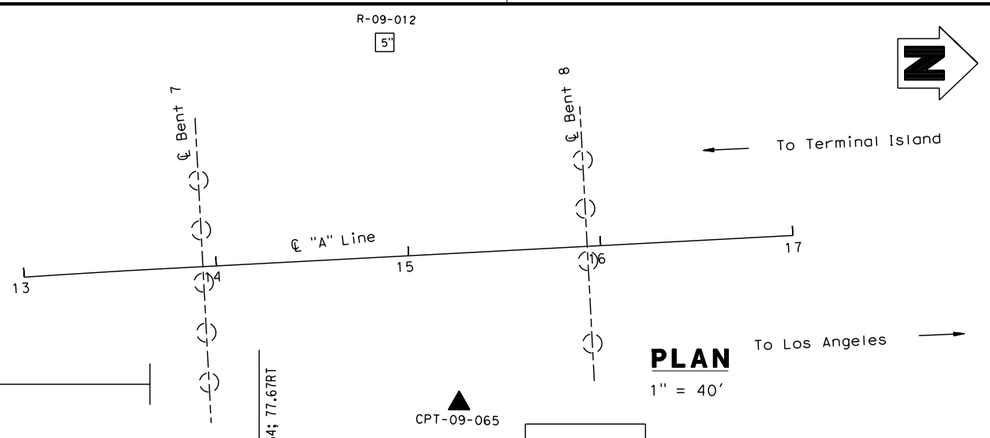
PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

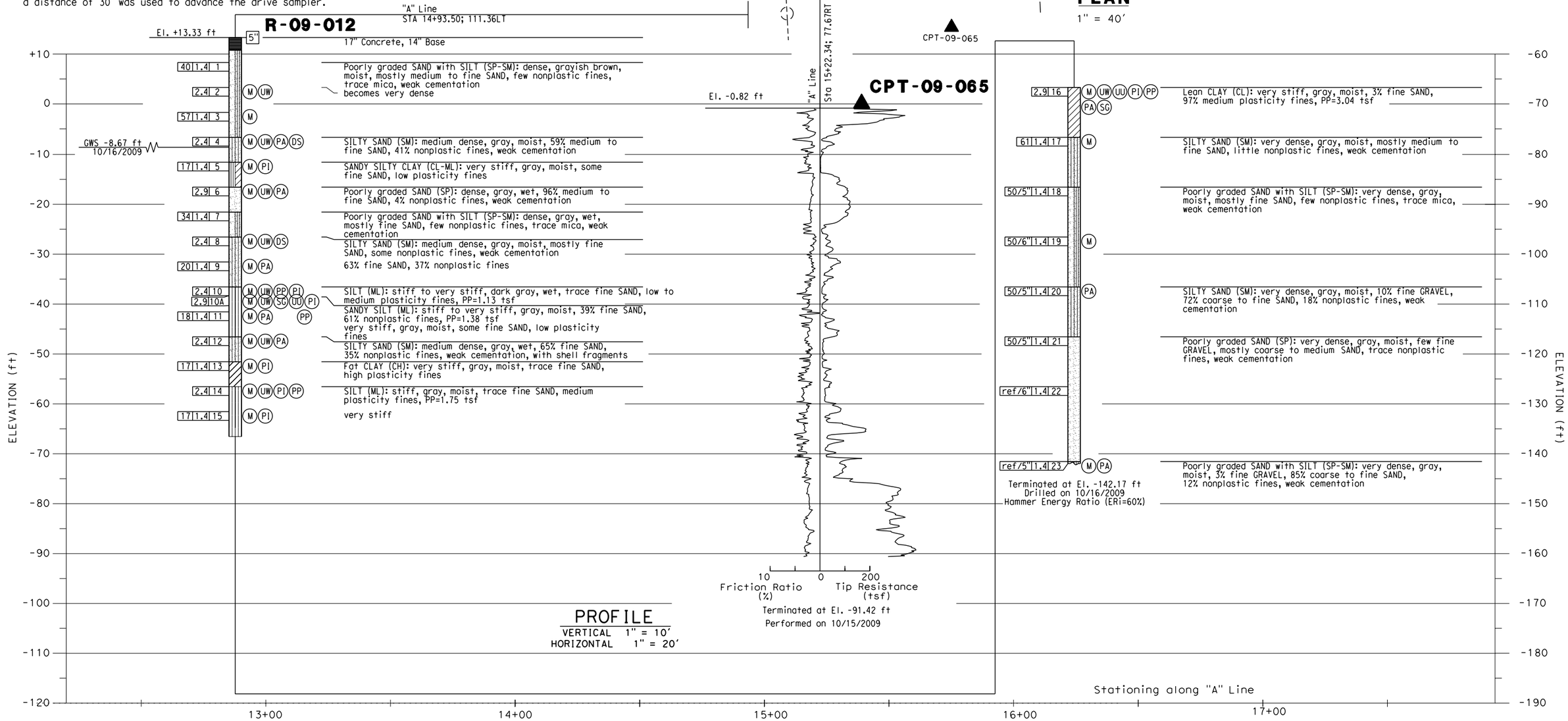
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.





PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.8 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER
G. J. Gunaranjan
No. C71758
Exp. 12-31-11
CIVIL
STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY: J. Fang
CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
R. Jie

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

BRIDGE NO. 53-3032
POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)
LOG OF TEST BORINGS NO. 11 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
02/08/10	03/24/10								X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

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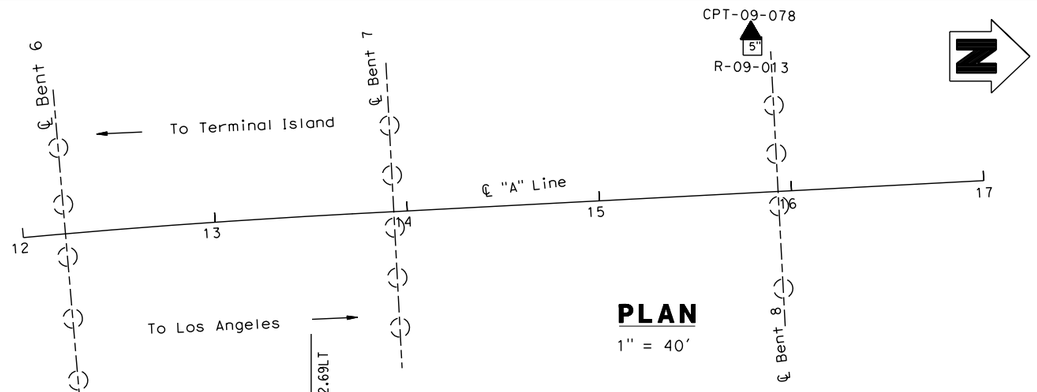
(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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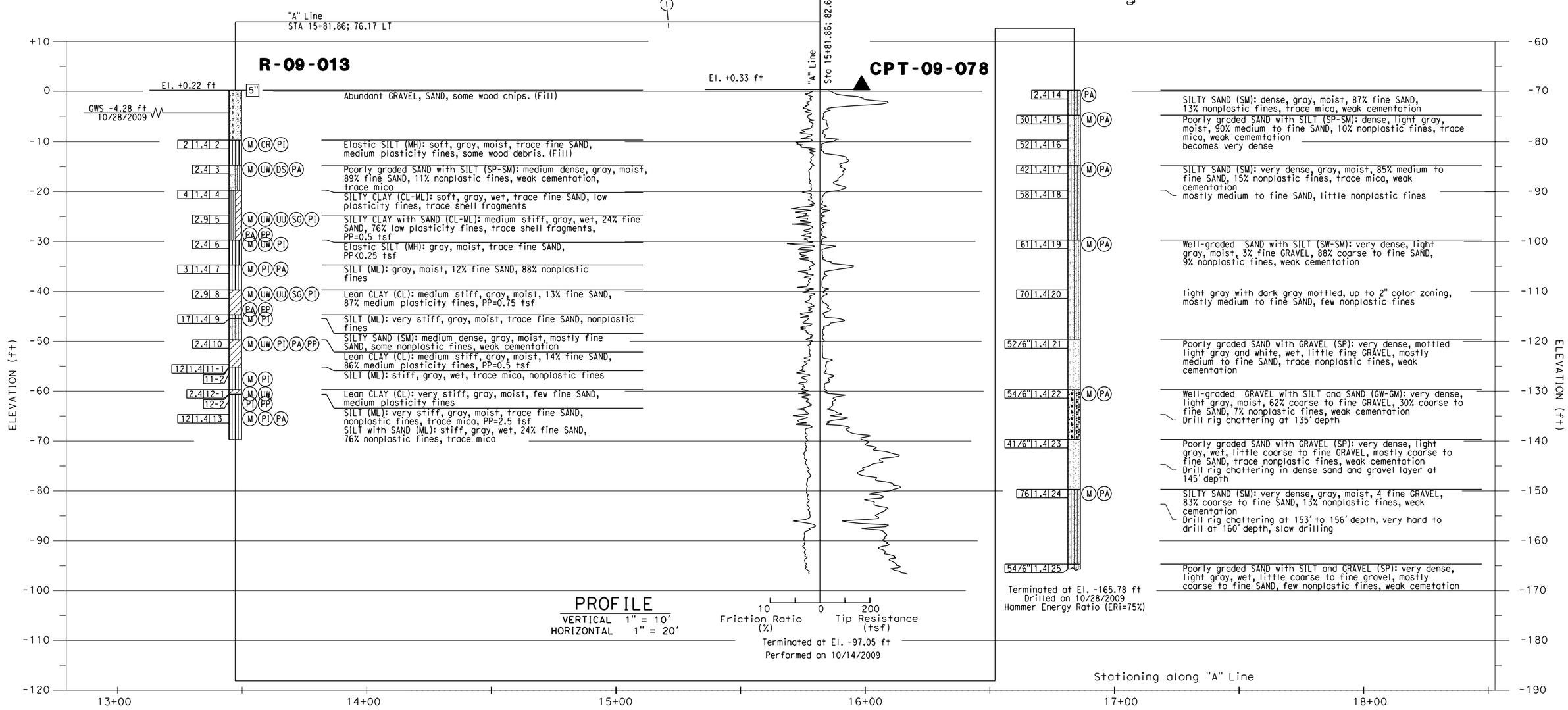
ACTA
ONE CIVIC PLAZA. SUITE 350.
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 12 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

G. J. Gunaranjan
No. C71758
Exp. 12-31-11
CIVIL
REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

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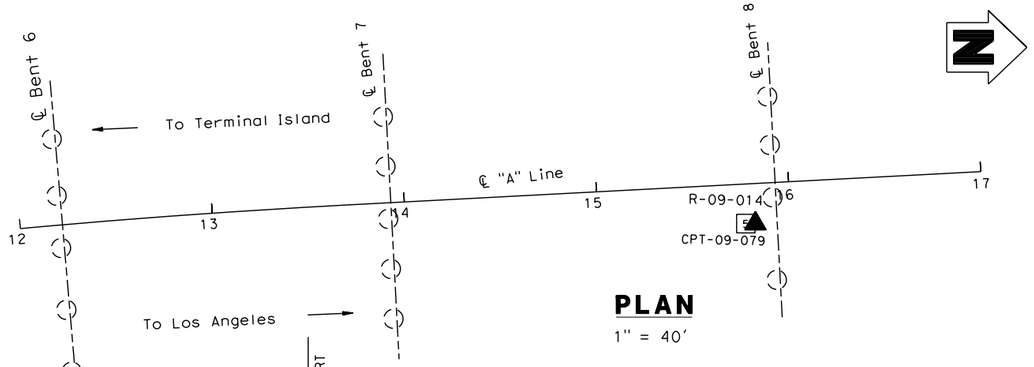
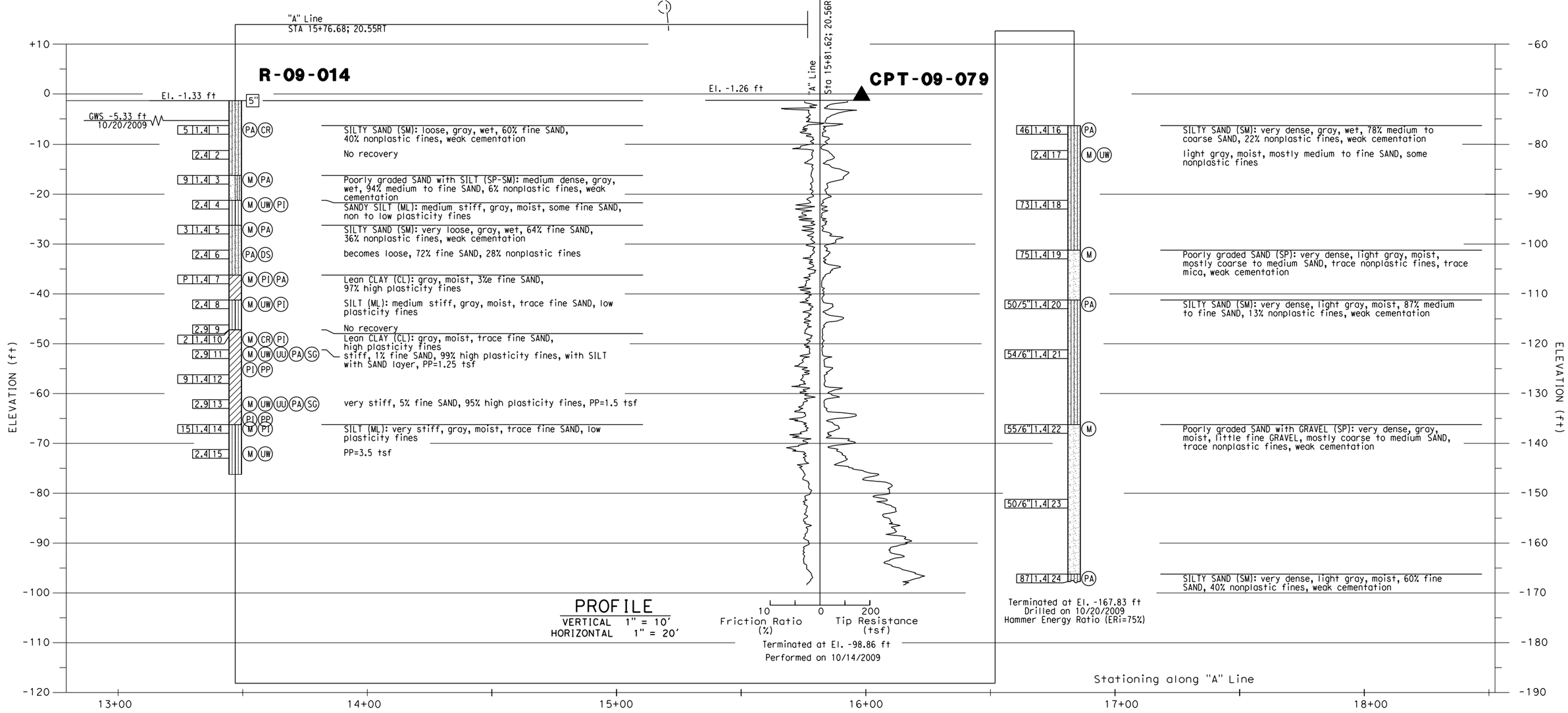


PLAN
1" = 40'



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 13 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

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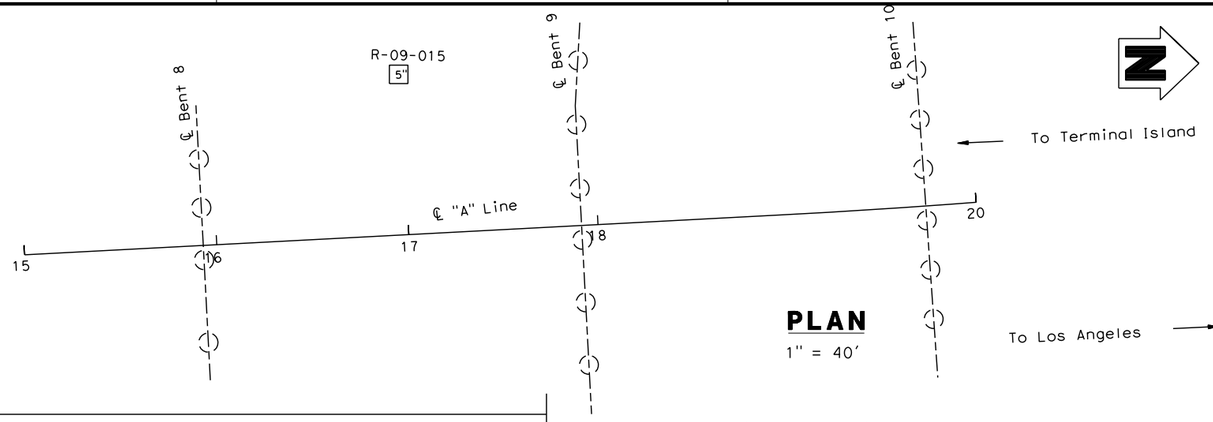

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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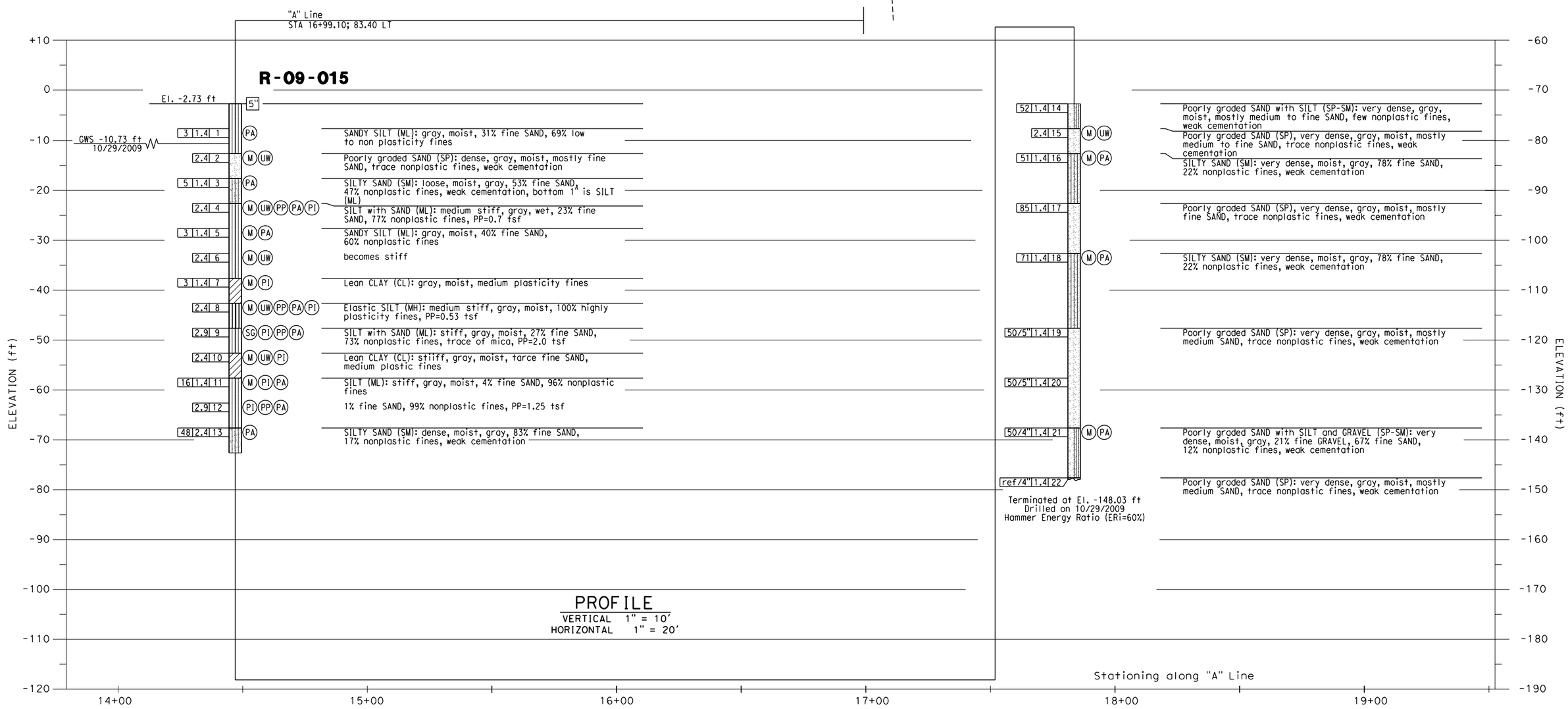
ACTA
ONE CIVIC PLAZA. SUITE 350.
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 14 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
02/08/10	03/24/10								X	X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

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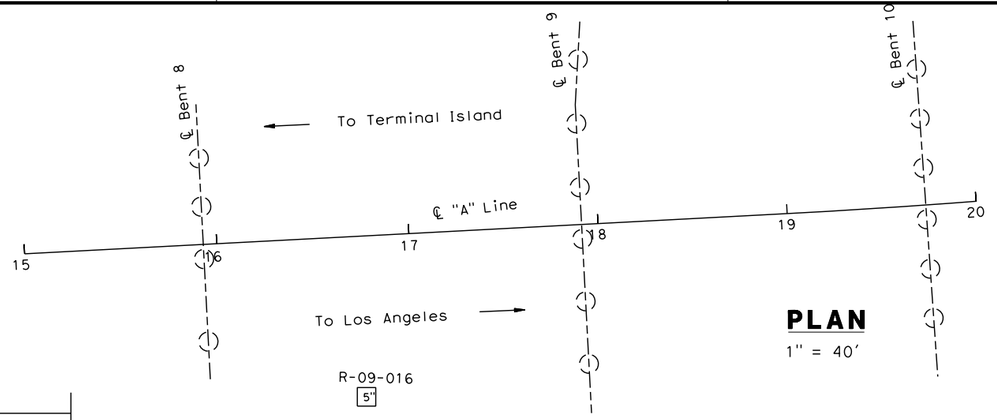

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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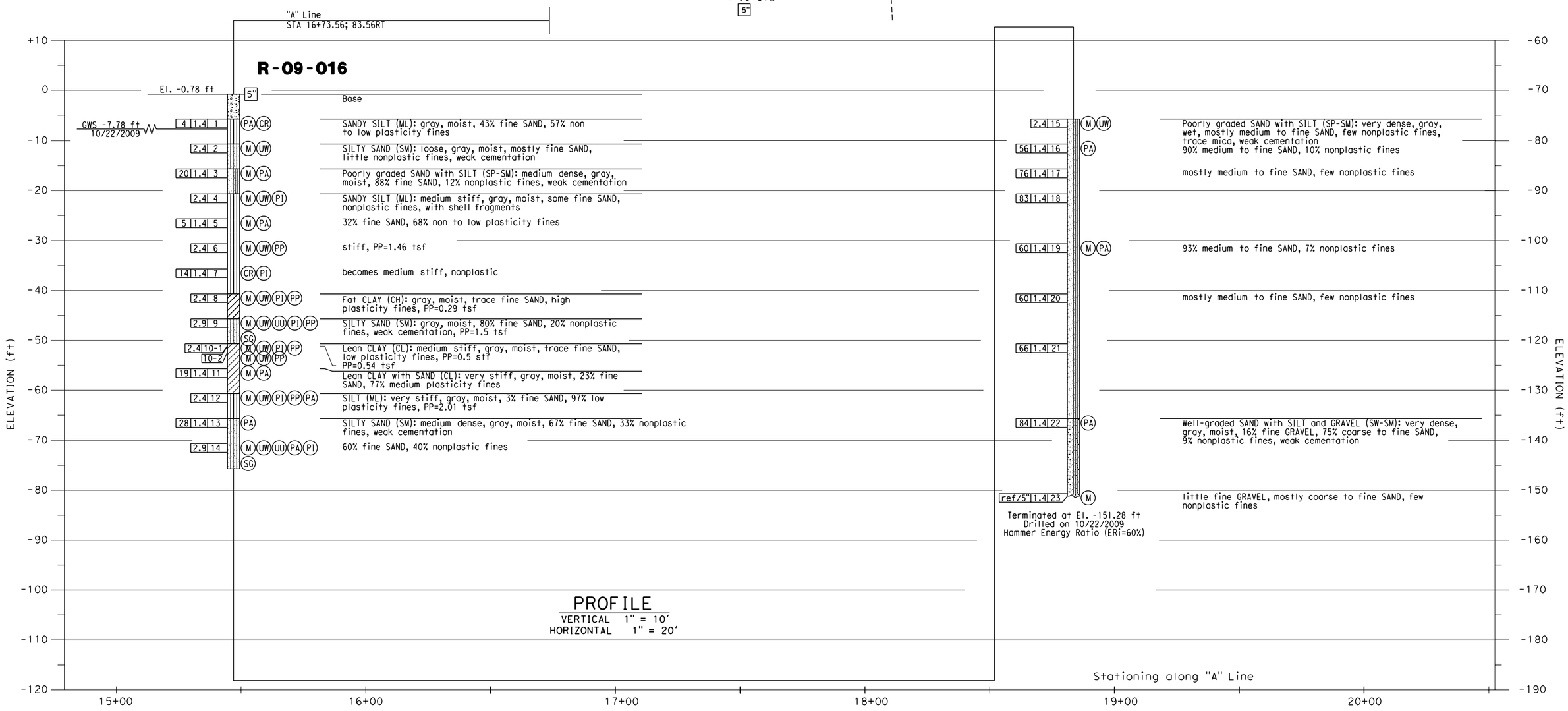
ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 15 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA. SUITE 350.
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

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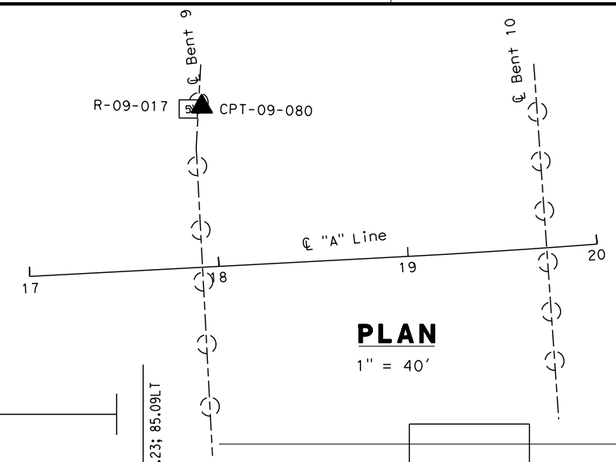
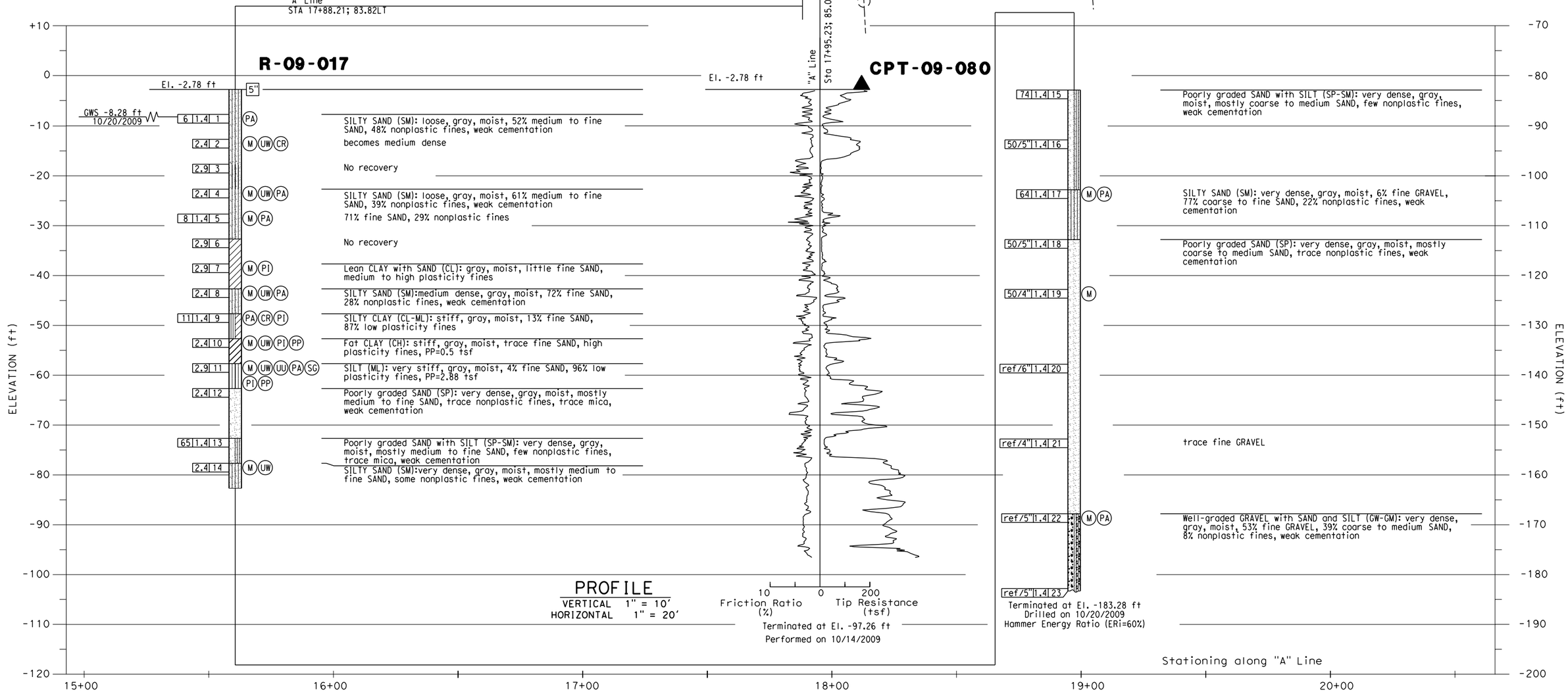


PLAN
1" = 40'



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 16 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

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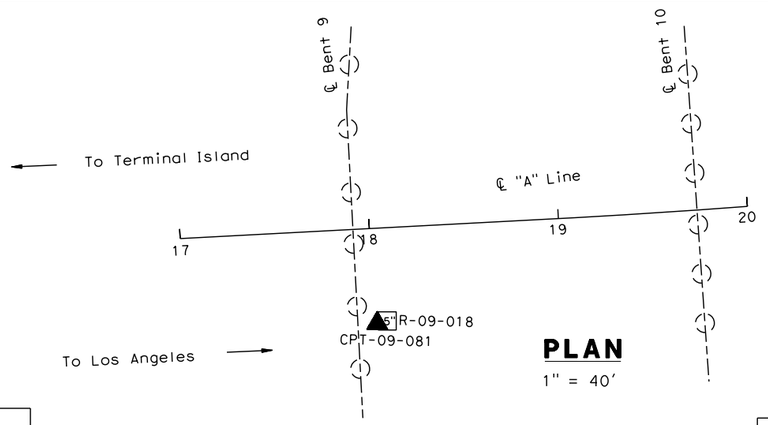

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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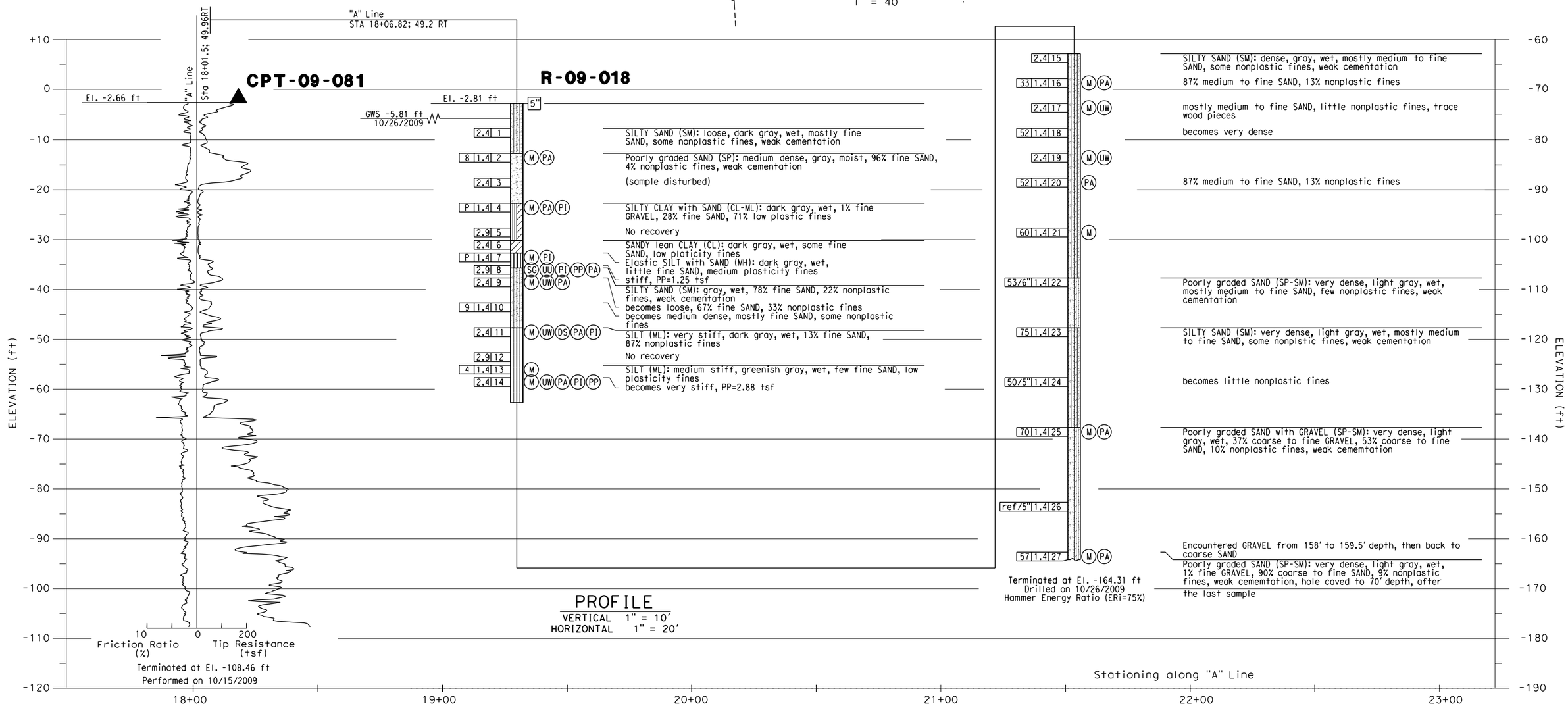
ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant			POST MILE 3.58	LOG OF TEST BORINGS NO. 17 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-523	PT-533
SET + WALK	SET REBAR
86.853'Rt ℄ "A"Line	85.280'Lt ℄ "A" Line
Sta. 29+3.99	Sta. 22+43.67
N 1736450.01	N 1736766.95
E 6489057.72	E 6488855.46
Elev. = 1.26	Elev. = 11.56

NOTES:

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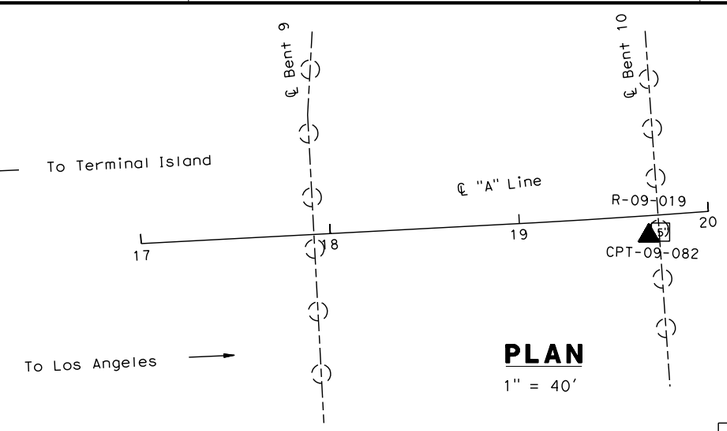

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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ACTA
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CARSON, CA 90745

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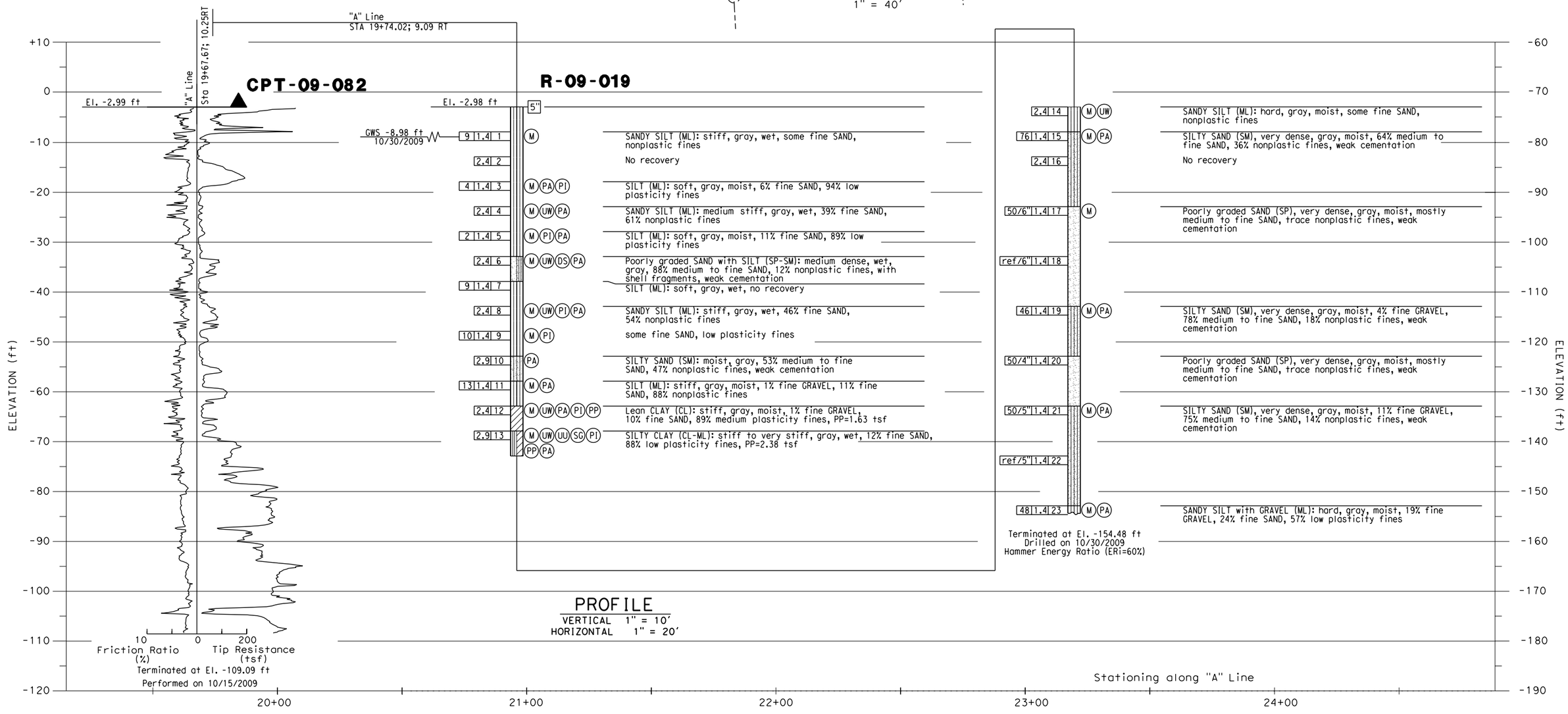
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 18 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

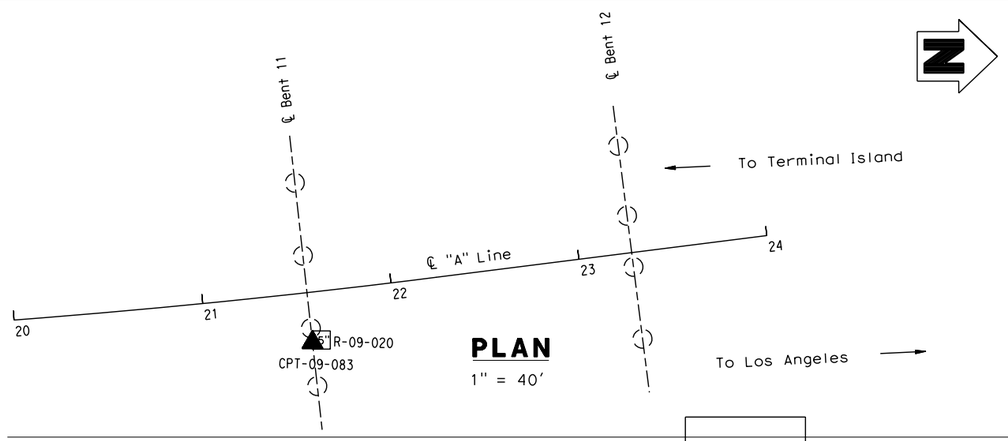
PT-523	PT-533
SET + WALK	SET REBAR
86.853'Rt ℄ "A"Line	85.280'Lt ℄ "A" Line
Sta. 29+3.99	Sta. 22+43.67
N 1736450.01	N 1736766.95
E 6489057.72	E 6488855.46
Elev. = 1.26	Elev. = 11.56

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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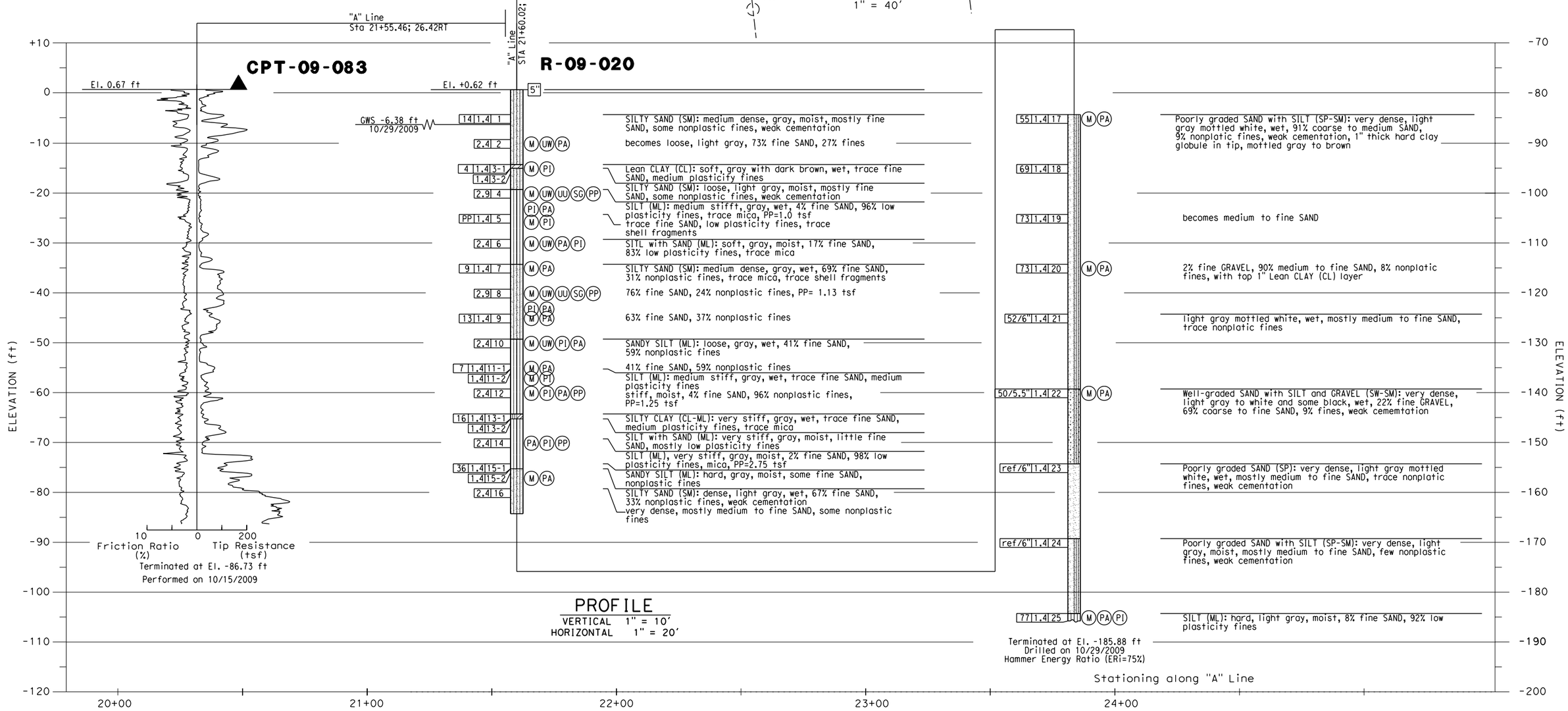
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY: R. Jie	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032 / POST MILE 3.58
SIGN OFF DATE	CHECKED BY: K. Pratheepan				

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 19 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

BENCHMARKS:

PT-523	PT-533
SET + WALK	SET REBAR
86.853'Rt ℄ "A"Line	85.280'Lt ℄ "A" Line
Sta. 29+3.99	Sta. 22+43.67
N 1736450.01	N 1736766.95
E 6489057.72	E 6488855.46
Elev. = 1.26	Elev. = 11.56

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

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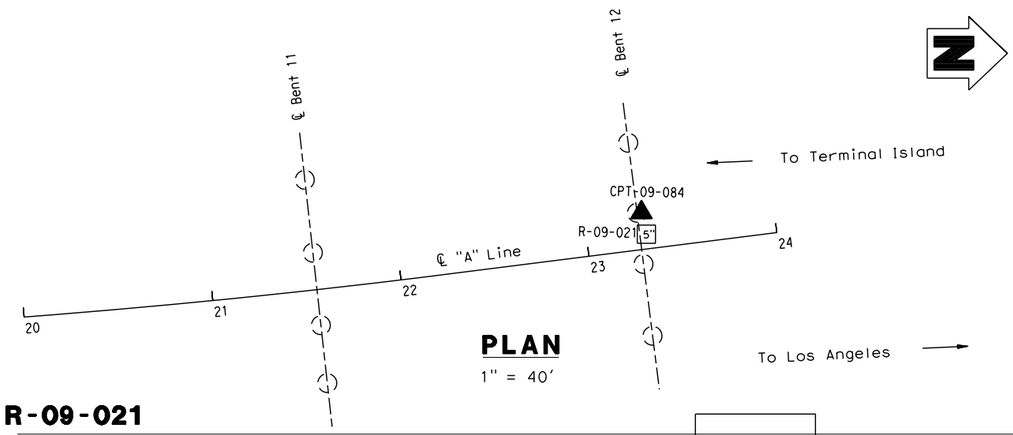
(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.9.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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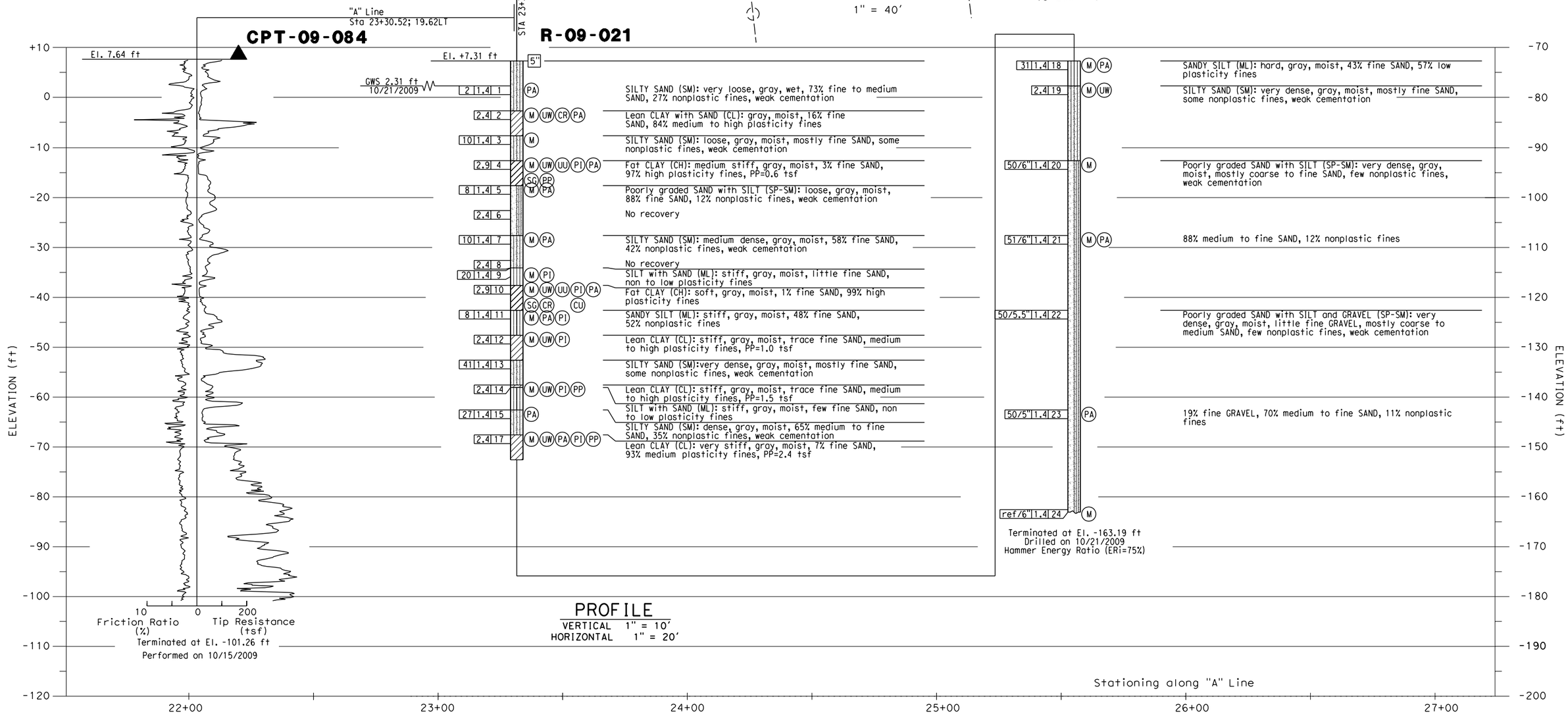
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 20 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-535	PT-86000
SET REBAR	TBM SOUTH SIDE
52.253' Lt ℄ "A"Line	121.813' Lt ℄ "A" Line
Sta. 24+66.03	Sta. 24+66.03
N 1736991.65	N 1736960.63
E 6488860.38	E 6488794.18
Elev. = 8.08	Elev. = 13.38

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

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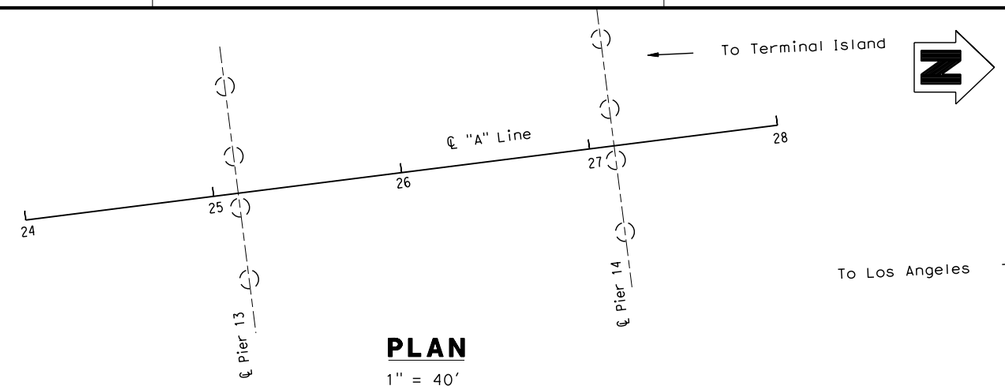

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIL PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

WR-09-041
5.5'

"A" Line
STA 25+13.2 ±; 125.6 RT ±

WR-09-041

El. -37.0 ft

3 | 1.4 | 1	M PA	5.5'		SILTY SAND (SM): very loose, dark greenish gray, wet, 1% shell fragments, 58% medium to fine SAND, 41% non to low plasticity fines, weak cementation, trace mica
1 | 1.4 | 2	M PA			1% shell fragments, 78% medium to fine SAND, 21% nonplastic fines
2.4 | 3	M PA			Poorly-graded SAND with SILT (SP-SM): loose, dark greenish gray, wet, 89% medium to fine SAND, 11% nonplastic fines, weak cementation, trace mica
8 | 1.4 | 4-1				Lean CLAY with SAND (CL): stiff, gray, moist, 15% fine SAND, 85% medium plasticity fines, trace mica
1.4 | 4-2	M PA PI			
2.4 | 5	M UW DS			SANDY SILT (ML): stiff, gray, moist, some fine SAND, low plasticity fines
15 | 1.4 | 6-1	M PA PI			Lean CLAY (CL): very stiff, gray, moist, 2% fine SAND, 98% medium plasticity fines, trace mica
1.4 | 6-2	CR			
2.4 | 7	M UW PA			SILT with SAND (ML): very stiff, gray, moist, little fine SAND, low plasticity fines
23 | 1.4 | 8	PA			SANDY SILT (ML): hard, gray, moist, 43% fine SAND, 57% low plasticity fines 48% fine SAND, 52% low plasticity fines
2.4 | 9	M UW			Poorly graded SAND with SILT (SP-SM): very dense, gray, moist, mostly medium to fine SAND, few nonplastic fines, weak cementation
92 | 1.4 | 10	PA			90% medium to fine SAND, 10% nonplastic fines
2.4 | 11	M UW			mostly coarse to fine SAND, few nonplastic fines
82 | 1.4 | 12				
83 | 1.4 | 13	M PA			2% fine GRAVEL, 87% coarse to fine SAND, 11% nonplastic fines
77 | 1.4 | 14				SILTY SAND (SM): very dense, gray, wet, mostly medium to fine SAND, little nonplastic fines, trace mica, weak cementation
98 | 1.4 | 15				Poorly graded SAND (SP): very dense, gray, moist, mostly coarse to medium SAND, trace nonplastic fines, weak cementation
87 | 1.4 | 16	M PA			SILTY SAND with GRAVEL (SM): very dense, gray, moist, 30% coarse to fine GRAVEL, 57% medium to fine SAND, 13% nonplastic fines, weak cementation
54 | 1.4 | 17				Poorly graded SAND with SILT and GRAVEL (SP-SM): very dense, gray, wet, little coarse to fine GRAVEL, mostly coarse to medium SAND, few nonplastic fines, weak cementation
98 | 1.4 | 18				
ref/4" | 1.4 | 19	M PA			39% coarse to fine GRAVEL, 50% coarse to fine SAND, 11% nonplastic fines
ref/6" | 1.4 | 20				
83/10" | 1.4 | 21	M PA			SILT with SAND (ML): hard, gray, moist, 12% fine SAND, 88% nonplastic fines
50/6" | 1.4 | 22-1	M			Lean CLAY with SAND (CL): hard, gray, moist, little fine SAND, medium plasticity fines
1.4 | 22-2				SILTY SAND (SM): very dense, gray, moist, mostly fine SAND, some nonplastic fines, trace mica, weak cementation
50/5" | 1.4 | 23				
50/4" | 1.4 | 24	M PA			Well-graded SAND with SILT (SW-SM): very dense, gray, wet, 1% fine GRAVEL, 89% coarse to fine SAND, 10% nonplastic fines, weak cementation
50/5" | 1.4 | 25				Poorly graded SAND with SILT (SP-SM): very dense, gray, moist, little fine GRAVEL, mostly medium to coarse SAND, few nonplastic fines, weak cementation
55 | 1.4 | 26-1	PA			88% medium to fine SAND, 12% nonplastic fines
1.4 | 26-2	M PI			SILT (ML): hard, gray, moist, trace fine SAND, medium plasticity fines
50/4" | 1.4 | 27	M PA			Poorly graded SAND (SP): very dense, gray, moist, 98% coarse to fine SAND, 2% nonplastic fines, weak cementation

Terminated at El. -222.8 ft
Drilled from 11/09/2009 to 11/10/2009
Hammer Energy Ratio (ERi=80%)

PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

ELEVATION (ft): -30, -40, -50, -60, -70, -80, -90, -100, -110, -120, -130, -140, -150, -160 / -120, -130, -140, -150, -160, -170, -180, -190, -200, -210, -220, -230, -240, -250

Stationing along "A" Line
24+00, 25+00, 26+00, 27+00, 28+00, 29+00

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant		PROJECT ENGINEER	POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 21 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10, 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-535	PT-86000
SET REBAR	TBM SOUTH SIDE
52.253' Lt ℄ "A"Line	121.813' Lt ℄ "A" Line
Sta. 24+66.03	Sta. 24+66.03
N 1736991.65	N 1736960.63
E 6488860.38	E 6488794.18
Elev. = 8.08	Elev. = 13.38

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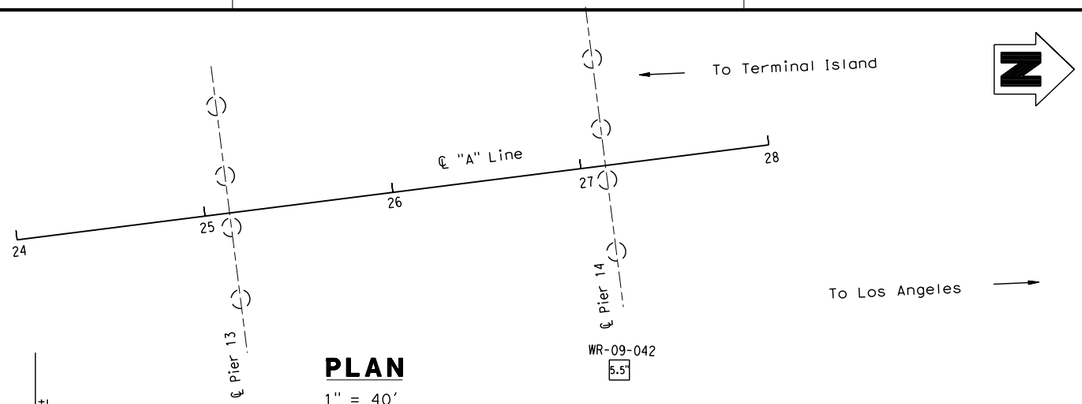
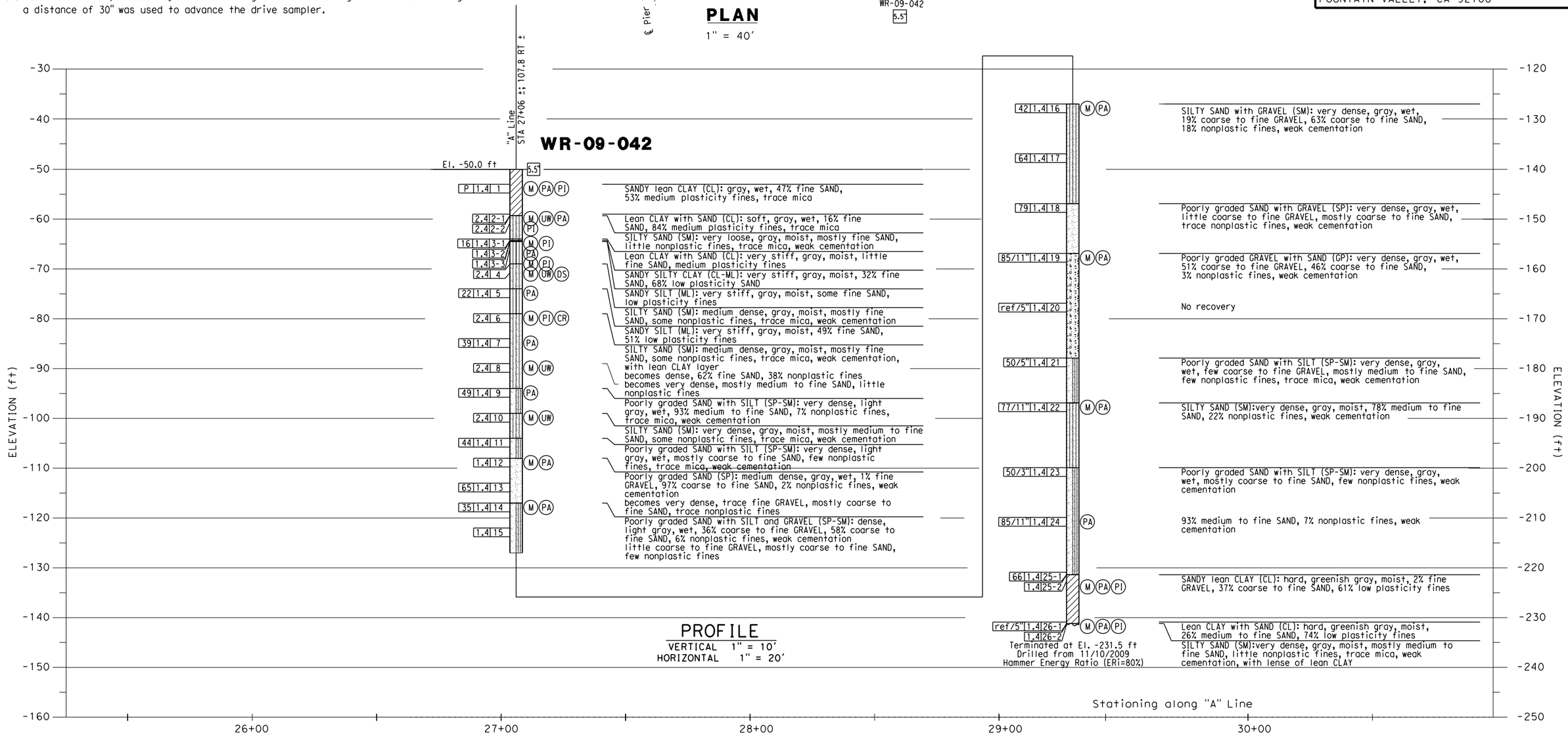


PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032 / POST MILE 3.58
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant			

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 22 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-516	PT-517
SET REBAR	SET MAG NAIL
116.456' Lt ℄ "A"Line	63.606' Lt ℄ "A" Line
Sta. 33+50.41	Sta. 32+19.25
N 1737861.02	N 1737737.54
E 6488685.90	E 6488754.76
Elev. = -2.56	Elev. = 9.21

NOTES:

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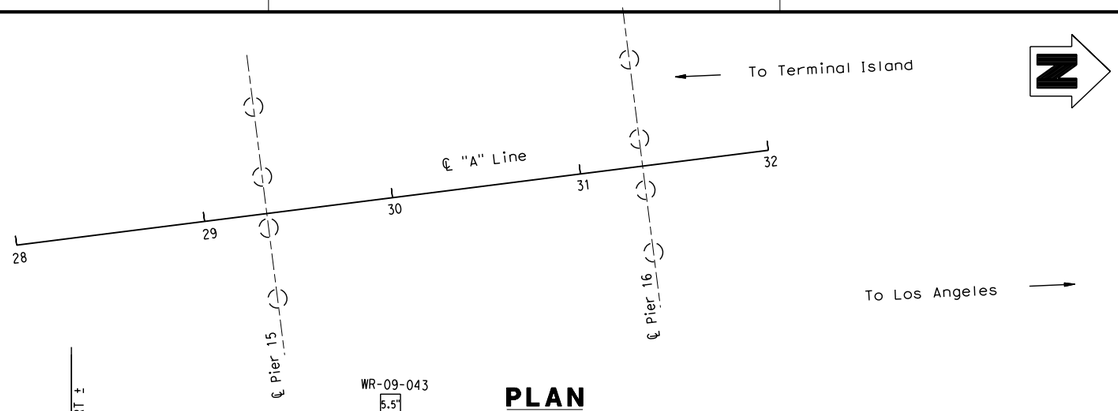
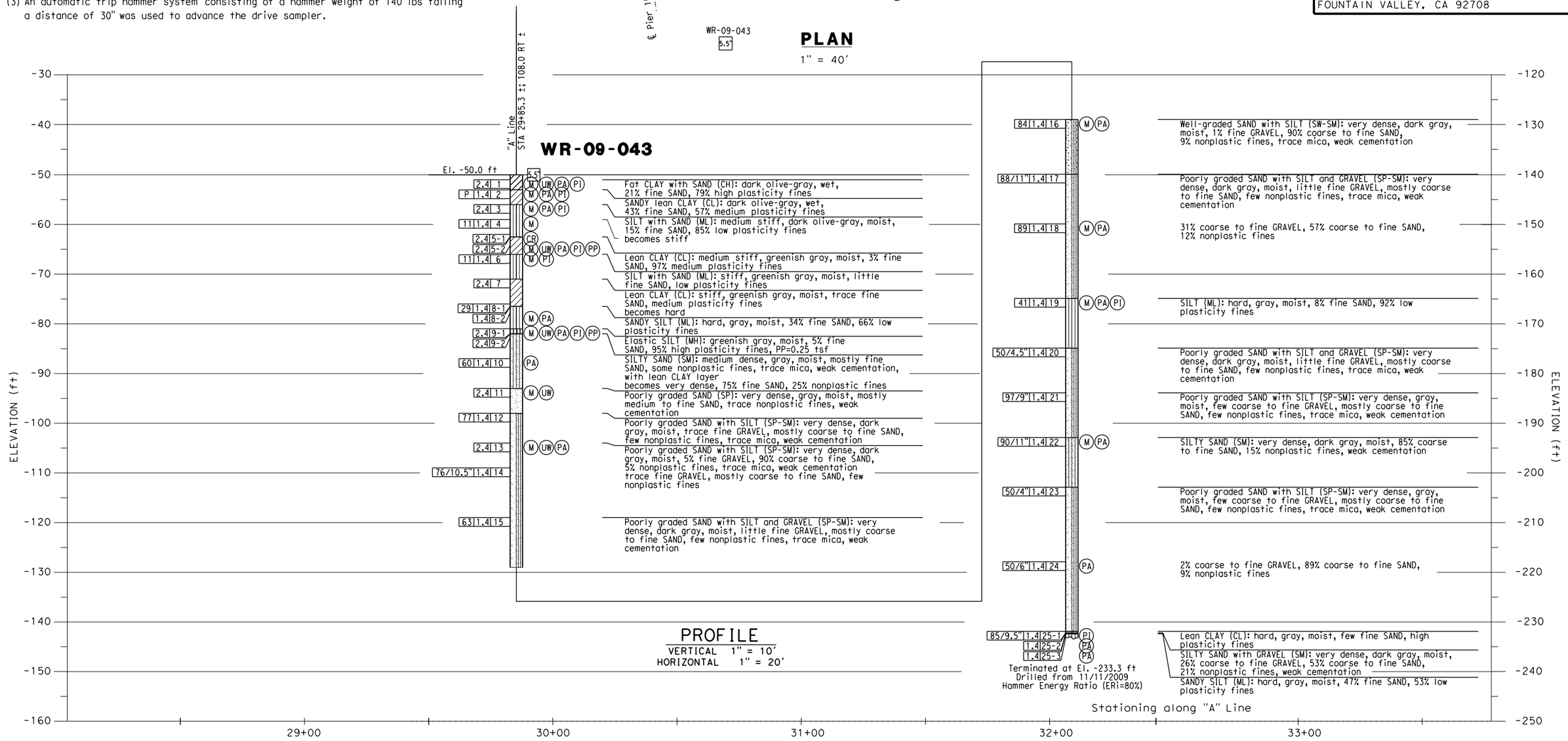


PLAN

1" = 40'



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER
G. J. Gunaranjan
No. C71758
Exp. 12-31-11
CIVIL
STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
K. Thant

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

CU 07
EA 238501

BRIDGE NO. 53-3032
POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 23 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-516	PT-517
SET REBAR	SET MAG NAIL
116.456' Lt ℄ "A"Line	63.606' Lt ℄ "A" Line
Sta. 33+50.41	Sta. 32+19.25
N 1737861.02	N 1737737.54
E 6488685.90	E 6488754.76
Elev. = -2.56	Elev. = 9.21

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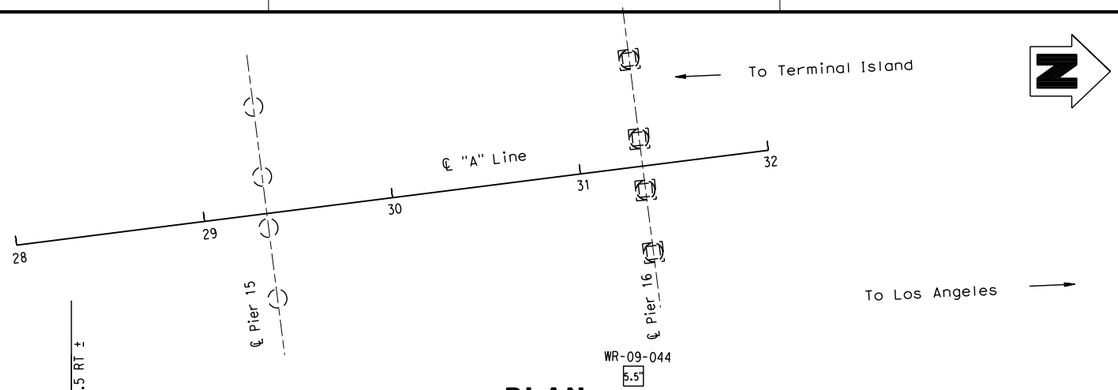
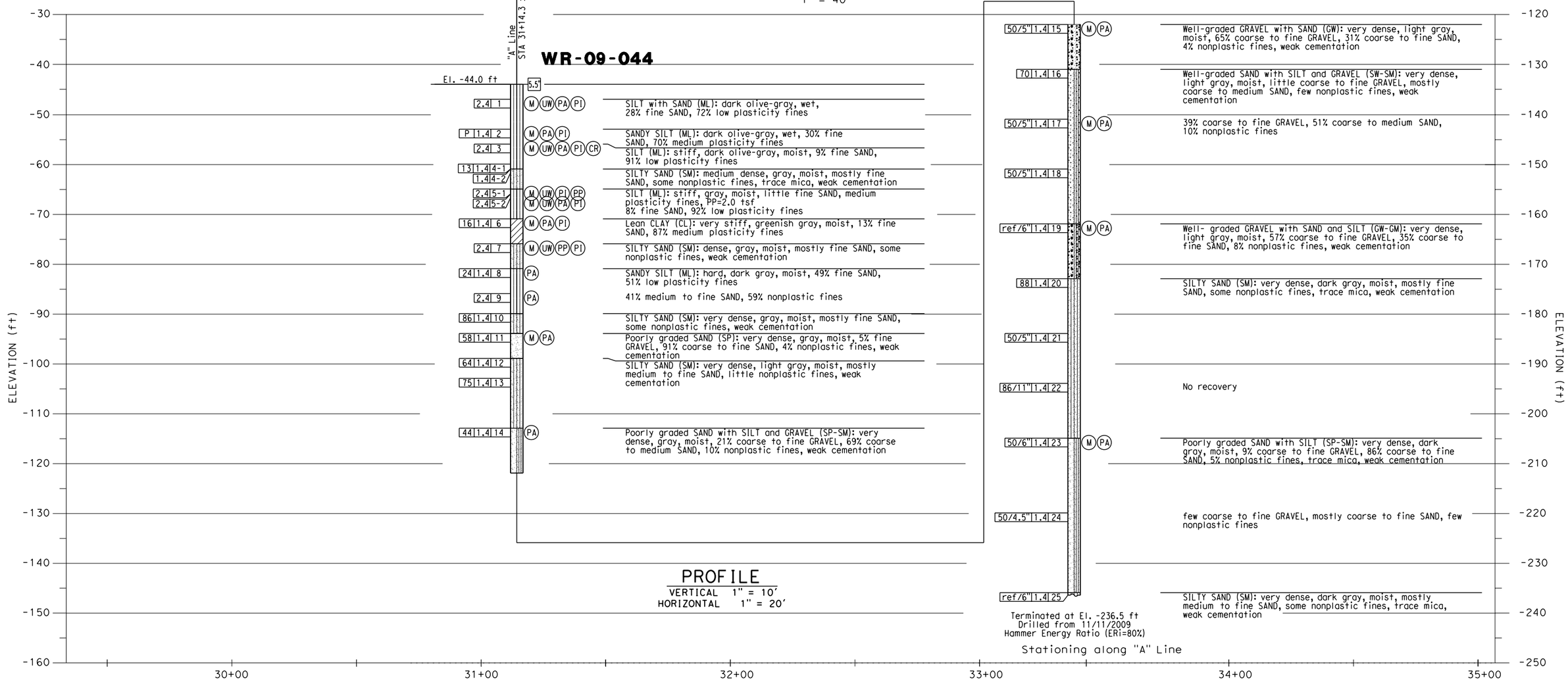


PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan, PROJECT ENGINEER	BRIDGE NO. 53-3032 / POST MILE 3.58
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant			SCHUYLER HEIM BRIDGE (REPLACE)
					LOG OF TEST BORINGS NO. 24 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-516	PT-517
SET REBAR	SET MAG NAIL
116.456' Lt ℄ "A"Line	63.606' Lt ℄ "A" Line
Sta. 33+50.41	Sta. 32+19.25
N 1737861.02	N 1737737.54
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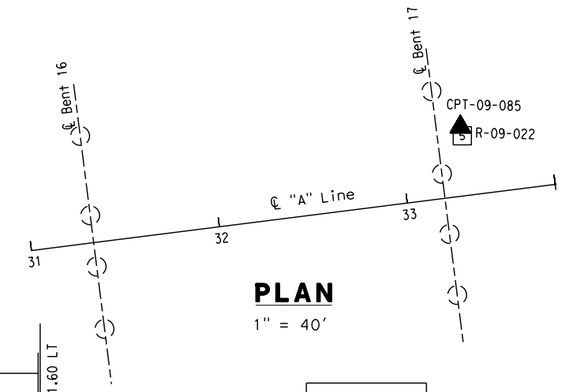
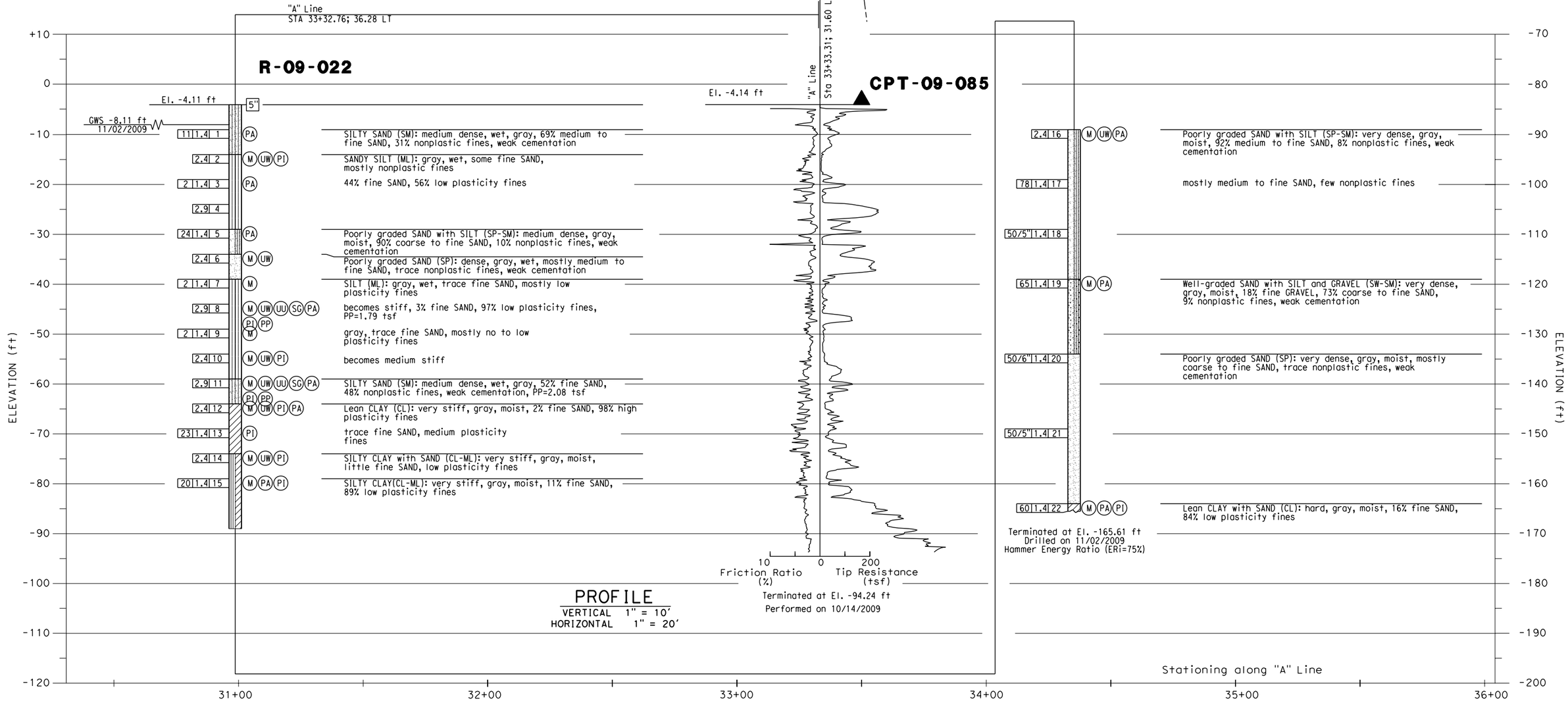


PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER G. J. Gunaranjan No. C71758 Exp. 12-31-11 CIVIL STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY: J. Fang
CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
R. Jie

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

BRIDGE NO. 53-3032
POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)
LOG OF TEST BORINGS NO. 25 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →
REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

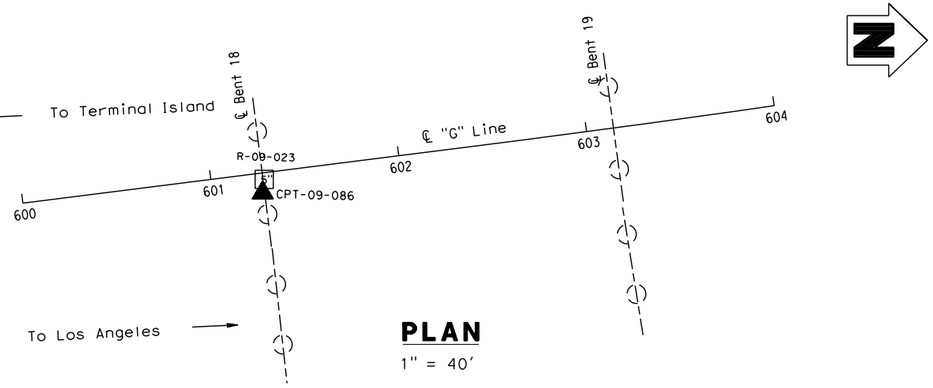
PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671′ Lt ℄ "G"Line	28.517′ Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

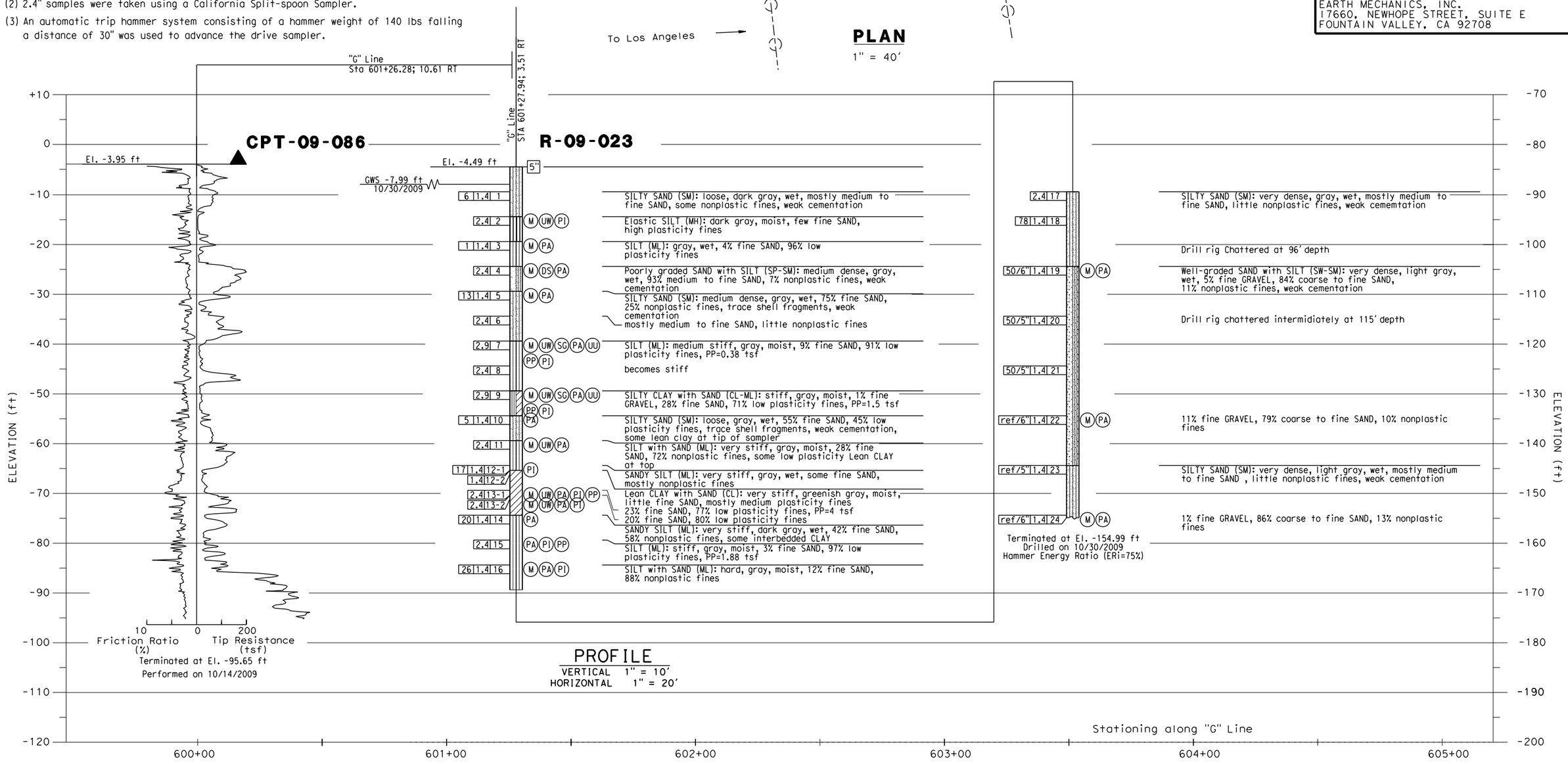
(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40′



PROFILE
VERTICAL 1" = 10′
HORIZONTAL 1" = 20′

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 26 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.8.80 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

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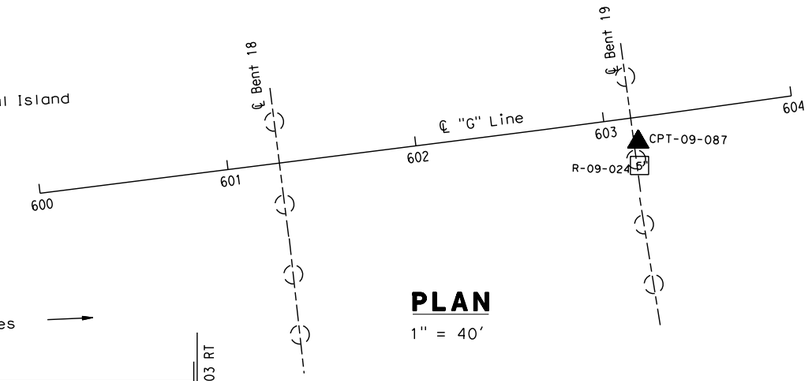
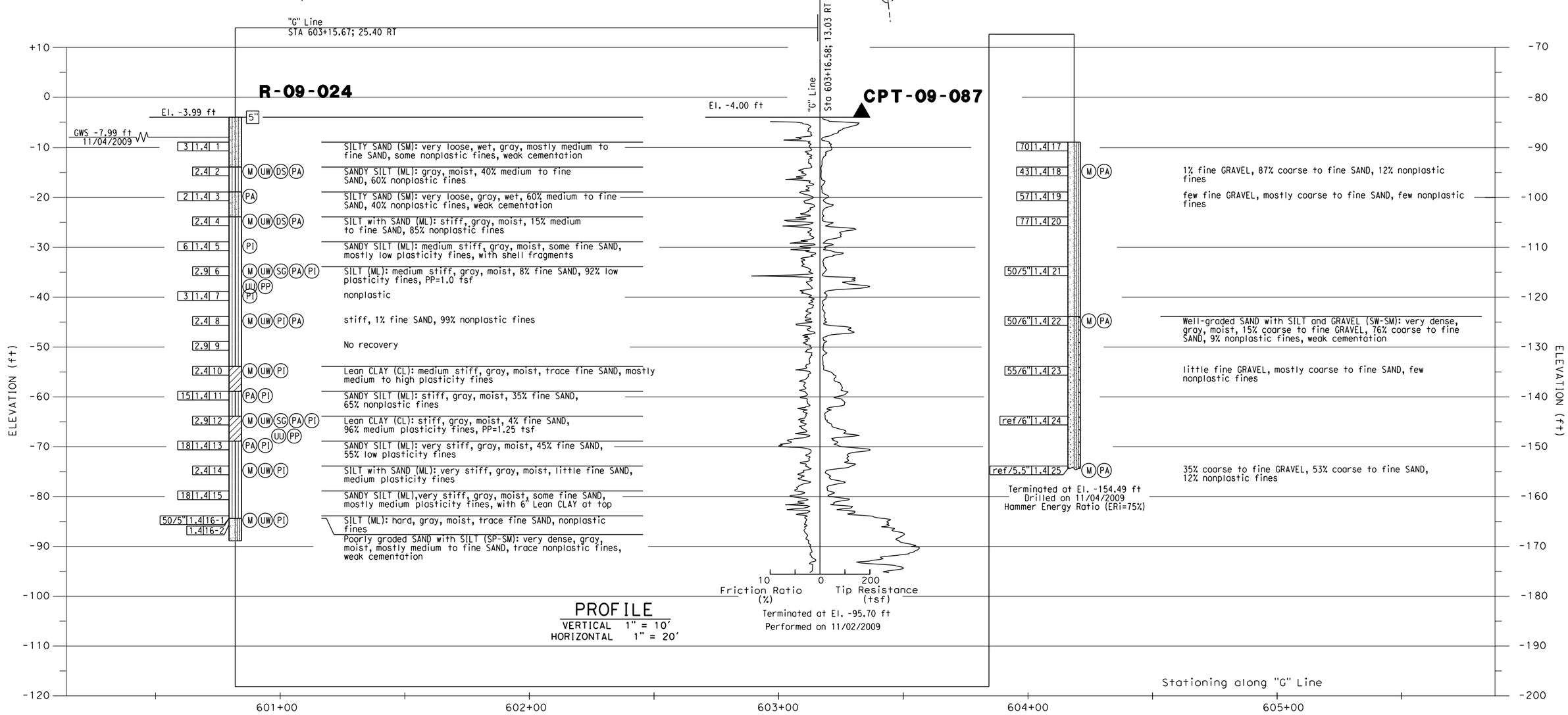


PLAN
1" = 40'



PROFILE
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HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan, PROJECT ENGINEER	BRIDGE NO. 53-3032 / POST MILE 3.58
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 27 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

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Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

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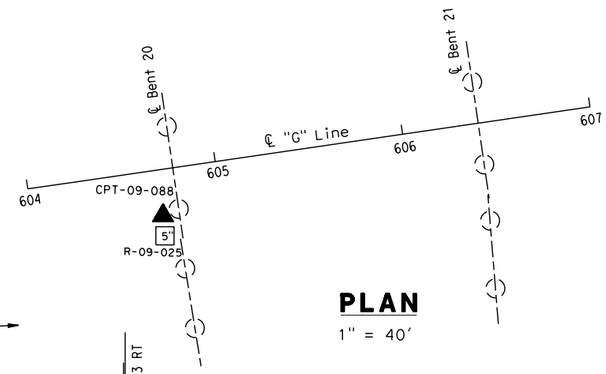

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

G. J. Gunaranjan No. C71758 Exp. 12-31-11 CIVIL — REGISTERED PROFESSIONAL ENGINEER — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
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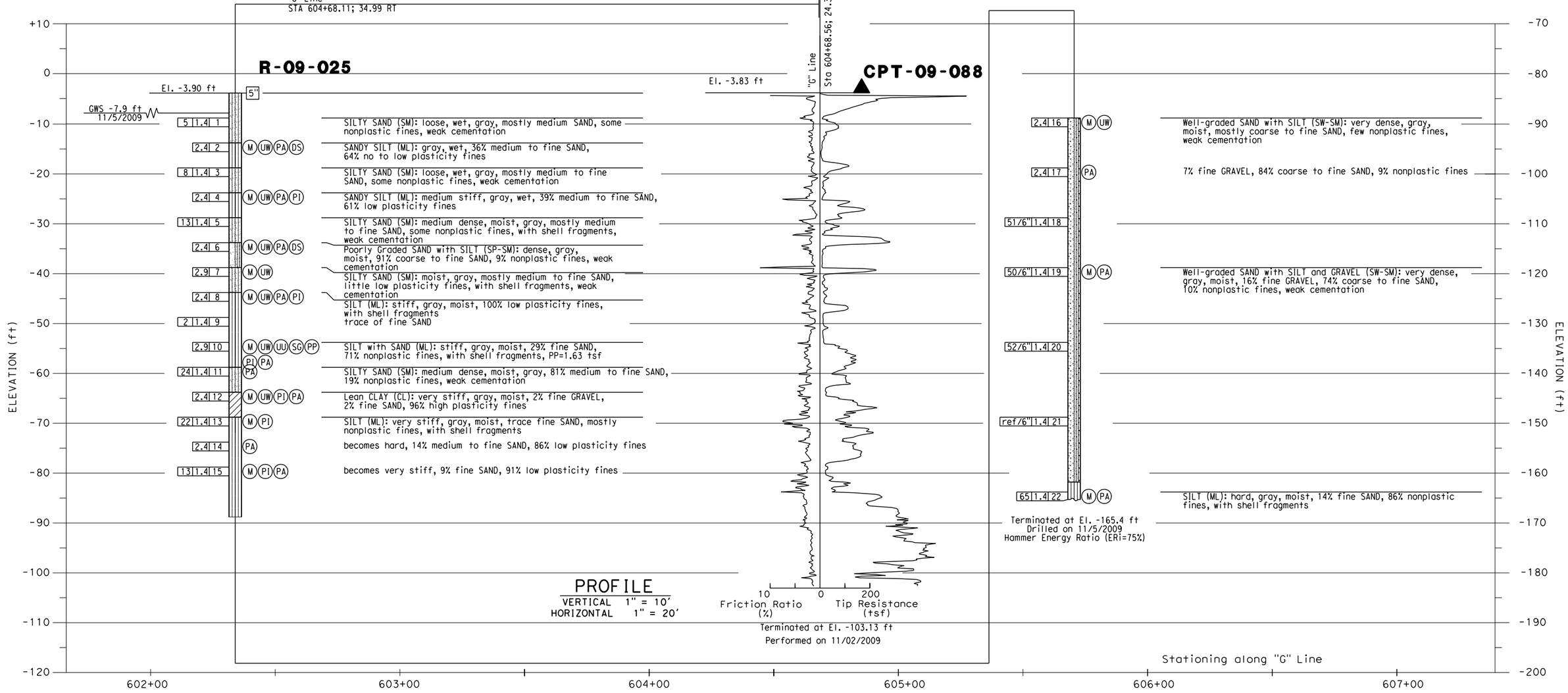
EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 28 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-508	PT-513
SET MAG NAIL	SET PUN SPK
59.862' Rt ℄ "G"Line	5.264' Rt ℄ "G" Line
Sta. 611+10.34	Sta. 609+51.88
N 1739008.13	N 1738843.39
E 6488683.32	E 6488642.44
Elev. = 12.18	Elev. = -3.62

NOTES:

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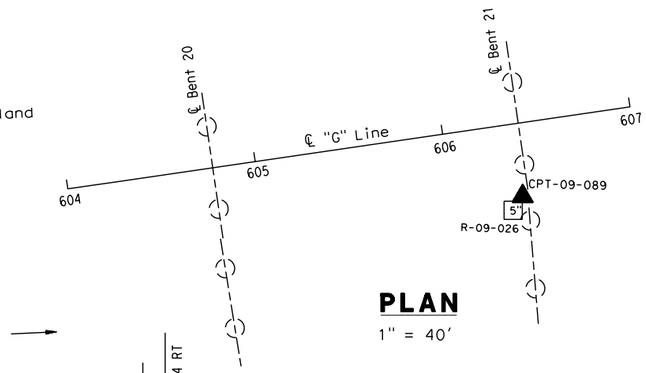
(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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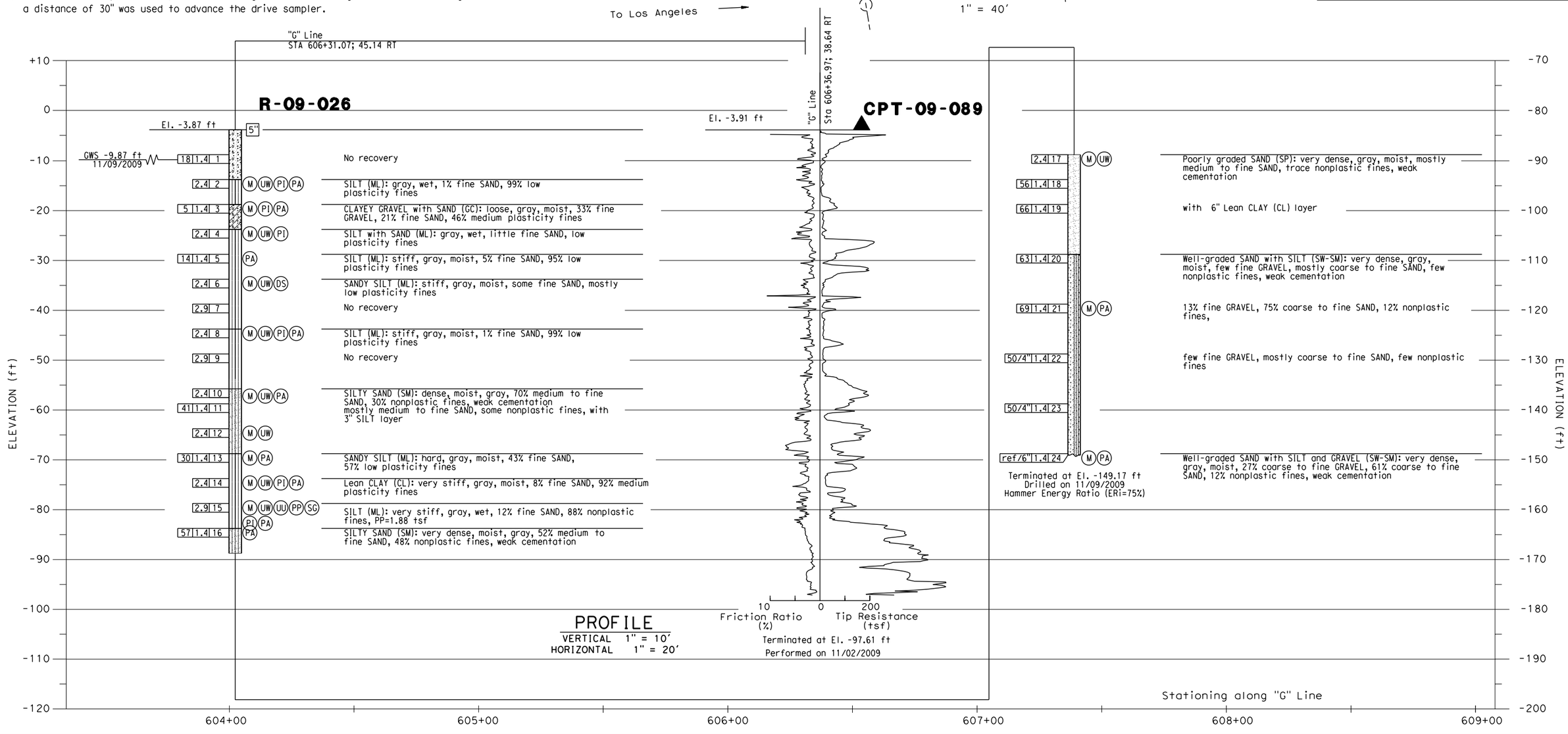
ACTA
ONE CIVIC PLAZA. SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)	
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.58	LOG OF TEST BORINGS NO. 29 OF 34	

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

BENCHMARKS:

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Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

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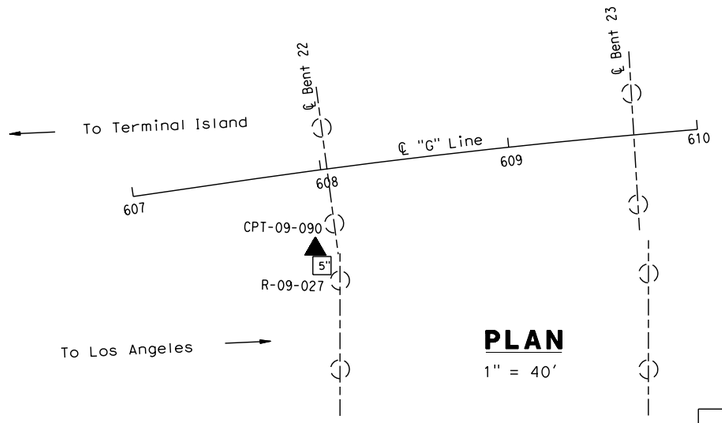

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan, No. C71758, Exp. 12-31-11, CIVIL, STATE OF CALIFORNIA

PLANS APPROVAL DATE

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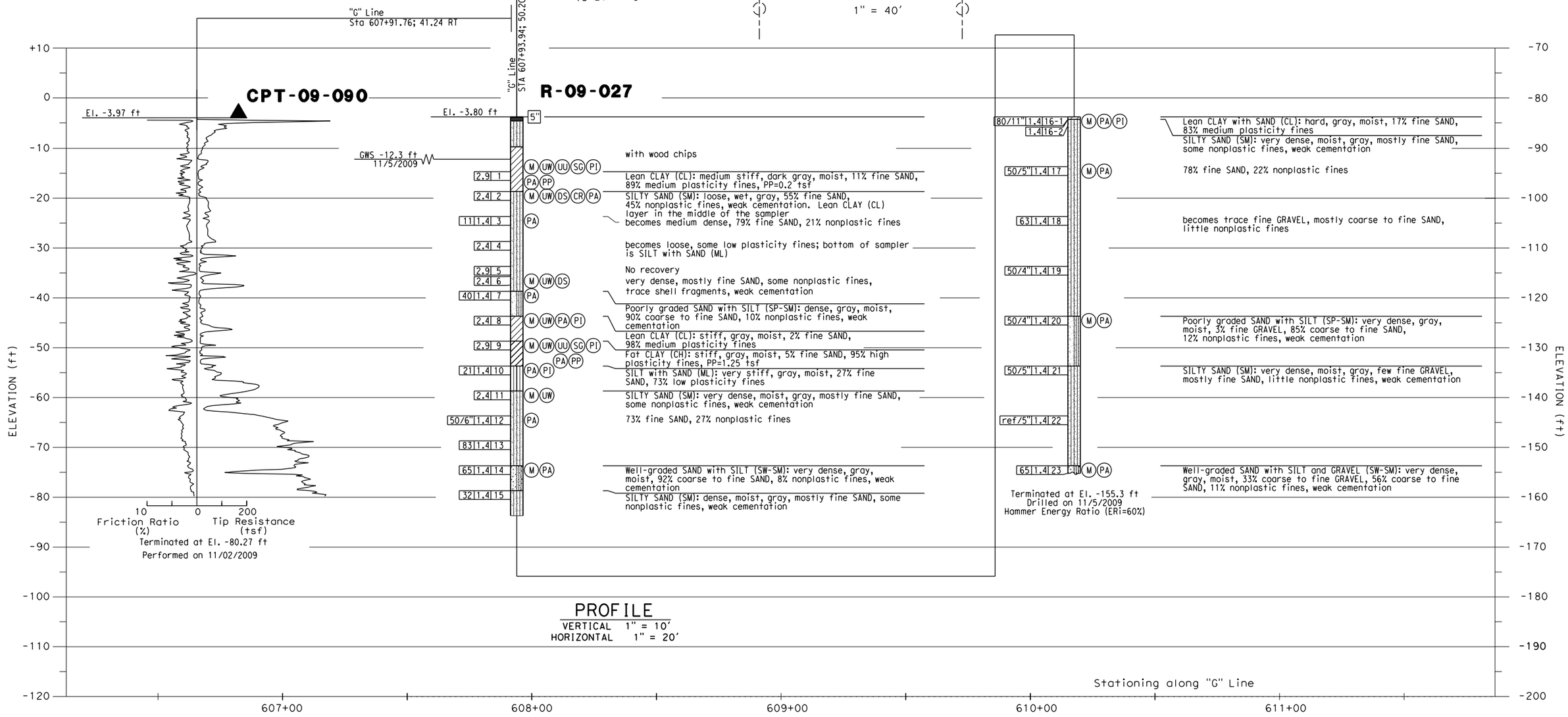
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
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DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan, PROJECT ENGINEER	BRIDGE NO. 53-3032	SCHUYLER HEIM BRIDGE (REPLACE)
SIGN OFF DATE	CHECKED BY: K. Pratheepan	K. Thant			POST MILE 3.58	LOG OF TEST BORINGS NO. 30 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

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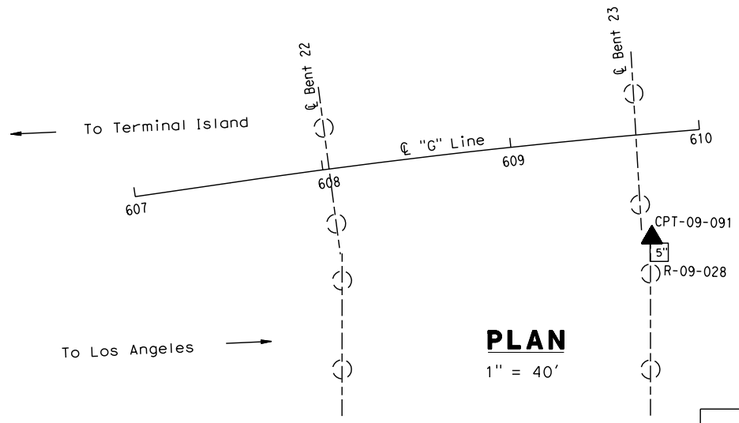

PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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ACTA
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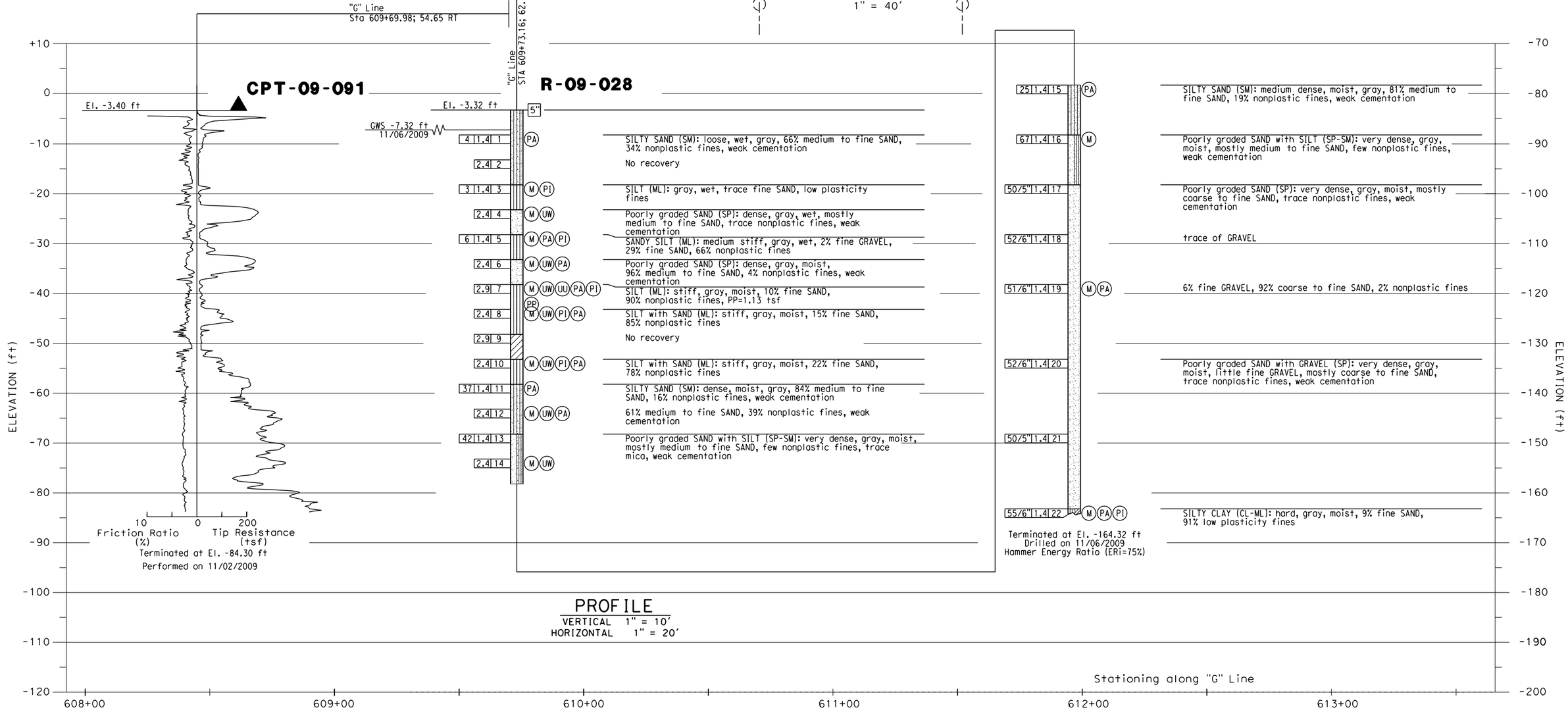
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
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HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY: R. Jie	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032 / POST MILE 3.58
SIGN OFF DATE	CHECKED BY: K. Pratheepan				

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 31 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

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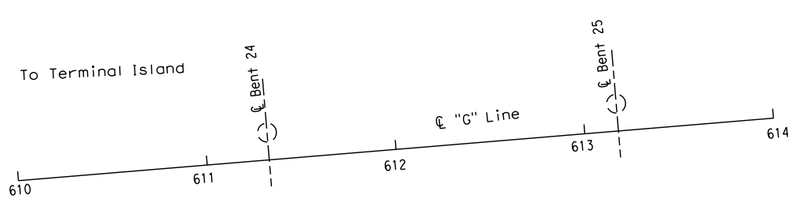

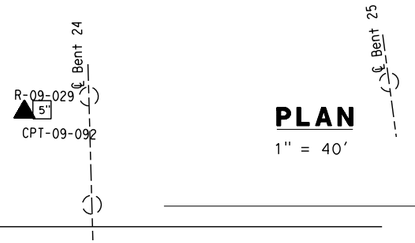

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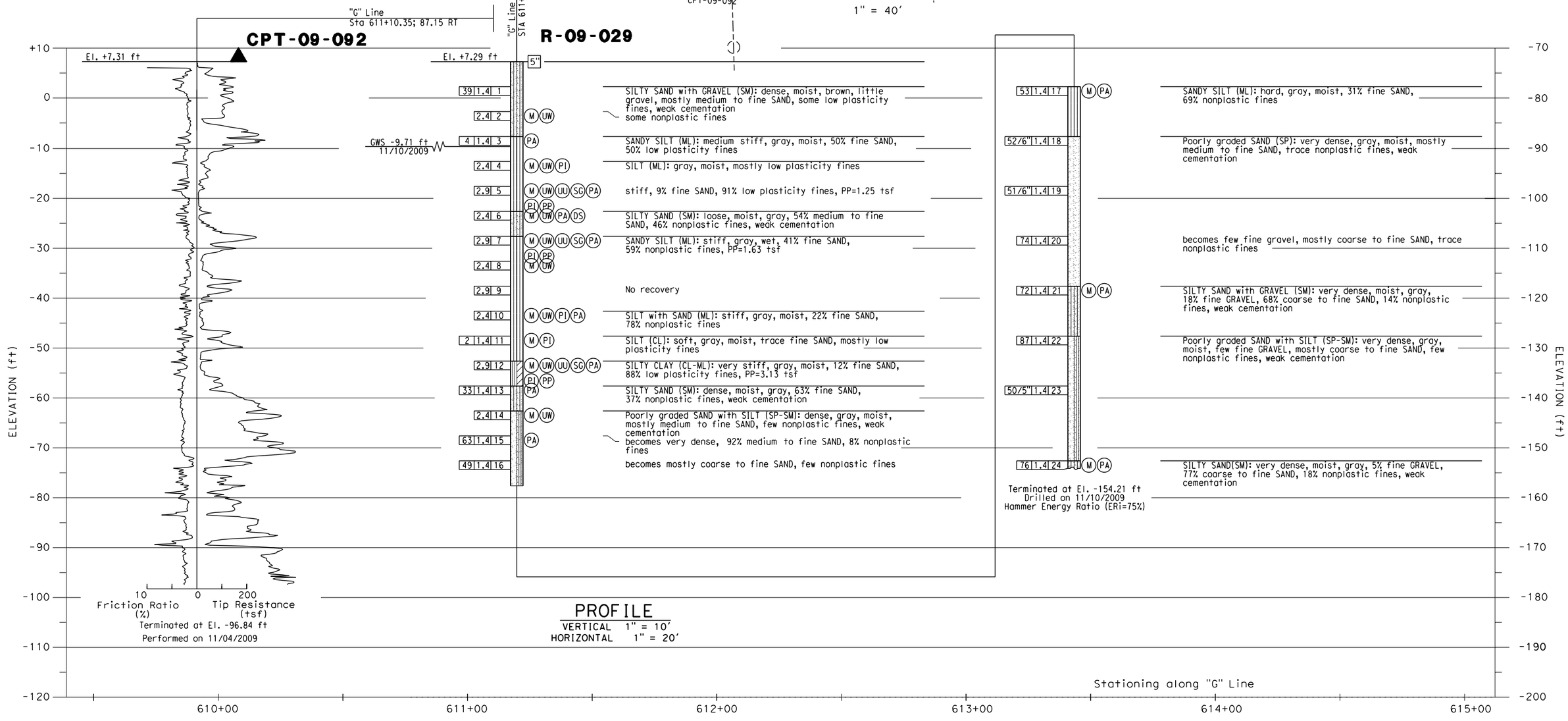

PROFILE

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HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
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8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER
G. J. Gunaranjan
No. C71758
Exp. 12-31-11
CIVIL
STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY: J. Fang
CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
R. Jie

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

BRIDGE NO.	53-3032
POST MILE	3.58

SCHUYLER HEIM BRIDGE (REPLACE)

LOG OF TEST BORINGS NO. 32 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
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8.880 04/19/10
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17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

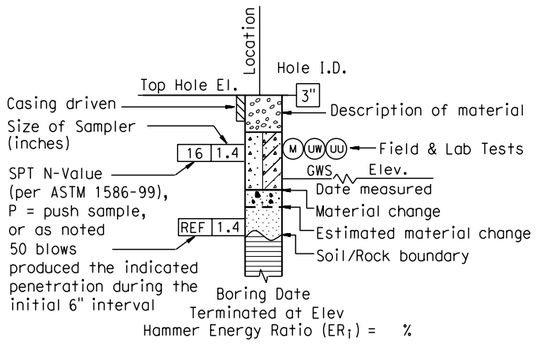
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

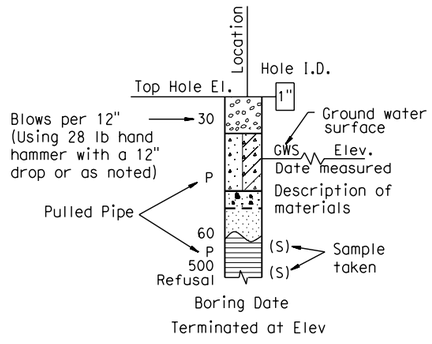
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

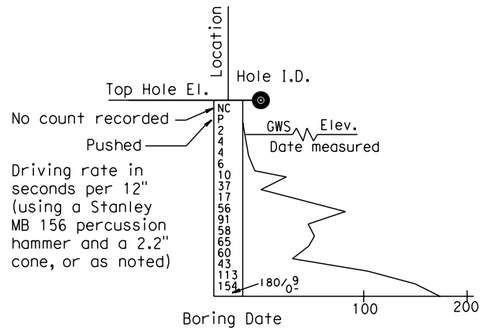
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



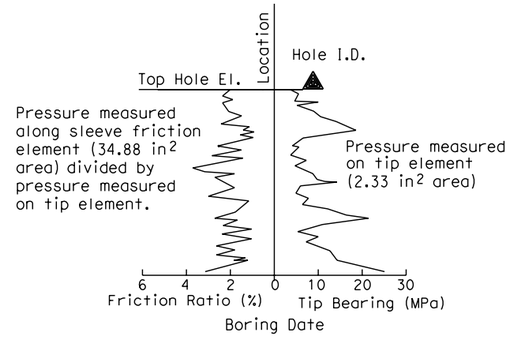
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: R. Jie, K. Thant, E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53-3032 POST MILE 3.58	SCHUYLER HEIM BRIDGE (REPLACE) LOG OF TEST BORINGS NO. 33 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10, 03/24/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.880 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
R. Jie, K. Thant, E. Brown

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

BRIDGE NO. 53-3032
POST MILE 3.58

SCHUYLER HEIM BRIDGE (REPLACE)
LOG OF TEST BORINGS NO. 34 OF 34

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	03/24/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A

SELECTED AS-BUILT PLAN SHEETS FOR SCHUYLER HEIM BRIDGE

VII LA Acc LA18dh I 146

OFF Ramp Profile
Stationing and Grades in Low Gutter

ON Ramp Profile
Stationing and Grades in Low Gutter

℄ Profile

Elevation

Plan

Cross Slope Transition

Superelevation Transition

Typical Sections
Scale 1"=10'-0"

Span Designation

TOTAL LENGTH OF BRIDGE FACE TO FACE OF PAVING NOTCHES = 3975'-10"

LENGTHS ALONG ℄ 17 @ 80' = 1360' | 71' 3@60'=180 84' 3@93'=279' | 700'-0" | 2@93'=186' 6@80'=480' 8@70'=560'

Approximate Ground Line along Freeway ℄

TERMINAL ISLAND

SEASIDE BOULEVARD

ANAHEIM AVENUE

Dock St.

To Terminal Island

OFF Ramp

ON Ramp

Paving Notch OFF Sta. 12+46.58

Paving Notch ON Sta. 8+19.07

Paving Notch Sta. 4+38.98

Paving Notch Sta. 44+64.82

OFF Ramp Sta. 0+00 = Freeway Sta. 28+52.88

ON Ramp Sta. 0+00 = Freeway Sta. 22+60.10

Limit of Contract

Future track

Right of Way for channel purposes

Cerritos Channel

Los Angeles City Boundary

Long Beach City Boundary

Retaining Wall

Sta. 57+00 on Tangent

Sta. 35+42.74 B.C.

Sta. 41+35.42 E.C.

N 4° 52' 04" W

N 3° 32' 04" W

N 7° 17' 04" W

N 70° 57' 47" E

Sta 0+72.47 P.O.T.

Δ = 2° 25' 00"
R = 15,000'
T = 316.39'
L = 632.68'

416,762'

For alignment of gutters between Sta. 20 and 25 see Sheet No. 135

Datum used is USC&GS for Inland work. 0.00= Mean Sea Level

MICROFILMED

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

RECORD DRAWING
SHEET 1 OF 162
SEE LETTER NO. V 13195 DATED 11/20/44

For Index of Plans and General Notes - See Sheet 2

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

TERMINAL ISLAND ACCESS FREEWAY
BRIDGE ACROSS CERRITOS CHANNEL
LOS ANGELES COUNTY
GENERAL PLAN

SCALE: 1"=200' | BRIDGE: 53C-48 | FILE | DRAWING C-1121-200

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTION OF TRANSPORTATION

DATE 3/30/16

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL				

DIST	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	LA	Acc	14-L&A		146

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

DESIGN
DETAILS
QUANTITIES
SPECIFICATIONS

Bent 0 | Bent 1 | Bent 2 | Bent 3 | Bent 4 | Bent 5 | Bent 6 | Bent 7

Abutment 0

Bent 1

Bent 2

Bent 3

Bent 4

Bent 5

Bent 6

Bent 7

Abutment 8

Abutment 0 and Bents 1 to 5, are similar.

AVOCA BOLT LAYOUT

Note: bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141A.

U.P. Well No. 208

B.M. 14-T.1-45 Elev. 3.88
Cut X on painted bolt on E. side of S.E. leg of U.P. office well #208

B.M. 13-T.1-45 Elev. 10.48
Cut X on painted bolt on N.W. leg of U.P. office well #178

Proposed additional Track location

Elev. 147 (Bottom of footing)

70.50

80.000

79.990

79.994

79.985

80.000

79.990

N 7°-17' 04" W

℄ Freeway

℄ Existing Track

℄ S.P.R.R.

Top of rail Elev. 17.6

Bent 0 Sta. 3+91.65

Bent 1 Sta. 3+62.15

Bent 2 Sta. 3+42.15

Bent 3 Sta. 7+22.15

Bent 4 Sta. 8+06.15

Bent 5 Sta. 8+46.15

Bent 6 Sta. 9+32.15

Bent 7 Sta. 10+42.15

16" Steel pipe piles

55' TEST PILES

Note: Footing dimensions, elevations, and pile spacing at Bents 2, 3, 4, 5, 7 & 8 are similar to Bent 1.

FOUNDATION NOTES

Piles in abutments are 14" P.S.73 shell. Length for estimating purposes, 50 ft. Piles in bents 1-6 are cast in timber. Length for estimating purposes, 50 ft. For piles in plans 26, 27, 28 & 29 see Sheet No. 6.

Approach fills not shown.

17-18-19	YEAR	A.S. SPAN LENGTH AS OF 7-15-48	
4-13-49	CHANGED: PILE LENGTHS		13

RECORD DRAWING
SHEET 3 OF 162
SEE LETTER NOY 13195 DATED 11-7-49

Revised on Record, See District Book for data

NAVAL OPERATING BASE TERMINAL ISLAND

416,764

N846 NH-1(3)

SHEET 3 OF 146

BRIDGE ACROSS CERRITOS CHANNEL

FOUNDATION PLAN-ABUTMENT 0 to BENT 8

SCALE 1"=20'-0"

FILE NO.

BRIDGE No. 53L-48

DRAWING No. C 1221-202-3

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

MICROFILMED

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DATED 5/31/16

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

DIST	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	LA	Acc.	LA-Bob 4	1146	

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

BENTS 9-16 INCL.

"OFF" ABUTMENT 5

"ON" ABUTMENT 6

"OFF" BENTS 1-4 INCL.

"ON" BENTS 1-5 INCL.

ANCHOR BOLT LAYOUT

Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141 A.

SERVICE ROAD PLAN
SCALE 1"=50'

"OFF" RAMP

"ON" RAMP

Drainage Ditch

Oiled Road

Note: Footing dimensions, elevation, and pile spacing for Bents 10, 11, 12, 13, & 15, ℄16 are similar to Bent 9.
Footing dimensions and pile spacing for "OFF" Abutment 5 are similar to "ON" Abutment 6.
Footing dimensions, elevation, and pile spacing for ON Bents 2, 3 & 4 and "OFF" Bents 3 & 4 are similar to ON Bent 5 except as noted.

MICROFILMED
MAR 3 0 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 70001372

RECORD DRAWING
SHEET ___ OF ___
SEE LETTER NO. ___ DATED ___

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

5/30/76 Date Verified Gardner Engineer

REV	DATE	DRTR	CHK
1	7-19-46	MEAS SPAN LENGTH AS OF 7-19-46	
2	6-10-46	CHANGE SIZE OF PILE ABUT.	
3	6-10-46	SERVICE ROAD ADDED	

F.A.P. DRAWING NO.	NAVAL OPERATING BASE, TERMINAL ISLAND, SAN PEDRO, CALIFORNIA
416.765	
F.A.P. DRAWING NO.	APPROVED ____ 1943
N.B.&C./M.A.T.C.	
SUPERSEDES	

BRIDGE ACROSS OFFICE ROAD

FOUNDATION PLAN - BENTS 9 TO 16

SCALE 1"=20'-0" FILE NO.

BRIDGE NO. 53C-68 DRAWING NO. 40-1132-1-06

FED. AID PROJ. NO.	STATE	ROUTE NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS NO.
2	CAL.				

DIST.	COUNTY	ROUTE NO.	POST MILES	SHEET NO.	TOTAL SHEETS NO.
VII	SD	5	24.55	126	

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

DESIGN DETAILS CHECKED BY

± OFF Bent 2

± OFF Bent 1

± Bent 17

± OFF Bent 1

± Bent 18

± Bent 19

± Bent 20

± Bent 21

± Bent 22

± Bent 23

± Bent 24

ANCHOR BOLT LAYOUT

Note Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see Sh. No. 141.1.

RECORD DRAWING
SHEET 5 OF 162
SEE LETTER NO. V13195 DATED 1/20/49

OFF Bent 2 Sta 10+12.90

OFF Bent 1 Sta 9+32.28

Bent 17 Sta 13+42.15

Throw track 7" ± Existing Railroad Tracks

± Relocation of Railroad track

Throw track

Bent 19 Sta 16+69.15

Bent 20 Sta 17+37.15

Bent 21 Sta 18+13.15

U.P. Offset Well No 99

Elevation Station

B.M. 11-71-45 Elev. 11.04
Ch. X on painted bolt on W. side of S.W. leg of U.P. well #99.

MICROFILMED MAR 3 0 1976

± ON RAMP

± OFF RAMP

± of FREEWAY

Off Ramp Sta 5+34.55
Freeway Sta. 22+63.10
On Ramp Sta 0+00

Note: Concrete Columns only to be skewed 50° Abut. & Bent 6 following locations; Column 1, Bent 19 " 1 & 2, " 20 " 3 & 4, " 21 " 4, " 22

S.M. 10-71-45
Elev. 10.45
Ch. X on painted bolt on S.W. side of S.W'ly leg of U.P. offset well #81.

Power
Telephone
Power

U.S.N. DRAWING NO.	NAVAL OPERATING BASE, TERMINAL ISLAND AND NORTH ISLAND, CALIFORNIA
415,766	
118.56/N14-1(5)	APPROVED ____ 1945
SPECIFICATION NO.	

7-19-45 WEAR CRAN LENGTH AS 3" MIN. 11.15.5

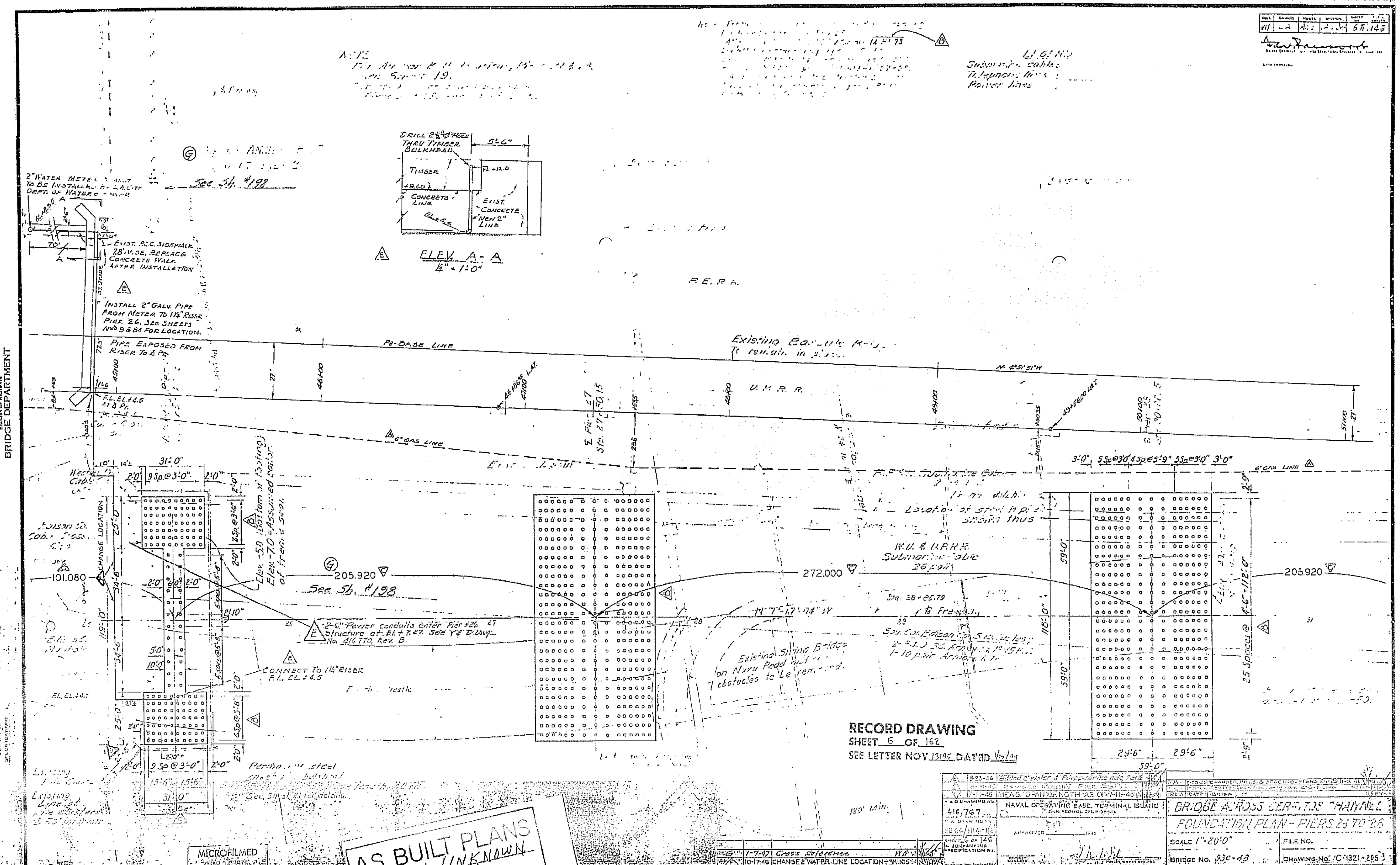
BRIDGE ACROSS CERRITOS CHANNEL
FOUNDATION PLANS - BENTS 17 TO 25

SCALE 1" = 20' | FILE NO.
BRIDGE NO. 53C-48 | DRAWING NO. C-1321-2042

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/16 SIGNATURE



RECORD DRAWING
SHEET 6 OF 162
SEE LETTER NOV 13195 DATED 1/10/44

FED. ROAD DIST. NO.	2
STATE	CAL.

NAVAL OPERATING BASE, TERMINAL ISLAND

Y & D DRAWING NO. 416,767

BRIDGE ACROSS CERRITOS CHANNEL

FOUNDATION PLAN - PIERS 25 TO 28

SCALE 1" = 20'-0"

BRIDGE No. 53C-48

DRAWING No. C-1321-205

G	1-7-47	Cross Reference
F	10-17-46	CHANGE 2" WATER LINE LOCATION

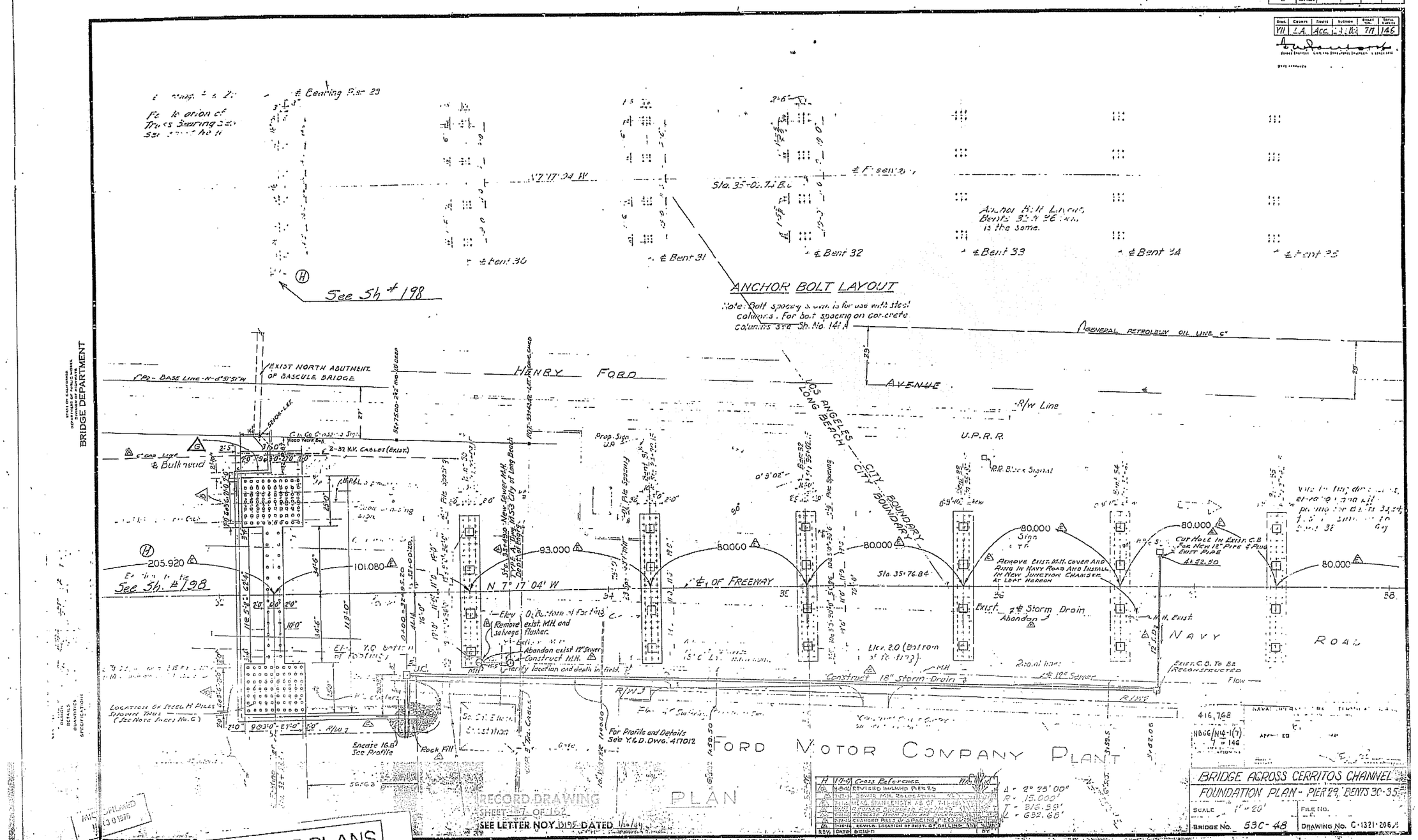
BRIDGE DEPARTMENT

MICROFILMED MAR 30 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/86



I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/12

FED. AID PROJ. NO.	STATE	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
	CAL			

DIST.	COUNTY	ROUTE	SECTION	POST MILE	TOTAL SHEETS
11	SD			8	1126

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

ANCHOR BOLT LAYOUT

Not to Scale

Note: Bolt spacing shown is for use with steel columns. For bolt spacing on concrete columns see St. No. 141 A.

Anchor Bolt Layouts, Bents 37 to 44 inch, are similar.

℄ Freeway

N 4° 52' 24" W

Sta 41+35.42 E.C.

℄ Bent 36 · ℄ Bent 37 · ℄ Bent 38 · ℄ Bent 39 · ℄ Bent 40 · ℄ Bent 41 · ℄ Bent 42 · ℄ Bent 43 · ℄ R.R. L.&T.

Approx. End of 8" Oil Line

℄ of Bearings Equiv. to N 45° E

R.R. L&T IN CURB - W SIDE H. FORD BLVD. LINE ONLY

R.R. LINE ONLY IN CURB

GENERAL PETROLEUM OIL LINE 6"

R.R. - M.S.T. IN HEADER BOARD

HENRY FORD AVENUE

29

U.S.C.&G.S. BENCH MARK

B.M. USC&GS. Tidal 37
Elev. 12.26
At the N. side of Cerritos Channel E. side of Henry Ford Ave. at drawbridge in top of E. wing of N. conc. abut. a steel disc stamped "37-1936"

See Sh. "14A" for reference no. on Abutment Details

R/W Line

R.R. - M.S.T. IN HEADER BOARD

U.P.R.R. Main Line

Spur Track

Spur Track

Bent 36 Sta. 38+12.15

Bent 37 Sta. 39+02.15

Bent 38 Sta. 39+72.15

Bent 39 Sta. 40+42.15

Bent 40 Sta. 41+12.15

Bent 41 Sta. 41+82.15

Bent 42 Sta. 42+52.15

Bent 43 Sta. 43+22.15

Bent 44 Sta. 43+92.15

Abutment 45 Sta. 44+62.15

70.000

80.000

0°-9'-10" Skew

0°-8'-01" Skew

0°-6'-01" Skew

0°-8'-01" Skew

0°-9'-10" Skew

90°

Semi-Tangent

℄ of Bridge

N 4° 52' 04" W

38 · 40 · 41 · 42 · 43

NAVY ROAD

REROUTE EXISTING WATER LINE AS INDICATED

THIS G.B. WAS BEAM REMOVED ALSO CURB

R.R. Crossing Sign

R.R. Prep. Sign

Radial Line

Elev. 20 (Bottom of Footing)

Note: Footing dimensions, elevation, and pile spacing for Bents 37, 38, 39, 40, 41, 42, 43, & 44 are similar to Bent 36 except as shown.

FORD MOTOR CO. IN SERVICE 6" C.I.R.

6" CONC. METER BOX

Layout Lines

Abutment 45 Sta 44+62.15

18 Short Outlet 12" Storm S. Drain M.H. Iron Cover L.25°Skew

Storm S. Drain Inlet

Sta 41+35.42 E.C.

℄ of 12" Sewer

S.D. SPR. S.W.

X IN CONC. SILL, 15 BAYS NO. OF SO. END OF FORD BLDG.

FORD MOTOR COMPANY PLANT

		AS-BUILT
5-7-46	CORRECT LEGS OF MARKERS 43+35 & 44+12	
7-12-46	RESURVEY TIES AS STAKED 7-12-46	
7-26-46	REROUT 6" WATER P 41+27.15	
7-11-46	MEAS. SPAN LENGTH AS OF 7-11-46	

A 16 769

NAVAL OPERATING BASE, TERMINAL ISLAND, SAN PEDRO, CALIFORNIA

PWD. DRAWING NO. NB 66/1114-1 (6)

SHEET 6 OF 162

APPROVED Lieut. Comdr. CEC USNR

BRIDGE ACROSS CERRITOS CHANNEL

FOUNDATION PLAN - BENT 36 TO ABUTMENT 45

SCALE: 1" = 20'-0" Except as Noted

FILE NO.

BRIDGE NO. 53C-1454

DRAWING NO. B 132,127

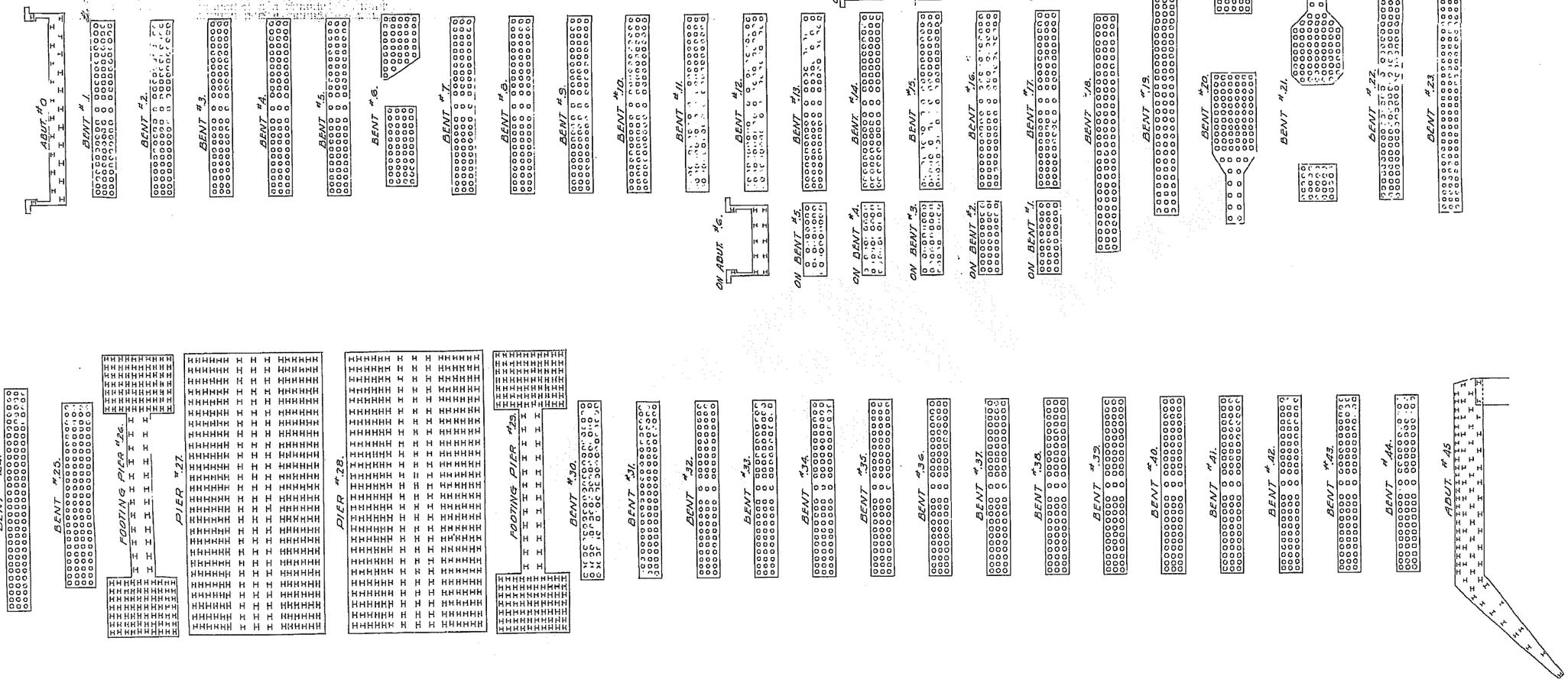
RECORD DRAWING
SHEET 6 OF 162
SEE LETTER NOV 13 1946 DATED July

MICROFILMED
MAR 30 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 3/30/76 SIGNATURE



RECORD DRAWING
SHEET 162 OF 162
SEE LETTER NOY 13195 DATED 1/10/79

CONSTRUCTION PILING CHART

TERMINAL ISLAND FREEWAY

CONTRACT NO. 13195

SCALE 1"=20'

NB66/NH-1 (157)

MICROFILMED
MAR 30 1979

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

FED. ROAD DIST. NO.	STATE	ROAD NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL				

DIST.	COUNTY	ROUTE	KILOPOST	SHEET NO.	TOTAL SHEETS
17					

Elev. 9.0 OFF Ramp bents
Elev. 9.0 ON Ramp bents
Elev. 8.0 Bents No.1 to No.5
Elev. 9.0 Bents No.6 to No.18
Elev. 1'-0 above existing surfacing at Bents No.32 to No.43
Elev. 12.0 Col. No.1, East Wall

PLAN
Scale: 1/8" = 1'-0"

SECTION Ⓓ Ⓓ
Scale: 1/8" = 1'-0"

Elev. Varies
Construction joint
This portion to be placed after completion of steel erection before concrete deck is placed
Elev. 2.0

BENTS 33 THRU 44

ELEVATION

BENTS 1-5, 7-17 & 32-31

SECTION Ⓐ Ⓐ
Scale: 1/8" = 1'-0"

SECTION Ⓑ Ⓑ

TOP REINFORCEMENT

BENTS 33 THRU 44

Symmetrical about ℄ Freeway

BENTS 1-5, 7-17 & 32-37

BOTTOM REINFORCEMENT
Scale: 1/8" = 1'-0"

See Sheet 22 A - As Built

~~RECORD DRAWING~~
~~SHEET 22 OF~~
~~SEE LETTER NOV DATED~~

416,783	NAVAL OPERATING BASE, TERMINAL ISLAND, SAN PEDRO, CALIFORNIA
N66(1114-1(52)	APPROVED 1943
22-146	

BRIDGE ACROSS CERRITOS CHANNEL

FOOTING DETAILS - BENTS 1-5, 7-17 & 32-44

SCALE 1/8"=1'-0" & 3/8"=1'-0"	FILE NO.
BRIDGE No. 53C-48	DRAWING No. C-1321-22A

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
BRIDGE DEPARTMENT

MICROFILMED
MAR 30 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/96 SIGNATURE [illegible] TITLE Project Engineer

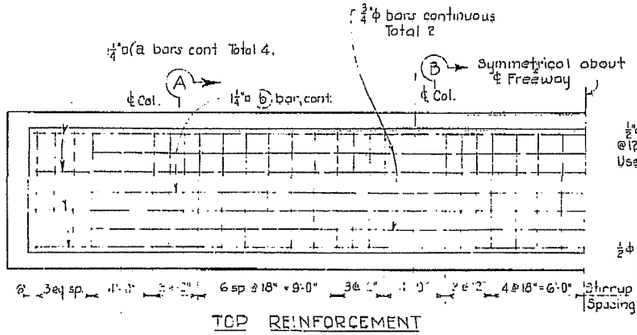
DIST	COUNTY	ROUTE	POST MILES	PROJECT NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
3	CAL						

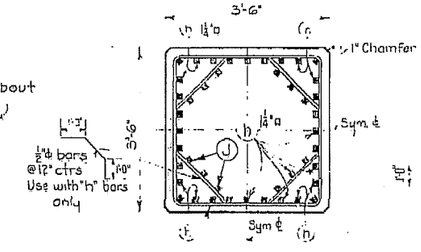
STATE OF CALIFORNIA
BUSINESS AND TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS

BRIDGE DEPARTMENT

DESIGN
DETAILS
QUANTITIES
SPECIFICATIONS

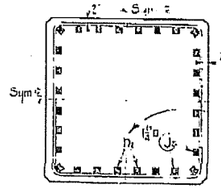
TOP REINFORCEMENT





SECTION D-D
BENTS 32,33 & COLS 2,3,4 of BENT 19

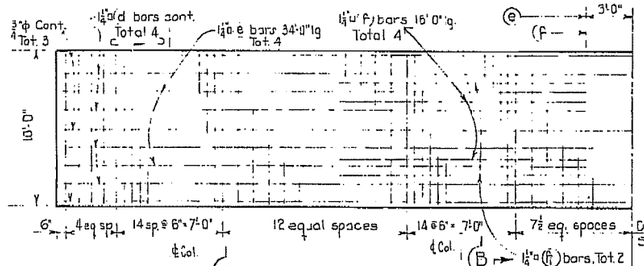
SECTION D-D
BENTS 9 thru 18, 34 & 35
Scale ¾"=1'-0"

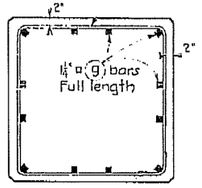


SECTION D-D
BENTS 1 thru 8, 38 thru 44
BENTS 19 thru 31

NOTES
Column details apply to Bents as noted
For Footing details not shown see Sheets No. 21 & 22
For Anchor Bolts See Sheet No. 25

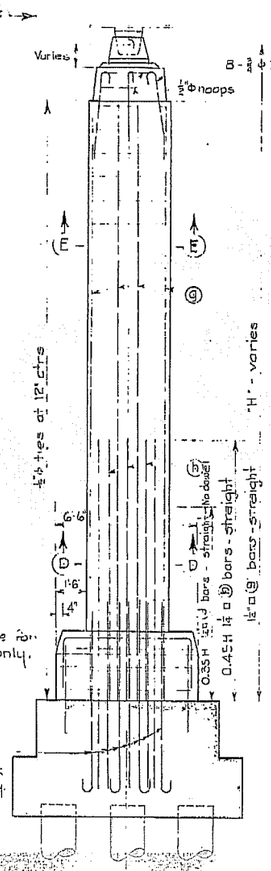
Lengths of h & j bars may be detailed to nearest foot.



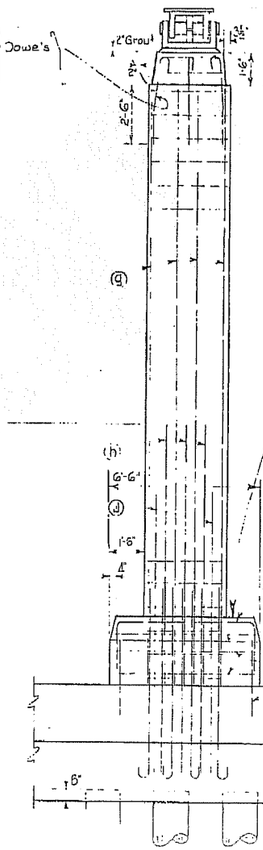


SECTION E-E
Scale ¾"=1'-0"

This section also typical for full length of 'ON' and 'OFF' Ramp columns.



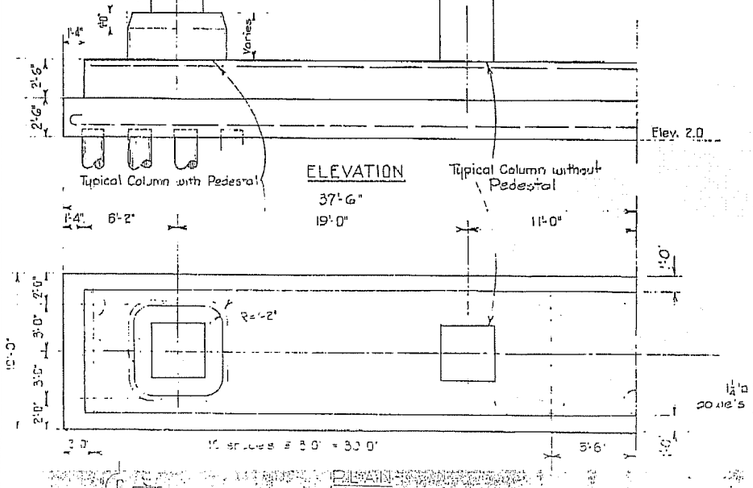
SECTION C-C



VIEW F-F

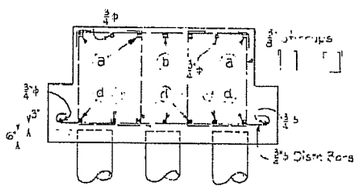
BOTTOM REINFORCEMENT

Scale : ¼" = 1'-0"



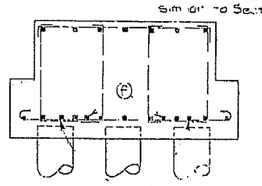
ELEVATION
37'-6"
19'-0"

PLAN
Scale ¼"=1'-0"



SECTION A-A
Scale ¾"=1'-0"

Bars not noted are similar to Section A-A



SECTION B-B
38 thru 44
Scale ¾"=1'-0"

NAVAL OPERATING BASE TREASURE ISLAND

APPROVED

BRIDGE ACROSS CERRITOS CHANNEL
FOOTING DETAILS - BENTS 1-5, 7-17, 32-44

SCALE As Noted
FILE No.
BRIDGE No. 33C-45
DRAWING No. C-13.21 365

RECORD DRAWING
SHEET 22 A OF 162
SEE LETTER NOV 13 1975 DATED 1/10/49

MICROFILMED
MAR 3 0 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 3/30/76 SIGNATURE

FED ROAD DIST NO	STATE		FISCAL YEAR	SHEET NO	TOTAL SHEETS
3	CAL				

DIST	COUNTY	ROUTE	SECTION	SHEET NO	TOTAL SHEETS
VII					146

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

DESIGN
DETAILS
QUANTITIES
SPECIFICATIONS

TOP REINFORCEMENT

BOTTOM REINFORCEMENT

PLAN
BOTTOM REINFORCEMENT

PLAN
BENT NO. 18
Scale: 1"=1'-0"

BENT NO. 6
Scale: 1"=1'-0"

SECTION B-B
Scale 3"=1'-0"

SECTION A-A
Scale 3"=1'-0"

SECTION C-C
Scale 3"=1'-0"

Note: For layout of footings, anchor bars and pile spacing see sheets 3 & 5.
For column base details see sheet 22
For details and notes not shown see sheet No. 22

Note: For details of columns see Sheet No. 22 or 22A

MICROFILMED
MAR 3 0 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 20007372

RECORD DRAWING
SHEET 23 OF 162
SEE LETTER NOY 13198 DATED 1/23/44

NAVAL OPERATING BASE, TERMINAL ISLAND
APPROVED [illegible] 1943

BRIDGE ACROSS CERRITOS CHANNEL
FOOTING DETAILS - BENTS NO. 6 & 18
SCALE AS NOTED
FILE NO.
BRIDGE No. 53 C-1.8
DRAWING No. C-1321-222

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/96 SIGNATURE [illegible] TITLE Project Engineer

4.0. HWAY DIST. NO.	STATE	HWAY NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				1

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	LA			27	146

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

BENT 22

BENT 19

BENT 23

SECTION (A)-(A)
Scale: 1/2"=1'0"

SECTION (B)-(B)
Scale: 1/2"=1'0"

ELEVATION

SECTION (D)-(D)
Scale: 1/2"=1'0"

SECTION (C)-(C)

PLAN
TYPE 'A' CONCRETE COLUMN BASE
Scale: 1/2"=1'0"

Note: For layout of footings, anchor bolts, and pile spacing see Sh. No. 5
For details of steel column bases (except Type 'A') see Sh. No. 26.
For details of concrete columns see Sh. #22A & 131A

RECORD DRAWING
SHEET 24 OF 162
SEE LETTER NOY 13195 DATED 11/6/41

4/6/785	NAVAL OPERATING BASE, TERMINAL ISLAND SAN PEDRO, CALIFORNIA	BRIDGE ACROSS CERRITOS CHANNEL
W.O. NO. & MATERIAL NO. 1466/M-1(24)	APPROVED SEP 7 1943	FOOTING DETAILS-BENTS 19, 22 & 23
SHEET 24 OF 146 ACCOMPANYING SPECIFICATION No.		SCALE 1/2"=1'0" Except as noted / FILE No.
		BRIDGE No. 53C 45 / DRAWING No. C-1321-823

MICROFILMED
MAR 3 0 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 70007372

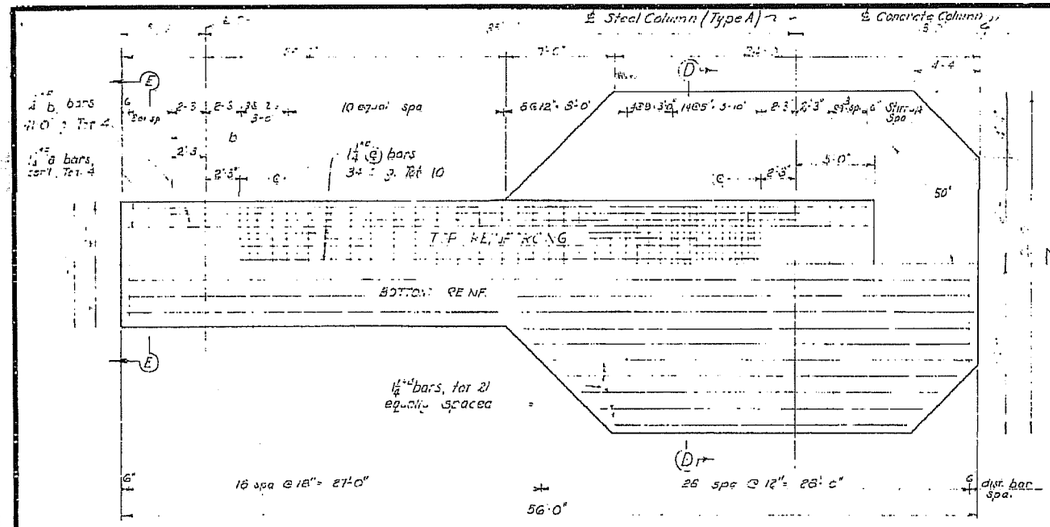
I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.
DATE 5/30/76

FED. AID PROJ. NO.	STATE	MISC. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL				

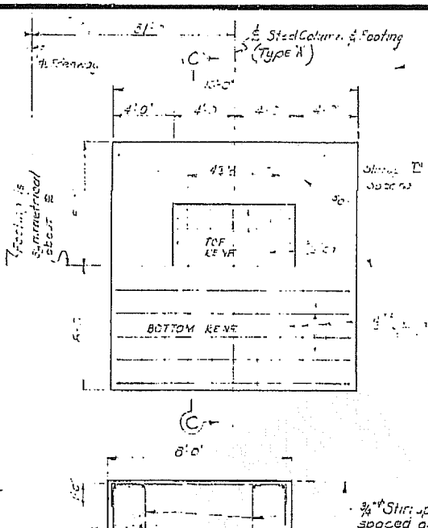
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE DEPARTMENT

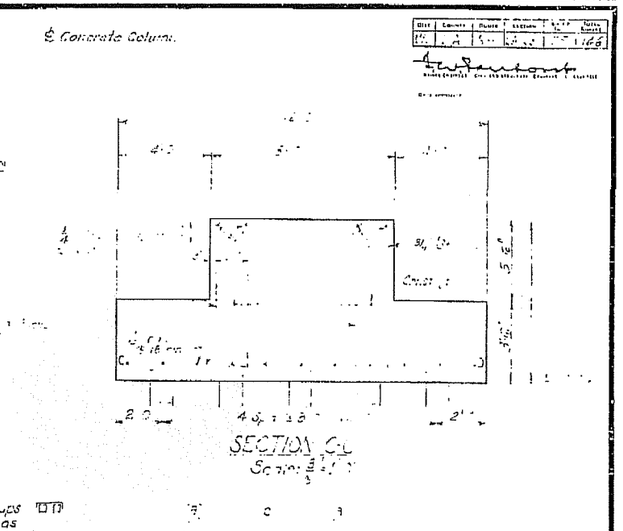
Notes: For layout of footings, anchor bolts and pile spacing see sheet No. 5
For details of steel columns, type 'A' bases, see sheet #26. For Type 'A' concrete column bases see sheet #24
For details of concrete columns see sheet # 131A

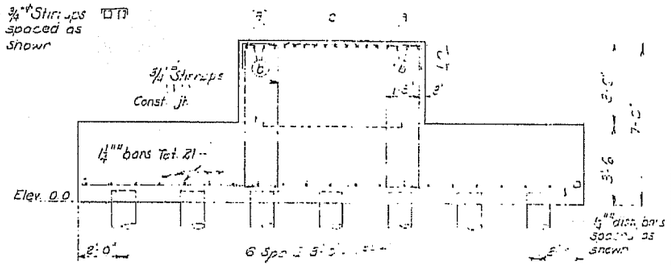


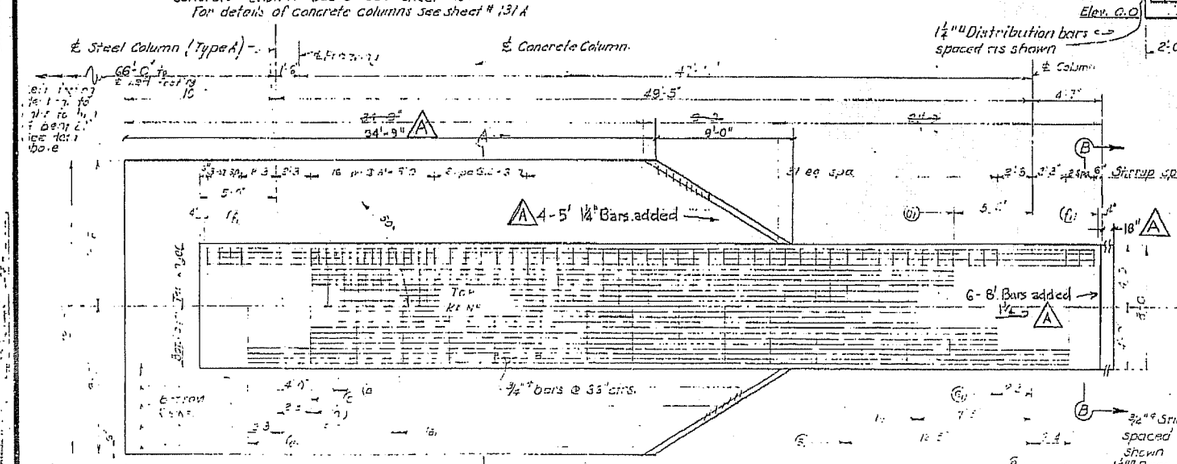
BENT 21
Scale: ½"=1'-0"



SECTION E-E
Scale: ⅜"=1'-0"

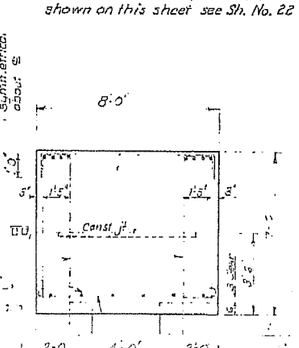




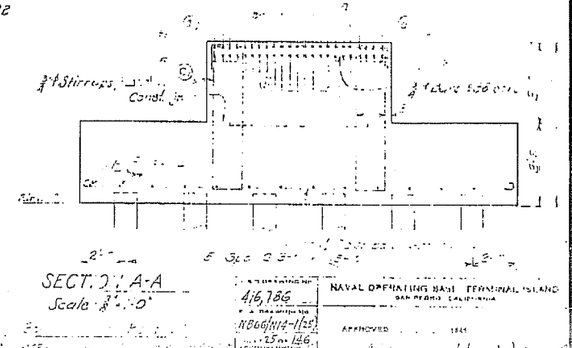


BENT 20
Scale: ½"=1'-0"

Note: For Details and Notes not shown on this sheet see Sh. No. 22



SECTION B-B
Scale: ½"=1'-0"



SECT. 2 - 2 A-A
Scale: ½"=1'-0"

RECORD DRAWING
SHEET 25 OF 162
SEE LETTER NOY 13195 DATED 1/20/44

Rev.	AS BUILT
Bkd.	

4/6,186	NAVAL OPERATING BASE TERMINAL ISLAND SAN PEDRO CALIFORNIA
N866(14)-1[illegible]	APPROVED 1941
25 on 146	

BRIDGE ACROSS CERRITOS CHANNEL
FOOTING DETAILS - BENTS 20 & 21

SCALE As Shown	FILE NO.
BRIDGE No. 53C-43	DRAWING No. C-1321-224

MICROFILMED
MAR 30 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 2000 7372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

DATE 5/30/96 SIGNATURE [illegible] TITLE Photographer

FED ROAD DIST NO.	STATE	MISC NO	FISCAL YEAR	SHEET NO	TOTAL SHEETS
2	CAL				

Dist	County	Route	Postmile	Total Project
11	SD	5	13.4/15.4	63 : 46

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
BRIDGE DEPARTMENT

Bottom Reinforcement Top Reinforcement

BENT NO. 30

BENT NO. 31

SECTION (A)(A)

Note: For details and dimensions not shown see Sh. No. 22.

BENT NO. 24

BENT NO. 25

Note: For layout of footings, anchor bolts, and pile spacing see Sh. No. 5 & No. 7. For details of concrete columns & bases see Sh. # 131 A

PLAN STEEL COLUMN TYPICAL BASE
Scale 3/8" = 1'-0"

SECTION (B)(B)
Scale 3/8" = 1'-0"

SECTION (C)(C)
Scale 3/8" = 1'-0"

SECTION D-D
Scale 3/8" = 1'-0"

RECORD DRAWING
SHEET 26 OF 162
SEE LETTER NOY 13DE DATED 4/10/56

41/6,787	NAVAL OPERATING BASE, TERMINAL ISLAND SAN DIEGO, CALIFORNIA
SUBMITTED	APPROVED
16 of 146 SHEETS	

BRIDGE ACROSS CERRITOS CHANNEL
FOOTING DETAILS-BENTS 24, 25, 30 & 31
SCALE 1"=10" Except As Noted | FILE No.
BRIDGE No. 53C-48 | DRAWING No. C-1321-225

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 70007372

MICROFILMED MAR 30 1970

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.

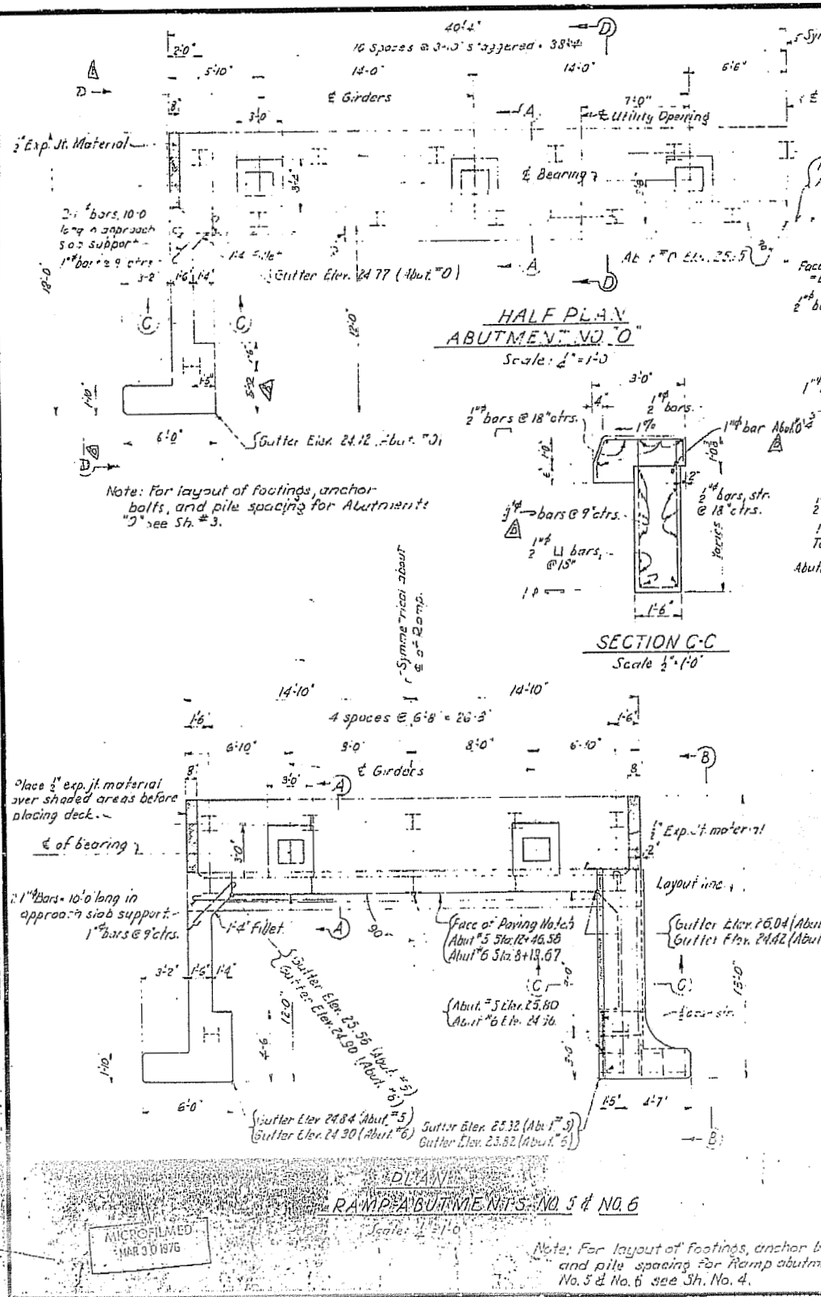
DATE 3/30/70

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.				

CONTRACT NO.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
	L.A.	ACC			146

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
BRIDGE DEPARTMENT

DESIGN
DETAILS
QUANTITIES
SPECIFICATIONS
CHECKED



RECORD DRAWING
SHEET 27 OF 162
SEE LETTER NOV 12 1965 DATED Nov 8 1965

REV.	DATE	BY	
1	7-14-66		Revised Abut "O" Wing Details
2	5-17-66		Changed Size of Pipe, Sec. A & Bridge

NAVAL OPERATING BASE TERMINAL ISLAND
SAN PEDRO, CALIFORNIA
416,788
(1366) (114-1) (27)
27 of 146
APPROVED
BRIDGE ACROSS CERRITOS CHANNEL
FOOTING DETAILS-ABUTMENT "O" & RAMPS
SCALE, AS NOTED
FILE No.
BRIDGE No. 53 C-45.
DRAWING No. C-1321-226

MICROFILMED MAR 30 1976

AS BUILT PLANS
Contract No. UNKNOWN
Date Completed
Document No. 70007372

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF TRANSPORTATION.
3/30/76

APPENDIX B

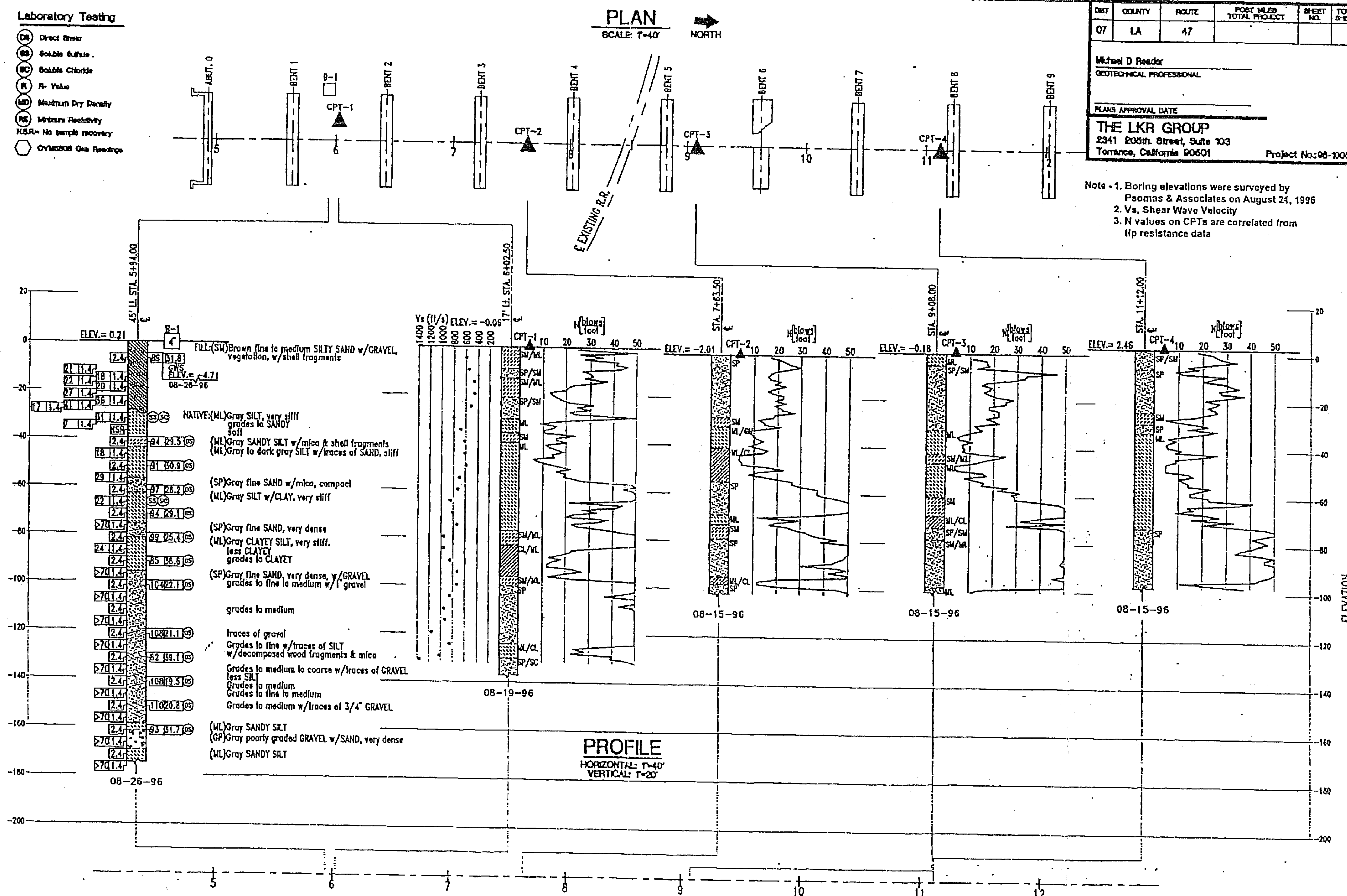
AS-BUILT LOTBS AND AVAILABLE LOGS OF BORINGS AND CPT SOUNDINGS

L.K.R. GROUP, INC. (1988)

"GEOTECHNICAL INESTIGATION FOR PS&E PHASE OF SEISMIC

RETROFIT ANALYSIS, SCHUYLER HEIM BRIDGE (53-2618),

LONG BEACH, CALIFORNIA"



Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No: 96-1005

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

2½" CONE PENETROMETER, SAMPLE BORING (DRY), ROTARY SAMPLE BORING (WET), AUGER BORING (DRY), TEST PIT, DIAMOND CORE BORING, JET BORING, ELECTRONIC CONE PENETROMETER

CONSISTENCY CLASSIFICATION FOR SOILS

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

DESIGN OVERSIGHT	DRAWN BY	NL	CB-LH-MC
SIGN OFF DATE	CHECKED BY	MR	FIELD INVESTIGATOR 08-15-96

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

BRIDGE NO. 53-2618
POST MILE 3.58

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.1

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 141 OF 148

JOBNLKR\LTBBDR 8-15-96 11:45:15 am EST

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47		-	

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

PLAN
SCALE: 1"=40'

NORTH

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (MC) Minimum Resistivity
- N.S.R.= No sample recovery
- OVM580B Gas Readings

BENT 9, CPT-5, BENT 10, BENT 11, CPT-6, BENT 12, "ONF" BENT 6, "OFF" BENT 5, "ONF" BENT 5, B-2, CPT-7, "OFF" BENT 4, "ONF" BENT 4, "OFF" BENT 3, "ONF" BENT 3, CPT-8, "OFF" BENT 2, "ONF" BENT 2, "OFF" BENT 1, "ONF" BENT 1, BENT 18

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

45° Lt. STA. 12+82.50 — ELEV.= -0.68 — CPT-5 — 08-15-96

STA. 14+05.00 — ELEV.= -1.78 — CPT-6 — 08-15-96

STA. 15+63.50 — ELEV.= -1.56 — CPT-7 — 08-15-96

5° Lt. STA. 15+51.50 — ELEV.= -1.54 — GWS ELEV.= -5.54' 08-23-96 — B-2 — 08-21-96

STA. 17+23.00 — ELEV.= -0.02 — CPT-8 — 08-15-96

FILL:(SM)Brown fine SILTY SAND w/GRAVEL & shell fragments
(ML)Dark gray CLAYEY SILT w/roots, very soft
NATIVE:(SP)Gray fine SAND w/mica, slightly compact
(ML)Gray SILT w/traces of SAND, stiff
grades to SANDY, very soft
grades to w/SAND and shells
grades to SANDY
Increasing shells, stiff
grades to CLAYEY w/traces of mica
Decreasing in CLAY, soft
grades to CLAYEY w/mica
Decreasing in mica, very stiff
stiff
w/traces of SAND
interbedded w/ SANDY SILT
(SP)Gray fine SAND, dense
(ML/SM)Gray SANDY SILT
(SP)Gray fine SAND w/traces of SILT
grades to w/mica, decreasing in SILT, very dense
traces of SILT
traces of GRAVEL, 0.5" dia.
w/o GRAVEL
grades to fine to medium
grades to fine to medium w/traces of GRAVEL
grades to w/traces of SILT
(ML)Gray SANDY SILT
(SP)Gray fine SAND, very dense
grades to medium to coarse w/GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND, 3/8" max. dia.
(SP)Gray fine SAND w/GRAVEL
Decreasing in GRAVEL
(ML)Dark gray SILT w/decomposed wood & mica
(SP)Gray fine to medium SAND w/1.5" GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND
(ML)Dark gray SILT w/SAND
(SM)Dark gray fine to medium SILTY SAND w/traces of CLAY
(ML)Gray SILT w/SAND

PROFILE
HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS (According to the Standard Penetration Test)

Penetration Index (Blows/Ft)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
>70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed as imply mechanical analysis

2" I.D. CONE PENETROMETER; SAMPLE BORING (DRY); ROTARY SAMPLE BORING (WET); AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; JET BORING; ELECTRONIC CONE PENETROMETER

PENETRATION BORING; ROTARY SAMPLE BORING (WET); BORING (DRY); ELECTRONIC CONE PENETROMETER TEST

DESIGN OVERNIGHT — BEGIN DRY DATE

DRAWN BY: NL — CHECKED BY: MR

CB-LN-MC — FIELD INVESTIGATION DATE: 09-15-96

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS: 0 1 2 3

CU 07
EA 138201

BRIDGE NO. 53-2618
POST MILE 9.58

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 4/6/98 9/2/98

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.2

SHEET 142 OF 148

C:\CADDD\VGV_JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reeder
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

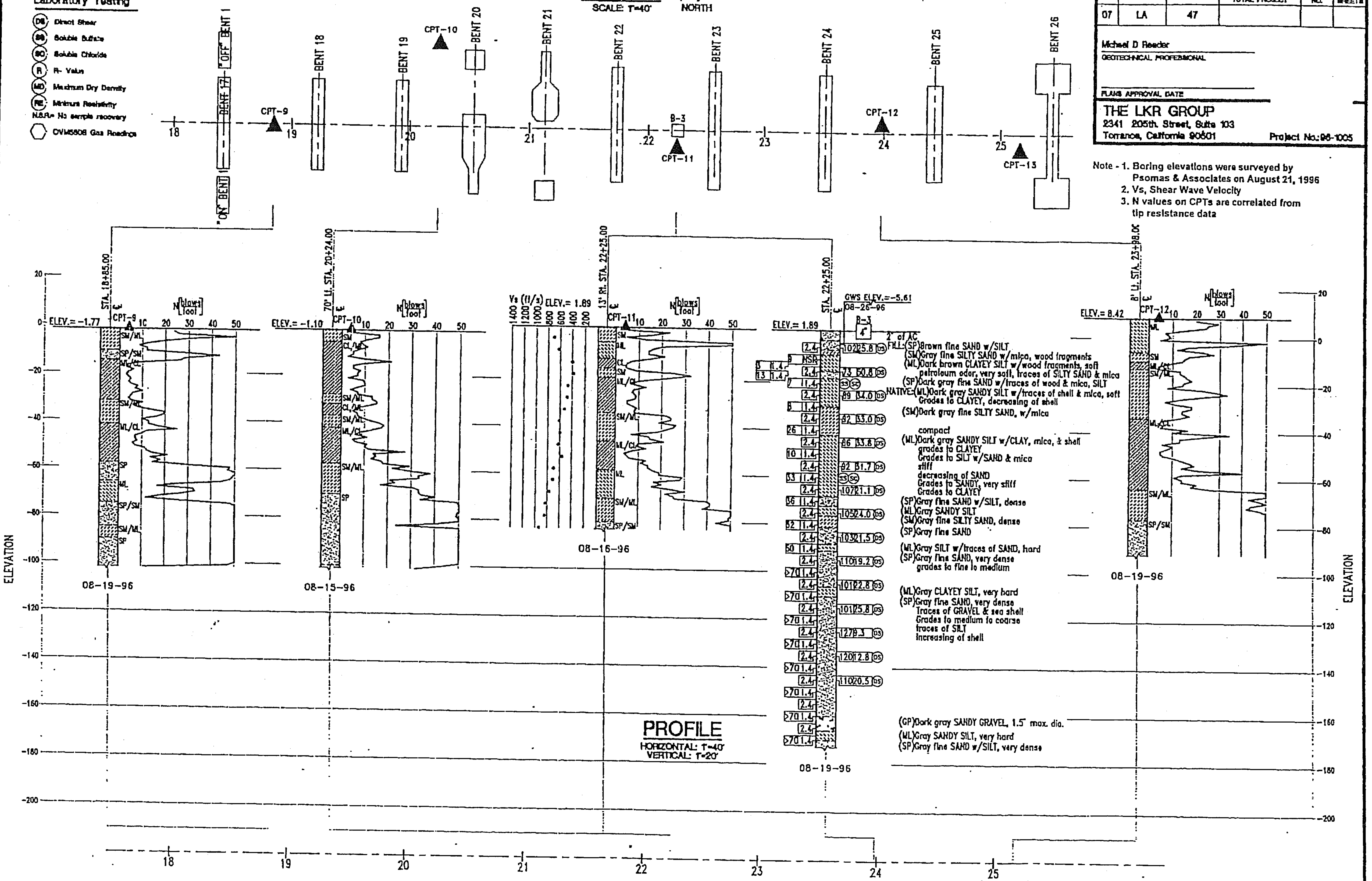
PLAN

SCALE: 1"=40'

NORTH

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity
- N.S.R.= No sample recovery
- OVM5808 Gas Readings



LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS (According to the Standard Penetration Test)

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
4-10	Loose	Soft
10-30	Slightly compact	Stiff
20-34	Compact	Very stiff
34-50	Dense	Hard
170	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

DESIGN OVERSIGHT	
DRAWN BY	NL
CHECKED BY	MR
	C8-LN-MC
FIELD INVESTIGATOR	
DATE	09-18-93

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

BRIDGE NO.	53-2618
POST MILE	3.58

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.3

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 143 OF 148

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (D) Maximum Dry Density
- (RE) Minimum Resistivity

N.S.R.= No sample recovery

OVM580B Gas Readings

PLAN

SCALE: 1"=40' NORTH

BENT 26 · BENT 28 · BENT 29 · BENT 30 · BENT 31 · BENT 32

CERRITOS CHANNEL

CPT-13 · CPT-14 · CPT-15 · B-4

25 · 26 · 30 · 31 · 32 · 33 · 34 · 35

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

112' Rt. STA. 25+18.50 — ELEV.= 8.87 — CPT-13 — 08-19-96

25' Rt. STA. 32+47.50 — ELEV.=5.00 — CPT-14 — 08-19-96

47' Lt. STA. 34+47.50 — ELEV.= -2.64 — B-4 — 09-25-96

34' Lt. STA. 34+56.50 — ELEV.= -2.64 — CPT-15 — 08-16-96

N [blows/foot]

FILL: (SM)Gray fine SILTY SAND w/shell fragments & GRAVEL
(ML)Gray CLAYEY SILT w/wood fragments
very soft
NATIVE: (SM)Gray fine SILTY SAND w/mica
Very loose
Grades to w/SILT, compact
Grades to fine to medium, slightly compact
GWS ELEV.= -5.64
Grades to less SILT w/shell, very loose
compact
(ML)Gray SANDY SILT w/mica, stiff
Grades to w/shell fragments & CLAY
soft
grades to CLAYEY w/traces of SAND, mica, and shell fragments, stiff
Grades to without SAND
Grades to without shell fragments, stiff
(SM)Gray fine SILTY SAND w/mica and shell
(ML)Gray CLAYEY SILT w/mica, stiff
(SP)Gray fine to medium SAND w/mica
Grades to w/shell
Grades to w/CLAY, medium
Grades to medium to coarse, decreasing in CLAY content
fine to medium w/SILT
Very dense
Grades to w/mica, without SILT, fine to coarse
Dense
Grades to medium to coarse and with 0.5" GRAVEL
Grades to medium to coarse and w/1" GRAVEL
(SM)Gray fine SILTY SAND w/mica, very dense
(SP)Gray fine SAND w/0.5" GRAVEL
(ML)Gray CLAYEY SILT w/GRAVEL & shell
(GP)Gray poorly graded GRAVEL 0.75"
Grades to 0.5" diameter
(SM)Gray fine SILTY SAND w/mica
Grades to w/SILT
Grades to without SILT
Grades to fine to medium
Grades to with sea shell
(ML)Gray CLAYEY SILT w/traces of SAND
Grades to with mica
(GP)Gray poorly graded GRAVEL w./sea shell
(ML/CL)Gray CLAYEY SILT to SILTY CLAY w/ 3/8" GRAVEL
Grades to without GRAVEL

ELEVATION

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, GNEISS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS (Numbers to the Standard Penetration Test)

Penetration Value (Blows/ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Firm
20-34	Compact	Very stiff
35-69	Dense	Hard
70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

DESIGN OVERSIGHT
DRAWN BY: ML
CHECKED BY: MR
CB-LH-MC — FIELD INVESTIGATOR
DATE: 09-15-96
BRM OFF DATE
PROJECT ENGINEER

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

CU 07
EA 138201

BRIDGE NO. 53-2618
POST MILE 9.58

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.4

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS: 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 144 OF 148

C:\CADDD\VGN_JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

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CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
4-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
/70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

LEGEND OF EARTH MATERIALS

- GRAVEL
- SAND
- SILT
- CLAY
- SANDY CLAY or CLAYEY SAND
- SANDY SILT or SILTY SAND
- SILTY CLAY
- CLAYEY SILT
- PEAT and/or ORGANIC MATTER
- FILL MATERIAL
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

- 2¼" CONE PENETROMETER
- SAMPLE BORING (DRY)
- ROTARY SAMPLE BORING (WET)
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- JET BORING
- ELECTRONIC CONE PENETROMETER

SAMPLE BORING (DRY)

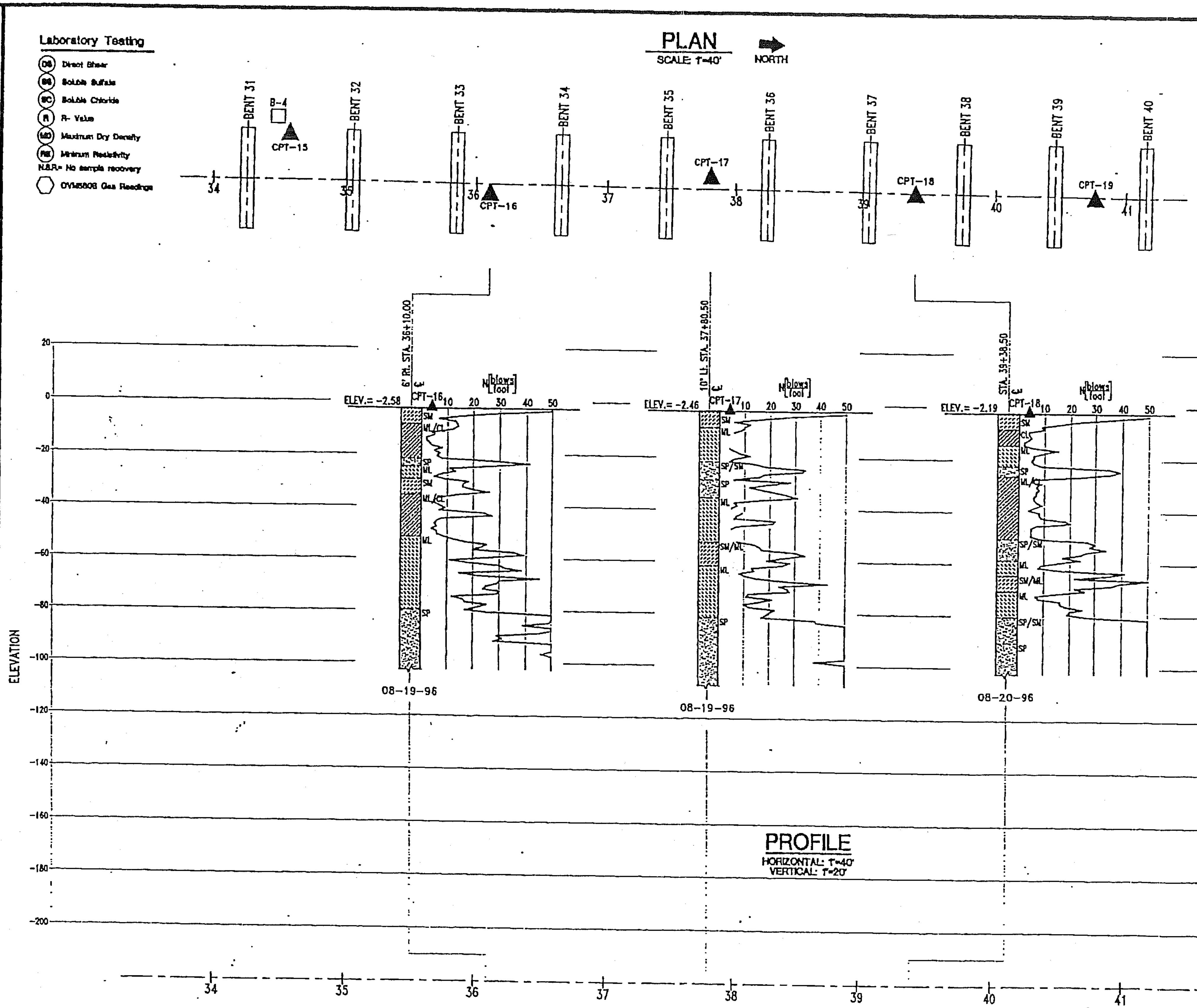
ROTARY SAMPLE BORING (WET)

2 ¼" CONE PENETRATION BORING

ELECTRONIC CONE PENETROMETER TEST

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity
- N.S.R= No sample recovery
- OVM580B Gas Readings



DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

DESIGN OVERSIGHT | SIGN OFF DATE

DRAWN BY: NL
CHECKED BY: MR

CB-LN-MC
FIELD INVESTIGATOR
DATE 08-15-96

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

BRIDGE NO. 53-2618
POST MILE 3.58

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.5

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 145 OF 148

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity

N.S.R= No sample recovery

OVM5608 Gas Readings

PLAN

SCALE: 1"=40' NORTH

BENT 37, CPT-18, BENT 38, BENT 39, CPT-19, BENT 40, BENT 41, CPT-20, BENT 42, BENT 43, BENT 44, CPT-22, ABUT. 45

CPT-21

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

STA. 40+76.50 — ELEV.= -2.30 — CPT-19 — 08-20-96

STA. 42+18.50 — ELEV.= -2.15 — CPT-20 — 08-20-96

50' Rt. STA. 43+58.00 — Vs (ft/s) — ELEV.= -2.42 — CPT-21 — 08-19-96

62' Rt. STA. 43+68.00 — GWS ELEV.=-12.0 08-26-96 — B-5 — ELEV.= -2.17 — 08-29-96

22' Rt. STA. 44+44.00 — ELEV.= -1.88 — CPT-22 — 08-20-96

N [blows/foot] 10 20 30 40 50

3"-7" of AC
FILL-(SP)Brown coarse SAND w/GRAVEL Grades to fine w/mica & SILT
NATIVE-(ML)Dark gray SANDY SILT, very soft
(SM)Dark gray fine SILTY SAND
(SP)Gray fine SILTY SAND, compact
(ML)Dark gray SANDY SILT, soft, traces of SILT
(SM/SP)Gray fine SILTY SAND, dense
(ML)Dark gray SANDY SILT, soft very stiff
(CL)Gray SILTY CLAY
(SM/ML)Gray fine SILTY SAND/SANDY SILT w/mica, dense
(ML)Gray SANDY SILT hard
(SM/ML)Gray fine SILTY SAND/SANDY SILT w/mica very dense
very dense
(SP)Gray fine to medium SAND w/mica
(ML/CL)Gray CLAYEY SILT/SANDY SILT, very hard
(ML)Gray SANDY SILT w/mica
(SM)Gray fine SILTY SAND w/mica, very dense

BENT 37 BENT 38 BENT 39 BENT 40 BENT 41 BENT 42 BENT 43 BENT 44 ABUT. 45

CPT-18 CPT-19 CPT-20 CPT-21 CPT-22

38 39 40 41 42 43 44 45

LEGEND OF EARTH MATERIALS

GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK, SANDY CLAY or CLAYEY SAND, SILTY SAND or SILT, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS

Assembly to the Standard Penetration Test

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
+70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

2nd " CONE PENETROMETER — SAMPLE (DRY) — ROTARY SAMPLE BORING (WET) — AUGER BORING (DRY) — TEST PIT — DIAMOND CORE BORING — JET BORING — ELECTRONIC CONE PENETROMETER

2nd " CONE PENETROMETER TEST — 2 1/2" CORE PENETRATION BORING — ROTARY SAMPLE BORING (WET) — AUGER SAMPLE BORING (DRY)

DESIGN OVERSIGHT — SIGN OFF DATE

DRAWN BY: NL — CHECKED BY: MR

CS-LN-MC — FIELD INVESTIGATOR — DATE 08-15-96

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

BRIDGE NO. 53-2618
POST MILE 3.58

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO.6

DISREGARD PRINTS BEARING EARLIER REVISION DATES!

REVISION DATES (PRELIMINARY STAGE ONLY)

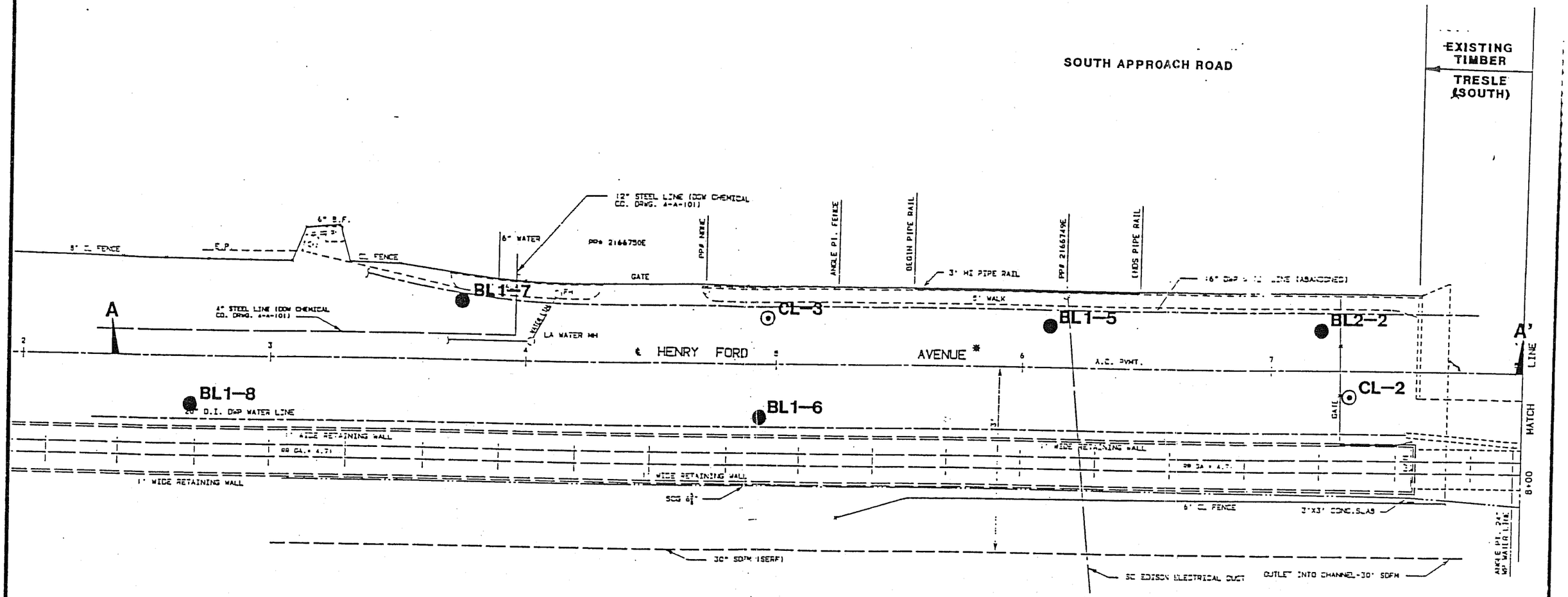
SHEET 14C OF 148

CA\CADDVG\JOB\LKR\LTBBDR 8-15-96 11:45:15 an EST

MAA ENGINEERING CONSULTANTS, INC. (1993)

"FINAL GEOTECHNICAL REPORT, BADGER AVENUE BRIDGE REPLACEMENT,

PORT OF LOS ANGELES, CALIFORNIA"



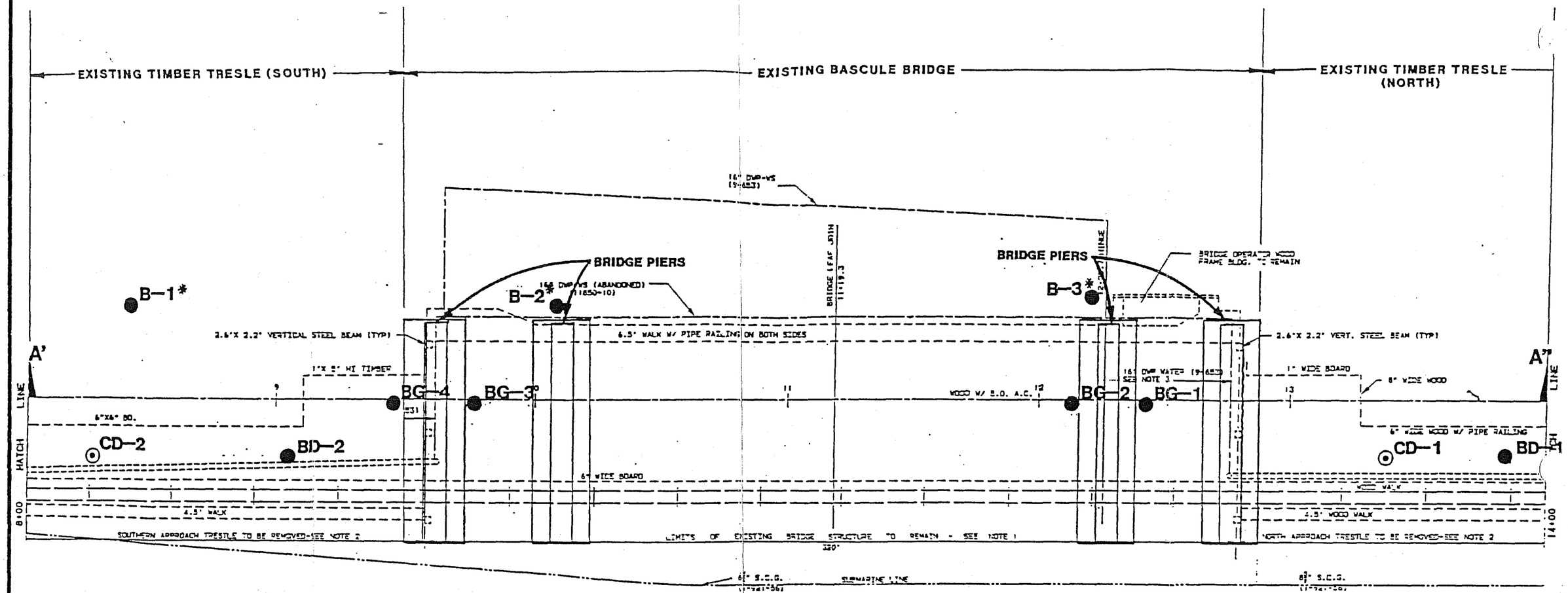
● BORING LOCATION
⊙ CPT LOCATION

BASE MAP PROVIDED BY PORT OF LOS ANGELES

MAA ENGINEERING CONSULTANTS, INC.
360 East Second Street, Suite 102
Los Angeles, CA 90012

EXPLORATION LOCATION PLAN
SOUTH APPROACH

DATE	5-31-89	SCALE	1" = 40'
DRAWN BY	D.P.F.	FIGURE	3.1
APPROVED BY	H.L.J.	PROJECT NO.	0042-004



● BORING LOCATION

⊙ CPT LOCATION

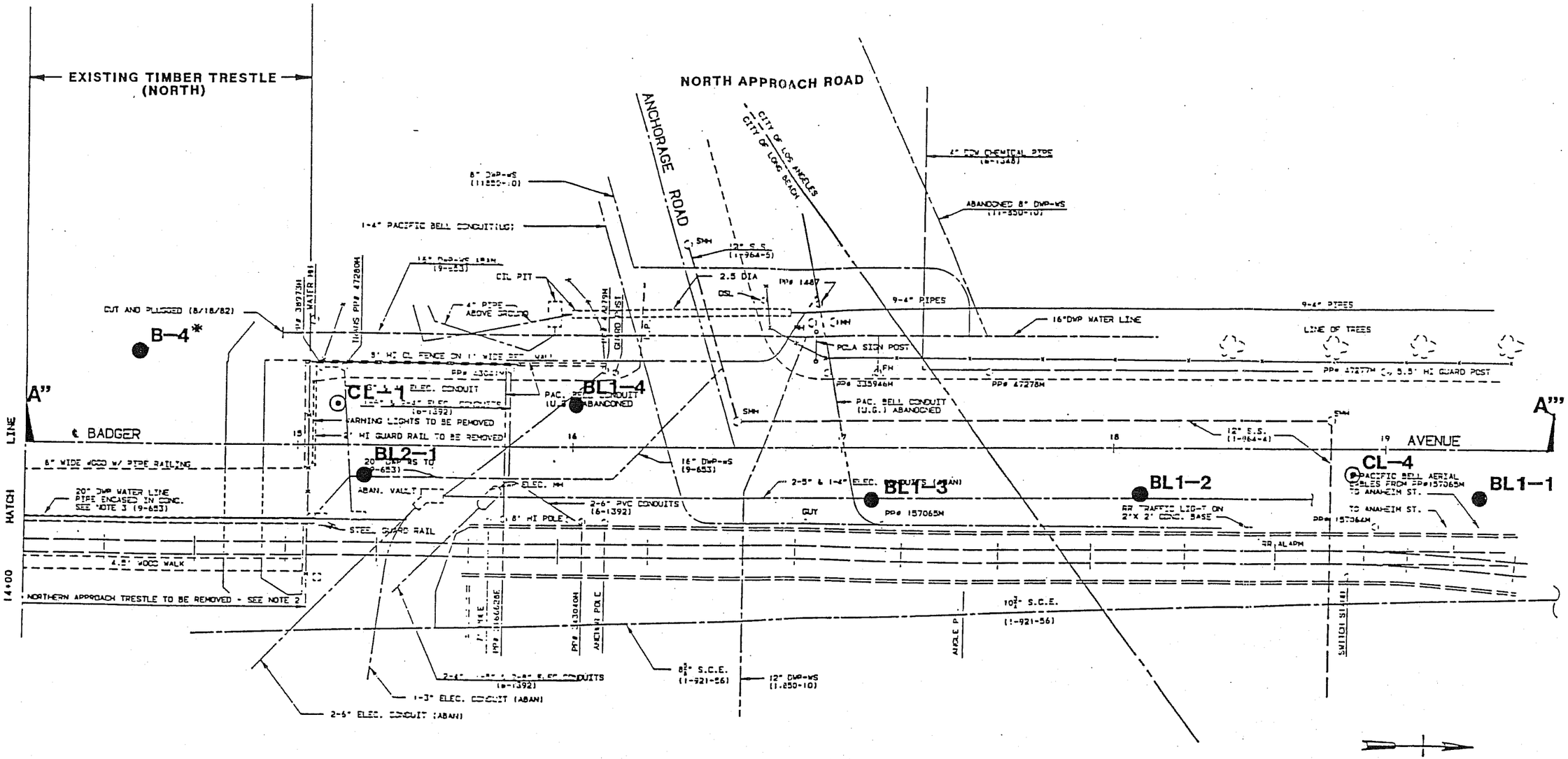
* BORINGS PERFORMED BY DAMES & MOORE (1975).

BASE MAP PROVIDED BY PORT OF LOS ANGELES

MAA ENGINEERING CONSULTANTS, INC.
360 East Second Street, Suite 102
Los Angeles, CA 90012

EXPLORATION LOCATION PLAN
TRESTLES AND BASCULE SPAN

DATE	5-31-89	SCALE	1" = 40'
DRAWN BY	D.P.F.	FIGURE	3.2
APPROVED BY	H.L.J.	PROJECT NO.	0042-004



● BORING LOCATION

⊙ CPT LOCATION

* BORINGS PERFORMED BY DAMES & MOORE (1975)

BASE MAP PROVIDED BY PORT OF LOS ANGELES

MAA ENGINEERING CONSULTANTS, INC.
360 East Second Street, Suite 102
Los Angeles, CA 90012

EXPLORATION LOCATION PLAN
NORTH TRESTLE AND APPROACH

DATE	5-31-89	SCALE	1" = 40'
DRAWN BY	D.P.F.	FIGURE	3.3
APPROVED BY	H.L.J.	PROJECT NO.	0040-3004

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISION			GROUP SYMBOL	DESCRIPTION	GRAPHIC LOG
COARSE GRAINED SOILS Over 50% By Weight Coarser Than No. 200 Sieve Size	GRAVELLY SOILS OVER 50% OF COARSE FRACTION LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELLY SOILS LITTLE OR NO FINES	GW	WELL GRADED GRAVELS OR GRAVEL - SAND MIXTURES	
			GP	POORLY GRADED GRAVELS OR POORLY GRADED GRAVEL -SAND SILT MIXTURES	
		GRAVELLY SOILS WITH FINES OVER 12% FINES	GM	SILTY GRAVELS OR POORLY GRADED GRAVEL - SAND SILT MIXTURES	
			GC	CLAYEY GRAVELS OR POORLY GRADED GRAVEL - SAND - CLAY MIXTURES	
	SANDY SOILS OVER 50% OF COARSE FRACTION SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDY SOILS LITTLE OR NO FINES	SW	WELL GRADED SANDS OR GRAVELLY SANDS	
			SP	POORLY GRADED SANDS OR GRAVELLY SANDS	
		SANDY SOILS WITH FINES OVER 12% FINES	SM	SILTY SANDS OR POORLY GRADED SAND - SILT MIXTURES	
			SC	CLAYEY SANDS OR POORLY GRADED SAND - CLAY MIXTURES	
FINE GRAINED SOILS Over 50% By Weight Finer Than No. 200 Sieve Size	SILTY AND CLAYEY SOILS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, VERY FINE SANDS SILTY/CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY	
			CL	INORGANIC CLAYS-LOW TO MEDIUM PLASTICITY, GRAVELLY, SANDY, SILTY OR LEAN CLAYS	
			OL	ORGANIC CLAYS OR ORGANIC SILTY CLAYS OF LOW PLASTICITY	
	SILTY AND CLAYEY SOILS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, OR ELASTIC SILTS	
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, OR FAT CLAYS	
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, OR ORGANIC SILTS	
HIGHLY ORGANIC SOILS			Pt	PEAT OR OTHER HIGHLY ORGANIC SOIL	

SAMPLE TYPES:

- UNDISTURBED
- DISTURBED
- UNSUCCESSFUL ATTEMPT
- STANDARD PENETRATION

WATER LEVEL

WATER INFLOW

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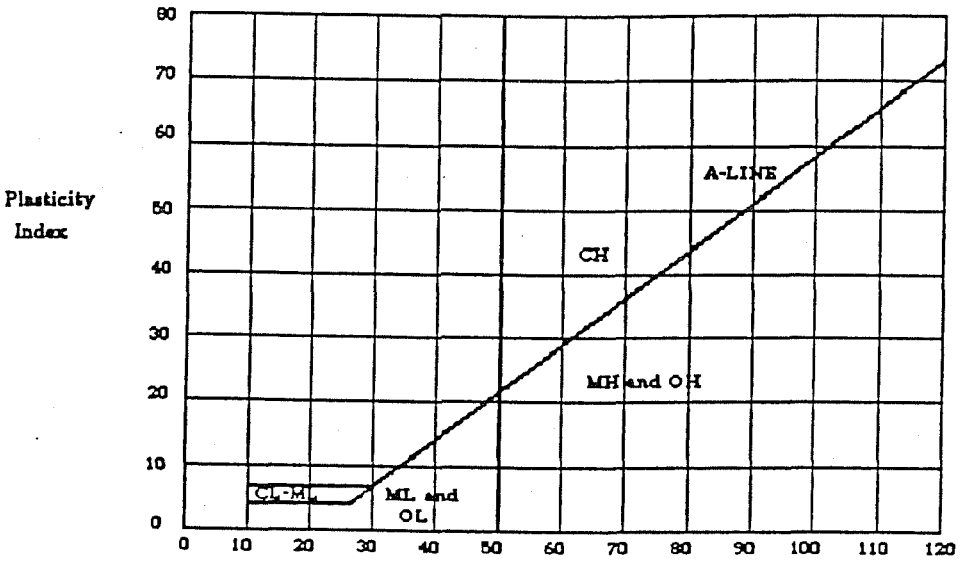
LEGEND TO LOGS(A)

PROJECT NO.	0033-003	FIGURE NO.	A1-1(A)

PLASTICITY CHART - Used for Classification of Fine Grained Soils



BLOW COUNT - The number of blows required to drive the indicated sampler the last 12 inches of an 18 inch drive. The notation 100/9 indicates only 9 inches of penetration were achieved in 100 blows. Hammer weights and drop heights are shown below:

Symbol	Driving Weight (pounds)	Drop Height (inches)
S	180	30
R*	180	30
T*	180	30

* = For Drill Hole BD-1, hammer weight and drop height is 320 pounds and 18 inches, respectively.

ADDITIONAL TESTS -

UC : Unconfined Compression
CD :Consolidated Drained
UU :Unconsolidated Undrained
CU :Consolidated Undrained
R :R-Value
AL :Atterberg Limits
SA :Seive Analysis

WS : Wet Seive #200
HM :Hydrometer
TX : Triaxial
RS :Residual Strength
SP : Specific Gravity
CP : Compaction
CO : Consolidation
DS : Direct Shear

PM : Permeability
EP : Expansion
RES: Resistivity
S : Swell
CL : Chloride
SU : Sulphate

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LEGEND TO LOGS(B)

PROJECT NO.	0033-003	FIGURE NO.	A1-1(B)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BL1-5
DRILLING DATE: June 11, 1989
DATUM: MLLW
REFERENCE EL.: 8 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
						Asphalt Pavement, 8-inch						
						Fill, SILTY SAND (SP-SM), brownish gray, dry, medium dense, fine sand, with about 10% fines.						
						Asphalt Pavement, 8-inch						
0						BASE GRAVELS (GC), dark brownish gray, dry, angular, up to 2-inch size.						
						SILTY SAND (SM), dark greenish gray, moist, medium dense, with about 30% fines, lot of sea shells at 8 feet.						
10			T-1 R6	24		SILTY SAND (SP-SM), dark greenish gray, wet, loose, with lot of sea shells, with about 5% fines.	87	41				
			S-1	16		SILTY SAND (SM), greenish gray, wet, medium dense, with about 15% fines, micaceous, medium to high dilatancy.						WS
-10						SILTY CLAY (CL) layer at 17.5 feet, 6-inch.						
20						SILTY SAND (SM), dark gray, wet, loose, with about 30% fines, micaceous, high dilatancy, fine sand grains.						
			B-1 R12	7			92	32				WS,DS CO
			S-2	50/ 6"		SILTY SAND (SP-SM), grading to gray, wet, dense, with less than 10% fines, clean, some seashells.						
-20												
30			T-2 R18	91			95	30				
			S-3	77/ 5"								
-30												
40			R25	34		SILTY SAND to SANDY SILT (SM-ML), dark gray, wet, medium stiff, with some sea shells, fine Sand grains, with about 45 to 55% fines.	93	31				
			S-4	14		grading to SILTY SAND (SM), dark gray, wet, loose.						
-40						SILTY CLAY (CL) with some sea shells.						
50			T-3 R30	52		SILTY SAND to SANDY SILT (SM-ML), dark gray, wet, medium stiff, fine sand grains, with about 55% fines.	88	33				
						End of boring at 51.5 feet.						

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LOG OF DRILL HOLE BL1-5

PROJECT NO.	0033-003	FIGURE NO.	A1-6

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ/FS
CHECKED BY: FC

DRILL HOLE NO.: BD-1
DRILLING DATE: June 12, 1989
DATUM: MLLW
REFERENCE EL.: -17 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
-20						Bay Mud, ORGANIC CLAY (OH), black to dark greenish gray, wet, very soft, with lots of sea shells. casing sinking under its own weight. set casing to EL. -25.3 feet.						
10 -30			S	9		SILTY CLAY (CH), bluish gray, wet, very soft, with minor sand grains.						
			R6	41		SILTY SAND (SM), bluish gray, wet, medium dense, fine sand grains, with about 25 to 30% fines. installed casing to EL. -33.3 feet.	91	27				
20 -40			S-1	6		SANDY SILT to SILTY SAND (SM-ML), dark bluish gray, wet, soft, sand content is about 30 to 50%.						WS
			T-1 R12	20		SILTY CLAY to CLAYEY SILT (CL-ML), bluish gray, wet, medium dense, low to medium plasticity, uniform with less than 10% sand grains.	86	39	33	30		AL
30 -50			S-2	44		SANDY SILT (ML), bluish gray, wet, stiff, sand content is about 20-30%, lots of mica flakes, fine sand grains.						SU,CL, RES
			T-2 R18	3		SILTY CLAY (CL-ML), bluish gray, wet, soft, medium plasticity.	81	41				TX-UU, CO
						SANDY SILT (ML), bluish gray, wet, sand content up to 25%, fine sand grains.						
40 -60			S-3	62		CLAYEY SILT to SILTY CLAY(CL-ML), bluish gray, wet, stiff, medium plasticity.						
			T-3 R24	39			88	35				
50 -70			S-4	83		grading from low to medium plasticity.						SU,CL, RES
			T-4 R30	69								DS-CD

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LOG OF DRILL HOLE BD—1(A)

PROJECT NO.	0033—003	FIGURE NO.	A1—10(A)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ/FS
CHECKED BY: FC

DRILL HOLE NO.: BD-1
DRILLING DATE: June 12, 1989
DATUM: MLLW
REFERENCE EL.: -17 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
60 / -80			S-5	95/ 11"		drill rig starts to shatter, possible dense sand layer, about 6-inch thick. CLAYEY SILT to SILTY CLAY(CL-ML), bluish gray, wet, stiff, medium plasticity.						
			T-6 R36	42		SILTY CLAY (CL), dark bluish gray, medium plasticity. SAND (SP), dense. SILTY CLAY to CLAYEY SILT (CL-ML), possible SAND (SP), dense.	92	32				
70 / -90			S-6	50/ 4"		SILTY CLAY (CL-ML), dark bluish gray, wet, stiff, 6-inch thick.						SU,CL, RES
			R	96/ 6"		SILTY SAND (SP-SM), bluish gray, wet, dense, fine sand grains with about 15% fines, with mica flakes, high dilatancy. about 25% fines, drill rig shatter.						
80 / -100						SAND (SP), light bluish gray, dense, poorly graded grain size up to 1mm, with occasional granite gravels up to 1-inch in size, predominantly quartz grains.						
			S-7	48		SANDY CLAY (CL), dark brownish gray, medium stiff, medium plasticity, sand content less than 15%.						
90 / -110			S-8	76/ 11"		GRAVEL (GP) layer, 6-inch thick, very dense, drill rig shatter. SAND (SP), light bluish gray, dense, coarse grains up to 2mm in size, predominantly quartz grains. 6-inch thick GRAVEL (GP) layer. clean GRAVELLY SAND (SP), dense, grain size up to 1/2-inch. CLAY (CL) layer, dark bluish gray, wet, stiff, medium plasticity. SAND (SP), drill rig shatter.						
100 / -120			S-9	50/ 3"		GRAVELLY SAND (SP), light greenish gray, very dense, gravels up to 1/2-inch in size.						

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LOG OF DRILL HOLE BD—1(B)

PROJECT NO.	0033—003	FIGURE NO.	A1—10(B)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ/FS
CHECKED BY: FC

DRILL HOLE NO.: BD-1
DRILLING DATE: June 12, 1989
DATUM: MLLW
REFERENCE EL.: -17 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
-130						6-inch layer of gravel (GP), drill rig shatter violently. Gravelly SAND (SP).						
						End of boring at 115.5 feet.						

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LOG OF DRILL HOLE BD—1(C)

PROJECT NO.	0033—003	FIGURE NO.	A1—10(C)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BD-2
DRILLING DATE: June 8, 1989
DATUM: MLLW
REFERENCE EL.: -30 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE / REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
-30			S	0		PEAT, or ORGANIC CLAY (OH), black, very soft, bay mud, lots of sea shells. set casing down to EL.-40.0 feet.						
-40 10			S	0		SILTY CLAY (CL-CH), light gray, very soft.						
			S-1	0		SILTY SAND (SM), bluish gray, medium dense, slight dilatancy, about 15 to 25% fines. pushed casing to EL.-48.0 feet.						WS
-50 20			R6	13		6-inch thick layer of SANDY SILT (ML) SILTY SAND (SM). set casing to EL.-52.5 feet.	87	34				
			S-2	12/6"		SILTY CLAY (CL), bluish gray, medium stiff, almost no coarse grains (<5%), medium to high plasticity, some mica flakes. grading to sandier.						
			T-1 R12	15			90	34				
-60 30			S-3	21								
			T-2 R18	33		SILTY SAND (SM), bluish gray, medium dense to dense, with about 25 to 35% fines.						DS-CD
-70 40			S-4	77		SAND (SP), gray dense, less than 5% fines, poorly graded, grain size to 1/2mm.						
			T-3 R24	35		SILTY SAND (SP-SM), poorly graded, grain size about 1/4mm, about 10 to 20% fines, with fresh mica flakes. drill rig shatter.	98	25				
-80 50			S-5	67/6"		SAND (SP), bluish gray, very dense, less than 5% fines, poorly graded, size up to 1/2mm, predominantly quartz grains, drill rig shatter.						

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LOG OF DRILL HOLE BD-2(A)

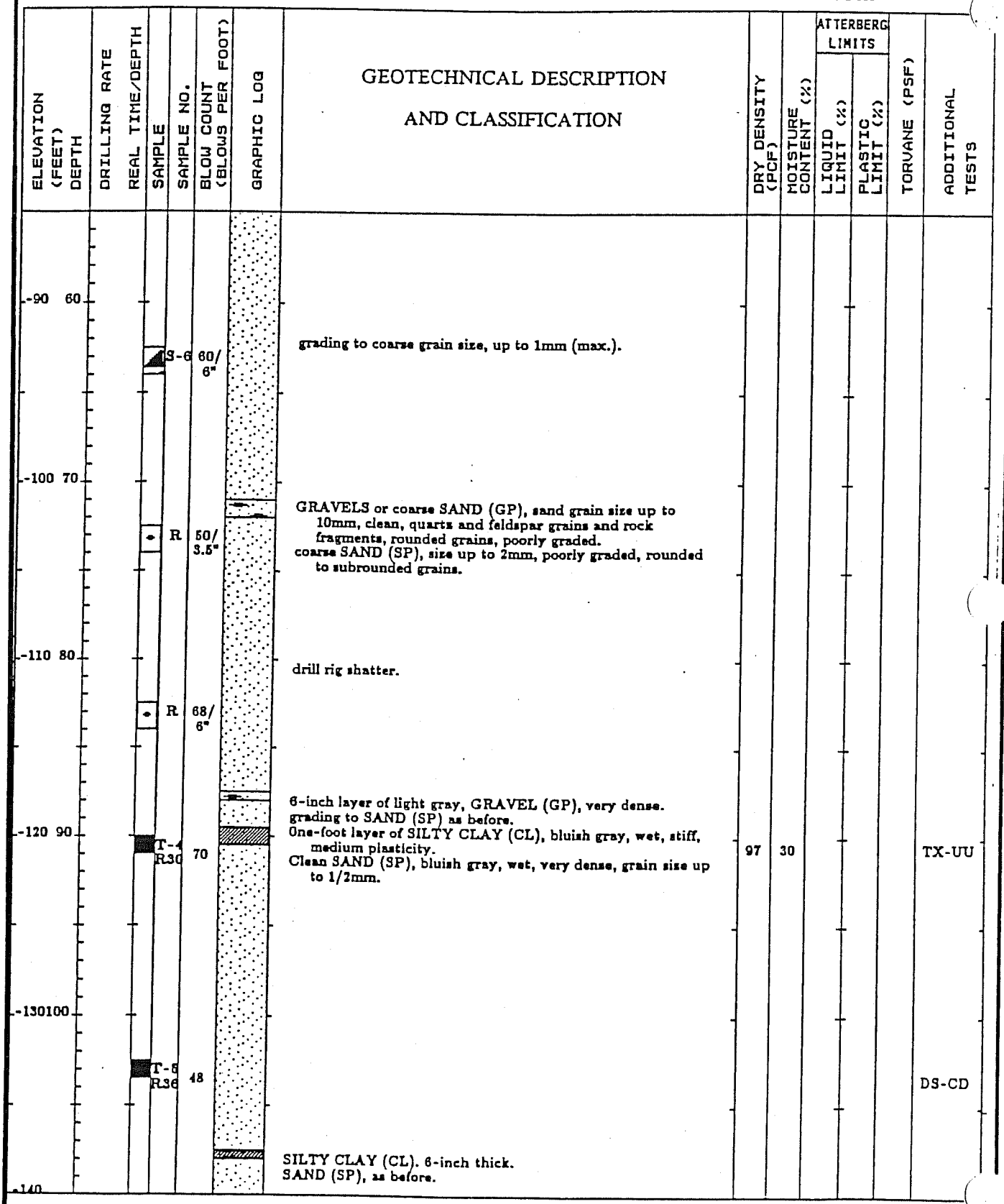
PROJECT NO.	0033-003	FIGURE NO.	A1-11(A)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BD-2
DRILLING DATE: June 8, 1989
DATUM: MLLW
REFERENCE EL.: -30 Feet



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LOG OF DRILL HOLE BD—2(B)

PROJECT NO.	0033—003	FIGURE NO.	A1—11(B)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BD-2
DRILLING DATE: June 8, 1989
DATUM: MLLW
REFERENCE EL.: -30 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
-140						112.5 feet: GRAVEL (GP) very dense, grain size up to 1-inch, quarts grains and granite fragments.						
						End of boring at 113.5 feet.						

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LOG OF DRILL HOLE BD—2(C)

PROJECT NO.	0033—003	FIGURE NO.	A1—11(C)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BL2-1
DRILLING DATE: June 10, 1989
DATUM: MLLW
REFERENCE EL.: 17 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
10						Asphalt Concrete Pavement, 8-inch. Fill, SILTY SAND (SM), light yellowish gray, moist, soft, about 15% fines, no sea shells, fine sand grains.						
						asphalt mixture with gravel and silty clay. Asphalt concrete, 6-inch.						
10			S-1	22		SILTY CLAY (ML), red brownish gray, about 35% fine sand grains, low plasticity. SANDY SILT (SM-ML), light gray, moist, loose, low plasticity						
0						Asphalt concrete, 12-inch. Base GRAVEL (GP), granite fragments up to 2-inch in size, angular..						
			R6	74		SILTY SAND (SM), bluish gray, wet, medium dense, with shell fragments up to 1-inch in size, about 15 to 20% fines.	103	22				
20						SILTY CLAY (CL), bluish gray, wet, medium stiff, medium to high plasticity, less than 5% fines.						
-10			T-1 R12	21		SILTY SAND (SM), bluish greenish gray, wet, medium dense, about 20 to 30% fines, fine sand grains.	83	31				
30			S-2	23		grading to SAND/SILTY SAND (SP-SM), bluish gray, wet, medium dense, about 10% fines.						
						SILTY CLAY (CL), soft to medium soft, low to medium plasticity, with less than 5% coarse grains.						
-20			R18	33		SILTY SAND (SM), bluish gray, 15 to 20% fines, fine sand grains, some shells.	87	37				
40			S-3	21								
-30			T-2	25		SILTY SAND - SANDY SILT (SM-ML). SILTY SAND (SM) as before, about 15-20% fines.						
50			S-4	90		grading to bluish gray, wet, dense, SILTY SAND (SM), about 15% fines, fine sand grains.						

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LOG OF DRILL HOLE BL2—1(A)

PROJECT NO.	0033—003	FIGURE NO.	A1—12(A)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BL2-1
DRILLING DATE: June 10, 1989
DATUM: MLLW
REFERENCE EL.: 17 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
-40			R24	74		SILTY SAND-SANDY SILT (SM-ML), bluish gray, wet, dense, about 35-45% fines, interlayers of clean sand, silty sand and sandy silt, 6-inch each layer.	99	27				
60			S-5	22		CLAYEY SILT (ML), bluish gray, wet, medium stiff, less than 10% coarse grains, medium plasticity.			39	32		AL
						SILTY SAND (SM) bluish gray, dense.						
-50			T-3 R30	23		SILTY CLAY (CL), bluish gray, medium stiff, less than 10% coarse grains.	84	34				
						SILTY SAND (SM-ML), dense, with about 40% fines.						
70			S-6	7		SILTY CLAY (CL) interlayered with silty sand or sandy silt, each may be 6-inch thick.						WS
						SILTY SAND (SM).						
			T-4 R36	49		interlayers of silty sand, sandy silt and silty clay, lots of 2-inch size sea shell fragments.	95	30				
						End of boring at 76.5 feet.						

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LOG OF DRILL HOLE BL2-1(B)

PROJECT NO.	0033-003	FIGURE NO.	A1-12(B)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BL2-2
DRILLING DATE: June 11, 1989
DATUM: MLLW
REFERENCE EL.: 13 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
10						Asphalt Concrete Pavement, 9-inch.						
						Fill, SILTY SAND (SM), light yellowish gray, dry to moist, medium dense, about 10 to 15% fines, poorly graded.						
						6-inch thick layer of CLAYEY SAND (SC).						
			S-1	22		Fill, SILTY SAND (SM), same as before.						
						set casing to 8.5 feet deep.						
10						Fill, asphalt, gravels, sandy clay mixture.						
0						Hydraulic Fill, SILTY SAND (SM) with gravels up to 3-inch in size, medium dense.						
			R6	11		Fill, mixture of SILTY SAND (SM) and SILTY CLAY (CL), mixture of brownish gray and bluish gray.						DS-CD
20			S-2	33		SAND (SP), bluish gray, wet, medium dense, poorly graded, with less than 5% fines.						
-10			B-1	62		SILTY SAND (SP-SM), bluish greenish gray, wet, dense, about 10% fines, fine sand grains, poorly graded.						
30			S-3	34		6-inch layer of SILTY CLAY (CL), bluish gray, wet, medium stiff, lots of sea shell fragments. SILTY SAND (SM), bluish gray, medium dense, about 20% fines.						SU,CL, RES
-20			T-1 R12	64		SILTY SAND (SP-SM), bluish gray, wet, dense, fine sand grains, with about 10 to 15% fines.	103	23				
40			S	33								
-30						set casing to 25 feet deep.						
						some clay cuttings observed, could be in thin layers.						
			R18	67/ 11"		CLAYEY SILT (ML) bluish gray, wet, medium stiff, low plasticity, about with 25% coarse grains.						
						SILTY SAND (SM), dense, with about 10-20% fines, medium dilatancy, poorly graded, fine sand grains.						
50			S	3		SILTY CLAY (CL), bluish gray, wet, soft, medium plasticity, less than 5% coarse grains.						
-40						SILTY SAND-SANDY CLAY (SM/CL), interlayers, dense, few inches in thickness each layer.						

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LOG OF DRILL HOLE BL2-2(A)

PROJECT NO.	0033-003	FIGURE NO.	A1-13(A)

LOG OF DRILL HOLE

JOB NO.: 0033-003
PROJECT: Henry Ford Avenue Bridge - POLA
LOCATION: Port of Los Angeles
DRILLING METHOD: Rotary Wash

LOGGED BY: HJ
CHECKED BY: FC

DRILL HOLE NO.: BL2-2
DRILLING DATE: June 11, 1989
DATUM: MLLW
REFERENCE EL.: 13 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTIC LIMIT (%)	TORVANE (PSF)	ADDITIONAL TESTS
				70								
60			B-2			SILTY CLAY (CL), bluish gray, wet, medium stiff, less than about 5% coarse grains, medium plasticity.	99	28				
-50			T-2 R24	66/ 11"		SILTY SAND (SP-SM), with about 10% fines.						
			S-4	20		SILTY CLAY (CL), bluish gray, medium stiff, less than 5% coarse grains, medium plasticity.						
						SILTY SAND (SM), as before.						
70			T-3 R30	50/ 6"		interlayers of SILTY CLAY (CL), SANDY SILT(ML), and SILTY SAND (SM), bluish gray, stiff and dense, each layer about 6-inch thick.	93	32				
-60			S-5	44		grading to SILTY CLAY (CL), with occasional higher sand content, mostly clayey, medium plasticity.						
						End of boring at 76.5 feet.						

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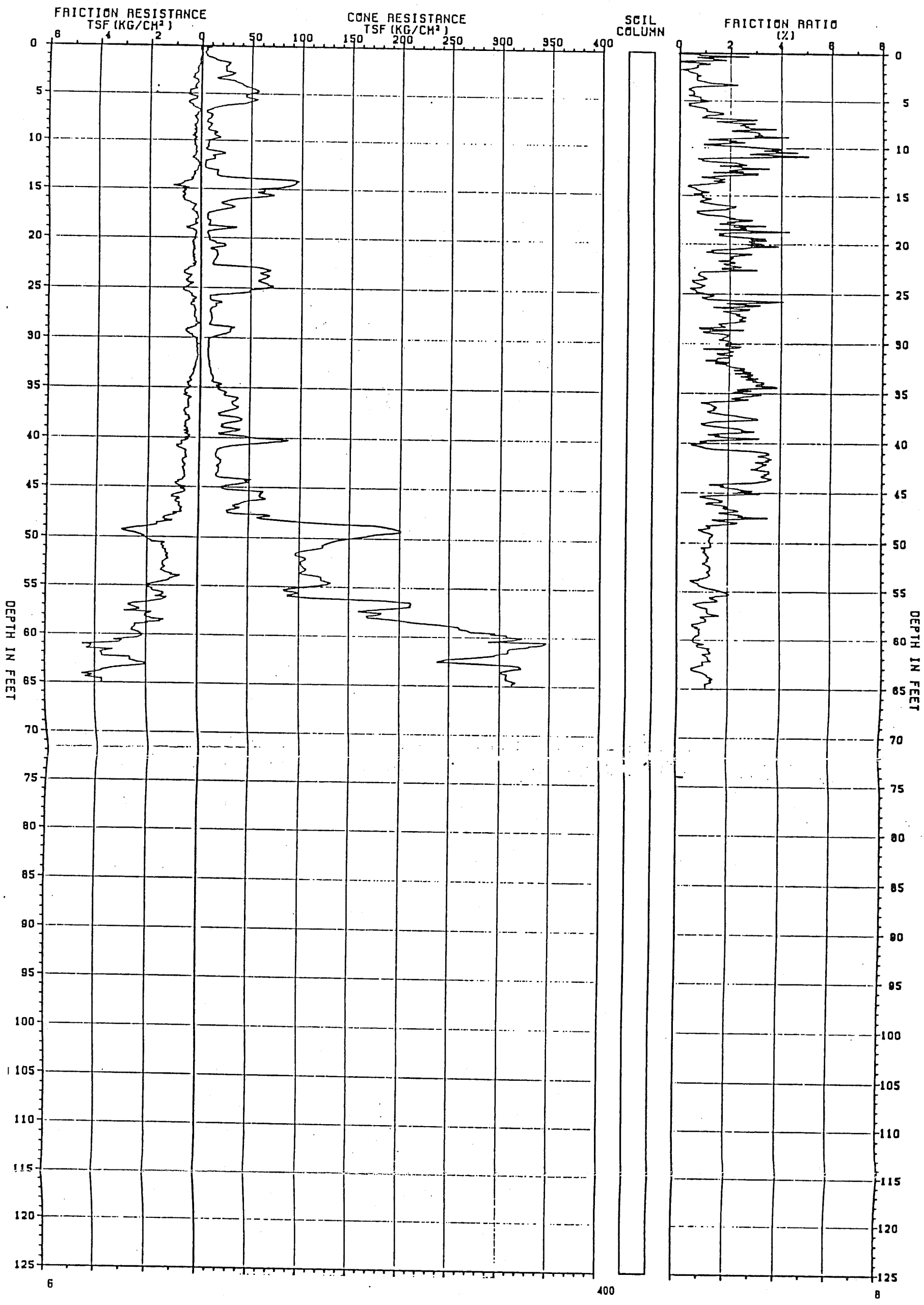
LOG OF DRILL HOLE BL2–2(B)

PROJECT NO. 0033–003 | FIGURE NO. A1–13(B)



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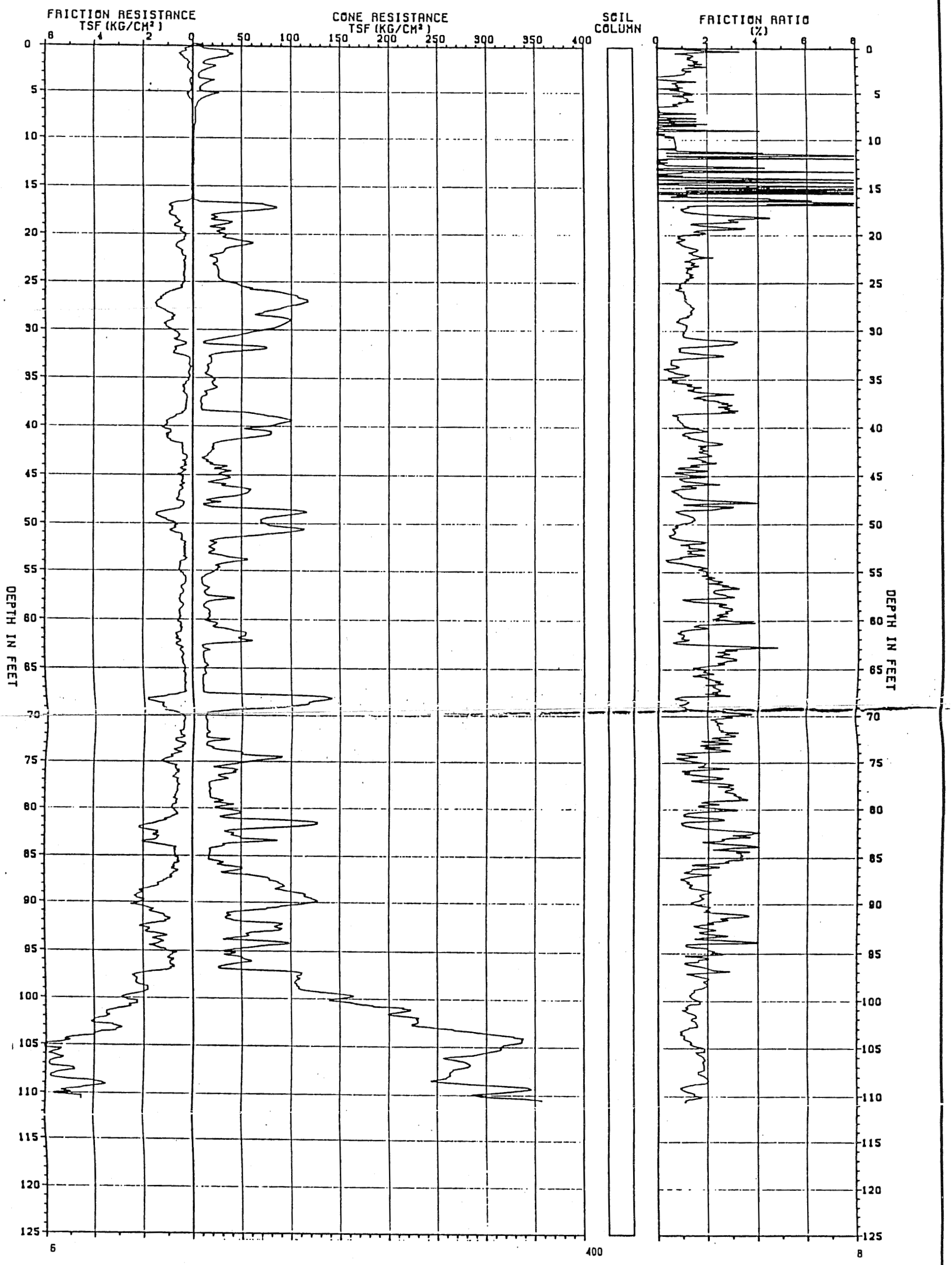
360 East Second Street, Suite 102
Los Angeles, CA 90012

CONE PENETROMETER TEST
PROBE: CD–2

PROJECT NO.	0033–003	FIGURE NO.	A1–15



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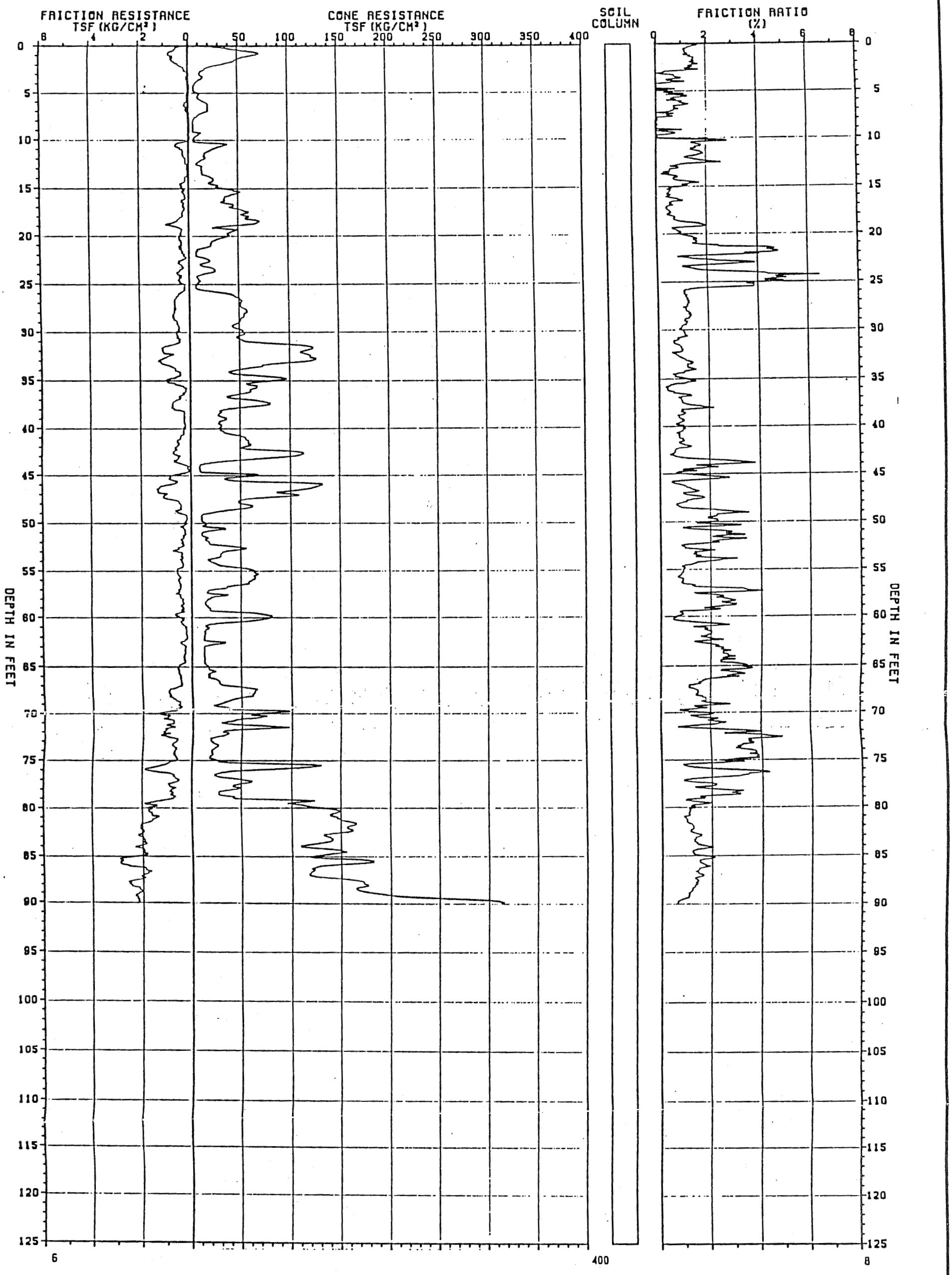
CONE PENETROMETER TEST
PROBE: CL—1

PROJECT NO.	0033—003	FIGURE NO.	A1—16



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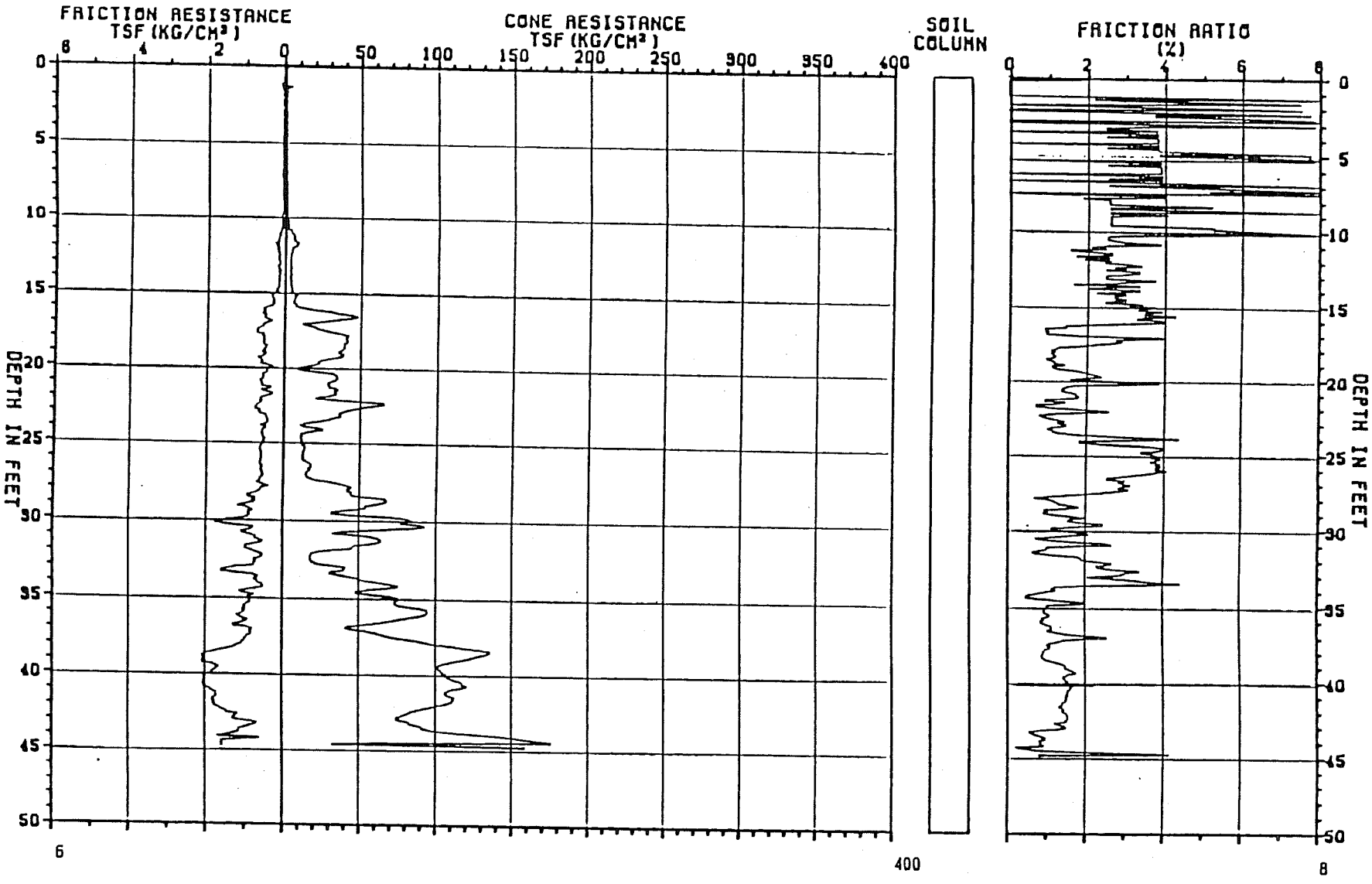
Los Angeles, CA 90012

CONE PENETROMETER TEST
PROBE: CL—2

PROJECT NO.	0033—003	FIGURE NO.	A1—17



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360 East Second Street, Suite 102
Los Angeles, CA 90012

CONE PENETROMETER TEST
PROBE: CD—1

PROJECT NO.	0033—003	FIGURE NO.	A1—14

DIAZ-YOURMAN AND ASSOCIATES (2000)

"REVISED GEOTECHNICAL DESIGN REPORT, NON-BRIDGE PORTIONS,

HENRY FORD AVENUE GRADE SEPARATION, LOS ANGELES, CALIFORNIA"

ALAMEDA CORRIDOR SOUTH END

HENRY FORD AVENUE GRADE SEPARATION

APPROXIMATE SCALE 1:5000

0 50 100

LEGEND:

- RETAINING MSE WALL
- ROADWAY
- STRUCTURE
- B-1 EMI SOIL BORING
- DY-1 DYA SOIL BORING
- LC-7 LAW/CRANDALL SOIL BORING
- MAA-2-1 MAA SOIL BORING
- LKR-4 LKR SOILD BORING
- C-1 CPT PERFORMED BY EMI
- CP-1 CPT PERFORMED BY DYA
- A ____ A' CROSS SECTION LOCATION

SR-47 TERMINAL ISLAND FREEWAY

PIER A ACCESS ROAD

PIER A (HANJIN)

T.I. FREEWAY OFF RAMP

T.I. FREEWAY ON RAMP

SCHUYLER HEIM BRIDGE

SEGMENT 1

SEGMENT 2

SEGMENT 3

SEGMENT 4

SEGMENT 5A

SEGMENT 5B NORTH

SEGMENT 5B SOUTH

ANAHEIM STREET

DOMINGUEZ CHANNEL

ACTA 1 & 2 VIADUCT

ACTA 3 (INTERIM RAIL)

HENRY FORD AVENUE (NORTH)

HENRY FORD AVENUE (SOUTH)

TIDELAND

TEMPORARY ACCESS ROAD (SEE FIGURE 5-2)

HENRY FORD AVE. BRIDGE

HARBOR BELT LINE BRIDGE

BADGER BRIDGE

ANCHORAGE ROAD

CERRITOS CHANNEL

FIGURE 5-1 SITE PLAN

SOIL CLASSIFICATION SYSTEM-ASTM D2487

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS
				FILL	

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Drive sampler (Modified California) with liner

Standard Penetration Test (SPT) Sampler

Concrete

Groundwater Surface

RV = R-Value

CA = Corrosion Analysis

DS = Direct Shear

C = Consolidation

GS = Grain size

CM = Compaction Test

EIT = Expansion Index Test

SPT "N" = Total blow count for last 300 mm of driving, set to 100 when refusal was met

Equivalent SPT "N" = 0.5 * Drive sampler blow count for last 300 mm

NP = Non-plastic

KEY TO LOG OF BORINGS

Henry Ford Avenue Grade Separation
Project No. 165-07

PLATE
B1

BORING LOCATION: See Figure 5-1	**ELEVATION AND DATUM (m):** 5.0 MSL
DRILLING EQUIPMENT: Mobile B-80	**DRILLING METHOD:** Rotary Wash
BORING DIAMETER (cm): 10	**BORING DEPTH (m):** 18.7
DATE STARTED: 12/30/97	**DATE COMPLETED:** 12/30/97
SPT HAMMER DROP: 76 cm **WT:** 0.62 kN	**DRIVE HAMMER DROP:** 76 cm **WT:** 0.62 kN
LOGGED BY: SM **CHECKED BY:** CMD	**DRIVE SAMPLER DIAMETER (cm)** ID: 6.1 OD: 7.6

Elevation (meter)	Depth (meter)	Sampler	Symbol	Blows per 15 cm	SPT N Blows/30 cm	Field Unc. Comp. Str (kPa)	DESCRIPTION	Dry Density (kg/m^3)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Passing #200 Sieve	Other Tests [PID]
							ASPHALT - 150 mm						
							POORLY GRADED GRAVEL with SAND (GP); brown, moist, dense, fine-grained sand (base material) - 305 mm						
4	1			7 13 17	30		SILTY SAND (SM); brown, wet, compact, fine-grained sand, trace fine gravel, trace wood and asphalt - FILL						[2.4]
				5 9 20	15		slightly compact, trace asphalt						[11.7]
3	2			7 15 18	33		compact olive brown					15	[17.5]
2	3			5 12 16	14		POORLY GRADED GRAVEL with SILT and SAND (GP-GM); olive brown, wet, slightly compact, fine-grained sand, fine gravel, little asphalt - FILL						[5.8]
1	4												
0	5			17 38 19	57		dense					9	[16.9]
-1	6												
				7 9 11	10		slightly compact, increased coarse gravel content						[12.9]
-2	7												

LOG OF BORING DY-18

Page 1 of 3

Henry Ford Avenue Grade Separation

Project No. 165-07

PLATE

B24

Elevation (meter)	Depth (meter)	Sampler	Symbol	Blows per 15 cm	SPT N Blows/30 cm	Field Unc. Comp. Str (kPa)	DESCRIPTION	Dry Density (kg/m^3)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Passing #200 Sieve	Other Tests [PID]
-3	8			6 9 11	20		SILTY SAND (SM); very dark gray, wet, compact, trace marine shells					32	[4.9]
-4	9			5 6 5	5	50	loose, fine-grained sand, trace marine shells						[23.1]
-5	10												
-6	11			5 5 5	10		slightly compact			NP	NP	35	[11.9]
-7	12												
-8	13			6 17 18	17	110	trace marine shells						[16.5]
-9	14			13 17 17	34		compact, trace marine shells, increased sand content						[16.2]
-10	15						dense, fine- to medium-grained sand, trace marine shells						
-11	16			25 33 38	35							28	[19.6]
-12	17			3 4 5	9		SILT (ML); very dark gray, wet, soft, low plasticity, trace marine shells, trace fine-grained sand						[16.7]

LOG OF BORING DY-18

Page 2 of 3

Henry Ford Avenue Grade Separation

Project No. 165-07

PLATE

B25

Elevation (meter)	Depth (meter)	Sampler	Symbol	Blows per 15 cm	SPT N Blows/30 cm	Field Unc. Comp. Str (kPa)	DESCRIPTION	Dry Density (kg/m^3)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Passing #200 Sieve	Other Tests [PID]
-13	18			17 17 50	33	80	very stiff						[132]
-14	19						Bottom of boring at 18.7 meters. Groundwater encountered at 1 meter. Boring backfilled with cement/bentonite grout and surface patched with cold patch asphalt.						
-15	20												
-16	21												
-17	22												
-18	23												
-19	24												
-20	25												
-21	26												
-22	27												

LOG OF BORING DY-18

Page 3 of 3

Henry Ford Avenue Grade Separation

Project No. 165-07

PLATE

B26

BORING LOCATION: See Figure 5-1	ELEVATION AND DATUM (m): 2.5 MSL
DRILLING EQUIPMENT: Mobile B-80	DRILLING METHOD: Rotary Wash
ORING DIAMETER (cm): 10	BORING DEPTH (m): 18.7
DATE STARTED: 12/31/97	DATE COMPLETED: 12/31/97
SPT HAMMER DROP: 76 cm WT: 0.62 kN	DRIVE HAMMER DROP: 76 cm WT: 0.62 kN
LOGGED BY: SM CHECKED BY: CMD	DRIVE SAMPLER DIAMETER (cm) ID: 6.1 OD: 7.6

Elevation (meter)	Depth (meter)	Sampler	Symbol	Blows per 15 cm	SPT N Blows/30 cm	Field Unc. Comp. Str (kPa)	DESCRIPTION	Dry Density (kg/m^3)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Passing #200 Sieve	Other Tests [PID]
2				50	100		SILT SAND (SM); olive gray, moist, very dense, fine-grained sand, trace asphalt - FILL						[13.0]
1	1			4 4 3	7		loose, little fine gravel, few marine shells					42	[8.0]
1				3 6 8	7		no recovery ▼wet						
0	2			2 5 6	5		SILTY GRAVEL (GM); brown, wet, loose, fine gravel, trace marine shells - FILL						[7.8]
-1	3			1 3 9	12		SILT (ML); very dark gray, wet, stiff, low plasticity, trace marine shells and pieces of wood, trace fine-grained sand - FILL			45	17	87	[3.8]
-2	4			3 4 6	5	40	SANDY SILT (ML); dark gray, wet, soft, fine-grained sand	1379	34	NP	NP	39	[6.1] DS
-3	5												
-4	6			3 6 7	13		stiff						[3.7]
-5	7						SILTY SAND (SM); dark gray, wet, very dense, fine- to						

LOG OF BORING DY-19

Page 1 of 3

Henry Ford Avenue Grade Separation

Project No. 165-07

PLATE

B27

Elevation (meter)	Depth (meter)	Sampler	Symbol	Blows per 15 cm	SPT N Blows/30 cm	Field Unc. Comp. Str (kPa)	DESCRIPTION	Dry Density (kg/m^3)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Passing #200 Sieve	Other Tests [PID]
				20 50/ 13cm	100		medium-grained sand, trace marine shells and pieces of wood	1605	24			13	
-6	8												
	9			6 12 13	25		compact						[3.8]
-7													
	10												
-8				10 24 25	24		little marine shells					14	[4.3]
	11												
-9													
	12			2 3 5	8		SILT (ML); dark gray, wet, soft, nonplastic, trace sand and marine shells			NP	NP	94	[4.2]
-10	13												
-11				10 27 29	28		SILTY SAND (SM); dark gray, wet, compact, fine- to medium-grained sand, little marine shells, trace gravel						[4.6]
	14												
-12													
	15			2 2 4	6	50	LEAN CLAY (CL); dark gray, wet, soft, low plasticity, trace sand and marine shells						[0.0]
-13													
	16												
-14													
	17			12 23 43	33	80	SANDY SILT (ML); dark gray, wet, very stiff, nonplastic, fine-grained sand, trace marine shells						
-15													

LOG OF BORING DY-19

Page 2 of 3

Henry Ford Avenue Grade Separation

Project No. 165-07

PLATE

B28

Elevation (meter)	Depth (meter)	Sampler	Symbol	Blows per 15 cm	SPT N Blows/30 cm	Field Unc. Comp. Str (kPa)	DESCRIPTION	Dry Density (kg/m^3)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Passing #200 Sieve	Other Tests [PID]
	18												
-16				12 23 32	55		SILTY SAND (SM); dark gray, wet, dense, fine-grained sand						[0.0]
	19						Bottom of boring at 18.7 meters. Groundwater encountered at 1.8 meters. Boring backfilled with cement/bentonite grout.						
-17													
	20												
-18													
	21												
-19													
	22												
-20													
	23												
-21													
	24												
-22													
	25												
-23													
	26												
-24													
	27												
-25													

LOG OF BORING DY-19

Page 3 of 3

Henry Ford Avenue Grade Separation

Project No. 165-07

PLATE

B29

APPENDIX C

SPT HAMMER ENERGY MEASUREMENT REPORT

FOR LAND BORINGS BY EARTHSPECTIVES

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

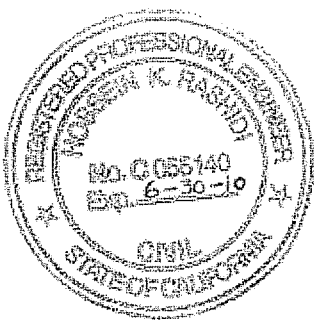
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

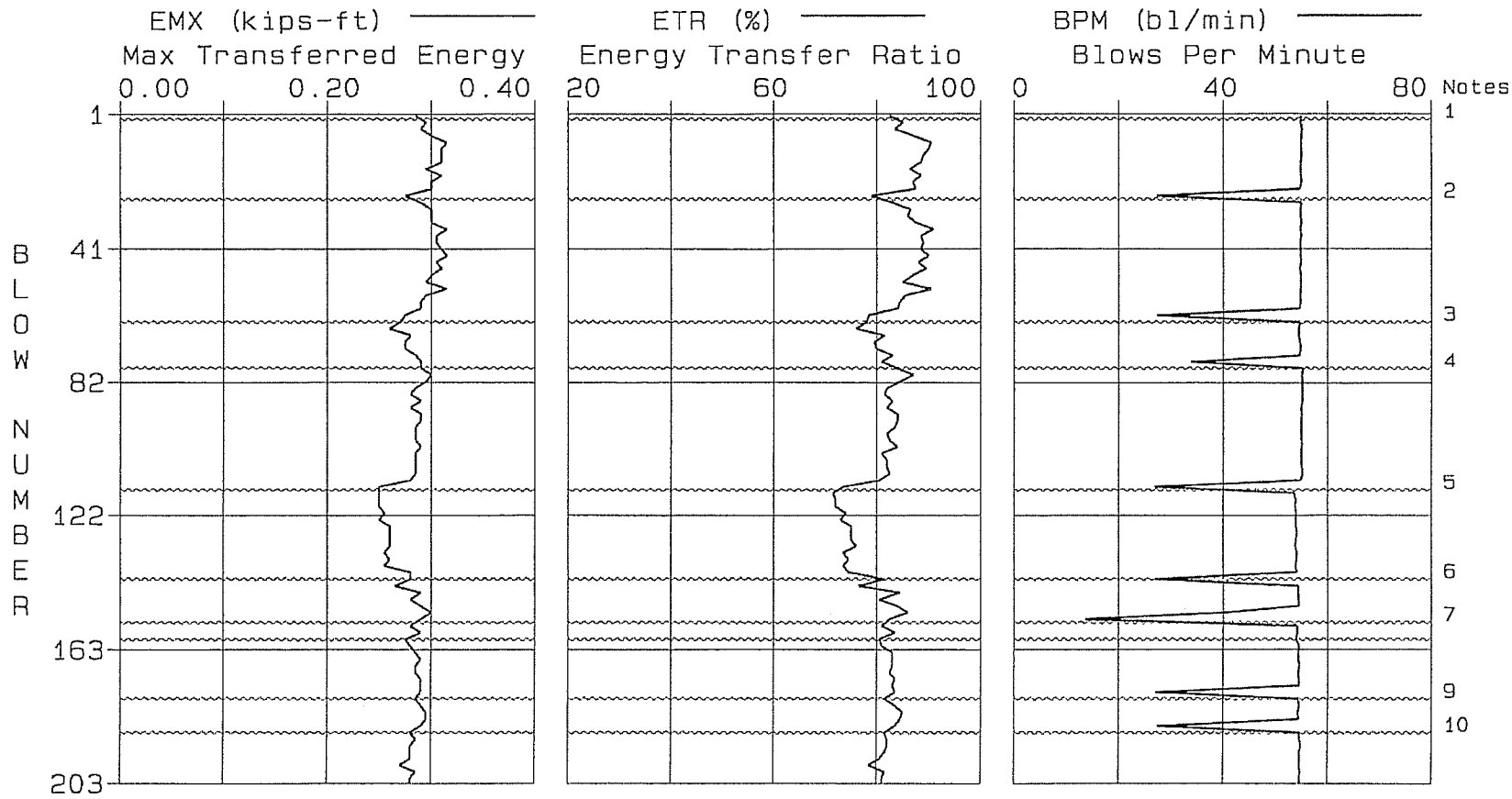
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

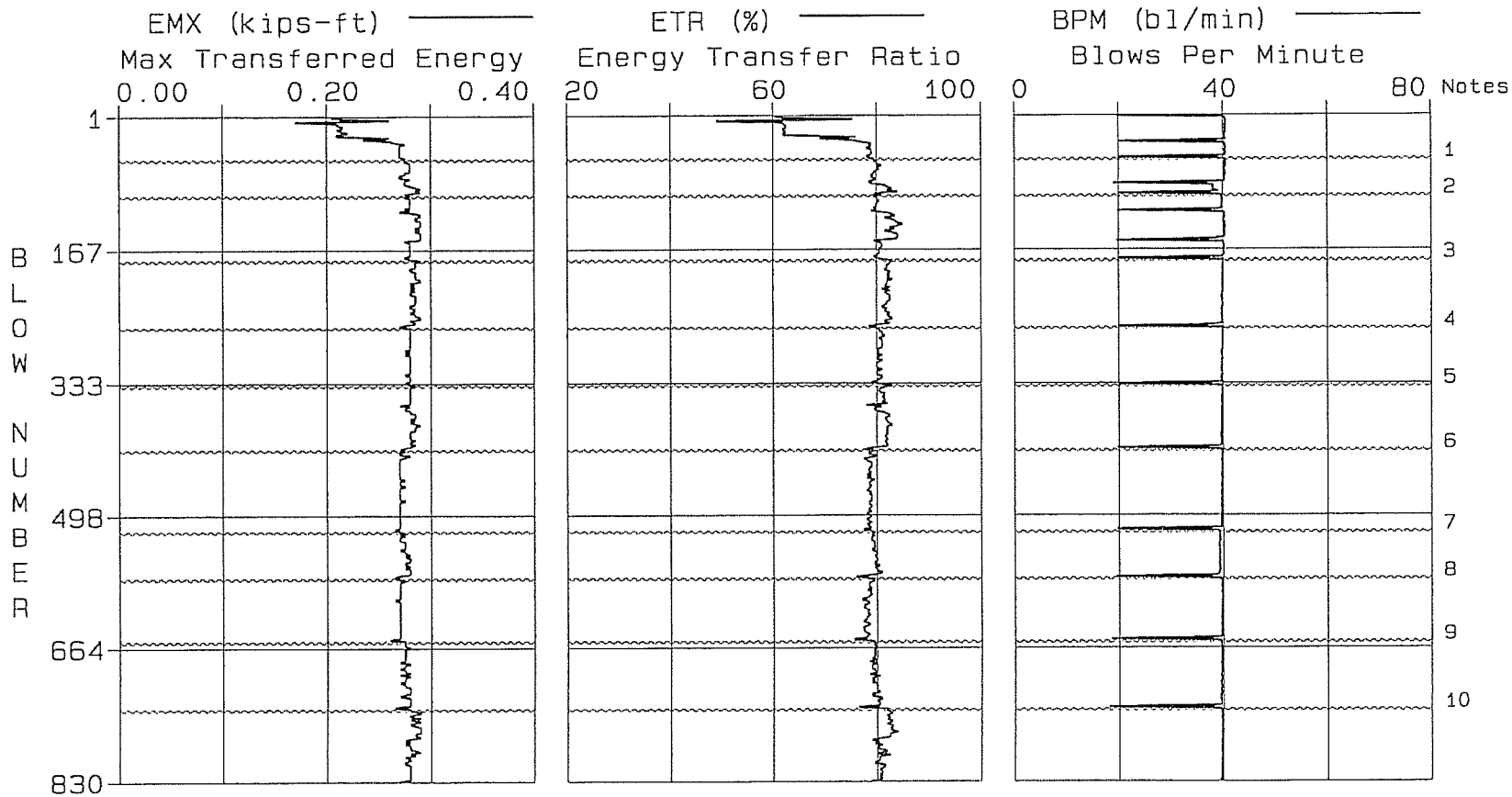
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

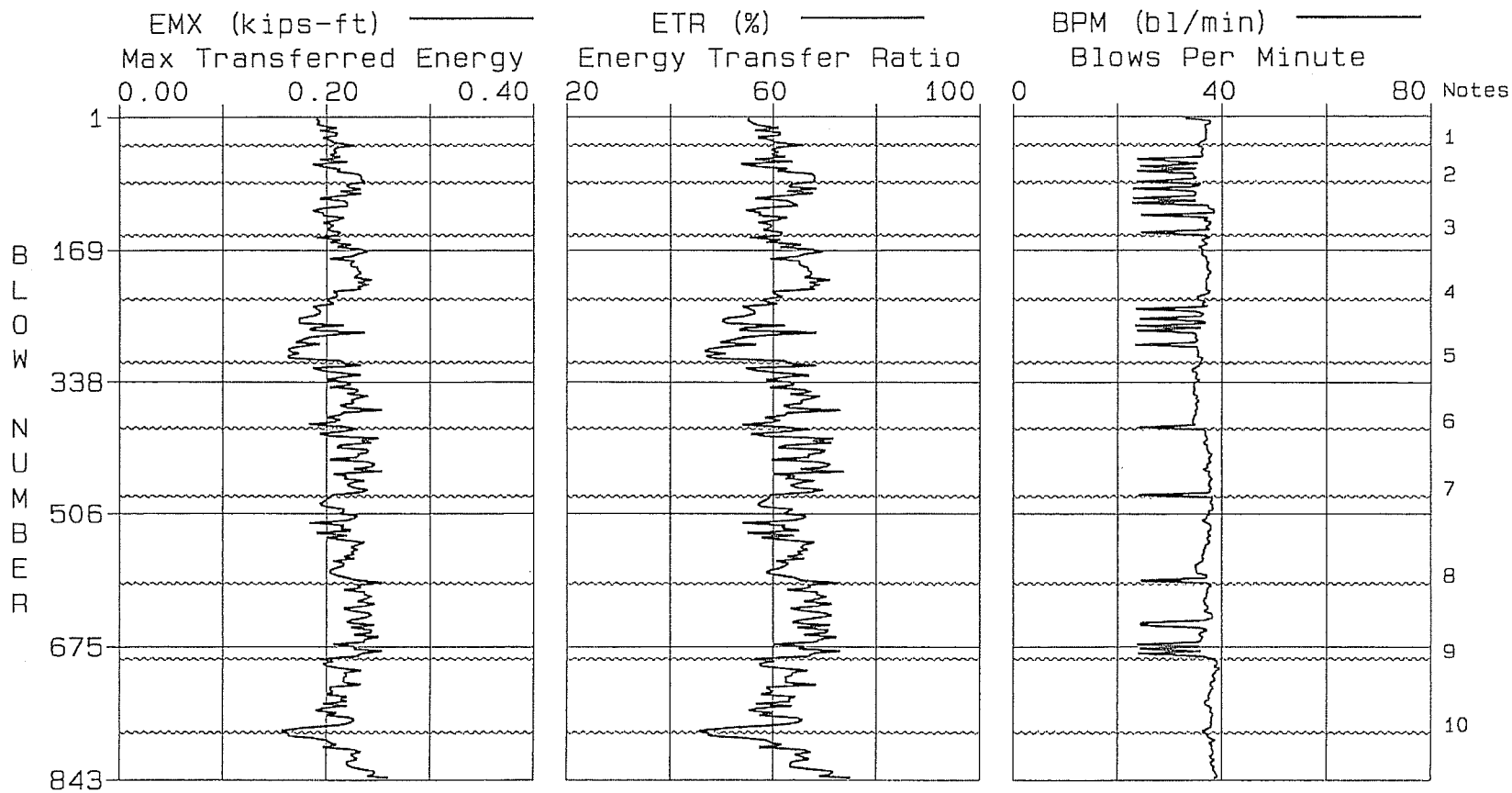
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

FOR OVER WATER BORINGS BY GREGG

November 10, 2009

Mr. Eric Brown
Earth Mechanics
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Re: Standard Penetration Energy Measurements
Automatic Hammer on B-80 Mud Rotary Drill Rig
Heim Bridge Investigation,
Los Angeles, California

Dear Mr. Brown,

This report offers results of energy measurements and related calculations made on November 9, 2009 during Standard Penetration Testing (SPT) on Gregg Drilling's B-80 mud rotary drill rig. Dynamic tests were performed on an instrumented section of NWJ drill rod attached to the sampler rod string. All dynamic measurements were obtained and recorded using a Pile Driving Analyzer®.

Equipment:

SPT energy measurements were made on SPT samplers driven by the hammer/anvil system on the Gregg Drilling B-80 drill rig on November 9, 2009. The rig was tested on the Quin Delta drilling ship for the Heim Bridge project investigation. In total, 11 energy measurements were collected corresponding to 11 different samples at increasing depth.

Gregg used a Model PAK Pile Driving Analyzer (PDA) to acquire and process measurements of force and velocity with every impact of the automatic hammer on the sample rods. Two strain gauges mounted on a two foot section of NWJ rod measured force, while two piezoresistive accelerometers bolted on the same rod measured acceleration. The gauges were mounted approximately 6" from the top of the rod.
Analog signals from the gauges and accelerometers were collected, digitized, displayed in real-time, and stored by the PDA. Selected output from the PDA for each recorded impact of the hammer included:

- Maximum force in the rod (FMX)
- Maximum velocity in the rod (VMX)
- Maximum calculated transferred energy (EMX)
- Blows per minute (BPM)
- Energy transferred to the rods (ETR)

Data and Calculations:

The purpose of testing was to measure the energy transferred from the hammer to the drill rod and to calculate the energy efficiency of the hammer. The PDA measurements of force and velocity were reviewed after field testing and analyzed to calculate the transferred energy (EMX).

The maximum energy transferred past the gauge location, EMX, is computed by the PDA using force (F) and velocity (V) records as follows:

$$EMX = \int_a^b F(t)\, V(t)\, dt$$

The time "a" corresponds to the start of the record when the energy transfer begins and "b" is the time at which energy transferred to the rod reaches a maximum value. The energy transferred is defined as ETR, and is usually used to define the efficiency of the hammer/anvil system.

Results:

Table 1 summarizes the average calculated energies for each sample tested as well as the type of sample and depth. It is shown that the overall average (ETR) energy for this system is 86%. Appendix A provides plots and tables of PDA results for all hammer blows at each sampling depth. The plots and tables present selected measured and calculated results as a function of blow number. The results include:

- the blow number
- depth
- BLC (blow count in blows per foot)
- FMX (maximum rod force)
- VMX (maximum rod velocity)
- EMX (maximum transferred energy)
- BPM (blows per minute)
- ETR (energy transferred in percent of maximum)

At the end of each table is a statistical evaluation of the results for each variable including the average, standard deviation, maximum, and what blow number this maximum occurred.

If you have any questions or comments on this report, please do not hesitate to call our office at (562) 427-6899.

Sincerely,

Kelly Cabal

Kelly Cabal
Engineer

GREGG

Client: Earth Mechanics
Project: Heim Bridge
Date: 11/10/2009
Rig: B-80 on Quin Delta

Table 1 - SPT Sample Summary

Sample #	Sampler	Total Rod Length* (ft)	Depth of Sample (below Mudline) (ft)	Total Blows Analyzed by PDA	Average Energy Transferred to Rods (% of Theoretical Max.)	Maximum Efficiency Recorded (%)	Standard Deviation
1	SPT	67.0	15	9	82.1	83.9	1
2	SPT	77.0	25	15	86.5	88.5	2
3	SPT	87.0	35	31	87.6	91.1	1
4	SPT	97.0	45	110	85.7	87.5	1
5	SPT	107.0	55	101	86.2	89.8	1
6	SPT	117.0	65	93	90.5	95.3	1
7	SPT	132.0	80	111	87.3	91.0	1
8	SPT	142.0	90	86	87.3	90.5	2
9	SPT	151.0	100	126	82.3	88.0	2
10	SPT	171.0	120	55	82.4	85.5	1
11	SPT	181.0	130	90	82.1	85.7	2
				Average	85.5		

* Total rod length includes, sampler, rod, adaptors, and instrumented section below gauges

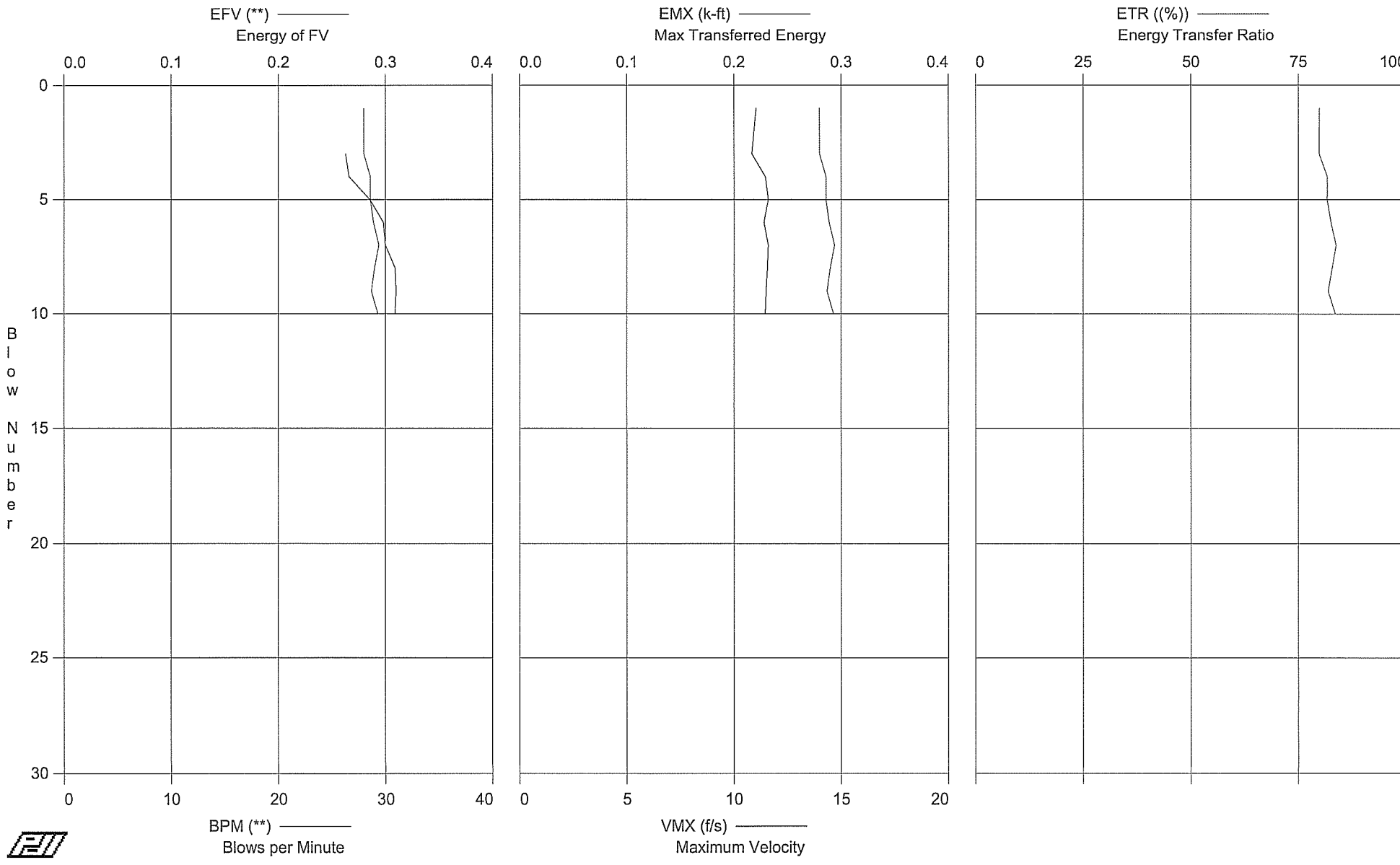
Appendix A

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-200

Heim Bridge - WR-09-041 @ 15'



Gregg Drilling & Testing
Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Heim Bridge - WR-09-041 @ 15'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 67.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	11.0	79.9
3	0.00	0	26.3	0.3	10.8	79.9
4	0.00	0	26.6	0.3	11.5	81.8
5	0.00	0	28.6	0.3	11.6	81.8
6	0.00	0	29.8	0.3	11.4	82.7
7	0.00	0	30.0	0.3	11.6	83.9
8	0.00	0	30.9	0.3	11.6	82.9
9	0.00	0	31.0	0.3	11.5	82.0
10	0.00	0	30.9	0.3	11.5	83.7
	Average	0	29.3	0.3	11.4	82.1
	Std. Dev.	0	1.8	0.0	0.3	1.3
	Maximum	0	31.0	0.3	11.6	83.9
	@ Blow#	7	9	7	5	7

Total number of blows analyzed: 9

Time Summary

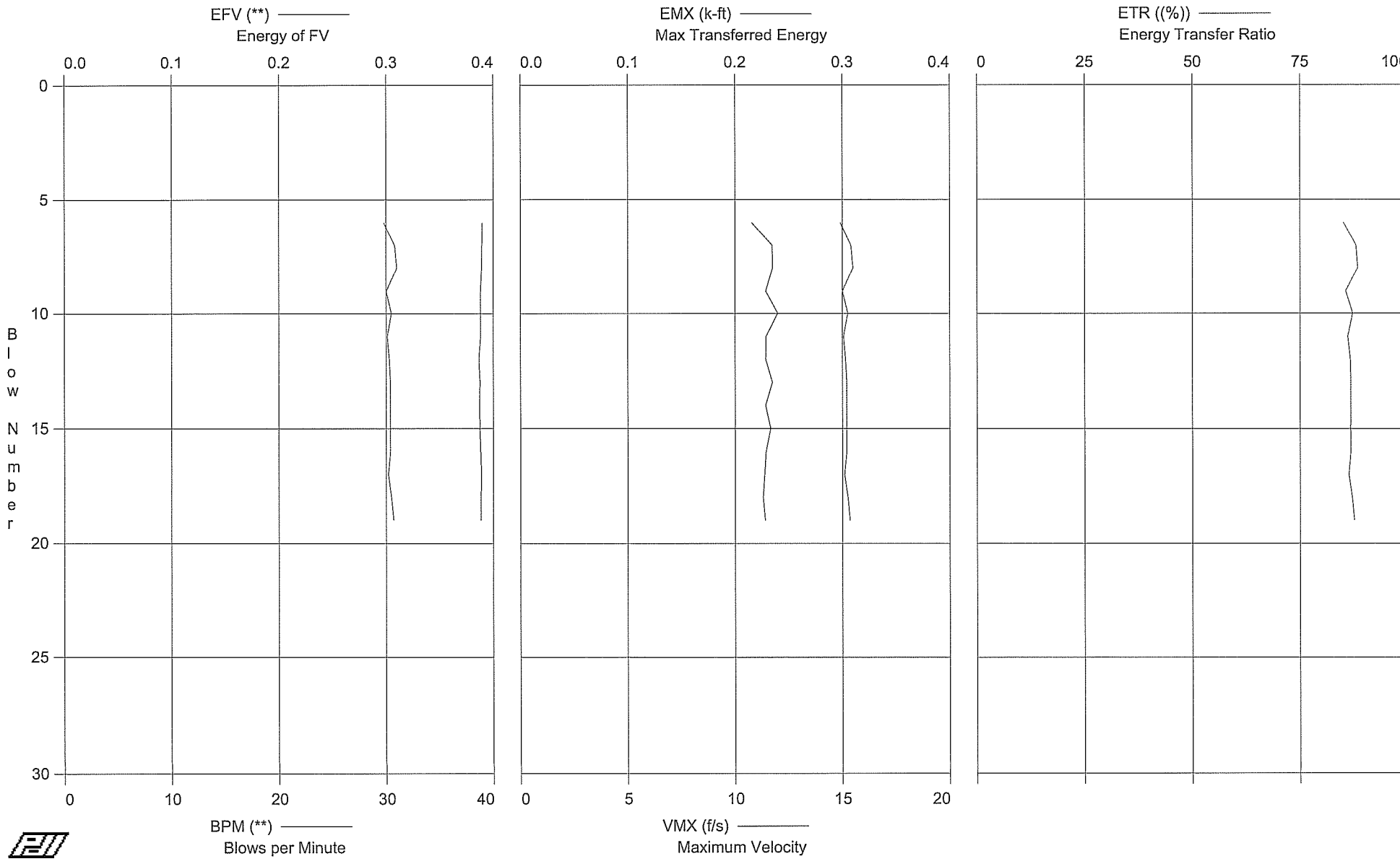
Drive 18 seconds 14:47:38 - 14:47:56 (2009-01-19) BN 1 - 10

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 25'



Heim Bridge - WR-09-041 @ 25'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 77.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	10.7	81.9
6	0.00	0	39.0	0.3	10.8	85.1
7	0.00	0	38.9	0.3	11.7	88.0
8	0.00	0	38.9	0.3	11.8	88.5
9	0.00	0	38.8	0.3	11.4	85.6
10	0.00	0	38.8	0.3	12.0	87.2
11	0.00	0	38.8	0.3	11.4	86.1
12	0.00	0	38.7	0.3	11.4	86.7
13	0.00	0	38.8	0.3	11.7	86.8
14	0.00	0	38.7	0.3	11.4	86.8
15	0.00	0	38.7	0.3	11.7	86.8
16	0.00	0	38.8	0.3	11.4	86.8
17	0.00	0	38.9	0.3	11.4	86.4
18	0.00	0	38.8	0.3	11.3	87.1
19	0.00	0	38.9	0.3	11.4	87.6
	Average	0	38.8	0.3	11.4	86.5
	Std. Dev.	0	0.1	0.0	0.3	1.5
	Maximum	0	39.0	0.3	12.0	88.5
	@ Blow#	8	6	8	10	8

Total number of blows analyzed: 15

Time Summary

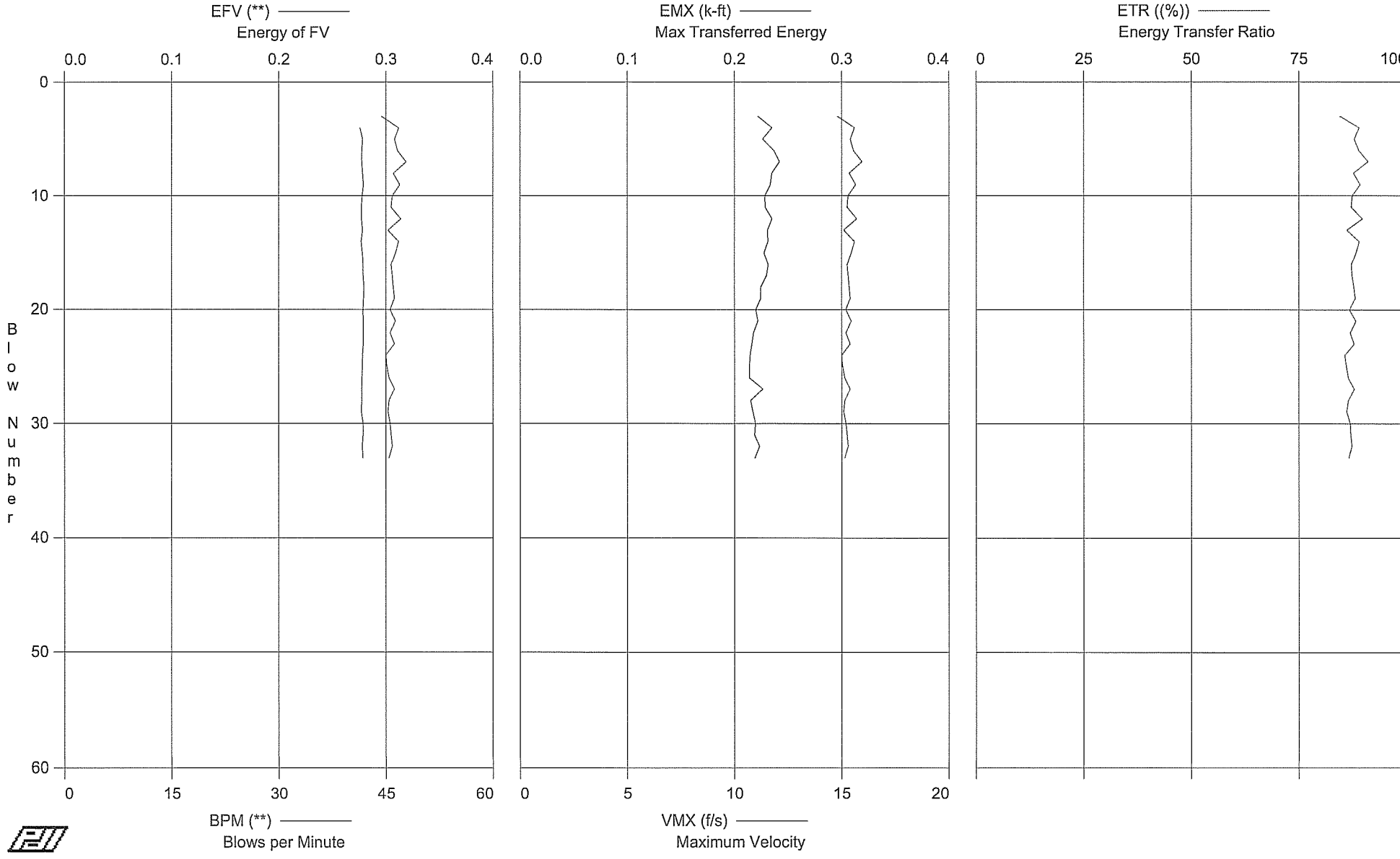
Drive 28 seconds 15:14:51 - 15:15:19 (2009-01-19) BN 1 - 19

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 35'



Gregg Drilling & Testing
Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Heim Bridge - WR-09-041 @ 35'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 87.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
3	0.00	0	0.0	0.3	11.1	84.5
4	0.00	0	41.4	0.3	11.8	89.0
5	0.00	0	41.8	0.3	11.3	87.9
6	0.00	0	41.6	0.3	11.8	89.0
7	0.00	0	41.6	0.3	12.1	91.1
8	0.00	0	41.8	0.3	11.7	87.7
9	0.00	0	41.9	0.3	11.7	89.3
10	0.00	0	41.7	0.3	11.4	87.4
11	0.00	0	41.6	0.3	11.4	87.2
12	0.00	0	41.6	0.3	11.8	89.8
13	0.00	0	41.8	0.3	11.5	86.2
14	0.00	0	41.6	0.3	11.6	89.1
15	0.00	0	41.7	0.3	11.4	88.3
16	0.00	0	41.8	0.3	11.6	87.2
17	0.00	0	41.8	0.3	11.5	87.4
18	0.00	0	42.0	0.3	11.2	87.8
19	0.00	0	41.9	0.3	11.2	88.1
20	0.00	0	41.8	0.3	11.0	86.8
21	0.00	0	41.8	0.3	11.1	88.3
22	0.00	0	41.8	0.3	10.9	87.0
23	0.00	0	41.8	0.3	10.8	87.9
24	0.00	0	41.8	0.3	10.7	85.7
25	0.00	0	41.7	0.3	10.7	86.1
26	0.00	0	41.7	0.3	10.7	86.5
27	0.00	0	41.6	0.3	11.3	88.0
28	0.00	0	41.6	0.3	10.8	86.5
29	0.00	0	41.6	0.3	10.9	86.2
30	0.00	0	41.8	0.3	11.0	87.0
31	0.00	0	41.8	0.3	10.9	87.1
32	0.00	0	41.7	0.3	11.2	87.4
33	0.00	0	41.8	0.3	11.0	86.7
	Average	0	41.7	0.3	11.3	87.6
	Std. Dev.	0	0.1	0.0	0.4	1.3
	Maximum	0	42.0	0.3	12.1	91.1
	@ Blow#	7	18	7	7	7

Total number of blows analyzed: 31

Time Summary

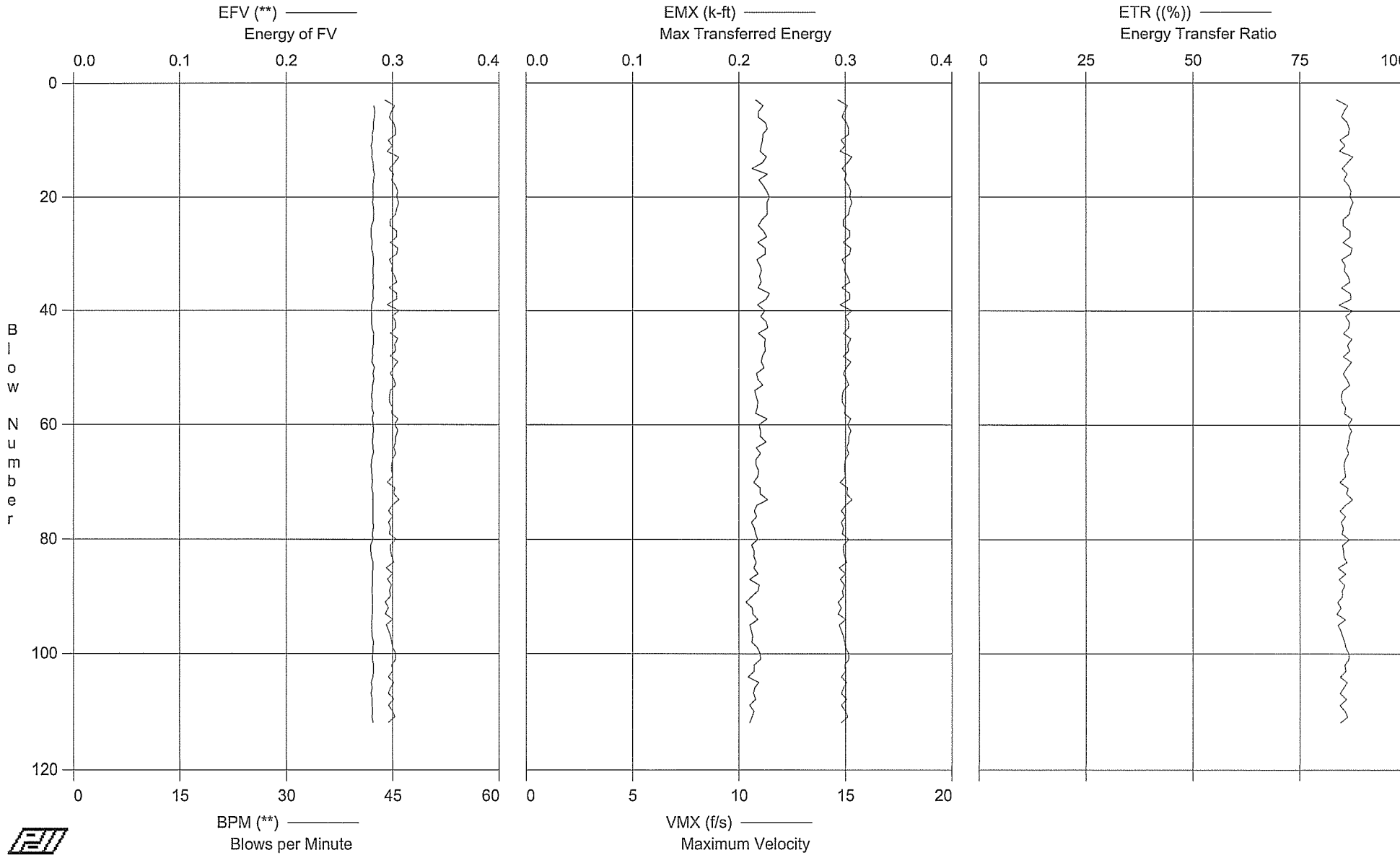
Drive 44 seconds 15:51:10 - 15:51:54 (2009-01-19) BN 3 - 33

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 45'



Heim Bridge - WR-09-041 @ 45'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 97.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
3	0.00	0	0.0	0.3	10.8	83.6
4	0.00	0	42.4	0.3	11.1	86.3
5	0.00	0	42.5	0.3	10.9	85.4
6	0.00	0	42.4	0.3	10.9	84.9
7	0.00	0	42.3	0.3	11.2	86.1
8	0.00	0	42.3	0.3	11.3	86.6
9	0.00	0	42.1	0.3	11.1	86.4
10	0.00	0	42.2	0.3	11.1	84.5
11	0.00	0	42.0	0.3	11.1	85.6
12	0.00	0	42.1	0.3	11.0	84.3
13	0.00	0	42.1	0.3	11.3	87.5
14	0.00	0	42.3	0.3	11.1	86.2
15	0.00	0	42.3	0.3	10.6	84.9
16	0.00	0	42.4	0.3	11.3	86.1
17	0.00	0	42.3	0.3	10.9	85.3
18	0.00	0	42.2	0.3	11.1	86.4
19	0.00	0	42.3	0.3	11.3	87.0
20	0.00	0	42.3	0.3	11.4	86.8
21	0.00	0	42.2	0.3	11.3	87.5
22	0.00	0	42.3	0.3	11.3	86.9
23	0.00	0	42.3	0.3	11.3	86.7
24	0.00	0	42.3	0.3	11.1	85.2
25	0.00	0	42.0	0.3	10.9	85.2
26	0.00	0	42.0	0.3	11.2	86.8
27	0.00	0	42.0	0.3	11.3	86.8
28	0.00	0	42.2	0.3	10.9	85.2
29	0.00	0	42.0	0.3	11.2	87.2
30	0.00	0	42.3	0.3	11.2	86.9
31	0.00	0	42.3	0.3	10.8	84.8
32	0.00	0	42.3	0.3	11.0	85.7
33	0.00	0	42.2	0.3	11.1	85.4
34	0.00	0	42.3	0.3	11.0	86.3
35	0.00	0	42.3	0.3	11.0	86.7
36	0.00	0	42.3	0.3	10.9	84.8
37	0.00	0	42.2	0.3	11.4	86.9
38	0.00	0	42.3	0.3	11.3	87.0
39	0.00	0	42.0	0.3	10.9	84.2
40	0.00	0	42.0	0.3	11.2	87.3
41	0.00	0	42.0	0.3	11.0	85.7
42	0.00	0	42.0	0.3	11.3	86.7
43	0.00	0	42.1	0.3	11.4	86.5
44	0.00	0	42.3	0.3	10.9	85.2
45	0.00	0	42.3	0.3	11.2	87.2
46	0.00	0	42.3	0.3	11.2	86.2
47	0.00	0	42.1	0.3	11.2	86.7
48	0.00	0	42.2	0.3	11.1	85.2
49	0.00	0	42.1	0.3	11.1	87.1
50	0.00	0	42.4	0.3	11.2	86.1
51	0.00	0	42.3	0.3	10.8	85.2
52	0.00	0	42.4	0.3	10.9	86.1
53	0.00	0	42.2	0.3	11.1	86.7
54	0.00	0	42.2	0.3	10.7	85.1
55	0.00	0	42.0	0.3	10.8	84.7
56	0.00	0	42.2	0.3	10.9	85.0
57	0.00	0	42.1	0.3	10.9	85.8
58	0.00	0	42.3	0.3	10.8	85.5
59	0.00	0	42.2	0.3	11.3	87.2
60	0.00	0	42.3	0.3	10.9	86.4
61	0.00	0	42.3	0.3	11.0	87.2
62	0.00	0	42.2	0.3	11.0	86.6
63	0.00	0	42.2	0.3	11.3	86.5
64	0.00	0	42.3	0.3	10.8	86.0
65	0.00	0	42.3	0.3	11.0	86.5
66	0.00	0	42.1	0.3	10.8	85.6
67	0.00	0	42.0	0.3	10.8	85.4
68	0.00	0	42.0	0.3	10.9	85.5
69	0.00	0	42.1	0.3	10.9	85.7

Heim Bridge - WR-09-041 @ 45'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
70	0.00	0	42.2	0.3	10.7	84.4
71	0.00	0	42.0	0.3	11.0	86.3
72	0.00	0	42.3	0.3	11.0	86.0
73	0.00	0	42.2	0.3	11.3	87.4
74	0.00	0	42.3	0.3	10.8	85.6
75	0.00	0	42.2	0.3	10.7	84.4
76	0.00	0	42.3	0.3	10.8	85.7
77	0.00	0	42.3	0.3	10.6	84.7
78	0.00	0	42.3	0.3	10.7	85.2
79	0.00	0	42.1	0.3	10.8	84.9
80	0.00	0	42.2	0.3	10.9	86.5
81	0.00	0	41.9	0.3	10.6	85.0
82	0.00	0	41.9	0.3	10.7	85.2
83	0.00	0	42.0	0.3	10.7	85.3
84	0.00	0	42.2	0.3	10.8	86.1
85	0.00	0	42.2	0.3	10.7	84.0
86	0.00	0	42.2	0.3	10.9	85.7
87	0.00	0	42.2	0.3	10.5	84.2
88	0.00	0	42.1	0.3	11.0	85.5
89	0.00	0	42.1	0.3	10.9	84.9
90	0.00	0	42.1	0.3	10.6	85.0
91	0.00	0	42.2	0.3	10.3	83.8
92	0.00	0	42.2	0.3	10.6	84.6
93	0.00	0	42.1	0.3	10.6	83.7
94	0.00	0	42.1	0.3	10.9	85.7
95	0.00	0	42.0	0.3	10.5	83.9
96	0.00	0	42.0	0.3	10.6	84.6
97	0.00	0	42.1	0.3	10.6	85.0
98	0.00	0	42.3	0.3	10.6	85.5
99	0.00	0	42.2	0.3	10.9	85.8
100	0.00	0	42.2	0.3	11.0	86.5
101	0.00	0	42.1	0.3	11.0	86.5
102	0.00	0	42.3	0.3	10.7	85.5
103	0.00	0	42.3	0.3	10.7	85.8
104	0.00	0	42.2	0.3	10.4	84.5
105	0.00	0	42.0	0.3	10.9	86.1
106	0.00	0	42.1	0.3	10.7	85.3
107	0.00	0	42.0	0.3	10.7	84.4
108	0.00	0	42.1	0.3	10.8	85.9
109	0.00	0	42.1	0.3	10.5	84.4
110	0.00	0	42.2	0.3	10.7	85.6
111	0.00	0	42.1	0.3	10.6	86.2
112	0.00	0	42.3	0.3	10.5	84.5
	Average	0	42.2	0.3	10.9	85.7
	Std. Dev.	0	0.1	0.0	0.3	0.9
	Maximum	0	42.5	0.3	11.4	87.5
	@ Blow#	13	5	13	37	21

Total number of blows analyzed: 110

Time Summary

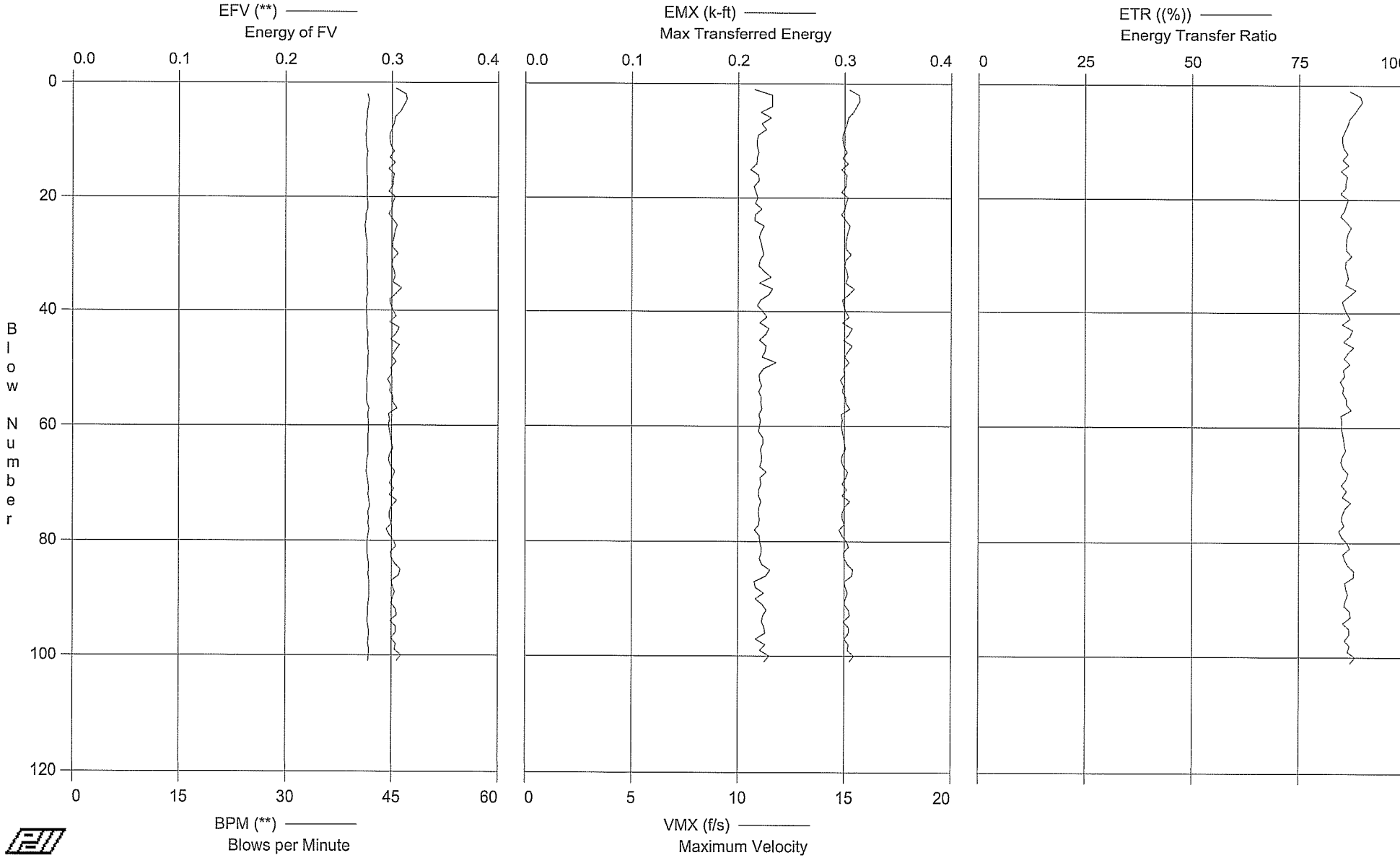
Drive 2 minutes 36 seconds 17:02:08 - 17:04:44 (2009-01-19) BN 3 - 112

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Gregg Drilling & Testing - Case Method Results

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 55'



Heim Bridge - WR-09-041 @ 55'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 107.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth ft	EFV **	BPM **	EMX k-ft	VMX f/s	ETR (%)
1	0.00	0	0.0	0.3	10.8	86.8
2	0.00	0	41.6	0.3	11.6	89.3
3	0.00	0	41.8	0.3	11.6	89.8
4	0.00	0	41.7	0.3	11.6	88.7
5	0.00	0	41.5	0.3	11.1	87.9
6	0.00	0	41.5	0.3	11.5	86.7
7	0.00	0	41.4	0.3	11.1	86.4
8	0.00	0	41.4	0.3	11.3	85.7
9	0.00	0	41.3	0.3	10.9	85.1
10	0.00	0	41.4	0.3	10.9	85.1
11	0.00	0	41.4	0.3	10.9	85.5
12	0.00	0	41.6	0.3	11.0	86.4
13	0.00	0	41.5	0.3	10.9	85.2
14	0.00	0	41.4	0.3	10.9	86.6
15	0.00	0	41.4	0.3	10.6	84.8
16	0.00	0	41.5	0.3	10.9	86.3
17	0.00	0	41.5	0.3	11.0	85.9
18	0.00	0	41.5	0.3	10.7	85.9
19	0.00	0	41.5	0.3	10.8	84.7
20	0.00	0	41.5	0.3	10.9	86.5
21	0.00	0	41.6	0.3	10.8	86.1
22	0.00	0	41.6	0.3	11.1	85.6
23	0.00	0	41.4	0.3	10.8	84.7
24	0.00	0	41.3	0.3	10.8	86.1
25	0.00	0	41.2	0.3	11.2	87.2
26	0.00	0	41.3	0.3	11.1	86.4
27	0.00	0	41.3	0.3	11.0	86.2
28	0.00	0	41.5	0.3	11.1	86.1
29	0.00	0	41.5	0.3	11.1	86.1
30	0.00	0	41.4	0.3	11.2	87.3
31	0.00	0	41.6	0.3	11.0	86.0
32	0.00	0	41.5	0.3	11.0	85.9
33	0.00	0	41.5	0.3	11.2	86.3
34	0.00	0	41.6	0.3	11.5	86.5
35	0.00	0	41.6	0.3	11.0	85.9
36	0.00	0	41.5	0.3	11.6	88.3
37	0.00	0	41.6	0.3	11.4	86.7
38	0.00	0	41.4	0.3	11.1	85.1
39	0.00	0	41.5	0.3	10.9	85.6
40	0.00	0	41.4	0.3	11.2	86.1
41	0.00	0	41.5	0.3	11.3	87.0
42	0.00	0	41.5	0.3	11.0	85.2
43	0.00	0	41.5	0.3	11.4	87.6
44	0.00	0	41.6	0.3	11.3	86.9
45	0.00	0	41.6	0.3	11.0	85.4
46	0.00	0	41.6	0.3	11.3	87.8
47	0.00	0	41.7	0.3	11.3	86.4
48	0.00	0	41.6	0.3	11.1	85.6
49	0.00	0	41.6	0.3	11.8	86.9
50	0.00	0	41.6	0.3	11.2	85.3
51	0.00	0	41.6	0.3	11.0	85.7
52	0.00	0	41.4	0.3	11.0	84.7
53	0.00	0	41.5	0.3	11.1	85.4
54	0.00	0	41.5	0.3	11.0	85.3
55	0.00	0	41.4	0.3	11.1	86.1
56	0.00	0	41.5	0.3	11.1	86.1
57	0.00	0	41.8	0.3	11.1	87.3
58	0.00	0	41.6	0.3	11.0	84.8
59	0.00	0	41.7	0.3	11.1	85.1
60	0.00	0	41.7	0.3	11.0	84.9
61	0.00	0	41.7	0.3	11.0	85.2
62	0.00	0	41.6	0.3	11.2	85.5
63	0.00	0	41.7	0.3	11.2	85.6
64	0.00	0	41.7	0.3	11.1	86.0
65	0.00	0	41.7	0.3	11.1	85.2
66	0.00	0	41.5	0.3	11.1	84.9
67	0.00	0	41.5	0.3	11.0	85.4

Heim Bridge - WR-09-041 @ 55'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
68	0.00	0	41.4	0.3	11.3	86.5
69	0.00	0	41.6	0.3	11.0	86.1
70	0.00	0	41.7	0.3	11.1	85.0
71	0.00	0	41.8	0.3	11.0	86.2
72	0.00	0	41.7	0.3	11.0	85.3
73	0.00	0	41.8	0.3	11.1	87.2
74	0.00	0	41.9	0.3	11.0	85.8
75	0.00	0	41.7	0.3	11.0	85.2
76	0.00	0	41.8	0.3	11.0	85.0
77	0.00	0	41.7	0.3	11.0	85.6
78	0.00	0	41.8	0.3	10.8	84.4
79	0.00	0	41.7	0.3	11.0	85.1
80	0.00	0	41.6	0.3	11.0	86.3
81	0.00	0	41.6	0.3	11.1	86.9
82	0.00	0	41.6	0.3	11.1	85.4
83	0.00	0	41.6	0.3	11.0	85.8
84	0.00	0	41.8	0.3	11.1	86.5
85	0.00	0	41.8	0.3	11.5	87.9
86	0.00	0	41.7	0.3	11.3	87.8
87	0.00	0	41.8	0.3	10.8	85.8
88	0.00	0	41.8	0.3	10.8	86.1
89	0.00	0	41.8	0.3	11.2	86.5
90	0.00	0	41.8	0.3	10.8	86.0
91	0.00	0	41.7	0.3	11.1	85.6
92	0.00	0	41.7	0.3	11.3	87.0
93	0.00	0	41.7	0.3	11.2	87.1
94	0.00	0	41.6	0.3	11.1	85.3
95	0.00	0	41.7	0.3	11.2	86.8
96	0.00	0	41.8	0.3	11.3	86.8
97	0.00	0	41.8	0.3	10.8	85.8
98	0.00	0	41.7	0.3	11.3	86.9
99	0.00	0	41.8	0.3	11.0	86.4
100	0.00	0	41.8	0.3	11.5	88.2
101	0.00	0	41.7	0.3	11.3	87.1
	Average	0	41.6	0.3	11.1	86.2
	Std. Dev.	0	0.1	0.0	0.2	1.0
	Maximum	0	41.9	0.3	11.8	89.8
	@ Blow#	3	74	3	49	3

Total number of blows analyzed: 101

Time Summary

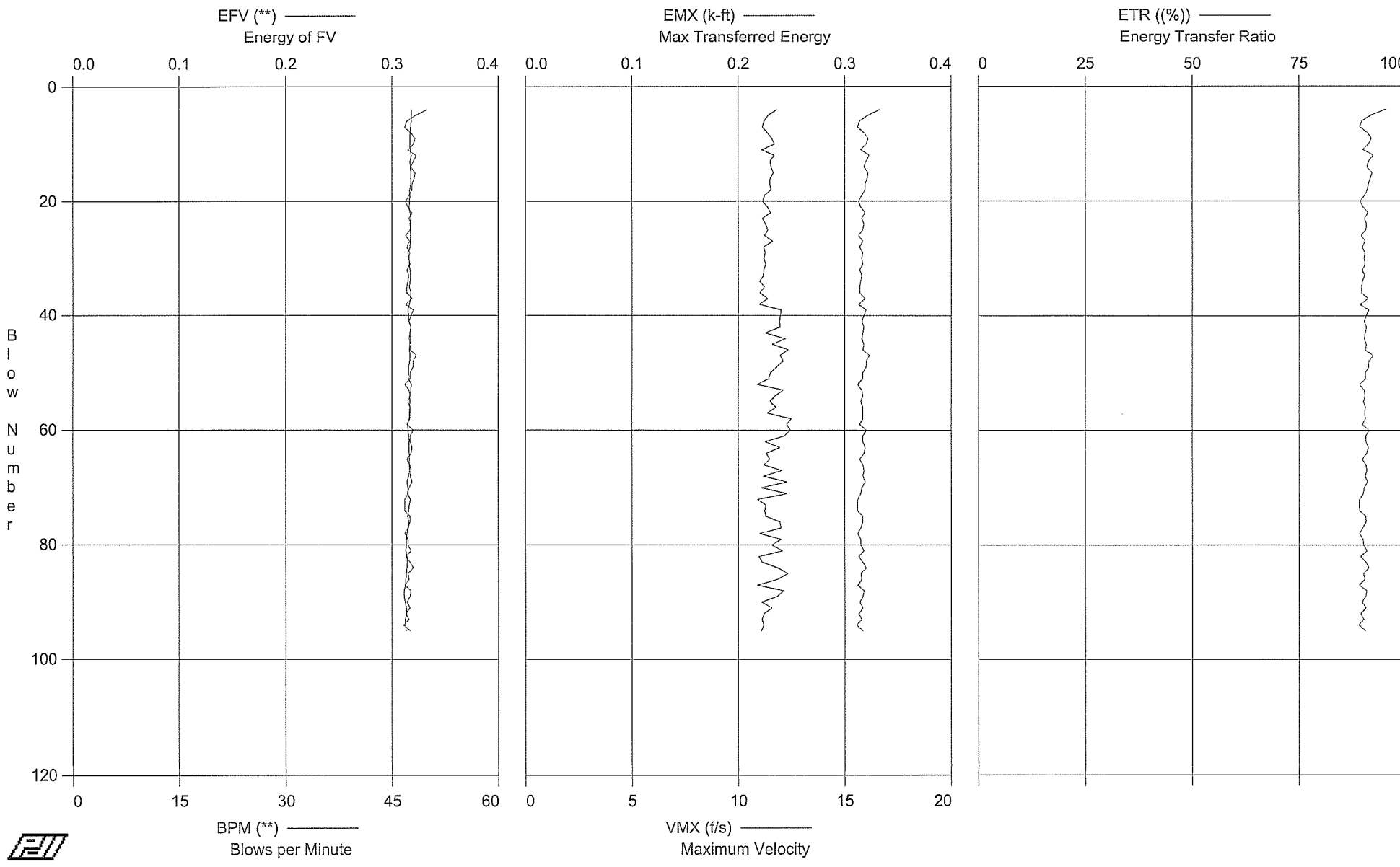
Drive 2 minutes 24 seconds 17:37:55 - 17:40:19 (2009-01-19) BN 1 - 101

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 65'



Heim Bridge - WR-09-041 @ 65'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 117.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	11.2	89.5
4	0.00	0	47.8	0.3	11.8	95.3
5	0.00	0	47.7	0.3	11.4	92.0
6	0.00	0	47.7	0.3	11.2	89.8
7	0.00	0	47.7	0.3	11.1	89.2
8	0.00	0	47.6	0.3	11.4	91.0
9	0.00	0	47.5	0.3	11.6	92.0
10	0.00	0	47.5	0.3	11.7	91.3
11	0.00	0	47.6	0.3	11.1	90.0
12	0.00	0	47.7	0.3	11.7	92.4
13	0.00	0	47.6	0.3	11.5	91.3
14	0.00	0	47.6	0.3	11.5	90.9
15	0.00	0	47.7	0.3	11.7	92.1
16	0.00	0	47.7	0.3	11.5	91.8
17	0.00	0	47.7	0.3	11.5	91.3
18	0.00	0	47.5	0.3	11.6	91.0
19	0.00	0	47.5	0.3	11.2	90.4
20	0.00	0	47.5	0.3	11.1	89.3
21	0.00	0	47.4	0.3	11.4	90.0
22	0.00	0	47.6	0.3	11.5	91.2
23	0.00	0	47.7	0.3	11.1	90.3
24	0.00	0	47.5	0.3	11.3	90.8
25	0.00	0	47.7	0.3	11.4	90.7
26	0.00	0	47.7	0.3	11.2	89.6
27	0.00	0	47.6	0.3	11.6	90.5
28	0.00	0	47.6	0.3	11.2	89.8
29	0.00	0	47.3	0.3	11.3	90.5
30	0.00	0	47.5	0.3	11.2	90.3
31	0.00	0	47.4	0.3	11.3	90.5
32	0.00	0	47.6	0.3	11.2	89.8
33	0.00	0	47.6	0.3	11.2	90.4
34	0.00	0	47.6	0.3	11.0	89.9
35	0.00	0	47.5	0.3	11.2	89.7
36	0.00	0	47.7	0.3	11.0	89.7
37	0.00	0	47.6	0.3	11.4	91.2
38	0.00	0	47.5	0.3	11.0	89.3
39	0.00	0	47.2	0.3	12.0	91.4
40	0.00	0	47.4	0.3	12.0	90.8
41	0.00	0	47.4	0.3	11.9	90.3
42	0.00	0	47.7	0.3	12.0	90.8
43	0.00	0	47.5	0.3	11.3	90.5
44	0.00	0	47.6	0.3	12.2	90.3
45	0.00	0	47.5	0.3	11.6	90.8
46	0.00	0	47.5	0.3	12.3	90.6
47	0.00	0	47.5	0.3	12.0	92.4
48	0.00	0	47.5	0.3	12.1	91.4
49	0.00	0	47.4	0.3	11.8	91.3
50	0.00	0	47.4	0.3	11.5	90.5
51	0.00	0	47.3	0.3	11.4	90.6
52	0.00	0	47.7	0.3	10.9	89.2
53	0.00	0	47.7	0.3	12.1	90.3
54	0.00	0	47.5	0.3	11.7	90.5
55	0.00	0	47.5	0.3	11.5	90.1
56	0.00	0	47.5	0.3	11.8	90.6
57	0.00	0	47.5	0.3	11.4	90.4
58	0.00	0	47.4	0.3	12.5	90.6
59	0.00	0	47.2	0.3	12.3	89.8
60	0.00	0	47.3	0.3	12.4	91.4
61	0.00	0	47.4	0.3	12.2	90.6
62	0.00	0	47.4	0.3	11.3	90.6
63	0.00	0	47.4	0.3	11.9	91.3
64	0.00	0	47.4	0.3	11.3	90.9
65	0.00	0	47.5	0.3	11.5	89.8
66	0.00	0	47.4	0.3	11.2	90.7
67	0.00	0	47.5	0.3	12.1	90.9
68	0.00	0	47.4	0.3	11.2	90.5
69	0.00	0	47.1	0.3	12.3	91.0

Heim Bridge - WR-09-041 @ 65'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
70	0.00	0	47.2	0.3	11.1	90.3
71	0.00	0	47.2	0.3	12.3	90.1
72	0.00	0	47.6	0.3	10.9	89.2
73	0.00	0	47.4	0.3	11.3	89.1
74	0.00	0	47.4	0.3	11.2	89.2
75	0.00	0	47.2	0.3	11.3	90.6
76	0.00	0	47.4	0.3	12.0	90.7
77	0.00	0	47.3	0.3	12.0	89.9
78	0.00	0	47.1	0.3	11.0	89.1
79	0.00	0	47.1	0.3	12.0	90.0
80	0.00	0	47.0	0.3	11.6	90.1
81	0.00	0	46.9	0.3	12.1	90.9
82	0.00	0	47.1	0.3	11.0	89.4
83	0.00	0	47.2	0.3	11.1	90.7
84	0.00	0	47.1	0.3	11.9	91.3
85	0.00	0	47.0	0.3	12.3	90.1
86	0.00	0	46.9	0.3	11.8	90.4
87	0.00	0	46.9	0.3	10.9	89.1
88	0.00	0	46.7	0.3	12.1	90.8
89	0.00	0	46.7	0.3	11.8	90.6
90	0.00	0	46.9	0.3	11.1	89.7
91	0.00	0	47.0	0.3	11.6	90.7
92	0.00	0	47.1	0.3	11.2	89.4
93	0.00	0	46.9	0.3	11.1	90.2
94	0.00	0	46.9	0.3	11.2	89.0
95	0.00	0	47.0	0.3	11.1	90.5
	Average	0	47.4	0.3	11.5	90.5
	Std. Dev.	0	0.3	0.0	0.4	0.9
	Maximum	0	47.8	0.3	12.5	95.3
	@ Blow#	4	4	4	58	4

Total number of blows analyzed: 93

Time Summary

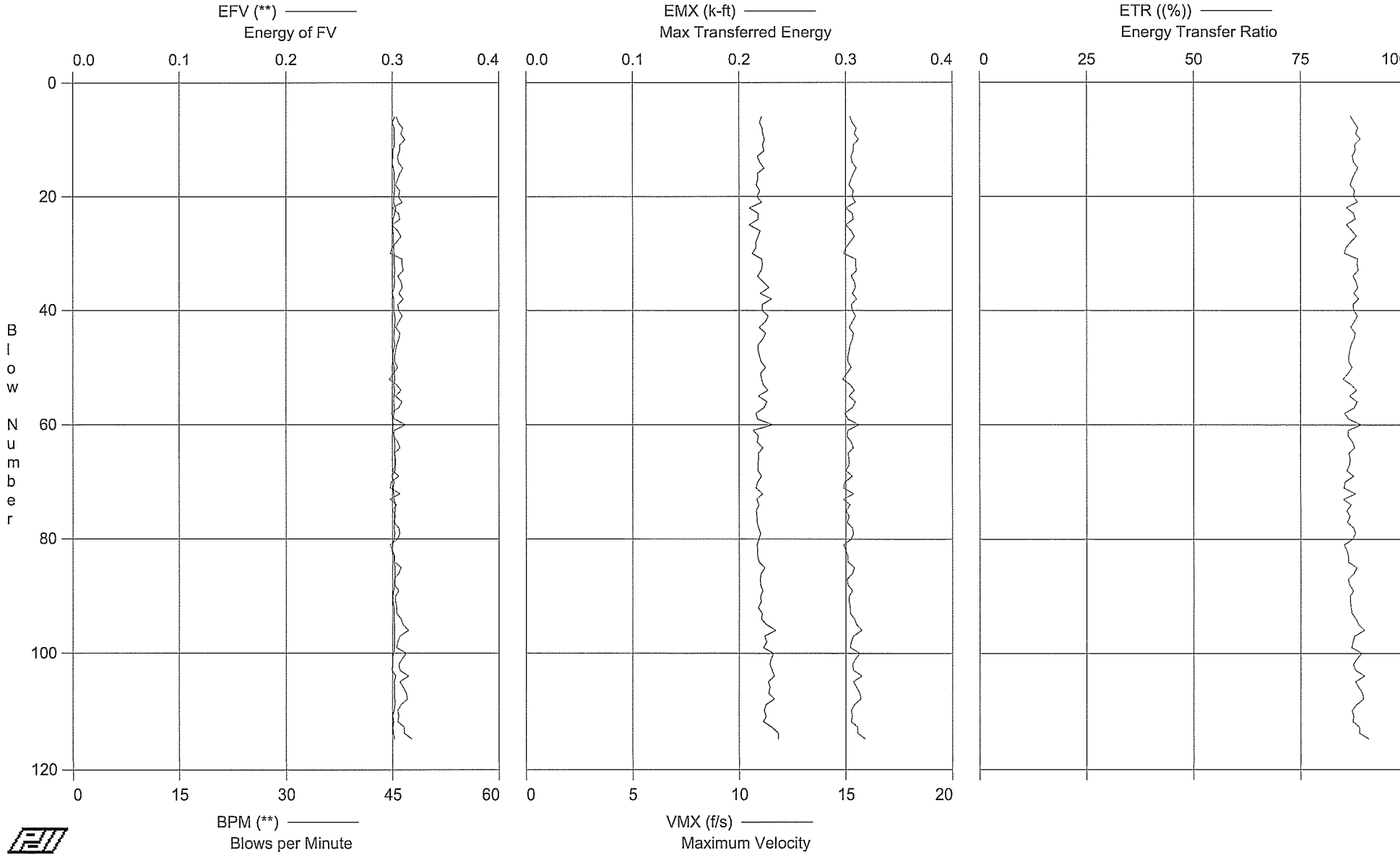
Drive 1 minute 59 seconds 18:11:42 - 18:13:41 (2009-01-19) BN 1 - 95

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 80'



Heim Bridge - WR-09-041 @ 80'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 132.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	10.7	87.2
6	0.00	0	45.3	0.3	11.1	86.7
7	0.00	0	45.0	0.3	11.0	87.5
8	0.00	0	45.3	0.3	11.1	88.5
9	0.00	0	45.3	0.3	11.1	87.9
10	0.00	0	45.3	0.3	11.2	89.0
11	0.00	0	45.3	0.3	11.1	87.7
12	0.00	0	45.1	0.3	11.2	87.8
13	0.00	0	45.1	0.3	10.9	87.1
14	0.00	0	45.0	0.3	11.0	87.4
15	0.00	0	45.1	0.3	11.2	88.5
16	0.00	0	45.3	0.3	10.9	87.7
17	0.00	0	45.3	0.3	10.9	87.1
18	0.00	0	45.3	0.3	10.8	86.6
19	0.00	0	45.3	0.3	11.0	87.6
20	0.00	0	45.2	0.3	10.8	87.4
21	0.00	0	45.2	0.3	11.1	88.3
22	0.00	0	45.5	0.3	10.5	85.8
23	0.00	0	45.4	0.3	10.9	87.3
24	0.00	0	45.1	0.3	10.9	87.8
25	0.00	0	45.1	0.3	10.5	85.7
26	0.00	0	45.1	0.3	11.0	87.0
27	0.00	0	45.1	0.3	10.9	88.1
28	0.00	0	45.1	0.3	10.8	86.8
29	0.00	0	45.2	0.3	10.8	85.7
30	0.00	0	45.2	0.3	10.6	85.2
31	0.00	0	45.2	0.3	11.1	88.3
32	0.00	0	45.2	0.3	11.1	88.2
33	0.00	0	45.4	0.3	11.0	88.5
34	0.00	0	45.2	0.3	10.9	87.2
35	0.00	0	45.3	0.3	11.1	87.9
36	0.00	0	45.2	0.3	11.4	88.4
37	0.00	0	45.0	0.3	11.0	87.4
38	0.00	0	45.2	0.3	11.5	88.6
39	0.00	0	45.2	0.3	11.1	87.2
40	0.00	0	45.2	0.3	11.1	87.4
41	0.00	0	45.3	0.3	11.4	88.3
42	0.00	0	45.4	0.3	11.2	87.6
43	0.00	0	45.3	0.3	10.9	86.7
44	0.00	0	45.2	0.3	11.2	87.8
45	0.00	0	45.2	0.3	11.1	87.5
46	0.00	0	45.4	0.3	10.9	86.8
47	0.00	0	45.1	0.3	10.9	86.5
48	0.00	0	45.1	0.3	10.9	86.3
49	0.00	0	45.1	0.3	11.0	86.3
50	0.00	0	45.2	0.3	11.2	87.0
51	0.00	0	45.2	0.3	11.0	86.1
52	0.00	0	45.4	0.3	11.0	84.9
53	0.00	0	45.1	0.3	11.1	86.9
54	0.00	0	45.3	0.3	11.3	88.1
55	0.00	0	45.2	0.3	10.9	86.5
56	0.00	0	45.2	0.3	11.3	88.2
57	0.00	0	45.3	0.3	11.2	87.5
58	0.00	0	45.2	0.3	10.8	85.3
59	0.00	0	45.0	0.3	10.9	86.3
60	0.00	0	45.1	0.3	11.6	89.1
61	0.00	0	45.0	0.3	10.7	86.1
62	0.00	0	45.2	0.3	10.9	86.1
63	0.00	0	45.3	0.3	10.8	87.1
64	0.00	0	45.4	0.3	11.1	87.6
65	0.00	0	45.3	0.3	10.9	86.3
66	0.00	0	45.4	0.3	10.9	86.6
67	0.00	0	45.4	0.3	10.9	86.4
68	0.00	0	45.4	0.3	10.9	85.8
69	0.00	0	44.9	0.3	11.0	87.4
70	0.00	0	45.2	0.3	10.9	85.4
71	0.00	0	45.1	0.3	10.8	85.2

Heim Bridge - WR-09-041 @ 80'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
72	0.00	0	45.2	0.3	11.1	87.8
73	0.00	0	45.2	0.3	10.8	85.0
74	0.00	0	45.4	0.3	10.9	86.8
75	0.00	0	45.4	0.3	10.8	85.8
76	0.00	0	45.3	0.3	10.8	86.5
77	0.00	0	45.4	0.3	10.8	86.0
78	0.00	0	45.2	0.3	10.9	87.4
79	0.00	0	45.4	0.3	11.0	87.8
80	0.00	0	45.2	0.3	10.9	87.1
81	0.00	0	45.0	0.3	10.8	85.2
82	0.00	0	44.9	0.3	10.9	85.8
83	0.00	0	45.2	0.3	10.9	86.2
84	0.00	0	45.1	0.3	10.9	86.2
85	0.00	0	45.4	0.3	11.2	88.1
86	0.00	0	45.4	0.3	11.0	87.5
87	0.00	0	45.4	0.3	11.0	86.1
88	0.00	0	45.3	0.3	11.0	86.4
89	0.00	0	45.1	0.3	11.1	87.3
90	0.00	0	45.1	0.3	11.0	86.6
91	0.00	0	45.1	0.3	11.0	86.6
92	0.00	0	45.2	0.3	10.9	86.8
93	0.00	0	45.2	0.3	11.1	87.0
94	0.00	0	45.2	0.3	11.0	87.9
95	0.00	0	45.3	0.3	11.3	88.6
96	0.00	0	45.3	0.3	11.7	89.9
97	0.00	0	45.3	0.3	11.2	87.6
98	0.00	0	45.3	0.3	11.3	87.2
99	0.00	0	45.3	0.3	11.1	86.9
100	0.00	0	45.1	0.3	11.6	89.3
101	0.00	0	45.0	0.3	11.5	88.2
102	0.00	0	45.1	0.3	11.4	87.3
103	0.00	0	44.9	0.3	11.5	87.8
104	0.00	0	45.5	0.3	11.6	89.9
105	0.00	0	45.2	0.3	11.4	87.8
106	0.00	0	45.3	0.3	11.4	88.6
107	0.00	0	45.3	0.3	11.4	89.5
108	0.00	0	45.3	0.3	11.6	89.7
109	0.00	0	45.4	0.3	11.3	88.1
110	0.00	0	45.2	0.3	11.2	87.0
111	0.00	0	45.0	0.3	11.3	87.4
112	0.00	0	45.2	0.3	11.1	87.2
113	0.00	0	45.1	0.3	11.5	88.7
114	0.00	0	45.1	0.3	11.8	88.7
115	0.00	0	45.3	0.3	11.8	91.0
	Average	0	45.2	0.3	11.1	87.3
	Std. Dev.	0	0.1	0.0	0.3	1.1
	Maximum	0	45.5	0.3	11.8	91.0
	@ Blow#	115	22	115	114	115

Total number of blows analyzed: 111

Time Summary

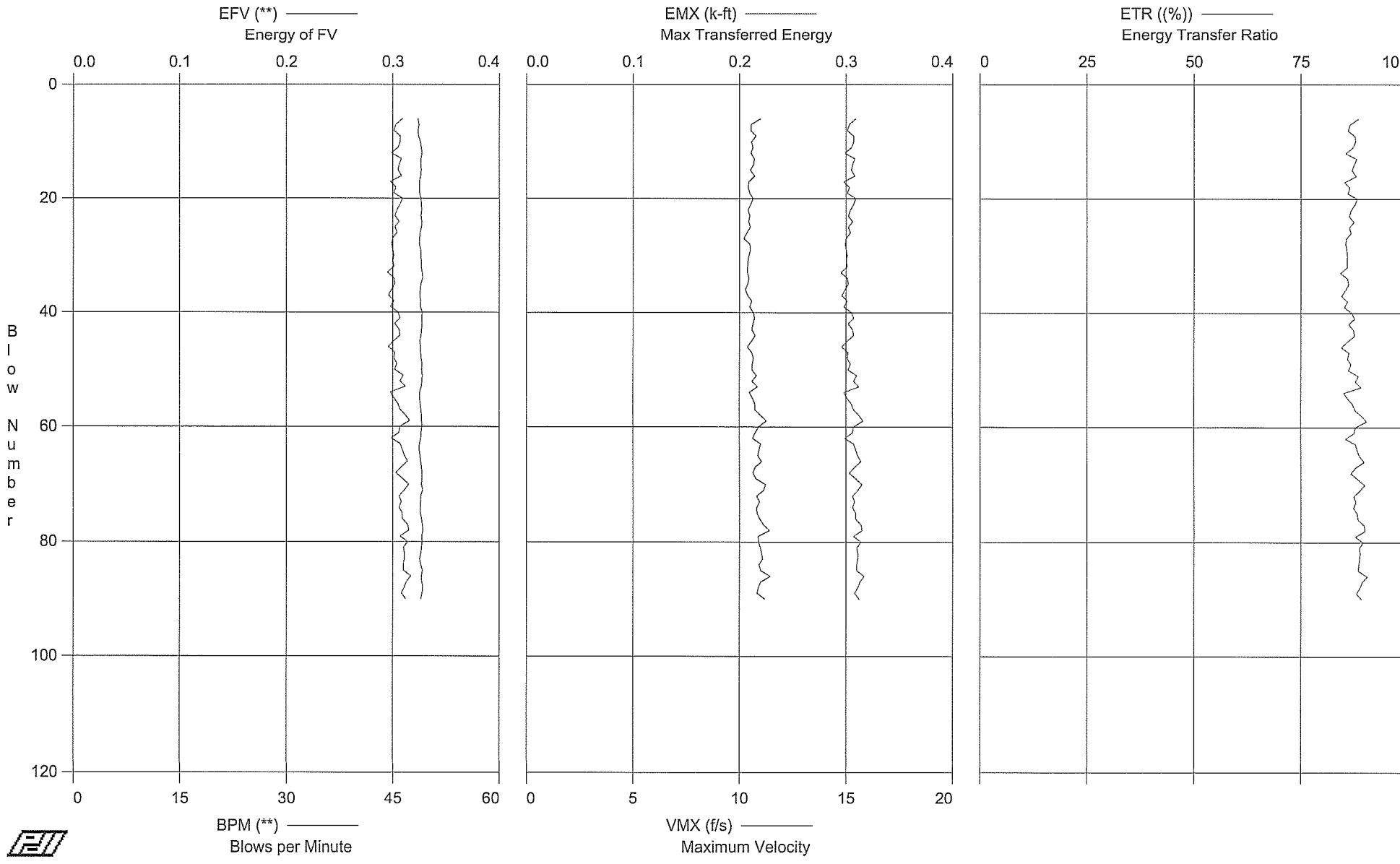
Drive 2 minutes 31 seconds 19:05:12 - 19:07:43 (2009-01-19) BN 1 - 115

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 90'



Heim Bridge - WR-09-041 @ 90'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 142.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	10.5	84.7
6	0.00	0	48.5	0.3	11.0	88.4
7	0.00	0	48.7	0.3	10.5	86.5
8	0.00	0	48.6	0.3	10.5	86.1
9	0.00	0	48.6	0.3	10.8	87.7
10	0.00	0	48.9	0.3	10.6	87.8
11	0.00	0	49.0	0.3	10.6	87.1
12	0.00	0	49.1	0.3	10.5	85.5
13	0.00	0	49.0	0.3	10.7	88.1
14	0.00	0	48.9	0.3	10.7	87.5
15	0.00	0	49.0	0.3	10.5	87.0
16	0.00	0	48.9	0.3	10.7	88.0
17	0.00	0	48.7	0.3	10.4	85.2
18	0.00	0	48.8	0.3	10.4	86.5
19	0.00	0	48.8	0.3	10.5	86.0
20	0.00	0	49.0	0.3	10.6	88.2
21	0.00	0	49.0	0.3	10.5	87.6
22	0.00	0	49.1	0.3	10.4	86.7
23	0.00	0	49.0	0.3	10.5	86.4
24	0.00	0	49.1	0.3	10.4	87.4
25	0.00	0	49.1	0.3	10.5	86.3
26	0.00	0	48.9	0.3	10.4	86.7
27	0.00	0	48.8	0.3	10.2	85.6
28	0.00	0	48.7	0.3	10.5	85.5
29	0.00	0	48.9	0.3	10.5	85.8
30	0.00	0	49.0	0.3	10.4	85.9
31	0.00	0	49.0	0.3	10.4	85.8
32	0.00	0	49.0	0.3	10.4	85.9
33	0.00	0	49.1	0.3	10.4	84.3
34	0.00	0	49.2	0.3	10.4	85.9
35	0.00	0	49.0	0.3	10.4	86.2
36	0.00	0	48.9	0.3	10.3	85.4
37	0.00	0	48.8	0.3	10.4	84.5
38	0.00	0	48.9	0.3	10.6	85.9
39	0.00	0	48.9	0.3	10.5	85.2
40	0.00	0	49.2	0.3	10.7	87.0
41	0.00	0	49.1	0.3	10.7	87.6
42	0.00	0	49.1	0.3	10.6	86.2
43	0.00	0	49.1	0.3	10.6	87.3
44	0.00	0	49.0	0.3	10.7	87.6
45	0.00	0	48.8	0.3	10.6	85.9
46	0.00	0	48.9	0.3	10.4	84.5
47	0.00	0	48.9	0.3	10.6	86.3
48	0.00	0	49.0	0.3	10.7	85.9
49	0.00	0	49.1	0.3	10.6	86.8
50	0.00	0	49.1	0.3	10.6	86.2
51	0.00	0	49.2	0.3	10.8	88.5
52	0.00	0	49.1	0.3	10.6	87.8
53	0.00	0	49.1	0.3	10.8	89.1
54	0.00	0	48.8	0.3	10.5	85.0
55	0.00	0	48.8	0.3	10.6	86.0
56	0.00	0	48.9	0.3	10.7	87.2
57	0.00	0	49.0	0.3	10.7	87.7
58	0.00	0	49.1	0.3	11.0	89.2
59	0.00	0	49.1	0.3	11.3	90.4
60	0.00	0	49.1	0.3	10.9	87.9
61	0.00	0	49.0	0.3	10.7	87.5
62	0.00	0	49.0	0.3	10.6	85.5
63	0.00	0	48.8	0.3	11.0	87.8
64	0.00	0	48.7	0.3	10.9	88.2
65	0.00	0	48.9	0.3	10.9	88.7
66	0.00	0	48.9	0.3	11.0	89.8
67	0.00	0	49.1	0.3	10.7	87.9
68	0.00	0	49.1	0.3	10.6	86.7
69	0.00	0	49.1	0.3	10.8	88.3
70	0.00	0	49.1	0.3	11.2	90.0
71	0.00	0	49.2	0.3	11.1	88.8

Heim Bridge - WR-09-041 @ 90'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
72	0.00	0	48.9	0.3	10.8	87.4
73	0.00	0	48.9	0.3	10.9	87.9
74	0.00	0	48.9	0.3	10.8	87.3
75	0.00	0	48.9	0.3	10.8	88.2
76	0.00	0	49.1	0.3	11.0	88.4
77	0.00	0	49.2	0.3	11.1	89.8
78	0.00	0	49.3	0.3	11.4	90.1
79	0.00	0	49.1	0.3	10.9	87.8
80	0.00	0	49.1	0.3	10.9	89.6
81	0.00	0	49.1	0.3	11.0	88.7
82	0.00	0	49.0	0.3	11.0	88.9
83	0.00	0	48.8	0.3	11.1	88.7
84	0.00	0	48.9	0.3	10.9	88.6
85	0.00	0	49.2	0.3	11.0	88.5
86	0.00	0	49.1	0.3	11.4	90.5
87	0.00	0	49.1	0.3	11.0	89.4
88	0.00	0	49.2	0.3	10.9	88.8
89	0.00	0	49.1	0.3	10.8	88.0
90	0.00	0	49.0	0.3	11.2	89.2
	Average	0	49.0	0.3	10.7	87.3
	Std. Dev.	0	0.2	0.0	0.3	1.5
	Maximum	0	49.3	0.3	11.4	90.5
	@ Blow#	86	78	86	86	86

Total number of blows analyzed: 86

Time Summary

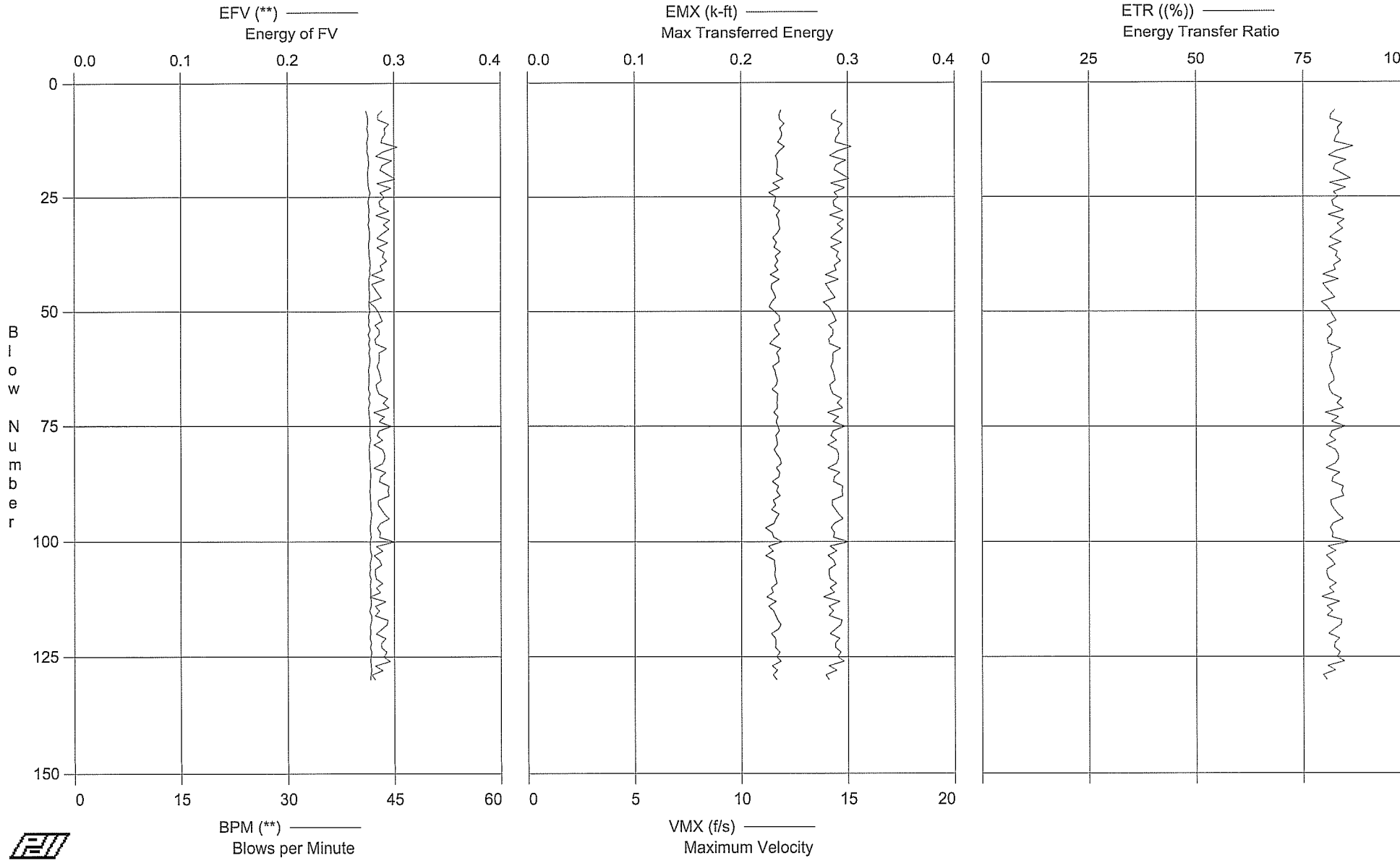
Drive 1 minute 50 seconds 20:23:29 - 20:25:19 (2009-01-19) BN 1 - 90

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 100'



Heim Bridge - WR-09-041 @ 100'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 151.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	11.7	88.0
6	0.00	0	41.0	0.3	11.9	82.5
7	0.00	0	41.2	0.3	11.8	81.6
8	0.00	0	41.4	0.3	11.8	81.3
9	0.00	0	41.3	0.3	12.0	84.2
10	0.00	0	41.2	0.3	11.8	83.1
11	0.00	0	41.4	0.3	11.9	83.4
12	0.00	0	41.4	0.3	11.9	82.6
13	0.00	0	41.2	0.3	11.7	82.3
14	0.00	0	41.3	0.3	12.0	86.7
15	0.00	0	41.2	0.3	11.8	82.9
16	0.00	0	41.4	0.3	11.6	81.0
17	0.00	0	41.4	0.3	11.7	85.1
18	0.00	0	41.4	0.3	11.7	82.6
19	0.00	0	41.3	0.3	11.7	82.1
20	0.00	0	41.3	0.3	11.7	84.1
21	0.00	0	41.4	0.3	12.0	86.1
22	0.00	0	41.4	0.3	11.5	81.2
23	0.00	0	41.4	0.3	11.8	84.9
24	0.00	0	41.6	0.3	11.3	82.1
25	0.00	0	41.5	0.3	11.6	83.1
26	0.00	0	41.3	0.3	11.6	81.7
27	0.00	0	41.4	0.3	11.5	82.0
28	0.00	0	41.5	0.3	11.8	84.4
29	0.00	0	41.4	0.3	11.6	80.9
30	0.00	0	41.5	0.3	11.8	84.6
31	0.00	0	41.4	0.3	11.8	83.0
32	0.00	0	41.5	0.3	11.8	84.3
33	0.00	0	41.6	0.3	11.7	82.6
34	0.00	0	41.6	0.3	11.5	81.3
35	0.00	0	41.4	0.3	11.7	83.9
36	0.00	0	41.4	0.3	11.5	81.0
37	0.00	0	41.5	0.3	11.8	83.0
38	0.00	0	41.5	0.3	11.6	82.6
39	0.00	0	41.6	0.3	11.7	83.8
40	0.00	0	41.7	0.3	11.6	82.1
41	0.00	0	41.6	0.3	11.7	82.5
42	0.00	0	41.6	0.3	11.4	79.6
43	0.00	0	41.4	0.3	11.8	83.2
44	0.00	0	41.5	0.3	11.4	79.6
45	0.00	0	41.5	0.3	11.4	80.5
46	0.00	0	41.6	0.3	11.5	81.5
47	0.00	0	41.6	0.3	11.6	82.4
48	0.00	0	41.5	0.3	11.4	79.3
49	0.00	0	41.5	0.3	11.3	80.6
50	0.00	0	41.6	0.3	11.6	81.5
51	0.00	0	41.4	0.3	11.8	82.0
52	0.00	0	41.5	0.3	11.8	82.7
53	0.00	0	41.4	0.3	11.5	80.6
54	0.00	0	41.7	0.3	11.6	81.7
55	0.00	0	41.4	0.3	11.8	81.7
56	0.00	0	41.6	0.3	11.5	80.6
57	0.00	0	41.4	0.3	11.3	80.9
58	0.00	0	41.6	0.3	11.9	83.8
59	0.00	0	41.5	0.3	11.7	81.6
60	0.00	0	41.6	0.3	11.8	81.8
61	0.00	0	41.6	0.3	11.8	81.6
62	0.00	0	41.5	0.3	11.5	81.2
63	0.00	0	41.4	0.3	11.6	81.6
64	0.00	0	41.5	0.3	11.6	82.1
65	0.00	0	41.5	0.3	11.7	82.3
66	0.00	0	41.5	0.3	11.7	81.0
67	0.00	0	41.4	0.3	11.4	81.2
68	0.00	0	41.6	0.3	11.7	81.8
69	0.00	0	41.4	0.3	11.7	84.0
70	0.00	0	41.6	0.3	11.7	82.9
71	0.00	0	41.4	0.3	11.7	84.4

Heim Bridge - WR-09-041 @ 100'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
72	0.00	0	41.5	0.3	11.5	80.2
73	0.00	0	41.5	0.3	11.7	83.3
74	0.00	0	41.6	0.3	11.6	81.6
75	0.00	0	41.6	0.3	11.7	84.8
76	0.00	0	41.6	0.3	11.8	81.8
77	0.00	0	41.6	0.3	11.6	81.2
78	0.00	0	41.7	0.3	11.7	82.6
79	0.00	0	41.5	0.3	11.7	80.3
80	0.00	0	41.5	0.3	11.5	82.4
81	0.00	0	41.5	0.3	11.7	83.1
82	0.00	0	41.5	0.3	11.8	83.3
83	0.00	0	41.6	0.3	11.9	82.4
84	0.00	0	41.6	0.3	11.6	80.3
85	0.00	0	41.7	0.3	11.8	83.5
86	0.00	0	41.7	0.3	11.7	82.0
87	0.00	0	41.6	0.3	11.4	81.7
88	0.00	0	41.6	0.3	11.7	84.3
89	0.00	0	41.6	0.3	11.6	83.9
90	0.00	0	41.6	0.3	11.8	84.4
91	0.00	0	41.6	0.3	11.5	81.4
92	0.00	0	41.7	0.3	11.6	81.5
93	0.00	0	41.7	0.3	11.4	82.2
94	0.00	0	41.8	0.3	11.8	83.1
95	0.00	0	41.7	0.3	11.6	84.3
96	0.00	0	41.7	0.3	11.5	81.9
97	0.00	0	41.6	0.3	11.1	81.2
98	0.00	0	41.6	0.3	11.4	81.9
99	0.00	0	41.7	0.3	11.5	81.7
100	0.00	0	41.6	0.3	11.9	85.7
101	0.00	0	41.6	0.3	11.3	80.8
102	0.00	0	41.6	0.3	11.5	82.6
103	0.00	0	41.8	0.3	11.1	80.3
104	0.00	0	41.7	0.3	11.5	81.6
105	0.00	0	41.6	0.3	11.5	82.3
106	0.00	0	41.7	0.3	11.6	80.5
107	0.00	0	41.5	0.3	11.5	80.5
108	0.00	0	41.7	0.3	11.6	80.9
109	0.00	0	41.6	0.3	11.7	82.6
110	0.00	0	41.6	0.3	11.4	81.0
111	0.00	0	41.7	0.3	11.5	82.1
112	0.00	0	41.6	0.3	11.2	79.2
113	0.00	0	41.8	0.3	11.6	83.4
114	0.00	0	41.7	0.3	11.3	80.5
115	0.00	0	41.5	0.3	11.5	81.8
116	0.00	0	41.8	0.3	11.6	80.5
117	0.00	0	41.8	0.3	11.7	84.0
118	0.00	0	41.6	0.3	11.8	83.8
119	0.00	0	41.6	0.3	11.7	82.2
120	0.00	0	41.7	0.3	11.4	80.9
121	0.00	0	41.6	0.3	11.6	83.4
122	0.00	0	41.8	0.3	11.6	82.4
123	0.00	0	41.6	0.3	11.6	82.2
124	0.00	0	41.8	0.3	11.8	83.6
125	0.00	0	41.7	0.3	11.6	82.8
126	0.00	0	41.7	0.3	11.8	84.5
127	0.00	0	41.7	0.3	11.4	80.7
128	0.00	0	41.8	0.3	11.7	82.4
129	0.00	0	41.7	0.3	11.5	79.6
130	0.00	0	41.6	0.3	11.7	80.5
	Average	0	41.5	0.3	11.6	82.3
	Std. Dev.	0	0.1	0.0	0.2	1.5
	Maximum	0	41.8	0.3	12.0	88.0
	@ Blow#	1	94	1	14	1

Total number of blows analyzed: 126

Time Summary

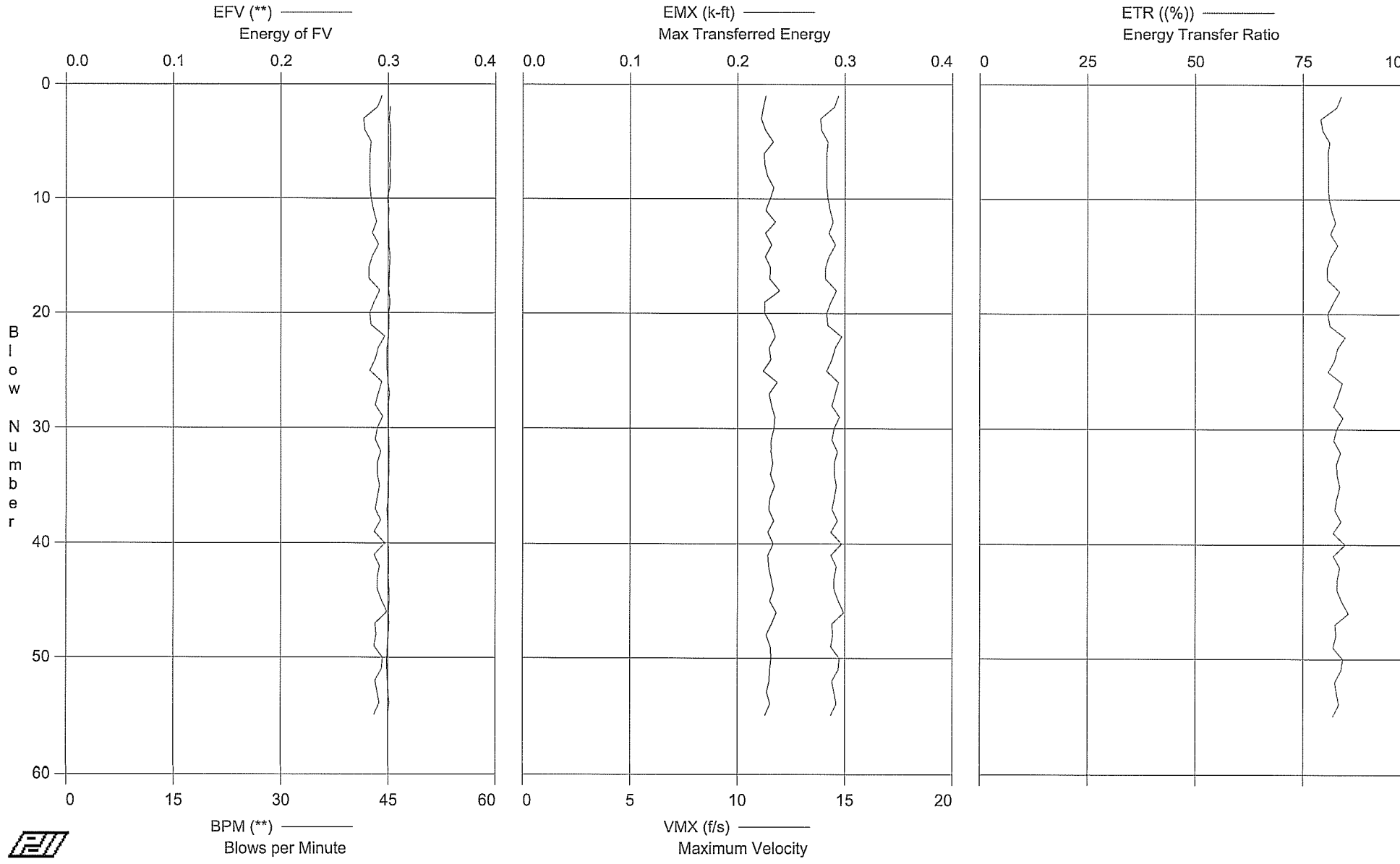
Drive 3 minutes 7 seconds 20:51:00 - 20:54:07 (2009-01-19) BN 1 - 130

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 120'



Heim Bridge - WR-09-041 @ 120'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 171.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
1	0.00	0	0.0	0.3	11.3	83.9
2	0.00	0	45.3	0.3	11.2	82.8
3	0.00	0	45.1	0.3	11.1	79.1
4	0.00	0	45.3	0.3	11.3	79.5
5	0.00	0	45.3	0.3	11.7	81.2
6	0.00	0	45.4	0.3	11.2	80.8
7	0.00	0	45.2	0.3	11.3	80.9
8	0.00	0	45.3	0.3	11.4	80.9
9	0.00	0	45.2	0.3	11.7	80.9
10	0.00	0	44.9	0.3	11.5	81.0
11	0.00	0	45.1	0.3	11.3	81.6
12	0.00	0	45.0	0.3	11.8	82.5
13	0.00	0	45.1	0.3	11.3	81.3
14	0.00	0	45.1	0.3	11.6	83.0
15	0.00	0	45.2	0.3	11.3	81.4
16	0.00	0	45.2	0.3	11.5	80.6
17	0.00	0	45.1	0.3	11.5	80.6
18	0.00	0	45.1	0.3	12.0	83.5
19	0.00	0	45.2	0.3	11.3	82.1
20	0.00	0	45.1	0.3	11.3	80.7
21	0.00	0	45.1	0.3	11.6	81.3
22	0.00	0	45.1	0.3	11.8	84.8
23	0.00	0	44.9	0.3	11.5	83.0
24	0.00	0	44.9	0.3	11.6	82.4
25	0.00	0	44.9	0.3	11.2	80.9
26	0.00	0	45.0	0.3	11.9	84.1
27	0.00	0	45.2	0.3	11.5	83.3
28	0.00	0	45.0	0.3	11.6	82.2
29	0.00	0	45.0	0.3	11.7	84.3
30	0.00	0	45.0	0.3	11.7	82.8
31	0.00	0	45.1	0.3	11.6	82.2
32	0.00	0	45.1	0.3	11.6	83.7
33	0.00	0	45.1	0.3	11.6	82.8
34	0.00	0	45.1	0.3	11.5	82.9
35	0.00	0	45.0	0.3	11.7	83.5
36	0.00	0	45.0	0.3	11.5	82.8
37	0.00	0	44.8	0.3	11.5	82.4
38	0.00	0	44.9	0.3	11.7	83.8
39	0.00	0	45.0	0.3	11.4	82.0
40	0.00	0	45.0	0.3	11.7	84.8
41	0.00	0	45.1	0.3	11.4	82.0
42	0.00	0	45.1	0.3	11.5	83.5
43	0.00	0	45.0	0.3	11.6	83.0
44	0.00	0	45.1	0.3	11.7	82.9
45	0.00	0	45.2	0.3	11.5	84.0
46	0.00	0	45.1	0.3	11.8	85.5
47	0.00	0	45.1	0.3	11.6	82.4
48	0.00	0	45.1	0.3	11.3	82.7
49	0.00	0	44.9	0.3	11.5	82.0
50	0.00	0	44.9	0.3	11.6	84.3
51	0.00	0	44.9	0.3	11.5	83.9
52	0.00	0	44.9	0.3	11.5	82.4
53	0.00	0	45.0	0.3	11.4	82.8
54	0.00	0	45.2	0.3	11.5	83.3
55	0.00	0	45.0	0.3	11.3	82.0
	Average	0	45.1	0.3	11.5	82.4
	Std. Dev.	0	0.1	0.0	0.2	1.3
	Maximum	0	45.4	0.3	12.0	85.5
	@ Blow#	46	6	46	18	46

Total number of blows analyzed: 55

Time Summary

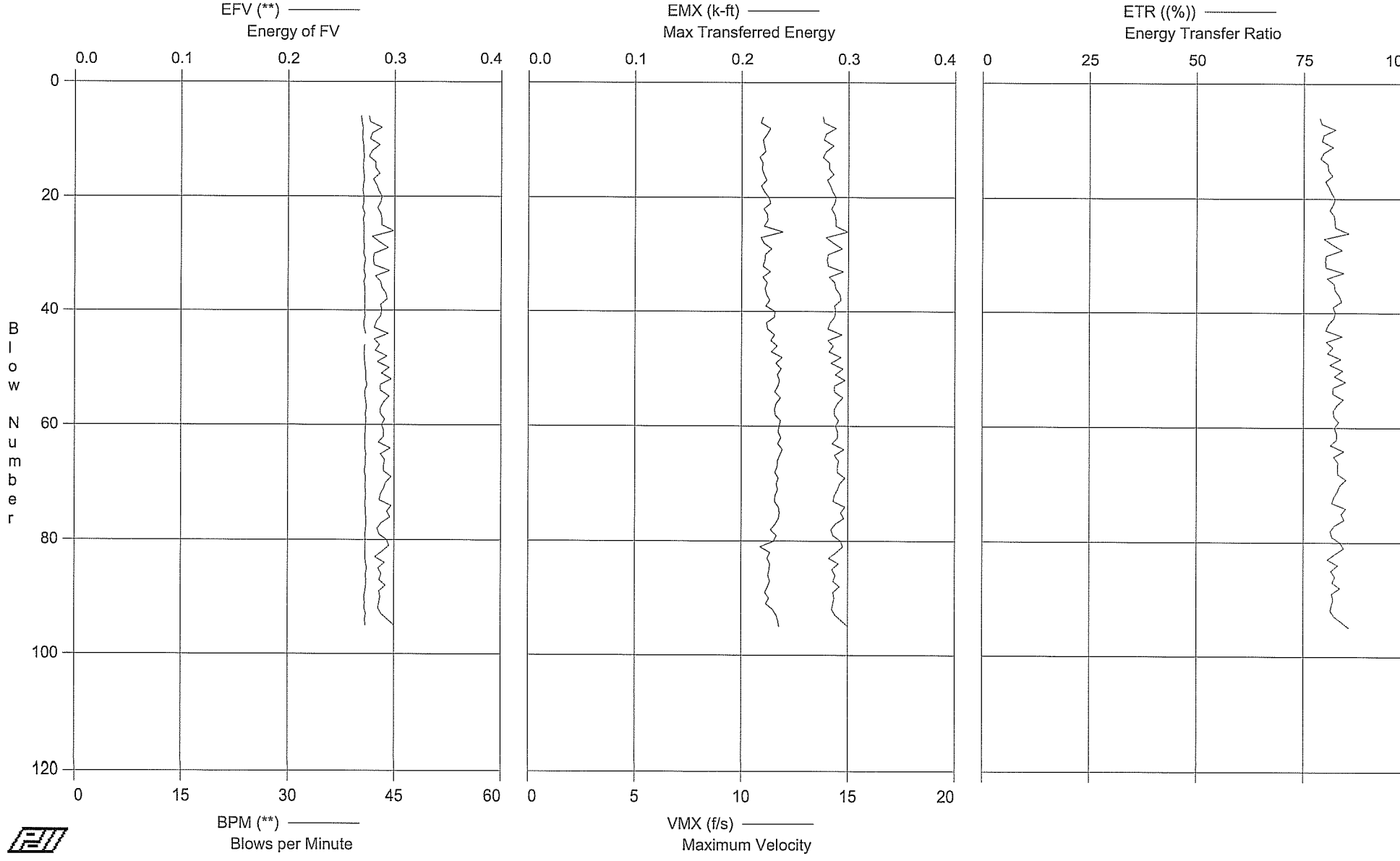
Drive 1 minute 12 seconds 22:21:07 - 22:22:19 (2009-01-19) BN 1 - 55

Gregg Drilling & Testing - Case Method Results

PDIPLOT Ver. 2008.2 - Printed: 10-Nov-2009

Test date: 19-Jan-20

Heim Bridge - WR-09-041 @ 130'



Heim Bridge - WR-09-041 @ 130'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

AR: 1.41 in^2
LE: 181.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

EFV: Energy of FV
BPM: Blows per Minute
EMX: Max Transferred Energy

VMX: Maximum Velocity
ETR: Energy Transfer Ratio

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
6	0.00	0	40.3	0.3	11.0	78.7
7	0.00	0	40.4	0.3	10.9	79.2
8	0.00	0	40.5	0.3	11.3	82.4
9	0.00	0	40.5	0.3	11.2	79.6
10	0.00	0	40.5	0.3	11.0	79.2
11	0.00	0	40.6	0.3	11.0	81.8
12	0.00	0	40.6	0.3	11.1	79.7
13	0.00	0	40.7	0.3	10.8	78.9
14	0.00	0	40.6	0.3	11.0	80.6
15	0.00	0	40.6	0.3	10.9	80.7
16	0.00	0	40.7	0.3	11.0	81.7
17	0.00	0	40.7	0.3	11.2	80.1
18	0.00	0	40.6	0.3	10.9	80.8
19	0.00	0	40.5	0.3	11.1	81.5
20	0.00	0	40.7	0.3	11.3	82.3
21	0.00	0	40.7	0.3	11.3	81.9
22	0.00	0	40.5	0.3	11.0	81.1
23	0.00	0	40.8	0.3	11.2	82.1
24	0.00	0	40.6	0.3	11.2	82.3
25	0.00	0	40.7	0.3	11.0	82.3
26	0.00	0	40.7	0.3	11.9	85.6
27	0.00	0	40.7	0.3	10.9	79.8
28	0.00	0	40.7	0.3	11.0	81.6
29	0.00	0	40.7	0.3	11.4	84.0
30	0.00	0	40.7	0.3	11.1	80.2
31	0.00	0	40.9	0.3	11.1	80.1
32	0.00	0	40.8	0.3	11.0	80.2
33	0.00	0	40.7	0.3	11.3	84.4
34	0.00	0	40.9	0.3	11.0	80.5
35	0.00	0	40.7	0.3	11.2	82.1
36	0.00	0	40.8	0.3	11.1	82.3
37	0.00	0	40.8	0.3	11.2	83.3
38	0.00	0	40.8	0.3	11.3	83.8
39	0.00	0	40.8	0.3	11.1	81.9
40	0.00	0	40.8	0.3	11.6	82.4
41	0.00	0	40.9	0.3	11.5	82.0
42	0.00	0	40.7	0.3	11.2	80.8
43	0.00	0	40.7	0.3	11.2	80.2
44	0.00	0	41.0	0.3	11.5	84.0
45	0.00	0	0.0	0.3	11.4	80.3
46	0.00	0	40.8	0.3	11.7	81.8
47	0.00	0	40.8	0.3	11.4	80.6
48	0.00	0	40.8	0.3	11.9	83.7
49	0.00	0	40.8	0.3	11.6	81.2
50	0.00	0	40.9	0.3	11.9	84.2
51	0.00	0	41.0	0.3	11.7	82.3
52	0.00	0	41.0	0.3	11.8	84.8
53	0.00	0	41.2	0.3	11.7	81.9
54	0.00	0	40.9	0.3	11.6	81.9
55	0.00	0	40.9	0.3	11.8	84.3
56	0.00	0	41.0	0.3	11.6	82.8
57	0.00	0	41.1	0.3	11.6	81.9
58	0.00	0	40.9	0.3	11.6	82.1
59	0.00	0	41.0	0.3	11.8	83.2
60	0.00	0	41.0	0.3	11.8	82.2
61	0.00	0	40.9	0.3	11.7	82.7
62	0.00	0	40.9	0.3	11.8	82.7
63	0.00	0	40.8	0.3	11.7	81.3
64	0.00	0	40.8	0.3	11.9	84.4
65	0.00	0	41.0	0.3	11.8	82.1
66	0.00	0	40.9	0.3	11.7	83.1
67	0.00	0	40.9	0.3	11.7	82.9
68	0.00	0	40.8	0.3	11.6	83.0
69	0.00	0	41.0	0.3	11.7	85.0
70	0.00	0	40.9	0.3	11.6	83.5
71	0.00	0	40.9	0.3	11.7	83.0
72	0.00	0	41.0	0.3	11.6	82.1

Heim Bridge - WR-09-041 @ 130'
OP: catwell

140lb Auto Hammer
Test date: 19-Jan-2009

BL#	depth	EFV	BPM	EMX	VMX	ETR
	ft	**	**	k-ft	f/s	(%)
73	0.00	0	40.9	0.3	11.6	81.6
74	0.00	0	40.9	0.3	11.7	84.9
75	0.00	0	41.0	0.3	11.8	83.8
76	0.00	0	41.0	0.3	11.7	84.5
77	0.00	0	41.0	0.3	11.6	82.3
78	0.00	0	41.0	0.3	11.4	81.3
79	0.00	0	40.9	0.3	11.6	81.7
80	0.00	0	41.0	0.3	11.5	83.6
81	0.00	0	41.0	0.3	10.9	84.4
82	0.00	0	40.9	0.3	11.3	82.4
83	0.00	0	40.9	0.3	11.2	80.6
84	0.00	0	41.0	0.3	11.3	83.0
85	0.00	0	41.2	0.3	11.3	81.4
86	0.00	0	41.0	0.3	11.3	82.4
87	0.00	0	41.0	0.3	11.3	81.8
88	0.00	0	41.0	0.3	11.2	83.5
89	0.00	0	40.9	0.3	11.1	81.6
90	0.00	0	40.8	0.3	11.3	82.0
91	0.00	0	40.9	0.3	11.1	81.6
92	0.00	0	40.8	0.3	11.5	81.3
93	0.00	0	41.0	0.3	11.6	82.2
94	0.00	0	40.9	0.3	11.7	84.0
95	0.00	0	41.0	0.3	11.8	85.7
	Average	0	40.8	0.3	11.4	82.1
	Std. Dev.	0	0.2	0.0	0.3	1.5
	Maximum	0	41.2	0.3	11.9	85.7
	@ Blow#	95	53	95	26	95

Total number of blows analyzed: 90

Time Summary

Drive 2 minutes 17 seconds 23:05:39 - 23:07:56 (2009-01-19) BN 6 - 95

APPENDIX D

GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

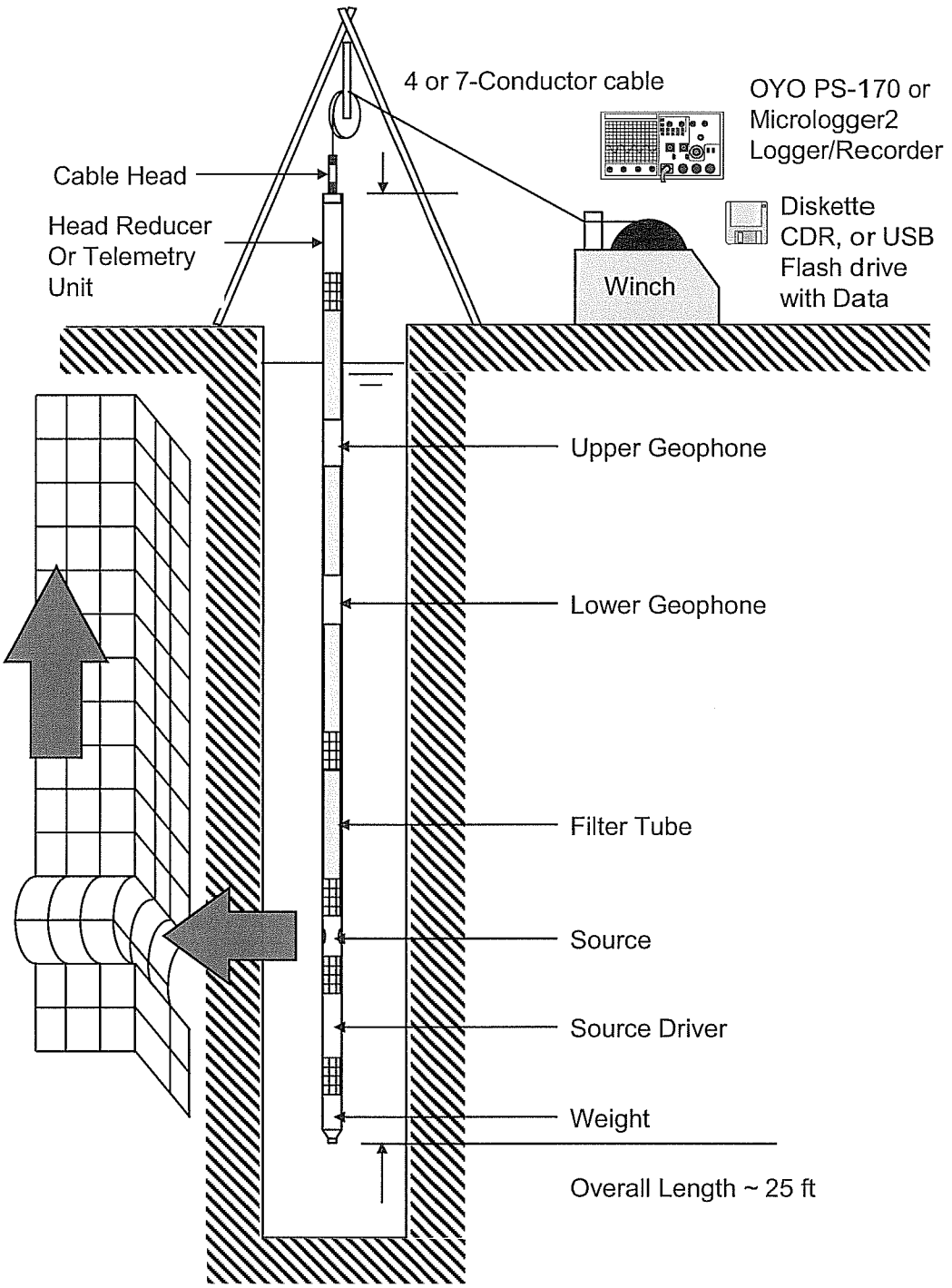

Figure 1: Concept illustration of P-S logging system

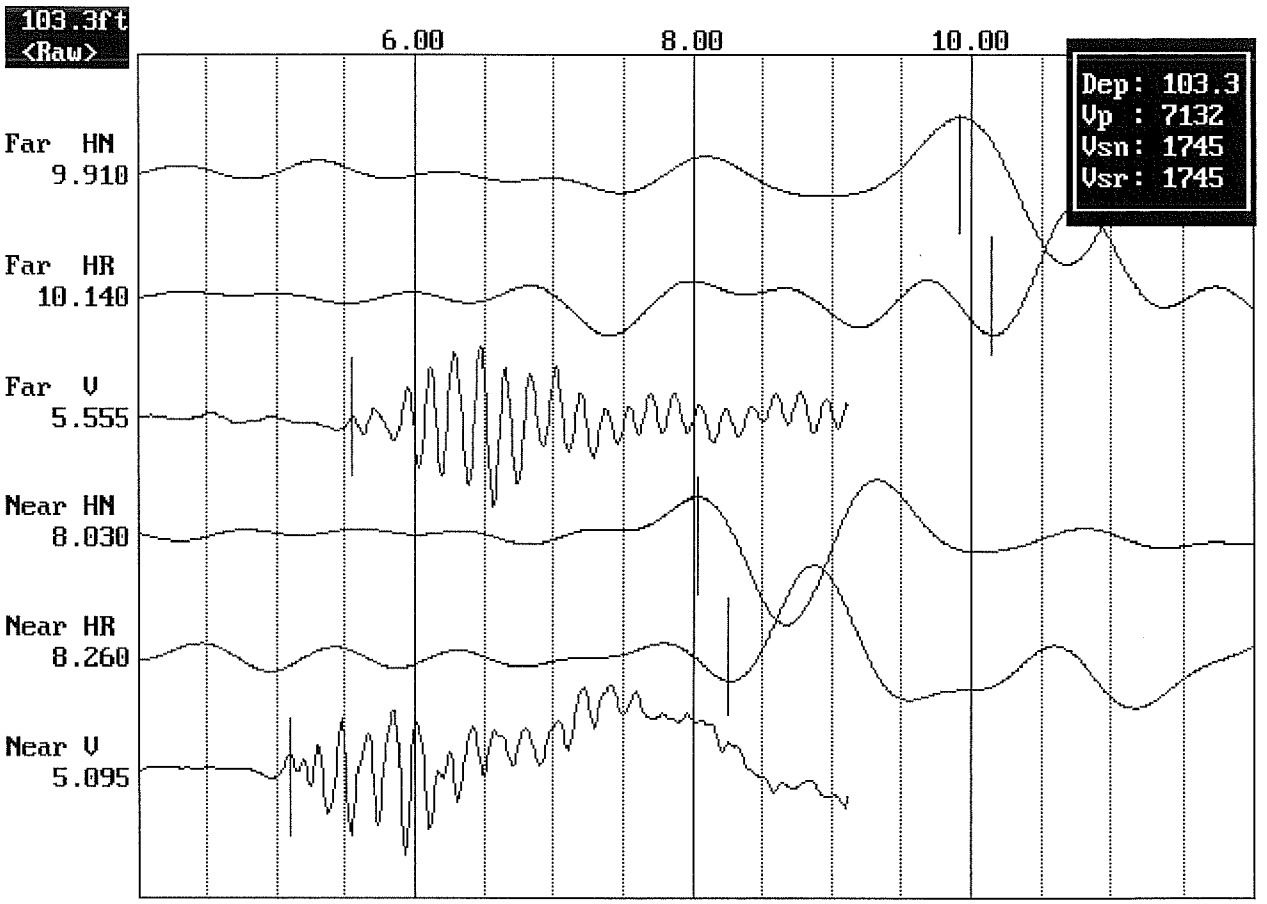

Figure 2: Example of filtered (1400 Hz lowpass) record

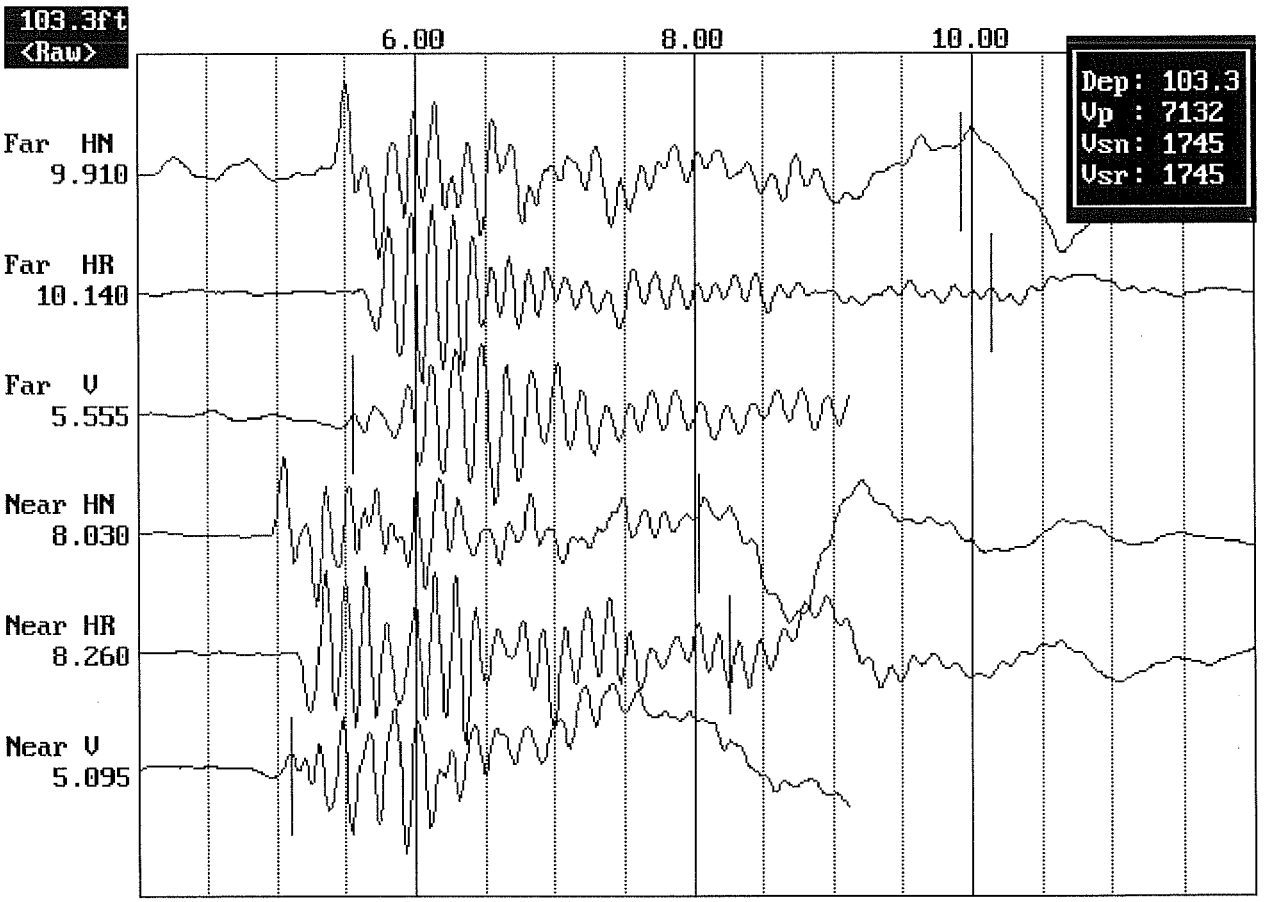

Figure 3. Example of unfiltered record

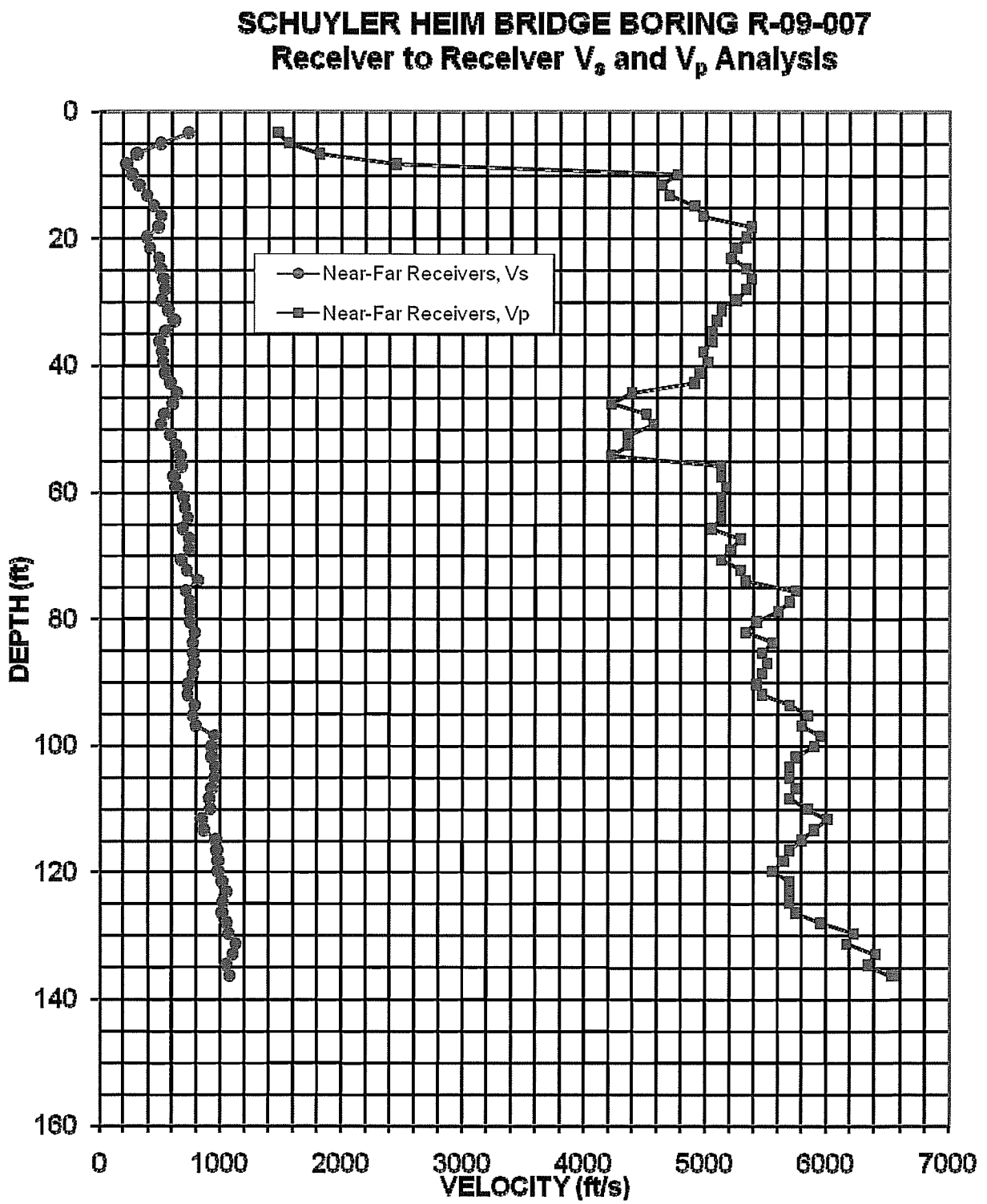

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

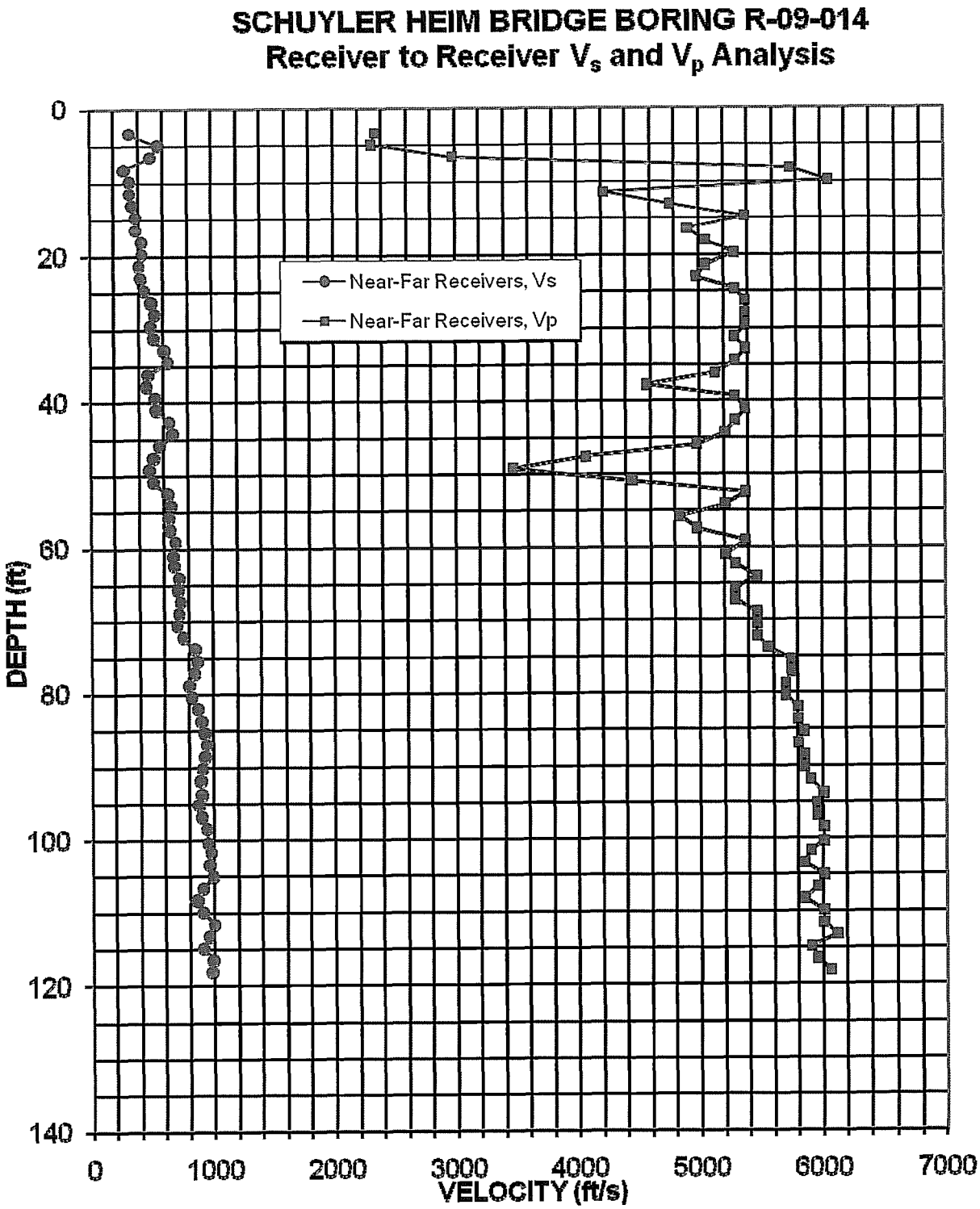

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

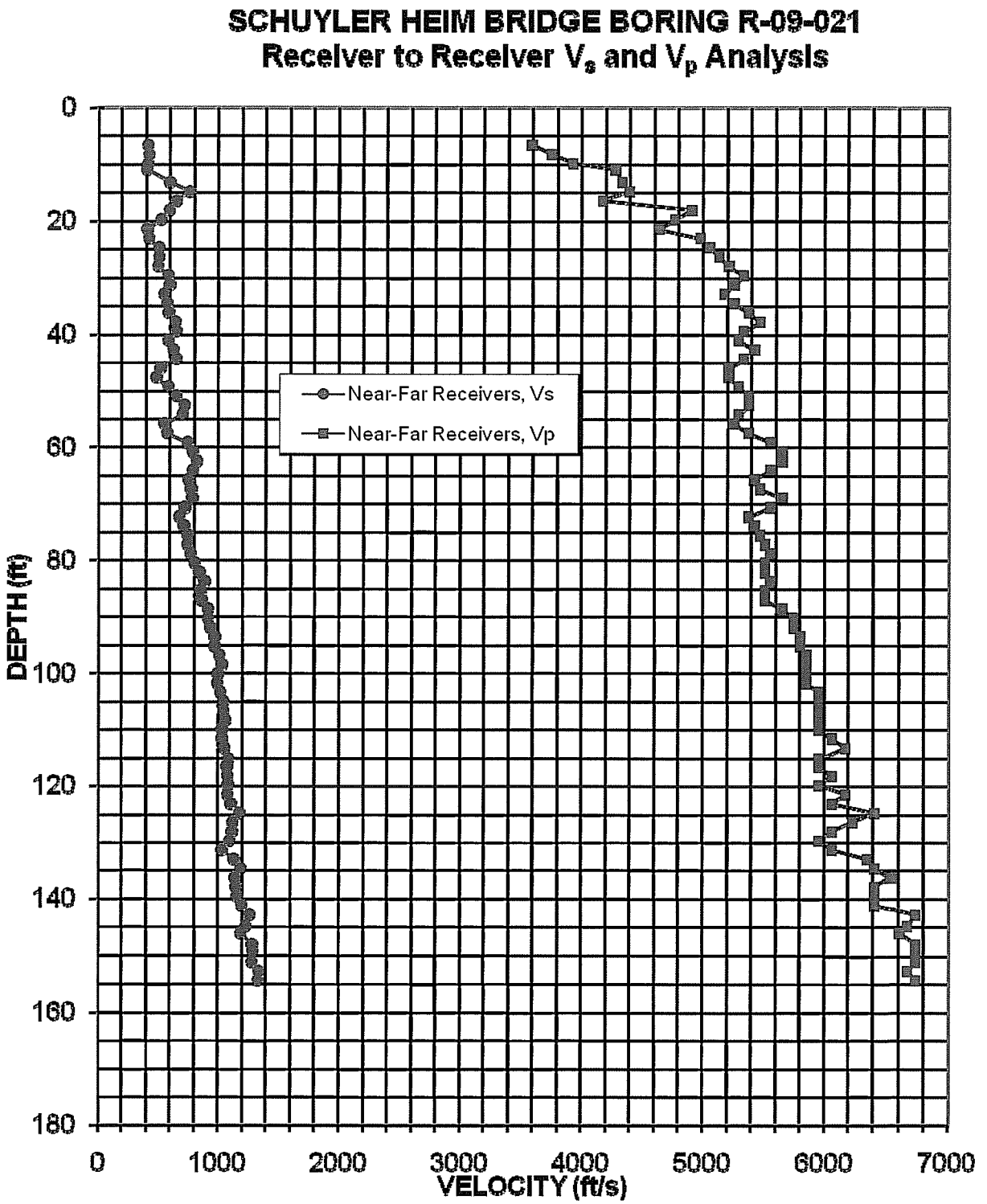

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

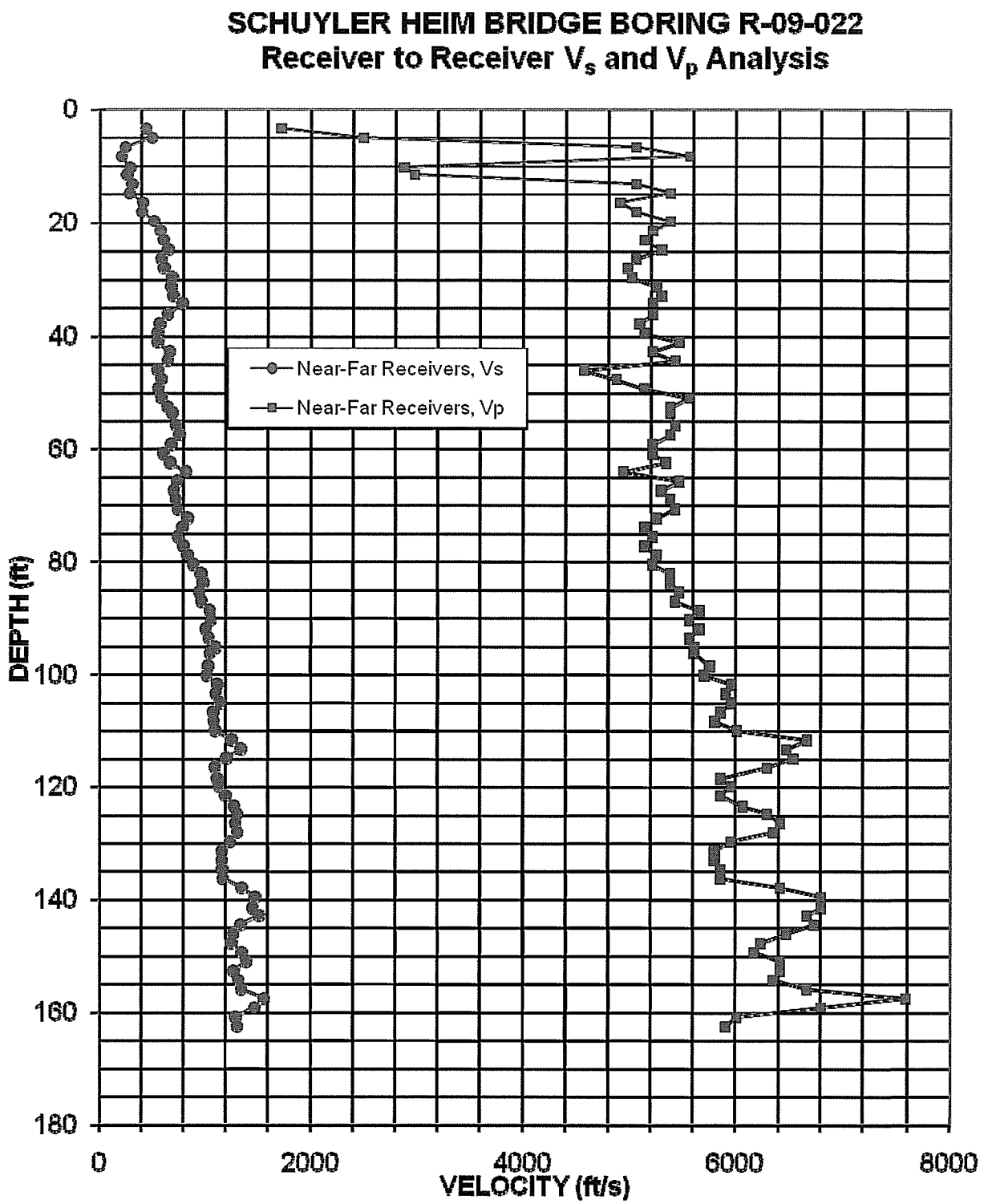

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

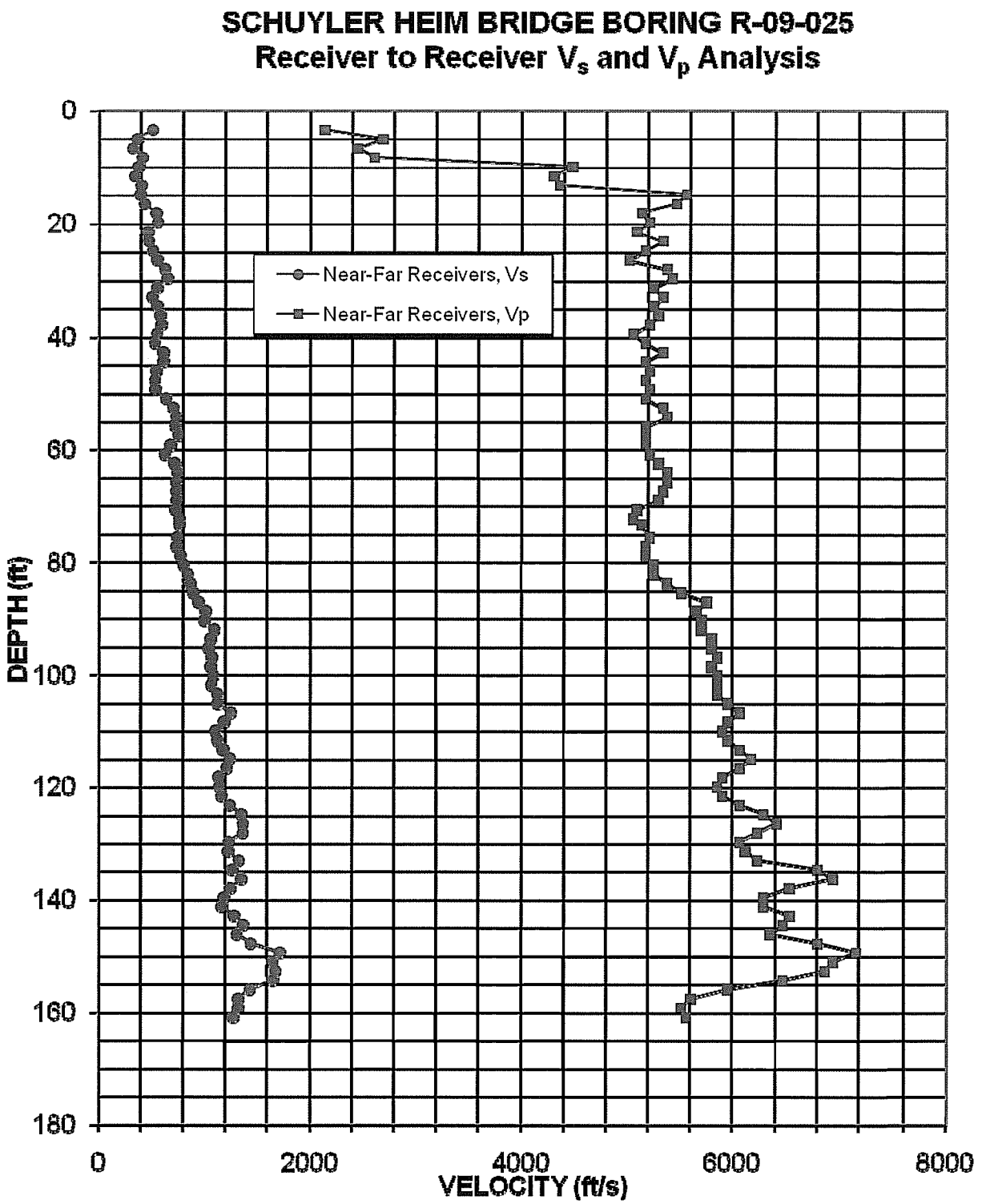

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

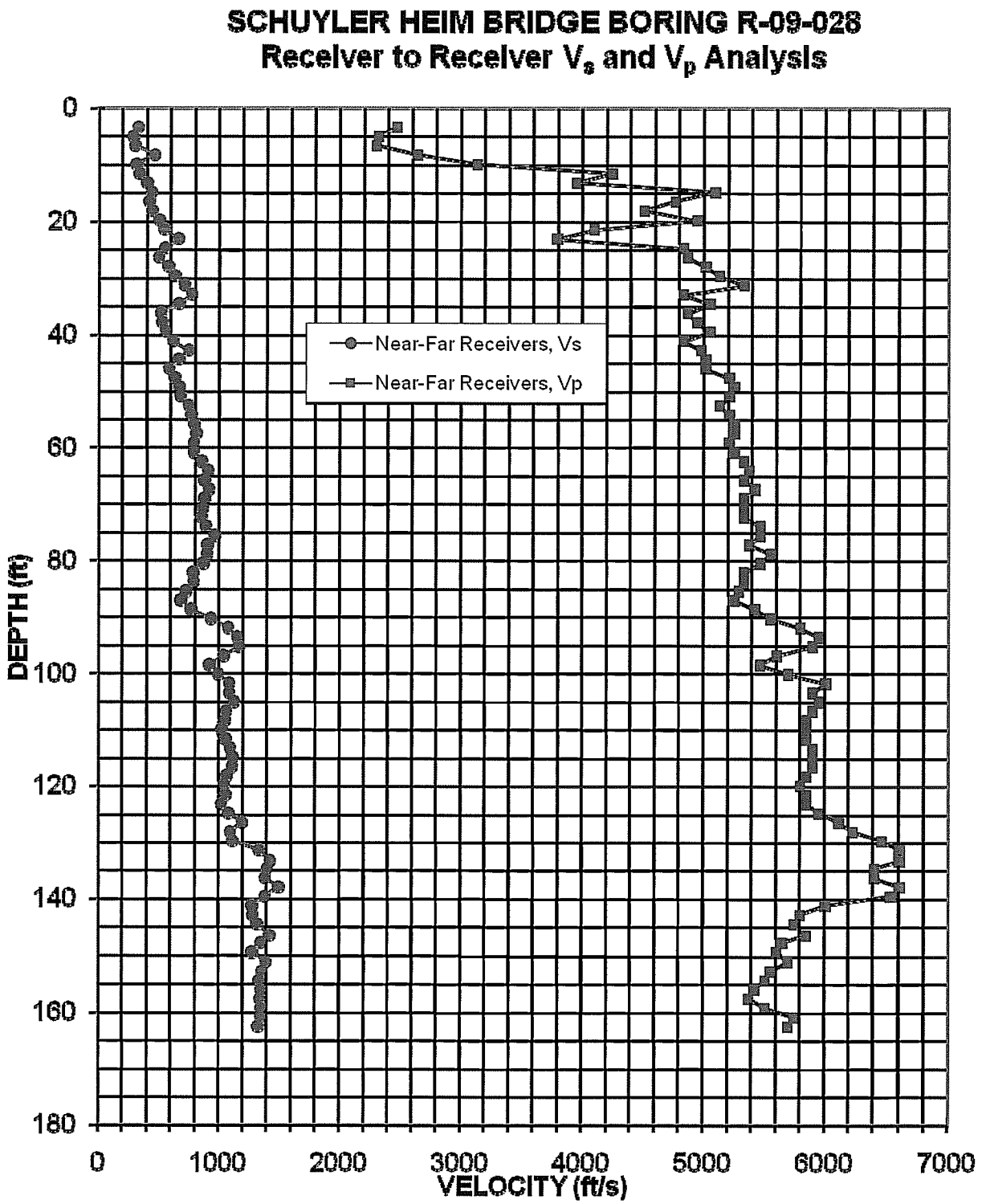

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

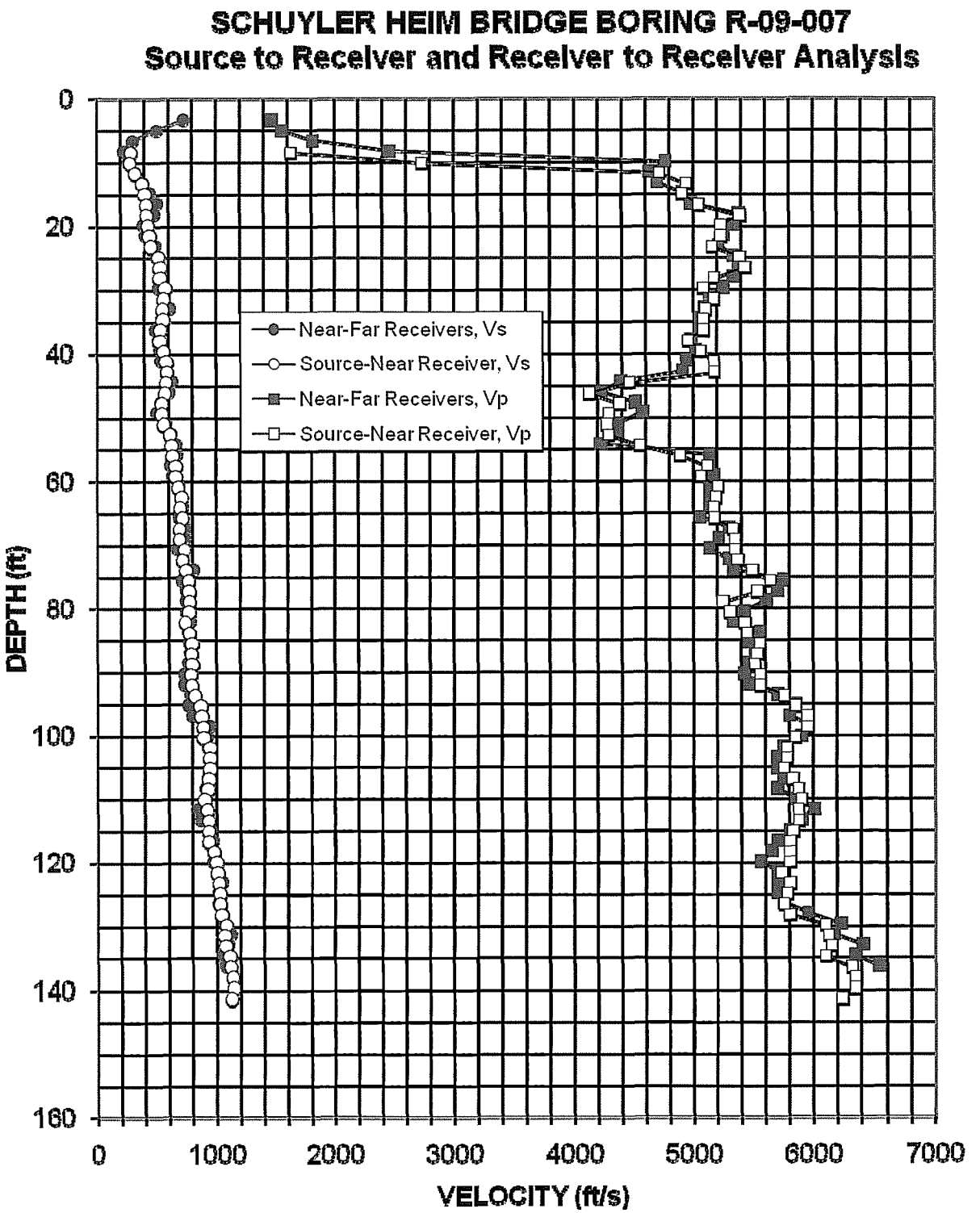

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

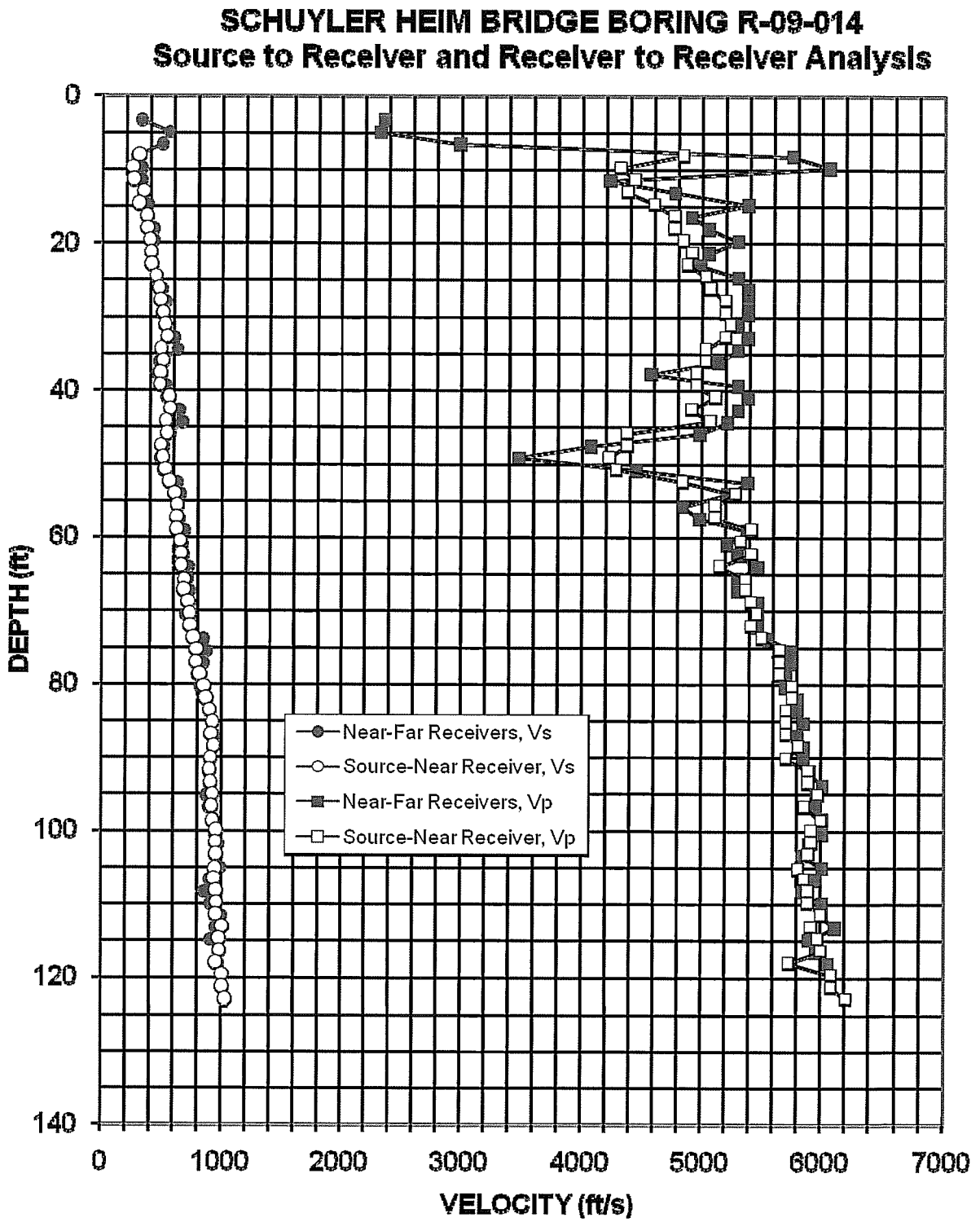

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

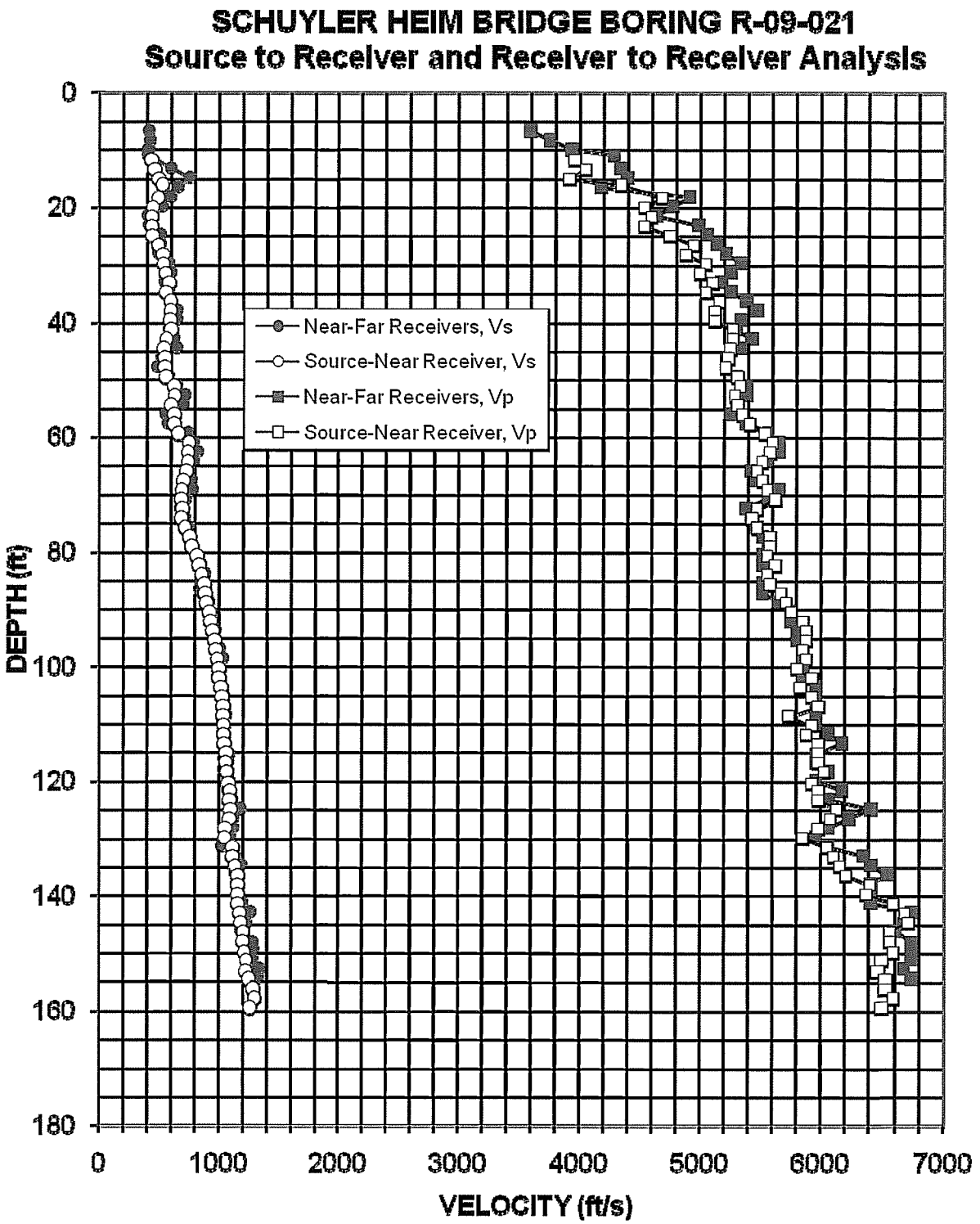

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

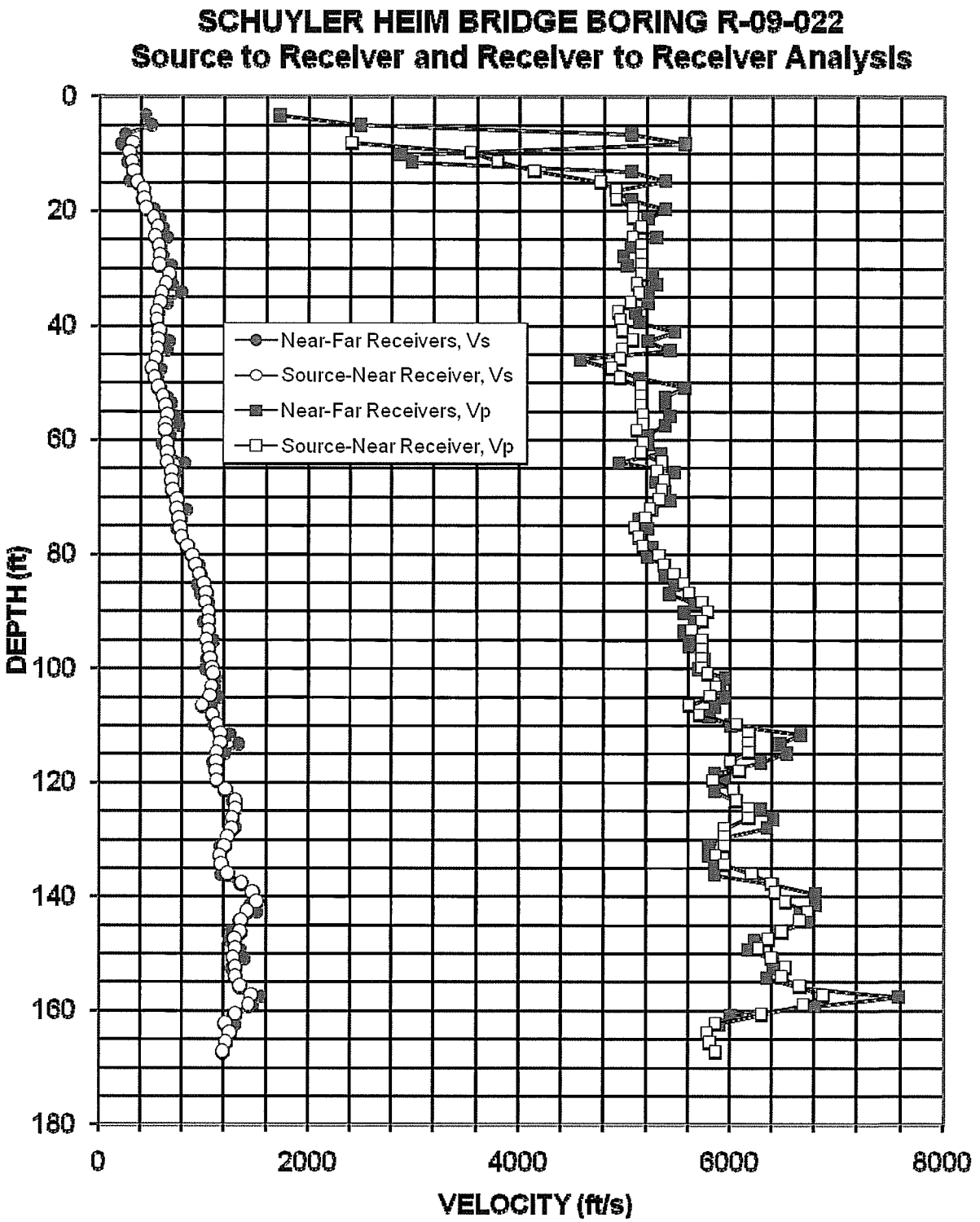

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

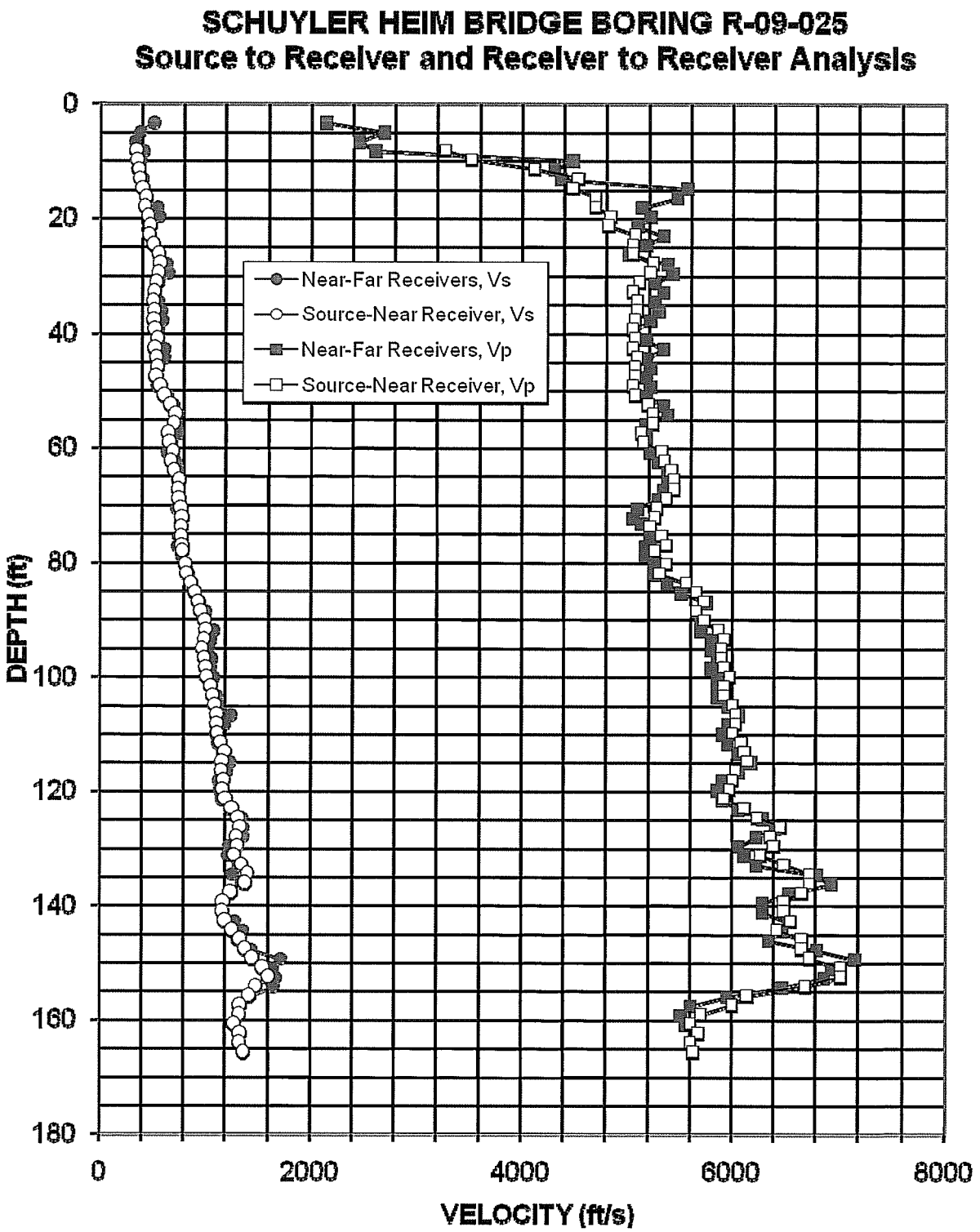

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

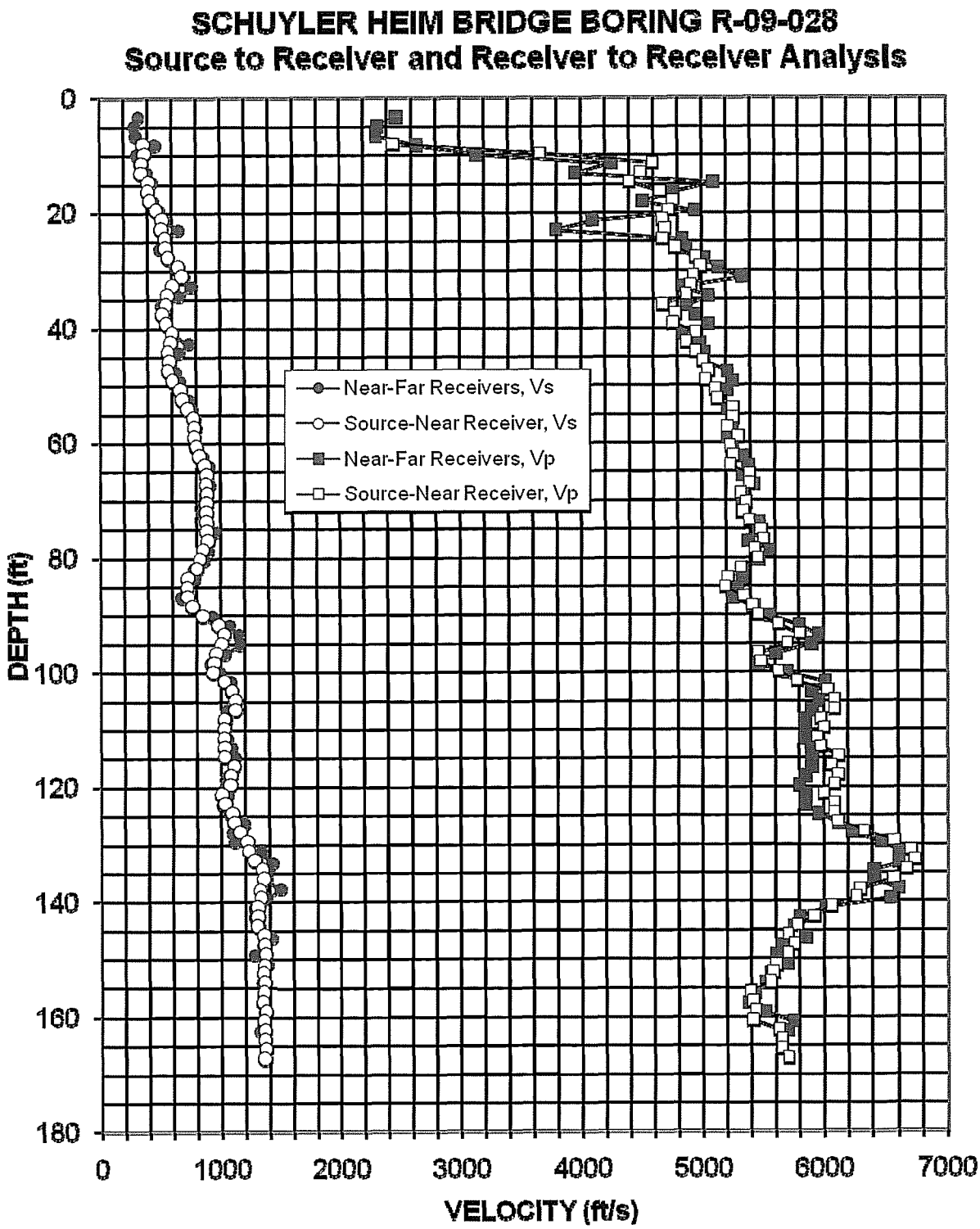

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®

Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CXB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	|	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	|	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

MudCats CPM: Version 2.2.2 (Professional)
Src DUI: {9548AF3D-C74D-4C9F-AEEF-21EF560BC451} (c)
Doc DUI: {1269C0B2-3A13-416A-81BF-409D9887DDDA} (o)

ATTACHMENT 2
Page 2 of 2

Customer

160824 Project Number 06-123 7-17 CB

~~160024~~ CB

573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX E

LABORATORY SOIL TEST RESULTS

MOISTURE AND DENSITY

In-Situ Moisture Content and Dry Density

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-001	D-01	5	21.1	107.2
R-09-001	D-03	15	26.7	96.3
R-09-001	S-04	20	26.7	NA
R-09-001	D-05	25	24.6	101.6
R-09-001	S-08	40	29.9	NA
R-09-001	S-10	50	57.0	NA
R-09-001	D-11	55	30.9	90.9
R-09-001	D-13	65	27.5	98.2
R-09-001	S-14	70	29.6	NS
R-09-001	S-15	75	35.5	NA
R-09-002	D-01	5	17.3	109.8
R-09-002	S-02	10	32.7	NA
R-09-002	D-05	25	13.9	114.6
R-09-002	S-08	40	31.0	NA
R-09-002	S-10	50	35.2	NA
R-09-002	D-11	55	35.7	93.8
R-09-002	S-12	60	26.1	NA
R-09-002	S-14	70	35.0	NA
R-09-002	S-15	75	33.7	NA
R-09-003	D-02	10	19.7	103.3
R-09-003	S-03	15	26.7	NA
R-09-003	D-06	30	18.1	108.4
R-09-003	S-07	35	35.7	NA
R-09-003	S-09	45	32.4	NA
R-09-003	D-14	70	25.5	99.7
R-09-003	S-15	75	37.1	NA
R-09-003	S-17	85	22.2	NA
R-09-003	S-19	100	29.8	NA
R-09-003	S-20	110	19.2	NA
R-09-003	S-23	150	7.5	NA
R-09-005	D-02	10	30.1	87.6
R-09-005	S-03	15	27.3	NA
R-09-005	D-06	30	30.6	91.8
R-09-005	D-08	40	43.4	78.4
R-09-005	S-13	65	41.7	NA
R-09-005	S-15	75	20.7	NA
R-09-005	S-18	100	22.4	NA
R-09-005	S-20	120	20.2	NA
R-09-005	S-21	130	14.0	NA
R-09-005	S-23	160	9.3	NA
R-09-006	D-01	5	25.3	91.2
R-09-006	S-04	15	23.8	NA
R-09-006	D-08	40	34.1	87.9

In-Situ Moisture Content and Dry Density (Continued)

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-006	D-11	52.5	28.6	95.3
R-09-006	D-12-2	56	38.8	NA
R-09-006	D-13	60	25.3	NA
R-09-006	S-16	75	27.8	NA
R-09-006	D-17	80	22.0	101.8
R-09-006	D-19	90	25.0	99.2
R-09-006	S-23	130	20.1	NA
R-09-006	S-25	160	9.0	NA
R-09-008	D-01	5	28.2	86.0
R-09-008	D-05	25	24.7	98.4
R-09-008	D-07	35	47.5	79.1
R-09-008	D-09	45	52.3	71.3
R-09-008	S-10	50	54.1	NA
R-09-008	D-11	55	33.4	88.0
R-09-008	D-13	65	30.4	91.2
R-09-008	S-14	70	35.1	NA
R-09-008	U-15	75	19.4	98.9
R-09-008	S-16	80	20.8	NA
R-09-008	S-20	120	21.5	NA
R-09-008	S-23	150	10.8	NA
R-09-009	D-01	5	24.5	94.3
R-09-009	S-03	15	24.7	NA
R-09-009	D-07	35	52.9	72.3
R-09-009	S-10	50	52.6	NA
R-09-009	D-11	55	28.6	92.9
R-09-009	D-13	65	32.0	89.6
R-09-009	S-14	70	29.2	NA
R-09-009	S-16	80	26.6	NA
R-09-009	S-19	110	12.0	NA
R-09-009	S-22	140	9.6	NA
R-09-011	D-02	10	27.2	91.4
R-09-011	D-04	20	26.6	97.2
R-09-011	S-07	35	39.1	NA
R-09-011	D-08	40	35.1	87.9
R-09-011	D-10	50	39.8	78.5
R-09-011	S-11	55	38.8	NA
R-09-011	S-13	65	32.2	NA
R-09-011	S-15	75	21.8	NA
R-09-011	D-16	80	28.9	97.1
R-09-011	S-19	110	22.1	NA
R-09-011	S-23	150	18.7	NA
R-09-012	D-02	10	14.1	97.7

In-Situ Moisture Content and Dry Density (Continued)

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-012	S-03	15	23.7	MA
R-09-012	S-05	25	44.5	NA
R-09-012	U-06	30	36.6	85.0
R-09-012	D-08	40	29.2	94.6
R-09-012	S-09	45	28.4	NA
R-09-012	D-10	50	38.3	86.2
R-09-012	S-11	55	32.0	NA
R-09-012	D-12	60	31.6	89.8
R-09-012	S-13	65	48.0	NA
R-09-012	D-14	70	35.0	87.9
R-09-012	S-15	75	39.1	NA
R-09-012	S-17	90	39.3	NA
R-09-012	S-19	110	17.3	NA
R-09-012	S-22	140	18.8	NA
R-09-013	S-02	10	73.7	NA
R-09-013	D-03	15	30.2	93.4
R-09-013	D-06	30	52.7	70.1
R-09-013	S-07	35	36.2	NA
R-09-013	S-09-1	45	41.9	NA
R-09-013	D-10	50	39.4	79.7
R-09-013	S-11-2	55.5	35.5	NA
R-09-013	D-12	60	32.8	88.2
R-09-013	S-13	65	33.9	NA
R-09-013	S-15	75	24.5	NA
R-09-013	S-17	85	24.9	NA
R-09-013	S-19	100	18.3	NA
R-09-013	S-22	130	5.9	NA
R-09-013	S-24	150	18.7	NA
R-09-015	D-02	10	25.6	98.3
R-09-015	D-04	20	42.9	79.4
R-09-015	S-05	25	36.5	NA
R09-015	D-06	30	34.8	84.9
R-09-015	S-07	35	51.0	NA
R-09-015	D-08	40	62.8	62.4
R-09-015	D-10	50	35.3	82.8
R-09-015	S-11	55	37.2	NA
R-09-015	D-15	75	27.0	98.0
R-09-015	S-16	80	24.7	NA
R-09-015	S-18	100	17.5	NA
R-09-015	S-21	135	13.6	NA
R-09-016	D-02	10	20.2	108.7
R-09-016	S-03	15	28.8	NA

In-Situ Moisture Content and Dry Density (Continued)

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-016	D-04	20	29.2	93.9
R-09-016	S-05	25	45.0	NA
R-09-016	D-06	30	31.9	86.7
R-09-016	D-08	40	56.2	65.9
R-09-016	D-10-1	50	36.2	79.6
R-09-016	D-10-2	50.5	41.8	78.1
R-09-016	S-11	55	35.8	NA
R-09-016	D-12-1	60	33.7	88.3
R-09-016	D-15	75	24.3	100.3
R-09-016	S-19	100	19.3	NA
R-09-016	S-23	150	10.7	NA
R-09-017	D-02	10	22.9	102.6
R-09-017	D-04	20	33.0	83.8
R-09-017	S-05	25	32.1	NA
R-09-017	U-07	35	44.9	NA
R-09-017	D-08	40	28.0	94.8
R-09-017	D-10	50	46.6	74.6
R-09-017	D-14	75	29.8	95.8
R-09-017	S-17	100	24.5	NA
R-09-017	S-19	120	21.0	NA
R-09-017	S-22	165	7.0	NA
R-09-018	S-02	10	26.5	NA
R-09-018	S-04	20	37.5	NA
R-09-018	S-07	30	57.1	NA
R-09-018	D-09	35	33.5	83.9
R-09-018	S-13	52.5	47.6	NA
R-09-018	D-14	55	32.4	89.7
R-09-018	S-16	65	28.9	NA
R-09-018	D-17	70	23.3	103.6
R-09-018	D-19	80	21.3	104.4
R-09-018	S-21	95	23.3	NA
R-09-018	S-25	135	11.9	NA
R-09-018	S-27	160	23.9	NA
R-09-019	S-01	5	32.4	NA
R-09-019	S-03	15	46.2	NA
R-09-019	D-04	20	34.5	85.2
R-09-019	S-05	25	44.6	NA
R-09-019	D-08	40	34.8	87.5
R-09-019	S-09	45	45.6	NA
R-09-019	S-11	55	36.6	NA
R-09-019	D-12	60	34.6	86.0
R-09-019	D-14	70	25.0	97.6

In-Situ Moisture Content and Dry Density (Continued)

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-019	S-15	75	22.3	NA
R-09-019	S-17	90	19.5	NA
R-09-019	S-19	110	19.9	NA
R-09-019	S-21	130	13.6	NA
R-09-019	S-23	150	28.5	NA
R-09-020	D-02	10	28.5	88.3
R-09-020	S-03-1	15	53.8	NA
R-09-020	S-05	25	48.8	NA
R-09-020	D-06	30	39.4	83.2
R-09-020	S-07	35	35.5	NA
R-09-020	S-09	45	26.6	NA
R-09-020	D-10	50	29.0	94.0
R-09-020	S-11-1	55	33.5	NA
R-09-020	S-11-2	55.9	49.0	NA
R-09-020	D-12	60	33.4	87.1
R-09-020	S-15-2	75.3	28.2	NA
R-09-020	S-17	85	19.8	NA
R-09-020	S-20	115	17.0	NA
R-09-020	S-22	140	11.5	NA
R-09-020	S-25	185	31.8	NA
R-09-022	D-02	10	58.1	66.8
R-09-022	D-06	30	27.1	95.6
R-09-022	S-09	45	47.0	NA
R-09-022	D-10	50	30.6	92.2
R-09-022	D-12	60	38.3	83.2
R-09-022	D-14	70	23.0	102.0
R-09-022	S-15	75	37.4	NA
R-09-022	D-16	85	25.6	99.2
R-09-022	S-19	115	14.3	NA
R-09-022	S-22	160	30.1	NA
R-09-023	D-02	10	45.0	69.7
R-09-023	S-03	15	36.4	NA
R-09-023	S-05	25	27.8	NA
R-09-023	D-11	55	28.6	92.7
R-09-023	D-13-1	65	23.6	103.2
R-09-023	D-13-2	65.5	26.8	95.9
R-09-023	S-16	80	36.2	NA
R-09-023	D-17	85	22.3	103.9
R-09-023	S-19	100	18.3	NA
R-09-023	S-22	130	14.7	NA
R-09-023	S-24	150	18.5	NA
R-09-024	D-08	40	39.9	81.6

In-Situ Moisture Content and Dry Density (Continued)

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-024	D-10	50	43.2	77.0
R-09-024	D-14	70	40.2	83.3
R-09-024	D-16-1	80	32.9	89.6
R-09-024	S-18	90	24.7	NA
R-09-024	S-22	120	13.3	NA
R-09-024	S-25	150	11.2	NA
R-09-025	D-04	20	42.0	79.9
R-09-025	U-07	35	19.0	99.7
R-09-025	D-08	40	39.5	82.1
R-09-025	D-12-2	60.5	38.3	84.6
R-09-025	S-13	65	26.1	NA
R-09-025	D-15	75	38.9	NA
R-09-025	D-16	85	27.7	97.4
R-09-025	S-19	115	14.3	NA
R-09-025	S-22	160	29.8	NA
R-09-026	D-02	10	35.3	82.2
R-09-026	S-03	15	38.4	NA
R-09-026	D-04	20	41.0	79.5
R-09-026	D-08	40	36.2	85.9
R-09-026	D-10	52	24.7	99.4
R-09-026	D-12	60	23.1	104.3
R-09-026	S-13	65	23.6	NA
R-09-026	D-14	70	29.8	91.7
R-09-026	D-17	85	22.9	103.2
R-09-026	S-21	115	12.5	NA
R-09-026	S-24	145	12.9	NA
R-09-028	S-03	15	59.0	NA
R-09-028	D-04	20	23.3	102.7
R-09-028	S-05	25	38.7	NA
R-09-028	D-06	30	25.1	100.5
R-09-028	D-08	40	32.8	89.4
R-09-028	D-10	50	24.7	101.2
R-09-028	D-12	60	25.8	96.7
R-09-028	D-14	70	27.1	97.2
R-09-028	S-16	85	22.9	NA
R-09-028	S-19	115	16.1	NA
R-09-028	S-22	160	32.8	NA
R-09-029	D-02	10	41.6	76.8
R-09-029	D-04	20	43.9	76.7
R-09-029	D-08	40	29.3	92.4
R-09-029	D-10	50	32.1	90.3
R-09-029	S-11	55	37.2	NA

In-Situ Moisture Content and Dry Density (Continued)

Boring No.	Sample No.	Depth (ft)	Moisture Content ASTM D2216 (%)	Dry Density ASTM D2937 (pcf)
R-09-029	D-14	70	19.7	102.8
R-09-029	S-17	85	30.7	NA
R-09-029	S-21	125	16.5	NA
R-09-029	S-24	160	27.8	NA

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO.: 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-004	D-01	5.0	23.2	104.3		30,22,8
R-09-004	D-03	15.0	27.0	97.7		
R-09-004	D-05	25.0			19.1	
R-09-004	S-06	30.0	22.8			
R-09-004	D-07	35.0				27,24,3
R-09-004	S-08	41.0	34.0			25,22,3
R-09-004	S-11	56.0	28.7			27,22,5
R-09-004	S-13	60.0	29.5		35.8	
R-09-004	D-14	65.0	26.4	101.4		
R-09-004	S-15	70.0	30.7			33,21,12
R-09-004	D-16	75.0	27.0	98.6		
R-09-004	S-17	80.0	25.4			
R-09-004	D-18	85.0	27.8	98.4		
R-09-004	S-20	95.0	23.2			
R-09-004	U-21	100.0				58,28,30
R-09-004	S-22	115.0	16.4			
R-09-004	S-23-2	126.2	49.5			50,25,25
R-09-004	S-26	155.0	15.7			
R-09-007	S-01	5.0			36.2	
R-09-007	D-02	10.0	26.7	98.6		
R-09-007	S-03	15.0	29.7			
R-09-007	D-04	20.0			2.1	
R-09-007	S-05	25.0	35.7			
R-09-007	D-07	35.0	34.8	89.7		26,24,2
R-09-007	U-08	40.0				40,24,16
R-09-007	S-09	45.0	36.2			
R-09-007	S-11	55.0	36.0			38,26,12
R-09-007	D-12	60.0	34.0	90.7		29,25,4
R-09-007	S-13	65.0	39.1			31,24,7
R-09-007	S-15	75.0			40.9	
R-09-007	D-17	85.0	16.3	115.5		
R-09-007	S-21	125.0	22.3			
R-09-007	S-23	150.0	11.5			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-010	S-01	5.0	25.9			
R-09-010	D-02	10.0	26.7	107.3		
R-09-010	D-04	20.0			3.3	
R-09-010	U-06	30.0				29,23,6
R-09-010	S-07	35.0			14.1	
R-09-010	D-8-1	40.0			66.9	
R-09-010	D-8-2	40.5	39.5	82.7		40,23,17
R-09-010	D-10	50.0				51,27,24
R-09-010	D-12	60.0	30.4	93.2		33,26,7
R-09-010	S-13-1	65.0	21.9			
R-09-010	S13-2	65.7	34.1			35,20,15
R-09-010	D-14	70.0	32.4	90.4		31,22,9
R-09-010	S-15	75.0	34.0		79.3	26,23,3
R-09-010	D-16	80.0	30.1	93.8		
R-09-010	S-18	90.0	25.8		8.9	
R-09-010	S-20	110.0	18.7			
R-09-010	S-23	140.0	12.4			
R-09-014	S-01	5.0			39.6	
R-09-014	S-03	15.0	30.0		5.6	
R-09-014	D-04	20.0	38.0	86.9		34,24,10
R-09-014	S-05	25.0	30.6		35.5	
R-09-014	D-06	30.0			28.3	
R-09-014	S-07	35.0	53.2			49,24,25
R-09-014	D-08	40.0	33.4	90.6		26,24,2
R-09-014	S-10	46.0	48.2			45,22,23
R-09-014	U-11	50.0	46.5	75.1		49,24,25
R-09-014	U-13	60.0				43,24,19
R-09-014	S-14	65.0	36.7			28,25,3
R-09-014	D-15	70.0	20.1	109.1		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO.: 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-014	S-16	75.0			21.9	
R-09-014	D-17	80.0	25.6	103.1		
R-09-014	S-19	100.0	19.2			
R-09-014	S-22	135.0	16.0			
R-09-014	S-24	165.0	25.3			
R-09-021	S-01	5.0			27.0	
R-09-021	D-02	10.0	32.9	89.4		
R-09-021	S-03	15.0	32.8			
R-09-021	U-04	20.0				61,29,32
R-09-021	S-05	25.0	33.0		12.4	
R-09-021	S-07	35.0	32.9		41.6	
R-09-021	S-09	41.5	34.0			23,22,1
R-09-021	U-10	45.0				56,26,30
R-09-021	S-11	50.0	39.2		52.4	
R-09-021	D-12	55.0	33.2	91.5		36,22,14
R-09-021	D-14	65.0	29.7	96.0		30,21,9
R-09-021	S-15	70.0			35.0	
R-09-021	D-17	75.0	31.7	92.5		35,23,12
R-09-021	S-18	80.0	26.8			
R-09-021	D-19	85.0	22.6	105.2		
R-09-021	S-20	100.0	23.5			
R-09-021	S-21	115.0	21.1			
R-09-021	S-24	170.0	8.9			
R-09-030	S-01	5.0	21.6			
R-09-030	D-02	10.0	11.2	120.0		
R-09-030	S-03	15.0	42.9		72.3	
R-09-030	U-05	25.0				43,25,18
R-09-030	S-07	35.0	30.5		34.3	
R-09-030	U-09	45.0				45,25,20
R-09-030	D-11-1	55.0	35.3	82.9		35,20,15
R-09-030	S-12	60.0			46.2	
R-09-030	S-14	70.0	27.4			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008A

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-027	U-01	11.0				44,23,21
R-09-027	D-02-2	15.5	56.9	70.2	45.1	
R-09-027	S-03	20.0			20.9	
R-09-027	D-06	32.0	21.6	107.2		
R-09-027	S-07	35.0			10.2	
R-09-027	D-08-1	40.0	35.2	82.0		41,24,17
R-09-027	U-09	45.0				54,24,30
R-09-027	S-10	50.0	27.7			25,23,2
R-09-027	D-11	55.0	26.4	101.0		
R-09-027	S-12	60.0			27.1	
R-09-027	S-14	70.0	16.8			
R-09-027	S-16-1	80.0	32.3			32,23,9
R-09-027	S-17	90.0	21.7			
R-09-027	S-20	120.0	17.9			
R-09-027	S-23	150.0	11.7			
R-09-033	S-01	5.0	12.7			
R-09-033	D-02	10.0	12.7	104.6	21.4	
R-09-033	U-04	20.0				61,26,35
R-09-033	D-05	25.0			10.9	
R-09-033	S-08-1	40.0	47.8			41,23,18
R-09-033	U-09	45.0				25,24,1
R-09-033	D-10-1	50.0			55.5	
R-09-033	S-11-1	55.0	31.9			29,21,8
R-09-033	S-11-2	55.8	30.5			24,23,1
R-09-033	D-12-1	60.0	25.5	100.4		
R-09-033	S-13-1	65.0	38.6			38,24,14
R-09-033	S-16	80.0	20.7			
R-09-033	S-17-2	90.6	35.5			33,22,11
R-09-033	S-19	100.0	14.2			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-041	S-4-2	57.6	CL	39.9				0:15:85		43/24/19				
WR-09-041	S-6-1	67	CL	37.8				0:2:98		46/27/19				
WR-09-041	S-6-2	67.4	ML								98	8.2	360	7929
WR-09-041	D-7	72	ML	18.7	135.0			0:43:57						
WR-09-041	S-8	77	ML					0:48:52						
WR-09-041	D-9	82	SP-SM	24.0	125.9									
WR-09-041	S-10	87	SP-SM					0:90:10						
WR-09-041	D-11	92	SP-SM	21.0	128.0									
WR-09-041	S-13	107	SP-SM	15.9				2:87:11						
WR-09-041	S-16	127	SM	10.8				30:57:13						
WR-09-041	S-19	157	SP-SM	11.4				39:50:11						
WR-09-041	S-21	177	ML	26.3				0:12:88						
WR-09-041	S-22-1	187	CL	36.5										
WR-09-041	S-24	202	SW-SM	20.6				1:89:10						
WR-09-041	S-26-1	222	SP-SM					0:88:12						
WR-09-041	S-26-2	223	ML	27.5						36/27/9				
WR-09-041	S-27	227	SP	22.3				0:98:2						
WR-09-042	S-3-1	68	CL	32.7						44/24/20				
WR-09-042	S-3-2	68.3	CL-ML					0:32:68						
WR-09-042	S-3-3	68.5	ML	29.8						34/25/9				
WR-09-042	S-5	78	ML					0:49:51						
WR-09-042	D-6	83	SM	26.8	125.8					N.P.	130	7.6	300	6417
WR-09-042	S-7	88	SM					0:62:38						
WR-09-042	D-8	93	SM	25.5	126.0									
WR-09-042	S-9	98	SP-SM					0:93:7						
WR-09-042	D-10	103	SM	27.0	125.1									
WR-09-042	S-12	113	SP	19.6				1:97:2						
WR-09-042	S-14	123	SP-SM	11.1				36:58:6						
WR-09-042	S-16	133	SM	16.8				18:63:18						
WR-09-042	D-19	163	GP	5.2				51:46:3						
WR-09-042	S-22	193	SM	23.1				0:78:22						
WR-09-042	S-24	213	SP-SM					0:93:7						
WR-09-042	S-25-2	223.5	CL	16.9				2:37:61		28/14/14				
WR-09-042	S-26-1	233	CL	28.4				0:26:74		39/17/22				
WR-09-043	D-5-1	68	ML								87	7.5	390	9074
WR-09-043	D-5-2	68.5	CL	33.8	114.3	0.5		0:3:97		46/25/21				
WR-09-043	S-6	73	ML	32.2						44/33/11				
WR-09-043	S-8-2	83.5	ML	29.6				0:34:66						
WR-09-043	D-9-1	88	MH	37.4	113.6	0.25		0:5:95		50/37/13				
WR-09-043	S-10	93	SM					0:75:25						

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-043	D-11	98	SP	20.4	127.1									
WR-09-043	D-13	108	SP-SM	14.4	134.2			5:90:5						
WR-09-043	S-16	133	SW-SM	14.1				1:90:9						
WR-09-043	S-18	153	SP-SM	9.3				31:57:12						
WR-09-043	S-19	168	ML	31.5				0:8:92		35/26/9				
WR-09-043	S-22	198	SM	20.6				0:85:15						
WR-09-043	S-24	223	SP-SM					2:89:9						
WR-09-043	S-25-1	238	CL	45.4						49/27/22				
WR-09-043	S-25-2	238.3	SM					26:53:21						
WR-09-043	S-25-3	238.5	ML					0:47:53						
WR-09-044	D-3-2	59.5	ML								88	7.6	310	8416
WR-09-044	D-5-1	68	ML	31.2	120.6	2.0				39/27/12				
WR-09-044	D-5-2	68.5	ML	29.5	120.0	1.0		0:8:92		35/32/3				
WR-09-044	S-6	73	CL	42.8				0:13:81		44/26/18				
WR-09-044	D-7	78	SM	30.0	123.5	1.0				N.P.				
WR-09-044	S-8	83	ML					0:49:51						
WR-09-044	D-9	88	ML	33.8	117.5			0:41:59						
WR-09-044	S-11	98	SP	15.7				5:91:4						
WR-09-044	S-14	118	SP-SM					21:69:10						
WR-09-044	S-15	128	GW	6.8				65:31:4						
WR-09-044	S-17	148	SW-SM	8.7				39:51:10						
WR-09-044	S-19	168	GW-GM	8.0				57:35:8						
WR-09-044	S-23	208	SP-SM	25.0				9:86:5						

PERCENTAGE PASSING NO. 200 SIEVE

Percent Passing No. 200 Sieve

Boring No.	Sample No.	Depth (ft)	Percent Fines (%)
R-09-001	S-02	10	5.03
R-09-001	S-04	20	3.29
R-09-001	S-08	40	32.62
R-09-001	S-12	60	49.91
R-09-001	S-14	70	73.42
R-09-002	S-02	10	10.37
R-09-002	S-04	20	3.44
R-09-002	S-08	40	46.23
R-09-003	S-01	5	6.21
R-09-003	D-04	20	3.79
R-09-003	S-07	35	53.64
R-09-003	S-15	75	89.44
R-09-005	S-01	5	36.69
R-09-005	S-03	15	3.67
R-09-005	S-07	35	85.35
R-09-005	D-10	50	34.92
R-09-006	S-02	10	4.07
R-09-006	S-04	20	4.20
R-09-006	S-06	30	4.19
R-09-006	S-09	45	39.77
R-09-006	D-11	52.5	72.37
R-09-006	S-14	65	60.50
R-09-008	S-02	10	3.73
R-09-008	S-04	20	3.30
R-09-008	S-06	30	35.54
R-09-009	S-02	10	5.44
R-09-009	S-04	20	3.42
R-09-009	S-06	30	67.93
R-09-009	S-07	35	99.15
R-09-009	D-11	55	63.85
R-09-011	D-02	10	6.60
R-09-011	D-04	20	4.17
R-09-011	U-06	30	23.02
R-09-012	D-04	20	40.74
R-09-012	U-06	30	4.18
R-09-012	S-09	45	36.91
R-09-012	D-12	60	35.36
R-09-013	D-03	15	10.68
R-09-013	D-14	70	12.69
R-09-015	S-01	5	69.40
R-09-015	S-03	15	47.28
R-09-015	D-13	65	16.69
R-09-016	S-01	5	56.60
R-09-016	S-03	15	12.41
R-09-016	S-13	65	32.94
R-09-016	U-14	70	40.05

Percent Passing No. 200 Sieve
(Continued)

Boring No.	Sample No.	Depth (ft)	Percent Fines (%)
R-09-016	S-16	80	9.89
R-09-017	S-01	5	48.08
R-09-017	D-04	20	38.81
R-09-017	S-05	25	29.26
R-09-017	D-08	40	27.72
R-09-017	S-09	45	87.44
R-09-018	S-02	10	4.19
R-09-018	D-09	35	32.96
R-09-018	D-11	45	87.27
R-09-019	D-04	20	61.07
R-09-019	D-06	30	11.62
R-09-019	U-10	50	46.52
R-09-020	D-02	10	26.51
R-09-020	S-07	35	30.79
R-09-020	S-09	45	36.90
R-09-020	S-11-1	55	58.72
R-09-022	S-01	5	30.70
R-09-022	S-05	25	10.12
R-09-023	D-04	20	6.60
R-09-023	S-05	25	24.75
R-09-023	S-10	50	44.56
R-09-023	D-11	55	71.78
R-09-024	D-02	10	60.15
R-09-024	S-03	15	39.61
R-09-024	D-04-2	20.5	85.31
R-09-024	S-11	55	65.03
R-09-024	S-13	65	54.79
R-09-025	D-02	10	63.93
R-09-025	D-04	20	60.99
R-09-025	D-06	30	8.70
R-09-025	D-08	40	99.79
R-09-025	S-11	55	18.54
R-09-025	D-14	70	86.23
R-09-026	D-10	52	29.71
R-09-026	S-13	65	56.84
R-09-028	S-01	5	34.25
R-09-028	D-06	30	3.84
R-09-028	S-11	55	16.48
R-09-028	D-12	60	38.98
R-09-028	S-15	75	19.41
R-09-029	S-03	15	50.05
R-09-029	D-06	30	46.18
R-09-029	S-13	65	36.93
R-09-029	S-15	75	8.01

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO.: 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-004	D-01	5.0	23.2	104.3		30,22,8
R-09-004	D-03	15.0	27.0	97.7		
R-09-004	D-05	25.0			19.1	
R-09-004	S-06	30.0	22.8			
R-09-004	D-07	35.0				27,24,3
R-09-004	S-08	41.0	34.0			25,22,3
R-09-004	S-11	56.0	28.7			27,22,5
R-09-004	S-13	60.0	29.5		35.8	
R-09-004	D-14	65.0	26.4	101.4		
R-09-004	S-15	70.0	30.7			33,21,12
R-09-004	D-16	75.0	27.0	98.6		
R-09-004	S-17	80.0	25.4			
R-09-004	D-18	85.0	27.8	98.4		
R-09-004	S-20	95.0	23.2			
R-09-004	U-21	100.0				58,28,30
R-09-004	S-22	115.0	16.4			
R-09-004	S-23-2	126.2	49.5			50,25,25
R-09-004	S-26	155.0	15.7			
R-09-007	S-01	5.0			36.2	
R-09-007	D-02	10.0	26.7	98.6		
R-09-007	S-03	15.0	29.7			
R-09-007	D-04	20.0			2.1	
R-09-007	S-05	25.0	35.7			
R-09-007	D-07	35.0	34.8	89.7		26,24,2
R-09-007	U-08	40.0				40,24,16
R-09-007	S-09	45.0	36.2			
R-09-007	S-11	55.0	36.0			38,26,12
R-09-007	D-12	60.0	34.0	90.7		29,25,4
R-09-007	S-13	65.0	39.1			31,24,7
R-09-007	S-15	75.0			40.9	
R-09-007	D-17	85.0	16.3	115.5		
R-09-007	S-21	125.0	22.3			
R-09-007	S-23	150.0	11.5			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-010	S-01	5.0	25.9			
R-09-010	D-02	10.0	26.7	107.3		
R-09-010	D-04	20.0			3.3	
R-09-010	U-06	30.0				29,23,6
R-09-010	S-07	35.0			14.1	
R-09-010	D-8-1	40.0			66.9	
R-09-010	D-8-2	40.5	39.5	82.7		40,23,17
R-09-010	D-10	50.0				51,27,24
R-09-010	D-12	60.0	30.4	93.2		33,26,7
R-09-010	S-13-1	65.0	21.9			
R-09-010	S13-2	65.7	34.1			35,20,15
R-09-010	D-14	70.0	32.4	90.4		31,22,9
R-09-010	S-15	75.0	34.0		79.3	26,23,3
R-09-010	D-16	80.0	30.1	93.8		
R-09-010	S-18	90.0	25.8		8.9	
R-09-010	S-20	110.0	18.7			
R-09-010	S-23	140.0	12.4			
R-09-014	S-01	5.0			39.6	
R-09-014	S-03	15.0	30.0		5.6	
R-09-014	D-04	20.0	38.0	86.9		34,24,10
R-09-014	S-05	25.0	30.6		35.5	
R-09-014	D-06	30.0			28.3	
R-09-014	S-07	35.0	53.2			49,24,25
R-09-014	D-08	40.0	33.4	90.6		26,24,2
R-09-014	S-10	46.0	48.2			45,22,23
R-09-014	U-11	50.0	46.5	75.1		49,24,25
R-09-014	U-13	60.0				43,24,19
R-09-014	S-14	65.0	36.7			28,25,3
R-09-014	D-15	70.0	20.1	109.1		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO.: 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-014	S-16	75.0			21.9	
R-09-014	D-17	80.0	25.6	103.1		
R-09-014	S-19	100.0	19.2			
R-09-014	S-22	135.0	16.0			
R-09-014	S-24	165.0	25.3			
R-09-021	S-01	5.0			27.0	
R-09-021	D-02	10.0	32.9	89.4		
R-09-021	S-03	15.0	32.8			
R-09-021	U-04	20.0				61,29,32
R-09-021	S-05	25.0	33.0		12.4	
R-09-021	S-07	35.0	32.9		41.6	
R-09-021	S-09	41.5	34.0			23,22,1
R-09-021	U-10	45.0				56,26,30
R-09-021	S-11	50.0	39.2		52.4	
R-09-021	D-12	55.0	33.2	91.5		36,22,14
R-09-021	D-14	65.0	29.7	96.0		30,21,9
R-09-021	S-15	70.0			35.0	
R-09-021	D-17	75.0	31.7	92.5		35,23,12
R-09-021	S-18	80.0	26.8			
R-09-021	D-19	85.0	22.6	105.2		
R-09-021	S-20	100.0	23.5			
R-09-021	S-21	115.0	21.1			
R-09-021	S-24	170.0	8.9			
~~R-09-030~~	~~S-01~~	~~5.0~~	~~21.6~~			
R-09-030	D-02	10.0	11.2	120.0		
R-09-030	S-03	15.0	42.9		72.3	
R-09-030	U-05	25.0				43,25,18
R-09-030	S-07	35.0	30.5		34.3	
R-09-030	U-09	45.0				45,25,20
R-09-030	D-11-1	55.0	35.3	82.9		35,20,15
R-09-030	S-12	60.0			46.2	
~~R-09-030~~	~~S-14~~	~~70.0~~	~~27.4~~			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008A

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-027	U-01	11.0				44,23,21
R-09-027	D-02-2	15.5	56.9	70.2	45.1	
R-09-027	S-03	20.0			20.9	
R-09-027	D-06	32.0	21.6	107.2		
R-09-027	S-07	35.0			10.2	
R-09-027	D-08-1	40.0	35.2	82.0		41,24,17
R-09-027	U-09	45.0				54,24,30
R-09-027	S-10	50.0	27.7			25,23,2
R-09-027	D-11	55.0	26.4	101.0		
R-09-027	S-12	60.0			27.1	
R-09-027	S-14	70.0	18.8			
R-09-027	S-16-1	80.0	32.3			32,23,9
R-09-027	S-17	90.0	21.7			
R-09-027	S-20	120.0	17.9			
R-09-027	S-23	150.0	11.7			
~~R-09-033~~	~~S-01~~	~~5.0~~	~~12.7~~			
R-09-033	D-02	10.0	12.7	104.6	21.4	
R-09-033	U-04	20.0				61,26,35
R-09-033	D-05	25.0			10.9	
R-09-033	S-08-1	40.0	47.8			41,23,18
R-09-033	U-09	45.0				25,24,1
R-09-033	D-10-1	50.0			55.5	
R-09-033	S-11-1	55.0	31.9			29,21,8
R-09-033	S-11-2	55.8	30.5			24,23,1
R-09-033	D-12-1	60.0	25.5	100.4		
R-09-033	S-13-1	65.0	38.6			38,24,14
R-09-033	S-16	80.0	20.7			
R-09-033	S-17-2	90.6	35.5			33,22,11
~~R-09-033~~	~~S-19~~	~~100.0~~	~~14.2~~			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-041	S-4-2	57.6	CL	39.9				0:15:85		43/24/19				
WR-09-041	S-6-1	67	CL	37.8				0:2:98		46/27/19				
WR-09-041	S-6-2	67.4	ML								98	8.2	360	7929
WR-09-041	D-7	72	ML	18.7	135.0			0:43:57						
WR-09-041	S-8	77	ML					0:48:52						
WR-09-041	D-9	82	SP-SM	24.0	125.9									
WR-09-041	S-10	87	SP-SM					0:90:10						
WR-09-041	D-11	92	SP-SM	21.0	128.0									
WR-09-041	S-13	107	SP-SM	15.9				2:87:11						
WR-09-041	S-16	127	SM	10.8				30:57:13						
WR-09-041	S-19	157	SP-SM	11.4				39:50:11						
WR-09-041	S-21	177	ML	26.3				0:12:88						
WR-09-041	S-22-1	187	CL	36.5										
WR-09-041	S-24	202	SW-SM	20.6				1:89:10						
WR-09-041	S-26-1	222	SP-SM					0:88:12						
WR-09-041	S-26-2	223	ML	27.5						36/27/9				
WR-09-041	S-27	227	SP	22.3				0:98:2						
WR-09-042	S-3-1	68	CL	32.7						44/24/20				
WR-09-042	S-3-2	68.3	CL-ML					0:32:68						
WR-09-042	S-3-3	68.5	ML	29.8						34/25/9				
WR-09-042	S-5	78	ML					0:49:51						
WR-09-042	D-6	83	SM	26.8	125.8					N.P.	130	7.6	300	6417
WR-09-042	S-7	88	SM					0:62:38						
WR-09-042	D-8	93	SM	25.5	126.0									
WR-09-042	S-9	98	SP-SM					0:93:7						
WR-09-042	D-10	103	SM	27.0	125.1									
WR-09-042	S-12	113	SP	19.6				1:97:2						
WR-09-042	S-14	123	SP-SM	11.1				36:58:6						
WR-09-042	S-16	133	SM	16.8				19:63:18						
WR-09-042	D-19	163	GP	5.2				51:46:3						
WR-09-042	S-22	193	SM	23.1				0:78:22						
WR-09-042	S-24	213	SP-SM					0:93:7						
WR-09-042	S-25-2	223.5	CL	16.9				2:37:61		28/14/14				
WR-09-042	S-26-1	233	CL	28.4				0:26:74		39/17/22				
WR-09-043	D-5-1	68	ML								87	7.5	390	9074
WR-09-043	D-5-2	68.5	CL	33.8	114.3	0.5		0:3:97		46/25/21				
WR-09-043	S-6	73	ML	32.2						44/33/11				
WR-09-043	S-8-2	83.5	ML	29.6				0:34:66						
WR-09-043	D-9-1	88	MH	37.4	113.6	0.25		0:5:95		50/37/13				
WR-09-043	S-10	93	SM					0:75:25						

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

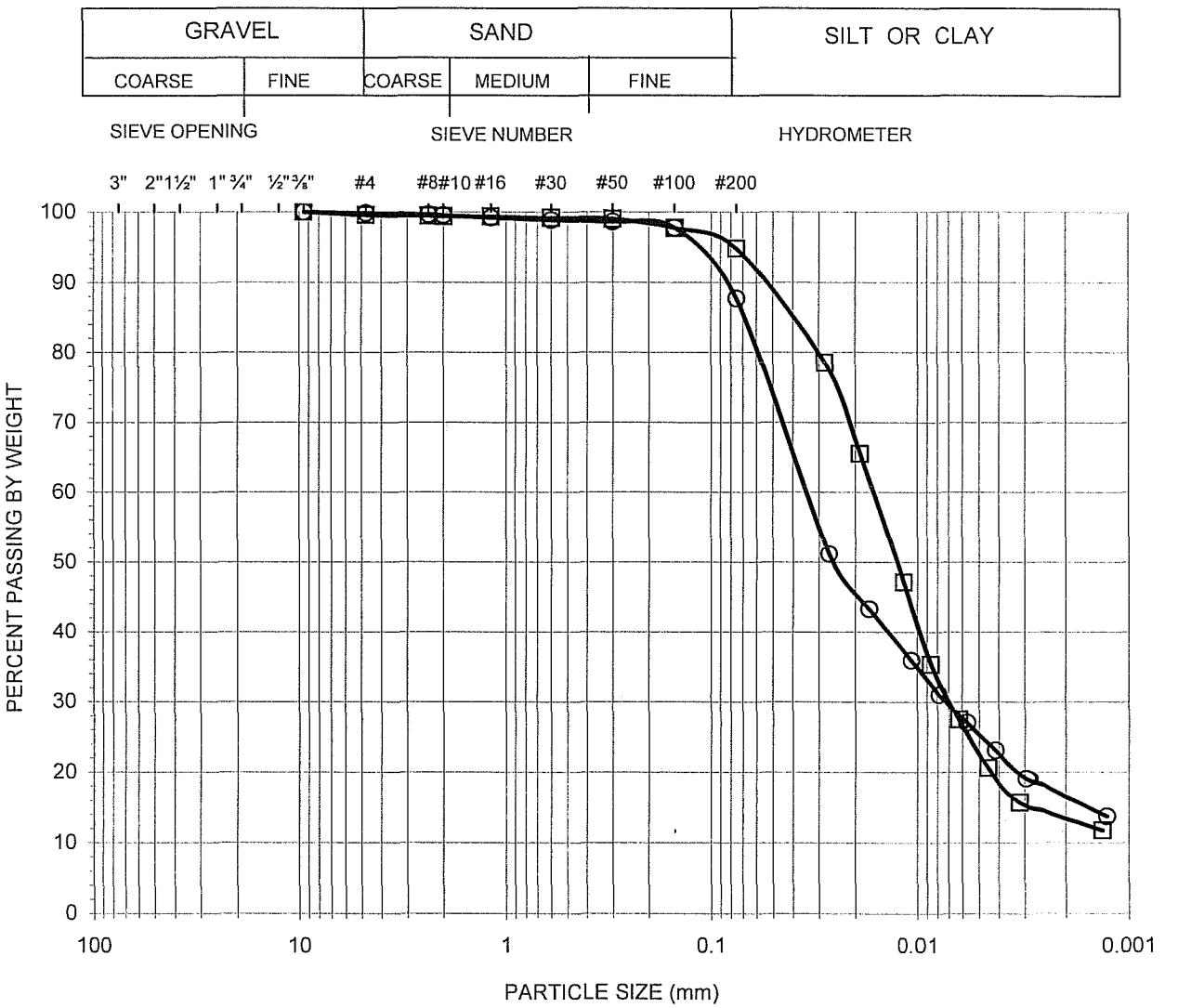
Boring No .	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-043	D-11	98	SP	20.4	127.1									
WR-09-043	D-13	108	SP-SM	14.4	134.2			5:90:5						
WR-09-043	S-16	133	SW-SM	14.1				1:90:9						
WR-09-043	S-18	153	SP-SM	9.3				31:57:12						
WR-09-043	S-19	168	ML	31.5				0:8:92		35/26/9				
WR-09-043	S-22	198	SM	20.6				0:85:15						
WR-09-043	S-24	223	SP-SM					2:89:9						
WR-09-043	S-25-1	238	CL	45.4						49/27/22				
WR-09-043	S-25-2	238.3	SM					26:53:21						
WR-09-043	S-25-3	238.5	ML					0:47:53						
WR-09-044	D-3-2	59.5	ML								88	7.6	310	8416
WR-09-044	D-5-1	68	ML	31.2	120.6	2.0				39/27/12				
WR-09-044	D-5-2	68.5	ML	29.5	120.0	1.0		0:8:92		35/32/3				
WR-09-044	S-6	73	CL	42.8				0:13:81		44/26/18				
WR-09-044	D-7	78	SM	30.0	128.5	1.0				N.P.				
WR-09-044	S-8	83	ML					0:49:51						
WR-09-044	D-9	88	ML	33.8	117.5			0:41:59						
WR-09-044	S-11	98	SP	15.7				5:91:4						
WR-09-044	S-14	118	SP-SM					21:69:10						
WR-09-044	S-15	128	GW	6.8				65:31:4						
WR-09-044	S-17	148	SW-SM	8.7				39:51:10						
WR-09-044	S-19	168	GW-GM	8.0				57:35:8						
WR-09-044	S-23	208	SP-SM	25.0				9:86:5						

GRAIN SIZE ANALYSES

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/12/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

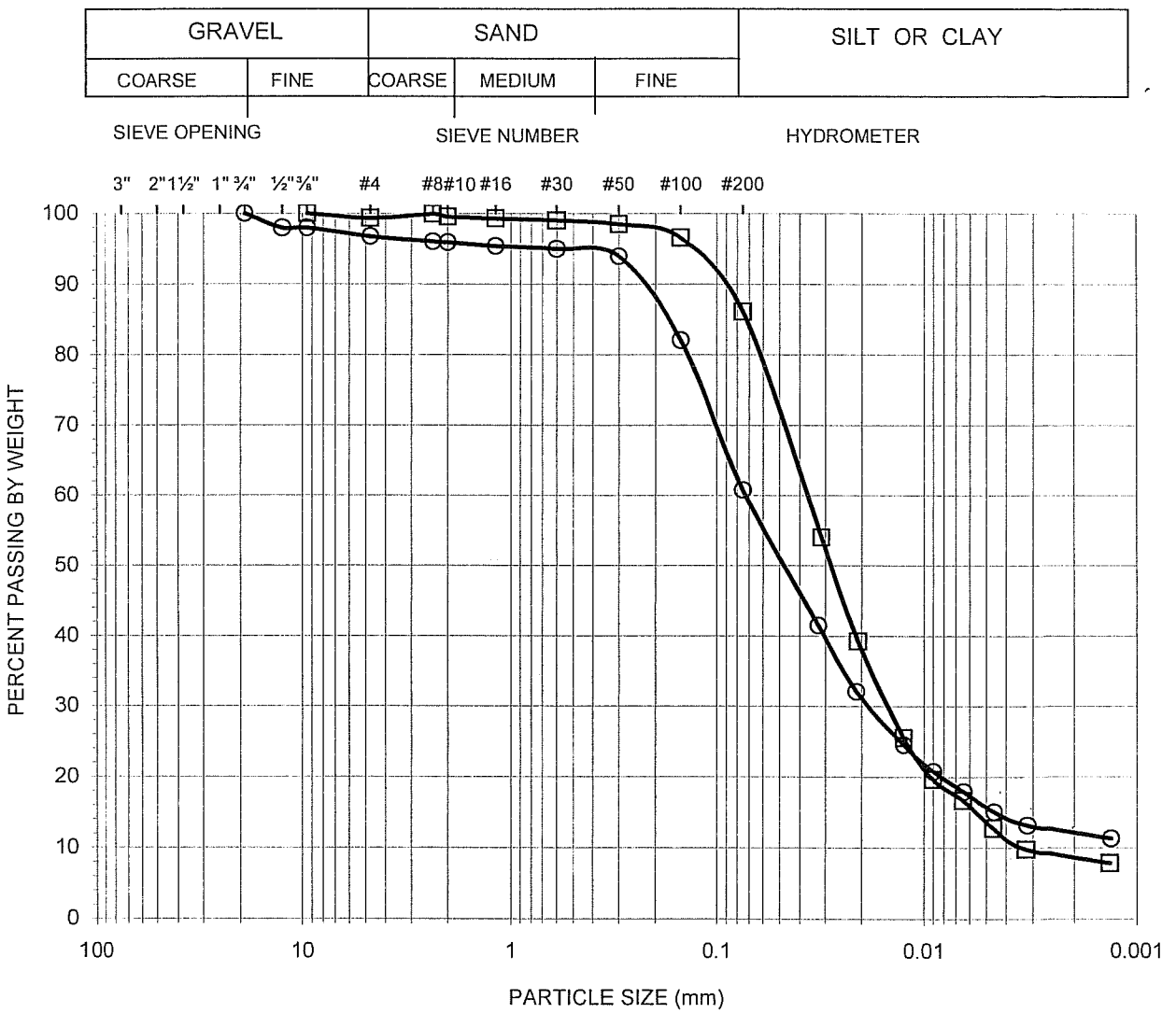


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-001	D-11	55	0.18	12.08	87.74	46:27:19	CL
□	R-09-001	S-15	75	0.46	4.73	94.81	N/A	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

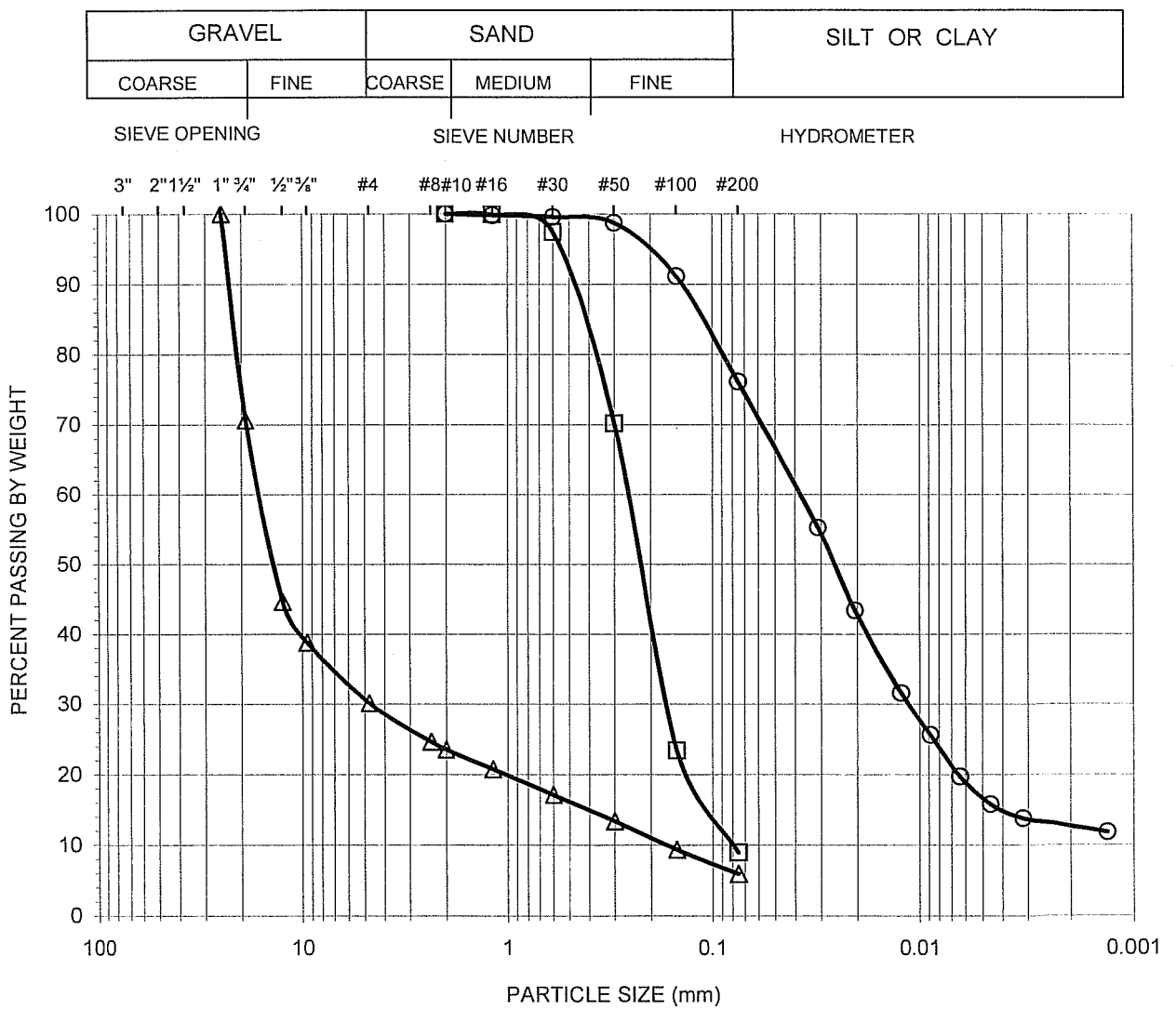


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-002	S-10	50	3.23	36.02	60.75	29:23:6	ML
□	R-09-002	S-15	75	0.68	13.21	86.11	N/A	ML

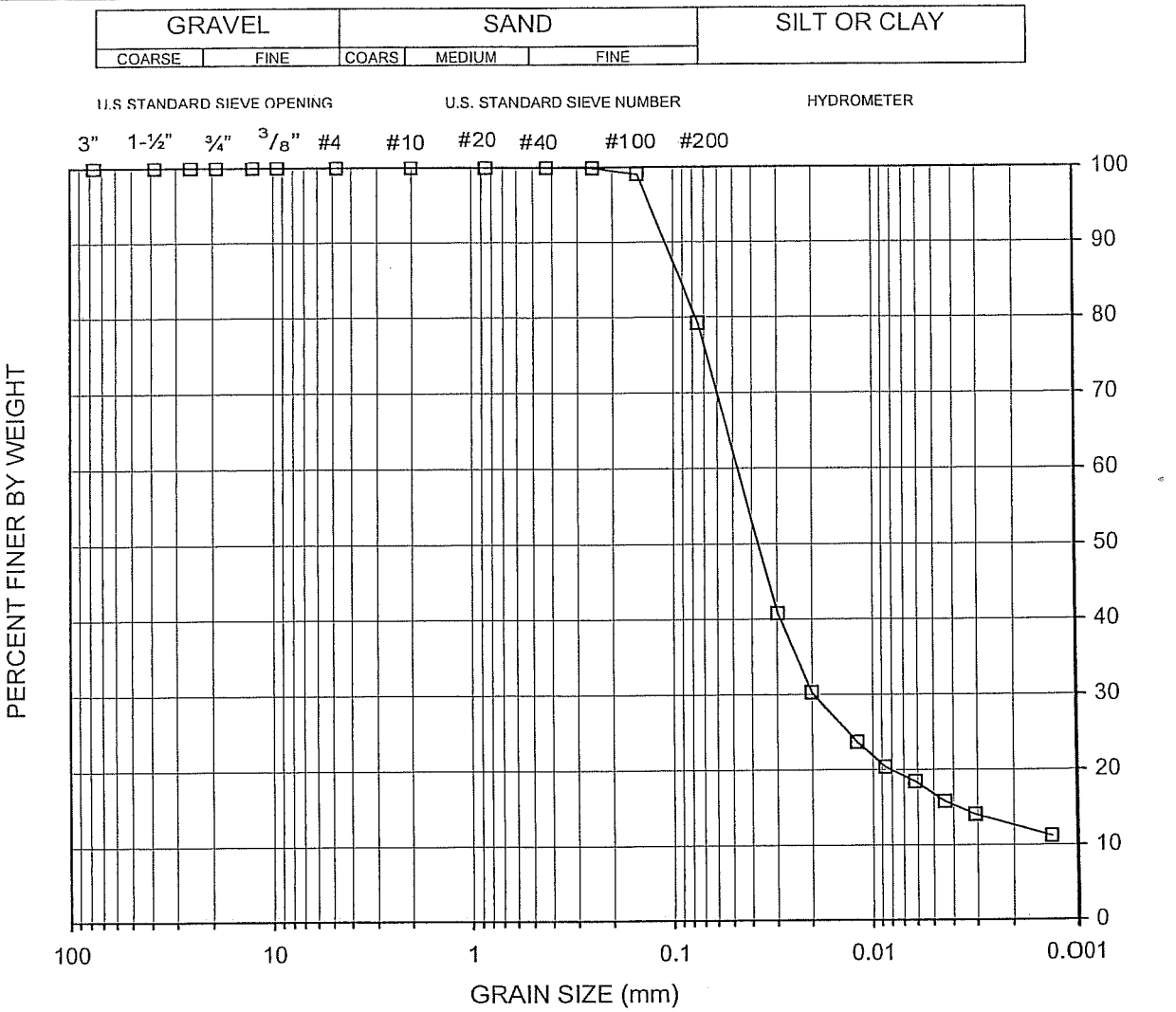
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-003	U-11	55	0.00	23.87	76.13	28:23:5	ML
□	R-09-003	S-18	90	0.00	91.05	8.95	N/A	SP-SM
△	R-09-003	S-22+S-23	135	69.86	24.21	5.93	N/A	GP-GM



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-004	D-07	35	RING	ML	27	3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.

Job No: 06-123-03

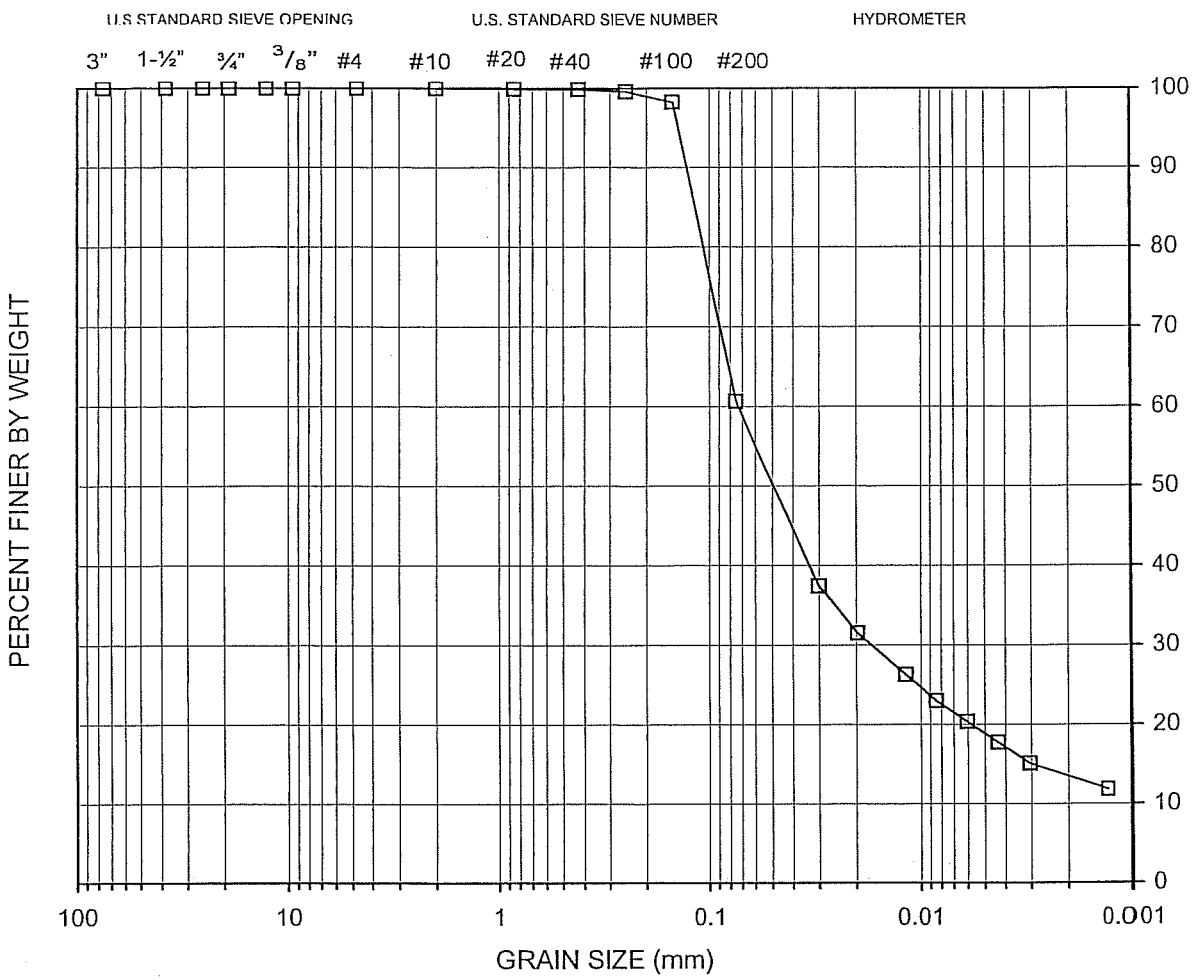
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09

(ASTM D422)

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-004	S-08	41	BAG	ML	25	3

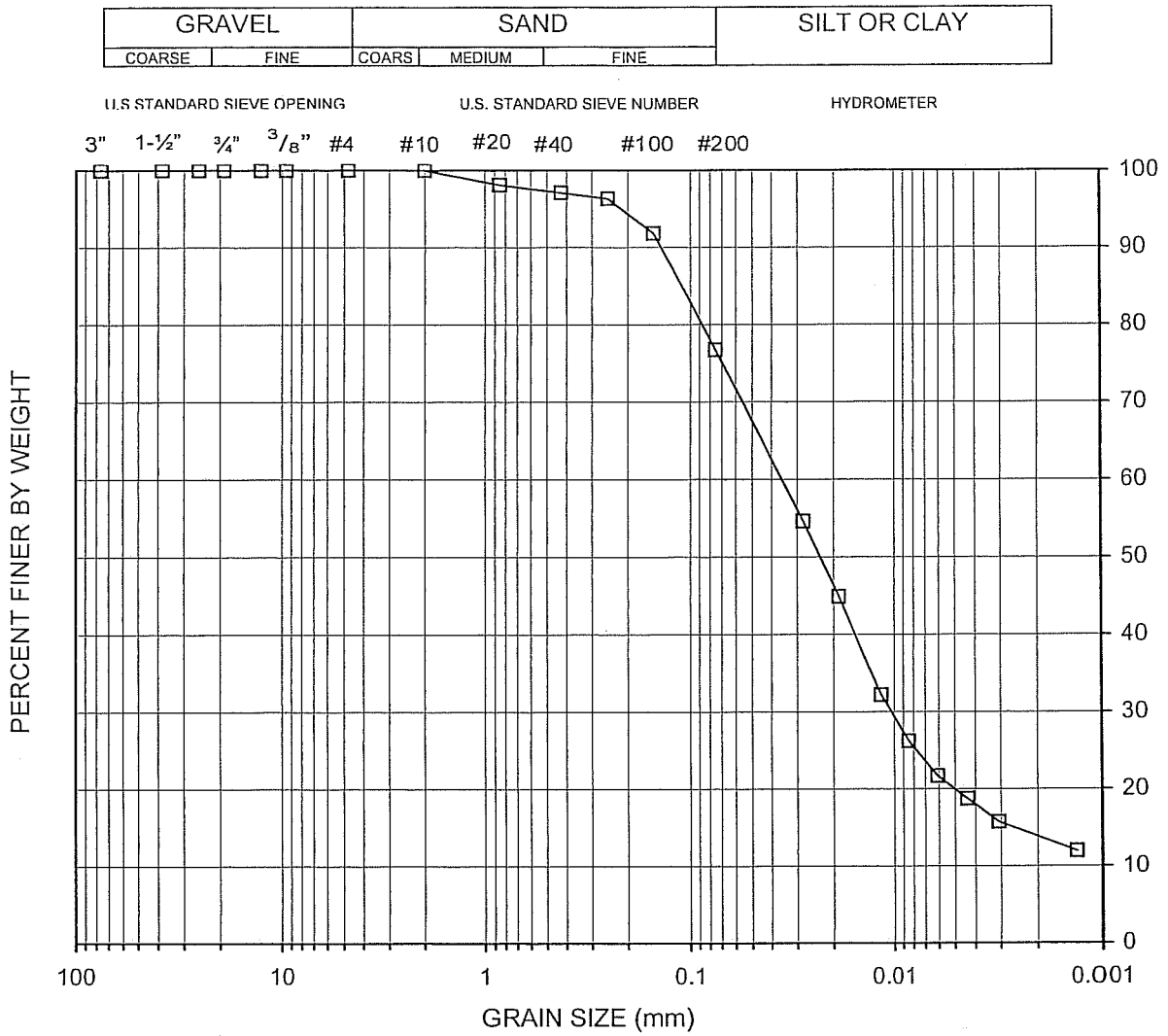
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-004	S-11	56	BAG	ML	27	5

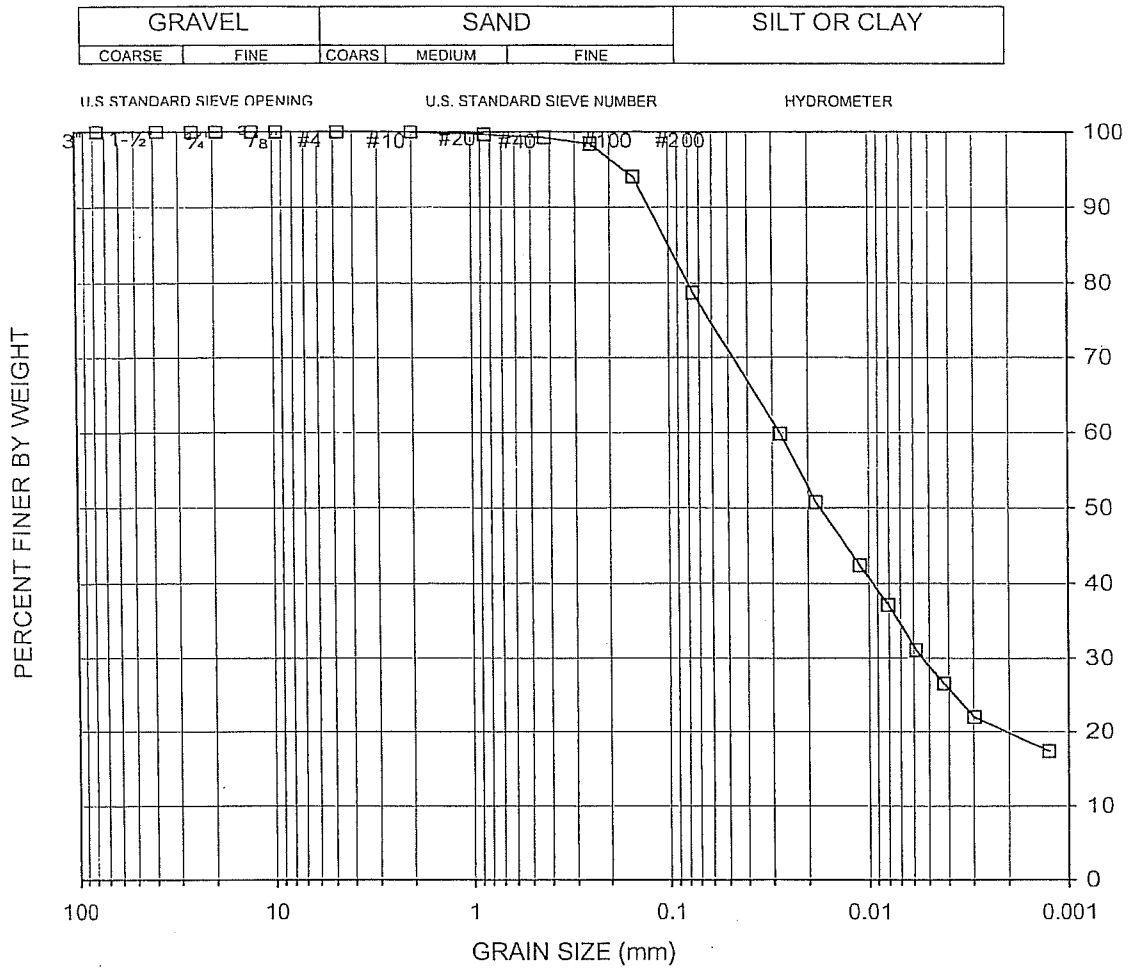
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-004	S-15	70	BAG	CL	33	12

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.

Job No: 06-123-03

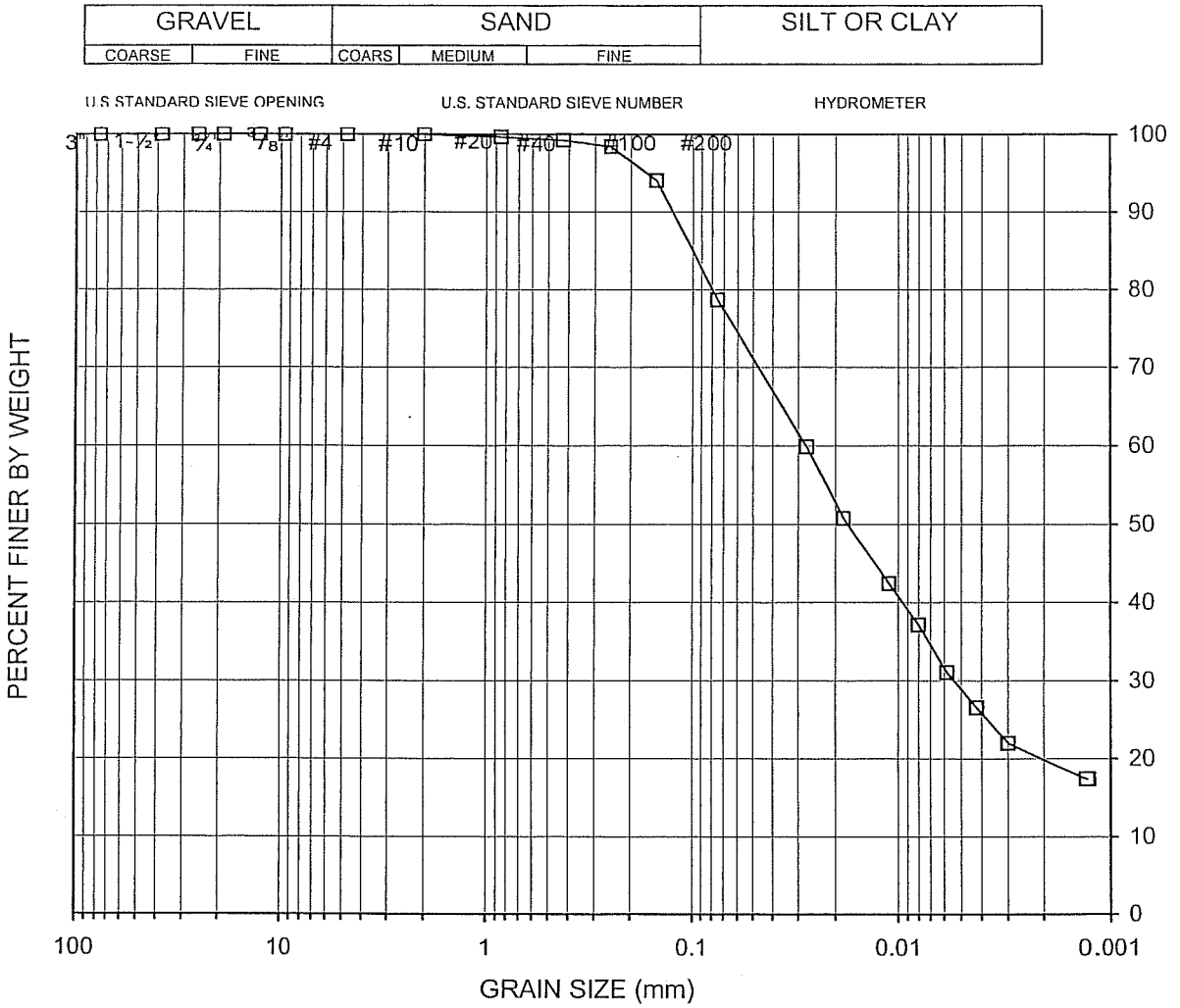
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

(ASTM D422)

01/04/10

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-004	S-17	70	BAG	CL	33	12

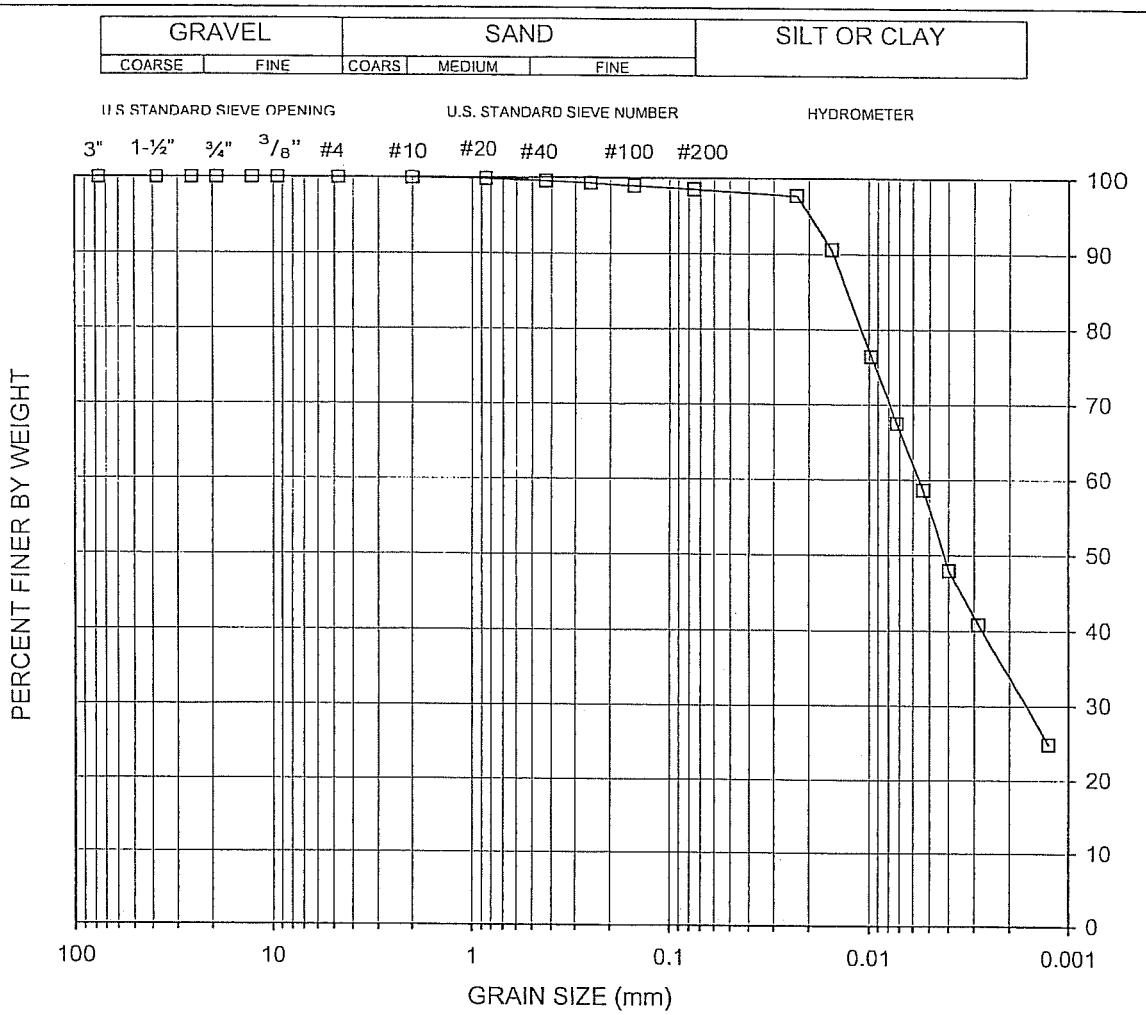
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-004	U-21	100	Shelby Tube	CH	58	30

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

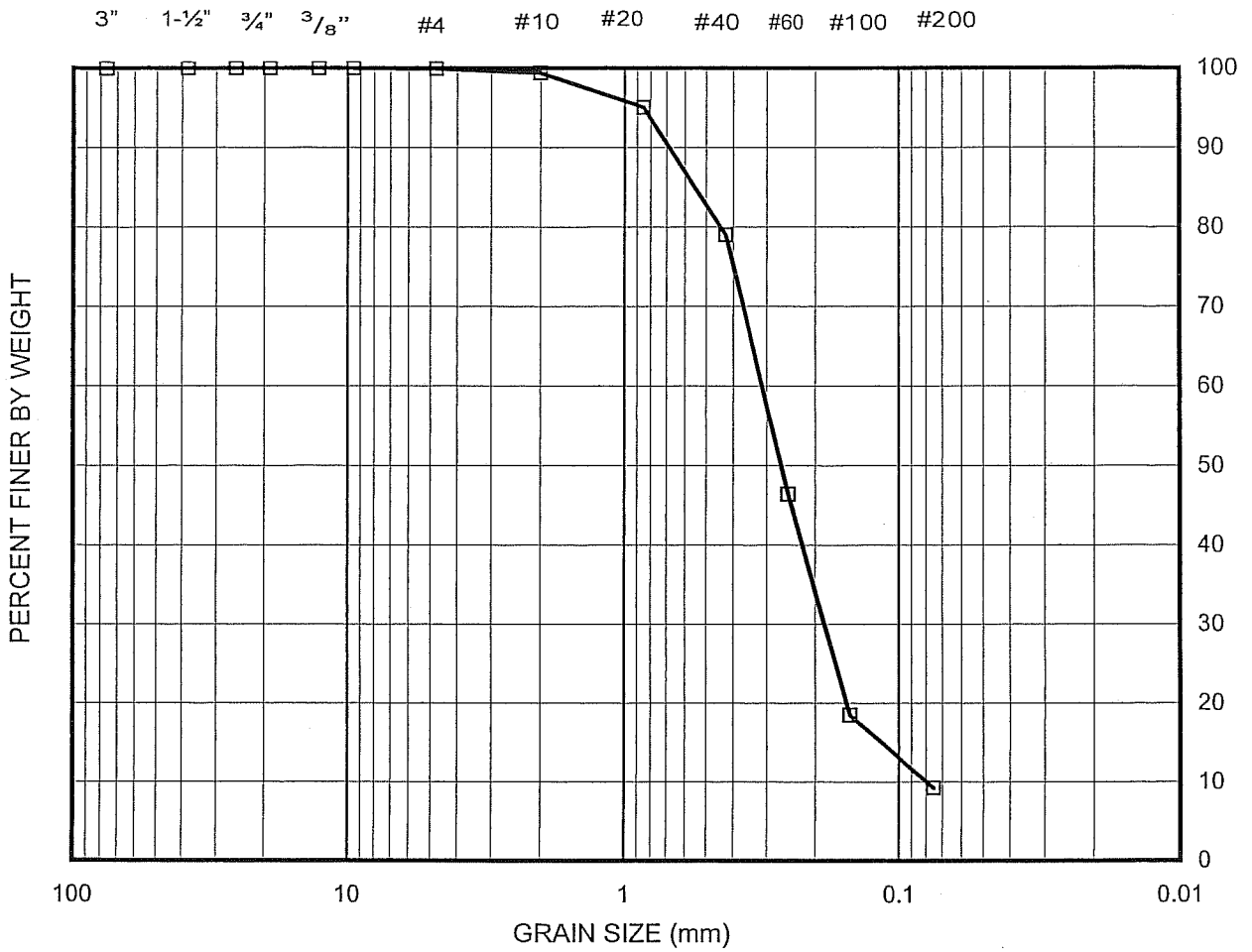
Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

01/04/10 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-004	S-21	105	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

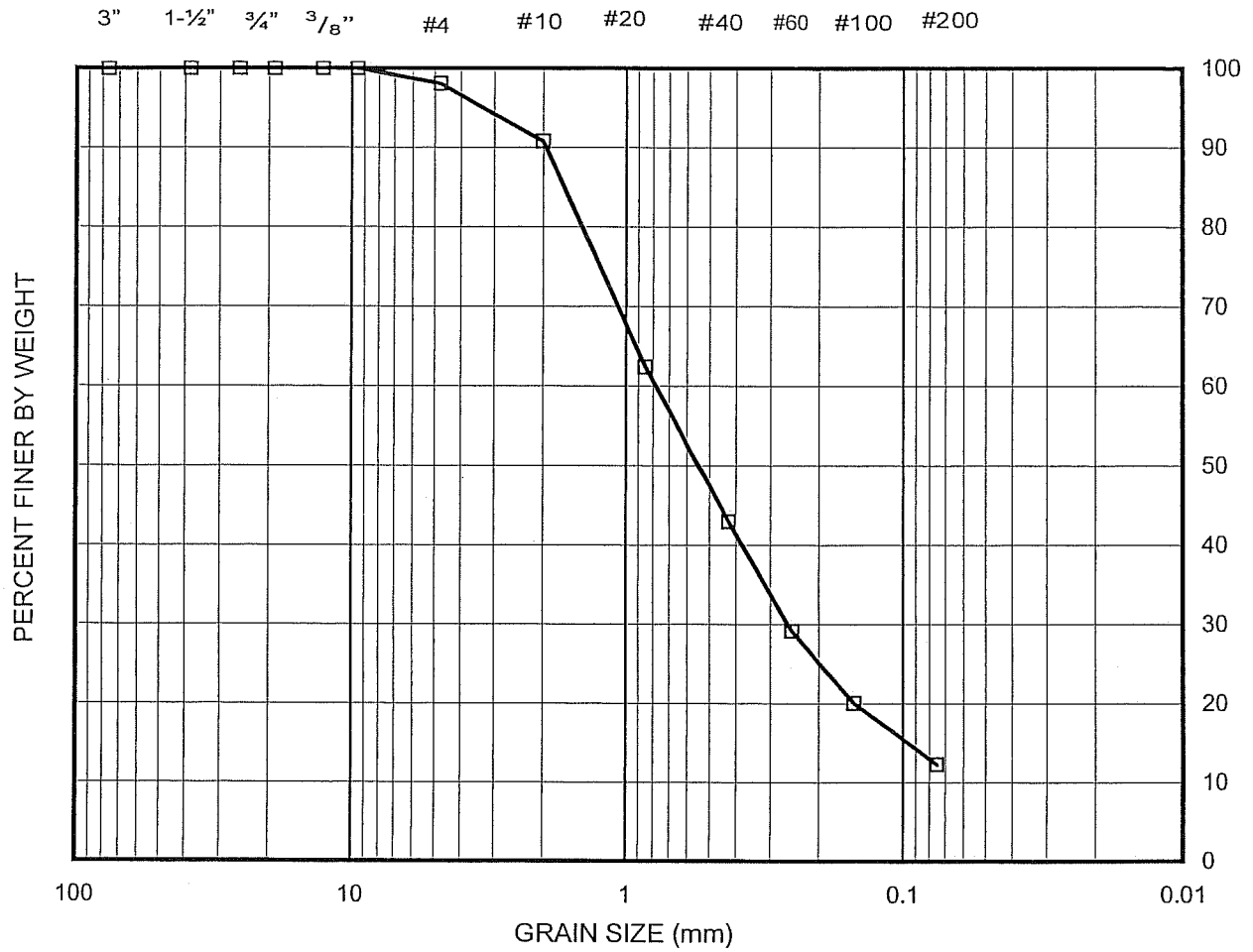
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-004	S-24	135	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

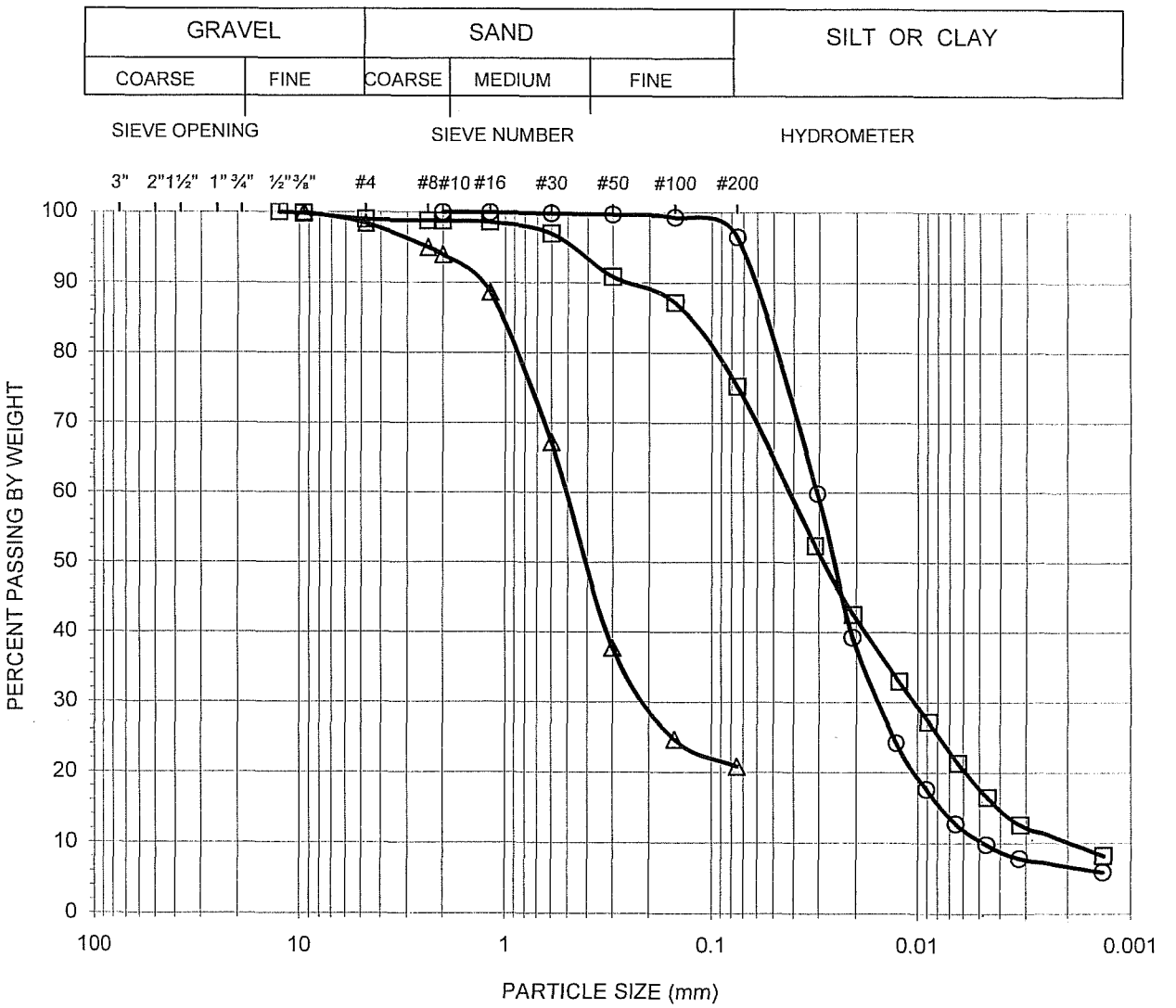
GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/03/09

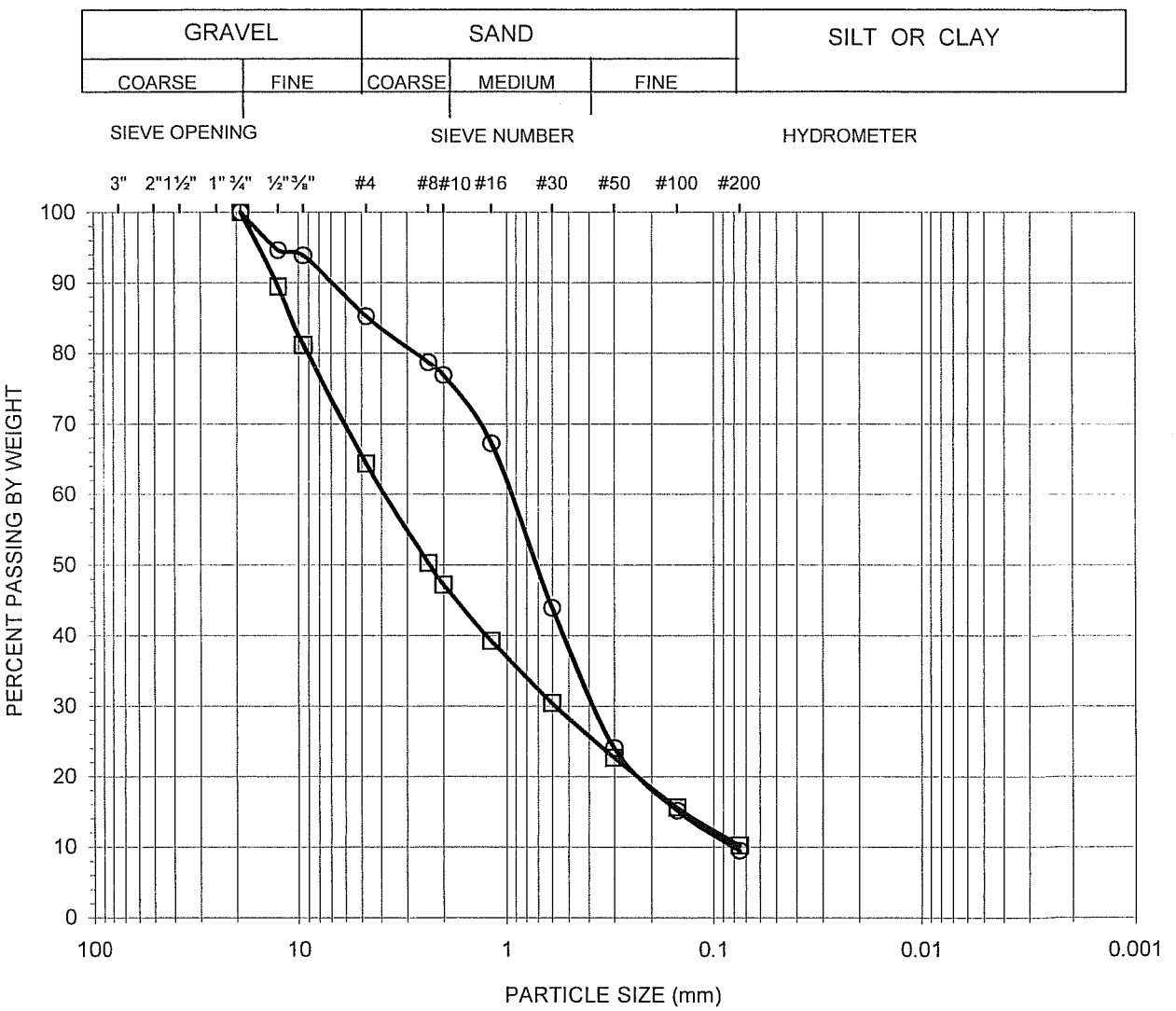


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-005	D-12	60	0.00	3.51	96.49	N/A	ML
□	R-09-005	U-14	70	1.03	23.78	75.19	N/P	ML
△	R-09-005	S-17	90	1.61	77.57	20.82	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/03/09

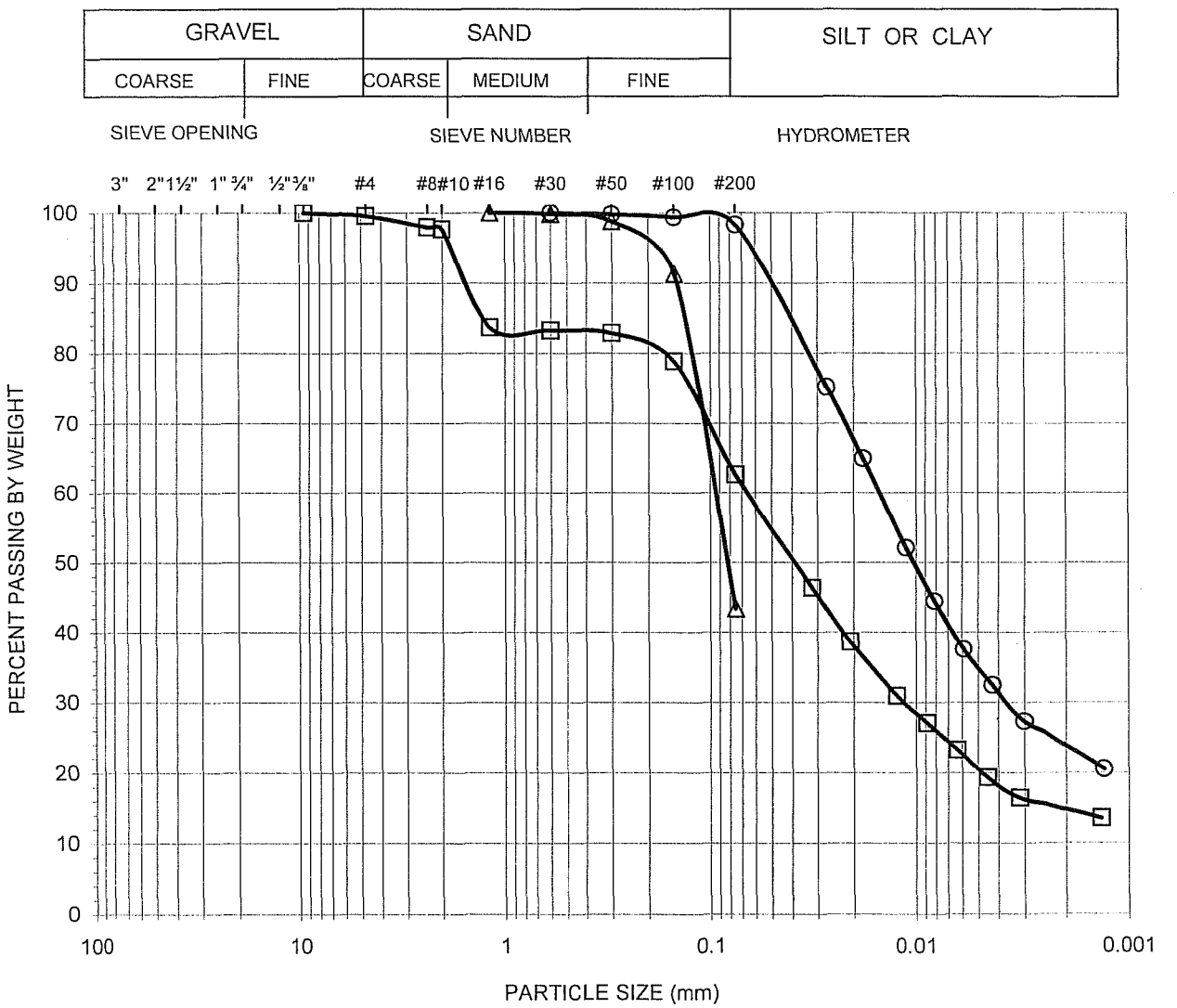


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-005	S-21	130	14.77	75.77	9.46	N/A	SW-SM
□	R-09-005	S-23	160	35.66	54.17	10.17	N/A	SW-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/11/09

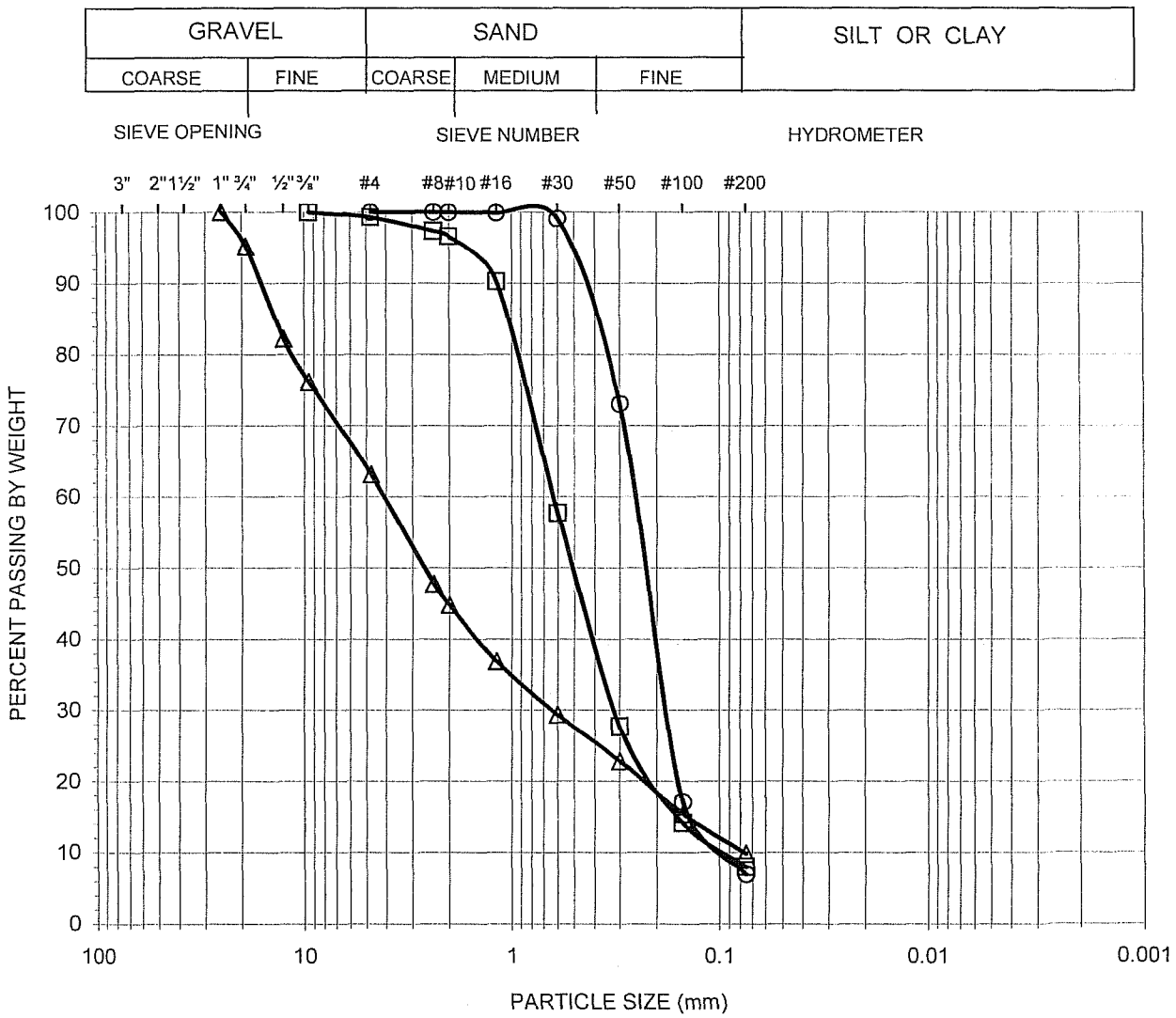


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-006	U-07	35	0.00	1.71	98.29	46:28:18	ML
□	R-09-006	D-13	60	0.48	36.95	62.57	25:21:4	CL-ML
△	R-09-006	S-16	75	0.00	56.64	43.36	N/A	SM

AP Engineering & Testing, Inc.

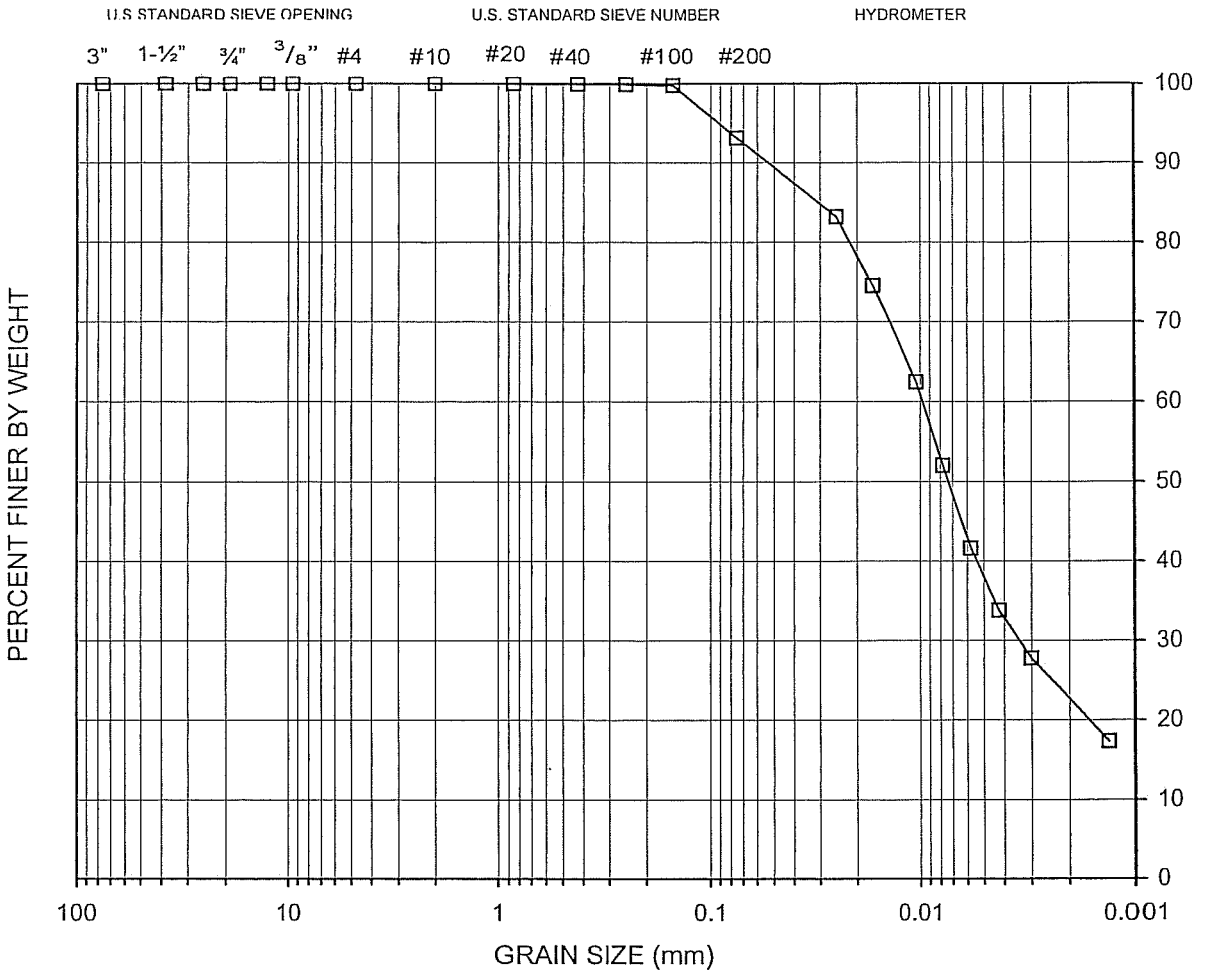
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/11/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-006	S-20	100	0.00	93.04	6.96	N/A	SP-SM
□	R-09-006	S-23	130	0.70	91.30	7.99	N/A	SW-SM
△	R-09-006	S-25	160	36.82	53.38	9.80	N/A	SW-SM

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-007	U-08	40	Shelby Tube	CL	40	16

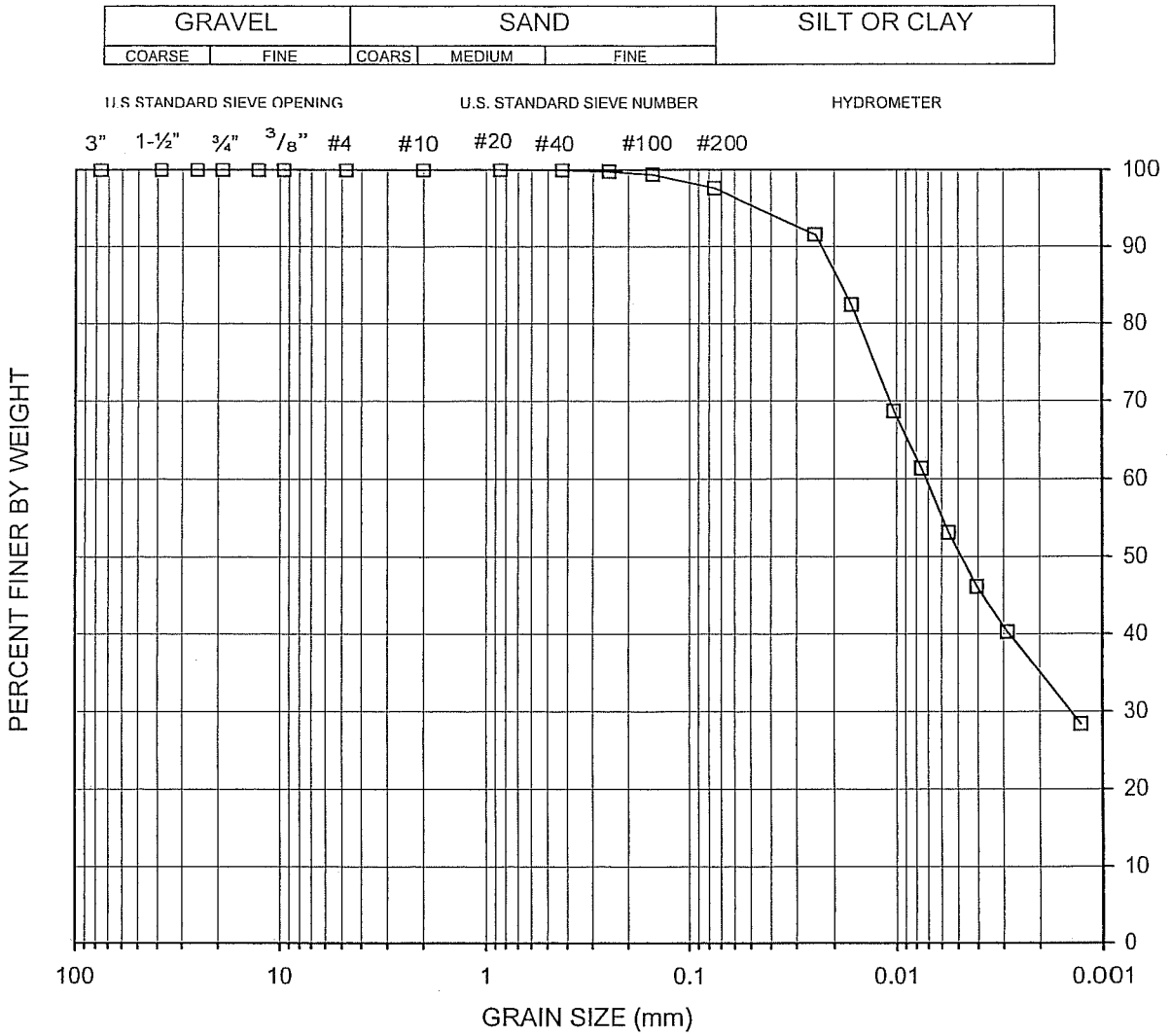
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-007	U-10	50	Shelby Tube	CL	N/A	N/A

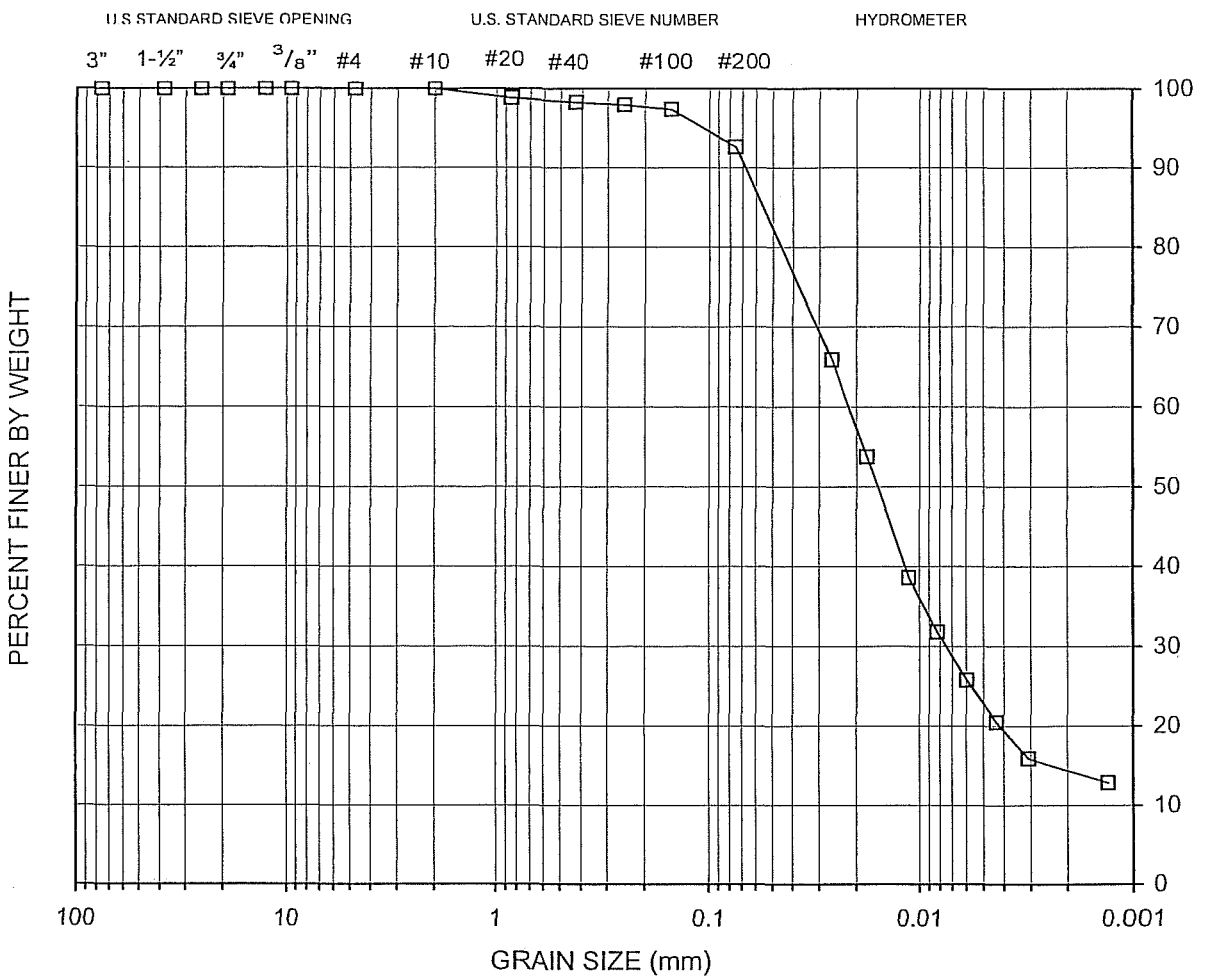
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-007	S-13	65	BAG	ML	31	7

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

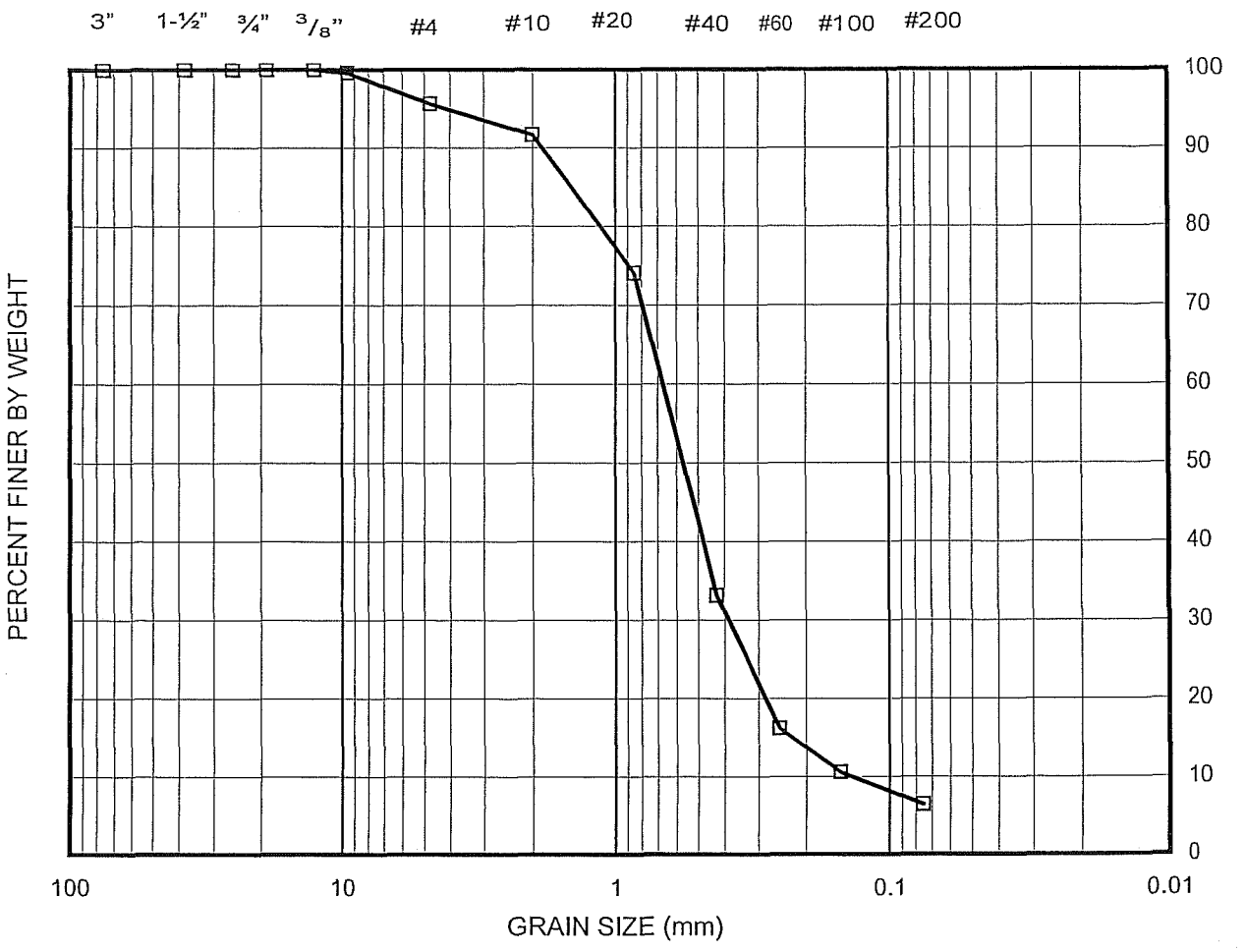
Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-007	S-18	95	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

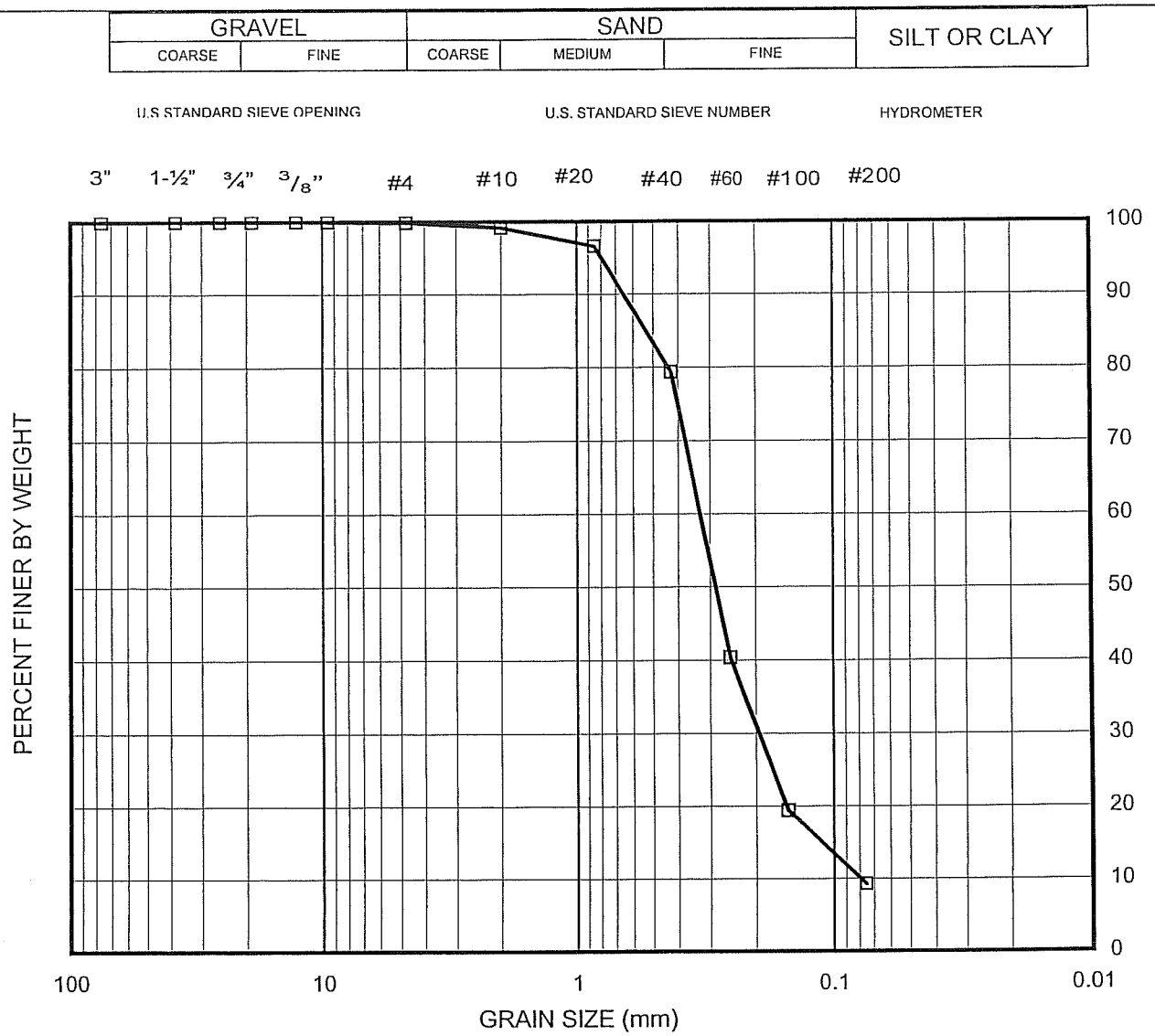
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-007	S-21	125	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

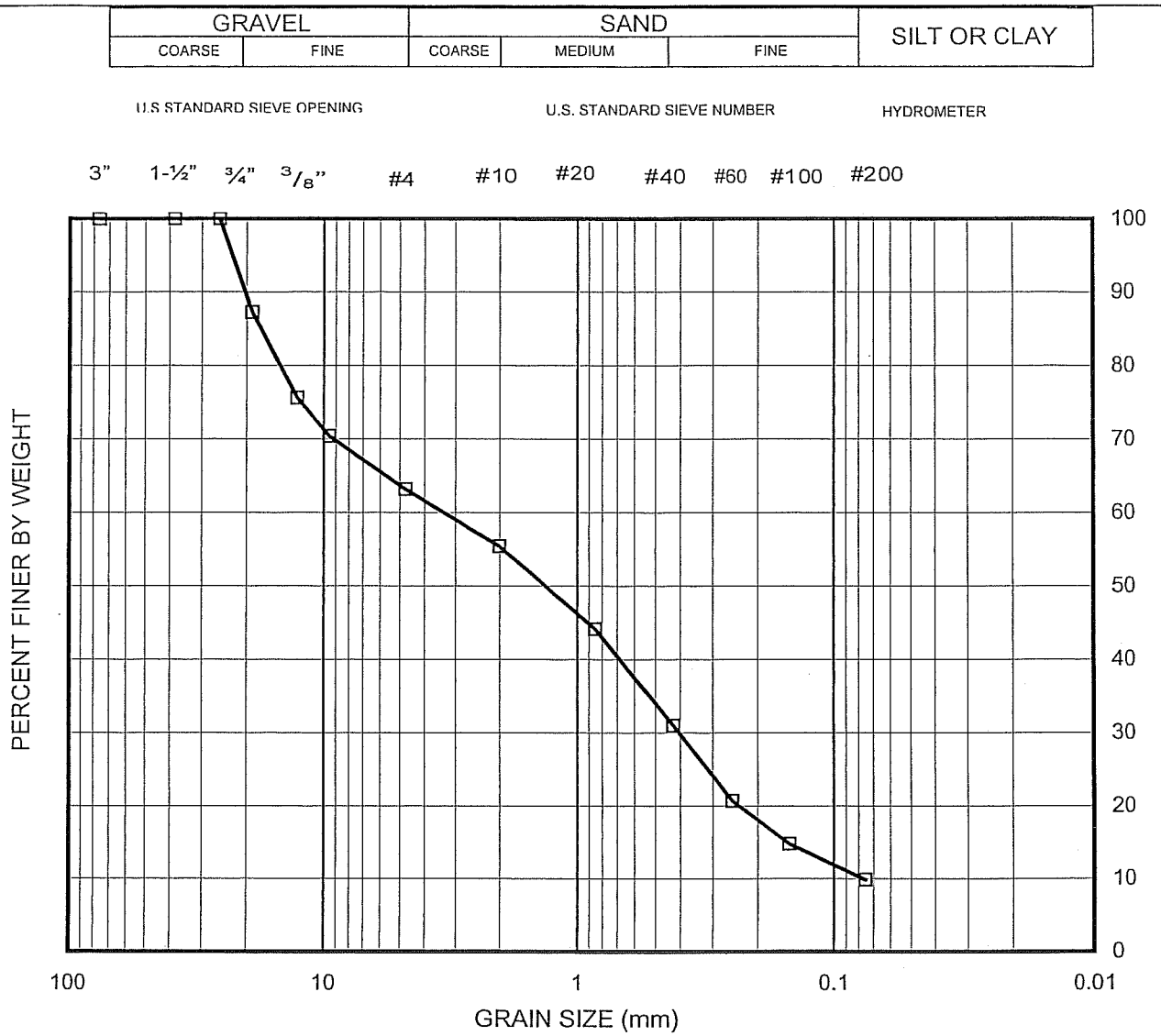
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-007	S-23	150	Bag	SW-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

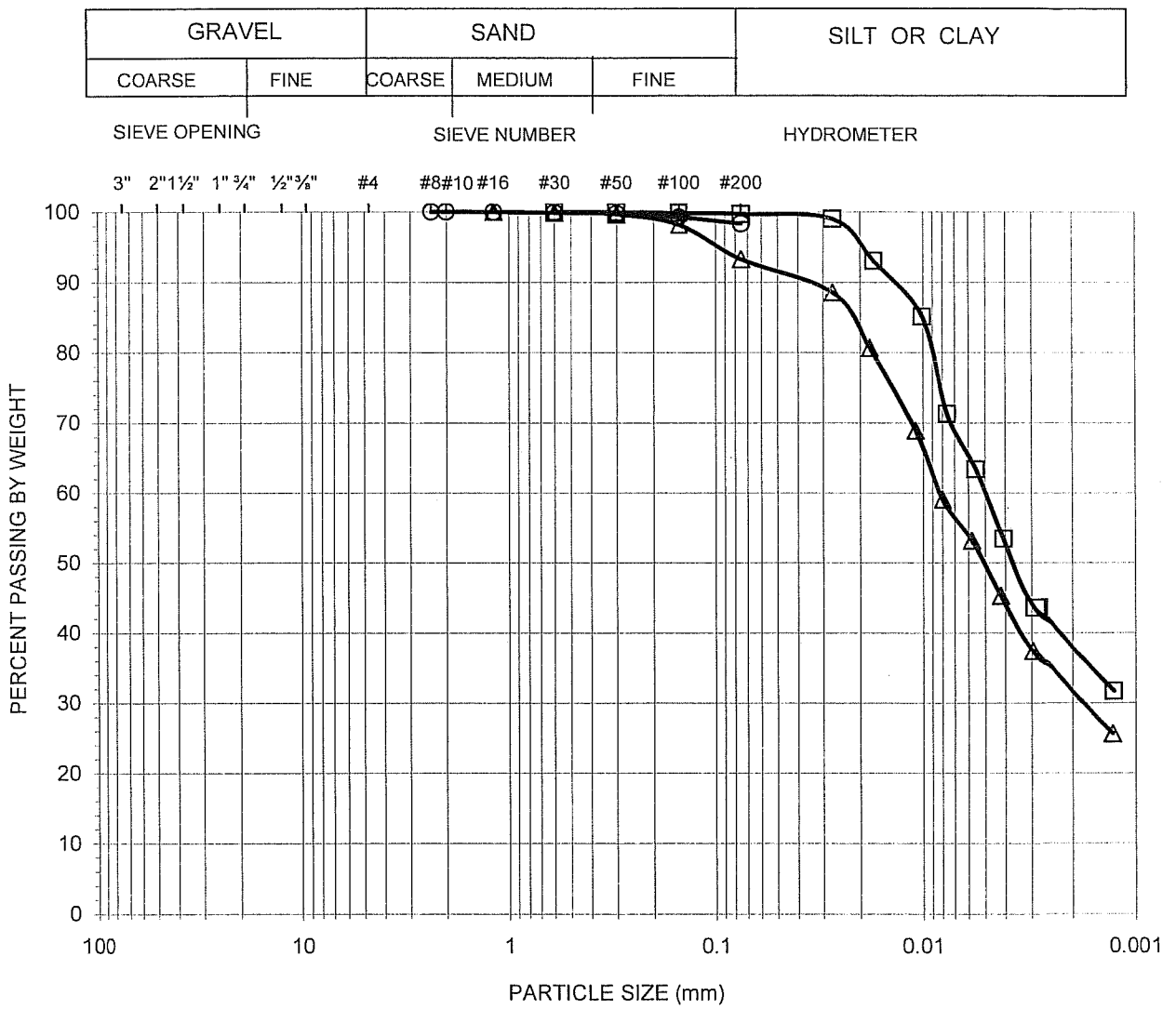
GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/11/09

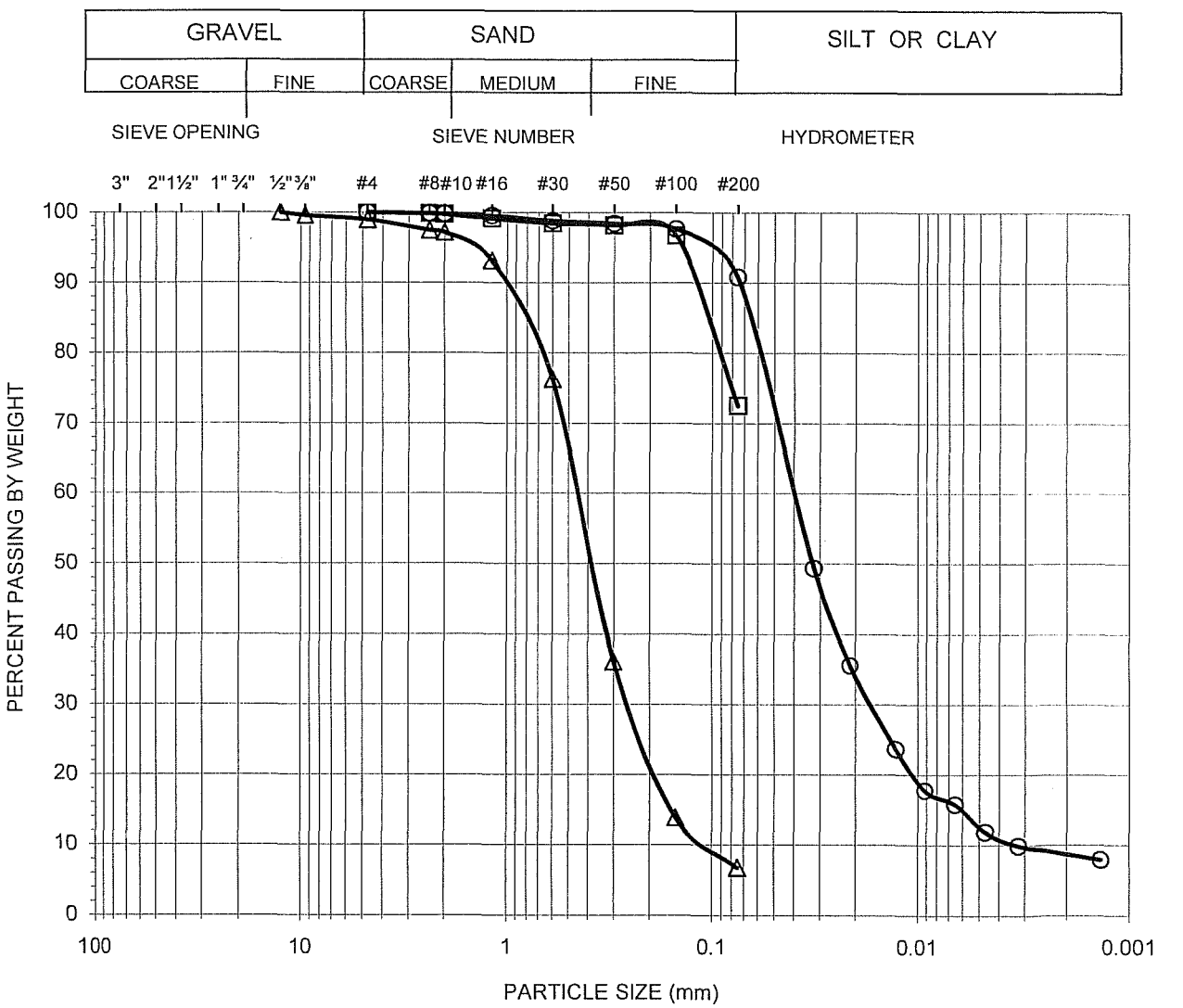


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-008	D-07	35	0.00	1.69	98.31	N/A	ML
□	R-09-008	D-09	45	0.00	0.32	99.68	57:33:24	MH
△	R-09-008	S-10	50	0.00	6.72	93.28	47:23:24	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/11/09

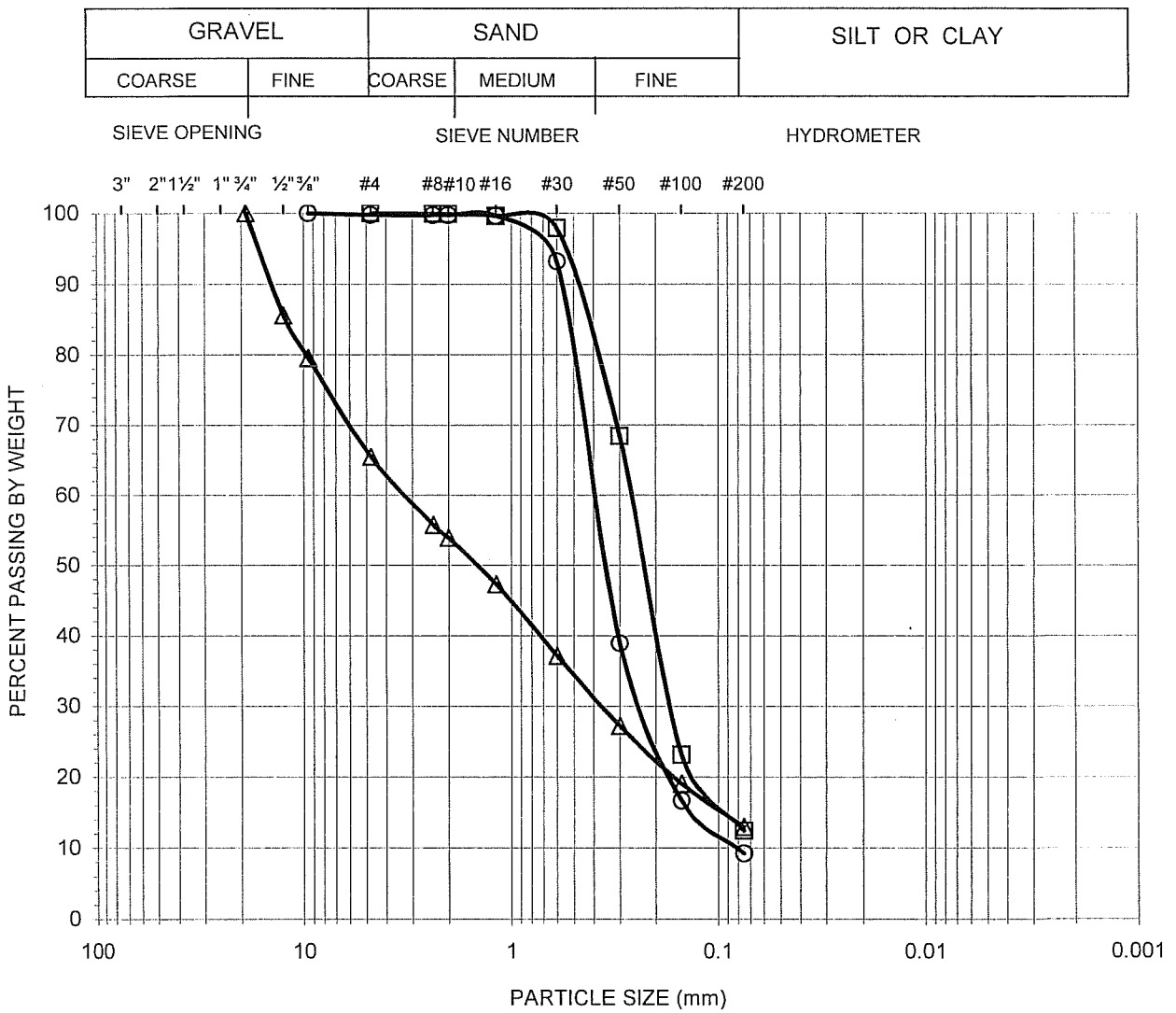


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-008	D-11	55	0.00	9.20	90.80	N/P	ML
□	R-09-008	D-13	65	0.00	27.50	72.50	N/A	ML
△	R-09-008	U-15	75	1.02	92.25	6.74	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/11/09

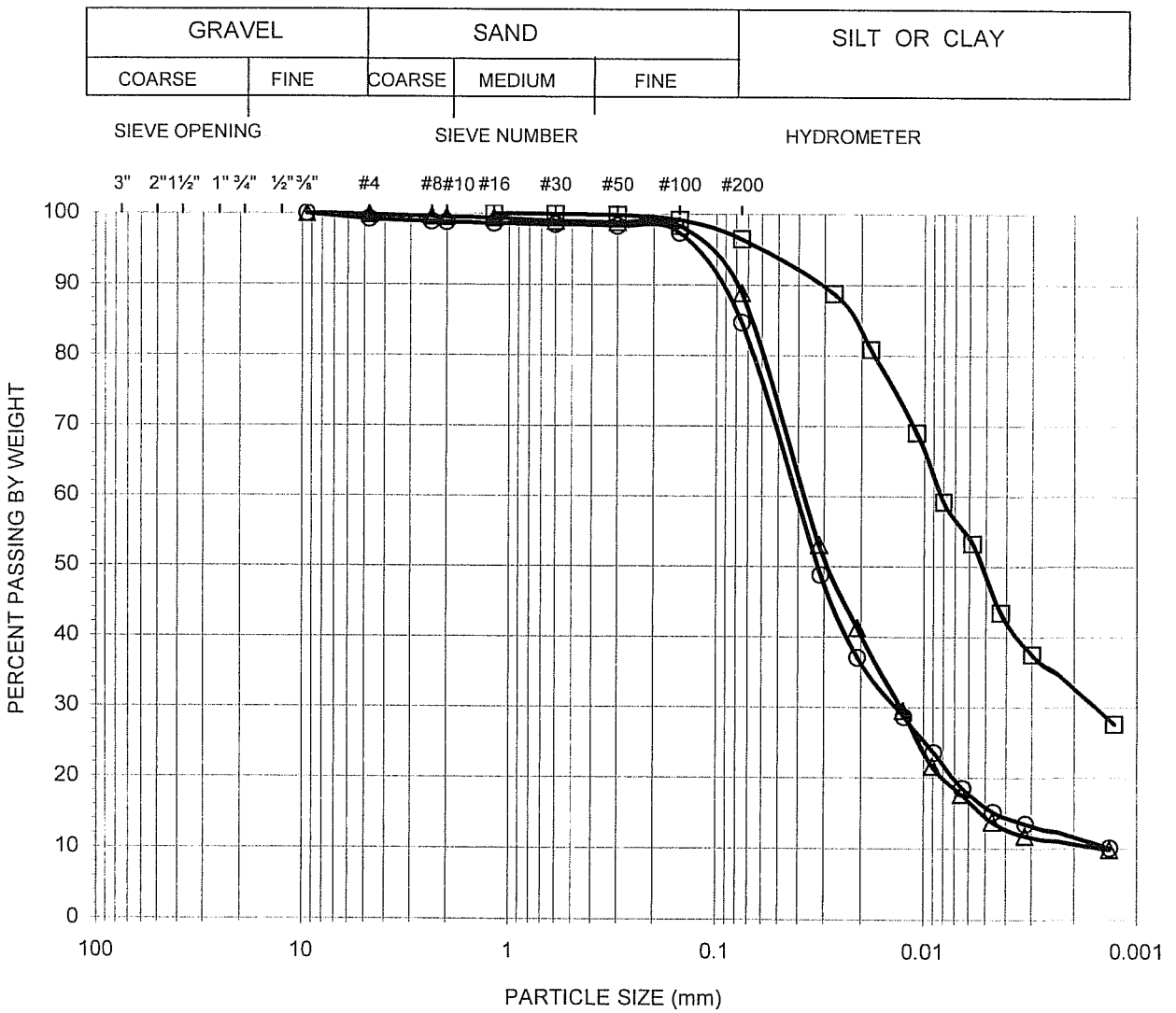


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-008	S-16	80	0.24	90.53	9.23	N/A	SP-SM
□	R-09-008	S-20	120	0.00	87.57	12.43	N/A	SM
△	R-09-008	S-23	150	34.56	52.50	12.94	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

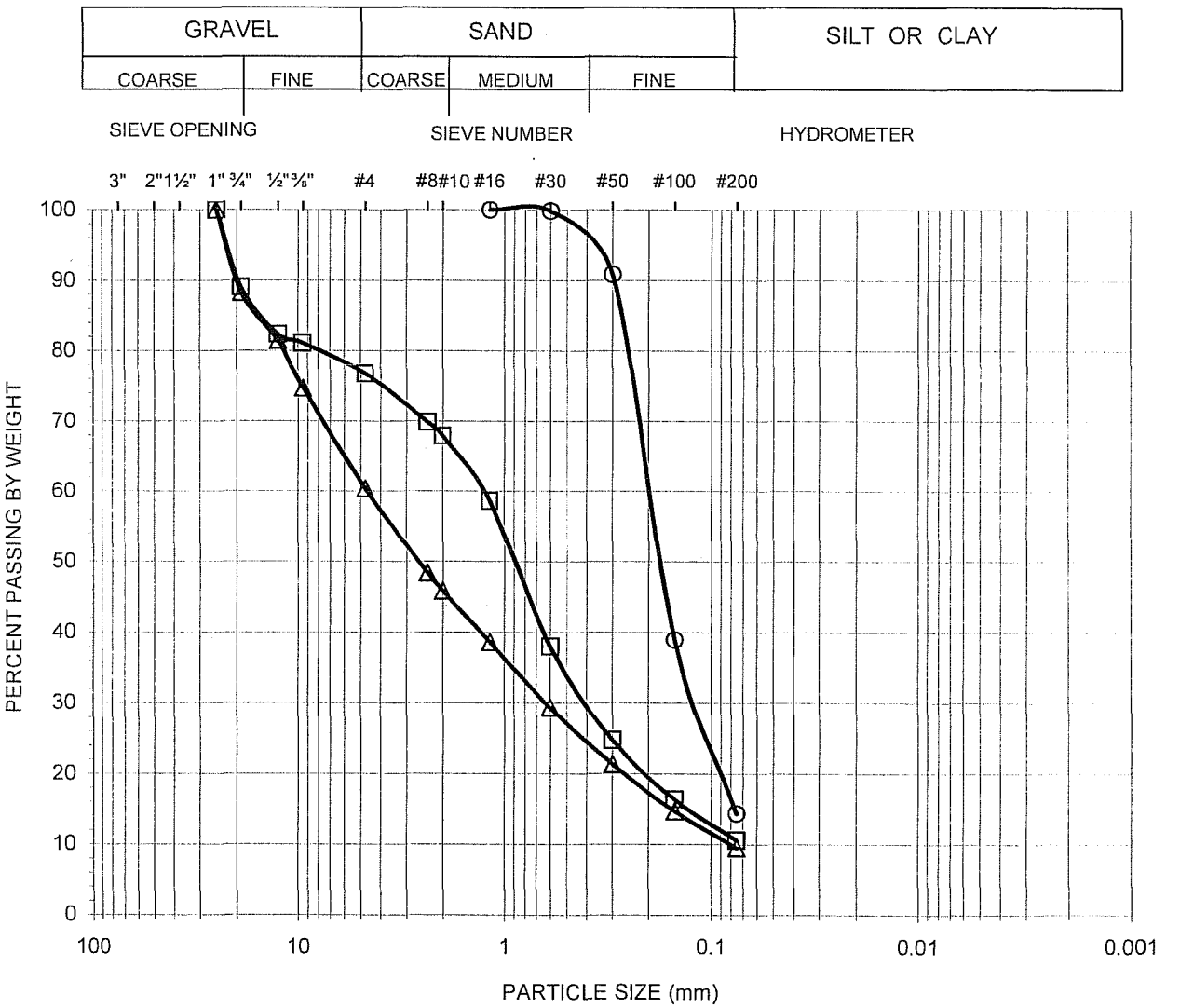


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-009	U-09	45	0.77	14.53	84.70	31:22:9	CL
□	R-09-009	S-10	50	0.00	3.55	96.45	49:27:22	CL
△	R-09-009	D-13	65	0.14	10.96	88.90	N/P	ML

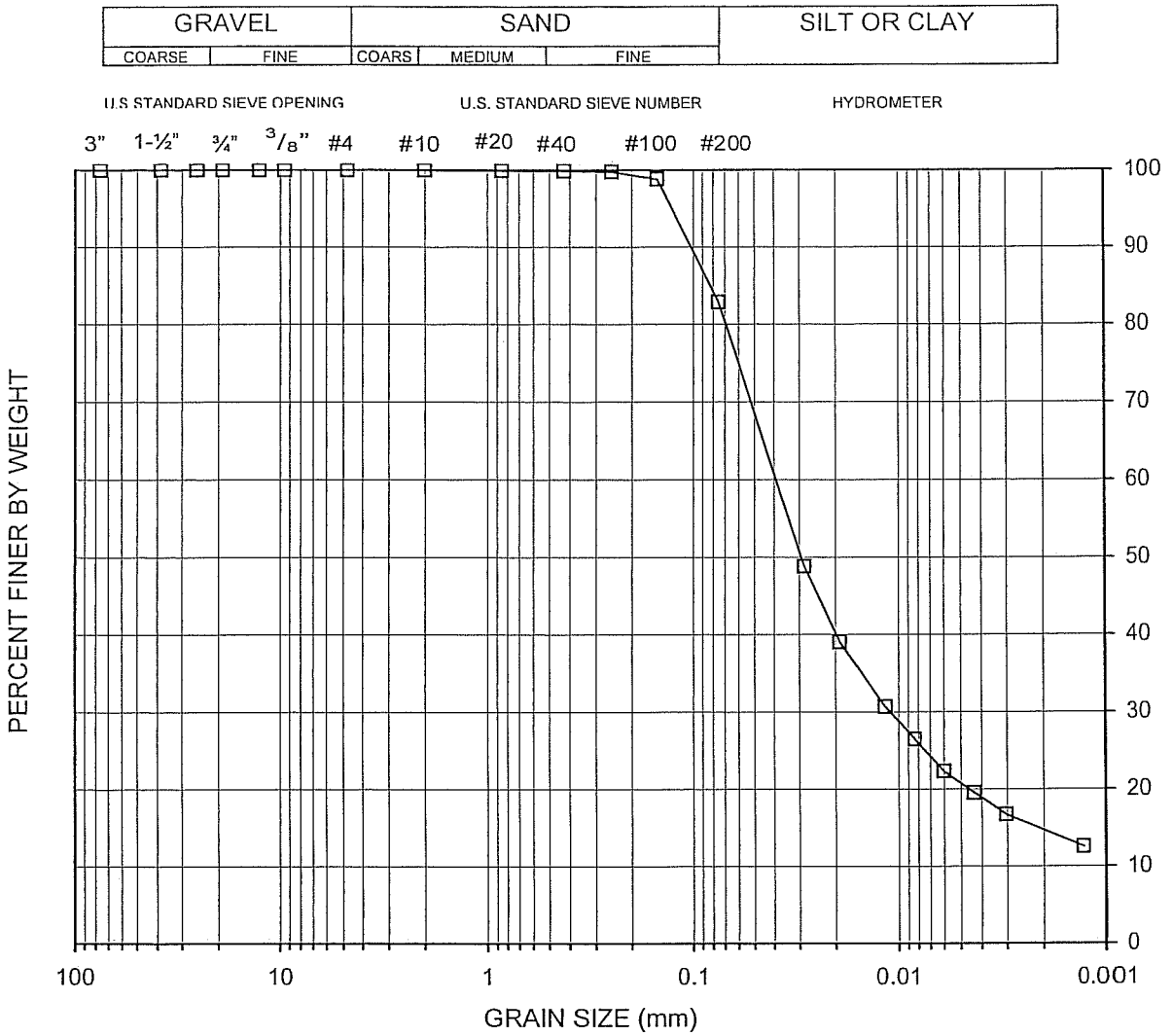
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-009	S-16	80	0.00	85.64	14.36	N/A	SM
□	R-09-009	S-19	110	23.28	66.13	10.59	N/A	SW-SM
△	R-09-009	S-22	140	39.61	50.88	9.51	N/A	SW-SM



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-010	U-06	30	Shelby Tube	ML	29	6

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

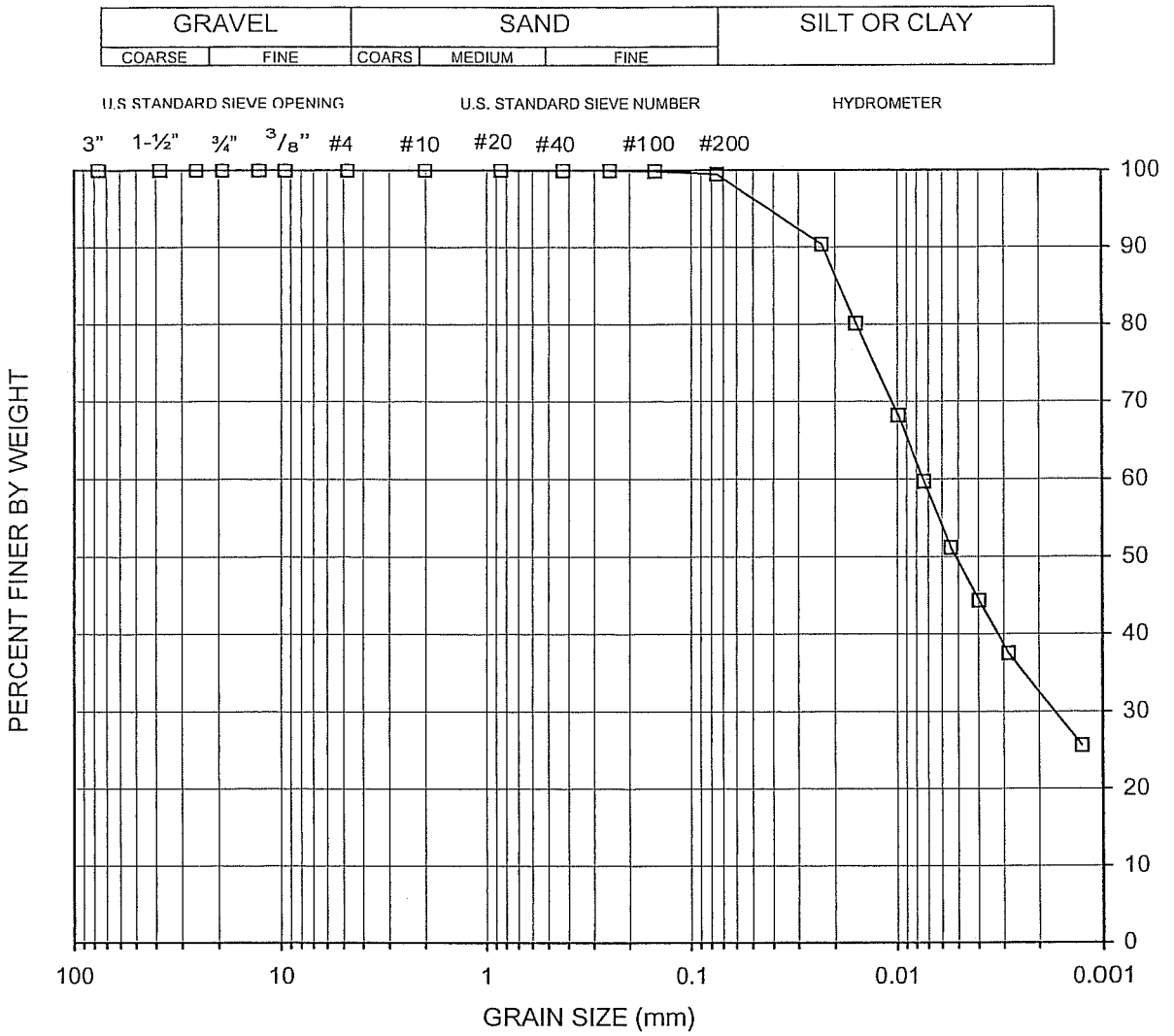
Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-010	D-10	50	RING	CH	51	24

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

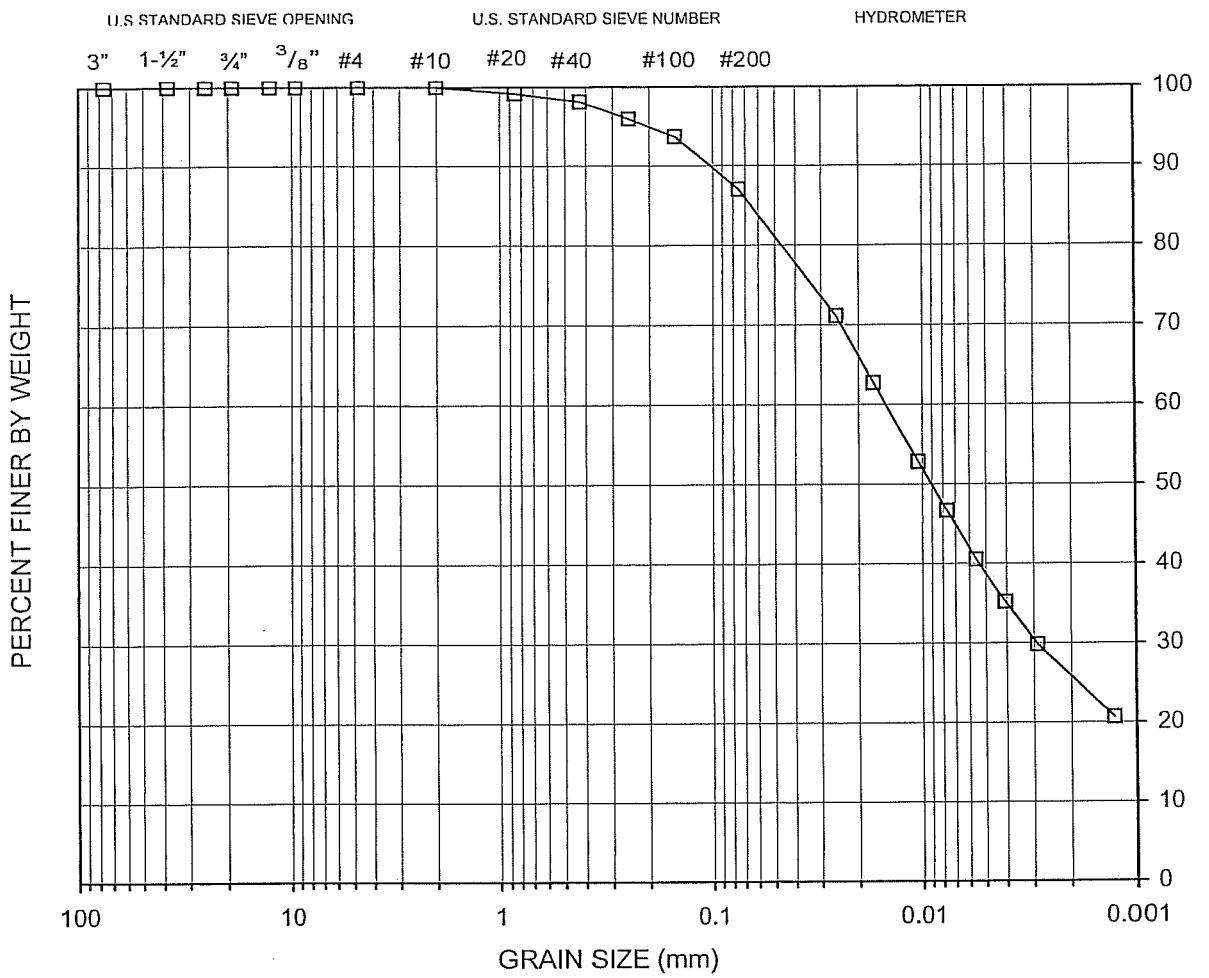
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-010	S-13-2	65.7	BAG	CL	35	15

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

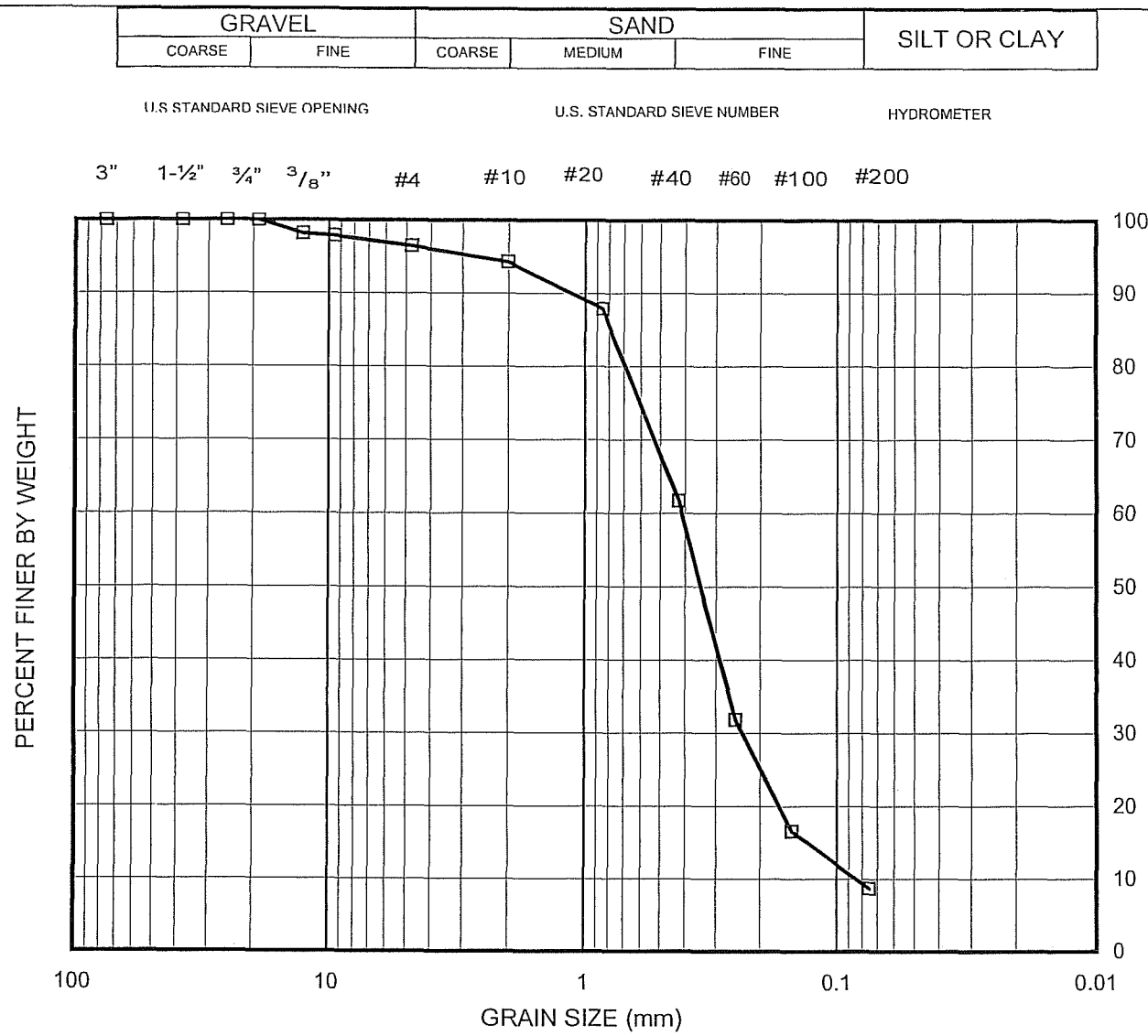
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

11/29/09

FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-010	S-21	120	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

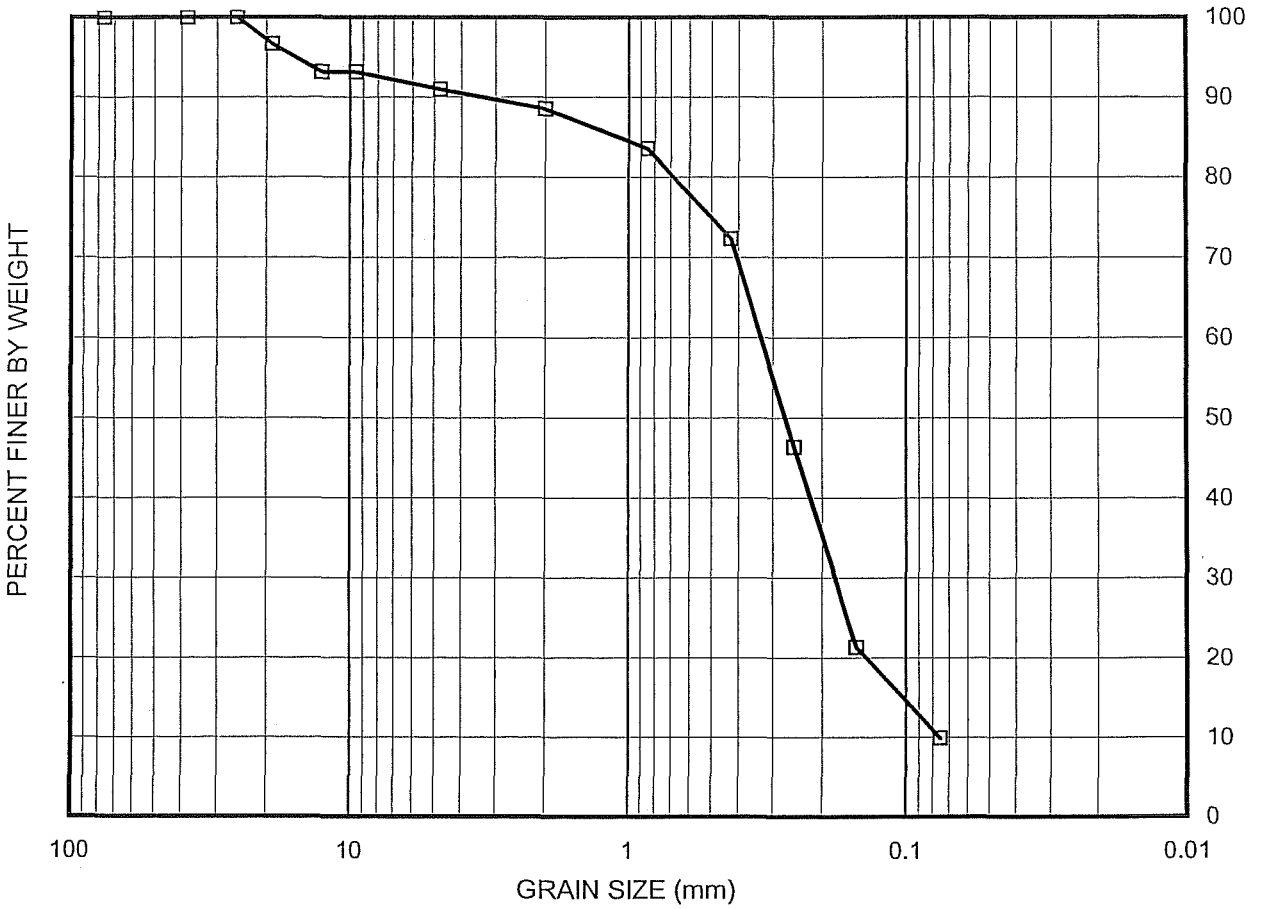
GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER

3" 1-½" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-010	S-24	150	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

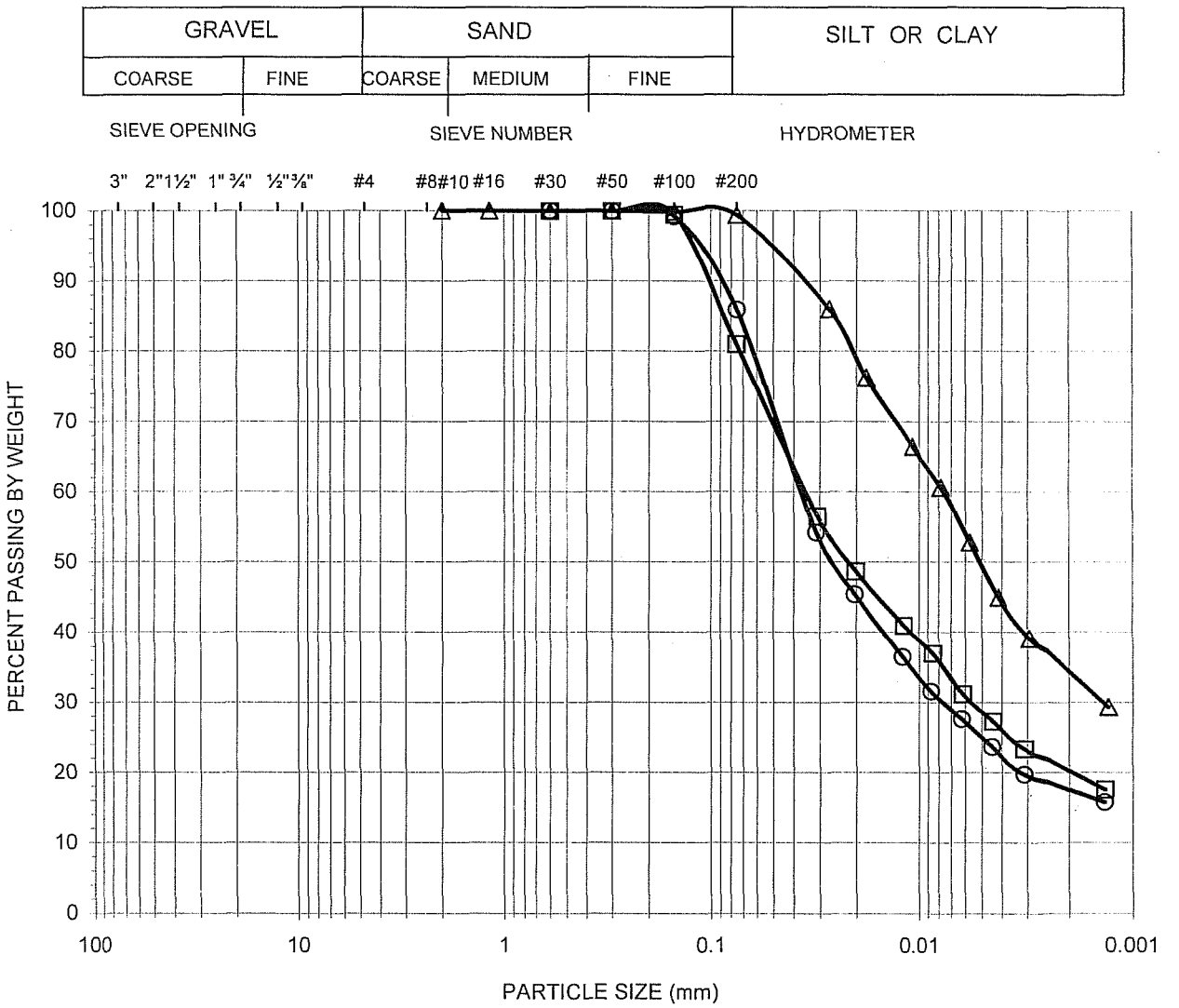
GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

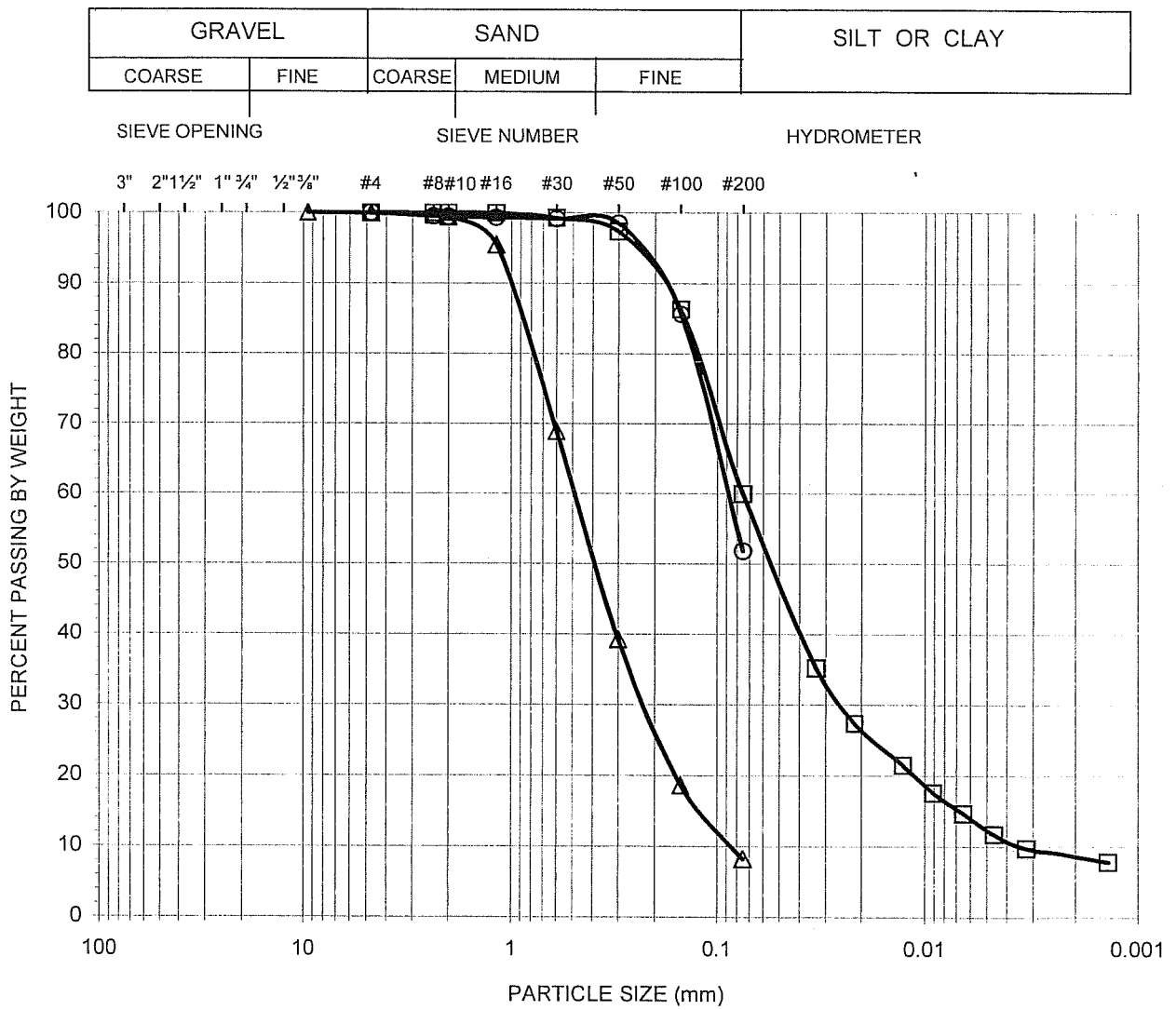


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-07	35	0.00	14.12	85.88	29:23:6	CL-ML
□	R-09-011	D-08	40	0.00	19.09	80.91	29:22:7	CL-ML
△	R-09-011	D-10	50	0.00	0.65	99.35	51:23:28	CH

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	D-12	60	0.00	48.16	51.84	N/A	ML
□	R-09-011	U-14	70	0.00	40.02	59.98	N/P	ML
△	R-09-011	S-15	75	0.07	91.69	8.24	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

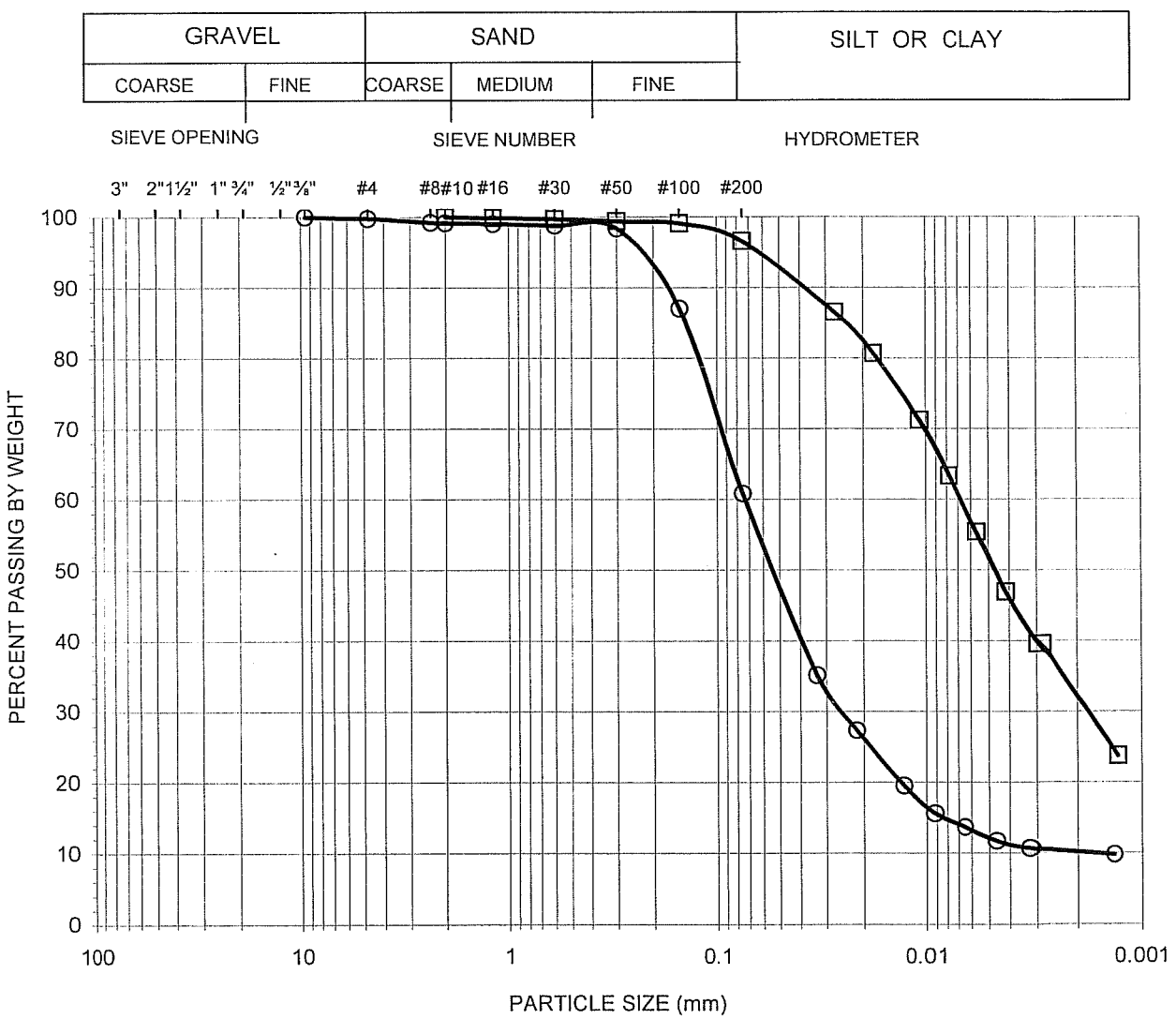
Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-17	90	0.00	85.42	14.58	N/A	SM
□	R-09-011	S-19	110	0.00	84.84	15.16	N/A	SM
△	R-09-011	S-23	150	7.02	75.27	17.71	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

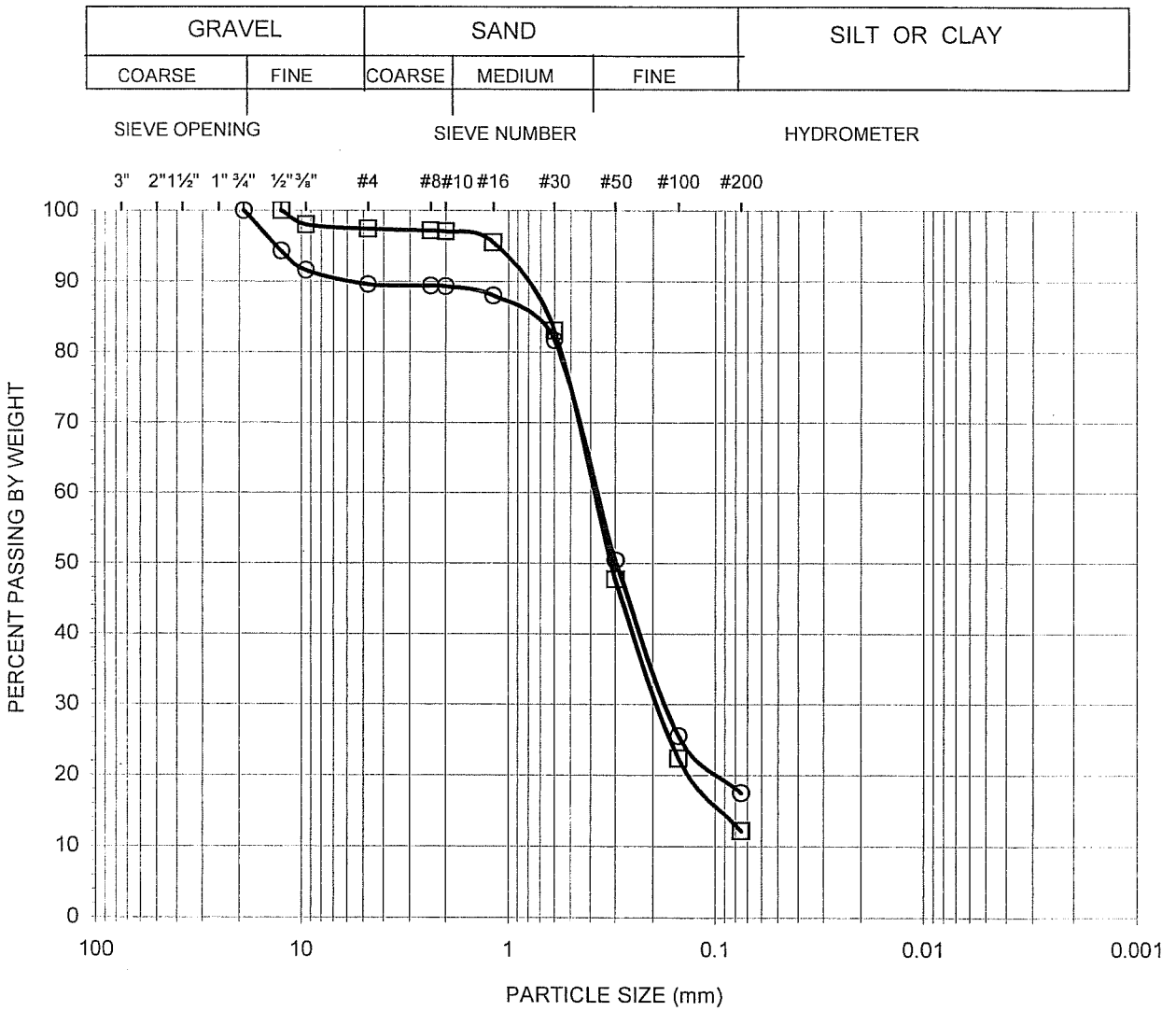


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-012	U-10A	51.5	0.25	38.93	60.82	N/P	ML
□	R-09-012	U-16	80	0.00	3.46	96.54	35:23:12	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

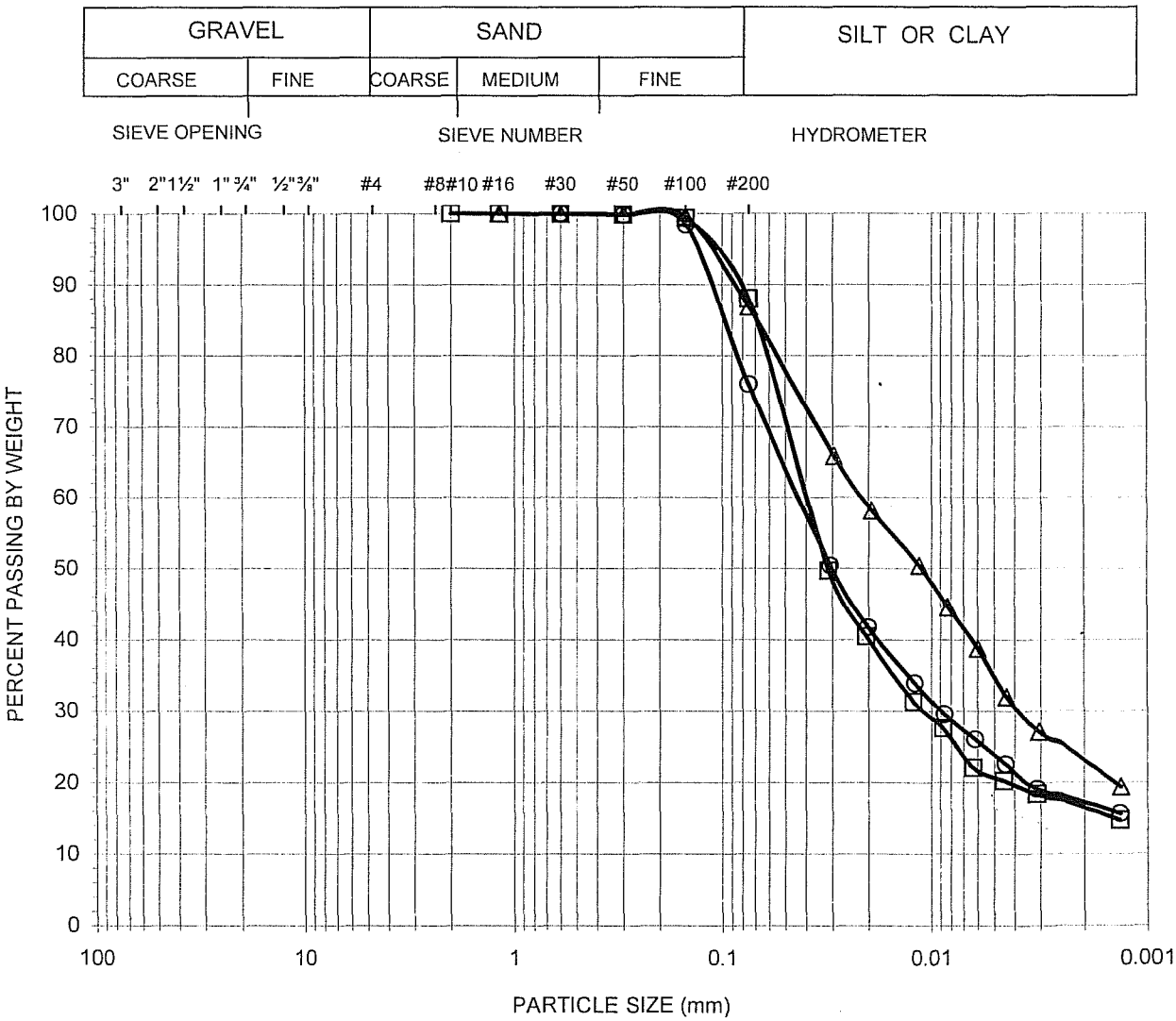


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-012	S-20	120	10.40	72.09	17.51	N/A	SM
□	R-09-012	S-23	155	2.59	85.23	12.18	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

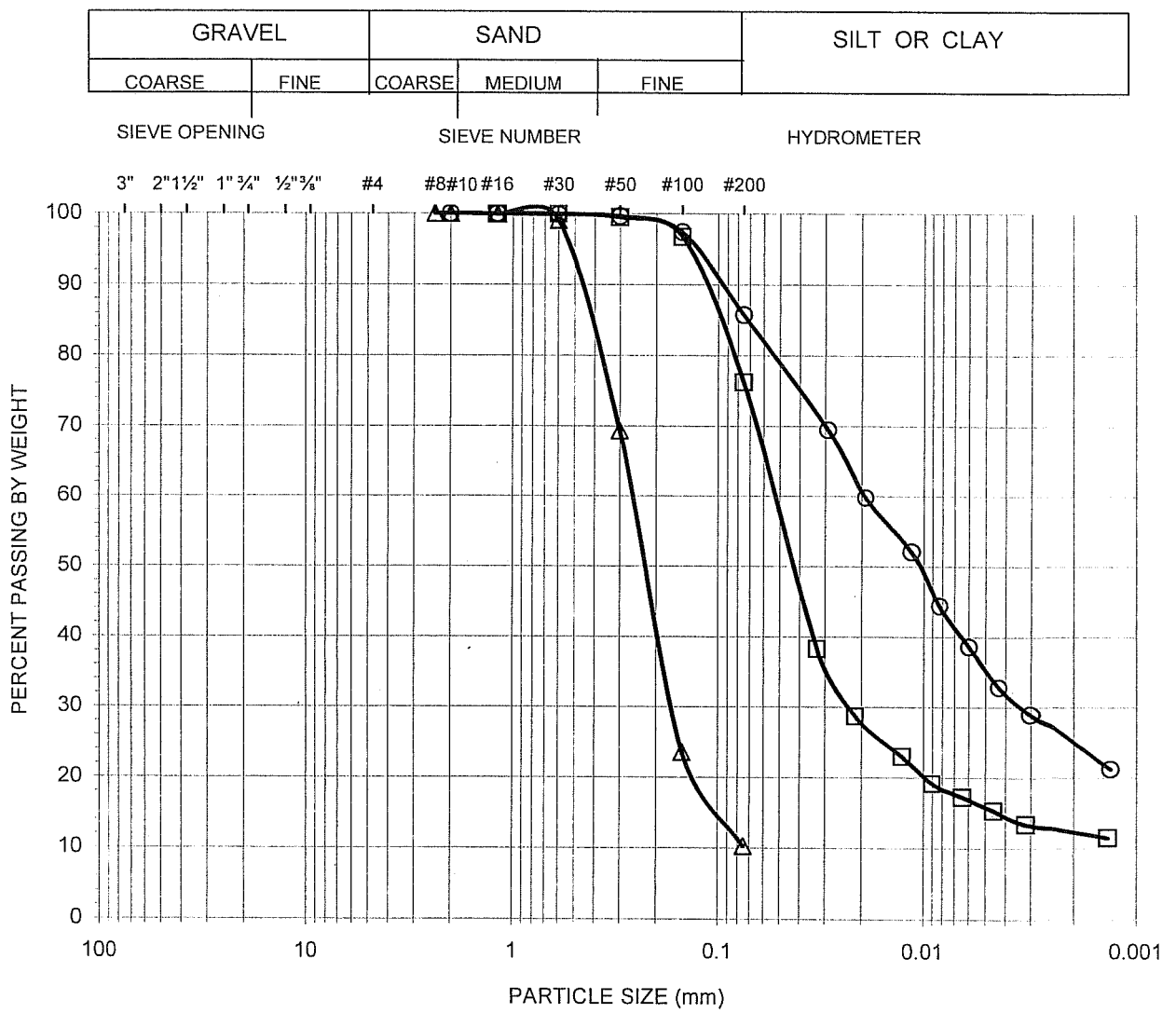


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	U-05	25	0.00	24.03	75.97	30:23:7	CL-ML
□	R-09-013	S-07	35	0.00	11.97	88.03	N/P	ML
△	R-09-013	U-08	40	0.00	13.09	86.91	36:24:12	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

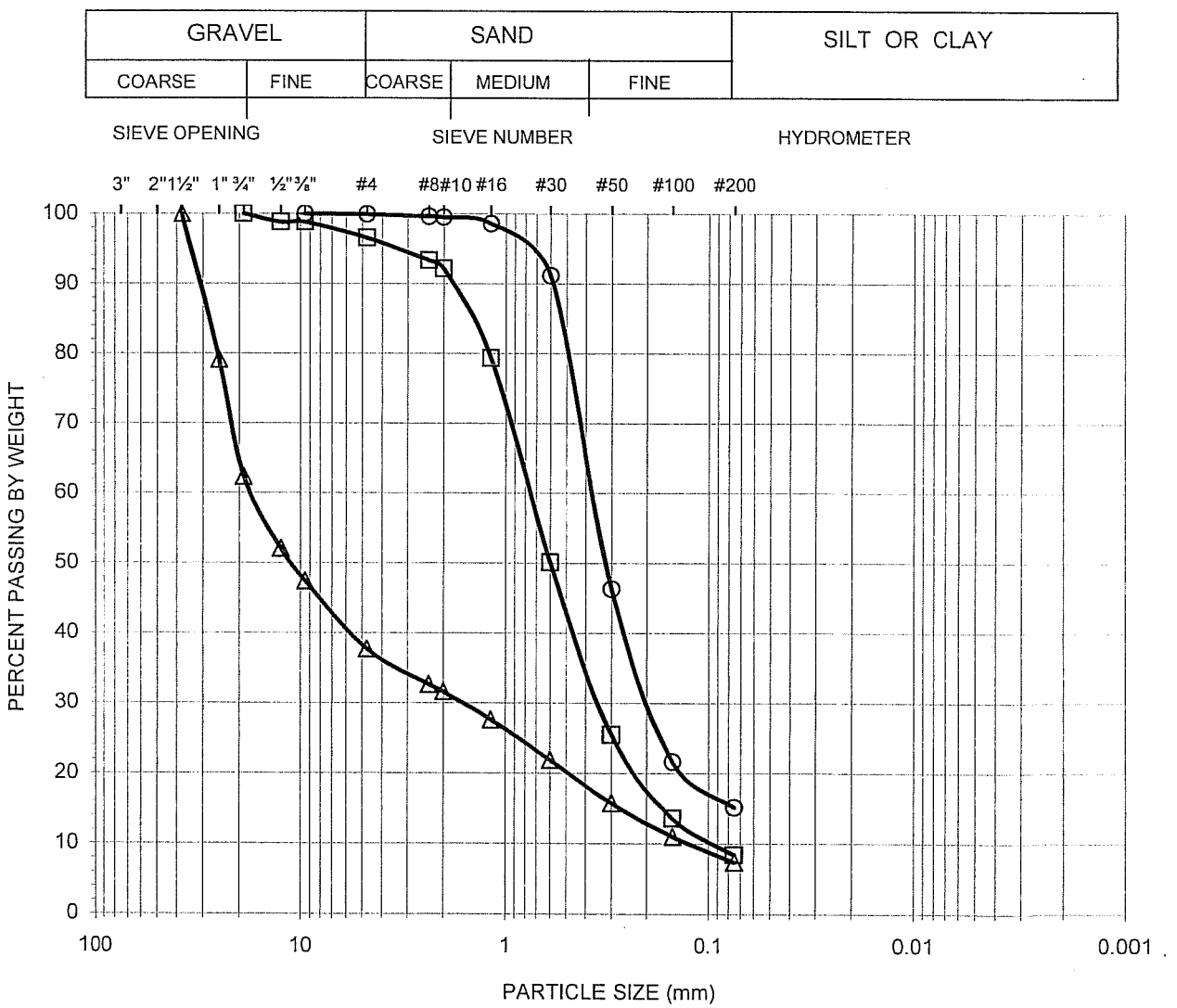


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	D-10	50	0.00	14.25	85.75	38:25:13	CL
□	R-09-013	S-13	65	0.00	23.80	76.20	N/P	ML
△	R-09-013	S-15	75	0.00	89.76	10.24	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

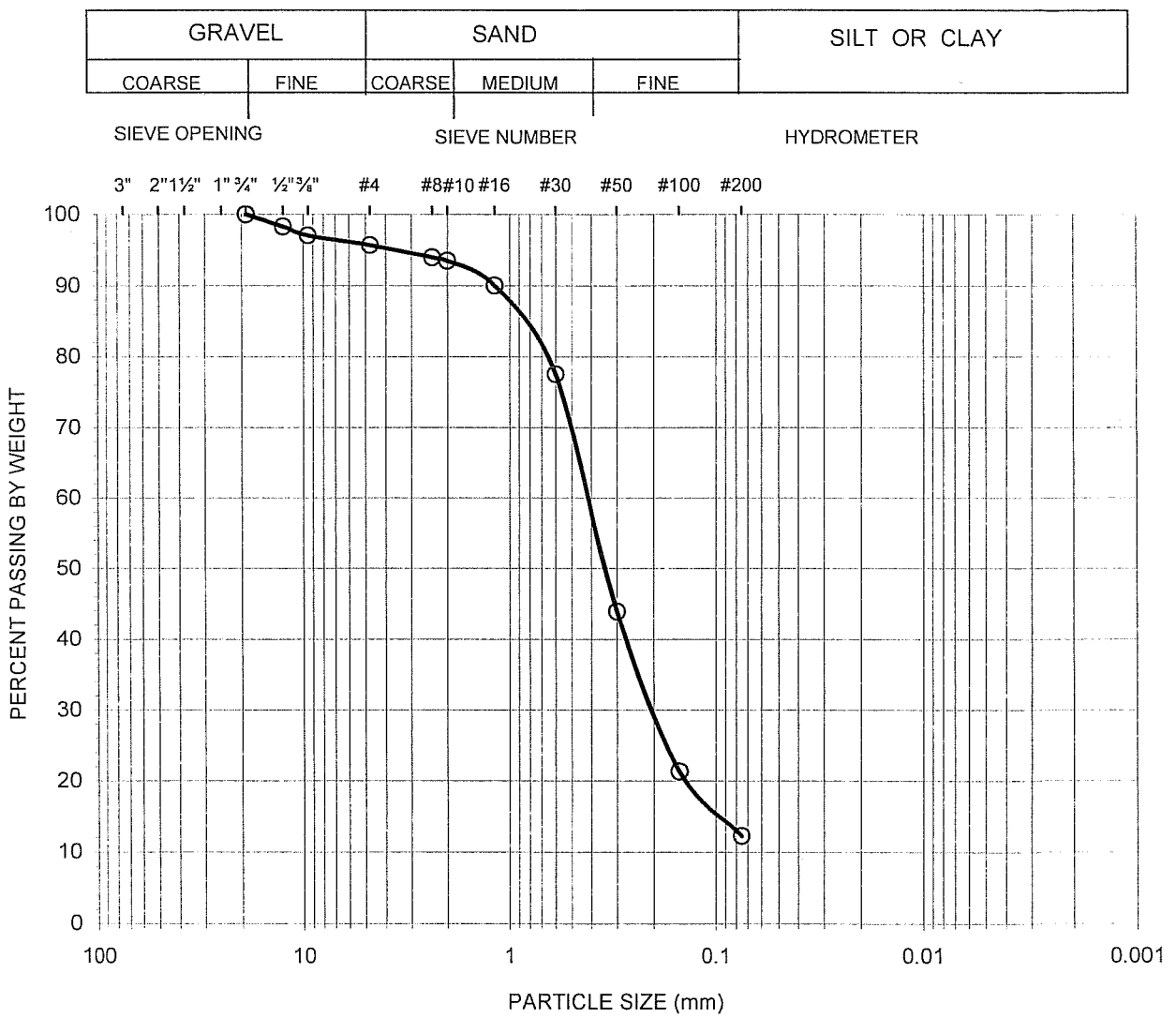


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	S-17	85	0.06	84.77	15.17	N/A	SM
□	R-09-013	S-19	100	3.49	88.11	8.40	N/A	SW-SM
△	R-09-013	S-22	130	62.32	30.32	7.36	N/A	GW-GM

AP Engineering & Testing, Inc.

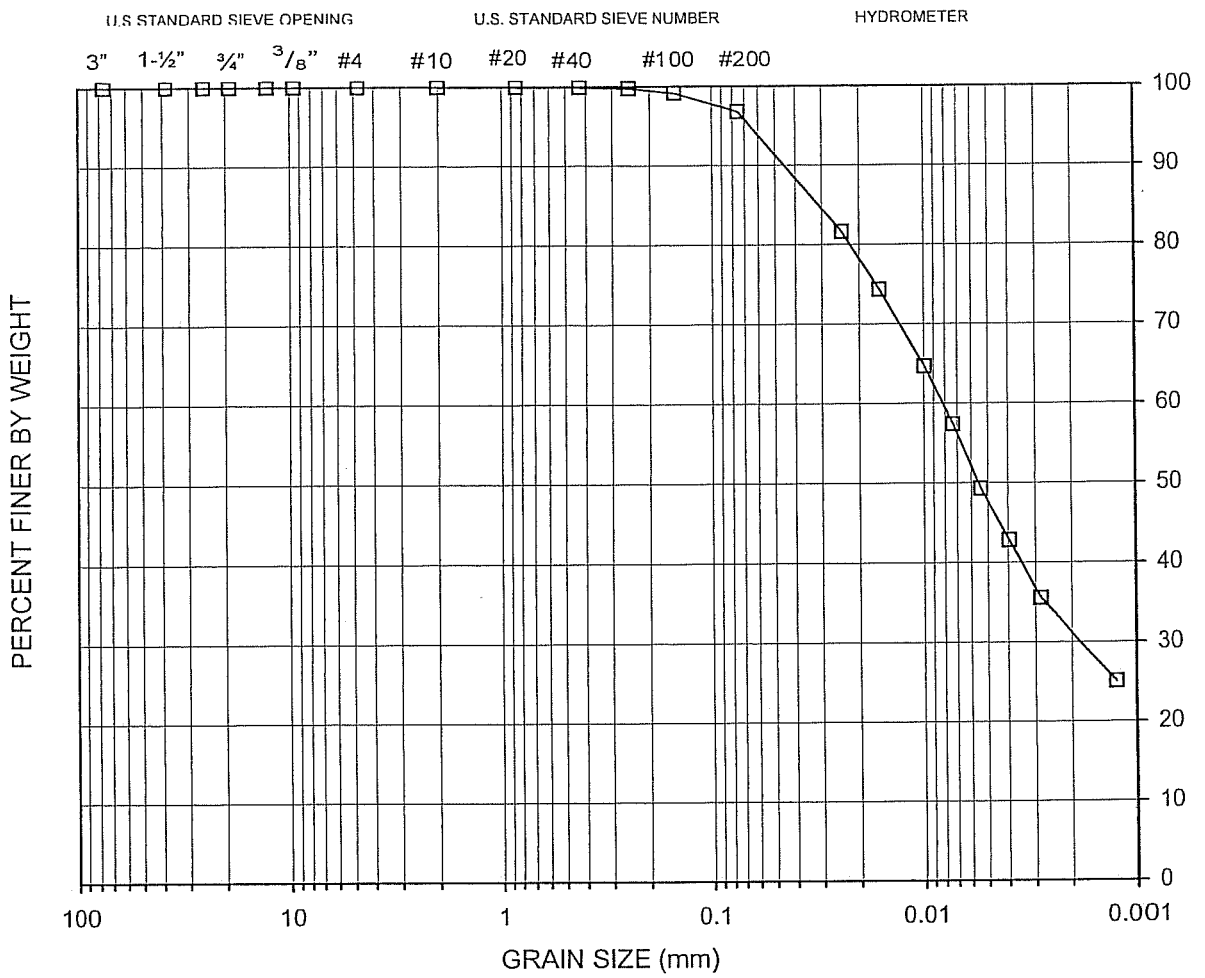
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-013	S-24	150	4.31	83.40	12.29	N/A	SM

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-014	S-07	35	BAG	CL	49	25

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.

Job No: 06-123-03

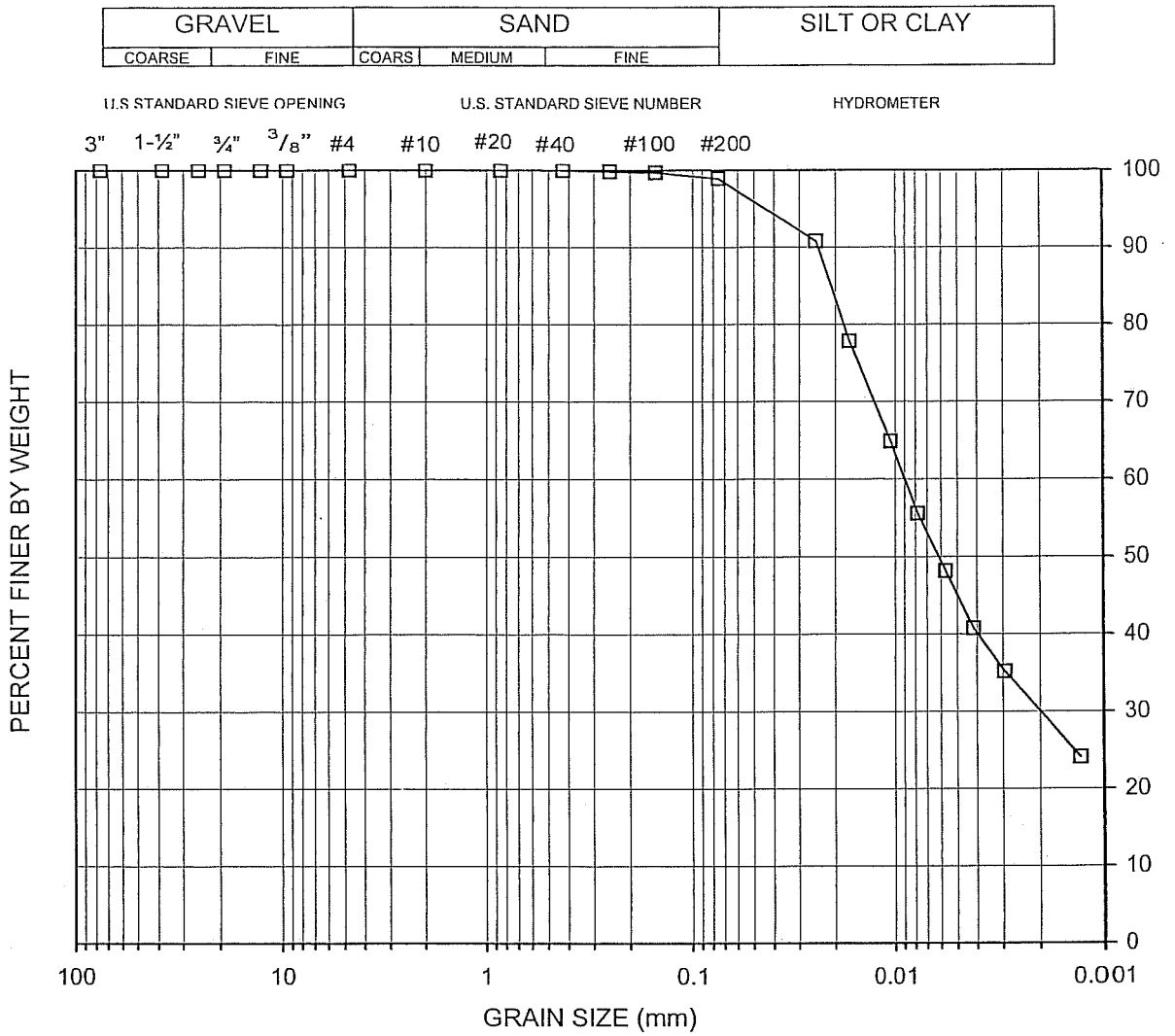
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09

(ASTM D422)

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-014	U-11	50	Shelby Tube	CL	49	25

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

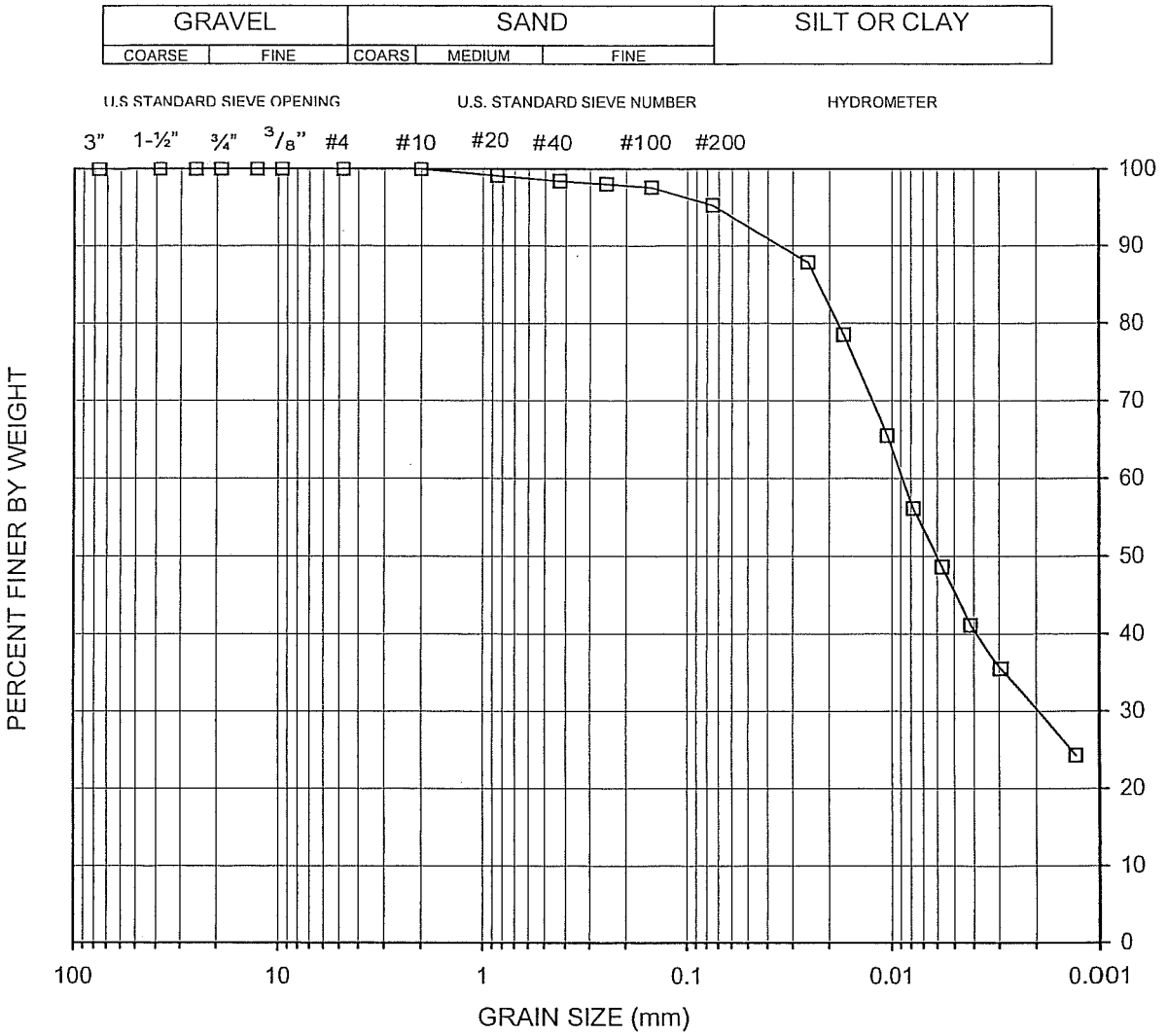
Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-014	U-13	60	Shelby Tube	CL	43	19

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

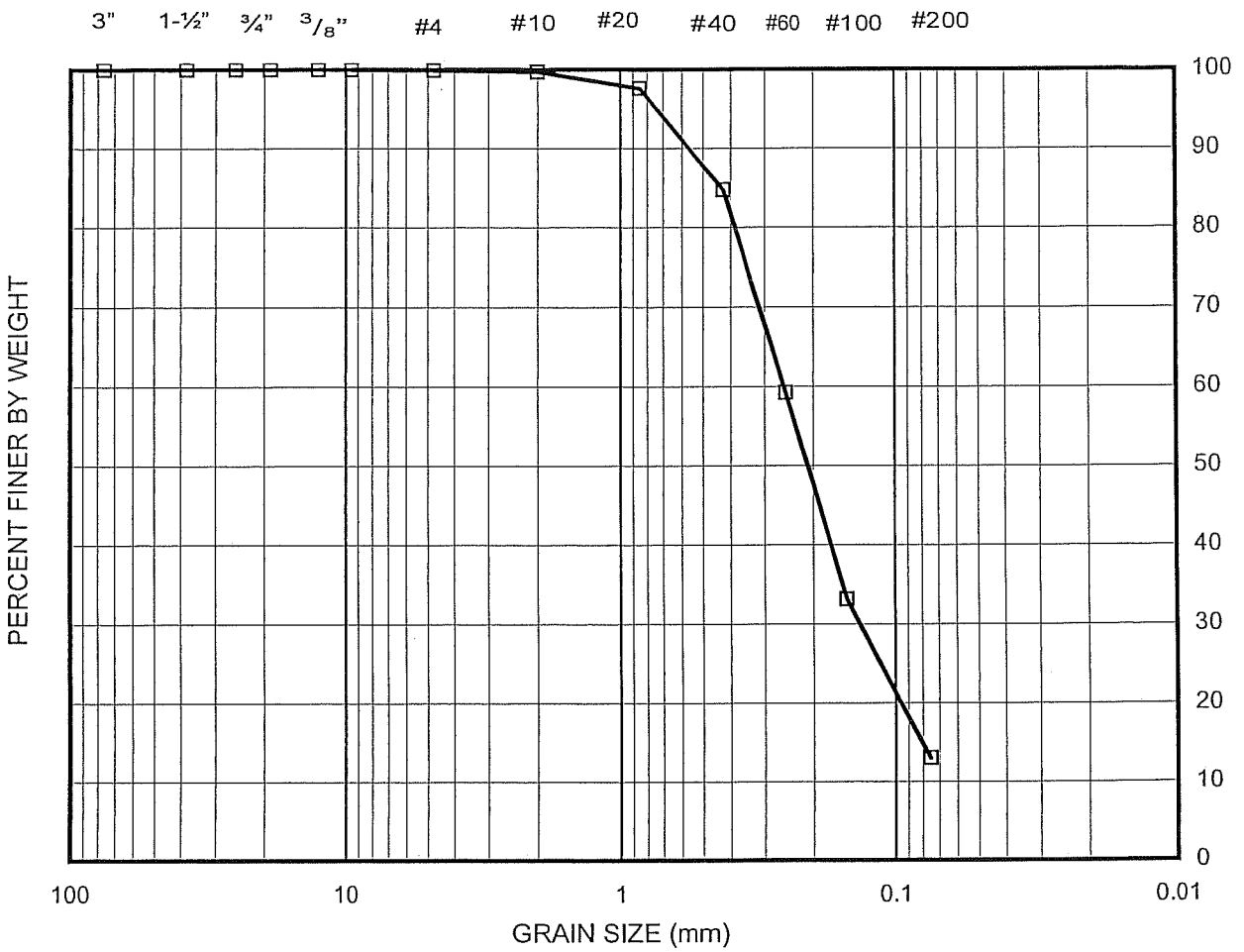
Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-014	S-20	110	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

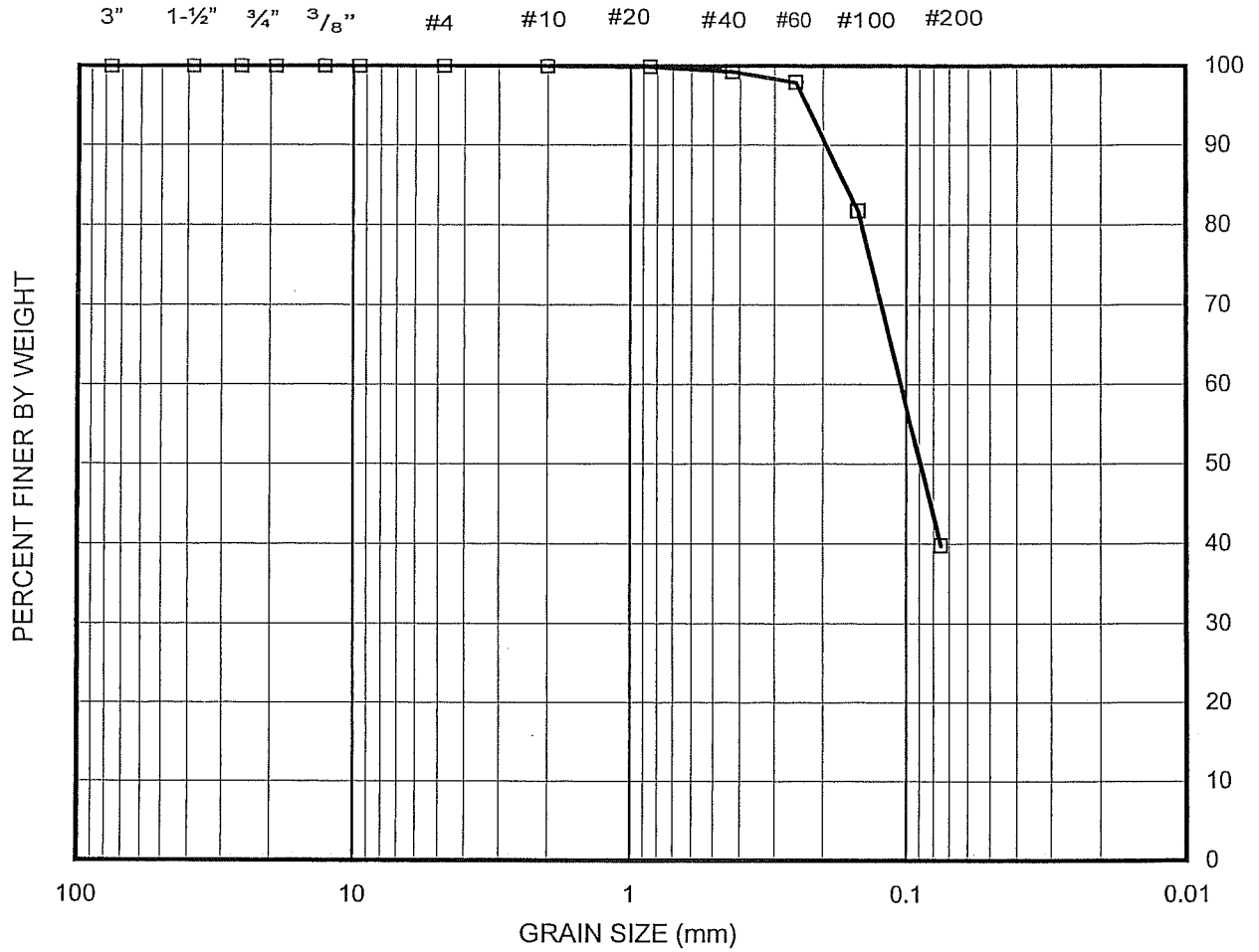
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-014	S-24	165	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

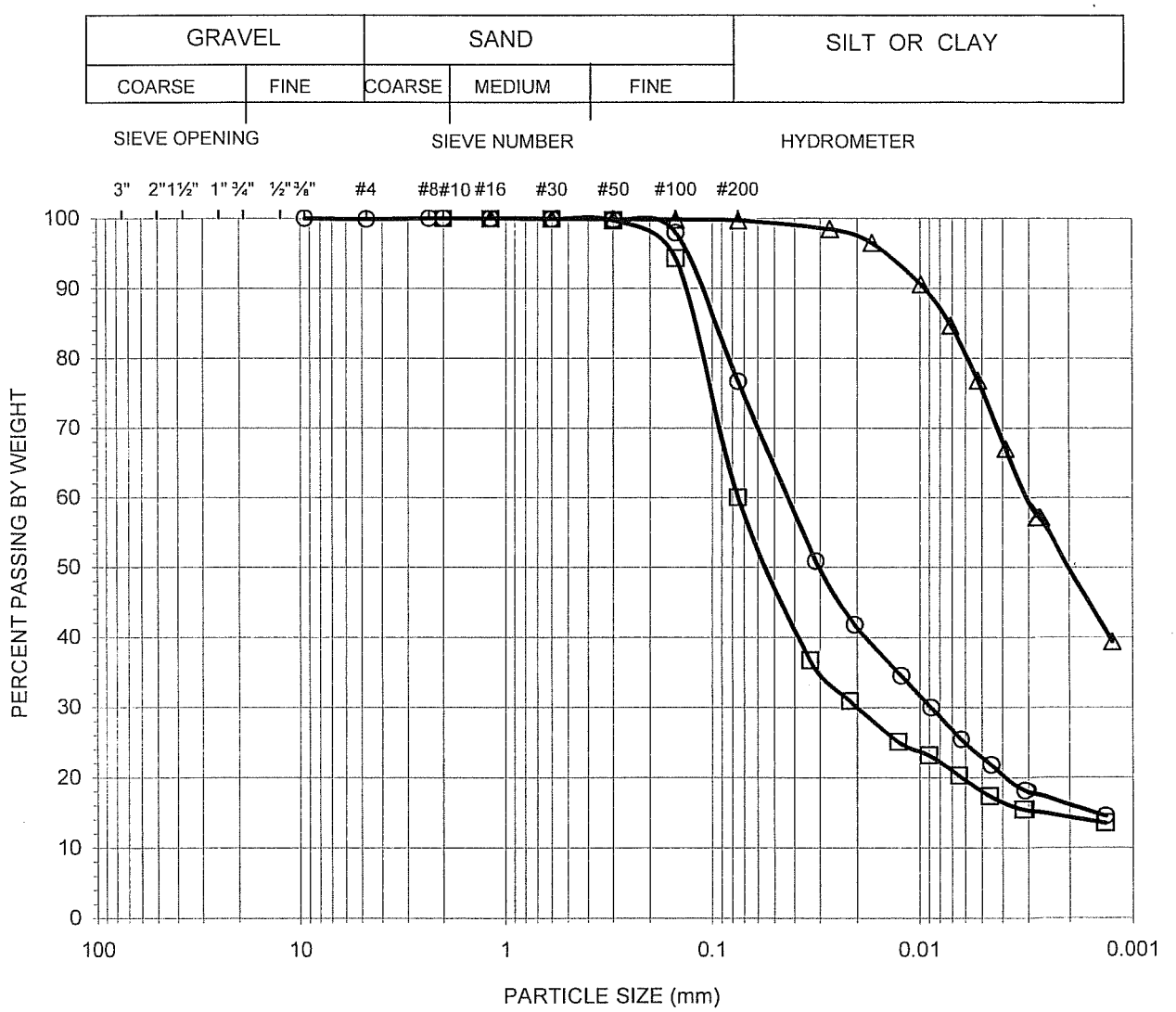
GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

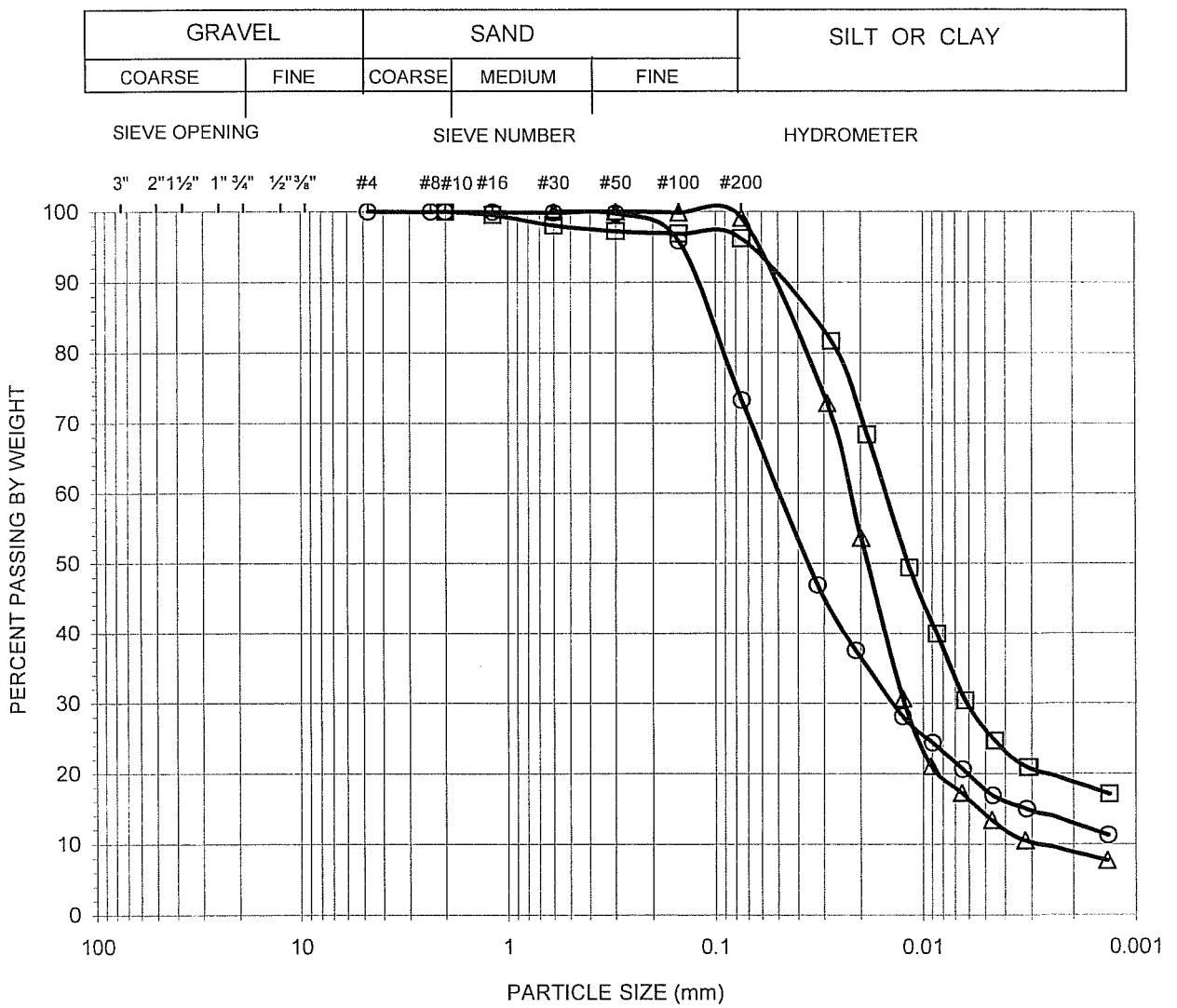


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-015	D-04	20	0.10	23.22	76.68	N/P	ML
□	R-09-015	S-05	25	0.00	40.02	59.98	N/A	ML
△	R-09-015	D-08	40	0.00	0.32	99.68	71:37:34	MH

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

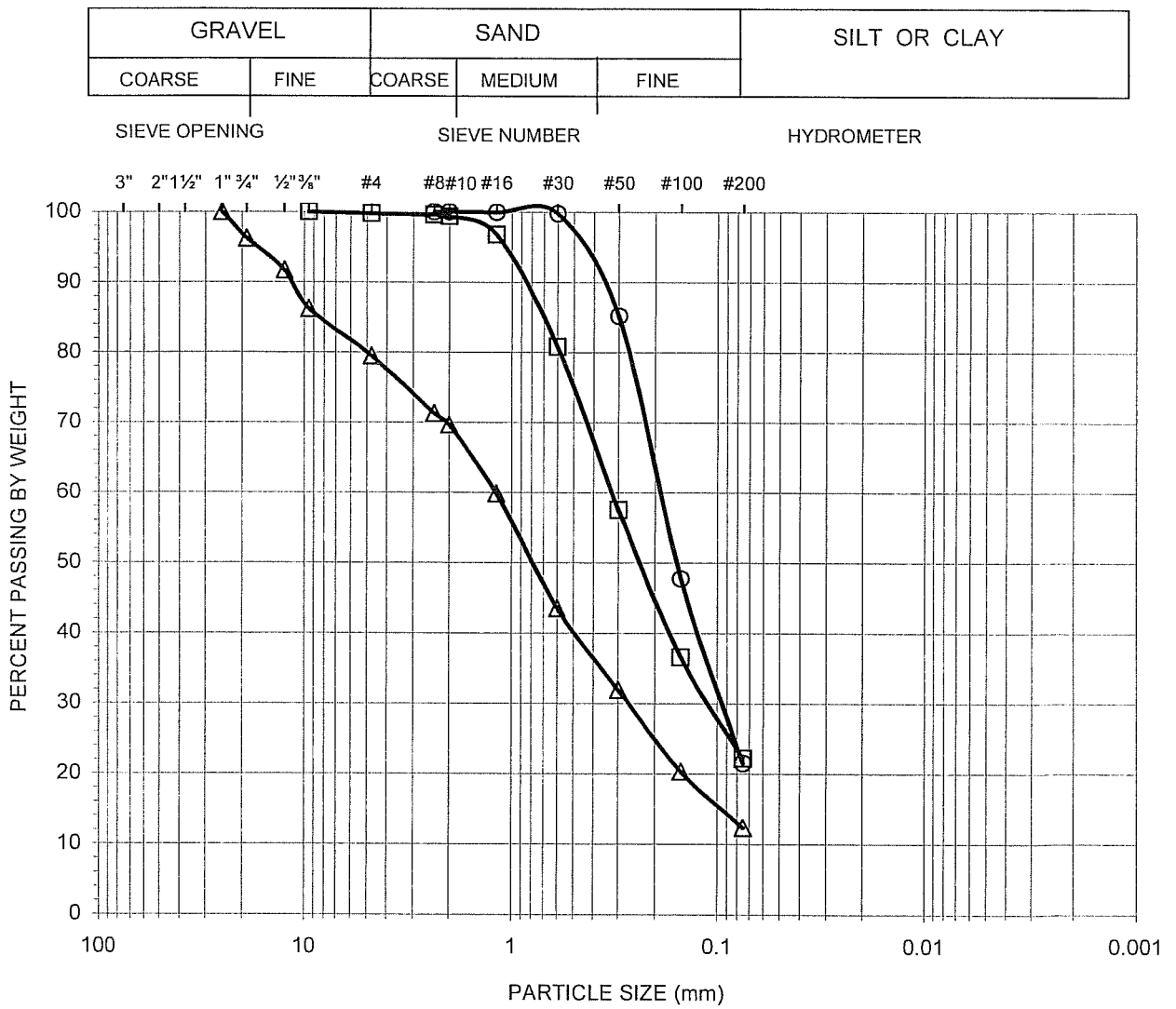


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-015	U-09	45	0.00	26.74	73.26	N/P	ML
□	R-09-015	S-11	55	0.00	3.82	96.18	38:26:12	ML
△	R-09-015	U-12	60	0.00	0.93	99.07	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

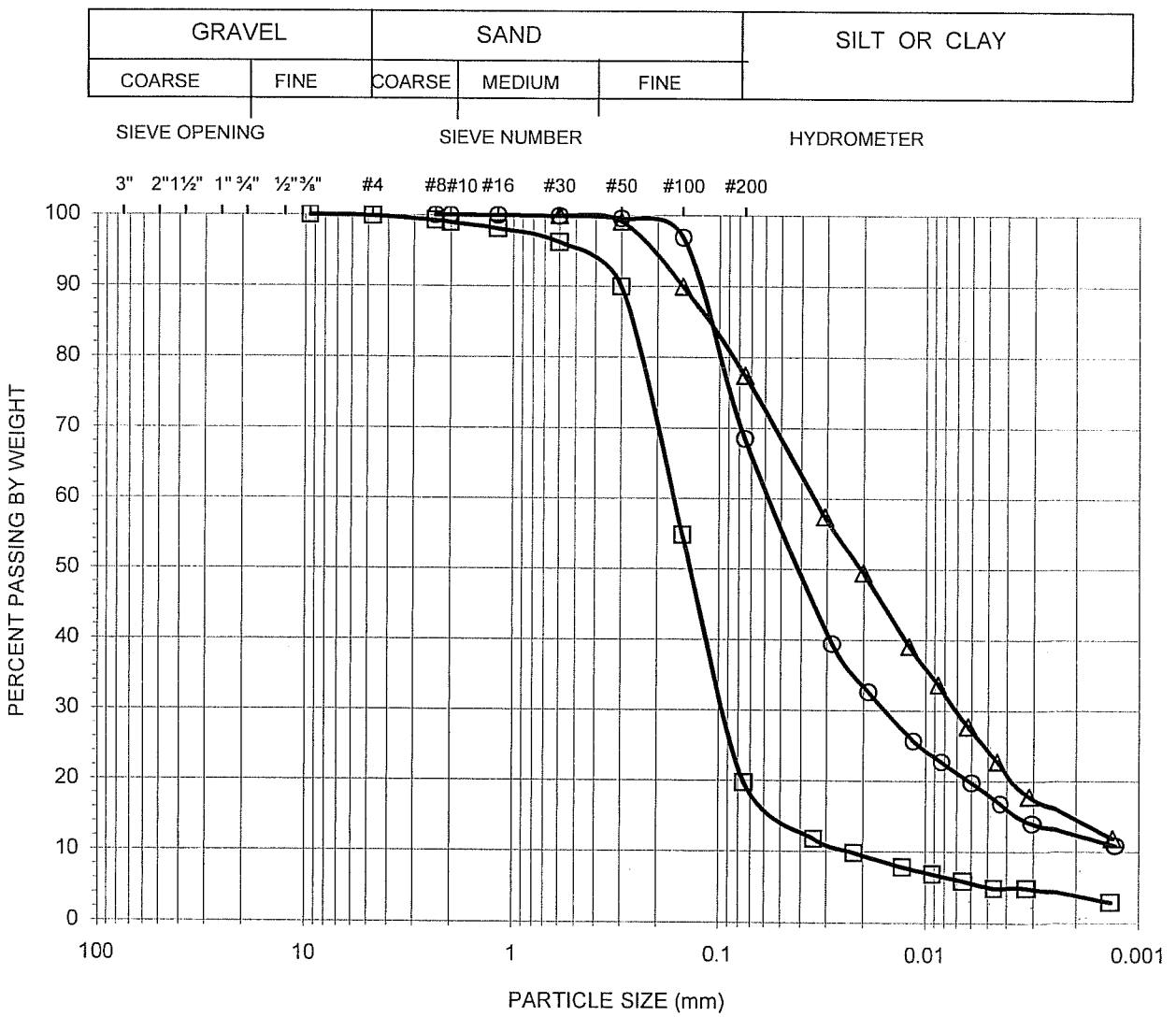


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-015	S-16	80	0.00	78.48	21.52	N/A	SM
□	R-09-015	S-18	100	0.22	77.57	22.21	N/A	SM
△	R-09-015	S-21	135	20.52	67.10	12.38	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

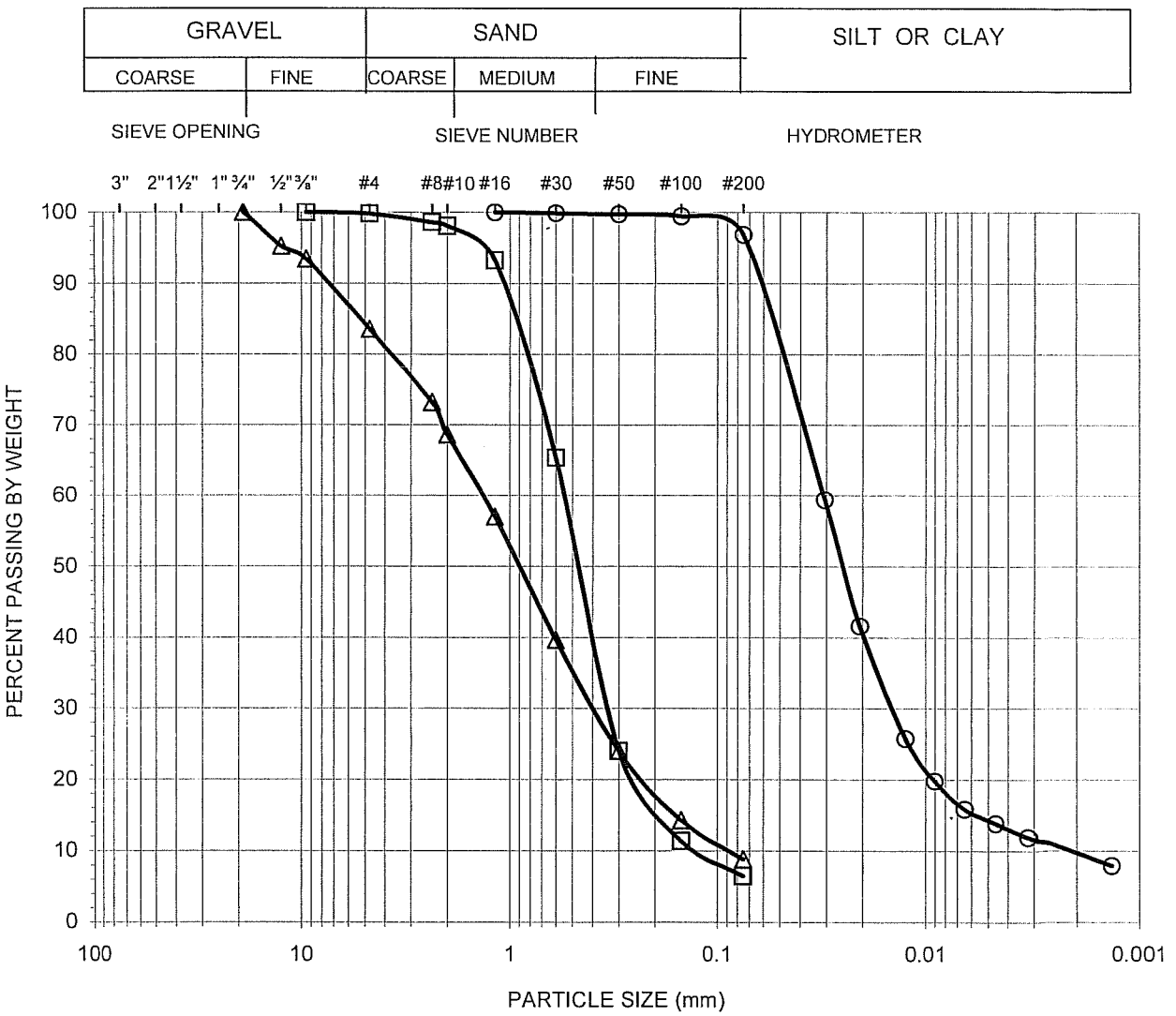


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-016	S-05	25	0.00	31.51	68.49	N/A	ML
□	R-09-016	U-09	45	0.13	80.18	19.69	N/P	SM
△	R-09-016	S-11	55	0.00	22.55	77.45	N/A	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

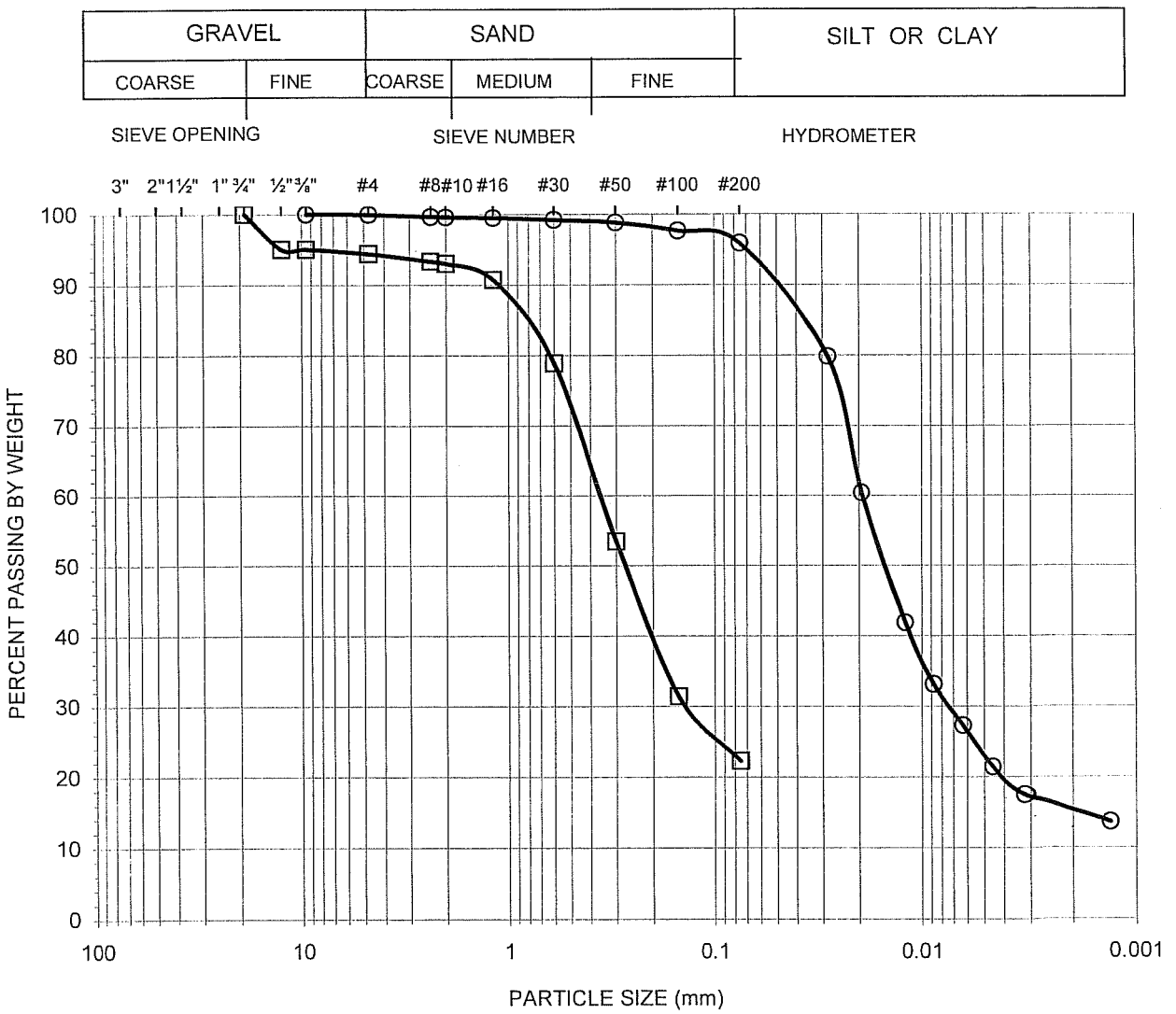


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-016	D-12-2	60.5	0.00	3.14	96.86	N/A	ML
□	R-09-016	S-19	100	0.19	93.34	6.47	N/A	SP-SM
△	R-09-016	S-22	135	16.45	74.72	8.83	N/A	SW-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

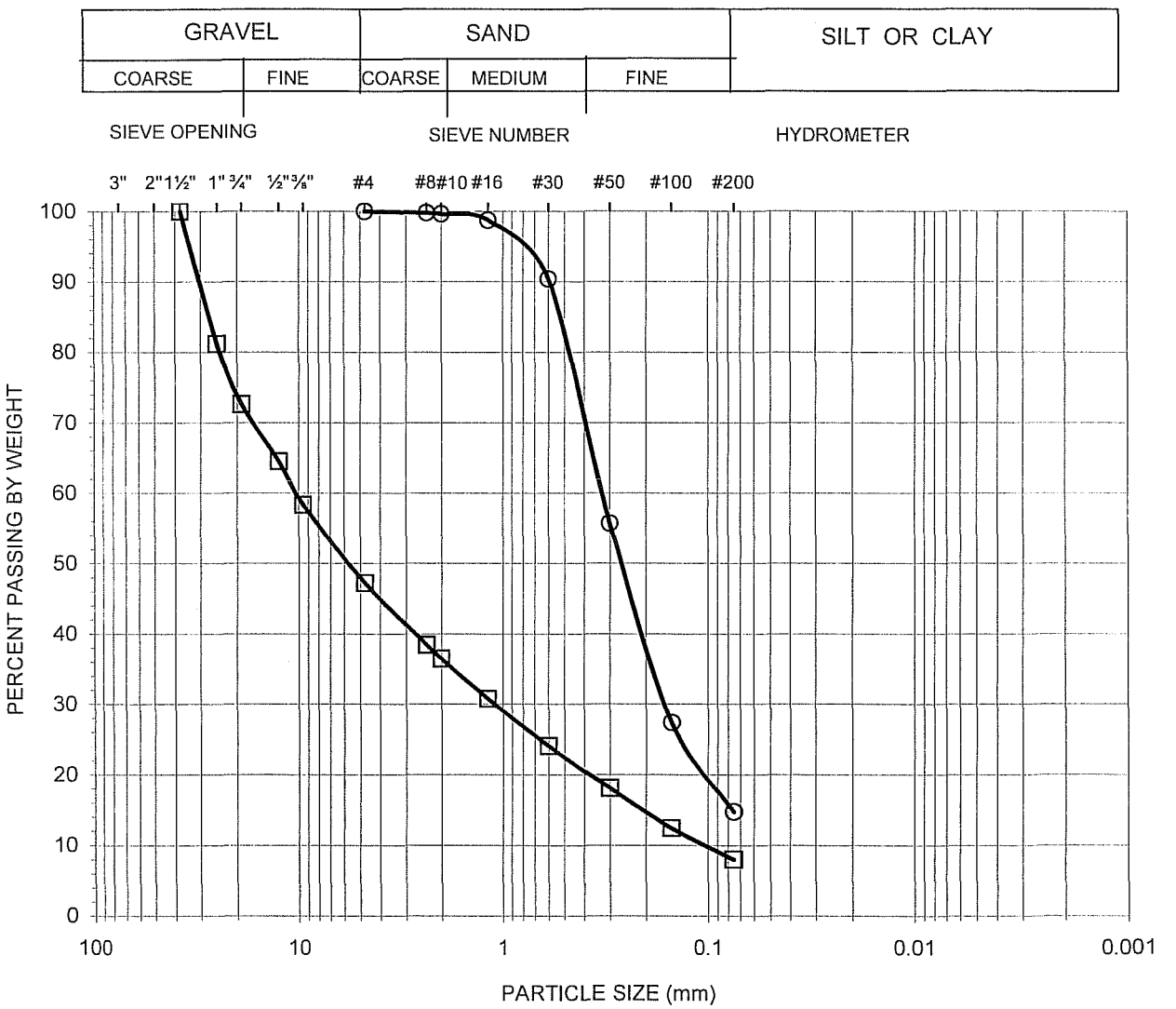


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-017	U-11	55	0.04	4.09	95.87	36:29:7	ML
□	R-09-017	S-17	100	5.59	72.13	22.28	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

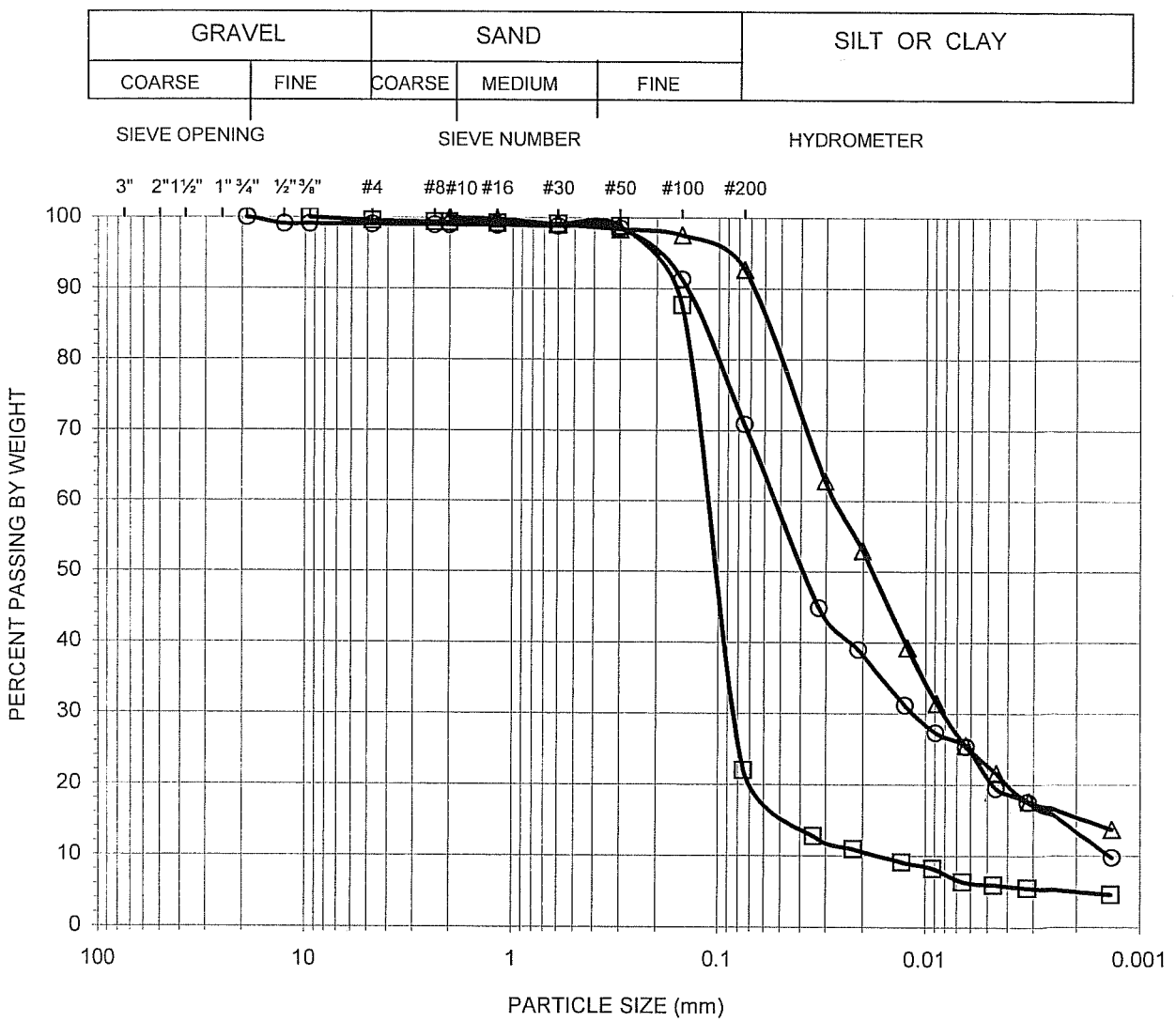


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Fines		
○	R-09-017	S-20	135	0.00	85.25	14.75	N/A	SM
□	R-09-017	S-22+S-23	165-180	52.79	39.24	7.97	N/A	SW-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

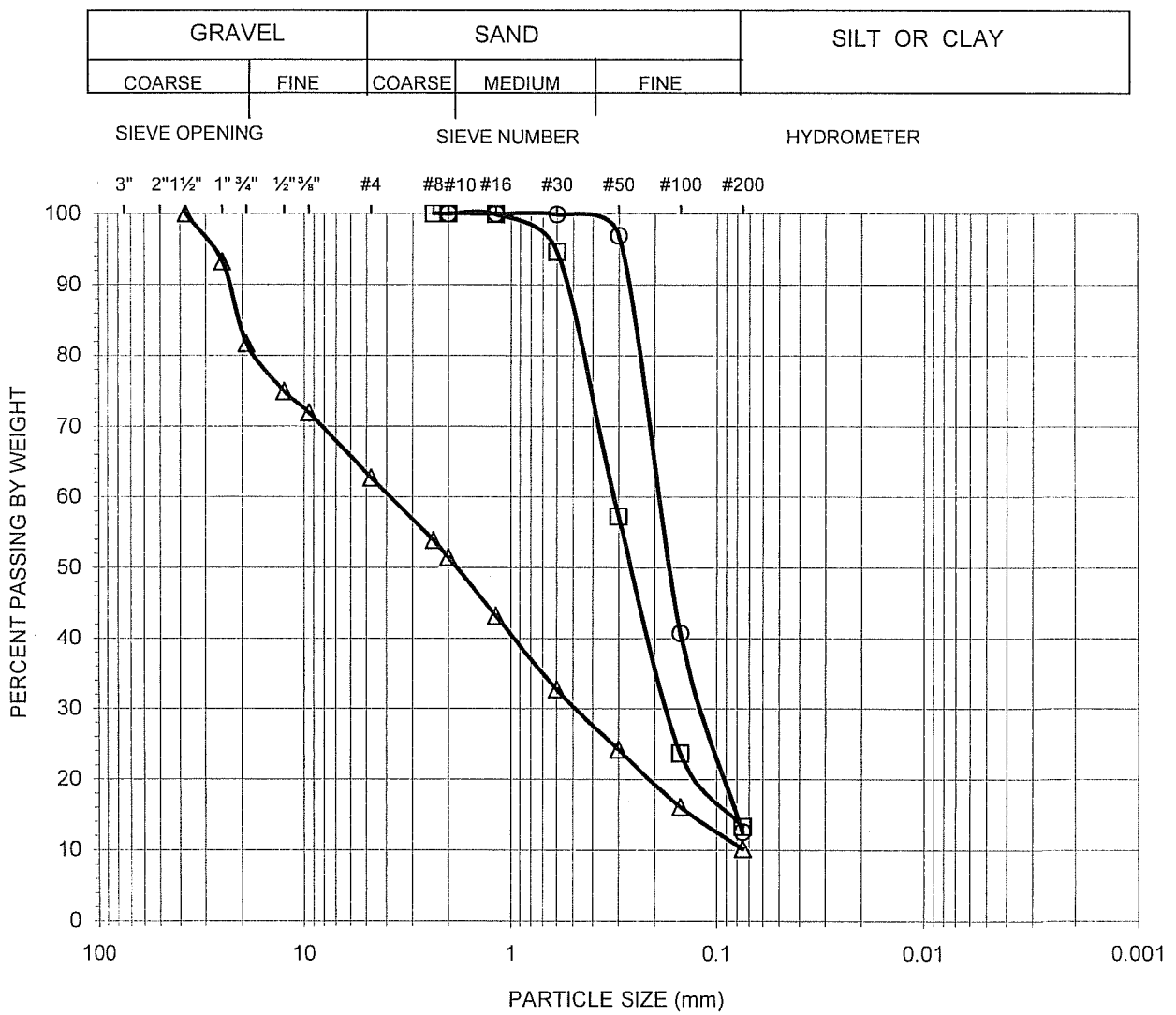


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-018	S-04	20	0.95	28.19	70.86	26:21:5	CL-ML
□	R-09-018	U-08	32.5	0.43	77.56	22.01	N/P	SM
△	R-09-018	D-14	55	0.00	7.33	92.67	32:25:7	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

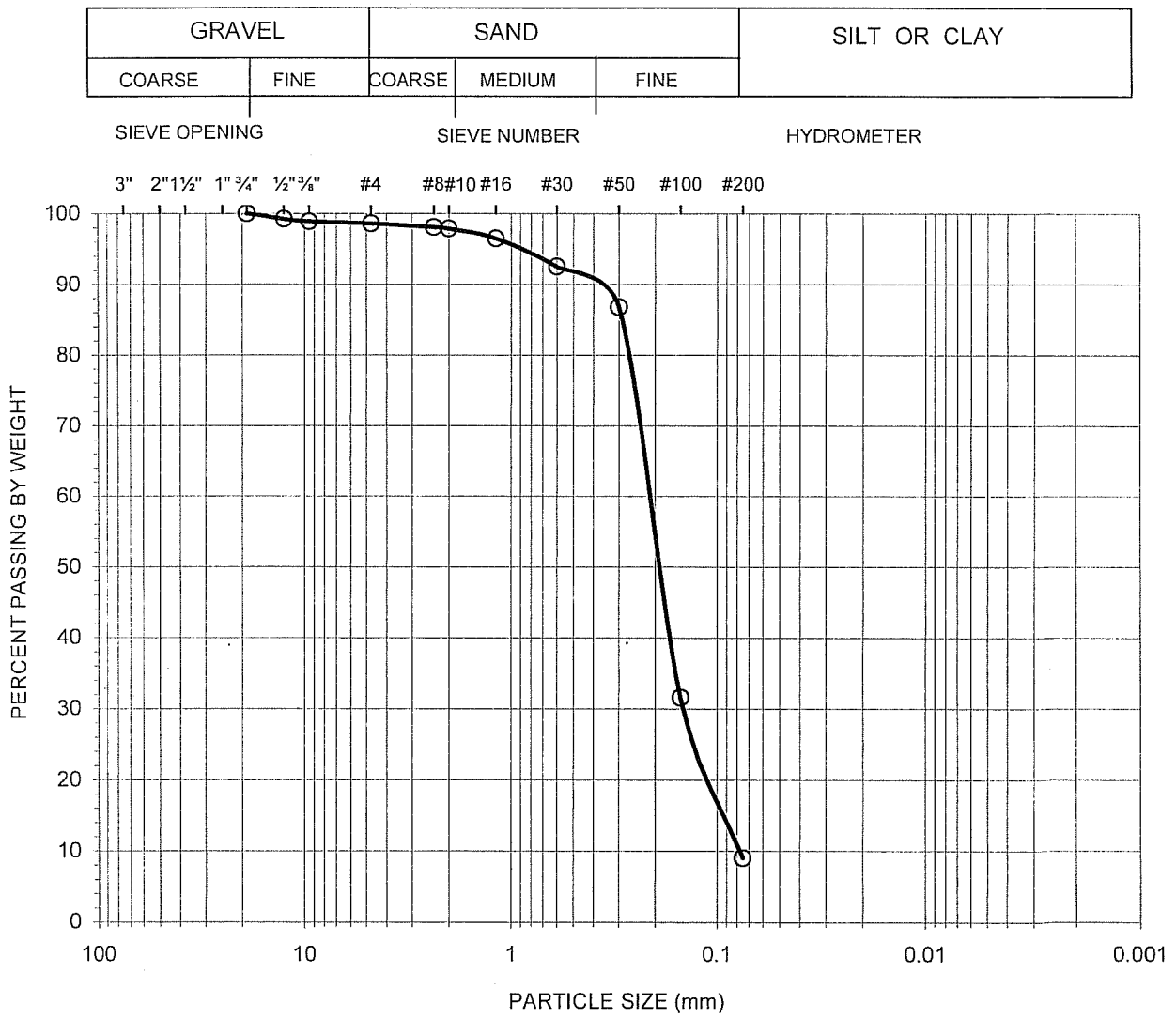


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-018	S-16	65	0.00	87.44	12.56	N/A	SM
□	R-09-018	S-20	85	0.00	86.72	13.28	N/A	SM
△	R-09-018	S-25	135	37.26	52.56	10.18	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/10/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

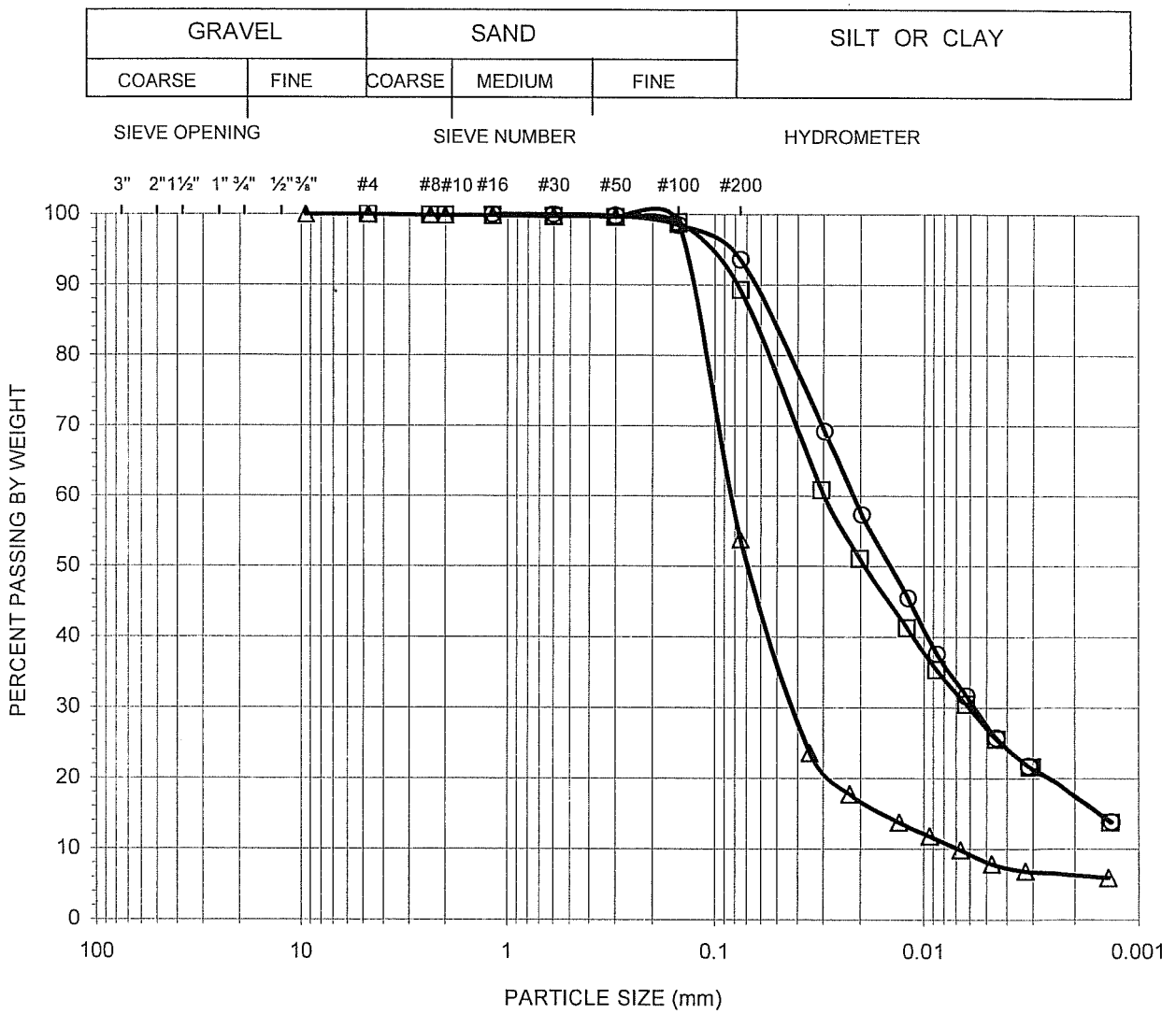


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-018	S-27	160	1.41	89.54	9.05	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

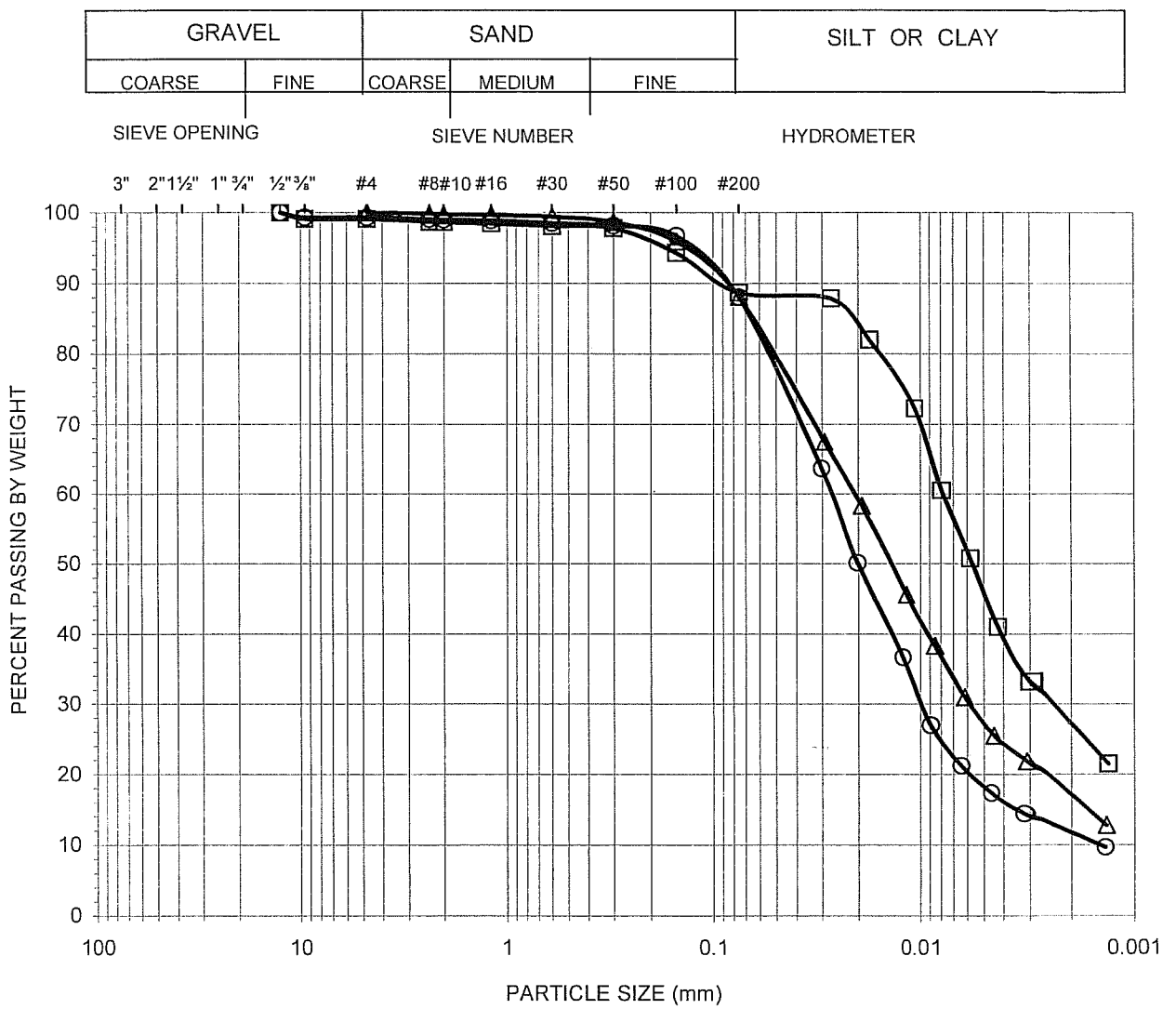


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-019	S-03	15	0.00	6.41	93.59	37:27:10	ML
□	R-09-019	S-05	25	0.00	10.72	89.28	32:24:8	ML
△	R-09-019	D-08	40	0.00	46.18	53.82	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

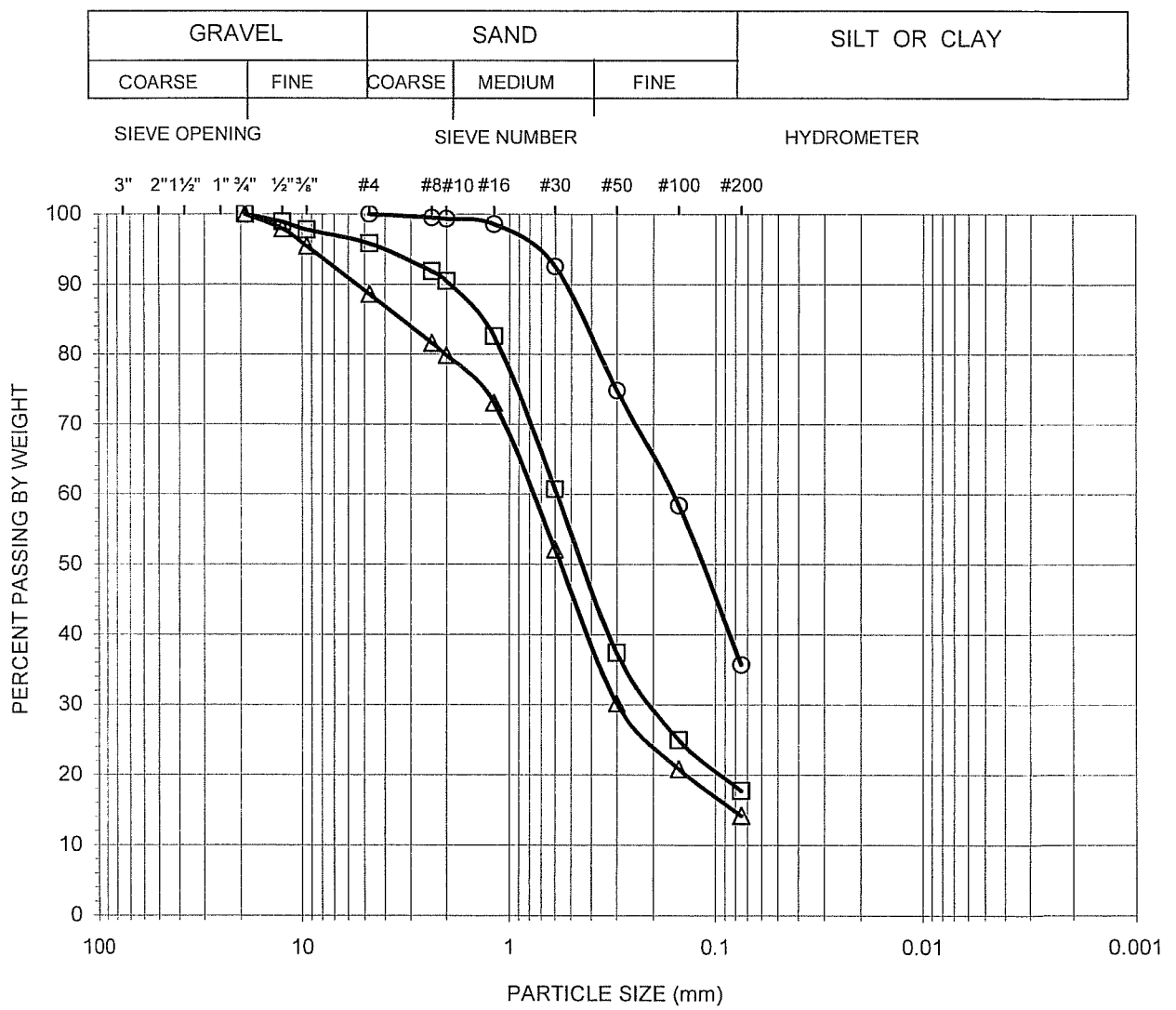


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-019	S-11	55	0.69	11.27	88.04	N/A	ML
□	R-09-019	D-12	60	0.93	10.38	88.69	38:24:14	CL
△	R-09-019	U-13	65	0.00	11.88	88.12	28:22:6	CL-ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/13/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

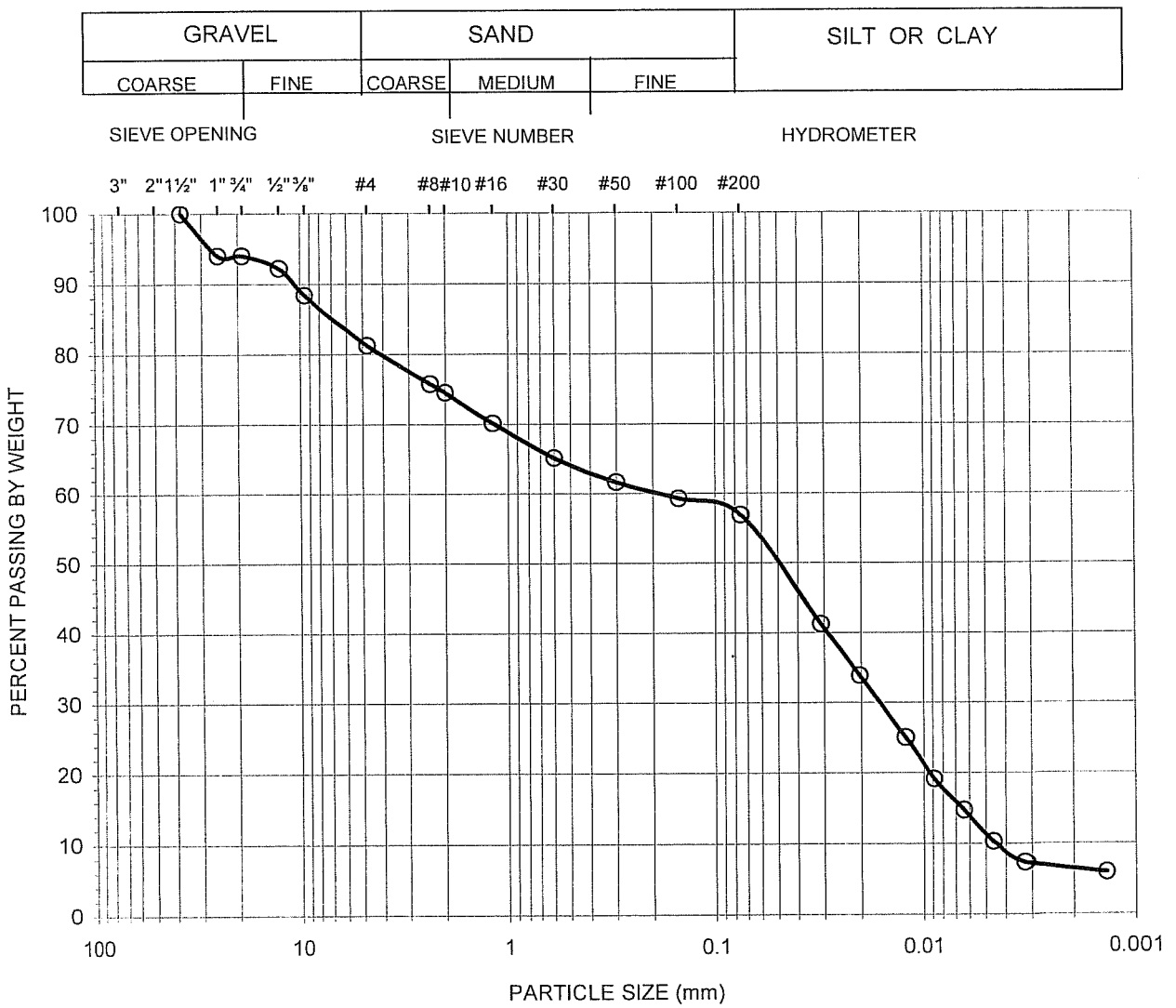


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-019	S-15	75	0.00	64.32	35.68	N/A	SM
□	R-09-019	S-19	110	4.20	78.07	17.73	N/A	SM
△	R-09-019	S-21	130	11.38	74.40	14.22	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/13/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/20/09

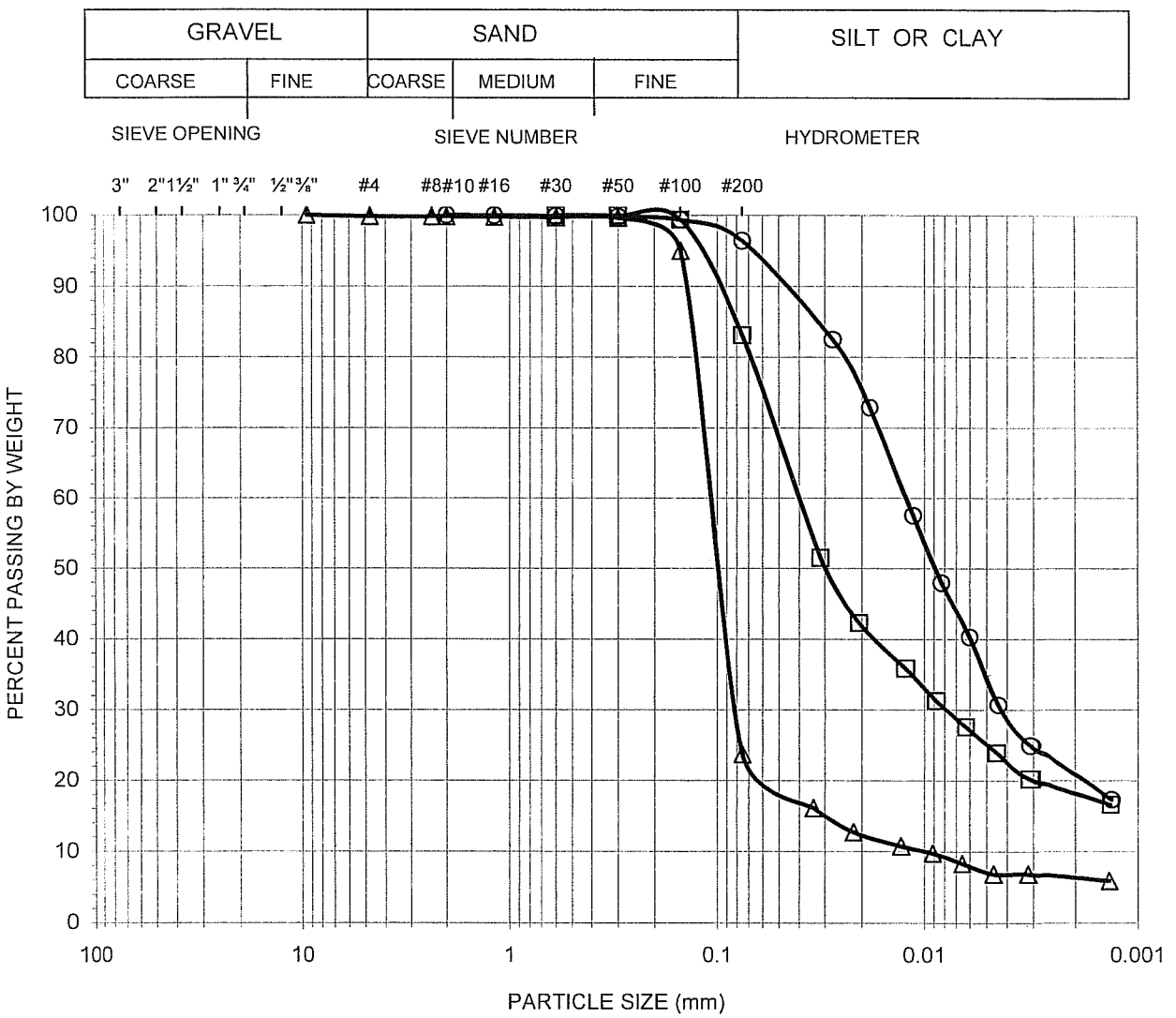


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-019	S-23	150	18.74	24.34	56.92	30:25:5	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

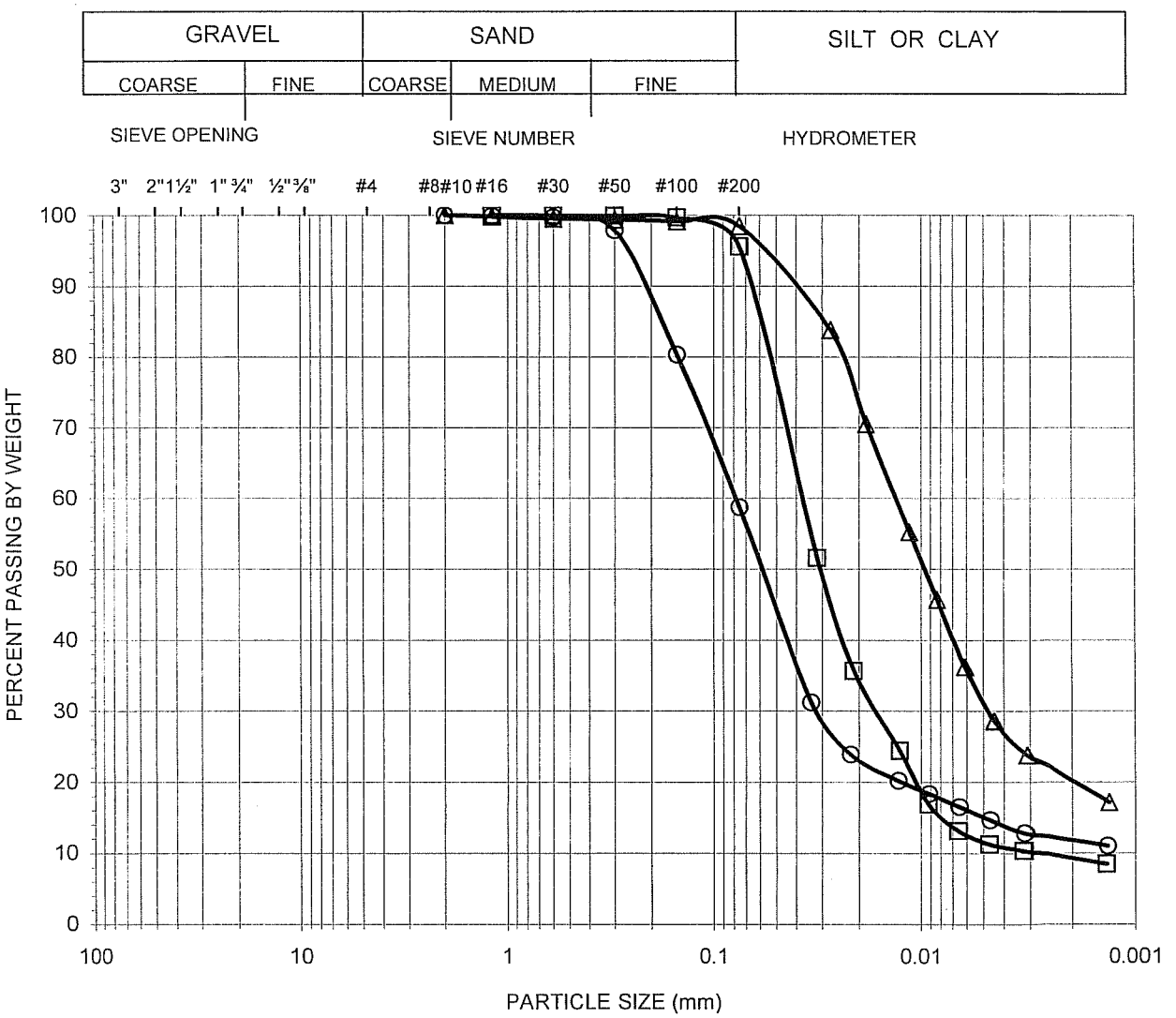


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-020	U-04	20	0.00	3.58	96.42	39:24:15	CL
□	R-09-020	D-06	30	0.00	16.93	83.07	30:26:4	ML
△	R-09-020	U-08	40	0.17	76.17	23.66	N/P	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

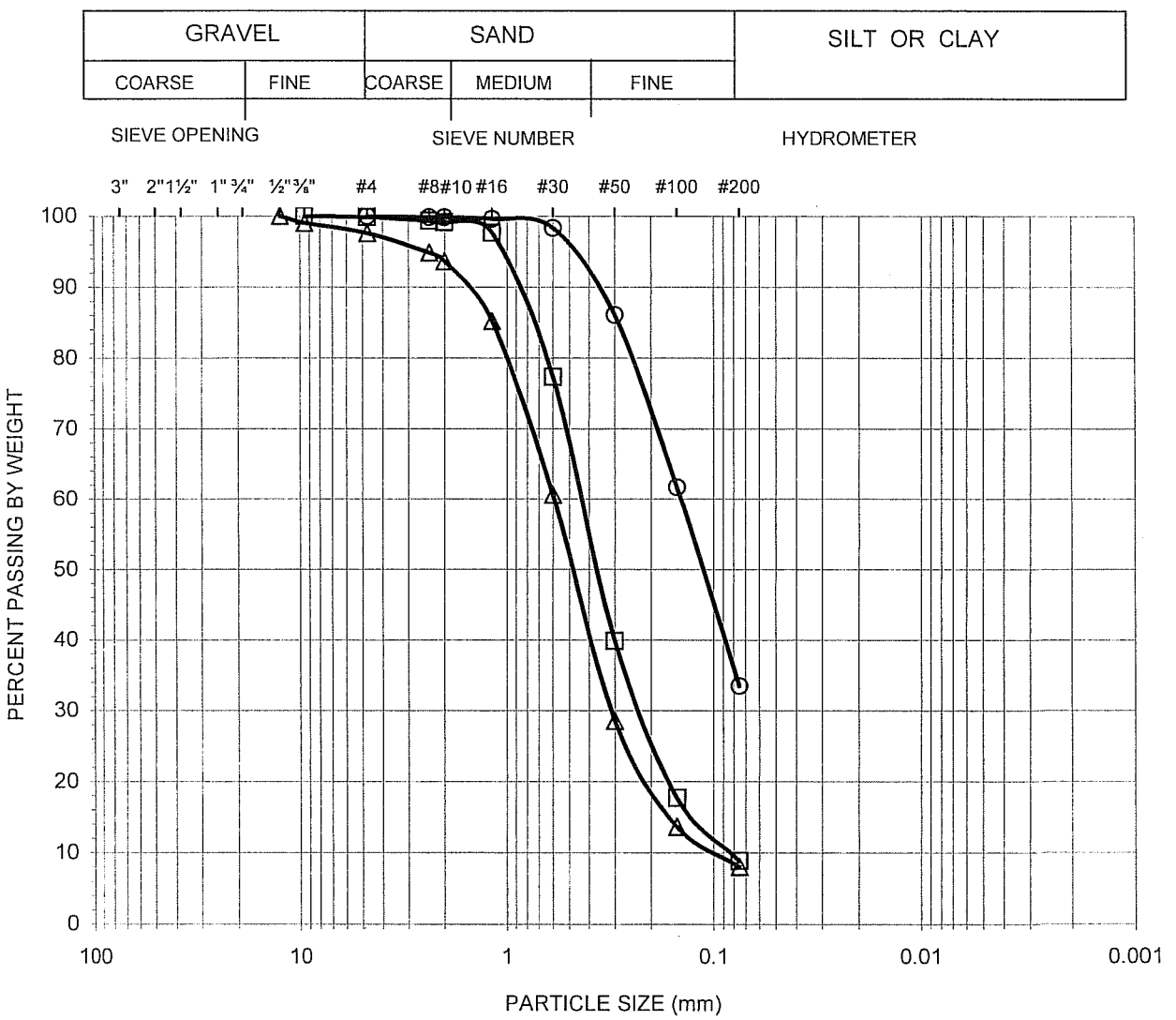


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-020	D-10	50	0.00	41.25	58.75	N/P	ML
□	R-09-020	D-12	60	0.00	4.42	95.58	N/P	ML
△	R-09-020	D-14	70	0.00	1.56	98.44	36:27:9	CL-ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

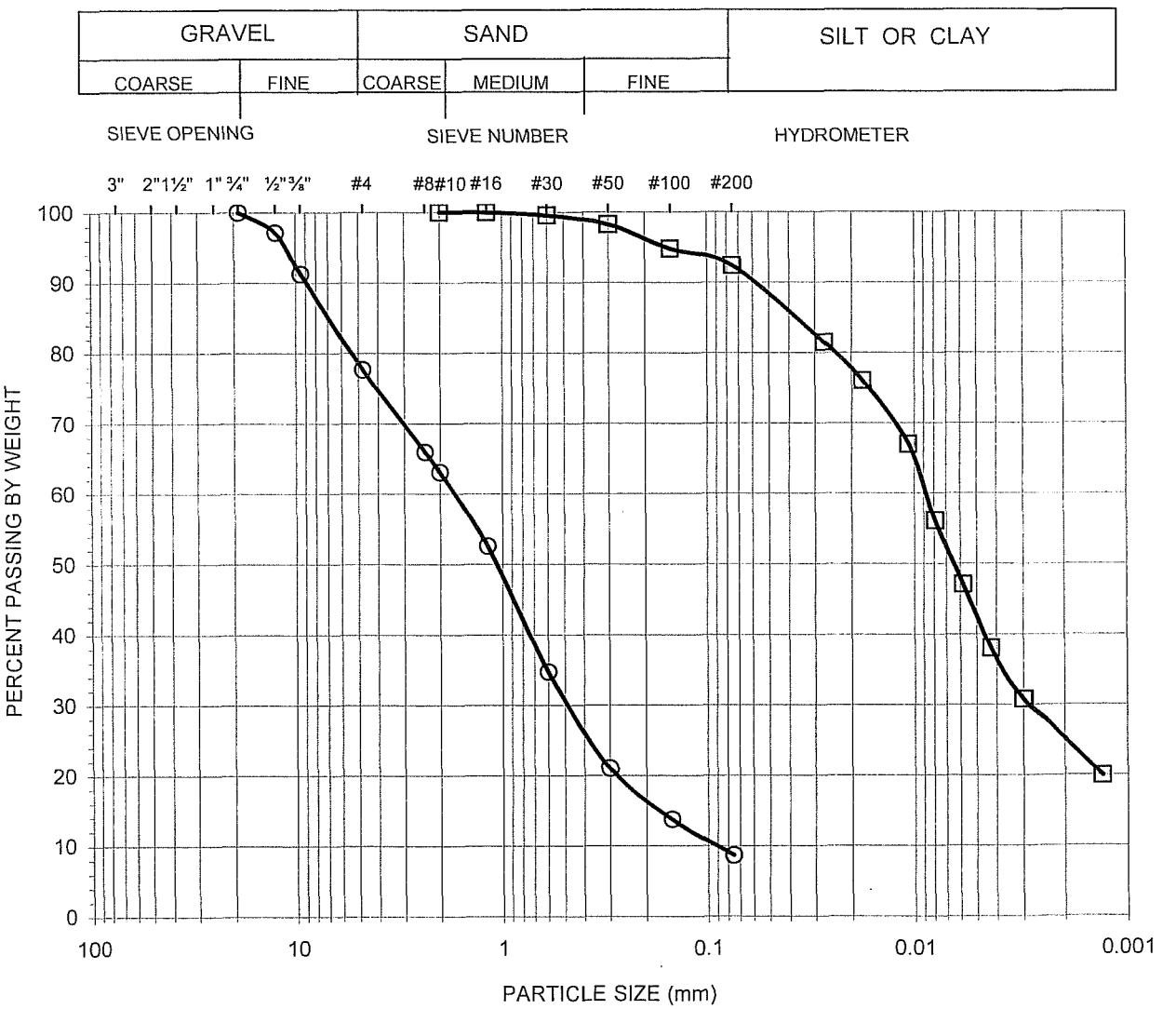


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-020	S-15-2	75.3	0.00	66.51	33.49	N/A	SM
□	R-09-020	S-17	85	0.15	91.02	8.83	N/A	SP-SM
△	R-09-020	S-20	115	2.41	89.55	8.04	N/A	SP-SM

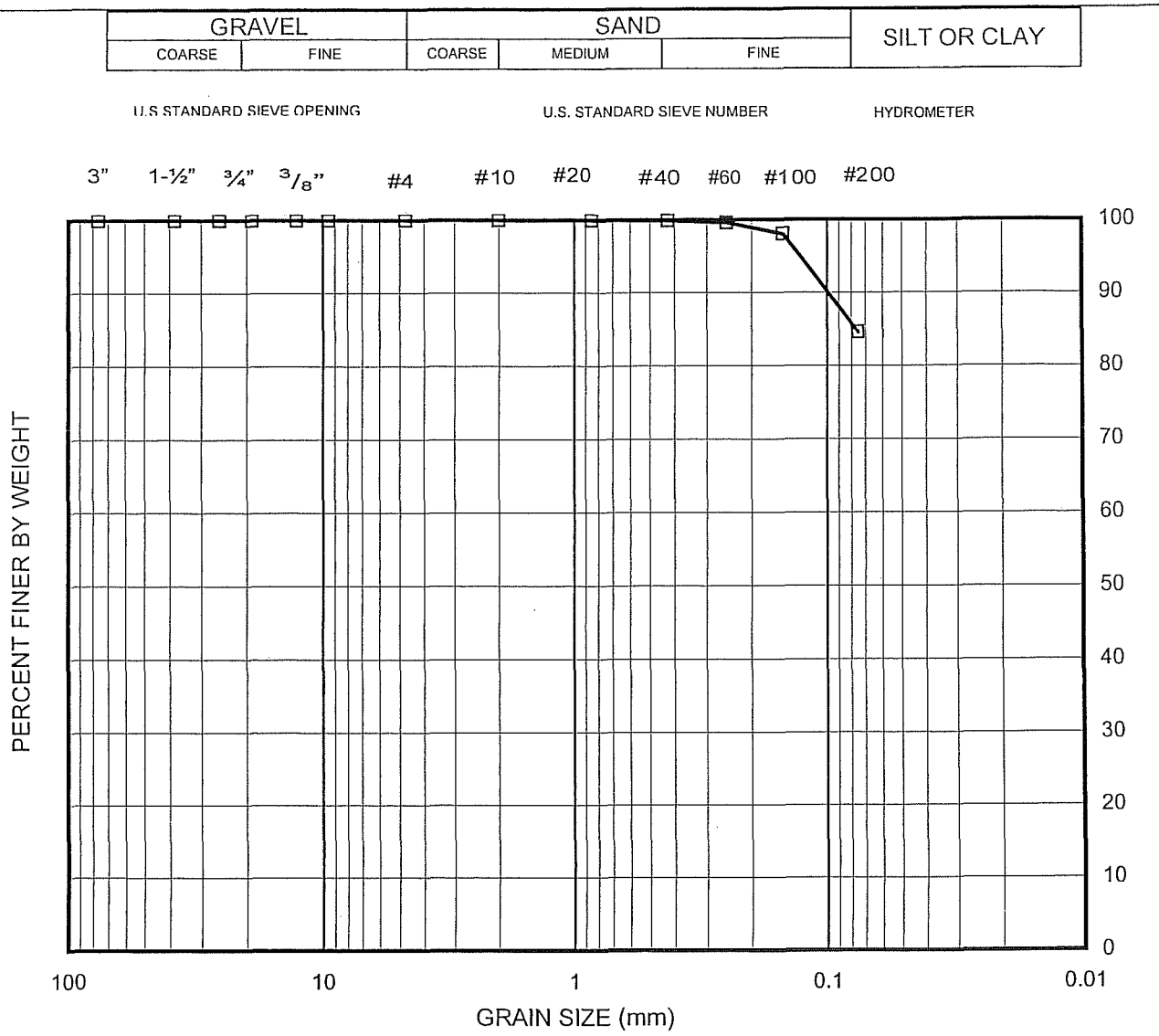
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-020	S-22	140	22.36	69.03	8.61	N/A	SW-SM
□	R-09-020	S-25	185	0.00	7.62	92.38	33:24:9	ML



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-021	D-02	10	RING	ML	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

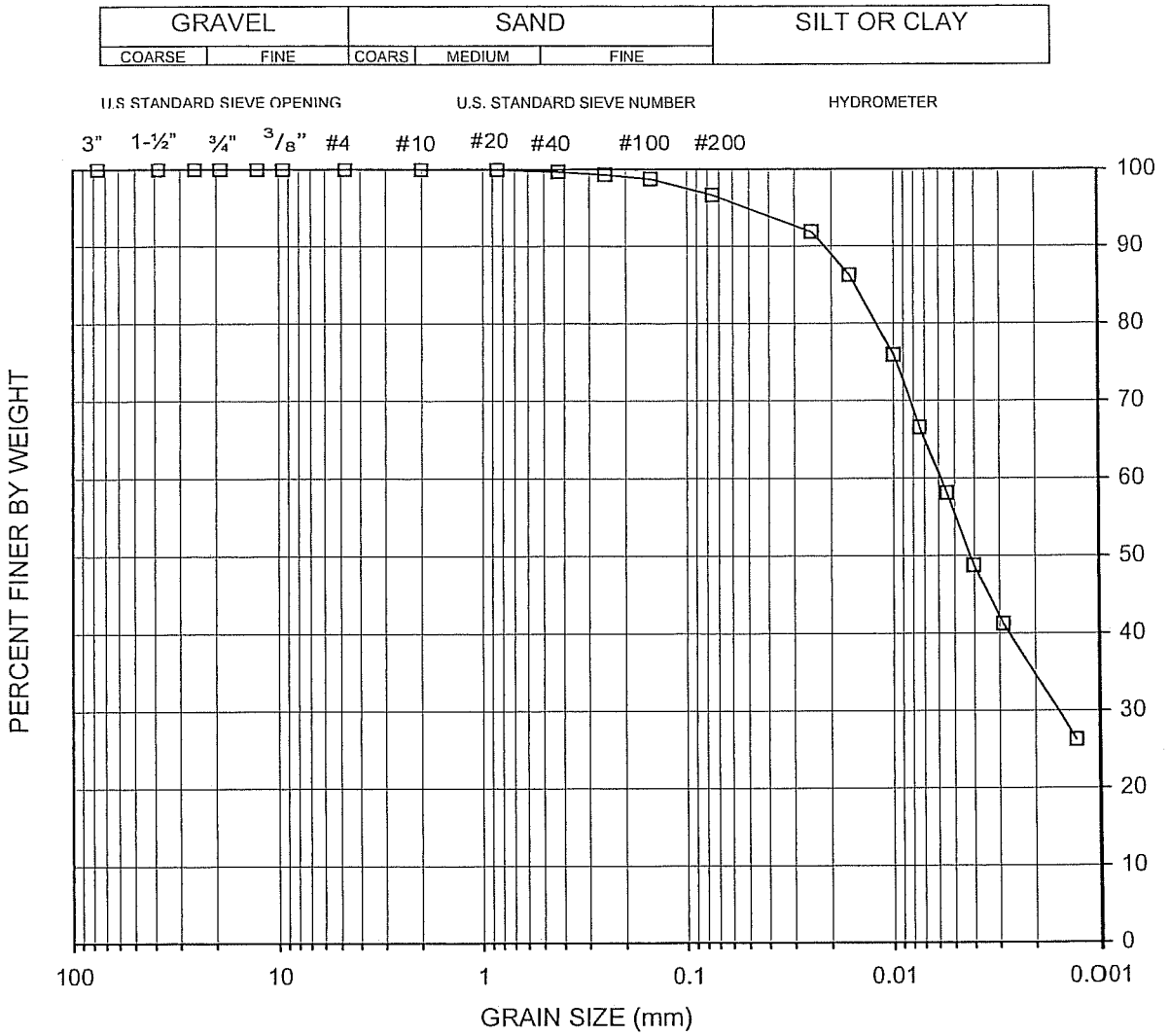
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-021	U-04	20	Shelby Tube	CH	61	32

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

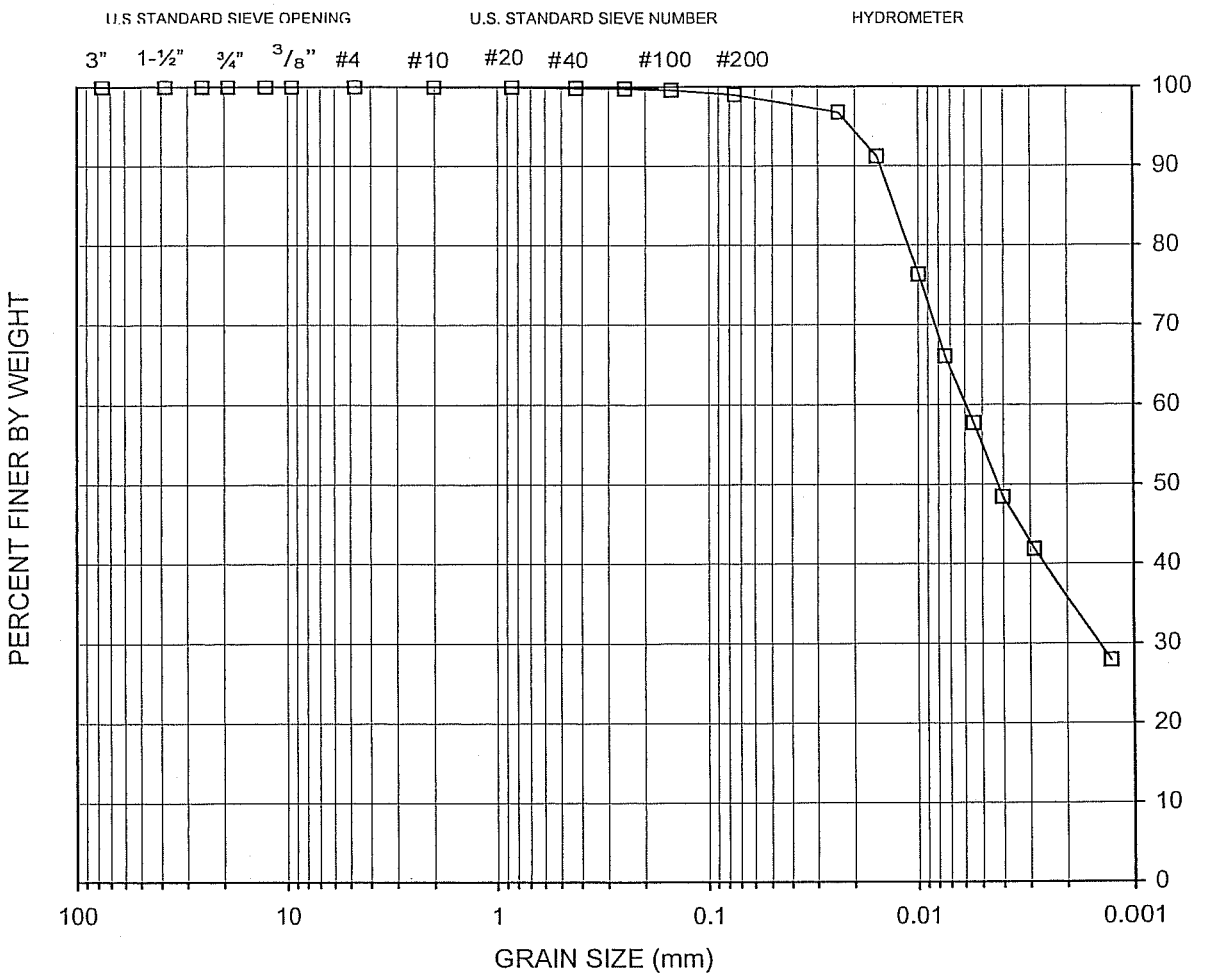
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-021	U-10	45	Shelby Tube	CH	56	30

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

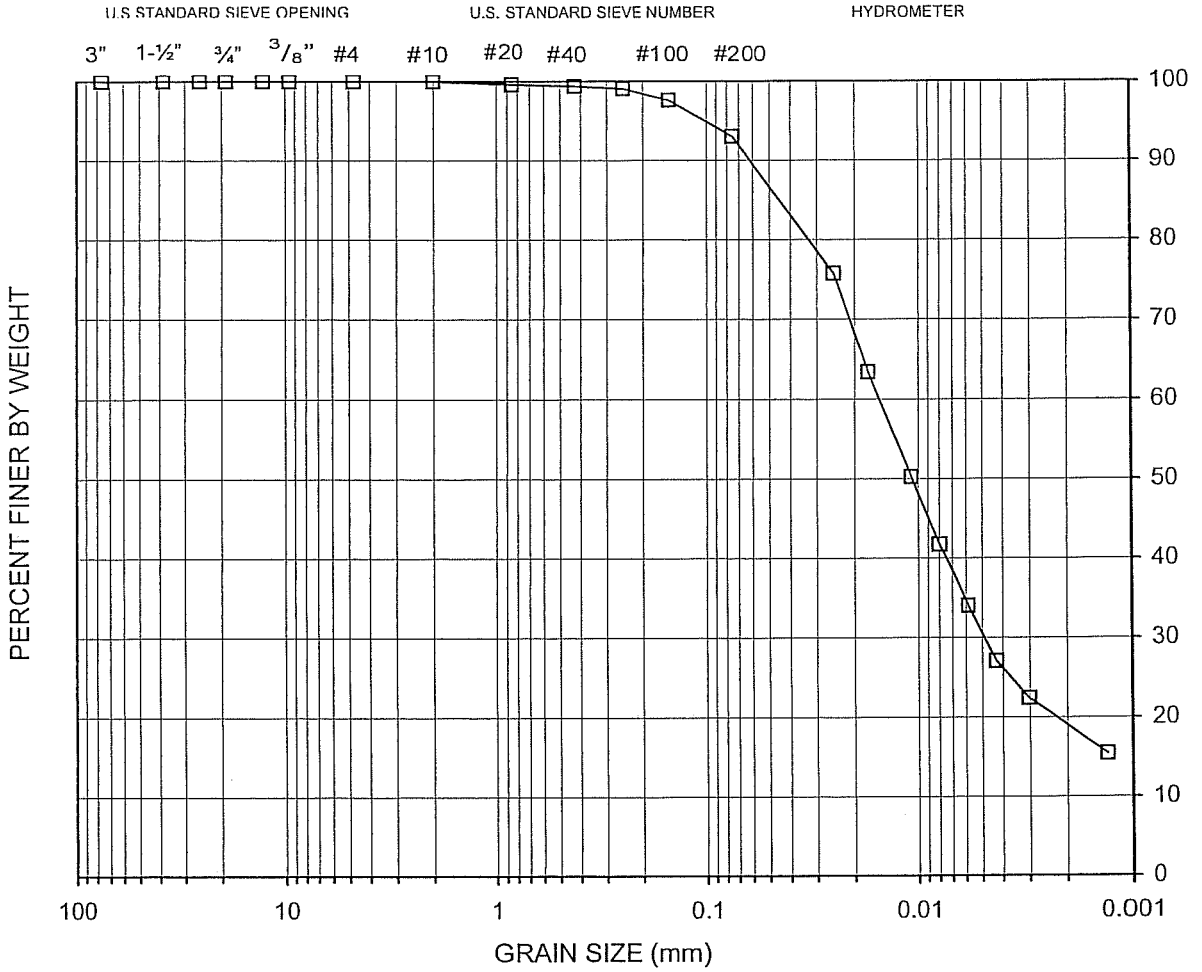
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-021	D-17	75	RING	CL	35	12

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

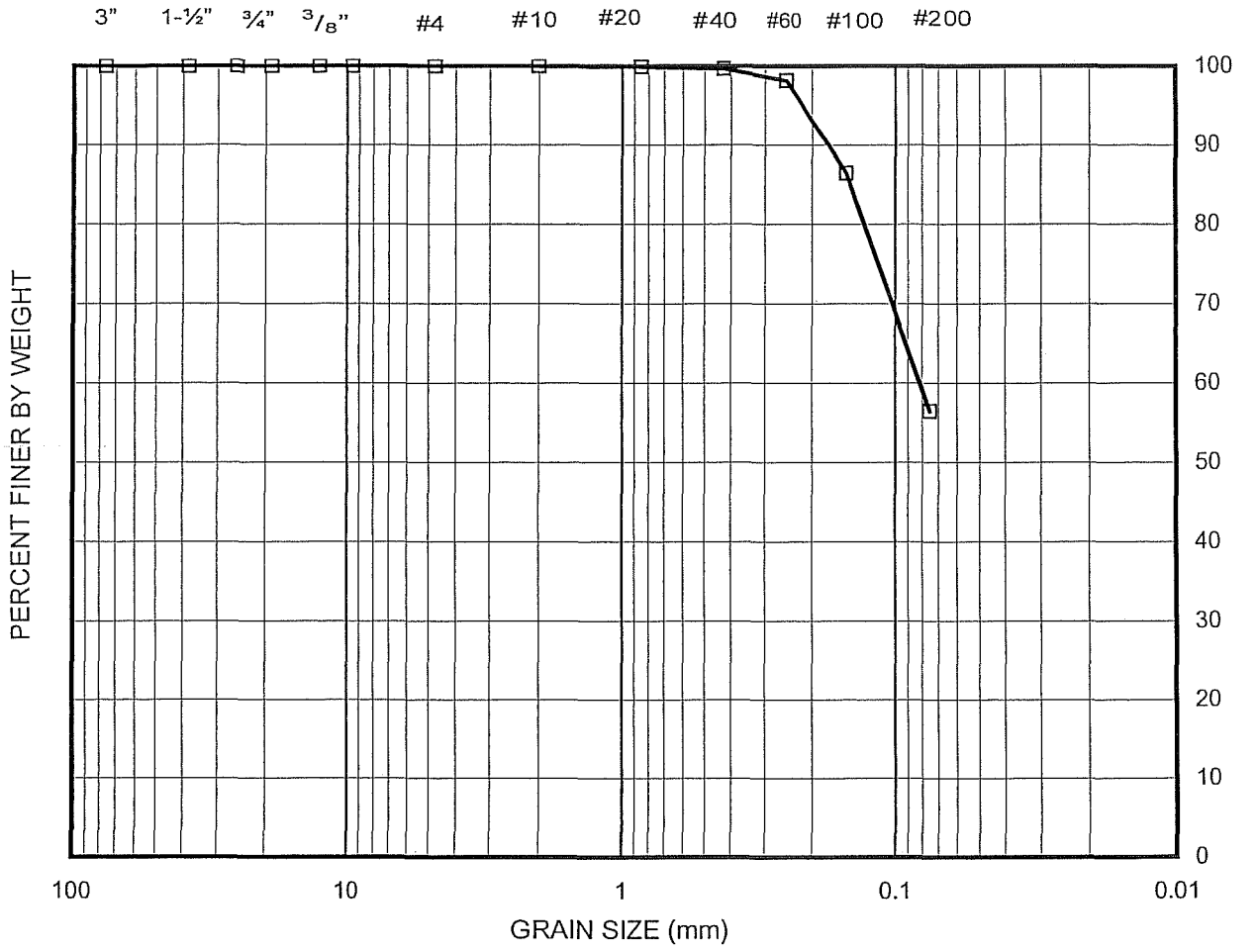
11/29/09

(ASTM D422)

FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-021	S-18	80	Bag	ML	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

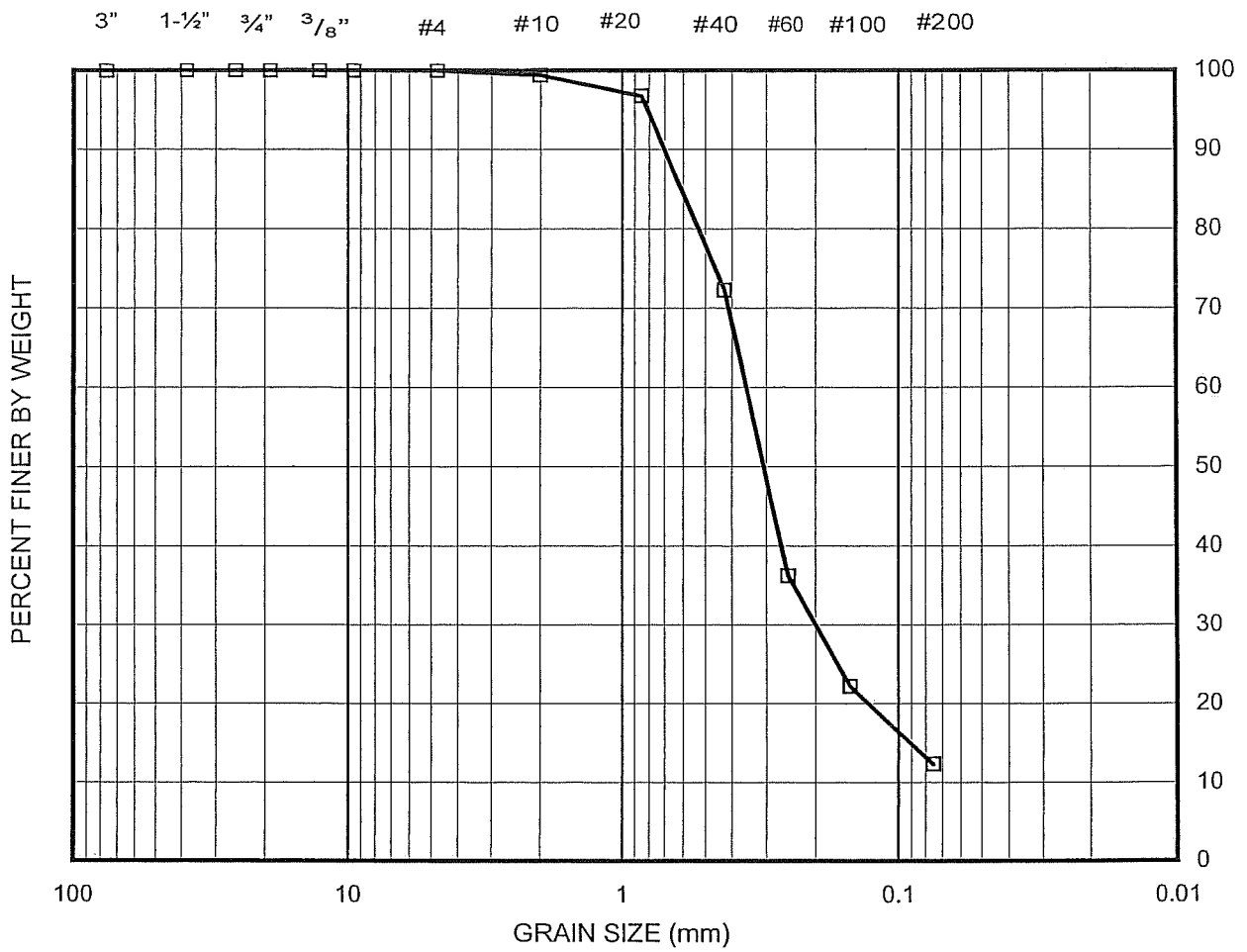
EGL Project No: 09-230-008

GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-021	S-21	115	Bag	SP-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008

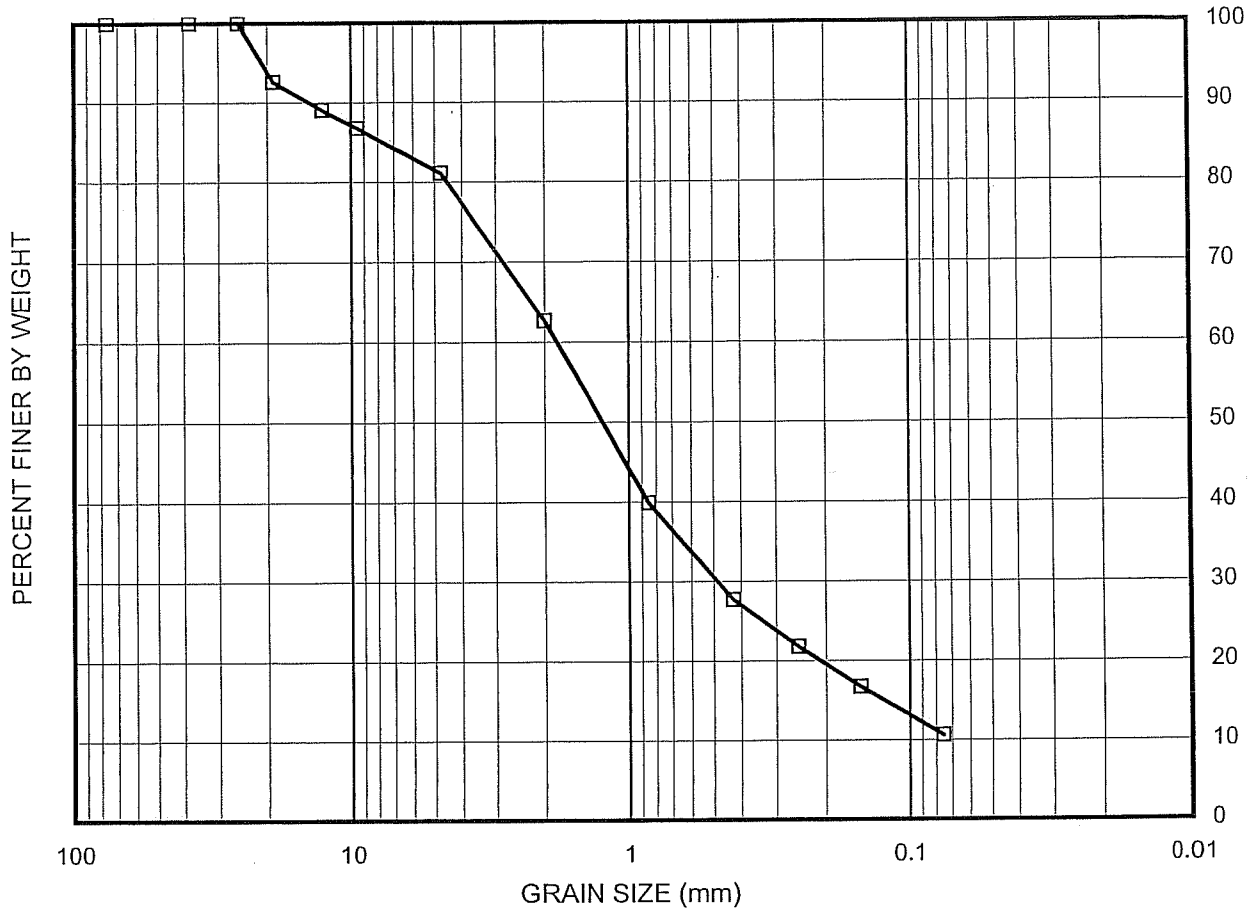
GRAIN SIZE DISTRIBUTION CURVE

Nov-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING U.S. STANDARD SIEVE NUMBER HYDROMETER

3" 1-½" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-021	S-23	150	Bag	SW-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client Job No.: 06-123-03
Client Name: Earth Mechanics, Inc.
EGL Project No: 09-230-008

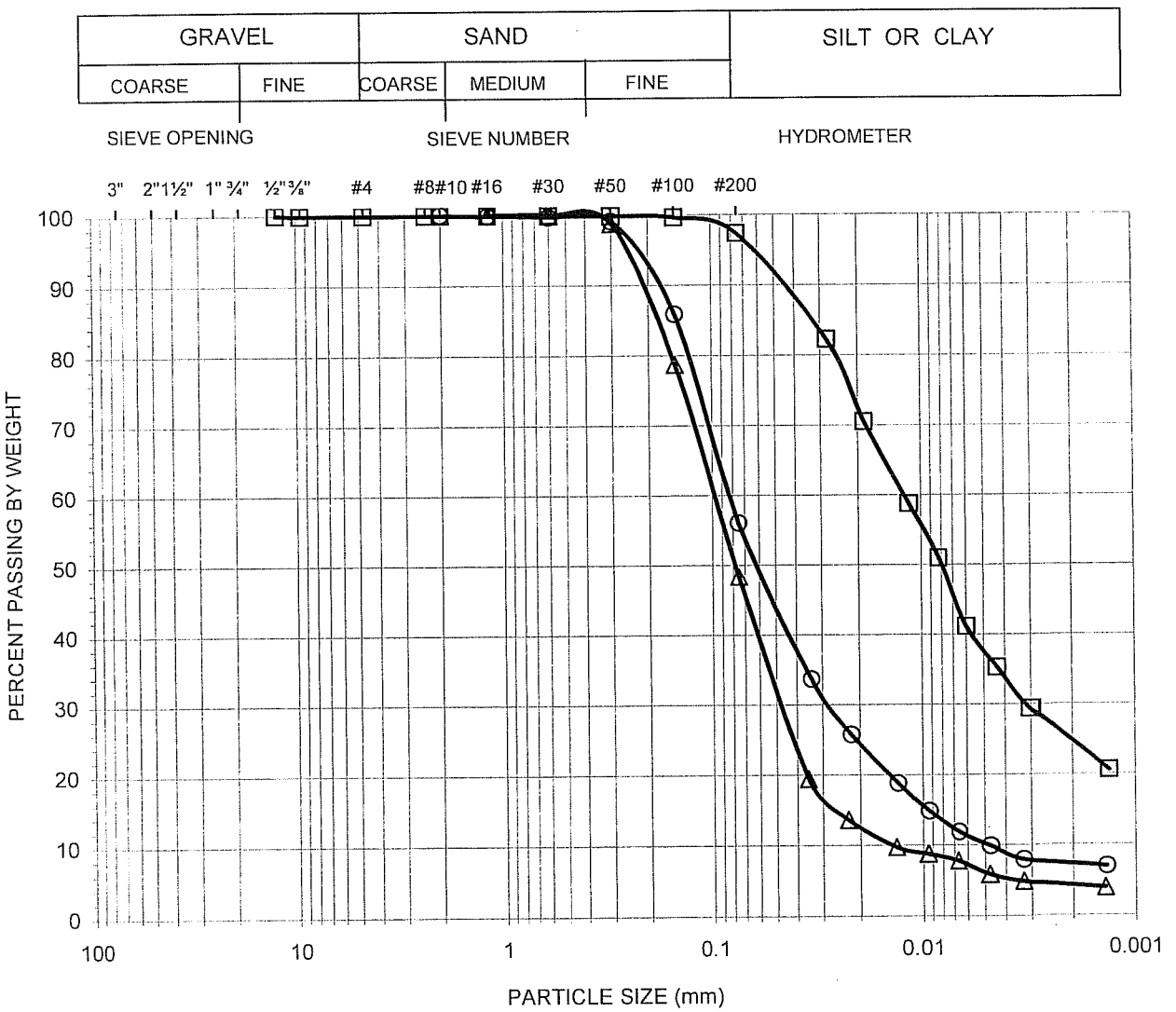
GRAIN SIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/03/10

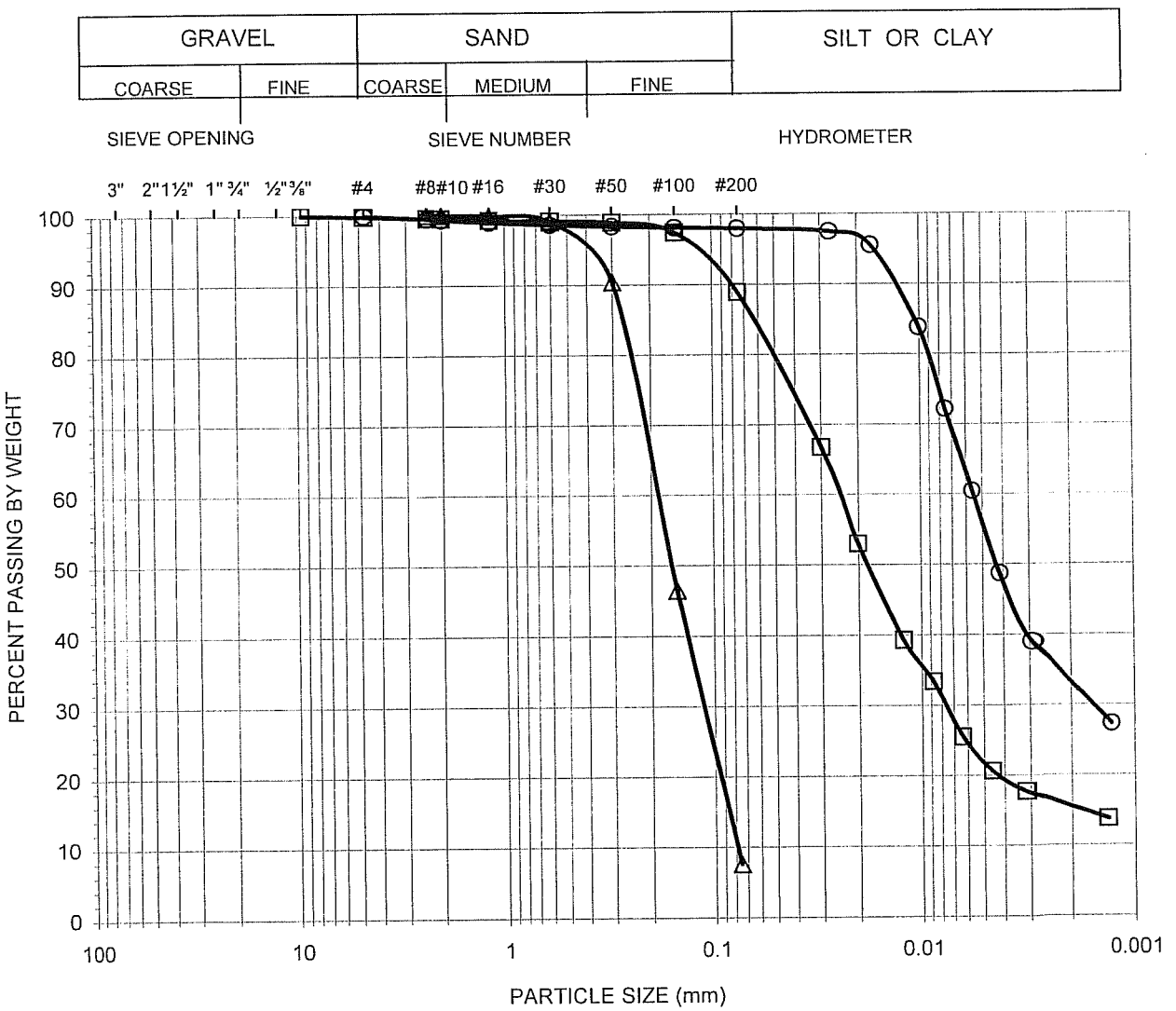


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-022	S-03	15	0.00	43.95	56.05	N/A	ML
□	R-09-022	U-08	40	0.06	2.60	97.34	34:24:10	CL
△	R-09-022	U-11	55	0.00	51.66	48.34	N/P	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/03/10

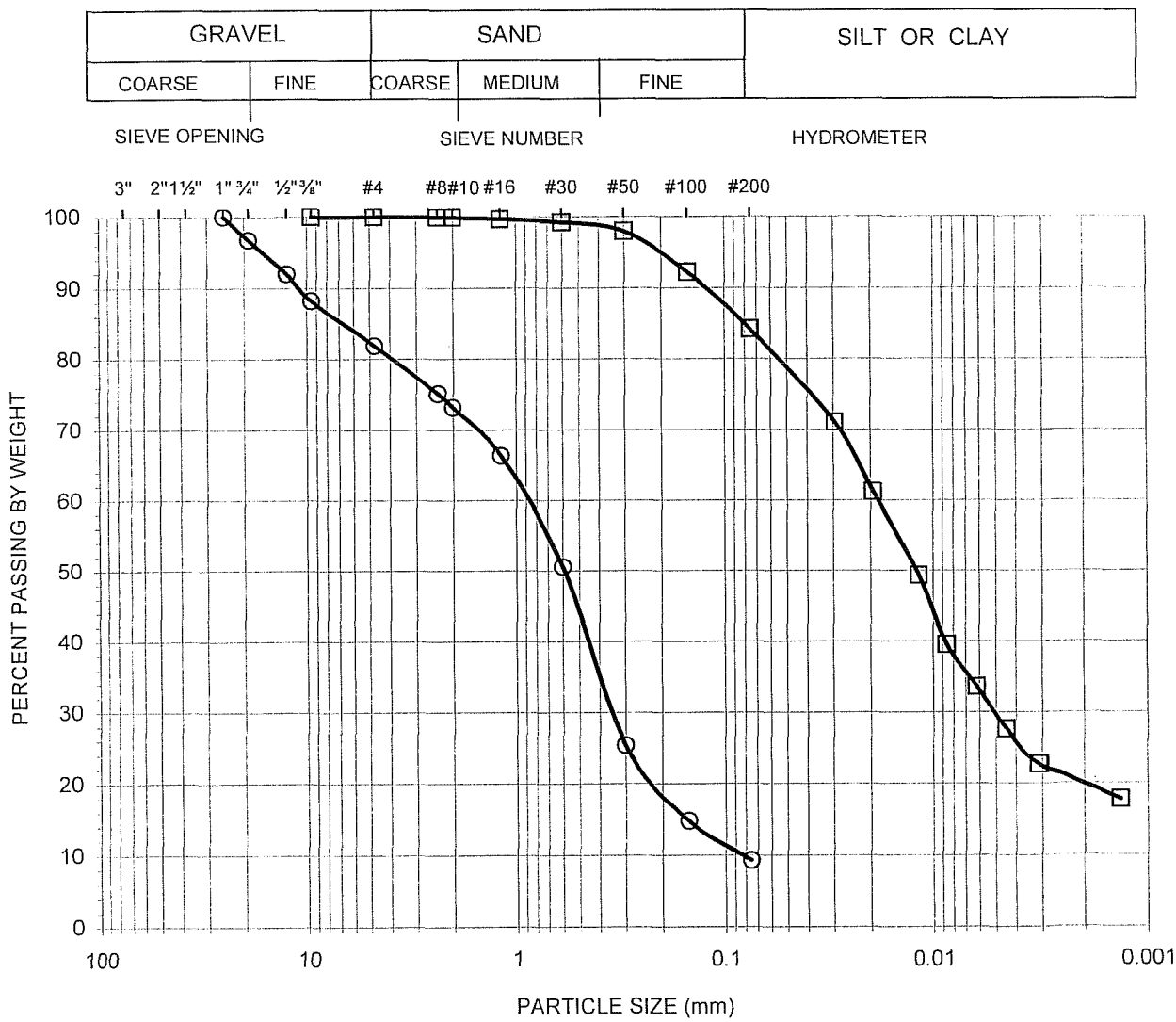


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-022	D-12	60	0.00	2.02	97.98	46:27:19	CL
□	R-09-022	S-15	75	0.16	10.98	88.86	29:22:7	CL-ML
△	R-09-022	D-16	85	0.00	92.48	7.52	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/03/10

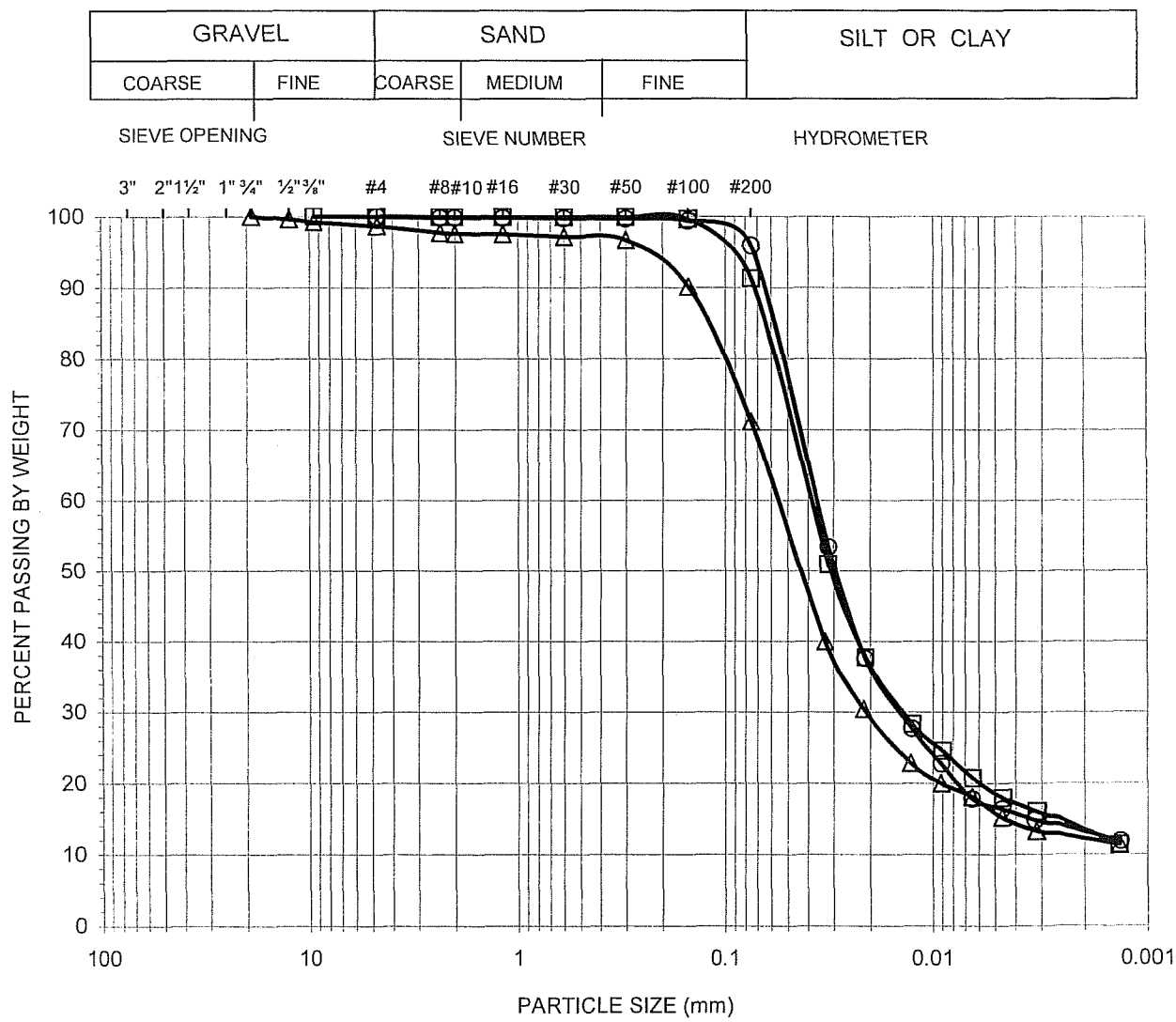


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-022	S-19	115	18.11	72.59	9.30	N/A	SW-SM
□	R-09-022	S-22	160	0.03	15.75	84.22	30:22:8	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

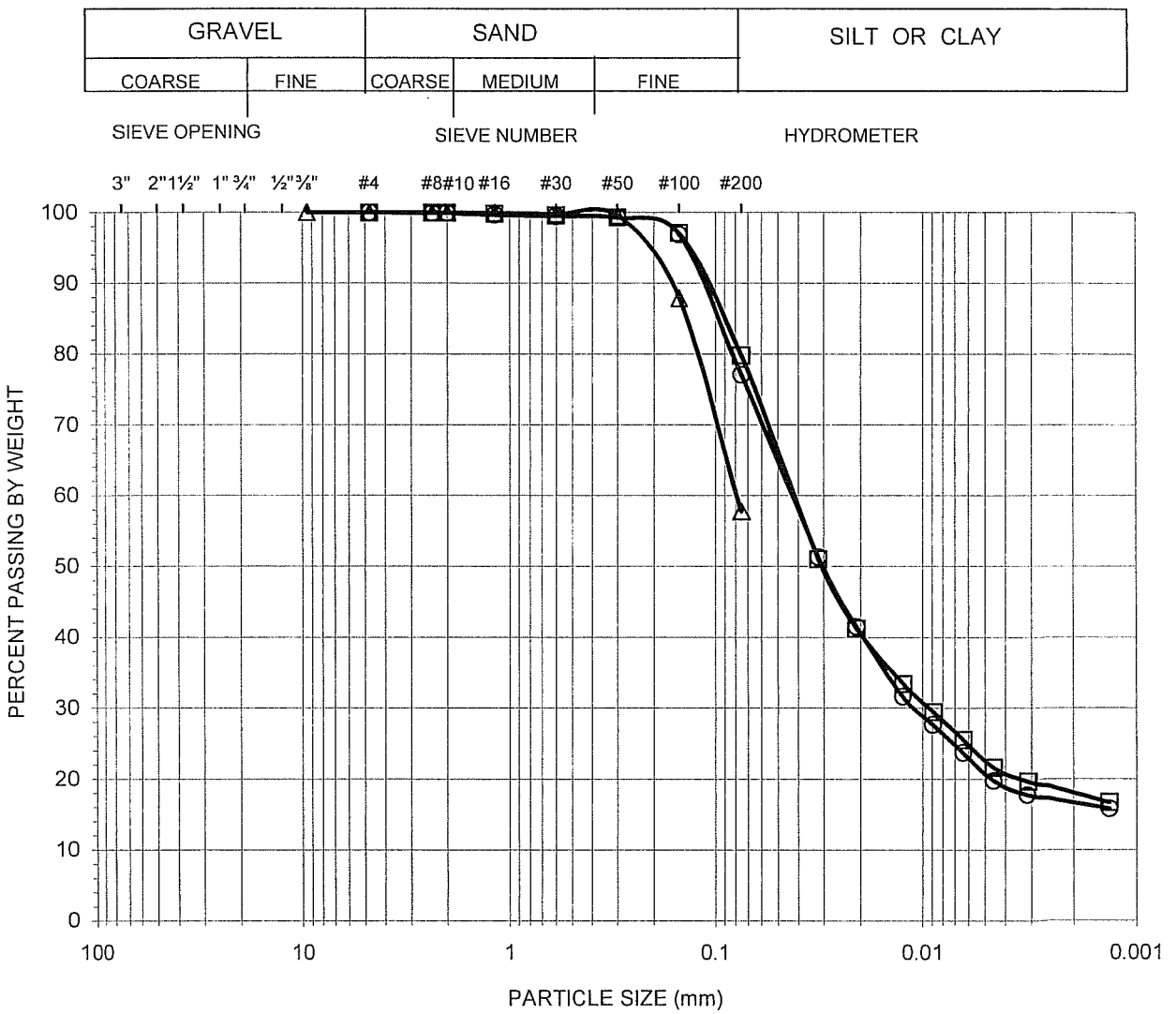


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-023	S-03	15	0.00	4.09	95.91	N/A	ML
□	R-09-023	U-07	35	0.01	8.67	91.32	32:25:7	ML
△	R-09-023	U-09	45	1.34	27.50	71.16	29:22:7	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

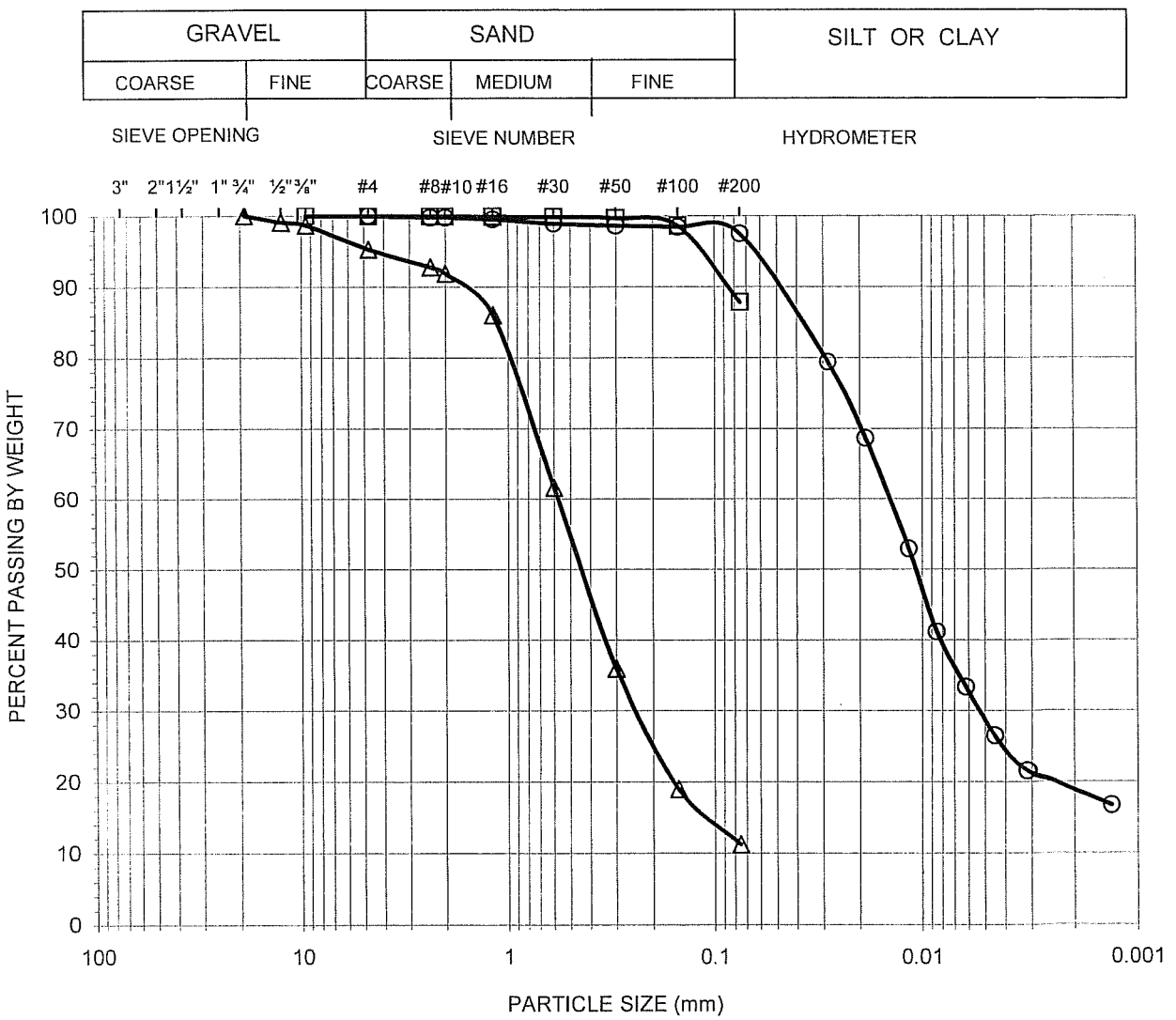


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-023	D-13-1	65	0.00	22.94	77.06	33:21:12	CL
□	R-09-023	D-13-2	65.5	0.00	20.21	79.79	32:20:12	CL
△	R-09-023	S-14	70	0.03	42.23	57.74	N/A	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

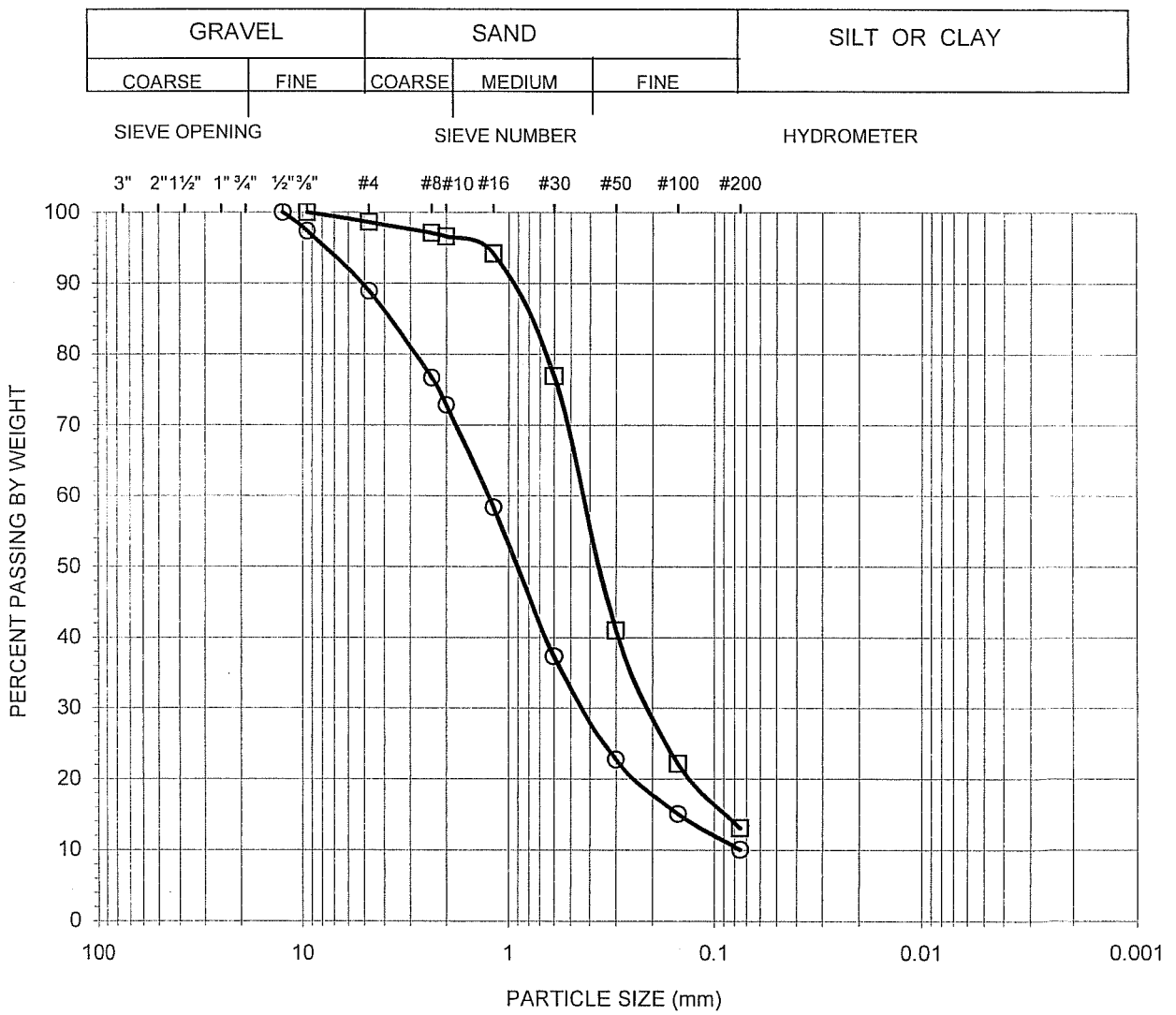


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-023	D-15	75	0.00	2.51	97.49	37:27:10	ML
□	R-09-023	S-16	80	0.03	12.12	87.85	N/P	ML
△	R-09-023	S-19	100	4.73	84.01	11.26	N/A	SW-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/14/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/20/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/21/09

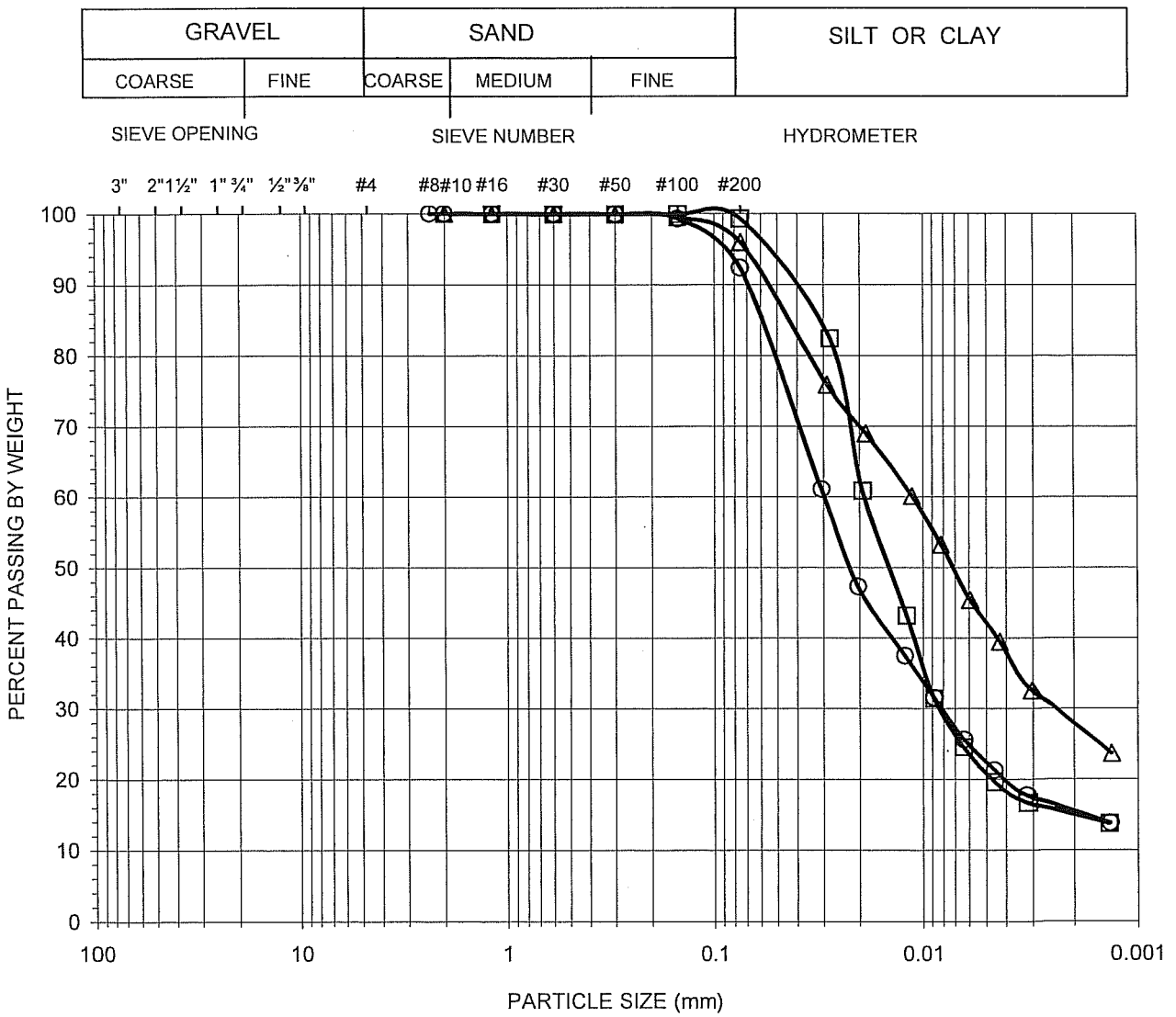


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-023	S-22	130	11.10	78.85	10.05	N/A	SW-SM
□	R-09-023	S-24	150	1.41	85.51	13.08	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/05/10

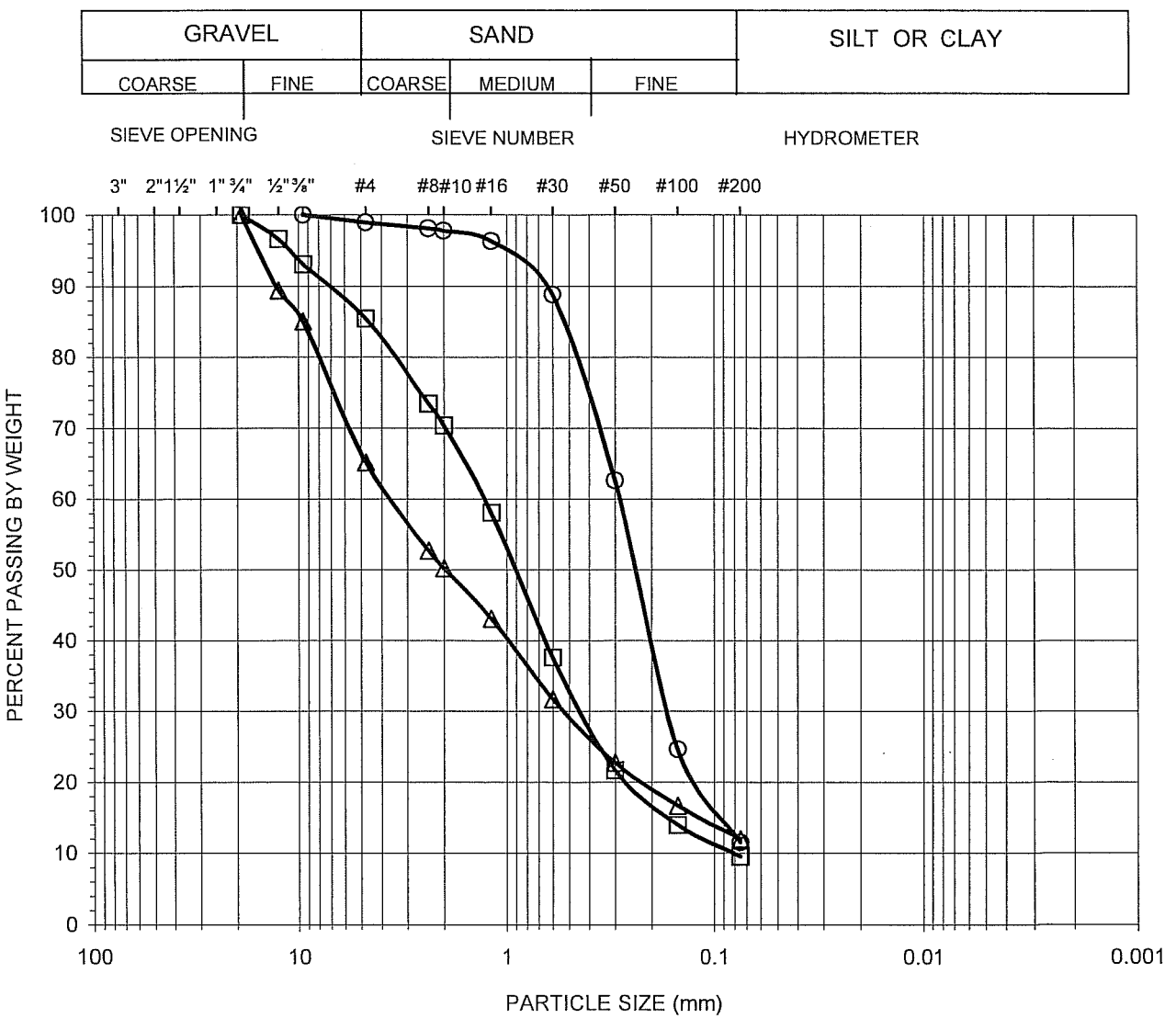


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-024	U-06	30	0.00	7.65	92.35	35:25:9	ML
□	R-09-024	D-08	40	0.00	0.71	99.29	N/P	ML
△	R-09-024	U-12	60	0.00	4.04	95.96	40:25:15	CL

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/05/10

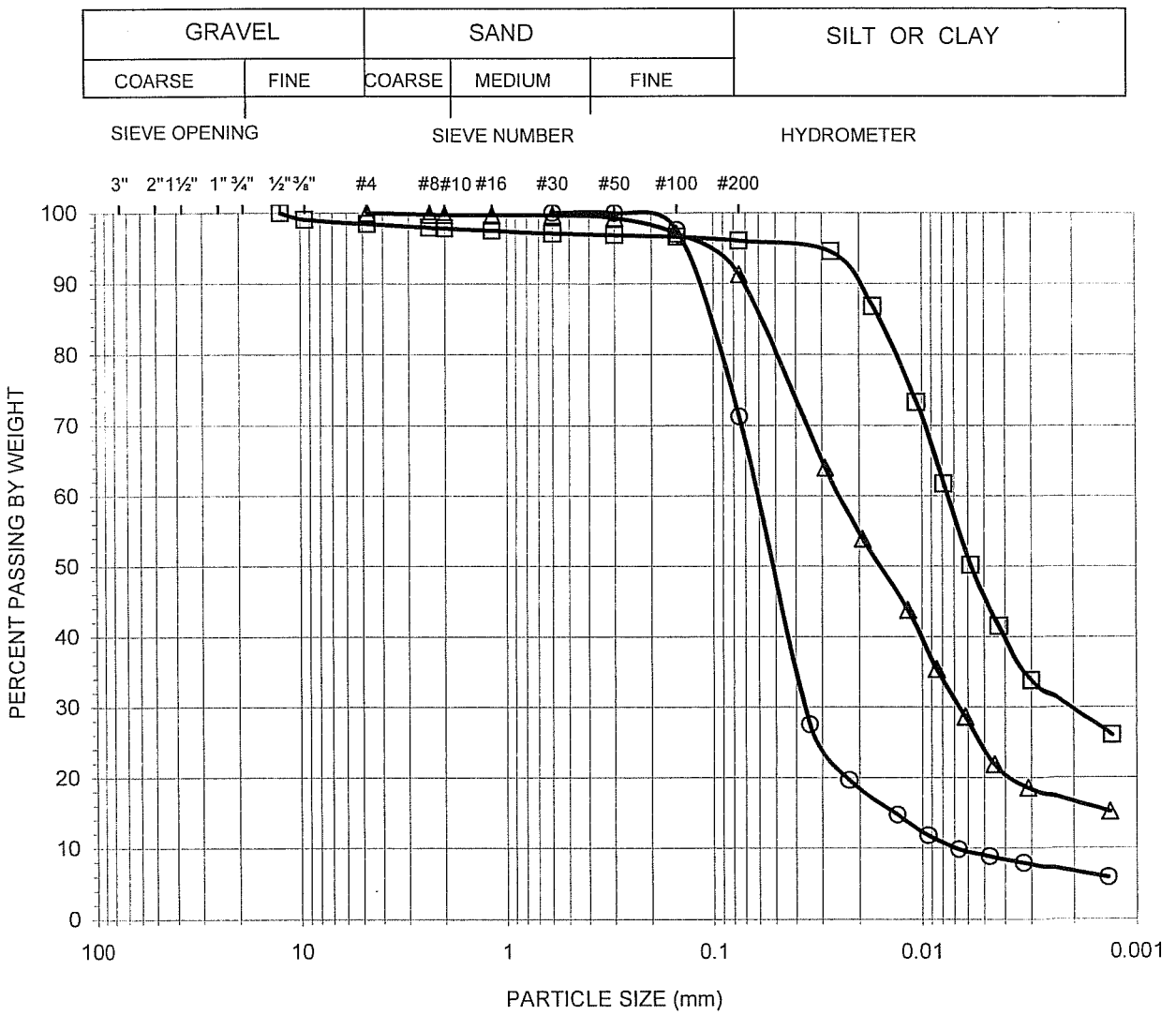


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-024	S-18	90	1.08	87.40	11.52	N/A	SP-SM
□	R-09-024	S-22	120	14.55	75.93	9.52	N/A	SW-SM
△	R-09-024	S-25	150	34.83	53.18	11.99	N/A	SW-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/28/09

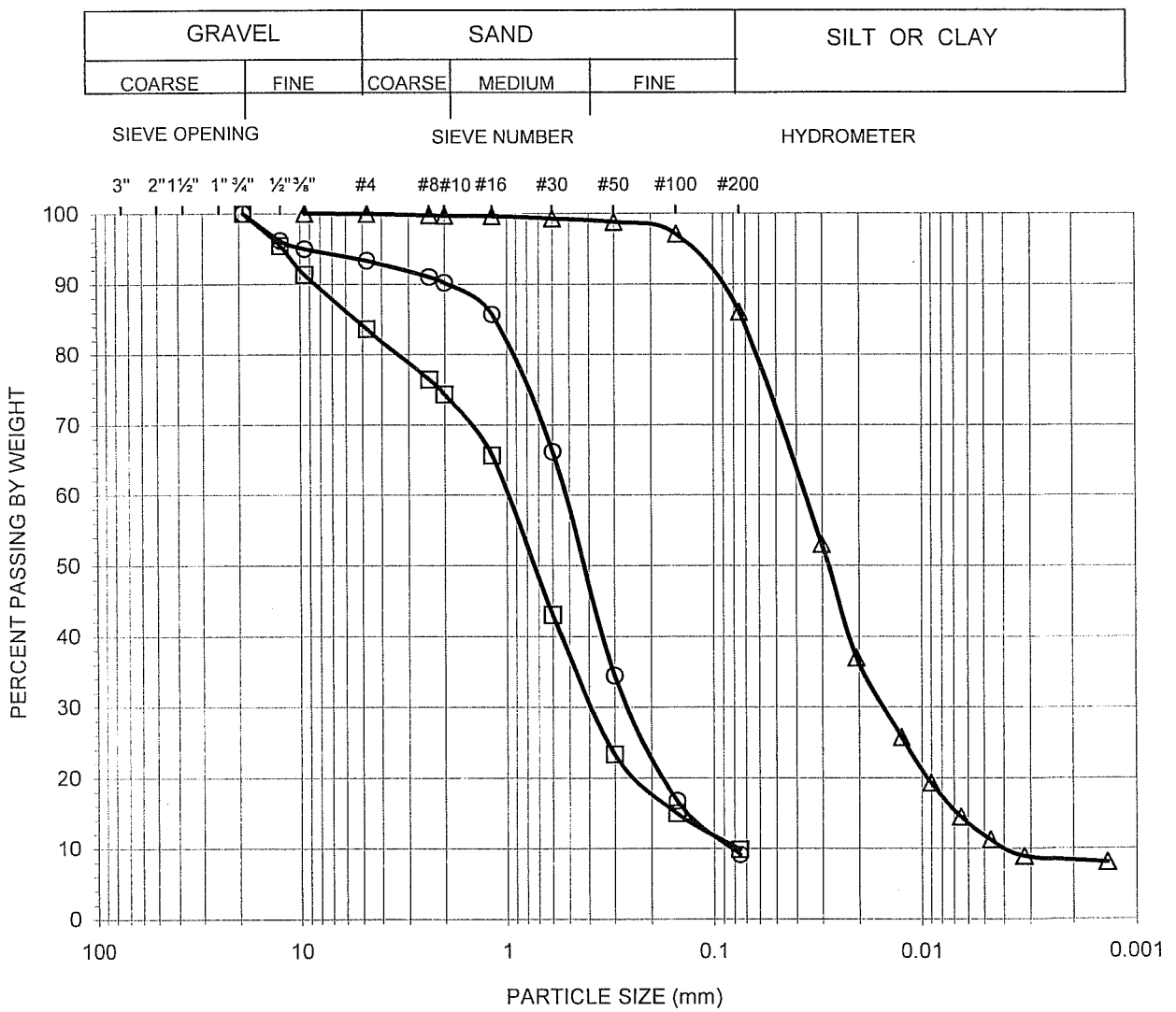


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-025	U-10	50	0.00	28.70	71.30	N/P	ML
□	R-09-025	D-12-2	60.5	1.56	2.38	96.06	44:25:19	CL
△	R-09-025	S-15	75	0.00	8.71	91.29	31:25:6	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/28/09

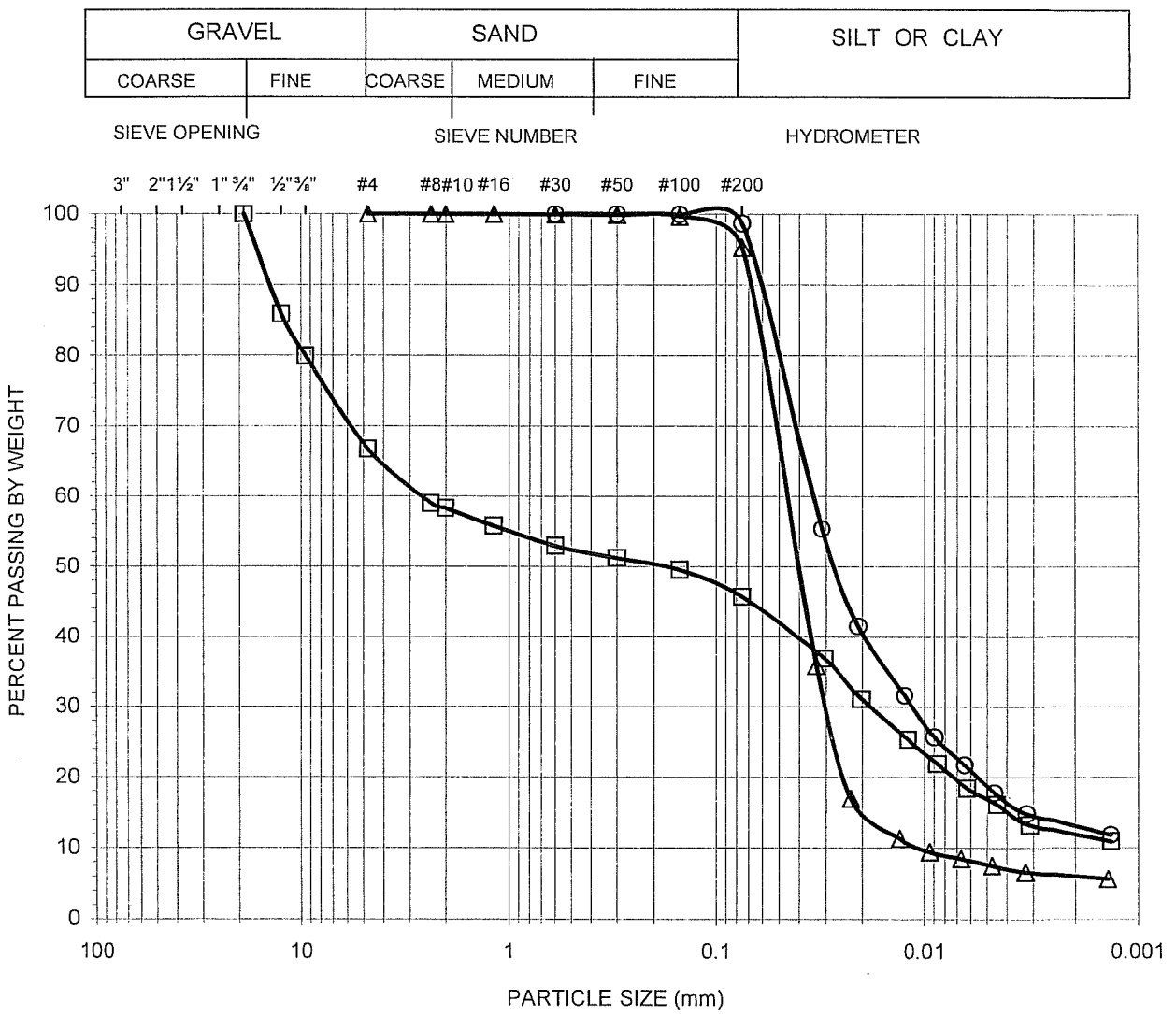


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-025	S-17	95	6.65	84.31	9.04	N/A	SW-SM
□	R-09-025	S-19	115	16.38	73.81	9.81	N/A	SW-SM
△	R-09-025	S-22	160	0.05	13.92	86.03	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/29/09

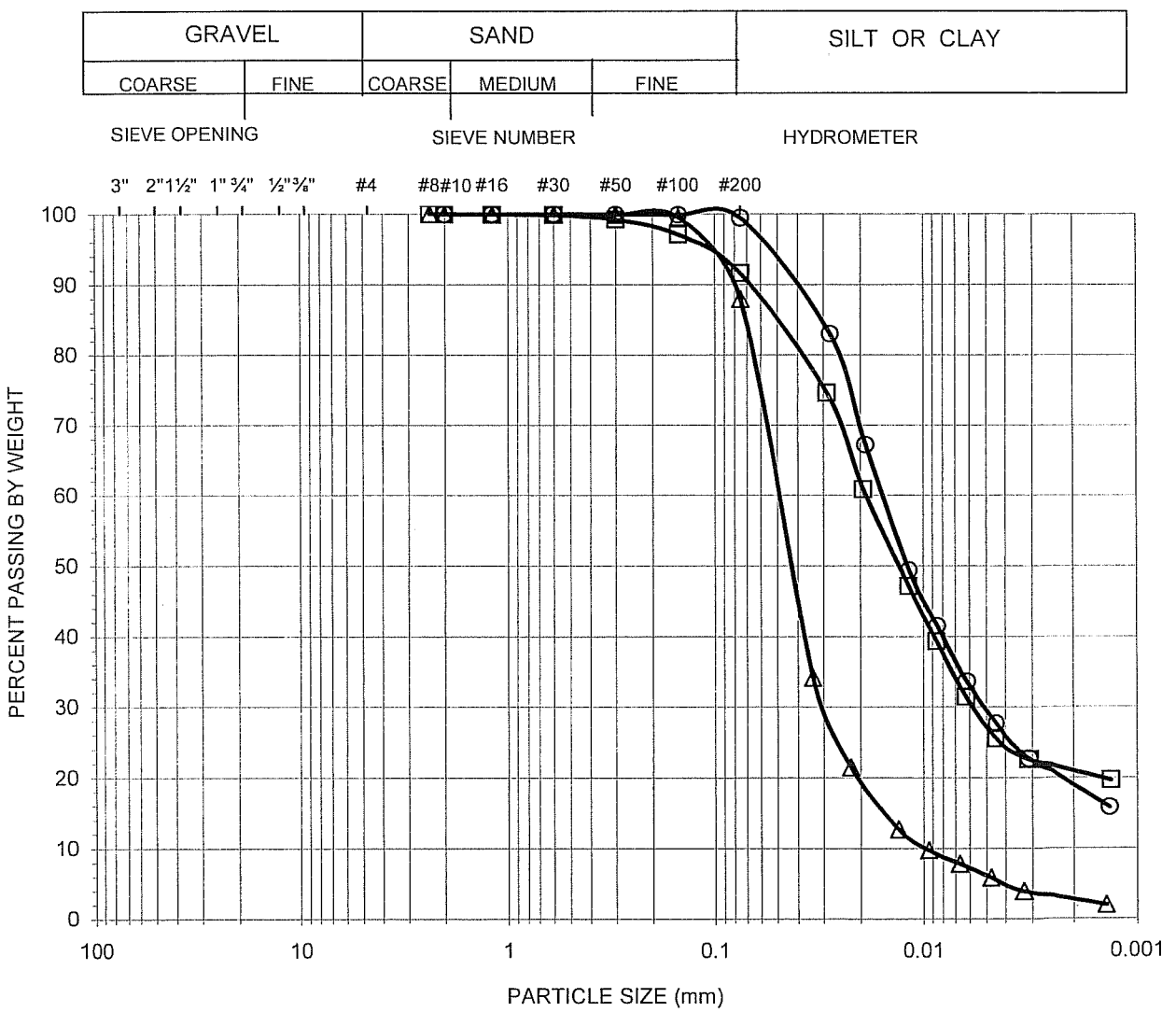


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-026	D-02	10	0.00	1.38	98.62	29:25:4	ML
□	R-09-026	S-03	15	33.31	20.99	45.70	38:24:14	SC
△	R-09-026	S-05	25	0.00	4.74	95.26	N/A	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/29/09

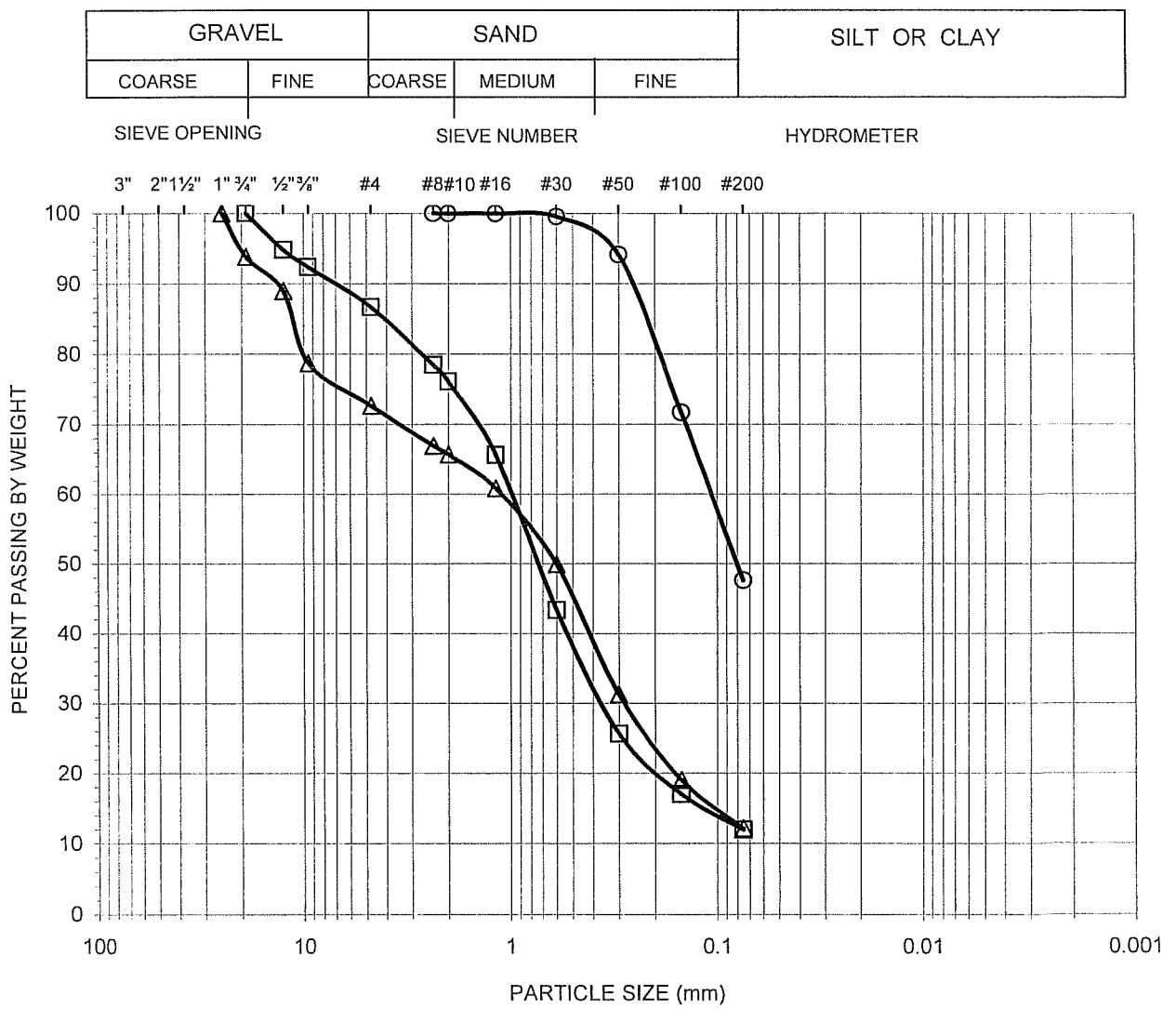


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-026	D-08	40	0.00	0.56	99.44	34:26:8	ML
□	R-09-026	D-14	70	0.00	8.37	91.63	34:22:12	CL
△	R-09-026	U-15	75	0.00	12.03	87.97	N/P	ML

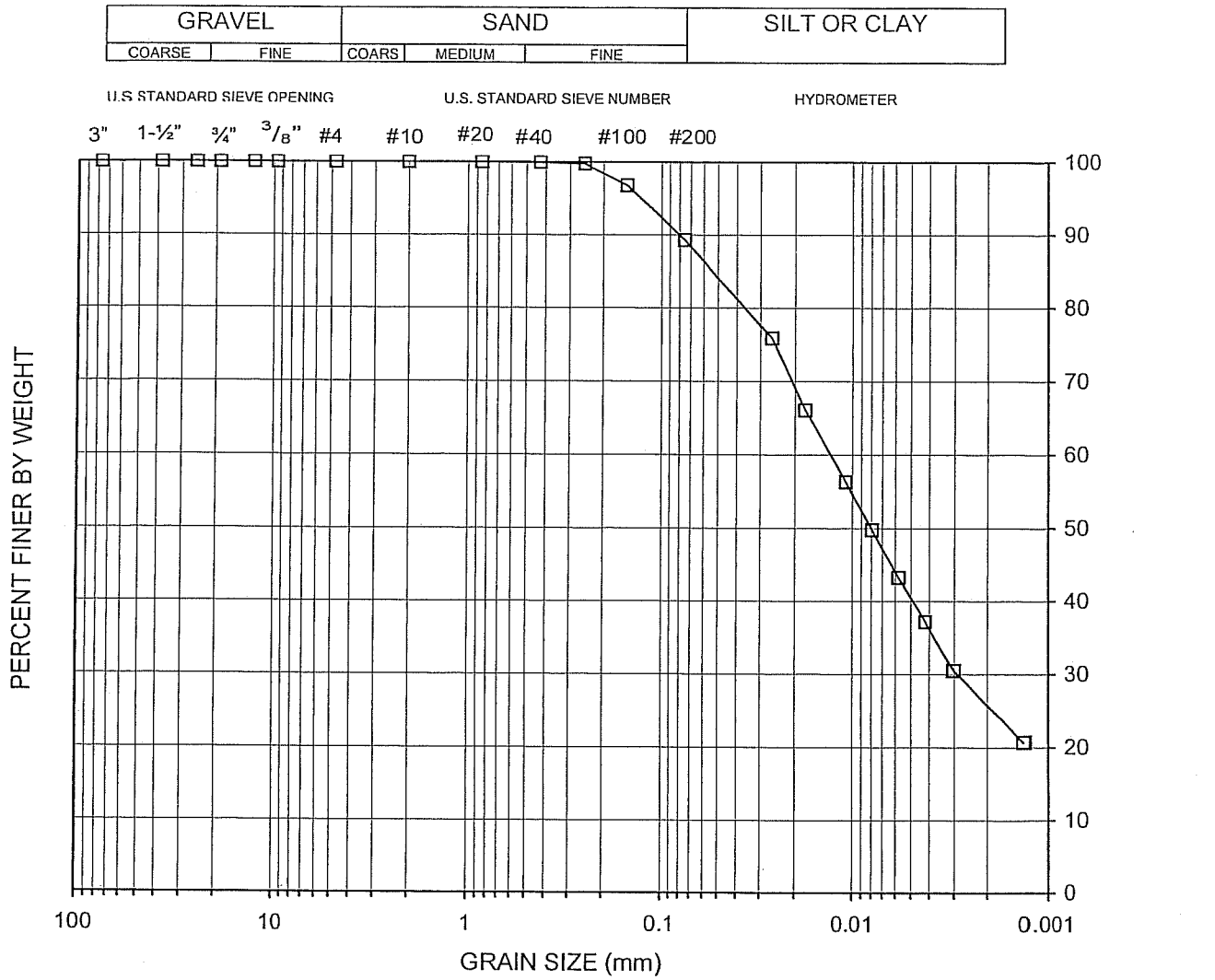
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/17/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/26/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/29/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-026	S-16	80	0.00	52.40	47.60	N/A	SM
□	R-09-026	S-21	115	13.30	74.72	11.98	N/A	SW-SM
△	R-09-026	S-24	145	27.34	60.51	12.15	N/A	SW-SM



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-027	U-01	11	Shelby Tube	CL	44	21

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

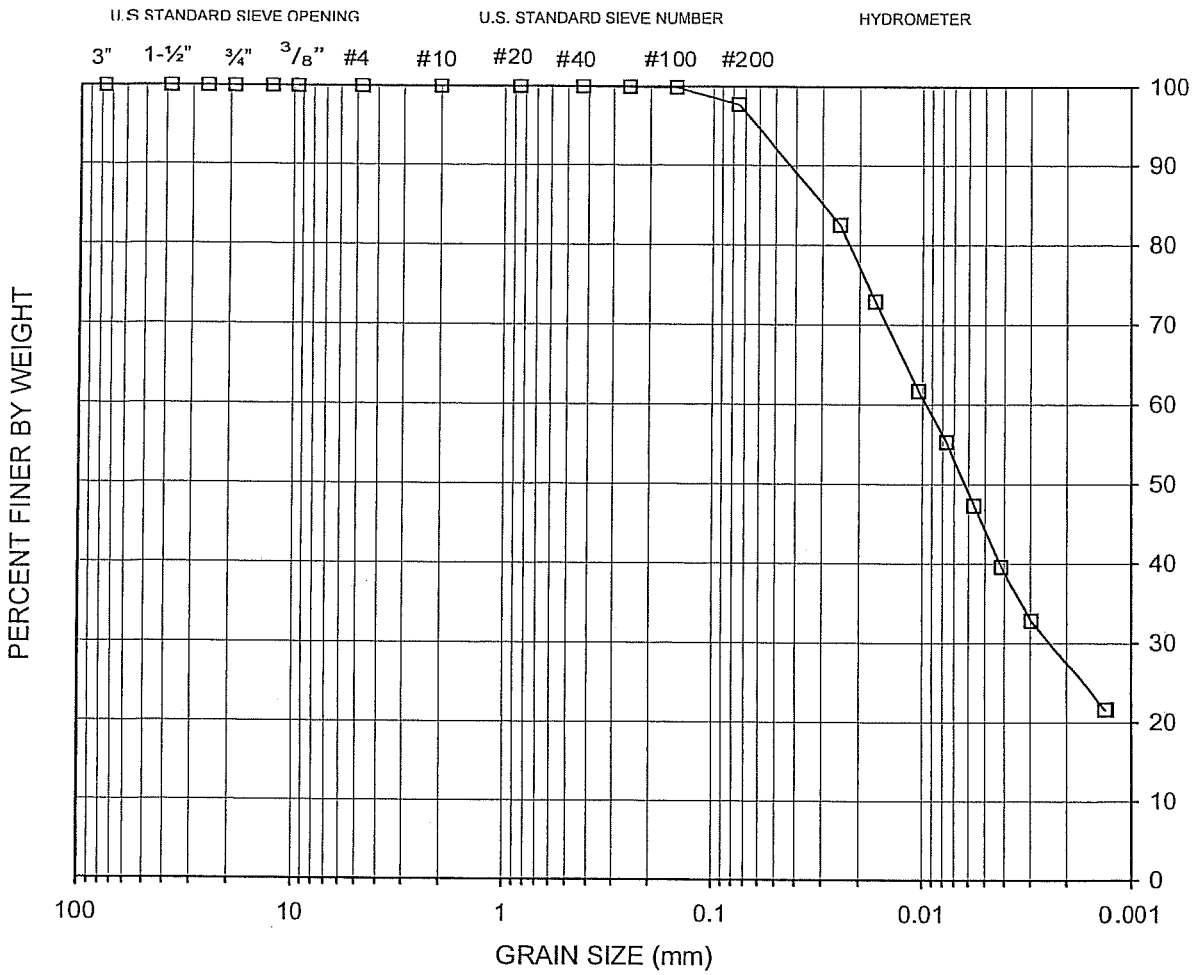
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-027	D-08-1	40	Ring	CL	41	17

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

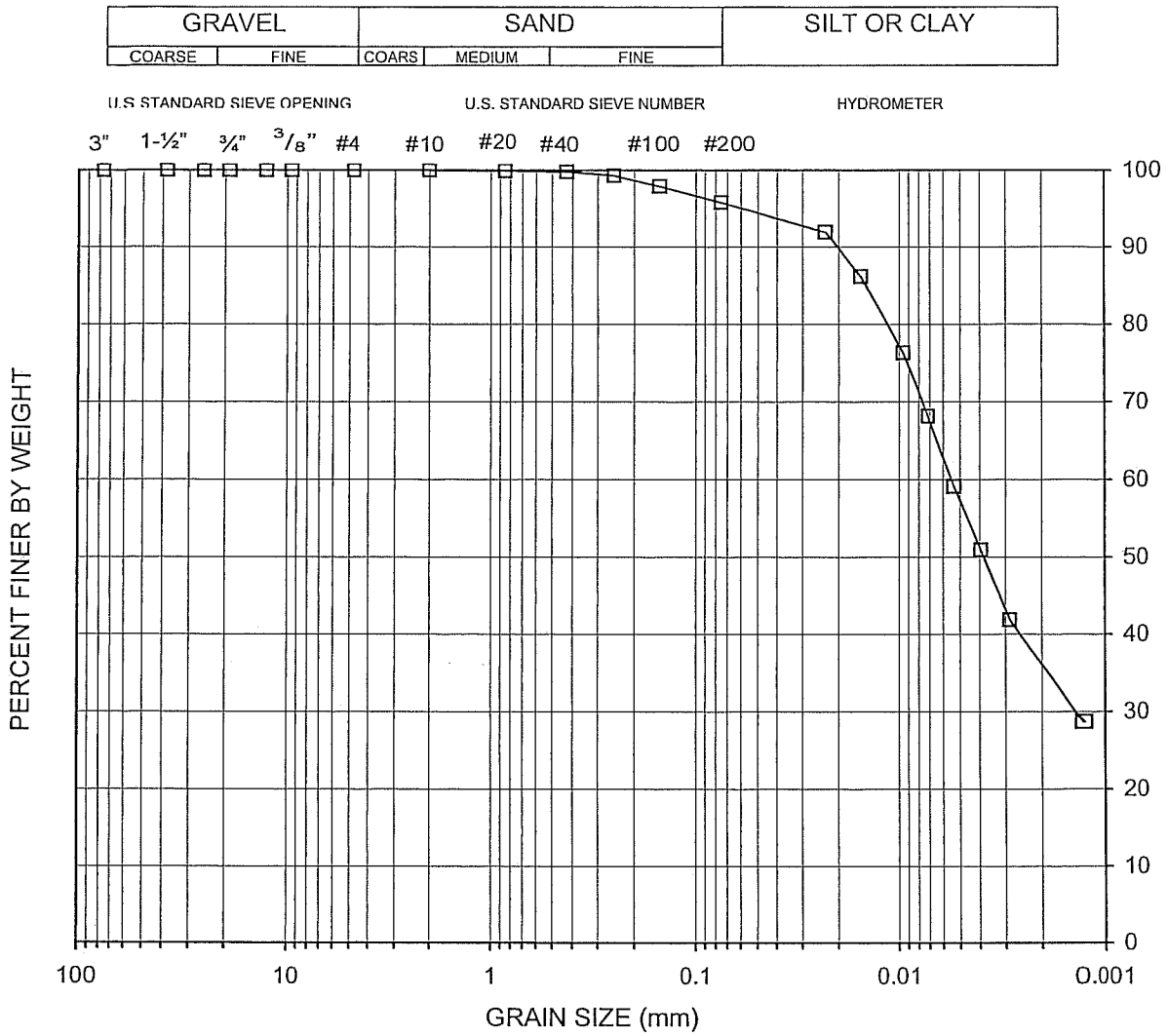
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09

(ASTM D422)

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-027	U-09	45	Shelby Tube	CH	54	30

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

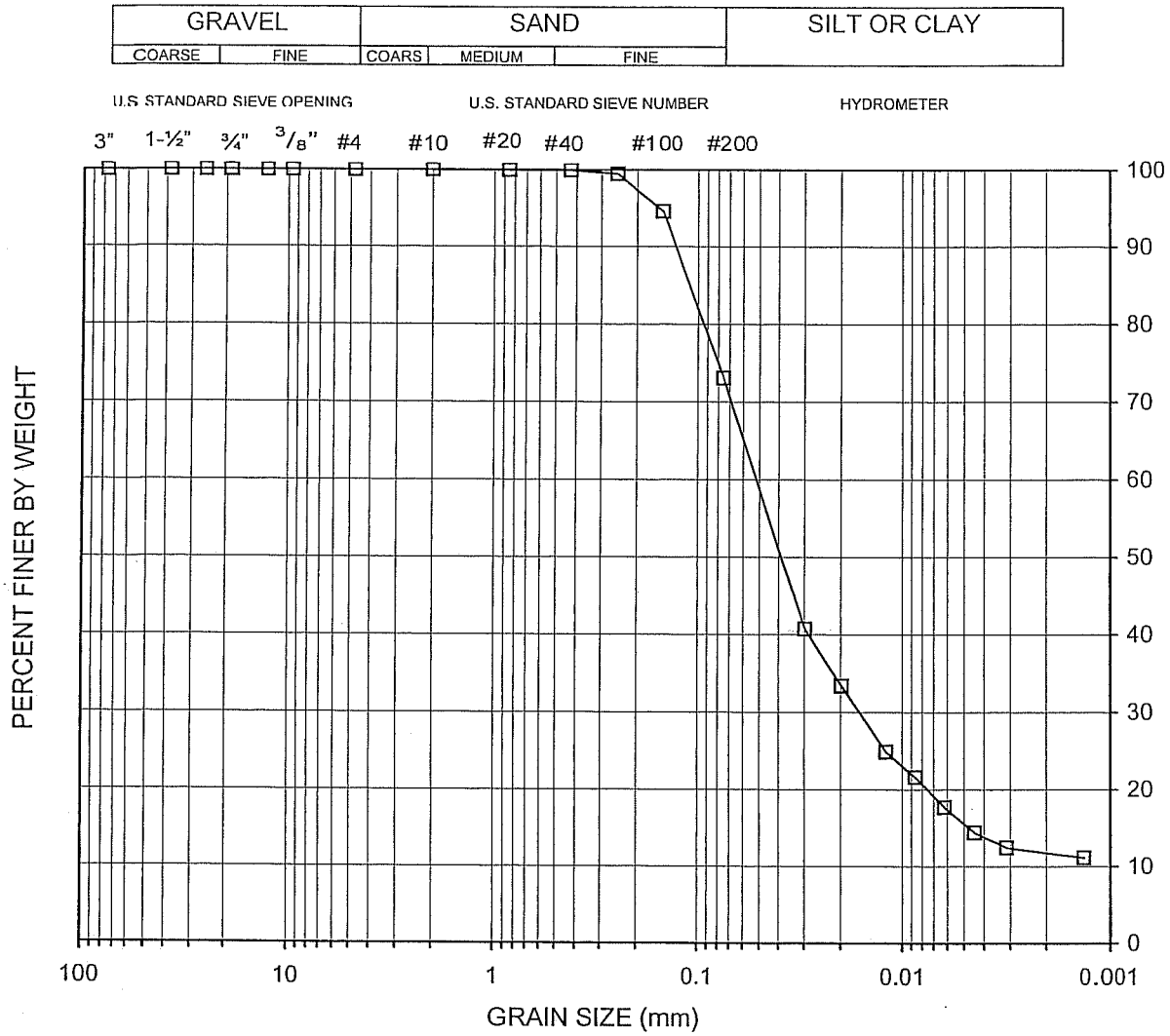
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-027	S-10	50	Bag	ML	25	2

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

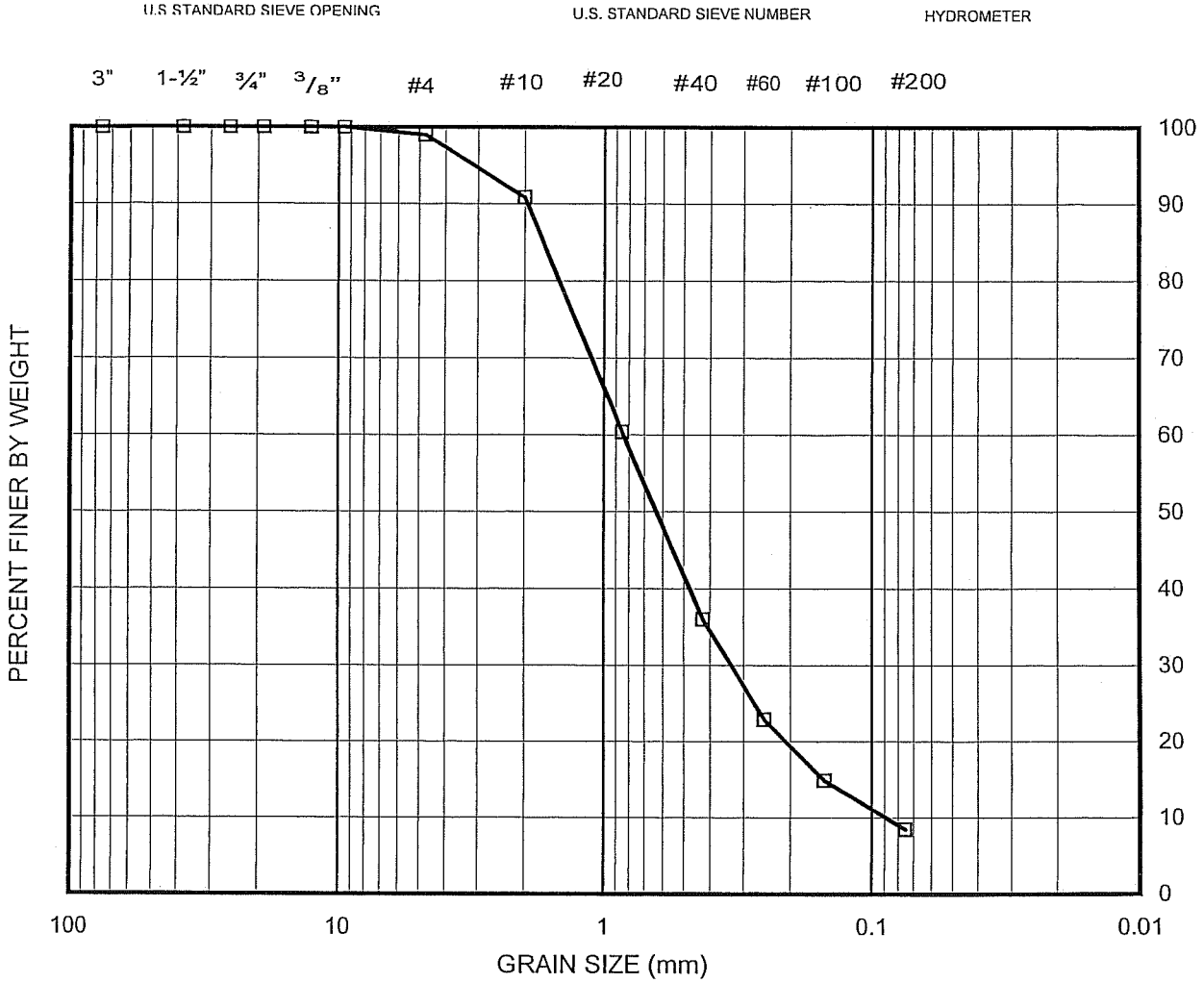
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/22/09

FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-027	S-14	70	Bag	SW-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

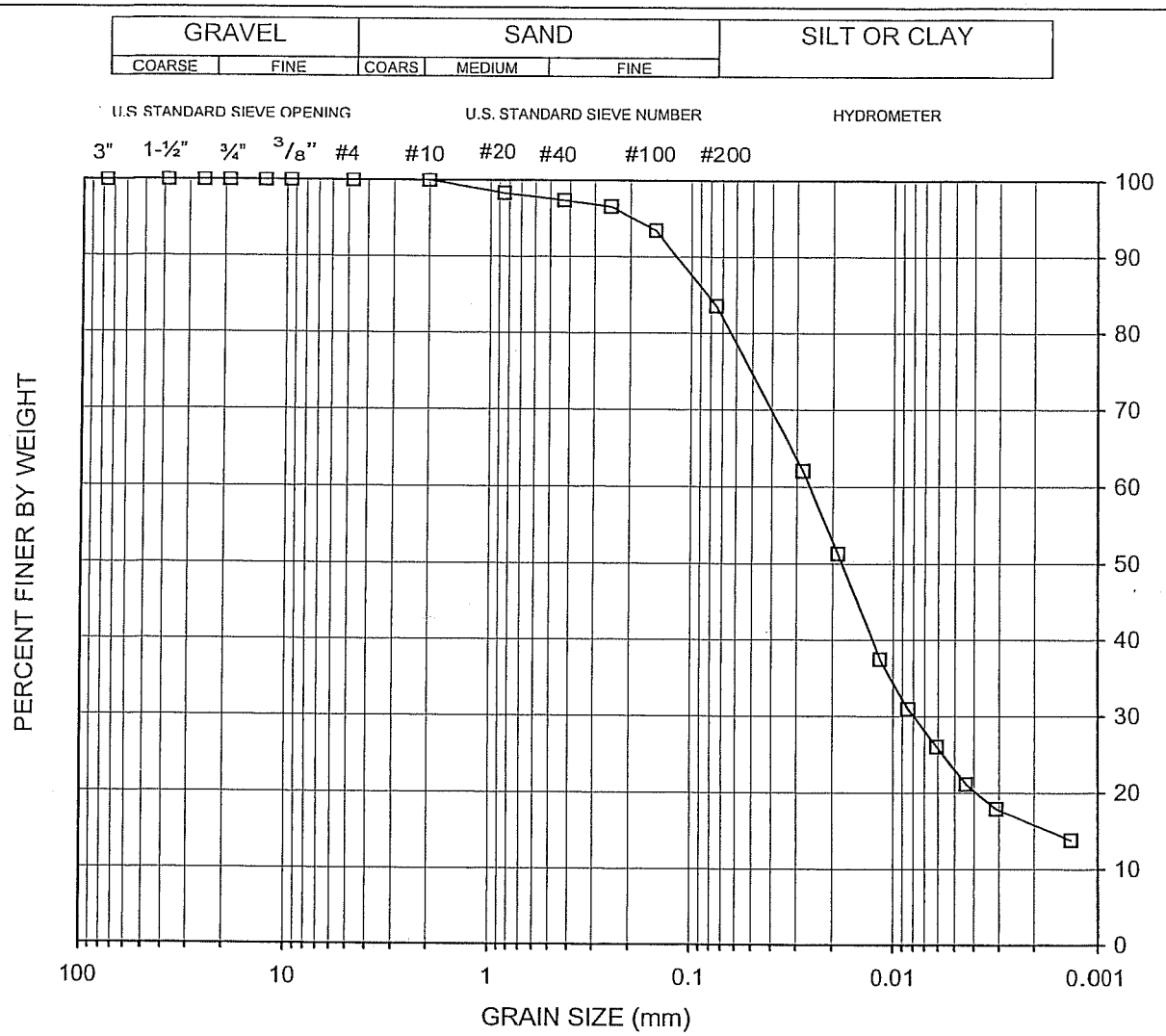
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-027	S-16-1	80	Bag	CL	32	9

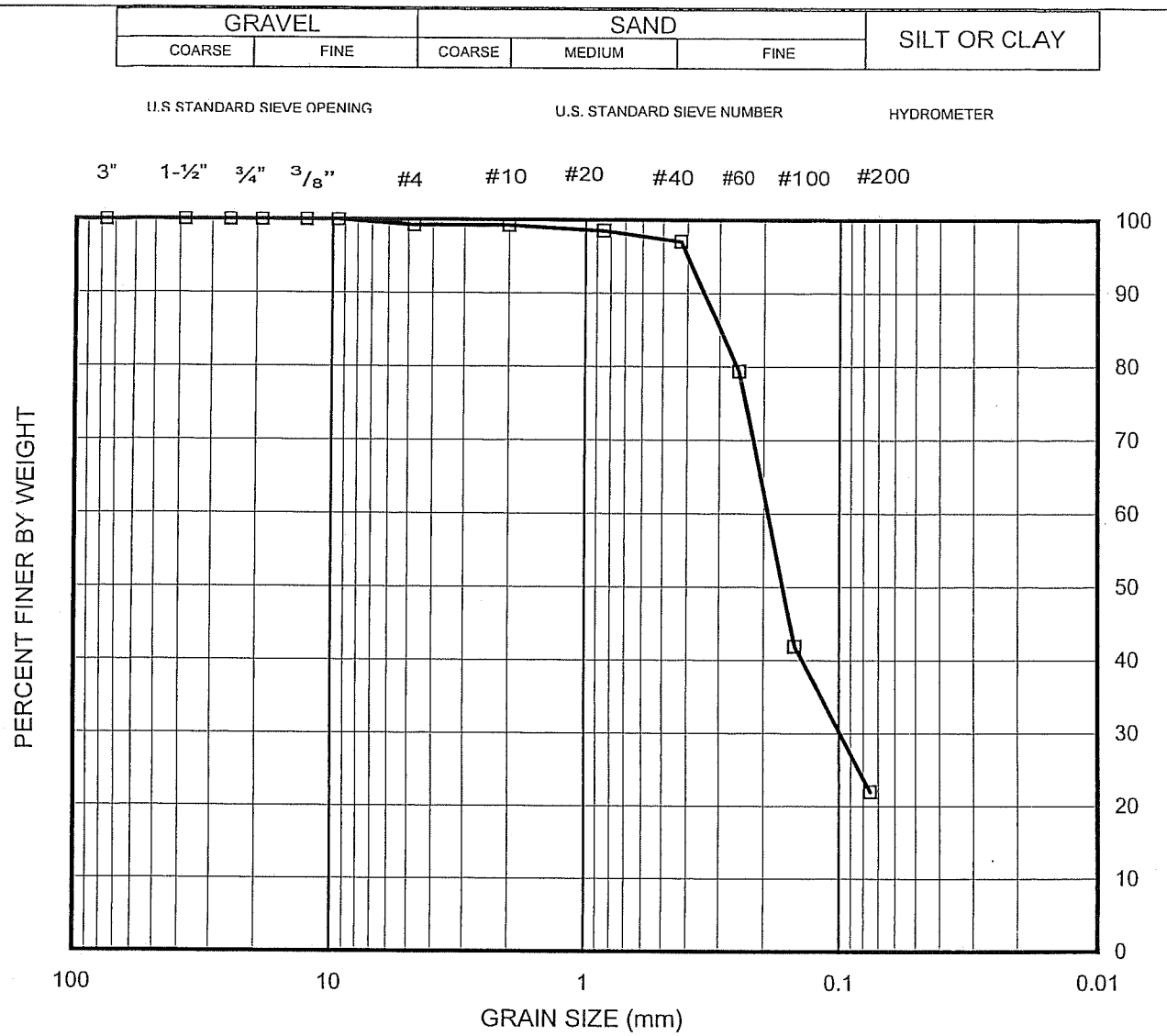
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-027	S-17	90	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

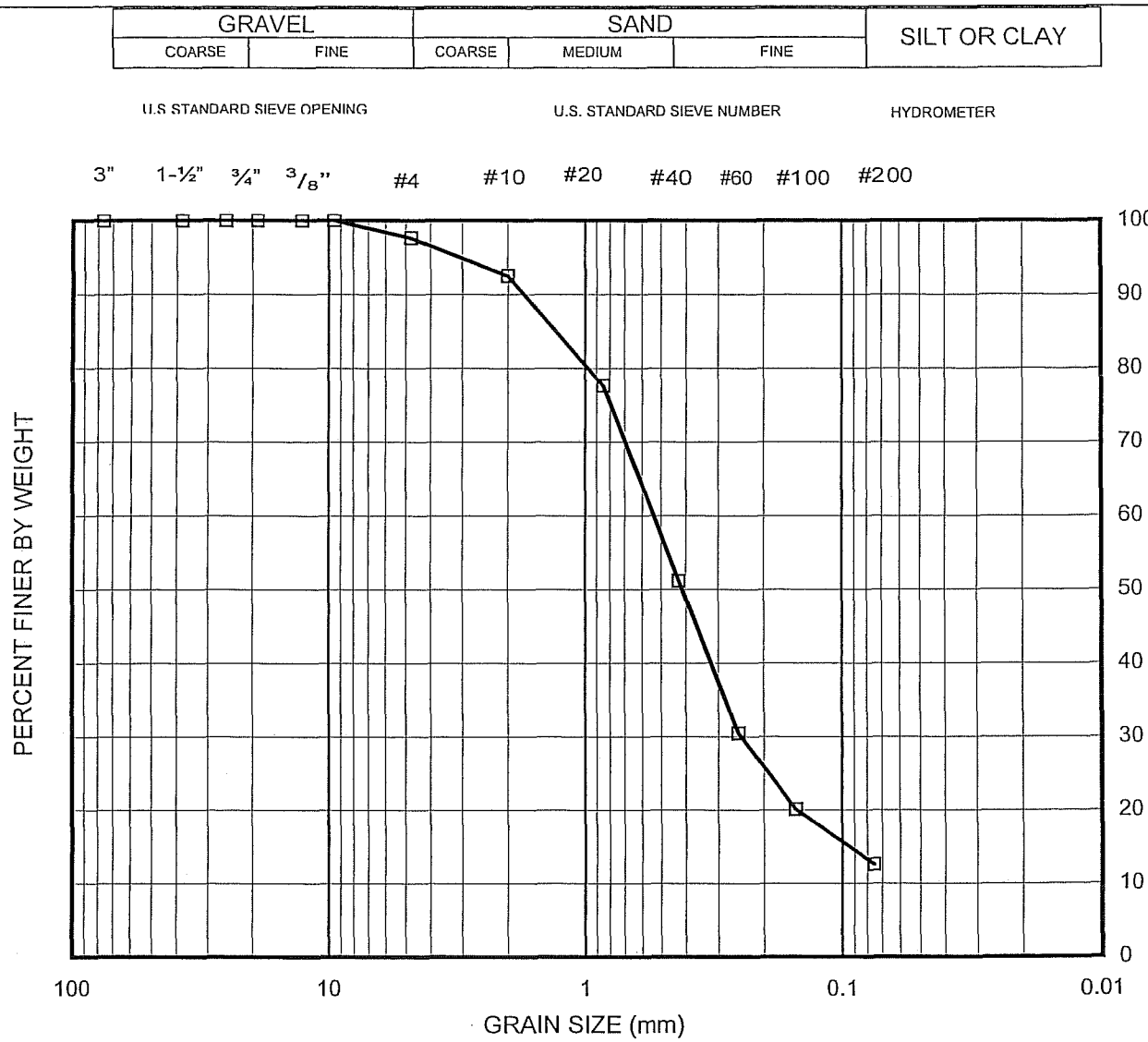
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-027	S-20	120	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

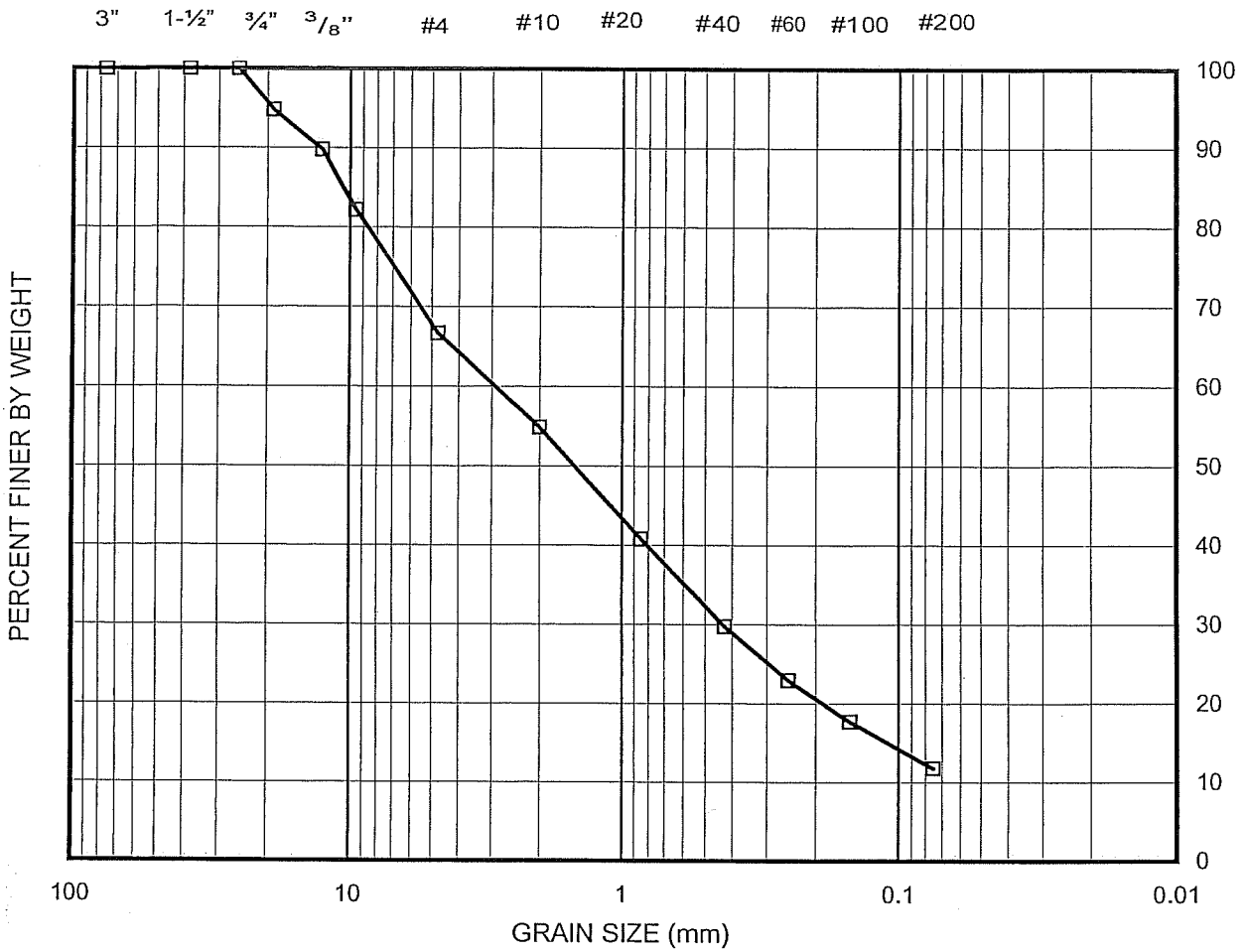
EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
☐	R-09-027	S-23	150	Bag	SW-SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

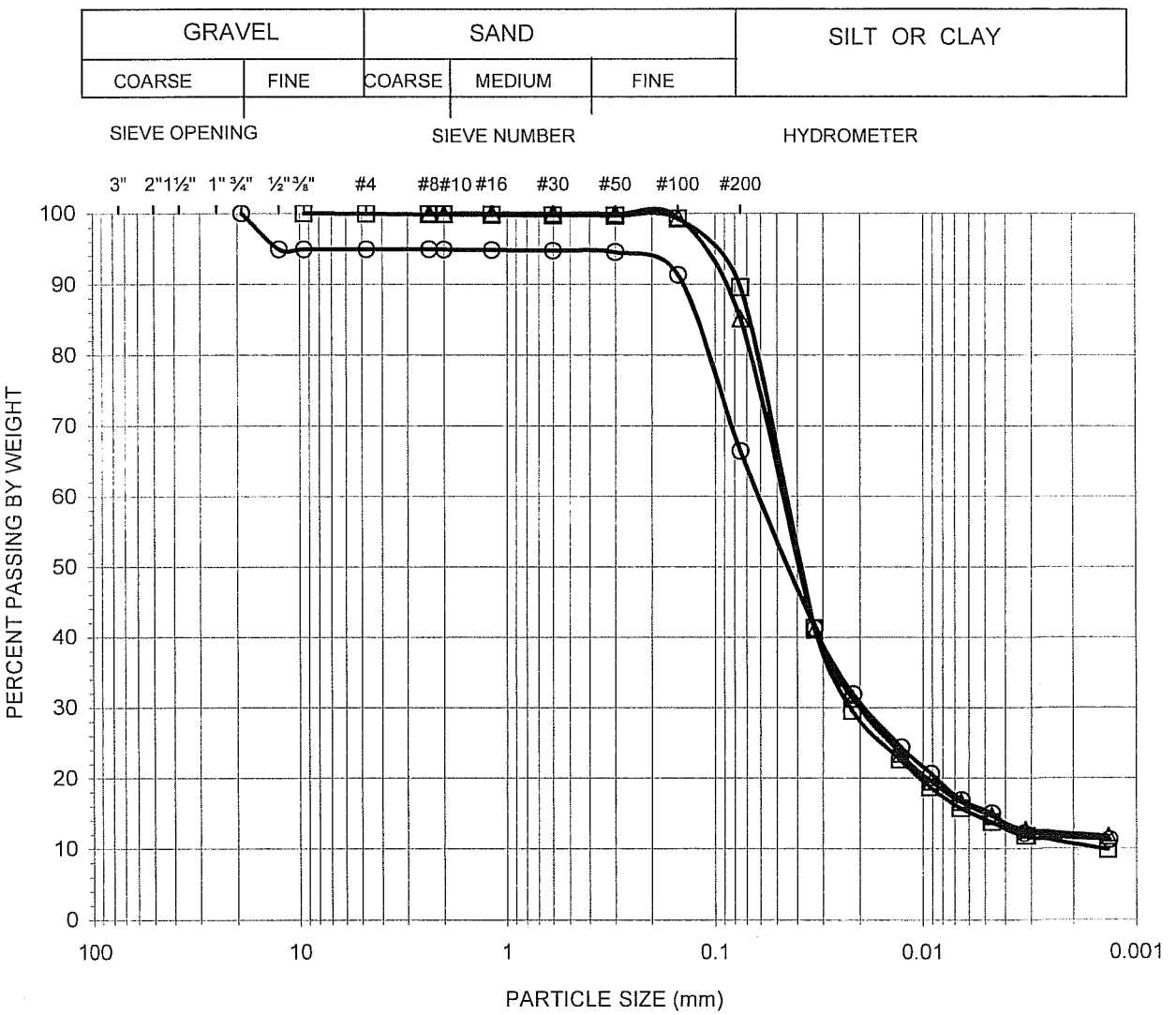
GRAIN SIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	0	Date:	01/00/00
Project Name:	ACTA Heim Bridge Replacement	Computed by:	0	Date:	01/00/00
Project No.:	06-123-03	Checked by:	AP	Date:	12/30/09

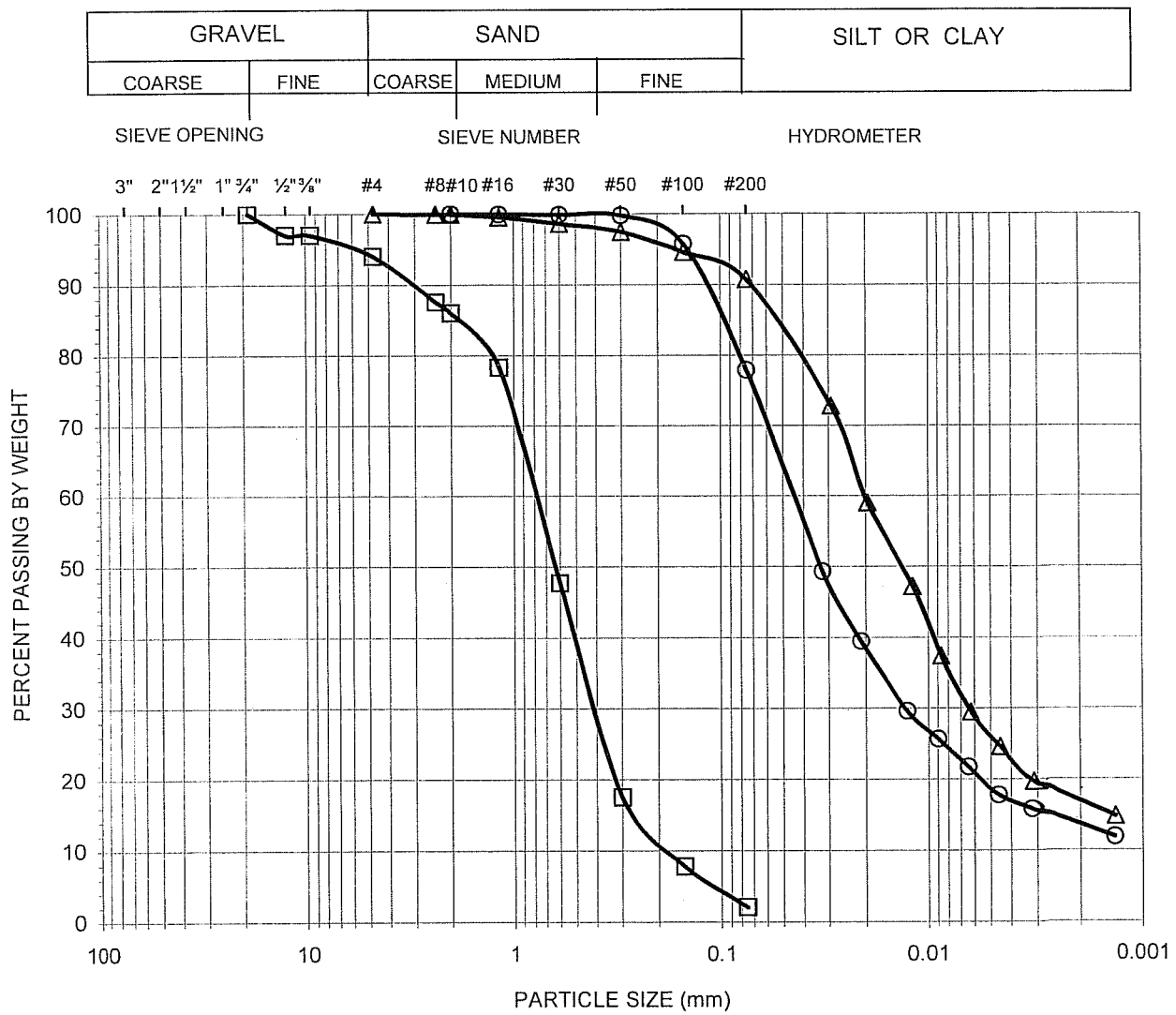


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-028	S-05	25	5.08	28.53	66.39	N/A	ML
□	R-09-028	U-07	35	0.04	10.41	89.55	N/A	ML
△	R-09-028	D-08	40	0.00	14.84	85.16	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	0	Date:	01/00/00
Project Name:	ACTA Heim Bridge Replacement	Computed by:	0	Date:	01/00/00
Project No.:	06-123-03	Checked by:	AP	Date:	12/30/09

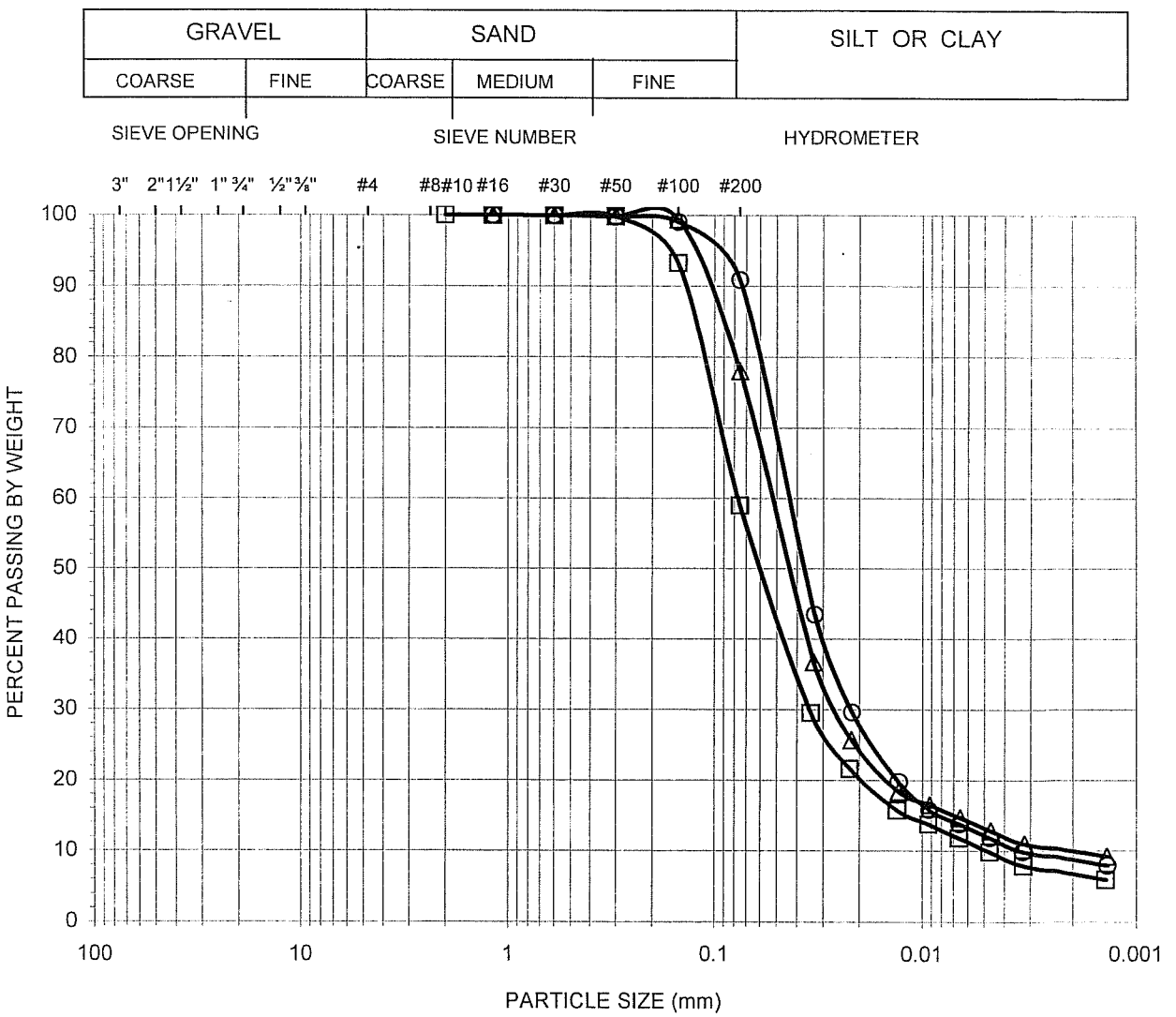


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-028	D-10	50	0.00	22.10	77.90	N/P	ML
□	R-09-028	S-19	115	5.97	91.98	2.05	N/A	SP
△	R-09-028	S-22	160	0.00	9.27	90.73	30:23:7	CL-ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

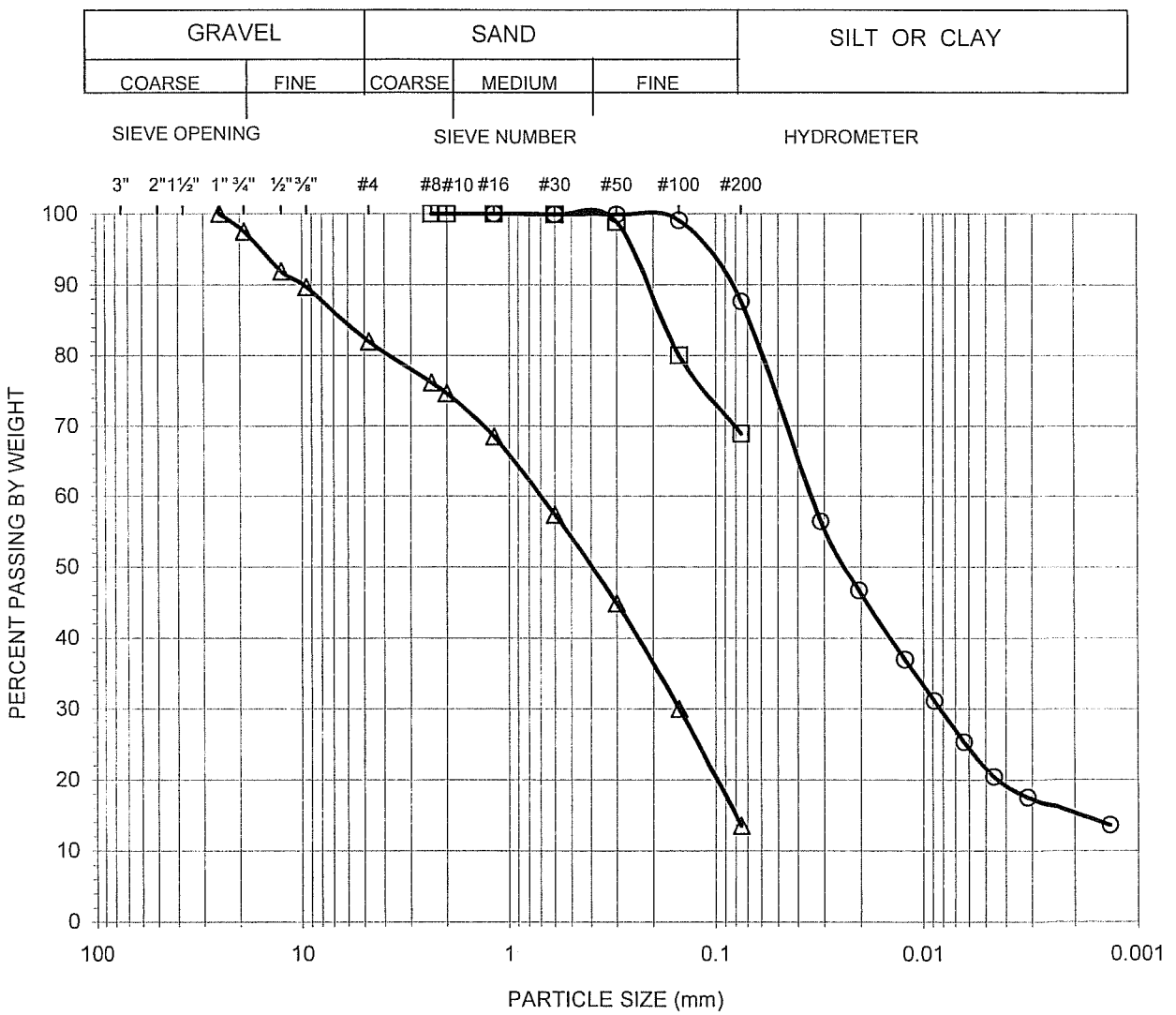


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-029	U-05	25	0.00	9.13	90.87	N/P	ML
□	R-09-029	U-07	35	0.00	41.03	58.97	N/A	ML
△	R-09-029	D-10	50	0.00	21.98	78.02	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

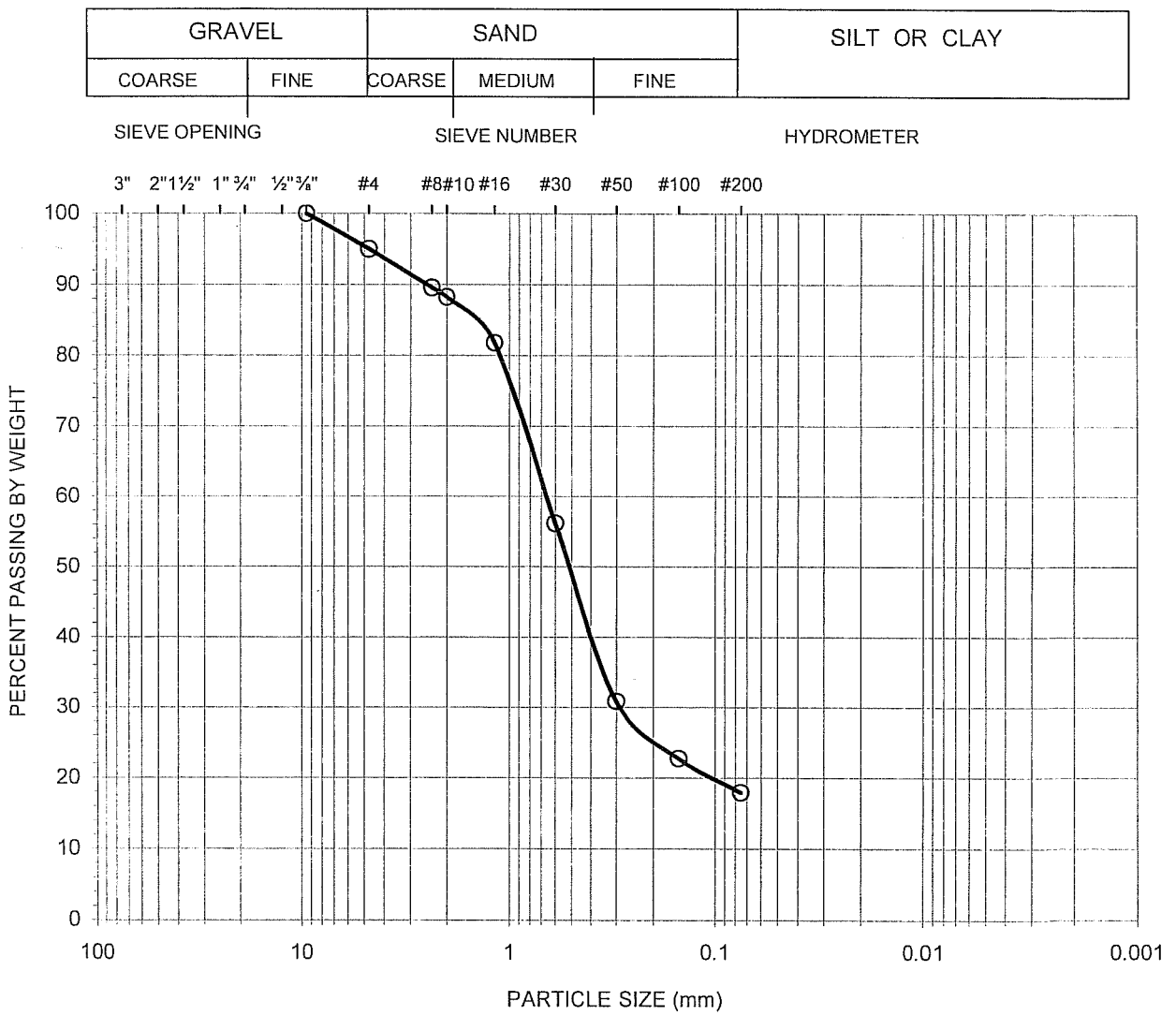


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-029	U-12	60	0.00	12.36	87.64	27:22:5	ML
□	R-09-029	S-17	85	0.00	31.14	68.86	N/A	ML
△	R-09-029	S-21	125	18.02	68.46	13.52	N/A	SM

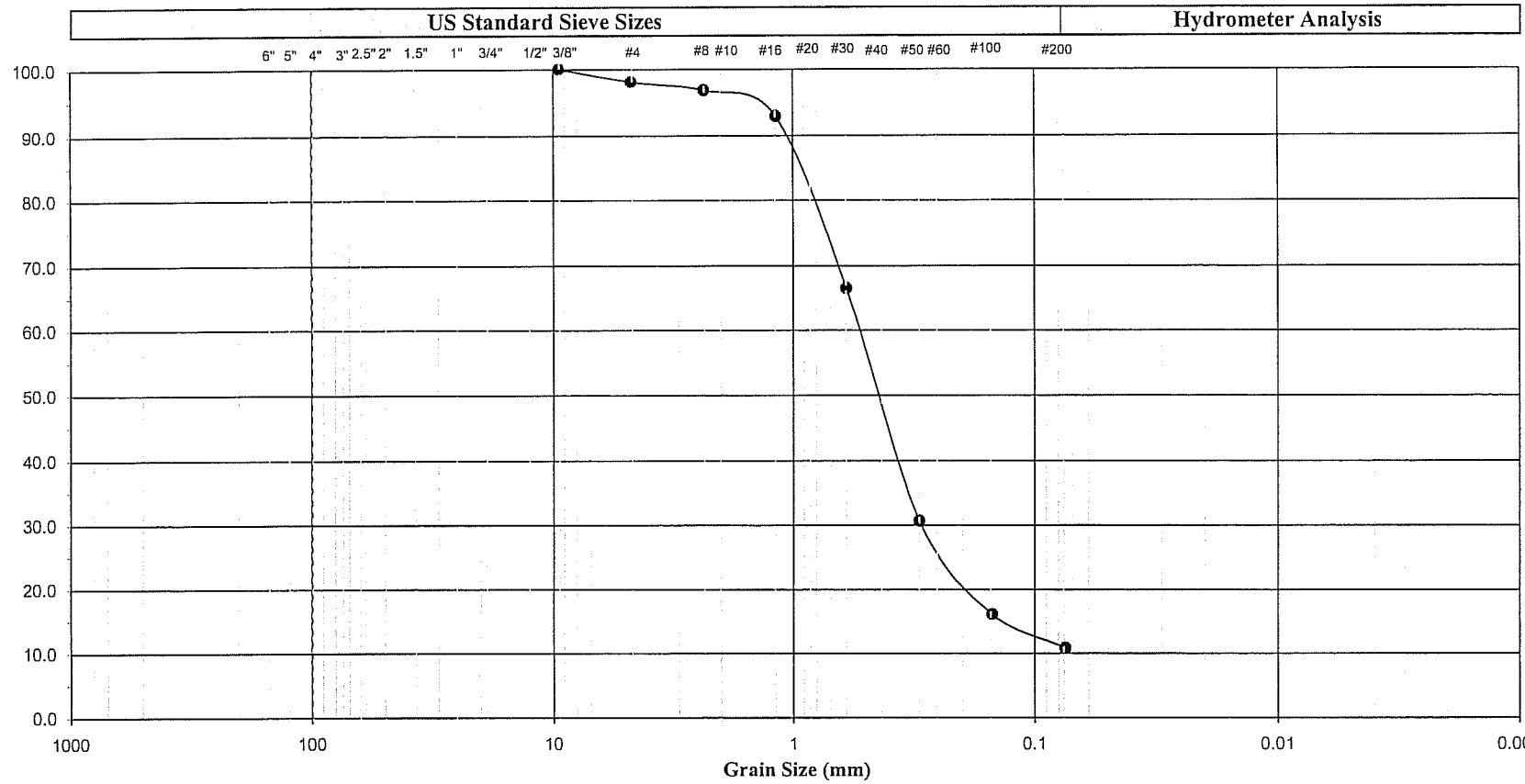
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-029	S-24	160	5.00	77.08	17.92	N/A	SM



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-13	107.0		65.0		olive-gray	Poorly graded sand with silt	SP-SM

Remark: 0.00

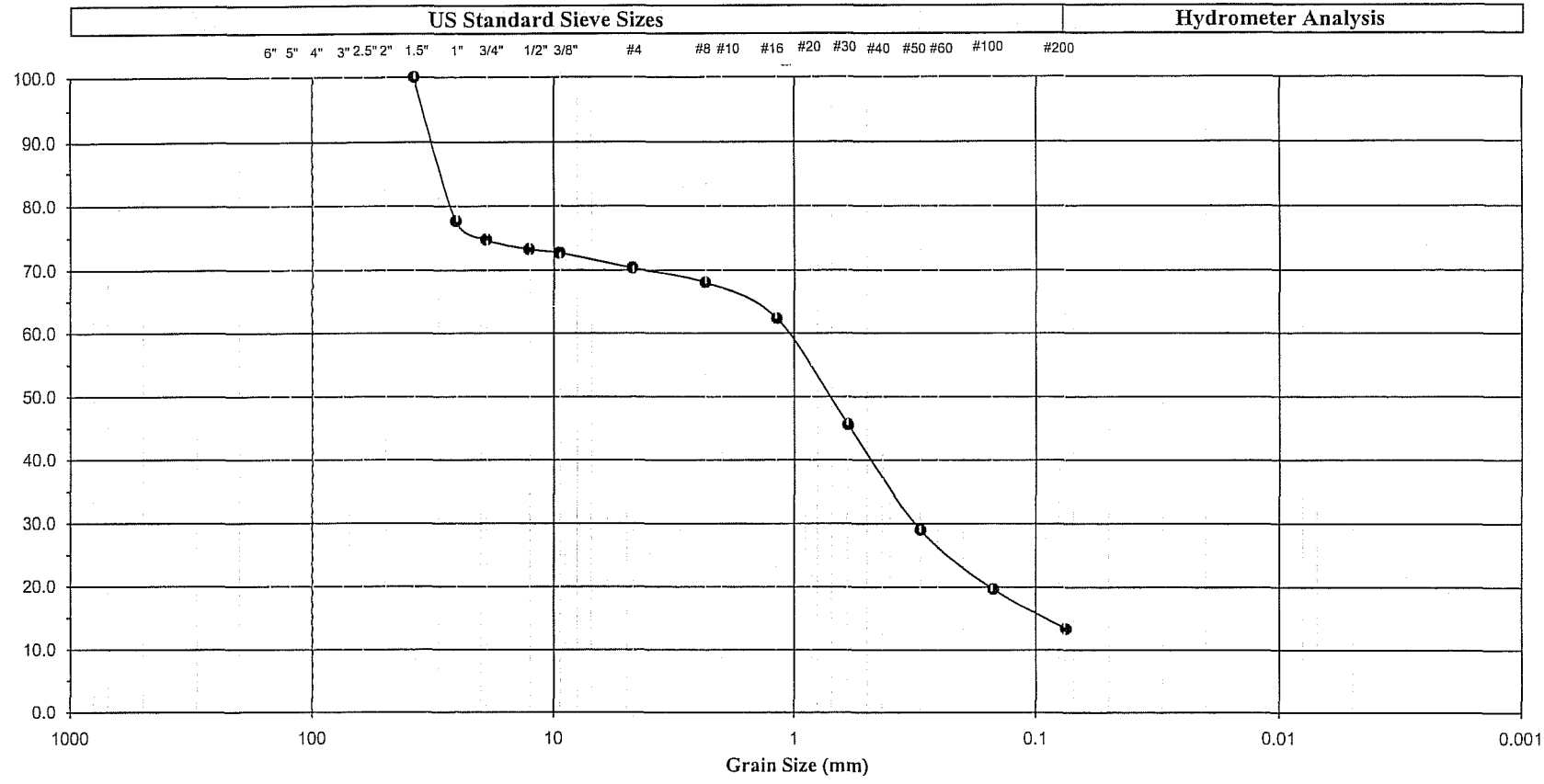
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-16	127.0		85.0		olive-gray	Silty sand with gravel	SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

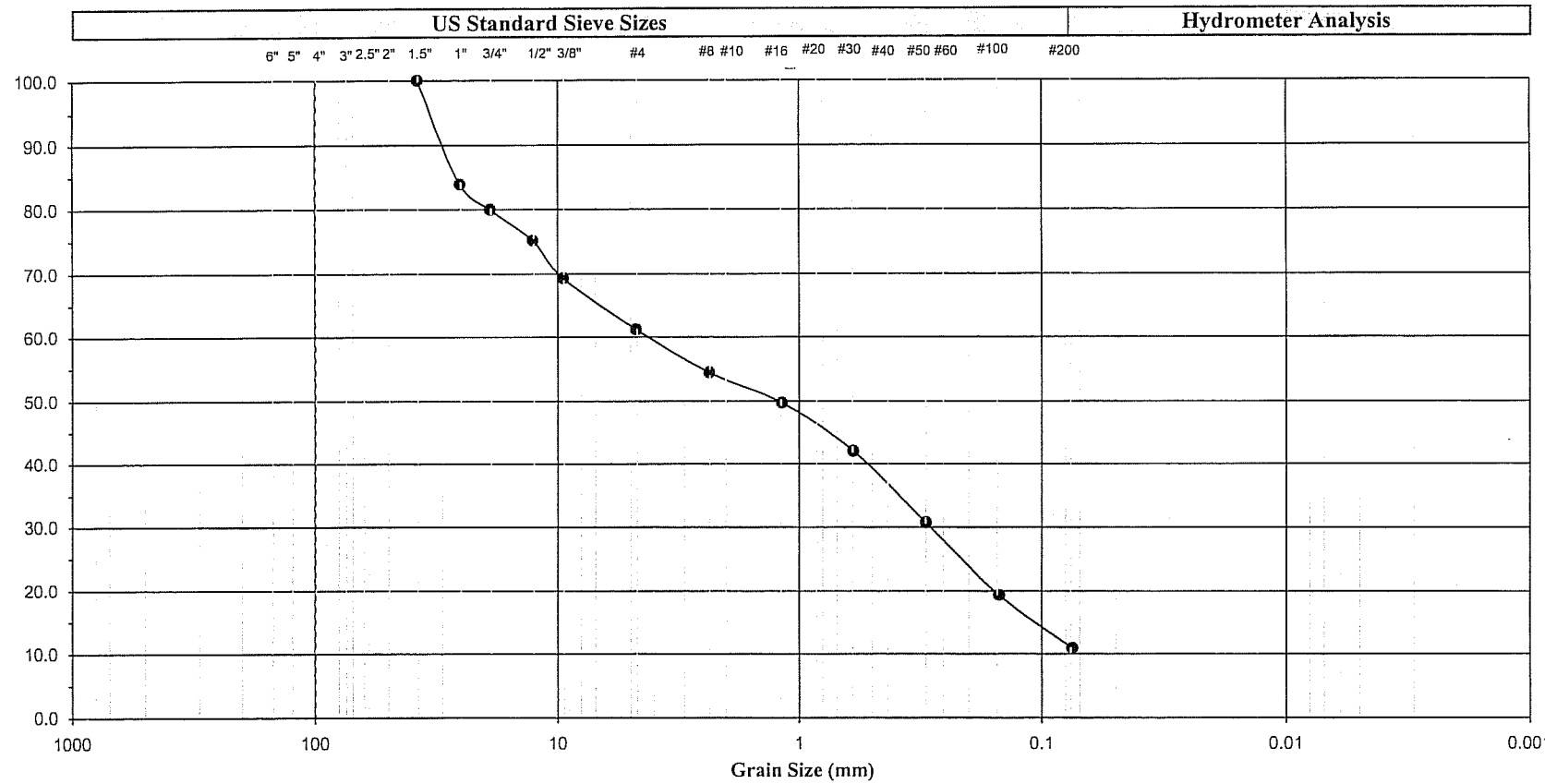
Project No. : 06-123-3

Date : 12/18/09

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-19	157.0		115.0		Olive-gray	Poorly graded sand with silt with gravel	SP-SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

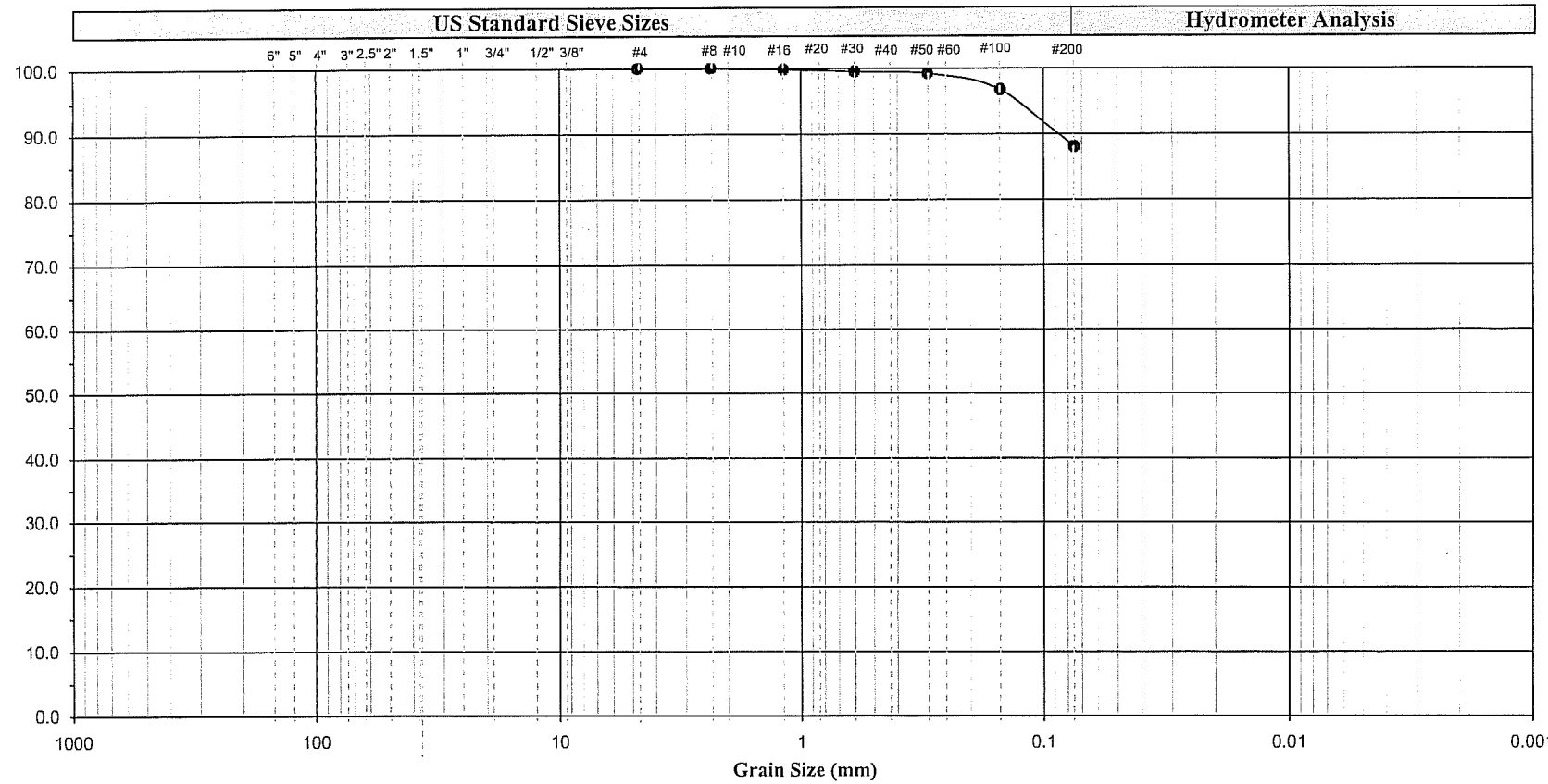
ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-21	177.0		135.0		olive-gray	Silt	ML
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

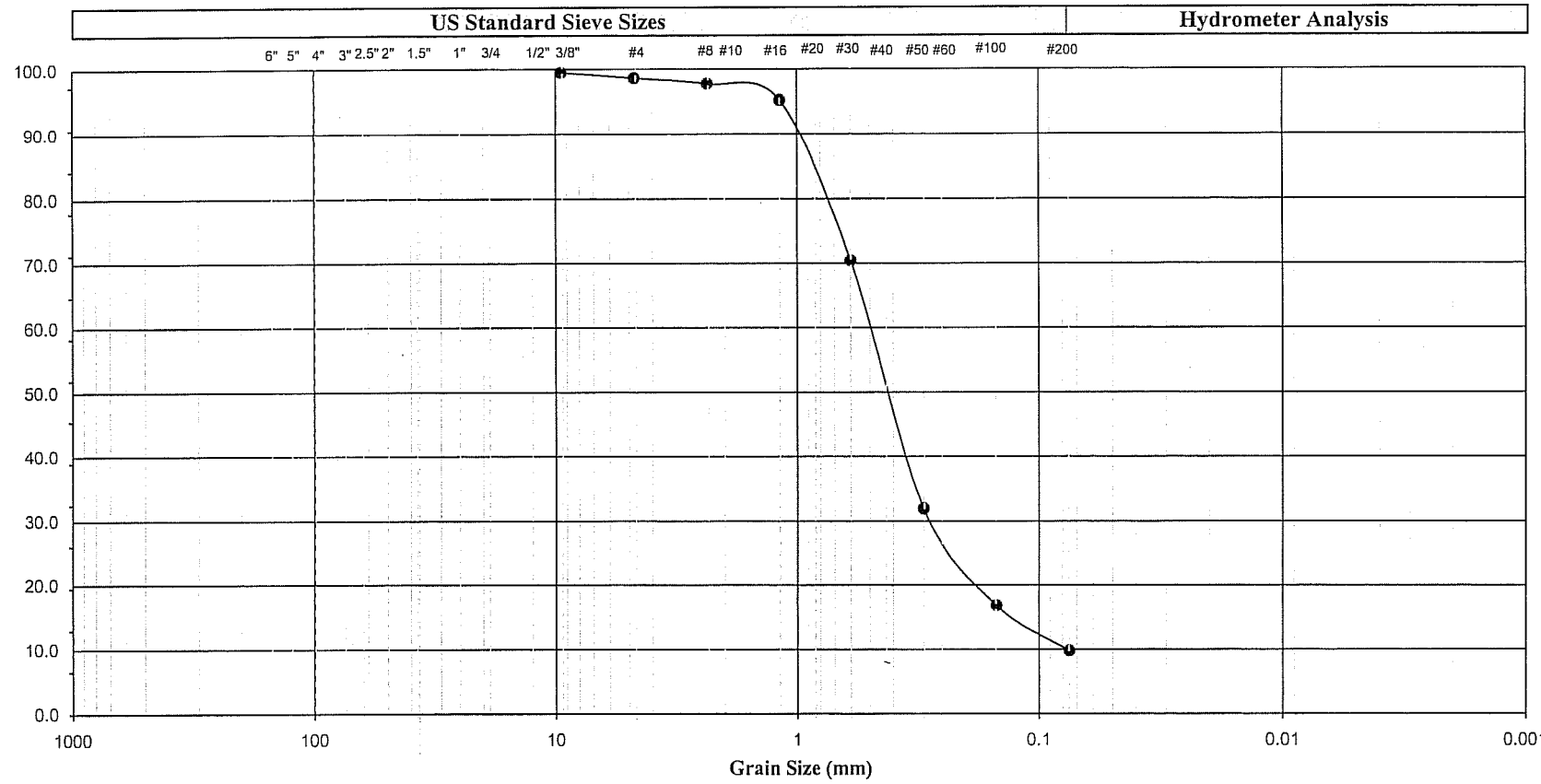
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-24	202.0		160.0		dark olive-gray	Well graded sand with silt	SW-SM
Remark									

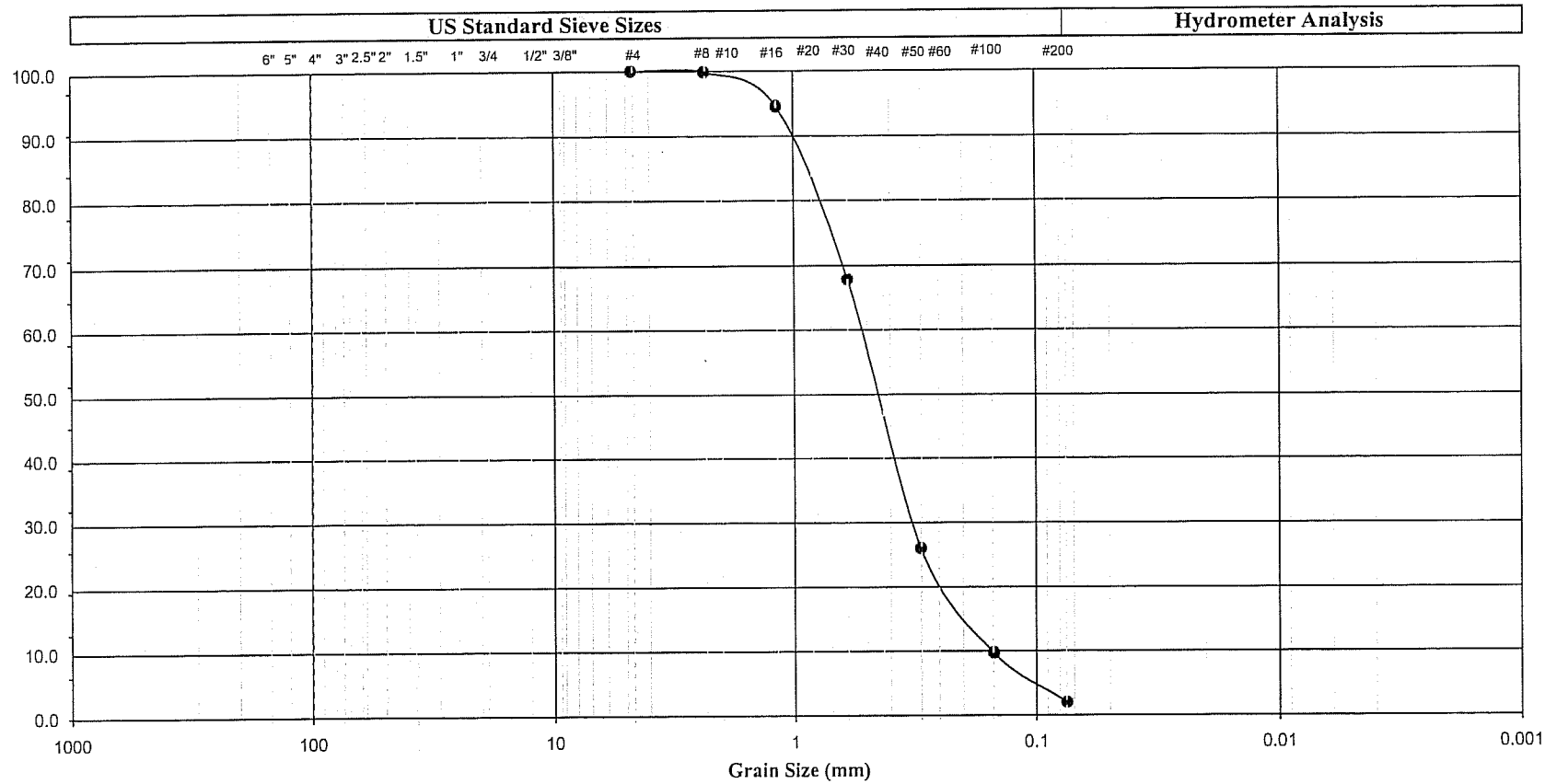
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-27	227.0		185.0		dark olive-gray	Poorly graded sand	SP
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 06-123-3	**Project Name :** ACTA Schuyler Heim Bridge Project
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No. : WR-09-042	Depth below	Deck (ft):	68.3
Sample No. : S-3-2		Mudline (ft):	14.30

Description : Olive-gray, SANDY SILTY CLAY (CL-ML)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-5	S-5	S-5
Wet Wt. of Soil + Cont. (gm)	163.38	163.38	
Dry Wt. of Soil + Cont. (gm)		153.30	130.82
Weight of Container (gm)	117.80	117.8	117.80
Weight of Dry Soil (gm)	35.50	35.5	13.02
Moisture Content (%)		28.39	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	0.00	100.00
4"			No. 10		
3"			No. 16	0.00	100.00
2.5"			No. 20		
2.0"			No. 30	0.03	99.92
1.5"			No. 40		
1.0"			No. 50	0.11	99.69
3/4"			No. 60		
1/2"			No. 100	1.76	95.04
3/8"			No. 200	11.43	67.80
No. 4	0.00	100.00	Pan		
Cu :			Gravel	Sand	Fine
Cc :			0	32	68

Remark : 1

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No. : WR-09-042	Depth below	Deck (ft):	98.0
Sample No. : S-9		Mudline (ft):	44.00

Description : Olive-gray, Poorly graded SAND with SILT (SP-SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-9	S-9	S-9
Wet Wt. of Soil + Cont. (gm)	395.62	395.62	
Dry Wt. of Soil + Cont. (gm)		348.65	333.66
Weight of Container (gm)	115.79	115.79	115.79
Weight of Dry Soil (gm)	232.86	232.86	217.87
Moisture Content (%)		20.17	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	1.48	99.36
4"			No. 10		
3"			No. 16	5.69	97.56
2.5"			No. 20		
2.0"			No. 30	26.13	88.78
1.5"			No. 40		
1.0"			No. 50	120.13	48.41
3/4"			No. 60		
1/2"			No. 100	196.19	15.75
3/8"			No. 200	216.15	7.18
No. 4	0.00	100.00	Pan		
Cu :	3.9		Gravel	Sand	Fine
Cc :	1.21		0	93	7

Remark : 2

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No. : WR-09-042	Depth below	Deck (ft):	113.0
Sample No. : S-12		Mudline (ft):	59.00

Description : Olive-gray, Poorly graded SAND (SP)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-10	S-10	S-10
Wet Wt. of Soil + Cont. (gm)	427.62	427.62	
Dry Wt. of Soil + Cont. (gm)		377.13	373.01
Weight of Container (gm)	119.14	119.14	119.14
Weight of Dry Soil (gm)	257.99	257.99	253.87
Moisture Content (%)		19.57	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	13.90	94.61
4"			No. 10		
3"			No. 16	34.43	86.65
2.5"			No. 20		
2.0"			No. 30	99.40	61.47
1.5"			No. 40		
1.0"			No. 50	207.05	19.74
3/4"			No. 60		
1/2"			No. 100	247.29	4.15
3/8"	0.00	100.00	No. 200	253.53	1.73
No. 4	2.65	98.97	Pan		
Cu :	2.9		Gravel	Sand	Fine
Cc :	1.1		1	97	2

Remark : 3

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 06-123-3	Project Name : ACTA Schuyler Heim Bridge Project
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :						
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :						
Boring No. : WR-09-042	Depth below	Deck (ft):	133.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)	
Sample No. : S-16		Mudline (ft):	79.00							
Description : Olive-gray, SILTY SAND with GRAVEL (SM)				5"			No. 8	69.71	78.96	
				4"			No. 10			
	Before Washing Sample		After Wet Sieve	3"			No. 16	81.01	75.55	
				2.5"			No. 20			
	Tested	Moisture		2.0"			No. 30	114.02	65.58	
Container Number	S-12	S-12	S-12	1.5"	0.00	100.00	No. 40			
Wet Wt. of Soil + Cont. (gm)	501.24	501.24		1.0"	43.07	87.00	No. 50	188.64	43.06	
Dry Wt. of Soil + Cont. (gm)		445.57	388.35	3/4"	43.07	87.00	No. 60			
Weight of Container (gm)	114.28	114.28	114.28	1/2"	45.63	86.23	No. 100	242.88	26.69	
Weight of Dry Soil (gm)	331.29	331.29	274.07	3/8"	50.32	84.81	No. 200	270.29	18.41	
Moisture Content (%)		16.80		No. 4	62.15	81.24	Pan			
Remark :				Cu :			Gravel	Sand	Fine	
4				Cc :			19	63	18	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :						
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :						
Boring No. : WR-09-042	Depth below	Deck (ft):	163.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)	
Sample No. : D-19		Mudline (ft):	109.00							
Description : Dark olive-gray, Poorly graded GRAVEL with SAND(GP)				5"			No. 8	288.21	37.29	
				4"			No. 10			
	Before Washing Sample		After Wet Sieve	3"			No. 16	333.35	27.47	
				2.5"			No. 20			
	Tested	Moisture		2.0"			No. 30	388.99	15.37	
Container Number	S-14	S-14	S-14	1.5"			No. 40			
Wet Wt. of Soil + Cont. (gm)	599.22	599.22		1.0"	0.00	100.00	No. 50	426.78	7.14	
Dry Wt. of Soil + Cont. (gm)		575.43	564.25	3/4"	18.93	95.88	No. 60			
Weight of Container (gm)	115.82	115.82	115.82	1/2"	87.99	80.86	No. 100	440.68	4.12	
Weight of Dry Soil (gm)	459.61	459.61	448.43	3/8"	150.33	67.29	No. 200	447.72	2.59	
Moisture Content (%)		5.18		No. 4	232.66	49.38	Pan	448.27		
Remark :				Cu :	18.7		Gravel	Sand	Fine	
5				Cc :	0.7	0.71985	51	46	3	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :						
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :						
Boring No. : WR-09-042	Depth below	Deck (ft):	193.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)	
Sample No. : S-22		Mudline (ft):	139.00							
Description : Dark olive-gray, SILTY SAND (SM)				5"			No. 8	0.44	99.82	
				4"			No. 10			
	Before Washing Sample		After Wet Sieve	3"			No. 16	2.59	98.93	
				2.5"			No. 20			
	Tested	Moisture		2.0"			No. 30	12.94	94.67	
Container Number	S-15	S-15	S-15	1.5"			No. 40			
Wet Wt. of Soil + Cont. (gm)	413.48	413.48		1.0"			No. 50	52.35	78.44	
Dry Wt. of Soil + Cont. (gm)		357.56	311.58	3/4"			No. 60			
Weight of Container (gm)	114.75	114.75	114.75	1/2"			No. 100	128.13	47.23	
Weight of Dry Soil (gm)	242.81	242.81	196.83	3/8"			No. 200	188.84	22.23	
Moisture Content (%)		23.03		No. 4	0.00	100.00	Pan	196.84		
Remark :				Cu :			Gravel	Sand	Fine	
6				Cc :			0	78	22	

PARTICLE SIZE ANALYSIS OF SOIL

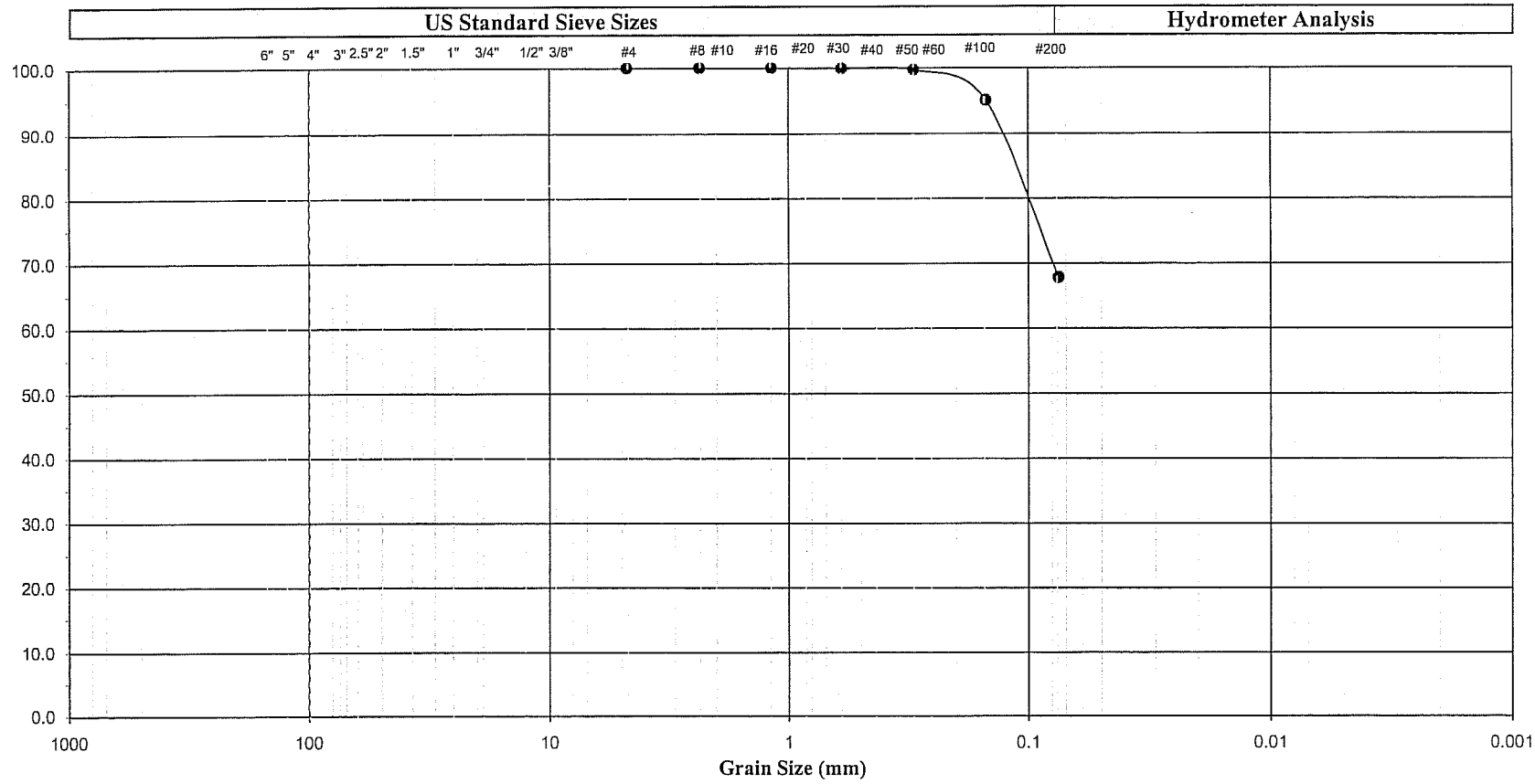
ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 06-123-3	Project Name : ACTA Schuyler Heim Bridge Project
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :					
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :					
Boring No. : WR-09-042	Depth below	Deck (ft):	213.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
Sample No. : S-24		Mudline (ft):	159.00						
Description : Dark greenish gray, Poorly graded SAND with SILT (SP-SM)				5"			No. 8	0.54	99.72
				4"			No. 10		
	Before Washing Sample		After Wet Sieve	3"			No. 16	0.77	99.61
	Tested	Moisture		2.5"			No. 20		
Container Number	S-16	S-16	S-16	2.0"			No. 30	4.61	97.65
Wet Wt. of Soil + Cont. (gm)	357.60	357.6		1.5"			No. 40		
Dry Wt. of Soil + Cont. (gm)		310.44	297.17	1.0"			No. 50	84.93	56.72
Weight of Container (gm)	114.19	114.19	114.19	3/4"			No. 60		
Weight of Dry Soil (gm)	196.25	196.25	182.98	1/2"			No. 100	167.41	14.70
Moisture Content (%)		24.03		3/8"	0.00	100.00	No. 200	181.88	7.32
Remark : >#16 cemented SAND (#30)				No. 4	0.32	99.84	Pan	182.91	
7				Cu :			Gravel	Sand	Fine
				Cc :			0	93	7

Prepared By :	Date :	Tested By :	Date :	Checked By :					
Washed By :	Date :	Computed By :	Date :	Date :					
Boring No. :	Depth :	(ft) :		Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
Sample No. :		(m) :							
Description :				5"			No. 8		
				4"			No. 10		
	Before Washing Sample		After Wet Sieve	3"			No. 16		
	Tested	Moisture		2.5"			No. 20		
Container Number				2.0"			No. 30		
Wet Wt. of Soil + Cont. (gm)				1.5"			No. 40		
Dry Wt. of Soil + Cont. (gm)				1.0"			No. 50		
Weight of Container (gm)				3/4"			No. 60		
Weight of Dry Soil (gm)				1/2"			No. 100		
Moisture Content (%)				3/8"			No. 200		
Remark :				No. 4			Pan		
8				Cu :			Gravel	Sand	Fine
				Cc :					

Prepared By :	Date :	Tested By :	Date :	Checked By :					
Washed By :	Date :	Computed By :	Date :	Date :					
Boring No. :	Depth :	(ft) :		Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
Sample No. :		(m) :							
Description :				5"			No. 8		
				4"			No. 10		
	Before Washing Sample		After Wet Sieve	3"			No. 16		
	Tested	Moisture		2.5"			No. 20		
Container Number				2.0"			No. 30		
Wet Wt. of Soil + Cont. (gm)				1.5"			No. 40		
Dry Wt. of Soil + Cont. (gm)				1.0"			No. 50		
Weight of Container (gm)				3/4"			No. 60		
Weight of Dry Soil (gm)				1/2"			No. 100		
Moisture Content (%)				3/8"			No. 200		
Remark :				No. 4			Pan		
9				Cu :			Gravel	Sand	Fine
				Cc :					



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-3-2	68.3		14.3		olive-gray	Sandy silty clay to clayey silt	CL-ML
Remark	0.00								

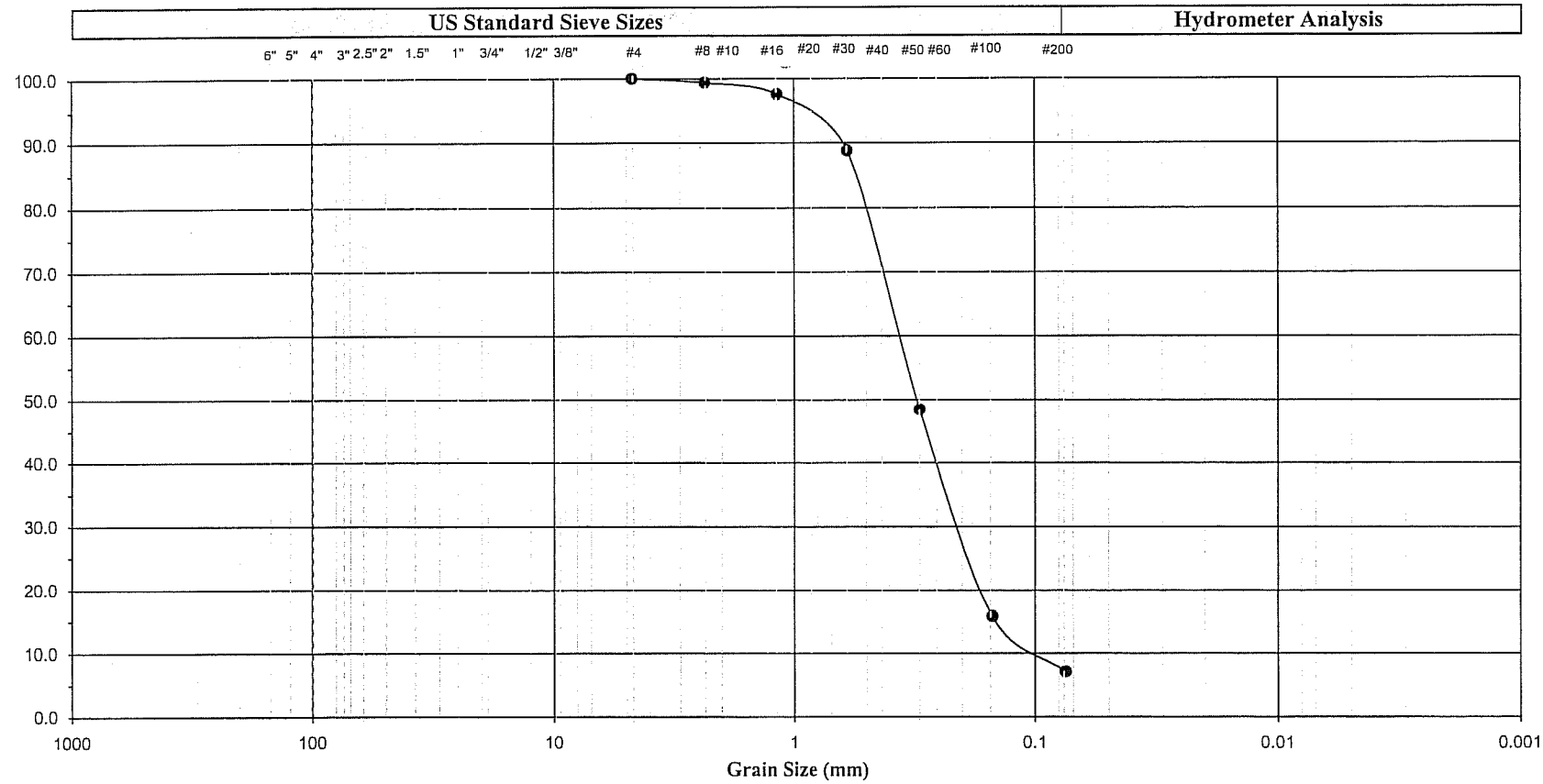
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-9	98.0		44.0		olive-gray	Poorly graded sand with silt	SP-SM
Remark									

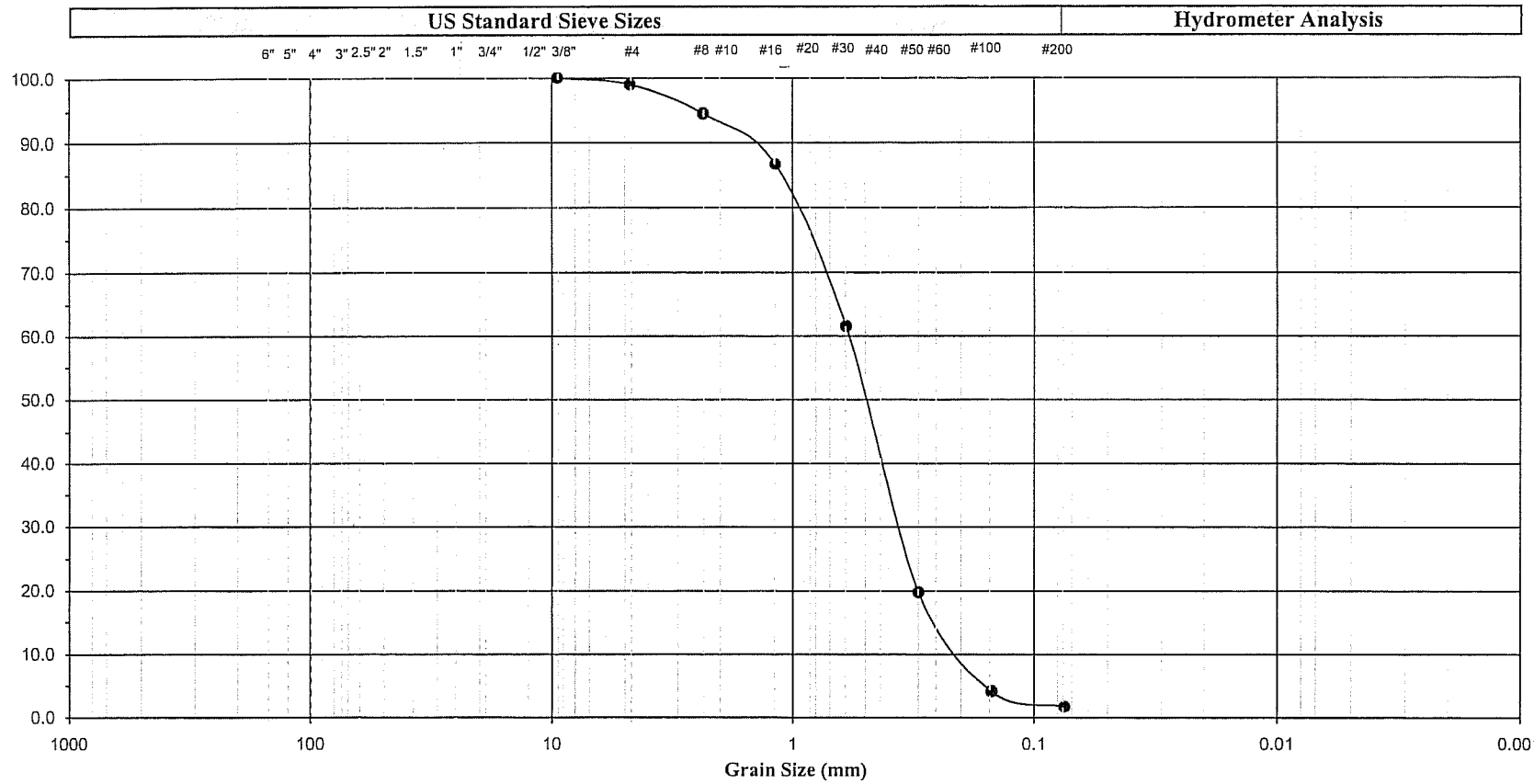
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)	Depth below Mudline (ft)	Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-12	113.0	59.0	Olive-gray	Poorly graded sand	SP
Remark							

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

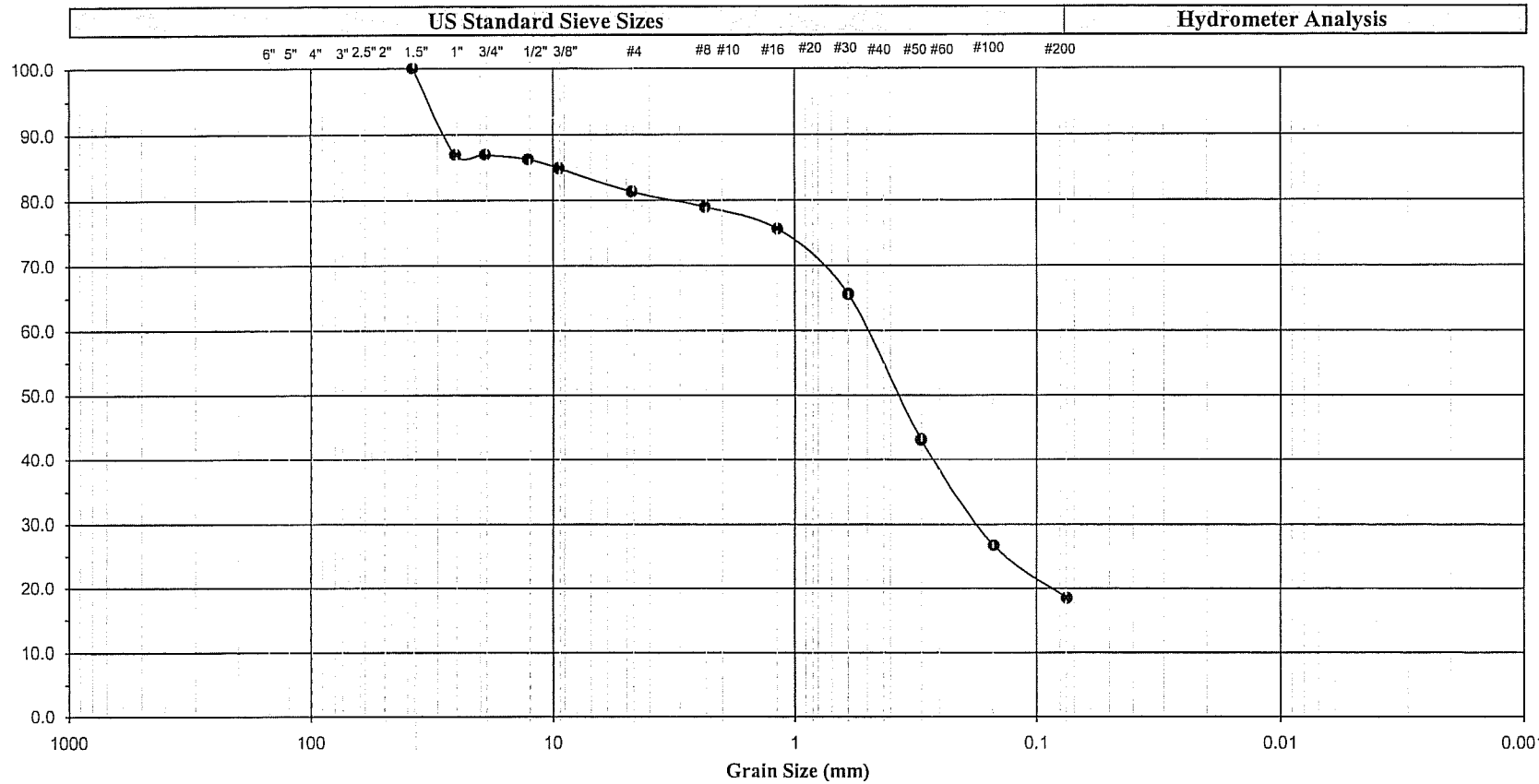
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)	Depth below Mudline (ft)	Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-16	133.0	79.0	olive-gray	Silty sand with gravel	SM
Remark							

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

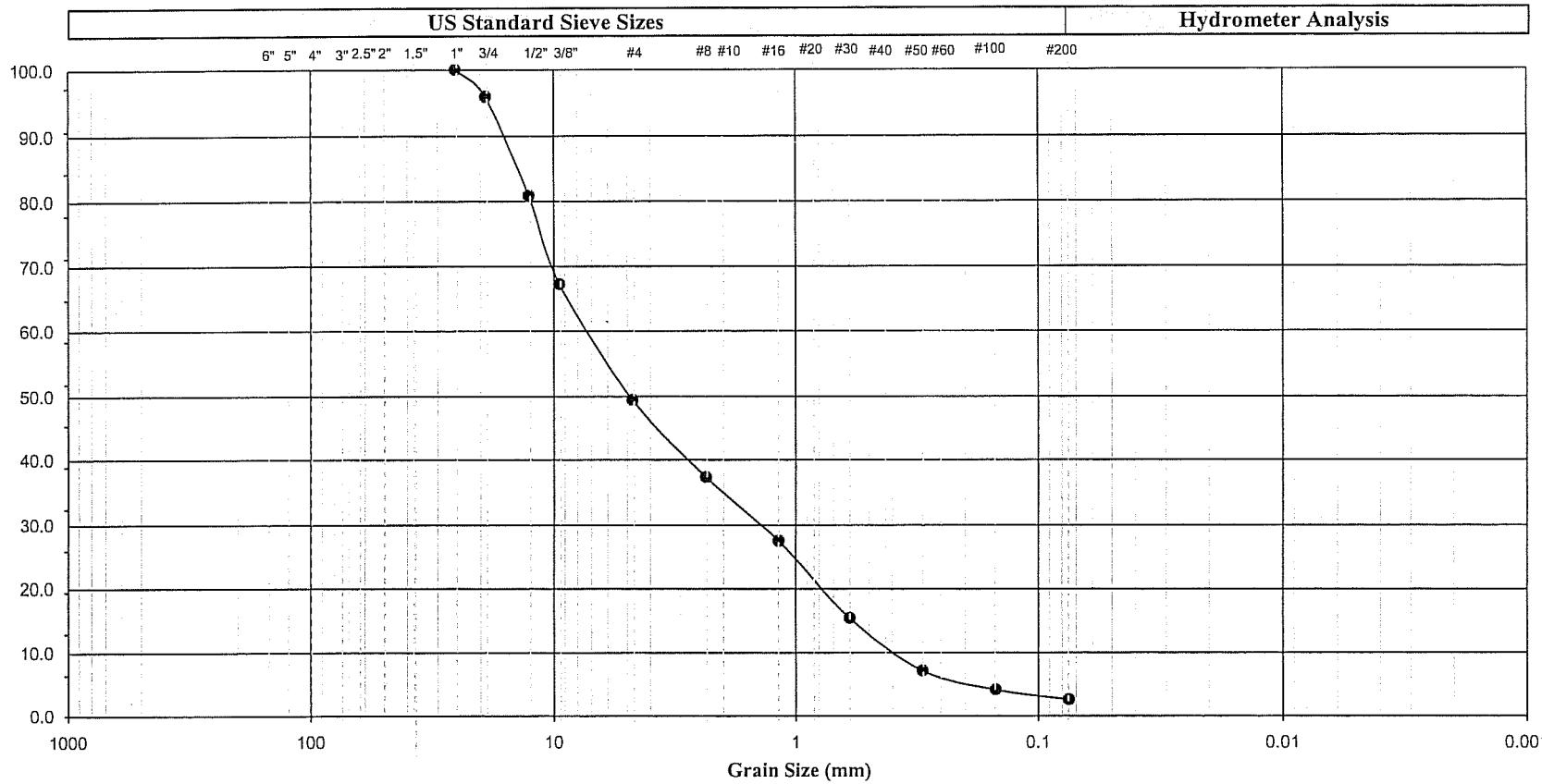
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	D-19	163.0		109.0		dark olive-gray	Poorly graded gravel with sand	GP
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

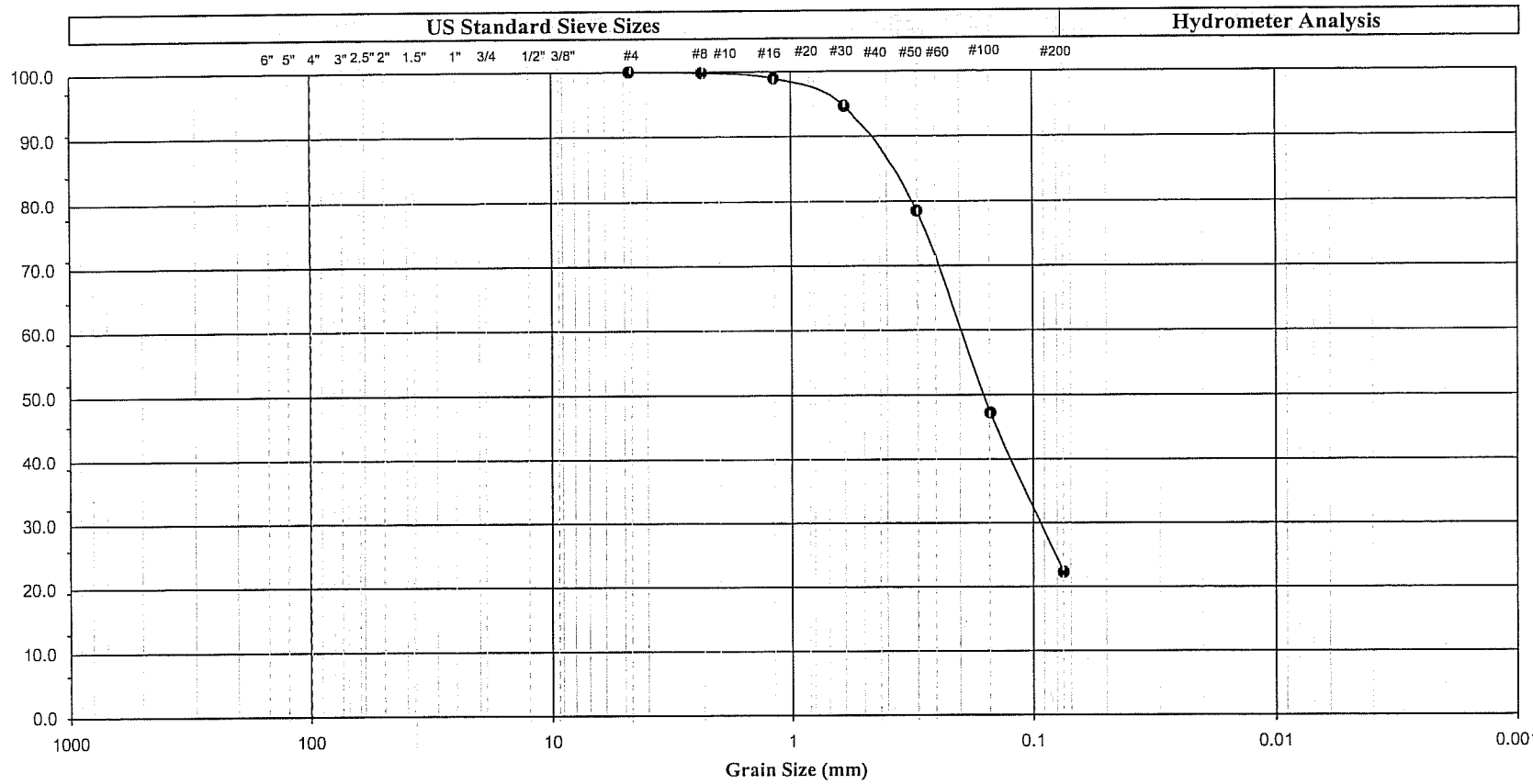
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-22	193.0		139.0		dark olive-gray	Silty sand	SM
Remark									

Earth Mechanics, Inc.
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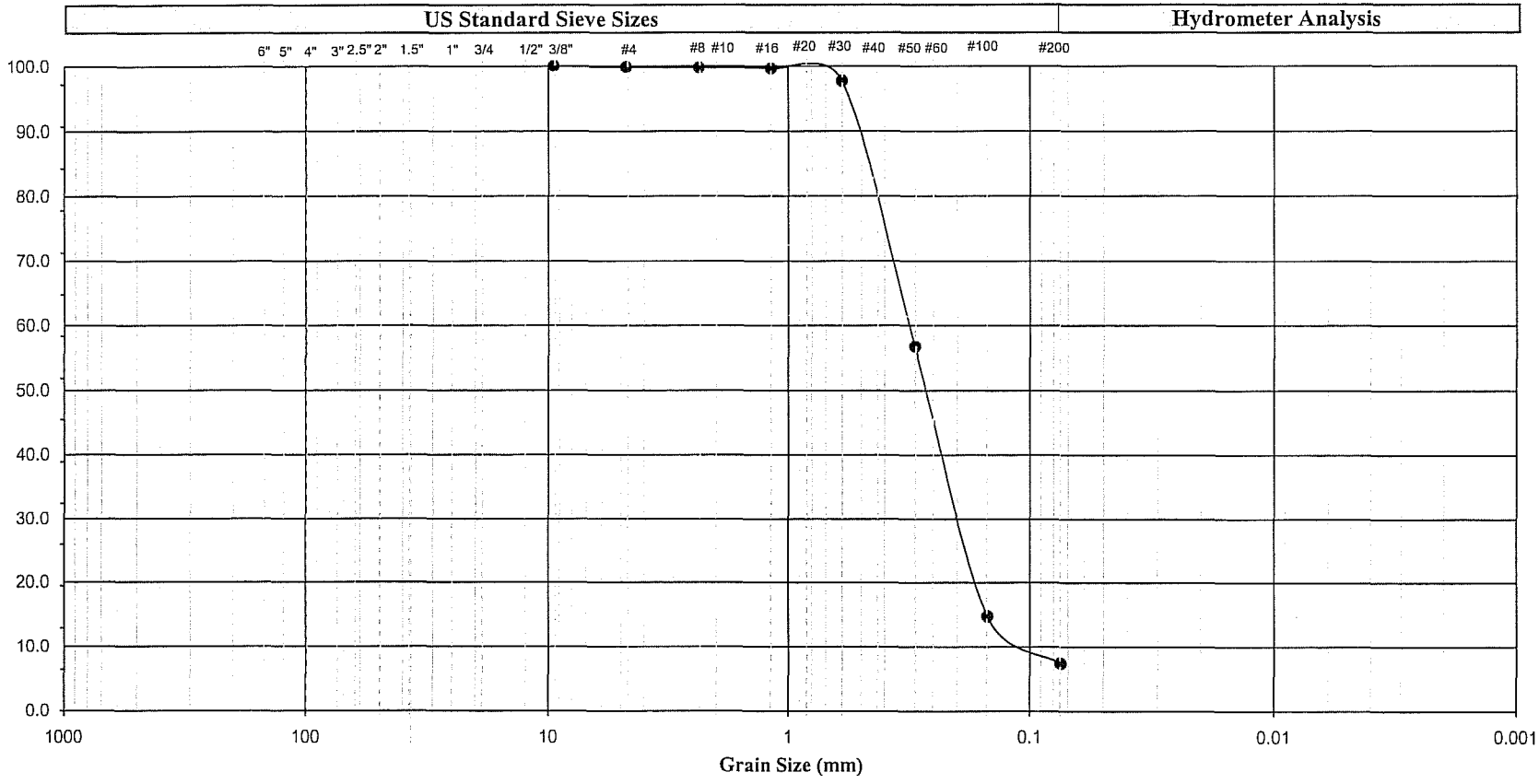
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-24	213.0		159.0		dark greenish gray	Poorly graded sand with silt	SP-SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 06-123-3	Project Name : ACTA Schuyler Heim Bridge Project
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :	
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :	

Boring No. : WR-09-043	Depth below	Deck (ft):	108.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)	
Sample No. : D-13		Mudline (ft):	52.00	5"			No. 8	33.83	88.23	
Description : Olive-gray, Poorly graded SAND with SILT (SP-SM)				4"			No. 10			
	Before Washing Sample		After Wet Sieve	3"			No. 16	74.09	74.21	
	Tested	Moisture		2.5"			No. 20			
Container Number	S-19	S-19	S-19	2.0"			No. 30	150.81	47.51	
Wet Wt. of Soil + Cont. (gm)	445.42	445.42		1.5"			No. 40			
Dry Wt. of Soil + Cont. (gm)		403.91	389.91	1.0"			No. 50	232.04	19.24	
Weight of Container (gm)	116.58	116.58	116.58	3/4"	0.00	100.00	No. 60			
Weight of Dry Soil (gm)	287.33	287.33	273.33	1/2"	4.73	98.35	No. 100	261.95	8.83	
Moisture Content (%)		14.45		3/8"	6.91	97.60	No. 200	272.32	5.22	
Remark :				No. 4	13.05	95.46	Pan	273.15		
1				Cu :	5.2		Gravel	Sand	Fine	
				Cc :	1.2		5	90	5	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :						
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :						
Boring No. : WR-09-043	Depth below	Deck (ft):	133.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)	
Sample No. : S-16		Mudline (ft):	77.00	5"			No. 8	12.05	95.47	
Description : Dark greenish gray, Well-graded SAND with SILT (SW-SM)				4"			No. 10			
	Before Washing Sample		After Wet Sieve	3"			No. 16	39.67	85.07	
	Tested	Moisture		2.5"			No. 20			
Container Number	S-20	S-20	S-20	2.0"			No. 30	114.35	56.98	
Wet Wt. of Soil + Cont. (gm)	418.34	418.34		1.5"			No. 40			
Dry Wt. of Soil + Cont. (gm)		380.93	358.49	1.0"			No. 50	191.02	28.13	
Weight of Container (gm)	115.15	115.15	115.15	3/4"			No. 60			
Weight of Dry Soil (gm)	265.78	265.78	243.34	1/2"			No. 100	226.71	14.70	
Moisture Content (%)		14.08		3/8"	0.00	100.00	No. 200	242.46	8.77	
Remark :				No. 4	2.03	99.24	Pan	243.35		
2				Cu :	7.3		Gravel	Sand	Fine	
				Cc :	1.70		1	90	9	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :						
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :						
Boring No. : WR-09-043	Depth below	Deck (ft):	153.0	Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)	
Sample No. : S-18		Mudline (ft):	97.00	5"			No. 8	157.74	61.27	
Description : Dark greenish gray, Poorly graded SAND with SILT and GRAVEL (SP-SM)				4"			No. 10			
	Before Washing Sample		After Wet Sieve	3"			No. 16	185.17	54.54	
	Tested	Moisture		2.5"			No. 20			
Container Number	S-21	S-21	S-21	2.0"			No. 30	231.66	43.12	
Wet Wt. of Soil + Cont. (gm)	560.62	560.62		1.5"	0.00	100.00	No. 40			
Dry Wt. of Soil + Cont. (gm)		522.52	473.82	1.0"	34.49	91.53	No. 50	287.87	29.32	
Weight of Container (gm)	115.21	115.21	115.21	3/4"	55.07	86.48	No. 60			
Weight of Dry Soil (gm)	407.31	407.31	358.61	1/2"	71.37	82.48	No. 100	329.92	19.00	
Moisture Content (%)		9.35		3/8"	87.04	78.63	No. 200	356.75	12.41	
Remark :				No. 4	125.99	69.07	Pan	359.03		
3				Cu :			Gravel	Sand	Fine	
				Cc :			31	57	12	

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No	: 06-123-3	Project Name : ACTA Schuyler Heim Bridge Project
Standard	: ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By	: PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By	: PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No.	: WR-09-043	Depth below	Deck (ft):	198.0
Sample No.	: S-22		Mudline (ft):	142.00

Description : Dark greenish gray, SILTY SAND (SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-22	S-22	S-22
Wet Wt. of Soil + Cont. (gm)	412.56	412.56	
Dry Wt. of Soil + Cont. (gm)		361.80	328.42
Weight of Container (gm)	115.21	115.21	115.21
Weight of Dry Soil (gm)	246.59	246.59	213.21
Moisture Content (%)		20.58	

Sieve	Cimulative Weight	(%)
5"		
4"		
3"		
2.5"		
2.0"		
1.5"		
1.0"		
3/4"		
1/2"		
3/8"	0.00	100.00
No. 4	0.89	99.64
Cu :		
Cc :		

Sieve	Cimulative Weight	(%)
No. 8	2.03	99.18
No. 10		
No. 16	3.68	98.51
No. 20		
No. 30	14.08	94.29
No. 40		
No. 50	82.80	66.42
No. 60		
No. 100	177.79	27.90
No. 200	209.22	15.15
Pan	213.11	
Gravel	Sand	Fine
0	85	15

Remark : 4

Prepared By	: PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By	: PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No.	: WR-09-043	Depth below	Deck (ft):	223.0
Sample No.	: S-24		Mudline (ft):	169.00

Description : Dark greensih gray, Poorly graded SAND with SILT (SP-SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-23	S-23	S-23
Wet Wt. of Soil + Cont. (gm)	387.28	387.28	
Dry Wt. of Soil + Cont. (gm)		342.10	322.69
Weight of Container (gm)	113.83	113.83	113.83
Weight of Dry Soil (gm)	228.27	228.27	208.86
Moisture Content (%)		19.79	

Sieve	Cimulative Weight	(%)
5"		
4"		
3"		
2.5"		
2.0"		
1.5"		
1.0"		
3/4"	0.00	100.00
1/2"	3.58	98.43
3/8"	3.58	98.43
No. 4	4.56	98.00
Cu :	5.8	
Cc :	2.1	2.05058

Sieve	Cimulative Weight	(%)
No. 8	6.14	97.31
No. 10		
No. 16	11.15	95.12
No. 20		
No. 30	60.51	73.49
No. 40		
No. 50	160.42	29.72
No. 60		
No. 100	194.04	15.00
No. 200	207.74	8.99
Pan	208.68	
Gravel	Sand	Fine
2	89	9

Remark : Cemented #30 sand on 1/2" sieve — 5

Prepared By	: PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By	: PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No.	: WR-09-044	Depth below	Deck (ft):	128.0
Sample No.	: S-15		Mudline (ft):	81.00

Description : Oive-gray, Well-graed GRAVEL with SAND (GW)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-12	S-12	S-12
Wet Wt. of Soil + Cont. (gm)	336.09	336.09	
Dry Wt. of Soil + Cont. (gm)		322.01	314.31
Weight of Container (gm)	114.28	114.28	114.28
Weight of Dry Soil (gm)	207.73	207.73	200.03
Moisture Content (%)		6.78	

Sieve	Cimulative Weight	(%)
5"		
4"		
3"		
2.5"		
2.0"		
1.5"		
1.0"	0.00	100.00
3/4"	33.98	83.64
1/2"	79.71	61.63
3/8"	95.76	53.90
No. 4	134.44	35.28
Cu :	31.1	31.0727
Cc :	2.5	2.47434

Sieve	Cimulative Weight	(%)
No. 8	153.77	25.98
No. 10		
No. 16	168.53	18.87
No. 20		
No. 30	181.10	12.82
No. 40		
No. 50	189.35	8.85
No. 60		
No. 100	195.57	5.85
No. 200	199.81	3.81
Pan	200.02	
Gravel	Sand	Fine
65	31	4

Remark : 6

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 06-123-3	Project Name : ACTA Schuyler Heim Bridge Project
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No. : WR-09-044	Depth below	Deck (ft):	148.0
Sample No. : S-17		Mudline (ft):	101.00

Description : Gray, Well-graded SAND with SILT and GRAVEL (SW-SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-13	S-13	S-13
Wet Wt. of Soil + Cont. (gm)	454.75	454.75	
Dry Wt. of Soil + Cont. (gm)		427.56	398.32
Weight of Container (gm)	113.63	113.63	113.63
Weight of Dry Soil (gm)	313.93	313.93	284.69
Moisture Content (%)		8.66	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	159.41	49.22
4"			No. 10		
3"			No. 16	191.42	39.02
2.5"			No. 20		
2.0"			No. 30	222.51	29.12
1.5"	0.00	100.00	No. 40		
1.0"	36.17	88.48	No. 50	250.22	20.29
3/4"	45.97	85.36	No. 60		
1/2"	64.44	79.47	No. 100	270.55	13.82
3/8"	86.50	72.45	No. 200	283.78	9.60
No. 4	120.96	61.47	Pan	284.72	
Cu :	54.4	31.0727	Gravel	Sand	Fine
Cc :	1.2	2.47434	39	51	10

Remark :

7

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No. : WR-09-044	Depth below	Deck (ft):	148.0
Sample No. : S-19		Mudline (ft):	101.00

Description : Gray, Well-graded GRAVEL with SILT and SAND (GW-GM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-14	S-14	S-14
Wet Wt. of Soil + Cont. (gm)	290.81	290.81	
Dry Wt. of Soil + Cont. (gm)		277.81	264.74
Weight of Container (gm)	115.82	115.82	115.82
Weight of Dry Soil (gm)	161.99	161.99	148.92
Moisture Content (%)		8.03	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	108.18	33.22
4"			No. 10		
3"			No. 16	120.21	25.79
2.5"			No. 20		
2.0"			No. 30	129.92	19.80
1.5"	0.00	100.00	No. 40		
1.0"	31.58	80.50	No. 50	137.32	15.23
3/4"	52.23	67.76	No. 60		
1/2"	67.55	58.30	No. 100	143.45	11.45
3/8"	74.35	54.10	No. 200	148.52	8.32
No. 4	93.02	42.58	Pan	148.93	
Cu :	120.1	31.0727	Gravel	Sand	Fine
Cc :	2.1	2.47434	57	35	8

Remark :

8

Prepared By : PA	Date : 12/16/09	Tested By : PA	Date : 12/18/09	Checked By :
Washed By : PA	Date : 12/17/09	Computed By : JF	Date : 12/29/09	Date :

Boring No. : WR-09-044	Depth below	Deck (ft):	208.0
Sample No. : S-23		Mudline (ft):	161.00

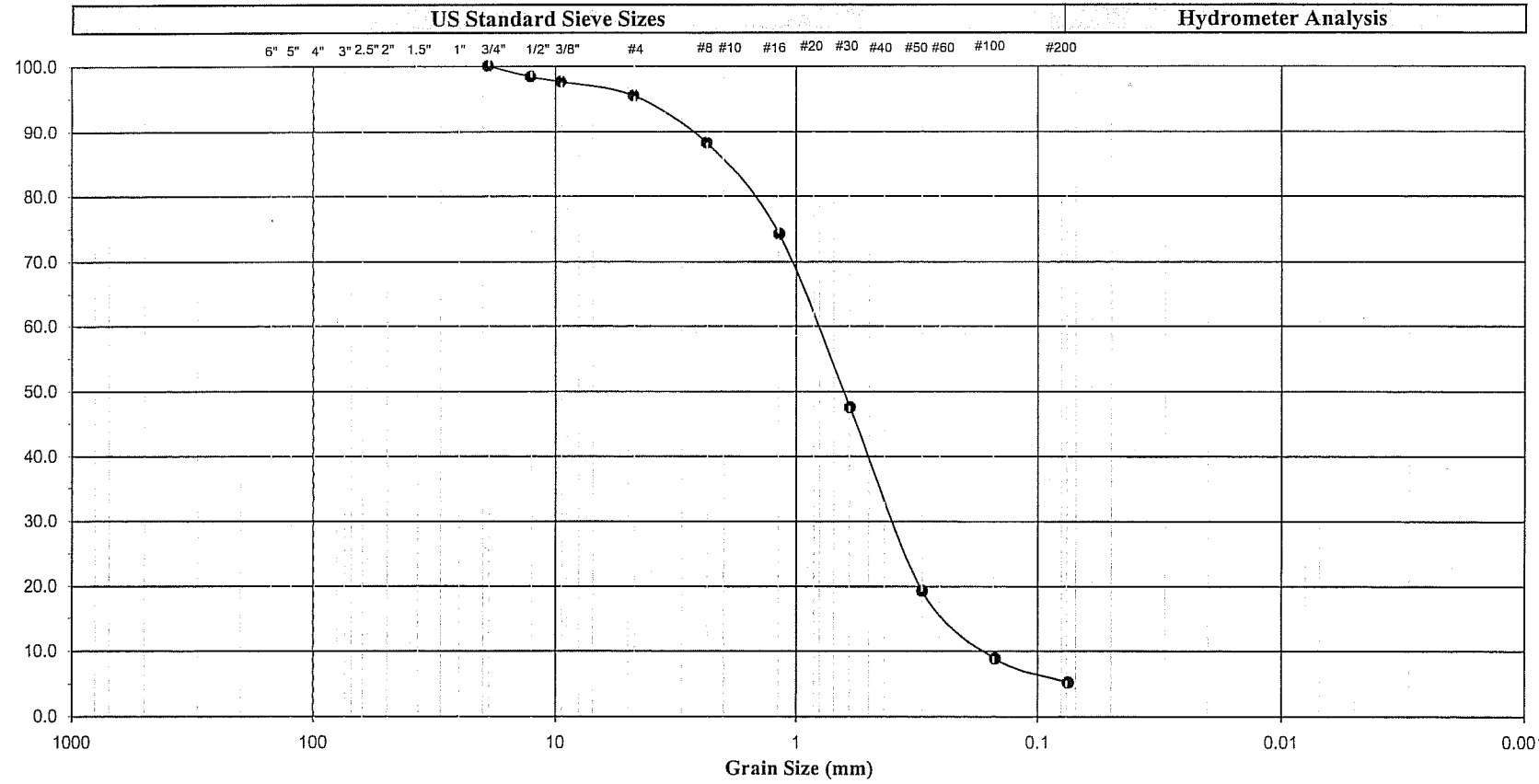
Description : Dark olive-gray, Poorly graded SAND with SILT (SP-SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-15	S-15	S-15
Wet Wt. of Soil + Cont. (gm)	379.91	379.91	
Dry Wt. of Soil + Cont. (gm)		326.86	398.32
Weight of Container (gm)	114.73	114.73	114.73
Weight of Dry Soil (gm)	212.13	212.13	283.59
Moisture Content (%)		25.01	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	23.08	89.12
4"			No. 10		
3"			No. 16	34.84	83.58
2.5"			No. 20		
2.0"			No. 30	76.08	64.14
1.5"	0.00	100.00	No. 40		
1.0"	18.73	91.17	No. 50	169.98	19.87
3/4"	18.73	91.17	No. 60		
1/2"	18.73	91.17	No. 100	199.43	5.99
3/8"	18.73	91.17	No. 200	201.94	4.80
No. 4	19.18	90.96	Pan	206.74	
Cu :	3.0	31.0727	Gravel	Sand	Fine
Cc :	1.2	2.47434	9	86	5

Remark :

9



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	D-13	108.0		52.0		olive-gray	Poorly graded sand with silt	SP-SM
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

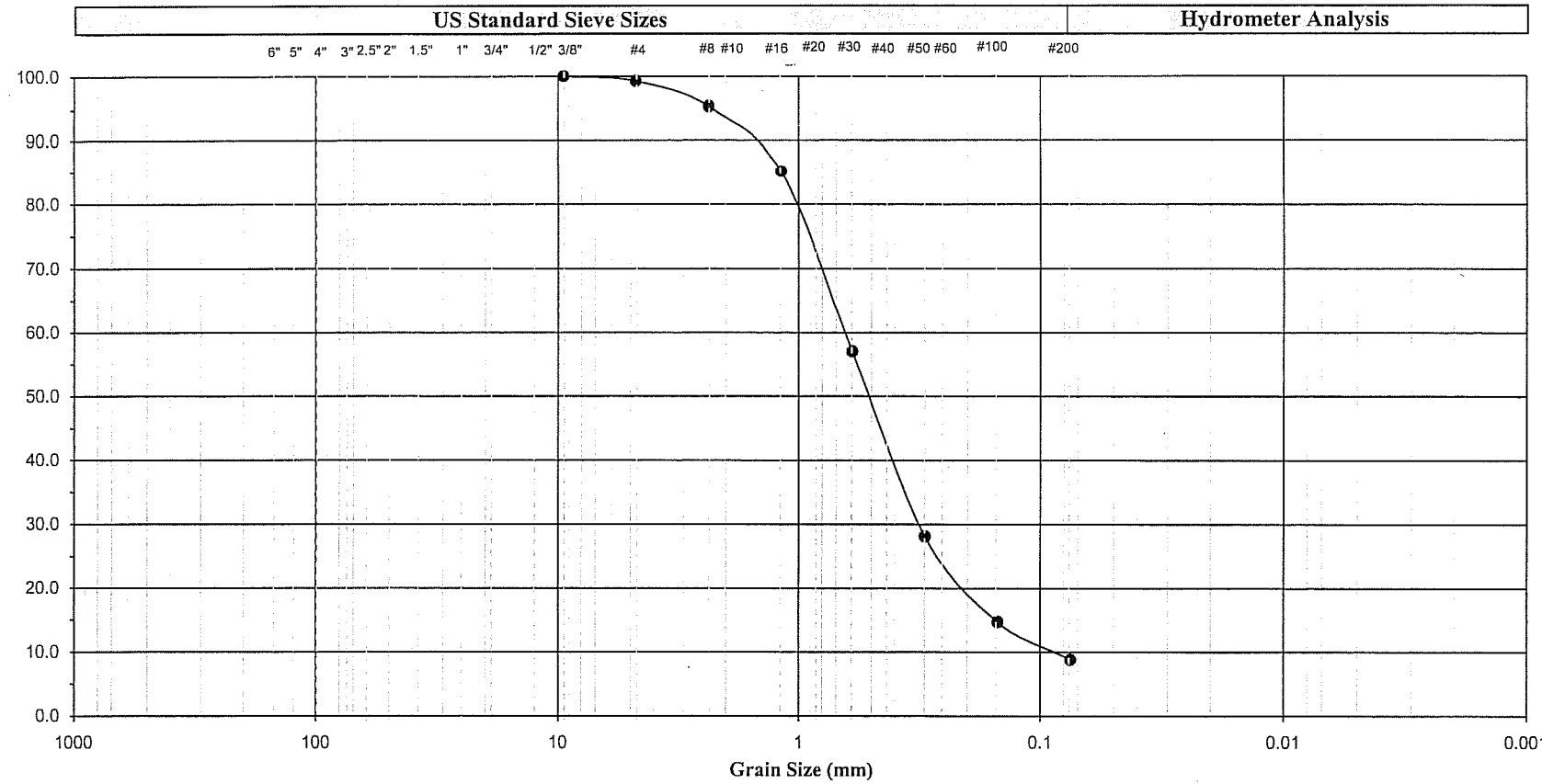
ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	S-16	133.0		77.0		dark greenish gray	Well graded sand with silt	SW-SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

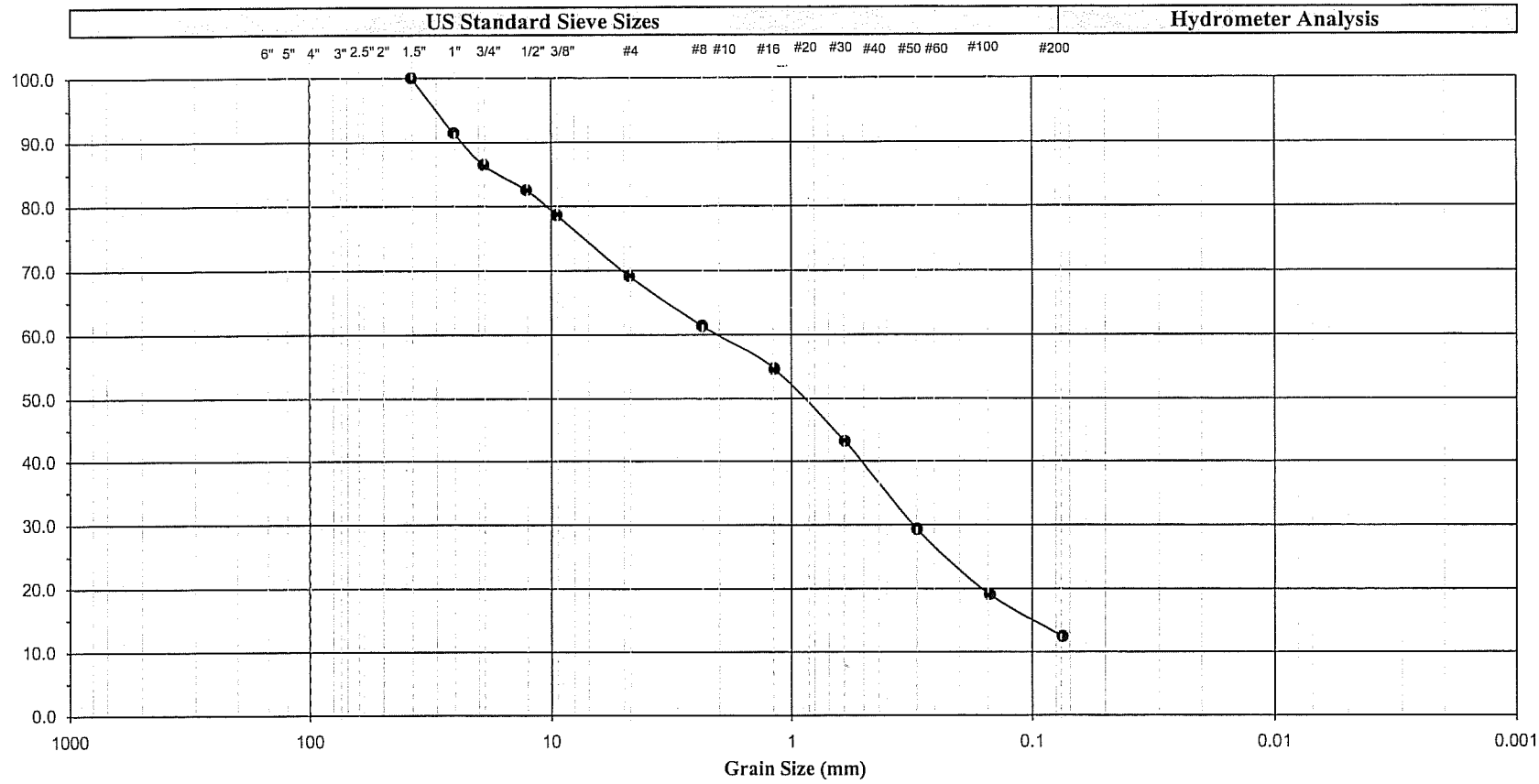
Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	S-18	153.0		97.0		dark greenish gray	Poorly graded sand with silt with gravel	SP-SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

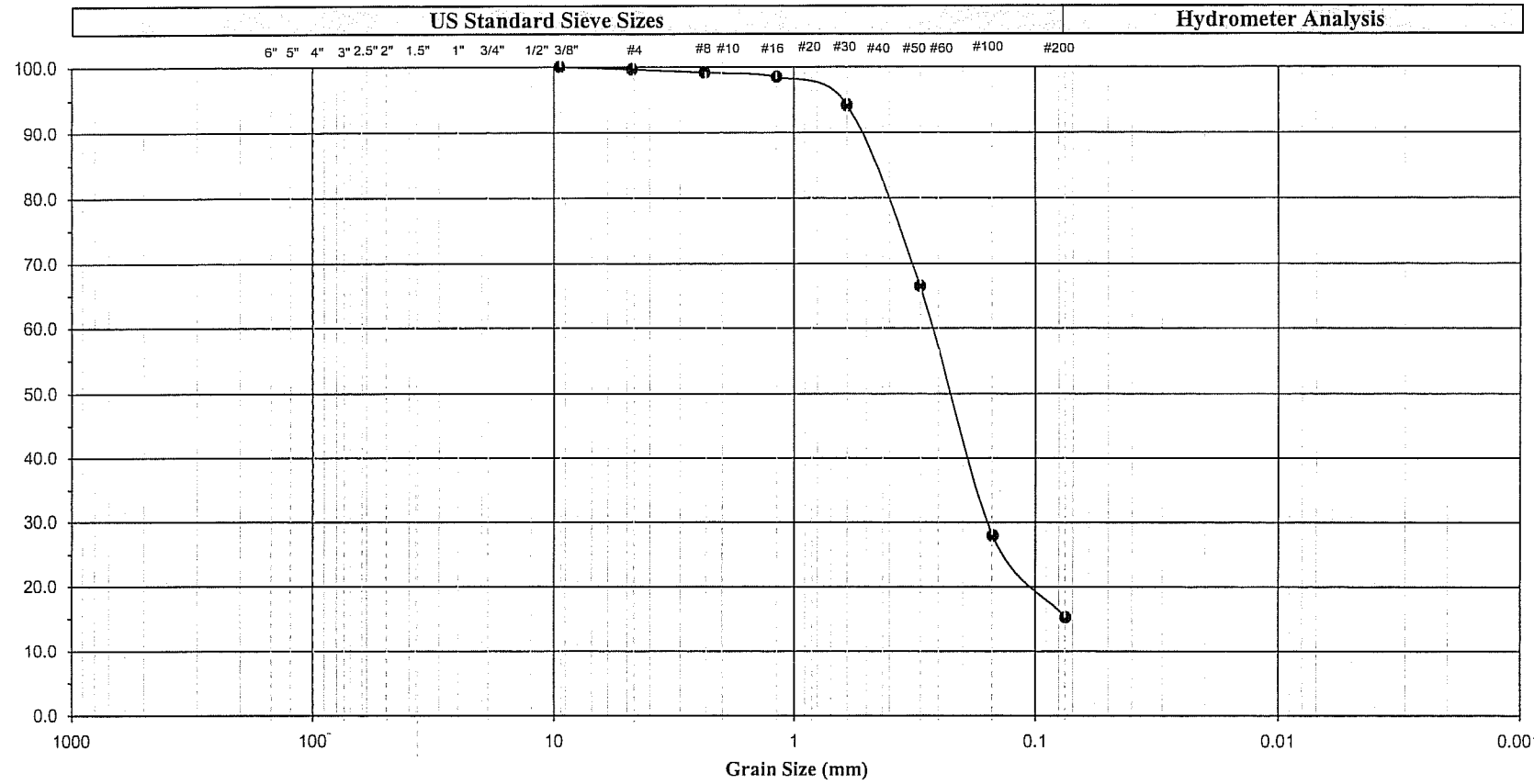
Project No. : 06-123-3

Date : 12/18/09

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	S-22	198.0		142.0		dark greenish gray	Silty sand	SM
Remark									

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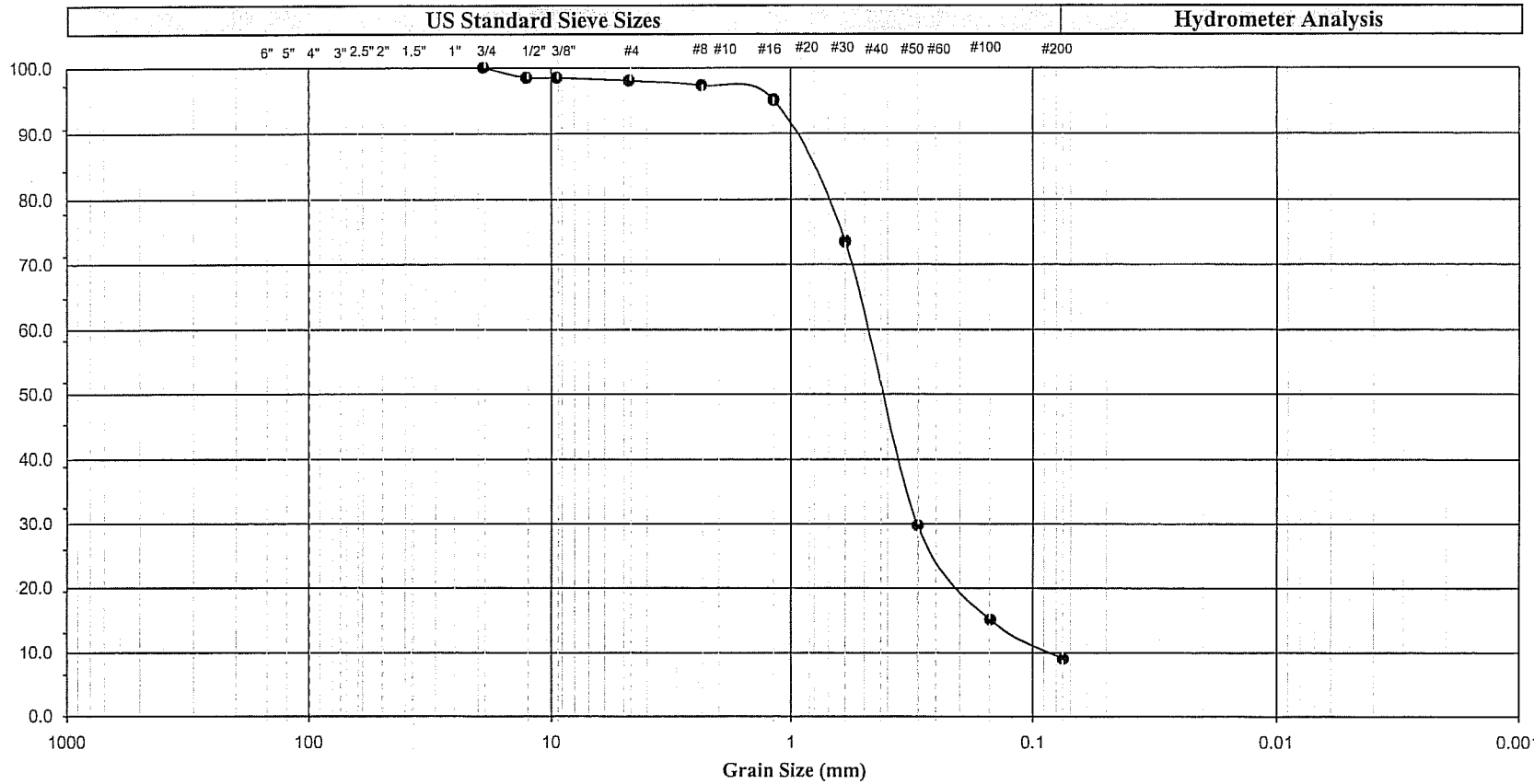
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	S-24	223.0		169.0		dark greenish gray	Poorly graded sand with silt	SP-SM
Remark									

Earth Mechanics, Inc.
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ACTA Schuyler Heim Bridge Project

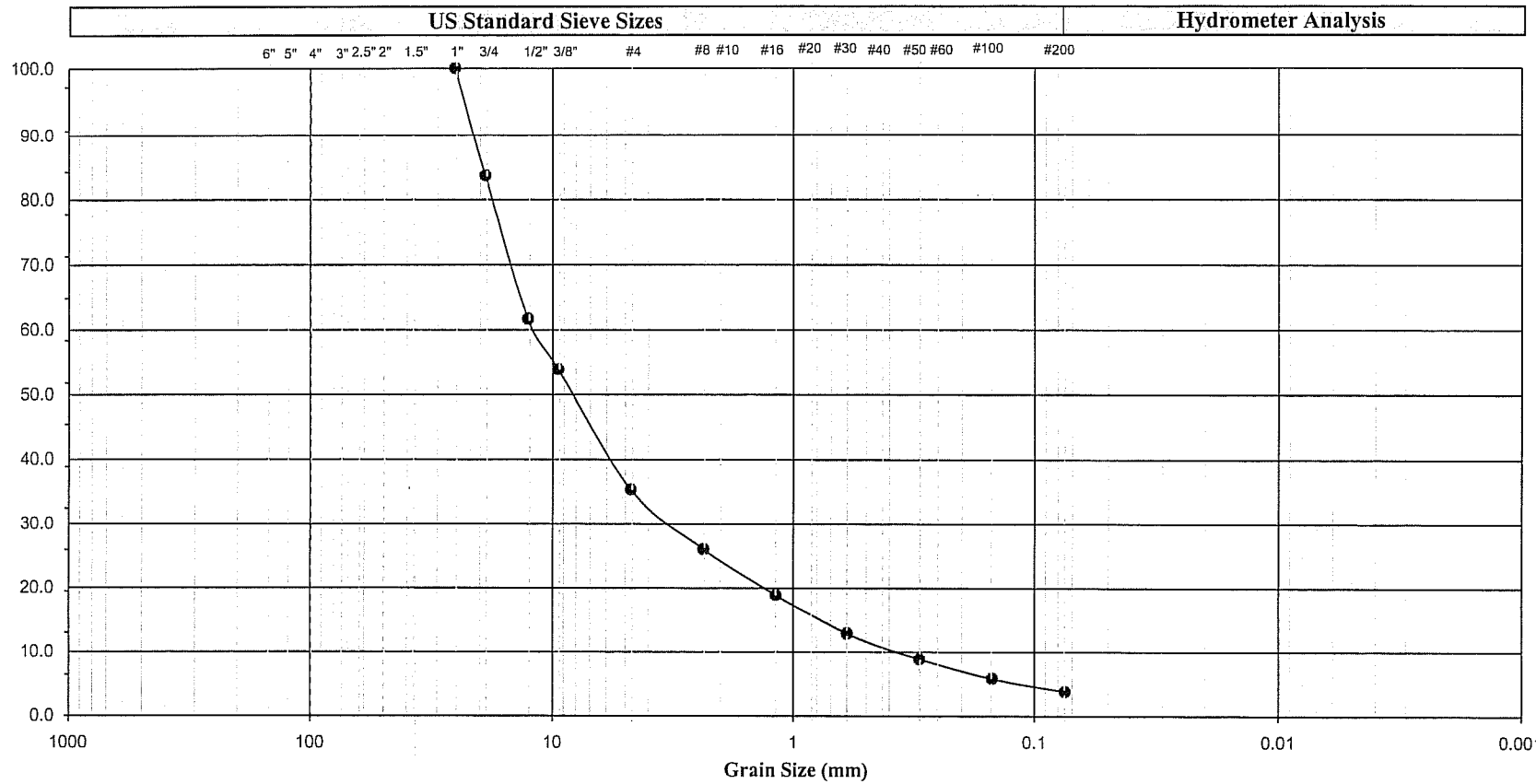
Project No. : 06-123-3

Date : 12/18/09

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-15	128.0		81.0		olive-gray	Well graded gravel with sand	GW
Remark									

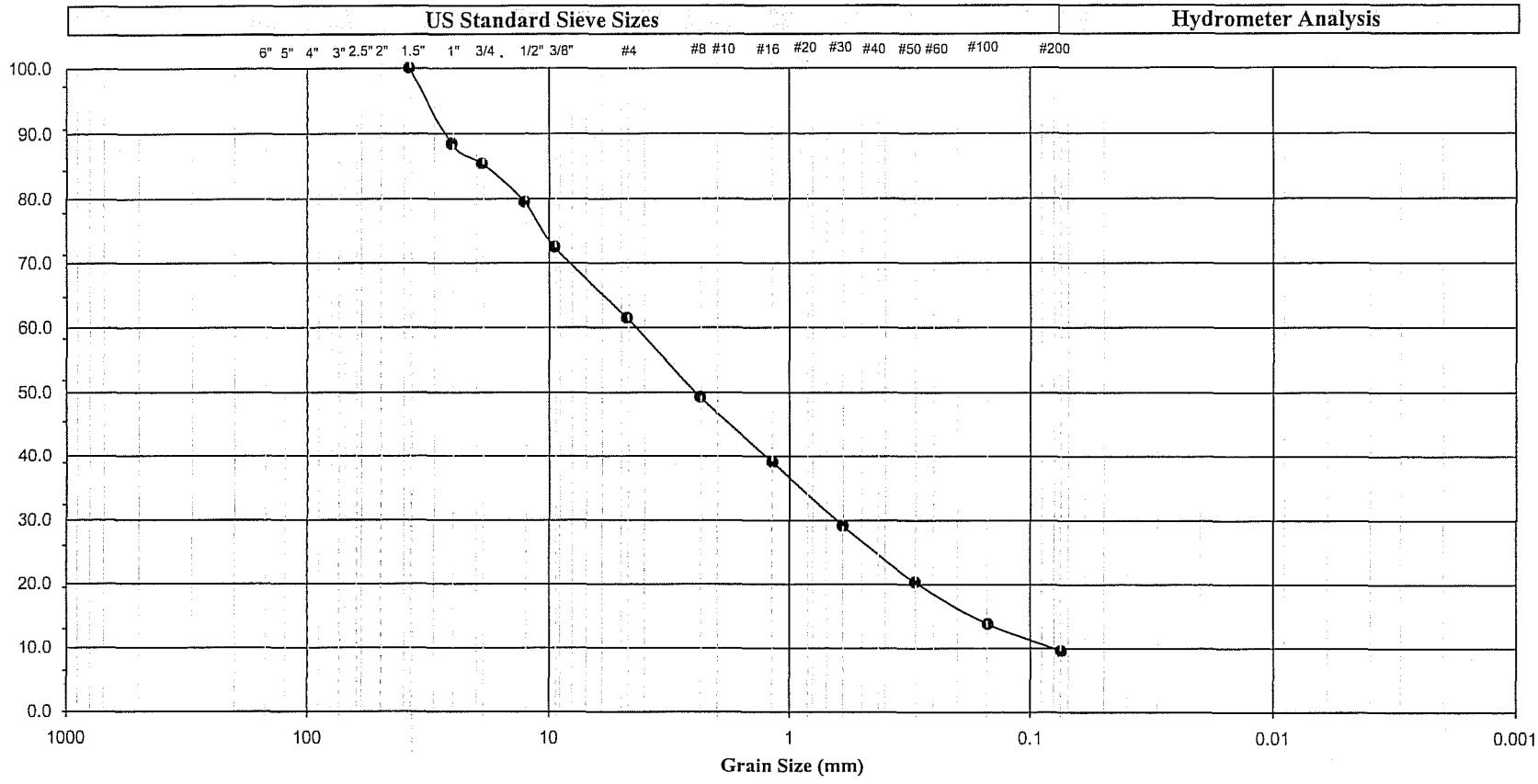
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-17	148.0		101.0		dark greenish gray	Well graded sand with silt with gravel	SW-SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

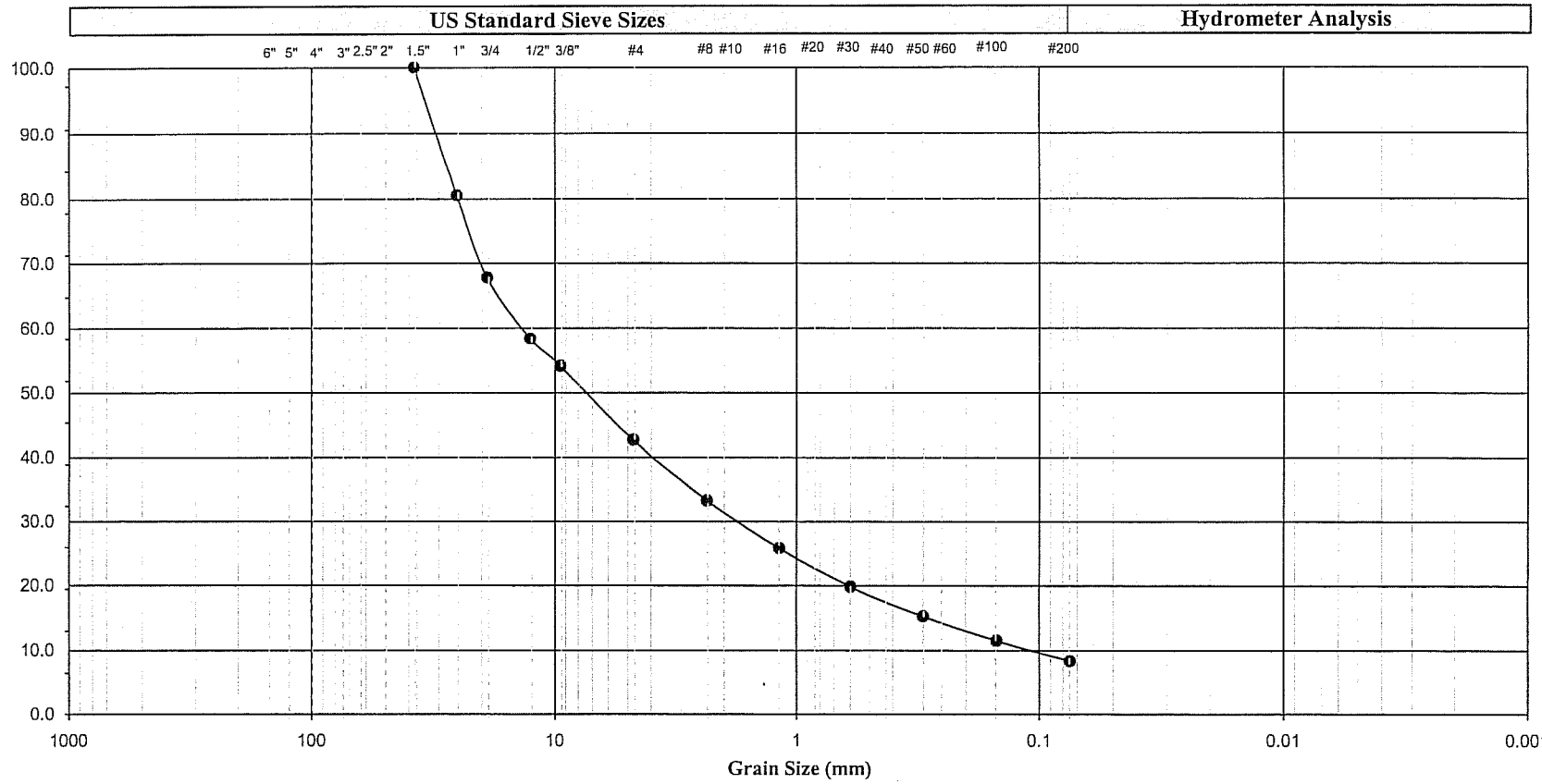
ACTA Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)	Depth below Mudline (ft)	Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-19	148.0	101.0	Gray	Well graded gravel with silt and sand	GW-GM
Remark							

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

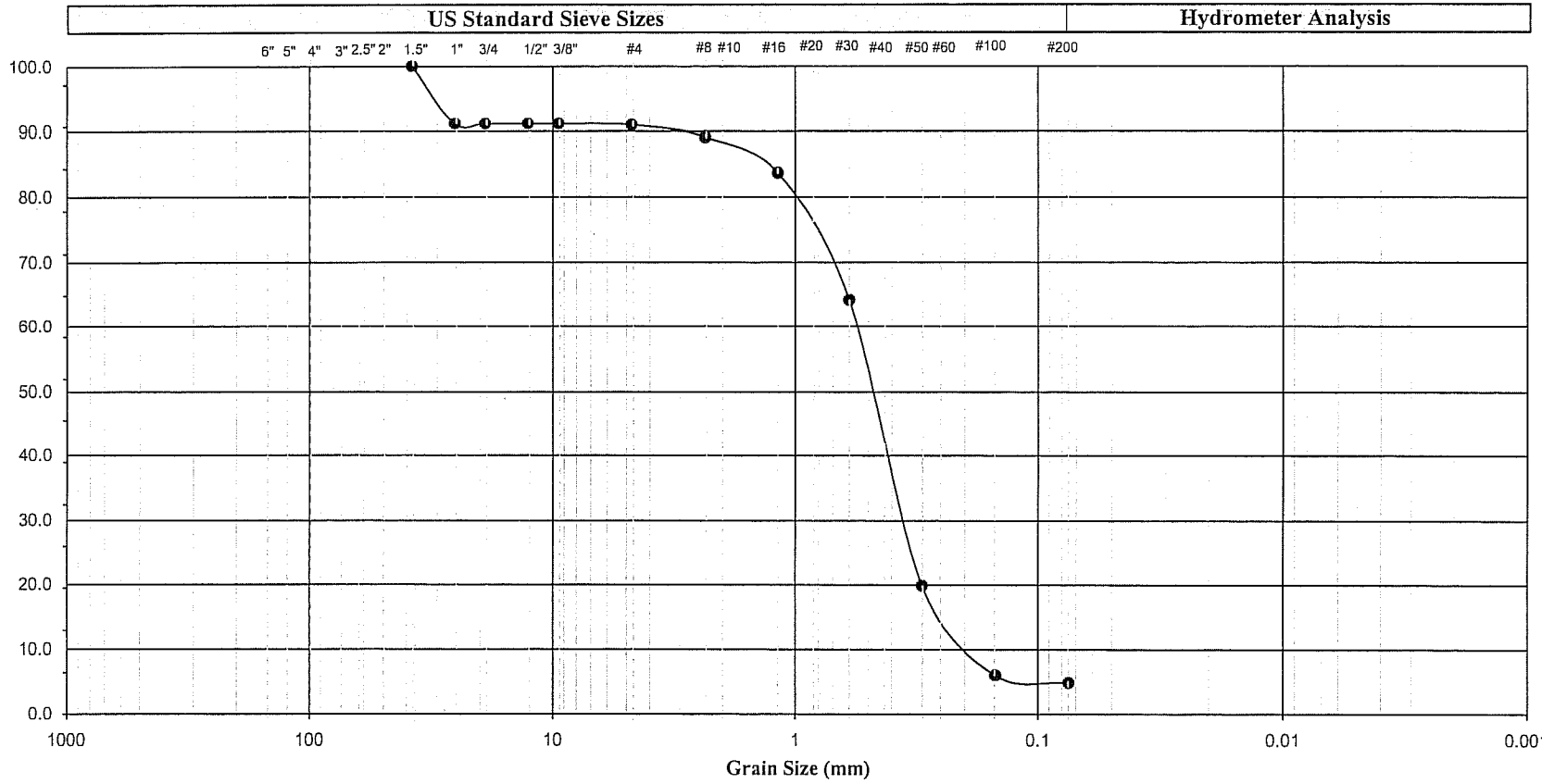
Project No. : *06-123-3*

Date : *12/18/09*

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below Deck (ft)		Depth below Mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-23	208.0		161.0		Dark olive-gray	Poorly graded sand with silt	SP-SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/18/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

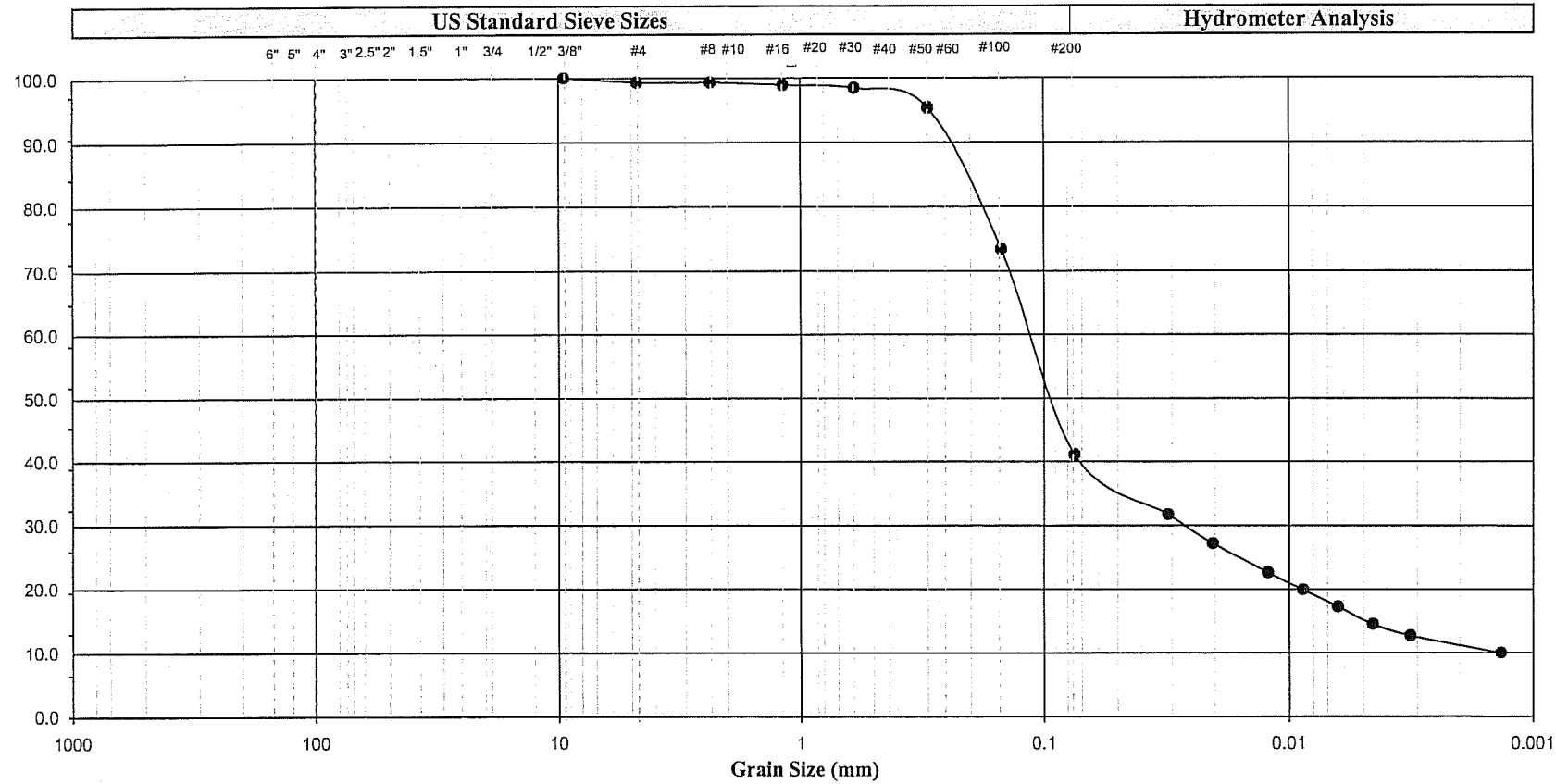
Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑ **CAL. TRANS.**	
Boring No.	: *WR-09-041*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-1*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *42.0*	**Depth below Mudline (ft):** 0.2	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, SILTY SAND (SM)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand.			*1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :								*2.70*	
Test Cylinder No. :	*6*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**		
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*S-9*		*J-2*	*12*	*S-9*	*S-11*		
Wt. of Wet Soil + Container (gm)		*251.36*		*110.56*	*173.46*			*0.99*	
Wt. of Dry Soil + Container (gm)					*171.55*	*117.57*	*187.36*	**Hydrometer Type**	
Wt. of Container (gm)					*57.23*	*115.90*	*119.94*	*152H*	
Wt. of Dry Soil (gm)		*247.23*		*108.74*		*1.67*	*67.42*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*1.67*			*0.01353*	*19.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*0.47*		*99.57*	***98.90***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*1.01*		*99.07*	***98.40***
1.0"					No. 40				
3/4"				-	No. 50	*4.23*		*96.11*	***95.46***
1/2"					No. 60				
3/8"	*0.00*		***100.00***	Plastic Index	No. 100	*28.43*		*73.86*	***73.36***
No. 4	*1.67*		***99.32***		No. 140				
No. 8	*0.00*		***99.32***	-	No. 200	*63.82*		*41.31*	***41.03***
No. 10					Pan	*67.37*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	w			(K)	(L)	
0:01	(T)							(mm)			(D)
8:30	*0:00:00*			*5.0*							
	2	*19.5*	*40.0*	*5.0*	*35.0*	*31.86*	***31.65***	*0.05500*	*0.01353*	*10.6*	***0.03107***
	5	*19.5*	*35.0*	*5.0*	*30.0*	*27.31*	***27.13***	*0.03500*	*0.01353*	*11.4*	***0.02040***
	15	*19.5*	*30.0*	*5.0*	*25.0*	*22.76*	***22.61***	*0.02000*	*0.01353*	*12.2*	***0.01220***
	30	*19.5*	*27.0*	*5.0*	*22.0*	*20.03*	***19.89***	*0.01400*	*0.01353*	*12.7*	***0.00880***
	60	*19.5*	*24.0*	*5.0*	*19.0*	*17.30*	***17.18***	*0.01000*	*0.01353*	*13.2*	***0.00634***
	120	*19.5*	*21.0*	*5.0*	*16.0*	*14.57*	***14.47***	*0.00700*	*0.01353*	*13.7*	***0.00457***
	240	*20.5*	*19.0*	*5.0*	*14.0*	*12.75*	***12.66***	*0.00500*	*0.01353*	*14.0*	***0.00320***
	1440	*19.0*	*16.0*	*5.0*	*11.0*	*10.01*	***9.95***	*0.00100*	*0.01353*	*14.5*	***0.00136***

Remark :	*Retaining on #4 are shell fragments*	**Cu :** *85.4*	**Gravel**	**Sand**	**Fine**
		Cc : *4.5*	***1***	***58***	***41***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-1	42.0		0.2		dark greenish gray	Silty sand	SM
Remark	Retaining on #4 are shell fragments								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: WR-09-041	Prepared By : PA	Date : 11/25/09
Sample No.	: S-2	Tested By : PA	Date : 11/26/09
Depth below Decl	: 47.0 Depth below Mudline (ft): 5	Sieved By : RJ	Date : 11/28/09
Description	: Dark greenish gray, SILTY SAND (SM)	Calculated By : JF	Date : 12/03/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

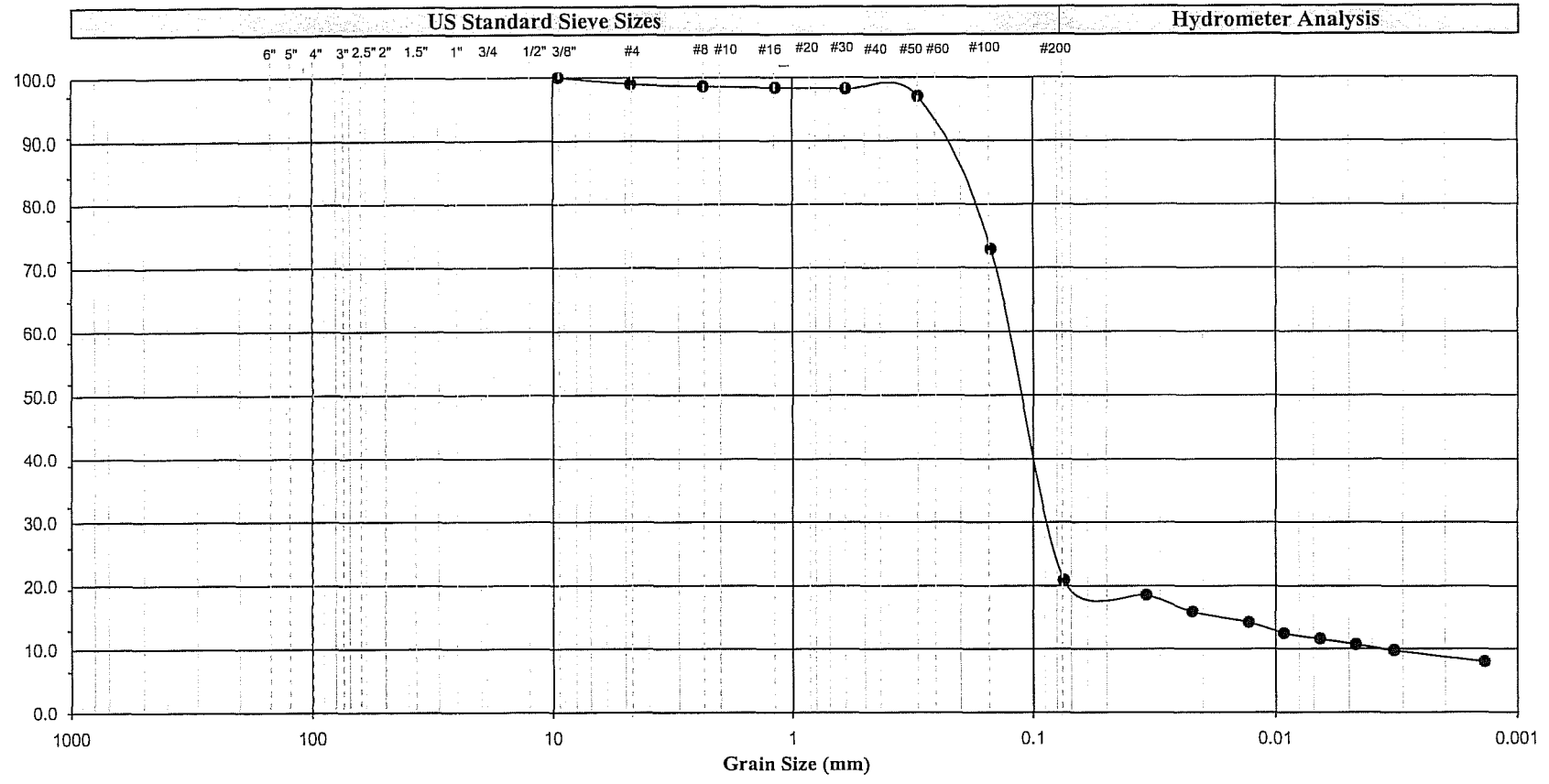
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	J-3	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	8	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-10		J-3	13	S-10	S-12		
Wt. of Wet Soil + Container (gm)		251.36		114.84	211.69			0.99	
Wt. of Dry Soil + Container (gm)					206.70	121.59	202.91	Hydrometer Type	
Wt. of Container (gm)					57.88	119.14	114.27	152H	
Wt. of Dry Soil (gm)		243.21		111.11		2.45	88.64	(K) Value	Temp. °C
Moisture Content (%)					3.35			0.01353	19.5

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	0.68		99.39	**98.39**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.92		99.17	**98.17**
1.0"					No. 40				
3/4"				-	No. 50	2.21		98.01	**97.02**
1/2"					No. 60				
3/8"	0.00		**100.00**	Plastic Index	No. 100	29.18		73.74	**73.00**
No. 4	2.45		**98.99**		No. 140				
No. 8	0.41		**98.63**	-	No. 200	87.75		21.03	**20.82**
No. 10					Pan	88.61			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	W		(mm)	(K)	(L)	(D)
0:01	(T)										
8:34	0:00:00			5.0							
	2	19.5	26.0	5.0	21.0	18.71	**18.52**	0.05500	0.01353	12.9	**0.03429**
	5	19.5	23.0	5.0	18.0	16.04	**15.88**	0.03500	0.01353	13.3	**0.02210**
	15	19.5	21.0	5.0	16.0	14.26	**14.11**	0.02000	0.01353	13.7	**0.01291**
	30	19.5	19.0	5.0	14.0	12.47	**12.35**	0.01400	0.01353	14.0	**0.00924**
	60	19.5	18.0	5.0	13.0	11.58	**11.47**	0.01000	0.01353	14.2	**0.00657**
	120	19.5	17.0	5.0	12.0	10.69	**10.58**	0.00700	0.01353	14.3	**0.00467**
	240	20.5	16.0	5.0	11.0	9.80	**9.70**	0.00500	0.01353	14.5	**0.00326**
	1440	19.0	14.0	5.0	9.0	8.02	**7.94**	0.00100	0.01353	14.8	**0.00137**

Remark :	Retaining on #4 are shell fragments	Cu : 35.2	Gravel	Sand	Fine
		Cc : 15.9	**1**	**78**	**21**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)	Depth below mudline (ft)	Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-2	47.0	5.0	dark greenish gray	Silty sand	SM

Remark: Retaining on #4 are shell fragments

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *WR-09-041*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-3*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *52.0*	**Depth below Mudline (ft):** 10	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, Porely graded SAND with SILT (SP-SM)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

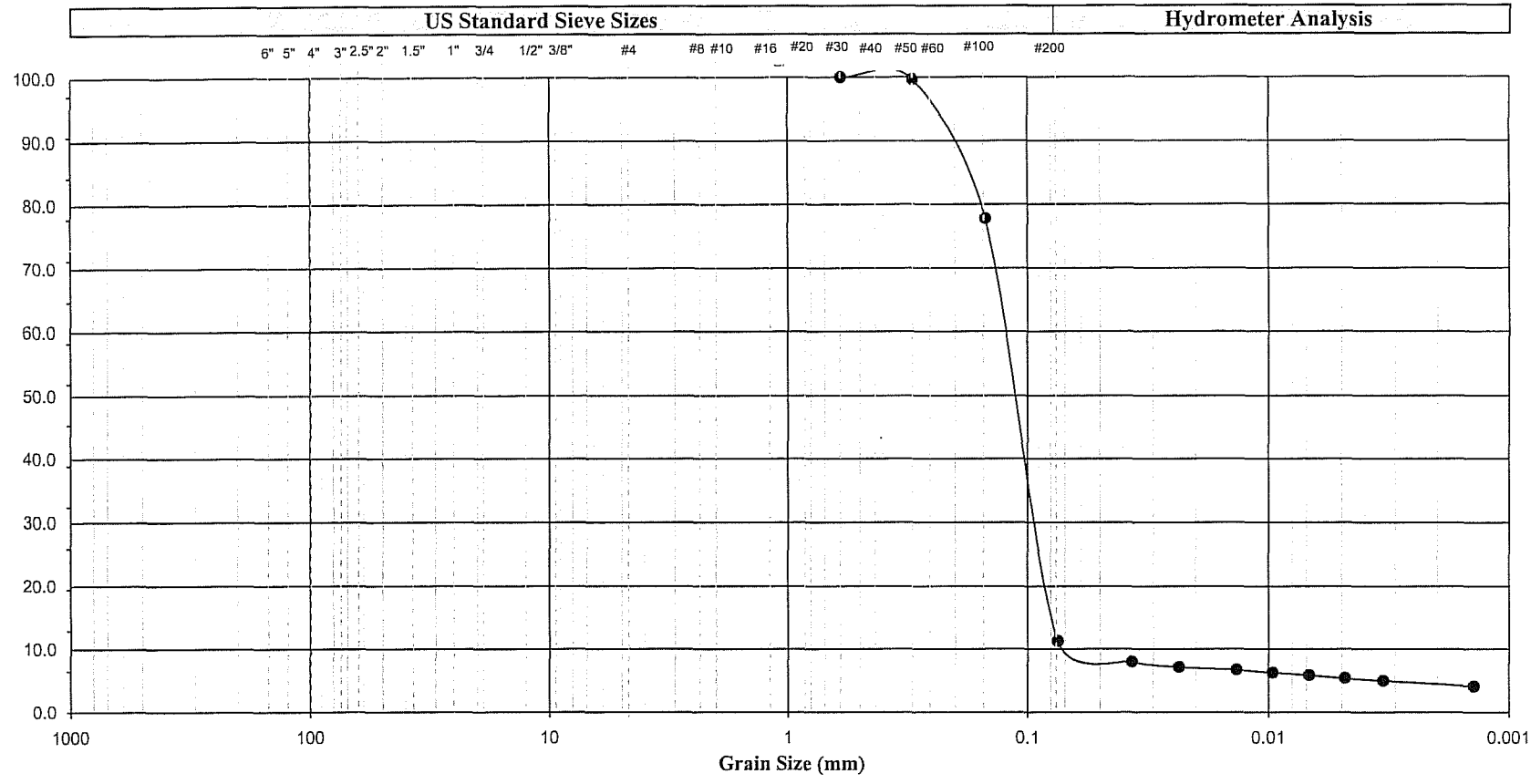
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

Setup Container No. :	*J-4*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*2*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-11*		*J-4*	*14*		*S-13*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*327.68*		*115.66*	*186.14*			*0.99*	
Wt. of Dry Soil + Container (gm)					*181.94*		*219.44*	**Hydrometer Type**	
Wt. of Container (gm)					*56.89*		*113.63*	*152H*	
Wt. of Dry Soil (gm)		*317.03*		*111.90*			*105.81*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*3.36*			*0.01353*	*19.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*0.02*		*99.98*	***99.98***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.04*		*99.96*	***99.96***
1.0"					No. 40				
3/4"				-	No. 50	*0.47*		*99.58*	***99.58***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*24.88*		*77.77*	***77.77***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	-	No. 200	*99.33*		*11.23*	***11.23***
No. 10					Pan	*105.72*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	W			(K)	(L)	
0:01	(T)							(mm)			(D)
8:38	*0:00:00*			*5.0*							
	2	*19.5*	*14.0*	*5.0*	*9.0*	*7.96*	***7.96***	*0.05500*	*0.01353*	*14.8*	***0.03682***
	5	*19.5*	*13.0*	*5.0*	*8.0*	*7.08*	***7.08***	*0.03500*	*0.01353*	*15.0*	***0.02341***
	15	*19.5*	*12.5*	*5.0*	*7.5*	*6.64*	***6.64***	*0.02000*	*0.01353*	*15.1*	***0.01356***
	30	*19.5*	*12.0*	*5.0*	*7.0*	*6.19*	***6.19***	*0.01400*	*0.01353*	*15.1*	***0.00961***
	60	*19.5*	*11.5*	*5.0*	*6.5*	*5.75*	***5.75***	*0.01000*	*0.01353*	*15.2*	***0.00681***
	120	*19.5*	*11.0*	*5.0*	*6.0*	*5.31*	***5.31***	*0.00700*	*0.01353*	*15.3*	***0.00483***
	240	*20.5*	*10.5*	*5.0*	*5.5*	*4.87*	***4.87***	*0.00500*	*0.01353*	*15.4*	***0.00336***
	1440	*19.0*	*9.5*	*5.0*	*4.5*	*3.98*	***3.98***	*0.00100*	*0.01353*	*15.6*	***0.00141***

Remark :	*Retaining on #4 are shell fragments*	**Cu :** *2.1*	**Gravel**	**Sand**	**Fine**
		Cc : *1.2*	***0***	***89***	***11***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	D-3	52.0		10.0		dark greenish gray	Poorly graded sand with silt	SP-SM
Remark	Retaining on #4 are shell fragments								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: *WR-09-041*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-4-2*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Decl : *57.6*	**Depth below Mudline (ft):** *15.6*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray,Lean CLAY with SAND (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

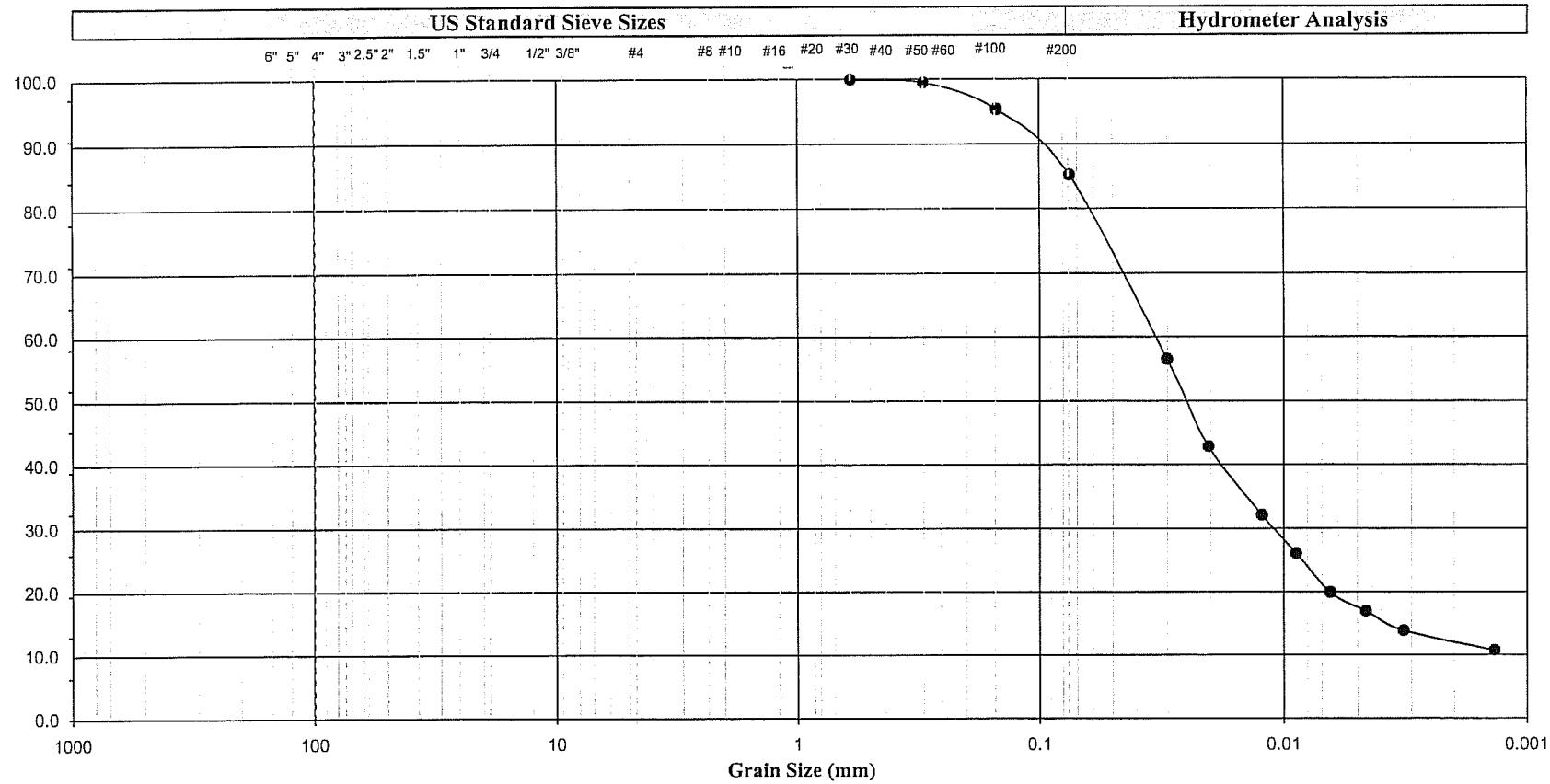
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-14*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*1*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-27*		*J-14*	*79*		*S-4*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*192.40*		*65.15*	*125.66*			*0.99*	
Wt. of Dry Soil + Container (gm)					*125.30*		*130.15*	**Hydrometer Type**	
Wt. of Container (gm)					*59.75*		*118.06*	*152H*	
Wt. of Dry Soil (gm)		*191.35*		*64.79*			*12.09*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.55*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**43**	No. 16	*0.05*		*99.92*	***99.92***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.09*		*99.86*	***99.86***
1.0"					No. 40				
3/4"				**24**	No. 50	*0.39*		*99.40*	***99.40***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*2.98*		*95.40*	***95.40***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	**19**	No. 200	*9.64*		*85.12*	***85.12***
No. 10					Pan	*12.01*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	——— w		(mm)	(K)	(L)	(D)
13:54	***0:00:00***			*6.0*							
	2	*21.0*	*43.0*	*6.0*	*37.0*	*56.53*	***56.53***	*0.05500*	*0.01328*	*10.2*	***0.03003***
	5	*21.0*	*34.0*	*6.0*	*28.0*	*42.78*	***42.78***	*0.03500*	*0.01328*	*11.7*	***0.02032***
	15	*21.0*	*27.0*	*6.0*	*21.0*	*32.09*	***32.09***	*0.02000*	*0.01328*	*12.9*	***0.01229***
	30	*21.0*	*23.0*	*6.0*	*17.0*	*25.97*	***25.97***	*0.01400*	*0.01328*	*13.5*	***0.00891***
	60	*21.0*	*19.0*	*6.0*	*13.0*	*19.86*	***19.86***	*0.01000*	*0.01328*	*14.2*	***0.00645***
	120	*21.5*	*17.0*	*6.0*	*11.0*	*16.81*	***16.81***	*0.00700*	*0.01328*	*14.5*	***0.00462***
	240	*22.0*	*15.0*	*6.0*	*9.0*	*13.75*	***13.75***	*0.00500*	*0.01328*	*14.8*	***0.00323***
	1440	*21.5*	*13.0*	*6.0*	*7.0*	*10.70*	***10.70***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :	*Retaining on #4 are shell fragments*	**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***15***	***85***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-4-2	57.6		15.6		dark greenish gray	Lean clay with sand	CL
Remark	Retaining on #4 are shell fragments								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑	CAL. TRANS.

Boring No.	: *WR-09-041*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-6*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *67.0*	**Depth below Mudline (ft):** *25.0*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, Lean CLAY (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

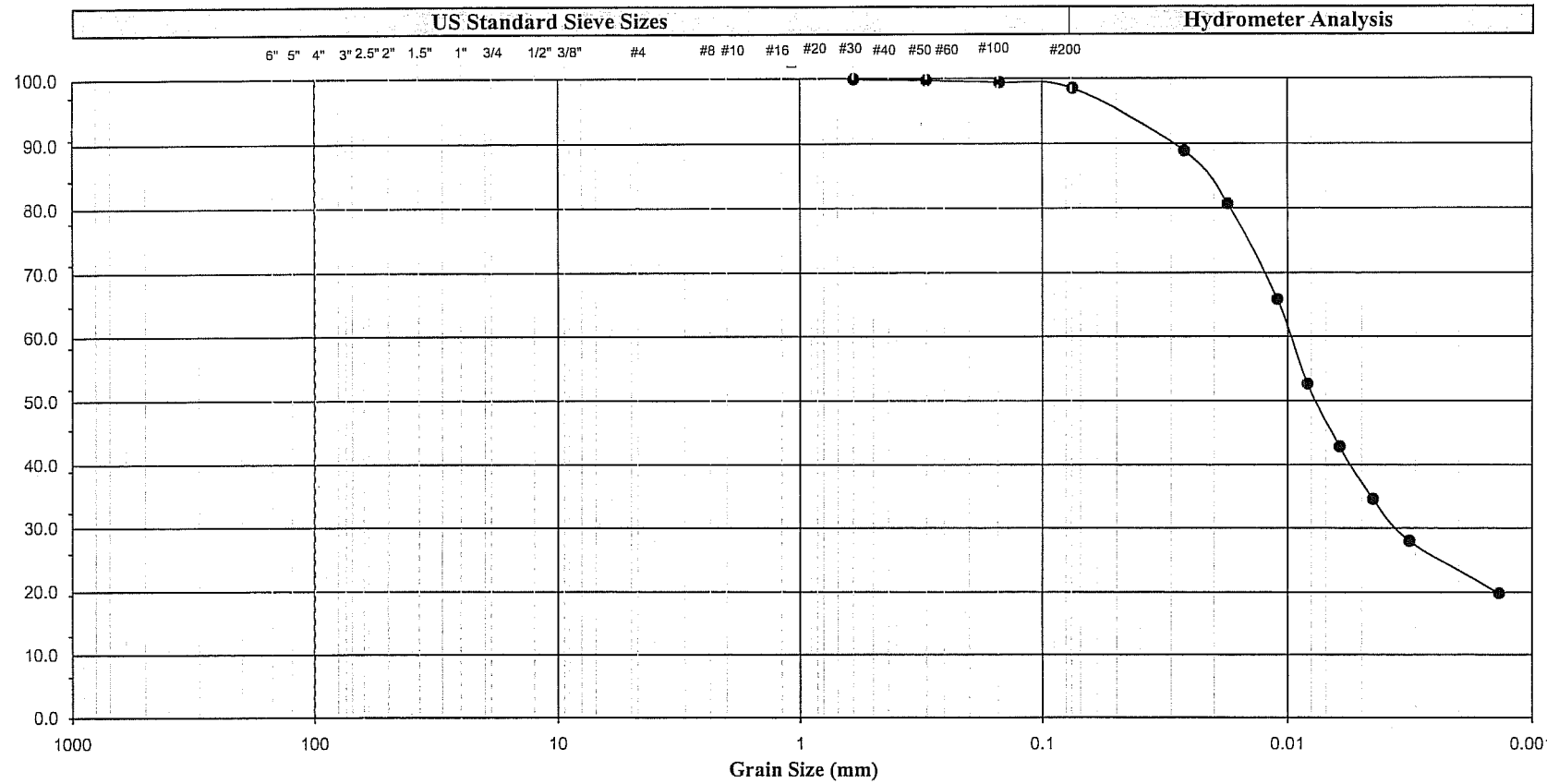
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-17*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*1*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-17*		*J-17*	*1*		*S-19*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*161.98*		*60.61*	*157.99*			*0.99*	
Wt. of Dry Soil + Container (gm)					*157.28*		*117.55*	**Hydrometer Type**	
Wt. of Container (gm)					*57.24*		*116.56*	*152H*	
Wt. of Dry Soil (gm)		*160.84*		*60.18*			*0.99*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.71*			*0.01369*	*18.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***46***	No. 16	*0.02*		*99.97*	***99.97***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.09*		*99.85*	***99.85***
1.0"					No. 40				
3/4"				***27***	No. 50	*0.19*		*99.68*	***99.68***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*0.40*		*99.34*	***99.34***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	***19***	No. 200	*0.93*		*98.45*	***98.45***
No. 10					Pan	*0.97*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01											
10:07	***0:00:00***			*6.0*							
	2	*20.0*	*60.0*	*6.0*	*54.0*	*88.83*	***88.83***	*0.05500*	*0.01369*	*7.4*	***0.02641***
	5	*20.0*	*55.0*	*6.0*	*49.0*	*80.60*	***80.60***	*0.03500*	*0.01369*	*8.3*	***0.01760***
	15	*20.0*	*46.0*	*6.0*	*40.0*	*65.80*	***65.80***	*0.02000*	*0.01369*	*9.7*	***0.01103***
	30	*20.0*	*38.0*	*6.0*	*32.0*	*52.64*	***52.64***	*0.01400*	*0.01369*	*11.0*	***0.00831***
	60	*21.0*	*32.0*	*6.0*	*26.0*	*42.77*	***42.77***	*0.01000*	*0.01369*	*12.0*	***0.00613***
	120	*21.0*	*27.0*	*6.0*	*21.0*	*34.54*	***34.54***	*0.00700*	*0.01369*	*12.9*	***0.00448***
	240	*22.0*	*23.0*	*6.0*	*17.0*	*27.96*	***27.96***	*0.00500*	*0.01369*	*13.5*	***0.00318***
	1440	*21.0*	*18.0*	*6.0*	*12.0*	*19.74*	***19.74***	*0.00100*	*0.01369*	*14.3*	***0.00137***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***0***	***2***	***98***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-041	S-6	67.0		25.0		dark olive-gray	Lean clay	CL
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑ **CAL. TRANS.**	
Boring No.	: *WR-09-042*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-1*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *57.0*	**Depth below Mudline (ft):** 3	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, SANDY lean CLAY (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

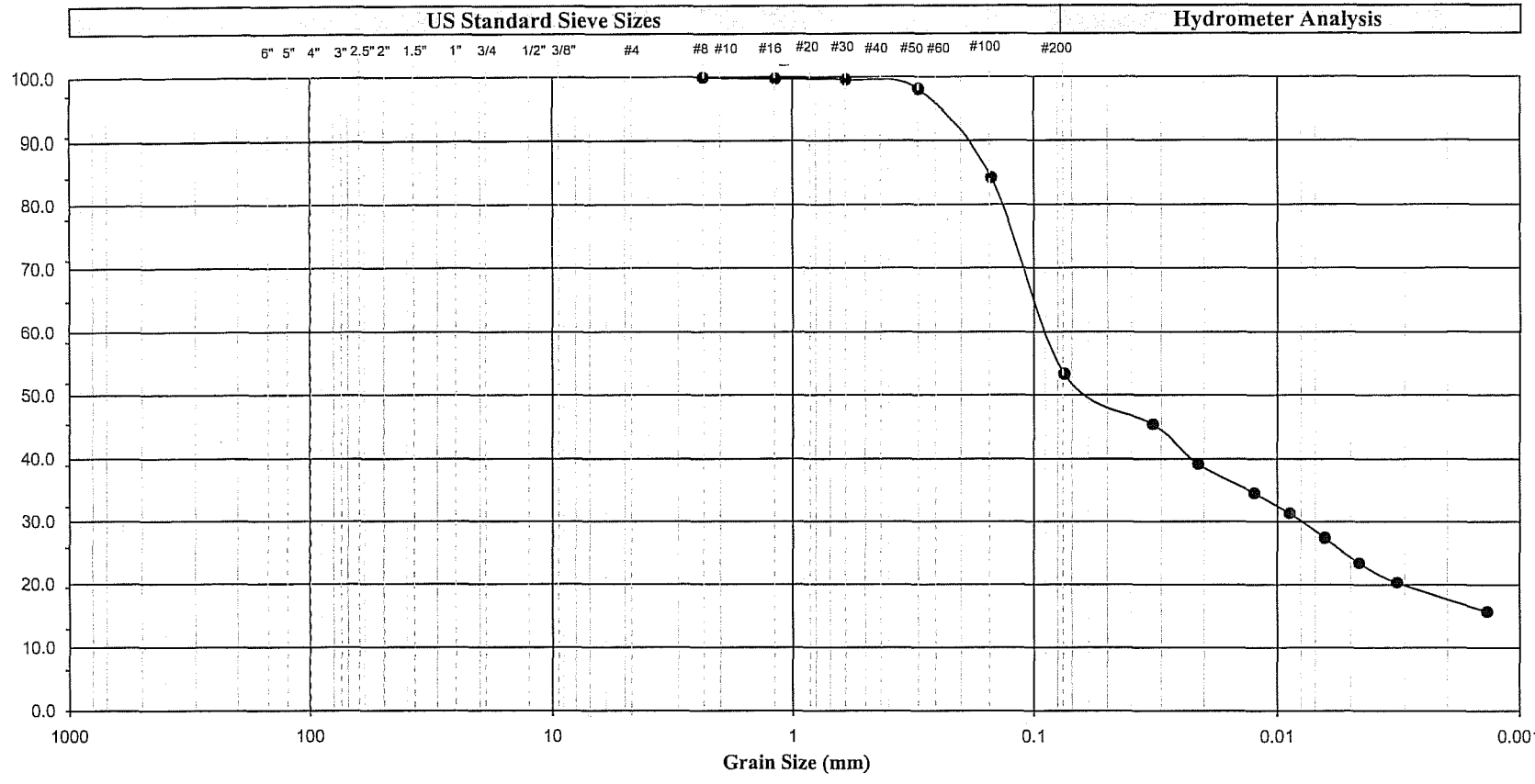
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. — *1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-13*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*3*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-11*	*15*	*J-13*	*15*		*S-14*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*163.01*	*153.86*	*66.20*	*153.86*			*0.99*	
Wt. of Dry Soil + Container (gm)			*149.62*		*149.62*		*147.82*	**Hydrometer Type**	
Wt. of Container (gm)			*57.14*		*57.14*		*115.81*	*152H*	
Wt. of Dry Soil (gm)		*101.23*		*63.30*			*32.01*	**(K) Value**	**Temp. °C**
Moisture Content (%)			*4.58*		*4.58*			*0.01353*	*19.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**36**	No. 16	*0.20*		*99.68*	***99.68***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.30*		*99.53*	***99.53***
1.0"					No. 40				
3/4"				**21**	No. 50	*1.25*		*98.03*	***98.03***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*10.02*		*84.17*	***84.17***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.09*		***99.86***	**15**	No. 200	*29.59*		*53.25*	***53.25***
No. 10					Pan	*31.96*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01											
8:42	*0:00:00*			*5.0*							
	2	*19.5*	*34.0*	*5.0*	*29.0*	*45.36*	***45.36***	*0.05500*	*0.01353*	*11.5*	***0.03249***
	5	*19.5*	*30.0*	*5.0*	*25.0*	*39.10*	***39.10***	*0.03500*	*0.01353*	*12.2*	***0.02112***
	15	*19.5*	*27.0*	*5.0*	*22.0*	*34.41*	***34.41***	*0.02000*	*0.01353*	*12.7*	***0.01244***
	30	*19.5*	*25.0*	*5.0*	*20.0*	*31.28*	***31.28***	*0.01400*	*0.01353*	*13.0*	***0.00891***
	60	*19.5*	*22.5*	*5.0*	*17.5*	*27.37*	***27.37***	*0.01000*	*0.01353*	*13.4*	***0.00640***
	120	*19.5*	*20.0*	*5.0*	*15.0*	*23.46*	***23.46***	*0.00700*	*0.01353*	*13.8*	***0.00459***
	240	*21.0*	*18.0*	*5.0*	*13.0*	*20.33*	***20.33***	*0.00500*	*0.01353*	*14.2*	***0.00322***
	1440	*19.0*	*15.0*	*5.0*	*10.0*	*15.64*	***15.64***	*0.00100*	*0.01353*	*14.7*	***0.00136***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***47***	***53***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)	Depth below mudline (ft)	Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-1	57.0	3.0	dark olive gray	Sandy lean clay	CL
Remark	0.00						

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: WR-09-042	Prepared By : PA	Date : 11/25/09
Sample No.	: D-2-1	Tested By : PA	Date : 11/26/09
Depth below Deck	: 63.0 Depth below Mudline (ft): 9	Sieved By : RJ	Date : 11/28/09
Description	: Dark olive-gray, Lean CLAY with SAND (CL)	Calculated By : JF	Date : 12/03/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

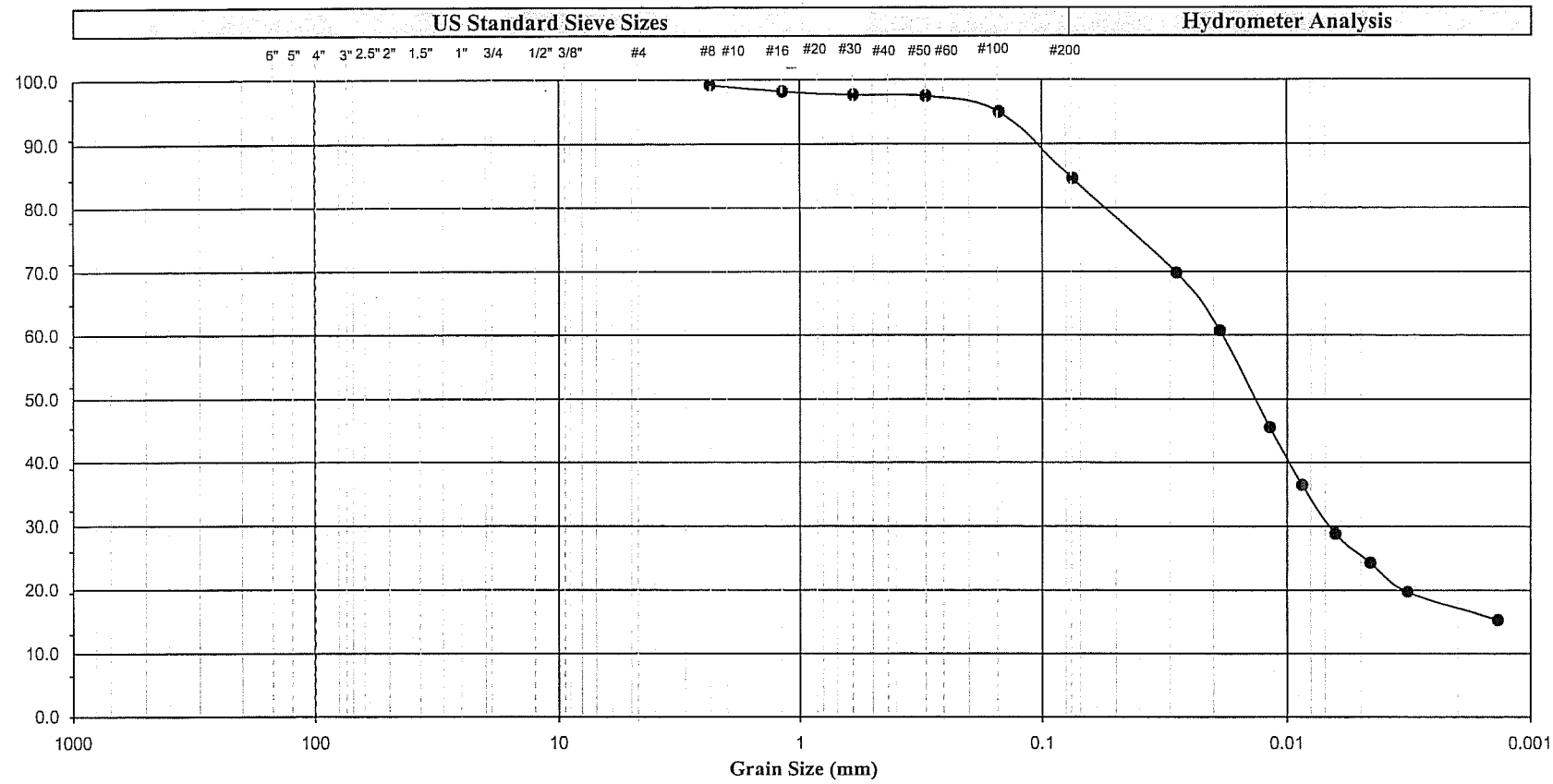
Sample for Hydrometer should passing (No.10-ASTM) & (No.4-Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	J-14	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Test Cylinder No. :	3	Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor	
Computer File No. :								for difference S.G.	
Container No.		S-11	16	J-14	16		S-16	0.99	
Wt. of Wet Soil + Container (gm)		196.51	187.08	66.48	187.08			Hydrometer Type	
Wt. of Dry Soil + Container (gm)			184.73		184.73		125.61	152H	
Wt. of Container (gm)			57.42		57.42		114.19	(K) Value	Temp. °C
Wt. of Dry Soil (gm)		136.57		65.28			11.42	0.01353	19.5
Moisture Content (%)			1.85		1.85				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	1.22		98.13	**98.13**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	1.54		97.64	**97.64**
1.0"					No. 40				
3/4"				-	No. 50	1.68		97.43	**97.43**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	3.23		95.05	**95.05**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.59		**99.10**	-	No. 200	10.17		84.42	**84.42**
No. 10					Pan	11.42			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
0:01	(T)										
8:46	0:00:00			5.0							
	2	19.5	51.0	5.0	46.0	69.77	**69.77**	0.05500	0.01353	8.8	**0.02829**
	5	19.5	45.0	5.0	40.0	60.67	**60.67**	0.03500	0.01353	9.7	**0.01887**
	15	19.5	35.0	5.0	30.0	45.50	**45.50**	0.02000	0.01353	11.4	**0.01178**
	30	19.5	29.0	5.0	24.0	36.40	**36.40**	0.01400	0.01353	12.4	**0.00868**
	60	19.5	24.0	5.0	19.0	28.82	**28.82**	0.01000	0.01353	13.2	**0.00634**
	120	20.0	21.0	5.0	16.0	24.27	**24.27**	0.00700	0.01353	13.7	**0.00457**
	240	21.0	18.0	5.0	13.0	19.72	**19.72**	0.00500	0.01353	14.2	**0.00322**
	1440	19.0	15.0	5.0	10.0	15.17	**15.17**	0.00100	0.01353	14.7	**0.00136**

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	**0**	**16**	**84**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	D-2-1	63.0		9.0		dark olive gray	Lean clay with sand	CL
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *WR-09-042*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-25-2*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck	: *223.5* **Depth below Mudline (ft):** *171.5*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, SANDY lean CLAY (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

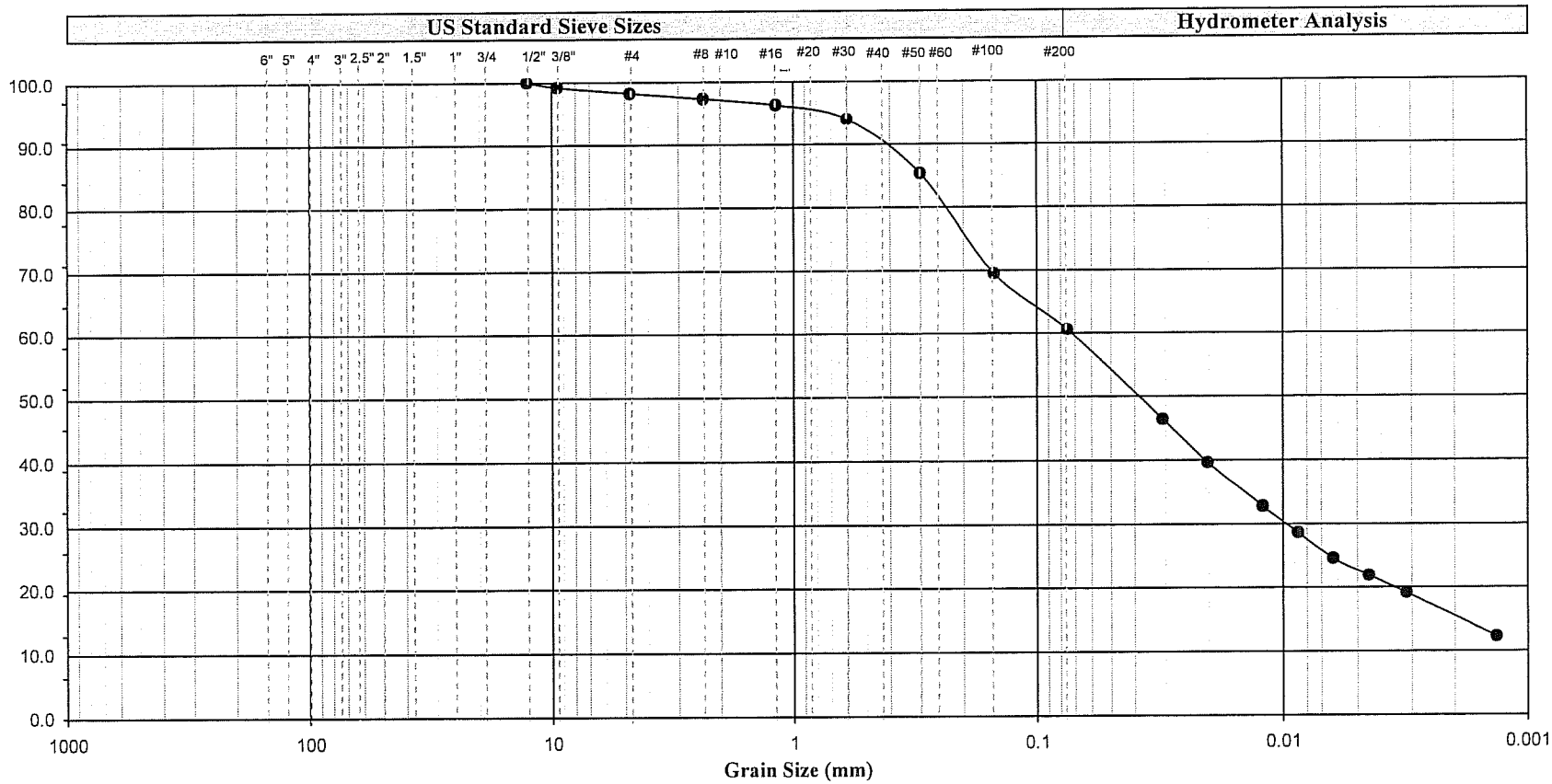
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*S-20*							*2.70*	
Test Cylinder No. :	*5*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**		
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-27*		*S-20*	*80*		*S-5*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*194.60*		*71.81*	*177.84*			*0.99*	
Wt. of Dry Soil + Container (gm)					*176.97*		*145.47*	**Hydrometer Type**	
Wt. of Container (gm)					*58.96*		*117.79*	*152H*	
Wt. of Dry Soil (gm)		*193.18*		*71.28*			*27.68*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.74*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**28**	No. 16	*1.38*		*98.06*	***96.35***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*3.01*		*95.78*	***94.11***
1.0"					No. 40				
3/4"				**14**	No. 50	*9.38*		*86.84*	***85.33***
1/2"	*0.00*		***100.00***		No. 60				
3/8"	*1.52*		***99.21***	**Plastic Index**	No. 100	*20.81*		*70.81*	***69.57***
No. 4	*3.37*		***98.26***		No. 140				
No. 8	*0.65*		***97.36***	**14**	No. 200	*27.33*		*61.66*	***60.58***
No. 10					Pan	*27.66*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
10:07	***0:00:00***			*6.0*							
	2	*21.0*	*40.0*	*6.0*	*34.0*	*47.22*	***46.40***	*0.05500*	*0.01328*	*10.7*	***0.03075***
	5	*21.0*	*35.0*	*6.0*	*29.0*	*40.28*	***39.57***	*0.03500*	*0.01328*	*11.5*	***0.02018***
	15	*21.0*	*30.0*	*6.0*	*24.0*	*33.33*	***32.75***	*0.02000*	*0.01328*	*12.4*	***0.01206***
	30	*21.0*	*27.0*	*6.0*	*21.0*	*29.16*	***28.66***	*0.01400*	*0.01328*	*12.9*	***0.00869***
	60	*21.0*	*24.0*	*6.0*	*18.0*	*25.00*	***24.56***	*0.01000*	*0.01328*	*13.3*	***0.00626***
	120	*21.5*	*22.0*	*6.0*	*16.0*	*22.22*	***21.83***	*0.00700*	*0.01328*	*13.7*	***0.00448***
	240	*22.0*	*20.0*	*6.0*	*14.0*	*19.44*	***19.10***	*0.00500*	*0.01328*	*14.0*	***0.00314***
	1440	*21.5*	*15.0*	*6.0*	*9.0*	*12.50*	***12.28***	*0.00100*	*0.01328*	*14.8*	***0.00135***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***2***	***37***	***61***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-25-2	223.5		171.5		dark olive-gray	Sandy lean clay	CL
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: *WR-09-042*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-26-1*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *233.0*	**Depth below Mudline (ft):** *181.0*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, Lean CLAY with SAND (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

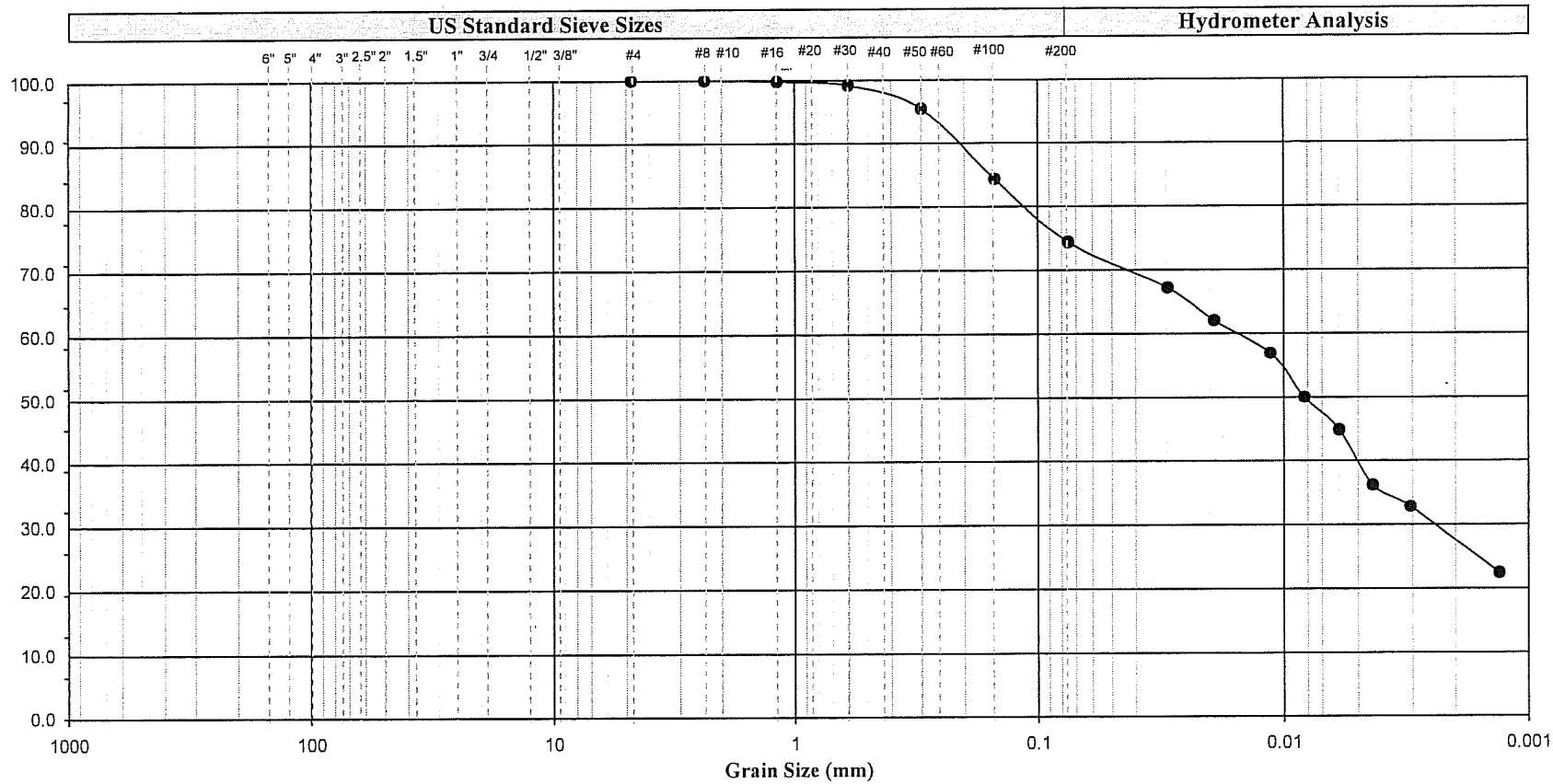
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. — *1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-18*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*4*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-27*		*J-18*	*2*		*S-20*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*194.60*		*57.61*	*69.97*			*0.99*	
Wt. of Dry Soil + Container (gm)					*69.94*		*130.04*	**Hydrometer Type**	
Wt. of Container (gm)					*58.66*		*115.12*	*152H*	
Wt. of Dry Soil (gm)		*194.08*		*57.46*			*14.92*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.27*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***39***	No. 16	*0.11*		*99.81*	***99.81***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.46*		*99.20*	***99.20***
1.0"					No. 40				
3/4"				***17***	No. 50	*2.55*		*95.56*	***95.56***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*9.04*		*84.27*	***84.27***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	***22***	No. 200	*14.73*		*74.36*	***74.36***
No. 10					Pan	*14.90*			

Obersved Time	EL. Time (min.)	Temp. (°C)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	——— W		(mm)	(K)	(L)	(D)
10:08	*0:00:00*			*6.0*							
	2	*20.0*	*45.0*	*6.0*	*39.0*	*67.20*	***67.20***	*0.05500*	*0.01328*	*9.9*	***0.02955***
	5	*20.0*	*42.0*	*6.0*	*36.0*	*62.03*	***62.03***	*0.03500*	*0.01328*	*10.4*	***0.01915***
	15	*20.0*	*39.0*	*6.0*	*33.0*	*56.86*	***56.86***	*0.02000*	*0.01328*	*10.9*	***0.01131***
	30	*20.0*	*35.0*	*6.0*	*29.0*	*49.97*	***49.97***	*0.01400*	*0.01328*	*11.5*	***0.00824***
	60	*21.0*	*32.0*	*6.0*	*26.0*	*44.80*	***44.80***	*0.01000*	*0.01328*	*12.0*	***0.00595***
	120	*21.0*	*27.0*	*6.0*	*21.0*	*36.18*	***36.18***	*0.00700*	*0.01328*	*12.9*	***0.00435***
	240	*22.0*	*25.0*	*6.0*	*19.0*	*32.74*	***32.74***	*0.00500*	*0.01328*	*13.2*	***0.00305***
	1440	*21.0*	*19.0*	*6.0*	*13.0*	*22.40*	***22.40***	*0.00100*	*0.01328*	*14.2*	***0.00132***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***26***	***74***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-042	S-26-1	233.0		181.0		dark olive-gray	Lean clay with sand	CL
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

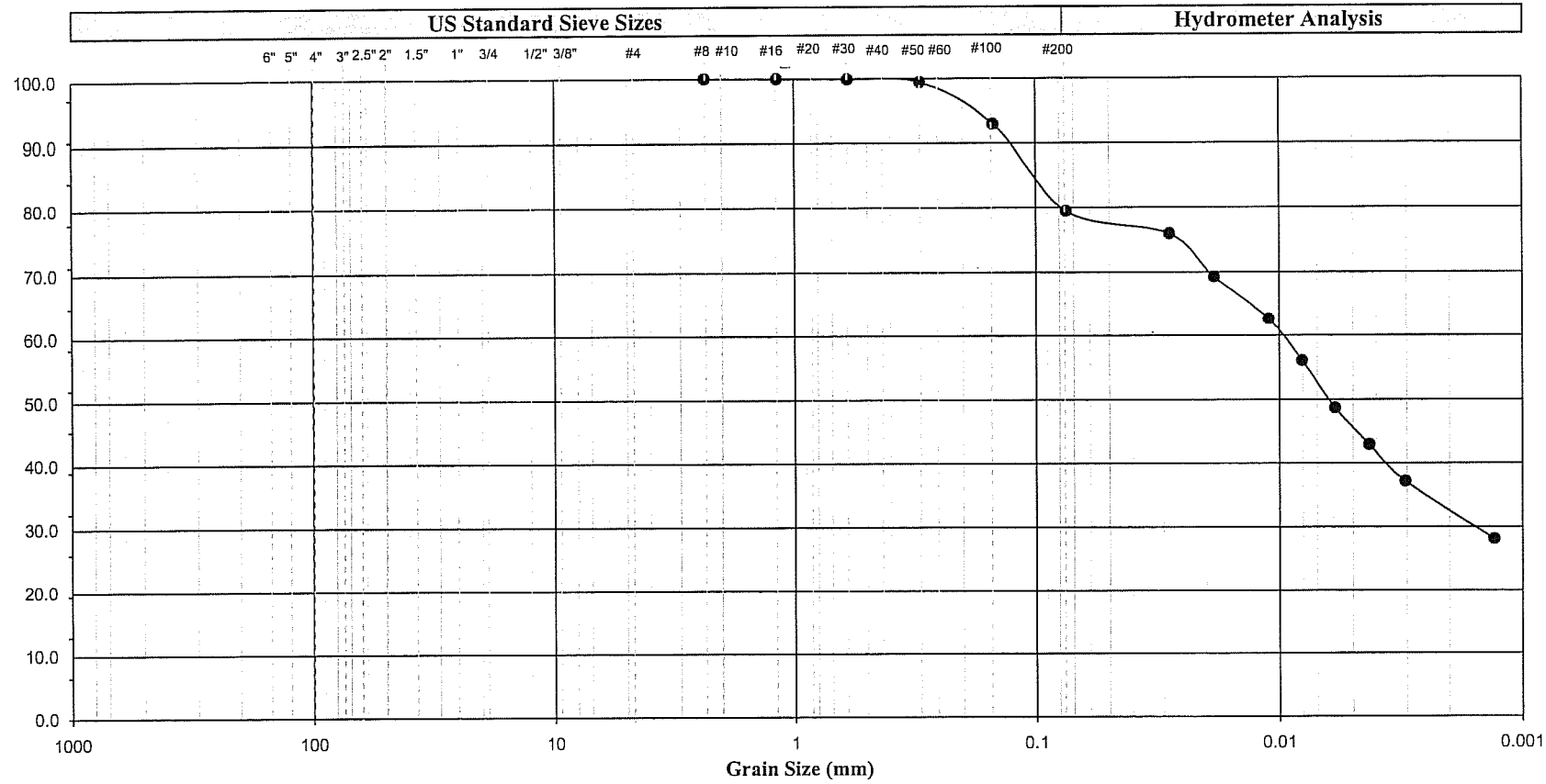
Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *WR-09-043*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-1-2*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *57.5*	**Depth below Mudline (ft):** *1.5*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, Fat CLAY with SAND (CH)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand.			*1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-17*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*5*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-11*		*J-17*	*17*		*S-15*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*151.46*		*66.09*	*142.49*			*0.99*	
Wt. of Dry Soil + Container (gm)					*134.72*		*127.65*	**Hydrometer Type**	
Wt. of Container (gm)					*57.19*		*114.75*	*152H*	
Wt. of Dry Soil (gm)		*137.66*		*60.07*			*12.90*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*10.02*			*0.01353*	*19.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**65**	No. 16	*0.04*		*99.93*	***99.93***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.08*		*99.87*	***99.87***
1.0"					No. 40				
3/4"				**28**	No. 50	*0.37*		*99.38*	***99.38***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*4.13*		*93.12*	***93.12***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	**37**	No. 200	*12.36*		*79.42*	***79.42***
No. 10					Pan	*12.92*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
0:01	(T)										
8:50	*0:00:00*			*5.0*							
	2	*19.5*	*51.0*	*5.0*	*46.0*	*75.81*	***75.81***	*0.05500*	*0.01353*	*8.8*	***0.02829***
	5	*19.5*	*47.0*	*5.0*	*42.0*	*69.22*	***69.22***	*0.03500*	*0.01353*	*9.4*	***0.01855***
	15	*19.5*	*43.0*	*5.0*	*38.0*	*62.63*	***62.63***	*0.02000*	*0.01353*	*10.1*	***0.01108***
	30	*19.5*	*39.0*	*5.0*	*34.0*	*56.03*	***56.03***	*0.01400*	*0.01353*	*10.7*	***0.00809***
	60	*19.5*	*34.5*	*5.0*	*29.5*	*48.62*	***48.62***	*0.01000*	*0.01353*	*11.5*	***0.00591***
	120	*20.0*	*31.0*	*5.0*	*26.0*	*42.85*	***42.85***	*0.00700*	*0.01353*	*12.0*	***0.00428***
	240	*21.0*	*27.5*	*5.0*	*22.5*	*37.08*	***37.08***	*0.00500*	*0.01353*	*12.6*	***0.00304***
	1440	*19.0*	*22.0*	*5.0*	*17.0*	*28.02*	***28.02***	*0.00100*	*0.01353*	*13.5*	***0.00131***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***21***	***79***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	D-1-2	57.5		1.5		dark olive gray	Fat clay with sand	CH
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑ **CAL. TRANS.**	
Boring No.	: *WR-09-043*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-2*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *59.0*	**Depth below Mudline (ft):** 3	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, SANDY lean CLAY (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

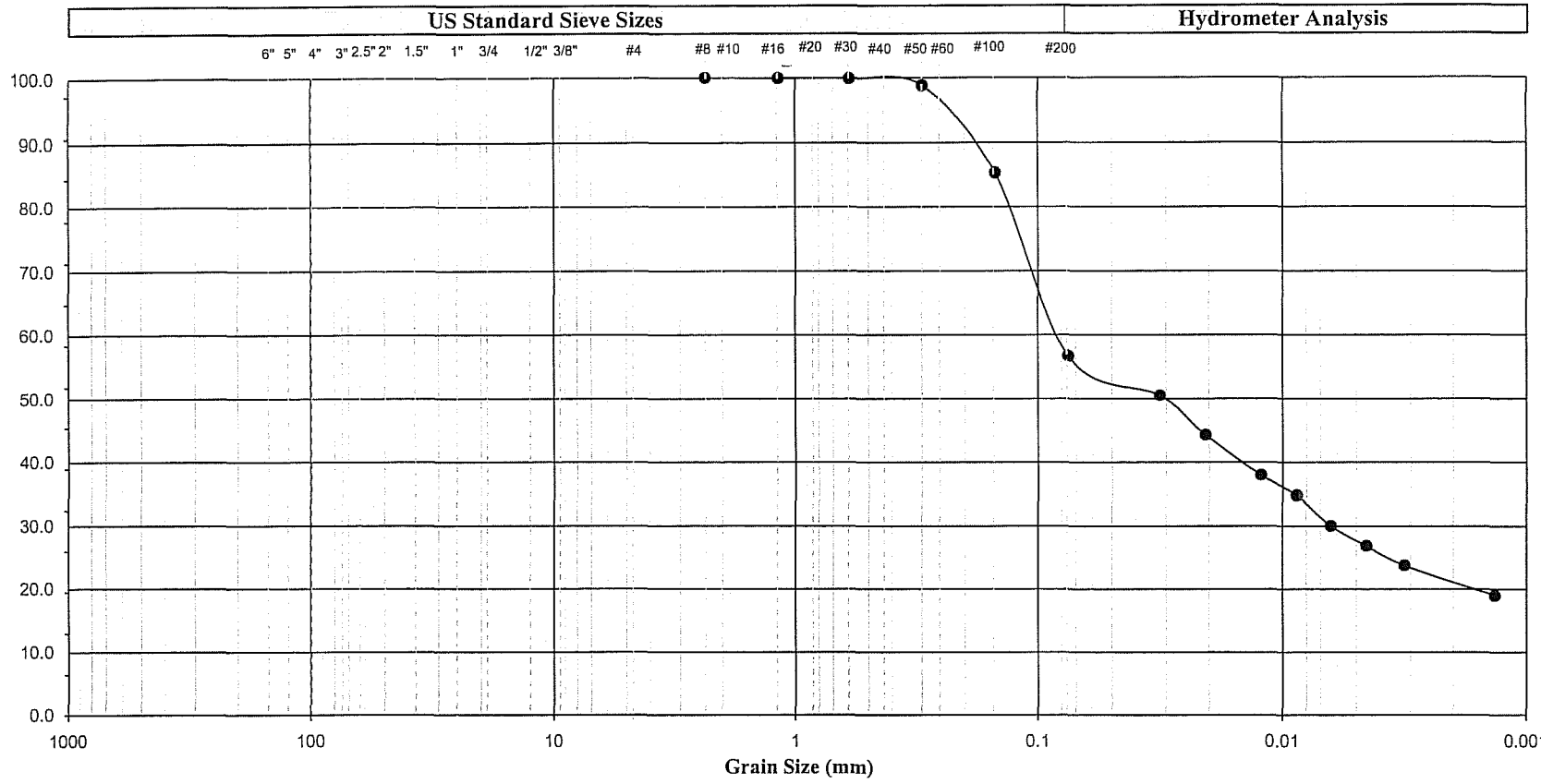
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-15*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*3*	**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Computer File No. :								**for difference S.G.**	
Container No.		*S-11*		*J-15*	*18*		*S-17*	*0.99*	
Wt. of Wet Soil + Container (gm)		*140.70*		*65.90*	*132.20*			**Hydrometer Type**	
Wt. of Dry Soil + Container (gm)					*128.60*		*145.14*	*152H*	
Wt. of Container (gm)					*57.46*		*114.79*	**(K) Value**	**Temp. °C**
Wt. of Dry Soil (gm)		*133.92*		*62.73*			*30.35*	*0.01353*	*19.5*
Moisture Content (%)					*5.06*				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*0.07*		*99.89*	***99.89***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.10*		*99.84*	***99.84***
1.0"					No. 40				
3/4"				-	No. 50	*0.76*		*98.79*	***98.79***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*9.32*		*85.14*	***85.14***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	-	No. 200	*27.22*		*56.60*	***56.60***
No. 10					Pan	*30.34*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	W		(mm)	(K)	(L)	(D)
0:01	(T)										
8:54	*0:00:00*			*5.0*							
	2	*19.5*	*37.0*	*5.0*	*32.0*	*50.51*	***50.51***	*0.05500*	*0.01353*	*11.0*	***0.03179***
	5	*19.5*	*33.0*	*5.0*	*28.0*	*44.19*	***44.19***	*0.03500*	*0.01353*	*11.7*	***0.02069***
	15	*19.5*	*29.0*	*5.0*	*24.0*	*37.88*	***37.88***	*0.02000*	*0.01353*	*12.4*	***0.01228***
	30	*19.5*	*27.0*	*5.0*	*22.0*	*34.72*	***34.72***	*0.01400*	*0.01353*	*12.7*	***0.00880***
	60	*19.5*	*24.0*	*5.0*	*19.0*	*29.99*	***29.99***	*0.01000*	*0.01353*	*13.2*	***0.00634***
	120	*20.0*	*22.0*	*5.0*	*17.0*	*26.83*	***26.83***	*0.00700*	*0.01353*	*13.5*	***0.00454***
	240	*21.0*	*20.0*	*5.0*	*15.0*	*23.67*	***23.67***	*0.00500*	*0.01353*	*13.8*	***0.00318***
	1440	*19.0*	*17.0*	*5.0*	*12.0*	*18.94*	***18.94***	*0.00100*	*0.01353*	*14.3*	***0.00135***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***43***	***57***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	S-2	59.0		3.0		dark olive gray	Sandy lean clay	CL
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑	**CAL. TRANS.**

Boring No.	: *WR-09-043*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-3*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Decl : *62.0*	**Depth below Mudline (ft):** 6	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, SILT with SAND (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

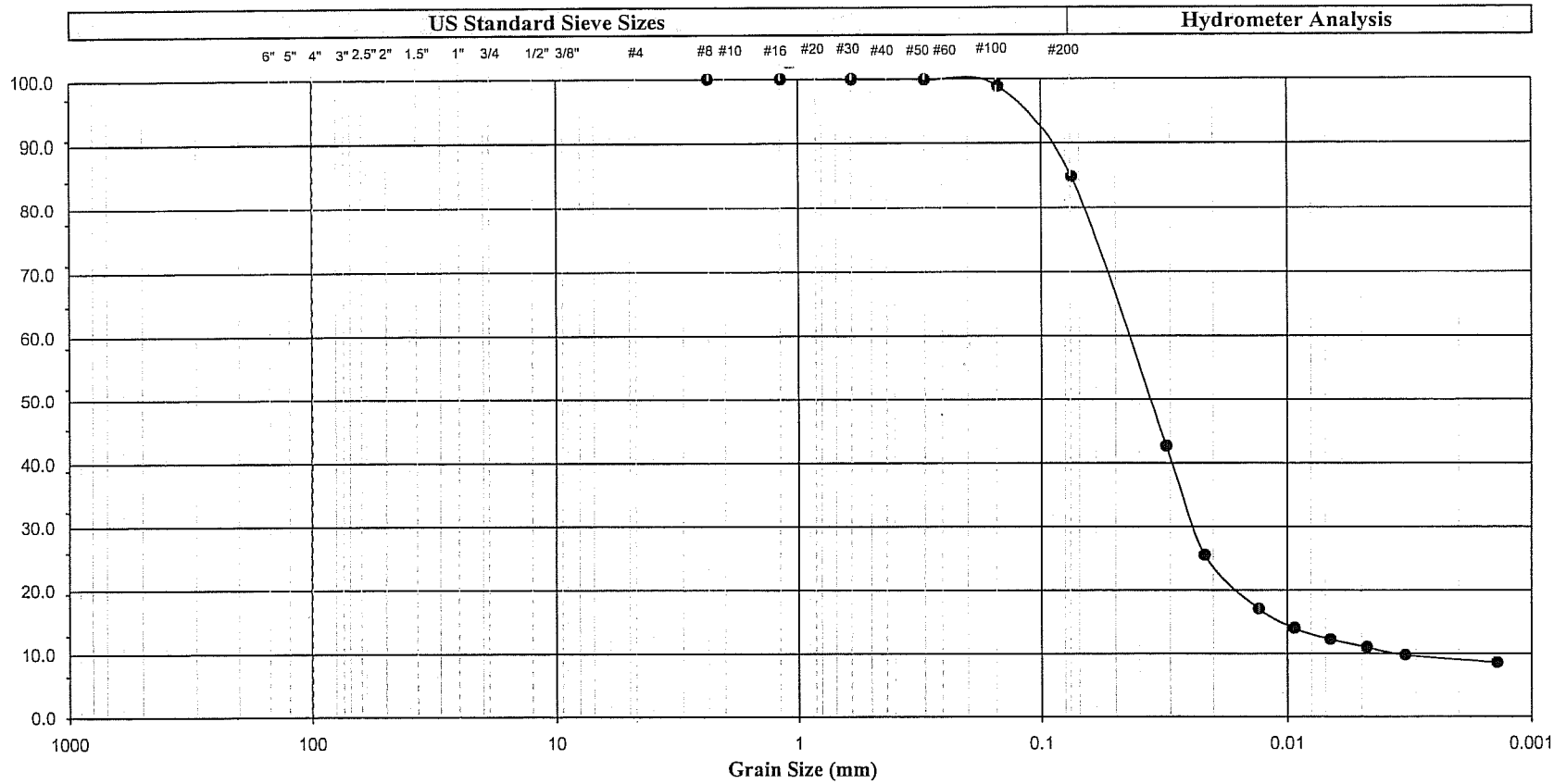
*Sample for Hydrometer should passing (**No.10**-ASTM) & (**No.4**-Cal. Tran.), **65** gm for fine & **115** gm for Sand.* 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-18*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*4*	**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Computer File No. :								**for difference S.G.**	
Container No.		*S-11*		*J-18*	*19*		*S-18*	*0.99*	
Wt. of Wet Soil + Container (gm)		*211.82*		*81.94*	*188.04*			**Hydrometer Type**	
Wt. of Dry Soil + Container (gm)					*187.19*		*145.71*	*152H*	
Wt. of Container (gm)					*58.20*		*115.59*	**(K) Value**	**Temp. °C**
Wt. of Dry Soil (gm)		*210.43*		*81.40*			*30.12*	*0.01353*	*19.5*
Moisture Content (%)					*0.66*				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**25**	No. 16	*0.00*		*100.00*	***100.00***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.03*		*99.96*	***99.96***
1.0"					No. 40				
3/4"				**23**	No. 50	*0.13*		*99.84*	***99.84***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*0.90*		*98.89*	***98.89***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	**2**	No. 200	*12.46*		*84.69*	***84.69***
No. 10					Pan	*30.04*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
0:01	(T)										
8:58	*0:00:00*			*5.0*							
	2	*19.5*	*40.0*	*5.0*	*35.0*	*42.57*	***42.57***	*0.05500*	*0.01353*	*10.6*	***0.03107***
	5	*19.5*	*26.0*	*5.0*	*21.0*	*25.54*	***25.54***	*0.03500*	*0.01353*	*12.9*	***0.02168***
	15	*19.5*	*19.0*	*5.0*	*14.0*	*17.03*	***17.03***	*0.02000*	*0.01353*	*14.0*	***0.01307***
	30	*19.5*	*16.5*	*5.0*	*11.5*	*13.99*	***13.99***	*0.01400*	*0.01353*	*14.4*	***0.00937***
	60	*19.5*	*15.0*	*5.0*	*10.0*	*12.16*	***12.16***	*0.01000*	*0.01353*	*14.7*	***0.00668***
	120	*20.0*	*14.0*	*5.0*	*9.0*	*10.95*	***10.95***	*0.00700*	*0.01353*	*14.8*	***0.00475***
	240	*21.0*	*13.0*	*5.0*	*8.0*	*9.73*	***9.73***	*0.00500*	*0.01353*	*15.0*	***0.00331***
	1440	*19.0*	*12.0*	*5.0*	*7.0*	*8.51*	***8.51***	*0.00100*	*0.01353*	*15.1*	***0.00139***

Remark :		Cu : *13.6*	Gravel	Sand	Fine
		Cc : *3.3*	***0***	***15***	***85***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	D-3	62.0		6.0		dark olive gray	Silt with sand	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: *WR-09-043*			**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-5-2*			**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Decl	: *68.5*	**Depth below Mudline (ft):**	*12.5*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, Lean CLAY (CL)*			**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution				**Checked By:** *R.J.*	**Date :** *12/03/09*

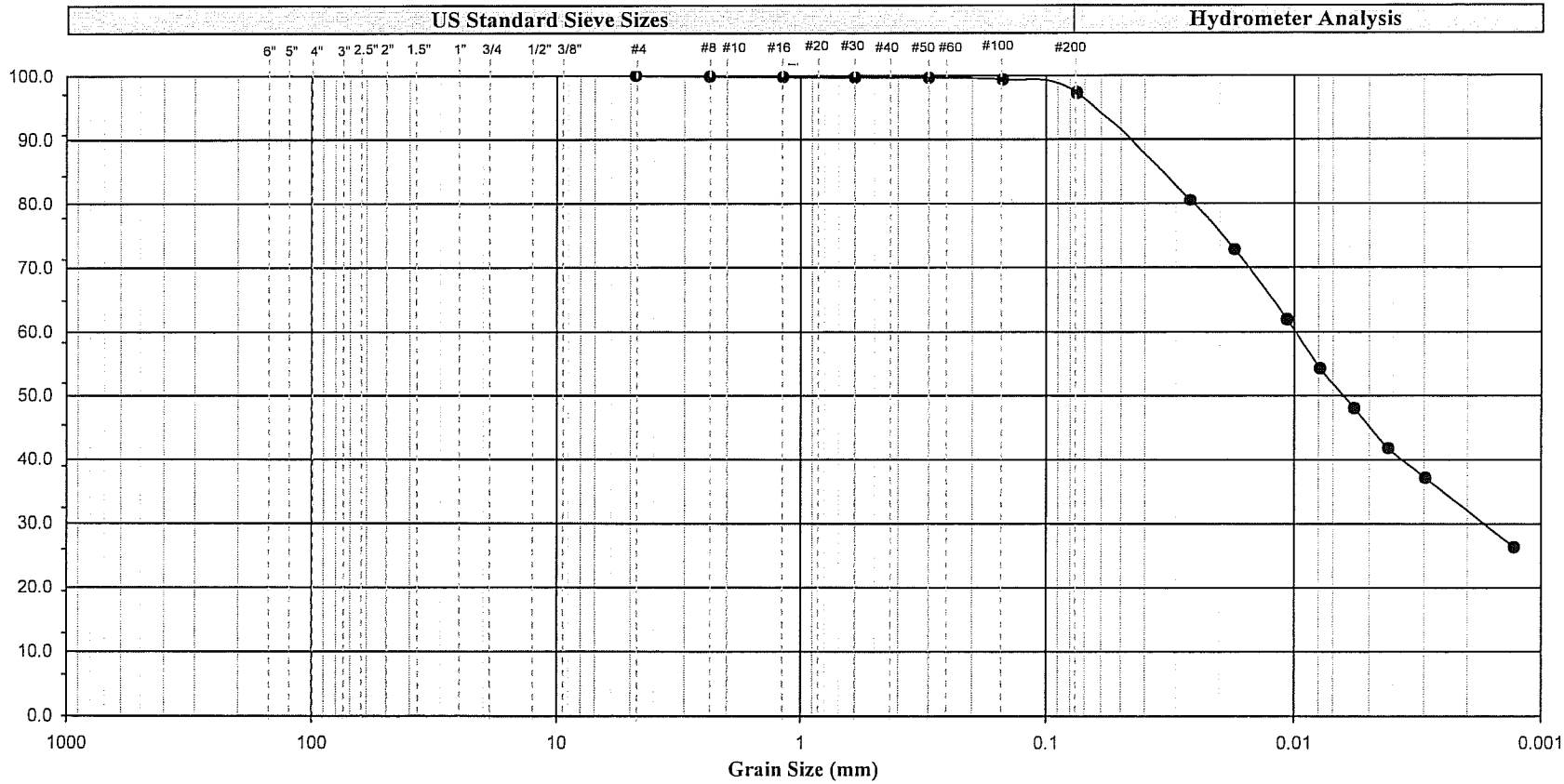
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

Setup Container No. :	*J-3*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*3*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-28*		*J-3*	*81*		*S-6*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*197.97*		*65.02*	*126.34*			*0.99*	
Wt. of Dry Soil + Container (gm)					*125.23*		*118.49*	**Hydrometer Type**	
Wt. of Container (gm)					*60.02*		*116.78*	*152H*	
Wt. of Dry Soil (gm)		*194.66*		*63.93*			*1.71*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*1.70*			*0.01328*	*21.0*

U.S. Sieve Size	**Cumulative Wt. of Dry Soil (gm)**	**Wt. of Dry Soil (gm)**	**% Finer Than**	**Liquid Limit**	**U.S. Sieve Size**	**Cumulative Weight of Dry Soil (gm)**	**Wt. of Dry Soil (gm)**	**% Finer Than**	**% Total Sample**
2.5"				**46**	**No. 16**	*0.15*		*99.77*	***99.77***
2.0"					**No. 20**				
1.5"				**Plastic Limit**	**No. 30**	*0.21*		*99.67*	***99.67***
1.0"					**No. 40**				
3/4"				**25**	**No. 50**	*0.24*		*99.62*	***99.62***
1/2"					**No. 60**				
3/8"				**Plastic Index**	**No. 100**	*0.41*		*99.36*	***99.36***
No. 4	*0.00*		***100.00***		**No. 140**				
No. 8	*0.08*		***99.87***	**21**	**No. 200**	*1.70*		*97.34*	***97.34***
No. 10					**Pan**	*1.17*			

Obersved Time	**EL. Time (min.)**	**Temp. (oC)**	**Hydrometer Reading**			**100 Ra**	**% Total Sample**	**Grain Diameter**	**Correction Coefficient**		**Correction Dia. (mm)**
0:01	**(T)**		**Orginal**	**Composite Correction**	**Correction (R)**	**w**		**(mm)**	**(K)**	**(L)**	**(D)**
14:02	*0:00:00*			*6.0*							
	2	*21.0*	*58.0*	*6.0*	*52.0*	*80.52*	***80.52***	*0.05500*	*0.01328*	*7.8*	***0.02617***
	5	*21.0*	*53.0*	*6.0*	*47.0*	*72.78*	***72.78***	*0.03500*	*0.01328*	*8.6*	***0.01741***
	15	*21.0*	*46.0*	*6.0*	*40.0*	*61.94*	***61.94***	*0.02000*	*0.01328*	*9.7*	***0.01070***
	30	*21.0*	*41.0*	*6.0*	*35.0*	*54.20*	***54.20***	*0.01400*	*0.01328*	*10.6*	***0.00788***
	60	*21.0*	*37.0*	*6.0*	*31.0*	*48.00*	***48.00***	*0.01000*	*0.01328*	*11.2*	***0.00574***
	120	*21.5*	*33.0*	*6.0*	*27.0*	*41.81*	***41.81***	*0.00700*	*0.01328*	*11.9*	***0.00418***
	240	*22.0*	*30.0*	*6.0*	*24.0*	*37.16*	***37.16***	*0.00500*	*0.01328*	*12.4*	***0.00295***
	1440	*21.5*	*23.0*	*6.0*	*17.0*	*26.32*	***26.32***	*0.00100*	*0.01328*	*13.5*	***0.00129***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***3***	***97***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	D-5-2	68.5		12.5		dark greenish gray	Lean clay	CL
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: WR-09-043	Prepared By : PA	Date : 11/25/09
Sample No.	: D-9-1	Tested By : PA	Date : 11/26/09
Depth below Deck	: 88.0 Depth below Mudline (ft): 31.0	Sieved By : RJ	Date : 11/28/09
Description	: Dark greenish gray, Elastic SILT (MH)	Calculated By : JF	Date : 12/03/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date : 12/03/09

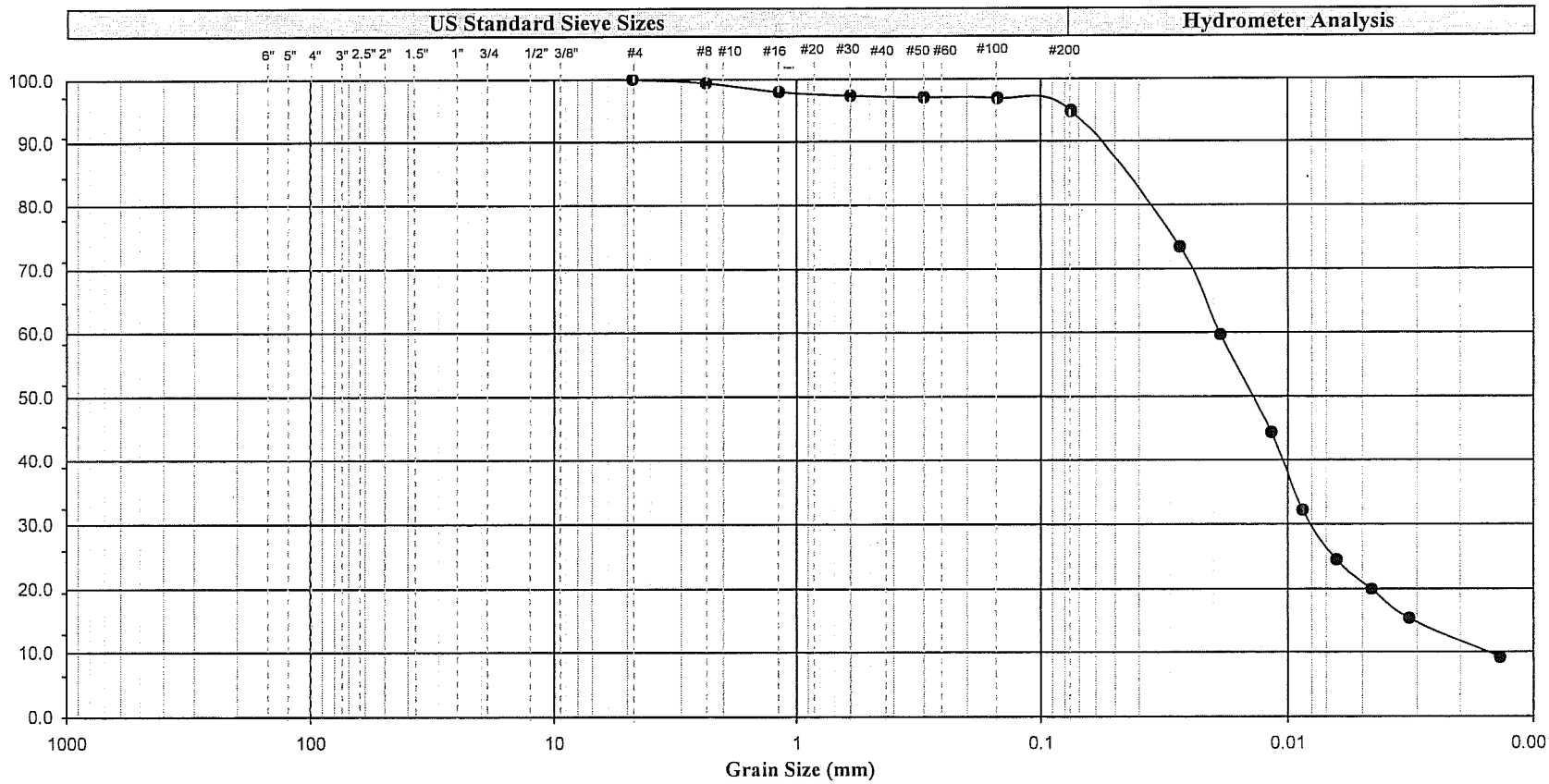
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	J-18	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	7	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor	
Container No.		S-28		J-18	82		S-8	for difference S.G.	
Wt. of Wet Soil + Container (gm)		203.77		65.19	117.67			0.99	
Wt. of Dry Soil + Container (gm)					117.25		121.91	Hydrometer Type	
Wt. of Container (gm)					58.49		118.29	152H	
Wt. of Dry Soil (gm)		202.32		64.73			3.62	(K) Value	Temp. °C
Moisture Content (%)					0.71			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				50	No. 16	1.32		97.96	**97.96**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	1.72		97.34	**97.34**
1.0"					No. 40				
3/4"				37	No. 50	1.91		97.05	**97.05**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	1.98		96.94	**96.94**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.39		**99.40**	13	No. 200	3.22		95.03	**95.03**
No. 10					Pan	3.78			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading Orginal	Composite Correction	Correction (R)	100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient (K)	(L)	Correction Dia. (mm) (D)
0:01											
14:06	0:00:00			6.0							
	2	21.0	54.0	6.0	48.0	73.42	**73.42**	0.05500	0.01328	8.4	**0.02726**
	5	21.0	45.0	6.0	39.0	59.65	**59.65**	0.03500	0.01328	9.9	**0.01869**
	15	21.0	35.0	6.0	29.0	44.36	**44.36**	0.02000	0.01328	11.5	**0.01165**
	30	21.0	27.0	6.0	21.0	32.12	**32.12**	0.01400	0.01328	12.9	**0.00869**
	60	21.0	22.0	6.0	16.0	24.47	**24.47**	0.01000	0.01328	13.7	**0.00634**
	120	21.5	19.0	6.0	13.0	19.88	**19.88**	0.00700	0.01328	14.2	**0.00456**
	240	22.0	16.0	6.0	10.0	15.29	**15.29**	0.00500	0.01328	14.7	**0.00322**
	1440	21.5	12.0	6.0	6.0	9.18	**9.18**	0.00100	0.01328	15.3	**0.00137**

Remark :		Cu : 11.7	Gravel	Sand	Fine
		Cc : 2.1	**0**	**5**	**95**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	D-9-1	88.0		31.0		dark greenish gray	Elastic silt	MH
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: *WR-09-043*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-19*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *168.0*	**Depth below Mudline (ft):** *115.0*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

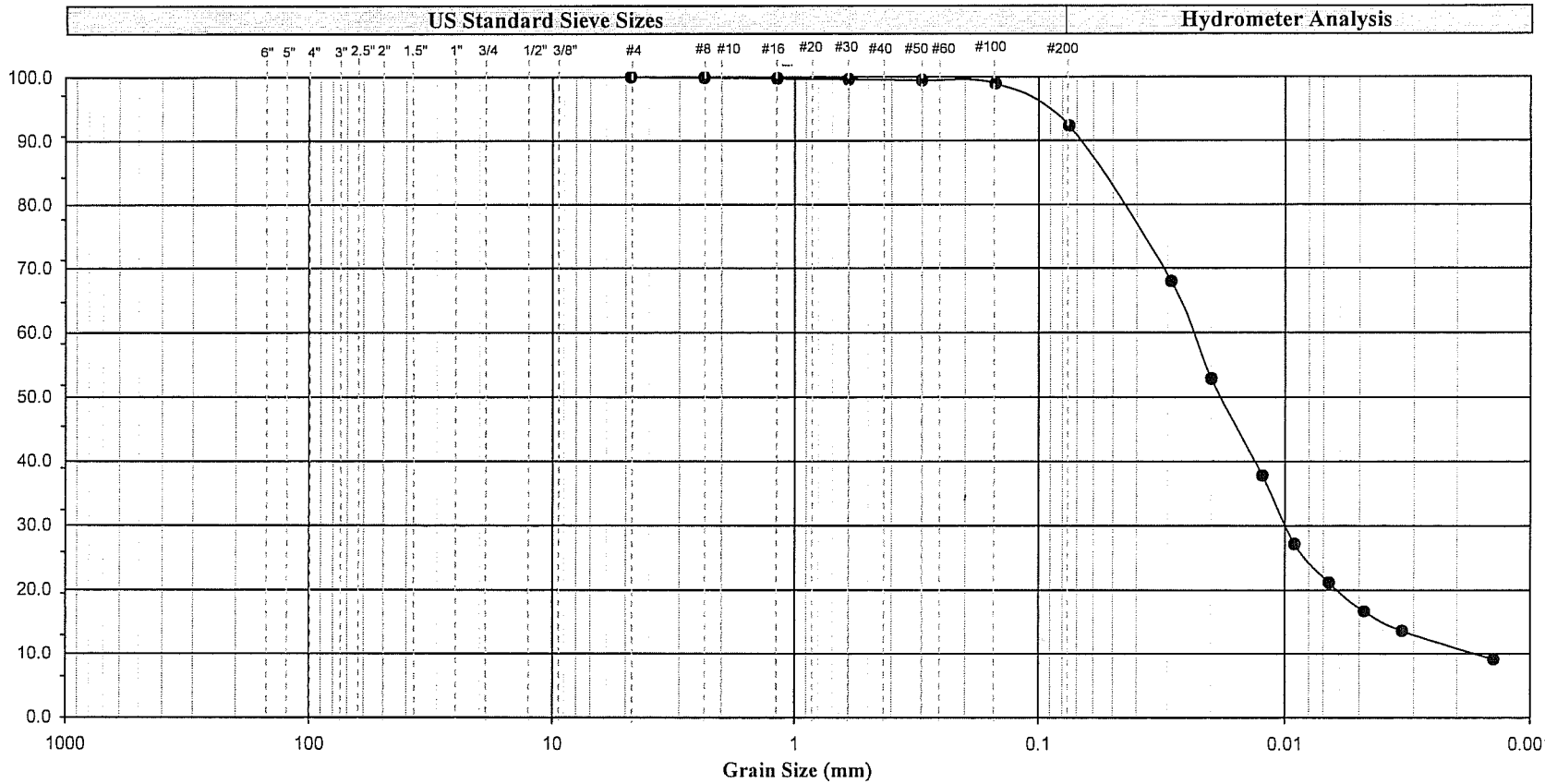
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

Setup Container No. :	*J-3*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*3*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-17*		*J-3*	*3*		*S-8*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*224.16*		*65.90*	*158.46*			*0.99*	
Wt. of Dry Soil + Container (gm)					*157.90*		*120.15*	**Hydrometer Type**	
Wt. of Container (gm)					*58.48*		*114.59*	*152H*	
Wt. of Dry Soil (gm)		*222.90*		*65.53*			*5.56*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.56*			*0.01369*	*18.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***35***	No. 16	*0.16*		*99.76*	***99.76***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.25*		*99.62*	***99.62***
1.0"					No. 40				
3/4"				***26***	No. 50	*0.33*		*99.50*	***99.50***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*0.68*		*98.96*	***98.96***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.06*		***99.91***	***9***	No. 200	*5.05*		*92.29*	***92.29***
No. 10					Pan	*5.52*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
10:12	***0:00:00***			*6.0*							
	2	*20.0*	*51.0*	*6.0*	*45.0*	*67.98*	***67.98***	*0.05500*	*0.01369*	*8.9*	***0.02891***
	5	*20.0*	*41.0*	*6.0*	*35.0*	*52.88*	***52.88***	*0.03500*	*0.01369*	*10.6*	***0.01989***
	15	*20.0*	*31.0*	*6.0*	*25.0*	*37.77*	***37.77***	*0.02000*	*0.01369*	*12.2*	***0.01235***
	30	*20.0*	*24.0*	*6.0*	*18.0*	*27.19*	***27.19***	*0.01400*	*0.01369*	*13.3*	***0.00913***
	60	*21.0*	*20.0*	*6.0*	*14.0*	*21.15*	***21.15***	*0.01000*	*0.01369*	*14.0*	***0.00661***
	120	*21.0*	*17.0*	*6.0*	*11.0*	*16.62*	***16.62***	*0.00700*	*0.01369*	*14.5*	***0.00476***
	240	*22.0*	*15.0*	*6.0*	*9.0*	*13.60*	***13.60***	*0.00500*	*0.01369*	*14.8*	***0.00333***
	1440	*21.0*	*12.0*	*6.0*	*6.0*	*9.06*	***9.06***	*0.00100*	*0.01369*	*15.3*	***0.00141***

Remark :		Cu : *13.4*	**Gravel**	**Sand**	**Fine**
		Cc : *2.3*	***0***	***8***	***92***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-043	S-19	168.0		115.0		dark greenish gray	Silt	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

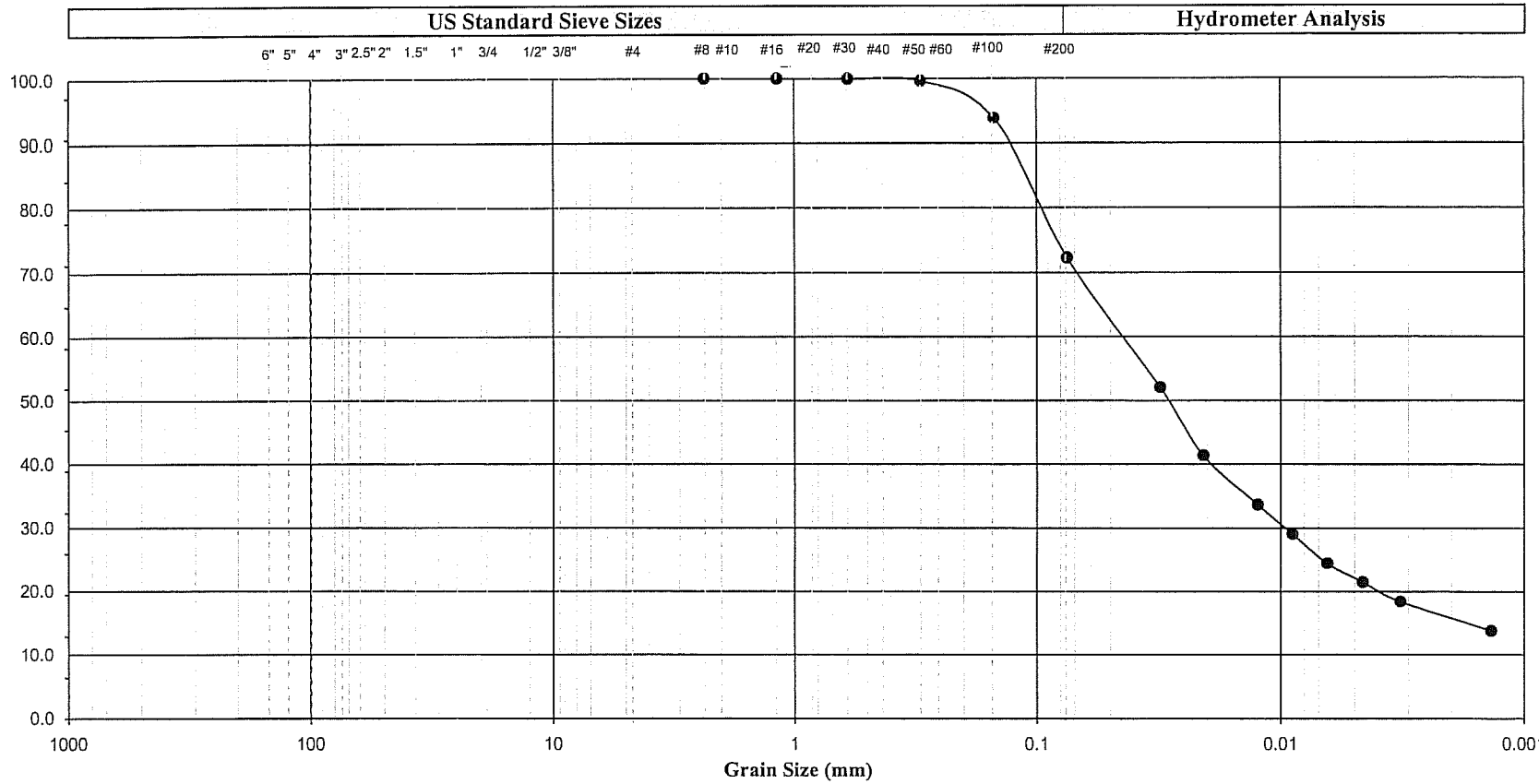
Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *WR-09-044*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-1*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *51.0*	**Depth below Mudline (ft):** 3	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, SILT with SAND (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**
Sample for Hydrometer should passing (No.10-ASTM) & (No.4-Cal. Tran.), 65 gm for fine & 115 gm for Sand.			*1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-19*	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	*2.70*	
Test Cylinder No. :	*7*							Correction factor	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	for difference S.G.	
Container No.		*S-11*		*J-19*	*20*		*S-19*	*0.99*	
Wt. of Wet Soil + Container (gm)		*195.84*		*66.91*	*185.87*			Hydrometer Type	
Wt. of Dry Soil + Container (gm)					*181.65*		*138.18*	*152H*	
Wt. of Container (gm)					*57.04*		*116.59*	(K) Value	Temp. °C
Wt. of Dry Soil (gm)		*189.42*		*64.72*			*21.59*	*0.01353*	*19.5*
Moisture Content (%)					*3.39*				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**36**	No. 16	*0.03*		*99.95*	***99.95***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.06*		*99.91*	***99.91***
1.0"					No. 40				
3/4"				**26**	No. 50	*0.26*		*99.60*	***99.60***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*3.92*		*93.94*	***93.94***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	**10**	No. 200	*17.94*		*72.28*	***72.28***
No. 10					Pan	*21.59*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
0:01	(T)										
9:02	*0:00:00*			*5.0*							
	2	*19.5*	*39.0*	*5.0*	*34.0*	*52.01*	***52.01***	*0.05500*	*0.01353*	*10.7*	***0.03131***
	5	*19.5*	*32.0*	*5.0*	*27.0*	*41.30*	***41.30***	*0.03500*	*0.01353*	*11.9*	***0.02084***
	15	*19.5*	*27.0*	*5.0*	*22.0*	*33.65*	***33.65***	*0.02000*	*0.01353*	*12.7*	***0.01244***
	30	*19.5*	*24.0*	*5.0*	*19.0*	*29.06*	***29.06***	*0.01400*	*0.01353*	*13.2*	***0.00896***
	60	*19.5*	*21.0*	*5.0*	*16.0*	*24.48*	***24.48***	*0.01000*	*0.01353*	*13.7*	***0.00646***
	120	*20.0*	*19.0*	*5.0*	*14.0*	*21.42*	***21.42***	*0.00700*	*0.01353*	*14.0*	***0.00462***
	240	*21.0*	*17.0*	*5.0*	*12.0*	*18.36*	***18.36***	*0.00500*	*0.01353*	*14.3*	***0.00324***
	1440	*19.0*	*14.0*	*5.0*	*9.0*	*13.77*	***13.77***	*0.00100*	*0.01353*	*14.8*	***0.00137***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***0***	***28***	***72***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	D-1	51.0		3.0		dark olive gray	Silt with sand	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑ **CAL. TRANS.**	

Boring No.	: *WR-09-044*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-2*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Decl	: *56.0* **Depth below Mudline (ft):** *9*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, SANDY SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

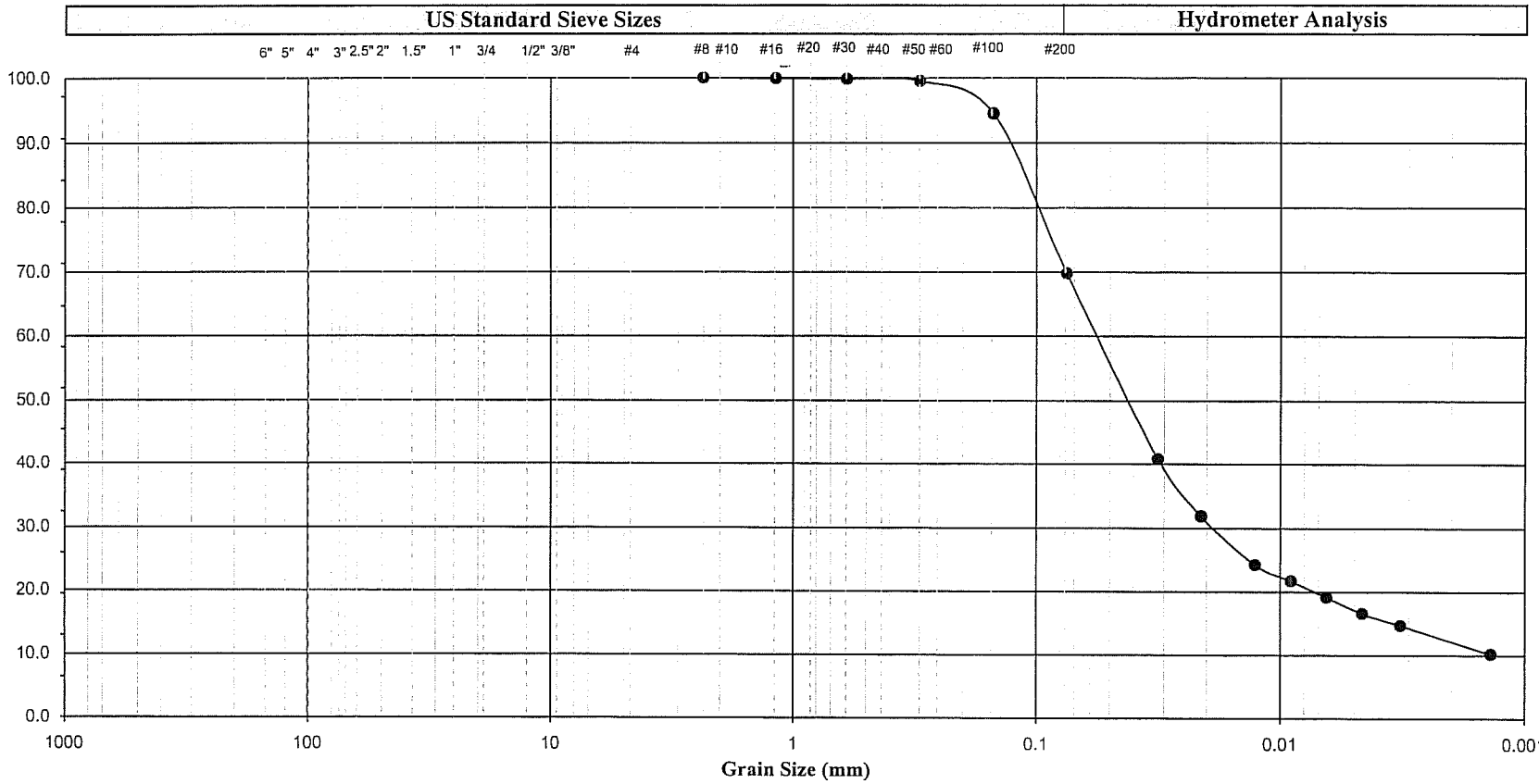
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-20*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*1*	**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Computer File No. :								**for difference S.G.**	
Container No.		*S-11*		*J-20*	*21*		*S-20*	*0.99*	
Wt. of Wet Soil + Container (gm)		*220.46*		*78.42*	*199.77*			**Hydrometer Type**	
Wt. of Dry Soil + Container (gm)					*198.46*		*144.52*	*152H*	
Wt. of Container (gm)					*57.80*		*115.13*		
Wt. of Dry Soil (gm)		*218.43*		*77.70*			*29.39*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.93*			*0.01353*	*19.5*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**36**	No. 16	*0.07*		*99.91*	***99.91***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.13*		*99.83*	***99.83***
1.0"					No. 40				
3/4"				**26**	No. 50	*0.39*		*99.50*	***99.50***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*4.28*		*94.49*	***94.49***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	**10**	No. 200	*23.47*		*69.79*	***69.79***
No. 10					Pan	*29.38*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	W		(mm)	(K)	(L)	(D)
9:06	*0:00:00*			*5.0*							
	2	*19.5*	*37.0*	*5.0*	*32.0*	*40.77*	***40.77***	*0.05500*	*0.01353*	*11.0*	***0.03179***
	5	*19.5*	*30.0*	*5.0*	*25.0*	*31.85*	***31.85***	*0.03500*	*0.01353*	*12.2*	***0.02112***
	15	*19.5*	*24.0*	*5.0*	*19.0*	*24.21*	***24.21***	*0.02000*	*0.01353*	*13.2*	***0.01268***
	30	*19.5*	*22.0*	*5.0*	*17.0*	*21.66*	***21.66***	*0.01400*	*0.01353*	*13.5*	***0.00908***
	60	*19.5*	*20.0*	*5.0*	*15.0*	*19.11*	***19.11***	*0.01000*	*0.01353*	*13.8*	***0.00650***
	120	*20.0*	*18.0*	*5.0*	*13.0*	*16.56*	***16.56***	*0.00700*	*0.01353*	*14.2*	***0.00465***
	240	*21.0*	*16.5*	*5.0*	*11.5*	*14.65*	***14.65***	*0.00500*	*0.01353*	*14.4*	***0.00325***
	1440	*19.0*	*13.0*	*5.0*	*8.0*	*10.19*	***10.19***	*0.00100*	*0.01353*	*15.0*	***0.00138***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***0***	***30***	***70***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-2	56.0		9.0		dark olive gray	Sandy silt	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*
Project No.	: *06-123-3*

Tested Standard : ☐ ASTM ☑ CAL. TRANS.

Boring No.	: *WR-09-044*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-3-1*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *59.0*	**Depth below Mudline (ft):** 12	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark olive-gray, SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

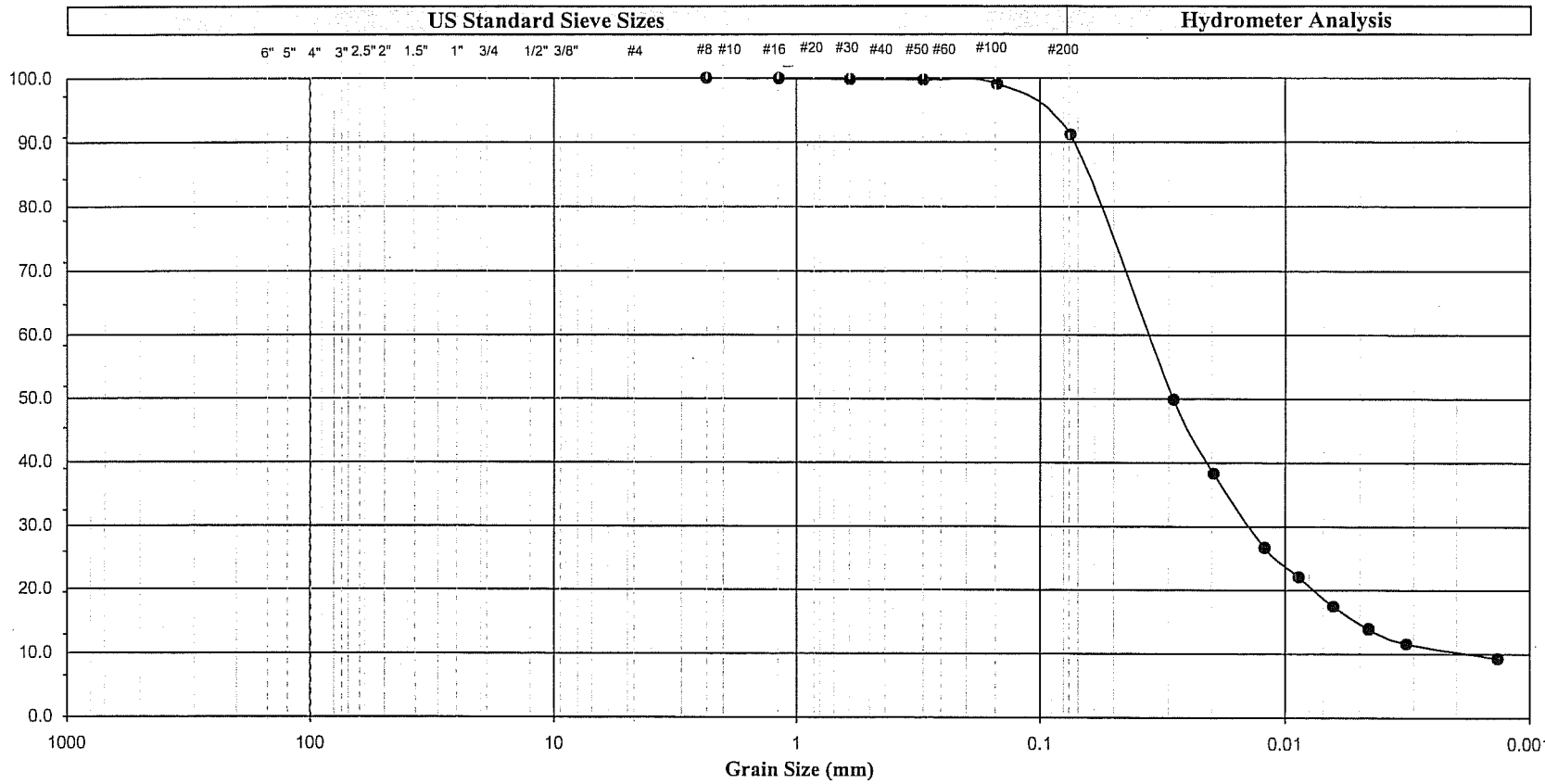
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-20*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*5*							**Correction factor**	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**for difference S.G.**	
Container No.		*S-11*		*J-20*	*25*		*S-12*	*0.99*	
Wt. of Wet Soil + Container (gm)		*228.70*		*85.73*	*202.11*			**Hydrometer Type**	
Wt. of Dry Soil + Container (gm)					*201.56*		*128.75*	*152H*	
Wt. of Container (gm)					*59.27*		*114.28*	**(K) Value**	**Temp. °C**
Wt. of Dry Soil (gm)		*227.82*		*85.40*			*14.47*	*0.01328*	*21.0*
Moisture Content (%)					*0.39*				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				*30*	No. 16	*0.08*		*99.91*	***99.91***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.19*		*99.78*	***99.78***
1.0"					No. 40				
3/4"				*27*	No. 50	*0.29*		*99.66*	***99.66***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*0.79*		*99.07*	***99.07***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	*3*	No. 200	*7.56*		*91.15*	***91.15***
No. 10					Pan				

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading: Orginal	Composite Correction	Correction (R)	100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient (K)	Correction Coefficient (L)	Correction Dia. (mm) (D)
0:01											
13:30	*0:00:00*			*5.0*							
	2	*21.0*	*48.0*	*5.0*	*43.0*	*49.85*	***49.85***	*0.05500*	*0.01328*	*9.2*	***0.02855***
	5	*21.0*	*38.0*	*5.0*	*33.0*	*38.26*	***38.26***	*0.03500*	*0.01328*	*10.9*	***0.01960***
	15	*21.0*	*28.0*	*5.0*	*23.0*	*26.66*	***26.66***	*0.02000*	*0.01328*	*12.5*	***0.01214***
	30	*22.0*	*24.0*	*5.0*	*19.0*	*22.03*	***22.03***	*0.01400*	*0.01328*	*13.2*	***0.00880***
	60	*23.0*	*20.0*	*5.0*	*15.0*	*17.39*	***17.39***	*0.01000*	*0.01328*	*13.8*	***0.00638***
	120	*23.0*	*17.0*	*5.0*	*12.0*	*13.91*	***13.91***	*0.00700*	*0.01328*	*14.3*	***0.00459***
	240	*23.5*	*15.0*	*5.0*	*10.0*	*11.59*	***11.59***	*0.00500*	*0.01328*	*14.7*	***0.00322***
	1440	*21.5*	*13.0*	*5.0*	*8.0*	*9.27*	***9.27***	*0.00100*	*0.01328*	*15.0*	***0.00135***

Remark :		Cu : *20.6*	**Gravel**	**Sand**	**Fine**
		Cc : *2.6*	***0***	***9***	***91***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	D-3-1	59.0		12.0		dark olive gray	Silt	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *WR-09-044*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *D-5-2*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *68.5*	**Depth below Mudline (ft):** *21.5*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

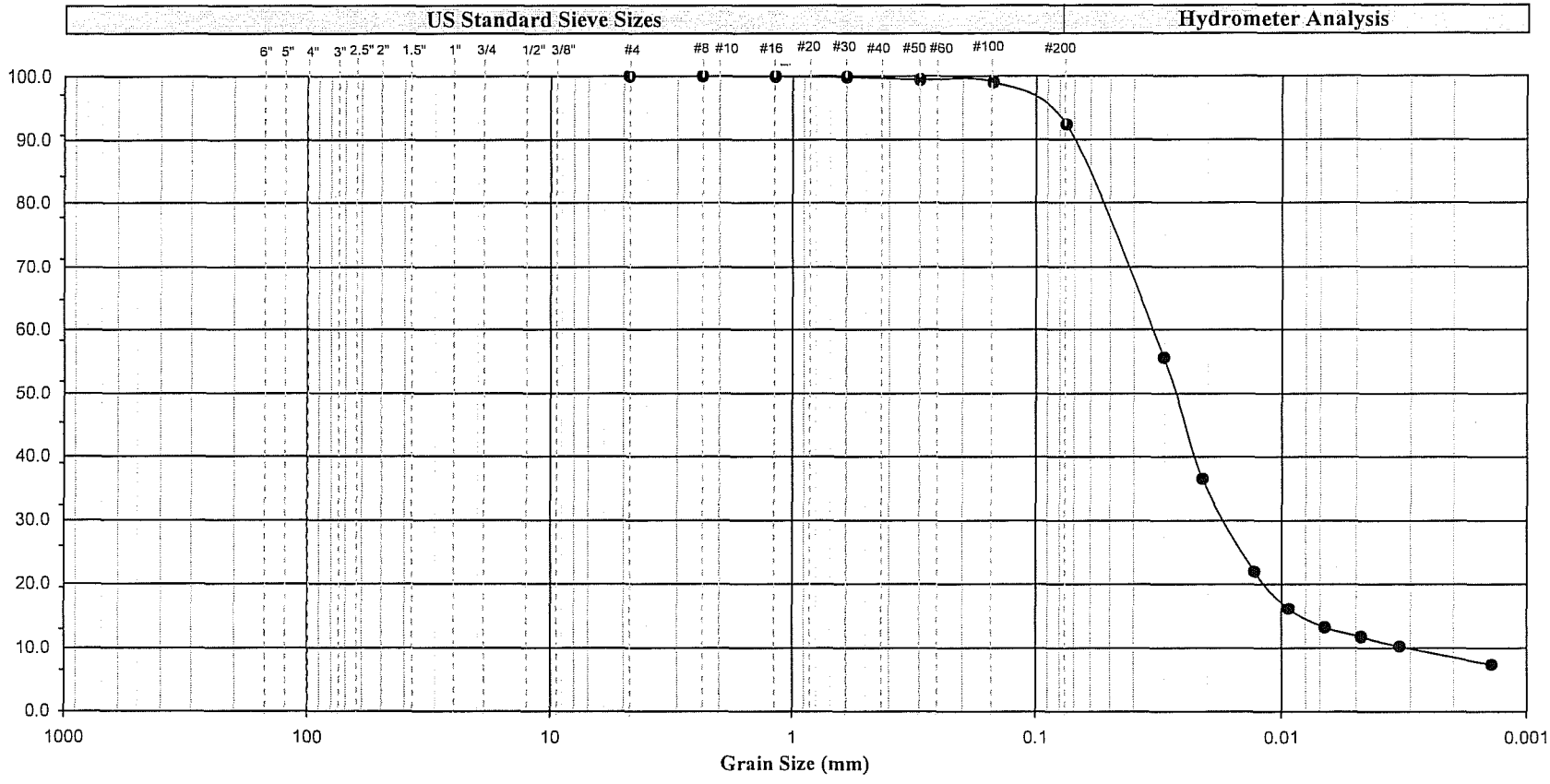
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-19*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*2p*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-17*		*J-19*	*4*		*S-22*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*220.47*		*68.32*	*170.32*			*0.99*	
Wt. of Dry Soil + Container (gm)					*169.30*		*121.19*	**Hydrometer Type**	
Wt. of Container (gm)					*58.97*		*115.19*	*152H*	
Wt. of Dry Soil (gm)		*218.45*		*67.69*			*6.00*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.92*			*0.01344*	*20.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***35***	No. 16	*0.02*		*99.97*	***99.97***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.11*		*99.84*	***99.84***
1.0"					No. 40				
3/4"				***32***	No. 50	*0.38*		*99.44*	***99.44***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*0.63*		*99.07*	***99.07***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	***3***	No. 200	*5.14*		*92.41*	***92.41***
No. 10					Pan	*5.96*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)						
0:01	(T)							(mm)	(K)	(L)	(D)
10:13	***0:00:00***			*6.0*							
	2	*20.0*	*44.0*	*6.0*	*38.0*	*55.57*	***55.57***	*0.05500*	*0.01344*	*10.1*	***0.03016***
	5	*20.0*	*31.0*	*6.0*	*25.0*	*36.56*	***36.56***	*0.03500*	*0.01344*	*12.2*	***0.02100***
	15	*20.0*	*21.0*	*6.0*	*15.0*	*21.94*	***21.94***	*0.02000*	*0.01344*	*13.8*	***0.01291***
	30	*20.0*	*17.0*	*6.0*	*11.0*	*16.09*	***16.09***	*0.01400*	*0.01344*	*14.5*	***0.00934***
	60	*21.0*	*15.0*	*6.0*	*9.0*	*13.16*	***13.16***	*0.01000*	*0.01344*	*14.8*	***0.00668***
	120	*21.0*	*14.0*	*6.0*	*8.0*	*11.70*	***11.70***	*0.00700*	*0.01344*	*15.0*	***0.00475***
	240	*22.0*	*13.0*	*6.0*	*7.0*	*10.24*	***10.24***	*0.00500*	*0.01344*	*15.1*	***0.00331***
	1440	*21.0*	*11.0*	*6.0*	*5.0*	*7.31*	***7.31***	*0.00100*	*0.01344*	*15.5*	***0.00139***

Remark :		Cu : *11.3*	Gravel	Sand	Fine
		Cc : *2.7*	***0***	***8***	***92***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	D-5-2	68.5		21.5		dark greenish gray	Silt	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑ **CAL. TRANS.**	
Boring No.	: *WR-09-044*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-6*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *73.0*	**Depth below Mudline (ft):** *27.0*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, Lean CLAY (CL)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

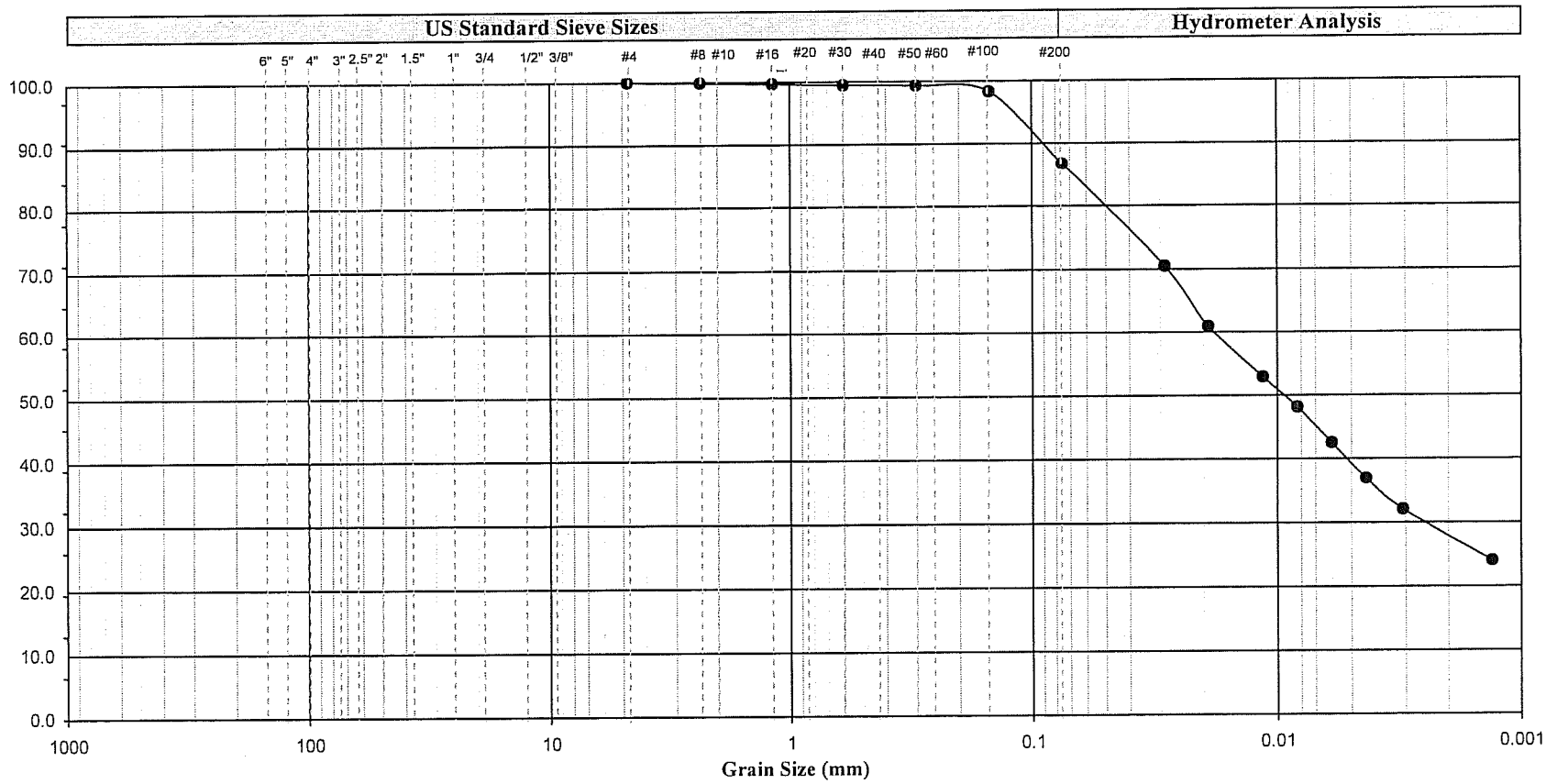
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. — *1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-15*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*5*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*S-17*		*J-15*	*5*		*S-23*		
Wt. of Wet Soil + Container (gm)		*212.26*		*63.32*	*176.21*			*0.99*	
Wt. of Dry Soil + Container (gm)					*173.27*		*122.43*	**Hydrometer Type**	
Wt. of Container (gm)					*57.92*		*113.81*	*152H*	
Wt. of Dry Soil (gm)		*206.98*		*61.75*			*8.62*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*2.55*			*0.01344*	*20.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***44***	No. 16	*0.20*		*99.68*	***99.68***
2.0"					No. 20				
1.5"				**Plastic Limit**	No. 30	*0.35*		*99.43*	***99.43***
1.0"					No. 40				
3/4"				***26***	No. 50	*0.44*		*99.29*	***99.29***
1/2"					No. 60				
3/8"				**Plastic Index**	No. 100	*1.02*		*98.35*	***98.35***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.09*		***99.85***	***18***	No. 200	*8.19*		*86.74*	***86.74***
No. 10					Pan	*8.61*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
10:17	***0:00:00***			*6.0*							
	2	*20.0*	*50.0*	*6.0*	*44.0*	*70.55*	***70.55***	*0.05500*	*0.01344*	*9.1*	***0.02864***
	5	*20.0*	*44.0*	*6.0*	*38.0*	*60.93*	***60.93***	*0.03500*	*0.01344*	*10.1*	***0.01907***
	15	*20.0*	*39.0*	*6.0*	*33.0*	*52.91*	***52.91***	*0.02000*	*0.01344*	*10.9*	***0.01145***
	30	*20.0*	*36.0*	*6.0*	*30.0*	*48.10*	***48.10***	*0.01400*	*0.01344*	*11.4*	***0.00828***
	60	*21.0*	*32.5*	*6.0*	*26.5*	*42.49*	***42.49***	*0.01000*	*0.01344*	*11.9*	***0.00600***
	120	*21.0*	*29.0*	*6.0*	*23.0*	*36.88*	***36.88***	*0.00700*	*0.01344*	*12.5*	***0.00434***
	240	*22.0*	*26.0*	*6.0*	*20.0*	*32.07*	***32.07***	*0.00500*	*0.01344*	*13.0*	***0.00307***
	1440	*21.0*	*21.0*	*6.0*	*15.0*	*24.05*	***24.05***	*0.00100*	*0.01344*	*13.8*	***0.00132***

Remark :	*>#30 were cemented nodules*	**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***13***	***87***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-6	73.0		27.0		dark greenish gray	Lean clay	CL
Remark	>#30 were cemented nodules								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/03/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: *WR-09-044*	**Prepared By :** *PA*	**Date :** *11/25/09*
Sample No.	: *S-8*	**Tested By :** *PA*	**Date :** *11/26/09*
Depth below Deck : *83.0*	**Depth below Mudline (ft):** *37.0*	**Sieved By :** *RJ*	**Date :** *11/28/09*
Description	: *Dark greenish gray, SANDY SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/03/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :** *12/03/09*

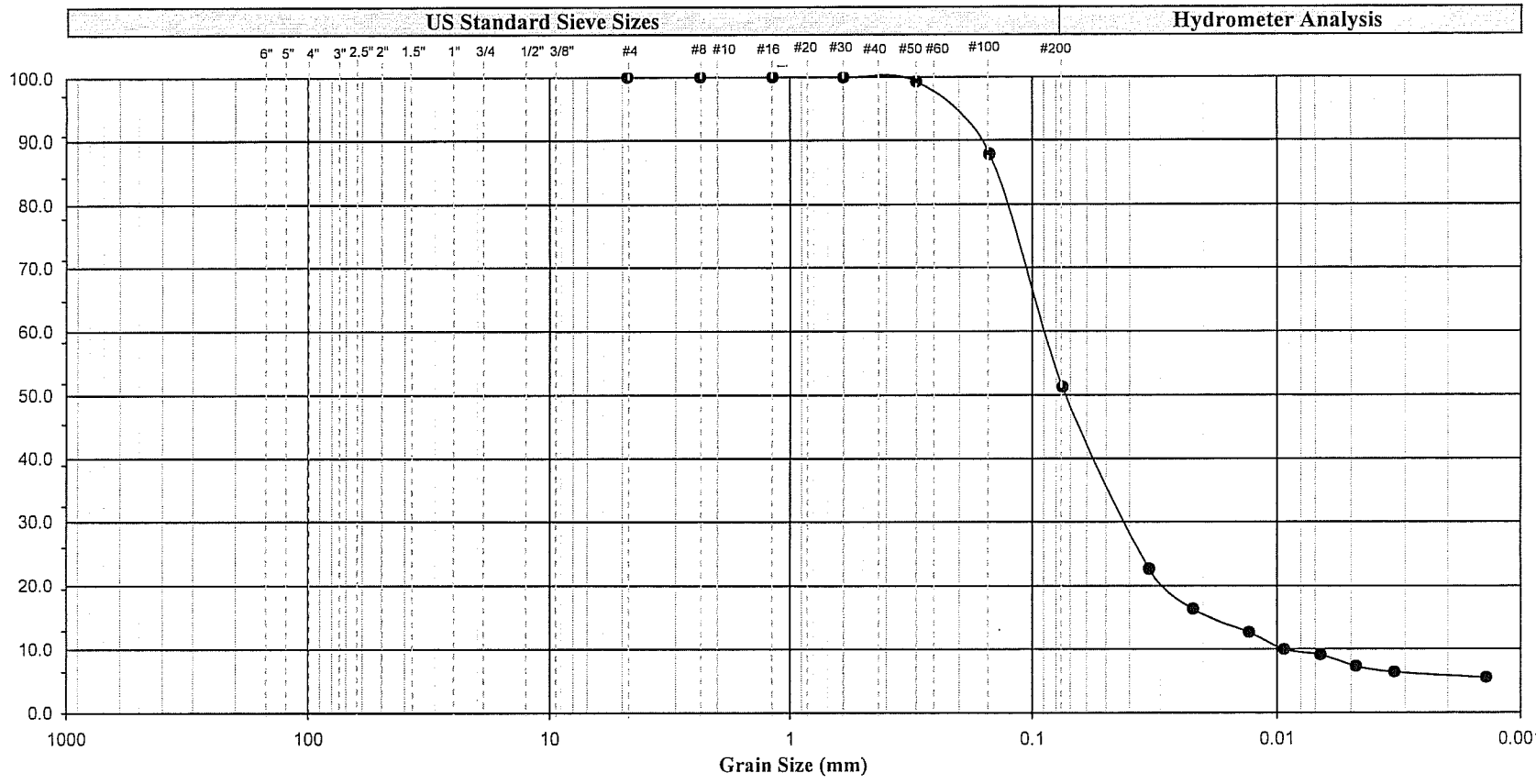
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*J-13*	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	*2.70*	
Test Cylinder No. :	*7*								
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor	
Container No.		*S-17*		*J-13*	*6*		*S-24*	for difference S.G.	
Wt. of Wet Soil + Container (gm)		*259.73*		*109.94*	*184.81*			*0.99*	
Wt. of Dry Soil + Container (gm)					*184.06*		*170.99*	Hydrometer Type	
Wt. of Container (gm)					*57.20*		*113.09*	*152H*	
Wt. of Dry Soil (gm)		*258.20*		*109.29*			*57.90*	(K) Value	Temp. °C
Moisture Content (%)					*0.59*			*0.01344*	*20.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*0.00*		*100.00*	***100.00***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.03*		*99.97*	***99.97***
1.0"					No. 40				
3/4"				-	No. 50	*0.83*		*99.24*	***99.24***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*13.21*		*87.91*	***87.91***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	-	No. 200	*53.32*		*51.21*	***51.21***
No. 10					Pan	*57.82*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
10:17	*0:00:00*			*6.0*							
	2	*20.0*	*31.0*	*6.0*	*25.0*	*22.65*	***22.65***	*0.05500*	*0.01344*	*12.2*	***0.03320***
	5	*20.0*	*24.0*	*6.0*	*18.0*	*16.30*	***16.30***	*0.03500*	*0.01344*	*13.3*	***0.02196***
	15	*20.0*	*20.0*	*6.0*	*14.0*	*12.68*	***12.68***	*0.02000*	*0.01344*	*14.0*	***0.01299***
	30	*20.0*	*17.0*	*6.0*	*11.0*	*9.96*	***9.96***	*0.01400*	*0.01344*	*14.5*	***0.00934***
	60	*21.0*	*16.0*	*6.0*	*10.0*	*9.06*	***9.06***	*0.01000*	*0.01344*	*14.7*	***0.00664***
	120	*21.0*	*14.0*	*6.0*	*8.0*	*7.25*	***7.25***	*0.00700*	*0.01344*	*15.0*	***0.00475***
	240	*22.0*	*13.0*	*6.0*	*7.0*	*6.34*	***6.34***	*0.00500*	*0.01344*	*15.1*	***0.00331***
	1440	*21.0*	*12.0*	*6.0*	*6.0*	*5.43*	***5.43***	*0.00100*	*0.01344*	*15.3*	***0.00139***

Remark :		Cu : *9.9*	Gravel	Sand	Fine
		Cc : *2.2*	***0***	***49***	***51***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below deck(ft)		Depth below mudline (ft)		Soil Color	Soil Description	U.S.C.S.
●	WR-09-044	S-8	83.0		37.0		dark greenish gray	Sandy silt	ML
Remark	0.00								

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/03/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ATTERBERG LIMITS

Atterberg Limit Test Results

Boring No.	Sample No.	Depth (ft)	Predominant Soil Type	Atterberg Limit ASTM D4318 (LL,PL,PI)
R-09-001	D-11	55	CL	46,27,19
R-09-002	D-09	45	ML	49,29,20
R-09-002	S-10	50	ML	29,23,6
R-09-002	S-12	60	-	N.P
R-09-002	S-14	70	CL	29,20,9
R-09-003	S-07	35	-	N.P
R-09-003	U-11	55	ML	28,23,5
R-09-005	D-08	40	ML	39,29,10
R-09-005	D-12	60	-	N.P
R-09-005	S-13	65	CL	35,24,11
R-09-005	U-14	70	-	N.P
R-09-006	U-07	35	ML	46,28,18
R-09-006	D-08	40	ML	27,22,5
R-09-006	D-11	52.5	ML	N.P
R-09-006	S-12-2	56	ML	40,28,12
R-09-006	D-13	60	CL-ML	25,21,4
R-09-008	D-07	35	ML	29,24,5
R-09-008	D-09	45	MH	57,33,24
R-09-008	S-10	50	CL	47,23,24
R-09-008	D-11	55	-	N.P
R-09-008	S-14	70	CL	36,21,15
R-09-009	S-06	30	CL-ML	20,24,4
R-09-009	D-07	35	CH	56,25,31
R-09-009	U-09	45	CL	31,22,9
R-09-009	S-10	50	CL	49,27,22
R-09-009	D-11	55	ML	27,22,5
R-09-009	D-13	65	-	N.P
R-09-009	S-14	70	ML	N.P
R-09-011	S-07	35	CL-ML	29,23,6
R-09-011	D-08	40	CL-ML	29,22,7
R-09-011	D-10	50	CH	51,23,28
R-09-011	S-11	55	ML	31,26,5
R-09-011	S-13	65	-	N.P
R-09-011	U-14	70	-	N.P
R-09-012	S-05	25	CL-ML	26,19,7
R-09-012	D-10	50	ML	31,27,4
R-09-012	U-10A	51.5	-	N.P
R-09-012	S-13	65	CH	71,29,42
R-09-012	D-14	70	ML	38,27,11
R-09-012	S-15	75	ML	44,30,14
R-09-012	U-16	80	CL	35,23,12
R-09-013	S-02	10	MH	63,38,25
R-09-013	U-05	25	CL-ML	30,23,7

Atterberg Limit Test Results
(Continued)

Boring No.	Sample No.	Depth (ft)	Predominant Soil Type	Atterberg Limit ASTM D4318 (LL,PL,PI)
R-09-013	D-06	30	ML-MH	50,29,21
R-09-013	S-07	35	ML	N.P
R-09-013	U-08	40	CL	36,24,12
R-09-013	S-09-1	45	-	N.P
R-09-013	D-10	50	CL	38,25,13
R-09-013	S-11-2	55.5	-	N.P
R-09-013	D-12	60	ML	N.P
R-09-013	S-13	65	ML	N.P
R-09-015	D-04	20	-	N.P
R-09-015	S-07	35	CL	39,24,15
R-09-015	D-08	40	MH	71,37,34
R-09-015	U-09	45	-	N.P
R-09-015	D-10	50	CL	37,24,13
R-09-015	S-11	55	ML	38,26,12
R-09-015	U-12	60	-	N.P
R-09-016	D-04	20	-	N.P
R-09-016	S-07	35	-	N.P
R-09-016	D-08	40	CH	28,26,32
R-09-016	U-09	45	-	N.P
R-09-016	D-10-1	50	CL	45,22,23
R-09-016	D-12-1	60	-	N.P
R-09-016	U-14	70	-	N.P
R-09-017	S-09	45	CL-ML	24,20,4
R-09-017	U-07	35	CL	31,21,10
R-09-017	D-10	50	CH	50,24,26
R-09-017	U-11	55	ML	36,29,7
R-09-018	S-04	20	CL-ML	26,21,5
R-09-018	S-07	30	MH	57,31,26
R-09-018	U-08	32.5	-	N.P
R-09-018	D-11	45	-	N.P
R-09-018	D-14	55	ML	32,25,7
R-09-019	S-03	15	ML	37,27,10
R-09-019	S-05	25	ML	32,24,8
R-09-019	D-08	40	-	N.P
R-09-019	S-09	45	ML	29,24,5
R-09-019	D-12	60	CL	38,24,14
R-09-019	U-13	65	CL-ML	28,22,6
R-09-019	S-23	150	ML	30,25,5
R-09-020	S-03-1	15	CL	39,23,16
R-09-020	U-04	20	ML	39,26,13
R-09-020	S-05	25	ML	35,26,9
R-09-020	D-06	30	ML	30,26,4

Atterberg Limit Test Results
(Continued)

Boring No.	Sample No.	Depth (ft)	Predominant Soil Type	Atterberg Limit ASTM D4318 (LL,PL,PI)
R-09-020	U-08	40	-	N.P
R-09-020	D-10	50	-	N.P
R-09-020	S-11-2	55.9	ML	48,29,19
R-09-020	D-12	60	-	N.P
R-09-020	D-14	70	ML	36,27,9
R-09-020	S-25	185	ML	33,24,9
R-09-022	D-02	10	ML	37,33,4
R-09-022	U-08	40	CL	34,24,10
R-09-022	D-10	50	-	N.P
R-09-022	U-11	55	-	N.P
R-09-022	D-12	60	CL	46,27,19
R-09-022	S-13	65	CL	33,22,11
R-09-022	D-14	70	CL-ML	26,20,6
R-09-022	S-15	75	CL-ML	29,22,7
R-09-022	S-22	160	CL	30,22,8
R-09-023	D-02	10	MH	54,30,24
R-09-023	U-07	32	ML	32,25,7
R-09-023	U-09	45	CL-ML	29,22,7
R-09-023	S-12-1	60	-	N.P
R-09-023	D-13-1	65	CL	33,21,12
R-09-023	D-13-2	65.5	CL	32,20,12
R-09-023	D-15	75	ML	37,27,10
R-09-023	S-16	80	-	N.P
R-09-024	S-05	25	ML	30,24,6
R-09-024	S-07	35	-	N.P
R-09-024	U-06	30	ML	35,25,10
R-09-024	U-08	40	-	N.P
R-09-024	S-11	55	-	N.P
R-09-024	D-10	50	CL	47,26,21
R-09-024	U-12	60	CL	39,25,14
R-09-024	S-13	65	ML	25,22,3
R-09-024	D-14	70	ML	43,28,15
R-09-024	D-16-1	80	-	N.P
R-09-025	D-04	20	ML	30,25,5
R-09-025	D-08	40	ML	31,26,5
R-09-025	U-10	50	-	N.P
R-09-025	D-12-2	60.5	CL	44,-25,19
R-09-025	S-13	65	-	N.P
R-09-025	S-15	75	ML	31,25,6
R-09-025	S-22	160	-	N.P
R-09-026	D-02	10	ML	29,25,4
R-09-026	S-03	15	CL	38,24,14

Atterberg Limit Test Results
(Continued)

Boring No.	Sample No.	Depth (ft)	Predominant Soil Type	Atterberg Limit ASTM D4318 (LL,PL,PI)
R-09-026	D-04	20	ML	31,24,7
R-09-026	D-08	40	ML	34,26,8
R-09-026	D-14	70	CL	34,22,12
R-09-026	U-15	75	-	N.P
R-09-028	S-03	15	ML	36,28,8
R-09-028	S-05	25	-	N.P
R-09-028	U-07	35	-	N.P
R-09-028	D-08	40	-	N.P
R-09-028	D-10	50	-	N.P
R-09-028	S-22	160	CL-ML	30,23,7
R-09-029	D-04	20	ML	36,28,8
R-09-029	U-05	25	-	N.P
R-09-029	U-07	35	-	N.P
R-09-029	D-10	50	-	N.P
R-09-029	S-11	55	ML	34,25,9
R-09-029	U-12	60	ML	27,22,5

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO.: 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-004	D-01	5.0	23.2	104.3		30,22,8
R-09-004	D-03	15.0	27.0	97.7		
R-09-004	D-05	25.0			19.1	
R-09-004	S-06	30.0	22.8			
R-09-004	D-07	35.0				27,24,3
R-09-004	S-08	41.0	34.0			25,22,3
R-09-004	S-11	56.0	28.7			27,22,5
R-09-004	S-13	60.0	29.5		35.8	
R-09-004	D-14	65.0	26.4	101.4		
R-09-004	S-15	70.0	30.7			33,21,12
R-09-004	D-16	75.0	27.0	98.6		
R-09-004	S-17	80.0	25.4			
R-09-004	D-18	85.0	27.8	98.4		
R-09-004	S-20	95.0	23.2			
R-09-004	U-21	100.0				58,28,30
R-09-004	S-22	115.0	16.4			
R-09-004	S-23-2	126.2	49.5			50,25,25
R-09-004	S-26	155.0	15.7			
R-09-007	S-01	5.0			36.2	
R-09-007	D-02	10.0	26.7	98.6		
R-09-007	S-03	15.0	29.7			
R-09-007	D-04	20.0			21	
R-09-007	S-05	25.0	35.7			
R-09-007	D-07	35.0	34.8	89.7		26,24,2
R-09-007	U-08	40.0				40,24,16
R-09-007	S-09	45.0	36.2			
R-09-007	S-11	55.0	36.0			38,26,12
R-09-007	D-12	60.0	34.0	90.7		29,25,4
R-09-007	S-13	65.0	39.1			31,24,7
R-09-007	S-15	75.0			40.9	
R-09-007	D-17	85.0	16.3	115.5		
R-09-007	S-21	125.0	22.3			
R-09-007	S-23	150.0	11.5			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-010	S-01	5.0	25.9			
R-09-010	D-02	10.0	26.7	107.3		
R-09-010	D-04	20.0			8.3	
R-09-010	U-06	30.0				29,23,6
R-09-010	S-07	35.0			14.1	
R-09-010	D-8-1	40.0			66.9	
R-09-010	D-8-2	40.5	39.5	82.7		40,23,17
R-09-010	D-10	50.0				51,27,24
R-09-010	D-12	60.0	30.4	93.2		33,26,7
R-09-010	S-13-1	65.0	21.9			
R-09-010	S13-2	65.7	34.1			35,20,15
R-09-010	D-14	70.0	32.4	90.4		31,22,9
R-09-010	S-15	75.0	34.0		79.3	26,23,3
R-09-010	D-16	80.0	30.1	93.8		
R-09-010	S-18	90.0	25.8		8.9	
R-09-010	S-20	110.0	18.7			
R-09-010	S-23	140.0	12.4			
R-09-014	S-01	5.0			39.6	
R-09-014	S-03	15.0	30.0		5.6	
R-09-014	D-04	20.0	38.0	86.9		34,24,10
R-09-014	S-05	25.0	30.6		35.5	
R-09-014	D-06	30.0			28.3	
R-09-014	S-07	35.0	53.2			49,24,25
R-09-014	D-08	40.0	33.4	90.6		26,24,2
R-09-014	S-10	46.0	48.2			45,22,23
R-09-014	U-11	50.0	46.5	75.1		49,24,25
R-09-014	U-13	60.0				43,24,19
R-09-014	S-14	65.0	36.7			28,25,3
R-09-014	D-15	70.0	20.1	109.1		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO.: 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-014	S-16	75.0			21.9	
R-09-014	D-17	80.0	25.6	103.1		
R-09-014	S-19	100.0	19.2			
R-09-014	S-22	135.0	16.0			
R-09-014	S-24	165.0	25.3			
R-09-021	S-01	5.0			27.0	
R-09-021	D-02	10.0	32.9	89.4		
R-09-021	S-03	15.0	32.8			
R-09-021	U-04	20.0				61,29,32
R-09-021	S-05	25.0	33.0		12.4	
R-09-021	S-07	35.0	32.9		41.6	
R-09-021	S-09	41.5	34.0			23,22,1
R-09-021	U-10	45.0				56,26,30
R-09-021	S-11	50.0	39.2		52.4	
R-09-021	D-12	55.0	33.2	91.5		36,22,14
R-09-021	D-14	65.0	29.7	96.0		30,21,9
R-09-021	S-15	70.0			35.0	
R-09-021	D-17	75.0	31.7	92.5		35,23,12
R-09-021	S-18	80.0	26.8			
R-09-021	D-19	85.0	22.6	105.2		
R-09-021	S-20	100.0	23.5			
R-09-021	S-21	115.0	21.1			
R-09-021	S-24	170.0	8.9			
R-09-030	S-01	5.0	21.6			
R-09-030	D-02	10.0	11.2	120.0		
R-09-030	S-03	15.0	42.9		72.3	
R-09-030	U-05	25.0				43,25,18
R-09-030	S-07	35.0	30.5		34.3	
R-09-030	U-09	45.0				45,25,20
R-09-030	D-11-1	55.0	35.3	82.9		35,20,15
R-09-030	S-12	60.0			46.2	
R-09-030	S-14	70.0	27.4			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS
ATTERBERG LIMITS

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 1/8/2010 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	ATTERBERG LIMITS ASTM D 4318 (LL,PL,PI)*
R-09-010	D-02	10	26,14,12
R-09-021	S-11	50	NP
~~R-09-035~~	~~D-02~~	~~10~~	~~39,29,10~~
~~R-09-038~~	~~D-07-2~~	~~41~~	~~24,23,1~~
~~R-09-038~~	~~D-10-1~~	~~55~~	~~24,22,2~~

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008A

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-027	U-01	11.0				44,23,21
R-09-027	D-02-2	15.5	56.9	70.2	45.1	
R-09-027	S-03	20.0			20.9	
R-09-027	D-06	32.0	21.6	107.2		
R-09-027	S-07	35.0			10.2	
R-09-027	D-08-1	40.0	35.2	82.0		41,24,17
R-09-027	U-09	45.0				54,24,30
R-09-027	S-10	50.0	27.7			25,23,2
R-09-027	D-11	55.0	26.4	101.0		
R-09-027	S-12	60.0			27.1	
R-09-027	S-14	70.0	16.8			
R-09-027	S-16-1	80.0	32.3			32,23,9
R-09-027	S-17	90.0	21.7			
R-09-027	S-20	120.0	17.9			
R-09-027	S-23	150.0	11.7			
~~R-09-033~~	~~S-01~~	~~5.0~~	~~12.7~~			
R-09-033	D-02	10.0	12.7	104.6	21.4	
R-09-033	U-04	20.0				61,26,35
R-09-033	D-05	25.0			10.9	
R-09-033	S-08-1	40.0	47.8			41,23,18
R-09-033	U-09	45.0				25,24,1
R-09-033	D-10-1	50.0			55.5	
R-09-033	S-11-1	55.0	31.9			29,21,8
R-09-033	S-11-2	55.8	30.5			24,23,1
R-09-033	D-12-1	60.0	25.5	100.4		
R-09-033	S-13-1	65.0	38.6			38,24,14
R-09-033	S-16	80.0	20.7			
R-09-033	S-17-2	90.6	35.5			33,22,11
~~R-09-033~~	~~S-19~~	~~100.0~~	~~14.2~~			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resistivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-041	S-4-2	57.6	CL	39.9				0:15:85		43/24/19				
WR-09-041	S-6-1	67	CL	37.8				0:2:98		46/27/19				
WR-09-041	S-6-2	67.4	ML								98	8.2	360	7929
WR-09-041	D-7	72	ML	18.7	135.0			0:43:57						
WR-09-041	S-8	77	ML					0:48:52						
WR-09-041	D-9	82	SP-SM	24.0	125.9									
WR-09-041	S-10	87	SP-SM					0:90:10						
WR-09-041	D-11	92	SP-SM	21.0	128.0									
WR-09-041	S-13	107	SP-SM	15.9				2:87:11						
WR-09-041	S-16	127	SM	10.8				30:57:13						
WR-09-041	S-19	157	SP-SM	11.4				39:50:11						
WR-09-041	S-21	177	ML	26.3				0:12:88						
WR-09-041	S-22-1	187	CL	36.5										
WR-09-041	S-24	202	SW-SM	20.6				1:89:10						
WR-09-041	S-26-1	222	SP-SM					0:88:12						
WR-09-041	S-26-2	223	ML	27.5						36/27/9				
WR-09-041	S-27	227	SP	22.3				0:98:2						
WR-09-042	S-3-1	68	CL	32.7						44/24/20				
WR-09-042	S-3-2	68.3	CL-ML					0:32:68						
WR-09-042	S-3-3	68.5	ML	29.8						34/25/9				
WR-09-042	S-5	78	ML					0:49:51						
WR-09-042	D-6	83	SM	26.8	125.8					N.P.	130	7.6	300	6417
WR-09-042	S-7	88	SM					0:62:38						
WR-09-042	D-8	93	SM	25.5	126.0									
WR-09-042	S-9	98	SP-SM					0:93:7						
WR-09-042	D-10	103	SM	27.0	125.1									
WR-09-042	S-12	113	SP	19.6				1:97:2						
WR-09-042	S-14	123	SP-SM	11.1				36:58:6						
WR-09-042	S-16	133	SM	16.8				19:63:18						
WR-09-042	D-19	163	GP	5.2				51:46:3						
WR-09-042	S-22	193	SM	23.1				0:78:22						
WR-09-042	S-24	213	SP-SM					0:93:7						
WR-09-042	S-25-2	223.5	CL	16.9				2:37:61		28/14/14				
WR-09-042	S-26-1	233	CL	28.4				0:26:74		39/17/22				
WR-09-043	D-5-1	68	ML								87	7.5	390	9074
WR-09-043	D-5-2	68.5	CL	33.8	114.3	0.5		0:3:97		46/25/21				
WR-09-043	S-6	73	ML	32.2						44/33/11				
WR-09-043	S-8-2	83.5	ML	29.6				0:34:66						
WR-09-043	D-9-1	88	MH	37.4	113.6	0.25		0:5:95		50/37/13				
WR-09-043	S-10	93	SM					0:75:25						

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

Boring No .	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resistivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-043	D-11	98	SP	20.4	127.1									
WR-09-043	D-13	108	SP-SM	14.4	134.2			5:90:5						
WR-09-043	S-16	133	SW-SM	14.1				1:90:9						
WR-09-043	S-18	153	SP-SM	9.3				31:57:12						
WR-09-043	S-19	168	ML	31.5				0:8:92		35/26/9				
WR-09-043	S-22	198	SM	20.6				0:85:15						
WR-09-043	S-24	223	SP-SM					2:89:9						
WR-09-043	S-25-1	238	CL	45.4						49/27/22				
WR-09-043	S-25-2	238.3	SM					26:53:21						
WR-09-043	S-25-3	238.5	ML					0:47:53						
WR-09-044	D-3-2	59.5	ML								88	7.6	310	8416
WR-09-044	D-5-1	68	ML	31.2	120.6	2.0				39/27/12				
WR-09-044	D-5-2	68.5	ML	29.5	120.0	1.0		0:8:92		35/32/3				
WR-09-044	S-6	73	CL	42.8				0:13:81		44/26/18				
WR-09-044	D-7	78	SM	30.0	123.5	1.0				N.P.				
WR-09-044	S-8	83	ML					0:49:51						
WR-09-044	D-9	88	ML	33.8	117.5			0:41:59						
WR-09-044	S-11	98	SP	15.7				5:91:4						
WR-09-044	S-14	118	SP-SM					21:69:10						
WR-09-044	S-15	128	GW	6.8				65:31:4						
WR-09-044	S-17	148	SW-SM	8.7				39:51:10						
WR-09-044	S-19	168	GW-GM	8.0				57:35:8						
WR-09-044	S-23	208	SP-SM	25.0				9:86:5						

SPECIFIC GRAVITY

Specific Gravity data (ASTM D854)

Boring No.	Sample No.	Depth (ft)	Specific Gravity ($G_{s,\ 20°C}$)
R-09-003	U-11	55	2.66
R-09-005	U-14	70	2.71
R-09-006	U-07	35	2.68
R-09-009	U-09	45	2.68
R-09-011	U-14	70	2.69
R-09-012	U-10A	51.5	2.67
R-09-012	U-16	80	2.79
R-09-013	U-5	25	2.71
R-09-013	U-8	40	2.69
R-09-015	U-09	45	2.75
R-09-016	U-09	45	2.73
R-09-016	U-14	70	2.75
R-09-017	U-11	55	2.74
R-09-018	U-08	32.5	2.74
R-09-019	U-13	65	2.75
R-09-020	U-04	20	2.74
R-09-020	U-08	40	2.71
R-09-022	U-08	40	2.79
R-09-022	U-11	55	2.75
R-09-023	U-07	35	2.74
R-09-023	U-09	45	2.70
R-09-024	U-06	30	2.77
R-09-024	U-12	30	2.79
R-09-025	U-10	50	2.86
R-09-026	U-15	75	2.77
R-09-029	U-05	25	2.82
R-09-029	U-07	35	2.83
R-09-029	U-12	60	2.81

SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-004	U-21	100	2.708
R-09-007	U-08	40	2.764
R-09-007	U-10	50	2.767
R-09-010	U-06	30	2.769
R-09-014	U-11	50	2.751
R-09-014	U-13	60	2.771
R-09-021	U-04	20	2.73
R-09-021	U-10	45	2.759
~~R-09-030~~	~~U-05~~	~~25~~	~~2.764~~
R-09-030	U-09	45	2.745
R-09-031	U-11	55	2.729
R-09-035	U-03	15	2.763
~~R-09-035~~	~~U-10~~	~~50~~	~~2.742~~

SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-027	U-01	11	2.736
R-09-027	U-09	45	2.77
~~R-09-033~~	~~U-04~~	~~20~~	~~2.697~~
R-09-033	U-09	45	2.746
R-09-038	U-06	35	2.768
R-09-038	U-08	46	2.737
~~R-09-038~~	~~U-11~~	~~61~~	~~2.741~~

POCKET PENETROMETER

Pocket Penetrometer data

Boring No.	Sample No.	Depth (ft)	Pocket Penetrometer (tsf)
R-09-001	D-11	55	2.07
R-09-005	D-08	40	0.81
R-09-005	D-12	60	1.94
R-09-005	U-14	70	2.75
R-09-009	U-09	45	1.38
R-09-009	D-13	65	2.86
R-09-011	D-10	50	0.50
R-09-011	U-14	70	3.25
R-09-012	D-10	50	1.13
R-09-012	U-10A	51.5	1.38
R-09-012	D-14	70	1.75
R-09-012	U-16	80	3.04
R-09-013	U-05	25	0.50
R-09-013	U-08	40	0.75
R-09-013	D-10	50	0.50
R-09-015	D-04	20	0.70
R-09-015	D-08	40	0.53
R-09-015	U-09	45	2.00
R-09-015	U-12	60	1.25
R-09-016	D-06	30	1.46
R-09-016	D-08	40	0.29
R-09-016	U-09	45	1.50
R-09-016	D-10-1	50	0.50
R-09-016	D-10-2	50.5	0.54
R-09-016	D-12-1	60	2.01
R-09-017	D-10	50	0.50
R-09-017	U-11	55	2.88
R-09-018	U-08	32.5	1.25
R-09-018	D-14	55	2.88
R-09-019	D-12	60	1.63
R-09-019	U-13	65	2.38
R-09-020	U-04	20	1.00
R-09-020	U-08	40	1.13
R-09-020	D-14	70	2.75
R-09-022	U-08	40	1.79
R-09-022	U-11	55	2.08
R-09-023	U-07	35	0.38
R-09-023	U-09	45	1.50
R-09-023	D-13-1	65	4.00
R-09-023	D-15	75	1.88
R-09-024	U-06	30	1.00
R-09-024	U-12	60	1.25
R-09-025	U-10	50	1.63
R-09-026	U-15	75	1.88
R-09-028	U-07	35	1.13
R-09-029	U-05	25	1.25
R-09-029	U-07	35	1.63
R-09-029	U-12	60	3.13

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/2/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
R-09-004	D-01	5	4.25
R-09-004	D-07	35	1.5
R-09-007	D-07	35	1.4
R-09-007	U-08	40	0.5
R-09-007	U-10	50	0.6
R-09-010	D-02	10	0.25
R-09-010	D-08-2	41	0.75
R-09-010	D-10	50	1.25
R-09-010	D-12	60	2.75
R-09-021	U-04	20	0.6
R-09-021	D-17	75	2.4
R-09-030	D-04	20	0.5
R-09-030	U-05	25	0.4
R-09-030	U-09	45	0.75
R-09-030	D-11-1	55	0.75
R-09-031	D-04	20	0.5
R-09-031	D-10	50	3.75
R-09-031	U-11	55	1
R-09-032	D-04	20	0.25
R-09-032	D-08	40	1.25
R-09-035	D-02	10	0.4
R-09-035	U-03	15	0.5
R-09-035	D-04	20	0.25
R-09-035	D-06	30	1.25
R-09-035	D-08	40	2
R-09-035	U-10	50	4.25

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
R-09-027	U-01	11	0.2
R-09-027	U-09	45	1.25
~~R-09-033~~	~~U-04~~	~~20~~	~~0.5~~
R-09-033	U-09	45	1.75
R-09-038	U-06	~~35~~	0.8
R-09-038	~~U-08~~	46	1.75
~~R-09-038~~	~~U-11~~	~~61~~	~~4~~

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-041	S-4-2	57.6	CL	39.9				0:15:85		43/24/19				
WR-09-041	S-6-1	67	CL	37.8				0:2:98		46/27/19				
WR-09-041	S-6-2	67.4	ML								98	8.2	360	7929
WR-09-041	D-7	72	ML	18.7	135.0			0:43:57						
WR-09-041	S-8	77	ML					0:48:52						
WR-09-041	D-9	82	SP-SM	24.0	125.9									
WR-09-041	S-10	87	SP-SM					0:90:10						
WR-09-041	D-11	92	SP-SM	21.0	128.0									
WR-09-041	S-13	107	SP-SM	15.9				2:87:11						
WR-09-041	S-16	127	SM	10.8				30:57:13						
WR-09-041	S-19	157	SP-SM	11.4				39:50:11						
WR-09-041	S-21	177	ML	26.3				0:12:88						
WR-09-041	S-22-1	187	CL	36.5										
WR-09-041	S-24	202	SW-SM	20.6				1:89:10						
WR-09-041	S-26-1	222	SP-SM					0:88:12						
WR-09-041	S-26-2	223	ML	27.5						36/27/9				
WR-09-041	S-27	227	SP	22.3				0:98:2						
WR-09-042	S-3-1	68	CL	32.7						44/24/20				
WR-09-042	S-3-2	68.3	CL-ML					0:32:68						
WR-09-042	S-3-3	68.5	ML	29.8						34/25/9				
WR-09-042	S-5	78	ML					0:49:51						
WR-09-042	D-6	83	SM	26.8	125.8					N.P.	130	7.6	300	6417
WR-09-042	S-7	88	SM					0:62:38						
WR-09-042	D-8	93	SM	25.5	126.0									
WR-09-042	S-9	98	SP-SM					0:93:7						
WR-09-042	D-10	103	SM	27.0	125.1									
WR-09-042	S-12	113	SP	19.6				1:97:2						
WR-09-042	S-14	123	SP-SM	11.1				36:58:6						
WR-09-042	S-16	133	SM	16.8				19:63:18						
WR-09-042	D-19	163	GP	5.2				51:46:3						
WR-09-042	S-22	193	SM	23.1				0:78:22						
WR-09-042	S-24	213	SP-SM					0:93:7						
WR-09-042	S-25-2	223.5	CL	16.9				2:37:61		28/14/14				
WR-09-042	S-26-1	233	CL	28.4				0:26:74		39/17/22				
WR-09-043	D-5-1	68	ML								87	7.5	390	9074
WR-09-043	D-5-2	68.5	CL	33.8	114.3	0.5		0:3:97		46/25/21				
WR-09-043	S-6	73	ML	32.2						44/33/11				
WR-09-043	S-8-2	83.5	ML	29.6				0:34:66						
WR-09-043	D-9-1	88	MH	37.4	113.6	0.25		0:5:95		50/37/13				
WR-09-043	S-10	93	SM					0:75:25						

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 Project Name : ACTA Schuyler Heim Bridge Project

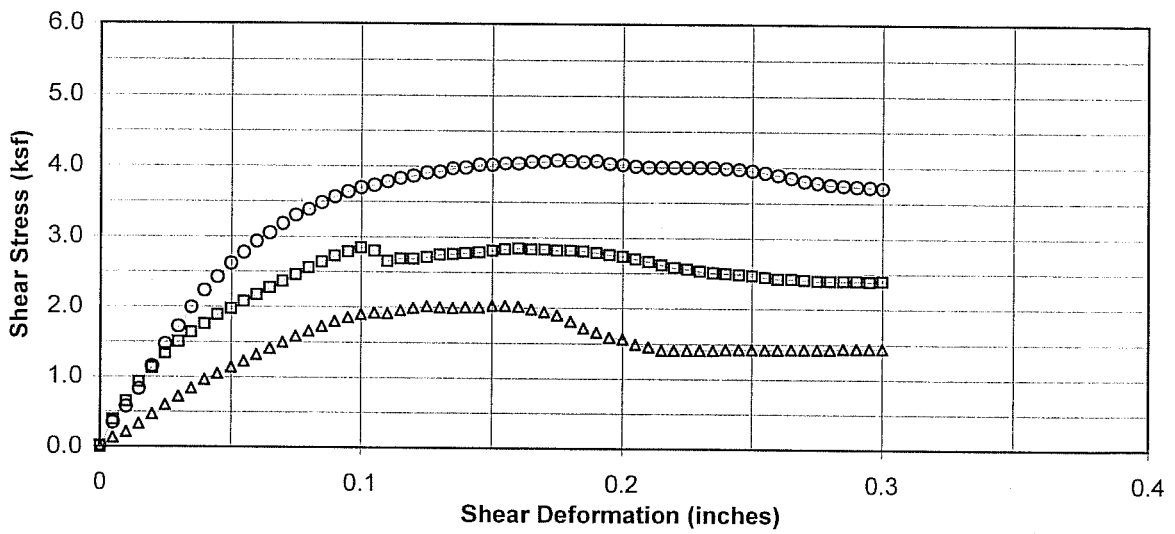
Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
WR-09-043	D-11	98	SP	20.4	127.1									
WR-09-043	D-13	108	SP-SM	14.4	134.2			5:90:5						
WR-09-043	S-16	133	SW-SM	14.1				1:90:9						
WR-09-043	S-18	153	SP-SM	9.3				31:57:12						
WR-09-043	S-19	168	ML	31.5				0:8:92		35/26/9				
WR-09-043	S-22	198	SM	20.6				0:85:15						
WR-09-043	S-24	223	SP-SM					2:89:9						
WR-09-043	S-25-1	238	CL	45.4						49/27/22				
WR-09-043	S-25-2	238.3	SM					26:53:21						
WR-09-043	S-25-3	238.5	ML					0:47:53						
WR-09-044	D-3-2	59.5	ML								88	7.6	310	8416
WR-09-044	D-5-1	68	ML	31.2	120.6	2.0				39/27/12				
WR-09-044	D-5-2	68.5	ML	29.5	120.0	1.0		0:8:92		35/32/3				
WR-09-044	S-6	73	CL	42.8				0:13:81		44/26/18				
WR-09-044	D-7	78	SM	30.0	128.5	1.0				N.P.				
WR-09-044	S-8	83	ML					0:49:51						
WR-09-044	D-9	88	ML	33.8	117.5			0:41:59						
WR-09-044	S-11	98	SP	15.7				5:91:4						
WR-09-044	S-14	118	SP-SM					21:69:10						
WR-09-044	S-15	128	GW	6.8				65:31:4						
WR-09-044	S-17	148	SW-SM	8.7				39:51:10						
WR-09-044	S-19	168	GW-GM	8.0				57:35:8						
WR-09-044	S-23	208	SP-SM	25.0				9:86:5						

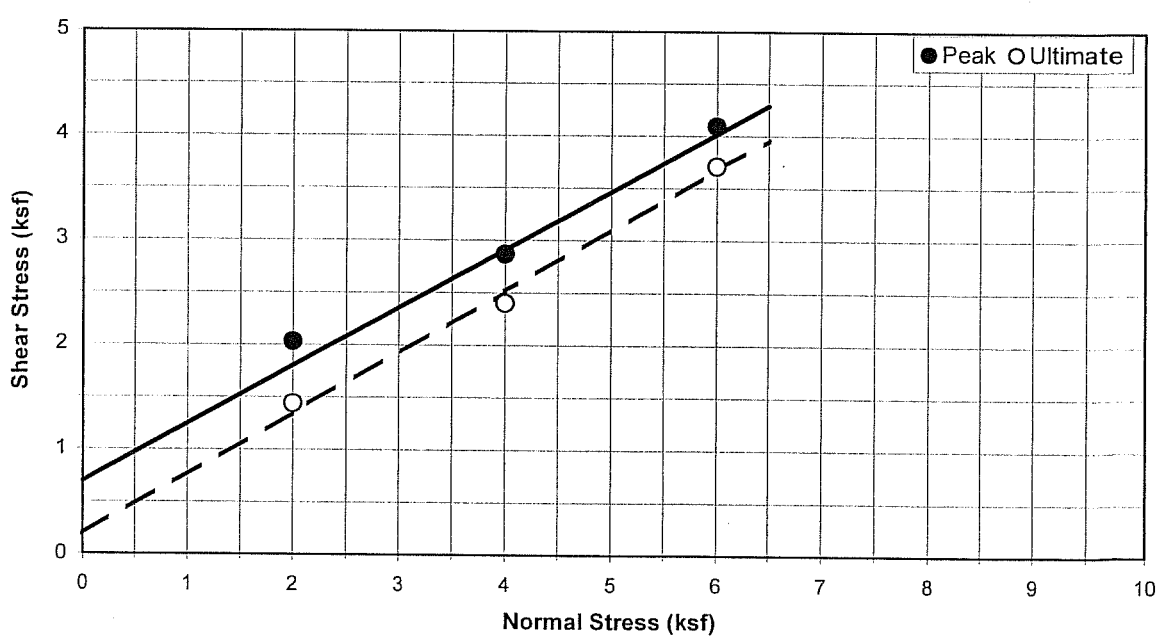
DIRECT SHEAR

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	95.3	pcf
Boring No.:	R-09-001	Moisture Content (before):	28.0	%
Sample No.:	D-07	Moisture Content (after):	29.9	%
Depth (ft):	35			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Poorly-Graded w/silt			
Test Condition:	Saturated			



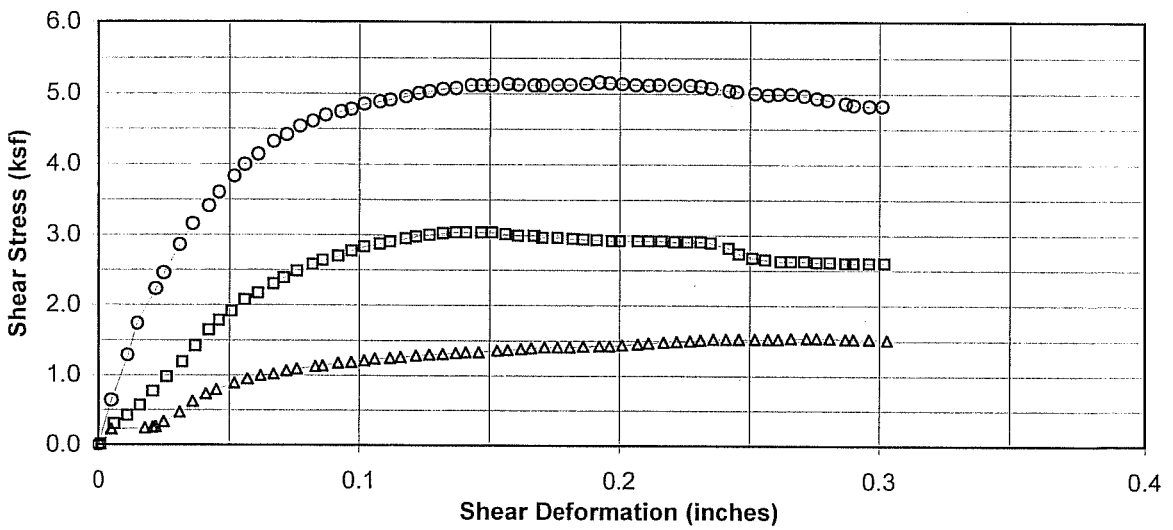


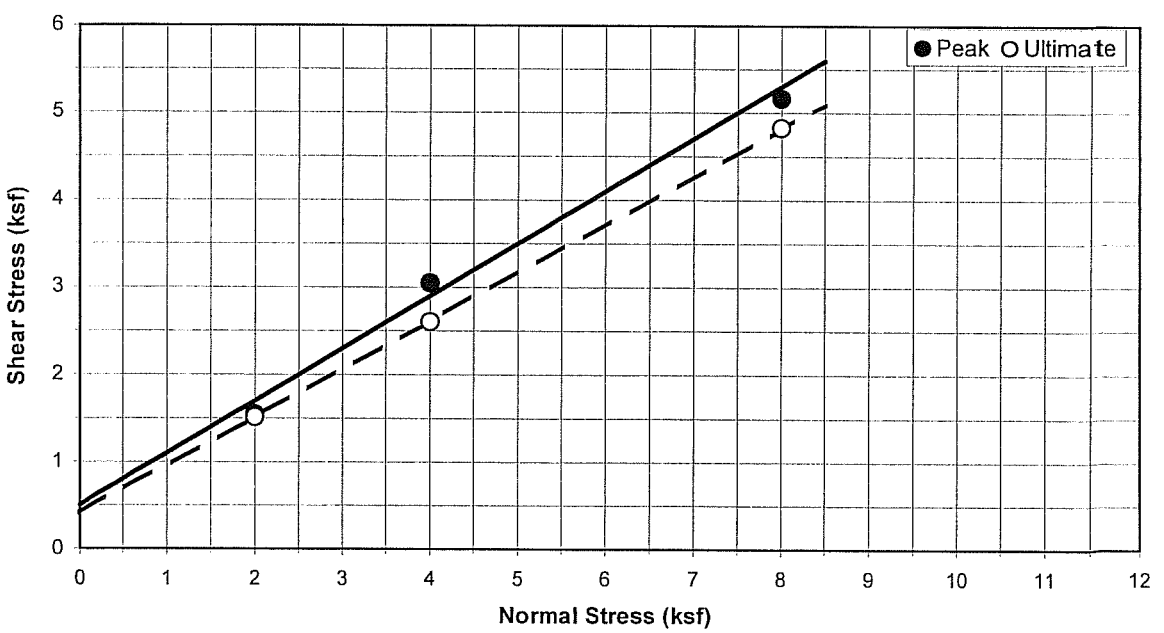
Strength Parameters	Peak	Ultimate
Cohesion (psf):	700	200
Friction Angle:	29 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.4	pcf
Boring No.:	R-09-001	Moisture Content (before):	29.5	%
Sample No.:	D-09	Moisture Content (after):	29.9	%
Depth (ft):	45			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Silty Sand			
Test Condition:	Saturated			



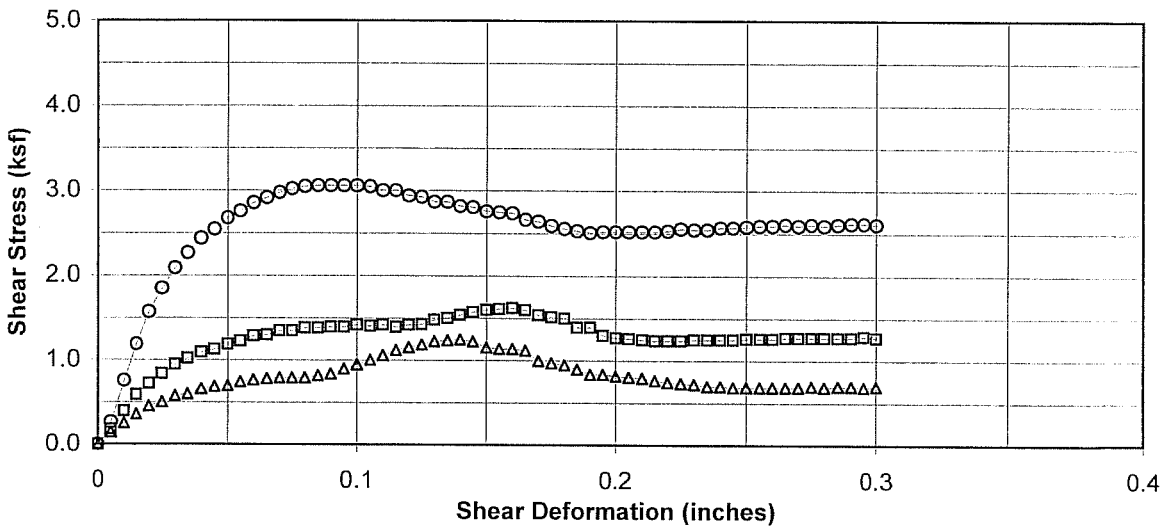


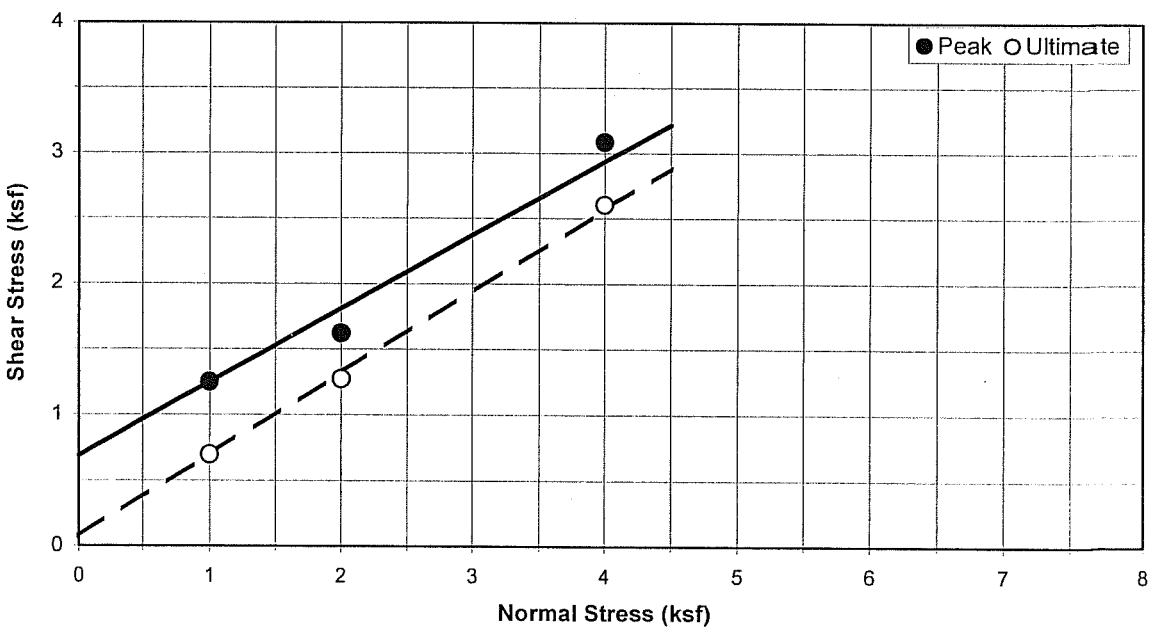
Strength Parameters	Peak	Ultimate
Cohesion (psf):	500	400
Friction Angle:	31 °	29 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	95.1	pcf
Boring No.:	R-09-002	Moisture Content (before):	27.1	%
Sample No.:	D-03	Moisture Content (after):	30.7	%
Depth (ft):	15			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Sand with silt			
Test Condition:	Saturated			



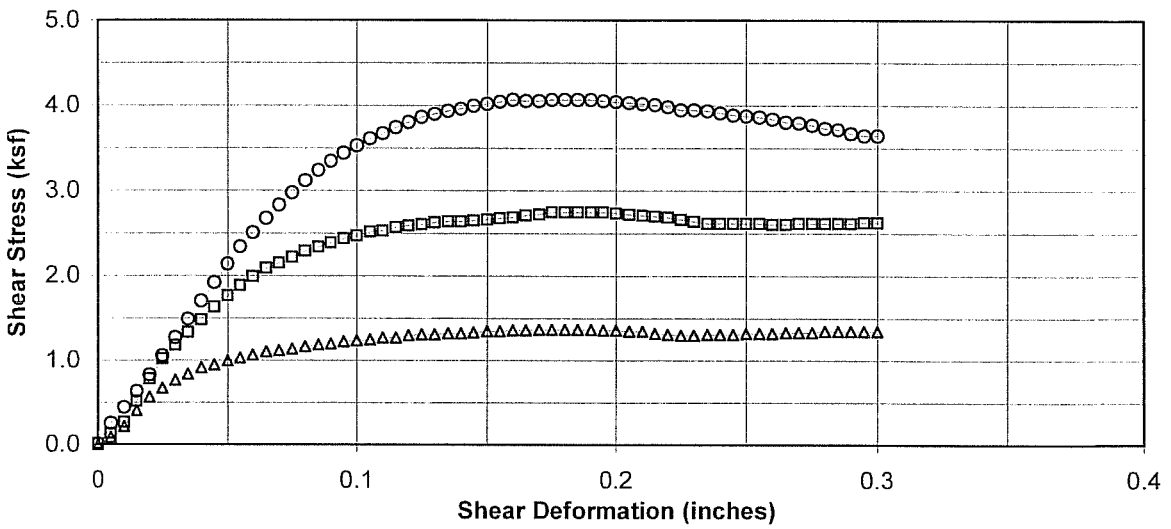


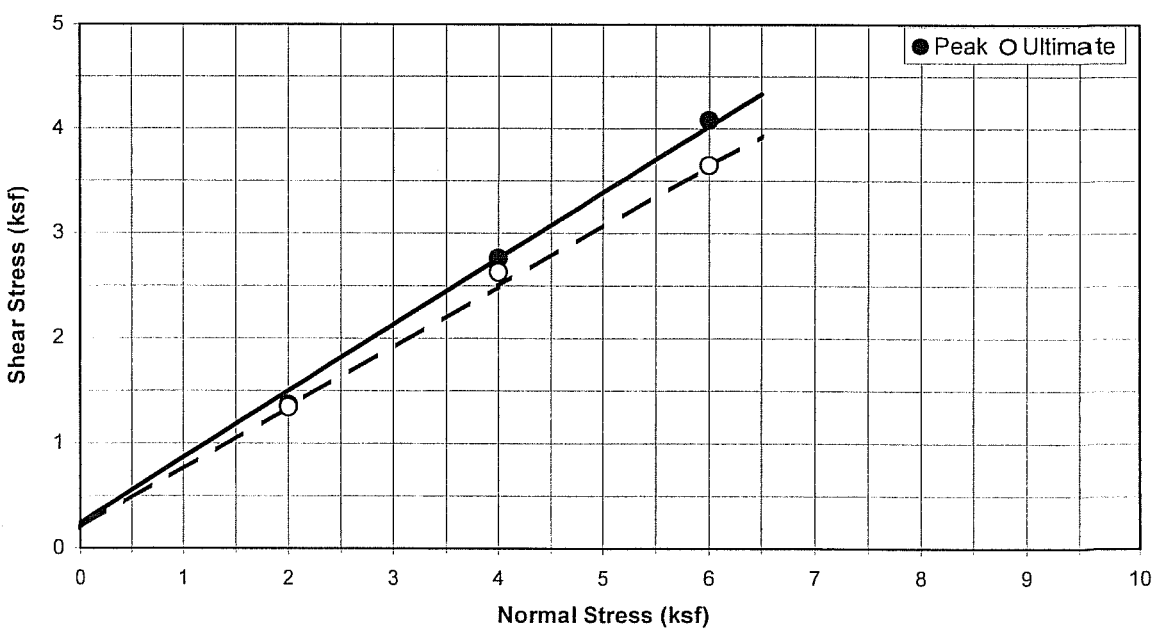
Strength Parameters	Peak	Ultimate
Cohesion (psf):	700	50
Friction Angle:	29 °	32 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	91.5	pcf
Boring No.:	R-09-002	Moisture Content (before):	32.1	%
Sample No.:	D-07	Moisture Content (after):	32.3	%
Depth (ft):	35			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sitly Sand			
Test Condition:	Saturated			



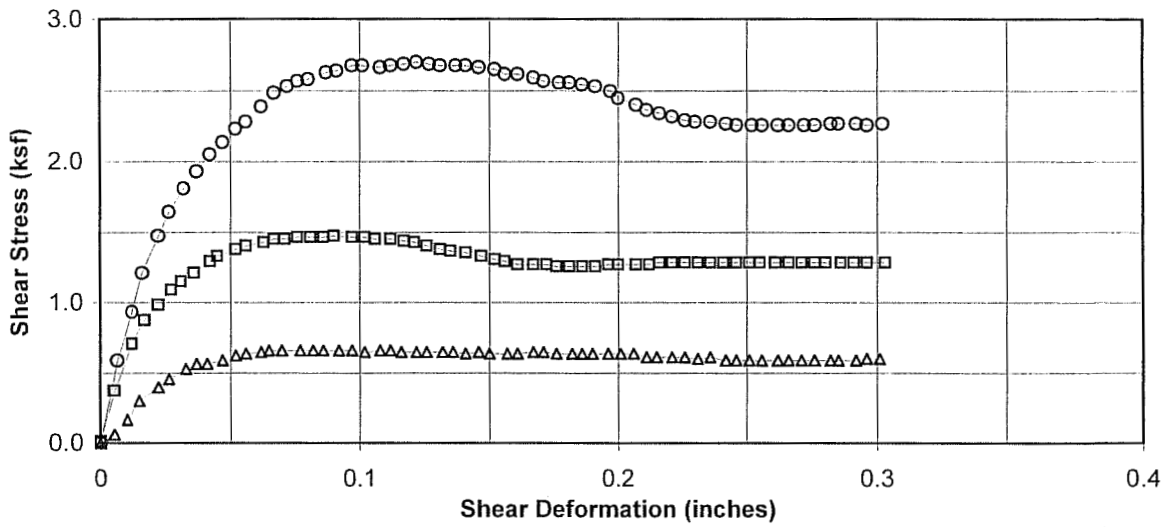


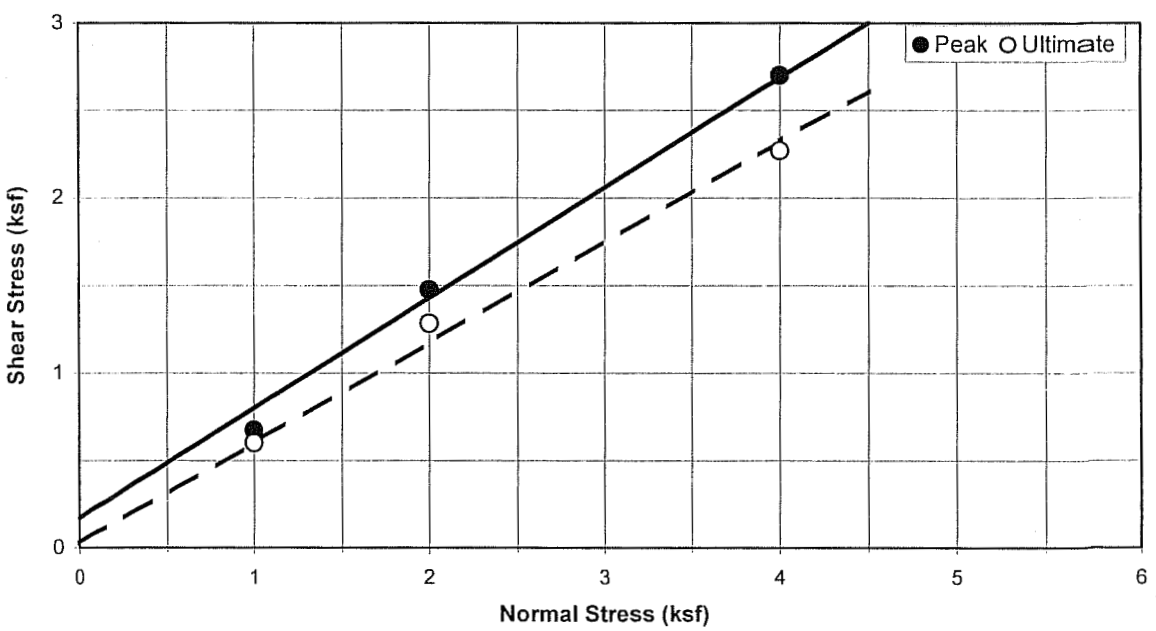
Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	200
Friction Angle:	32 °	30 °

AP Engineering & Testing, Inc.

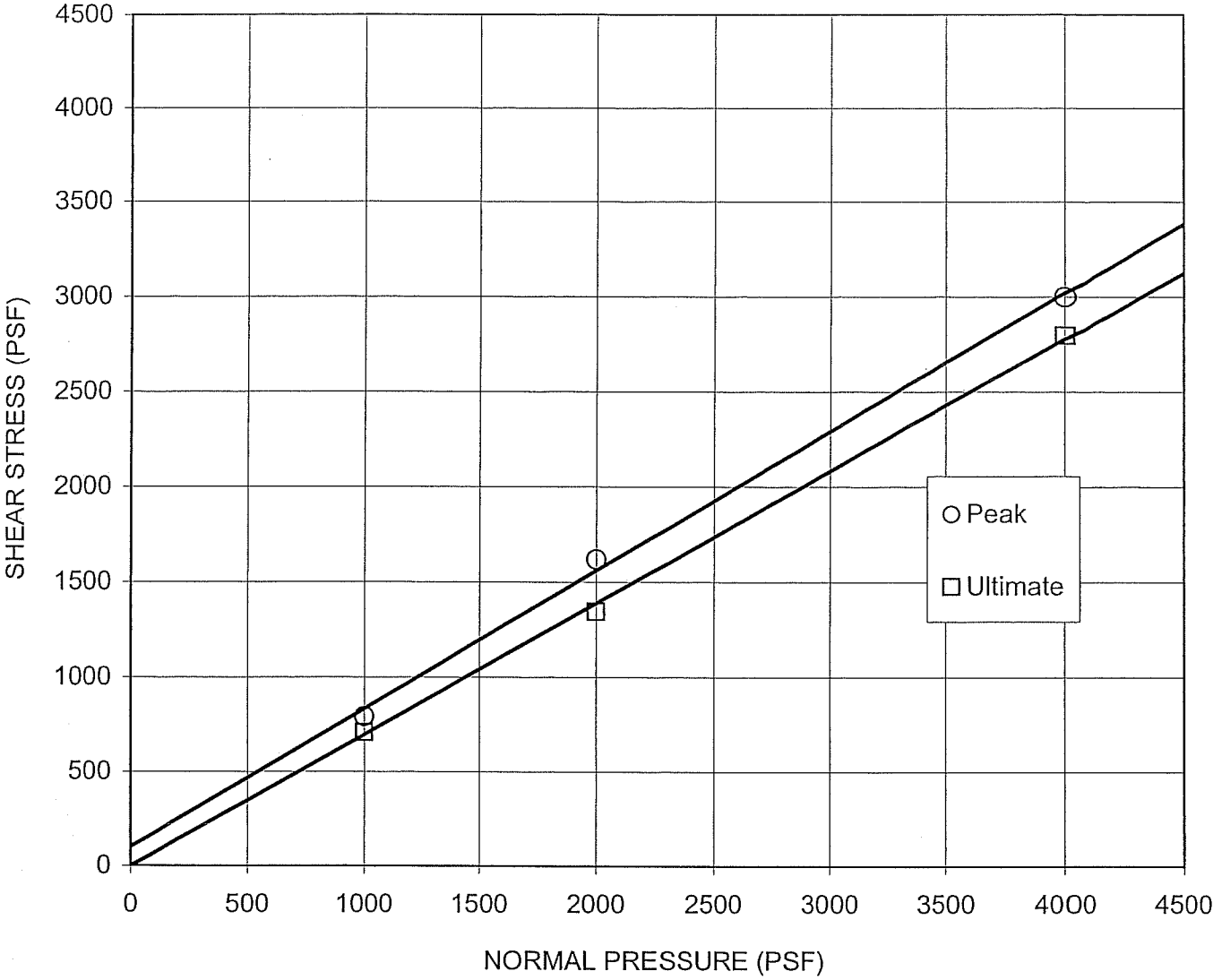
DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	98.7	pcf
Boring No.:	R-09-003	Moisture Content (before):	23.2	%
Sample No.:	D-04	Moisture Content (after):	27.4	%
Depth (ft):	20			
Sample Type:	Cal. Mod.			
Soil Description:	Olive Gray Poorly-Graded Sand w/silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	50
Friction Angle:	32 °	30 °



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-004	D-05	25	Ring	SM	○	102	36
					□	0	35

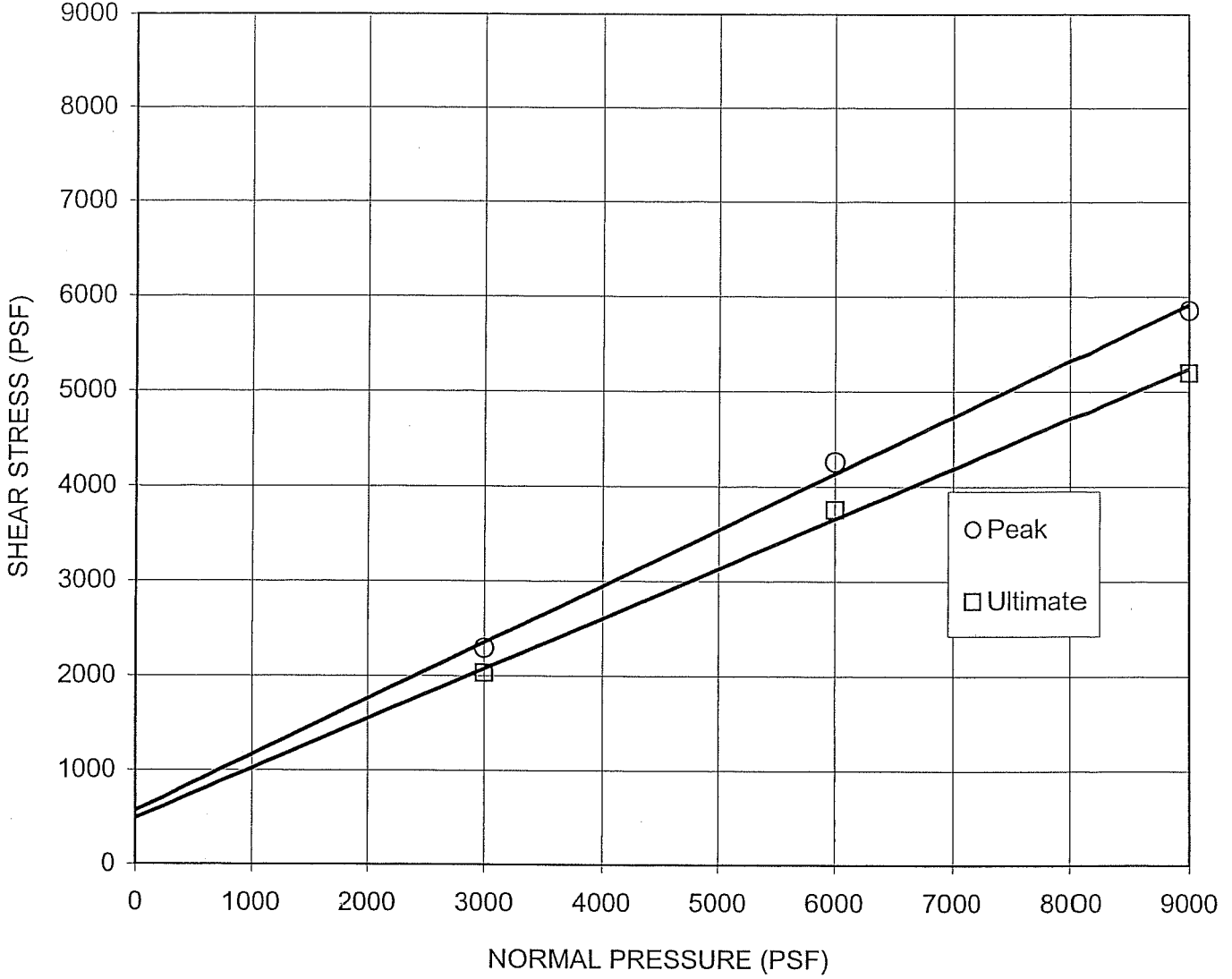
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	26.2	28.6
2000	26.2	27.3
4000	26.2	26.8

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-004	U-12	58	Shelby Tube	SM	○	573	31
					□	492	28

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
3000	23.1	26.1
6000	23.1	25.5
9000	23.1	24.7

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Project No: 06-123-03

EGL Project No: 09-230-008

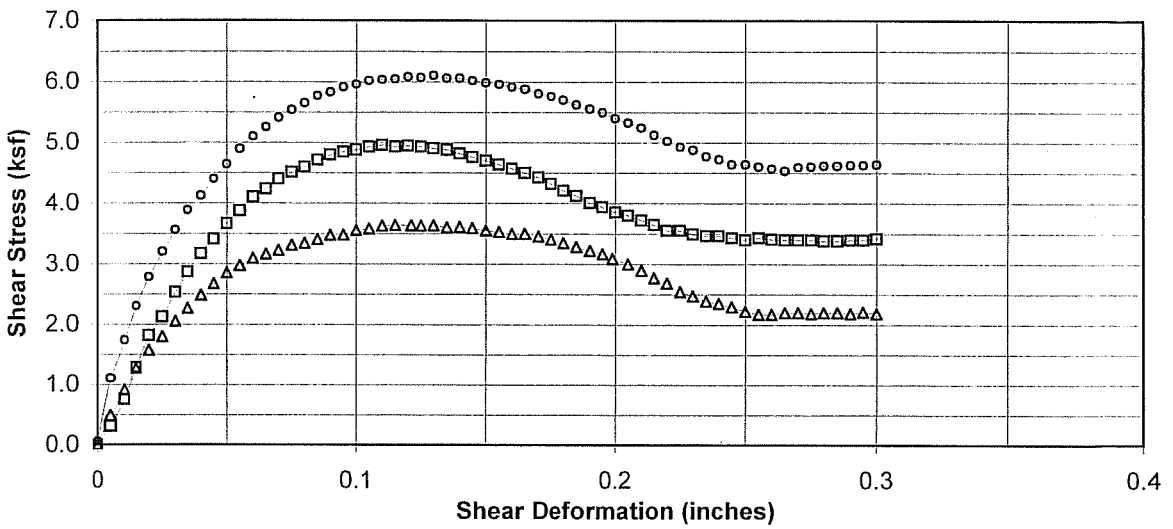
DIRECT SHEAR

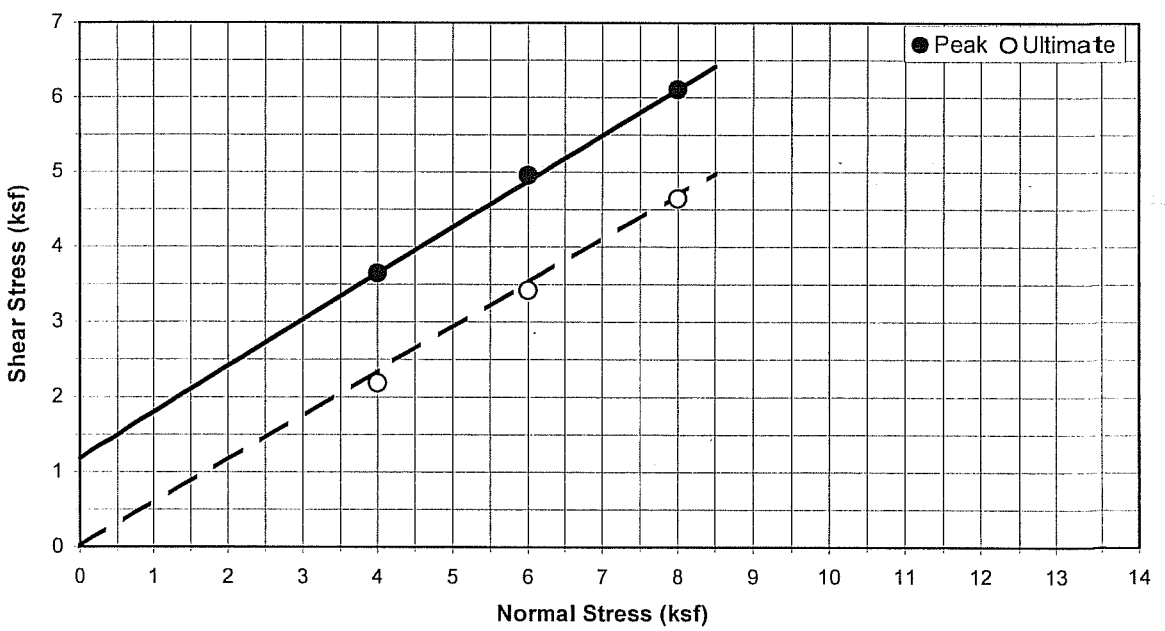
12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	101.4	pcf
Boring No.:	R-09-005	Moisture Content (before):	22.4	%
Sample No.:	D-16	Moisture Content (after):	23.8	%
Depth (ft):	80			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand			
Test Condition:	Saturated			



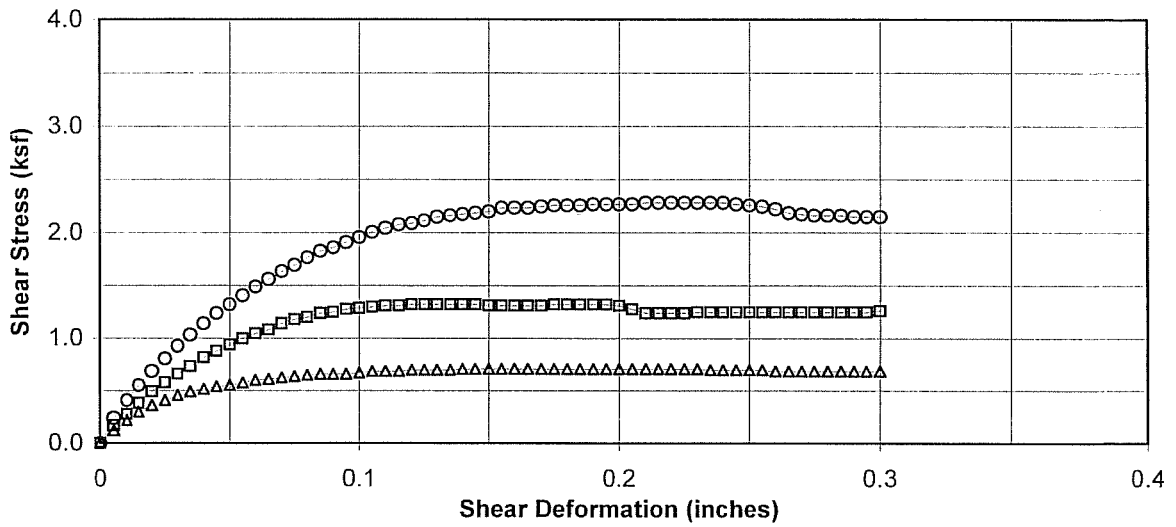


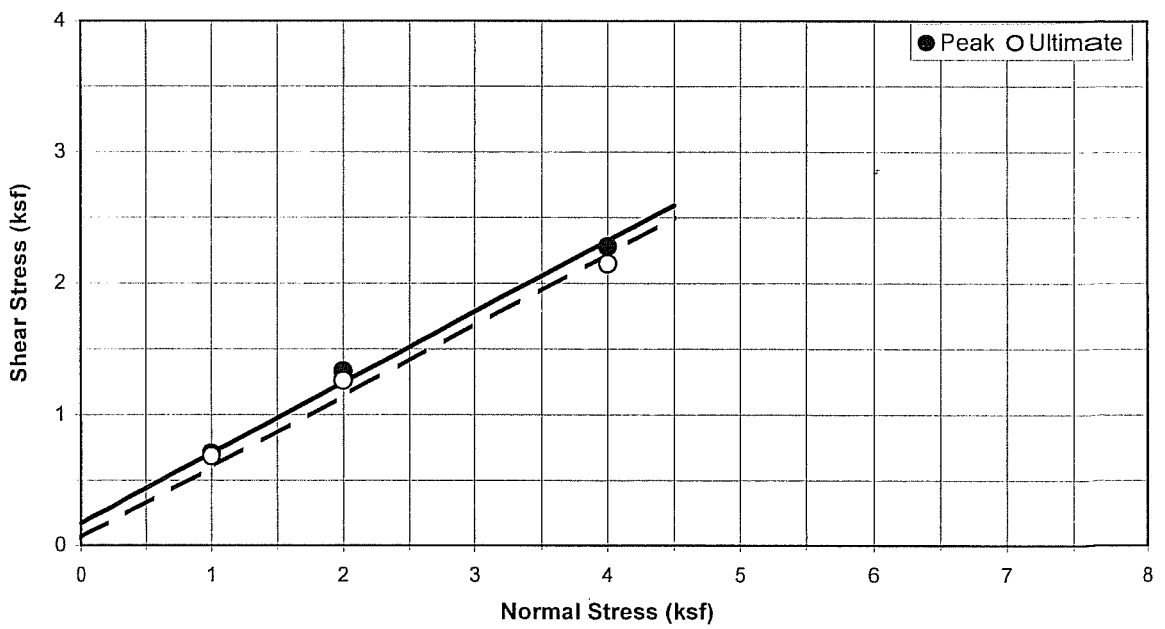
Strength Parameters	Peak	Ultimate
Cohesion (psf):	1200	0
Friction Angle:	32 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	84.3	pcf
Boring No.:	R-09-005	Moisture Content (before):	39.1	%
Sample No.:	D-04	Moisture Content (after):	37.9	%
Depth (ft):	20			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand			
Test Condition:	Saturated			



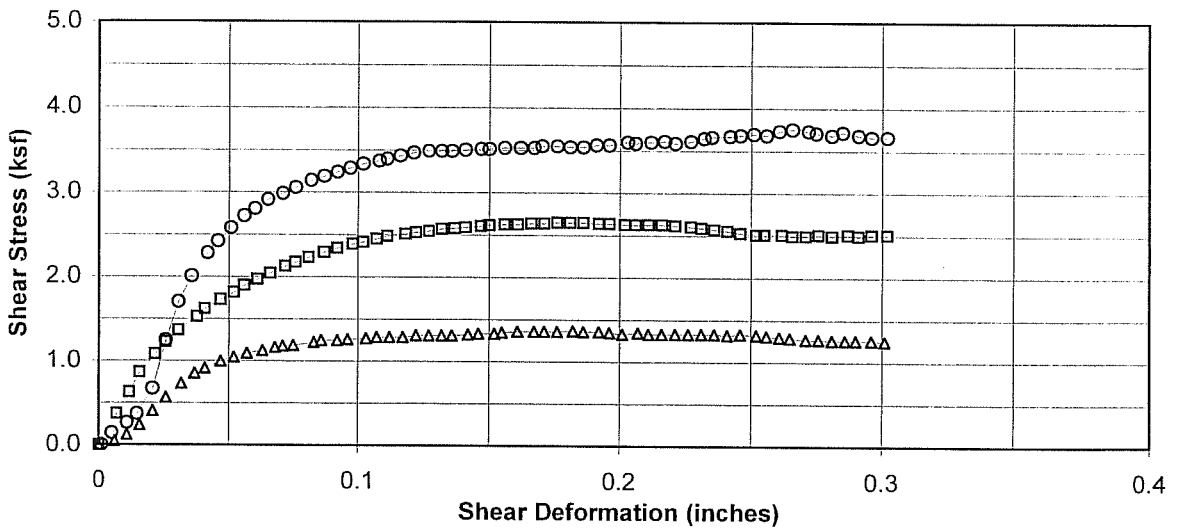


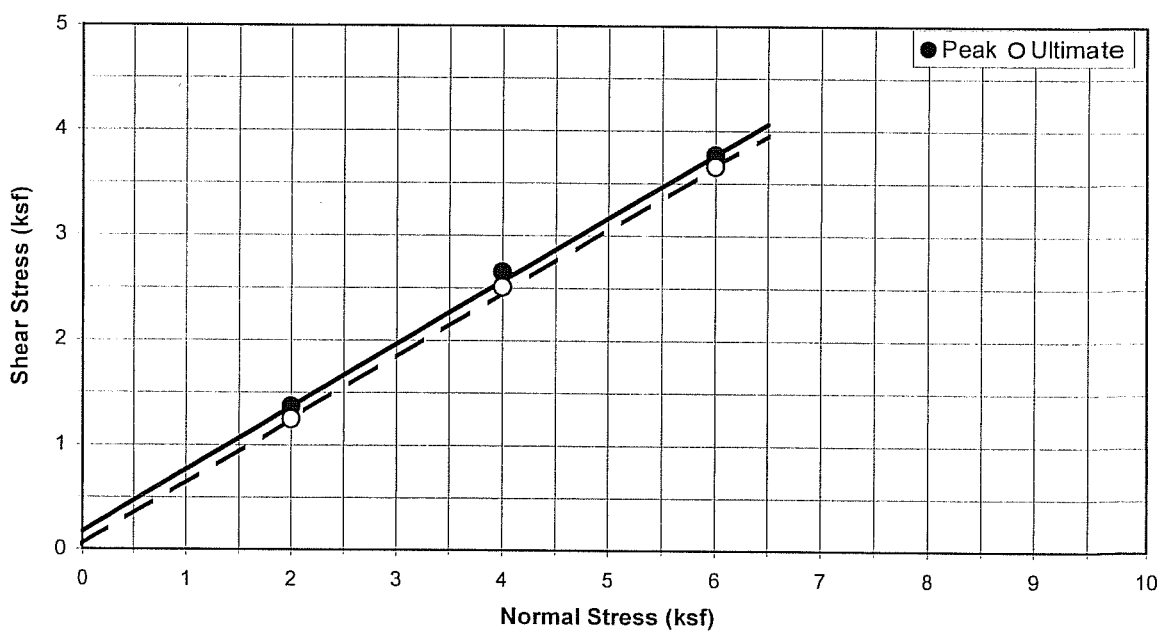
Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	50
Friction Angle:	28 °	28 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	91.8	pcf
Boring No.:	R-09-005	Moisture Content (before):	30.6	%
Sample No.:	D-06	Moisture Content (after):	31.1	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Poorly-Graded Sand w/silt			
Test Condition:	Saturated			



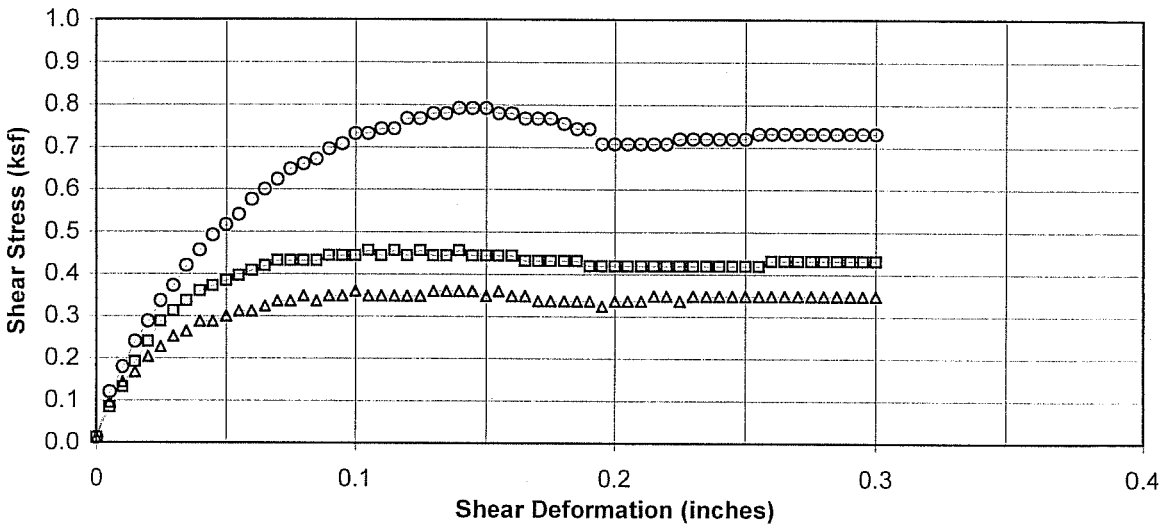


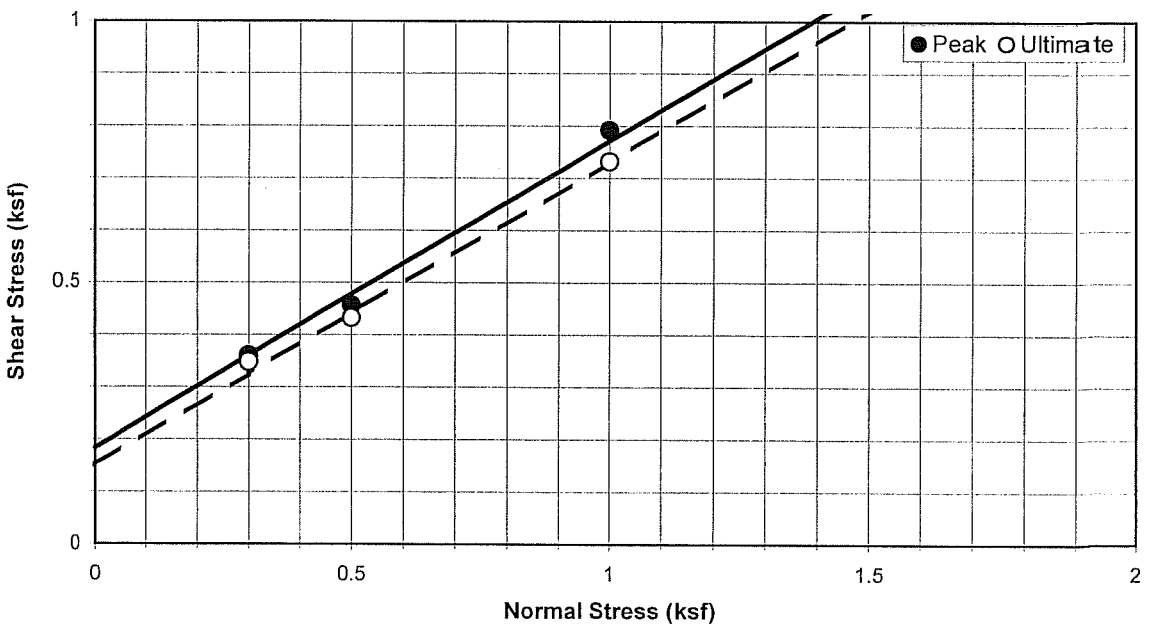
Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	50
Friction Angle:	31 °	31 °

AP Engineering & Testing, Inc.

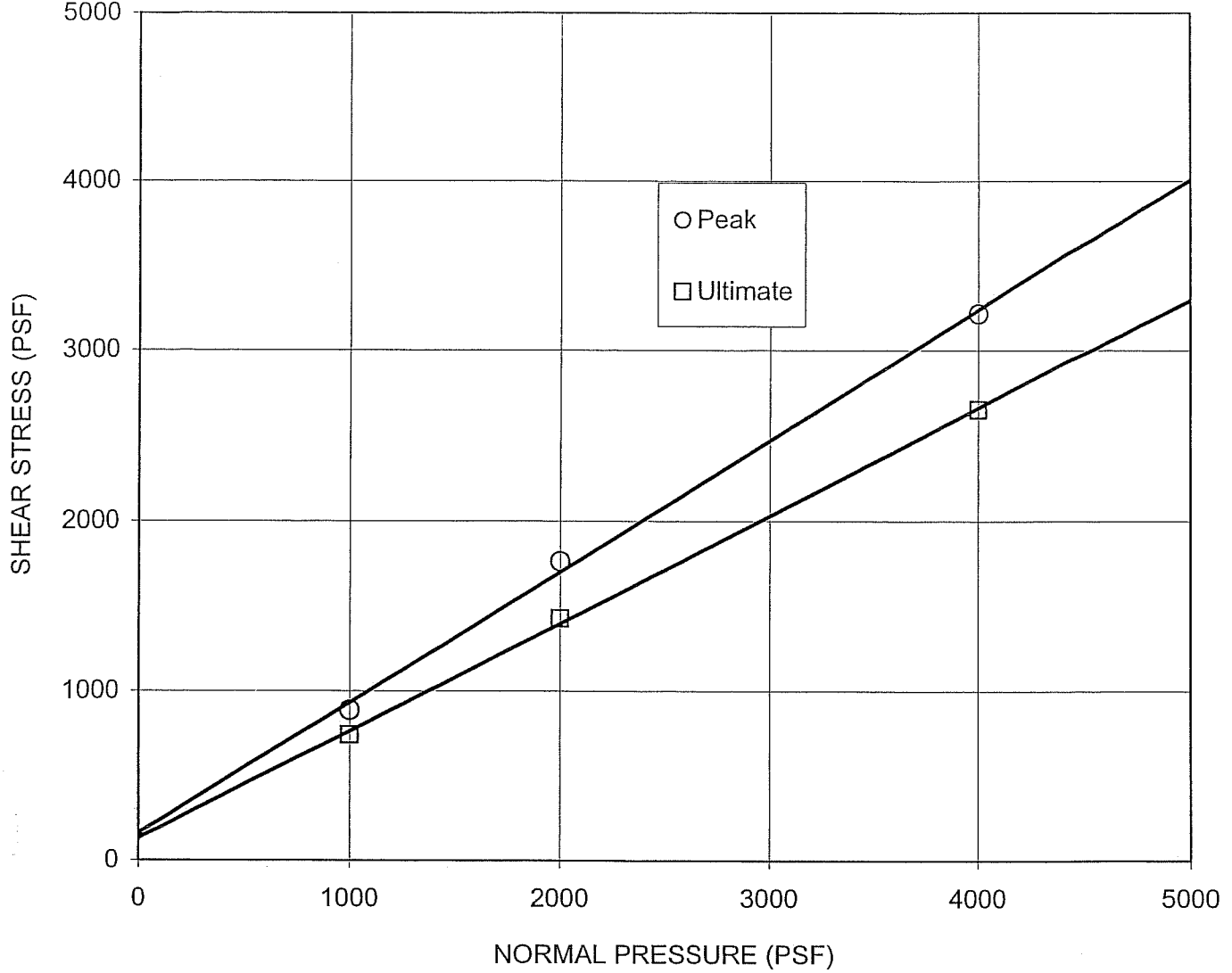
DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	91.4	pcf
Boring No.:	R-09-006	Moisture Content (before):	25.3	%
Sample No.:	D-01	Moisture Content (after):	30.1	%
Depth (ft):	5			
Sample Type:	Cal. Mod.			
Soil Description:	Olive Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	200	150
Friction Angle:	30 °	30 °



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-007	D-04	20	Ring	SP	○	162	38
					□	132	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	21.9	26.0
2000	21.9	25.5
4000	21.9	25.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

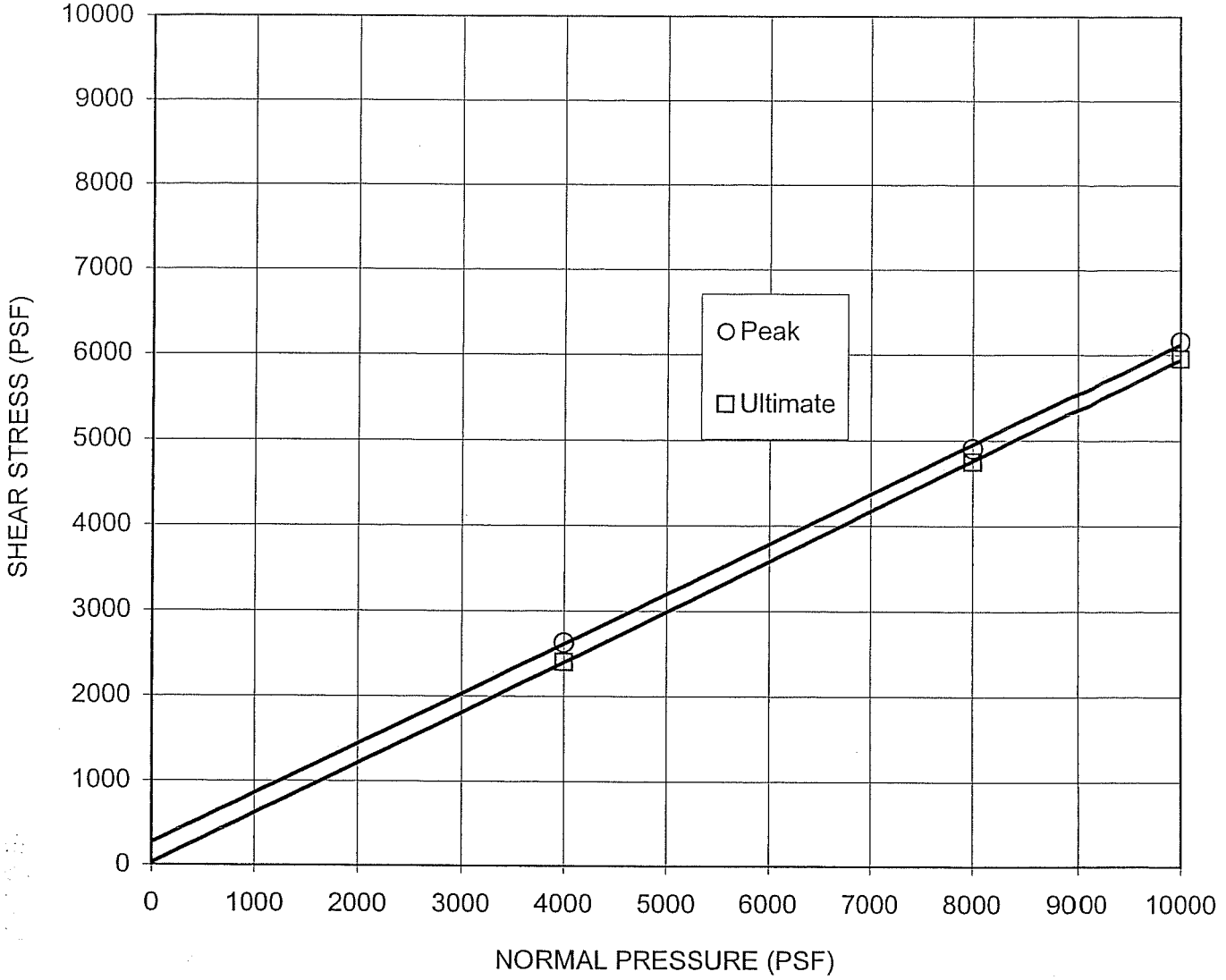
Client: Earth Mechanics, Inc.

Project No: 06-123-03

EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-007	D-12	60	Ring	ML	○	272	30
					□	32	31

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	34.0	32.3
8000	34.0	29.2
10000	34.0	27.6

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Project No: 06-123-03

EGL Project No: 09-230-008

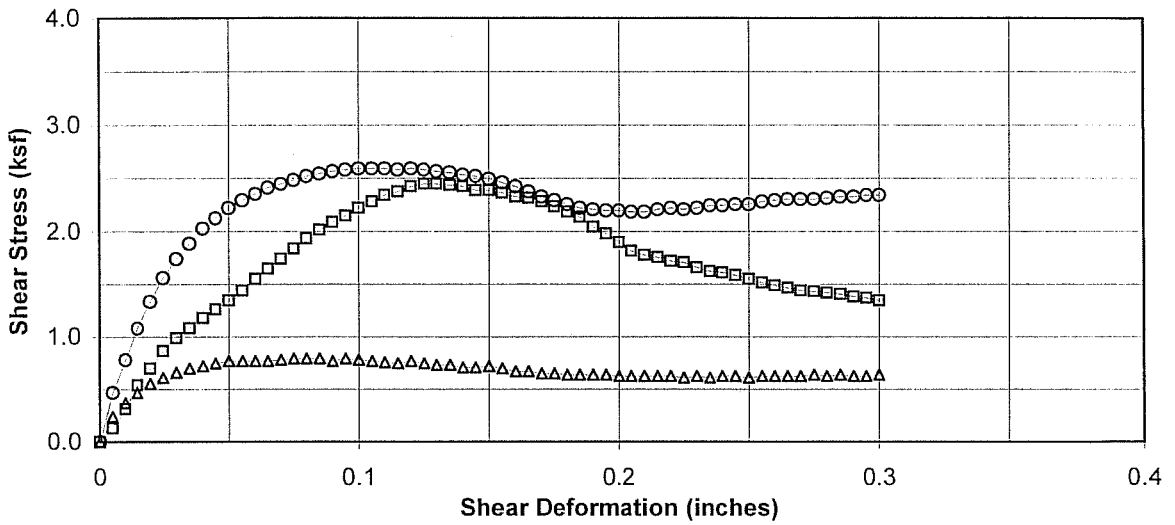
DIRECT SHEAR

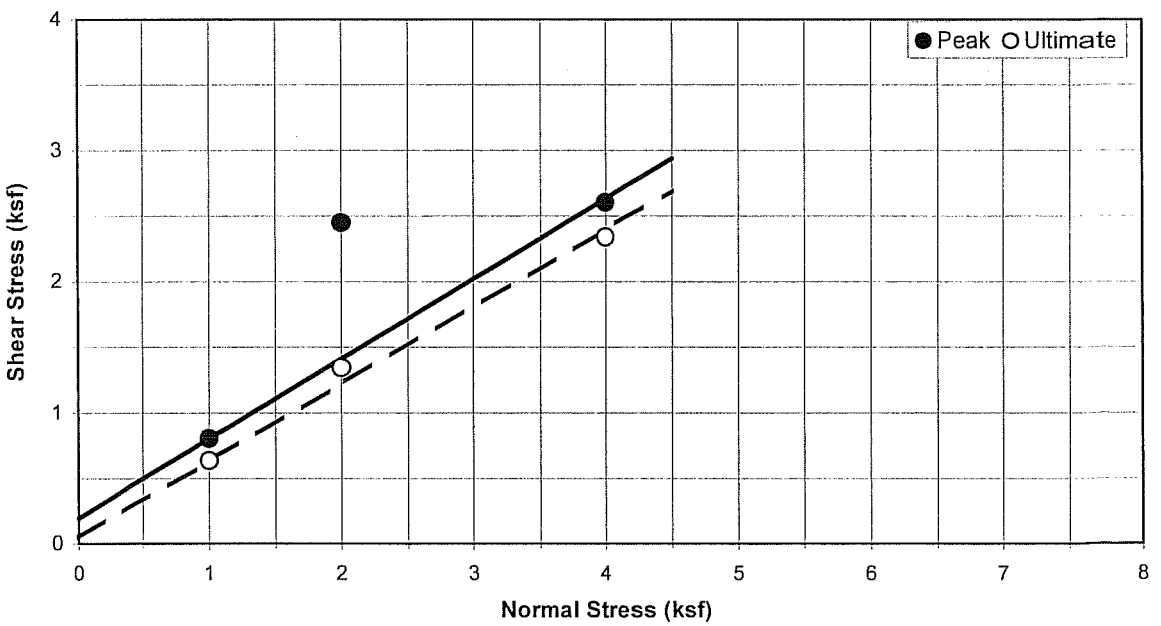
12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	96.9	pcf
Boring No.:	R-09-008	Moisture Content (before):	25.3	%
Sample No.:	D-03	Moisture Content (after):	28.8	%
Depth (ft):	15			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand			
Test Condition:	Saturated			



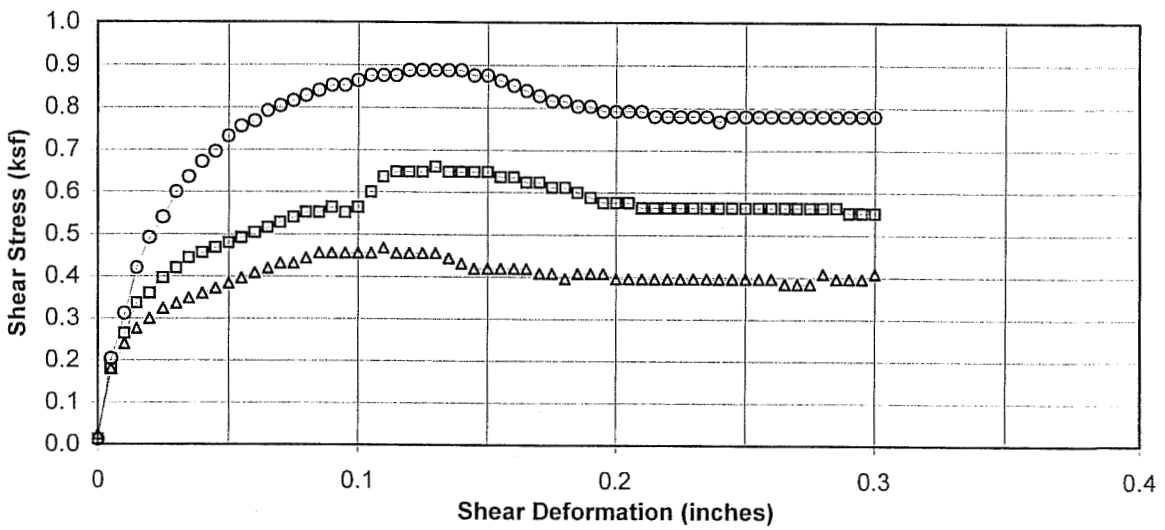


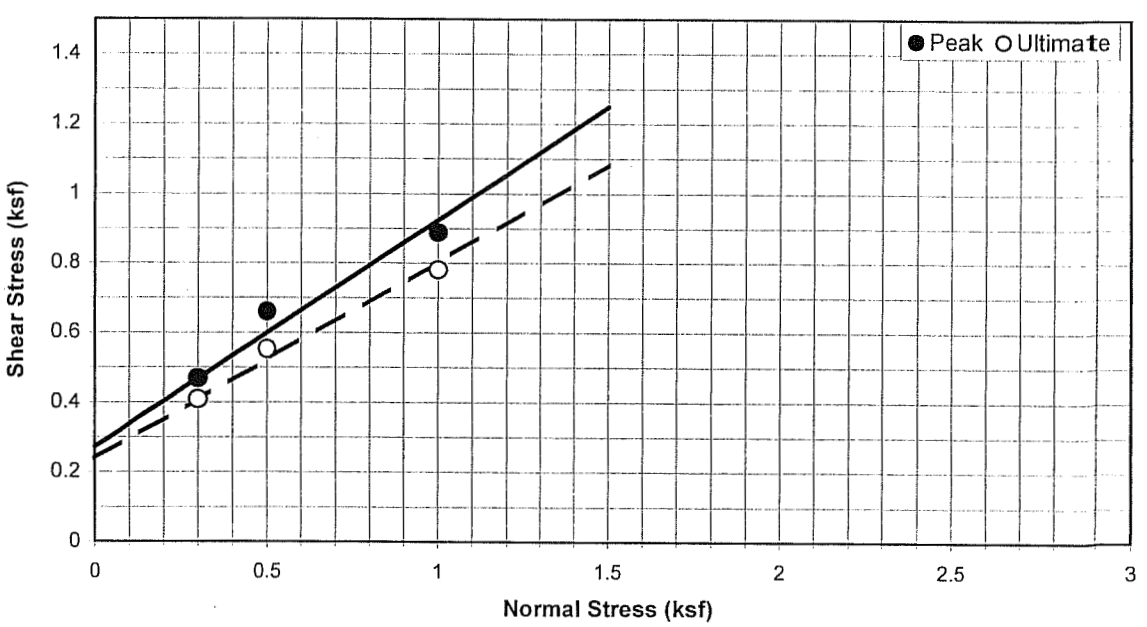
Strength Parameters	Peak	Ultimate
Cohesion (psf):	200	50
Friction Angle:	31 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.3	pcf
Boring No.:	R-09-009	Moisture Content (before):	24.5	%
Sample No.:	D-01	Moisture Content (after):	29.2	%
Depth (ft):	5			
Sample Type:	Cal. Mod.			
Soil Description:	Olive Gray Silty Sand			
Test Condition:	Saturated			



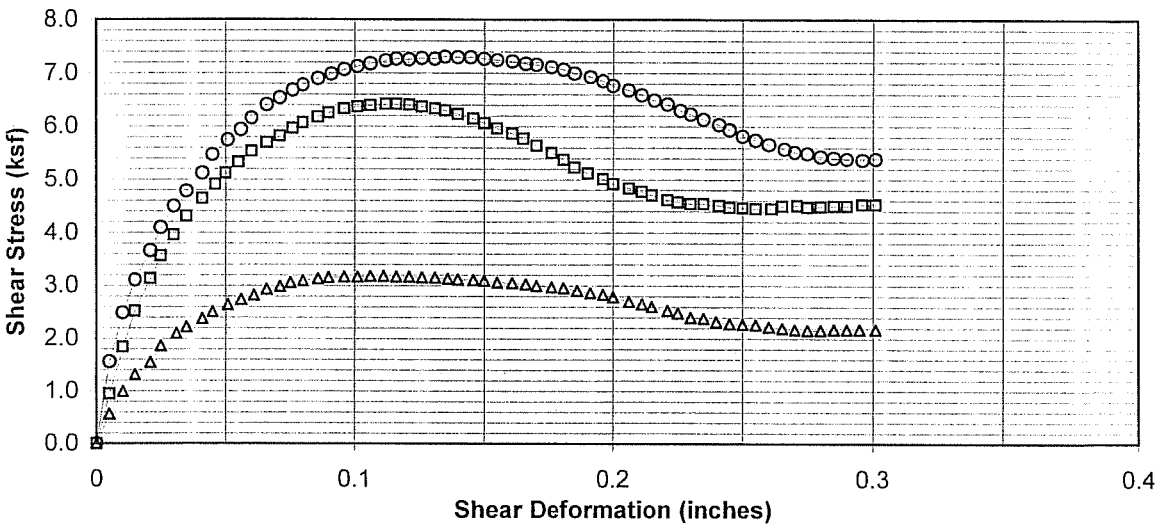


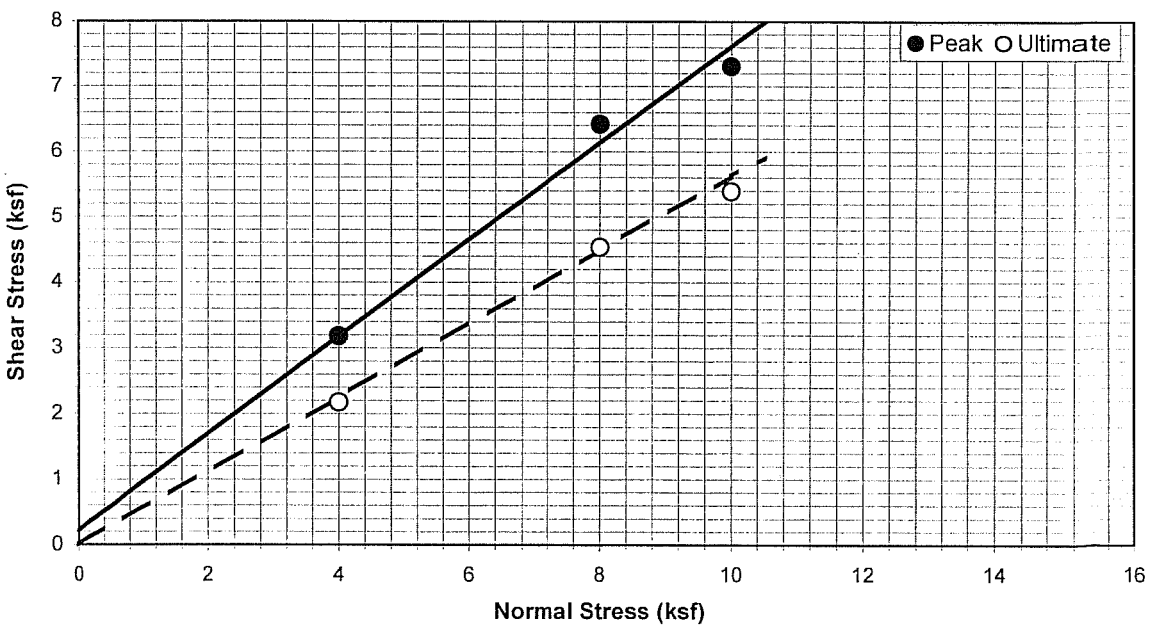
Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	250
Friction Angle:	33 °	29 °

AP Engineering & Testing, Inc.

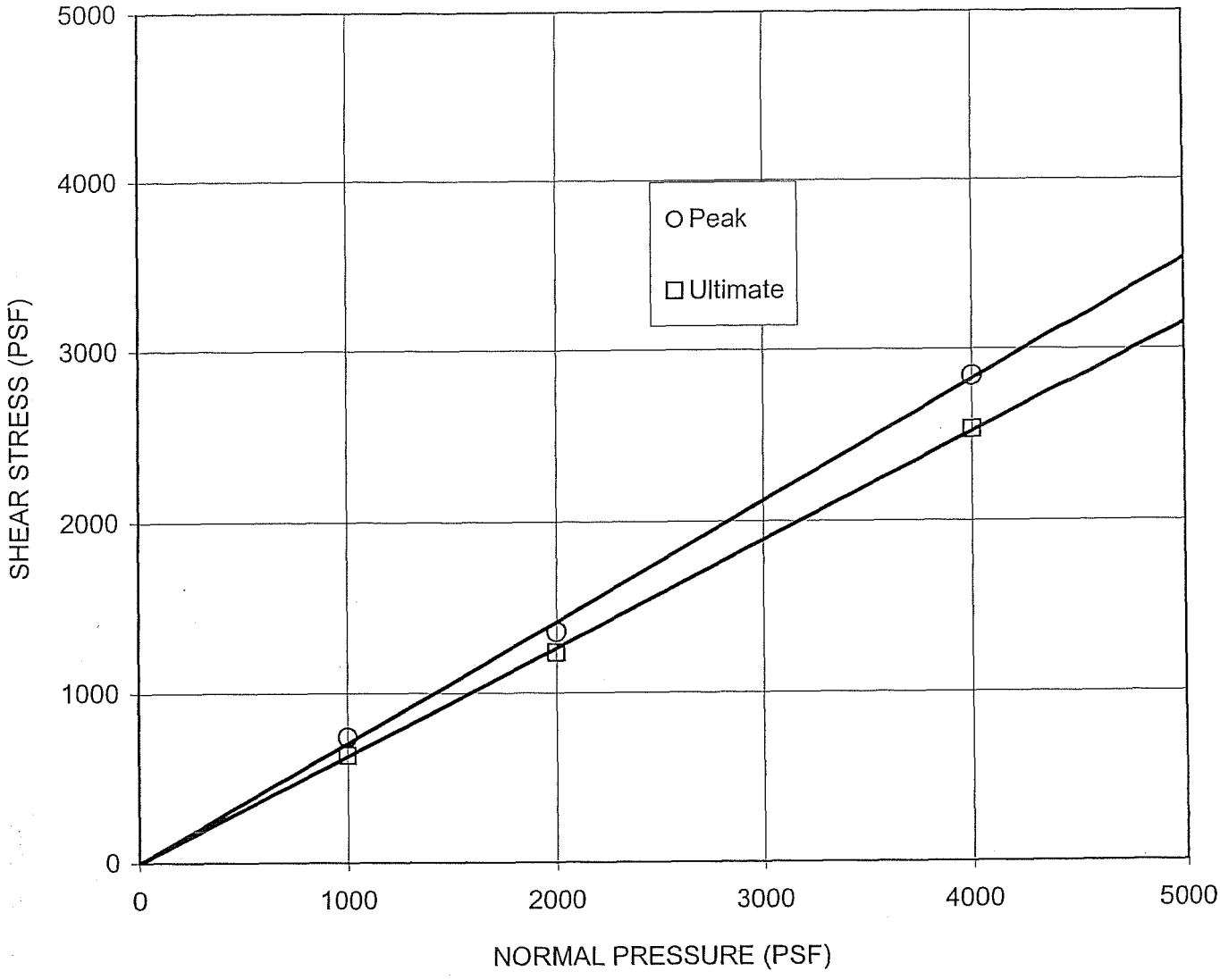
DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	104.8	pcf
Boring No.:	R-09-009	Moisture Content (before):	21.7	%
Sample No.:	D-15	Moisture Content (after):	24.0	%
Depth (ft):	75			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	200	0
Friction Angle:	36 °	29 °



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-010	D-04	20	Ring	SM	○	0	35
					□	0	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	31.2	35.7
2000	31.2	34.8
4000	31.2	34.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

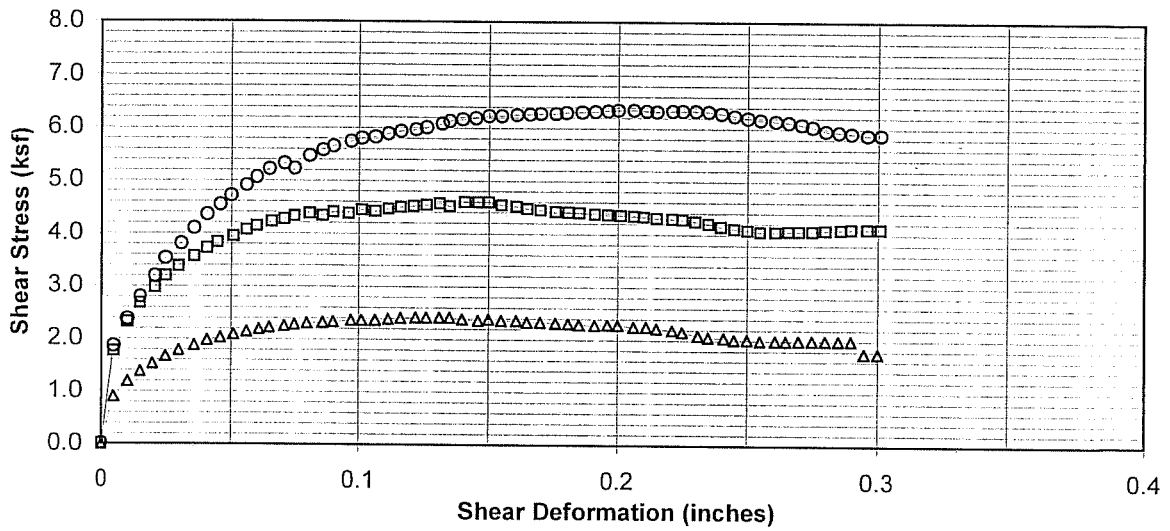
DIRECT SHEAR

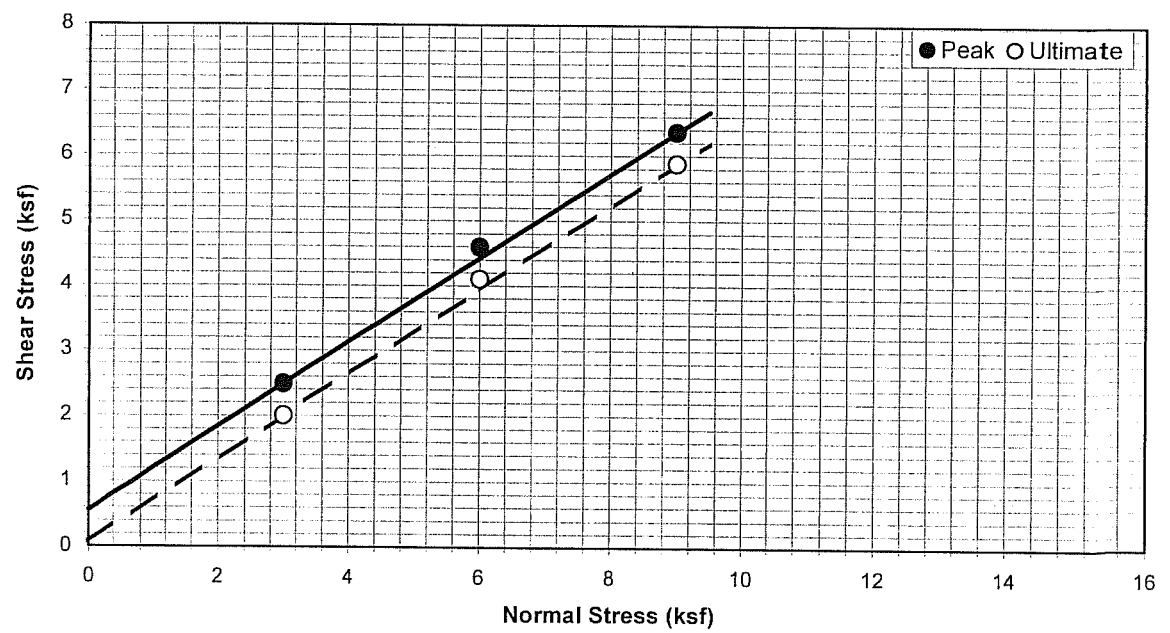
12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	97.3	pcf
Boring No.:	R-09-011	Moisture Content (before):	29.7	%
Sample No.:	D-12	Moisture Content (after):	27.3	%
Depth (ft):	60			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			



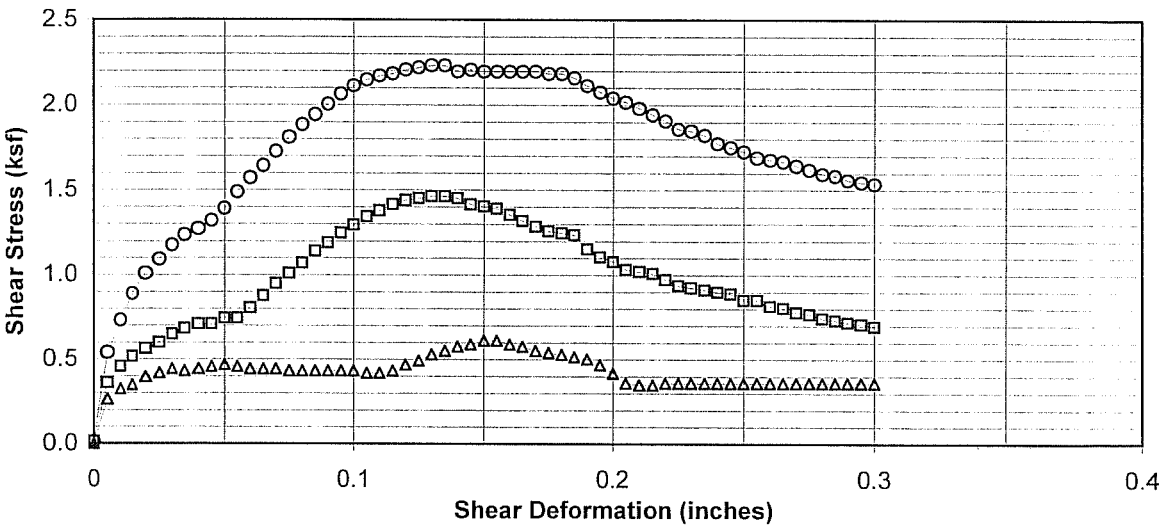


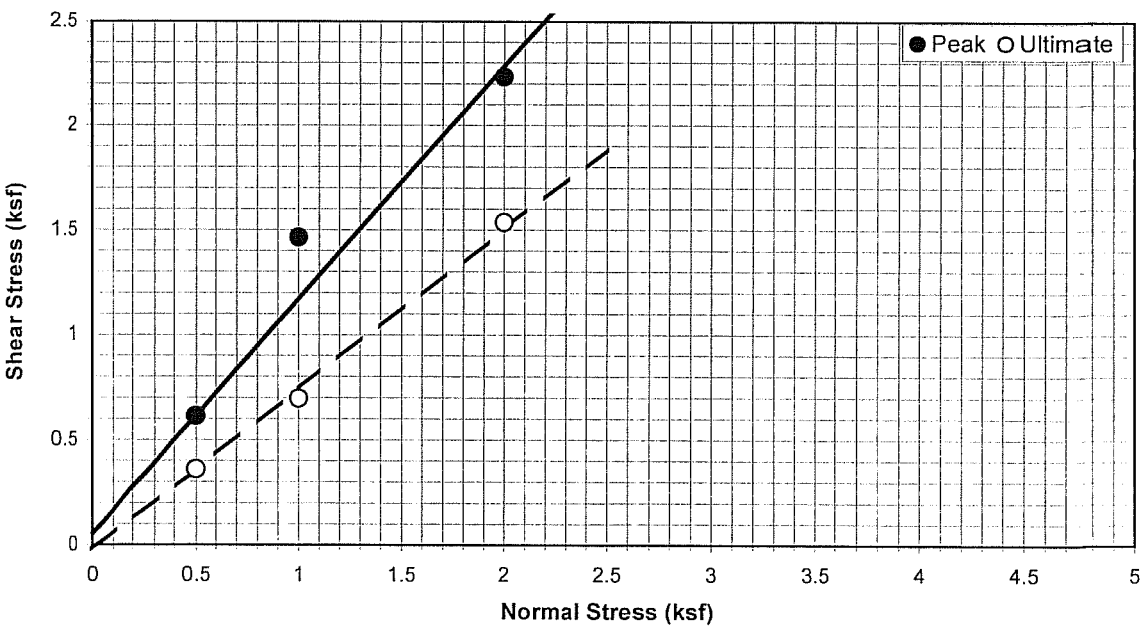
Strength Parameters	Peak	Ultimate
Cohesion (psf):	550	50
Friction Angle:	33 °	33 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.2	pcf
Boring No.:	R-09-011	Moisture Content (before):	27.2	%
Sample No.:	D-02	Moisture Content (after):	30.7	%
Depth (ft):	10			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/ silt			
Test Condition:	Saturated			



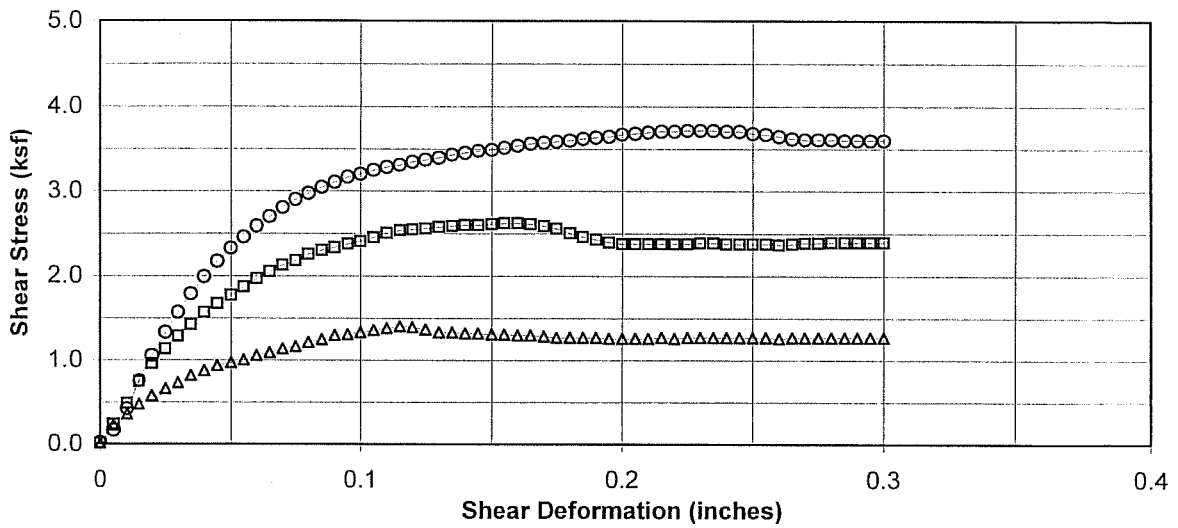


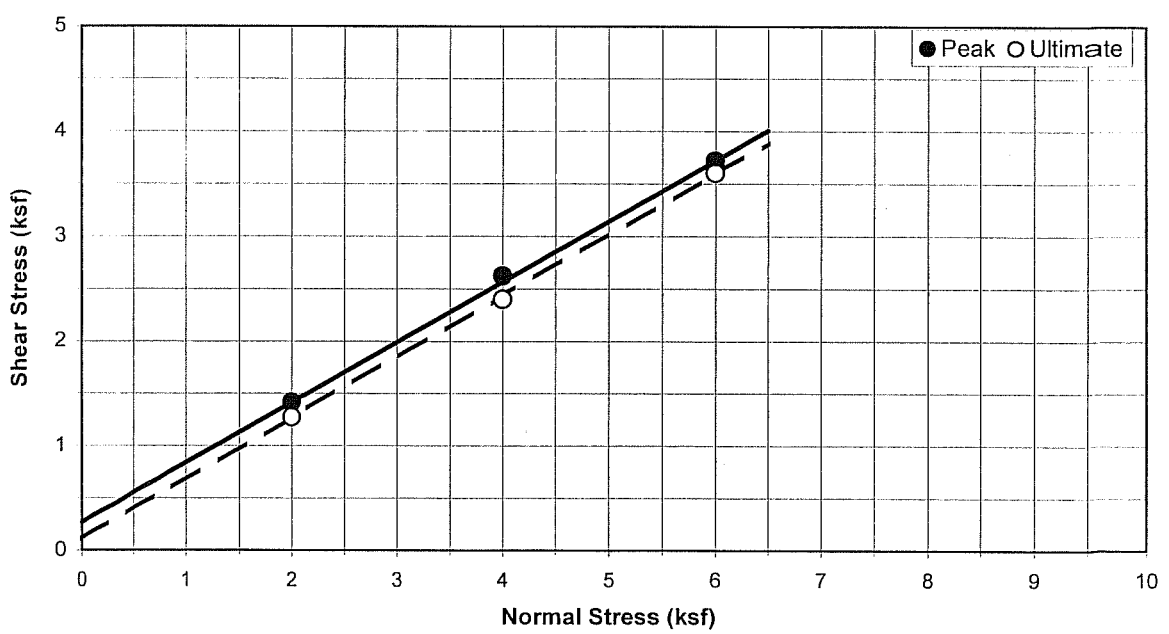
Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	48 °	37 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.6	pcf
Boring No.:	R-09-012	Moisture Content (before):	25.5	%
Sample No.:	D-04	Moisture Content (after):	28.2	%
Depth (ft):	20			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand, fine grained sand w/shell			
Test Condition:	Saturated			



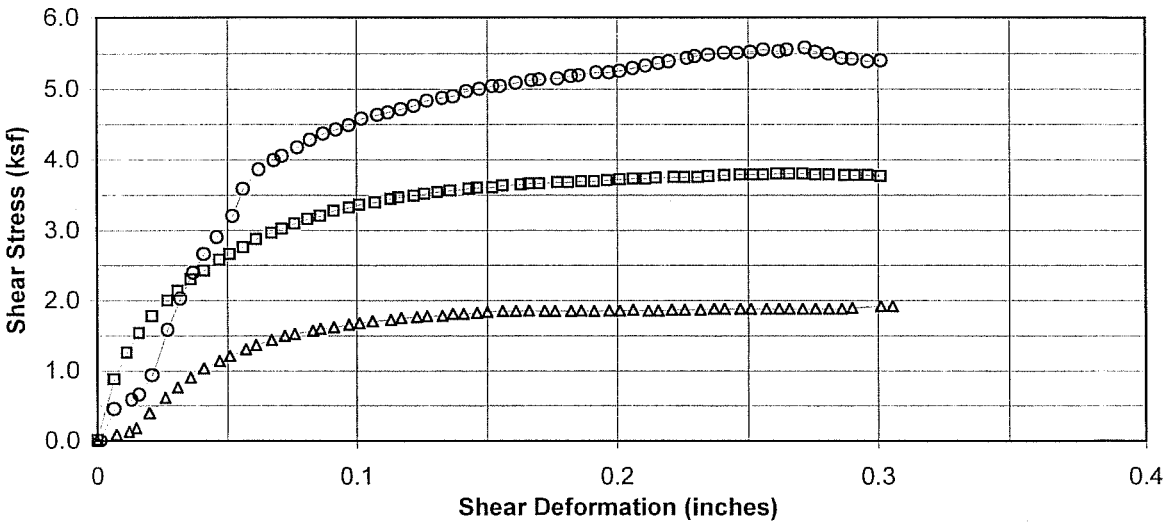


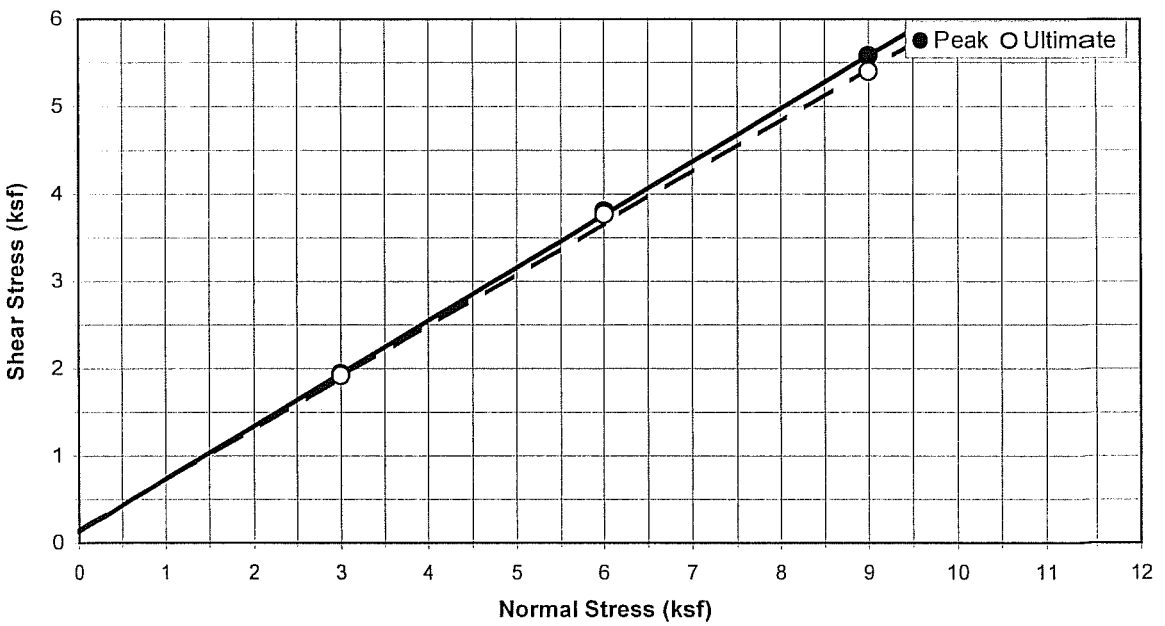
Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	100
Friction Angle:	30 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.8	pcf
Boring No.:	R-09-012	Moisture Content (before):	29.2	%
Sample No.:	D-08	Moisture Content (after):	29.3	%
Depth (ft):	40			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand, fine grained			
Test Condition:	Saturated			



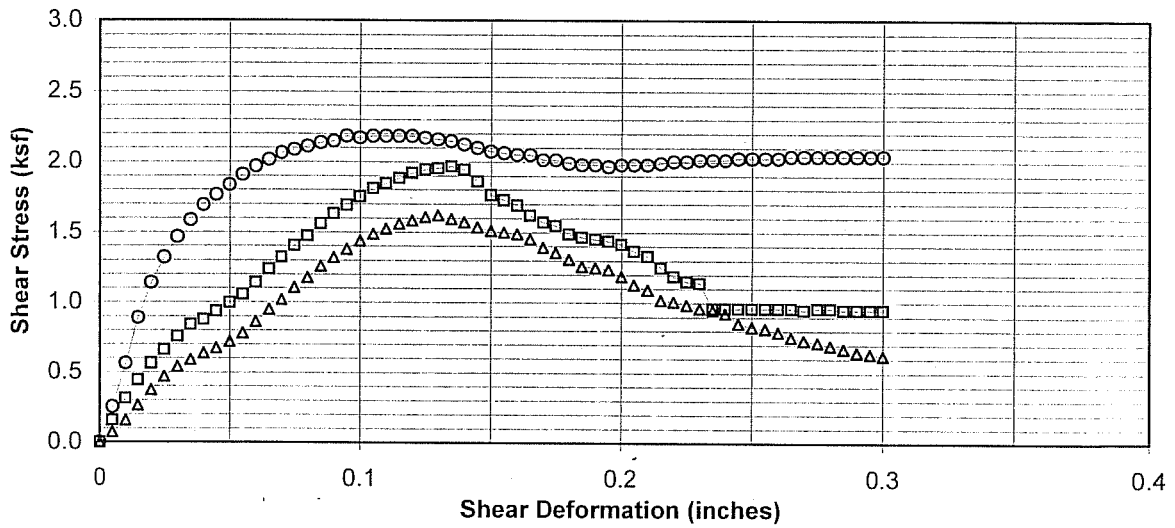


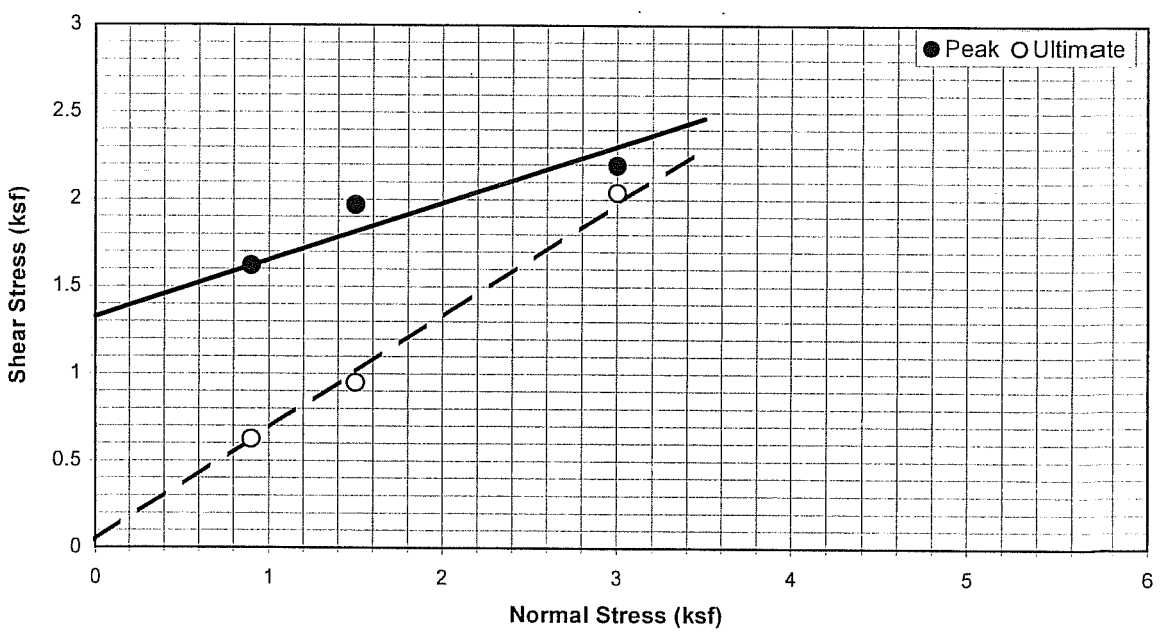
Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	150
Friction Angle:	31 °	30 °

AP Engineering & Testing, Inc.

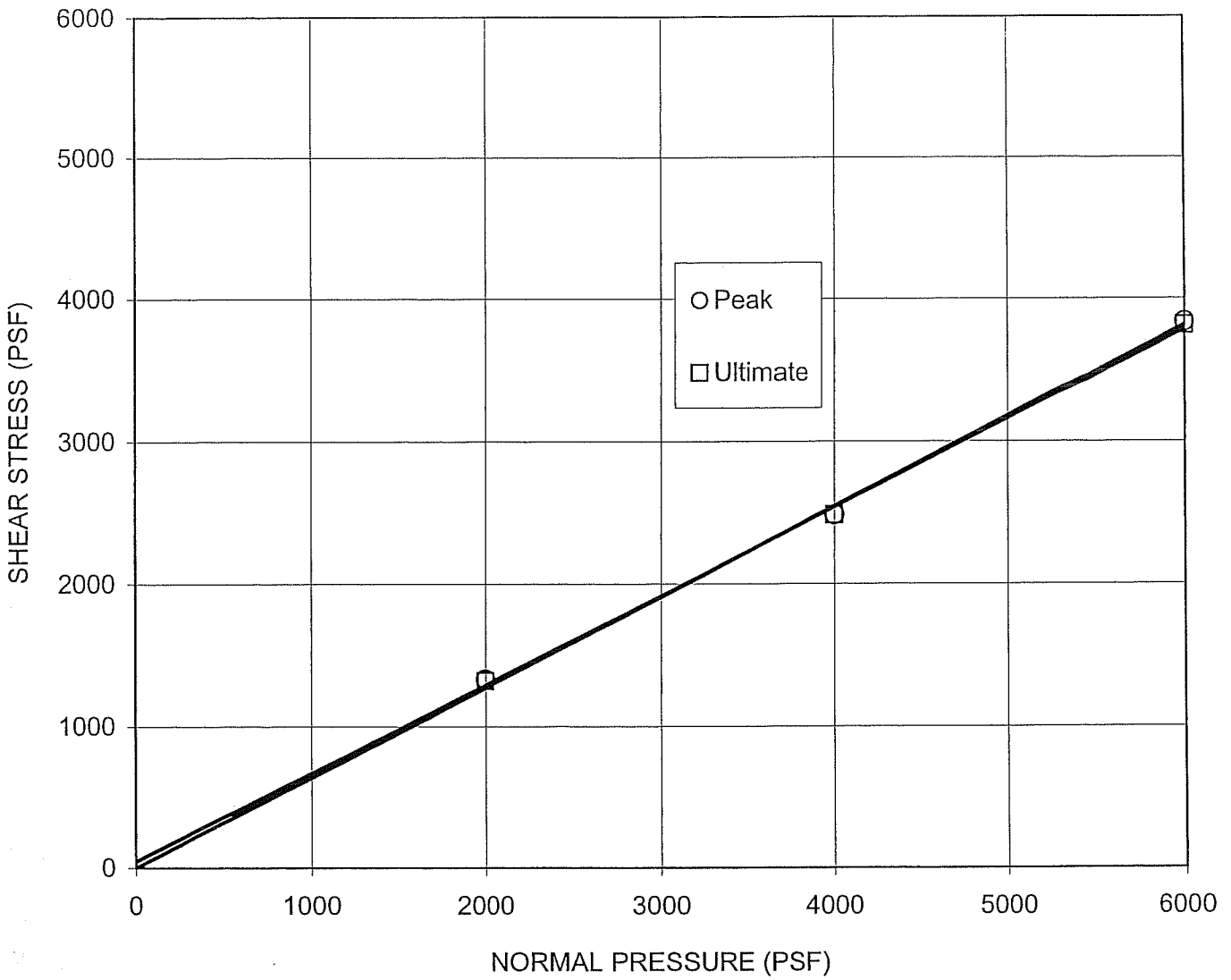
DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.7	pcf
Boring No.:	R-09-013	Moisture Content (before):	30.2	%
Sample No.:	D-03	Moisture Content (after):	30.4	%
Depth (ft):	15			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sand with Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	1350	50
Friction Angle:	18 °	33 °



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-014	D-06	30	Ring	SM	○	47	32
					□	47	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2000	31.6	32.6
4000	31.6	31.1
6000	31.6	30.6

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Project No: 06-123-03

EGL Project No: 09-230-008

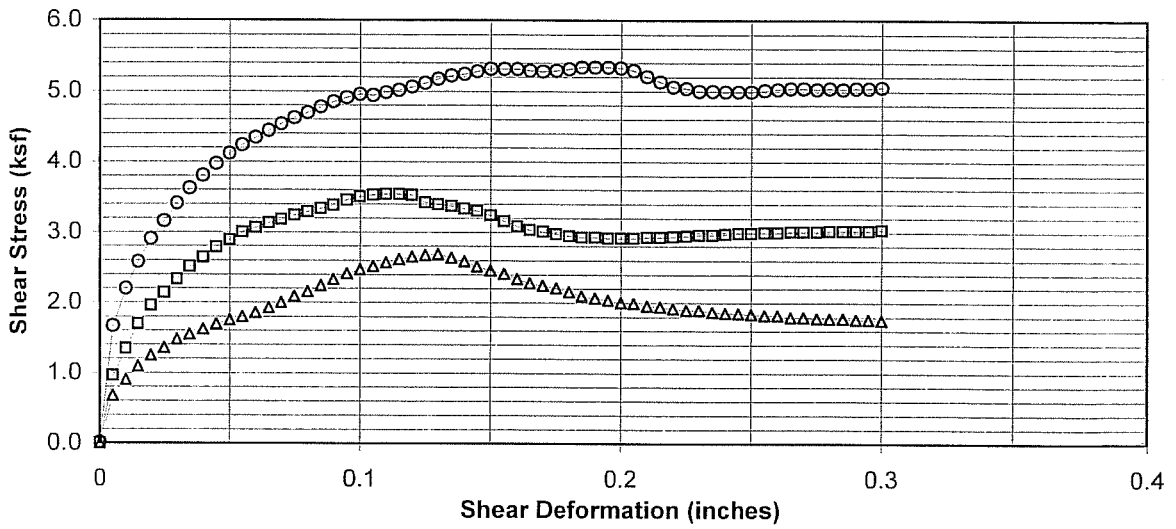
DIRECT SHEAR

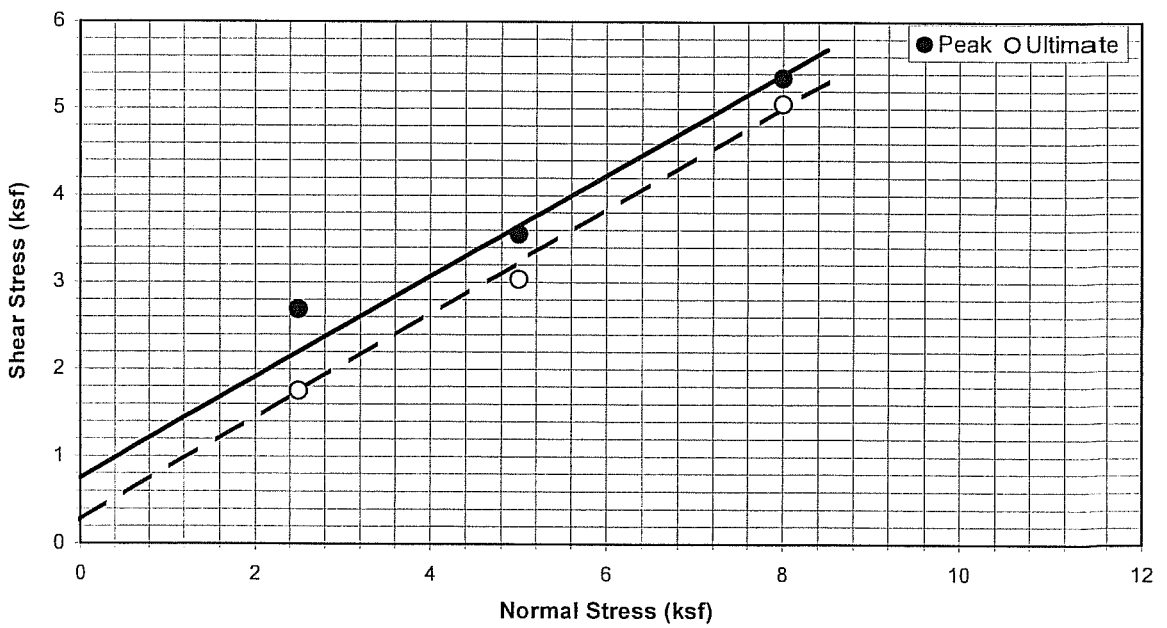
12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	92.0	pcf
Boring No.:	R-09-015	Moisture Content (before):	33.4	%
Sample No.:	D-11	Moisture Content (after):	32.2	%
Depth (ft):	45			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silt with sand			
Test Condition:	Saturated			



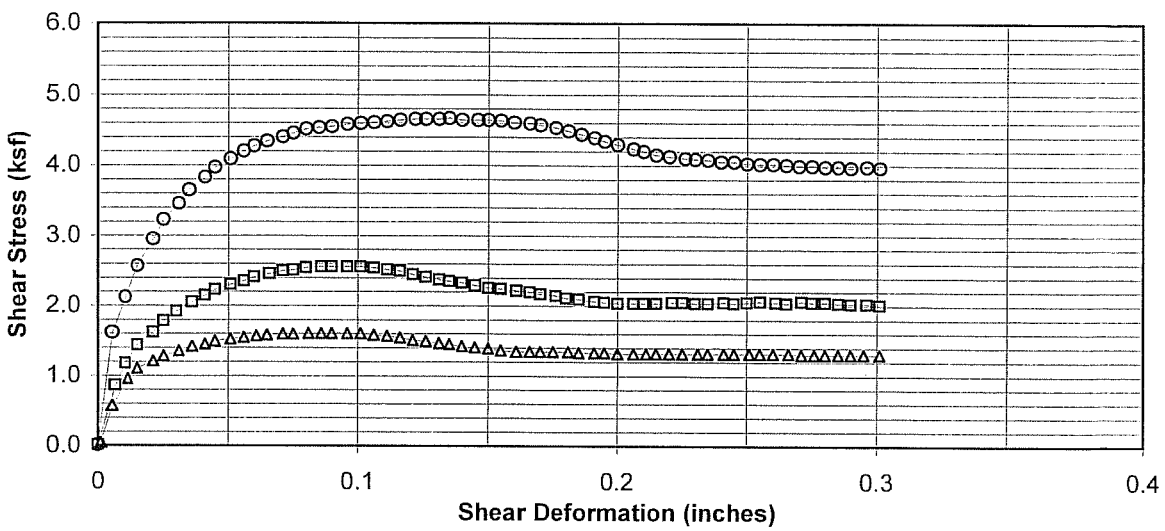


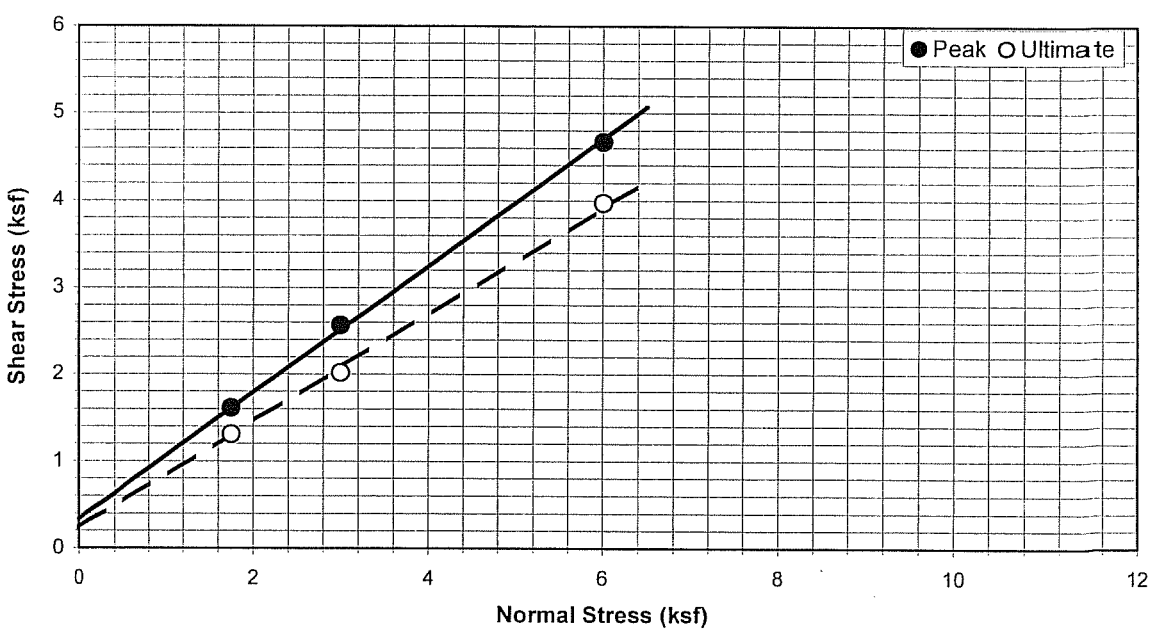
Strength Parameters	Peak	Ultimate
Cohesion (psf):	750	250
Friction Angle:	30 °	31 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	98.1	pcf
Boring No.:	R-09-019	Moisture Content (before):	26.1	%
Sample No.:	D-06	Moisture Content (after):	27.7	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sand with silt			
Test Condition:	Saturated			



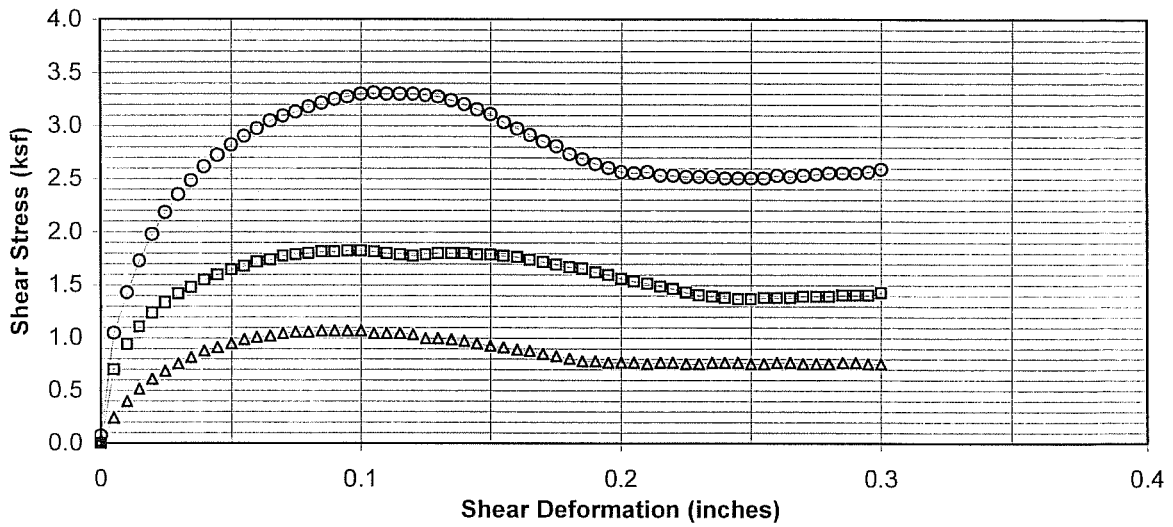


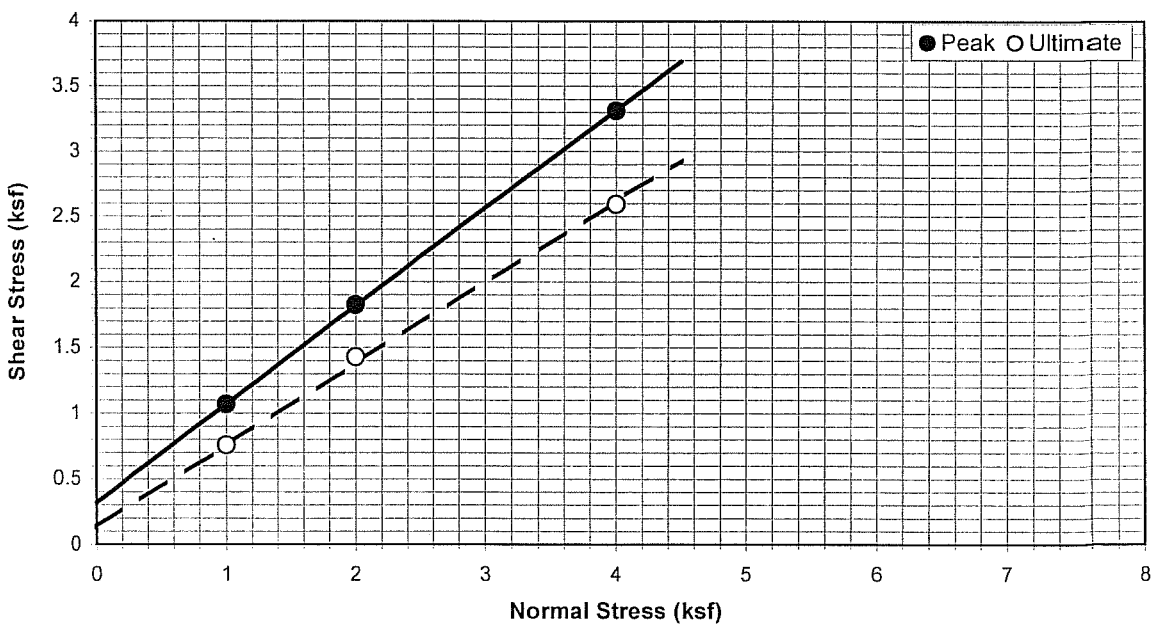
Strength Parameters	Peak	Ultimate
Cohesion (psf):	350	250
Friction Angle:	36 °	32 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	99.1	pcf
Boring No.:	R-09-023	Moisture Content (before):	25.0	%
Sample No.:	D-04	Moisture Content (after):	27.5	%
Depth (ft):	20			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/silt			
Test Condition:	Saturated			



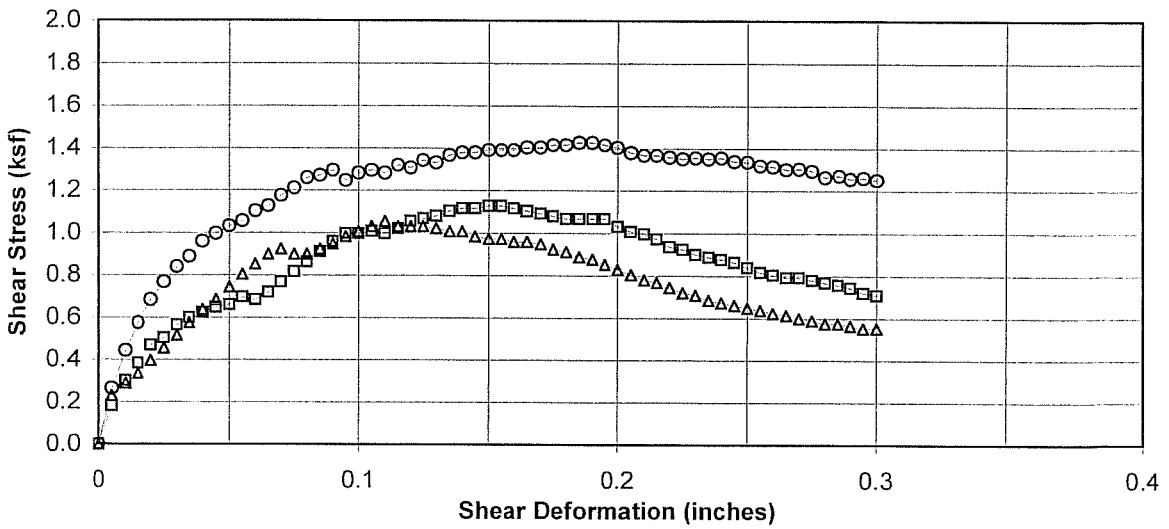


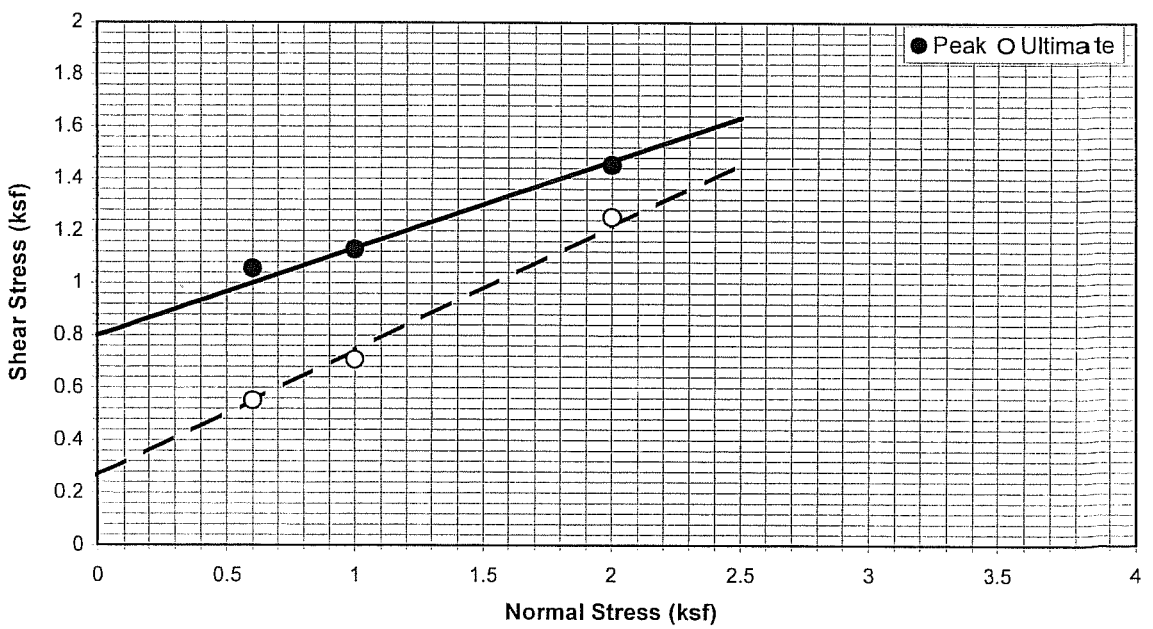
Strength Parameters	Peak	Ultimate
Cohesion (psf):	300	150
Friction Angle:	37 °	32 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	86.4	pcf
Boring No.:	R-09-024	Moisture Content (before):	34.0	%
Sample No.:	D-02	Moisture Content (after):	36.0	%
Depth (ft):	10			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			



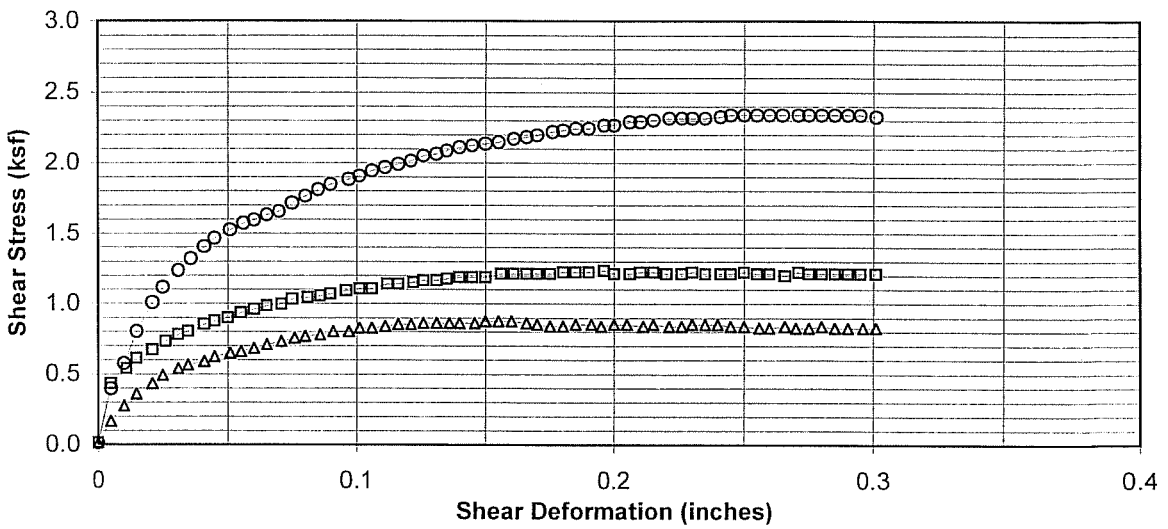


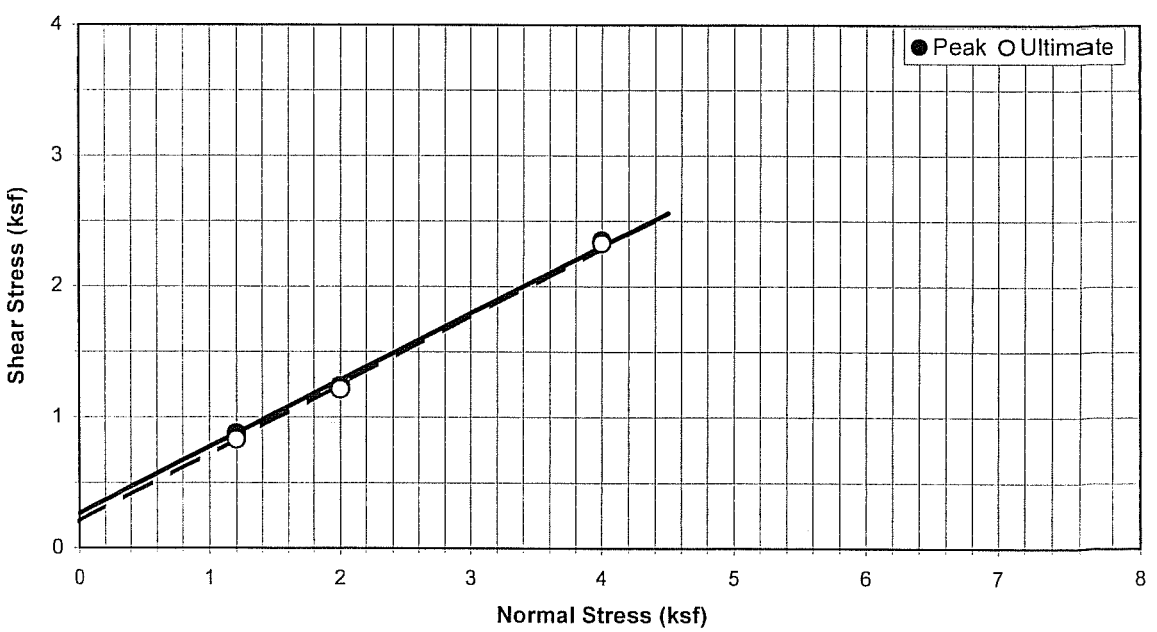
Strength Parameters	Peak	Ultimate
Cohesion (psf):	800	250
Friction Angle:	18 °	25 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	81.0	pcf
Boring No.:	R-09-024	Moisture Content (before):	39.8	%
Sample No.:	D-04-2	Moisture Content (after):	40.0	%
Depth (ft):	20.5			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silt with fine sand			
Test Condition:	Saturated			



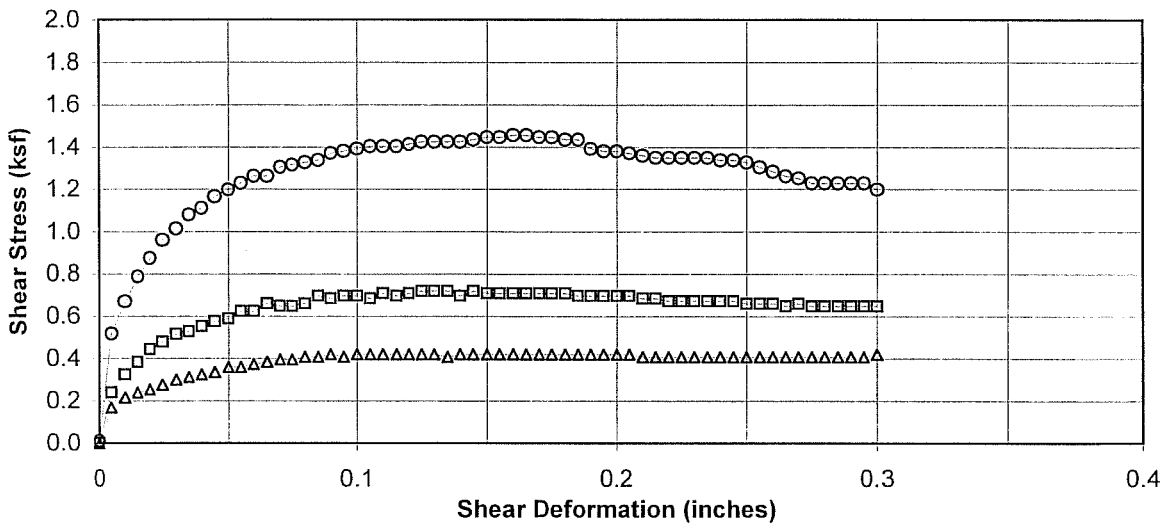


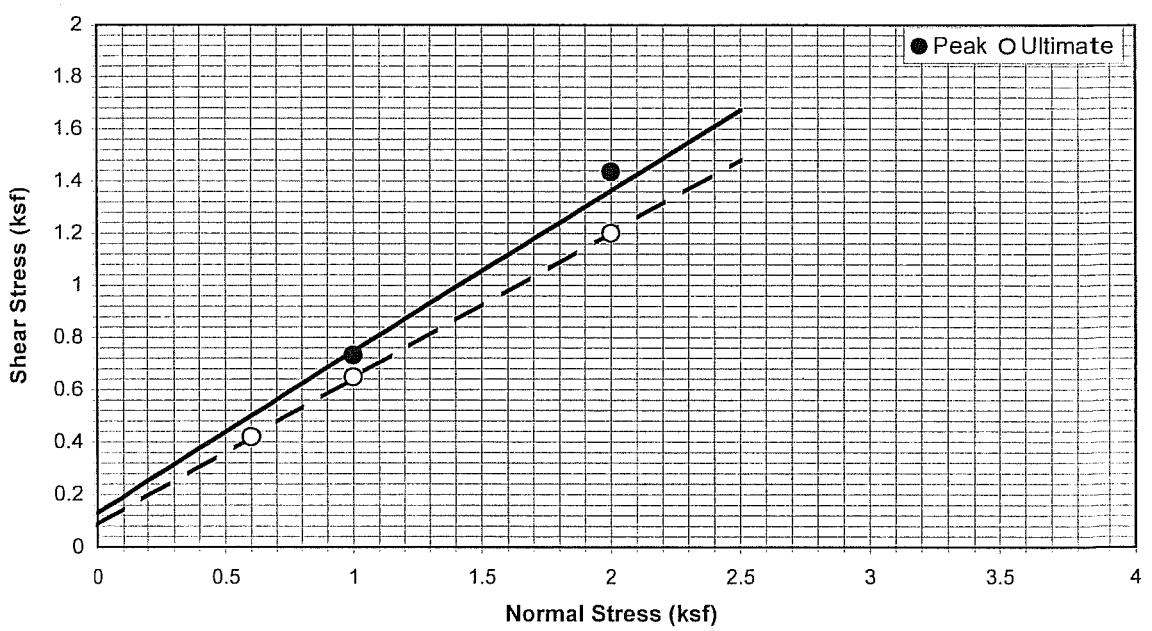
Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	200
Friction Angle:	27 °	28 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	85.3	pcf
Boring No.:	R-09-025	Moisture Content (before):	35.8	%
Sample No.:	D-02	Moisture Content (after):	38.0	%
Depth (ft):	10			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			



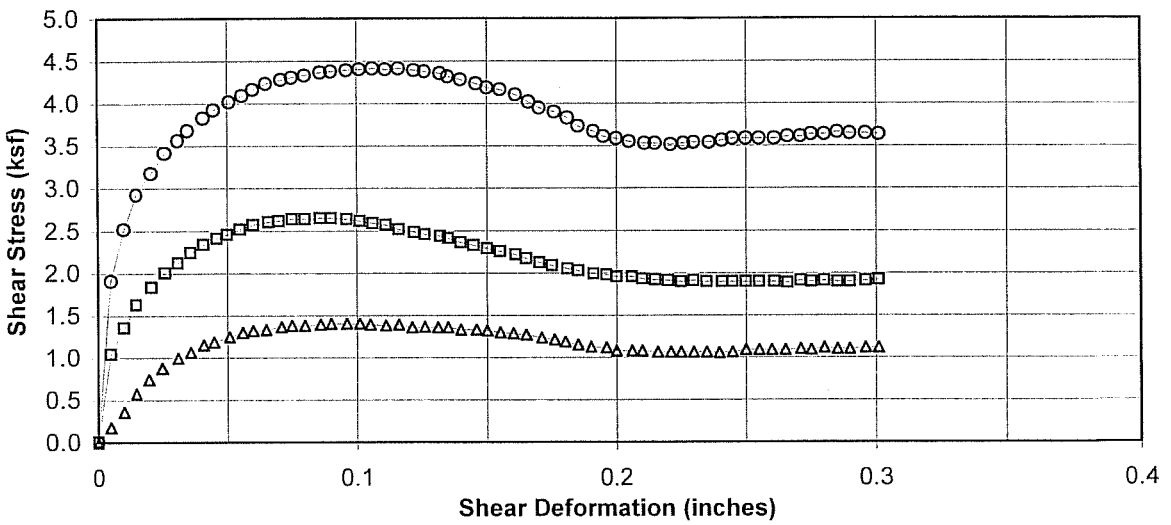


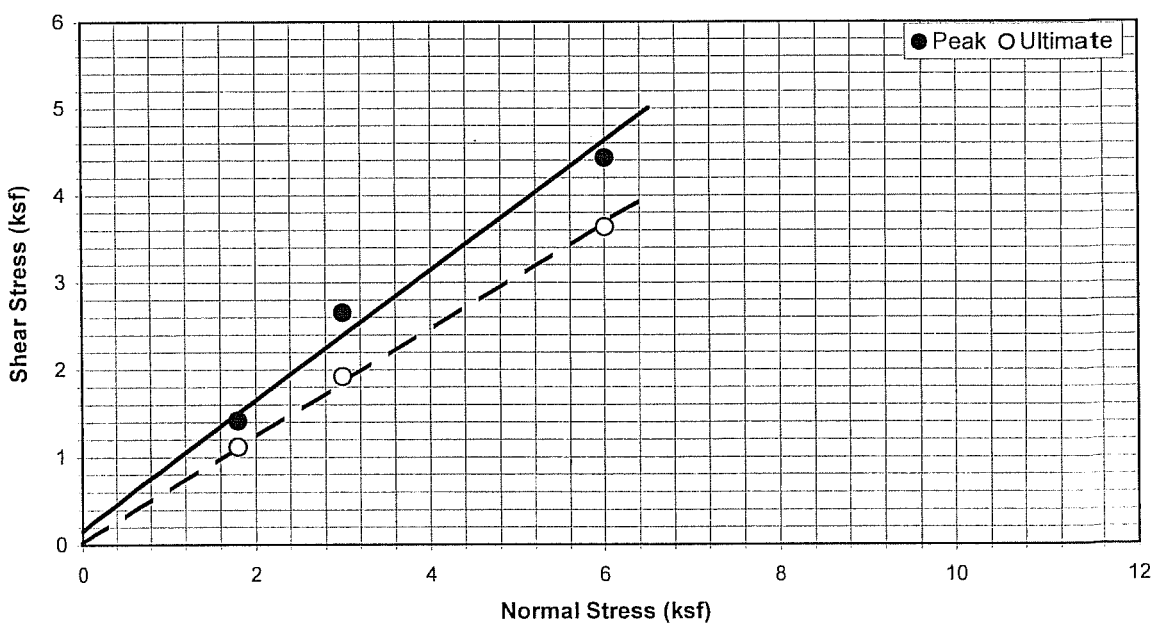
Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	100
Friction Angle:	32 °	29 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	99.9	pcf
Boring No.:	R-09-025	Moisture Content (before):	24.3	%
Sample No.:	D-06	Moisture Content (after):	26.9	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/Silt			
Test Condition:	Saturated			



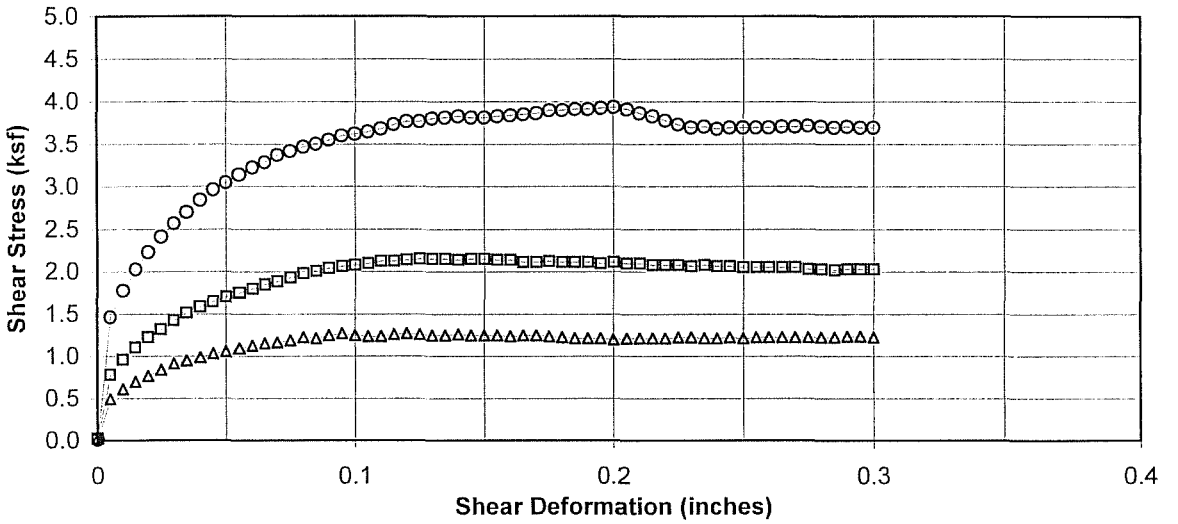


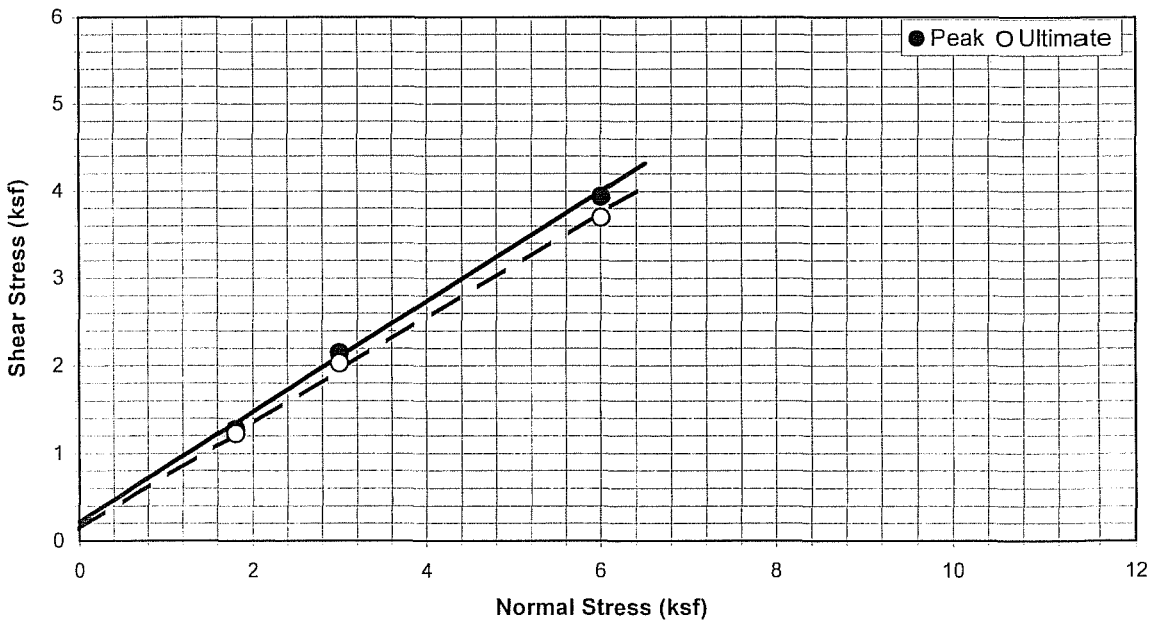
Strength Parameters	Peak	Ultimate
Cohesion (psf):	150	0
Friction Angle:	37 °	32 °

AP Engineering & Testing, Inc.

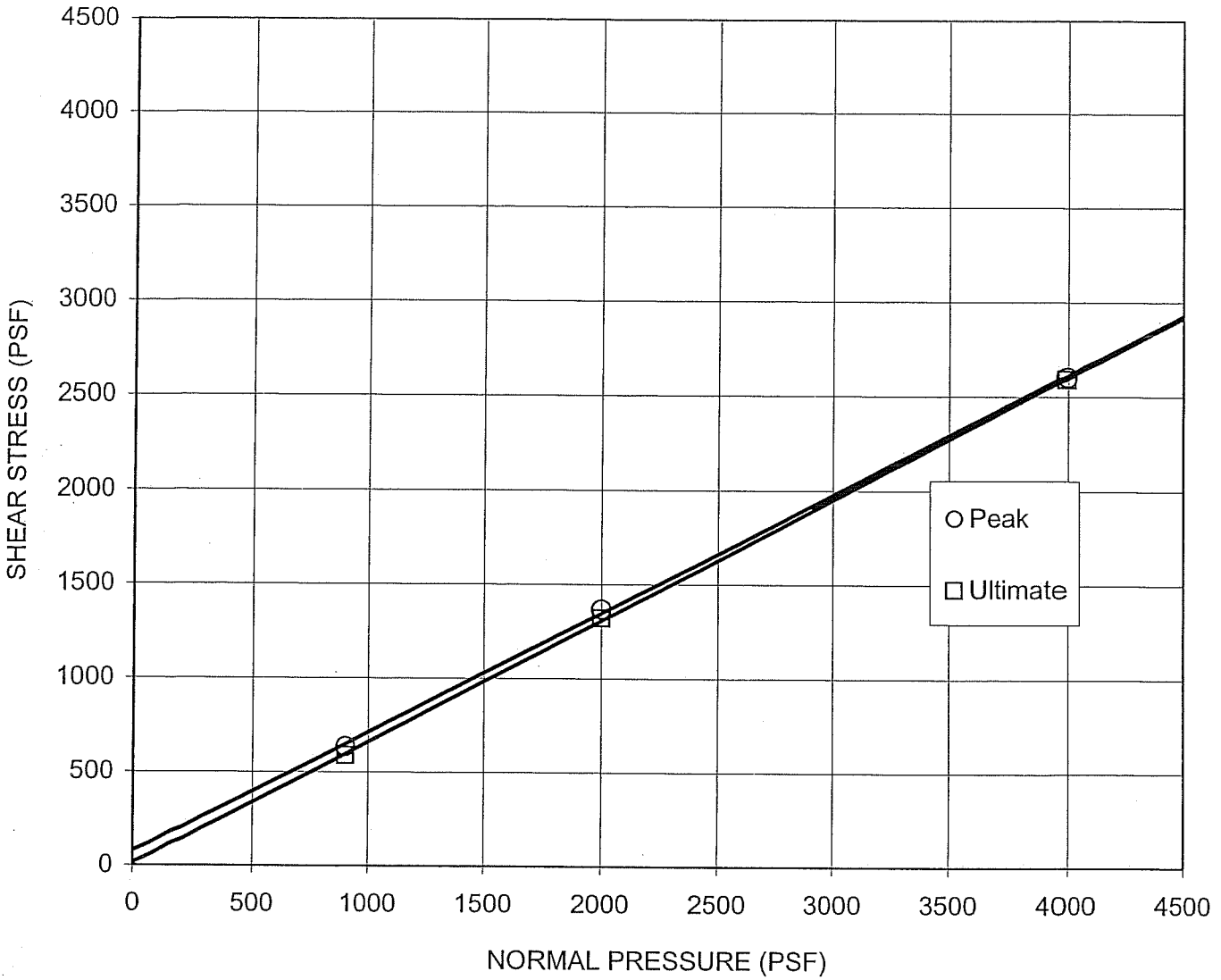
DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	89.8	pcf
Boring No.:	R-09-026	Moisture Content (before):	34.0	%
Sample No.:	D-06	Moisture Content (after):	33.8	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	200	150
Friction Angle:	32 °	31 °



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-027	D-02-1	15	Ring	SM	O	81	32
					□	17	33

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
900	60.8	54.8
2000	60.8	53.4
4000	60.8	47.9

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Project No: 06-123-03

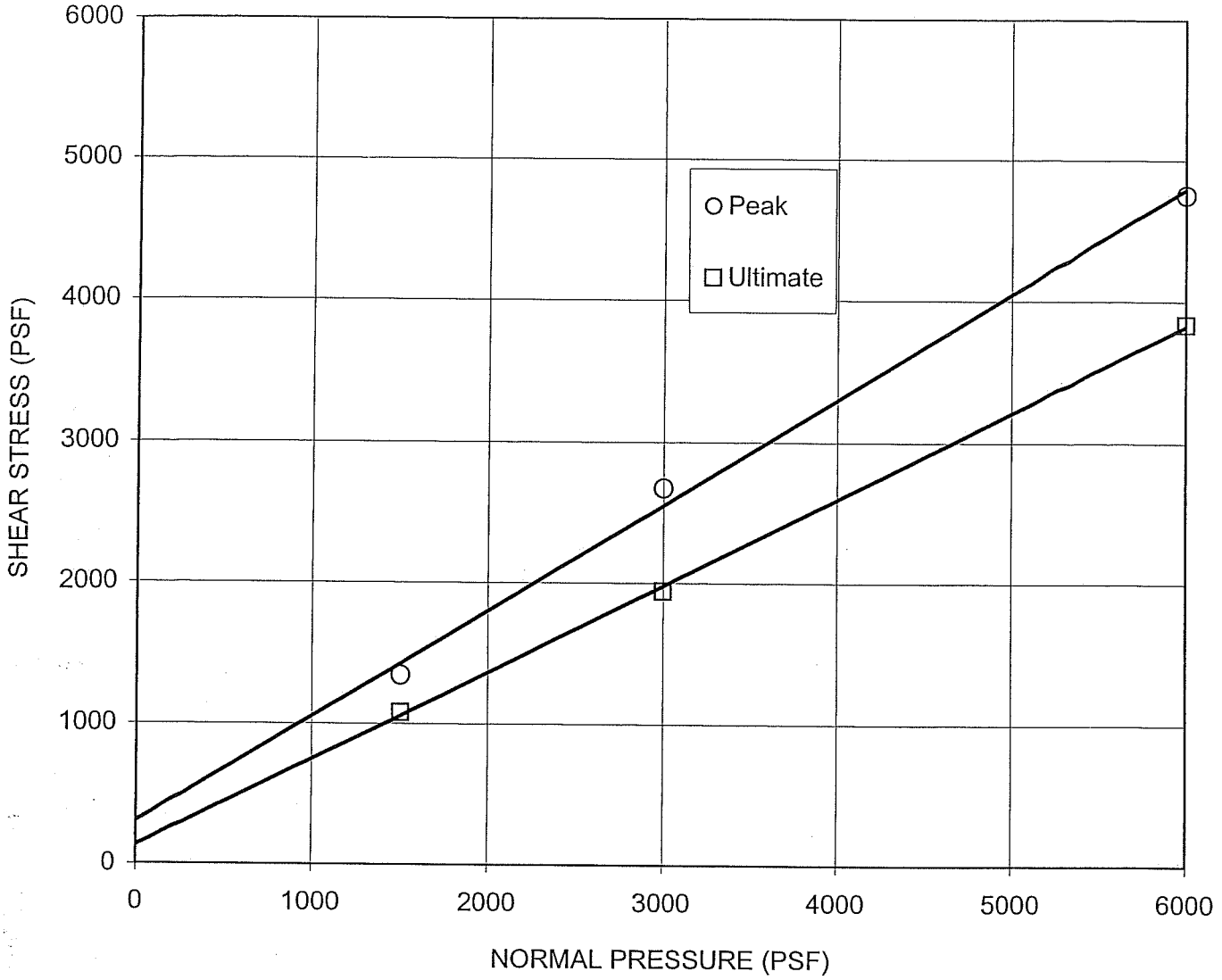
EGL Project No: 09-230-008

DIRECT SHEAR

12/09

(ASTM D3080)

Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-027	D-06	32	Ring	SM	○	306	37
					□	134	32

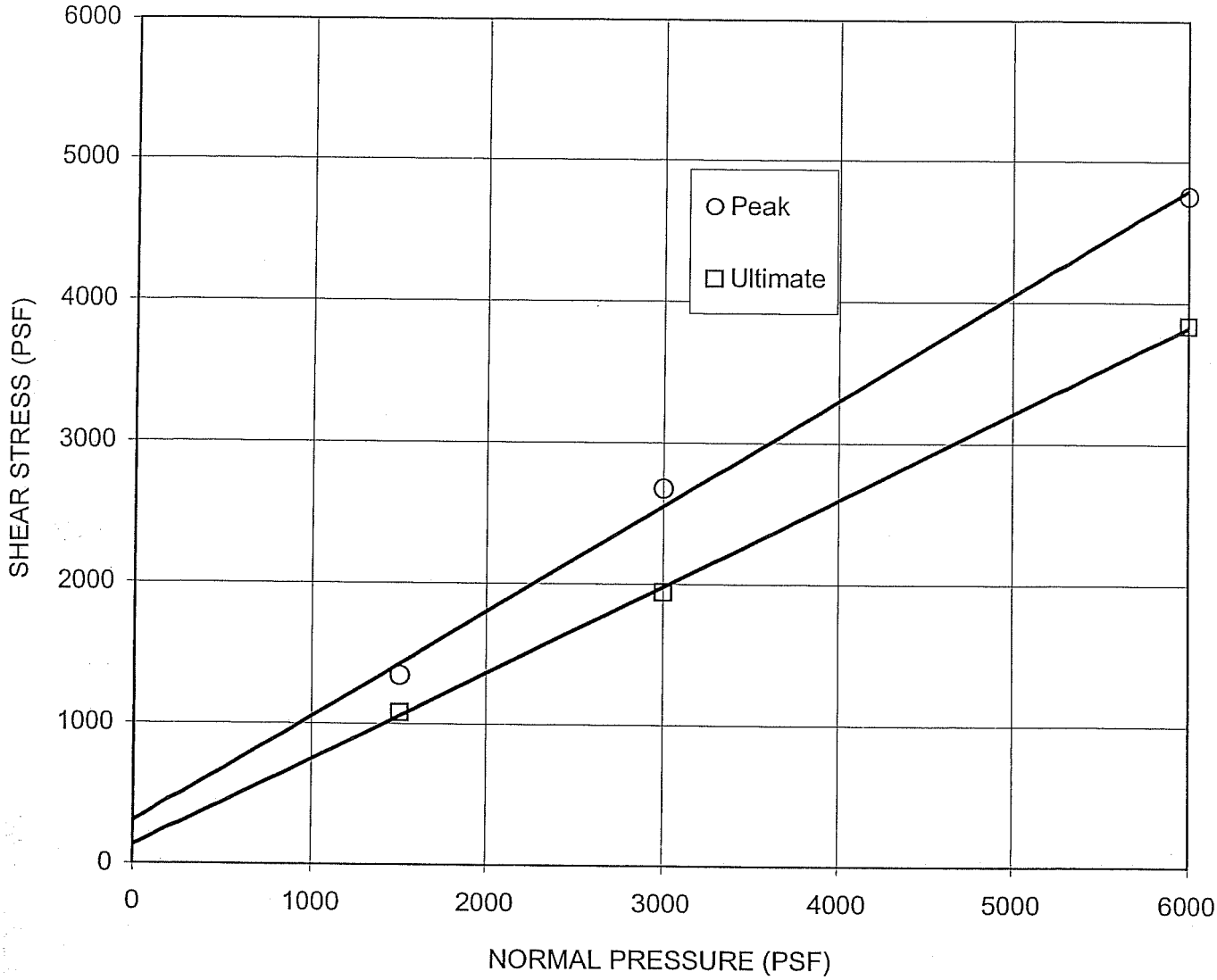
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1500	21.6	24.5
3000	21.6	23.1
6000	21.6	22.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-027	D-06	32	Ring	SP-SM	○	306	37
					□	134	32

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1500	21.6	24.5
3000	21.6	23.1
6000	21.6	22.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

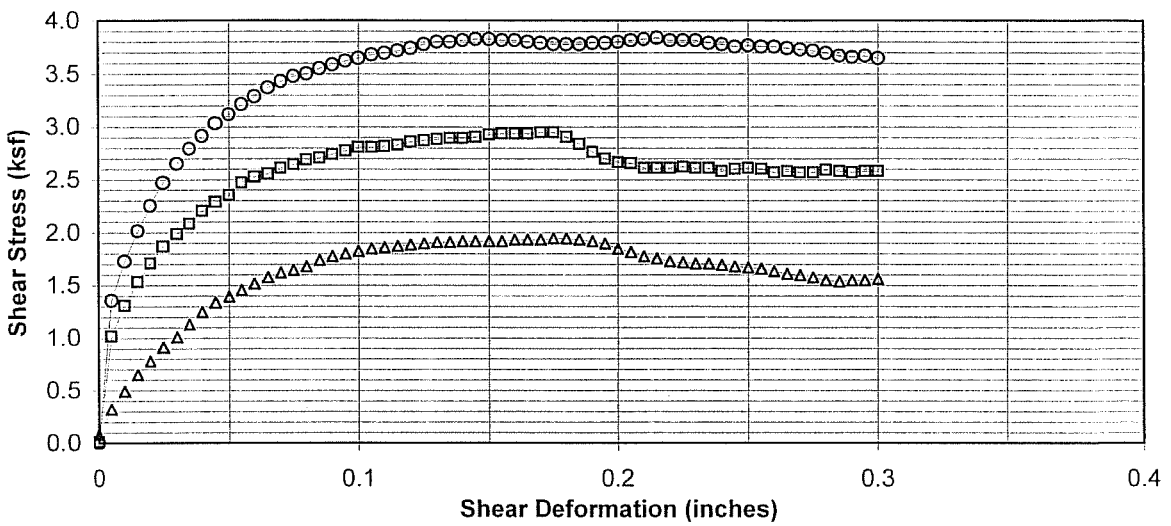
DIRECT SHEAR

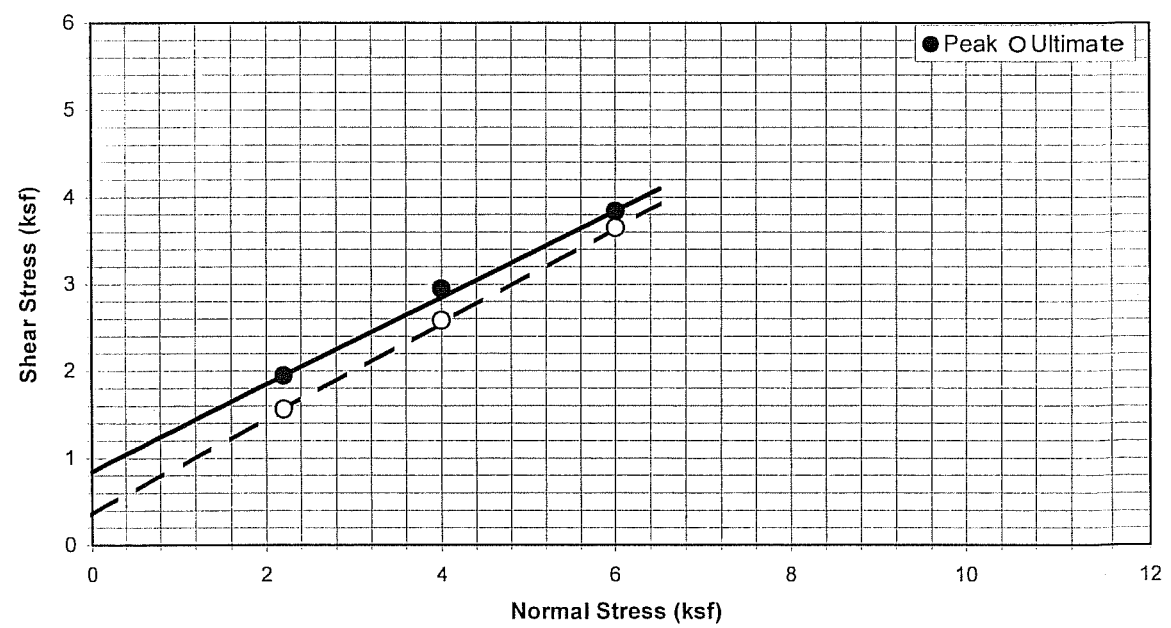
12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

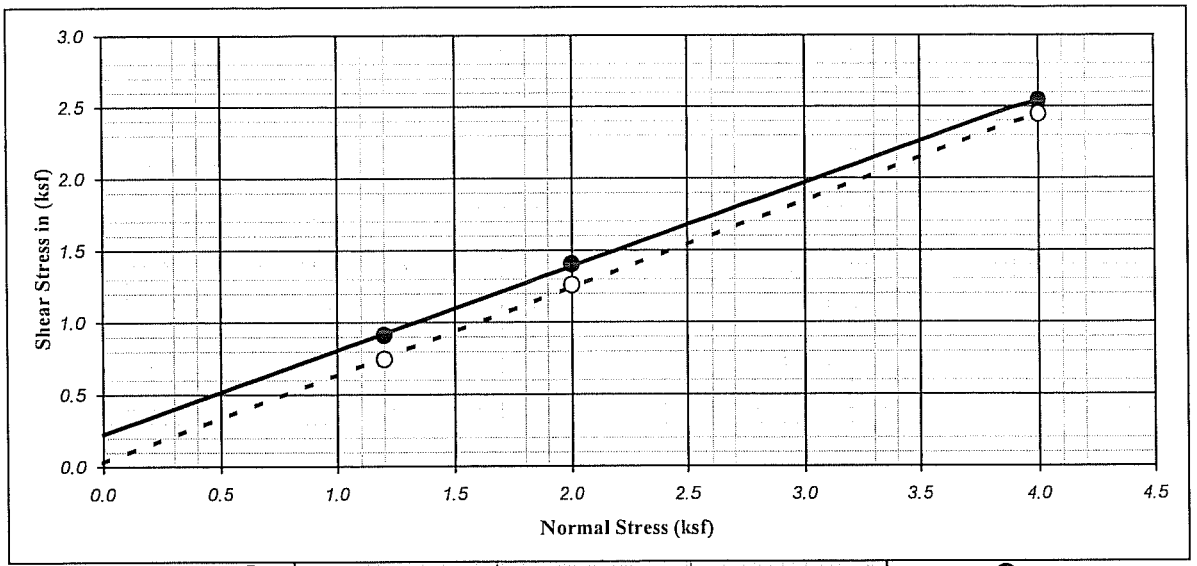
DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	92.6	pcf
Boring No.:	R-09-029	Moisture Content (before):	31.7	%
Sample No.:	D-06	Moisture Content (after):	30.8	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			

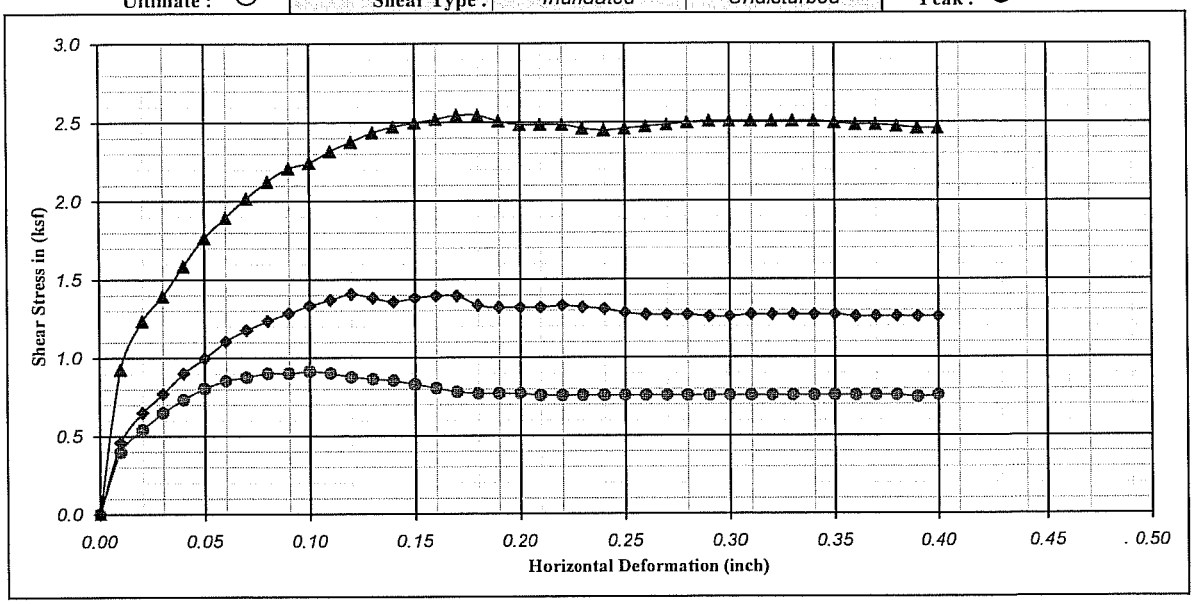




Strength Parameters	Peak	Ultimate
Cohesion (psf):	850	350
Friction Angle:	27 °	29 °



Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No. : *WR-09-041*	Strength Intercept (C) :	*0.23*	(ksf)	Peak	*0.03*	(ksf)	Ultimate
Sample No. : *D-5*		*10.87*	(kPa)		*1.44*	(kPa)	
Depth (ft/m) : *62.0* *20.00*	Friction Angle (ϕ) :	*30.13*	Degree		*31.21*	Degree	
Description : *Gray, SANDY SILT (ML)*					Shear Rate (inch/minute) :		*0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*32.33*	*91.06*	*14.33*	*0.85*	*1.20*	*57.46*	*0.91*	*43.67*	*0.74*	*35.62*
◆	*32.31*	*91.46*	*14.40*	*0.84*	*2.00*	*95.76*	*1.40*	*67.22*	*1.26*	*60.33*
▲	*32.55*	*91.10*	*14.34*	*0.85*	*4.00*	*191.52*	*2.54*	*121.81*	*2.45*	*117.21*

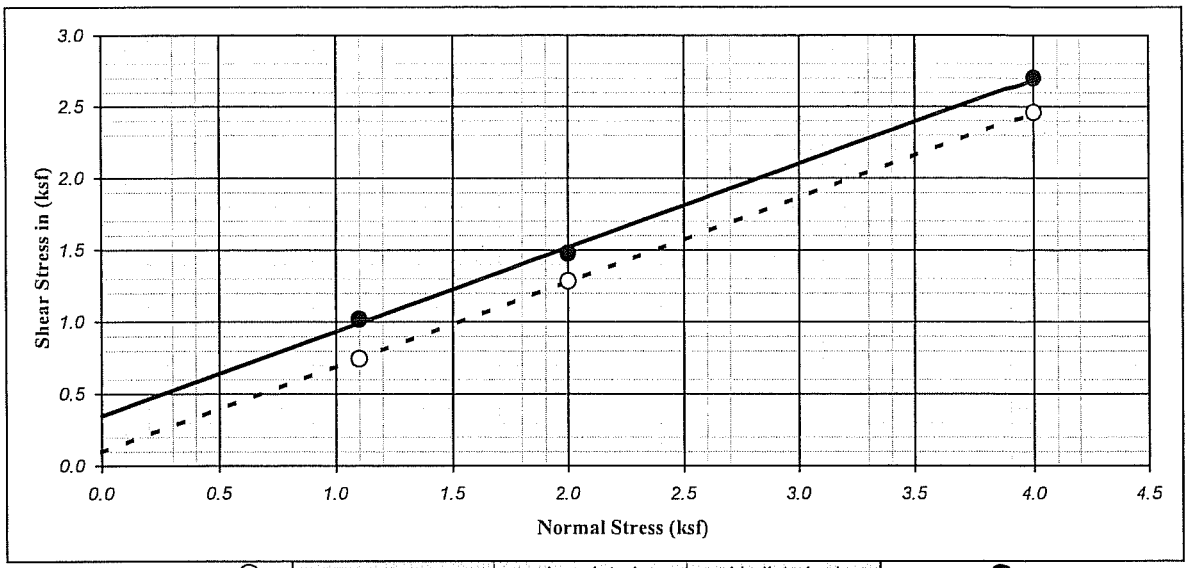
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

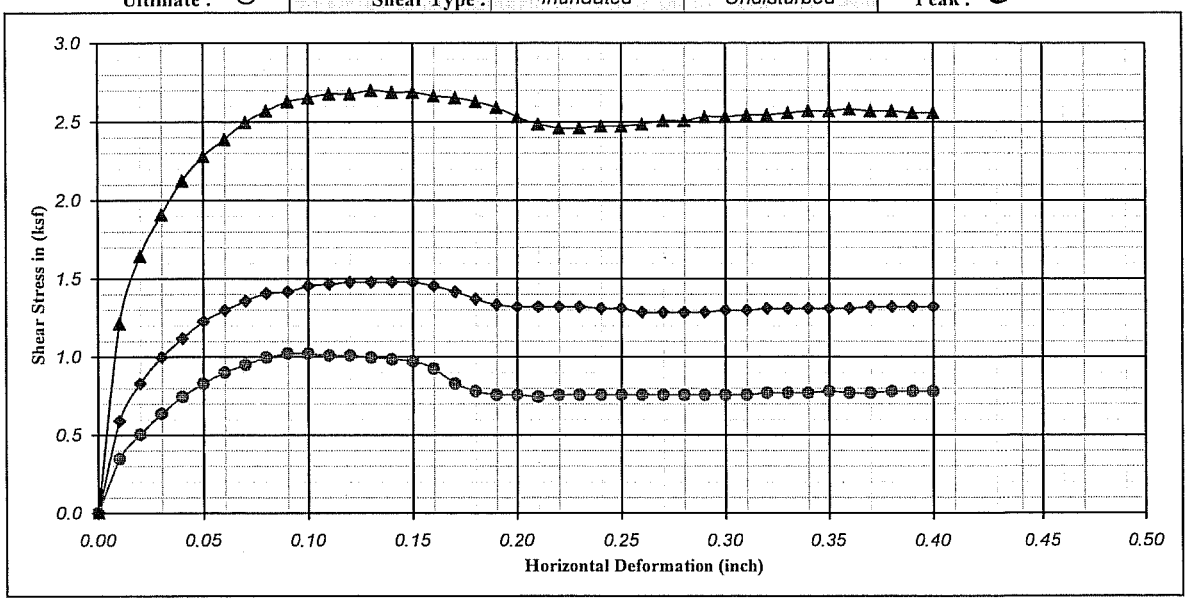
DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* | Date : *11/30/09*

Figure No. :



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : WR-09-042	Strength Intercept (C) :	0.35	(ksf)	Peak	0.10	(ksf)	Ultimate
Sample No. : D-4		16.67	(kPa)		4.65	(kPa)	
Depth (ft/ft) : 73.0 19.00	Friction Angle (ϕ) :	30.32	Degree		30.59	Degree	
Description : Dark gray, SANDY SILT (ML)					Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	24.35	104.28	16.41	0.62	1.10	52.67	1.02	48.84	0.74	35.62
◆	25.42	102.10	16.07	0.65	2.00	95.76	1.48	70.67	1.28	61.48
▲	25.73	102.18	16.08	0.65	4.00	191.52	2.70	129.28	2.46	117.78

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

UNCONSOLIDATED UNDRAINED TRIAXIAL

AP Engineering & Testing, Inc.

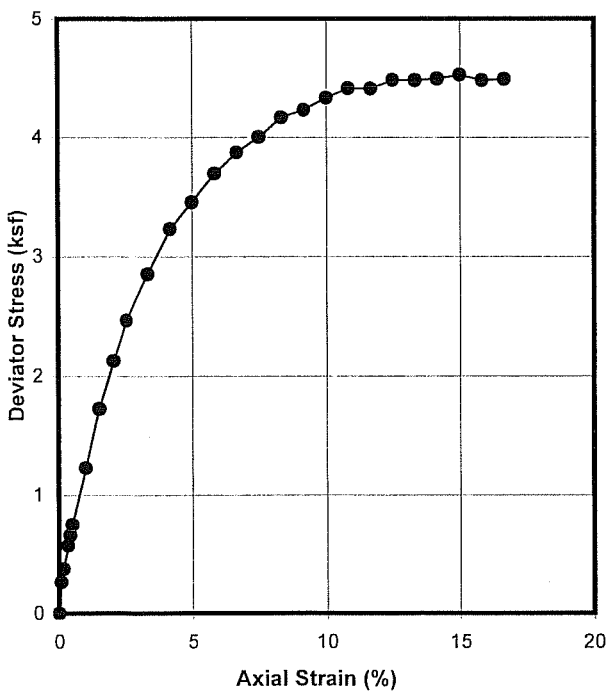
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KM Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/01/09
Project No.:	06-123-03		
Boring No.:	R-09-003		
Sample No.:	U-11 Depth (feet): 55		
Soil Description	Gray Silt with sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	123.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	95.8
Sample Weight (gms):	1260.99	Moisture Content (%):	28.7
Wt. Wet Soil+Container(gms)	1414.86	Void Ratio for Gs=2.7:	0.76
Wt. Dry Soil+Container(gms)	1132.6	% Saturation:	102.0
Wt. Container (gms)	148.77		

TEST DATA

Cell Pressure (ksf):	2.16
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.16
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.5
Ultimate Deviator Stress (ksf):	4.5
Ultimate Undrained Shear Strength (ksf):	2.2
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
17	0.010	6.50	0.38	0.17
26	0.020	6.51	0.57	0.33
30	0.025	6.52	0.66	0.42
34	0.030	6.52	0.75	0.50
56	0.060	6.56	1.23	1.00
79	0.090	6.59	1.73	1.50
98	0.120	6.62	2.13	2.00
114	0.150	6.66	2.47	2.50
133	0.200	6.72	2.85	3.33
152	0.250	6.77	3.23	4.17
164	0.300	6.83	3.46	5.00
177	0.350	6.89	3.70	5.83
187	0.400	6.96	3.87	6.67
195	0.450	7.02	4.00	7.50
205	0.500	7.08	4.17	8.33
210	0.550	7.15	4.23	9.17
217	0.600	7.21	4.33	10.00
223	0.650	7.28	4.41	10.83
225	0.700	7.35	4.41	11.67
231	0.750	7.42	4.48	12.50
233	0.800	7.49	4.48	13.33
236	0.850	7.56	4.49	14.17
240	0.900	7.64	4.53	15.00
240	0.950	7.71	4.48	15.83
243	1.000	7.79	4.49	16.67

AP Engineering & Testing, Inc.

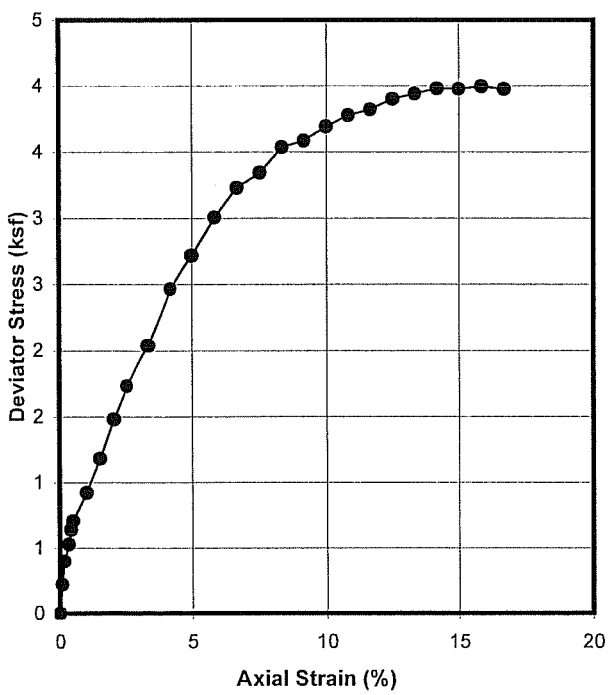
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-005				
Sample No.:	U-14	Depth (feet): 70			
Soil Description	Gray Silty Clay		Sample Type:	Shelby	

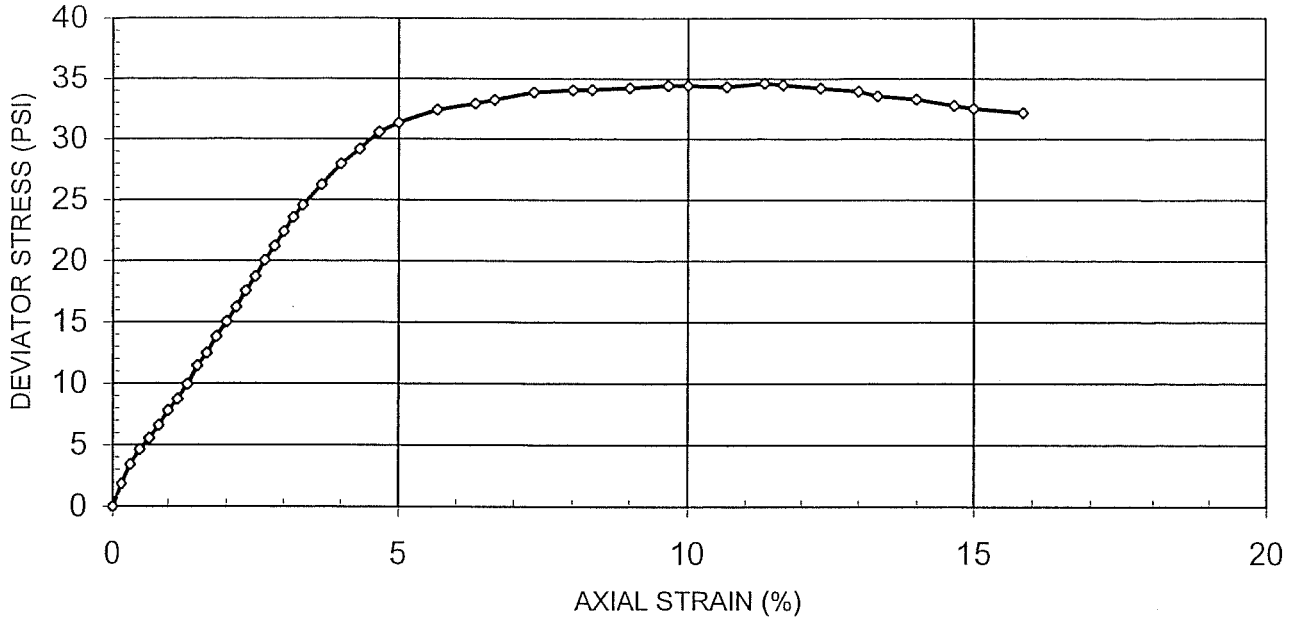
Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	123.2
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	95.6
Sample Weight (gms):	1260.28	Moisture Content (%):	28.9
Wt. Wet Soil+Container(gms)	1463.88	Void Ratio for Gs=2.7:	0.76
Wt. Dry Soil+Container(gms)	1179.00	% Saturation:	102.3
Wt. Container (gms)	193.47		

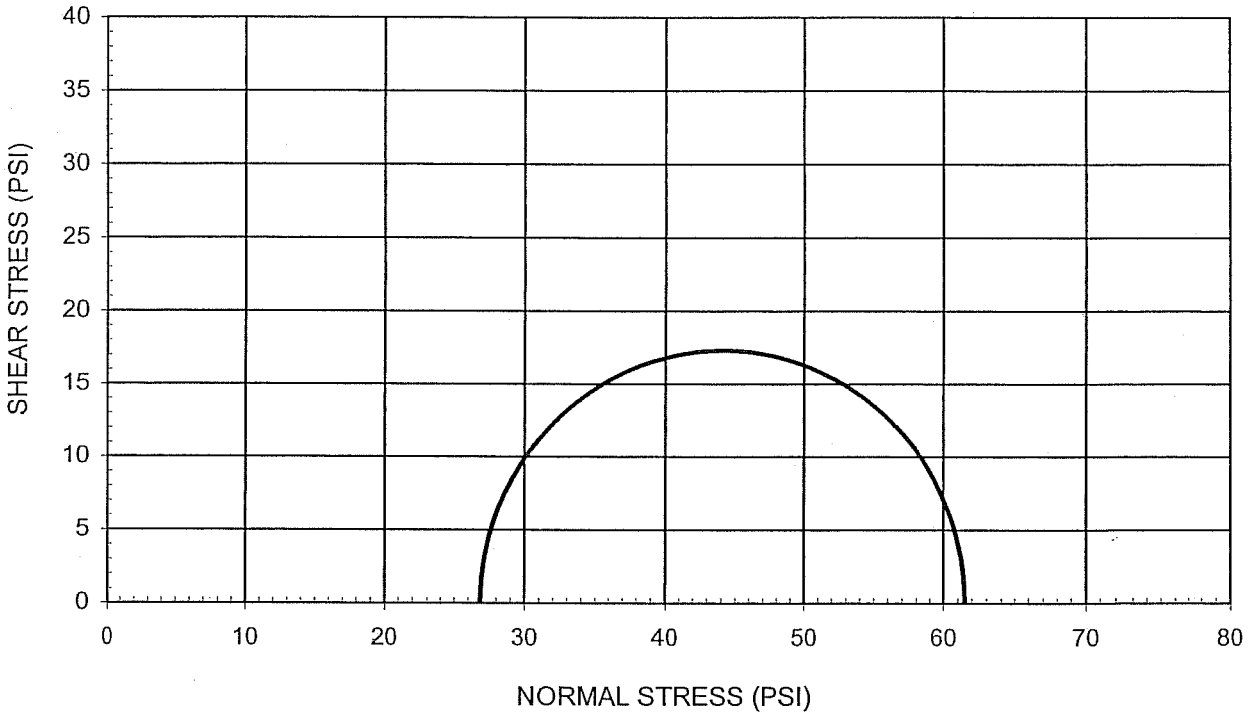
TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.0
Ultimate Deviator Stress (ksf):	4.0
Ultimate Undrained Shear Strength (ksf):	2.0
Axial Strain @ Maximum Stress (%)	15.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
10	0.005	6.50	0.22	0.08
18	0.010	6.50	0.40	0.17
24	0.020	6.51	0.53	0.33
29	0.025	6.52	0.64	0.42
32	0.030	6.52	0.71	0.50
42	0.060	6.56	0.92	1.00
54	0.090	6.59	1.18	1.50
68	0.120	6.62	1.48	2.00
80	0.150	6.66	1.73	2.50
95	0.200	6.72	2.04	3.33
116	0.250	6.77	2.47	4.17
129	0.300	6.83	2.72	5.00
144	0.350	6.89	3.01	5.83
156	0.400	6.96	3.23	6.67
163	0.450	7.02	3.34	7.50
174	0.500	7.08	3.54	8.33
178	0.550	7.15	3.59	9.17
185	0.600	7.21	3.69	10.00
191	0.650	7.28	3.78	10.83
195	0.700	7.35	3.82	11.67
201	0.750	7.42	3.90	12.50
205	0.800	7.49	3.94	13.33
209	0.850	7.56	3.98	14.17
211	0.900	7.64	3.98	15.00
214	0.950	7.71	4.00	15.83
215	1.000	7.79	3.97	16.67





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-004	100	U-21	CH	Shelby Tube	46.17	73.6	27.0	34.6	0.06	96.6

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

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(ASTM D2850)

11/30/09

Figure

AP Engineering & Testing, Inc.

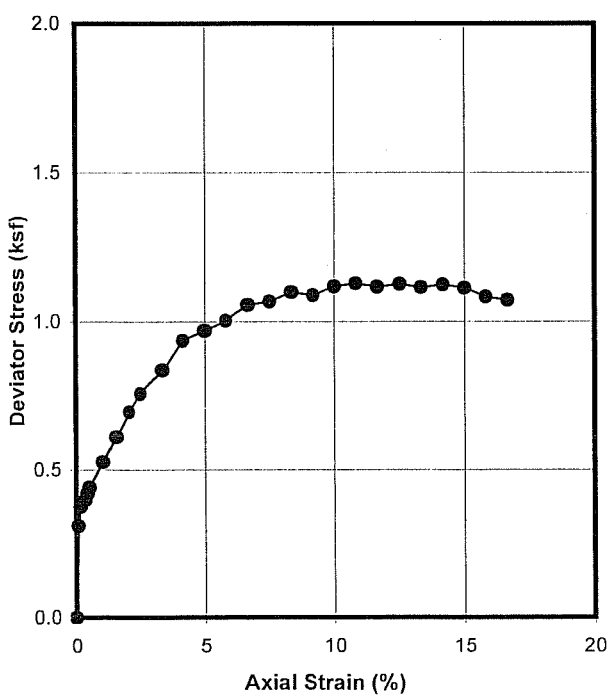
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/11/09
Project No.:	06-123-03				
Boring No.:	R-09-006				
Sample No.:	U-07	Depth (feet): 35			
Soil Description	Gray Silt		Sample Type:	Shelby	

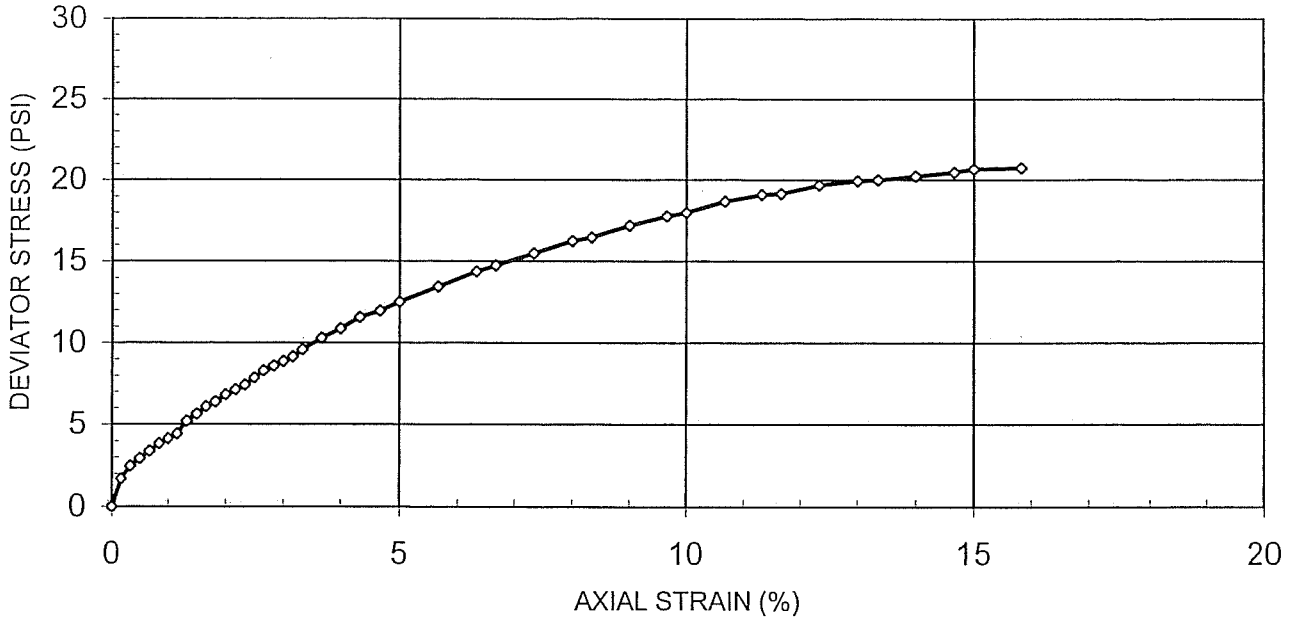
Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	108.6
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	73.4
Sample Weight (gms):	1111.12	Moisture Content (%):	48.0
Wt. Wet Soil+Container(gms)	1308.27	Void Ratio for Gs=2.7:	1.30
Wt. Dry Soil+Container(gms)	947.43	% Saturation:	100.0
Wt. Container (gms)	195.18		

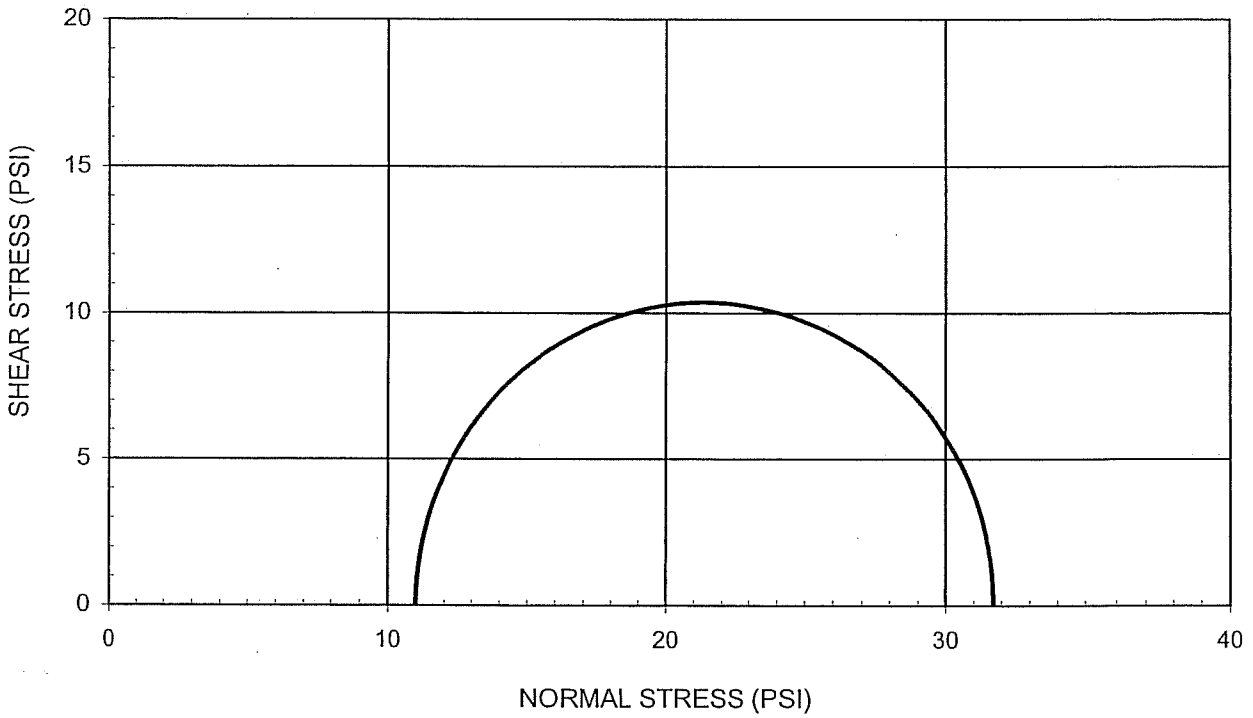
TEST DATA

Cell Pressure (ksf):	1.30
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.30
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.1
Ultimate Deviator Stress (ksf):	1.1
Ultimate Undrained Shear Strength (ksf):	0.6
Axial Strain @ Maximum Stress (%)	10.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
14	0.005	6.50	0.31	0.08
17	0.010	6.50	0.38	0.17
18	0.020	6.51	0.40	0.33
19	0.025	6.52	0.42	0.42
20	0.030	6.52	0.44	0.50
24	0.060	6.56	0.53	1.00
28	0.090	6.59	0.61	1.50
32	0.120	6.62	0.70	2.00
35	0.150	6.66	0.76	2.50
39	0.200	6.72	0.84	3.33
44	0.250	6.77	0.94	4.17
46	0.300	6.83	0.97	5.00
48	0.350	6.89	1.00	5.83
51	0.400	6.96	1.06	6.67
52	0.450	7.02	1.07	7.50
54	0.500	7.08	1.10	8.33
54	0.550	7.15	1.09	9.17
56	0.600	7.21	1.12	10.00
57	0.650	7.28	1.13	10.83
57	0.700	7.35	1.12	11.67
58	0.750	7.42	1.13	12.50
58	0.800	7.49	1.12	13.33
59	0.850	7.56	1.12	14.17
59	0.900	7.64	1.11	15.00
58	0.950	7.71	1.08	15.83
58	1.000	7.79	1.07	16.67





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-007	40	U-08	CL	Shelby Tube	40.84	80.7	11.0	20.7	0.06	101.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

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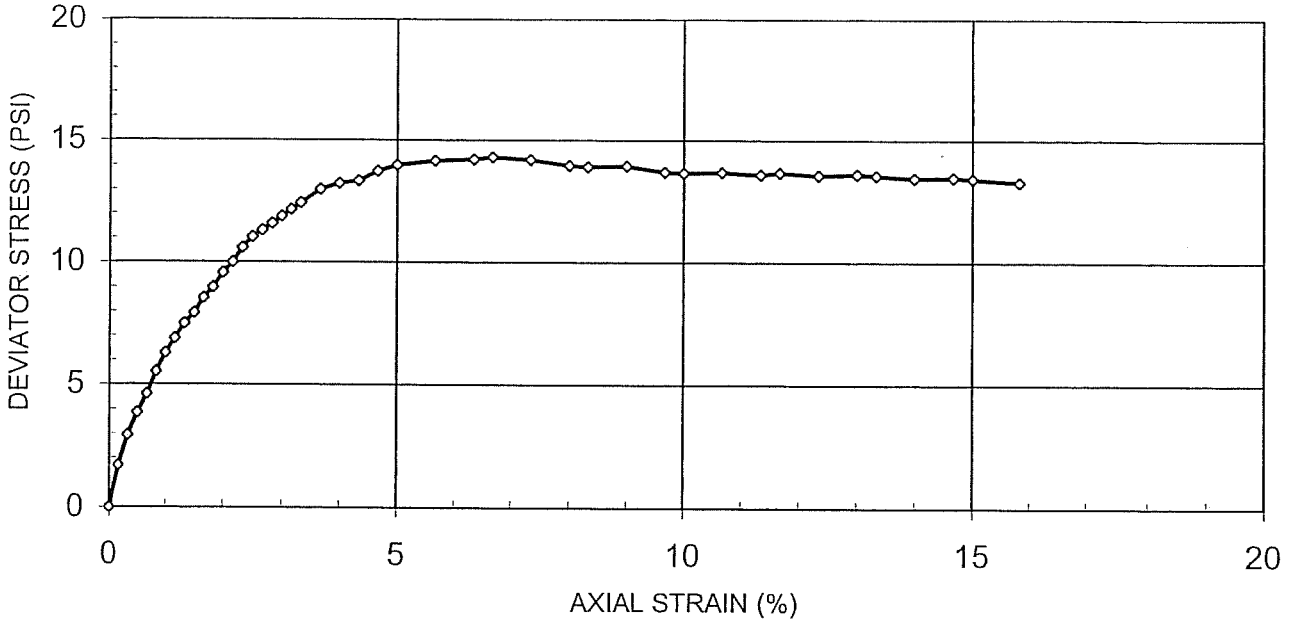
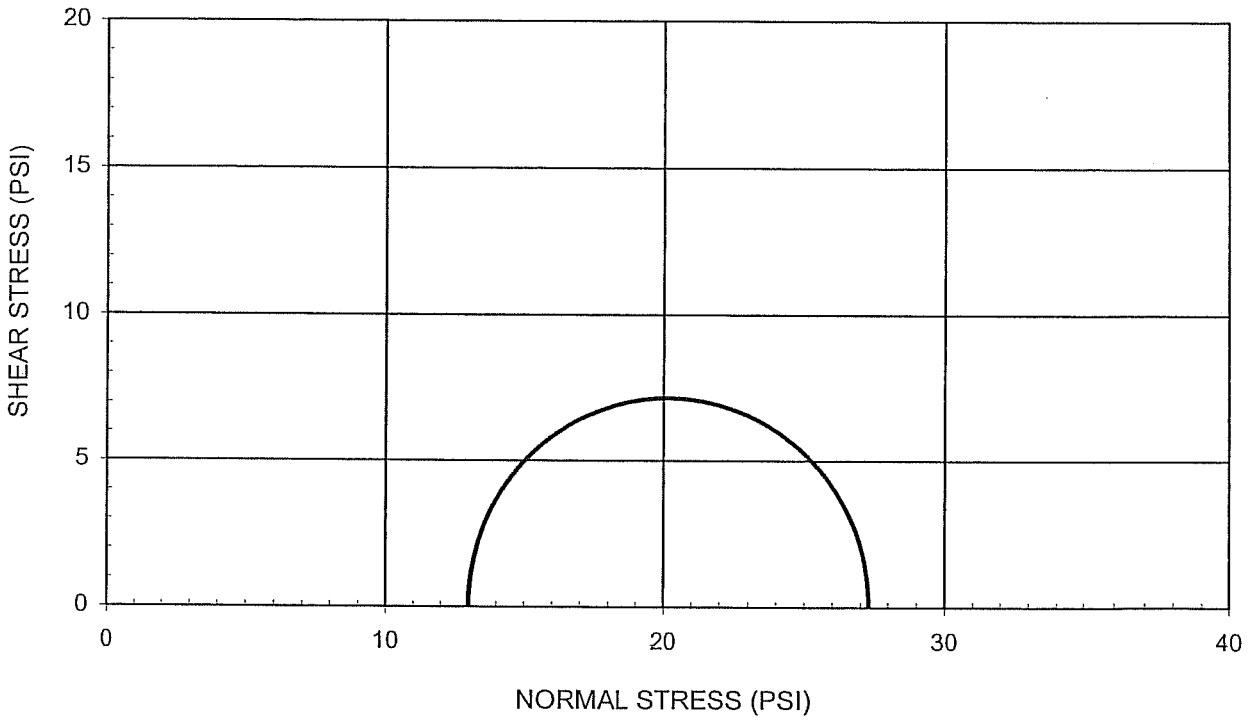
Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-007	50	U-10	CL	Shelby Tube	46.65	74.5	13.0	14.3	0.06	99.9

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

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11/30/09

Figure

AP Engineering & Testing, Inc.

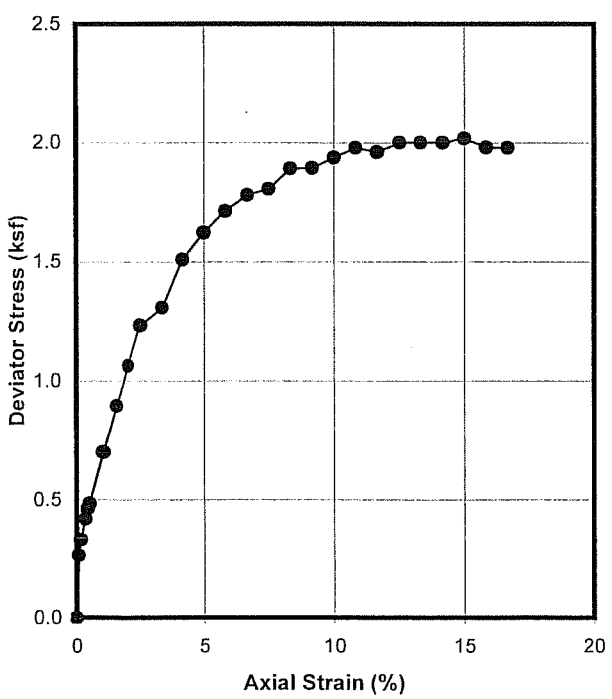
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-009				
Sample No.:	U-09	Depth (feet): 45			
Soil Description	Gray Lean Clay w/sand and shell fragments		Sample Type:	Shelby	

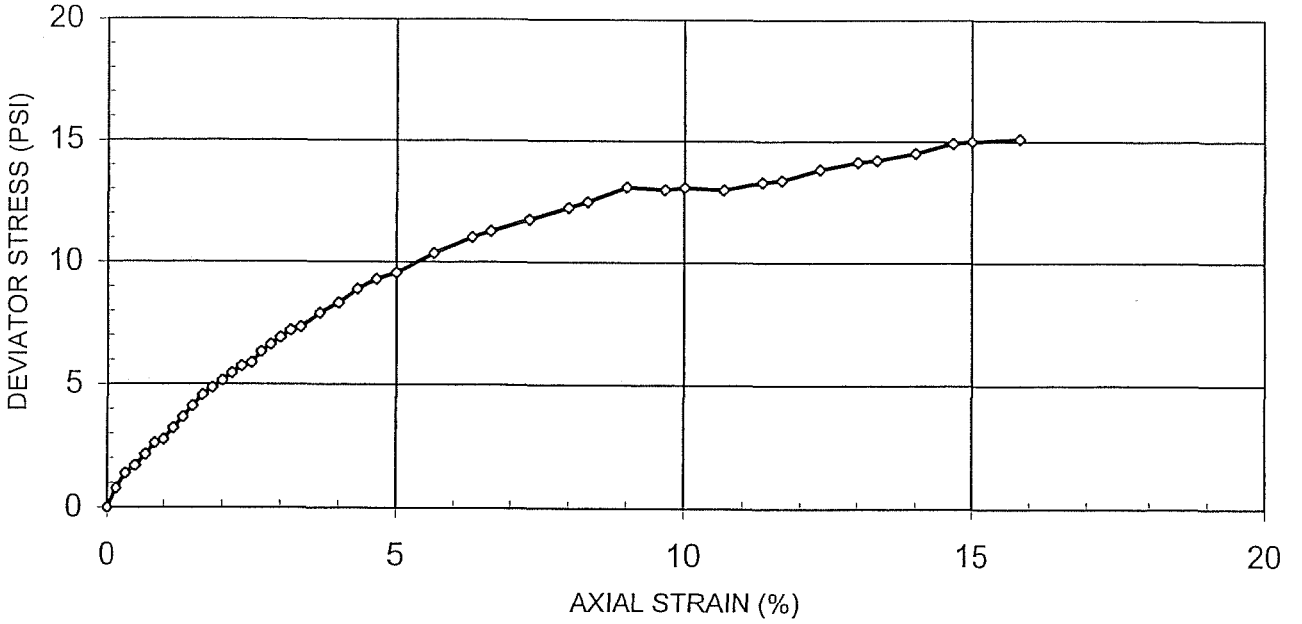
Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	118.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	89.1
Sample Weight (gms):	1216.40	Moisture Content (%):	33.5
Wt. Wet Soil+Container(gms)	1327.82	Void Ratio for Gs=2.7:	0.89
Wt. Dry Soil+Container(gms)	1020.96	% Saturation:	101.4
Wt. Container (gms)	104.89		

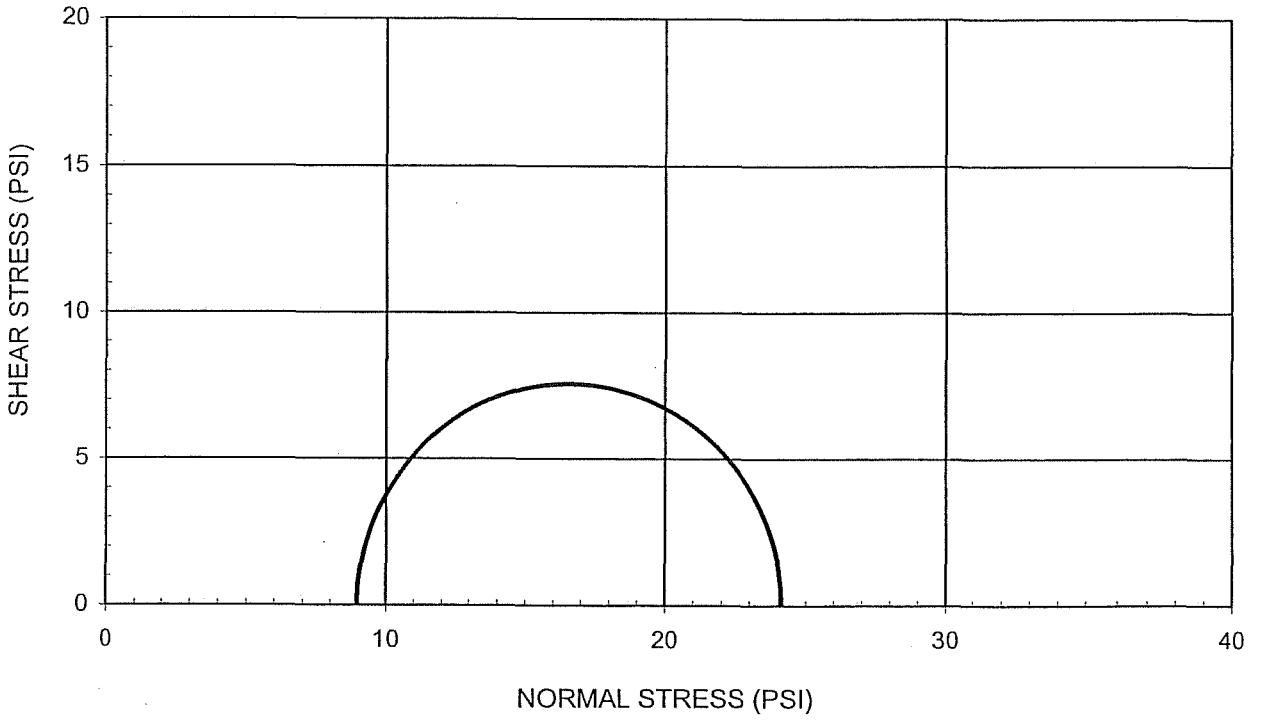
TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	2.0
Ultimate Deviator Stress (ksf):	2.0
Ultimate Undrained Shear Strength (ksf):	1.0
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
15	0.010	6.50	0.33	0.17
19	0.020	6.51	0.42	0.33
21	0.025	6.52	0.46	0.42
22	0.030	6.52	0.49	0.50
32	0.060	6.56	0.70	1.00
41	0.090	6.59	0.90	1.50
49	0.120	6.62	1.07	2.00
57	0.150	6.66	1.23	2.50
61	0.200	6.72	1.31	3.33
71	0.250	6.77	1.51	4.17
77	0.300	6.83	1.62	5.00
82	0.350	6.89	1.71	5.83
86	0.400	6.96	1.78	6.67
88	0.450	7.02	1.81	7.50
93	0.500	7.08	1.89	8.33
94	0.550	7.15	1.89	9.17
97	0.600	7.21	1.94	10.00
100	0.650	7.28	1.98	10.83
100	0.700	7.35	1.96	11.67
103	0.750	7.42	2.00	12.50
104	0.800	7.49	2.00	13.33
105	0.850	7.56	2.00	14.17
107	0.900	7.64	2.02	15.00
106	0.950	7.71	1.98	15.83
107	1.000	7.79	1.98	16.67





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-010	30	U-06	ML	Shelby Tube	32.09	90.5	9.0	15.1	0.06	100.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

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Figure

AP Engineering & Testing, Inc.

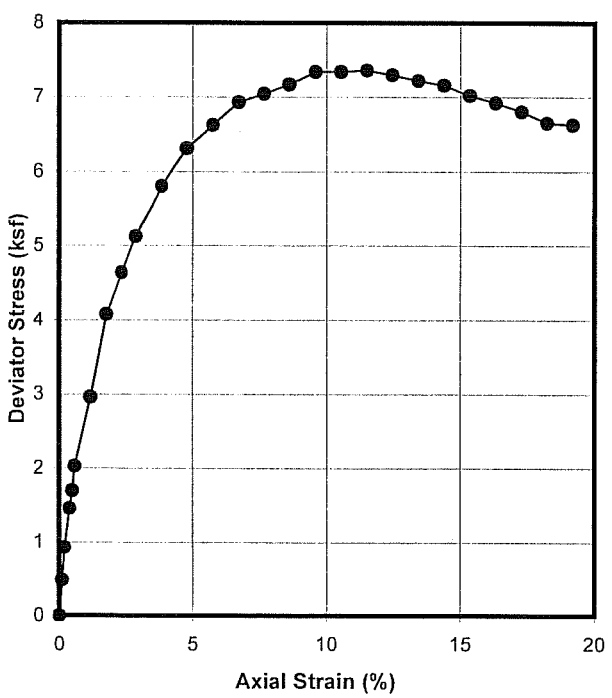
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-011				
Sample No.:	U-14	Depth (feet): 70			
Soil Description	Gray Sandy Silt		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	129.4
Sample Hieght (inch):	5.2	Dry Unit Weight (pcf):	106.1
Sample Weight (gms):	1149.87	Moisture Content (%):	22.0
Wt. Wet Soil+Container(gms)	1310.19	Void Ratio for Gs=2.7:	0.59
Wt. Dry Soil+Container(gms)	1101.86	% Saturation:	101.0
Wt. Container (gms)	154.83		

TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	7.4
Ultimate Deviator Stress (ksf):	6.9
Ultimate Undrained Shear Strength (ksf):	3.5
Axial Strain @ Maximum Stress (%)	11.52



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
22	0.005	6.50	0.49	0.10
42	0.010	6.50	0.93	0.19
66	0.020	6.52	1.46	0.38
77	0.025	6.52	1.70	0.48
92	0.030	6.53	2.03	0.58
135	0.060	6.57	2.96	1.15
187	0.090	6.61	4.08	1.73
214	0.120	6.64	4.64	2.30
238	0.150	6.68	5.13	2.88
272	0.200	6.75	5.80	3.84
299	0.250	6.82	6.31	4.80
317	0.300	6.89	6.63	5.76
335	0.350	6.96	6.93	6.72
344	0.400	7.03	7.04	7.68
354	0.450	7.11	7.17	8.64
366	0.500	7.18	7.34	9.60
370	0.550	7.26	7.34	10.56
375	0.600	7.34	7.36	11.52
376	0.650	7.42	7.30	12.48
376	0.700	7.50	7.22	13.44
377	0.750	7.58	7.16	14.40
374	0.800	7.67	7.02	15.36
373	0.850	7.76	6.92	16.31
371	0.900	7.85	6.81	17.27
367	0.950	7.94	6.66	18.23
370	1.000	8.03	6.63	19.19

AP Engineering & Testing, Inc.

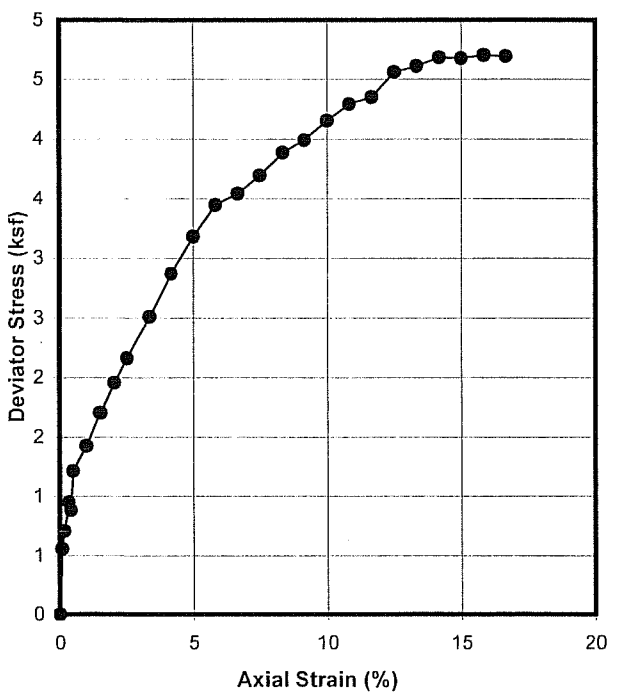
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-012				
Sample No.:	U-10A	Depth (feet): 51.5			
Soil Description	Gray Sandy Silt		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	123.5
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	96.9
Sample Weight (gms):	1263.87	Moisture Content (%):	27.5
Wt. Wet Soil+Container(gms)	1451.08	Void Ratio for Gs=2.7:	0.74
Wt. Dry Soil+Container(gms)	1179.72	% Saturation:	100.4
Wt. Container (gms)	191.91		

TEST DATA

Cell Pressure (ksf):	2.59
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.59
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.7
Ultimate Deviator Stress (ksf):	4.7
Ultimate Undrained Shear Strength (ksf):	2.3
Axial Strain @ Maximum Stress (%)	15.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
25	0.005	6.50	0.55	0.08
32	0.010	6.50	0.71	0.17
43	0.020	6.51	0.95	0.33
40	0.025	6.52	0.88	0.42
55	0.030	6.52	1.21	0.50
65	0.060	6.56	1.43	1.00
78	0.090	6.59	1.70	1.50
90	0.120	6.62	1.96	2.00
100	0.150	6.66	2.16	2.50
117	0.200	6.72	2.51	3.33
135	0.250	6.77	2.87	4.17
151	0.300	6.83	3.18	5.00
165	0.350	6.89	3.45	5.83
171	0.400	6.96	3.54	6.67
180	0.450	7.02	3.69	7.50
191	0.500	7.08	3.88	8.33
198	0.550	7.15	3.99	9.17
208	0.600	7.21	4.15	10.00
217	0.650	7.28	4.29	10.83
222	0.700	7.35	4.35	11.67
235	0.750	7.42	4.56	12.50
240	0.800	7.49	4.61	13.33
246	0.850	7.56	4.68	14.17
248	0.900	7.64	4.68	15.00
252	0.950	7.71	4.70	15.83
254	1.000	7.79	4.70	16.67

AP Engineering & Testing, Inc.

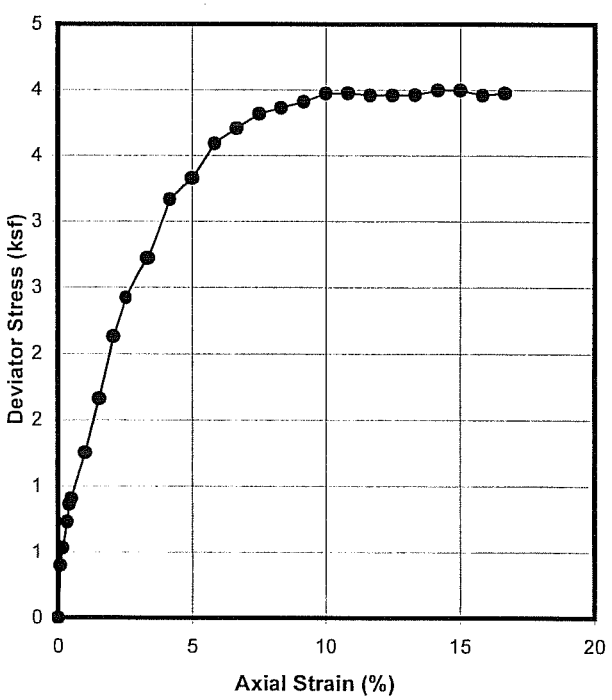
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-012				
Sample No.:	U-16	Depth (feet): 80			
Soil Description	Gray Lean Clay		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	116.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	85.1
Sample Weight (gms):	1190.00	Moisture Content (%):	36.6
Wt. Wet Soil+Container(gms)	1396.63	Void Ratio for Gs=2.7:	0.98
Wt. Dry Soil+Container(gms)	1075.08	% Saturation:	101.0
Wt. Container (gms)	196.61		

TEST DATA

Cell Pressure (ksf):	3.60
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	3.60
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.0
Ultimate Deviator Stress (ksf):	4.0
Ultimate Undrained Shear Strength (ksf):	2.0
Axial Strain @ Maximum Stress (%)	14.17



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
18	0.005	6.50	0.40	0.08
24	0.010	6.50	0.53	0.17
33	0.020	6.51	0.73	0.33
39	0.025	6.52	0.86	0.42
41	0.030	6.52	0.90	0.50
57	0.060	6.56	1.25	1.00
76	0.090	6.59	1.66	1.50
98	0.120	6.62	2.13	2.00
112	0.150	6.66	2.42	2.50
127	0.200	6.72	2.72	3.33
149	0.250	6.77	3.17	4.17
158	0.300	6.83	3.33	5.00
172	0.350	6.89	3.59	5.83
179	0.400	6.96	3.71	6.67
186	0.450	7.02	3.82	7.50
190	0.500	7.08	3.86	8.33
194	0.550	7.15	3.91	9.17
199	0.600	7.21	3.97	10.00
201	0.650	7.28	3.98	10.83
202	0.700	7.35	3.96	11.67
204	0.750	7.42	3.96	12.50
206	0.800	7.49	3.96	13.33
210	0.850	7.56	4.00	14.17
212	0.900	7.64	4.00	15.00
212	0.950	7.71	3.96	15.83
215	1.000	7.79	3.97	16.67

AP Engineering & Testing, Inc.

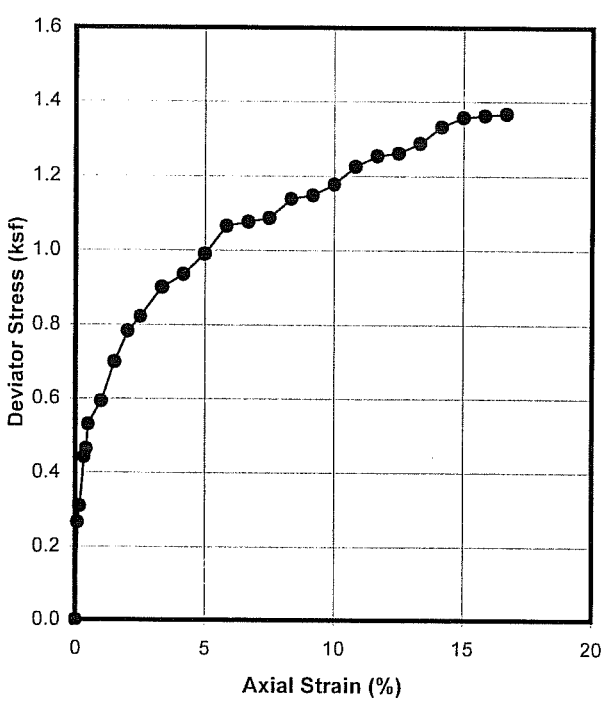
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/12/09
Project No.:	06-123-03		
Boring No.:	R-09-013		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silty Clay with sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	110.8
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	77.7
Sample Weight (gms):	1133.95	Moisture Content (%):	42.7
Wt. Wet Soil+Container(gms)	1238.93	Void Ratio for Gs=2.7:	1.17
Wt. Dry Soil+Container(gms)	899.10	% Saturation:	98.6
Wt. Container (gms)	103.89		

TEST DATA

Cell Pressure (ksf):	1.01
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.01
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.4
Ultimate Deviator Stress (ksf):	1.3
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
14	0.010	6.50	0.31	0.17
20	0.020	6.51	0.44	0.33
21	0.025	6.52	0.46	0.42
24	0.030	6.52	0.53	0.50
27	0.060	6.56	0.59	1.00
32	0.090	6.59	0.70	1.50
36	0.120	6.62	0.78	2.00
38	0.150	6.66	0.82	2.50
42	0.200	6.72	0.90	3.33
44	0.250	6.77	0.94	4.17
47	0.300	6.83	0.99	5.00
51	0.350	6.89	1.07	5.83
52	0.400	6.96	1.08	6.67
53	0.450	7.02	1.09	7.50
56	0.500	7.08	1.14	8.33
57	0.550	7.15	1.15	9.17
59	0.600	7.21	1.18	10.00
62	0.650	7.28	1.23	10.83
64	0.700	7.35	1.25	11.67
65	0.750	7.42	1.26	12.50
67	0.800	7.49	1.29	13.33
70	0.850	7.56	1.33	14.17
72	0.900	7.64	1.36	15.00
73	0.950	7.71	1.36	15.83
74	1.000	7.79	1.37	16.67

AP Engineering & Testing, Inc.

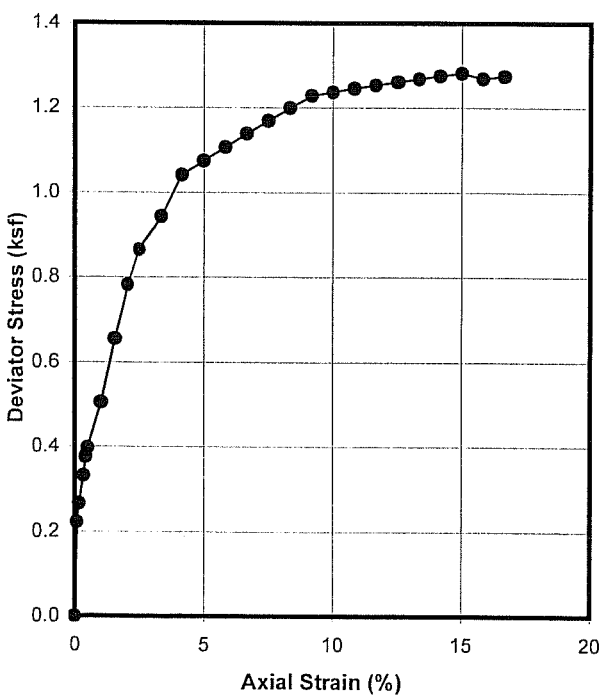
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-013				
Sample No.:	U-08	Depth (feet): 25			
Soil Description	Gray Lean Clay with sand		Sample Type:	Shelby	

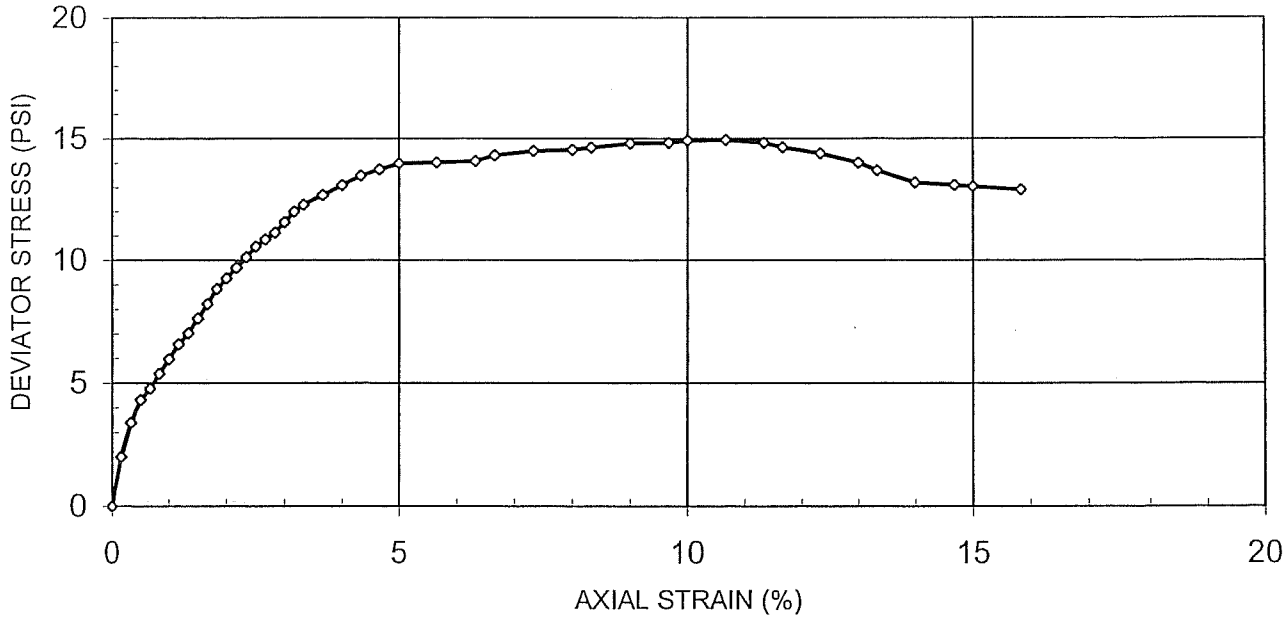
Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	114.5
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	81.1
Sample Weight (gms):	1171.80	Moisture Content (%):	41.3
Wt. Wet Soil+Container(gms)	1327.70	Void Ratio for Gs=2.7:	1.08
Wt. Dry Soil+Container(gms)	984.72	% Saturation:	103.4
Wt. Container (gms)	154.45		

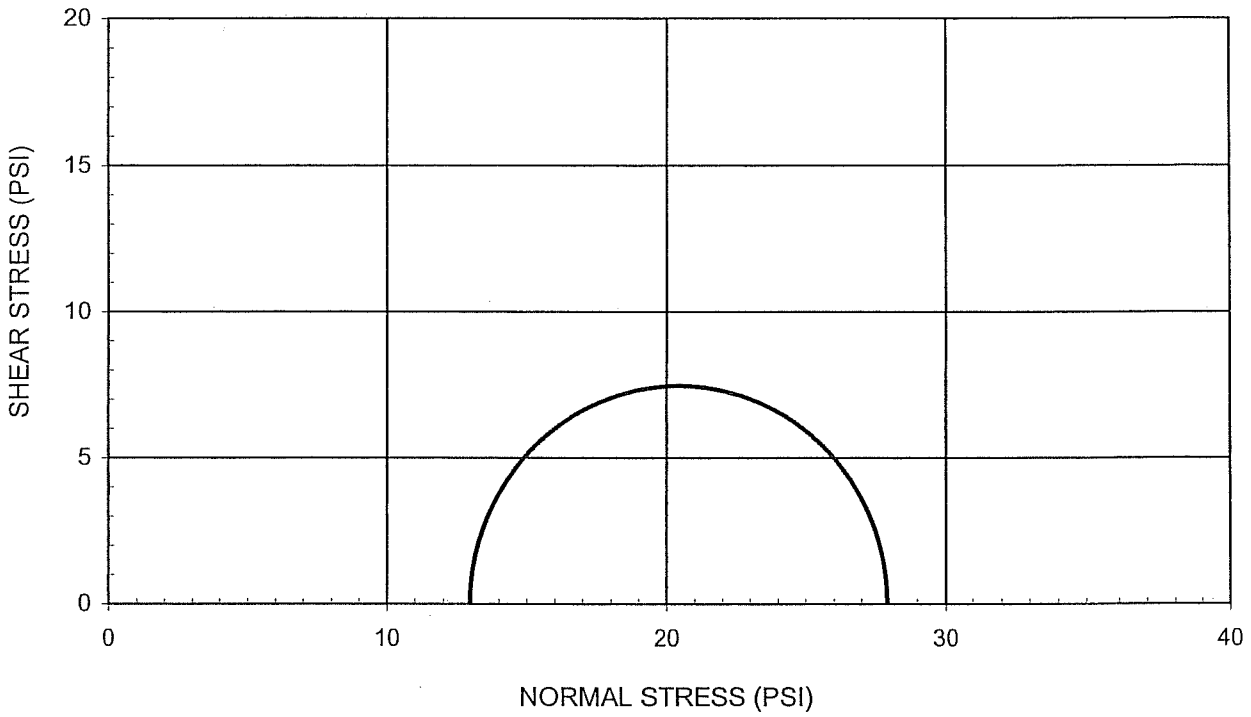
TEST DATA

Cell Pressure (ksf):	1.58
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.58
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.3
Ultimate Deviator Stress (ksf):	1.3
Ultimate Undrained Shear Strength (ksf):	0.6
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
10	0.005	6.50	0.22	0.08
12	0.010	6.50	0.27	0.17
15	0.020	6.51	0.33	0.33
17	0.025	6.52	0.38	0.42
18	0.030	6.52	0.40	0.50
23	0.060	6.56	0.51	1.00
30	0.090	6.59	0.66	1.50
36	0.120	6.62	0.78	2.00
40	0.150	6.66	0.87	2.50
44	0.200	6.72	0.94	3.33
49	0.250	6.77	1.04	4.17
51	0.300	6.83	1.07	5.00
53	0.350	6.89	1.11	5.83
55	0.400	6.96	1.14	6.67
57	0.450	7.02	1.17	7.50
59	0.500	7.08	1.20	8.33
61	0.550	7.15	1.23	9.17
62	0.600	7.21	1.24	10.00
63	0.650	7.28	1.25	10.83
64	0.700	7.35	1.25	11.67
65	0.750	7.42	1.26	12.50
66	0.800	7.49	1.27	13.33
67	0.850	7.56	1.28	14.17
68	0.900	7.64	1.28	15.00
68	0.950	7.71	1.27	15.83
69	1.000	7.79	1.28	16.67





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-014	50	U-11	CL	Shelby Tube	46.54	75.1	13.0	14.9	0.06	101.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

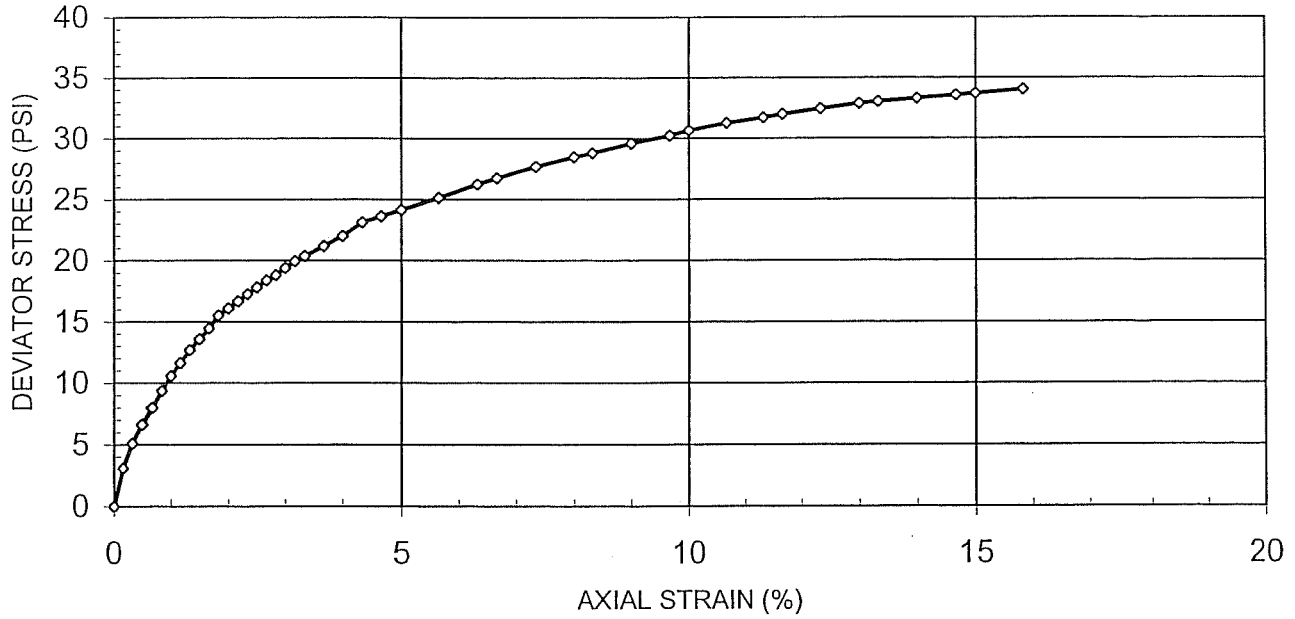
EGL Project No: 09-230-008

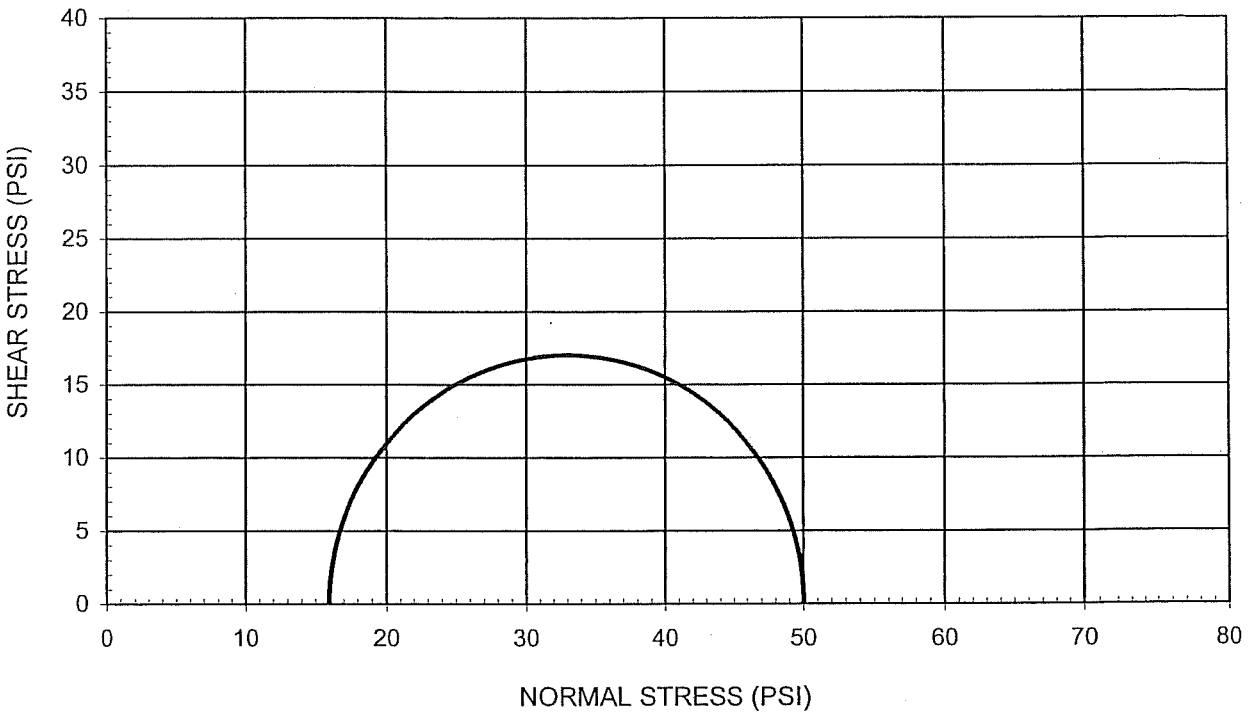
UNCONSOLIDATED UNDRAINED

(ASTM D2850)

11/30/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-014	60	U-13	CL	Shelby Tube	36.13	86.2	16.0	34.0	0.06	102.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

(ASTM D2850)

11/29/09

Figure

AP Engineering & Testing, Inc.

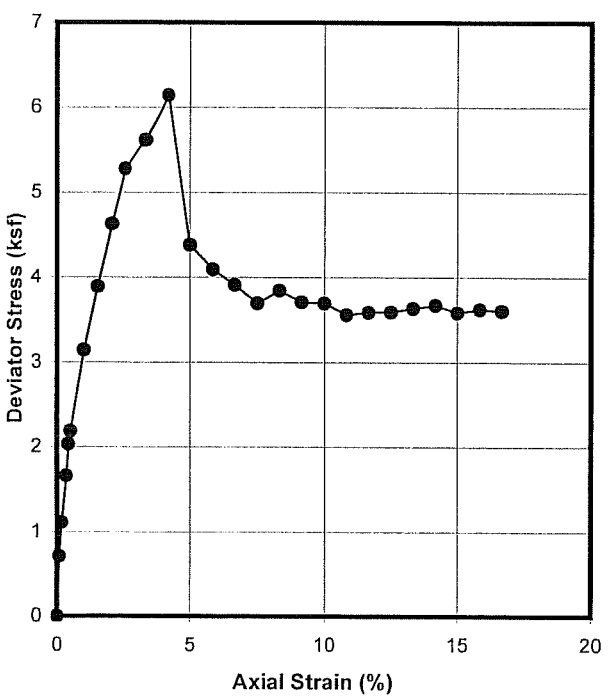
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-016				
Sample No.:	U-09	Depth (feet): 45			
Soil Description	Gray Silty Sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	121.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	96.0
Sample Weight (gms):	1241.34	Moisture Content (%):	26.4
Wt. Wet Soil+Container(gms)	1448.54	Void Ratio for Gs=2.7:	0.76
Wt. Dry Soil+Container(gms)	1186.41	% Saturation:	94.4
Wt. Container (gms)	194.62		

TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	6.1
Ultimate Deviator Stress (ksf):	3.7
Ultimate Undrained Shear Strength (ksf):	1.8
Axial Strain @ Maximum Stress (%)	4.17



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
32	0.005	6.50	0.71	0.08
50	0.010	6.50	1.11	0.17
75	0.020	6.51	1.66	0.33
92	0.025	6.52	2.03	0.42
99	0.030	6.52	2.19	0.50
143	0.060	6.56	3.14	1.00
178	0.090	6.59	3.89	1.50
213	0.120	6.62	4.63	2.00
244	0.150	6.66	5.28	2.50
262	0.200	6.72	5.62	3.33
289	0.250	6.77	6.14	4.17
208	0.300	6.83	4.38	5.00
196	0.350	6.89	4.09	5.83
189	0.400	6.96	3.91	6.67
180	0.450	7.02	3.69	7.50
189	0.500	7.08	3.84	8.33
184	0.550	7.15	3.71	9.17
185	0.600	7.21	3.69	10.00
180	0.650	7.28	3.56	10.83
183	0.700	7.35	3.59	11.67
185	0.750	7.42	3.59	12.50
189	0.800	7.49	3.63	13.33
193	0.850	7.56	3.67	14.17
190	0.900	7.64	3.58	15.00
194	0.950	7.71	3.62	15.83
195	1.000	7.79	3.60	16.67

AP Engineering & Testing, Inc.

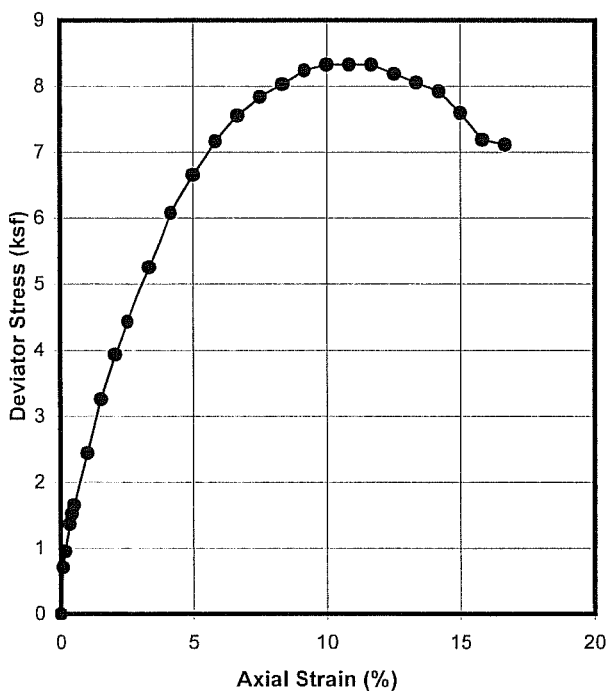
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-016				
Sample No.:	U-14	Depth (feet): 70			
Soil Description	Gray Silty Sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	127.4
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	102.8
Sample Weight (gms):	1303.38	Moisture Content (%):	24.0
Wt. Wet Soil+Container(gms)	1419.78	Void Ratio for Gs=2.7:	0.64
Wt. Dry Soil+Container(gms)	1165.60	% Saturation:	101.2
Wt. Container (gms)	104.45		

TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	8.3
Ultimate Deviator Stress (ksf):	7.9
Ultimate Undrained Shear Strength (ksf):	4.0
Axial Strain @ Maximum Stress (%)	11.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
32	0.005	6.50	0.71	0.08
43	0.010	6.50	0.95	0.17
62	0.020	6.51	1.37	0.33
69	0.025	6.52	1.52	0.42
75	0.030	6.52	1.66	0.50
111	0.060	6.56	2.44	1.00
149	0.090	6.59	3.26	1.50
181	0.120	6.62	3.93	2.00
205	0.150	6.66	4.43	2.50
245	0.200	6.72	5.25	3.33
286	0.250	6.77	6.08	4.17
316	0.300	6.83	6.66	5.00
343	0.350	6.89	7.16	5.83
365	0.400	6.96	7.56	6.67
382	0.450	7.02	7.84	7.50
395	0.500	7.08	8.03	8.33
409	0.550	7.15	8.24	9.17
417	0.600	7.21	8.32	10.00
421	0.650	7.28	8.33	10.83
425	0.700	7.35	8.33	11.67
422	0.750	7.42	8.19	12.50
419	0.800	7.49	8.05	13.33
416	0.850	7.56	7.92	14.17
403	0.900	7.64	7.60	15.00
385	0.950	7.71	7.19	15.83
385	1.000	7.79	7.12	16.67

AP Engineering & Testing, Inc.

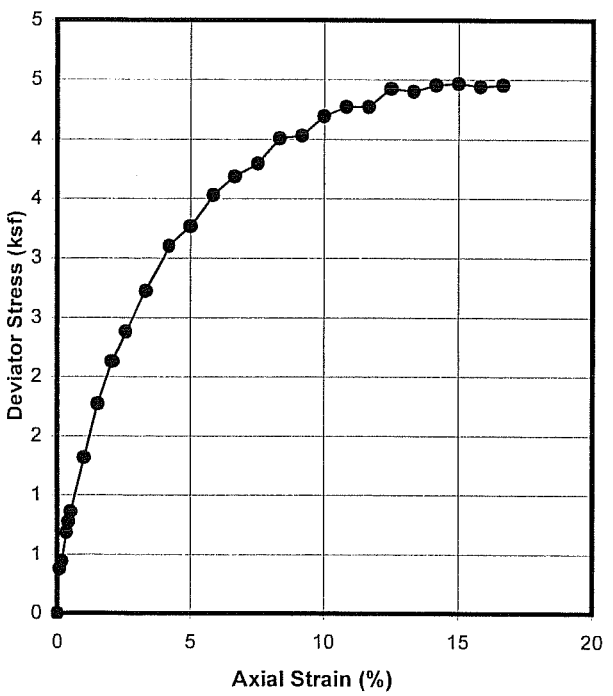
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KM	Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-017				
Sample No.:	U-11	Depth (feet): 55			
Soil Description	Gray Silt		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	120.2
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	90.4
Sample Weight (gms):	1229.71	Moisture Content (%):	32.9
Wt. Wet Soil+Container(gms)	1418.96	Void Ratio for Gs=2.7:	0.86
Wt. Dry Soil+Container(gms)	1112.21	% Saturation:	102.9
Wt. Container (gms)	179.69		

TEST DATA

Cell Pressure (ksf):	2.16
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.16
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.5
Ultimate Deviator Stress (ksf):	4.5
Ultimate Undrained Shear Strength (ksf):	2.2
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
17	0.005	6.50	0.38	0.08
20	0.010	6.50	0.44	0.17
31	0.020	6.51	0.69	0.33
35	0.025	6.52	0.77	0.42
39	0.030	6.52	0.86	0.50
60	0.060	6.56	1.32	1.00
81	0.090	6.59	1.77	1.50
98	0.120	6.62	2.13	2.00
110	0.150	6.66	2.38	2.50
127	0.200	6.72	2.72	3.33
146	0.250	6.77	3.10	4.17
155	0.300	6.83	3.27	5.00
169	0.350	6.89	3.53	5.83
178	0.400	6.96	3.69	6.67
185	0.450	7.02	3.80	7.50
197	0.500	7.08	4.01	8.33
200	0.550	7.15	4.03	9.17
210	0.600	7.21	4.19	10.00
216	0.650	7.28	4.27	10.83
218	0.700	7.35	4.27	11.67
228	0.750	7.42	4.43	12.50
229	0.800	7.49	4.40	13.33
234	0.850	7.56	4.46	14.17
237	0.900	7.64	4.47	15.00
238	0.950	7.71	4.44	15.83
241	1.000	7.79	4.45	16.67

AP Engineering & Testing, Inc.

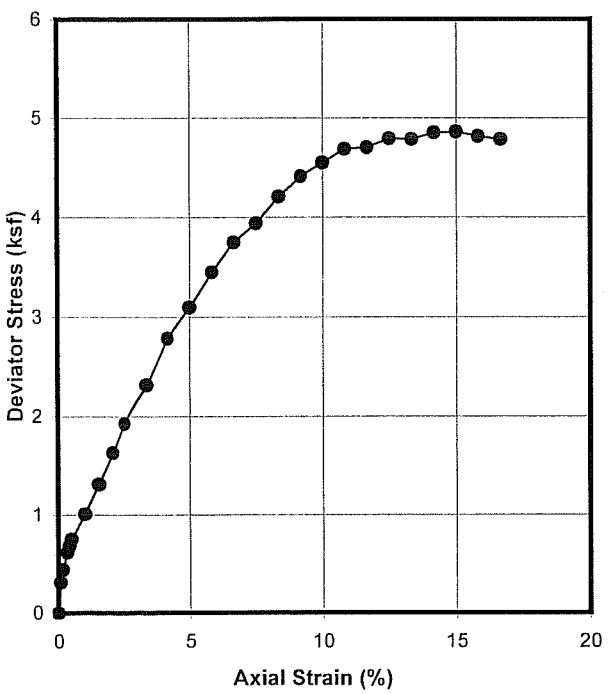
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/20/09
Project No.:	06-123-03				
Boring No.:	R-09-018				
Sample No.:	U-08	Depth (feet): 32.5			
Soil Description	Gray Silty Sand w/shell		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	120.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	93.0
Sample Weight (gms):	1236.83	Moisture Content (%):	30.0
Wt. Wet Soil+Container(gms)	1351.60	Void Ratio for Gs=2.7:	0.81
Wt. Dry Soil+Container(gms)	1063.44	% Saturation:	99.9
Wt. Container (gms)	104.20		

TEST DATA

Cell Pressure (ksf):	1.30
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.30
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	4.9
Ultimate Deviator Stress (ksf):	4.9
Ultimate Undrained Shear Strength (ksf):	2.4
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
14	0.005	6.50	0.31	0.08
20	0.010	6.50	0.44	0.17
28	0.020	6.51	0.62	0.33
31	0.025	6.52	0.68	0.42
34	0.030	6.52	0.75	0.50
46	0.060	6.56	1.01	1.00
60	0.090	6.59	1.31	1.50
75	0.120	6.62	1.63	2.00
89	0.150	6.66	1.92	2.50
108	0.200	6.72	2.32	3.33
131	0.250	6.77	2.78	4.17
147	0.300	6.83	3.10	5.00
165	0.350	6.89	3.45	5.83
181	0.400	6.96	3.75	6.67
192	0.450	7.02	3.94	7.50
207	0.500	7.08	4.21	8.33
219	0.550	7.15	4.41	9.17
228	0.600	7.21	4.55	10.00
237	0.650	7.28	4.69	10.83
240	0.700	7.35	4.70	11.67
247	0.750	7.42	4.79	12.50
249	0.800	7.49	4.79	13.33
255	0.850	7.56	4.86	14.17
258	0.900	7.64	4.86	15.00
258	0.950	7.71	4.82	15.83
259	1.000	7.79	4.79	16.67

AP Engineering & Testing, Inc.

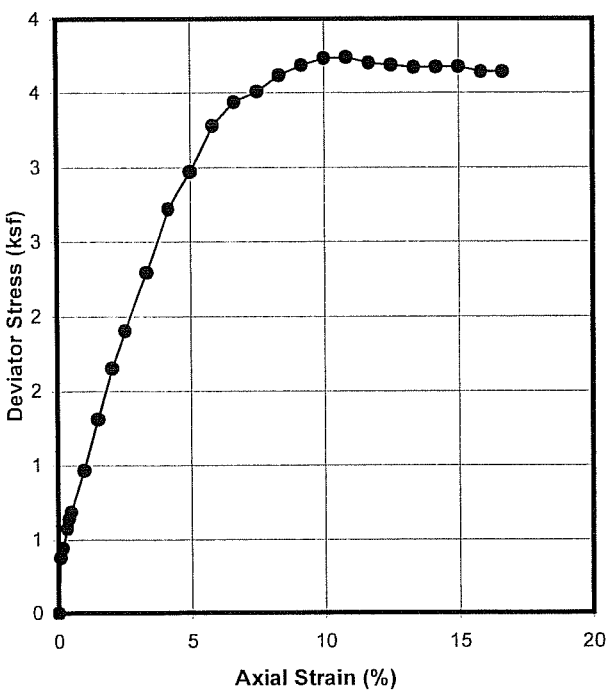
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/20/09
Project No.:	06-123-03				
Boring No.:	R-09-019				
Sample No.:	U-13	Depth (feet): 65			
Soil Description	Gray Clayey Silt w/ sand and shell		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	123.7
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	95.1
Sample Weight (gms):	1265.14	Moisture Content (%):	30.0
Wt. Wet Soil+Container(gms)	1385.32	Void Ratio for Gs=2.7:	0.77
Wt. Dry Soil+Container(gms)	1089.32	% Saturation:	105.0
Wt. Container (gms)	103.00		

TEST DATA

Cell Pressure (ksf):	2.45
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.45
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	3.7
Ultimate Deviator Stress (ksf):	3.7
Ultimate Undrained Shear Strength (ksf):	1.8
Axial Strain @ Maximum Stress (%)	10.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
17	0.005	6.50	0.38	0.08
20	0.010	6.50	0.44	0.17
26	0.020	6.51	0.57	0.33
29	0.025	6.52	0.64	0.42
31	0.030	6.52	0.68	0.50
44	0.060	6.56	0.97	1.00
60	0.090	6.59	1.31	1.50
76	0.120	6.62	1.65	2.00
88	0.150	6.66	1.90	2.50
107	0.200	6.72	2.29	3.33
128	0.250	6.77	2.72	4.17
141	0.300	6.83	2.97	5.00
157	0.350	6.89	3.28	5.83
166	0.400	6.96	3.44	6.67
171	0.450	7.02	3.51	7.50
178	0.500	7.08	3.62	8.33
183	0.550	7.15	3.69	9.17
187	0.600	7.21	3.73	10.00
189	0.650	7.28	3.74	10.83
189	0.700	7.35	3.70	11.67
190	0.750	7.42	3.69	12.50
191	0.800	7.49	3.67	13.33
193	0.850	7.56	3.67	14.17
195	0.900	7.64	3.68	15.00
195	0.950	7.71	3.64	15.83
197	1.000	7.79	3.64	16.67

AP Engineering & Testing, Inc.

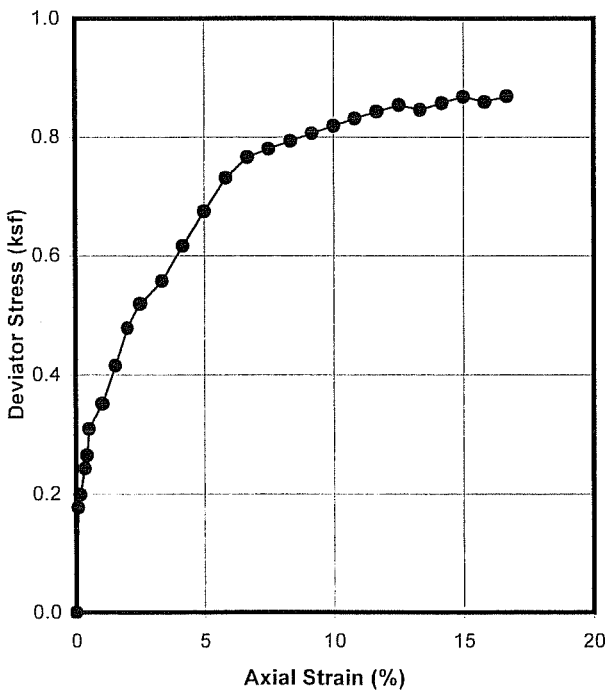
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/21/09
Project No.:	06-123-03				
Boring No.:	R-09-020				
Sample No.:	U-04	Depth (feet): 20			
Soil Description	Gray Lean Clay		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	107.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	71.9
Sample Weight (gms):	1103.60	Moisture Content (%):	50.1
Wt. Wet Soil+Container(gms)	1207.81	Void Ratio for Gs=2.7:	1.34
Wt. Dry Soil+Container(gms)	839.45	% Saturation:	100.6
Wt. Container (gms)	104.39		

TEST DATA

Cell Pressure (ksf):	0.72
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	0.72
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	0.9
Ultimate Deviator Stress (ksf):	0.9
Ultimate Undrained Shear Strength (ksf):	0.4
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
8	0.005	6.50	0.18	0.08
9	0.010	6.50	0.20	0.17
11	0.020	6.51	0.24	0.33
12	0.025	6.52	0.27	0.42
14	0.030	6.52	0.31	0.50
16	0.060	6.56	0.35	1.00
19	0.090	6.59	0.42	1.50
22	0.120	6.62	0.48	2.00
24	0.150	6.66	0.52	2.50
26	0.200	6.72	0.56	3.33
29	0.250	6.77	0.62	4.17
32	0.300	6.83	0.67	5.00
35	0.350	6.89	0.73	5.83
37	0.400	6.96	0.77	6.67
38	0.450	7.02	0.78	7.50
39	0.500	7.08	0.79	8.33
40	0.550	7.15	0.81	9.17
41	0.600	7.21	0.82	10.00
42	0.650	7.28	0.83	10.83
43	0.700	7.35	0.84	11.67
44	0.750	7.42	0.85	12.50
44	0.800	7.49	0.85	13.33
45	0.850	7.56	0.86	14.17
46	0.900	7.64	0.87	15.00
46	0.950	7.71	0.86	15.83
47	1.000	7.79	0.87	16.67

AP Engineering & Testing, Inc.

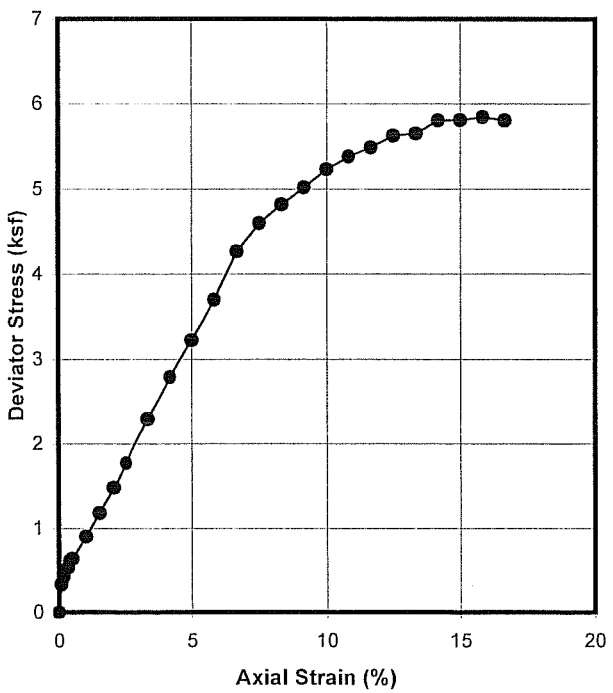
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/21/09
Project No.:	06-123-03				
Boring No.:	R-09-020				
Sample No.:	U-08	Depth (feet): 40			
Soil Description	Gray Silty Sand		Sample Type:	Shelby	

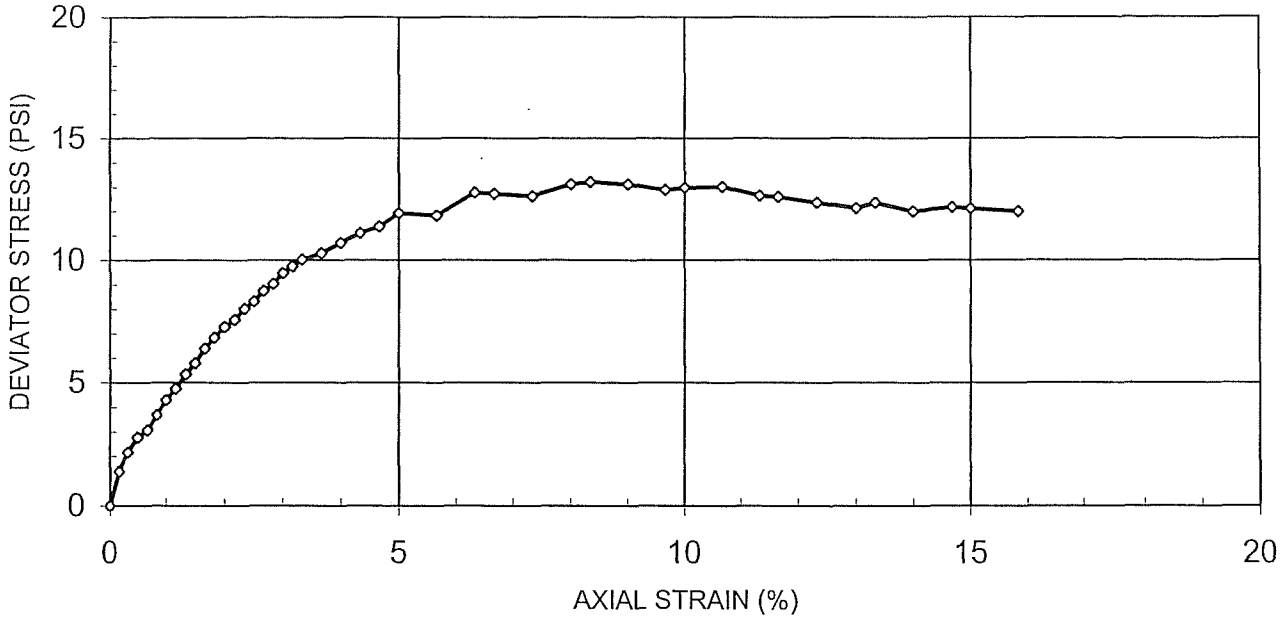
Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	122.1
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	94.3
Sample Weight (gms):	1248.77	Moisture Content (%):	29.4
Wt. Wet Soil+Container(gms)	1451.10	Void Ratio for Gs=2.7:	0.79
Wt. Dry Soil+Container(gms)	1166.42	% Saturation:	101.0
Wt. Container (gms)	198.97		

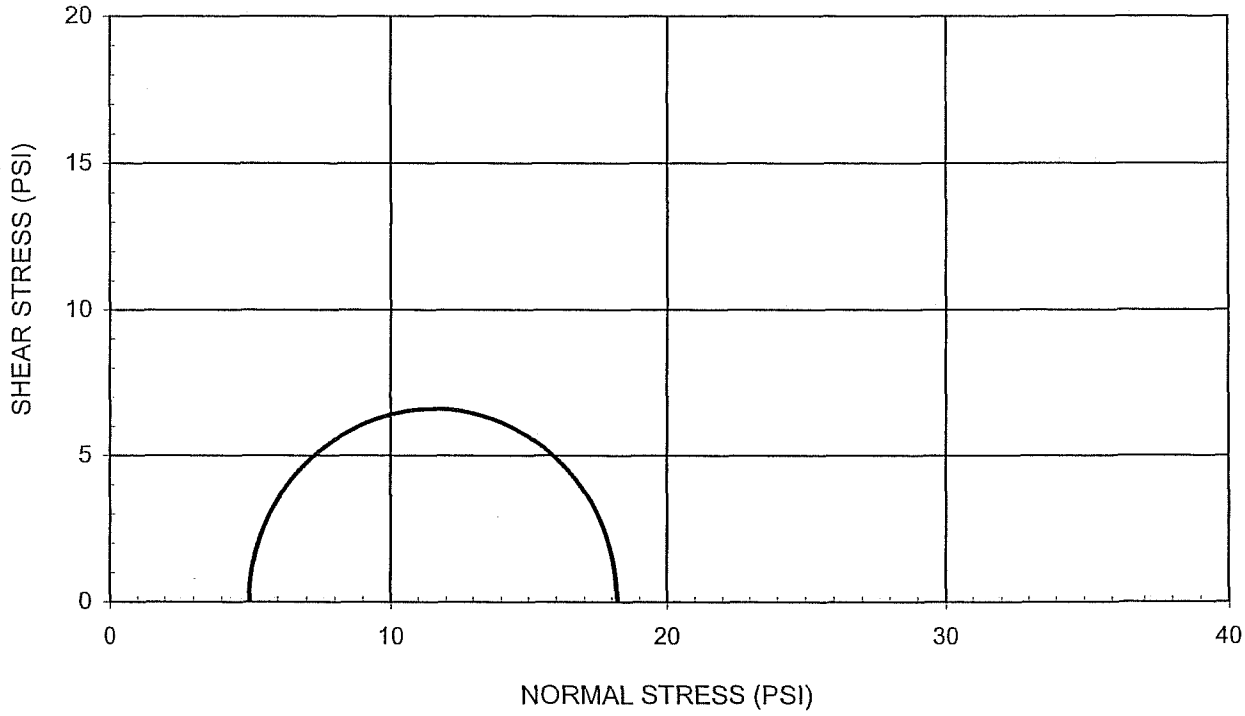
TEST DATA

Cell Pressure (ksf):	0.72
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	0.72
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	5.8
Ultimate Deviator Stress (ksf):	5.8
Ultimate Undrained Shear Strength (ksf):	2.9
Axial Strain @ Maximum Stress (%)	15.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
15	0.005	6.50	0.33	0.08
19	0.010	6.50	0.42	0.17
24	0.020	6.51	0.53	0.33
28	0.025	6.52	0.62	0.42
29	0.030	6.52	0.64	0.50
41	0.060	6.56	0.90	1.00
54	0.090	6.59	1.18	1.50
68	0.120	6.62	1.48	2.00
82	0.150	6.66	1.77	2.50
107	0.200	6.72	2.29	3.33
131	0.250	6.77	2.78	4.17
153	0.300	6.83	3.22	5.00
177	0.350	6.89	3.70	5.83
206	0.400	6.96	4.26	6.67
224	0.450	7.02	4.60	7.50
237	0.500	7.08	4.82	8.33
249	0.550	7.15	5.02	9.17
262	0.600	7.21	5.23	10.00
272	0.650	7.28	5.38	10.83
280	0.700	7.35	5.49	11.67
290	0.750	7.42	5.63	12.50
294	0.800	7.49	5.65	13.33
305	0.850	7.56	5.81	14.17
308	0.900	7.64	5.81	15.00
313	0.950	7.71	5.84	15.83
314	1.000	7.79	5.80	16.67





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-021	20	U-04	CH	Shelby Tube	58.87	64.5	5.0	13.2	0.06	98.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

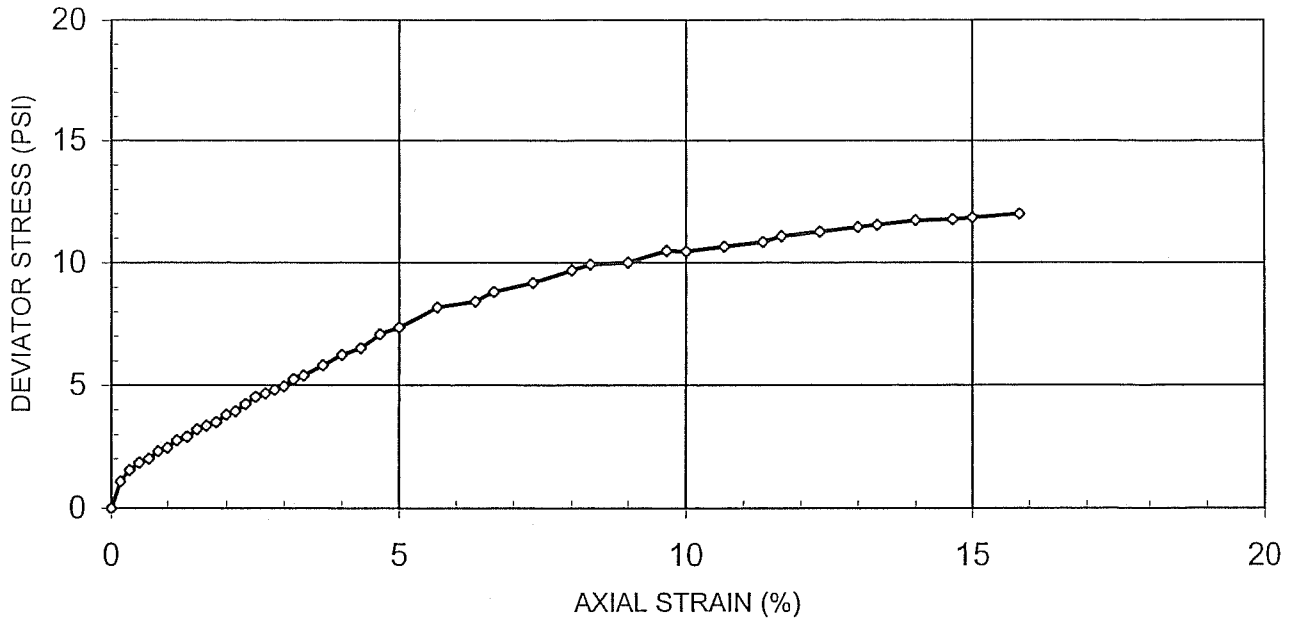
Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

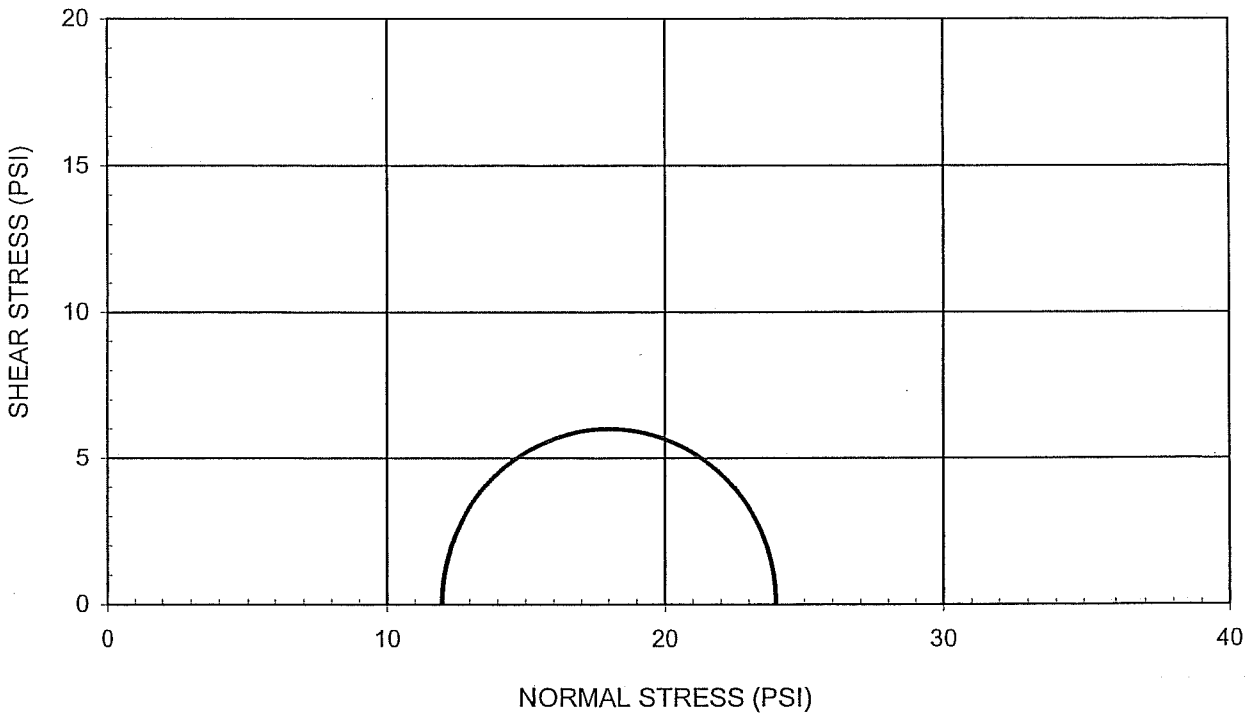
UNCONSOLIDATED UNDRAINED

(ASTM D2850)

11/30/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-021	45	U-10	CH	Shelby Tube	49.76	72.3	12.0	12.0	0.06	101.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

UNCONSOLIDATED UNDRAINED

(ASTM D2850)

11/29/09

Figure

AP Engineering & Testing, Inc.

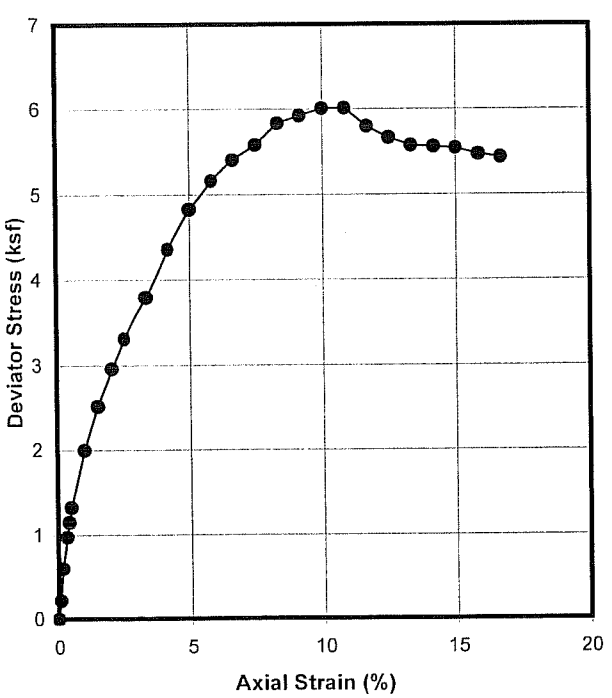
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/03/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 01/03/10
Project No.:	06-123-03		
Boring No.:	R-09-022		
Sample No.:	U-11 Depth (feet): 55		
Soil Description	Gray Silty Sand	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	122.6
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	96.2
Sample Weight (gms):	1254.33	Moisture Content (%):	27.5
Wt. Wet Soil+Container(gms)	1369.43	Void Ratio for Gs=2.7:	0.75
Wt. Dry Soil+Container(gms)	1096.65	% Saturation:	98.7
Wt. Container (gms)	103.90		

TEST DATA

Cell Pressure (ksf):	2.16
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.16
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	6.0
Ultimate Deviator Stress (ksf):	5.6
Ultimate Undrained Shear Strength (ksf):	2.8
Axial Strain @ Maximum Stress (%)	10.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
10	0.005	6.50	0.22	0.08
27	0.010	6.50	0.60	0.17
44	0.020	6.51	0.97	0.33
52	0.025	6.52	1.15	0.42
60	0.030	6.52	1.32	0.50
91	0.060	6.56	2.00	1.00
115	0.090	6.59	2.51	1.50
136	0.120	6.62	2.96	2.00
153	0.150	6.66	3.31	2.50
177	0.200	6.72	3.80	3.33
205	0.250	6.77	4.36	4.17
229	0.300	6.83	4.83	5.00
247	0.350	6.89	5.16	5.83
261	0.400	6.96	5.40	6.67
272	0.450	7.02	5.58	7.50
287	0.500	7.08	5.84	8.33
294	0.550	7.15	5.92	9.17
301	0.600	7.21	6.01	10.00
304	0.650	7.28	6.01	10.83
296	0.700	7.35	5.80	11.67
292	0.750	7.42	5.67	12.50
290	0.800	7.49	5.58	13.33
292	0.850	7.56	5.56	14.17
294	0.900	7.64	5.54	15.00
293	0.950	7.71	5.47	15.83
294	1.000	7.79	5.43	16.67

AP Engineering & Testing, Inc.

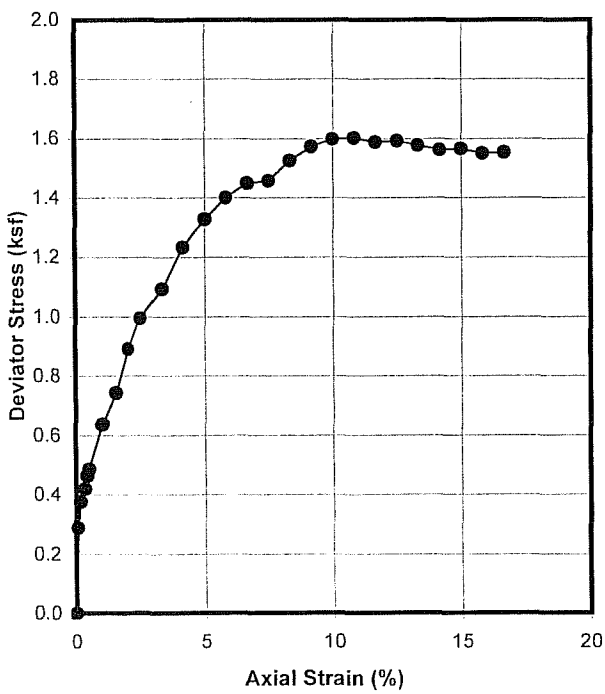
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/03/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 01/03/10
Project No.:	06-123-03		
Boring No.:	R-09-022		
Sample No.:	U-08 Depth (feet): 40		
Soil Description	Gray Lean Clay	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	113.7
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	79.9
Sample Weight (gms):	1163.69	Moisture Content (%):	42.4
Wt. Wet Soil+Container(gms)	1315.87	Void Ratio for Gs=2.7:	1.11
Wt. Dry Soil+Container(gms)	969.54	% Saturation:	103.2
Wt. Container (gms)	152.07		

TEST DATA

Cell Pressure (ksf):	1.58
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.58
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.6
Ultimate Deviator Stress (ksf):	1.6
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	10.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
13	0.005	6.50	0.29	0.08
17	0.010	6.50	0.38	0.17
19	0.020	6.51	0.42	0.33
21	0.025	6.52	0.46	0.42
22	0.030	6.52	0.49	0.50
29	0.060	6.56	0.64	1.00
34	0.090	6.59	0.74	1.50
41	0.120	6.62	0.89	2.00
46	0.150	6.66	0.99	2.50
51	0.200	6.72	1.09	3.33
58	0.250	6.77	1.23	4.17
63	0.300	6.83	1.33	5.00
67	0.350	6.89	1.40	5.83
70	0.400	6.96	1.45	6.67
71	0.450	7.02	1.46	7.50
75	0.500	7.08	1.52	8.33
78	0.550	7.15	1.57	9.17
80	0.600	7.21	1.60	10.00
81	0.650	7.28	1.60	10.83
81	0.700	7.35	1.59	11.67
82	0.750	7.42	1.59	12.50
82	0.800	7.49	1.58	13.33
82	0.850	7.56	1.56	14.17
83	0.900	7.64	1.56	15.00
83	0.950	7.71	1.55	15.83
84	1.000	7.79	1.55	16.67

AP Engineering & Testing, Inc.

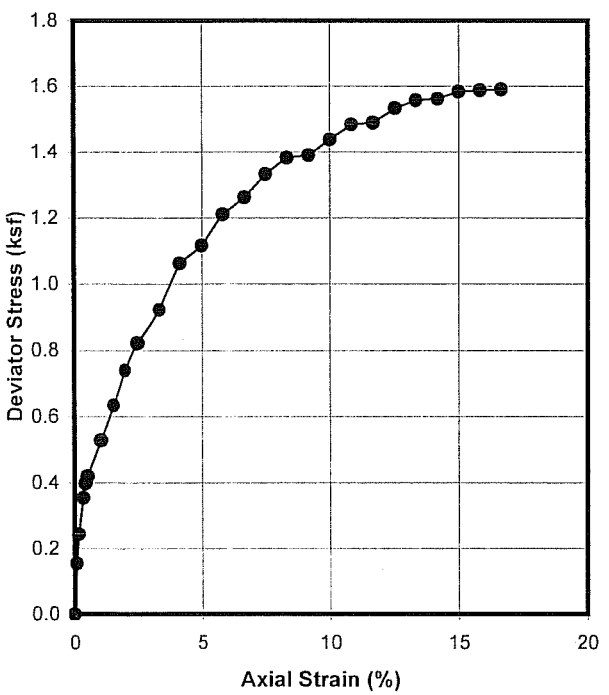
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/21/09
Project No.:	06-123-03		
Boring No.:	R-09-023		
Sample No.:	U-07 Depth (feet): 35		
Soil Description	Gray Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	118.5
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	87.2
Sample Weight (gms):	1211.89	Moisture Content (%):	35.8
Wt. Wet Soil+Container(gms)	1413.72	Void Ratio for Gs=2.7:	0.93
Wt. Dry Soil+Container(gms)	1093.03	% Saturation:	103.8
Wt. Container (gms)	198.20		

TEST DATA

Cell Pressure (ksf):	1.30
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.30
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.6
Ultimate Deviator Stress (ksf):	1.6
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
7	0.005	6.50	0.16	0.08
11	0.010	6.50	0.24	0.17
16	0.020	6.51	0.35	0.33
18	0.025	6.52	0.40	0.42
19	0.030	6.52	0.42	0.50
24	0.060	6.56	0.53	1.00
29	0.090	6.59	0.63	1.50
34	0.120	6.62	0.74	2.00
38	0.150	6.66	0.82	2.50
43	0.200	6.72	0.92	3.33
50	0.250	6.77	1.06	4.17
53	0.300	6.83	1.12	5.00
58	0.350	6.89	1.21	5.83
61	0.400	6.96	1.26	6.67
65	0.450	7.02	1.33	7.50
68	0.500	7.08	1.38	8.33
69	0.550	7.15	1.39	9.17
72	0.600	7.21	1.44	10.00
75	0.650	7.28	1.48	10.83
76	0.700	7.35	1.49	11.67
79	0.750	7.42	1.53	12.50
81	0.800	7.49	1.56	13.33
82	0.850	7.56	1.56	14.17
84	0.900	7.64	1.58	15.00
85	0.950	7.71	1.59	15.83
86	1.000	7.79	1.59	16.67

AP Engineering & Testing, Inc.

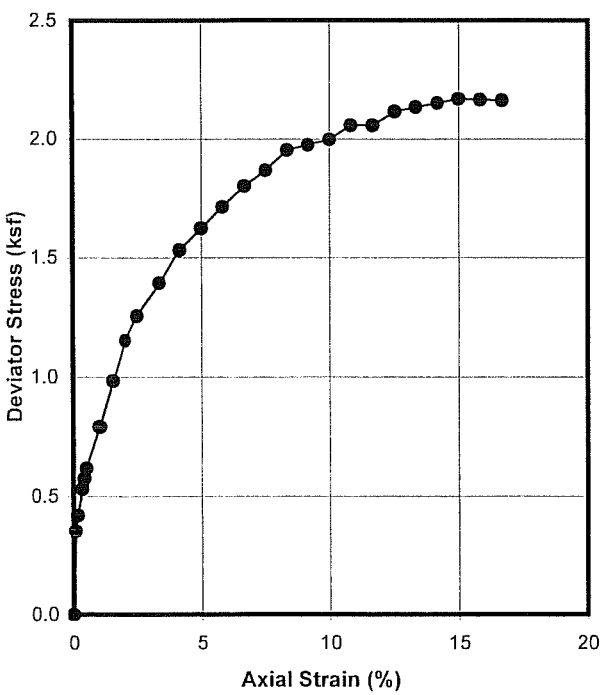
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/21/09
Project No.:	06-123-03		
Boring No.:	R-09-023		
Sample No.:	U-09 Depth (feet): 45		
Soil Description	Gray Silt w/shell fragments	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	121.4
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	92.9
Sample Weight (gms):	1242.18	Moisture Content (%):	30.7
Wt. Wet Soil+Container(gms)	1439.02	Void Ratio for Gs=2.7:	0.81
Wt. Dry Soil+Container(gms)	1146.61	% Saturation:	101.8
Wt. Container (gms)	193.32		

TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	2.2
Ultimate Deviator Stress (ksf):	2.2
Ultimate Undrained Shear Strength (ksf):	1.1
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
16	0.005	6.50	0.35	0.08
19	0.010	6.50	0.42	0.17
24	0.020	6.51	0.53	0.33
26	0.025	6.52	0.57	0.42
28	0.030	6.52	0.62	0.50
36	0.060	6.56	0.79	1.00
45	0.090	6.59	0.98	1.50
53	0.120	6.62	1.15	2.00
58	0.150	6.66	1.25	2.50
65	0.200	6.72	1.39	3.33
72	0.250	6.77	1.53	4.17
77	0.300	6.83	1.62	5.00
82	0.350	6.89	1.71	5.83
87	0.400	6.96	1.80	6.67
91	0.450	7.02	1.87	7.50
96	0.500	7.08	1.95	8.33
98	0.550	7.15	1.97	9.17
100	0.600	7.21	2.00	10.00
104	0.650	7.28	2.06	10.83
105	0.700	7.35	2.06	11.67
109	0.750	7.42	2.12	12.50
111	0.800	7.49	2.13	13.33
113	0.850	7.56	2.15	14.17
115	0.900	7.64	2.17	15.00
116	0.950	7.71	2.17	15.83
117	1.000	7.79	2.16	16.67

AP Engineering & Testing, Inc.

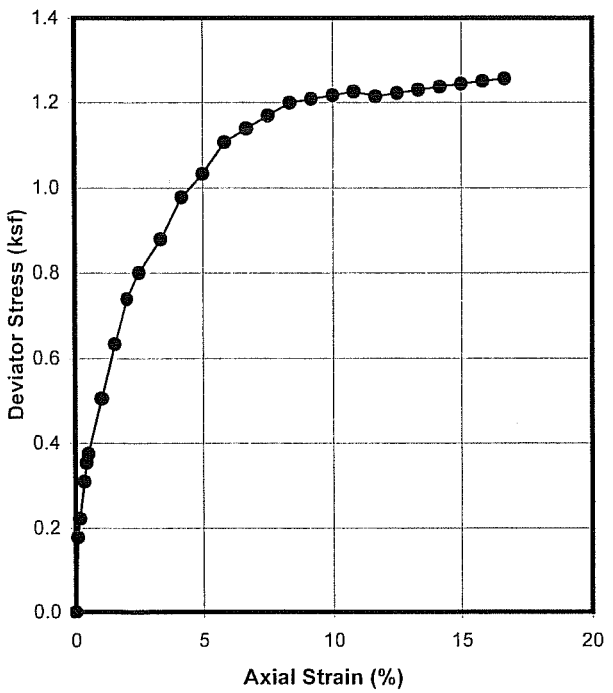
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/03/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/28/09
Project No.:	06-123-03				
Boring No.:	R-09-024				
Sample No.:	U-06	Depth (feet): 30			
Soil Description	Gray Silt		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	114.5
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	80.9
Sample Weight (gms):	1171.45	Moisture Content (%):	41.5
Wt. Wet Soil+Container(gms)	1366.49	Void Ratio for Gs=2.7:	1.08
Wt. Dry Soil+Container(gms)	1020.36	% Saturation:	103.6
Wt. Container (gms)	187.01		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.3
Ultimate Deviator Stress (ksf):	1.2
Ultimate Undrained Shear Strength (ksf):	0.6
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
8	0.005	6.50	0.18	0.08
10	0.010	6.50	0.22	0.17
14	0.020	6.51	0.31	0.33
16	0.025	6.52	0.35	0.42
17	0.030	6.52	0.38	0.50
23	0.060	6.56	0.51	1.00
29	0.090	6.59	0.63	1.50
34	0.120	6.62	0.74	2.00
37	0.150	6.66	0.80	2.50
41	0.200	6.72	0.88	3.33
46	0.250	6.77	0.98	4.17
49	0.300	6.83	1.03	5.00
53	0.350	6.89	1.11	5.83
55	0.400	6.96	1.14	6.67
57	0.450	7.02	1.17	7.50
59	0.500	7.08	1.20	8.33
60	0.550	7.15	1.21	9.17
61	0.600	7.21	1.22	10.00
62	0.650	7.28	1.23	10.83
62	0.700	7.35	1.21	11.67
63	0.750	7.42	1.22	12.50
64	0.800	7.49	1.23	13.33
65	0.850	7.56	1.24	14.17
66	0.900	7.64	1.24	15.00
67	0.950	7.71	1.25	15.83
68	1.000	7.79	1.26	16.67

AP Engineering & Testing, Inc.

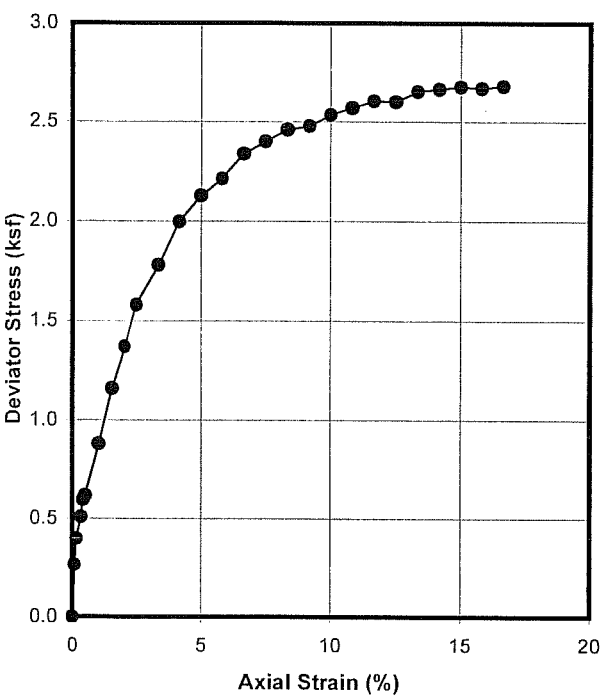
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/03/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/28/09
Project No.:	06-123-03		
Boring No.:	R-09-024		
Sample No.:	U-12 Depth (feet): 60		
Soil Description	Gray Lean Clay	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	119.8
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	90.2
Sample Weight (gms):	1225.94	Moisture Content (%):	32.9
Wt. Wet Soil+Container(gms)	1332.94	Void Ratio for Gs=2.7:	0.87
Wt. Dry Soil+Container(gms)	1029.10	% Saturation:	102.2
Wt. Container (gms)	105.17		

TEST DATA

Cell Pressure (ksf):	2.30
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.30
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	2.7
Ultimate Deviator Stress (ksf):	2.7
Ultimate Undrained Shear Strength (ksf):	1.3
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
18	0.010	6.50	0.40	0.17
23	0.020	6.51	0.51	0.33
27	0.025	6.52	0.60	0.42
28	0.030	6.52	0.62	0.50
40	0.060	6.56	0.88	1.00
53	0.090	6.59	1.16	1.50
63	0.120	6.62	1.37	2.00
73	0.150	6.66	1.58	2.50
83	0.200	6.72	1.78	3.33
94	0.250	6.77	2.00	4.17
101	0.300	6.83	2.13	5.00
106	0.350	6.89	2.21	5.83
113	0.400	6.96	2.34	6.67
117	0.450	7.02	2.40	7.50
121	0.500	7.08	2.46	8.33
123	0.550	7.15	2.48	9.17
127	0.600	7.21	2.54	10.00
130	0.650	7.28	2.57	10.83
133	0.700	7.35	2.61	11.67
134	0.750	7.42	2.60	12.50
138	0.800	7.49	2.65	13.33
140	0.850	7.56	2.67	14.17
142	0.900	7.64	2.68	15.00
143	0.950	7.71	2.67	15.83
145	1.000	7.79	2.68	16.67

AP Engineering & Testing, Inc.

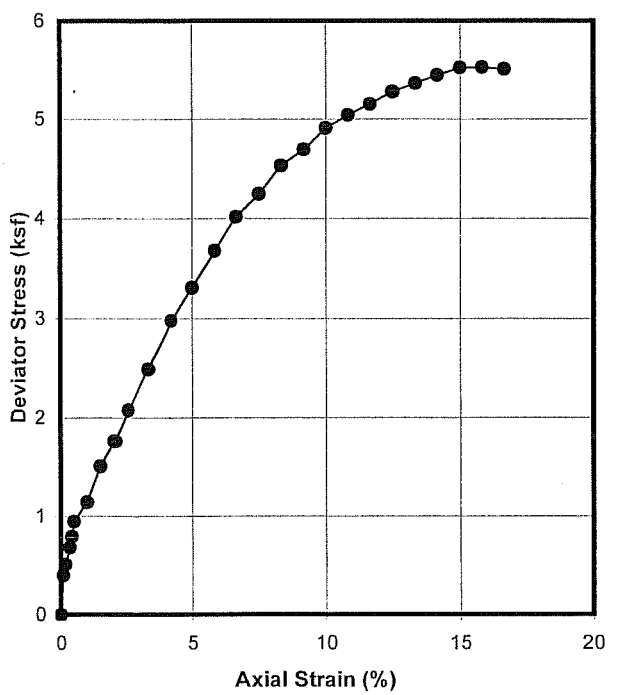
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/03/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/29/09
Project No.:	06-123-03				
Boring No.:	R-09-025				
Sample No.:	U-10	Depth (feet): 50			
Soil Description	Gray Silt with fine sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	123.2
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	95.6
Sample Weight (gms):	1260.64	Moisture Content (%):	28.9
Wt. Wet Soil+Container(gms)	1423.47	Void Ratio for Gs=2.7:	0.76
Wt. Dry Soil+Container(gms)	1139.09	% Saturation:	102.4
Wt. Container (gms)	156.00		

TEST DATA

Cell Pressure (ksf):	2.02
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.02
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	5.5
Ultimate Deviator Stress (ksf):	5.4
Ultimate Undrained Shear Strength (ksf):	2.7
Axial Strain @ Maximum Stress (%)	15.83



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
18	0.005	6.50	0.40	0.08
23	0.010	6.50	0.51	0.17
31	0.020	6.51	0.69	0.33
36	0.025	6.52	0.80	0.42
43	0.030	6.52	0.95	0.50
52	0.060	6.56	1.14	1.00
69	0.090	6.59	1.51	1.50
81	0.120	6.62	1.76	2.00
96	0.150	6.66	2.08	2.50
116	0.200	6.72	2.49	3.33
140	0.250	6.77	2.98	4.17
157	0.300	6.83	3.31	5.00
176	0.350	6.89	3.68	5.83
194	0.400	6.96	4.02	6.67
207	0.450	7.02	4.25	7.50
223	0.500	7.08	4.53	8.33
233	0.550	7.15	4.69	9.17
246	0.600	7.21	4.91	10.00
255	0.650	7.28	5.04	10.83
263	0.700	7.35	5.15	11.67
272	0.750	7.42	5.28	12.50
279	0.800	7.49	5.36	13.33
286	0.850	7.56	5.45	14.17
293	0.900	7.64	5.52	15.00
296	0.950	7.71	5.53	15.83
298	1.000	7.79	5.51	16.67

AP Engineering & Testing, Inc.

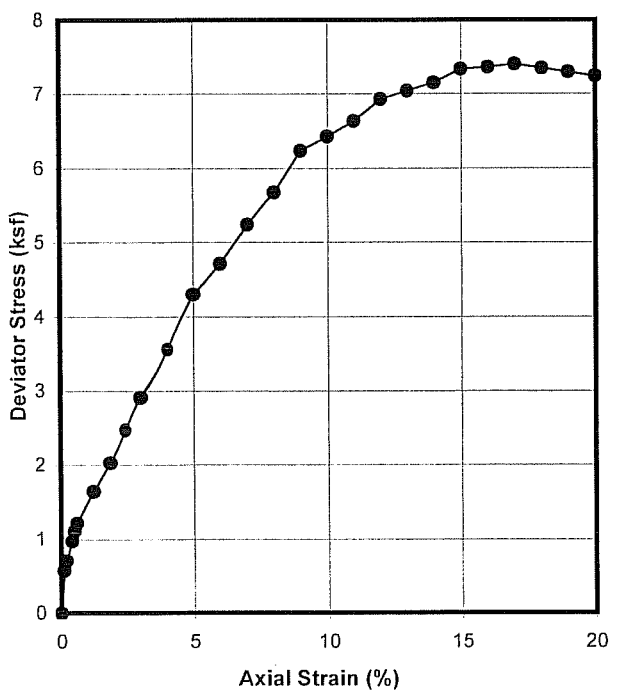
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/03/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/29/09
Project No.:	06-123-03				
Boring No.:	R-09-026				
Sample No.:	U-15	Depth (feet): 75			
Soil Description	Gray Silt with fine sand		Sample Type:	Shelby	

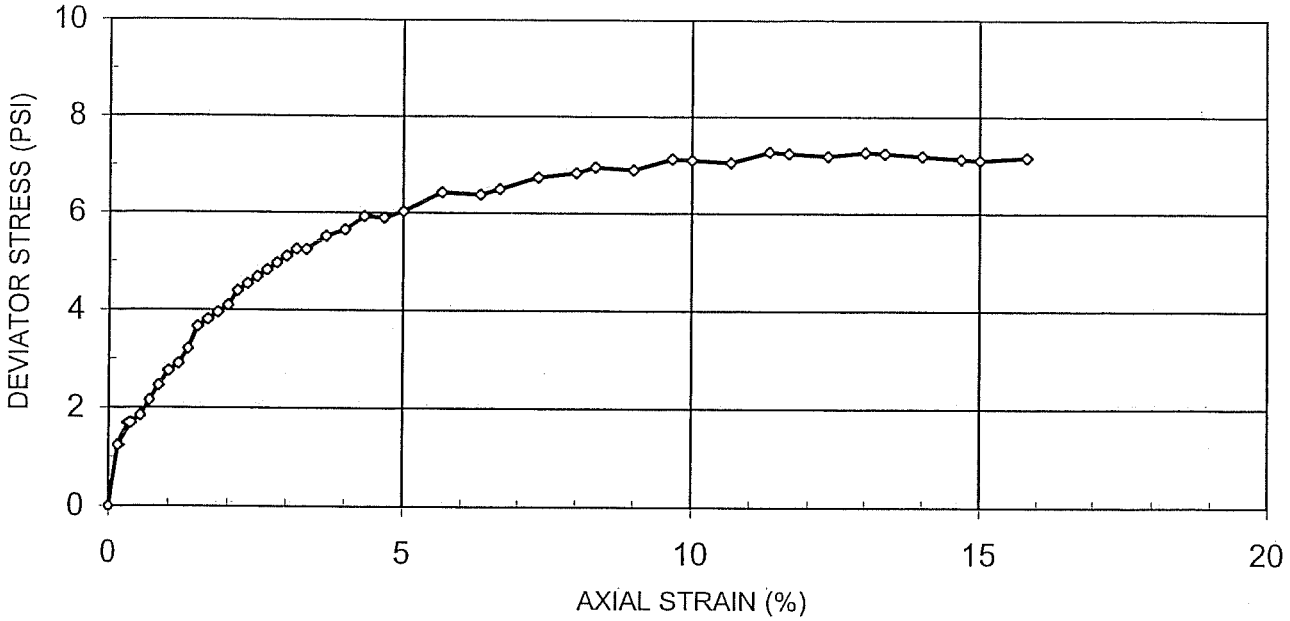
Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	118.5
Sample Hieght (inch):	5.0	Dry Unit Weight (pcf):	89.4
Sample Weight (gms):	1010.10	Moisture Content (%):	32.5
Wt. Wet Soil+Container(gms)	1115.00	Void Ratio for Gs=2.7:	0.88
Wt. Dry Soil+Container(gms)	867.25	% Saturation:	99.3
Wt. Container (gms)	105.49		

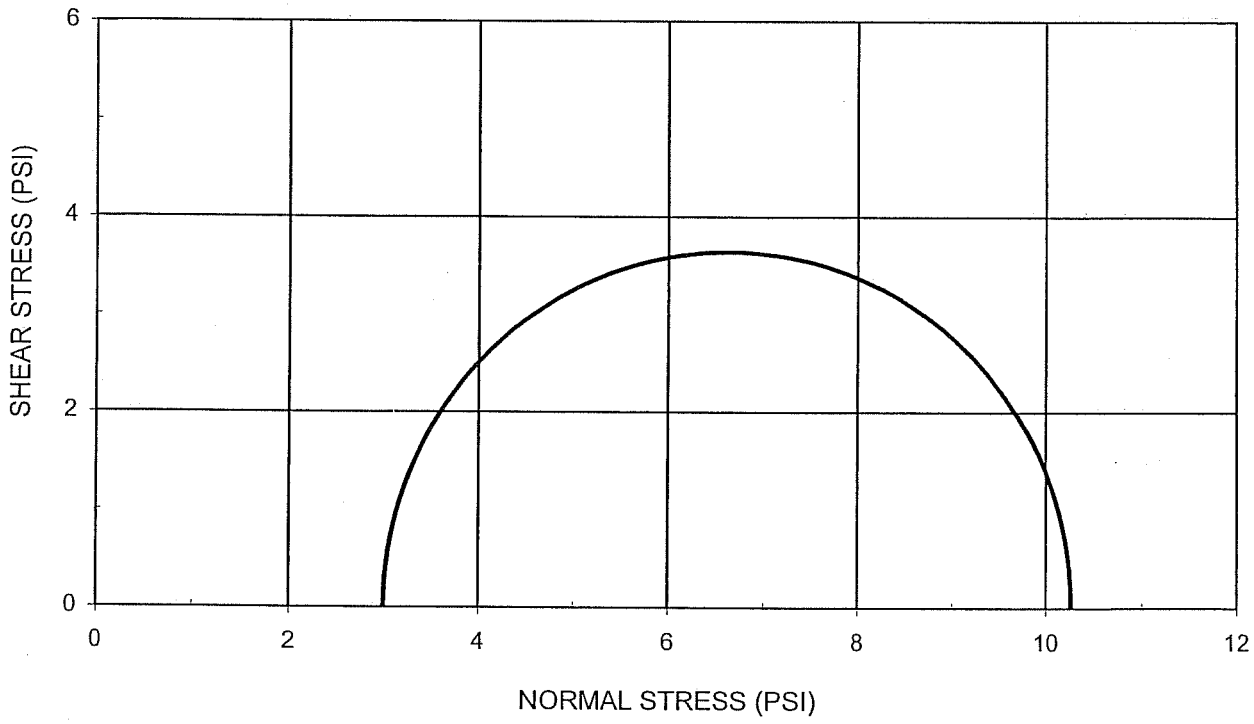
TEST DATA

Cell Pressure (ksf):	2.88
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.88
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	7.4
Ultimate Deviator Stress (ksf):	7.4
Ultimate Undrained Shear Strength (ksf):	3.7
Axial Strain @ Maximum Stress (%)	17.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
26	0.005	6.50	0.58	0.10
32	0.010	6.50	0.71	0.20
44	0.020	6.52	0.97	0.40
50	0.025	6.52	1.10	0.50
55	0.030	6.53	1.21	0.60
75	0.060	6.57	1.64	1.20
93	0.090	6.61	2.03	1.80
114	0.120	6.65	2.47	2.40
135	0.150	6.69	2.90	3.00
167	0.200	6.76	3.56	4.00
204	0.250	6.83	4.30	5.00
226	0.300	6.91	4.71	6.00
254	0.350	6.98	5.24	7.00
278	0.400	7.06	5.67	8.00
309	0.450	7.13	6.24	9.00
322	0.500	7.21	6.43	10.00
336	0.550	7.29	6.63	11.00
355	0.600	7.38	6.93	12.00
365	0.650	7.46	7.04	13.00
375	0.700	7.55	7.15	14.00
389	0.750	7.64	7.33	15.00
395	0.800	7.73	7.36	16.00
402	0.850	7.82	7.40	17.00
404	0.900	7.92	7.35	18.00
406	0.950	8.01	7.29	19.00
408	1.000	8.11	7.24	20.00





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-027	11	U-01	CL	Shelby Tube	53.54	69.4	3.0	7.3	0.06	101.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

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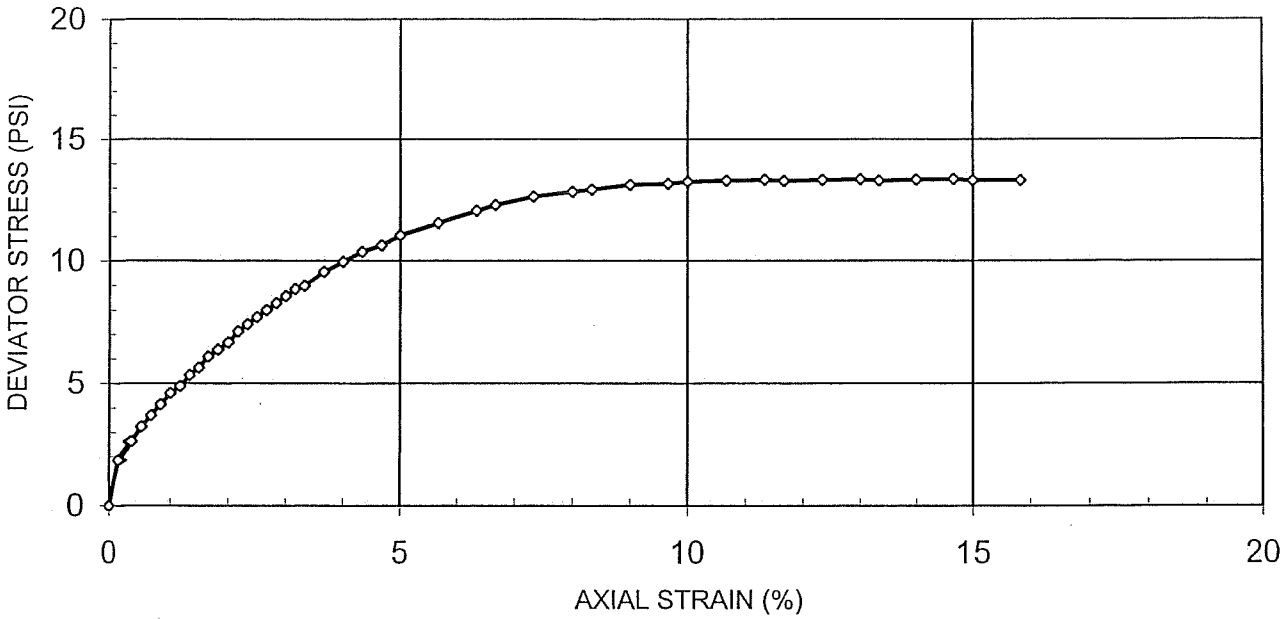
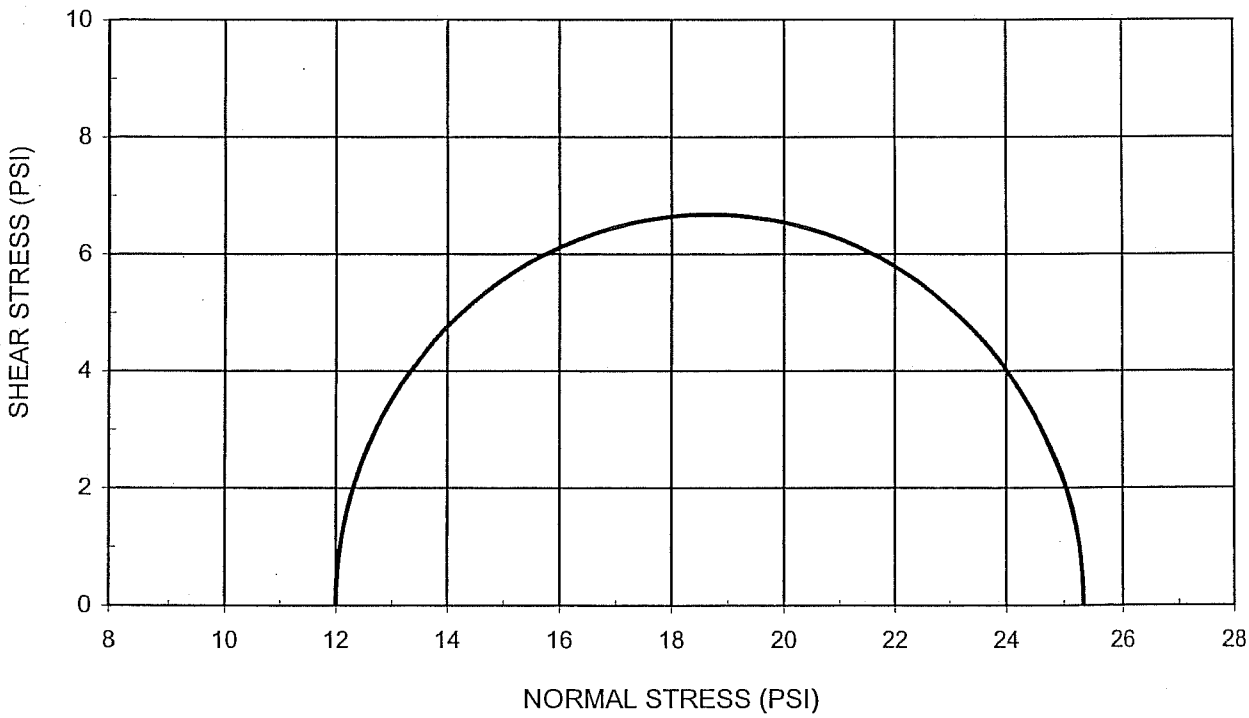
(ASTM D2850)

12/21/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-027	45	U-09	CH	Shelby Tube	46.80	74.8	12.0	13.4	0.06	101.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure

AP Engineering & Testing, Inc.

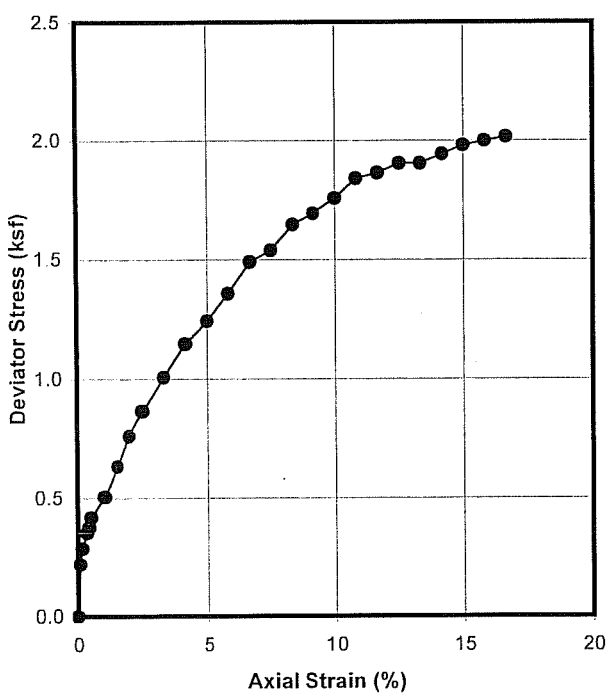
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/30/09
Project No.:	06-123-03				
Boring No.:	R-09-028				
Sample No.:	U-07	Depth (feet): 35			
Soil Description	Gray Silt with sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	118.2
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	87.3
Sample Weight (gms):	1209.10	Moisture Content (%):	35.4
Wt. Wet Soil+Container(gms)	1357.70	Void Ratio for Gs=2.7:	0.93
Wt. Dry Soil+Container(gms)	1041.72	% Saturation:	102.7
Wt. Container (gms)	148.63		

TEST DATA

Cell Pressure (ksf):	1.44
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.44
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	2.0
Ultimate Deviator Stress (ksf):	1.9
Ultimate Undrained Shear Strength (ksf):	1.0
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
10	0.005	6.50	0.22	0.08
13	0.010	6.50	0.29	0.17
16	0.020	6.51	0.35	0.33
17	0.025	6.52	0.38	0.42
19	0.030	6.52	0.42	0.50
23	0.060	6.56	0.51	1.00
29	0.090	6.59	0.63	1.50
35	0.120	6.62	0.76	2.00
40	0.150	6.66	0.87	2.50
47	0.200	6.72	1.01	3.33
54	0.250	6.77	1.15	4.17
59	0.300	6.83	1.24	5.00
65	0.350	6.89	1.36	5.83
72	0.400	6.96	1.49	6.67
75	0.450	7.02	1.54	7.50
81	0.500	7.08	1.65	8.33
84	0.550	7.15	1.69	9.17
88	0.600	7.21	1.76	10.00
93	0.650	7.28	1.84	10.83
95	0.700	7.35	1.86	11.67
98	0.750	7.42	1.90	12.50
99	0.800	7.49	1.90	13.33
102	0.850	7.56	1.94	14.17
105	0.900	7.64	1.98	15.00
107	0.950	7.71	2.00	15.83
109	1.000	7.79	2.01	16.67

AP Engineering & Testing, Inc.

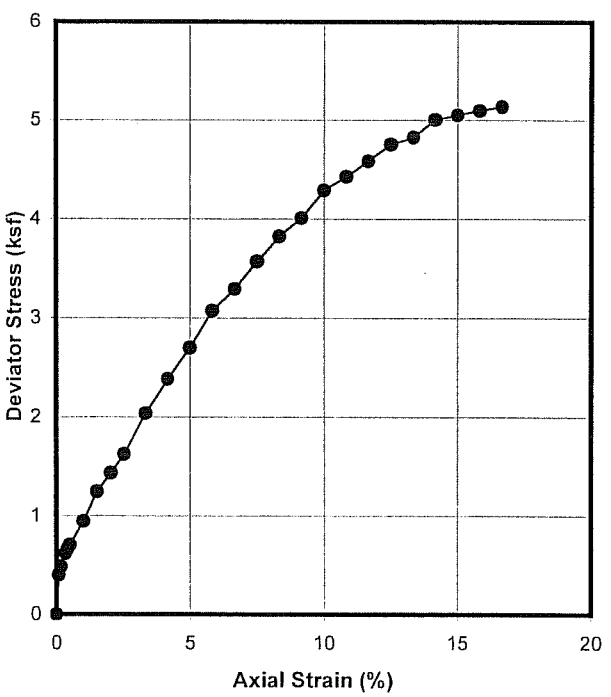
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/31/09
Project No.:	06-123-03				
Boring No.:	R-09-029				
Sample No.:	U-12	Depth (feet): 60			
Soil Description	Gray Silt with sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	127.6
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	101.1
Sample Weight (gms):	1305.57	Moisture Content (%):	26.3
Wt. Wet Soil+Container(gms)	1505.68	Void Ratio for Gs=2.7:	0.67
Wt. Dry Soil+Container(gms)	1233.50	% Saturation:	106.3
Wt. Container (gms)	196.95		

TEST DATA

Cell Pressure (ksf):	2.59
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.59
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	5.1
Ultimate Deviator Stress (ksf):	5.0
Ultimate Undrained Shear Strength (ksf):	2.5
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
18	0.005	6.50	0.40	0.08
22	0.010	6.50	0.49	0.17
28	0.020	6.51	0.62	0.33
30	0.025	6.52	0.66	0.42
32	0.030	6.52	0.71	0.50
43	0.060	6.56	0.94	1.00
57	0.090	6.59	1.25	1.50
66	0.120	6.62	1.43	2.00
75	0.150	6.66	1.62	2.50
95	0.200	6.72	2.04	3.33
112	0.250	6.77	2.38	4.17
128	0.300	6.83	2.70	5.00
147	0.350	6.89	3.07	5.83
159	0.400	6.96	3.29	6.67
174	0.450	7.02	3.57	7.50
188	0.500	7.08	3.82	8.33
199	0.550	7.15	4.01	9.17
215	0.600	7.21	4.29	10.00
224	0.650	7.28	4.43	10.83
234	0.700	7.35	4.58	11.67
245	0.750	7.42	4.76	12.50
251	0.800	7.49	4.83	13.33
263	0.850	7.56	5.01	14.17
268	0.900	7.64	5.05	15.00
273	0.950	7.71	5.10	15.83
278	1.000	7.79	5.14	16.67

AP Engineering & Testing, Inc.

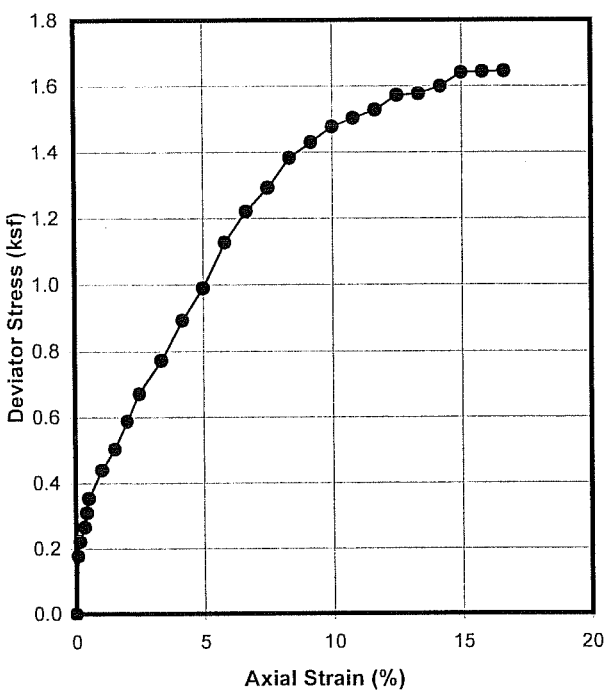
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/31/09
Project No.:	06-123-03		
Boring No.:	R-09-029		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	116.3
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	83.2
Sample Weight (gms):	1190.00	Moisture Content (%):	39.8
Wt. Wet Soil+Container(gms)	1339.05	Void Ratio for Gs=2.7:	1.03
Wt. Dry Soil+Container(gms)	1000.29	% Saturation:	104.9
Wt. Container (gms)	149.61		

TEST DATA

Cell Pressure (ksf):	1.30
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.30
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.6
Ultimate Deviator Stress (ksf):	1.6
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
8	0.005	6.50	0.18	0.08
10	0.010	6.50	0.22	0.17
12	0.020	6.51	0.27	0.33
14	0.025	6.52	0.31	0.42
16	0.030	6.52	0.35	0.50
20	0.060	6.56	0.44	1.00
23	0.090	6.59	0.50	1.50
27	0.120	6.62	0.59	2.00
31	0.150	6.66	0.67	2.50
36	0.200	6.72	0.77	3.33
42	0.250	6.77	0.89	4.17
47	0.300	6.83	0.99	5.00
54	0.350	6.89	1.13	5.83
59	0.400	6.96	1.22	6.67
63	0.450	7.02	1.29	7.50
68	0.500	7.08	1.38	8.33
71	0.550	7.15	1.43	9.17
74	0.600	7.21	1.48	10.00
76	0.650	7.28	1.50	10.83
77.98352	0.700	7.35	1.53	11.67
81	0.750	7.42	1.57	12.50
82	0.800	7.49	1.58	13.33
84	0.850	7.56	1.60	14.17
87	0.900	7.64	1.64	15.00
88	0.950	7.71	1.64	15.83
89	1.000	7.79	1.65	16.67

AP Engineering & Testing, Inc.

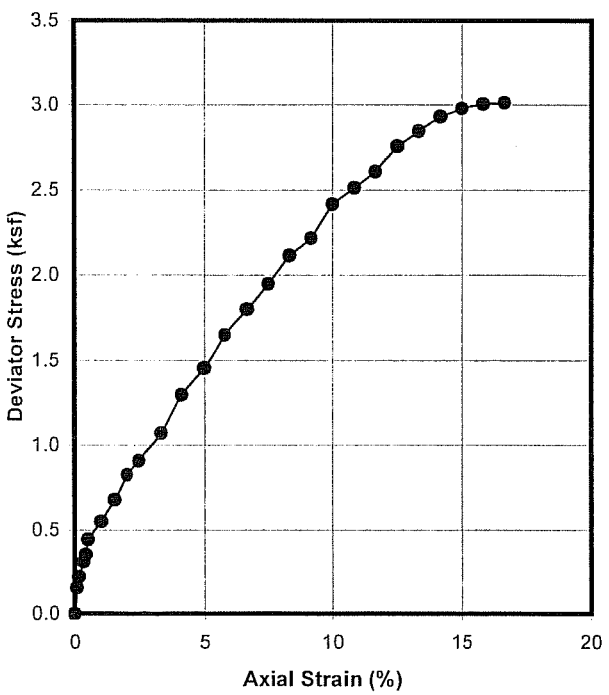
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/04/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/31/09
Project No.:	06-123-03				
Boring No.:	R-09-029				
Sample No.:	U-07	Depth (feet): 35			
Soil Description	Gray Sandy Silt		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	122.8
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	93.0
Sample Weight (gms):	1255.86	Moisture Content (%):	32.0
Wt. Wet Soil+Container(gms)	1361.96	Void Ratio for Gs=2.7:	0.81
Wt. Dry Soil+Container(gms)	1057.14	% Saturation:	106.5
Wt. Container (gms)	105.05		

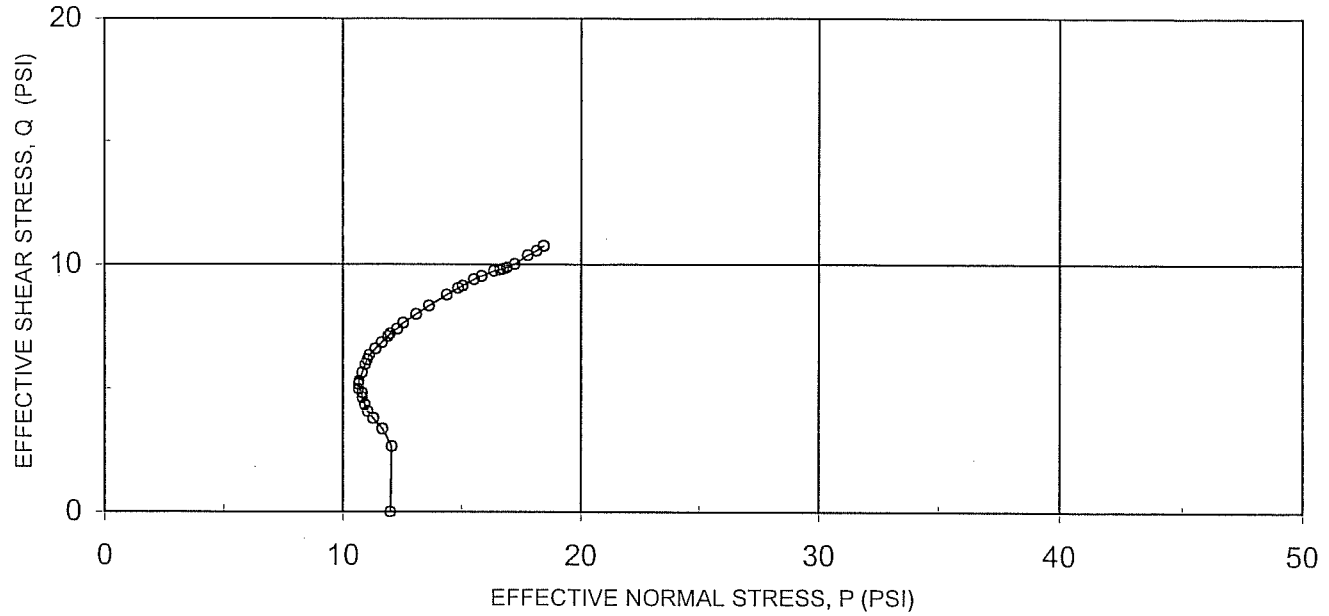
TEST DATA

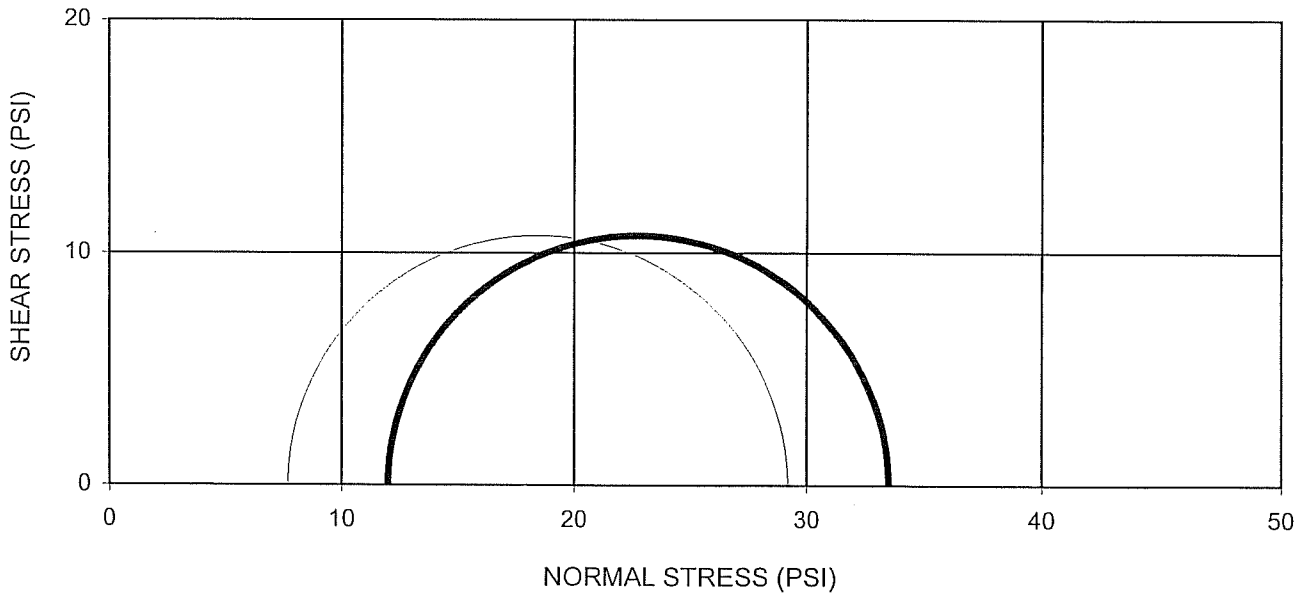
Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	3.0
Ultimate Deviator Stress (ksf):	2.9
Ultimate Undrained Shear Strength (ksf):	1.5
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
7	0.005	6.50	0.16	0.08
10	0.010	6.50	0.22	0.17
14	0.020	6.51	0.31	0.33
16	0.025	6.52	0.35	0.42
20	0.030	6.52	0.44	0.50
25	0.060	6.56	0.55	1.00
31	0.090	6.59	0.68	1.50
38	0.120	6.62	0.83	2.00
42	0.150	6.66	0.91	2.50
50	0.200	6.72	1.07	3.33
61	0.250	6.77	1.30	4.17
69	0.300	6.83	1.45	5.00
79	0.350	6.89	1.65	5.83
87	0.400	6.96	1.80	6.67
95	0.450	7.02	1.95	7.50
104	0.500	7.08	2.11	8.33
110	0.550	7.15	2.22	9.17
121	0.600	7.21	2.42	10.00
127	0.650	7.28	2.51	10.83
133	0.700	7.35	2.61	11.67
142	0.750	7.42	2.76	12.50
148	0.800	7.49	2.85	13.33
154	0.850	7.56	2.93	14.17
158	0.900	7.64	2.98	15.00
161	0.950	7.71	3.01	15.83
163	1.000	7.79	3.01	16.67

CONSOLIDATED UNDRAINED TRIAXIAL





Symbol	Boring No	Sample No	Depth (ft)	Sample Type	Soil Type
○	R-09-021	U-10	45	Shelby Tube	CL

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

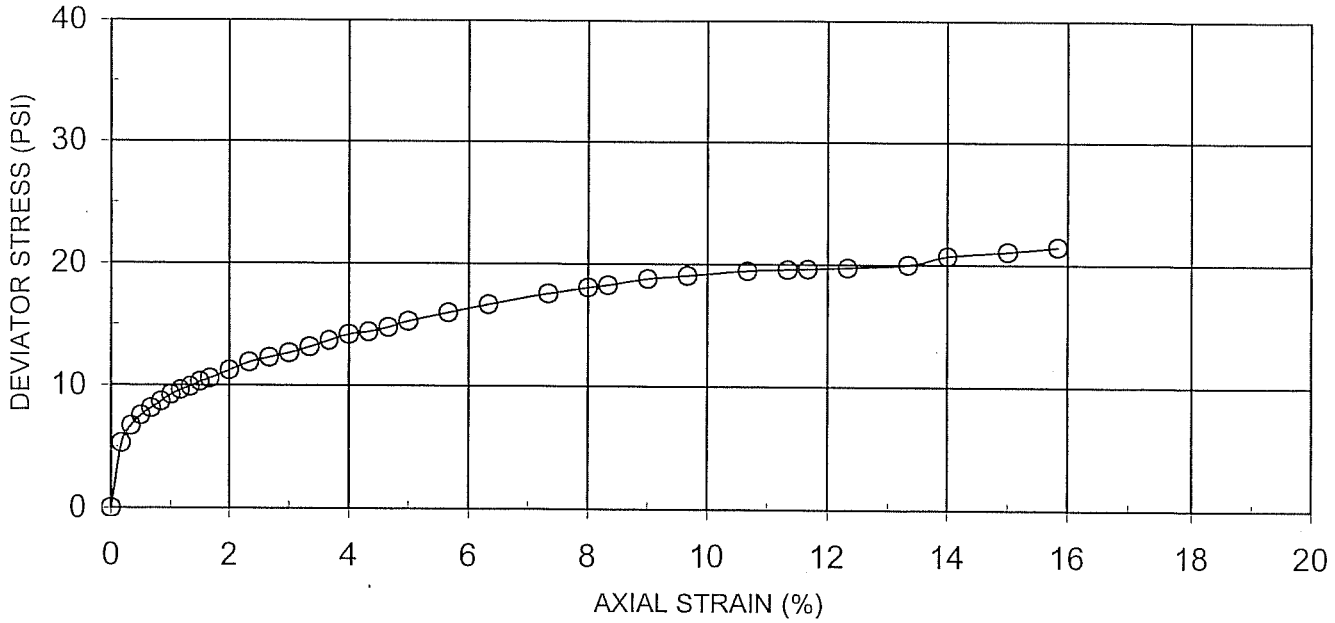
EGL Project No: 09-230-008

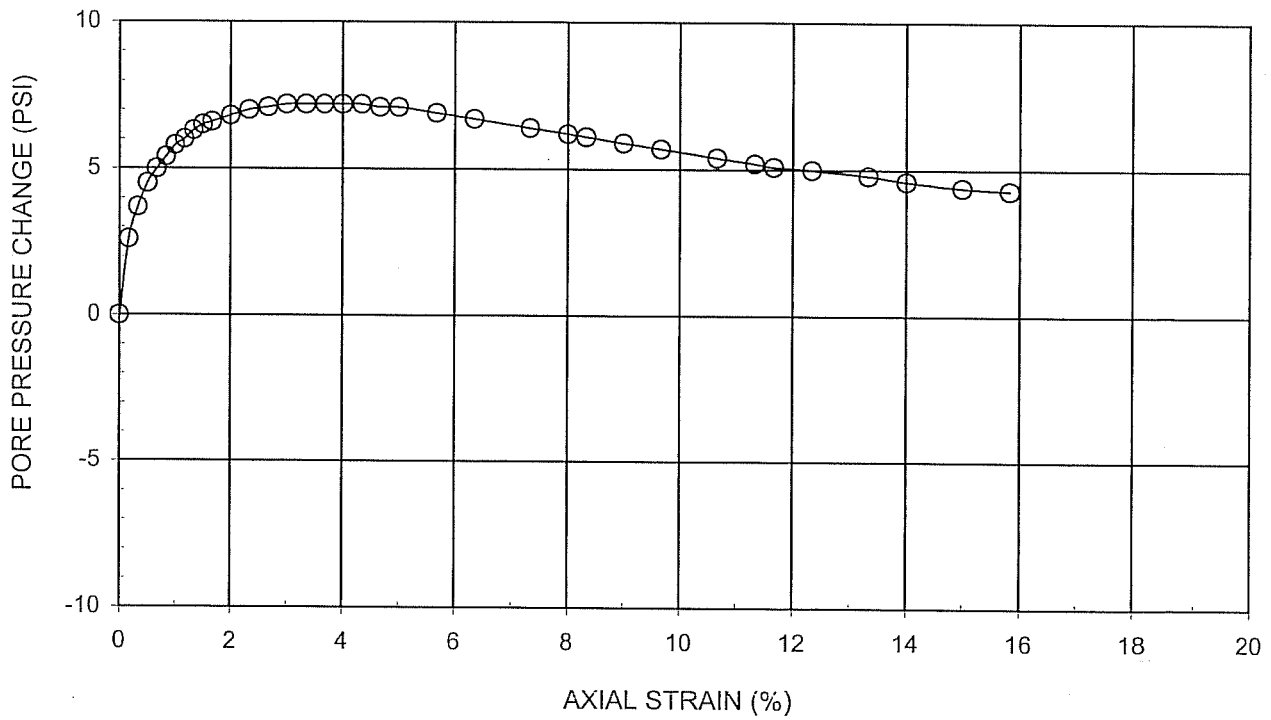
CONSOLIDATED UNDRAINED

(ASTM D4767)

1/19/10

Figure





Symbol	Boring No	Sample No	Depth (ft)	Soil Type	Sample Type	Initial Moisture Content (%)	Initial Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)
○	R-09-021	U-10	45	CL	Shelby Tube	36.90	84.7	12.0	21.5	0.0125

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No 09-230-008

CONSOLIDATED UNDRAINED

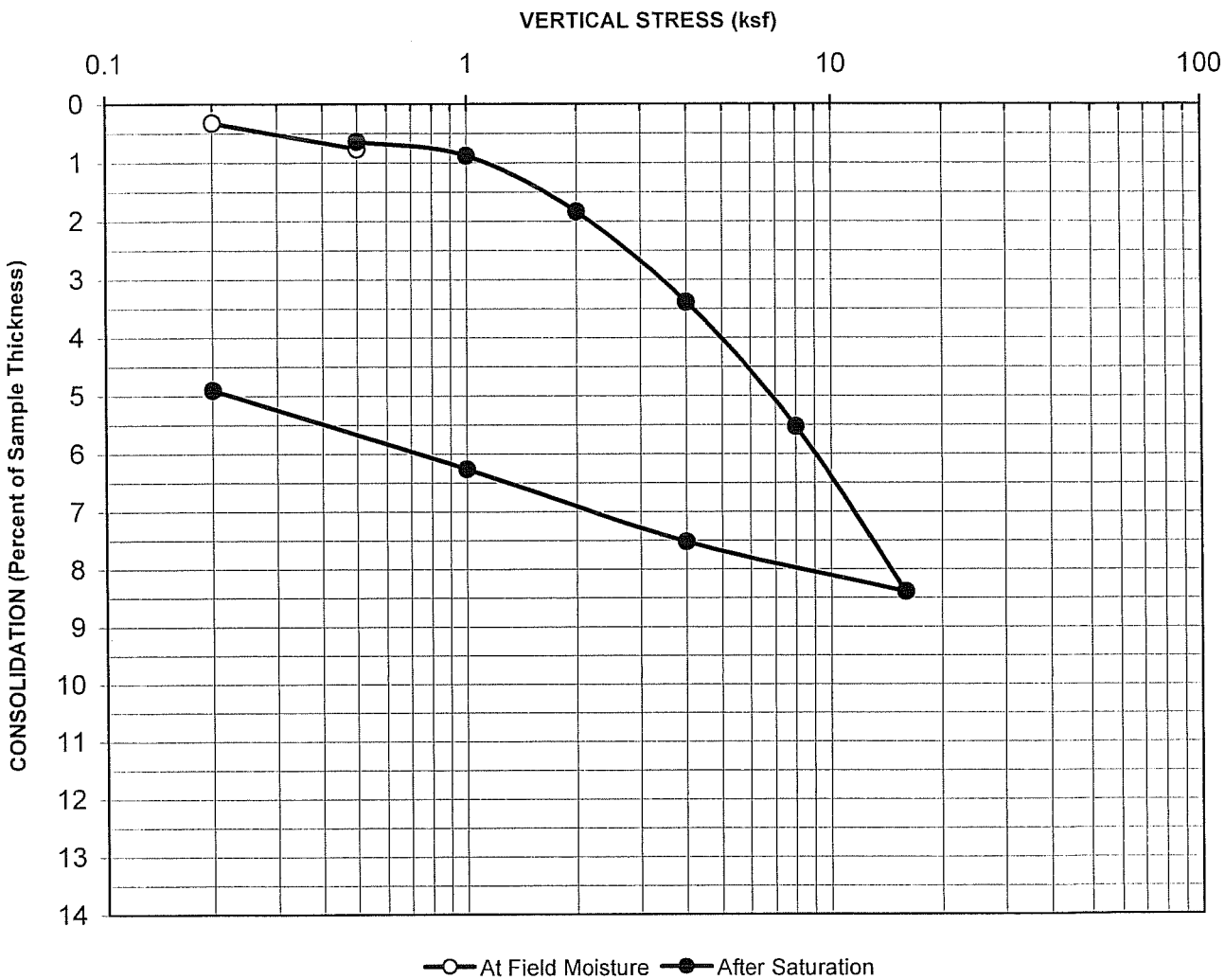
(ASTM D4767)

1/19/10

Figure

CONSOLIDATION

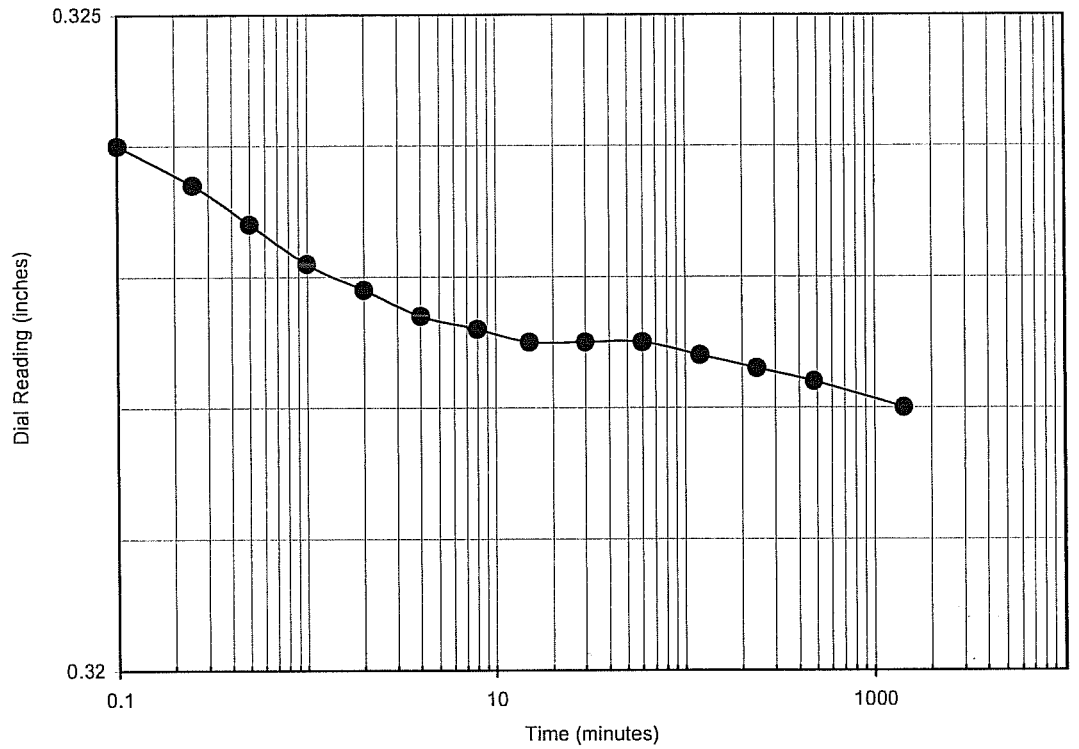
AP Engineering & Testing, Inc.



Boring No. :	R-09-001	Initial Dry Unit Weight (pcf):	90.6
Sample No.:	D-11	Initial Moisture Content (%):	30.9
Depth (feet):	55	Final Moisture Content (%):	33.9
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Lean Clay with fine sand	Initial Void Ratio:	0.86
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/27/2009
AP No:	29-1121

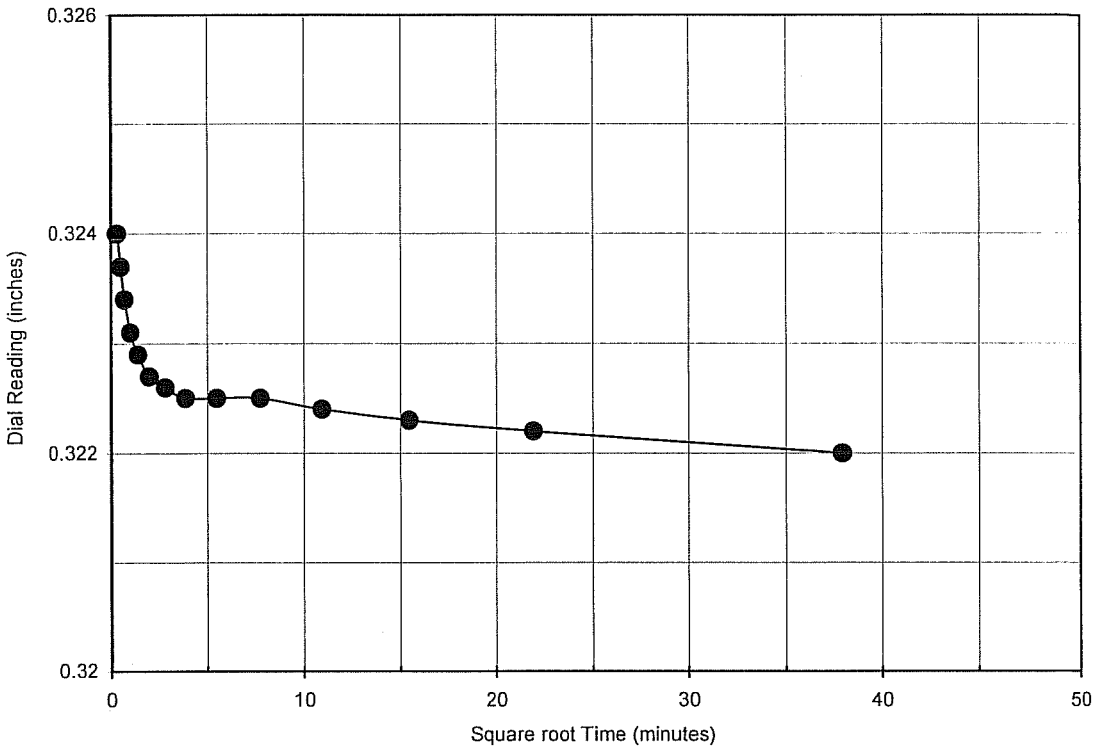


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.324
0.25	0.3237
0.5	0.3234
1	0.3231
2	0.3229
4	0.3227
8	0.3226
15	0.3225
30	0.3225
60	0.3225
120	0.3224
240	0.3223
480	0.3222
1440	0.322

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

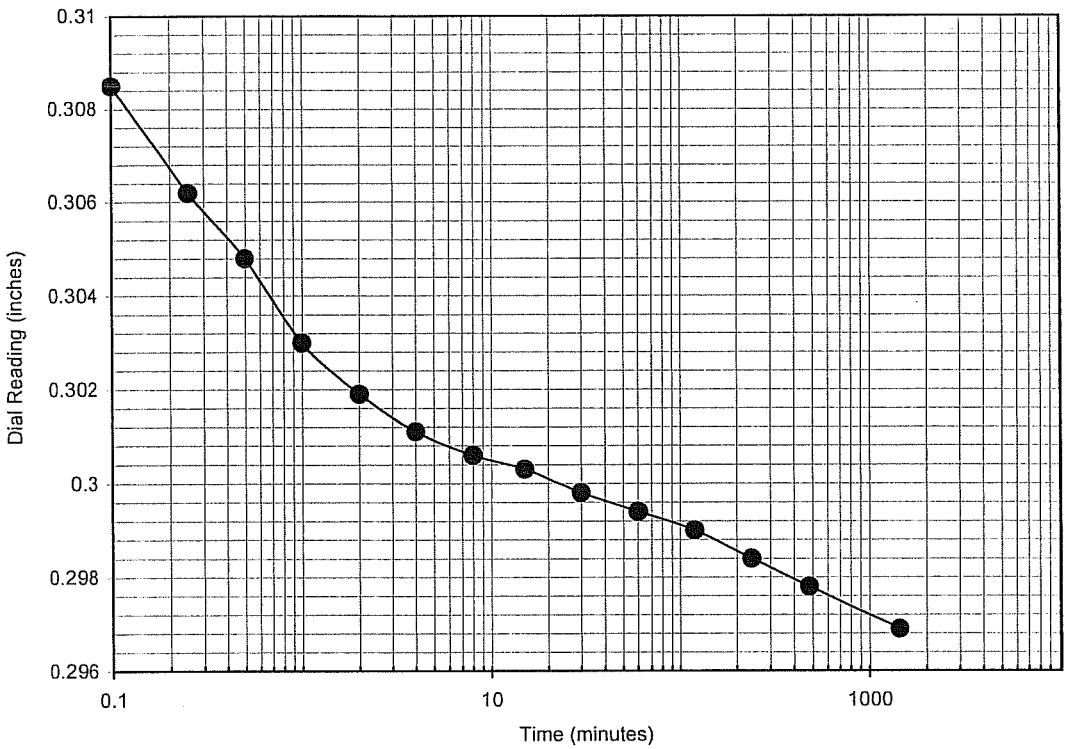


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3240
0.5000	0.3237
0.7071	0.3234
1.0000	0.3231
1.4142	0.3229
2.0000	0.3227
2.8284	0.3226
3.8730	0.3225
5.4772	0.3225
7.7460	0.3225
10.9545	0.3224
15.4919	0.3223
21.9089	0.3222
37.9473	0.3220

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

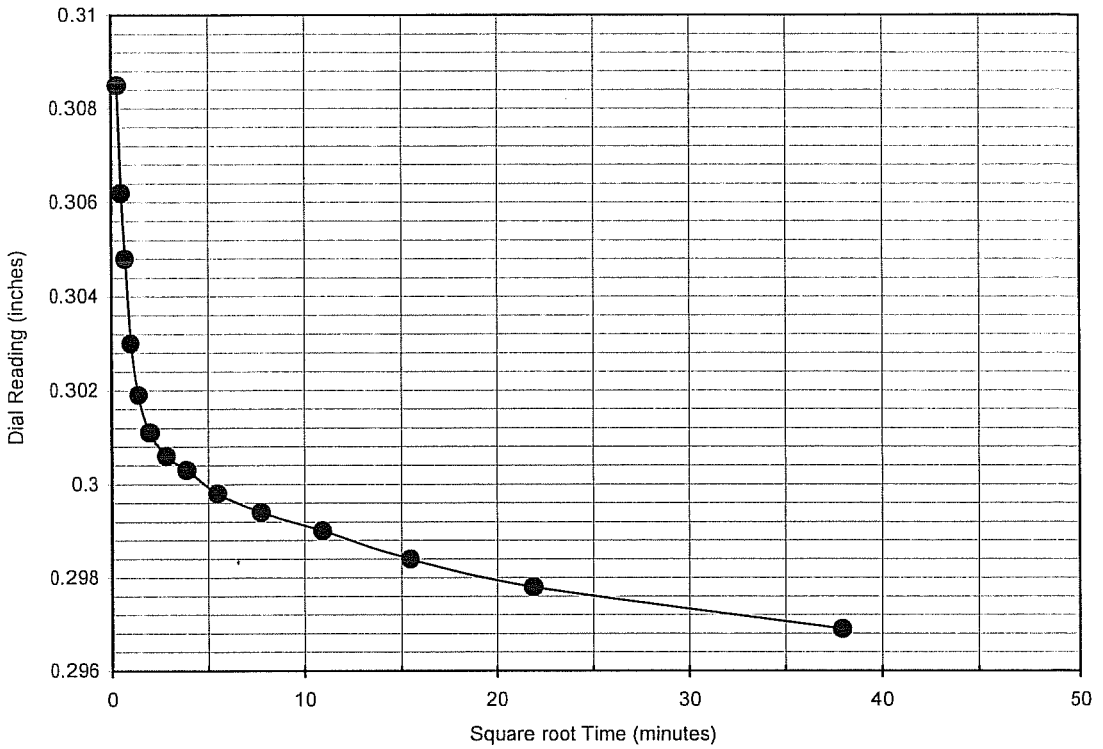


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3085
0.25	0.3062
0.5	0.3048
1	0.303
2	0.3019
4	0.3011
8	0.3006
15	0.3003
30	0.2998
60	0.2994
120	0.299
240	0.2984
480	0.2978
1440	0.2969

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**



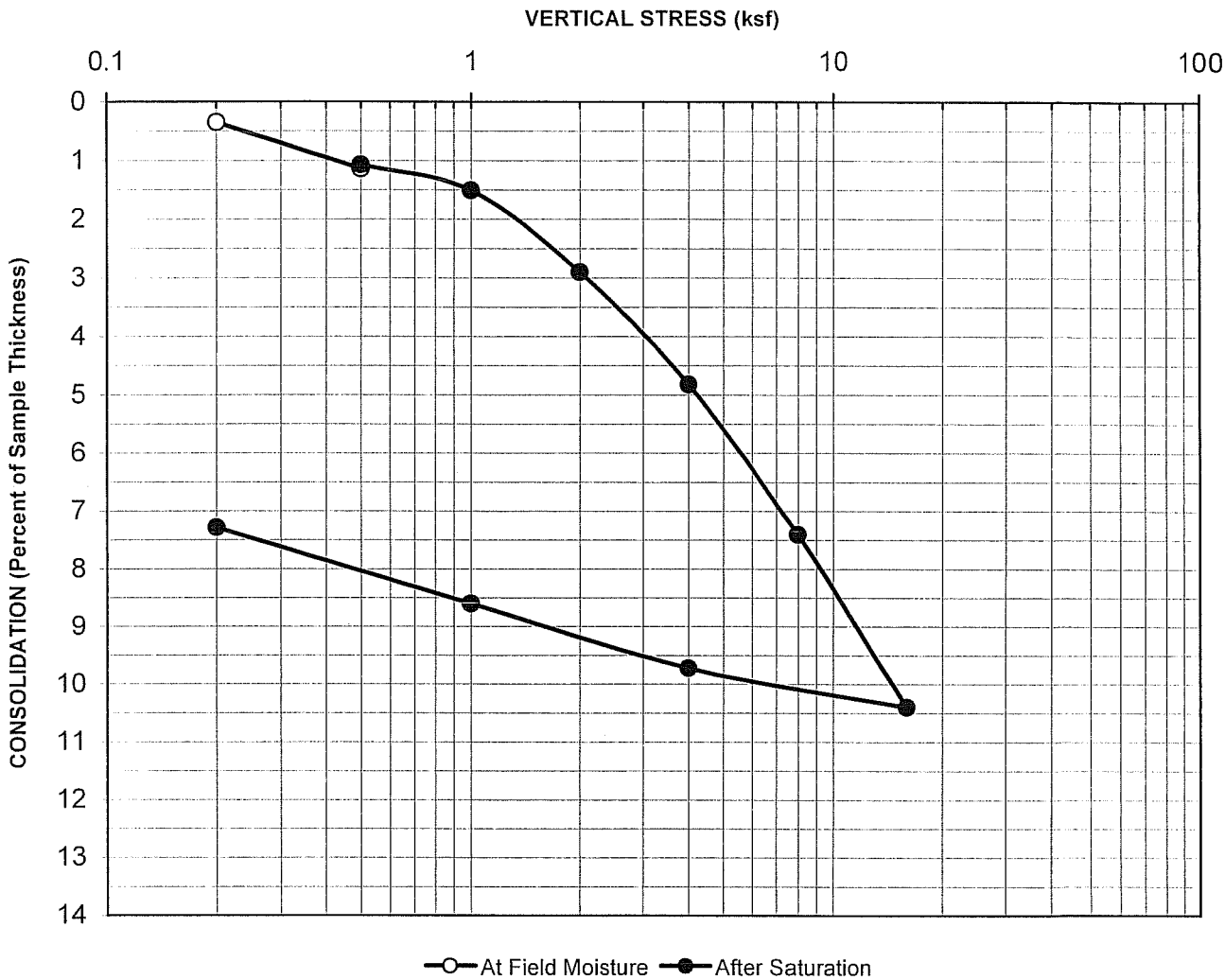
Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3085
0.5000	0.3062
0.7071	0.3048
1.0000	0.3030
1.4142	0.3019
2.0000	0.3011
2.8284	0.3006
3.8730	0.3003
5.4772	0.2998
7.7460	0.2994
10.9545	0.2990
15.4919	0.2984
21.9089	0.2978
37.9473	0.2969

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

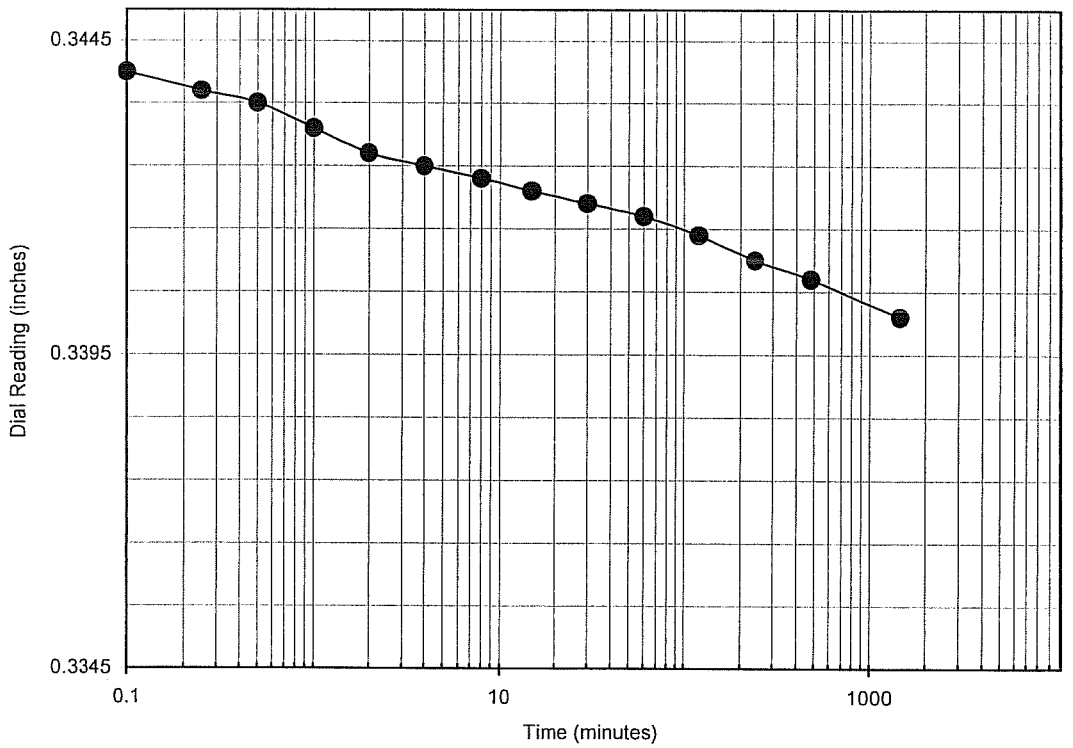
AP Engineering & Testing, Inc.



Boring No. :	R-09-002	Initial Dry Unit Weight (pcf):	89.1
Sample No.:	D-09	Initial Moisture Content (%):	35.7
Depth (feet):	45	Final Moisture Content (%):	28.4
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Silt with sand	Initial Void Ratio:	0.89
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/27/2009
AP No:	29-1121

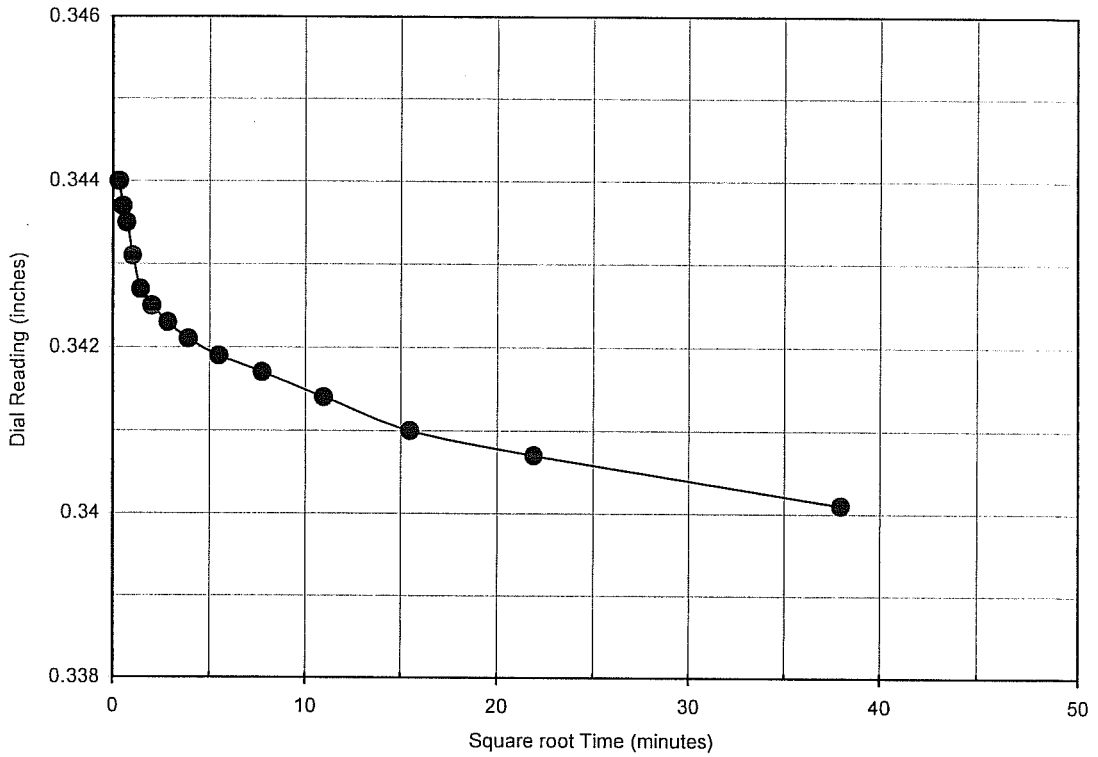


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.344
0.25	0.3437
0.5	0.3435
1	0.3431
2	0.3427
4	0.3425
8	0.3423
15	0.3421
30	0.3419
60	0.3417
120	0.3414
240	0.341
480	0.3407
1440	0.3401

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

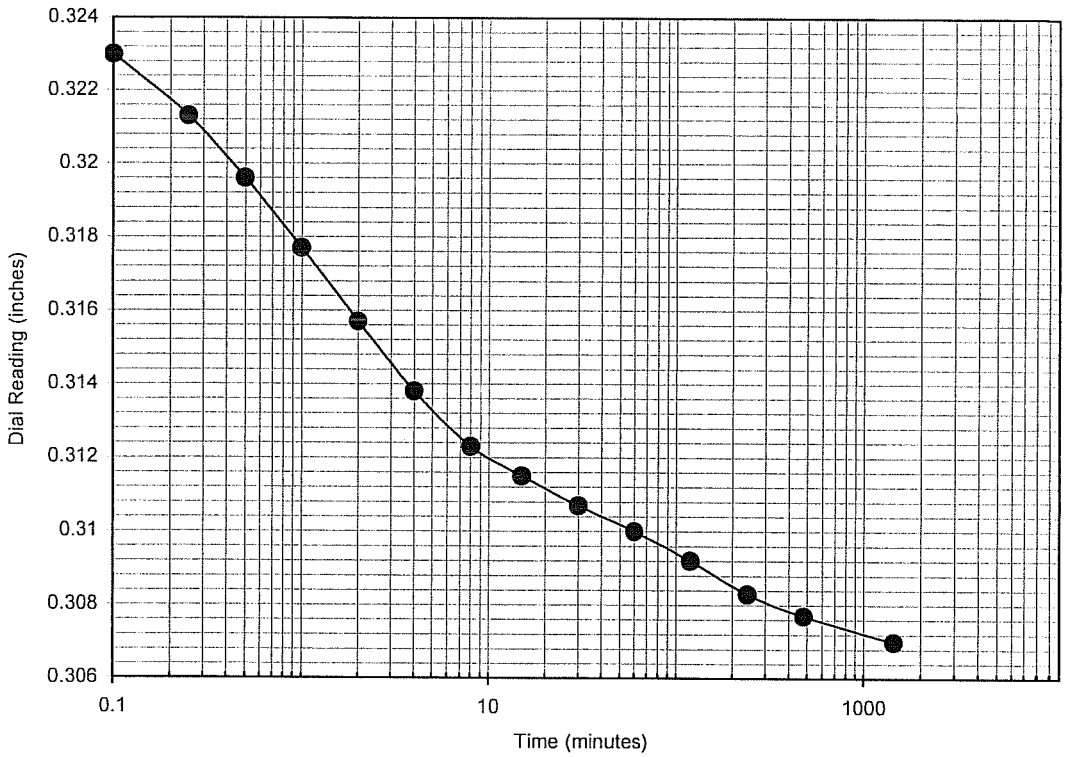


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3440
0.5000	0.3437
0.7071	0.3435
1.0000	0.3431
1.4142	0.3427
2.0000	0.3425
2.8284	0.3423
3.8730	0.3421
5.4772	0.3419
7.7460	0.3417
10.9545	0.3414
15.4919	0.3410
21.9089	0.3407
37.9473	0.3401

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

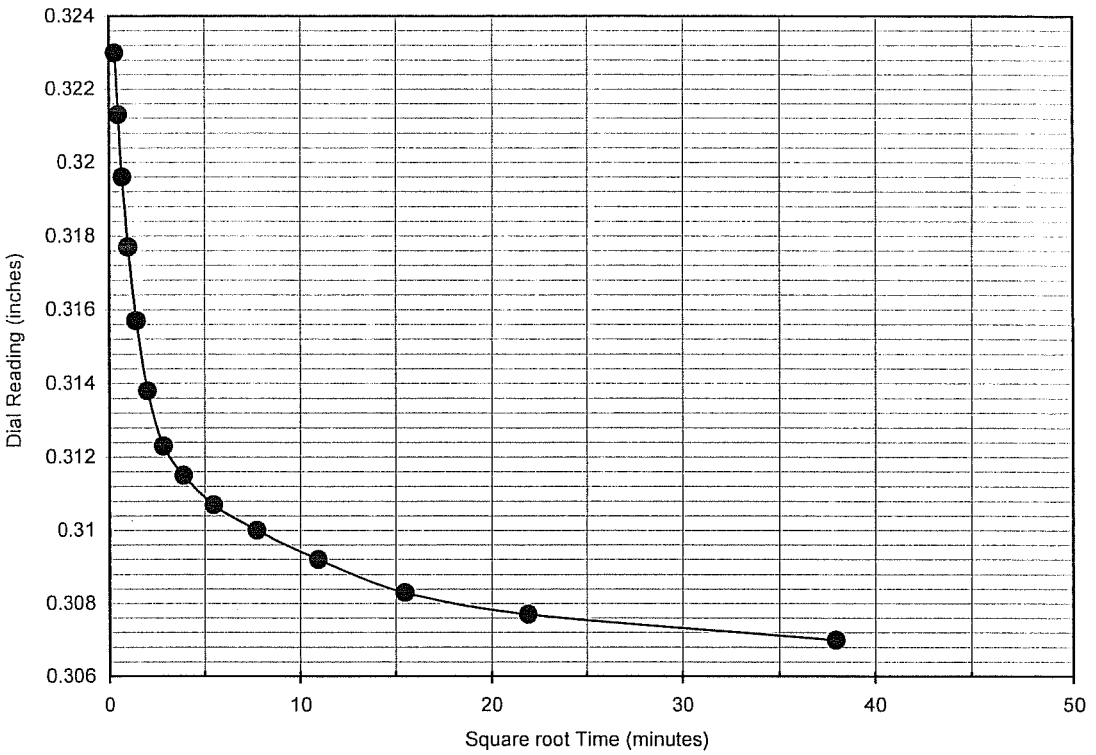


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.323
0.25	0.3213
0.5	0.3196
1	0.3177
2	0.3157
4	0.3138
8	0.3123
15	0.3115
30	0.3107
60	0.31
120	0.3092
240	0.3083
480	0.3077
1440	0.307

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**



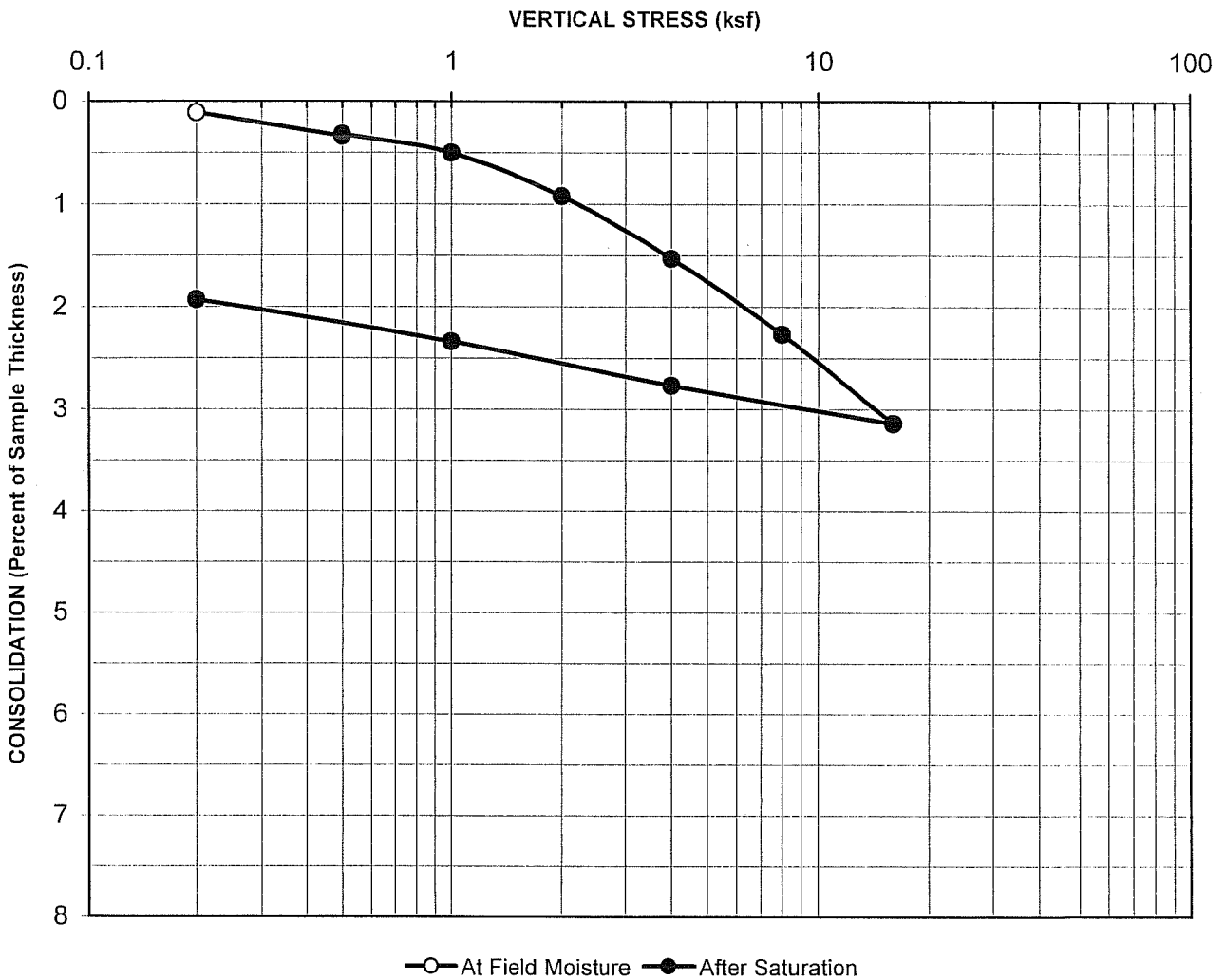
Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3230
0.5000	0.3213
0.7071	0.3196
1.0000	0.3177
1.4142	0.3157
2.0000	0.3138
2.8284	0.3123
3.8730	0.3115
5.4772	0.3107
7.7460	0.3100
10.9545	0.3092
15.4919	0.3083
21.9089	0.3077
37.9473	0.3070

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

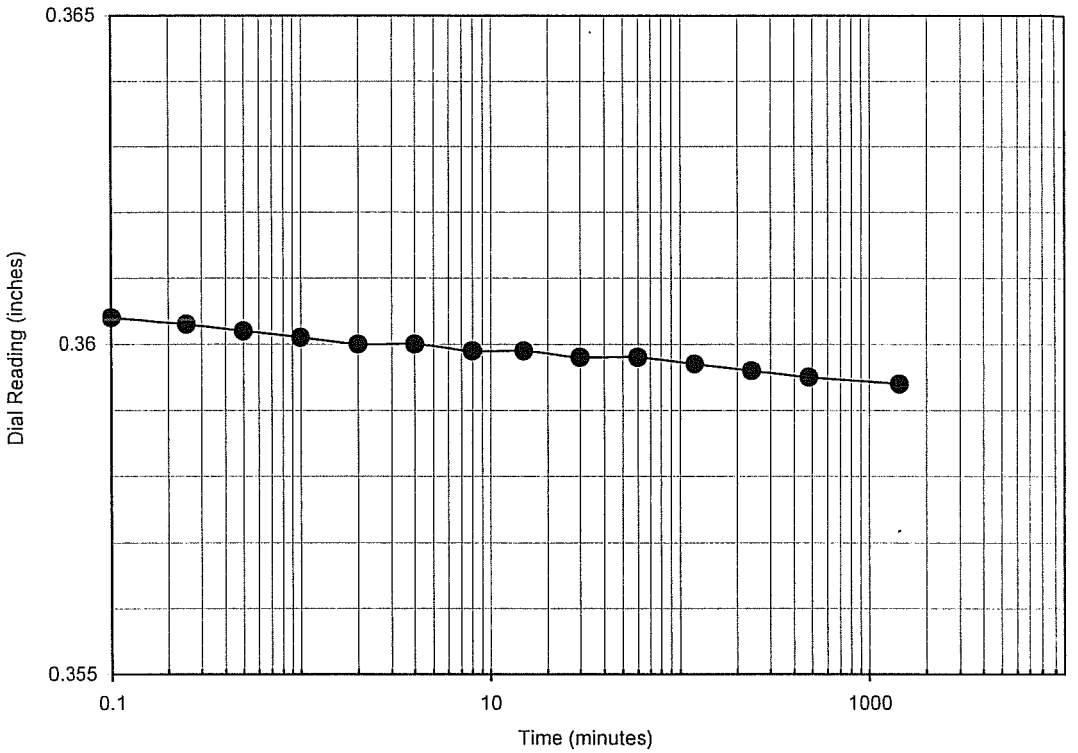
AP Engineering & Testing, Inc.



Boring No. :	R-09-003	Initial Dry Unit Weight (pcf):	109.7
Sample No.:	U-11	Initial Moisture Content (%):	20.3
Depth (feet):	55	Final Moisture Content (%):	18.5
Sample Type:	Shelby	Assumed Specific Gravity:	2.7
Soil Description:	Silt with sand	Initial Void Ratio:	0.54
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	12/1/2009
AP No:	29-1121

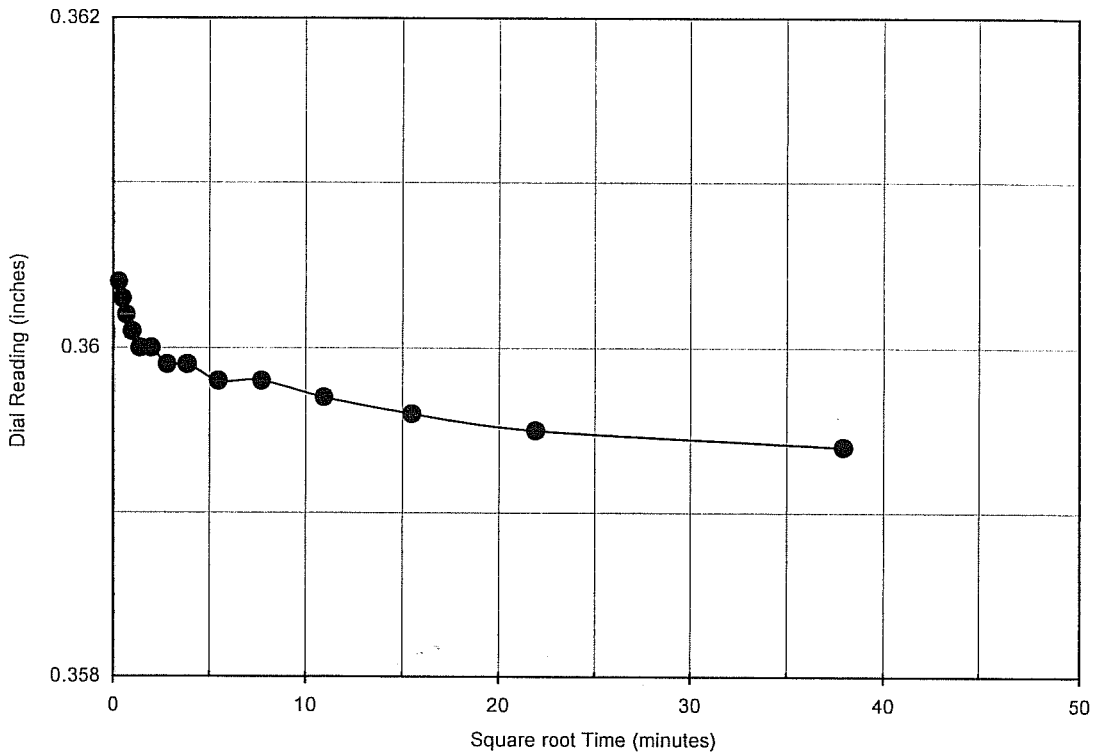


Boring No. :	R-09-003	Sample Type:	Shelby
Sample No.:	U-11	Soil Description:	Silt with sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3604
0.25	0.3603
0.5	0.3602
1	0.3601
2	0.36
4	0.36
8	0.3599
15	0.3599
30	0.3598
60	0.3598
120	0.3597
240	0.3596
480	0.3595
1440	0.3594

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/16/09
AP No: 29-1121 **Figure No:**

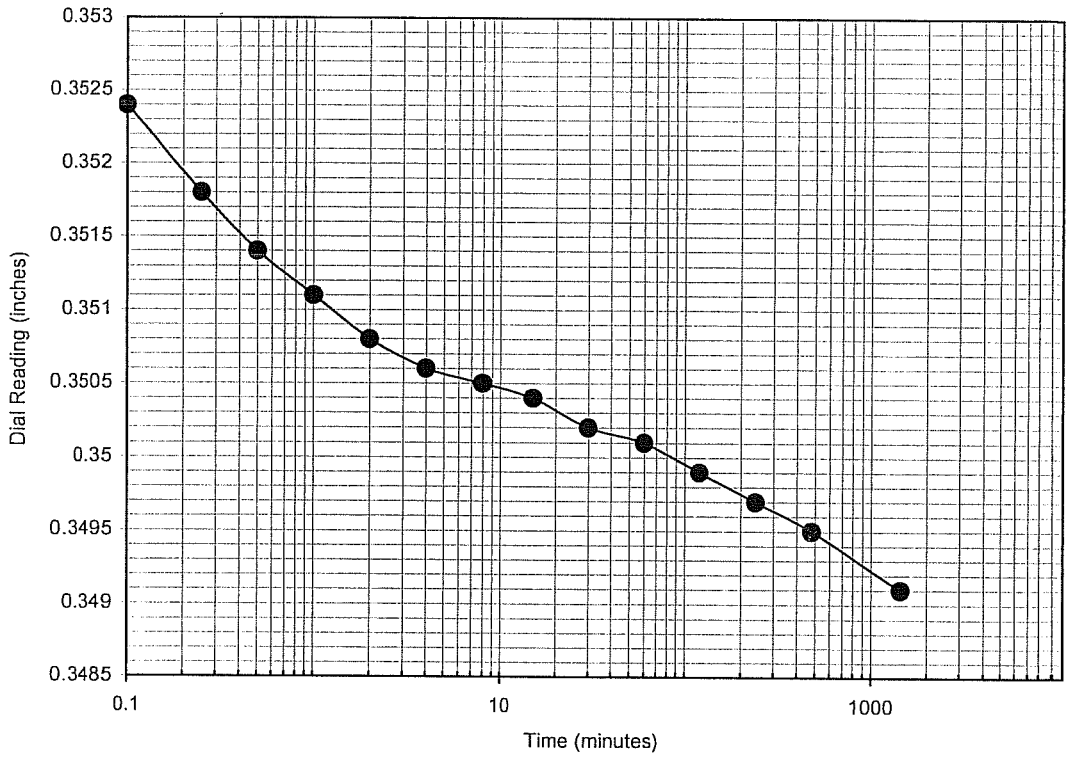


Boring No. :	R-09-003	Sample Type:	Shelby
Sample No.:	U-11	Soil Description:	Silt with sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3604
0.5000	0.3603
0.7071	0.3602
1.0000	0.3601
1.4142	0.3600
2.0000	0.3600
2.8284	0.3599
3.8730	0.3599
5.4772	0.3598
7.7460	0.3598
10.9545	0.3597
15.4919	0.3596
21.9089	0.3595
37.9473	0.3594

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/16/09
AP No: 29-1121 **Figure No:**

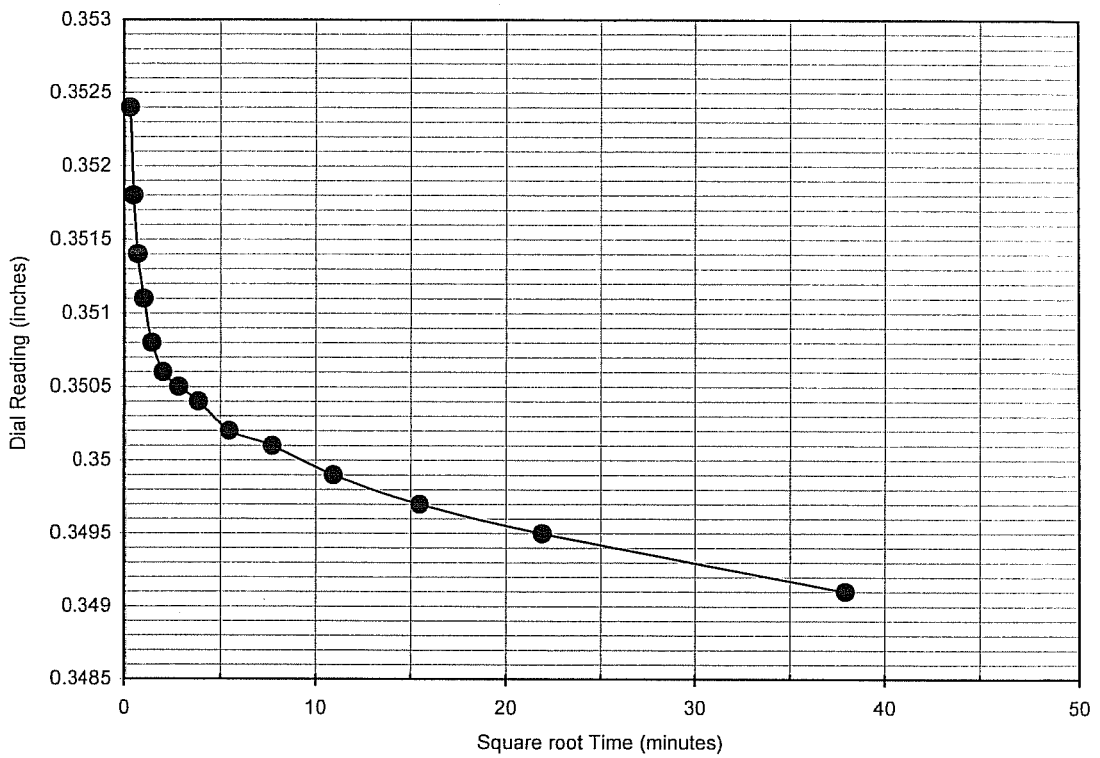


Boring No. :	R-09-003	Sample Type:	Shelby
Sample No.:	U-11	Soil Description:	Silt with sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3524
0.25	0.3518
0.5	0.3514
1	0.3511
2	0.3508
4	0.3506
8	0.3505
15	0.3504
30	0.3502
60	0.3501
120	0.3499
240	0.3497
480	0.3495
1440	0.3491

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/16/09
AP No: 29-1121 **Figure No:**

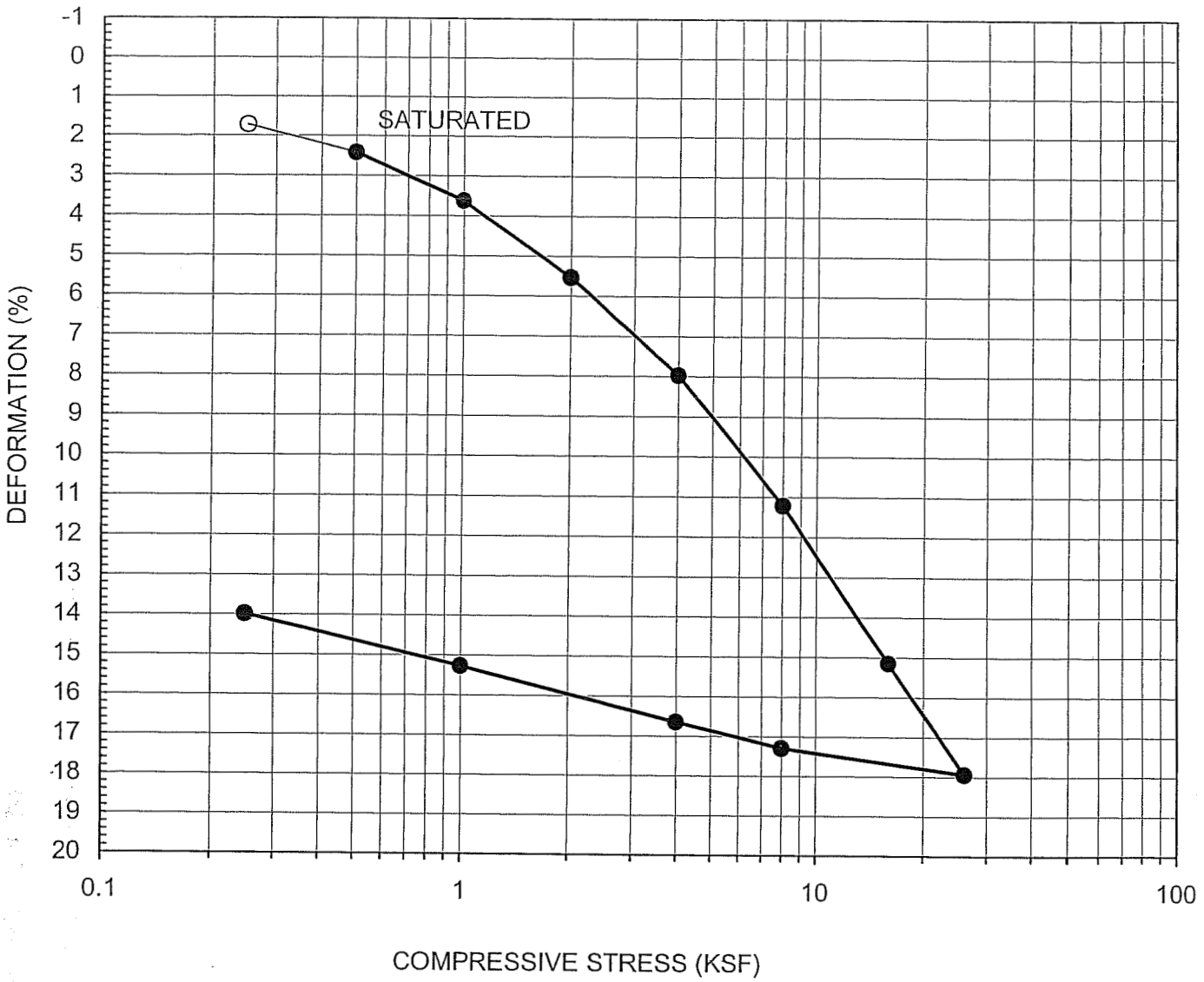


Boring No. :	R-09-003	Sample Type:	Shelby
Sample No.:	U-11	Soil Description:	Silt with sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3524
0.5000	0.3518
0.7071	0.3514
1.0000	0.3511
1.4142	0.3508
2.0000	0.3506
2.8284	0.3505
3.8730	0.3504
5.4772	0.3502
7.7460	0.3501
10.9545	0.3499
15.4919	0.3497
21.9089	0.3495
37.9473	0.3491

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/16/09
AP No: 29-1121 **Figure No:**



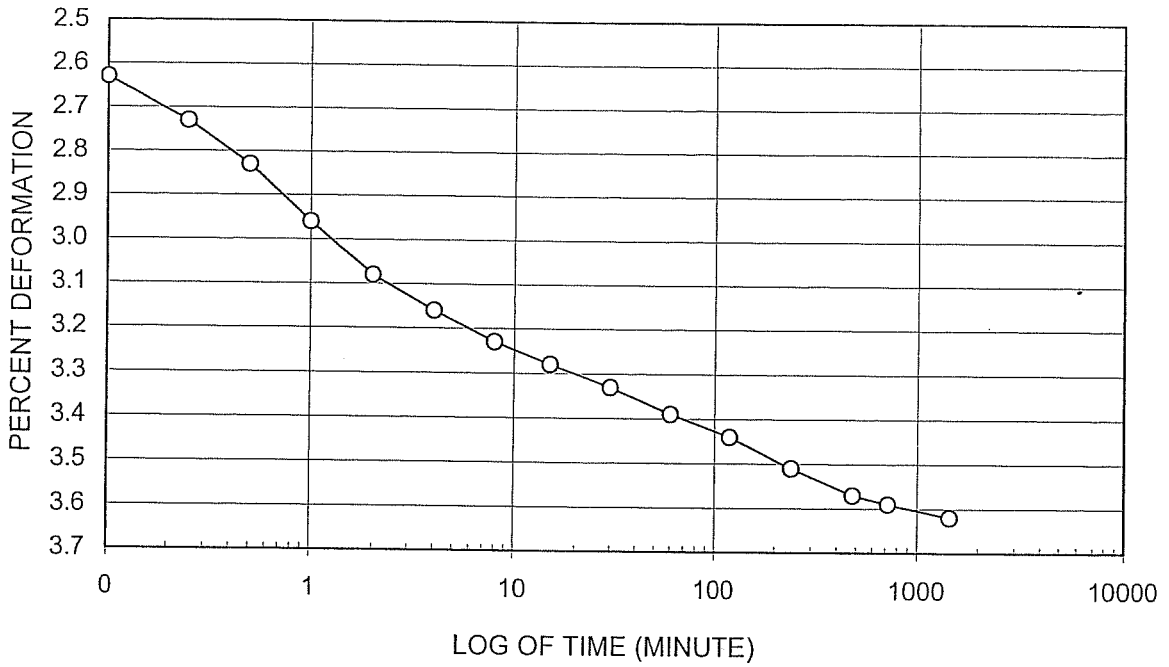
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-010	U-06	30.0	ML	34.8	84.9	0.984

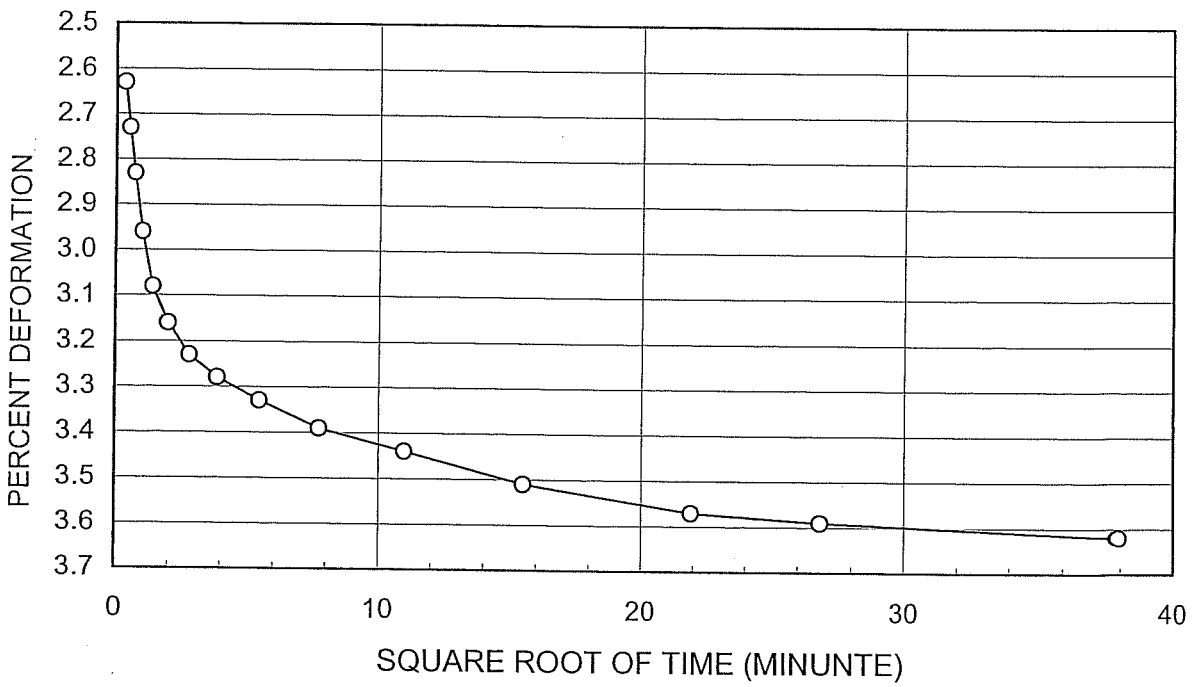
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





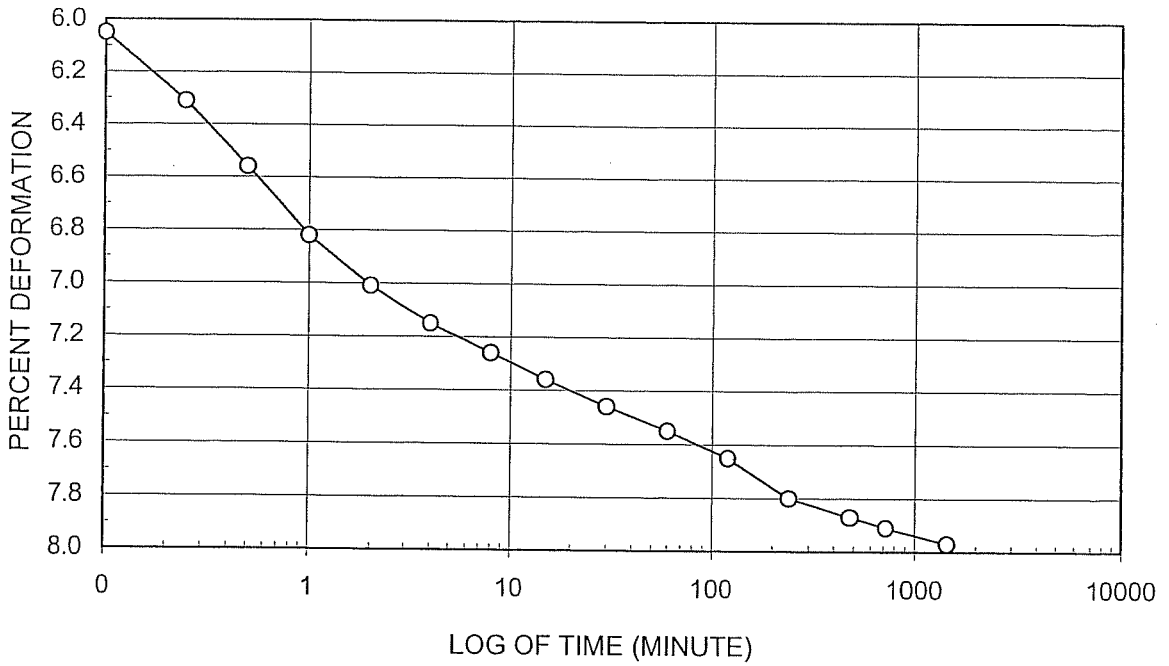
Boring No: R-09-010
Sample No: U-06
Depth (ft): 30
Soil Type: ML
Normal Stress: 1.0 ksf

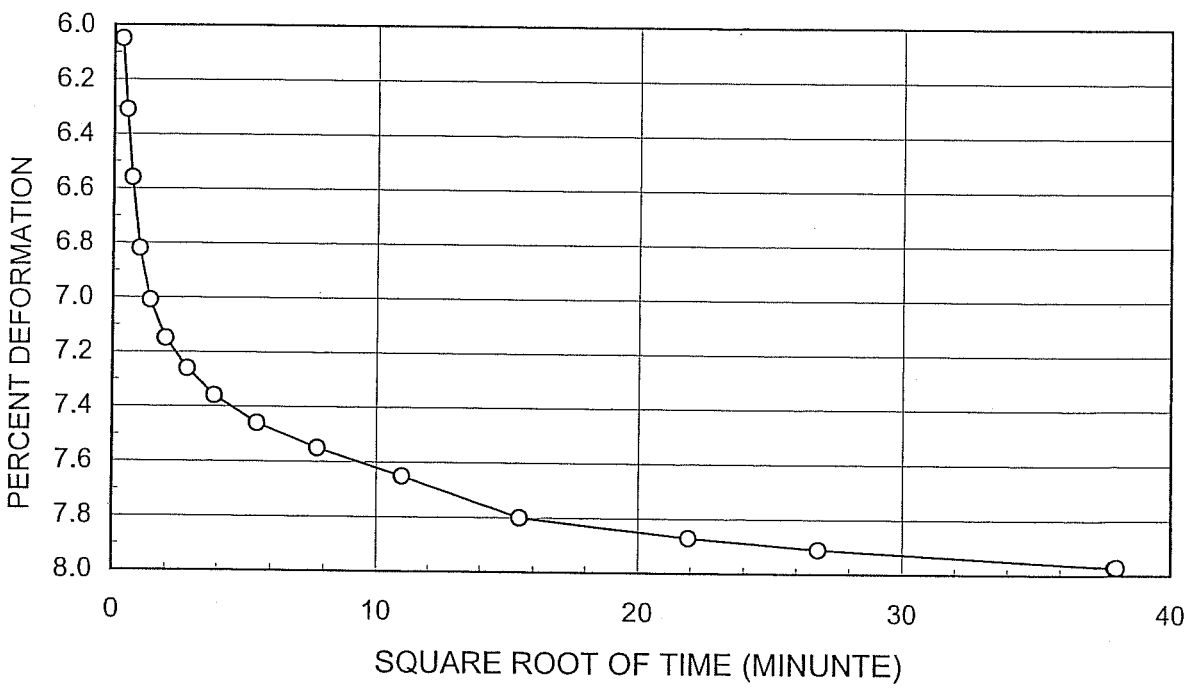
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





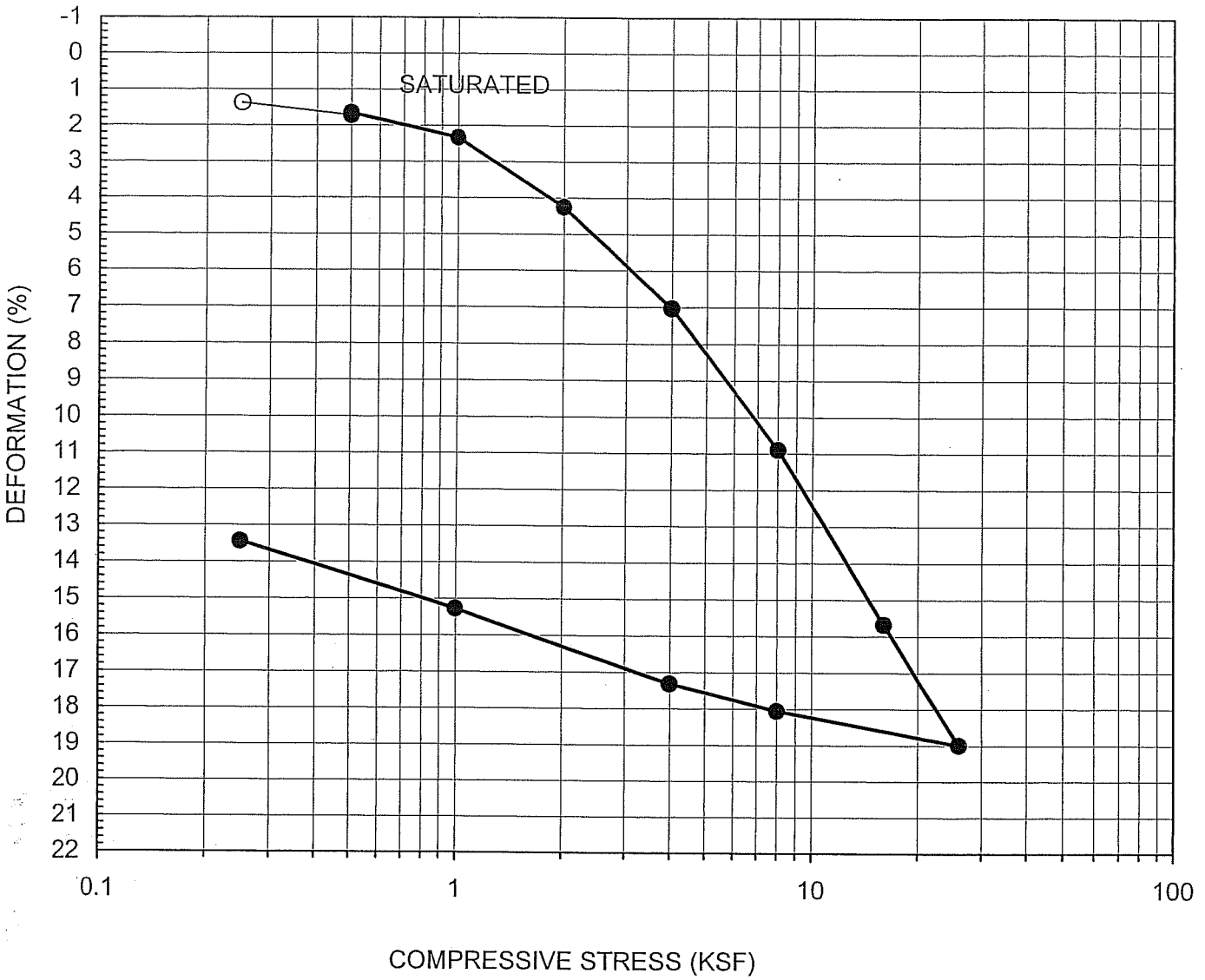
Boring No: R-09-010
Sample No: U-06
Depth (ft): 30
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



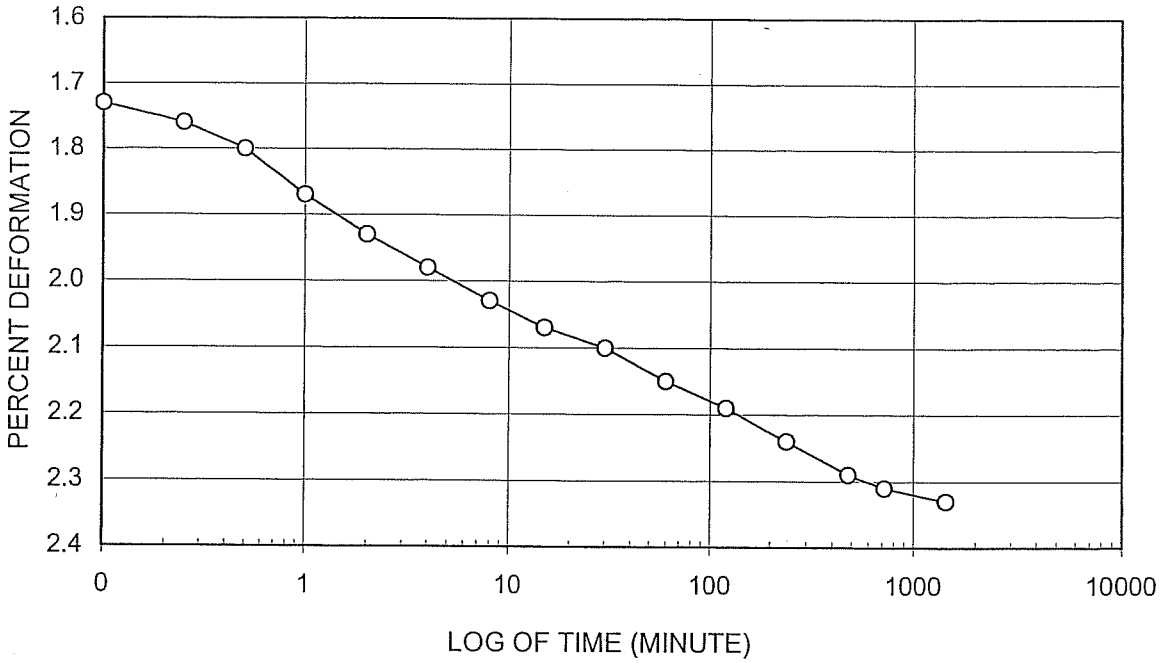
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-010	D-08-2	40.5	CL	39.5	81.7	1.063

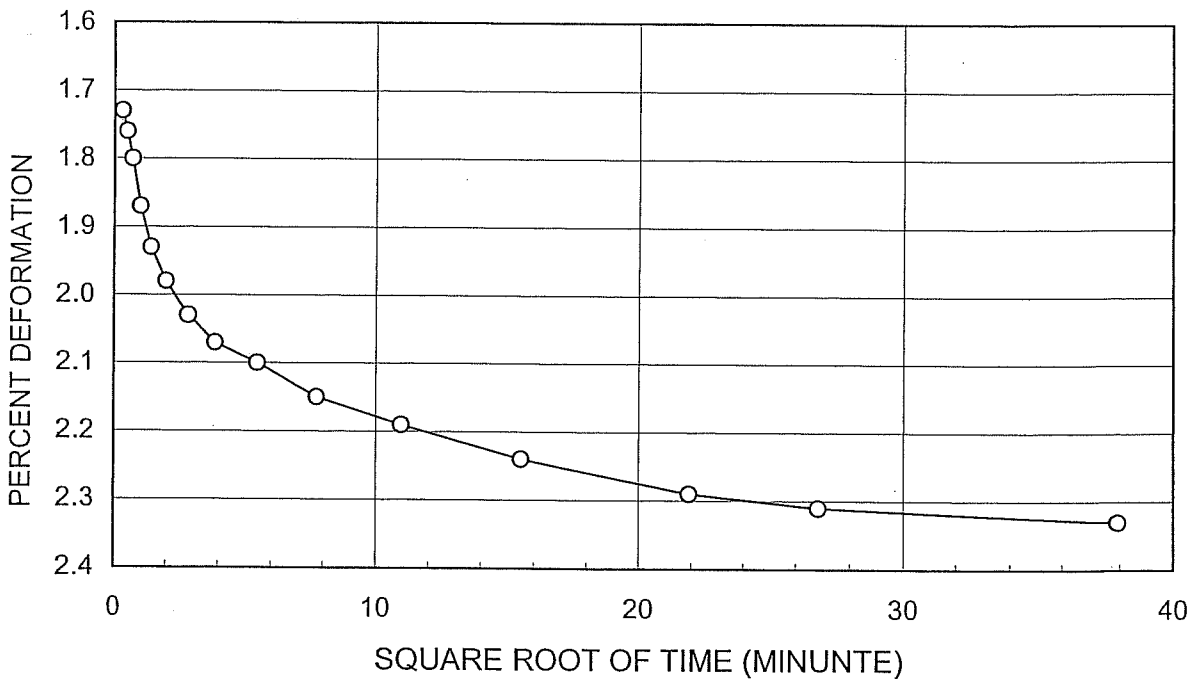
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





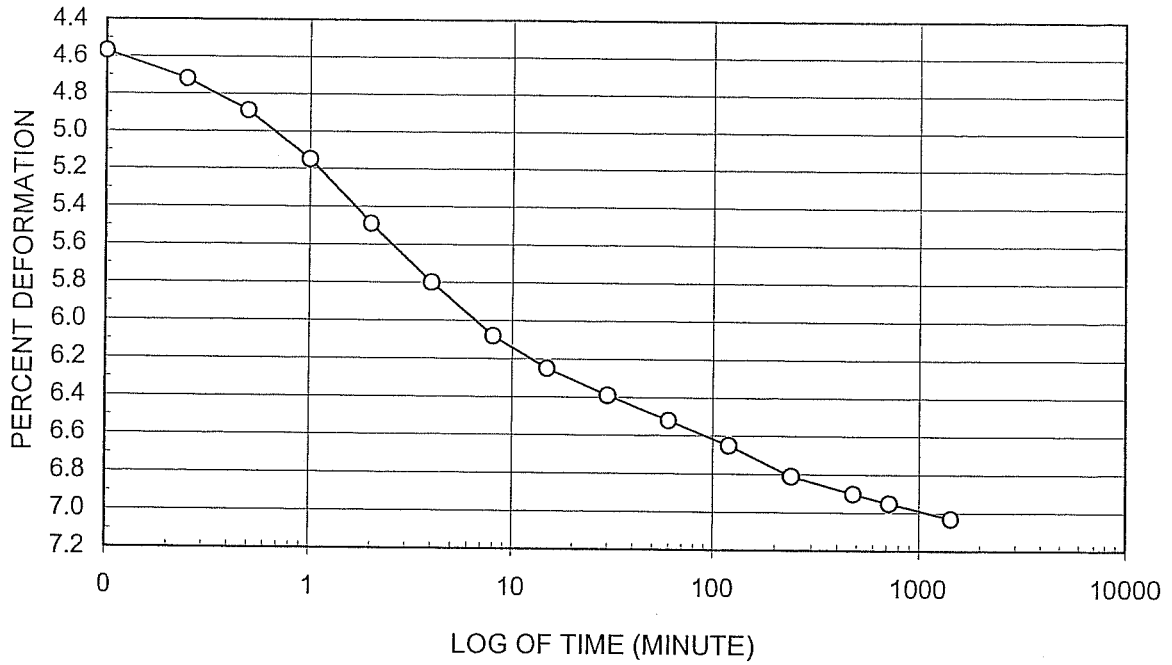
Boring No: R-09-010
Sample No: D-08-2
Depth (ft): 40.5
Soil Type: CL
Normal Stress: 1.0 ksf

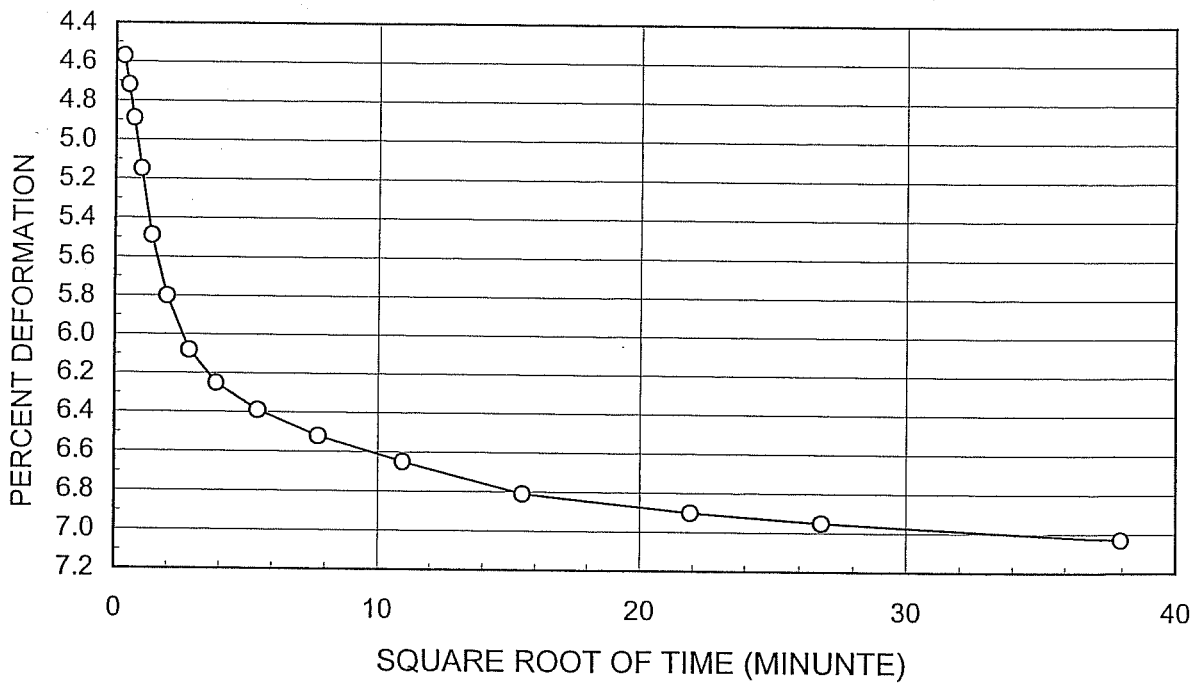
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





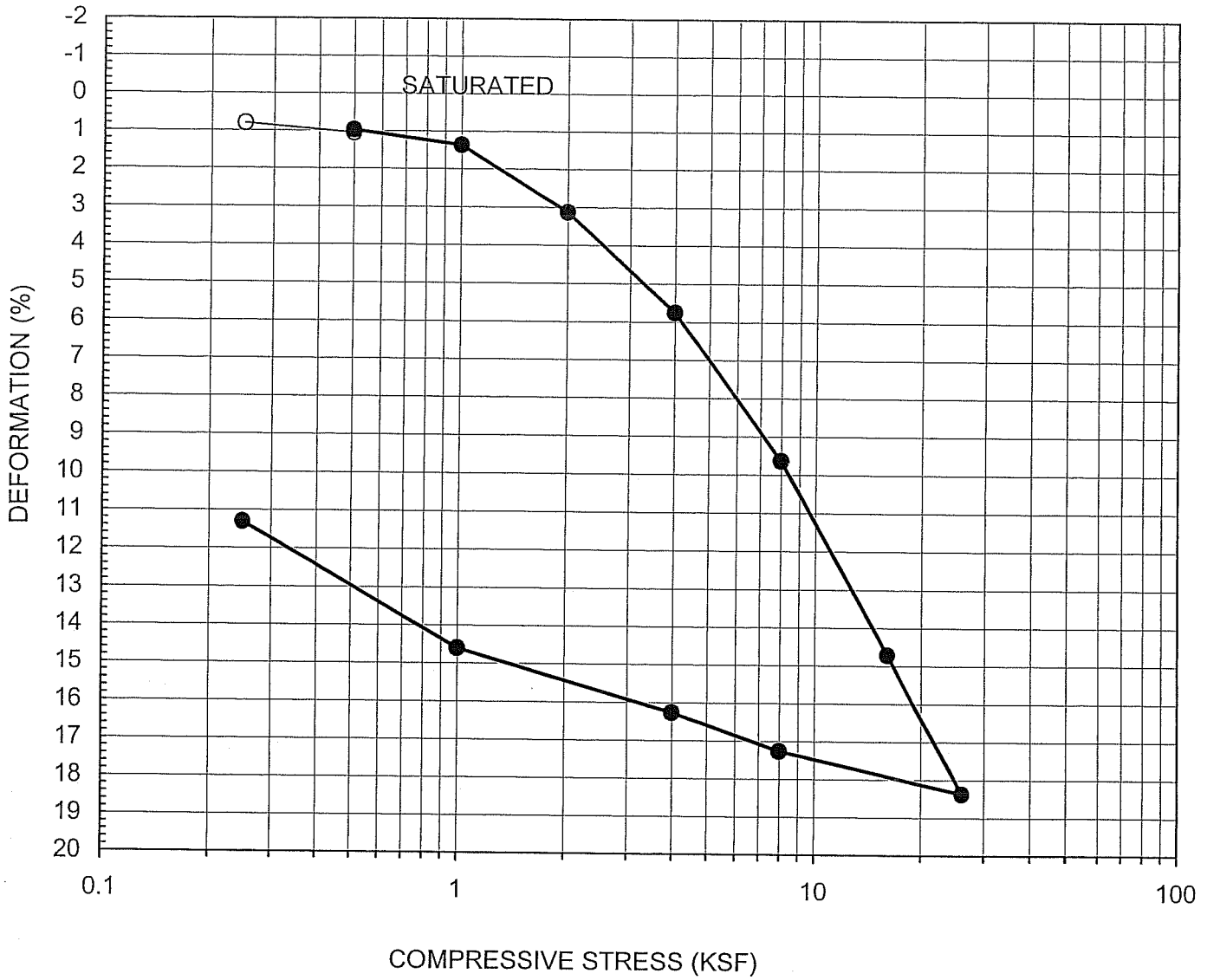
Boring No: R-09-010
Sample No: D-08-2
Depth (ft): 40.5
Soil Type: CL
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



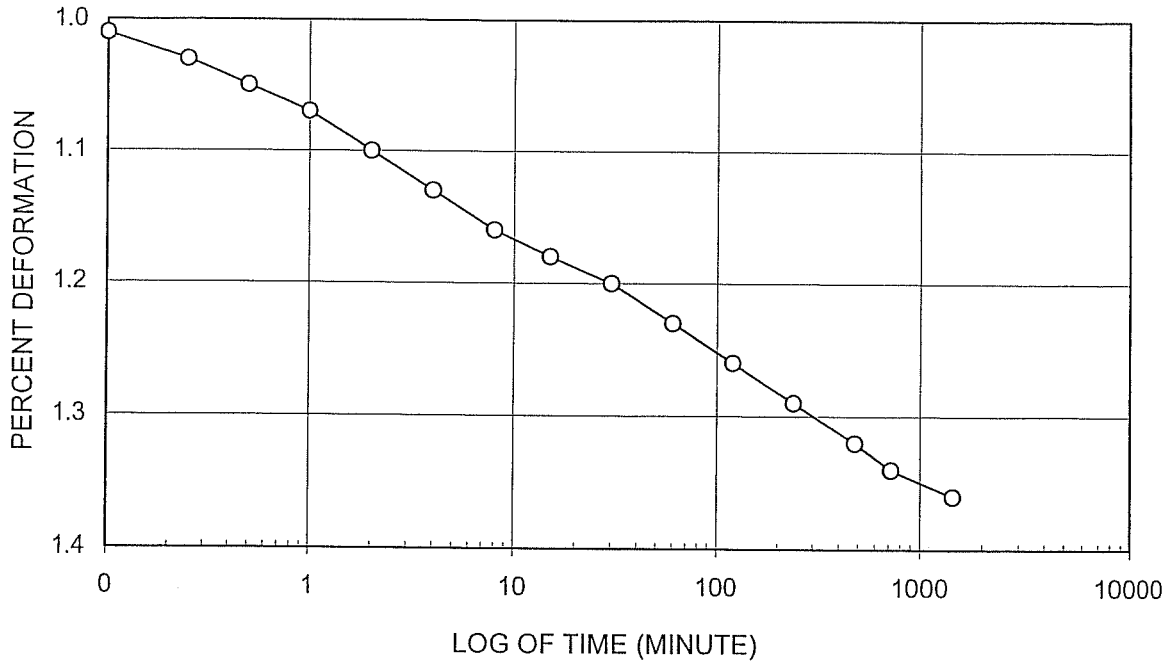
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-010	D-10	50.0	CH	44.1	76.1	1.215

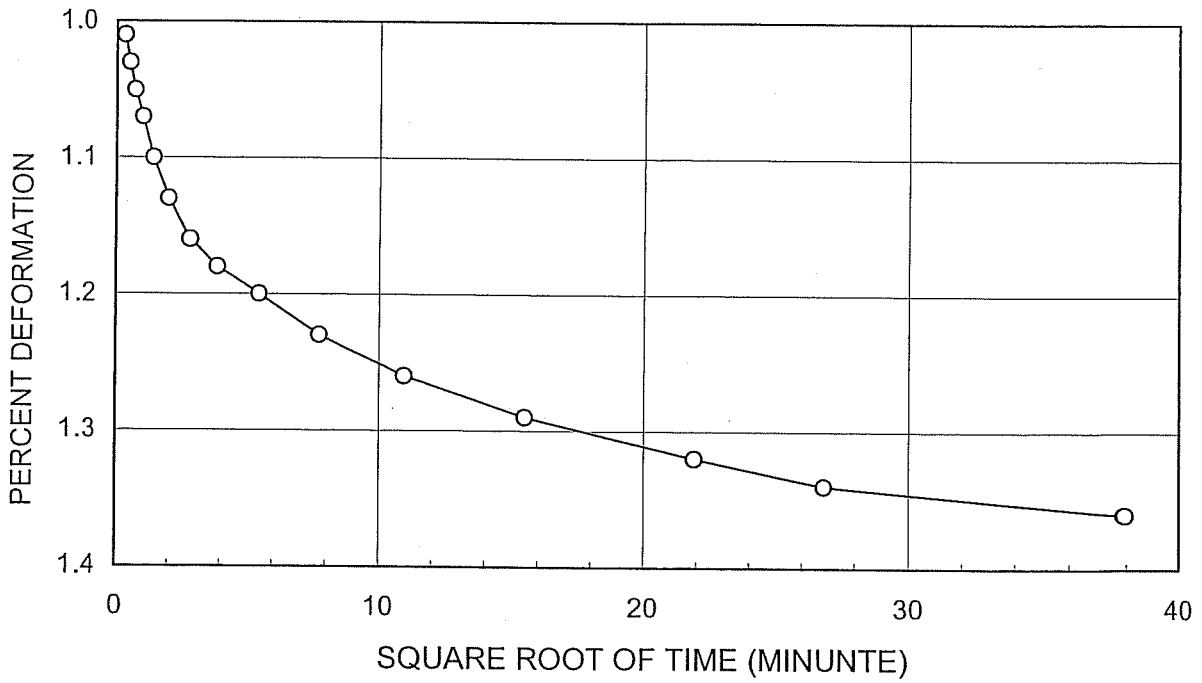
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





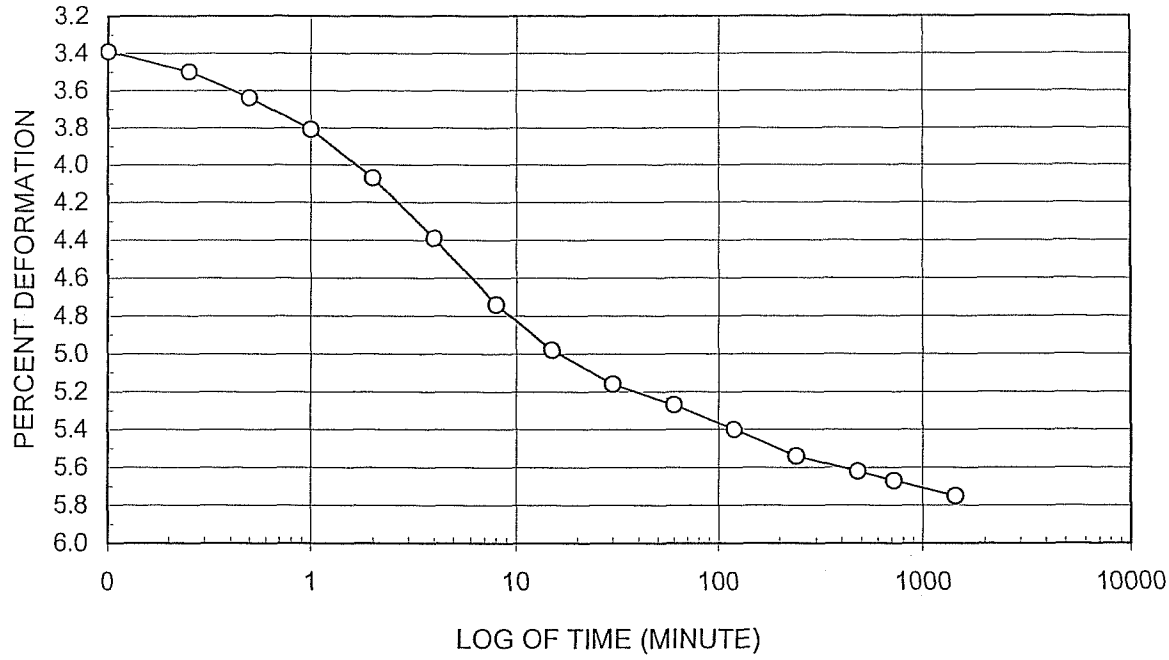
Boring No: R-09-010
Sample No: D-10
Depth (ft): 50
Soil Type: CH
Normal Stress: 1.0 ksf

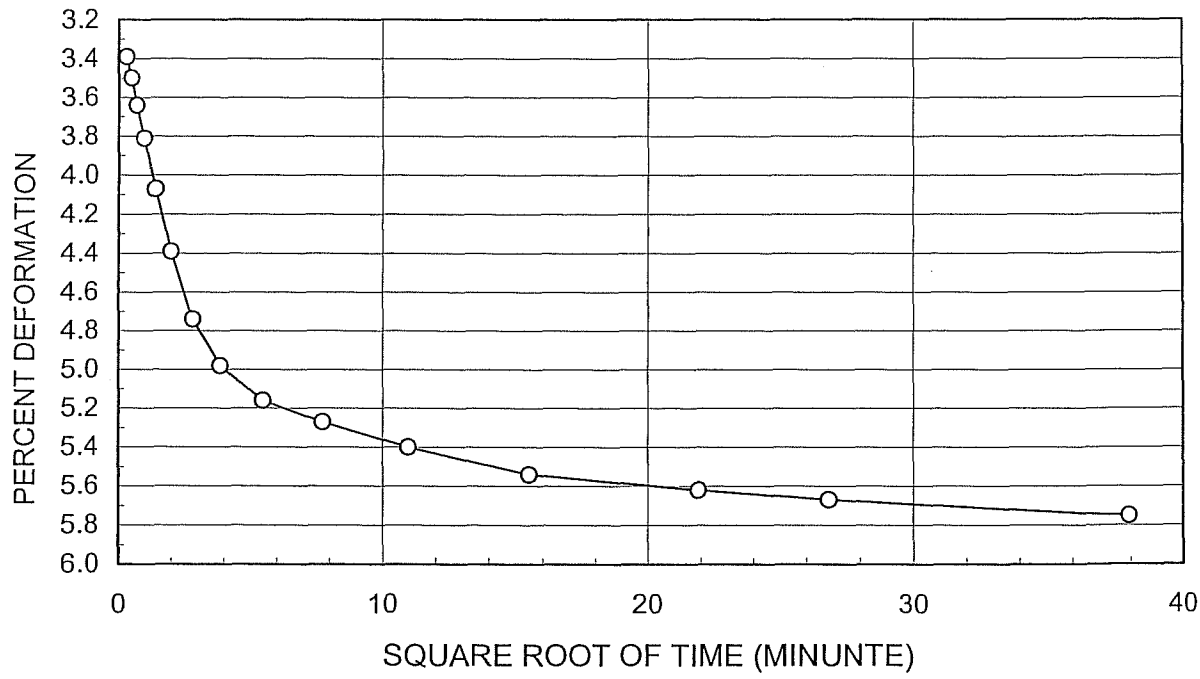
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





Boring No: R-09-010
Sample No: D-10
Depth (ft): 50
Soil Type: CH
Normal Stress: 4.0 ksf

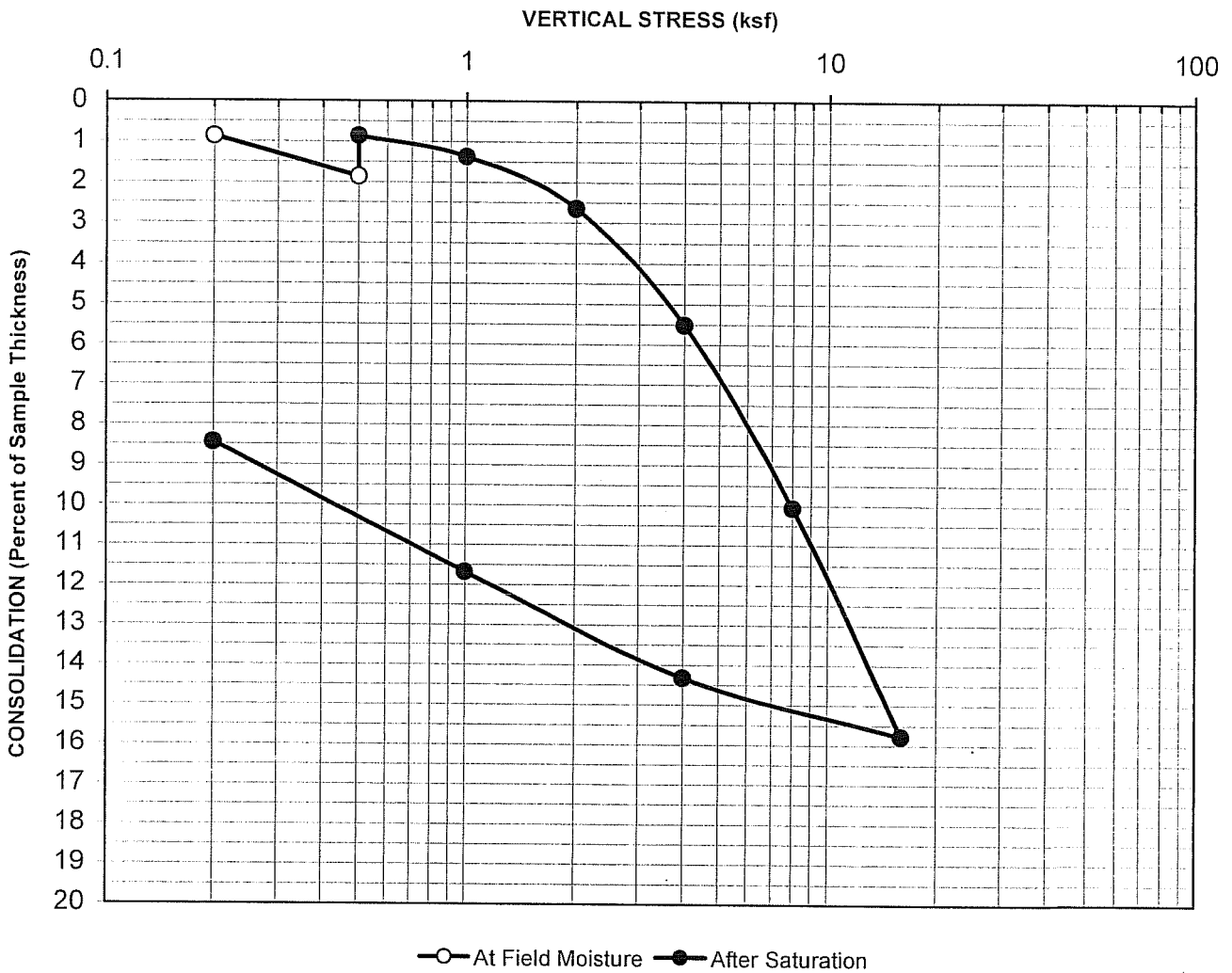
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure

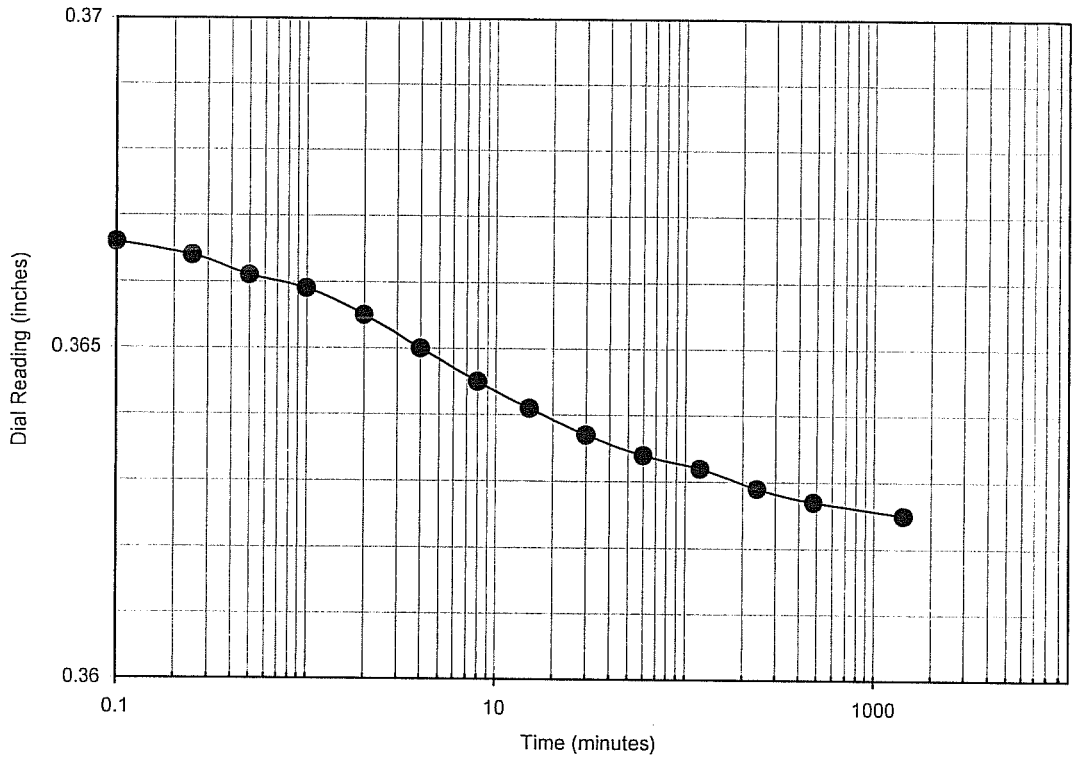
AP Engineering & Testing, Inc.



Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	77.3
Sample No.:	D-10	Initial Moisture Content (%):	39.8
Depth (feet):	50	Final Moisture Content (%):	39.1
Sample Type:	Mod. Cal.	Assumed Specific Gravity:	2.7
Soil Description:	Fat Clay	Initial Void Ratio:	1.18
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

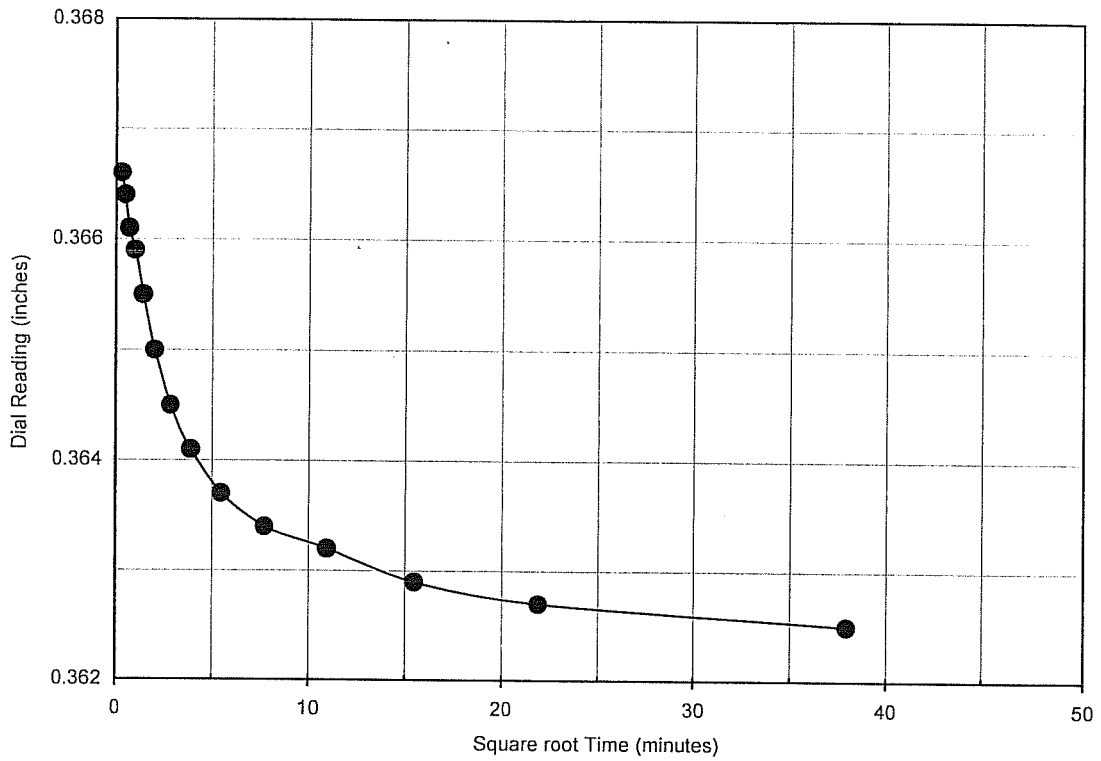


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3666
0.25	0.3664
0.5	0.3661
1	0.3659
2	0.3655
4	0.365
8	0.3645
15	0.3641
30	0.3637
60	0.3634
120	0.3632
240	0.3629
480	0.3627
1440	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

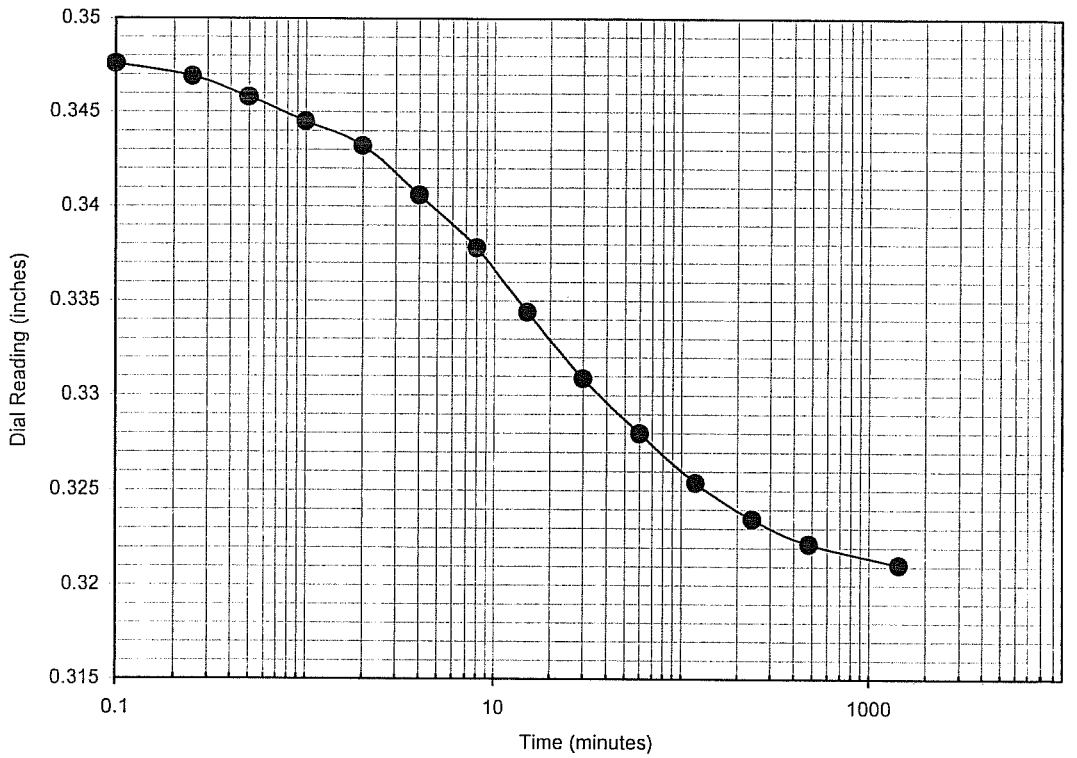


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3666
0.5000	0.3664
0.7071	0.3661
1.0000	0.3659
1.4142	0.3655
2.0000	0.3650
2.8284	0.3645
3.8730	0.3641
5.4772	0.3637
7.7460	0.3634
10.9545	0.3632
15.4919	0.3629
21.9089	0.3627
37.9473	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

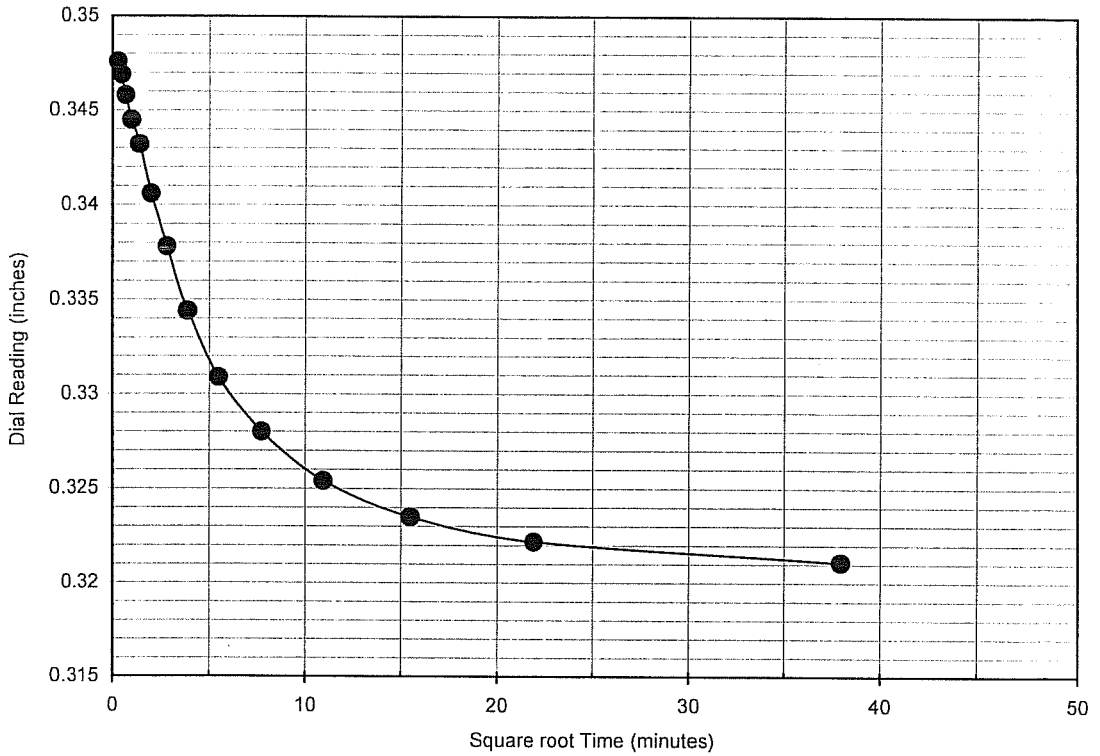


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3476
0.25	0.3469
0.5	0.3458
1	0.3445
2	0.3432
4	0.3406
8	0.3378
15	0.3344
30	0.3309
60	0.328
120	0.3254
240	0.3235
480	0.3222
1440	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



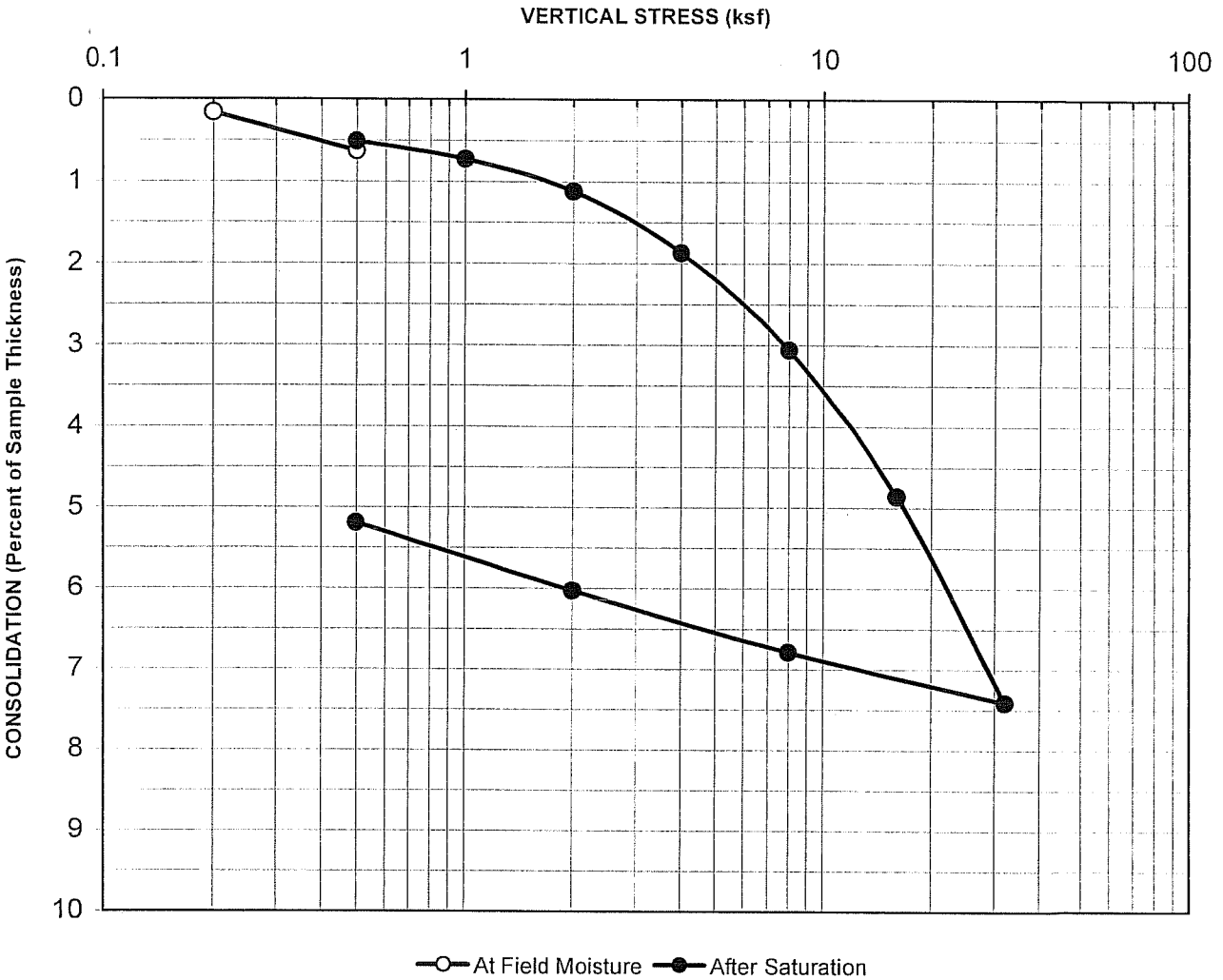
Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3476
0.5000	0.3469
0.7071	0.3458
1.0000	0.3445
1.4142	0.3432
2.0000	0.3406
2.8284	0.3378
3.8730	0.3344
5.4772	0.3309
7.7460	0.3280
10.9545	0.3254
15.4919	0.3235
21.9089	0.3222
37.9473	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

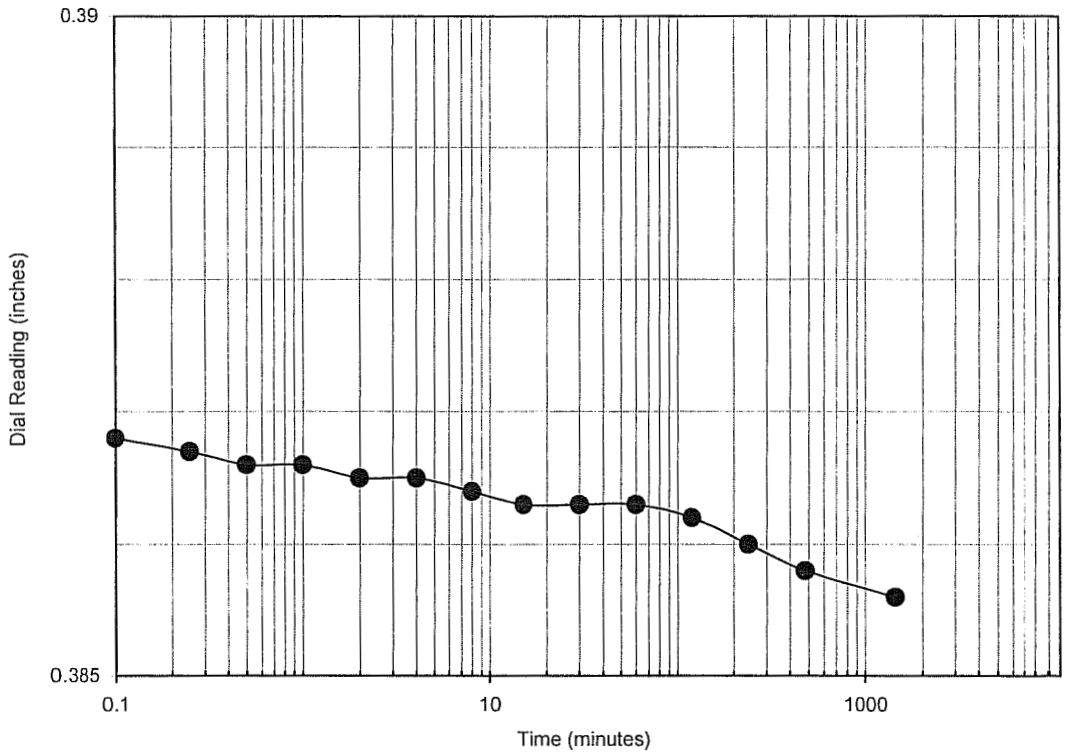
AP Engineering & Testing, Inc.



Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	104.2
Sample No.:	U-14	Initial Moisture Content (%):	22.0
Depth (feet):	70	Final Moisture Content (%):	20.4
Sample Type:	Shelby	Assumed Specific Gravity:	2.7
Soil Description:	Sandy Silt	Initial Void Ratio:	0.62
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

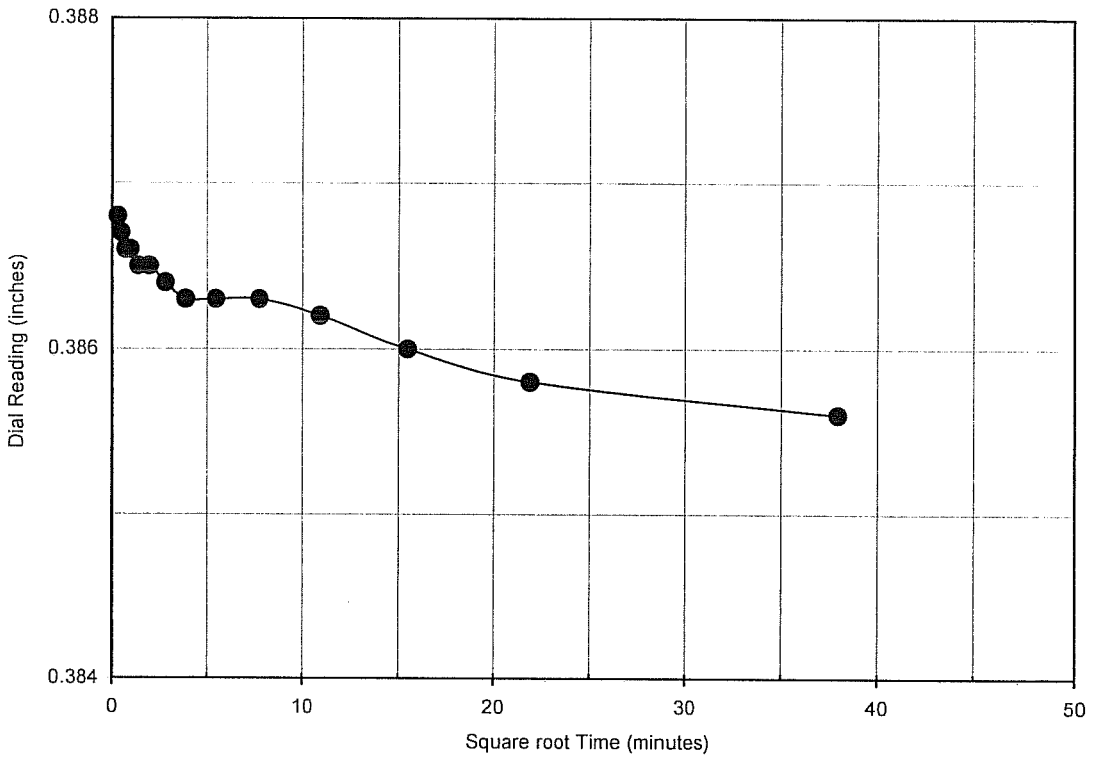


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3868
0.25	0.3867
0.5	0.3866
1	0.3866
2	0.3865
4	0.3865
8	0.3864
15	0.3863
30	0.3863
60	0.3863
120	0.3862
240	0.386
480	0.3858
1440	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

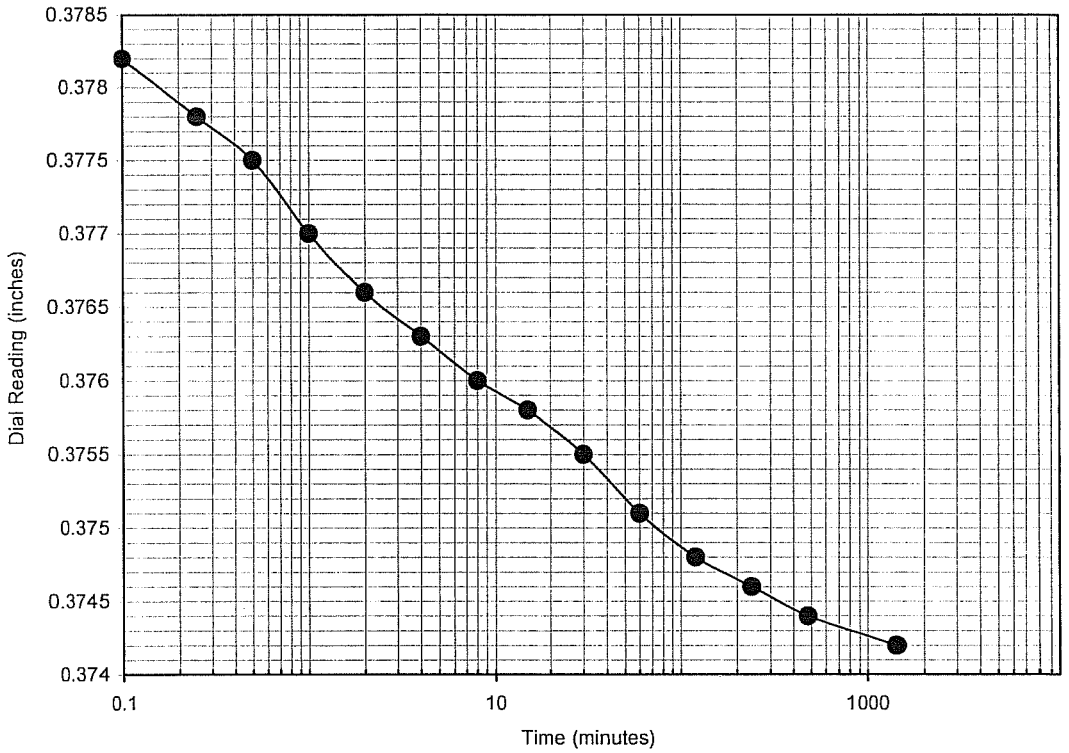


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3868
0.5000	0.3867
0.7071	0.3866
1.0000	0.3866
1.4142	0.3865
2.0000	0.3865
2.8284	0.3864
3.8730	0.3863
5.4772	0.3863
7.7460	0.3863
10.9545	0.3862
15.4919	0.3860
21.9089	0.3858
37.9473	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

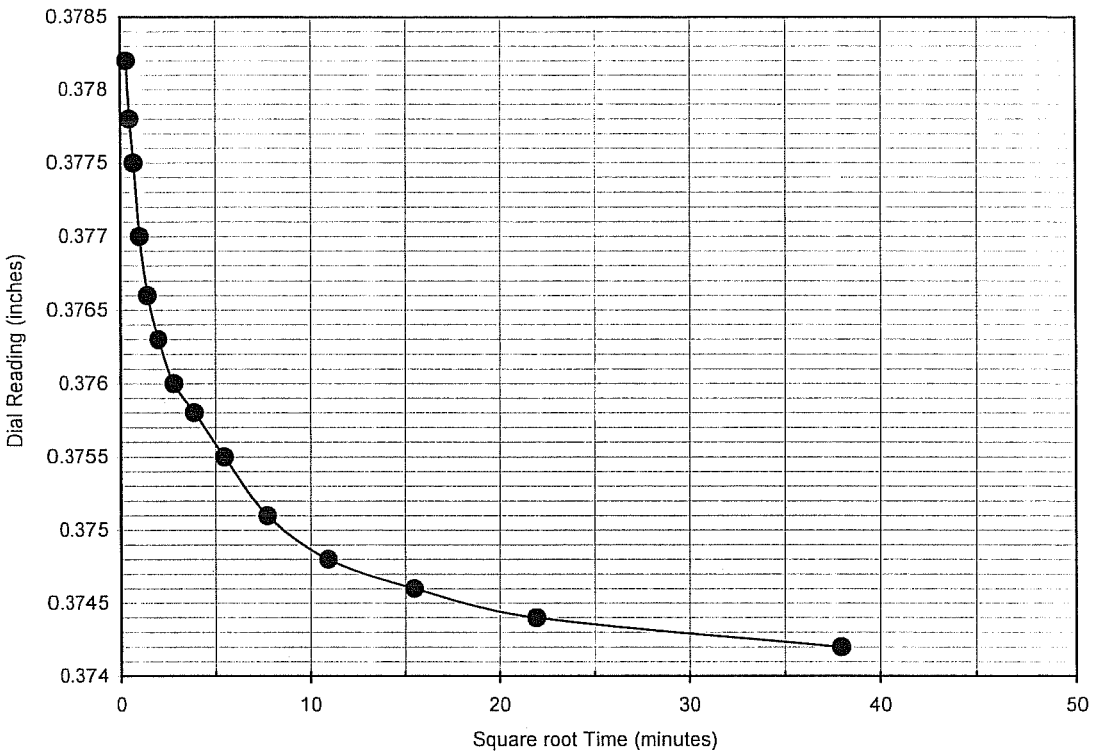


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3782
0.25	0.3778
0.5	0.3775
1	0.377
2	0.3766
4	0.3763
8	0.376
15	0.3758
30	0.3755
60	0.3751
120	0.3748
240	0.3746
480	0.3744
1440	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3782
0.5000	0.3778
0.7071	0.3775
1.0000	0.3770
1.4142	0.3766
2.0000	0.3763
2.8284	0.3760
3.8730	0.3758
5.4772	0.3755
7.7460	0.3751
10.9545	0.3748
15.4919	0.3746
21.9089	0.3744
37.9473	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

APPENDIX F

SITE-SPECIFIC GROUND MOTION STUDY MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

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——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

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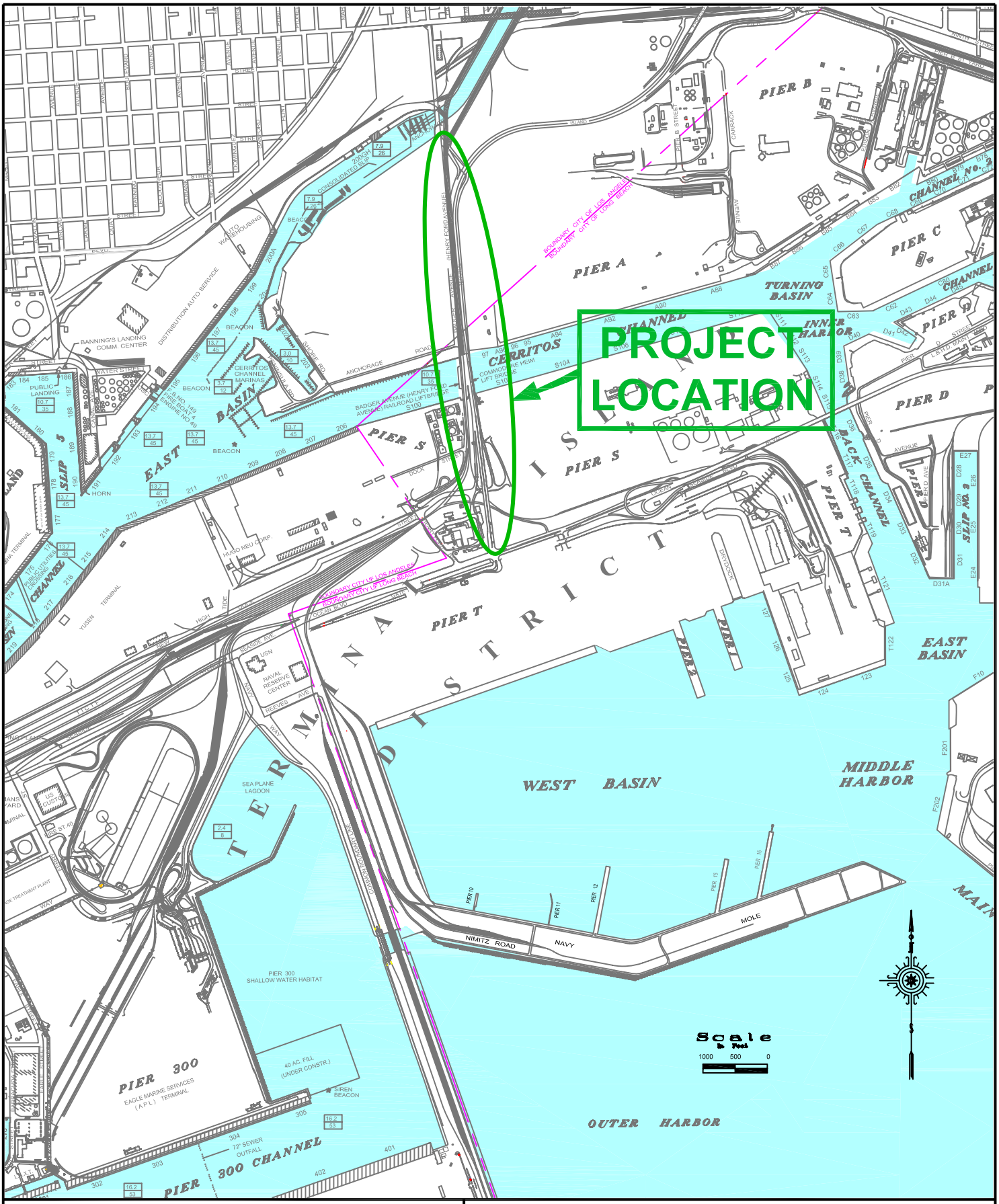
——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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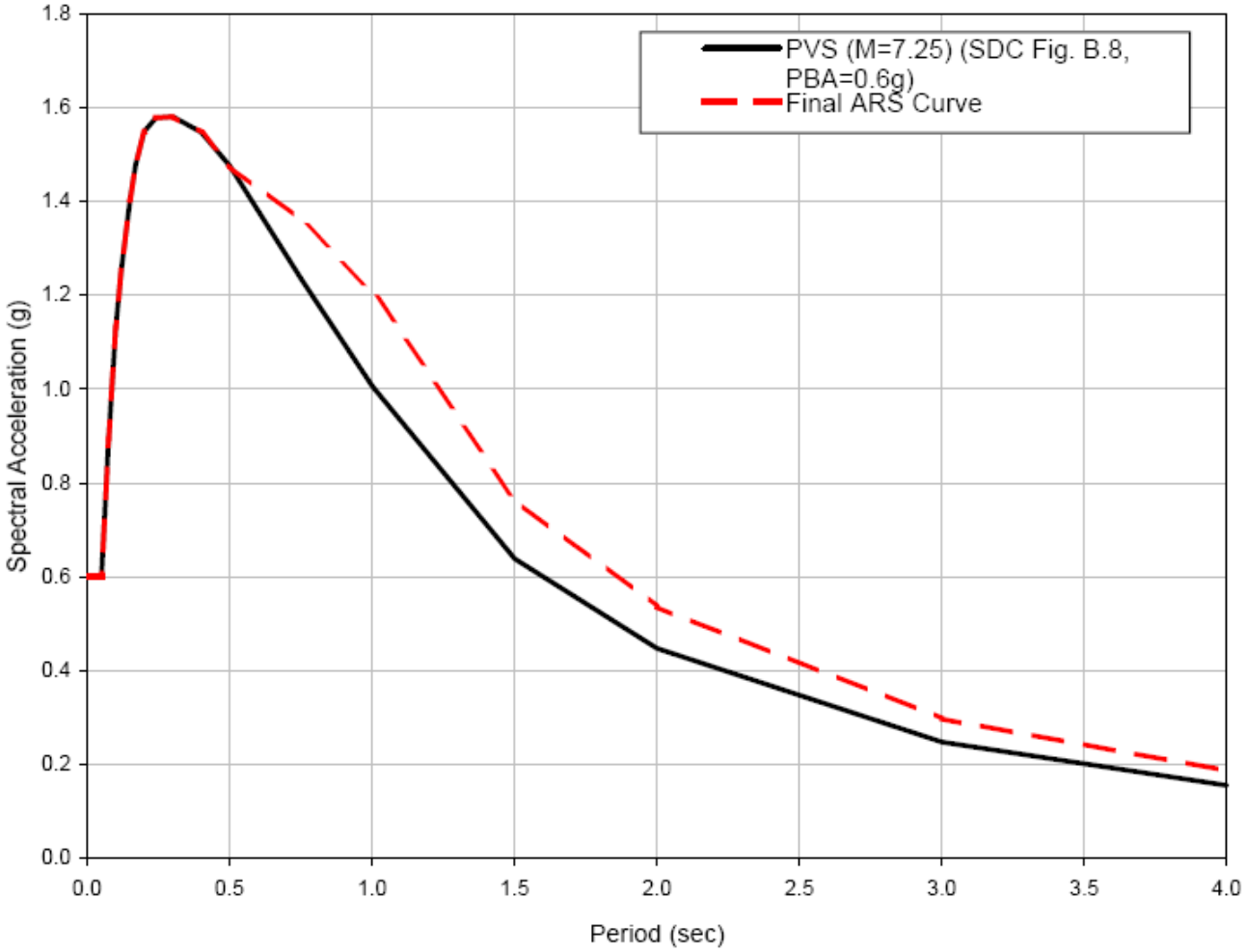
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

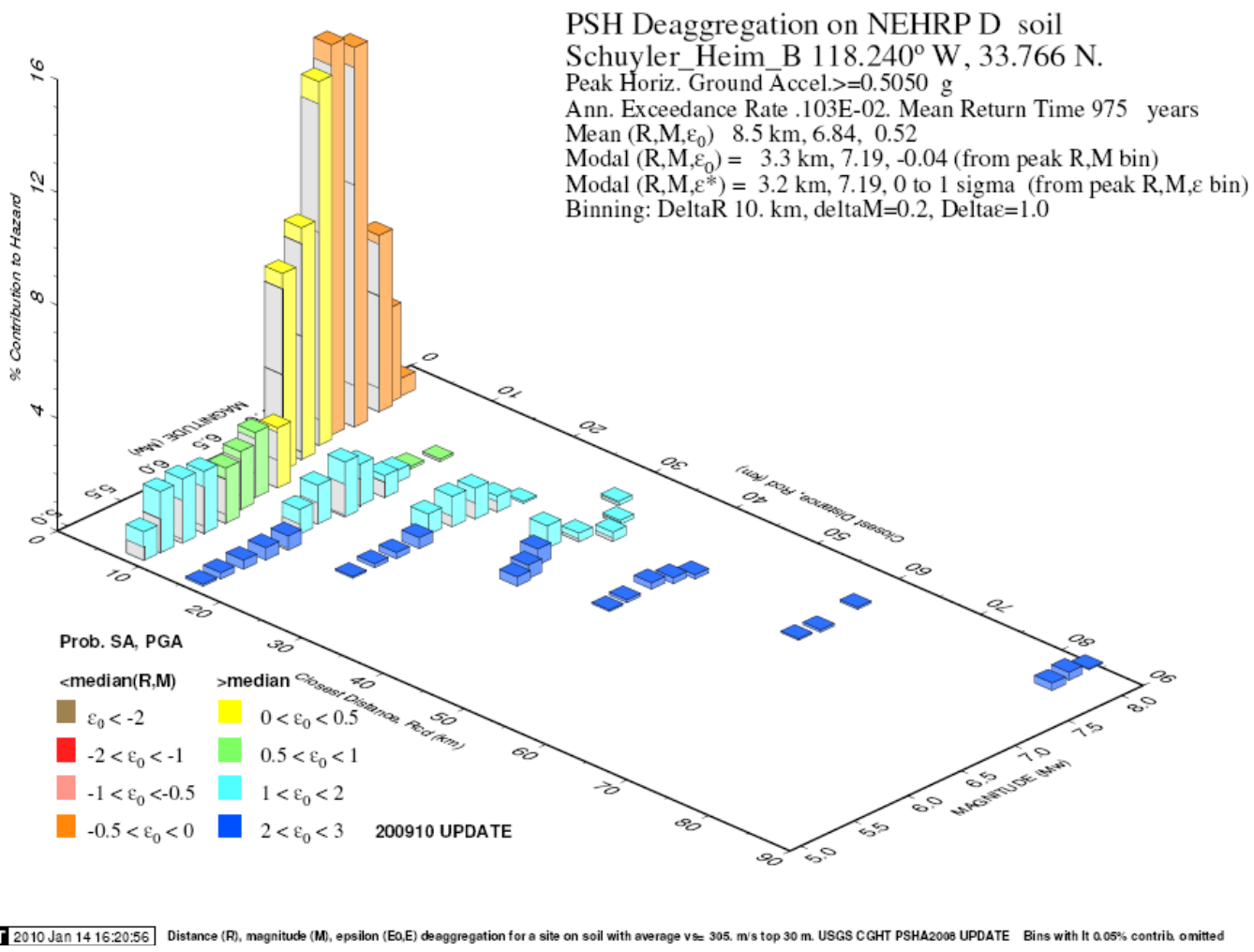


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

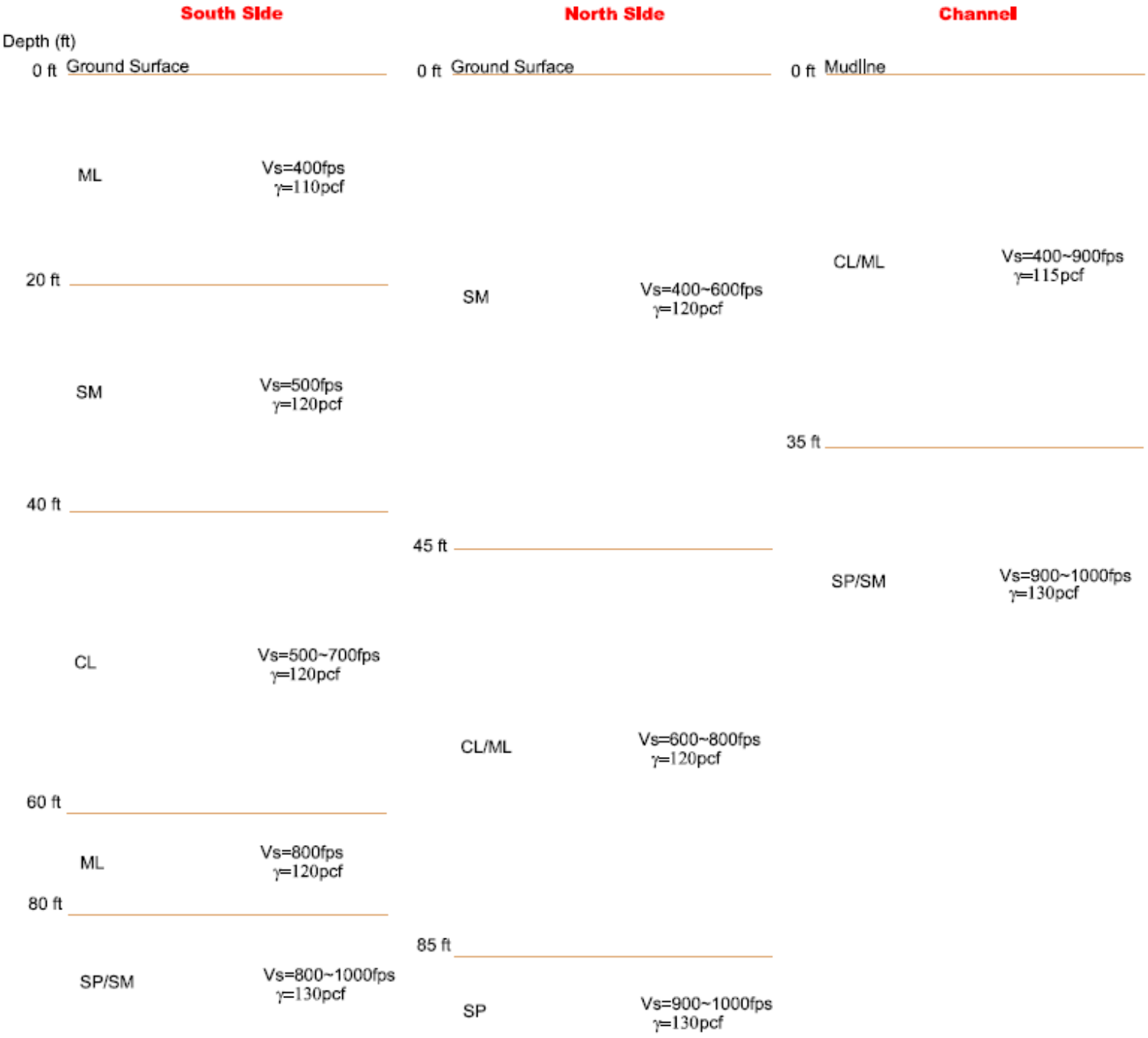
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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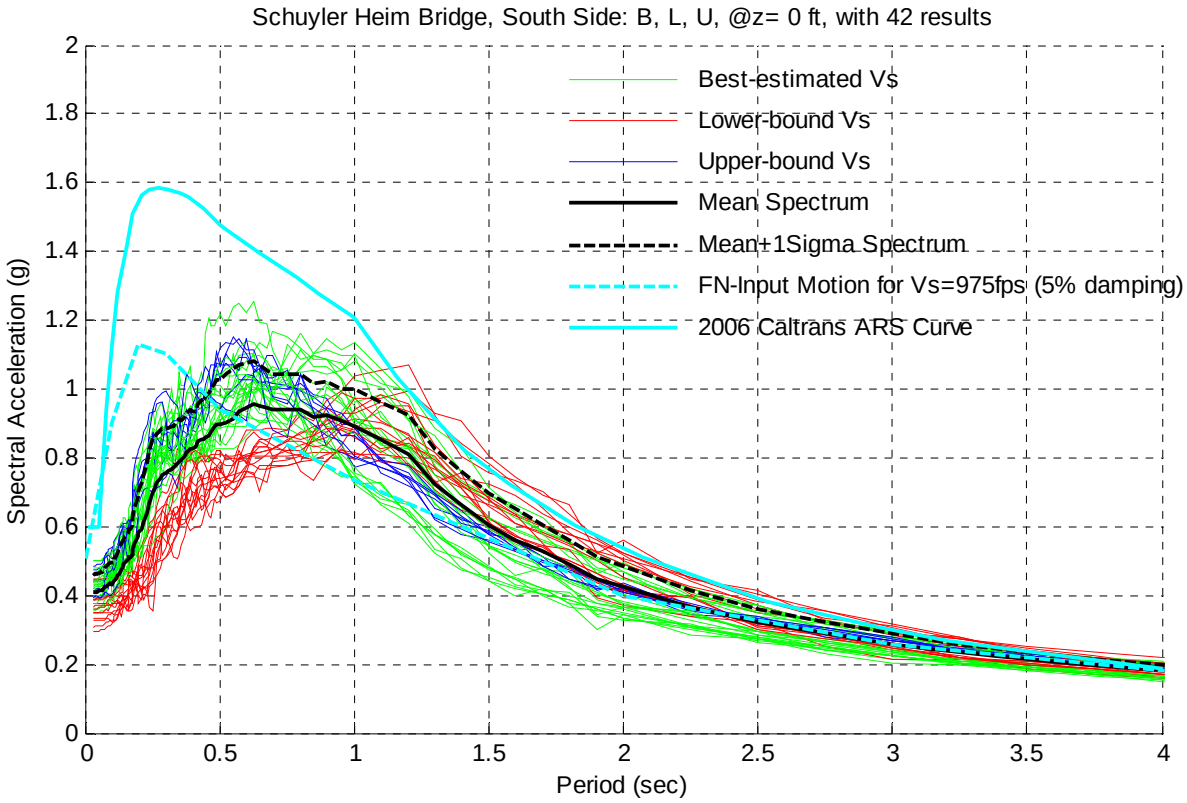
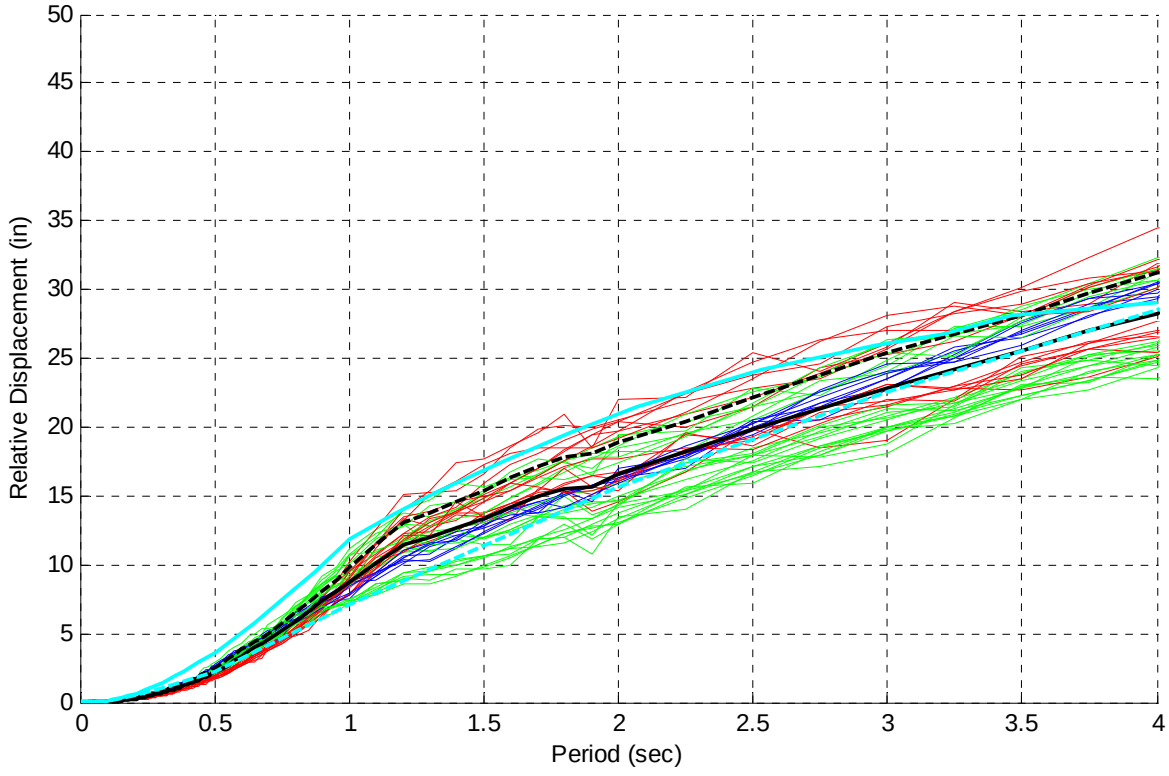
Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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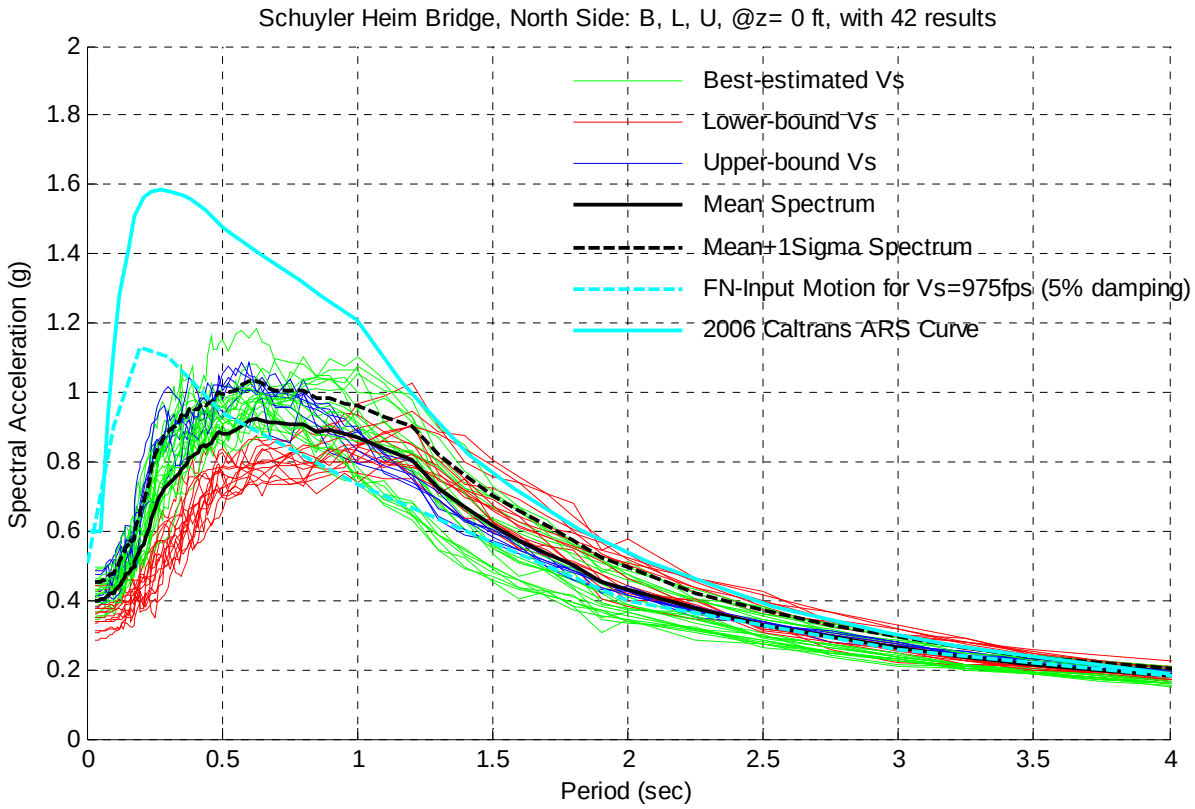
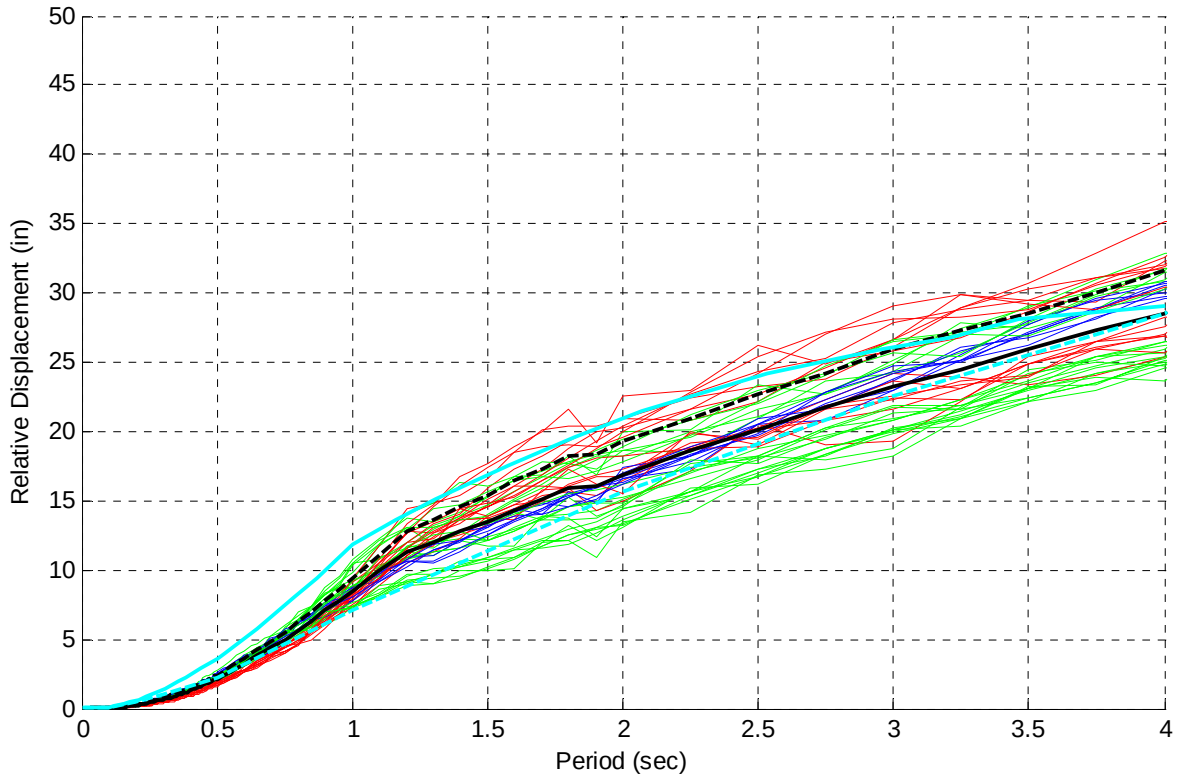
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





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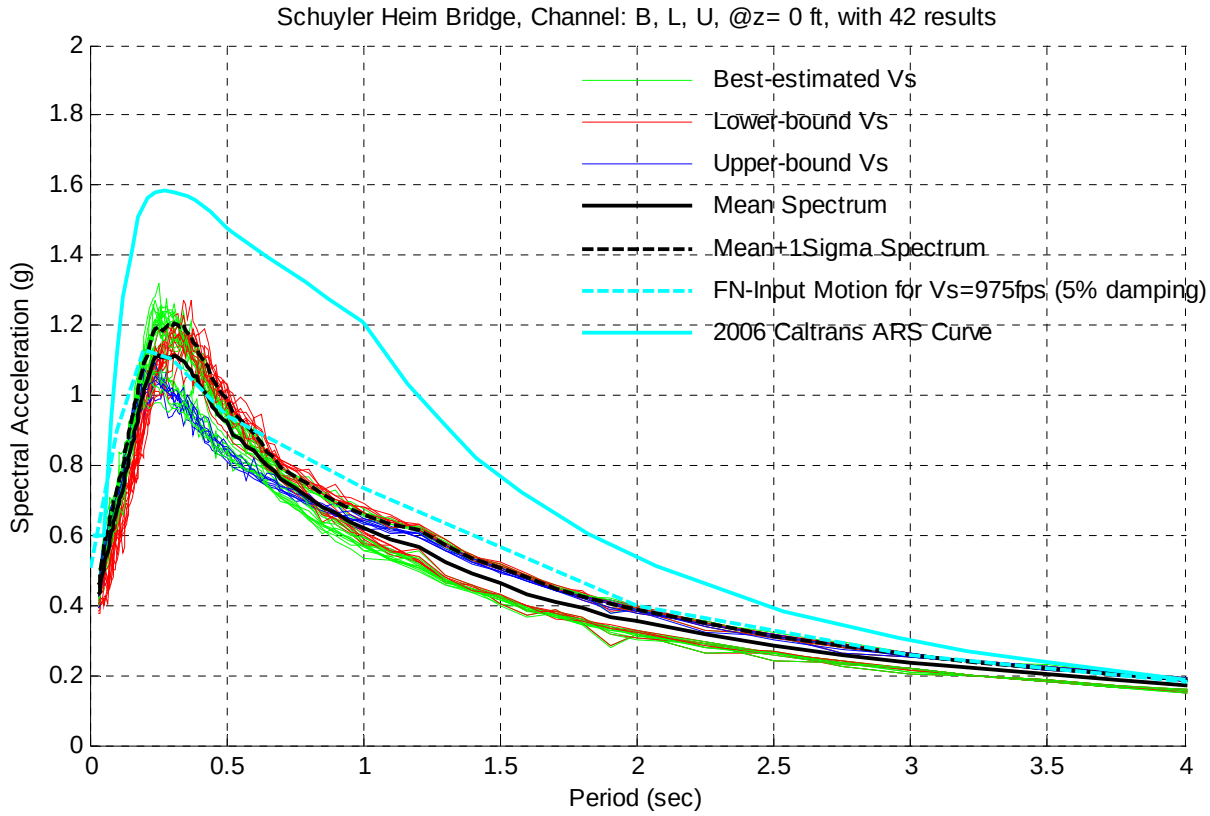
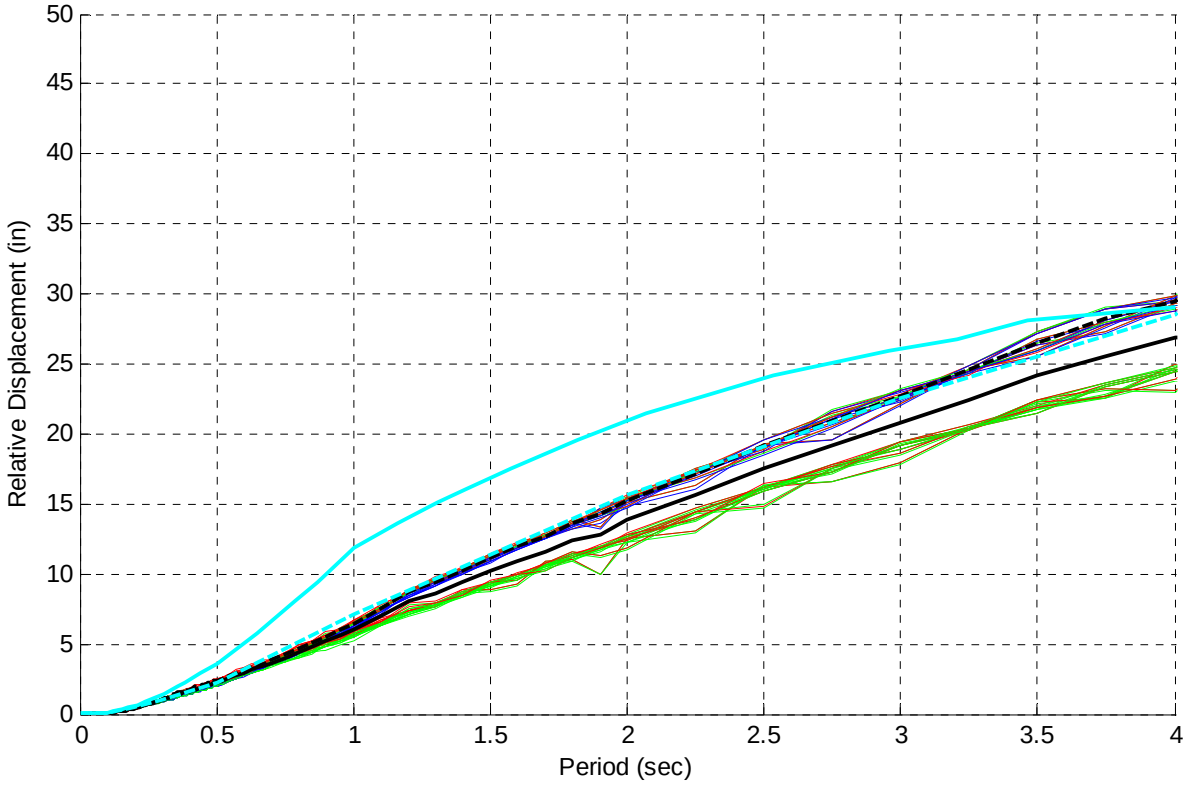
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





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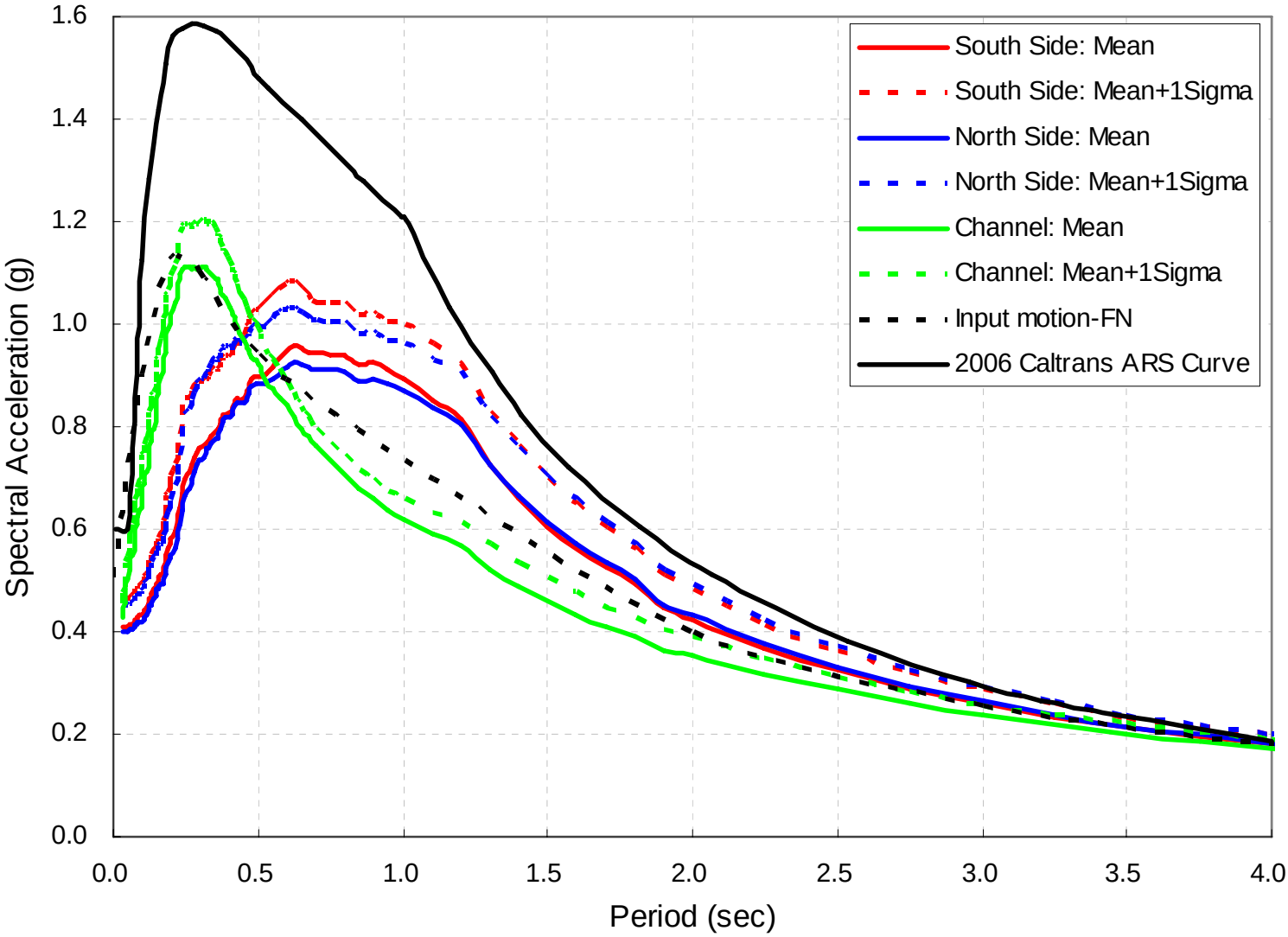
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

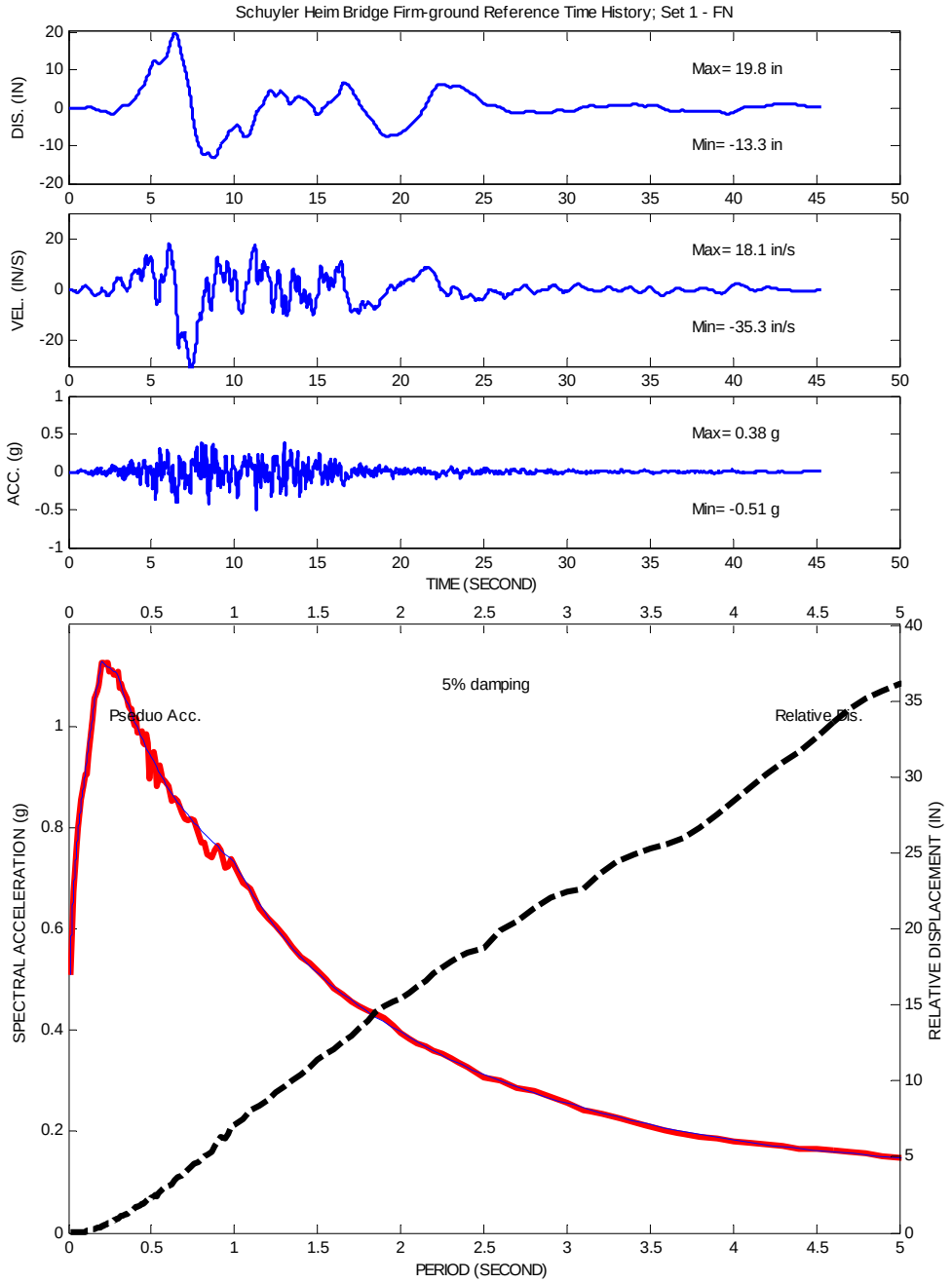

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

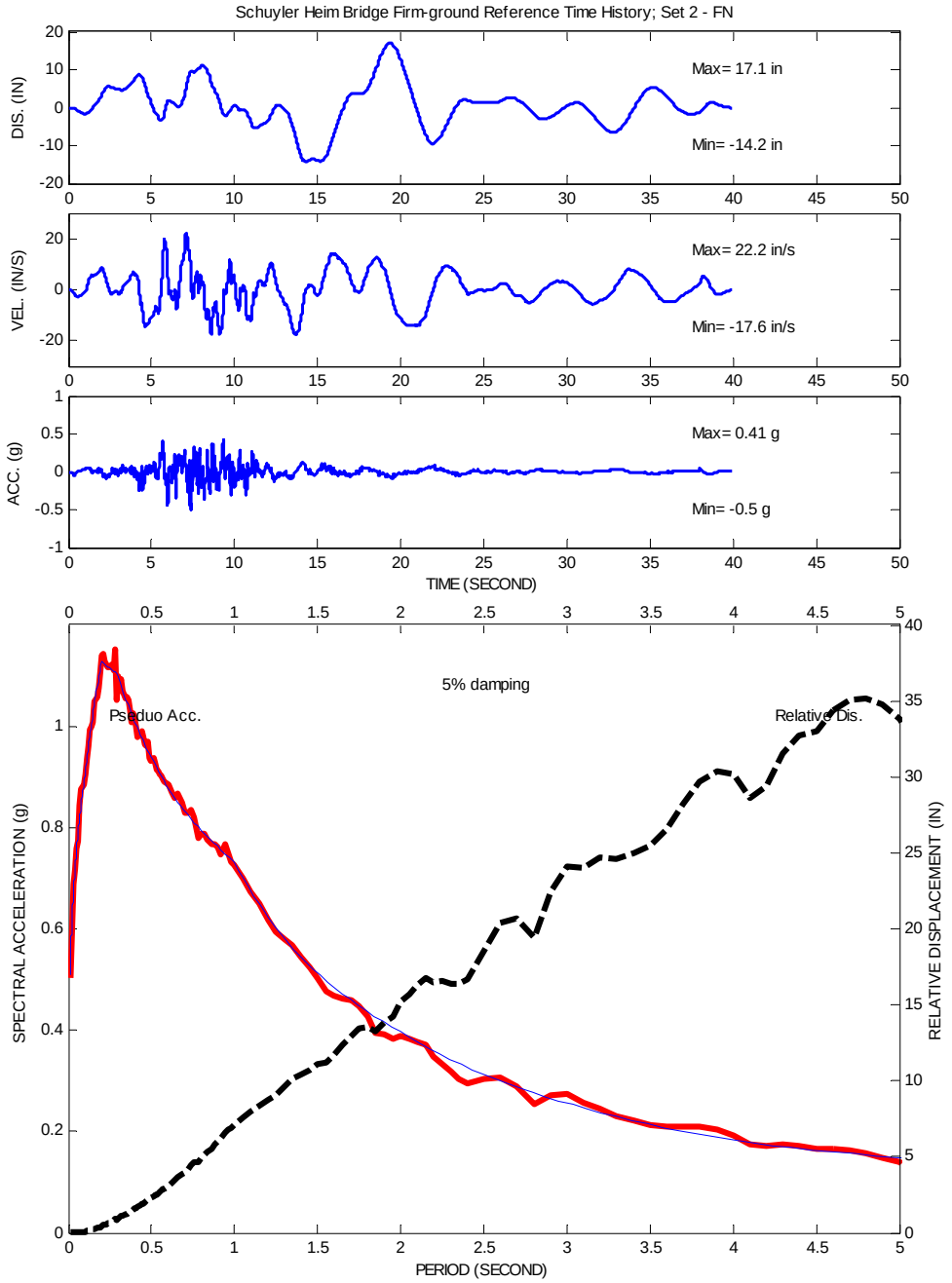

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

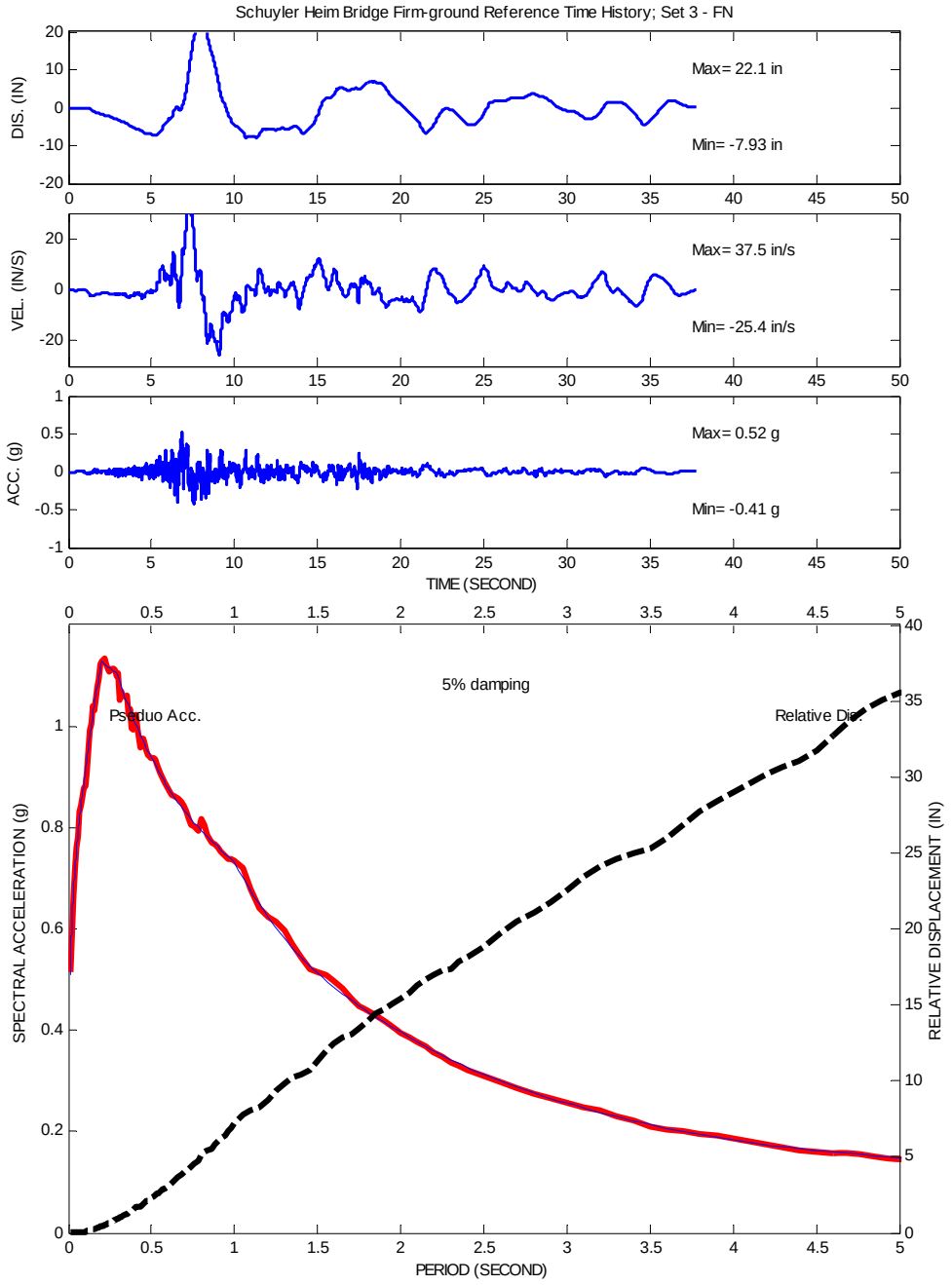

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

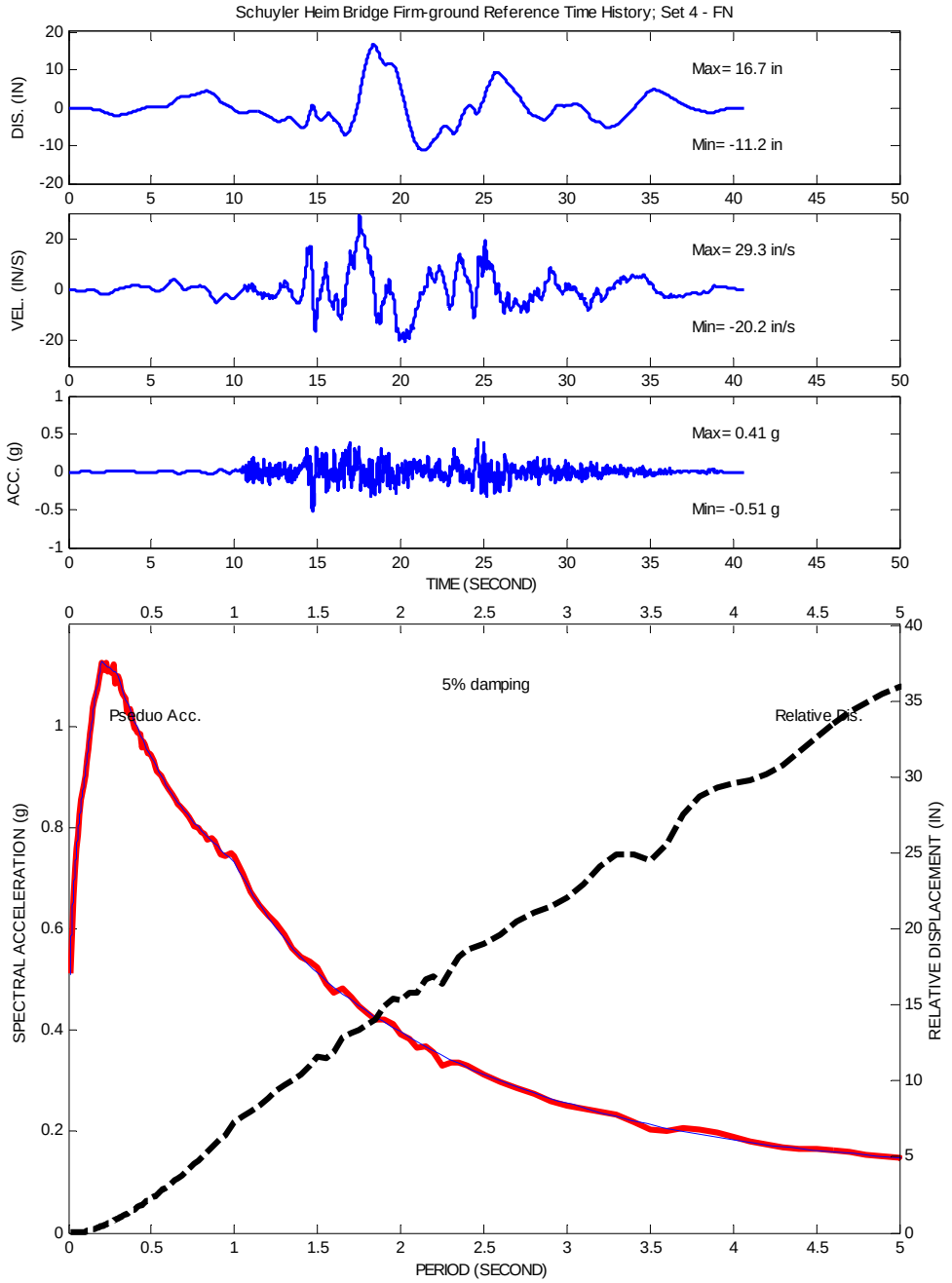

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

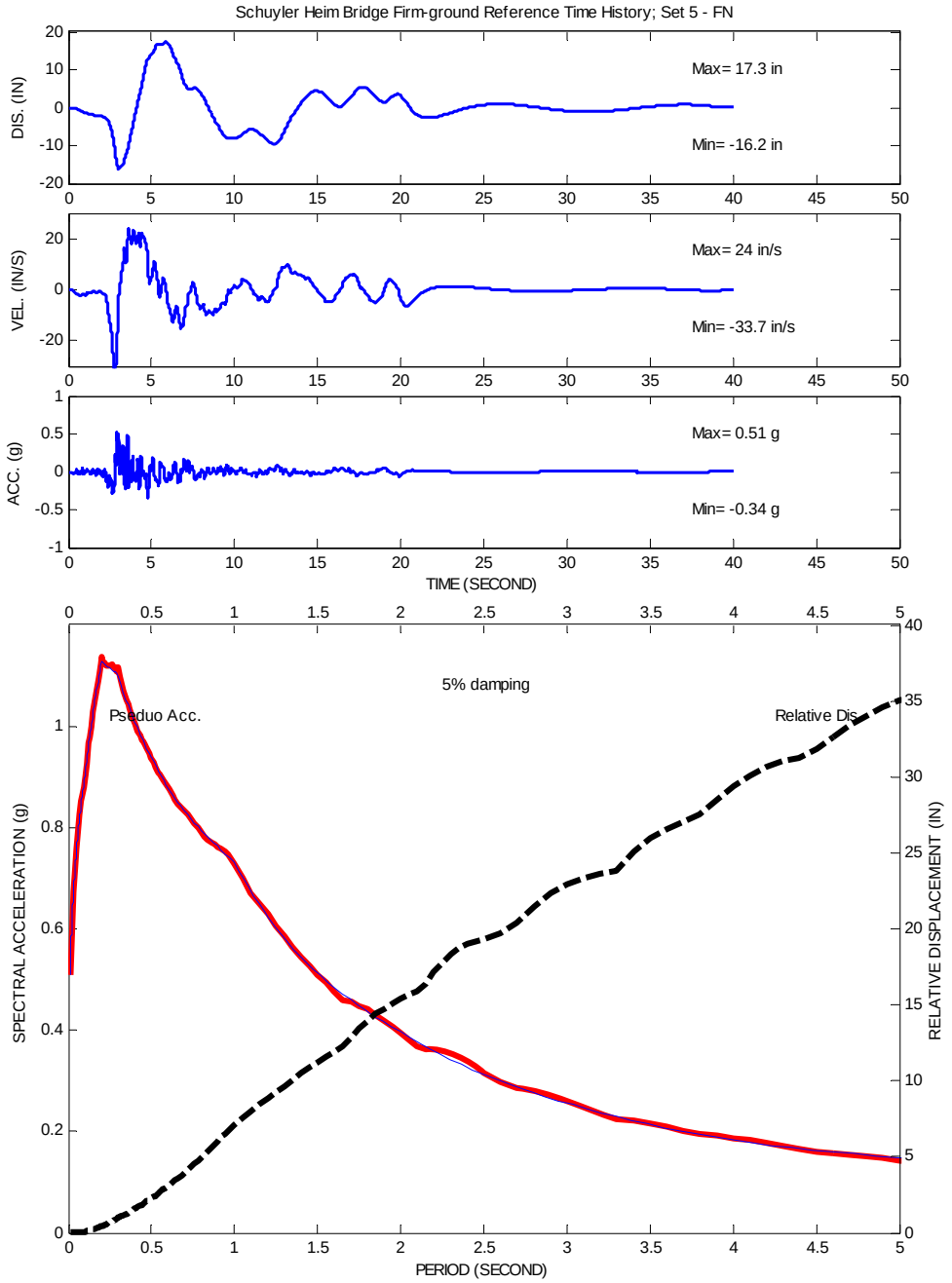

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

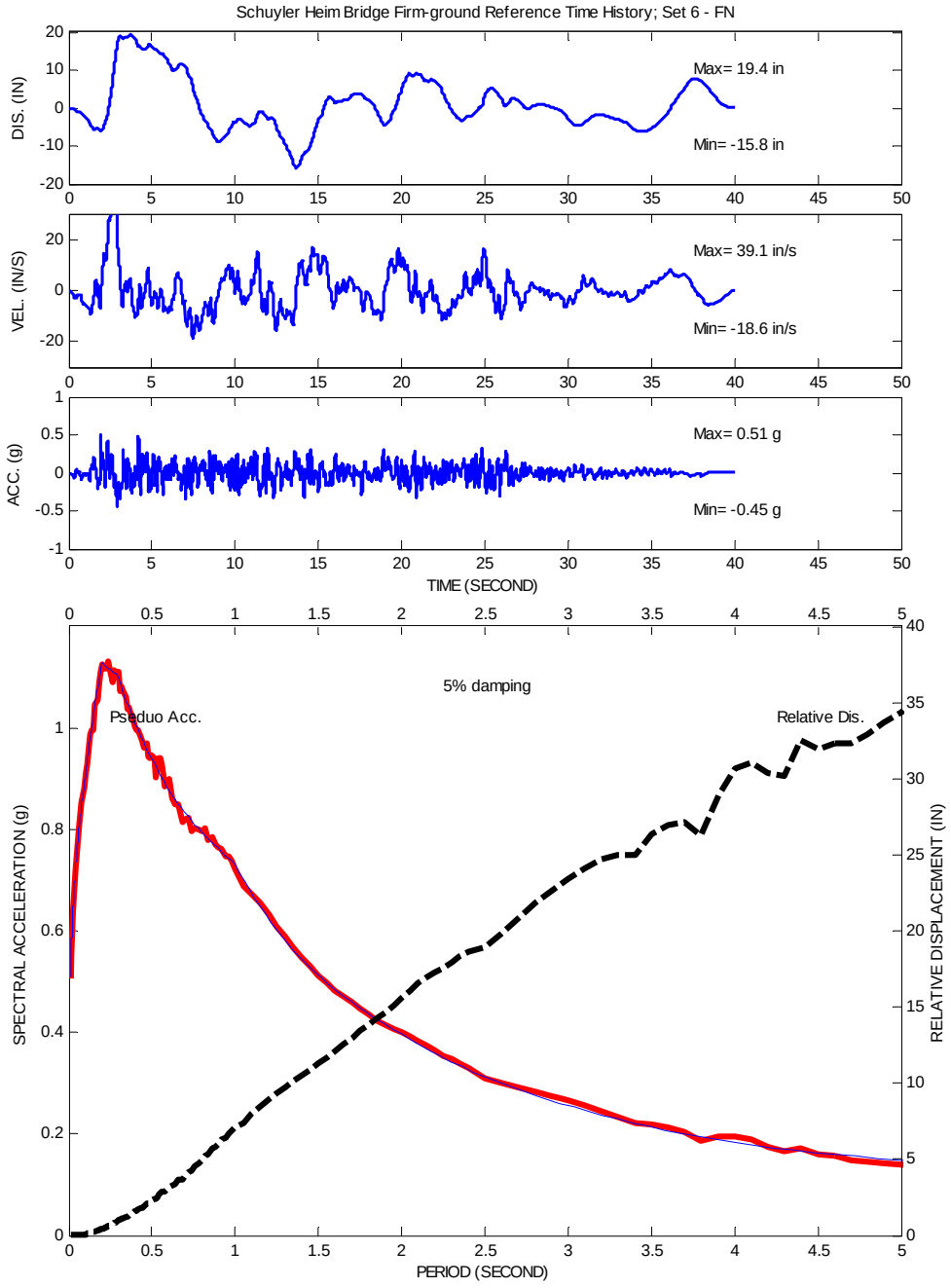

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

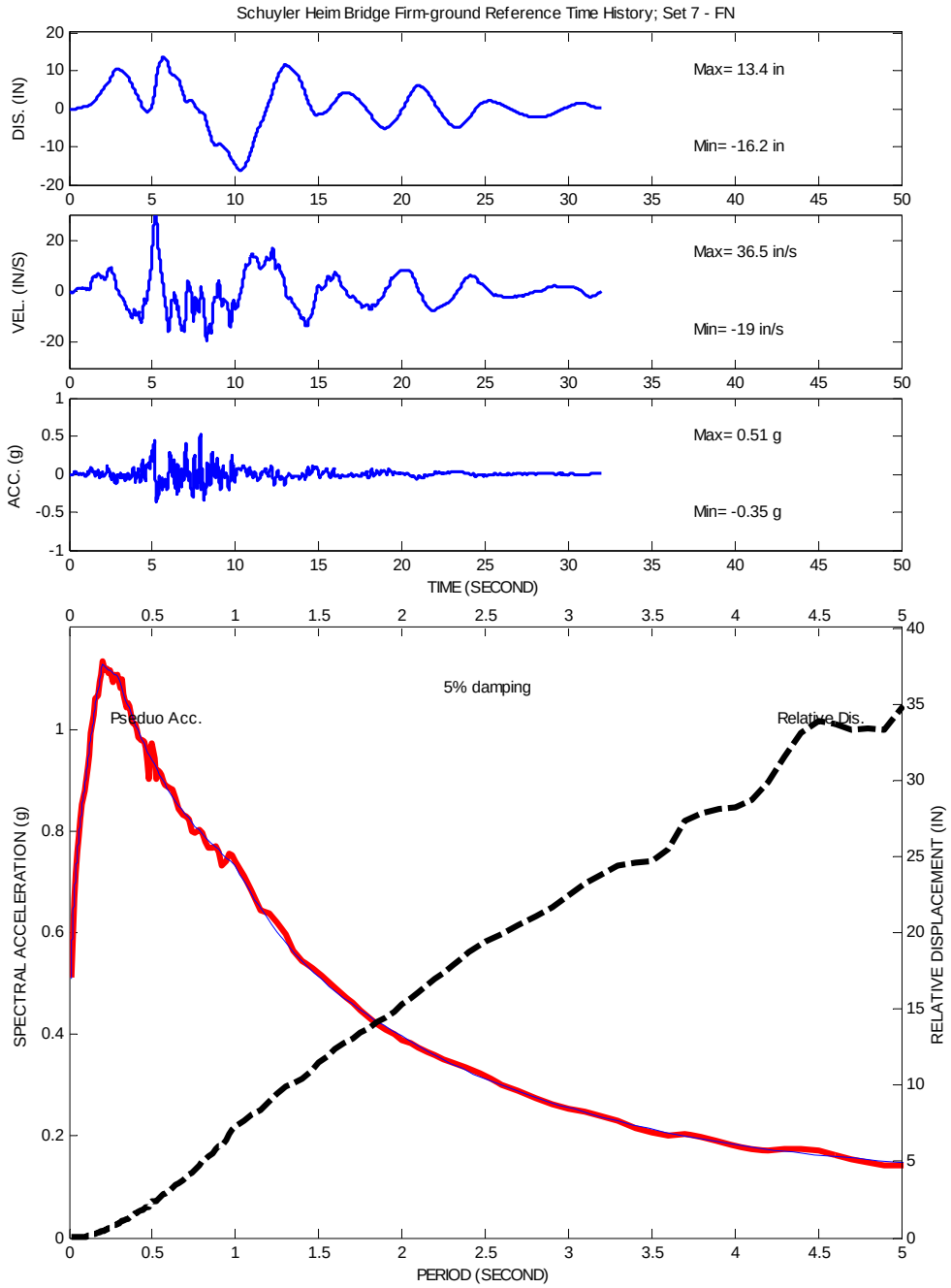

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

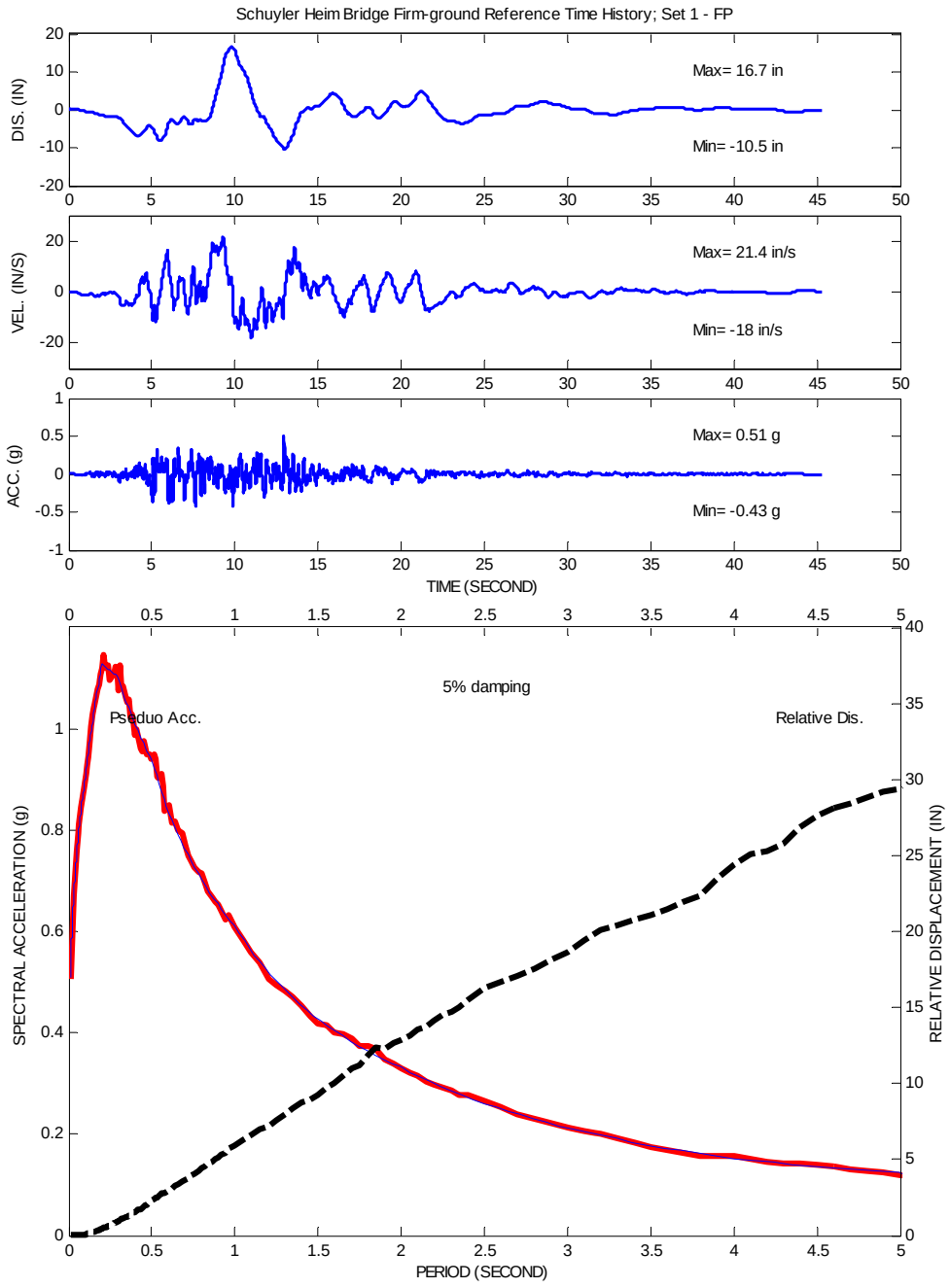

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

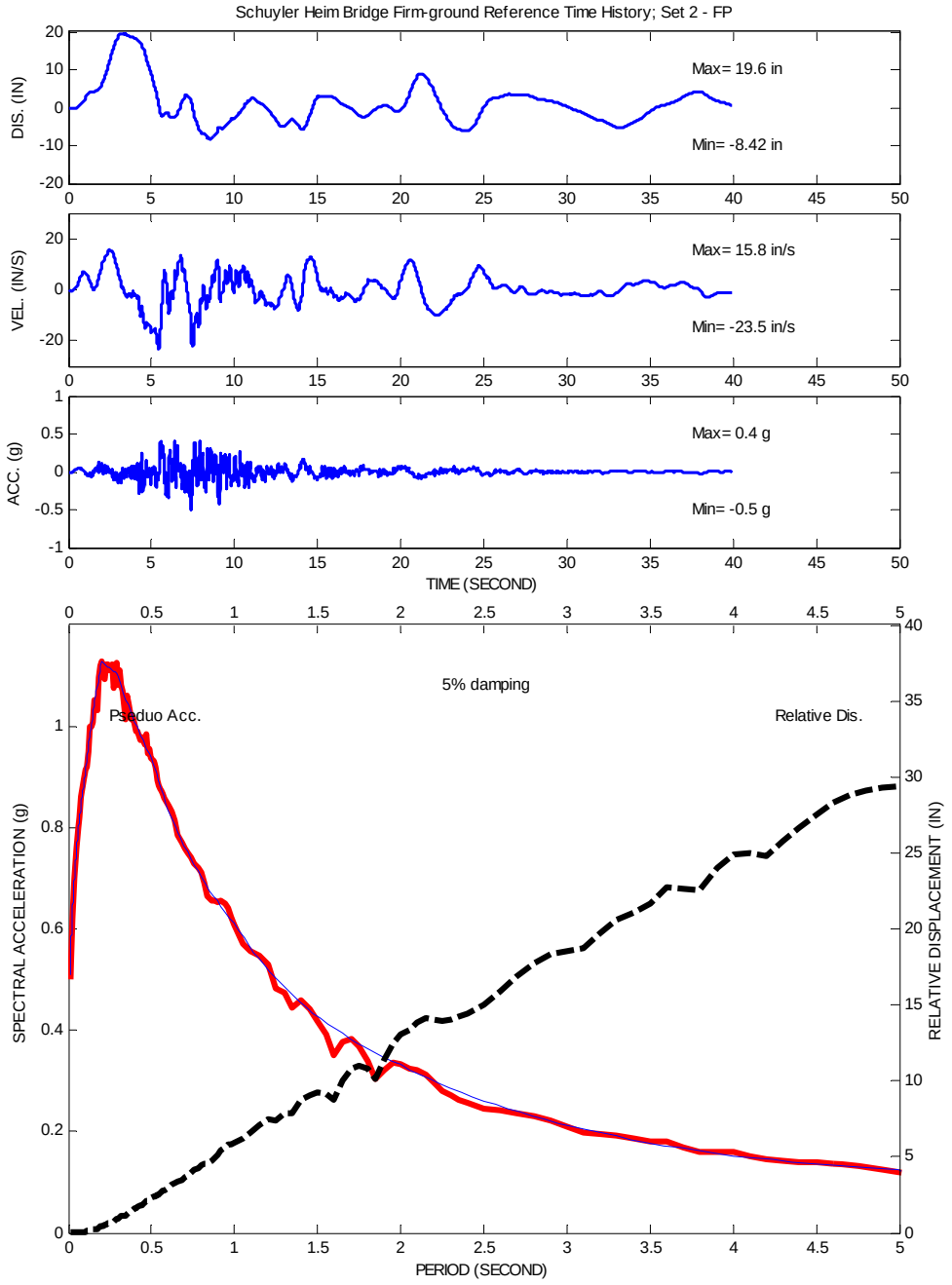

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

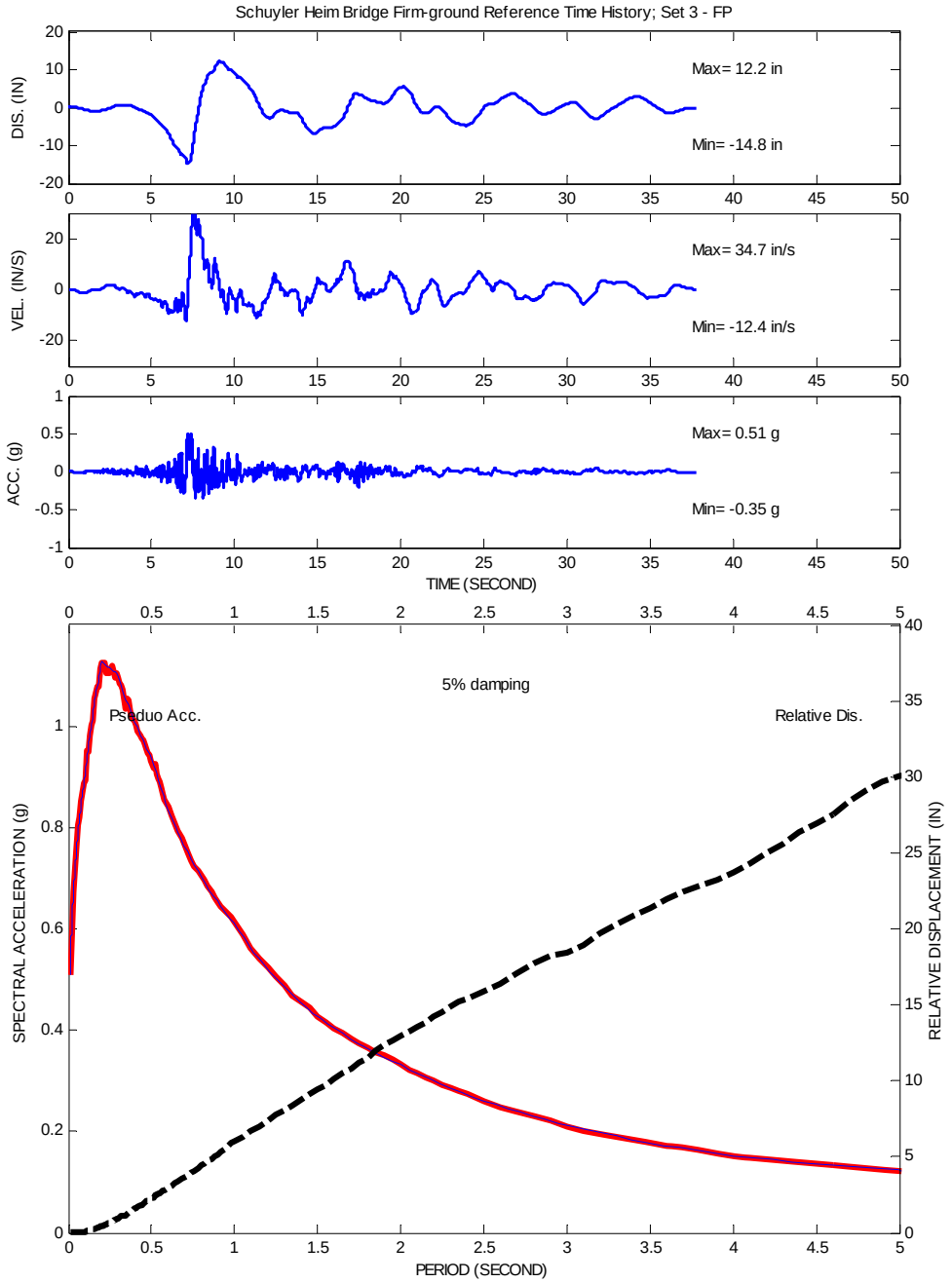

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

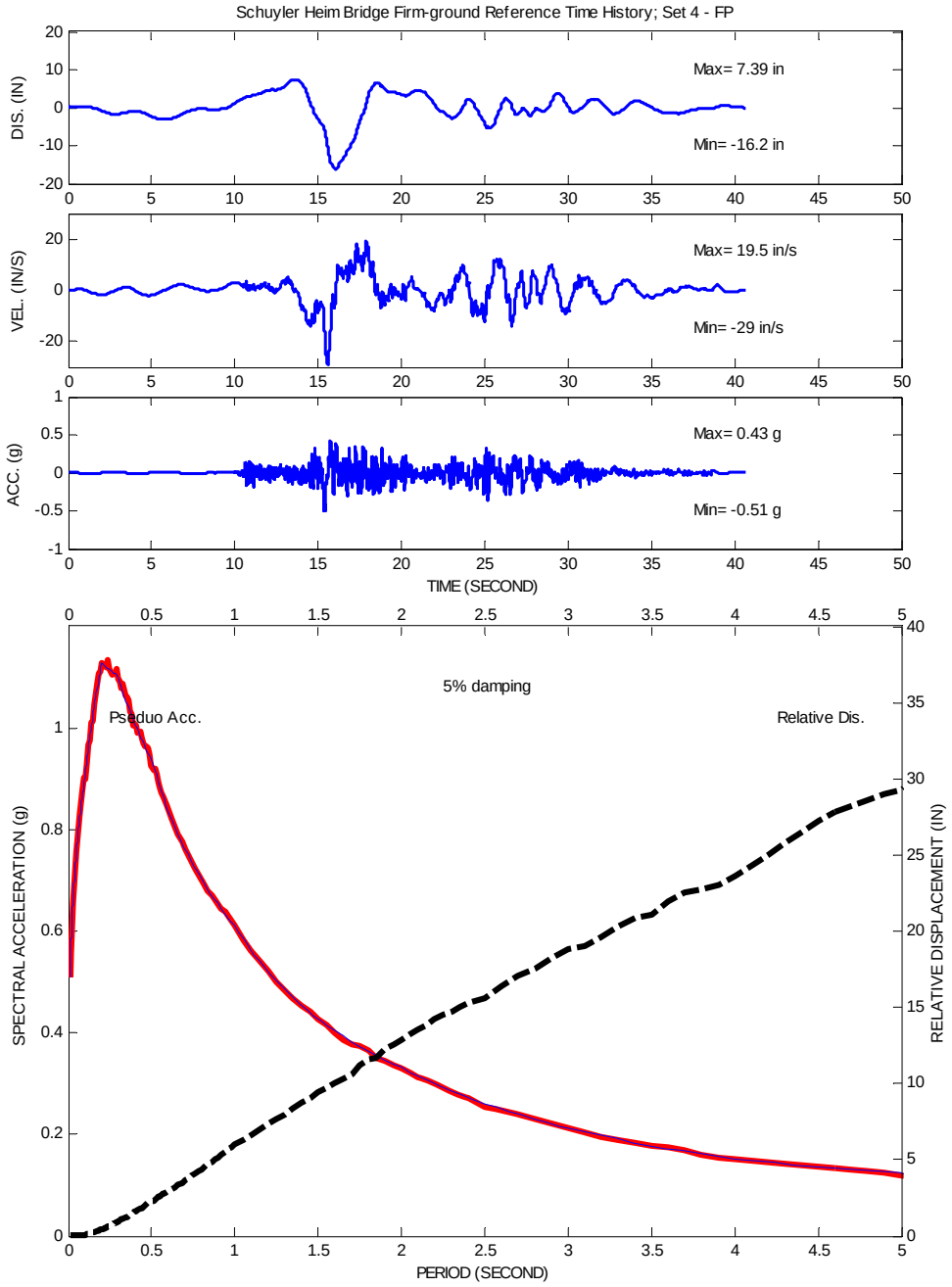

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

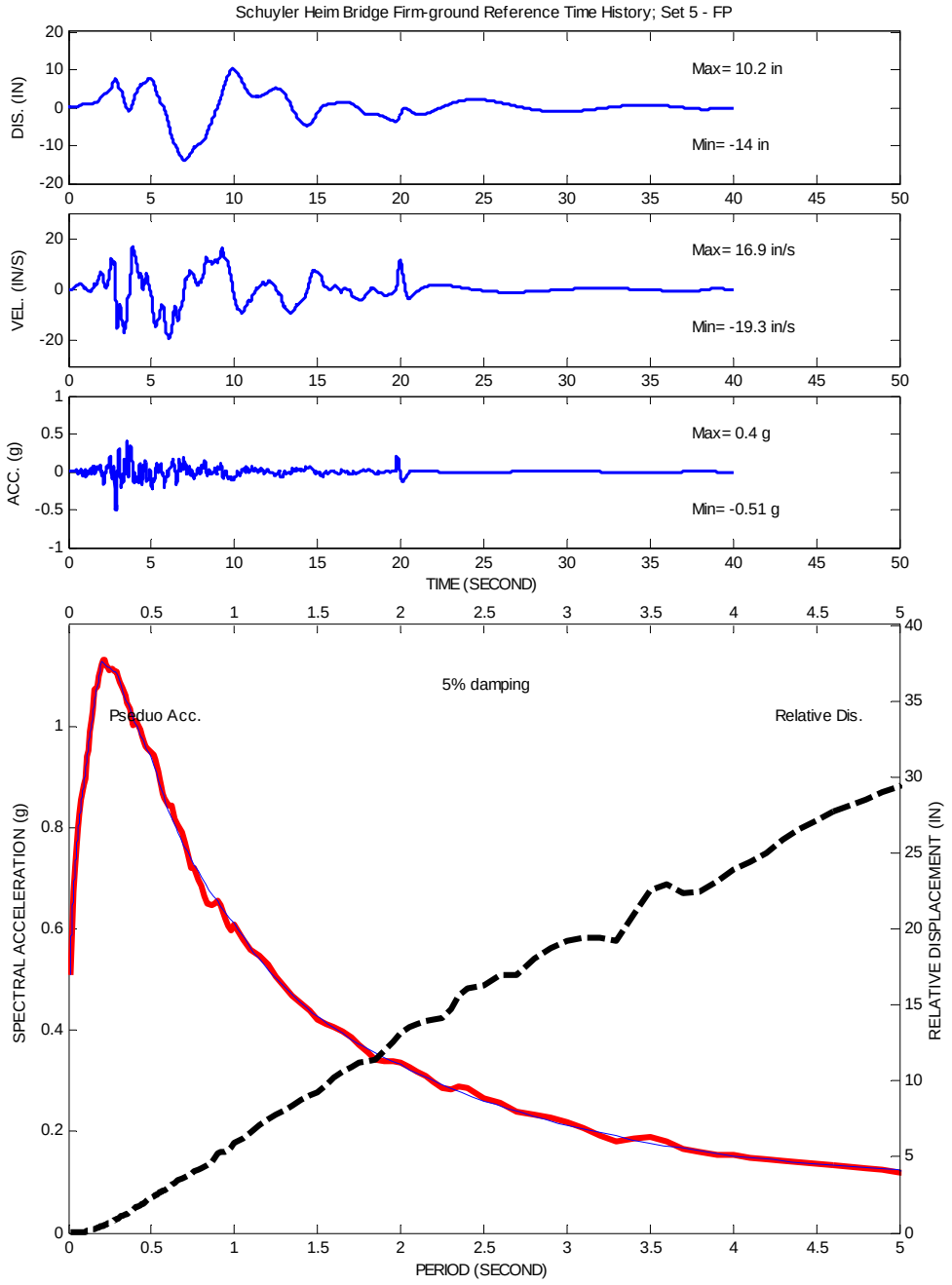

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

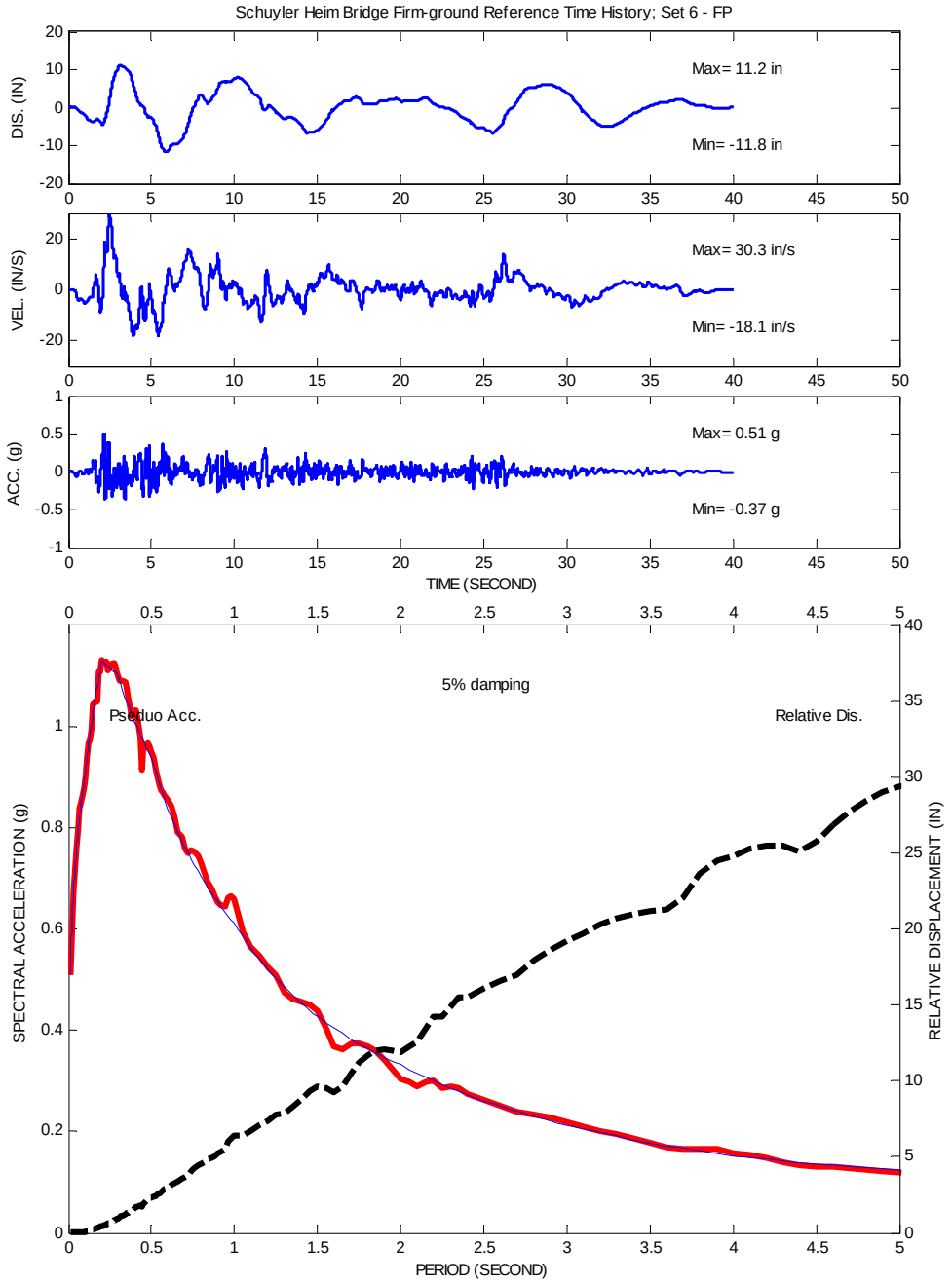

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

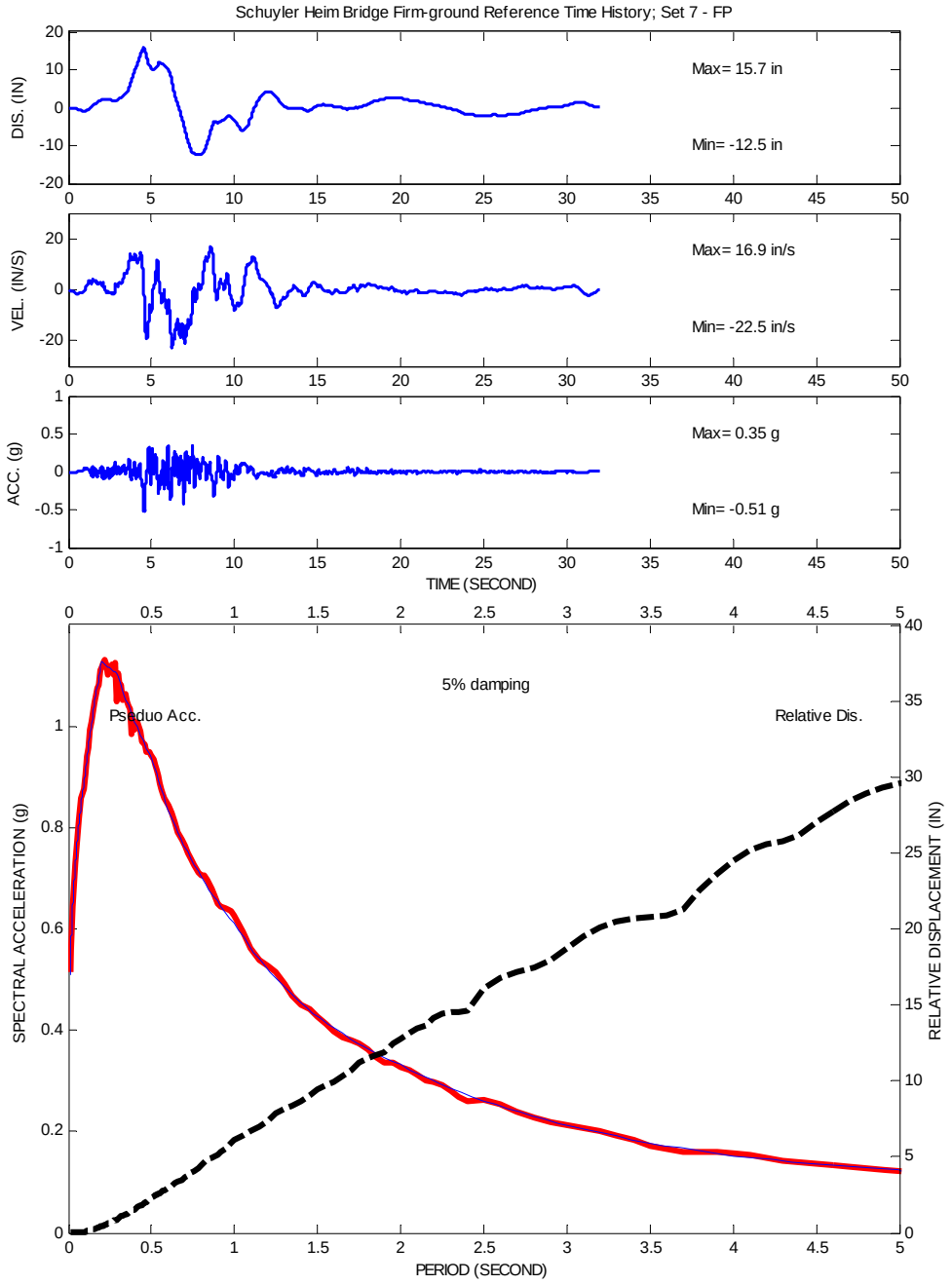

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX G

P-Y CURVE COMPARISON MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 2, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
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COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
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Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul K. Arulmoli, Eric Brown & Patrick Wilson / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge (Replace)
Los Angeles and Long Beach, CA
Bent Foundation Lateral Pile Analysis (p-y Curve Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge (Replace) and associated ramp structures (New Dock Street On-Ramp, New Dock Street Off-Ramp, State Route-103 On-Ramp and State Route-103 Off-Ramp) in the cities of Los Angeles and Long Beach, California.

This memorandum summarizes the results of our lateral pile analysis following completion of the recent field investigation and laboratory testing program and is intended to verify that p-y curves developed during the preliminary design phase are suitable and conservative for use in final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California. The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and W. Ocean Boulevard on the south side.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge and the new alignment shifts east along the existing alignment. The proposed fixed bridge will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge will also include southbound exit ramps and northbound entrance ramps at New Dock Street and State Route (SR) 103.

The typical bridge bent will have either multiple columns (mainline) or single columns (ramp structures) supported on Type II cast-in-drilled-hole (CIDH) piles. South of Cerritos Channel, the CIDH piles are 10 ft diameter while the spans across Cerritos Channel and north of Cerritos Channel are supported on 11 to 12 ft diameter CIDH piles. The abutments for the mainline and the ramp structures are expected to be supported on 2.5-foot diameter CIDH piles; however the subject memorandum only pertains to the bent pile analysis.

Project Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by EMI (EMI, 2006) based upon existing subsurface information available at the time and was intended to be used for bridge type selection and preliminary design. The PFR included a general description of the subsurface conditions including eight idealized soil profiles along the proposed structure alignment with each idealized soil profile typically spanning across multiple bents. The idealized soil profile was used by EMI to develop pile lengths for cost estimating purposes based upon preliminary design loads provided by the designers. Each idealized soil profile included stratigraphy and idealized soil strength parameters (unit weight, friction angle and undrained shear strength) including post-liquefaction "residual" shear strengths for the layers identified as being potentially liquefiable based on a liquefaction analysis performed on the existing soil borings.

It is our understanding that following approval of bridge type selection, design soil springs (p-y curves) were generated by Caltrans using the idealized soil profiles provided in the PFR (EMI, 2006). The preliminary p-y curves were intended to be used during the initial stages of design until a project specific geotechnical field investigation was conducted and the bridge foundation report was prepared. A set of p-y curves was generated at each bent of the mainline and ramp structures for a single 10-ft diameter CIDH pile and included reduced soil strengths for the layers identified in the PFR as potentially liquefiable. Since the project specific geotechnical field investigation could not be initiated until late during the project timeline, the preliminary p-y curves were used by the Caltrans bridge designers in final design. Based upon our conversations with the bridge designers, the only modifications that were made to the preliminary p-y curves was the application of a p-multiplier of 1.2 to curves where the CIDH pile diameter was increased to 12 ft.

In September 2009, EMI was requested by the Alameda Corridor Transportation Agency (ACTA) to perform the project-specific geotechnical field investigation which when completed consisted of 42 rotary wash borings, 33 cone penetration test (CPT) soundings and 8 hollow-stem auger borings along the proposed bridge and ramp alignment; including at least one boring performed near each support of the proposed structure. After completion of the geotechnical field investigation and laboratory testing program, a complete liquefaction analysis was conducted using the new boring information and the idealized soil profile along the proposed bridge alignment was revised.

Because the geotechnical field investigation was not able to be initiated until late during the project timeline, re-analyzing the structure based upon p-y curves generated using the updated soil profile was not feasible given project deadlines. Therefore, EMI performed a set of lateral pile analyses at selected bent locations representing the entire bridge alignment to compare the

preliminary p-y curves (referred to as Design Curves in this memorandum) generated from the idealized soil profiles in the PFR to the p-y curves developed using the updated soil profile (referred to as Revised Profile Curves in this memorandum) to verify that the preliminary curves are suitable and conservative for use in final design.

Method of Analysis

As described above, the Design Curves were generated from eight different soil profiles provided in the PFR (EMI, 2006). For comparison purposes, five bent locations were selected where the individual p-y curves and the overall pile behavior (pile head shear resistance and maximum pile moment versus pile-top deflection) could be compared. The bents selected for comparison were at locations where five of the eight different soil profiles generated during preliminary design could be analyzed. The bent locations selected consisted of two bents south of Cerritos Channel (Bent 2 and Bent 11), one of the bents inside the Cerritos Channel (Bent 14) and two bents north of Cerritos Channel (Bent 18 and Bent 24). The five different idealized soil profiles are shown in Figures 1 to 5.

A review of the Design Curves indicated that coarse-grained soils appear to have been developed using the method proposed by Reese et al. (1974) and fine-grained soils appear to have been developed using the method proposed by Reese and Cox (1975) for stiff clay in the presence of free water. The Revised Profile Curves generated by EMI were developed using API criteria (2000) for coarse grained soils, Matlock's soft clay criteria (Matlock, 1970) for clays with undrained shear strength less than 1 ksf and Reese's method (Reese and Cox, 1975) for stiff clay in the presence of free water for clays with an undrained shear strength greater than 1 ksf.

For comparison of the individual p-y curves, the design curves were provided by the designers. The Revised Profile Curves were generated using LPILE (Ensoft, 2004) based upon the revised idealized soil profile developed at the different bent locations. For the comparison of overall pile behavior (pile head shear resistance and pile moment versus pile-top deflection), the Design Curves were input into LPILE using the "user input p-y curves" option. Based upon our conversations with the designers, a "cracked" section modulus (EI) equal to 75% of the gross EI was used for both models.

Liquefiable Soil. As described above, the Design Curves were generated from soil profiles that indicated the presence of potentially liquefiable material. Based upon a review of the Design Curves, liquefied strengths were generated by applying a p-reduction factor varying between 0.15 and 0.20 for potentially liquefiable layers.

The Revised Profile Curves were generated based upon an updated liquefaction analysis performed on the borings completed in the EMI field investigation. Liquefied soil strengths for layers identified to be potentially liquefiable were modeled using a p-reduction factor based upon the values provided in Ashford et al. (2008). The p-reduction factors are correlated to an average normalized clean sand SPT blowcount $(N1)_{60\text{-}CS}$ for the liquefiable layer with discrete values provided for a range of $(N1)_{60\text{-}CS}$. An approximate trend line was drawn through the ranges proposed by Ashford and used in the analysis as shown in Figure 6.

Group Effects. It is our understanding that the Design Curves were generated prior to Caltrans implementation of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2007) which required p-reduction factors to p-y curves to account for group effects. P-reduction factors to account for group effects for the Revised Profile Curves followed the recommendations for pile group efficiency reduction factors provided in Caltrans Amendments to AASHTO LRFD BDS (Caltrans, 2008) and were based upon the CIDH pile on-center spacing in the bridge transverse direction at the individual bent locations. Since each bent consists of a single row of piles, the bridge transverse direction controls the pile design as it has a greater group reduction than the longitudinal direction. The pile spacing and p-reduction factors used in the analysis for each bent are listed in Table 1.

Table 1. Group Reduction Factors for Revised Profile Curves

Bent Location	Pile Diameter (ft)	Average Spacing in Transverse Direction (ft)	P-Reduction Factor for Group Effects
Bent 2	10	30 = 3.0 x D	0.53
Bent 11	10	36 = 3.6 x D	0.61
Bent 14	12	33 = 2.9 x D	0.48
Bent 18	12	35 = 3.0 x D	0.53
Bent 24	12	45 = 4.0 x D	0.67
Note: Group reduction effects were not accounted for in development of Design Curves.			

Groundwater. The design groundwater elevation for the Revised Profile Curves was placed at an elevation of +5 ft MLLW or the ground surface in locations where proposed grade is indicated on the plans as being below elevation +5 ft MLLW.

Results

The revised soil profiles resulting from the information gathered during the recent investigation are generally consistent with those provided in the PFR that were used to develop the Design Curves. Site soils can be characterized by alluvial deposits consisting of loose to medium dense fine-grained silty sand and sandy silt with abundant silty clay and clayey silt layers between the ground surface and about 50 to 70 ft below grade. The near surface alluvium is underlain by dense to very dense coarse-grained Gaspur Formation sand. The coarse grained portions of the alluvium is generally liquefiable with some pockets and lenses with medium dense to dense consistency that are not considered susceptible to liquefaction.

Since lateral pile behavior is primarily dictated by the soil profile within the upper portion of the pile (within about 5 to 7 pile diameters from the pile top), the lateral pile stiffness throughout the project is dominated by soft to stiff fine-grained material and liquefiable sand. In generating the revised soil profiles, the recent soil borings and laboratory test results justify using more appropriate p-reduction factors to account for liquefaction throughout the profile and higher undrained shear strengths in some of the fine-grained material. Though the Design Curves were generated during early stages of the project without considering group effects, when the more appropriate p-reduction factors for liquefiable soils and increased undrained shear strengths for the appropriate fine-grained soils are used in conjunction with the group reduction factors, the Revised Profile Curves are generally comparable to the Design Curves. Figures 7 to 11 show the

Design Curves plotted along side the Revised Profile Curves at each bent location for the top 100 ft of pile length.

Due to some revisions in the idealized soil profile stratigraphy based upon the new soil information, there are some depths that the Revised Profile Curves model a layer or a portion of a layer as softer than the Design Curves; therefore, it isn't necessarily clear upon initial inspection which set of p-y curves generates a more conservative soil model. Based upon our conversations with the designers, performing a pile pushover analysis using a free-head pile, the curves that generate a pile response where a smaller pile-head shear is required to produce a prescribed lateral pile displacement is considered to be more conservative. In addition, since earthquake loading on a bridge is force based (i.e., mass times the spectral acceleration), the curve that predicts more moment in the pile for a given pile-head shear would also be an indication of a more conservative analysis.

For the five different bents considered, the lateral pile head shear and maximum moment are plotted against lateral pile-top displacement in Figures 12 to 16 using the analysis methods described above. Figures 12, 15 and 16 show that for Bent 2, Bent 18 and Bent 24, respectively, the Design Curves produce a more conservative lateral pile response than the analysis using the Revised Profile Curves. For Bent 11 and Bent 14 shown in Figures 13 and 14, respectively, the lateral pile head shear to produce the same lateral pile deflection is about 15 percent less for the Revised Profile Curves than that for the Design Curves. These differences are considered small and acceptable. In addition, as shown in Figures 12 through 16, the maximum moments for given pile-head shear values predicted using the Design Curves are approximately equal to or greater those predicted using the Revised Profile Curves.

Conclusions

Based upon the results of the above described analysis and our discussions with the designers, we conclude that the Design Curves are appropriate for use in the bridge final design as they typically generate a more conservative lateral pile response than the response predicted by the Revised Curves.

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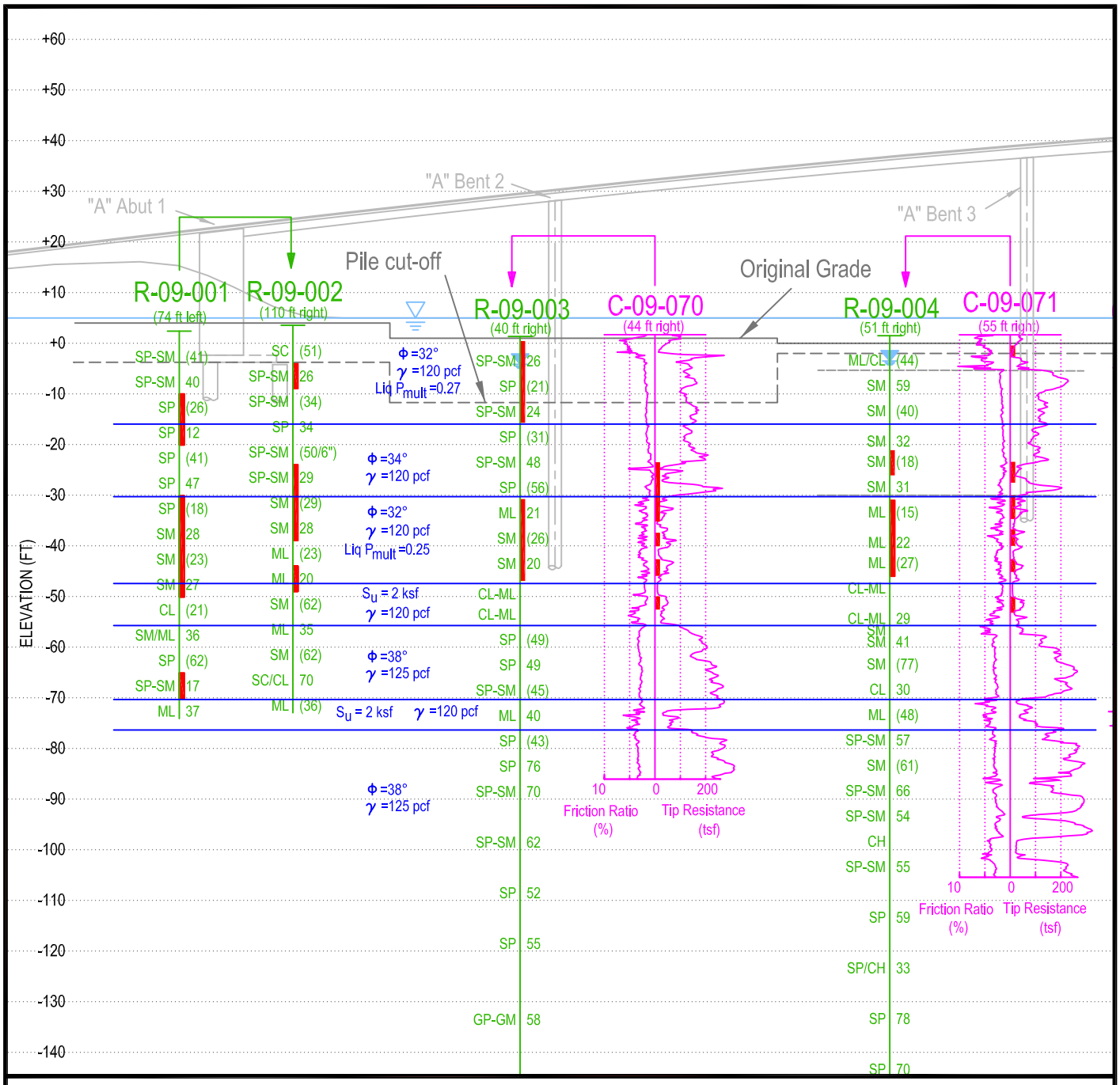

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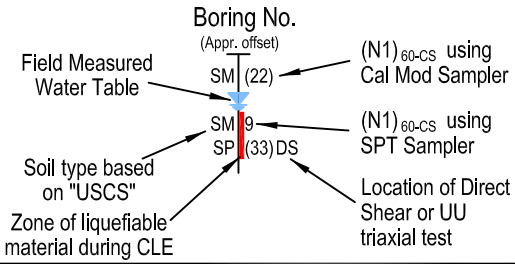
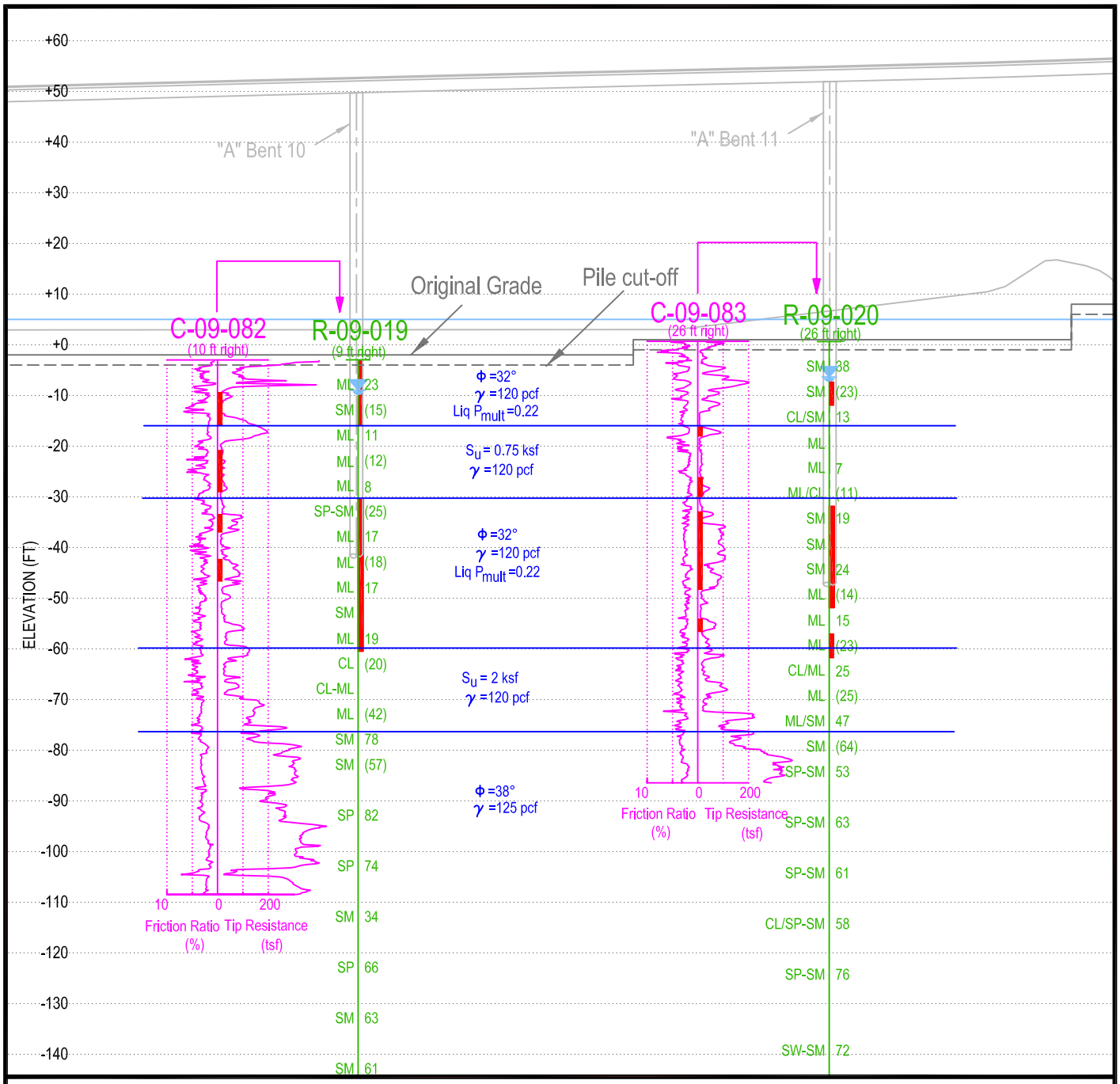


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 2 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 1



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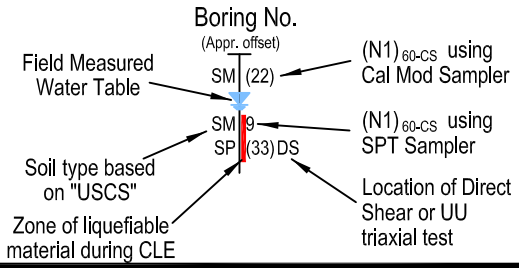

Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Idealized Soil Profile
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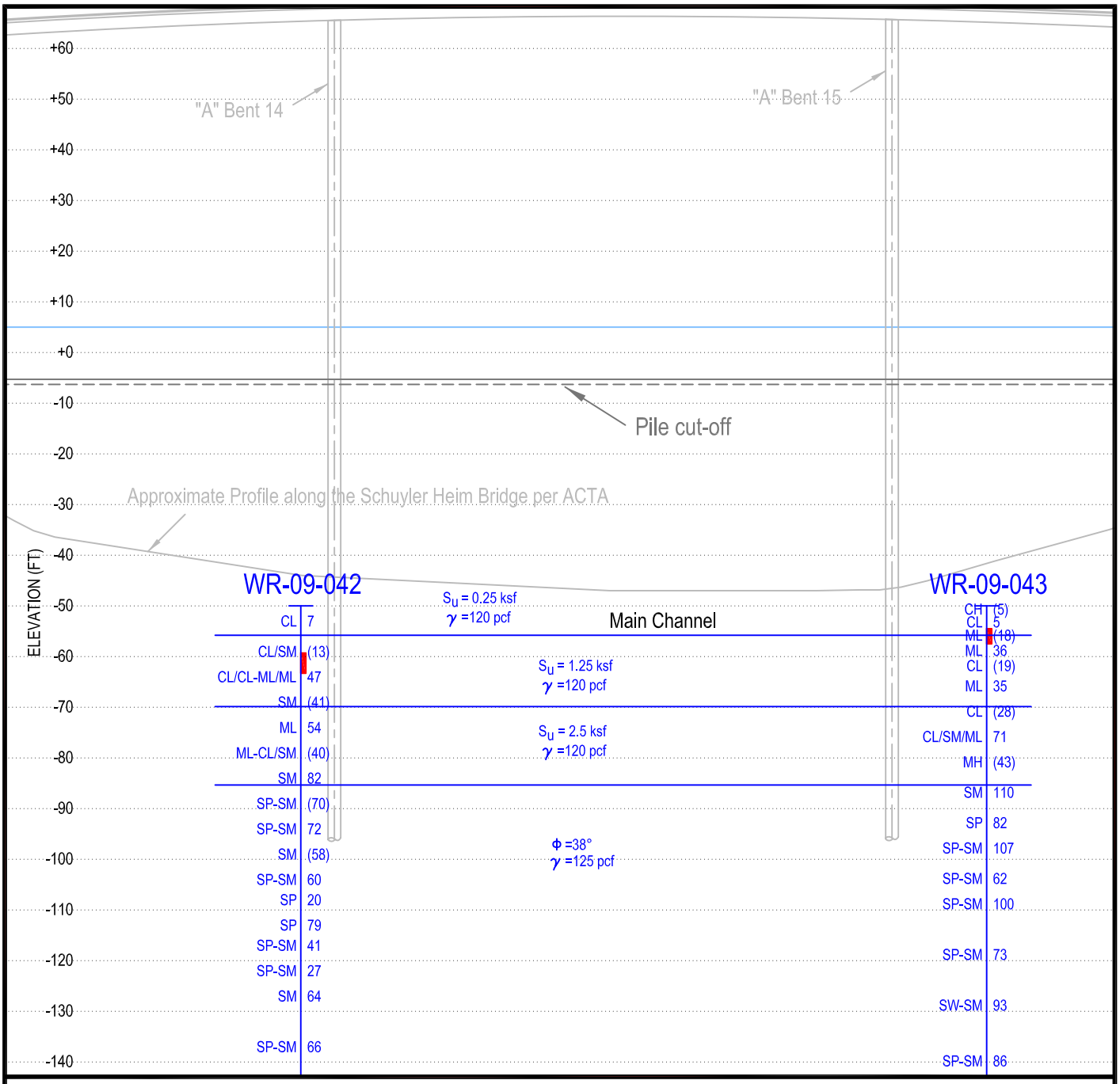

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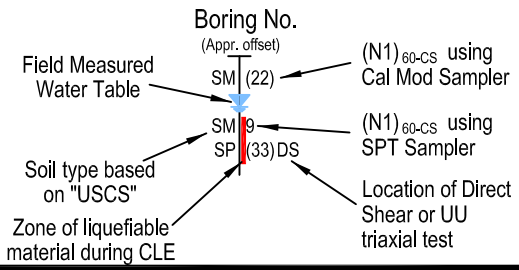
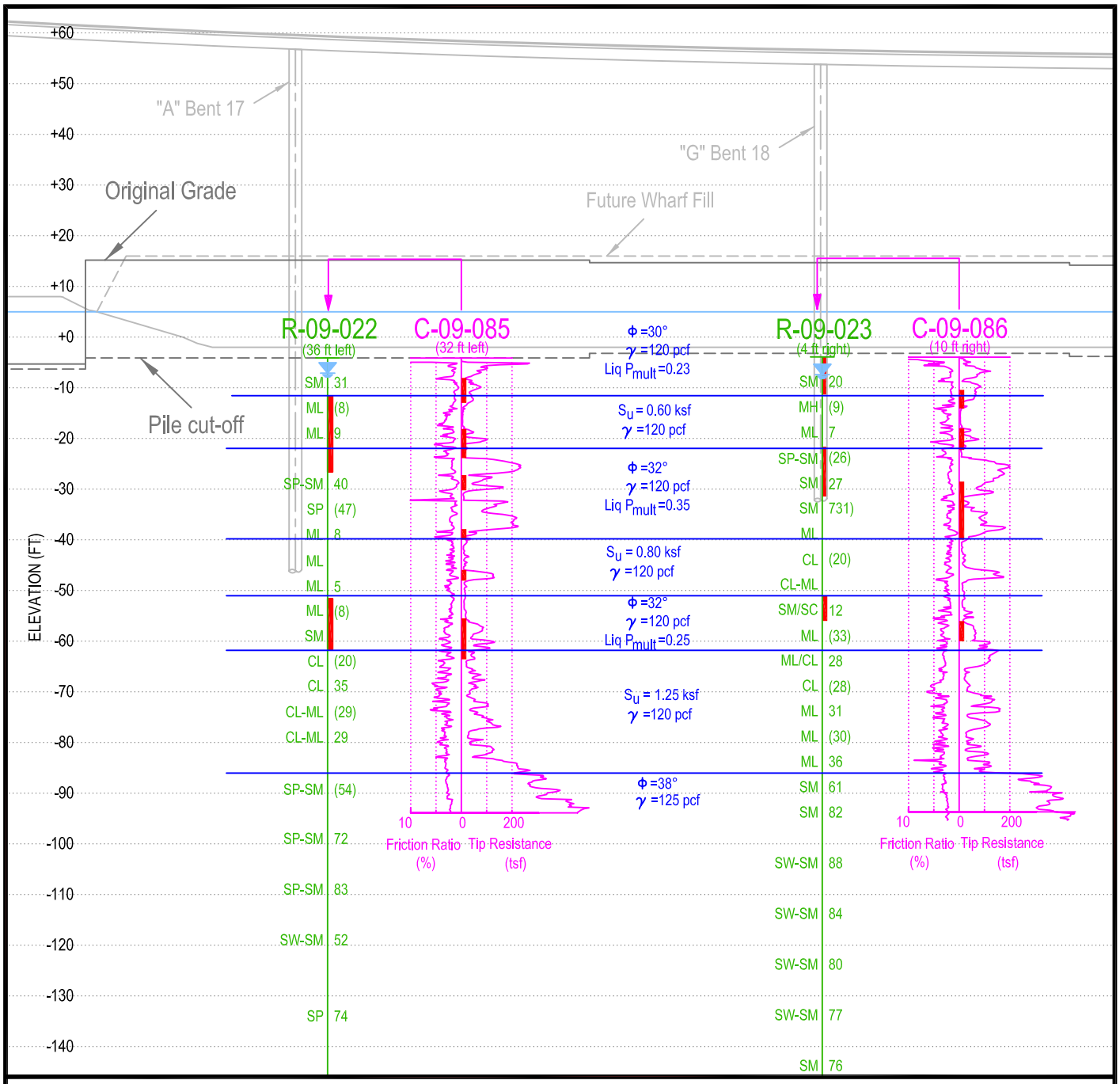


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 3



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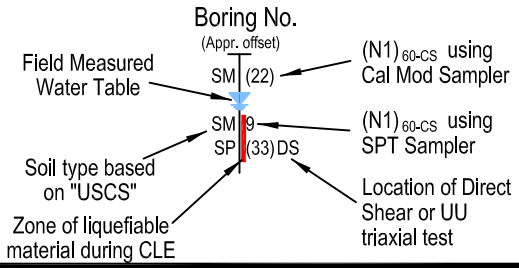
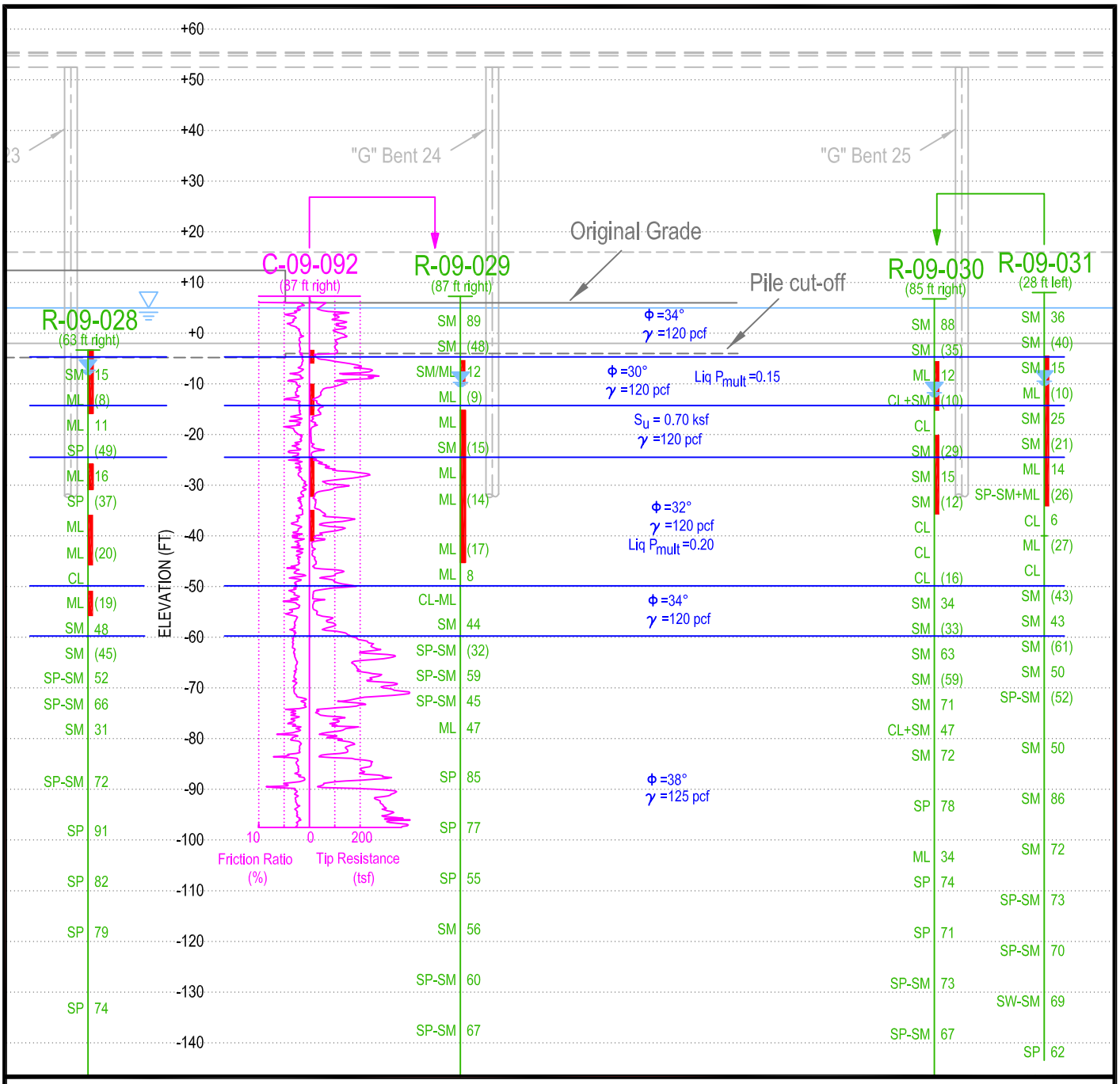


Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Idealized Soil Profile
	Project Number: 06-123	Date: 1/20/2010	Figure 4



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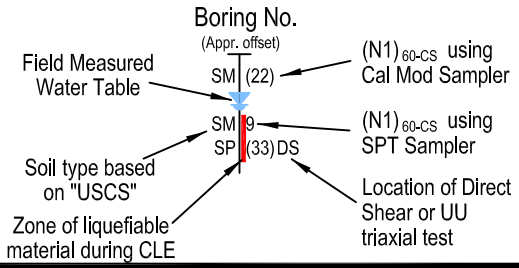


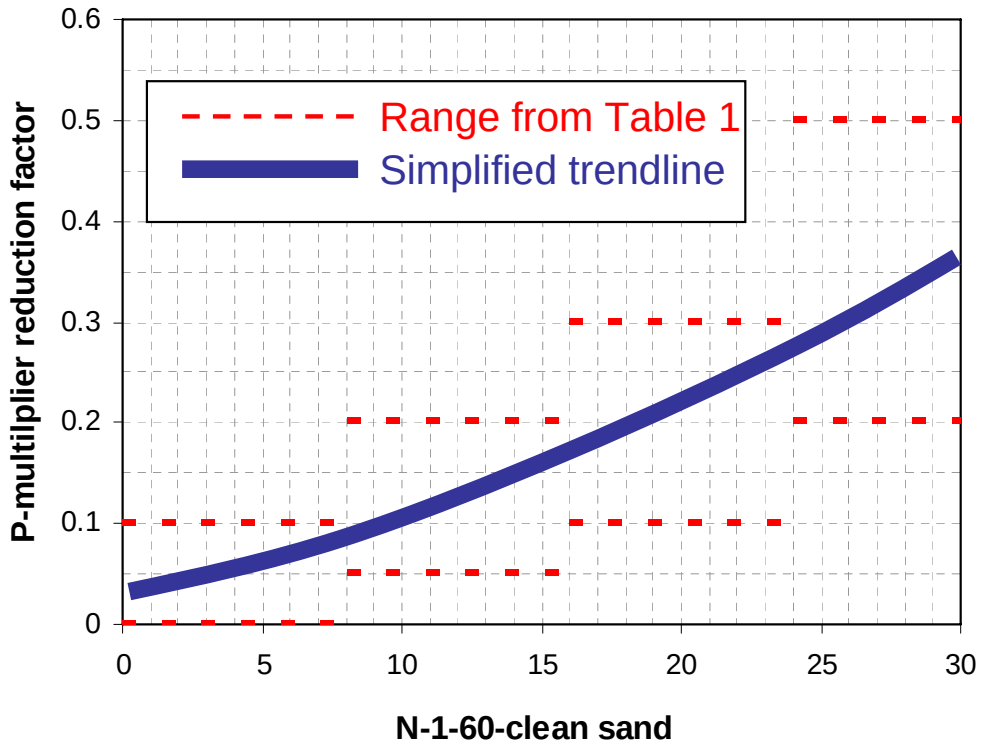
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)	Bent 24 Idealized Soil Profile
	Project Number: 06-123 / Date: 1/20/2010	Figure 5

Recommended values (after Ashford et al. 2008)

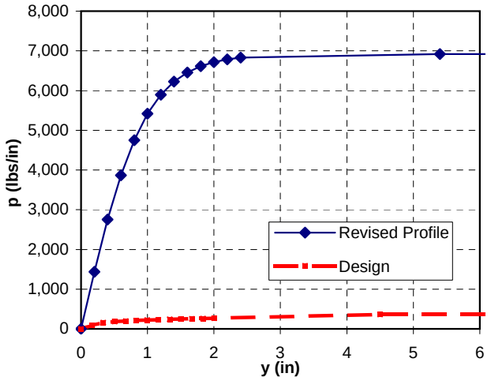
Table 1. p-multipliers, m_p, to account for liquefaction

$(N_1)_{60\text{-}CS}$	m_p
<8	0.0 to 0.1
8-16	0.05 to 0.2
16-24	0.1 to 0.3
>24	0.2 to 0.5

Chart for selecting p-multiplier based on $(N1)60_{cs}$

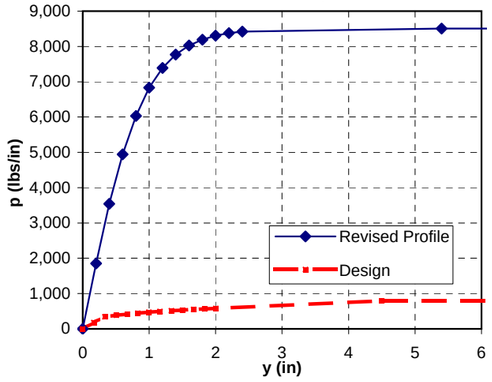


5 ft depth



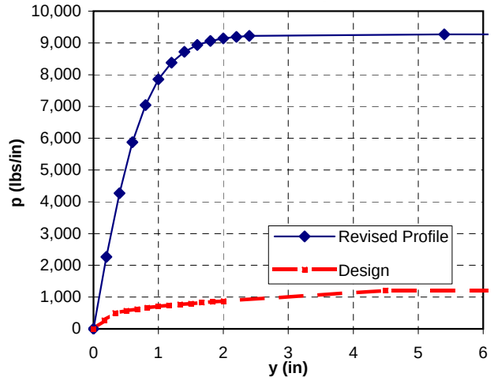
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	1,436
0.34	162	0.40	2,753
0.50	182	0.60	3,869
0.67	197	0.80	4,753
0.83	210	1.00	5,416
1.00	221	1.20	5,894
1.16	231	1.40	6,228
1.33	240	1.60	6,457
1.50	248	1.80	6,611
1.67	256	2.00	6,715
1.84	263	2.20	6,783
2.00	269	2.40	6,829
4.50	365	5.40	6,916
124.50	365	149.40	6,916

10 ft depth



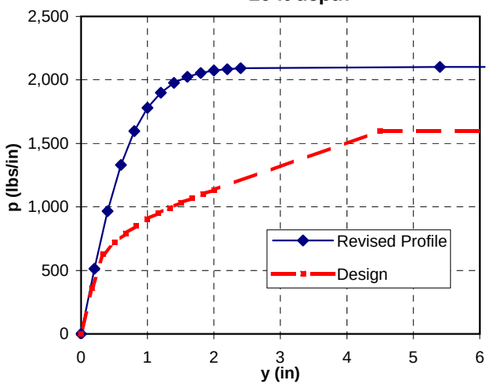
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	1,853
0.34	341	0.40	3,538
0.50	384	0.60	4,943
0.67	418	0.80	6,032
0.83	447	1.00	6,829
1.00	472	1.20	7,389
1.16	494	1.40	7,771
1.33	514	1.60	8,025
1.50	532	1.80	8,193
1.67	549	2.00	8,303
1.84	565	2.20	8,374
2.00	579	2.40	8,420
4.50	794	5.40	8,503
124.50	794	149.40	8,503

15 ft depth



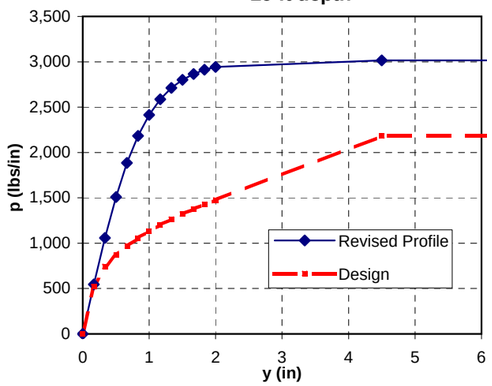
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.20	2,263
0.34	502	0.40	4,271
0.50	569	0.60	5,873
0.67	622	0.80	7,046
0.83	666	1.00	7,852
1.00	705	1.20	8,381
1.16	739	1.40	8,719
1.33	770	1.60	8,931
1.50	799	1.80	9,062
1.67	825	2.00	9,143
1.84	850	2.20	9,192
2.00	873	2.40	9,222
4.50	1,210	5.40	9,269
124.50	1,210	149.40	9,269

20 ft depth



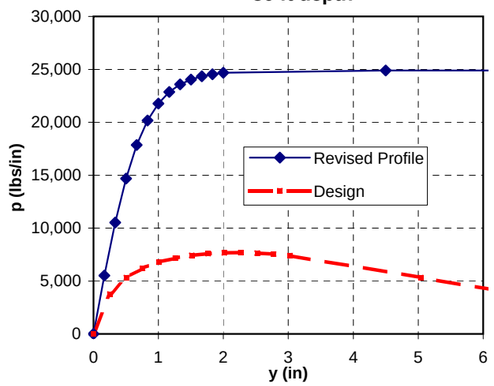
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	360	0.20	512
0.34	631	0.40	967
0.50	720	0.60	1,330
0.67	792	0.80	1,597
0.83	852	1.00	1,780
1.00	904	1.20	1,900
1.16	951	1.40	1,977
1.33	993	1.60	2,026
1.50	1,032	1.80	2,055
1.67	1,069	2.00	2,074
1.84	1,103	2.20	2,085
2.00	1,134	2.40	2,092
4.50	1,599	5.40	2,103
124.50	1,599	149.40	2,103

29 ft depth



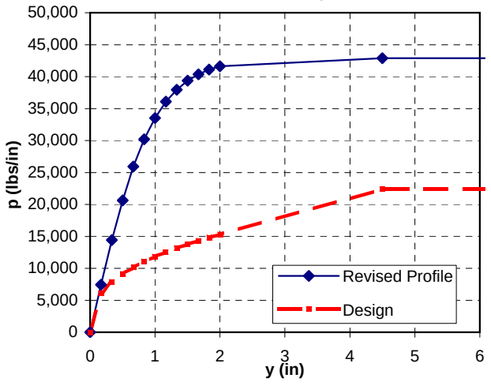
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	522	0.17	547
0.34	744	0.33	1,058
0.50	868	0.50	1,509
0.67	970	0.67	1,885
0.83	1,056	0.83	2,184
1.00	1,132	1.00	2,414
1.16	1,201	1.17	2,586
1.33	1,264	1.33	2,711
1.50	1,322	1.50	2,802
1.67	1,377	1.67	2,866
1.84	1,428	1.83	2,911
2.00	1,476	2.00	2,943
4.50	2,182	4.50	3,016
124.50	2,182	124.50	3,017

50 ft depth



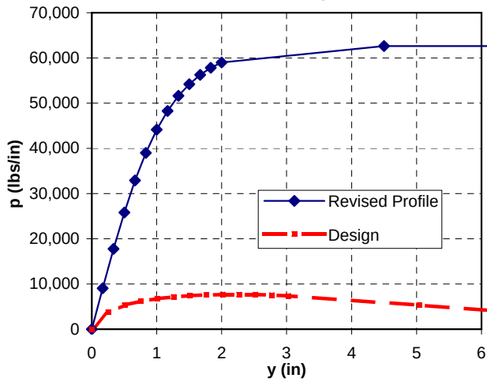
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	5,521
0.50	5,325	0.33	10,523
0.76	6,204	0.50	14,668
1.01	6,775	0.67	17,855
1.26	7,164	0.83	20,166
1.51	7,425	1.00	21,774
1.76	7,585	1.17	22,858
2.02	7,664	1.33	23,576
2.27	7,676	1.50	24,045
2.52	7,629	1.67	24,348
2.77	7,532	1.83	24,543
3.02	7,390	2.00	24,668
5.04	5,330	4.50	24,888
7.06	3,268	124.50	24,889

71 ft depth



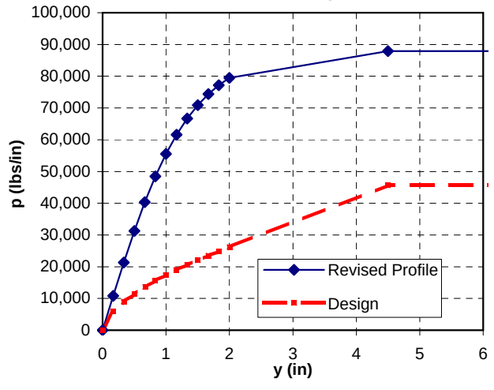
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	6,081	0.17	7,430
0.34	7,867	0.33	14,426
0.50	9,145	0.50	20,652
0.67	10,176	0.67	25,918
0.83	11,056	0.83	30,186
1.00	11,830	1.00	33,525
1.16	12,527	1.17	36,068
1.33	13,164	1.33	37,963
1.50	13,753	1.50	39,354
1.67	14,302	1.67	40,363
1.84	14,817	1.83	41,089
2.00	15,303	2.00	41,609
4.50	22,408	4.50	42,867
124.50	22,408	124.50	42,874

85 ft depth



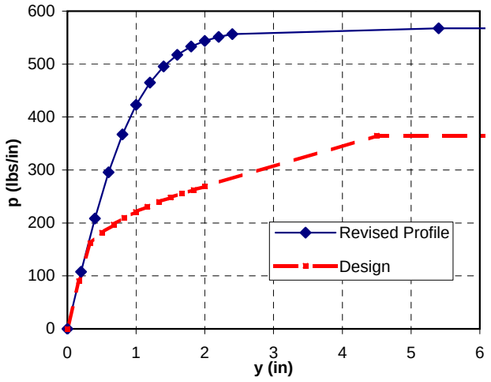
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	9,074
0.50	5,325	0.33	17,775
0.76	6,204	0.50	25,790
1.01	6,775	0.67	32,904
1.26	7,164	0.83	39,014
1.51	7,425	1.00	44,113
1.76	7,585	1.17	48,270
2.02	7,664	1.33	51,593
2.27	7,676	1.50	54,208
2.52	7,629	1.67	56,241
2.77	7,532	1.83	57,807
3.02	7,390	2.00	59,004
5.04	5,330	4.50	62,636
7.06	3,268	124.50	62,684

100 ft depth



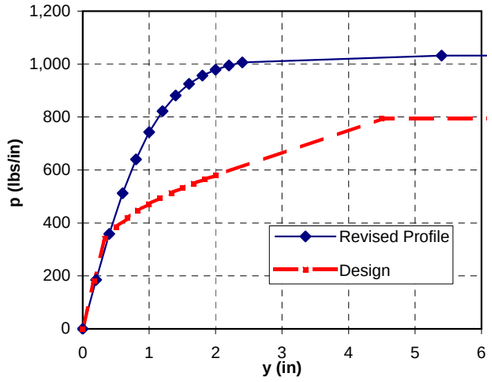
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	5,976	0.17	10,832
0.34	9,023	0.33	21,341
0.50	11,483	0.50	31,242
0.67	13,624	0.67	40,316
0.83	15,557	0.83	48,423
1.00	17,338	1.00	55,503
1.16	19,001	1.17	61,565
1.33	20,571	1.33	66,668
1.50	22,063	1.50	70,902
1.67	23,489	1.67	74,373
1.84	24,858	1.83	77,191
2.00	26,177	2.00	79,461
4.50	45,628	4.50	87,868
124.50	45,628	124.50	88,090

5 ft depth



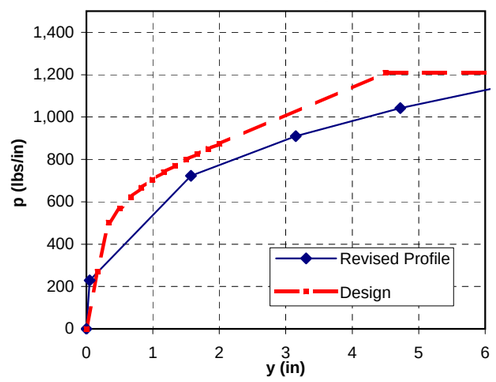
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	90	0.20	108
0.34	162	0.40	208
0.50	182	0.60	295
0.67	197	0.80	367
0.83	210	1.00	423
1.00	221	1.20	465
1.16	231	1.40	496
1.33	240	1.60	518
1.50	248	1.80	533
1.67	256	2.00	544
1.84	263	2.20	551
2.00	269	2.40	556
4.50	365	5.40	567
124.50	365	149.40	568

10 ft depth



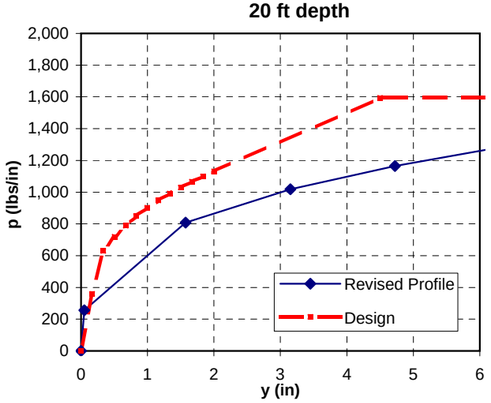
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	180	0.20	185
0.34	341	0.40	359
0.50	384	0.60	512
0.67	418	0.80	640
0.83	447	1.00	743
1.00	472	1.20	822
1.16	494	1.40	881
1.33	514	1.60	925
1.50	532	1.80	956
1.67	549	2.00	979
1.84	565	2.20	995
2.00	579	2.40	1,006
4.50	794	5.40	1,032
124.50	794	149.40	1,033

15 ft depth



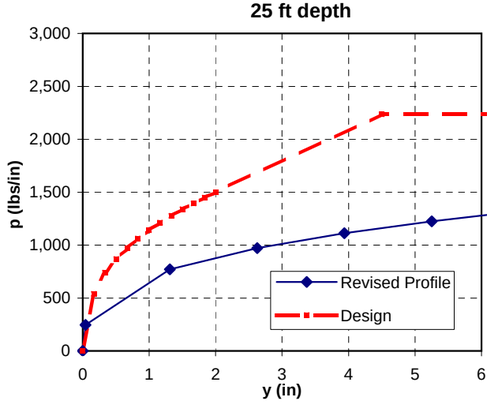
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	270	0.05	229
0.34	502	1.58	723
0.50	569	3.15	910
0.67	622	4.73	1,042
0.83	666	6.30	1,147
1.00	705	7.88	1,235
1.16	739	9.45	1,313
1.33	770	11.03	1,382
1.50	799	12.60	1,445
1.67	825	14.18	1,503
1.84	850	15.75	1,557
2.00	873	17.33	1,607
4.50	1,210	18.90	1,654
124.50	1,210	50.40	2,294

20 ft depth



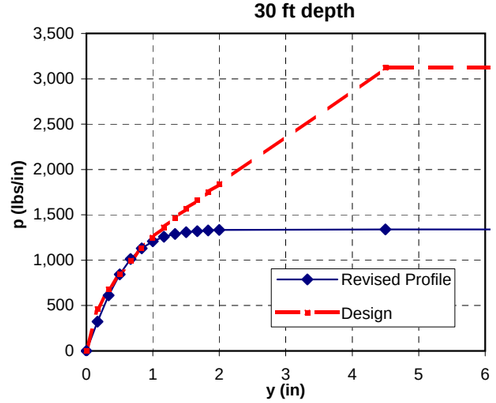
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	359	0.05	256
0.34	629	1.58	808
0.50	719	3.15	1,018
0.67	790	4.73	1,165
0.83	850	6.30	1,282
1.00	902	7.88	1,381
1.16	949	9.45	1,468
1.33	991	11.03	1,545
1.50	1,030	12.60	1,616
1.67	1,066	14.18	1,680
1.84	1,100	15.75	1,740
2.00	1,132	17.33	1,797
4.50	1,594	18.90	1,849
124.50	1,594	50.40	2,565

25 ft depth



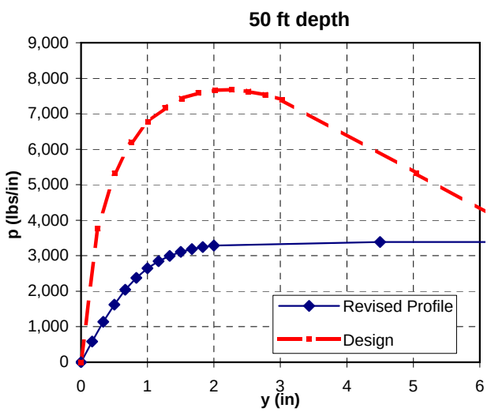
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	539	0.04	245
0.34	740	1.31	771
0.50	869	2.63	972
0.67	973	3.94	1,112
0.83	1,062	5.25	1,224
1.00	1,141	6.56	1,319
1.16	1,212	7.88	1,402
1.33	1,278	9.19	1,475
1.50	1,338	10.50	1,543
1.67	1,395	11.81	1,604
1.84	1,448	13.13	1,662
2.00	1,499	14.44	1,715
4.50	2,236	15.75	1,766
124.50	2,236	42.00	2,449

30 ft depth



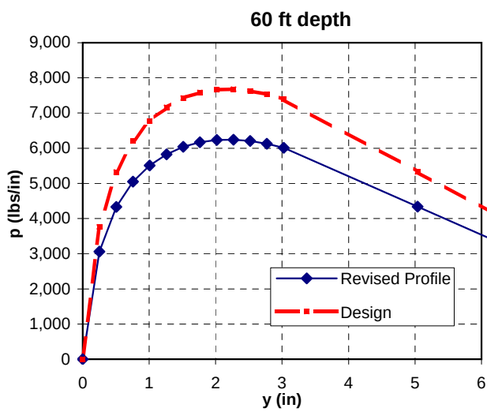
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	461	0.17	324
0.34	678	0.33	612
0.50	850	0.50	843
0.67	998	0.67	1,012
0.83	1,130	0.83	1,130
1.00	1,251	1.00	1,208
1.16	1,363	1.17	1,257
1.33	1,468	1.33	1,289
1.50	1,567	1.50	1,308
1.67	1,662	1.67	1,320
1.84	1,753	1.83	1,328
2.00	1,840	2.00	1,332
4.50	3,121	4.50	1,340
124.50	3,121	124.50	1,340

50 ft depth



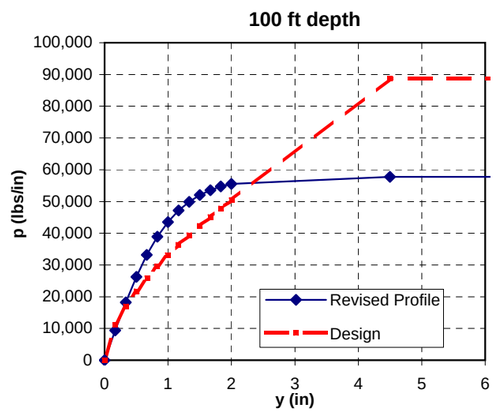
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.17	584
0.50	5,325	0.33	1,135
0.76	6,204	0.50	1,626
1.01	6,775	0.67	2,041
1.26	7,164	0.83	2,379
1.51	7,425	1.00	2,643
1.76	7,585	1.17	2,845
2.02	7,664	1.33	2,996
2.27	7,676	1.50	3,107
2.52	7,629	1.67	3,188
2.77	7,532	1.83	3,246
3.02	7,390	2.00	3,288
5.04	5,330	4.50	3,389
7.06	3,268	124.50	3,390

60 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	3,765	0.25	3,063
0.50	5,325	0.50	4,332
0.76	6,204	0.76	5,047
1.01	6,775	1.01	5,511
1.26	7,164	1.26	5,828
1.51	7,425	1.51	6,040
1.76	7,585	1.76	6,170
2.02	7,664	2.02	6,235
2.27	7,676	2.27	6,244
2.52	7,629	2.52	6,206
2.77	7,532	2.77	6,127
3.02	7,390	3.02	6,011
5.04	5,330	5.04	4,336
7.06	3,268	7.06	2,658

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	11,128	0.17	9,360
0.34	16,961	0.33	18,242
0.50	21,702	0.50	26,260
0.67	25,850	0.67	33,178
0.83	29,606	0.83	38,920
1.00	33,077	1.00	43,533
1.16	36,327	1.17	47,142
1.33	39,400	1.33	49,910
1.50	42,325	1.50	51,998
1.67	45,125	1.67	53,555
1.84	47,817	1.83	54,706
2.00	50,414	2.00	55,551
4.50	88,729	4.50	57,780
124.50	88,729	124.50	57,797

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

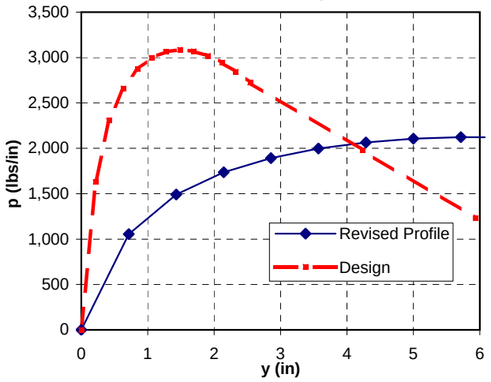
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 11

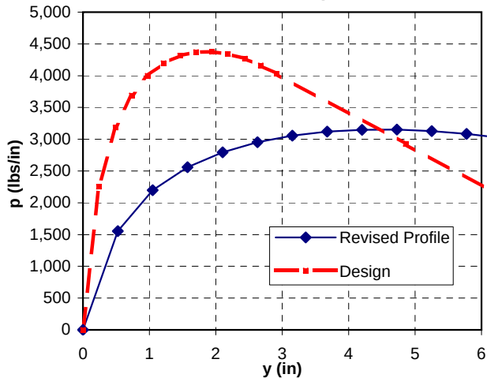
Figure 8

55 ft depth



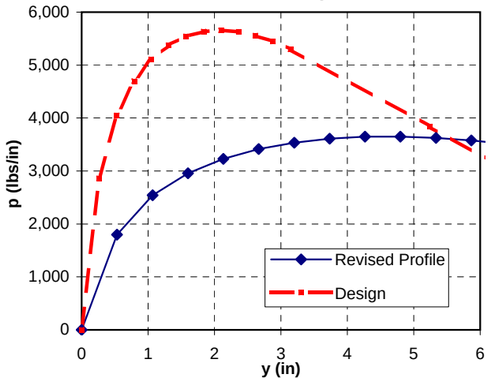
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	1,631	0.71	1,055
0.42	2,306	1.43	1,491
0.64	2,660	2.14	1,735
0.85	2,870	2.86	1,891
1.06	2,997	3.57	1,996
1.27	3,064	4.29	2,065
1.49	3,085	5.00	2,105
1.69	3,068	5.71	2,122
1.91	3,019	6.43	2,121
2.12	2,944	7.14	2,102
2.33	2,844	7.86	2,069
2.54	2,724	8.57	2,024
4.24	1,978	14.29	1,463
5.94	1,230	20.00	902

60 ft depth



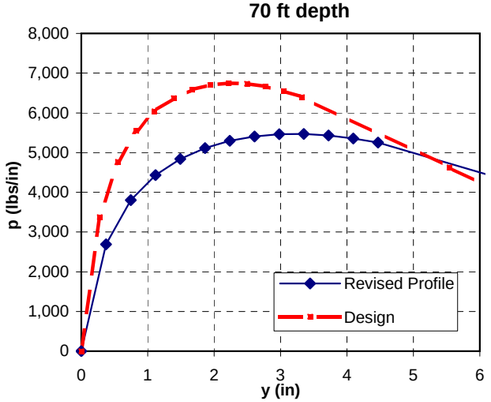
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.24	2,252	0.53	1,555
0.49	3,185	1.05	2,200
0.73	3,688	1.58	2,561
0.97	3,999	2.10	2,794
1.21	4,198	2.63	2,952
1.46	4,316	3.15	3,057
1.70	4,372	3.68	3,120
1.94	4,378	4.20	3,149
2.18	4,341	4.73	3,150
2.44	4,268	5.25	3,127
2.68	4,163	5.78	3,083
2.92	4,032	6.30	3,021
4.86	2,926	10.50	2,181
6.80	1,820	14.71	1,341

65 ft depth



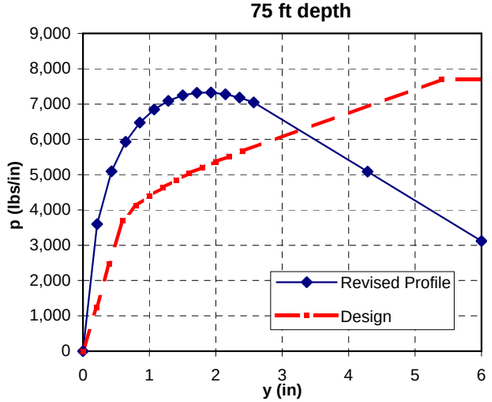
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.26	2,862	0.53	1,796
0.53	4,047	1.07	2,540
0.79	4,697	1.60	2,958
1.04	5,106	2.13	3,229
1.31	5,375	2.67	3,414
1.57	5,542	3.20	3,536
1.84	5,631	3.73	3,611
2.10	5,657	4.27	3,647
2.36	5,630	4.80	3,651
2.62	5,558	5.33	3,627
2.88	5,445	5.87	3,578
3.14	5,300	6.40	3,510
5.24	3,841	10.67	2,532
7.34	2,382	14.93	1,554

70 ft depth



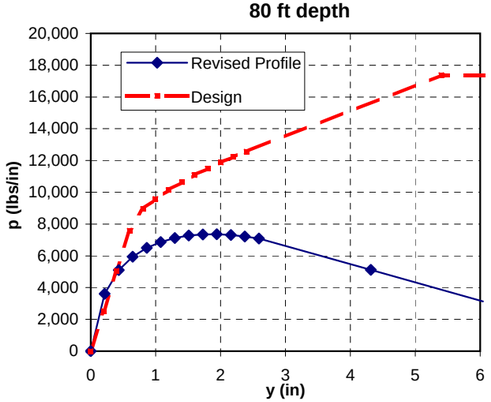
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.28	3,375	0.37	2,691
0.55	4,773	0.74	3,805
0.83	5,547	1.12	4,432
1.10	6,041	1.49	4,837
1.39	6,371	1.86	5,113
1.67	6,583	2.23	5,296
1.94	6,703	2.61	5,408
2.22	6,750	2.98	5,461
2.50	6,735	3.35	5,466
2.77	6,667	3.72	5,429
3.05	6,553	4.10	5,356
3.32	6,400	4.47	5,251
5.54	4,631	7.45	3,790
7.76	2,861	10.43	2,327

75 ft depth



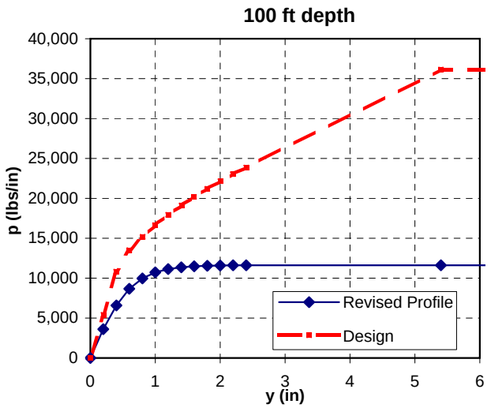
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	1,234	0.21	3,600
0.40	2,467	0.43	5,092
0.60	3,701	0.64	5,931
0.80	4,120	0.86	6,475
1.00	4,395	1.07	6,846
1.20	4,632	1.29	7,093
1.40	4,843	1.50	7,244
1.60	5,033	1.71	7,317
1.80	5,208	1.93	7,326
2.00	5,368	2.14	7,279
2.20	5,518	2.36	7,183
2.40	5,659	2.57	7,044
5.40	7,701	4.29	5,083
149.40	7,701	6.00	3,119

80 ft depth



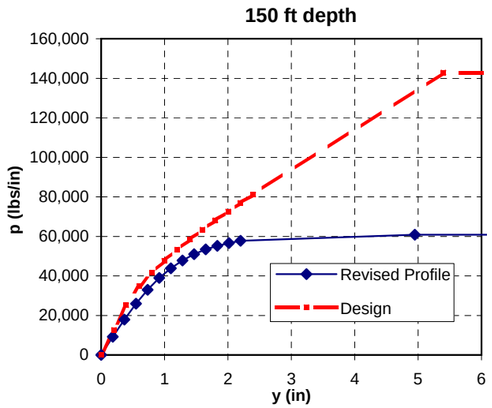
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	2,530	0.22	3,613
0.40	5,059	0.43	5,110
0.60	7,589	0.65	5,953
0.80	8,955	0.86	6,500
1.00	9,591	1.08	6,874
1.20	10,144	1.29	7,123
1.40	10,637	1.51	7,277
1.60	11,083	1.73	7,353
1.80	11,491	1.94	7,364
2.00	11,870	2.16	7,319
2.20	12,223	2.37	7,225
2.40	12,555	2.59	7,088
5.40	17,381	4.32	5,113
149.40	17,381	6.04	3,135

100 ft depth



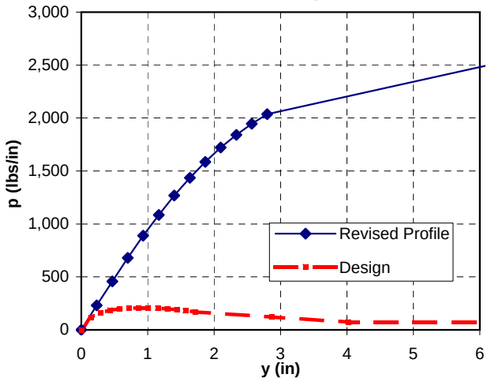
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	5,410	0.20	3,604
0.40	10,819	0.40	6,576
0.60	13,502	0.60	8,661
0.80	15,196	0.80	9,964
1.00	16,655	1.00	10,720
1.20	17,951	1.20	11,140
1.40	19,125	1.40	11,368
1.60	20,203	1.60	11,490
1.80	21,205	1.80	11,554
2.00	22,143	2.00	11,588
2.20	23,028	2.20	11,607
2.40	23,866	2.40	11,616
5.40	36,124	5.40	11,627
149.40	36,124	149.40	11,627

150 ft depth



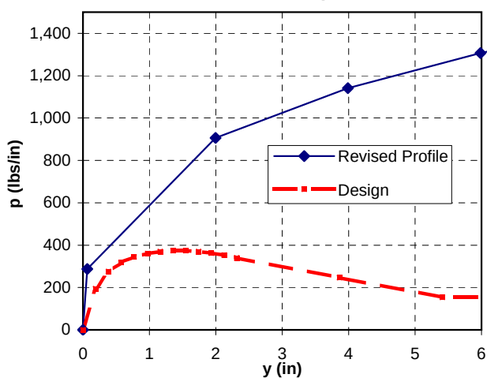
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.20	12,610	0.18	9,154
0.40	25,219	0.37	17,902
0.60	34,932	0.55	25,909
0.80	41,608	0.73	32,951
1.00	47,654	0.92	38,933
1.20	53,241	1.10	43,863
1.40	58,472	1.28	47,829
1.60	63,417	1.47	50,956
1.80	68,125	1.65	53,382
2.00	72,632	1.83	55,243
2.20	76,965	2.02	56,657
2.40	81,146	2.20	57,723
5.40	142,818	4.95	60,806
149.40	142,818	136.95	60,840

5 ft depth



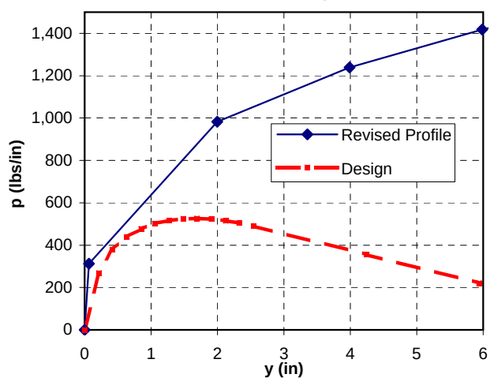
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	231
0.29	162	0.47	459
0.43	186	0.70	679
0.58	199	0.93	889
0.72	206	1.17	1,086
0.86	209	1.40	1,269
1.01	208	1.63	1,436
1.15	204	1.87	1,586
1.30	198	2.10	1,721
1.44	190	2.33	1,841
1.57	180	2.57	1,946
1.72	169	2.80	2,037
2.87	122	6.30	2,522
4.02	74	174.30	2,560
100.00	74	342.30	2,560

10 ft depth



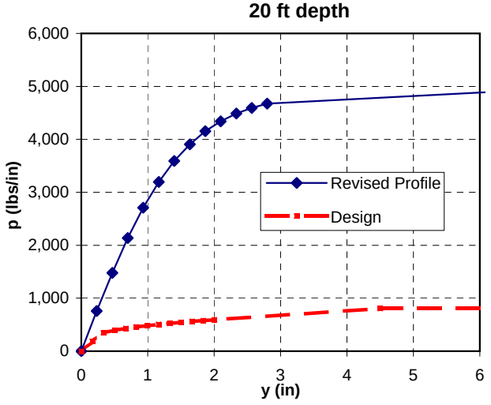
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.06	288
0.38	275	2.00	906
0.58	318	3.99	1,142
0.77	344	5.99	1,307
0.97	361	7.98	1,438
1.16	370	9.98	1,549
1.36	374	11.97	1,646
1.55	374	13.97	1,733
1.74	370	15.96	1,812
1.93	363	17.96	1,885
2.12	353	19.95	1,952
2.32	340	21.95	2,015
3.86	247	23.94	2,074
5.41	154	63.84	2,877
100.00	154	119.70	2,877

15 ft depth



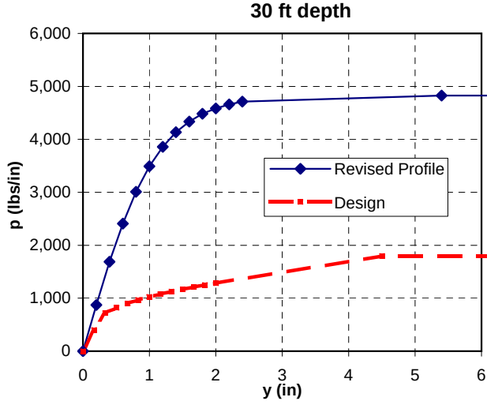
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	312
0.42	379	2.00	983
0.64	439	3.99	1,239
0.85	477	5.99	1,418
1.06	502	7.98	1,560
1.27	517	9.98	1,681
1.49	524	11.97	1,786
1.69	526	13.97	1,880
1.91	523	15.96	1,966
2.12	515	17.96	2,045
2.33	504	19.95	2,118
2.54	490	21.95	2,186
4.25	355	23.94	2,251
5.94	221	63.84	3,121
100.00	221	119.70	3,121

20 ft depth



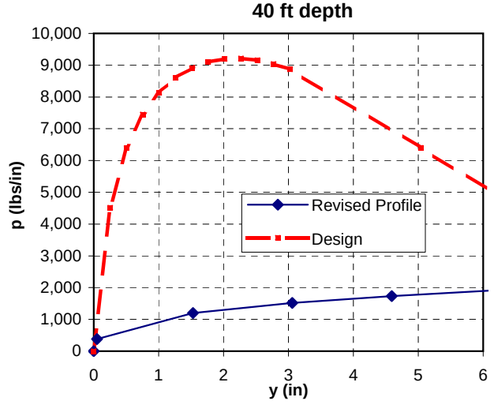
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	186	0.23	757
0.34	350	0.47	1,479
0.50	395	0.70	2,136
0.67	429	0.93	2,711
0.83	458	1.17	3,195
1.00	483	1.40	3,591
1.16	505	1.63	3,907
1.33	526	1.87	4,153
1.50	544	2.10	4,342
1.67	561	2.33	4,486
1.84	577	2.57	4,594
2.00	592	2.80	4,675
4.50	808	6.30	4,902
124.50	808	174.30	4,904

30 ft depth



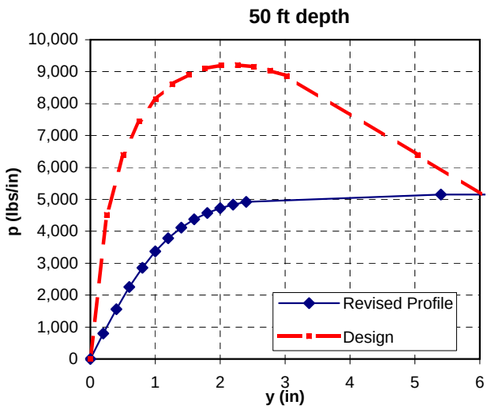
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	402	0.20	872
0.34	722	0.40	1,690
0.50	822	0.60	2,410
0.67	902	0.80	3,011
0.83	969	1.00	3,490
1.00	1,027	1.20	3,859
1.16	1,080	1.40	4,134
1.33	1,127	1.60	4,336
1.50	1,171	1.80	4,481
1.67	1,211	2.00	4,585
1.84	1,249	2.20	4,658
2.00	1,284	2.40	4,710
4.50	1,800	5.40	4,829
124.50	1,800	149.40	4,829

40 ft depth



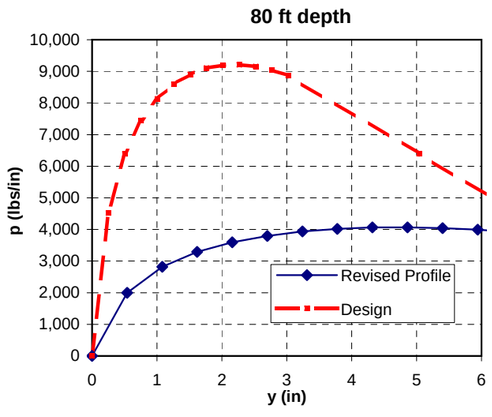
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.05	382
0.50	6,390	1.53	1,203
0.76	7,445	3.06	1,516
1.01	8,129	4.59	1,735
1.26	8,597	6.12	1,910
1.51	8,910	7.65	2,057
1.76	9,102	9.18	2,186
2.02	9,197	10.71	2,301
2.27	9,211	12.24	2,406
2.52	9,155	13.77	2,502
2.77	9,038	15.30	2,592
3.02	8,868	16.83	2,675
5.04	6,396	18.36	2,754
7.06	3,922	48.96	3,819

50 ft depth



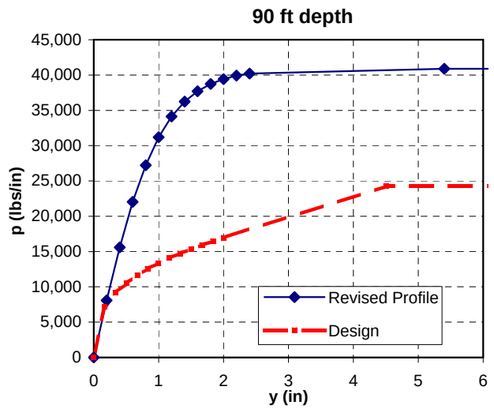
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	798
0.50	6,390	0.40	1,559
0.76	7,445	0.60	2,252
1.01	8,129	0.80	2,857
1.26	8,597	1.00	3,367
1.51	8,910	1.20	3,782
1.76	9,102	1.40	4,113
2.02	9,197	1.60	4,371
2.27	9,211	1.80	4,569
2.52	9,155	2.00	4,720
2.77	9,038	2.20	4,833
3.02	8,868	2.40	4,917
5.04	6,396	5.40	5,152
7.06	3,922	149.40	5,154

80 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.54	1,996
0.50	6,390	1.08	2,822
0.76	7,445	1.62	3,288
1.01	8,129	2.16	3,590
1.26	8,597	2.70	3,797
1.51	8,910	3.24	3,935
1.76	9,102	3.78	4,020
2.02	9,197	4.32	4,062
2.27	9,211	4.86	4,068
2.52	9,155	5.40	4,044
2.77	9,038	5.94	3,992
3.02	8,868	6.48	3,917
5.04	6,396	10.80	2,825
7.06	3,922	15.12	1,732

90 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	7,207	0.20	8,099
0.34	9,150	0.40	15,587
0.50	10,522	0.60	22,023
0.67	11,618	0.80	27,217
0.83	12,546	1.00	31,200
1.00	13,360	1.20	34,137
1.16	14,088	1.40	36,240
1.33	14,751	1.60	37,715
1.50	15,362	1.80	38,734
1.67	15,930	2.00	39,430
1.84	16,462	2.20	39,903
2.00	16,963	2.40	40,223
4.50	24,267	5.40	40,876
124.50	24,267	149.40	40,878

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA Schuyler Heim Bridge (Replace)

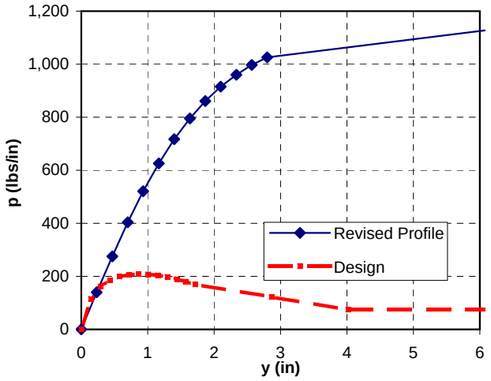
Project Number: 06-123

Date: 1/20/2010

p-y Curve Comparison for Bent 18

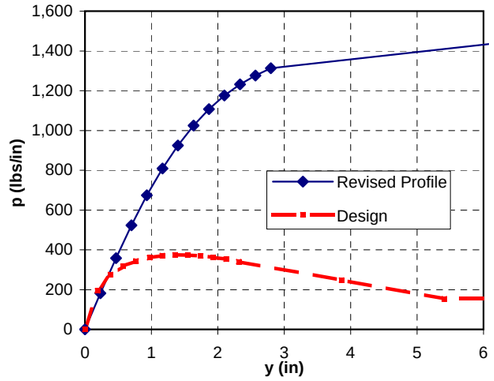
Figure 10

5 ft depth



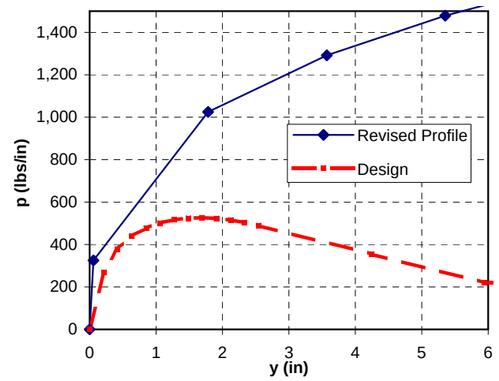
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.14	115	0.23	140
0.29	162	0.47	276
0.43	186	0.70	404
0.58	199	0.93	521
0.72	206	1.17	625
0.86	209	1.40	717
1.01	208	1.63	795
1.15	204	1.87	861
1.30	198	2.10	916
1.44	190	2.33	960
1.57	180	2.57	997
1.72	169	2.80	1,026
2.87	122	6.30	1,134
4.02	74	174.30	1,137
100.00	74	342.30	1,137

10 ft depth



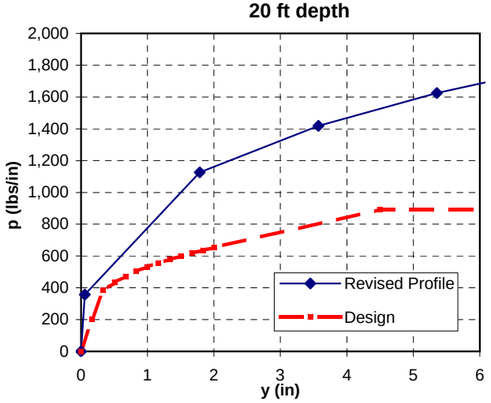
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.19	195	0.23	182
0.38	275	0.47	358
0.58	318	0.70	523
0.77	344	0.93	674
0.97	361	1.17	808
1.16	370	1.40	925
1.36	374	1.63	1,024
1.55	374	1.87	1,107
1.74	370	2.10	1,176
1.93	363	2.33	1,232
2.12	353	2.57	1,277
2.32	340	2.80	1,313
3.86	247	6.30	1,443
5.41	154	174.30	1,446
100.00	154	342.30	1,446

15 ft depth



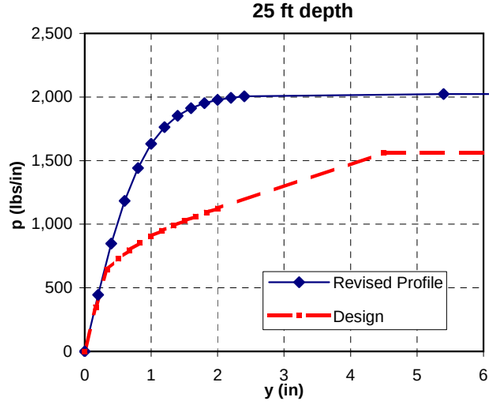
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.22	268	0.06	325
0.42	379	1.79	1,025
0.64	439	3.57	1,291
0.85	477	5.36	1,478
1.06	502	7.14	1,627
1.27	517	8.93	1,753
1.49	524	10.71	1,862
1.69	526	12.50	1,961
1.91	523	14.28	2,050
2.12	515	16.07	2,132
2.33	504	17.85	2,208
2.54	490	19.64	2,279
4.25	355	21.42	2,347
5.94	221	57.12	3,254
100.00	221	107.10	3,254

20 ft depth



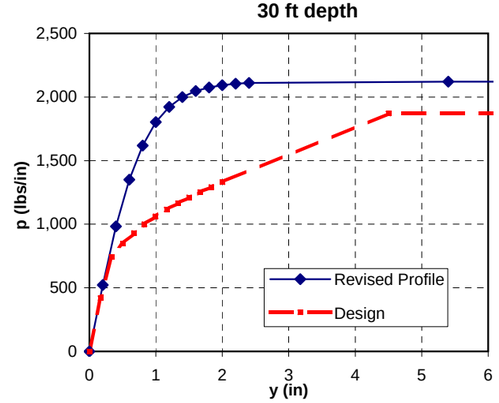
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	204	0.06	358
0.34	385	1.79	1,127
0.50	434	3.57	1,419
0.67	472	5.36	1,625
0.83	504	7.14	1,788
1.00	532	8.93	1,926
1.16	557	10.71	2,047
1.33	579	12.50	2,155
1.50	599	14.28	2,253
1.67	618	16.07	2,343
1.84	636	17.85	2,427
2.00	652	19.64	2,505
4.50	892	21.42	2,579
124.50	892	57.12	3,577

25 ft depth



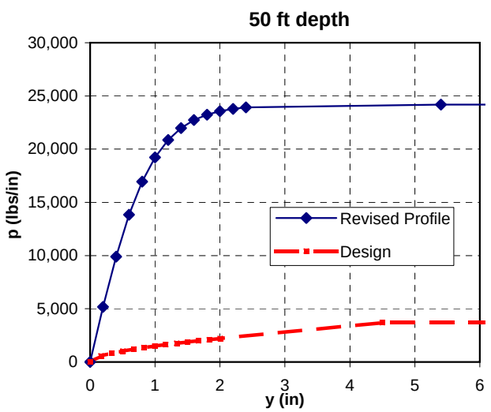
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	348	0.20	444
0.34	642	0.40	848
0.50	729	0.60	1,183
0.67	797	0.80	1,443
0.83	855	1.00	1,631
1.00	905	1.20	1,764
1.16	949	1.40	1,853
1.33	990	1.60	1,913
1.50	1,027	1.80	1,952
1.67	1,061	2.00	1,978
1.84	1,093	2.20	1,994
2.00	1,123	2.40	2,005
4.50	1,561	5.40	2,024
124.50	1,561	149.40	2,024

30 ft depth



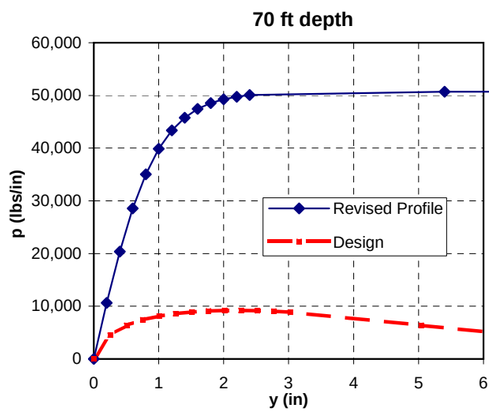
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	420	0.20	521
0.34	743	0.40	983
0.50	848	0.60	1,351
0.67	931	0.80	1,619
0.83	1,001	1.00	1,802
1.00	1,062	1.20	1,922
1.16	1,116	1.40	1,999
1.33	1,166	1.60	2,046
1.50	1,211	1.80	2,076
1.67	1,254	2.00	2,094
1.84	1,293	2.20	2,105
2.00	1,330	2.40	2,111
4.50	1,871	5.40	2,122
124.50	1,871	149.40	2,122

50 ft depth



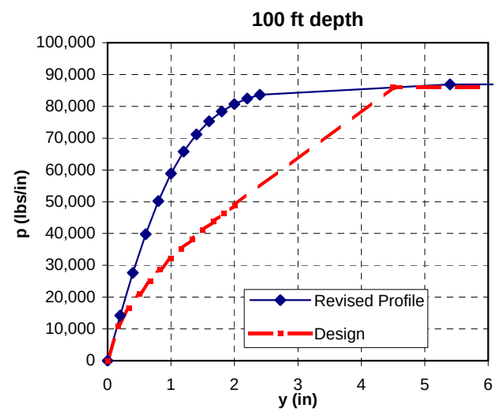
Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	565	0.20	5,169
0.34	826	0.40	9,886
0.50	1,030	0.60	13,846
0.67	1,205	0.80	16,941
0.83	1,361	1.00	19,231
1.00	1,504	1.20	20,855
1.16	1,636	1.40	21,973
1.33	1,760	1.60	22,728
1.50	1,877	1.80	23,230
1.67	1,988	2.00	23,561
1.84	2,094	2.20	23,778
2.00	2,196	2.40	23,920
4.50	3,694	5.40	24,182
124.50	3,694	149.40	24,182

70 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.25	4,519	0.20	10,619
0.50	6,390	0.40	20,345
0.76	7,445	0.60	28,563
1.01	8,129	0.80	35,046
1.26	8,597	1.00	39,889
1.51	8,910	1.20	43,362
1.76	9,102	1.40	45,780
2.02	9,197	1.60	47,429
2.27	9,211	1.80	48,537
2.52	9,155	2.00	49,275
2.77	9,038	2.20	49,764
3.02	8,868	2.40	50,086
5.04	6,396	5.40	50,698
7.06	3,922	149.40	50,699

100 ft depth



Design		Revised Profile	
y (in)	p (#/in)	y (in)	p (#/in)
0.00	0	0.00	0
0.17	10,788	0.20	14,188
0.34	16,443	0.40	27,639
0.50	21,040	0.60	39,764
0.67	25,061	0.80	50,205
0.83	28,702	1.00	58,848
1.00	32,067	1.20	65,771
1.16	35,218	1.40	71,173
1.33	38,197	1.60	75,301
1.50	41,032	1.80	78,408
1.67	43,747	2.00	80,717
1.84	46,357	2.20	82,418
2.00	48,875	2.40	83,664
4.50	86,020	5.40	86,920
124.50	86,020	149.40	86,943

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

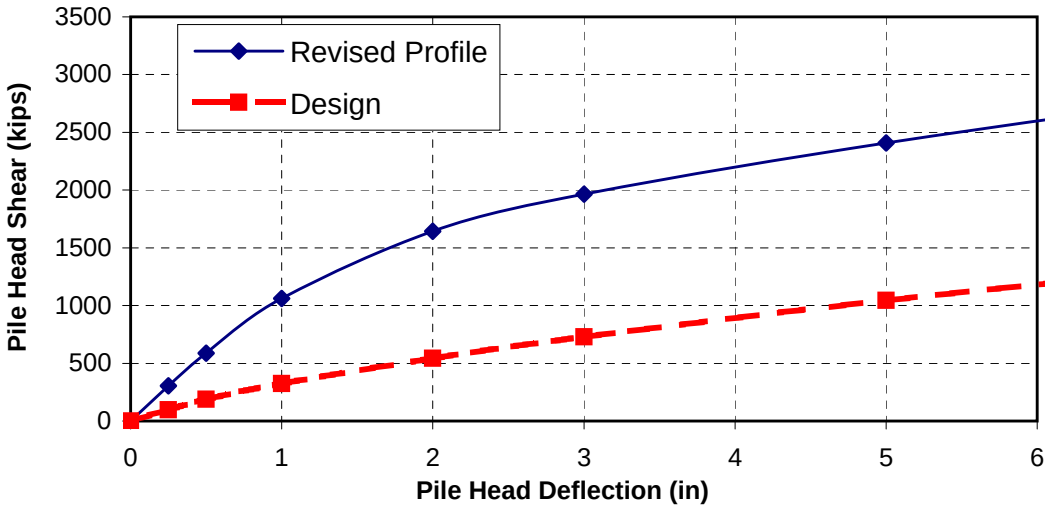
ACTA Schuyler Heim Bridge (Replace)

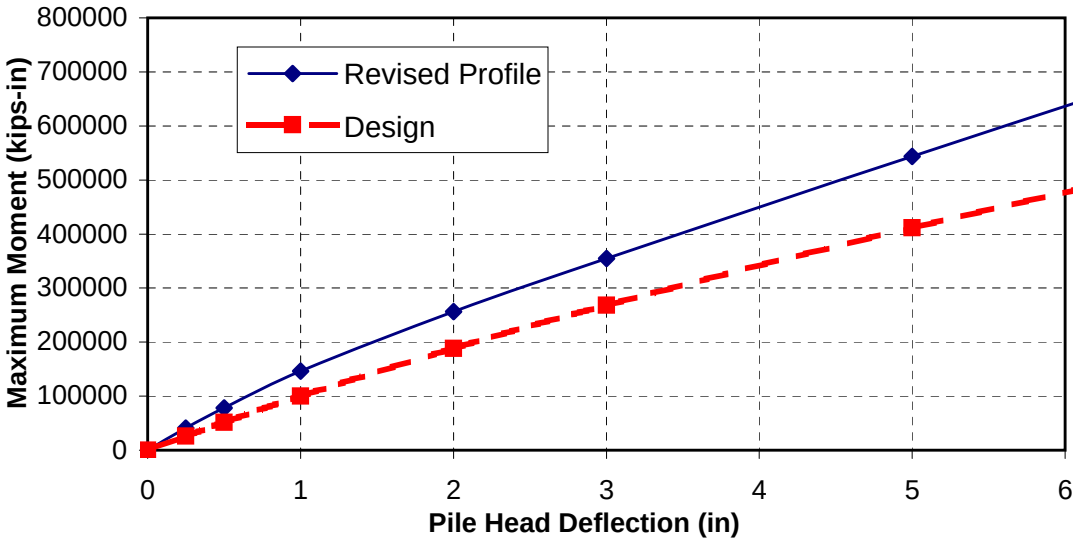
Project Number: 06-123

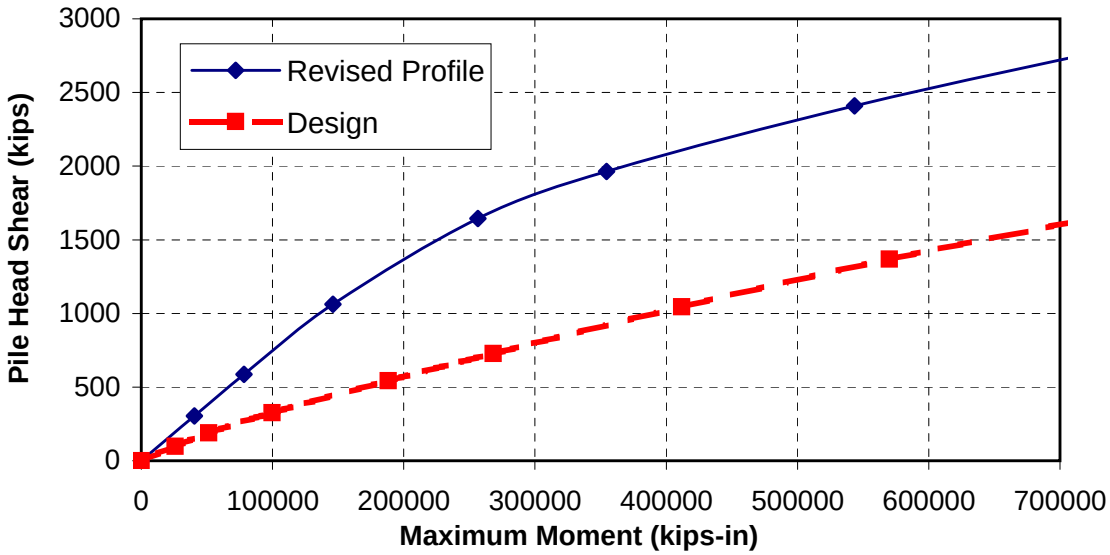
Date: 1/20/2010

p-y Curve Comparison for Bent 24

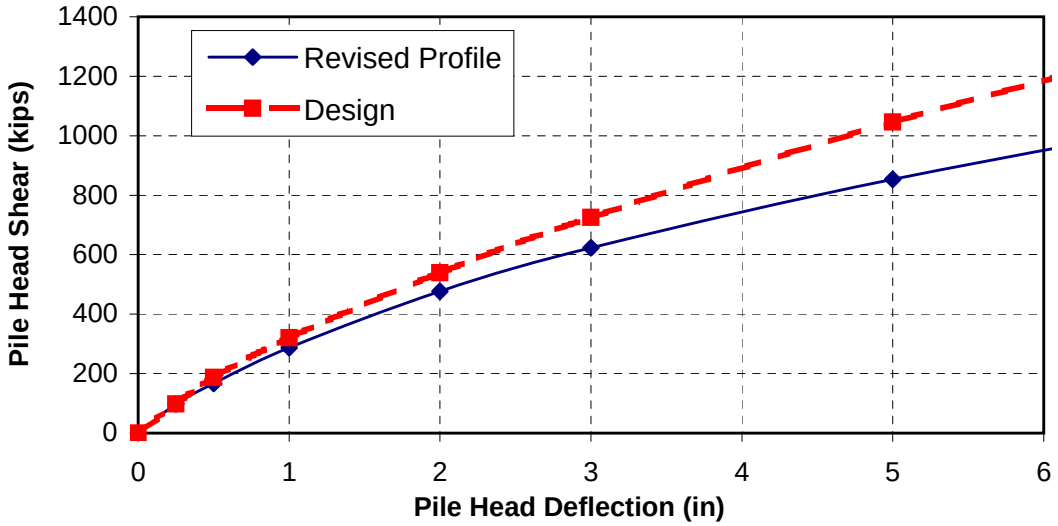
Figure 11

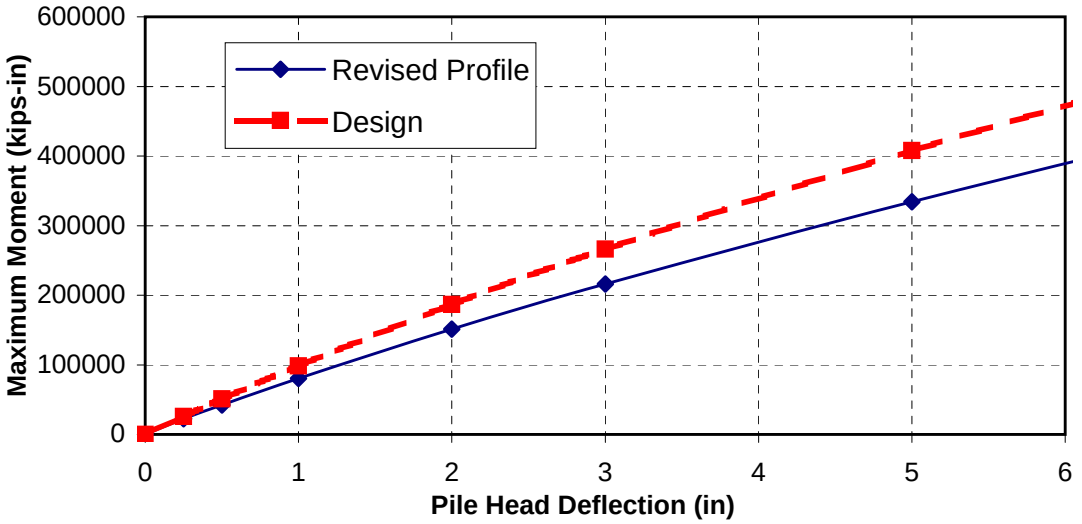


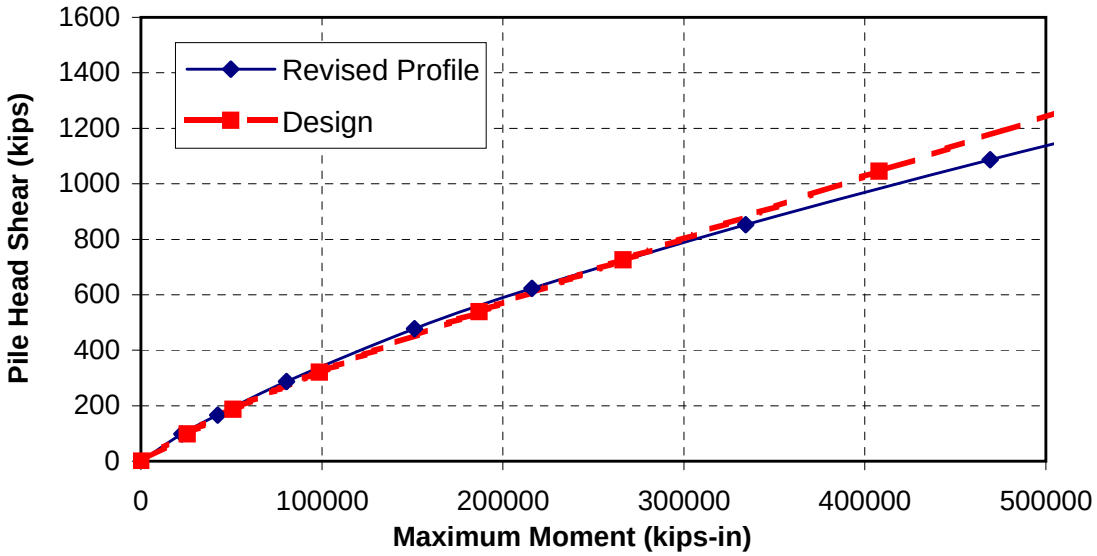




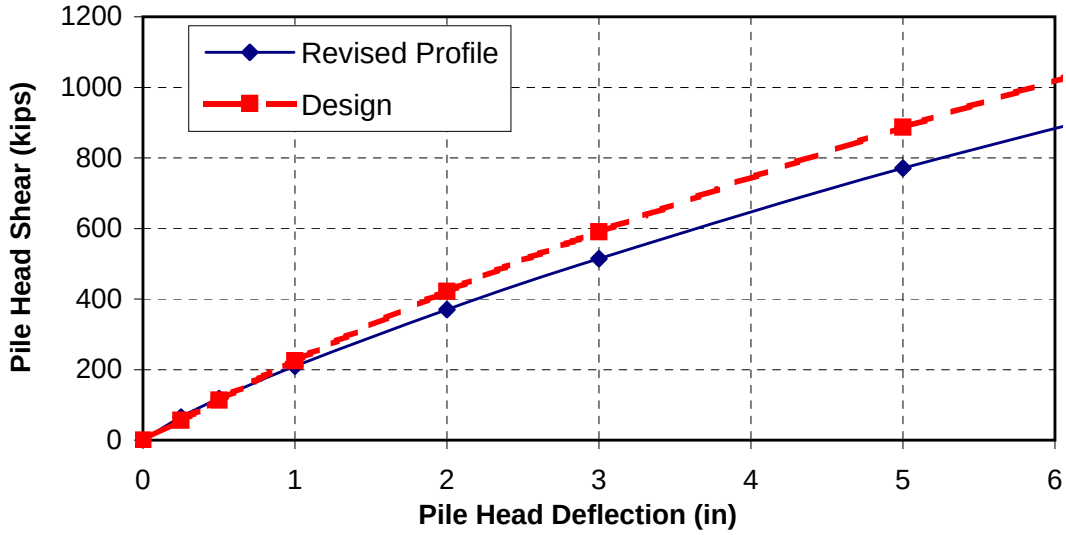
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 2 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 12

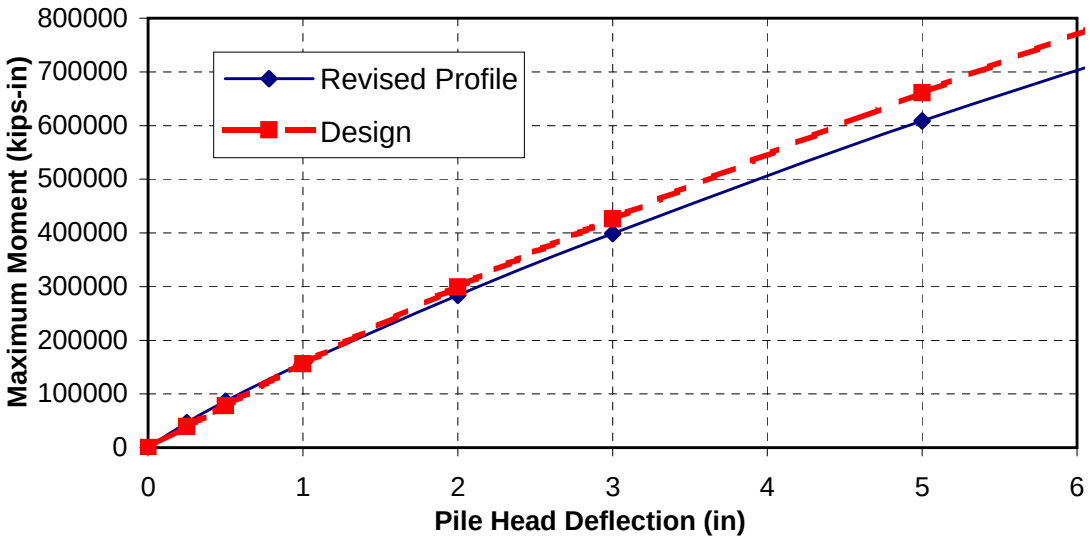


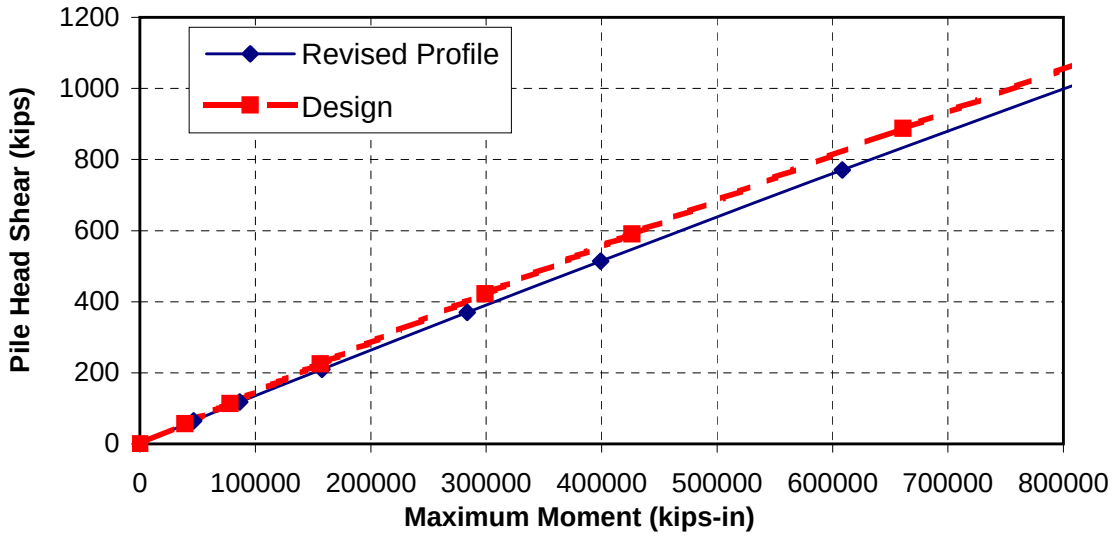




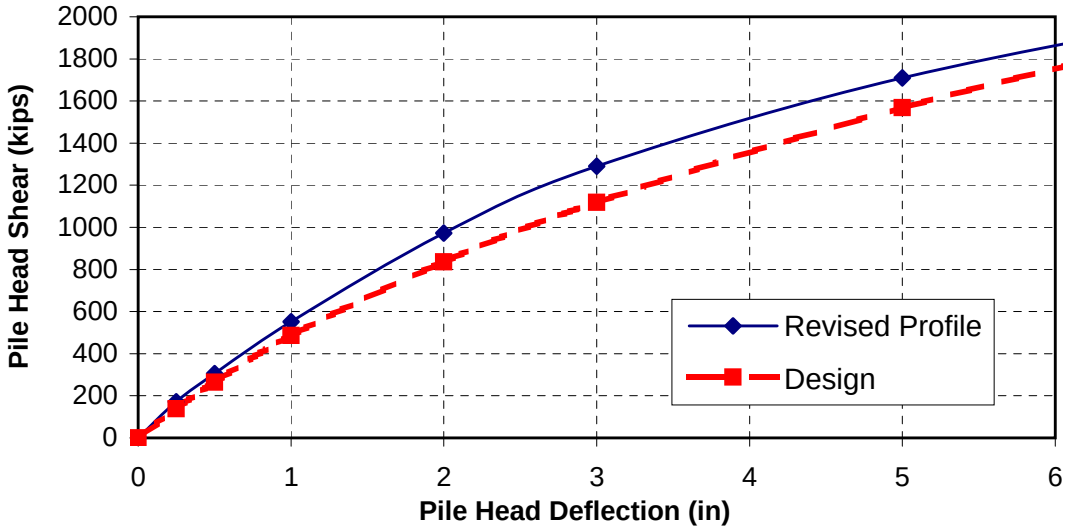
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 11 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 13

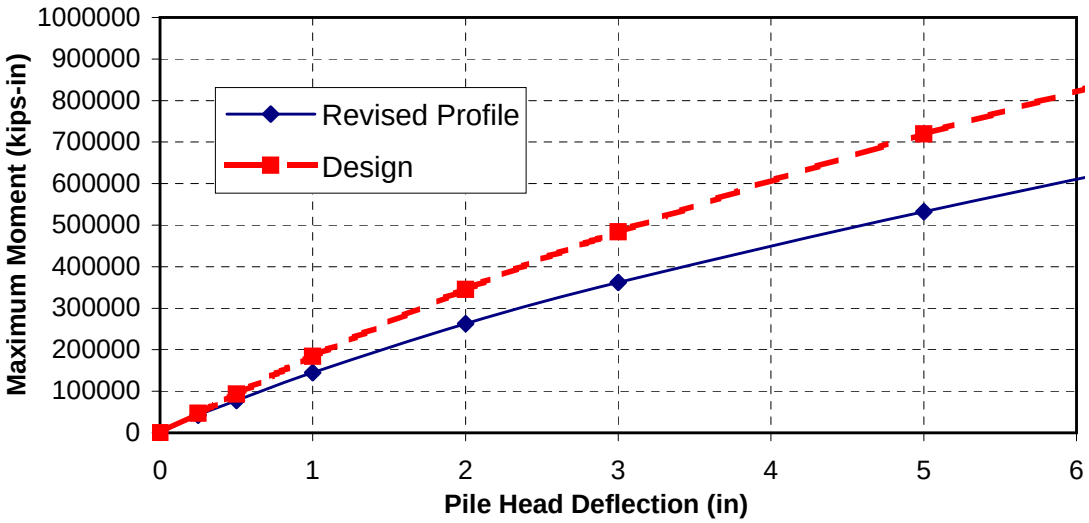


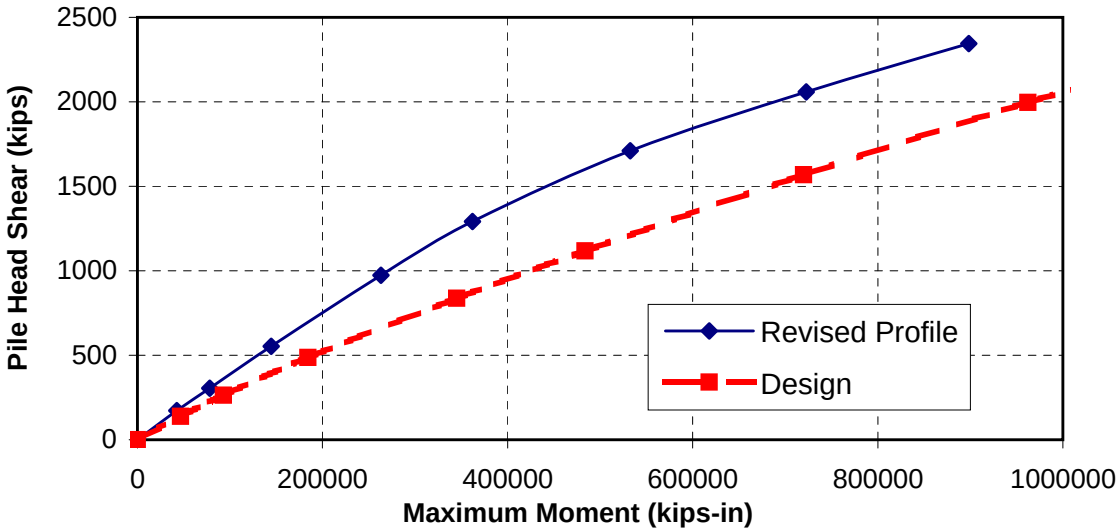




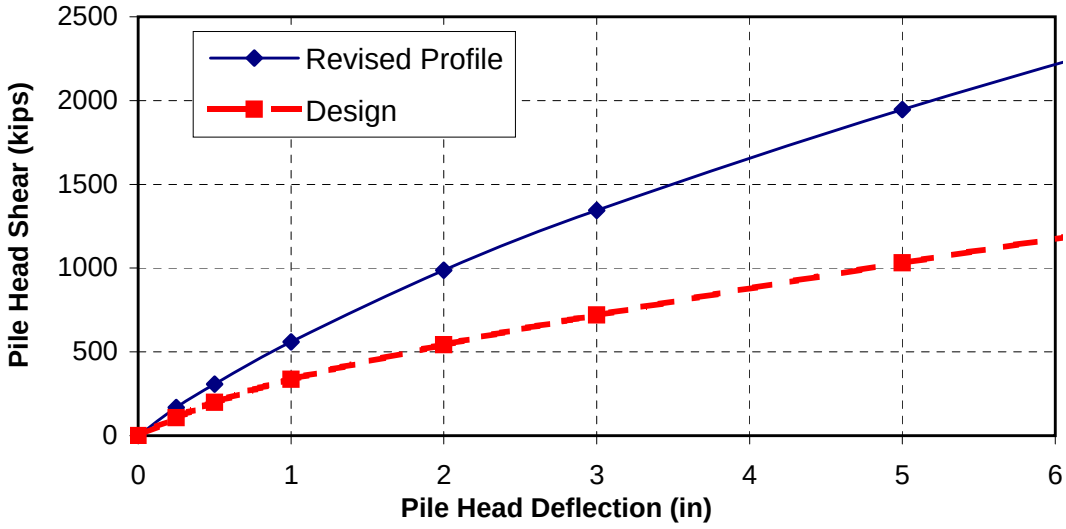
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 14 Pile Head Shear and Max Moment versus Deflection Figure 14
	Project Number: 06-123	Date: 1/20/2010	

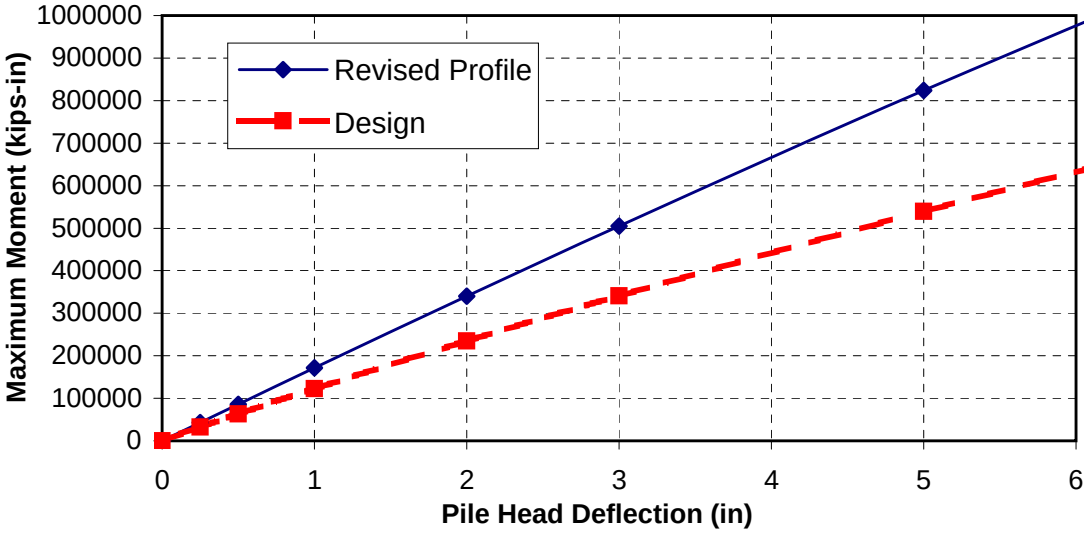


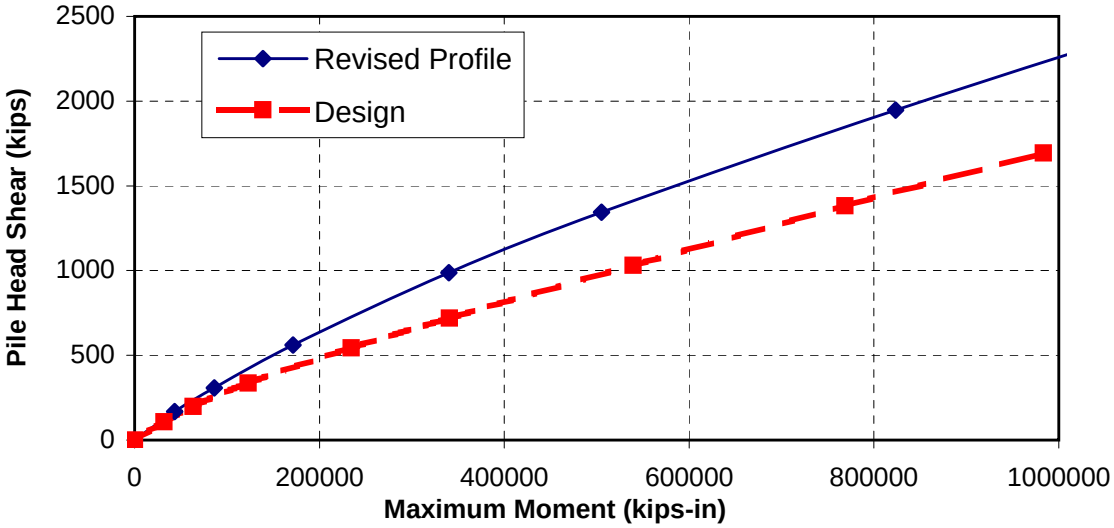




Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 18 Pile Head Shear and Max Moment versus Deflection
	Project Number: 06-123	Date: 1/20/2010	Figure 15







Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA Schuyler Heim Bridge (Replace)		Bent 24 Pile Head Shear and Max Moment versus Deflection Figure 16
	Project Number: 06-123	Date: 1/20/2010	

APPENDIX H

DESIGN P-Y CURVES FOR BENT LATERAL PILE ANALYSIS

Table H-1. Schuyler Heim Bridge Abutment 1
p-y Curves for 4' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		29 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.07	36	0.07	72	0.07	81	0.07	91	0.07	179
0.13	68	0.13	116	0.13	115	0.13	139	0.13	273
0.20	77	0.20	133	0.20	141	0.20	178	0.20	350
0.27	84	0.27	147	0.27	163	0.27	212	0.27	417
0.33	90	0.33	158	0.33	183	0.33	243	0.33	477
0.40	95	0.40	169	0.40	201	0.40	271	0.40	533
0.47	100	0.47	178	0.47	217	0.47	298	0.47	586
0.53	104	0.53	186	0.53	232	0.53	323	0.53	635
0.60	107	0.60	194	0.60	247	0.60	347	0.60	683
0.67	111	0.67	201	0.67	260	0.67	370	0.67	728
0.73	114	0.73	208	0.73	273	0.73	392	0.73	771
0.80	117	0.80	214	0.80	285	0.80	413	0.80	813
1.80	161	1.80	306	1.80	467	1.80	727	1.80	1,431
49.80	161	49.80	306	49.80	467	49.80	727	49.80	1,431
97.80	161	97.80	306	97.80	467	97.80	727	97.80	1,431
145.80	161	145.80	306	145.80	467	145.80	727	145.80	1,431

50 ft depth		71 ft depth		85 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.10	1,506	0.07	1,815	0.10	1,506	0.07	4,688	0.07	9,688
0.20	2,130	0.13	2,767	0.20	2,130	0.13	7,591	0.13	19,376
0.30	2,482	0.20	3,540	0.30	2,482	0.20	9,713	0.20	29,064
0.40	2,710	0.27	4,217	0.40	2,710	0.27	11,570	0.27	38,752
0.50	2,866	0.33	4,830	0.50	2,866	0.33	13,251	0.33	48,440
0.60	2,970	0.40	5,396	0.60	2,970	0.40	14,804	0.40	58,128
0.71	3,034	0.47	5,926	0.71	3,034	0.47	16,259	0.47	67,817
0.81	3,066	0.53	6,427	0.81	3,066	0.53	17,634	0.53	73,830
0.91	3,070	0.60	6,904	0.91	3,070	0.60	18,943	0.60	79,311
1.01	3,052	0.67	7,361	1.01	3,052	0.67	20,196	0.67	84,558
1.11	3,013	0.73	7,800	1.11	3,013	0.73	21,401	0.73	89,603
1.21	2,956	0.80	8,224	1.21	2,956	0.80	22,564	0.80	94,471
2.02	2,132	1.80	14,474	2.02	2,132	1.80	39,713	1.80	166,269
2.82	1,307	49.80	14,474	2.82	1,307	49.80	39,713	49.80	166,269
3.63	482	97.80	14,474	3.63	482	97.80	39,713	97.80	166,269
40.32	482	145.80	14,474	40.32	482	145.80	39,713	145.80	166,269

Note: For 2.5 ft diameter piles, "p" can be decreased by a factor of 0.625 equal to the ratio of the pile diameters.

Table H-2. Schuyler Heim Bridge Bents 2 through 5
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		29 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	90	0.17	180	0.17	270	0.17	360	0.17	522
0.33	162	0.33	341	0.33	502	0.33	631	0.33	744
0.50	181	0.50	384	0.50	569	0.50	720	0.50	868
0.67	197	0.67	418	0.67	622	0.67	791	0.67	969
0.83	210	0.83	447	0.83	666	0.83	852	0.83	1,056
1.00	221	1.00	472	1.00	705	1.00	904	1.00	1,132
1.17	231	1.17	494	1.17	739	1.17	951	1.17	1,201
1.33	240	1.33	514	1.33	770	1.33	993	1.33	1,264
1.50	248	1.50	532	1.50	799	1.50	1,032	1.50	1,322
1.67	255	1.67	549	1.67	825	1.67	1,069	1.67	1,377
1.83	262	1.83	564	1.83	850	1.83	1,102	1.83	1,428
2.00	269	2.00	579	2.00	873	2.00	1,134	2.00	1,476
4.50	365	4.50	794	4.50	1,209	4.50	1,599	4.50	2,182
124.50	365	124.50	794	124.50	1,209	124.50	1,599	124.50	2,182
244.50	365	244.50	794	244.50	1,209	244.50	1,599	244.50	2,182
364.50	365	364.50	794	364.50	1,209	364.50	1,599	364.50	2,182

50 ft depth		71 ft depth		85 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,765	0.17	6,081	0.25	3,765	0.17	5,976	0.17	22,337
0.50	5,325	0.33	7,867	0.50	5,325	0.33	9,023	0.33	34,044
0.76	6,204	0.50	9,145	0.76	6,204	0.50	11,483	0.50	43,562
1.01	6,775	0.67	10,176	1.01	6,775	0.67	13,624	0.67	51,889
1.26	7,164	0.83	11,056	1.26	7,164	0.83	15,557	0.83	59,428
1.51	7,425	1.00	11,830	1.51	7,425	1.00	17,337	1.00	66,395
1.76	7,585	1.17	12,527	1.76	7,585	1.17	19,001	1.17	72,919
2.02	7,664	1.33	13,164	2.02	7,664	1.33	20,571	1.33	79,086
2.27	7,676	1.50	13,753	2.27	7,676	1.50	22,063	1.50	84,957
2.52	7,629	1.67	14,301	2.52	7,629	1.67	23,489	1.67	90,577
2.77	7,532	1.83	14,817	2.77	7,532	1.83	24,858	1.83	95,981
3.02	7,390	2.00	15,303	3.02	7,390	2.00	26,177	2.00	101,196
5.04	5,330	4.50	22,408	5.04	5,330	4.50	45,628	4.50	178,104
7.06	3,268	124.50	22,408	7.06	3,268	124.50	45,628	124.50	178,104
9.07	1,206	244.50	22,408	9.07	1,206	244.50	45,628	244.50	178,104
100.80	1,206	364.50	22,408	100.80	1,206	364.50	45,628	364.50	178,104

Table H-3. Schuyler Heim Bridge Bents 6 and 7
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		29 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	90	0.17	180	0.17	270	0.17	360	0.17	522
0.33	162	0.33	341	0.33	502	0.33	631	0.33	744
0.50	181	0.50	384	0.50	569	0.50	720	0.50	868
0.67	197	0.67	418	0.67	622	0.67	791	0.67	969
0.83	210	0.83	447	0.83	666	0.83	852	0.83	1,056
1.00	221	1.00	472	1.00	705	1.00	904	1.00	1,132
1.17	231	1.17	494	1.17	739	1.17	951	1.17	1,201
1.33	240	1.33	514	1.33	770	1.33	993	1.33	1,264
1.50	248	1.50	532	1.50	799	1.50	1,032	1.50	1,322
1.67	255	1.67	549	1.67	825	1.67	1,069	1.67	1,377
1.83	262	1.83	564	1.83	850	1.83	1,102	1.83	1,428
2.00	269	2.00	579	2.00	873	2.00	1,134	2.00	1,476
4.50	365	4.50	794	4.50	1,209	4.50	1,599	4.50	2,182
124.50	365	124.50	794	124.50	1,209	124.50	1,599	124.50	2,182
244.50	365	244.50	794	244.50	1,209	244.50	1,599	244.50	2,182
364.50	365	364.50	794	364.50	1,209	364.50	1,599	364.50	2,182

50 ft depth		71 ft depth		85 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,765	0.17	6,081	0.17	5,276	0.17	8,042	0.17	26,736
0.50	5,325	0.33	7,867	0.33	7,820	0.33	12,257	0.33	40,944
0.76	6,204	0.50	9,145	0.50	9,844	0.50	15,684	0.50	52,390
1.01	6,775	0.67	10,176	0.67	11,590	0.67	18,682	0.67	62,404
1.26	7,164	0.83	11,056	0.83	13,155	0.83	21,396	0.83	71,471
1.51	7,425	1.00	11,830	1.00	14,590	1.00	23,904	1.00	79,850
1.76	7,585	1.17	12,527	1.17	15,924	1.17	26,253	1.17	87,696
2.02	7,664	1.33	13,164	1.33	17,178	1.33	28,474	1.33	95,113
2.27	7,676	1.50	13,753	1.50	18,366	1.50	30,587	1.50	102,174
2.52	7,629	1.67	14,301	1.67	19,498	1.67	32,611	1.67	108,934
2.77	7,532	1.83	14,817	1.83	20,582	1.83	34,556	1.83	115,433
3.02	7,390	2.00	15,303	2.00	21,624	2.00	36,434	2.00	121,704
5.04	5,330	4.50	22,408	4.50	36,968	4.50	64,124	4.50	214,199
7.06	3,268	124.50	22,408	124.50	36,968	124.50	64,124	124.50	214,199
9.07	1,206	244.50	22,408	244.50	36,968	244.50	64,124	244.50	214,199
100.80	1,206	364.50	22,408	364.50	36,968	364.50	64,124	364.50	214,199

Table H-4. Schuyler Heim Bridge Bents 8 and 9
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	90	0.17	180	0.17	270	0.25	3,765	0.25	3,765
0.33	162	0.33	341	0.33	502	0.50	5,325	0.50	5,325
0.50	181	0.50	384	0.50	569	0.76	6,204	0.76	6,204
0.67	197	0.67	418	0.67	622	1.01	6,775	1.01	6,775
0.83	210	0.83	447	0.83	666	1.26	7,164	1.26	7,164
1.00	221	1.00	472	1.00	705	1.51	7,425	1.51	7,425
1.17	231	1.17	494	1.17	739	1.76	7,585	1.76	7,585
1.33	240	1.33	514	1.33	770	2.02	7,664	2.02	7,664
1.50	248	1.50	532	1.50	799	2.27	7,676	2.27	7,676
1.67	255	1.67	549	1.67	825	2.52	7,629	2.52	7,629
1.83	262	1.83	564	1.83	850	2.77	7,532	2.77	7,532
2.00	269	2.00	579	2.00	873	3.02	7,390	3.02	7,390
4.50	365	4.50	794	4.50	1,209	5.04	5,330	5.04	5,330
124.50	365	124.50	794	124.50	1,209	7.06	3,268	7.06	3,268
244.50	365	244.50	794	244.50	1,209	9.07	1,206	9.07	1,206
364.50	365	364.50	794	364.50	1,209	100.80	1,206	100.80	1,206

40 ft depth		50 ft depth		55 ft depth		80 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,765	0.25	3,765	0.25	3,765	0.17	5,348	0.17	27,127
0.50	5,325	0.50	5,325	0.50	5,325	0.33	7,707	0.33	42,331
0.76	6,204	0.76	6,204	0.76	6,204	0.50	9,545	0.50	54,165
1.01	6,775	1.01	6,775	1.01	6,775	0.67	11,108	0.67	64,518
1.26	7,164	1.26	7,164	1.26	7,164	0.83	12,495	0.83	73,893
1.51	7,425	1.51	7,425	1.51	7,425	1.00	13,756	1.00	82,555
1.76	7,585	1.76	7,585	1.76	7,585	1.17	14,921	1.17	90,667
2.02	7,664	2.02	7,664	2.02	7,664	1.33	16,010	1.33	98,335
2.27	7,676	2.27	7,676	2.27	7,676	1.50	17,035	1.50	105,635
2.52	7,629	2.52	7,629	2.52	7,629	1.67	18,009	1.67	112,624
2.77	7,532	2.77	7,532	2.77	7,532	1.83	18,937	1.83	119,343
3.02	7,390	3.02	7,390	3.02	7,390	2.00	19,826	2.00	125,826
5.04	5,330	5.04	5,330	5.04	5,330	4.50	32,894	4.50	221,454
7.06	3,268	7.06	3,268	7.06	3,268	124.50	32,894	124.50	221,454
9.07	1,206	9.07	1,206	9.07	1,206	244.50	32,894	244.50	221,454
100.80	1,206	100.80	1,206	100.80	1,206	364.50	32,894	364.50	221,454

Table H-5. Schuyler Heim Bridge Bents 10 through 12
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	90	0.17	180	0.17	270	0.17	359	0.17	539
0.33	162	0.33	341	0.33	502	0.33	629	0.33	740
0.50	181	0.50	384	0.50	569	0.50	719	0.50	868
0.67	197	0.67	418	0.67	622	0.67	790	0.67	973
0.83	210	0.83	447	0.83	666	0.83	850	0.83	1,062
1.00	221	1.00	472	1.00	705	1.00	902	1.00	1,141
1.17	231	1.17	494	1.17	739	1.17	948	1.17	1,212
1.33	240	1.33	514	1.33	770	1.33	991	1.33	1,278
1.50	248	1.50	532	1.50	799	1.50	1,030	1.50	1,338
1.67	255	1.67	549	1.67	825	1.67	1,066	1.67	1,395
1.83	262	1.83	564	1.83	850	1.83	1,100	1.83	1,448
2.00	269	2.00	579	2.00	873	2.00	1,131	2.00	1,499
4.50	365	4.50	794	4.50	1,209	4.50	1,594	4.50	2,236
124.50	365	124.50	794	124.50	1,209	124.50	1,594	124.50	2,236
244.50	365	244.50	794	244.50	1,209	244.50	1,594	244.50	2,236
364.50	365	364.50	794	364.50	1,209	364.50	1,594	364.50	2,236

40 ft depth		50 ft depth		60 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	461	0.25	3,765	0.25	3,765	0.17	11,128	0.17	29,432
0.33	678	0.50	5,325	0.50	5,325	0.33	16,960	0.33	49,301
0.50	850	0.76	6,204	0.76	6,204	0.50	21,702	0.50	63,084
0.67	998	1.01	6,775	1.01	6,775	0.67	25,850	0.67	75,142
0.83	1,130	1.26	7,164	1.26	7,164	0.83	29,606	0.83	86,060
1.00	1,250	1.51	7,425	1.51	7,425	1.00	33,077	1.00	96,149
1.17	1,363	1.76	7,585	1.76	7,585	1.17	36,327	1.17	105,596
1.33	1,468	2.02	7,664	2.02	7,664	1.33	39,400	1.33	114,527
1.50	1,567	2.27	7,676	2.27	7,676	1.50	42,324	1.50	123,029
1.67	1,662	2.52	7,629	2.52	7,629	1.67	45,124	1.67	131,168
1.83	1,753	2.77	7,532	2.77	7,532	1.83	47,817	1.83	138,993
2.00	1,840	3.02	7,390	3.02	7,390	2.00	50,414	2.00	146,545
4.50	3,121	5.04	5,330	5.04	5,330	4.50	88,729	4.50	257,919
124.50	3,121	7.06	3,268	7.06	3,268	124.50	88,729	124.50	257,919
244.50	3,121	9.07	1,206	9.07	1,206	244.50	88,729	244.50	257,919
364.50	3,121	100.80	1,206	100.80	1,206	364.50	88,729	364.50	257,919

Table H-6. Schuyler Heim Bridge Bent 13
p-y Curves for 10' Diameter CIDH Piles

20 ft depth		25 ft depth		30 ft depth		35 ft depth		40 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.14	931	0.19	1,563	0.21	2,142	0.23	2,762	0.24	3,348
0.29	1,317	0.39	2,210	0.42	3,029	0.46	3,906	0.48	4,734
0.43	1,509	0.58	2,556	0.64	3,513	0.69	4,540	0.72	5,508
0.57	1,615	0.77	2,767	0.85	3,815	0.92	4,944	0.96	6,006
0.72	1,671	0.97	2,899	1.06	4,011	1.16	5,214	1.20	6,341
0.86	1,692	1.16	2,975	1.27	4,131	1.39	5,387	1.44	6,560
1.00	1,685	1.35	3,008	1.48	4,193	1.62	5,486	1.68	6,689
1.15	1,656	1.55	3,005	1.70	4,207	1.85	5,524	1.92	6,745
1.29	1,607	1.74	2,972	1.91	4,181	2.08	5,512	2.15	6,741
1.43	1,543	1.93	2,914	2.12	4,121	2.31	5,457	2.39	6,684
1.58	1,464	2.13	2,834	2.33	4,031	2.54	5,363	2.63	6,582
1.72	1,373	2.32	2,733	2.55	3,914	2.77	5,236	2.87	6,439
2.87	989	3.86	1,985	4.24	2,840	4.62	3,790	4.79	4,655
4.02	604	5.41	1,236	5.94	1,763	6.47	2,342	6.70	2,868
5.16	219	6.96	487	7.64	687	8.32	893	8.62	1,081
57.37	219	364.50	5,290	84.84	687	92.40	893	95.76	1,081

45 ft depth		50 ft depth		55 ft depth		70 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,734	0.25	3,750	0.25	3,765	0.17	5,543	0.17	24,892
0.50	5,280	0.50	5,303	0.50	5,325	0.33	7,206	0.33	37,939
0.74	6,149	0.75	6,177	0.76	6,204	0.50	8,251	0.50	48,546
0.99	6,711	1.00	6,743	1.01	6,775	0.67	9,083	0.67	57,825
1.24	7,094	1.25	7,129	1.26	7,164	0.83	9,786	0.83	66,227
1.49	7,347	1.50	7,386	1.51	7,425	1.00	10,401	1.00	73,991
1.73	7,502	1.75	7,543	1.76	7,585	1.17	10,950	1.17	81,261
1.98	7,575	2.00	7,620	2.02	7,664	1.33	11,450	1.33	88,134
2.23	7,581	2.25	7,629	2.27	7,676	1.50	11,909	1.50	94,677
2.48	7,530	2.50	7,580	2.52	7,629	1.67	12,336	1.67	100,940
2.73	7,428	2.75	7,480	2.77	7,532	1.83	12,735	1.83	106,962
2.97	7,280	3.00	7,335	3.02	7,390	2.00	13,110	2.00	112,773
4.96	5,256	5.00	5,293	5.04	5,330	4.50	18,584	4.50	198,480
6.94	3,228	7.00	3,248	7.06	3,268	124.50	18,584	124.50	198,480
8.92	1,200	9.00	1,203	9.07	1,206	244.50	18,584	244.50	198,480
99.12	1,200	99.96	1,203	100.80	1,206	364.50	18,584	364.50	198,480

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

Table H-7. Schuyler Heim Bridge Bents 14 and 15
p-y Curves for 12' Diameter CIDH Piles

55 ft depth		60 ft depth		65 ft depth		71 ft depth		80 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.16	1,014	0.21	1,631	0.24	2,252	0.26	2,737	0.20	2,224
0.32	1,434	0.42	2,306	0.49	3,184	0.52	3,871	0.40	2,871
0.49	1,639	0.64	2,660	0.73	3,688	0.77	4,491	0.60	3,225
0.65	1,750	0.85	2,870	0.97	3,999	1.03	4,879	0.80	3,502
0.81	1,806	1.06	2,997	1.22	4,198	1.29	5,133	1.00	3,733
0.97	1,822	1.27	3,064	1.46	4,316	1.55	5,290	1.20	3,934
1.14	1,809	1.48	3,085	1.70	4,372	1.81	5,372	1.40	4,111
1.30	1,770	1.70	3,068	1.95	4,378	2.07	5,393	1.60	4,272
1.46	1,711	1.91	3,019	2.19	4,341	2.32	5,364	1.80	4,418
1.62	1,633	2.12	2,944	2.43	4,268	2.58	5,291	2.00	4,554
1.78	1,540	2.33	2,844	2.68	4,163	2.84	5,180	2.20	4,680
1.95	1,433	2.54	2,724	2.92	4,032	3.10	5,037	2.40	4,798
3.24	1,028	4.24	1,978	4.86	2,926	5.17	3,651	5.40	6,517
4.54	621	5.93	1,230	6.81	1,820	7.23	2,266	149.40	6,517
5.84	214	7.63	482	8.75	714	9.30	880	293.40	6,517
64.86	214	84.77	482	97.27	714	103.32	880	437.40	6,517

100 ft depth		150 ft depth							
y (in)	p (lb/in)	y (in)	p (lb/in)						
0.00	0	0.00	0						
0.20	9,053	0.20	18,689						
0.40	11,935	0.40	28,485						
0.60	14,028	0.60	36,448						
0.80	15,733	0.80	43,415						
1.00	17,197	1.00	49,723						
1.20	18,493	1.20	55,552						
1.40	19,665	1.40	61,011						
1.60	20,740	1.60	66,171						
1.80	21,737	1.80	71,083						
2.00	22,670	2.00	75,785						
2.20	23,548	2.20	80,307						
2.40	24,379	2.40	84,670						
5.40	36,527	5.40	149,019						
149.40	36,527	149.40	149,019						
293.40	36,527	293.40	149,019						
437.40	36,527	437.40	149,019						

Table H-8. Schuyler Heim Bridge Bent 16
p-y Curves for 10' Diameter CIDH Piles

20 ft depth		25 ft depth		30 ft depth		35 ft depth		40 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.14	931	0.19	1,563	0.21	2,142	0.23	2,762	0.24	3,348
0.29	1,317	0.39	2,210	0.42	3,029	0.46	3,906	0.48	4,734
0.43	1,509	0.58	2,556	0.64	3,513	0.69	4,540	0.72	5,508
0.57	1,615	0.77	2,767	0.85	3,815	0.92	4,944	0.96	6,006
0.72	1,671	0.97	2,899	1.06	4,011	1.16	5,214	1.20	6,341
0.86	1,692	1.16	2,975	1.27	4,131	1.39	5,387	1.44	6,560
1.00	1,685	1.35	3,008	1.48	4,193	1.62	5,486	1.68	6,689
1.15	1,656	1.55	3,005	1.70	4,207	1.85	5,524	1.92	6,745
1.29	1,607	1.74	2,972	1.91	4,181	2.08	5,512	2.15	6,741
1.43	1,543	1.93	2,914	2.12	4,121	2.31	5,457	2.39	6,684
1.58	1,464	2.13	2,834	2.33	4,031	2.54	5,363	2.63	6,582
1.72	1,373	2.32	2,733	2.55	3,914	2.77	5,236	2.87	6,439
2.87	989	3.86	1,985	4.24	2,840	4.62	3,790	4.79	4,655
4.02	604	5.41	1,236	5.94	1,763	6.47	2,342	6.70	2,868
5.16	219	6.96	487	7.64	687	8.32	893	8.62	1,081
57.37	219	77.28	487	84.84	687	92.40	893	95.76	1,081

45 ft depth		50 ft depth		70 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,734	0.25	3,750	0.25	3,765	0.17	6,016	0.17	16,644
0.50	5,280	0.50	5,303	0.50	5,325	0.33	8,145	0.33	25,367
0.74	6,149	0.75	6,177	0.76	6,204	0.50	9,724	0.50	32,459
0.99	6,711	1.00	6,743	1.01	6,775	0.67	11,027	0.67	38,663
1.24	7,094	1.25	7,129	1.26	7,164	0.83	12,156	0.83	44,281
1.49	7,347	1.50	7,386	1.51	7,425	1.00	13,165	1.00	49,472
1.73	7,502	1.75	7,543	1.76	7,585	1.17	14,082	1.17	54,333
1.98	7,575	2.00	7,620	2.02	7,664	1.33	14,928	1.33	58,928
2.23	7,581	2.25	7,629	2.27	7,676	1.50	15,717	1.50	63,303
2.48	7,530	2.50	7,580	2.52	7,629	1.67	16,457	1.67	67,491
2.73	7,428	2.75	7,480	2.77	7,532	1.83	17,157	1.83	71,518
2.97	7,280	3.00	7,335	3.02	7,390	2.00	17,822	2.00	75,403
4.96	5,256	5.00	5,293	5.04	5,330	4.50	27,559	4.50	132,709
6.94	3,228	7.00	3,248	7.06	3,268	124.50	27,559	124.50	132,709
8.92	1,200	9.00	1,203	9.07	1,206	244.50	27,559	244.50	132,709
99.12	1,200	99.96	1,203	100.80	1,206	364.50	27,559	364.50	132,709

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

Table H-9. Schuyler Heim Bridge Bent 17
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		25 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.14	638	0.19	1,080	0.21	1,488	0.17	204	0.17	294
0.29	902	0.39	1,528	0.42	2,105	0.33	387	0.33	541
0.43	1,033	0.58	1,767	0.64	2,441	0.50	437	0.50	615
0.57	1,105	0.77	1,913	0.85	2,651	0.67	476	0.67	673
0.72	1,144	0.97	2,004	1.06	2,787	0.83	509	0.83	721
0.86	1,158	1.16	2,057	1.27	2,871	1.00	537	1.00	764
1.00	1,153	1.35	2,079	1.48	2,913	1.17	563	1.17	801
1.15	1,133	1.55	2,077	1.70	2,923	1.33	585	1.33	836
1.29	1,100	1.74	2,054	1.91	2,905	1.50	606	1.50	867
1.43	1,056	1.93	2,014	2.12	2,863	1.67	626	1.67	896
1.58	1,002	2.13	1,959	2.33	2,801	1.83	644	1.83	923
1.72	940	2.32	1,889	2.55	2,720	2.00	661	2.00	949
2.87	677	3.86	1,372	4.24	1,973	4.50	908	4.50	1,320
4.02	413	5.41	854	5.94	1,225	124.50	908	124.50	1,320
5.16	150	6.96	336	7.64	477	244.50	908	244.50	1,320
57.37	150	77.28	336	84.84	477	364.50	908	364.50	1,320

35 ft depth		50 ft depth		70 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	384	0.25	3,765	0.25	3,765	0.17	5,548	0.17	20,855
0.33	661	0.50	5,325	0.50	5,325	0.33	8,277	0.33	31,786
0.50	756	0.76	6,204	0.76	6,204	0.50	10,460	0.50	40,672
0.67	832	1.01	6,775	1.01	6,775	0.67	12,349	0.67	48,447
0.83	896	1.26	7,164	1.26	7,164	0.83	14,047	0.83	55,486
1.00	952	1.51	7,425	1.51	7,425	1.00	15,606	1.00	61,991
1.17	1,002	1.76	7,585	1.76	7,585	1.17	17,058	1.17	68,082
1.33	1,047	2.02	7,664	2.02	7,664	1.33	18,425	1.33	73,840
1.50	1,089	2.27	7,676	2.27	7,676	1.50	19,721	1.50	79,321
1.67	1,127	2.52	7,629	2.52	7,629	1.67	20,958	1.67	84,569
1.83	1,163	2.77	7,532	2.77	7,532	1.83	22,143	1.83	89,614
2.00	1,197	3.02	7,390	3.02	7,390	2.00	23,284	2.00	94,483
4.50	1,693	5.04	5,330	5.04	5,330	4.50	40,084	4.50	166,290
124.50	1,693	7.06	3,268	7.06	3,268	124.50	40,084	124.50	166,290
244.50	1,693	9.07	1,206	9.07	1,206	244.50	40,084	244.50	166,290
364.50	1,693	100.80	1,206	100.80	1,206	364.50	40,084	364.50	166,290

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

Table H-10. Schuyler Heim Bridge Bent 18
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		30 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.14	96	0.19	162	0.21	223	0.17	155	0.17	335
0.29	135	0.39	229	0.42	316	0.33	292	0.33	601
0.43	155	0.58	265	0.64	366	0.50	329	0.50	685
0.57	166	0.77	287	0.85	398	0.67	358	0.67	751
0.72	172	0.97	301	1.06	418	0.83	382	0.83	807
0.86	174	1.16	308	1.27	431	1.00	403	1.00	856
1.00	173	1.35	312	1.48	437	1.17	421	1.17	900
1.15	170	1.55	312	1.70	438	1.33	438	1.33	939
1.29	165	1.74	308	1.91	436	1.50	453	1.50	975
1.43	158	1.93	302	2.12	429	1.67	467	1.67	1,009
1.58	150	2.13	294	2.33	420	1.83	481	1.83	1,040
1.72	141	2.32	283	2.55	408	2.00	493	2.00	1,070
2.87	102	3.86	206	4.24	296	4.50	673	4.50	1,500
4.02	62	5.41	128	5.94	184	124.50	673	124.50	1,500
5.16	22	6.96	50	7.64	72	244.50	673	244.50	1,500
57.37	22	77.28	50	84.84	72	364.50	673	364.50	1,500

40 ft depth		50 ft depth		80 ft depth		90 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.25	3,765	0.25	3,765	0.25	3,765	0.17	6,006	0.17	17,212
0.50	5,325	0.50	5,325	0.50	5,325	0.33	7,625	0.33	26,234
0.76	6,204	0.76	6,204	0.76	6,204	0.50	8,768	0.50	33,569
1.01	6,775	1.01	6,775	1.01	6,775	0.67	9,682	0.67	39,985
1.26	7,164	1.26	7,164	1.26	7,164	0.83	10,455	0.83	45,795
1.51	7,425	1.51	7,425	1.51	7,425	1.00	11,133	1.00	51,163
1.76	7,585	1.76	7,585	1.76	7,585	1.17	11,740	1.17	56,191
2.02	7,664	2.02	7,664	2.02	7,664	1.33	12,293	1.33	60,943
2.27	7,676	2.27	7,676	2.27	7,676	1.50	12,802	1.50	65,467
2.52	7,629	2.52	7,629	2.52	7,629	1.67	13,275	1.67	69,798
2.77	7,532	2.77	7,532	2.77	7,532	1.83	13,718	1.83	73,962
3.02	7,390	3.02	7,390	3.02	7,390	2.00	14,135	2.00	77,980
5.04	5,330	5.04	5,330	5.04	5,330	4.50	20,222	4.50	137,246
7.06	3,268	7.06	3,268	7.06	3,268	124.50	20,222	124.50	137,246
9.07	1,206	9.07	1,206	9.07	1,206	244.50	20,222	244.50	137,246
100.80	1,206	100.80	1,206	100.80	1,206	364.50	20,222	364.50	137,246

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

Table H-11. Schuyler Heim Bridge Bents 19 through 24
p-y Curves for 10' Diameter CIDH Piles

5 ft depth		10 ft depth		15 ft depth		20 ft depth		25 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.14	96	0.19	162	0.21	223	0.17	170	0.17	290
0.29	135	0.39	229	0.42	316	0.33	321	0.33	535
0.43	155	0.58	265	0.64	366	0.50	361	0.50	607
0.57	166	0.77	287	0.85	398	0.67	393	0.67	664
0.72	172	0.97	301	1.06	418	0.83	420	0.83	712
0.86	174	1.16	308	1.27	431	1.00	443	1.00	754
1.00	173	1.35	312	1.48	437	1.17	464	1.17	791
1.15	170	1.55	312	1.70	438	1.33	482	1.33	825
1.29	165	1.74	308	1.91	436	1.50	499	1.50	855
1.43	158	1.93	302	2.12	429	1.67	515	1.67	884
1.58	150	2.13	294	2.33	420	1.83	530	1.83	911
1.72	141	2.32	283	2.55	408	2.00	543	2.00	936
2.87	102	3.86	206	4.24	296	4.50	744	4.50	1,301
4.02	62	5.41	128	5.94	184	124.50	744	124.50	1,301
5.16	22	6.96	50	7.64	72	244.50	744	244.50	1,301
57.37	22	77.28	50	84.84	72	364.50	744	364.50	1,301

30 ft depth		50 ft depth		70 ft depth		100 ft depth		150 ft depth	
y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)	y (in)	p (lb/in)
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.17	350	0.17	471	0.25	3,765	0.17	8,990	0.17	27,689
0.33	619	0.33	688	0.50	5,325	0.33	13,702	0.33	43,539
0.50	706	0.50	858	0.76	6,204	0.50	17,533	0.50	55,712
0.67	776	0.67	1,004	1.01	6,775	0.67	20,884	0.67	66,360
0.83	834	0.83	1,134	1.26	7,164	0.83	23,919	0.83	76,003
1.00	885	1.00	1,253	1.51	7,425	1.00	26,723	1.00	84,913
1.17	930	1.17	1,363	1.76	7,585	1.17	29,348	1.17	93,256
1.33	972	1.33	1,466	2.02	7,664	1.33	31,830	1.33	101,143
1.50	1,009	1.50	1,564	2.27	7,676	1.50	34,193	1.50	108,652
1.67	1,045	1.67	1,656	2.52	7,629	1.67	36,456	1.67	115,839
1.83	1,078	1.83	1,745	2.77	7,532	1.83	38,631	1.83	122,750
2.00	1,108	2.00	1,830	3.02	7,390	2.00	40,729	2.00	129,419
4.50	1,559	4.50	3,079	5.04	5,330	4.50	71,683	4.50	227,778
124.50	1,559	124.50	3,079	7.06	3,268	124.50	71,683	124.50	227,778
244.50	1,559	244.50	3,079	9.07	1,206	244.50	71,683	244.50	227,778
364.50	1,559	364.50	3,079	100.80	1,206	364.50	71,683	364.50	227,778

Note: For 12 ft diameter piles, "p" can be increased by a factor of 1.2 equal to the ratio of the pile diameters.

APPENDIX I

CALTRANS OFFICE OF GEOTECHNICAL DESIGN SOUTH 1

REVIEW COMMENTS AND EMI RESPONSES

Subject: Review Comments for Schuler Heim Bridge Replacement (BR53-3032)
From: Haitao Liu <haitao_liu@dot.ca.gov>
Date: Wed, 7 Apr 2010 23:14:04 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Hector Bedolla <hector_bedolla@dot.ca.gov>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>, Hamid R Toossi <hamid_r_toossi@dot.ca.gov>, Foued Zayati <foued_zayati@dot.ca.gov>, Bojan Misic <bojan_misic@dot.ca.gov>, Ranjan Gunaranjan <ranjan@earthmech.com>, Eric Brown <e.brown@earthmech.com>, Seungwoon Han <seungwoon_han@dot.ca.gov>

Hi Arul,

Below are our review comments for the subject bridge. Those are the comments in addition to all applicable comments for all previously reviewed ramp structures. Among them, two comments have already been addressed in our previous discussion, but also included here for documentation purpose.

1) Page 34-39 Table 5: Comments on idealized soil profile and strength parameters.

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2) Page 68, Section 5.7.1
Please provide technical reference for Yong's method (1985) specified in the Report.

3) Page 69, Section 5.8.1
Immediate settlement accounts for a significant portion of total settlement at the embankment location. It need to be considered, should the utility lines exist underneath the proposed fill.

4) Page 70, Section 5.9.2
Please provide detailed technical source to support the ultimate unit bond strengths, including grout method to be used to achieve these strengths.

5) Page 78, Section 6.2.1
Please specify the proposed tip elevation of the permanent casing for each bent within the channel, and justify the minimum required casing embedment below mudline.

6) Shaft Analysis for axial pile capacity (Calculation Volume)
Please apply energy corrected blowcounts directly for the evaluation of pile capacity in cohesionless materials. This will eliminate potential error occurred in unnecessary N-f correlation/interpretation process.

7) Settlement controlled tip elevation under service condition for Abutment 1 (Calculation Volume)
Settlement controlled tip elevation should be based on 154 tons of service load for individual pile, when group reduction factor of 0.9 is considered for pile axial capacity. This is to ensure that, when loaded in group, each pile can maintain 154X0.9 =139 tons of the required pile resistance under service condition.

8) Axial pile capacity for type II shaft within the channel (Bents 13 to 16, Calculation Volume).
API method for large diameter driven pile, instead of b method prescribed for CIDH piles, should be used for the evaluation of axial capacity for the embedded portion of the permanent casing. Please separate the pile axial analysis into two parts.

9) Global stability analysis for Abutment 1 (Calculation Volume)
In pseudo static analysis, please remove the traffic loading on top of the

embankment, as they are not part of the load combination under seismic condition.

10) Lateral soil loading on piles upon lateral spreading (Calculation Volume)
Please define the boundary condition based on contract plans (Bent Details No.3). Hinge connection, rather than double roller connection, is prescribed between column and superstructure.

11) Lateral soil loading on piles upon lateral spreading (Calculation Volume)
Please include complete input and output data from L-Pile kinematic analysis of the column/shaft in Calculation Volume.

Should you have any question, please contact me or Mr Seungwoon Han at (916) 227-4533.

Best Regards,

Haitao Liu, P.E.

Transportation Engineer - Civil
Office of Geotechnical Design South - 1
Division of Engineering Services
Department of Transportation, California

5900 Folsom Blvd.
Sacramento, CA 95819
Office phone: (916) 227-0992
Cell phone: (916) 704-6519

Bent 4	Grade to -32 ft	Based on the blowcounts and soil descriptions, sandy materials are loose. Direct shear results also shown friction angle of 28 to 31 degrees. Please revise current parameters.
Bent 7	-34 to -59 ft	Based on the pocket penetrometer reading (PP#) and soil descriptions, cohesive materials are mostly medium stiff. Please revise current parameters.
Bent 8	Grade to -34 ft	According to soil boring No. R-09-013 that was conducted at the southbound of the bridge, most of the soils are soft to medium stiff clay with PP# ranging from 0.25 to 0.5 tsf (UU test 0.65 ksf for soils in medium stiff layer). Please compare the above parameters with the friction angle in Table 5, and see which one will control the axial capacity of the pile in strength limit state.
Bent 12	-41 to -50 ft	Based on soil descriptions and PP#, no significant improvement of soil strength was observed, please use the same shear parameter as interpreted for soils from -31 to -41 ft.
Bent 17	Grade to -21 ft	Most of soils shown blowcounts of equal to, or less than 2. The correlated soil friction should be less than what was presented in the table. Please revise it.
	-38 to -56 ft	Based on UU test and soil descriptions (including blowcounts), most of the soils were identified as medium stiff to stiff. Please revise the current strength parameter.
Bent 19	-37 to -47 ft	Thirty-two degree friction angle may be high for soils with blowcounts of "3" at this depth. Please revise current parameter if necessary.
Bent 24	-46 to -57 ft	Soft clay was identified (blowcounts of "2") within the fupper half of this clay layer. The shear parameter need to be averaged down from current value.

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Bent 4	Grade to -32 ft	Based on the blowcounts and soil descriptions, sandy materials are loose. Direct shear results also shown friction angle of 28 to 31 degrees. Please revise current parameters.
Bent 7	-34 to -59 ft	Based on the pocket penetrometer reading (PP#) and soil descriptions, cohesive materials are mostly medium stiff. Please revise current parameters.
Bent 8	Grade to -34 ft	According to soil boring No. R-09-013 that was conducted at the southbound of the bridge, most of the soils are soft to medium stiff clay with PP# ranging from 0.25 to 0.5 tsf (UU test 0.65 ksf for soils in medium stiff layer). Please compare the above parameters with the friction angle in Table 5, and see which one will control the axial capacity of the pile in strength limit state.
Bent 12	-41 to -50 ft	Based on soil descriptions and PP#, no significant improvement of soil strength was observed, please use the same shear parameter as interpreted for soils from -31 to -41 ft.
Bent 17	Grade to -21 ft	Most of soils shown blowcounts of equal to, or less than 2. The correlated soil friction should be less than what was presented in the table. Please revise it.
	-38 to -56 ft	Based on UU test and soil descriptions (including blowcounts), most of the soils were identified as medium stiff to stiff. Please revise the current strength parameter.
Bent 19	-37 to -47 ft	Thirty-two degree friction angle may be high for soils with blowcounts of "3" at this depth. Please revise current parameter if necessary.
Bent 24	-46 to -57 ft	Soft clay was identified (blowcounts of "2") within the fupper half of this clay layer. The shear parameter need to be averaged down from current value.

Scuyler Heim Bridge (Replace) (Bridge No. 53-3032)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.58	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	April 7, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 27, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			1) Table 5 (Page 34-39): Comments on idealized soil profile and strength parameters.	Ranjan Gunaranjan (RG) / K. Arul Arulmoli (KA)	A	Will comply. Idealized soil profile and strength parameters have been revised based on laboratory test data, field blow counts, and interpretation of CPT sounding tip resistance. Table 5 has been revised in Foundation Report (FR) and is attached.		
2			2) Section 5.7.1 (Page 68): Please provide technical reference for Yong's method (1985) specified in the Report.	RG / KA	C	Based on our recent discussions about the lateral earth pressure on bridge abutment walls, only static lateral earth pressure recommendations will be included in Section 5.7.1 (Earth Pressures) of FR (seismic lateral earth pressure recommendations will not be included).		
3			3) Section 5.8.1 (Page 69): Immediate settlement accounts for a significant portion of total settlement at the embankment location. It need to be considered, should the utility lines exist underneath the proposed fill.	RG / KA	A	Will comply. Total settlement estimates of underlying soils beneath the utility lines due to the proposed embankment fill placement have been revised. The immediate settlement of cohesionless soils has been calculated using Section 10.6.2.4.3 of AASHTO LRFD BDS. A separate paragraph has been included in Section 5.8.1 of FR to address the total settlement of utility lines due to the proposed embankment fill placement.		
4			4) Section 5.9.2 (Page 70): Please provide detailed technical source to support the ultimate unit bond strengths, including grout method to be used to achieve these strengths.	RG / KA	A	Will comply. FHWA 1999 Publication for Ground Anchors and Anchored Systems that contains presumptive ultimate transfer loads for gravity-grouted ground anchors are attached.		
5			5) Section 6.2.1 (Page 78): Please specify the proposed tip elevation of the permanent casing for each bent within the channel, and justify the minimum required casing embedment below mudline.	RG / KA	A	Will comply. The specified tip elevations of permanent steel casings for all bents will be included in Section 6.2.1 of FR. As a result of design development and discussions with the designers, the CMP permanent casing has been replaced with driven permanent steel casing on all bents. The specified tip elevation of the permanent steel casing for all bents have been included in the Pile Data Table. The revised pile data table is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION

Scuyler Heim Bridge (Replace) (Bridge No. 53-3032)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.58	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	April 7, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 27, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			6) Shaft Analysis for Axial Pile Capacity (Calculation Volume): Please apply energy corrected blowcounts directly for the evaluation of pile capacity in cohesionless materials. This will eliminate potential error occurred in unnecessary N-f correlation/interpretation process.	RG / KA	A	Will comply. The axial pile calculations for all bents under Strength Limit Condition have been revised using the followings: 1. Using blowcounts (N) instead of the friction angle in SHAFT for sandy layers that has lower blowcounts (i.e., N < 15). 2 Using the maximum end bearing value as 20% of the nominal resistance. 3. Determining the axial capacity of permanent steel casing using API Recommended Practice (2000). The revised axial pile calculations and pile data table are attached.		
7			7) Settlement Controlled Tip Elevation Under Service Condition for Abutment 1 (Calculation Volume): Settlement controlled tip elevation should be based on 154 tons of service load for individual pile, when group reduction factor of 0.9 is considered for pile axial capacity. This is to ensure that, when loaded in group, each pile can maintain 154X0.9 =139 tons of the required pile resistance under service condition.	RG / KA	A	Will comply. A group reduction factor of 0.9 has been applied to determine the settlement controlled tip elevation under service limit condition for Abutment 1. A service load of 154 tons (139/0.9) has been used to determine the settlement controlled tip elevation for individual pile in Abutment 1. The revised axial pile calculation is attached.		
8			8) Axial pile capacity for type II shaft within the channel Bents 13 through 16 Calculation Volume: API method for large diameter driven pile, instead of β method prescribed for CIDH piles, should be used for the evaluation of axial capacity for the embedded portion of the permanent casing. Please separate the pile axial analysis into two parts.	RG / KA	A	Will comply. The axial capacity for the embedded portion of driven permanent steel casing has been determined using API Recommended Practice (2000). The axial capacity for the remaining portion below the permanent steel casing has been determined using SHAFT. The axial pile capacity calculations of the permanent steel casing are attached. The axial pile capacity calculations for the portion below the permanent steel casing are already attached in comment no 6.		
9			9) Global Stability Analysis for Abutment 1 (Calculation Volume): In pseudo static analysis, please remove the traffic loading on top of the embankment, as they are not part of the load combination under seismic condition.	RG / KA	A	Will comply. The traffic loading of 250 psf on top of the embankment has been removed in global stability analyses under seismic condition. The revised global stability analyses for Abutment 1 are attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Scuyler Heim Bridge (Replace) (Bridge No. 53-3032)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM 3.58	Reviewing Agency:	Caltrans
EA No.:	238501	Functional Unit:	Office of Geotechnical Design South - 1 (OGDS-1)
Milestone:	65% PS&E	Review Date:	April 7, 2010
Consultant:	Earth Mechanics, Inc.	Submission Date:	April 27, 2010

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
10			10) Lateral Soil Loading on Piles upon Lateral Spreading (Calculation Volume): Please define the boundary condition based on contract plans (Bent Details No.3). Hinge connection, rather than double roller connection, is prescribed between column and superstructure.	RG / KA	A	Will comply. Based on our previous discussions about the column-to-superstructure connection details and using the modified soil parameters and slope configurations, lateral soil (kinematic) loading evaluations for Cerritos channel slope bents (Bents 12, 13, 16, and 17) have been revised. The maximum moments have been calculated using both "hinge" and "cantilever" conditions at the column top and the average of these two moments will be recommended in Final FR. Table 17 has been revised in FR and is attached. The revised kinematic analyses for the channel slope bents are also attached.		
11			11) Lateral Soil Loading on Piles upon Lateral Spreading (Calculation Volume): Please include complete input and output data from L-Pile kinematic analysis of the column/shaft in Calculation Volume.	RG / KA	A	Will comply. The complete input and output data files from LPILE kinematic analyses will be included in Calculation Volume and are attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Retaining Wall A1, Bridge No. 53E0147***
Mechanically Stabilized Earth (MSE) Wall
Los Angeles County, California, (7-LA-47, PM 3.55, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining wall. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining wall.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix G. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

(Pratheep) K. Pratheepan
Staff Engineer

(Ranjan) G.J. Gunaranjan, PE
Senior Staff Engineer

REGISTERED PROFESSIONAL ENGINEER
GNANAPRAGASAM J. GUNARANJAN
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(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL A1, BRIDGE NO. 53E0147
MECHANICALLY STABILIZED EARTH (MSE) WALL
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 3.55, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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APPENDICES

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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Approach Embankment and Retaining Wall A1 (Bridge No 53E0147) in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Approach Embankment for the Schuyler Heim Bridge from the Ocean Boulevard and Retaining Wall A1 (Bridge No 53E0147) located on the west side of the approach embankment (Figure 2).

The proposed approach embankment has a maximum height of 17 ft at abutment 1, which is about 2 ft more than the existing embankment. Proposed width of the embankment varies approximately from 120 ft to 150 ft, which requires some fills and cuts to the existing embankment. The proposed approach embankment has a 2:1 slope on the east side and a MSE Wall (A1) on the west side. Retaining Wall A1, located between Sta. 2+38 and Sta. 4+20 ("A"

Line), will be approximately 185 ft long with retained heights varying from 10 ft at the southern end of the wall to a maximum height of 20 ft at the northern end of the wall where it terminates at the Abutment 1 of the Schuyler Heim Bridge. Recommendations for Abutment 1 of the Schuyler Heim Bridge are provided in a separate foundation report prepared by EMI (2010).

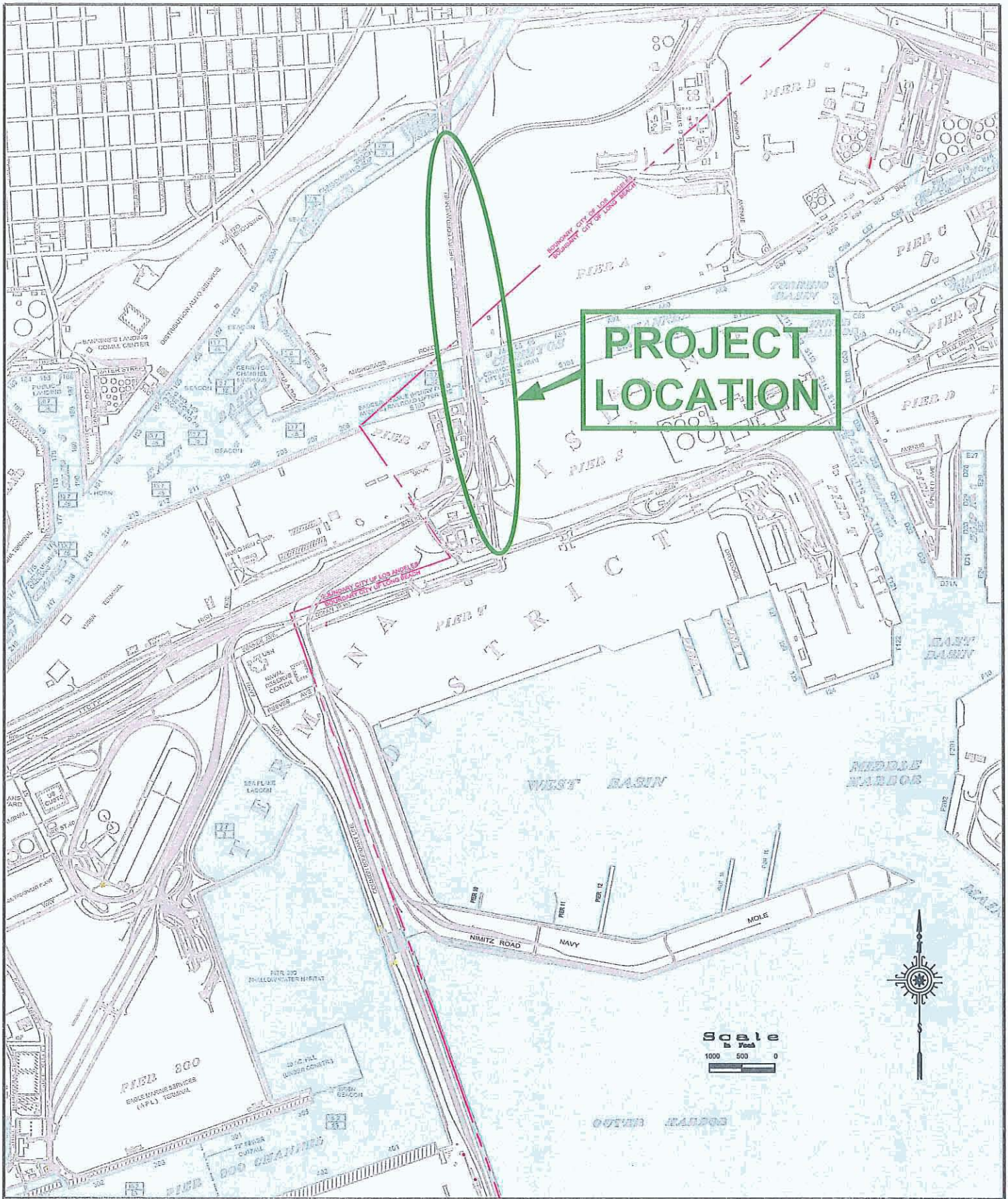
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Approach Embankment and Retaining Wall A1. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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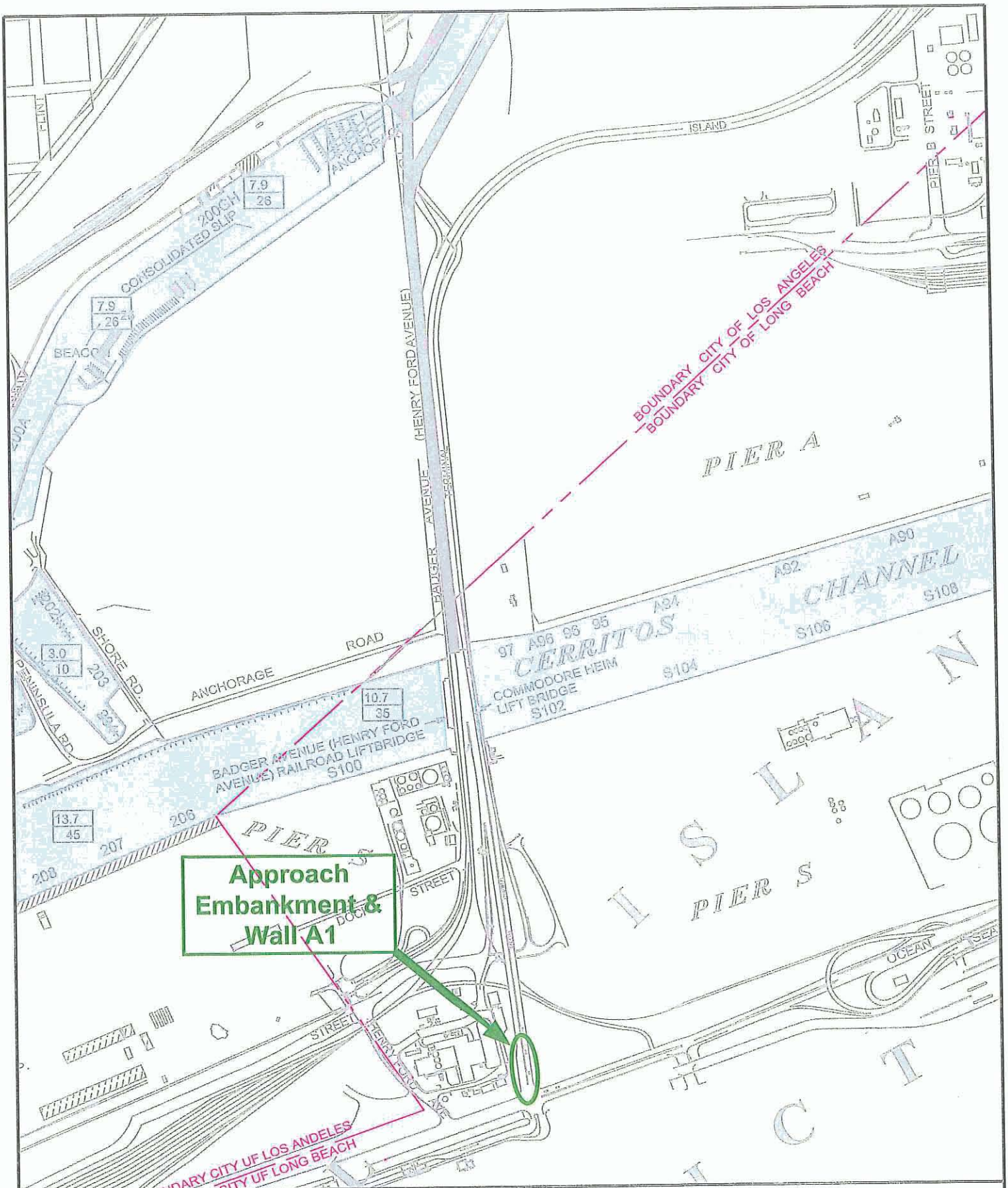
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structure Location Map

Figure 2

Project No. 06-123 | Date: 2-08-10

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of Approach Embankment and Retaining Wall A1 were those shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and, boring B-1 and CPT sounding CPT-1 were performed near the proposed wall site. The boring penetrated to a depth of 176 ft and CPT sounding penetrated to depth of 137 ft below existing grade with a deepest penetration to an elevation of -176 ft.

Copy of the as-built LOTB sheet prepared by LKR for the seismic retrofit study is provided in Appendix A.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, three hollow-stem auger borings, three rotary wash borings and three CPT soundings were performed in the vicinity of Approach Embankment and Retaining Wall A1. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed wall and bridge support locations. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI. Log-of-Test-Borings (LOTBs) for the borings and CPTs used to characterize the subsurface soil for the Retaining wall A1 are provided at the end of the text and Boring/CPT logs for the borings and CPT soundings used to characterize the subsurface soil for the east side embankment are provided in Appendix B.

2.2.1 Soil Borings

All of the borings surrounding the proposed embankment and wall were performed at grade in the undeveloped area near the existing Schuyler Heim Bridge. The deepest boring penetrated down to about elevation -112 ft, approximately 120 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a

subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of thin wall Shelby tubes and split-spoon drive samplers. Thin wall Shelby tubes (2.9 inch ID, 3.0 inch OD) were pushed into soft soils to collect undisturbed samples. Split-spoon drive samplers; Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix C.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix D.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
A-09-051	"A" Line	1+64.8	128.1 Lt	+5.7	-1.3	-45.8	HS
A-09-052		3+29.0	87.8 Lt	+3.2	-5.3	-48.3	HS
A-09-053		2+86.8	88.7 Rt	+6.0	-2.4	-45.5	HS
R-09-001		4+56.8	73.6 Lt	+2.4	NR	-74.1	RW
R-09-002		4+57.4	110.0 Rt	+3.6	NR	-72.9	RW
R-09-038		1+89.2	80.3 Rt	+8.8	+2.3	-111.7	RW
CPT-09-093		1+72.0	129.2 Lt	+5.7	NR	-105.2	CPT
CPT-09-094		3+35.2	89.1 Lt	+3.2	NR	-112.3	CPT
CPT-09-095		2+95.4	89.0 Rt	+5.9	NR	-104.3	CPT

Notes: *1. Top of boring elevations based upon NAVD88.*
2. GSE = Ground Surface Elevation.
3. GWE = Groundwater Elevation.
4. HS= Hollow-Stem Auger, RW = Rotary Wash, CPT = Cone Penetration Test.
5. NR = Not Recorded.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near the existing Schuyler Heim Bridge. The deepest sounding was advanced down to elevation -112.3 ft, approximately 115.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in^2 (10 cm^2) and a cylindrical friction sleeve with a surface area of 23.25 in^2 (150 cm^2). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

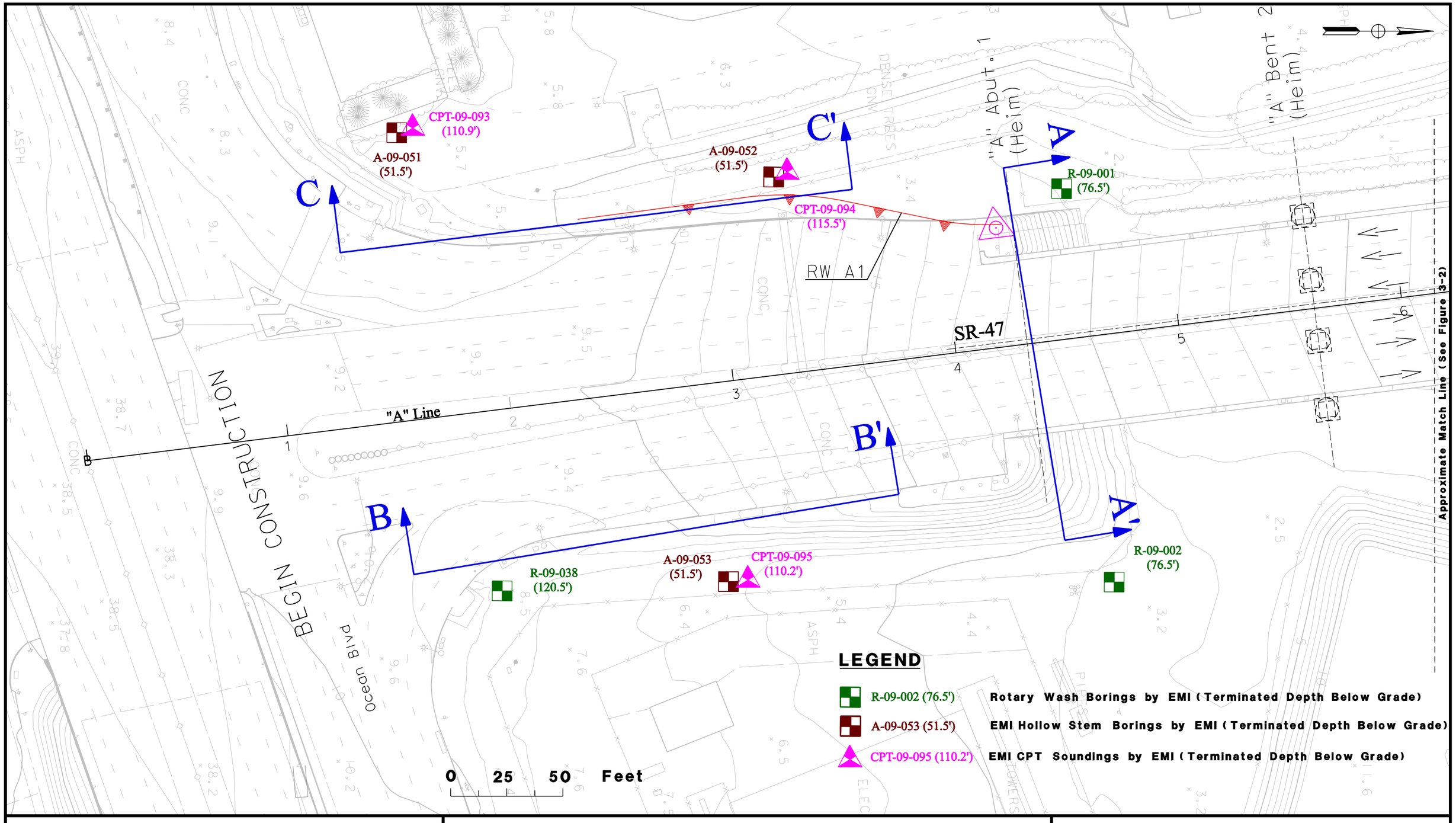
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix E.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department

(LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

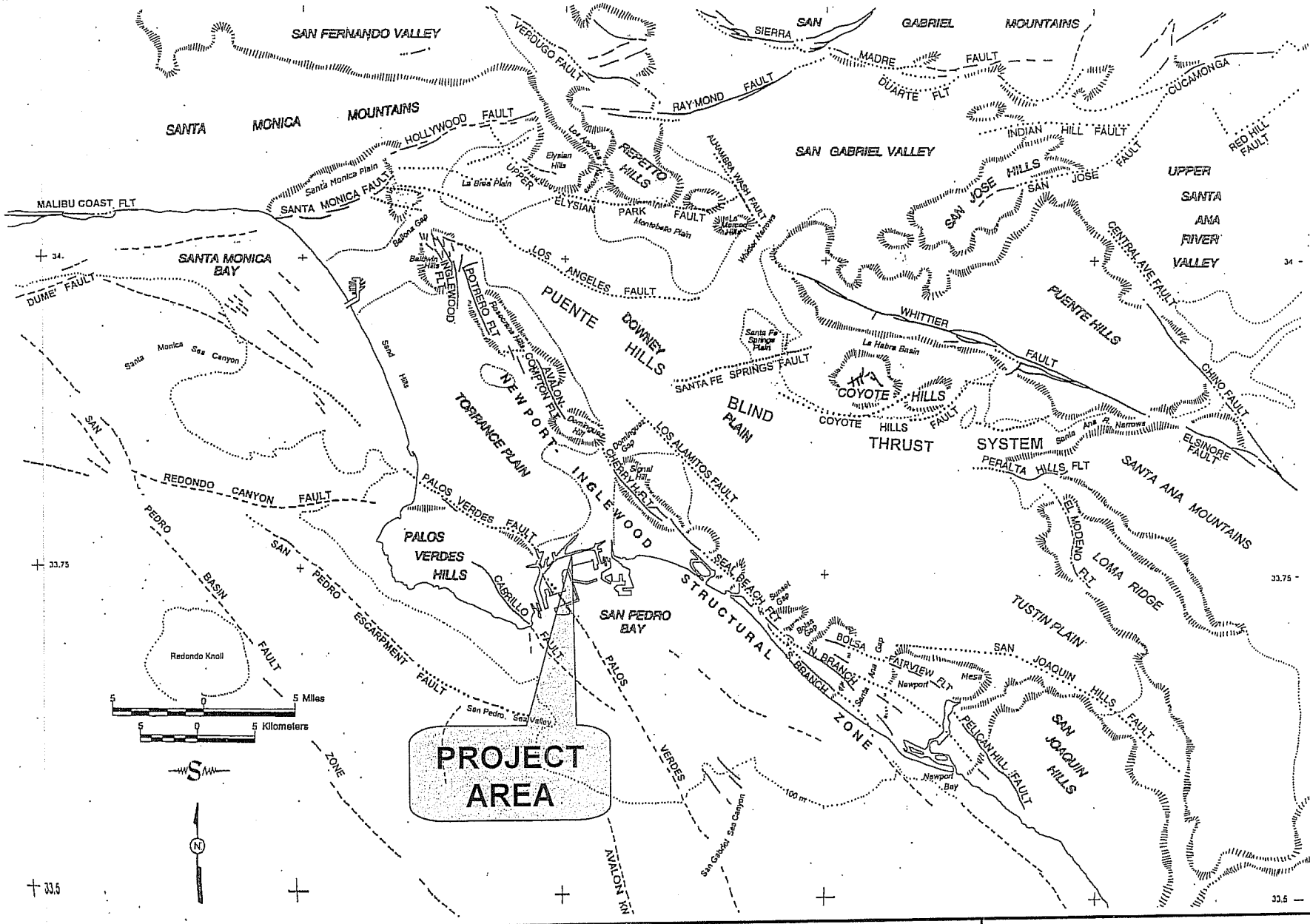
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

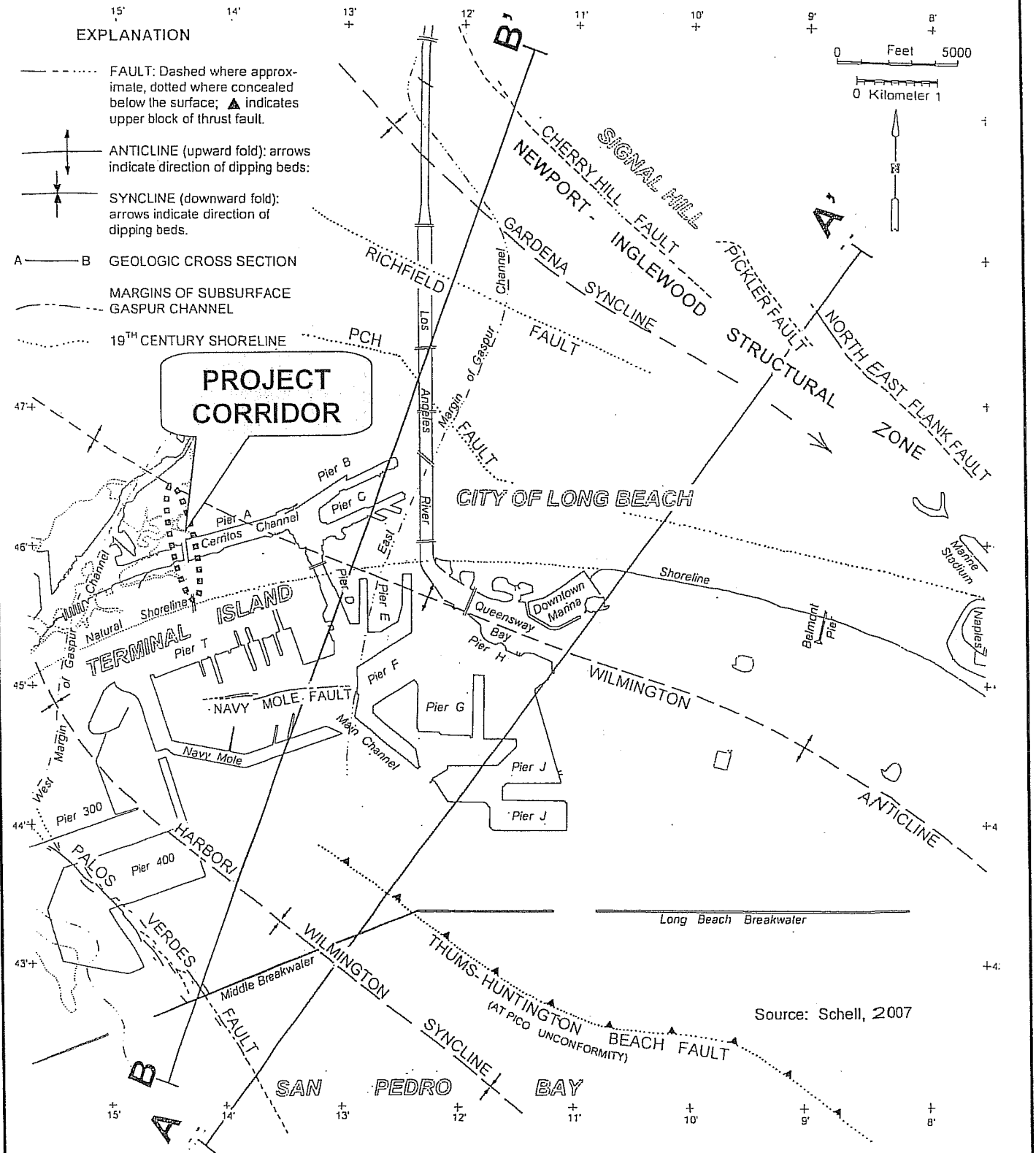
California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at

Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.

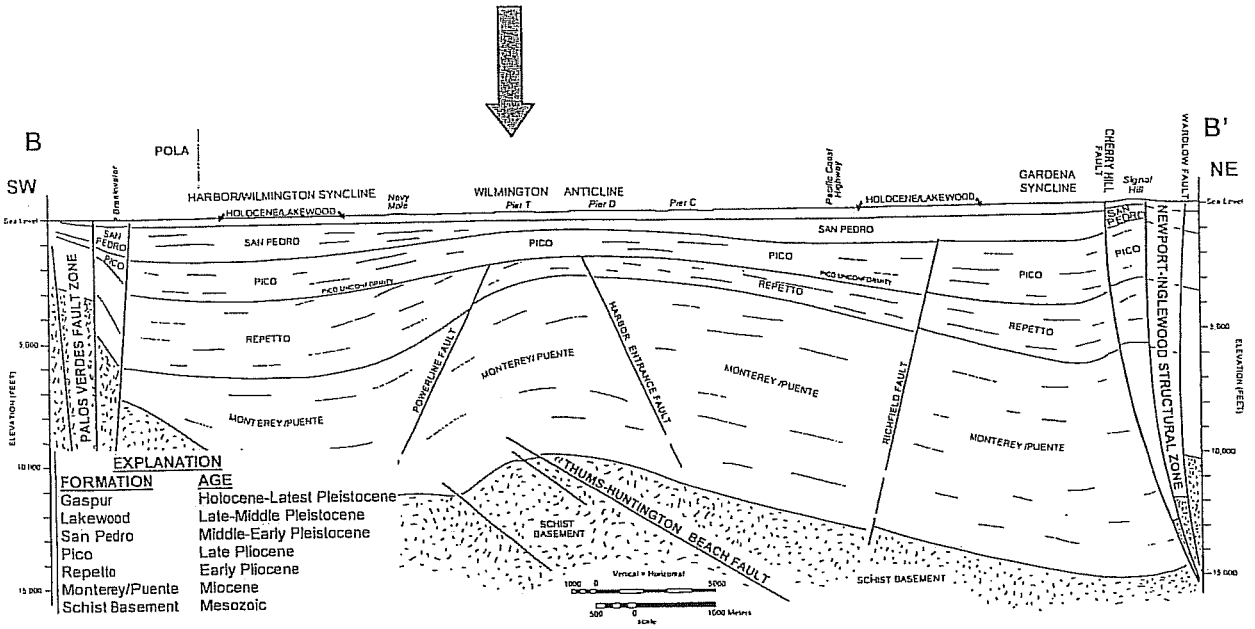


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 2-08-10	Figure 4

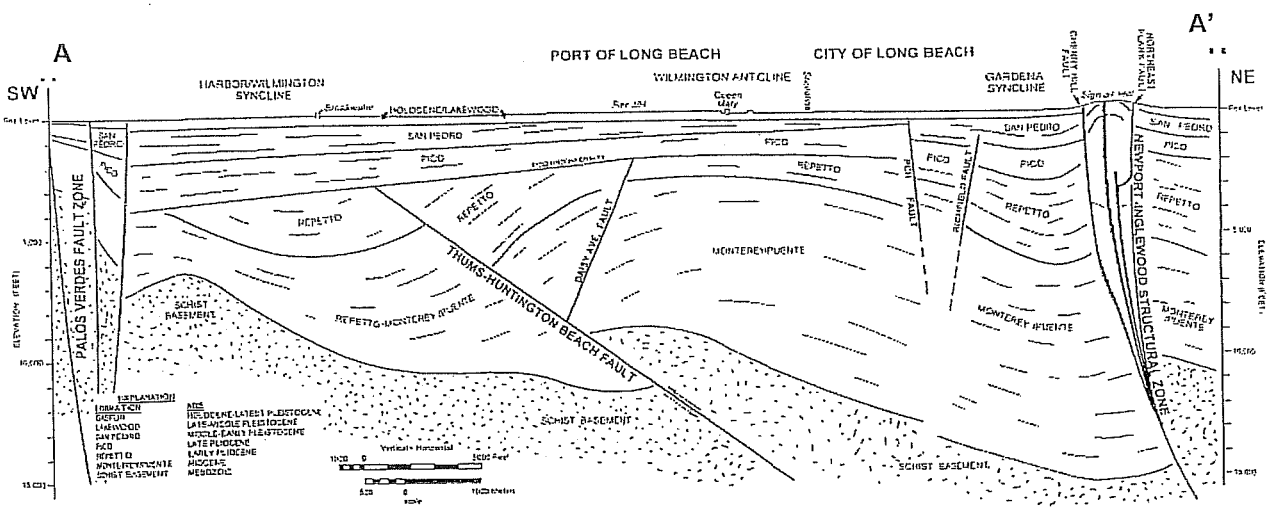


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM B RIDGE REPLACEMENT PROJECT
Project No. 06-123 Date: 2-08-10	Structural Geology Map, Long Beach Harbor Figure 5

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

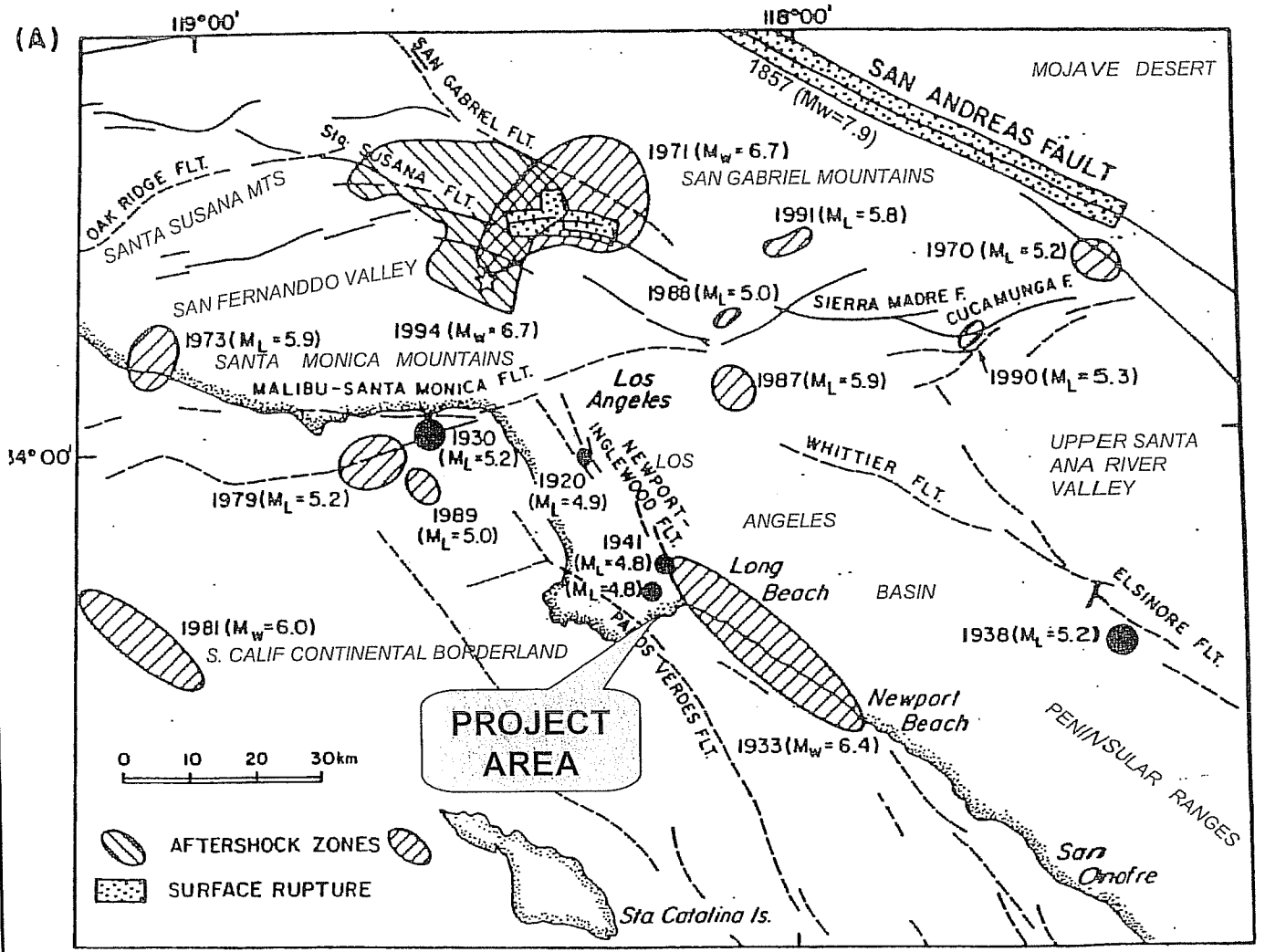


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

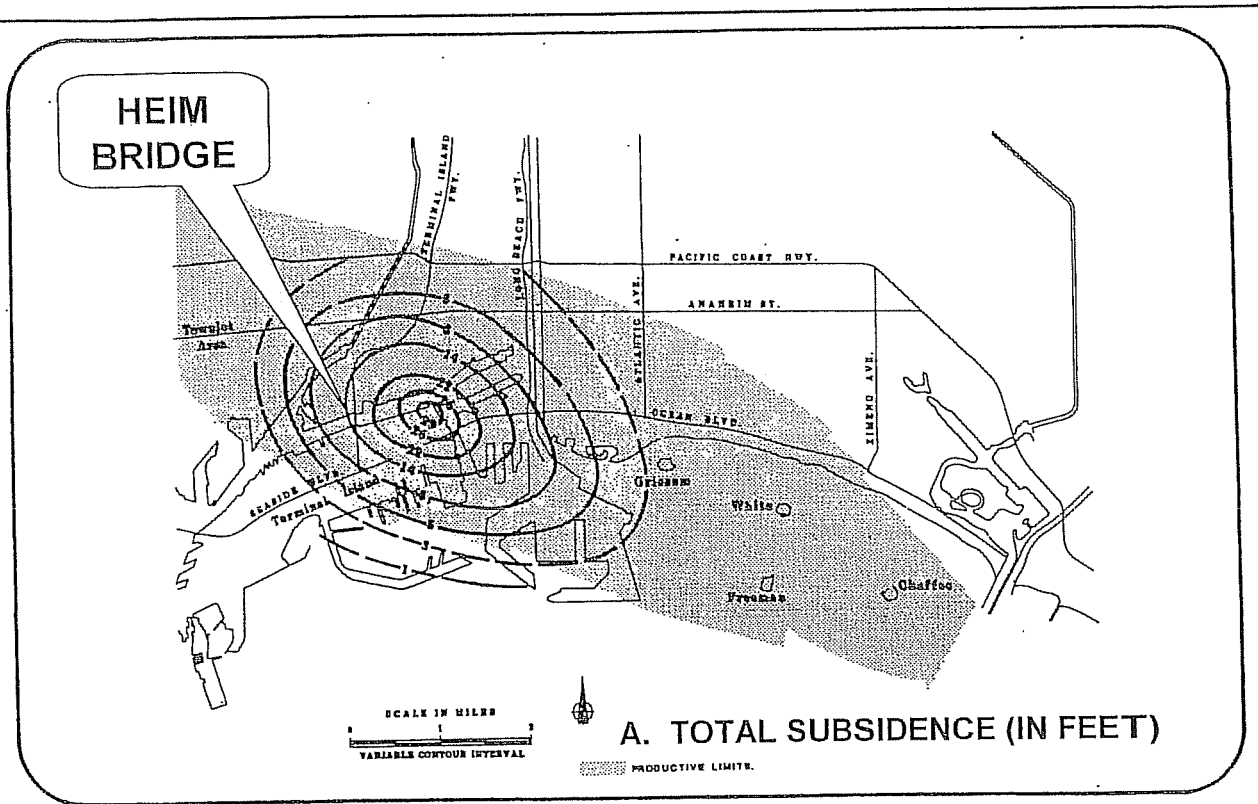
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
	Geologic Cross-Sections, LA Harbor
Project No. 06-123 | Date: 2-08-10	Figure 6

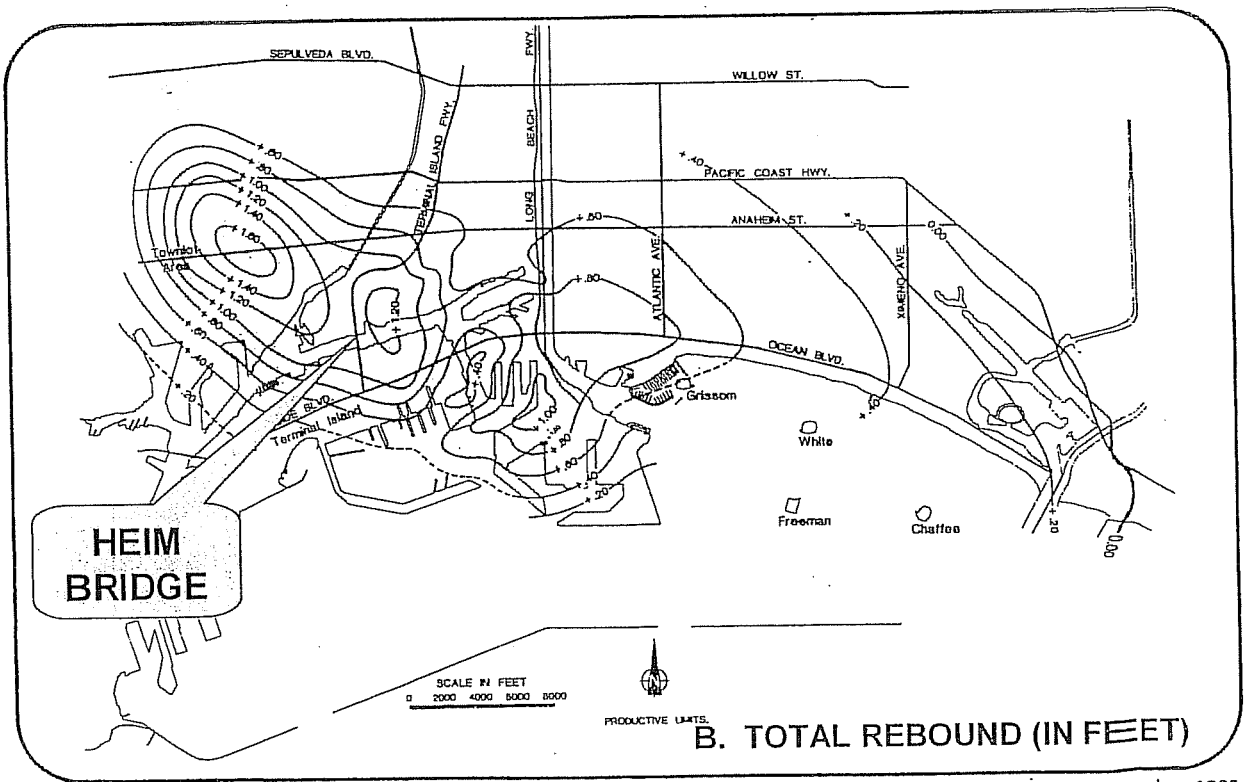


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 2-08-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM B RIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -112 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about 3 ft, with a few feet of import fill for the existing approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +18 ft near the northern end of the proposed wall. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -25 ft. The near surface deposits are underlain by a thick strata of inter-layered soft to stiff clay, silt, sandy silt, and loose to medium dense silty sand down to about elevation -70 ft. Below elevation -70 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB and Log of Boring sheets.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in four of the borings performed near the proposed approach embankment and wall, between elevation +2.3 ft and -5.3 ft. The elevation that groundwater was encountered in each boring is listed in Table 2 and also on LOTB/Log of Boring sheets attached with this report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

Based on the observed high water elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

Based on information collected from borings A-09-051, A-09-052, A-09-053, R-09-001, R-09-02, R-09-038 and CPT soundings CPT-09-093, CPT-09-094 and CPT-09-095 three separate sections of idealized soil profiles for foundation analysis and design were developed (A-A' for Abutment 1, B-B' for East Embankment and C-C' for Wall A1, See Figure 3). The subsurface profiles beneath the proposed structures are shown in Figures 9 through 11. The soil profiles and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

SECTION A-A' (FROM STA 3+75 TO 4+27)

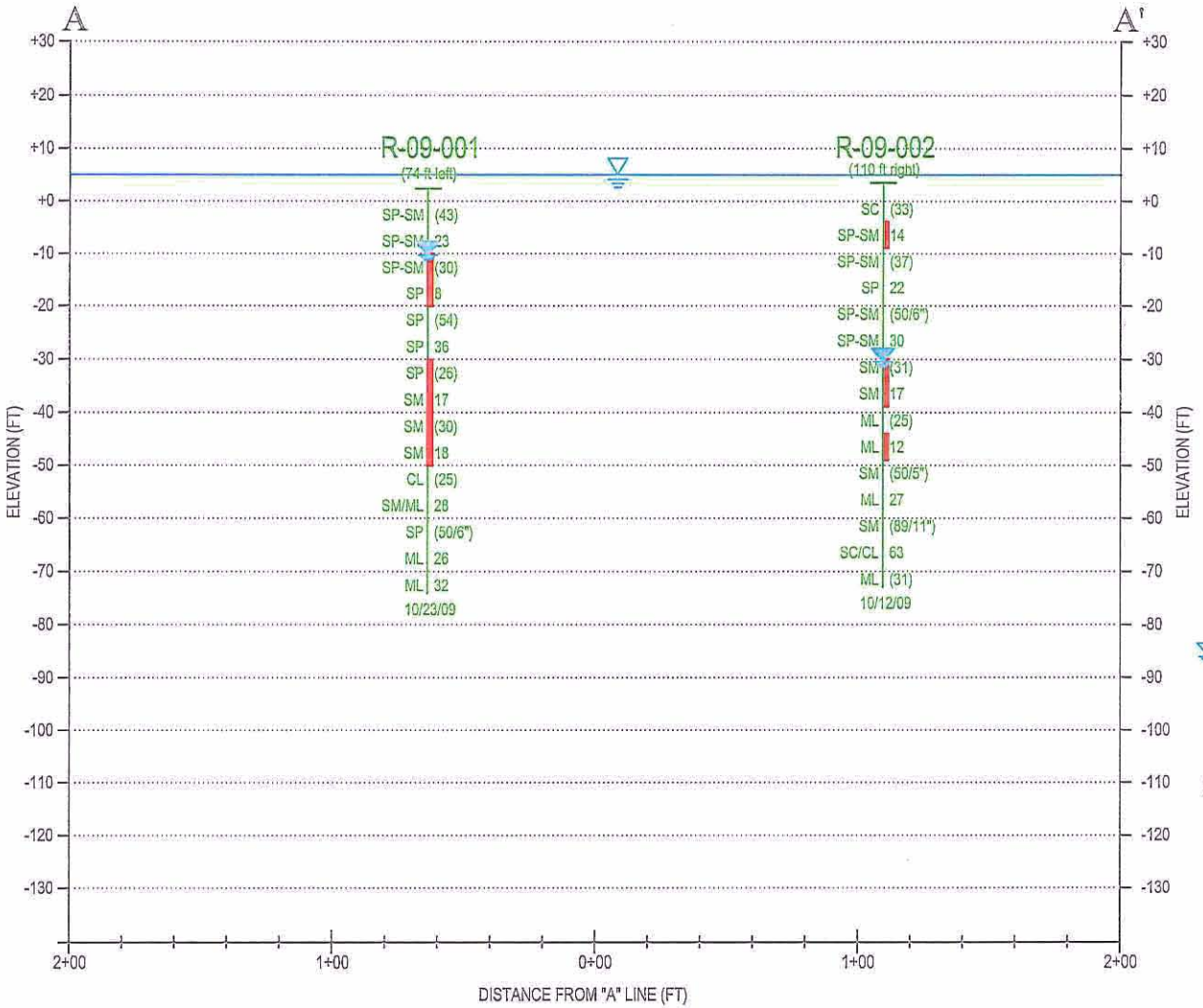
Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -20.0	Sand / Sand with Silt	120	100	32
-20.0 to -30.0	Sand / Sand with Silt	120	100	34
-30.0 to -50.0	Silty Sand / Sandy Silt	120	100	33
-50.0 to -68.0	Silty Sand / Sandy Silt / Lean Clay	120	100	36
-68.0 to -75.0	Silt / Silt with Sand	120	3,000	0
-75.0 to -110.0	Sand / Sand with Silt / Silty Sand	125	0	38

SECTION B-B' (FROM STA 1+00 TO 3+75, EAST SIDE)

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -5.0	Silty Sand	120	100	34
-5.0 to -25.0	Sand / Sand with Silt / Silty Sand	120	100	30
-25.0 to -35.0	Sandy Silt / Silt / Lean Clay / Fat Clay	120	700	0
-35.0 to -48.0	Clayey Silt / Silt / Sandy Silt	120	1,750	0
-48.0 to -72.0	Silt / Sandy Silt / Silty Sand	120	100	34
-75.0 to -110.0	Sand / Sand with Silt / Silty Sand	125	0	38

SECTION C-C' (FROM STA 1+00 TO 3+75, WEST SIDE)

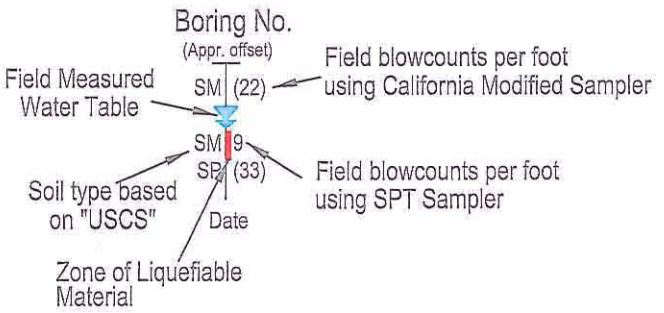
Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -5.0	Silty Sand	120	100	34
-5.0 to -22.0	Sand / Sand with Silt / Silty Sand	120	100	30
-22.0 to -40.0	Sandy Silt / Silt / Lean Clay	120	1,250	0
-40.0 to -50.0	Silt / Sandy Silt / Silty Sand	120	100	32
-50.0 to -70.0	Silt / Sandy Silt / Silty Sand	120	100	34
-70.0 to -110.0	Sand / Sand with Silt / Silty Sand	125	0	38



LEGEND

R-09-001 Rotary Wash Boring (2009)

Assumed Design Water Table at +5 ft MLLW



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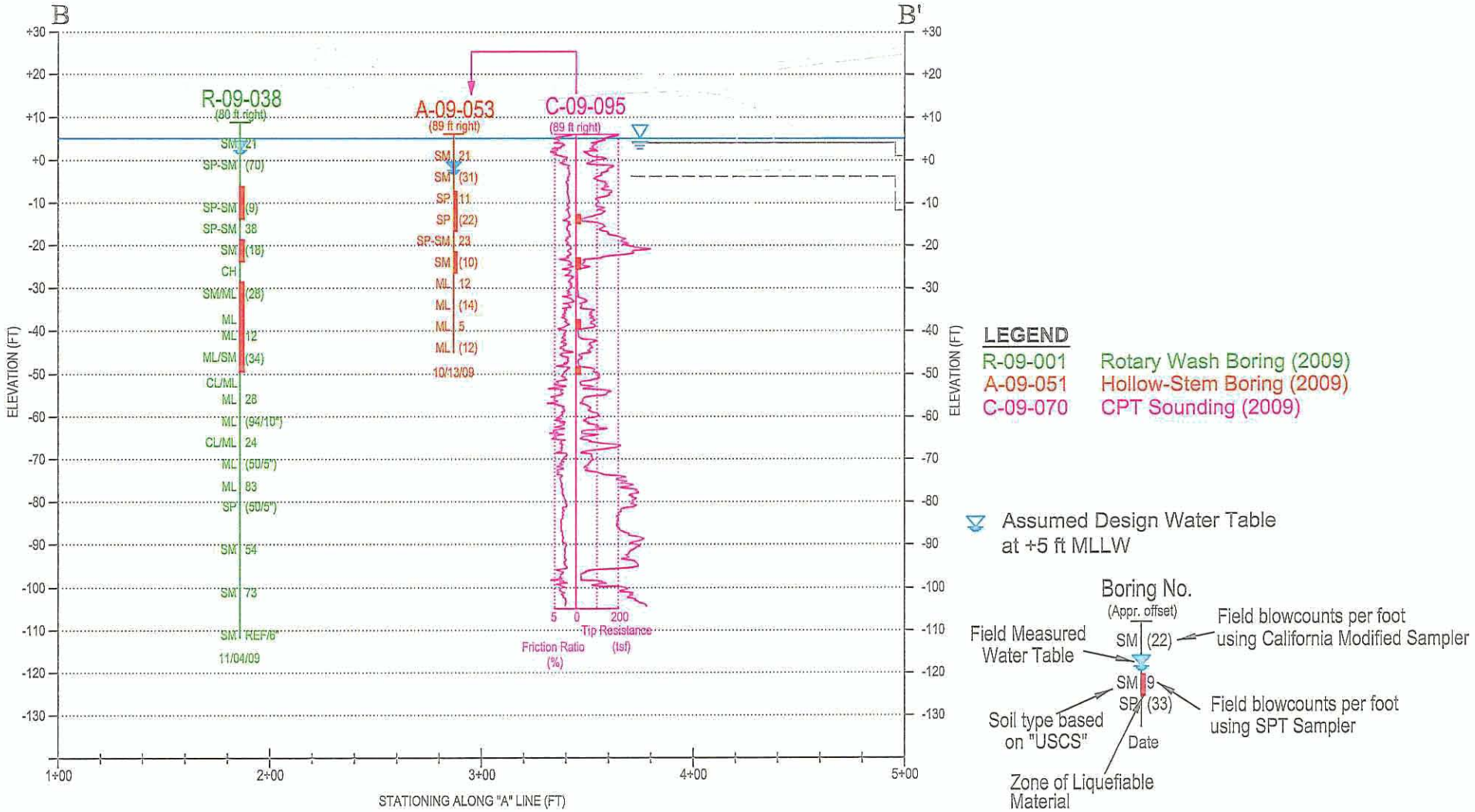
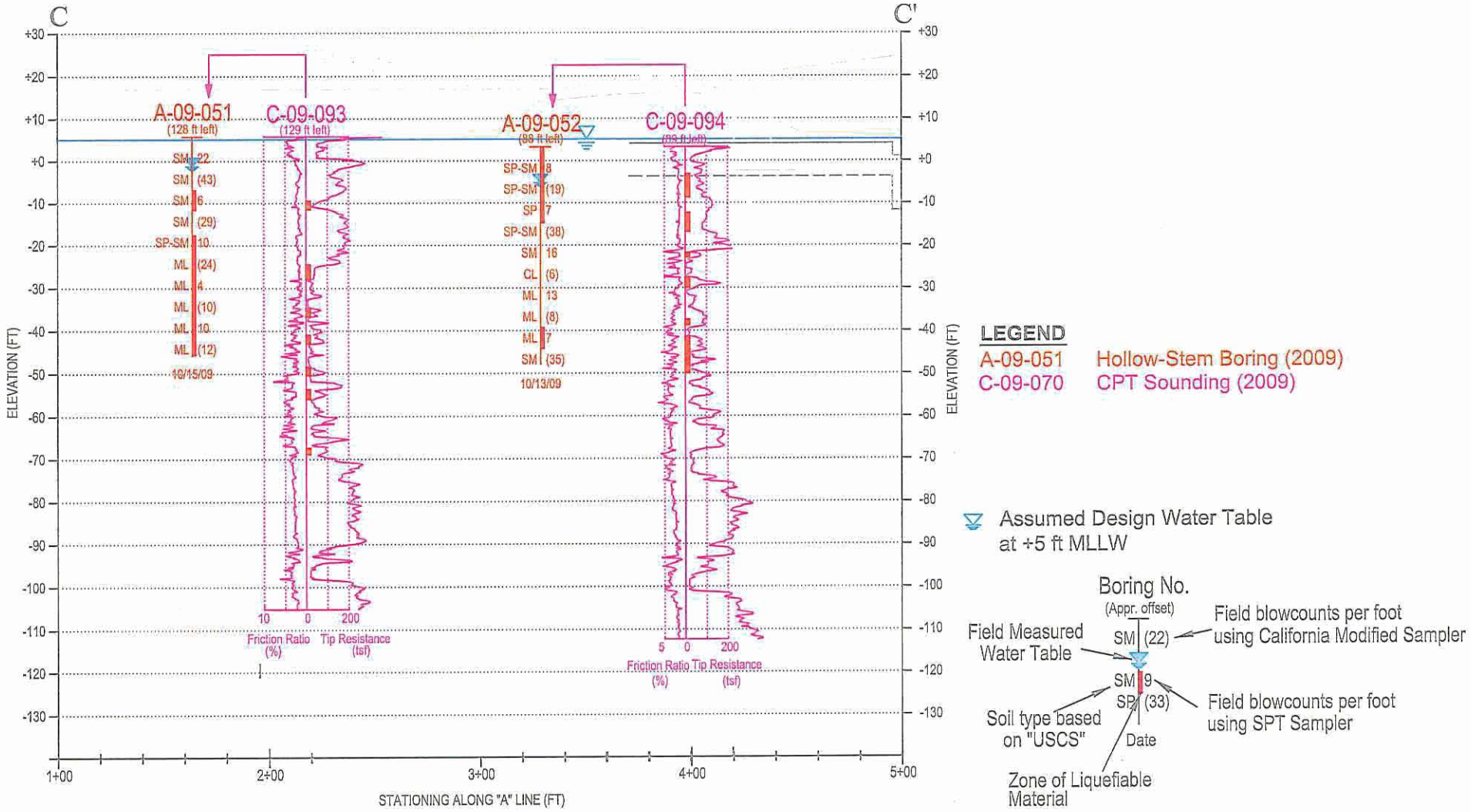
Idealized Soil Profile along Section A-A'

Figure 9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT		Idealized Soil Profile along Section B-B'
	EMI Project No. 06-123	Date: 02-08-10	Figure 10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Idealized Soil Profile along Section C-C'
	EMI Project No. 06-123 / Date: 02-08-10	Figure 11

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance to with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix F.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the approximate elevation -50 ft are expected to be susceptible to liquefaction. Seismically induced-settlements up to 9 inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake event is also identified in the subsurface profiles shown in Figures 9 through 11.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
A-09-051	-6.8 to -11.8	1.5	8.5
	-16.8 to -45.8	7.0	
A-09-052	+3.2 to -14.3	3.2	4.5
	-39.3 to -44.3	1.3	
A-09-053	-6.5 to -16.5	1.7	3.2
	-21.5 to -26.5	1.5	
R-09-001	-10.0 to -20.0	2.0	5.5
	-30.0 to -50.0	3.5	
R-09-002	-4.0 to -9.0	0.7	3.4
	-29.0 to -39.0	1.5	
	-44.0 to -49.0	-1.2	
R-09-038	-6.2 to -13.7	2.8	8.5
	-18.7 to -23.7	1.3	
	-28.7 to -50.0	4.4	
CPT-09-093	-9.5 to -11.4	0.1	1.3
	-24.5 to -27.8	0.6	
	-34.7 to -36.7	0.2	
	-41.0 to -43.0	0.1	
	-48.4 to -50.4	0.1	
	-53.8 to -56.0	0.1	
	-67.4 to -68.8	0.1	
CPT-09-094	-3.2 to -8.7	<0.1	0.5
	-12.4 to -16.8	<0.1	
	-21.8 to -22.8	<0.1	
	-27.6 to -30.0	0.1	
	-37.5 to -38.8	<0.1	
	-41.5 to -50.0	0.3	
CPT-09-095	-12.8 to -14.8	0.1	0.8
	-23.0 to -25.5	0.5	
	-37.5 to -39.5	0.1	
	-48.5 to -50	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. In the vicinity of the subject site six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.4 and 8.4, the minimum resistivities were between 390 and 2,000 ohm-cm, soluble

chloride contents were between 267 and 1,809 parts per million (ppm) and soluble sulfate contents were between 20 and 1,380 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Approach Embankment and Mechanically Stabilized Earth Wall Recommendations

As discussed in Section 1.2, the maximum design height of the approach embankment is about 17 ft. Due to the presence of compressible soil; construction of the proposed Schuyler Heim Bridge approach embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected to retain the soil on the west side of the approach embankment because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 20 ft and base width of 14 ft at Sta. 3+50 ("A" Line), the bearing pressure induced on the underlying foundation soil is 3.4 ksf. Using a base width of 14 ft, the allowable bearing capacity of the soil directly beneath

the MSE wall is greater than 3.4 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads supporting the wall face may be supported on the in-situ soil. They should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 2 ft below lowest adjacent grade. The allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL A1 STABILITY ANALYSES

Approx. "A" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety [3]	Global Stability Factor of Safety	
				Static[1]	Psuedo-Static[1],[2]
3+50	20	14	2.1	2.40	1.18

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1. Bearing capacity factor of safety is 2.1 for end of construction also

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

Based on cross-sections provided by the roadway designers, the potential settlement beneath the proposed embankment was evaluated at "A" Line Stations 2+50, 3+50, and 4+27. The results for settlement analysis at Sta. 4+27 are discussed in a separate foundation report prepared by EMI (2010) for the Schuyler Heim Bridge.

Based on cross-sections provided by roadway designers, the existing embankment will be widened as much as 3 feet on the east side and 9 ft on the west side and the embankment height is increased by up to about 2 feet. Based on our calculations, the maximum settlement of soils underlying the proposed approach embankment is estimated to be about 1.5 inch and the differential settlement along the wall is estimated to be less than 1 inch per 100 ft. The settlement period is estimated to be about 6 weeks to reduce the remaining long-term settlement to less than ½-inch.

Utilities: An existing 12-inch diameter high pressure gas line is located about 33 ft west of Abutment 1. Between Sta. 2+50 and 3+50 ("A" Line), this gas line is becoming as close as about 5 to 10 ft west of Retaining Wall A1. The maximum settlement below the gas line is estimated to be about 1.1 inch and the differential settlement along the pipe is on the order of 1 inch per 100 feet.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

The base of the MSE structure will be founded on native soils. EMI recommends remedial grading consisting of 1-ft overexcavation for the section founded on native soil. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted to a minimum 90 percent relative compaction. The overexcavation should be backfilled using granular, non-expansive soils. In the event the bottom of remedial excavations become saturated due to the presence of shallow groundwater or seepage, self compacting material such as gravel or lean concrete slurry can be placed within the limits of the overexcation. The overexcavation should extend at least 3 ft beyond the outer edge of the leveling pad and 3 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Stability

The "global" stabilities of the MSE and east slope were evaluated for both static and pseudo-static conditions using the computer program SLIDE 5.0 (Rocscience, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-sections selected for stability analysis were near "A" Line Sta. 4+27 and Sta. 3+50. The results for the global stability analysis at Sta. 4+27 are discussed in a separate foundation report prepared by EMI (2010) for the Schuyler Heim Bridge.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans show removal of existing retaining wall on the west side of the approach embankment is necessary to achieve finish grades. Temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all of the borings performed near the proposed approach embankment and wall A1 between Elevation +2.3 ft and -5.3 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad varies between about elevation +1 and +2.5 ft. The deepest excavation for the proposed MSE wall is expected to be below the observed groundwater elevations; therefore, groundwater is expected to be encountered during construction of the proposed MSE wall. Due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, even higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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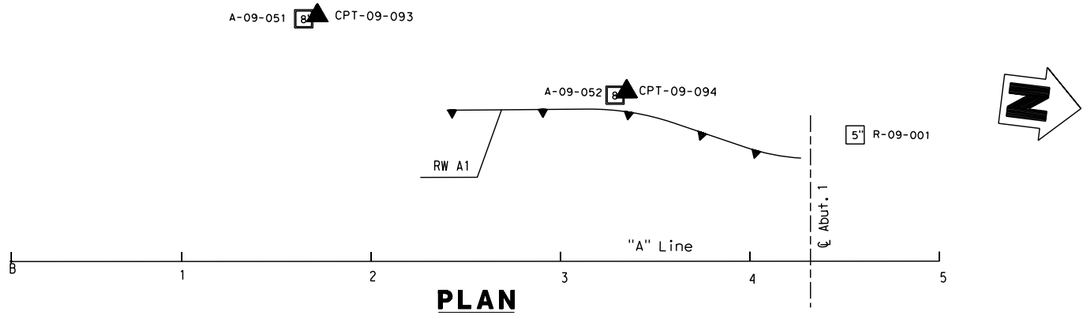
BENCHMARKS:

PT-503	PT-531065
REBAR	PK NAIL IN LEAD
18.51'Lt ℄ "A" Line	53.55'Lt ℄ "A" Line
Sta. 8+8.66	Sta. 4+24.53
N 1735350.13	N 1734960.02
E 6489075.70	E 6489051.67
Elev. = -0.53	Elev. = 17.75

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).
(2) 2.4" samples were taken using a California Modified Sampler.
(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8/8/10 04/19/10
REGISTERED CIVIL ENGINEER DATE

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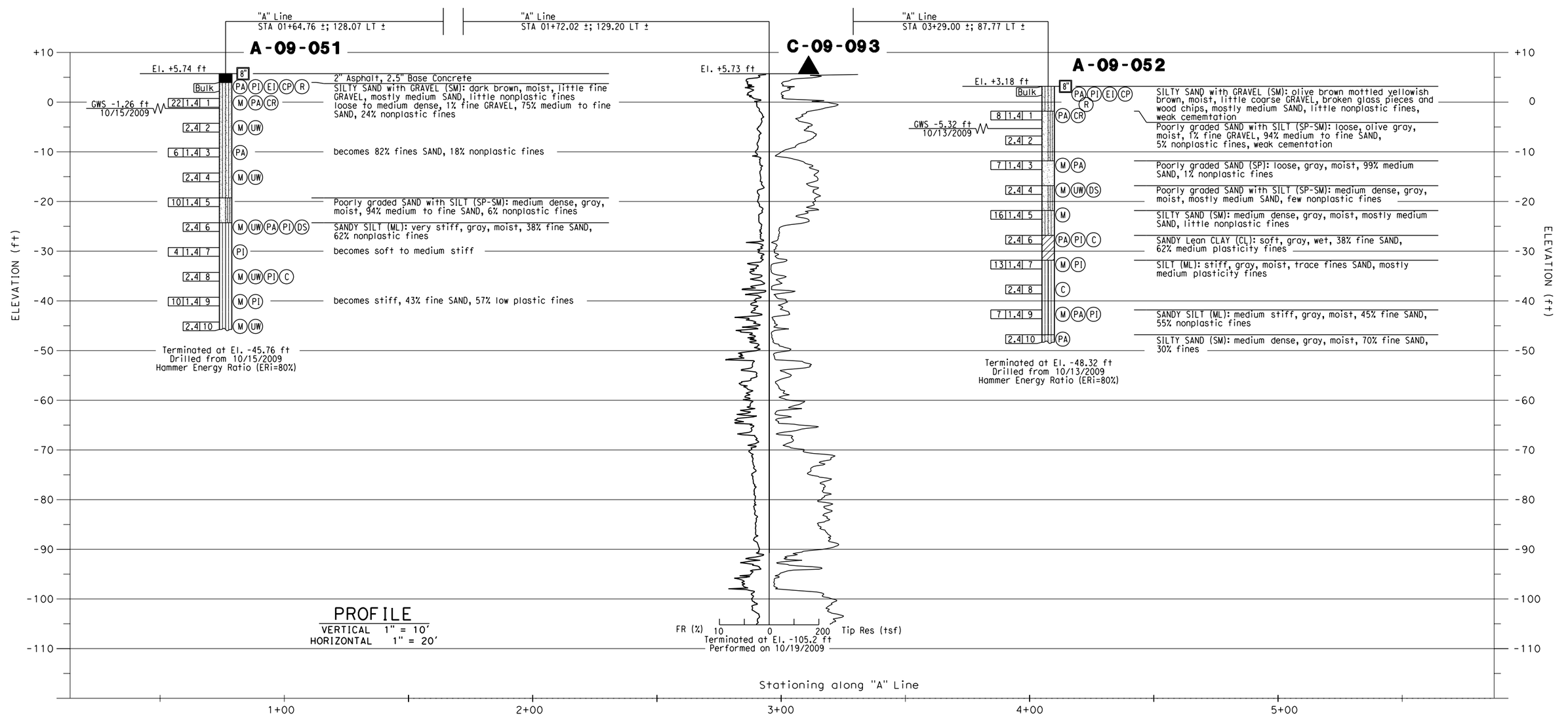
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



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SIGN OFF DATE	CHECKED BY: K. Pratheepan				POST MILE 3.55

MSE RETAINING WALL NO. A1

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

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BENCHMARKS:

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18.51'Lt ℄ "A" Line	53.55'Lt ℄ "A" Line
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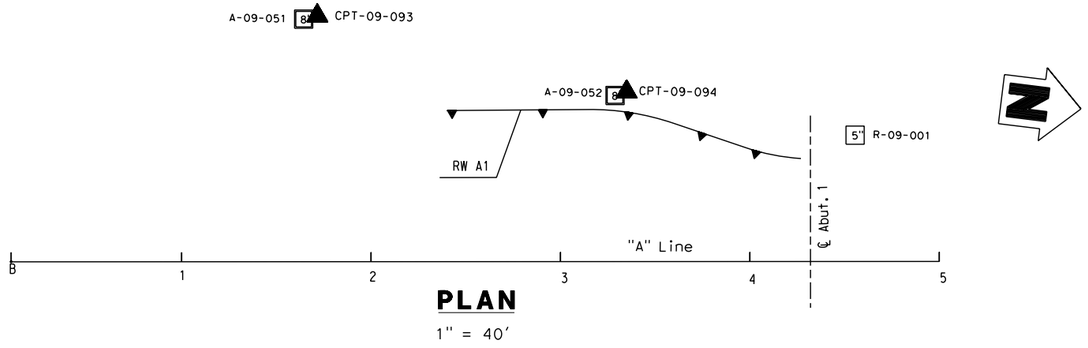

PLAN

1" = 40'

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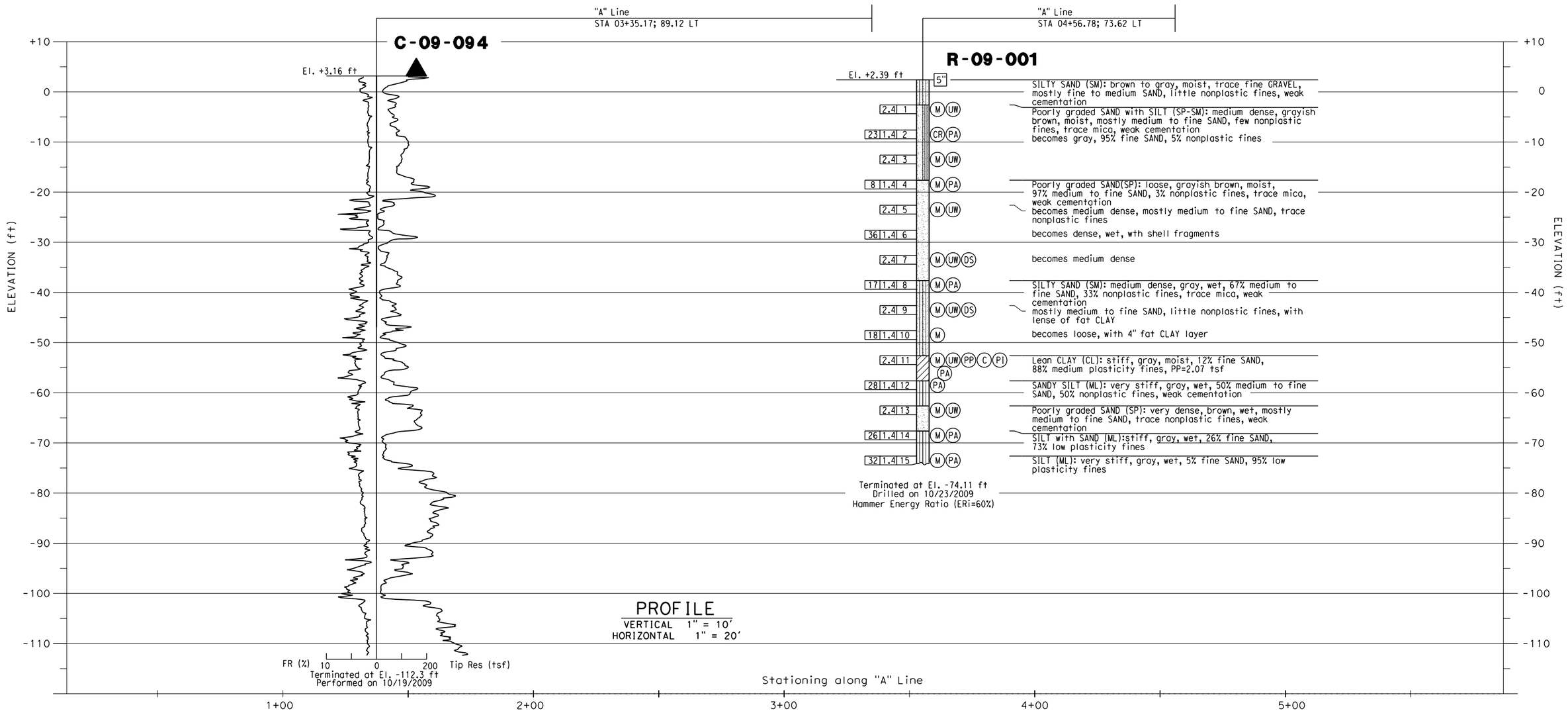

PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.55	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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8880 04/19/10
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CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

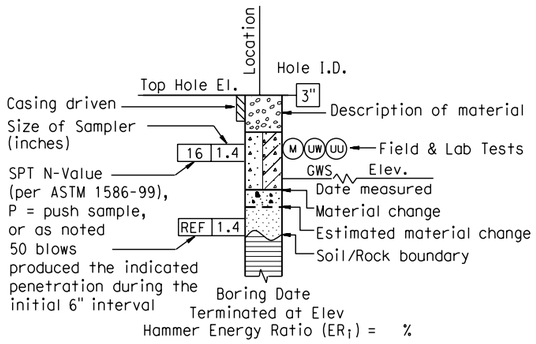
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

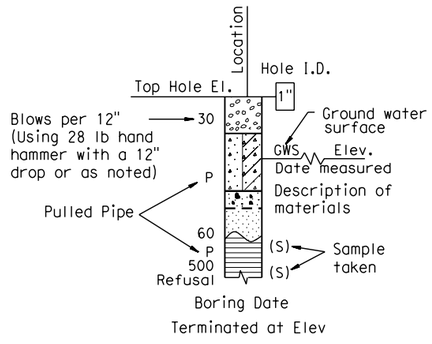
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

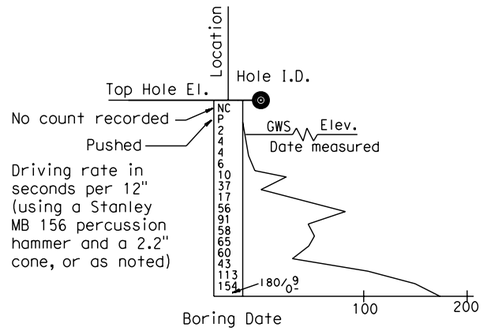
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



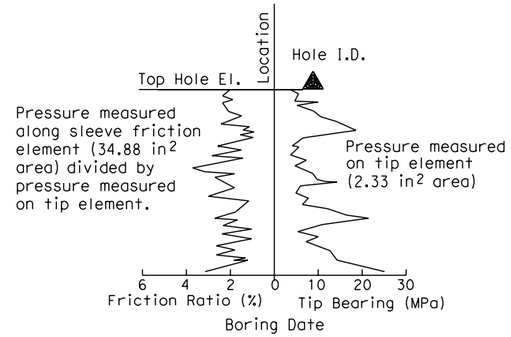
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

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OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

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04/06/09	04/14/10									X	X

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8880 04/19/10
REGISTERED ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:

R. Jie/K. Thant

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

BRIDGE NO. 53E0147
POST MILE 3.55

MSE RETAINING WALL NO. A1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 120301

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 04/06/09, 03/18/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A. SCHUYLER HEIM BRIDGE SEISMIC RETROFIT LOTB SHEETS PREPARED BY LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity

N.S.R.= No sample recovery

OVM5808 Gas Readings

PLAN

SCALE: 1"=40' NORTH

ABUT. 0, BENT 1, B-1, CPT-1, BENT 2, BENT 3, CPT-2, BENT 4, BENT 5, CPT-3, BENT 6, BENT 7, BENT 8, CPT-4, BENT 9

℄ EXISTING R.R.

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

45° LT. STA. 5+94.00 — ELEV.= 0.21

B-1

FILL:(SM)Brown fine to medium SILTY SAND w/GRAVEL, vegetation, w/shell fragments

GWS ELEV.= -4.71 08-26-96

NATIVE:(ML)Gray SILT, very stiff grades to SANDY soft

(ML)Gray SANDY SILT w/mica & shell fragments

(ML)Gray to dark gray SILT w/traces of SAND, stiff

(SP)Gray fine SAND w/mica, compact

(ML)Gray SILT w/CLAY, very stiff

(SP)Gray fine SAND, very dense

(ML)Gray CLAYEY SILT, very stiff, less CLAYEY grades to CLAYEY

(SP)Gray fine SAND, very dense, w/GRAVEL grades to fine to medium w/1" gravel

grades to medium

traces of gravel

Grades to fine w/traces of SILT w/decomposed wood fragments & mica

Grades to medium to coarse w/traces of GRAVEL less SILT

Grades to medium

Grades to fine to medium

Grades to medium w/traces of 3/4" GRAVEL

(ML)Gray SANDY SILT

(GP)Gray poorly graded GRAVEL w/SAND, very dense

(ML)Gray SANDY SILT

08-26-96

17° LT. STA. 6+02.50 — ELEV.= -0.06 — CPT-1 — 08-19-96

STA. 7+63.50 — ELEV.= -2.01 — CPT-2 — 08-15-96

STA. 9+08.00 — ELEV.= -0.18 — CPT-3 — 08-15-96

STA. 11+12.00 — ELEV.= 2.46 — CPT-4 — 08-15-96

Vs (ft/s) 1400 1200 1000 800 600 400 200

N (blows/foot) 10 20 30 40 50

ELEVATION 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

5 6 7 8 9 10 11 12

PENETROMETER TEST — ELECTRONIC CONE PENETROMETER

PENETRATION BORING — 2 1/2" CONE PENETROMETER

ROTARY SAMPLE BORING (WET) — 2½" CONE PENETROMETER

ROTARY SAMPLE BORING (DRY) — TEST PIT — DIAMOND CORE BORING — JET BORING — ELECTRONIC CONE PENETROMETER

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SANDY CLAY or CLAYEY SAND, SEDIMENTARY ROCK, SANDY SILT or SILTY SAND, METAMORPHIC ROCK, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS (According to the Standard Penetration Test)

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
4-10	Loose	Soft
10-30	Slightly compact	Stiff
30-50	Compact	Very stiff
50-90	Dense	Hard
>90	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERSIGHT — SIGN OFF DATE

DRAWN BY: NL
CHECKED BY: MR

CS-LH-MC — FIELD INVESTIGATOR
DATE: 08-15-96

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

BRIDGE NO. 53-2618
POST MILE 3.58

CU 07
EA 138201

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO. 1

SHEET 141 OF 148

DGN: A:\JOBS\LKR\LTBOR 8-15-96 11:45:15 am EST

APPENDIX B. SITE-SPECIFIC BORING AND CPT LOGS

SITE-SPECIFIC BORING LOGS

LOG OF BORING NO. A-09-053

Grade Elevation:	+8.80 feet				
Boring Depth:	51.5 feet	Driller:	2R Drilling Inc.		SHEET 1 OF 2
Borehole Diameter:	8 inches	Type of Rig:	Hollow-Stem Auger	Comments: 1. CME 75 with automatic hammer	
Date Drilled:	10-12-09	Drive Wt. (lbs):	140	2. 3.25" O.D. ring sampler	
Logged By:	K.K	Drop (inches):	30	3. "A" Line STA 02+86.77±; 88.67 RT ±	

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	Tests/ Results
0	D	1	15		SILTY SAND (SM): medium dense, brown, moist, fine-grained sand, trace of medium-grained sand, nonplastic	CR
5	S	2	Push		CLAYEY SAND (SC): medium dense, olive, moist, fine-grained sand, trace of medium-grained sand, slightly plasticity	PA
	D	3	50/6"		very dense	DS
10	S	4	21		SANDY SILT (ML): hard, olive, moist, fine-grained sand, trace of mica, nonplastic	PA

1. 'Sample Type' - Graphical representation of sample type as shown below.
   - S: Split Spoon - Standard Penetration Test Sample (SPT)
   - D: Drive Sample - California Drive Sampler
   - H: Hand Auger Sample - Obtained by collecting hand auger cuttings in a plastic bag
   - B: Bulk Sample - Obtained by collecting cuttings in a plastic bag
   - T: Tube Sample - Thin-walled Tube Sample
   - P: Thin-walled Pitcher Core Sample
2. 'Sample' - Sample Number
3. 'Blows/foot' - Number of blows required to advance sampler one foot (unless a distance is specified). Samplers in general were driven into the soil at the bottom of the hole with an automatic drop type 140-lb hammer dropping a standard 30 inches (as specified in header).

   'REC/RQD' - Sample Core Recovery (REC) in percent (%) and Rock Quality Designation (RQD) in percent (%). RQD is defined as the percentage of core in each run in which the spacing between natural fractures is greater than 4 inches. Mechanical breaks of the core are not considered.
4. 'Graphic Log' - Standard symbols for soil and rock types, as shown in Note B, Sheet 2 of 2
5. ▼ Encountered groundwater depth while drilling.
6. 'Geotechnical Description' (See also Note A, Sheet 2 of 2)
   Soil - Soil classifications are in general accordance with the American Society for Testing and Materials (ASTM) D2488.84. Designations include consistency, moisture, and color. Field description have been modified to reflect results of laboratory analyses where deemed appropriate.

   Rock - Rock classifications generally include a rock type, color, moisture, mineral constituents, degree of weathering, alteration and the mechanical properties of the rock.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 02-08-10

LEGEND FOR GEOTECHNICAL BORING LOGS

(SHEET 1 OF 2)

7. 'Moisture Content' and 'Dry Density' determined by laboratory testing.

8. 'Tests/Results' - Identify types of laboratory tests performed on samples collected from the field investigation. Abbreviations of tests are provided below:

PI	Atterberg Limits	PP	Pocket Penetrometer
CR	Corrosivity	R	R-Value
CBR	California Bearing Ratio	SE	Sand Equivalent
CP	Compaction Test	SG	Specific Gravity
C	Consolidation	TV	Torvane
CU	Consolidated-Undrained Triaxial	UC	Unconfined Compression
DS	Direct Shear	UU	Unconsolidated-Undrained Triaxial
EI	Expansion Index	VS	Vane Shear
PA	Particle Size Analysis		

Pocket penetrometer and Torvane Shear measurements are given on the boring logs directly as the reading taken from the measuring instrument.

NOTE A

Criteria for Describing Moisture Condition

Description	Criteria (After ASTM D 2488)
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Relative Density of Coarse-Grained Soil

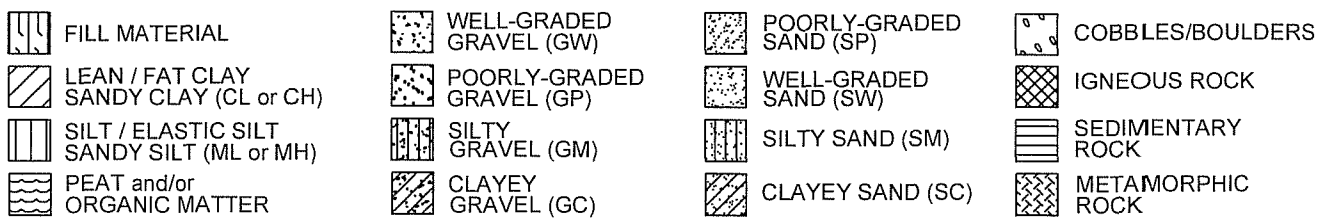
Blows/foot	Relative Density	Field Test (After Sowers, 1979)
0 - 4	Very Loose	Easily penetrated 12" with 0.5-inch steel rod pushed by hand
5 - 10	Loose	Easily penetrated with 0.5-inch steel rod pushed by hand
11 - 30	Medium Dense	Easily penetrated with 0.5-inch steel rod driven by 5-lb hammer
31 - 50	Dense	Penetrated a foot with 0.5-inch steel rod driven by 5-lb hammer
> 50	Very Dense	Penetrated a few inches with 0.5-inch steel rod driven by 5-lb hammer

Relative Density of Fine-Grained Soil

Unconfined Compressive Strength (tsf)	Consistency	Field Test (After Sowers, 1979)
< 0.25	Very Soft	Easily penetrated several inches by fist
0.25 - 0.5	Soft	Easily penetrated by thumb
0.5 - 1.0	Medium Stiff	Can be penetrated several inches by thumb with moderate effort
1.0 - 2.0	Stiff	Readily indented by thumb, but penetrated only with great effort
2.0 - 4.0	Very Stiff	Readily Indented by thumbnail
> 4.0	Hard	Indented with difficulty by thumbnail

NOTE B

Legend of Earth Materials



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 02-08-10

LEGEND FOR GEOTECHNICAL BORING LOGS

(SHEET 2 OF 2)

LOG OF BORING NO. A-09-053

Grade Elevation:	+ 6.05 ft			
Boring Depth:	51.5 feet	Driller:	2R Drilling Inc.	SHEET 1 OF 2
Borehole Diameter:	8 inches	Type of Rig:	Hollow-Stem Auger	Comments: 1. CME 75 with automatic hammer
Date Drilled:	10-13-09	Drive Wt. (lbs):	140	2. 3.25" O.D. ring sampler
Logged By:	K.T	Drop (inches):	30	3. "A" Line STA 02+86.77±; 88.67 RT ±

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	Tests/ Results
0	B	0			SILTY SAND with GRAVEL (SM): dark brown to gray, moist, little GRAVEL, mostly medium to fine SAND, some nonplastic fines	PA, PI, EI, CP, R
5	S	1	21		medium dense, 20% fine GRAVEL, 49% medium to fine SAND, 31% nonplastic fines	PA, CR
10	D	2	31		becomes mostly medium to fine SAND, some nonplastic fines	M, UW, DS
15	S	3	11		Poorly graded SAND (SP): medium dense, olive gray, moist, 97% medium SAND, 3% nonplastic fines	M, PA
20	D	4	22			M, UW
25	S	5	23		Poorly graded SAND with SILT (SP-SM): medium dense, light gray, moist, 95% medium SAND, 5% nonplastic fines	M, PA
30	D	6	10		SILTY SAND (SM): loose, gray, moist, mostly fine SAND, some nonplastic fines	DS
35						

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 Date: 02-08-10

CONTINUED LOG OF BORING NO. A-09-053

Date Drilled: 10-13-09
Logged By: K.T

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	Tests/ Results
35	S	7	12		SILT (ML): stiff, gray, moist, 13% fine SAND, 87% medium plasticity fines, trace shell fragments	M, PA, PI
40	D	8	14			C
45	S	9	5			M, PA, PI
50	D	10	12			C
					Terminated Boring at 51.5 feet depth. Groundwater encountered at 8.5 feet depth. Hammer Energy Ratio (ER=75%).	
55						
60						
65						
70						

LOG OF BORING NO. R-09-002

Grade Elevation:	+ 3.55 ft			
Boring Depth:	76.5 feet	Driller:	C&L Drilling Co.	SHEET 1 OF 3
Borehole Diameter:	5 inches	Type of Rig:	Mud Rotary	Comments: 1. Mayhew 1000 with rope and cat-head hammer
Date Drilled:	10-12-09	Drive Wt. (lbs):	140	2. 3.25" O.D. ring sampler
Logged By:	R.J	Drop (inches):	30	3. "A" Line STA 04+57.38 ±; 110.03RT ±

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
0						
5	D	1	42		CLAYEY SAND (SC): medium dense grayish brown, moist, trace fine GRAVEL, mostly fine to medium SAND, little non to low plasticity fines, weak cementation	M, UW
10	S	2	14		Poorly graded SAND with SILT (SP-SM): medium dense, gray, wet, 90% fine SAND, 10% nonplastic fines, trace mica, weak cementation	M, PA, CR
15	D	3	37			M, UW, DS
20	S	4	22		Poorly graded SAND (SP): medium dense, gray, wet, 97% fine SAND, 3% nonplastic fines, with shell fragments, weak cementation	PA
25	D	5	50/6"		Poorly graded SAND with SILT (SP-SM): very dense, gray, wet, mostly fine SAND, few nonplastic fines, with shell fragments, weak cementation	M, UW
30	S	6	30		becomes medium dense	
35						

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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 Date: 02-08-10

CONTINUED LOG OF BORING NO. R-09-002

Date Drilled: 10-12-09
Logged By: R.J
Comments:
1. Drillhole was backfilled with soil-cement mixture.
SHEET 2 OF 3

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
35	D	7	31		SILTY SAND (SM): medium dense, gray, wet, mostly medium to fine SAND, some nonplastic fines, trace mica and shell fragments, weak cementation	M, UW, DS
40	S	8	17		54% fine SAND, 46% fines	M, PA
45	D	9	25		SILT with SAND (ML): stiff, gray, wet, little fine SAND, low plasticity fines, trace mica	M, UW, C, PI
50	S	10	12		SANDY SILT (ML): stiff, gray, wet, 3% fine GRAVEL, 36% fine SAND, 61% low plasticity fines	M, PA
55	D	11	50/5"		SILTY SAND (SM): very dense, gray, wet, mostly fine SAND, little nonplastic fines, weak cementation	M, UW
60	S	12	27		SANDY SILT (ML): very stiff, gray, moist, some fine SAND, low plasticity fines, trace mica	M
65	D	13	89/11"		SILTY SAND (SM): very dense, gray, wet, mostly fine SAND, some nonplastic fines, weak cementation	
70	S	14	63		CLAYEY SAND (SC): very dense, gray, wet, mostly fine SAND, some low plasticity fines, weak cementation, with 8" lean CLAY layer	M, PI

CONTINUED LOG OF BORING NO. R-09-002

Date Drilled: 10-12-09

Logged By: R.J

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
75	S	15	31		SILT (ML): very stiff, gray, moist, 1% fine GRAVEL, 13% fine SAND, 86% low plasticity fines	M, PA
					Terminated Boring at 76.5 feet depth. Groundwater Table was not measured. Hammer Energy Ratio (ER=60%).	
80						
85						
90						
95						
100						
105						
110						

LOG OF BORING NO. R-09-038

Grade Elevation:	+ 8.80 ft MLLW				
Boring Depth:	120.5 feet	Driller:	C&L Drilling Co.	SHEET 1 OF 4	
Borehole Diameter:	5 inches	Type of Rig:	Mud Rotary	Comments: 1. Mayhew 1000 with rope and cat-head hammer 2. 3.25" O.D. ring sampler 3. "A" Line STA 01+86.19±; 80.30 RT±	
Date Drilled:	11-04-09	Drive Wt. (lbs):	140		
Logged By:	K.T/K.P	Drop (inches):	30		

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
0	B	0			SILTY SAND (SM): medium dense, moist, olive gray, 10% fine GRAVEL, 55% medium to fine SAND, 35% nonplastic fines, weak cementation	CR, CP, PA
5	S	2	21		mostly medium to fine SAND, somenonplastic fines	
10	D	2	60		Poorly SAND with SILT (SP-SM): dense, moist, olive gray, 95% medium to fine SAND, 5% nonplastic fines, weak cementation	M, UW, PA
15						
20	D	3	9		becomes loose, mostly fine SAND, few nonplastic fines	
25	S	4	38		becomes dense, gray, 88% fine SAND, 12% nonplastic fines	PA
30	D	5	18		SILTY SAND (SM): medium dense, moist, gray, mostly fine SAND, some nonplastic fines, weak cementation	M, DS
35						

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 Date: 02-08-10

CONTINUED LOG OF BORING NO. R-09-038

Date Drilled: 11-04-09	Comments:	SHEET 2 OF 4
Logged By: K.T/K.P	1. Drillhole was backfilled with soil-cement mixture.	

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
35	U	6			Fat CLAY (CH): medium stiff, gray, moist, 1% fine SAND, 99% high plasticity fines, PP=0.8 tsf	M, UW, UU, SG, PA, PI, PP
40	D	7-1 7-2	28		SILTY SAND (SM): medium dense, moist, 86% fine SAND, 14% nonplastic fines, trace shell fragments, weak cementation	M, UW, PA PI
					SANDY SILT (ML): very stiff, gray, moist, some fine SAND, nonplastic fines	
45	U	8			SILT with SAND (ML): stiff, gray, moist, 24% fine SAND, 76% low plasticity fines	M, UW, UU, SG, PA, PI, PP
50	S	9	12		SANDY SILT (ML): stiff, gray, moist, 42% fine SAND, 58% nonplastic fines	M, PA, PI
55	D	10-1 10-2	34			M, UW, C, PI M, UW
					SILTY SAND (SM): medium dense, moist, mostly fine SAND, some nonplastic fines, weak cementation	
60	U	11			SILT with SAND (ML): very stiff, dark gray, moist, 28% fine SAND, 72% low plasticity fines	M, UW, UU, SG, PA, PI, PP
65	S	12	24		SILT (ML): very stiff, gray, moist, 13% fine SAND, 72% nonplastic fines	M, PA, PI
70	D	13	94/10"		becomes hard	M, UW

CONTINUED LOG OF BORING NO. R-09-038

Date Drilled: 11-04-09
Logged By: K.T/K.P

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
75	S	14-1 14-2	24		Lean CLAY with SAND (CL): very stiff, moist, dark gray, trace fine SAND, mostly medium plasticity fines	M, Pi
					SILT with SAND (ML): very stiff, dark gray, moist, little fine SAND, moslty nonplastic fines	
80	D	15	50/5"		SANDY SILT (ML): hard, gray, moist, 41% fine SAND, 59% nonplastic fines	M, UW, PA, PI
85	S	16	83			
90	D	17	50/5"		Poorly graded SAND (SP): very dense, moist, gray, 96% medium to fine SAND, 4% low plasticity fines, weak cementation	M, UW, PA
95						
100	S	18	54		SILTY SAND (SM): very dense, moist, mostly medium to fine SAND, little nonplastic fines, weak cementation	
105						
110	S	19	73		81% medium to fine SAND, 19% nonplastic fines	M, PA

CONTINUED LOG OF BORING NO. R-09-038

Date Drilled: 11-04-09

Logged By: K.T/K.P

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION
115					
120	S	20	REF/6"		No Recovery
					Terminated Boring at 120.5 feet depth.
					Groundwater encountered at 6.5 feet depth.
					Hammer Energy Ratio (ER=60%).
125					
130					
135					
140					
145					
150					

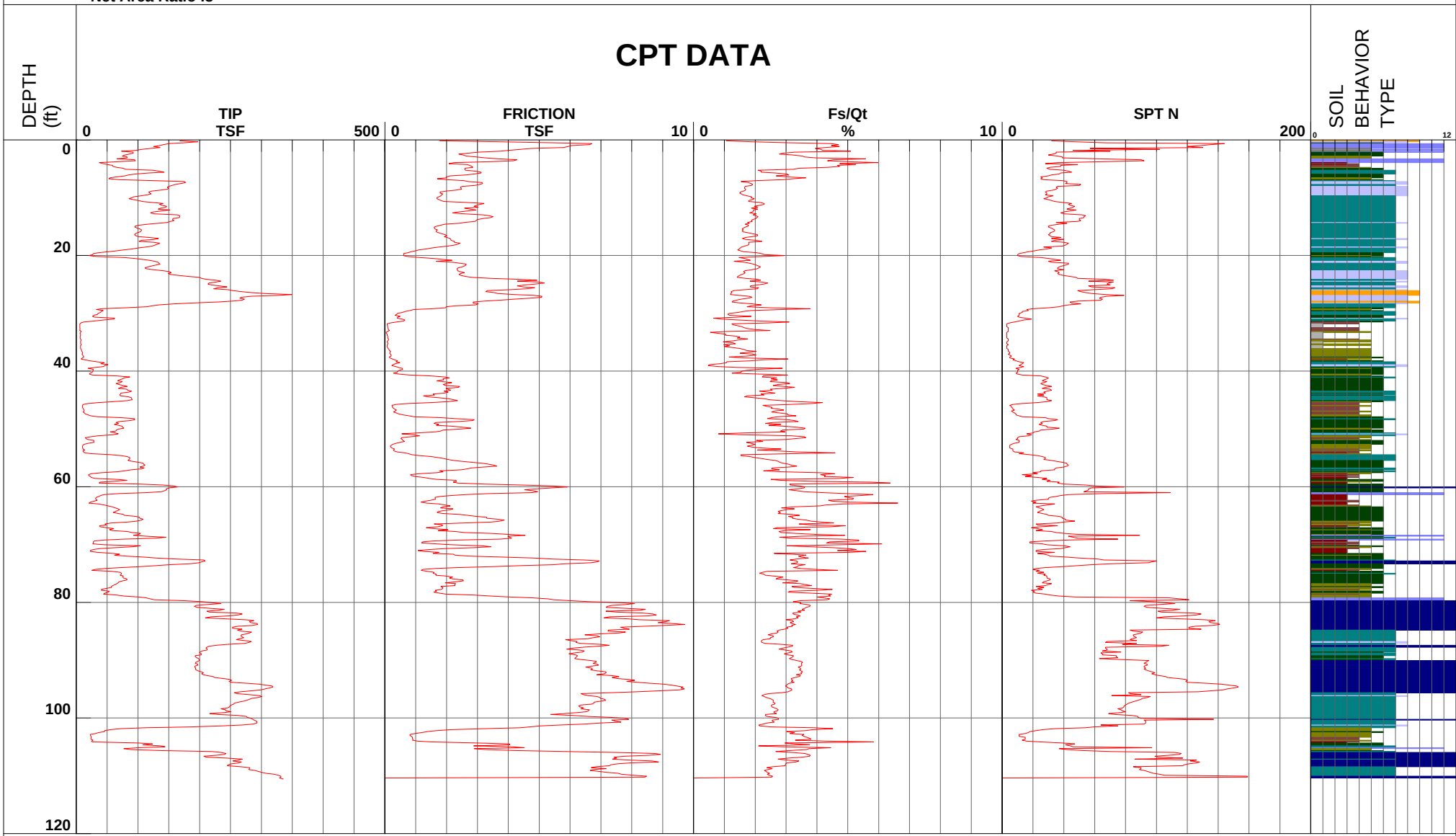
SITE-SPECIFIC CPT SOUNDING LOG

Earth Mechanics

Project	Schuyler Heim Bridge	Operator	DK-ML	Filename	SDF(297).cpt
Job Number	06-123	Cone Number	DSG1023	GPS	
Hole Number	C-09-095	Date and Time	10/20/2009 7:07:16 AM	Maximum Depth	110.56 ft
Water Table Depth	10.00 ft				

Net Area Ratio .8

CPT DATA



1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

Cone Size 10cm squared

*Soil behavior type and SPT based on data from UBC-1983

APPENDIX C. EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

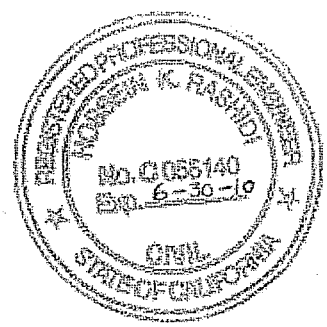
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

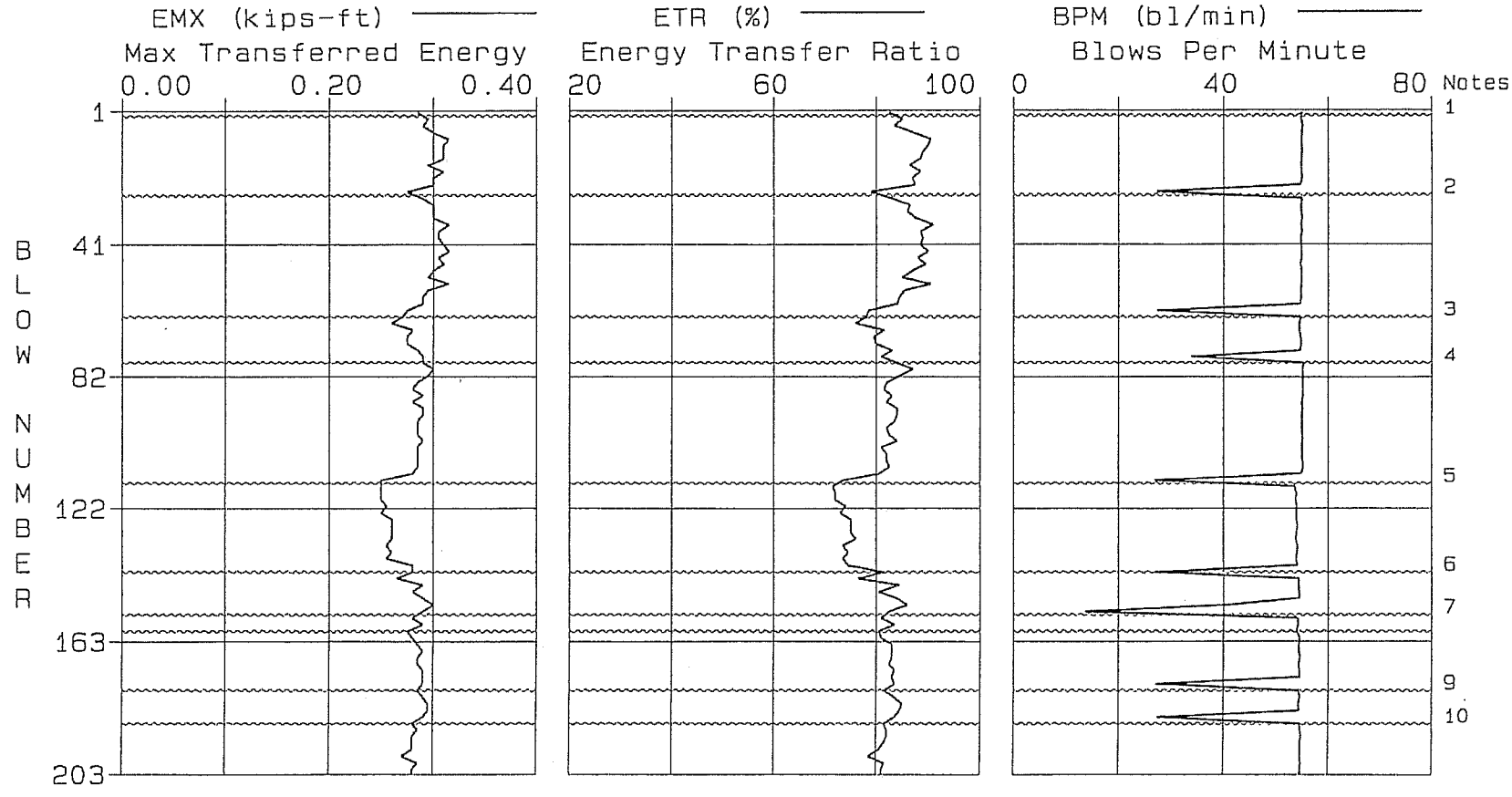
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

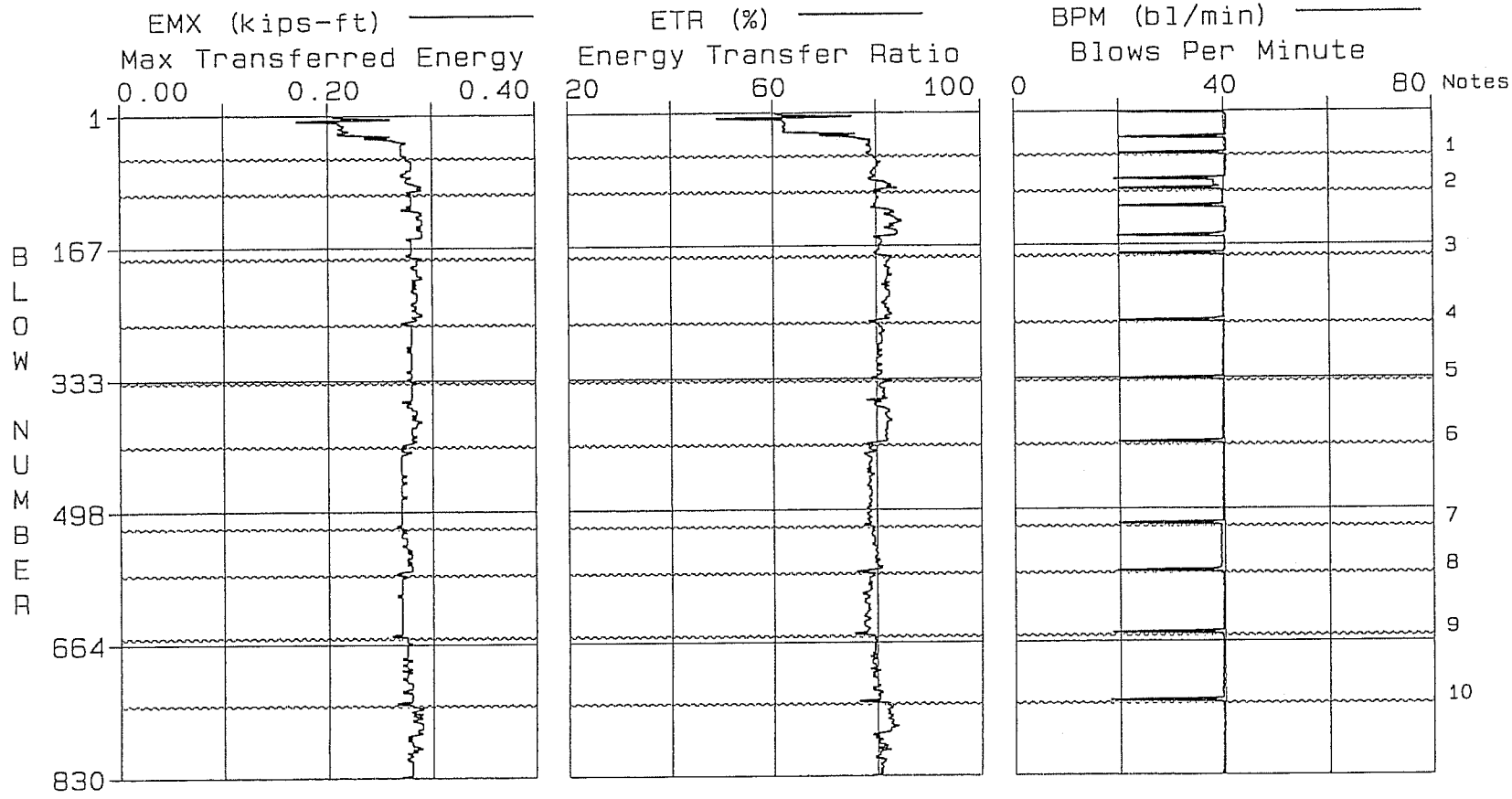
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

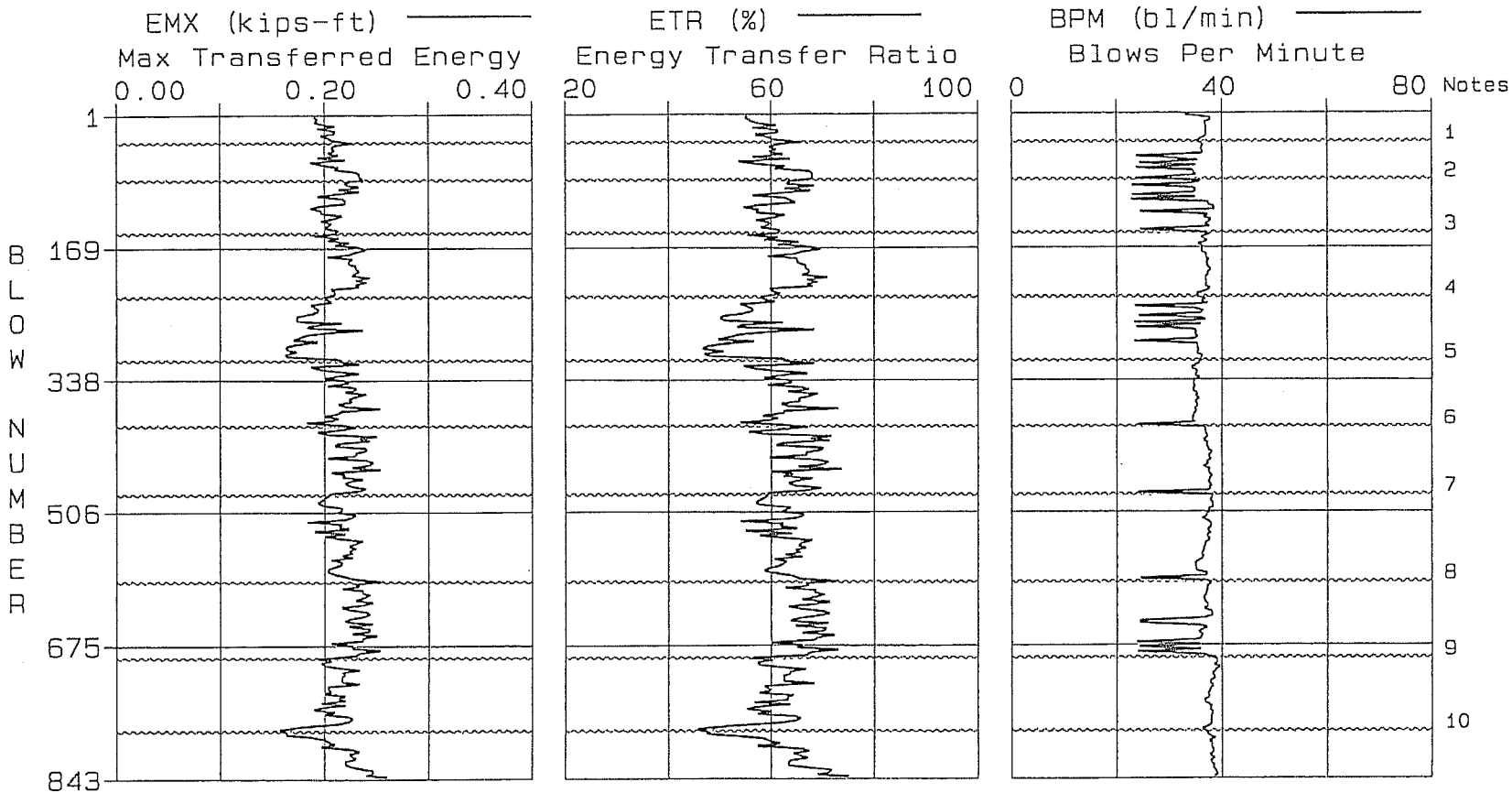
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX D. GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

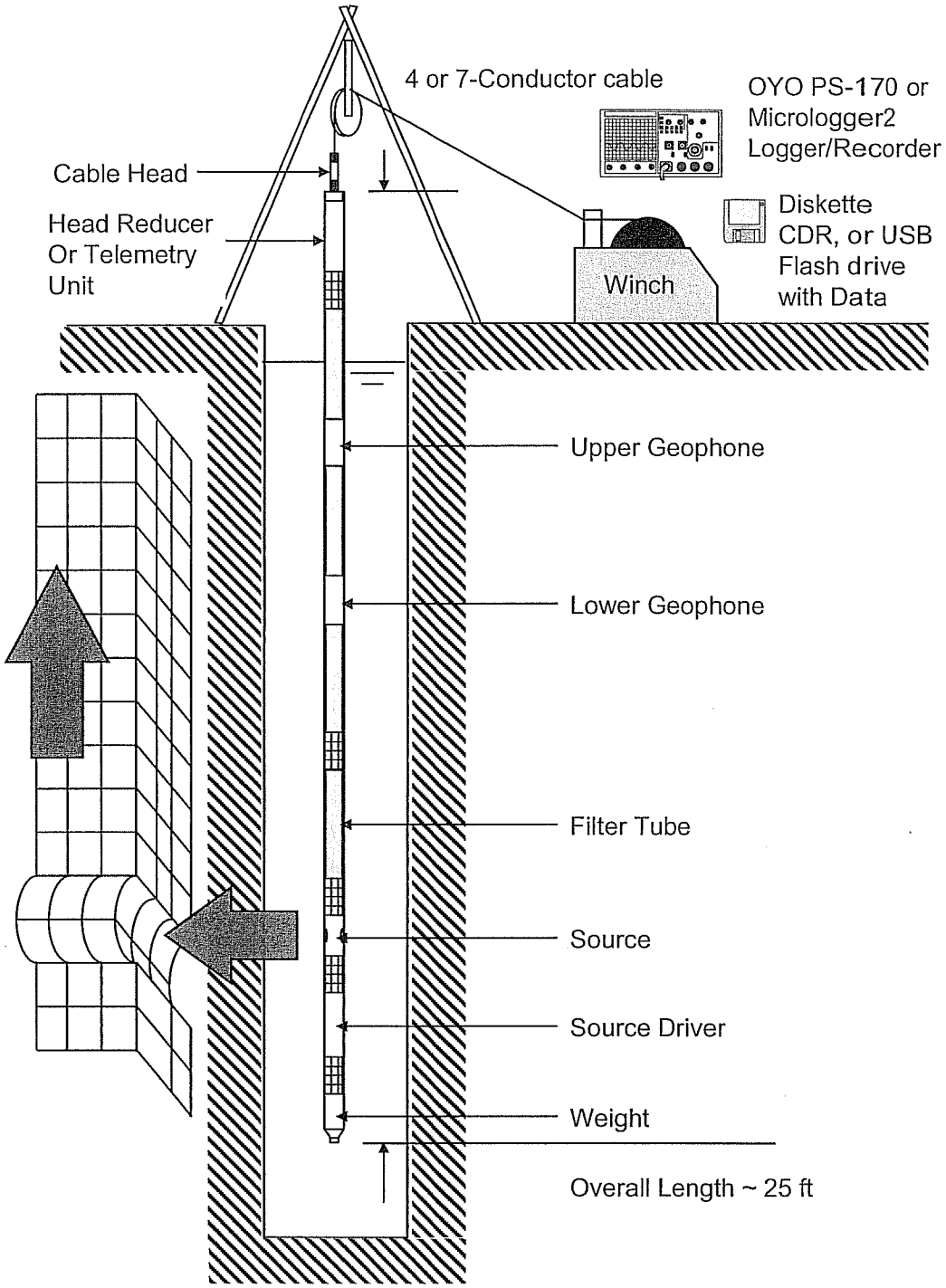

Figure 1: Concept illustration of P-S logging system

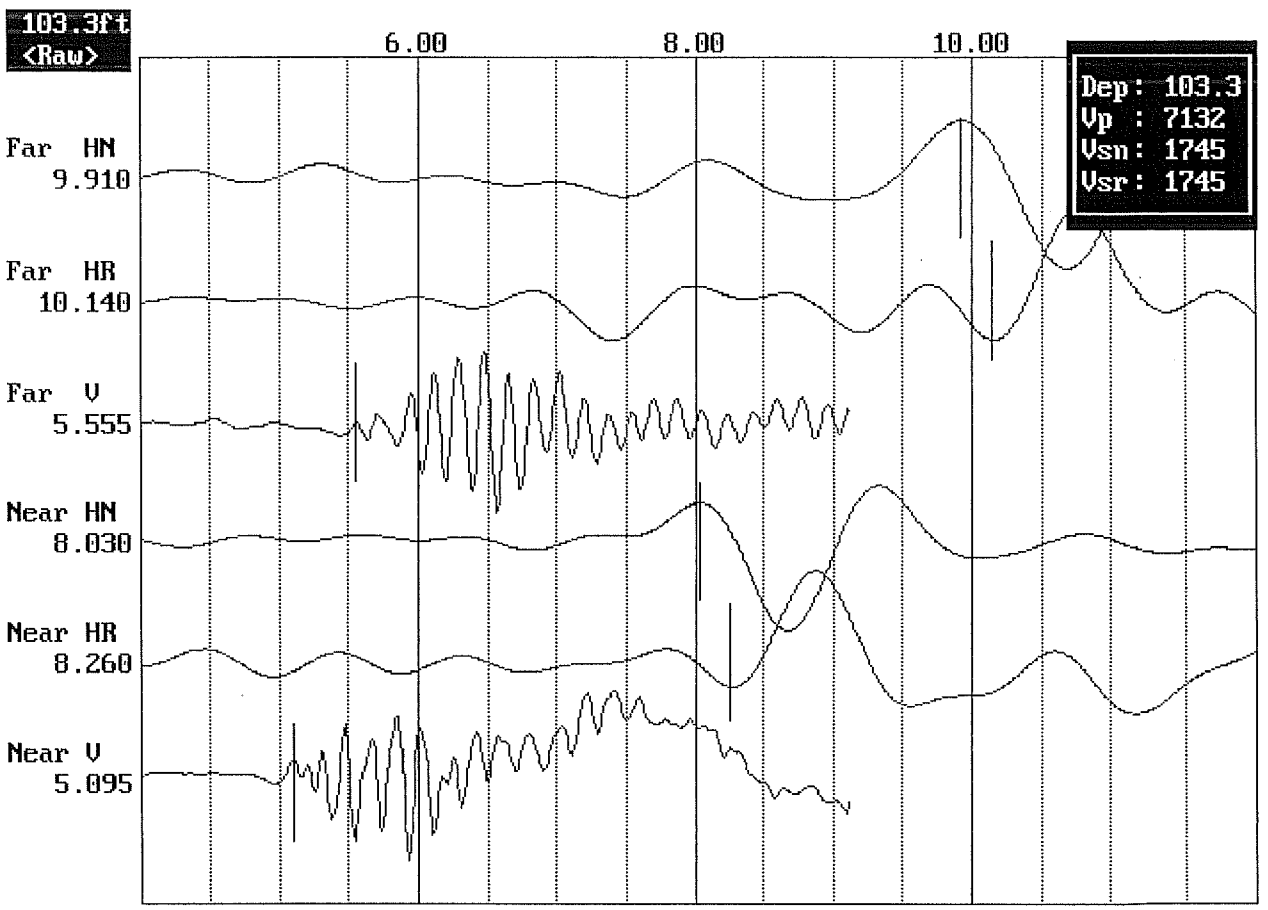

Figure 2: Example of filtered (1400 Hz lowpass) record

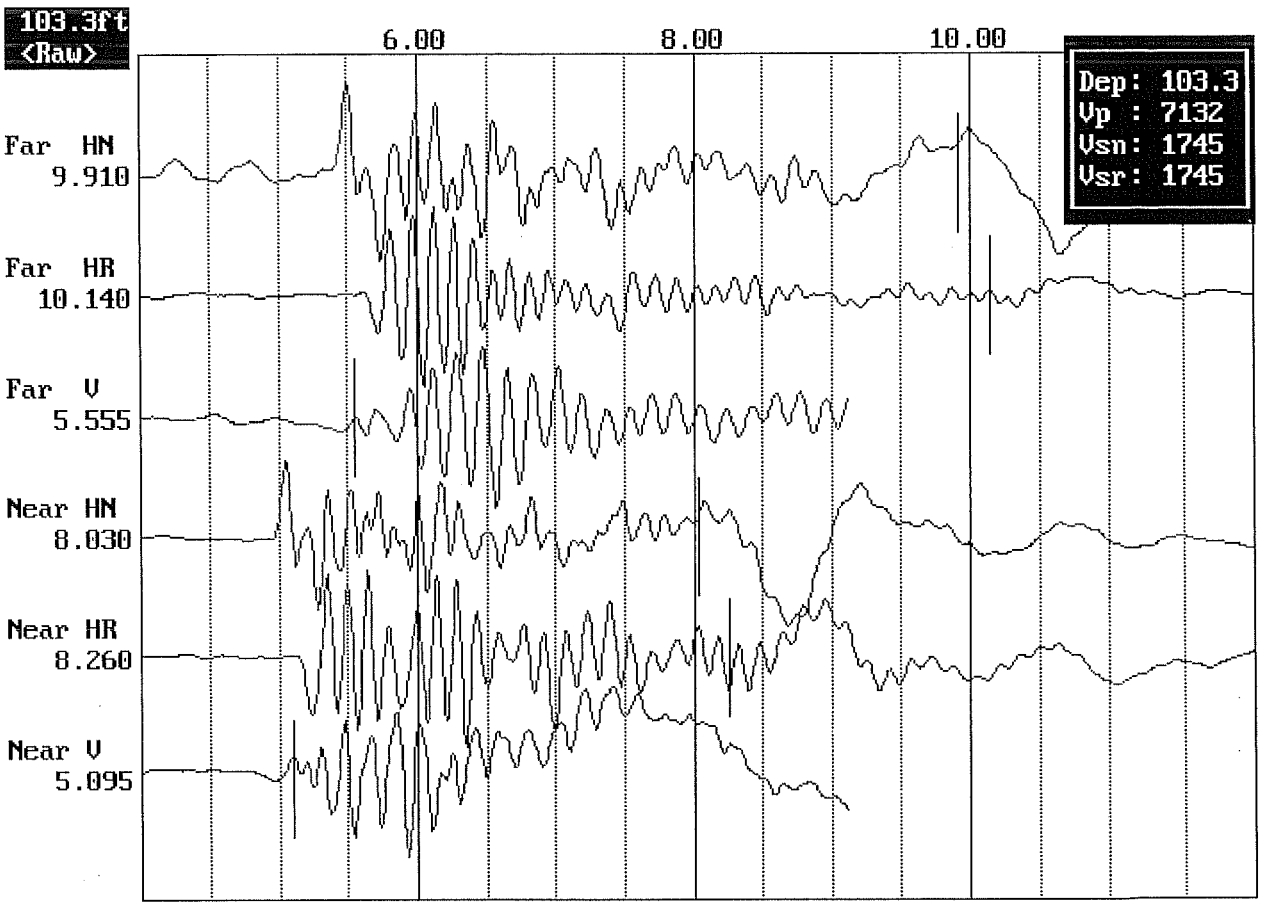

Figure 3. Example of unfiltered record

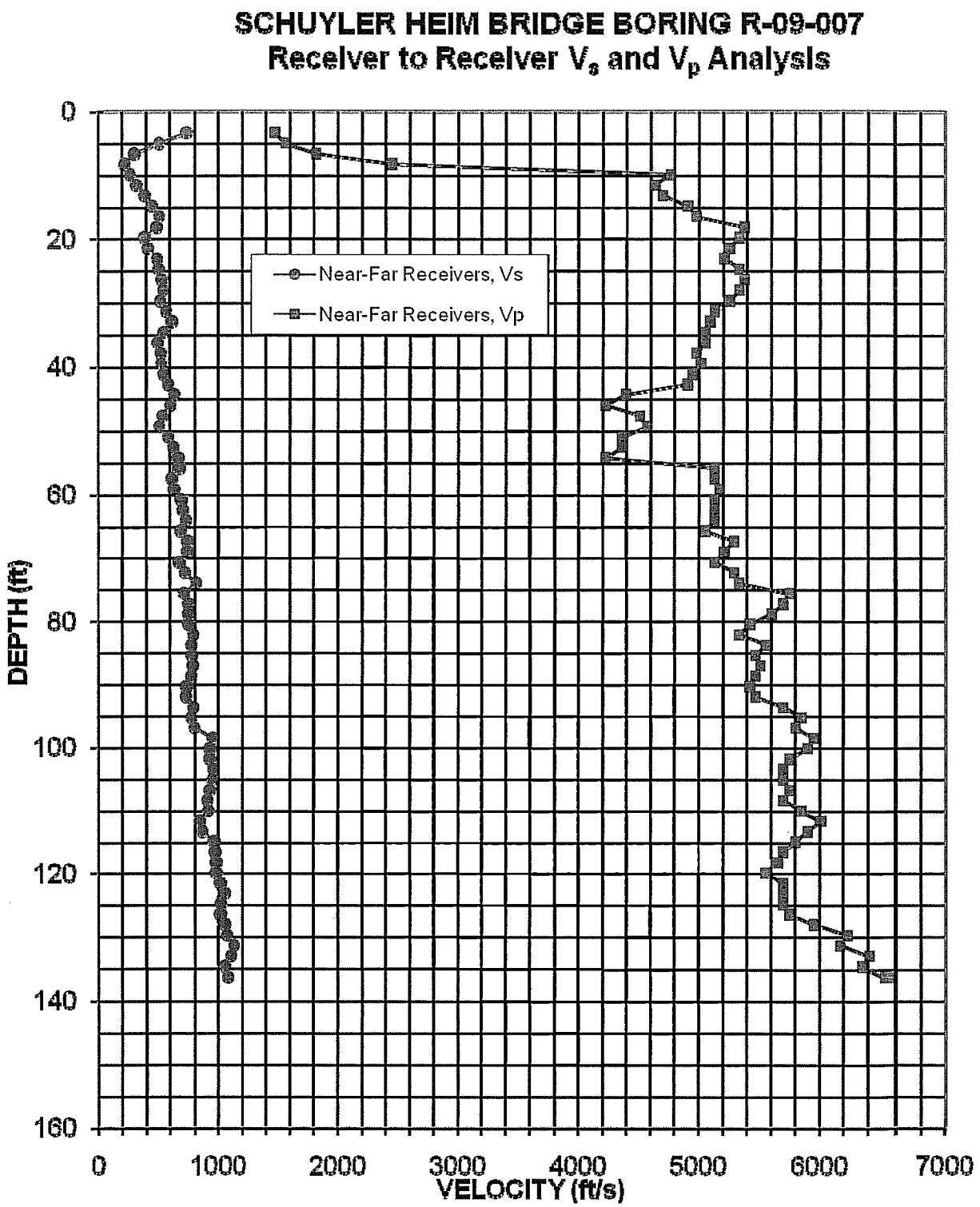

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

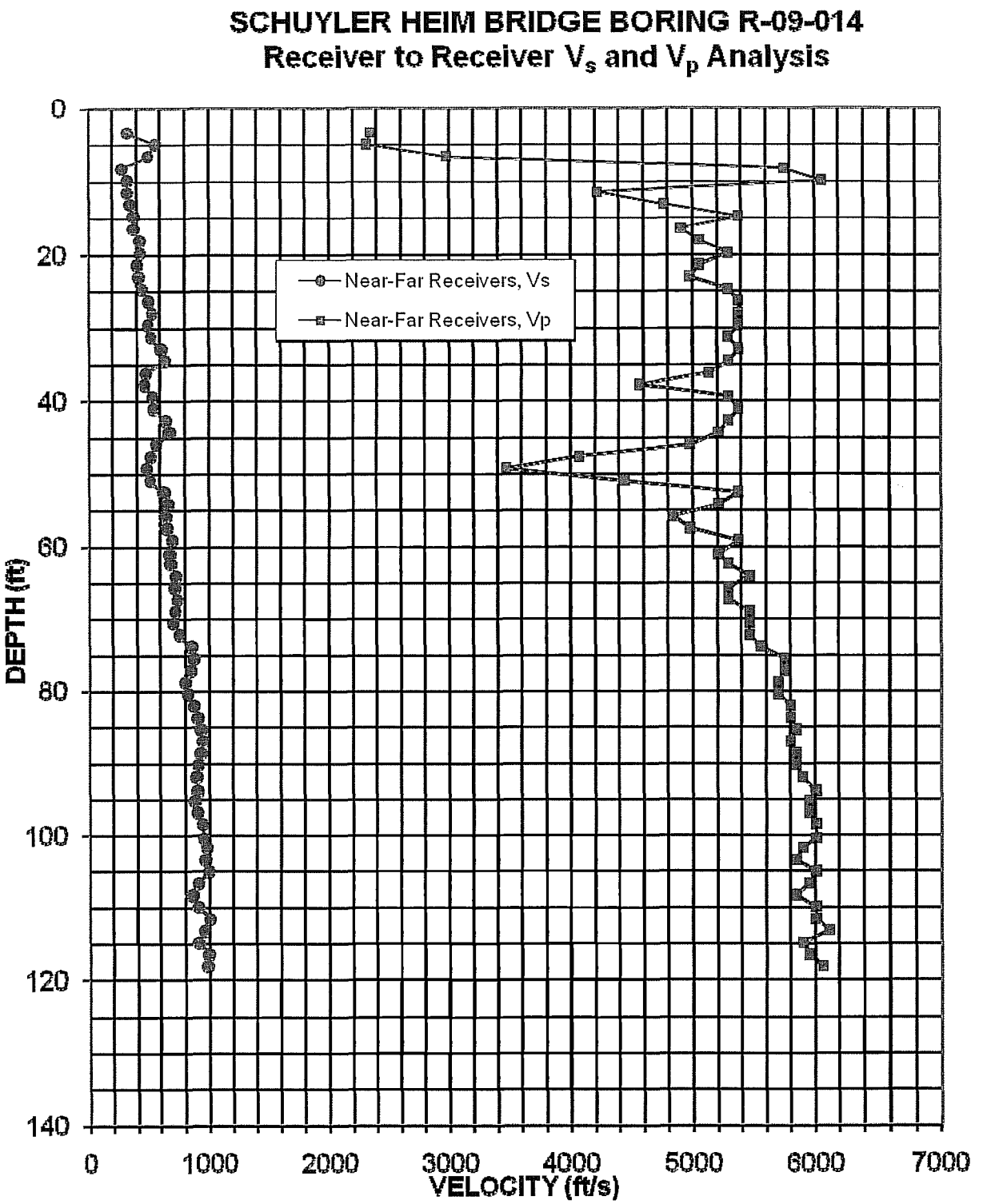

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

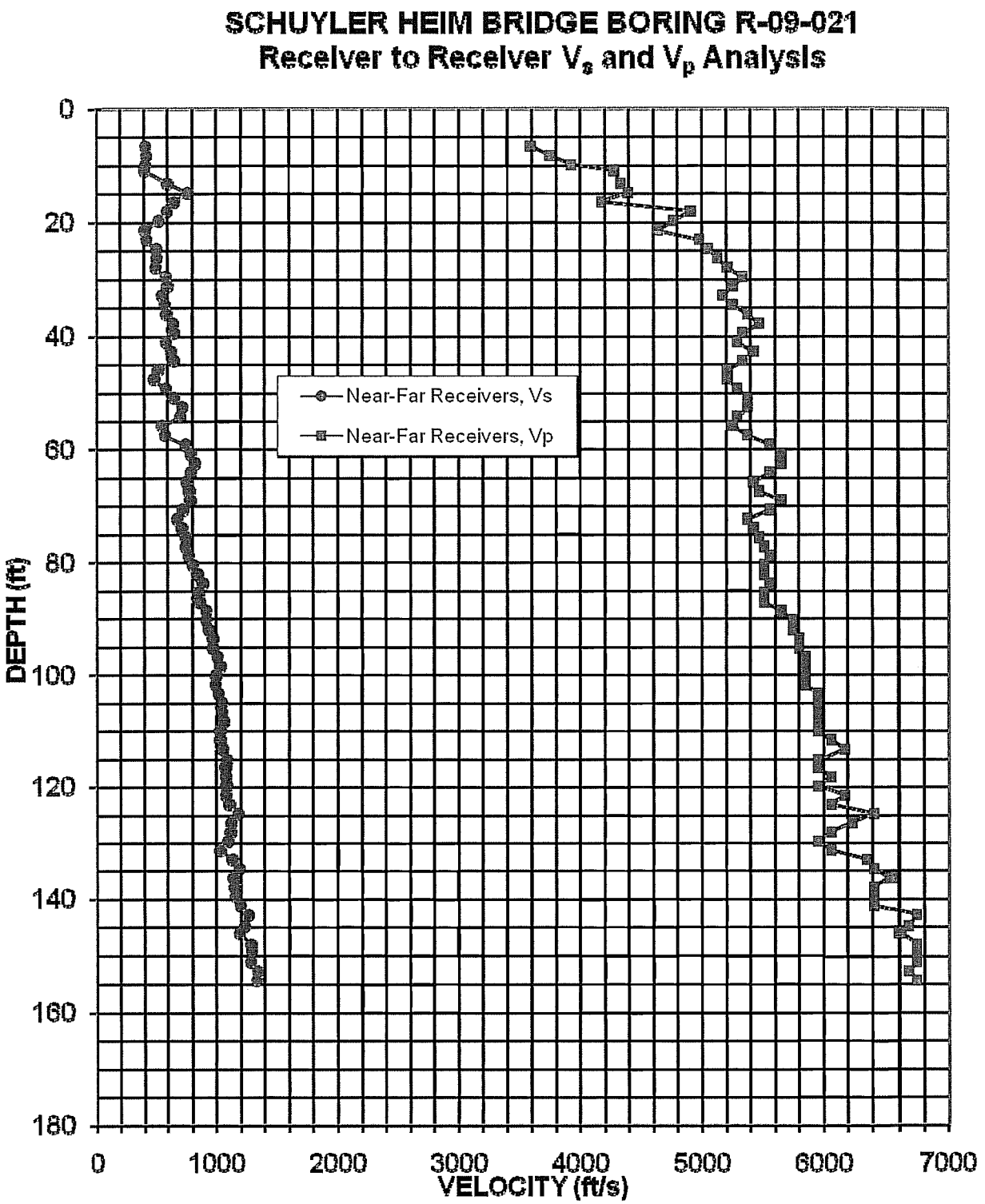

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

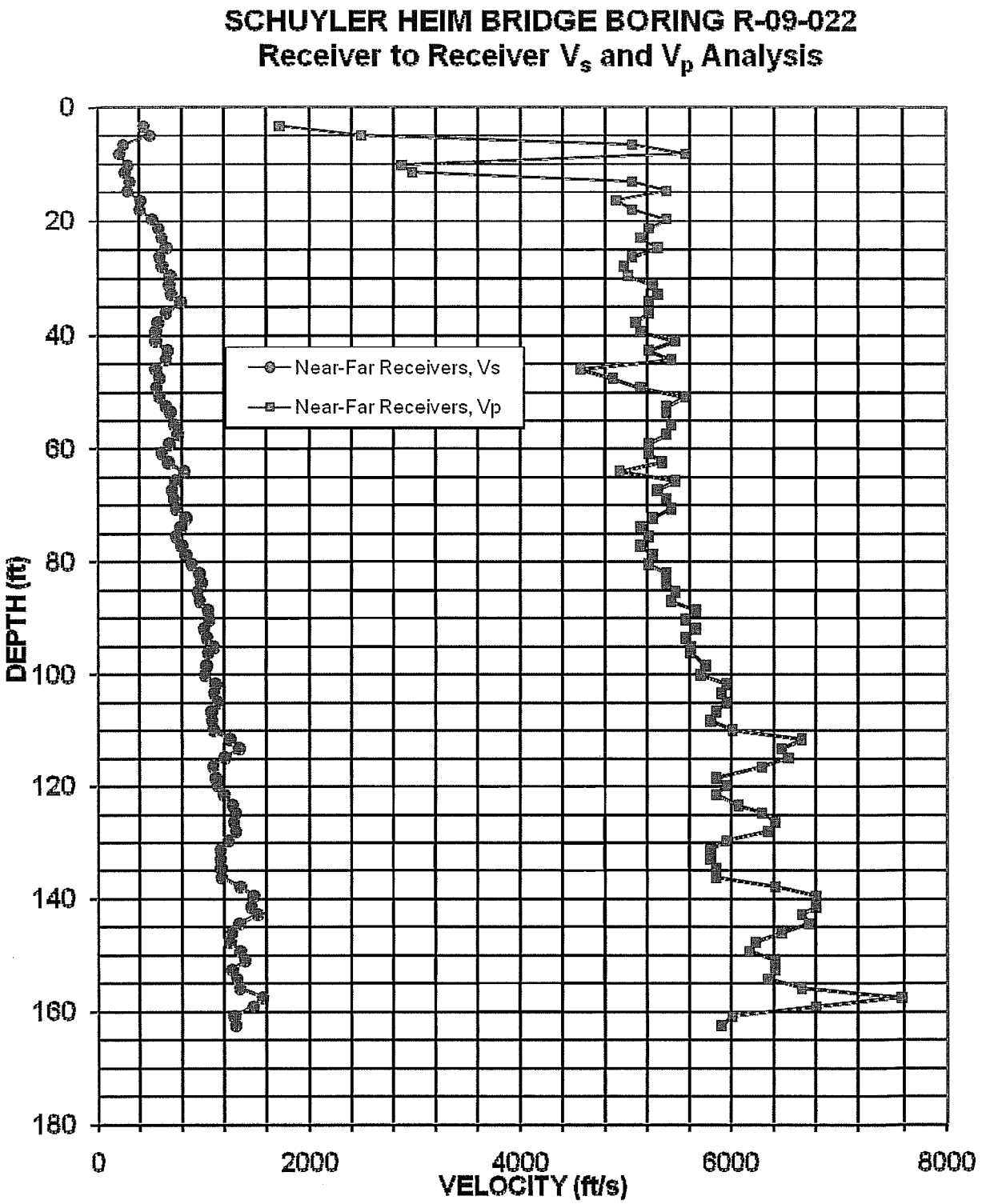

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

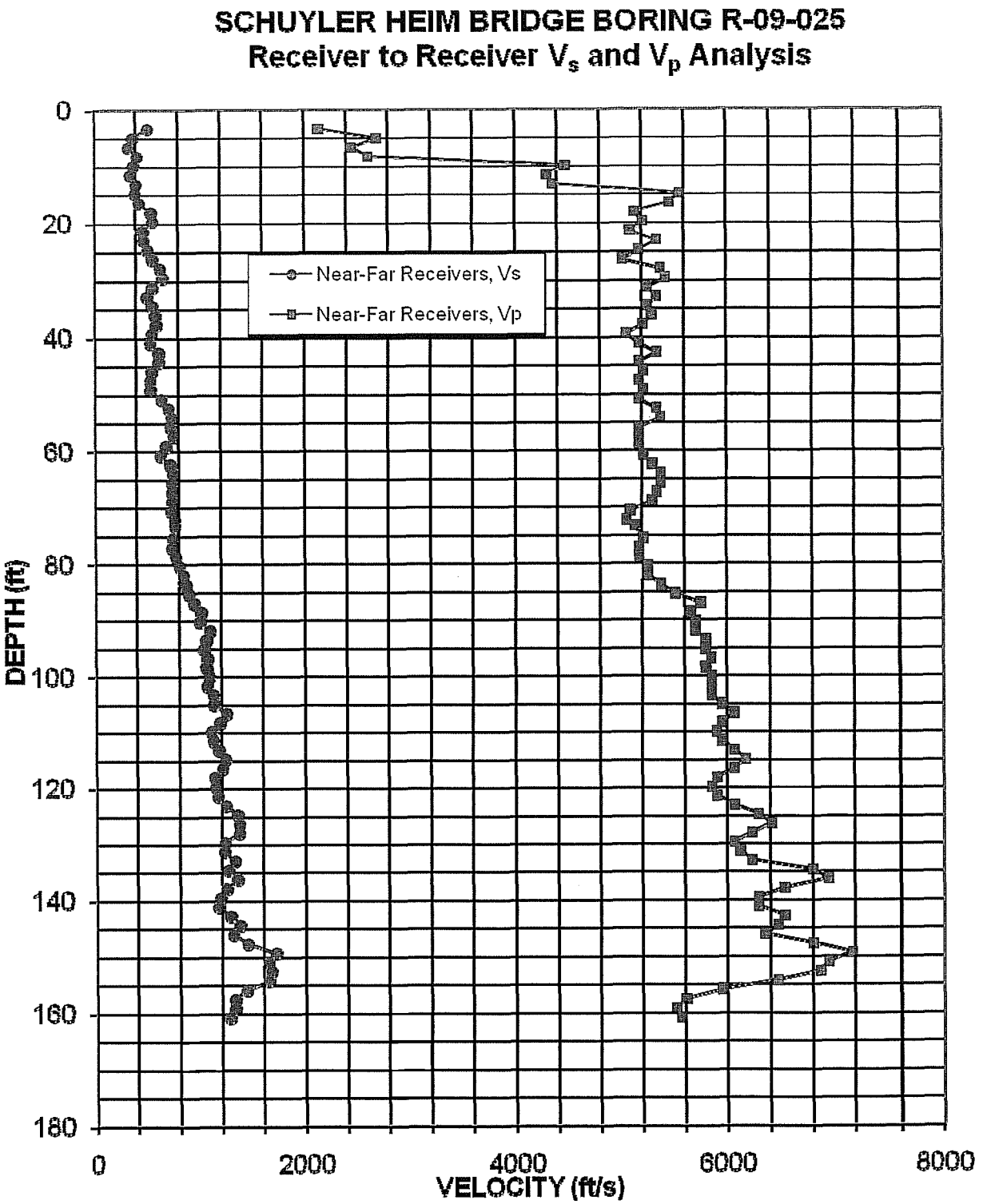

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

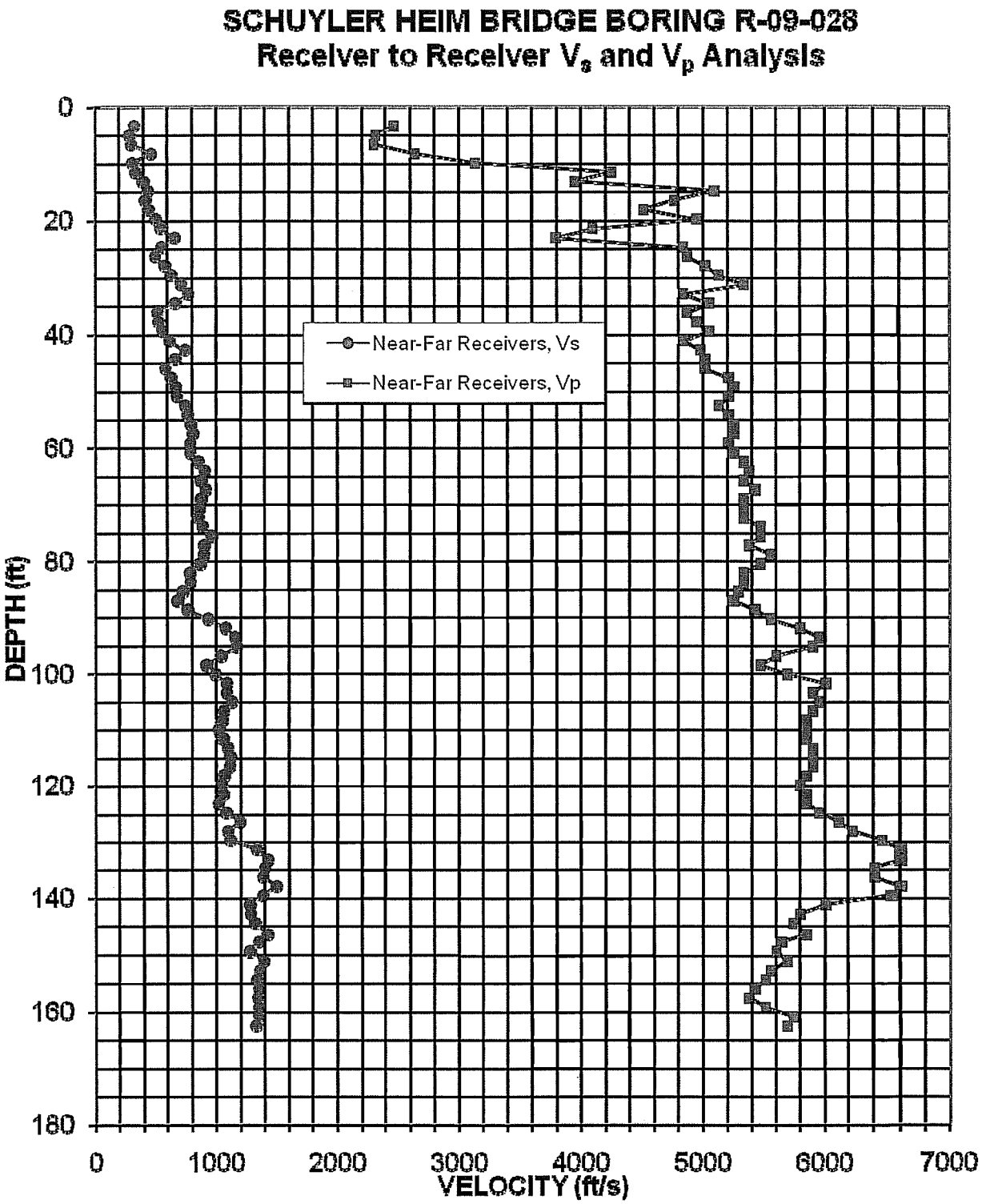

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

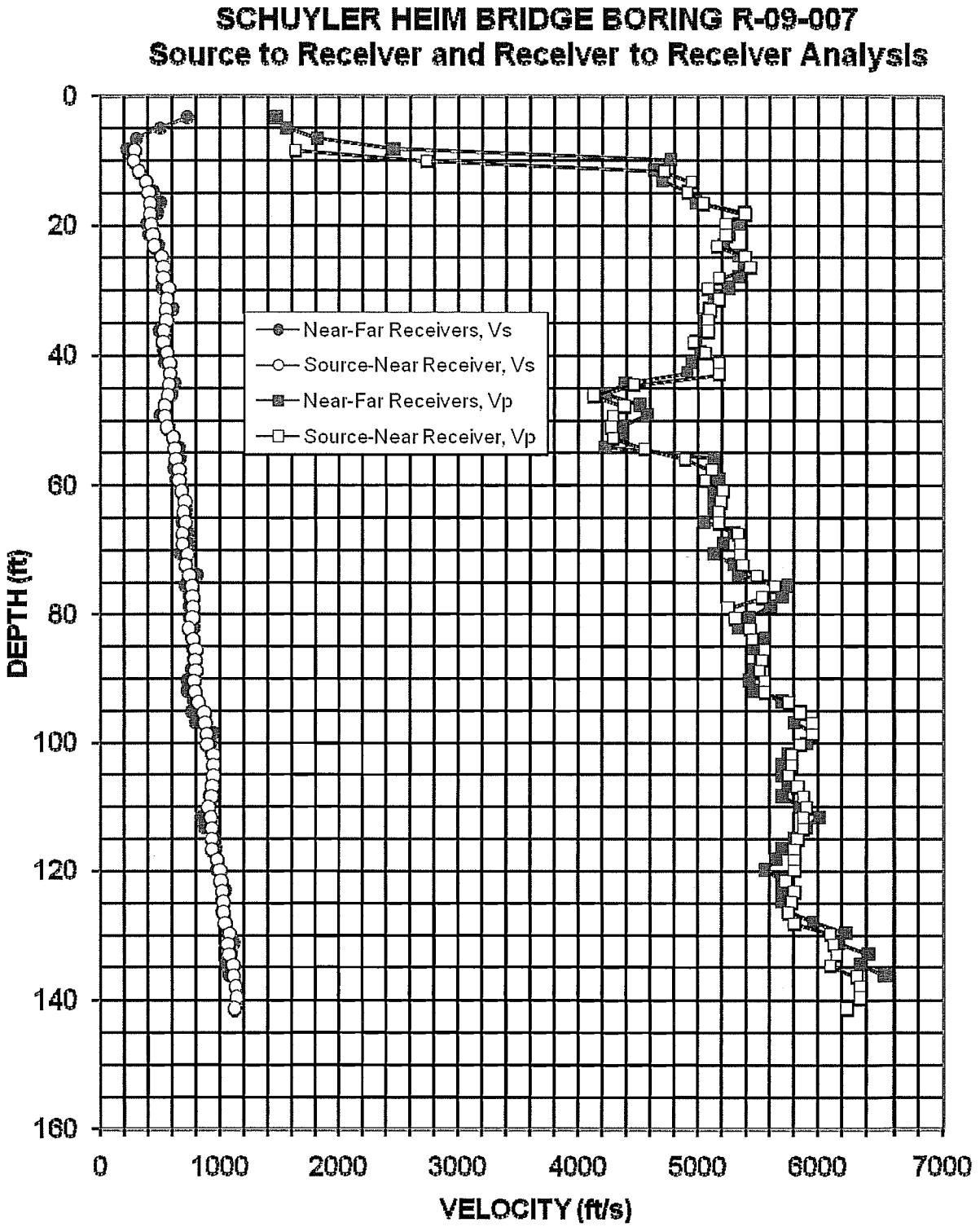

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

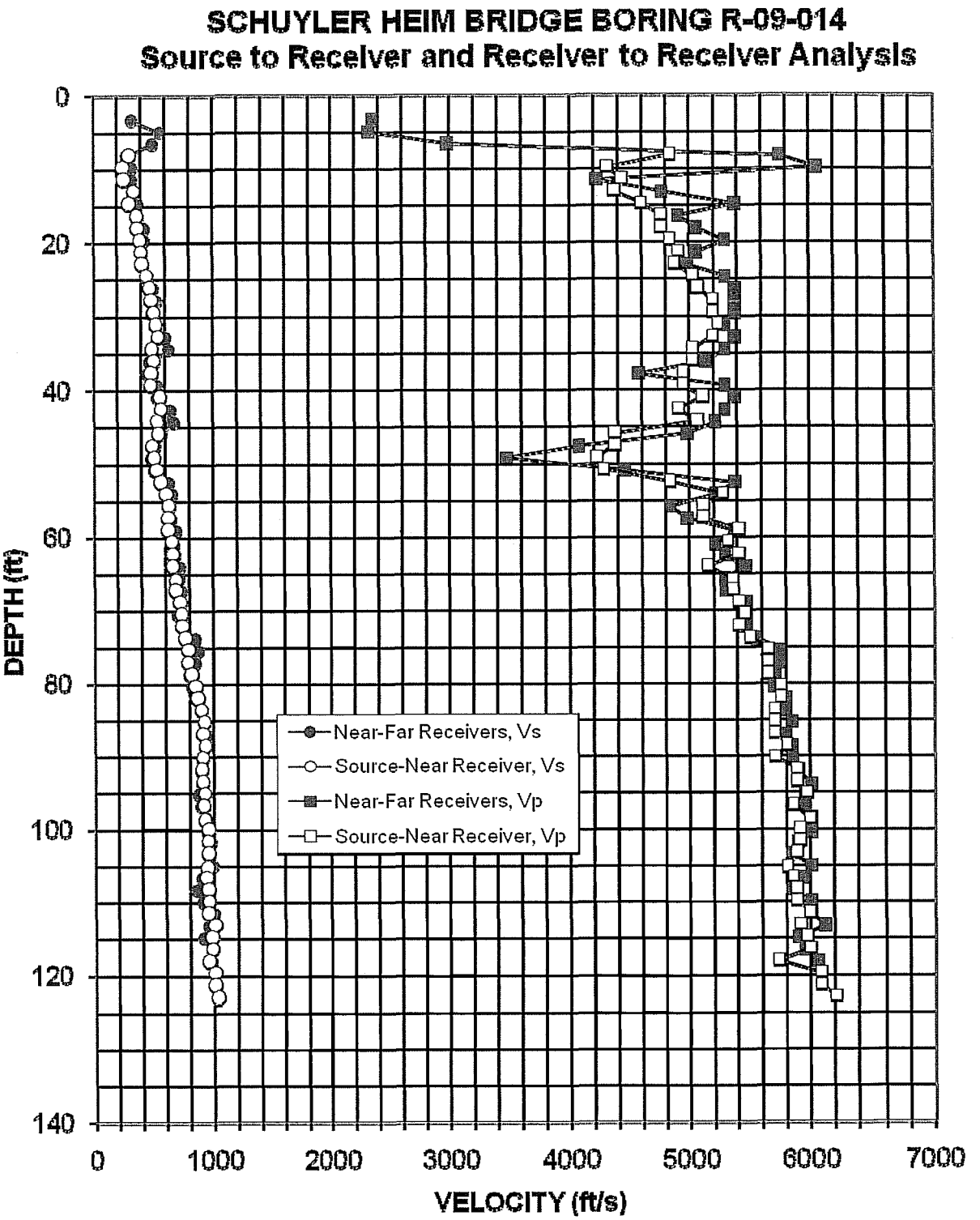

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

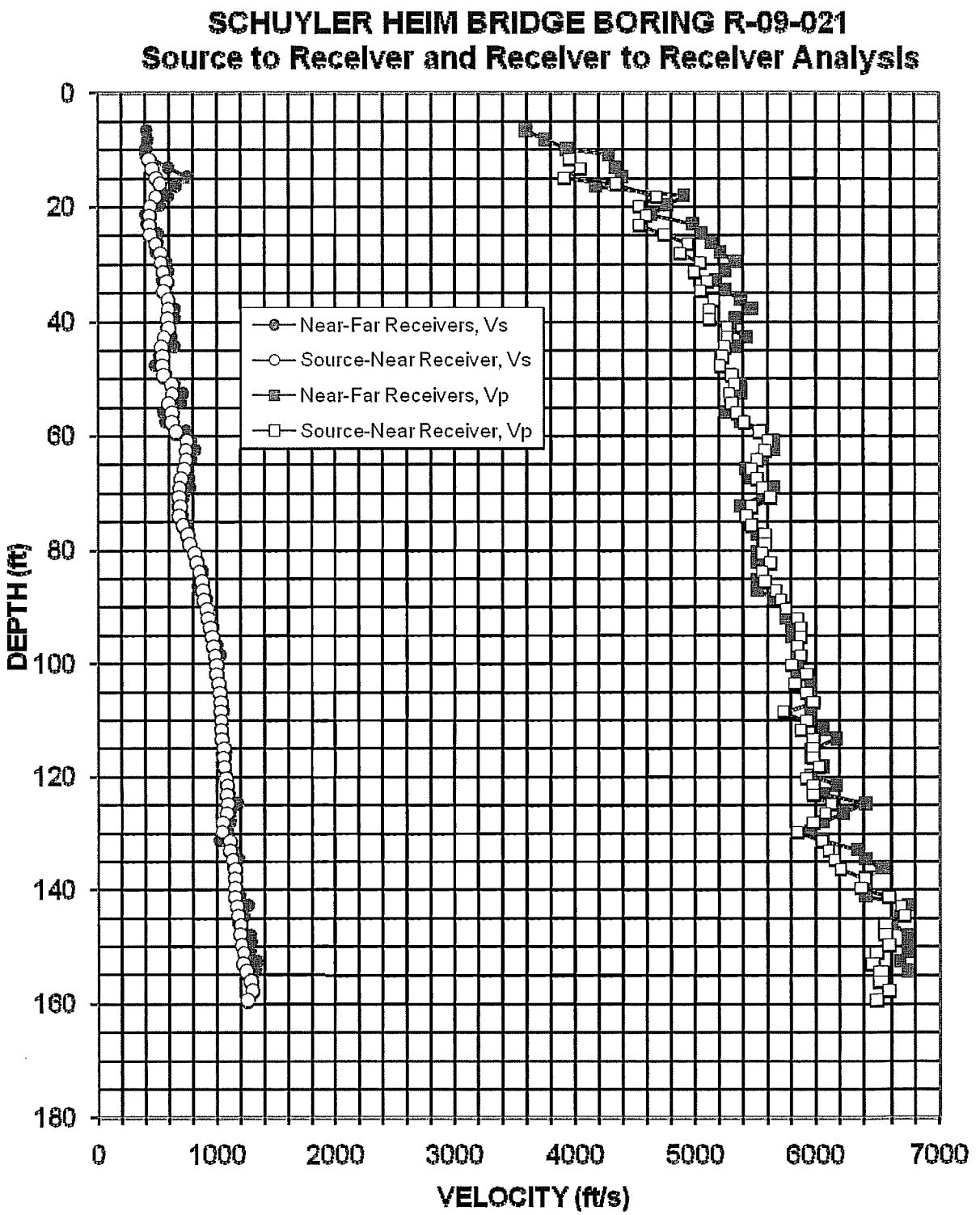

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

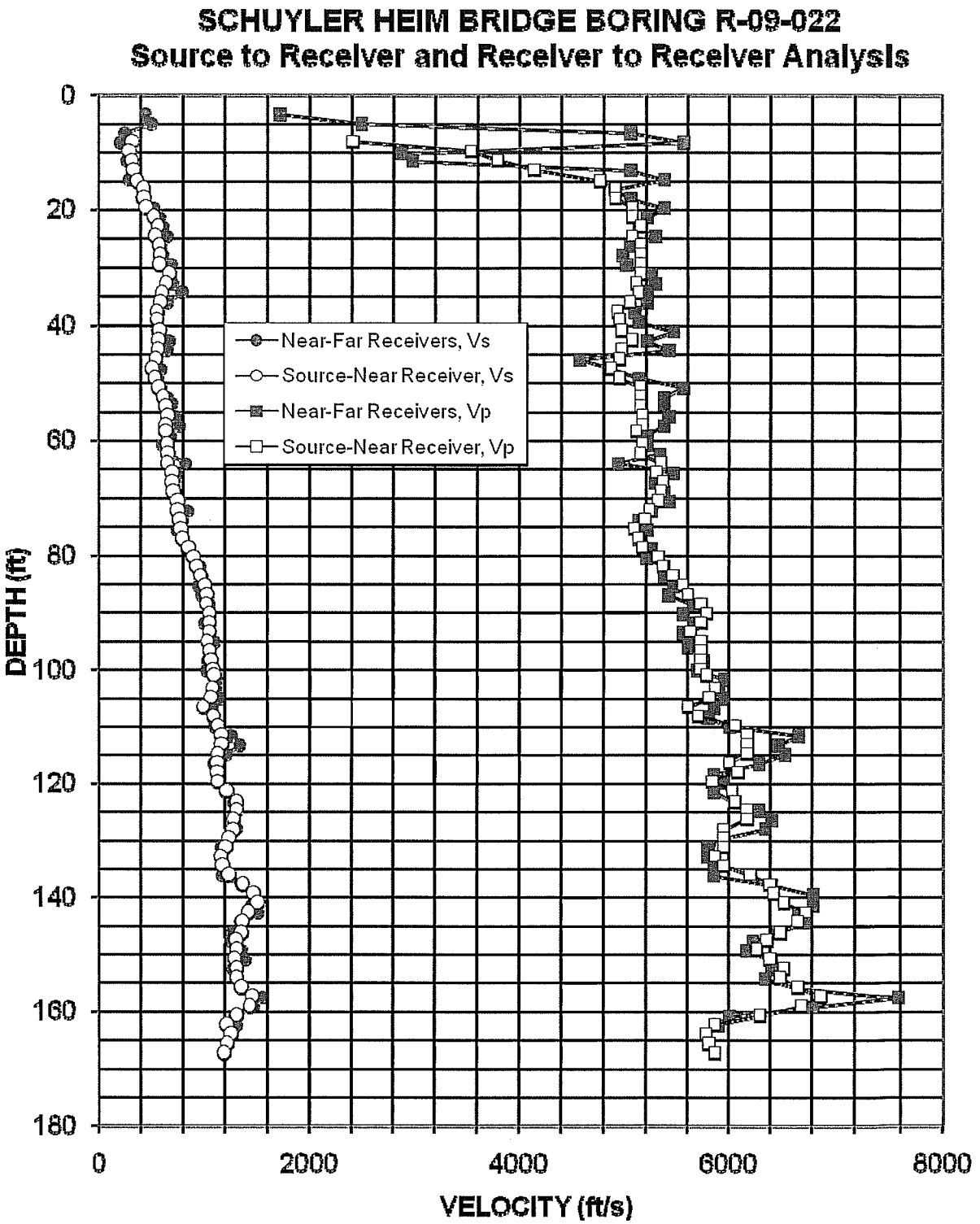

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

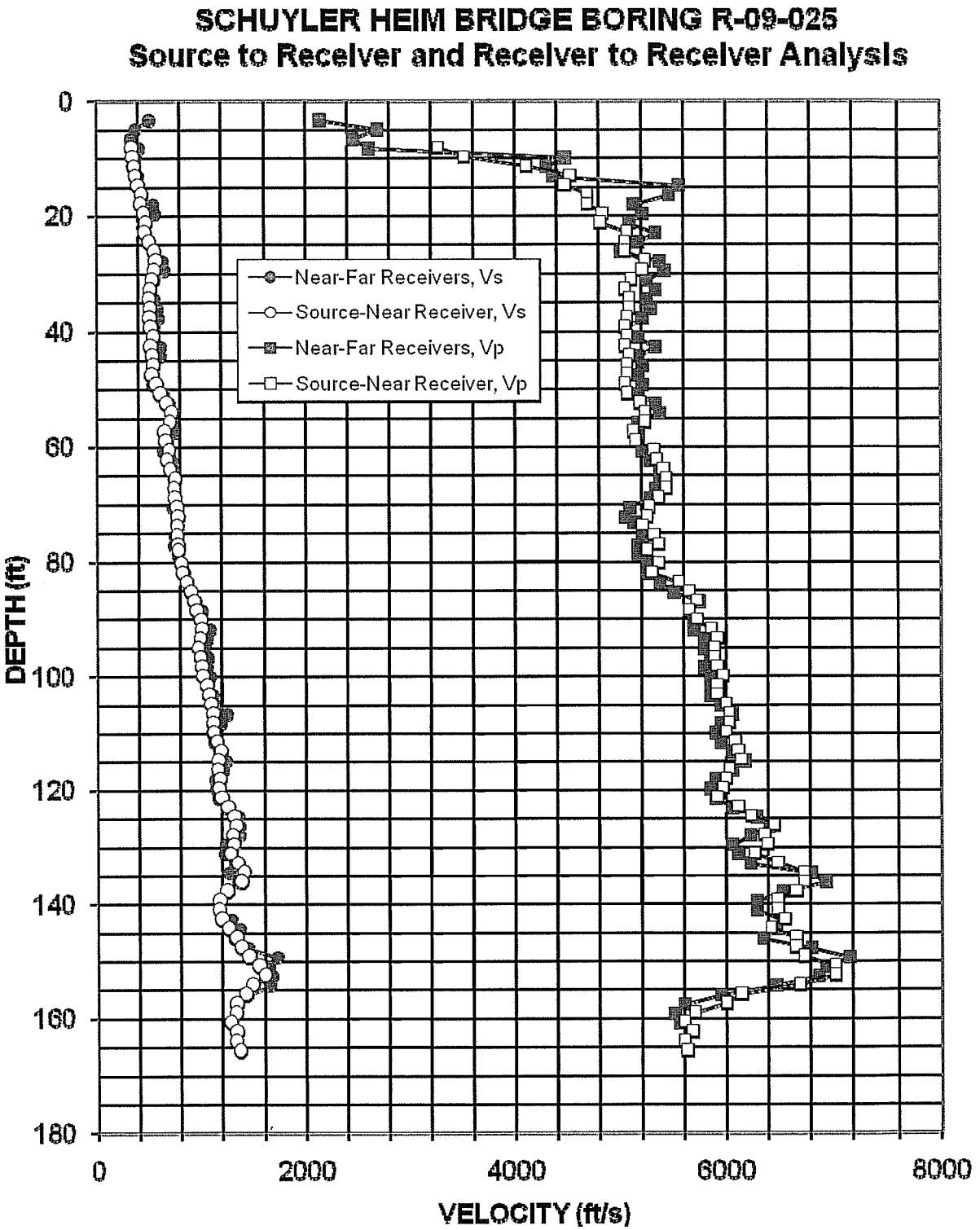

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

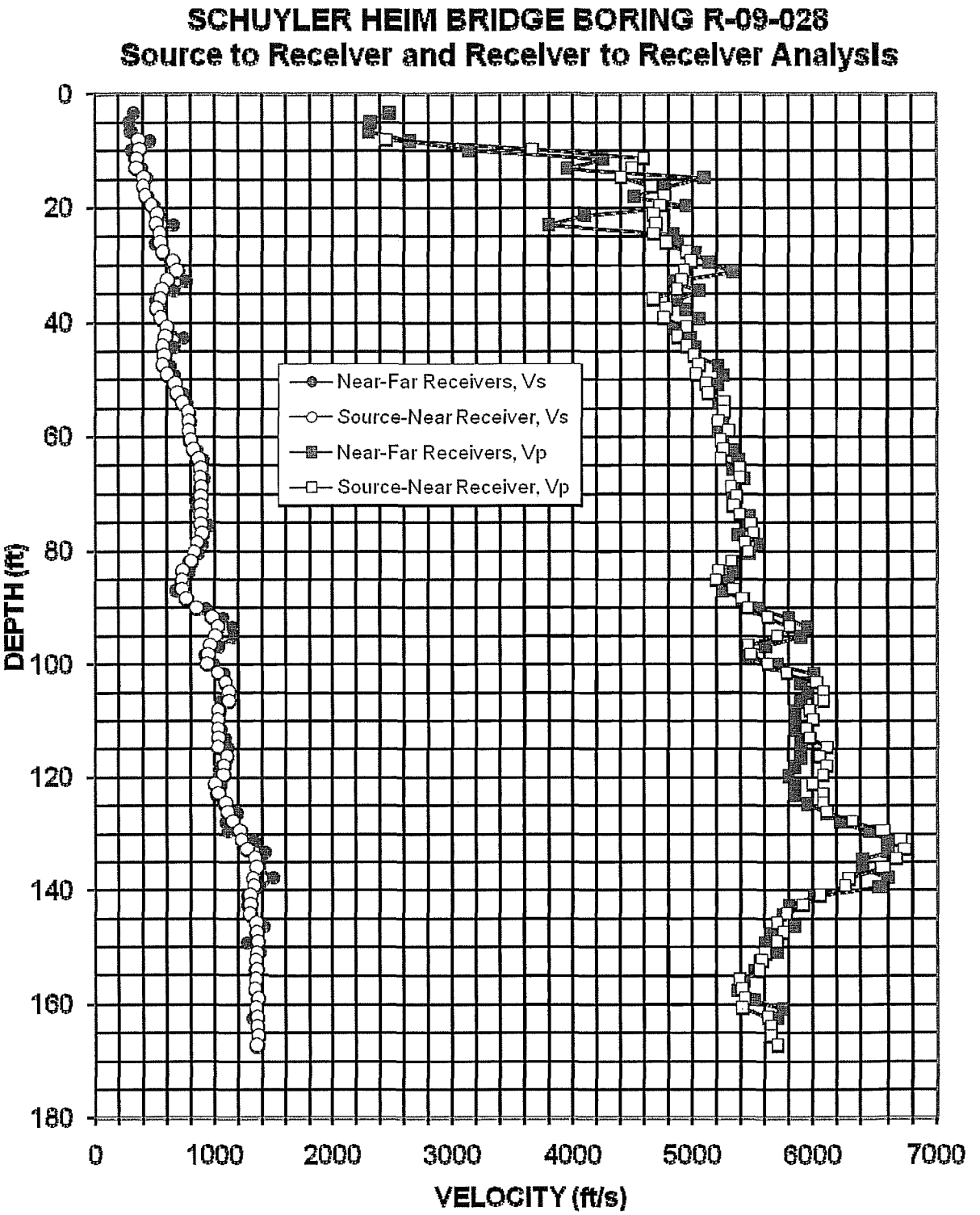

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
		2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No:	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 ~~160024~~ CH2
573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX E. LABORATORY SOIL TEST RESULTS

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No .	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil- Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil- Soluble Sulfate Content CT-417 (ppm)	Soil- Moisture Free Chloride Content CT-422 (ppm)
A-09-051	S-1	5	SM	11.3				1:75:24			2000	8.4	300	400
A-09-051	D-2	10	SM	24.1	127.8									
A-09-051	S-3	15	SM					0:82:18						
A-09-051	D-4	20	SM	22.6	127.5									
A-09-051	S-5	25	SP-SM					0:94:6						
A-09-051	D-6	30	ML	22.8	125.9					N.P				
A-09-051	D-7	35	ML							N.P				
A-09-051	D-8	40	ML	26.0	124.5					N.P				
A-09-051	S-9	45	ML	30.8				0:43:57		28/24/4				
A-09-051	D-10	50	ML	26.7	122.5									
A-09-052	S-1	5	SP-SM					1:94:5			1400	8.4	20	873
A-09-052	S-3	15	SP	21.6				0:99:1						
A-09-052	D-4	20	SP-SM	22.7	125.4									
A-09-052	S-5	25	SM	27.8										
A-09-052	D-6	30	CL					0:38:62		41/24/17				
A-09-052	S-7	35	ML	33.5						49/30/19				
A-09-052	S-9	45	ML	31.0				0:45:55		26/26/0				
A-09-052	D-10	50	SM			<0.25		0:70:30						
A-09-053	S-1	5	SM					20:49:31			430	7.8	730	1809
A-09-053	D-2	10	SP-SM	27.4	124.5									
A-09-053	S-3	15	SP	24.5				0:97:3						
A-09-053	D-4	20	SM	19.5	127.8									
A-09-053	S-5	25	SP-SM	26.2				0:95:5						
A-09-053	S-7	35	ML	32.7				0:13:87		42/27/15				
A-09-053	S-9	45	ML	29.9				0:7:93		46/29/17				
A-09-054	S-1	5	ML					0:45:55			780	7.9	420	817
A-09-054	S-3	15	SP	27.3				0:98:2						
A-09-054	S-5	25	SP	22.0				0:98:2						
A-09-054	S-7	35	ML	30.7				0:30:70		28/24/4				
A-09-054	D-8	40	ML			1.25								
A-09-054	S-9	45	ML	42.8						N.P.				
A-09-054	D-10	50	ML					0:10:90		41/26/15				

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 1

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-051
Sample No. : D-8
Depth (ft / m) : 40.0 | 12.20
File No. :
Soil Description : Dark gray, SANDY SILT (ML)

Set up By : J.F Date : 11/13/2009
Tested By : J.F/R.J. Date : 11/13/09-11/23/09
Time Rate Took By : J.F Date : 11/16/09,11/18/09
Computer By : JF Date : 11/24/2009
Checked By : R.J. Date :

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)
Internal Diameter	2.42	61.47
Height (Intial)	1.00	25.40
Height (Final)	0.9537	24.22

	(ksf)	(kPa)
Vertical Load		
Add Water at	0.50	23.94
Load to	16.00	766.08
Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

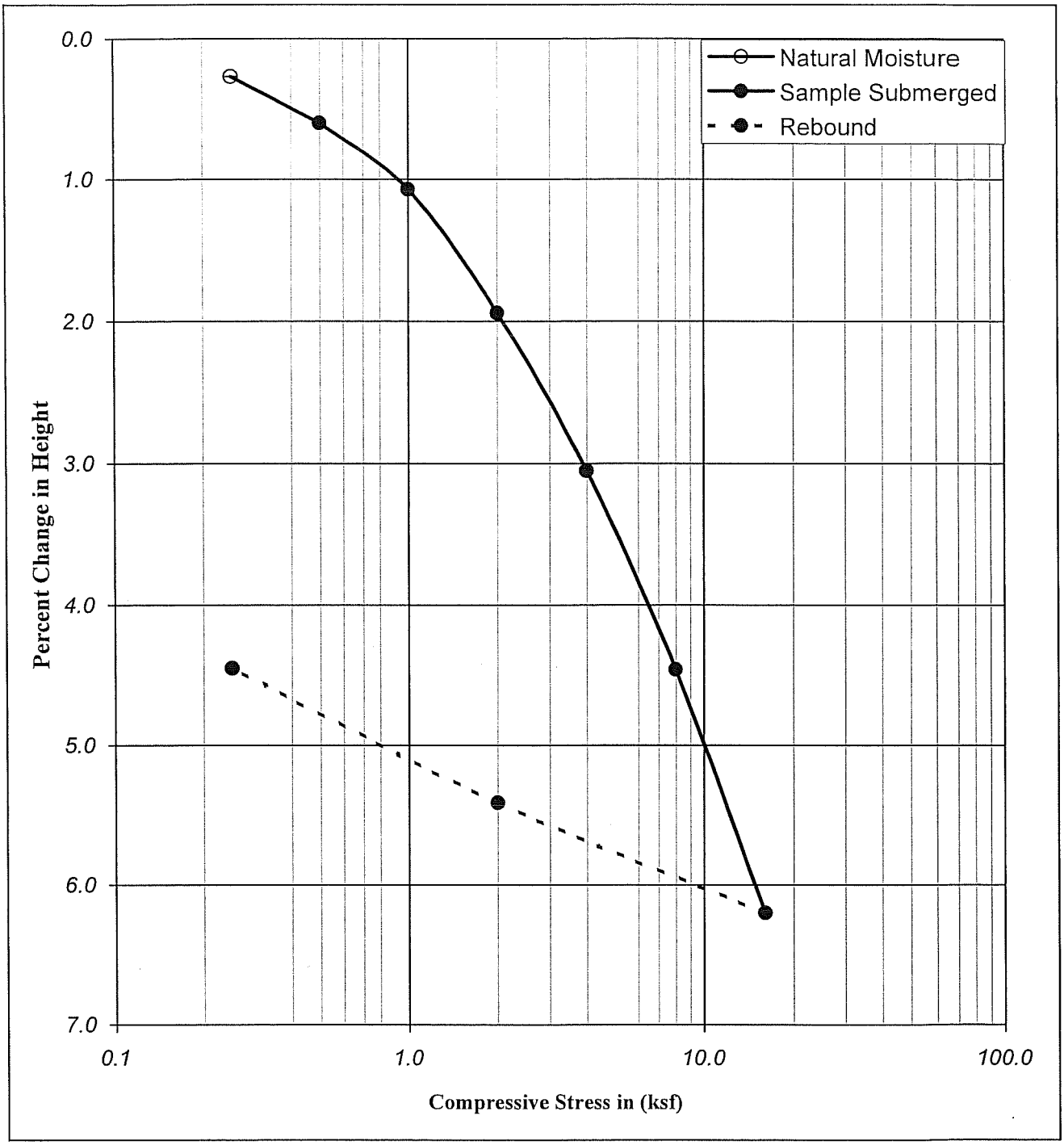
	Before	After
Weight of wet soil + ring (gm)	199.15	
Weight of ring (gm)	42.95	
Weight of wet soil + ring + container (gm)		255.03
Weight of dry soil + ring + container (gm)		226.83
No. 83 Weight of container (gm)		58.80
Weight of ring + container (gm)		101.75
Moisture Content (%)	24.88	22.55
Dial Reading (inch)	0.05	0.04
Sample Volume (ft³)	0.0027	0.0025
Wet Density (pcf)	129.4	133.1
Dry Density (pcf)	103.59	108.62

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
11/13/2009	14:42	0:00:00	Seating		0.04820	1.22		0.00
			Load					
	14:55		0.1	4.8	0.05000	1.27	0.00	
11/14/2009	9:10	0:00:00	0.25	12.0	0.05270	1.34	0.27	
11/15/2009	9:42	0:00:00	0.50	23.9	0.05600	1.42	0.60	
			Add Water					
11/16/2009	8:35	0:00:00	0.50	23.9	0.05600	1.42	0.60	
11/16/2009	8:38	0:00:00	1.00	47.9	0.05600	1.42	0.60	0.00
		0.10	1.0	47.9	0.05750	1.46	0.75	0.32
		0.25	1.0	47.9	0.0577	1.47	0.77	0.50
		0.50	1.0	47.9	0.05800	1.47	0.80	0.71
		1	1.0	47.9	0.05820	1.48	0.82	1.00
		2	1.0	47.9	0.05840	1.48	0.84	1.41
		4	1.0	47.9	0.05860	1.49	0.86	2.00
		8	1.0	47.9	0.05880	1.49	0.88	2.83
		15	1.0	47.9	0.05890	1.50	0.89	3.87
		30	1.0	47.9	0.05900	1.50	0.90	5.48
		60	1.0	47.9	0.05930	1.51	0.93	7.75
		120	1.0	47.9	0.05950	1.51	0.95	10.95
		240	1.0	47.9	0.05990	1.52	0.99	15.49
		480	1.0	47.9	0.06040	1.53	1.04	21.91
11/17/2009		1440	1.0	47.9	0.06070	1.54	1.07	37.95
11/18/2009	8:34	0	2.0	95.8	0.06940	1.76	1.94	
11/18/2009	8:42	0	4.0	191.5	0.0694	1.76	1.94	
		0.10	4.0	191.5	0.0752	1.91	2.52	
		0.25	4.0	191.5	0.0757	1.92	2.57	
		0.50	4.0	191.5	0.0764	1.94	2.64	
		1	4.0	191.5	0.0767	1.95	2.67	
		2	4.0	191.5	0.0771	1.96	2.71	
		4	4.0	191.5	0.0774	1.97	2.74	
		8	4.0	191.5	0.0777	1.97	2.77	
		15	4.0	191.5	0.0779	1.98	2.79	
		30	4.0	191.5	0.0783	1.99	2.83	
		60	4.0	191.5	0.0787	2.00	2.87	
		120	4.0	191.5	0.0792	2.01	2.92	
		240	4.0	191.5	0.0796	2.02	2.96	
		480	4.0	191.5	0.0802	2.04	3.02	
11/19/09		1440	4.0	191.5	0.0805	2.04	3.05	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.0946	2.40	4.46
11/21/2009	8:36		16.00	766.1	0.1120	2.84	6.20
11/22/2009	8:42		2.00	95.8	0.1041	2.64	5.41
11/23/2009	8:40		0.25	12.0	0.0945	2.40	4.45

Remark :

Final Dial Reading 0.0945



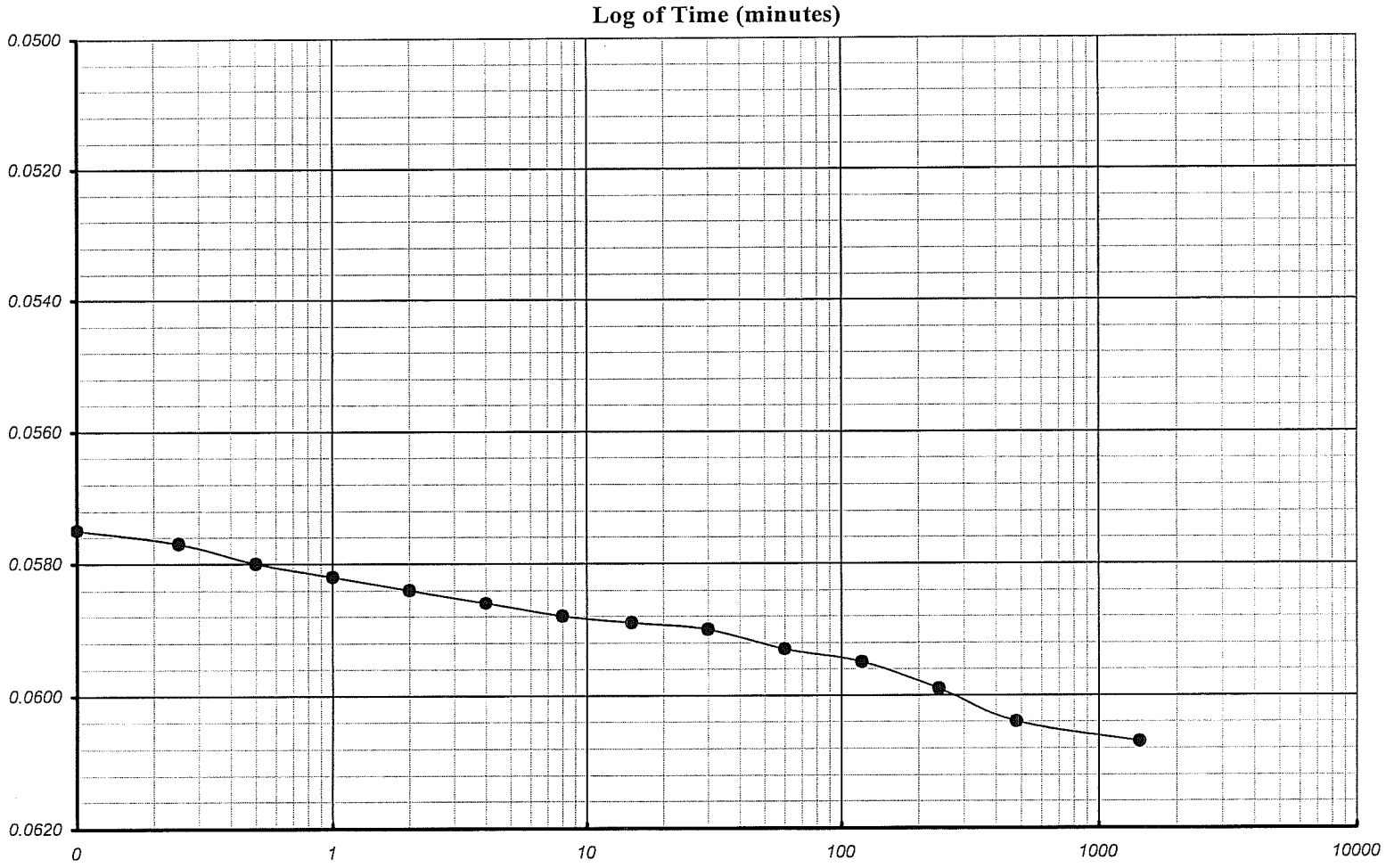
Boring No.	: A-09-051		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	24.88	103.59	16.31	107.12	0.63
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	22.55	108.62	17.10	110.32	0.55
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

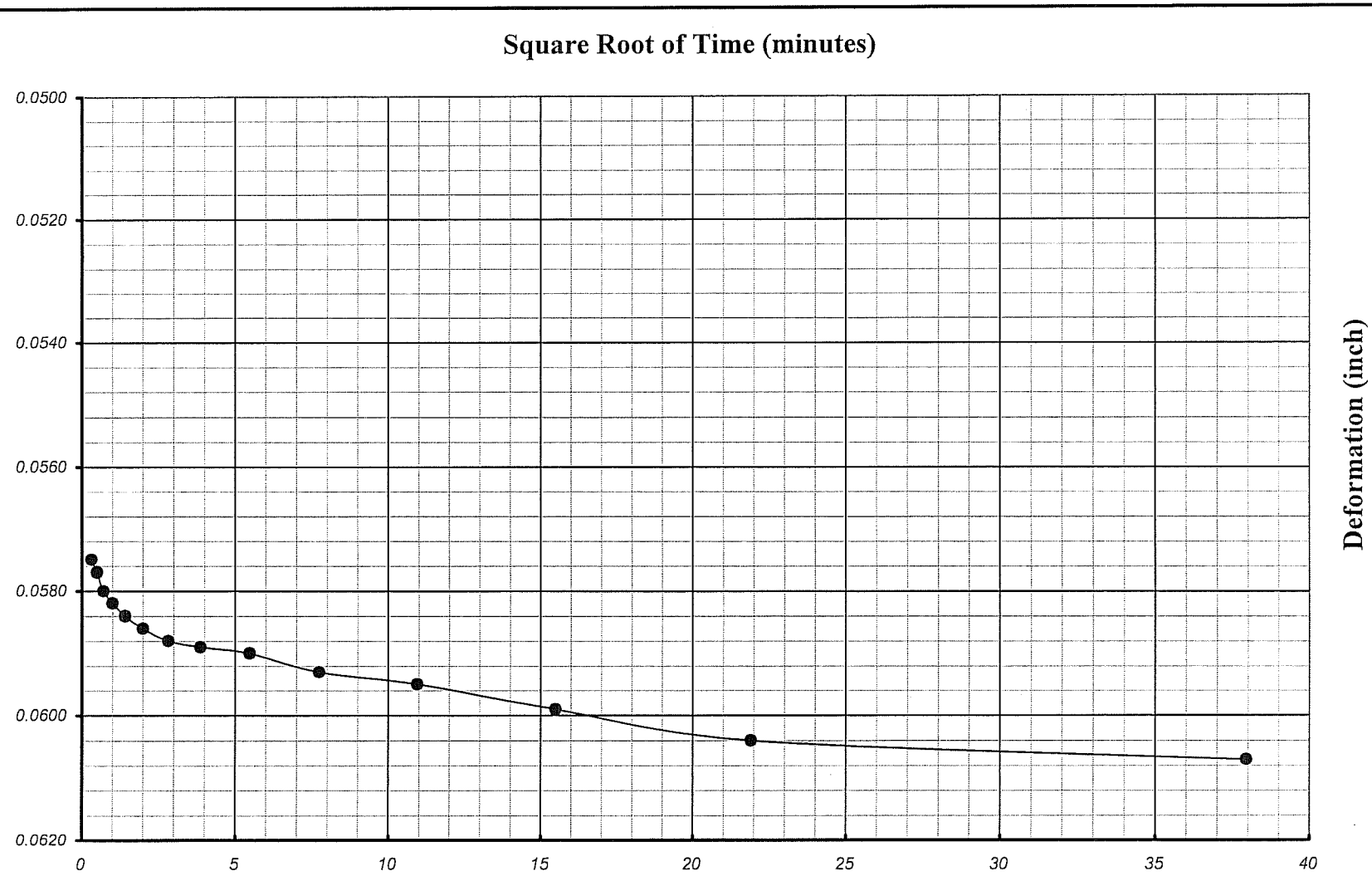
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

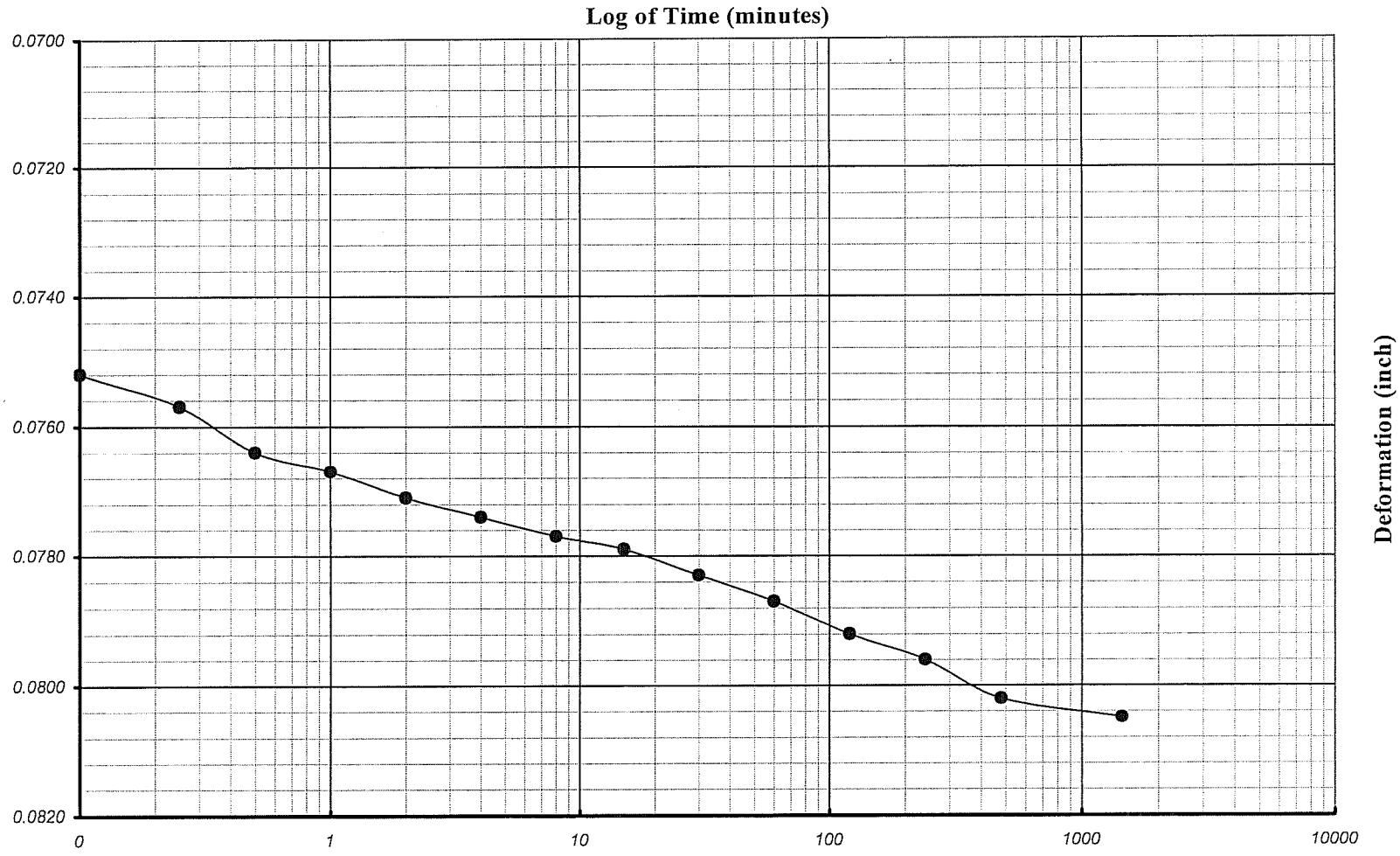
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



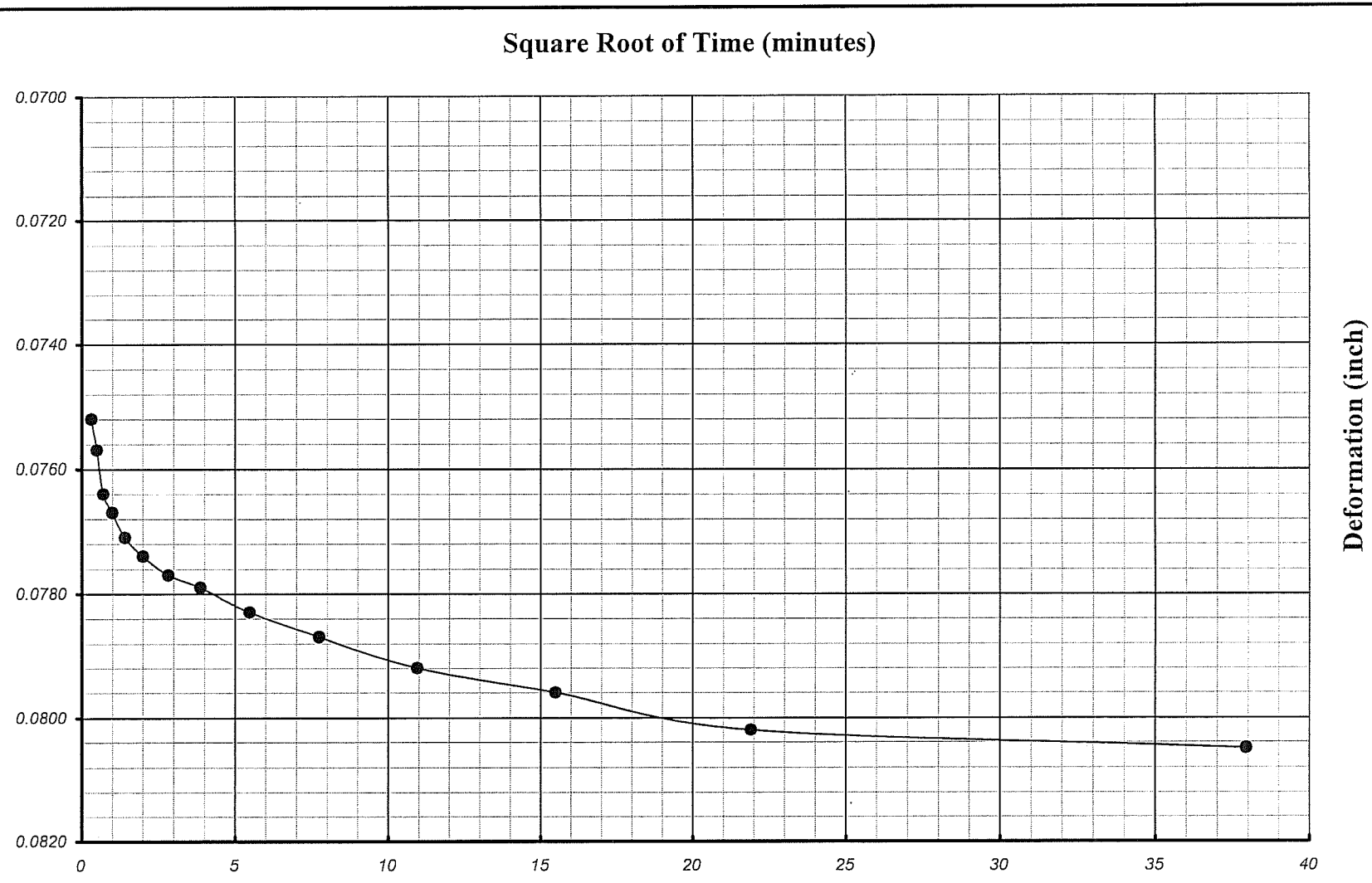
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-051*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-051*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* / *12.2*	Veritcal Load (ksf/kpa) : *1.0* / *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-051*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-051	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 4.0 191.5

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-051	Saturated	Field Moisture	X Inundated	**Specific Gravity** (Assumed) **:** 2.70
Sample No. : D-6	X Undisturbed	Remolded	Consolidated-Drained	**Shear Rate** (inch/min) **:** 0.02
Depth (ft/m) **:** 30.0	x Shear Once	Reshear	Residual	**Data File Number :** 0612301

Description : Dark olive-gray, Poorly graded SAND with SILT (SP-SM)

Specimen 1

Percent Saturation (%)	99.22	File No. : 0612301	1
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09		
Computed By : JF	Date : 12/11/09	2.00	(ksf)
Checked By :	Date :		

	Before		After
Percent Consolidation (%)			
Height of Sample (inch)	1.00		1.0000
Diameter of Sample (inch)	2.42		2.42
Dial Reading-Consolidation (inch)			
Weight of Soil + Ring (gm)	195.32		
Weight of Ring (gm)	45.25		
Weight of Wet Soil + Cont. (gm)			151.92
Weight of Dry Soil + Cont. (gm)			121.28
Weight of Cont. (gm) No. 1			3.84
Moisture Content (%)			26.09
Wet Density (pcf / kN/m³)	124.29	19.56	
Dry Density (pcf / kN/m³)	98.57	15.52	

Specimen 2

Percent Saturation (%)	98.30	File No. : 0612301	2
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09	4.00	(ksf)

	Before		After
Percent Consolidation (%)			
Height of Sample (inch)	1.00		1.0000
Diameter of Sample (inch)	2.42		2.42
Dial Reading-Consolidation (inch)			
Weight of Soil + Ring (gm)	193.80		
Weight of Ring (gm)	44.24		
Weight of Wet Soil + Cont. (gm)			151.83
Weight of Dry Soil + Cont. (gm)			121.25
Weight of Cont. (gm) No. 2			3.78
Moisture Content (%)			26.03
Wet Density (pcf / kN/m³)	123.87	19.50	
Dry Density (pcf / kN/m³)	98.28	15.47	

Specimen 3

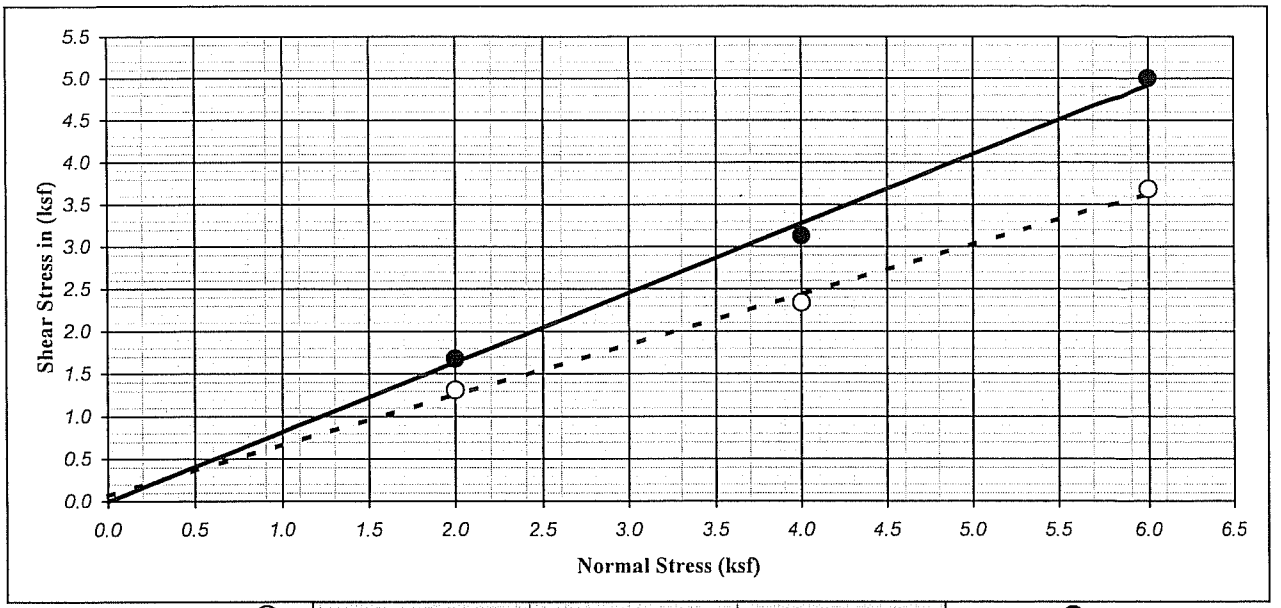
Percent Saturation (%)	103.78	File No. : 0612301	3
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09	6.00	(ksf)

	Before		After
Percent Consolidation (%)			
Height of Sample (inch)	1.00		1.0000
Diameter of Sample (inch)	2.42		2.42
Dial Reading-Consolidation (inch)			
Weight of Soil + Ring (gm)	199.77		
Weight of Ring (gm)	45.20		
Weight of Wet Soil + Cont. (gm)			157.56
Weight of Dry Soil + Cont. (gm)			127.13
Weight of Cont. (gm) No. 3			3.66
Moisture Content (%)			24.65
Wet Density (pcf / kN/m³)	128.02	20.15	
Dry Density (pcf / kN/m³)	102.71	16.17	

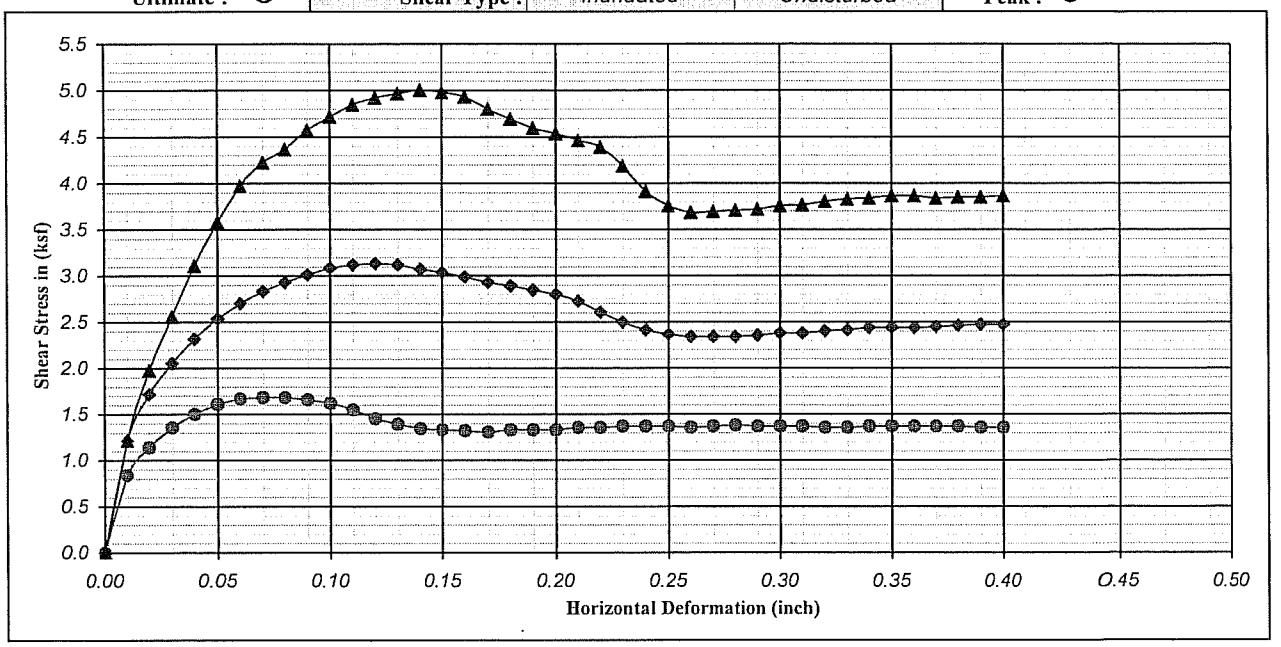
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.68	80.44	3.13	149.96	5.00	239.59
Ultimate	1.31	62.63	2.34	112.04	3.68	176.39

Shear Stress

Shear Deflection (inch)	Shear Deflection (mm)	Normal Stress (psf/ksf/kPa): 2000	2.00	95.8	4000	4.0	191.5	6000	6.0	287.3
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	840	0.84	40.2	1212	1.21	58.0	1220	1.22	58.2
0.020	0.05	1140	1.14	54.6	1716	1.72	82.2	1976	1.98	94.3
0.030	0.08	1356	1.36	64.9	2052	2.05	98.2	2556	2.56	121.9
0.040	0.10	1500	1.50	71.8	2316	2.32	110.9	3108	3.11	148.3
0.050	0.13	1608	1.61	77.0	2532	2.53	121.2	3576	3.58	170.6
0.060	0.15	1668	1.67	79.9	2700	2.70	129.3	3972	3.97	189.5
0.070	0.18	1680	1.68	80.4	2832	2.83	135.6	4224	4.22	201.5
0.080	0.20	1680	1.68	80.4	2928	2.93	140.2	4368	4.37	208.4
0.090	0.23	1656	1.66	79.3	3012	3.01	144.2	4572	4.57	218.1
0.100	0.25	1620	1.62	77.6	3084	3.08	147.7	4716	4.72	225.0
0.110	0.28	1548	1.55	74.1	3120	3.12	149.4	4848	4.85	231.3
0.120	0.30	1452	1.45	69.5	3132	3.13	150.0	4920	4.92	234.7
0.130	0.33	1392	1.39	66.6	3120	3.12	149.4	4968	4.97	237.0
0.140	0.36	1344	1.34	64.4	3072	3.07	147.1	5004	5.00	238.7
0.150	0.38	1332	1.33	63.8	3036	3.04	145.4	4980	4.98	237.6
0.160	0.41	1320	1.32	63.2	2988	2.99	143.1	4932	4.93	235.3
0.170	0.43	1308	1.31	62.6	2928	2.93	140.2	4800	4.80	229.0
0.180	0.46	1332	1.33	63.8	2892	2.89	138.5	4692	4.69	223.8
0.190	0.48	1332	1.33	63.8	2844	2.84	136.2	4596	4.60	219.2
0.200	0.51	1332	1.33	63.8	2796	2.80	133.9	4536	4.54	216.4
0.210	0.53	1356	1.36	64.9	2724	2.72	130.4	4464	4.46	212.9
0.220	0.56	1356	1.36	64.9	2604	2.60	124.7	4392	4.39	209.5
0.230	0.58	1368	1.37	65.5	2496	2.50	119.5	4188	4.19	199.8
0.240	0.61	1368	1.37	65.5	2412	2.41	115.5	3912	3.91	186.6
0.250	0.64	1368	1.37	65.5	2364	2.36	113.2	3756	3.76	179.2
0.260	0.66	1356	1.36	64.9	2340	2.34	112.0	3684	3.68	175.7
0.270	0.69	1368	1.37	65.5	2340	2.34	112.0	3696	3.70	176.3
0.280	0.71	1380	1.38	66.1	2340	2.34	112.0	3708	3.71	176.9
0.290	0.74	1368	1.37	65.5	2352	2.35	112.6	3720	3.72	177.5
0.300	0.76	1368	1.37	65.5	2376	2.38	113.8	3756	3.76	179.2
0.310	0.79	1368	1.37	65.5	2376	2.38	113.8	3768	3.77	179.7
0.320	0.81	1356	1.36	64.9	2400	2.40	114.9	3804	3.80	181.5
0.330	0.84	1356	1.36	64.9	2412	2.41	115.5	3828	3.83	182.6
0.340	0.86	1368	1.37	65.5	2436	2.44	116.6	3840	3.84	183.2
0.350	0.89	1368	1.37	65.5	2436	2.44	116.6	3864	3.86	184.3
0.360	0.91	1368	1.37	65.5	2436	2.44	116.6	3864	3.86	184.3
0.370	0.94	1368	1.37	65.5	2448	2.45	117.2	3840	3.84	183.2
0.380	0.97	1368	1.37	65.5	2460	2.46	117.8	3852	3.65	183.7
0.390	0.99	1356	1.36	64.9	2472	2.47	118.4	3852	3.85	183.7
0.400	1.02	1356	1.36	64.9	2472	2.47	118.4	3864	3.86	184.3
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No. : *A-09-051*	**Strength Intercept (C) :**	*0.00*	(ksf)	**Peak**	*0.07*	(ksf)	**Ultimate**
Sample No. : *D-6*		*0.00*	(kPa)		*3.26*	(kPa)	
Depth (ft/m) : *30.0* *0.00*	**Friction Angle (ϕ) :**	*39.35*	Degree		*30.71*	Degree	
Description : *Dark olive-gray, Poorly graded SAND with SILT (SP-SM)*				**Shear Rate** (inch/minute) :		*0.02*	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*26.09*	*98.57*	*15.52*	*0.71*	*2.00*	*95.76*	*1.68*	*80.44*	*1.31*	*62.63*
◆	*26.03*	*98.28*	*15.47*	*0.72*	*4.00*	*191.52*	*3.13*	*149.96*	*2.34*	*112.04*
▲	*24.65*	*102.71*	*16.17*	*0.64*	*6.00*	*287.28*	*5.00*	*239.59*	*3.68*	*176.39*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* **Date :** *11/30/09*

Figure No. :

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-051	S-1	5	SM	11.3				1:75:24			2000	8.4	300	400
A-09-051	D-2	10	SM	24.1	127.8									
A-09-051	S-3	15	SM					0:82:18						
A-09-051	D-4	20	SM	22.6	127.5									
A-09-051	S-5	25	SP-SM					0:94:6						
A-09-051	D-6	30	ML	22.8	125.9					N.P				
A-09-051	D-7	35	ML							N.P				
A-09-051	D-8	40	ML	26.0	124.5					N.P				
A-09-051	S-9	45	ML	30.8				0:43:57		28/24/4				
A-09-051	D-10	50	ML	26.7	122.5									
A-09-052	S-1	5	SP-SM					1:94:5			1400	8.4	20	673
A-09-052	S-3	15	SP	21.6				0:99:1						
A-09-052	D-4	20	SP-SM	22.7	125.4									
A-09-052	S-5	25	SM	27.8										
A-09-052	D-6	30	CL					0:38:62		41/24/17				
A-09-052	S-7	35	ML	33.5						49/30/19				
A-09-052	S-9	45	ML	31.0				0:45:55		26/26/0				
A-09-052	D-10	50	SM			<0.25		0:70:30						
A-09-053	S-1	5	SM					20:49:31			430	7.8	730	1809
A-09-053	D-2	10	SP-SM	27.4	124.5									
A-09-053	S-3	15	SP	24.5				0:97:3						
A-09-053	D-4	20	SM	19.5	127.8									
A-09-053	S-5	25	SP-SM	26.2				0:95:5						
A-09-053	S-7	35	ML	32.7				0:13:87		42/27/15				
A-09-053	S-9	45	ML	29.9				0:7:93		46/29/17				
A-09-054	S-1	5	ML					0:45:55			780	7.9	420	817
A-09-054	S-3	15	SP	27.3				0:98:2						
A-09-054	S-5	25	SP	22.0				0:98:2						
A-09-054	S-7	35	ML	30.7				0:30:70		28/24/4				
A-09-054	D-8	40	ML			1.25								
A-09-054	S-9	45	ML	42.8						N.P.				
A-09-054	D-10	50	ML					0:10:90		41/26/15				

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-052	Prepared By : PA	Date :
Sample No.	: D-6	Tested By : PA	Date :
Depth below Deck	: 30.0	Sieved By : RJ	Date :
Description	: Olive gray, SANDY Lean CLAY (CL)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

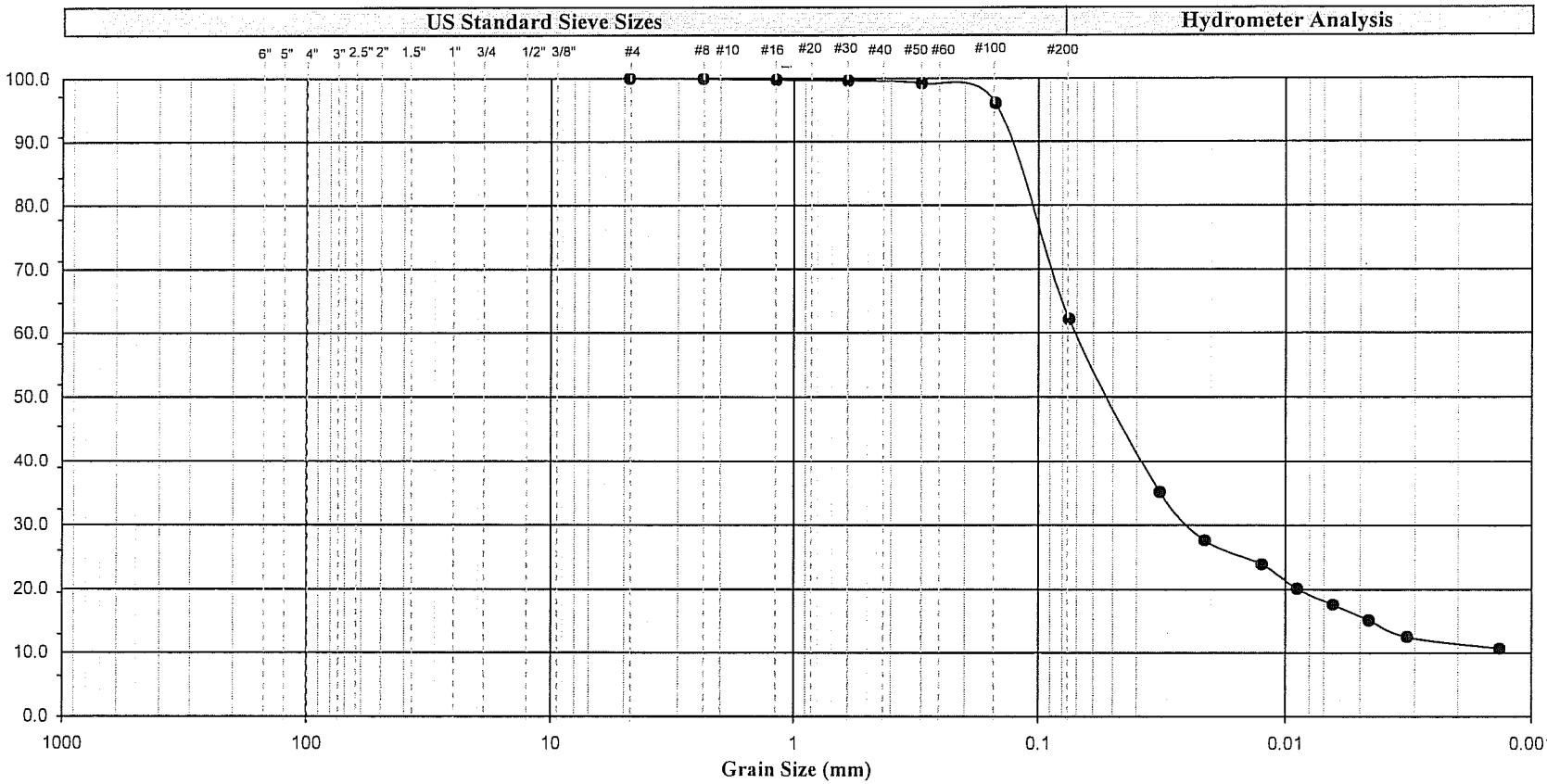
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-19	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	7	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-11		S-19	26		S-13		
Wt. of Wet Soil + Container (gm)		236.54		79.20	173.60			0.99	
Wt. of Dry Soil + Container (gm)					173.10		152.75	Hydrometer Type	
Wt. of Container (gm)					58.41		113.63	152H	
Wt. of Dry Soil (gm)		235.51		78.86			39.12	(K) Value	Temp. °C
Moisture Content (%)					0.44			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				41	No. 16	0.18		99.77	**99.77**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.29		99.63	**99.63**
1.0"					No. 40				
3/4"				24	No. 50	0.61		99.23	**99.23**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	3.04		96.14	**96.14**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.04		**99.95**	17	No. 200	29.84		62.16	**62.16**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)						
0:01	(T)					w		(mm)	(K)	(L)	(D)
13:34	0:00:00			5.0							
	2	21.0	33.0	5.0	28.0	35.15	**35.15**	0.05500	0.01328	11.7	**0.03213**
	5	21.0	27.0	5.0	22.0	27.62	**27.62**	0.03500	0.01328	12.7	**0.02116**
	15	21.0	24.0	5.0	19.0	23.85	**23.85**	0.02000	0.01328	13.2	**0.01245**
	30	22.0	21.0	5.0	16.0	20.09	**20.09**	0.01400	0.01328	13.7	**0.00897**
	60	23.0	19.0	5.0	14.0	17.58	**17.58**	0.01000	0.01328	14.0	**0.00642**
	120	23.0	17.0	5.0	12.0	15.07	**15.07**	0.00700	0.01328	14.3	**0.00459**
	240	23.5	15.0	5.0	10.0	12.55	**12.55**	0.00500	0.01328	14.7	**0.00322**
	1440	21.5	13.5	5.0	8.5	10.67	**10.67**	0.00100	0.01328	14.9	**0.00135**

Remark :	Retaining on #4 are shell fragments	Cu :	Gravel	Sand	Fine
		Cc :	0	38	62



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-052	D-6	30.0	olive gray	Sandy lean clay	CL
Remark	Retaining on #4 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *A-09-052*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-9*	**Tested By :** *PA*	**Date :**
Depth below Decl	: *45.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark greenish gray, SANDY SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

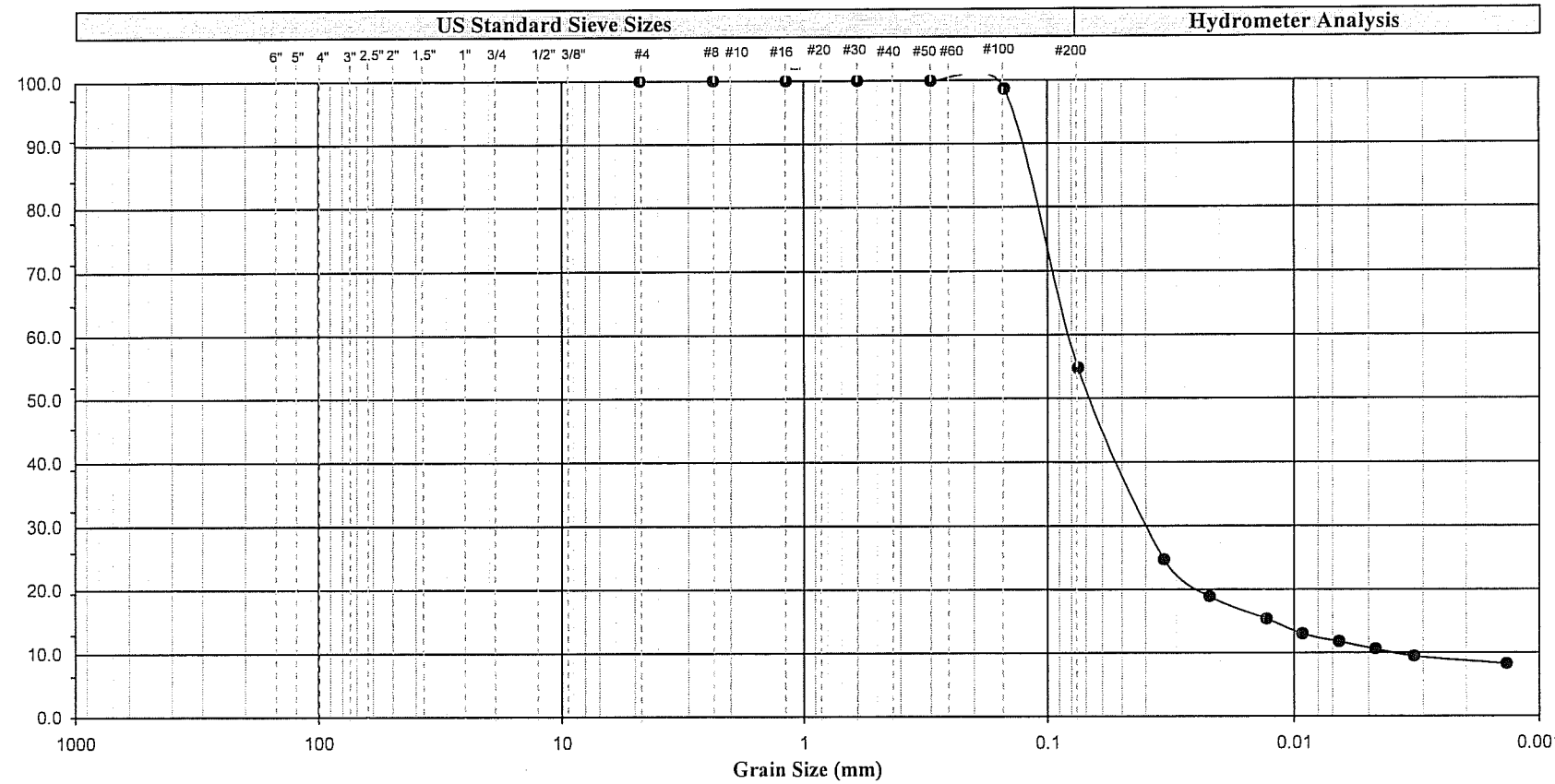
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*S-17*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*1*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-11*		*S-17*	*27*		*S-14*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*401.03*		*84.37*	*190.34*			*0.99*	
Wt. of Dry Soil + Container (gm)					*189.83*		*162.84*	**Hydrometer Type**	
Wt. of Container (gm)					*57.54*		*115.82*	*152H*	
Wt. of Dry Soil (gm)		*399.49*		*84.05*			*47.02*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.39*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***26***	No. 16	*0.02*		*99.98*	***99.98***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.04*		*99.95*	***99.95***
1.0"					No. 40				
3/4"				***26***	No. 50	*0.09*		*99.89*	***99.89***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*1.14*		*98.64*	***98.64***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	***0***	No. 200	*38.05*		*54.73*	***54.73***
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
13:38	***0:00:00***			*5.0*							
	2	*21.0*	*26.0*	*5.0*	*21.0*	*24.74*	***24.74***	*0.05500*	*0.01328*	*12.9*	***0.03367***
	5	*21.0*	*21.0*	*5.0*	*16.0*	*18.85*	***18.85***	*0.03500*	*0.01328*	*13.7*	***0.02196***
	15	*21.0*	*18.0*	*5.0*	*13.0*	*15.31*	***15.31***	*0.02000*	*0.01328*	*14.2*	***0.01291***
	30	*22.0*	*16.0*	*5.0*	*11.0*	*12.96*	***12.96***	*0.01400*	*0.01328*	*14.5*	***0.00923***
	60	*23.0*	*15.0*	*5.0*	*10.0*	*11.78*	***11.78***	*0.01000*	*0.01328*	*14.7*	***0.00656***
	120	*23.0*	*14.0*	*5.0*	*9.0*	*10.60*	***10.60***	*0.00700*	*0.01328*	*14.8*	***0.00467***
	240	*23.5*	*13.0*	*5.0*	*8.0*	*9.42*	***9.42***	*0.00500*	*0.01328*	*15.0*	***0.00325***
	1440	*21.5*	*12.0*	*5.0*	*7.0*	*8.25*	***8.25***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :	*Retaining on #4 are shell fragments*	**Cu :** *21.3*	**Gravel**	**Sand**	**Fine**
		Cc : *5.1*	***0***	***45***	***55***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-052	S-9	45.0	dark greenish gray	Sandy silt	ML
Remark	Retaining on #4 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 | Set up By : J.F | Date : 11/13/2009

Boring No. : A-09-052 | Tested By : J.F/R.J. | Date : 11/13/09-11/23/09

Sample No. : D-6 | Time Rate Took By : J.F | Date : 11/16/09,11/18/09

Depth (ft / m) : 30.0 | 9.15 | Computer By : JF | Date : 11/24/2009

File No. : | Checked By : R.J. | Date :

Soil Description : Gray, SANDY lean CLAY (CL)

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.9039	22.96	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/13/2009	14:43	0:00:00	Seating		0.04950	1.26	
			Load				
	14:55		0.1	4.8	0.05000	1.27	0.00
11/14/2009	9:10	0:00:00	0.25	12.0	0.05700	1.45	0.70
11/15/2009	9:42	0:00:00	0.50	23.9	0.06280	1.60	1.28
			Add Water				
11/16/2009	8:35	0:00:00	0.50	23.9	0.06280	1.60	1.28
11/16/2009	8:38	0:00:00	1.00	47.9	0.06280	1.60	1.28
		0.10	1.0	47.9	0.06450	1.64	1.45
		0.25	1.0	47.9	0.0650	1.65	1.50
		0.50	1.0	47.9	0.06560	1.67	1.56
		1	1.0	47.9	0.06640	1.69	1.64
		2	1.0	47.9	0.06680	1.70	1.68
		4	1.0	47.9	0.06710	1.70	1.71
		8	1.0	47.9	0.06770	1.72	1.77
		15	1.0	47.9	0.06805	1.73	1.80
		30	1.0	47.9	0.06845	1.74	1.85
		60	1.0	47.9	0.06910	1.76	1.91
		120	1.0	47.9	0.06970	1.77	1.97
		240	1.0	47.9	0.07050	1.79	2.05
		480	1.0	47.9	0.07130	1.81	2.13
11/17/2009		1440	1.0	47.9	0.07190	1.83	2.19
11/18/2009	8:34	0	2.0	95.8	0.09770	2.48	4.77
11/18/2009	8:42	0	4.0	191.5	0.0977	2.48	4.77
		0.10	4.0	191.5	0.1053	2.67	5.53
		0.25	4.0	191.5	0.1068	2.71	5.68
		0.50	4.0	191.5	0.1106	2.81	6.06
		1	4.0	191.5	0.1130	2.87	6.30
		2	4.0	191.5	0.1149	2.92	6.49
		4	4.0	191.5	0.1161	2.95	6.61
		8	4.0	191.5	0.1169	2.97	6.69
		15	4.0	191.5	0.1176	2.99	6.76
		30	4.0	191.5	0.1186	3.01	6.86
		60	4.0	191.5	0.1197	3.04	6.97
		120	4.0	191.5	0.1208	3.07	7.08
		240	4.0	191.5	0.1219	3.10	7.19
		480	4.0	191.5	0.1229	3.12	7.29
11/19/09		1440	4.0	191.5	0.1236	3.14	7.36

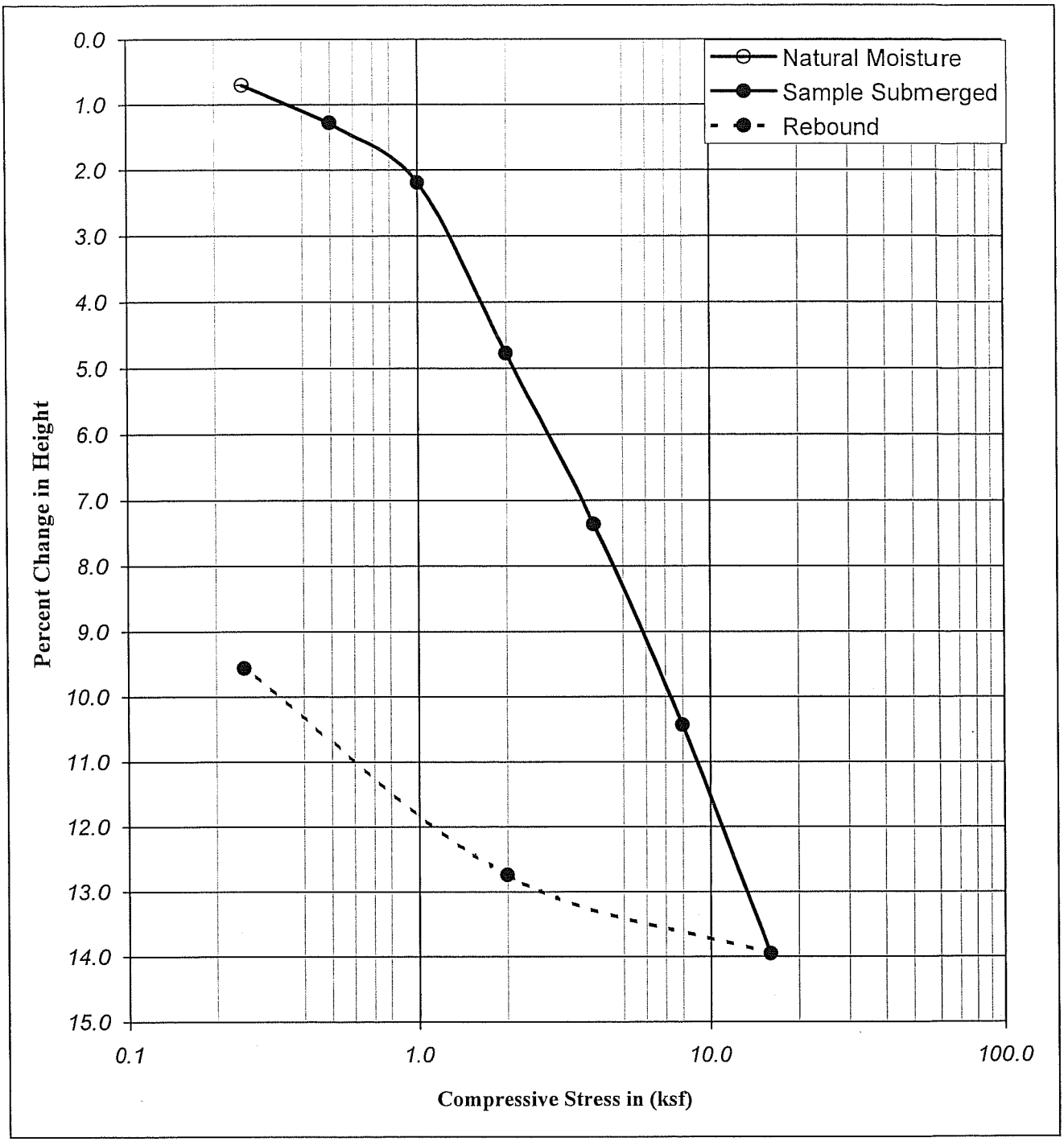
		Before	After
Weight of wet soil + ring (gm)		179.23	
Weight of ring (gm)		42.97	
Weight of wet soil + ring + container (gm)			232.23
Weight of dry soil + ring + container (gm)			198.94
No.	84		60.32
Weight of container (gm)			103.29
Weight of ring + container (gm)		42.46	34.80
Moisture Content (%)		0.05	0.04
Dial Reading (inch)		0.0027	0.0024
Sample Volume (ft^3)		112.9	118.1
Wet Density (pcf)		79.22	87.64
Dry Density (pcf)			

SQRT Time
0.00
0.32
0.50
0.71
1.00
1.41
2.00
2.83
3.87
5.48
7.75
10.95
15.49
21.91
37.95

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.1543	3.92	10.43
11/21/2009	8:36		16.00	766.1	0.1895	4.81	13.95
11/22/2009	8:42		2.00	95.8	0.1774	4.51	12.74
11/23/2009	8:40		0.25	12.0	0.1456	3.70	9.56

Remark :

Final Dial Reading 0.1456



Boring No.	: A-09-052		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-6		Plastic Limit :	-						
Depth (ft)	: 30.0	31.5	Plastic Index :	-	Initial	42.46	79.22	12.47	101.65	1.13
Depth (m)	: 9.15	9.61	Specific Gravity :	2.70	Final	34.80	87.64	13.79	101.78	0.92
Description	: Gray, SANDY lean CLAY (CL)									

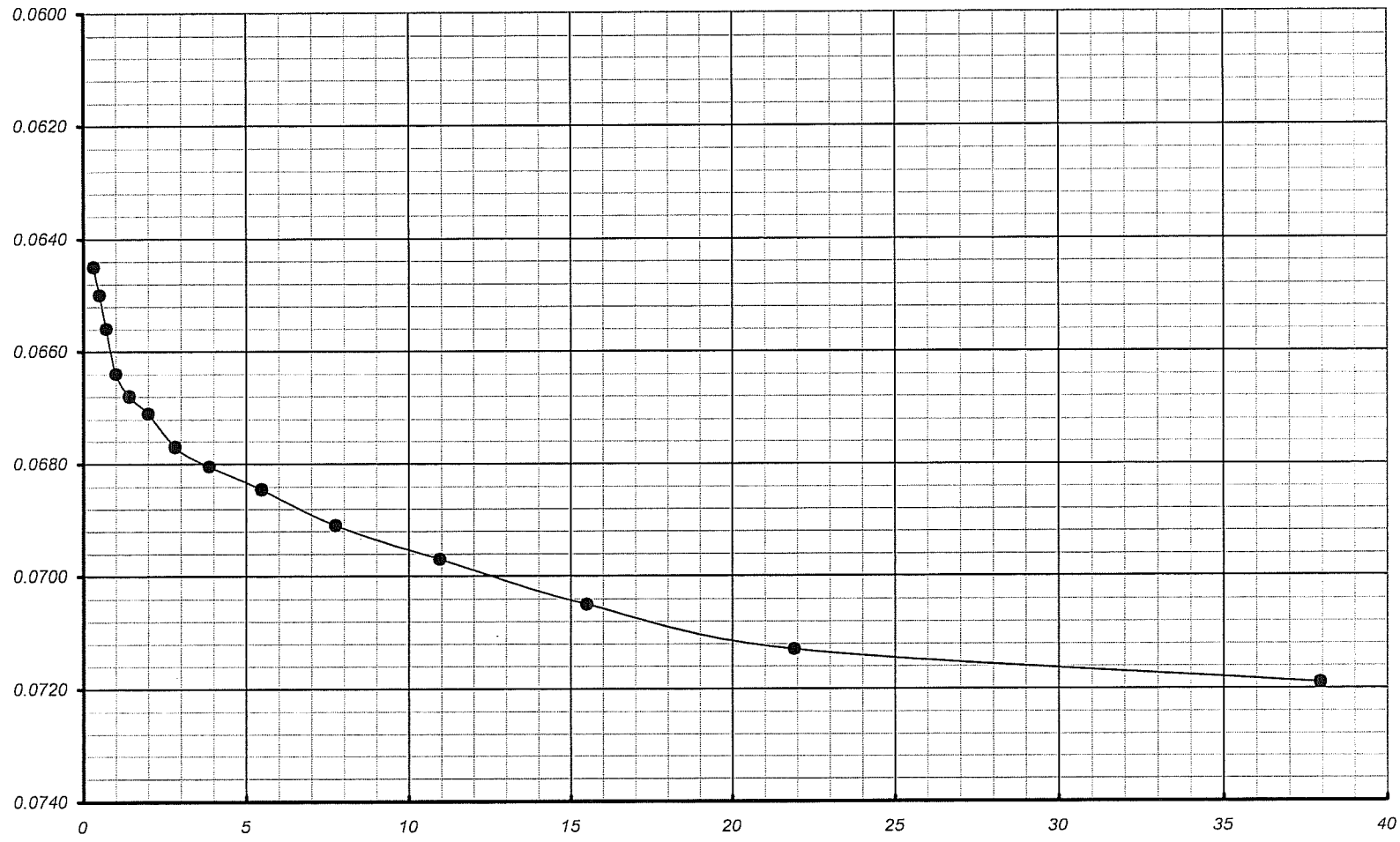
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

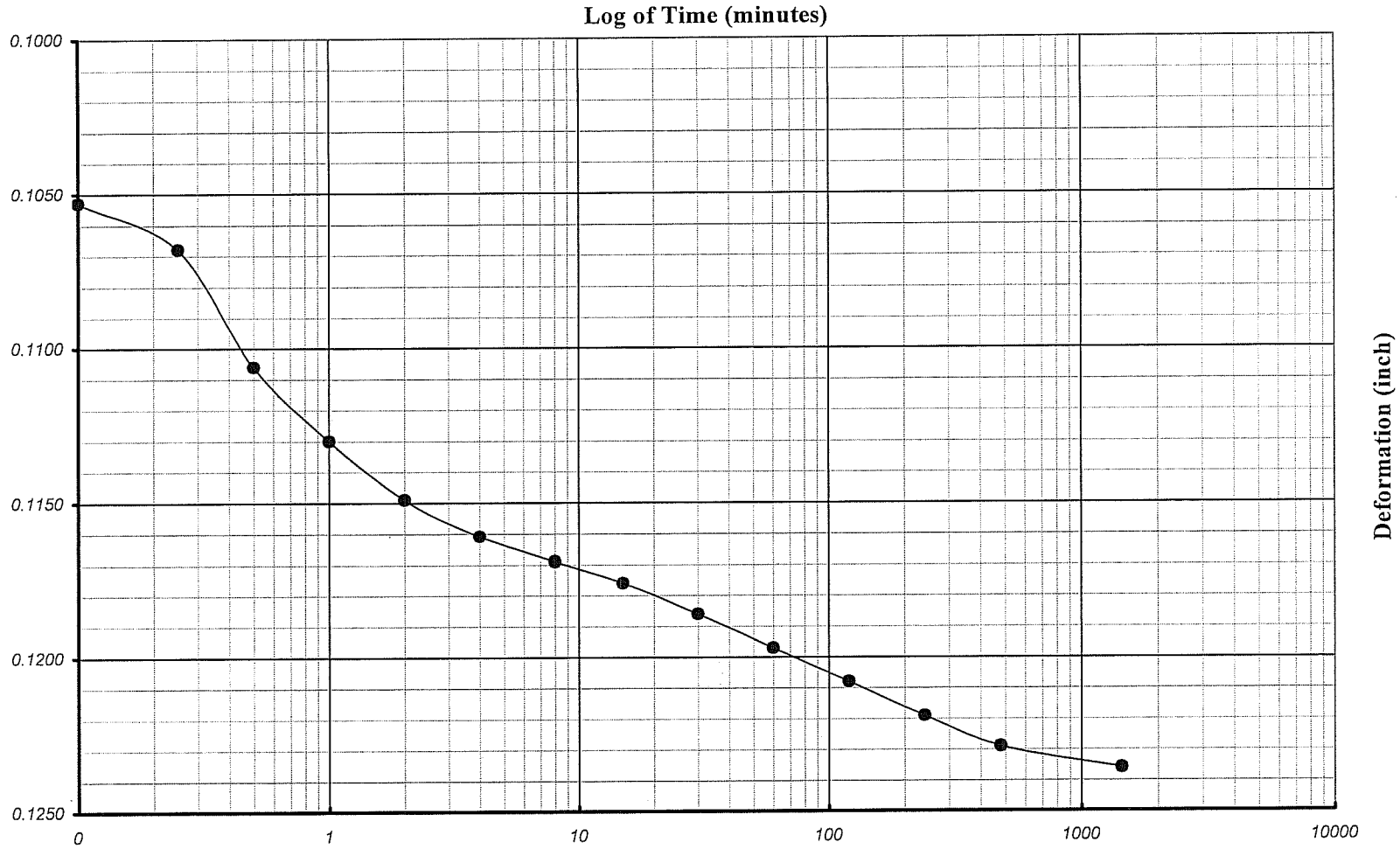
Project No. : 06-123-3 11/24/09

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

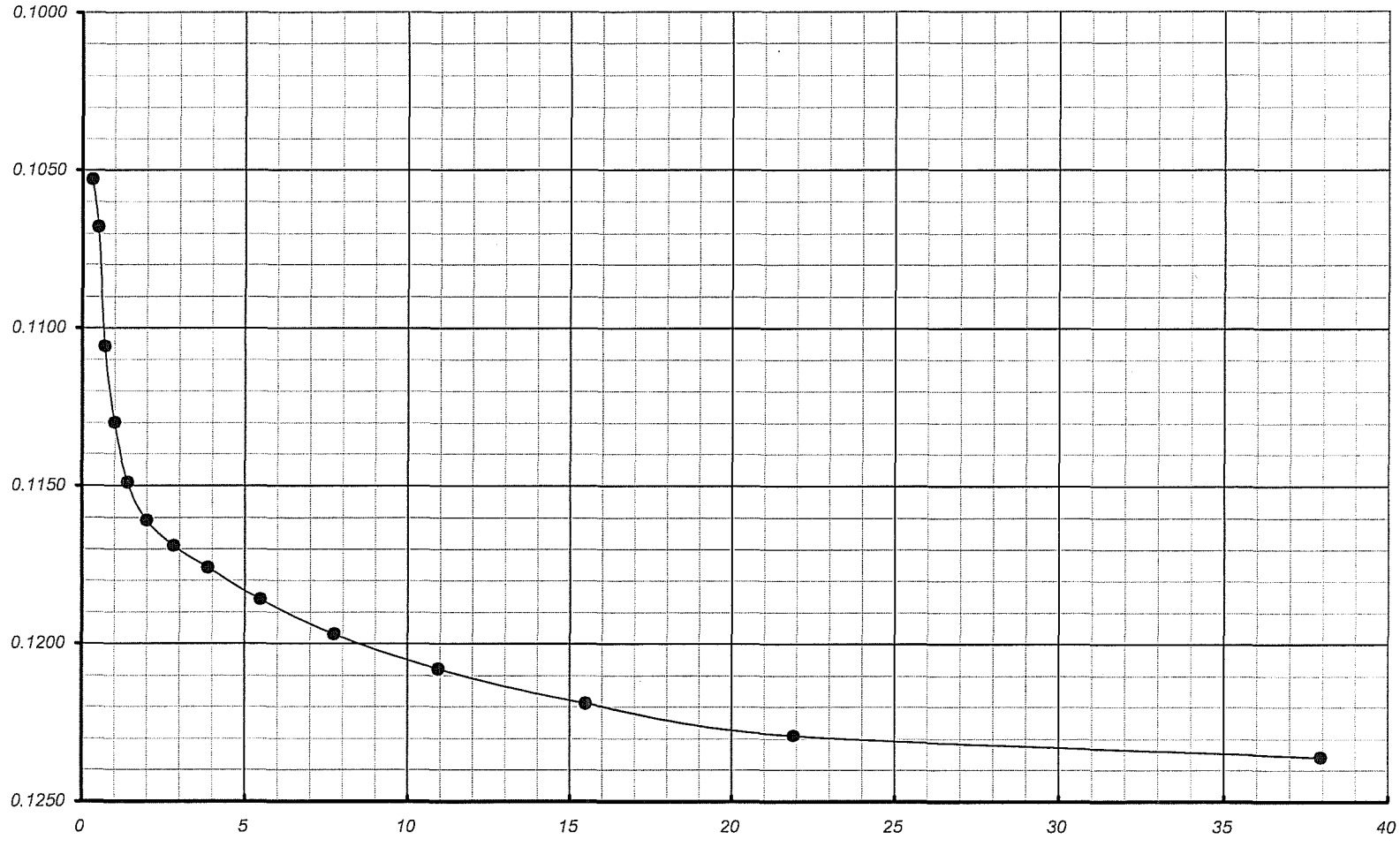
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-052	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-6	
EMI Project No. : 06-123-3		Depth (ft/m) : 30.0 | 9.2	Veritcal Load (ksf/kpa) : 1.00 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-052	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-6	
EMI Project No. : 06-123-3		Depth (ft/m) : 30.0 9.2	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-052
Sample No. : D-8
Depth (ft / m) : 40.0 | 12.20
File No. :
Soil Description : Dark gray, SANDY SILT (ML)

Set up By : J.F Date : 11/13/2009
Tested By : J.F/R.J. Date : 11/13/09-11/23/09
Time Rate Took By : J.F Date : 11/16/09,11/18/09
Computer By : JF Date : 11/24/2009
Checked By : R.J. Date :

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.
Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9678	24.58	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

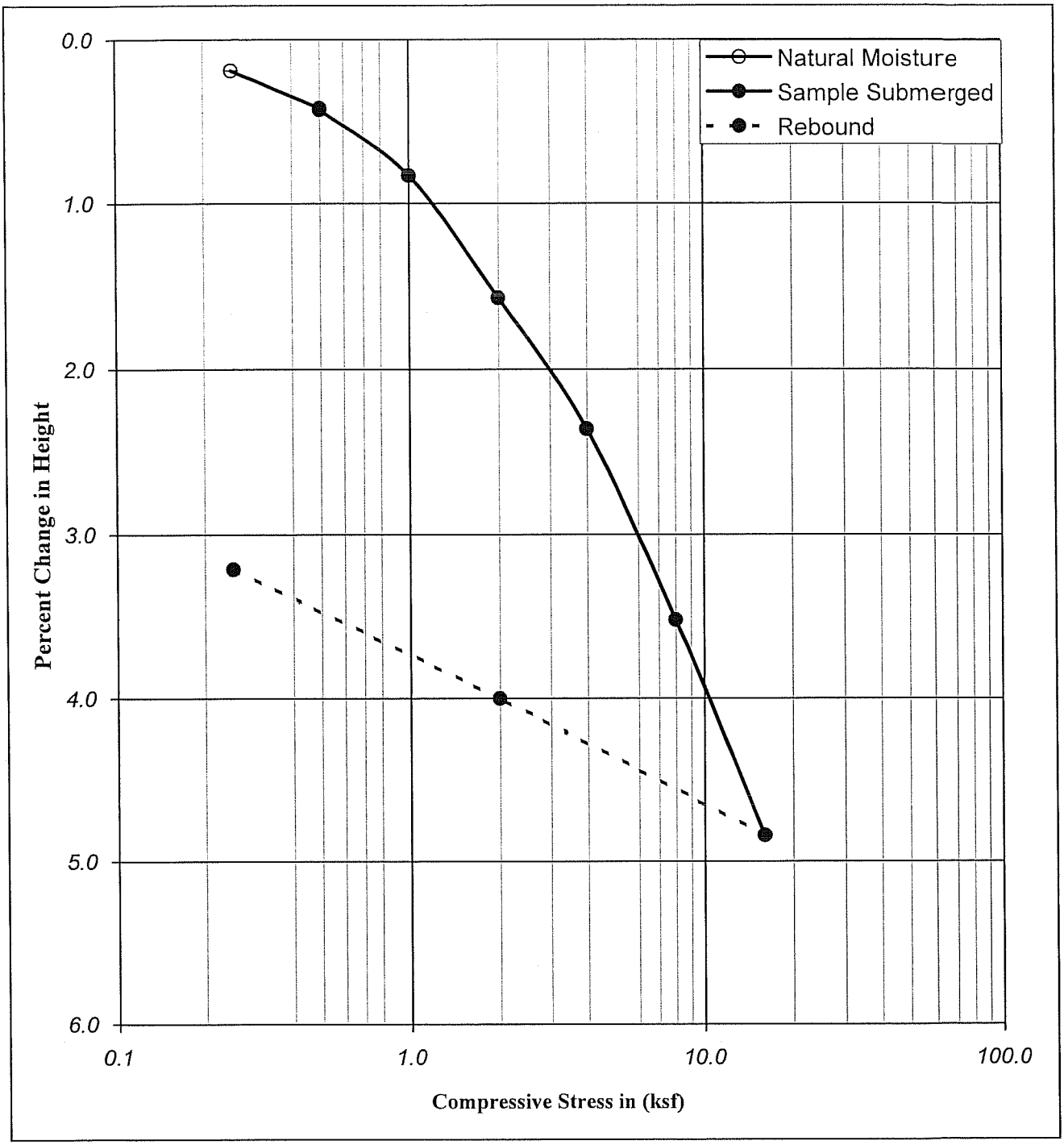
	Before	After
Weight of wet soil + ring (gm)	185.69	
Weight of ring (gm)	42.22	
Weight of wet soil + ring + container (gm)		243.21
Weight of dry soil + ring + container (gm)		209.42
No. 85 Weight of container (gm)		59.32
Weight of ring + container (gm)		101.54
Moisture Content (%)	32.99	31.32
Dial Reading (inch)	0.05	0.04
Sample Volume (ft^3)	0.0027	0.0026
Wet Density (pcf)	118.8	121.2
Dry Density (pcf)	89.35	92.32

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
11/13/2009	14:43	0:00:00	Seating		0.04990	1.27		
			Load					
	14:55		0.1	4.8	0.05000	1.27	0.00	
11/14/2009	9:10	0:00:00	0.25	12.0	0.05190	1.32	0.19	
11/15/2009	9:42	0:00:00	0.50	23.9	0.05420	1.38	0.42	
			Add Water					
11/16/2009	8:35	0:00:00	0.50	23.9	0.05430	1.38	0.43	
11/16/2009	8:38	0:00:00	1.00	47.9	0.05430	1.38	0.43	0.00
		0.10	1.0	47.9	0.05620	1.43	0.62	0.32
		0.25	1.0	47.9	0.0563	1.43	0.63	0.50
		0.50	1.0	47.9	0.05640	1.43	0.64	0.71
		1	1.0	47.9	0.05650	1.44	0.65	1.00
		2	1.0	47.9	0.05670	1.44	0.67	1.41
		4	1.0	47.9	0.05680	1.44	0.68	2.00
		8	1.0	47.9	0.05690	1.45	0.69	2.83
		15	1.0	47.9	0.05700	1.45	0.70	3.87
		30	1.0	47.9	0.05710	1.45	0.71	5.48
		60	1.0	47.9	0.05730	1.46	0.73	7.75
		120	1.0	47.9	0.05740	1.46	0.74	10.95
		240	1.0	47.9	0.05770	1.47	0.77	15.49
		480	1.0	47.9	0.05810	1.48	0.81	21.91
11/17/2009		1440	1.0	47.9	0.05830	1.48	0.83	37.95
11/18/2009	8:34	0	2.0	95.8	0.06570	1.67	1.57	
11/18/2009	8:42	0	4.0	191.5	0.0657	1.67	1.57	
		0.10	4.0	191.5	0.0705	1.79	2.05	
		0.25	4.0	191.5	0.0708	1.80	2.08	
		0.50	4.0	191.5	0.0711	1.81	2.11	
		1	4.0	191.5	0.0712	1.81	2.12	
		2	4.0	191.5	0.0714	1.81	2.14	
		4	4.0	191.5	0.0716	1.82	2.16	
		8	4.0	191.5	0.0718	1.82	2.18	
		15	4.0	191.5	0.0720	1.83	2.20	
		30	4.0	191.5	0.0722	1.83	2.22	
		60	4.0	191.5	0.0724	1.84	2.24	
		120	4.0	191.5	0.0728	1.85	2.28	
		240	4.0	191.5	0.0731	1.86	2.31	
		480	4.0	191.5	0.0734	1.86	2.34	
11/19/09		1440	4.0	191.5	0.0736	1.87	2.36	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.0852	2.16	3.52
11/21/2009	8:36		16.00	766.1	0.0984	2.50	4.84
11/22/2009	8:42		2.00	95.8	0.0900	2.29	4.00
11/23/2009	8:40		0.25	12.0	0.0821	2.09	3.21

Remark :

Final Dial Reading 0.0821



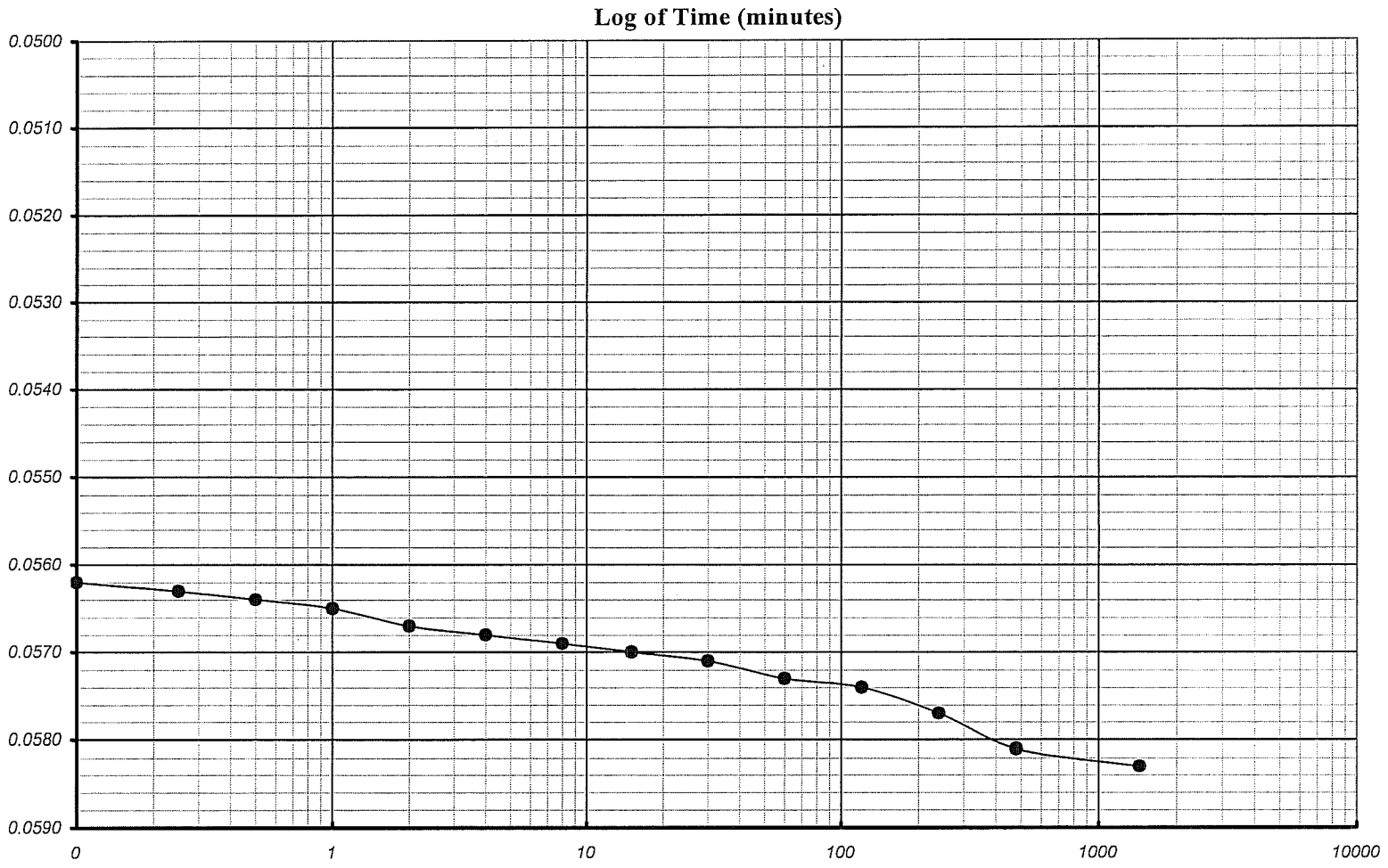
Boring No.	: A-09-052		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	32.99	89.35	14.06	100.47	0.89
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	31.32	92.32	14.53	102.41	0.83
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

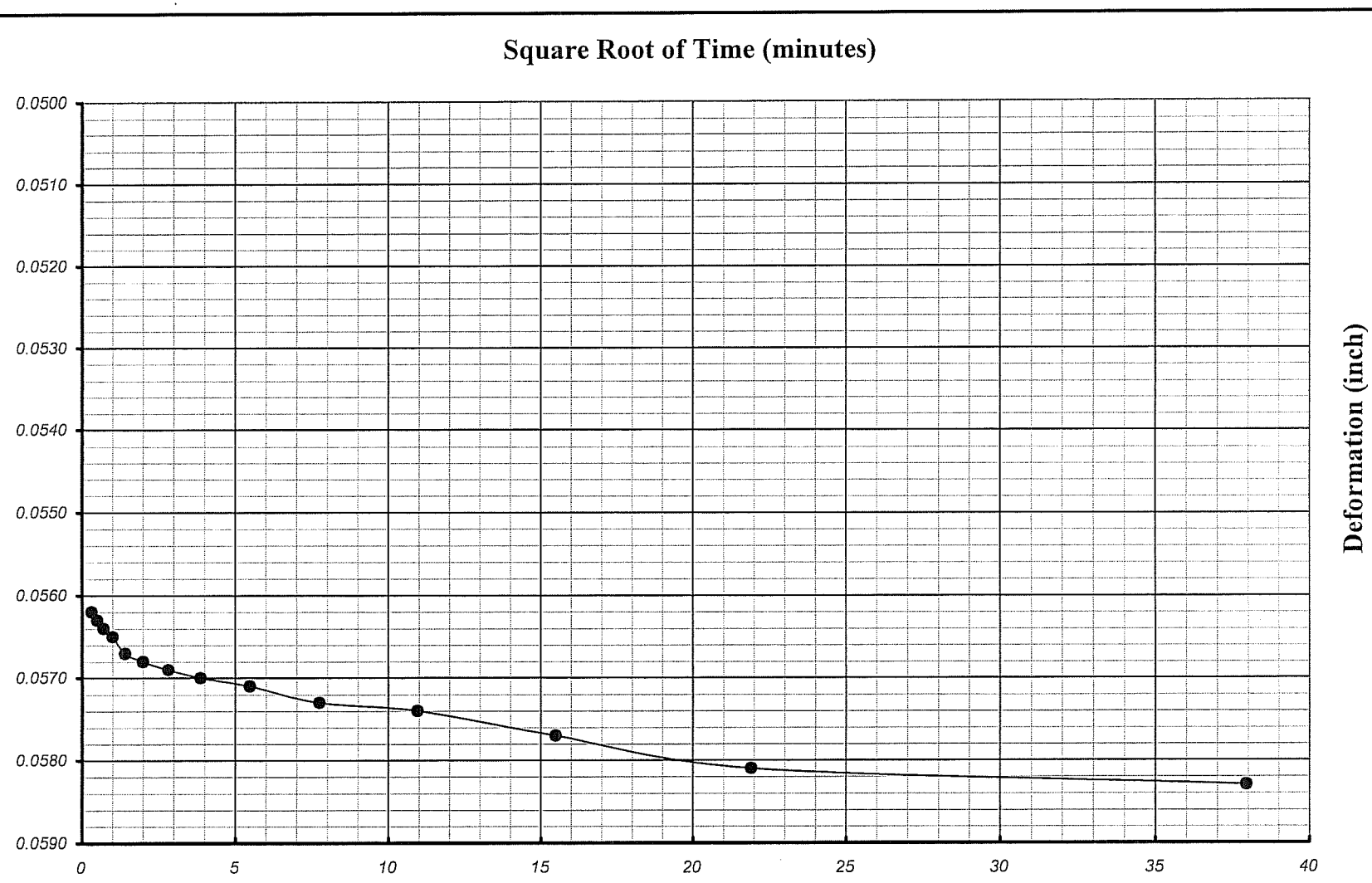
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

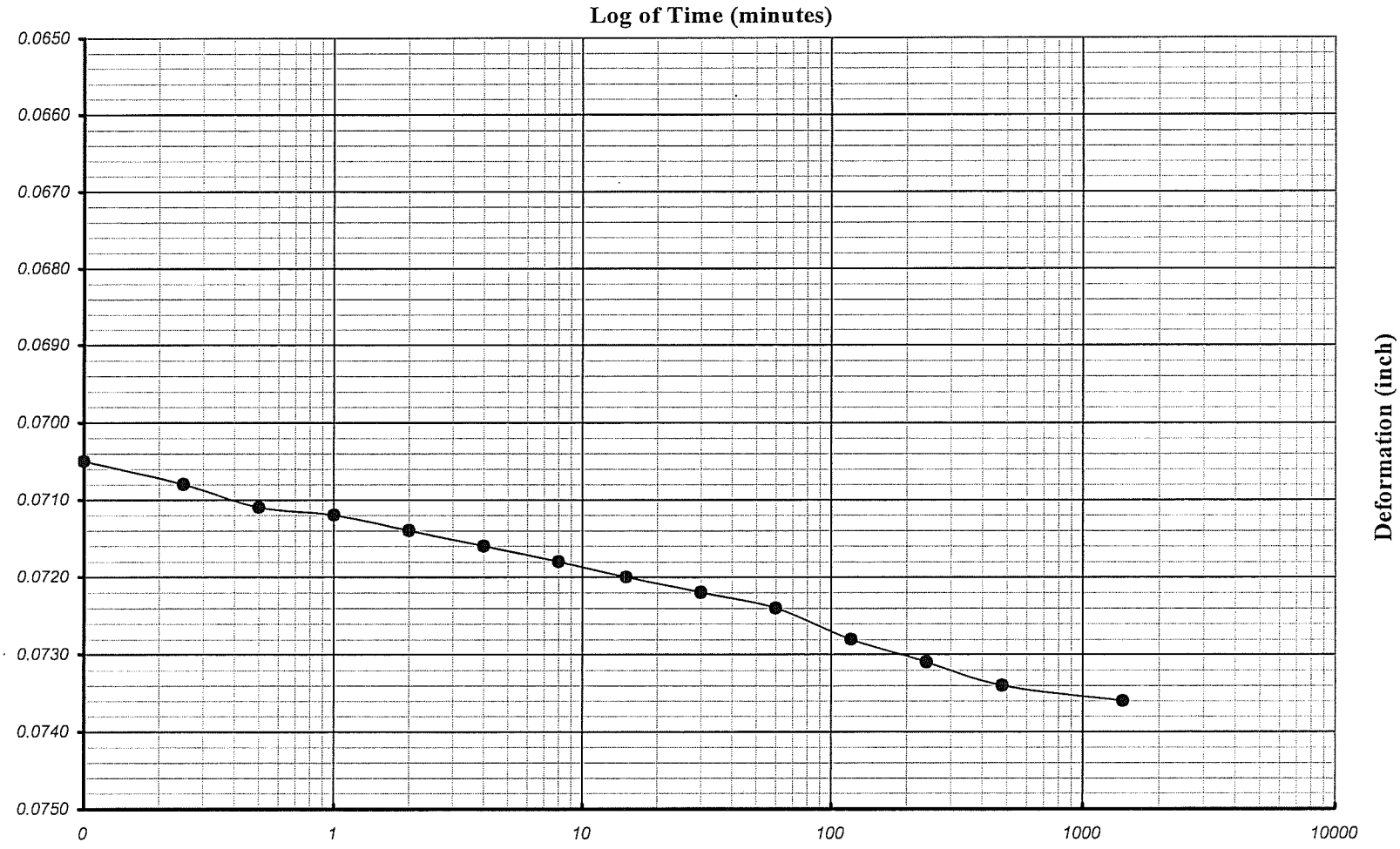
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



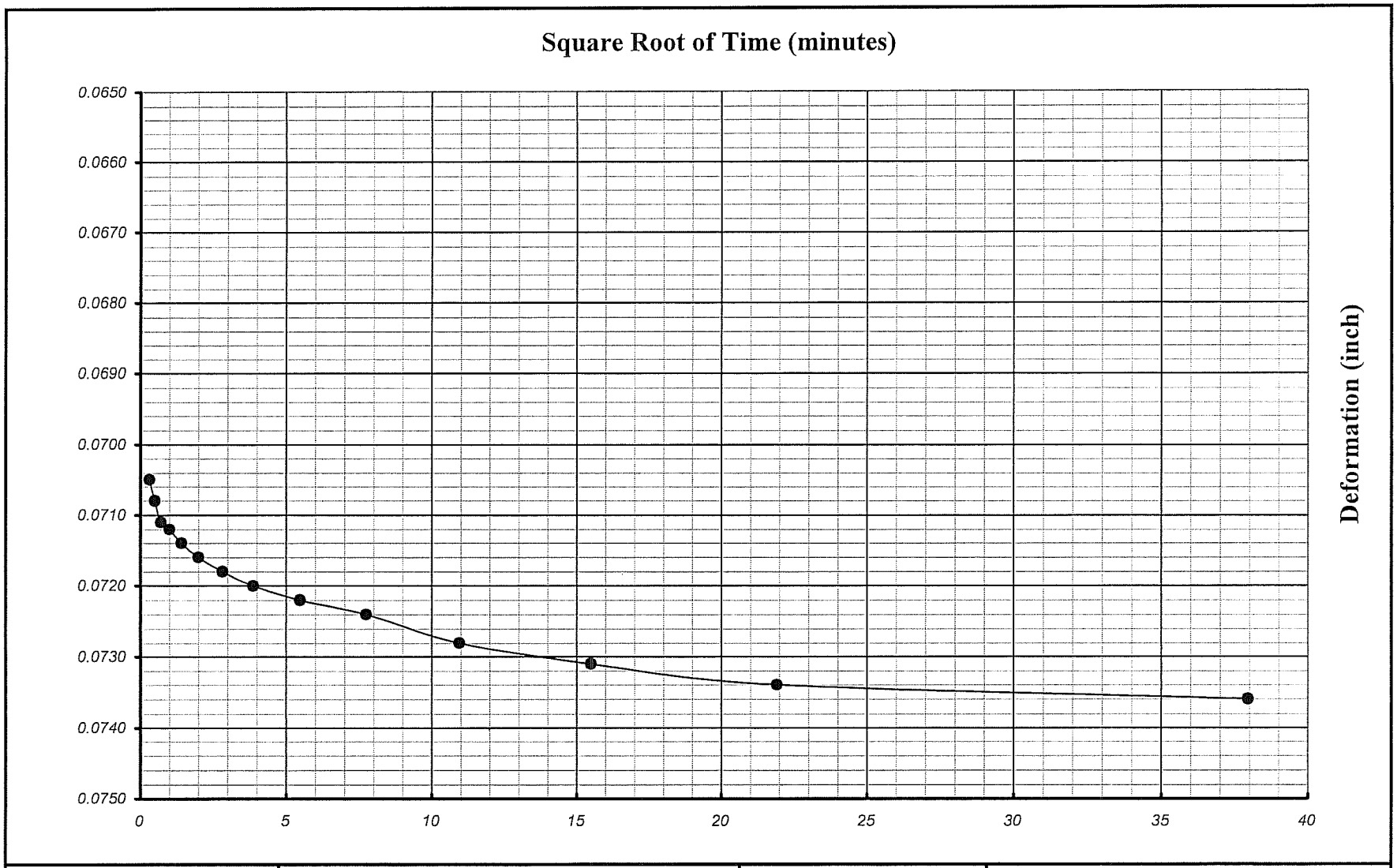
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-052	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

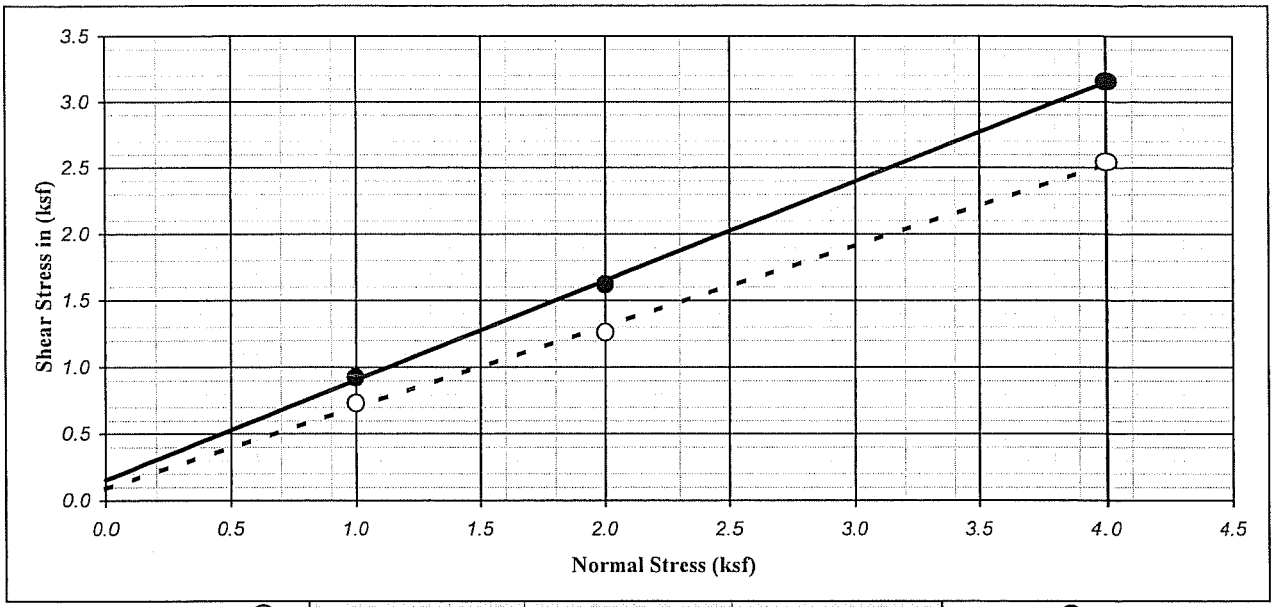
Boring No. :	A-09-052		Saturated		Field Moisiture	X	Inundated	**Specific Gravity** (Assumed) :	2.70
Sample No. :	D-4	X	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min) :	0.02
Depth (ft/m) :	20.0	x	Shear Once		Reshear		Residual	**Data File Number :**	0612302

Description : Gray, Poorly graded SAND with SILT (SP-SM)

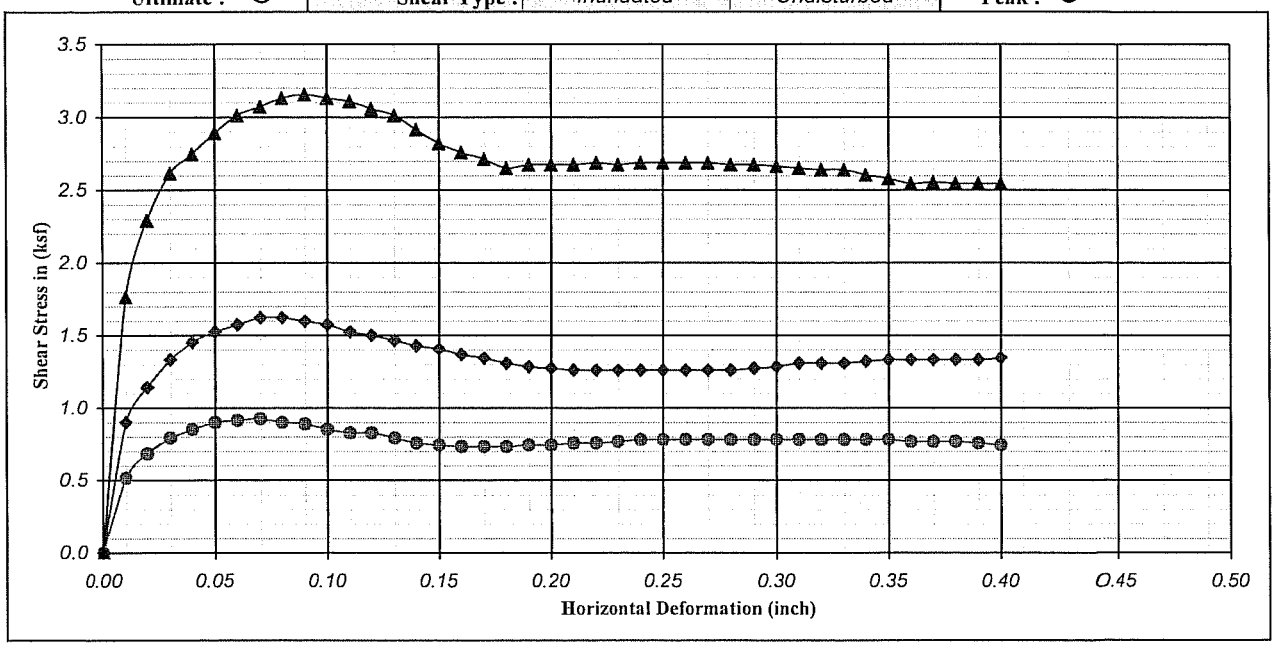
Percent Saturation (%)	101.61	**File No. :**	0612302	1																
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**																	
Tested By : JF	**Date :**	11/30/09																		
Computed By : JF	**Date :**	12/11/09	1.00	(ksf)																
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		194.51																		
Weight of Ring (gm)		43.45																		
Weight of Wet Soil + Cont. (gm)				152.47																
Weight of Dry Soil + Cont. (gm)				121.35																
Weight of Cont. (gm) No.	4			3.97																
Moisture Content (%)				26.51																
Wet Density (pcf / kN/m^3)		125.11	19.69																	
Dry Density (pcf / kN/m^3)		98.89	15.57																	
Percent Saturation (%)	104.82	**File No. :**	0612302	2																
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**																	
Tested By : JF	**Date :**	11/30/09	2.00	(ksf)																
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		196.09																		
Weight of Ring (gm)		43.22																		
Weight of Wet Soil + Cont. (gm)				154.22																
Weight of Dry Soil + Cont. (gm)				122.61																
Weight of Cont. (gm) No.	5			3.89																
Moisture Content (%)				26.63																
Wet Density (pcf / kN/m^3)		126.61	19.93																	
Dry Density (pcf / kN/m^3)		99.99	15.74																	
Percent Saturation (%)	100.15	**File No. :**	0612302	3																
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**																	
Tested By : JF	**Date :**	11/30/09	4.00	(ksf)																
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		195.00																		
Weight of Ring (gm)		43.98																		
Weight of Wet Soil + Cont. (gm)				151.53																
Weight of Dry Soil + Cont. (gm)				121.28																
Weight of Cont. (gm) No.	6			3.95																
Moisture Content (%)				25.78																
Wet Density (pcf / kN/m^3)		125.08	19.69																	
Dry Density (pcf / kN/m^3)		99.44	15.65																	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.92	44.24	1.62	77.57	3.16	151.11
Ultimate	0.73	35.05	1.26	60.33	2.54	121.81

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)** 1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	516	0.52	24.7	900	0.90	43.1	1764	1.76	84.1
0.020	0.05	684	0.68	32.7	1140	1.14	54.6	2292	2.29	109.3
0.030	0.08	792	0.79	37.9	1332	1.33	63.8	2616	2.62	124.8
0.040	0.10	852	0.85	40.8	1452	1.45	69.5	2748	2.75	131.1
0.050	0.13	900	0.90	43.1	1524	1.52	73.0	2892	2.89	138.0
0.060	0.15	912	0.91	43.7	1572	1.57	75.3	3012	3.01	143.7
0.070	0.18	924	0.92	44.2	1620	1.62	77.6	3072	3.07	146.5
0.080	0.20	900	0.90	43.1	1620	1.62	77.6	3132	3.13	149.4
0.090	0.23	888	0.89	42.5	1596	1.60	76.4	3156	3.16	150.5
0.100	0.25	852	0.85	40.8	1572	1.57	75.3	3132	3.13	149.4
0.110	0.28	828	0.83	39.6	1524	1.52	73.0	3108	3.11	148.3
0.120	0.30	828	0.83	39.6	1500	1.50	71.8	3060	3.06	146.0
0.130	0.33	792	0.79	37.9	1464	1.46	70.1	3012	3.01	143.7
0.140	0.36	756	0.76	36.2	1428	1.43	68.4	2916	2.92	139.1
0.150	0.38	744	0.74	35.6	1404	1.40	67.2	2820	2.82	134.5
0.160	0.41	732	0.73	35.0	1368	1.37	65.5	2760	2.76	131.7
0.170	0.43	732	0.73	35.0	1344	1.34	64.4	2712	2.71	129.4
0.180	0.46	732	0.73	35.0	1308	1.31	62.6	2652	2.65	126.5
0.190	0.48	744	0.74	35.6	1284	1.28	61.5	2676	2.68	127.7
0.200	0.51	744	0.74	35.6	1272	1.27	60.9	2676	2.68	127.7
0.210	0.53	756	0.76	36.2	1260	1.26	60.3	2676	2.68	127.7
0.220	0.56	756	0.76	36.2	1260	1.26	60.3	2688	2.69	128.2
0.230	0.58	768	0.77	36.8	1260	1.26	60.3	2676	2.68	127.7
0.240	0.61	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.250	0.64	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.260	0.66	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.270	0.69	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.280	0.71	780	0.78	37.3	1260	1.26	60.3	2676	2.68	127.7
0.290	0.74	780	0.78	37.3	1272	1.27	60.9	2676	2.68	127.7
0.300	0.76	780	0.78	37.3	1284	1.28	61.5	2664	2.66	127.1
0.310	0.79	780	0.78	37.3	1308	1.31	62.6	2652	2.65	126.5
0.320	0.81	780	0.78	37.3	1308	1.31	62.6	2640	2.64	125.9
0.330	0.84	780	0.78	37.3	1308	1.31	62.6	2640	2.64	125.9
0.340	0.86	780	0.78	37.3	1320	1.32	63.2	2604	2.60	124.2
0.350	0.89	780	0.78	37.3	1332	1.33	63.8	2580	2.58	123.1
0.360	0.91	768	0.77	36.8	1332	1.33	63.8	2544	2.54	121.4
0.370	0.94	768	0.77	36.8	1332	1.33	63.8	2556	2.56	121.9
0.380	0.97	768	0.77	36.8	1332	1.33	63.8	2544	2.54	121.4
0.390	0.99	756	0.76	36.2	1332	1.33	63.8	2544	2.54	121.4
0.400	1.02	744	0.74	35.6	1344	1.34	64.4	2544	2.54	121.4
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-052		Strength Intercept (C) :	0.16	(ksf)	Peak	0.09	(ksf)	Ultimate	
Sample No. : D-4			7.47	(kPa)		4.31	(kPa)		
Depth (ft/m) : 20.0	0.00	Friction Angle (ϕ) :	36.78	Degree		31.36	Degree		
Description : Gray, Poorly graded SAND with SILT (SP-SM)						Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	26.51	98.89	15.57	0.70	1.00	47.88	0.92	44.24	0.73	35.05
◆	26.63	99.99	15.74	0.69	2.00	95.76	1.62	77.57	1.26	60.33
▲	25.78	99.44	15.65	0.70	4.00	191.52	3.16	151.11	2.54	121.81

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-051	S-1	5	SM	11.3				1:75:24			2000	8.4	300	490
A-09-051	D-2	10	SM	24.1	127.8									
A-09-051	S-3	15	SM					0:82:18						
A-09-051	D-4	20	SM	22.6	127.5									
A-09-051	S-5	25	SP-SM					0:94:6						
A-09-051	D-6	30	ML	22.8	125.9					N.P				
A-09-051	D-7	35	ML							N.P				
A-09-051	D-8	40	ML	26.0	124.5					N.P				
A-09-051	S-9	45	ML	30.8				0:43:57		28/24/4				
A-09-051	D-10	50	ML	26.7	122.5									
A-09-052	S-1	5	SP-SM					1:94:5			1400	8.4	20	673
A-09-052	S-3	15	SP	21.6				0:99:1						
A-09-052	D-4	20	SP-SM	22.7	125.4									
A-09-052	S-5	25	SM	27.8										
A-09-052	D-6	30	CL					0:38:62		41/24/17				
A-09-052	S-7	35	ML	33.5						49/30/19				
A-09-052	S-9	45	ML	31.0				0:45:55		26/26/0				
A-09-052	D-10	50	SM			<0.25		0:70:30						
A-09-053	S-1	5	SM					20:49:31			430	7.8	730	1809
A-09-053	D-2	10	SP-SM	27.4	124.5									
A-09-053	S-3	15	SP	24.5				0:97:3						
A-09-053	D-4	20	SM	19.5	127.8									
A-09-053	S-5	25	SP-SM	26.2				0:95:5						
A-09-053	S-7	35	ML	32.7				0:13:87		42/27/15				
A-09-053	S-9	45	ML	29.9				0:7:93		46/29/17				
A-09-054	S-1	5	ML					0:45:55			780	7.9	420	817
A-09-054	S-3	15	SP	27.3				0:98:2						
A-09-054	S-5	25	SP	22.0				0:98:2						
A-09-054	S-7	35	ML	30.7				0:30:70		28/24/4				
A-09-054	D-8	40	ML			1.25								
A-09-054	S-9	45	ML	42.8						N.P.				
A-09-054	D-10	50	ML					0:10:90		41/26/15				

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-053	Prepared By : PA	Date :
Sample No.	: S-7	Tested By : PA	Date :
Depth below Deck	: 35.0	Sieved By : RJ	Date :
Description	: dark greenish gray, SILT (ML)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

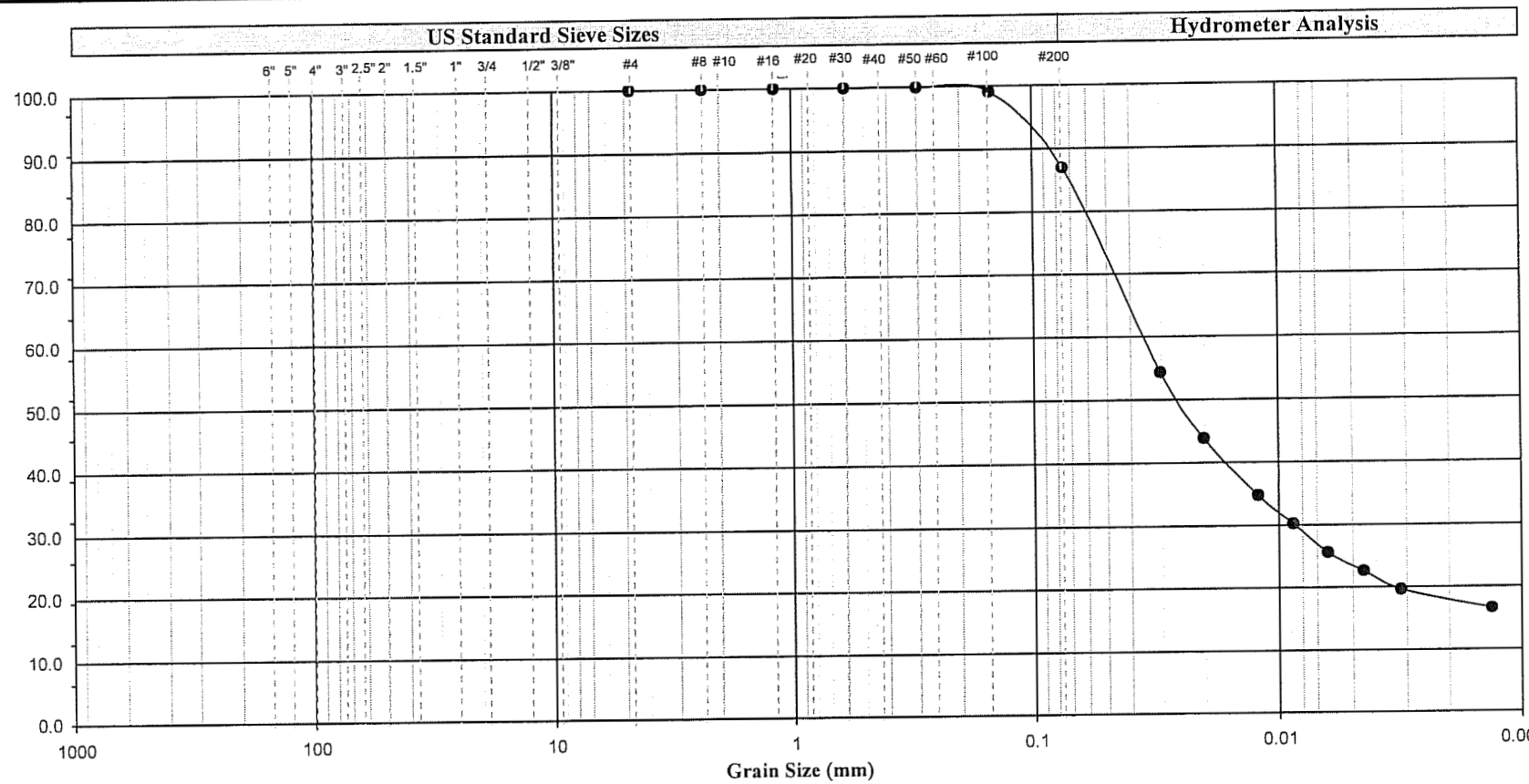
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-14	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	3	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-11		S-17	27		S-15	0.99	
Wt. of Wet Soil + Container (gm)		287.08		66.09	177.80			Hydrometer Type	
Wt. of Dry Soil + Container (gm)					176.85		129.96	152H	
Wt. of Container (gm)					57.68		114.75	(K) Value	Temp. °C
Wt. of Dry Soil (gm)		284.81		65.57			15.21	0.01328	21.0
Moisture Content (%)					0.80				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				42	No. 16	0.01		99.98	**99.98**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.02		99.97	**99.97**
1.0"					No. 40				
3/4"				27	No. 50	0.07		99.89	**99.89**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.59		99.10	**99.10**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.00		**100.00**	15	No. 200	8.54		86.98	**86.98**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)						
0:01	(T)					w		(mm)	(K)	(L)	(D)
13:42	0:00:00			5.0							
	2	21.0	41.0	5.0	36.0	54.36	**54.36**	0.05500	0.01328	10.4	**0.03027**
	5	21.0	34.0	5.0	29.0	43.79	**43.79**	0.03500	0.01328	11.5	**0.02018**
	15	21.0	28.0	5.0	23.0	34.73	**34.73**	0.02000	0.01328	12.5	**0.01214**
	30	22.0	25.0	5.0	20.0	30.20	**30.20**	0.01400	0.01328	13.0	**0.00875**
	60	23.0	22.0	5.0	17.0	25.67	**25.67**	0.01000	0.01328	13.5	**0.00630**
	120	23.0	20.0	5.0	15.0	22.65	**22.65**	0.00700	0.01328	13.8	**0.00451**
	240	23.5	18.0	5.0	13.0	19.63	**19.63**	0.00500	0.01328	14.2	**0.00316**
	1440	21.5	16.0	5.0	11.0	16.61	**16.61**	0.00100	0.01328	14.5	**0.00133**

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	0	13	87



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-053	S-7	35.0	dark greenish gray	Silt	ML
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-053	Prepared By : PA	Date :
Sample No.	: S-9	Tested By : PA	Date :
Depth below Deck	: 45.0	Sieved By : RJ	Date :
Description	: dark olive gray, SILT (ML)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

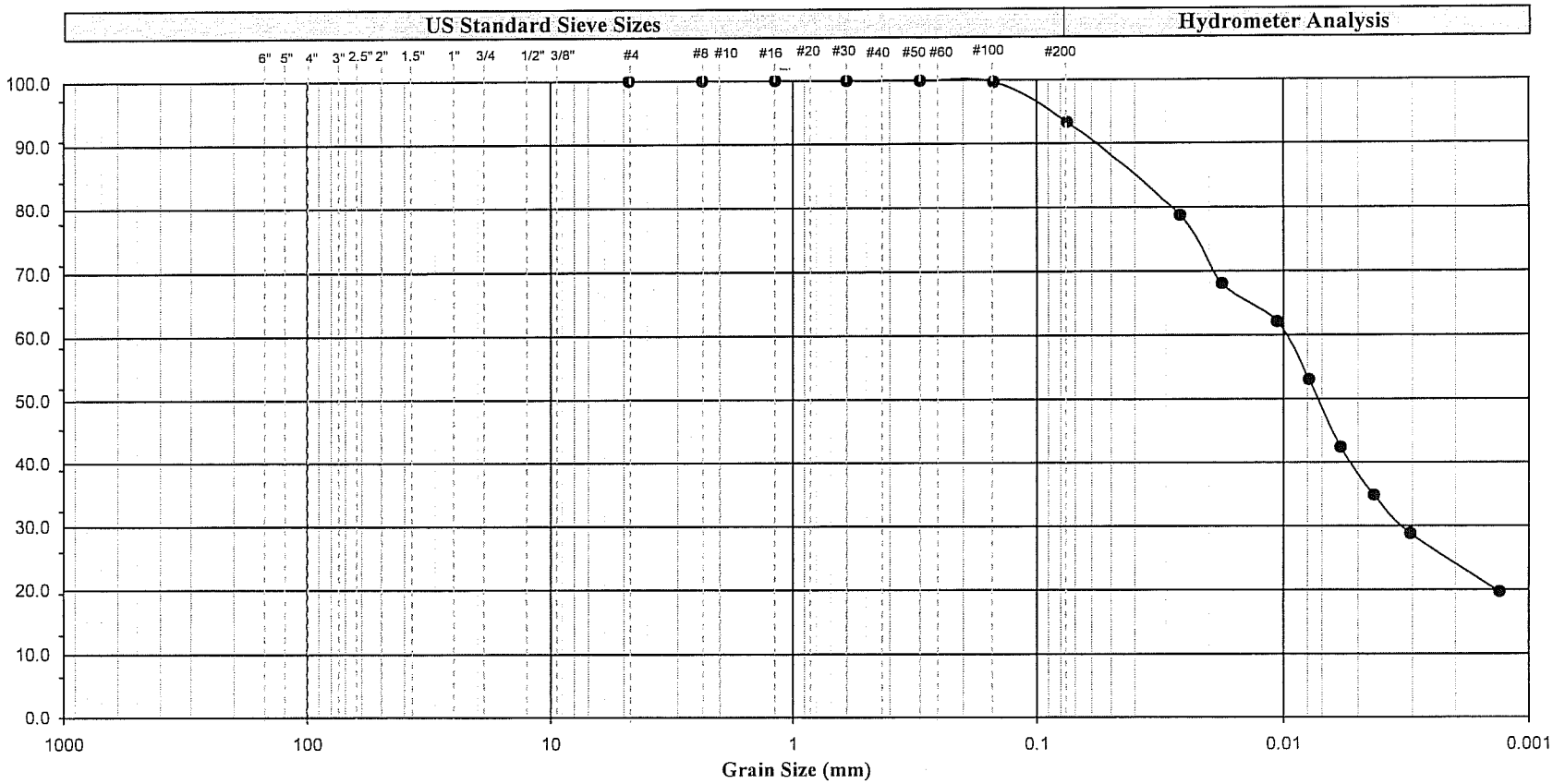
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	J-18	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Test Cylinder No. :	6								
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-11		S-18	29		S-16		
Wt. of Wet Soil + Container (gm)		225.62		66.06	172.34			0.99	
Wt. of Dry Soil + Container (gm)					171.19		119.01	Hydrometer Type	
Wt. of Container (gm)					56.80		114.20	152H	
Wt. of Dry Soil (gm)		223.37		65.40			4.81	(K) Value	Temp. °C
Moisture Content (%)					1.01			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				46	No. 16	0.01		99.98	**99.98**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.03		99.95	**99.95**
1.0"					No. 40				
3/4"				29	No. 50	0.05		99.92	**99.92**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.21		99.68	**99.68**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.00		**100.00**	17	No. 200	4.31		93.41	**93.41**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
13:46	0:00:00			5.0							
	2	21.0	57.0	5.0	52.0	78.71	**78.71**	0.05500	0.01328	7.8	**0.02617**
	5	21.0	50.0	5.0	45.0	68.12	**68.12**	0.03500	0.01328	8.9	**0.01774**
	15	21.0	46.0	5.0	41.0	62.06	**62.06**	0.02000	0.01328	9.6	**0.01061**
	30	22.0	40.0	5.0	35.0	52.98	**52.98**	0.01400	0.01328	10.6	**0.00788**
	60	23.0	33.0	5.0	28.0	42.38	**42.38**	0.01000	0.01328	11.7	**0.00587**
	120	23.0	28.0	5.0	23.0	34.82	**34.82**	0.00700	0.01328	12.5	**0.00429**
	240	23.5	24.0	5.0	19.0	28.76	**28.76**	0.00500	0.01328	13.2	**0.00305**
	1440	21.5	18.0	5.0	13.0	19.68	**19.68**	0.00100	0.01328	14.2	**0.00132**

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	**0**	**7**	**93**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-053	S-9	45.0	dark olive gray	Silt	ML
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 — Set up By : J.F — Date : 11/13/2009

Boring No. : A-09-053 — Tested By : J.F/R.J. — Date : 11/13/09-11/23/09

Sample No. : D-8 — Time Rate Took By : J.F — Date : 11/16/09,11/18/09

Depth (ft / m) : 40.0 | 12.20 — Computer By : JF — Date : 11/24/2009

File No. : — Checked By : R.J. — Date :

Soil Description : Dark gray, SANDY SILT (ML)

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)
Internal Diameter	2.42	61.47
Height (Intial)	1.00	25.40
Height (Final)	0.9588	24.35

Vertical Load	(ksf)	(kPa)
Add Water at	0.50	23.94
Load to	16.00	766.08
Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

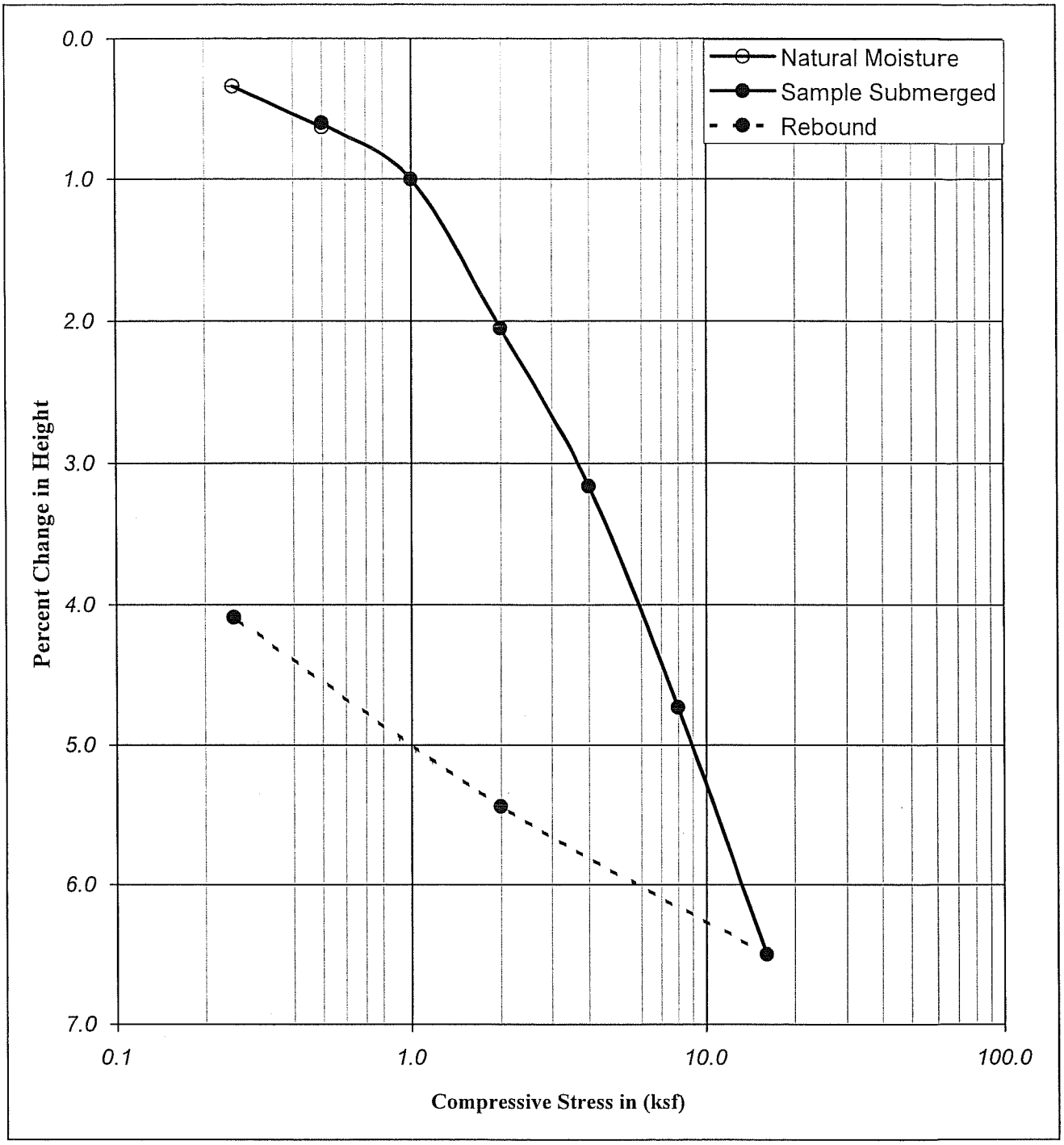
Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
11/13/2009	14:50	0:00:00	Seating		0.04970	1.26		
			Load					
	15:03:00 PM		0.1	4.8	0.05000	1.27	0.00	
11/14/2009	9:10	0:00:00	0.25	12.0	0.05340	1.36	0.34	
11/15/2009	9:42	0:00:00	0.50	23.9	0.05630	1.43	0.63	
			Add Water					
11/16/2009	8:35	0:00:00	0.50	23.9	0.05600	1.42	0.60	
11/16/2009	8:38	0:00:00	1.00	47.9	0.05600	1.42	0.60	0.00
		0.10	1.0	47.9	0.05770	1.47	0.77	0.32
		0.25	1.0	47.9	0.0579	1.47	0.79	0.50
		0.50	1.0	47.9	0.05810	1.48	0.81	0.71
		1	1.0	47.9	0.05820	1.48	0.82	1.00
		2	1.0	47.9	0.05840	1.48	0.84	1.41
		4	1.0	47.9	0.05850	1.49	0.85	2.00
		8	1.0	47.9	0.05860	1.49	0.86	2.83
		15	1.0	47.9	0.05870	1.49	0.87	3.87
		30	1.0	47.9	0.05880	1.49	0.88	5.48
		60	1.0	47.9	0.05890	1.50	0.89	7.75
		120	1.0	47.9	0.05910	1.50	0.91	10.95
		240	1.0	47.9	0.05930	1.51	0.93	15.49
		480	1.0	47.9	0.05950	1.51	0.95	21.91
11/17/2009		1440	1.0	47.9	0.06000	1.52	1.00	37.95
11/18/2009	8:34	0	2.0	95.8	0.07050	1.79	2.05	
11/18/2009	8:42	0	4.0	191.5	0.0705	1.79	2.05	
		0.10	4.0	191.5	0.0759	1.93	2.59	
		0.25	4.0	191.5	0.0769	1.95	2.69	
		0.50	4.0	191.5	0.0777	1.97	2.77	
		1	4.0	191.5	0.0781	1.98	2.81	
		2	4.0	191.5	0.0784	1.99	2.84	
		4	4.0	191.5	0.0787	2.00	2.87	
		8	4.0	191.5	0.0791	2.01	2.91	
		15	4.0	191.5	0.0793	2.01	2.93	
		30	4.0	191.5	0.0796	2.02	2.96	
		60	4.0	191.5	0.0799	2.03	2.99	
		120	4.0	191.5	0.0802	2.04	3.02	
		240	4.0	191.5	0.0807	2.05	3.07	
		480	4.0	191.5	0.0812	2.06	3.12	
11/19/09		1440	4.0	191.5	0.0816	2.07	3.16	

	No.	Before	After
Weight of wet soil + ring (gm)		193.94	
Weight of ring (gm)		43.63	
Weight of wet soil + ring + container (gm)			252.39
Weight of dry soil + ring + container (gm)			219.19
Weight of container (gm)	86		60.06
Weight of ring + container (gm)			103.69
Moisture Content (%)		30.14	28.74
Dial Reading (inch)		0.05	0.04
Sample Volume (ft^3)		0.0027	0.0026
Wet Density (pcf)		124.5	128.4
Dry Density (pcf)		95.66	99.77

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.0973	2.47	4.73
11/21/2009	8:36		16.00	766.1	0.1150	2.92	6.50
11/22/2009	8:42		2.00	95.8	0.1044	2.65	5.44
11/23/2009	8:40		0.25	12.0	0.0909	2.31	4.09

Remark :

Final Dial Reading 0.0909



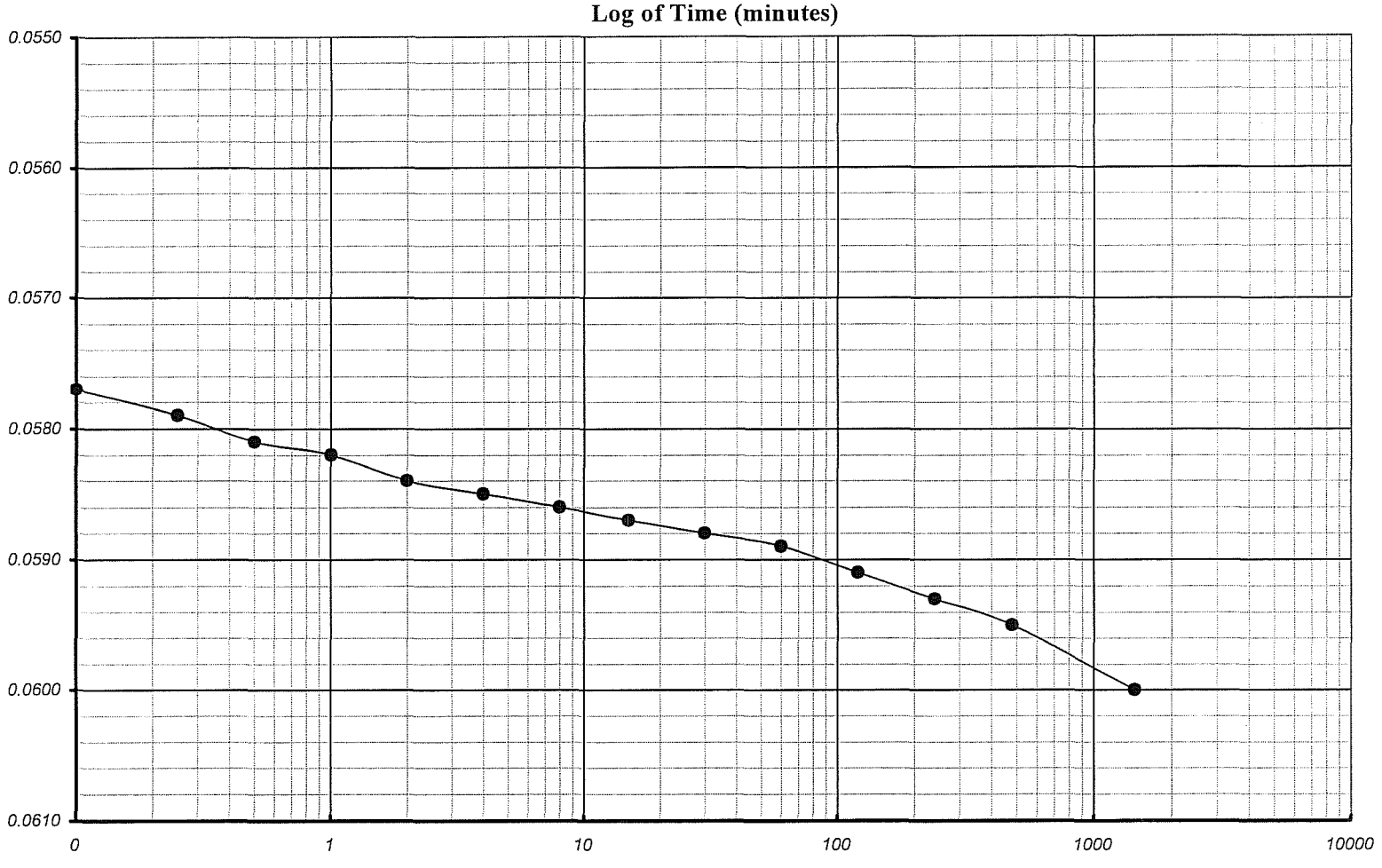
Boring No.	: A-09-053		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	30.14	95.66	15.06	106.78	0.76
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	28.74	99.77	15.70	112.56	0.69
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

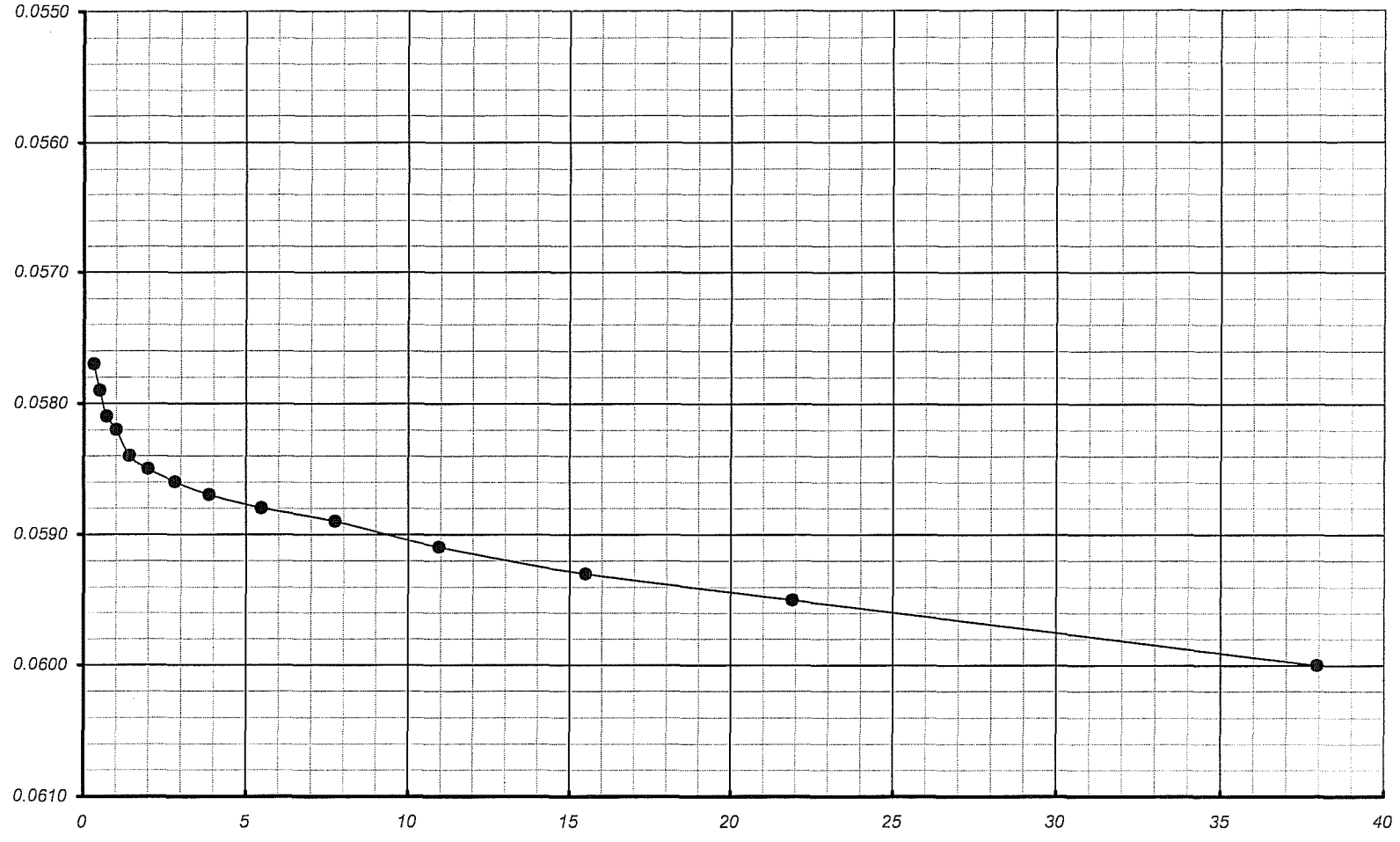
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

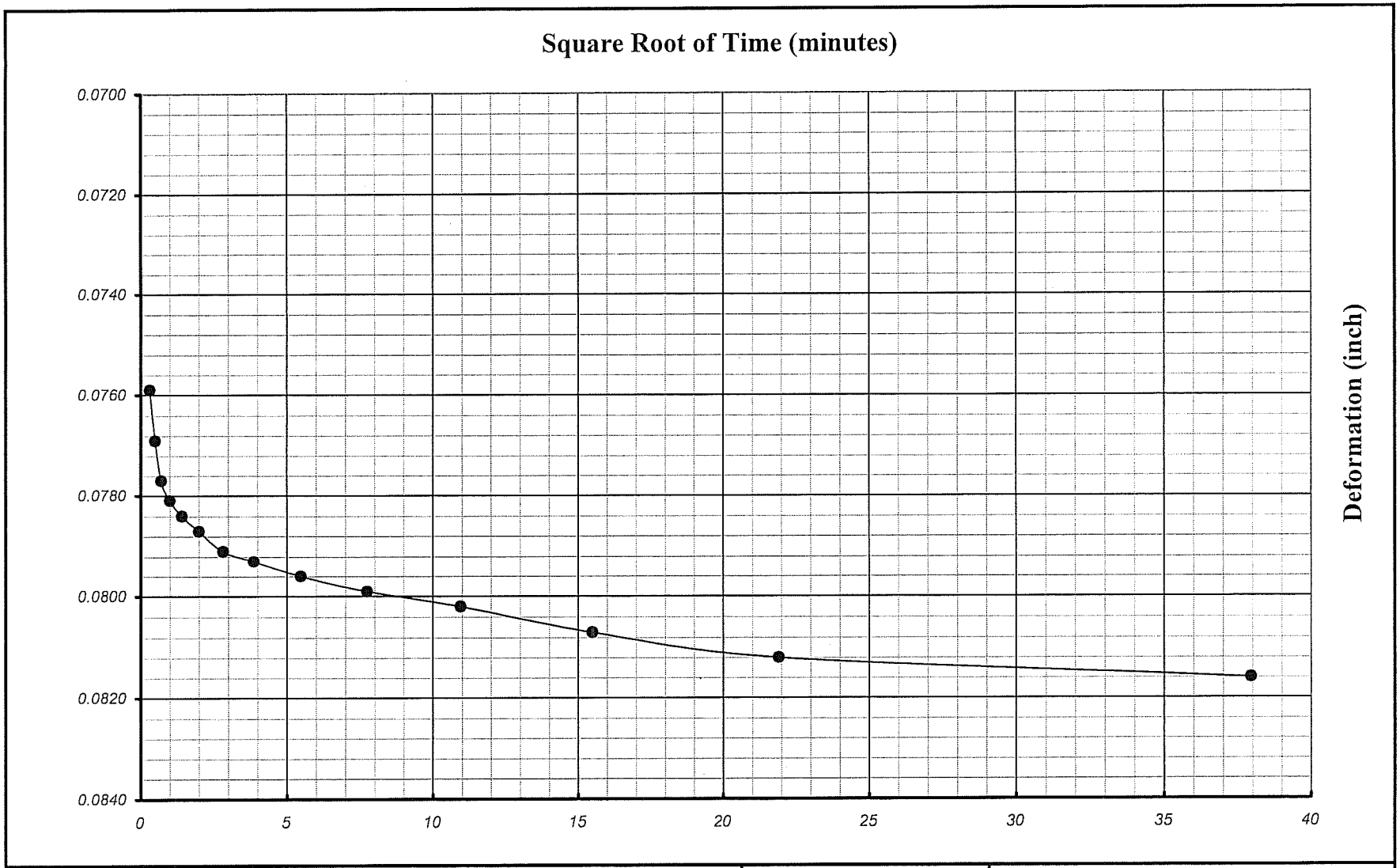


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-053	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 1.00 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-053	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 1

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-053
Sample No. : D-10
Depth (ft / m) : 50.0 | 15.25
File No. :
Soil Description : Dark gray, SILT with SAND (ML)

Set up By : J.F Date : 11/13/2009
Tested By : J.F/R.J. Date : 11/13/09-11/23/09
Time Rate Took By : J.F Date : 11/16/09, 11/18/09
Computer By : JF Date : 11/24/2009
Checked By : R.J. Date :

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.9297	23.61	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/13/2009	14:55	0:00:00	Seating		0.04980	1.26	
			Load				
	15:05		0.1	4.8	0.05000	1.27	0.00
11/14/2009	9:10	0:00:00	0.25	12.0	0.05530	1.40	0.53
11/15/2009	9:42	0:00:00	0.50	23.9	0.05930	1.51	0.93
			Add Water				
11/16/2009	8:35	0:00:00	0.50	23.9	0.05930	1.51	0.93
11/16/2009	8:44	0:00:00	1.00	47.9	0.05930	1.51	0.93
		0.10	1.0	47.9	0.05950	1.51	0.95
		0.25	1.0	47.9	0.0597	1.52	0.97
		0.50	1.0	47.9	0.06000	1.52	1.00
		1	1.0	47.9	0.06040	1.53	1.04
		2	1.0	47.9	0.06080	1.54	1.08
		4	1.0	47.9	0.06120	1.55	1.12
		8	1.0	47.9	0.06160	1.56	1.16
		15	1.0	47.9	0.06210	1.58	1.21
		30	1.0	47.9	0.06260	1.59	1.26
		60	1.0	47.9	0.06310	1.60	1.31
		120	1.0	47.9	0.06360	1.62	1.36
		240	1.0	47.9	0.06460	1.64	1.46
		480	1.0	47.9	0.06570	1.67	1.57
11/17/2009		1440	1.0	47.9	0.06620	1.68	1.62
11/18/2009	8:34	0	2.0	95.8	0.08240	2.09	3.24
11/18/2009	8:42	0	4.0	191.5	0.0824	2.09	3.24
		0.10	4.0	191.5	0.0831	2.11	3.31
		0.25	4.0	191.5	0.0860	2.18	3.60
		0.50	4.0	191.5	0.0885	2.25	3.85
		1	4.0	191.5	0.0897	2.28	3.97
		2	4.0	191.5	0.0908	2.31	4.08
		4	4.0	191.5	0.0923	2.34	4.23
		8	4.0	191.5	0.0928	2.36	4.28
		15	4.0	191.5	0.0935	2.37	4.35
		30	4.0	191.5	0.0945	2.40	4.45
		60	4.0	191.5	0.0953	2.42	4.53
		120	4.0	191.5	0.0961	2.44	4.61
		240	4.0	191.5	0.0972	2.47	4.72
		480	4.0	191.5	0.0980	2.49	4.80
11/19/09		1440	4.0	191.5	0.0987	2.51	4.87

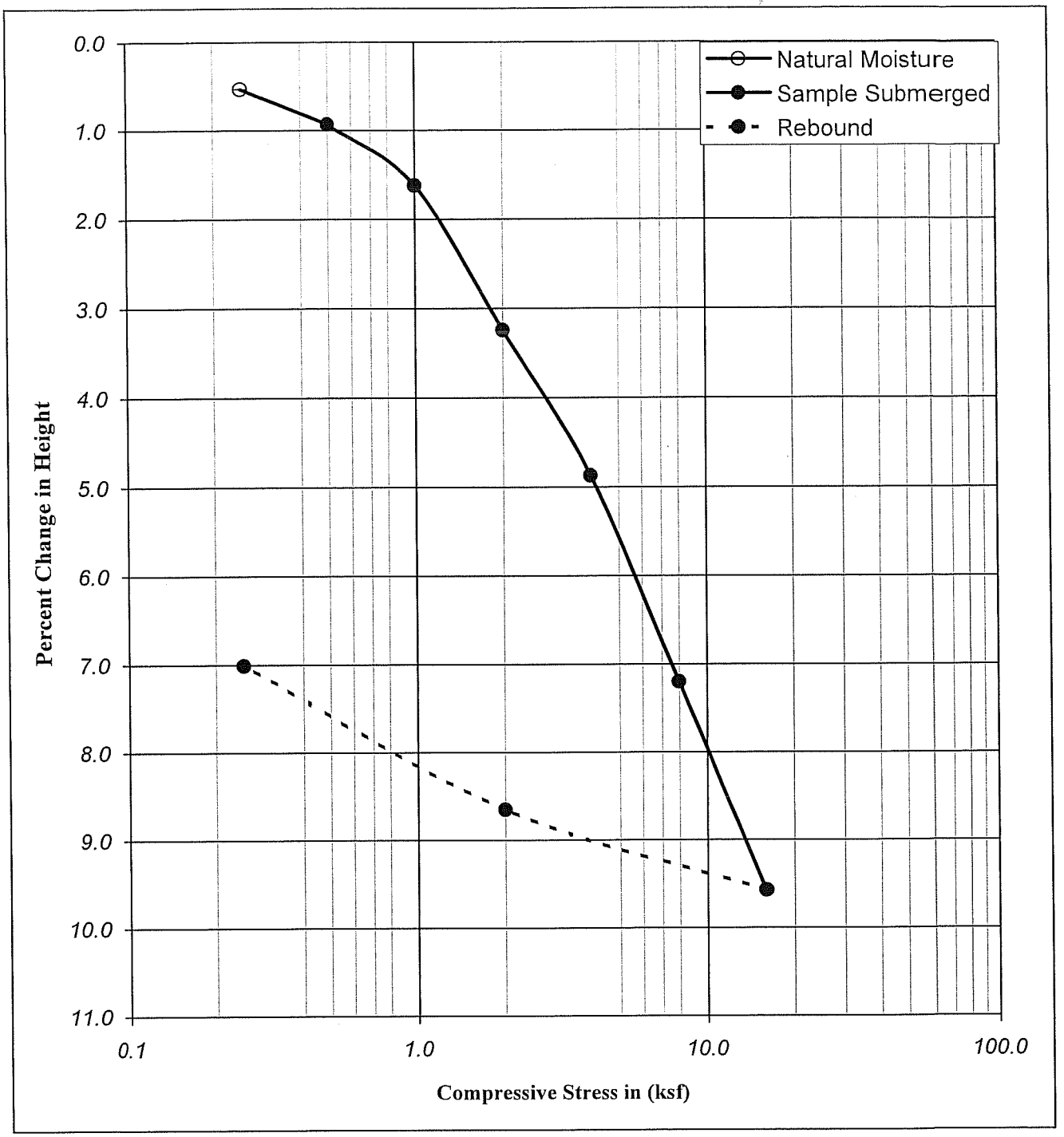
	Before	After
Weight of wet soil + ring (gm)	191.36	
Weight of ring (gm)	43.40	
Weight of wet soil + ring + container (gm)		246.58
Weight of dry soil + ring + container (gm)		216.82
No. 87 Weight of container (gm)		59.79
Weight of ring + container (gm)		103.19
Moisture Content (%)	30.21	26.19
Dial Reading (inch)	0.05	0.04
Sample Volume (ft^3)	0.0027	0.0025
Wet Density (pcf)	122.5	127.7
Dry Density (pcf)	94.11	101.23

SQRT Time
0.00
0.32
0.50
0.71
1.00
1.41
2.00
2.83
3.87
5.48
7.75
10.95
15.49
21.91
37.95

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.1220	3.10	7.20
11/21/2009	8:36		16.00	766.1	0.1457	3.70	9.57
11/22/2009	8:42		2.00	95.8	0.1365	3.47	8.65
11/23/2009	8:40		0.25	12.0	0.1201	3.05	7.01

Remark :

Final Dial Reading 0.1201



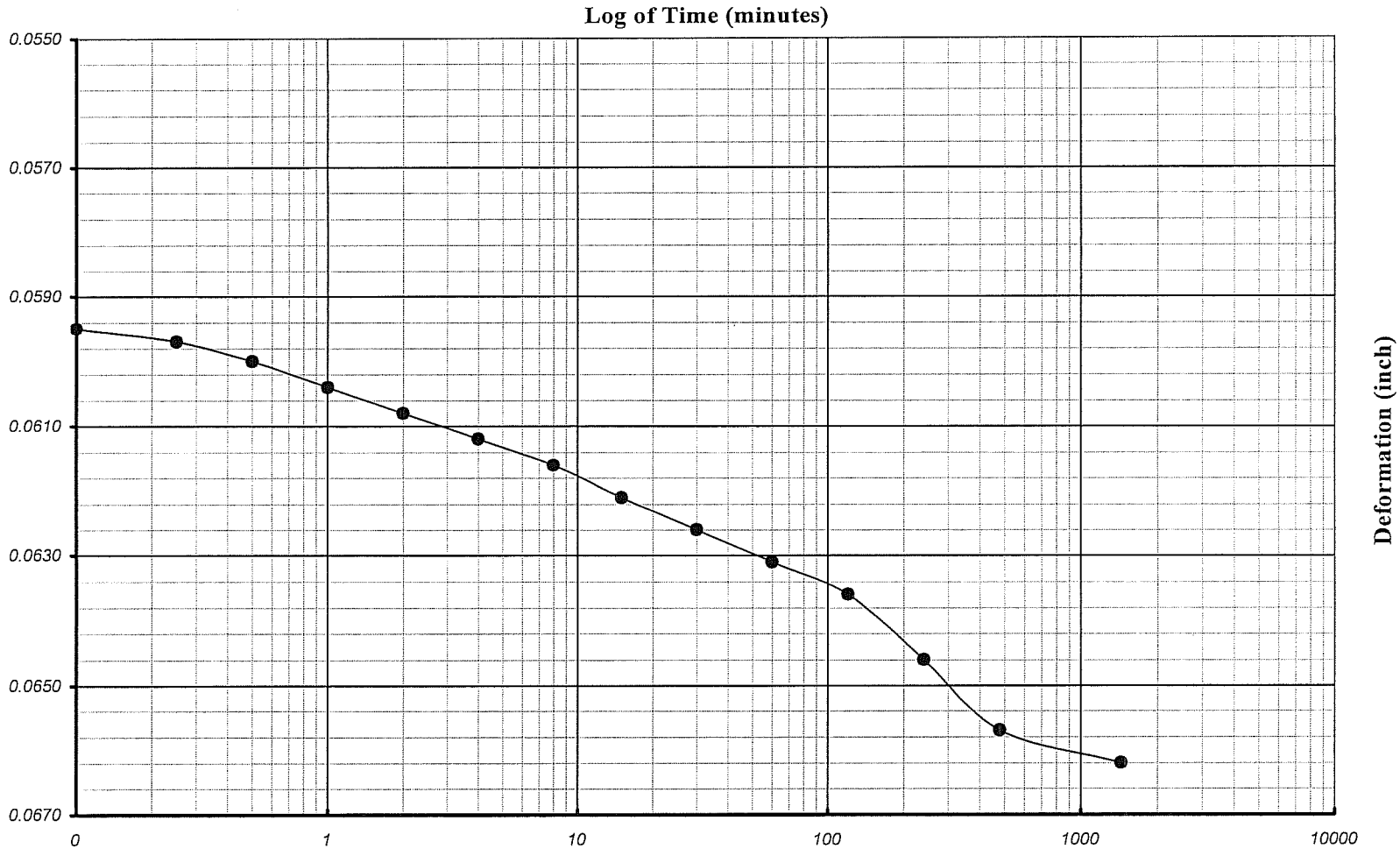
Boring No.	: A-09-053		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No.	: D-10		Plastic Limit :	-						
Depth (ft)	: 50.0	51.5	Plastic Index :	-	Initial	30.21	94.11	14.81	103.12	0.79
Depth (m)	: 15.25	15.71	Specific Gravity :	2.70	Final	26.19	101.23	15.93	106.31	0.67
Description	: Dark gray, SILT with SAND (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

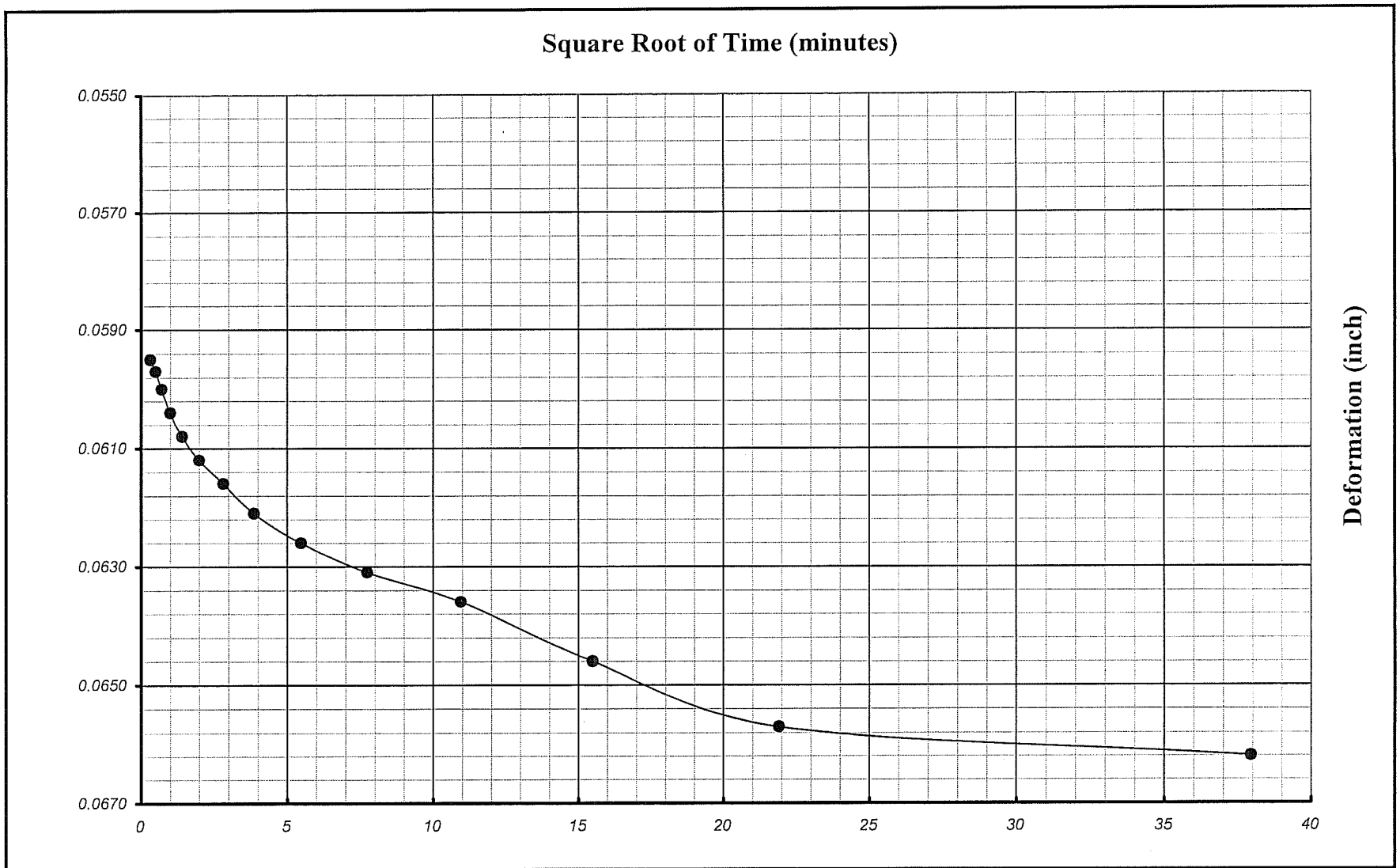
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

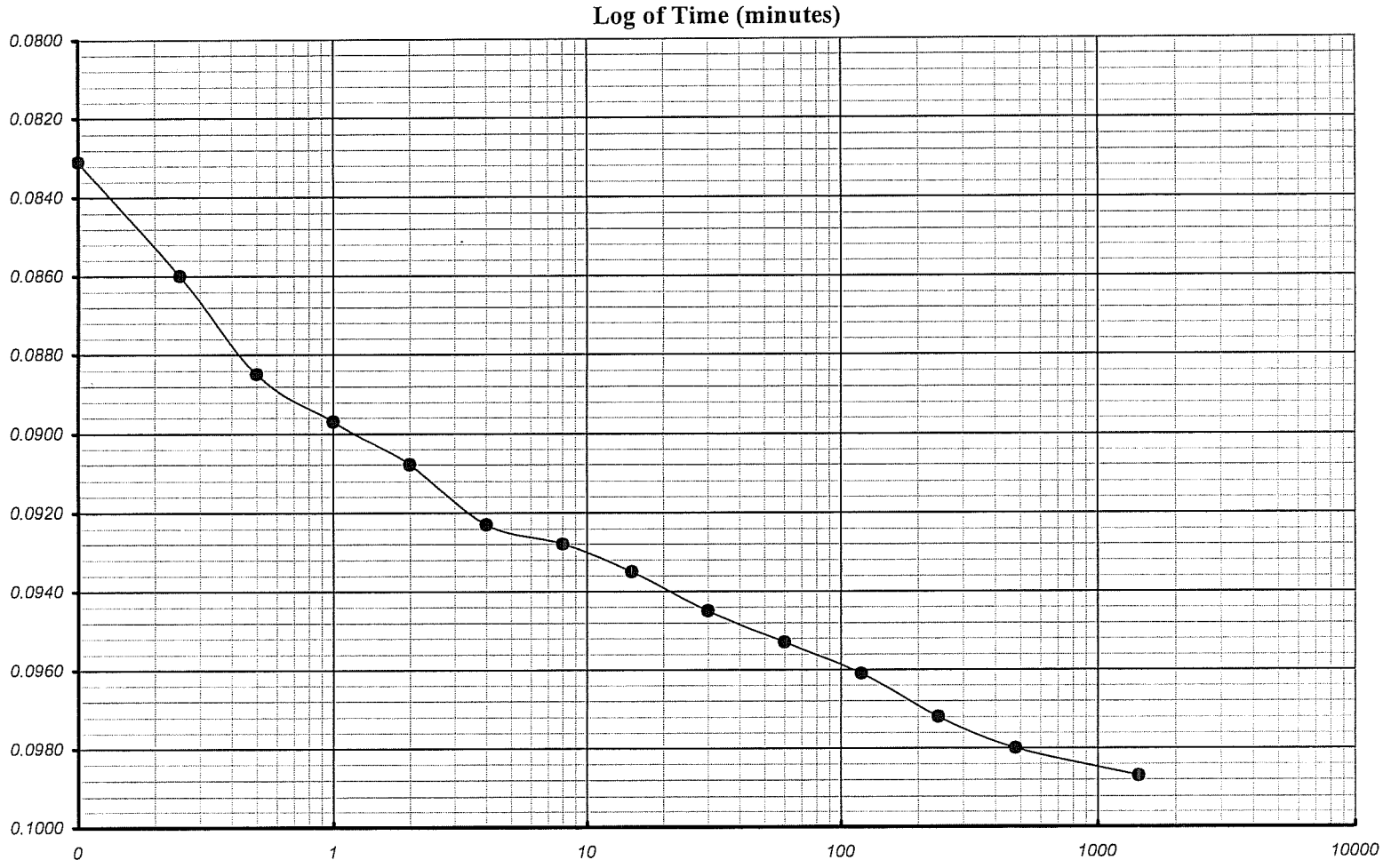
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



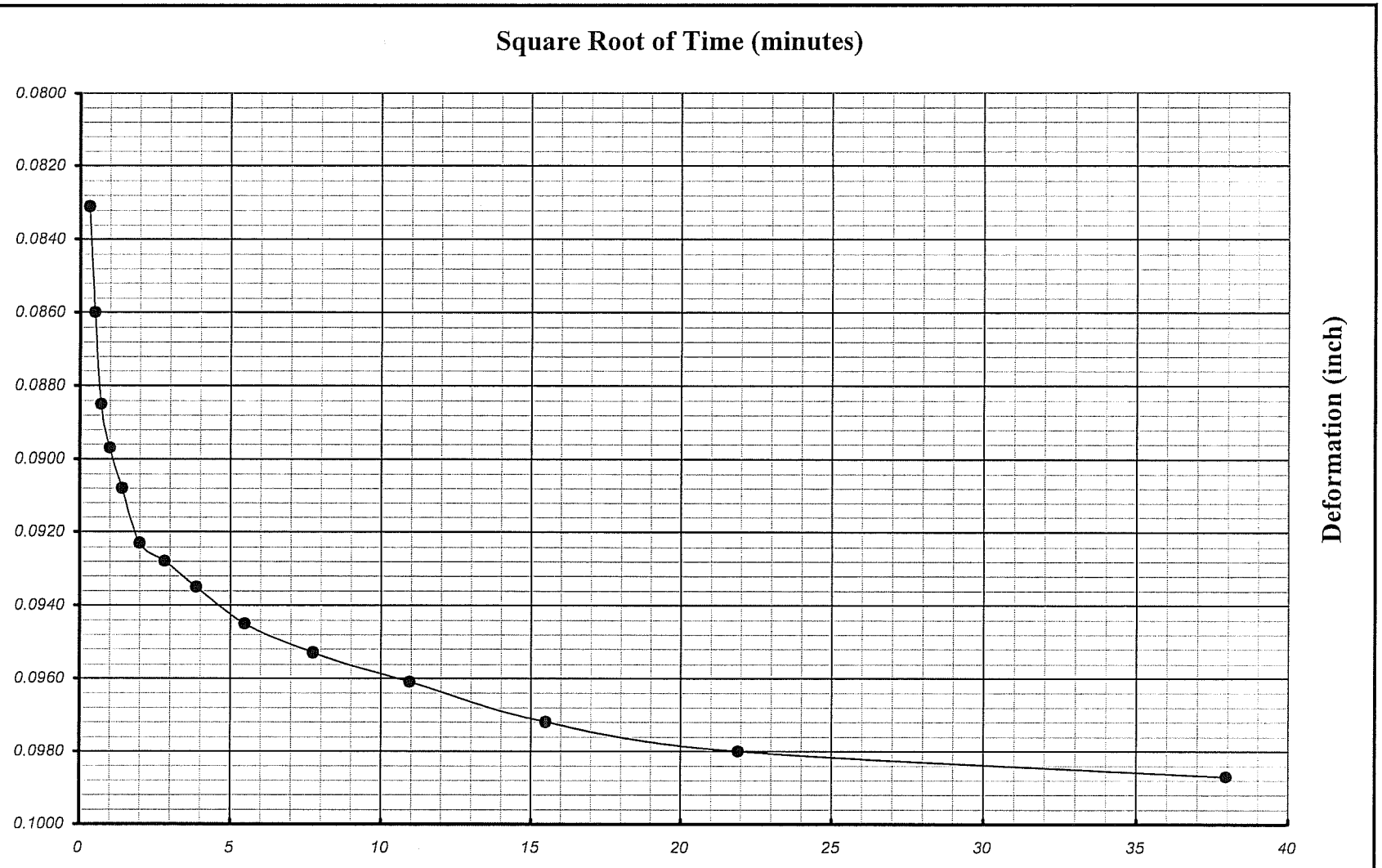
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-053	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-10	
EMI Project No. : 06-123-3		Depth (ft/m) : 50.0 15.3	Veritcal Load (ksf/kpa) : 1.00 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-10*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *50.0* *15.3*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-053	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-10	
EMI Project No. : 06-123-3		Depth (ft/m) : 50.0 15.3	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-10*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *50.0* *15.3*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

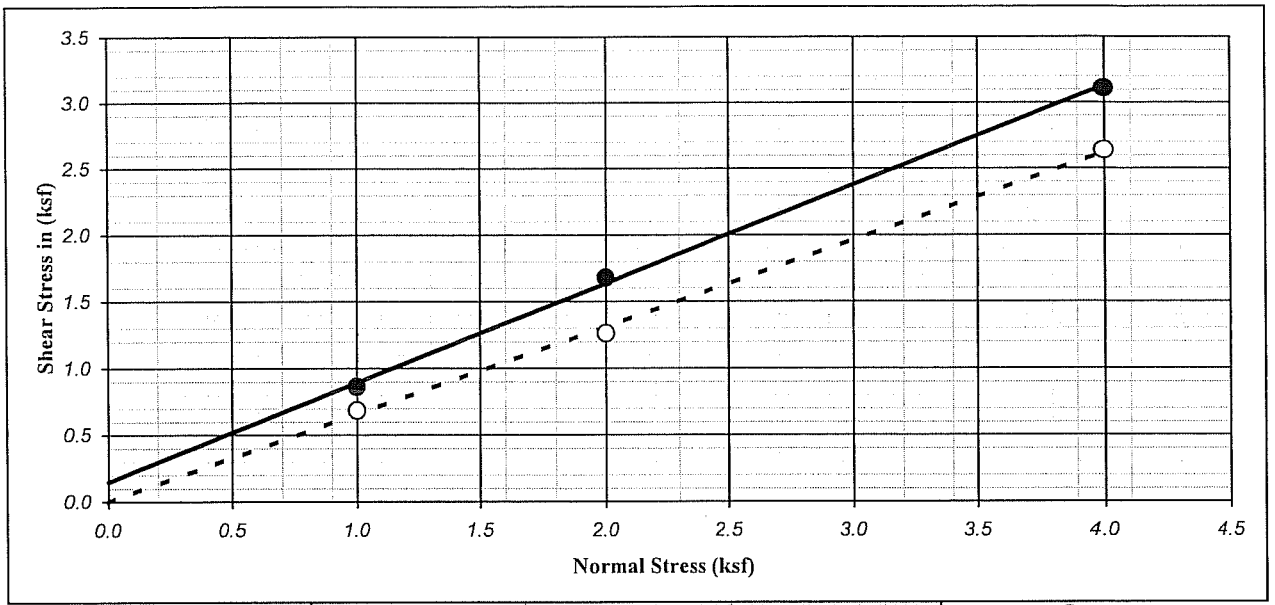
Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-053		Saturated		Field Moisiture	X	Inundated		**Specific Gravity** (Assumed) :	2.70
Sample No. : D-2	X	Undisturbed		Remolded		Consolidated-Drained		**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 10.0	x	Shear Once		Reshear		Residual		**Data File Number :**	0612303
Description : Dark grayish brown, Poorly graded SAND with SILT (SP-SM)									

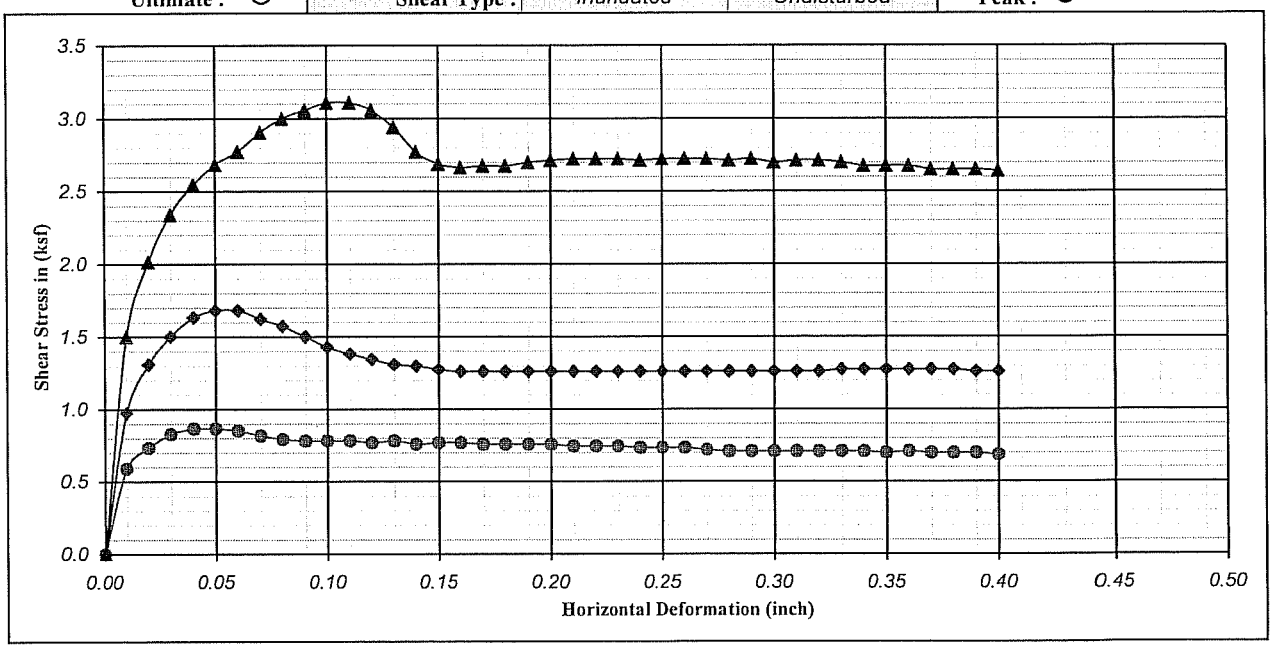
Percent Saturation (%)	106.86	**File No. :** 0612303 1																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09																			
Computed By : JF	**Date :** 12/11/09	**1.00** (ksf)																		
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		197.84																		
Weight of Ring (gm)		44.68																		
Weight of Wet Soil + Cont. (gm)				154.63																
Weight of Dry Soil + Cont. (gm)				122.13																
Weight of Cont. (gm) **No.**	7			3.72																
Moisture Content (%)				27.45																
Wet Density (pcf / kN/m³)		126.85	19.97																	
Dry Density (pcf / kN/m³)		99.53	15.67																	
Percent Saturation (%)	69.29	**File No. :** 0612303 2																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	**2.00** (ksf)																		
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		210.42																		
Weight of Ring (gm)		44.83																		
Weight of Wet Soil + Cont. (gm)				146.39																
Weight of Dry Soil + Cont. (gm)				135.11																
Weight of Cont. (gm) **No.**	8			3.74																
Moisture Content (%)				8.59																
Wet Density (pcf / kN/m³)		137.15	21.59																	
Dry Density (pcf / kN/m³)		126.30	19.88																	
Percent Saturation (%)	104.96	**File No. :** 0612303 3																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	**4.00** (ksf)																		
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		193.60																		
Weight of Ring (gm)		42.47																		
Weight of Wet Soil + Cont. (gm)				152.52																
Weight of Dry Soil + Cont. (gm)				119.73																
Weight of Cont. (gm) **No.**	9			3.78																
Moisture Content (%)				28.28																
Wet Density (pcf / kN/m³)		125.17	19.70																	
Dry Density (pcf / kN/m³)		97.58	15.36																	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.86	41.37	1.68	80.44	3.11	148.81
Ultimate	0.68	32.75	1.26	60.33	2.64	126.40

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)** 1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	588	0.59	28.2	972	0.97	46.5	1500	1.50	71.6
0.020	0.05	732	0.73	35.0	1308	1.31	62.6	2016	2.02	96.2
0.030	0.08	828	0.83	39.6	1500	1.50	71.8	2340	2.34	111.6
0.040	0.10	864	0.86	41.4	1632	1.63	78.1	2544	2.54	121.4
0.050	0.13	864	0.86	41.4	1680	1.68	80.4	2684	2.68	128.0
0.060	0.15	852	0.85	40.8	1680	1.68	80.4	2772	2.77	132.2
0.070	0.18	816	0.82	39.1	1620	1.62	77.6	2904	2.90	138.5
0.080	0.20	792	0.79	37.9	1572	1.57	75.3	3000	3.00	143.1
0.090	0.23	780	0.78	37.3	1500	1.50	71.8	3060	3.06	146.0
0.100	0.25	780	0.78	37.3	1428	1.43	68.4	3108	3.11	148.3
0.110	0.28	780	0.78	37.3	1380	1.38	66.1	3108	3.11	148.3
0.120	0.30	768	0.77	36.8	1344	1.34	64.4	3060	3.06	146.0
0.130	0.33	780	0.78	37.3	1308	1.31	62.6	2940	2.94	140.2
0.140	0.36	756	0.76	36.2	1296	1.30	62.1	2772	2.77	132.2
0.150	0.38	768	0.77	36.8	1272	1.27	60.9	2688	2.69	128.2
0.160	0.41	768	0.77	36.8	1260	1.26	60.3	2664	2.66	127.1
0.170	0.43	756	0.76	36.2	1260	1.26	60.3	2676	2.68	127.7
0.180	0.46	756	0.76	36.2	1260	1.26	60.3	2676	2.68	127.7
0.190	0.48	756	0.76	36.2	1260	1.26	60.3	2700	2.70	128.8
0.200	0.51	756	0.76	36.2	1260	1.26	60.3	2712	2.71	129.4
0.210	0.53	744	0.74	35.6	1260	1.26	60.3	2724	2.72	129.9
0.220	0.56	744	0.74	35.6	1260	1.26	60.3	2724	2.72	129.9
0.230	0.58	744	0.74	35.6	1260	1.26	60.3	2724	2.72	129.9
0.240	0.61	732	0.73	35.0	1260	1.26	60.3	2712	2.71	129.4
0.250	0.64	732	0.73	35.0	1260	1.26	60.3	2724	2.72	129.9
0.260	0.66	732	0.73	35.0	1260	1.26	60.3	2724	2.72	129.9
0.270	0.69	720	0.72	34.5	1260	1.26	60.3	2724	2.72	129.9
0.280	0.71	708	0.71	33.9	1260	1.26	60.3	2712	2.71	129.4
0.290	0.74	708	0.71	33.9	1260	1.26	60.3	2724	2.72	129.9
0.300	0.76	708	0.71	33.9	1260	1.26	60.3	2700	2.70	128.8
0.310	0.79	708	0.71	33.9	1260	1.26	60.3	2712	2.71	129.4
0.320	0.81	708	0.71	33.9	1260	1.26	60.3	2712	2.71	129.4
0.330	0.84	708	0.71	33.9	1272	1.27	60.9	2700	2.70	128.8
0.340	0.86	708	0.71	33.9	1272	1.27	60.9	2676	2.68	127.7
0.350	0.89	696	0.70	33.3	1272	1.27	60.9	2676	2.68	127.7
0.360	0.91	708	0.71	33.9	1272	1.27	60.9	2676	2.68	127.7
0.370	0.94	696	0.70	33.3	1272	1.27	60.9	2652	2.65	126.5
0.380	0.97	696	0.70	33.3	1272	1.27	60.9	2652	2.65	126.5
0.390	0.99	696	0.70	33.3	1260	1.26	60.3	2652	2.65	126.5
0.400	1.02	684	0.68	32.7	1260	1.26	60.3	2640	2.64	125.9
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-053	Strength Intercept (C) :	0.15	(ksf)	Peak	0.00	(ksf)	Ultimate
Sample No. : D-2		7.18	(kPa)		0.00	(kPa)	
Depth (ft/m) : 10.0 | 0.00	Friction Angle (ϕ) :	36.62	Degree		33.24	Degree	

Description : *Dark grayish brown, Poorly graded SAND with SILT (SP-SM)* — Shear Rate (inch/minute) : 0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	27.45	99.53	15.67	0.69	1.00	47.88	0.86	41.37	0.68	32.75
◆	8.59	126.30	19.88	0.33	2.00	95.76	1.68	80.44	1.26	60.33
▲	28.28	97.58	15.36	0.73	4.00	191.52	3.11	148.81	2.64	126.40

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09 | Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. :	A-09-053		Saturated		Field Moisture	X	Inundated — Specific Gravity (Assumed) : 2.70
Sample No. :	D-6	X	Undisturbed		Remolded		Consolidated-Drained — Shear Rate (inch/min) : 0.02
Depth (ft/m) :	30.0	x	Shear Once		Reshear		Residual — Data File Number : 0911804
Description :	Gray, SILTY SAND (SM)						

Specimen 1

Percent Saturation (%)	100.95	File No. : 0911804	1	
Prepared By : JF	Date : 11/30/09	Normal Stress		
Tested By : JF	Date : 11/30/09			
Computed By : JF	Date : 12/11/09	2.00	(ksf)	
Checked By :	Date :			
Percent Consolidation (%)		Before		After
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		190.81		
Weight of Ring (gm)		44.91		
Weight of Wet Soil + Cont. (gm)				149.76
Weight of Dry Soil + Cont. (gm)				115.30
Weight of Cont. (gm) No.	10			3.65
Moisture Content (%)				30.86
Wet Density (pcf / kN/m³)		120.84	19.02	
Dry Density (pcf / kN/m³)		92.34	14.53	

Specimen 2

Percent Saturation (%)	104.25	File No. : 0911804	2	
Prepared By : JF	Date : 11/30/09	Normal Stress		
Tested By : JF	Date : 11/30/09	4.00	(ksf)	
Percent Consolidation (%)		Before		After
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		190.63		
Weight of Ring (gm)		43.63		
Weight of Wet Soil + Cont. (gm)				149.90
Weight of Dry Soil + Cont. (gm)				114.53
Weight of Cont. (gm) No.	11			3.65
Moisture Content (%)				31.90
Wet Density (pcf / kN/m³)		121.75	19.16	
Dry Density (pcf / kN/m³)		92.30	14.53	

Specimen 3

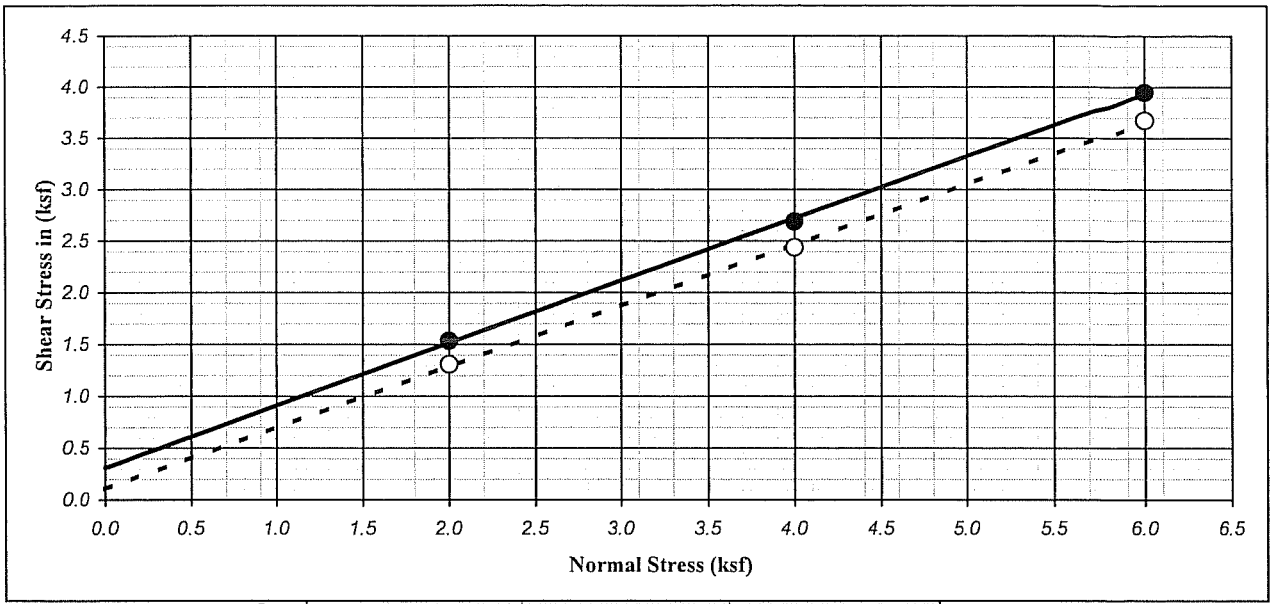
Percent Saturation (%)	103.92	File No. : 0911804	3	
Prepared By : JF	Date : 11/30/09	Normal Stress		
Tested By : JF	Date : 11/30/09	6.00	(ksf)	
Percent Consolidation (%)		Before		After
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		190.38		
Weight of Ring (gm)		43.43		
Weight of Wet Soil + Cont. (gm)				149.40
Weight of Dry Soil + Cont. (gm)				114.29
Weight of Cont. (gm) No.	12			3.65
Moisture Content (%)				31.73
Wet Density (pcf / kN/m³)		121.71	19.16	
Dry Density (pcf / kN/m³)		92.39	14.54	

Strength

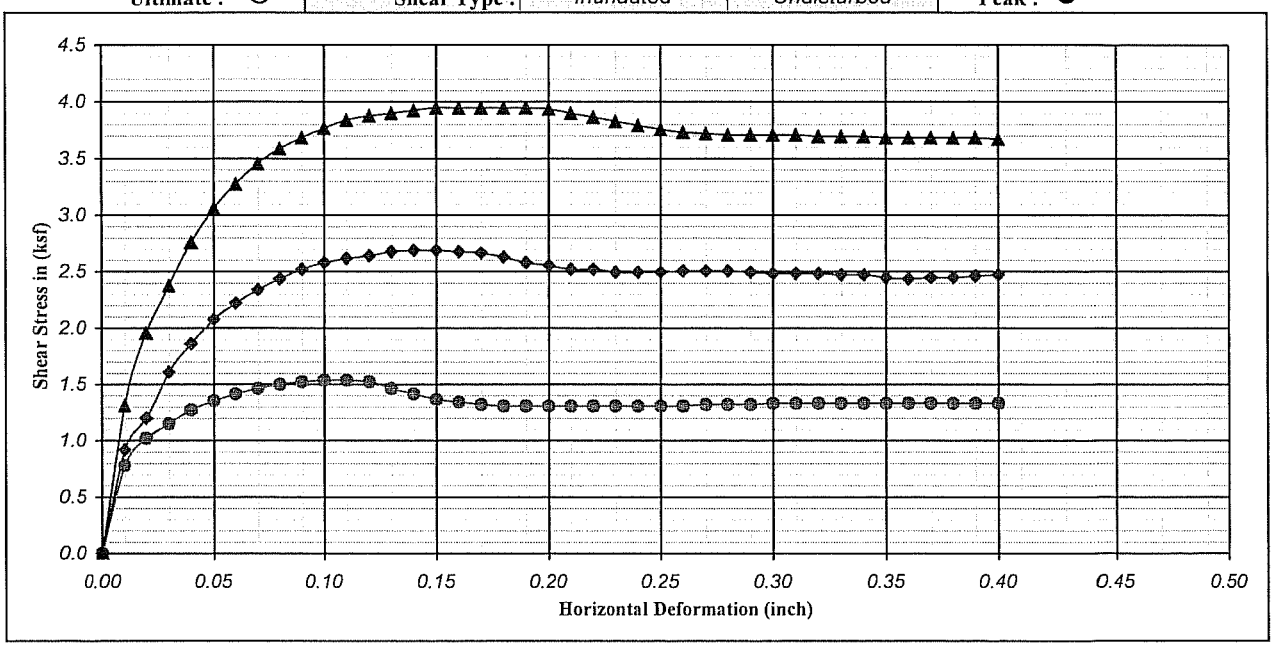
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.54	73.54	2.69	128.70	3.95	189.03
Ultimate	1.31	62.63	2.44	116.64	3.67	175.82

Shear Data

Shear Deflection (inch)	Shear Deflection (mm)	Normal Stress (psf/ksf/kPa) 2000	2.00	95.8	4000	4.0	191.5	6000	6.0	287.3
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	780	0.78	37.3	920	0.92	44.0	1312	1.31	62.6
0.020	0.05	1020	1.02	48.8	1200	1.20	57.5	1956	1.96	93.3
0.030	0.08	1152	1.15	55.2	1608	1.61	77.0	2376	2.38	113.3
0.040	0.10	1272	1.27	60.9	1860	1.86	89.1	2760	2.76	131.7
0.050	0.13	1356	1.36	64.9	2076	2.08	99.4	3060	3.06	146.0
0.060	0.15	1416	1.42	67.8	2220	2.22	106.3	3276	3.28	156.3
0.070	0.18	1464	1.46	70.1	2340	2.34	112.0	3456	3.46	164.9
0.080	0.20	1500	1.50	71.8	2436	2.44	116.6	3588	3.59	171.2
0.090	0.23	1524	1.52	73.0	2520	2.52	120.7	3684	3.68	175.7
0.100	0.25	1536	1.54	73.5	2580	2.58	123.5	3768	3.77	179.7
0.110	0.28	1536	1.54	73.5	2616	2.62	125.3	3840	3.84	183.2
0.120	0.30	1524	1.52	73.0	2640	2.64	126.4	3876	3.88	184.9
0.130	0.33	1464	1.46	70.1	2676	2.68	128.1	3900	3.90	186.0
0.140	0.36	1416	1.42	67.8	2688	2.69	128.7	3924	3.92	187.2
0.150	0.38	1368	1.37	65.5	2688	2.69	128.7	3948	3.95	188.3
0.160	0.41	1344	1.34	64.4	2676	2.68	128.1	3948	3.95	188.3
0.170	0.43	1320	1.32	63.2	2664	2.66	127.6	3948	3.95	188.3
0.180	0.46	1308	1.31	62.6	2628	2.63	125.8	3948	3.95	188.3
0.190	0.48	1308	1.31	62.6	2580	2.58	123.5	3948	3.95	188.3
0.200	0.51	1308	1.31	62.6	2556	2.56	122.4	3936	3.94	187.8
0.210	0.53	1308	1.31	62.6	2520	2.52	120.7	3900	3.90	186.0
0.220	0.56	1308	1.31	62.6	2520	2.52	120.7	3864	3.86	184.3
0.230	0.58	1308	1.31	62.6	2496	2.50	119.5	3828	3.83	182.6
0.240	0.61	1308	1.31	62.6	2496	2.50	119.5	3792	3.79	180.9
0.250	0.64	1308	1.31	62.6	2496	2.50	119.5	3756	3.76	179.2
0.260	0.66	1308	1.31	62.6	2508	2.51	120.1	3732	3.73	178.0
0.270	0.69	1320	1.32	63.2	2508	2.51	120.1	3720	3.72	177.5
0.280	0.71	1320	1.32	63.2	2508	2.51	120.1	3708	3.71	176.9
0.290	0.74	1320	1.32	63.2	2496	2.50	119.5	3708	3.71	176.9
0.300	0.76	1332	1.33	63.8	2484	2.48	118.9	3708	3.71	176.9
0.310	0.79	1332	1.33	63.8	2484	2.48	118.9	3708	3.71	176.9
0.320	0.81	1332	1.33	63.8	2484	2.48	118.9	3696	3.70	176.3
0.330	0.84	1332	1.33	63.8	2472	2.47	118.4	3696	3.70	176.3
0.340	0.86	1332	1.33	63.8	2472	2.47	118.4	3696	3.70	176.3
0.350	0.89	1332	1.33	63.8	2448	2.45	117.2	3684	3.68	175.7
0.360	0.91	1332	1.33	63.8	2436	2.44	116.6	3684	3.68	175.7
0.370	0.94	1332	1.33	63.8	2448	2.45	117.2	3684	3.68	175.7
0.380	0.97	1332	1.33	63.8	2448	2.45	117.2	3684	3.68	175.7
0.390	0.99	1332	1.33	63.8	2460	2.46	117.8	3684	3.68	175.7
0.400	1.02	1332	1.33	63.8	2472	2.47	118.4	3672	3.67	175.2
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-053		Strength Intercept (C) :	0.31	(ksf)		0.11	(ksf)	
Sample No. : D-6			14.94	(kPa)	Peak	5.17	(kPa)	Ultimate
Depth (ft/m) : 30.0	0.00	Friction Angle (ϕ) :	31.09	Degree		30.58	Degree	
Description : Gray, SILTY SAND (SM)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	30.86	92.34	14.53	0.83	2.00	95.76	1.54	73.54	1.31	62.63
◆	31.90	92.30	14.53	0.83	4.00	191.52	2.69	128.70	2.44	116.64
▲	31.73	92.39	14.54	0.82	6.00	287.28	3.95	189.03	3.67	175.82

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/12/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-001	S-02	10	5.03
R-09-001	S-04	20	3.29
R-09-001	S-08	40	32.62
R-09-001	S-12	60	49.91

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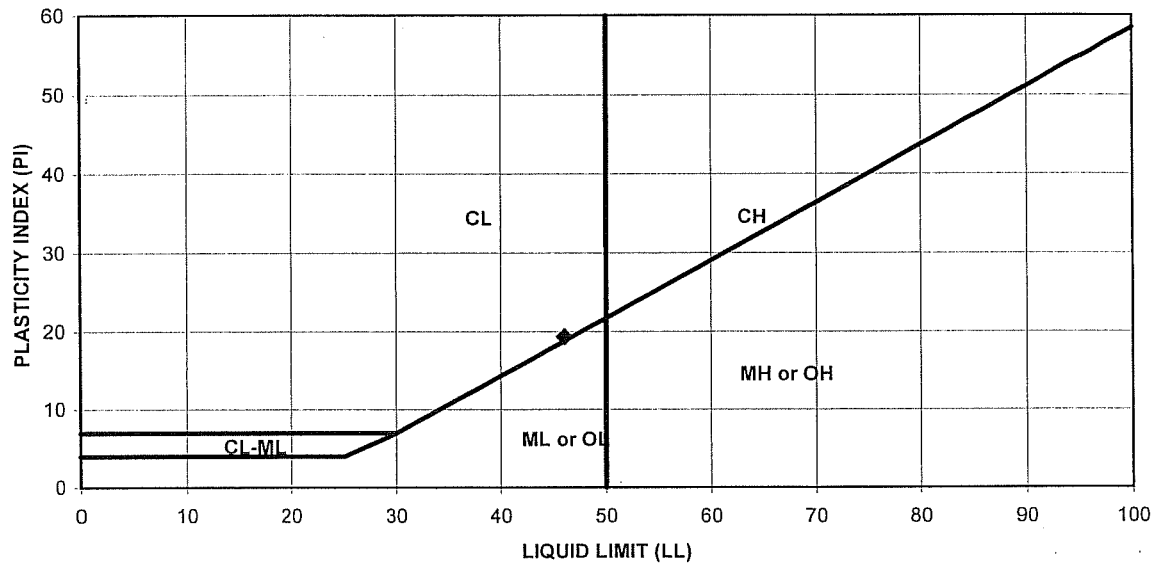
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

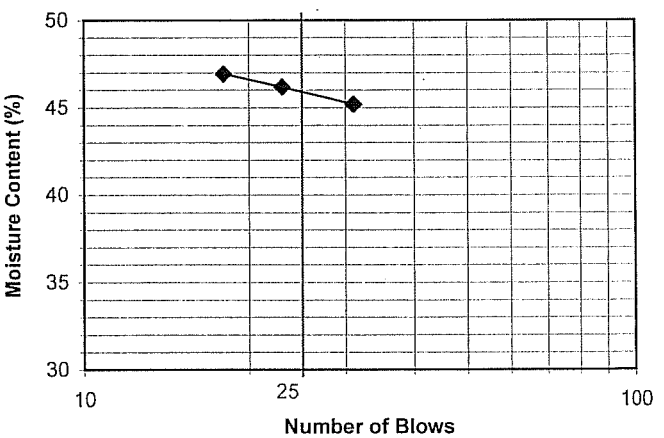
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/12/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-001	D-11	55	46	27	19	CL

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/12/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-001	S-02	10	SP-SM	1400	7.4	158	407

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/13/09

Boring No.: R-09-001 Checked By: AP Date: 12/01/09

Sample No.: D-07 Depth (ft): 35

Description: Dark Gray Poorly-Graded w/silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	574.89
Total Ring Weight (g)	135.20
Wet Density (pcf)	121.89
Dry Density (pcf)	95.26

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.11	104.07
Wet Soil+Cont. (g)	203.51	524.35
Dry Soil+Cont. (g)	170.00	427.51
Moisture Content (%)	28.0	29.9
Degree Saturation	98.1	100.4

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

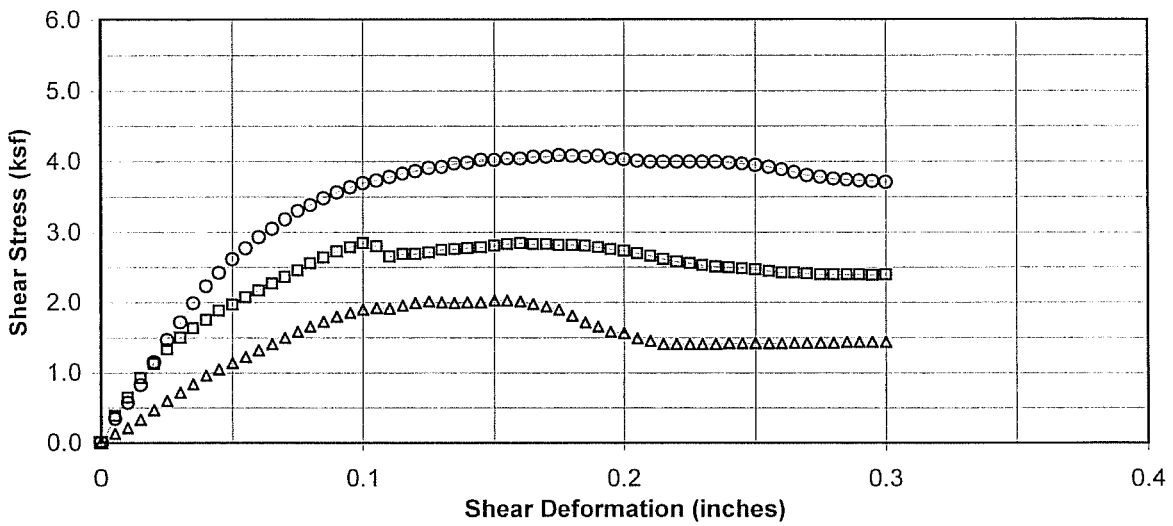
Shear Distance (in): **0.3**

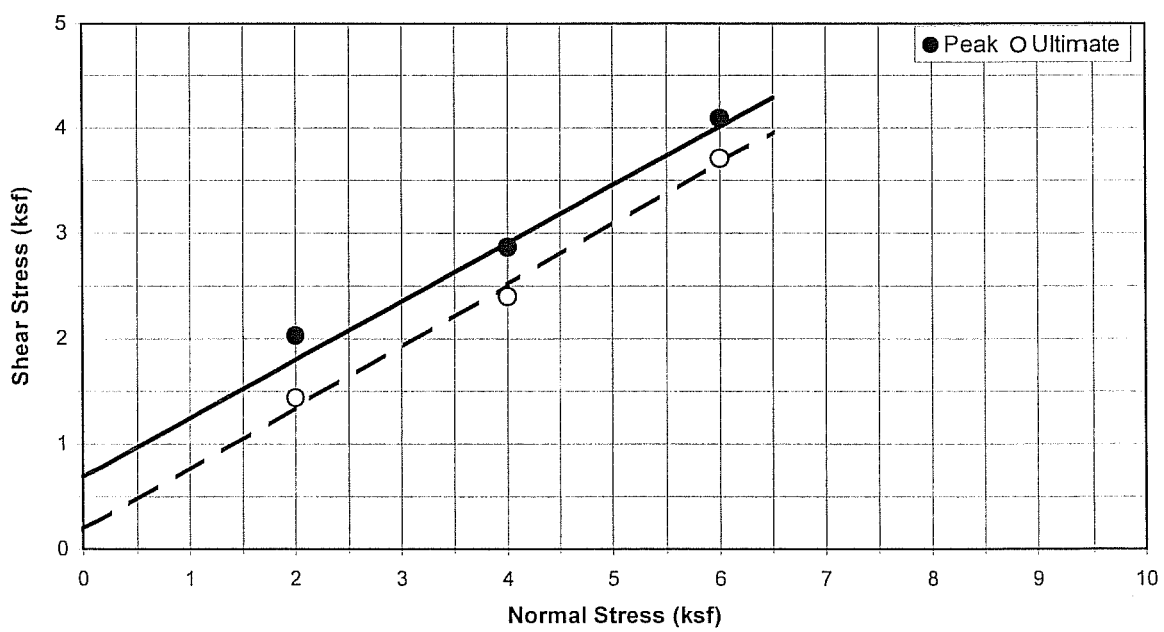
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**194.47**	**46.59**	**2.0**	**2028**	**1440**	
2	**188.74**	**43.43**	**4.0**	**2868**	**2400**	
3	**191.68**	**45.18**	**6.0**	**4092**	**3708**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	95.3	pcf
Boring No.:	R-09-001	Moisture Content (before):	28.0	%
Sample No.:	D-07	Moisture Content (after):	29.9	%
Depth (ft):	35			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Poorly-Graded w/silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	700	200
Friction Angle:	29 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/13/09

Boring No.: R-09-001 Checked By: AP Date: 11/27/09

Sample No.: D-09 Depth (ft): 45

Description: Dark Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	575.62
Total Ring Weight (g)	134.81
Wet Density (pcf)	122.20
Dry Density (pcf)	94.37

Moisture Determination	Before Test	After Test
Cont. Weight (g)	49.37	197.75
Wet Soil+Cont. (g)	208.71	612.93
Dry Soil+Cont. (g)	172.43	517.48
Moisture Content (%)	29.5	29.9
Degree Saturation	100.3	100.2

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

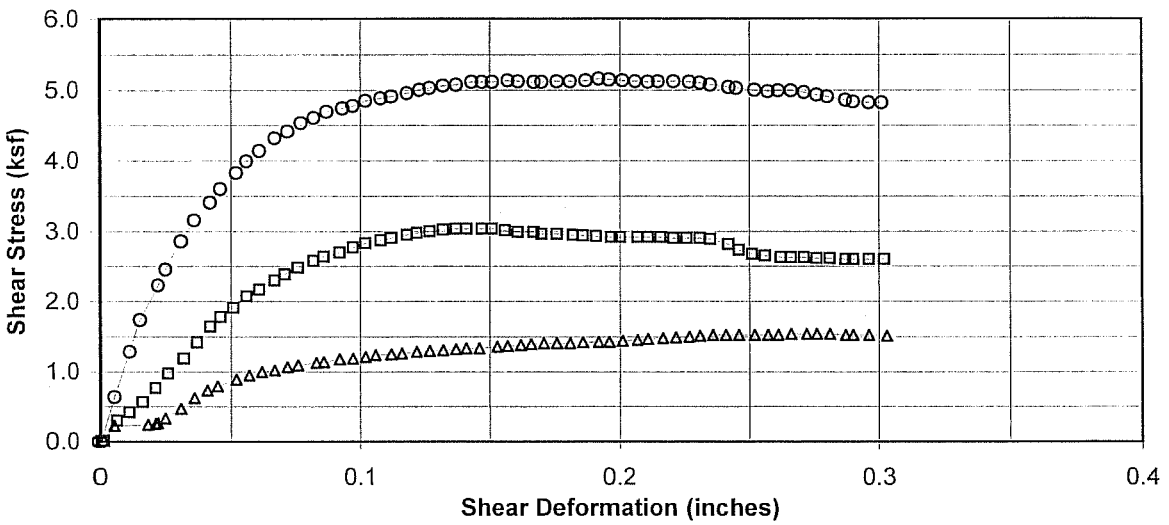
Shear Distance (in): **0.3**

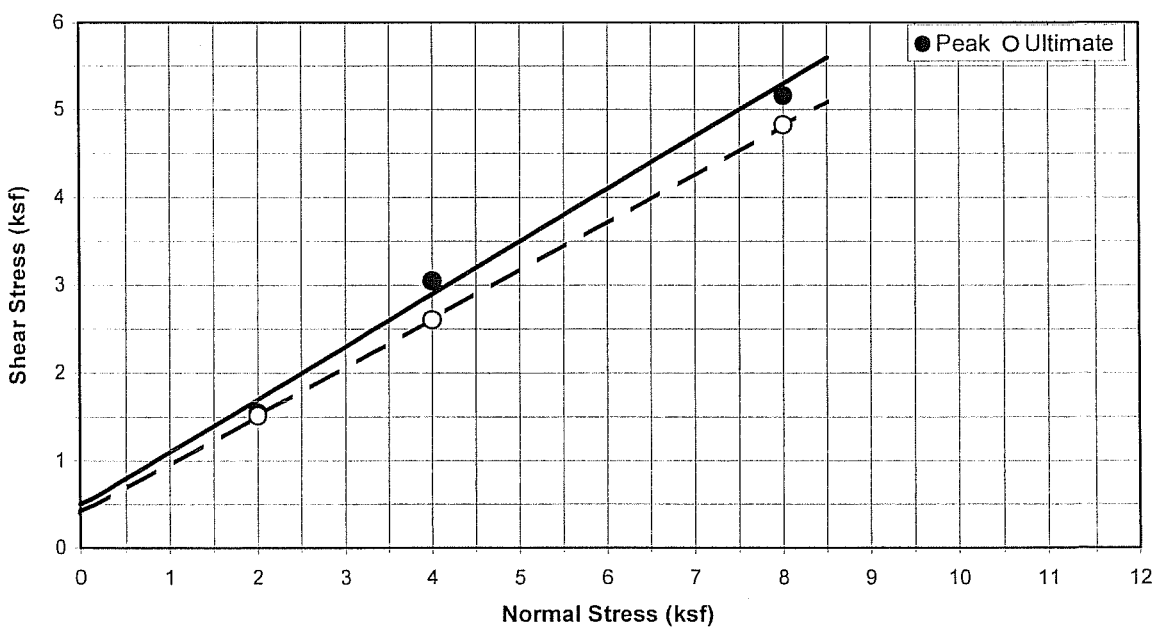
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**190.67**	**43.48**	**2.0**	**1548**	**1512**	
2	**192.52**	**44.89**	**4.0**	**3048**	**2604**	
3	**192.43**	**46.44**	**8.0**	**5160**	**4824**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.4	pcf
Boring No.:	R-09-001	Moisture Content (before):	29.5	%
Sample No.:	D-09	Moisture Content (after):	29.9	%
Depth (ft):	45			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	500	400
Friction Angle:	31 °	29 °

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/12/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-001	D-01	5	21.1	107.2
R-09-001	D-03	15	26.7	96.3
R-09-001	S-04	20	26.7	NA
R-09-001	D-05	25	24.6	101.6
R-09-001	S-08	40	29.9	NA
R-09-001	S-10	50	57.0	NA
R-09-001	D-11	55	30.9	90.9
R-09-001	D-13	65	27.5	98.2
R-09-001	S-14	70	29.6	NA
R-09-001	S-15	75	35.5	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

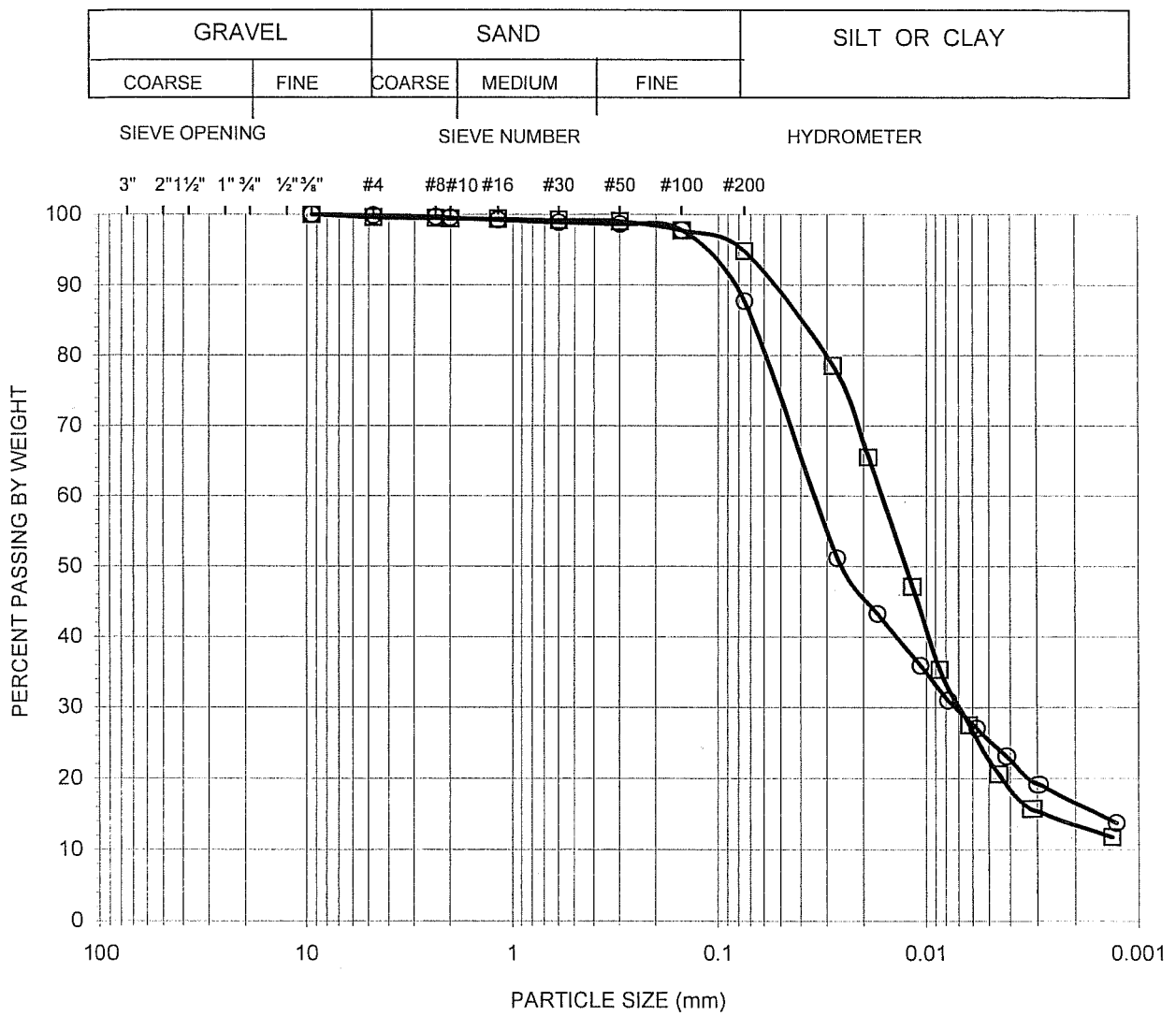
Client Name: Earth Mechanics, Inc. Laboratory No.: 29-1121
Project Name: ACTA Heim Bridge Replacement Date: 11/17/09
Project Number: 06-123-03

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-001	D-11	55	2.07

AP Engineering & Testing, Inc.

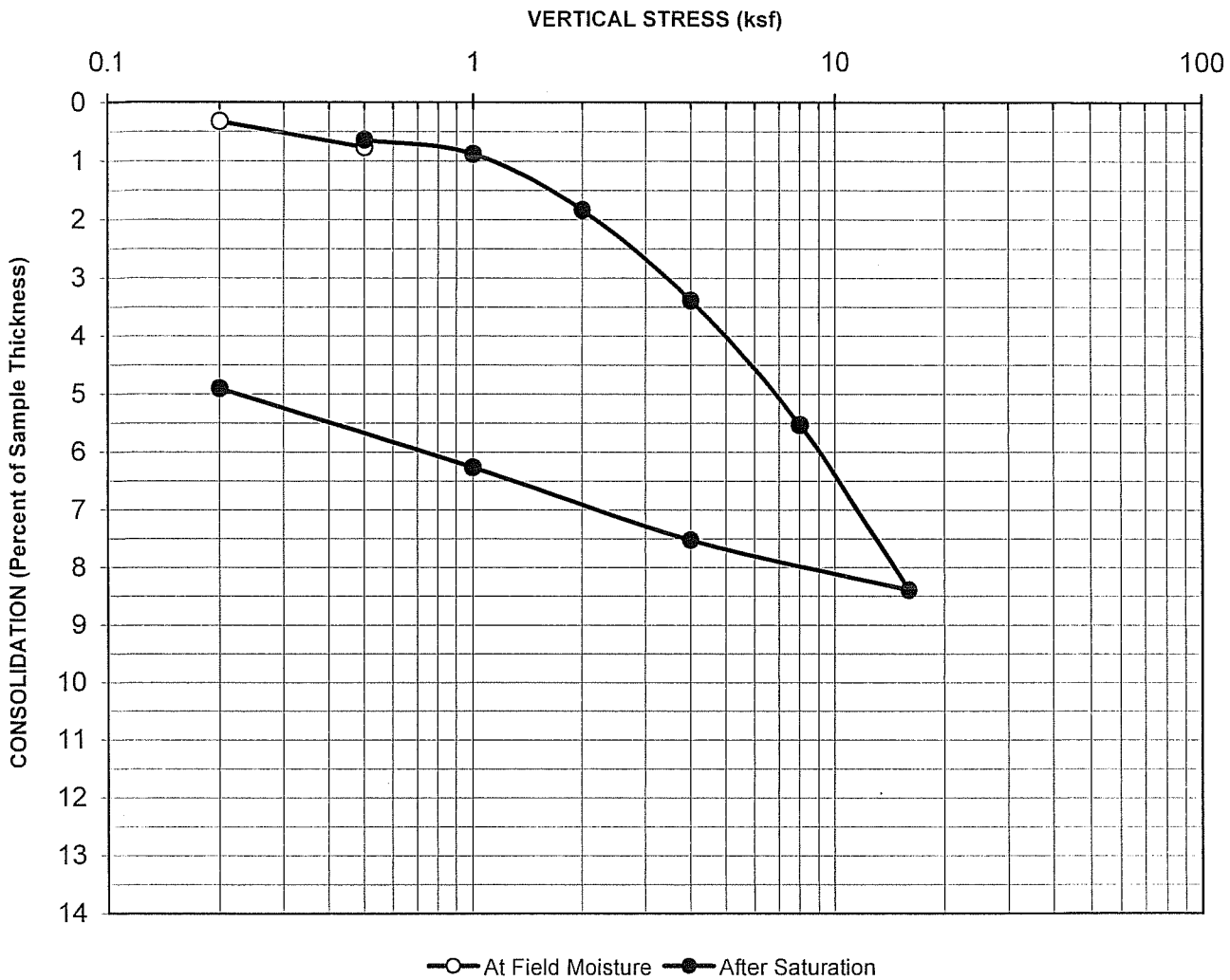
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/12/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-001	D-11	55	0.18	12.08	87.74	46:27:19	CL
□	R-09-001	S-15	75	0.46	4.73	94.81	N/A	CL

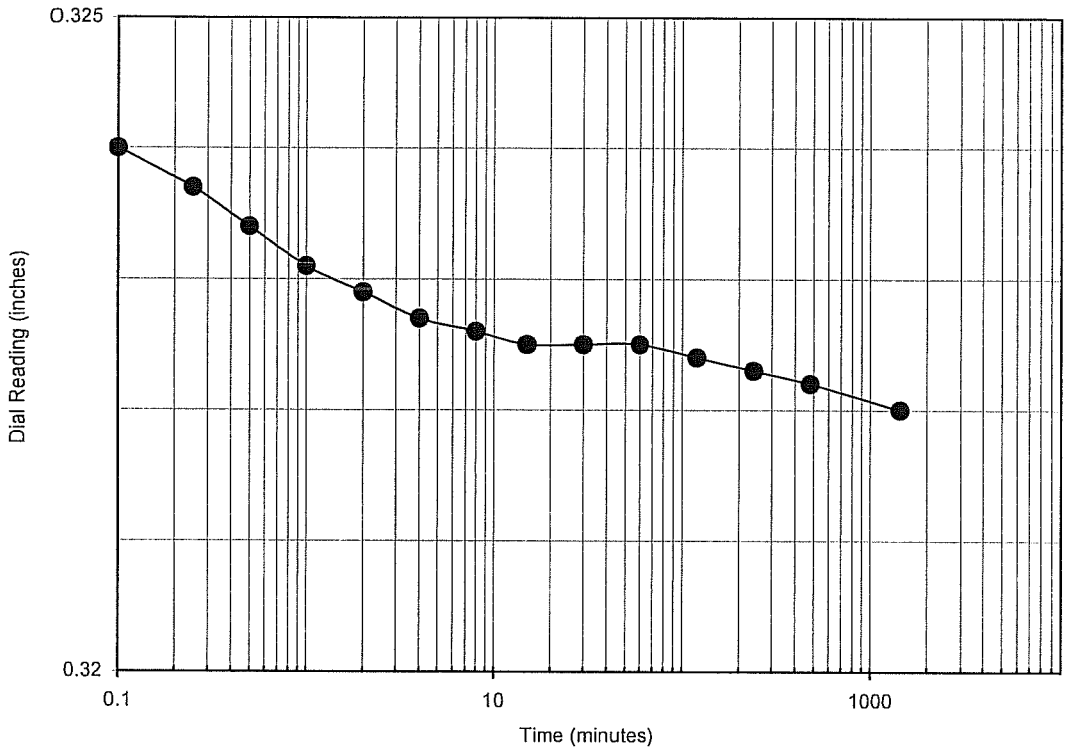
AP Engineering & Testing, Inc.



Boring No. :	R-09-001	Initial Dry Unit Weight (pcf):	90.6
Sample No.:	D-11	Initial Moisture Content (%):	30.9
Depth (feet):	55	Final Moisture Content (%):	33.9
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Lean Clay with fine sand	Initial Void Ratio:	0.86
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/27/2009
AP No:	29-1121

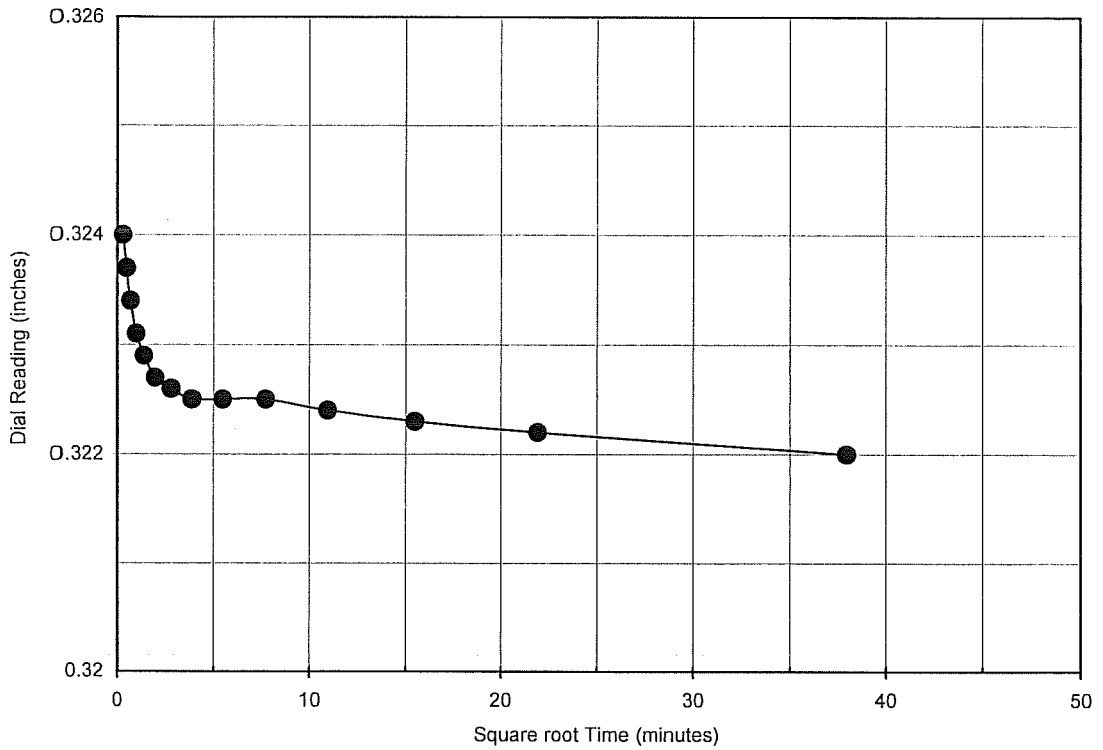


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.324
0.25	0.3237
0.5	0.3234
1	0.3231
2	0.3229
4	0.3227
8	0.3226
15	0.3225
30	0.3225
60	0.3225
120	0.3224
240	0.3223
480	0.3222
1440	0.322

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

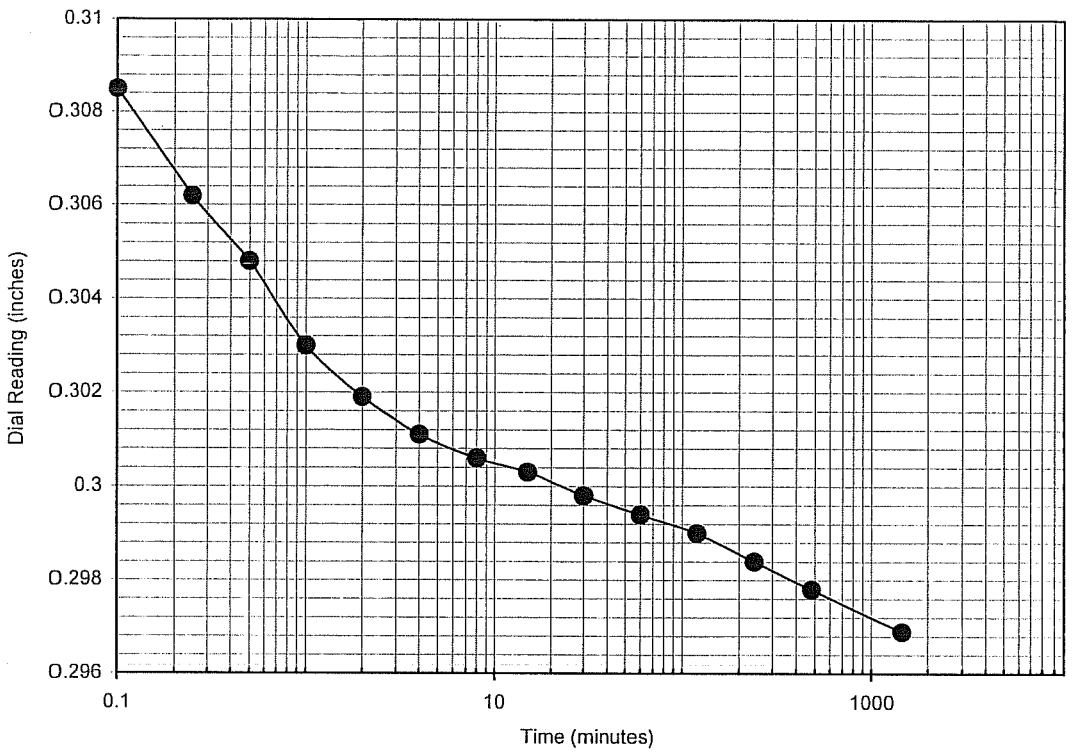


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3240
0.5000	0.3237
0.7071	0.3234
1.0000	0.3231
1.4142	0.3229
2.0000	0.3227
2.8284	0.3226
3.8730	0.3225
5.4772	0.3225
7.7460	0.3225
10.9545	0.3224
15.4919	0.3223
21.9089	0.3222
37.9473	0.3220

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

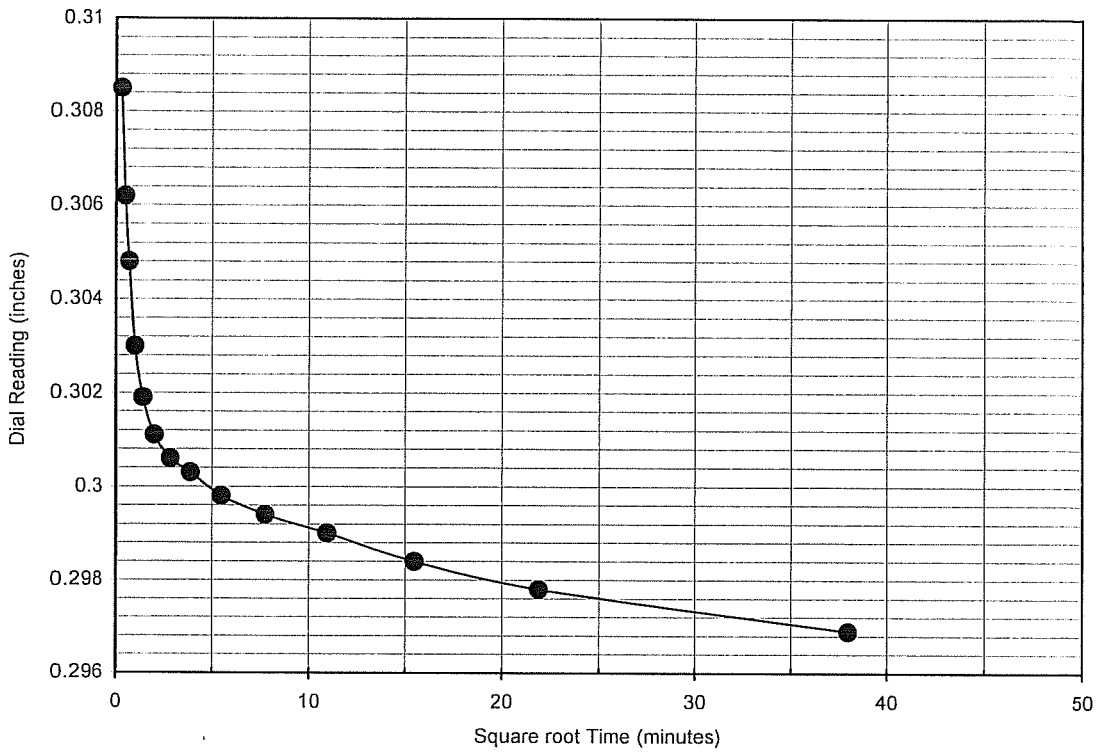


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3085
0.25	0.3062
0.5	0.3048
1	0.303
2	0.3019
4	0.3011
8	0.3006
15	0.3003
30	0.2998
60	0.2994
120	0.299
240	0.2984
480	0.2978
1440	0.2969

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3085
0.5000	0.3062
0.7071	0.3048
1.0000	0.3030
1.4142	0.3019
2.0000	0.3011
2.8284	0.3006
3.8730	0.3003
5.4772	0.2998
7.7460	0.2994
10.9545	0.2990
15.4919	0.2984
21.9089	0.2978
37.9473	0.2969

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/13/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-002	S-02	10	10.37
R-09-002	S-04	20	3.44
R-09-002	S-08	40	46.23

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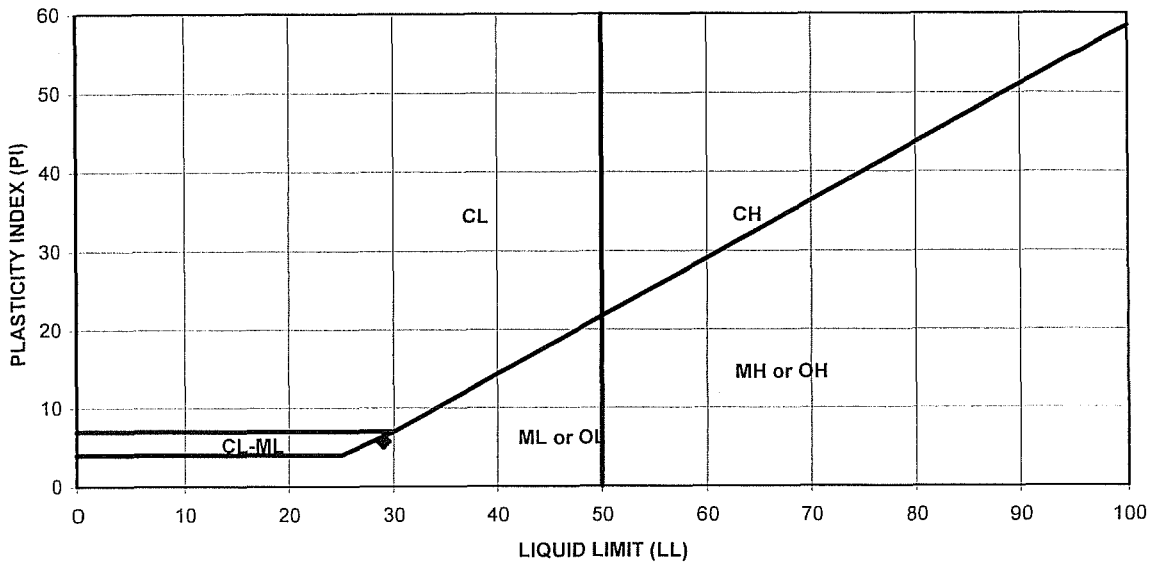
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

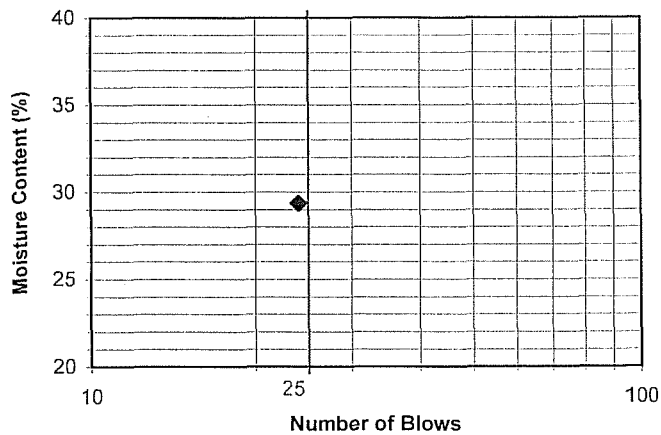
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/12/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



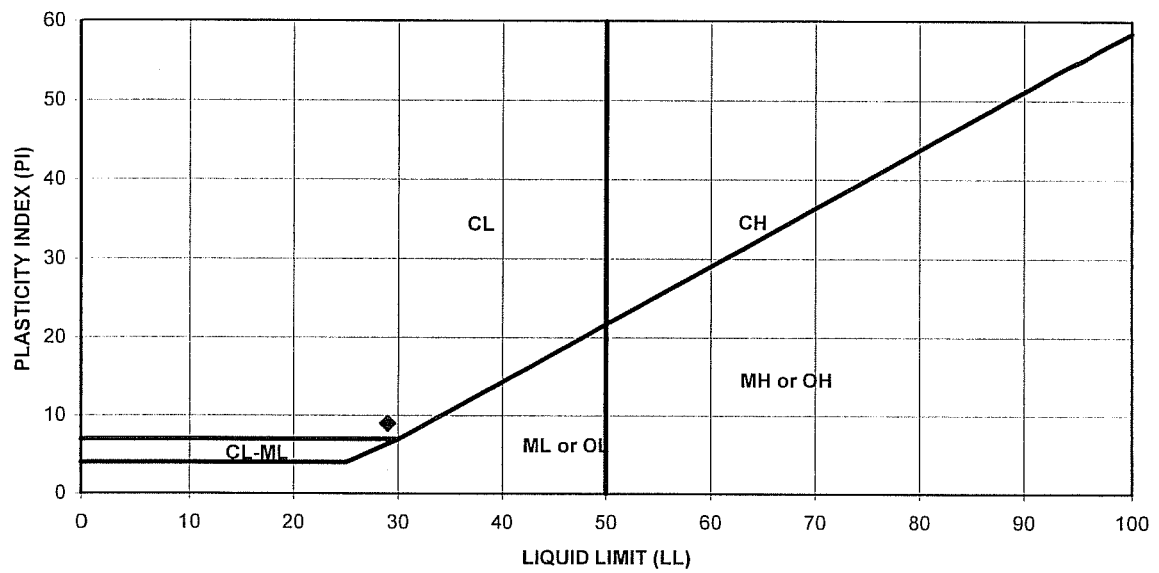
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-002	S-10	50	29	23	6	ML
	R-09-002	S-12	60	NP	NP	NP	

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

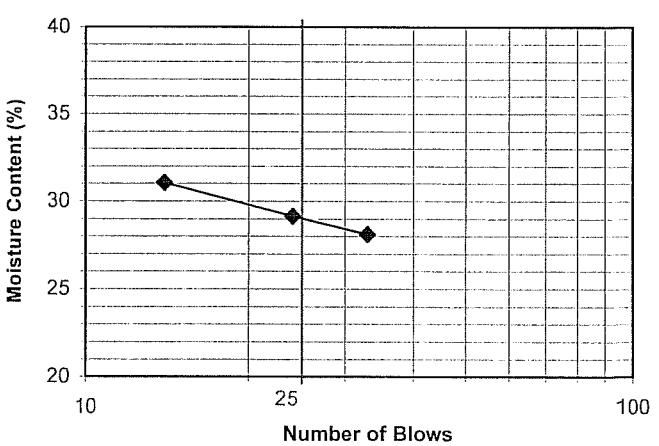
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/12/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-002	S-14	70	29	20	9	CL

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/12/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-002	S-02	10	SP-SM	1100	7.7	325	267

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/14/09

Boring No.: R-09-002 Checked By: AP Date: 12/01/09

Sample No.: D-03 Depth (ft): 15

Description: Dark Gray Sand with silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	570.48
Total Ring Weight (g)	134.68
Wet Density (pcf)	120.81
Dry Density (pcf)	95.07

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.13	157.94
Wet Soil+Cont. (g)	193.93	570.94
Dry Soil+Cont. (g)	163.29	473.95
Moisture Content (%)	27.1	30.7
Degree Saturation	94.6	102.5

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

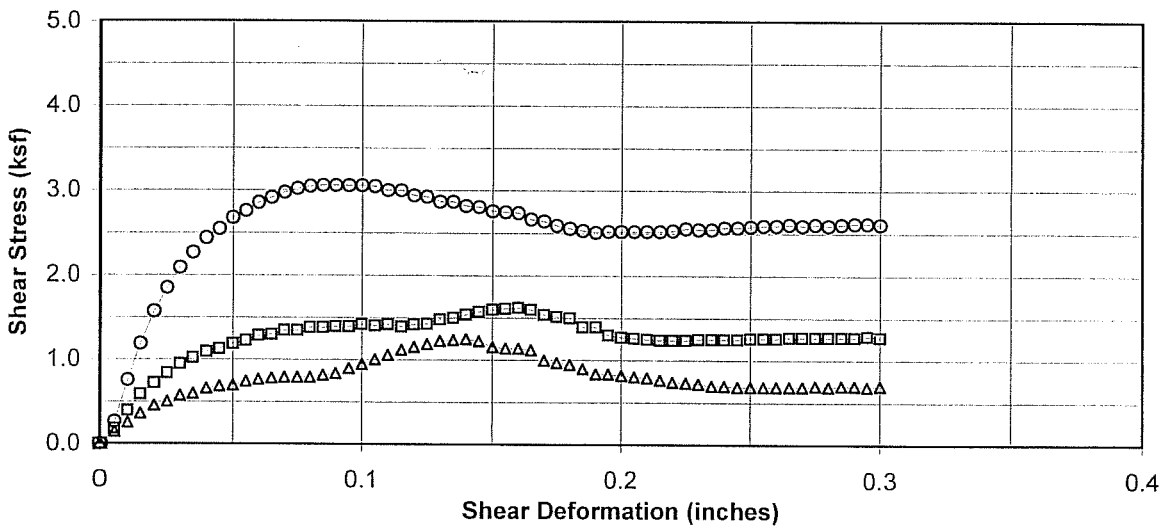
Shear Distance (in): **0.3**

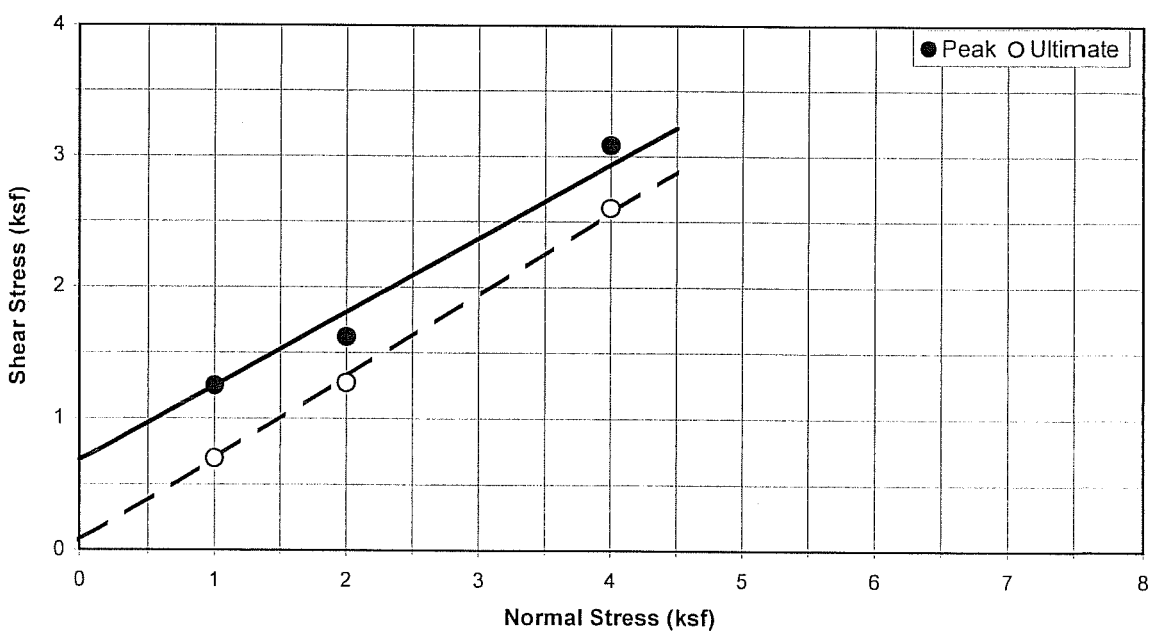
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**191.90**	**45.15**	**1.0**	**1248**	**696**	
2	**188.64**	**43.81**	**2.0**	**1620**	**1272**	
3	**189.94**	**45.72**	**4.0**	**3084**	**2604**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	95.1	pcf
Boring No.:	R-09-002	Moisture Content (before):	27.1	%
Sample No.:	D-03	Moisture Content (after):	30.7	%
Depth (ft):	15			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Sand with silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	700	50
Friction Angle:	29 °	32 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/14/09

Boring No.: R-09-002 Checked By: AP Date: 12/01/09

Sample No.: D-07 Depth (ft): 35

Description: Gray Sitly Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	571.64
Total Ring Weight (g)	135.52
Wet Density (pcf)	120.90
Dry Density (pcf)	91.52

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.39	195.18
Wet Soil+Cont. (g)	192.89	616.91
Dry Soil+Cont. (g)	158.27	513.85
Moisture Content (%)	32.1	32.3
Degree Saturation	100.3	101.1

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

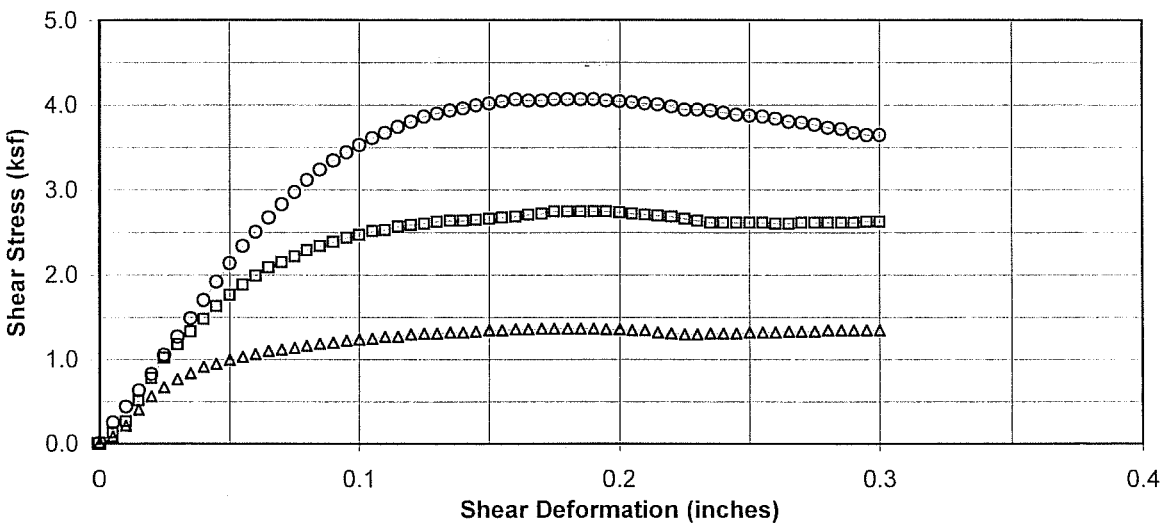
Shear Distance (in): **0.3**

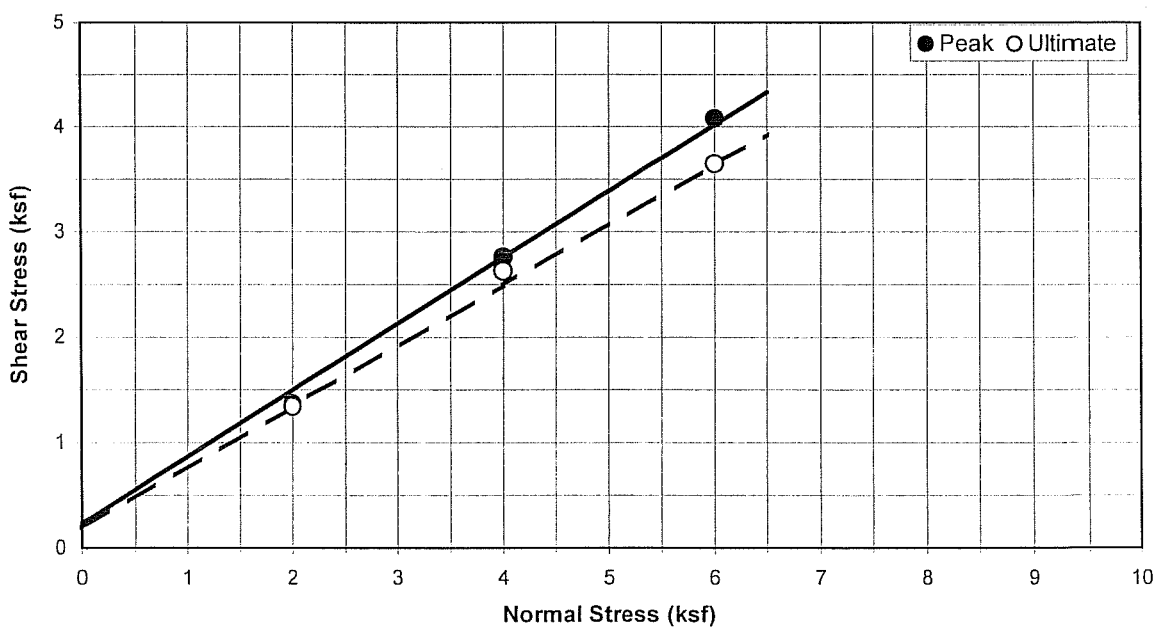
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**190.53**	**45.39**	**2.0**	**1368**	**1344**	
2	**188.75**	**44.69**	**4.0**	**2760**	**2628**	
3	**192.36**	**45.44**	**6.0**	**4080**	**3648**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	91.5	pcf
Boring No.:	R-09-002	Moisture Content (before):	32.1	%
Sample No.:	D-07	Moisture Content (after):	32.3	%
Depth (ft):	35			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sitly Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	200
Friction Angle:	32 °	30 °

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

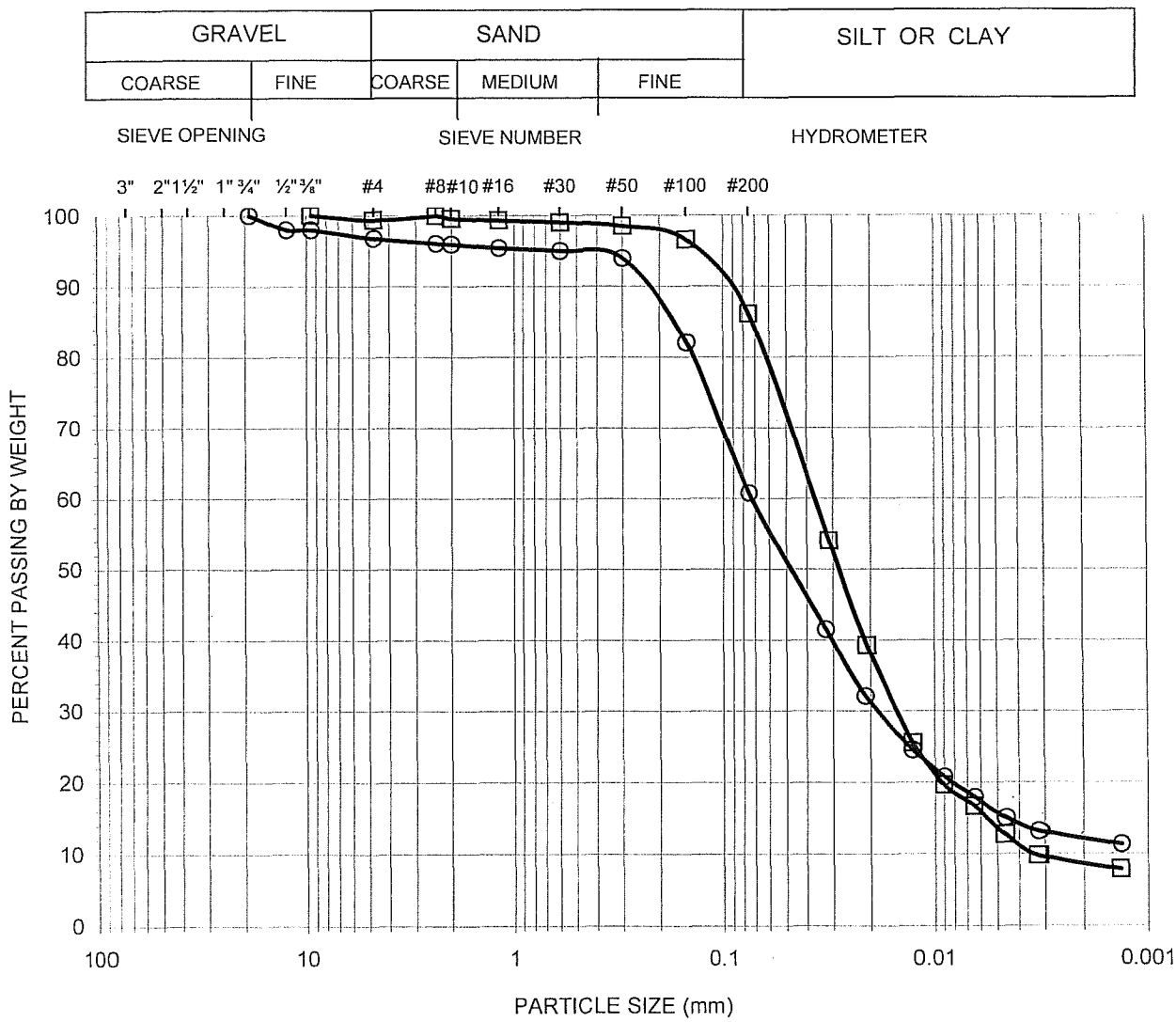
Laboratory No.: 29-1121
Date: 11/12/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-002	D-01	5	17.3	109.8
R-09-002	S-02	10	32.7	NA
R-09-002	D-05	25	13.9	114.6
R-09-002	S-08	40	31.0	NA
R-09-002	S-10	50	35.2	NA
R-09-002	D-11	55	35.7	93.8
R-09-002	S-12	60	26.1	NA
R-09-002	S-14	70	35.0	NA
R-09-002	S-15	75	33.7	NA

AP Engineering & Testing, Inc.

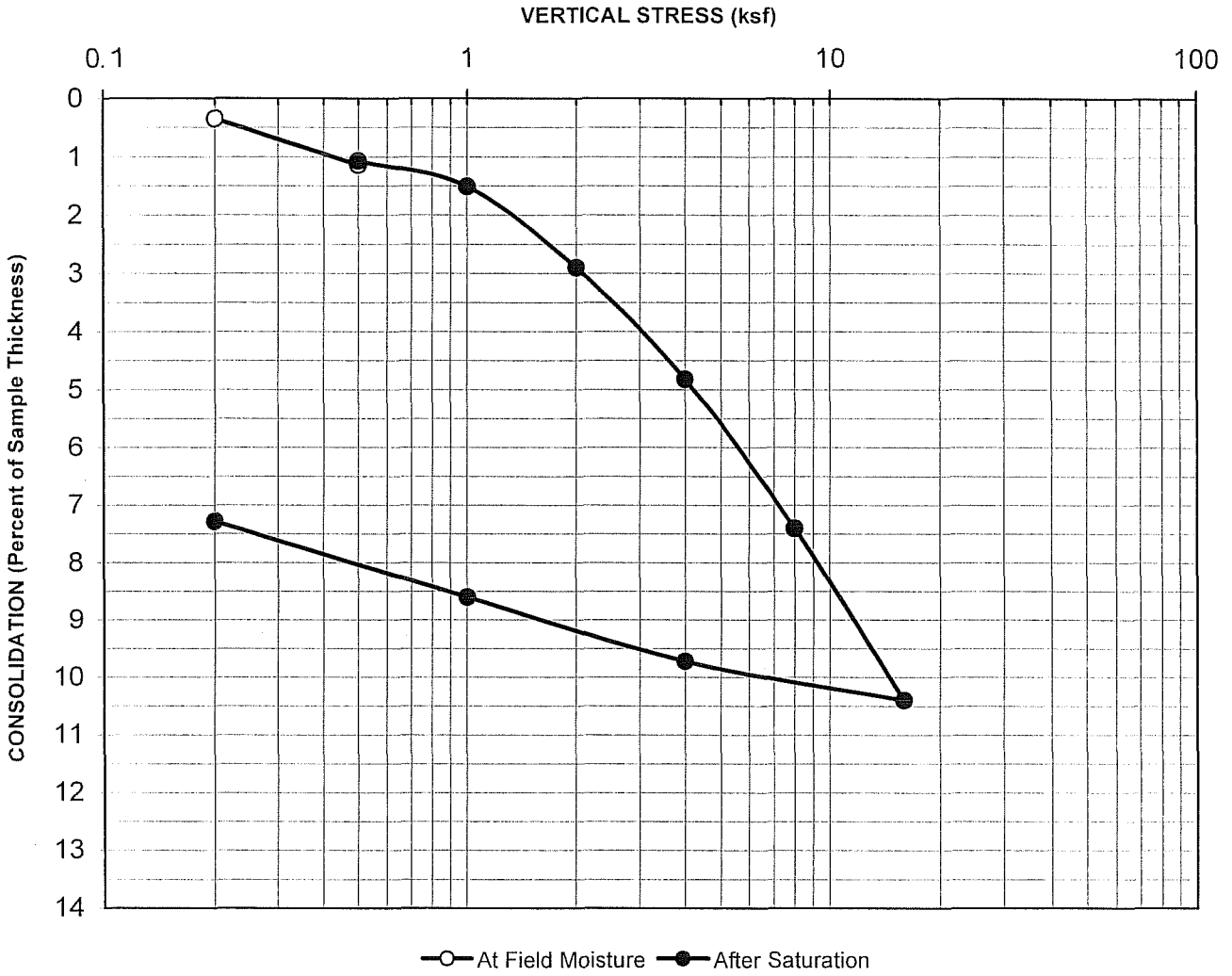
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-002	S-10	50	3.23	36.02	60.75	29:23:6	ML
□	R-09-002	S-15	75	0.68	13.21	86.11	N/A	ML

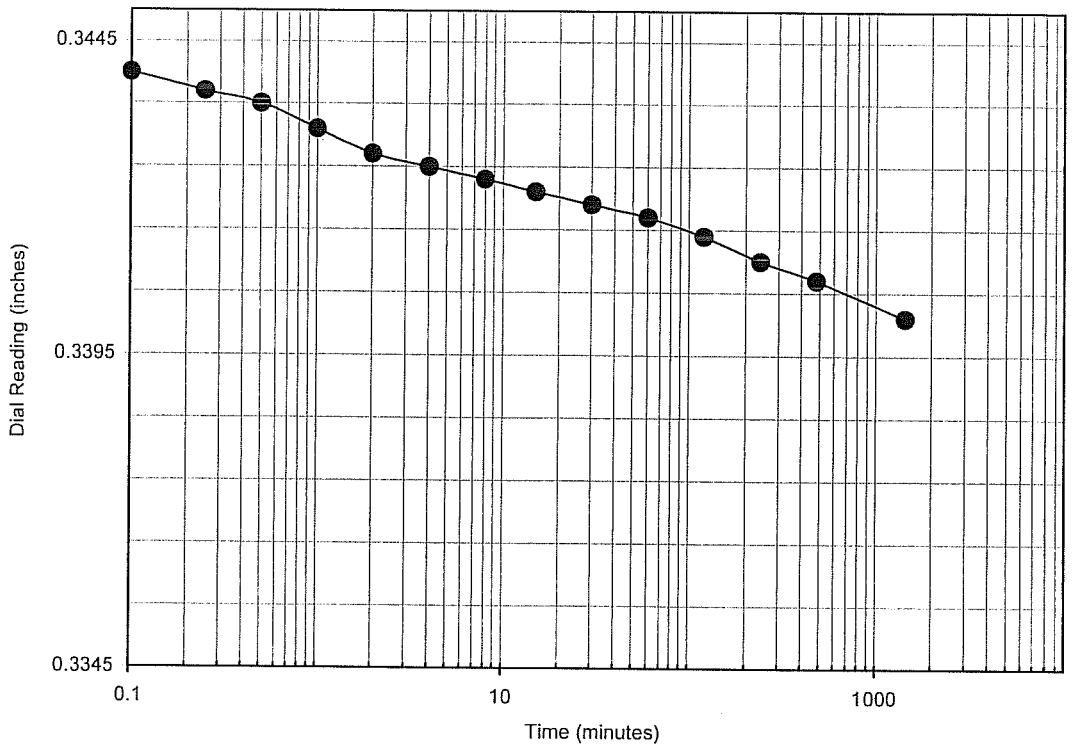
AP Engineering & Testing, Inc.



Boring No. :	R-09-002	Initial Dry Unit Weight (pcf):	89.1
Sample No.:	D-09	Initial Moisture Content (%):	35.7
Depth (feet):	45	Final Moisture Content (%):	28.4
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Silt with sand	Initial Void Ratio:	0.89
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/27/2009
AP No:	29-1121

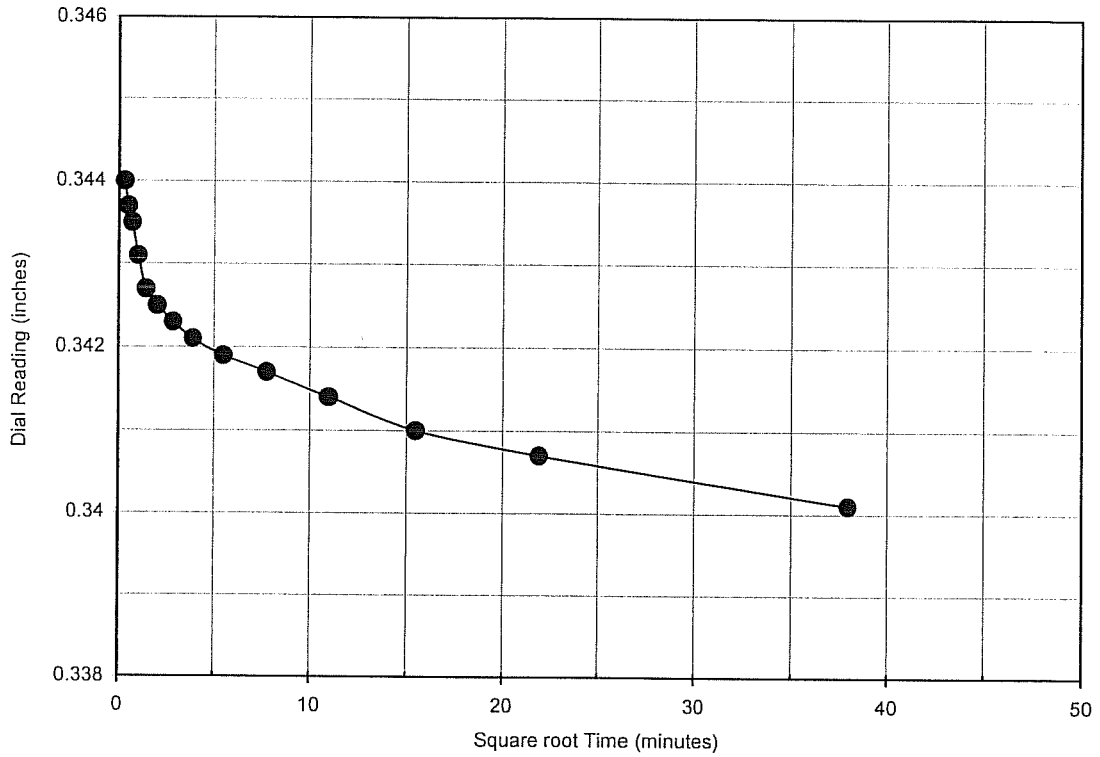


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.344
0.25	0.3437
0.5	0.3435
1	0.3431
2	0.3427
4	0.3425
8	0.3423
15	0.3421
30	0.3419
60	0.3417
120	0.3414
240	0.341
480	0.3407
1440	0.3401

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

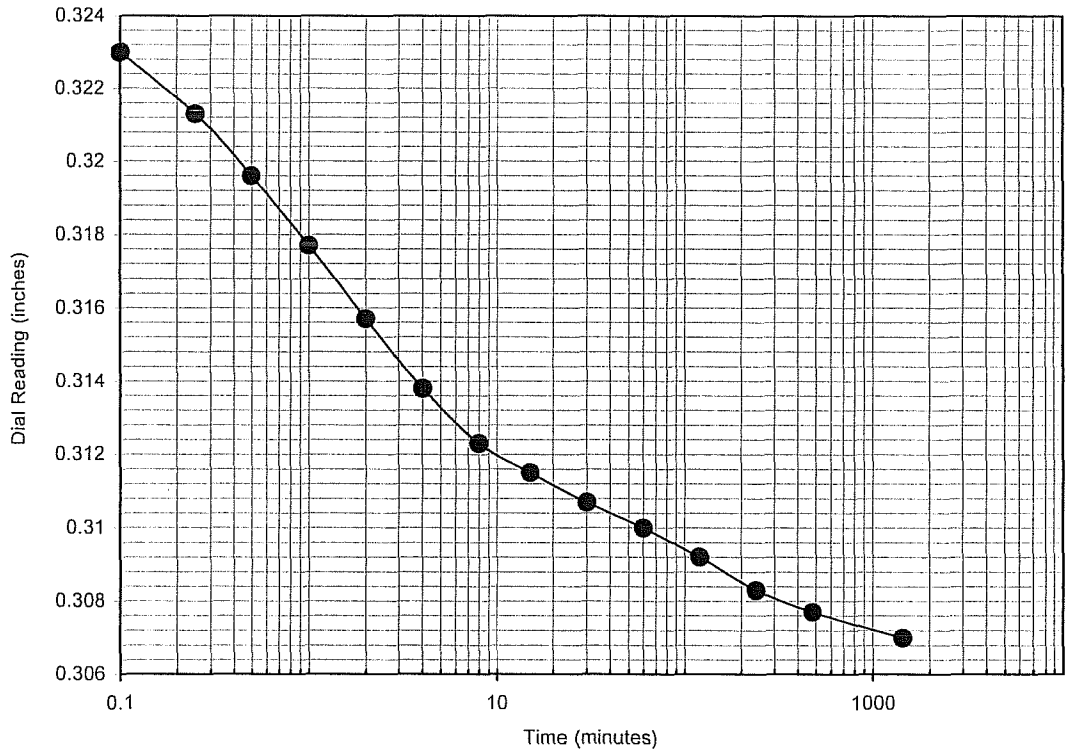


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3440
0.5000	0.3437
0.7071	0.3435
1.0000	0.3431
1.4142	0.3427
2.0000	0.3425
2.8284	0.3423
3.8730	0.3421
5.4772	0.3419
7.7460	0.3417
10.9545	0.3414
15.4919	0.3410
21.9089	0.3407
37.9473	0.3401

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

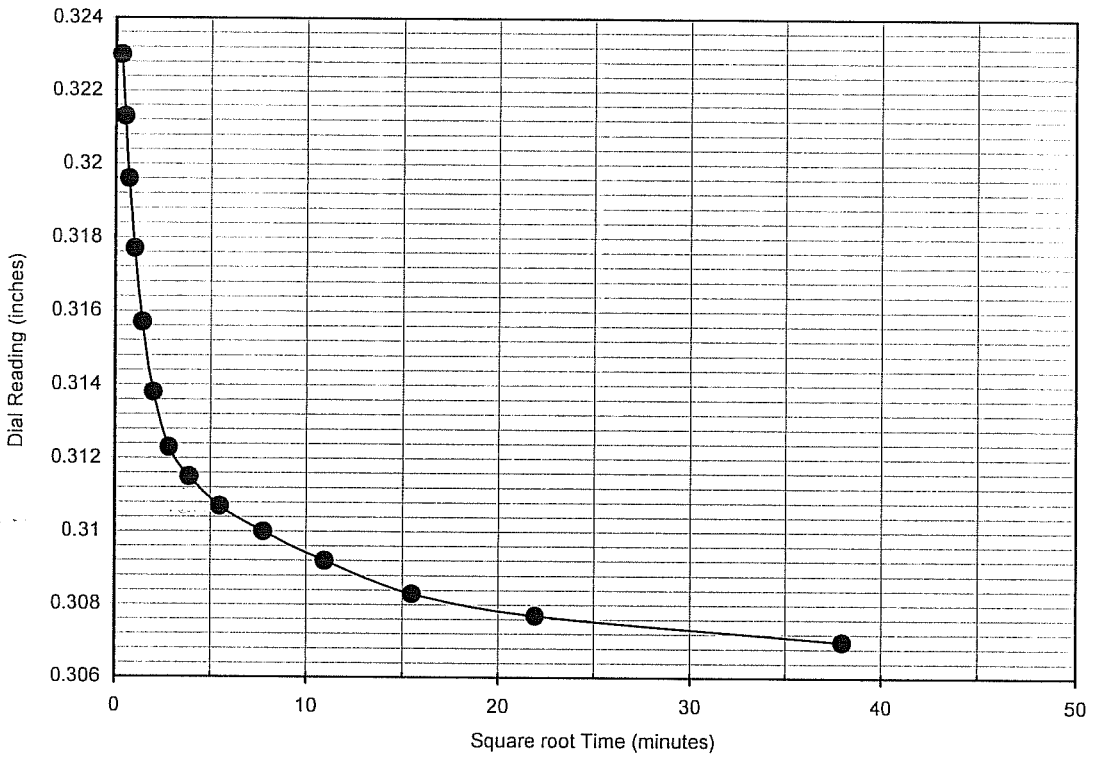


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.323
0.25	0.3213
0.5	0.3196
1	0.3177
2	0.3157
4	0.3138
8	0.3123
15	0.3115
30	0.3107
60	0.31
120	0.3092
240	0.3083
480	0.3077
1440	0.307

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3230
0.5000	0.3213
0.7071	0.3196
1.0000	0.3177
1.4142	0.3157
2.0000	0.3138
2.8284	0.3123
3.8730	0.3115
5.4772	0.3107
7.7460	0.3100
10.9545	0.3092
15.4919	0.3083
21.9089	0.3077
37.9473	0.3070

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008A

PROJECT NO.: 06-123-03

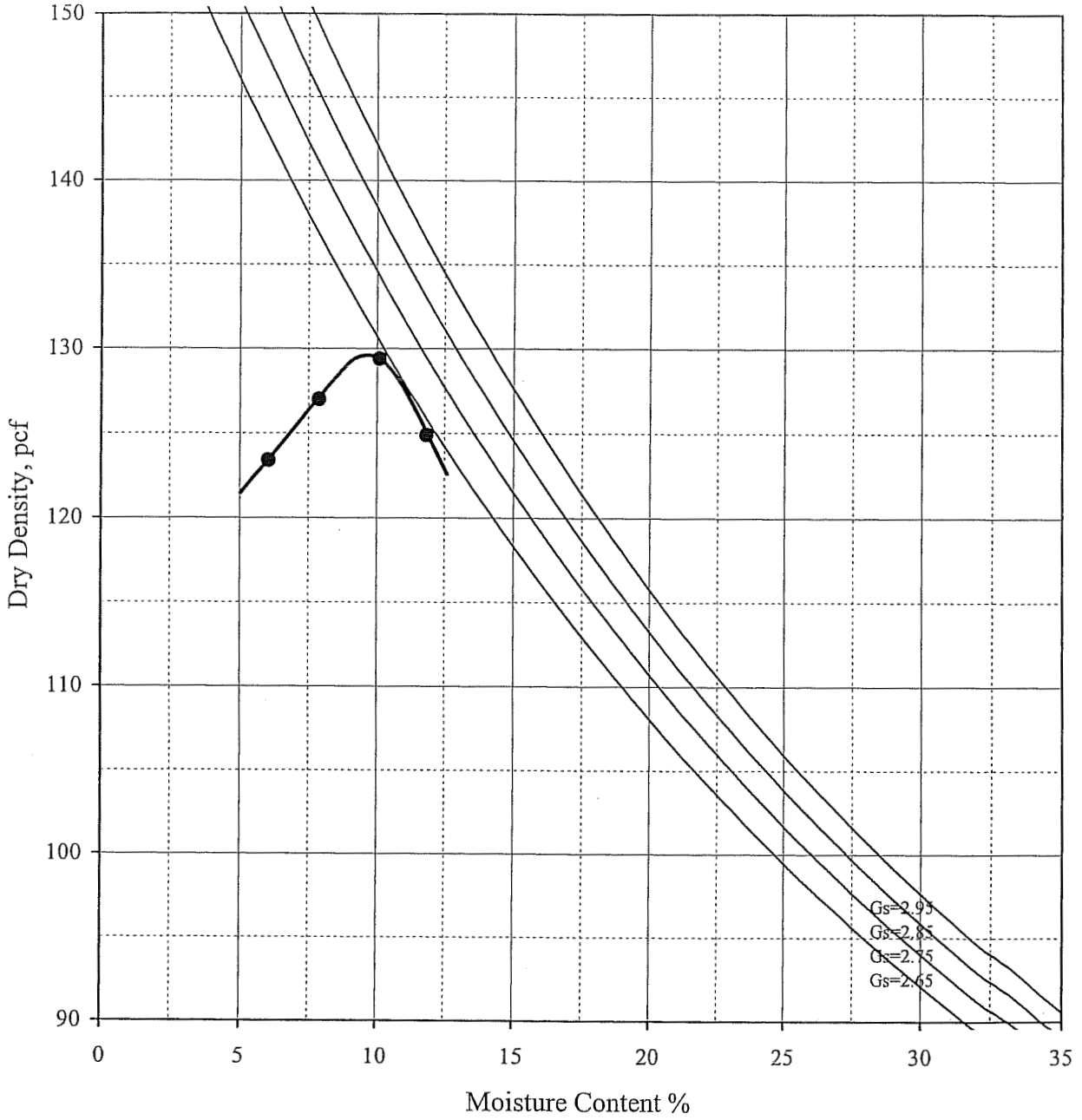
CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-038	B-0	0-2.0	9.7			
R-09-038	D-02	10.0	24.8	100.8	4.8	
R-09-038	S-04	25.0			12.0	
R-09-038	U-06	35.0				58,28,30
R-09-038	D-07-1	40.0	21.9	106.7	14.4	
R-09-038	U-08	46.0				26,24,2
R-09-038	S-09	50.0	33.1			NP
R-09-038	D-10-2	55.5	26.6	100.3		
R-09-038	U-11	61.0				25,23,2
R-09-038	S-12	65.0	36.9			26,24,2
R-09-038	D-13	70.0	28.0	97.9		
R-09-038	S-14-1	75.0	40.8			48,25,23
R-09-038	D-15	80.0	27.0	99.7		NP
R-09-038	D-17	90.0	25.3	100.9		
R-09-038	S-19	110.0	18.6			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index



Maximum Dry Density = 129.5 pcf	Boring No: R-09-038
Optimum Moisture Content = 10 %	Sample: B-0
	Depth : 0-2 feet
	Description : SM
Environmental Geotechnology Laboratory	Project Name: ACTA Heim Bridge Replacement
	Client Name: Earth Mechanics, Inc.
Modified Proctor	Job No: 06-123-03
	EGL Project No.: 09-230-008A
(ASTM D1557)	Date : Dec-09 Figure

SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
~~R-09-027~~	~~U-01~~	~~11~~	~~2.736~~
R-09-027	~~U-09~~	45	2.77
R-09-033	~~U-04~~	20	2.697
~~R-09-033~~	~~U-09~~	~~45~~	~~2.746~~
R-09-038	U-06	35	2.768
R-09-038	U-08	46	2.737
R-09-038	U-11	61	2.741

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

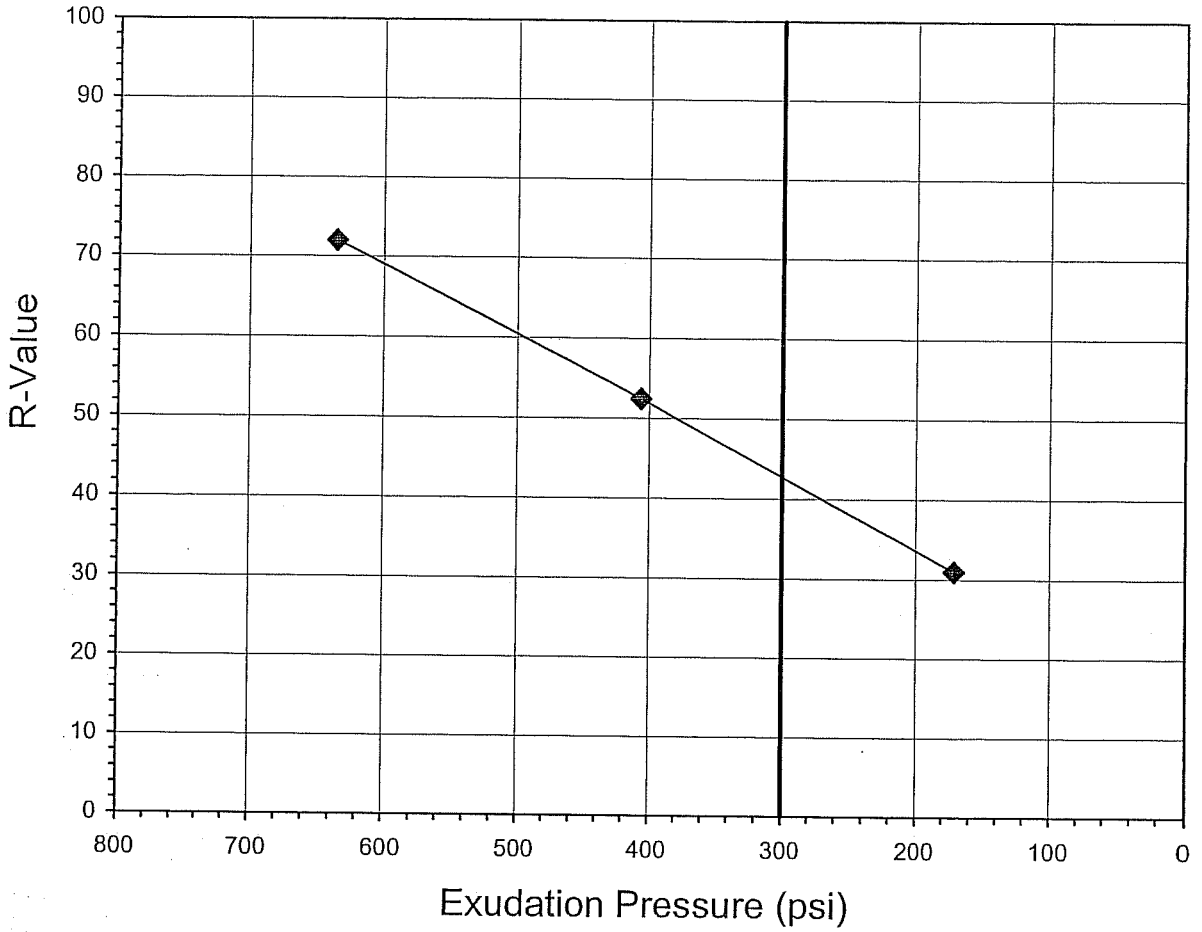
DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
~~R-09-027~~	~~U-01~~	~~11~~	~~0.2~~
R-09-027	U-09	45	1.25
R-09-033	U-04	20	0.5
~~R-09-033~~	~~U-09~~	~~45~~	~~1.75~~
R-09-038	U-06	35	0.8
R-09-038	U-08	46	1.75
R-09-038	U-11	61	4

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008A
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	12/18/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
~~R-09-027~~	~~D-2-2~~	~~15.5~~	~~8.05~~	~~10,655~~	~~0.106~~	~~72~~
~~R-09-033~~	~~T-3~~	~~15~~	~~8.40~~	~~605~~	~~0.018~~	~~630~~
R-09-038	B-0	0 - 2	8.11	710	0.138	390



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	150	121.3	12.2	0.00	92	2.52	171	31	31
2	200	122.9	11.3	0.00	59	2.52	406	52	52
3	250	124.6	10.4	0.48	34	2.49	635	72	72

Boring No: R-09-038
Sample No: B-0 @ 0-2'
Sample Type: Bulk
Sample Description: Silty sand (SM)
Test Date: 12/7/09

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008A

Test Results: R-Value at 300 psi
Exudation Pressure: 43

R-VALUE TEST REPORT

12/30/09

FIGURE 1

Resistance R - Value Testing Results

(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008A
Test Date:	12/7/2009
Boring No:	R-09-038
Sample No:	B-0 @ 0-2'
Sample Type:	Bulk
Sample Description:	Silty sand (SM), dark brown
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	150	200	250
Wet Weight (gms)	1230	1220	1210
Dry Weight (gms)	1096	1096	1096
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	2150	5100	7970
Total Weight (gms)	2915	3058	3002
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1132	1138	1130
Sample Height (in)	2.52	2.52	2.49
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0000	0.0000	0.0016
Expansion Pressure (psi)	0.0000	0.0000	0.4848
Ph @ 2000 lbs	92	59	34
D turns	4.12	3.88	3.6
R-Value from Exudation	31	52	72
Density (pcf)	121.3	122.9	124.6
Moisture (%)	12.2	11.3	10.4
Exudation Pressure (psi)	171	406	635
Corrected R-Value from Exudation:	31	52	72
Exudation Pressure (psi)	171	406	635

R-Value at 300 psi exudation pressure = 43

Note:
0.91% Retained on 3/4-inch Sieve

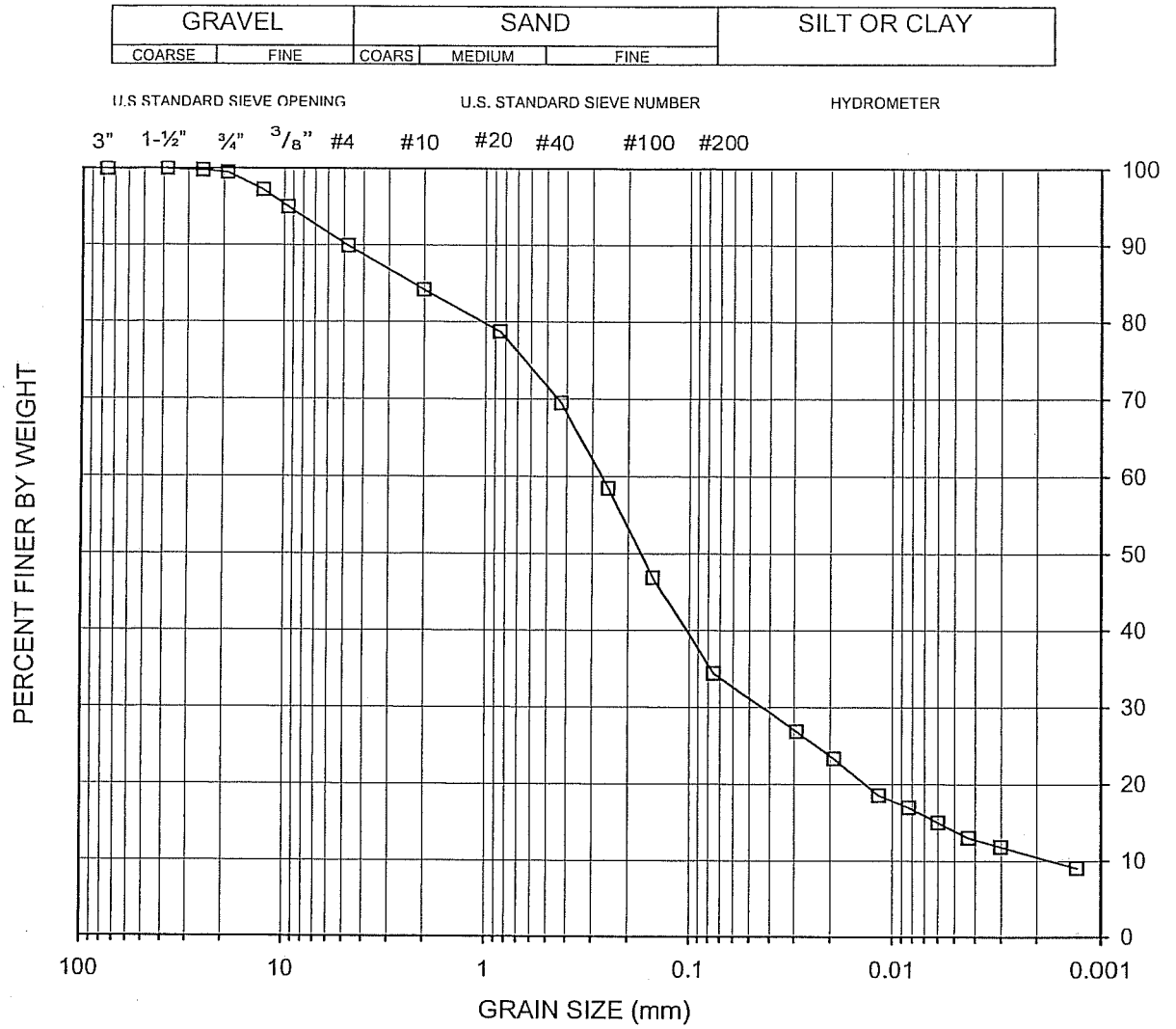
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008A

R-VALUE TEST RESULTS

12/30/09

FIGURE 2



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	B-0	0 - 2	Bulk	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

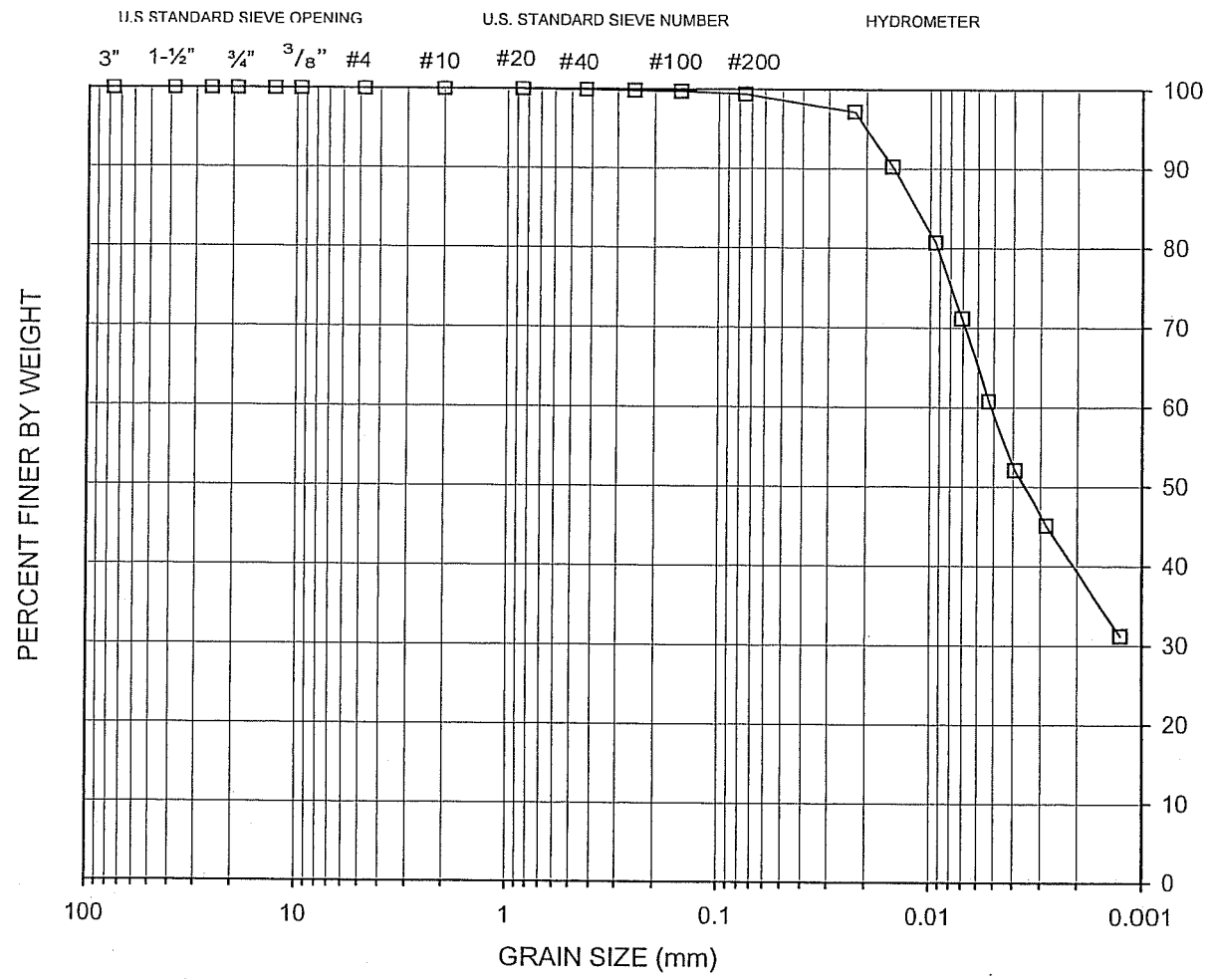
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09

(ASTM D422)

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	U-06	35	Shelby Tube	CH	58	30

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

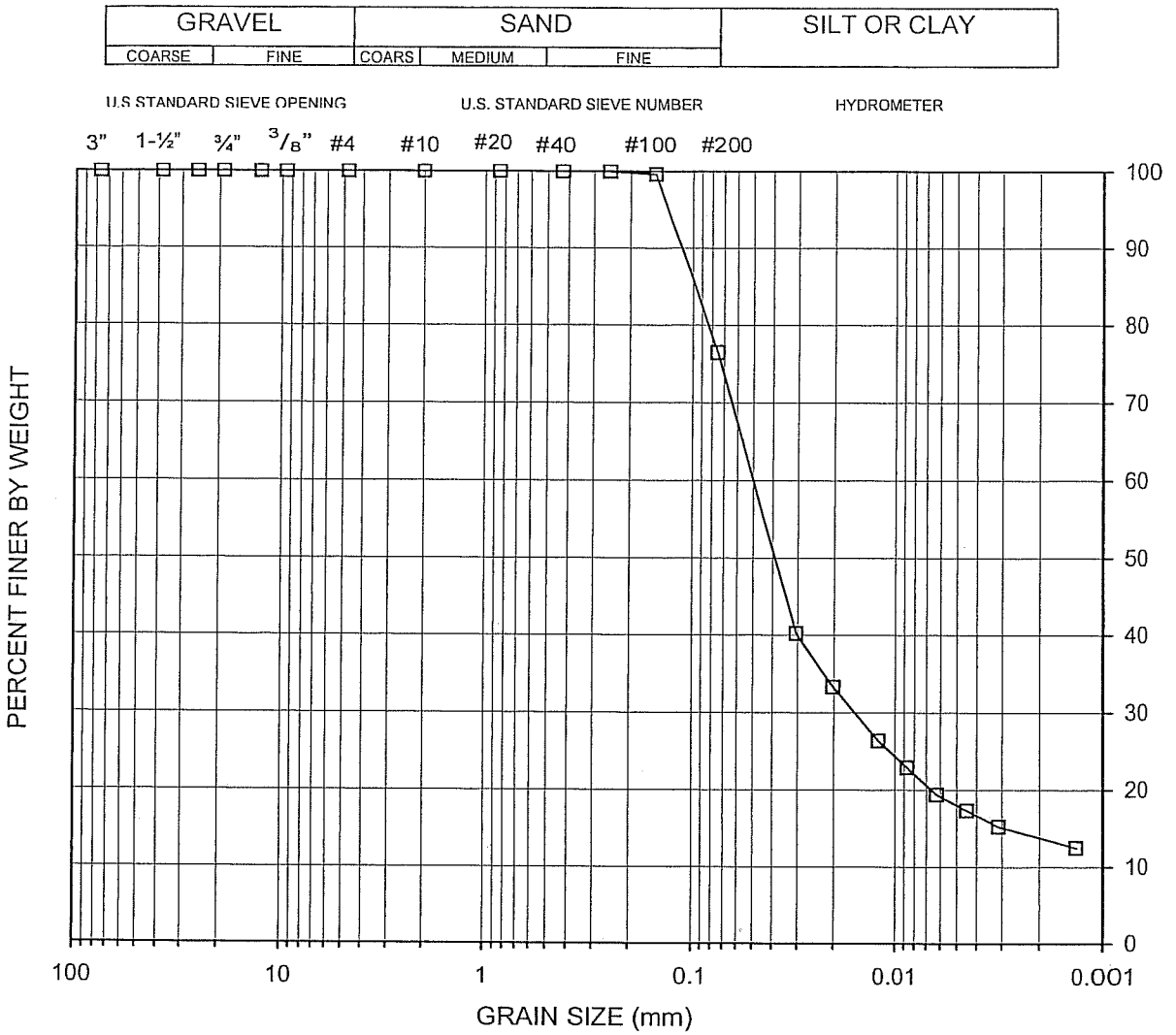
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09

(ASTM D422)

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	U-08	46	Shelby Tube	ML	26	2

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

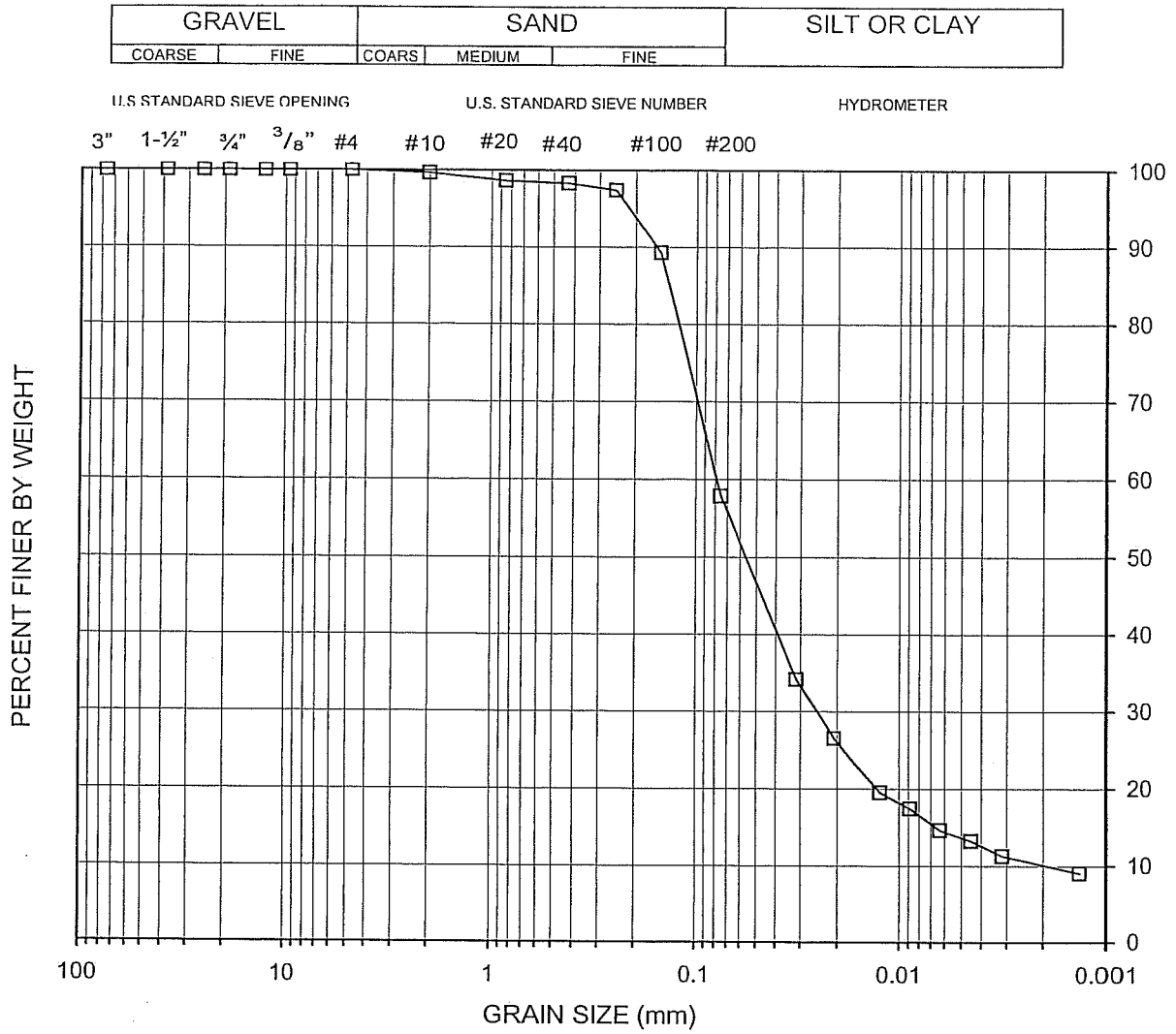
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09

(ASTM D422)

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	S-09	50	Bag	ML	NP	N/A

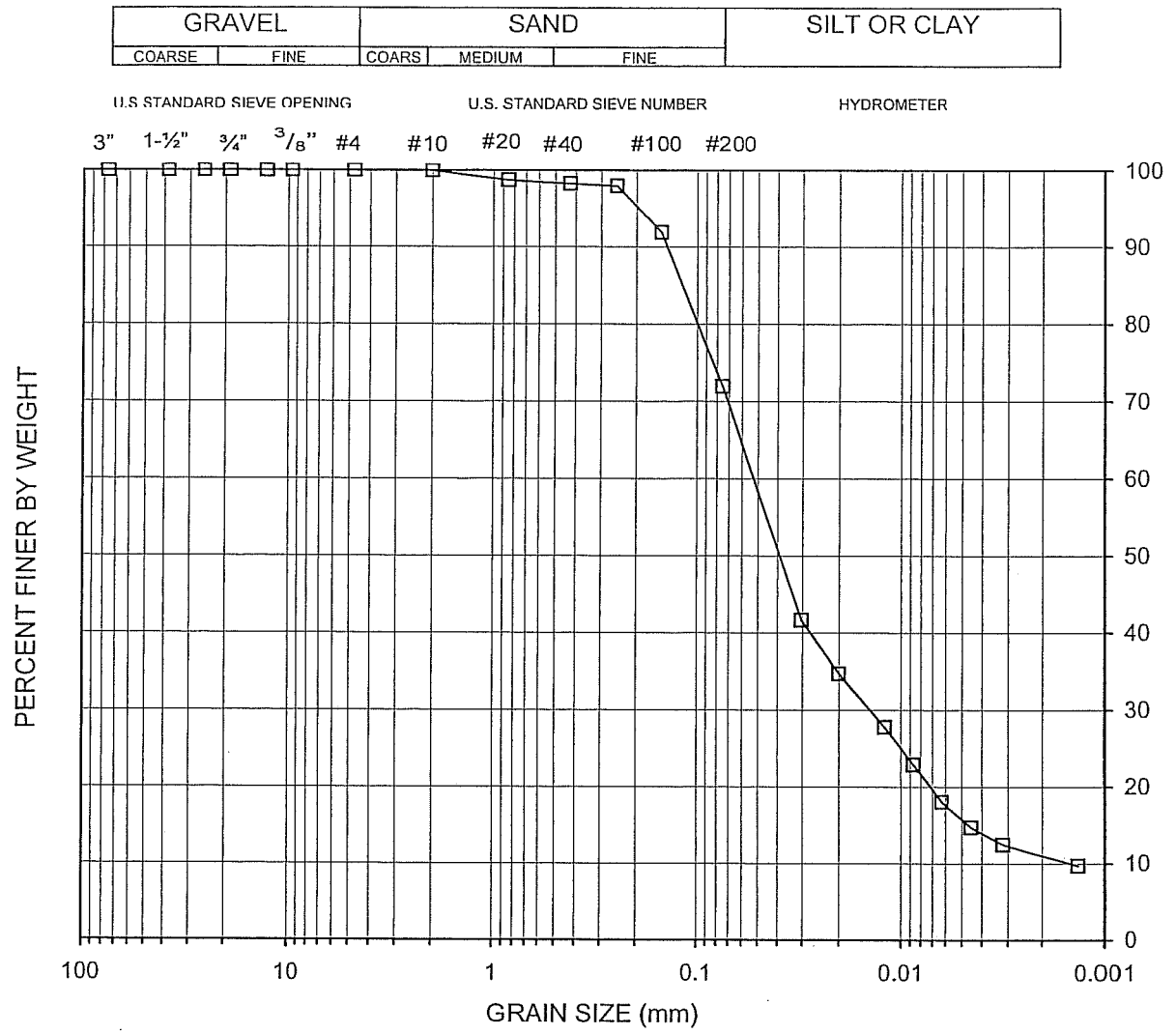
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/22/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	U-11	61	Shelby Tube	ML	25	2

ENVIRONMENTAL
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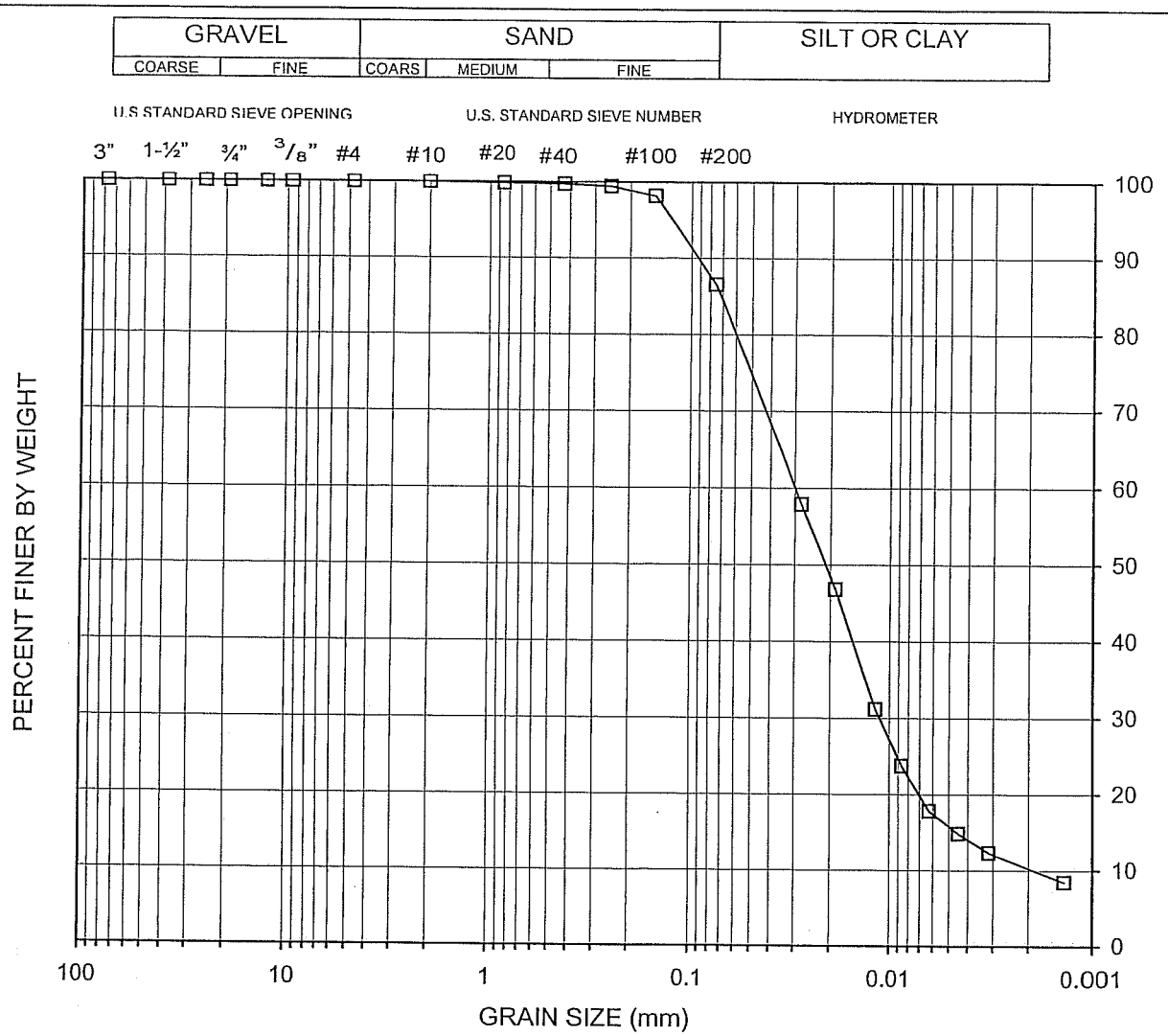
GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	S-12	65	Bag	ML	26	2

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

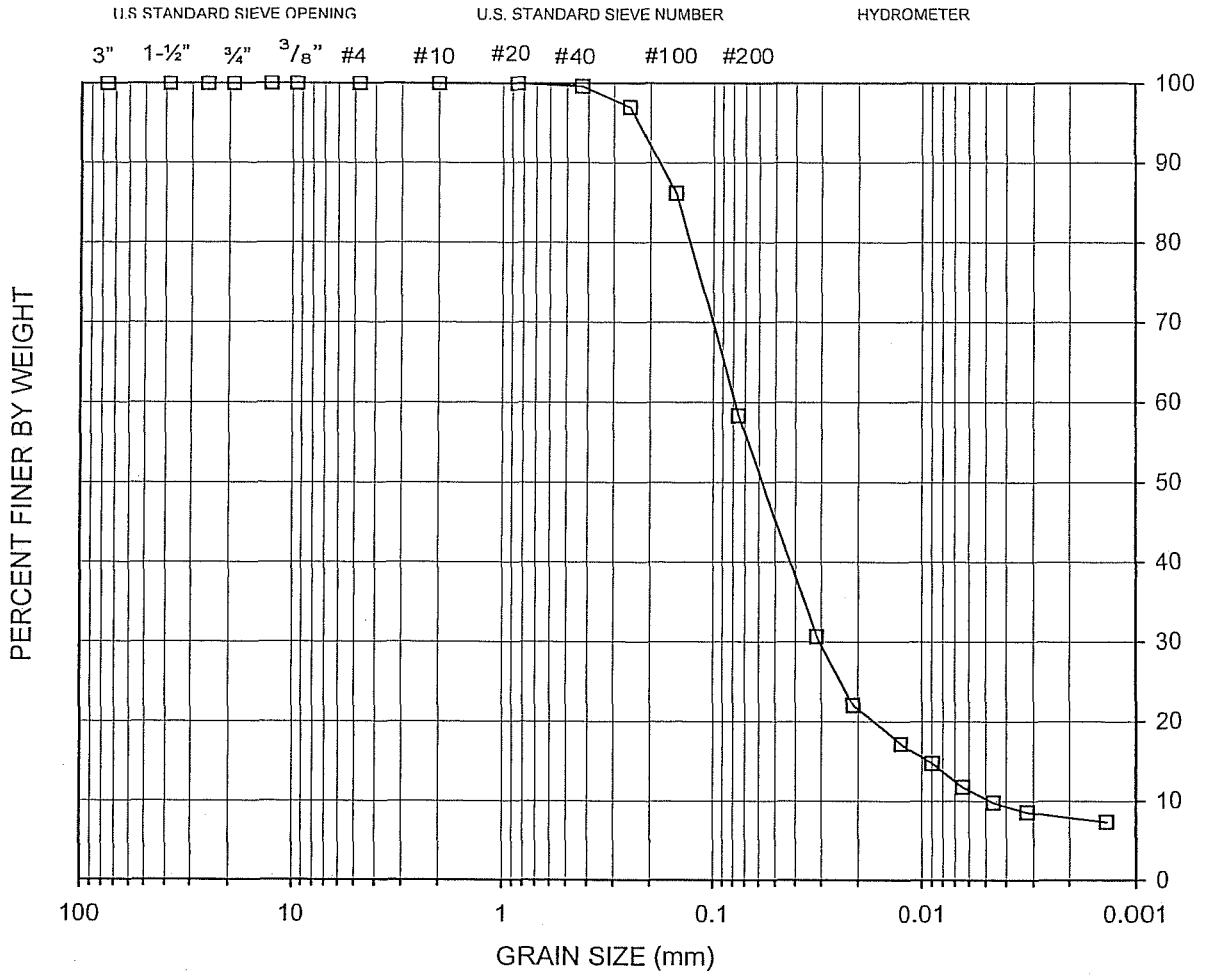
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	D-15	80	Ring	ML	NP	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

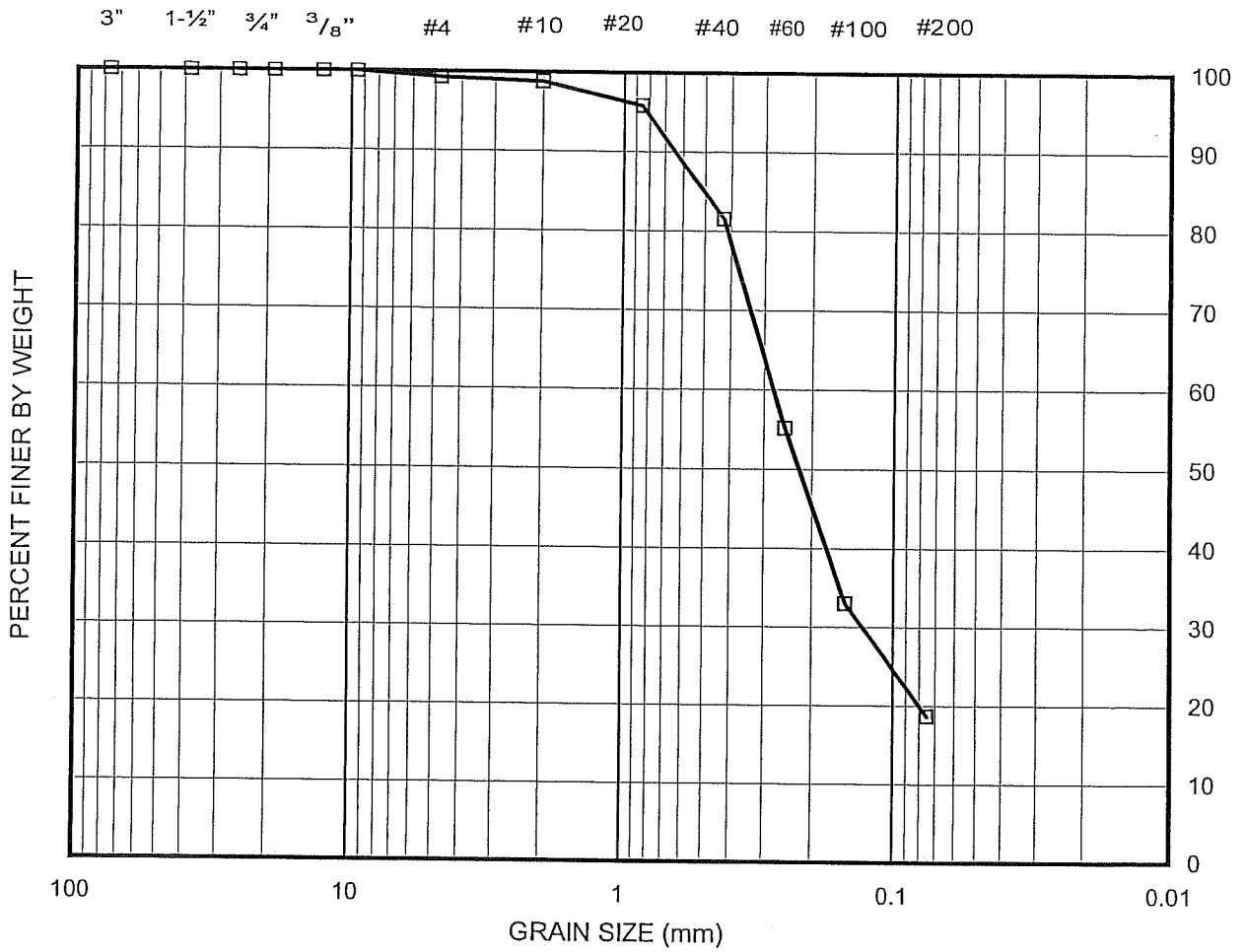
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/22/09 (ASTM D422) FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S STANDARD SIEVE OPENING | U.S. STANDARD SIEVE NUMBER | HYDROMETER



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-038	S-19	110	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

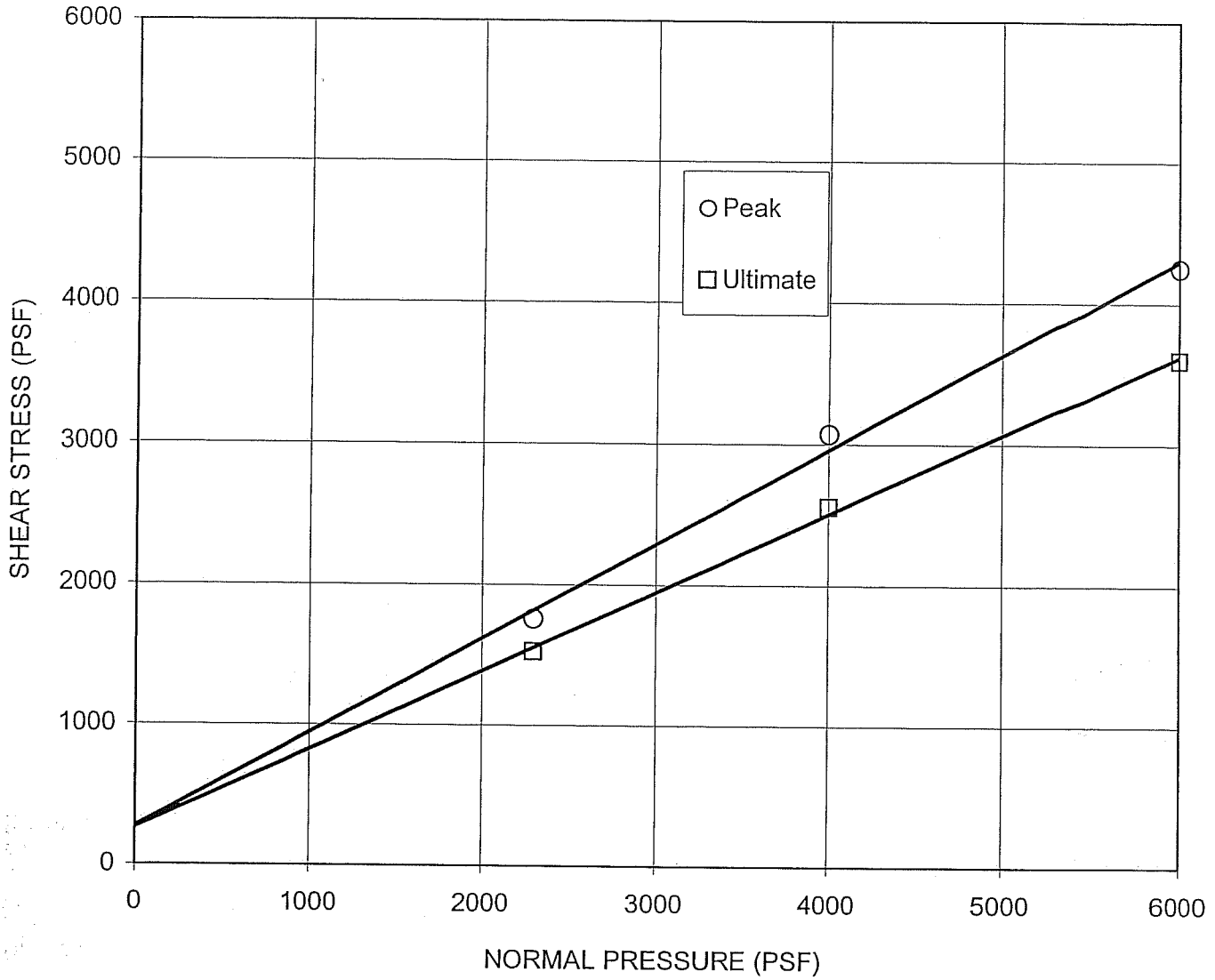
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-038	D-05	30	Ring	SM	○	275	34
					□	265	29

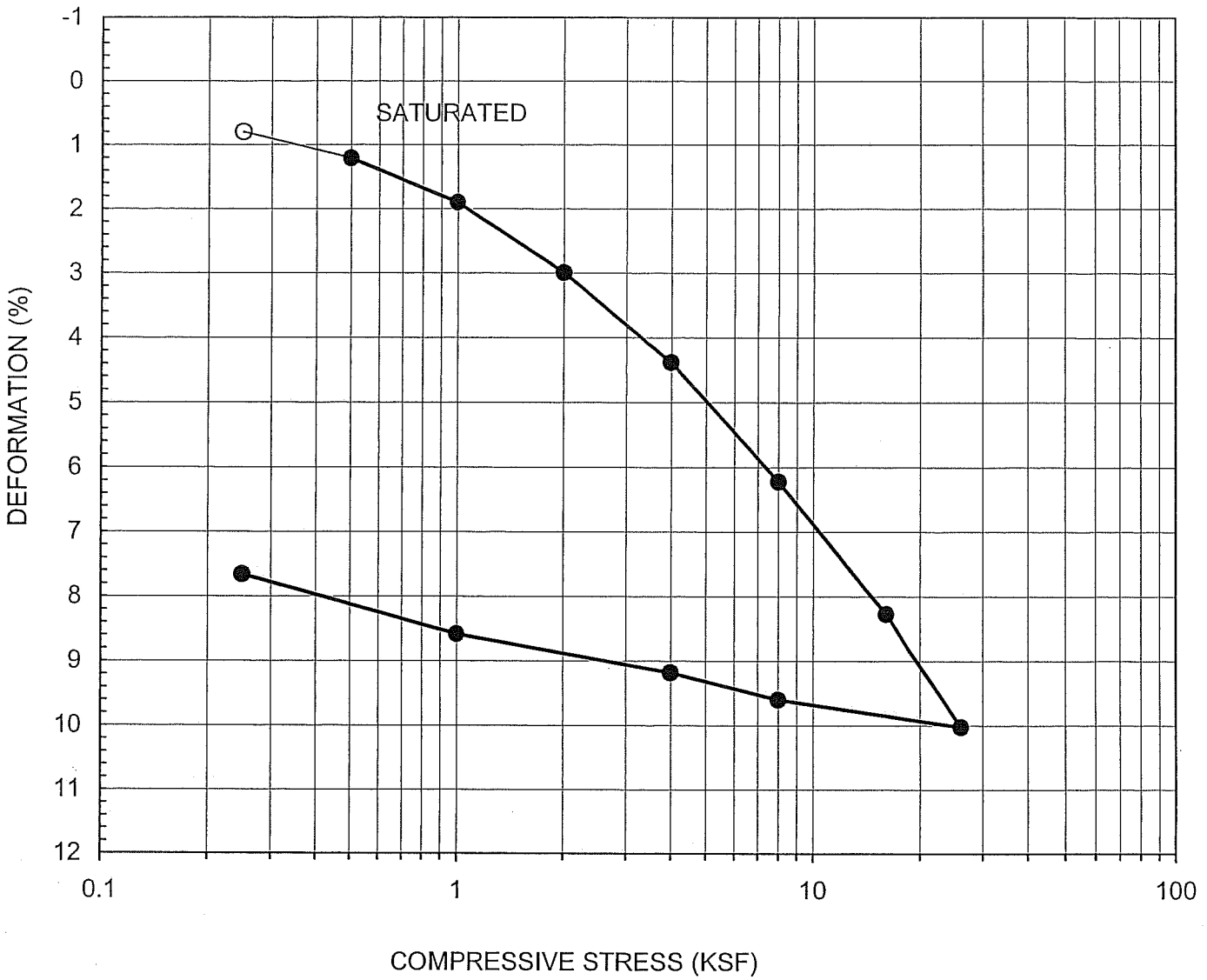
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2300	26.5	29.8
4000	26.5	28.3
6000	26.5	27.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



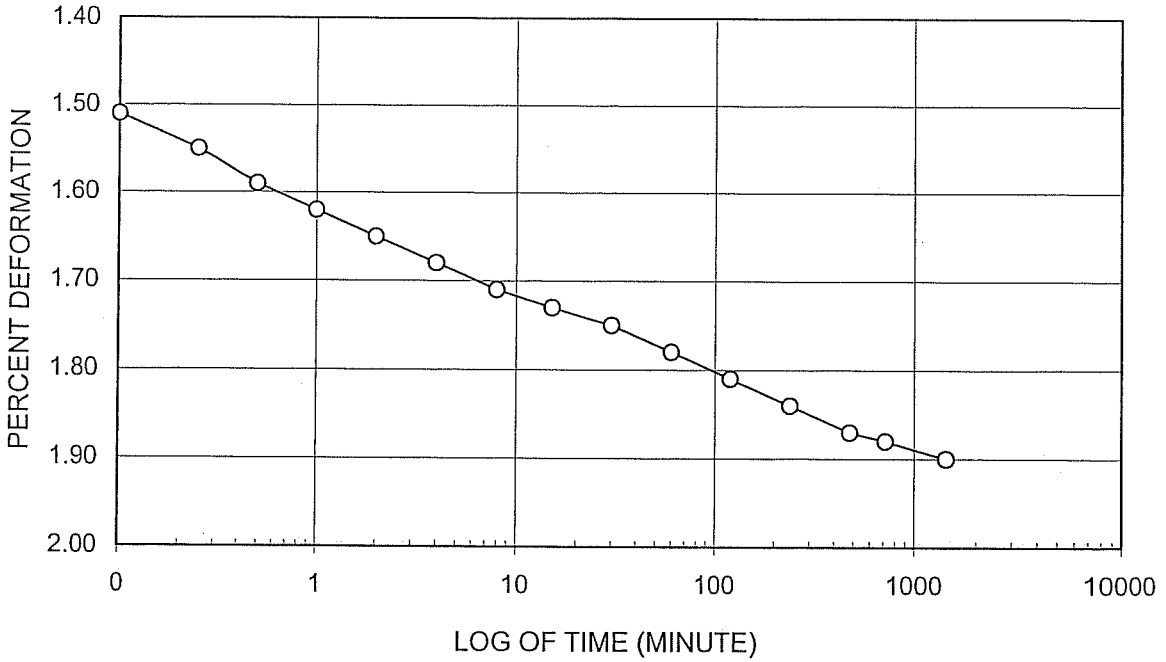
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-038	D-10-1	55.0	ML	26.1	96.9	0.738

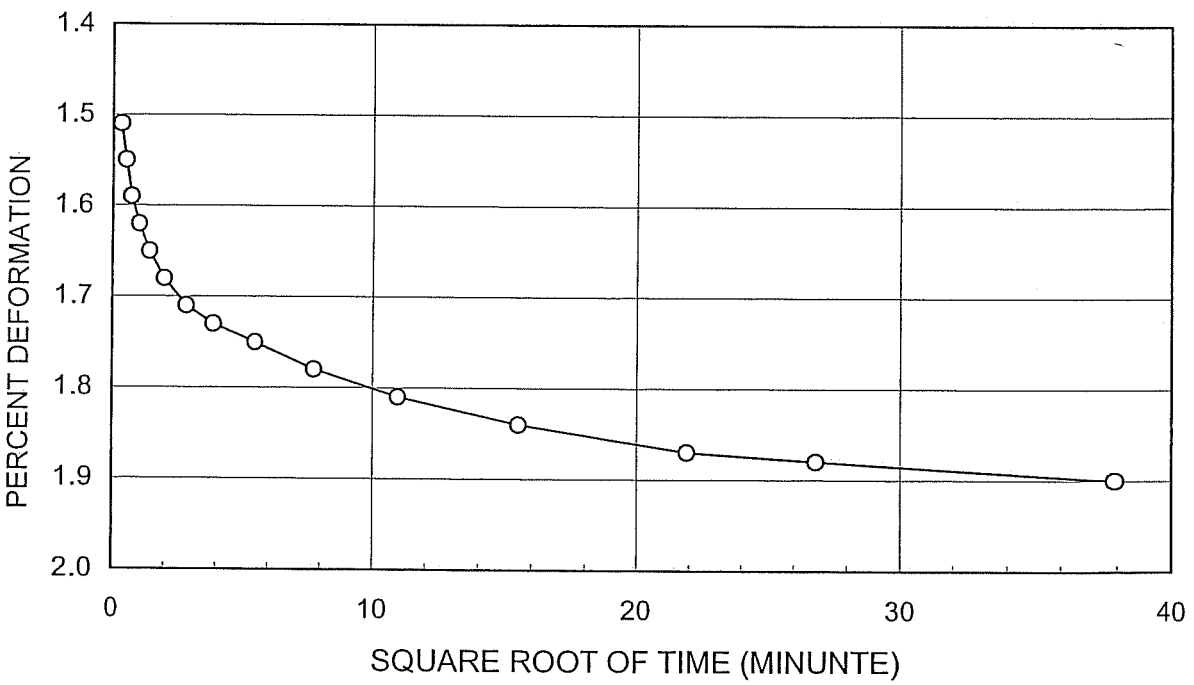
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





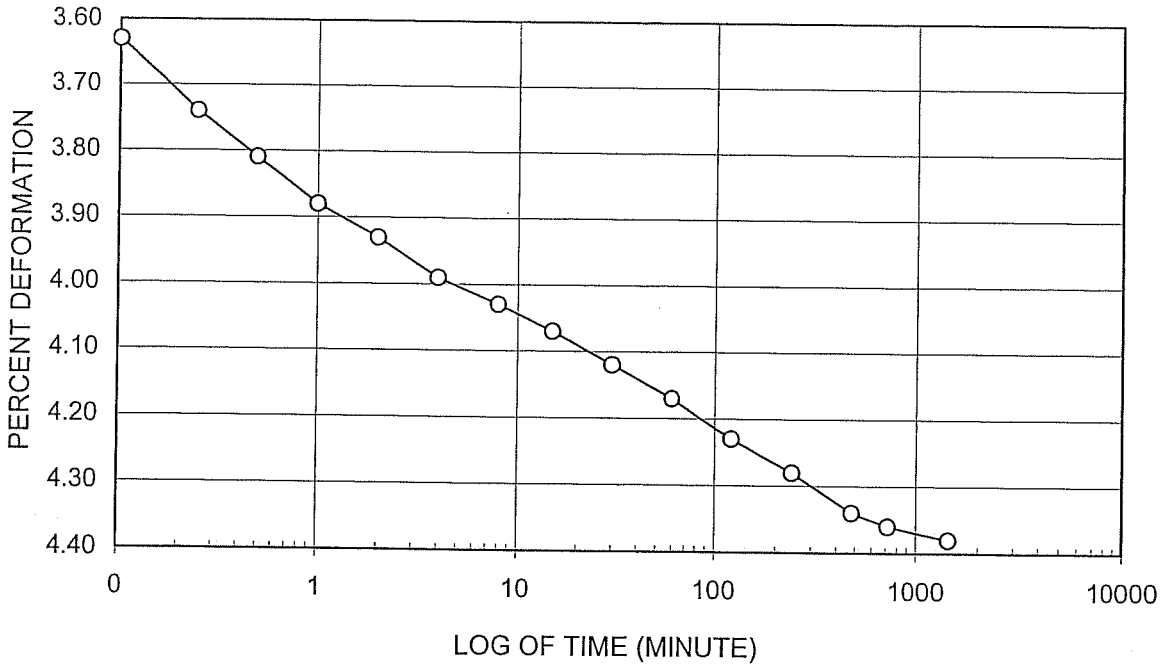
Boring No: R-09-038
Sample No: D-10-1
Depth (ft): 55
Soil Type: ML
Normal Stress: 1.0 ksf

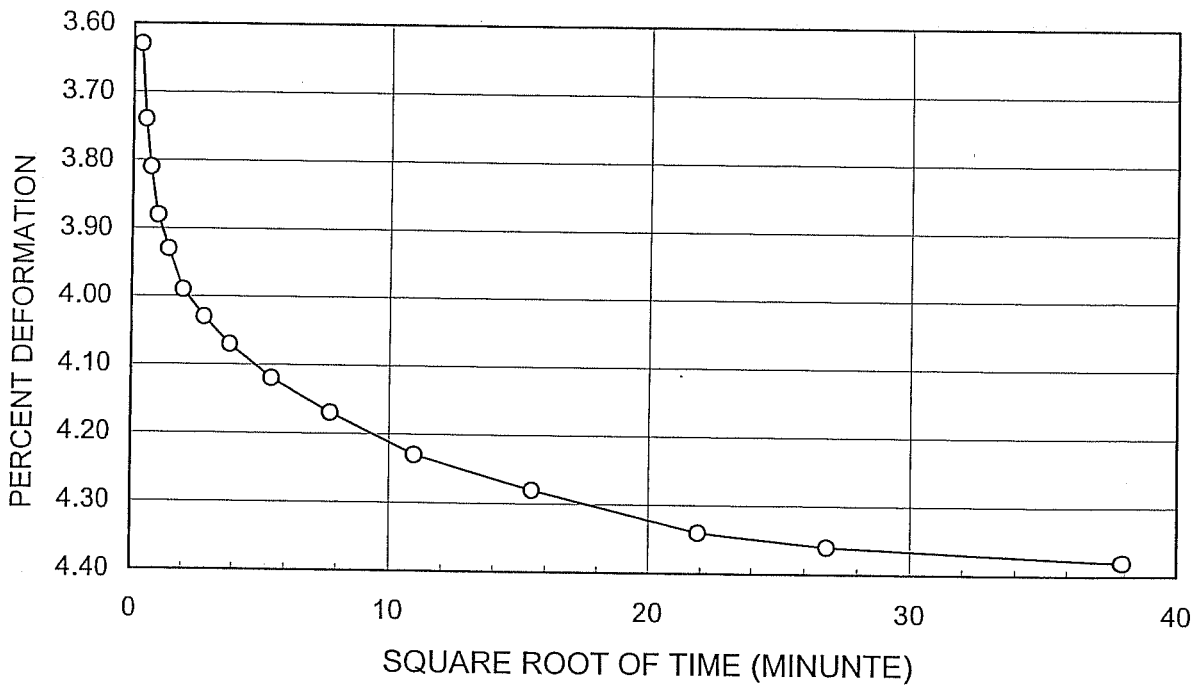
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





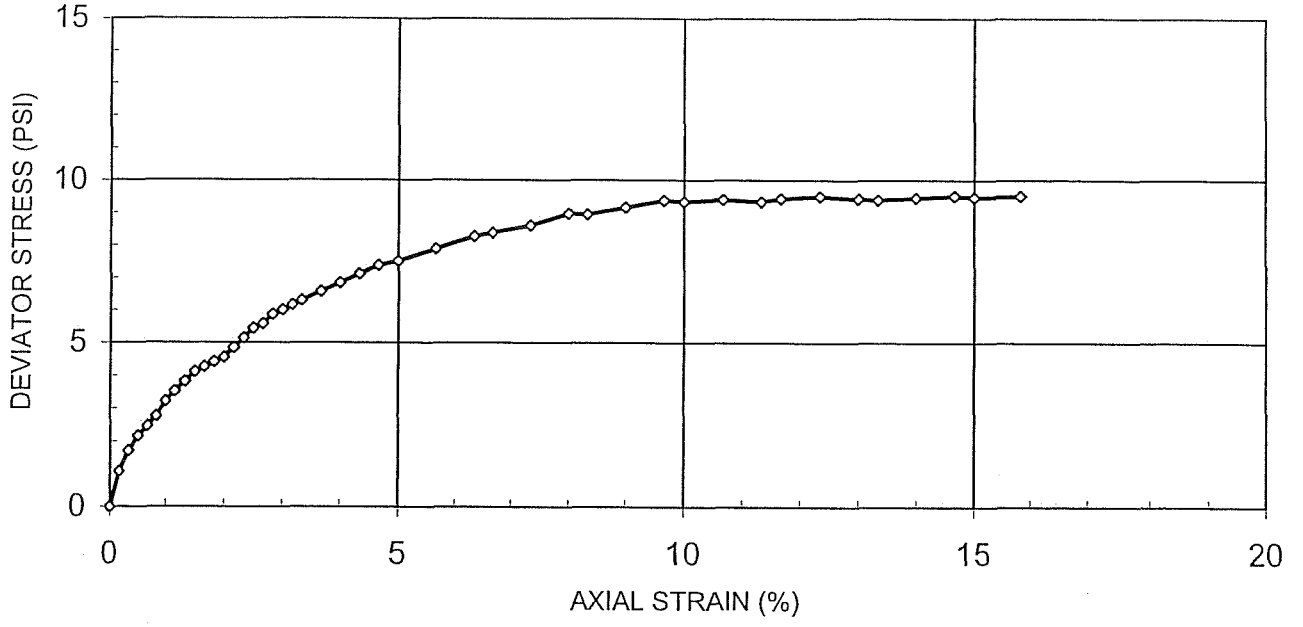
Boring No: R-09-038
Sample No: D-10-1
Depth (ft): 55
Soil Type: ML
Normal Stress: 4.0 ksf

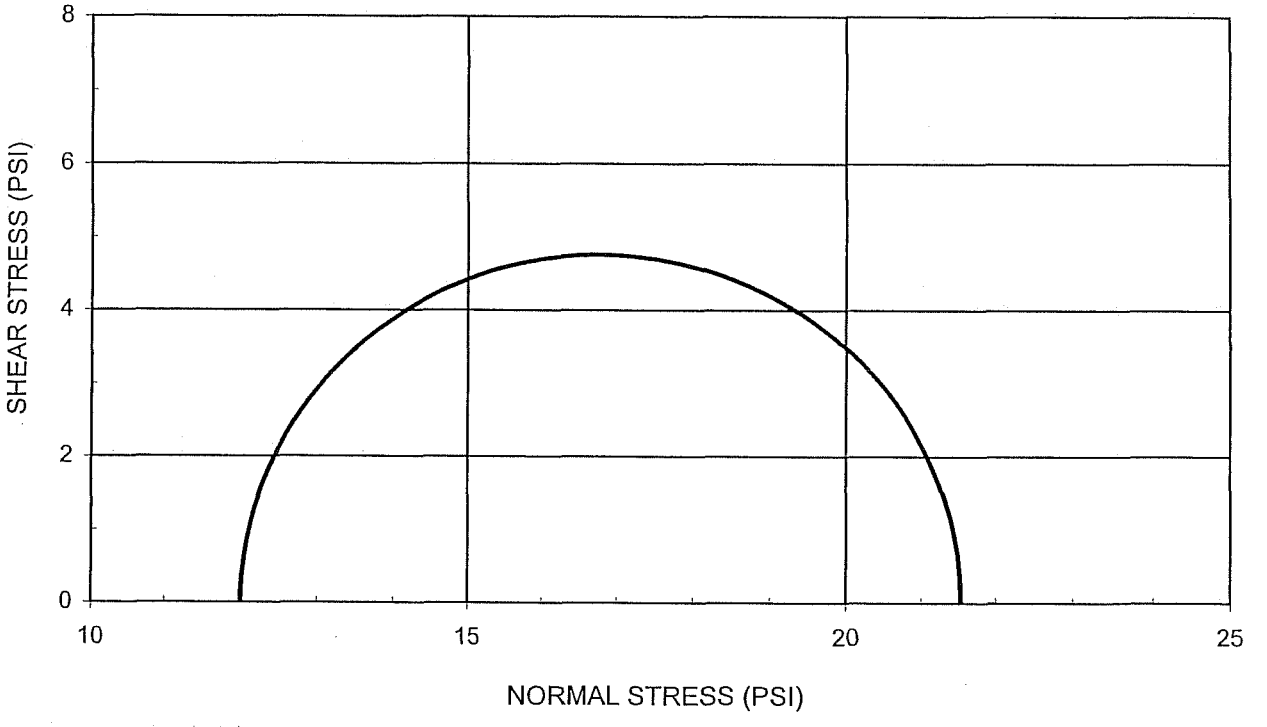
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-038	35	U-06	CH	Shelby Tube	57.95	66.5	12.0	9.5	0.06	102.2

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

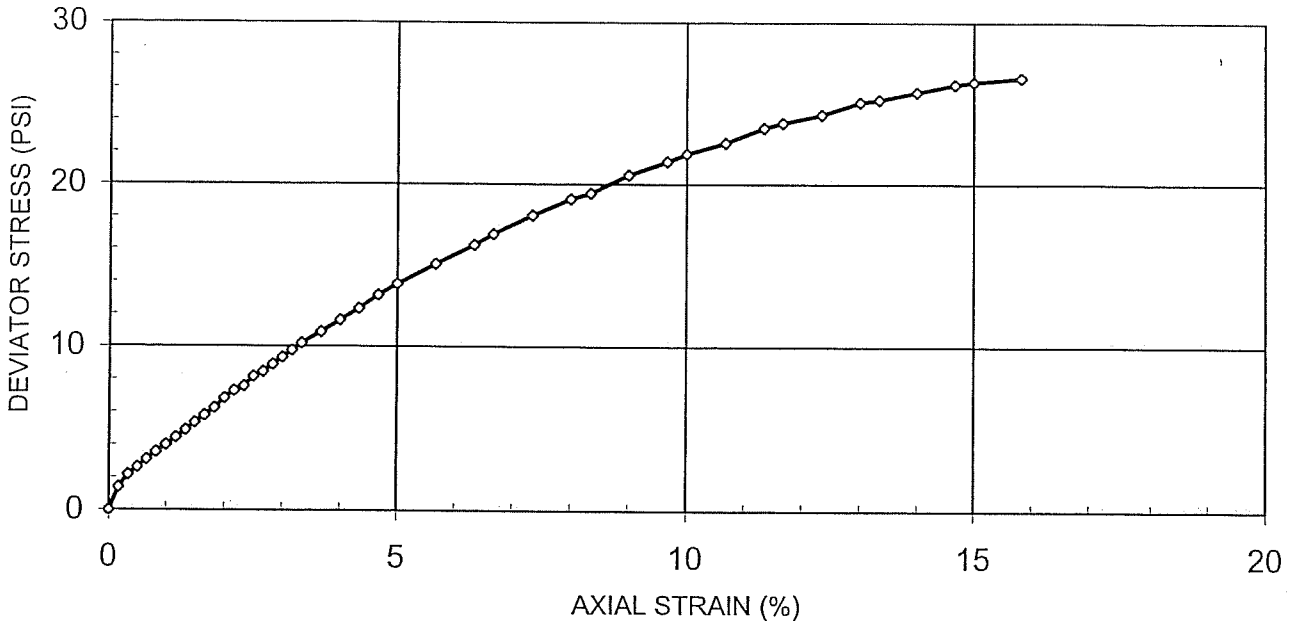
Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

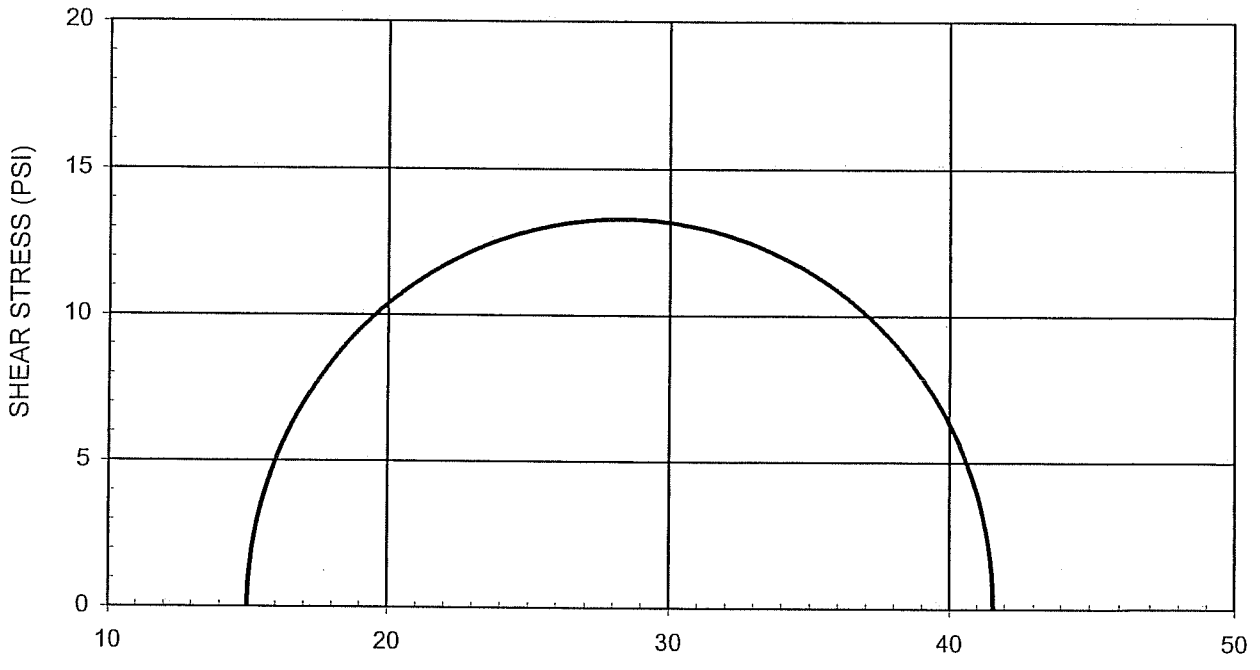
UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-038	46	U-08	ML	Shelby Tube	31.14	91.7	15.0	26.6	0.06	100.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

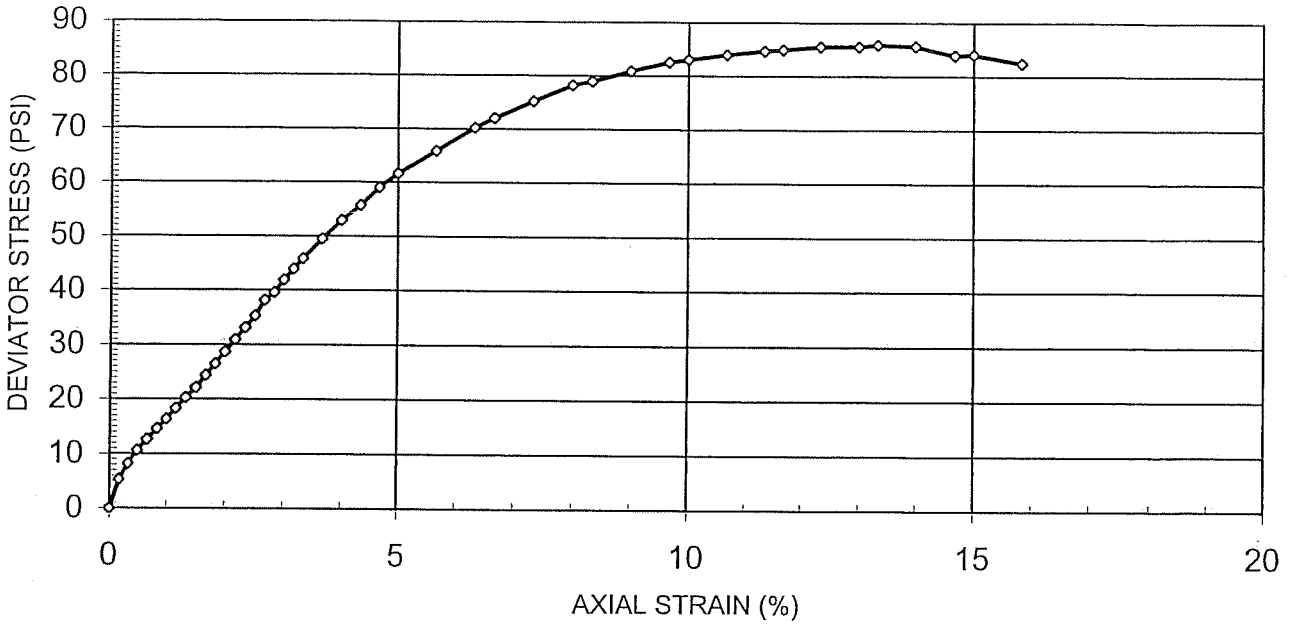
EGL Project No: 09-230-008A

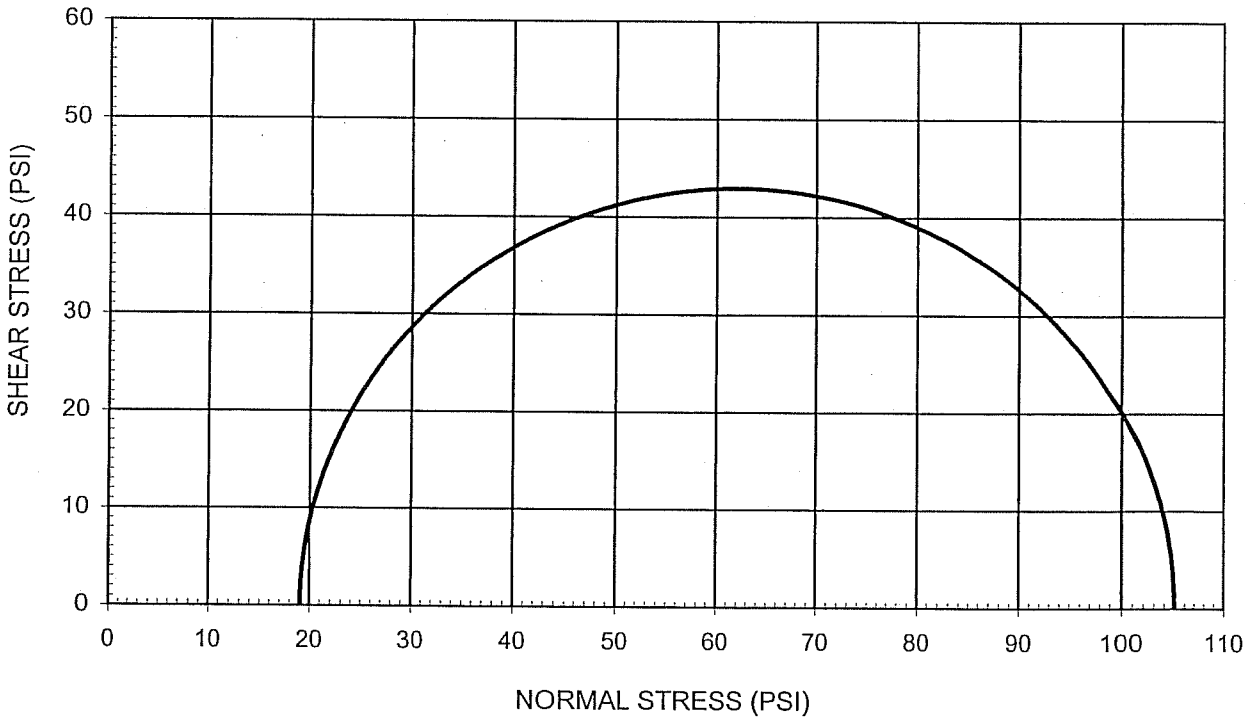
UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-038	61	U-11	ML	Shelby Tube	21.61	105.2	19.0	85.9	0.06	97.0

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure

APPENDIX F. SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

Earth Mechanics, Inc., 2006a, "Preliminary Foundation Report, ACTA Schuyler Heim Bridge (Replace), Los Angeles, California," Report Prepared for Alameda Corridor Transportation Authority, EMI Project No. 06-123, June 23.

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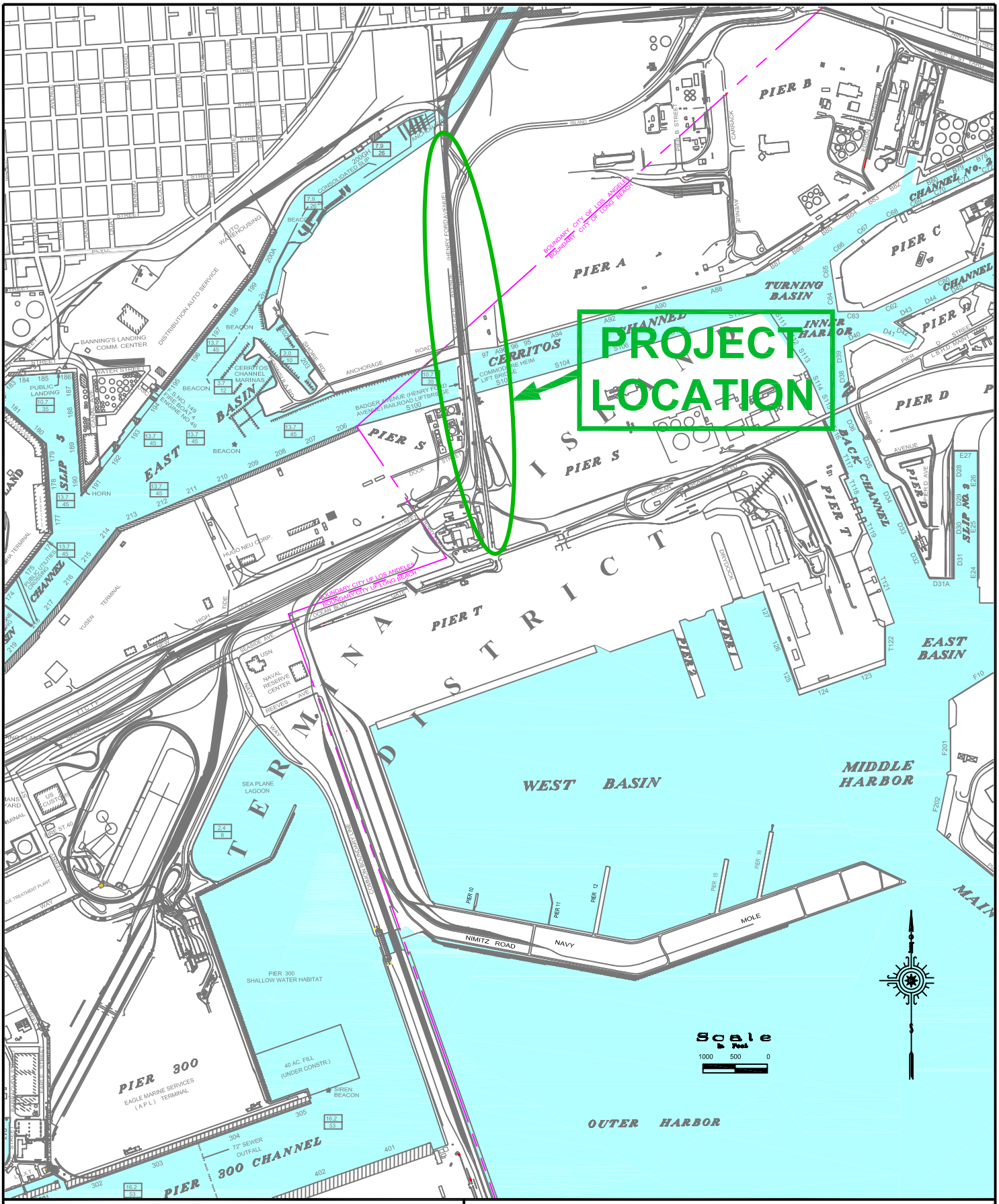
Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



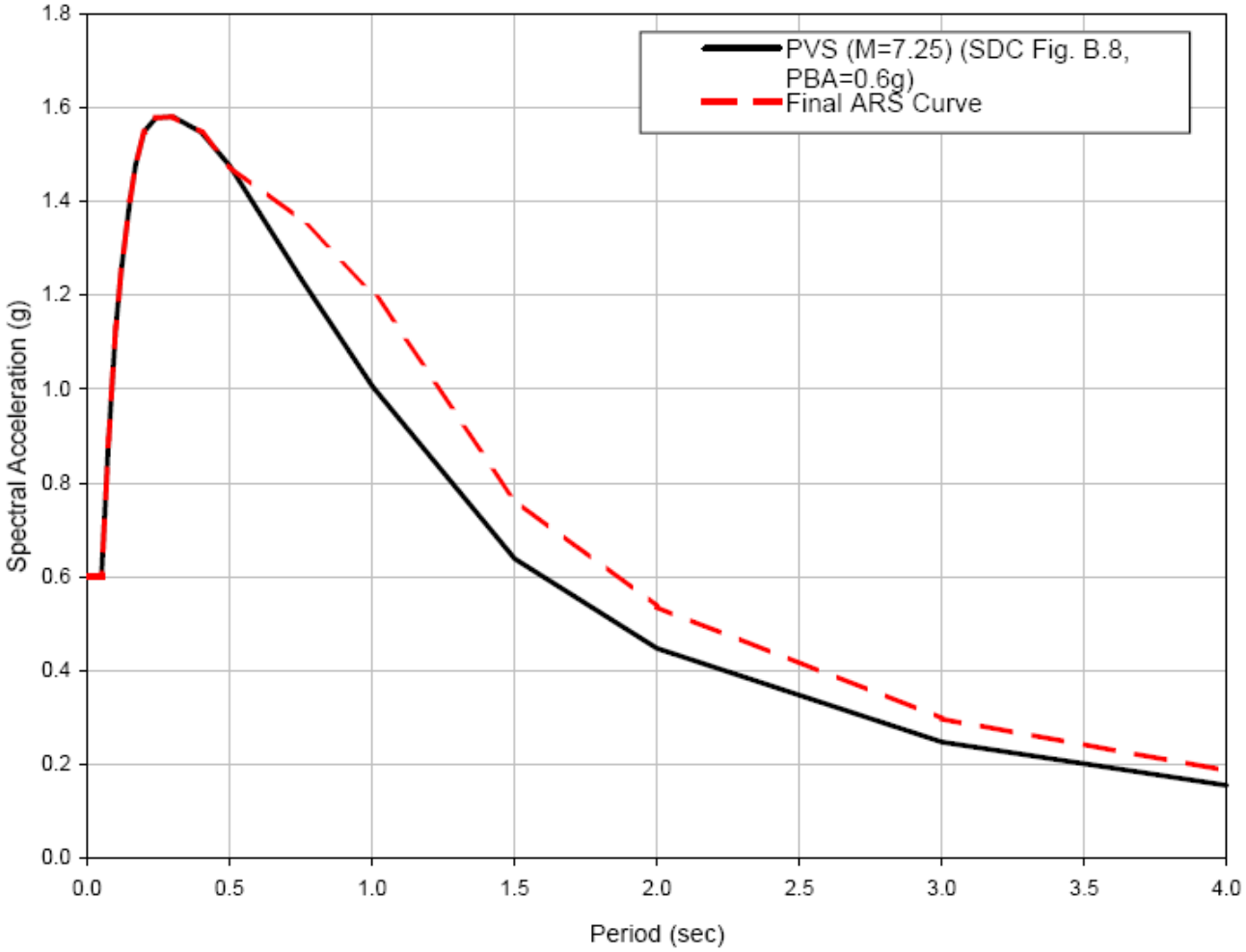
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

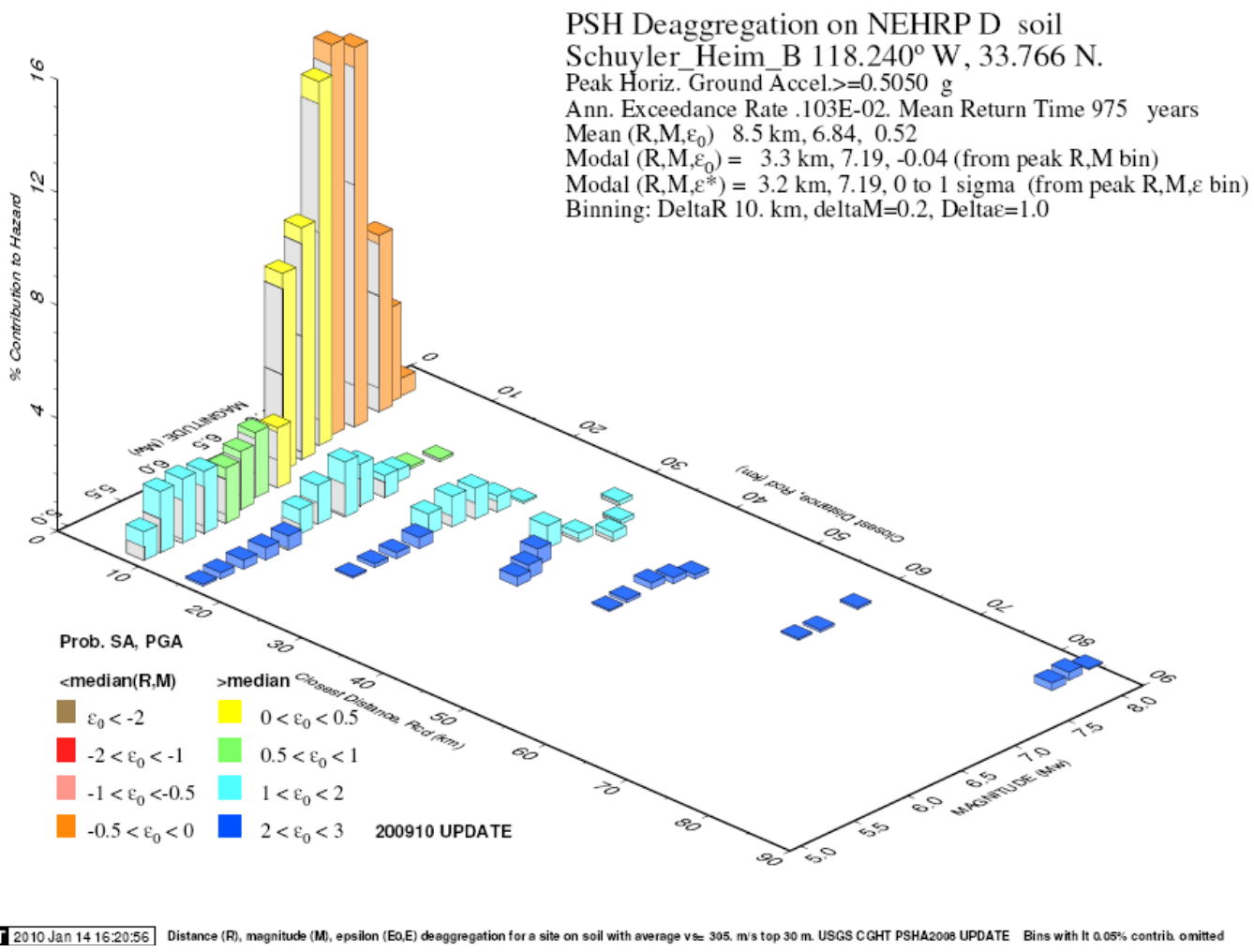


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

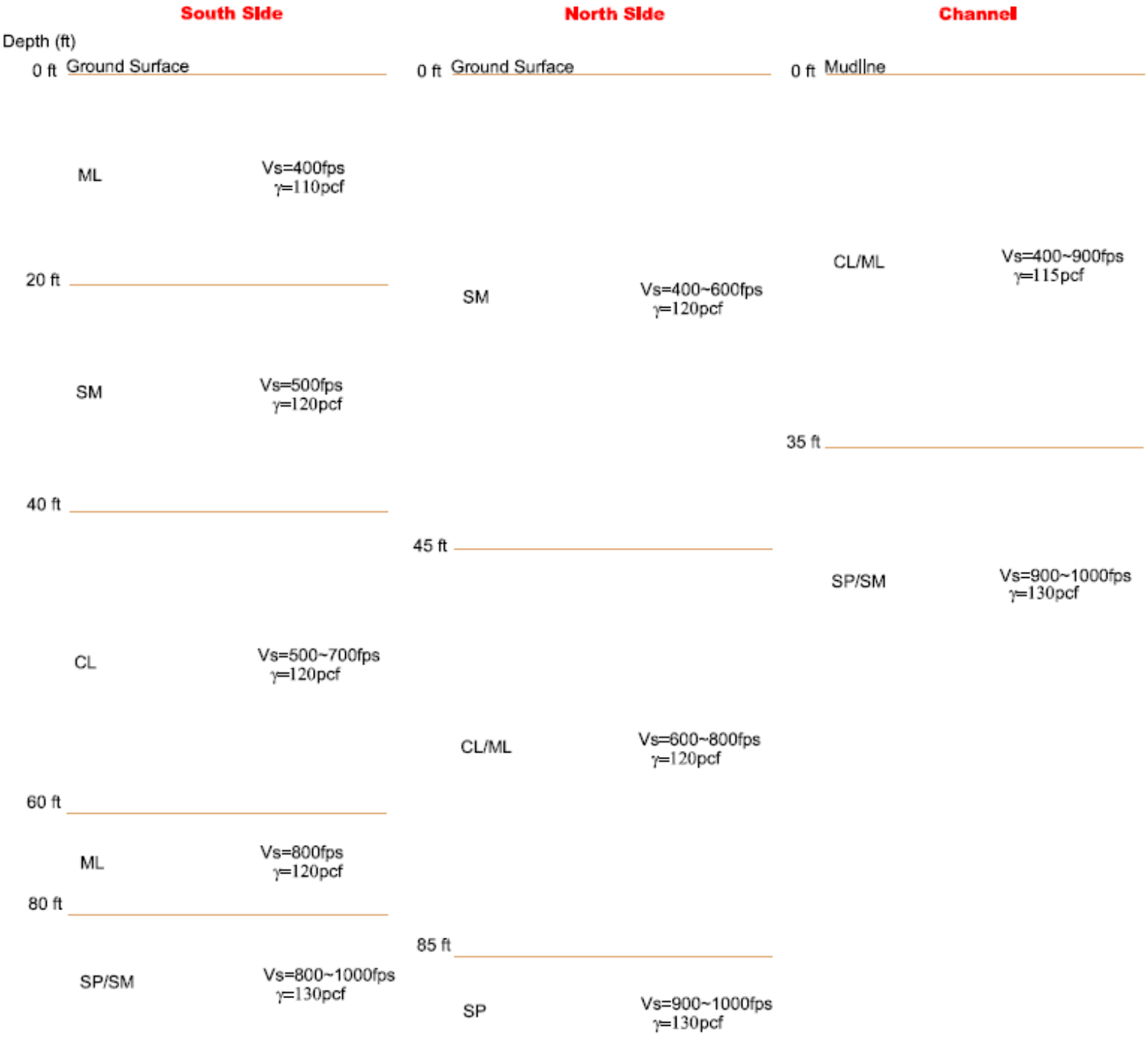
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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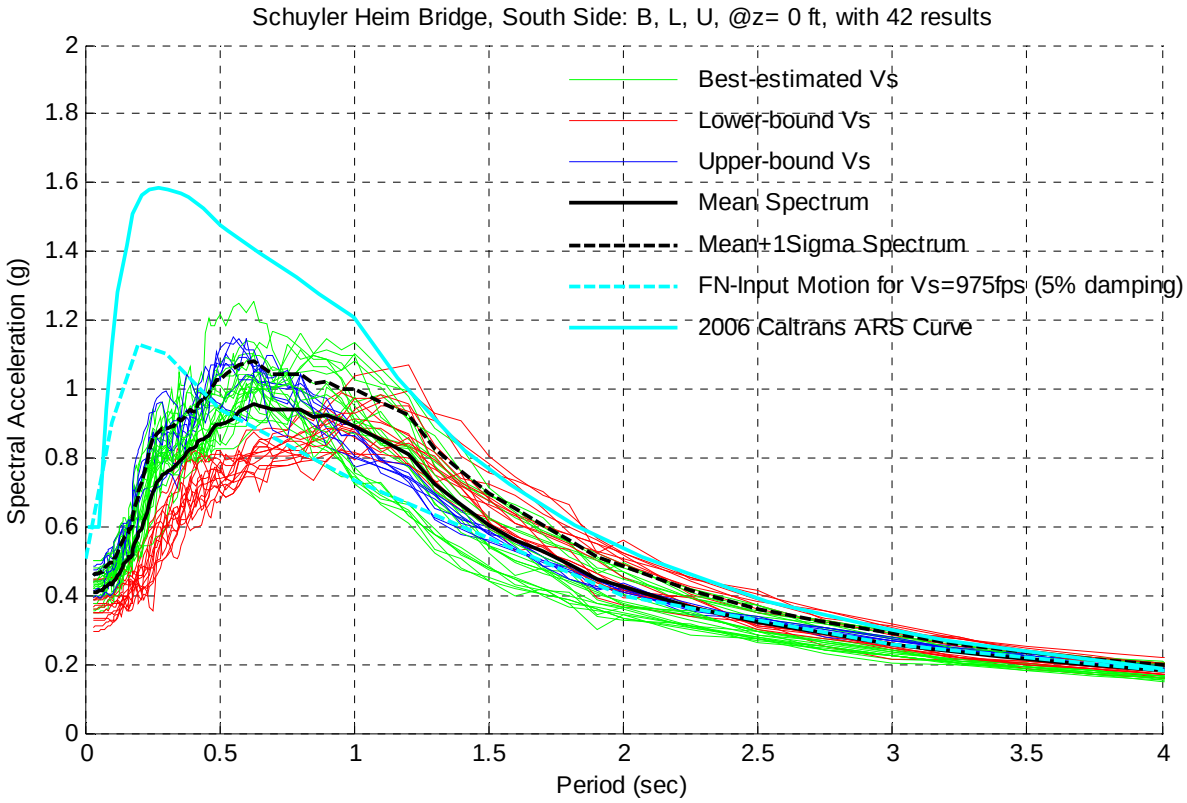
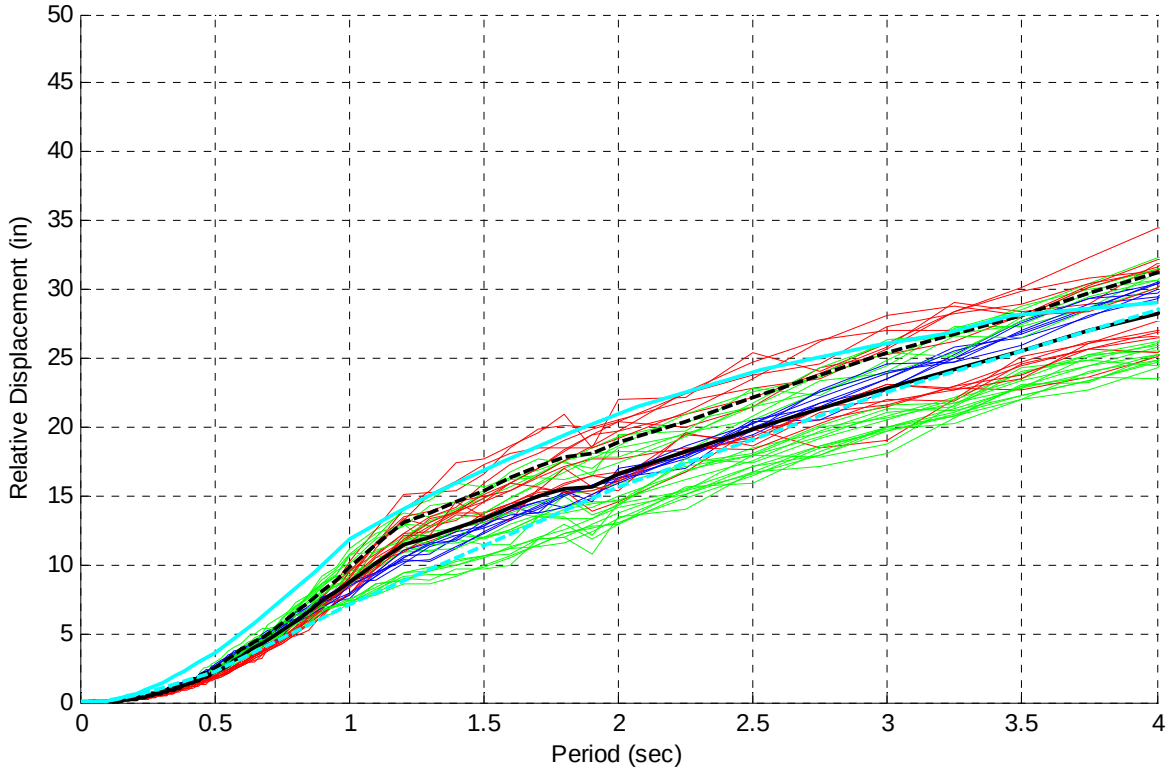
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





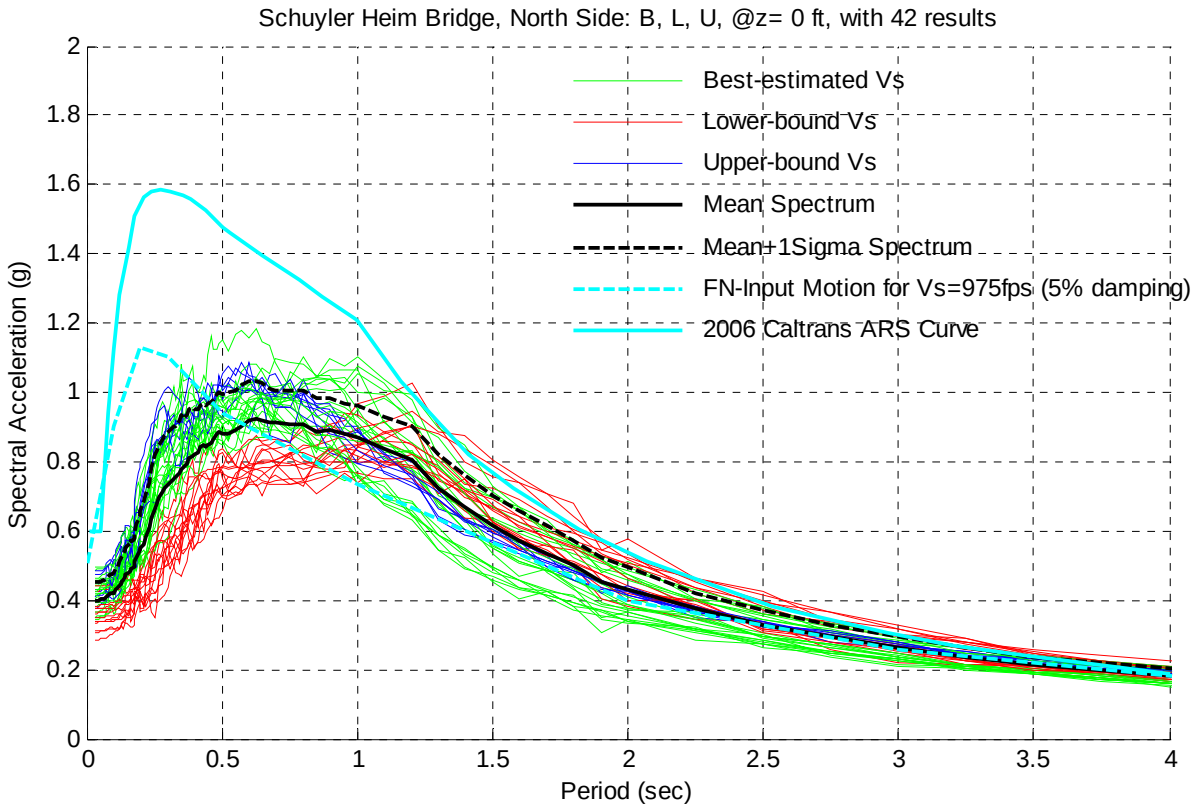
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

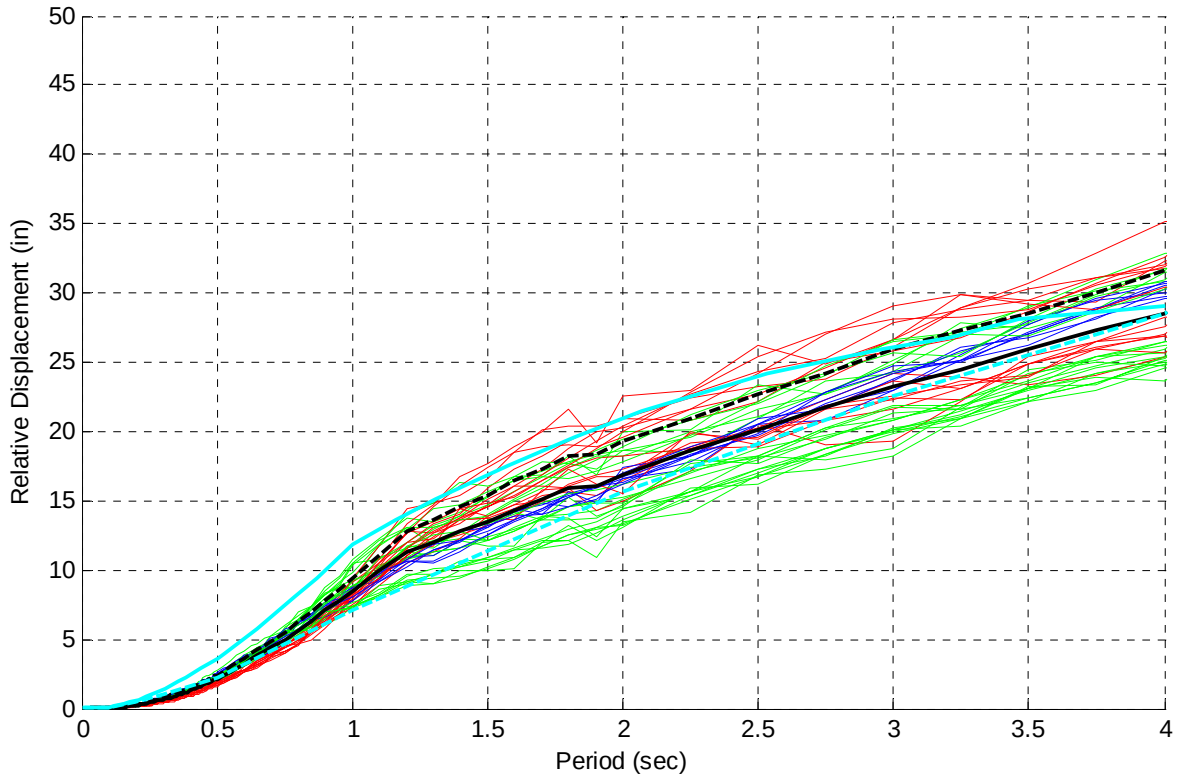
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





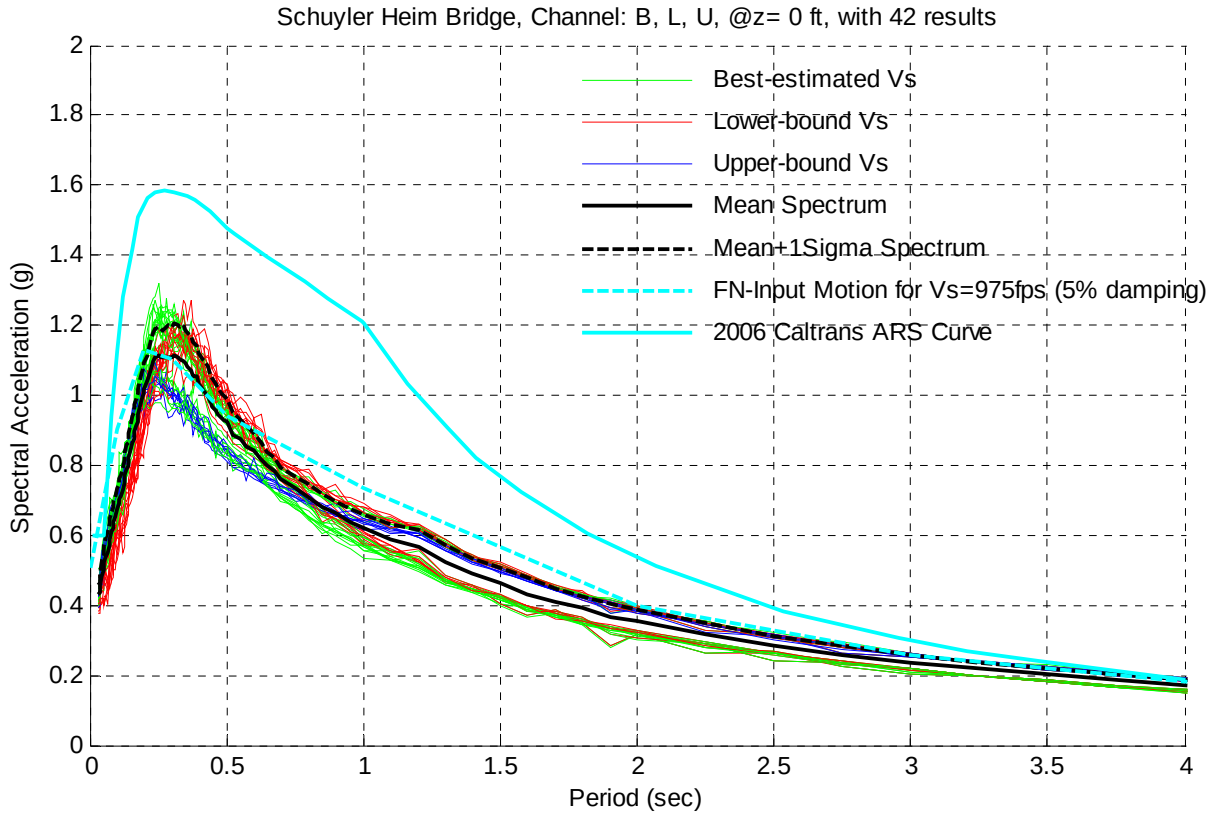
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

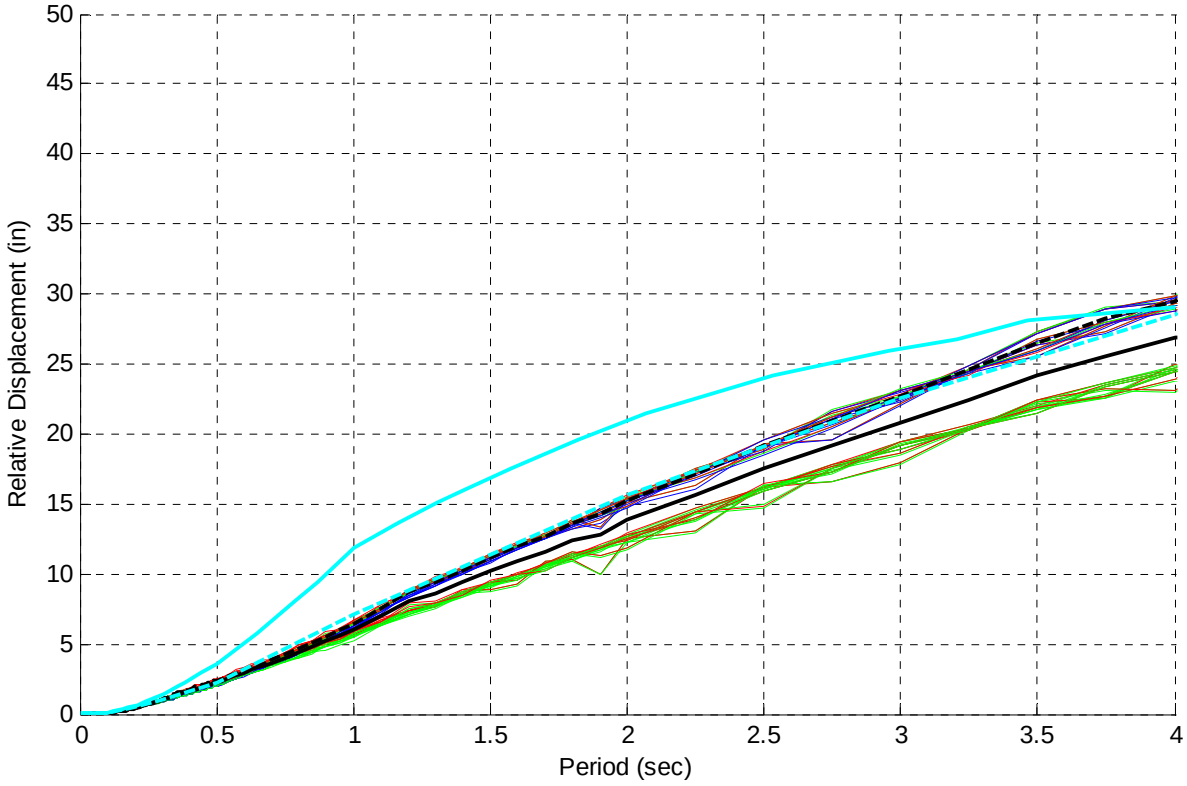
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





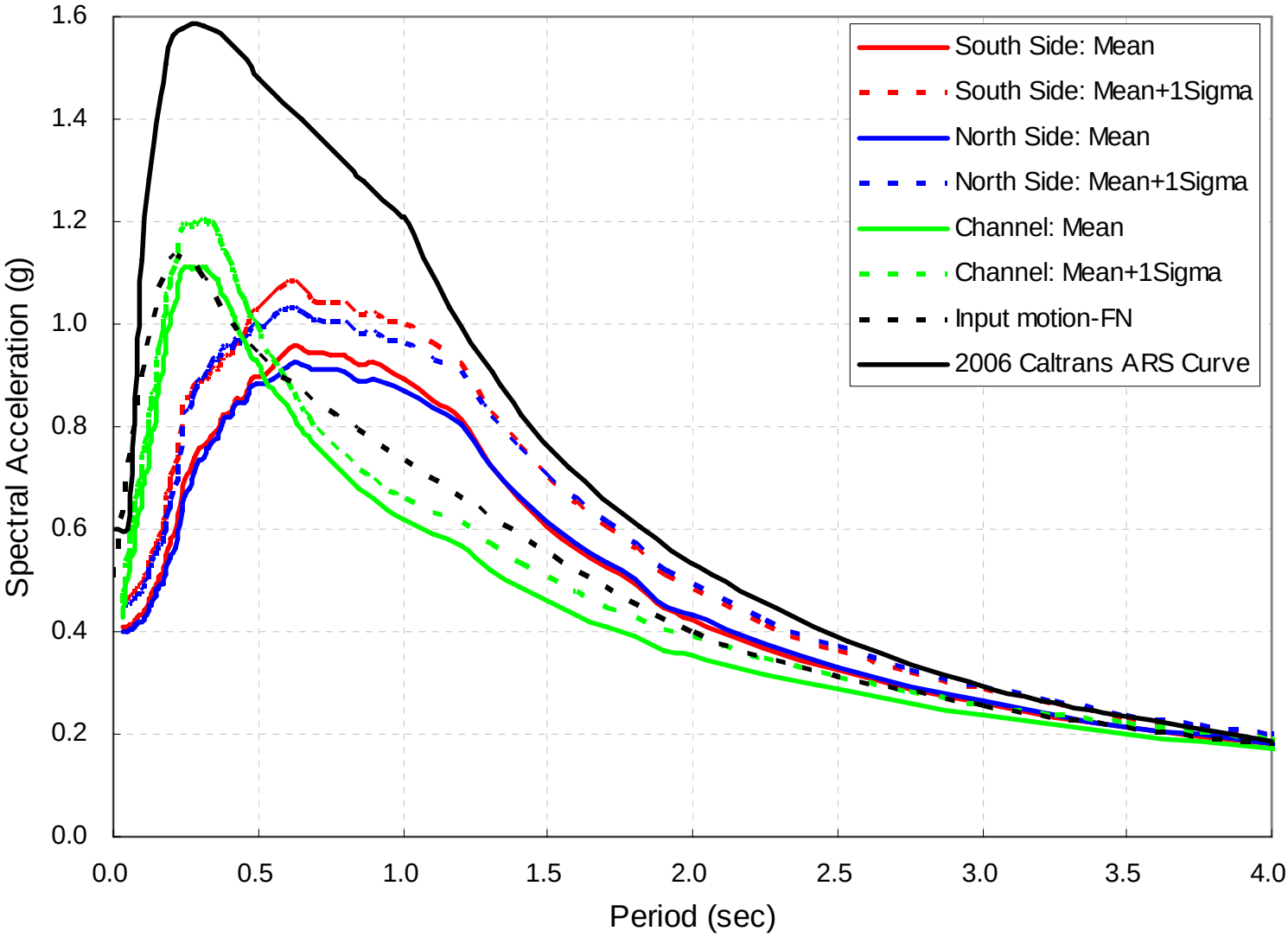
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



Earth Mechanics, Inc.
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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

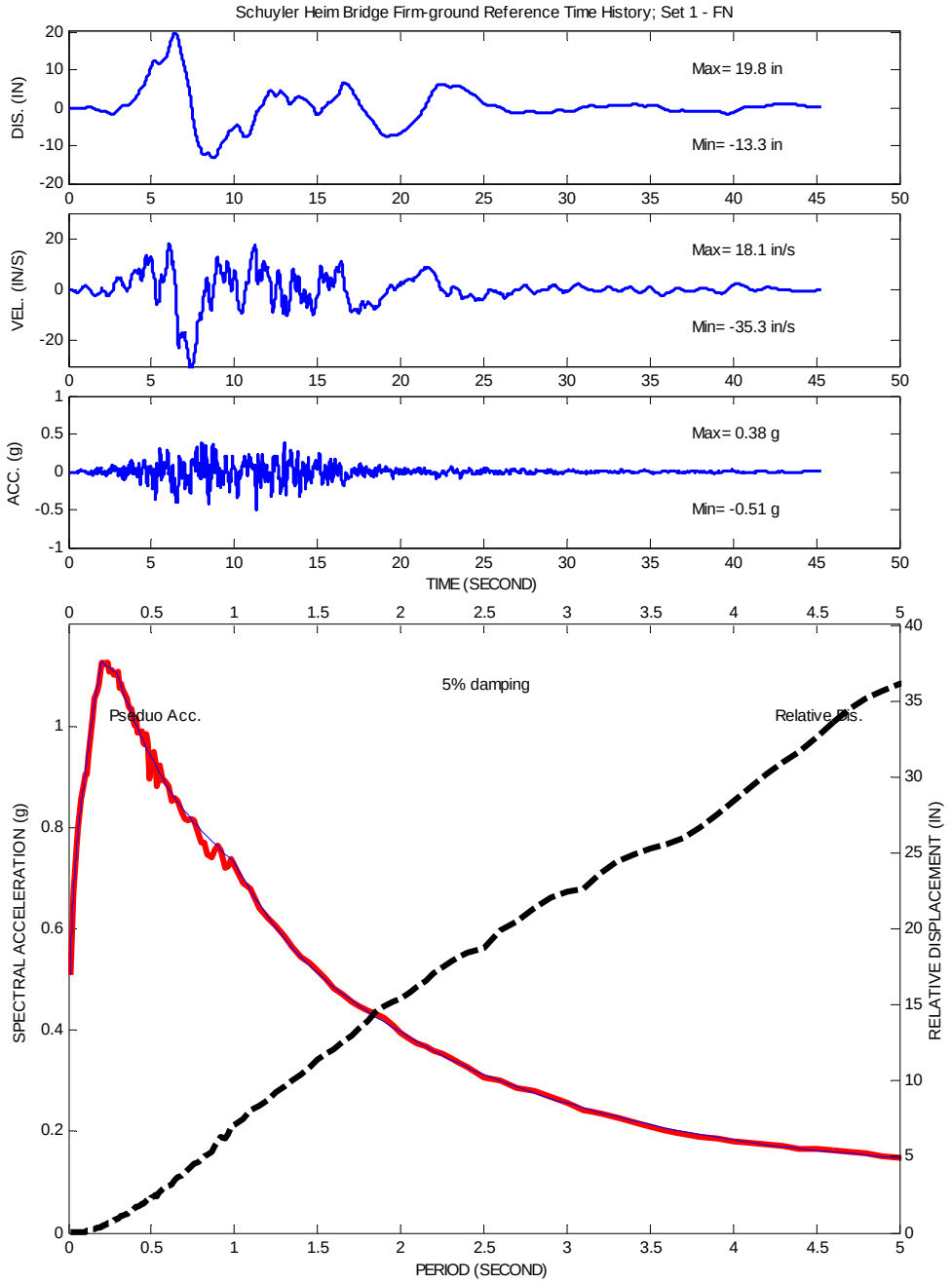

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

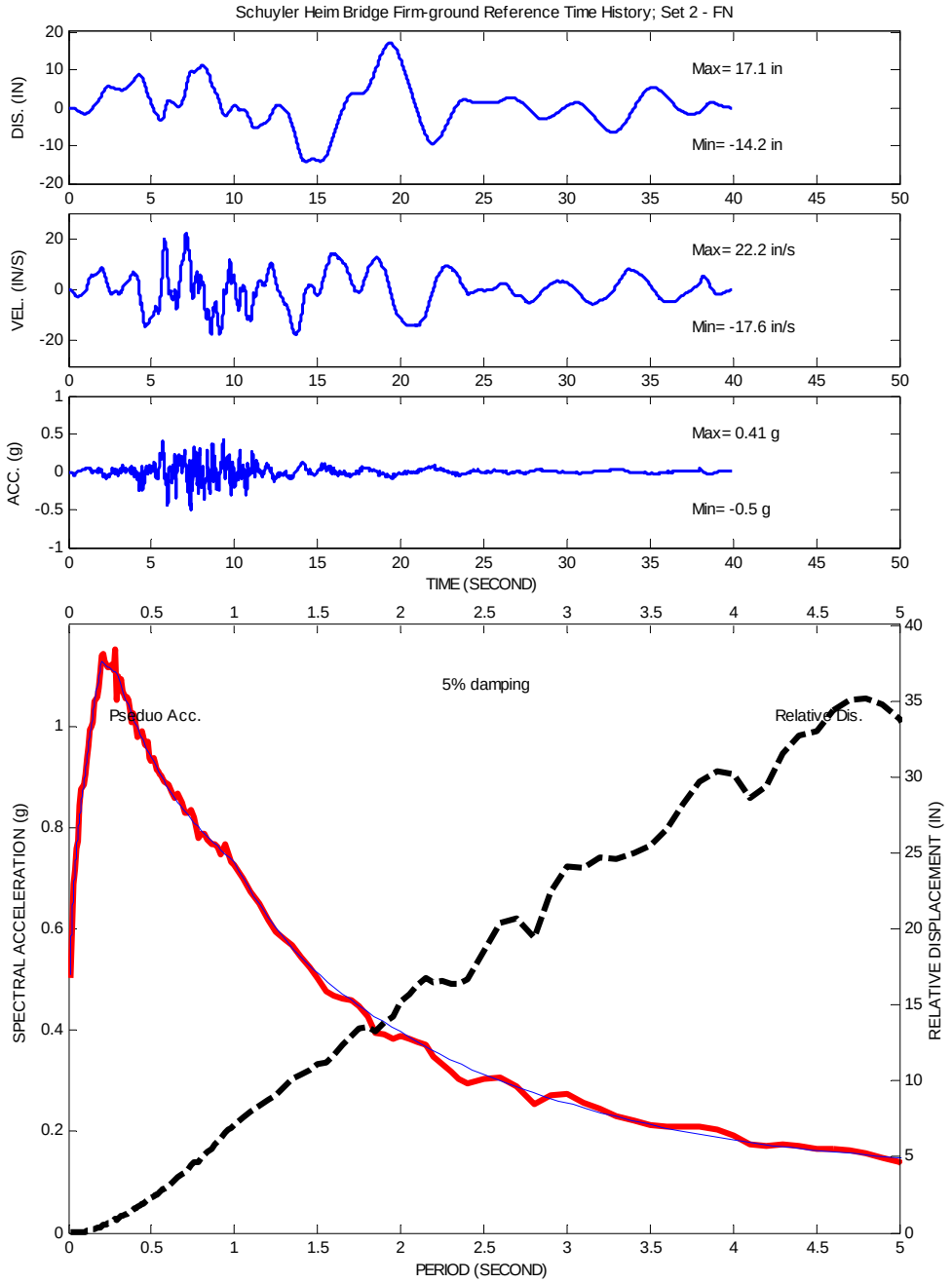

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

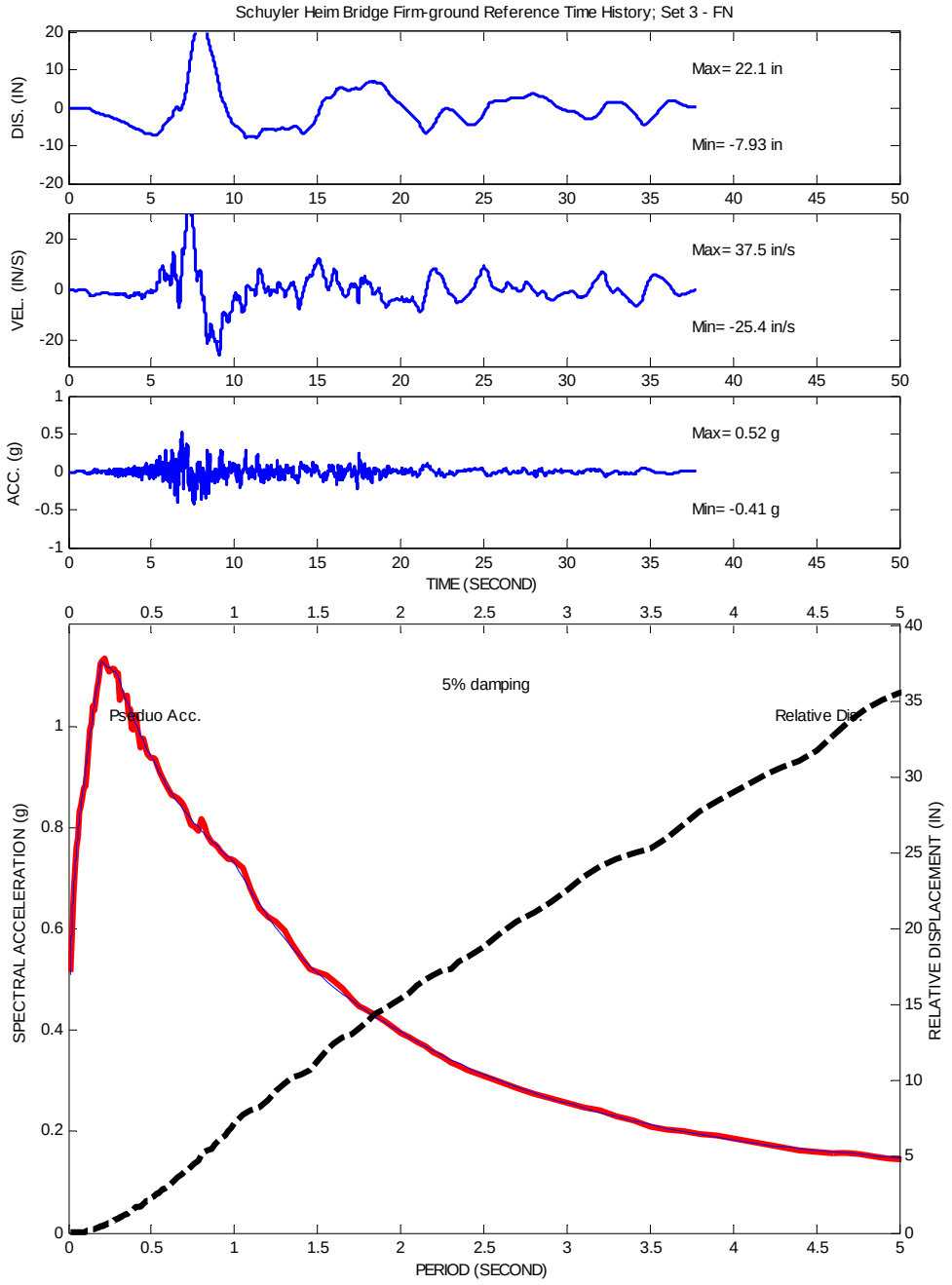

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

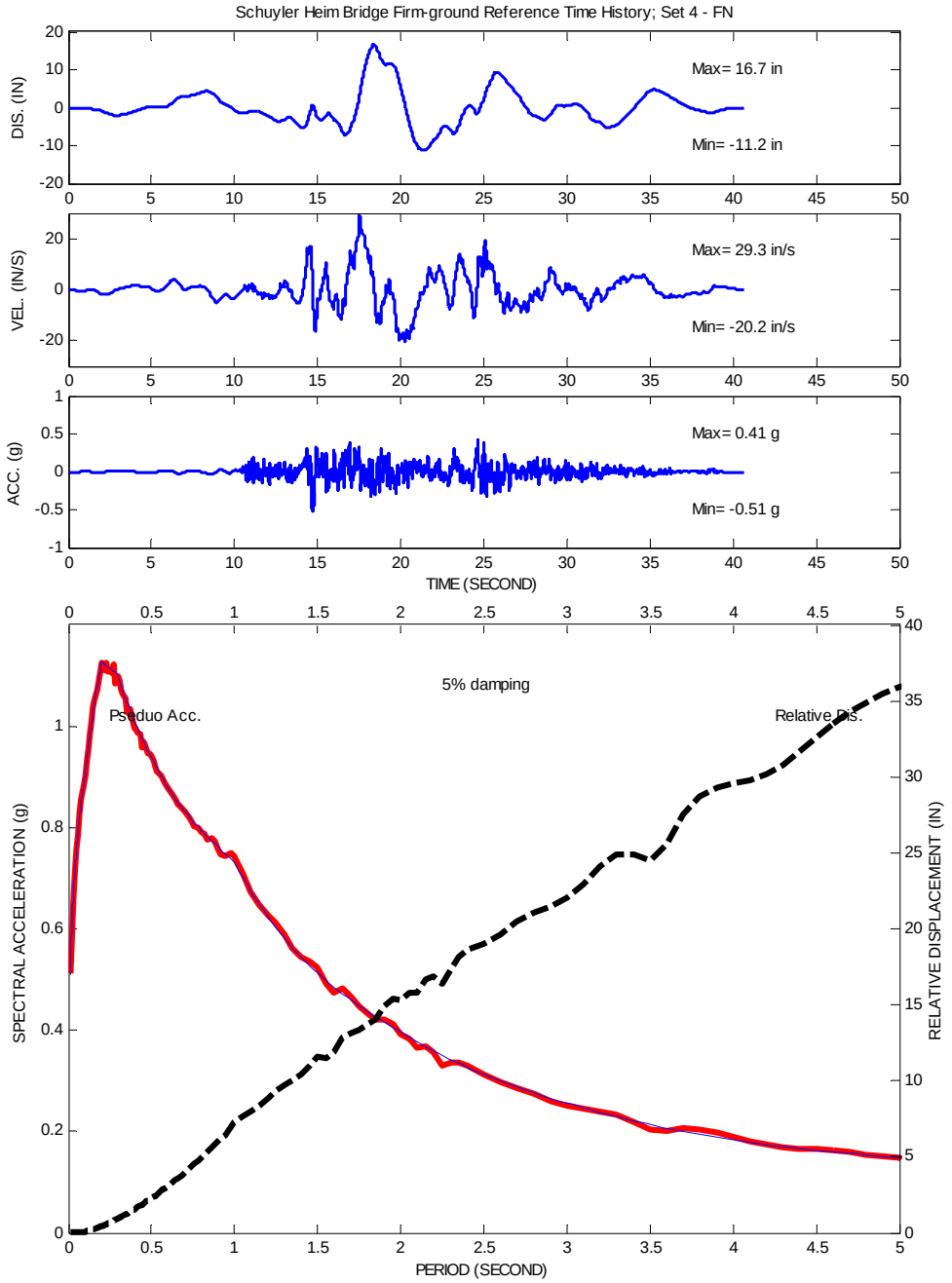

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

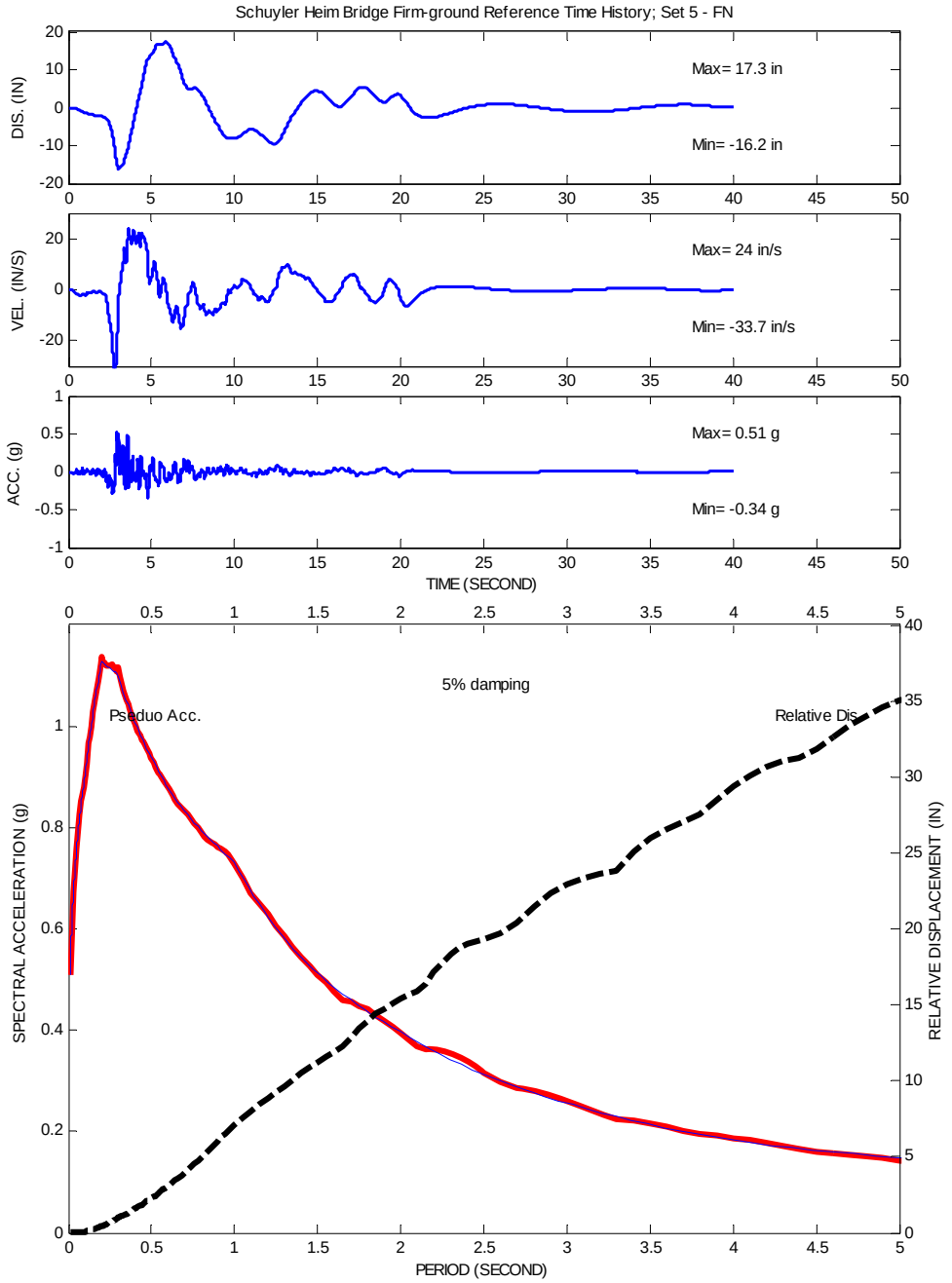

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

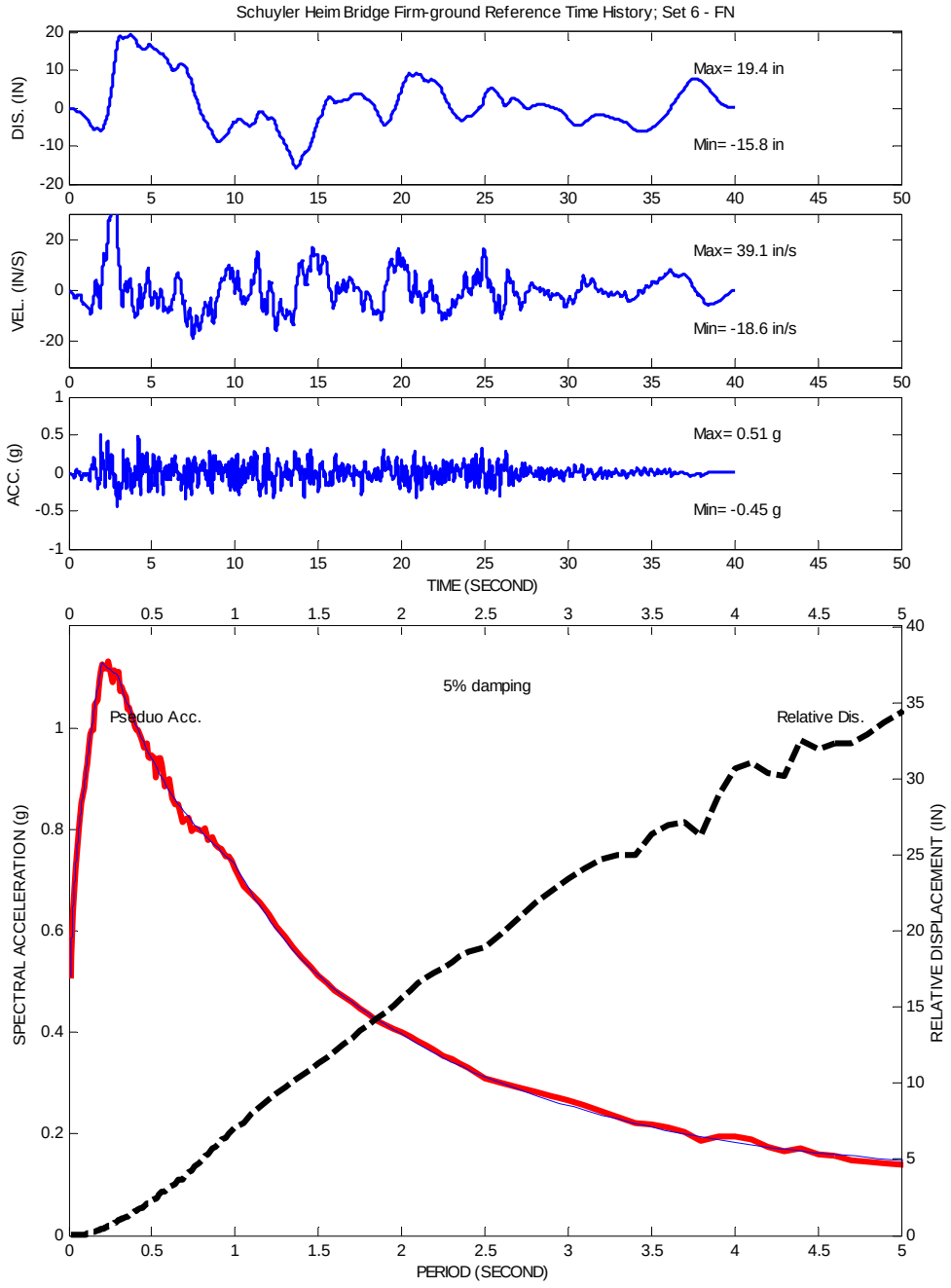

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

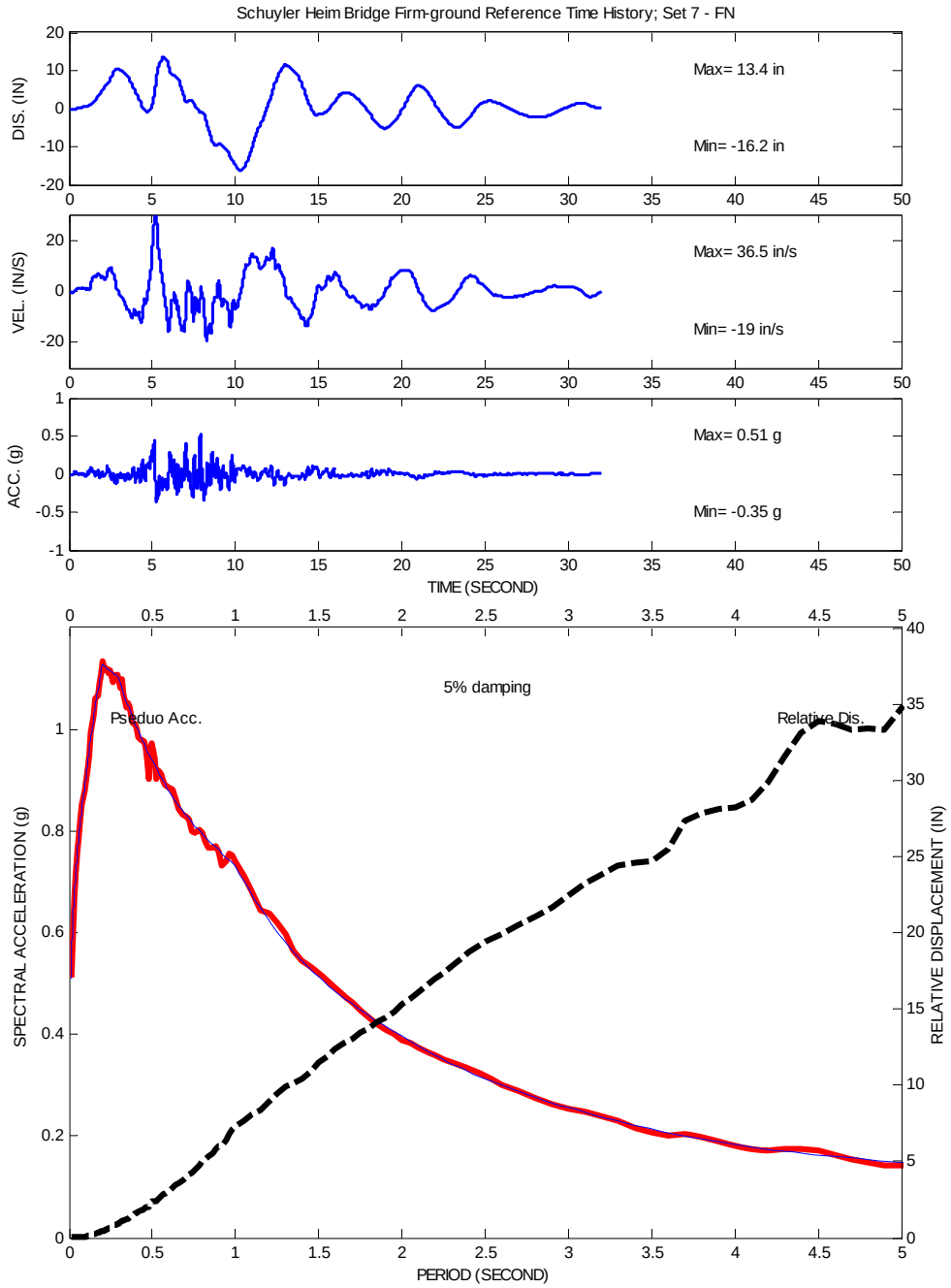

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

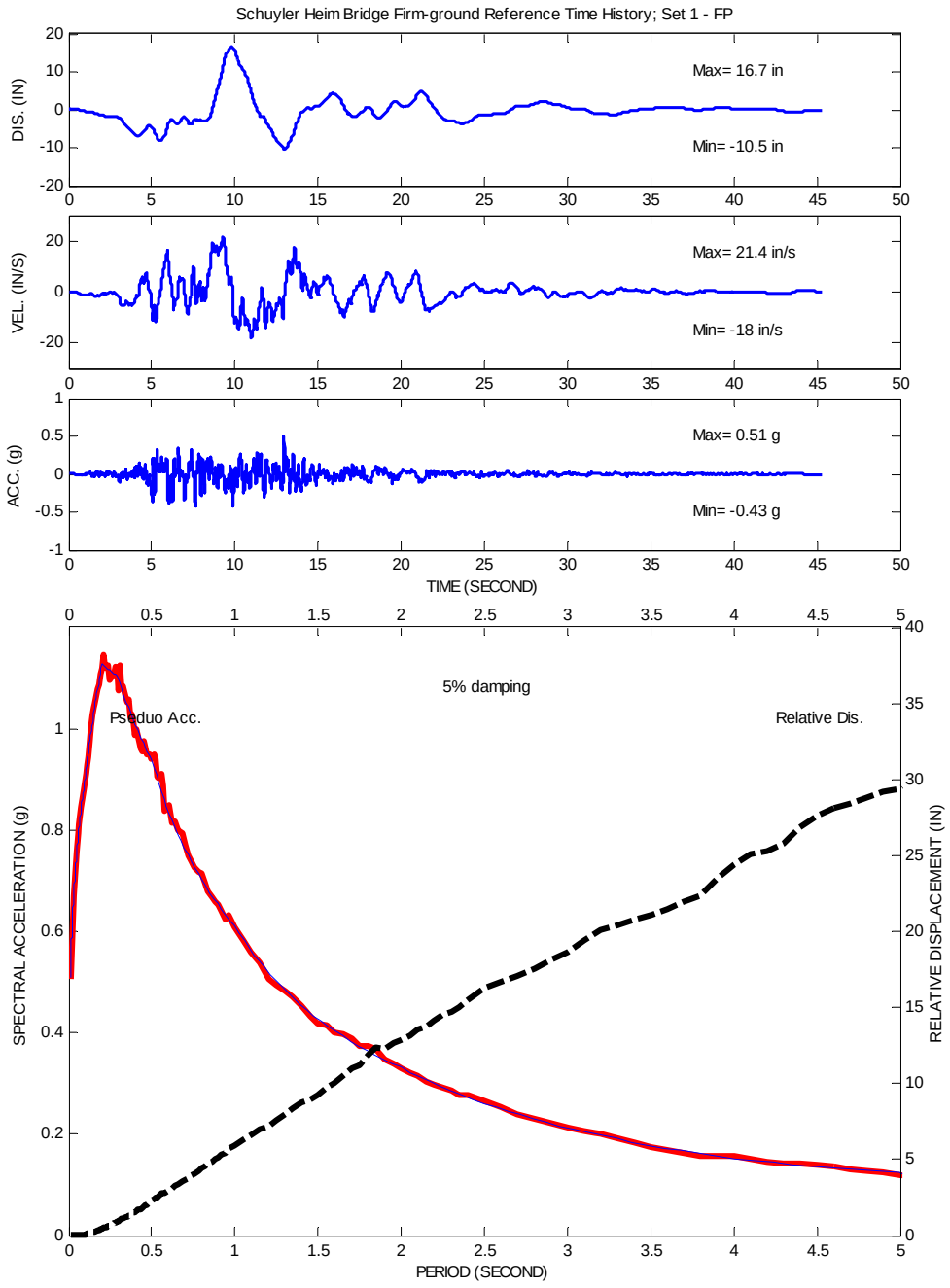

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

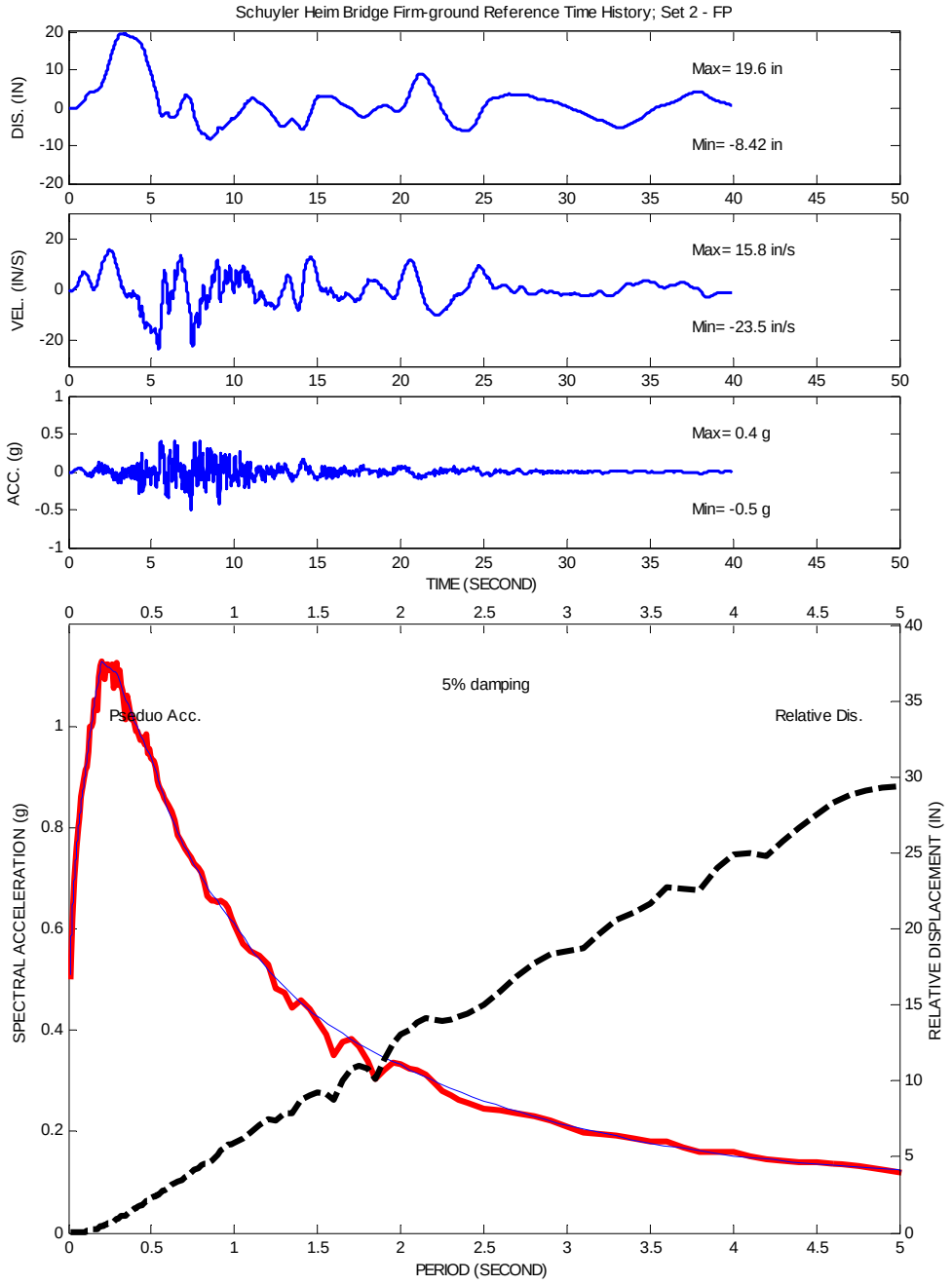

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

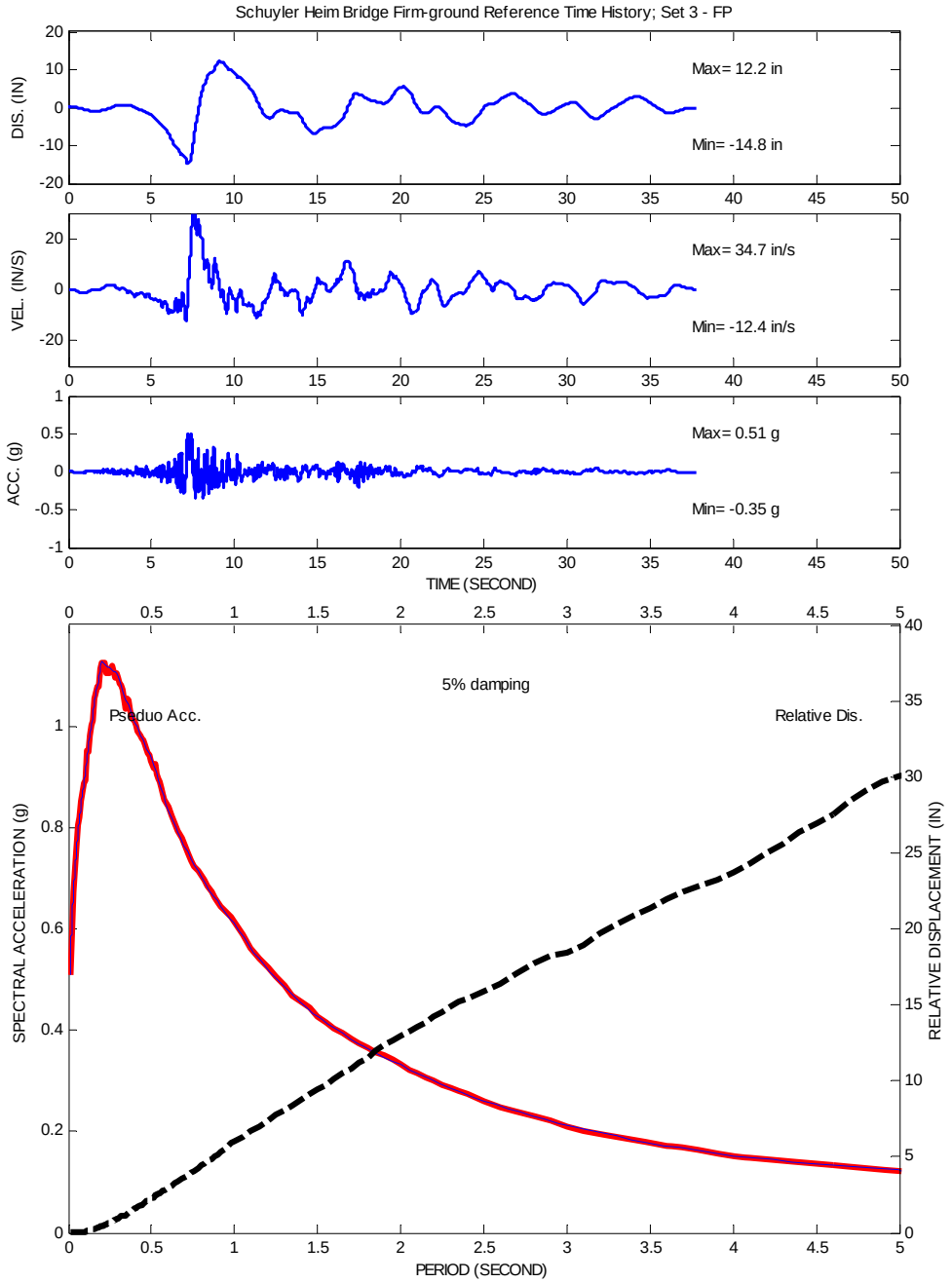

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

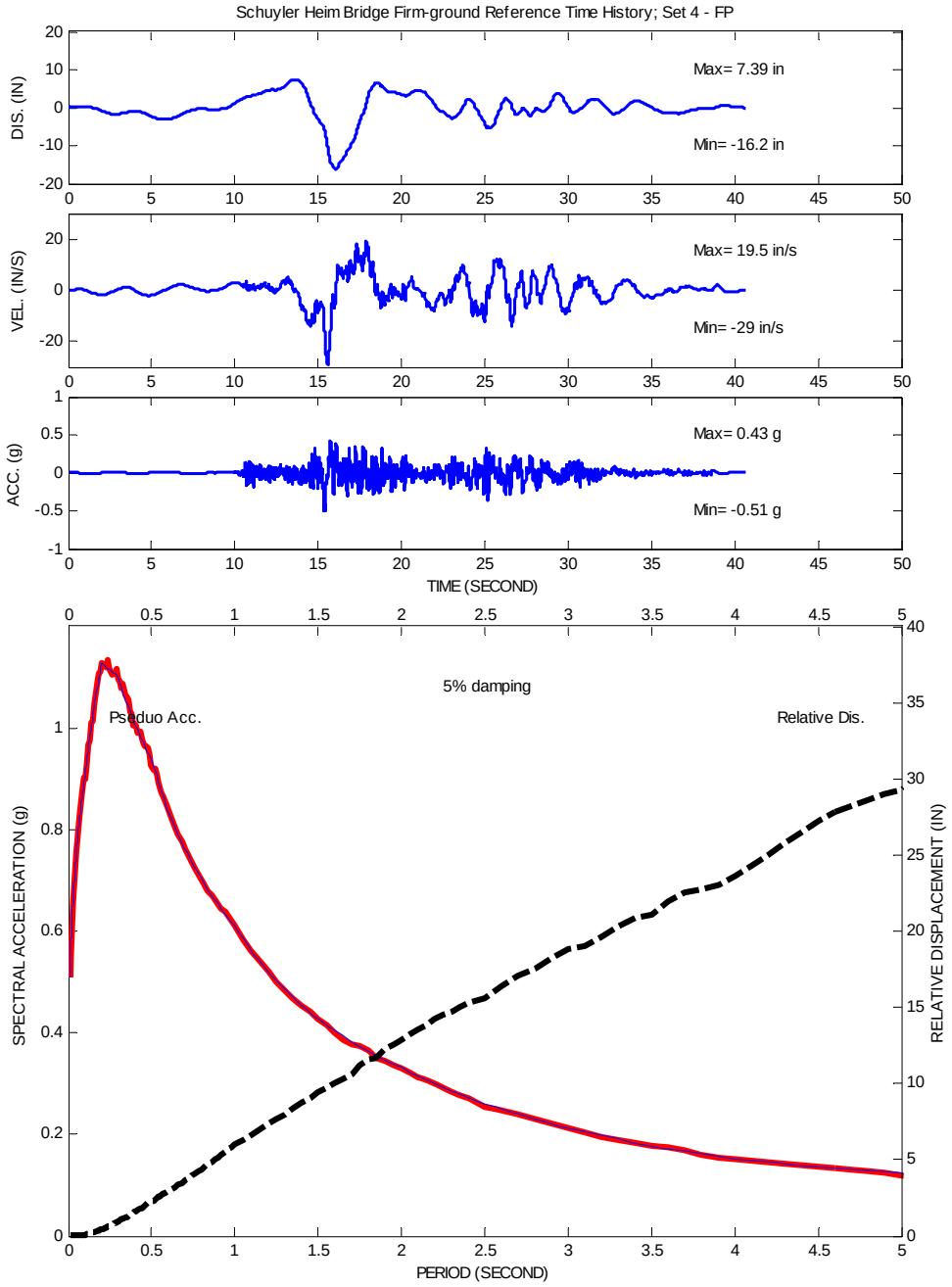

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

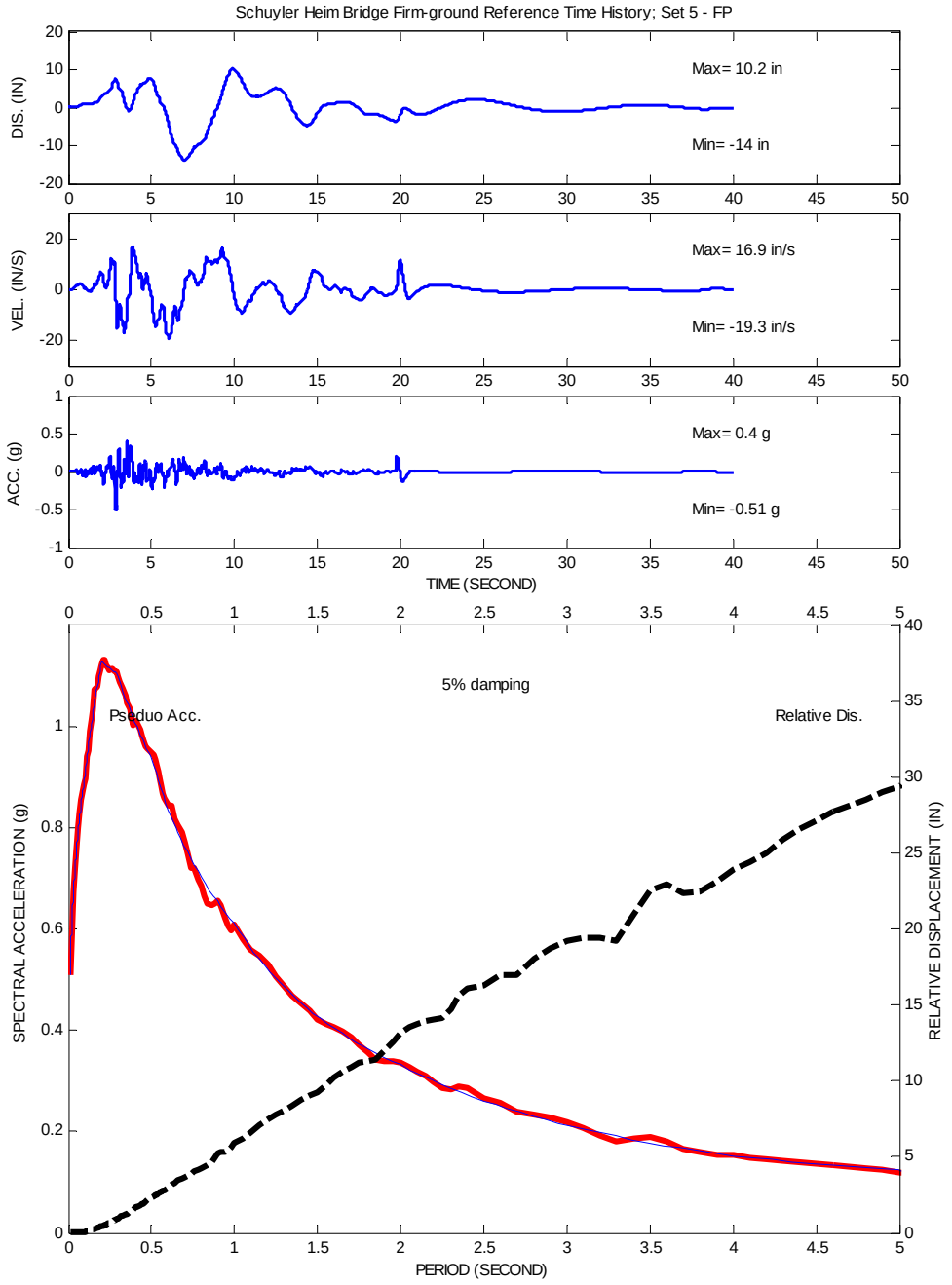

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

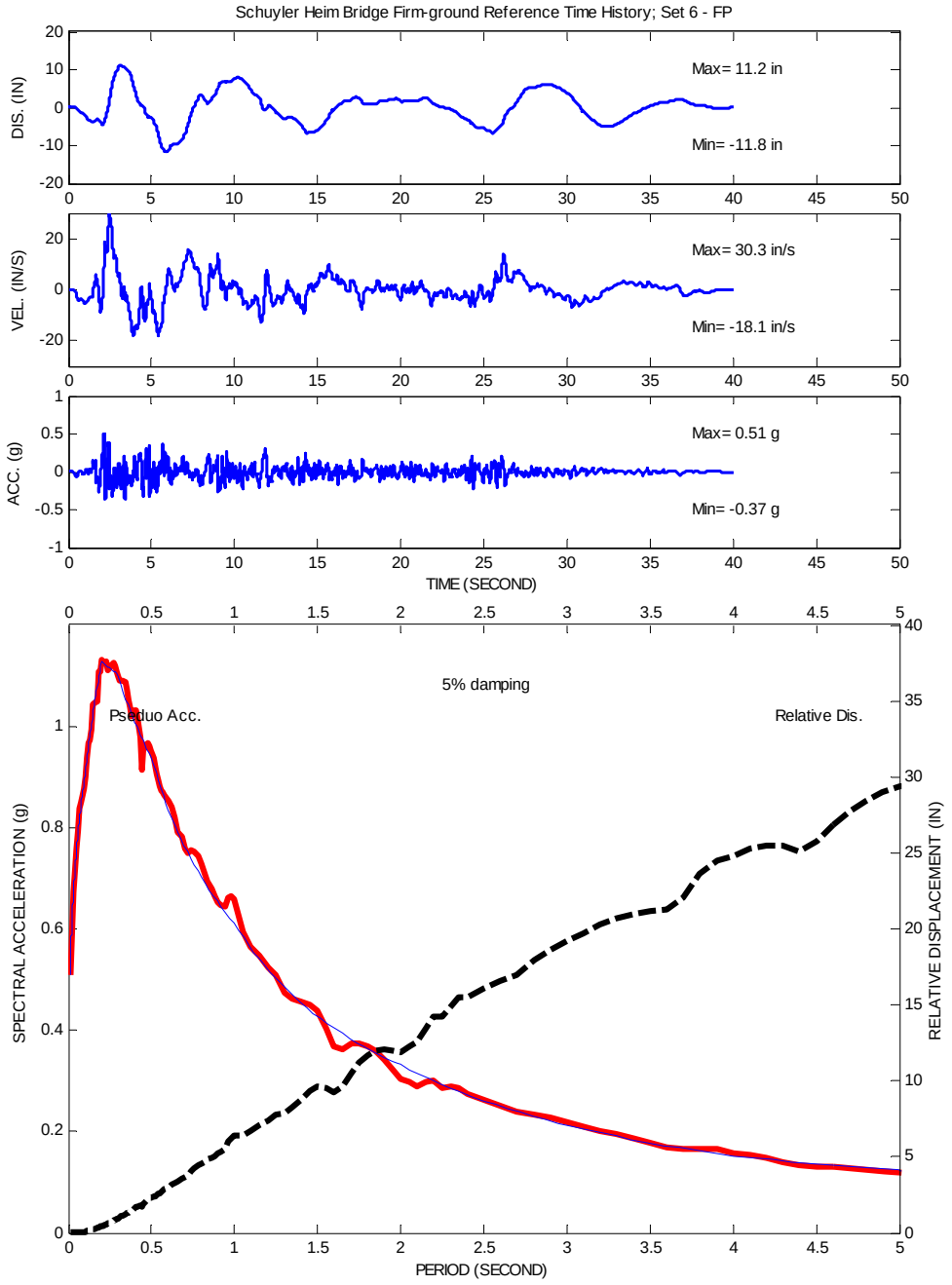

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

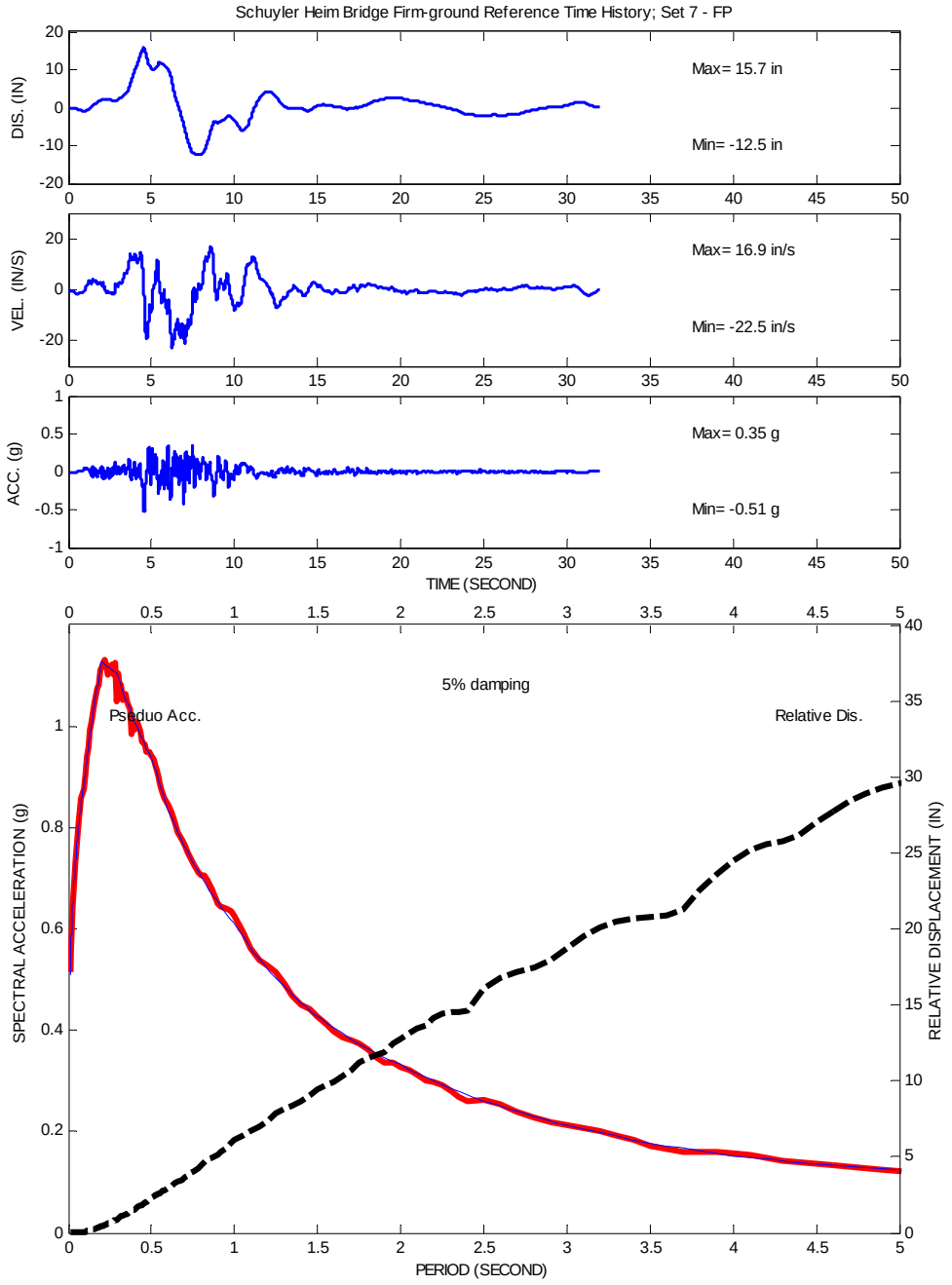

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX G. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Retaining Wall C1, Wall No. 53E0148***
Mechanically Stabilized Earth (MSE) Wall
Los Angeles County, California (7-LA-47, PM 3.74, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining wall. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining wall.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix F. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,

EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
ERIC BROWN
NO. GE 2806
EXP. 6-30-2010
GEOTECHNICAL
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
KANDIAH ARULMOLI
NO. 2090
EXP. 12-31-2011
GEOTECHNICAL
STATE OF CALIFORNIA

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL C1, WALL NO. 53E0148
MECHANICALLY STABILIZED EARTH (MSE) WALL
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 3.72, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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1.0	**INTRODUCTION**	**1**
1.1	Purpose Scope of Work	1
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APPENDICES

Appendix A. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)
Appendix B. EarthSpectives SPT Hammer Energy Measurement Report
Appendix C. GeoVision Geophysical Investigation Report
Appendix D. Laboratory Soil Test Results
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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall C1 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Retaining Wall C1 located on the east side of the approach embankment for the New Dock Street On-Ramp (Figure 2).

The proposed wall, located on the east side of the New Dock Street On-Ramp approach embankment between about Sta. 212+42 and Sta. 213+73 ("C" Line), will be approximately 131 ft long with retained heights varying from about 2 ft at the southern end of the wall to about 16 ft at the northern end of the wall where it terminates at Abutment 6 of the New Dock Street On-Ramp. The wall is proposed to be a mechanically stabilized embankment (MSE) wall.

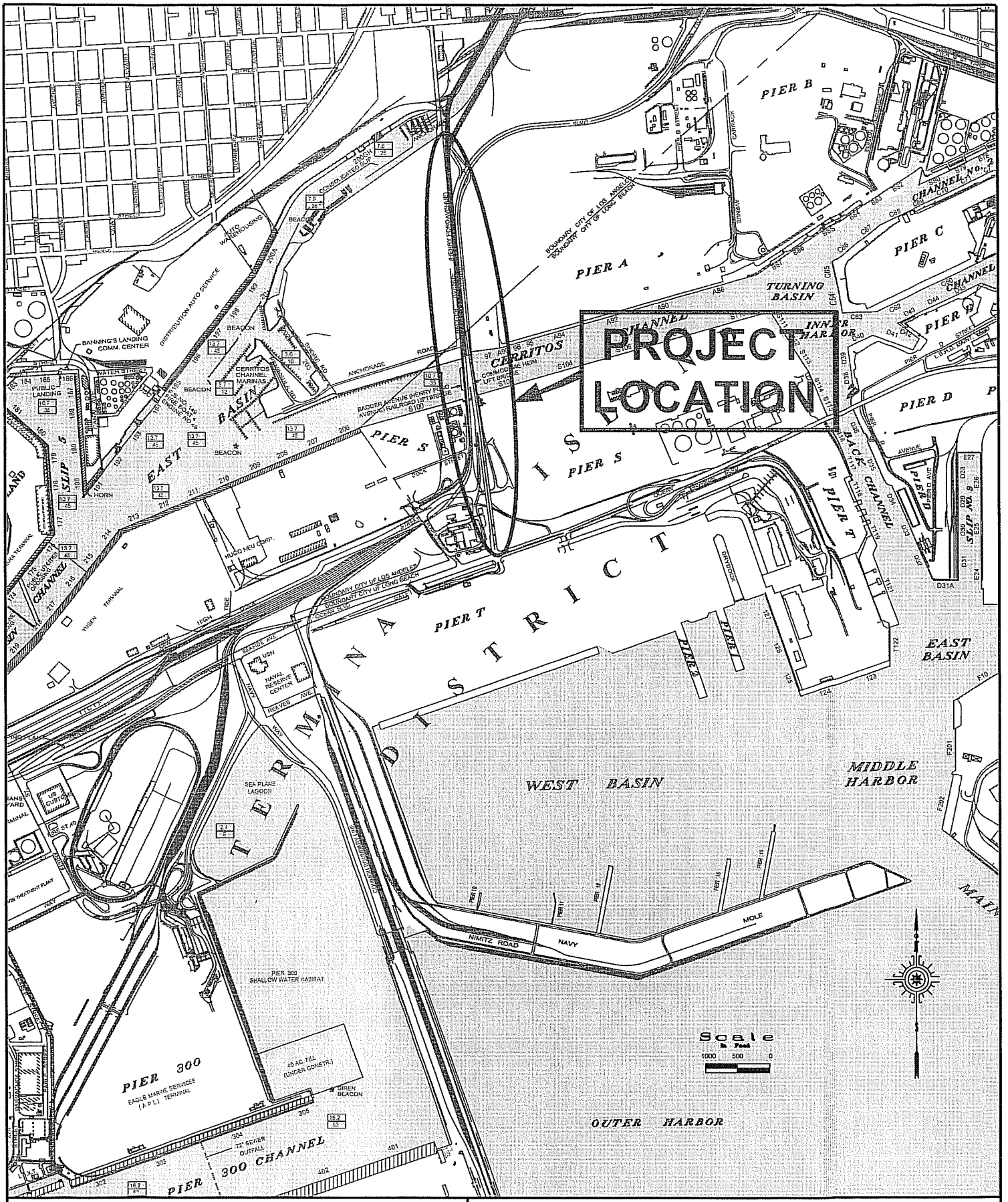
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Retaining Wall C1. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

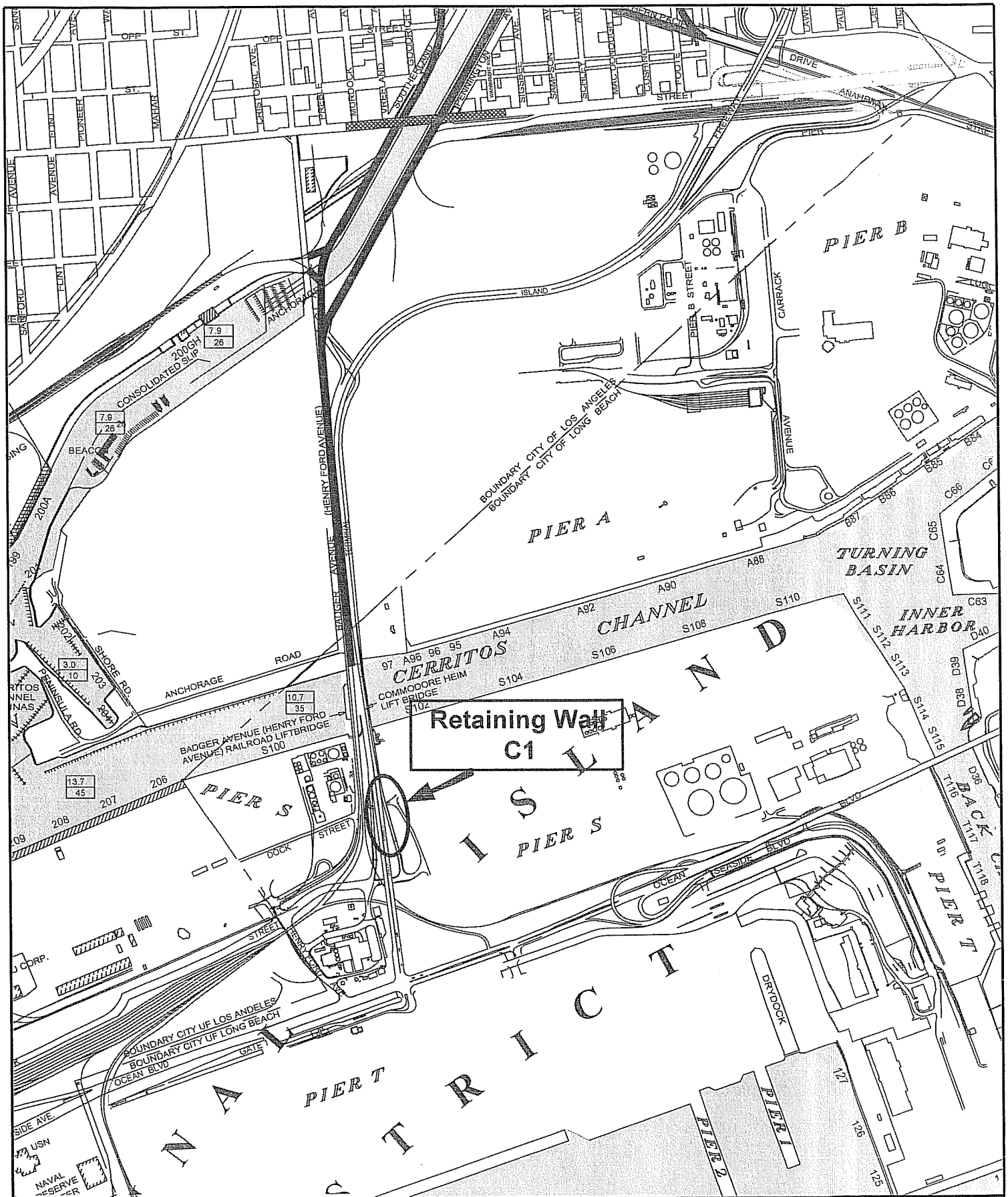
The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-10-10	Project Location Map — Figure 1



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Structure Location Map

Figure 2

Project No. 06-123	Date: 5-10-10

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of Retaining Wall C1 were those shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and borings, three CPTs were performed near the proposed wall site. The CPT soundings penetrated to depths between 100 and 133 ft below existing grade with a deepest penetration to an elevation of -134 ft.

Copies of the as-built LOTB sheets prepared by LKR the seismic retrofit study are provided in Appendix A.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of 22 hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, two rotary wash borings and two CPT soundings were performed in the vicinity of Retaining Wall C1. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed wall. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

All of the borings surrounding the proposed wall were performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp bridge, east of the mainline structure. The deepest boring penetrated down to about elevation -156 ft, approximately 155 ft below ground surface.

The borings were performed by C&L Drilling Co. (C&L), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California

Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the C&L borings. A copy of the ES report is provided in Appendix B.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix C.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-009	"C" Line	212+16.9	61.0 Lt	-0.9	-4.9	-156.3	RW
R-09-011		213+81.5	61.5 Lt	-1.0	-10.0	-151.3	RW
CPT-09-076		212+22.4	60.0 Lt	-0.9	NR	-92.1	CPT
CPT-09-077		213+86.4	61.3 Lt	-0.8	NR	-103.2	CPT

Notes: *1. Top of boring elevations based upon NAVD88.*
2. GSE = Ground Surface Elevation (estimated from topographic plans).
3. GWE = Groundwater Elevation.
4. RW = Rotary Wash, CPT = Cone Penetration Test.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -103.2 ft, approximately 102.4 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in^2 (10 cm^2) and a cylindrical friction sleeve with a surface area of 23.25 in^2 (150 cm^2). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance

during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

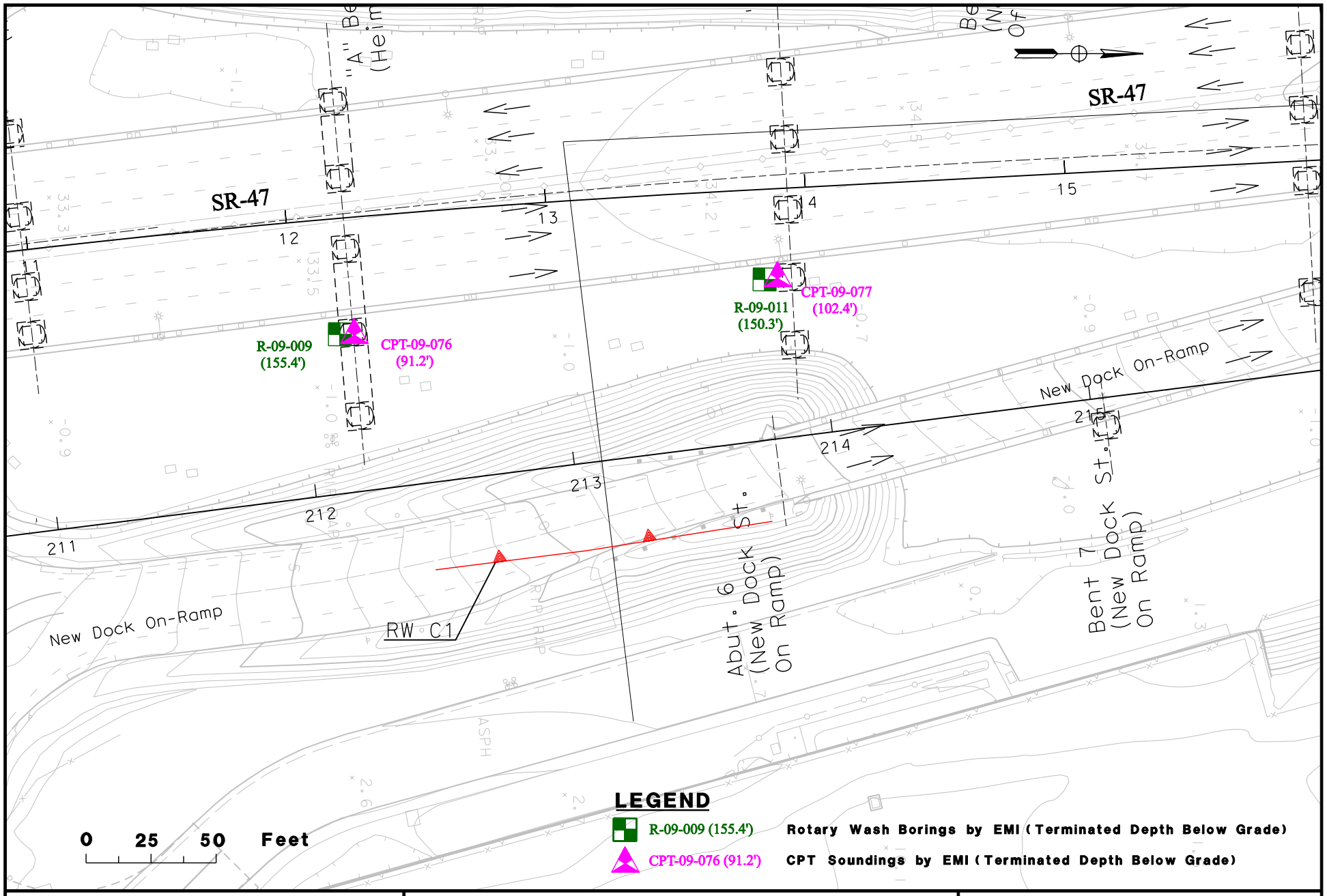
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix D.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Direct Shear	ASTM D 3080	Estimate strength parameters of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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Project No. 06-123

Date: 05-10-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 4 and 5). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (M_W) of about 6.7 (M_S = 6.8, M_L = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (M_W = 6.7, M_S = 6.4, M_L = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about M_W = 6.4 (M_L = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (M_L = 5.9, M_W = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1987; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas

are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

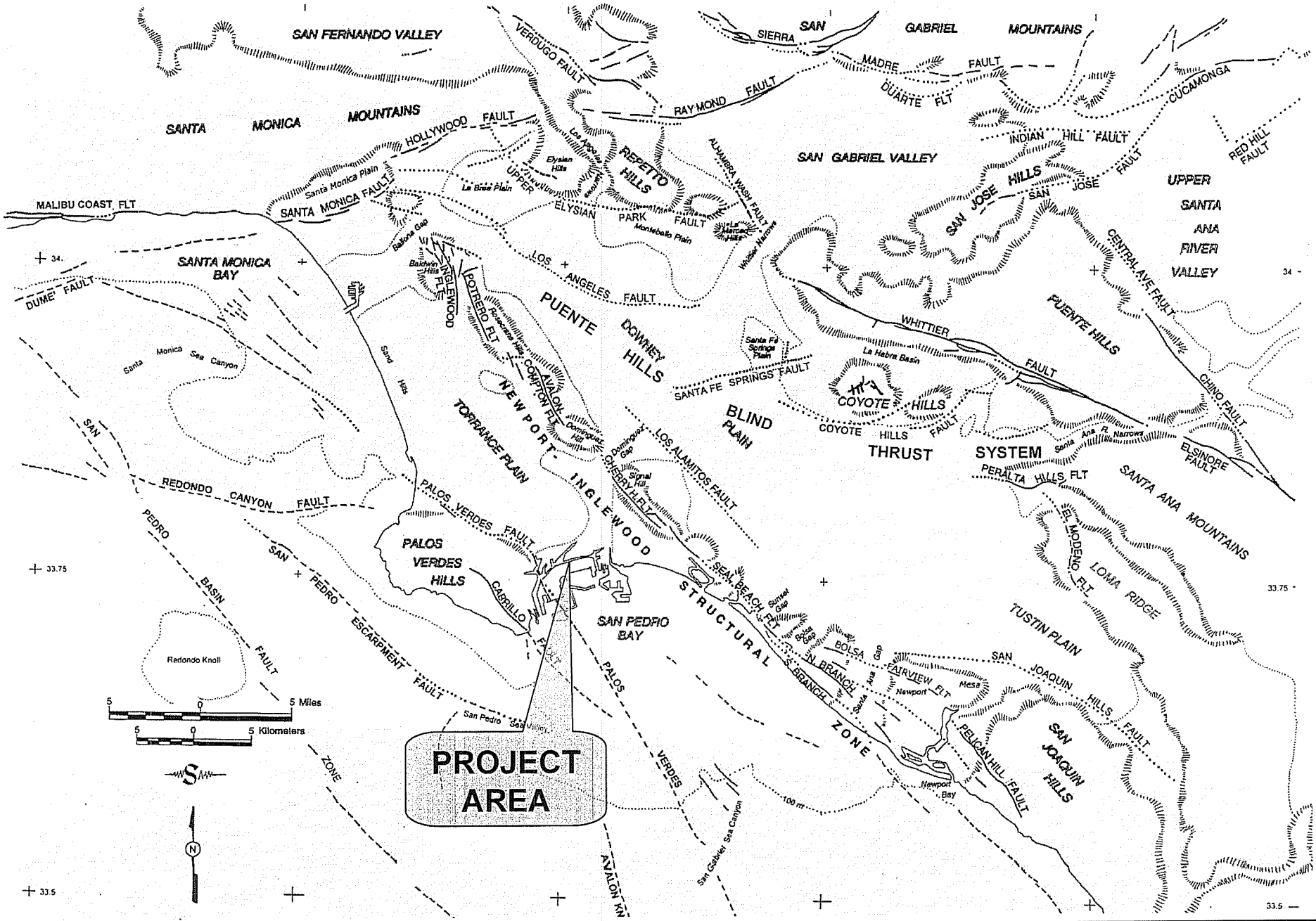
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of $M_w = 7.8$ and 1964 Alaska event of $M_w = 9.2$); and in the southern Pacific (1922 Chile earthquake of $M_w = 8.4$ and the 1960 Chile event of $M_w = 9.5$). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats

and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



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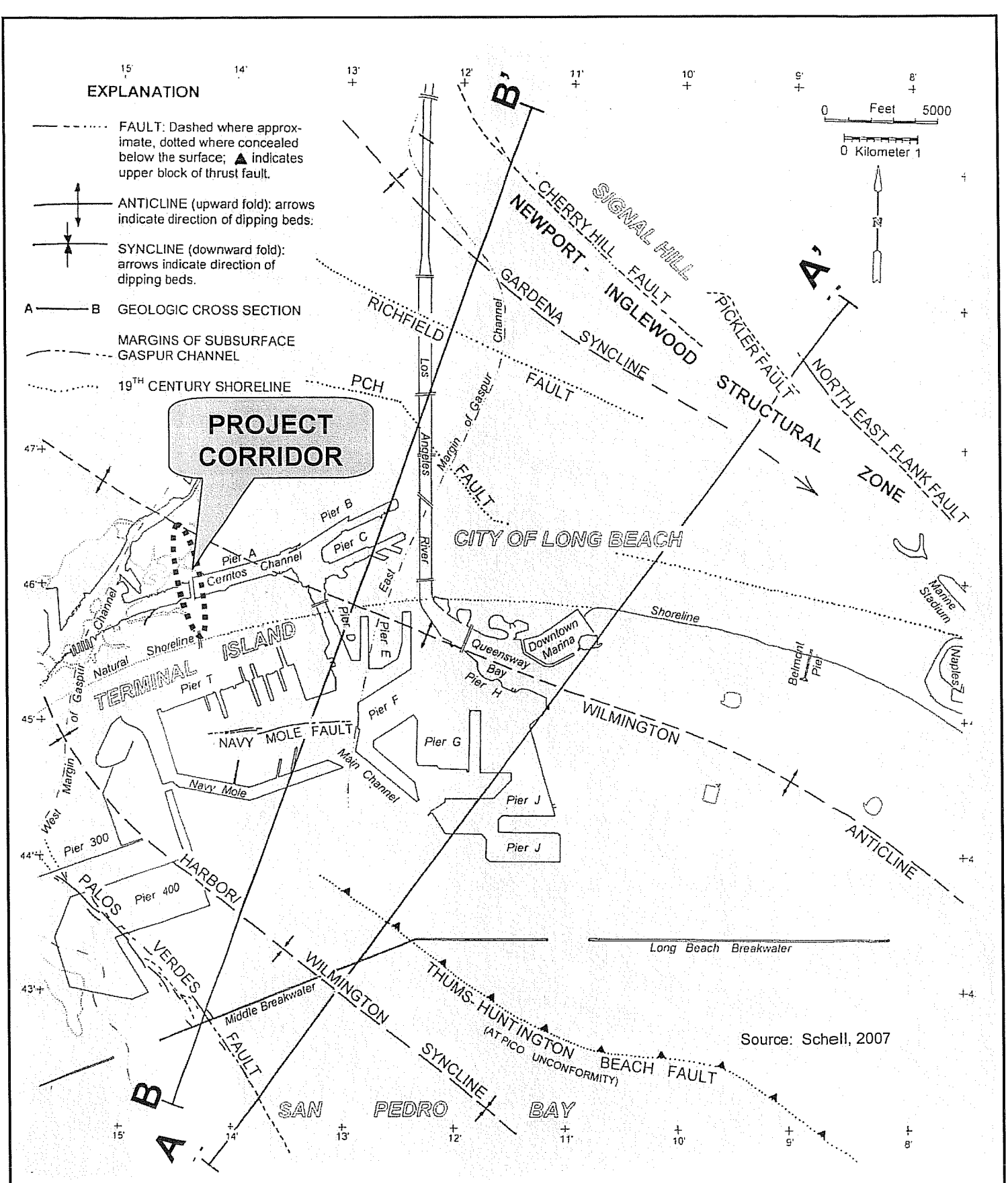
Map of Active Faults and Physiography, LA Basin

Figure 4



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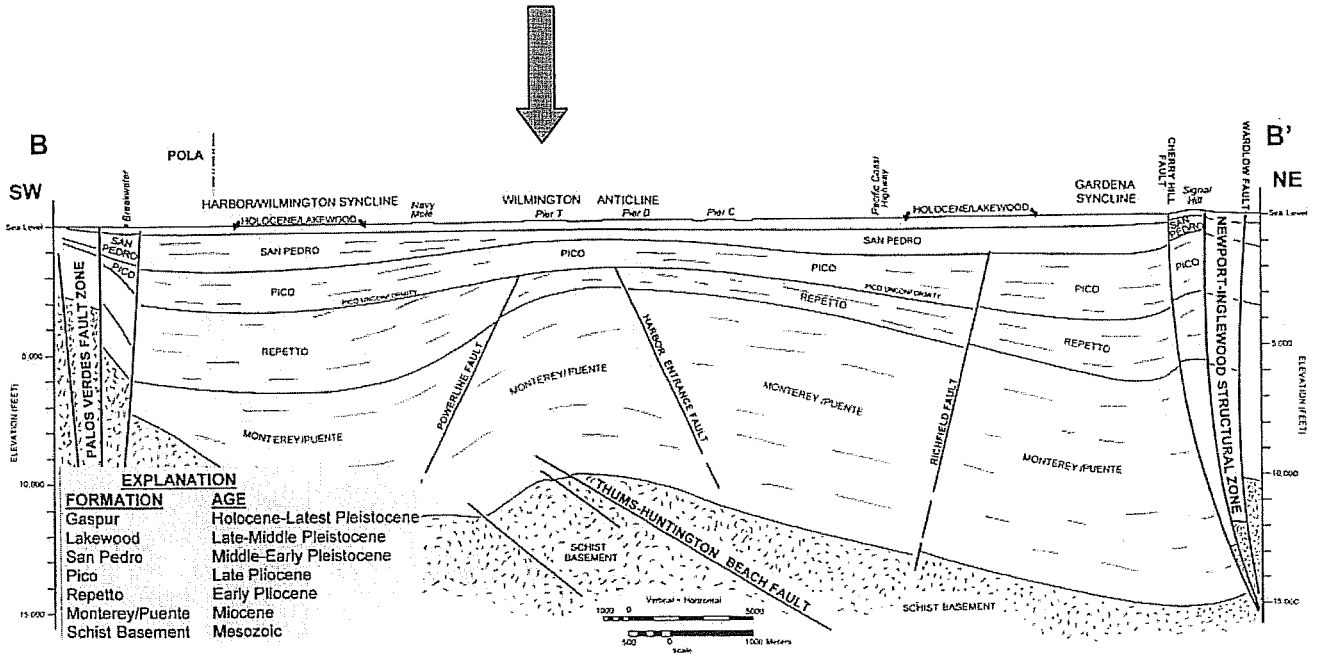
Structural Geology Map, Long Beach Harbor

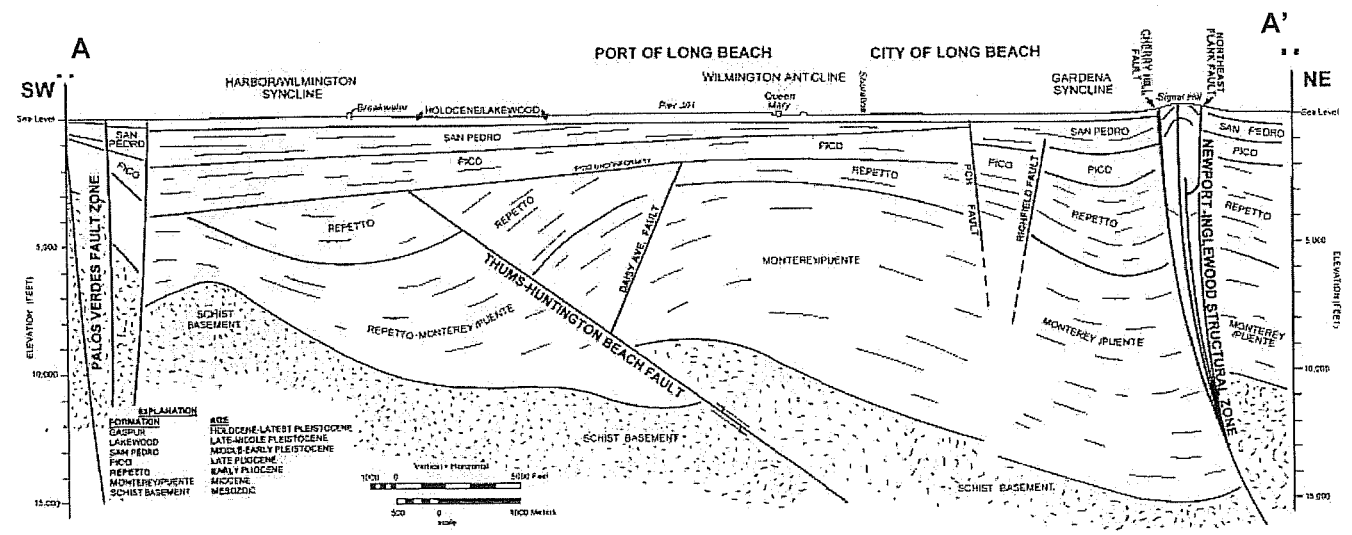
Figure 5

Project No. 06-123 | Date: 5-10-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH



A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

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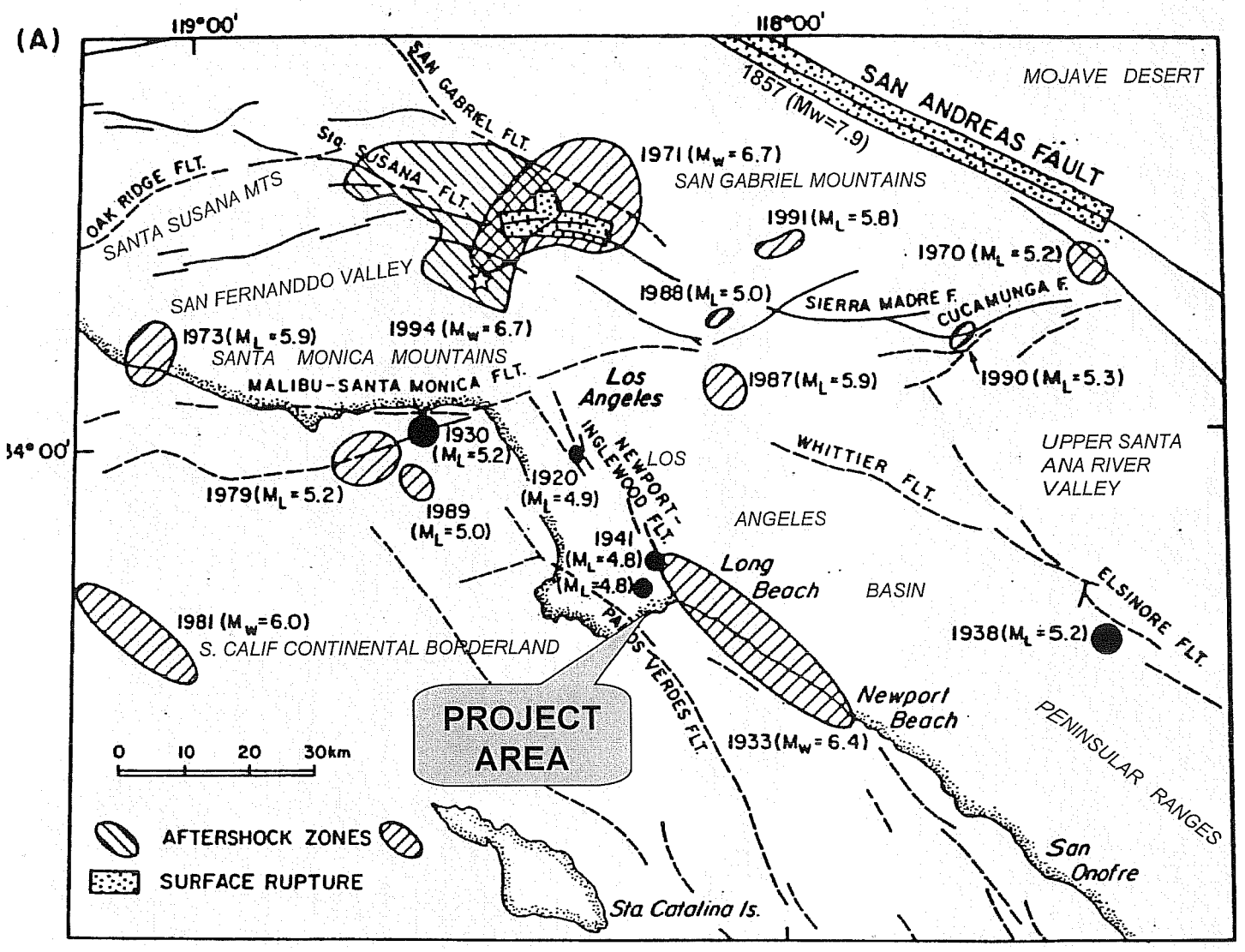
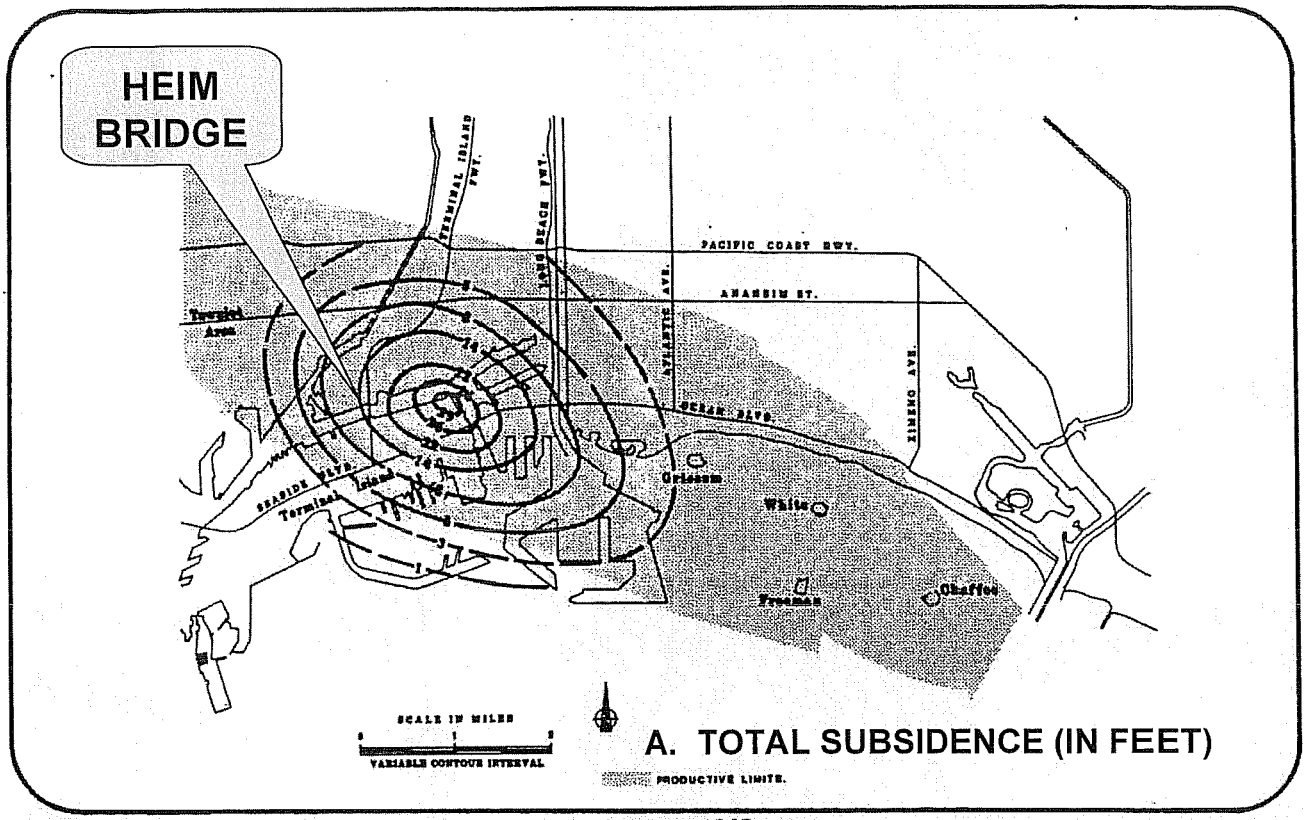
	Geologic Cross-Sections, LA Harbor	
Project No. 06-123	Date: 5-10-10	Figure 6

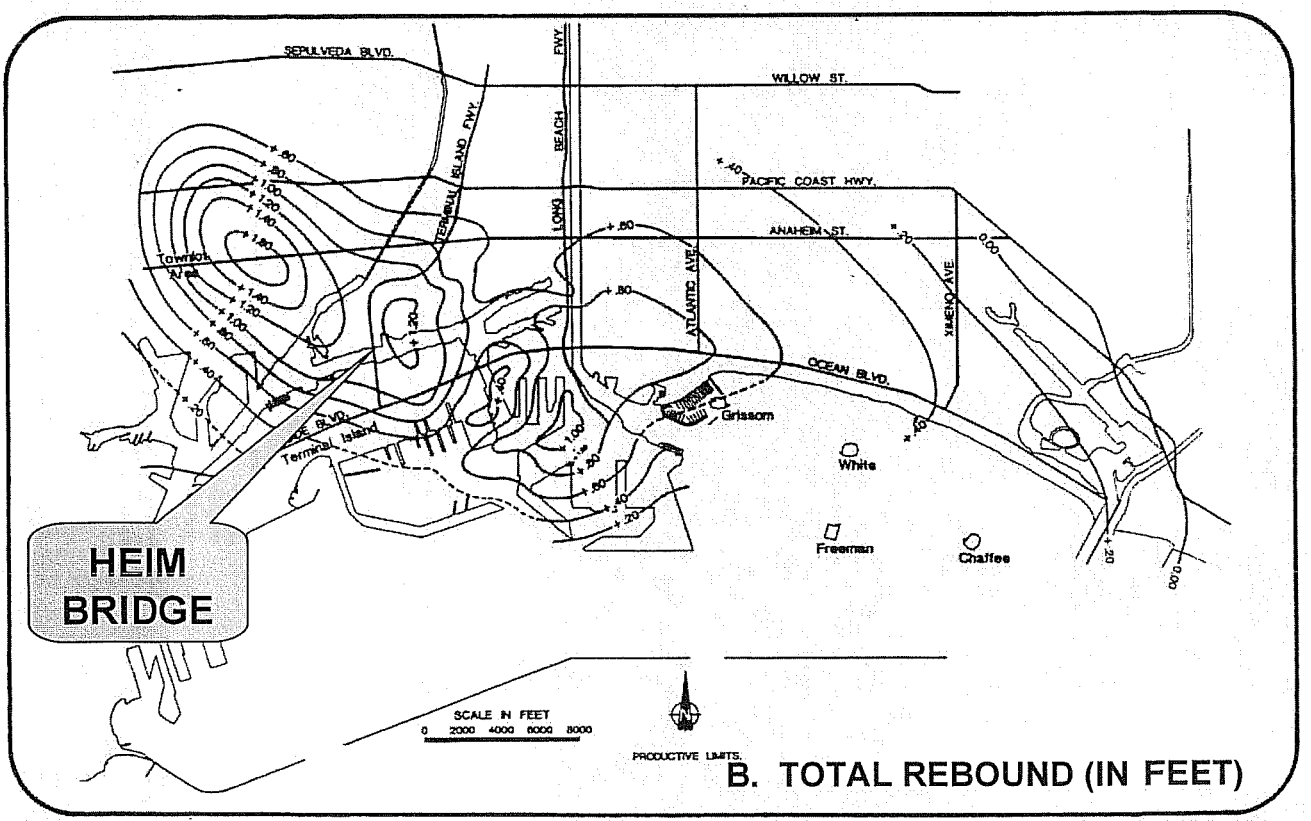


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-10-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

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Project No. 06-123	Date: 5-10-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -155.9 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject wall site, natural grade lies at an elevation of about zero, with the approach embankment for the existing New Dock Street On-Ramp consisting of import fill extending to a maximum elevation of about +15 ft. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -25 ft. The near surface deposits are underlain by a thick strata of inter-layered soft to stiff silt, sandy silt, clay, and loose silty sand down to about elevation -75 ft. Below elevation -75 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

Groundwater was not recorded in any of the CPT soundings performed in 1996 for the Geotechnical Investigation by LKR (LKR, 1998). During the EMI investigation in 2009, groundwater was recorded in both of the borings performed near the proposed wall between elevation -5.0 ft and -10.0 feet. The elevation that groundwater was encountered in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

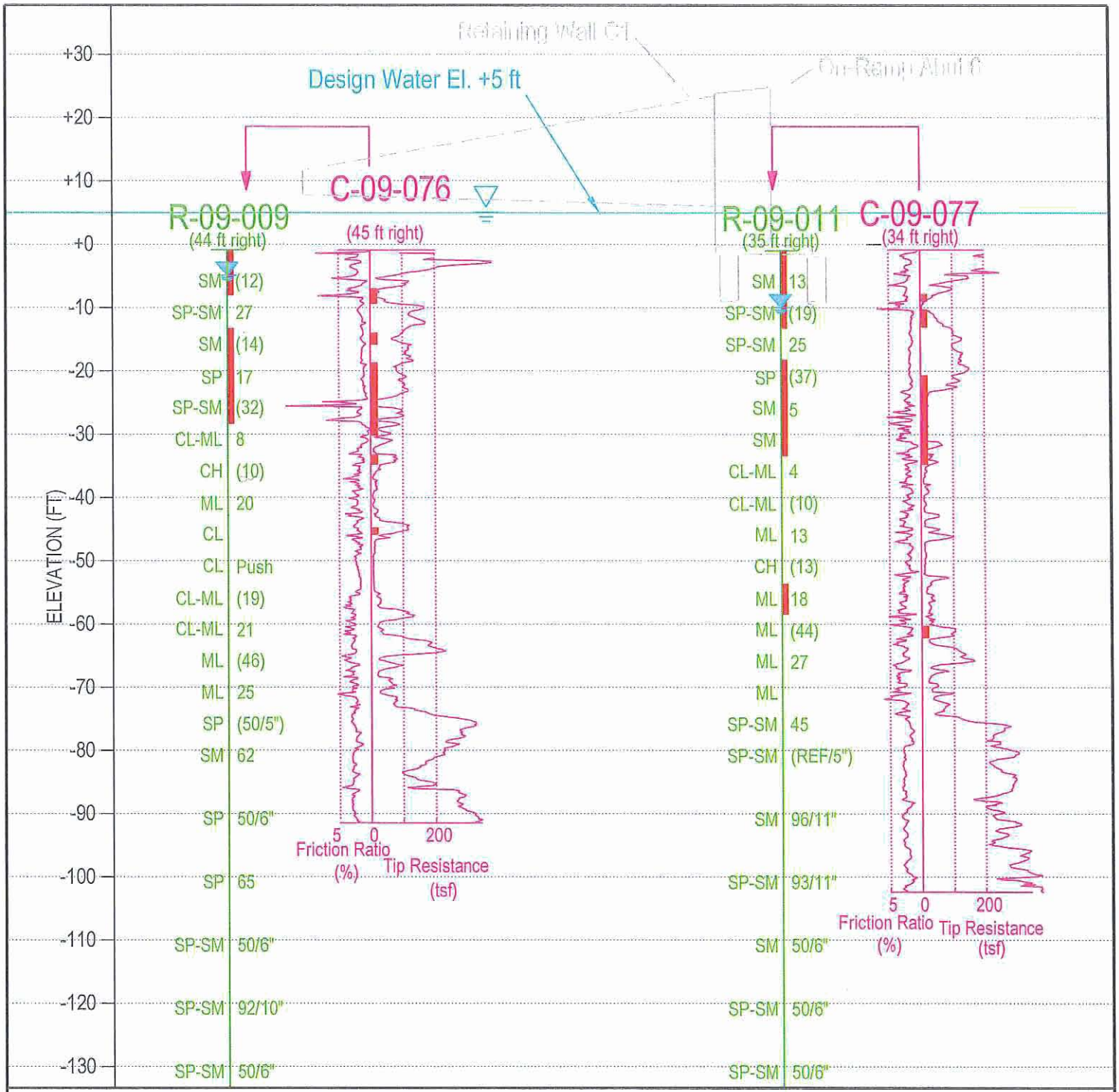
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

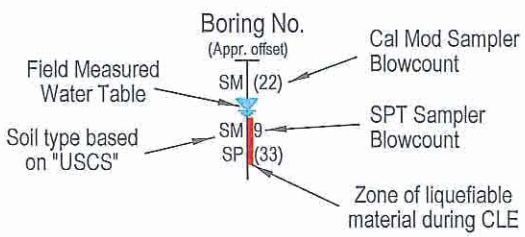
Based on information collected from borings R-09-009, R-09-011and CPT soundings CPT-09-076 and CPT-09-077 an idealized soil profile for foundation analysis and design was developed along the proposed wall alignment. The subsurface profile beneath the propose structure is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+23.0 to +0.0	Silty Sand (assumed embankment fill)	120	200	32
+0.0 to -11.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-11.0 to -20.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	32
-20.0 to -25.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-25.0 to -47.0	Sandy Silt / Silty Clay / Lean Clay	120	1,000	0
-47.0 to -62.0	Clayey Silt / Clay with Silt / Clay with Sand	120	2,000	0
-62.0 to -75.0	Clayey Silt / Silt with Sand / Silt with Clay	120	1,500	0
-75.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Project No. 06-123 | Date: 5-10-10 | Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix E.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -75 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-009	-1 to -8	1.4	3.7
	-13 to -28	2.3	
R-09-011	-1 to -13	2.0	6.5
	-18 to -33	3.7	
	-53 to -58	0.8	
CPT-09-076	-7.0 to -9.3	0.1	1.0
	-14.0 to -15.7	0.1	
	-18.7 to -30.1	0.5	
	-33.2 to -34.7	0.2	
	-44.8 to -45.8	0.1	
CPT-09-077	-7.9 to -8.9	0.1	3.2
	-10.3 to -13.0	0.1	
	-20.7 to -34.7	2.9	
	-60.3 to -62.1	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Two soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to be 7.4 and 7.5, the minimum resistivities were 200 and 2,200 ohm-cm, soluble chloride contents were 152 and 568 parts per million (ppm) and soluble sulfate contents were 116 and 514 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Mechanically Stabilized Earth Wall Recommendations

As discussed in Section 1.2, the maximum design height of the MSE is about 16 ft. Due to the presence of compressible soil, construction of the proposed New Dock Street On-Ramp embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall does not need to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 16 ft and base width of 12 ft near the northern end of the wall at Sta. 213+70 ("C" Line), the bearing pressure induced on the underlying foundation soil is 2.7 ksf. Using a base width of 12 ft and a remedial excavation of 1 ft (see Section 5.4.8), the allowable bearing capacity of the sand directly beneath the MSE wall is greater than 2.7 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads supporting the wall face may be supported on the in-situ soil. They should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 2 ft below lowest adjacent grade. The allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL C1 STABILITY ANALYSES

Approx. "E" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety		Global Stability Factor of Safety		
			During Surcharge	Permanent	During Surcharge	Static[1]	Psuedo-Static[1]
426+06	16	12	5.7	6.6	1.56	1.75	1.12

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1.

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

Based on cross-sections provided by the roadway designers, the potential settlement beneath the proposed wall was evaluated at "C" Line Stations 212+50, 213+00, and 213+50. The provided cross-sections indicate that the existing embankment will be widened by as much as 5 feet at the crest and the embankment height will be increased by up to about 7 feet. Based on our calculations, settlement of soils underlying the proposed retaining wall is estimated to be about 2 to 3 inches along the length of the wall, with a differential settlement of about 1 inch over a 100 feet long section. The settlement period is estimated to be about 30 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 13 weeks. For a 7-ft embankment surcharge, the settlement period is reduced to about 10 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

Along the proposed wall alignment, the base of the MSE structure will be founded on the existing approach embankment fill. EMI recommends remedial grading consisting of a 1 ft overexcavation. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted to a minimum 90 percent relative compaction. The overexcavation should be backfilled using granular, non-expansive soils. The overexcavation should extend at least 1 ft beyond the outer edge of the leveling pad and 1 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Wall Stability

The "global" stability of the western embankment side slope was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "C" Line Sta. 213+60.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and 200 psf cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix E) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in both of the borings performed near the proposed wall between Elevation -5.0 and -10.0 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad is at approximate El. +5 ft. The deepest excavation for the proposed MSE wall is expected to be several feet above the observed groundwater elevations. However, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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BENCHMARKS:

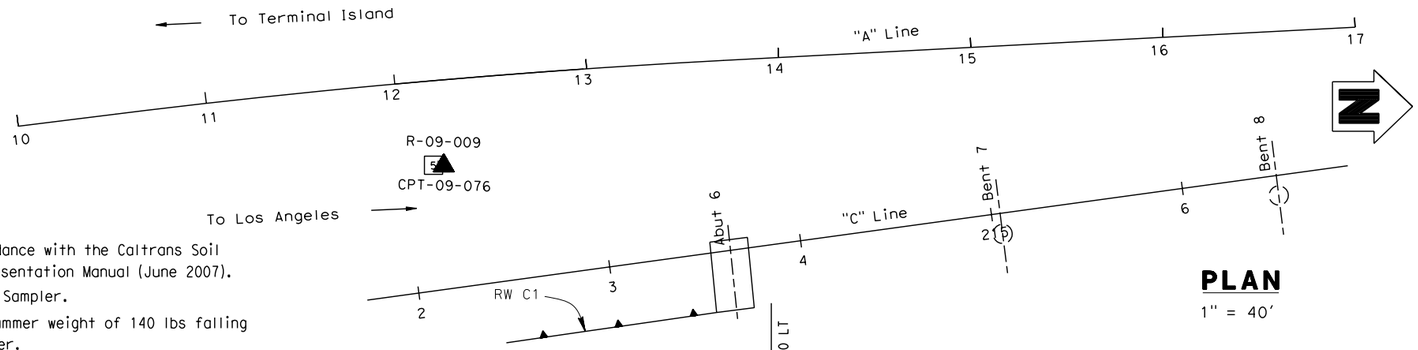
PT-501	PT-15001
SET + FOOTING 23.25'Rt ℄ "A" Line	STK601061 MAG NAIL IN LEAD CUT 113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER ERIC BROWN NO. GE-2806 EXP. 06-30-2010 GEOTECHNICAL STATE OF CALIFORNIA

PLANS APPROVAL DATE

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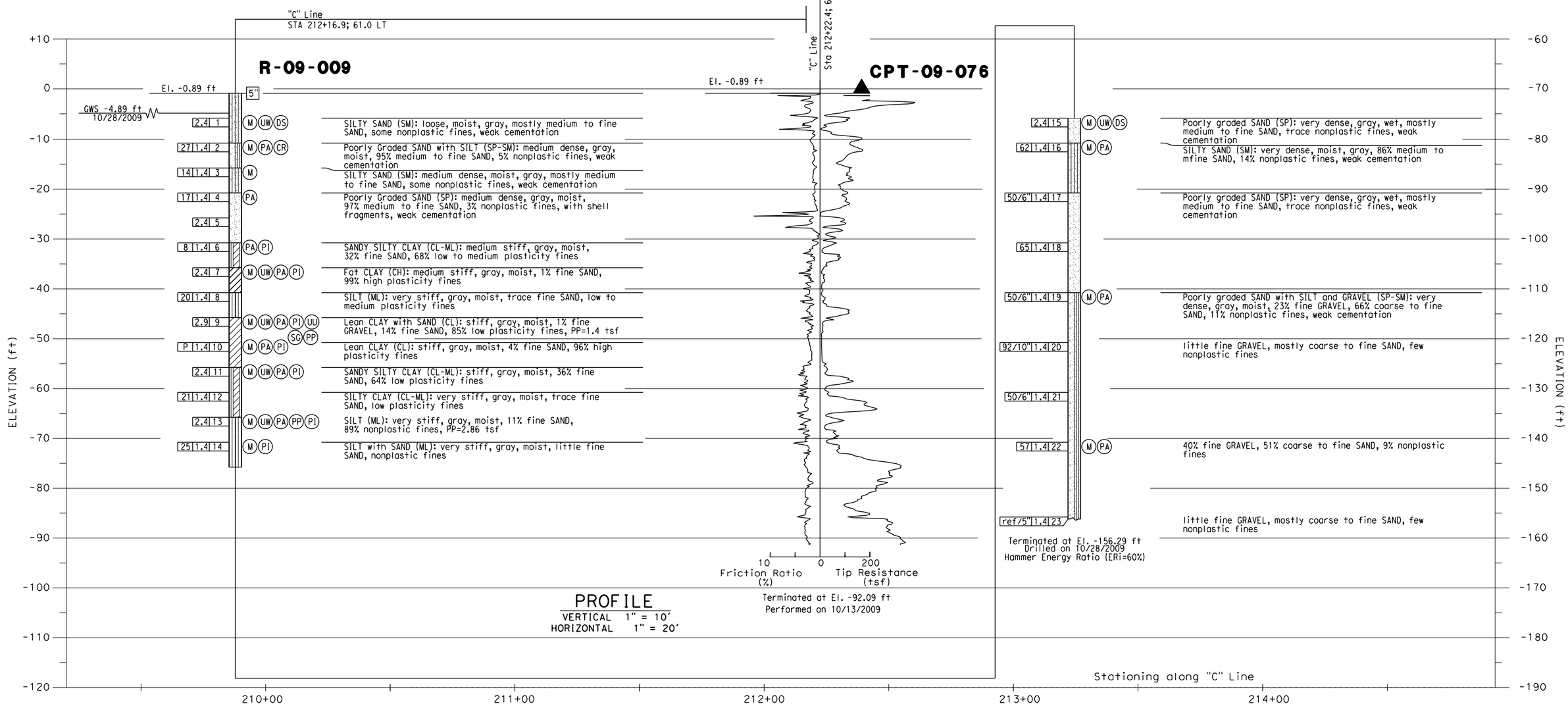
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.72	LOG OF TEST BORINGS NO. 1 OF 4	

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10 04/14/10

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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

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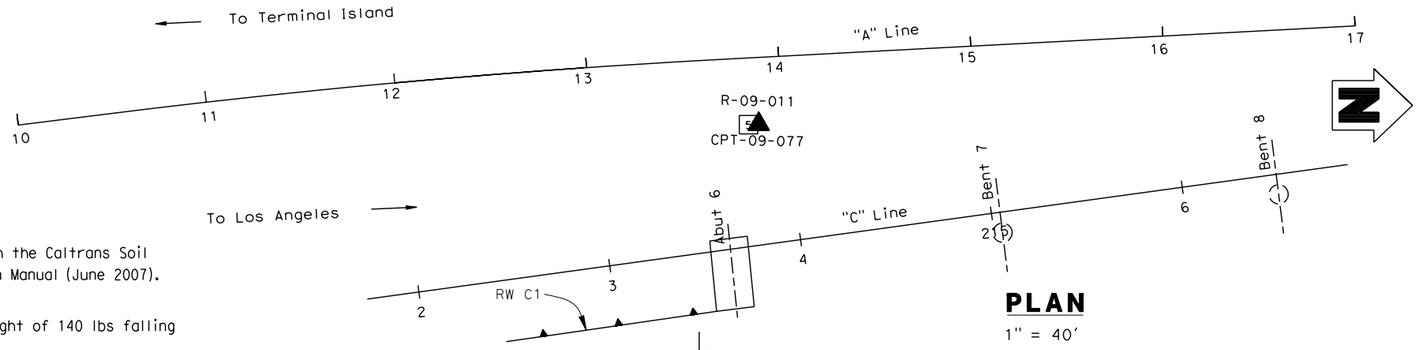
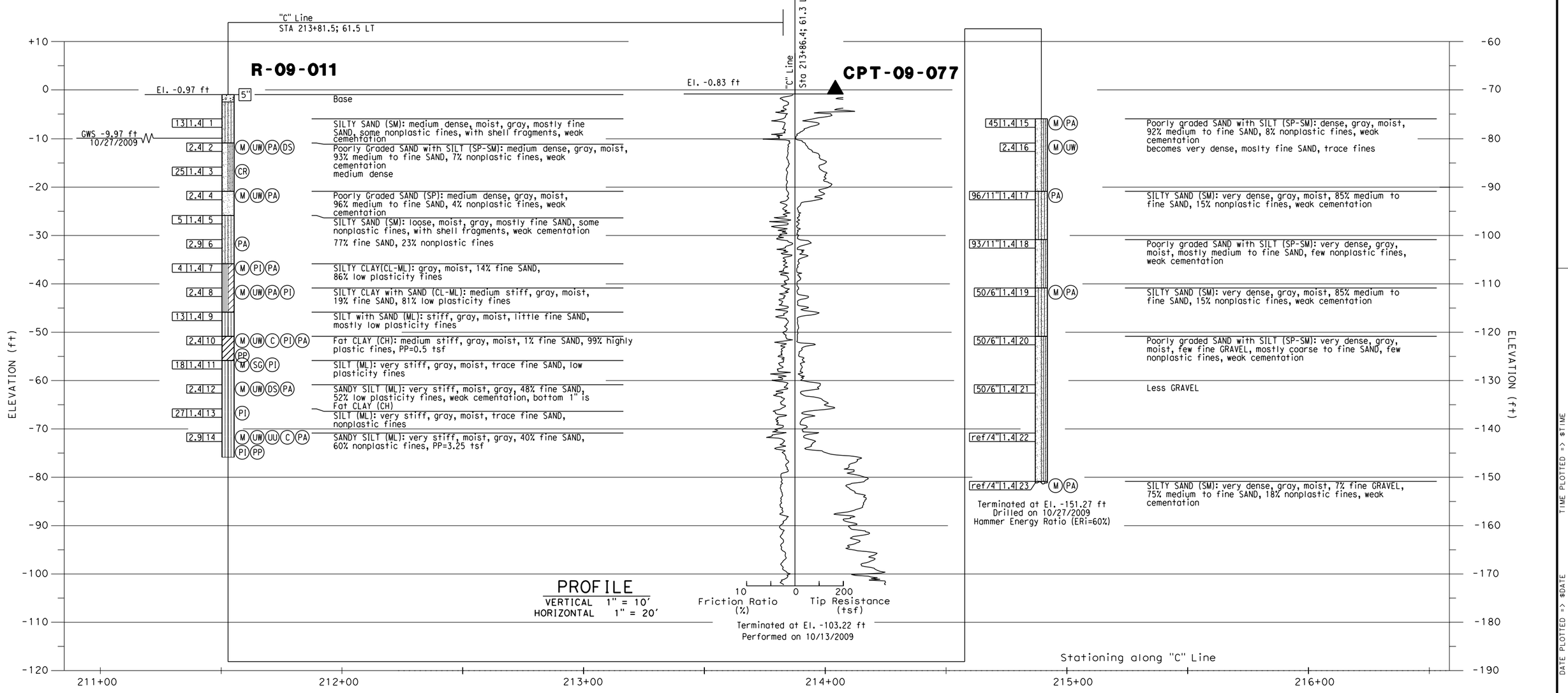


PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.72	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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CU 07
EA 238501

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07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

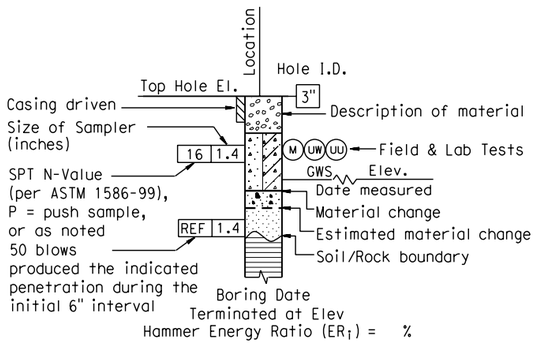
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

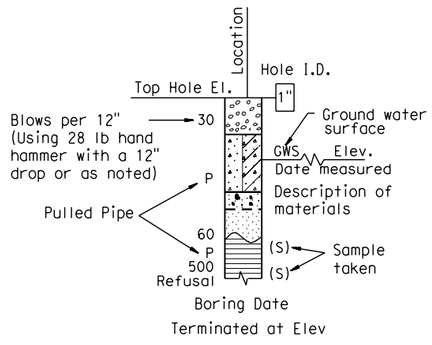
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

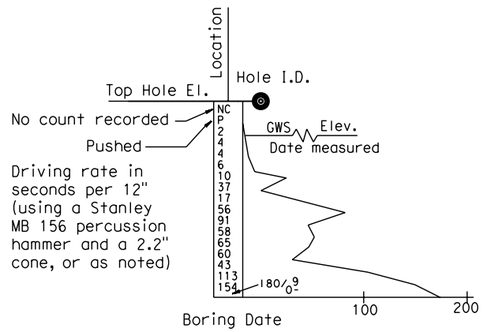
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



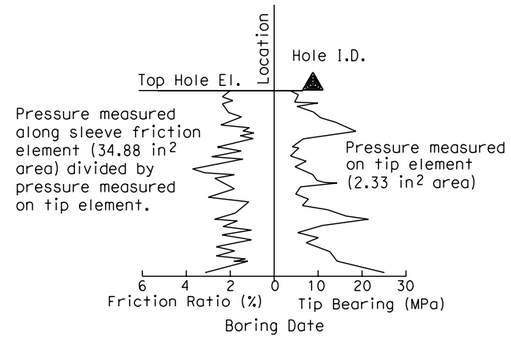
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0148 POST MILE 3.72	MSE RETAINING WALL NO. C1 LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90) Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166); Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0148
POST MILE 3.72

MSE RETAINING WALL NO. C1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10, 04/19/10

SHEET X OF X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

APPENDIX A.

SCHUYLER HEIM BRIDGE SEISMIC RETROFIT LOTB SHEETS

PREPARED BY LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:98-1005

Laboratory Testing

- DS Direct Shear
- SO Soluble Sulfate
- SC Soluble Chloride
- R R- Value
- MD Maximum Dry Density
- RK Minimum Resistivity
- N.S.R.= No sample recovery
- OVM8260 Gas Readings

PLAN

SCALE 1"=40' NORTH

ABUT. 0 4+93, BENT 1, P-1, CPT-1, BENT 2, BENT 3, CPT-2, BENT 4, 8+50, BENT 5, 9+08.00, CPT-3, BENT 6, BENT 7, 11+12.00, CPT-4, BENT 8, BENT 9

℄ EXISTING R.R.

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

45' Lt. STA. 5+94.00 — ELEV.= 0.21 — R-1

FILL:(SW)Brown fine to medium SILTY SAND w/GRAVEL, vegetation, w/shell fragments

GWS ELEV.= -4.71 08-26-96

NATIVE:(ML)Gray SILT, very stiff grades to SANDY soft

(ML)Gray SANDY SILT w/mica & shell fragments

(ML)Gray to dark gray SILT w/traces of SAND, stiff

(SP)Gray fine SAND w/mica, compact

(ML)Gray SILT w/CLAY, very stiff

(SP)Gray fine SAND, very dense

(ML)Gray CLAYEY SILT, very stiff. less CLAYEY grades to CLAYEY

(SP)Gray fine SAND, very dense, w/GRAVEL grades to fine to medium w/1" gravel

grades to medium

traces of gravel

Grades to fine w/traces of SILT w/decomposed wood fragments & mica

Grades to medium to coarse w/traces of GRAVEL less SILT

Grades to medium

Grades to fine to medium

Grades to medium w/traces of 3/4" GRAVEL

(ML)Gray SANDY SILT

(GP)Gray poorly graded GRAVEL w/SAND, very dense

(ML)Gray SANDY SILT

08-26-96

17' Lt. STA. 6+02.50 — ELEV.= -0.06 — CPT-1 — 08-19-96

STA. 7+63.50 — ELEV.= -2.01 — CPT-2 — 08-15-96

STA. 9+08.00 — ELEV.= -0.18 — CPT-3 — 08-15-96

STA. 11+12.00 — ELEV.= 2.46 — CPT-4 — 08-15-96

ELEVATION

LEGEND OF EARTH MATERIALS

GRAVEL, SAND, SILT, CLAY, SANDY CLAY or CLAYEY SAND, SANDY SILT or CLAYEY SILT, SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, GRANULAR ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

NOTE: Classification of earth materials as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

ASCY CLASSIFICATION FOR SOILS

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-30	Slightly compact	Firm
31-50	Compact	Very stiff
51-70	Dense	Hard
>70	Very dense	Very hard

LEGEND OF SAMPLE AND BORING TYPES

2½" I.D. CONE PENETROMETER; SUBAQUEOUS (DRY); ROTARY SUBAQUEOUS BORING (WET); AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; JET BORING; ELECTRONIC CONE PENETROMETER

DESIGN OVERSIGHT		DRAWN BY	NL	CS-LA-MC	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	PROJECT ENGINEER	BRIDGE NO. 53-2618	SEISMIC RETROFIT PROJECT No. 627
SIGN OFF DATE		CHECKED BY	MR	FIELD INVESTIGATION DATE 08-15-96			POST MILE 3.58	SCHUYLER HEIM BRIDGE
						CU 07 EA 138201	DEREGUARD PRINTS BEARING EARLIER REVISION DATES →	LOG OF TEST BORINGS NO.1

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

REVISION DATES (PRELIMINARY STAGE ONLY) 4/4/97 4/27/97

SHEET 141 OF 148

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No.:96-1005

PLAN
SCALE: 1"=40'

NORTH

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity
- N.S.R.= No sample recovery
- OVM5608 Gas Readings

BENT 9, CPT-5, BENT 10, BENT 11, BENT 12, CPT-6, 14+05.00, ABUT. 6, ON ABUT. 6, BENT 13, ON BENT 5, OFF BENT 5, ABUT. 5, B-2, CPT-7, OFF BENT 4, ON BENT 4, BENT 14, OFF BENT 3, ON BENT 3, BENT 15, CPT-8, OFF BENT 2, ON BENT 2, BENT 16, OFF BENT 1, ON BENT 1, BENT 17, BENT 18

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

45° Lt. STA. 12+82.50 — CPT-5 — ELEV.= -0.68 — 08-15-96

STA. 14+05.00 — CPT-6 — ELEV.= -1.78 — 08-15-96

STA. 15+63.50 — CPT-7 — ELEV.= -1.66 — 08-15-96

5° Lt. STA. 15+51.50 — ELEV.= -1.54 — GWS ELEV.= -5.54' 08-23-96 — B-2 — 08-21-96

STA. 17+23.00 — CPT-8 — ELEV.= -0.02 — 08-15-96

FILL-(SM)Brown fine SILTY SAND w/GRAVEL & shell fragments
(ML)Dark gray CLAYEY SILT w/roots, very soft
NATIVE-(SP)Gray fine SAND w/mica, slightly compact
(ML)Gray SILT w/traces of SAND, stiff -
grades to SANDY, very soft
grades to w/SAND and shells
grades to SANDY
Increasing shells, stiff
grades to CLAYEY w/traces of mica
Decreasing in CLAY, soft
grades to CLAYEY w/mica
Decreasing in mica, very stiff
stiff
w/traces of SAND -
interbedded w/ SANDY SILT
(SP)Gray fine SAND, dense
(ML/SM)Gray SANDY SILT
(SP)Gray fine SAND w/traces of SILT
grades to w/mica, decreasing in SILT, very dense
traces of SILT
traces of GRAVEL, 0.5" dia.
w/o GRAVEL
grades to fine to medium
grades to fine to medium w/traces of GRAVEL
grades to w/traces of SILT
(ML)Gray SANDY SILT
(SP)Gray fine SAND, very dense
grades to medium to coarse w/GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND, 3/8" max. dia.
(SP)Gray fine SAND w/GRAVEL
Decreasing in GRAVEL
(ML)Dark gray SILT w/decomposed wood & mica
(SP)Gray fine to medium SAND w/1.5" GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND
(ML)Dark gray SILT w/SAND
(SM)Dark gray fine to medium SILTY SAND w/traces of CLAY
(ML)Gray SILT w/SAND

PROFILE
HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

ELEVATION

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAYEY SILT, CLAY, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS (According to the Standard Penetration Test)

Penetration Index (Blows/ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Firm
20-34	Compact	Very stiff
35-69	Dense	Hard
170	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERSIGHT

BRIDGE DESIGN BY

DRAWN BY: NL
CHECKED BY: MR

CS-LN-MC
FIELD INVESTIGATOR
DATE 09-15-96

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

BRIDGE NO. 53-2618
POST MILE 9.58

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.2

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 142 OF 148

C:\CADDWG\JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

APPENDIX B.

EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

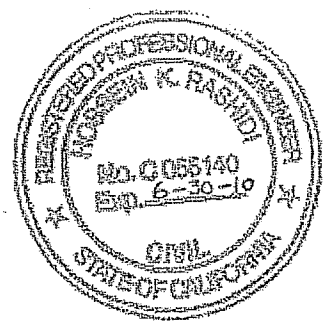
Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

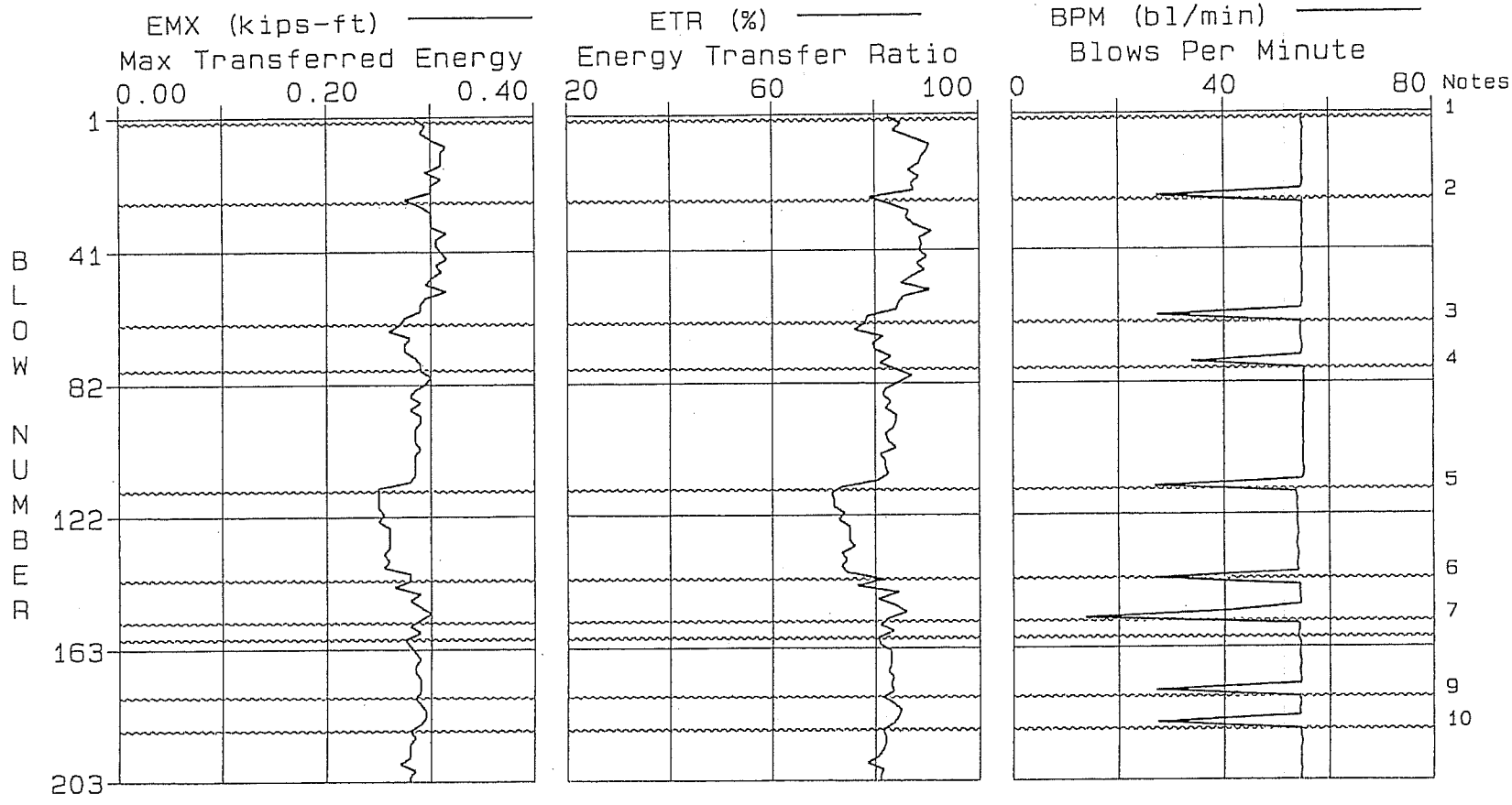
Sincerely Submitted for EarthSpectives

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

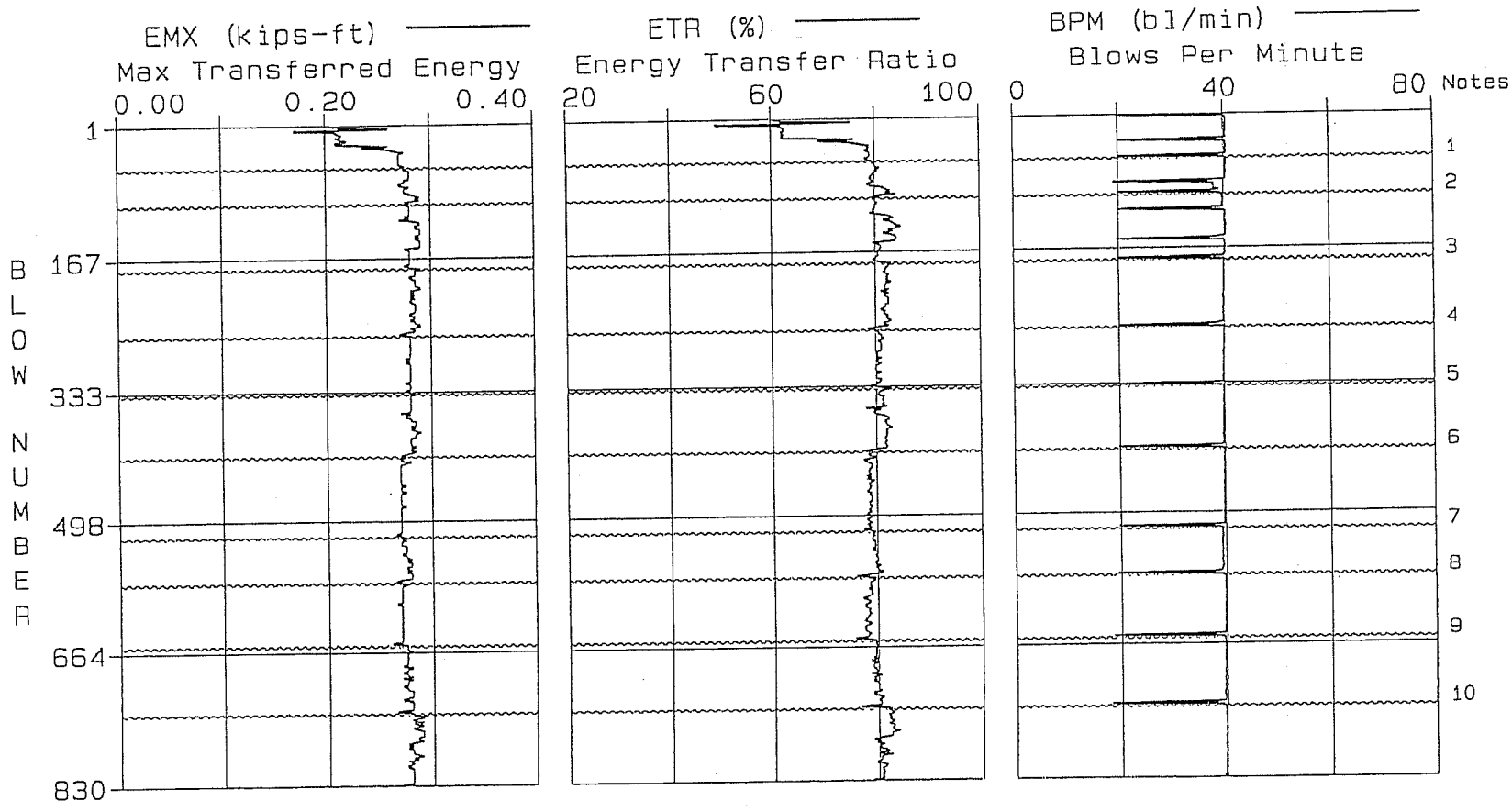
BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives

2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

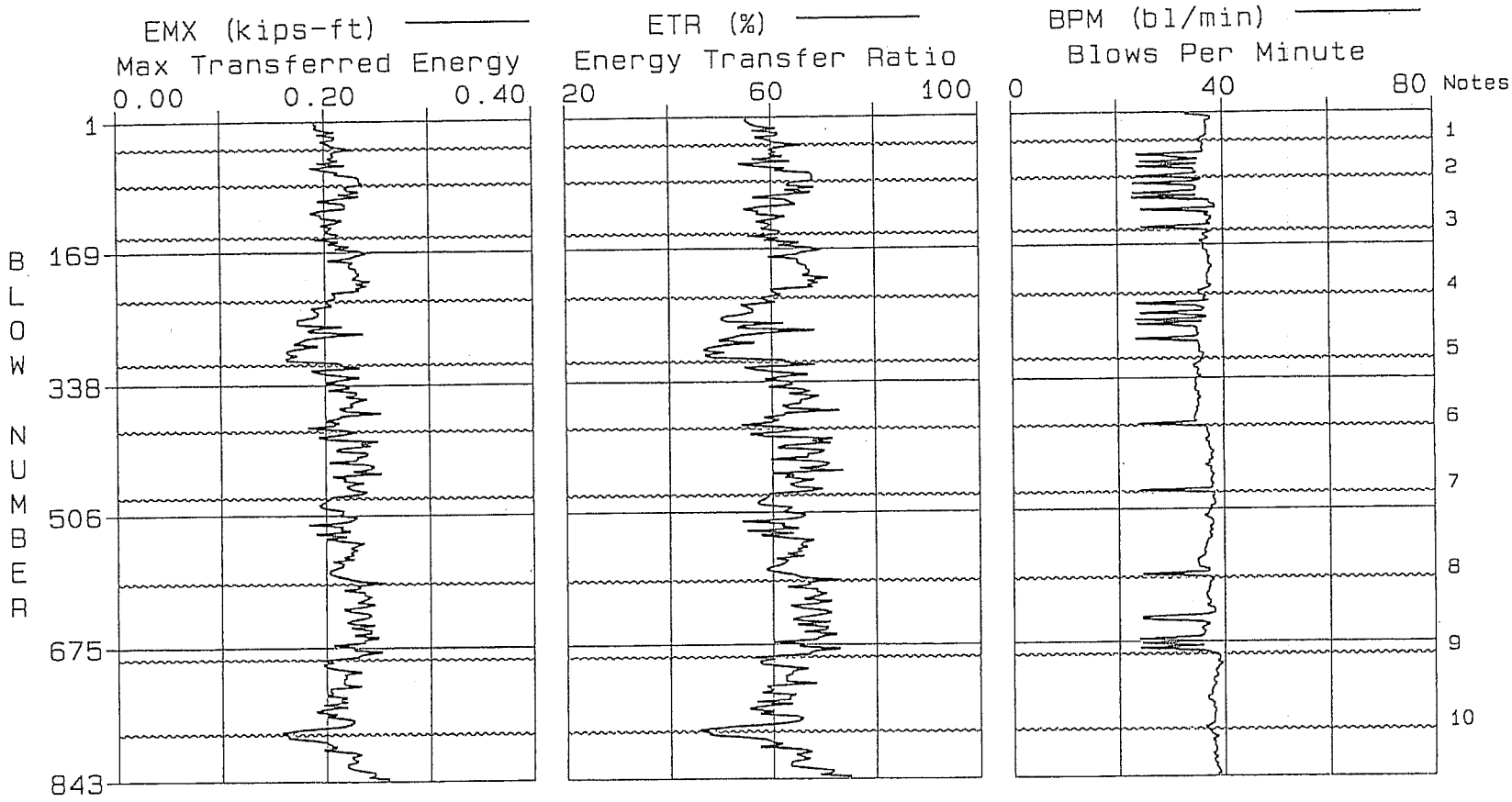
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX C.

GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

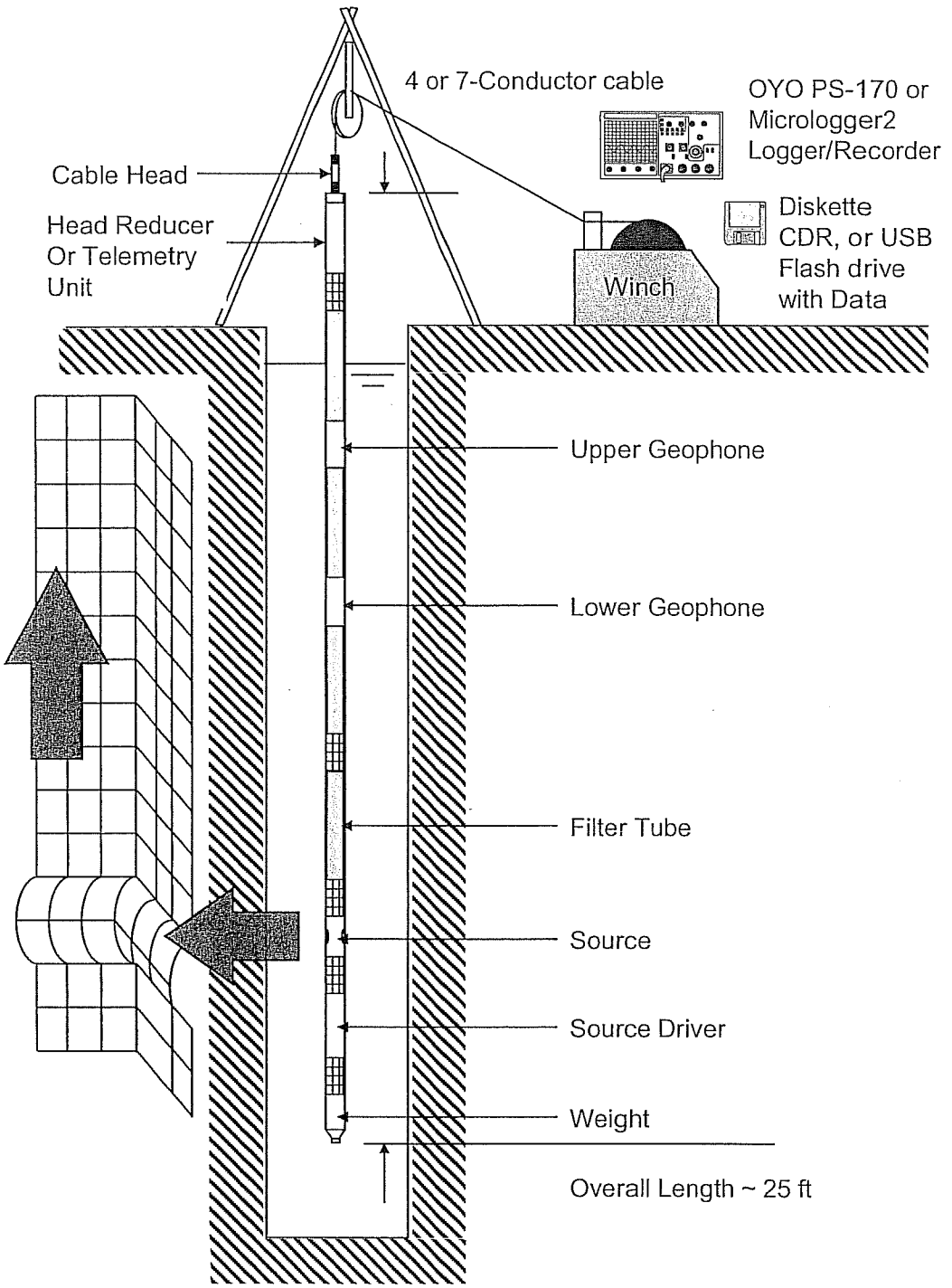

Figure 1: Concept illustration of P-S logging system

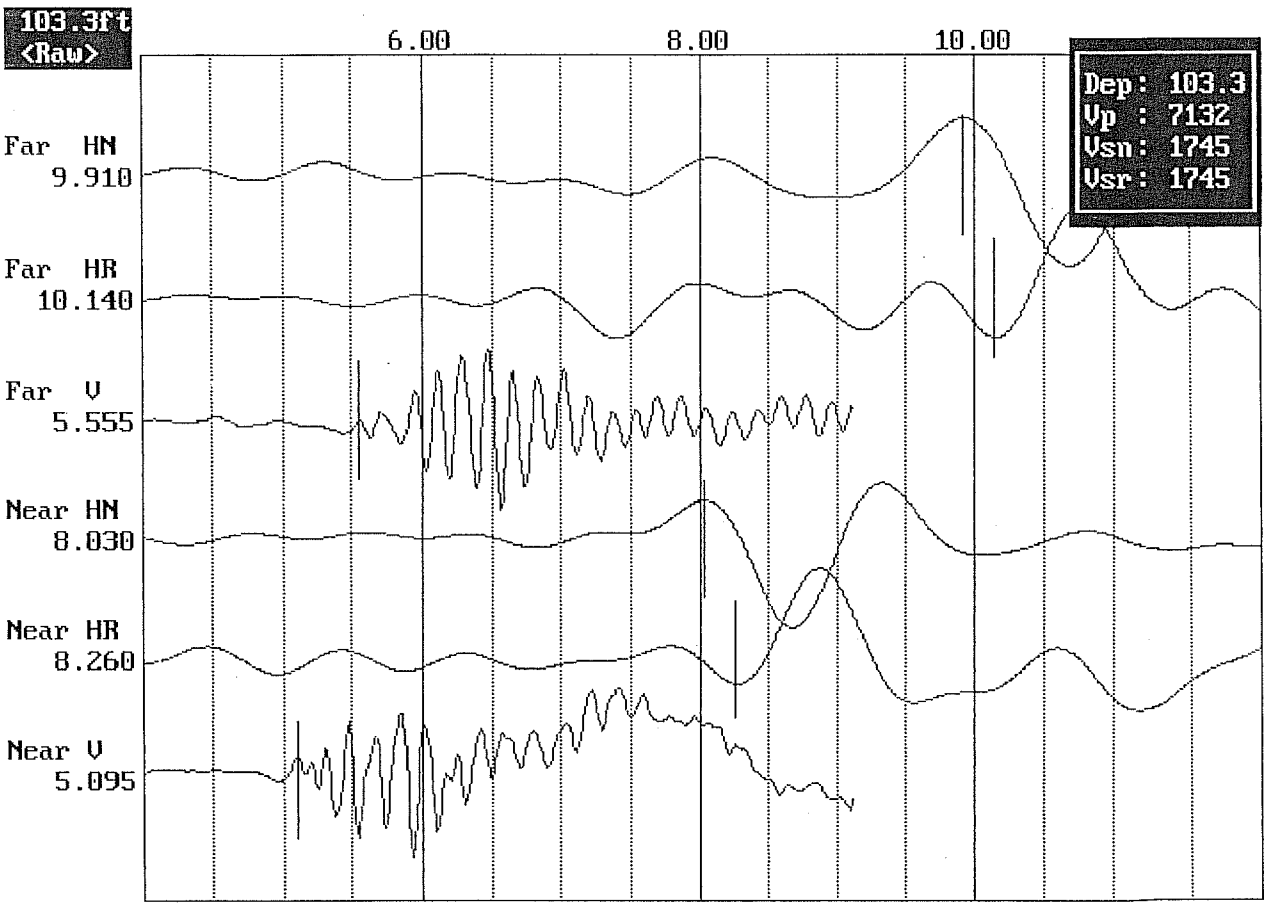

Figure 2: Example of filtered (1400 Hz lowpass) record

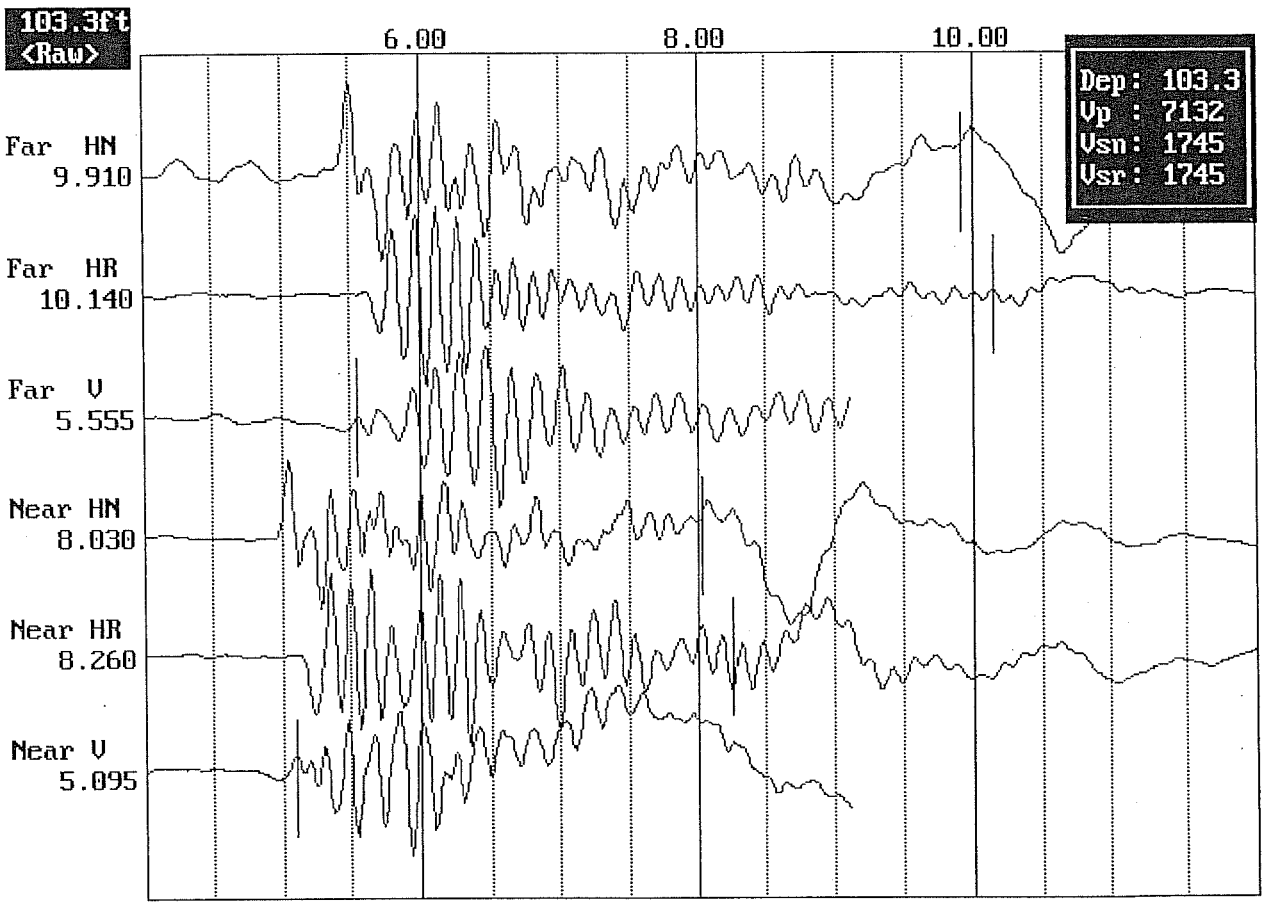

Figure 3. Example of unfiltered record

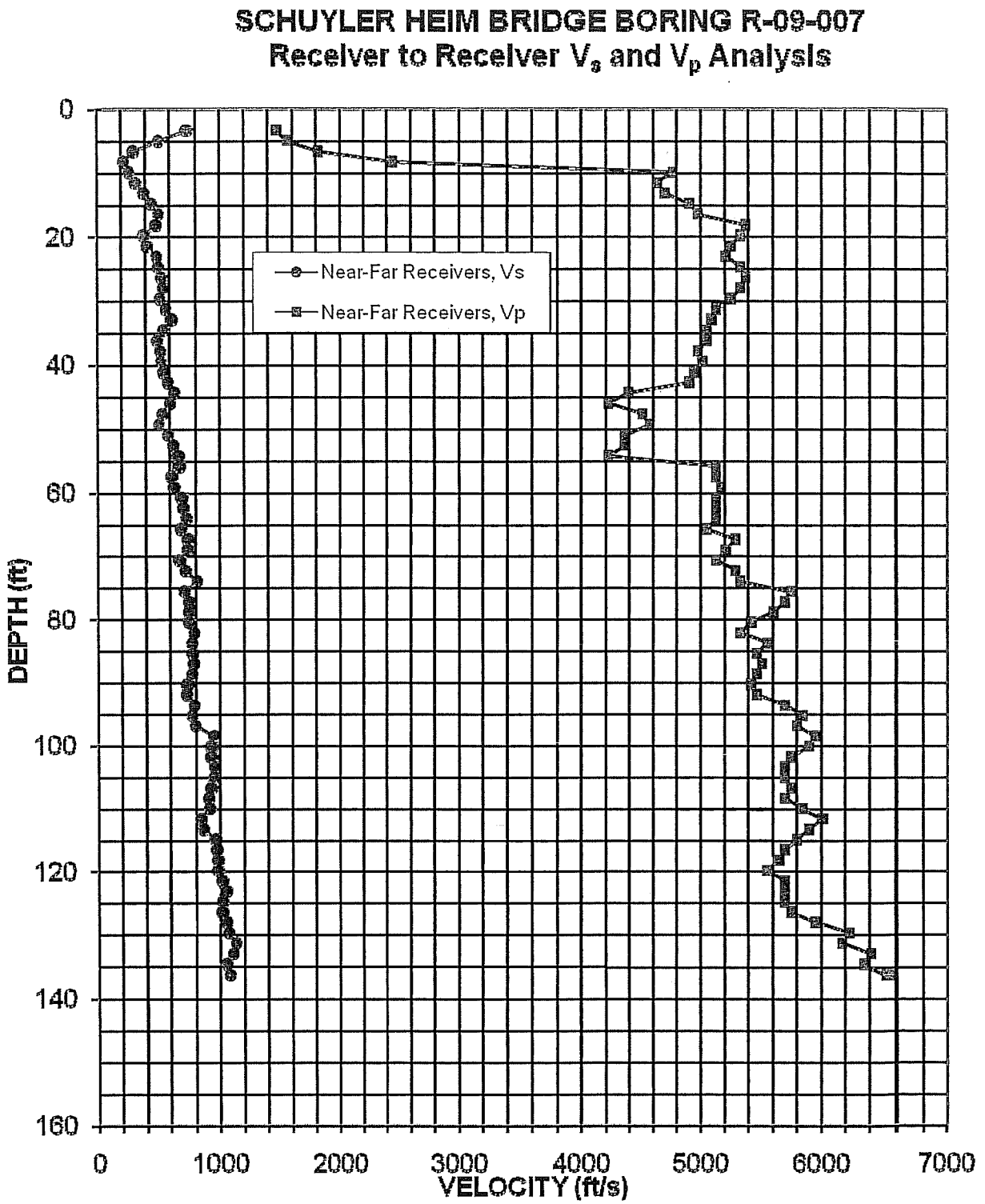

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

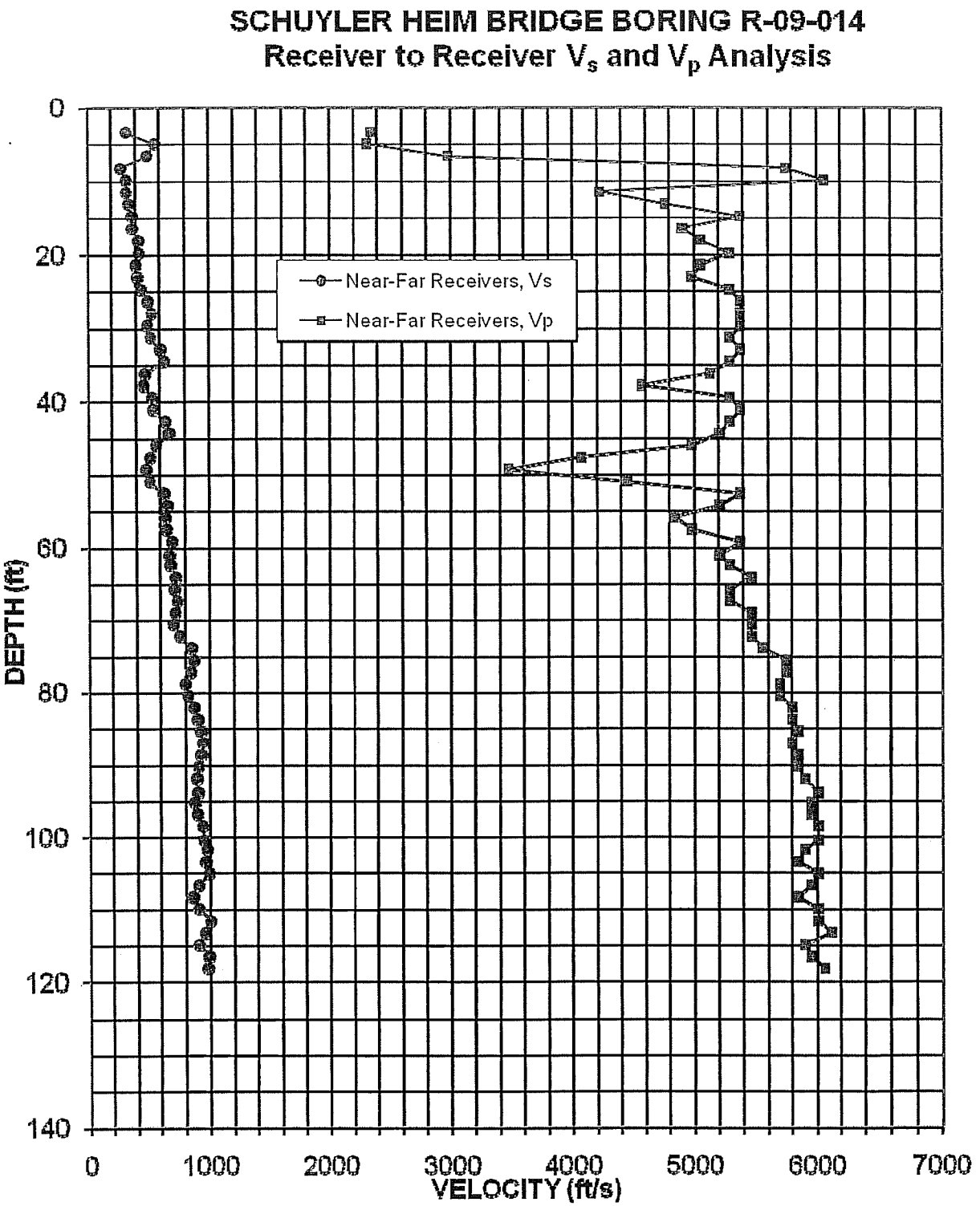

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

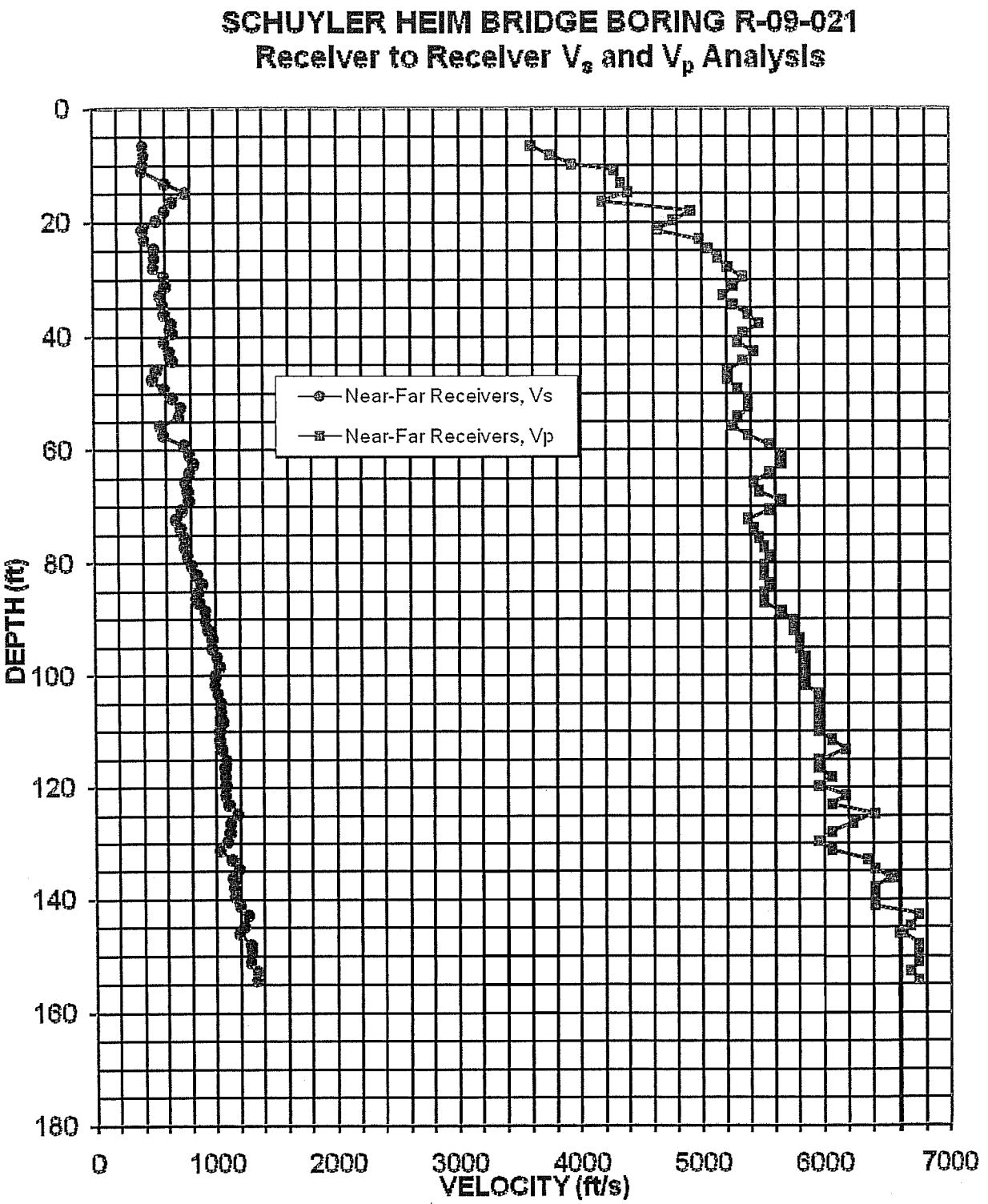

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

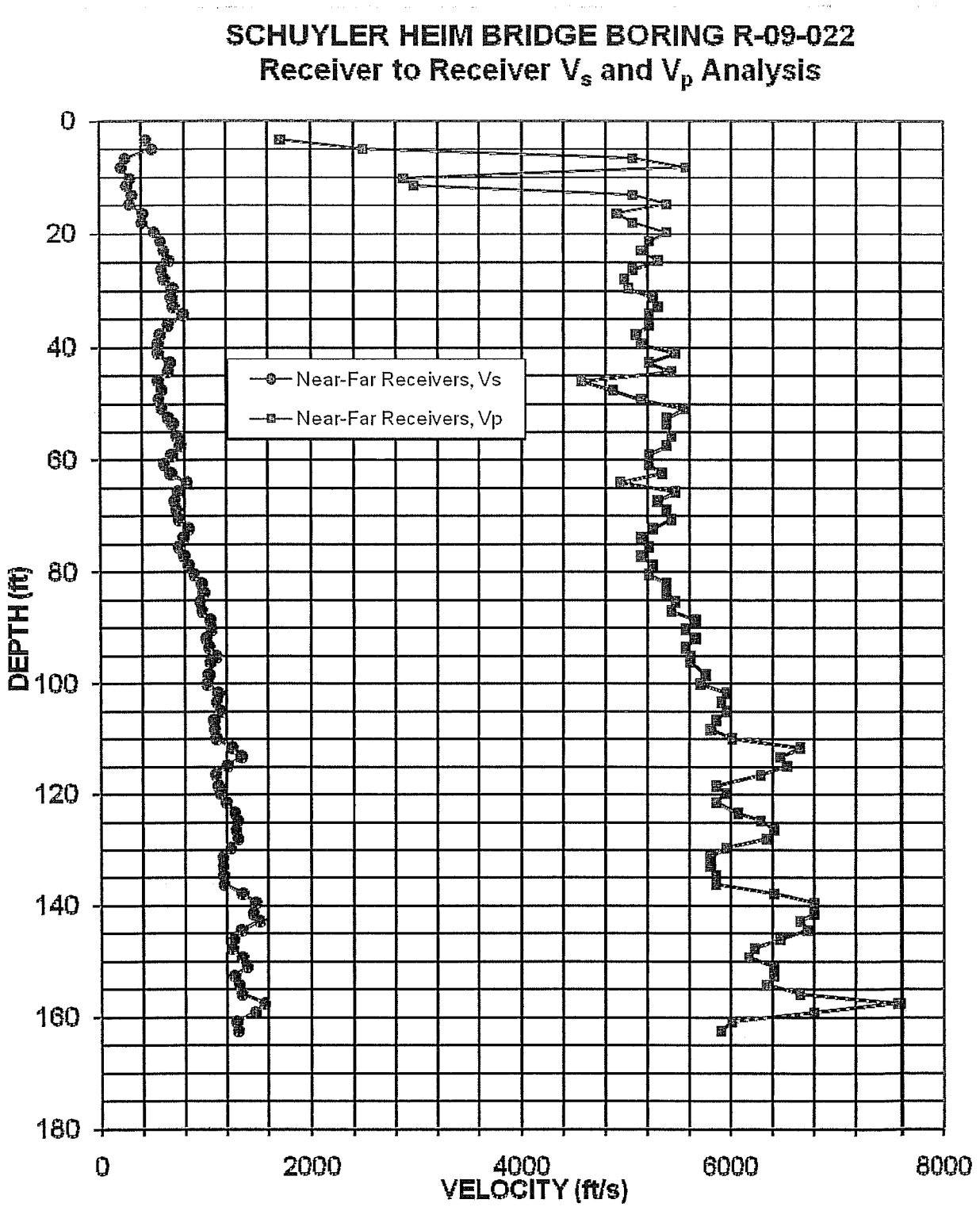

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

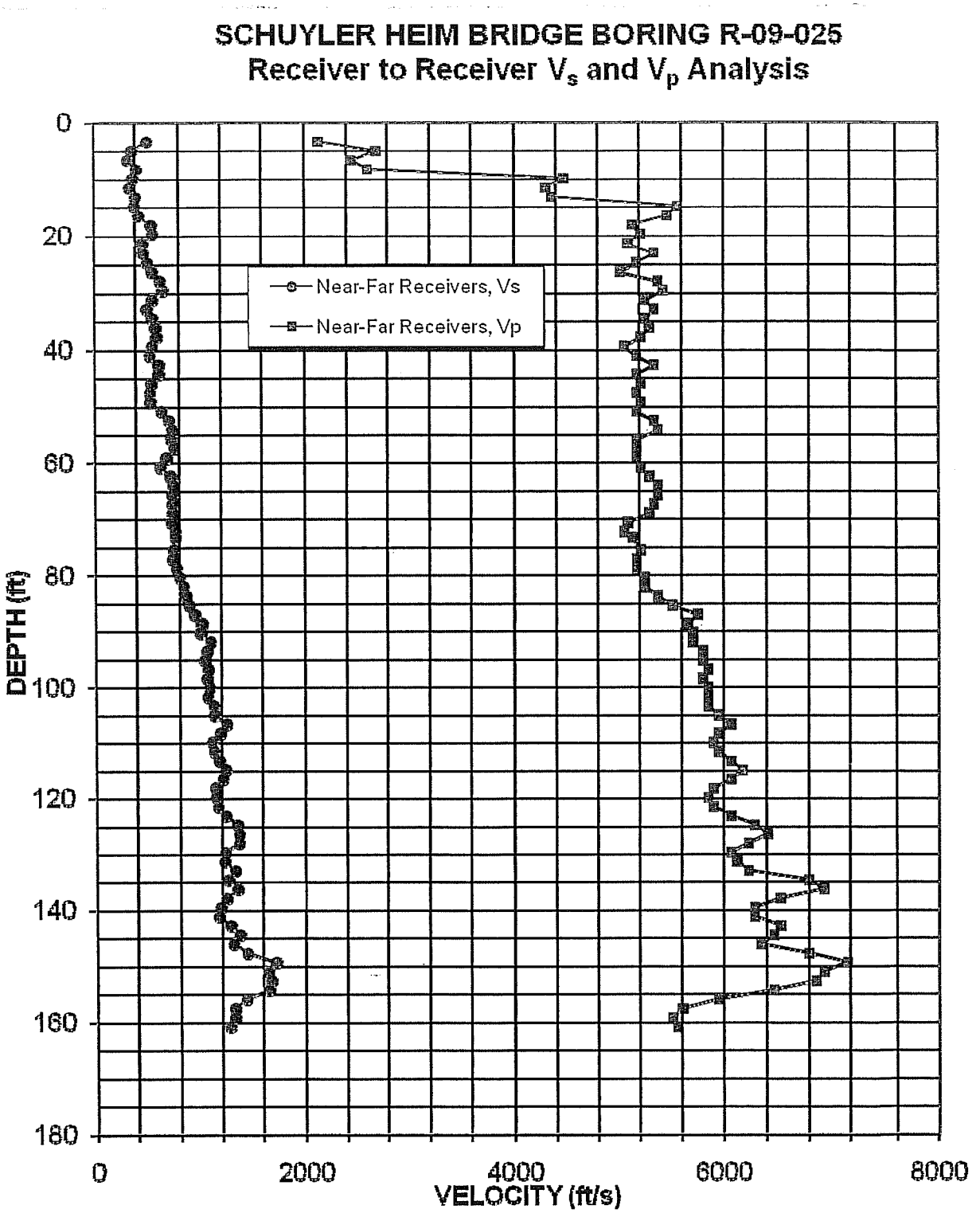

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

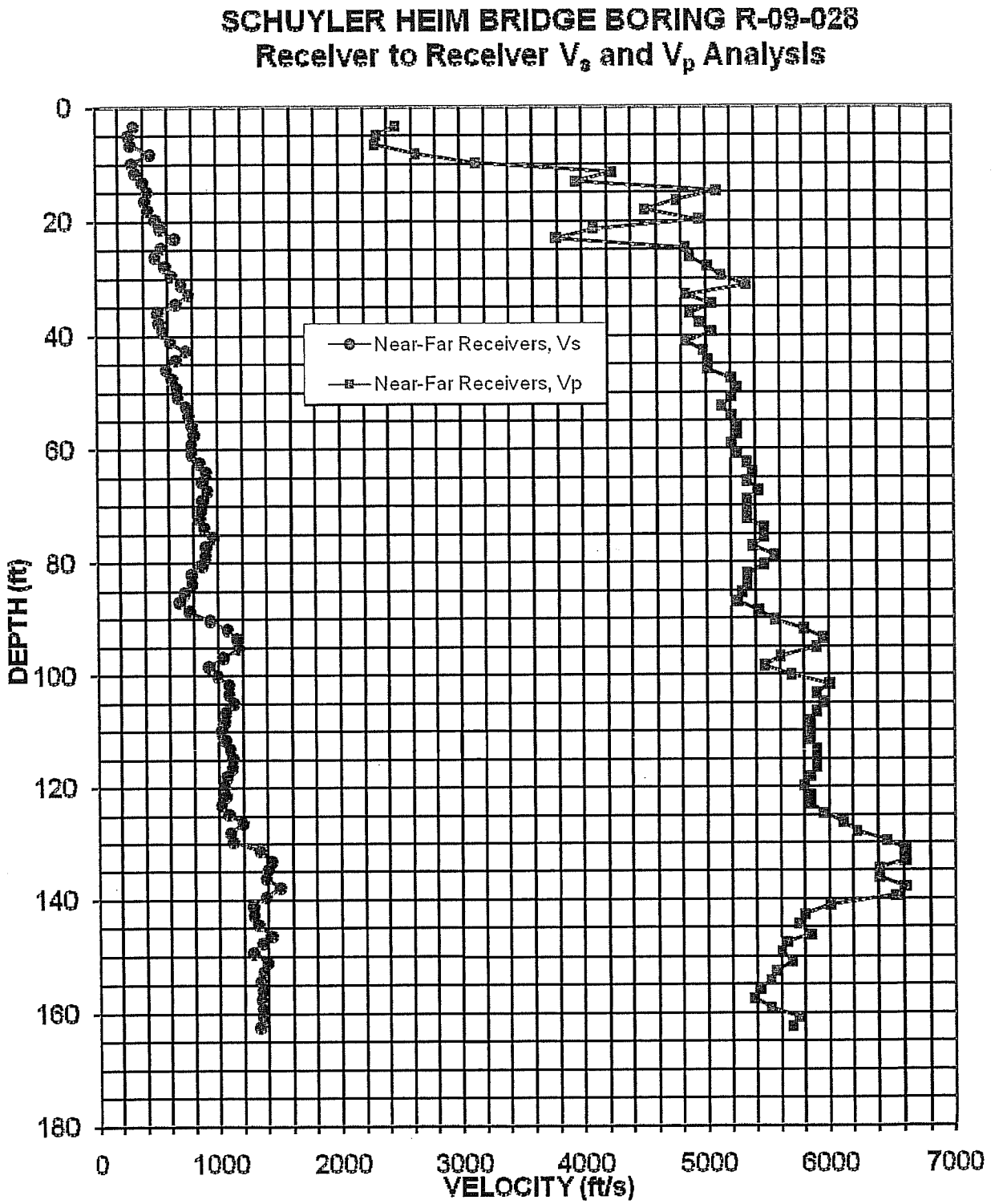

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

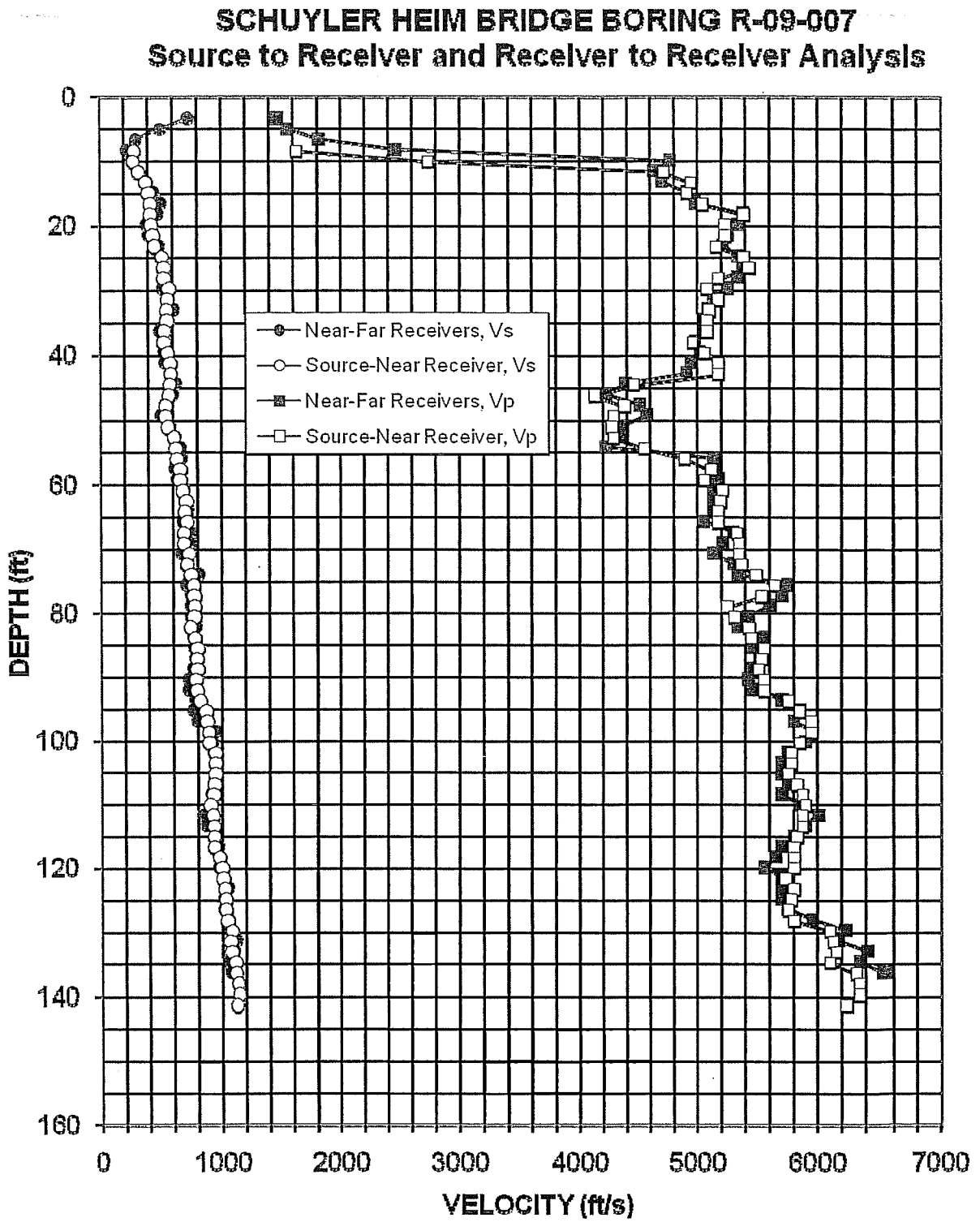

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

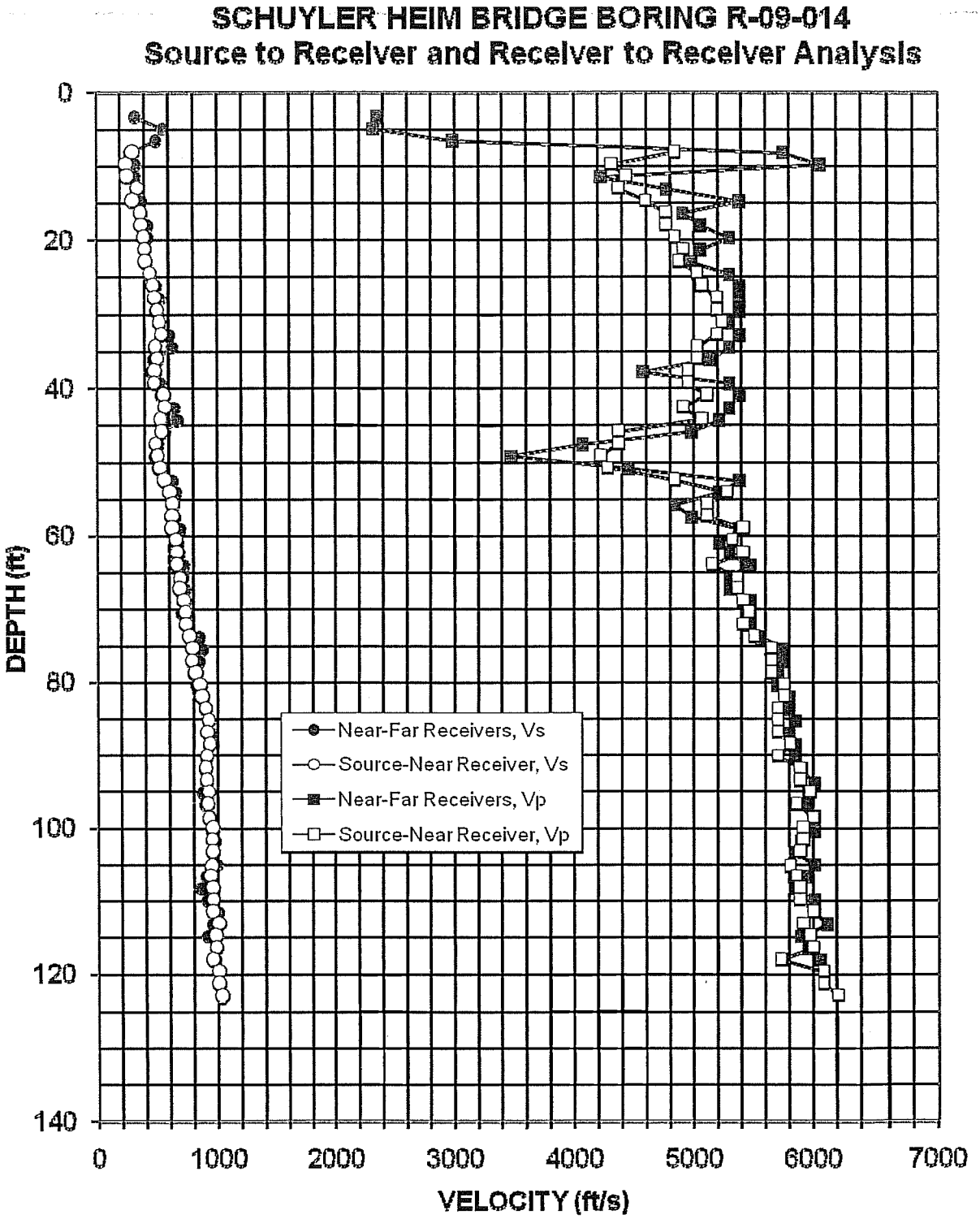

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

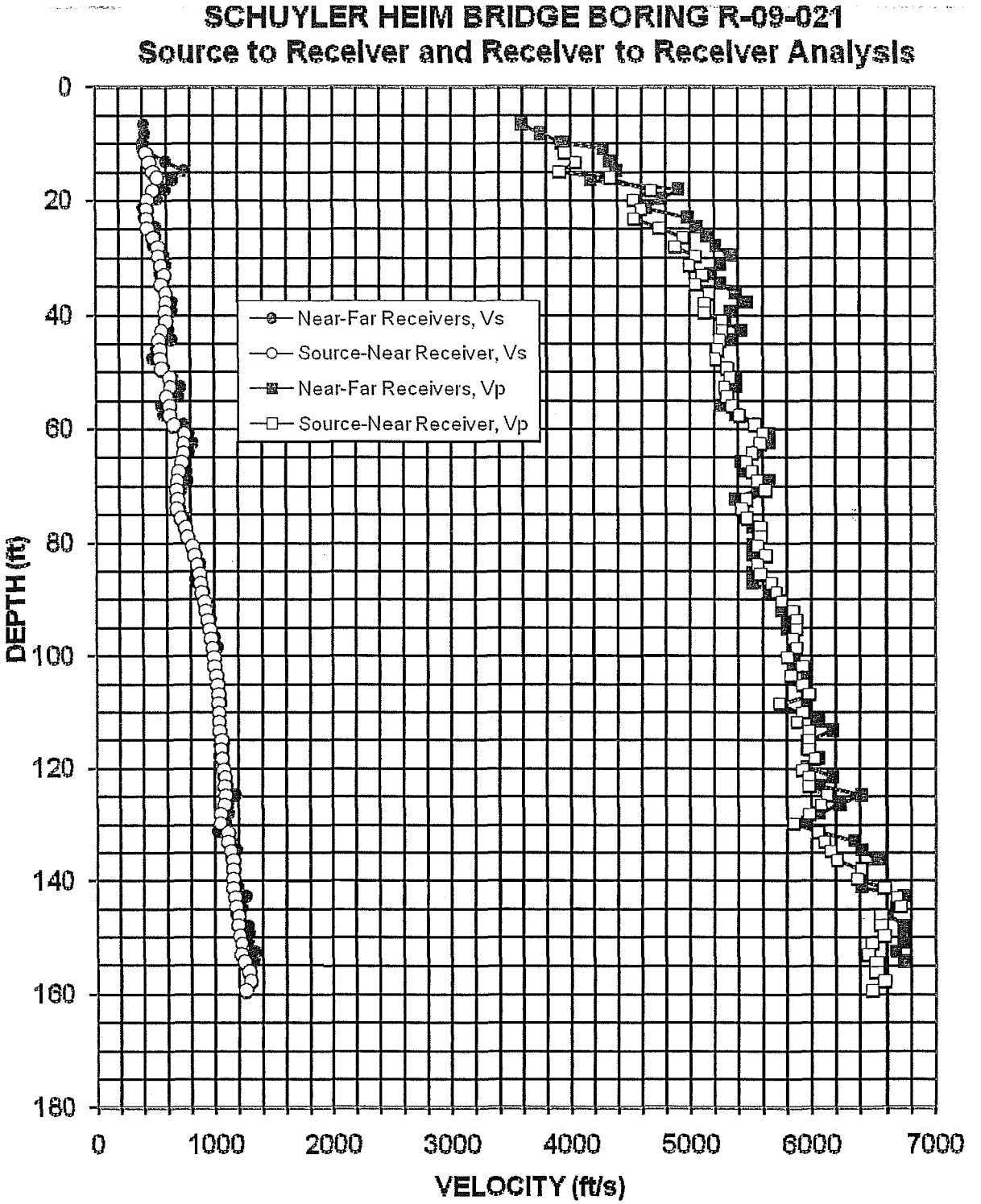

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

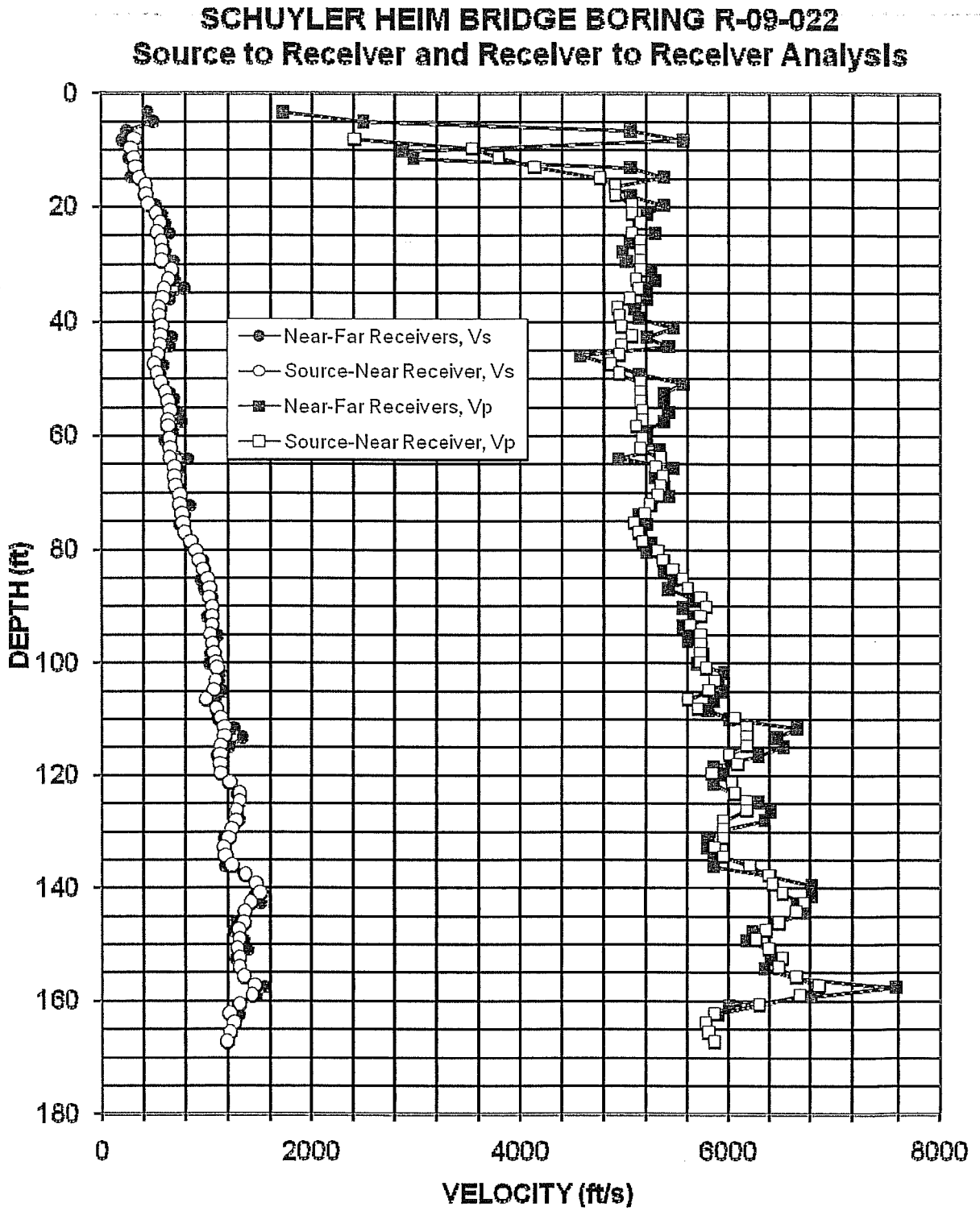

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

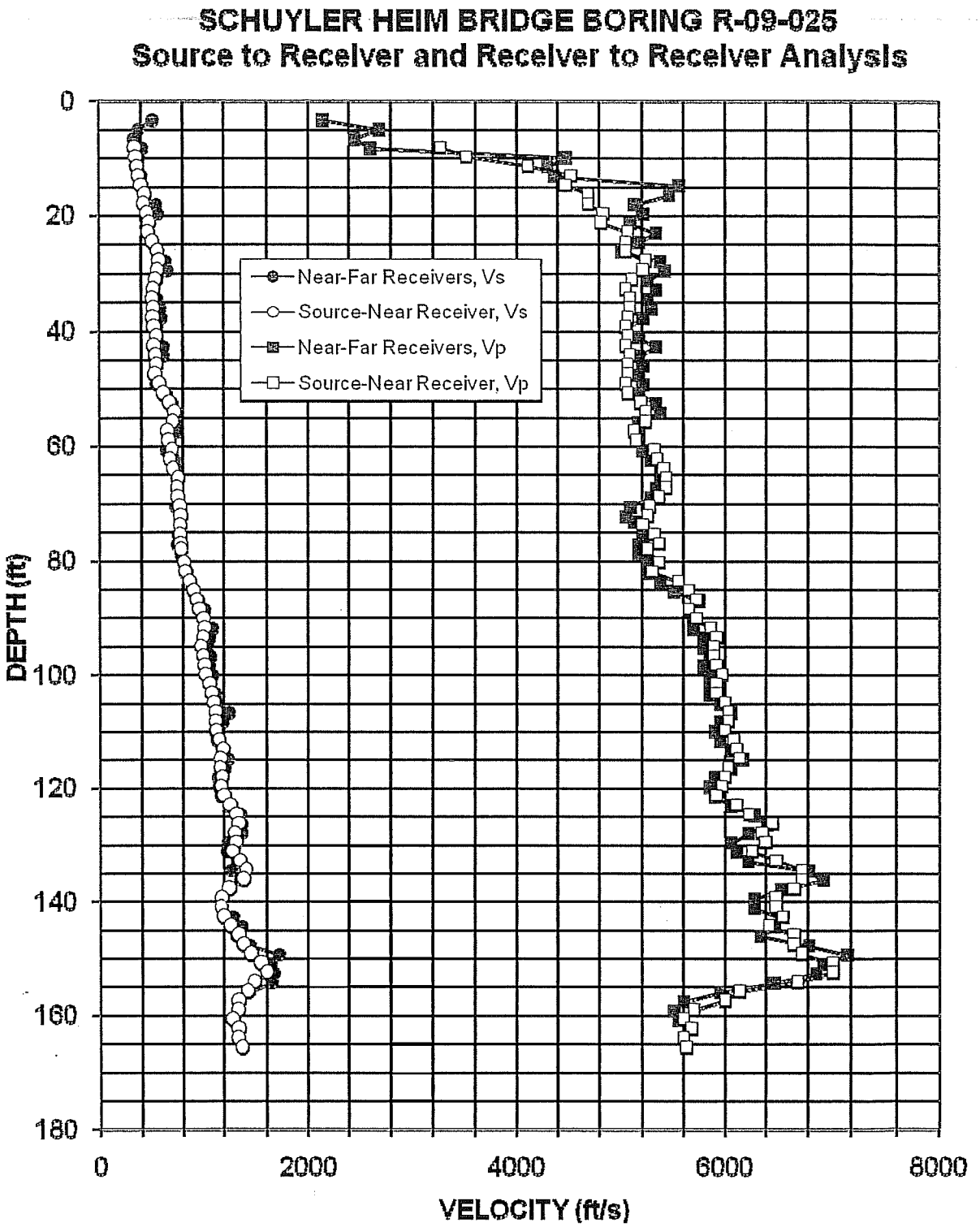

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

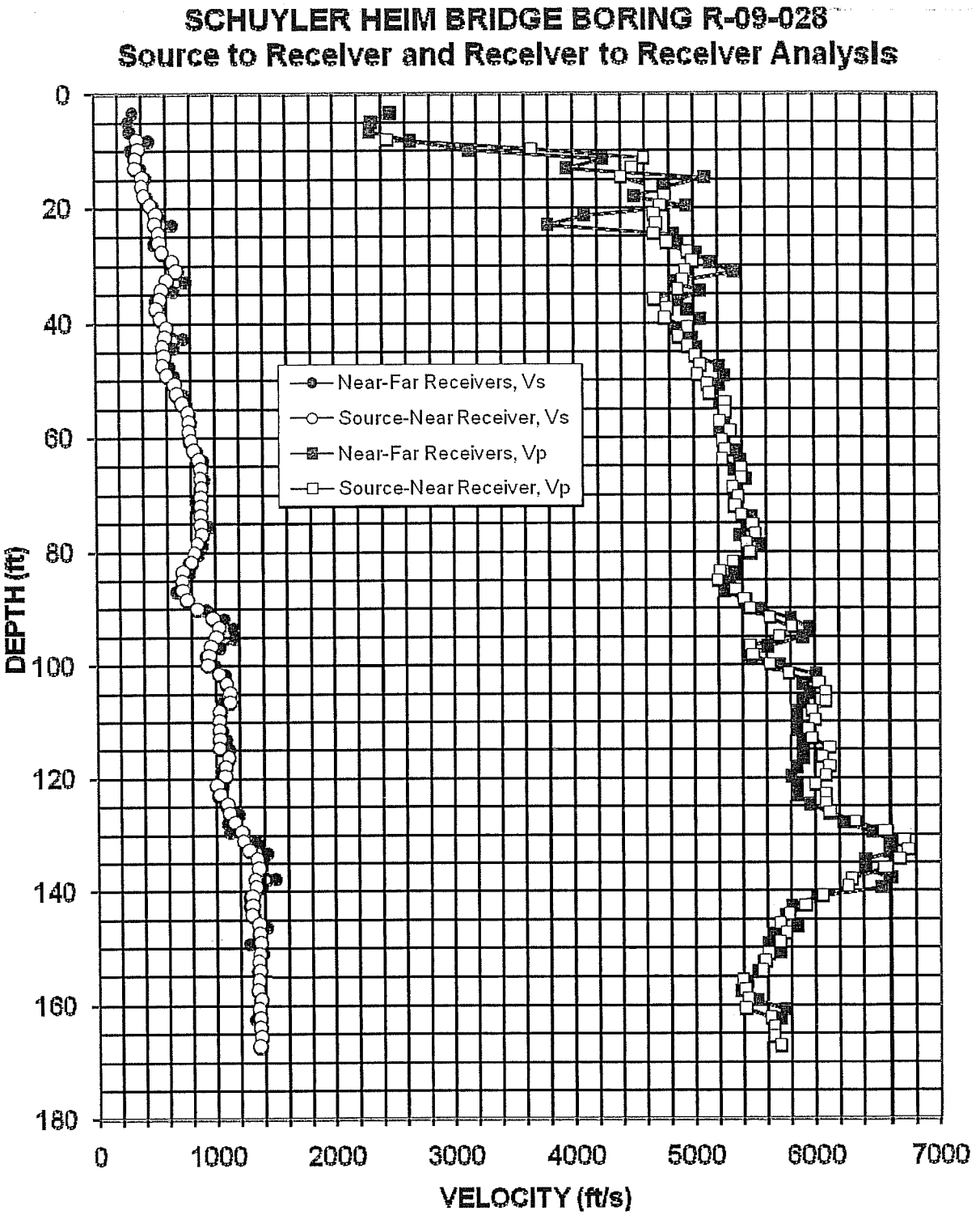

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®

Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson	
	Name	Date		Signature
Witnessed by:	Robert Steller	7/17/2009		
	Name	Date		Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®

Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 Project Number 06-123 7-17 GT

~~160024~~

573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX D.

LABORATORY SOIL TEST RESULTS

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/01/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-009	D-01	5	24.5	94.3
R-09-009	S-03	15	24.7	NA
R-09-009	D-07	35	52.9	72.3
R-09-009	S-10	50	52.6	NA
R-09-009	D-11	55	28.6	92.9
R-09-009	D-13	65	32.0	89.6
R-09-009	S-14	70	29.2	NA
R-09-009	S-16	80	26.6	NA
R-09-009	S-19	110	12.0	NA
R-09-009	S-22	140	9.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-009	U-09	45	1.38
R-09-009	D-13	65	2.86

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03
Laboratory No.: 29-1121
Date: 12/04/09

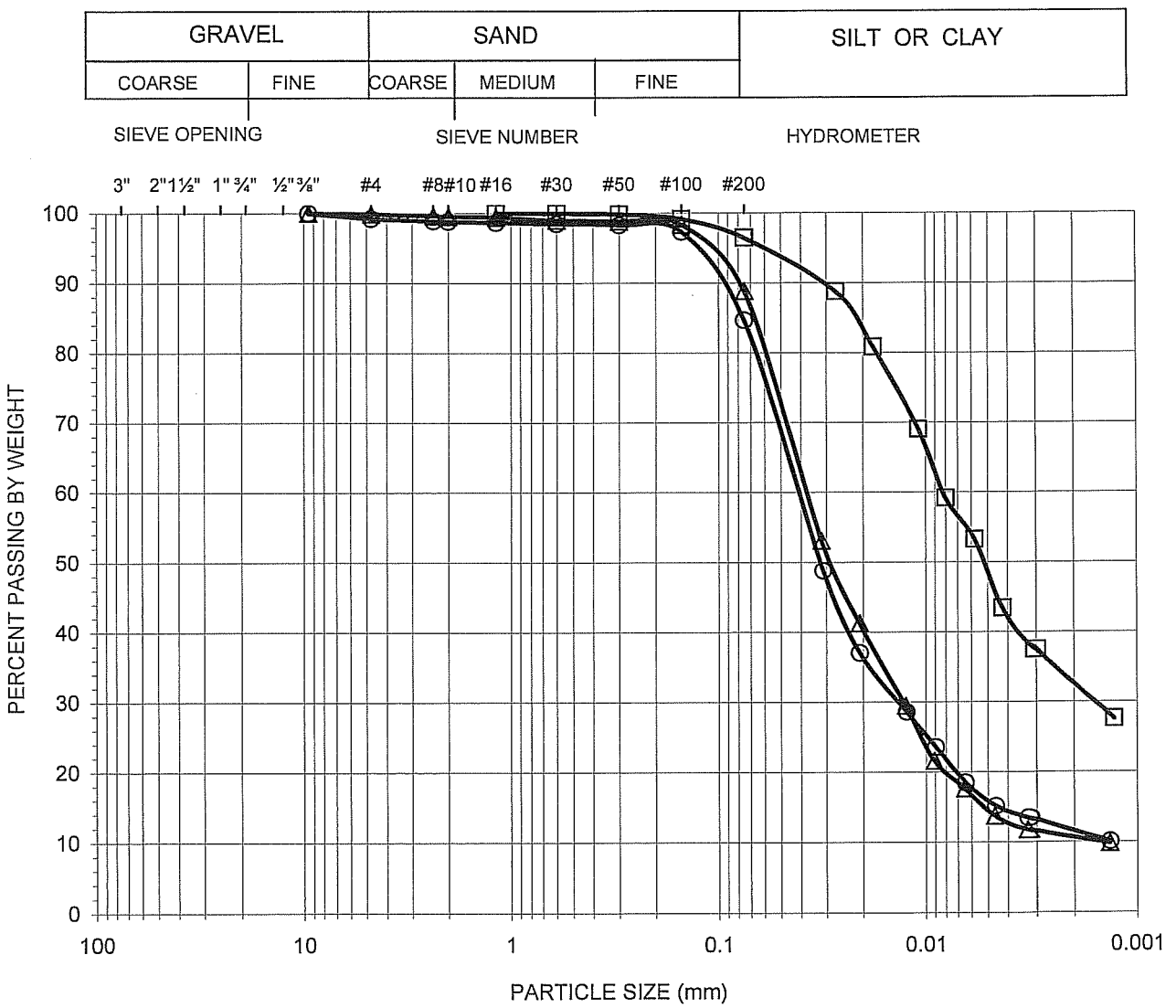
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-009	S-02	10	5.44
R-09-009	S-04	20	3.42
R-09-009	S-06	30	67.93
R-09-009	S-07	35	99.15
R-09-009	D-11	55	63.85

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

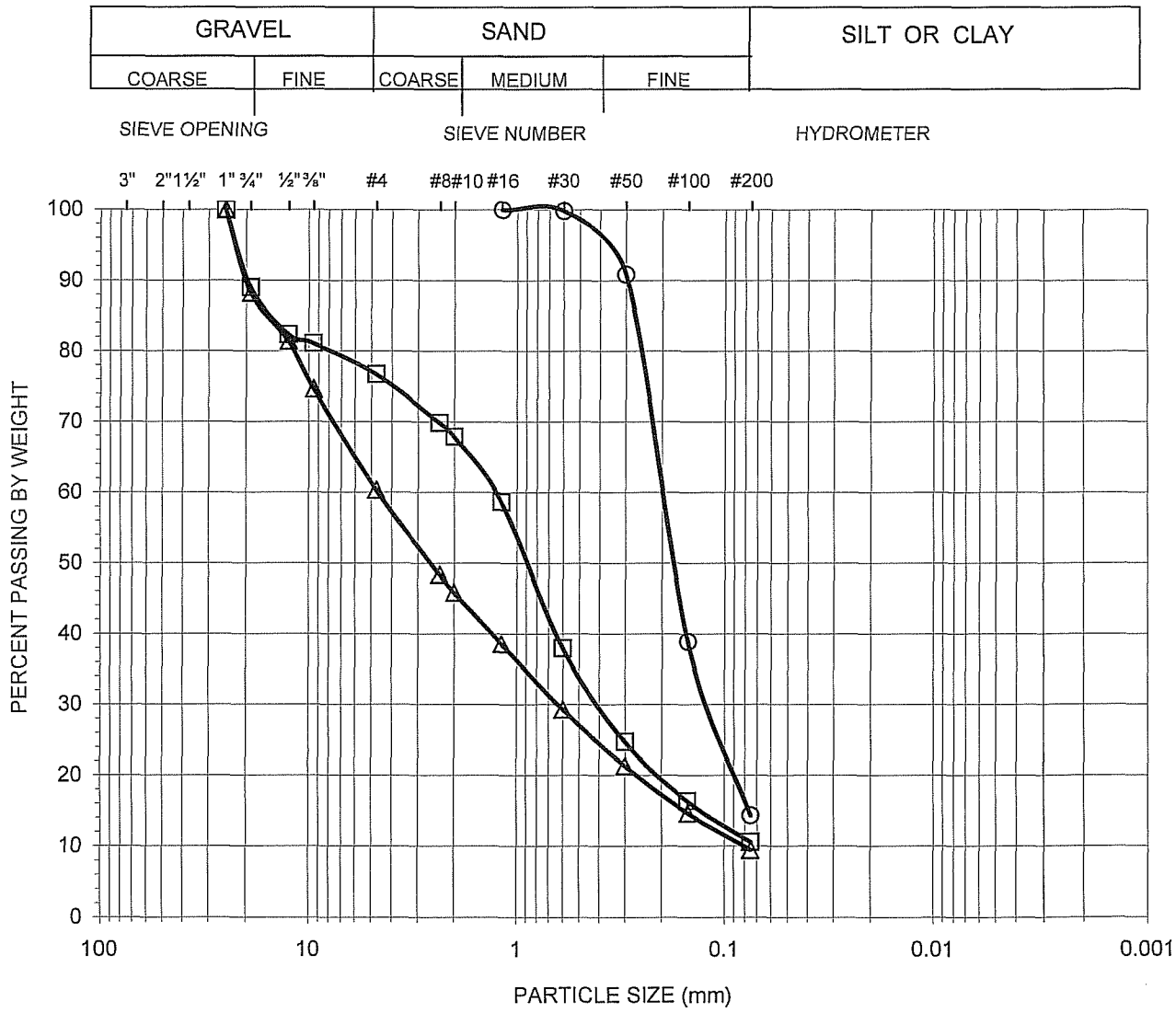


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-009	U-09	45	0.77	14.53	84.70	31:22:9	CL
□	R-09-009	S-10	50	0.00	3.55	96.45	49:27:22	CL
△	R-09-009	D-13	65	0.14	10.96	88.90	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



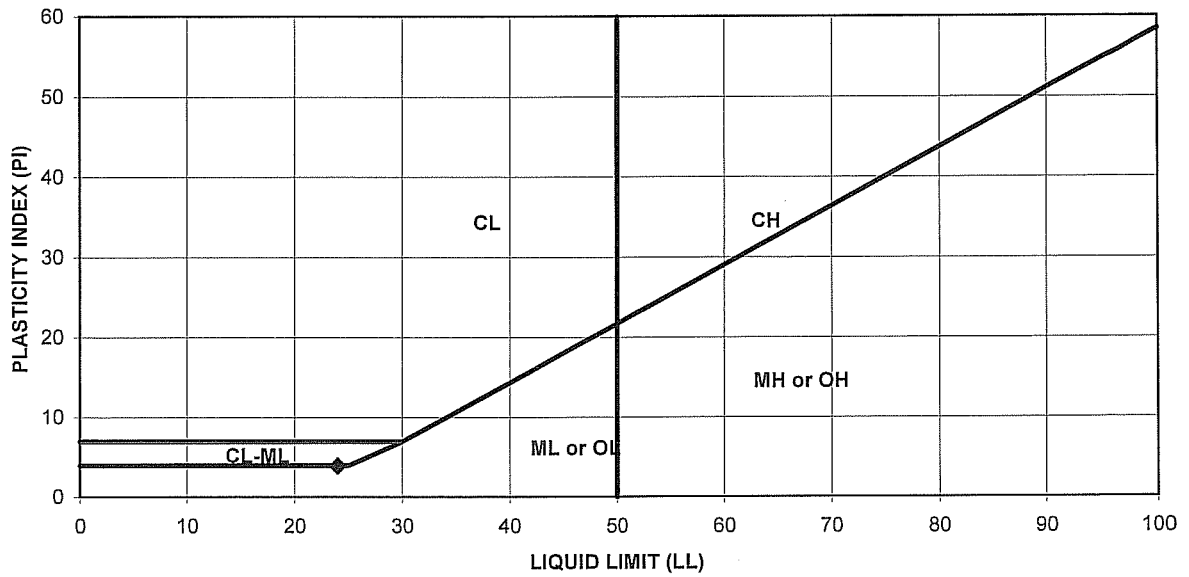
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-009	S-16	80	0.00	85.64	14.36	N/A	SM
□	R-09-009	S-19	110	23.28	66.13	10.59	N/A	SW-SM
△	R-09-009	S-22	140	39.61	50.88	9.51	N/A	SW-SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

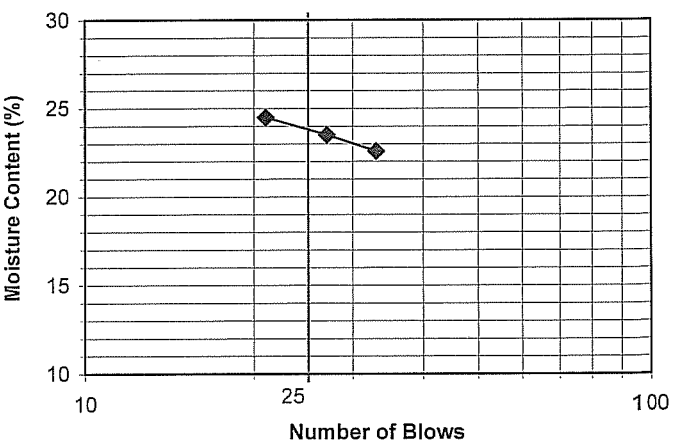
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/07/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	S-06	30	24	20	4	CL-ML

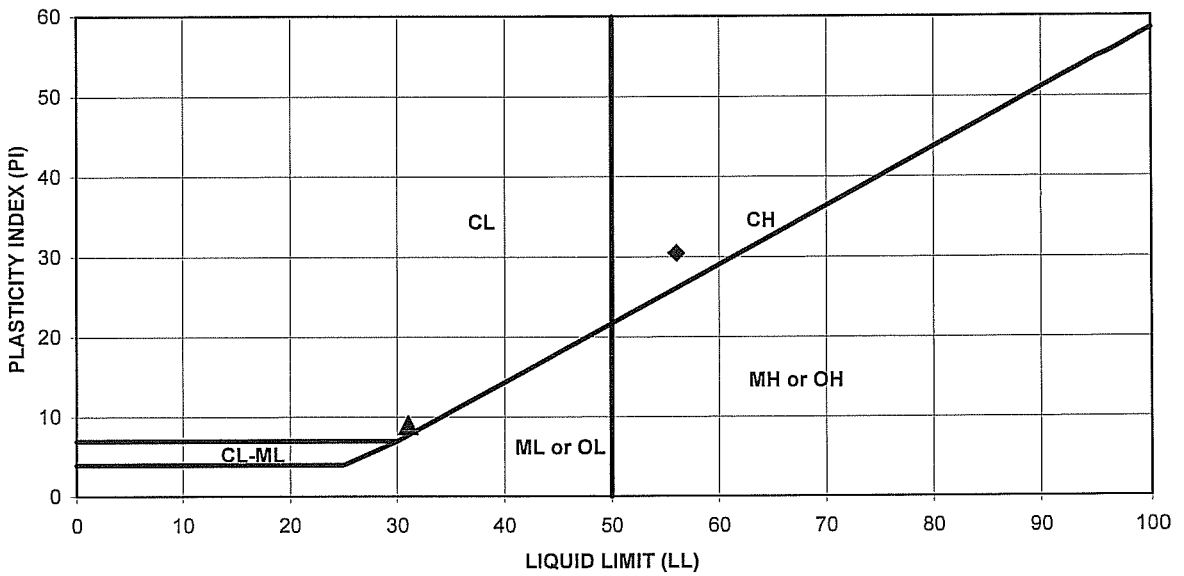
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

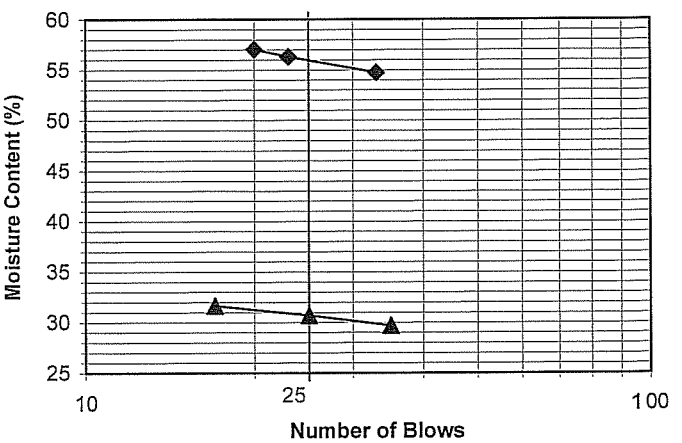
Tested By: WJO
Checked By: AP

Date: 12/01/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	D-07	35	56	25	31	CH
▲	R-09-009	U-09	45	31	22	9	CL

* NP denotes "non-plastic"

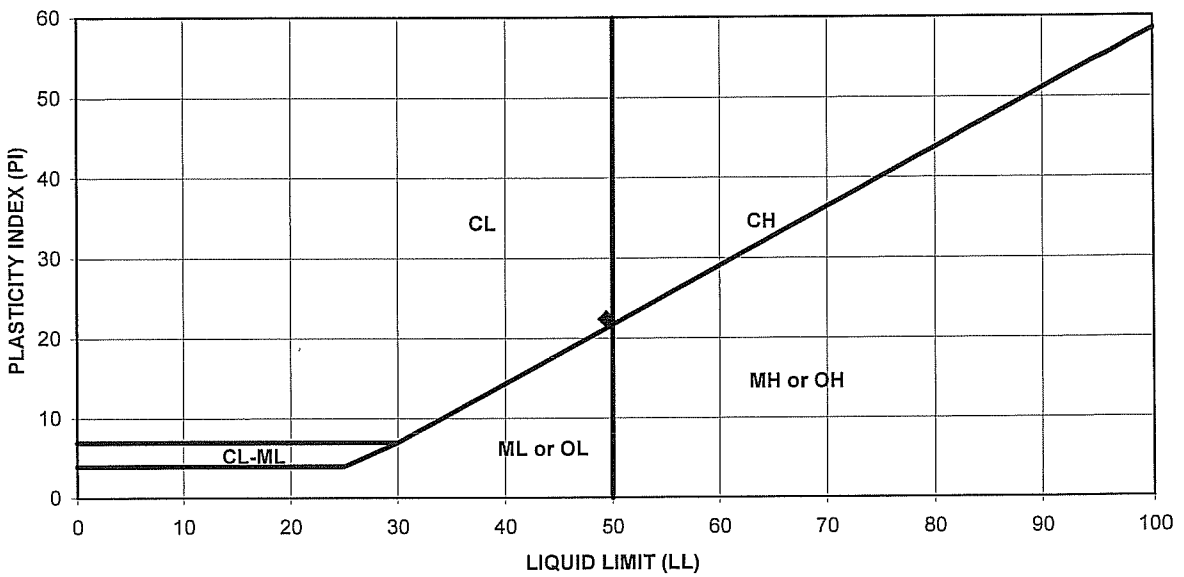
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

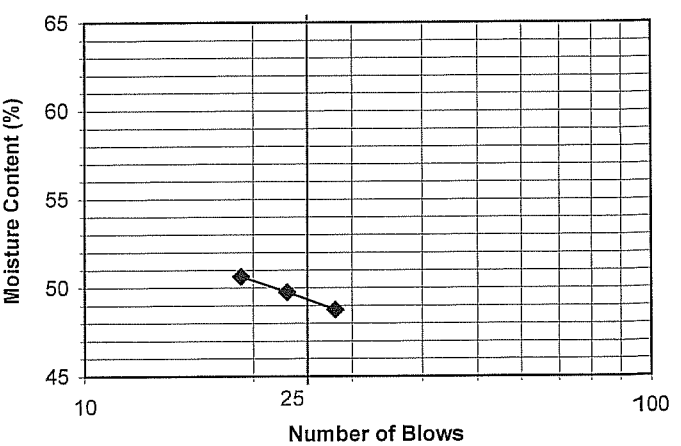
Tested By: WJO
Checked By: AP

Date: 12/01/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	S-10	50	49	27	22	CL
	R-09-009	D-13	65	NP	NP	NP	

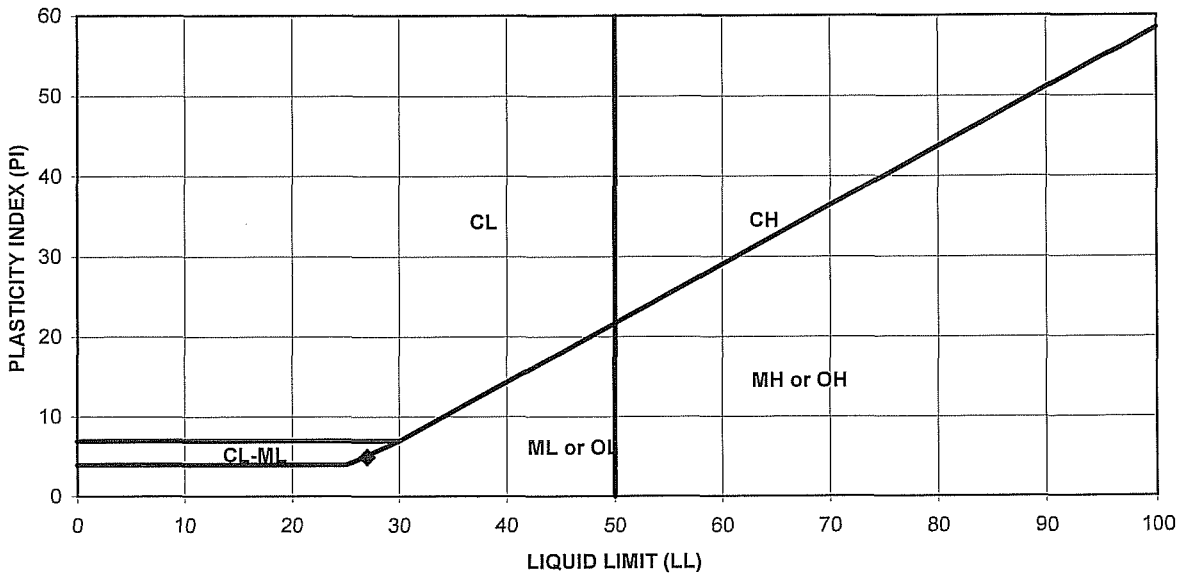
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

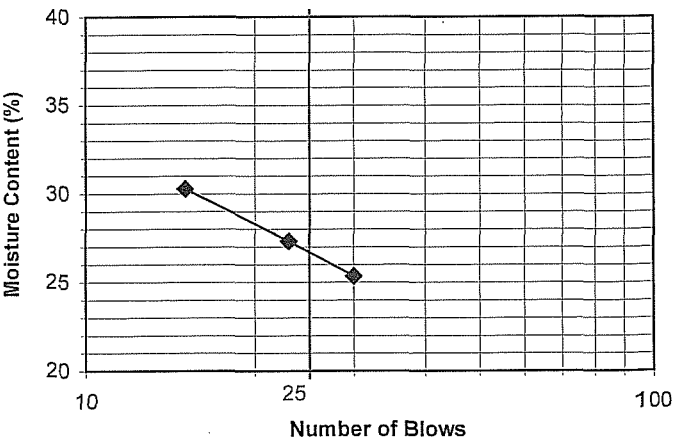
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/07/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	D-11	55	27	22	5	ML

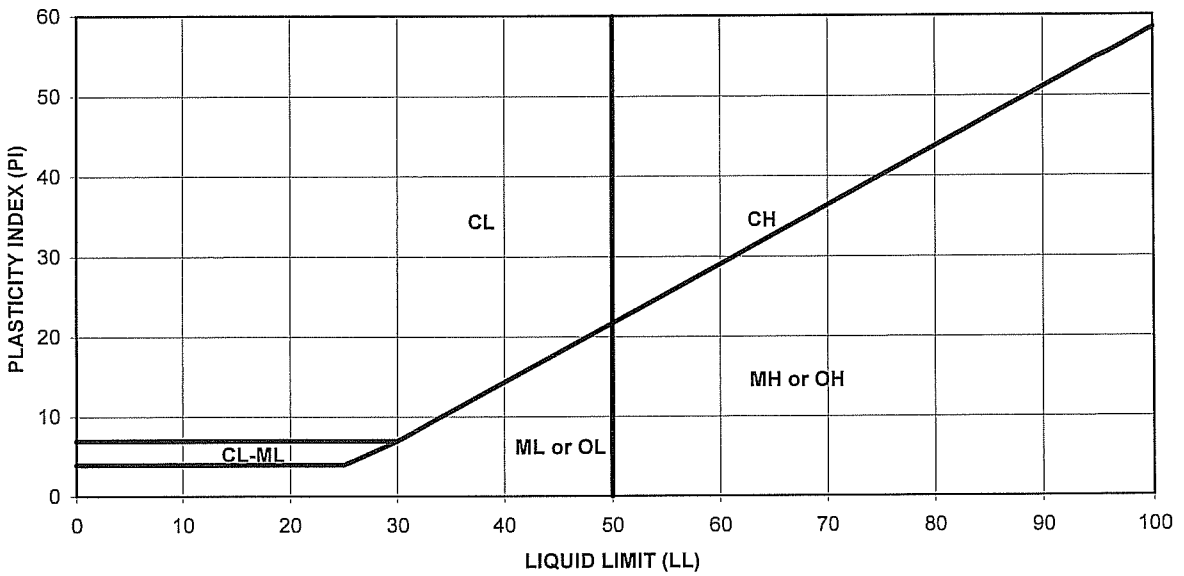
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

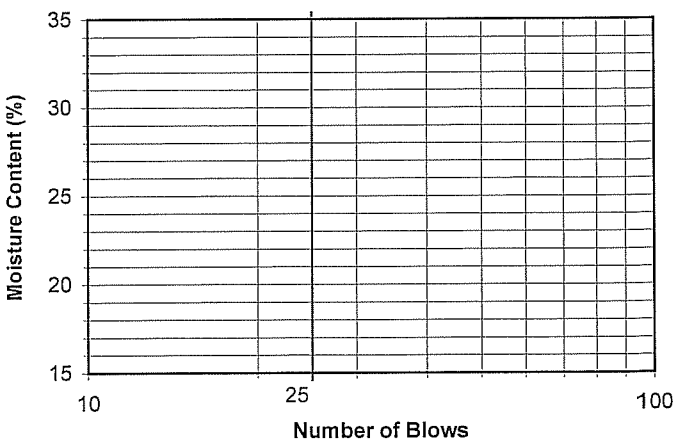
Tested By: WJO
Checked By: AP

Date: 12/01/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-009	S-14	70	NP	NP	NP	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/30/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/11/09

Project No. : 06-123-03 Checked By: AP Date: 12/11/09

BORING NUMBER	R-09-009					
SAMPLE NUMBER	U-09					
DEPTH (FT)	45					
SOIL CLASSIFICATION	Lean Clay with sand					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	387.65					
TEMPERATURE, °C	20.3					
CORRECTION FACTOR	0.9999					
WT. DRY SOIL, g	40.91					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.68**					

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/30/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-009	S-02	10	SP-SM	2200	7.4	116	152

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 11/22/09

Boring No.: R-09-009 Checked By: AP Date: 12/11/09

Sample No.: D-01 Depth (ft): 5

Description: Olive Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	558.28
Total Ring Weight (g)	139.33
Wet Density (pcf)	116.14
Dry Density (pcf)	93.31

Moisture Determination	Before Test	After Test
Cont. Weight (g)	49.87	195.04
Wet Soil+Cont. (g)	172.46	600.12
Dry Soil+Cont. (g)	148.37	508.61
Moisture Content (%)	24.5	29.2
Degree Saturation	78.4	97.7

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

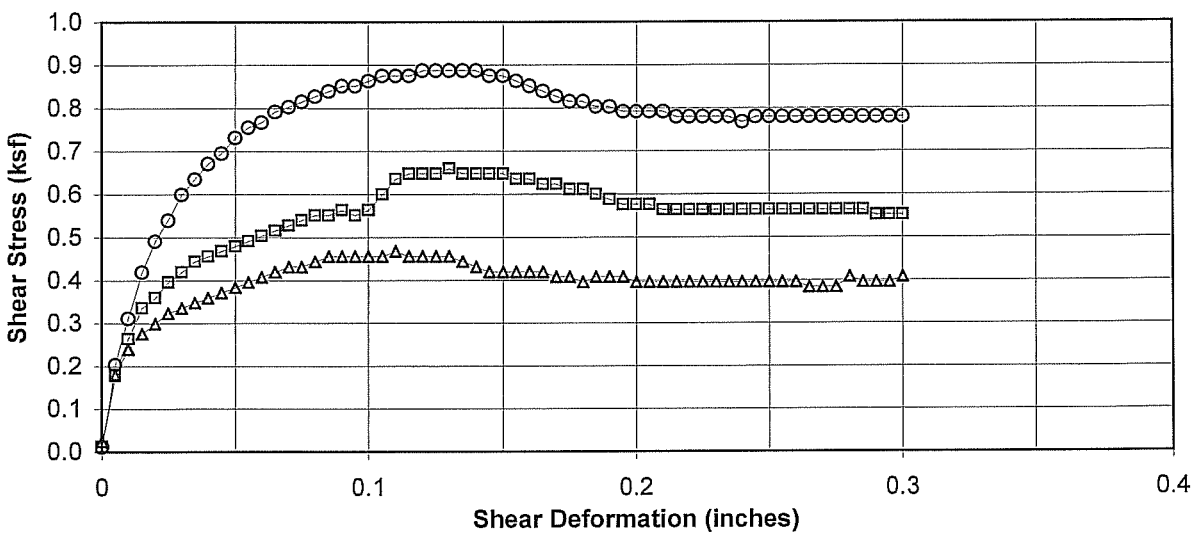
Shear Distance (in): **0.3**

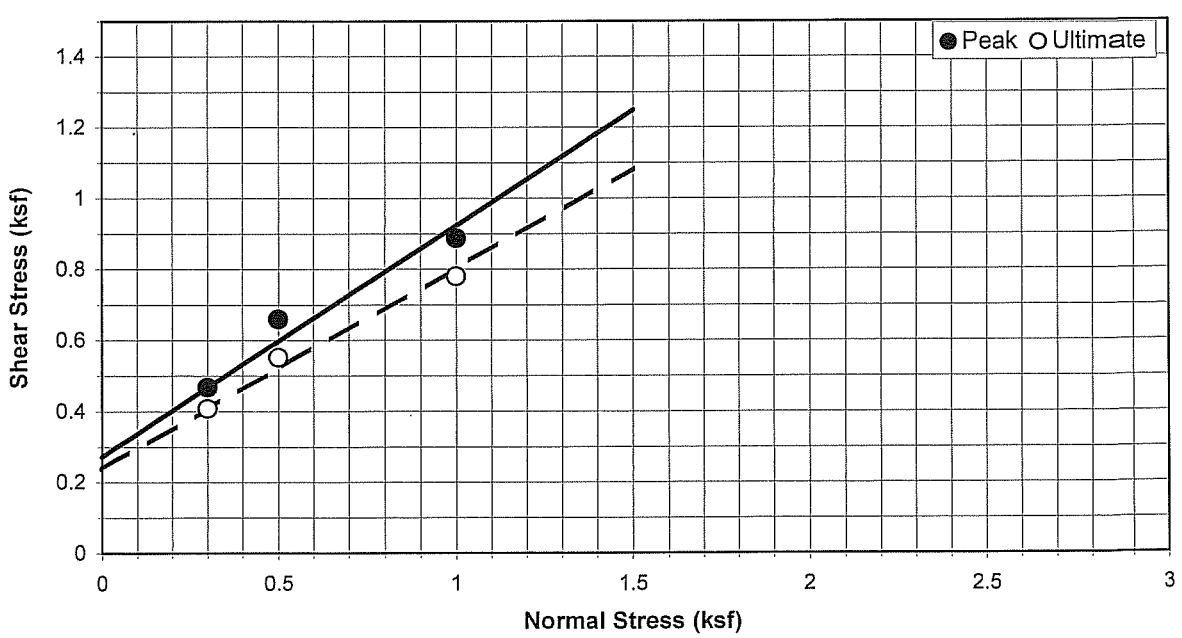
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**187.24**	**45.73**	**0.3**	**468**	**408**	
2	**185.57**	**46.01**	**0.5**	**660**	**552**	
3	**185.47**	**47.59**	**1.0**	**888**	**780**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.3	pcf
Boring No.:	R-09-009	Moisture Content (before):	24.5	%
Sample No.:	D-01	Moisture Content (after):	29.2	%
Depth (ft):	5			
Sample Type:	Cal. Mod.			
Soil Description:	Olive Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	250
Friction Angle:	33 °	29 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 11/22/09

Boring No.: R-09-009 Checked By: AP Date: 12/11/09

Sample No.: D-15 Depth (ft): 75

Description: Gray Poorly-Graded Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	590.70
Total Ring Weight (g)	130.88
Wet Density (pcf)	127.47
Dry Density (pcf)	104.77

Moisture Determination	Before Test	After Test
Cont. Weight (g)	49.48	191.28
Wet Soil+Cont. (g)	206.21	623.91
Dry Soil+Cont. (g)	178.30	540.24
Moisture Content (%)	21.7	24.0
Degree Saturation	90.7	103.2

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

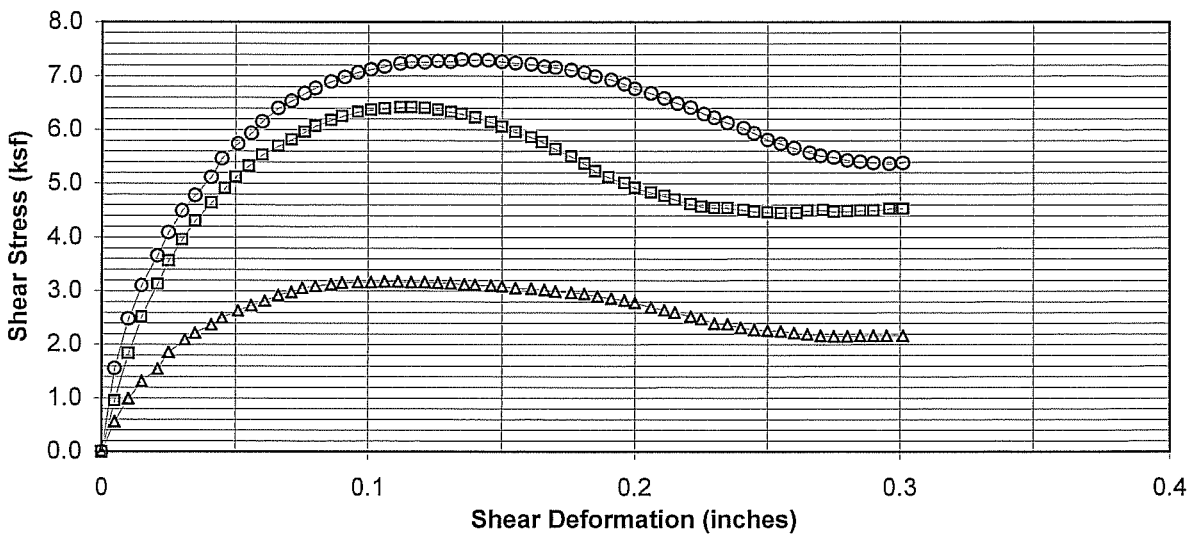
Shear Distance (in): **0.3**

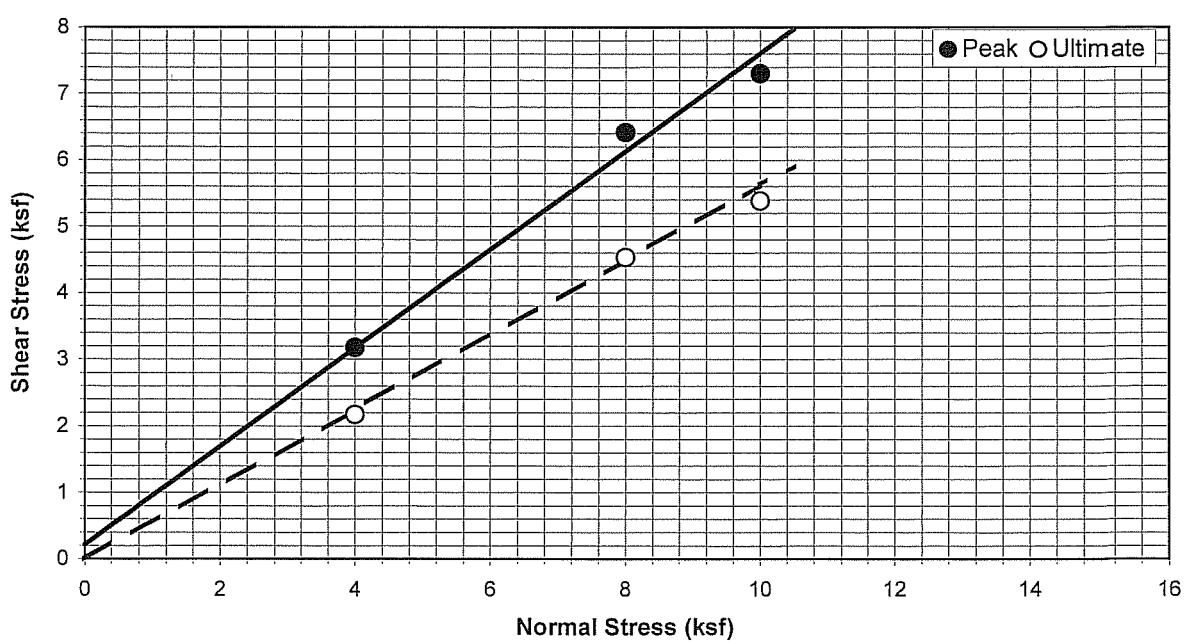
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**196.88**	**44.13**	**4.0**	**3180**	**2172**	
2	**196.90**	**43.86**	**8.0**	**6419**	**4536**	
3	**196.92**	**42.89**	**10.0**	**7307**	**5388**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	104.8	pcf
Boring No.:	R-09-009	Moisture Content (before):	21.7	%
Sample No.:	D-15	Moisture Content (after):	24.0	%
Depth (ft):	75			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	200	0
Friction Angle:	36 °	29 °

AP Engineering & Testing, Inc.

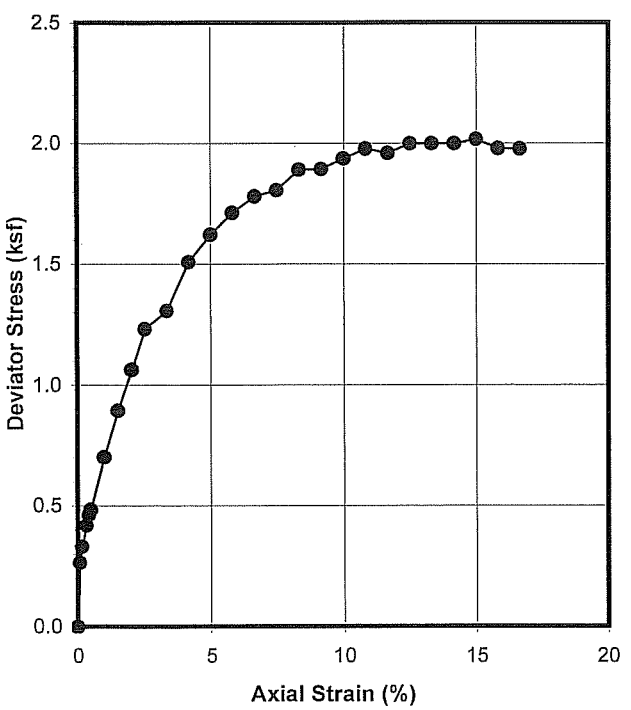
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-009				
Sample No.:	U-09	Depth (feet): 45			
Soil Description	Gray Lean Clay w/sand and shell fragments		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	118.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	89.1
Sample Weight (gms):	1216.40	Moisture Content (%):	33.5
Wt. Wet Soil+Container(gms)	1327.82	Void Ratio for Gs=2.7:	0.89
Wt. Dry Soil+Container(gms)	1020.96	% Saturation:	101.4
Wt. Container (gms)	104.89		

TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	2.0
Ultimate Deviator Stress (ksf):	2.0
Ultimate Undrained Shear Strength (ksf):	1.0
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
15	0.010	6.50	0.33	0.17
19	0.020	6.51	0.42	0.33
21	0.025	6.52	0.46	0.42
22	0.030	6.52	0.49	0.50
32	0.060	6.56	0.70	1.00
41	0.090	6.59	0.90	1.50
49	0.120	6.62	1.07	2.00
57	0.150	6.66	1.23	2.50
61	0.200	6.72	1.31	3.33
71	0.250	6.77	1.51	4.17
77	0.300	6.83	1.62	5.00
82	0.350	6.89	1.71	5.83
86	0.400	6.96	1.78	6.67
88	0.450	7.02	1.81	7.50
93	0.500	7.08	1.89	8.33
94	0.550	7.15	1.89	9.17
97	0.600	7.21	1.94	10.00
100	0.650	7.28	1.98	10.83
100	0.700	7.35	1.96	11.67
103	0.750	7.42	2.00	12.50
104	0.800	7.49	2.00	13.33
105	0.850	7.56	2.00	14.17
107	0.900	7.64	2.02	15.00
106	0.950	7.71	1.98	15.83
107	1.000	7.79	1.98	16.67

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/01/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-011	D-02	10	27.2	91.4
R-09-011	D-04	20	26.6	97.2
R-09-011	S-07	35	39.1	NA
R-09-011	D-08	40	35.1	87.9
R-09-011	D-10	50	39.8	78.5
R-09-011	S-11	55	38.8	NA
R-09-011	S-13	65	32.2	NA
R-09-011	S-15	75	21.8	NA
R-09-011	D-16	80	28.9	97.1
R-09-011	S-19	110	22.1	NA
R-09-011	S-23	150	18.7	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-011	D-10	50	0.50
R-09-011	U-14	70	3.25

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03
Laboratory No.: 29-1121
Date: 12/04/09

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-011	D-02	10	6.60
R-09-011	D-04	20	4.17
R-09-011	U-06	30	23.02

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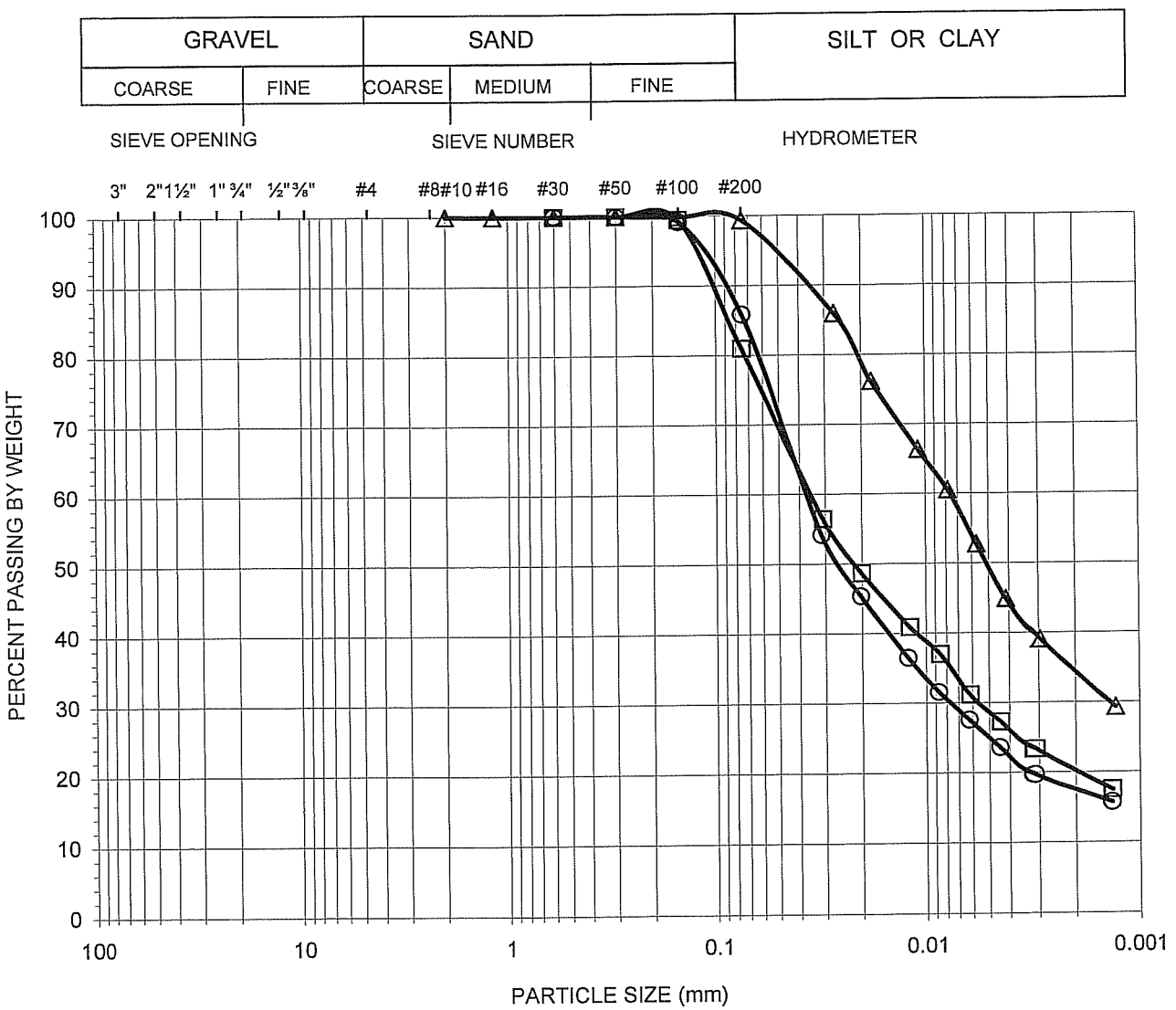
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

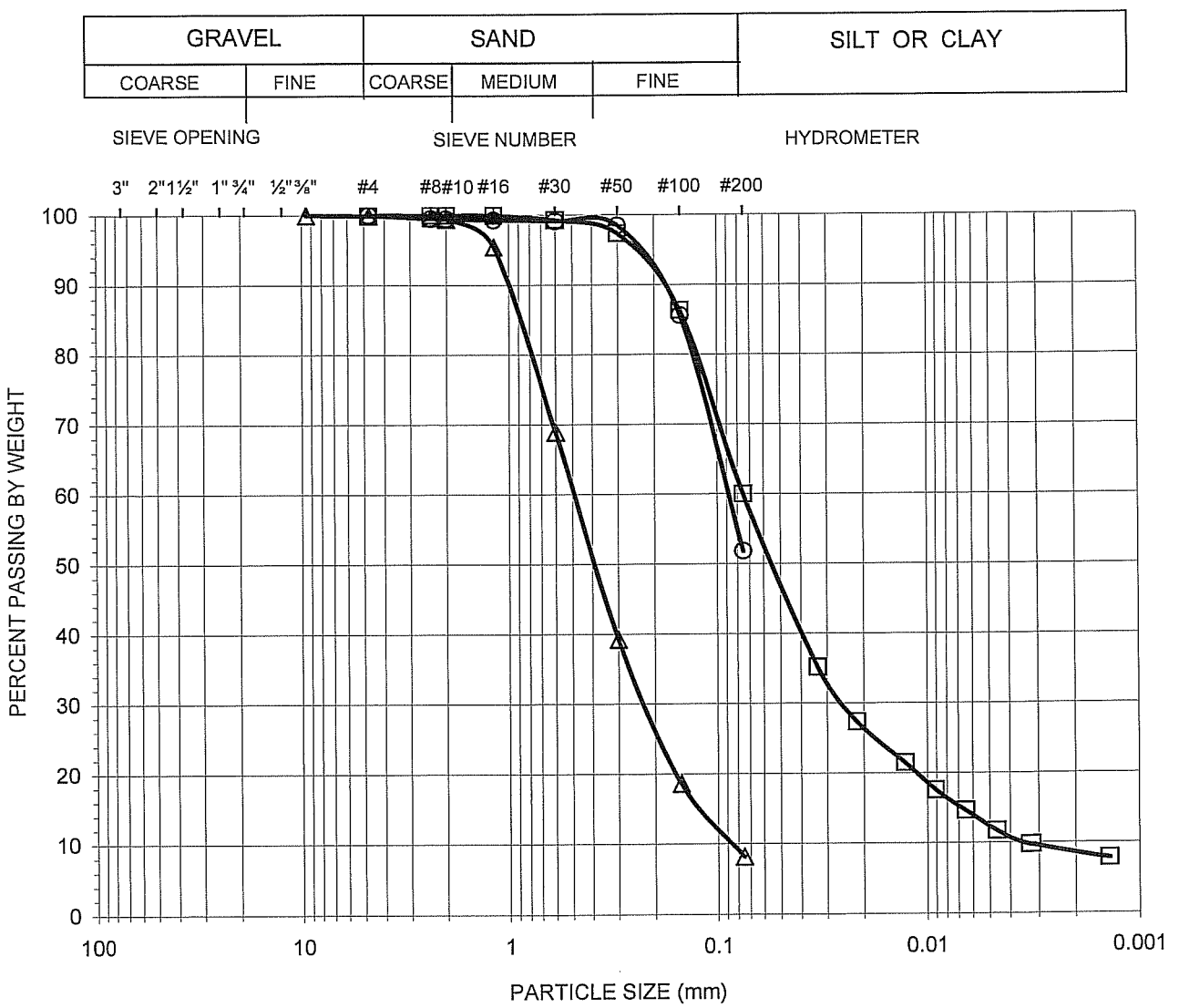


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-07	35	0.00	14.12	85.88	29:23:6	CL-ML
□	R-09-011	D-08	40	0.00	19.09	80.91	29:22:7	CL-ML
△	R-09-011	D-10	50	0.00	0.65	99.35	51:23:28	CH

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

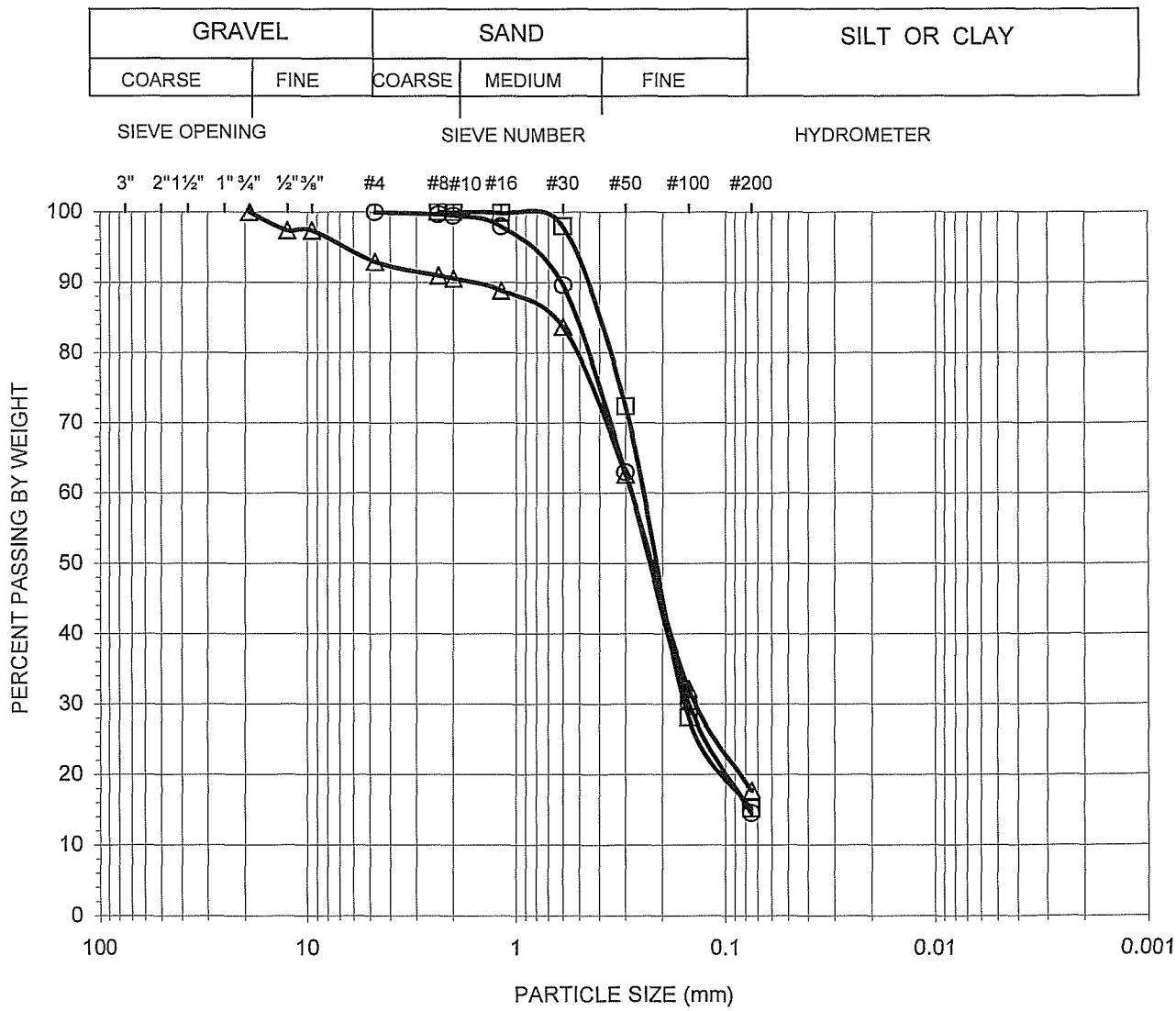


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	D-12	60	0.00	48.16	51.84	N/A	ML
□	R-09-011	U-14	70	0.00	40.02	59.98	N/P	ML
△	R-09-011	S-15	75	0.07	91.69	8.24	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



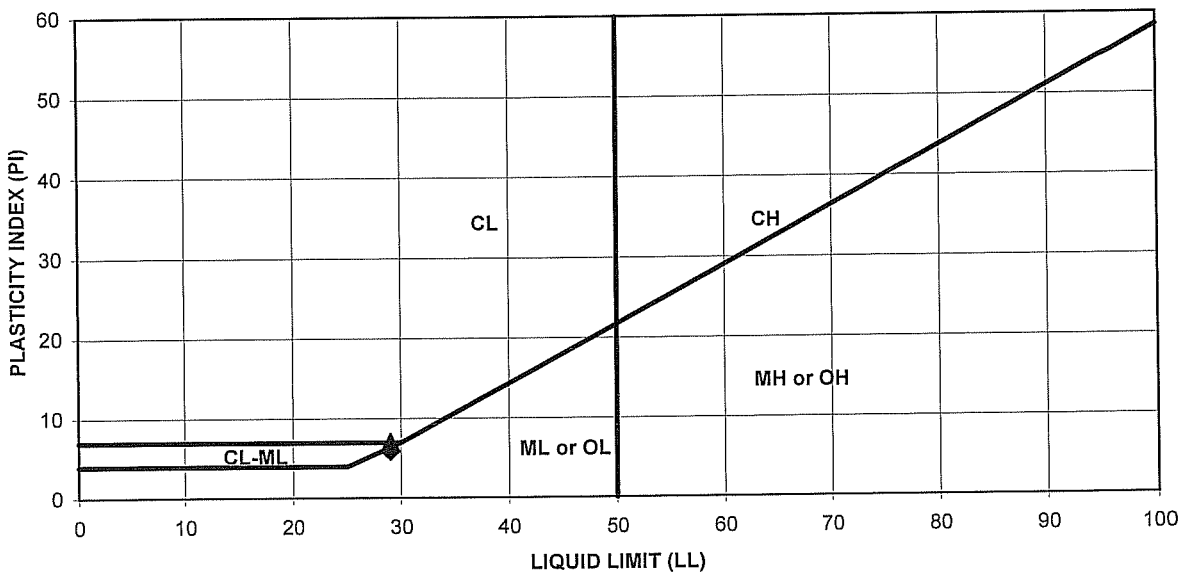
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-17	90	0.00	85.42	14.58	N/A	SM
□	R-09-011	S-19	110	0.00	84.84	15.16	N/A	SM
△	R-09-011	S-23	150	7.02	75.27	17.71	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

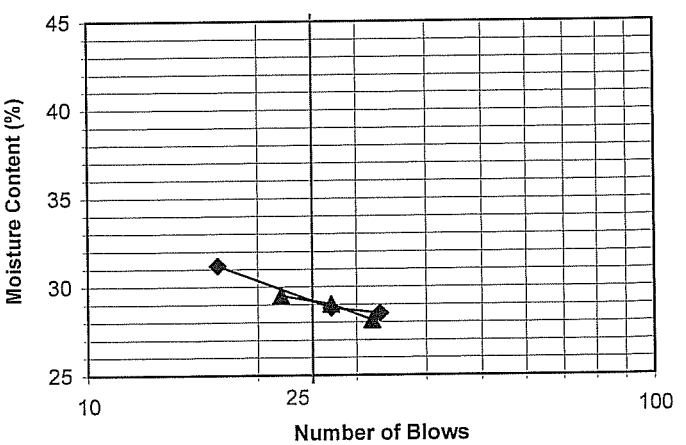
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-011	S-07	35	29	23	6	CL-ML
▲	R-09-011	D-08	40	29	22	7	CL-ML

* NP denotes "non-plastic"

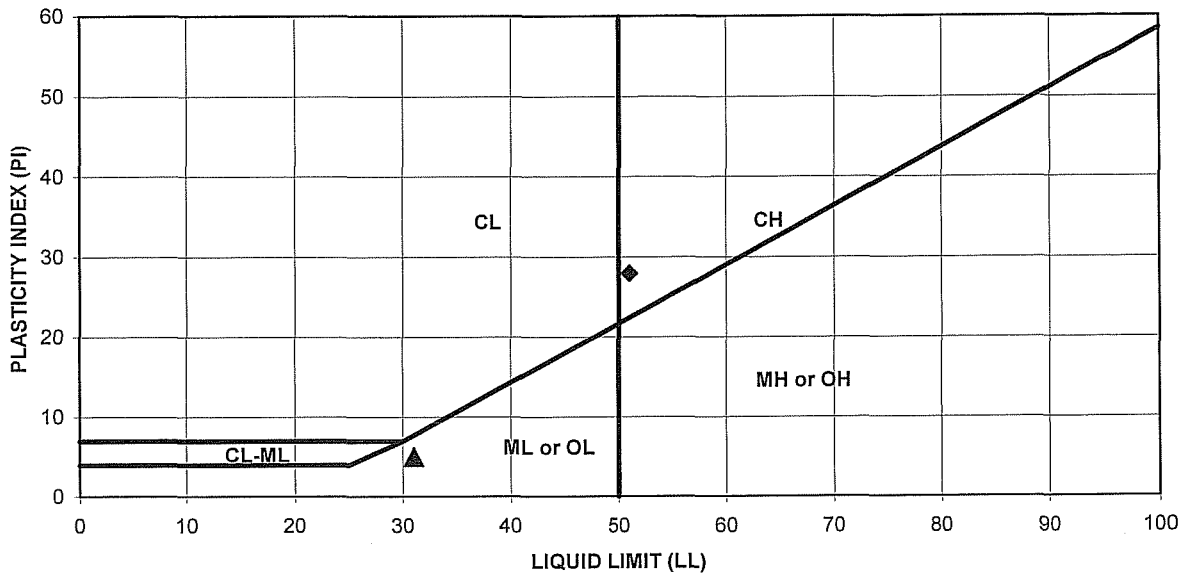
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

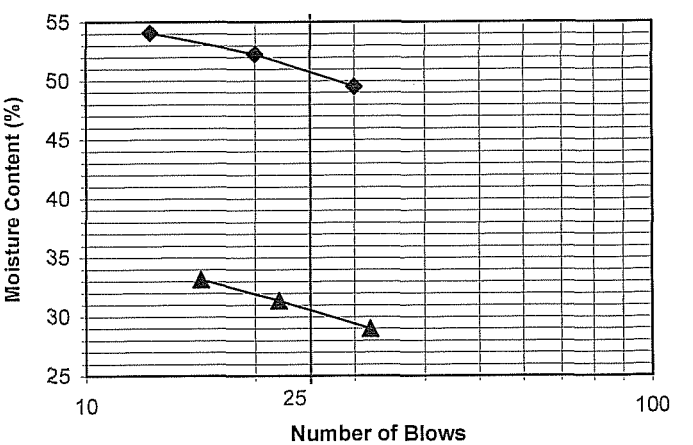
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-011	D-10	50	51	23	28	CH
▲	R-09-011	S-11	55	31	26	5	ML

* NP denotes "non-plastic"

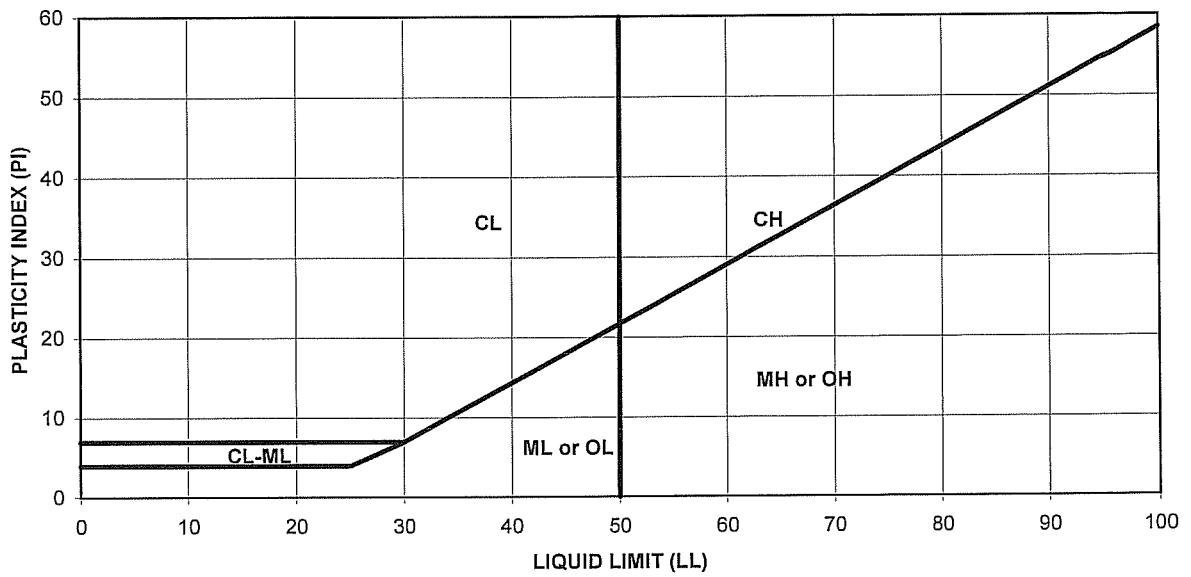
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

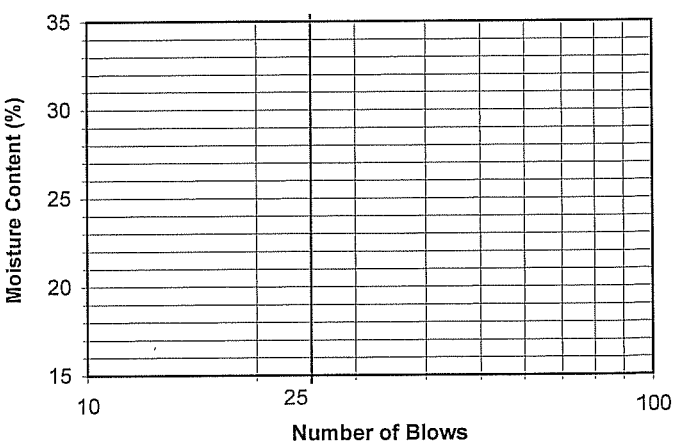
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-011	S-13	65	NP	NP	NP	
	R-09-011	U-14	70	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/30/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-011	S-03	15	SP-SM	200	7.5	514	568

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/11/09

Project No. : 06-123-03 Checked By: AP Date: 12/11/09

BORING NUMBER	R-09-011					
SAMPLE NUMBER	U-14					
DEPTH (FT)	70					
SOIL CLASSIFICATION	Sandy Silt					
METHOD (A OR B)	B					
FLASK NUMBER	2					
WT. FLASK+WATER+SOIL, g	368.25					
TEMPERATURE, °C	19.8					
CORRECTION FACTOR	1.0000					
WT. DRY SOIL, g	46.78					
WT. FLASK + WATER, g	249.30					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.69**					

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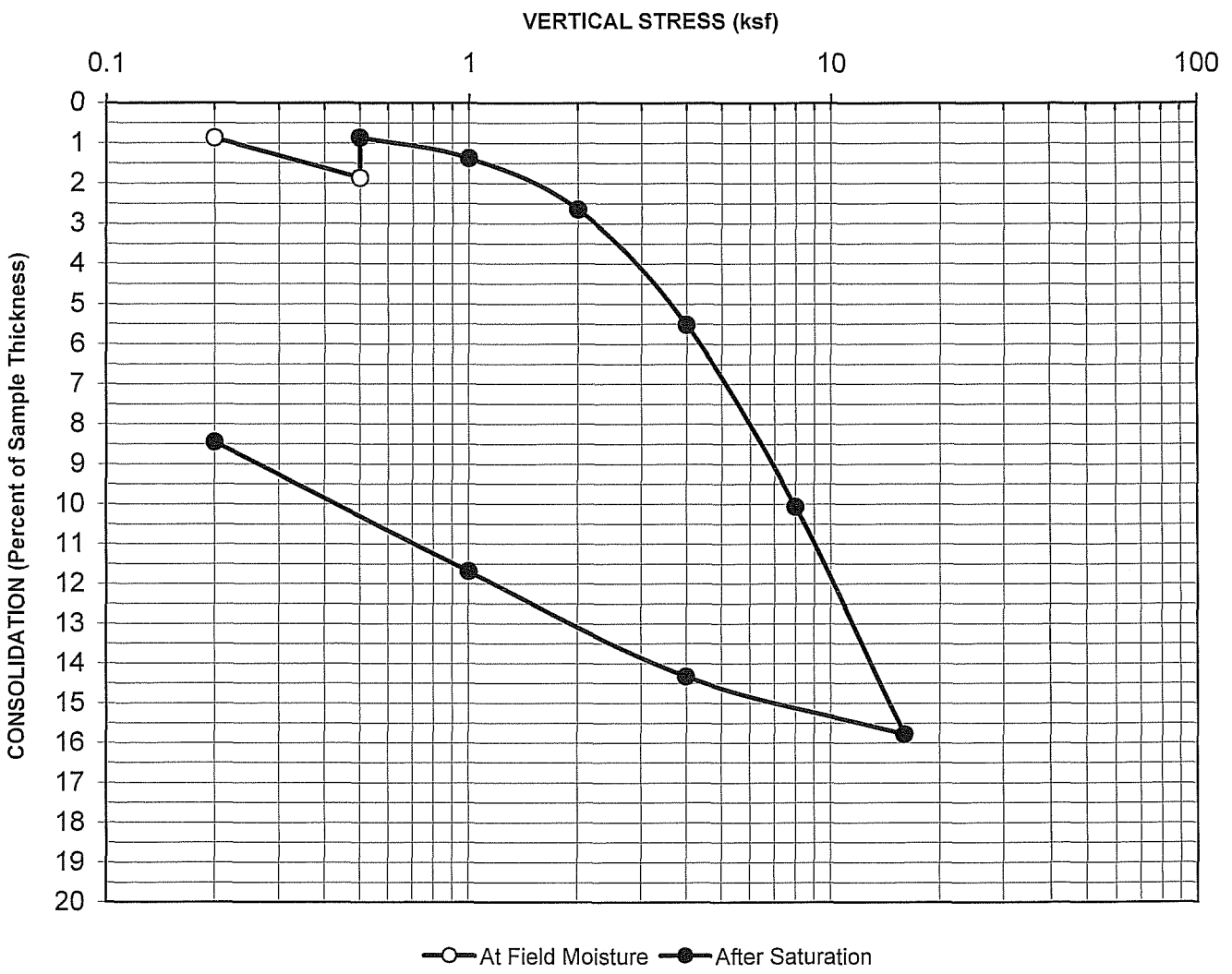
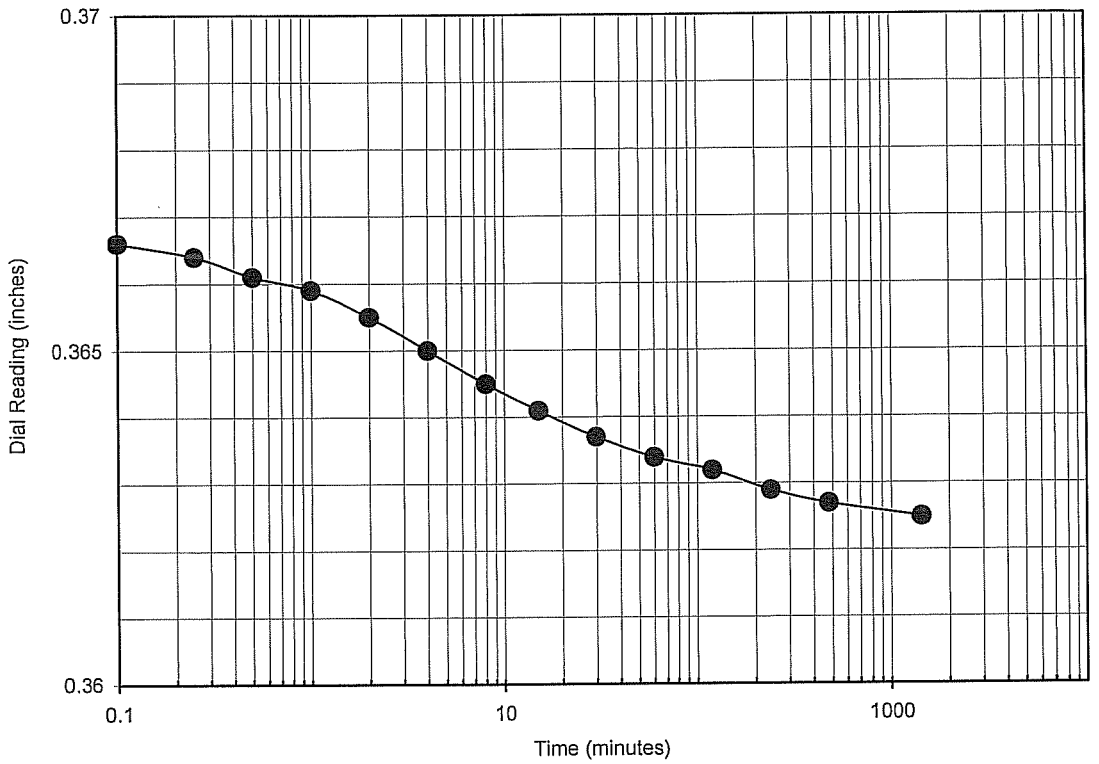


Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	77.3
Sample No.:	D-10	Initial Moisture Content (%):	39.8
Depth (feet):	50	Final Moisture Content (%):	39.1
Sample Type:	Mod. Cal.	Assumed Specific Gravity:	2.7
Soil Description:	Fat Clay	Initial Void Ratio:	1.18
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

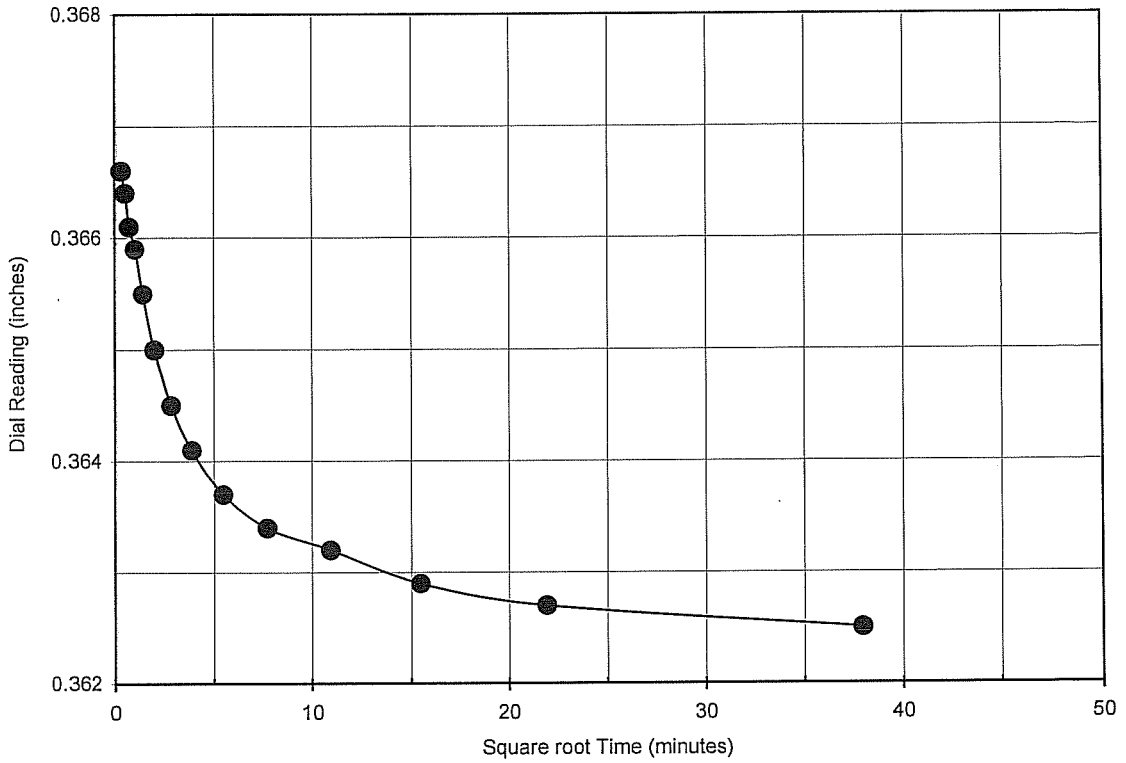


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3666
0.25	0.3664
0.5	0.3661
1	0.3659
2	0.3655
4	0.365
8	0.3645
15	0.3641
30	0.3637
60	0.3634
120	0.3632
240	0.3629
480	0.3627
1440	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

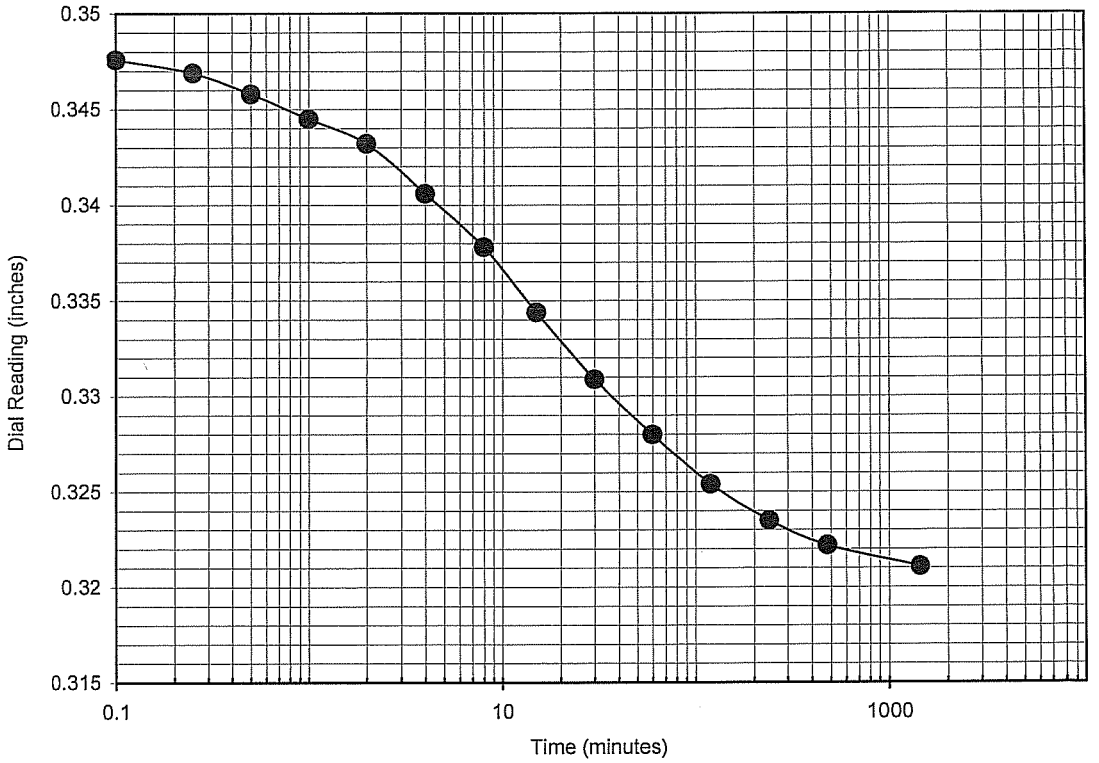


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3666
0.5000	0.3664
0.7071	0.3661
1.0000	0.3659
1.4142	0.3655
2.0000	0.3650
2.8284	0.3645
3.8730	0.3641
5.4772	0.3637
7.7460	0.3634
10.9545	0.3632
15.4919	0.3629
21.9089	0.3627
37.9473	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

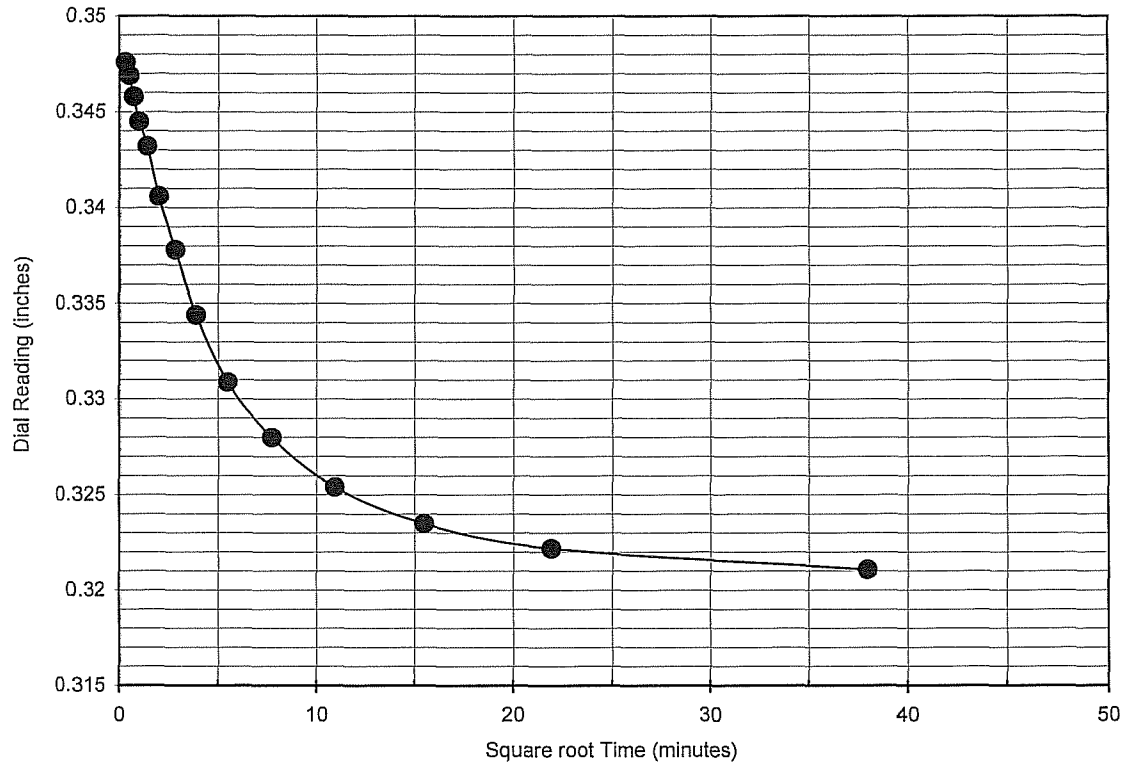


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3476
0.25	0.3469
0.5	0.3458
1	0.3445
2	0.3432
4	0.3406
8	0.3378
15	0.3344
30	0.3309
60	0.328
120	0.3254
240	0.3235
480	0.3222
1440	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3476
0.5000	0.3469
0.7071	0.3458
1.0000	0.3445
1.4142	0.3432
2.0000	0.3406
2.8284	0.3378
3.8730	0.3344
5.4772	0.3309
7.7460	0.3280
10.9545	0.3254
15.4919	0.3235
21.9089	0.3222
37.9473	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/01/09

Boring No.: R-09-011 Checked By: AP Date: 12/11/09

Sample No.: D-02 Depth (ft): 10

Description: Gray Poorly-Graded Sand w/ silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	554.38
Total Ring Weight (g)	126.64
Wet Density (pcf)	118.57
Dry Density (pcf)	93.24

Moisture Determination	Before Test	After Test
Cont. Weight (g)	194.13	104.46
Wet Soil+Cont. (g)	478.24	511.68
Dry Soil+Cont. (g)	417.54	416.03
Moisture Content (%)	27.2	30.7
Degree Saturation	87.0	100.3

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

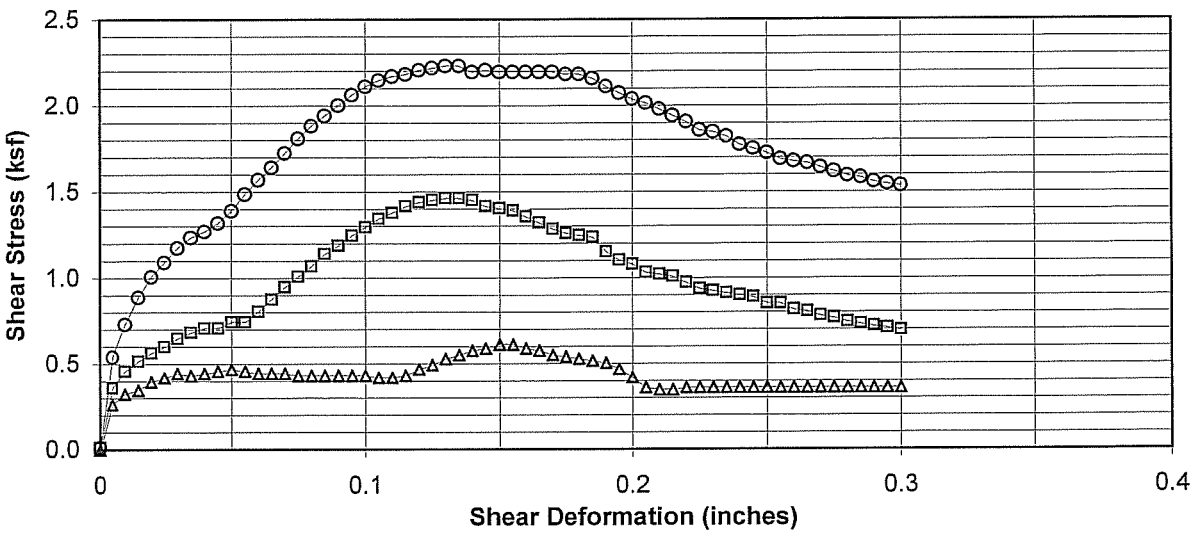
Shear Distance (in): **0.3**

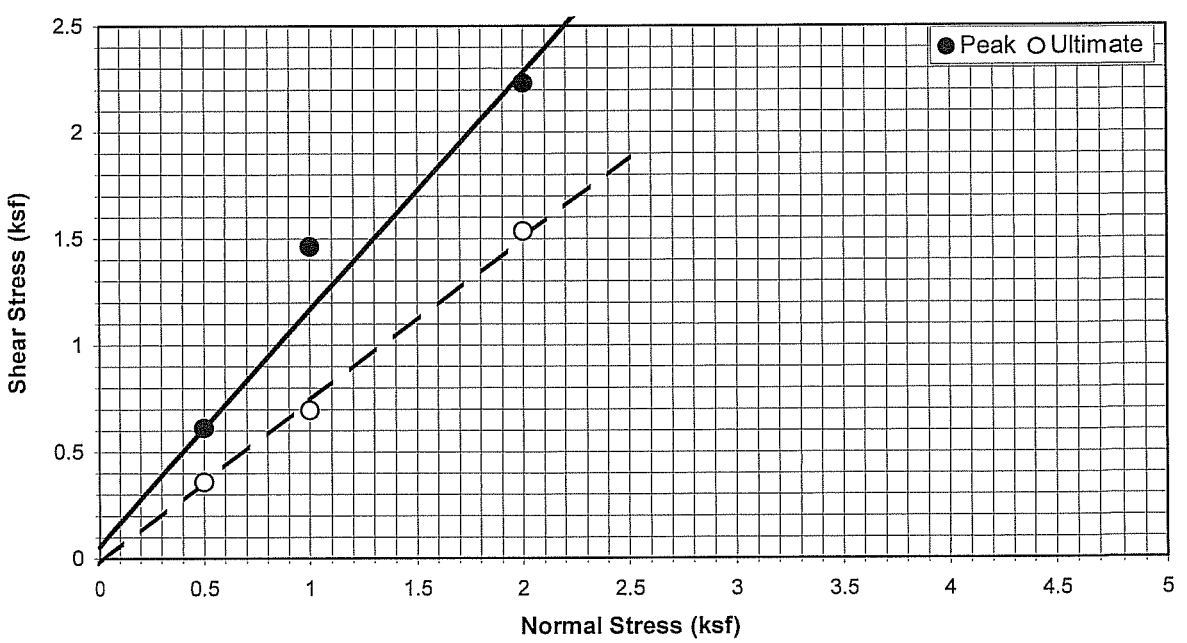
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**187.49**	**42.13**	**0.5**	**612**	**360**	
2	**184.75**	**42.70**	**1.0**	**1464**	**696**	
3	**182.14**	**41.81**	**2.0**	**2232**	**1536**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.2	pcf
Boring No.:	R-09-011	Moisture Content (before):	27.2	%
Sample No.:	D-02	Moisture Content (after):	30.7	%
Depth (ft):	10			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/ silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	48 °	37 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/01/09

Boring No.: R-09-011 Checked By: AP Date: 12/11/09

Sample No.: D-12 Depth (ft): 60

Description: Gray Sandy Silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	586.40
Total Ring Weight (g)	131.26
Wet Density (pcf)	126.17
Dry Density (pcf)	97.30

Moisture Determination	Before Test	After Test
Cont. Weight (g)	198.19	104.12
Wet Soil+Cont. (g)	480.64	542.99
Dry Soil+Cont. (g)	416.01	448.93
Moisture Content (%)	29.7	27.3
Degree Saturation	104.3	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

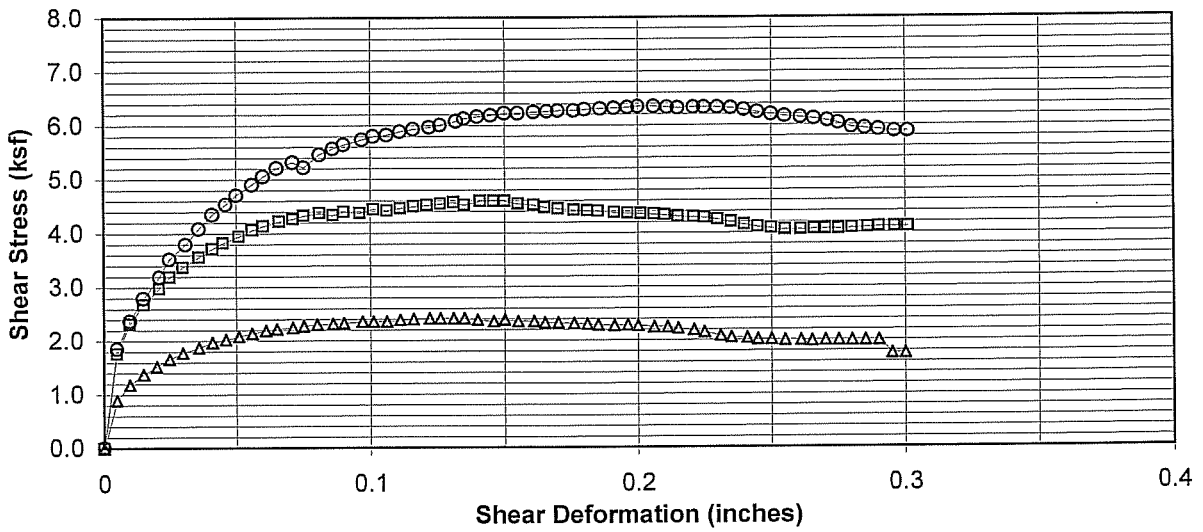
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

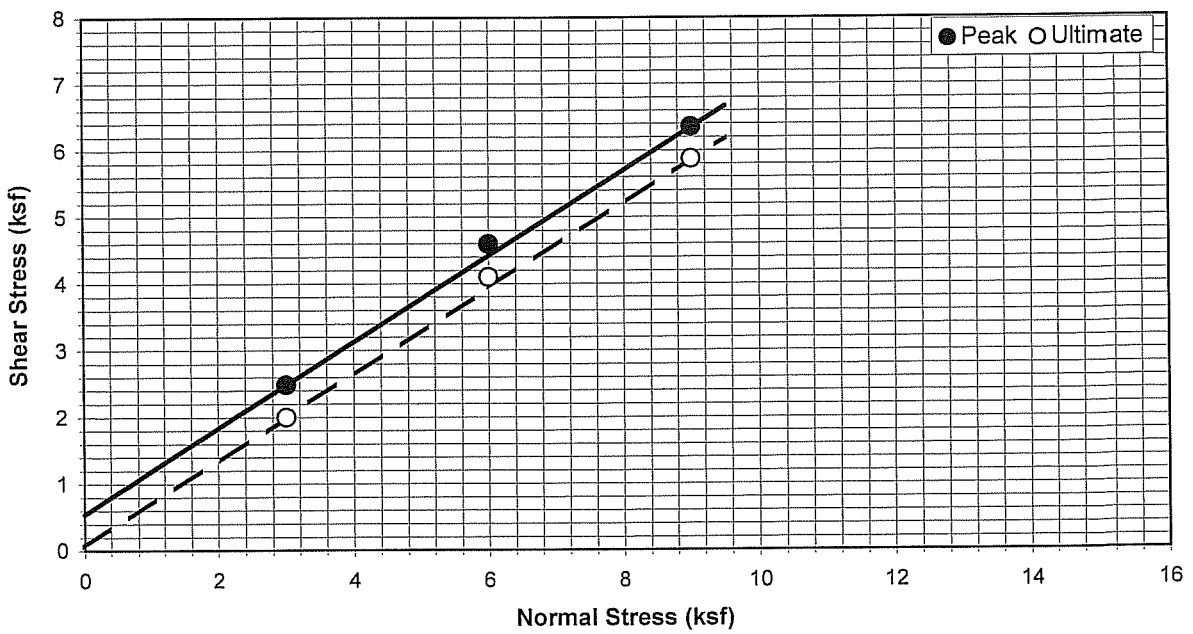
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**197.56**	**43.02**	**3.0**	**2487**	**2003**	
2	**196.67**	**44.97**	**6.0**	**4596**	**4104**	
3	**192.17**	**43.27**	**9.0**	**6359**	**5879**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

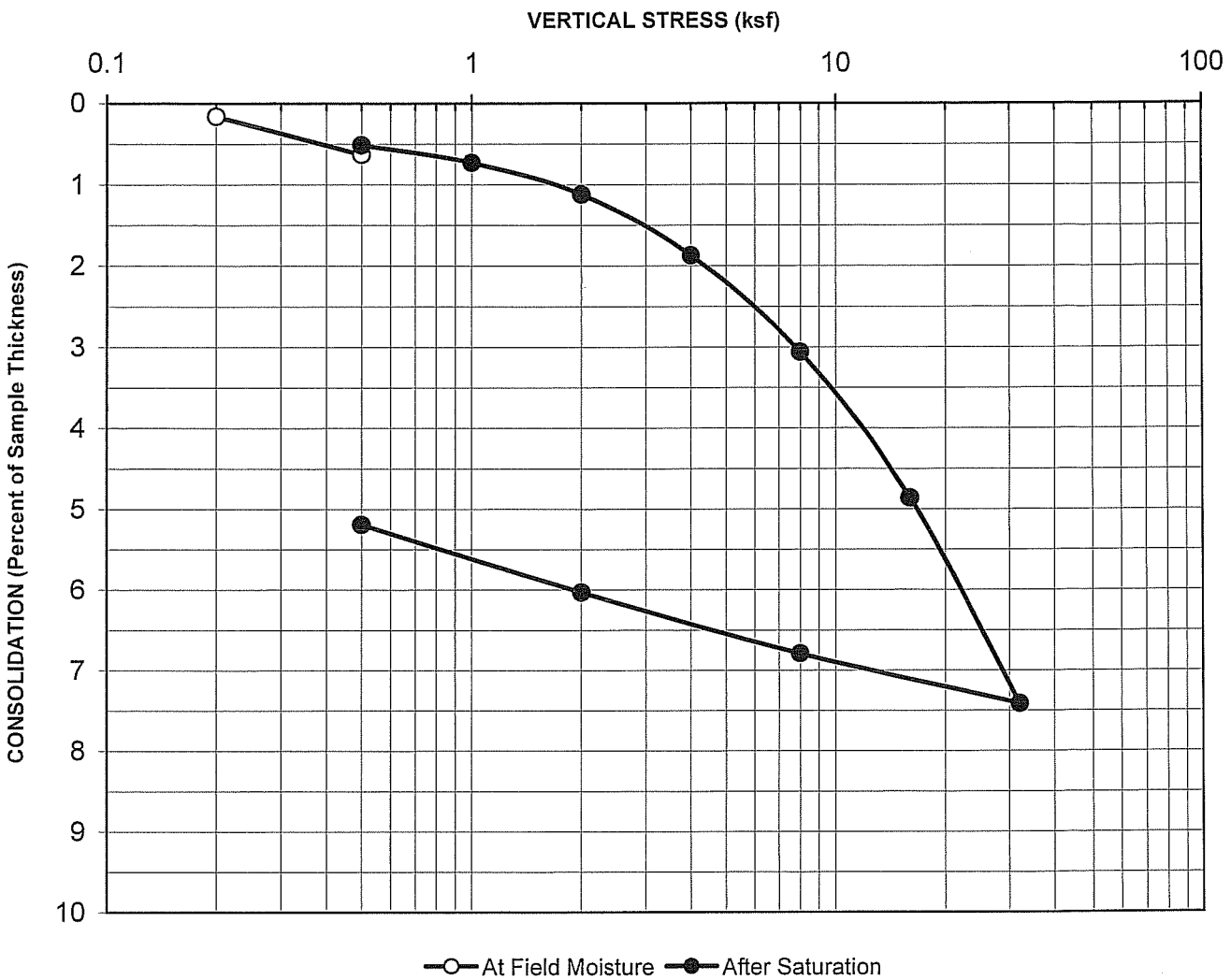
Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	97.3	pcf
Boring No.:	R-09-011	Moisture Content (before):	29.7	%
Sample No.:	D-12	Moisture Content (after):	27.3	%
Depth (ft):	60			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	550	50
Friction Angle:	33 °	33 °

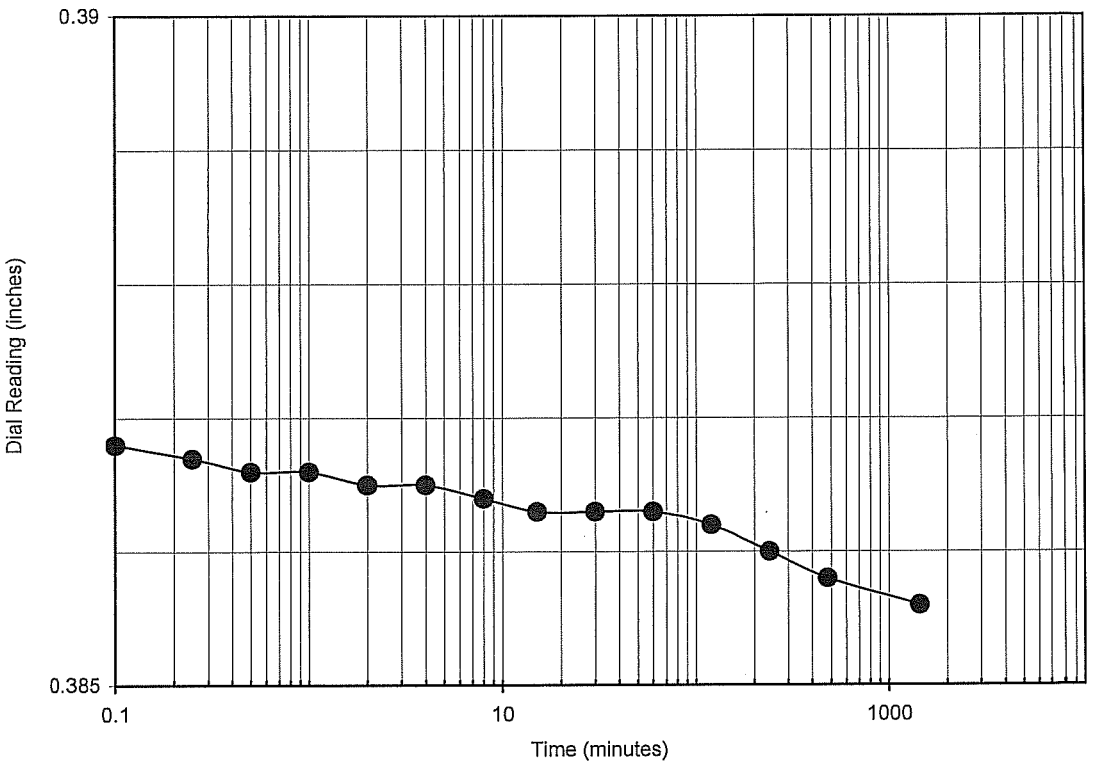
AP Engineering & Testing, Inc.



Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	104.2
Sample No.:	U-14	Initial Moisture Content (%):	22.0
Depth (feet):	70	Final Moisture Content (%):	20.4
Sample Type:	Shelby	Assumed Specific Gravity:	2.7
Soil Description:	Sandy Silt	Initial Void Ratio:	0.62
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

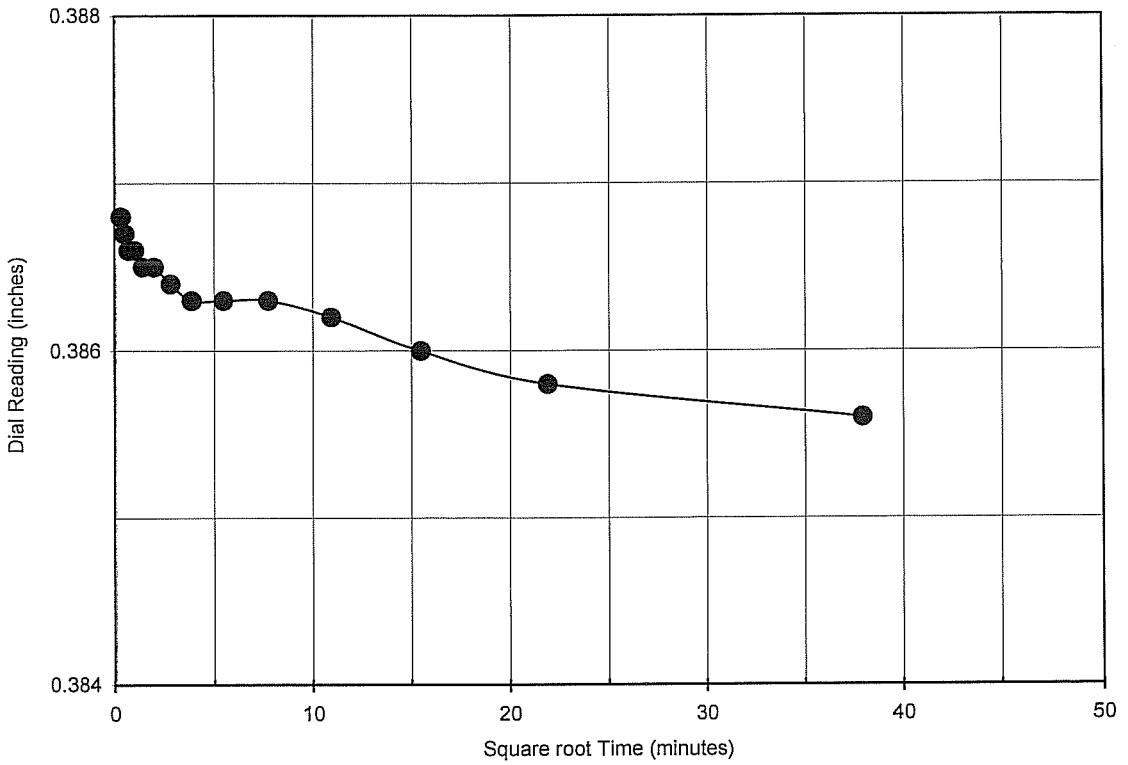


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3868
0.25	0.3867
0.5	0.3866
1	0.3866
2	0.3865
4	0.3865
8	0.3864
15	0.3863
30	0.3863
60	0.3863
120	0.3862
240	0.386
480	0.3858
1440	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

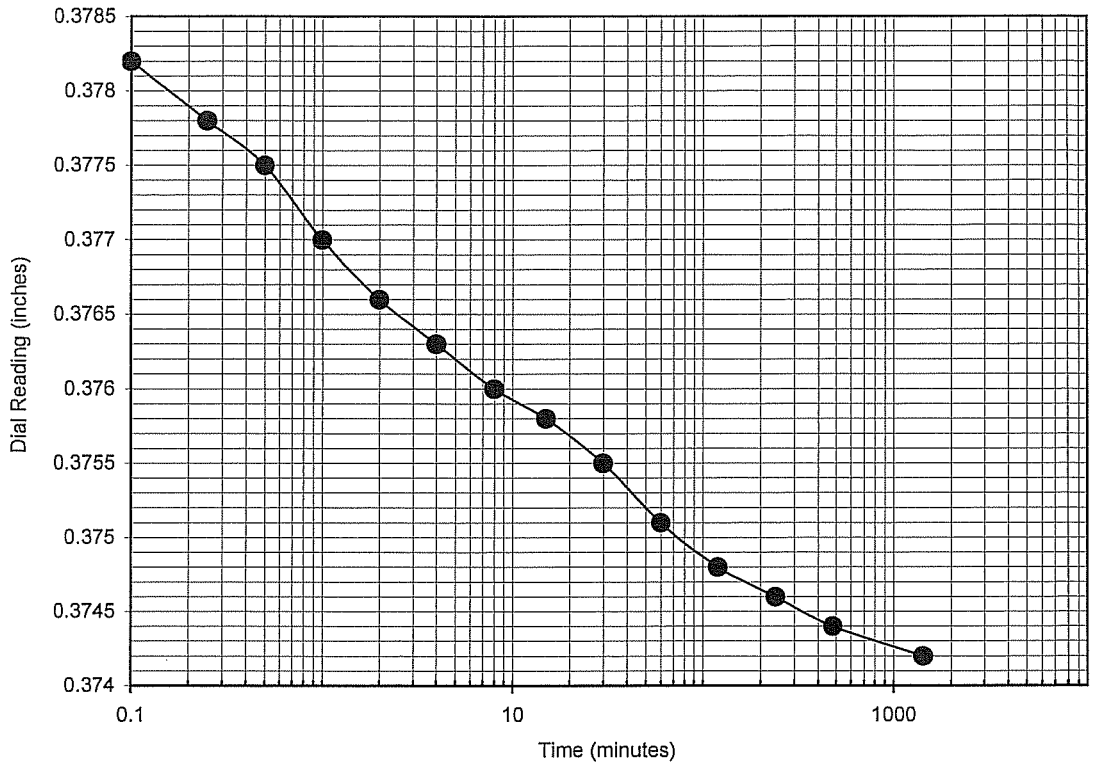


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3868
0.5000	0.3867
0.7071	0.3866
1.0000	0.3866
1.4142	0.3865
2.0000	0.3865
2.8284	0.3864
3.8730	0.3863
5.4772	0.3863
7.7460	0.3863
10.9545	0.3862
15.4919	0.3860
21.9089	0.3858
37.9473	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

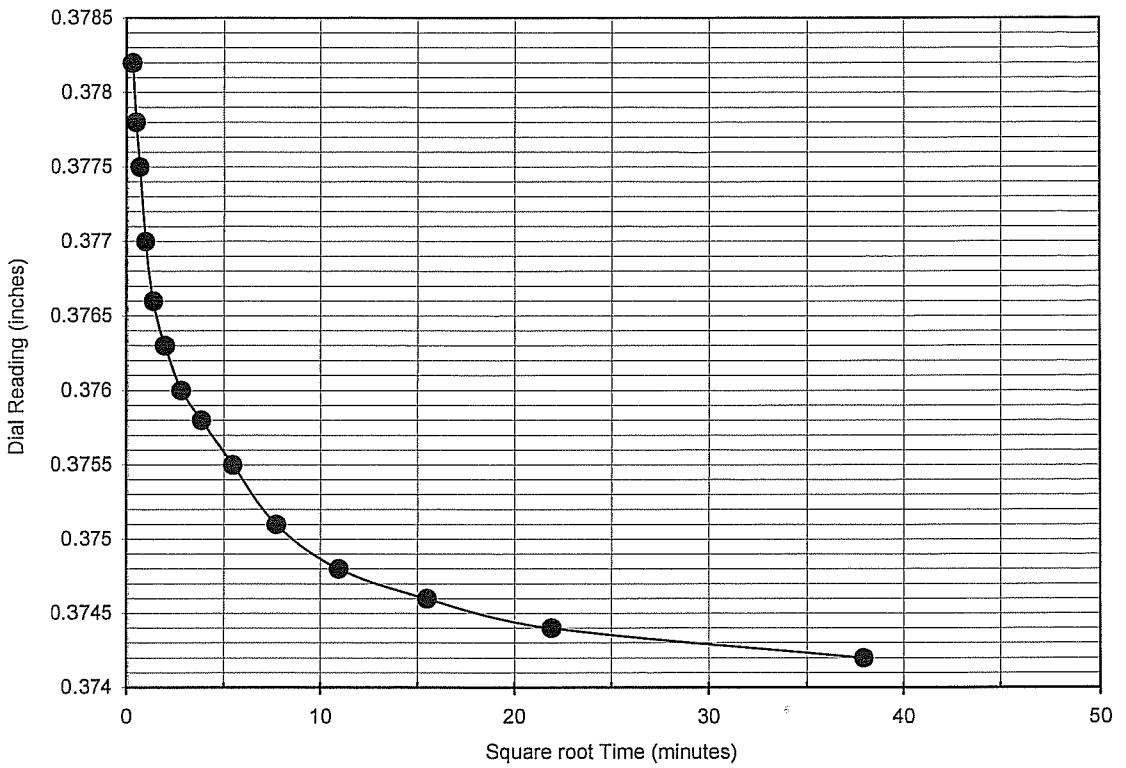


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3782
0.25	0.3778
0.5	0.3775
1	0.377
2	0.3766
4	0.3763
8	0.376
15	0.3758
30	0.3755
60	0.3751
120	0.3748
240	0.3746
480	0.3744
1440	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3782
0.5000	0.3778
0.7071	0.3775
1.0000	0.3770
1.4142	0.3766
2.0000	0.3763
2.8284	0.3760
3.8730	0.3758
5.4772	0.3755
7.7460	0.3751
10.9545	0.3748
15.4919	0.3746
21.9089	0.3744
37.9473	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

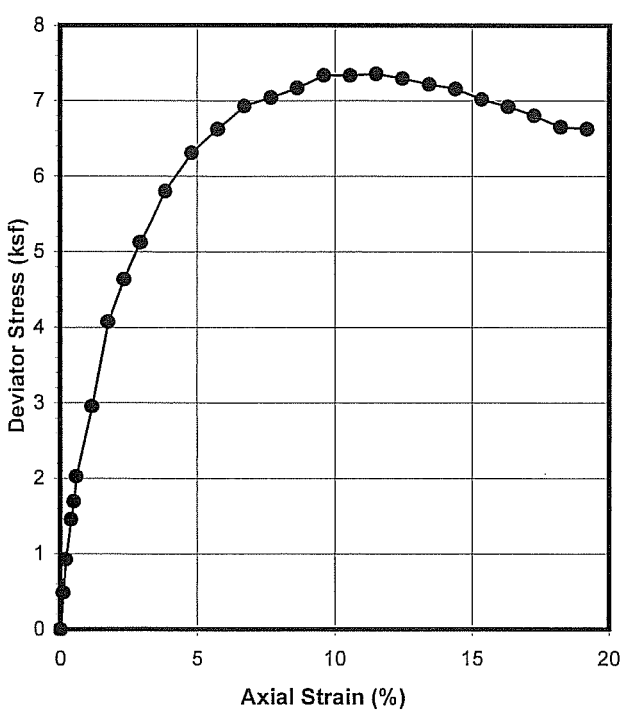
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/12/09
Project No.:	06-123-03		
Boring No.:	R-09-011		
Sample No.:	U-14 Depth (feet): 70		
Soil Description	Gray Sandy Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	129.4
Sample Hieght (inch):	5.2	Dry Unit Weight (pcf):	106.1
Sample Weight (gms):	1149.87	Moisture Content (%):	22.0
Wt. Wet Soil+Container(gms)	1310.19	Void Ratio for Gs=2.7:	0.59
Wt. Dry Soil+Container(gms)	1101.86	% Saturation:	101.0
Wt. Container (gms)	154.83		

TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	7.4
Ultimate Deviator Stress (ksf):	6.9
Ultimate Undrained Shear Strength (ksf):	3.5
Axial Strain @ Maximum Stress (%)	11.52



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
22	0.005	6.50	0.49	0.10
42	0.010	6.50	0.93	0.19
66	0.020	6.52	1.46	0.38
77	0.025	6.52	1.70	0.48
92	0.030	6.53	2.03	0.58
135	0.060	6.57	2.96	1.15
187	0.090	6.61	4.08	1.73
214	0.120	6.64	4.64	2.30
238	0.150	6.68	5.13	2.88
272	0.200	6.75	5.80	3.84
299	0.250	6.82	6.31	4.80
317	0.300	6.89	6.63	5.76
335	0.350	6.96	6.93	6.72
344	0.400	7.03	7.04	7.68
354	0.450	7.11	7.17	8.64
366	0.500	7.18	7.34	9.60
370	0.550	7.26	7.34	10.56
375	0.600	7.34	7.36	11.52
376	0.650	7.42	7.30	12.48
376	0.700	7.50	7.22	13.44
377	0.750	7.58	7.16	14.40
374	0.800	7.67	7.02	15.36
373	0.850	7.76	6.92	16.31
371	0.900	7.85	6.81	17.27
367	0.950	7.94	6.66	18.23
370	1.000	8.03	6.63	19.19

APPENDIX E.

SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

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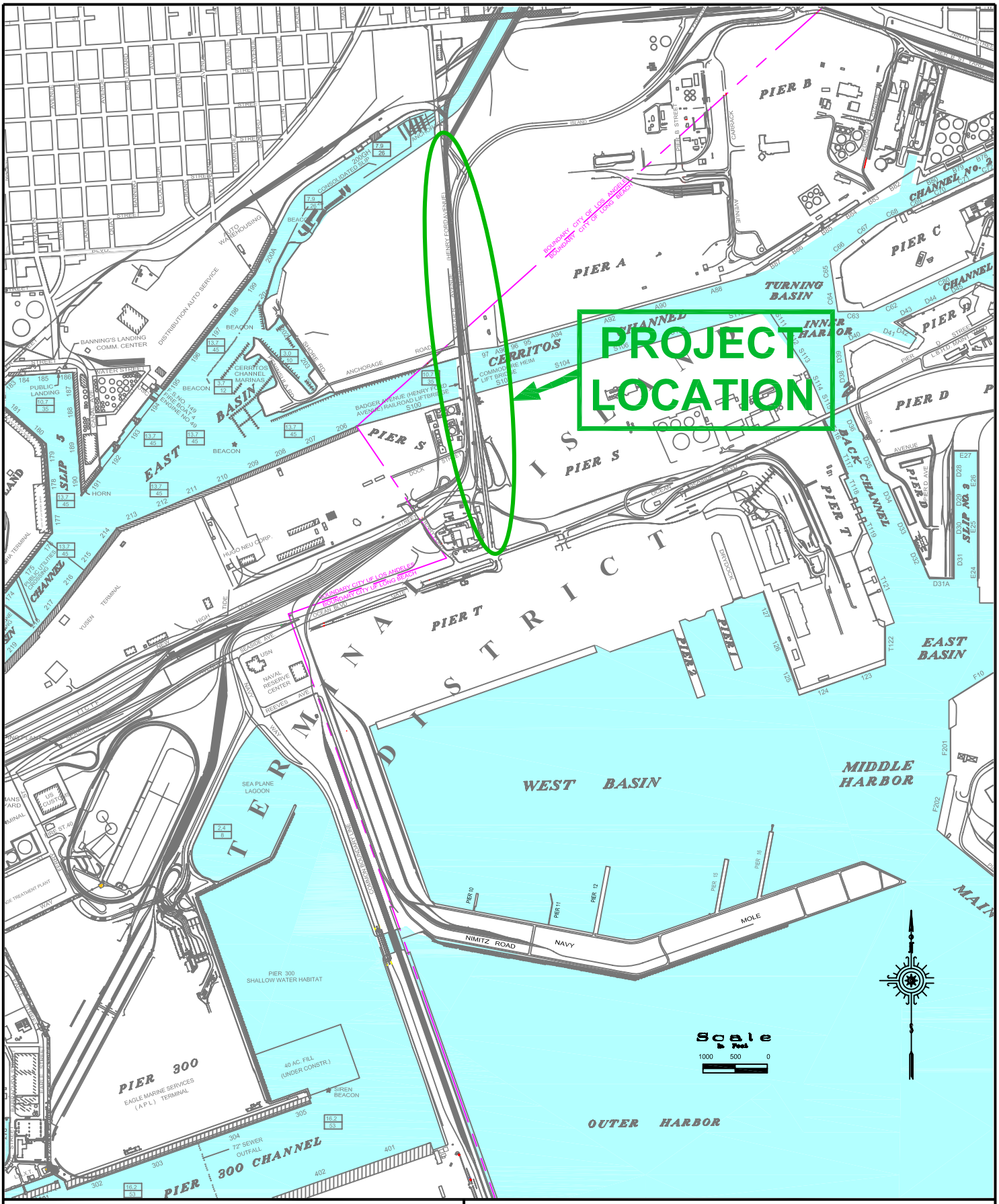
Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



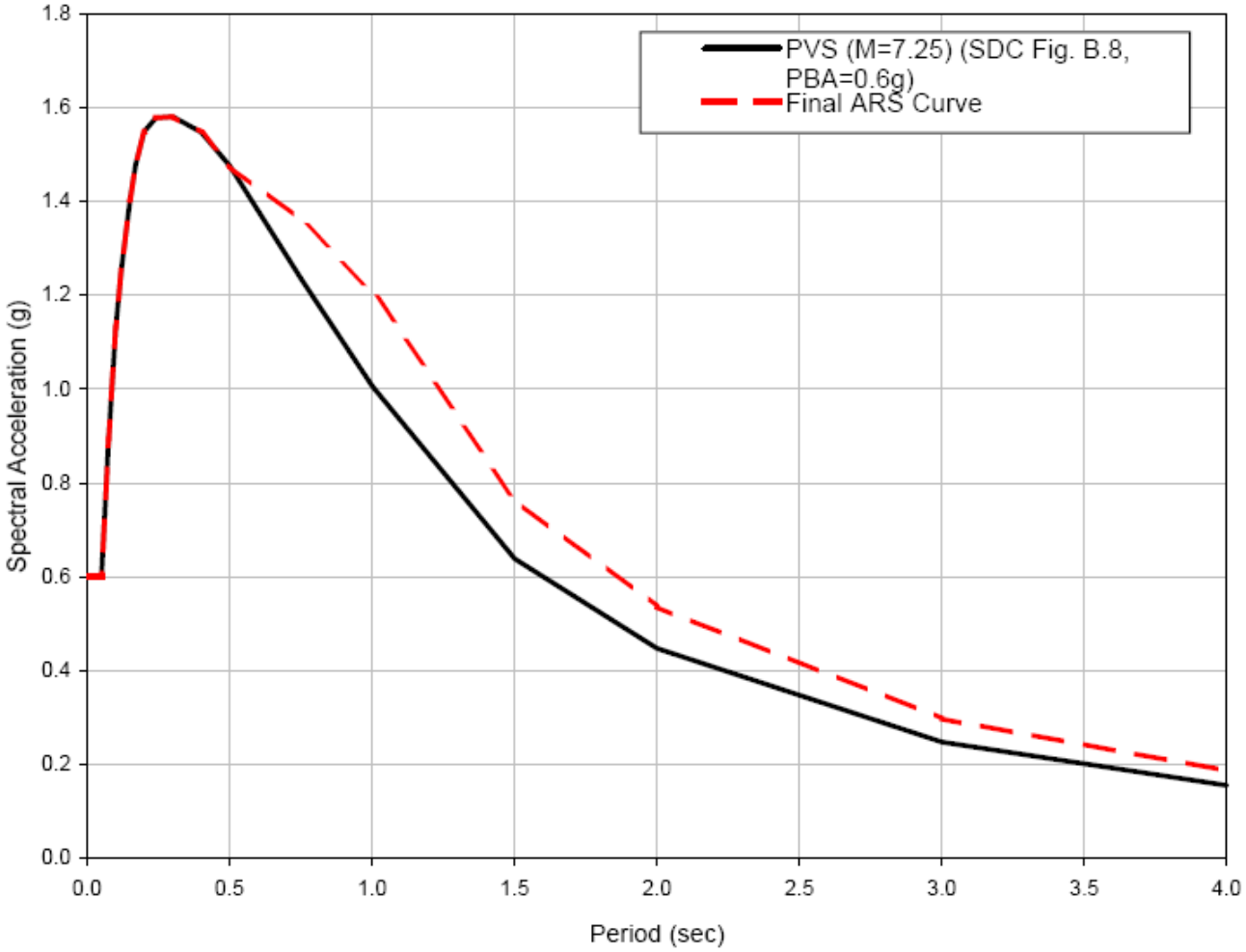
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

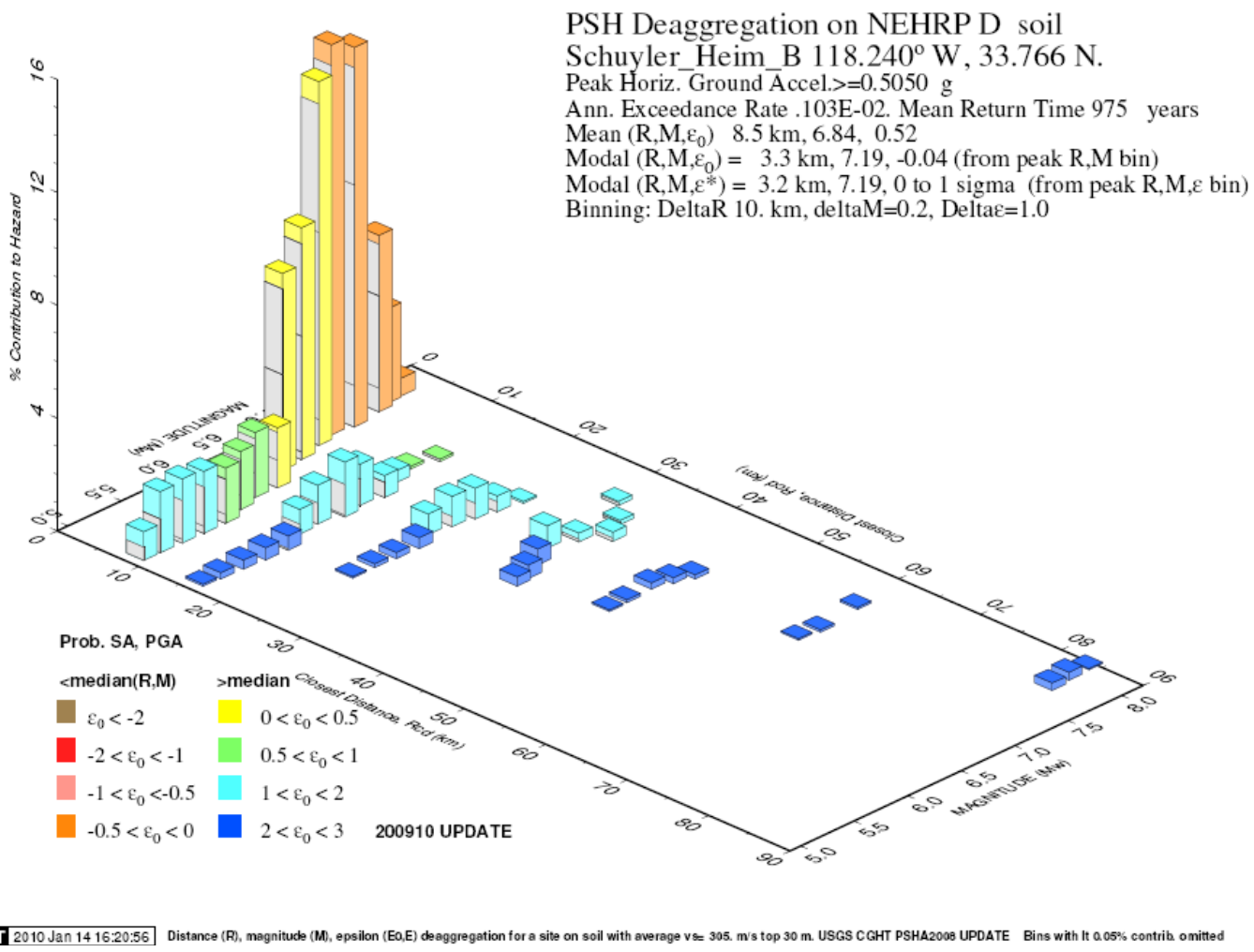


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

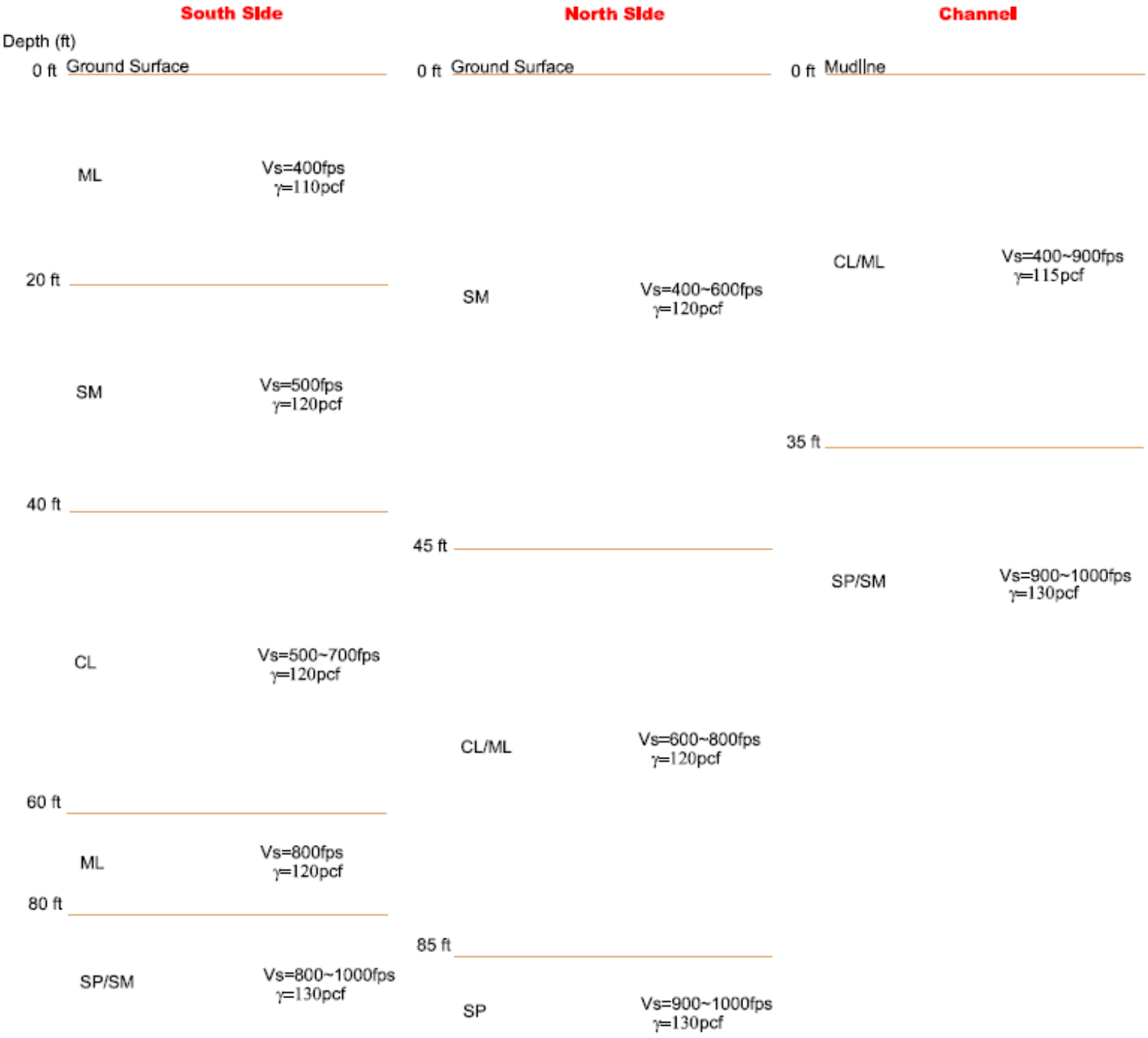
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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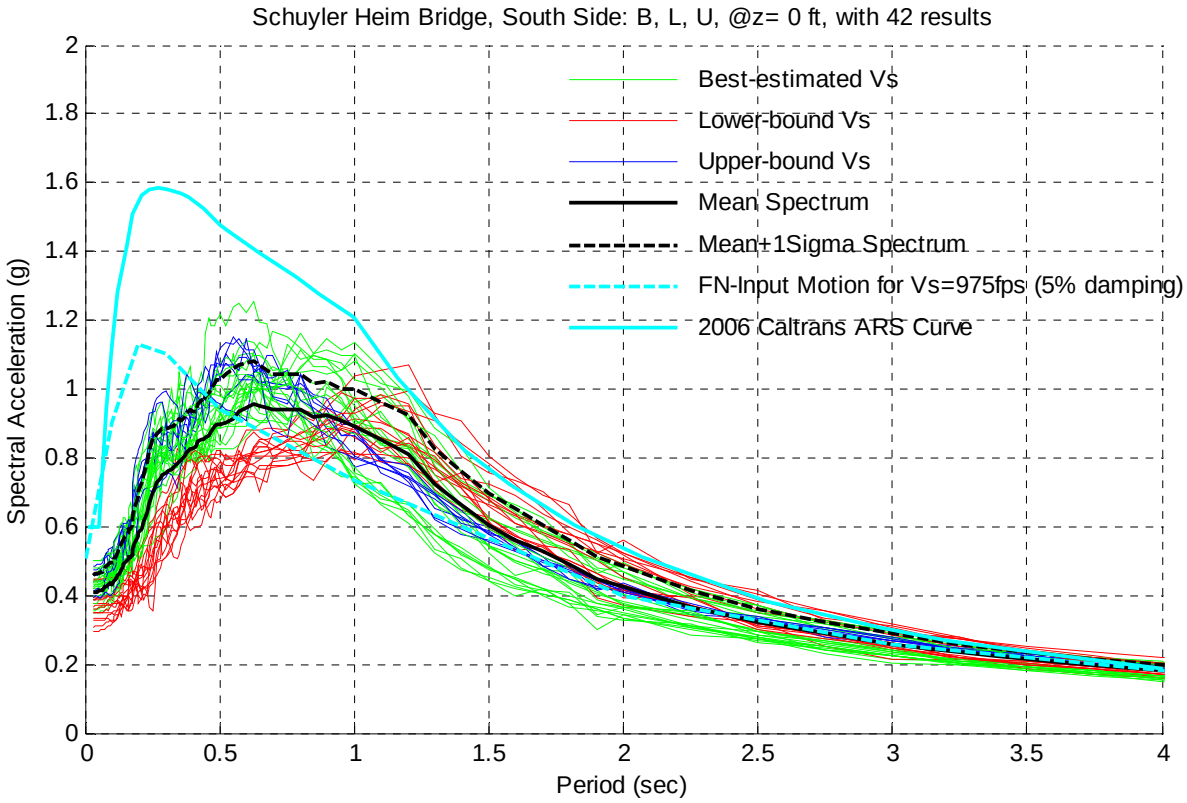
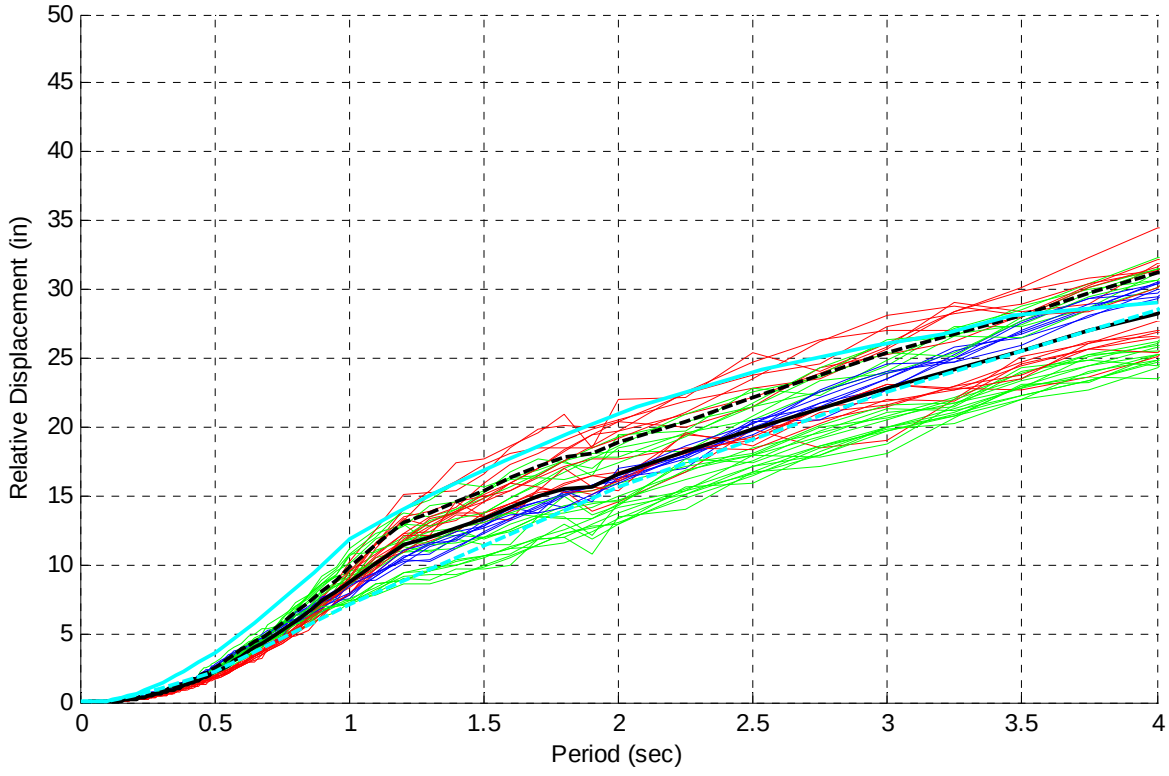
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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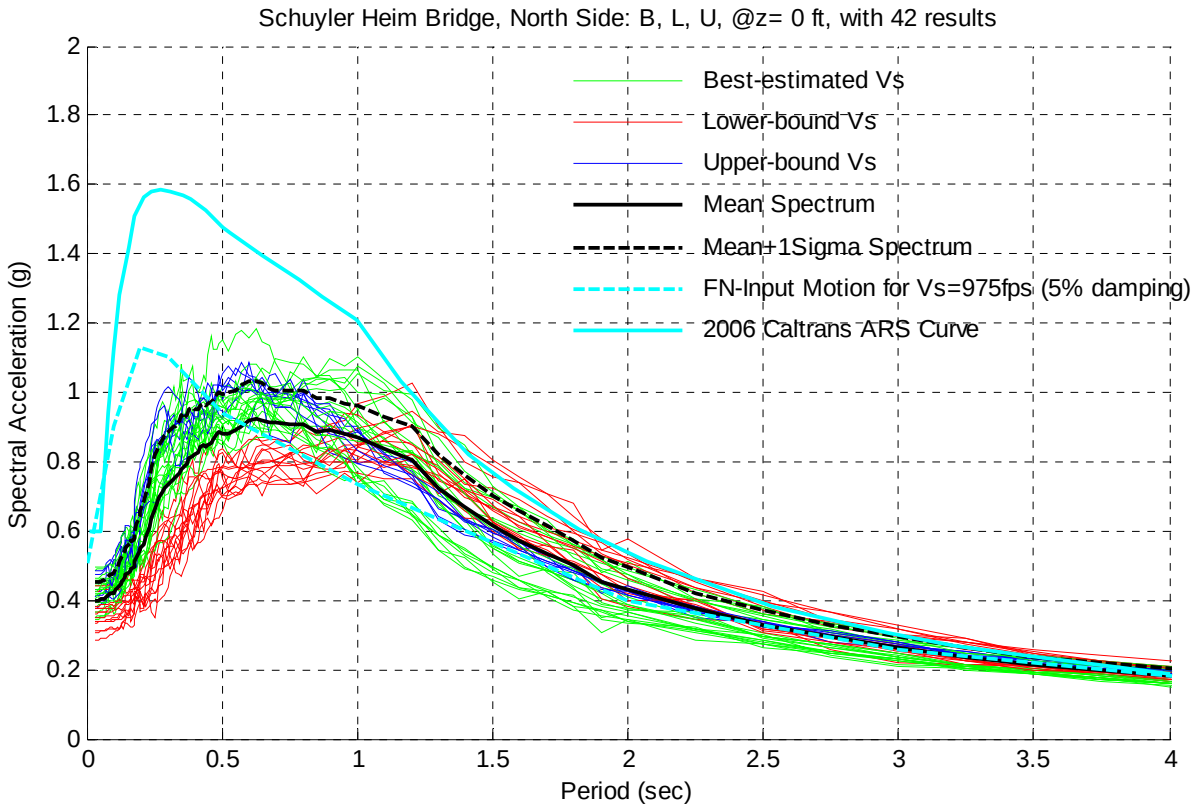
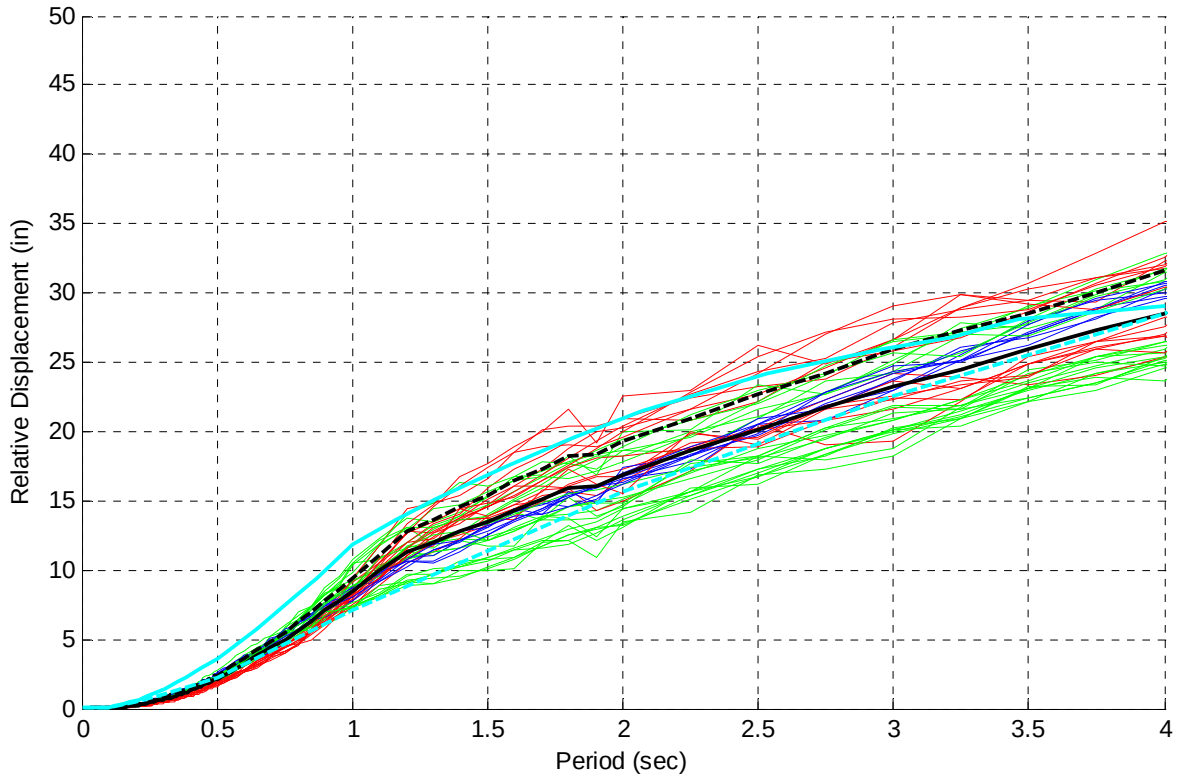
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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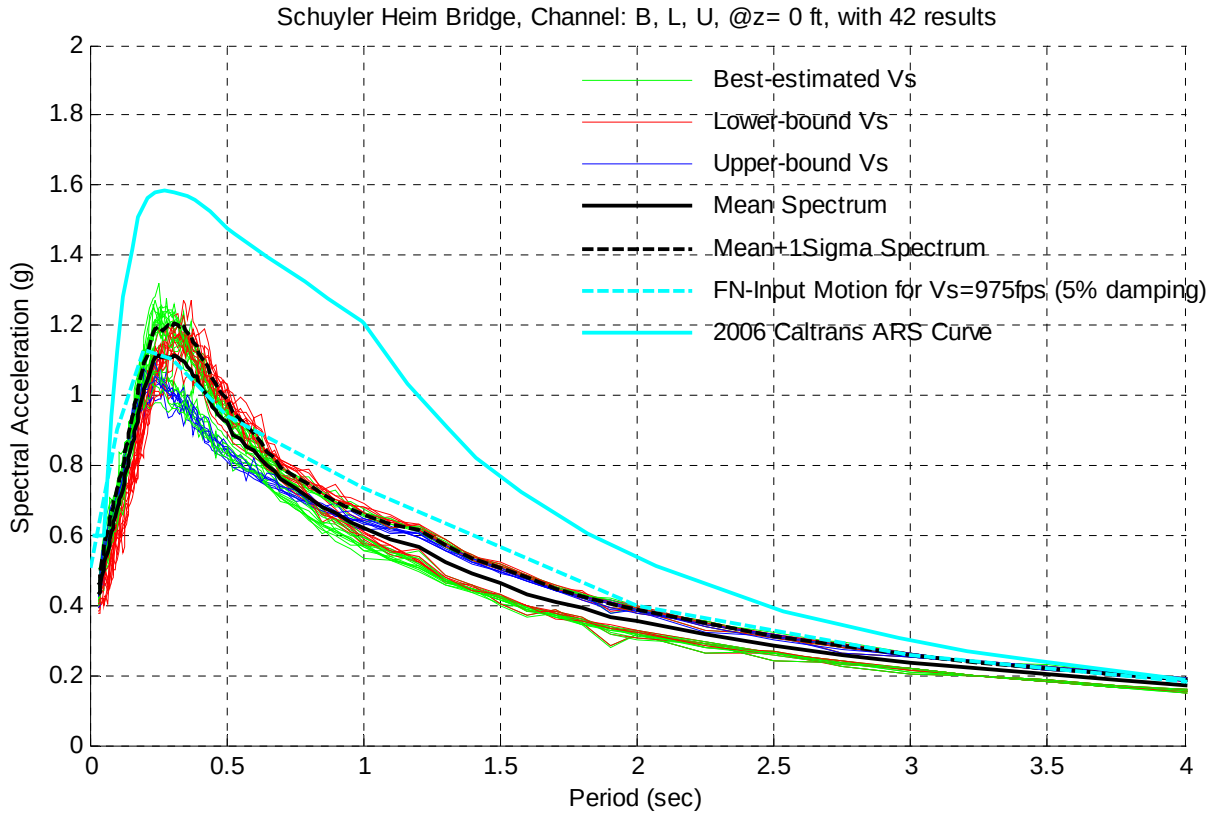
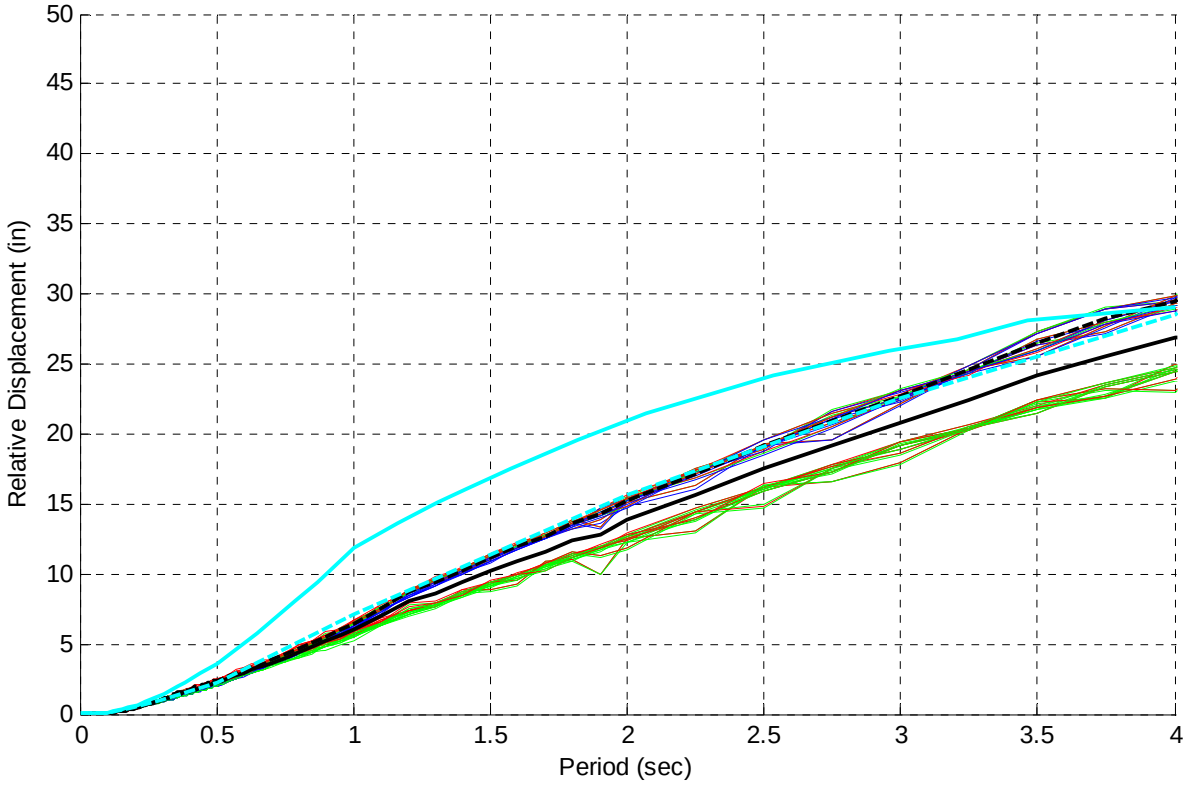
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





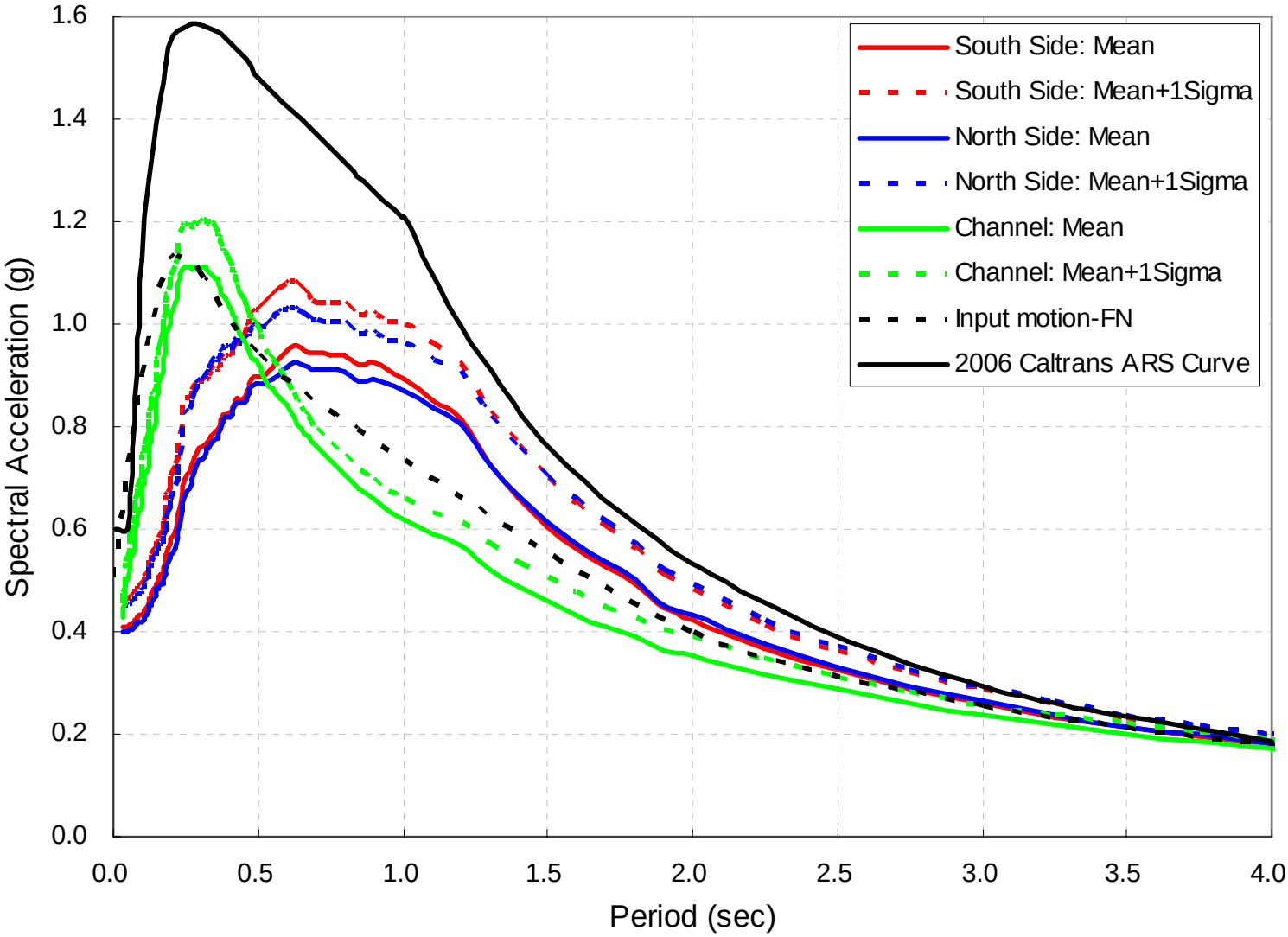
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



Earth Mechanics, Inc.
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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

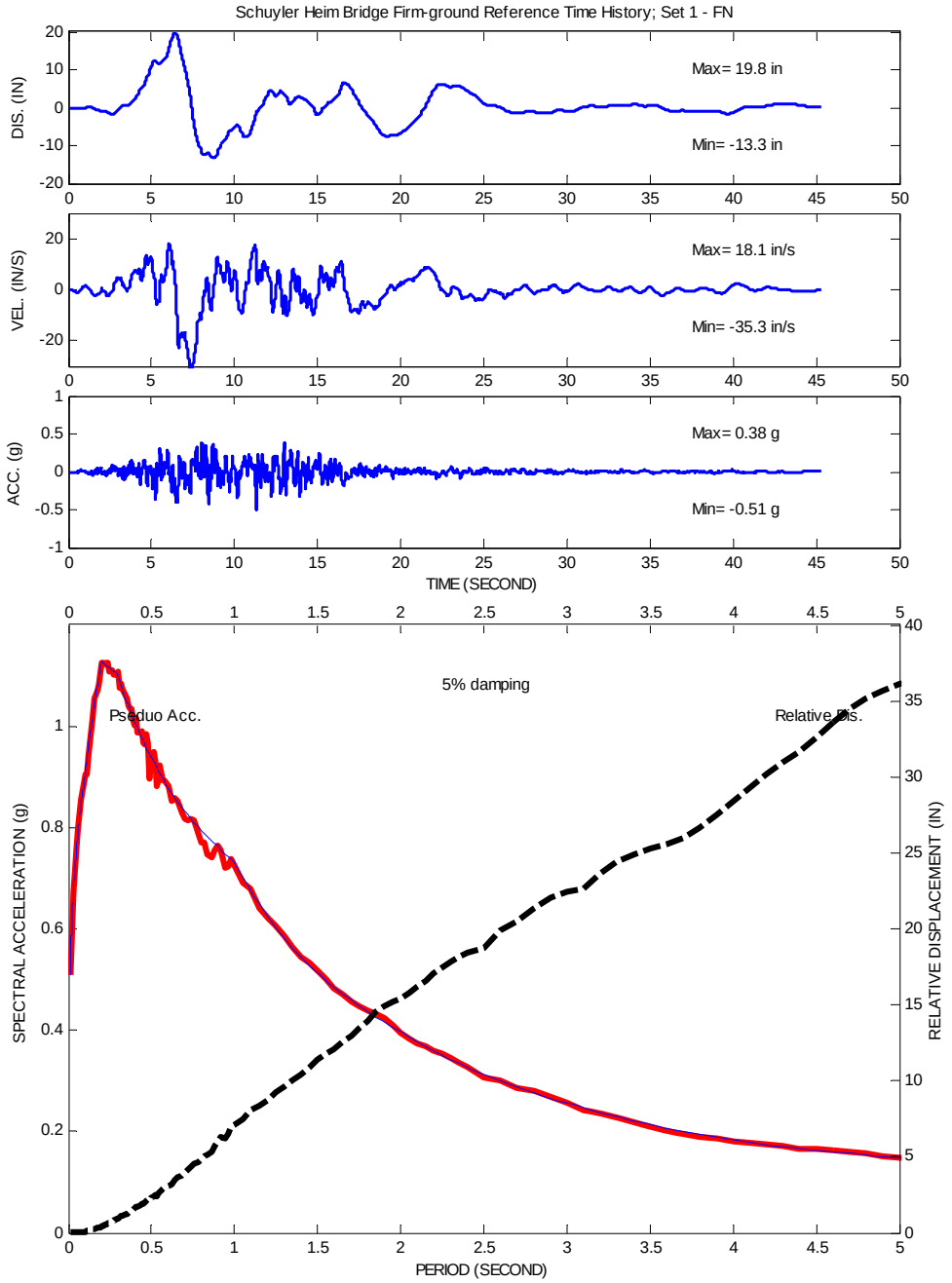

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

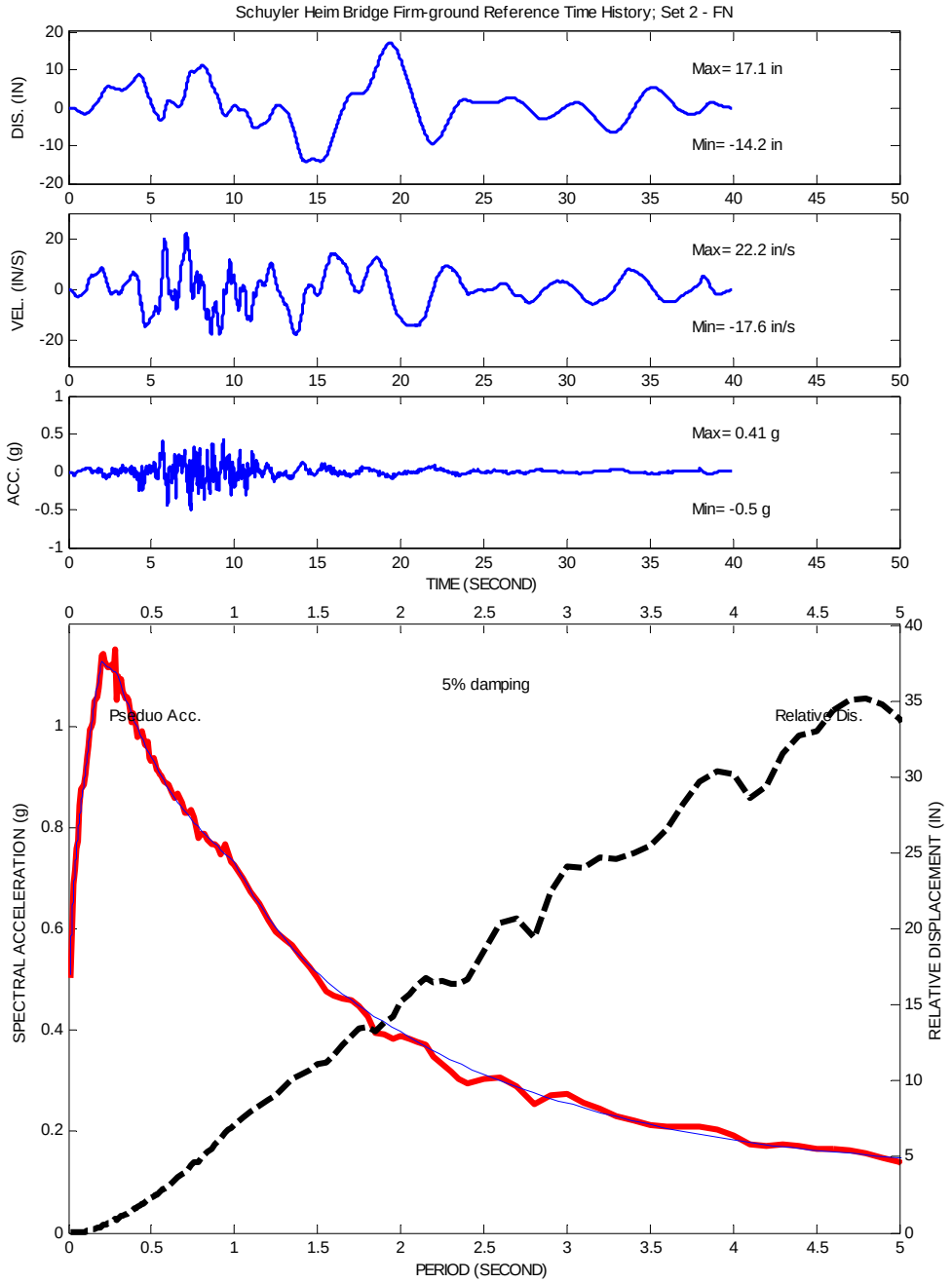

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

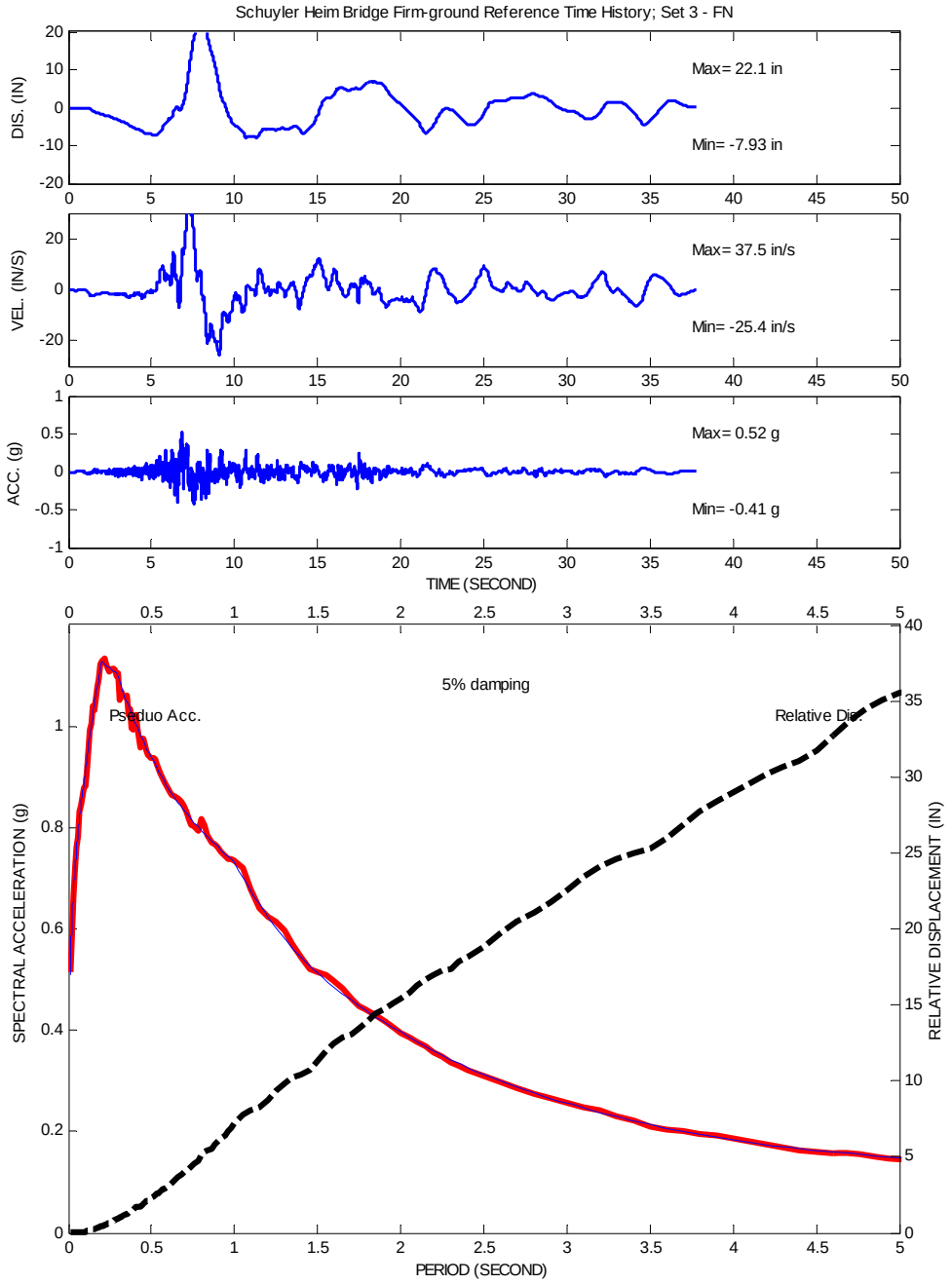

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

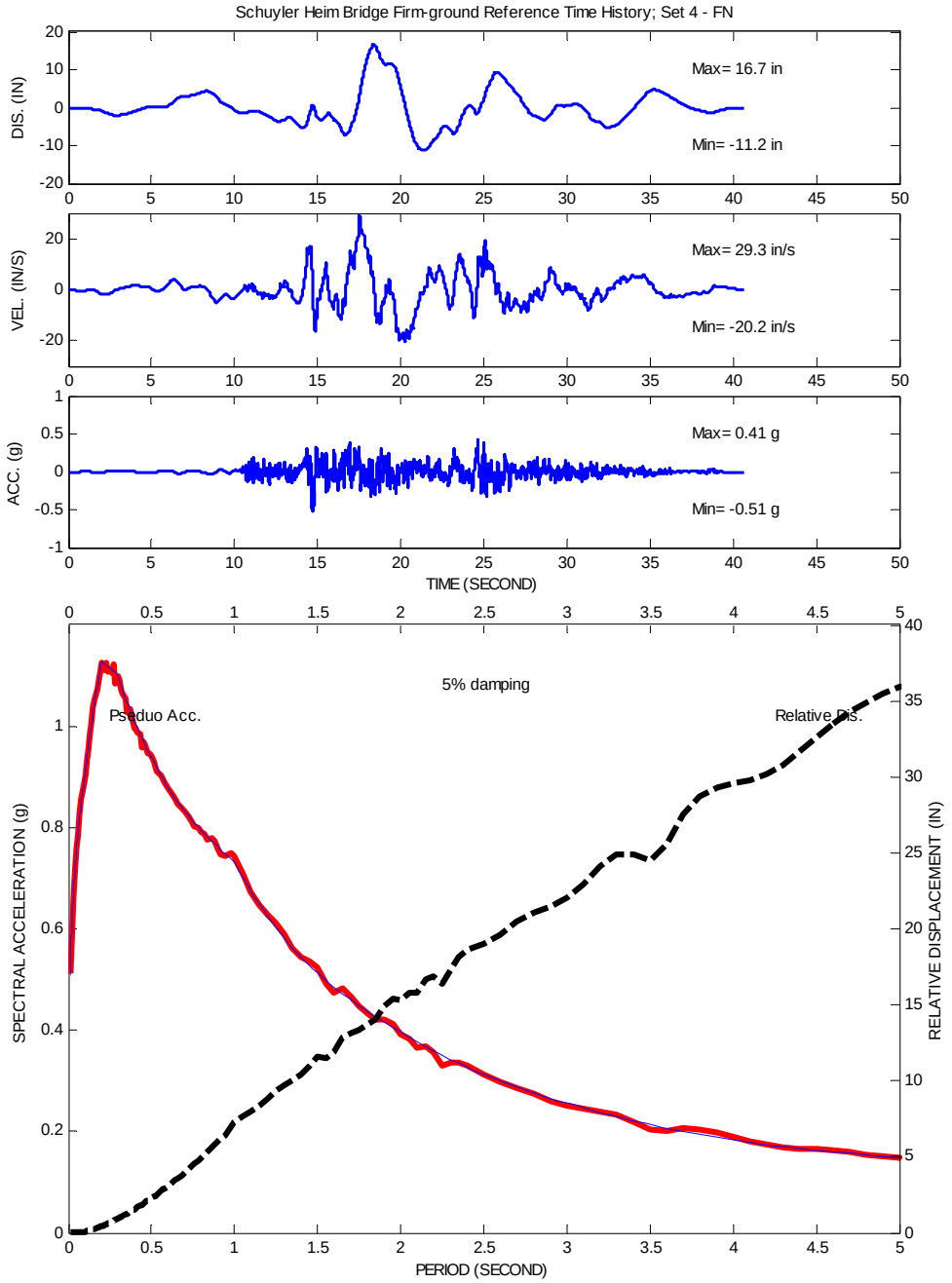

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

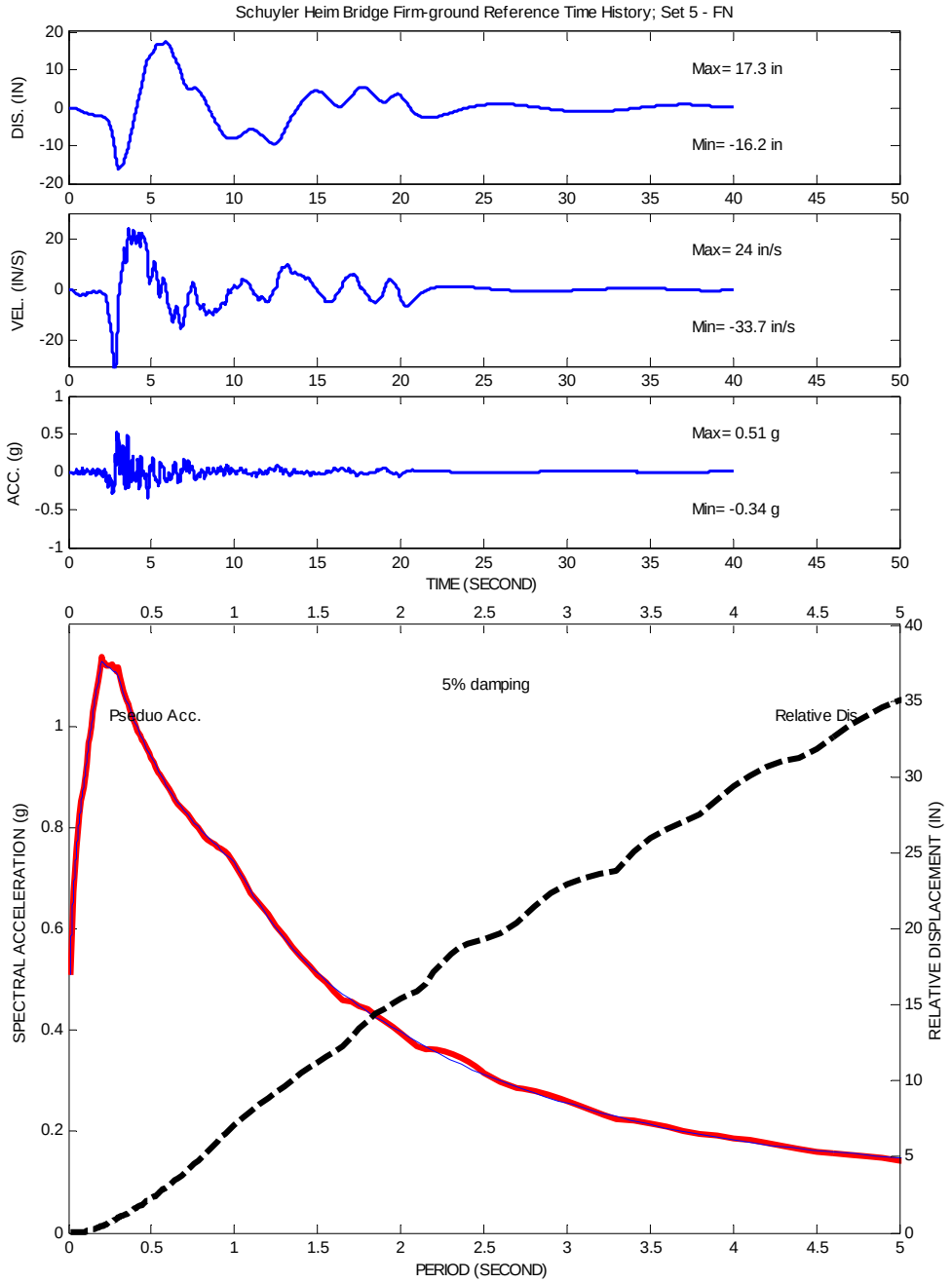

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

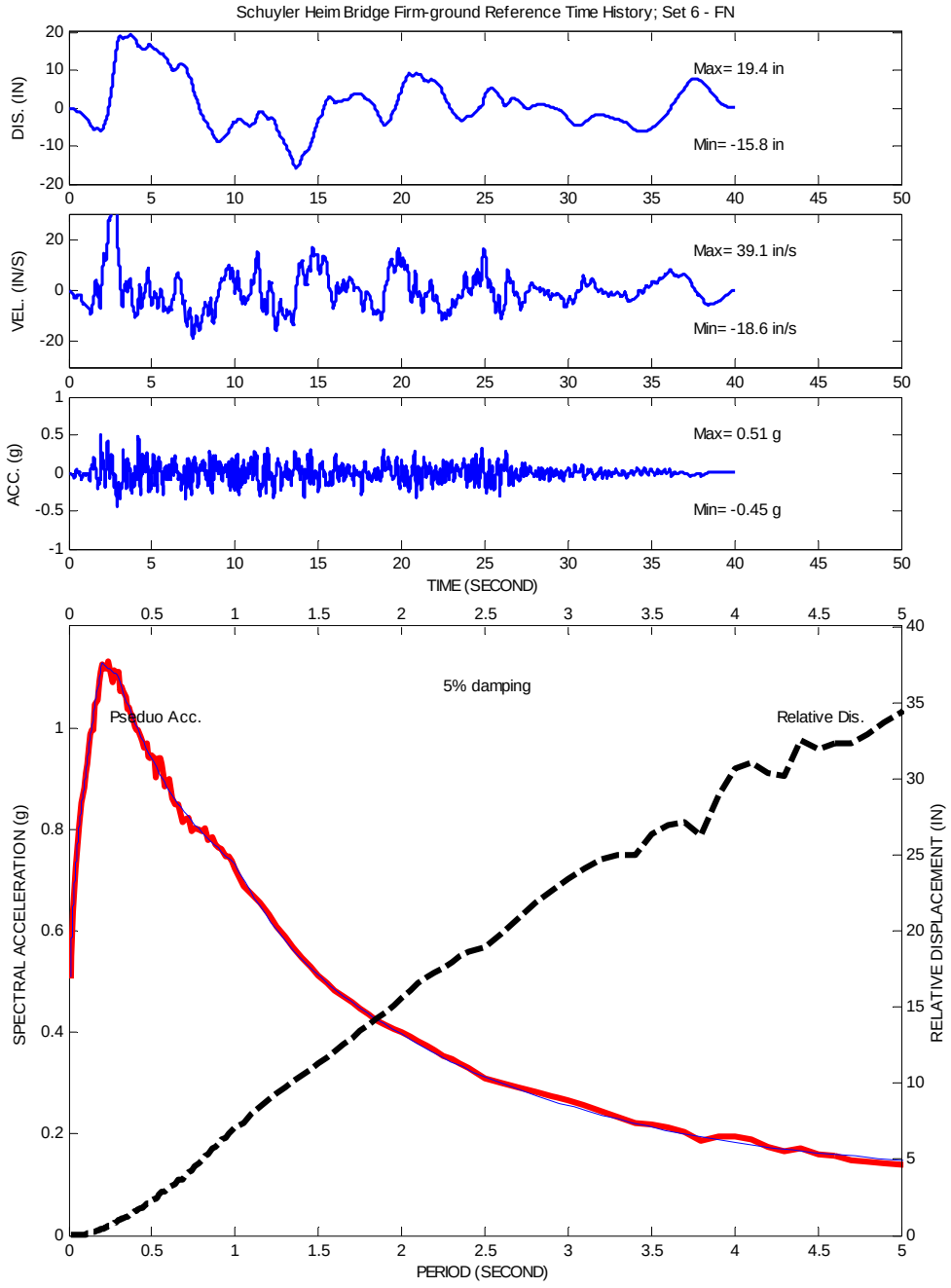

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

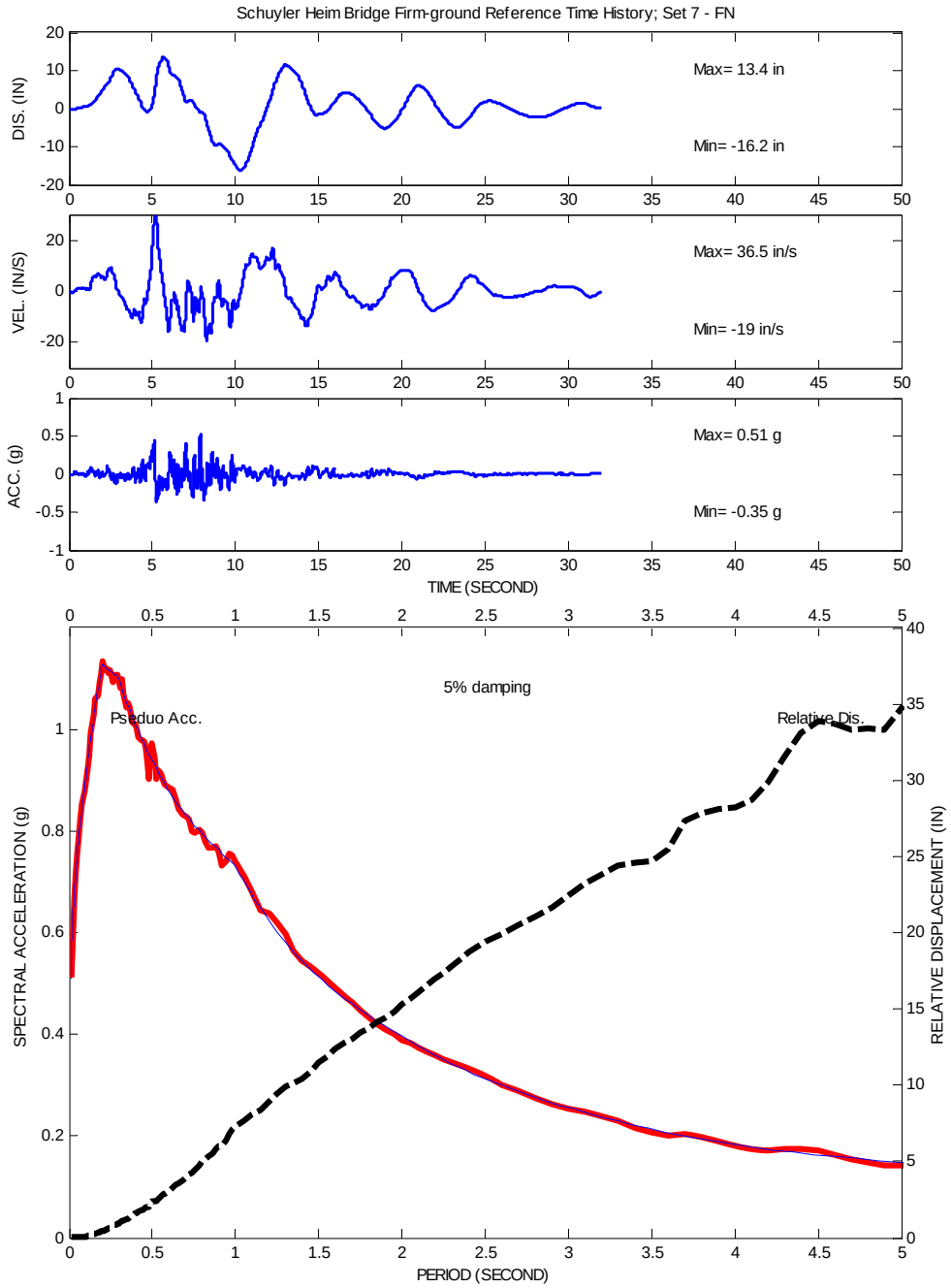

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

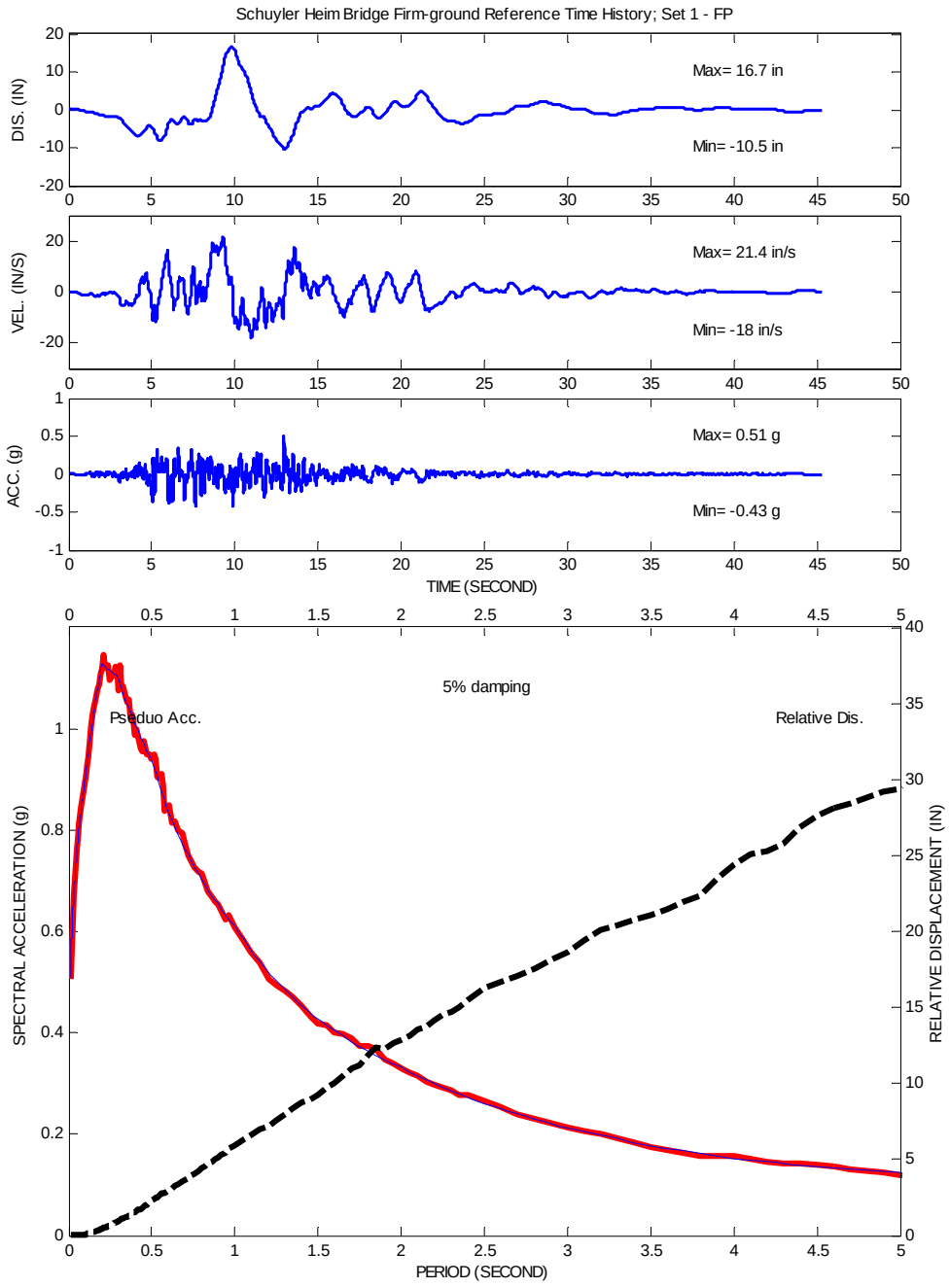

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

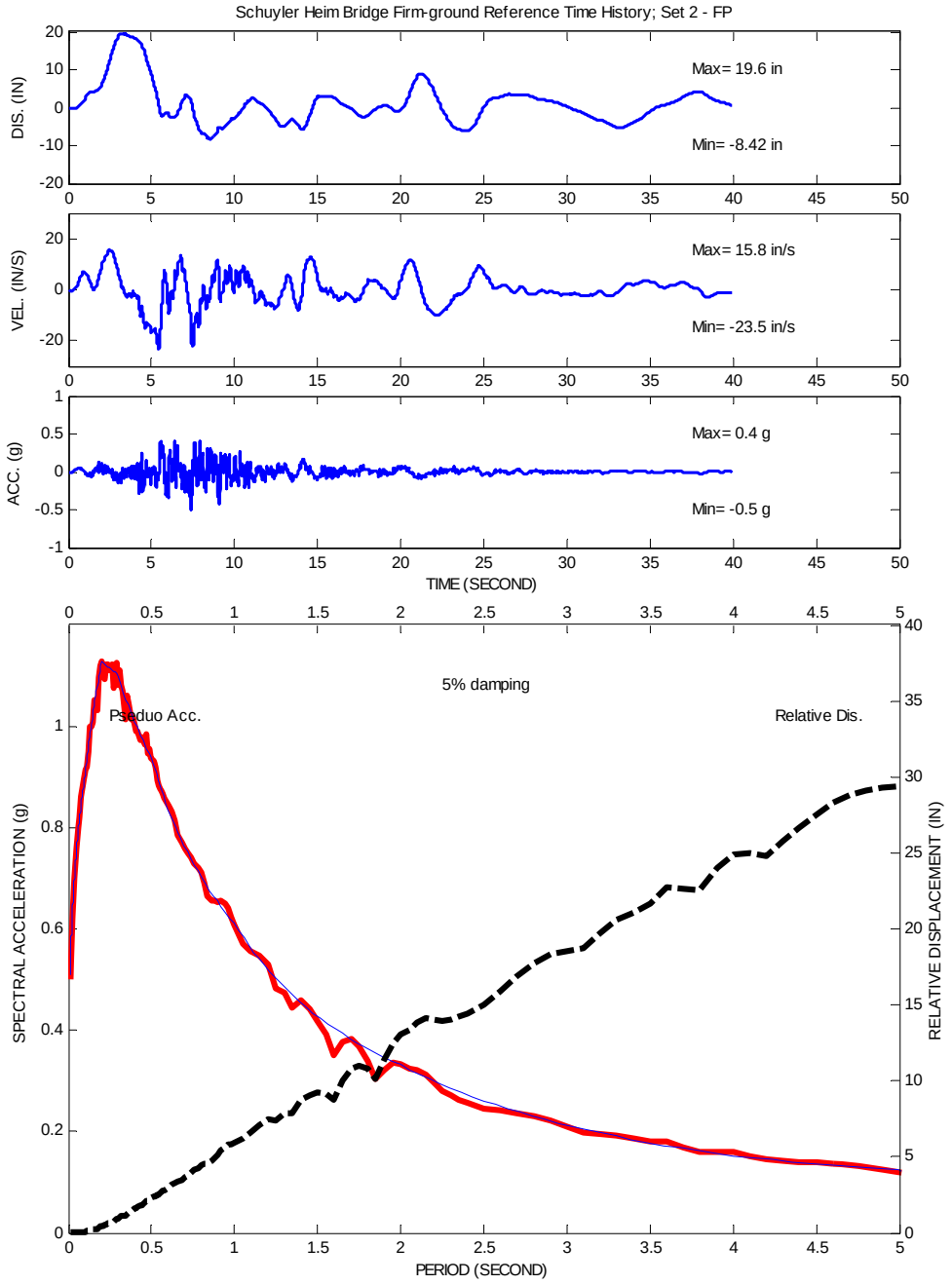

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

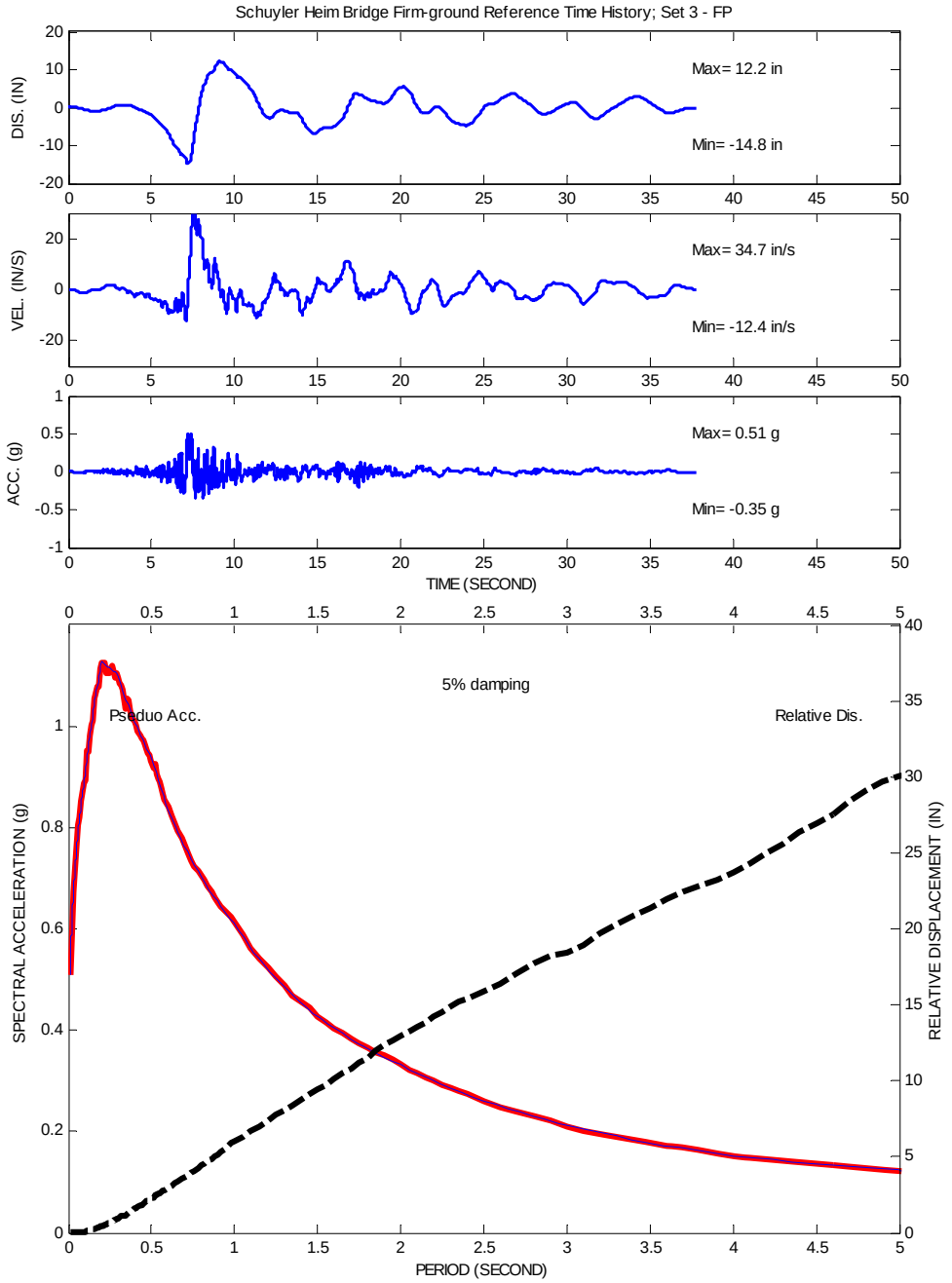

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

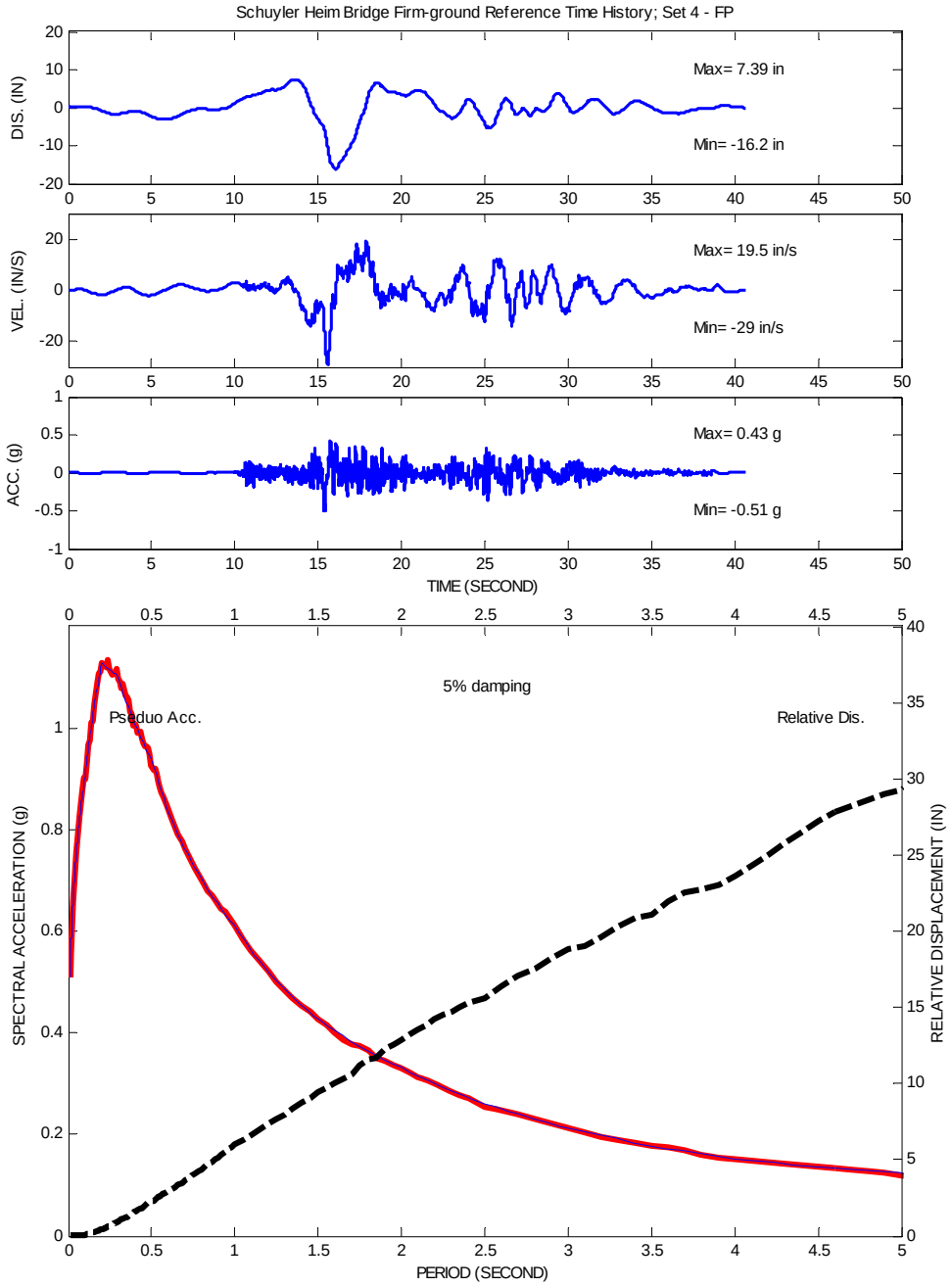

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

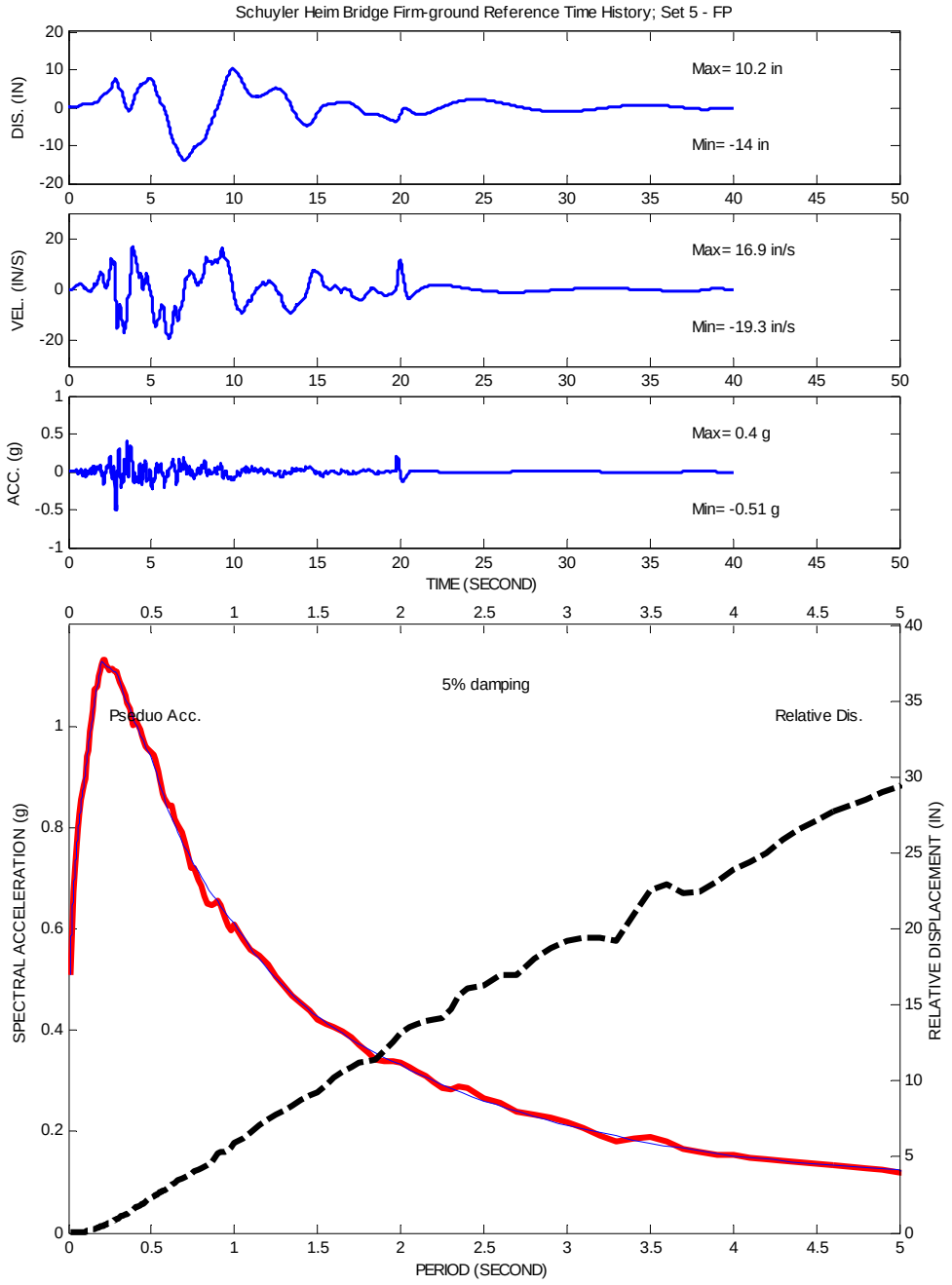

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

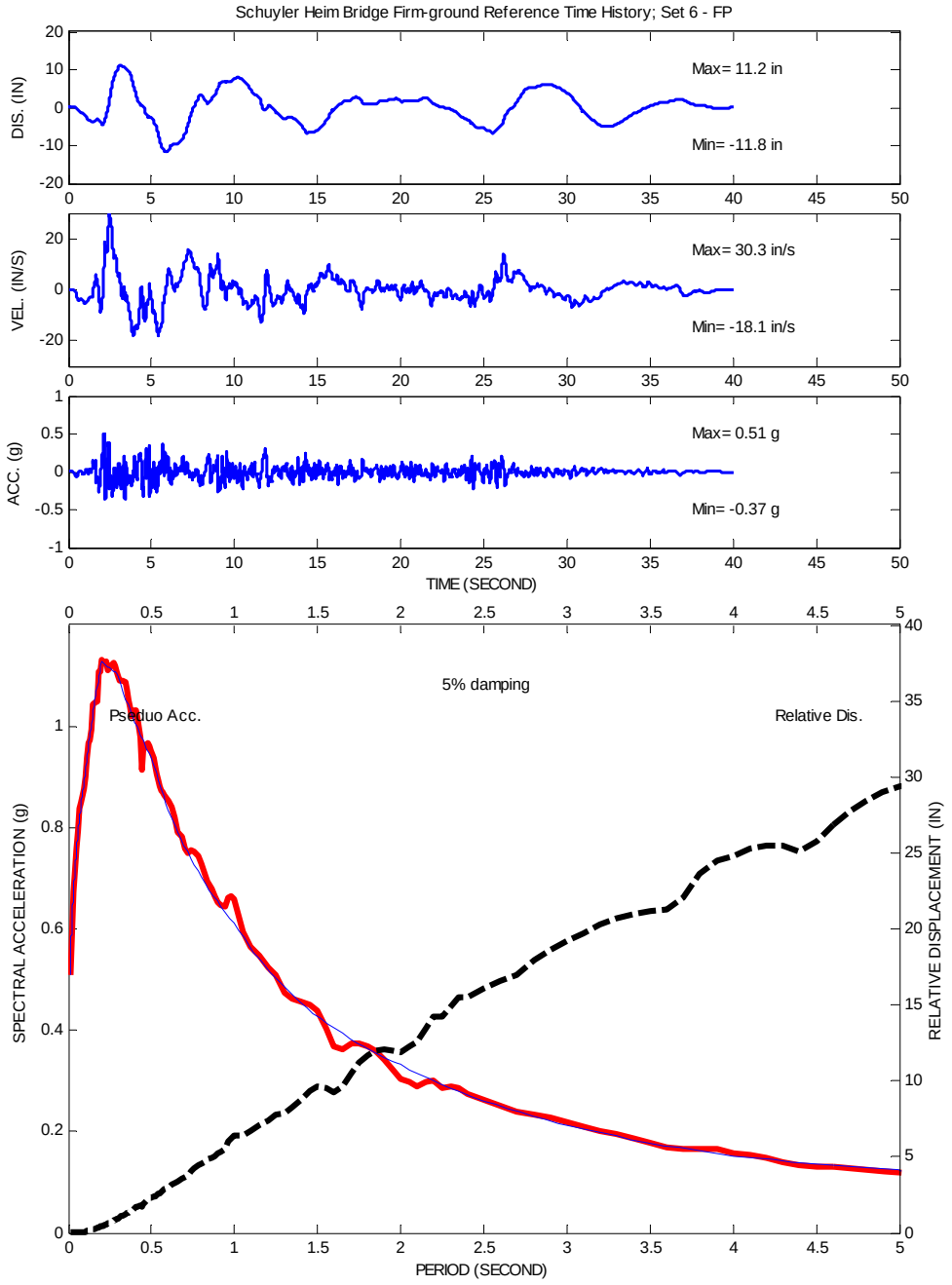

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

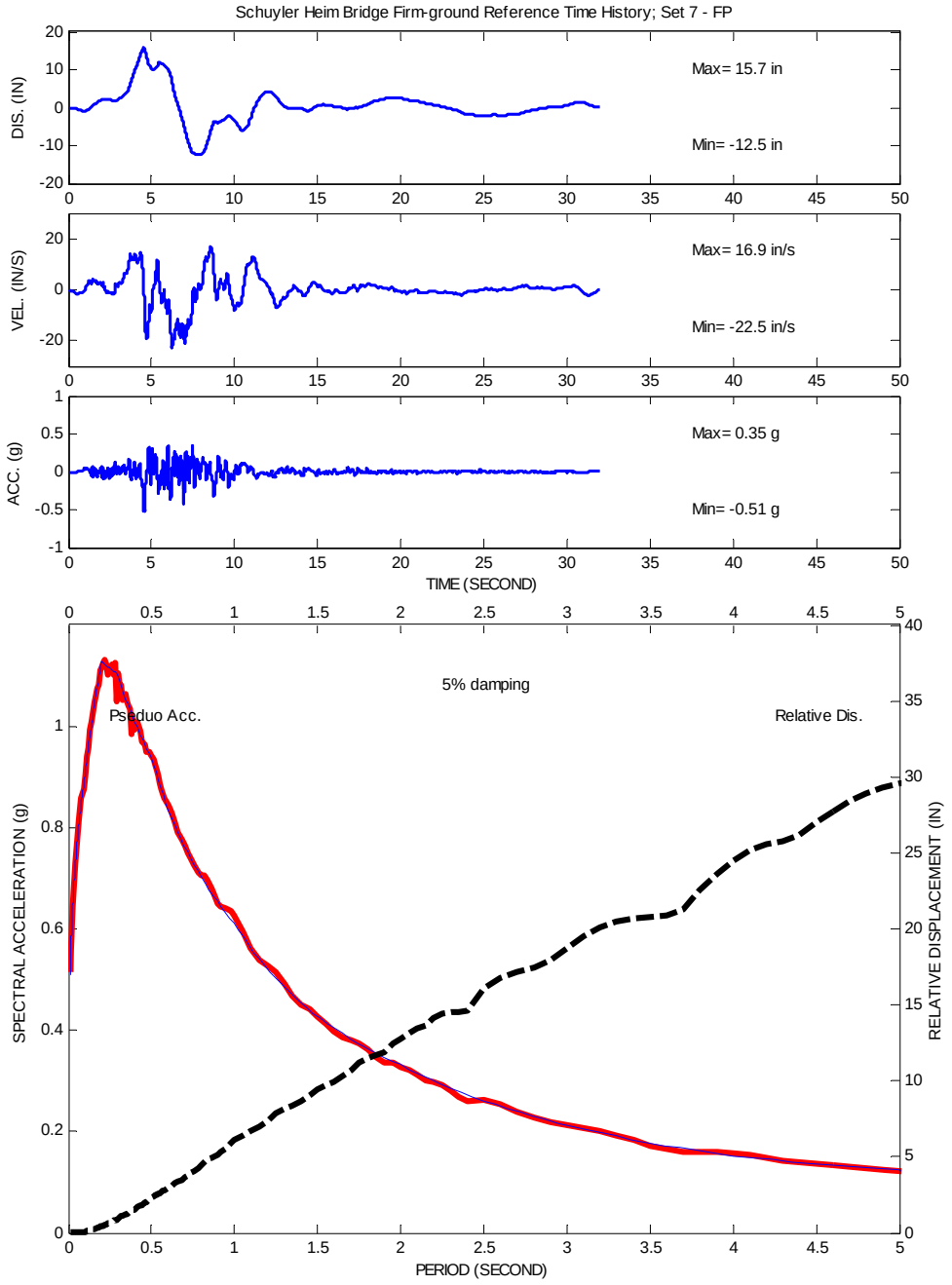

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX F. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Retaining Wall H1***
Los Angeles County, California, (7-LA-47, PM 0.18, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining wall. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining wall.

The Foundation Report for the subject wall, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix E. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,

EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

(Arul) K. Arulmoli, PhD, GE
Project Manager

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FINAL FOUNDATION REPORT
RETAINING WALL H1
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.18, EA 238501)

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EMI Project No. 06-123-03

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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall H1 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the proposed Retaining Wall H1 located on the east side of the SR-47/Henry Ford Avenue connector ramp (Figure 2).

Retaining Wall H1, located along the eastern edge of the SR-47/Henry Ford Avenue connector ramp between Sta. 702+90 and Sta. 707+25 ("H" Line) is proposed to be a Caltrans Type 1 retaining wall and will be approximately 428 ft long with retained heights varying from 4 ft to 10 ft.

1.3 Limitations

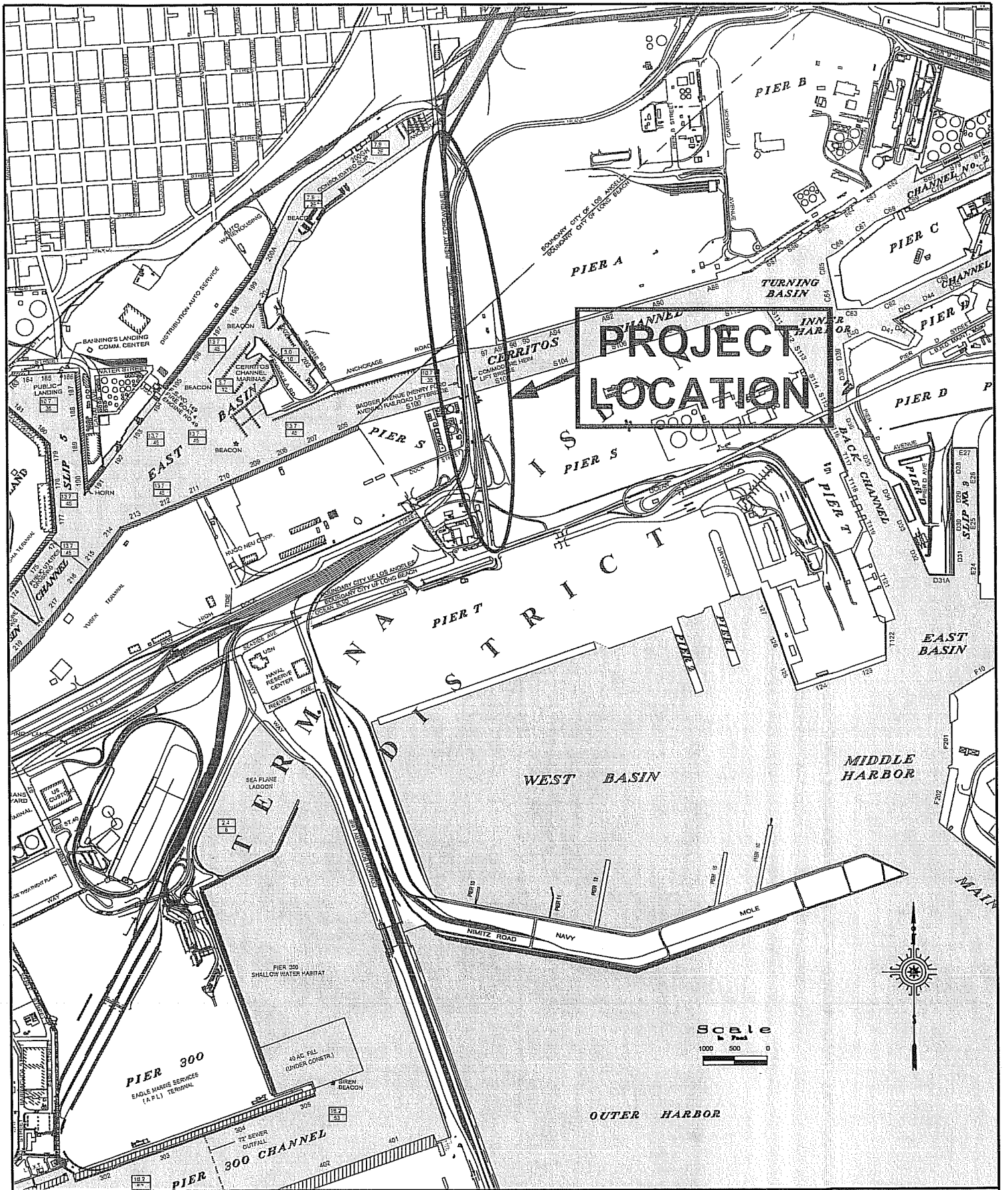
This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members, and the California Department of Transportation (Caltrans) for the

proposed Retaining Wall H1. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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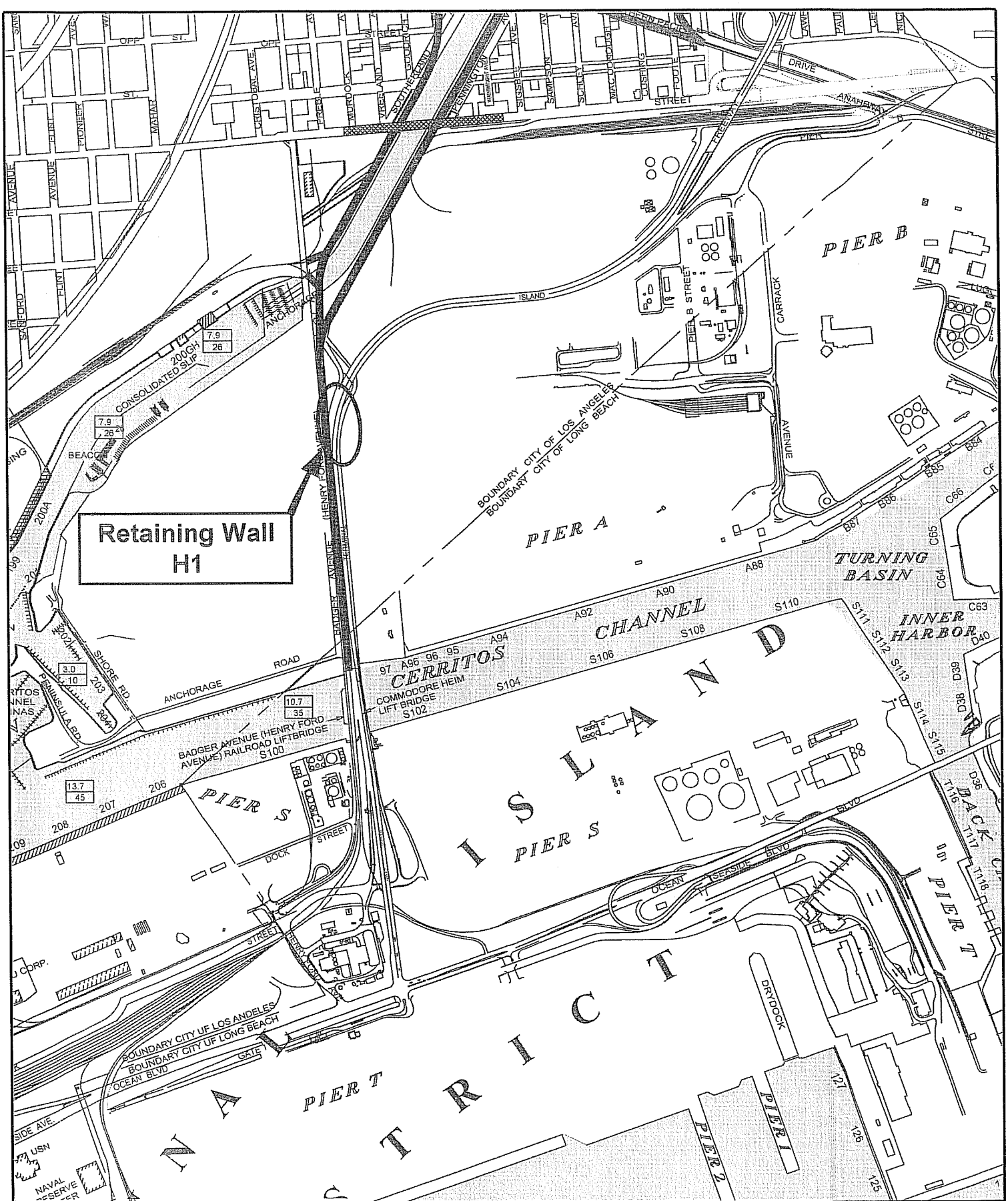
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123 | Date: 5-10-10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-10-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the nearest boring to Retaining Wall H1 is shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge and is approximately 950 ft south of the southern end of the proposed wall pair.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of 22 hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings for embankments and structures and 14 additional hollow-stem auger borings for pavement. From that exploration program, two rotary wash borings, one CPT sounding and three hollow-stem auger borings were performed in the vicinity of Retaining Wall H1. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed wall. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings surrounding the proposed retaining wall were performed at grade on the shoulder of the existing SR-47/Henry Ford Avenue Off-Ramp. The deepest boring penetrated down to about elevation -100.0 ft, approximately 99.2 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer

falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix A.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix B.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-036[1]	"H" Line	702+90.6	88.2 Lt	+3.4	-11.6	-72.6	RW
R-09-037[2]		704+03.1	48.5 Rt	-0.9	-8.4	-82.4	RW
A-09-106[3]		704+28.8	22.2 Lt	+1.0	NE	-10.5	HSA
A-09-109[3]		705+91.0	37.0 Rt	+0.9	NE	-10.6	HSA
A-09-110[3]		707+76.3	39.2 Rt	+1.2	NE	-10.3	HSA
CPT-09-066		702+17.7	51.1 Rt	-0.8	NR	-100.0	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3.Boring performed by 2R Drilling Co.
4. GWE = Groundwater Elevation.
5. GSE = Ground Surface Elevation (estimated from topographic plans).
6. Top of Boring Elevation Based on NAVD88.
7. RW = Rotary Wash, HSA = Hollow Stem Auger, CPT = Cone Penetration Test.
8. NR = Not Recorced, NE = Not Encountered.

2.2.2 CPT Soundings

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set

of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

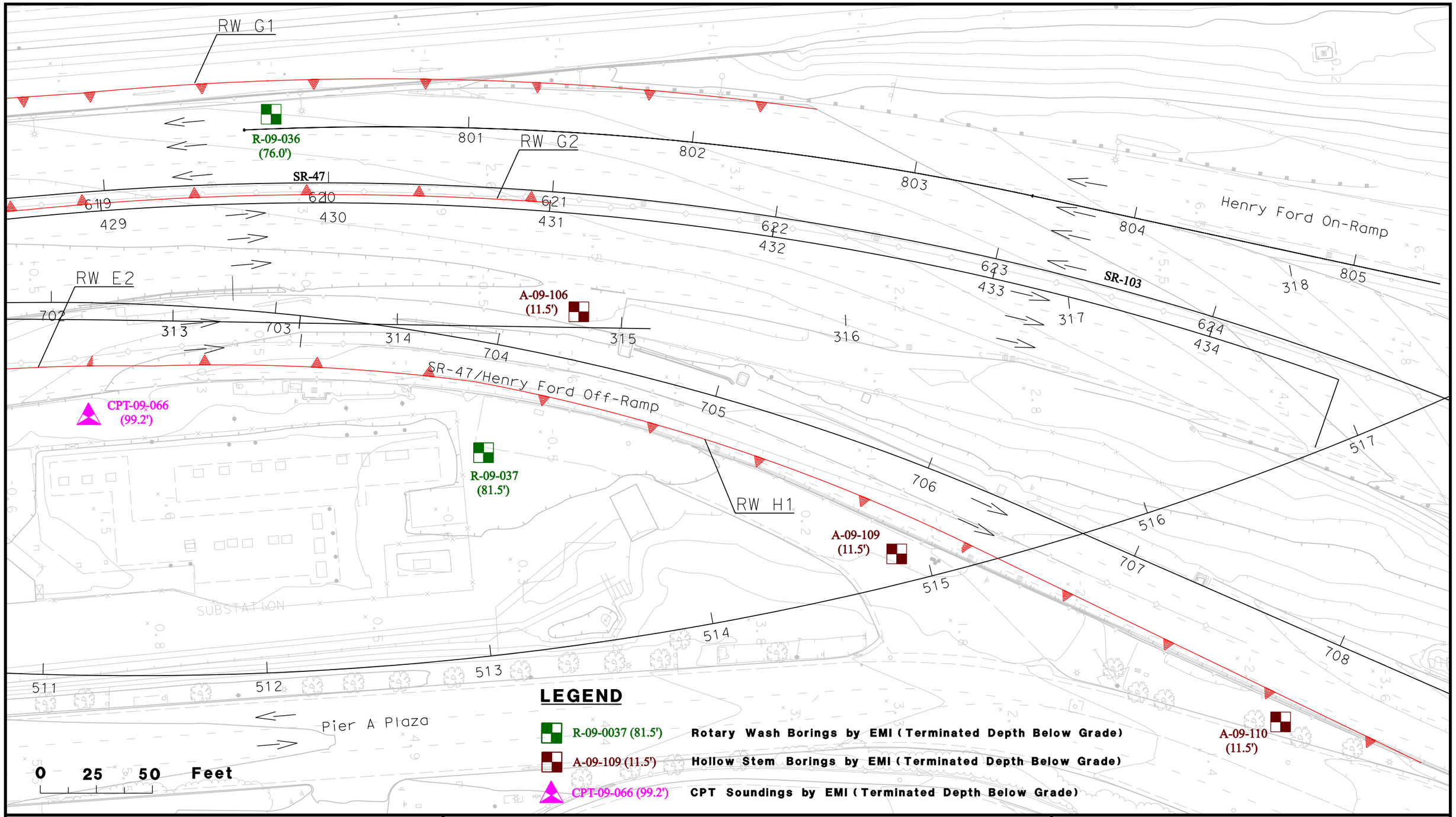
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix C.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-10-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 4 and 5). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas

are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

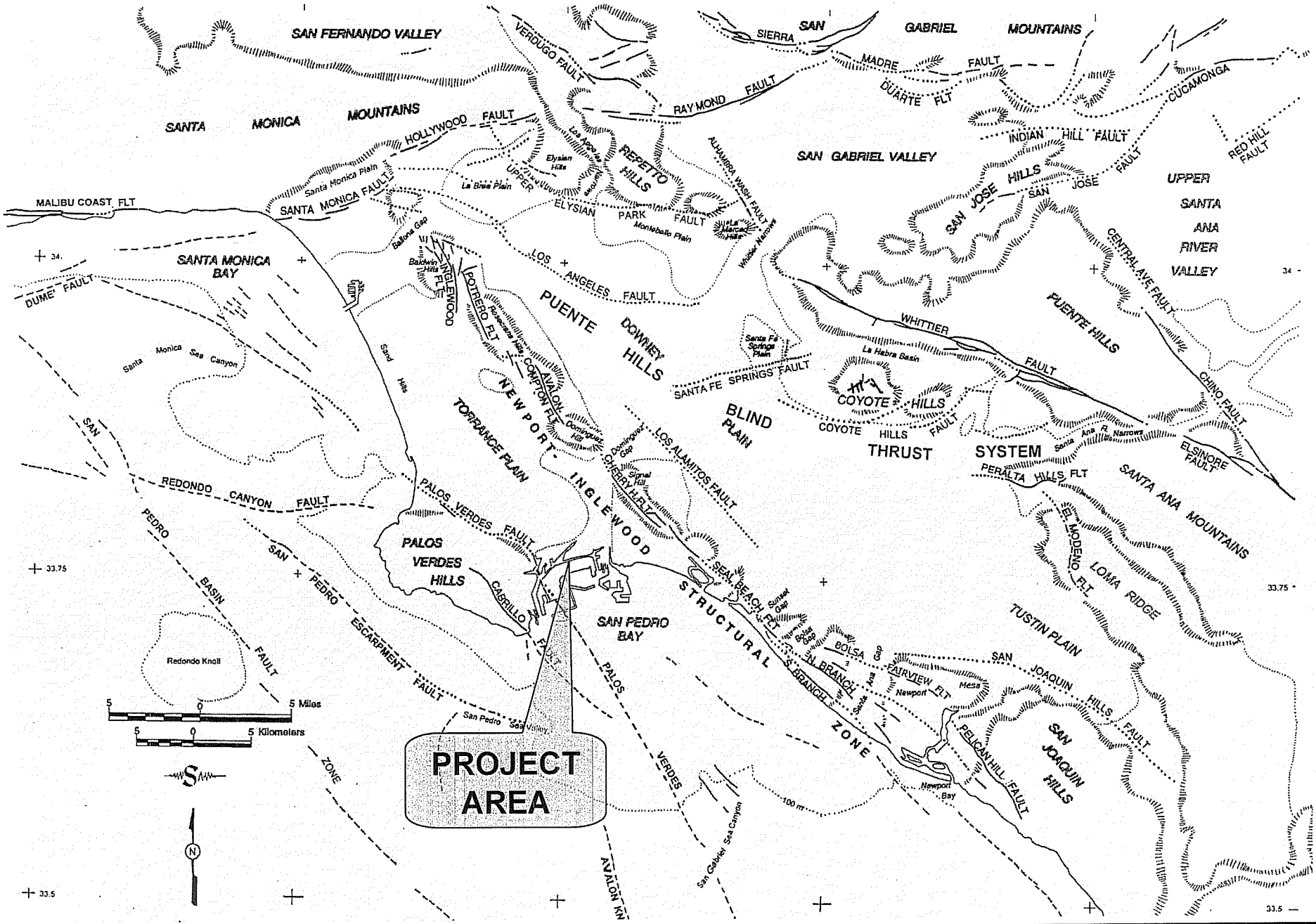
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

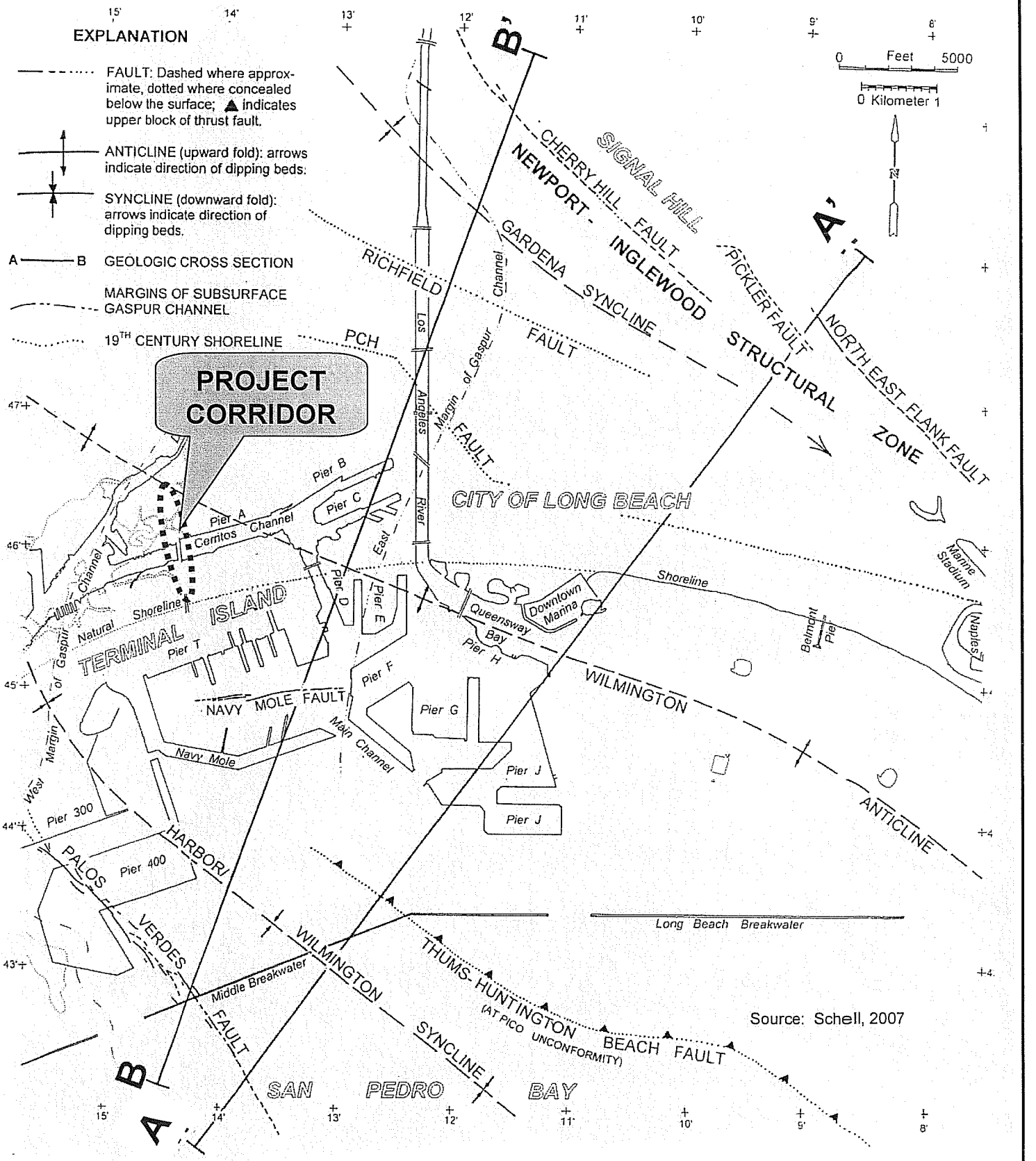
Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 5-10-10	Figure 4



Source: Schell, 2007

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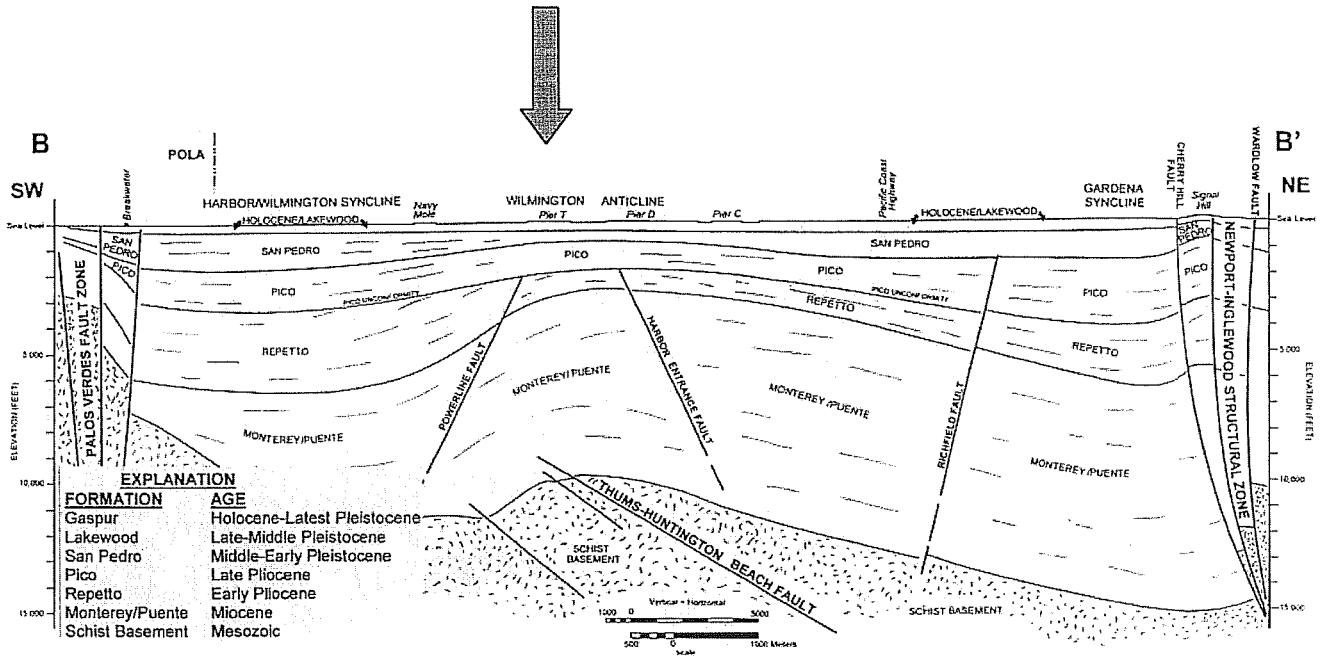
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structural Geology Map, Long Beach Harbor

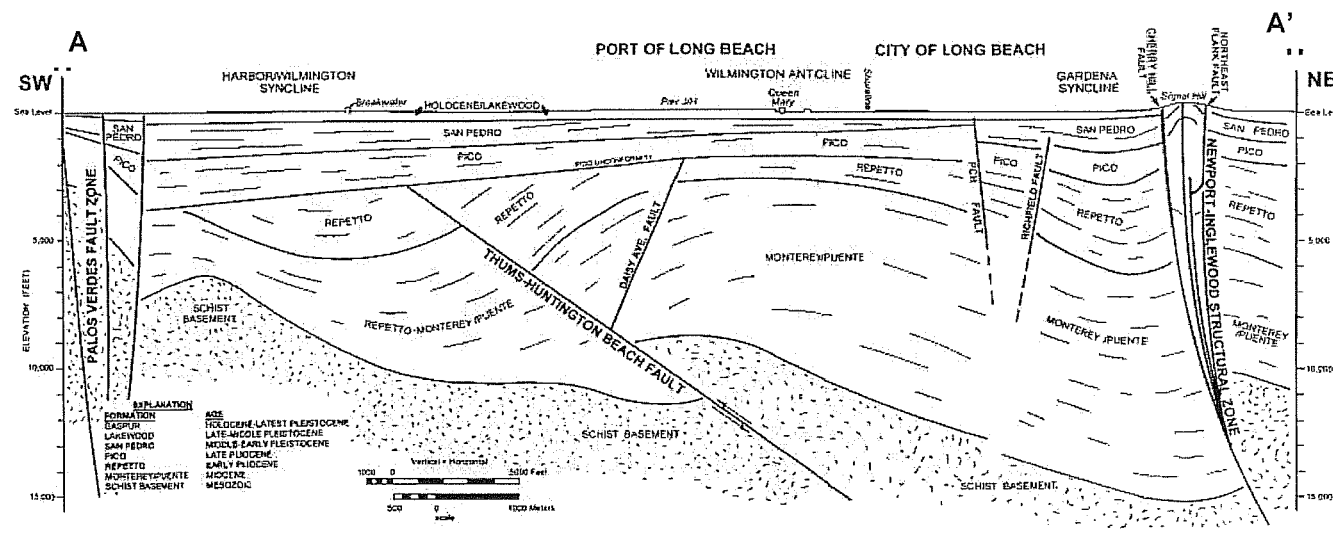
Figure 5

Project No. 06-123	Date: 5-10-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

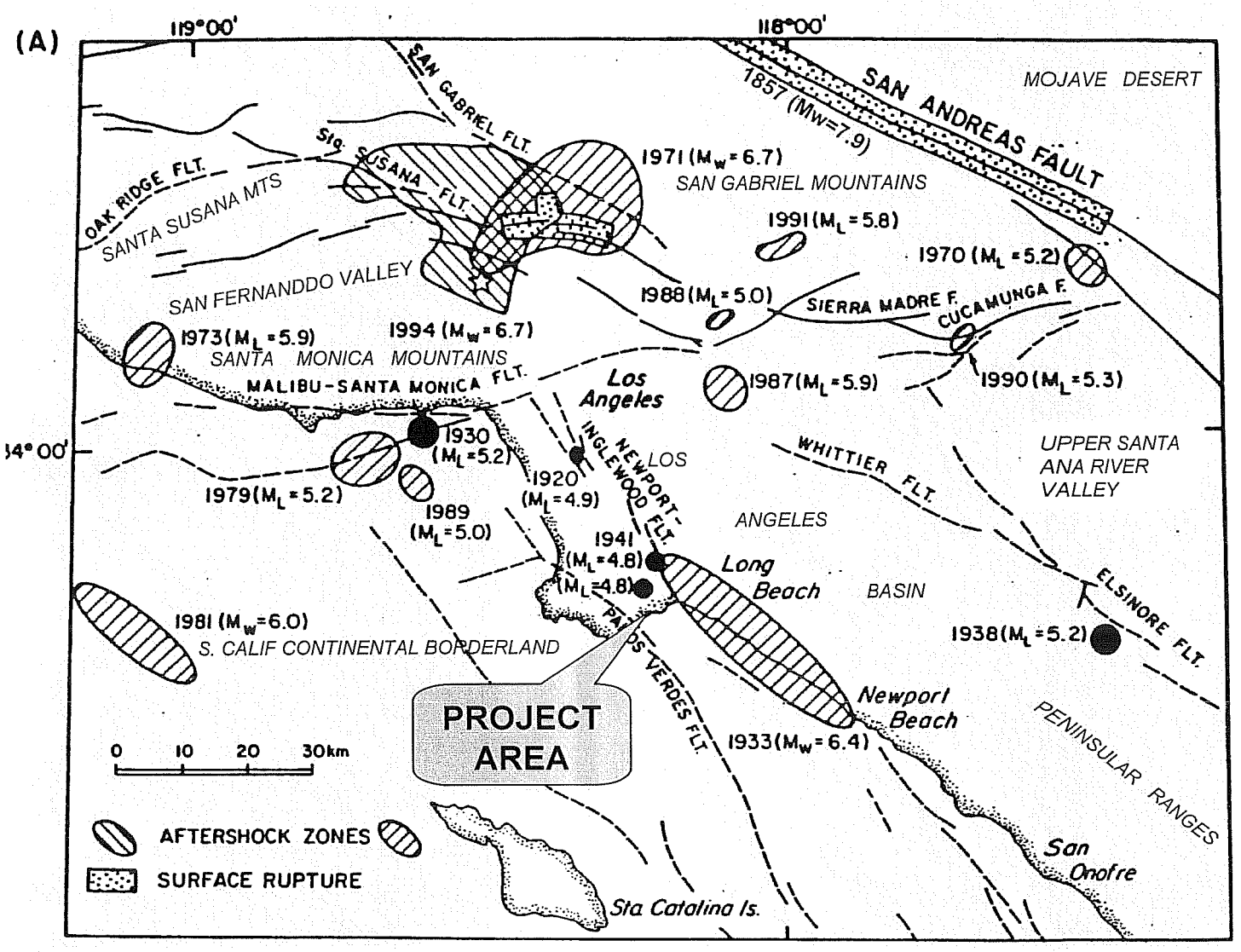


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

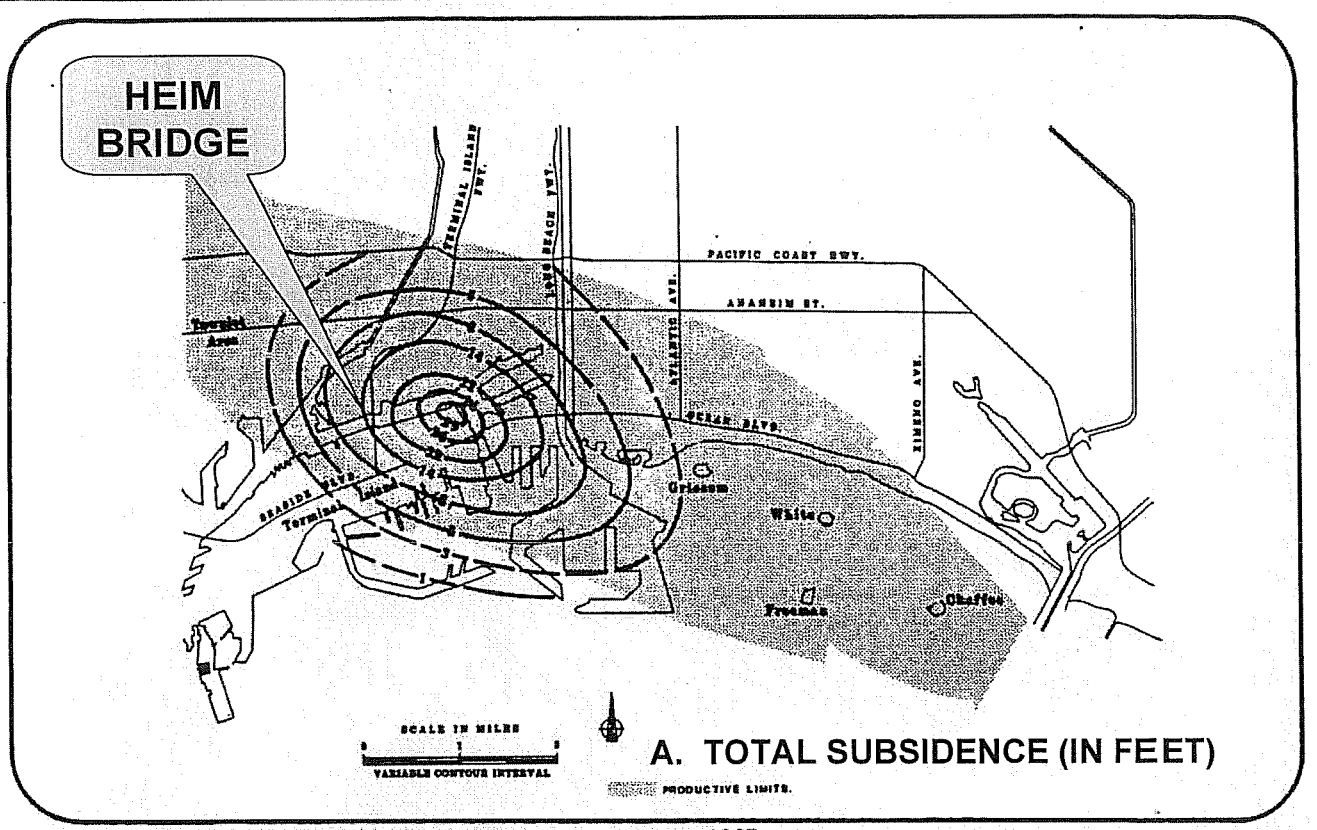
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	
	Geologic Cross-Sections, LA Harbor	
Project No. 06-123	Date: 5-10-10	Figure 6

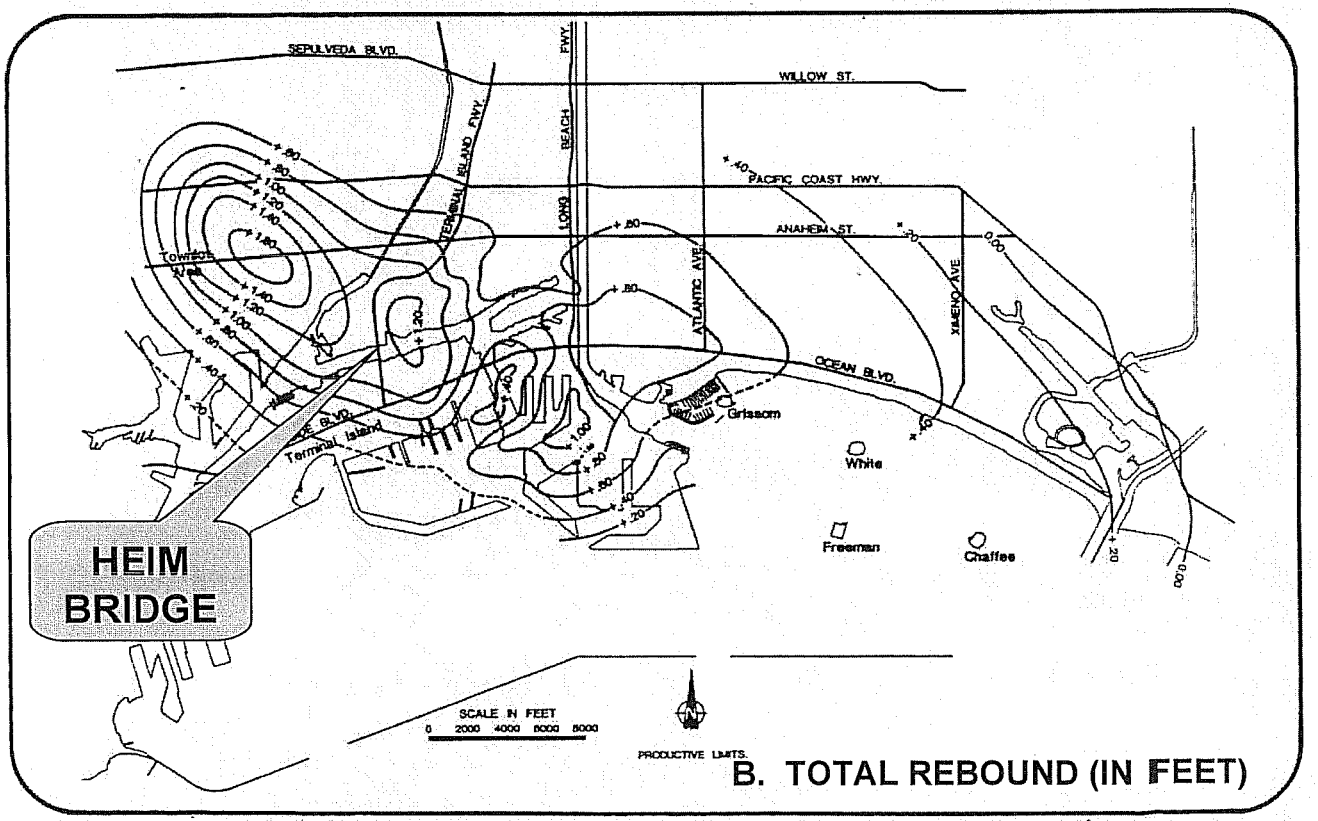


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-10-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-10-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -100 ft), the subsurface profile consists of about 55 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about zero. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -5 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -55 ft. Below elevation -55 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in both of the deep borings performed near the proposed wall at elevation -8.4 ft and -11.6 feet. The elevation that groundwater was encountered in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

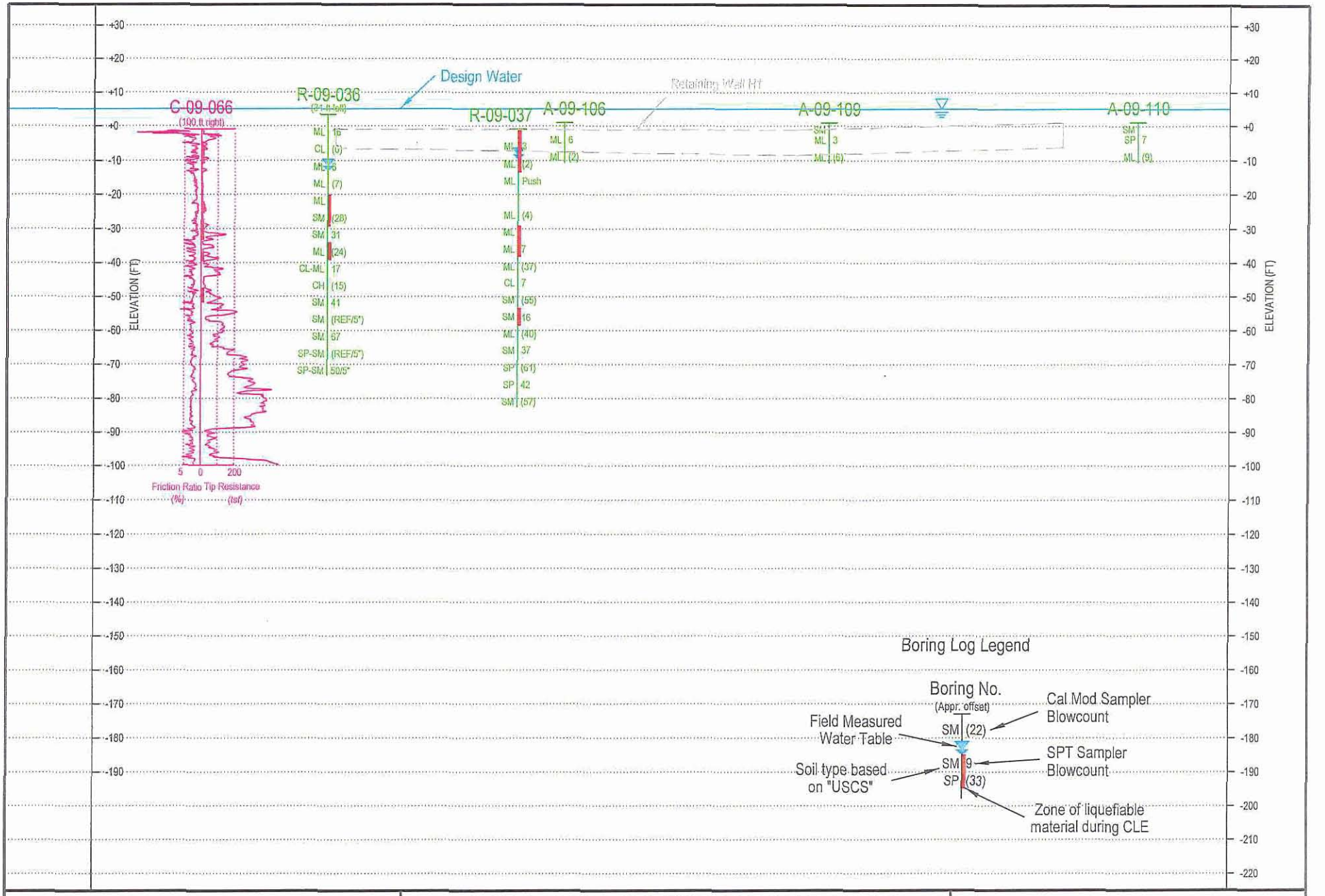
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

Based on information collected from borings R-09-036, R-09-037, A-09-106, A-09-109, A-09-110 and CPT sounding CPT-09-066, an idealized soil profile for foundation analysis and design was developed along the alignment of the proposed wall. The subsurface profile beneath the proposed structures is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+2.0 to -5.0	Silty Sand / Sandy Silt	120	0	30
-5.0 to -30.0	Clayey Silt / Sandy Silt	120	700	0
-30.0 to -40.0	Silty Sand / Sandy Silt	120	0	30
-40.0 to -50.0	Clayey Silt / Lean Clay / Silty Clay	120	2,500	0
-50.0 to -65.0	Silty Sand	120	0	34
-65.0 to -100.0	Sand / Sand with Silt / Silty Sand	125	0	38



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Subsurface Profile

Project No. 06-123

Date: 5-10-10

Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix D.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -55 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-036	-19 to -29	1.4	2.4
	-34 to -39	1.0	
R-09-037	-1 to -12	3.4	6.1
	-28 to -38	1.9	
	-53 to -58	0.8	
CPT-09-066	-4.0 to -10.0	0.5	2.0
	-22.6 to -24.8	0.6	
	-28.5 to -33.5	0.6	
	-37.0 to -39.3	0.3	
	-47.8 to -52.2	0.2	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Three soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.5 and 8.0, the minimum resistivities were found to vary between 65 and 190 ohm-cm, soluble chloride contents varied between 2,257 and 12,774 parts per million (ppm) and soluble sulfate contents varied between 518 and 1,187 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

5.4 Retaining Wall Recommendations

As described in Section 1.2, Proposed Retaining Wall H1 is a Caltrans Type I Retaining Wall located between approximate Stations 702+90 and Sta. 707+25 ("H" Line). The retaining wall is approximately 428 ft long and will vary in design height from 4 to 10 ft.

Based upon the preliminary cross sections provided by the wall designers, the proposed wall will have a footing bottom between approximately elevation -6 to -10 ft. Due to the soft to loose consistency of the near surface deposits along the proposed wall, spread footings are not suitable for support of the proposed wall. While both driven piles and Cast-In-Drilled-Hole (CIDH) piles are feasible foundation alternatives, it is our understanding that pile driving restrictions for the project make driven piles a less desireable foundation alternative compared to CIDH piles. Due

to the presence of shallow groundwater which will require "wet" construction methods and pile integrity testing, 24-inch diameter CIDH piles are recommended for support of the proposed structure.

5.4.1 Lateral Earth Pressures

The proposed retaining wall will be a "cut" wall and will retain the native, near-surface alluvium. A static active lateral earth pressure of 40 psf per ft of depth is recommended for design of cantilever retaining walls with a uniform lateral pressure of at least 80 psf due to vehicle surcharge load. This static active lateral earth pressure is applicable for a free-draining and level backfill.

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the subject wall need not to be designed for seismic earth pressures.

5.4.2 Pile Foundations

Axial Pile Capacity: Axial pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). The calculated axial geotechnical capacities and pile tip elevations for a single 24-inch CIDH pile is presented in Table 6. For the extreme event limit case, negative skin friction due to seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The bottom of the liquefiable layer contributing to negative skin friction was determined to be at elevation -40 ft based upon the seismic settlement analysis performed on boring C-09-066.

The maximum pile-head settlement due to the nominal resistance is estimated to be less than 1-inch. For axial loading, a group effect reduction factor of 0.8 was included in determining the tip elevation shown in Table 6.

TABLE 6. RECOMMENDED PILE TIP ELEVATIONS

Approx. Wall Station; "H" Line	Approx. Pile Cutoff El. (ft)	Design Loading (Service) (kip)	Nominal Resistance (kip)		Design Tip El. (ft)[1]	Specified Tip El. (ft)
			Compr.	Tension		
702+90 to 707+25	-3.5 to -7.0	90	180	0	-61.0 (a) -45.0 (b)	-61.0

Note: (1) Design tip elevation is controlled by the following demands: (a) Compression, (b) Lateral Loads.

Lateral Pile Capacity: Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a free-head connection with the pile cap are provided in Table 7. The design tip elevation for lateral loading is given in Table 6.

Lateral pile analyses were performed using the computer program LPILE (Ensoft 2007). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000). The internally generated p-y curves for stiff fine-grained soils were estimated using the method proposed by Reese (Reese et al., 1975), and the internally generated p-y curves for soft fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.9 was used in the analysis based a staggered pile layout with an average pile spacing of 6 ft along the length of the wall and the procedures outlined in the Ensoft Group 7.0 software Technical Manual (Ensoft 2006). Liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008).

The solutions presented are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and other connection details.

TABLE 7. 24-IN CIDH PILE "FREE" HEAD SOLUTION

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	19	928
0.5	27	1,484
1.0	38	2,380
2.0	55	3,839
3.0	68	5,091

Notes: 1. Group effects considered with a reduction factor of 0.9 on "p."

5.4.3 Global Wall Stability

The "global" stability of the Retaining Wall H1 was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The cross-section selected for stability analysis was near "H" Line Sta. 705+75 where the retained wall height is greatest.

Slope stability analyses were conducted for the static condition. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix D) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in both of the borings performed near the proposed wall between elevation -8.4 and -11.6 ft. Based on the latest cross sections provided by the designers, the bottom of proposed footing bottom varies between about elevation -6 and -10 ft. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

Due to the proposed footing bottom elevations, the contractor should anticipate encountering groundwater during construction. The contractor should be prepared to manage groundwater and conduct construction activities in soft ground conditions. The groundwater should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

Groundwater was encountered between elevation -8.4 and -11.6 feet in October and November 2009. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff and other man-made conditions. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is

being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.3 Backfill Requirements for Walls

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the walls in order to avoid damaging the walls due to large lateral earth pressures.

6.4 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.5 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of retaining wall.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
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REGISTERED ENGINEER — DATE 04/19/10

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ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

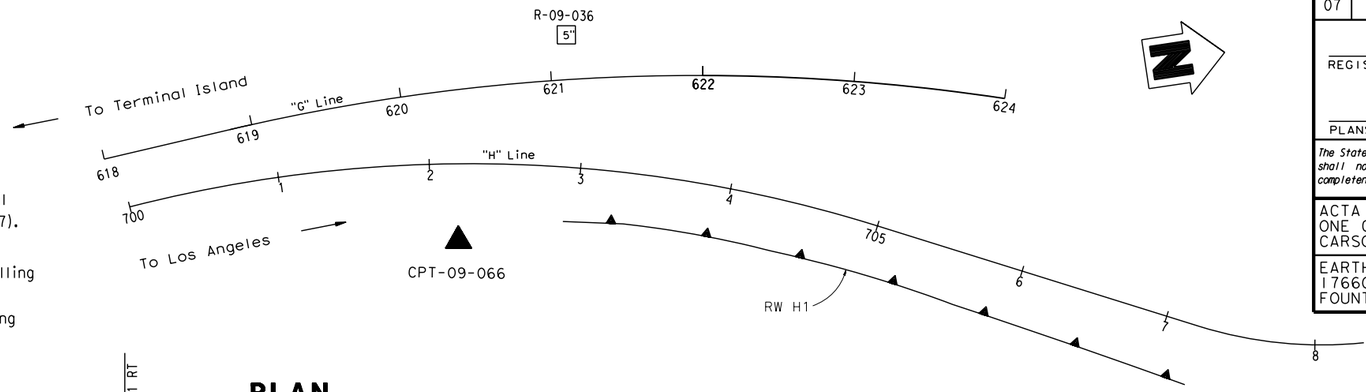
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

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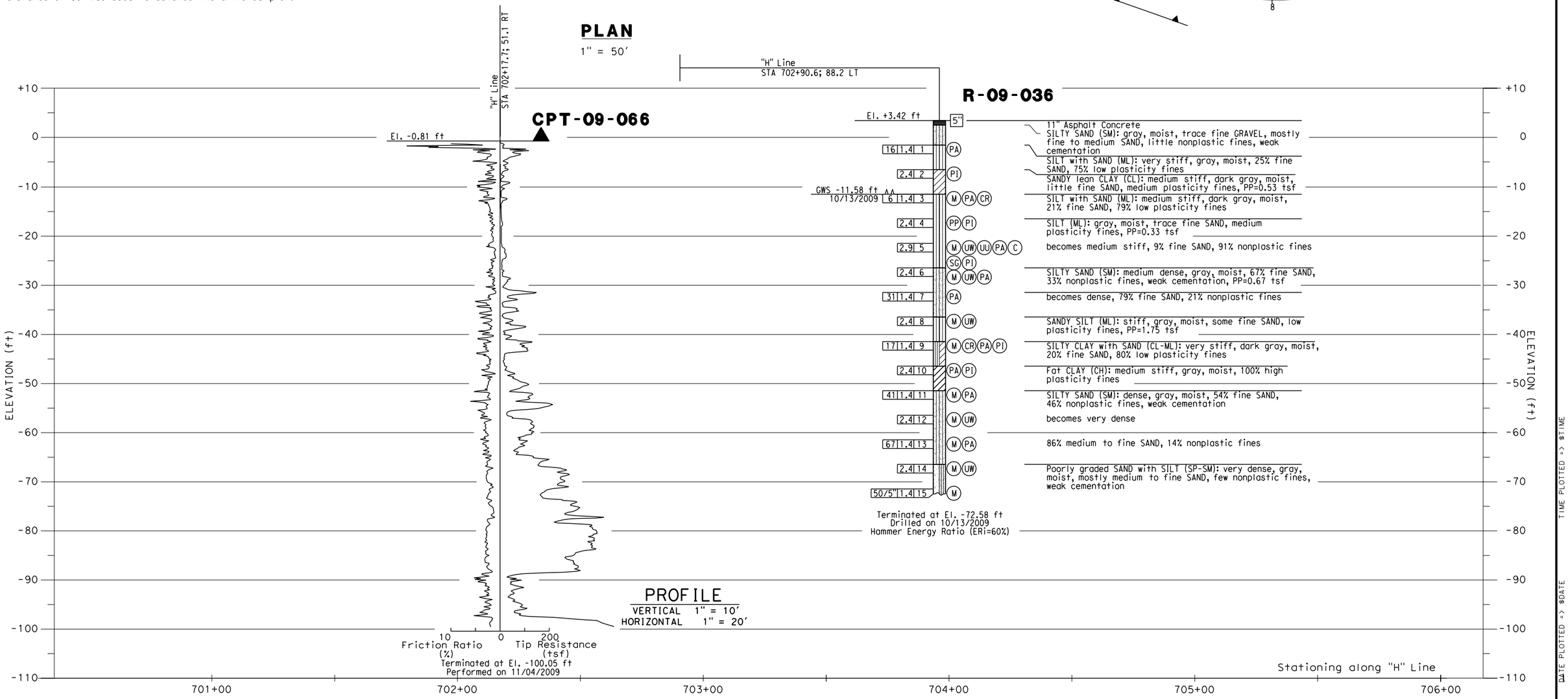

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			

RETAINING WALL NO. H1

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

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FOUNTAIN VALLEY, CA 92708

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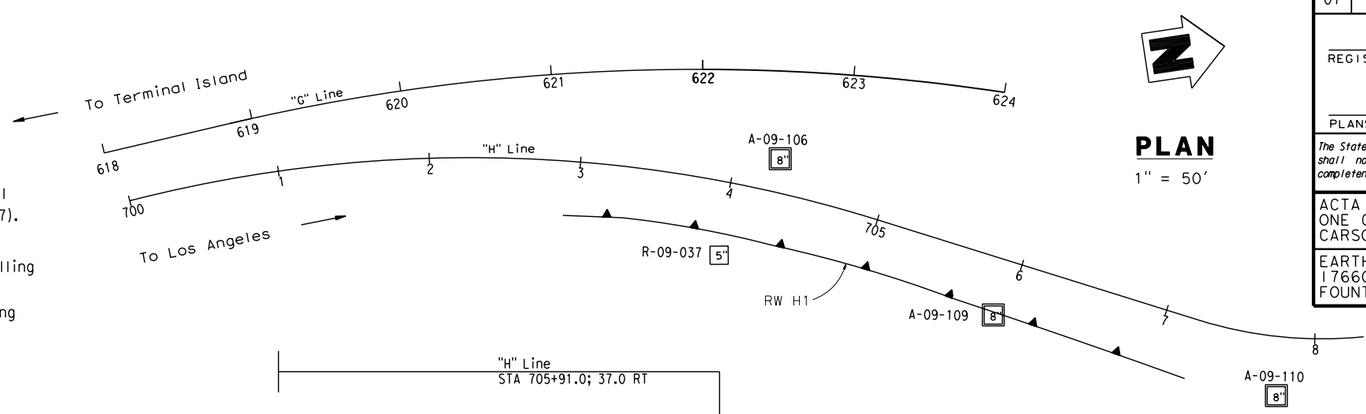

PLAN

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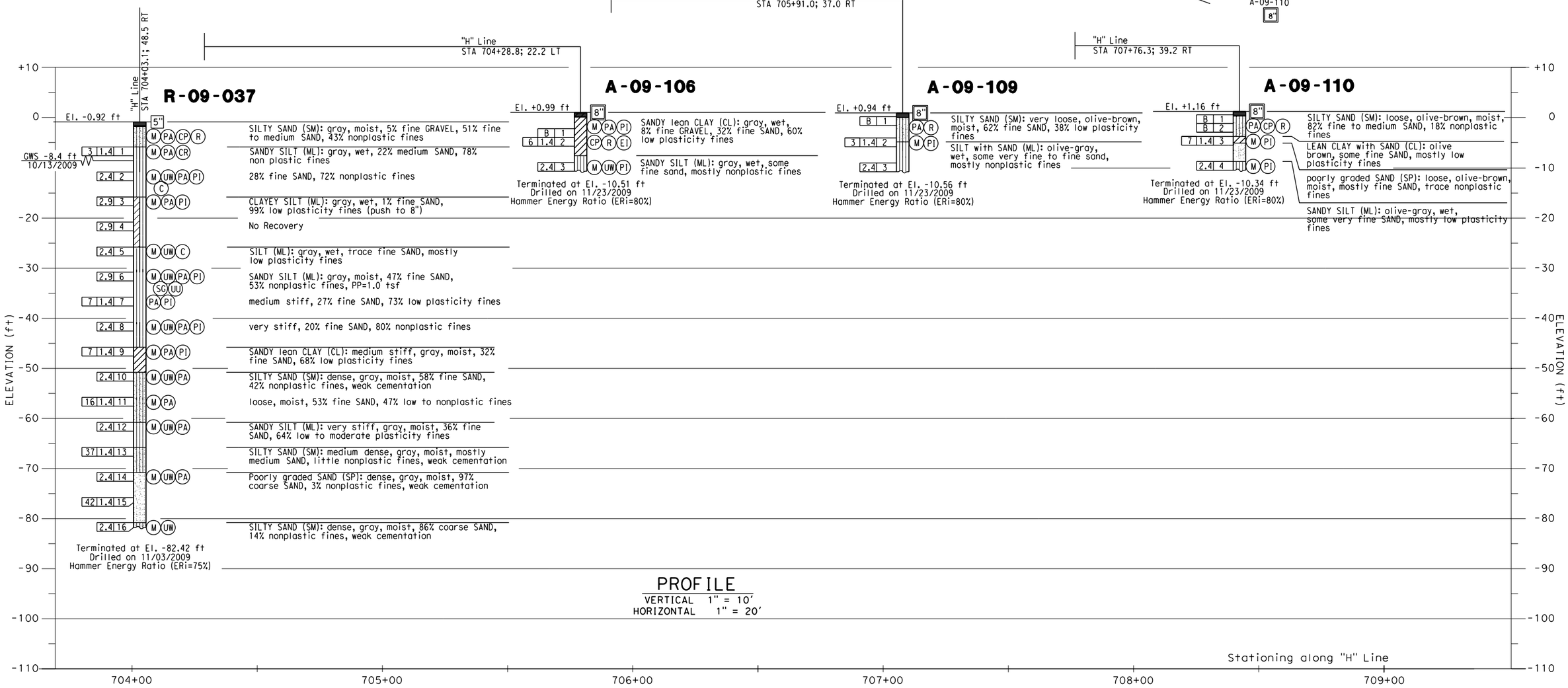

PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.18	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

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07	LA	47			

04/19/10
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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

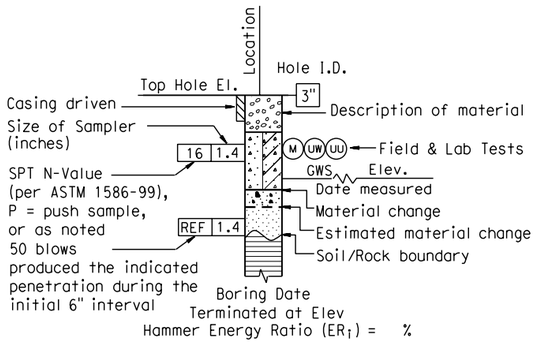
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

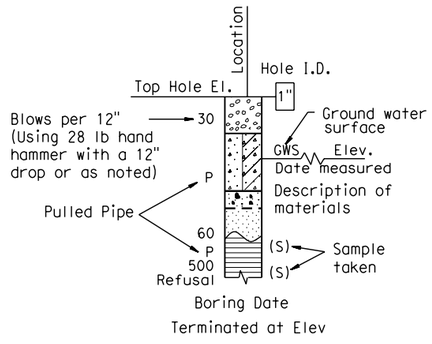
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

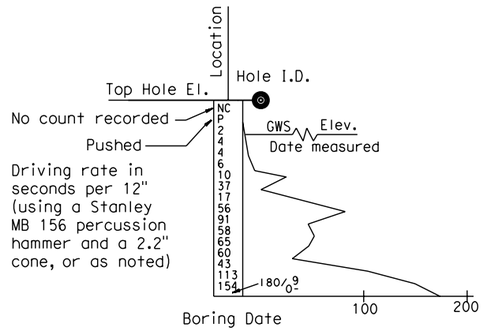
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



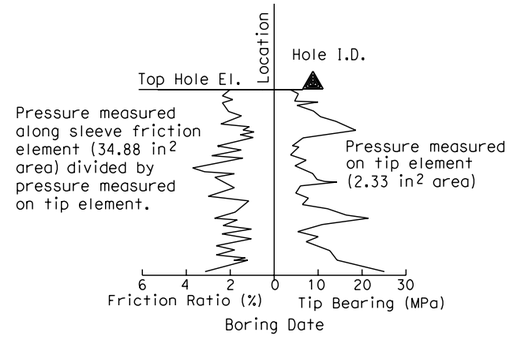
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

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RETAINING WALL NO. H1

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

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DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
03/01/10	04/14/10								X	X

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. -

POST MILE 0.18

RETAINING WALL NO. H1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10, 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A.

EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

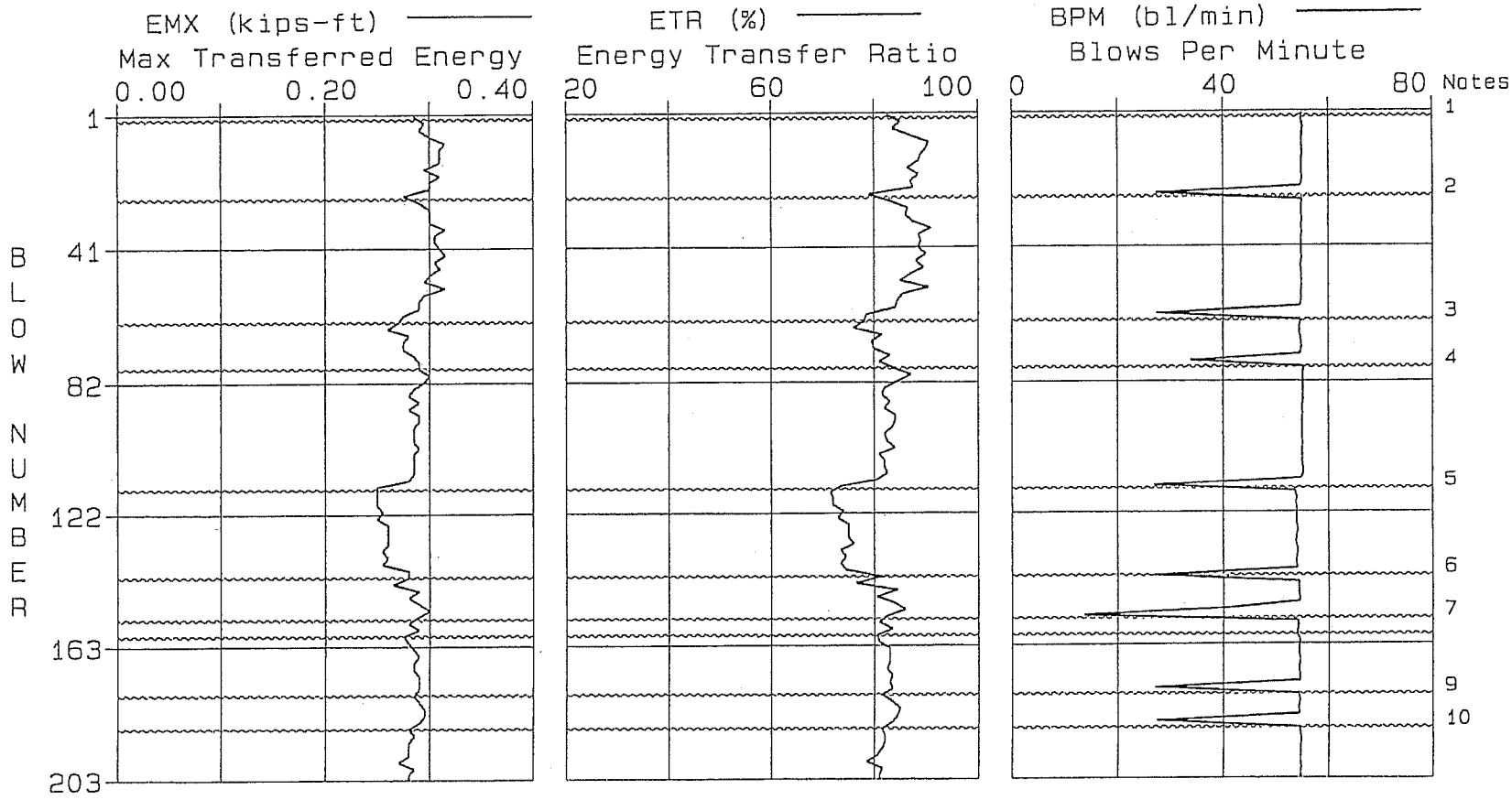
Sincerely Submitted for EarthSpectives

Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer

EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

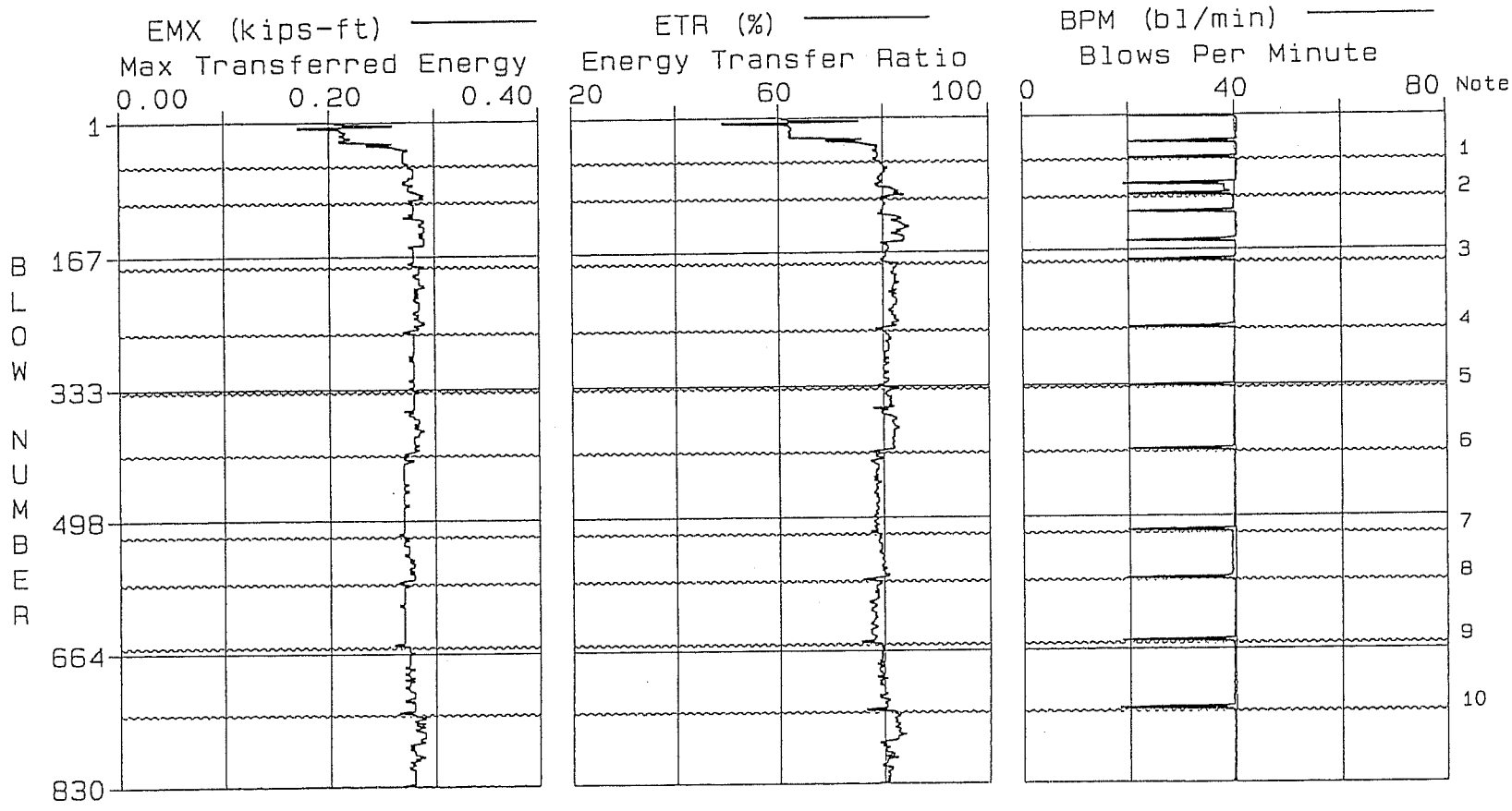
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

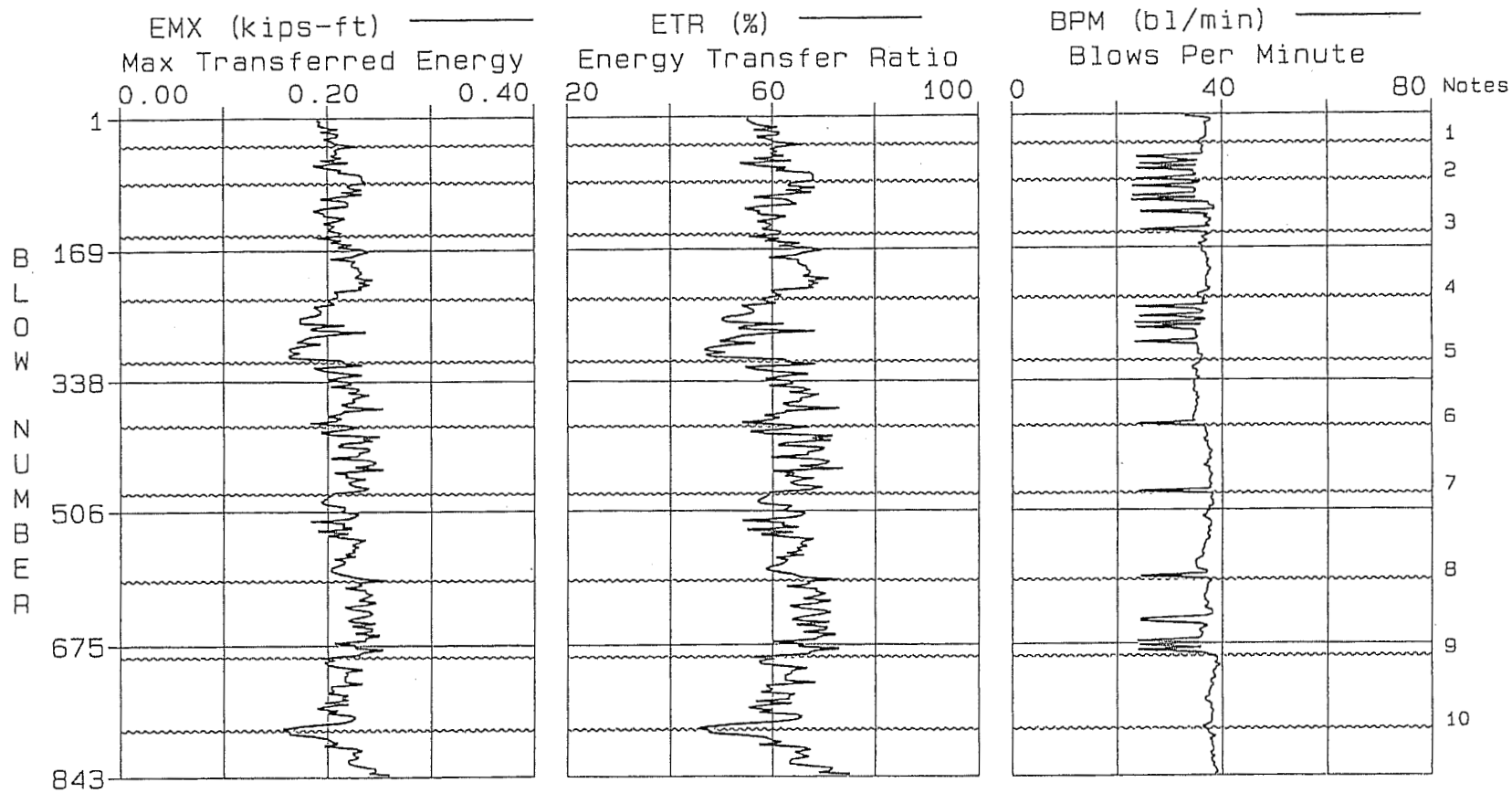
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX B.

GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

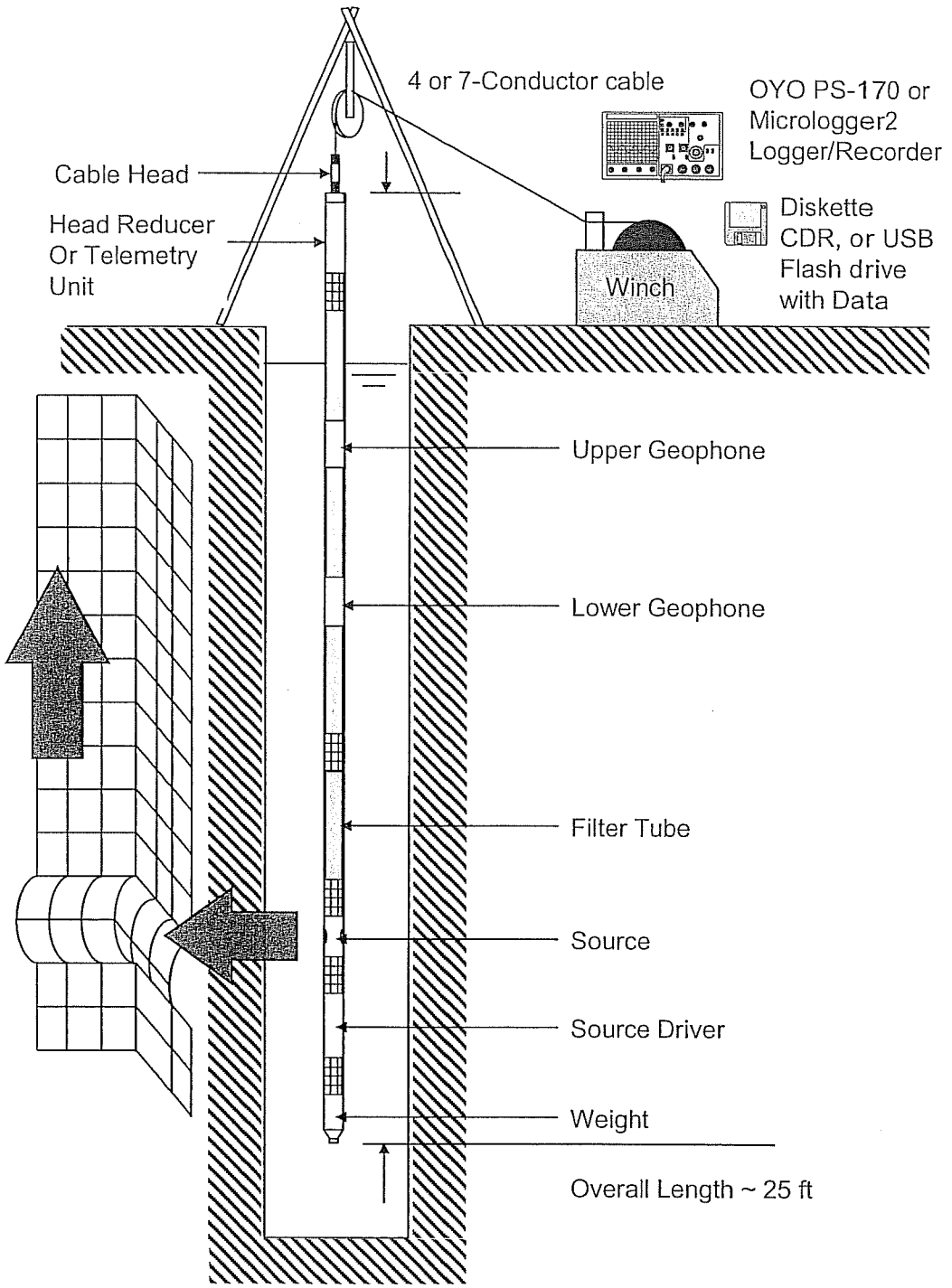

Figure 1: Concept illustration of P-S logging system

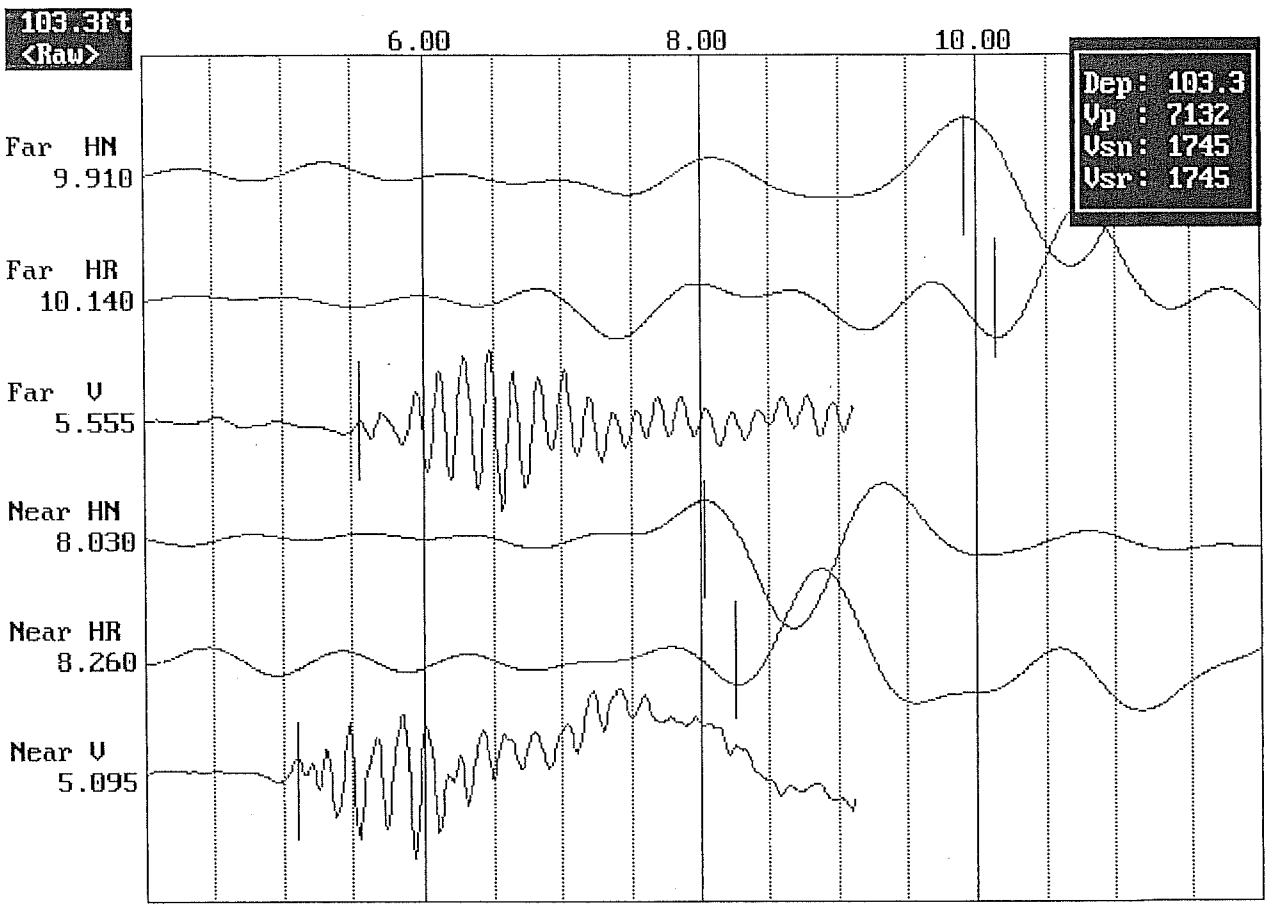

Figure 2: Example of filtered (1400 Hz lowpass) record

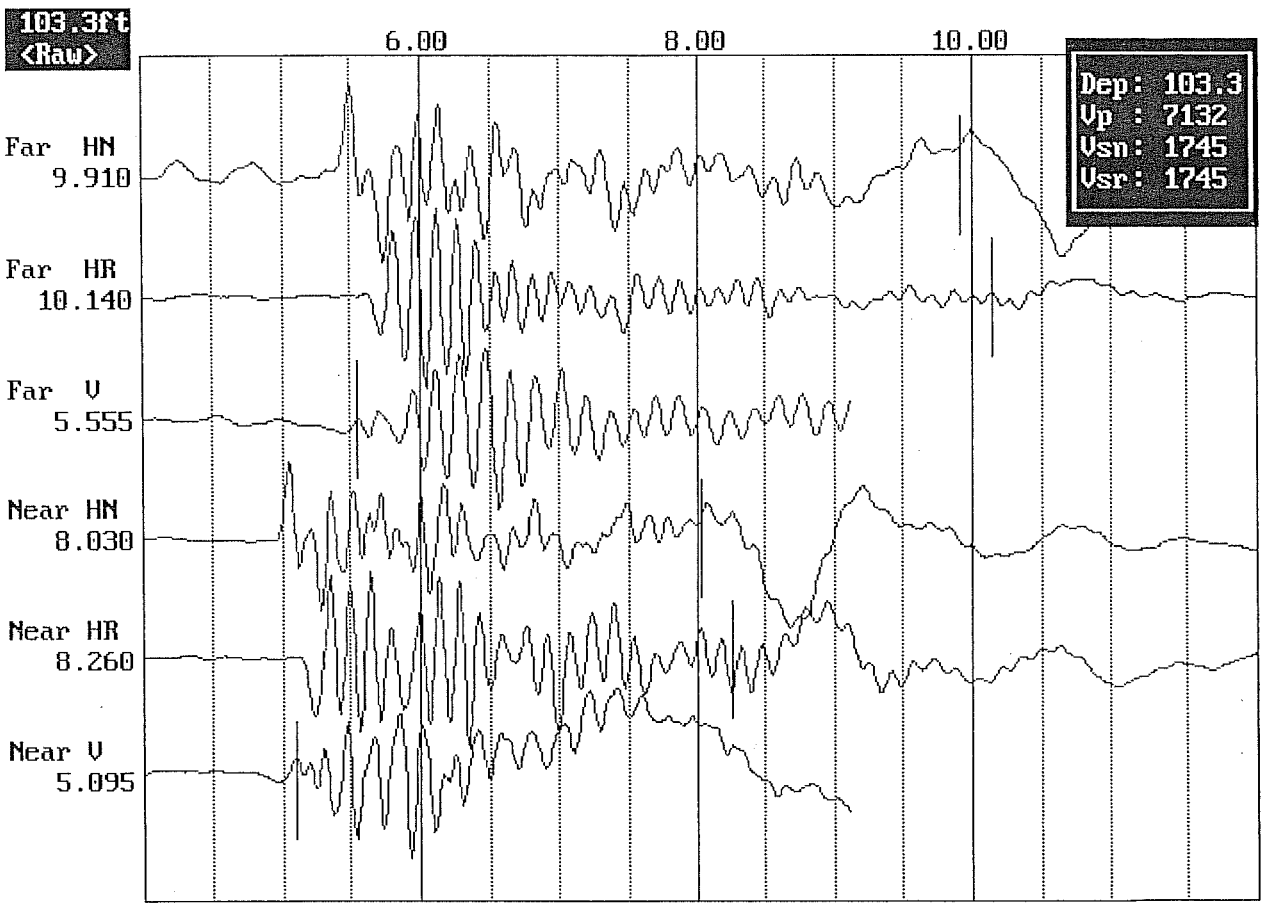

Figure 3. Example of unfiltered record

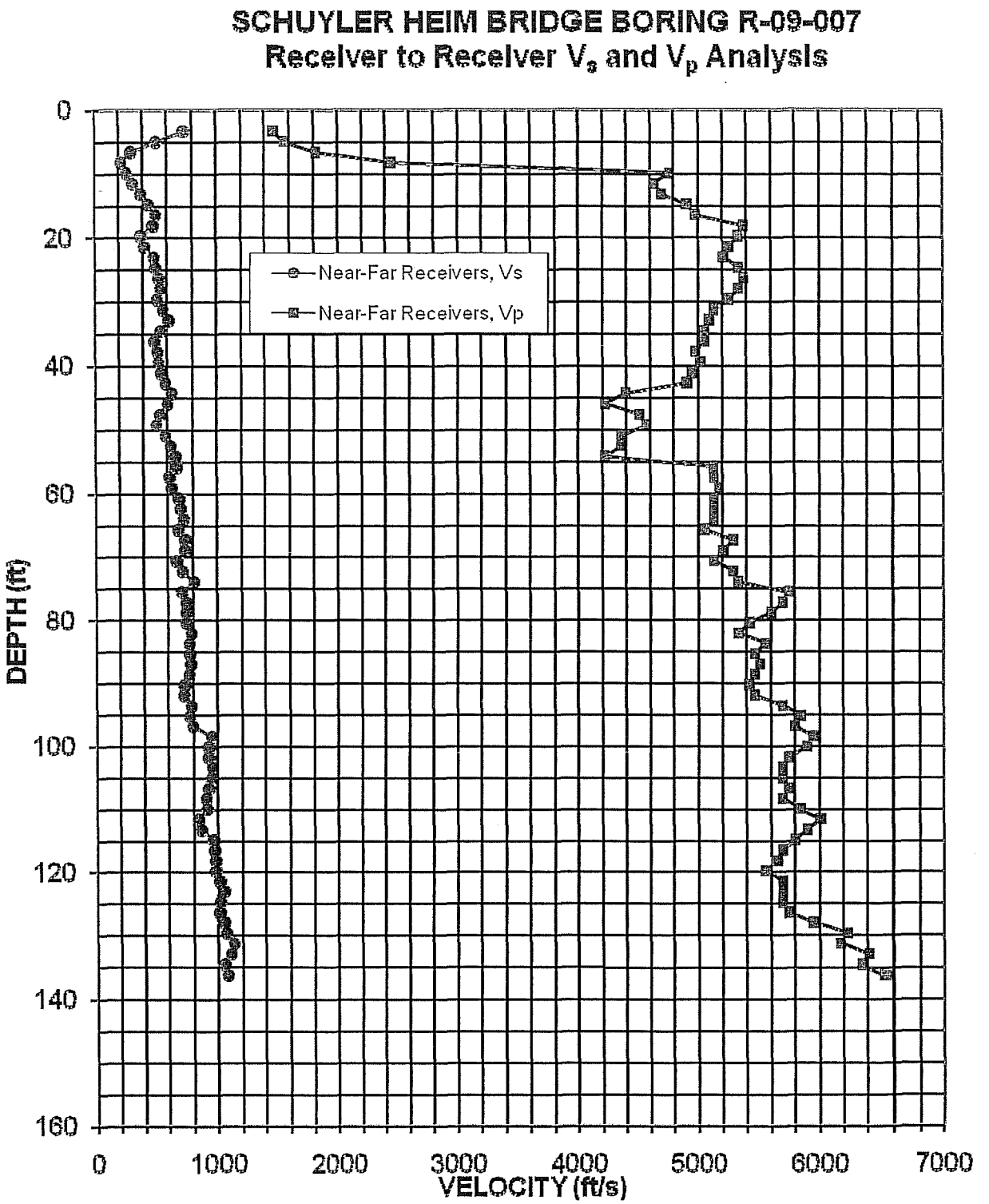

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

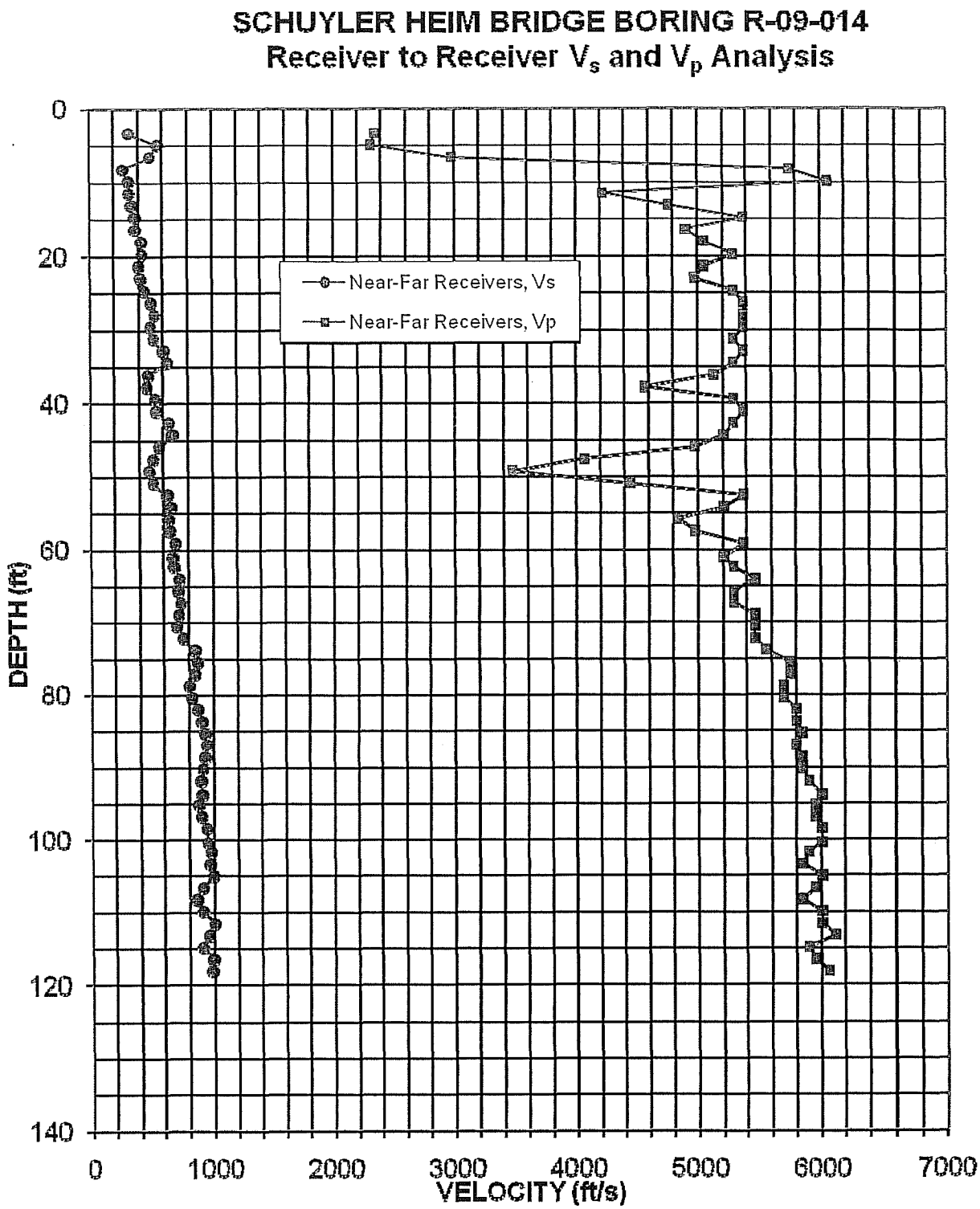

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

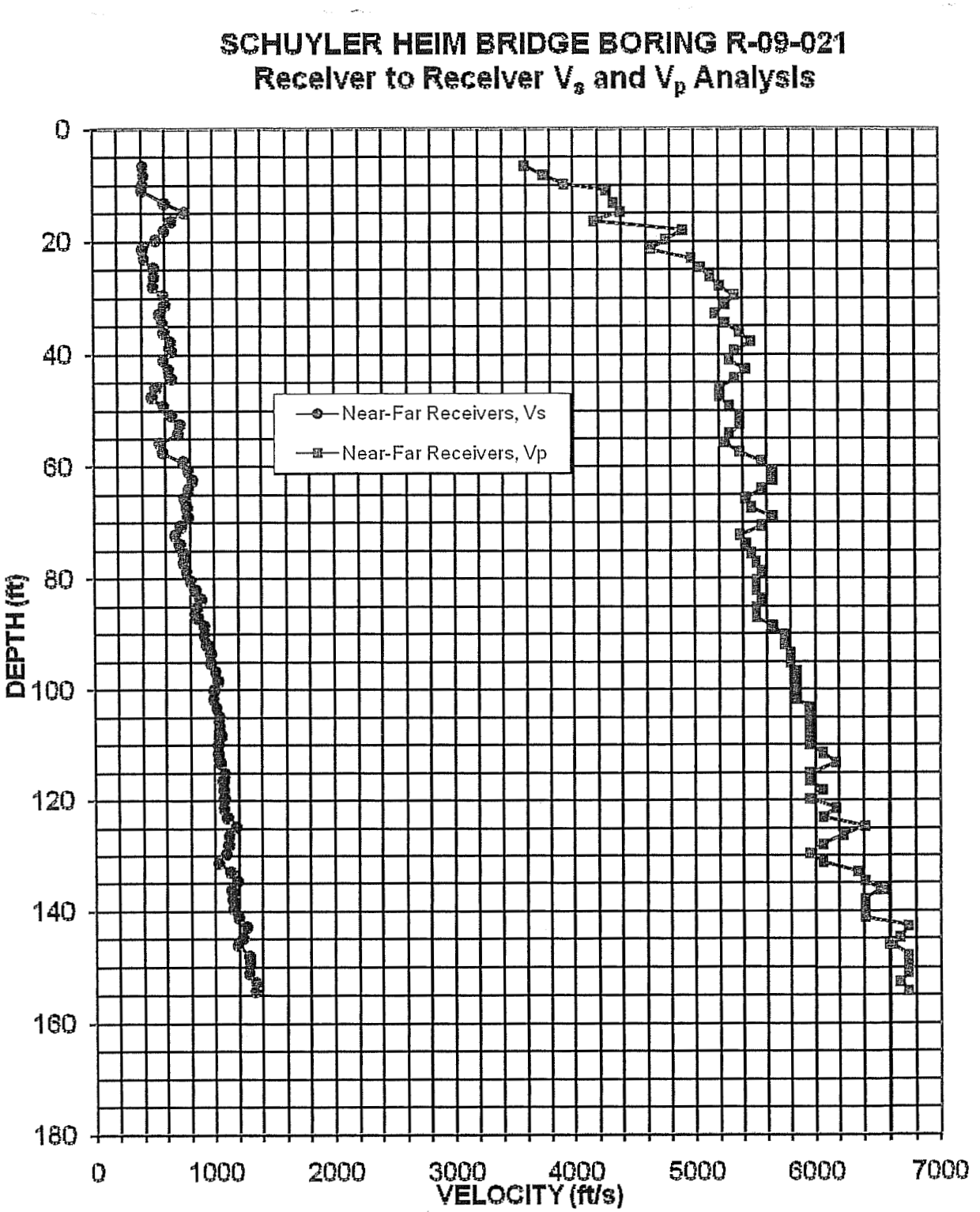

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

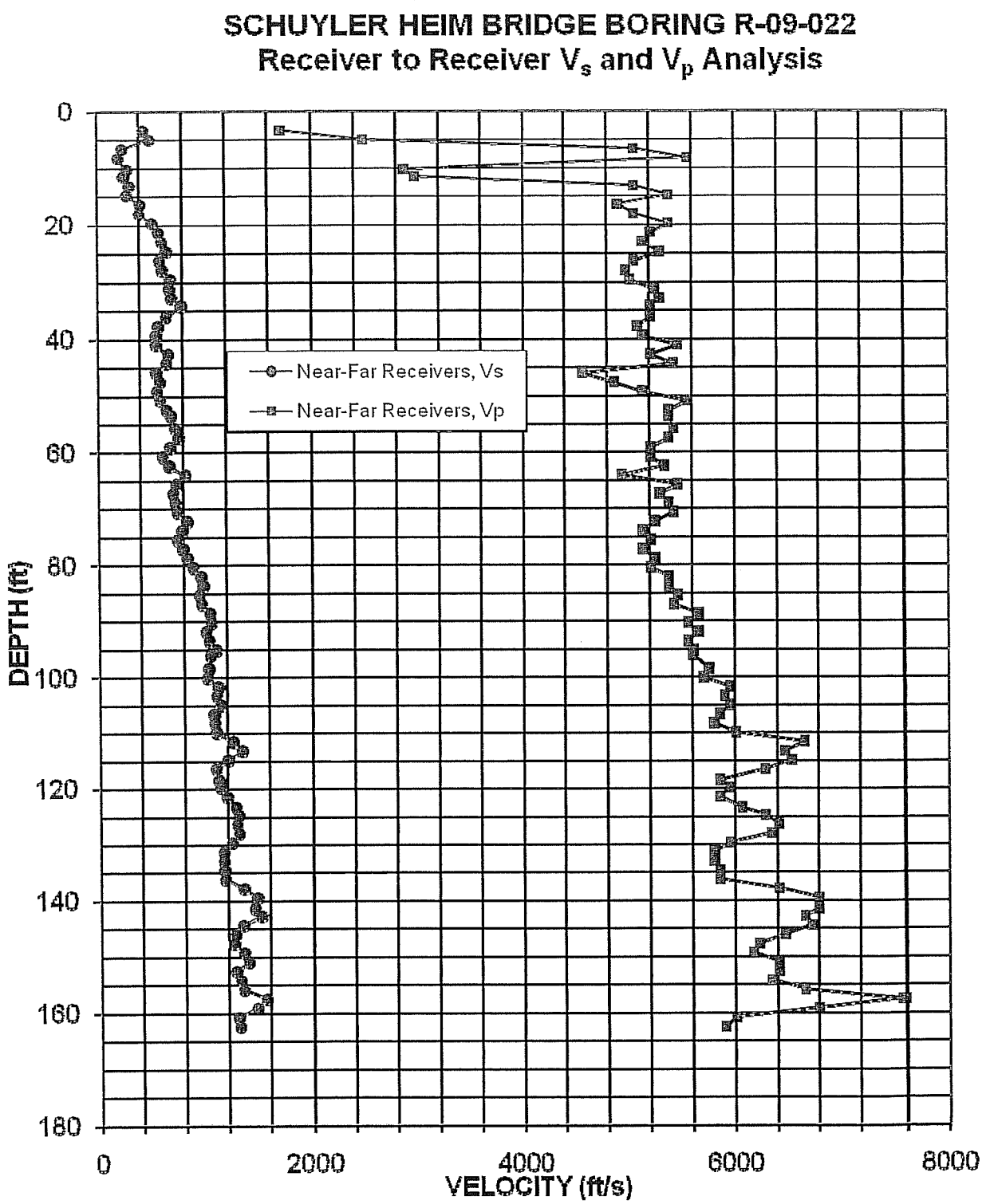

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

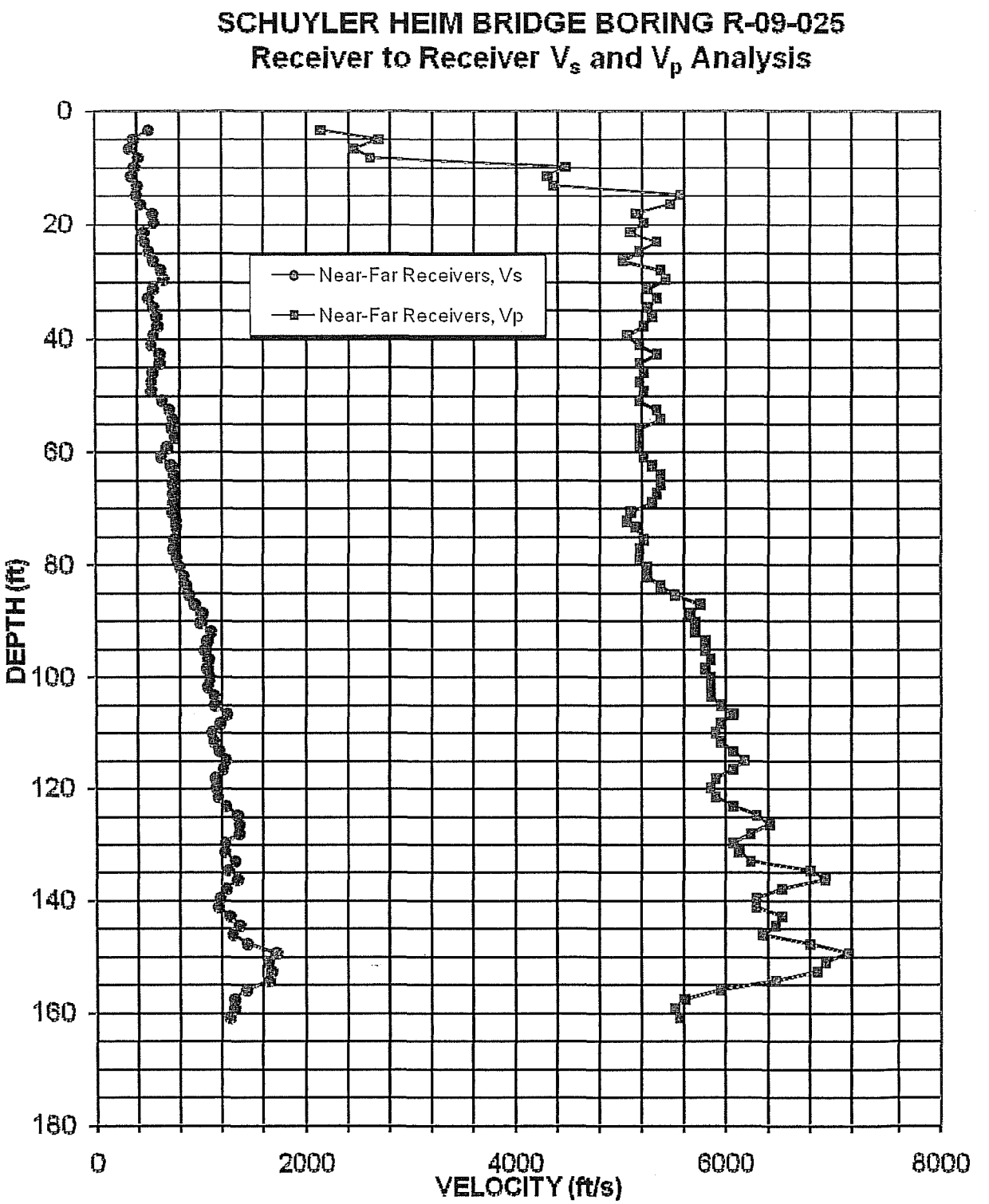

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

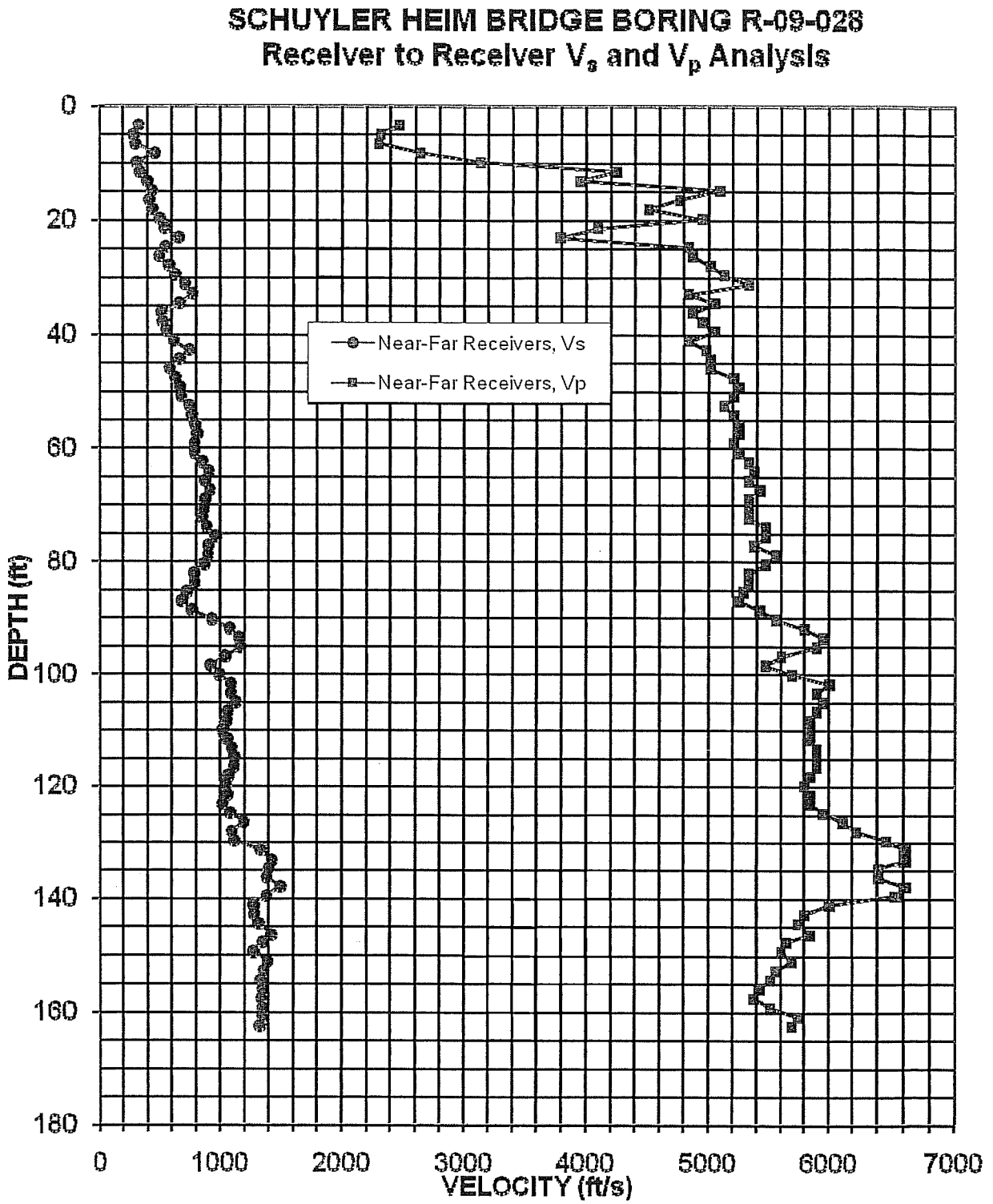

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

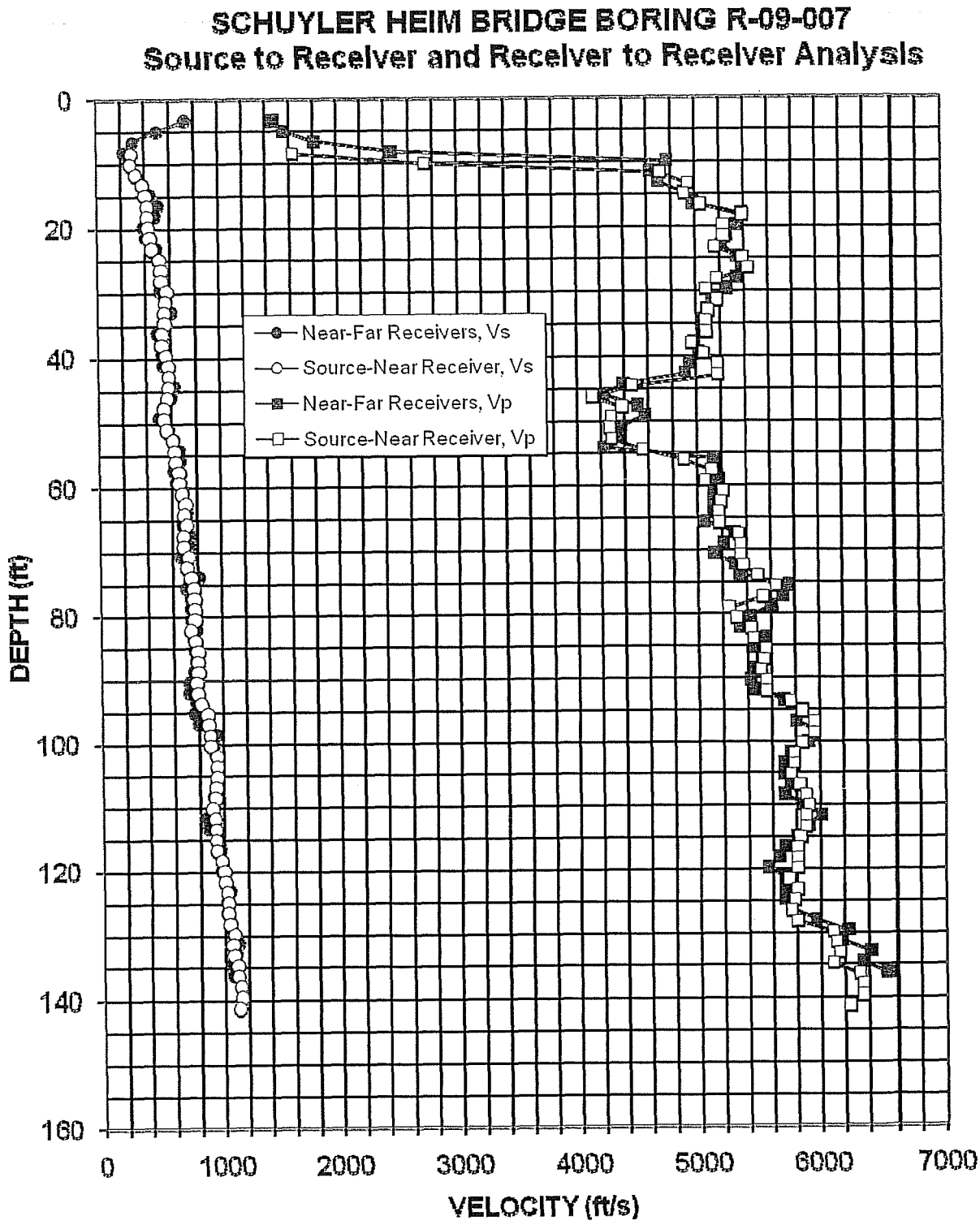

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P_- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

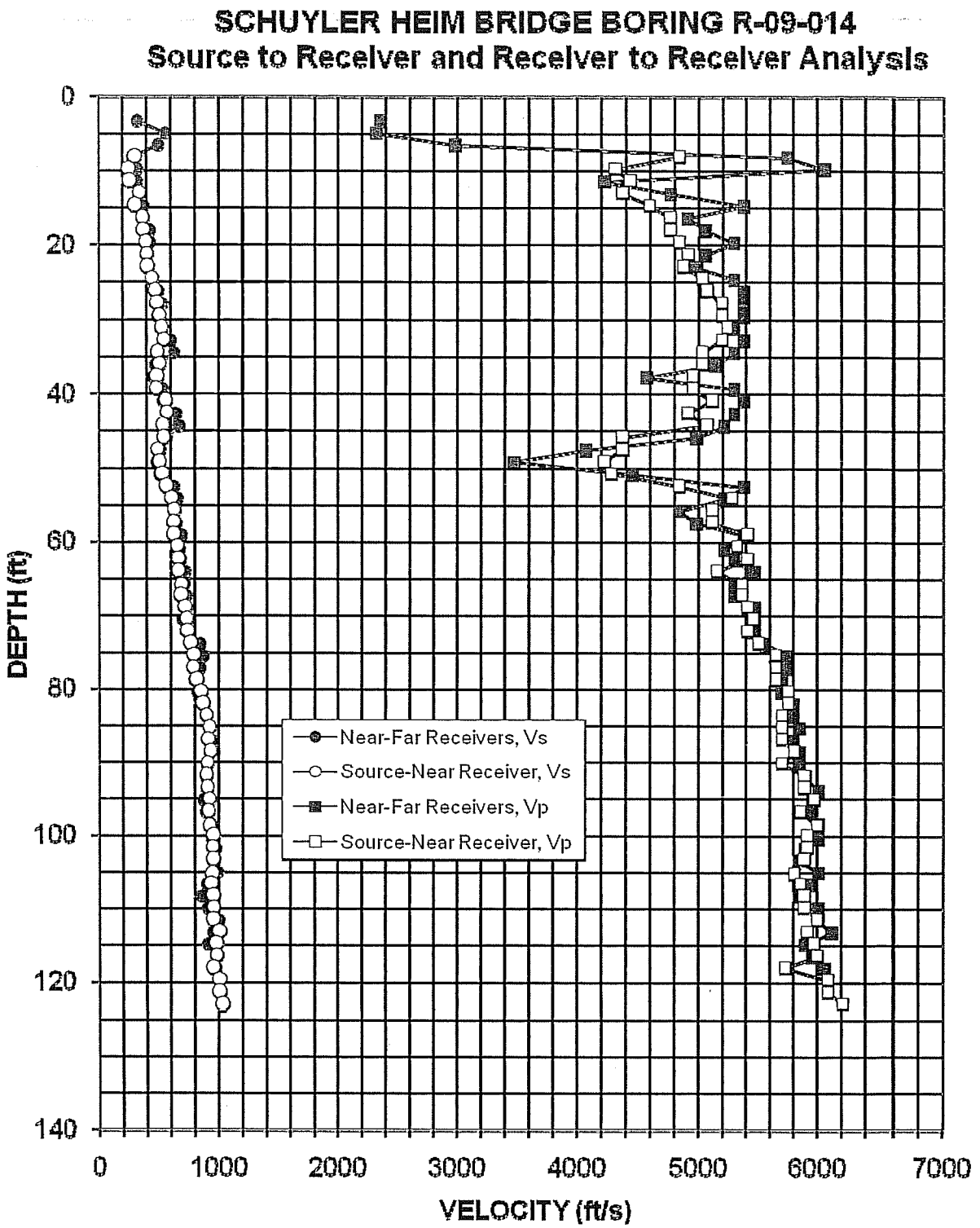

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

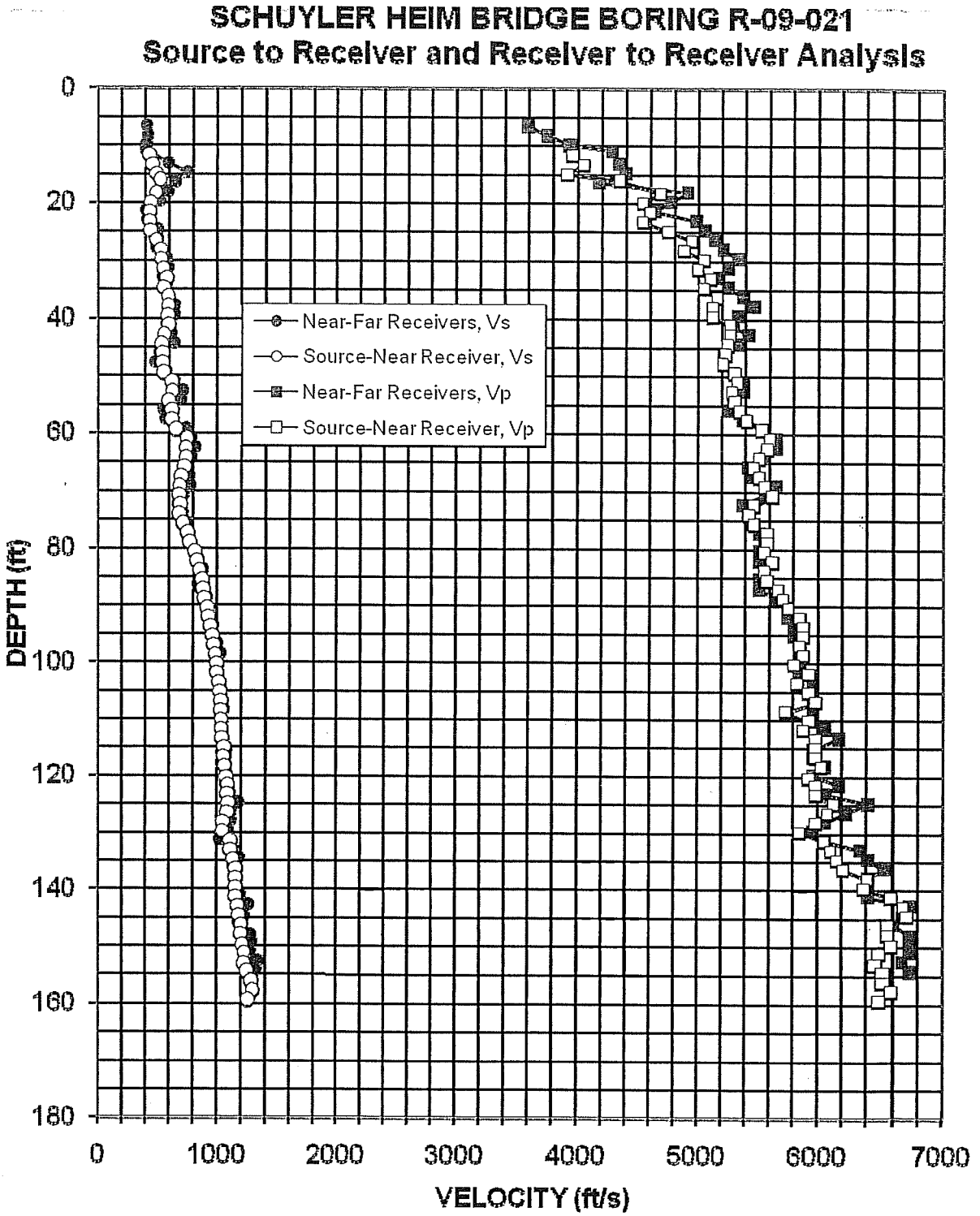

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S-- R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

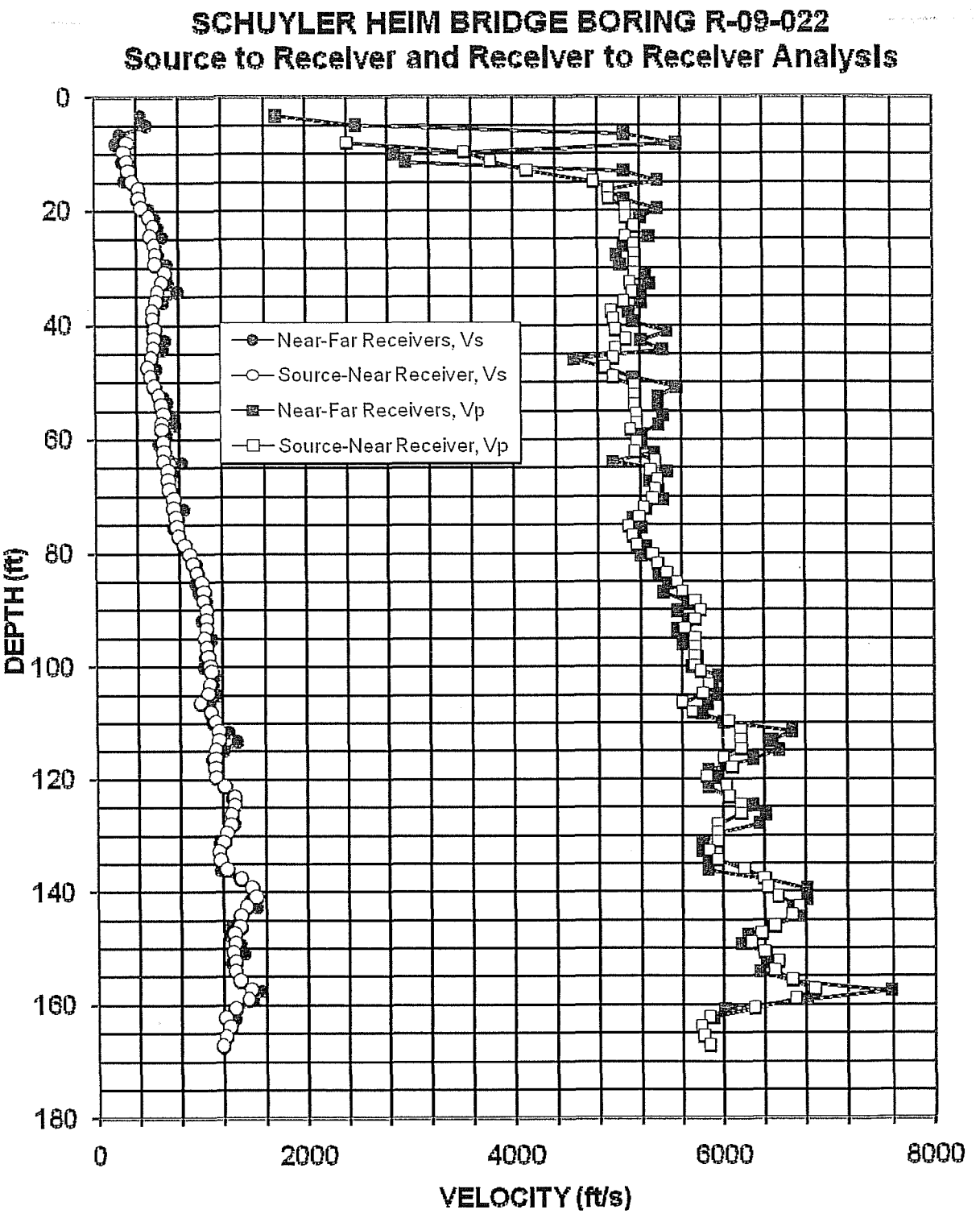

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5080	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

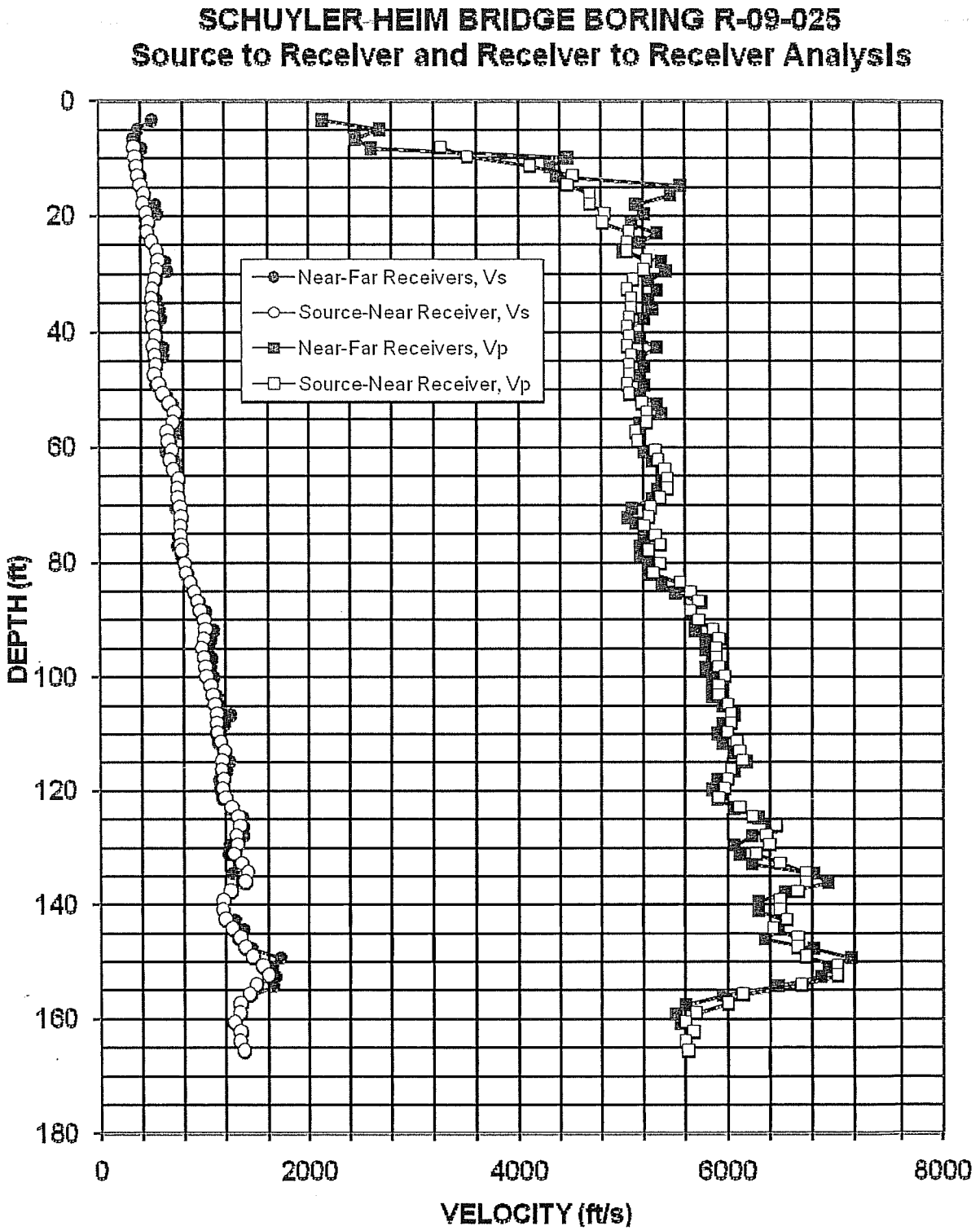

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

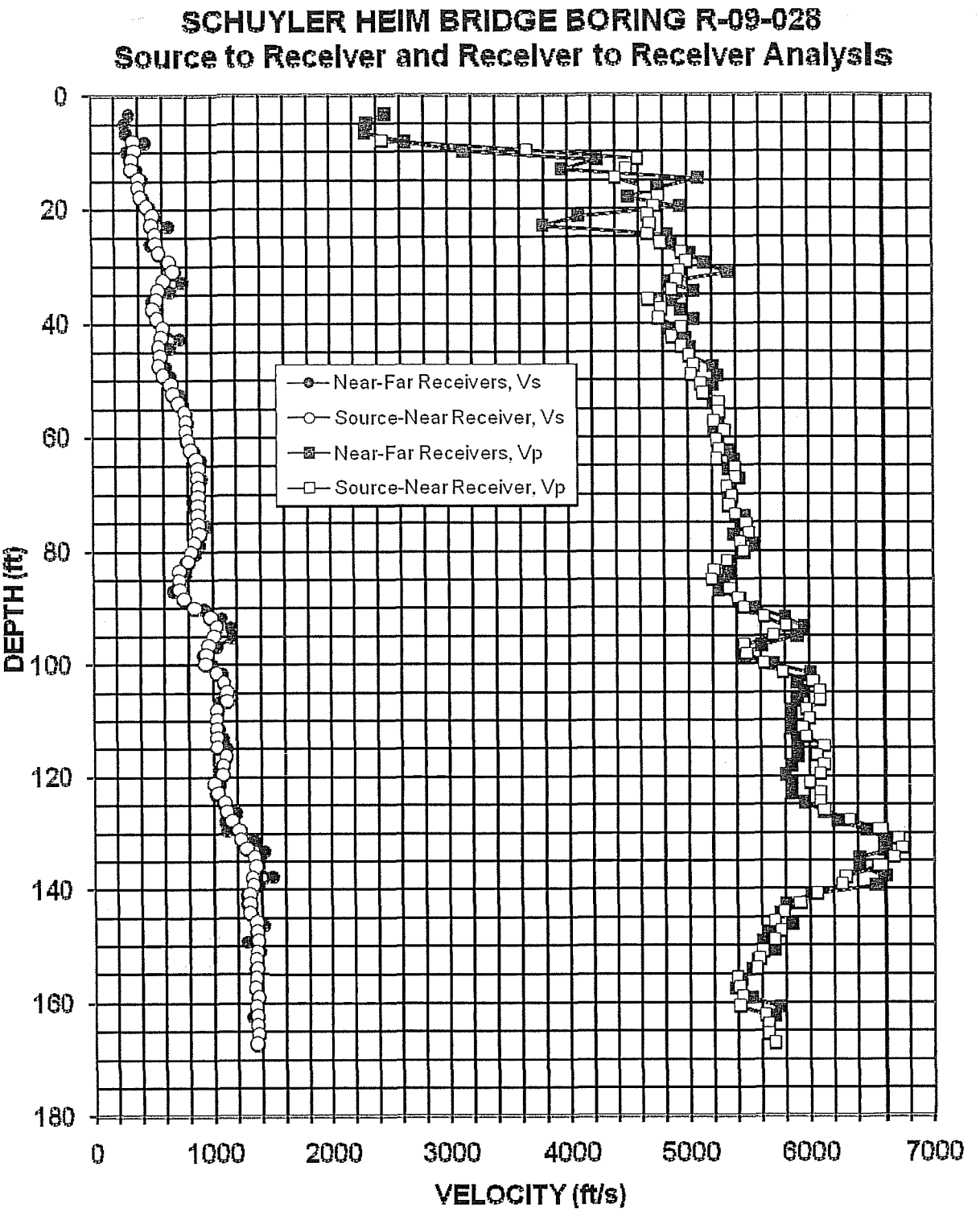

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠
A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024
573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson	
	Name	Date	Signature	
Witnessed by:	Robert Steller	7/17/2009		
	Name	Date	Signature	

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C.

LABORATORY SOIL TEST RESULTS

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/18/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-036	S-03	15	43.6	NA
R-09-036	D-06	30	32.2	91.8
R-09-036	D-08	40	32.8	89.5
R-09-036	S-09	45	38.7	NA
R-09-036	S-11	55	28.4	NA
R-09-036	D-12	60	36.7	91.0
R-09-036	S-13	65	25.2	NA
R-09-036	D-14	70	36.9	97.2
R-09-036	S-15	75	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-036	D-02	10	0.53
R-09-036	D-04	20	0.33
R-09-036	U-05	25	1.00
R-09-036	D-06	30	0.67
R-09-036	D-08	40	1.75

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03
Laboratory No.: 29-1121
Date: 11/18/09

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-036	S-01	5	75.38
R-09-036	S-03	15	79.26
R-09-036	D-06	30	32.51
R-09-036	S-07	35	21.13
R-09-036	S-09	45	80.15
R-09-036	S-11	55	45.51
R-09-036	S-13	65	14.11

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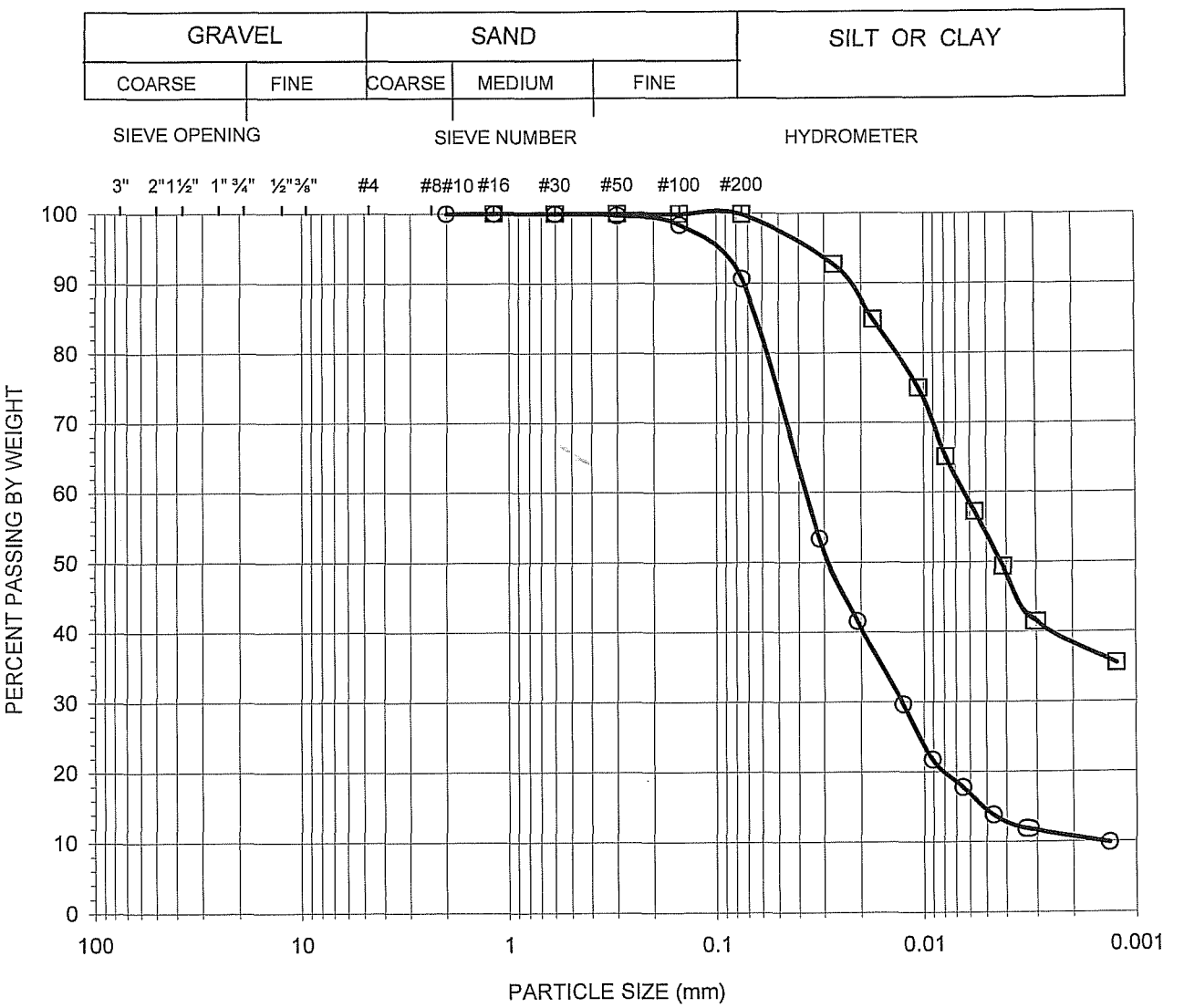
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



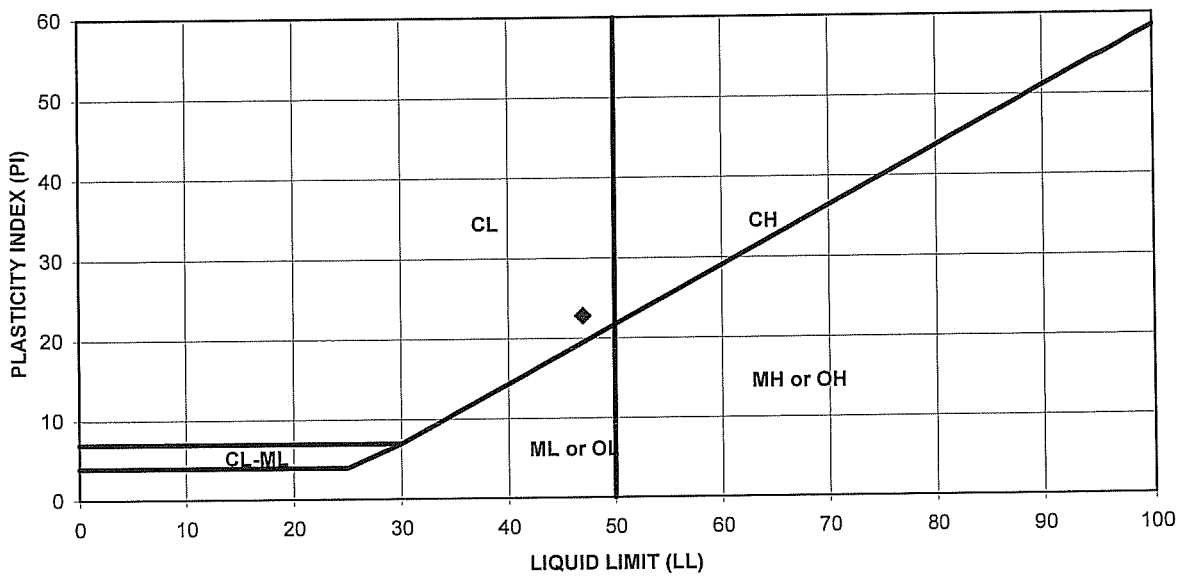
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-036	U-05	25	0.00	9.35	90.65	N/P	ML
□	R-09-036	D-10	50	0.00	0.16	99.84	56:29:27	CH

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

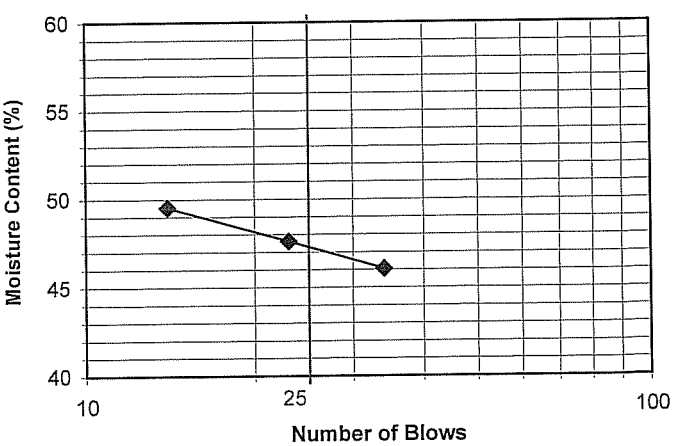
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-02	10	47	24	23	CL
	R-09-036	U-05	25	NP	NP	NP	

* NP denotes "non-plastic"

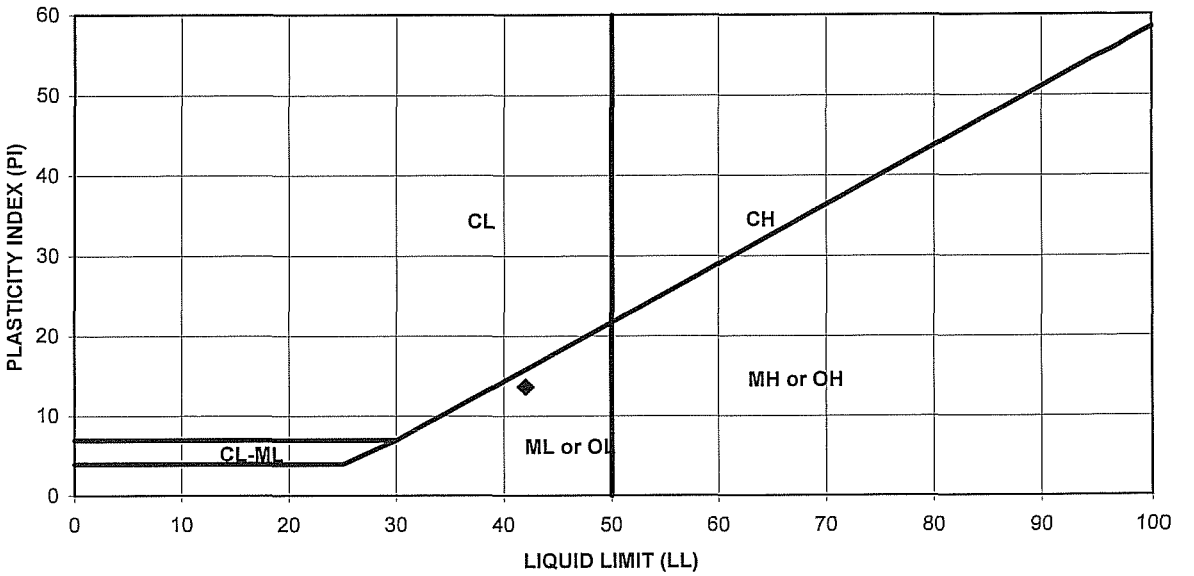
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

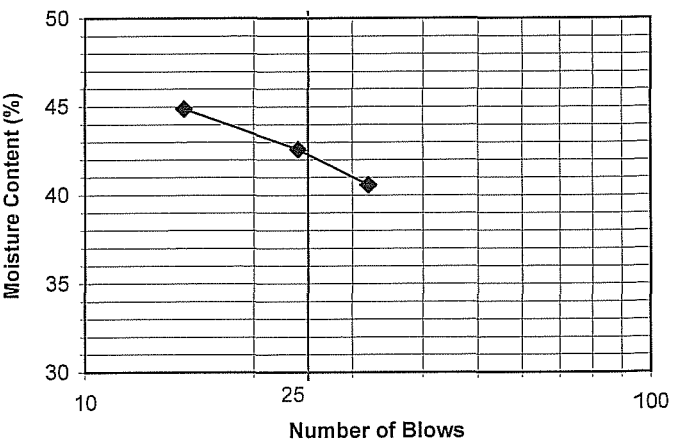
Tested By: DK
Checked By: AP

Date: 01/06/10
Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



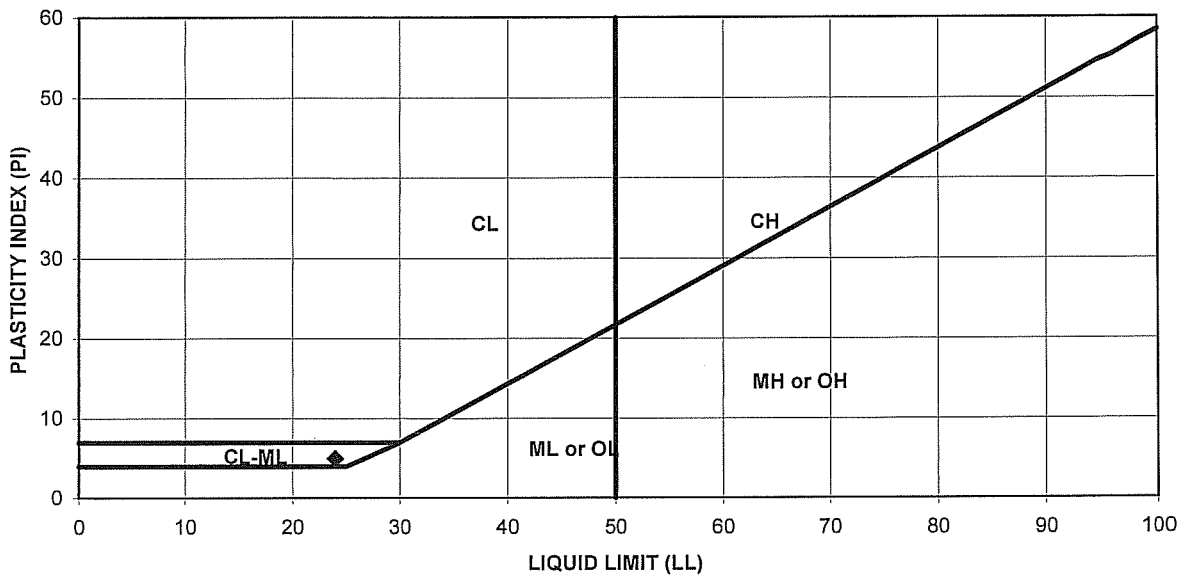
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-04	20	42	28	14	ML

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

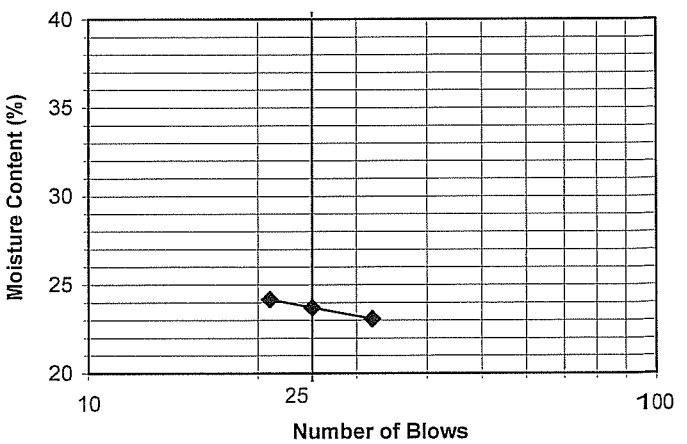
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	S-09	45	24	19	5	CL-ML

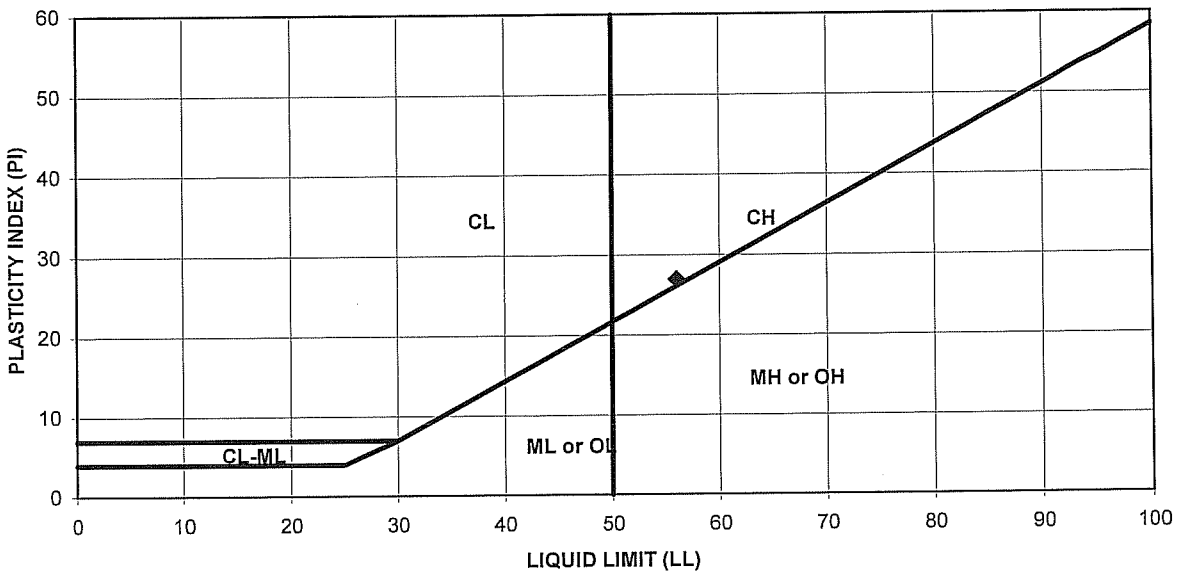
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

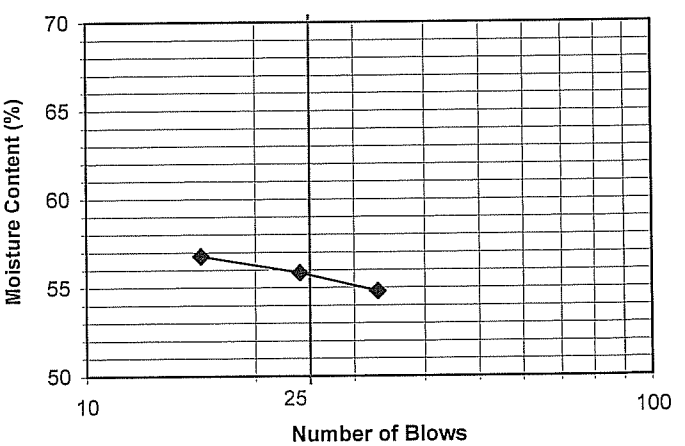
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-10	50	56	29	27	CH

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-036					
SAMPLE NUMBER	U-05					
DEPTH (FT)	25					
SOIL CLASSIFICATION	Silt					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	385.76					
TEMPERATURE, °C	19.5					
CORRECTION FACTOR	1.0001					
WT. DRY SOIL, g	37.81					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.68**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/18/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-036	S-03	15	ML	150	8.0	1187	12774
R-09-036	S-09	45	ML	190	7.7	680	9790

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

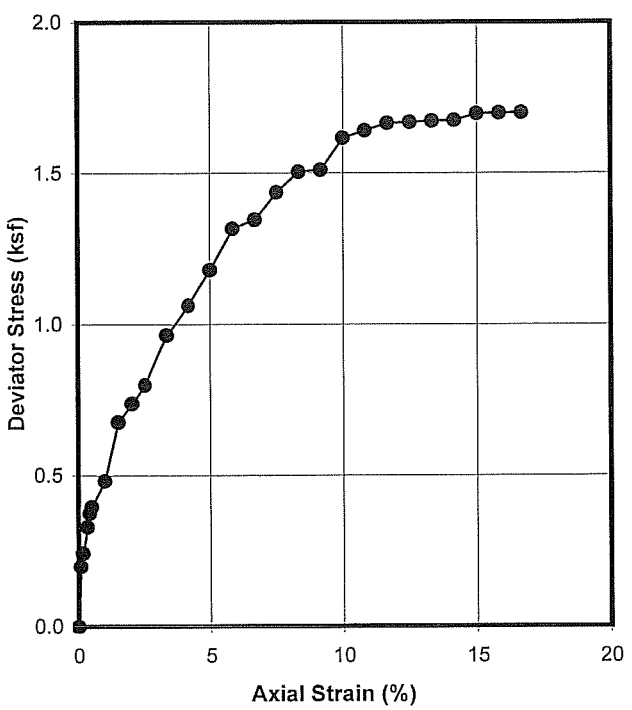
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-036		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silt w/shell	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	111.7
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	78.6
Sample Weight (gms):	1142.84	Moisture Content (%):	42.1
Wt. Wet Soil+Container(gms)	1351.61	Void Ratio for Gs=2.7:	1.14
Wt. Dry Soil+Container(gms)	1010.90	% Saturation:	99.5
Wt. Container (gms)	202.38		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.7
Ultimate Deviator Stress (ksf):	1.7
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
9	0.005	6.50	0.20	0.08
11	0.010	6.50	0.24	0.17
15	0.020	6.51	0.33	0.33
17	0.025	6.52	0.38	0.42
18	0.030	6.52	0.40	0.50
22	0.060	6.56	0.48	1.00
31	0.090	6.59	0.68	1.50
34	0.120	6.62	0.74	2.00
37	0.150	6.66	0.80	2.50
45	0.200	6.72	0.96	3.33
50	0.250	6.77	1.06	4.17
56	0.300	6.83	1.18	5.00
63	0.350	6.89	1.32	5.83
65	0.400	6.96	1.35	6.67
70	0.450	7.02	1.44	7.50
74	0.500	7.08	1.50	8.33
75	0.550	7.15	1.51	9.17
81	0.600	7.21	1.62	10.00
83	0.650	7.28	1.64	10.83
85	0.700	7.35	1.67	11.67
86	0.750	7.42	1.67	12.50
87	0.800	7.49	1.67	13.33
88	0.850	7.56	1.68	14.17
90	0.900	7.64	1.70	15.00
91	0.950	7.71	1.70	15.83
92	1.000	7.79	1.70	16.67

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/17/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-037	B-00	0-2	13.7	NA
R-09-037	S-01	5	46.8	NA
R-09-037	D-02-2	10.5	61.1	61.8
R-09-037	S-03	15	49.2	NA
R-09-037	D-05-2	25.5	42.3	78.4
R-09-037	D-08-2	40.5	32.1	90.3
R-09-037	S-09	45	34.9	NA
R-09-037	D-10-1	50	25.0	100.1
R-09-037	S-11	55	32.3	NA
R-09-037	D-12-1	60	32.9	89.0
R-09-037	D-14	70	23.2	78.2
R-09-037	D-16-1	80	23.5	100.2

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/18/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-037	U-06	30	1.00

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	12/21/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-037	S-01	5	77.72
R-09-037	D-02-2	10.5	72.38
R-09-037	S-7	35	71.57
R-09-037	D-10-1	50	41.77

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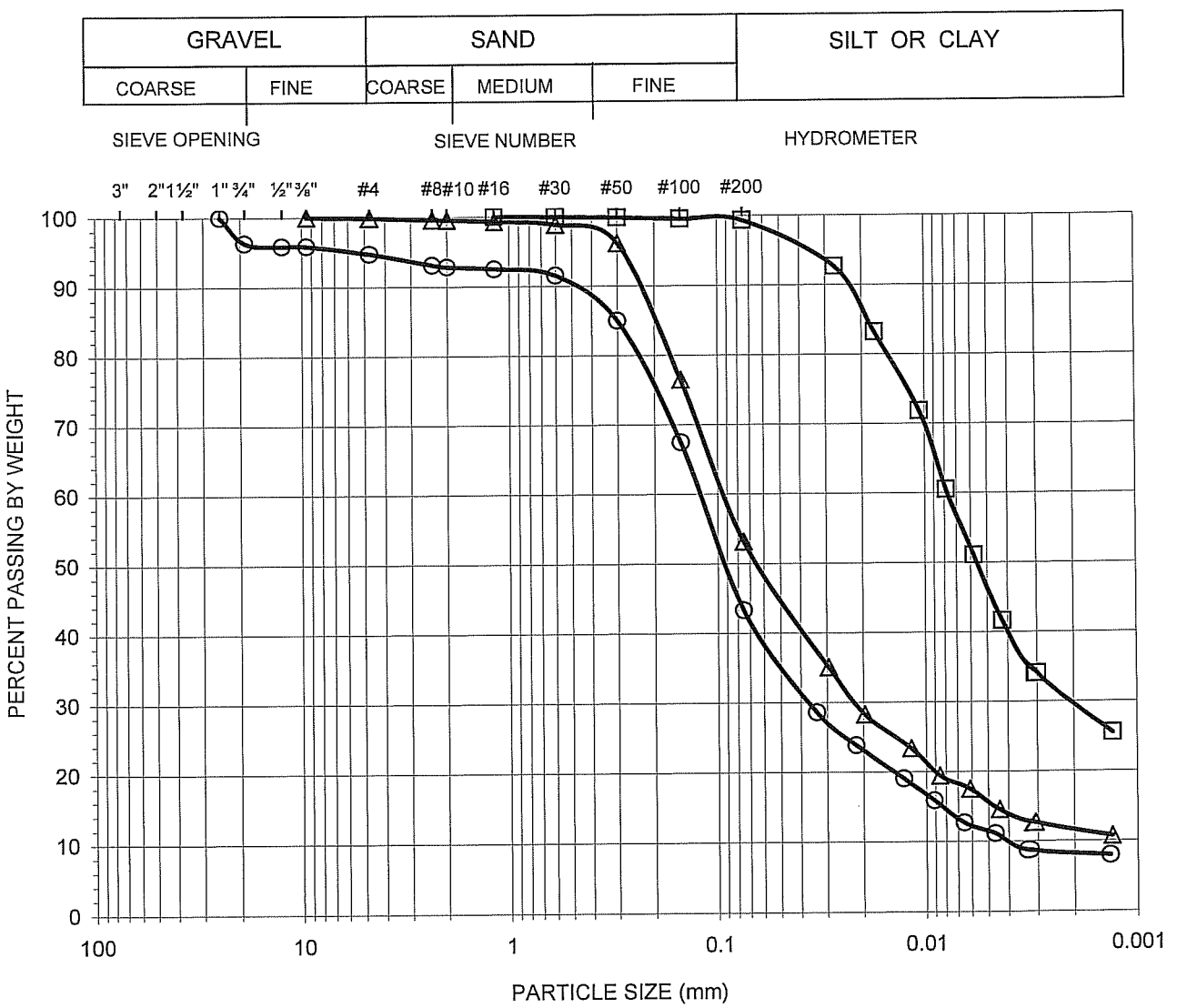
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

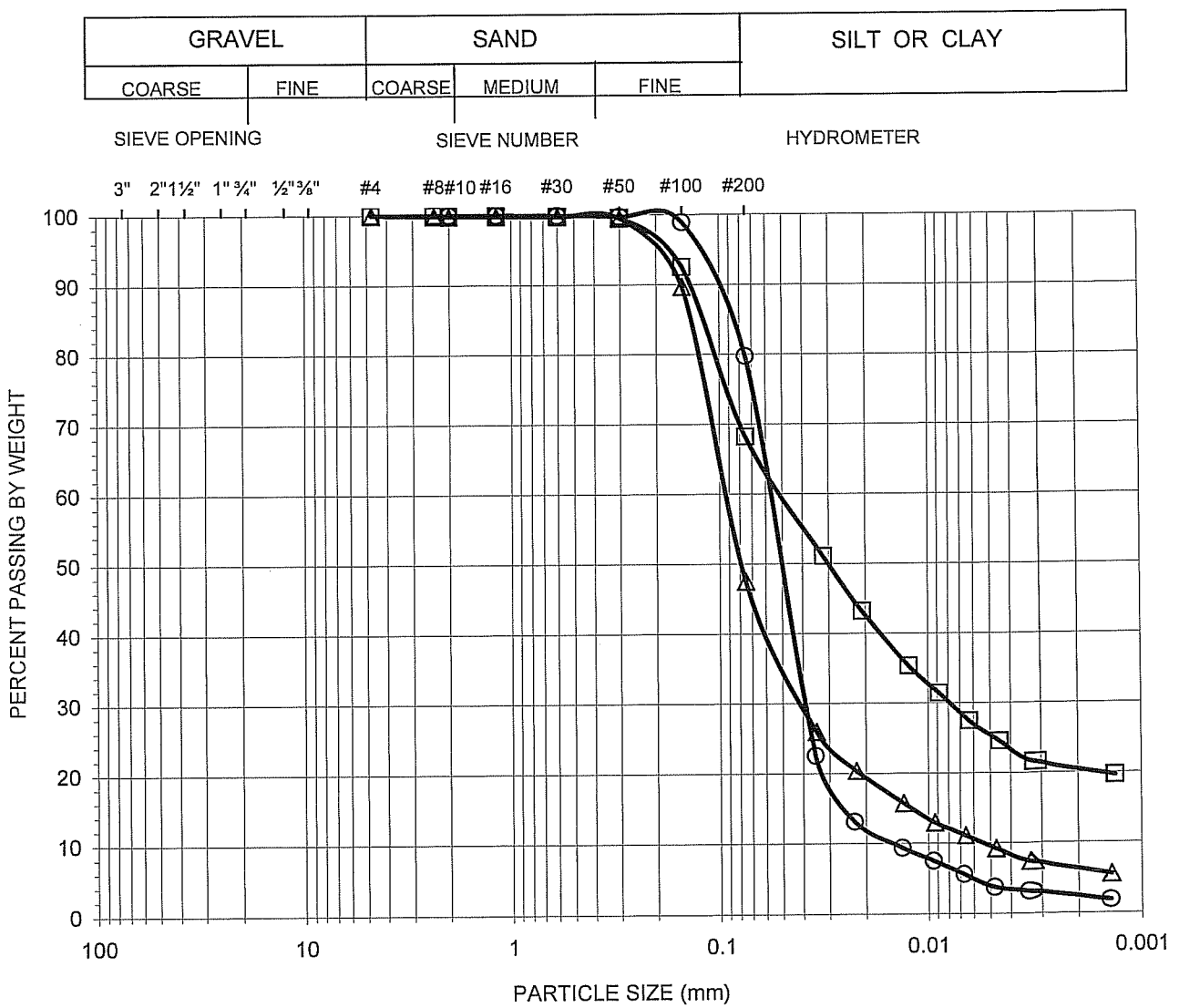


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-037	B-00	0-2	5.22	51.45	43.33	N/A	SM
□	R-09-037	S-03	15	0.00	0.67	99.33	48:29:19	ML
△	R-09-037	U-06	30	0.12	46.69	53.19	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

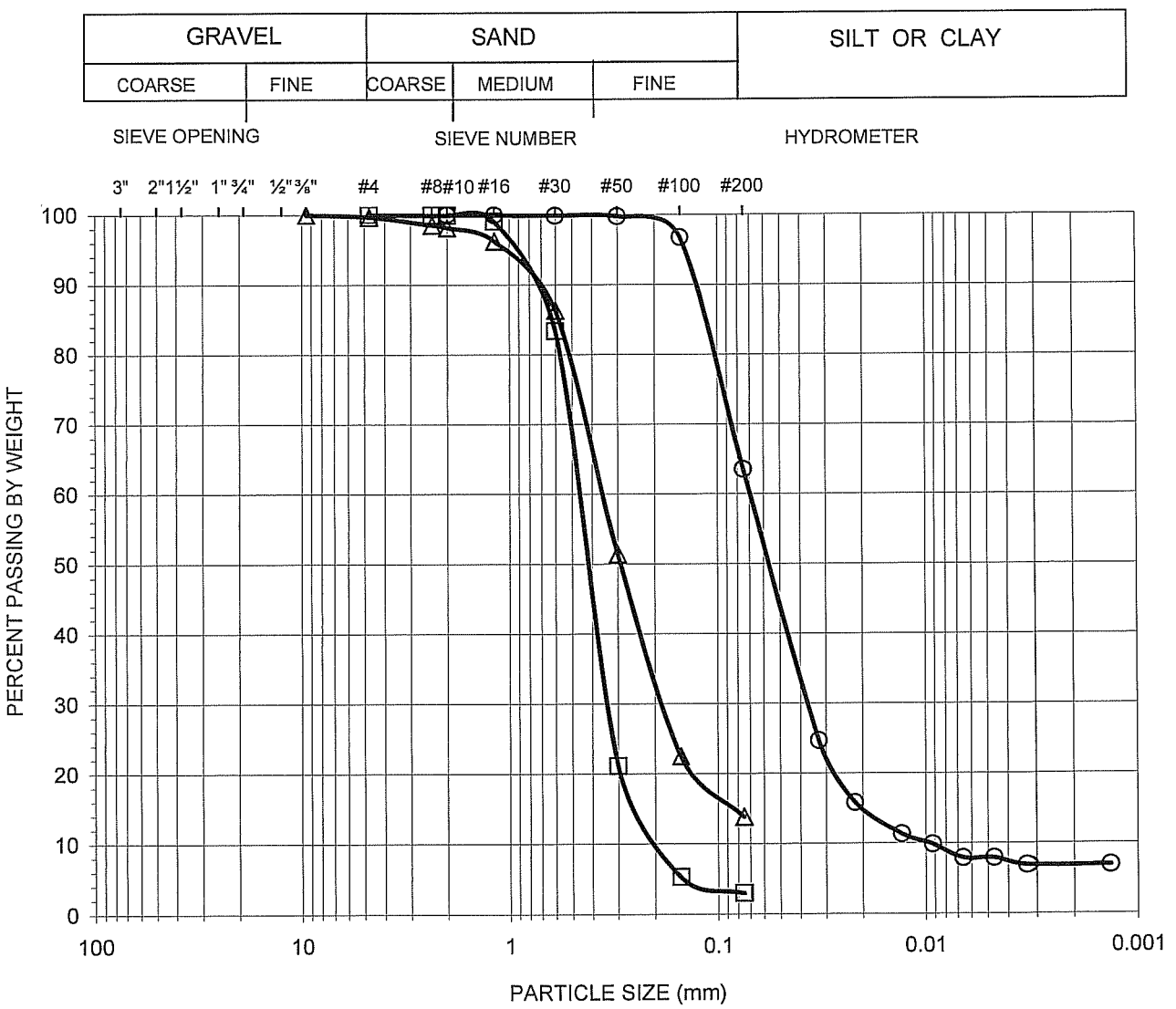


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-037	D-08-2	40	0.00	20.21	79.79	N/P	ML
□	R-09-037	S-09	45	0.00	31.82	68.18	28:20:8	CL
△	R-09-037	S-11	55	0.00	52.51	47.49	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/01/10



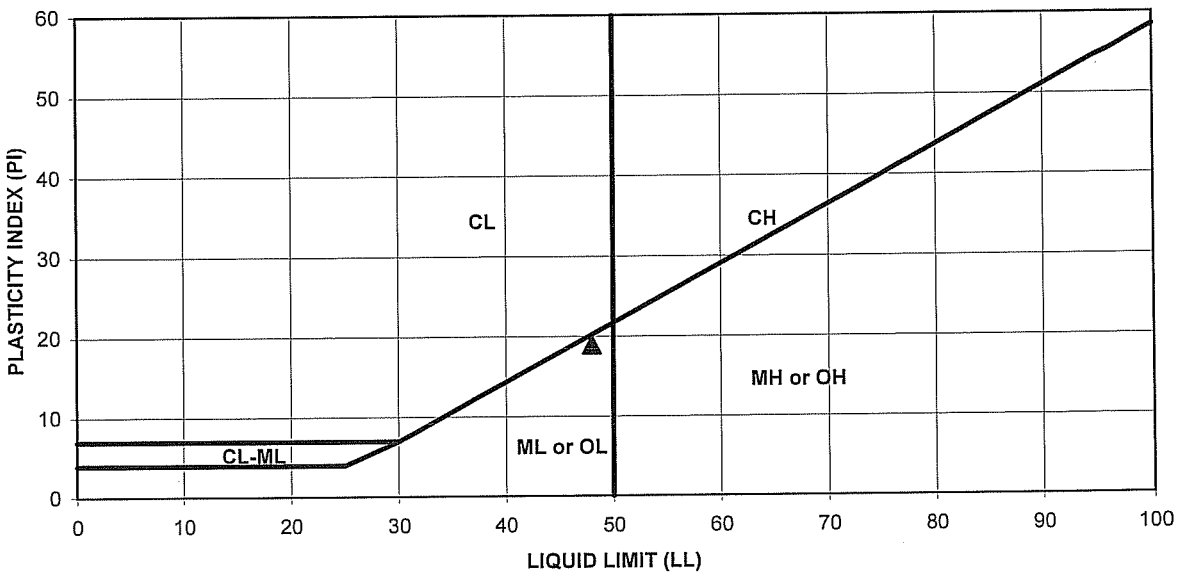
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-037	D-12-1	60	0.00	36.44	63.56	N/A	ML
□	R-09-037	D-14	70	0.00	97.04	2.96	N/A	SP
△	R-09-037	D-16-1	80	0.32	85.82	13.86	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

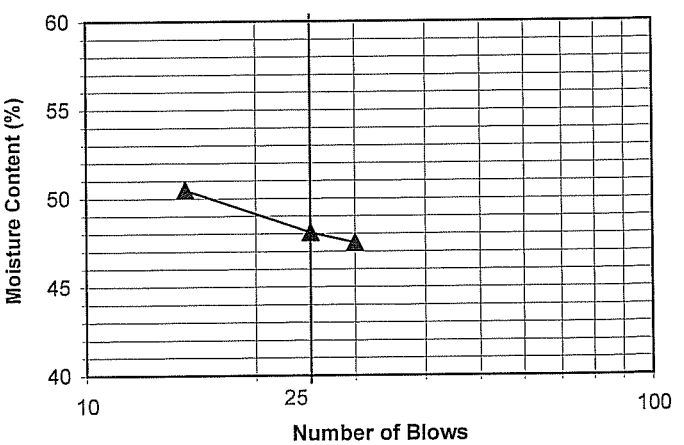
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 12/18/09
Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-037	D-02-2	10.5	NP	NP	NP	
▲	R-09-037	S-03	15	48	29	19	ML

* NP denotes "non-plastic"

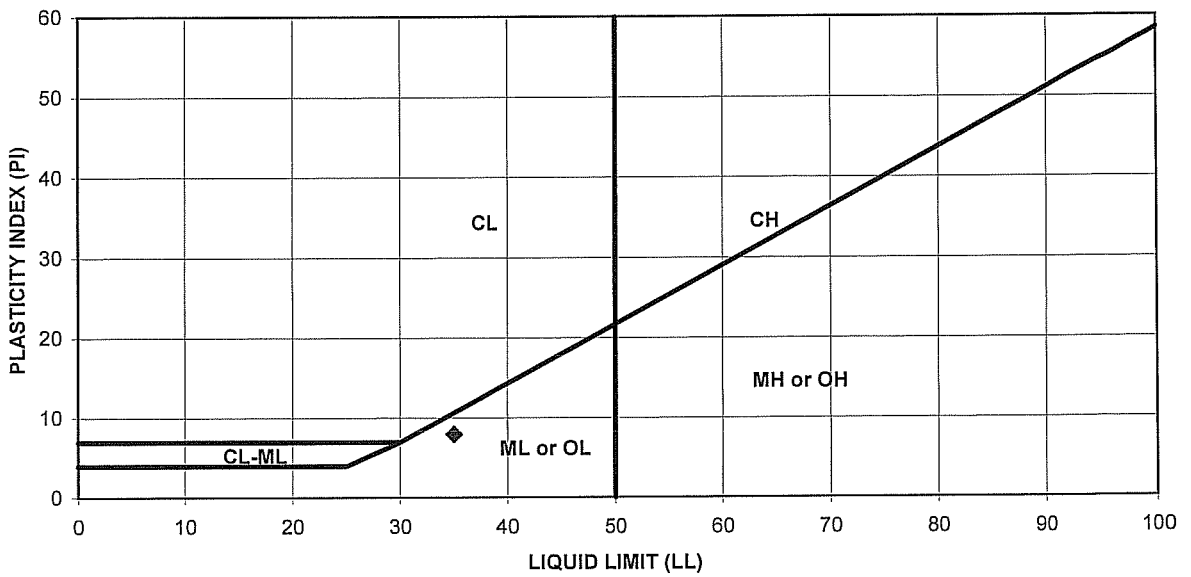
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

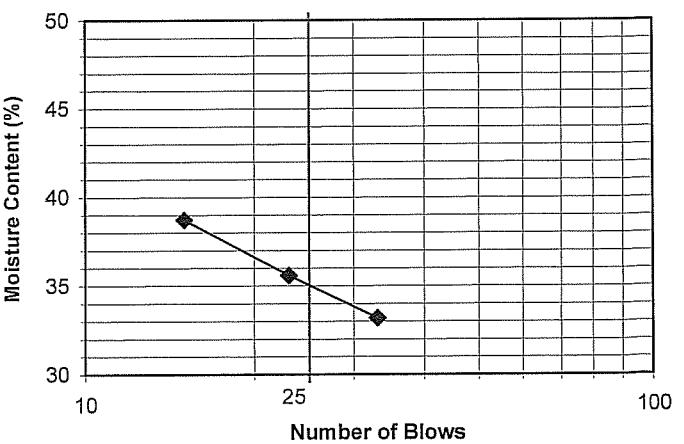
Tested By: WJO
Checked By: AP

Date: 12/18/09
Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-037	D-05-2	35.5	35	27	8	ML
	R-09-037	U-06	30	NP	NP	NP	

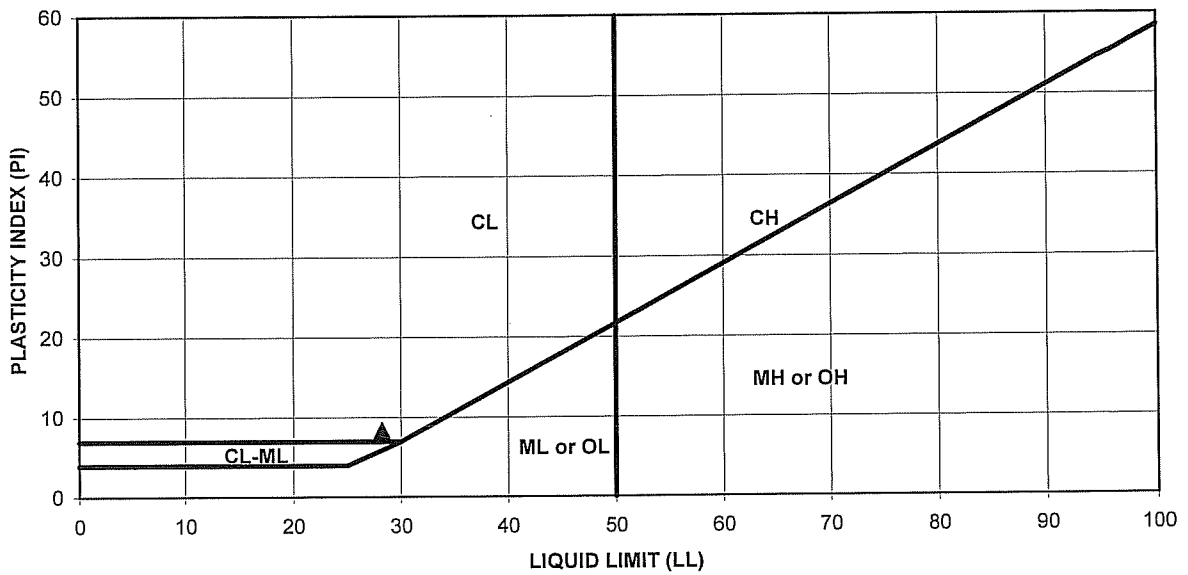
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

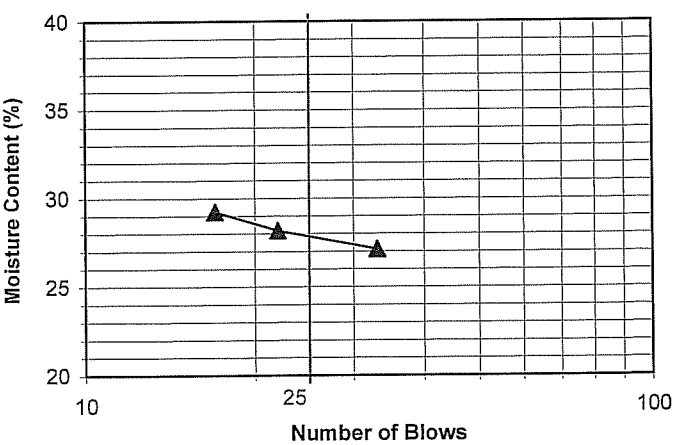
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 12/18/09
Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-037	D-08-2	40.5	NP	NP	NP	
▲	R-09-037	S-09	45	28	20	8	CL

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 12/23/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/26/09

Project No. : 06-123-03 Checked By: AP Date: 12/26/09

BORING NUMBER	R-09-037					
SAMPLE NUMBER	U-06					
DEPTH (FT)	30					
SOIL CLASSIFICATION	Sandy Silt (ML)					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	393.20					
TEMPERATURE, °C	18.4					
CORRECTION FACTOR	1.0003					
WT. DRY SOIL, g	47.95					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.85**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 12/09/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-037	D-01	5	ML	65	7.5	518	2257

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

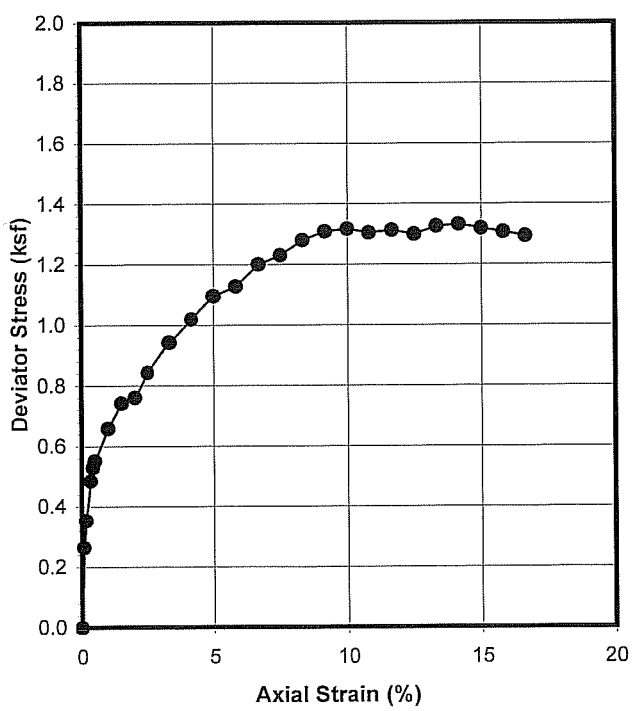
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 12/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 01/01/10
Project No.:	06-123-03		
Boring No.:	R-09-037		
Sample No.:	U-06 Depth (feet): 30		
Soil Description	Gray Sandy Silt w/shell	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	121.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	93.3
Sample Weight (gms):	1247.25	Moisture Content (%):	30.7
Wt. Wet Soil+Container(gms)	1348.76	Void Ratio for Gs=2.7:	0.81
Wt. Dry Soil+Container(gms)	1056.77	% Saturation:	102.8
Wt. Container (gms)	105.01		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.3
Ultimate Deviator Stress (ksf):	1.3
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	14.17



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
16	0.010	6.50	0.35	0.17
22	0.020	6.51	0.49	0.33
24	0.025	6.52	0.53	0.42
25	0.030	6.52	0.55	0.50
30	0.060	6.56	0.66	1.00
34	0.090	6.59	0.74	1.50
35	0.120	6.62	0.76	2.00
39	0.150	6.66	0.84	2.50
44	0.200	6.72	0.94	3.33
48	0.250	6.77	1.02	4.17
52	0.300	6.83	1.10	5.00
54	0.350	6.89	1.13	5.83
58	0.400	6.96	1.20	6.67
60	0.450	7.02	1.23	7.50
63	0.500	7.08	1.28	8.33
65	0.550	7.15	1.31	9.17
66	0.600	7.21	1.32	10.00
66	0.650	7.28	1.31	10.83
67	0.700	7.35	1.31	11.67
67	0.750	7.42	1.30	12.50
69	0.800	7.49	1.33	13.33
70	0.850	7.56	1.33	14.17
70	0.900	7.64	1.32	15.00
70	0.950	7.71	1.31	15.83
70	1.000	7.79	1.29	16.67

AP Engineering & Testing, Inc.

COMPACTION TEST

Client: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No. : 06-123-03
Boring No.: R-09-037
Sample No. : BB-00
Visual Sample Description: Grayish Brown Silty Sand

AP Number: 29-1121
Tested By: ST — Date: 12/29/09
Calculated By: KM — Date: 12/31/09
Checked By: AP — Date: 01/01/10
Depth (ft.): 0.5-3.5

Compaction Method: [X] ASTM D1557 [ ] ASTM D698
Preparation Method: [ ] Moist [X] Dry

METHOD: A
MOLD VOLUME (CU.FT): 0.0333

Trial No.	1	2	3	4	5	6
Wt. Comp. Soil + Mold (gm.)	3781	3856	3777	3649		
Wt. of Mold (gm.)	1762	1762	1762	1762		
Net Wt. of Soil (gm.)	2019	2094	2015	1887		
Container No.						
Wt. of Container (gm.)	103.90	103.80	104.60	104.80		
Wet Wt. of Soil + Cont. (gm.)	1103.00	1207.90	904.90	873.83		
Dry Wt. of Soil + Cont. (gm.)	1029.49	1096.36	805.79	831.81		
Moisture Content (%)	7.94	11.24	14.13	5.78		
Wet Density (pcf)	133.50	138.49	133.27	124.82		
Dry Density (pcf)	123.68	124.50	116.76	118.00		

Maximum Dry Density (pcf): **126.0**
Maximum Dry Density w/ Rock Correction (pcf): **127.9**
Optimum Moisture Content (%): **10.0**
Optimum Moisture Content w/ Rock Correction (%): **10.2**

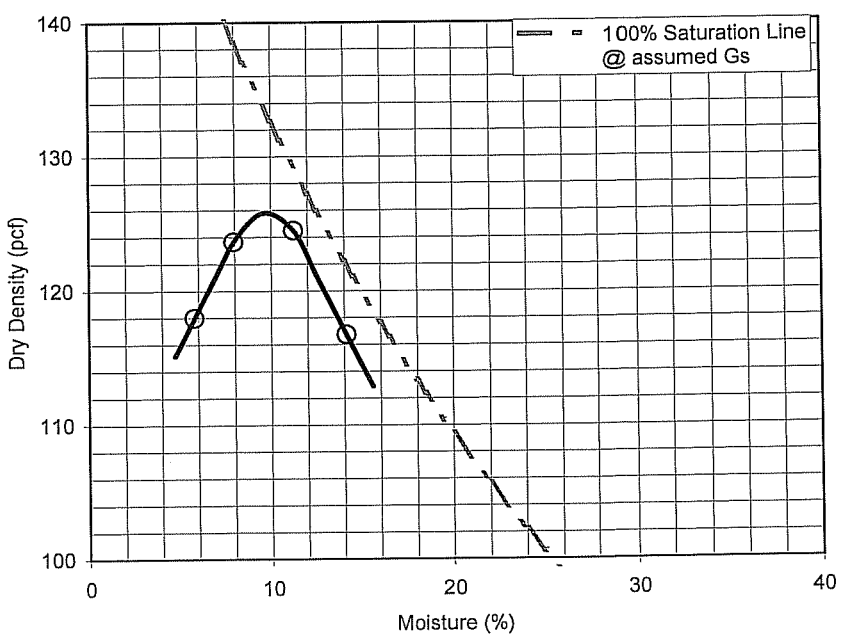
Assumed Specific Gravity = 2.7

PROCEDURE USED

[X] *METHOD A: Percent of Oversize:* 5.9%
Soil Passing No. 4 (4.75 mm) Sieve
Mold : 4 in. (101.6 mm) diameter
Layers : 5 (Five)
Blows per layer : 25 (twenty-five)
May be used if No.4 retained < 20%

[ ] *METHOD B: Percent of Oversize:* NA
Soil Passing 3/8 in. (9.5 mm) Sieve
Mold : 4 in. (101.6 mm) diameter
Layers : 5 (Five)
Blows per layer : 25 (twenty-five)
Use if + No.4 > 20% and - 3/8 in < 20%

[ ] *METHOD C: Percent of Oversize:* NA
Soil Passing 3/4 in. (19.0 mm) Sieve
Mold : 6 in. (152.4 mm) diameter
Layers : 5 (Five)
Blows per layer : 56 (fifty-six)
Use if + 3/8 in >20% and +3/4 in <30%



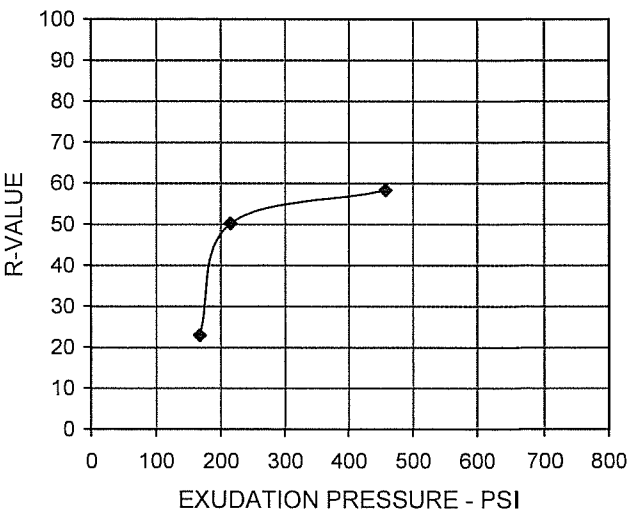
AP Engineering & Testing, Inc.

R-VALUE TEST DATA

ASTM D2844

Project Name:	ACTA Heim Bridge Replaceme	Tested By:	ST	Date:	12/29/09
Project Number:	06-123-03	Computed By:	KM	Date:	12/31/09
Boring No.:	R-09-037	Checked By:	AP	Date:	12/31/09
Sample No.:	BB-00	Depth (ft.):	0.5-3.5		
Location:					
Soil Description:	Grayish Brown Silty Sand				

Mold Number	A	B	D		
Water Added, g	40	35	45		
Compact Moisture(%)	18.0	17.5	18.5		
Compaction Gage Pressure, psi	160	200	120		
Exudation Pressure, psi	216	458	168		
Sample Height, Inches	2.5	2.5	2.5		
Gross Weight Mold, g	3078	3074	3081		
Tare Weight Mold, g	1970	1969	1971		
Net Sample Weight, g	1108	1105	1110		
Expansion, inches$x10^{-4}$	6	12	0		
Stability 2,000 (160 psi)	29/60	23/50	47/108		
Turns Displacement	4.14	3.95	4.06		
R-Value Uncorrected	50	58	23		
R-Value Corrected	50	58	23		
Dry Density, pcf	113.8	114.0	113.5		
Traffic Index	8.0	8.0	8.0		
G.E. by Stability	0.84	0.71	1.31		
G.E. by Expansion	0.20	0.40	0.00		

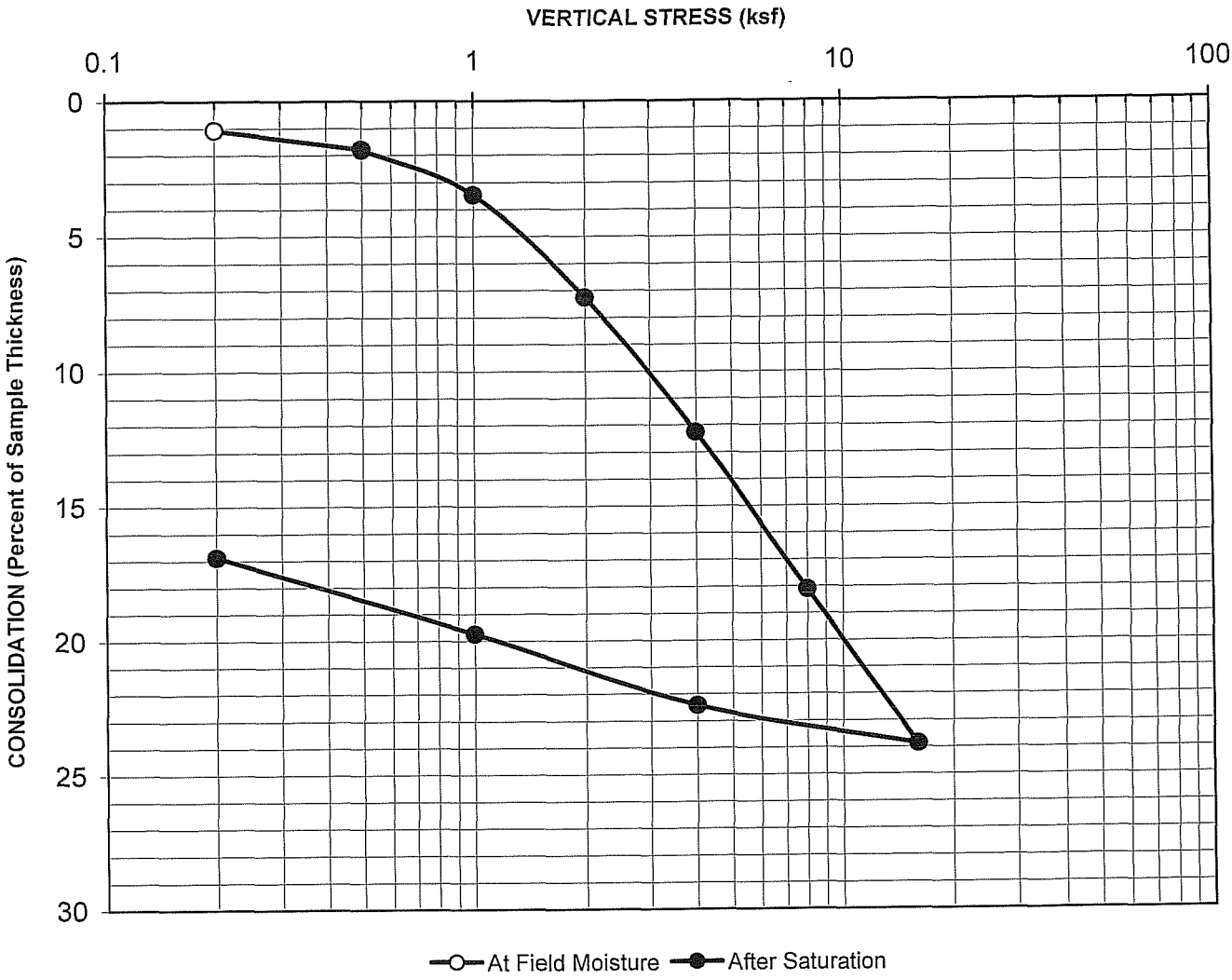


R-Value by Exudation = 54
R-Value by Expansion = N/A
Equilibrium R- Value = 54
(by Exudation)

Remarks: G_f = 1.5
3.7 % Retained on the ¾"

2607 Pomona Blvd, Pomona, CA 91768, Tel (909)869-6316 Fax (909) 869-6318

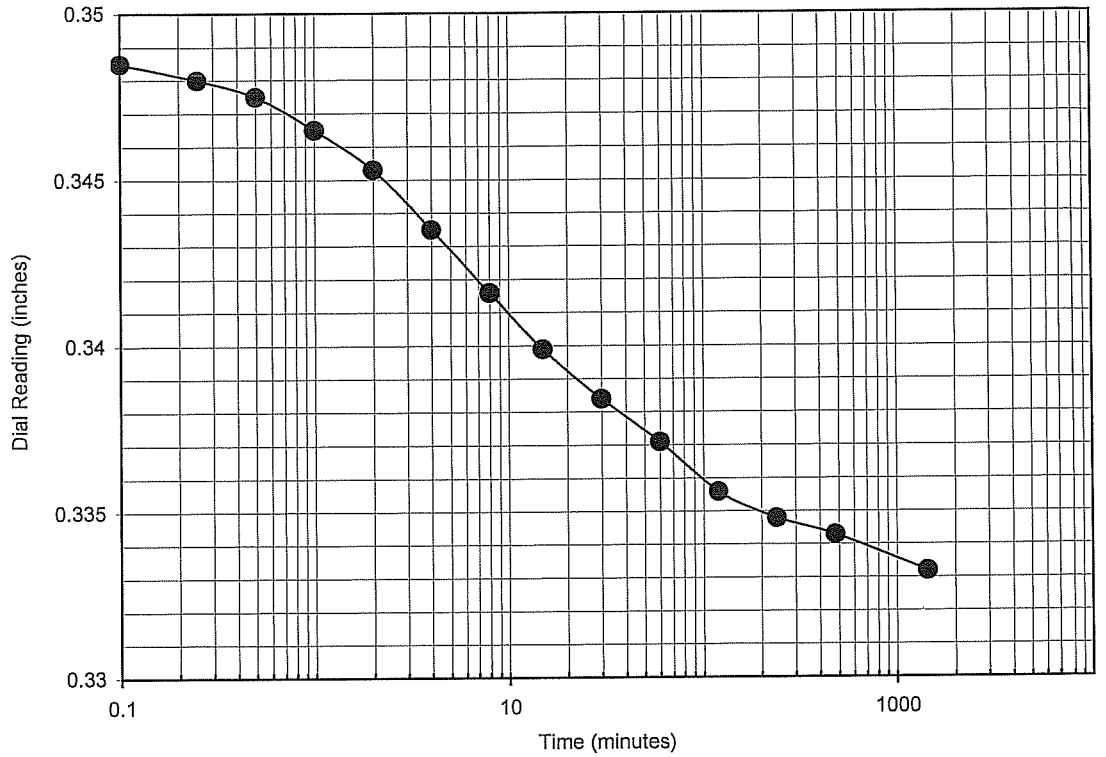
AP Engineering & Testing, Inc.



Boring No. :	R-09-037	Initial Dry Unit Weight (pcf):	68.6
Sample No.:	D-02-1	Initial Moisture Content (%):	54.2
Depth (feet):	10	Final Moisture Content (%):	44.8
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Silt with sand	Initial Void Ratio:	1.46
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	12/28/2009
AP No:	29-1121

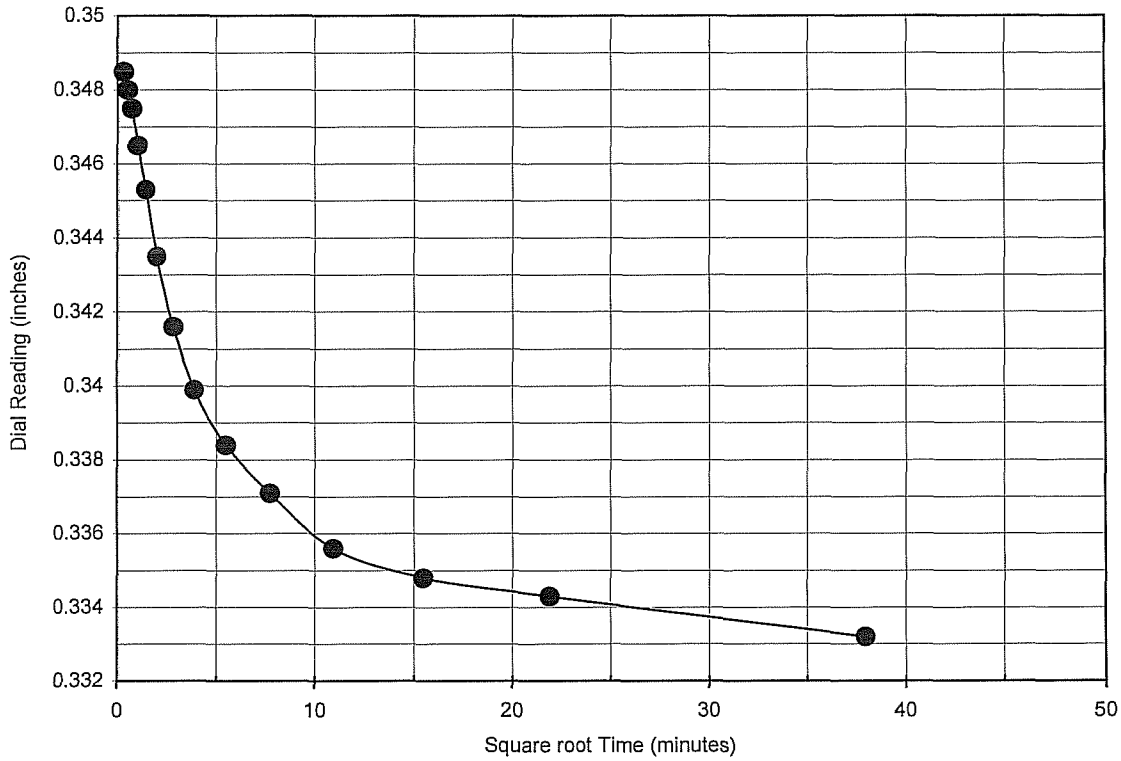


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3485
0.25	0.348
0.5	0.3475
1	0.3465
2	0.3453
4	0.3435
8	0.3416
15	0.3399
30	0.3384
60	0.3371
120	0.3356
240	0.3348
480	0.3343
1440	0.3332

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

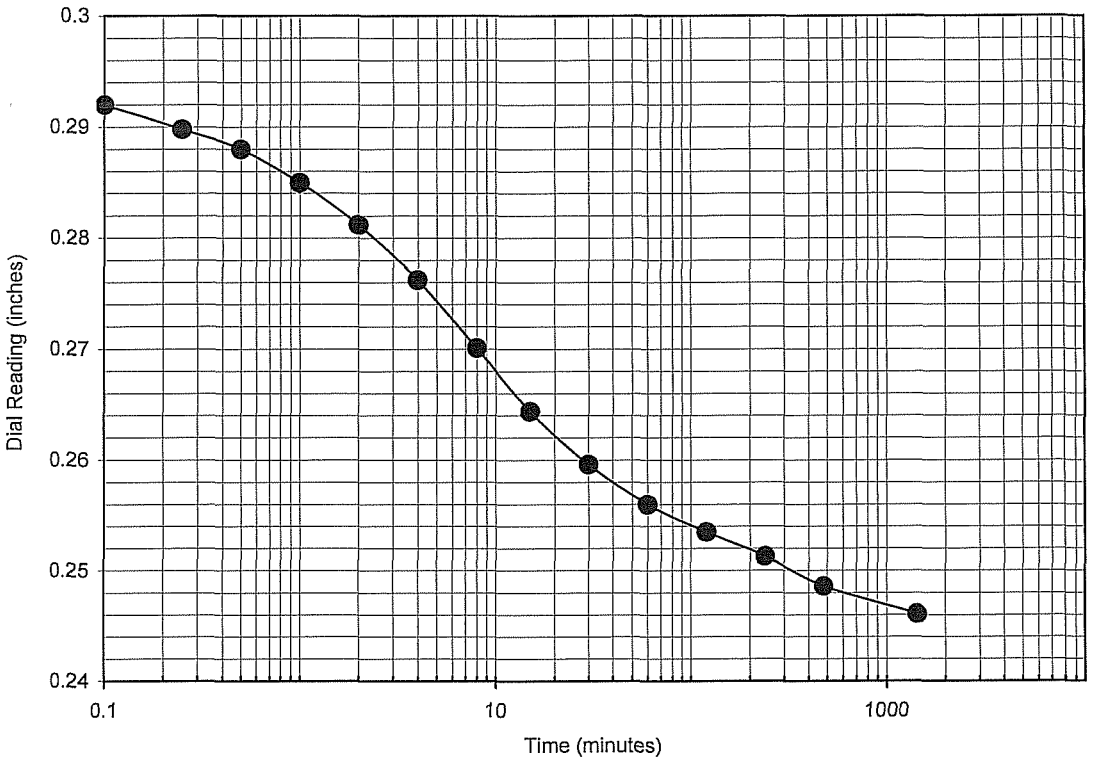


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3485
0.5000	0.3480
0.7071	0.3475
1.0000	0.3465
1.4142	0.3453
2.0000	0.3435
2.8284	0.3416
3.8730	0.3399
5.4772	0.3384
7.7460	0.3371
10.9545	0.3356
15.4919	0.3348
21.9089	0.3343
37.9473	0.3332

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

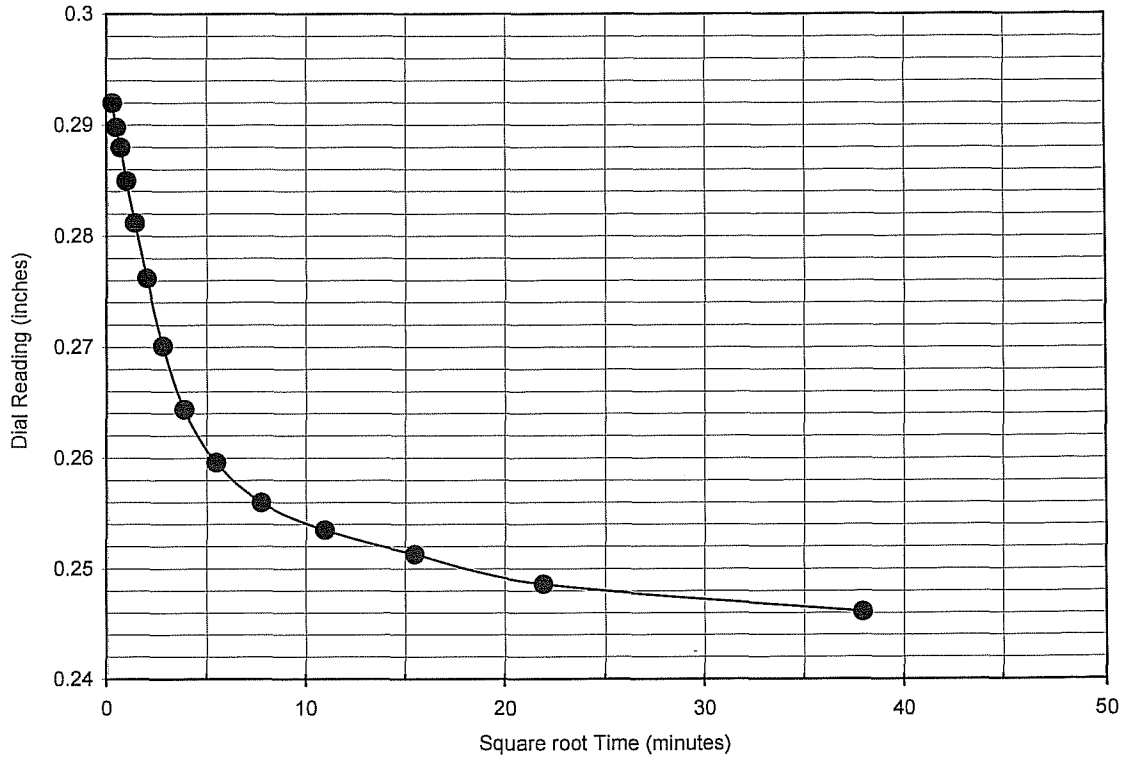


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.292
0.25	0.2898
0.5	0.288
1	0.285
2	0.2812
4	0.2762
8	0.2701
15	0.2644
30	0.2596
60	0.256
120	0.2535
240	0.2513
480	0.2486
1440	0.2461

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**



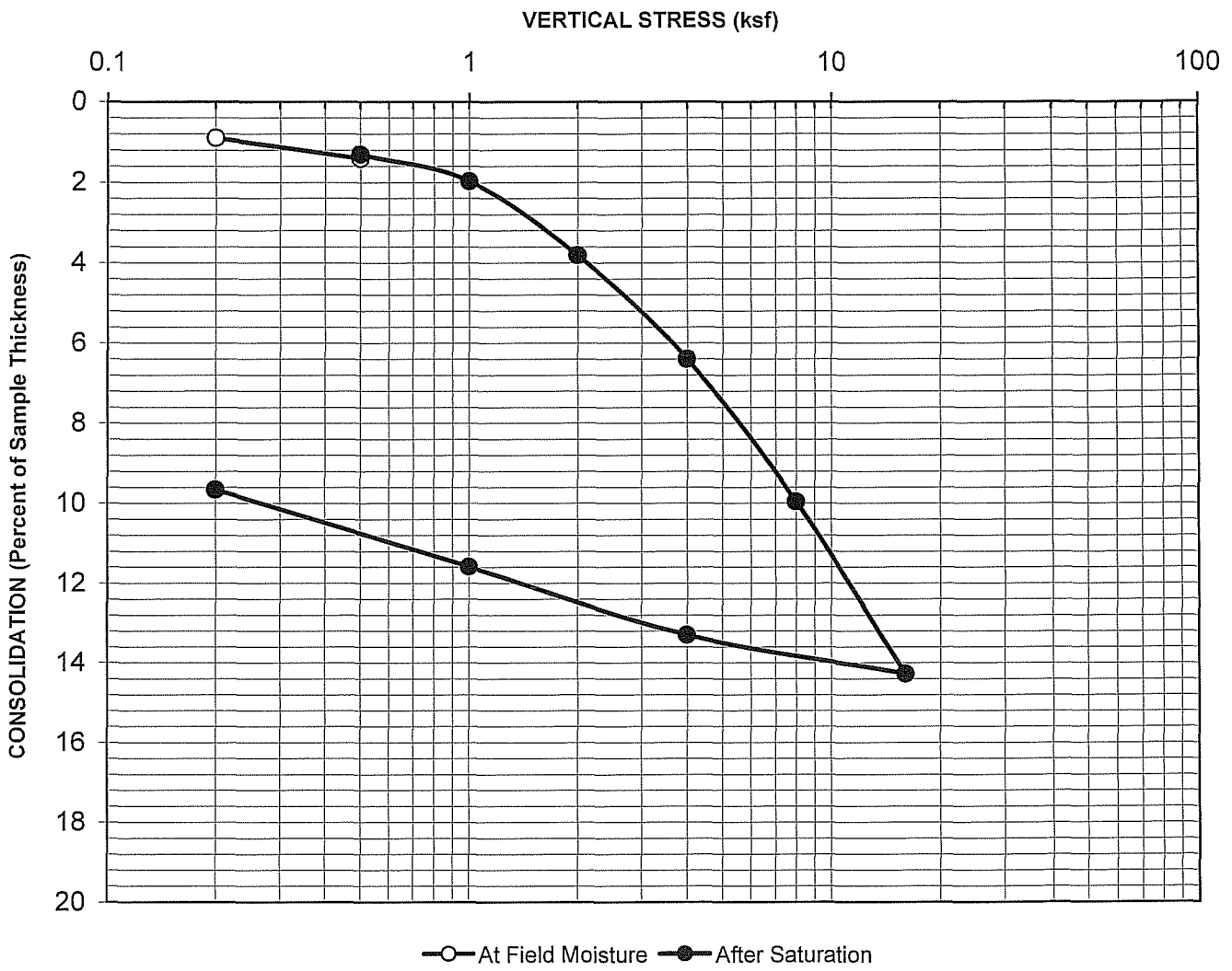
Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.2920
0.5000	0.2898
0.7071	0.2880
1.0000	0.2850
1.4142	0.2812
2.0000	0.2762
2.8284	0.2701
3.8730	0.2644
5.4772	0.2596
7.7460	0.2560
10.9545	0.2535
15.4919	0.2513
21.9089	0.2486
37.9473	0.2461

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

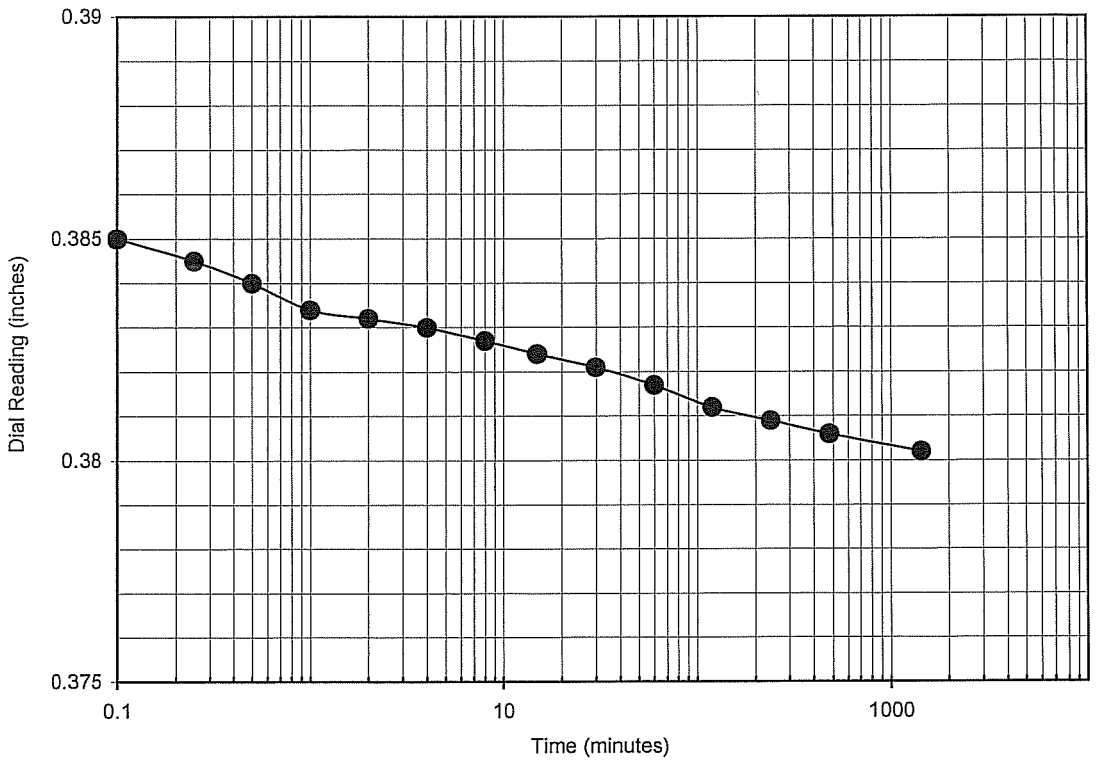
AP Engineering & Testing, Inc.



Boring No. :	R-09-037	Initial Dry Unit Weight (pcf):	78.3
Sample No.:	D-5A	Initial Moisture Content (%):	44.3
Depth (feet):	25	Final Moisture Content (%):	38.8
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Sandy Silt	Initial Void Ratio:	1.15
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	12/28/2009
AP No:	29-1121

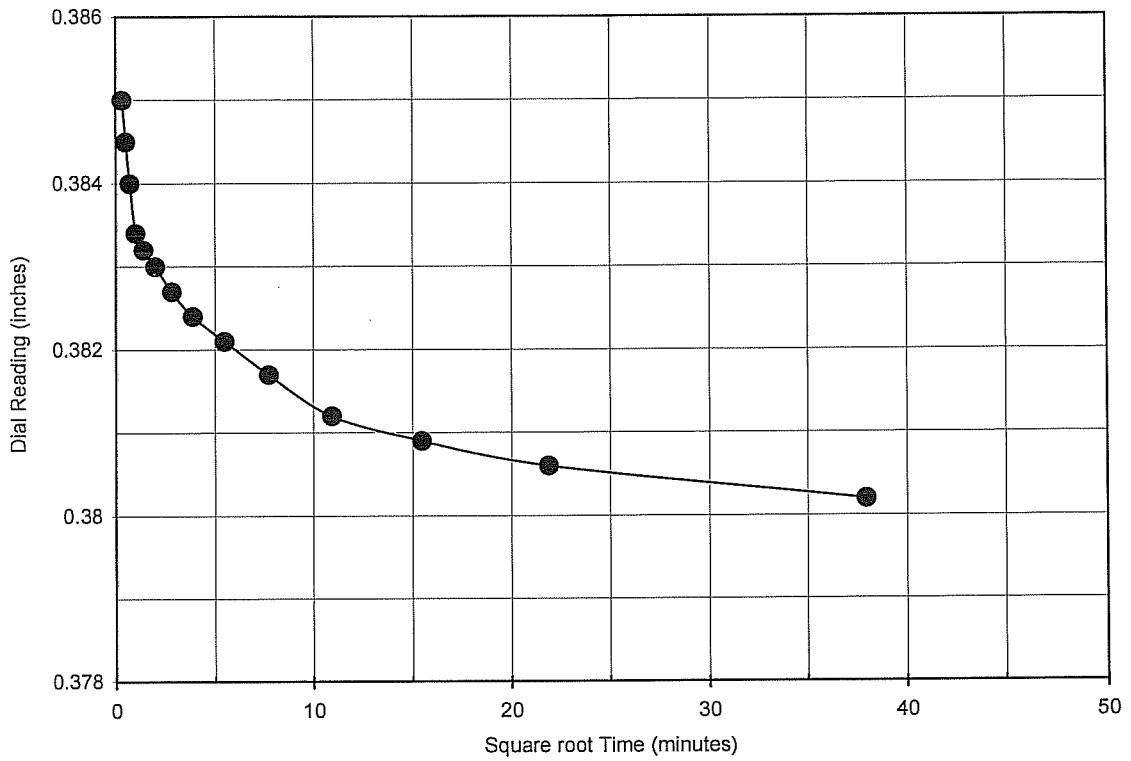


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.385
0.25	0.3845
0.5	0.384
1	0.3834
2	0.3832
4	0.383
8	0.3827
15	0.3824
30	0.3821
60	0.3817
120	0.3812
240	0.3809
480	0.3806
1440	0.3802

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

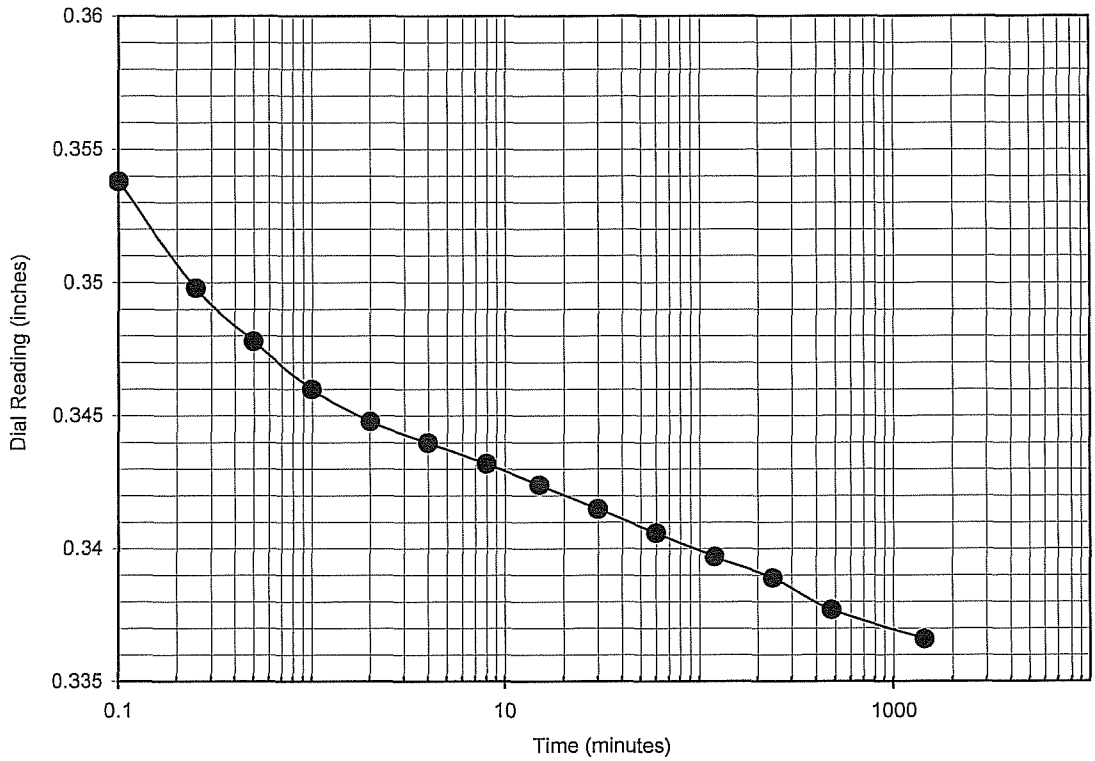


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3850
0.5000	0.3845
0.7071	0.3840
1.0000	0.3834
1.4142	0.3832
2.0000	0.3830
2.8284	0.3827
3.8730	0.3824
5.4772	0.3821
7.7460	0.3817
10.9545	0.3812
15.4919	0.3809
21.9089	0.3806
37.9473	0.3802

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

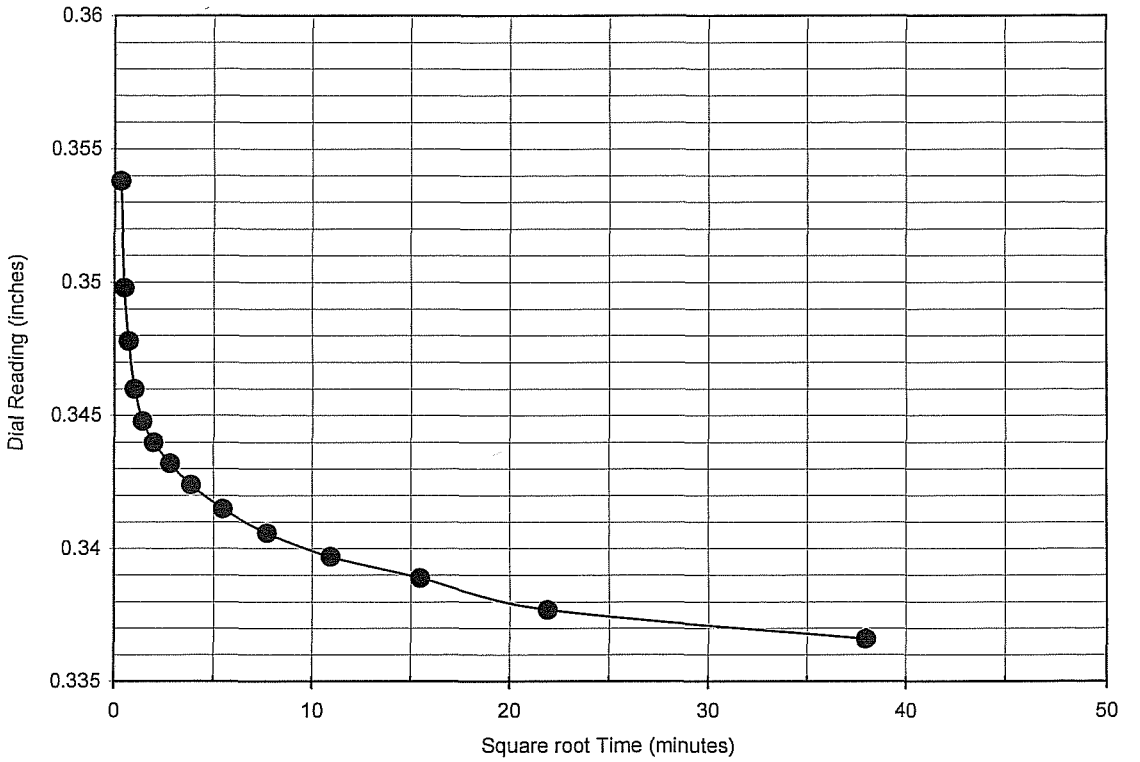


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3538
0.25	0.3498
0.5	0.3478
1	0.346
2	0.3448
4	0.344
8	0.3432
15	0.3424
30	0.3415
60	0.3406
120	0.3397
240	0.3389
480	0.3377
1440	0.3366

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3538
0.5000	0.3498
0.7071	0.3478
1.0000	0.3460
1.4142	0.3448
2.0000	0.3440
2.8284	0.3432
3.8730	0.3424
5.4772	0.3415
7.7460	0.3406
10.9545	0.3397
15.4919	0.3389
21.9089	0.3377
37.9473	0.3366

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008B

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 12/29/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
A-09-101	B-01	2.0			14.6	
A-09-101	D-03	10.0	6.5	116.0		
A-09-102	B-01	0.0	5.1		27.6	
A-09-102	D-04	10.0	10.3	113.7		
A-09-103	B-01	2.0			16.7	
A-09-103	S-02-2	5.5	41.4			29,25,4
A-09-104	B-01	2.0			11.0	
A-09-104	D-03	10.0	15.7	103.4		
A-09-105	B-01	0.0			13.5	
A-09-106	B-01	4.0	28.7			30,20,10
A-09-106	D-03	10.0	33.8	87.8		NP
A-09-107	B-01	0.0			27.1	
A-09-107	S-03	5.0	23.1			
A-09-108	B-01	0.0			29.4	
A-09-108	D-04	10.0	41.3	77.4		43,24,19
A-09-109	B-01	1.0			38.2	
A-09-109	S-02	5.0	34.3			25,24,1
A-09-110	B-01	0.0			18.4	
A-09-110	S-03-1	5.0	19.0			41,20,21
A-09-110	D-04	10.0	31.3			30,19,11
A-09-111	B-01	0.0			14.8	
A-09-111	D-04	10.0	11.8	93.2		
A-09-112	B-01	0.0			22.8	
A-09-112	S-03	5.0	8.2			NP
A-09-113	B-01	0.0			20.7	
A-09-113	D-04-2	10.6	47.9			38,24,14
A-09-114	B-01	0.0			20.2	
A-09-114	S-03	5.0	9.7			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

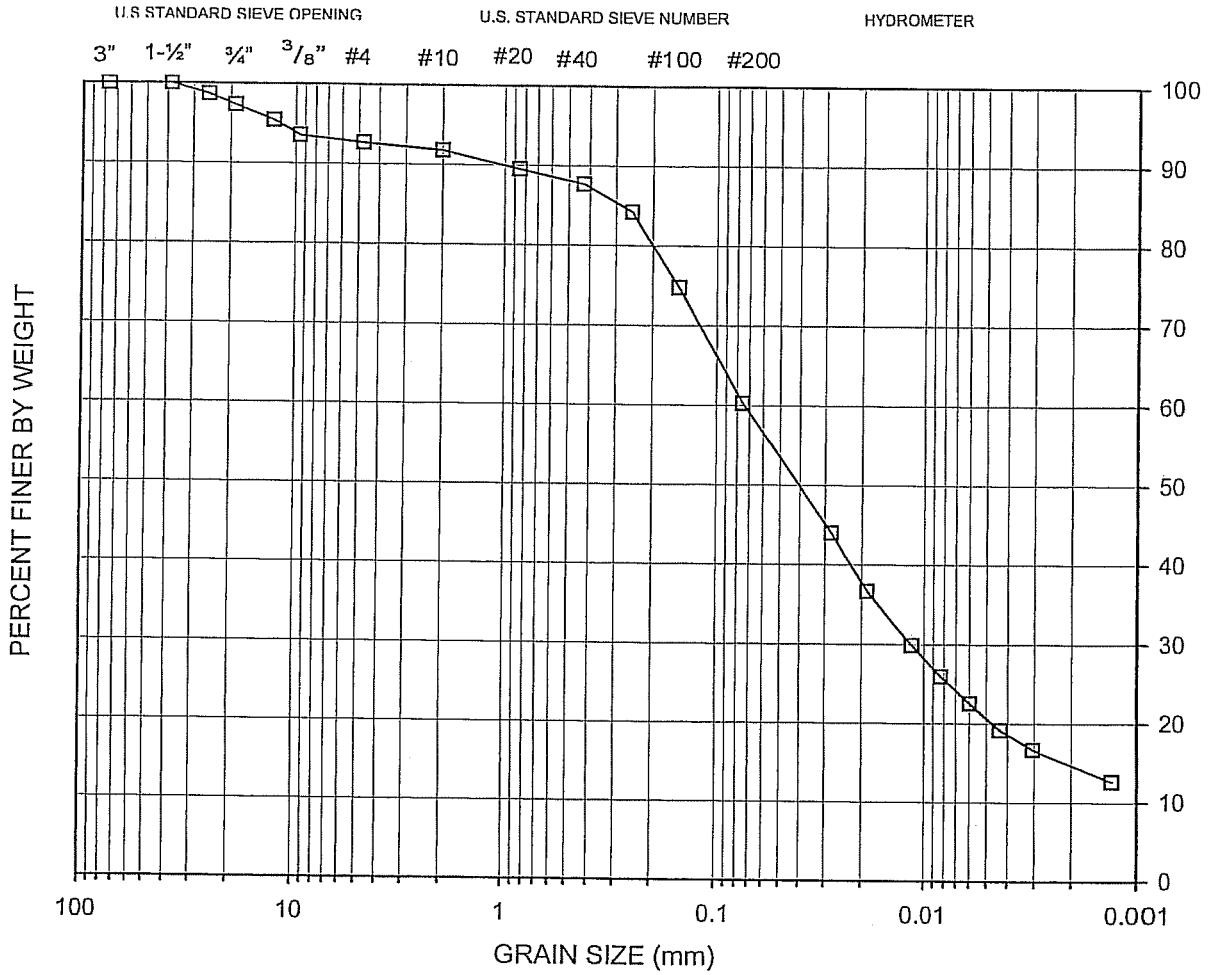
SUMMARY OF LABORATORY TEST RESULTS
EXPANSION INDEX

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008B

PROJECT NO.: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/18/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	EXPANSION INDEX ASTM D 4829
A-09-106	B-01	4	44



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	A-09-106	B-01	4	Bulk	CL	30	10

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

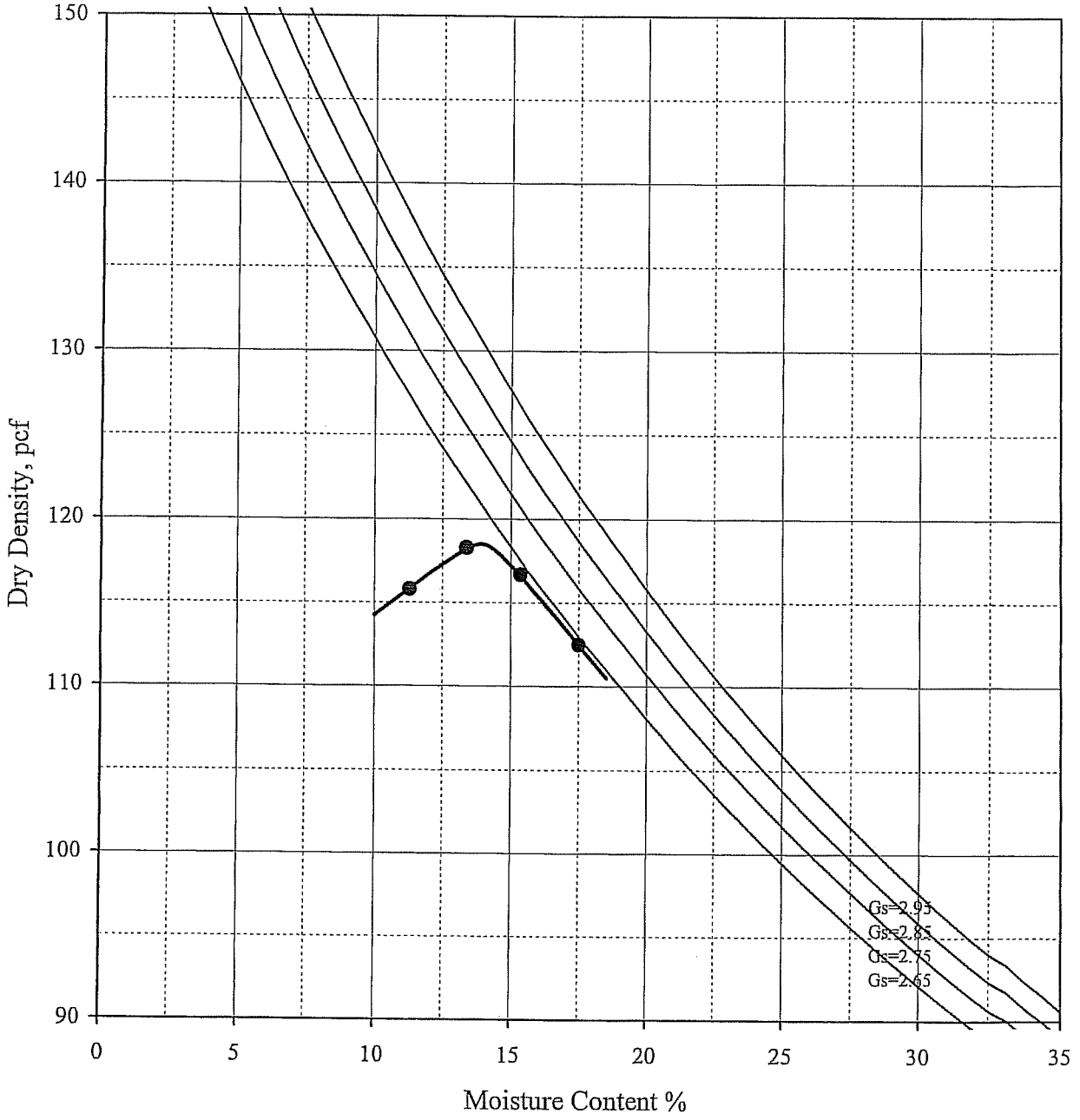
EGL Project No: 09-230-008B

GRAINSIZE DISTRIBUTION CURVE

(ASTM D422)

12/29/09

FIGURE



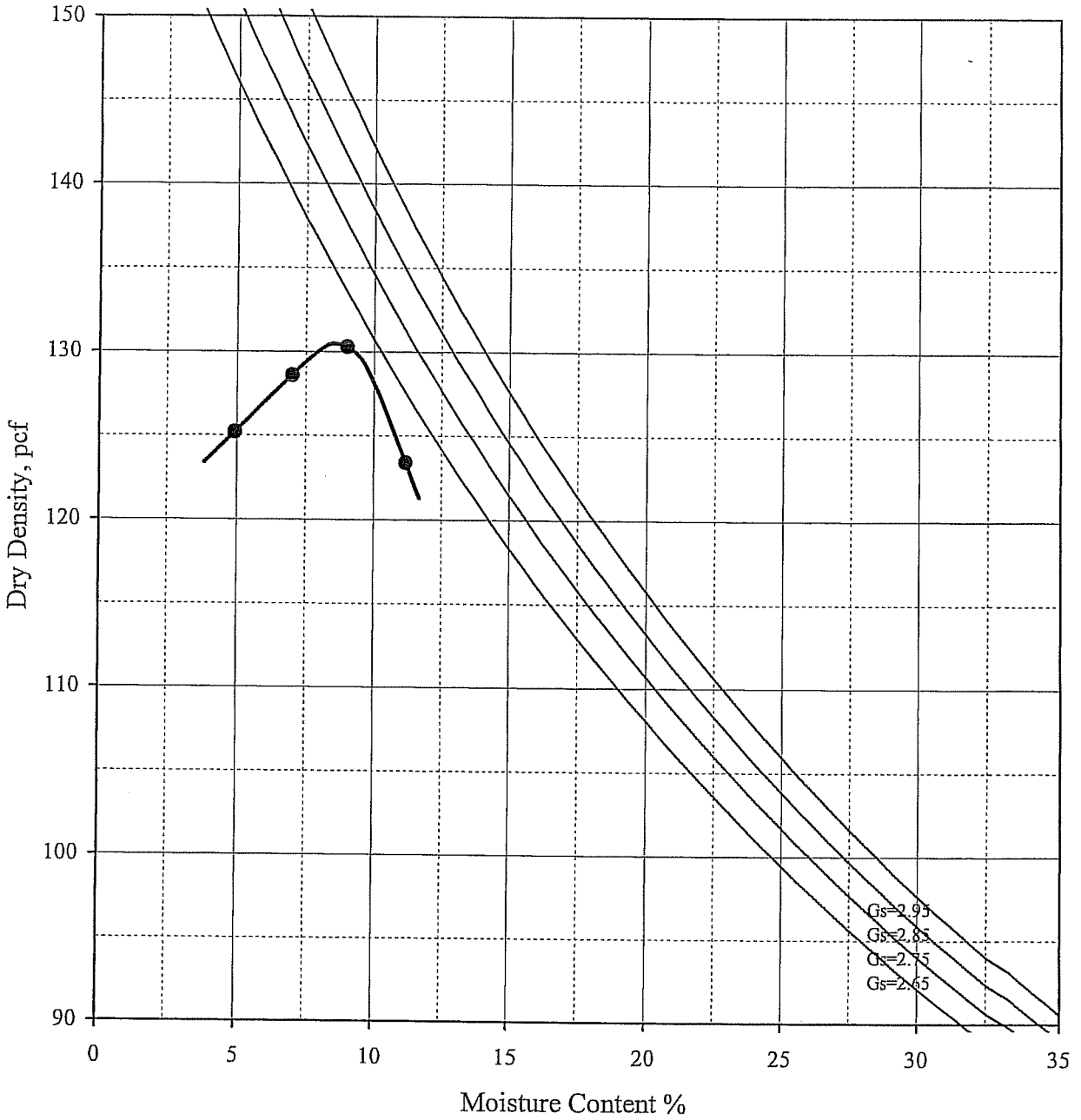
Maximum Dry Density = 118.5 pcf	Boring No: A-09-106
Optimum Moisture Content = 14 %	Sample: B-01
	Depth : 4 feet
	Description : Sandy clay (CL), dark brown

Environmental Geotechnology Laboratory

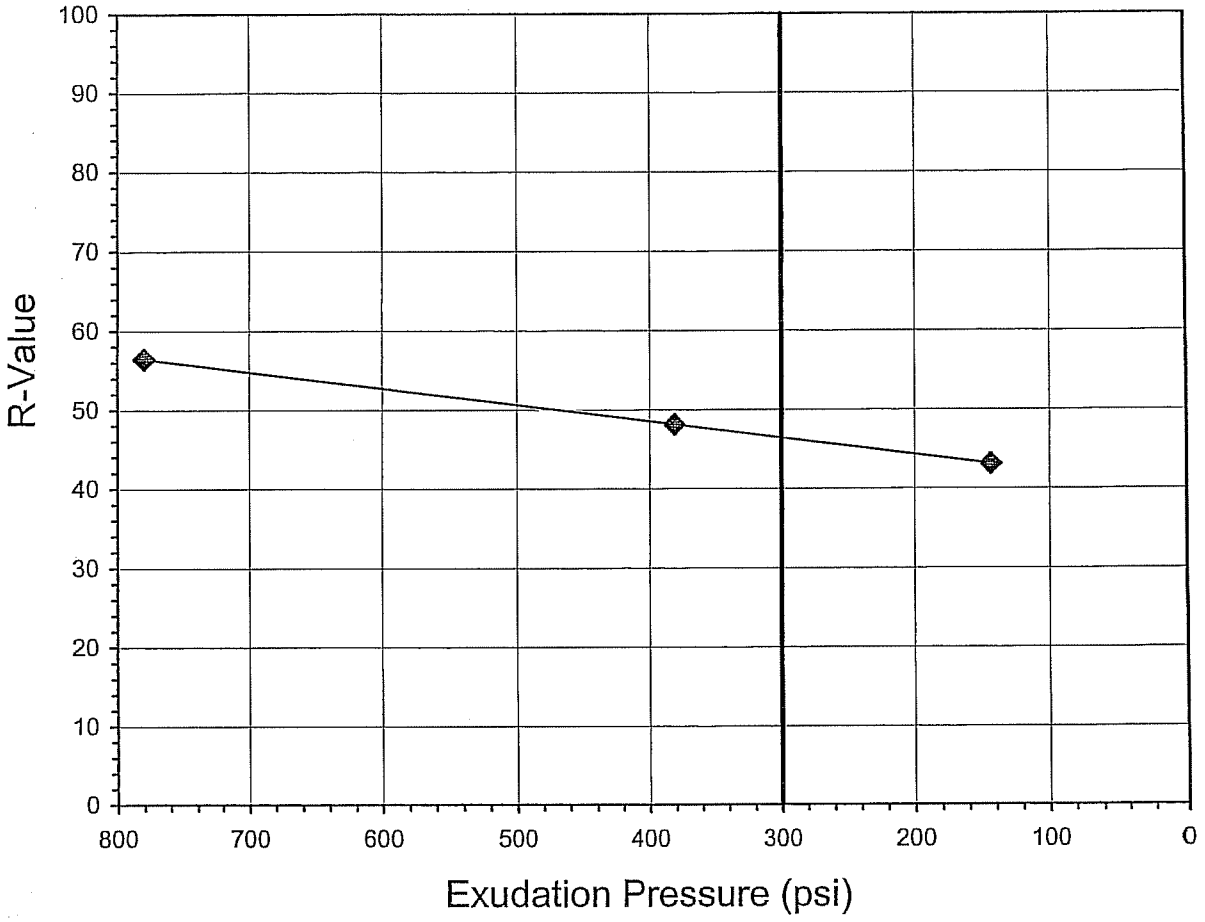
Modified Proctor

(ASTM D1557)

Project Name:	ACTA Heim Bridge Replacement	
Client Name:	Earth Mechanics, Inc.	
Job No:	06-123-03	
EGL Project No.:	09-230-O08B	
Date : Dec-09	Figure	



Maximum Dry Density = 130.5 pcf	Boring No: A-09-110
Optimum Moisture Content = 8.5 %	Sample: B-01
	Depth : 0 feet
	Description : Silty sand (SM), brown with some gravel
Environmental Geotechnology Laboratory	Project Name: ACTA Heim Bridge Replacement
	Client Name: Earth Mechanics, Inc.
Modified Proctor (ASTM D1557)	Job No: 06-123-03
	EGL Project No.: 09-230-008B
	Date : Dec-09 Figure



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	150	111.3	16.1	0.45	67	2.57	143	42	43
2	200	112.5	15.2	1.27	60	2.53	381	48	48
3	220	113.8	14.3	2.09	51	2.51	780	56	56

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

Boring No: A-09-106
Sample No: B-01 @ 4'
Sample Type: Bulk
Sample Description: Sandy clay (CL)
Test Date: 12/29/09

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

Test Results: R-Value at 300 psi
Exudation Pressure: 46

R-VALUE TEST REPORT

12/31/09

FIGURE 1

Resistance R - Value Testing Results

(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008B
Test Date:	12/29/2009
Boring No:	A-09-106
Sample No:	B-01 @ 4'
Sample Type:	Bulk
Sample Description:	Sandy clay (CL), dark brown
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	150	200	220
Wet Weight (gms)	1230	1220	1210
Dry Weight (gms)	1059	1059	1059
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	1800	4785	9800
Total Weight (gms)	2879	3002	2949
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1096	1082	1077
Sample Height (in)	2.57	2.53	2.51
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0015	0.0042	0.0069
Expansion Pressure (psi)	0.4545	1.2726	2.0907
Ph @ 2000 lbs	67	60	51
D turns	4.88	4.48	4.12
R-Value from Exudation	42	48	56
Density (pcf)	111.3	112.5	113.8
Moisture (%)	16.1	15.2	14.3
Exudation Pressure (psi)	143	381	780
Corrected R-Value from Exudation:	43	48	56
Exudation Pressure (psi)	143	381	780

R-Value at 300 psi exudation pressure = 46

Note:
0.87% Retained on 3/4-inch Sieve

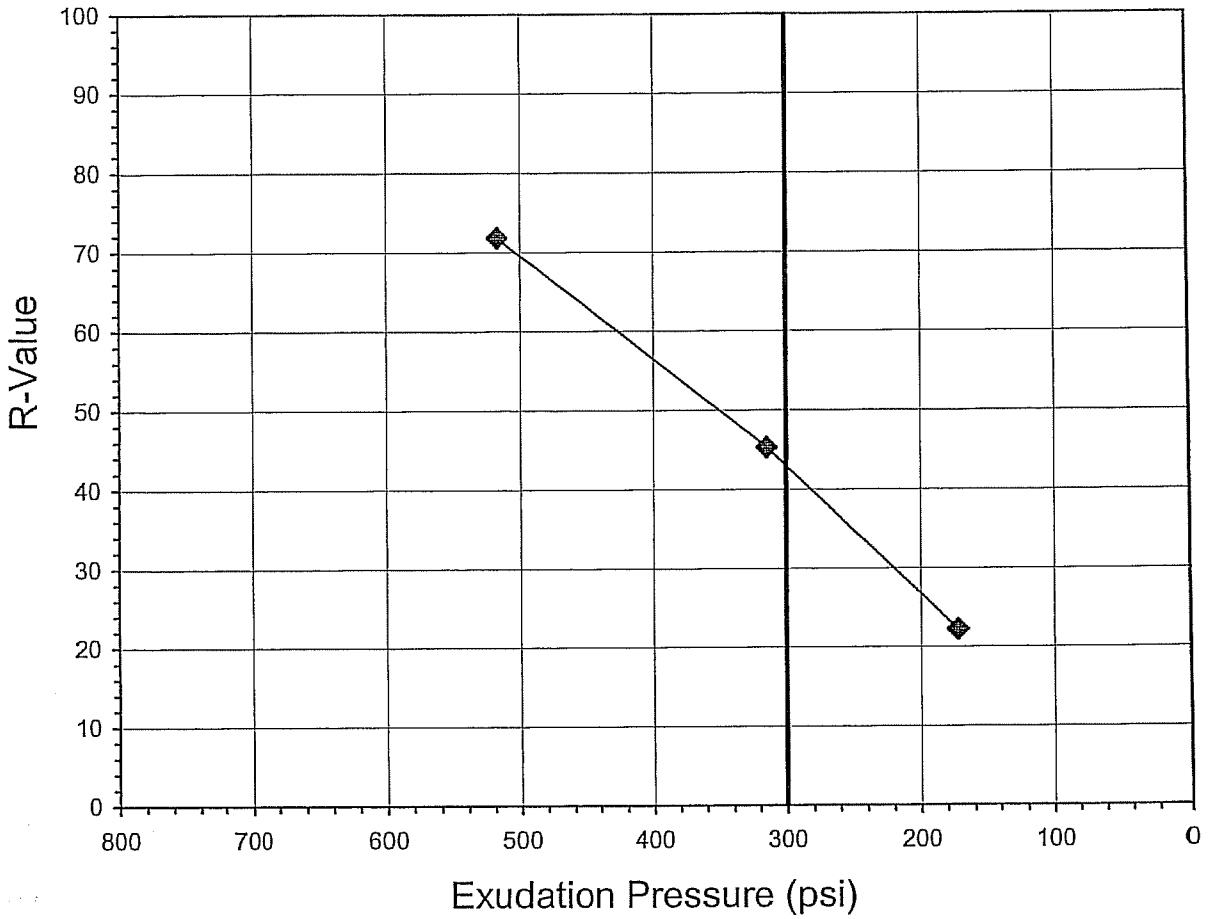
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

R-VALUE TEST RESULTS

12/31/09

FIGURE 2



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	250	122.2	11.1	0.79	35	2.53	518	72	72
2	120	119.5	12.9	0.00	109	2.50	172	22	22
3	200	121.0	12.0	0.52	70	2.52	314	45	45

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

Boring No: A-09-109
Sample No: B-01 @ 1'
Sample Type: Bulk
Sample Description: Clayey sand (SC)
Test Date: 12/14/09

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

Test Results: R-Value at 300 psi
Exudation Pressure: 42

R-VALUE TEST REPORT

12/30/09

FIGURE 1

Resistance R - Value Testing Results

(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008B
Test Date:	12/14/2009
Boring No:	A-09-109
Sample No:	B-01 @ 1'
Sample Type:	Bulk
Sample Description:	Clayey sand (SC), dark brown
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	250	120	200
Wet Weight (gms)	1210	1230	1220
Dry Weight (gms)	1089	1089	1089
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	6500	2161	3950
Total Weight (gms)	2917	3034	2999
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1134	1114	1127
Sample Height (in)	2.53	2.50	2.52
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0026	0.0000	0.0017
Expansion Pressure (psi)	0.7878	0.0000	0.5151
Ph @ 2000 lbs	35	109	70
D turns	3.5	4.09	3.88
R-Value from Exudation	72	22	45
Density (pcf)	122.2	119.5	121.0
Moisture (%)	11.1	12.9	12.0
Exudation Pressure (psi)	518	172	314
Corrected R-Value from Exudation:	72	22	45
Exudation Pressure (psi)	518	172	314

R-Value at 300 psi exudation pressure = 42

Note:
0.00% Retained on 3/4-inch Sieve

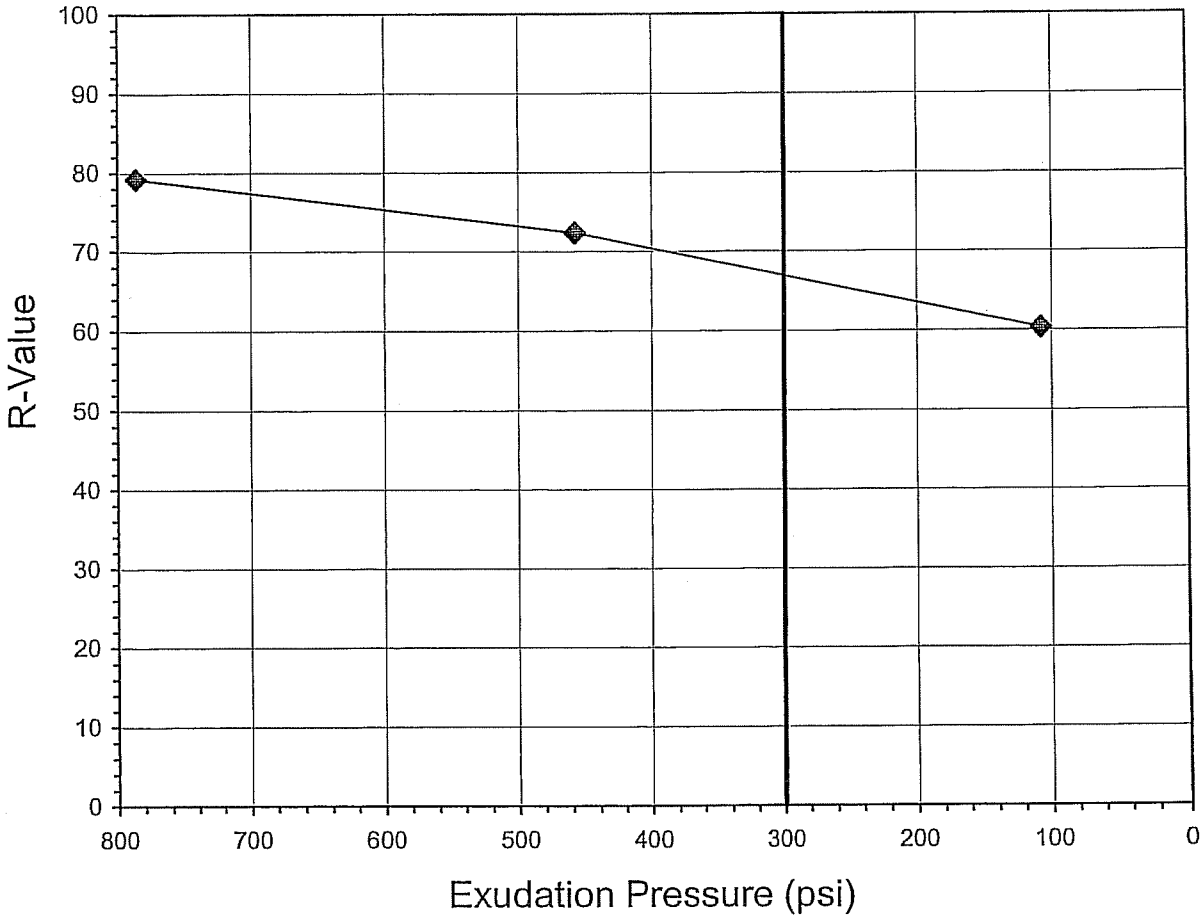
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

R-VALUE TEST RESULTS

12/30/09

FIGURE 2



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	350	125.0	9.3	0.00	31	2.55	458	72	72
2	250	123.8	10.1	0.00	42	2.50	107	60	60
3	350	126.2	8.4	0.39	25	2.50	786	79	79

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

Boring No: A-09-110
Sample No: B-01 @ 0'
Sample Type: Bulk
Sample Description: Silty sand (SM)
Test Date: 12/11/09

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

Test Results: R-Value at 300 psi
Exudation Pressure: 66

R-VALUE TEST REPORT

12/30/09

FIGURE 1

Resistance R - Value Testing Results

(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008B
Test Date:	12/11/2009
Boring No:	A-09-110
Sample No:	B-01 @ 0'
Sample Type:	Bulk
Sample Description:	Silty sand (SM), brown with some gravel
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	350	250	350
Wet Weight (gms)	1240	1250	1230
Dry Weight (gms)	1135	1135	1135
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	5750	1350	9870
Total Weight (gms)	2932	3045	3000
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1149	1125	1128
Sample Height (in)	2.55	2.50	2.50
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0000	0.0000	0.0013
Expansion Pressure (psi)	0.0000	0.0000	0.3939
Ph @ 2000 lbs	31	42	25
D turns	3.97	4.62	3.54
R-Value from Exudation	72	60	79
Density (pcf)	125.0	123.8	126.2
Moisture (%)	9.3	10.1	8.4
Exudation Pressure (psi)	458	107	786
Corrected R-Value from Exudation:	72	60	79
Exudation Pressure (psi)	458	107	786

R-Value at 300 psi exudation pressure = 66

Note:
6.74% Retained on 3/4-inch Sieve

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

R-VALUE TEST RESULTS

12/30/09

FIGURE 2

APPENDIX D.

SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

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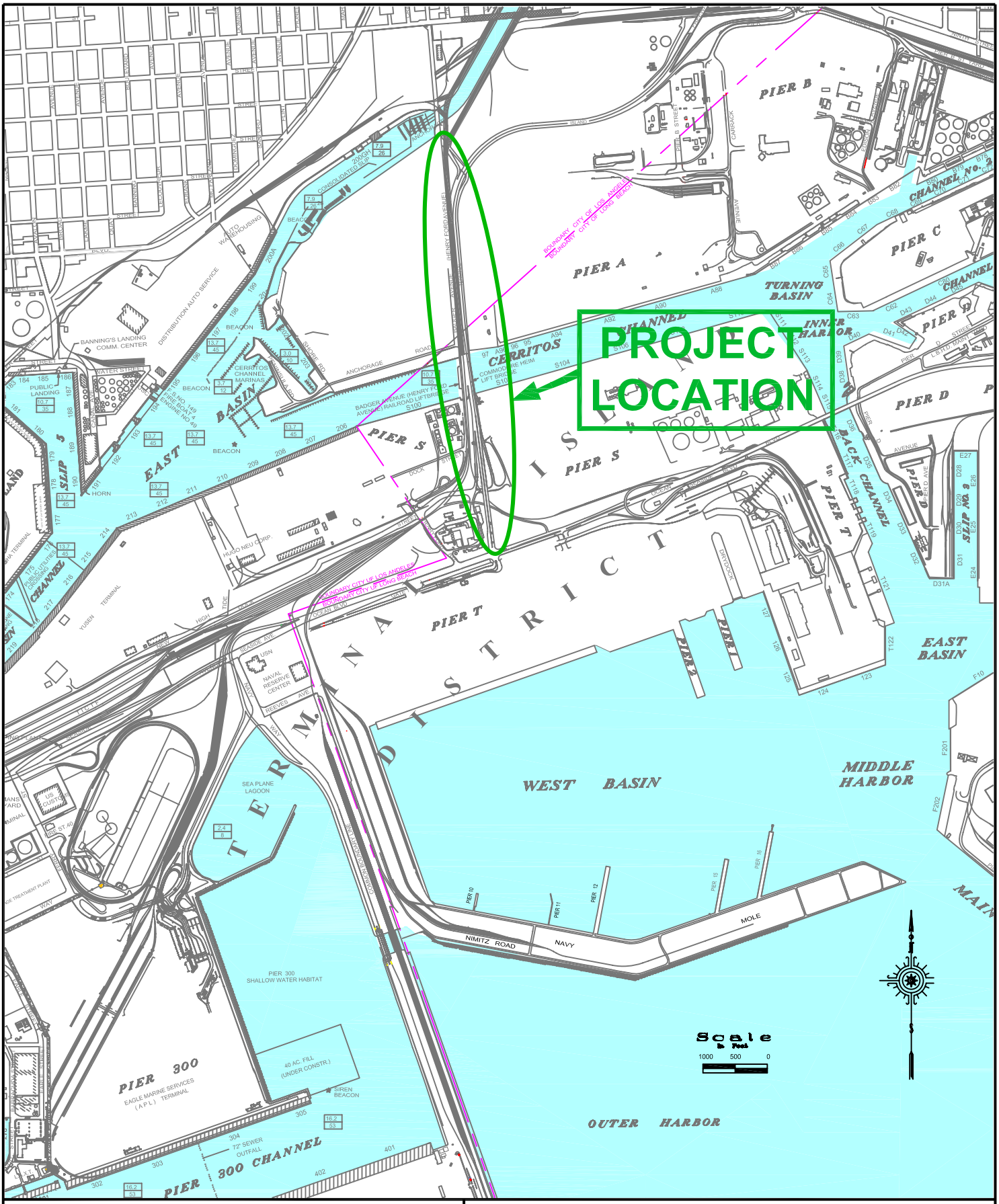
Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



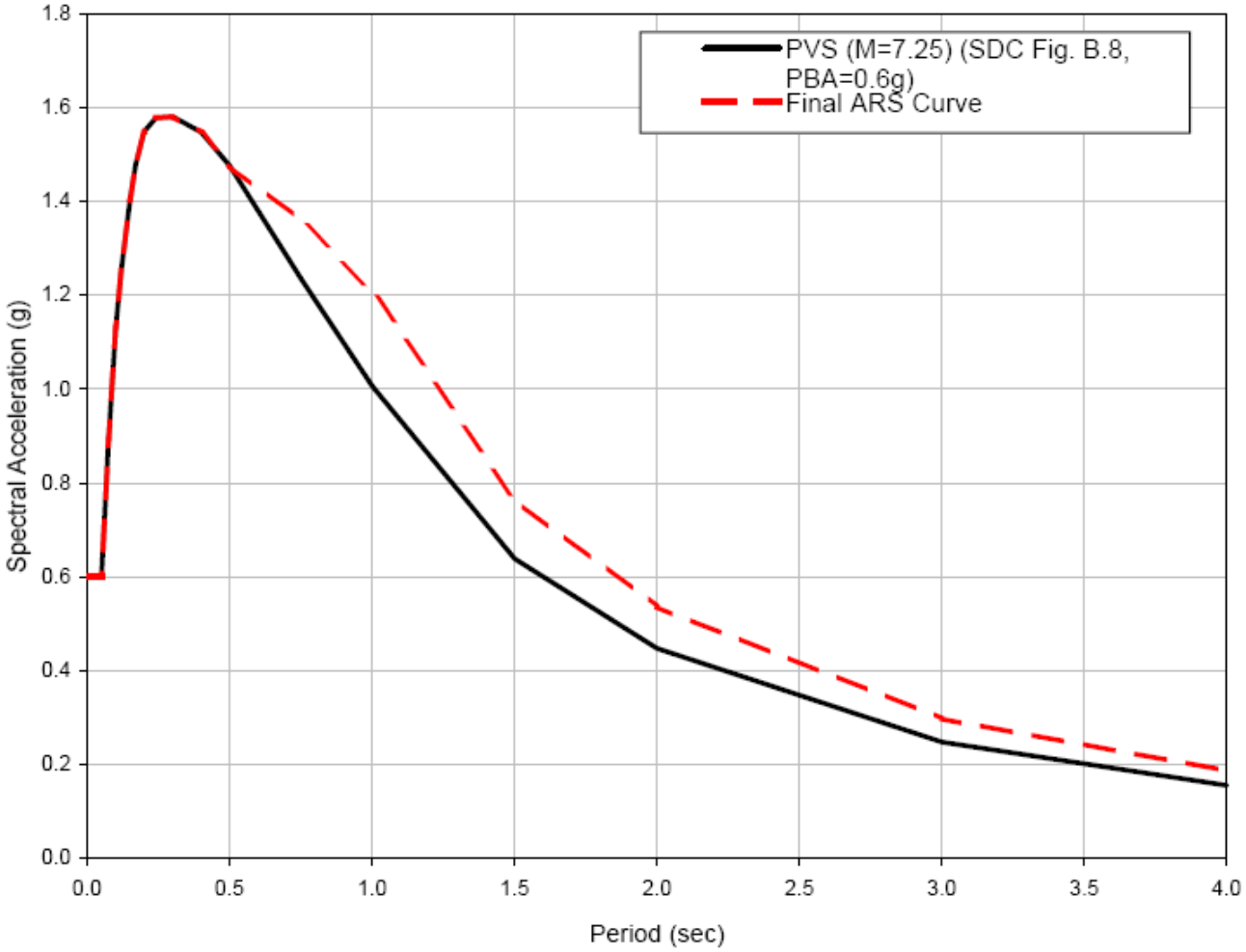
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

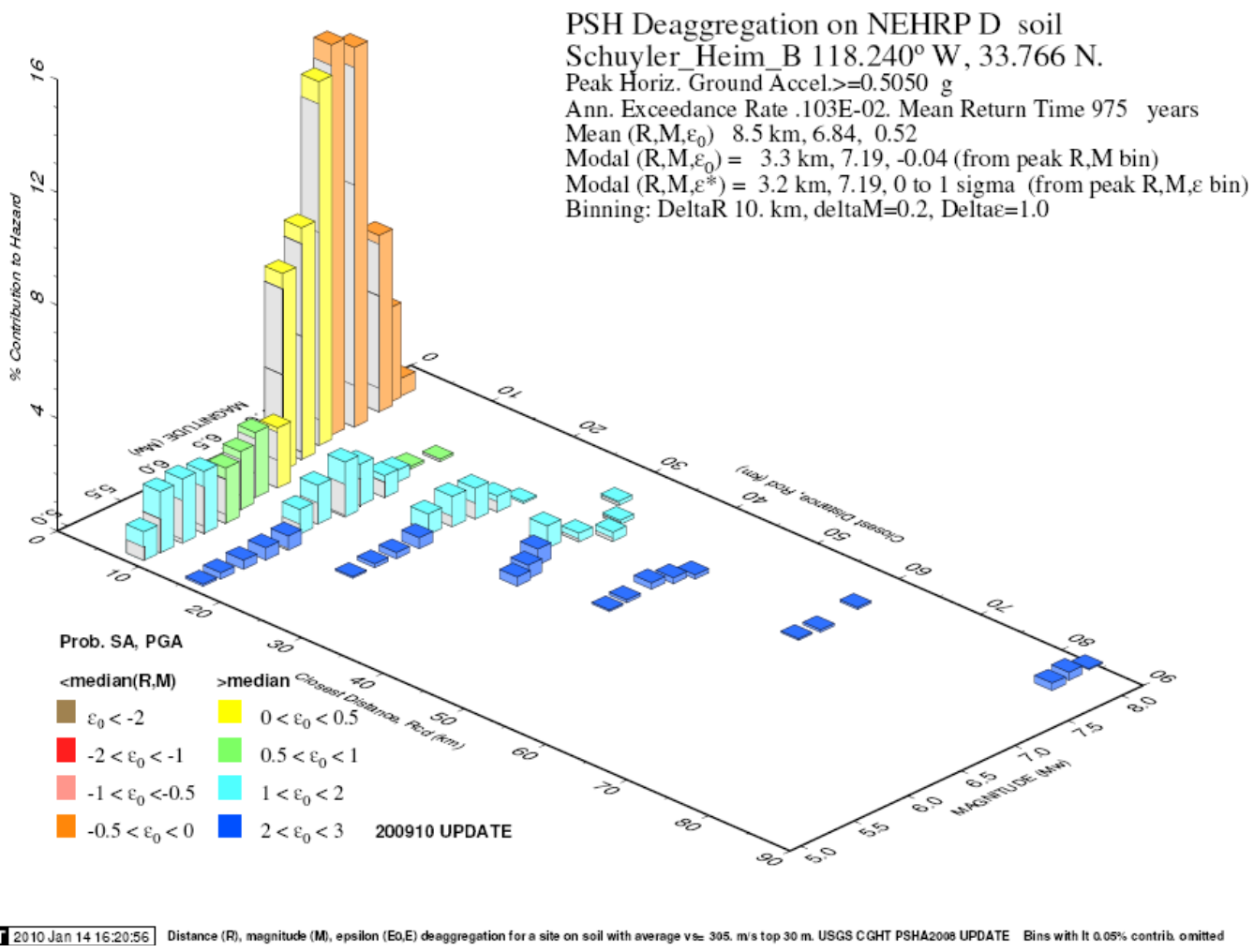


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

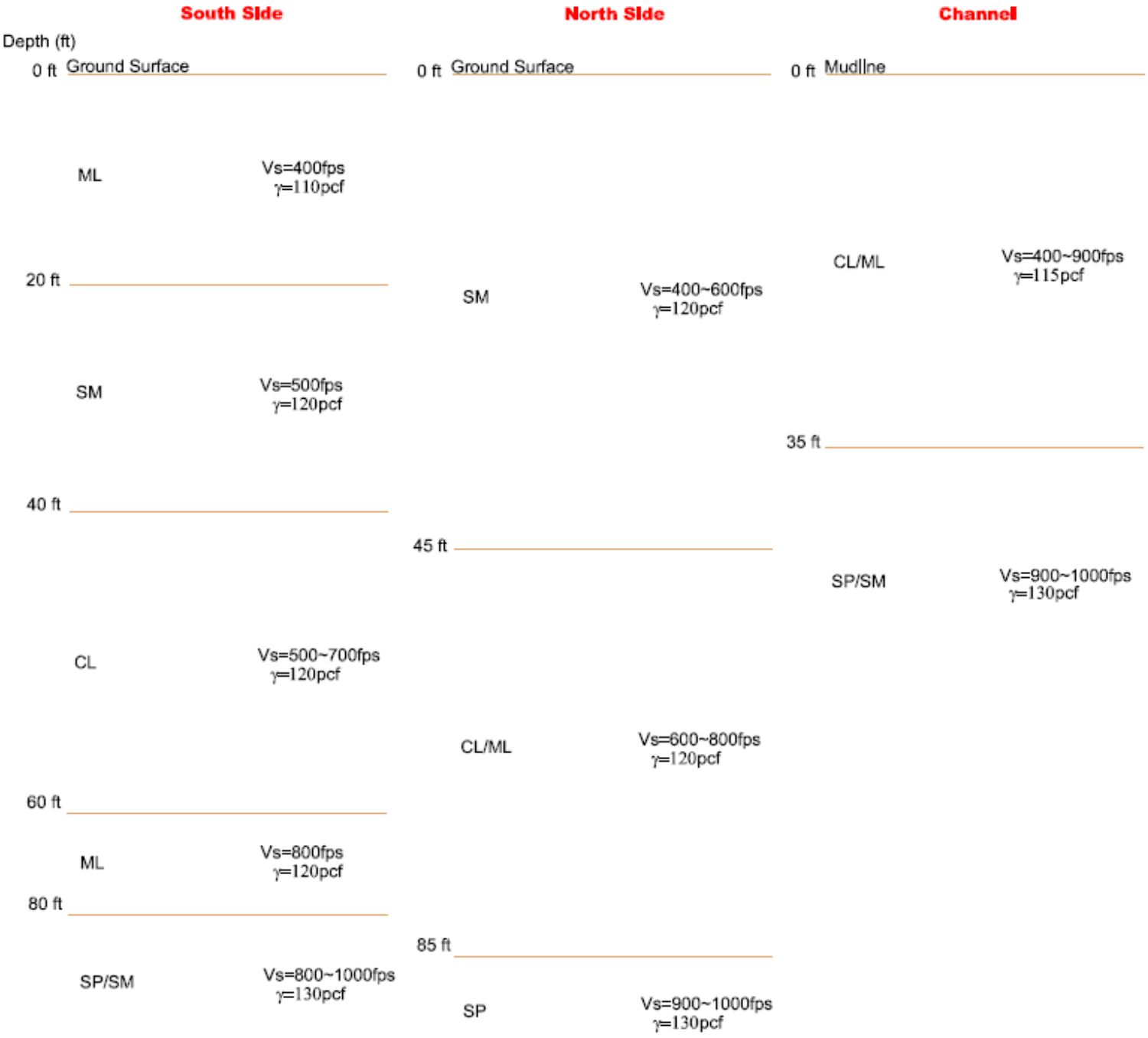
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



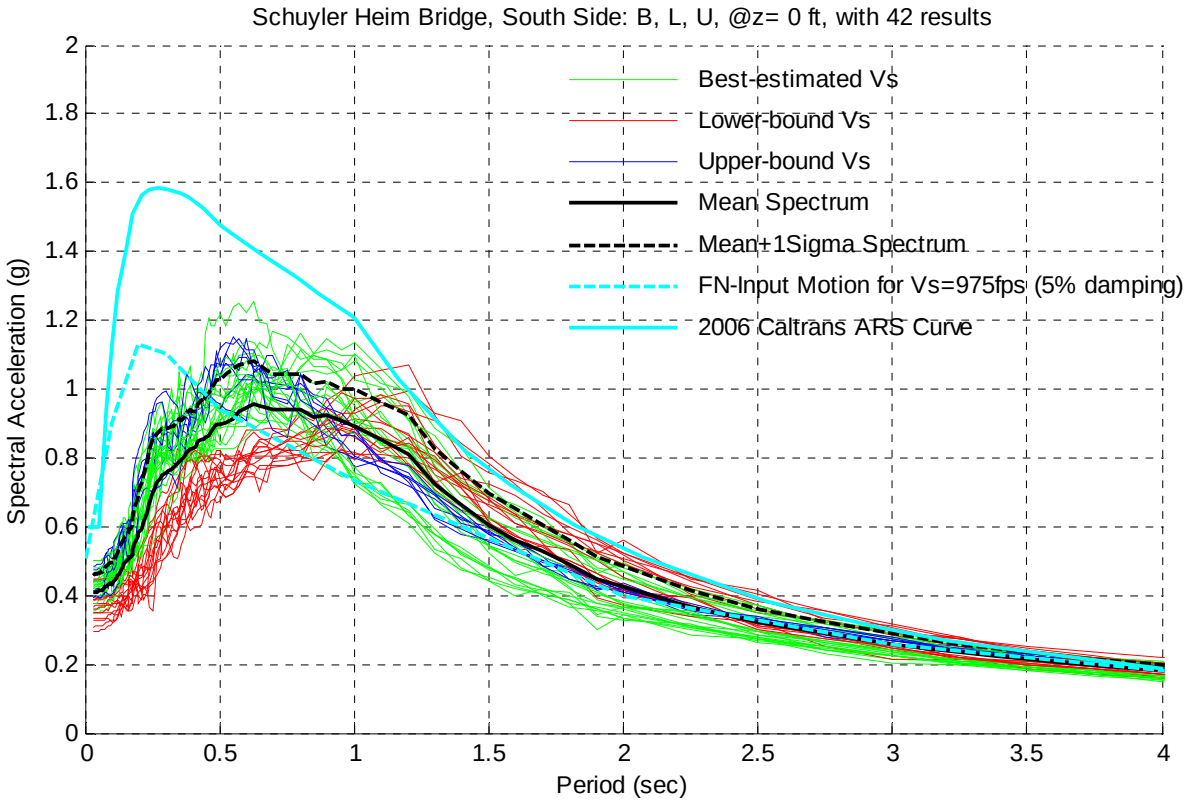
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

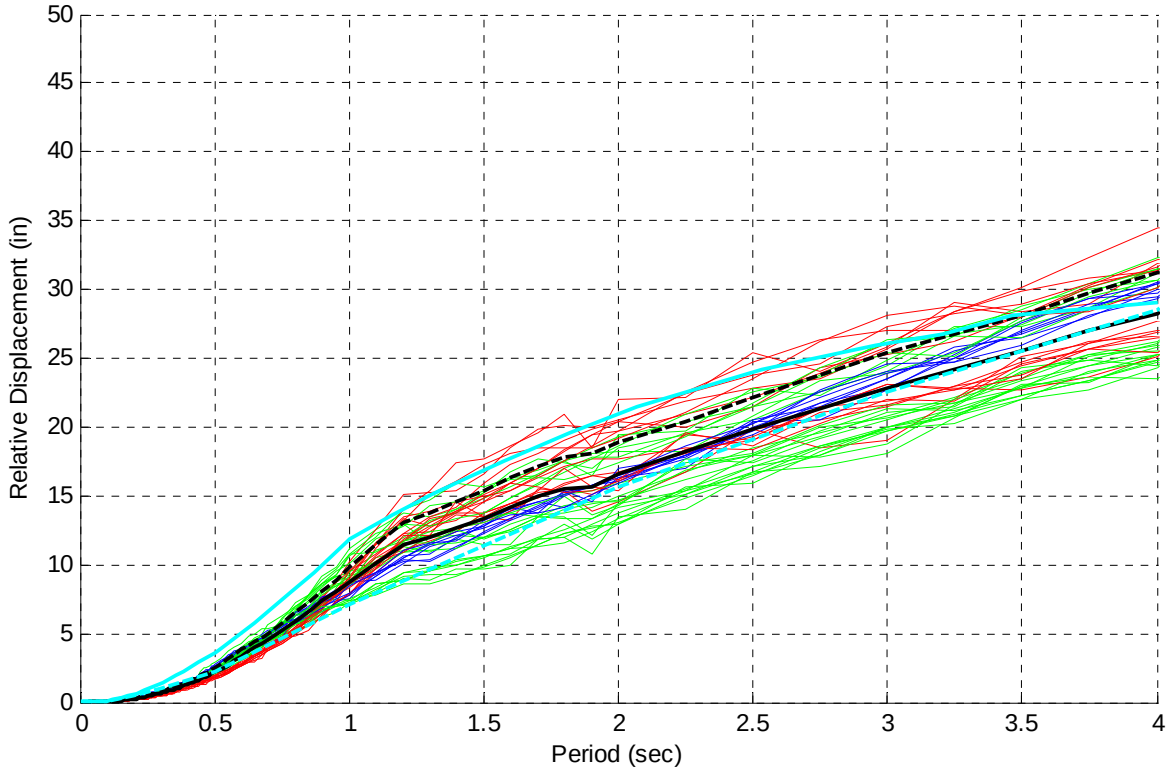
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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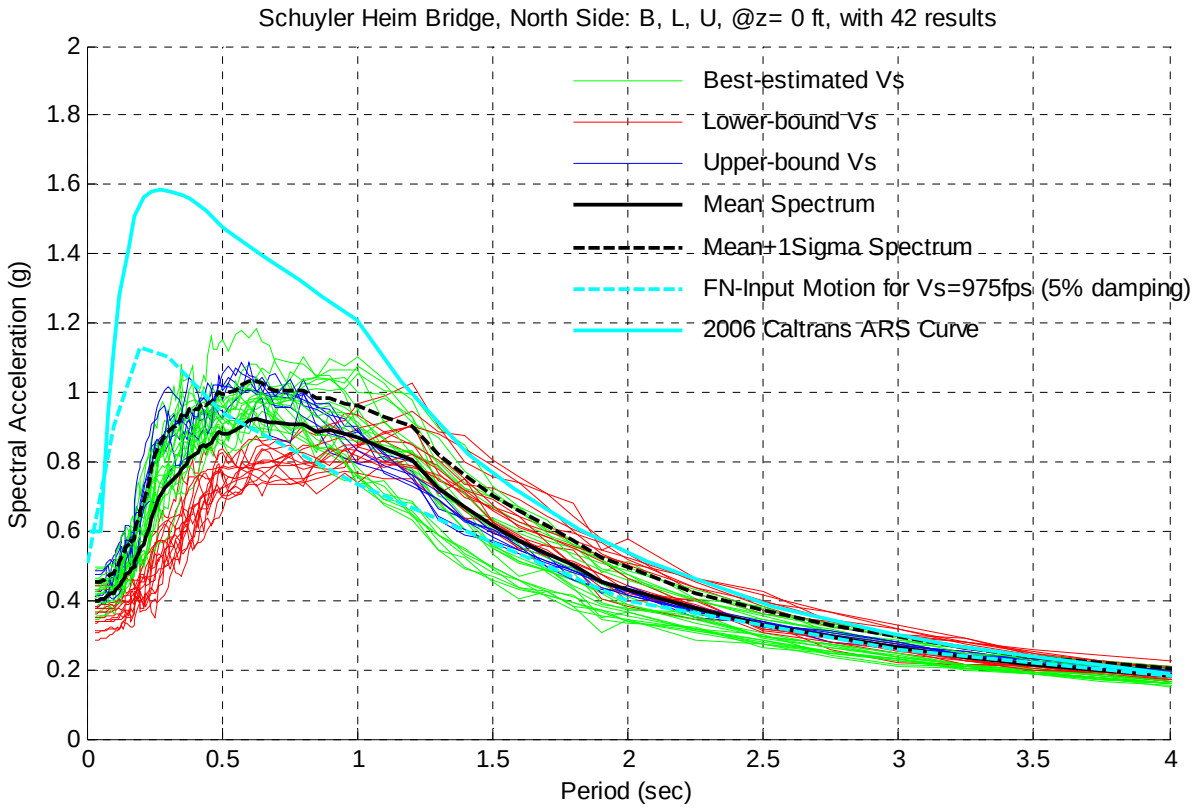
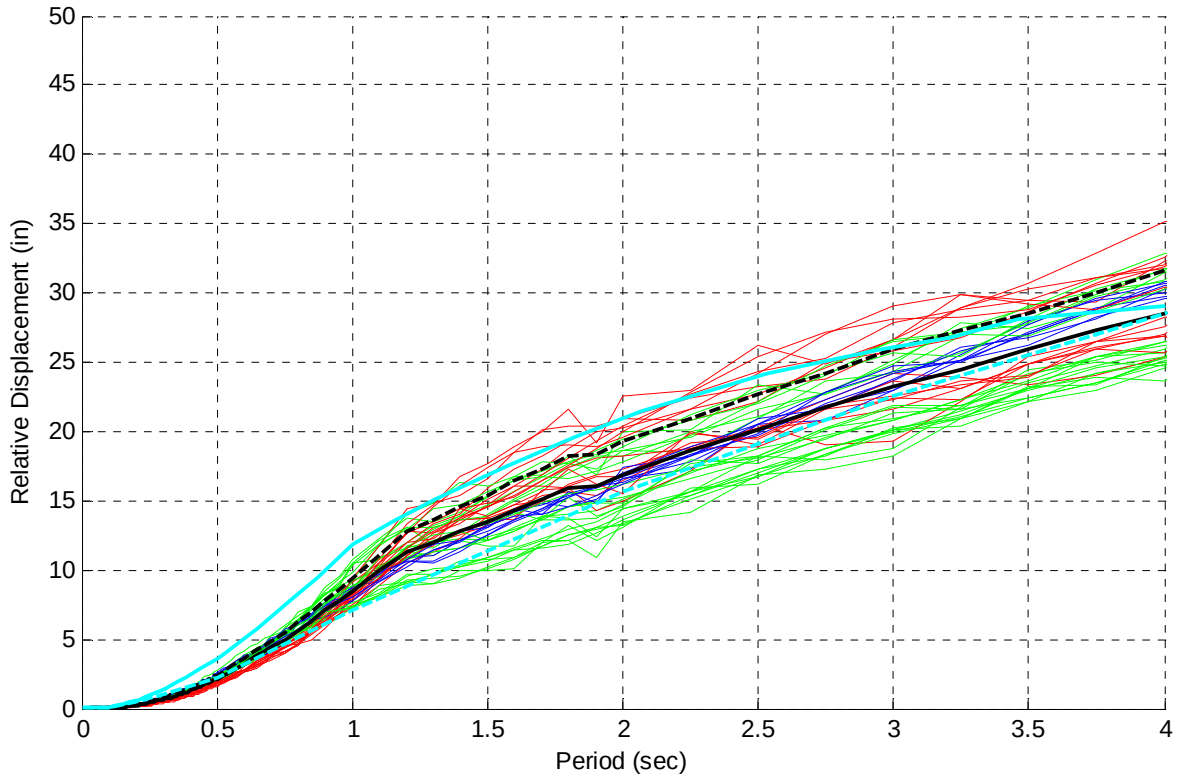
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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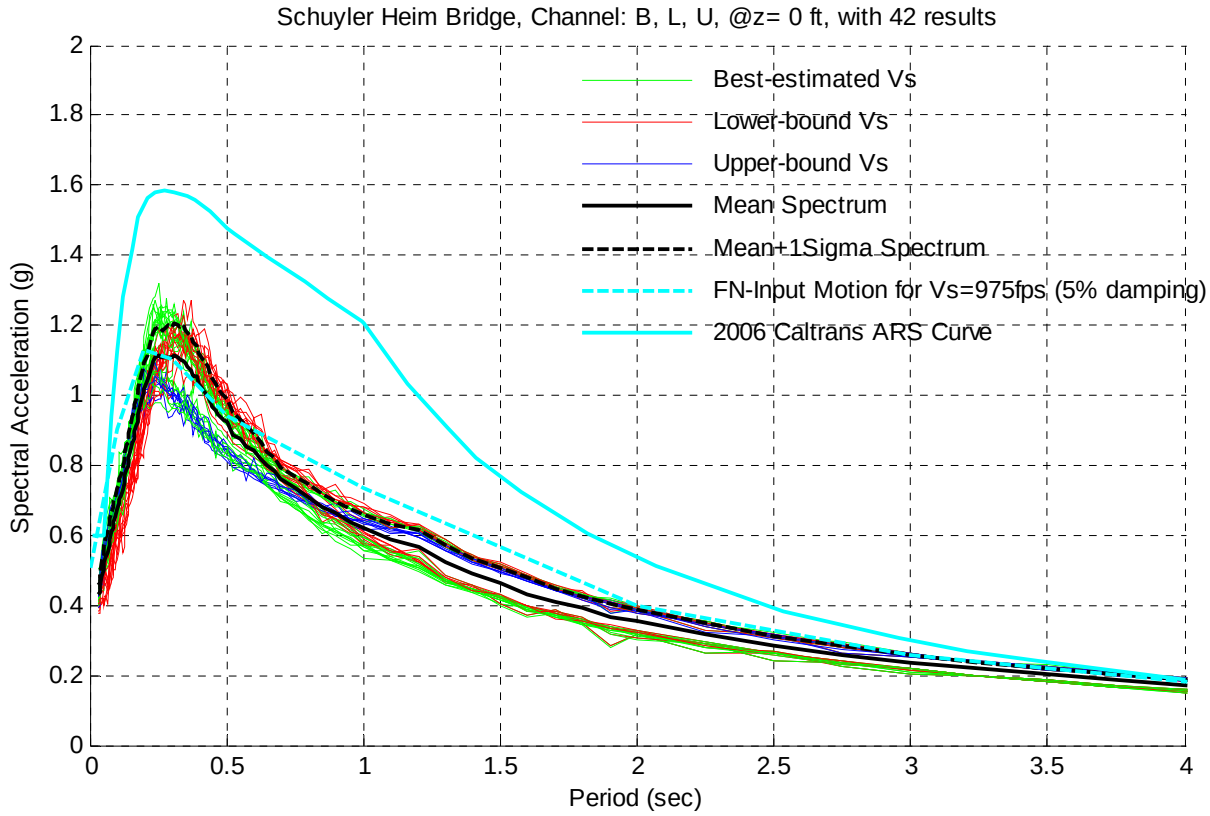
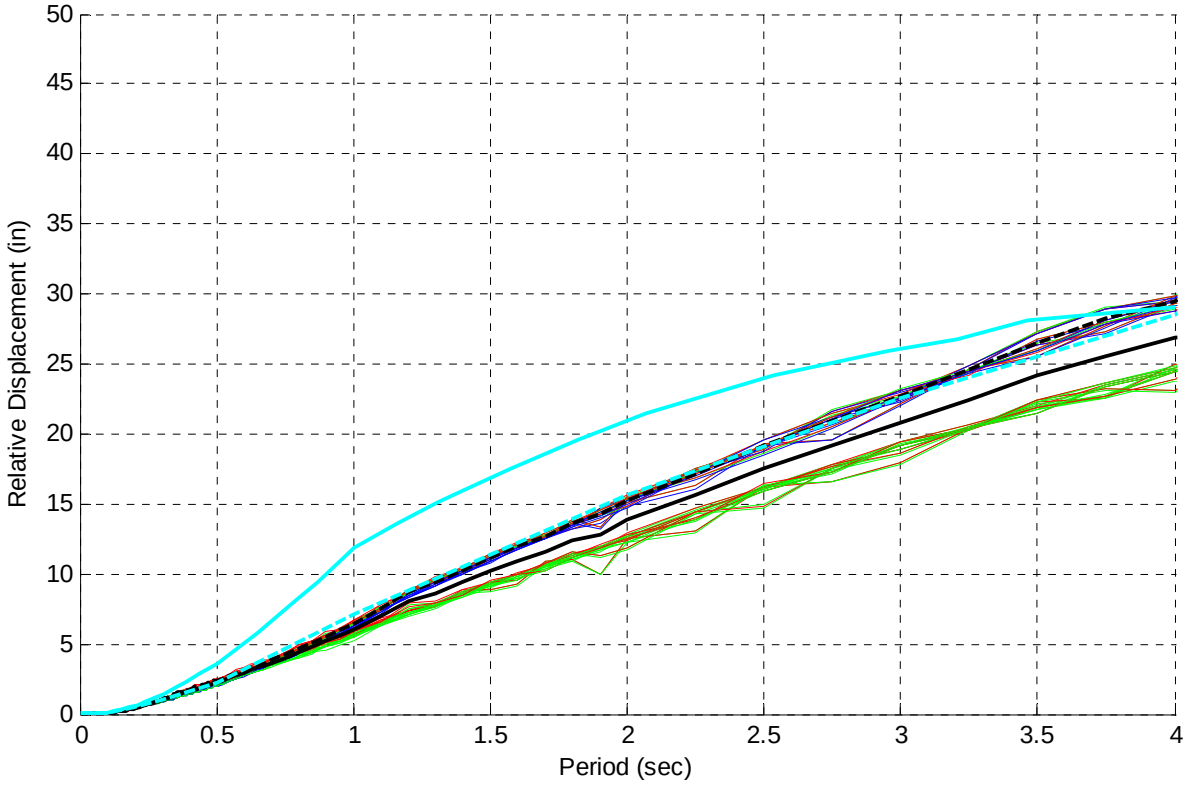
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





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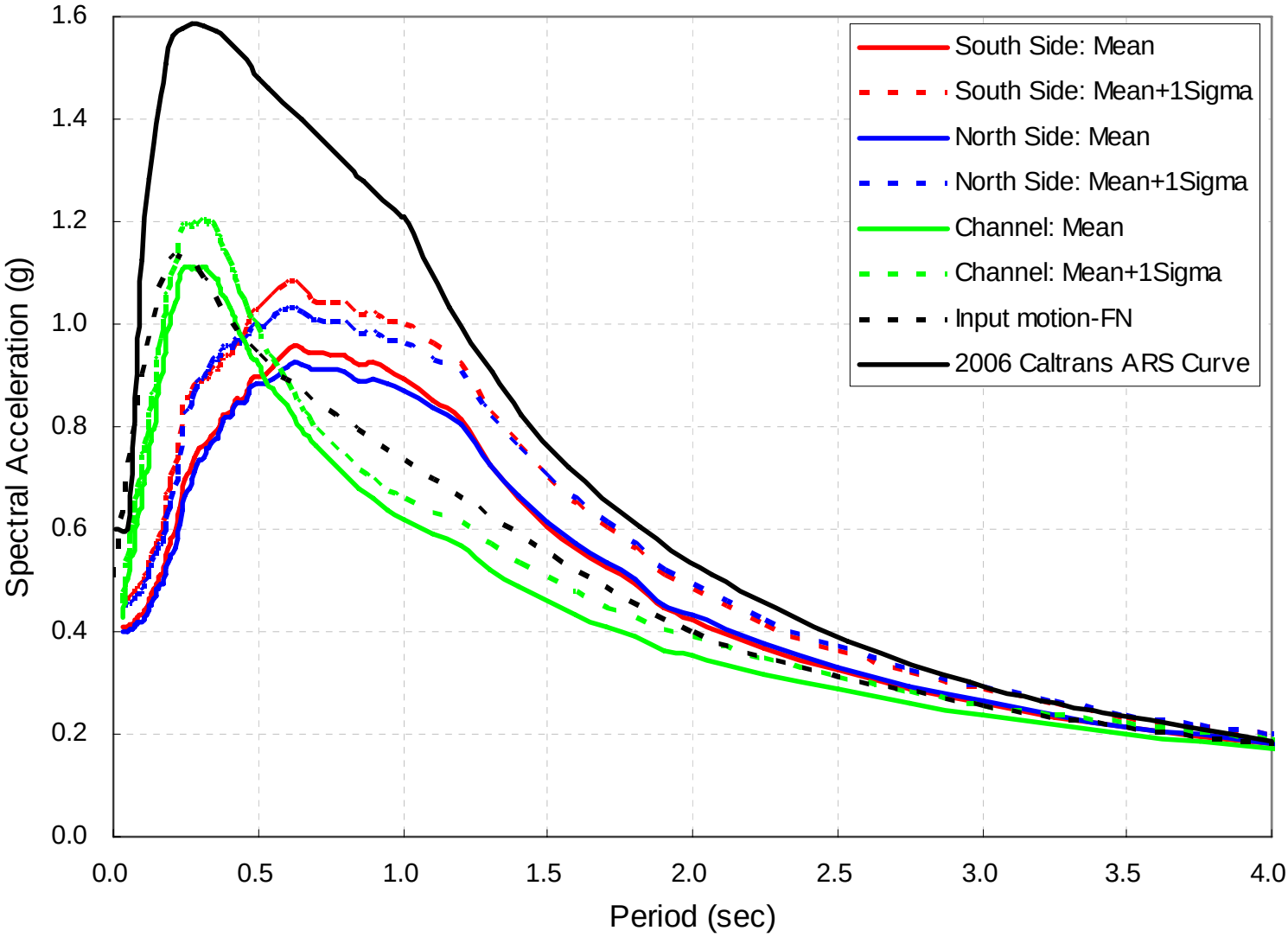
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

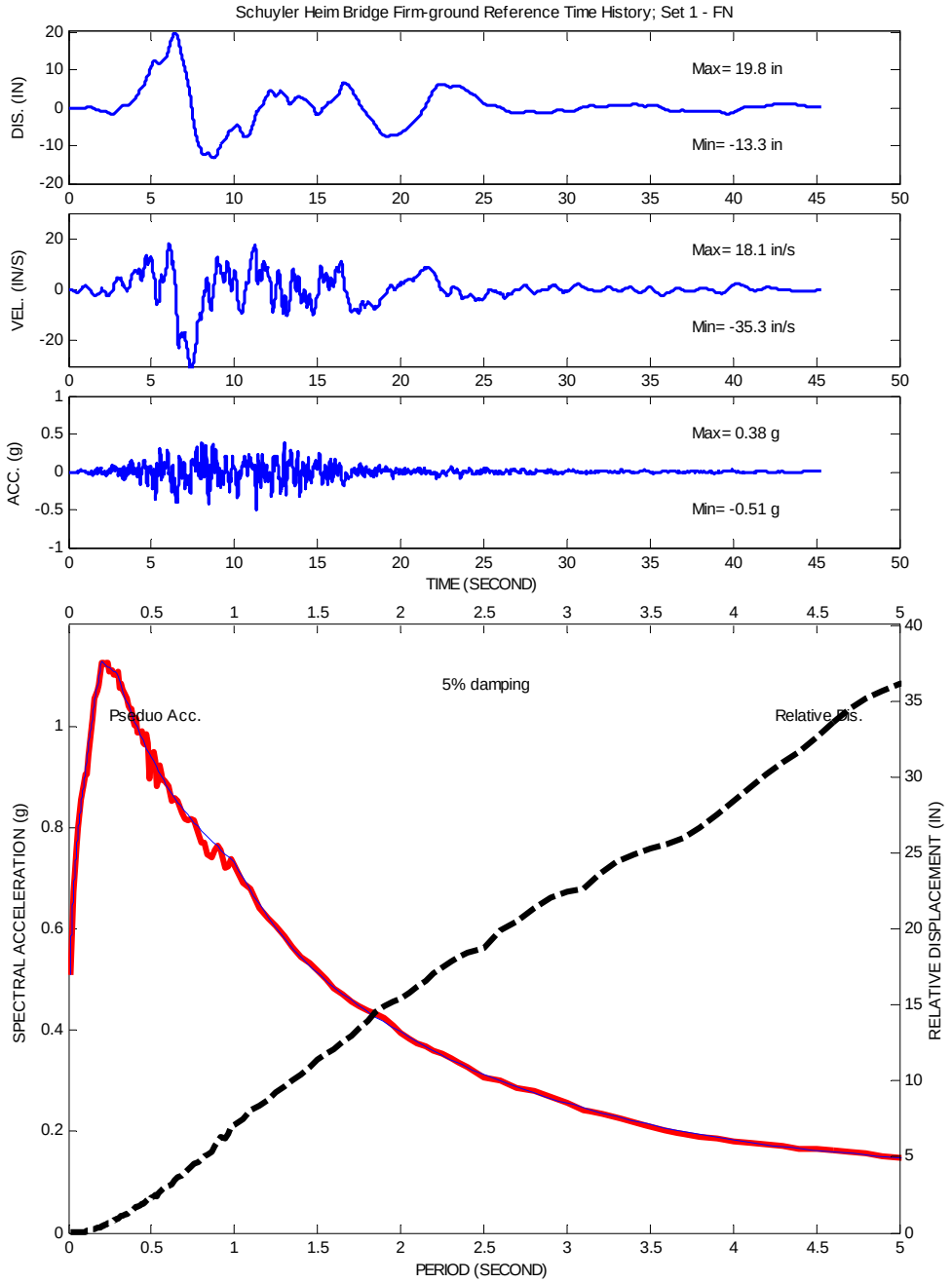

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

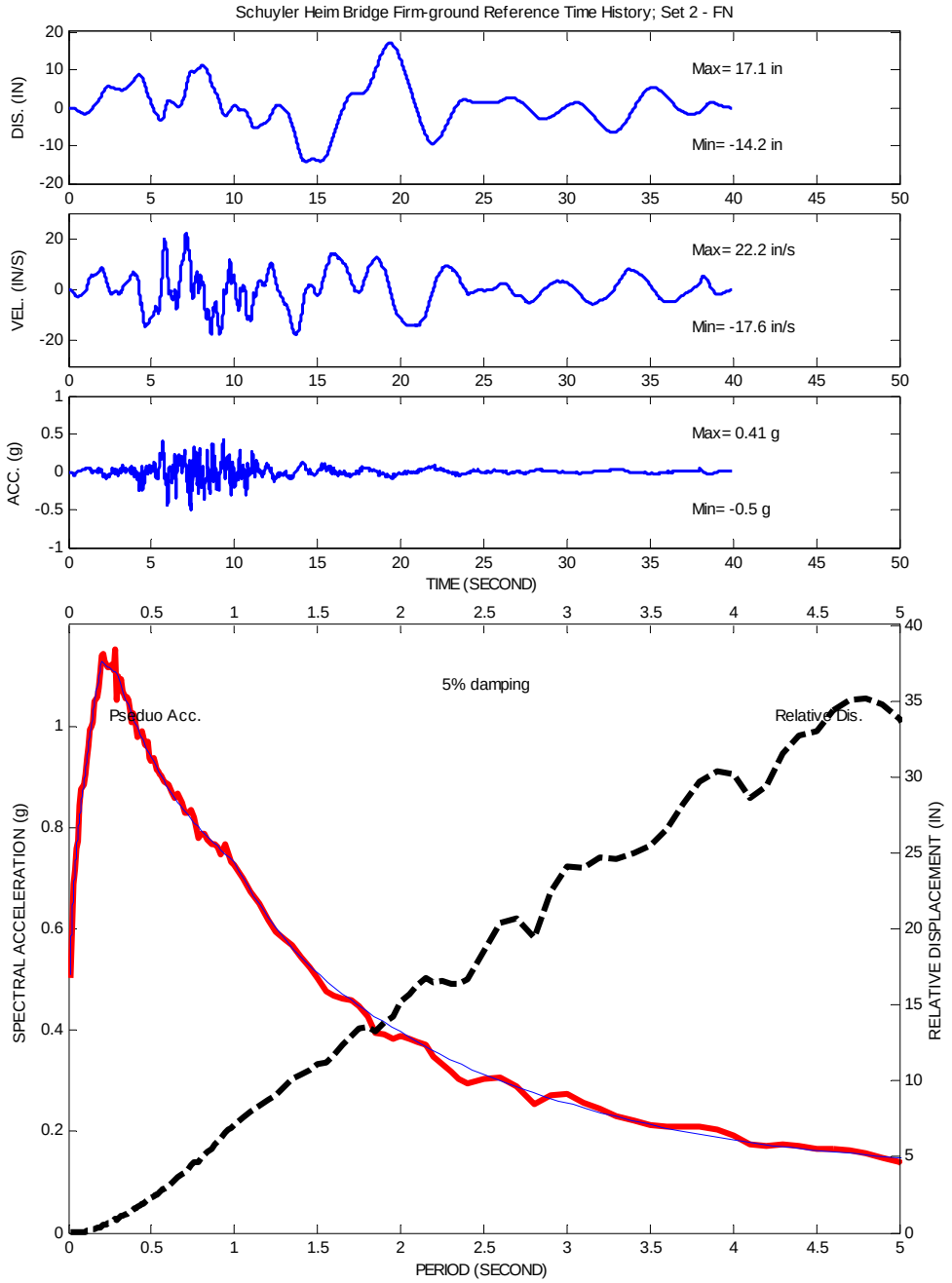

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

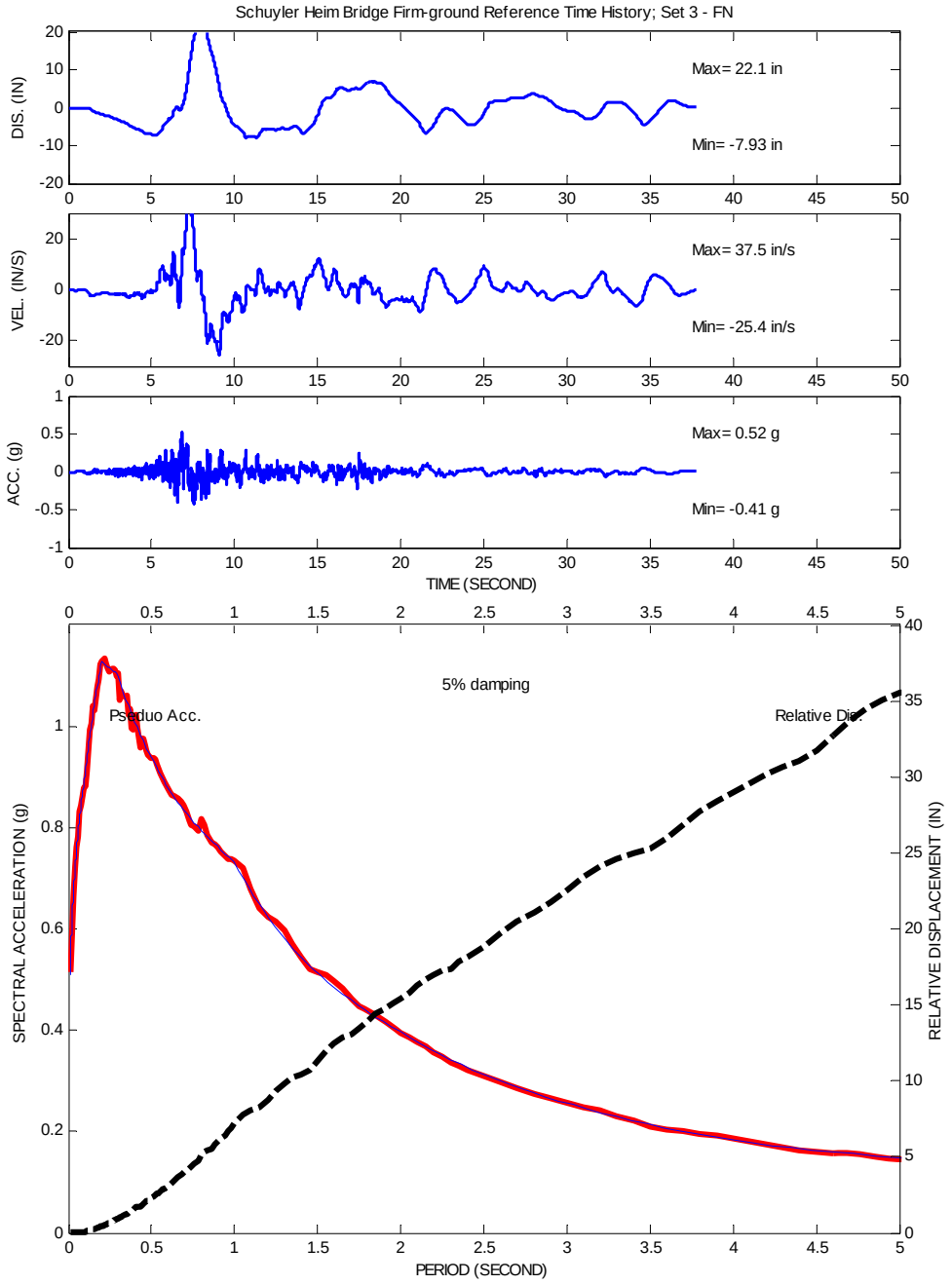

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

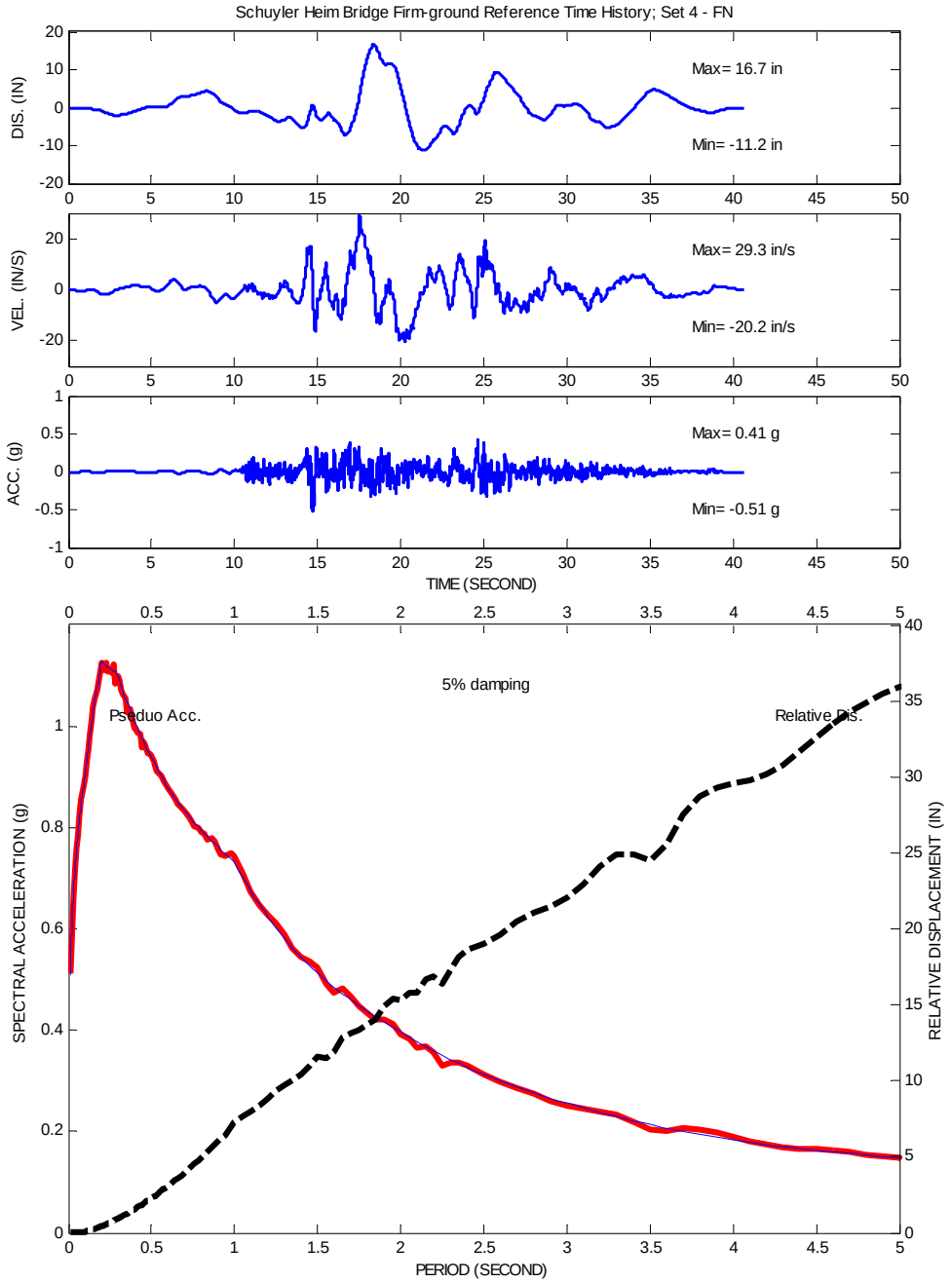

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

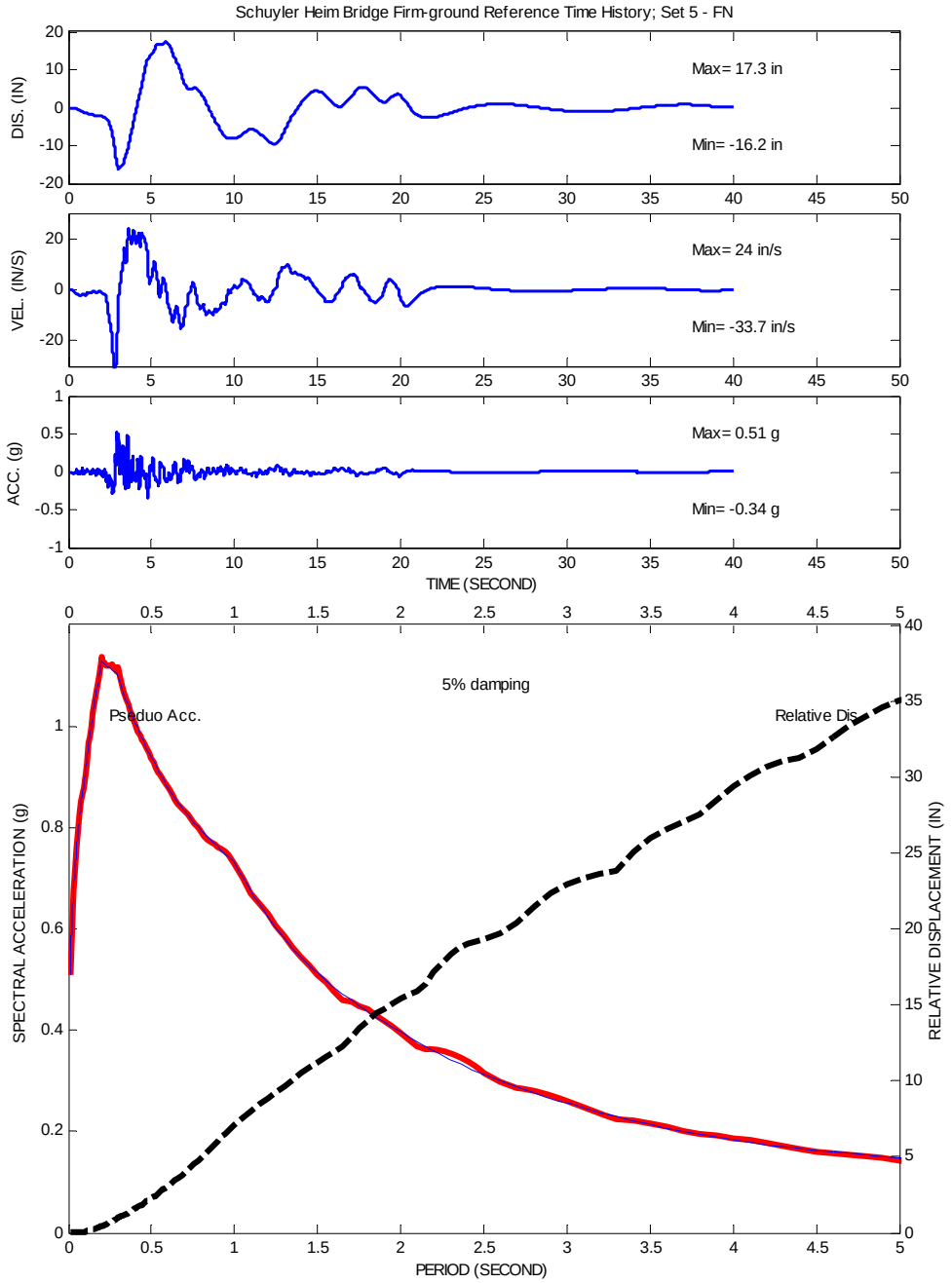

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

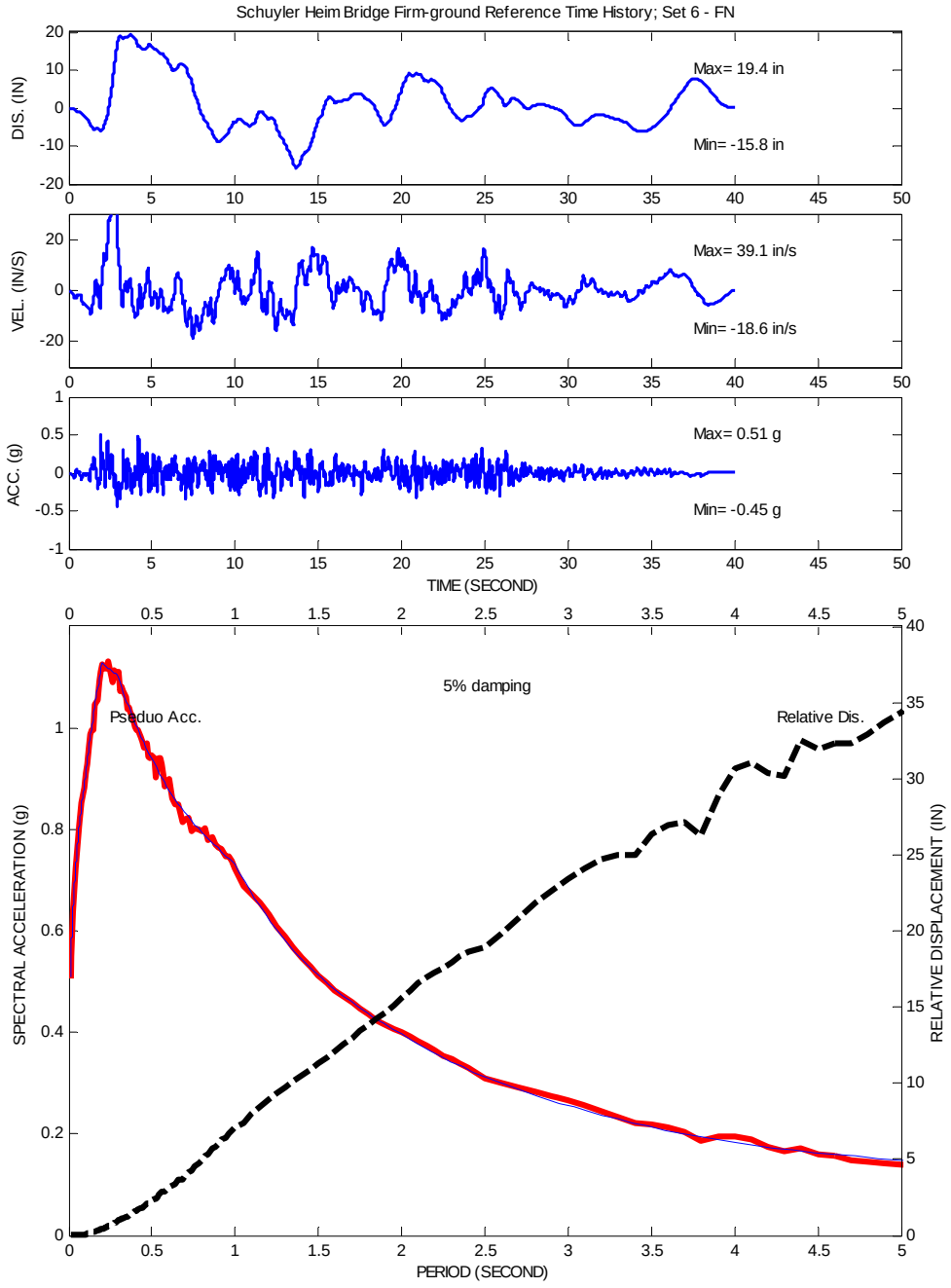

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

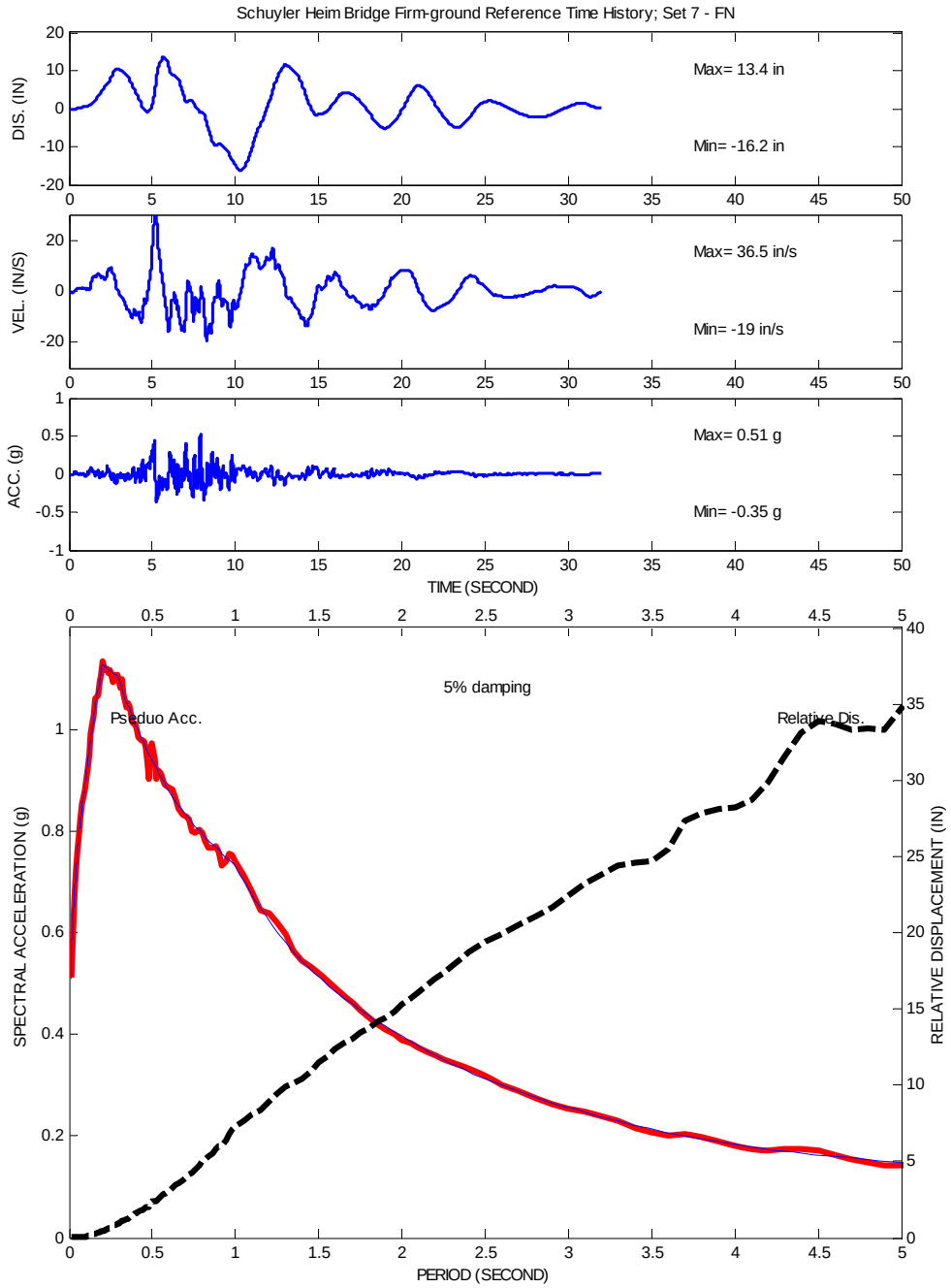

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

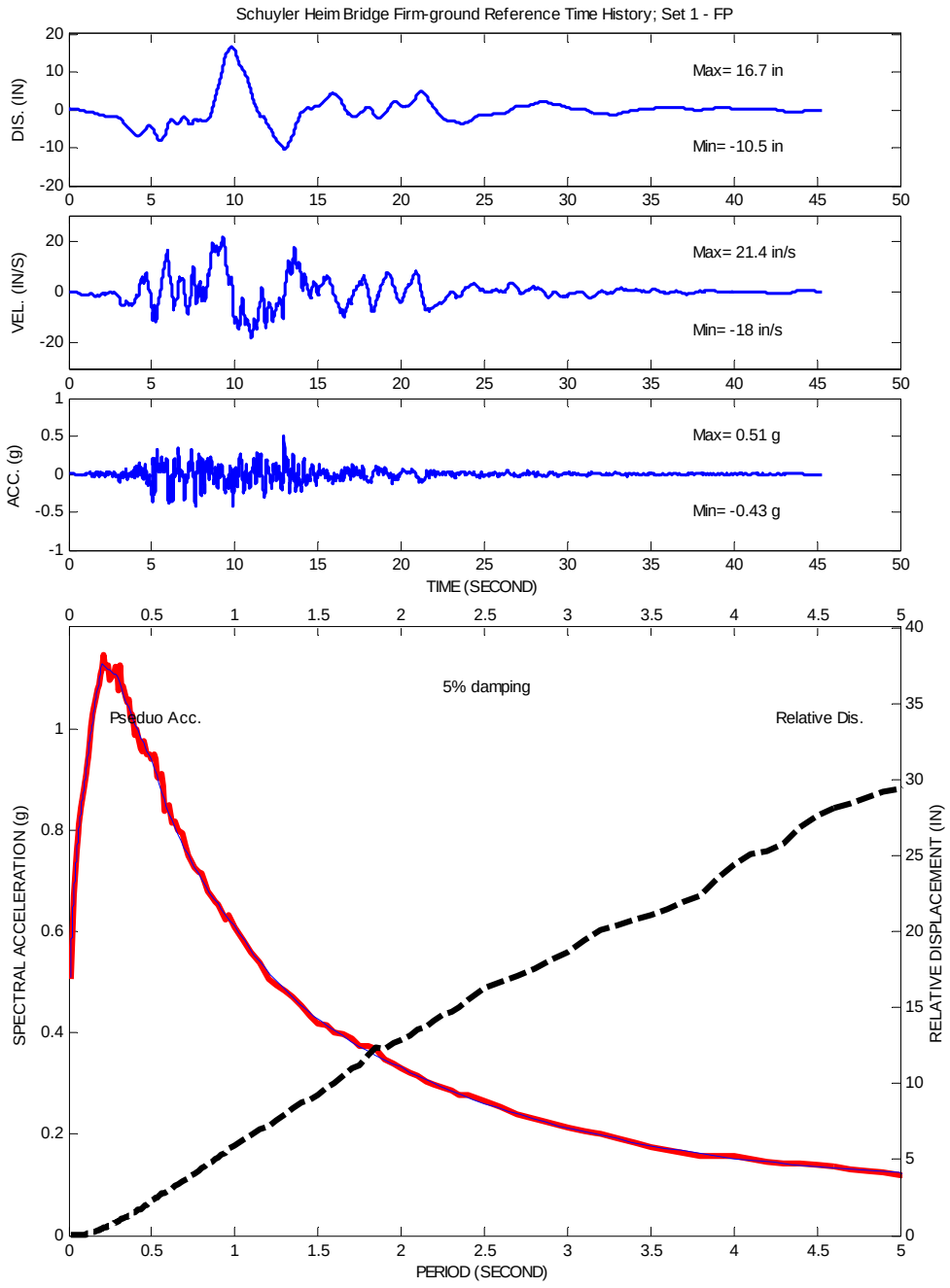

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

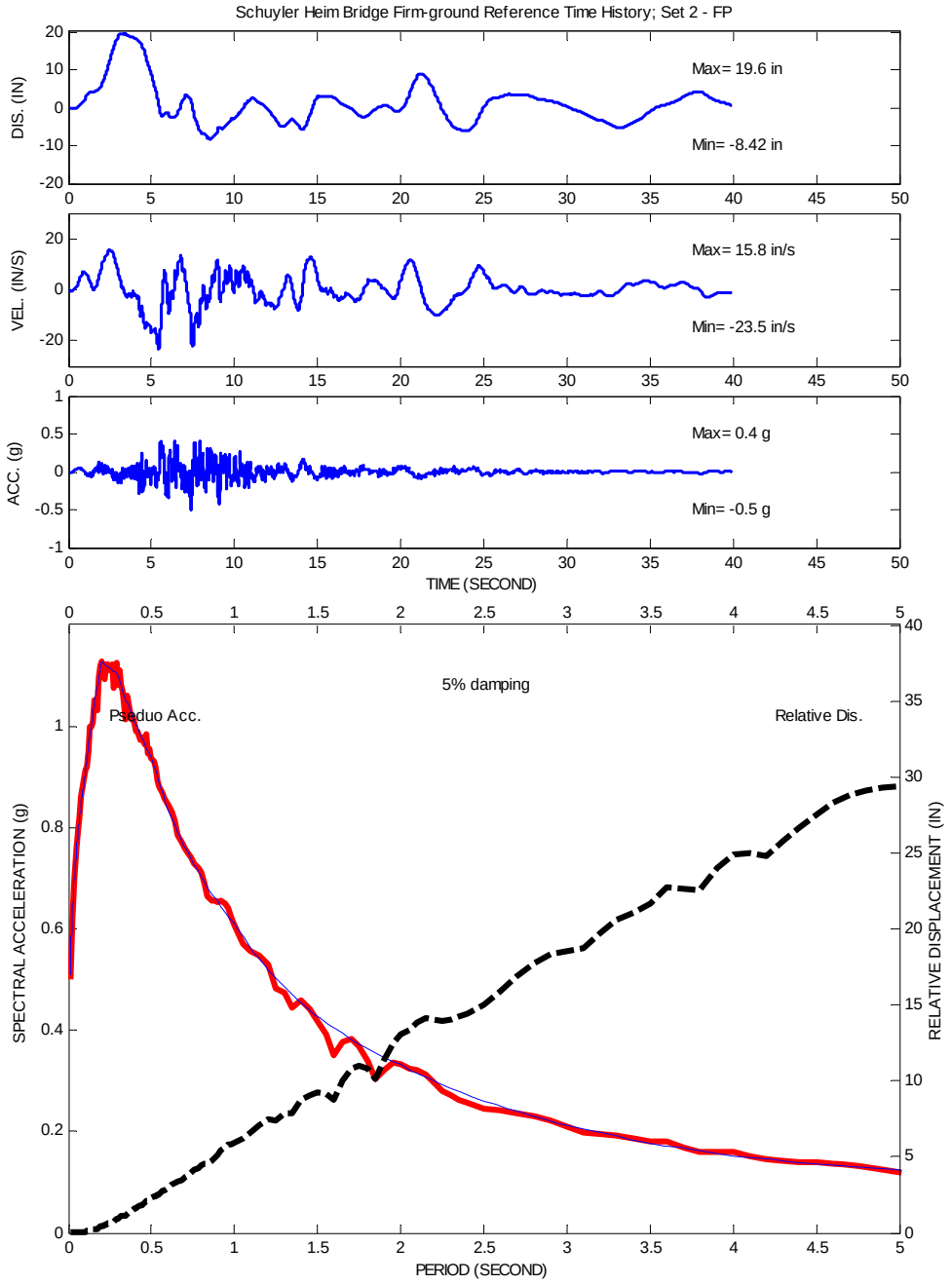

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

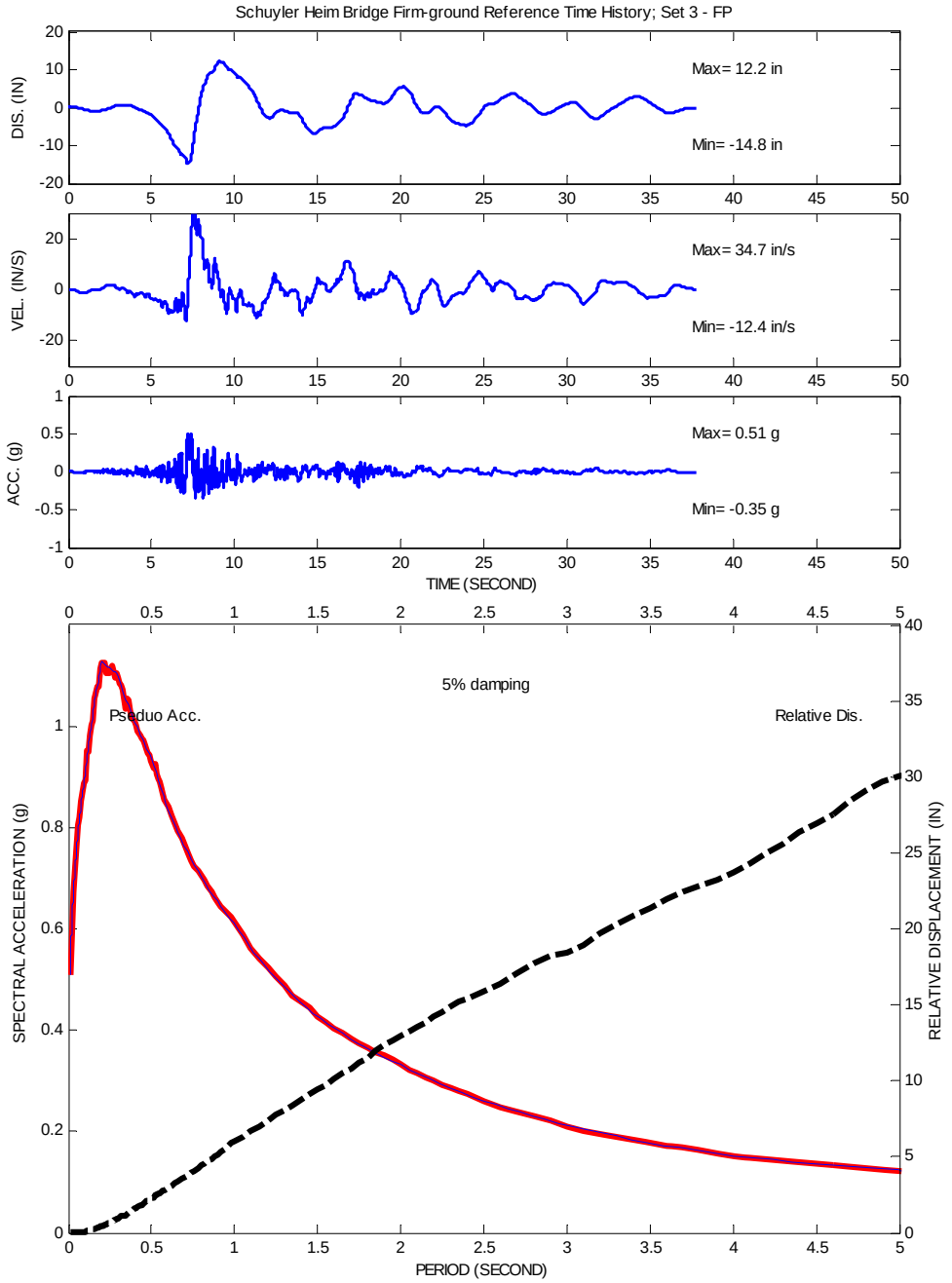

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

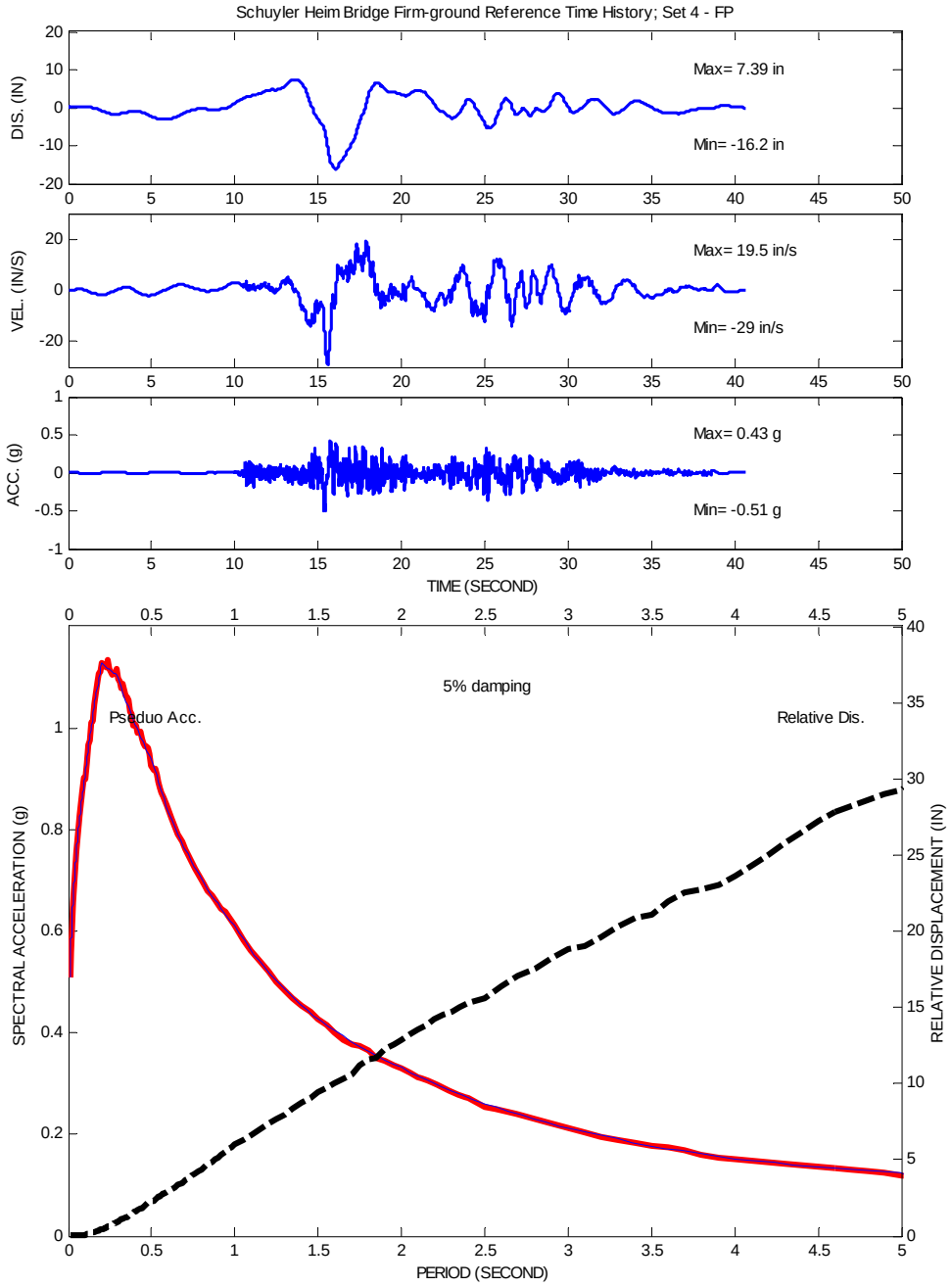

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

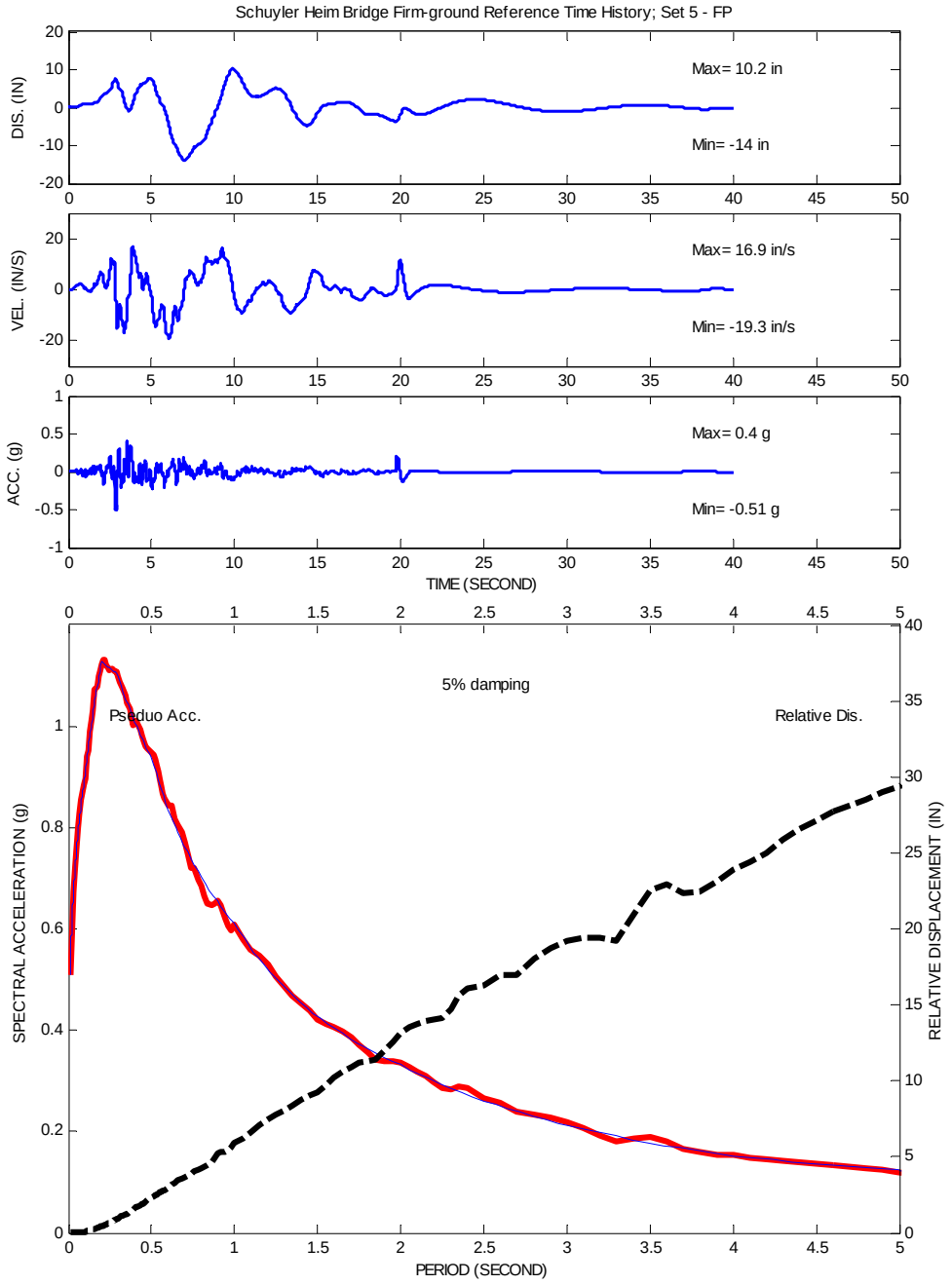

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

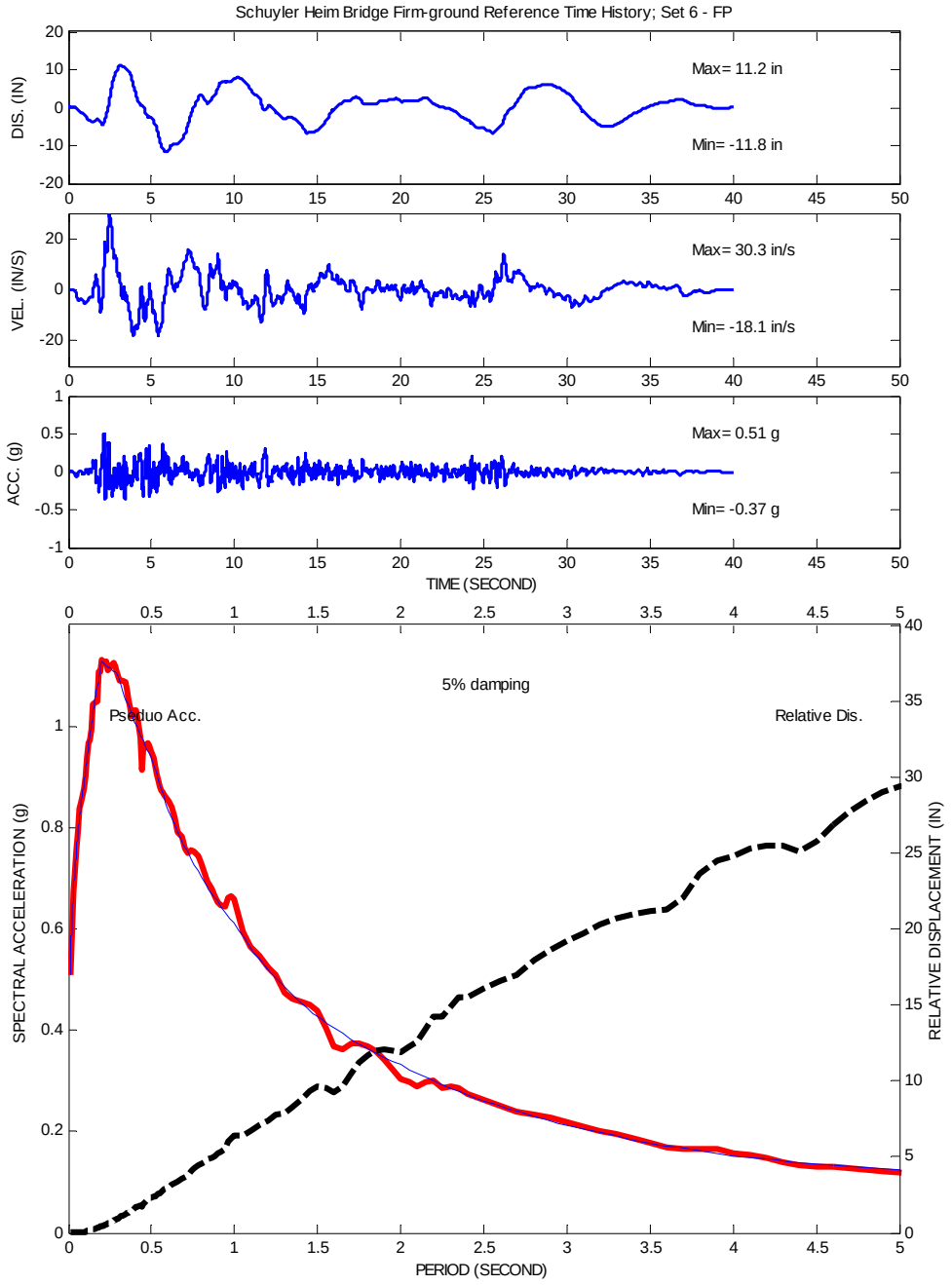

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

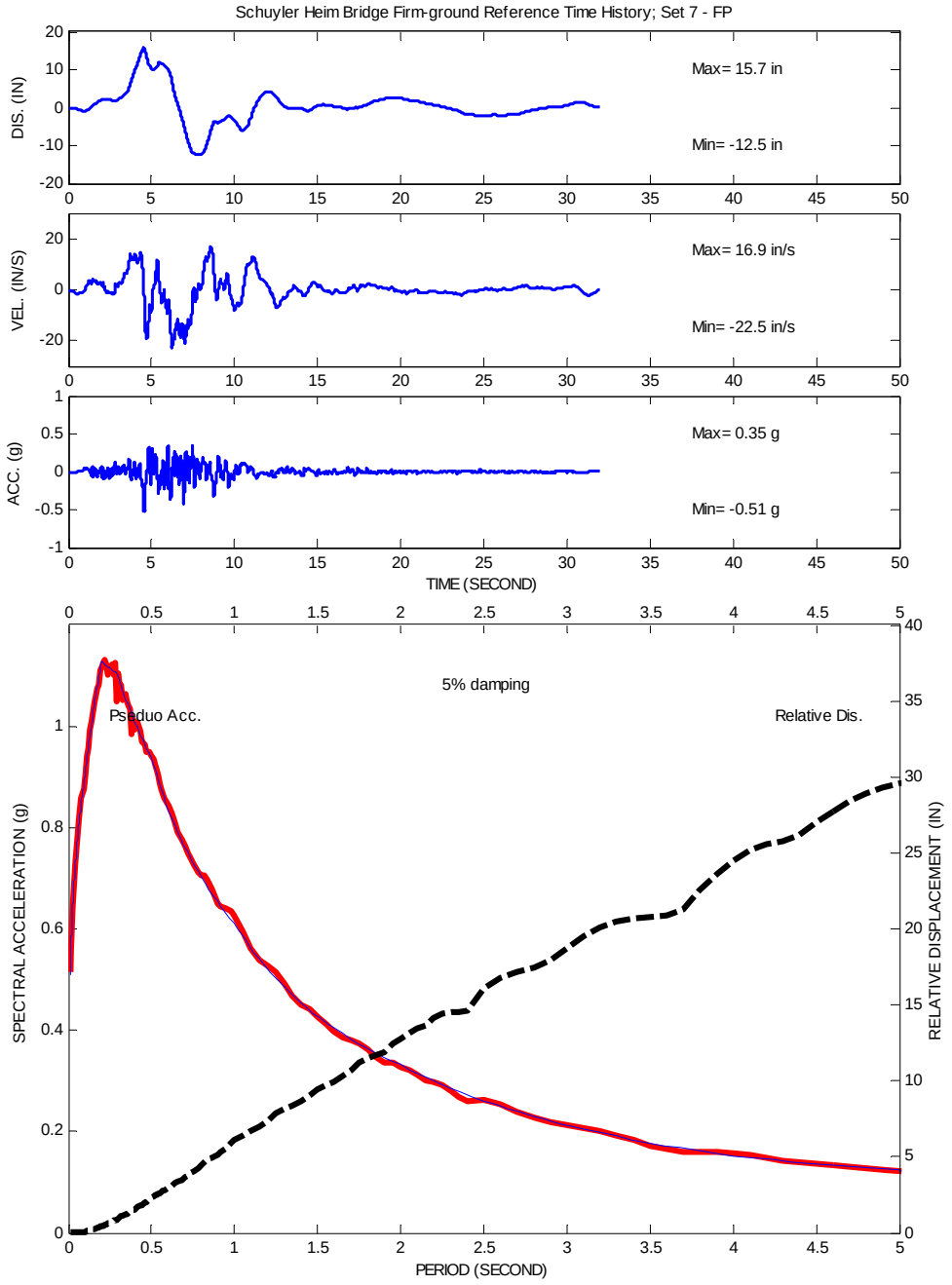

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX E. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 17, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report***
Retaining Wall E1, Wall No. 53E0149
Retaining Wall E2, Wall No. 53E0150
Mechanically Stabilized Earth (MSE) Walls
Los Angeles County, California, (7-LA-47, PM 0.10, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining walls. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining walls.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix E. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
ERIC BROWN
NO. GE 2806
EXP. 6-30-2010
GEOTECHNICAL
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
KANDIAH ARULMOLI
NO. 2090
EXP. 12-31-2011
GEOTECHNICAL
STATE OF CALIFORNIA

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL E1, WALL NO. 53E0149
RETAINING WALL E2, WALL NO. 53E0150
MECHANICALLY STABILIZED EARTH (MSE) WALLS
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.10, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 17, 2010

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APPENDICES

Appendix A. EarthSpectives SPT Hammer Energy Measurement Report
Appendix B. GeoVision Geophysical Investigation Report
Appendix C. Laboratory Soil Test Results
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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall E1 and E2 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Retaining Wall E1 and E2 located on the west and east side, respectively, of the approach embankment for the SR-103 Off-Ramp (Figure 2).

Retaining Wall E1, located along the western edge of the SR-103 Off-Ramp approach embankment between Sta. 426+06 and Sta. 428+35 ("E" Line), will be approximately 230 ft long with retained heights varying from 24 ft at the southern end of the wall to 16 ft at the northern end of the wall where it terminates at the southern end of Retaining Wall G2. Recommendations for Retaining Wall G2 and the SR-103 Off-Ramp bridge are provided in separate foundation reports prepared by EMI (2010a, 2010b). Retaining Wall E2, located along the eastern edge of the SR-103 Off-Ramp approach embankment between Sta. 426+06 and Sta.

429+95 ("E" Line), will be approximately 475 ft long with retained heights varying from 22 ft at the southern end of the wall to 4 ft at the northern end of the wall. Both walls are proposed to be mechanically stabilized embankment (MSE) walls.

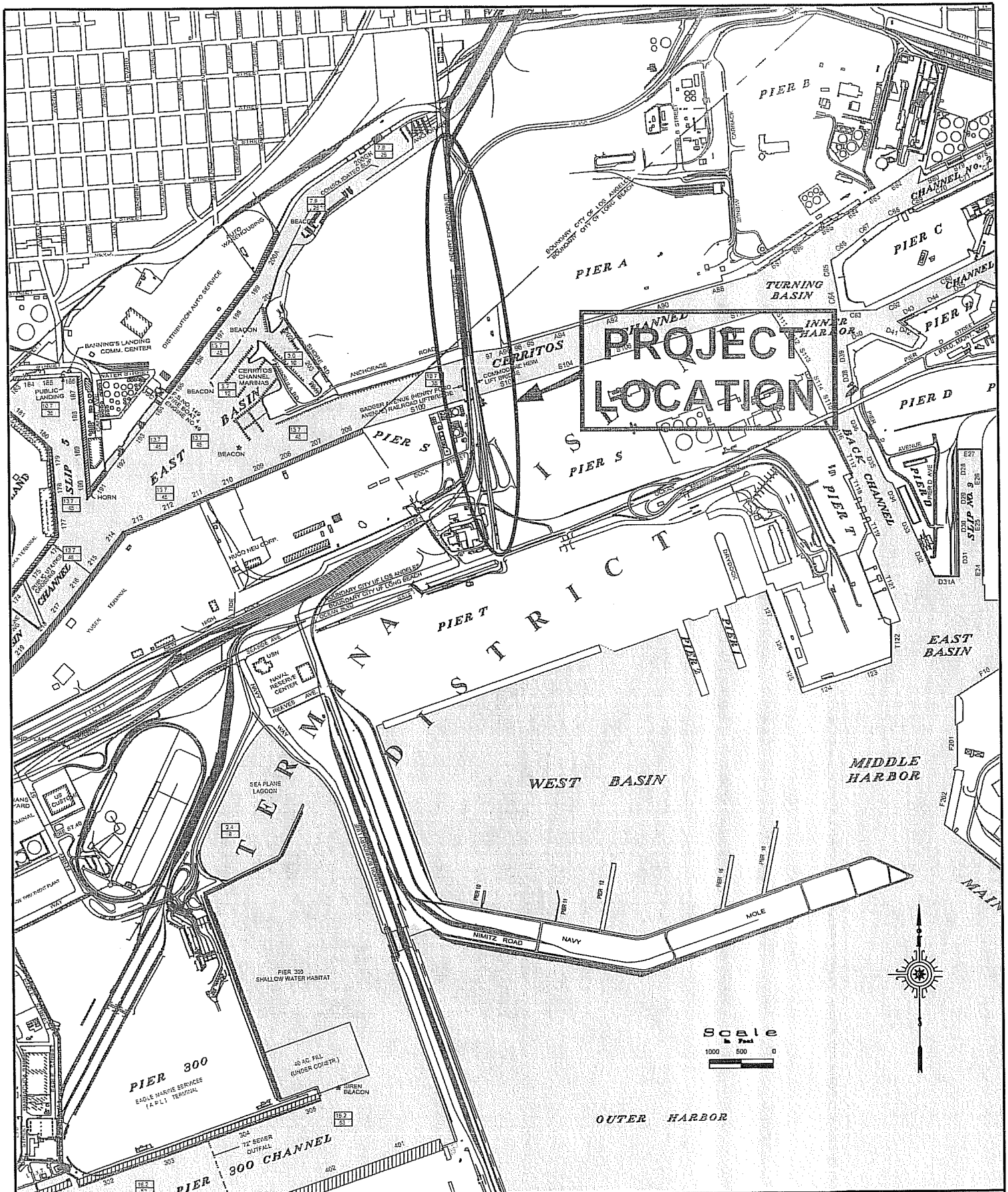
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Retaining Wall E1 and E2. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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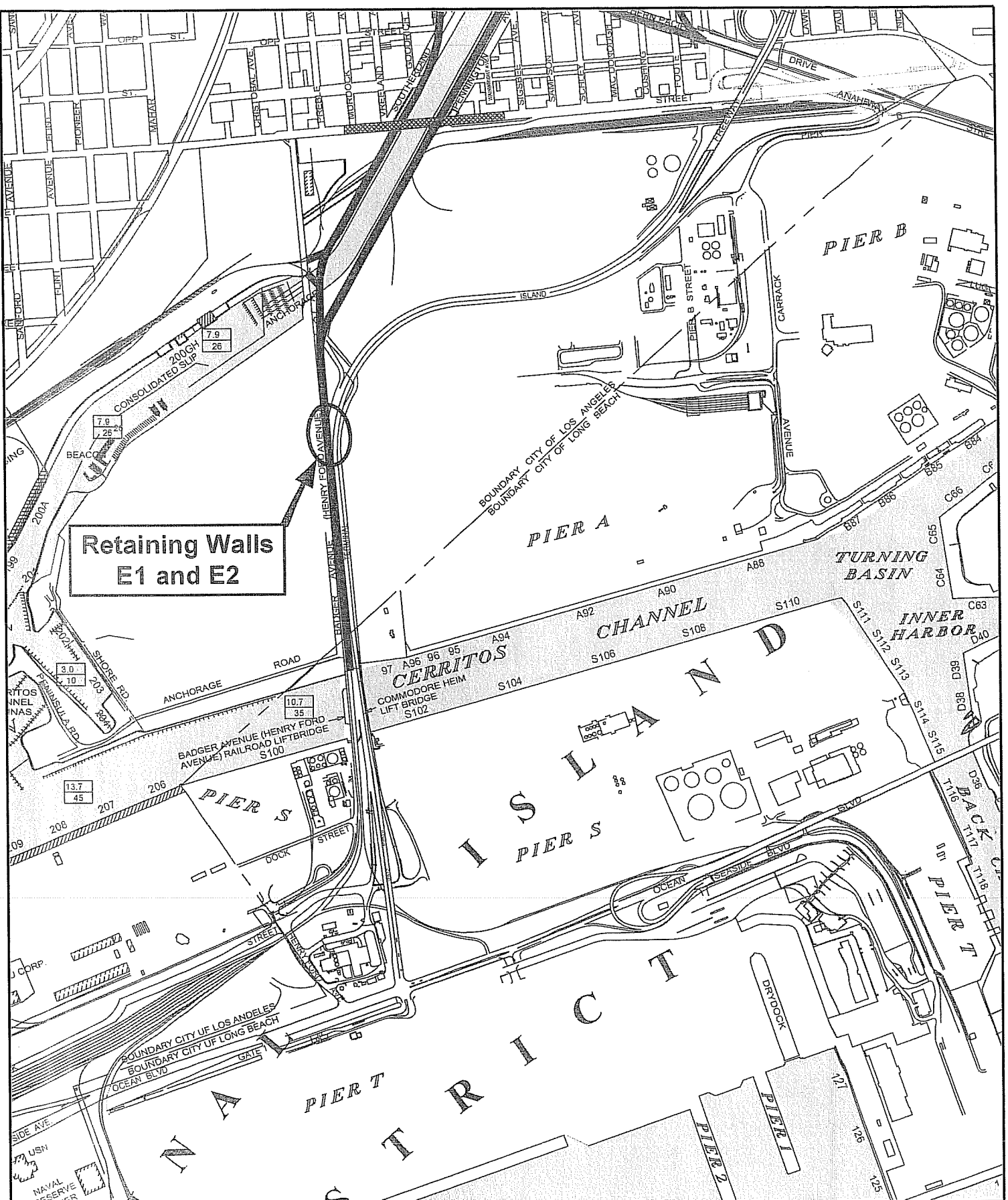
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 5-17-10



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Structure Location Map

Figure 2

Project No. 06-123	Date: 5-17-10

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the nearest boring to Retaining Wall E1 and E2 is shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge and is approximately 600 ft south of the southern end of the proposed wall pair.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, three rotary wash borings, two hollow-stem auger borings and two CPT soundings were performed in the vicinity of Retaining Wall E1 and E2. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed walls. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings and CPT soundings surrounding the proposed retaining wall pair were performed at grade on the shoulder of the existing SR-103/SR47 ramps. The deepest boring penetrated down to about elevation -149 ft, approximately 150 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix B.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix C.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-033[1]	"E" Line	425+87.5	84.7 Rt	+6.1	-9.9	-94.9	RW
R-09-034[1]		426+74.1	55.2 Lt	+1.3	-9.7	-149.0	RW
R-09-035[2]		428+42.7	38.1 Lt	+2.1	-11.9	-74.4	RW
A-09-056[3]		427+15.6	36.3 Rt	+0.2	-11.0	-36.3	HSA
CPT-09-066		428+87.0	91.4 Rt	-0.8	NR	-100.1	RW
CPT-09-098		427+19.4	36.4 Rt	+0.1	NR	-92.3	RW

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3.Boring performed by 2R Drilling Co.
4. GWE = Groundwater Elevation.
5. GSE = Ground Surface Elevation (estimated from topographic plans).
6. Top of Boring Elevation Based on NAVD88.
7. RW = Rotary Wash, HSA = Hollow Stem Auger, CPT = Cone Penetration Test.
8. NR = Not Recorced.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -102.7 ft, approximately 103.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle

and a projected cross sectional area of 1.55 in^2 (10 cm^2) and a cylindrical friction sleeve with a surface area of 23.25 in^2 (150 cm^2). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

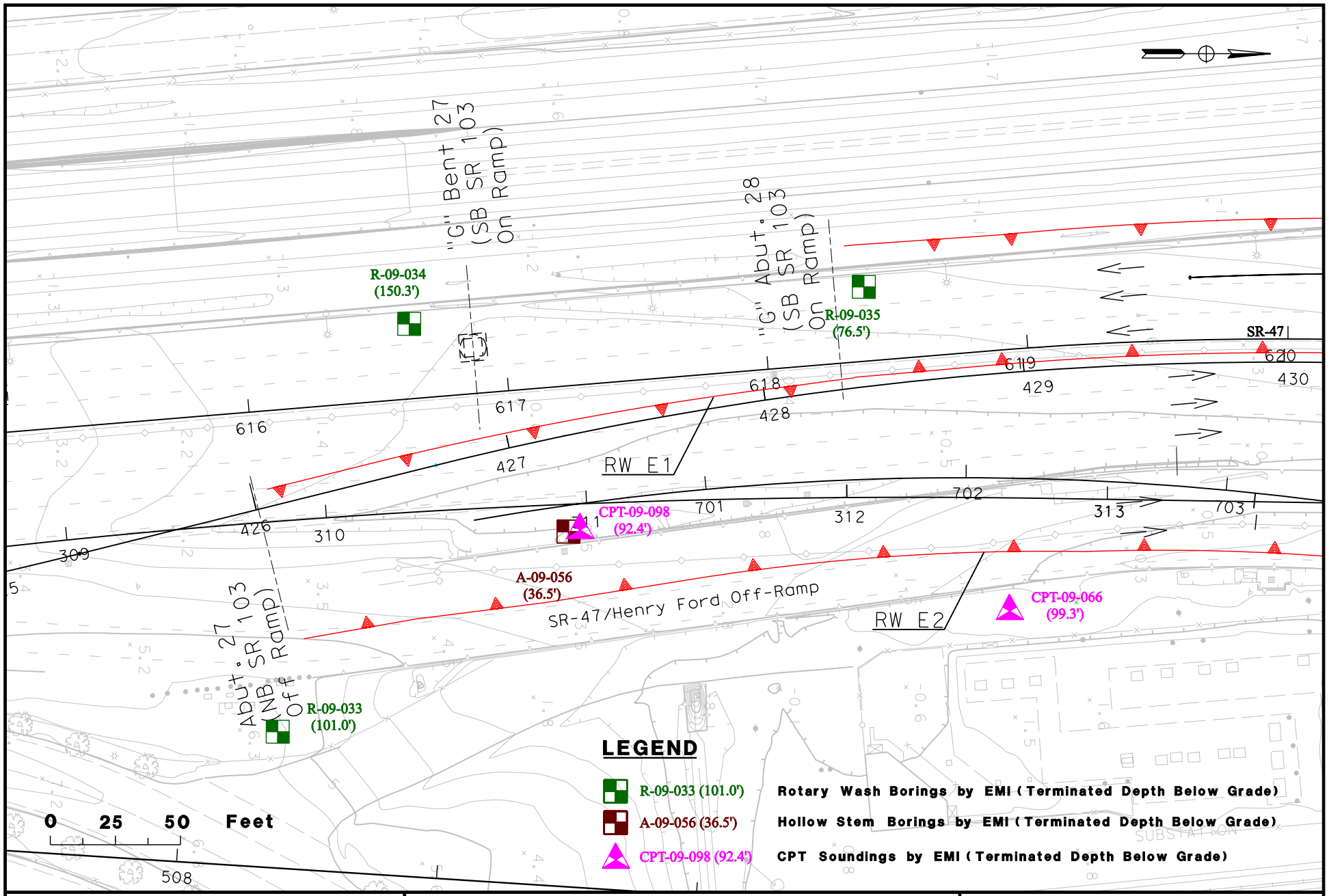
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix C.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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Project No. 06-123

Date: 05-17-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department

(LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

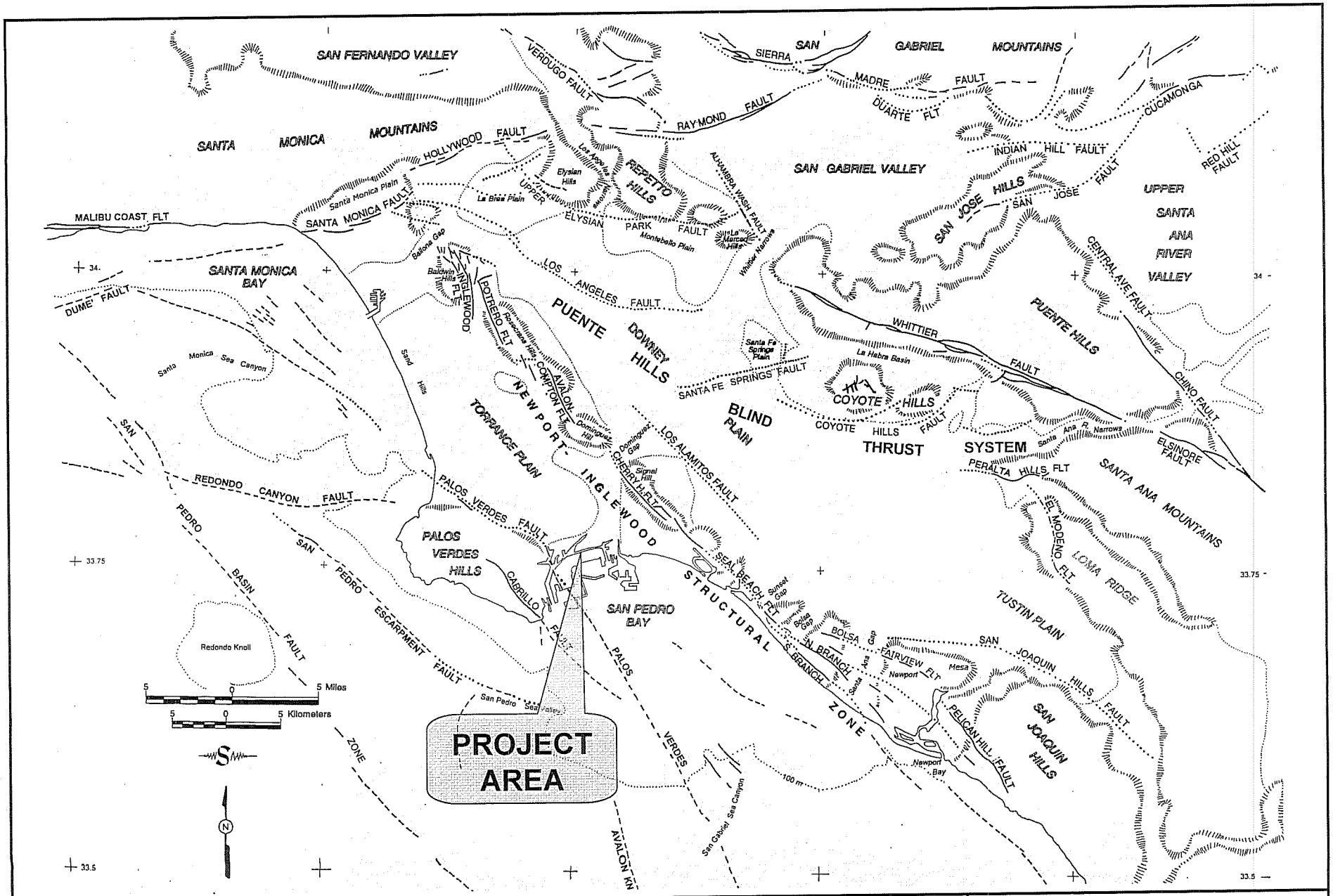
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

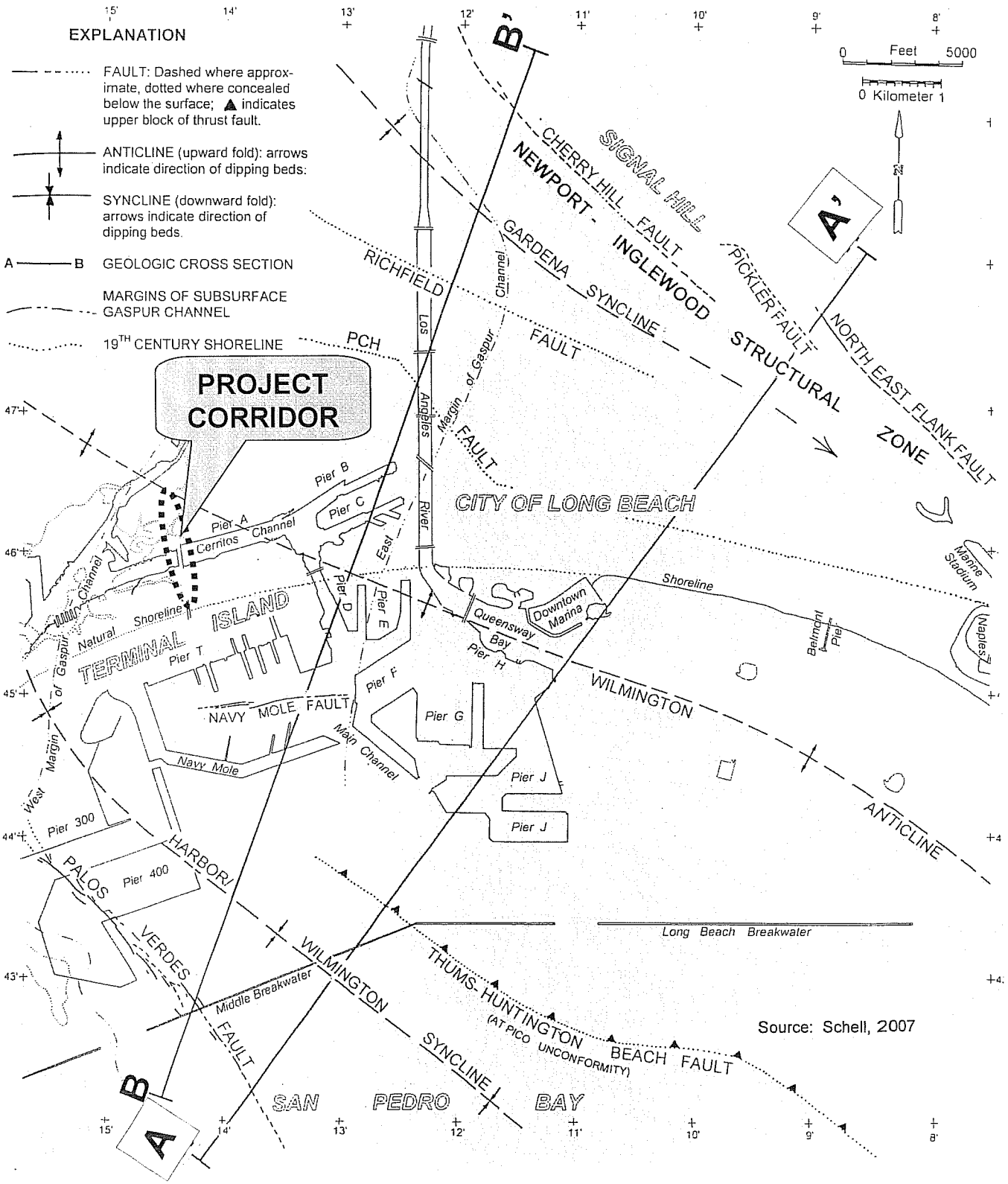
California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at

Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 5-17-10	Figure 4



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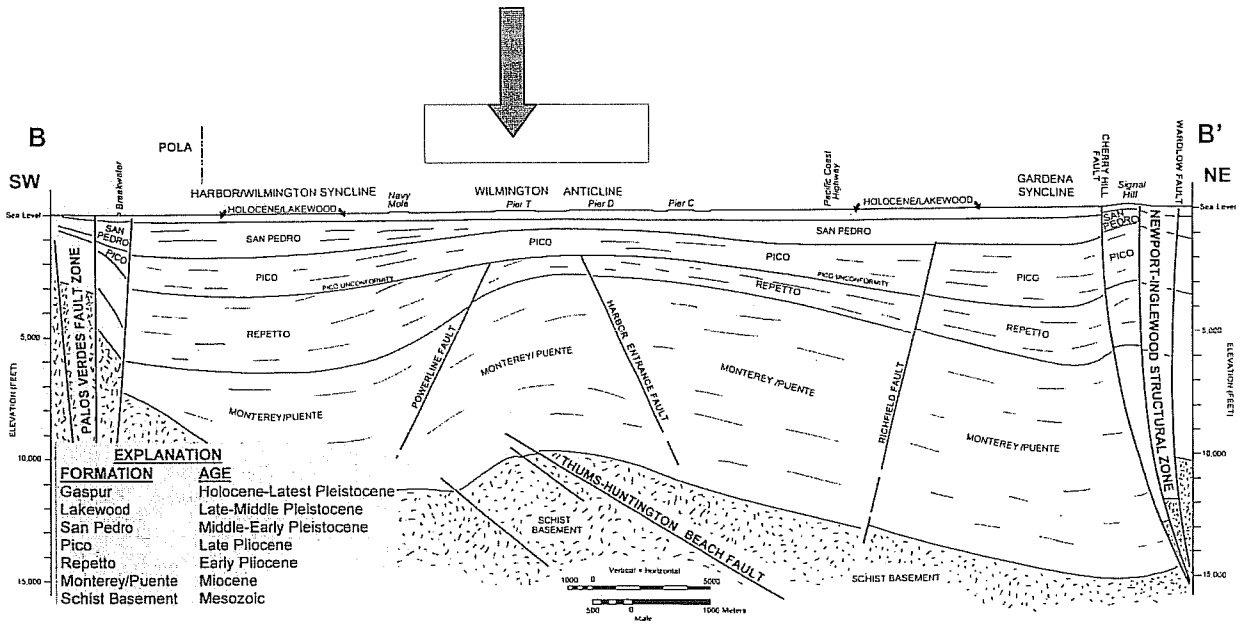
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

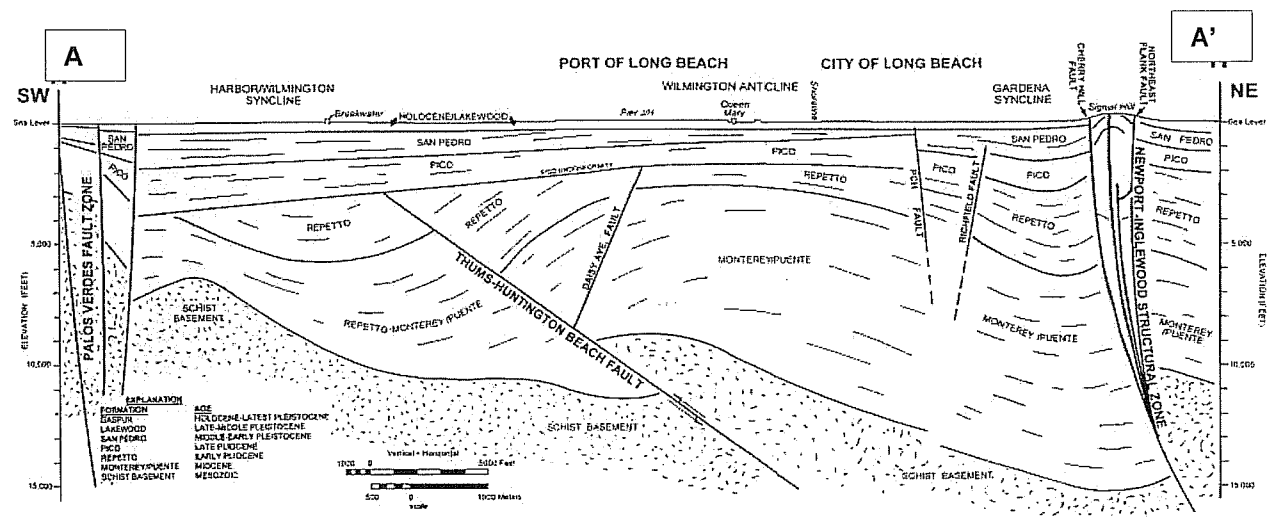
Structural Geology Map, Long Beach Harbor

Project No. 06-123 | Date: 5-17-10 | Figure 5

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

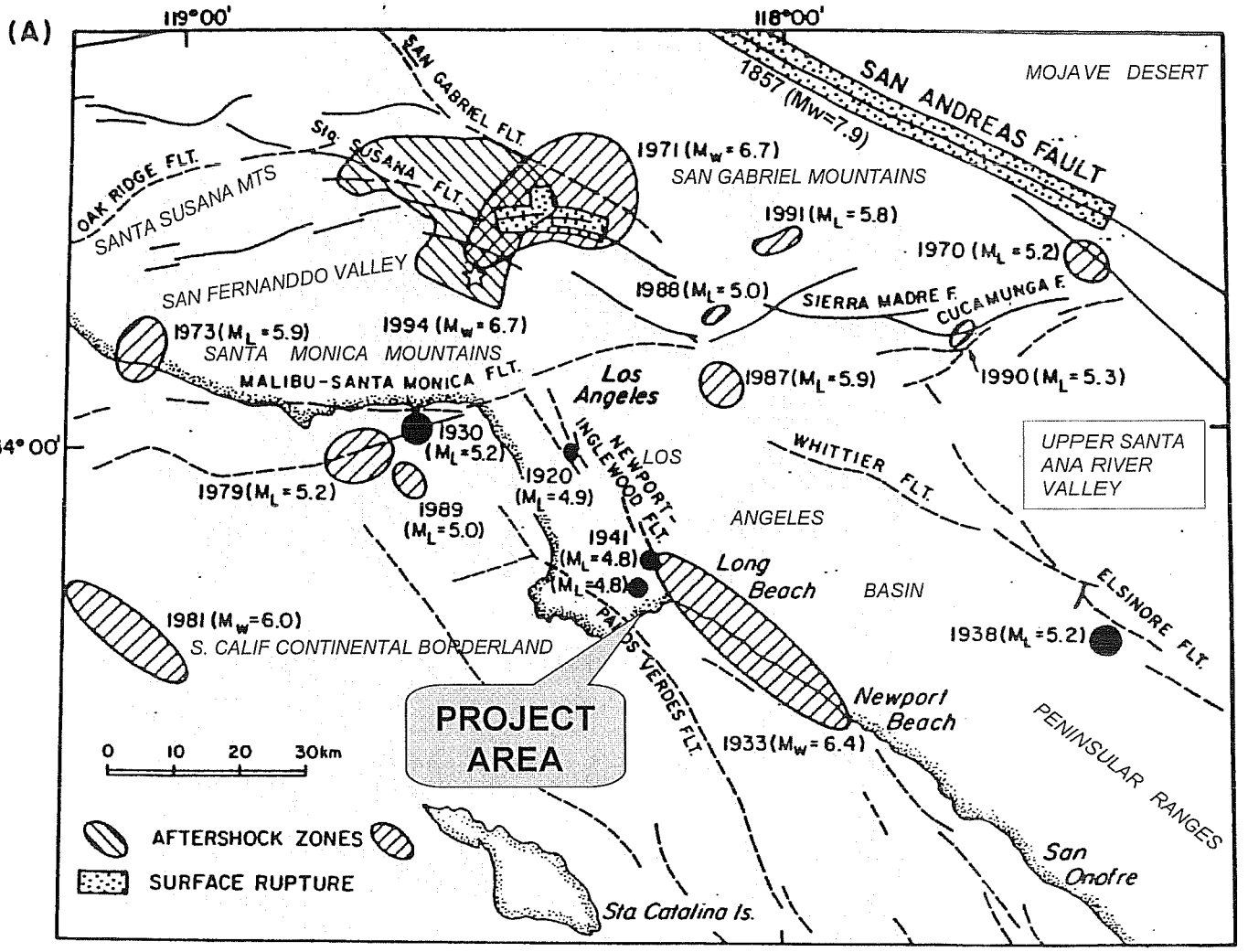


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

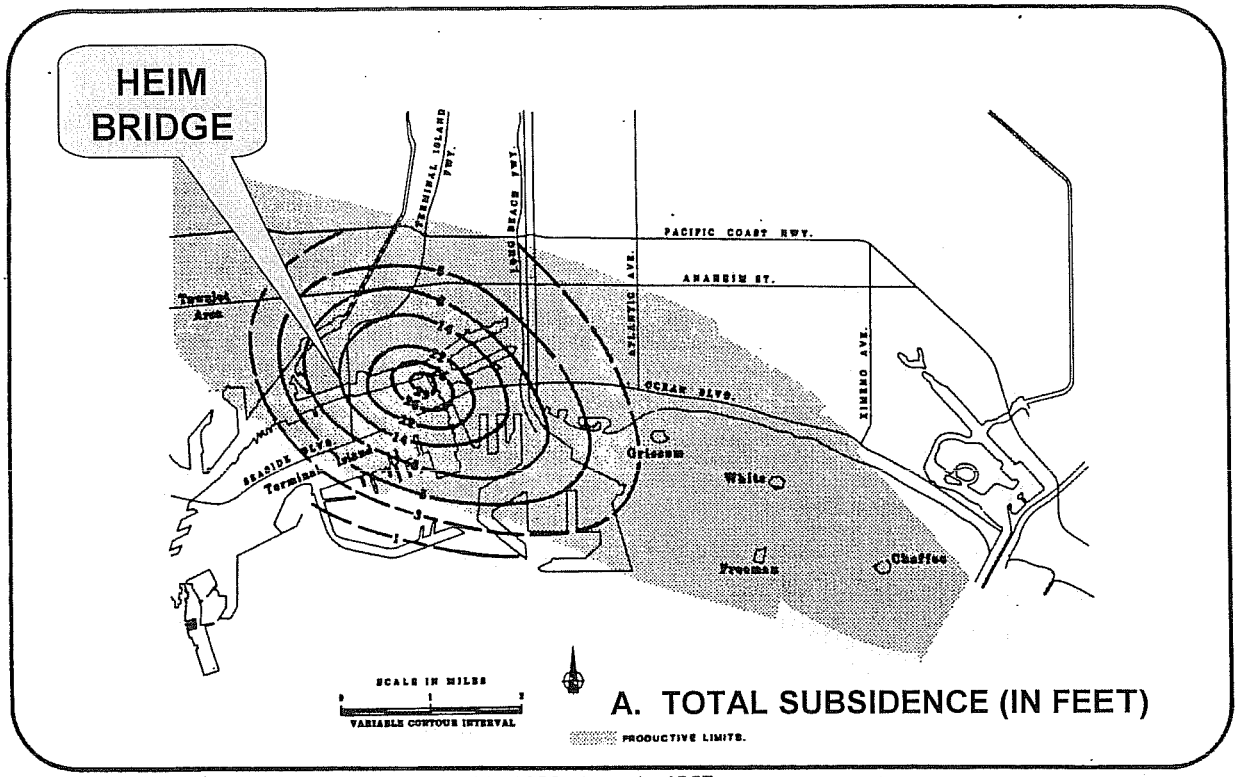
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	
Project No. 06-123	Date: 5-17-10	Geologic Cross-Sections, LA Harbor Figure 6

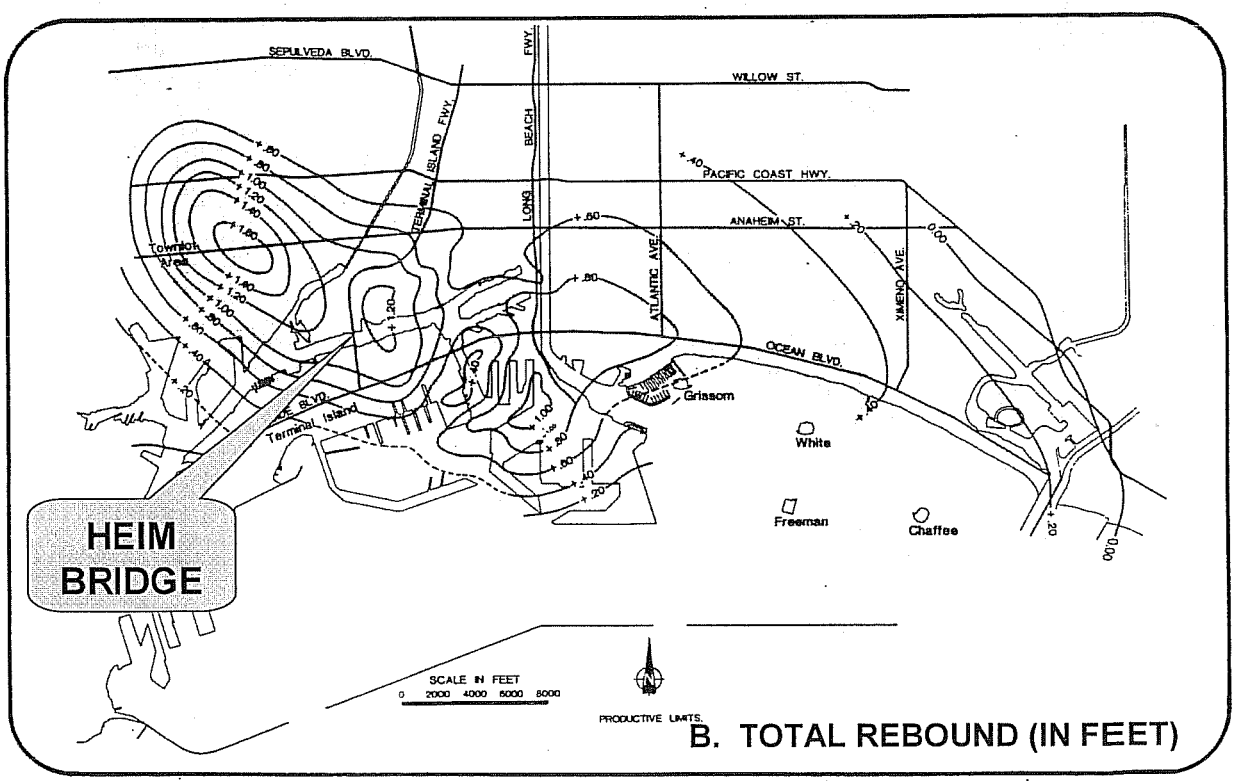


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-17-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-17-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -149 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about zero, with a few feet of import fill for the existing northern approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +2 ft near the southern end of the two walls. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -5 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -60 ft. Below elevation -60 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in all four of the borings performed near the proposed walls between elevation -9.9 ft and -11.9 feet. The elevation that groundwater was encountered in each boring is listed in Table 2 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

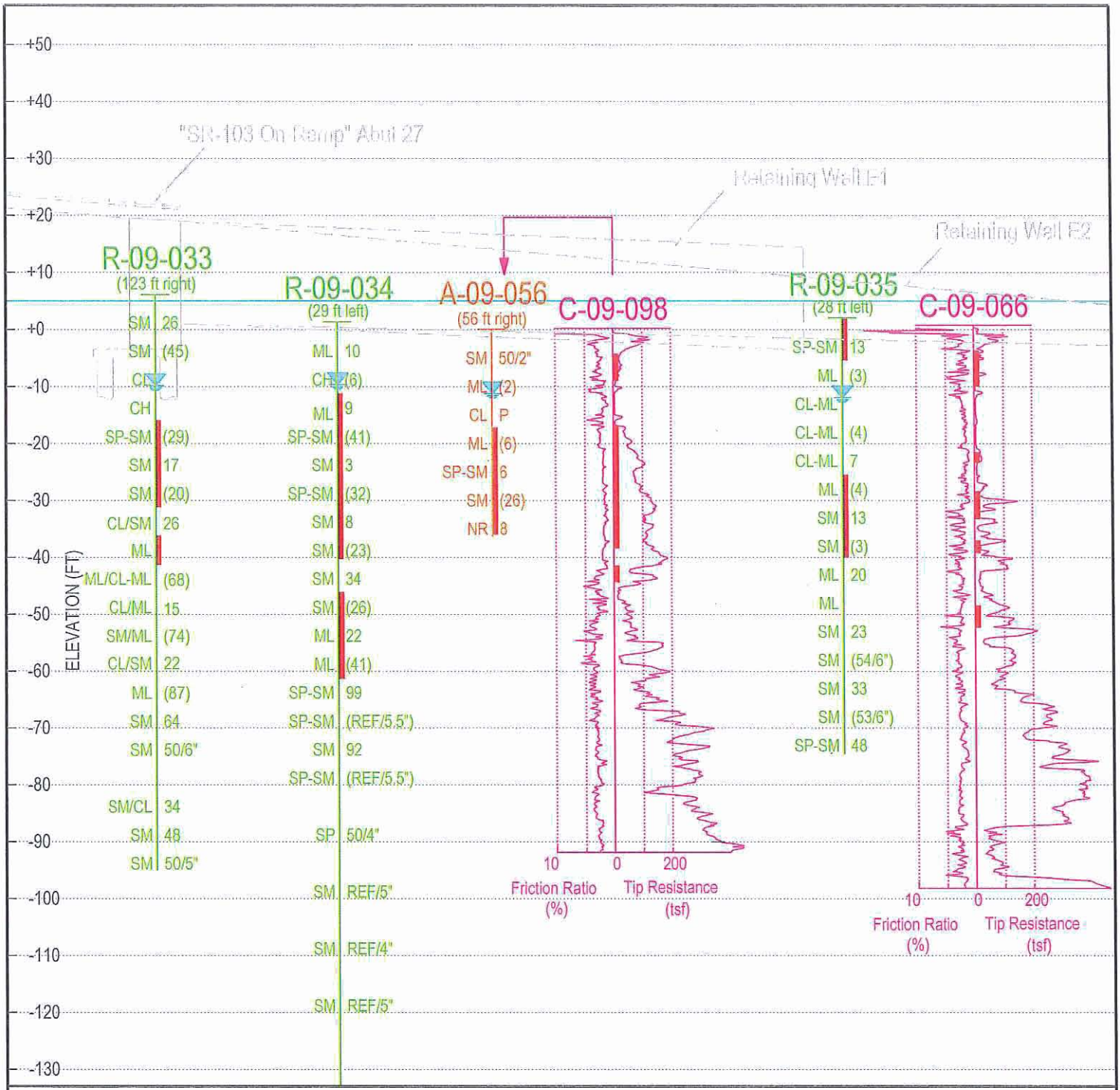
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

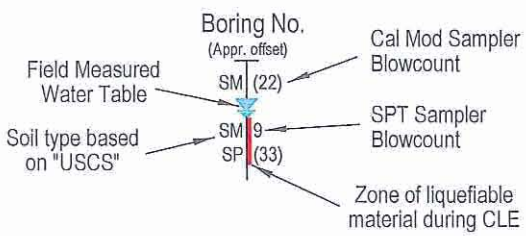
Based on information collected from borings R-09-033, R-09-034, R-09-035, A-09-056 and CPT soundings CPT-09-066 and CPT-09-098 an idealized soil profile for foundation analysis and design was developed along the alignment of the proposed walls. The subsurface profile beneath the proposed structures is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+24 to +2.0	Silty Sand (assumed MSE fill)	120	0	34
+2.0 to -5.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	32
-5.0 to -17.0	Sandy Silt / Silty Clay / Lean Clay	120	600	0
-17.0 to -25.0	Clayey Silt / Sandy Silt / Silty Sand	120	800	0
-25.0 to -43.0	Silty Sand / Sand with Silt / Sandy Silt	120	0	32
-43.0 to -55.0	Clayey Silt / Sandy Silt / Silty Sand	120	2,500	0
-55.0 to -65.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	34
-65.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Subsurface Profile

Figure 9

Project No. 06-123 | Date: 5-17-10

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance to with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix E.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -65 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-033	-16 to -31	3.1	3.2
	-37 to -42	0.1	
R-09-034	-10 to -40	7.7	9.5
	-45 to -55	1.8	
R-09-035	+2 to -5	0.7	6.3
	-25 to -40	5.6	
A-09-056	-17 to -27	3.4	4.7
	-32 to -37	1.3	
CPT-09-066	-4.0 to -10.0	0.5	2.0
	-22.6 to -24.8	0.6	
	-28.5 to -33.5	0.6	
	-37.0 to -39.3	0.3	
	-47.8 to -52.2	0.2	
CPT-09-098	-3.8 to -7.4	0.3	0.5
	-17.1 to -38.7	0.1	
	-41.3 to -43.1	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.7 and 8.7, the minimum resistivities were 230 and 670 ohm-cm, soluble chloride contents were 514 and 6,316 parts per million (ppm) and soluble sulfate contents were 107 and 915 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Mechanically Stabilized Earth Wall Recommendations

As discussed in Section 1.2, the maximum design height of the MSE is about 22 ft. Due to the presence of compressible soil, construction of the proposed SR-103 Off-Ramp embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 26 ft and base width of 26 ft near the southern end of the walls at Sta. 426+06 ("E" Line), the bearing pressure induced on the underlying foundation soil is 3.8 ksf. Using a base width of 26 ft and a remedial excavation of 3 ft (see Section 5.4.8), the allowable bearing capacity of the soil directly beneath the MSE wall is greater than 3.8 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 3 ft below lowest adjacent grade. Using a remedial excavation of 3 ft below the leveling pad, the allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL E1/E2 STABILITY ANALYSES

Approx. "E" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety		Global Stability Factor of Safety		
			During Surcharge	Permanent	During Surcharge	Static[1]	Psuedo-Static[1]
426+25	26	26	1.26	2.40	1.26	1.57	1.13

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1.

(4) A remedial overexcavation of 3 ft below the leveling pad and the MSE was considered in the analysis.

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed wall approximately 25 ft from the southern terminus of the wall near "E" Line Sta. 426+25.

Based on cross-sections provided by the roadway designers, the existing embankment at "E" Line Sta. 426+25 will be approximately 57 feet wide at the crest and the embankment height is approximately 20 feet above existing grade. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 10 inches. The settlement period is estimated to be about 20 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 11 weeks. For a 7-ft embankment surcharge, the settlement periods is reduced to about 9 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

Along the proposed wall alignment, the base of the MSE structure will be founded on native soils. EMI recommends remedial grading consisting of a 3-ft overexcavation. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted according to Caltrans Standard Specifications (2006c). The overexcavation should be backfilled using granular, non-expansive soils. In the event the bottom of remedial excavations become saturated due to the presence of shallow groundwater or seepage, self compacting material such as gravel or lean concrete slurry can be placed within the limits of the overexcation. The overexcavation should extend at least 3 ft beyond the outer edge of the leveling pad and 3 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Wall Stability

The "global" stability of the MSE was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "E" Line Sta. 426+25.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and zero cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

5.5 Settlement of Adjacent Utilities

Topko Pipe. An existing 60-inch Corrugated Metal Pipe (CMP), which contains an 8-inch diameter Topko oil line and 8-inch diameter water line inside, crosses beneath the proposed MSE at approximate "E" Line Sta. 427+65. At the location where the CMP crosses beneath the proposed embankment, the embankment height is approximately 16 ft and the width of the proposed embankment is approximately 57 ft.

Settlement of compressible fine-grained soils underlying the Topko pipe is estimated to be about 5 inches, 2.5 inches and 0.25 inches at the centerline of the embankment, beneath Retaining Walls E1/E2 and about 25 ft beyond the toe of Retaining Walls E1/E2, respectively.

A Technical Memorandum was prepared by EMI (EMI, 2009) that specifically addresses settlement of foundation soils underlying the Topko Pipe. The memorandum includes cross-sections of locations where the CMP line crosses beneath the proposed embankment, and the estimated settlement profile of the CMP at those locations. This memorandum is included in Appendix F.

Proposed Drainage Structure No. 34. A 24-inch diameter reinforced concrete pipe (RCP) storm drain, which runs in a north-south direction beneath the proposed MSE, will be abandoned due to the proposed improvements. The existing storm drain will be capped and replaced with proposed Drainage Structure No. 34 (DS 34) that will consist of a 24-inch diameter RCP that will connect to another existing storm drain located to the east of proposed Retaining Wall E2. DS 34 will run in an east-west direction crossing the "E" Line about 35 ft south of the proposed MSE (in front of Abutment 27 of the SR-103 Off-Ramp) and then turn north, running parallel to the "E" Line approximately 10 ft west of the toe of Retaining Wall E1.

Settlement estimates along the proposed alignment of DS 34 are anticipated to vary from less than 0.5-inch to a maximum of about 3-inches adjacent to Retaining Wall E1. The estimated maximum differential settlement along the alignment of DS 34 is approximately 2.5-inches over a 100-ft of length of pipe.

The proposed storm drain is expected to be sensitive to differential and total settlement due to gravity flow within the RCP. If the proposed settlement magnitudes are determined to be outside the tolerable limits of the storm drain, construction of DS 34 should not be initiated until after the settlement period for the proposed MSE is complete or the surcharge has been released

Settlement recommendations including embankment surcharge and settlement period estimates for the proposed MSE are included in Section 5.4.7.

5.6 Pier A Development

As part of its future development plans, the Port of Long Beach is considering expanding Pier A beneath the proposed Schuyler Heim Bridge Replacement south of the subject MSE walls. A Technical Memorandum has been prepared by EMI (EMI, 2010c) that details the potential development plans and the impact of the proposed development on the storm drain and sewer lines and recommends appropriate mitigation measures.

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all four of the borings performed near the proposed wall pair between elevation -9.9 and -11.9 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad varies between about elevation +0 and -5 ft. The deepest excavation for the proposed MSE wall is expected to be a couple of feet above the observed groundwater elevations. However, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER ★ ERIC BROWN ★ NO. GE-2806 EXP. 06-30-2010 ★ GEOTECHNICAL ★ STATE OF CALIFORNIA

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17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

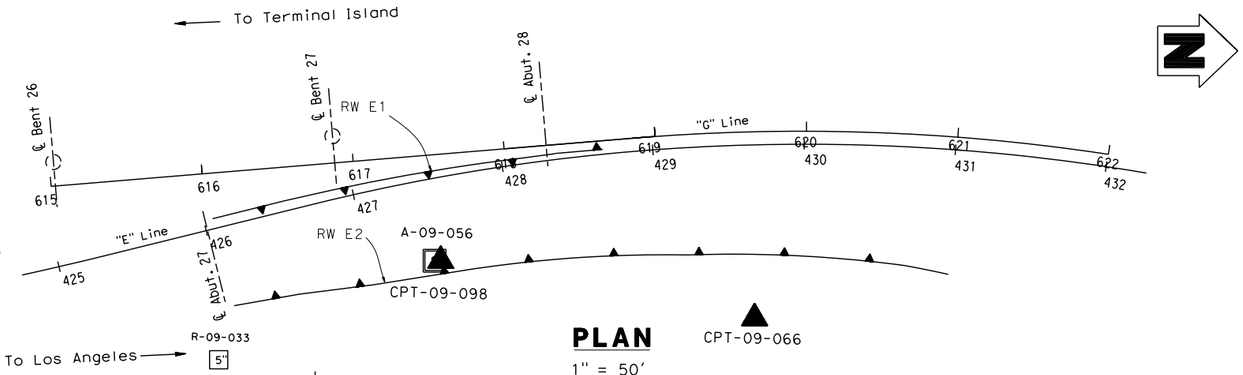
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) For A-09-056, an automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(3) For R-09-033, a rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



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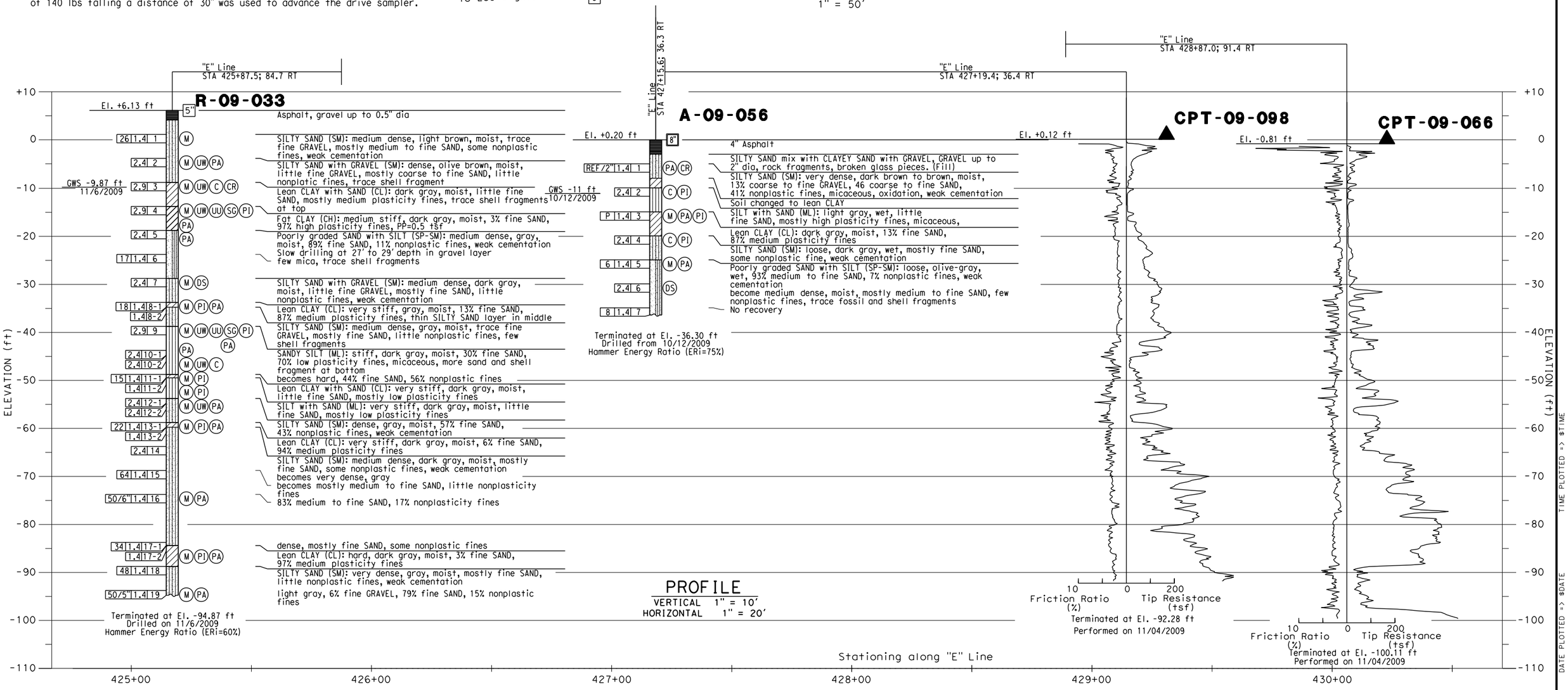

PROFILE
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HORIZONTAL 1" = 20'

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MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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CU 07
EA 238501

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N 1738366.89	N 1737997.51
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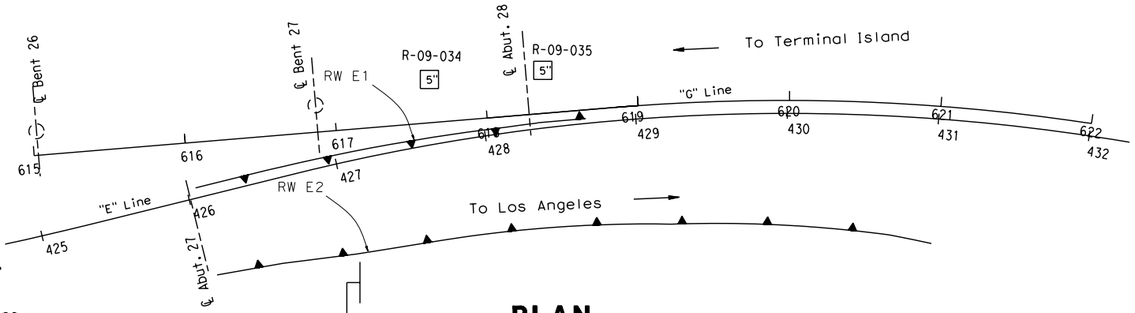

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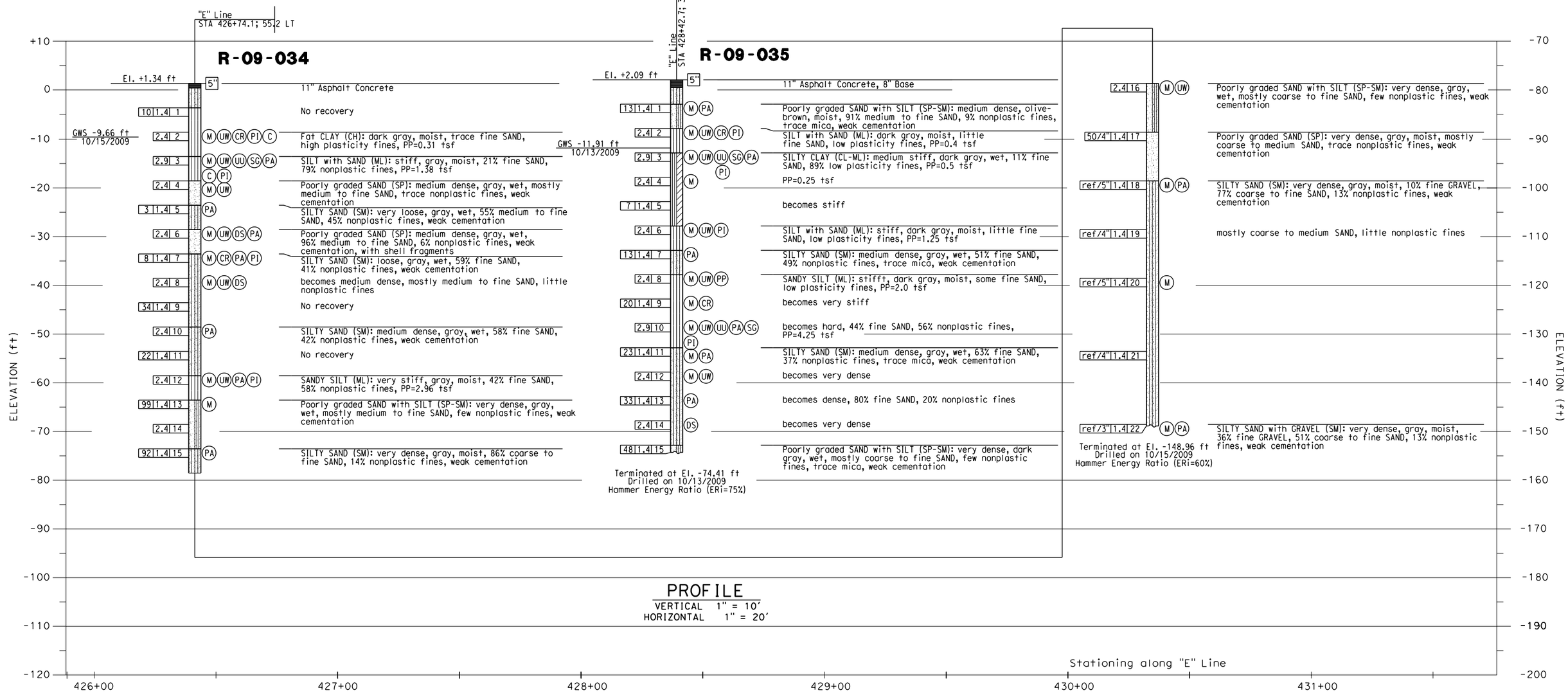

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07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

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DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J.Fang

CHECKED BY: K.Pratheepan

FIELD INVESTIGATION BY:
E.Brown

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0149
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MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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EA 23850I

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07	LA	47			

04/19/10
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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R	Rotary drilled boring
	P	Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

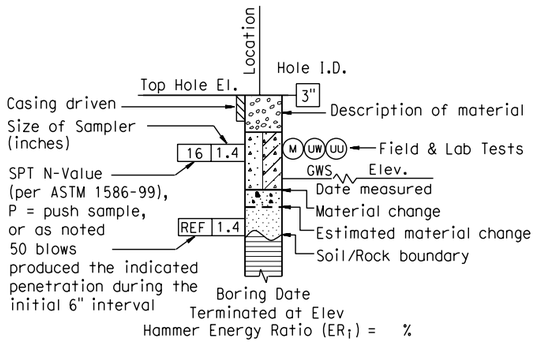
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

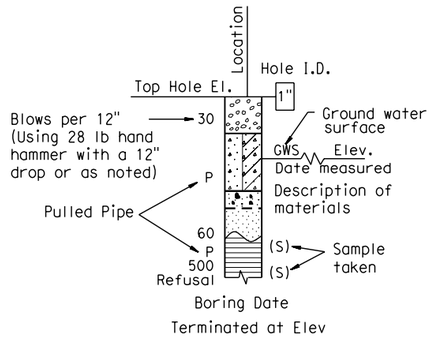
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

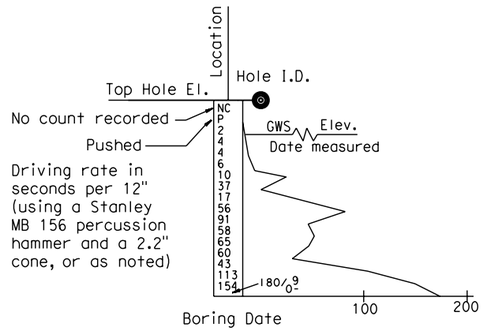
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



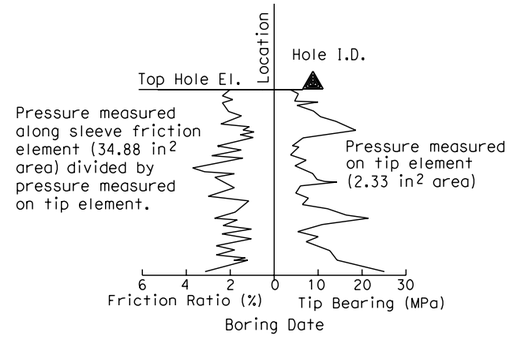
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.10

MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 23850I

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90) Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166) Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0149
POST MILE 0.10

MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/14/10

SHEET X OF X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

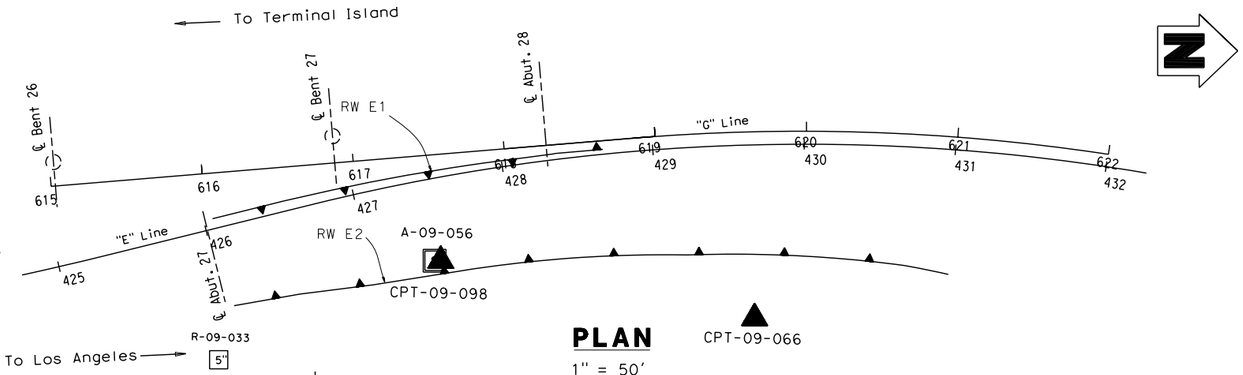
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) For A-09-056, an automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(3) For R-09-033, a rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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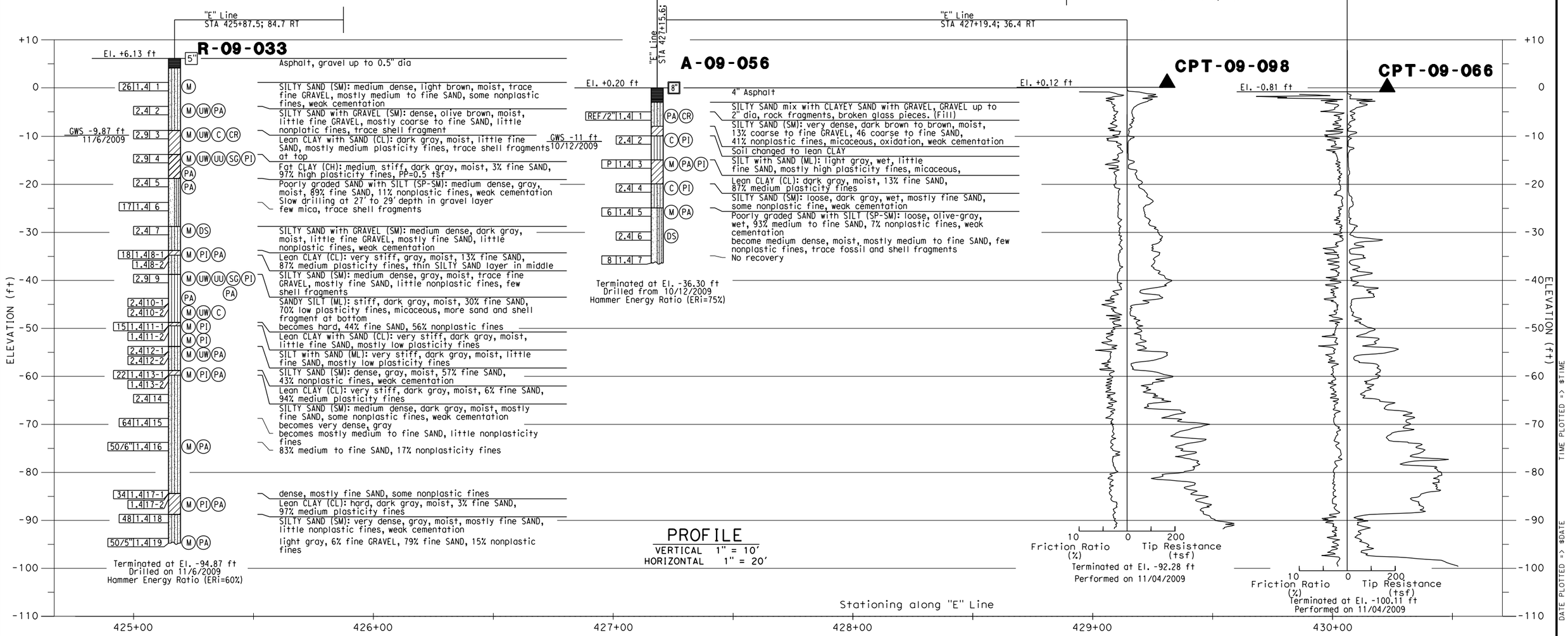
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT / SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53E0150 POST MILE 0.10

MSE RETAINING WALL NO. E2

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

FILE => $REQUEST

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 03/08/10 04/14/10

SHEET X OF X

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

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(2) 2.4" samples were taken using a California Split-spoon Sampler.

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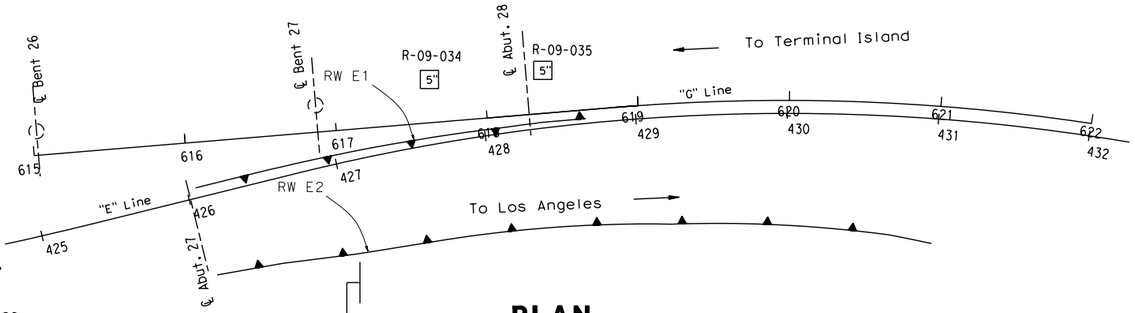
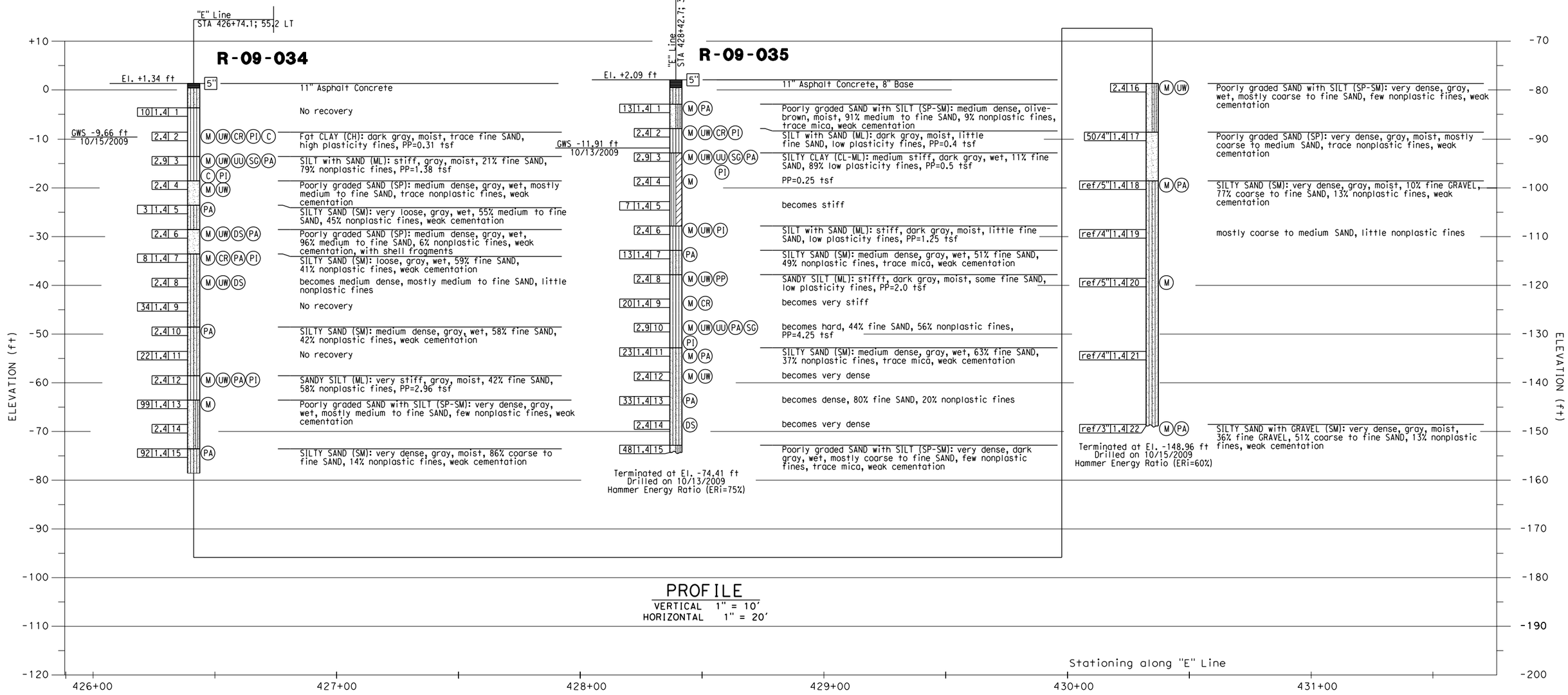


PLAN

1" = 50'



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER ERIC BROWN NO. GE-2806 EXP. 06-30-2010 GEOTECHNICAL STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0150
POST MILE 0.10

MSE RETAINING WALL NO. E2

LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 23850I

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER · ERIC BROWN · NO. GE-2806 EXP. 06-30-2010 · GEOTECHNICAL · STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R	Rotary drilled boring
	P	Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

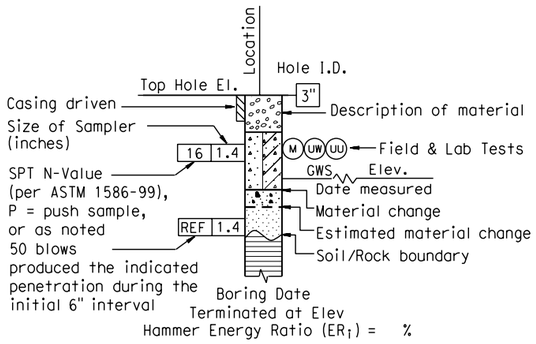
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

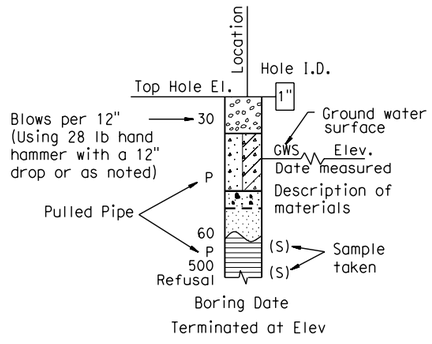
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

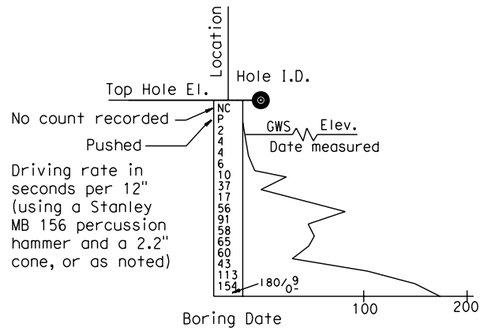
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



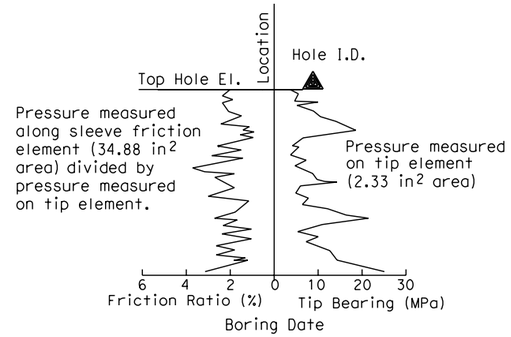
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53E0150	MSE RETAINING WALL NO. E2
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.10	LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	04/14/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
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- (DS) Direct Shear (ASTM D 3080)
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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
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REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA, SUITE 350,
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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0150
POST MILE 0.10

MSE RETAINING WALL NO. E2

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/19/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A. EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
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November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

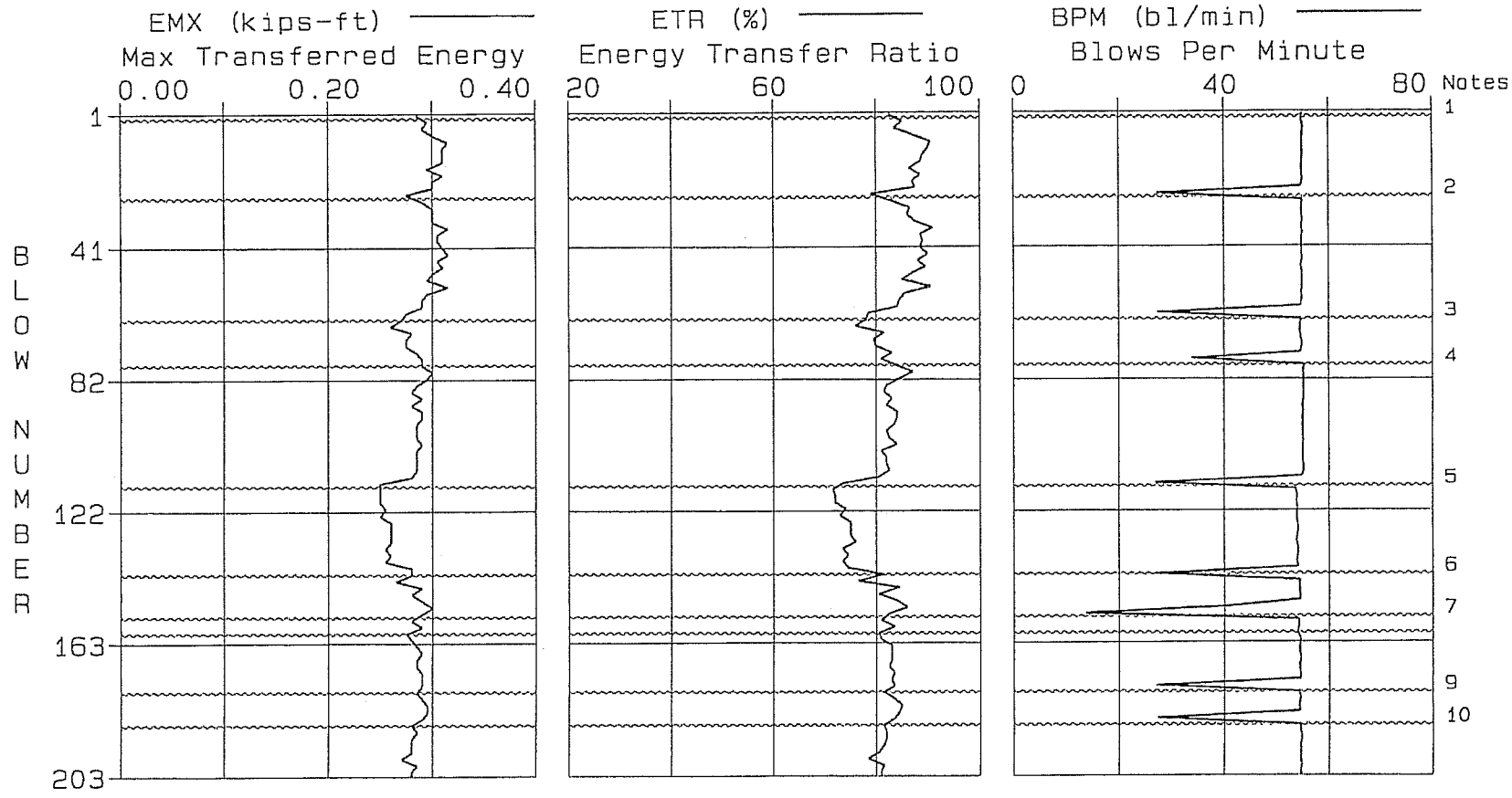
It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer

EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

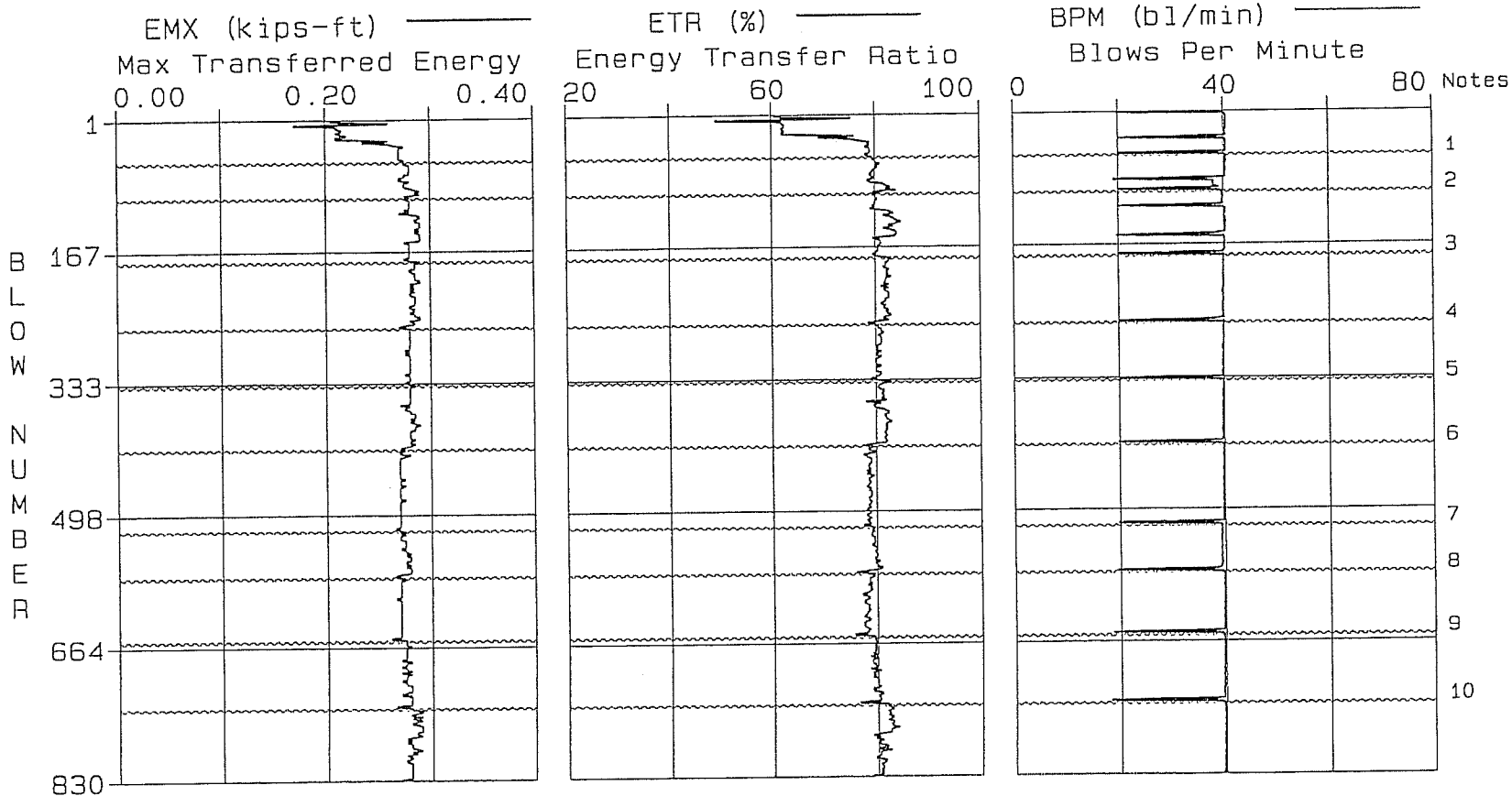
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

Info: MUD ROTARY

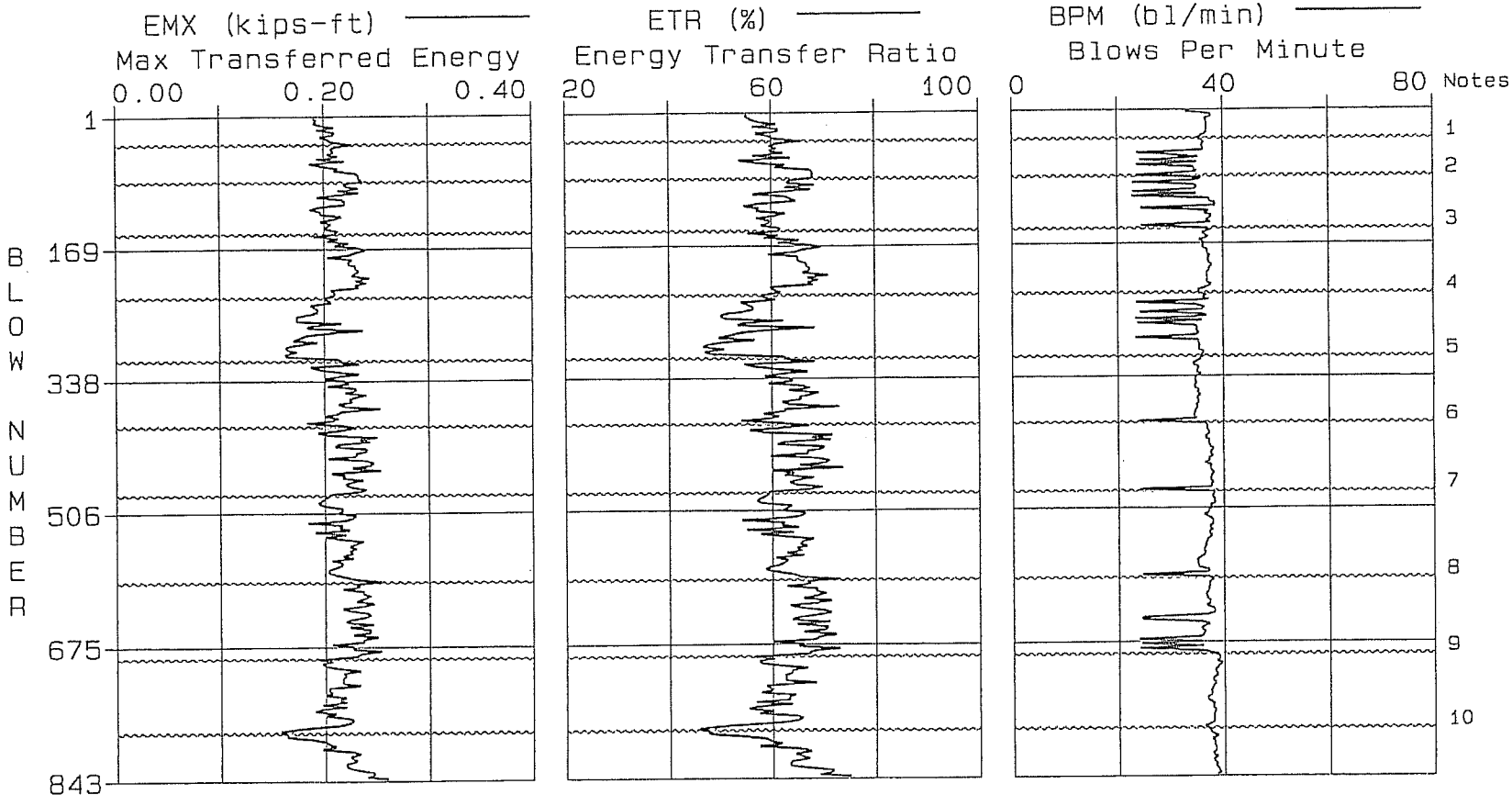
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX B. GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

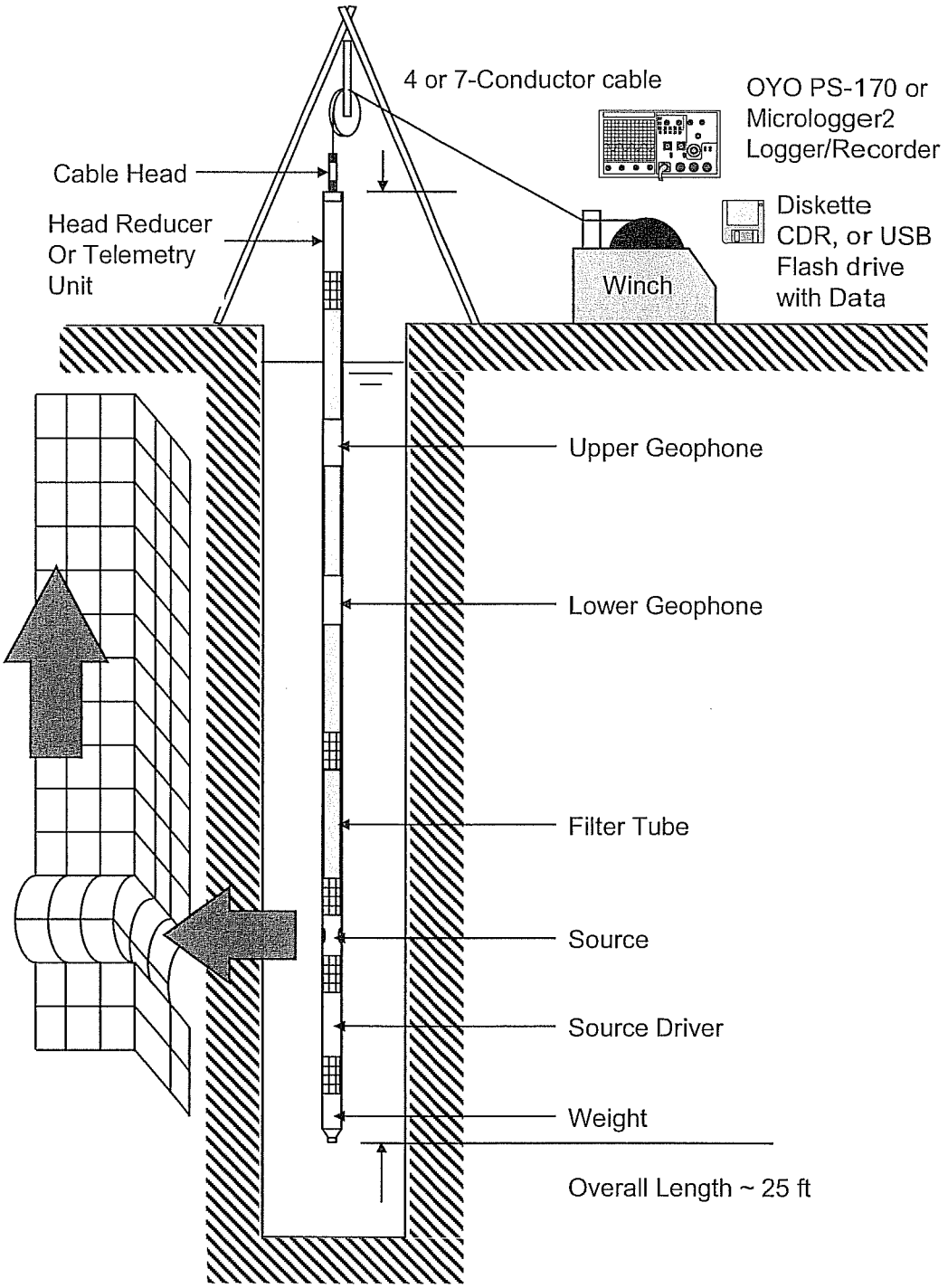

Figure 1: Concept illustration of P-S logging system

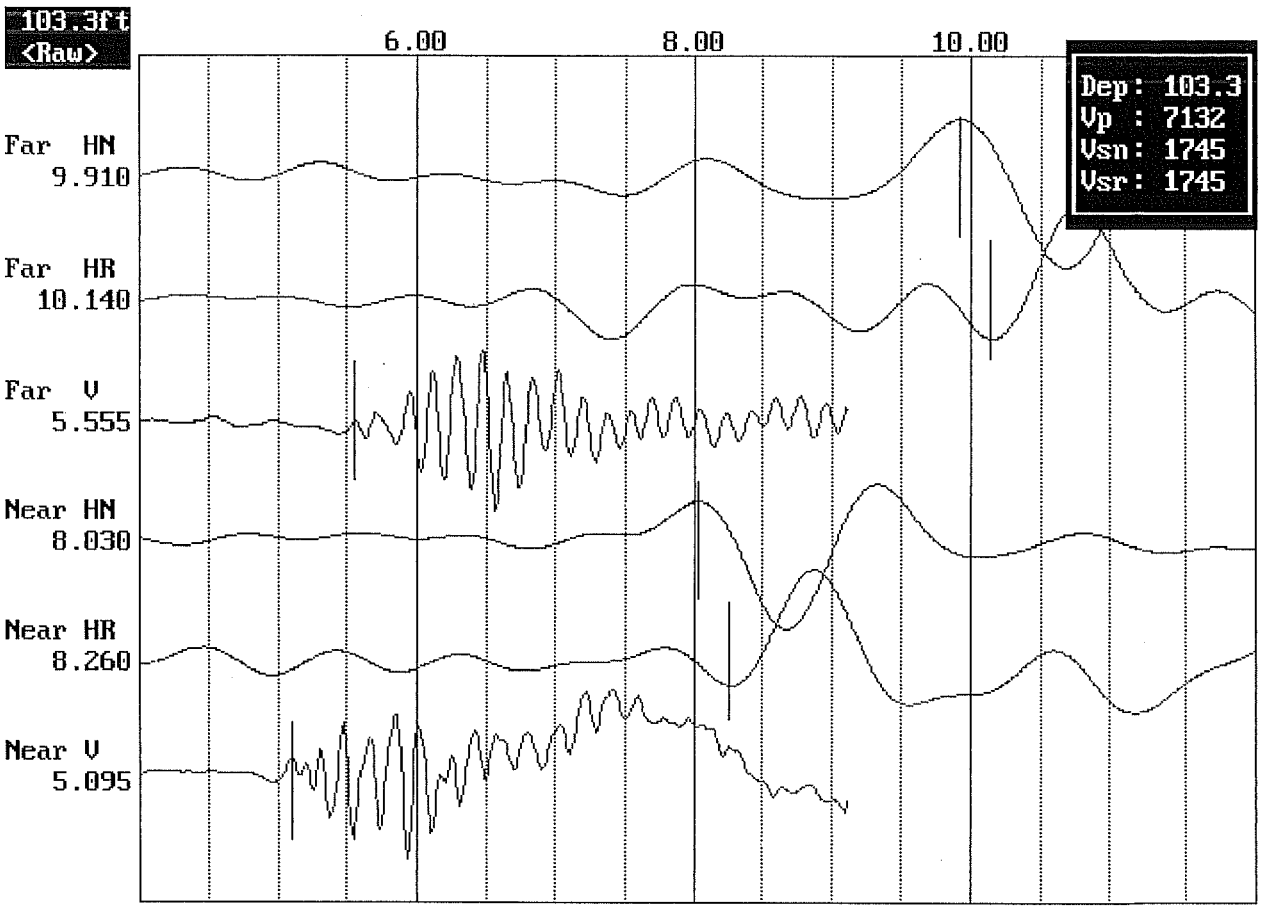

Figure 2: Example of filtered (1400 Hz lowpass) record

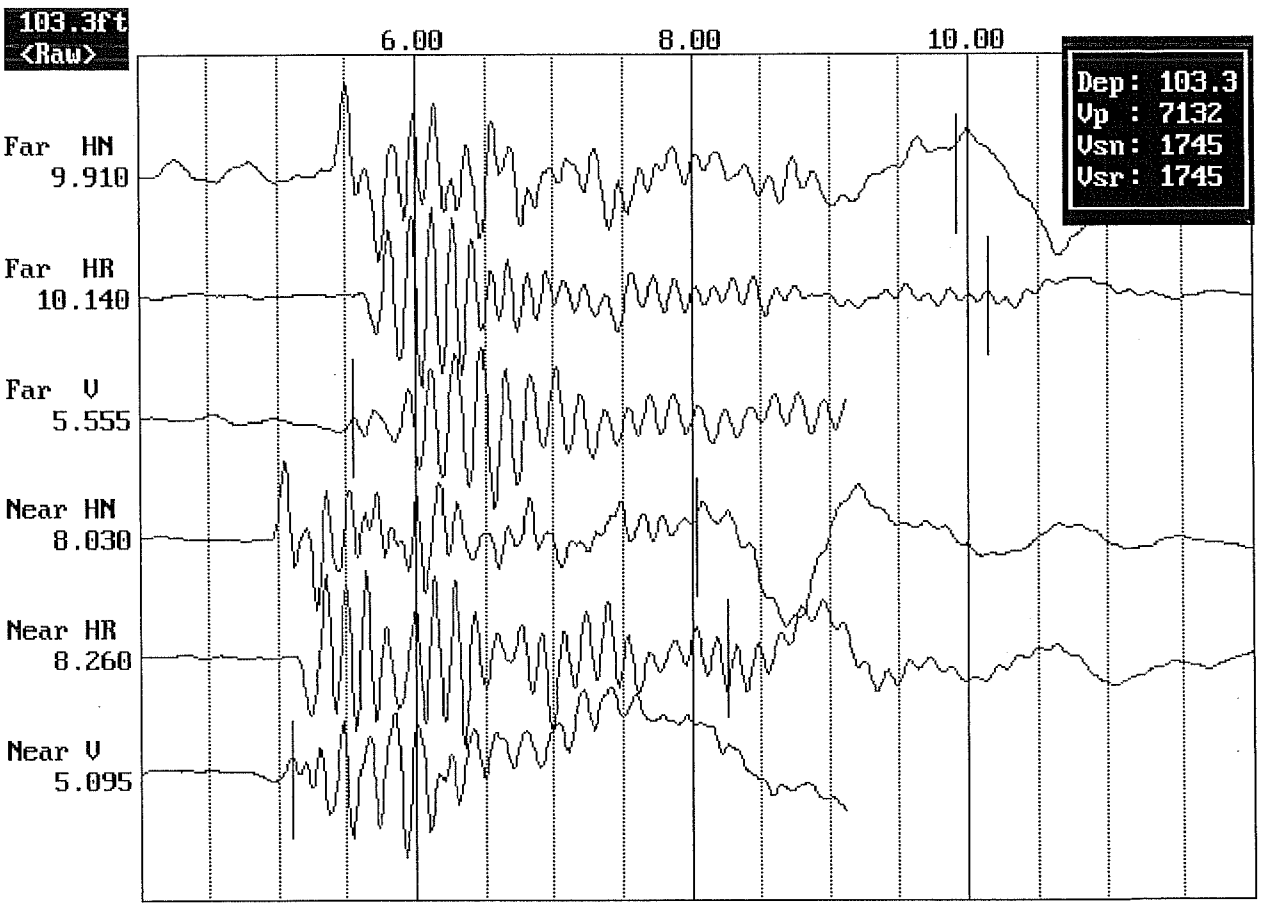

Figure 3. Example of unfiltered record

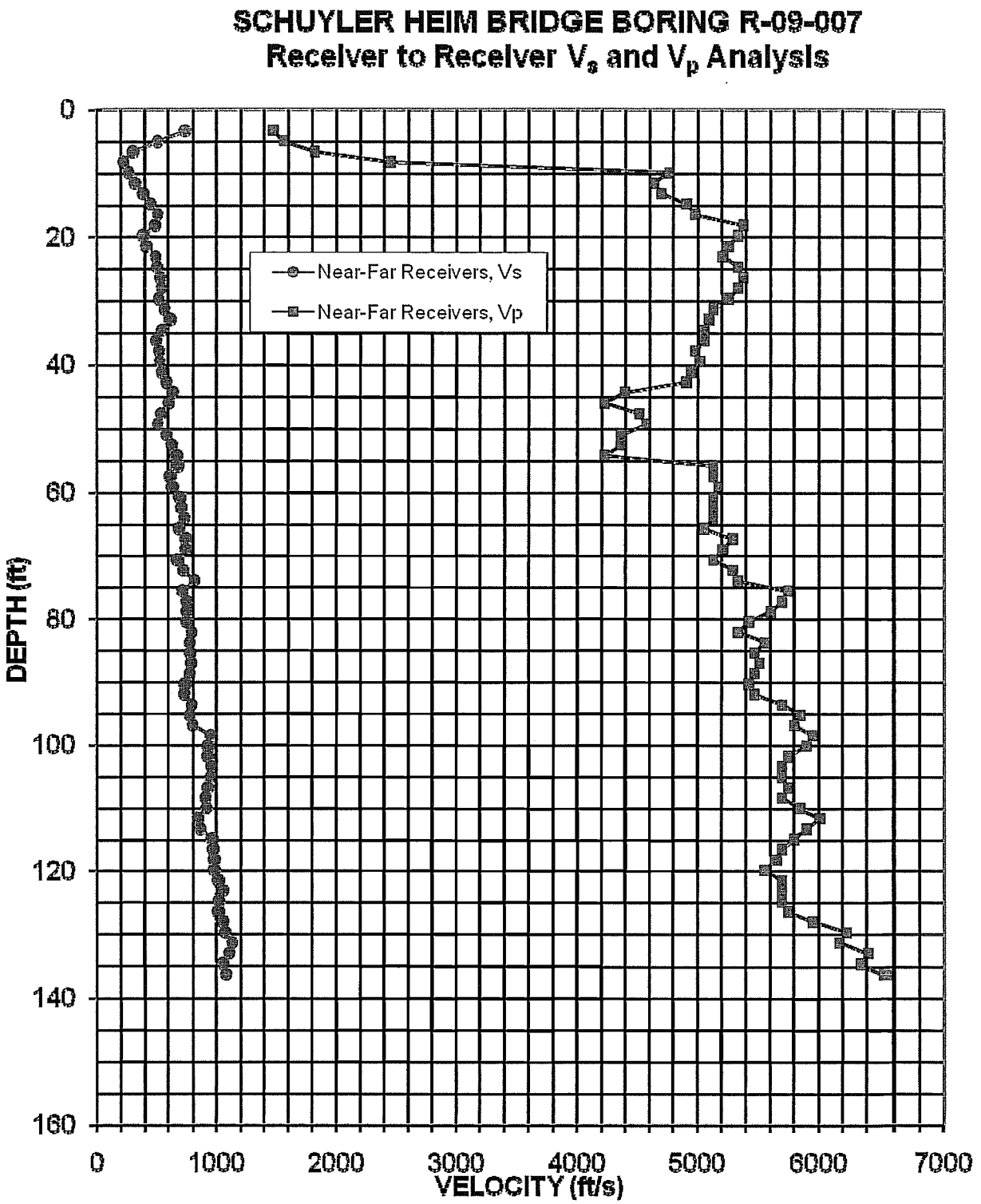

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

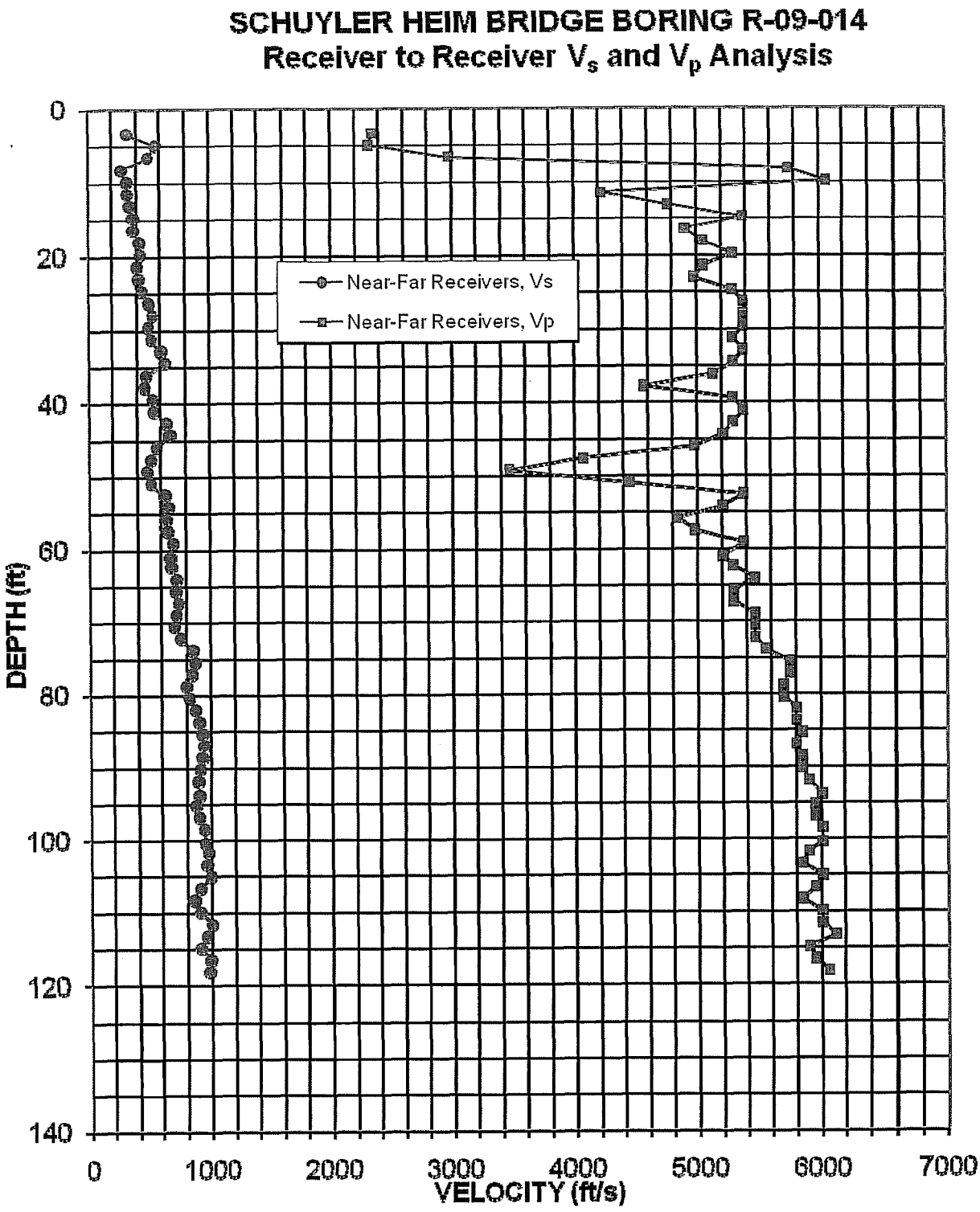

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

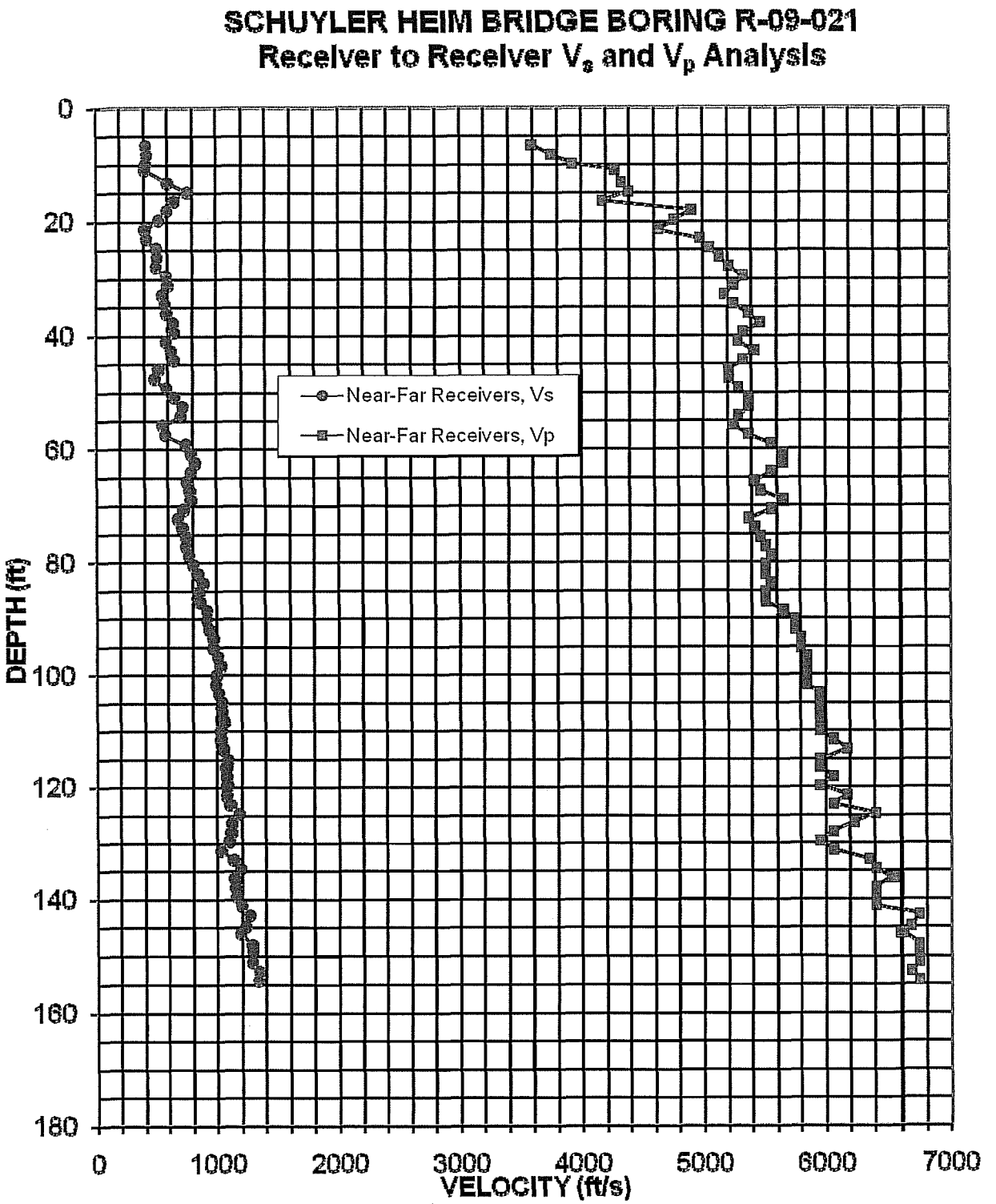

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

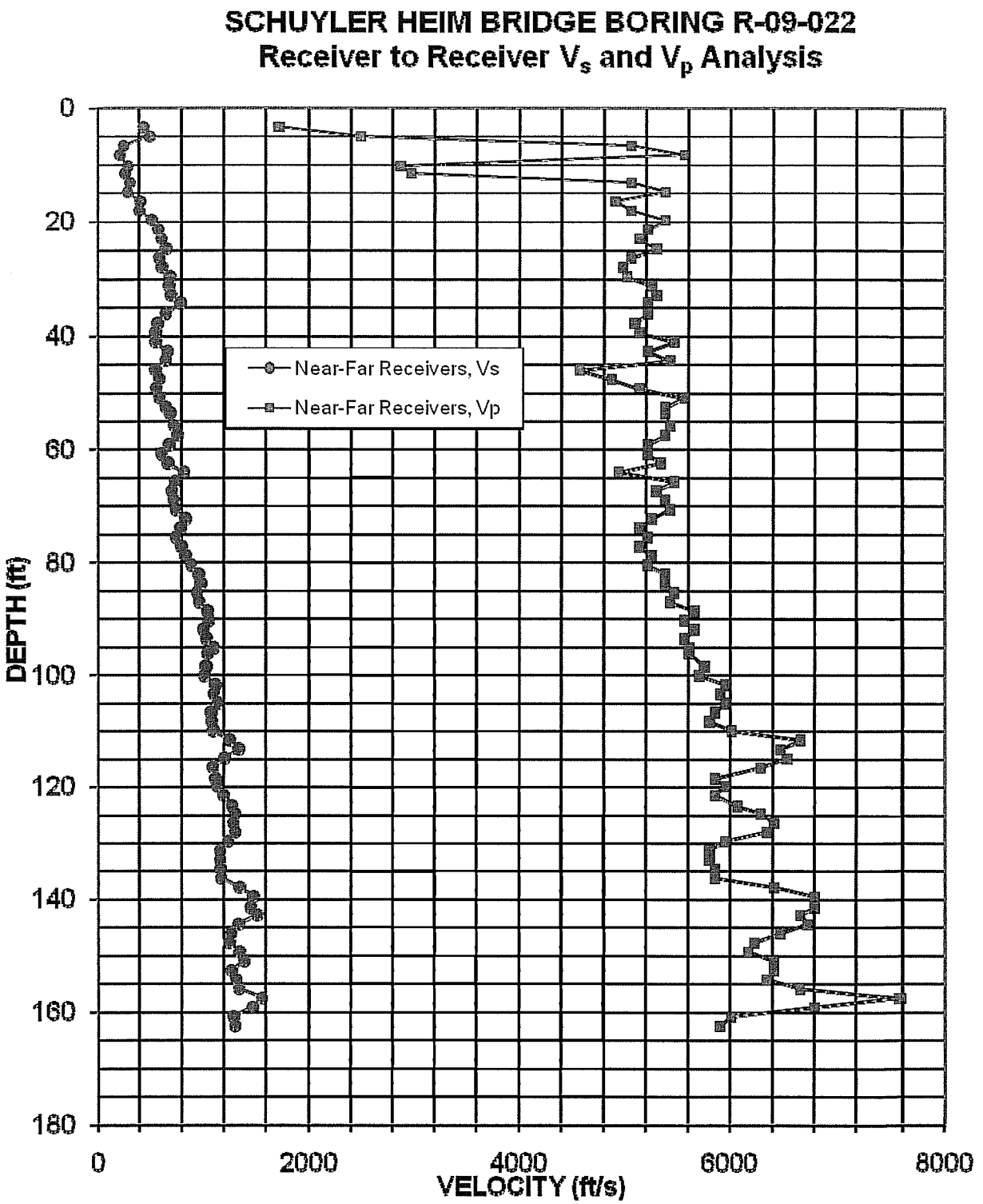

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

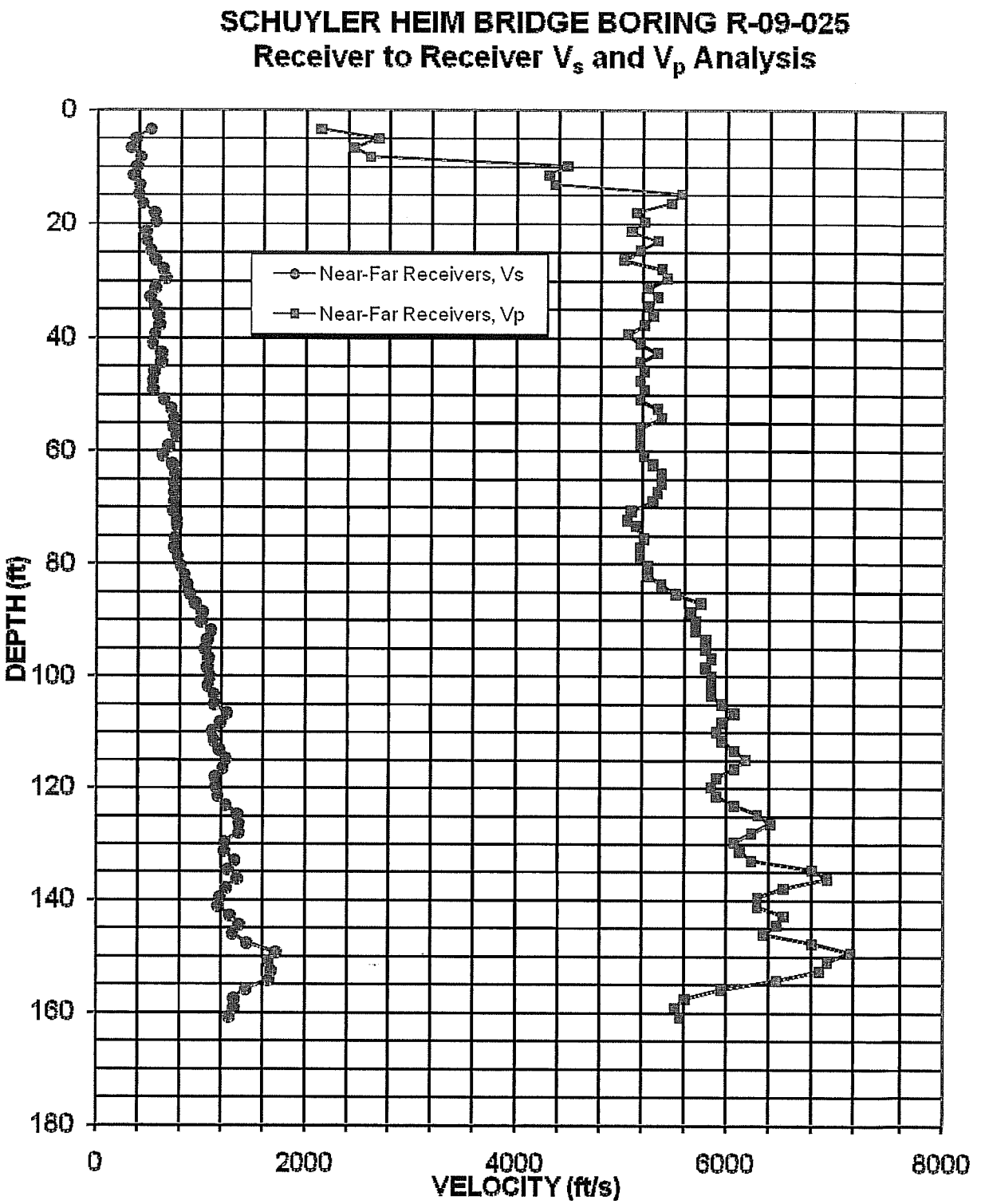

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

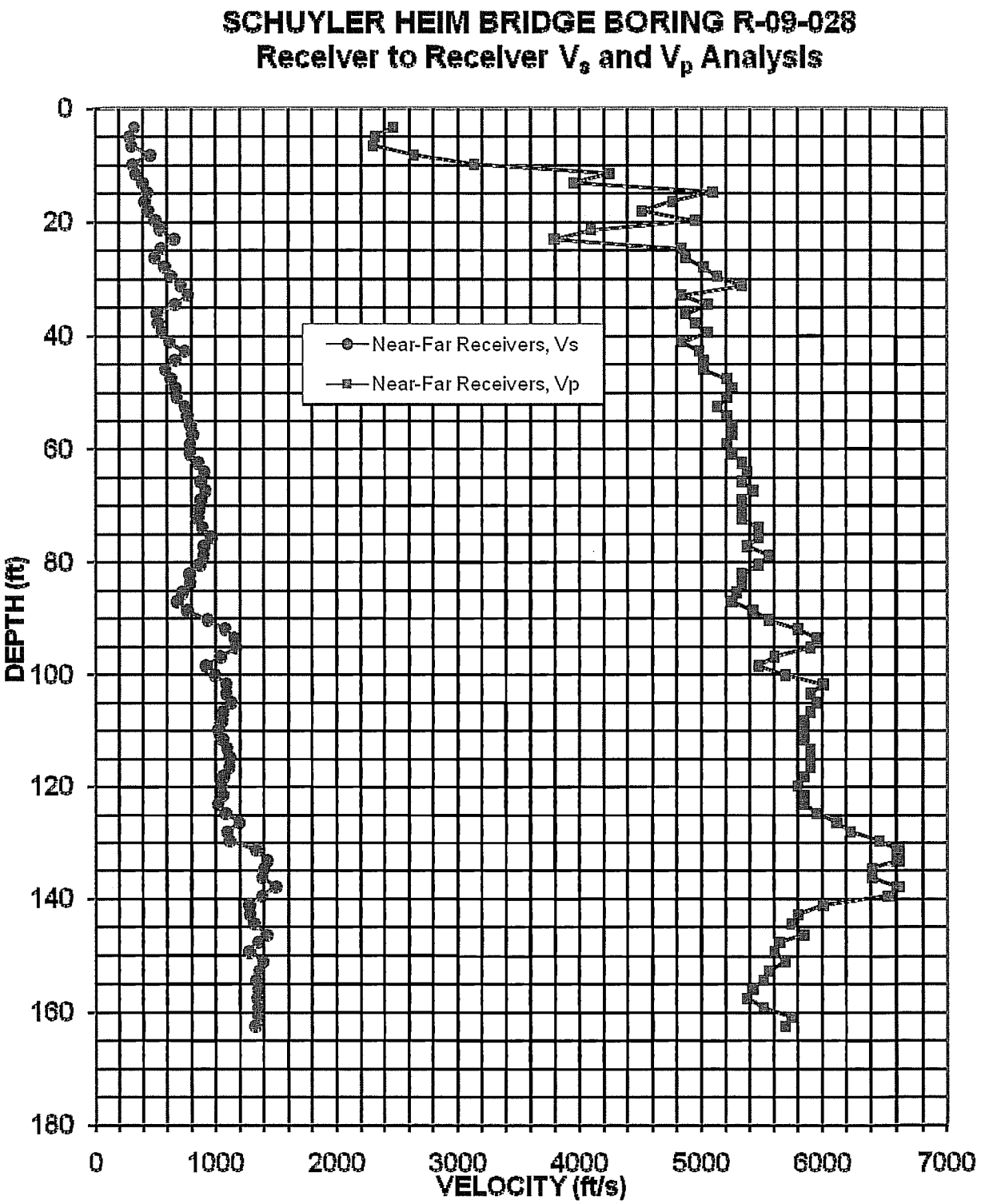

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

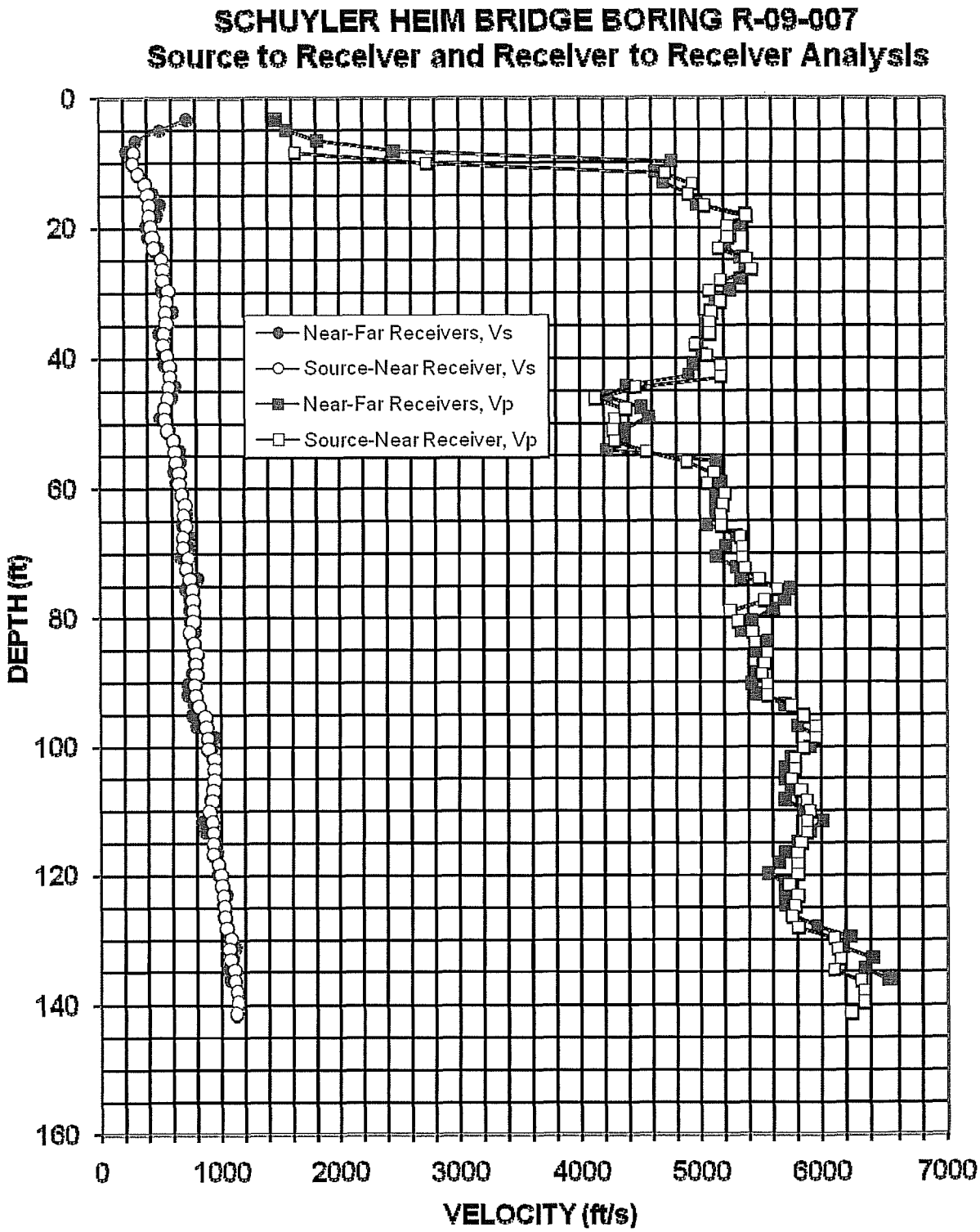

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

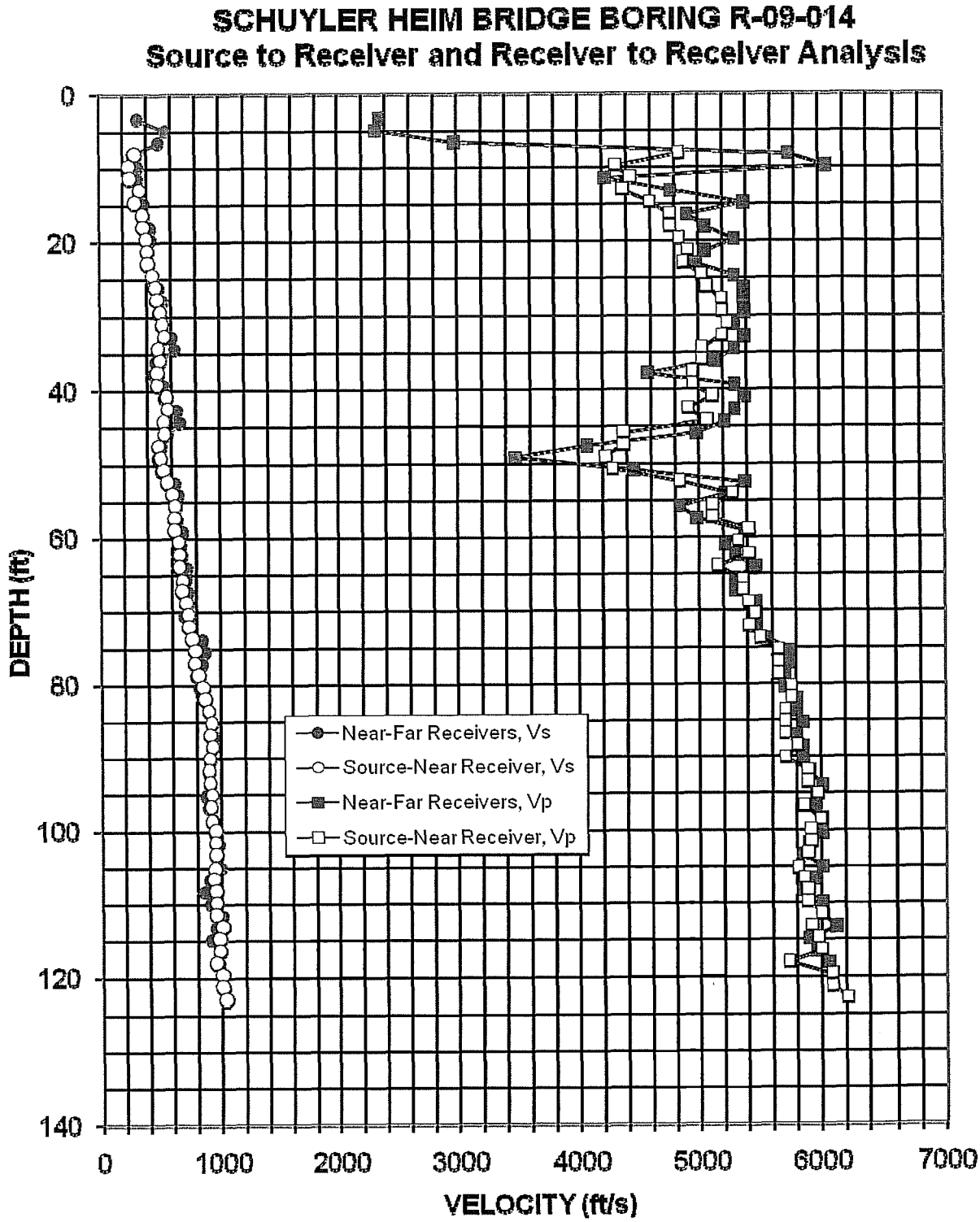

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

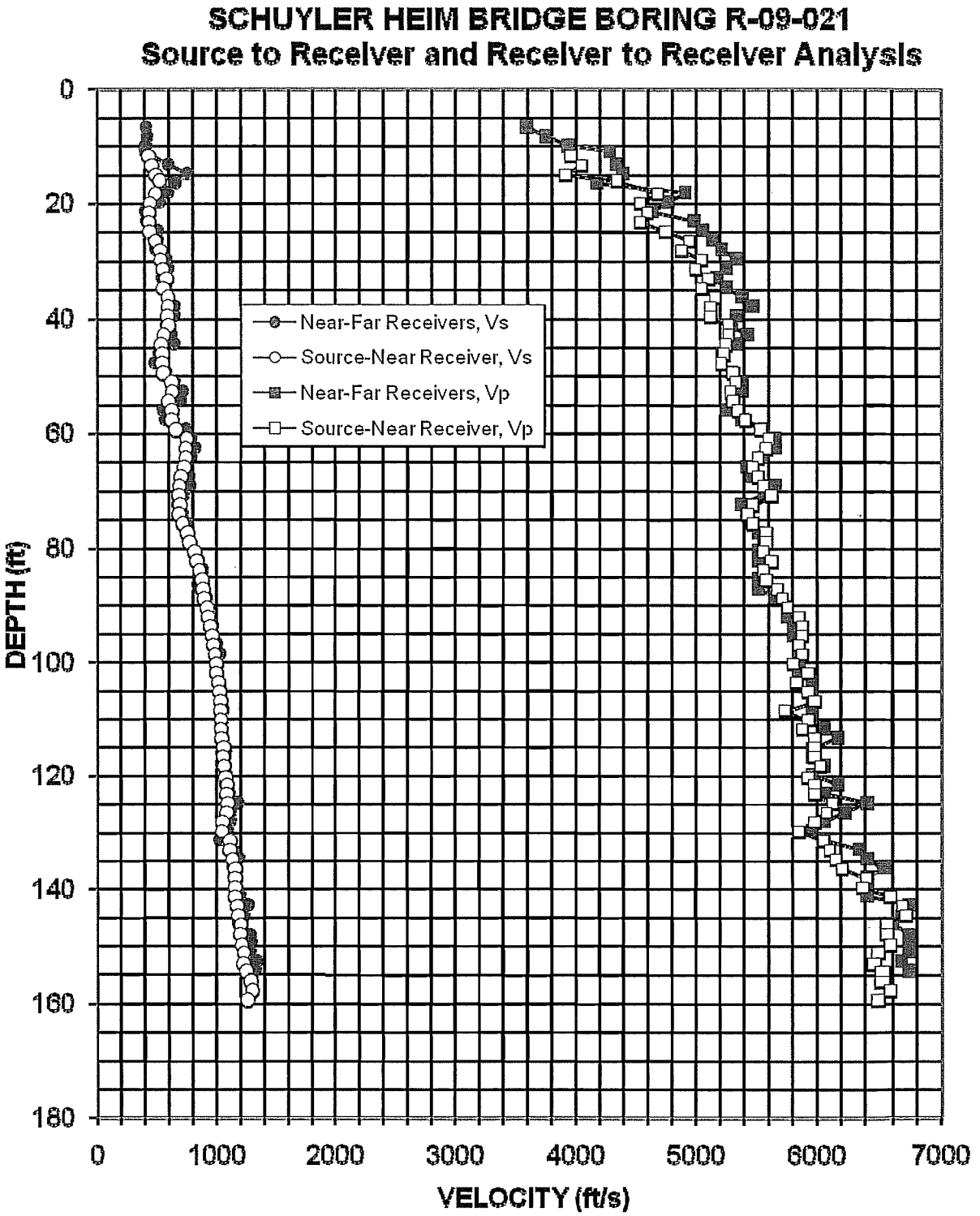

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

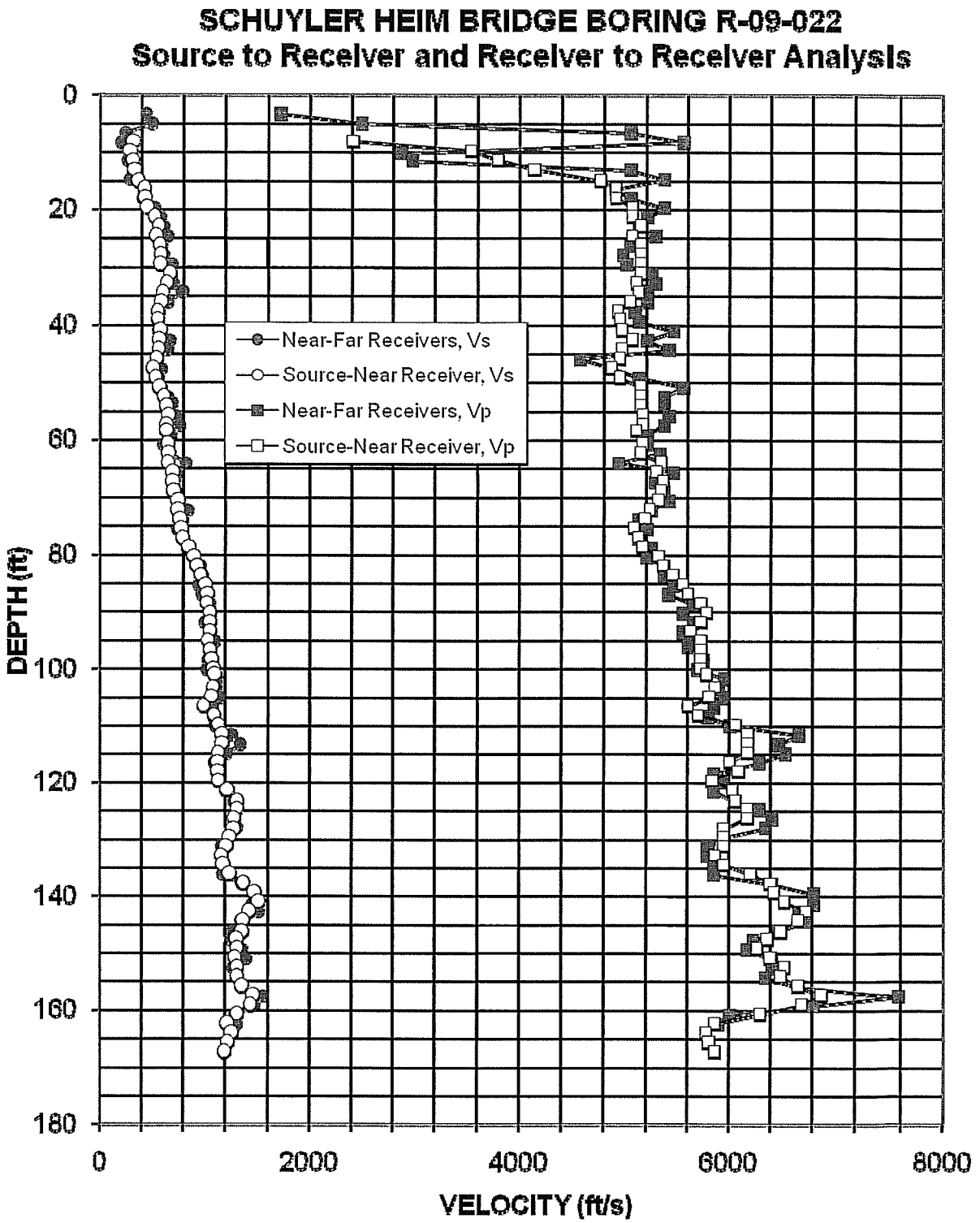

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

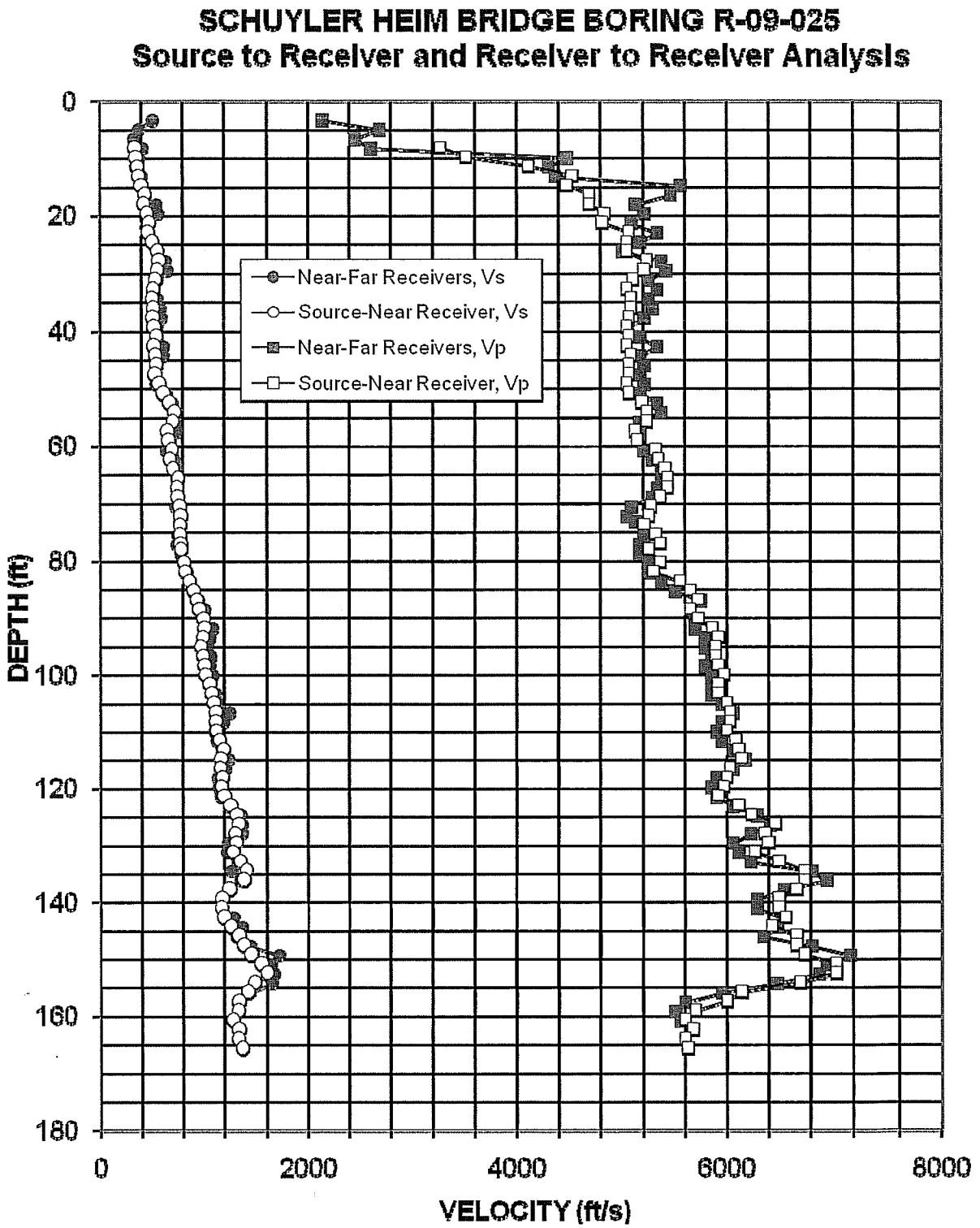

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

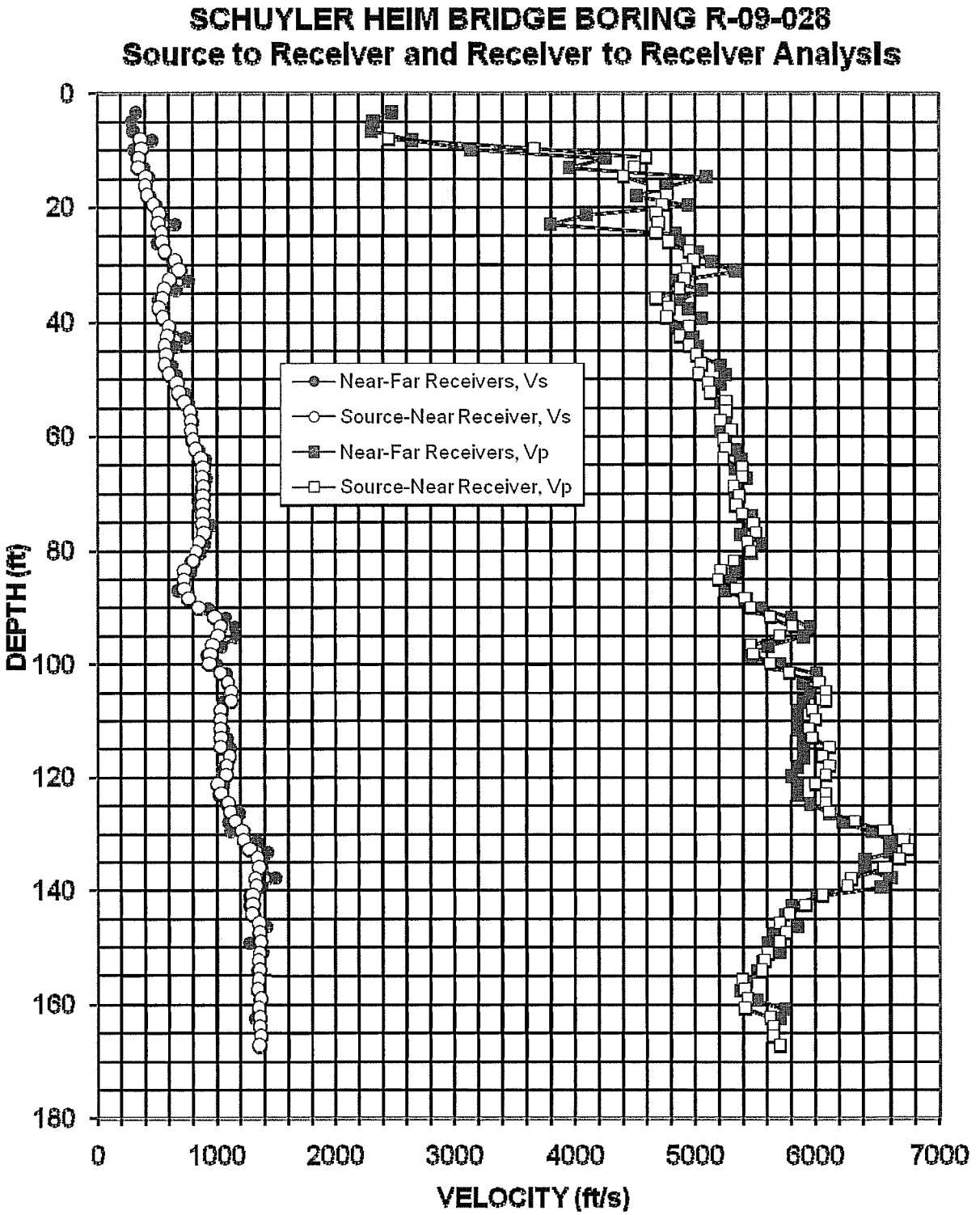

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠ Calibration Report

A SOUTHERN CALIFORNIA EDISON® Company

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573794
Asset No. 160023

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
		2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
5 73794

GEOVision
geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11% As left -0.11%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON℠ Company

Calibration Report

TEST NUMBER 573795

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 160024 573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C. LABORATORY SOIL TEST RESULTS

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

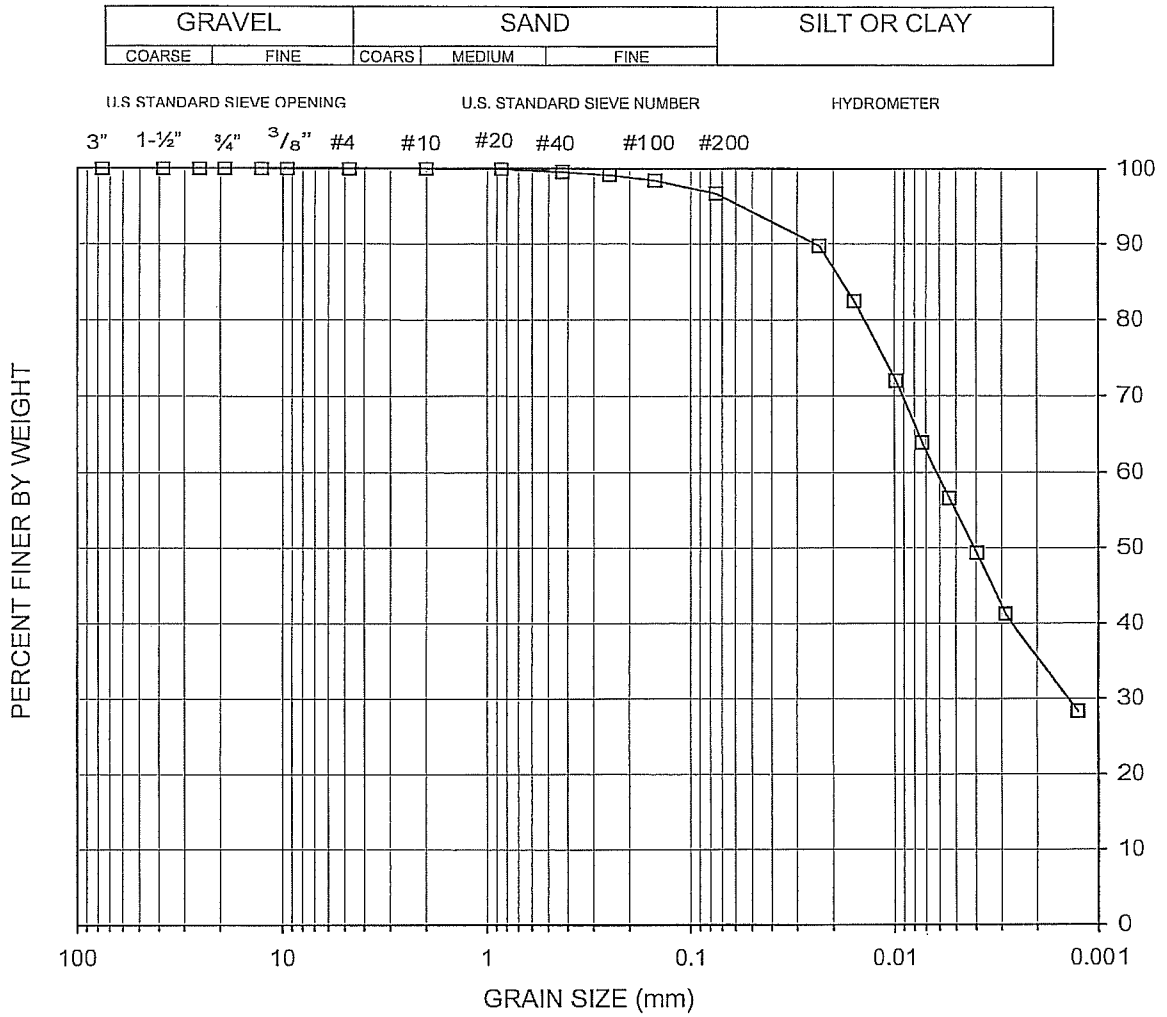
CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-033	S-01	5.0	12.7			
R-09-033	D-02	10.0	12.7	104.6	21.4	
R-09-033	U-04	20.0				61,26,35
R-09-033	D-05	25.0			10.9	
R-09-033	S-08-1	40.0	47.8			41,23,18
R-09-033	U-09	45.0				25,24,1
R-09-033	D-10-1	50.0			55.5	
R-09-033	S-11-1	55.0	31.9			29,28,1
R-09-033	S-11-2	55.8	30.5			24,23,1
R-09-033	D-12-1	60.0	25.5	100.4		
R-09-033	S-13-1	65.0	38.6			38,24,14
R-09-033	S-16	80.0	20.7			
R-09-033	S-17-2	90.6	35.5			33,22,11
R-09-033	S-19	100.0	14.2			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	U-04	20	Shelby Tube	CH	61	35

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

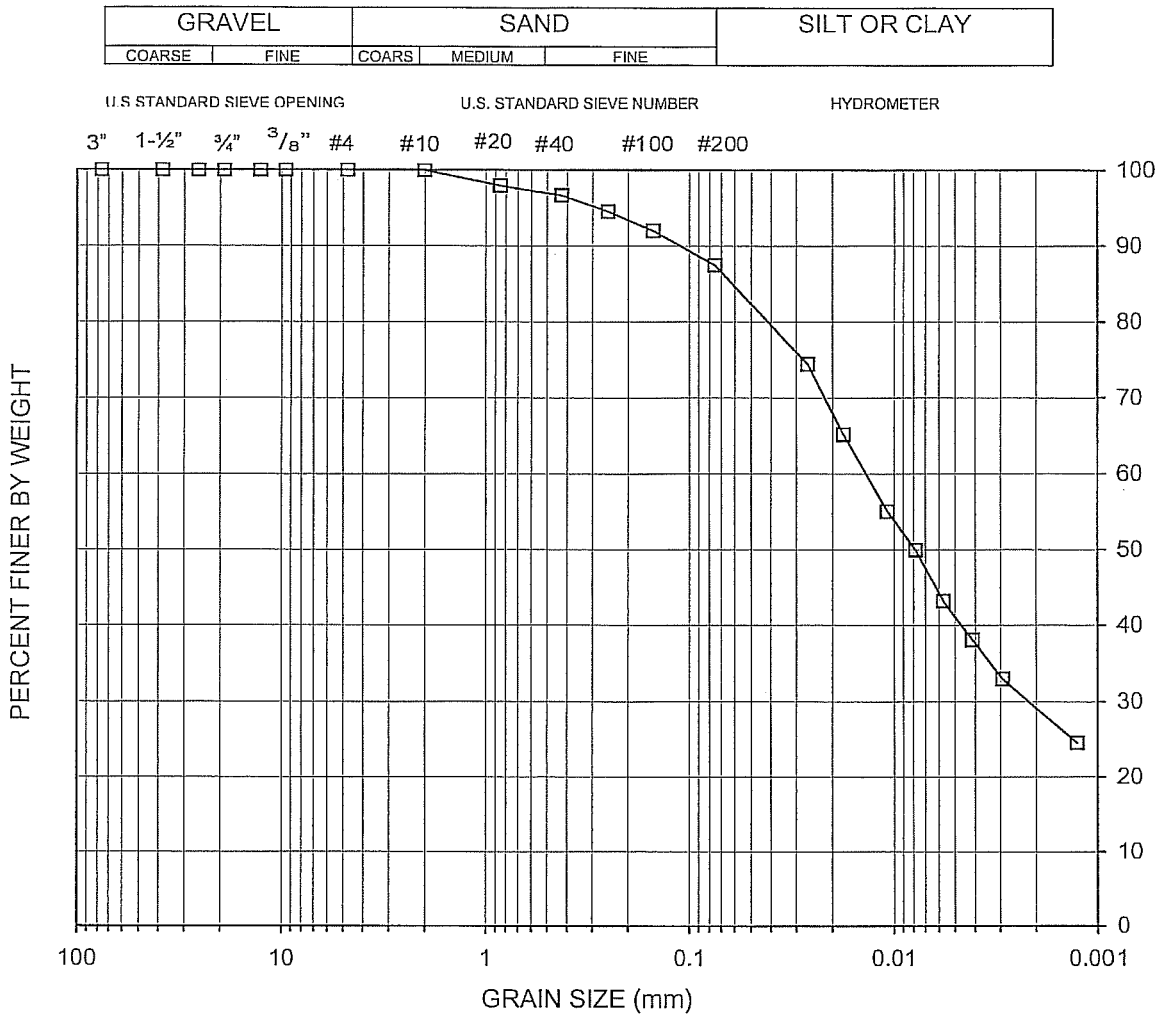
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-08-1	40	Bag	CL	41	18

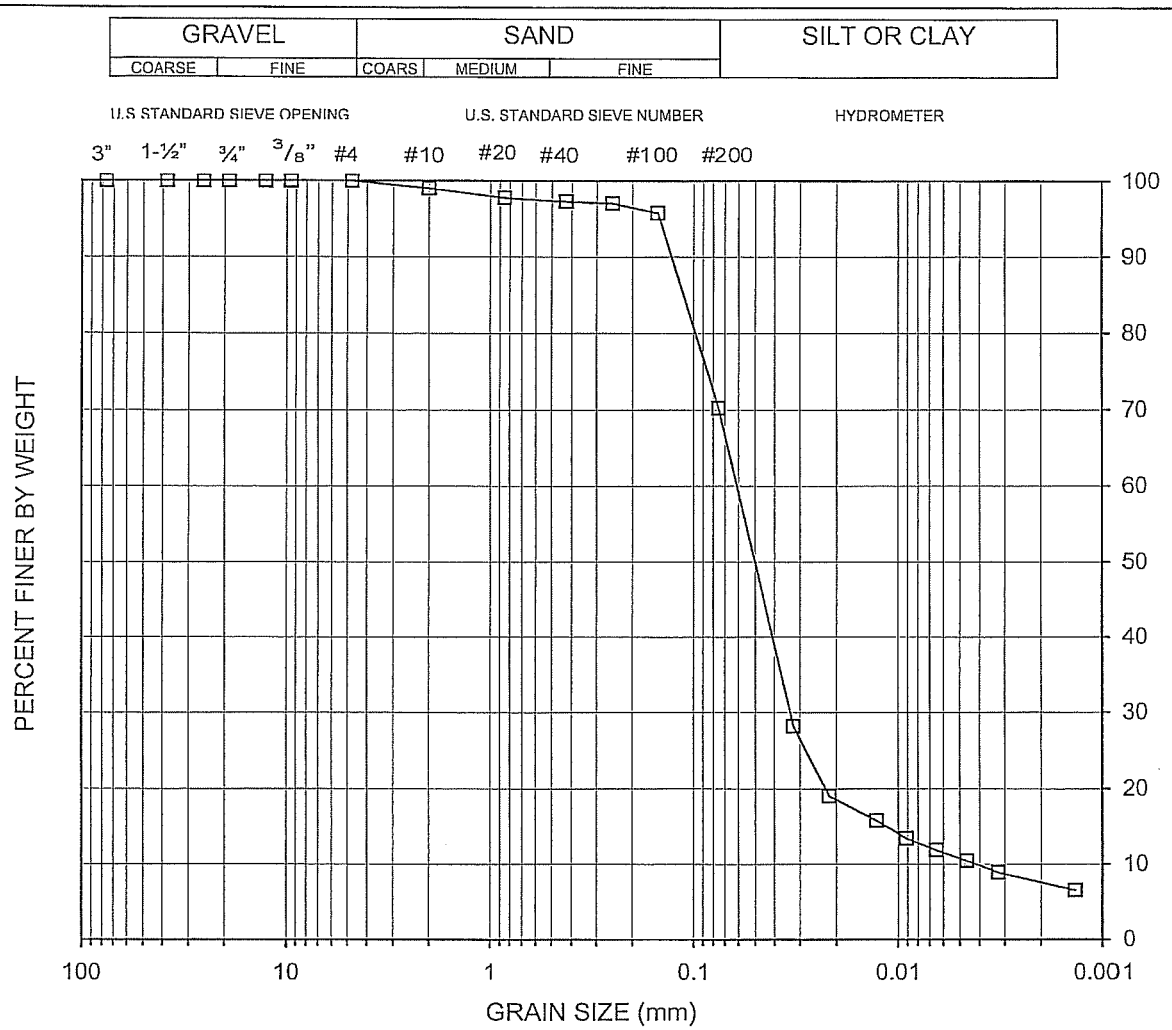
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	U-09	45	Shelby Tube	ML	24	1

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

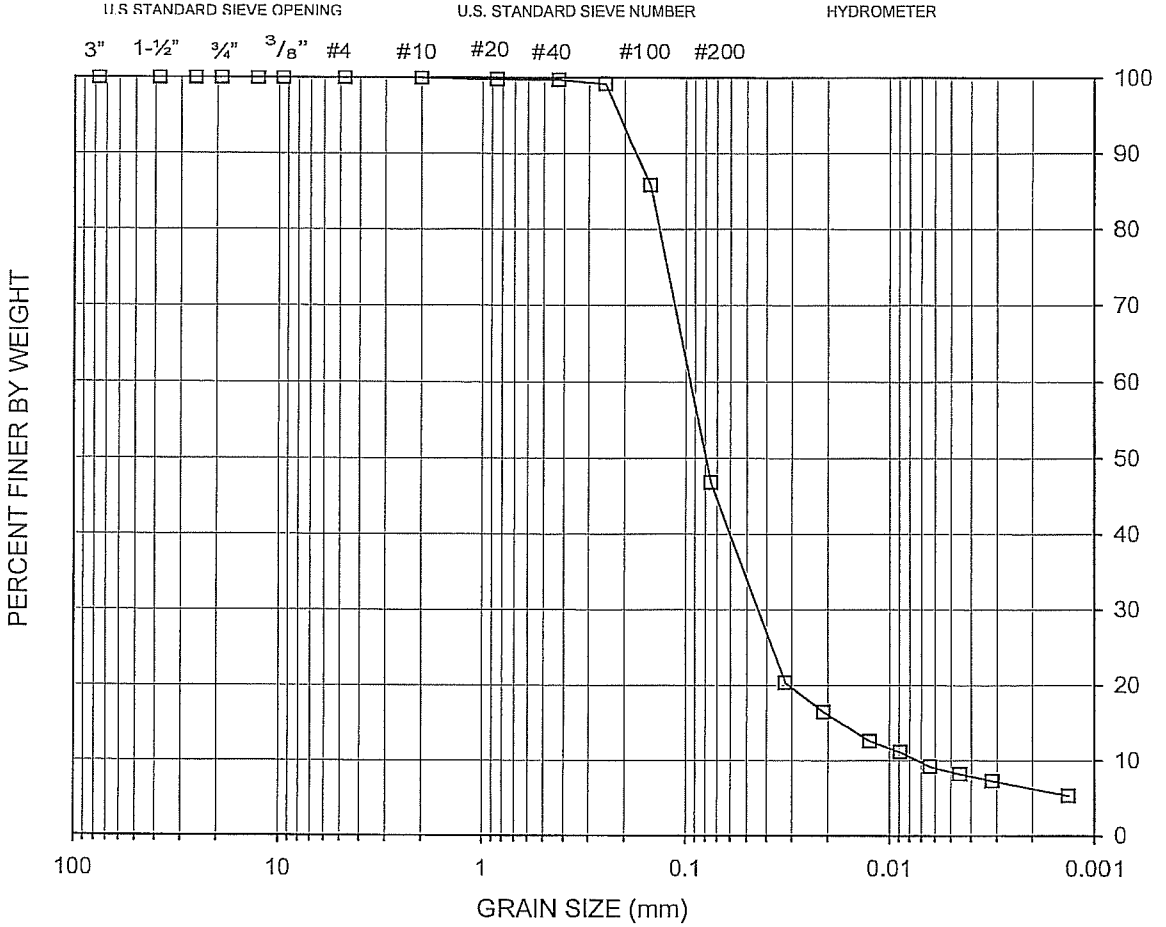
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/22/09

FIGURE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARS	MEDIUM	FINE	



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	D-12-1	60	Ring	SM	N/A	N/A

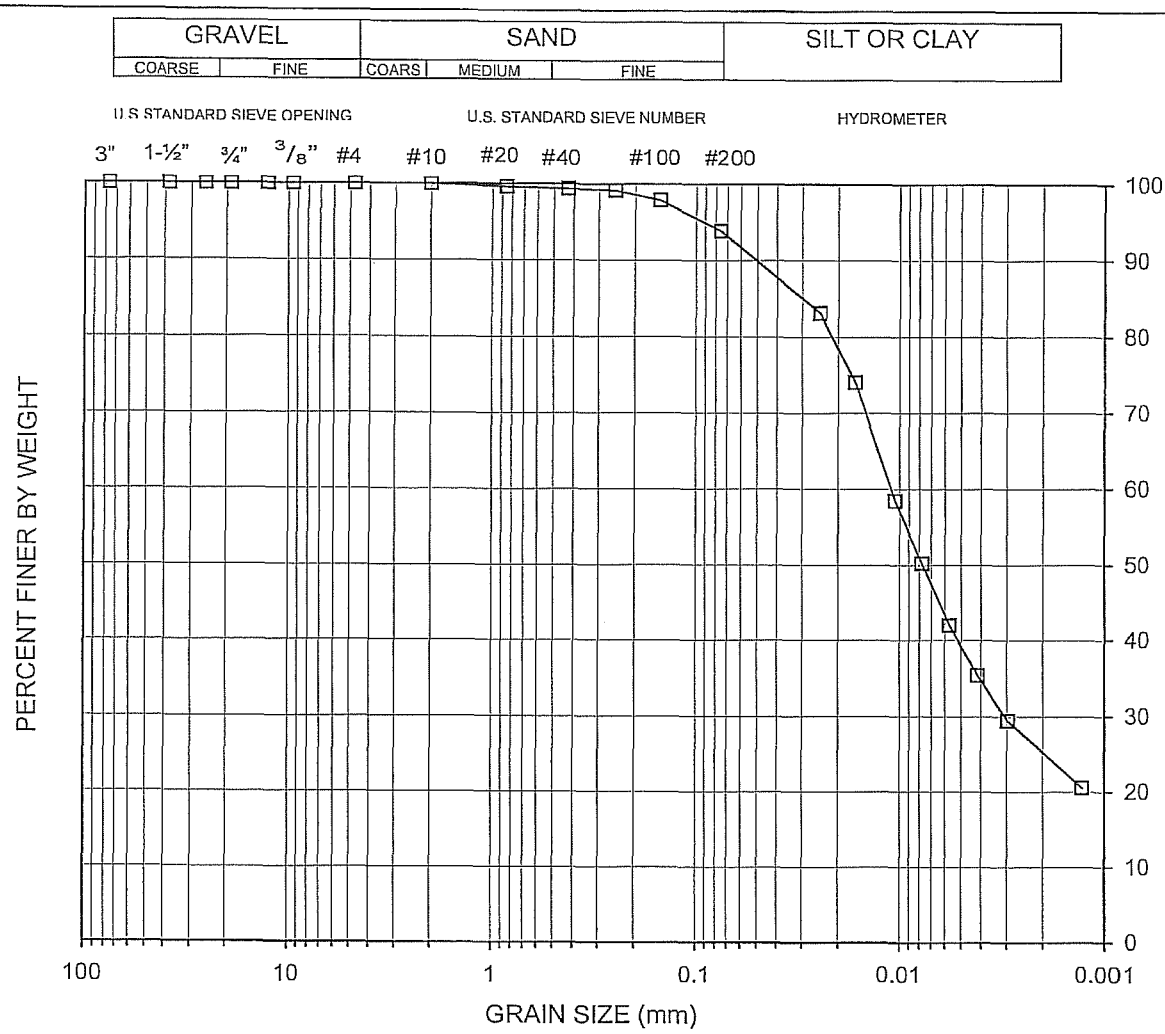
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-13-1	65	Bag	CL	38	14

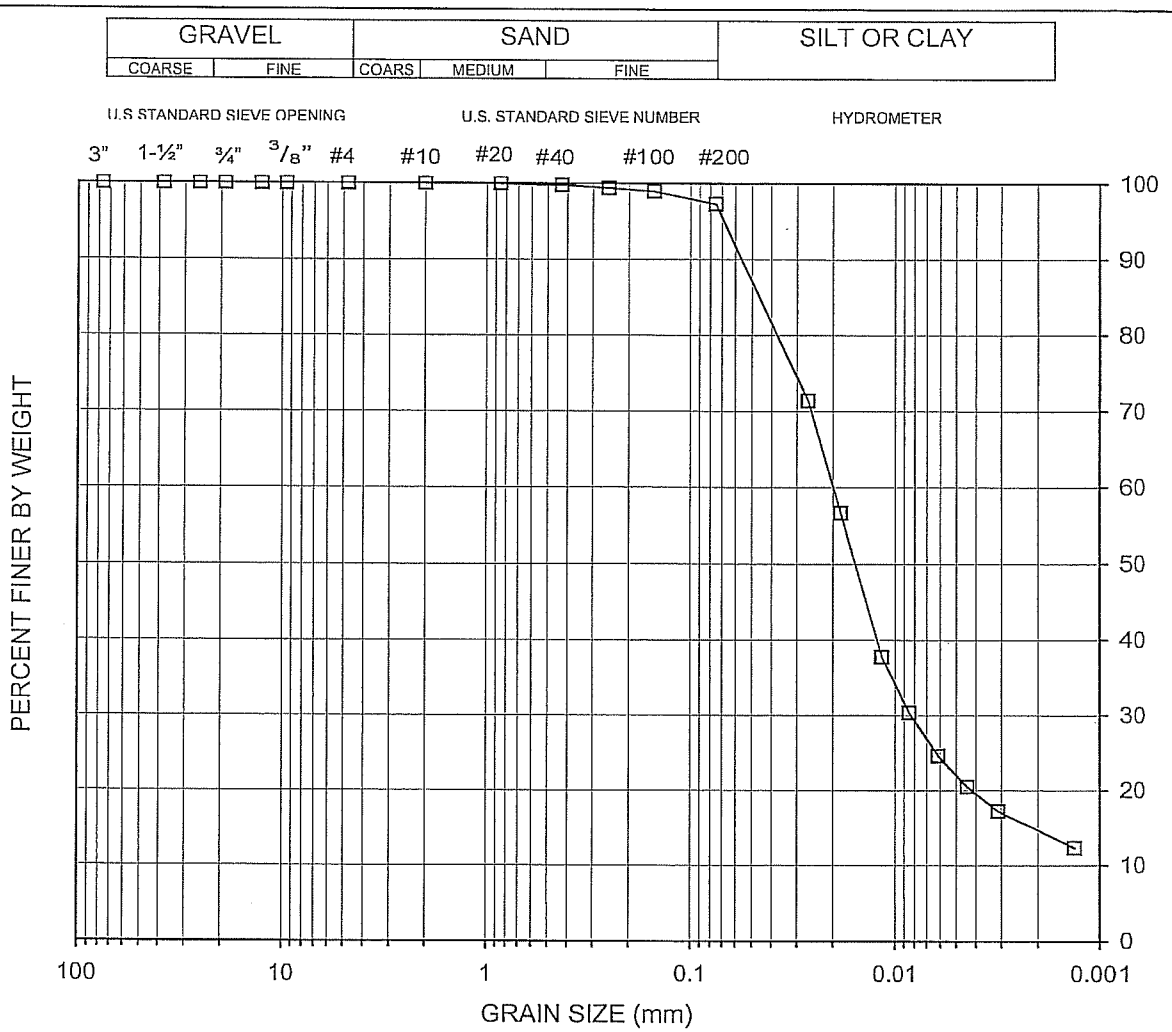
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-17-2	90.6	Bag	CL	33	11

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE

SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-033	S-16	80	Bag	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

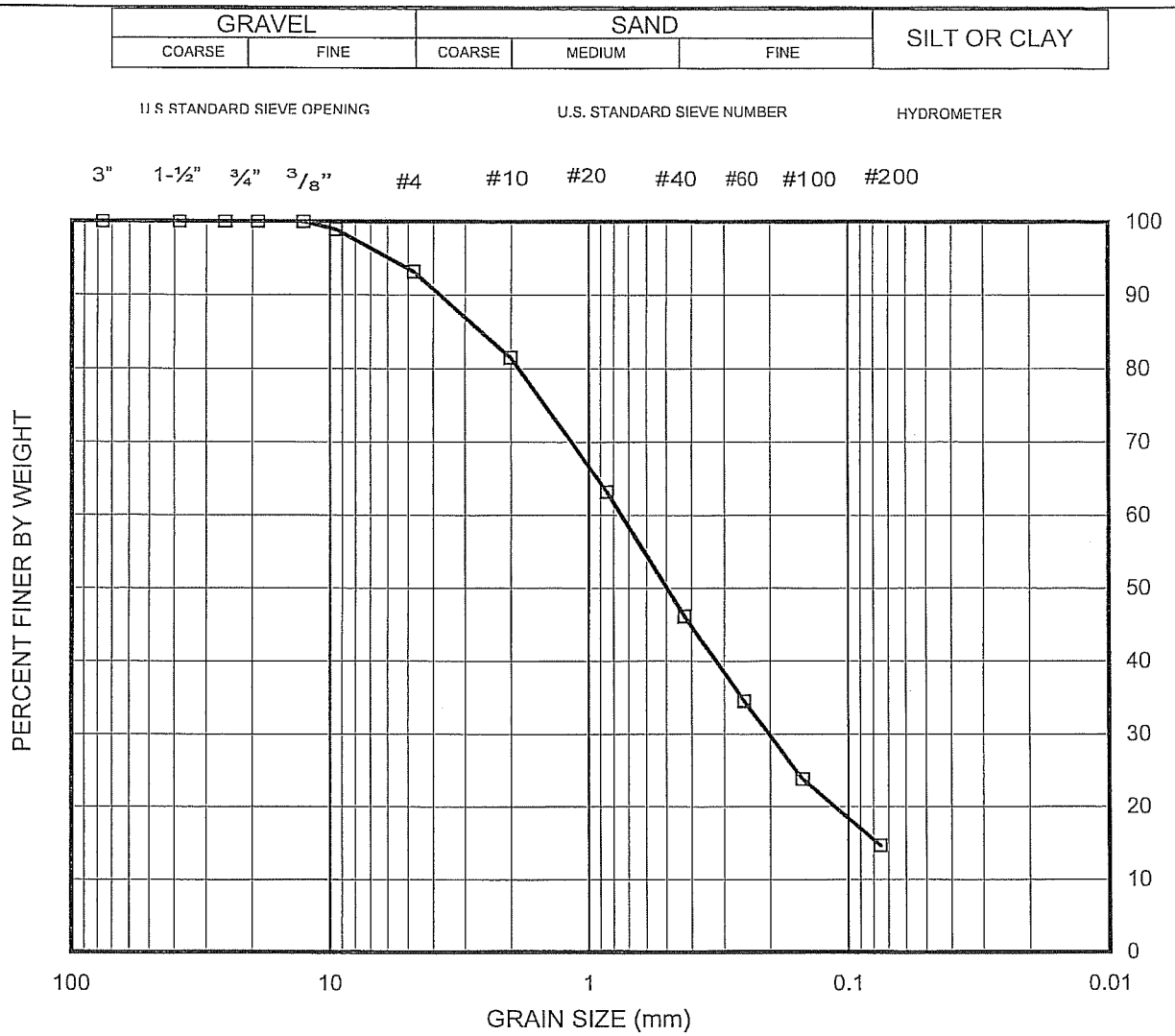
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-033	S-19	100	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008A
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	12/18/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-033	U-03	15	8.40	605	0.018	630

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
R-09-033	U-04	20	0.5
R-09-033	U-09	45	1.75

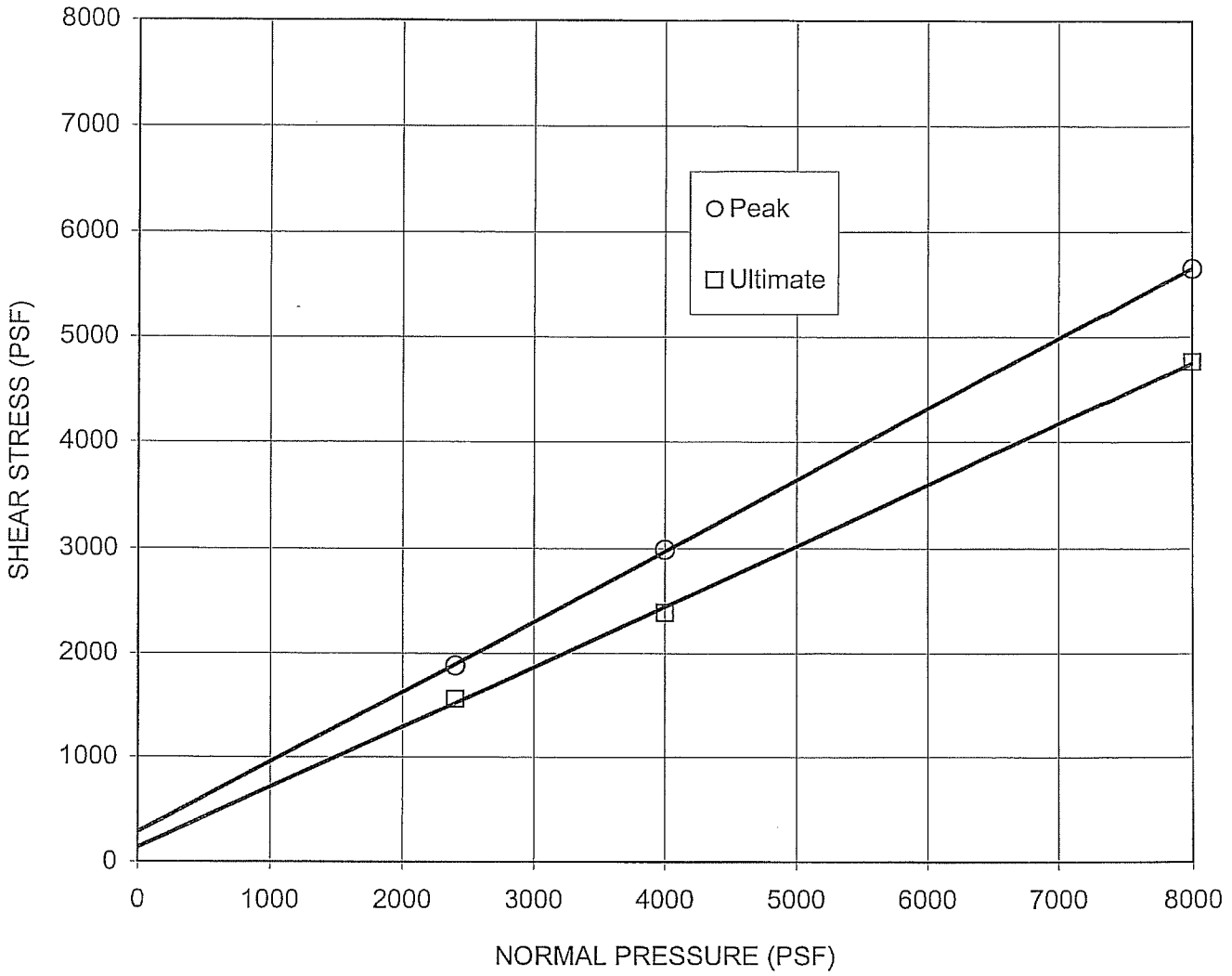
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-033	U-04	20	2.697
R-09-033	U-09	45	2.746



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-033	D-07	35	Ring	SP-SM	○	286	34
					□	138	30

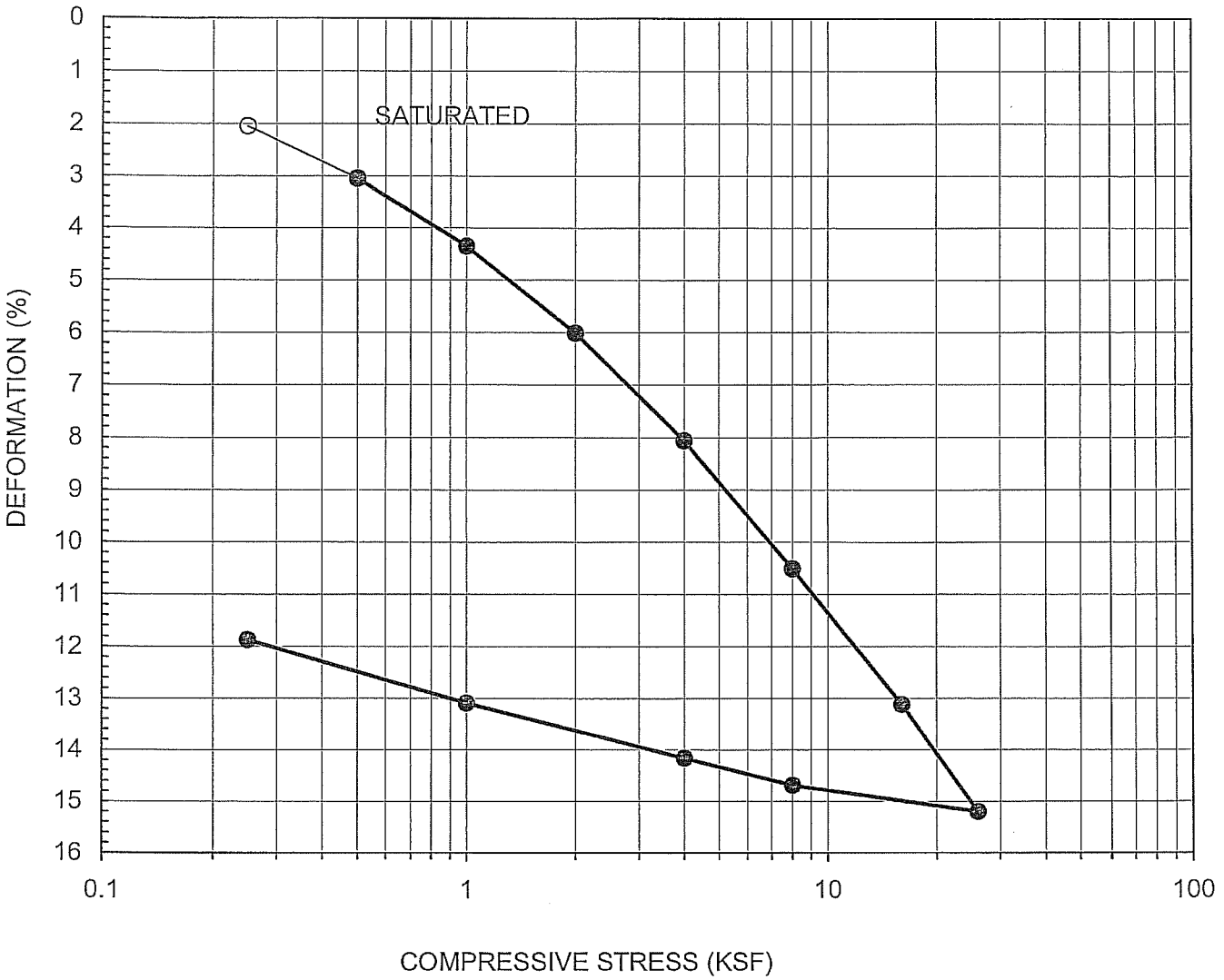
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2400	21.4	26.4
4000	21.4	25.8
8000	21.4	25.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



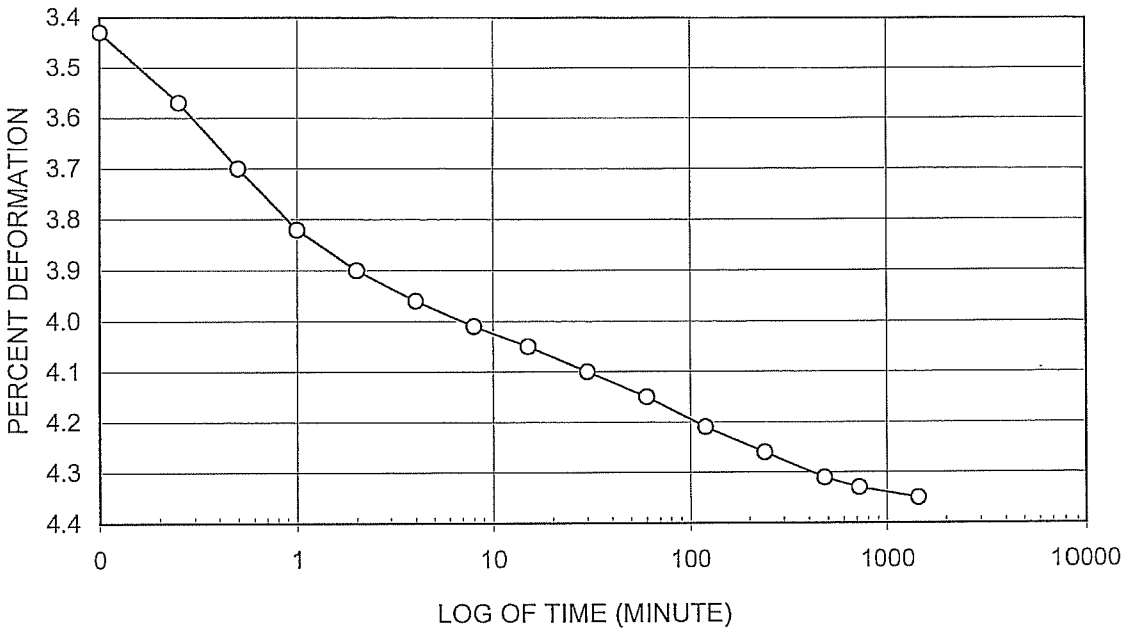
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-033	U-03	15.0	CL-ML	47.8	77.3	1.179

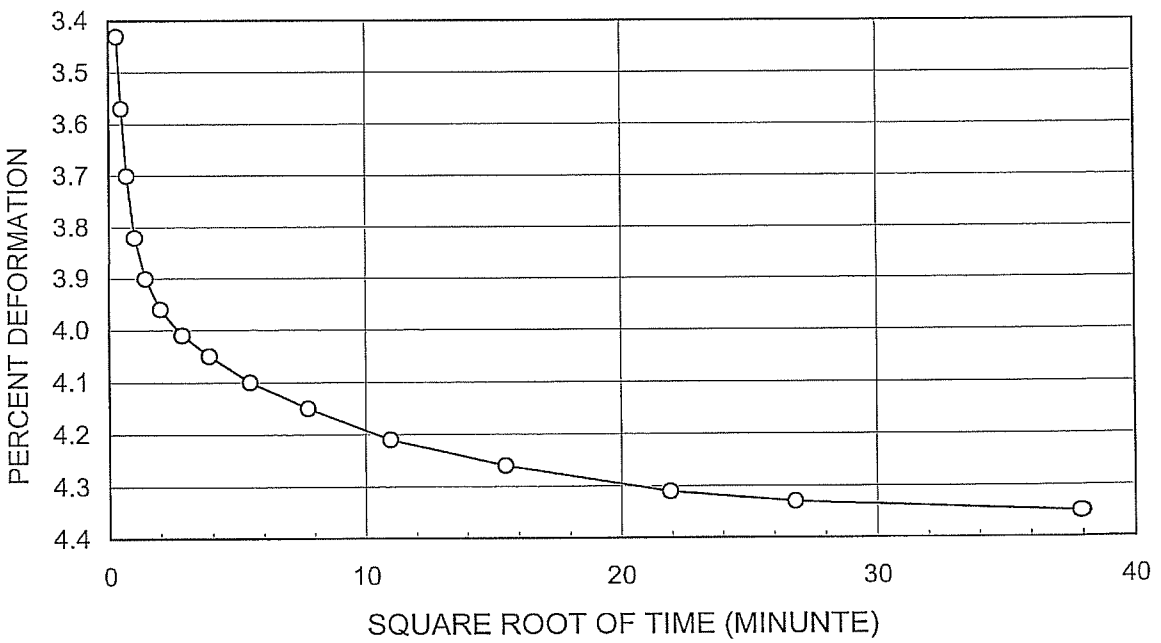
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





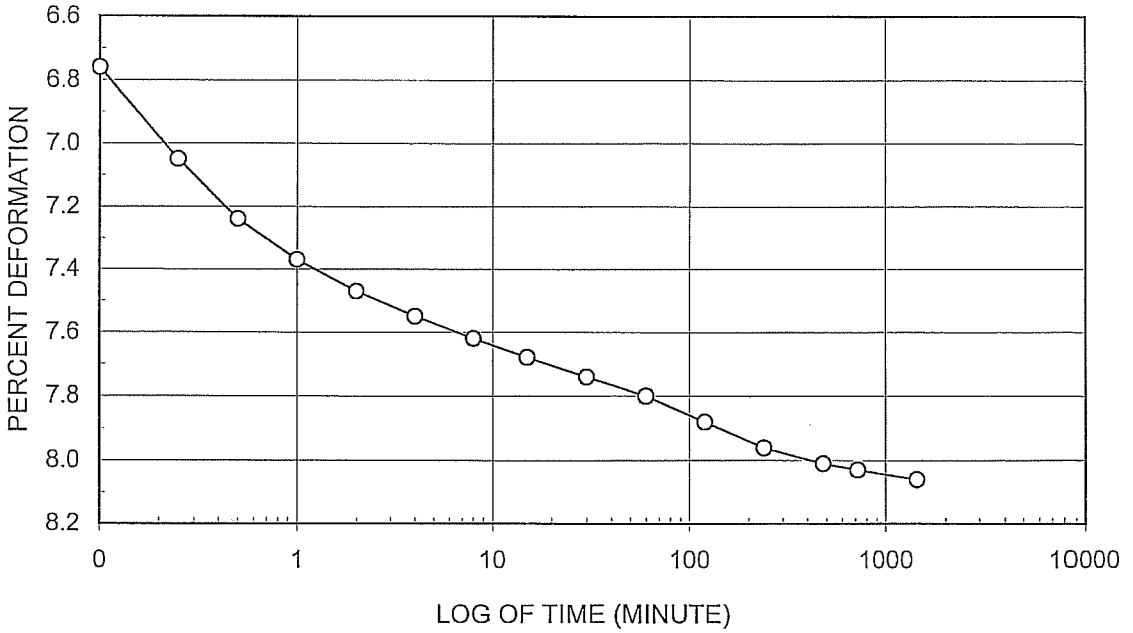
Boring No: R-09-033
Sample No: U-03
Depth (ft): 15
Soil Type: CL-ML
Normal Stress: 1.0 ksf

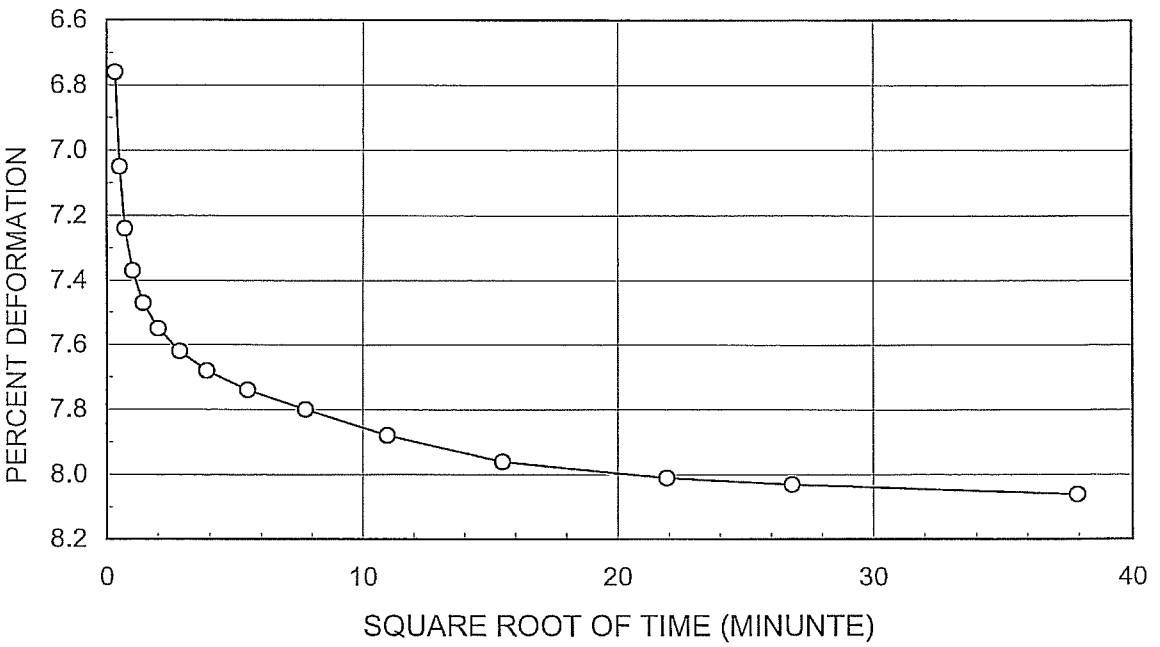
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





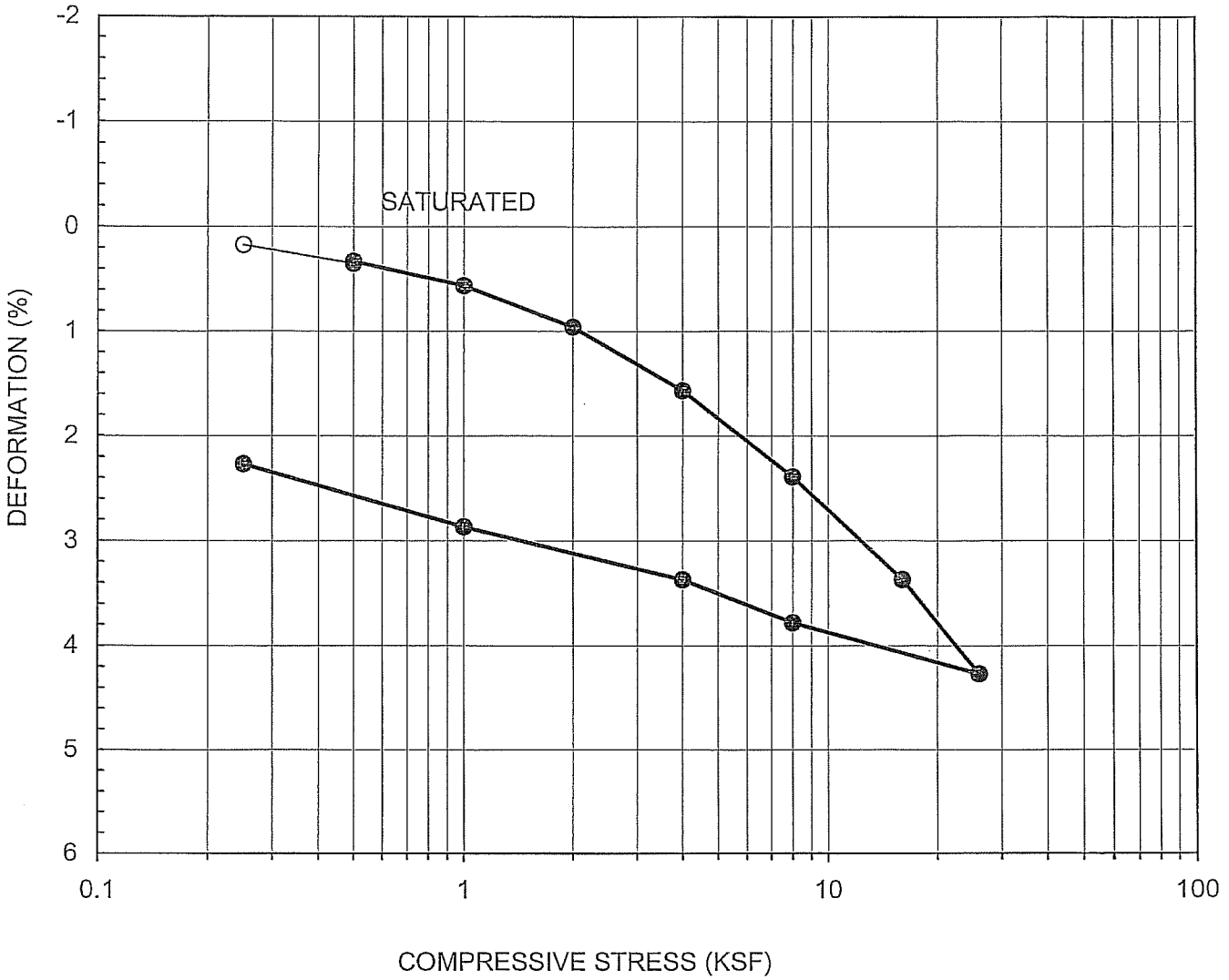
Boring No: R-09-033
Sample No: U-03
Depth (ft): 15
Soil Type: CL-ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



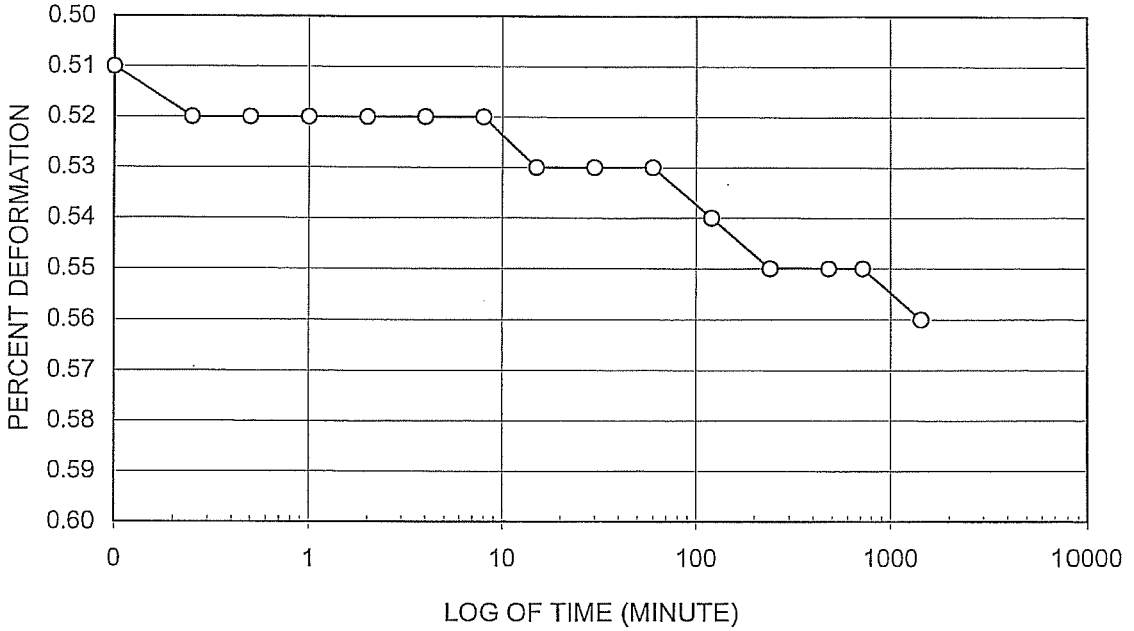
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
O	R-09-033	D-10-2	50.5	ML	27.1	95.7	0.761

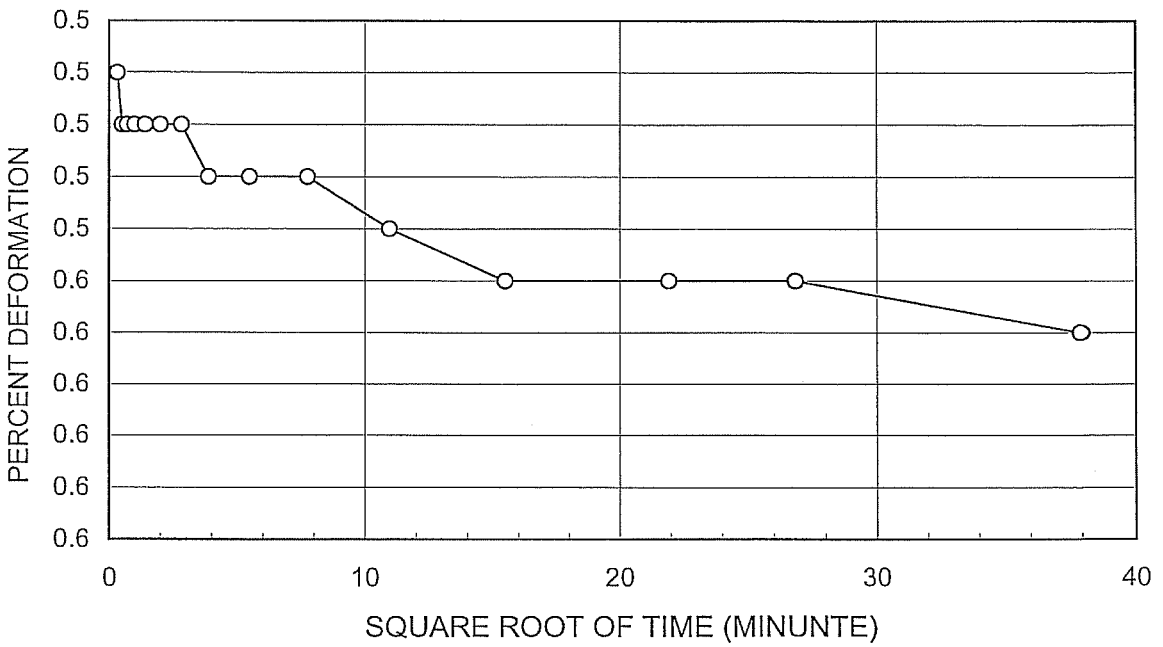
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





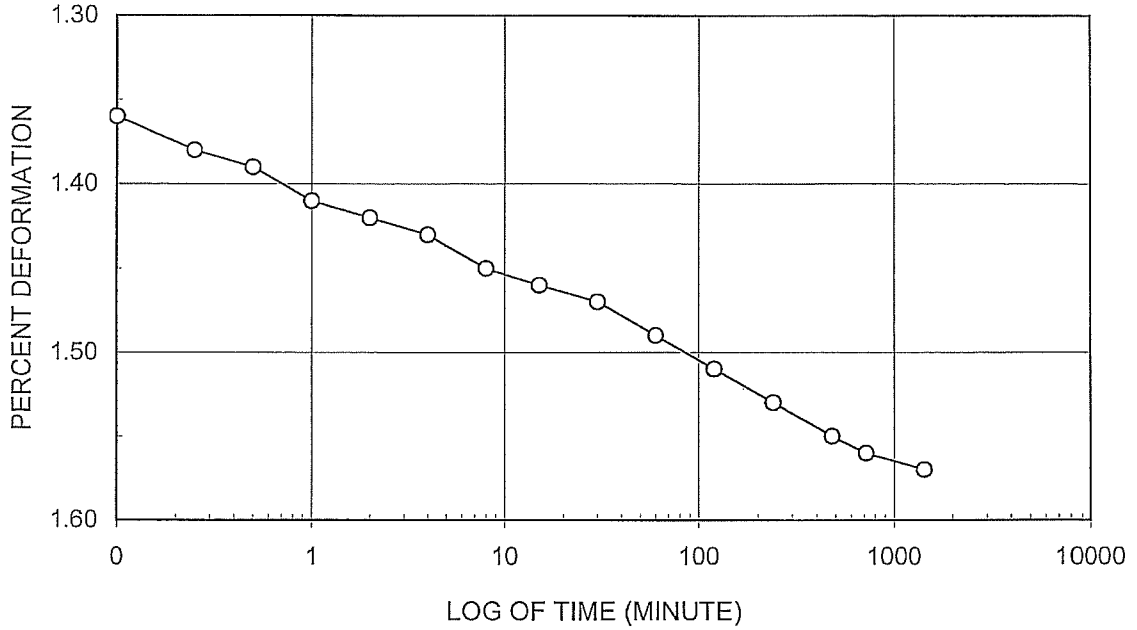
Boring No: R-09-033
Sample No: D-10-2
Depth (ft): 50.5
Soil Type: ML
Normal Stress: 1.0 ksf

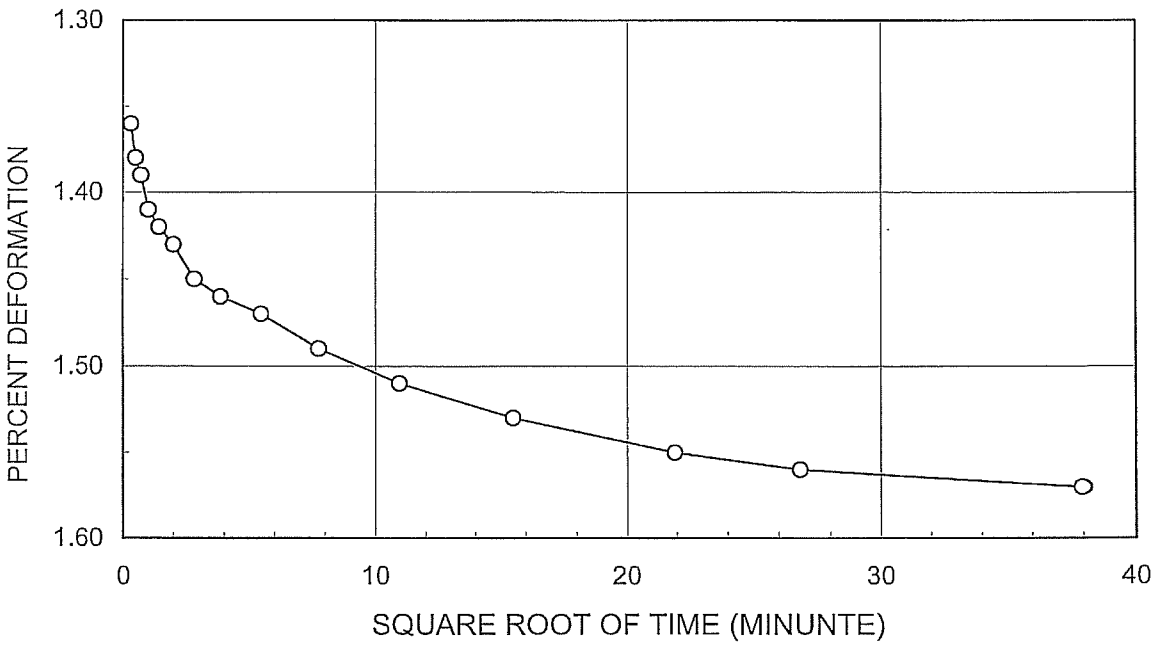
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





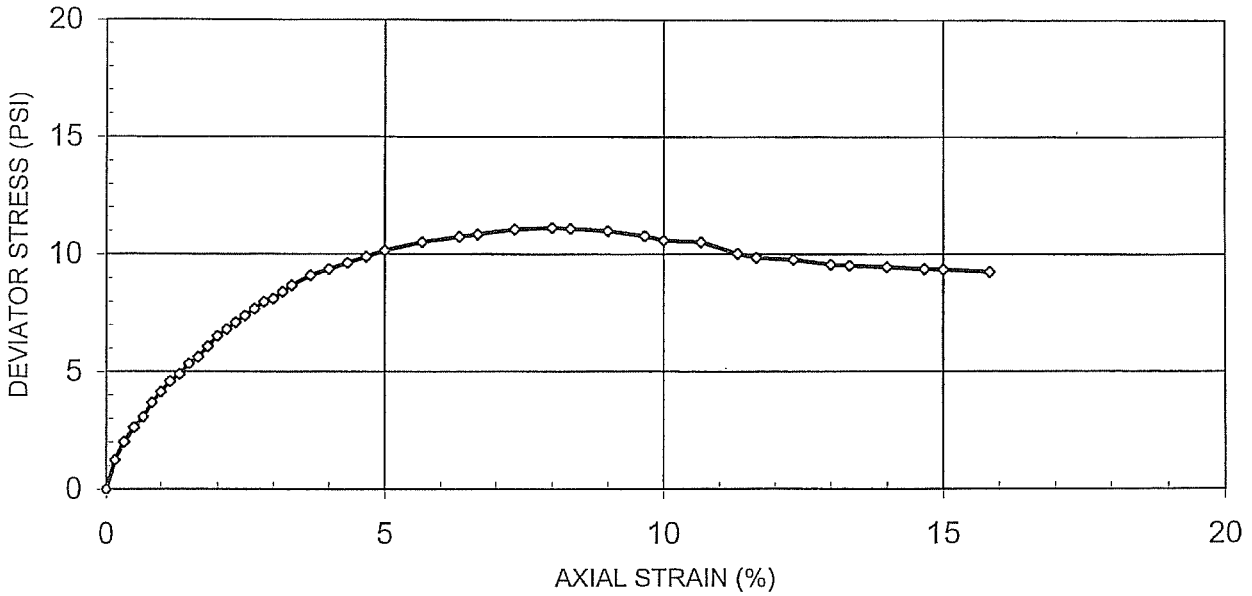
Boring No: R-09-033
Sample No: D-10-2
Depth (ft): 50.5
Soil Type: ML
Normal Stress: 4.0 ksf

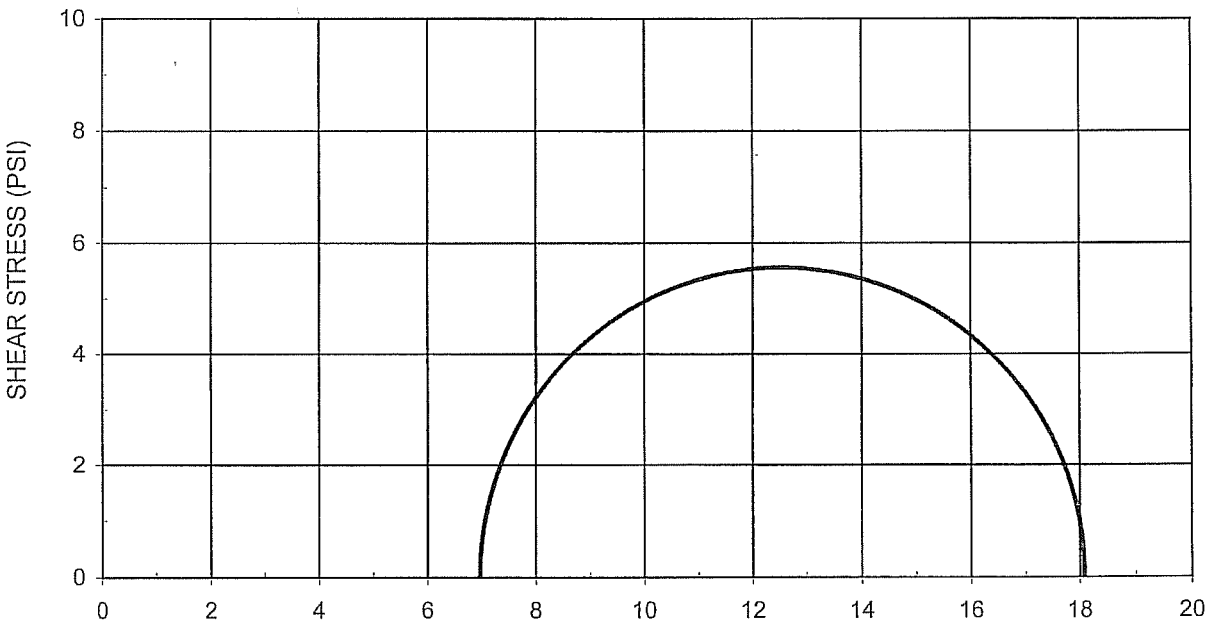
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-033	20	U-04	CH	Shelby Tube	59.44	64.1	7.0	11.1	0.06	98.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

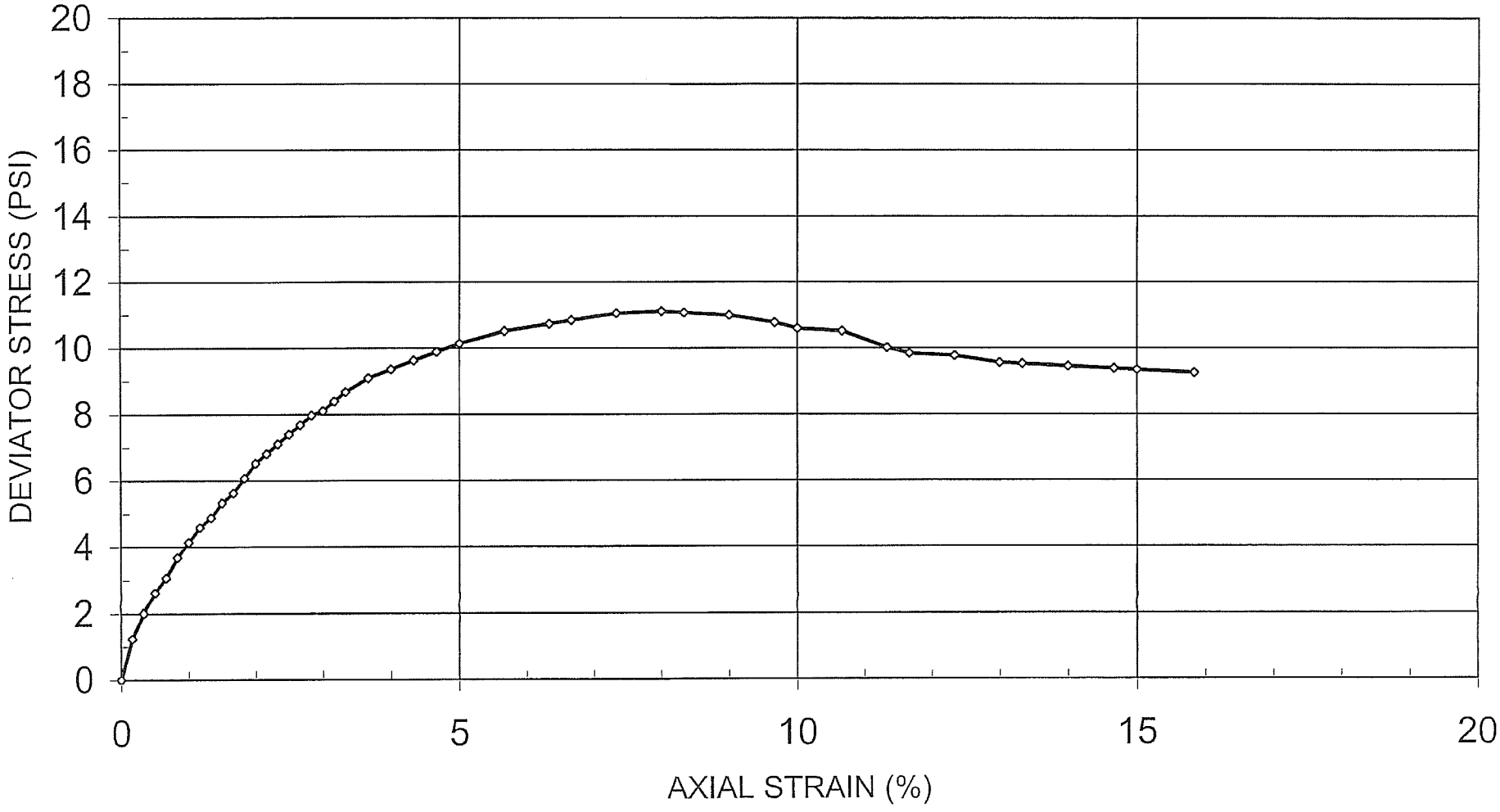
(ASTM D2850)

12/21/09

Figure

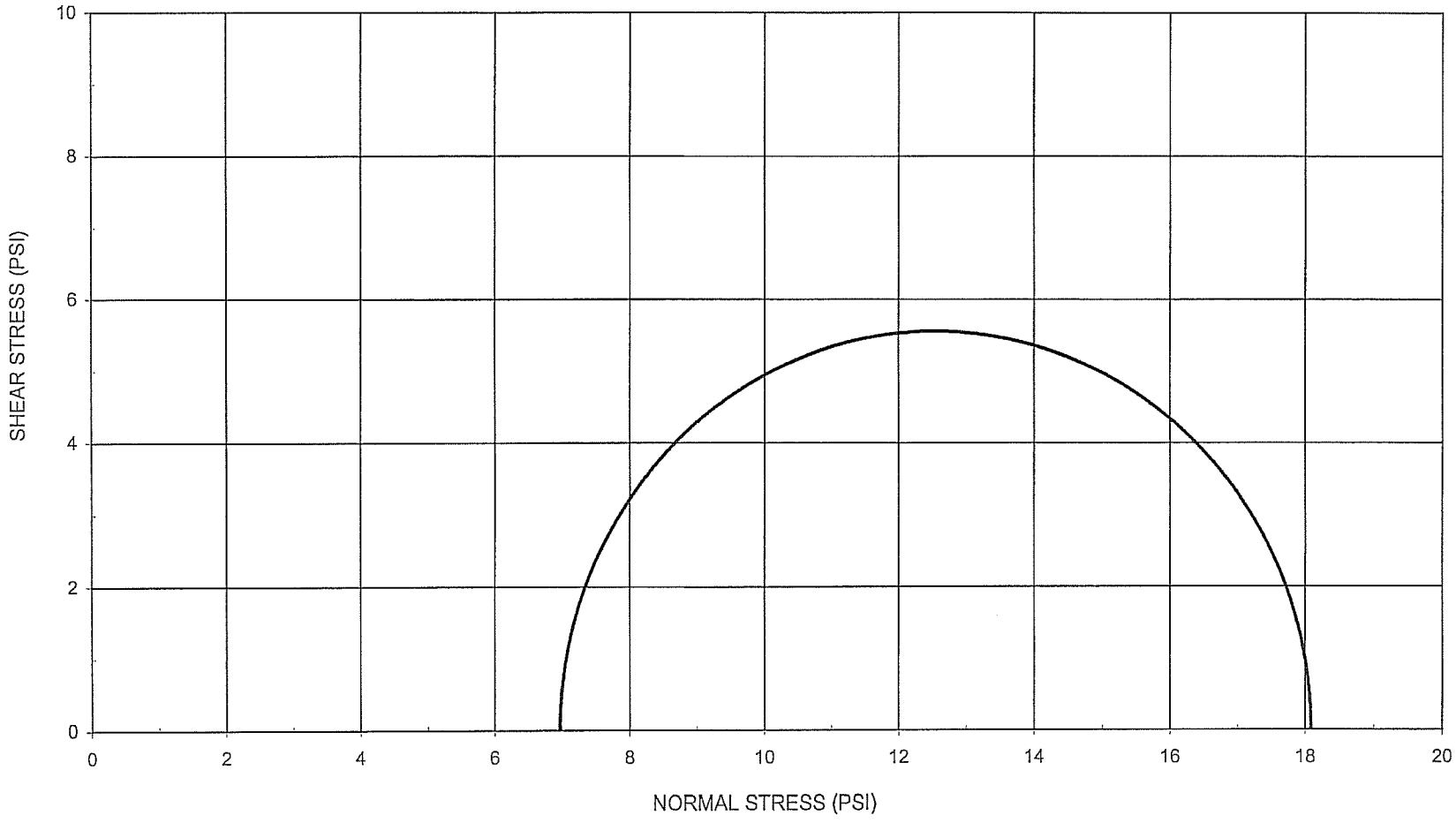
Project Name: ACTA Heim Bridge Replacement

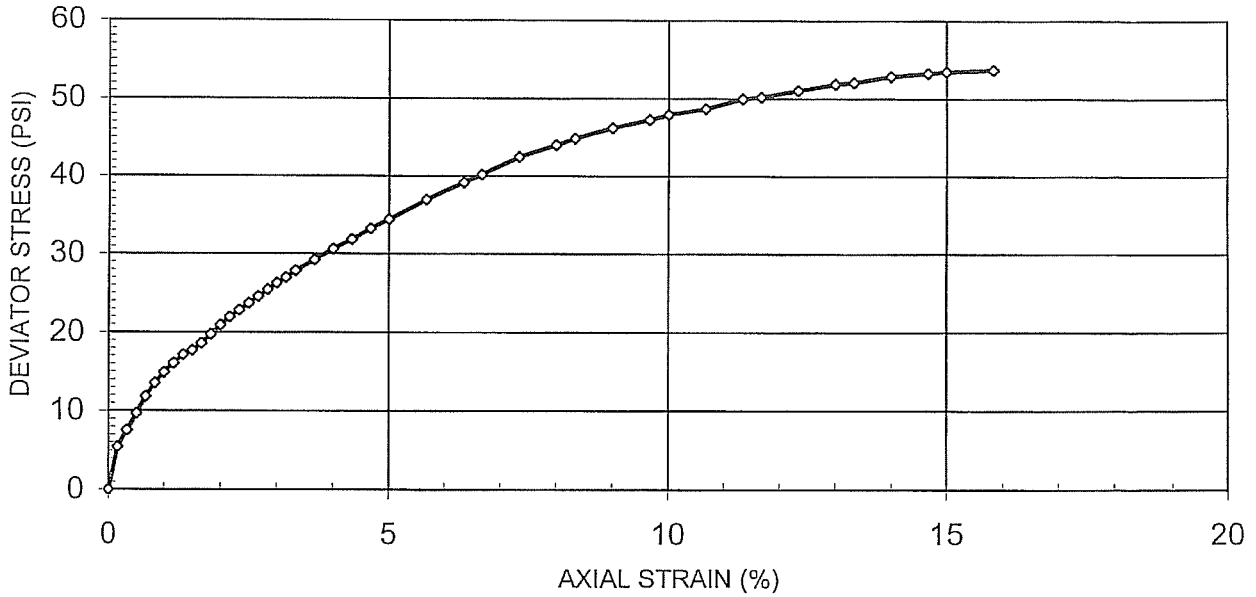
Boring: R-09-033 Sample ID: U-04 Depth (ft): 20

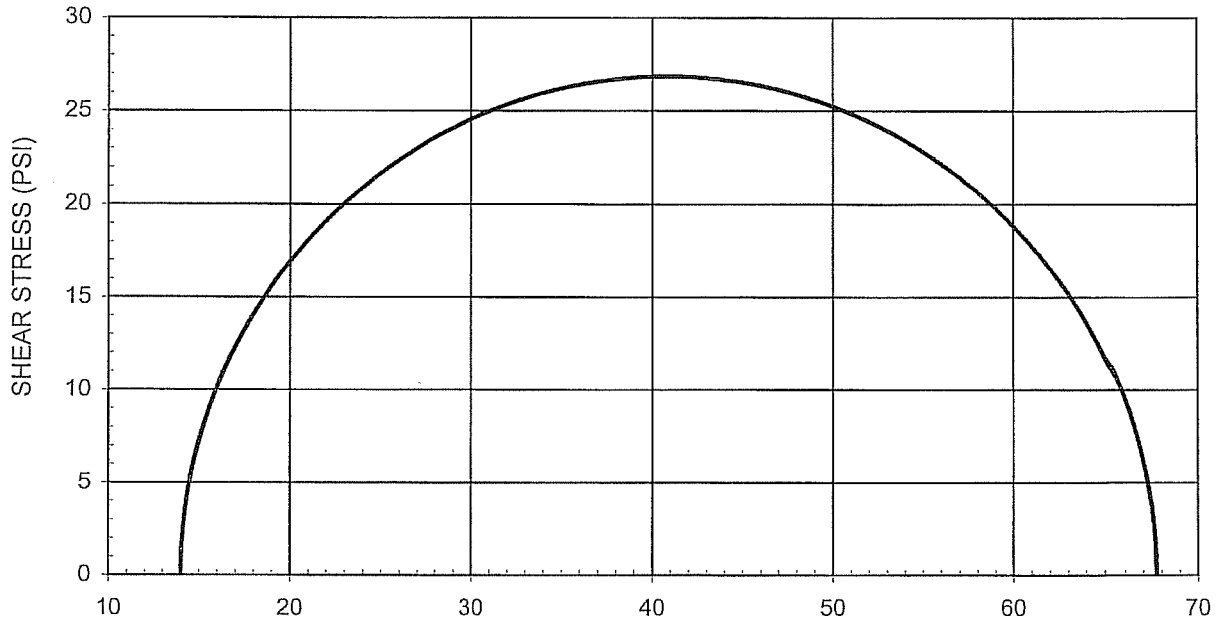


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-04 Depth (ft): 20







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-033	45	U-09	ML	Shelby Tube	30.47	92.2	14.0	53.7	0.06	99.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

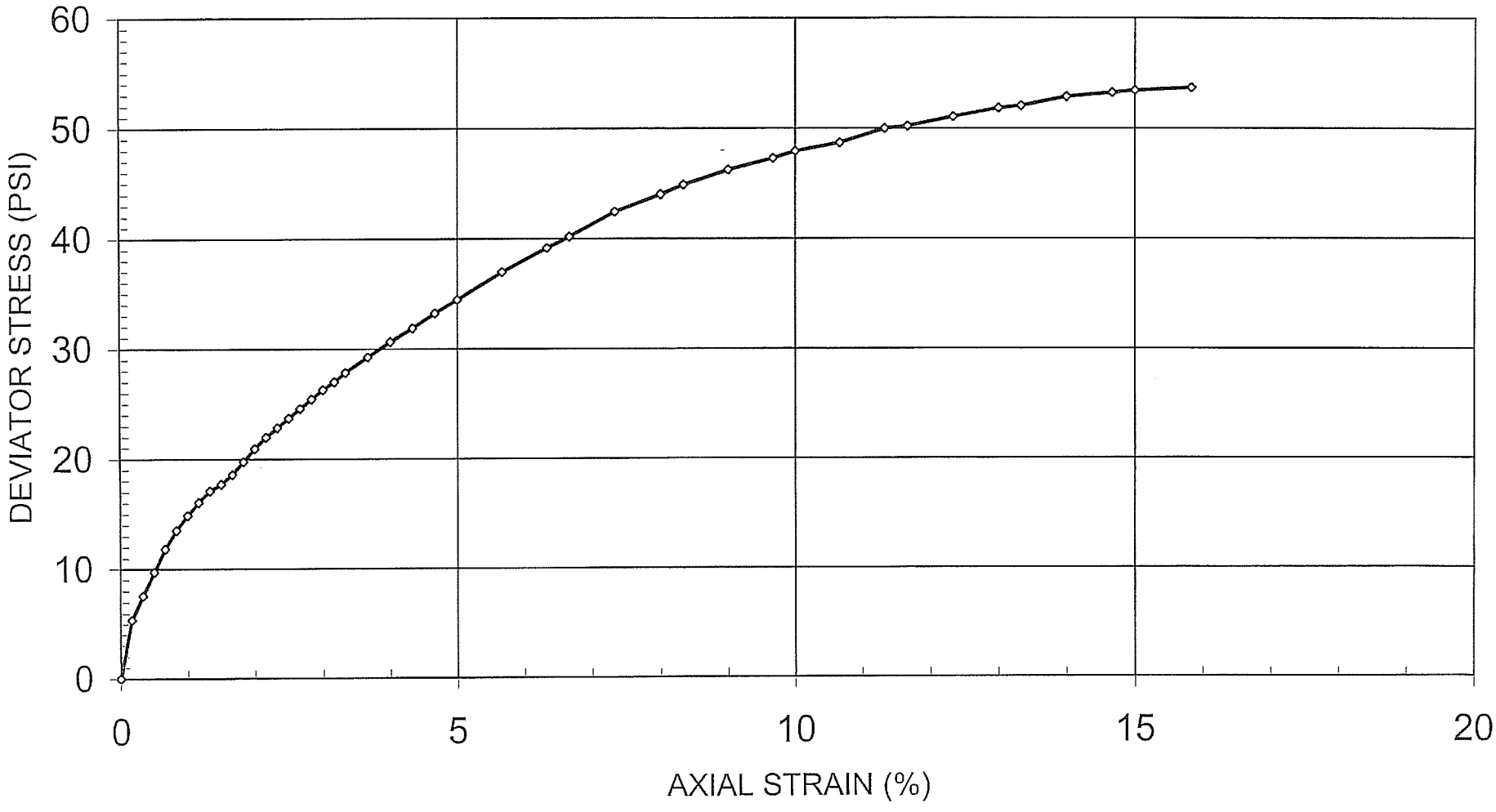
(ASTM D2850)

12/21/09

Figure

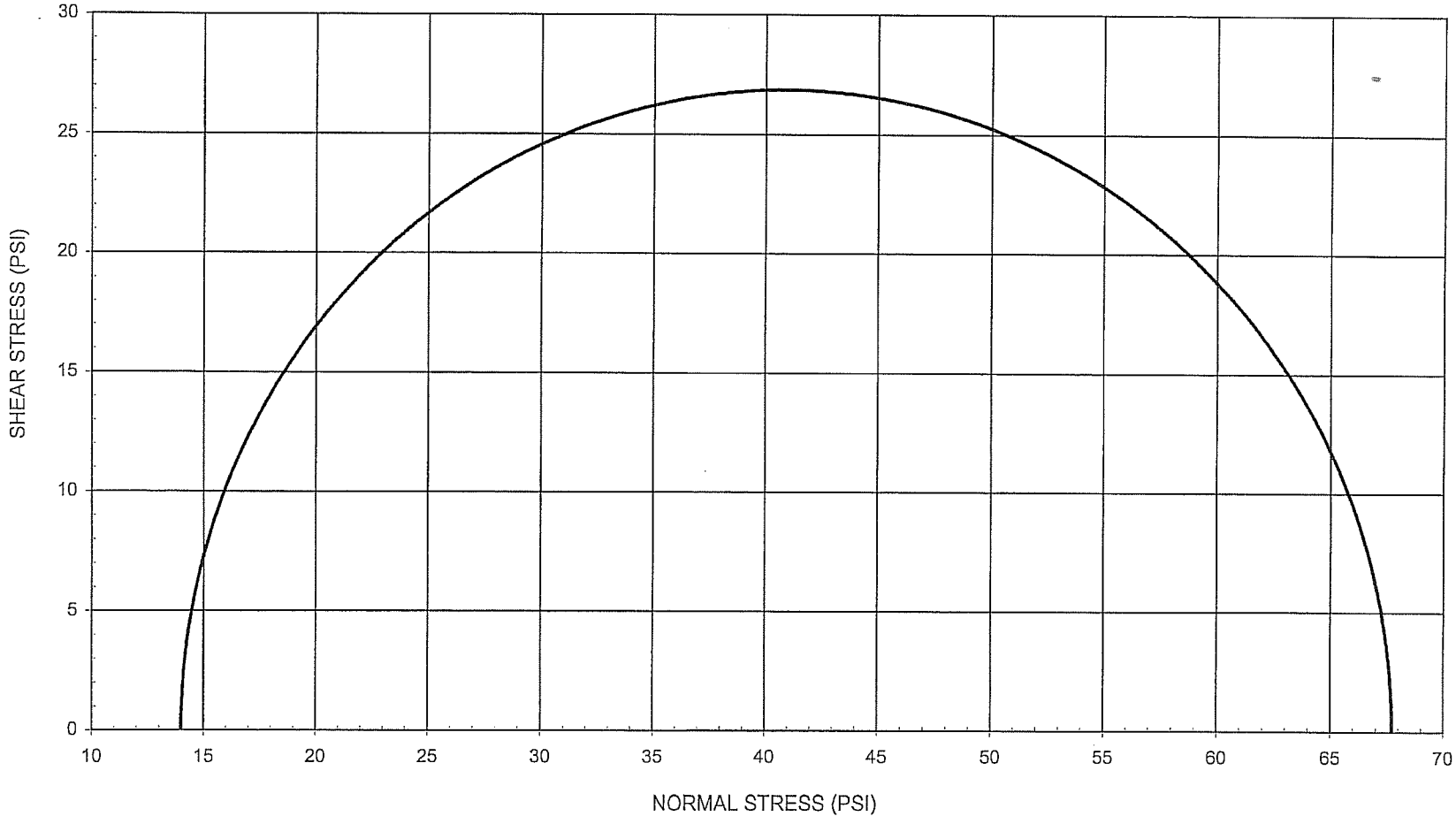
Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-09 Depth (ft): 45



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-09 Depth (ft): 45



AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-034	D-04	20	24.1	98.5
R-09-034	S-05	25	26.6	NA
R-09-034	S-07	35	33.5	NA
R-09-034	D-12	60	26.7	117.8
R-09-034	S-13	65	26.6	NA
R-09-034	D-16	80	21.1	98.3
R-09-034	S-18	100	34.9	NA
R-09-034	S-20	120	13.3	NA
R-09-034	S-22	150	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-034	D-02	10	0.31
R-09-034	U-03	16	1.38
R-09-034	D-12	60	2.96

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

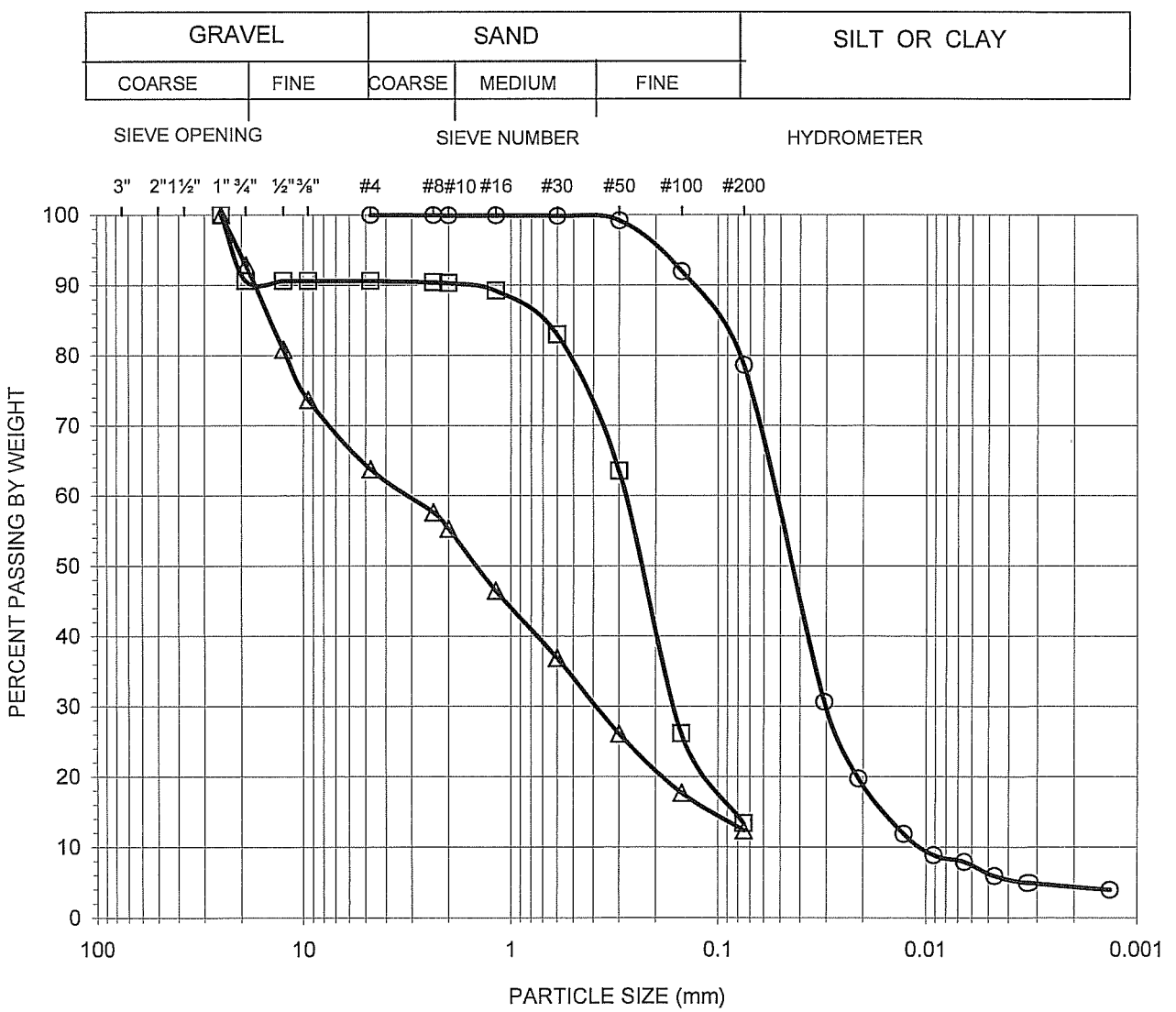
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-034	S-05	25	45.21
R-09-034	D-06	30	5.96
R-09-034	S-07	35	41.20
R-09-034	D-10	50	42.15
R-09-034	D-12	60	58.30
R-09-034	S-15	75	13.73

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

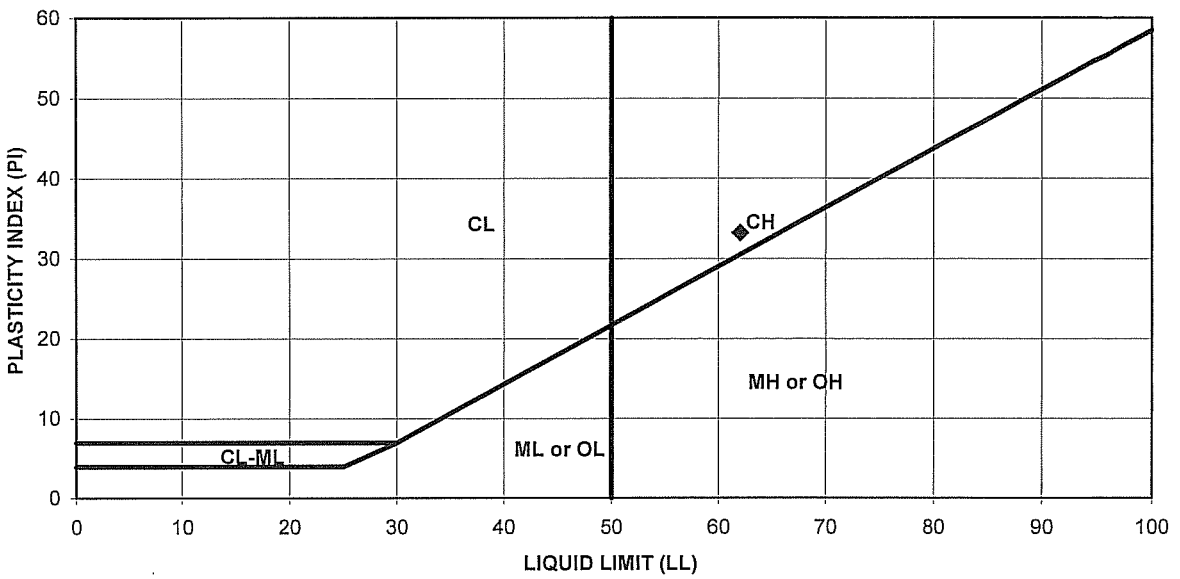


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-034	U-03	16	0.00	21.36	78.64	N/P	ML
□	R-09-034	S-18	100	9.40	77.23	13.37	N/A	SM
△	R-09-034	S-22	150	36.20	51.38	12.42	N/A	SM

AP Engineering & Testing, Inc.

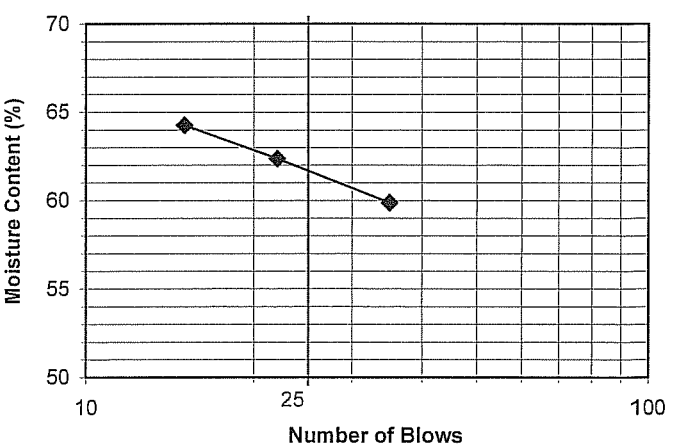
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



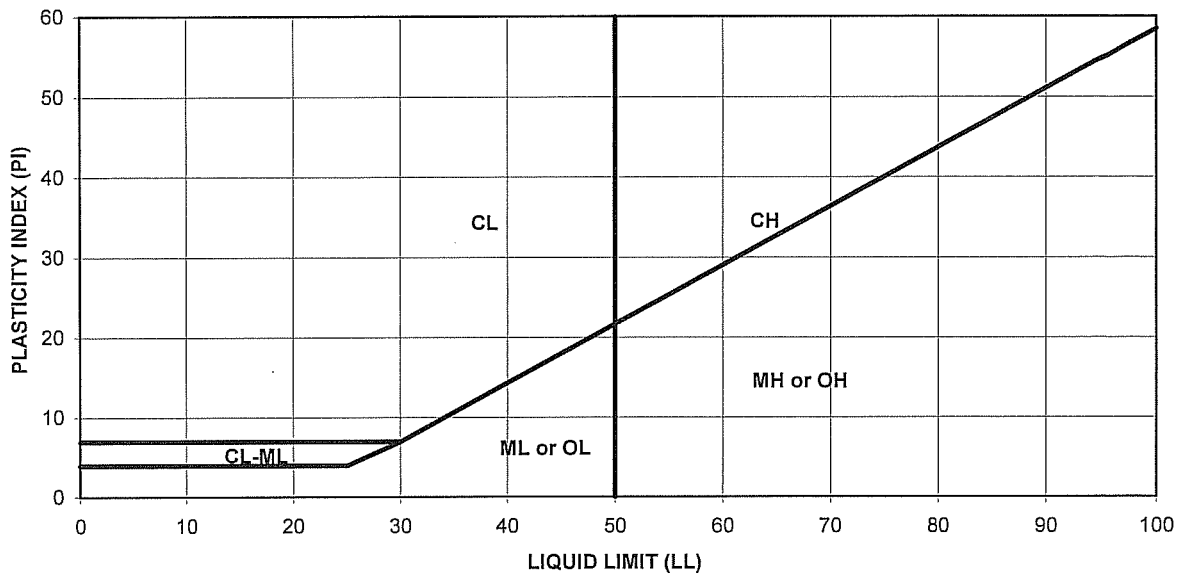
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-034	D-02	10	62	29	33	CH
	R-09-034	U-03	16	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

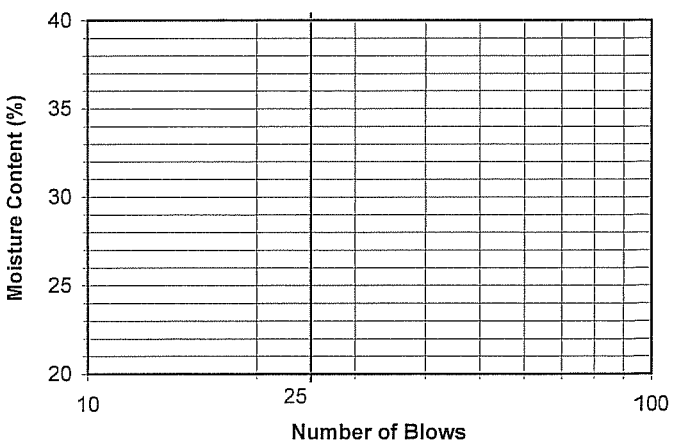
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-034	S-07	35	NP	NP	NP	

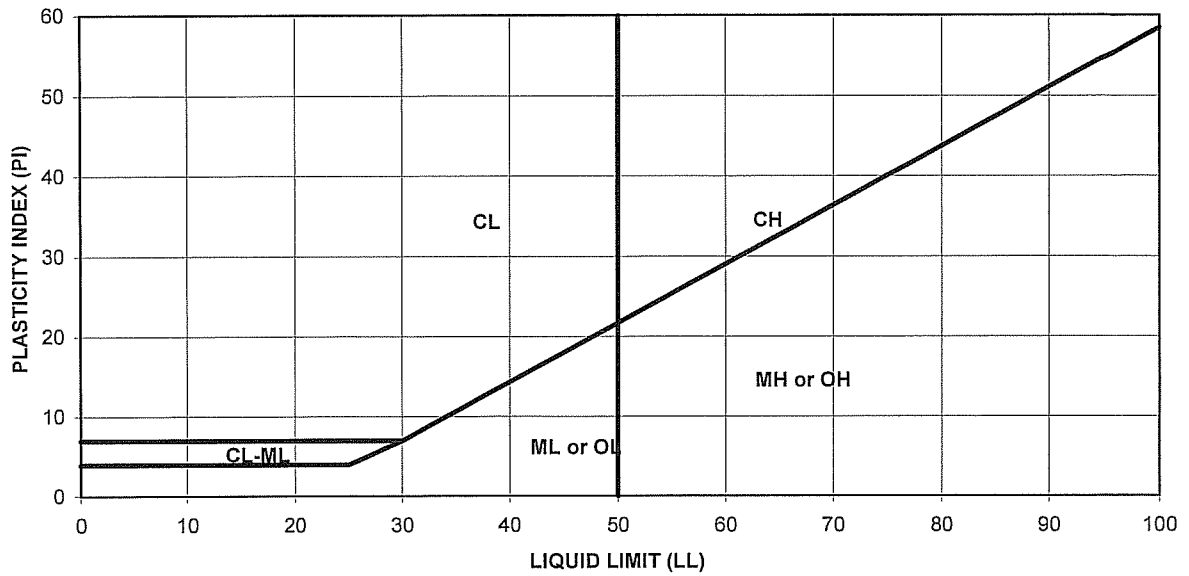
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

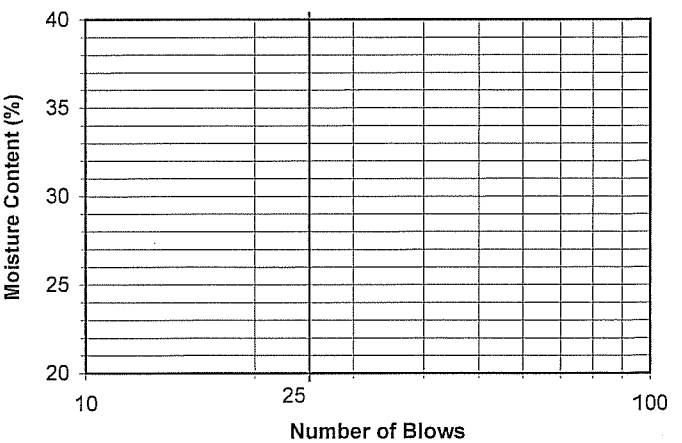
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/06/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-034	D-12	60	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/25/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-034					
SAMPLE NUMBER	U-03					
DEPTH (FT)	16					
SOIL CLASSIFICATION	Silt with sand					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	388.13					
TEMPERATURE, °C	20.0					
CORRECTION FACTOR	1.0000					
WT. DRY SOIL, g	41.27					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.72**					

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/16/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-034	D-02	10	CH	470	7.7	107	1281
R-09-034	S-07	35	SM	620	7.7	915	6316

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/19/09

Boring No.: R-09-034 Checked By: AP Date: 12/01/09

Sample No.: D-06 Depth (ft): 30

Description: Gray Poorly-Graded Sand w/silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	586.70
Total Ring Weight (g)	139.93
Wet Density (pcf)	123.85
Dry Density (pcf)	99.64

Moisture Determination	Before Test	After Test
Cont. Weight (g)	179.16	104.26
Wet Soil+Cont. (g)	346.93	532.23
Dry Soil+Cont. (g)	314.13	439.98
Moisture Content (%)	24.3	27.5
Degree Saturation	94.8	100.6

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

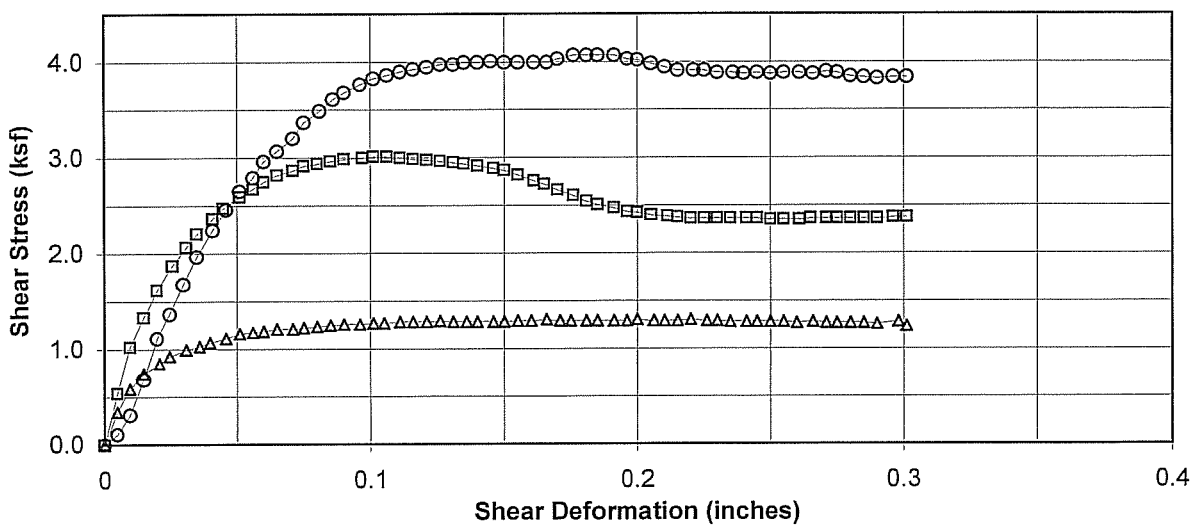
Shear Distance (in): **0.3**

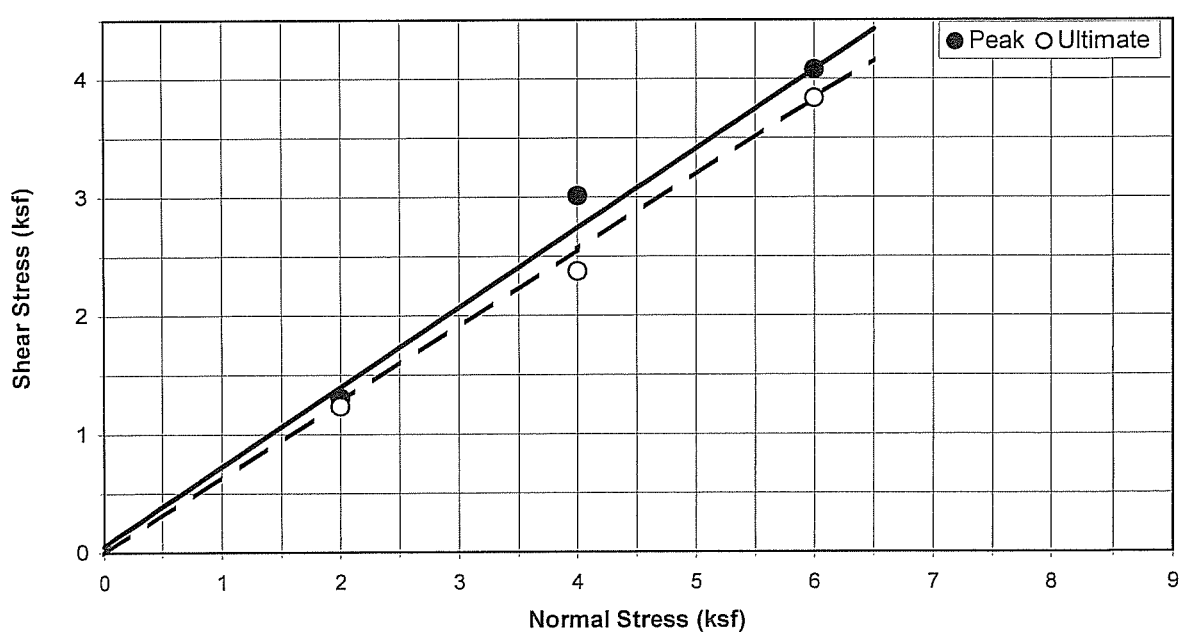
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**196.74**	**47.59**	**2.0**	**1308**	**1236**	
2	**194.81**	**46.29**	**4.0**	**3012**	**2376**	
3	**195.15**	**46.05**	**6.0**	**4080**	**3840**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	99.6	pcf
Boring No.:	R-09-034	Moisture Content (before):	24.3	%
Sample No.:	D-06	Moisture Content (after):	27.5	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	34 °	33 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/19/09

Boring No.: R-09-034 Checked By: AP Date: 12/01/09

Sample No.: D-08 Depth (ft): 40

Description: Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	576.23
Total Ring Weight (g)	133.93
Wet Density (pcf)	122.61
Dry Density (pcf)	94.17

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.44	104.78
Wet Soil+Cont. (g)	201.97	530.31
Dry Soil+Cont. (g)	166.82	431.86
Moisture Content (%)	30.2	30.1
Degree Saturation	98.8	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

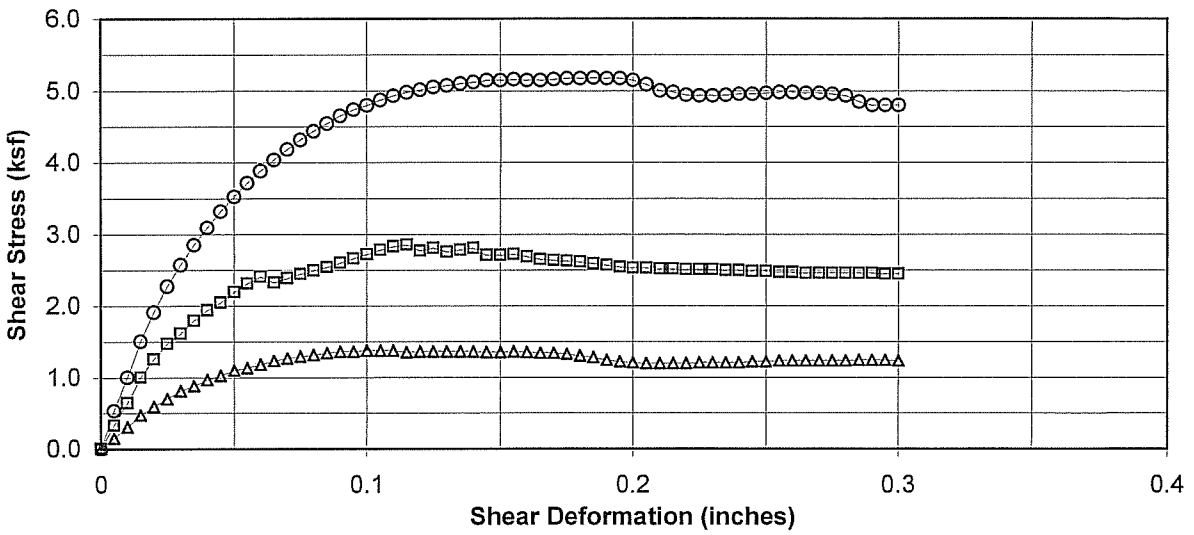
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

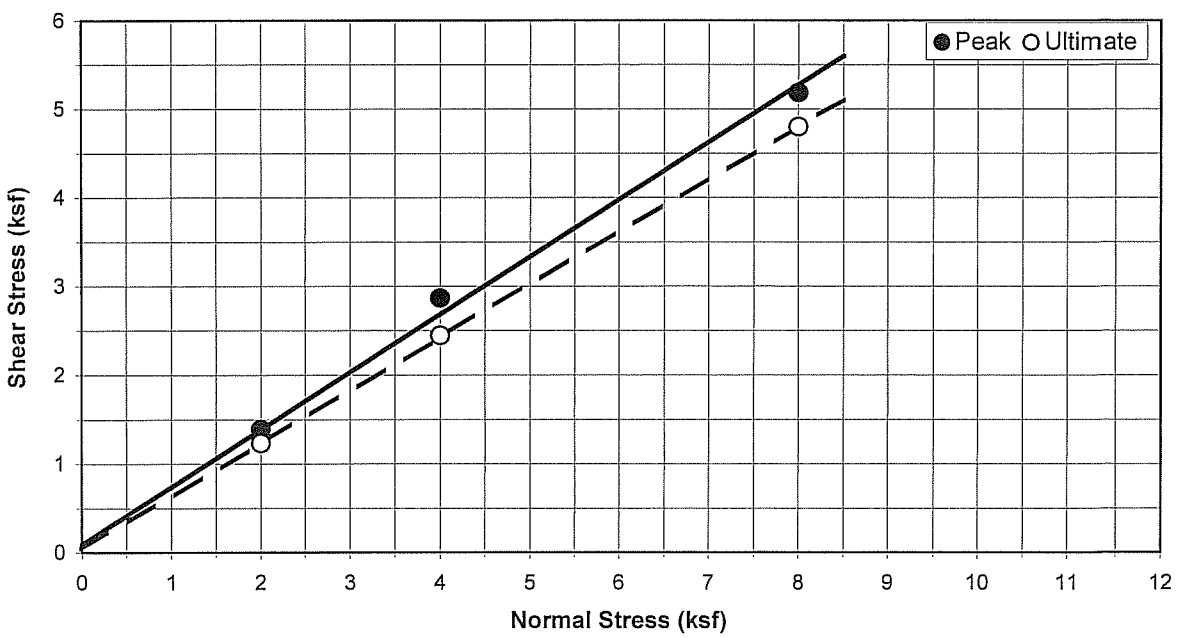
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**192.96**	**43.62**	**2.0**	**1392**	**1236**	
2	**193.96**	**46.65**	**4.0**	**2868**	**2448**	
3	**189.31**	**43.66**	**8.0**	**5184**	**4800**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.2	pcf
Boring No.:	R-09-034	Moisture Content (before):	30.2	%
Sample No.:	D-08	Moisture Content (after):	30.1	%
Depth (ft):	40			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	100	50
Friction Angle:	33 °	31 °

AP Engineering & Testing, Inc.

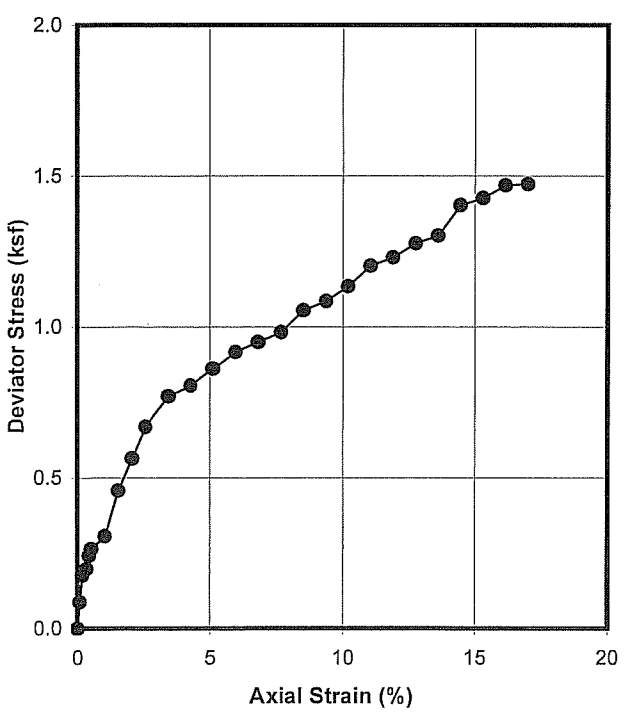
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-034				
Sample No.:	U-03	Depth (feet): 16			
Soil Description	Gray Silt with sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	117.9
Sample Hieght (inch):	5.9	Dry Unit Weight (pcf):	87.7
Sample Weight (gms):	1182.02	Moisture Content (%):	34.4
Wt. Wet Soil+Container(gms)	1373.35	Void Ratio for Gs=2.7:	0.92
Wt. Dry Soil+Container(gms)	1071.47	% Saturation:	100.9
Wt. Container (gms)	194.37		

TEST DATA

Cell Pressure (ksf):	0.72
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	0.72
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.5
Ultimate Deviator Stress (ksf):	1.4
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	17.01



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
4	0.005	6.50	0.09	0.09
8	0.010	6.50	0.18	0.17
9	0.020	6.51	0.20	0.34
11	0.025	6.52	0.24	0.43
12	0.030	6.53	0.26	0.51
14	0.060	6.56	0.31	1.02
21	0.090	6.59	0.46	1.53
26	0.120	6.63	0.56	2.04
31	0.150	6.66	0.67	2.55
36	0.200	6.72	0.77	3.40
38	0.250	6.78	0.81	4.25
41	0.300	6.84	0.86	5.10
44	0.350	6.90	0.92	5.95
46	0.400	6.97	0.95	6.80
48	0.450	7.03	0.98	7.65
52	0.500	7.10	1.06	8.50
54	0.550	7.16	1.09	9.35
57	0.600	7.23	1.14	10.20
61	0.650	7.30	1.20	11.05
63	0.700	7.37	1.23	11.90
66	0.750	7.44	1.28	12.76
68	0.800	7.51	1.30	13.61
74	0.850	7.59	1.40	14.46
76	0.900	7.67	1.43	15.31
79	0.950	7.74	1.47	16.16
80	1.000	7.82	1.47	17.01

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-035	S-01	5.0	25.4		9.3	
R-09-035	D-02	10.0				38,29,10
R-09-035	U-03	15.0				28,23,5
R-09-035	D-04	20.0	43.1	80.0		
R-09-035	D-06	30.0	33.3	90.2		24,22,2
R-09-035	S-07	35.0			48.8	
R-09-035	D-08	40.0	31.1	92.7		
R-09-035	S-09	45.0	39.7			
R-09-035	U-10	50.0				NP
R-09-035	S-11	55.0	33.4		37.0	
R-09-035	D-12	60.0	21.9	105.4		
R-09-035	S-13	65.0			19.9	
R-09-035	D-14	70.0	27.0	98.7		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-035	D-02	10	7.88	465	0.051	610
R-09-035	S-09	45	8.65	2215	0.056	230

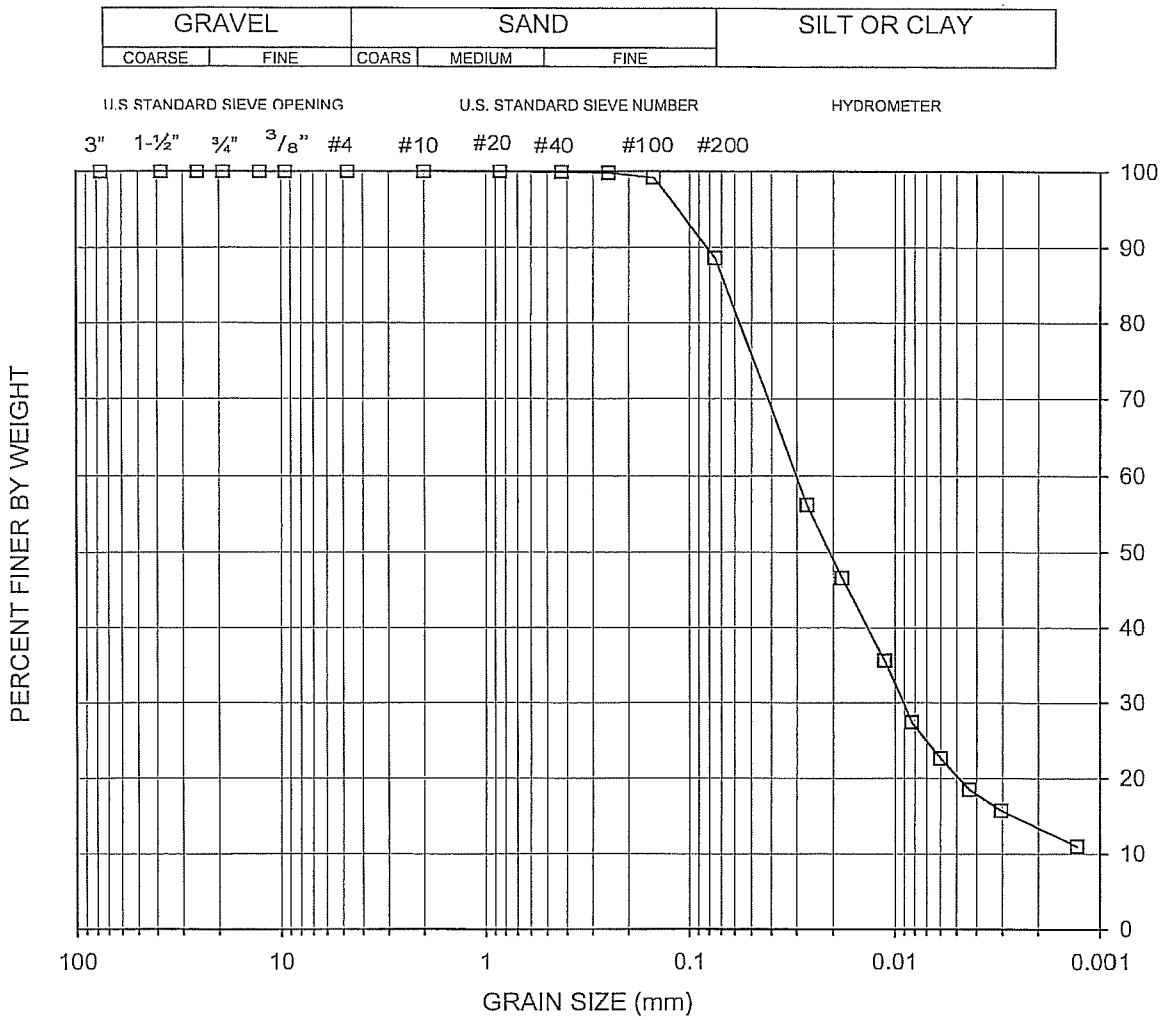
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-035	U-03	15	2.763
R-09-035	U-10	50	2.742



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-03	15	Shelby Tube	ML	28	5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

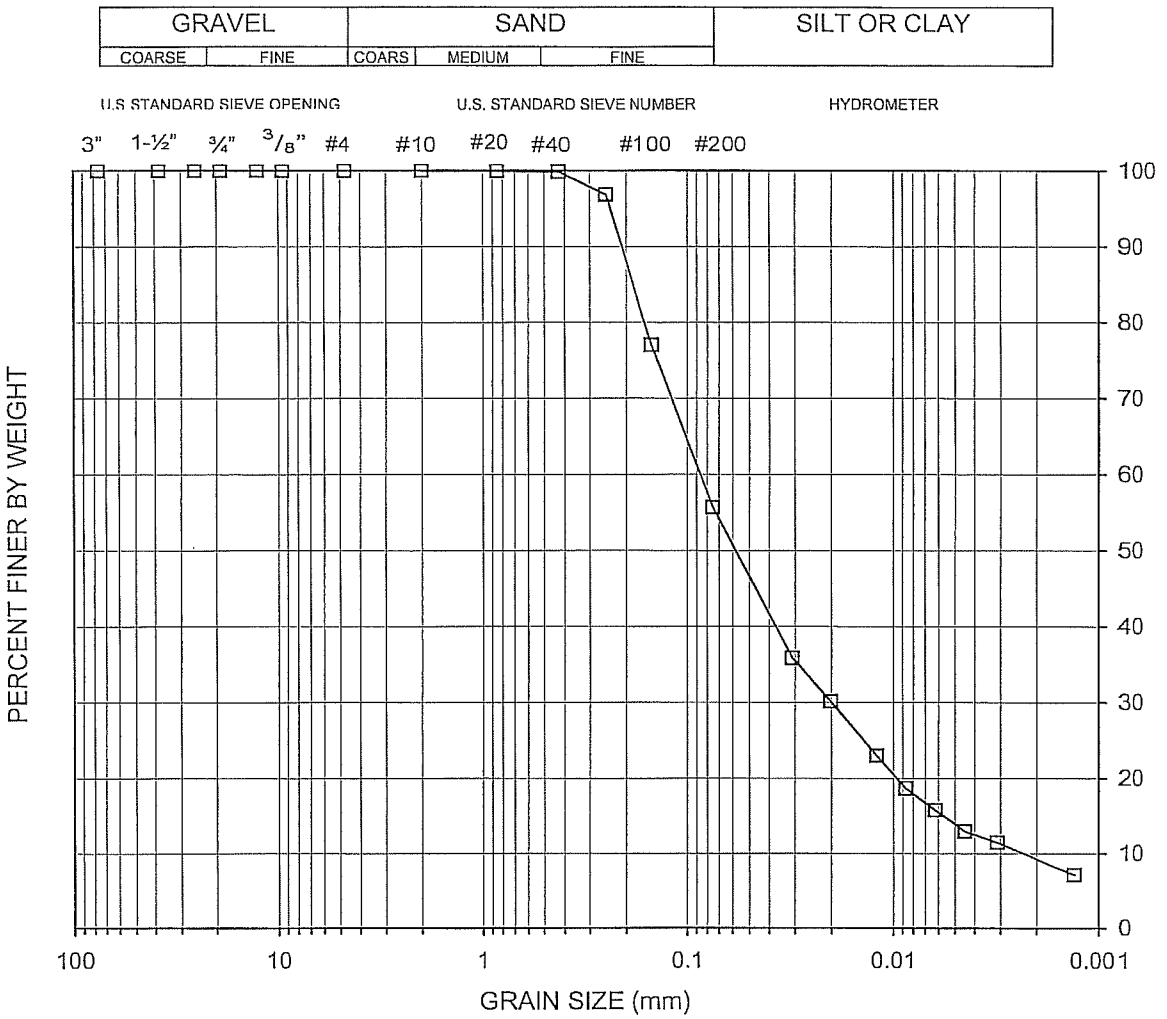
Client: Earth Mechanic, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-10	50	Shelby Tube	ML	NP	N/A

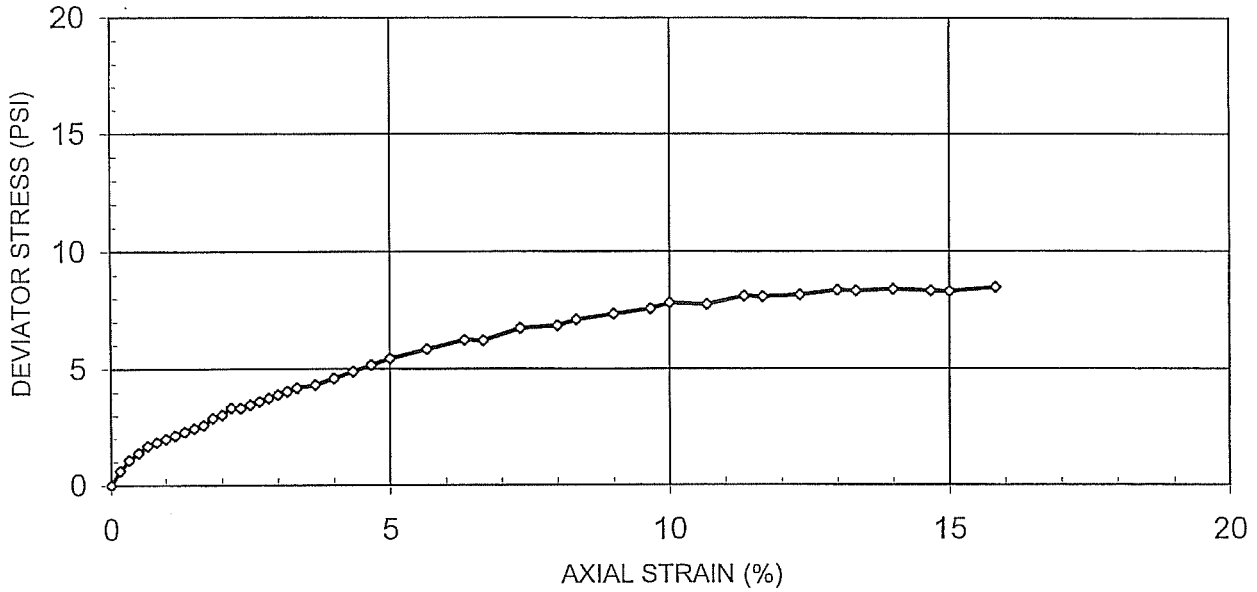
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

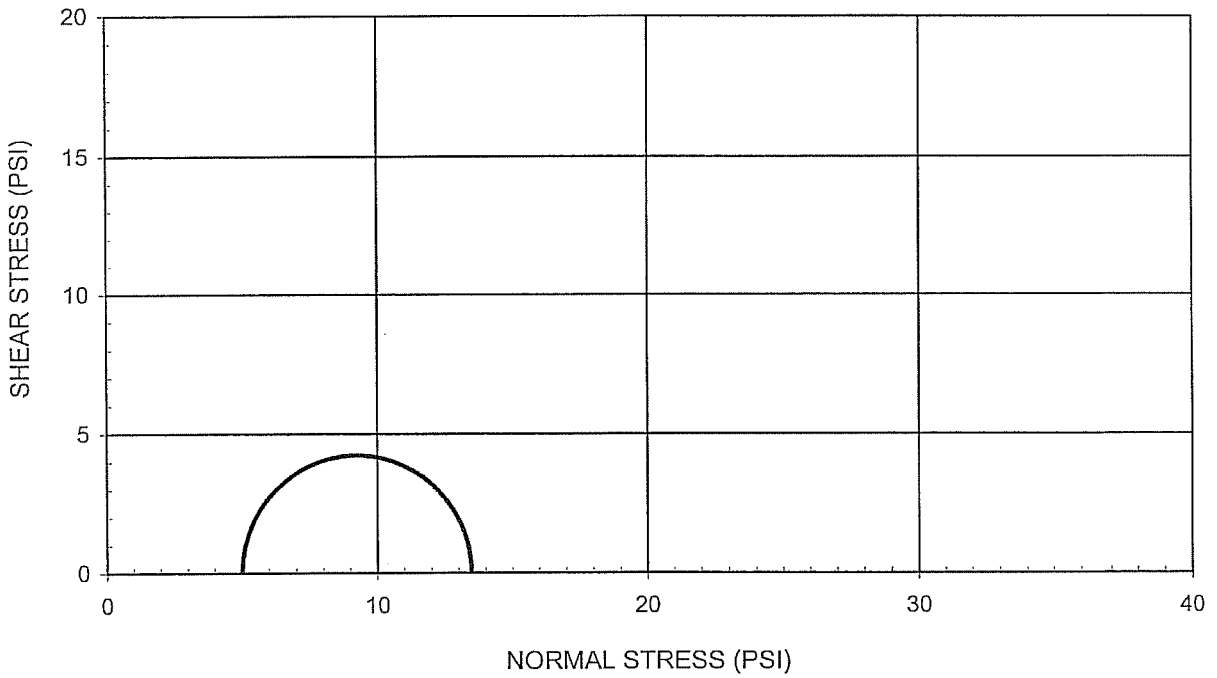
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	15	U-03	ML	Shelby Tube	41.01	80.0	5.0	8.5	0.06	100.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

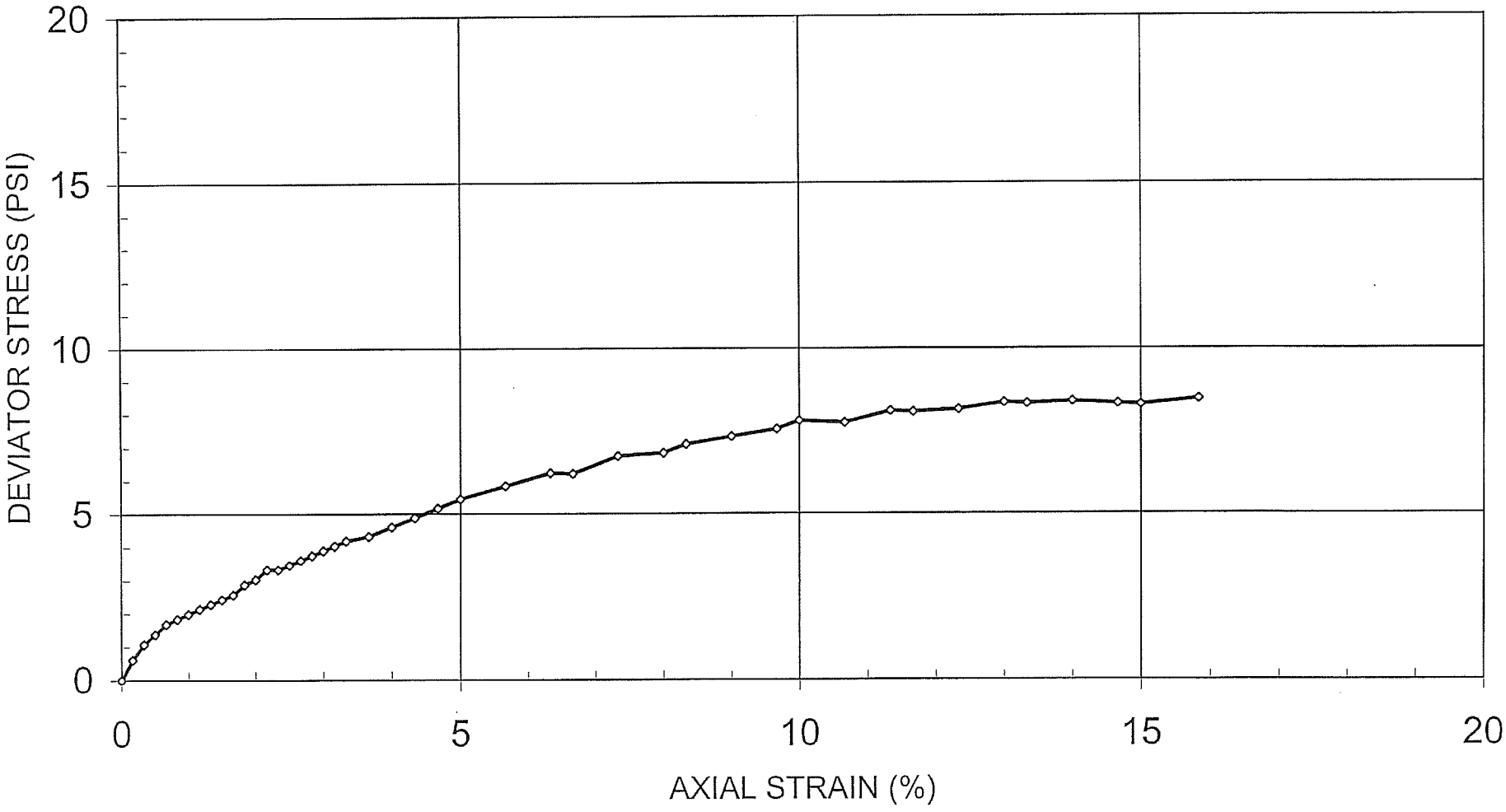
(ASTM D2850)

11/29/09

Figure

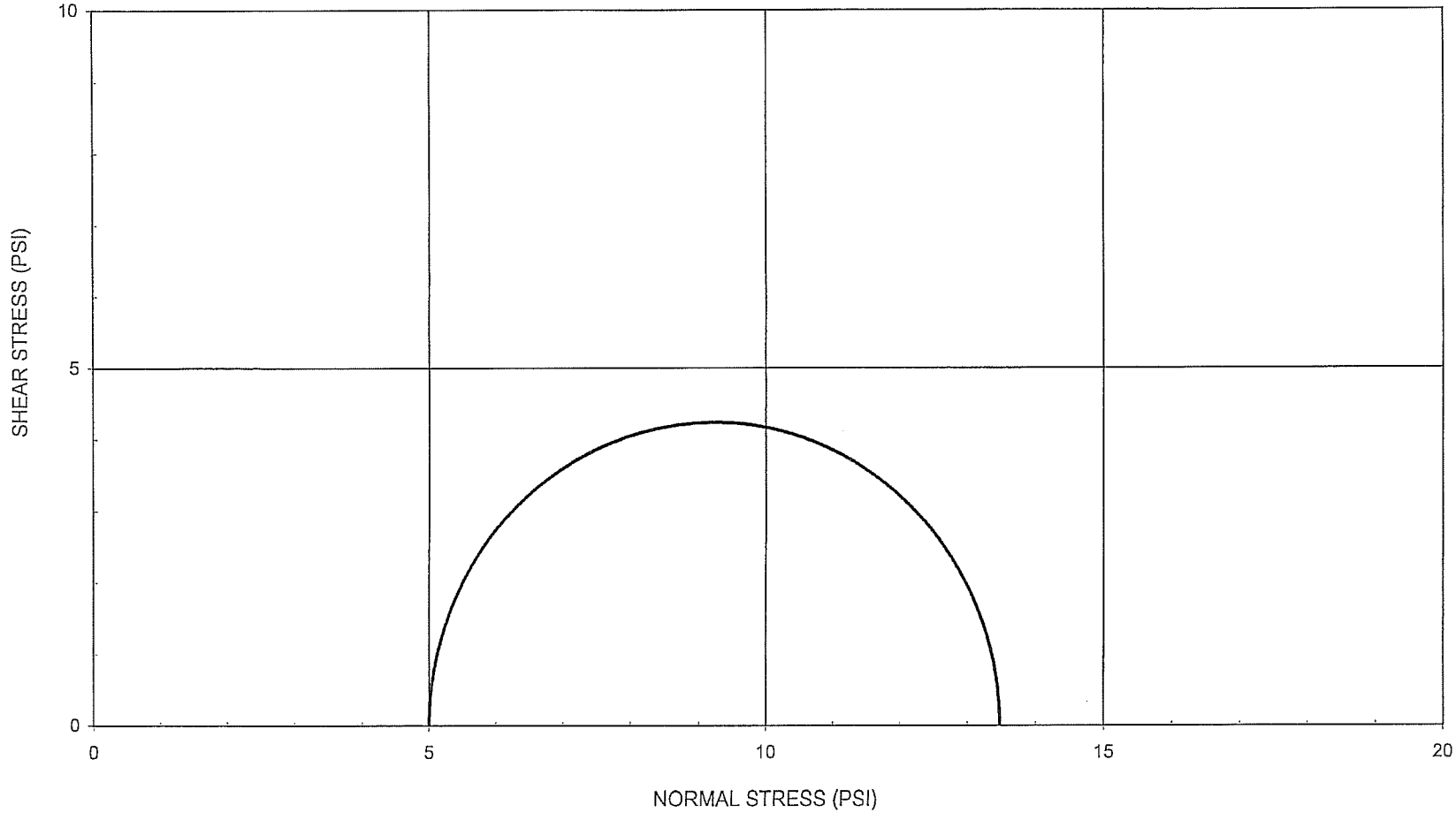
Project Name: ACTA Heim Bridge Replacement

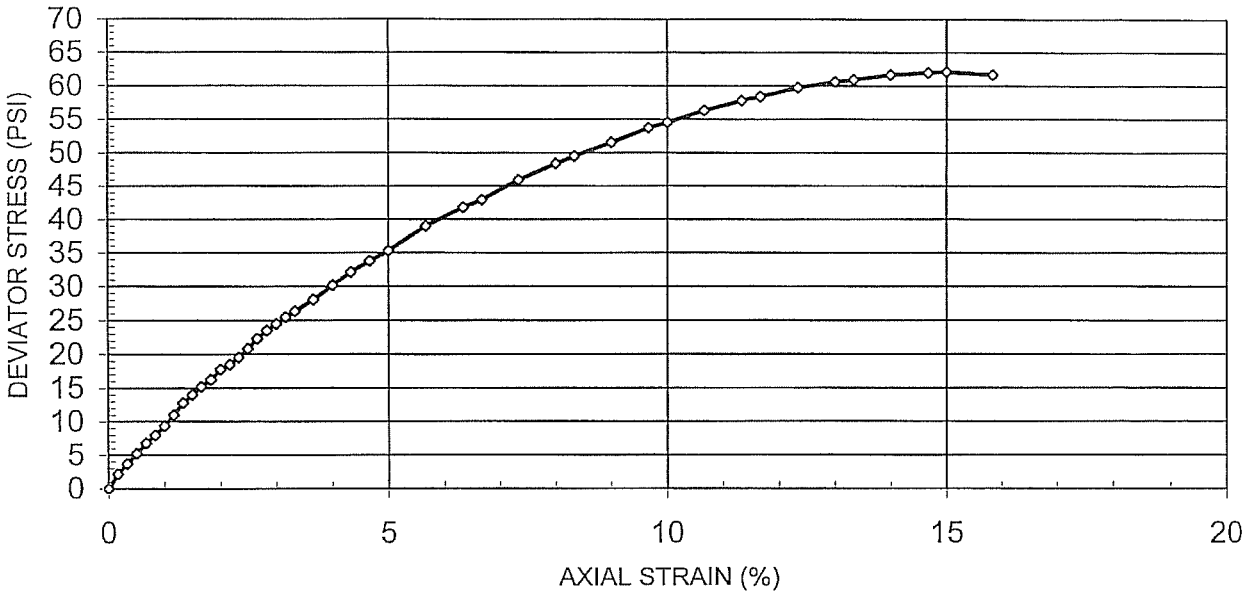
Boring: R-09-035 Sample ID: U-03 Depth (ft): 15

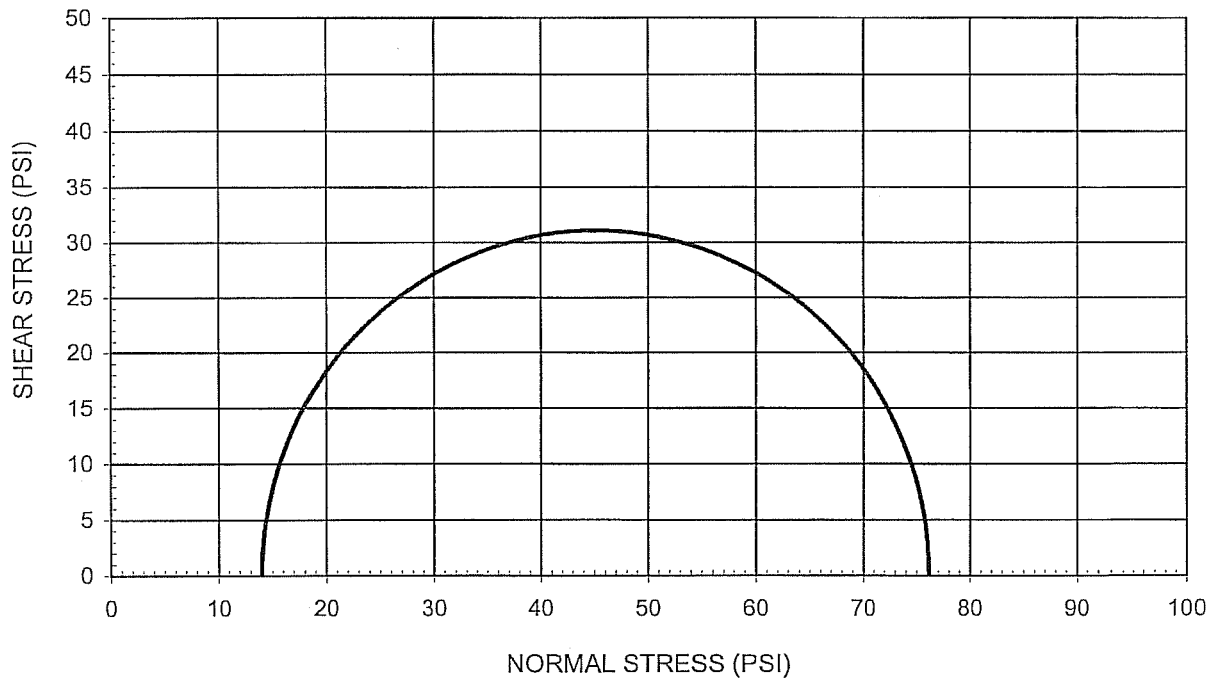


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-03 Depth (ft): 15







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	50	U-10	ML	Shelby Tube	22.25	106.6	14.0	62.1	0.06	103.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

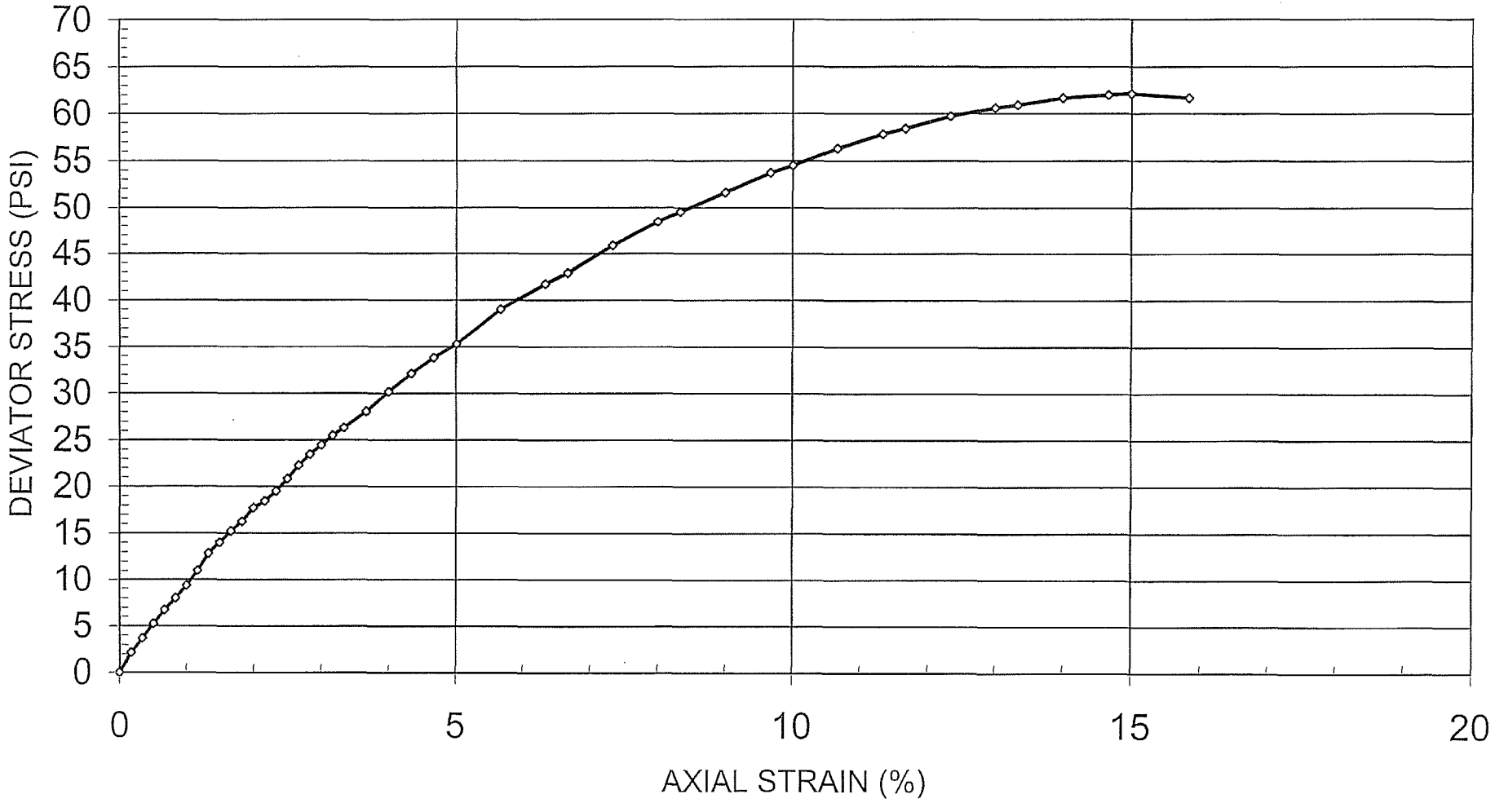
(ASTM D2850)

11/29/09

Figure

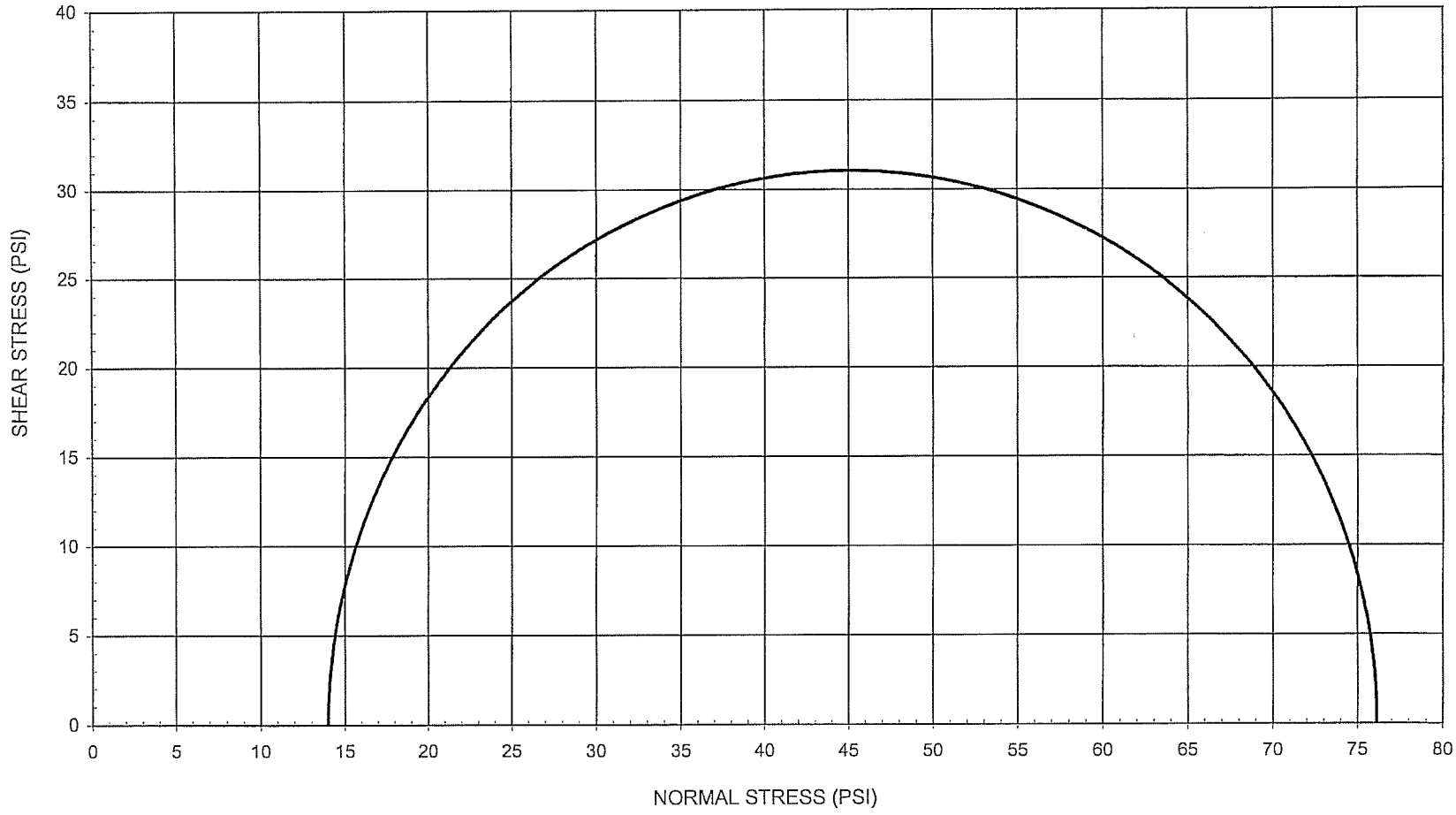
Project Name: ACTA Heim Bridge Replacement

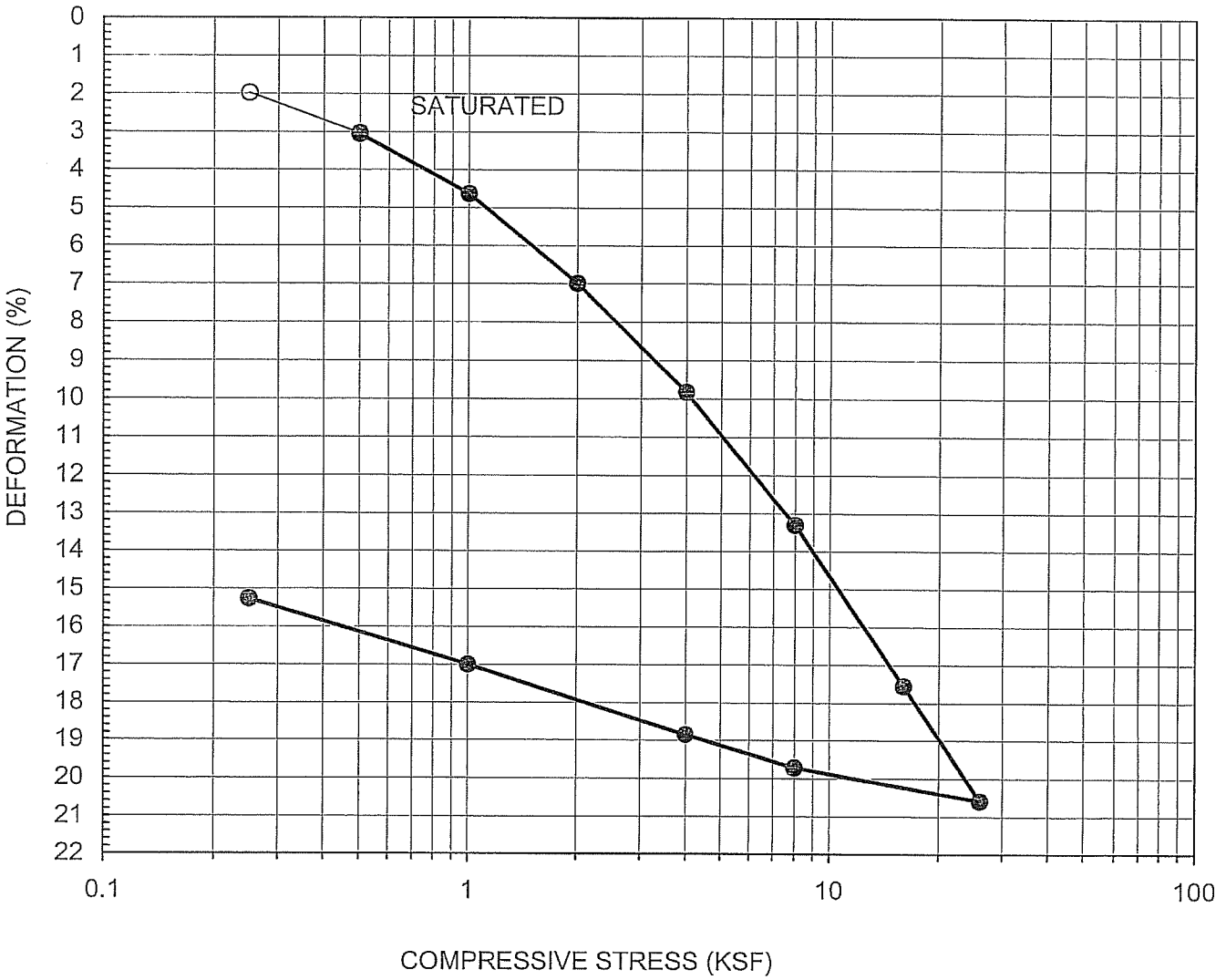
Boring: R-09-035 Sample ID: U-10 Depth (ft): 50



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-10 Depth (ft): 50





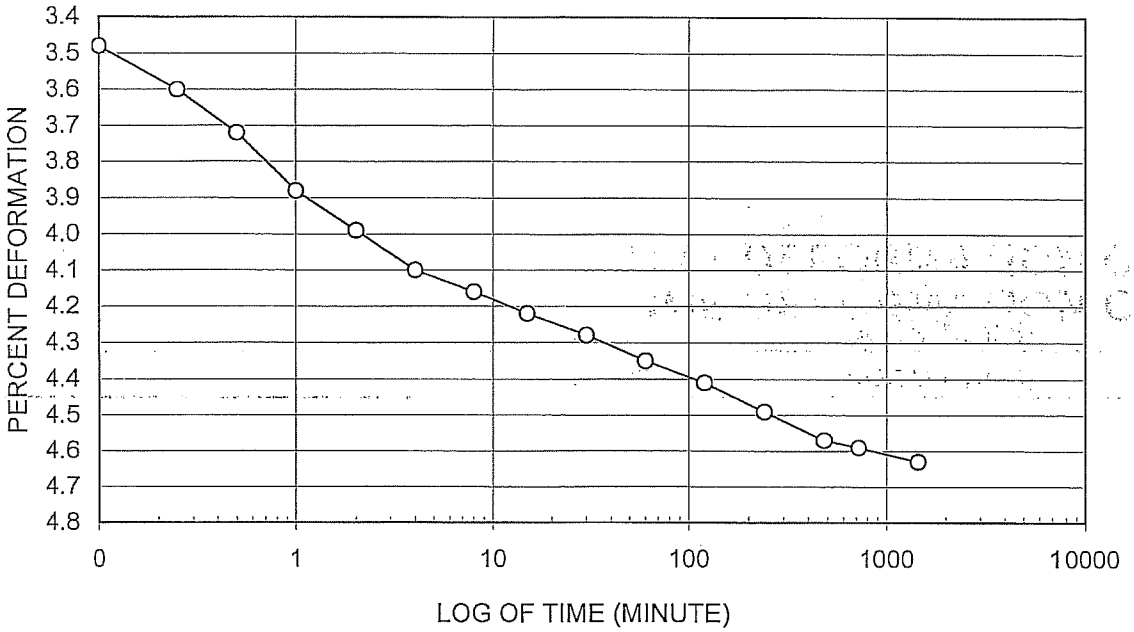
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	D-02	10.0	ML	48.0	73.9	1.279

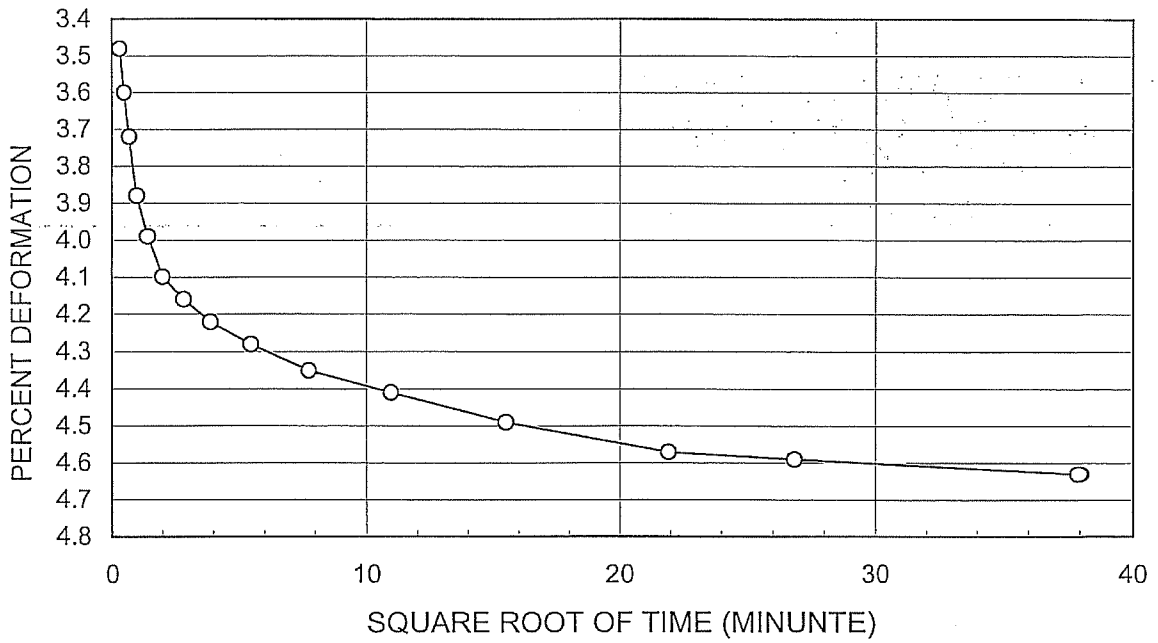
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





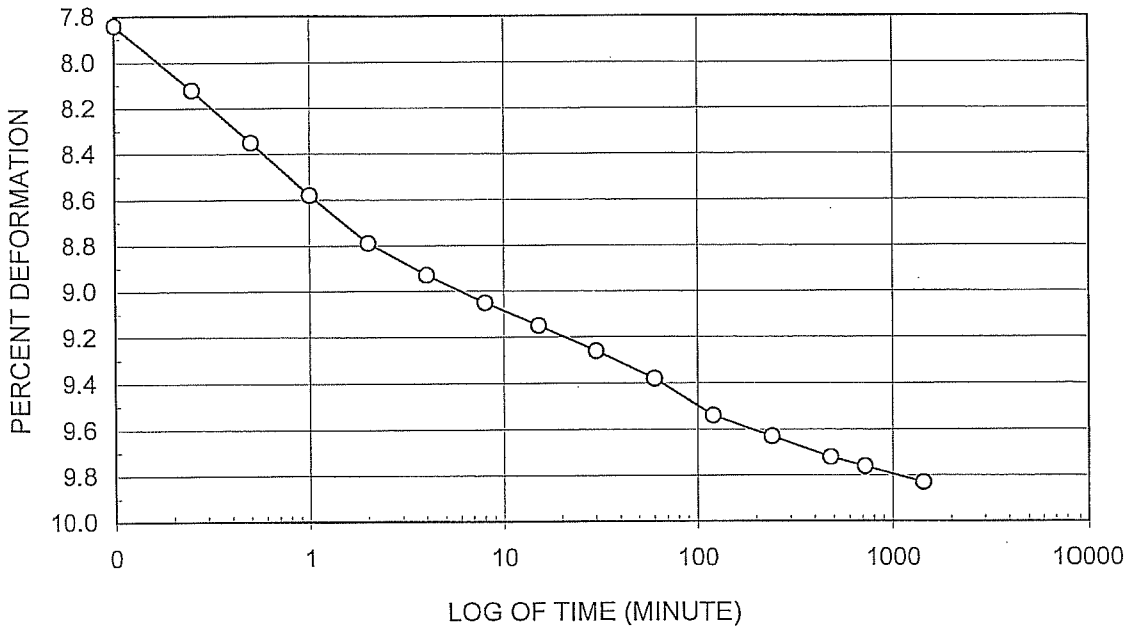
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 1.0 ksf

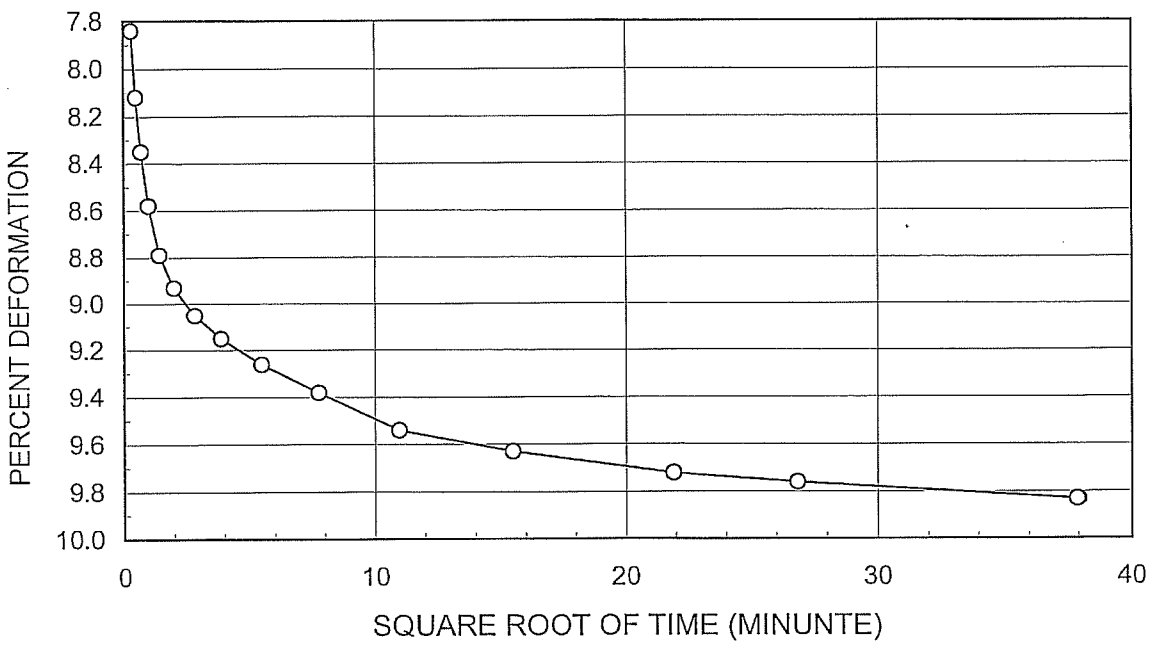
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





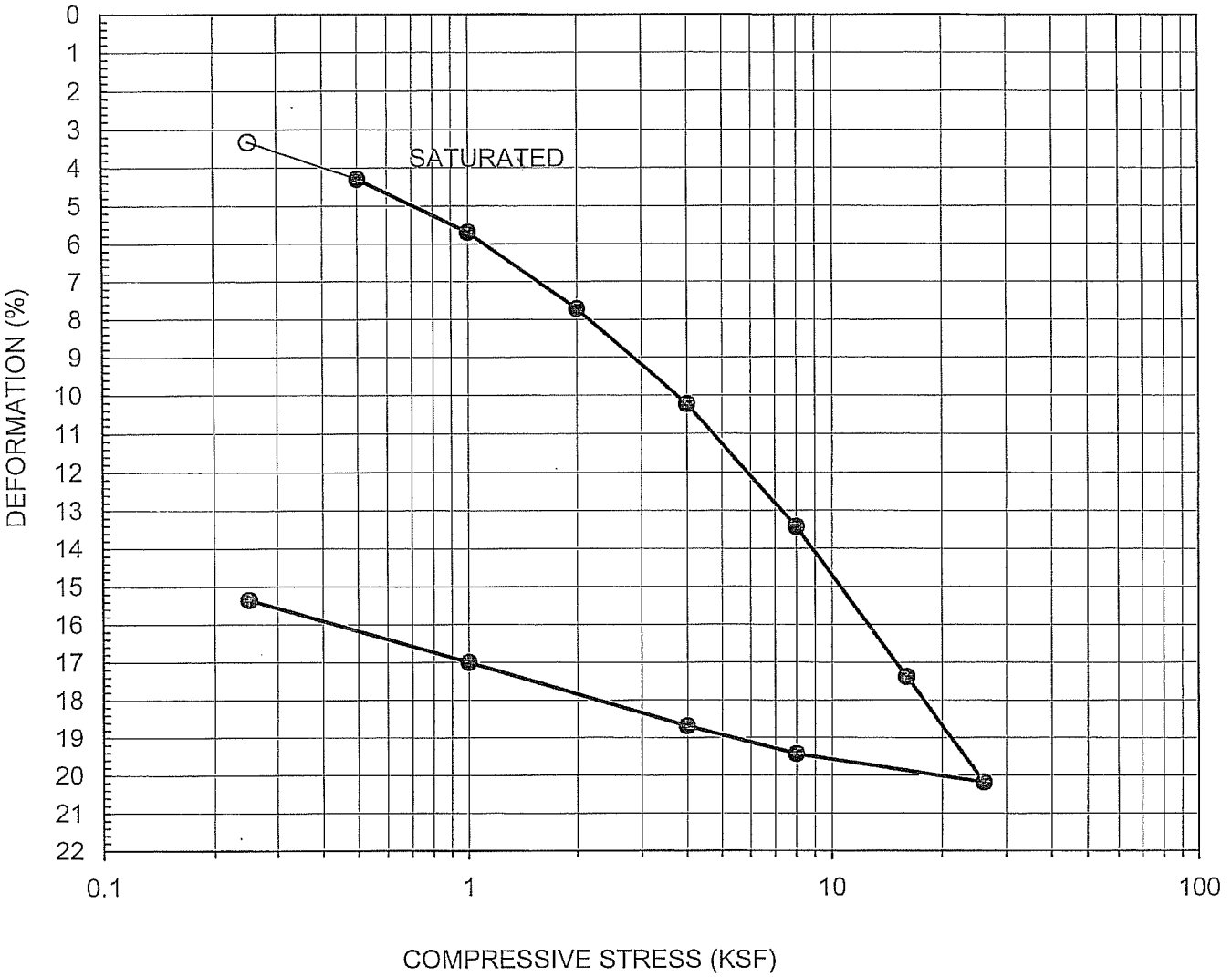
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



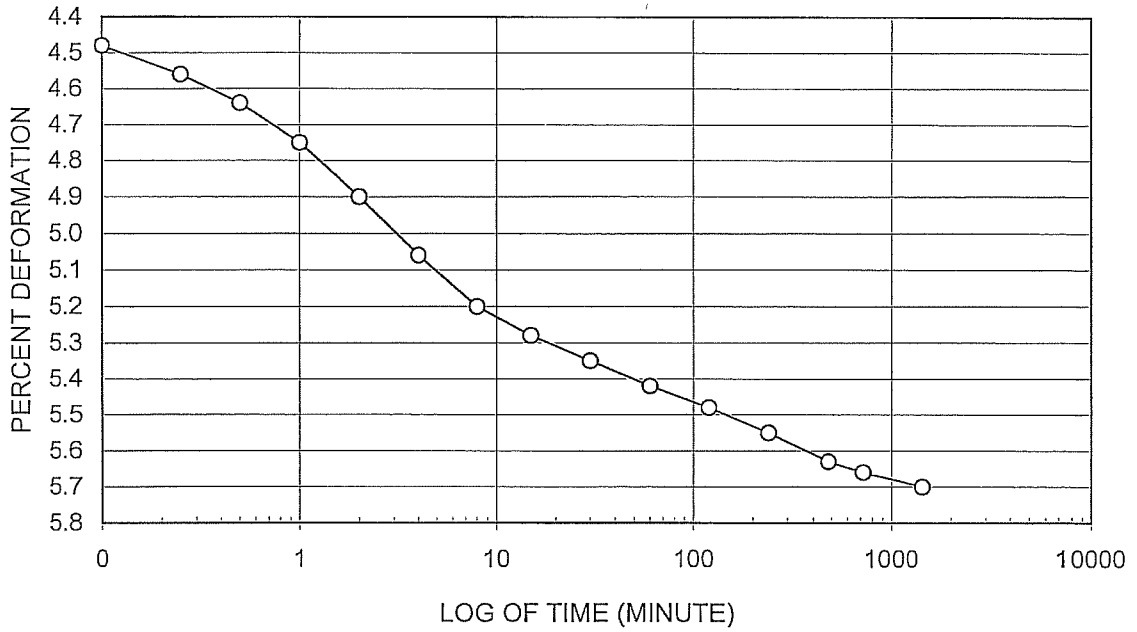
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-03	15.0	ML	40.8	78.1	1.157

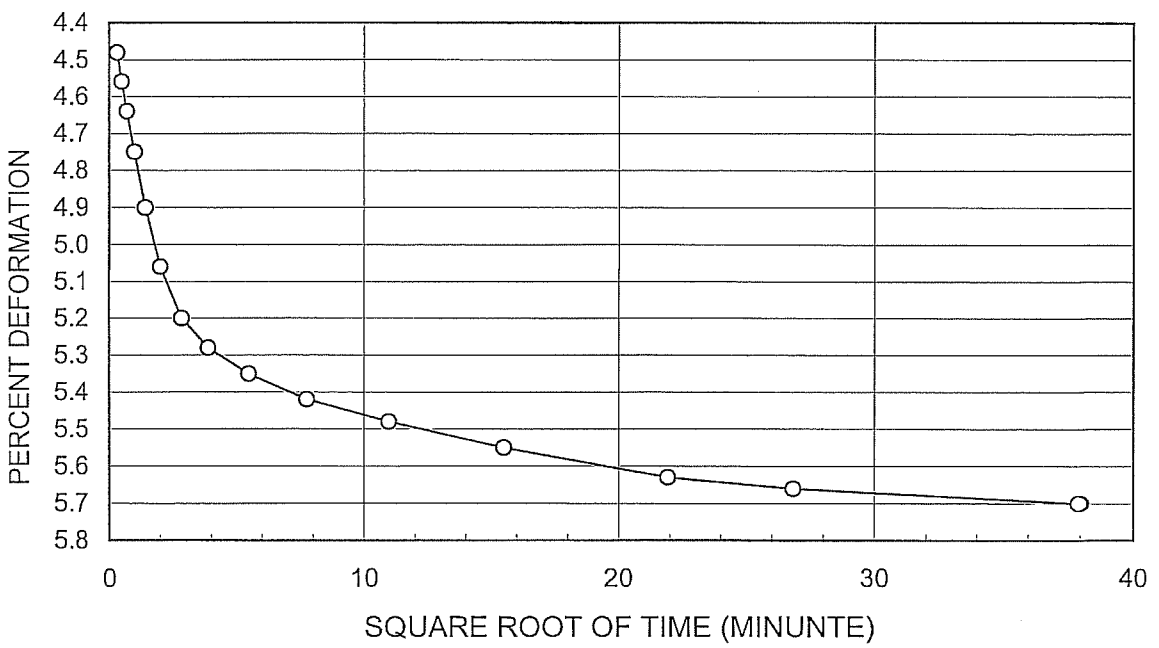
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





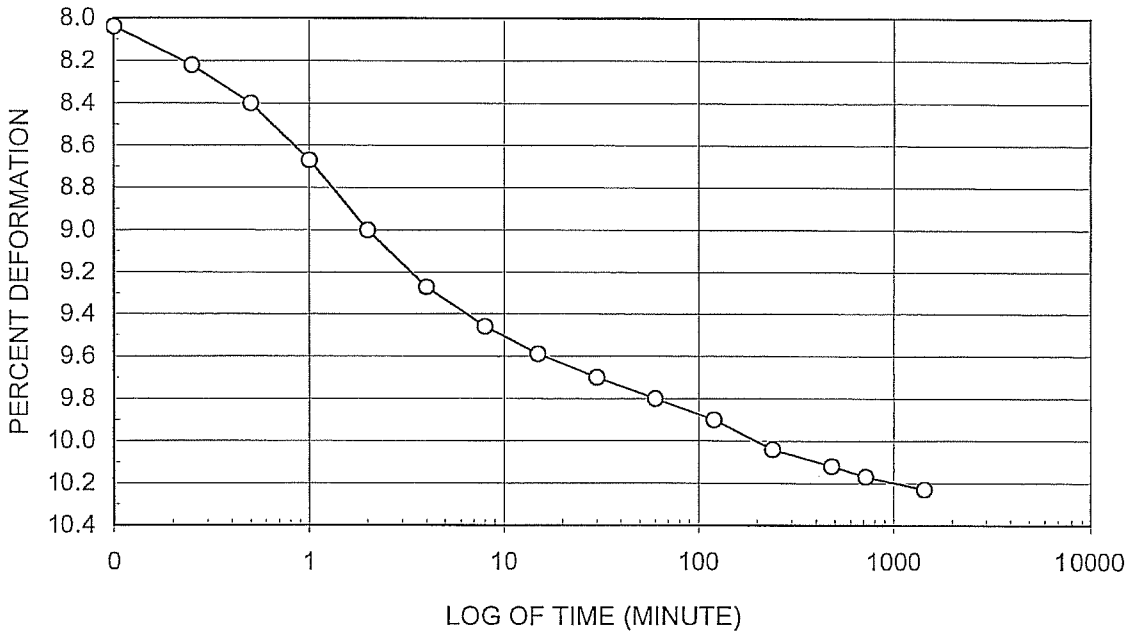
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 1.0 ksf

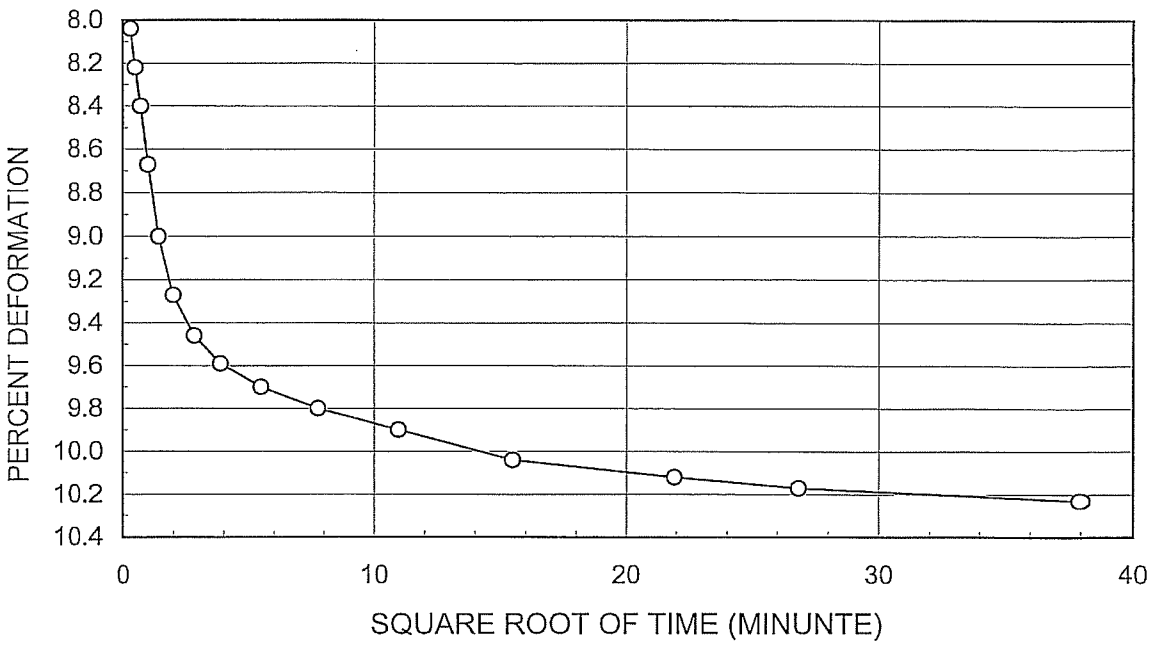
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





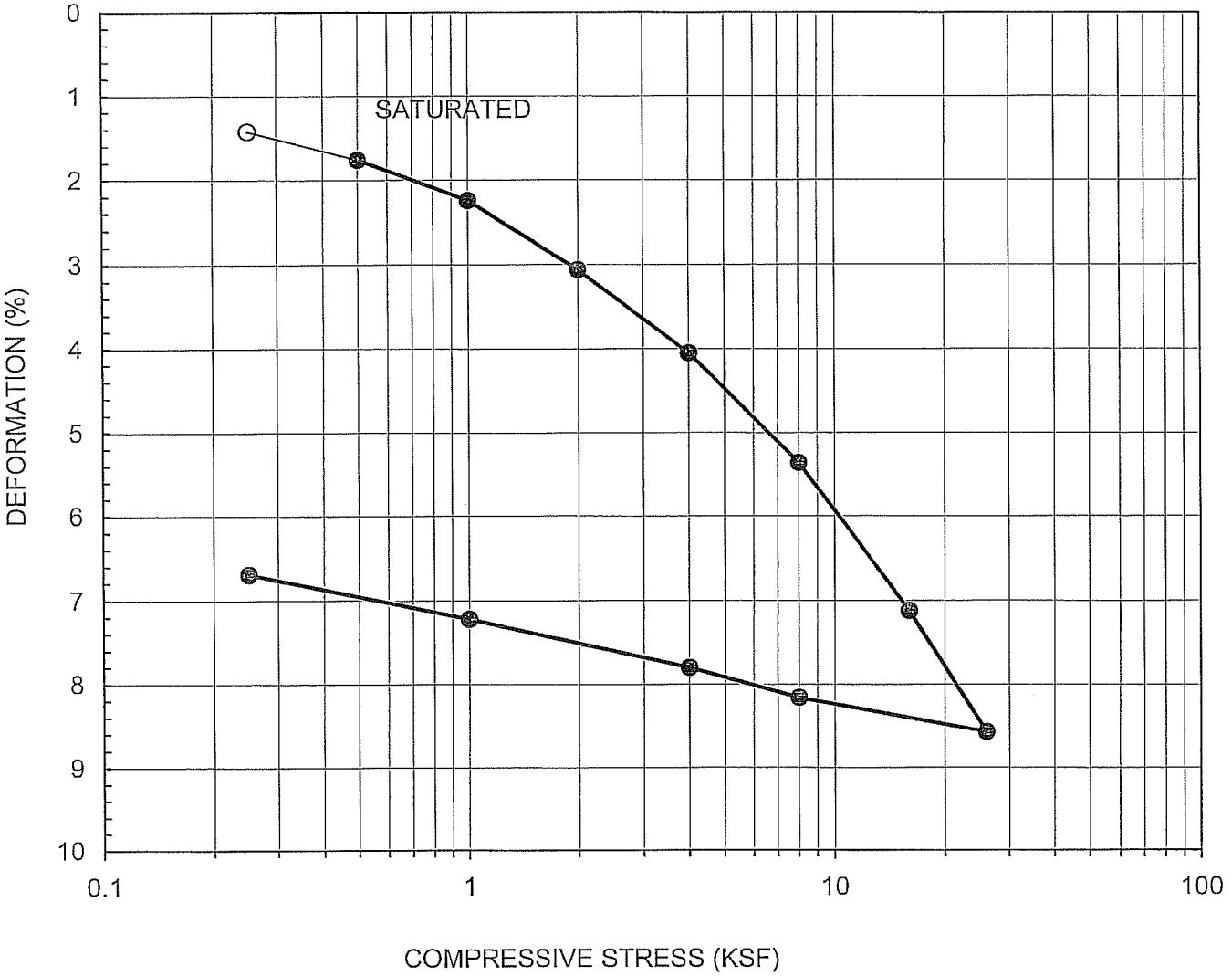
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



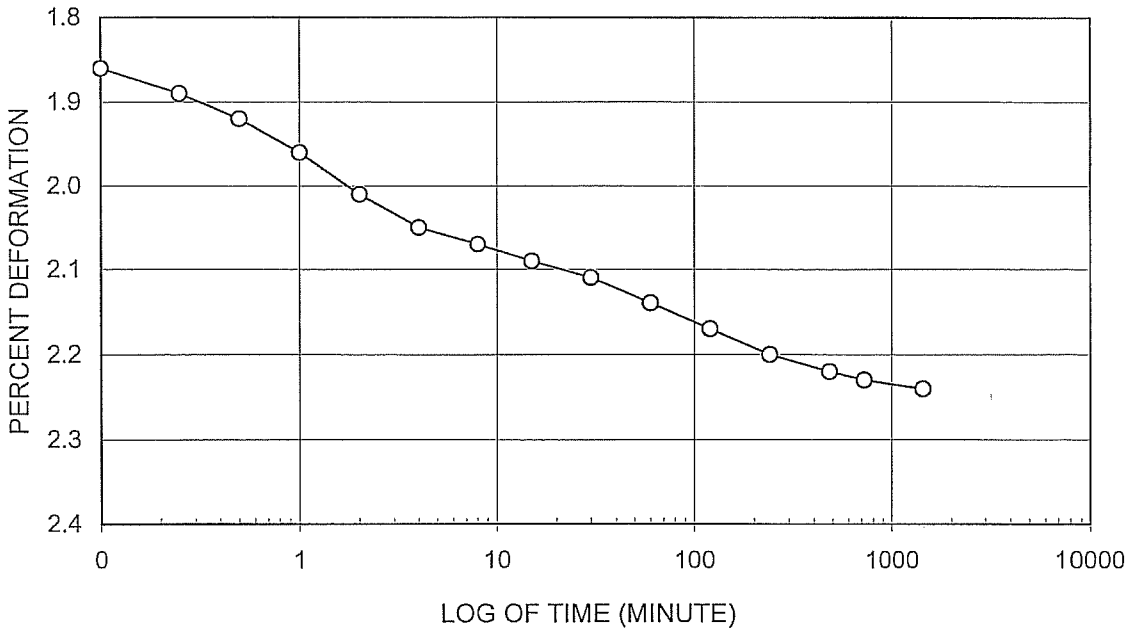
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-10	50.0	ML	21.6	109.1	0.544

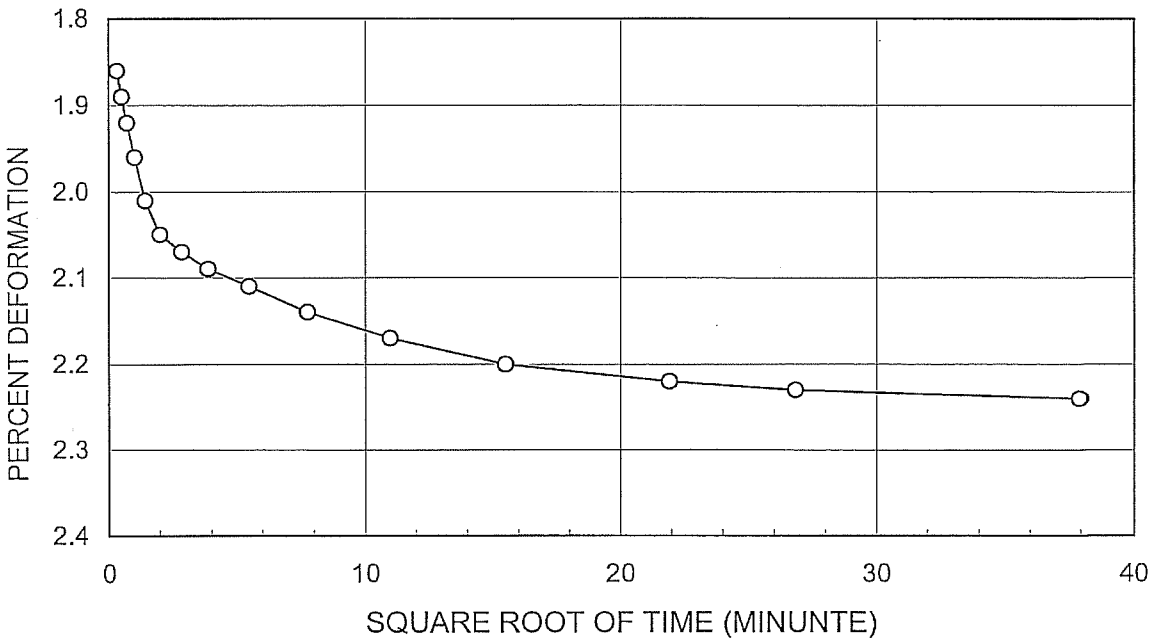
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





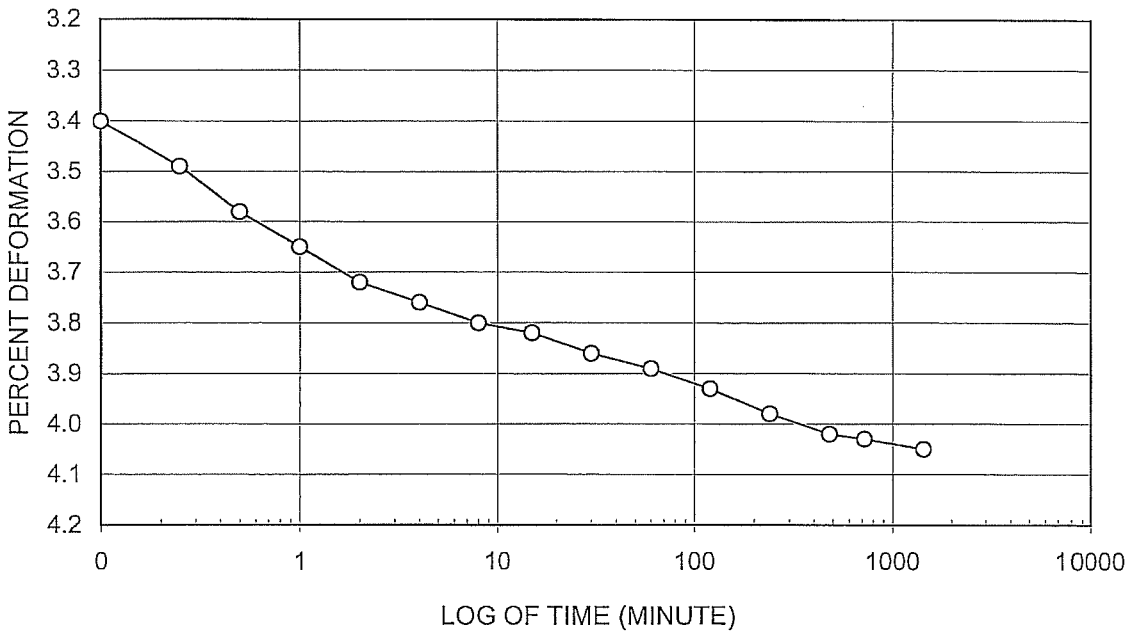
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 1.0 ksf

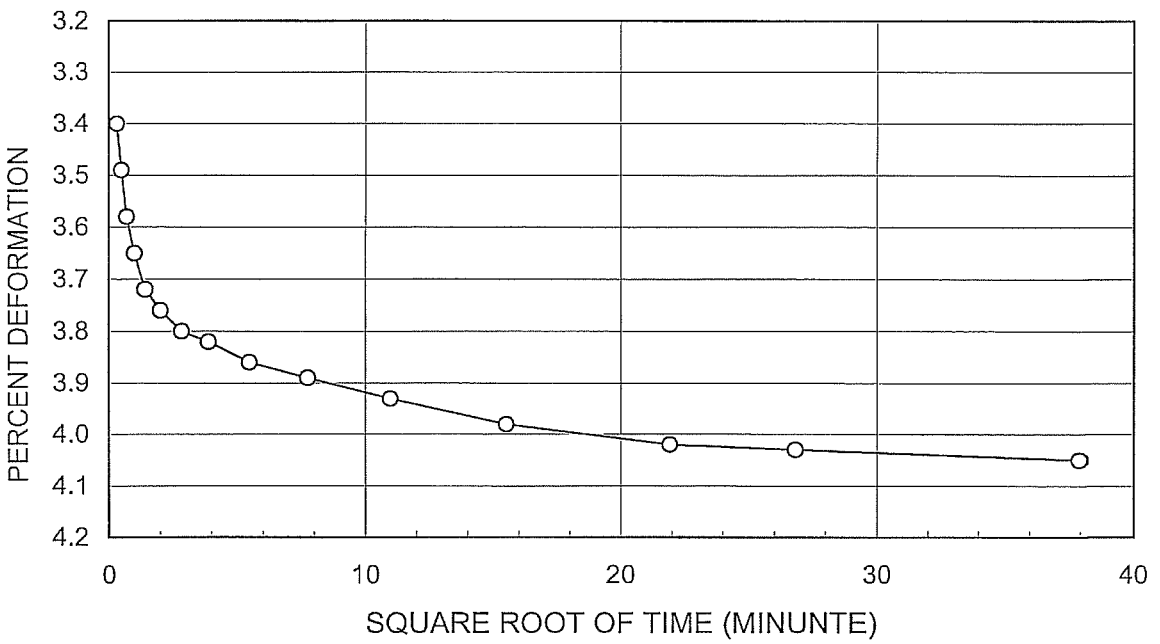
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





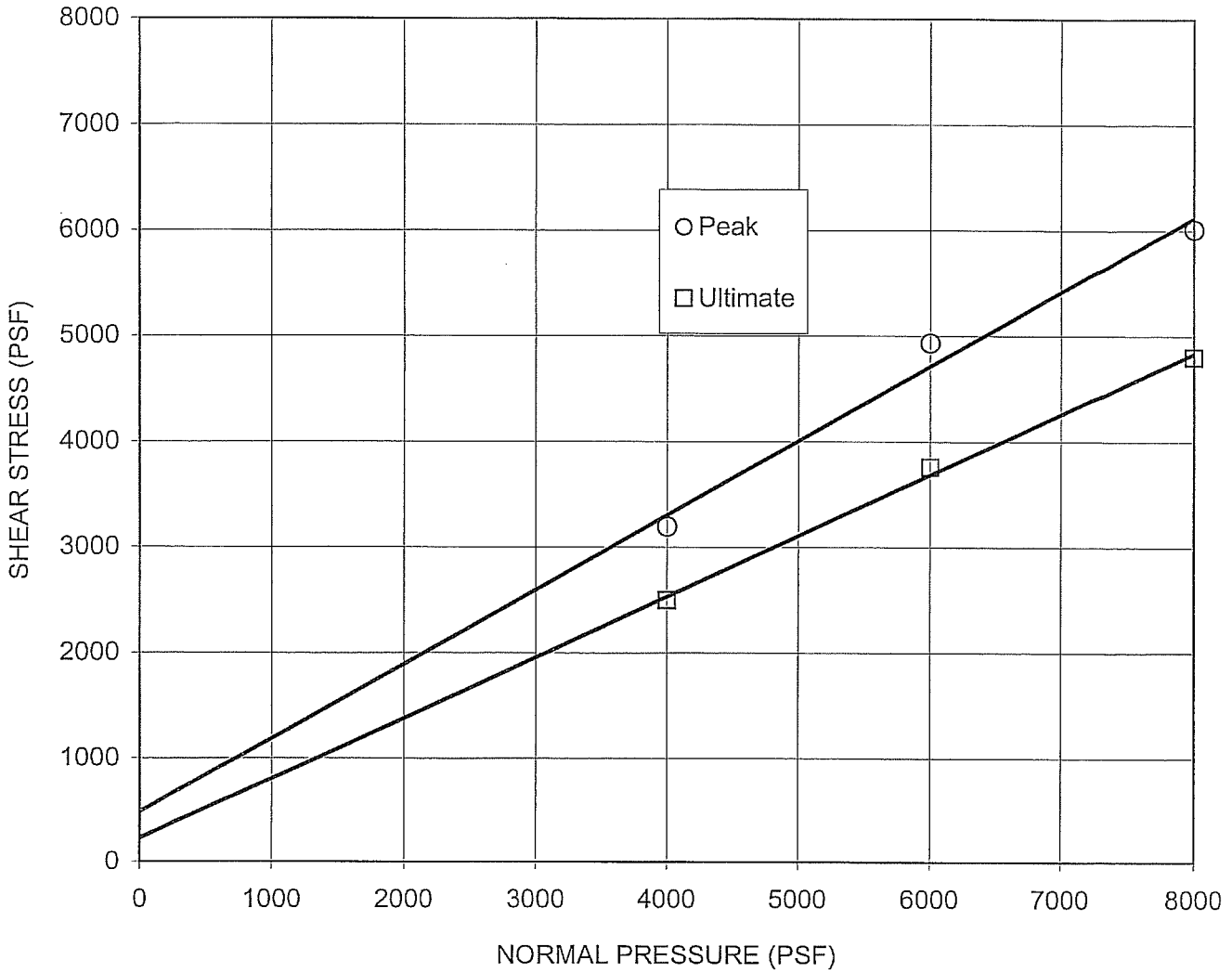
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-035	D-14	70	Ring	SM	○	484	35
					□	228	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	27.0	30.7
6000	27.0	29.3
8000	27.0	29.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-055	S-1	5	SP-SM	23.1				37:52:11						
A-09-055	D-2	10	0								2100	7.7	50	380
A-09-055	S-3	15	SP	24.3				0:99:1						
A-09-055	D-4	20	SP-SM	21.8	122.9									
A-09-055	S-5	25	SP	24.9				0:96:4						
A-09-055	S-7-2	35.5	CL	36.6										
A-09-055	S-9	45	CH	31.3				0:6:94		59/29/30				
A-09-055	D-10	50	CL			1.0								
A-09-055	S-11	55	ML	33.0				0:6:94		32/27/5				
A-09-055	D-12	60	ML			2.0				22/20/2				
A-09-056	S-1	5	SM					13:46:41			670	7.8	580	514
A-09-056	D-2	10	ML			<0.25				49/32/17				
A-09-056	S-3	15	CL	44.9				0:13:87		41/25/16				
A-09-056	D-4	20	SM							N.P.				
A-09-056	S-5	25	SP-SM	29.4				0:93:7						
A-09-058	S-1	5	SP					0:96:4			9300	8.6	30	248
A-09-058	S-3	15	CH	65.2				0:1:99		93/34/59				
A-09-058	S-5	25	CL	34.2				0:7:93		47/24/23				
A-09-058	D-6	30	ML			0.5								
A-09-058	S-7	35	ML	23.9						N.P.				
A-09-058	D-8	40	ML			1.5		0:26:74						
A-09-058	S-9	45	SM	29.5										
A-09-058	D-10	50	SC-SM					0:72:28						
A-09-059	S-1	5	SM					3:81:16			1300	8.1	380	542
A-09-059	S-3	15	MH	47.0				0:17:83		98/49/49				
A-09-059	S-6	30	MH	37.2				0:4:96		50/30/20				
A-09-059	S-8	40	SM	28.2				1:72:27		N.P.				
A-09-059	D-9	45	CL			0.5		0:6:94		40/24/16				
A-09-059	S-10	50	ML	37.3				0:31:69						

ATTERBERG LIMITS

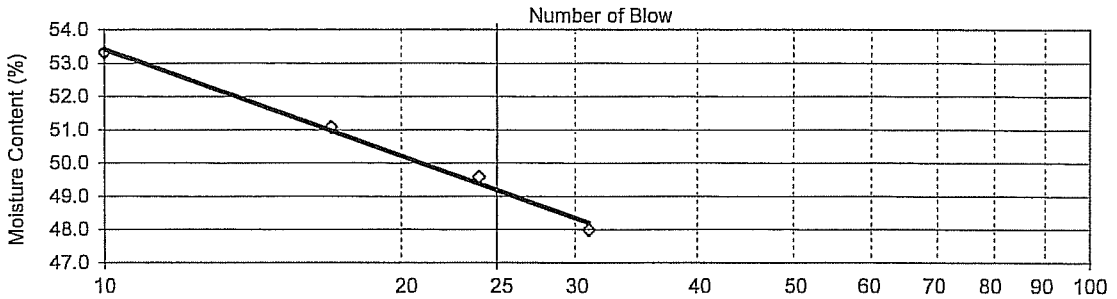
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-056	Depth (ft/m): 10 ft	3 m			1
Sample Number: D-2	Description: ML				
Prepared By: PA	Date:		Checked By: R.J.		Date:
Pulverized By: PA	Date:				Container Number
Tested By: PA	Date:				Air: G-2
Computed By: JF	Date:				Field:

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		31	24	17	10		
Can Number		13	14	15	16	17	18
Wt. Wet Soil +Can (gm)		43.87	41.20	39.38	40.44	34.01	33.00
Wt. Dry Soil +Can (gm)		38.74	35.31	34.14	34.57	31.93	30.96
Weight of Can (gm)		28.05	23.43	23.88	23.56	25.46	24.55
Water Content (%)		48.0	49.6	51.1	53.3	32.1	31.8

Liquid Limit (LL, %):	49	Plastic Limit (PL, %):	32	Plastic Index (PI, %):	17

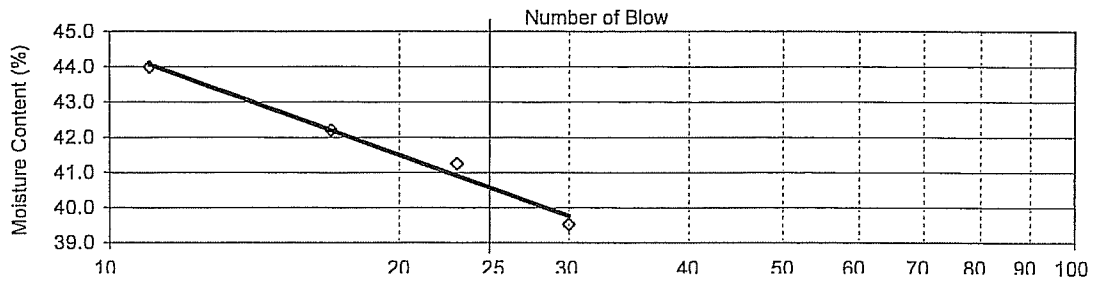


Remark:

Boring Number: A-09-056	Depth (ft/m): 15 ft	4.5 m			1
Sample Number: S-3	Description: CL				
Prepared By: PA	Date:		Checked By: R.J.		Date:
Pulverized By: PA	Date:				Container Number
Tested By: PA	Date:				Air: G-9
Computed By: JF	Date:				Field:

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		30	23	17	11		
Can Number		31	32	33	34	35	36
Wt. Wet Soil +Can (gm)		41.51	38.51	37.85	38.97	29.60	31.26
Wt. Dry Soil +Can (gm)		36.06	33.78	32.96	33.93	27.91	29.60
Weight of Can (gm)		22.27	22.31	21.37	22.47	21.14	22.94
Water Content (%)		39.5	41.2	42.2	44.0	25.0	24.9

Liquid Limit (LL,%)	41	Plastic Limit PL,%)	25	Plastic Index (PI,%)	16



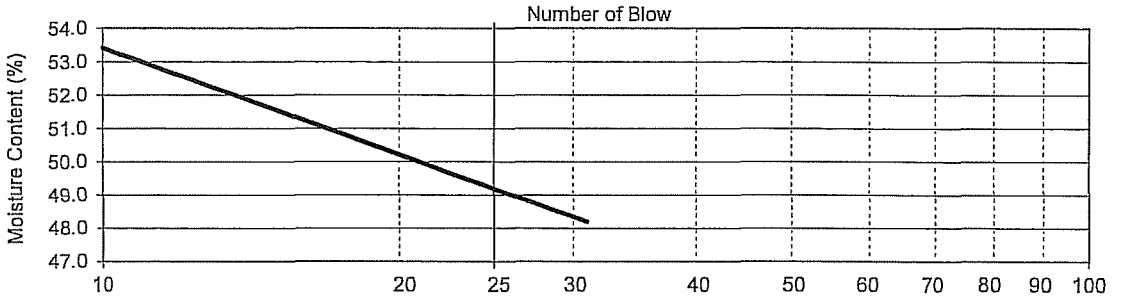
Remark:

ATTERBERG LIMITS

ASTM D-4318-84 / CT-204

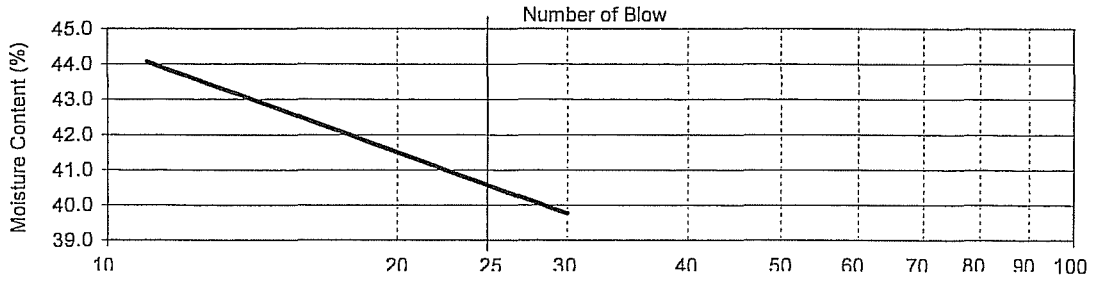
Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-056	Depth (ft/m): 20	3 m						1
Sample Number: D-4	Description: SM							
Prepared By: PA	Date:		Checked By: R.J.			Date:		
Pulverized By: PA	Date:					Container Number		
Tested By: PA	Date:					Air:	G-2	
Computed By: JF	Date:		NO PLASTIC			Field:		
Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2	
Number of Blow								
Can Number								
Wt. Wet Soil +Can (gm)								
Wt. Dry Soil +Can (gm)								
Weight of Can (gm)								
Water Content (%)								
Liquid Limit (LL, %):		**Plastic Limit (PL, %):**				**Plastic Index (PI, %):**		



Remark:

Boring Number: A-09-054	Depth (ft/m): 45	4.5 m						1
Sample Number: S-9	Description: ML							
Prepared By: PA	Date:		Checked By: R.J.			Date:		
Pulverized By: PA	Date:					Container Number		
Tested By: PA	Date:					Air:	G-9	
Computed By: JF	Date:		NO PLASTIC			Field:		
Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2	
Number of Blow								
Can Number								
Wt. Wet Soil +Can (gm)								
Wt. Dry Soil +Can (gm)								
Weight of Can (gm)								
Water Content (%)								
Liquid Limit (LL, %):		**Plastic Limit (PL, %):**				**Plastic Index (PI, %):**		



Remark:

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-056		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	**Size**
Depth (ft)	: 5.0		**Tested By :** PA	**Date :**	**13**	**46**	**41**	3/8"
Depth (m)	: 1.53		**Checked By :**	**Date :**				
Description	: Olive, SILTY SAND (SM)				**Sample**		**Retained On**	
X	**Method (A)** - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-5	S-5	S-5	S-5
Wet Weight of Soil + Container (gm)					308.92	308.92		
Dry Weight of Soil + Container (gm)						282.16	214.06	
Weight of Container (gm)					117.80	117.8	117.8	
Weight of Dry Soil (gm)					164.36	164.36	96.26	22.15
Moisture Content (%)						16.28		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							41.43	13.48
Remark :								1

Boring No.	: A-09-056		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum**
Sample No.	: S-5		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	**Size**
Depth (ft)	: 25.0		**Tested By :** PA	**Date :**	**0**	**93**	**7**	#30
Depth (m)	:		**Checked By :**	**Date :**				
Description	: Olive-gray, Poorly graded SAND with SILT (SP-SM)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-6	S-6	S-6	S-6
Wet Weight of Soil + Container (gm)					365.39	365.39		
Dry Weight of Soil + Container (gm)						308.86	295.04	
Weight of Container (gm)					116.77	116.77	116.77	
Weight of Dry Soil (gm)					192.09	192.09	178.27	0.00
Moisture Content (%)						29.43		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							7.19	0.00
Remark :								2

Boring No.	: A-09-058		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	**Size**
Depth (ft)	: 25.0		**Tested By :** PA	**Date :**	**0**	**96**	**4**	#10
Depth (m)	: 7.63		**Checked By :**	**Date :**				
Description	: Olive-gray, Poorly graded SAND (SP)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-8	S-8	S-8	S-8
Wet Weight of Soil + Container (gm)					358.92	358.92		
Dry Weight of Soil + Container (gm)						351.07	341.94	
Weight of Container (gm)					118.29	118.29	118.29	
Weight of Dry Soil (gm)					232.78	232.78	223.65	0.00
Moisture Content (%)						3.37		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							3.92	0.00
Remark :								3

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *A-09-056*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-3*	**Tested By :** *PA*	**Date :**
Depth below Decl	: *15.0*	**Sieved By :** *RJ*	**Date :**
Description	: *darkolive-gray, Lean CLAY (CL)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

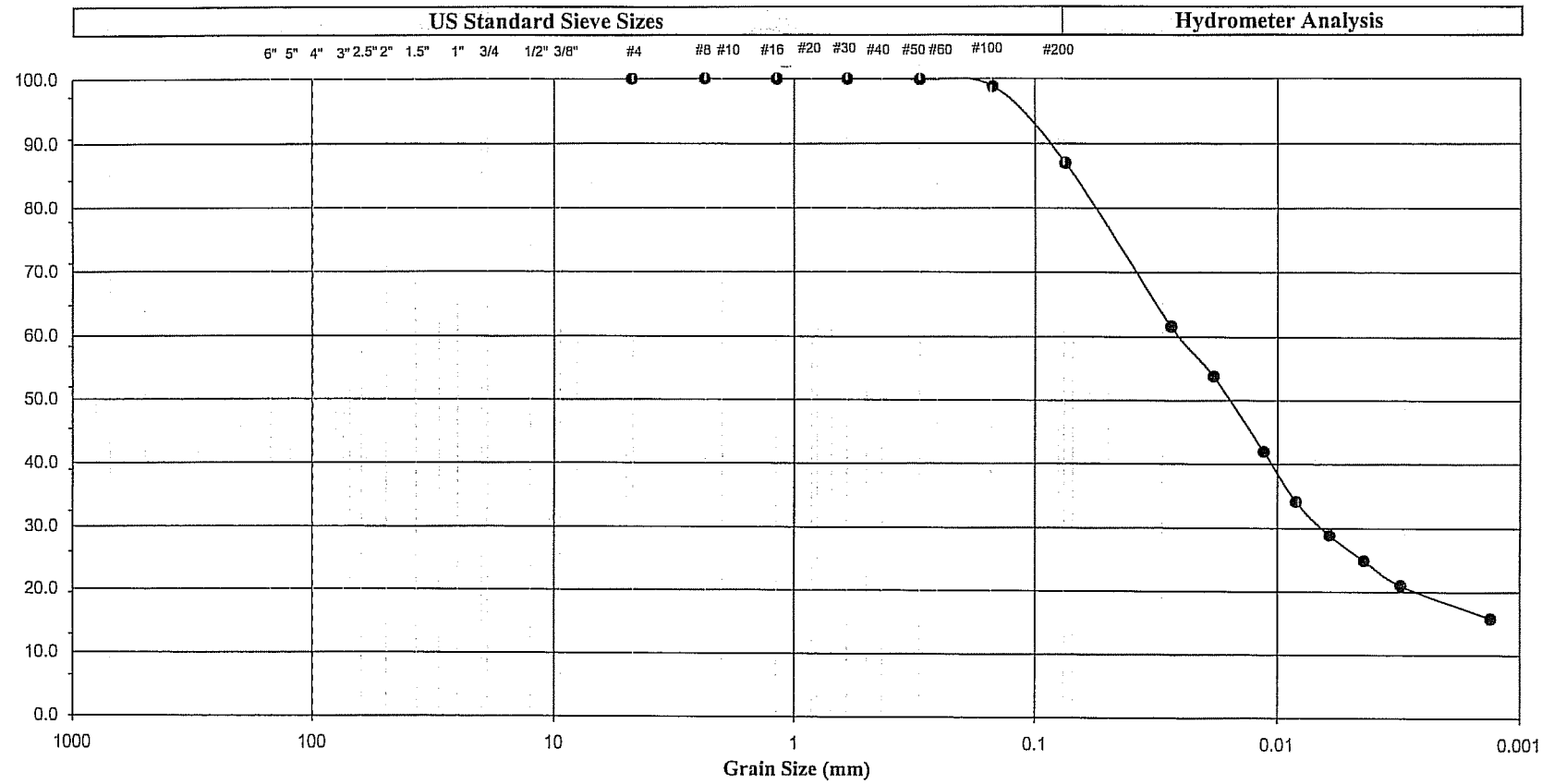
Sample for Hydrometer should passing (No.10-ASTM) & (No.4-Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	*S-15*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*3*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-11*		*S-15*	*34*		*S-21*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*228.27*		*76.25*	*154.19*			*0.99*	
Wt. of Dry Soil + Container (gm)					*153.31*		*128.30*	**Hydrometer Type**	
Wt. of Container (gm)					*57.35*		*114.62*	*152H*	
Wt. of Dry Soil (gm)		*226.20*		*75.56*			*13.68*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.92*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				*41*	No. 16	*0.02*		*99.97*	***99.97***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.04*		*99.95*	***99.95***
1.0"					No. 40				
3/4"				*25*	No. 50	*0.10*		*99.87*	***99.87***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*0.92*		*98.78*	***98.78***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	*16*	No. 200	*9.84*		*86.98*	***86.98***
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01	(T)					W		(mm)			(D)
14:06	*0:00:00*			*5.0*							
	2	*21.0*	*52.0*	*5.0*	*47.0*	*61.58*	***61.58***	*0.05500*	*0.01328*	*8.6*	***0.02752***
	5	*21.0*	*46.0*	*5.0*	*41.0*	*53.72*	***53.72***	*0.03500*	*0.01328*	*9.6*	***0.01838***
	15	*21.0*	*37.0*	*5.0*	*32.0*	*41.93*	***41.93***	*0.02000*	*0.01328*	*11.0*	***0.01140***
	30	*22.0*	*31.0*	*5.0*	*26.0*	*34.07*	***34.07***	*0.01400*	*0.01328*	*12.0*	***0.00841***
	60	*23.0*	*27.0*	*5.0*	*22.0*	*28.83*	***28.83***	*0.01000*	*0.01328*	*12.7*	***0.00611***
	120	*23.0*	*24.0*	*5.0*	*19.0*	*24.90*	***24.90***	*0.00700*	*0.01328*	*13.2*	***0.00440***
	240	*23.5*	*21.0*	*5.0*	*16.0*	*20.96*	***20.96***	*0.00500*	*0.01328*	*13.7*	***0.00311***
	1440	*21.5*	*17.0*	*5.0*	*12.0*	*15.72*	***15.72***	*0.00100*	*0.01328*	*14.3*	***0.00132***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***13***	***87***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-056	S-3	15.0	dark olive-gray	Lean clay	CL
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Date : 12/07/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 2

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-056
Sample No. : D-2
Depth (ft / m) : 10.0 | 3.05
File No. :
Soil Description : Dark gray, SILT (ML)

Set up By : J.F Date : 12/3/2009
Tested By : J.F/R.J. Date : 12/3/09-12/13/09
Time Rate Took By : J.F Date : 12/6/09,12/8/09
Computer By : JF Date : 12/9/2009
Checked By : R.J. Date :

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.
Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.8455	21.48	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

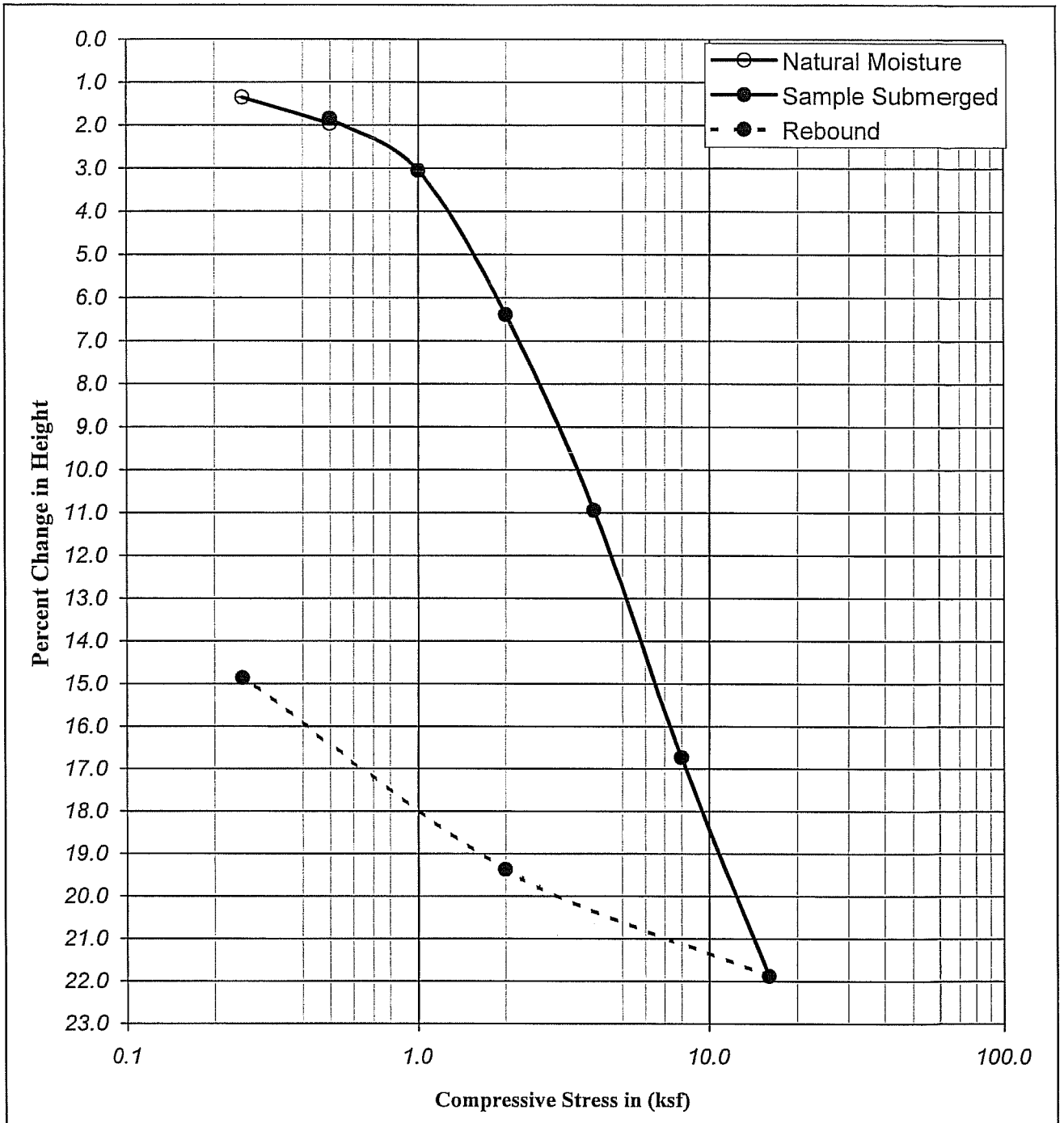
		Before	After
Weight of wet soil + ring (gm)		172.47	
Weight of ring (gm)		44.21	
Weight of wet soil + ring + container (gm)			220.58
Weight of dry soil + ring + container (gm)			186.69
No. 93	Weight of container (gm)		58.81
	Weight of ring + container (gm)		103.02
	Moisture Content (%)	53.29	40.50
	Dial Reading (inch)	0.05	0.04
	Sample Volume (ft^3)	0.0027	0.0023
	Wet Density (pcf)	106.2	115.2
	Dry Density (pcf)	69.30	81.96

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04410	1.12		
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	
12/4/2009	8:10	0:00:00	0.25	12.0	0.06350	1.61	1.35	
12/5/2009	9:44	0:00:00	0.50	23.9	0.06960	1.77	1.96	
			Add Water					
12/6/2009	8:40	0:00:00	0.50	23.9	0.06840	1.74	1.84	
12/6/2009	8:43	0:00:00	1.00	47.9	0.06840	1.74	1.84	0.00
		0.10	1.0	47.9	0.06990	1.78	1.99	0.32
		0.25	1.0	47.9	0.07050	1.79	2.05	0.50
		0.50	1.0	47.9	0.0711	1.81	2.11	0.71
		1	1.0	47.9	0.07200	1.83	2.20	1.00
		2	1.0	47.9	0.07310	1.86	2.31	1.41
		4	1.0	47.9	0.07420	1.88	2.42	2.00
		8	1.0	47.9	0.07530	1.91	2.53	2.83
		15	1.0	47.9	0.07610	1.93	2.61	3.87
		30	1.0	47.9	0.07680	1.95	2.68	5.48
		60	1.0	47.9	0.07750	1.97	2.75	7.75
		120	1.0	47.9	0.07820	1.99	2.82	10.95
		240	1.0	47.9	0.07890	2.00	2.89	15.49
		480	1.0	47.9	0.07960	2.02	2.96	21.91
12/7/2009		1440	1.0	47.9	0.08050	2.04	3.05	37.95
12/8/2009	8:28	0	2.0	95.8	0.11390	2.89	6.39	
12/8/2009	8:29	0	4.0	191.5	0.1139	2.89	6.39	
		0.10	4.0	191.5	0.1200	3.05	7.00	
		0.25	4.0	191.5	0.1217	3.09	7.17	
		0.50	4.0	191.5	0.1248	3.17	7.48	
		1	4.0	191.5	0.1267	3.22	7.67	
		2	4.0	191.5	0.1312	3.33	8.12	
		4	4.0	191.5	0.1355	3.44	8.55	
		8	4.0	191.5	0.1403	3.56	9.03	
		15	4.0	191.5	0.1446	3.67	9.46	
		30	4.0	191.5	0.1472	3.74	9.72	
		60	4.0	191.5	0.1495	3.80	9.95	
		120	4.0	191.5	0.1518	3.86	10.18	
		240	4.0	191.5	0.1545	3.92	10.45	
		480	4.0	191.5	0.1575	4.00	10.75	
12/09/09		1440	4.0	191.5	0.1594	4.05	10.94	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.2173	5.52	16.73
12/11/2009	8:23		16.00	766.1	0.2688	6.83	21.88
12/12/2009	8:40		2.00	95.8	0.2437	6.19	19.37
12/13/2009	9:15		0.25	12.0	0.1986	5.04	14.86

Remark

Final Dial Reading 0.1986



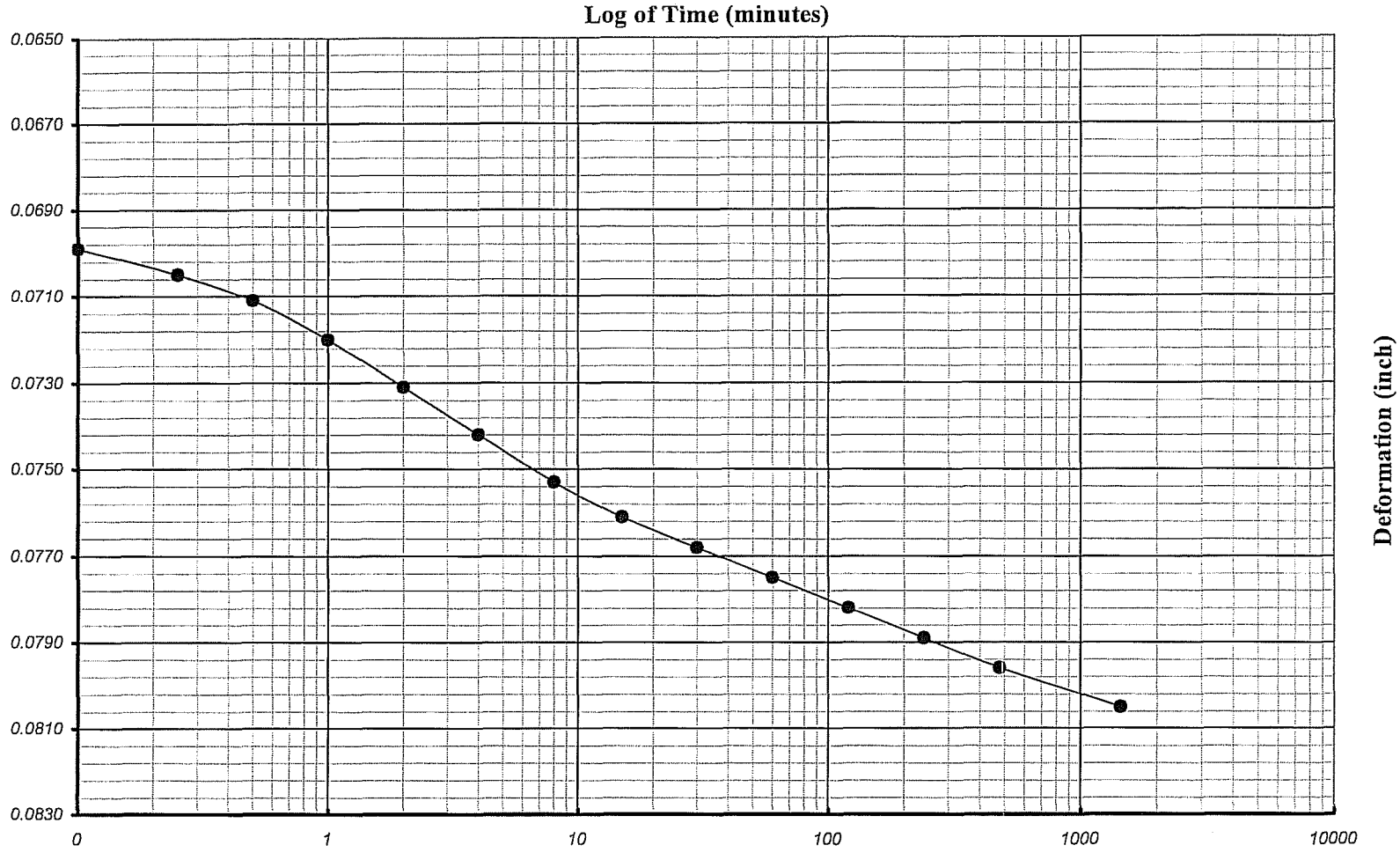
Boring No.	: A-09-056		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-2		Plastic Limit :	-						
Depth (ft)	: 10.0	11.5	Plastic Index :	-	Initial	53.29	69.30	10.91	100.45	1.43
Depth (m)	: 3.05	3.51	Specific Gravity :	2.70	Final	40.50	81.96	12.90	103.50	1.06
Description	: Dark gray, SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

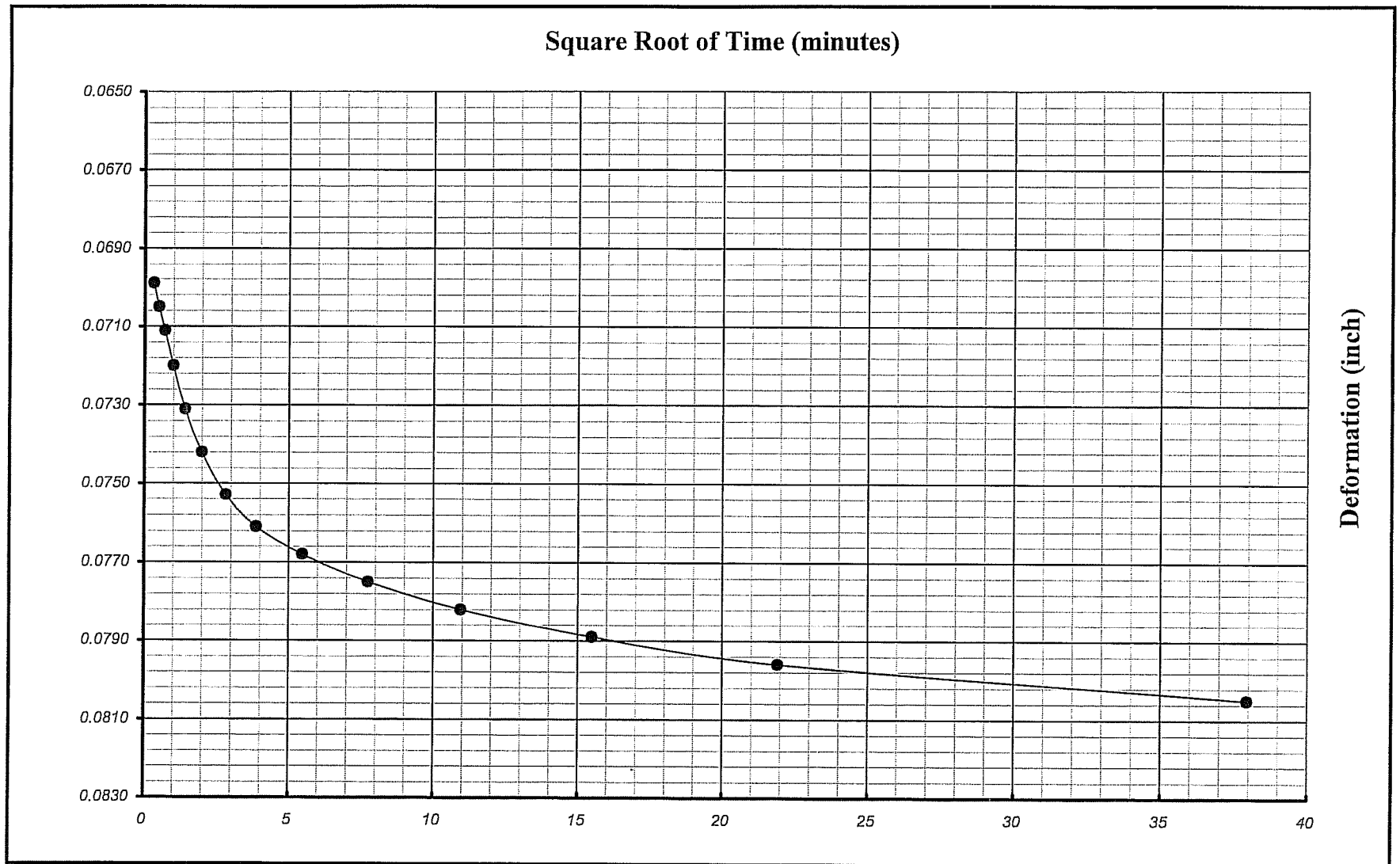
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 12/09/09

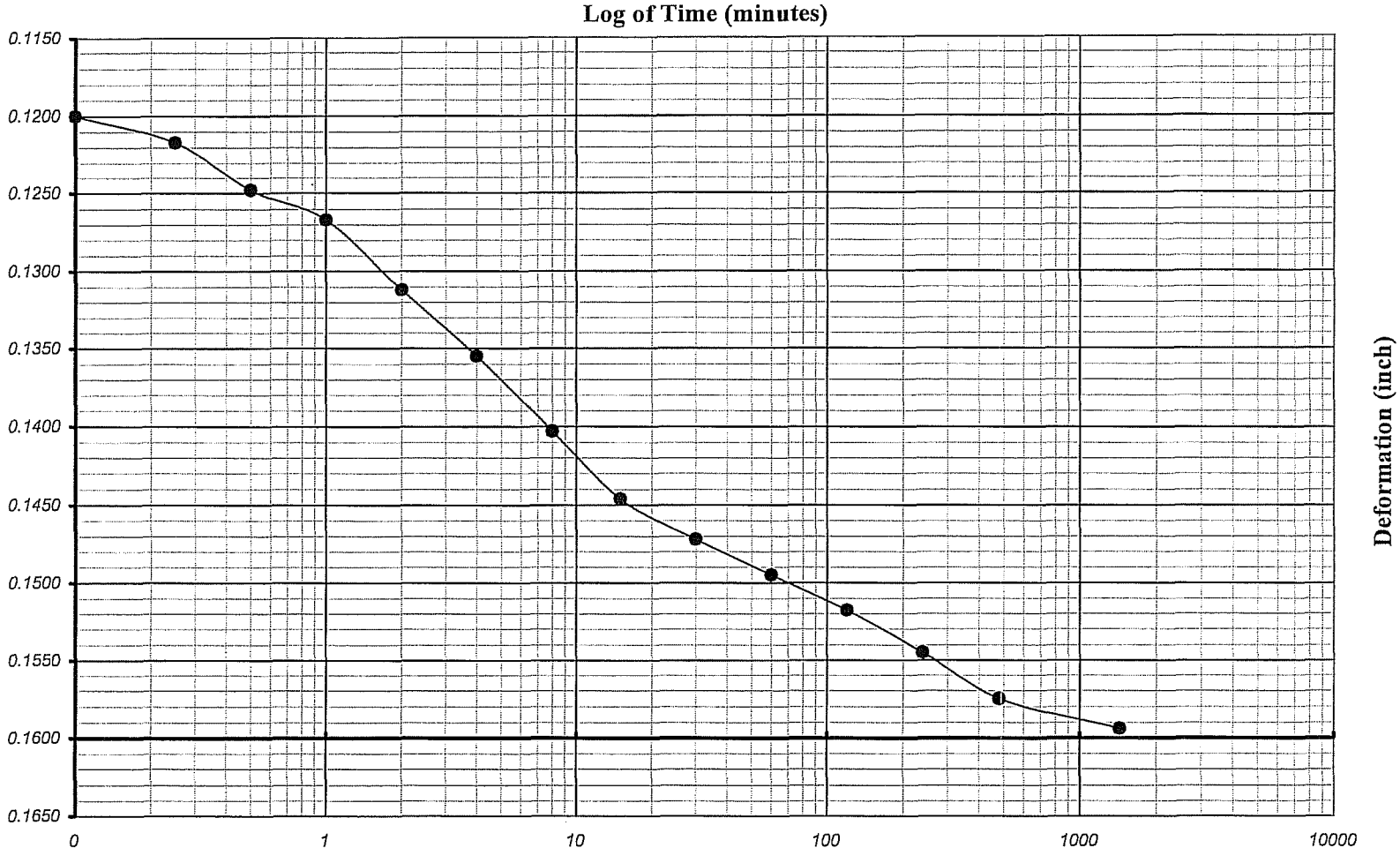
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



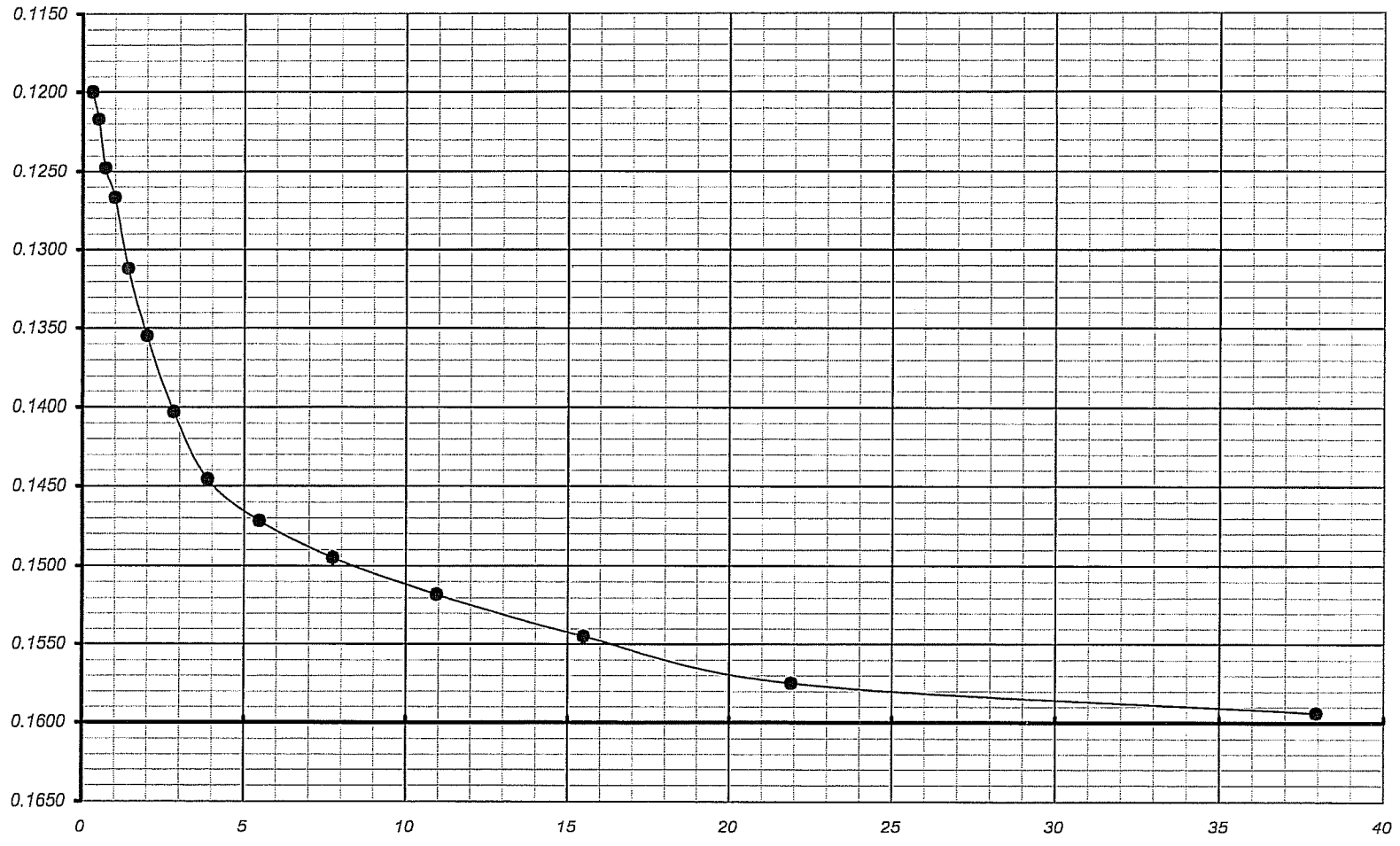
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-2*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *10.0* *3.1*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-056	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : D-2	
EMI Project No. : 06-123-3		Depth (ft/m) : 10.0 3.1	Veritcal Load (ksf/kpa) : 1.0 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-2*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *10.0* *3.1*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-2*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *10.0* *3.1*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 2

Project Name : *ACTA/Schuyler Heim Bridge Project*

Project No. : *06-123-3*

Boring No. : *A-09-056*

Sample No. : *D-4*

Depth (ft / m) : *20.0* | *6.10*

File No. :

Soil Description : *Dark gray, SILTY SAND (SM)*

Set up By : *J.F* Date : *12/3/2009*

Tested By : *J.F/R.J.* Date : *12/3/09-12/13/09*

Time Rate Took By : *J.F* Date : *12/6/09,12/8/09*

Computer By : *JF* Date : *12/9/2009*

Checked By : *R.J.* Date :

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.9728	24.71	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

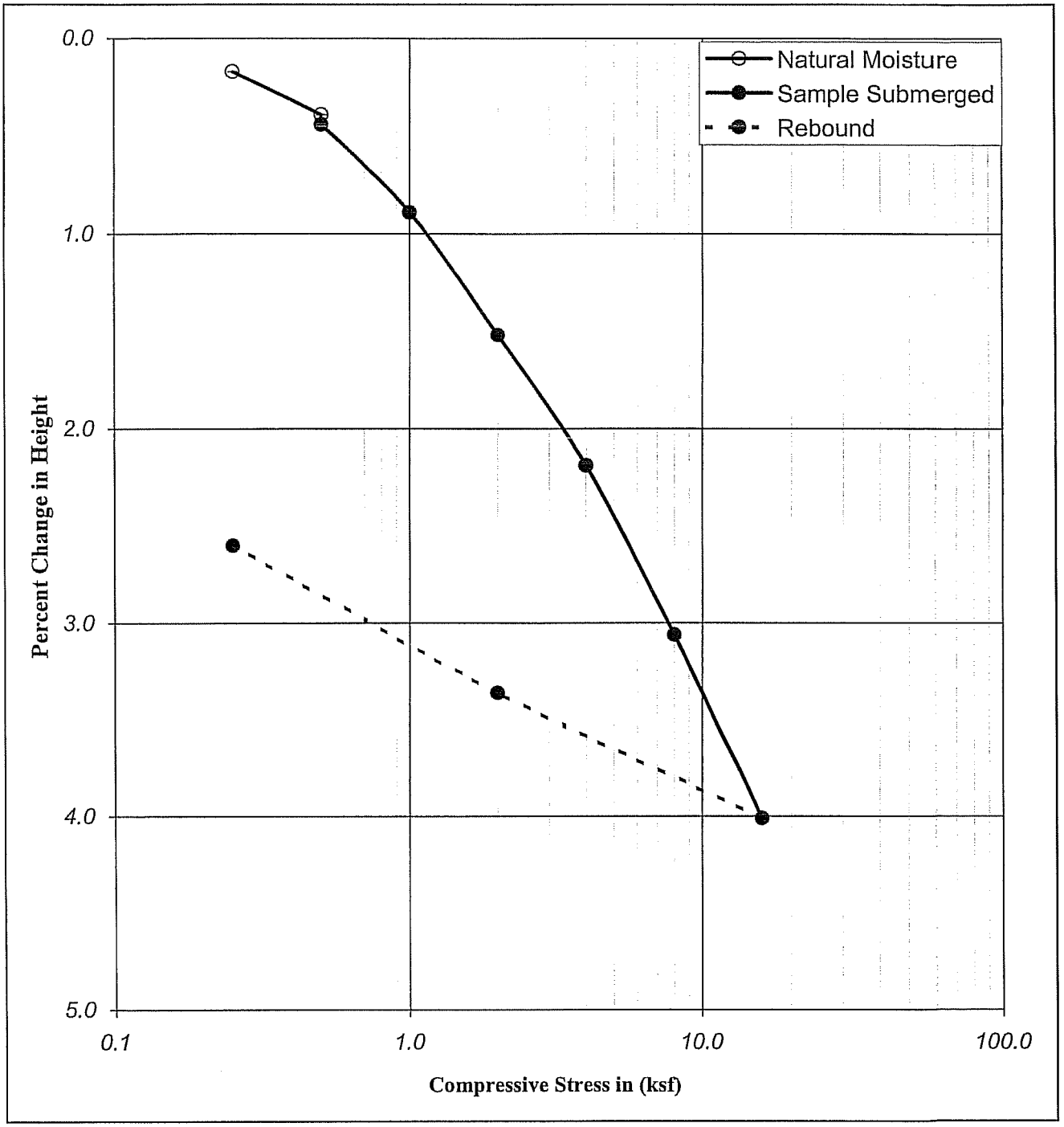
Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04880	1.24		
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	
12/4/2009	8:10	0:00:00	0.25	12.0	0.05170	1.31	0.17	
12/5/2009	9:44	0:00:00	0.50	23.9	0.05390	1.37	0.39	
			Add Water					
12/6/2009	8:40	0:00:00	0.50	23.9	0.05440	1.38	0.44	
12/6/2009	8:43	0:00:00	1.00	47.9	0.05440	1.38	0.44	0.00
		0.10	1.0	47.9	0.05720	1.45	0.72	0.32
		0.25	1.0	47.9	0.05730	1.46	0.73	0.50
		0.50	1.0	47.9	0.0574	1.46	0.74	0.71
		1	1.0	47.9	0.05750	1.46	0.75	1.00
		2	1.0	47.9	0.05760	1.46	0.76	1.41
		4	1.0	47.9	0.05770	1.47	0.77	2.00
		8	1.0	47.9	0.05790	1.47	0.79	2.83
		15	1.0	47.9	0.05800	1.47	0.80	3.87
		30	1.0	47.9	0.05810	1.48	0.81	5.48
		60	1.0	47.9	0.05820	1.48	0.82	7.75
		120	1.0	47.9	0.05840	1.48	0.84	10.95
		240	1.0	47.9	0.05850	1.49	0.85	15.49
		480	1.0	47.9	0.05870	1.49	0.87	21.91
12/7/2009		1440	1.0	47.9	0.05890	1.50	0.89	37.95
12/8/2009	8:28	0	2.0	95.8	0.06520	1.66	1.52	
12/8/2009	8:29	0	4.0	191.5	0.0652	1.66	1.52	
		0.10	4.0	191.5	0.0697	1.77	1.97	
		0.25	4.0	191.5	0.0698	1.77	1.98	
		0.50	4.0	191.5	0.0700	1.78	2.00	
		1	4.0	191.5	0.0701	1.78	2.01	
		2	4.0	191.5	0.0702	1.78	2.02	
		4	4.0	191.5	0.0703	1.79	2.03	
		8	4.0	191.5	0.0705	1.79	2.05	
		15	4.0	191.5	0.0706	1.79	2.06	
		30	4.0	191.5	0.0708	1.80	2.08	
		60	4.0	191.5	0.0709	1.80	2.09	
		120	4.0	191.5	0.0712	1.81	2.12	
		240	4.0	191.5	0.0714	1.81	2.14	
		480	4.0	191.5	0.0717	1.82	2.17	
12/09/09		1440	4.0	191.5	0.0719	1.83	2.19	

		Before	After
	Weight of wet soil + ring (gm)	193.90	
	Weight of ring (gm)	45.94	
	Weight of wet soil + ring + container (gm)		252.92
	Weight of dry soil + ring + container (gm)		220.84
No. 84	Weight of container (gm)		60.33
	Weight of ring + container (gm)		106.27
	Moisture Content (%)	29.14	28.00
	Dial Reading (inch)	0.05	0.04
	Sample Volume (ft³)	0.0027	0.0026
	Wet Density (pcf)	122.5	124.9
	Dry Density (pcf)	94.89	97.54

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.0806	2.05	3.06
12/11/2009	8:23		16.00	766.1	0.0901	2.29	4.01
12/12/2009	8:40		2.00	95.8	0.0836	2.12	3.36
12/13/2009	9:15		0.25	12.0	0.0760	1.93	2.60

Remark

Final Dial Reading 0.0760



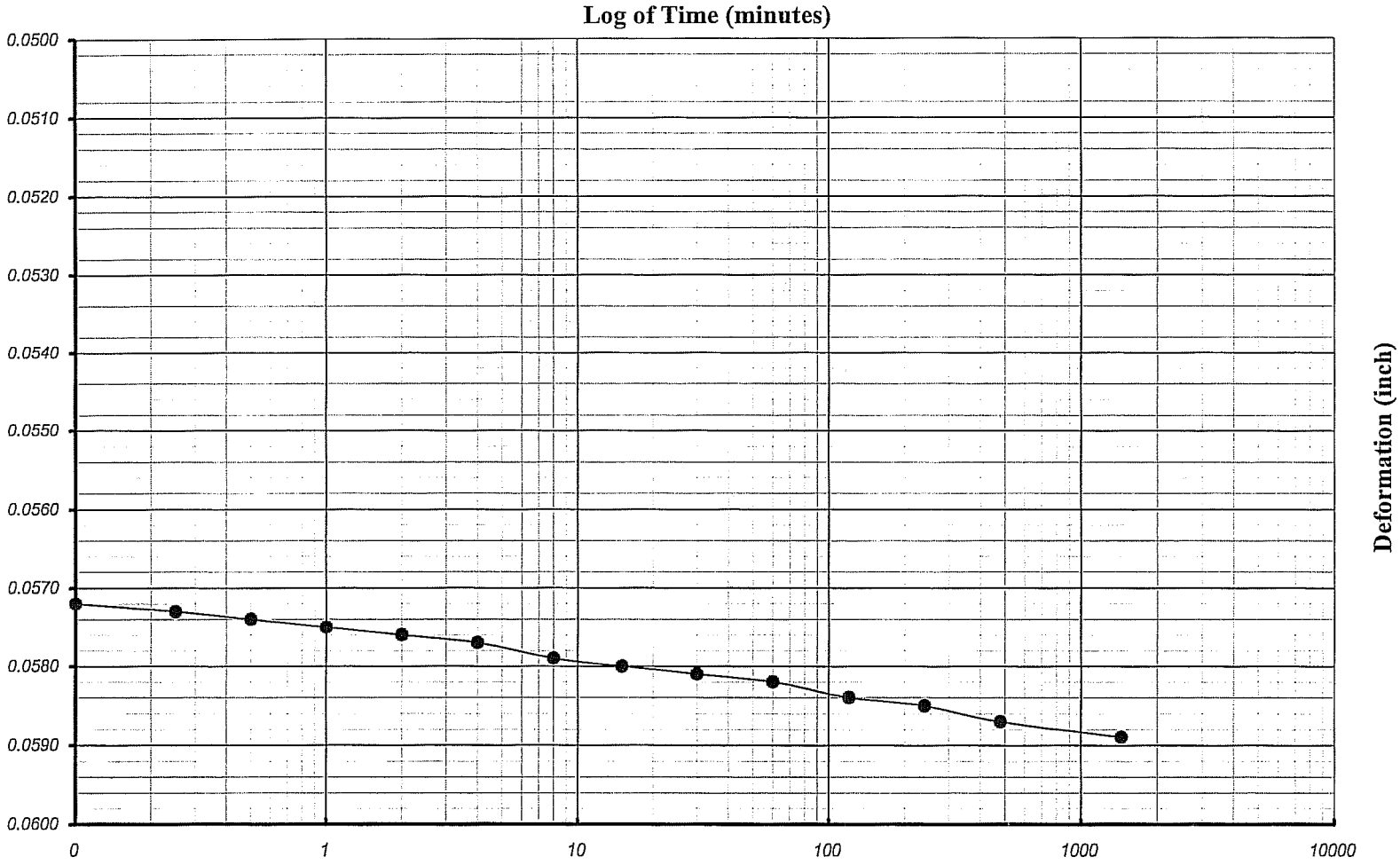
Boring No.	: A-09-056			Liquid Limit :	-		Moisture Content (%)	Dry Density		Percent Saturation	Void Ratio
Sample No.	: D-4			Plastic Limit :	-			(pcf)	(kN/m³)		
Depth	(ft) :	20.0	21.5	Plastic Index :	-	Initial	29.14	94.89	14.94	101.35	0.78
	(m) :	6.10	6.56	Specific Gravity :	2.70	Final	28.00	97.54	15.35	103.84	0.73
Description : Dark gray, SILTY SAND (SM)											

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

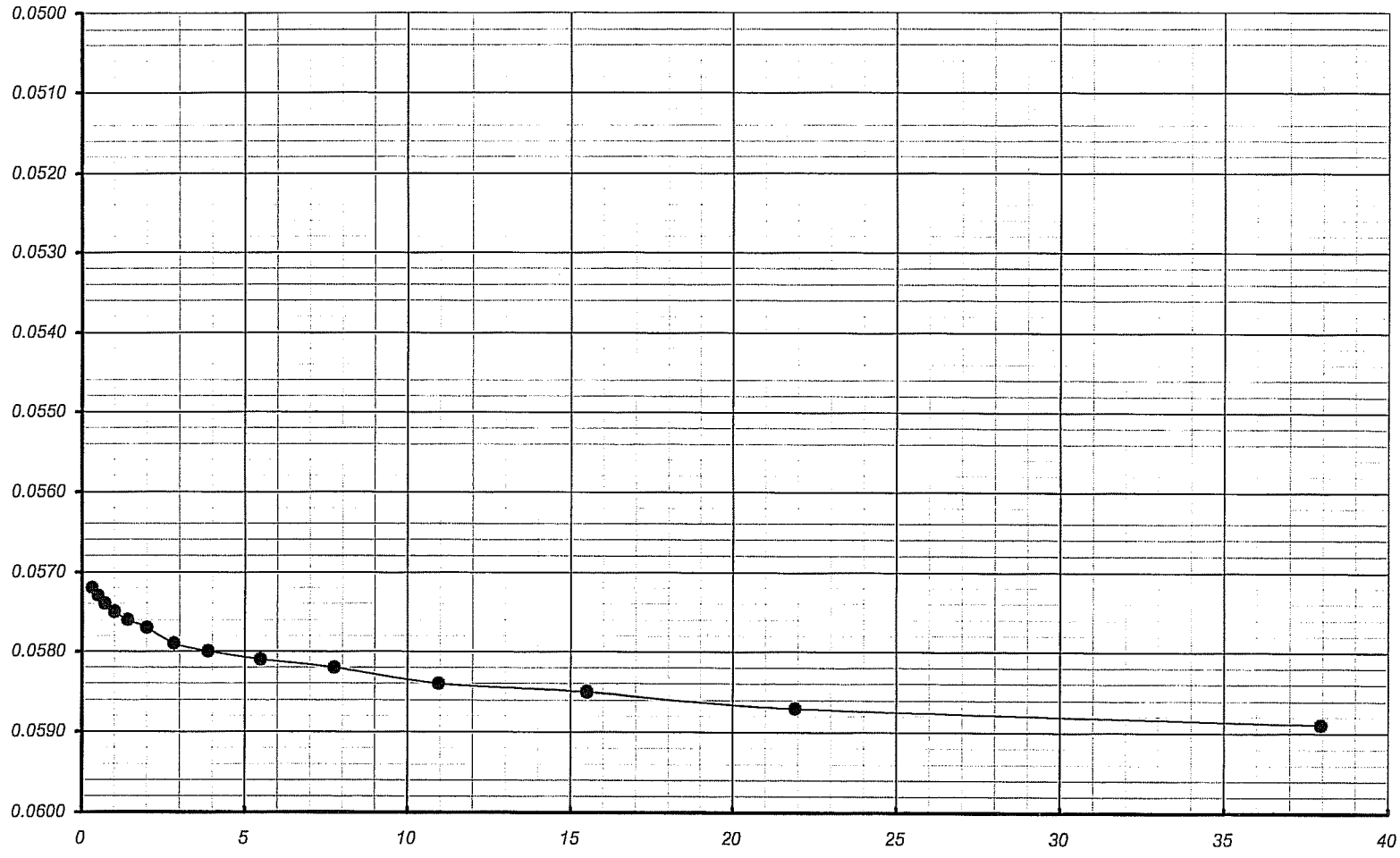
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 12/09/09

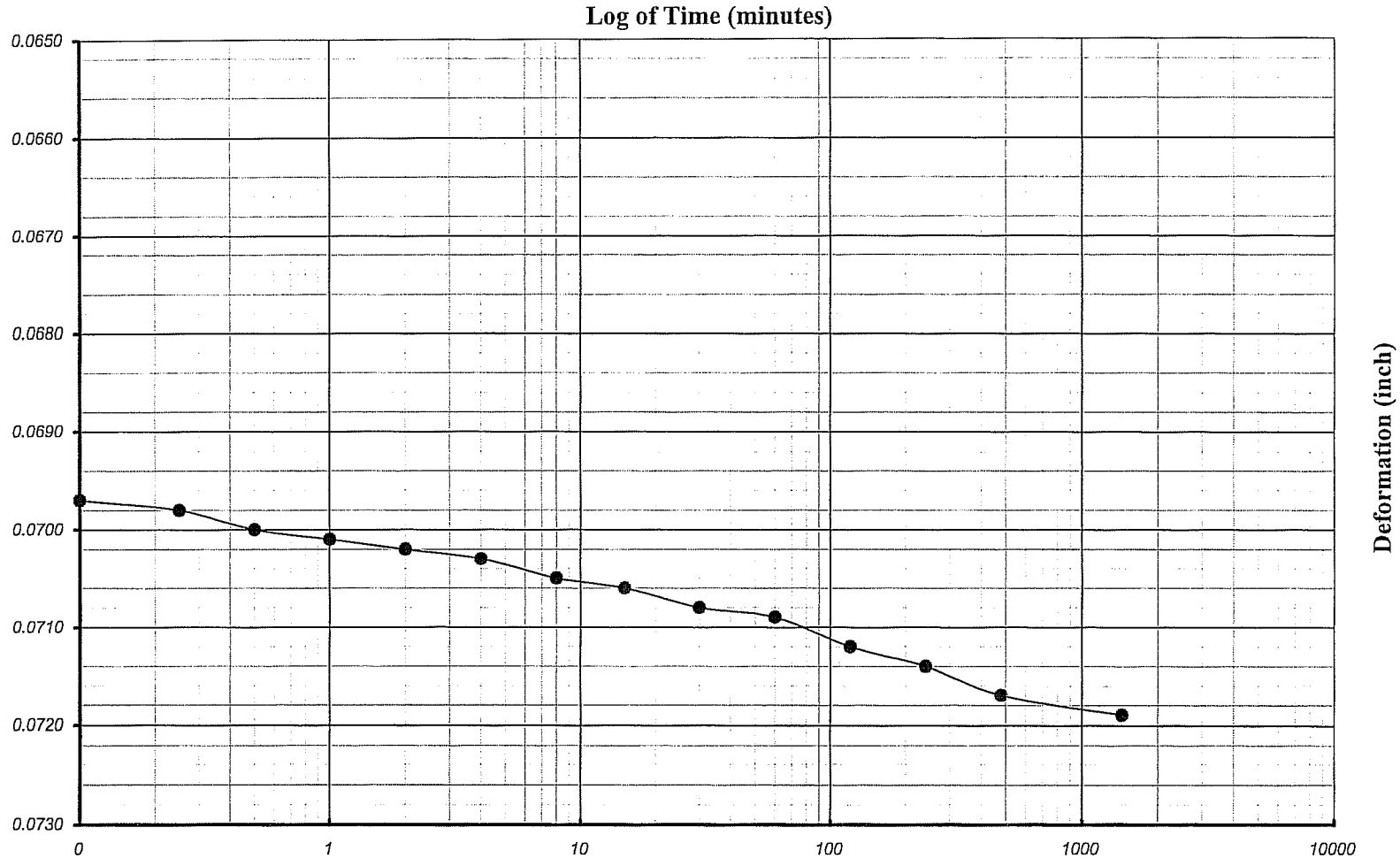
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



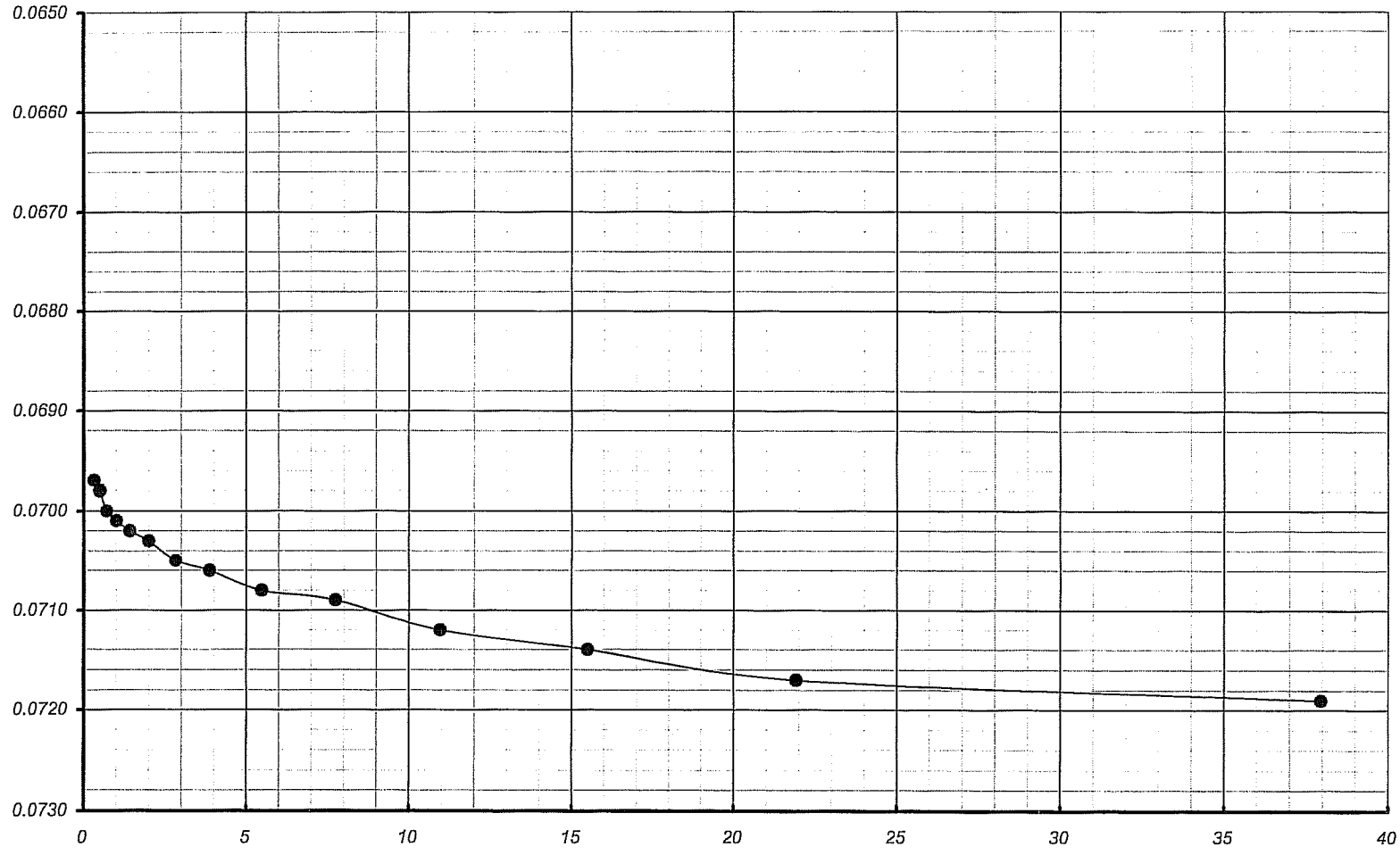
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-056	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 6.1	Veritcal Load (ksf/kpa) : 1.00 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* *6.1*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	**One-Dimensional Consolidation of Soil** **Time-Deformation Curve (Log of Time Method)**
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		**Depth** (ft/m) : *20.0* *6.1*	**Veritcal Load (ksf/kpa) :** *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve(Square Root of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* | *6.1*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. :	A-09-056		Saturated		Field Moisture	X	Inundated — **Specific Gravity (Assumed) :** 2.70
Sample No. :	D-6	X	Undisturbed		Remolded		Consolidated-Drained — **Shear Rate (inch/min) :** 0.02
Depth (ft/m) :	30.0	x	Shear Once		Reshear		Residual — **Data File Number :** 0612309

Description : Gray, Poorly graded SAND with SILT (SP-SM)

Percent Saturation (%)	98.94	**File No. :** 0612309	1
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**	
Tested By : JF	**Date :** 11/30/09		
Computed By : JF	**Date :** 12/11/09	2.00	(ksf)
Checked By :	**Date :**		

	Before		After
Percent Consolidation (%)			
Height of Sample (inch)	1.00		1.0000
Diameter of Sample (inch)	2.42		2.42
Dial Reading-Consolidation (inch)			
Weight of Soil + Ring (gm)	192.35		
Weight of Ring (gm)	43.45		
Weight of Wet Soil + Cont. (gm)			149.74
Weight of Dry Soil + Cont. (gm)			118.75
Weight of Cont. (gm) No. 7			3.67
Moisture Content (%)			26.93
Wet Density (pcf / kN/m³)	123.32	19.41	
Dry Density (pcf / kN/m³)	97.16	15.29	

Percent Saturation (%)	99.59	**File No. :** 0612309	2
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**	
Tested By : JF	**Date :** 11/30/09	4.00	(ksf)

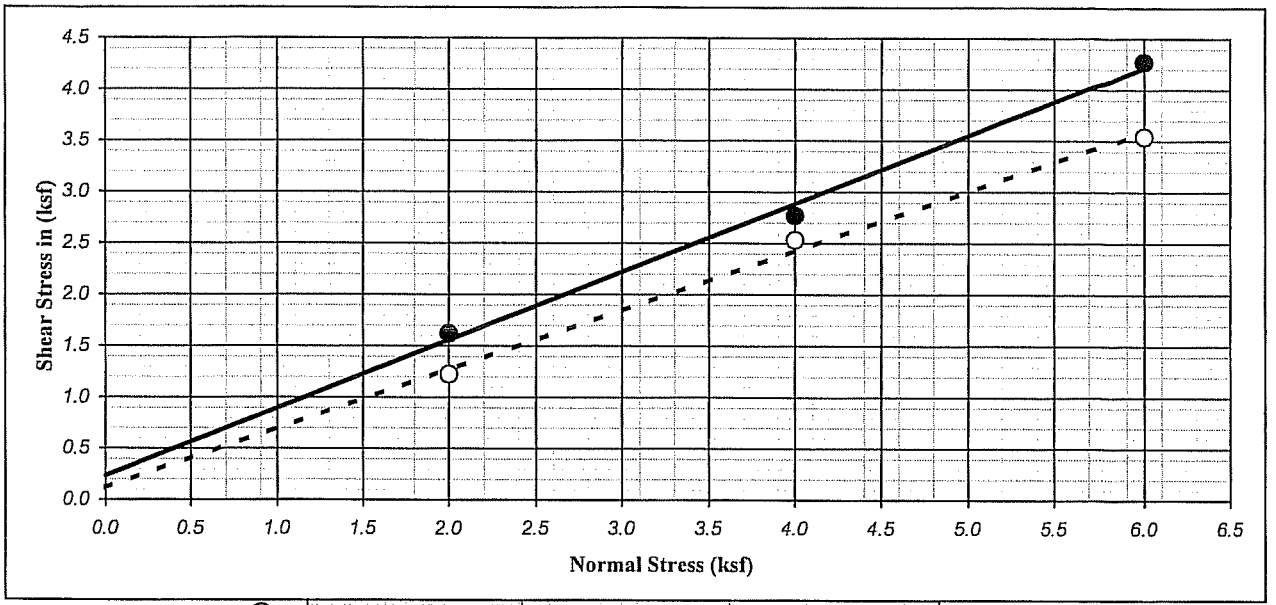
	Before		After
Percent Consolidation (%)			
Height of Sample (inch)	1.00		1.0000
Diameter of Sample (inch)	2.42		2.42
Dial Reading-Consolidation (inch)			
Weight of Soil + Ring (gm)	198.03		
Weight of Ring (gm)	46.92		
Weight of Wet Soil + Cont. (gm)			153.44
Weight of Dry Soil + Cont. (gm)			123.08
Weight of Cont. (gm) No. 8			3.66
Moisture Content (%)			25.42
Wet Density (pcf / kN/m³)	125.15	19.70	
Dry Density (pcf / kN/m³)	99.79	15.71	

Percent Saturation (%)	101.13	**File No. :** 0612309	3
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**	
Tested By : JF	**Date :** 11/30/09	6.00	(ksf)

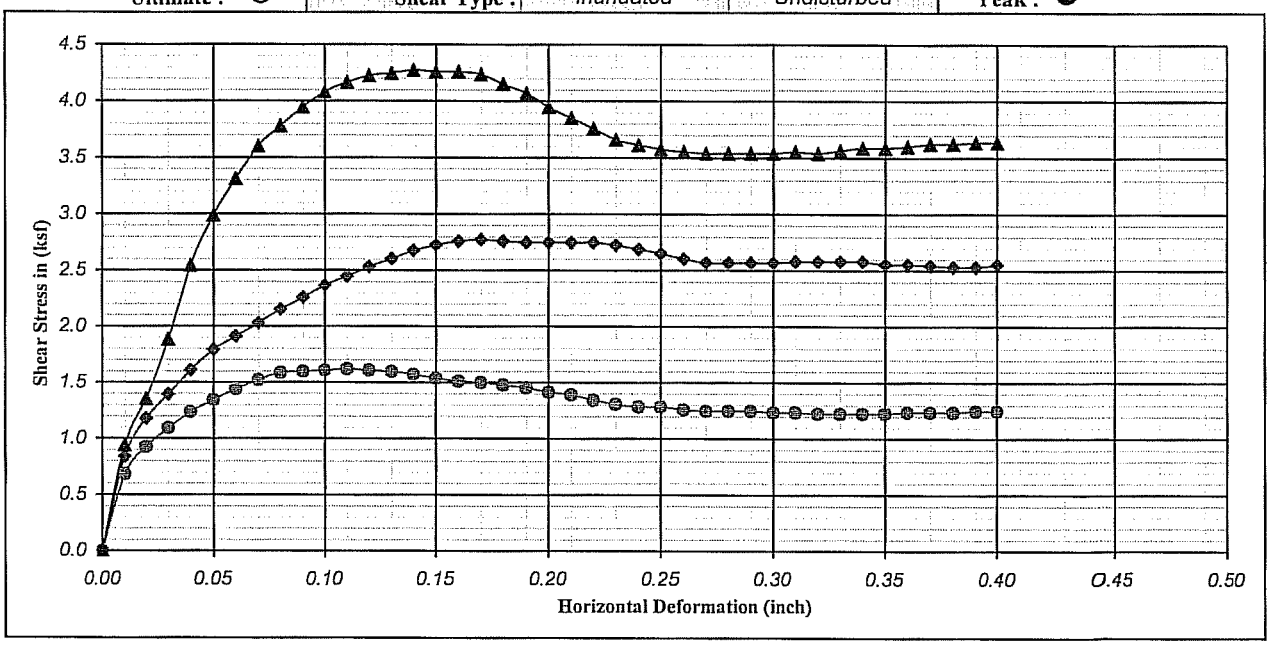
	Before		After
Percent Consolidation (%)			
Height of Sample (inch)	1.00		1.0000
Diameter of Sample (inch)	2.42		2.42
Dial Reading-Consolidation (inch)			
Weight of Soil + Ring (gm)	201.08		
Weight of Ring (gm)	47.03		
Weight of Wet Soil + Cont. (gm)			156.49
Weight of Dry Soil + Cont. (gm)			127.10
Weight of Cont. (gm) No. 9			3.67
Moisture Content (%)			23.81
Wet Density (pcf / kN/m³)	127.59	20.08	
Dry Density (pcf / kN/m³)	103.05	16.22	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.62	77.57	2.77	132.72	4.27	204.54
Ultimate	1.22	58.61	2.53	121.23	3.54	169.50

Shear Deflection		Normal Stress (psf/ksf/kPa)								
		2000	2.00	95.8	4000	4.0	191.5	6000	6.0	287.3
(inch)	(mm)	Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	684	0.68	32.7	840	0.84	40.2	940	0.94	44.8
0.020	0.05	924	0.92	44.2	1176	1.18	56.3	1352	1.35	64.5
0.030	0.08	1092	1.09	52.3	1392	1.39	66.6	1884	1.88	89.9
0.040	0.10	1236	1.24	59.2	1608	1.61	77.0	2544	2.54	121.4
0.050	0.13	1344	1.34	64.4	1788	1.79	85.6	2988	2.99	142.5
0.060	0.15	1440	1.44	68.9	1908	1.91	91.4	3312	3.31	158.0
0.070	0.18	1524	1.52	73.0	2028	2.03	97.1	3600	3.60	171.7
0.080	0.20	1584	1.58	75.8	2148	2.15	102.8	3780	3.78	180.3
0.090	0.23	1596	1.60	76.4	2256	2.26	108.0	3948	3.95	188.3
0.100	0.25	1608	1.61	77.0	2364	2.36	113.2	4080	4.08	194.6
0.110	0.28	1620	1.62	77.6	2448	2.45	117.2	4164	4.16	198.6
0.120	0.30	1608	1.61	77.0	2532	2.53	121.2	4224	4.22	201.5
0.130	0.33	1596	1.60	76.4	2604	2.60	124.7	4248	4.25	202.6
0.140	0.36	1572	1.57	75.3	2676	2.68	128.1	4272	4.27	203.8
0.150	0.38	1536	1.54	73.5	2724	2.72	130.4	4260	4.26	203.2
0.160	0.41	1512	1.51	72.4	2760	2.76	132.1	4260	4.26	203.2
0.170	0.43	1500	1.50	71.8	2772	2.77	132.7	4236	4.24	202.1
0.180	0.46	1476	1.48	70.7	2760	2.76	132.1	4152	4.15	198.1
0.190	0.48	1452	1.45	69.5	2748	2.75	131.6	4068	4.07	194.1
0.200	0.51	1416	1.42	67.8	2748	2.75	131.6	3948	3.95	188.3
0.210	0.53	1392	1.39	66.6	2748	2.75	131.6	3852	3.85	183.7
0.220	0.56	1344	1.34	64.4	2748	2.75	131.6	3756	3.76	179.2
0.230	0.58	1308	1.31	62.6	2724	2.72	130.4	3660	3.66	174.6
0.240	0.61	1284	1.28	61.5	2688	2.69	128.7	3612	3.61	172.3
0.250	0.64	1284	1.28	61.5	2652	2.65	127.0	3576	3.58	170.6
0.260	0.66	1260	1.26	60.3	2604	2.60	124.7	3552	3.55	169.4
0.270	0.69	1248	1.25	59.8	2568	2.57	123.0	3540	3.54	168.9
0.280	0.71	1248	1.25	59.8	2568	2.57	123.0	3540	3.54	168.9
0.290	0.74	1248	1.25	59.8	2568	2.57	123.0	3540	3.54	168.9
0.300	0.76	1236	1.24	59.2	2568	2.57	123.0	3540	3.54	168.9
0.310	0.79	1236	1.24	59.2	2580	2.58	123.5	3552	3.55	169.4
0.320	0.81	1224	1.22	58.6	2580	2.58	123.5	3540	3.54	168.9
0.330	0.84	1224	1.22	58.6	2580	2.58	123.5	3564	3.56	170.0
0.340	0.86	1224	1.22	58.6	2580	2.58	123.5	3588	3.59	171.2
0.350	0.89	1224	1.22	58.6	2556	2.56	122.4	3588	3.59	171.2
0.360	0.91	1236	1.24	59.2	2556	2.56	122.4	3600	3.60	171.7
0.370	0.94	1236	1.24	59.2	2544	2.54	121.8	3624	3.62	172.9
0.380	0.97	1236	1.24	59.2	2532	2.53	121.2	3624	3.62	172.9
0.390	0.99	1248	1.25	59.8	2532	2.53	121.2	3636	3.64	173.4
0.400	1.02	1248	1.25	59.8	2556	2.56	122.4	3636	3.64	173.4
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-056		Strength Intercept (C) :	0.24	(ksf)		0.12	(ksf)	
Sample No. : D-6			11.30	(kPa)	Peak	5.55	(kPa)	Ultimate
Depth (ft/m) : 30.0	0.00	Friction Angle (ϕ) :	33.54	Degree		30.07	Degree	
Description : Gray, Poorly graded SAND with SILT (SP-SM)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	26.93	97.16	15.29	0.73	2.00	95.76	1.62	77.57	1.22	58.61
◆	25.42	99.79	15.71	0.69	4.00	191.52	2.77	132.72	2.53	121.23
▲	23.81	103.05	16.22	0.64	6.00	287.28	4.27	204.54	3.54	169.50

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

MEASUREMENT OF SOIL CORROSIVITY

Project No.	: 06-123-3	Project Name : ACTA/Schuyler Heim Bridge Project	
Boring No.	: A-09-056	Depth (ft/m) : 5.00	1.53
Sample No.	: S-1	Description : Olive, SILTY SAND (SM)	

*** Sample for Corrosivity tests must screen through No. 8 Sieve

Measurement of Soil Resistivity (ASTM G-57-78 / CT- 643)

Test Standard	ASTM	X	CAL. TRAN.	Wt of Wet Soil + Cont. (gm)		118.91	Weight of Total
Soil Box Diamension (cm)	22.86 X 3.81 X 2.54		15.31 X 10.04 X4.41	Wt of Dry Soil + Cont. (gm)		111.34	Sample for Test (gm)
(L X W X H) / (inch)	9.0 X 1.5 X 1.0		6.04X 3.95 X 1.74	Wt. of Cont. No.	3	58.47	100.19
Soil Box Constant (C)	1.0		6.72	Setup Moisture Content (%)		14.32	

Trial	Resistivity Meter Reading (ohm-cm)						Prepared By : PA	Date : 12/14/09
	As received	1	2	3	4	5	Tested By : PA	Date : 12/15/09
Water added	0.0	5.00	5.00	5.00	5.00	5.00	Calculated By : JF	Date : 12/17/09
Meter reading	2200	1000	990	720	670	680	Checked By :	Date :
Resistivity	2200.0	1000.0	990.0	720.0	670.0	680.0	Minimum Resistivity :	670.0

Measurement of Soil pH (ASTM G-51-77 / CT- 643)

Weight 30 gm soil sample and add 30 ml distilled water, stir to a soil slurry and settle at least 1 hr.

						pH Reading				
Prepared By :	Date : 12/14/09	Time : 14:40	Beaker No. : 40			Trial	1	2	3	Average
Tested By :	Date : 12/15/09	Weigh of Wetsoil (gm)		30.01		Test Time	13:46:00	13:48:00	13:50:00	
Calculated By :	Date : 12/17/09	Distilled Water added (ml)		30.03		Reading	7.81	7.85	7.87	7.84
Checked By :	Date :	Moisture Content (%)		14.32						

Measurement of Soil Soluble Sulfate Content (CT - 417)

Weight 100.0 gm of sample soil & add 300 ml. of distilled water. Stopper and shake well. Allow to settle overnight. Prepare two 30 (ml.) of water layer into a 150 (ml.) beaker, dilute to 100 (ml.), add 5 (ml.) conditioning reagent. Turbidity Blank - Adjust the stirrer to the maximum speed, add 1 spoonfull Barium Chloride & start timing. Stir for exactly 1 minute.

Flask No. : 3	Prepared By :	Date : 12/14/09	
Weight of Soil (gm) : 100.01	Tested By :	Date : 12/15/09	
Distilled Water (ml.) : 300.07	Calculated By :	Date : 12/17/09	
Shaking at : 14:41:00	Checked By :	Date :	
Reshaking at :			

Total Water Sample Prepared	60.03	With BaCL		14	< Beaker Number >			15	Blank
Distilled Water added (ml)	200.04			100.01	Tested Sample Volume			100.03	
Time Intervals	0:00:00	0:00:30	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:04:00	Maximum
With BaCL (time)	14:02:00	14:02:30	14:03:00	14:03:30	14:04:00	14:04:30	14:05:00	14:06:00	
Turbidity with BaCL (NTV)		335.00	333.00	333.00	332.00	332.00	332.00	331.00	335.00
Blank (time)	16:03:00	16:03:30	16:04:00	16:04:30	16:05:00	16:05:30	16:06:00	16:07:00	
Turbidity Blank (NTV)		46.40	41.00	34.40	29.40	28.50	27.40	24.90	46.40
Difference (ppm)		288.60	292.00	298.60	302.60	303.50	304.60	306.10	288.60
SO_4 (from graph) (ppm)									580

Measurement of Soil Chloride Content (CT - 422)

1. Weight 100.0 gm sample soil & add 300 ml. of distilled water. Stopper and shake vigorously for 20 seconds, reshaking after one hour and let it settle over night. 2. Pour 30 ml aliquot of filtered solution into a 150 ml beaker, then check pH. If pH is in the range 6 through 8, go to step 4. If ph below 6, add Sodium Hydroxide and if above 8, add Acetic Acid to adjust to the range. 4. Add two drops of Potassium Chromate solution before titrate with Silver Nitrate and change color from Yellow to Red. ** If the titration is over 30 ml., take a smaller sample. Dilute any smaller sample to about 50 ml..

Flask No. : 3	Prepared By :	Date : 12/14/09	
Wt. of Soil (gm) : 100.01	Tested By :	Date : 12/15/09	
Distilled Water (mL) : 300.07	Calculated By :	Date : 12/17/09	
Shaking at : 14:41:00	Checked By :	Date :	
Reshaking at :	Vaccum & Filter at :		

Remark :

Titration of (I ml.) Sample Diluted to (F ml.)	15	< Beaker No.		24	>		
Total Sample Prepared : 60.09	Initial	Final	Total	Initial	Final	Total	
Sample Volume (ml)	30.04	30.04		30.05	30.05		
pH of Liquid Sample	7.84	7.84		7.84	7.84		
Sodium Hydroxide added (ml)	-	-	-	-	-	-	
Acetic Acid added (ml)	-	-	-	-	-	-	Average
Silver Nitrate added (ml)	5.00	9.60	4.60	9.60	14.20	4.60	
ppm CL= 100x(ml of Sil.Ni.-0.2 ml blank)*F/I			440.00			440.00	440.00
Moisture - Free CL = ppm CL X 100 / (100 - w)			513.53			513.53	514

APPENDIX D. SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

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SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

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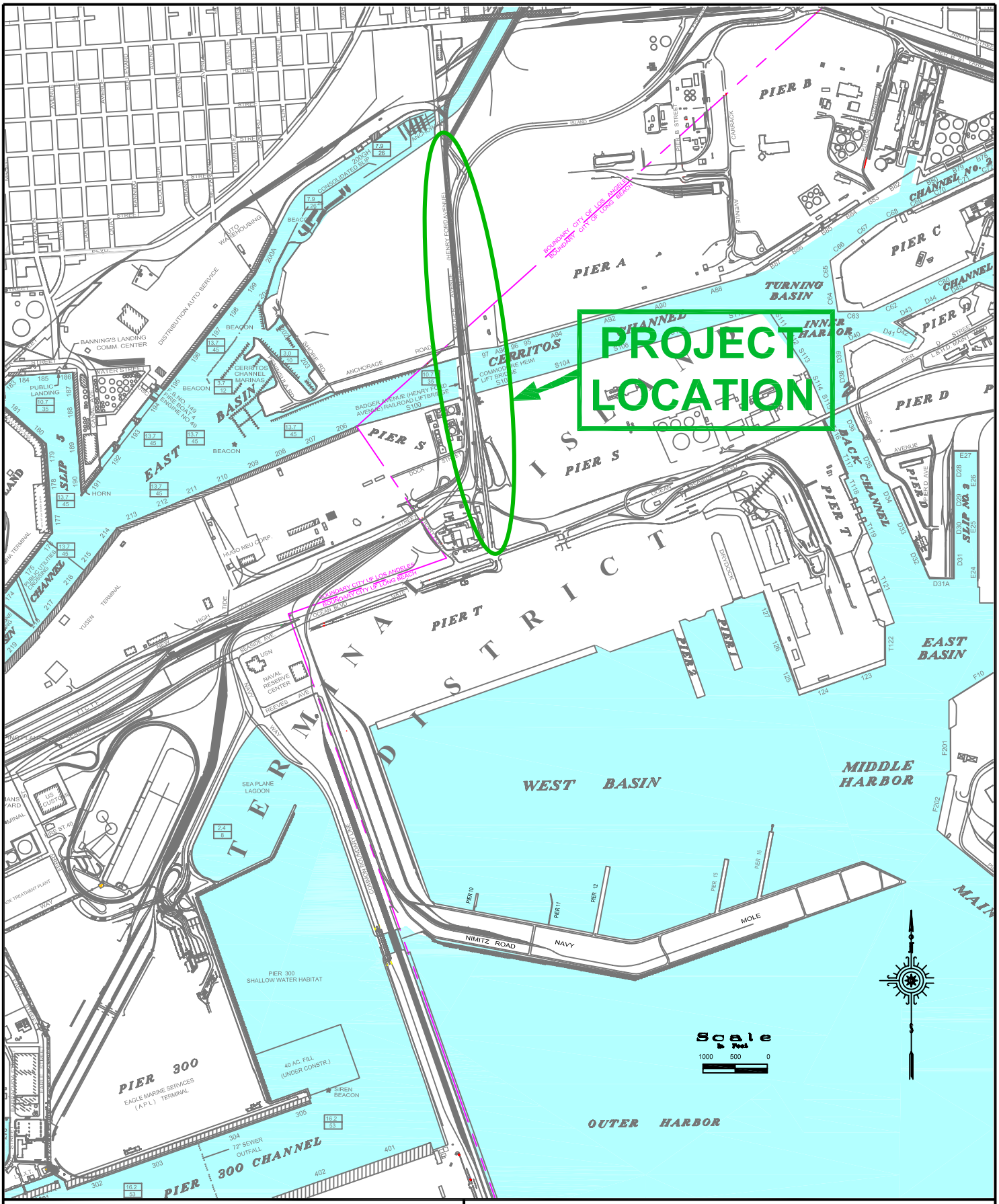
Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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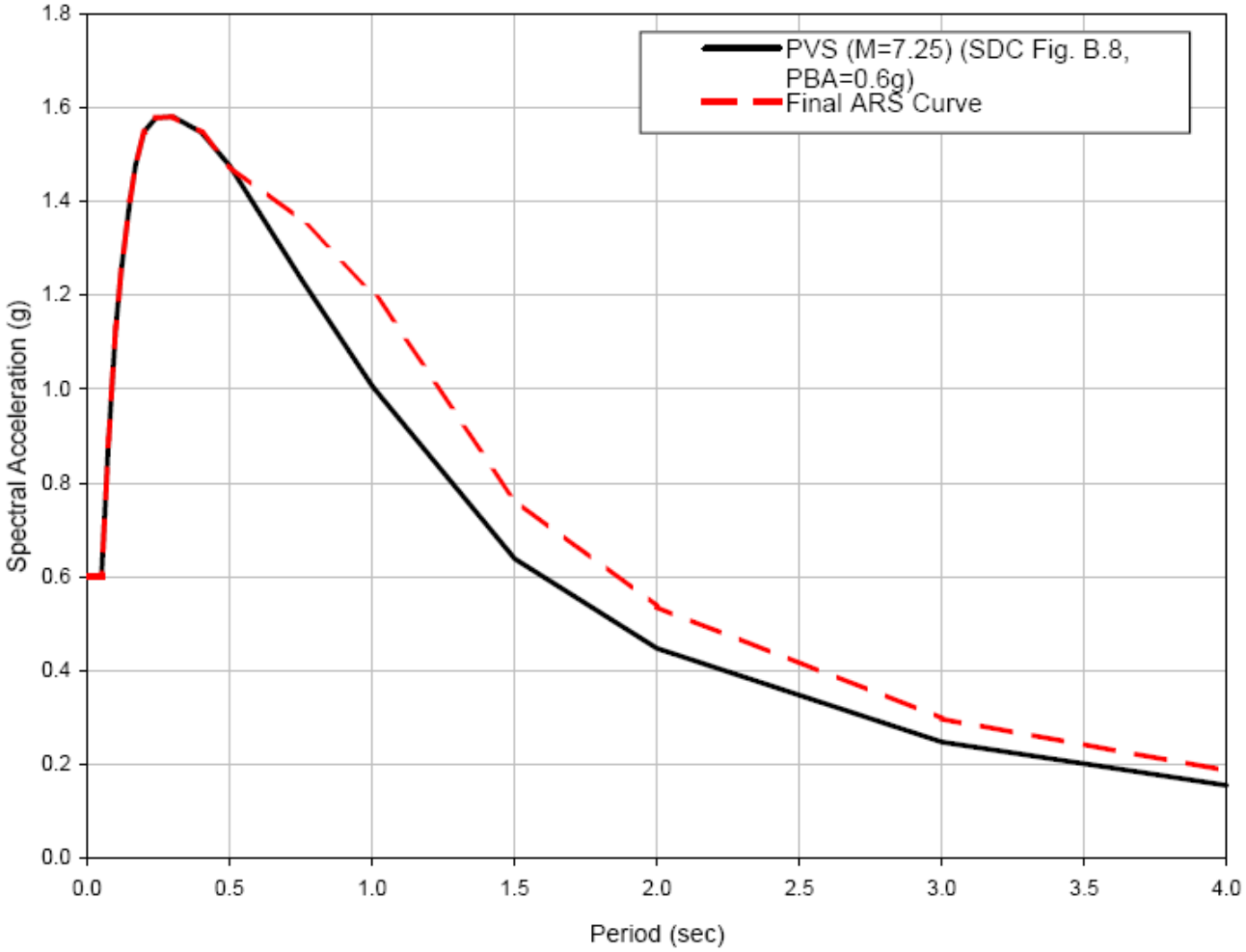
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

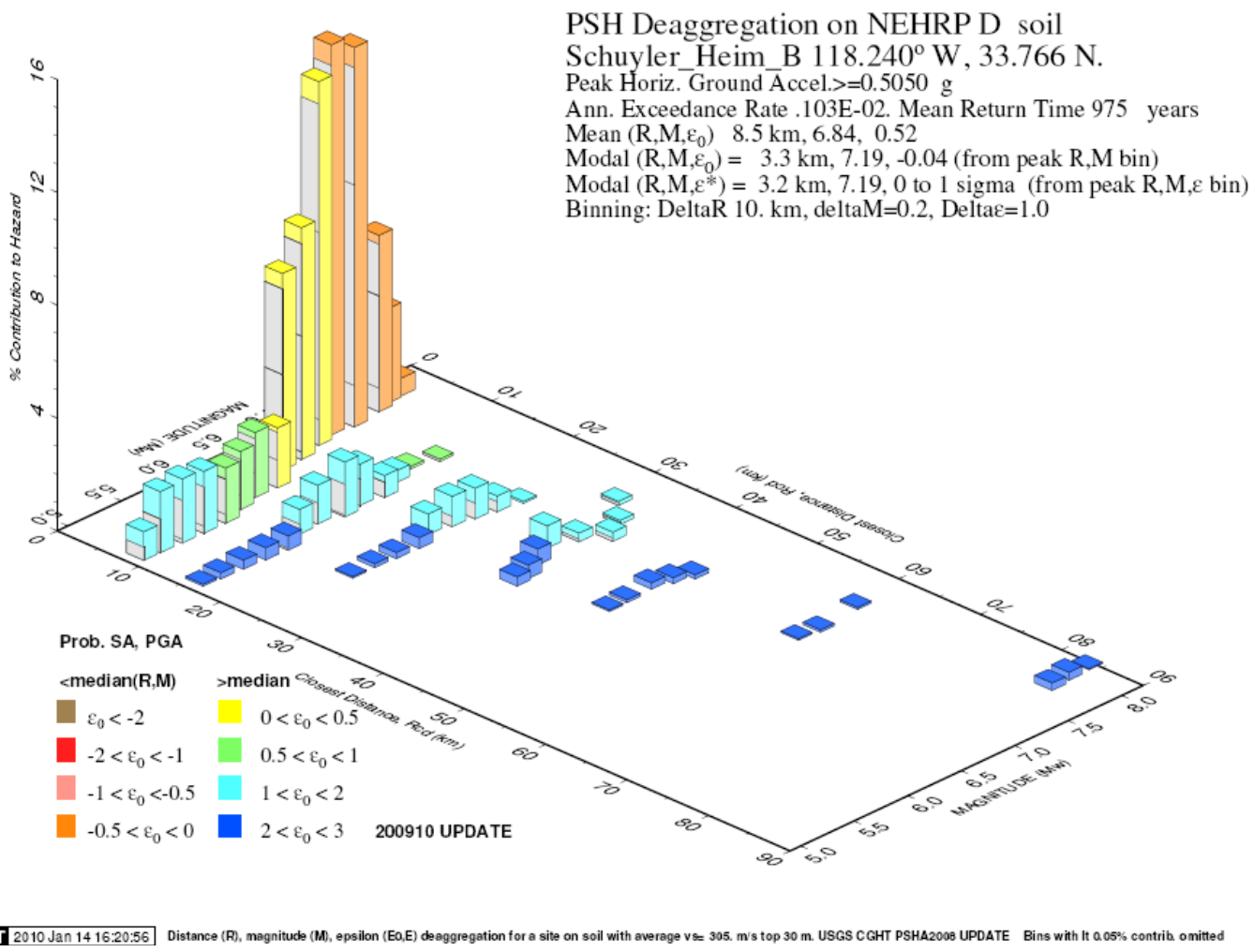


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

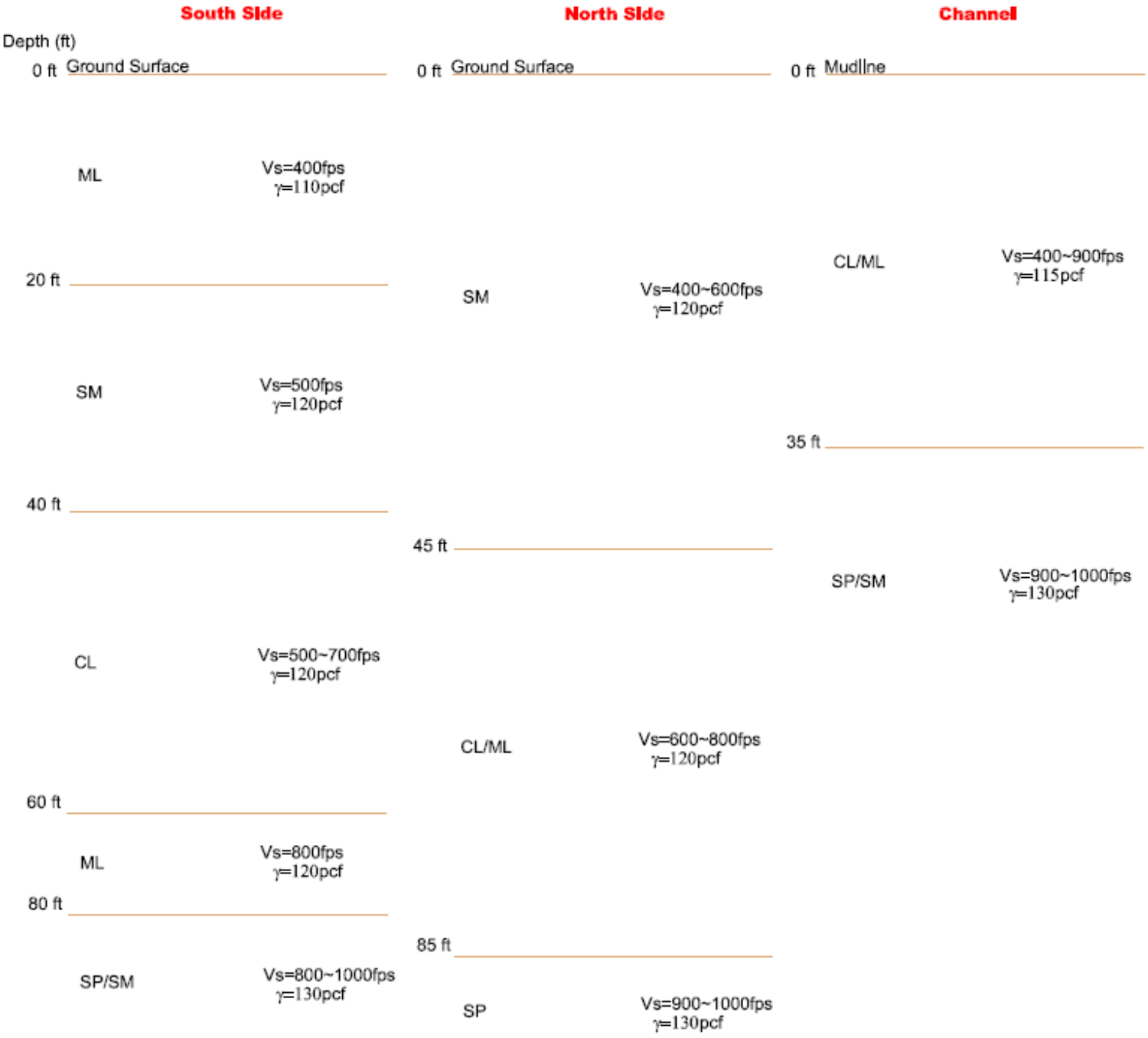
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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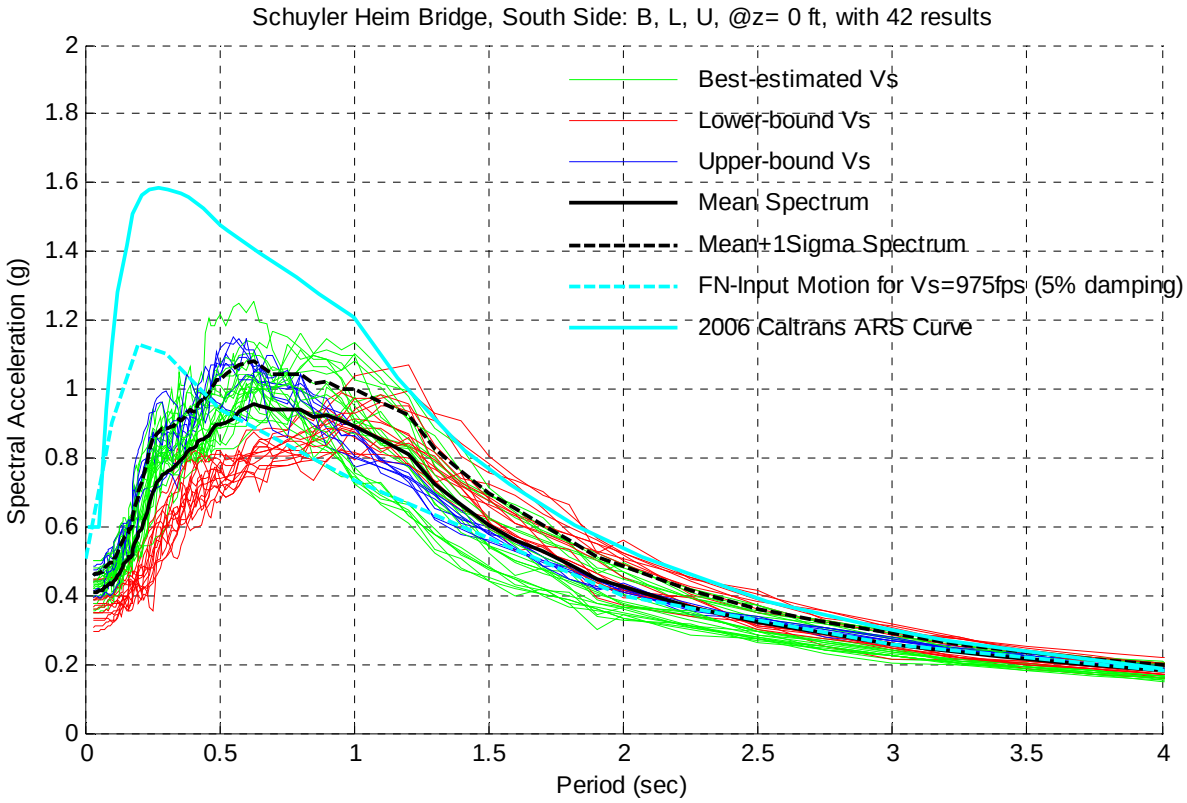
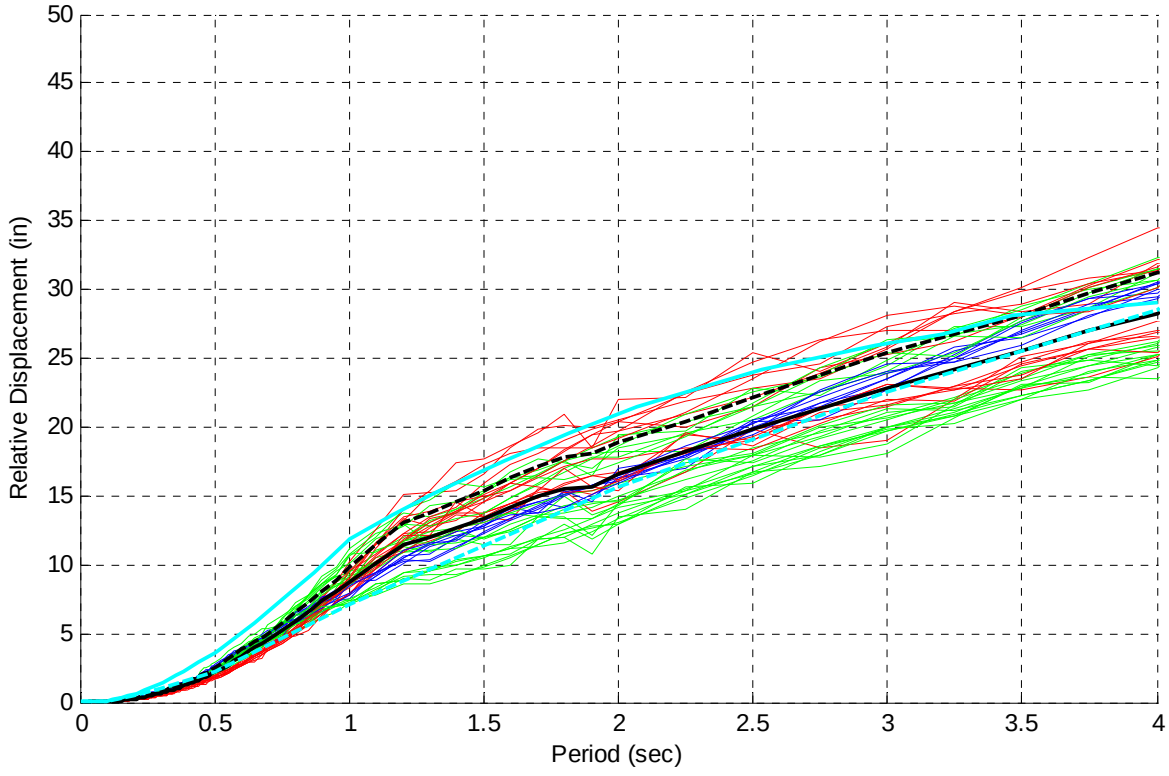
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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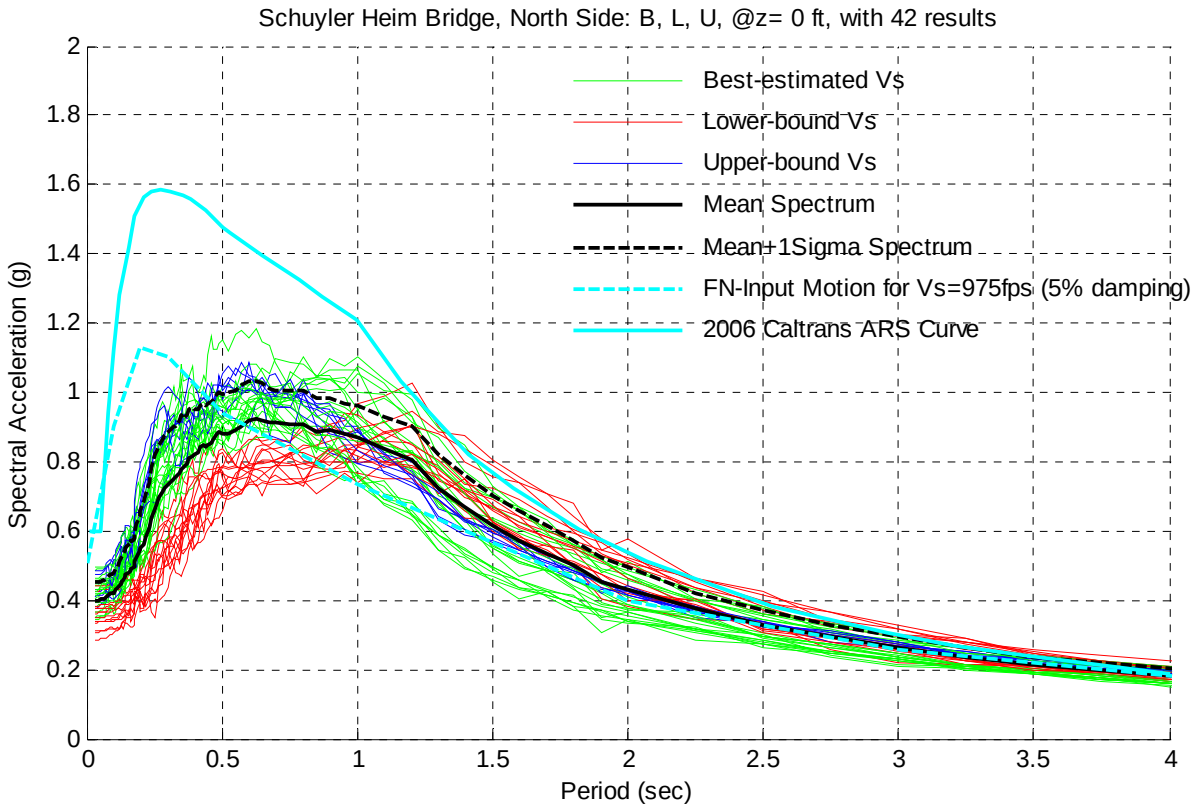
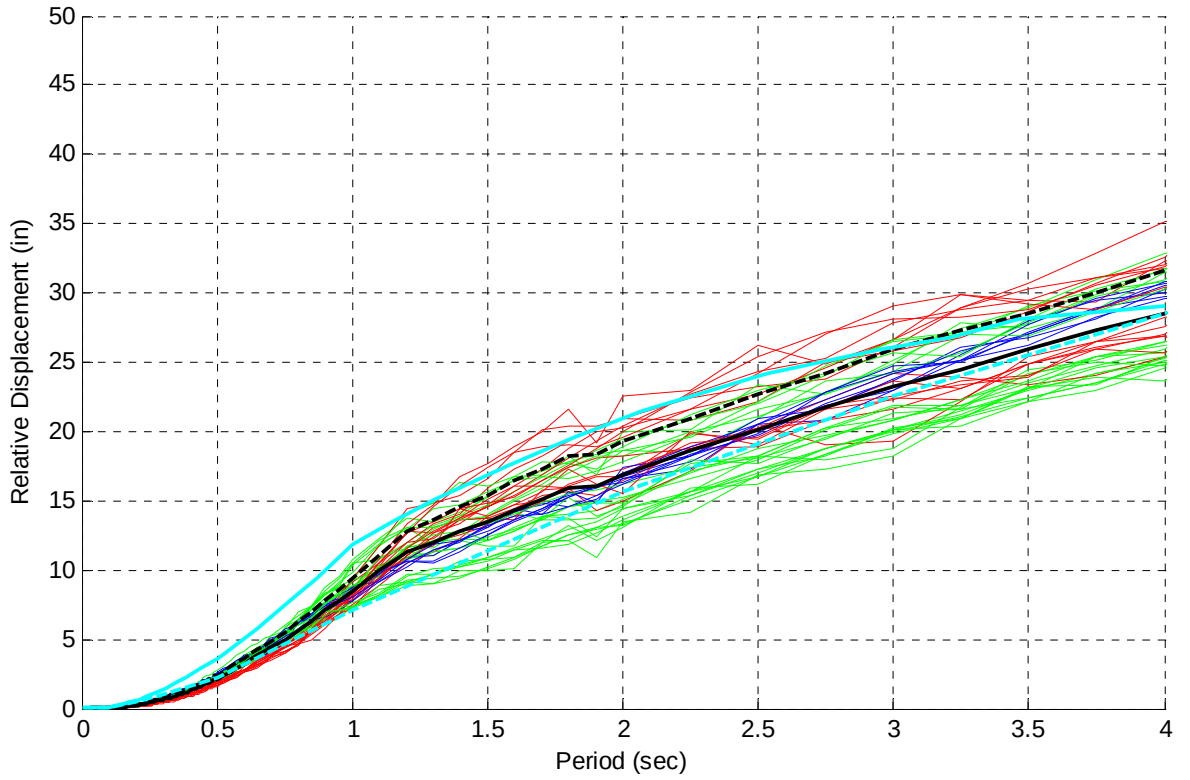
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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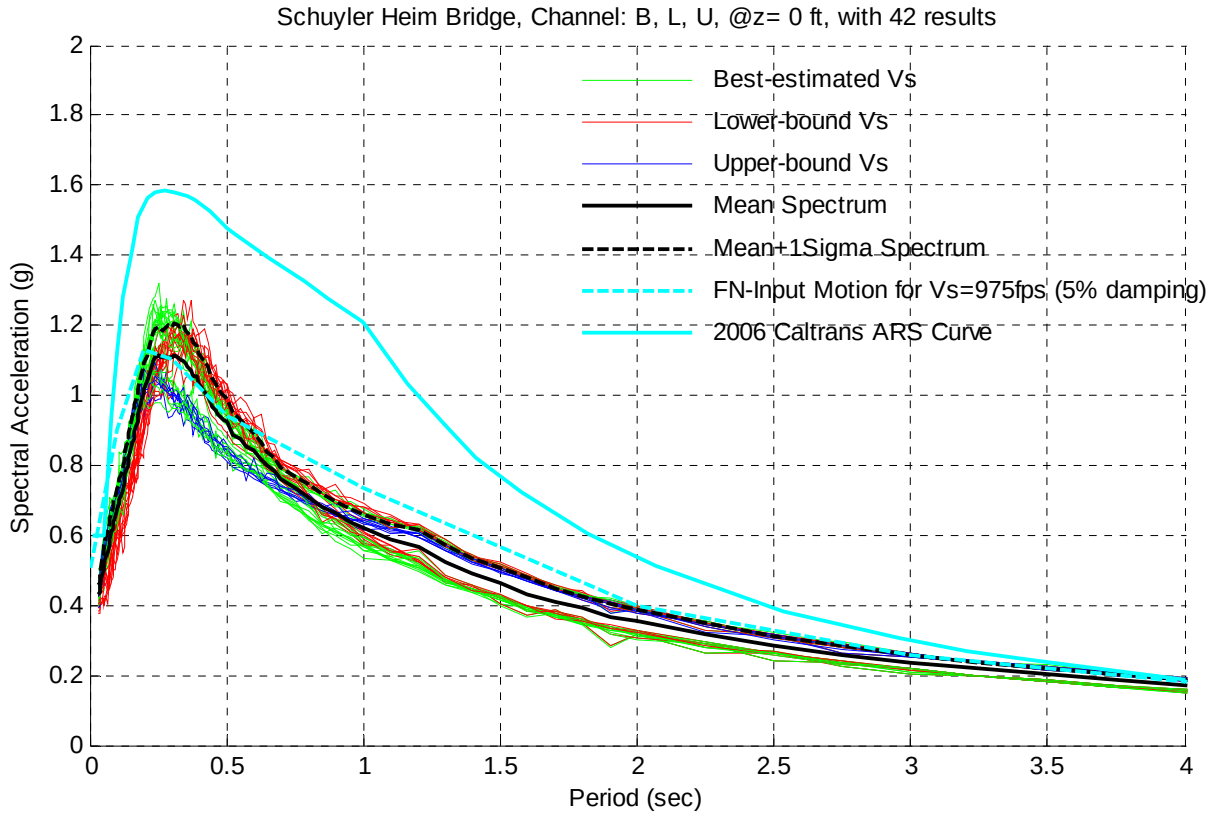
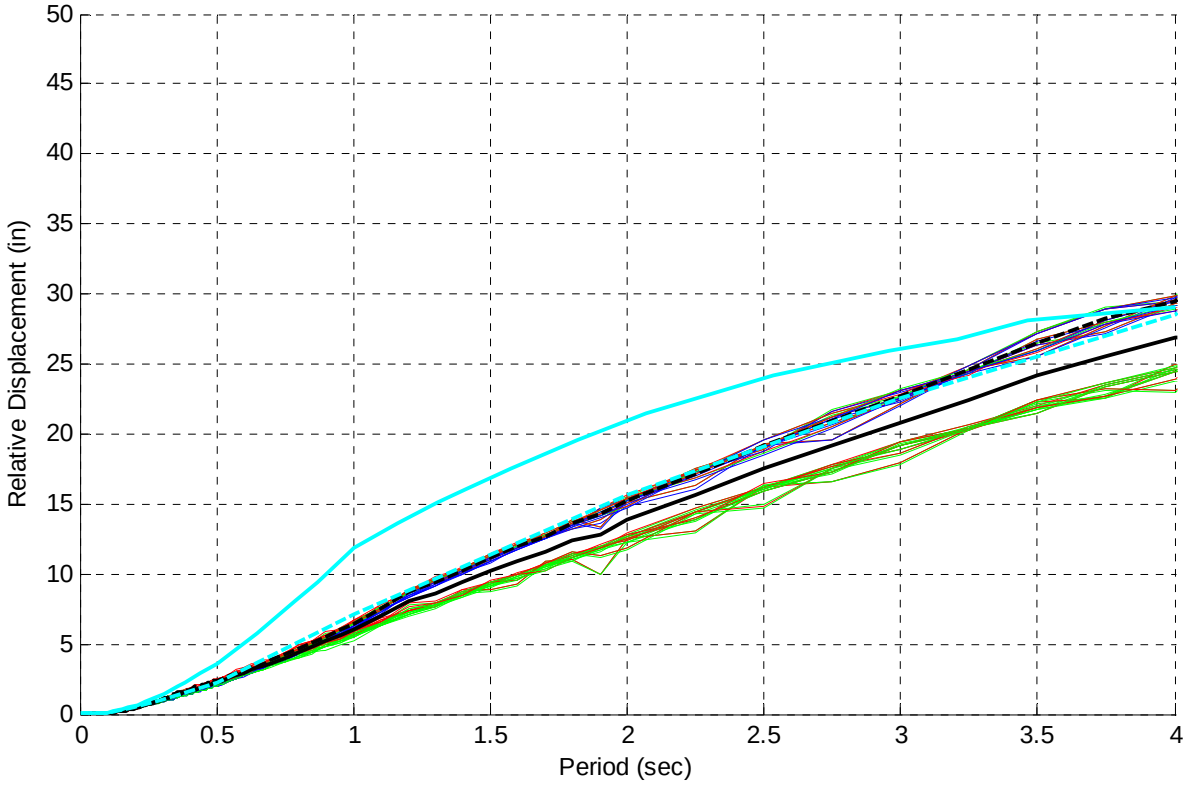
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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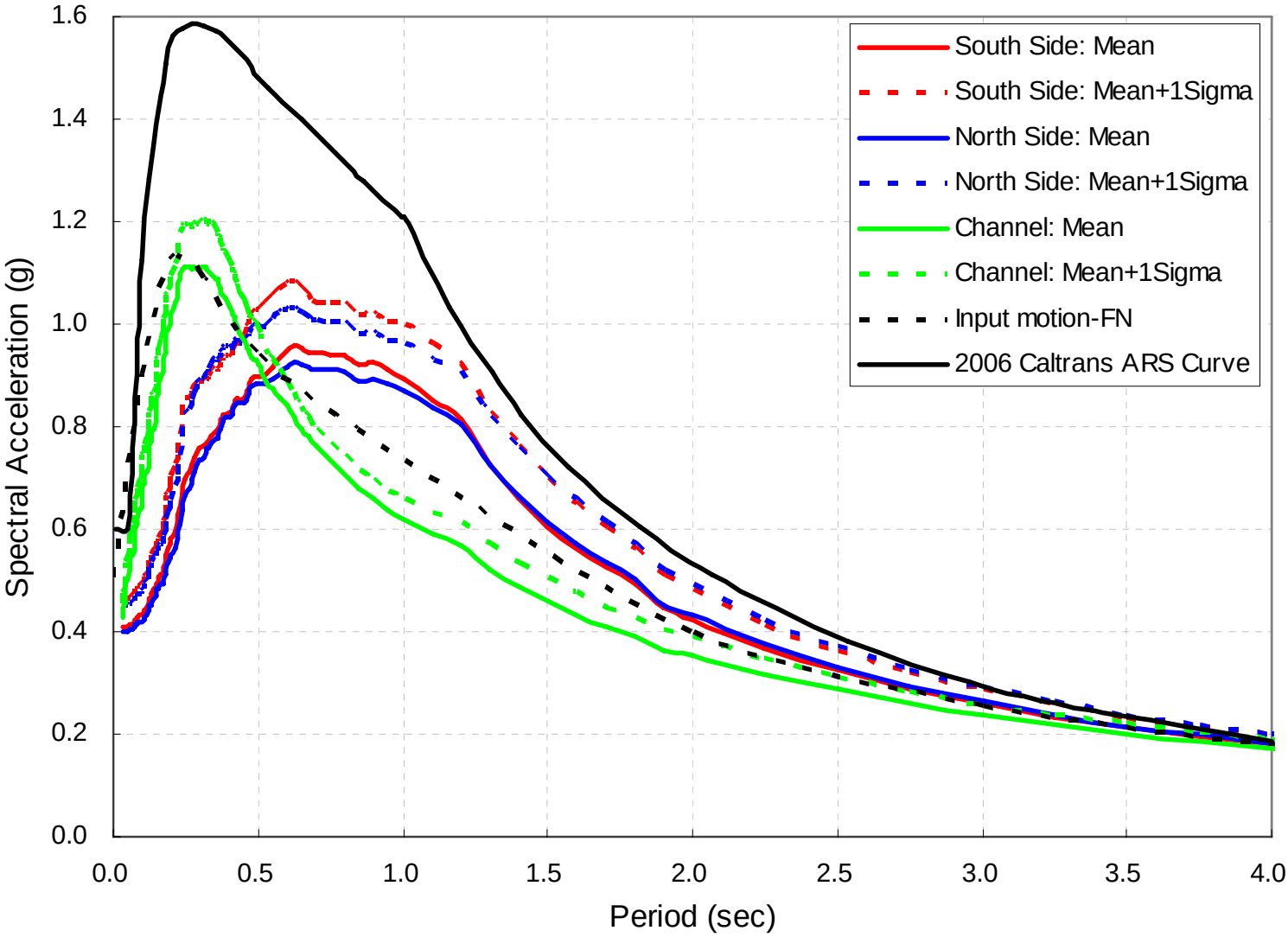
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

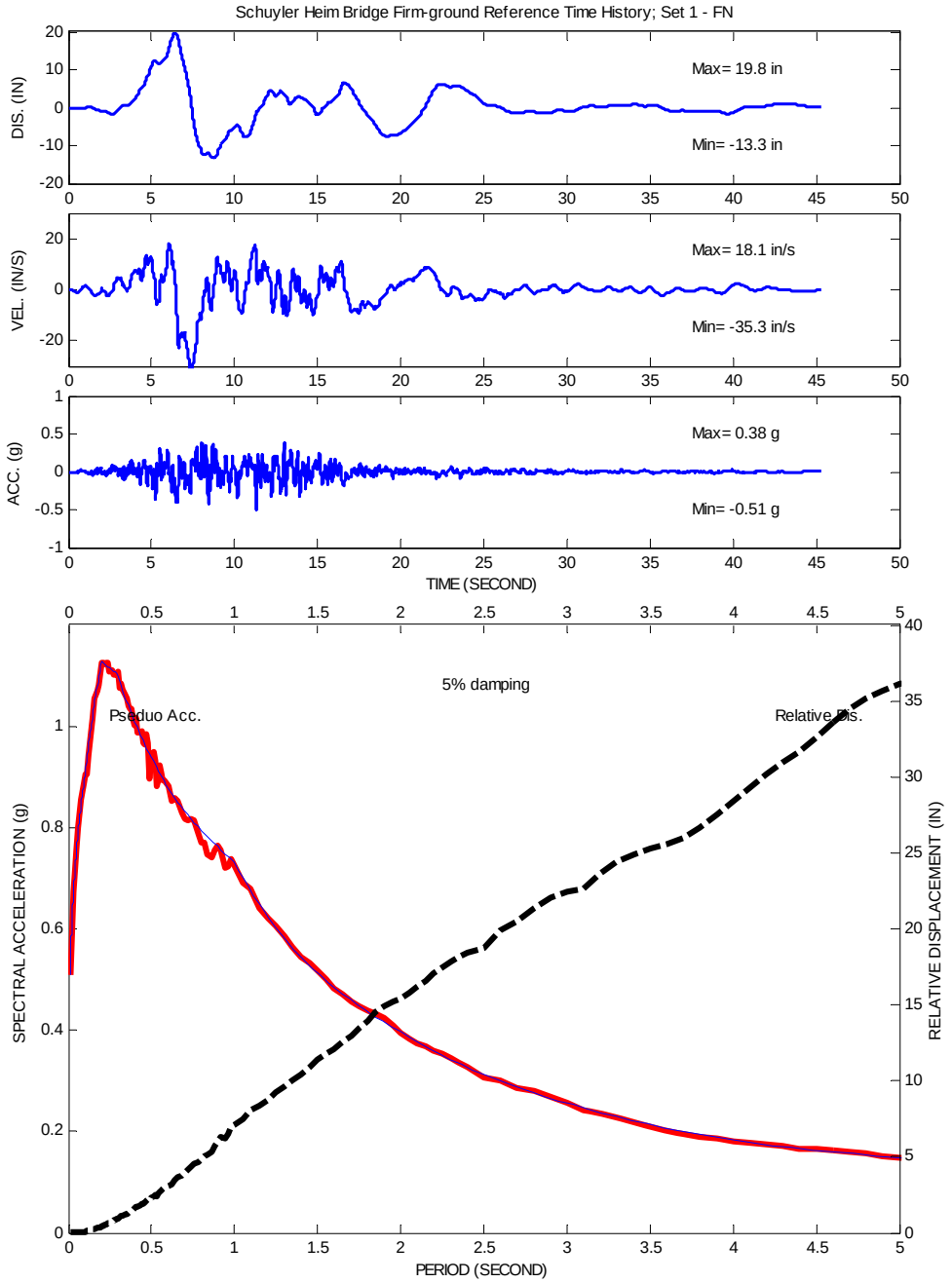


Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

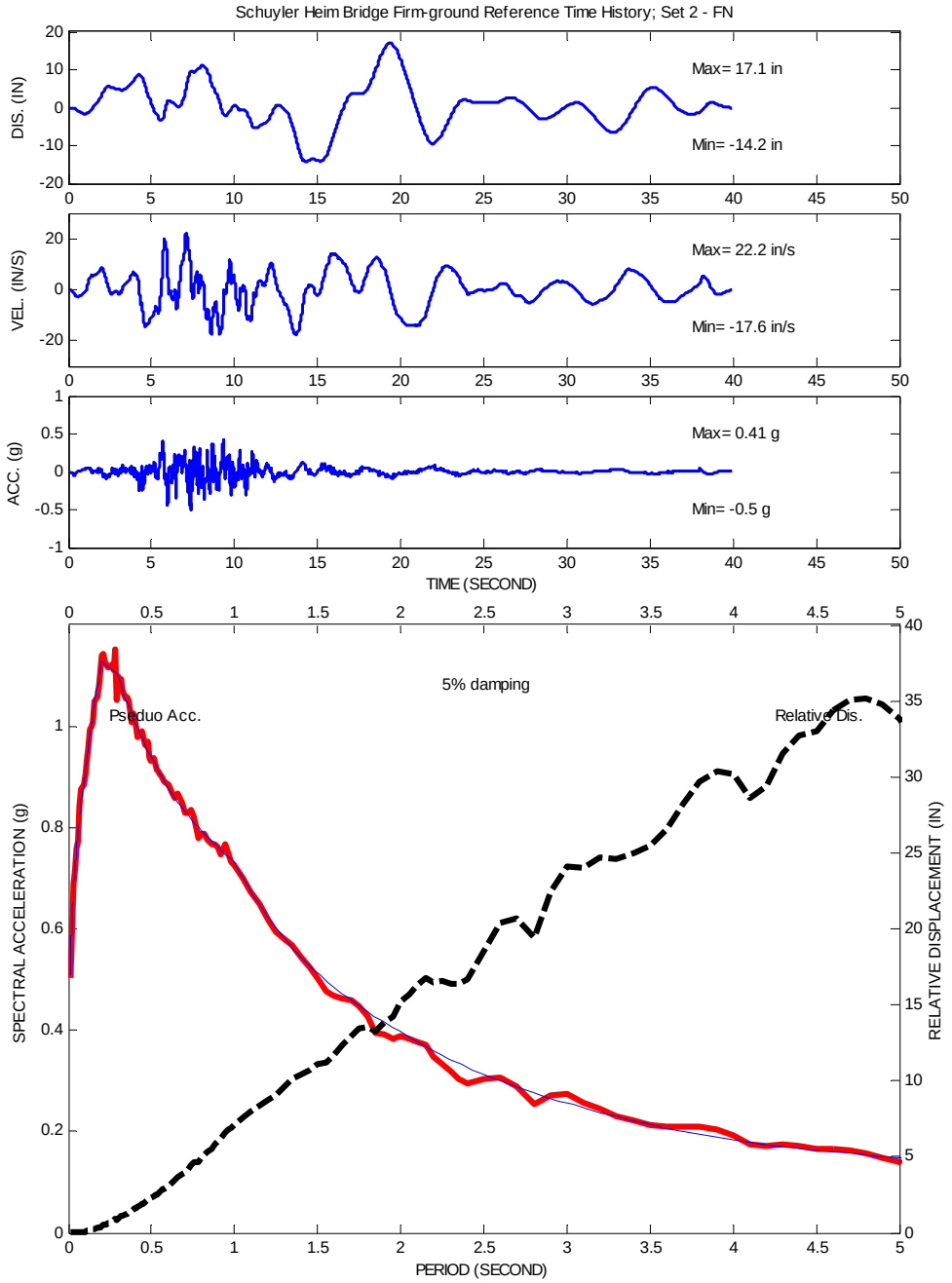


Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

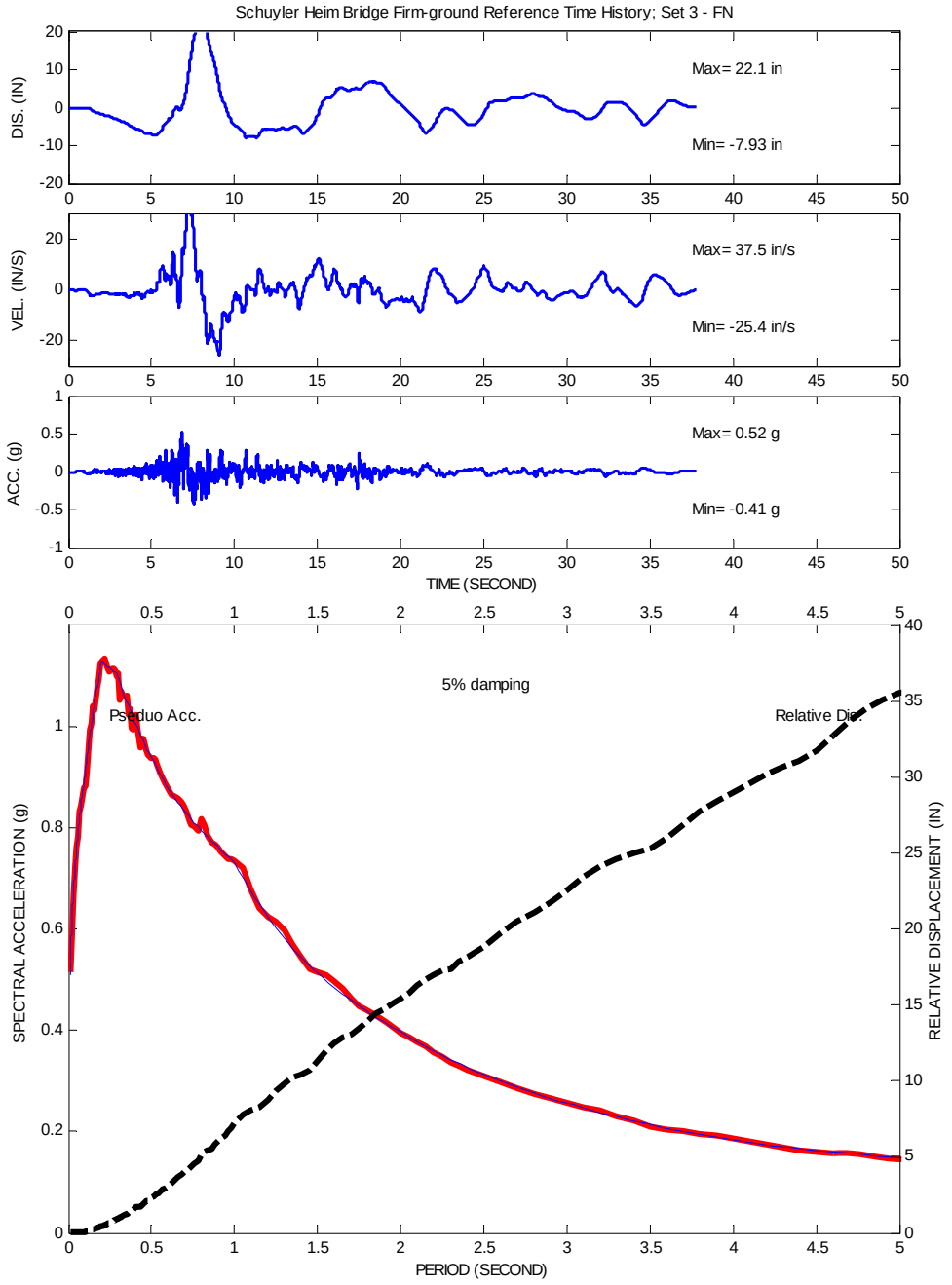


Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

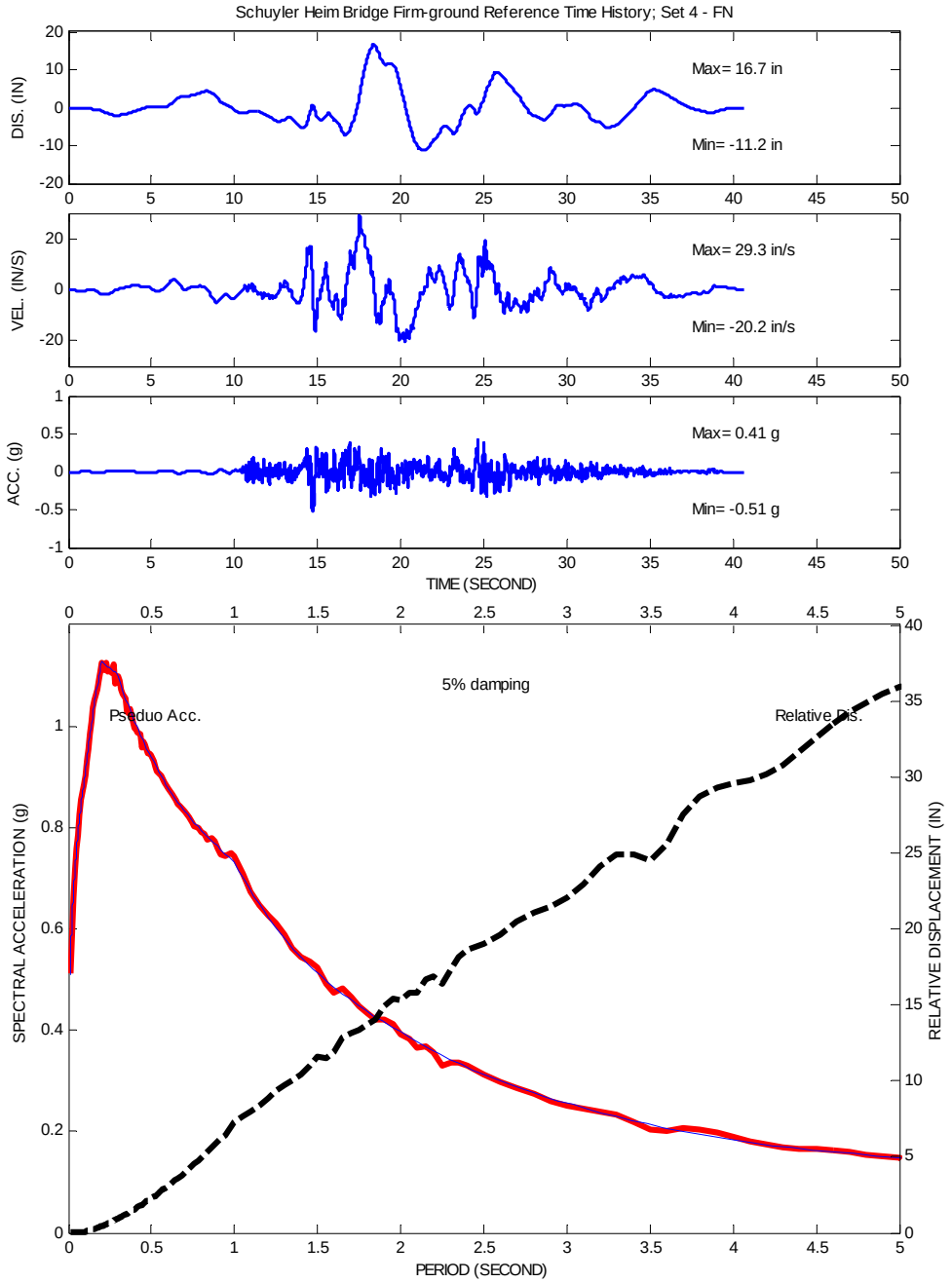


Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

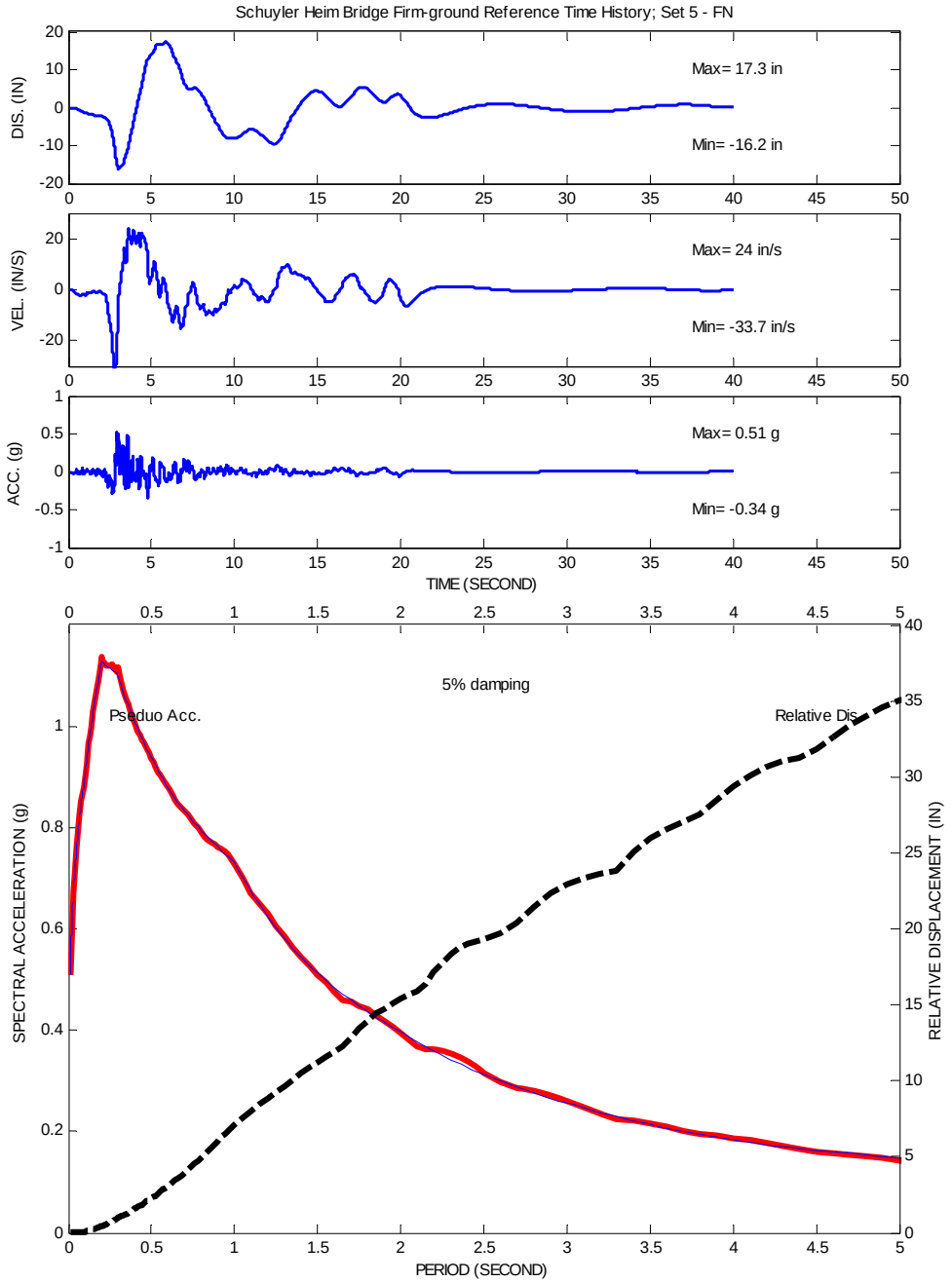


Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

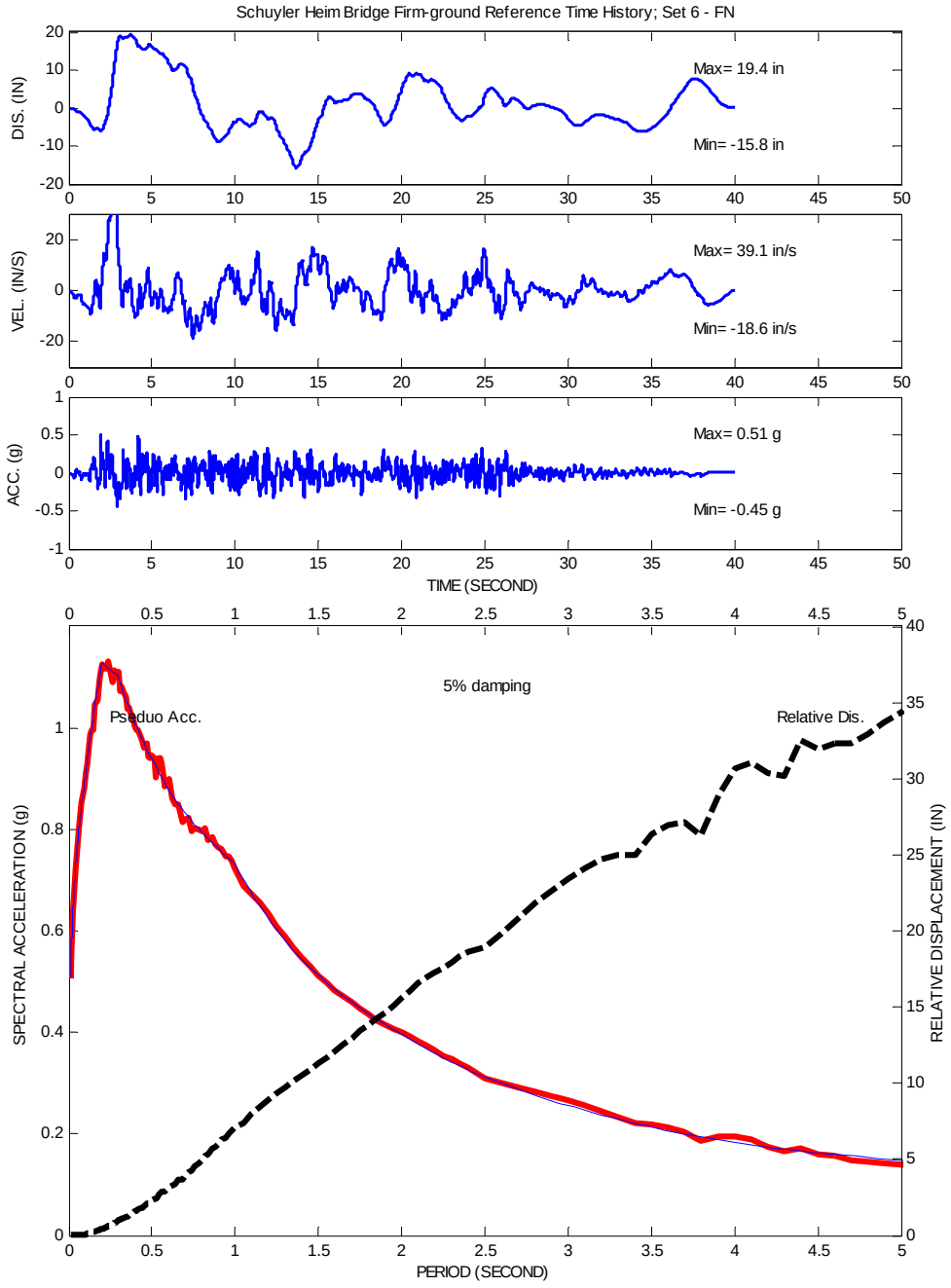


Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

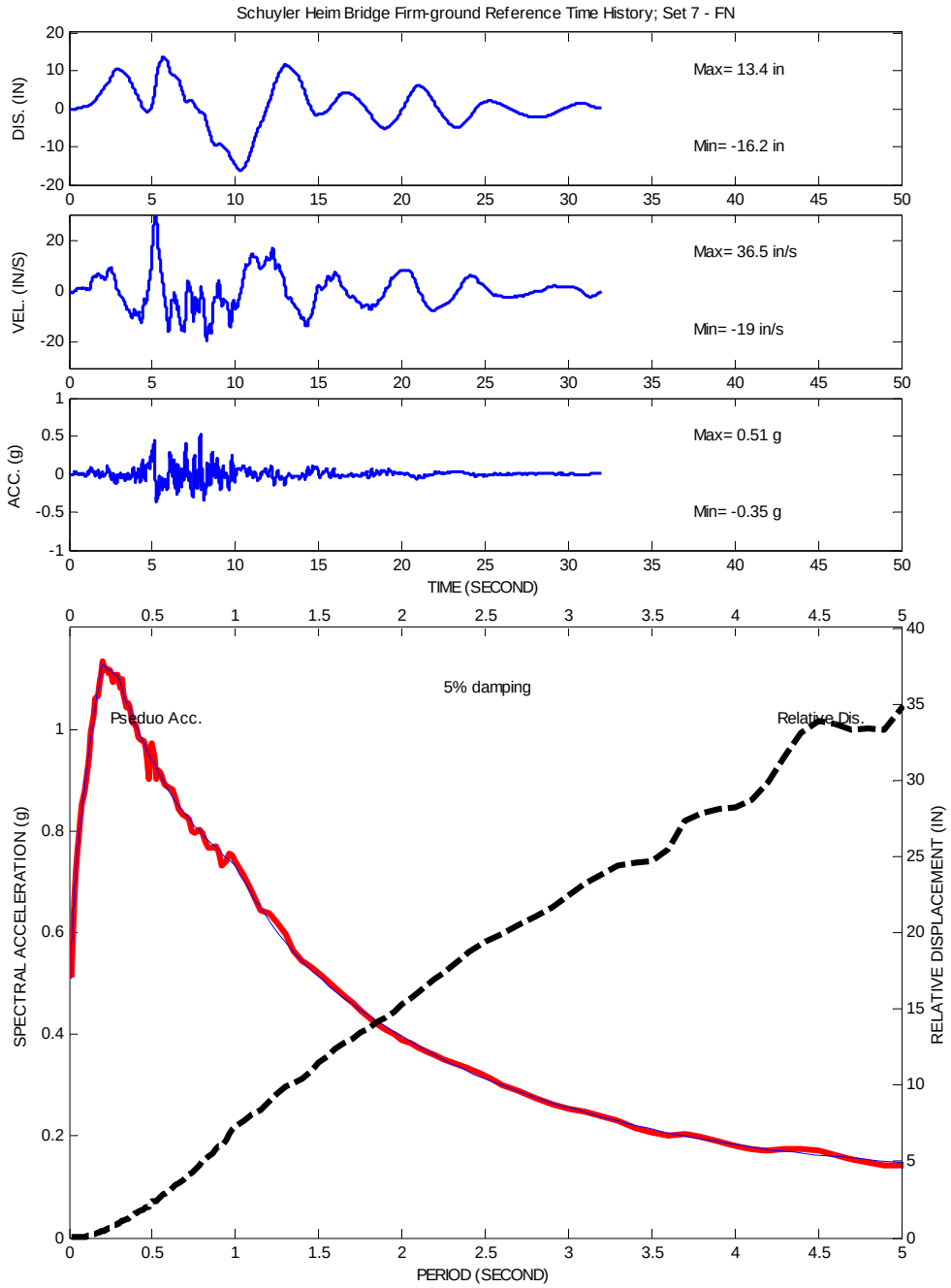


Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

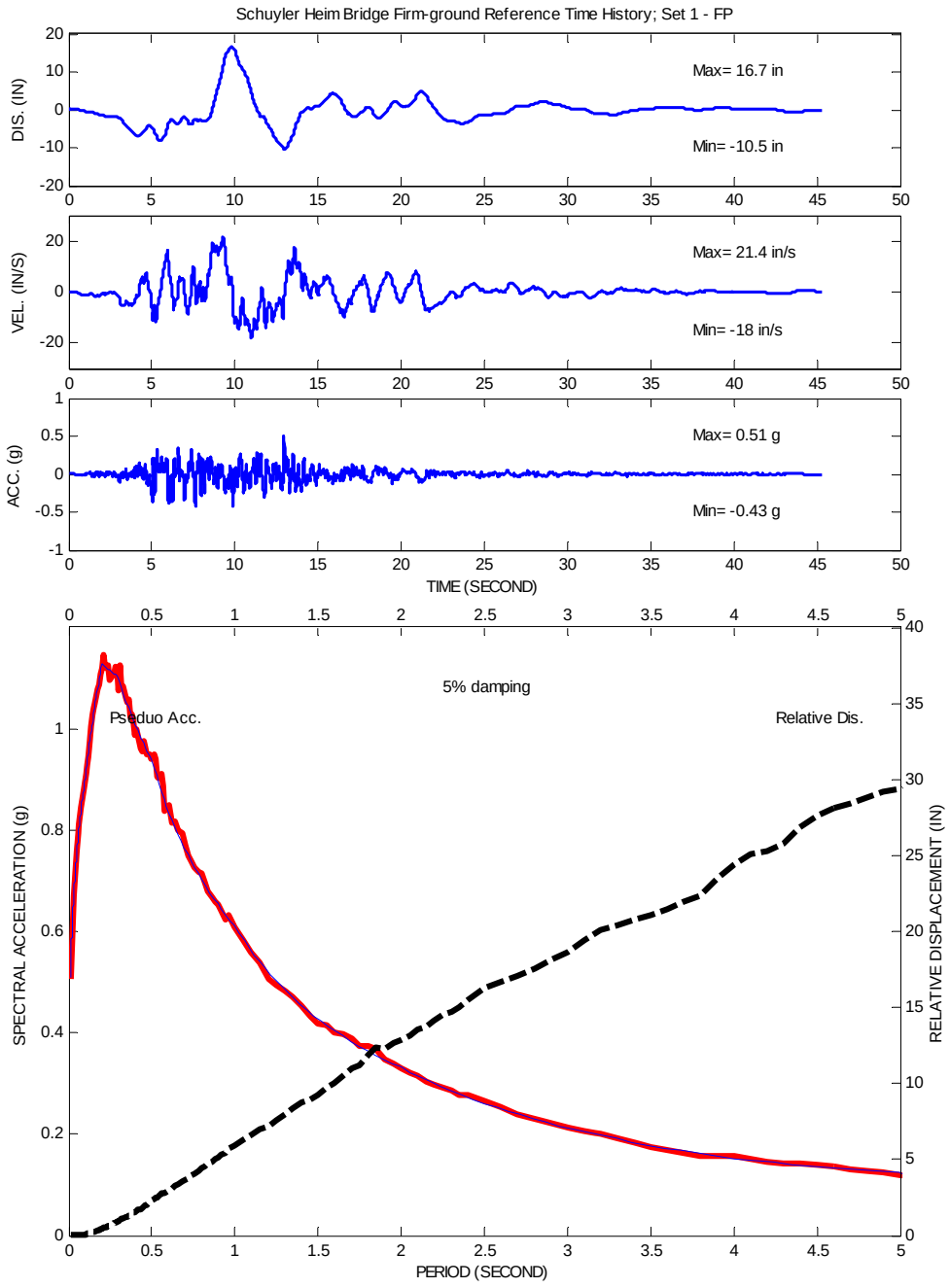


Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

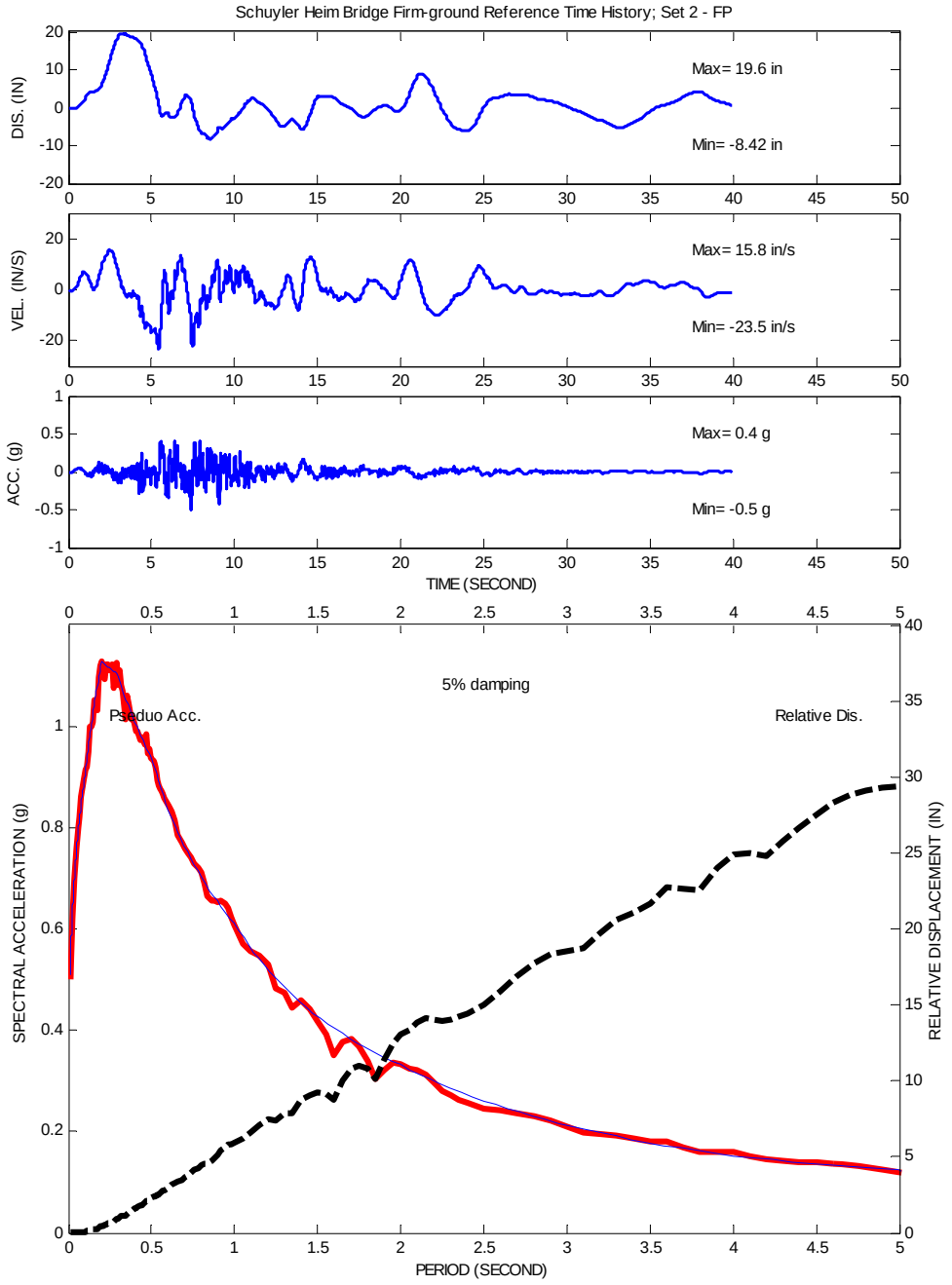


Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

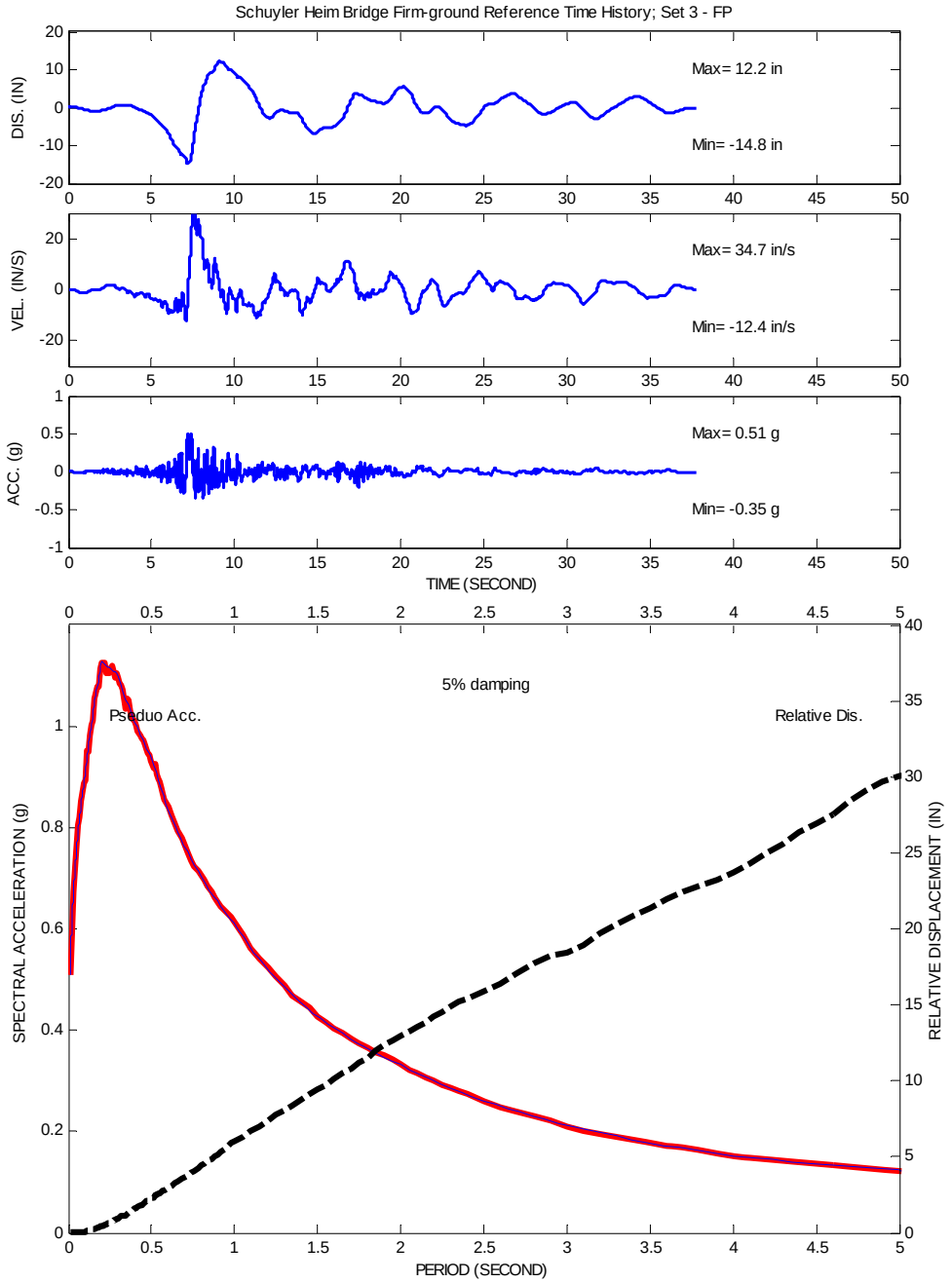


Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

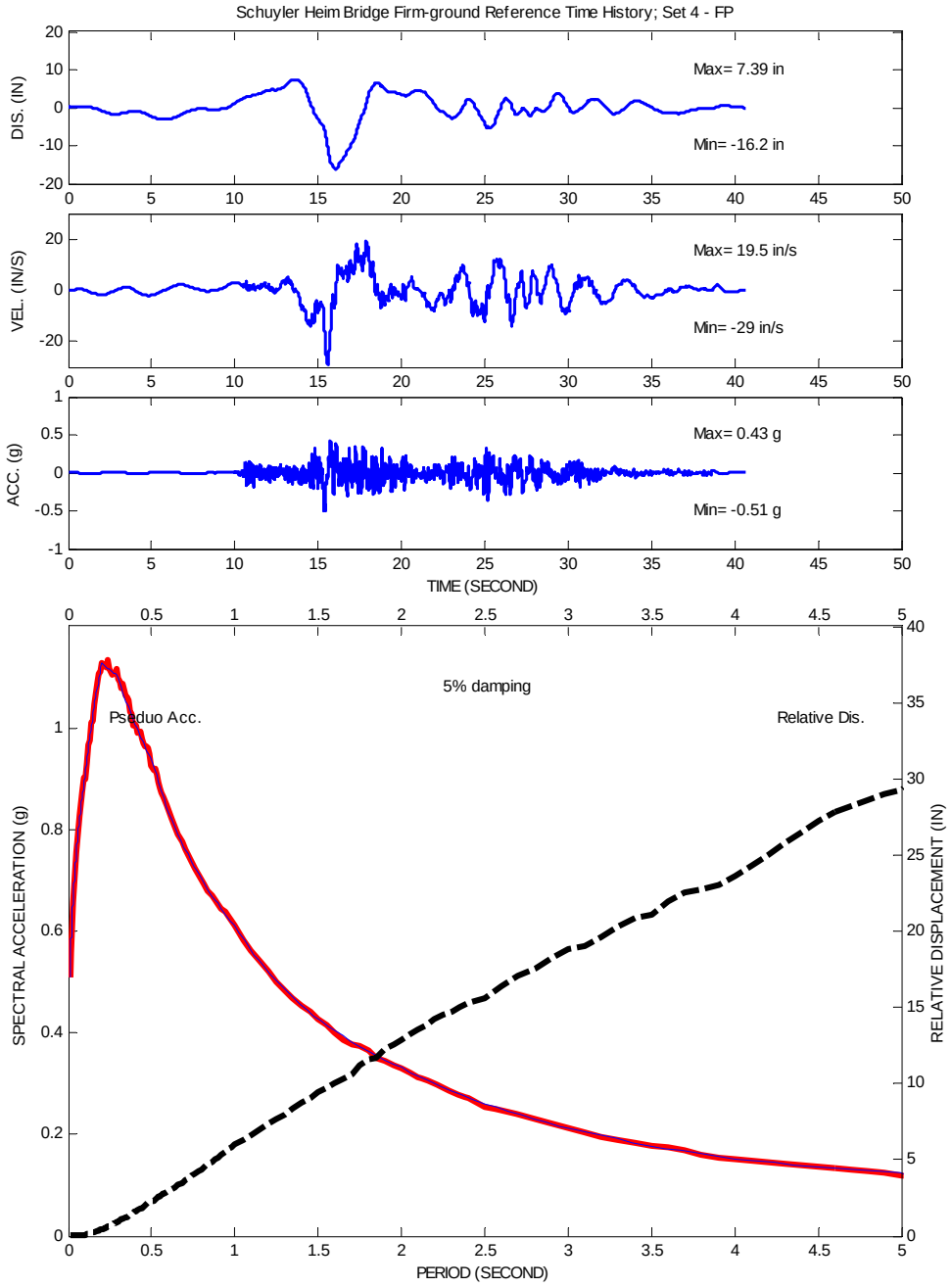


Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

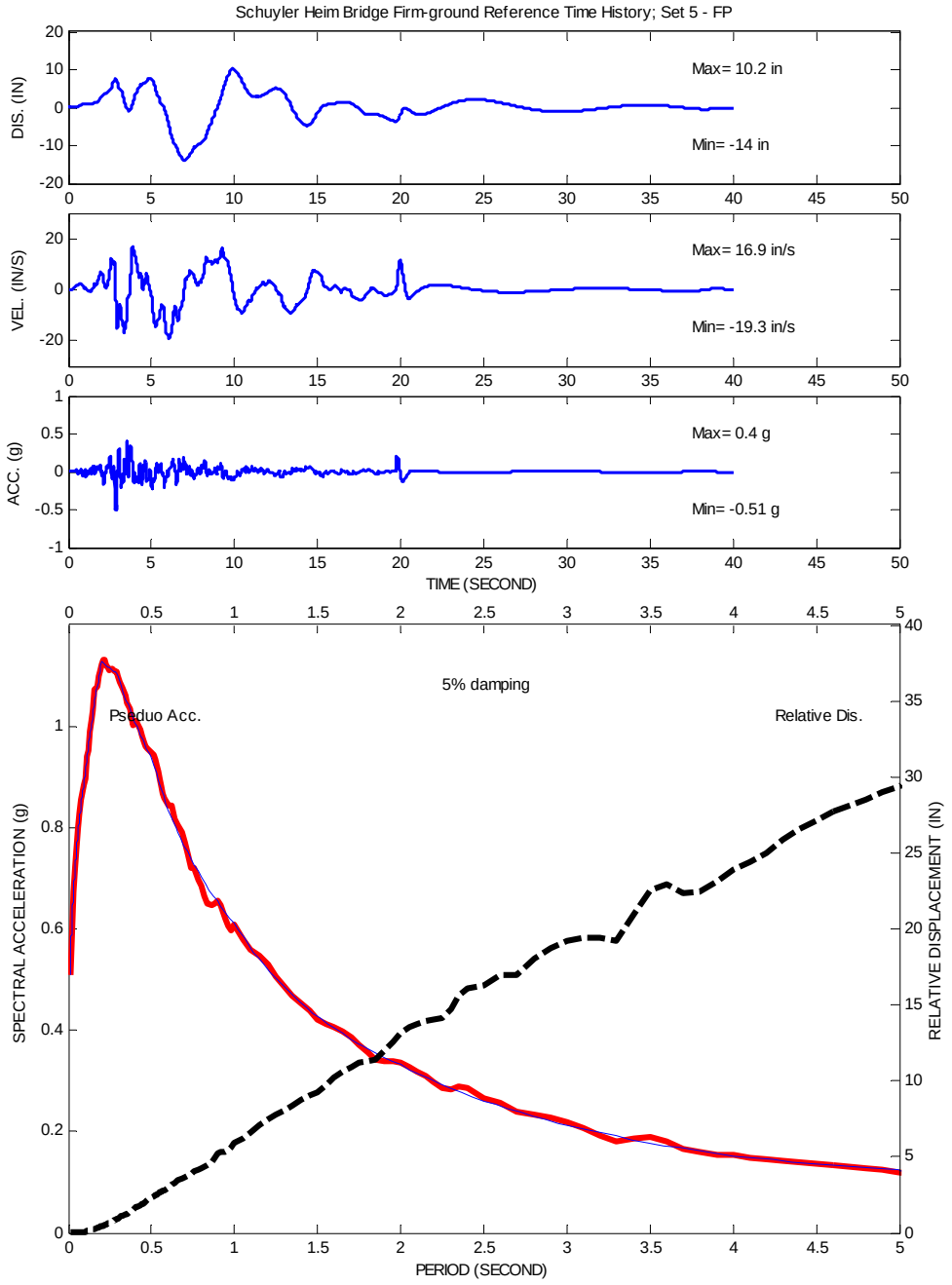


Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

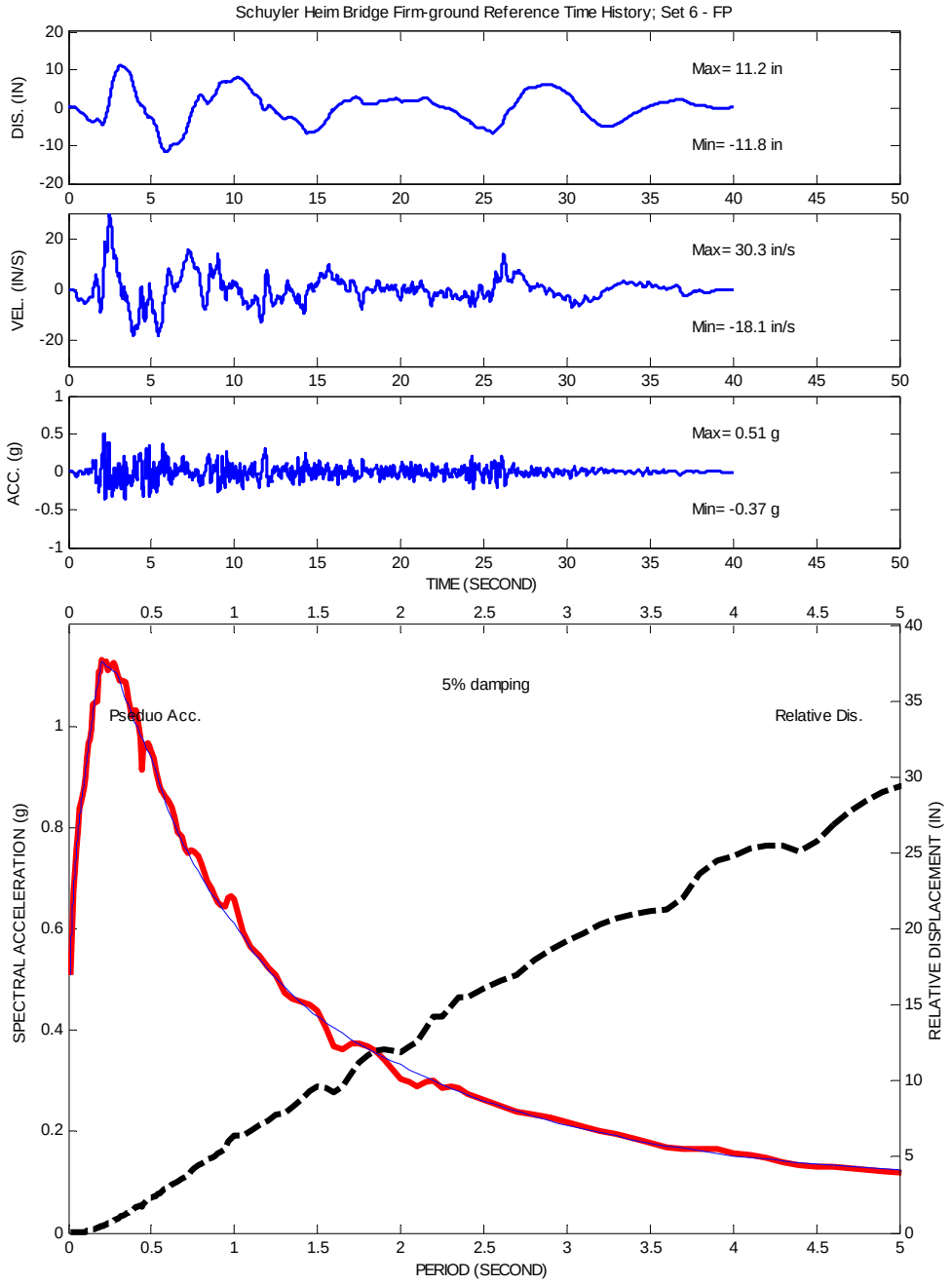


Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

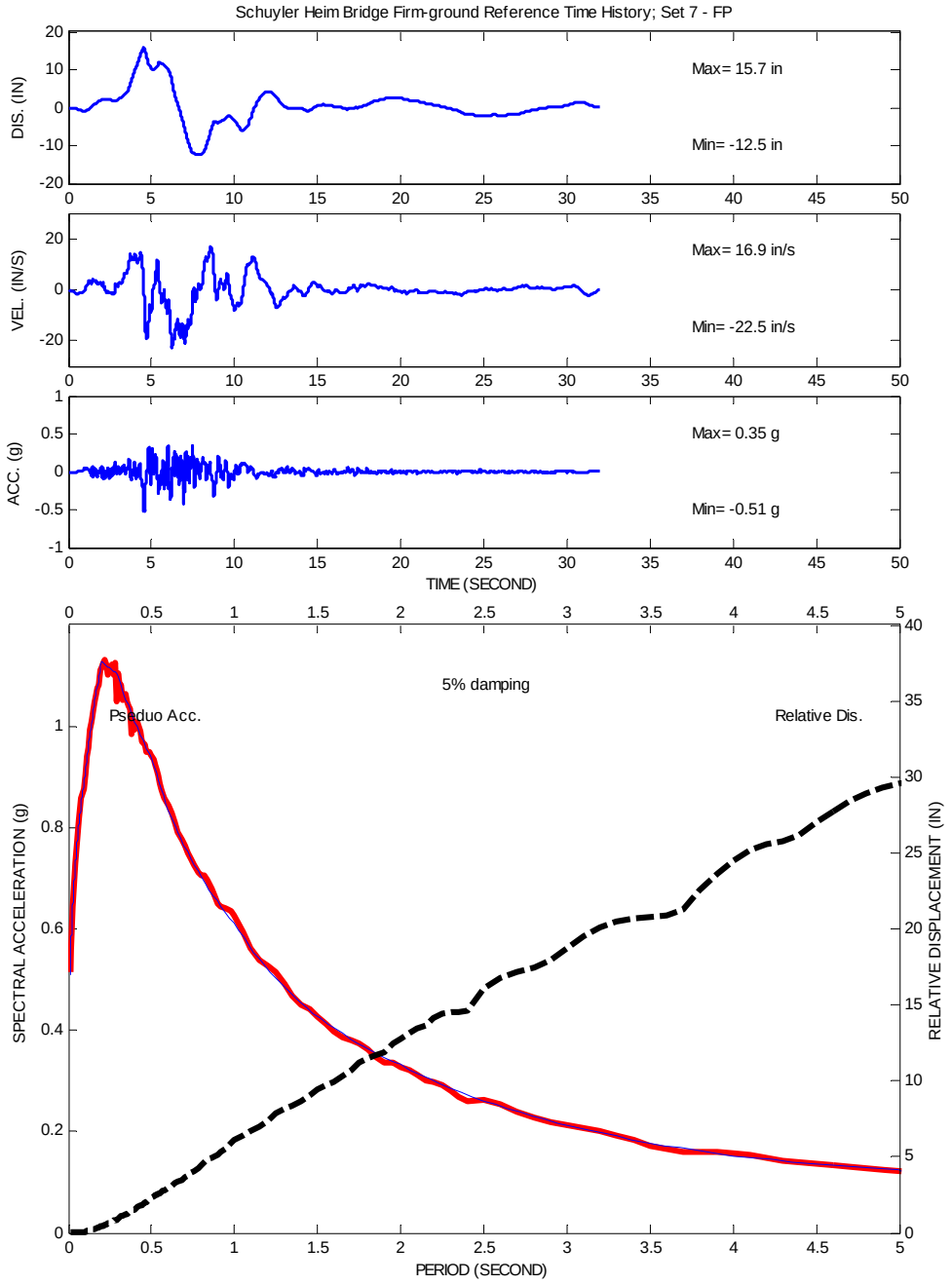


Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX E. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)

SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B. AGREE PARTLY SEE NOTED EXCEPTIONS.
C. DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

APPENDIX F. TOPKO PIPE SETTLEMENT ESTIMATES MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: December 31, 2009 **EMI PROJECT NO:** 06-123-03

TO: Lucien Hersh / Alameda Corridor Engineering Team (ACET)

COPY: Richard Norton / URS Corporation (URS)
Jeff Mills / URS

FROM: Arul Arulmoli / Earth Mechanics, Inc. (EMI)
Ranjan Gunaranjan / EMI

SUBJECT: Schuyler Heim Bridge Replacement Project, Geotechnical Memorandum for Settlement Estimates below Topko Pipe due to Proposed Retaining Wall Nos. E1 and E2.

Earth Mechanics, Inc. (EMI) has been requested by URS Corporation (URS) to estimate settlements below the existing Topko pipe due to the proposed embankment fill of Retaining Wall (RW) Nos. E1 and E2. This memorandum is prepared to provide settlement estimates below the Topko pipe due to the proposed RW Nos. E1 and E2 embankment fill.

Project Description

As a part of the Schuyler Heim Bridge Replacement Project, Retaining Wall (RW) Nos. E1 and E2 are proposed to be built at east and west sides of the northern approach embankment (Abutment 27) of Northbound SR-103 Off-Ramp Bridge to retain an approximately 57-ft wide approach embankment (Figure 1). Per plans provided by the designers, Wall No. E1, located on the west side of the approach between approximate Sta. 426+13 and Sta. 428+29 (“E” Line), will be approximately 216 ft long with a maximum design height of 23.5 ft at the south end of the wall while Wall No. E2, located on the east side of the approach between approximate Sta. 426+13 and Sta. 429+83 (“E” Line), will be approximately 370 ft long. The bottom elevation of the subject wall footings vary between -1.0 ft and -1.2 ft. Based on the information provided by URS, an existing 60-inch diameter Corrugated Metal Pipe (CMP), which contains an 8-inch diameter Topko oil line and 8-inch diameter water line inside, crosses the RW Nos. E1 and E2 at approximate Sta. 427+65 (“E” Line) (See Attachment 1 and Figure 1). The top elevations of the CMP line vary between -3.2 ft and -3.3 ft. At the location where the CMP line crosses the walls, the top elevation of the proposed wall will be approximately at +16 ft. The existing grade is at about El. 0 ft.

Settlement Estimates

Standard procedures were used to evaluate ground settlement underneath the Topko pipe due to the proposed wall and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and configuration (thicknesses and locations) of fine-grained soil layers. Immediate settlement is estimated to be negligible in this case (less than 0.25 inches) and is expected to occur during grading. Consolidation settlement is expected to occur over varying time periods.

Soil Parameters: The wall section provided by URS was used to evaluate potential settlement at approximate Sta. 427+65 ("E" Line), where the Topko pipe crosses the subject retaining walls. Using the subsurface information collected from site-specific soil borings A-09-056, R-09-034 and R-09-035 and Cone Penetration Test (CPT) soundings CPT-09-066 and CPT-09-098 (See Figure 1 for boring and CPT locations) and laboratory test results, an idealized soil profile was developed along the subject utility line for settlement estimates. The idealized soil profile and soil parameters used in the analyses are shown graphically in Figure 2. The design groundwater table was selected to be at El. +0 ft.

The consolidation parameters were estimated using laboratory test data. The compression index (C_c) was determined by measuring the slope of the virgin portion of the consolidation curves developed from laboratory consolidation tests. The Casagrande procedure was used to estimate the pre-consolidation pressure (σ_p). And, Taylor's square-root-of-time method and Casagrande's logarithm-of-time method were used to estimate the coefficient of consolidation (C_v). The methods for determining the compression index, recompression index, the pre-consolidation pressure, and the coefficient of consolidation are described in Holtz and Kovacs (2004).

Settlement Magnitudes: Based on our settlement calculations, settlement of soils underlying the Topko pipe is estimated to be about 5 inches, 2.5 inches, 0.25 inches at the centerline of the MSE embankment (*i.e.,* Point A, see Figure 2), at the edges of RW Nos. E1 and E2 locations (*i.e.,* Point B or B', see Figure 2), and about 25 ft away from the walls (*i.e.,* Point E or E', see Figure 2), respectively. The approximate settlement profile of the soil underlying the Topko pipe is shown in Figure 3.

Settlement Periods: The settlement period without any surcharge is estimated to be about 25 weeks to reduce the long-term post-construction settlement below the CMP to be less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is expected to be reduced to about 12 weeks. For a 7-ft embankment surcharge, the settlement period is expected to be reduced to about 9 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade. Settlement periods with surcharge begin once the full surcharge height is completed.

Closure

We appreciate the opportunity to work with you on this project to provide geotechnical recommendations for the project. If you have any questions, please do not hesitate to call us.

(Ranjan) G.J. Gunaranjan, PE 71758
Senior Staff Engineer

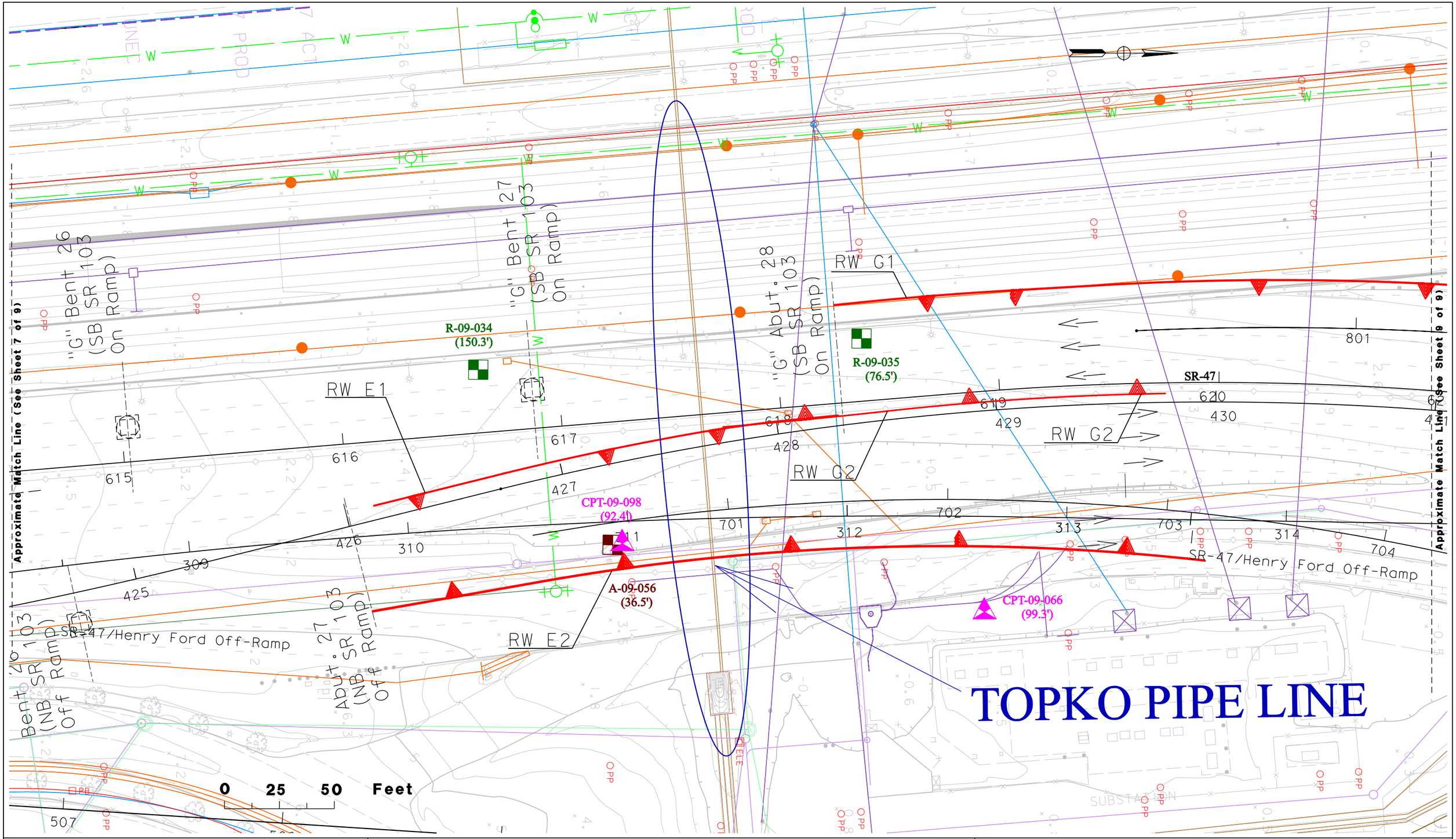
(Arul) K. Arulmoli, GE 2090
Project Manager

Reference

Holtz, R.D. and Kovacs, W.D., 2004, "An Introduction to Geotechnical Engineering", Prentice Hall Civil Engineering and Engineering Mechanics Series, September.

Attachments

Attachment 1 – Wall Section and Topko Pipe Location Information Provided by URS



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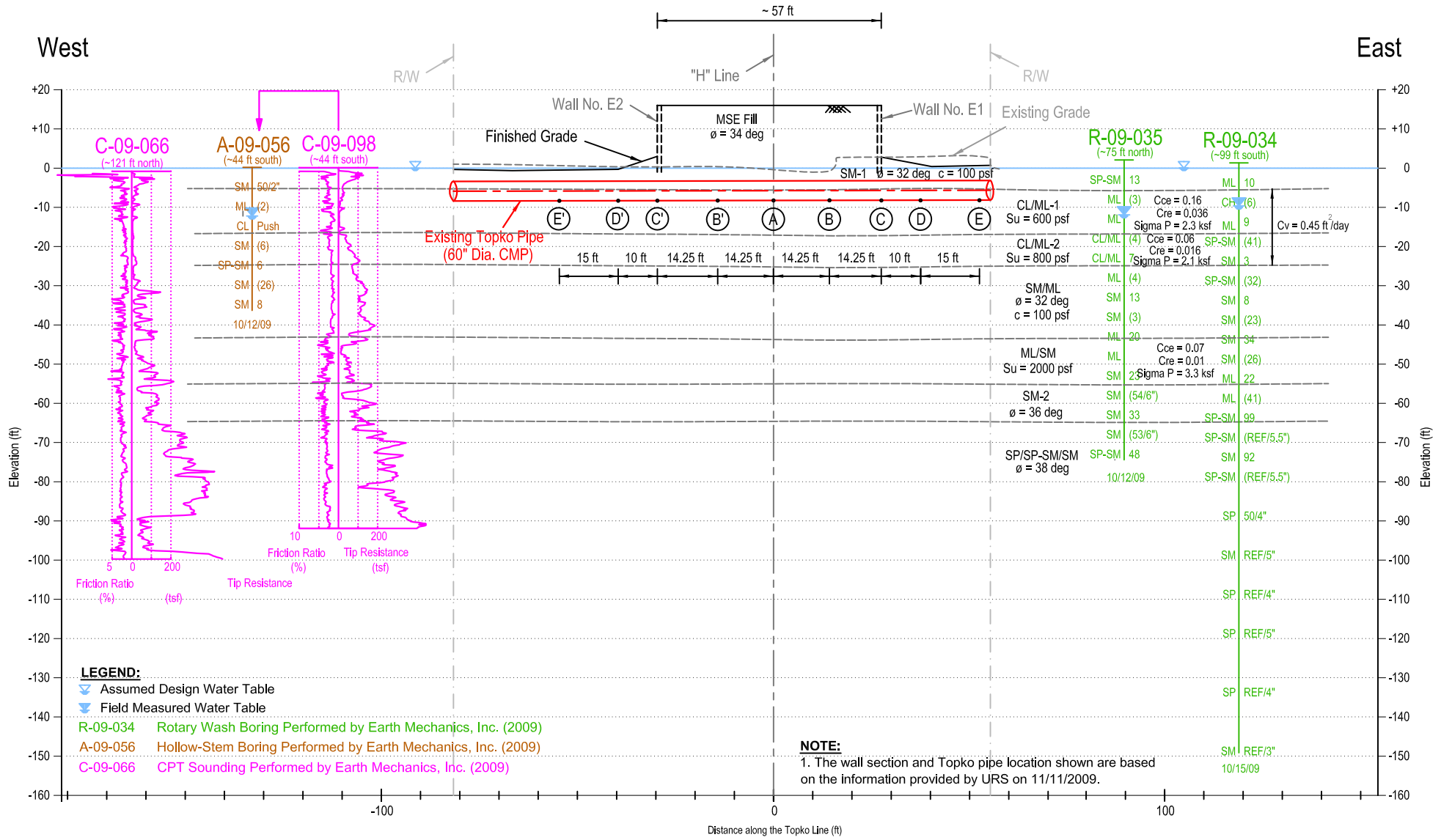
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No.: 06-123-03 | **Date: 12-22-09**

Site-Specific Exploration and Topko Pipe Location Map

Figure 1



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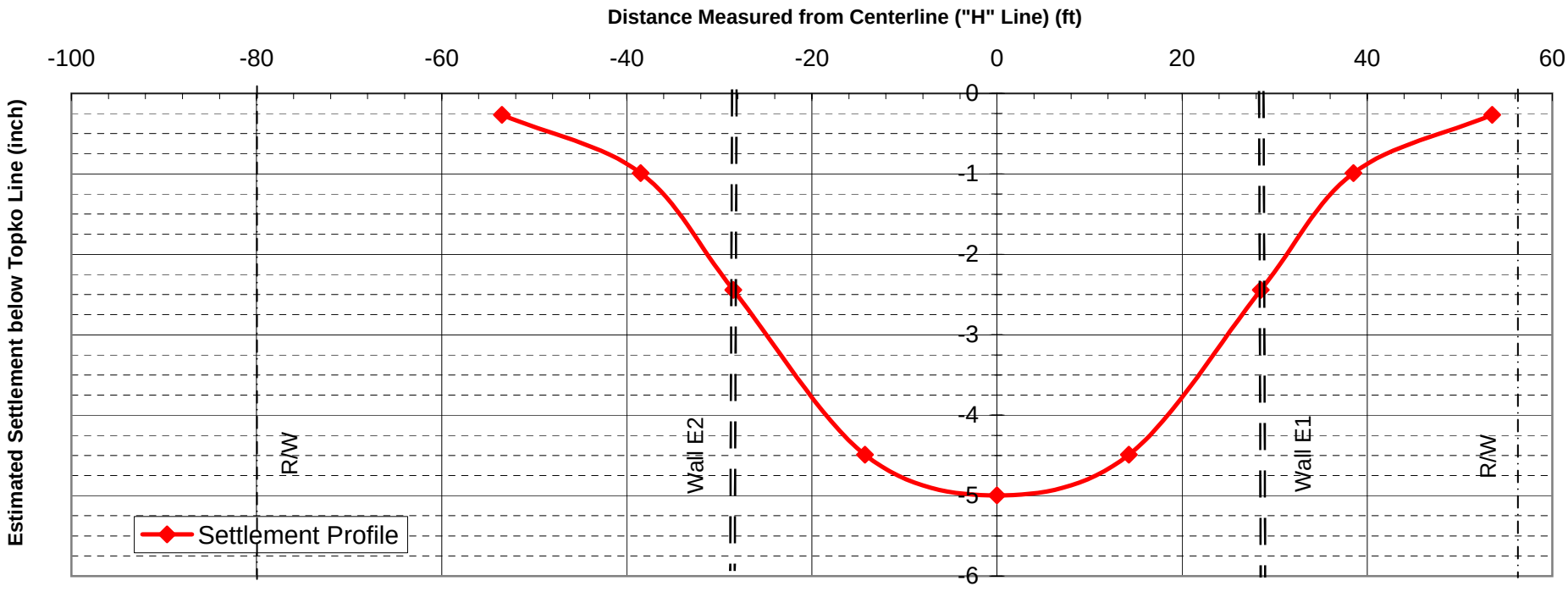
EMI Project No. 06-123-03 | Date: 12-21-09

Idealized Soil Profile along Topko Pipe at Approximate Sta. 427+65 ("E" Line)

Figure 2

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT



Consolidation Settlement Profile along Topko Pipe Line

ATTACHMENT 1

WALL SECTION AND TOPKO PIPE LOCATION INFORMATION

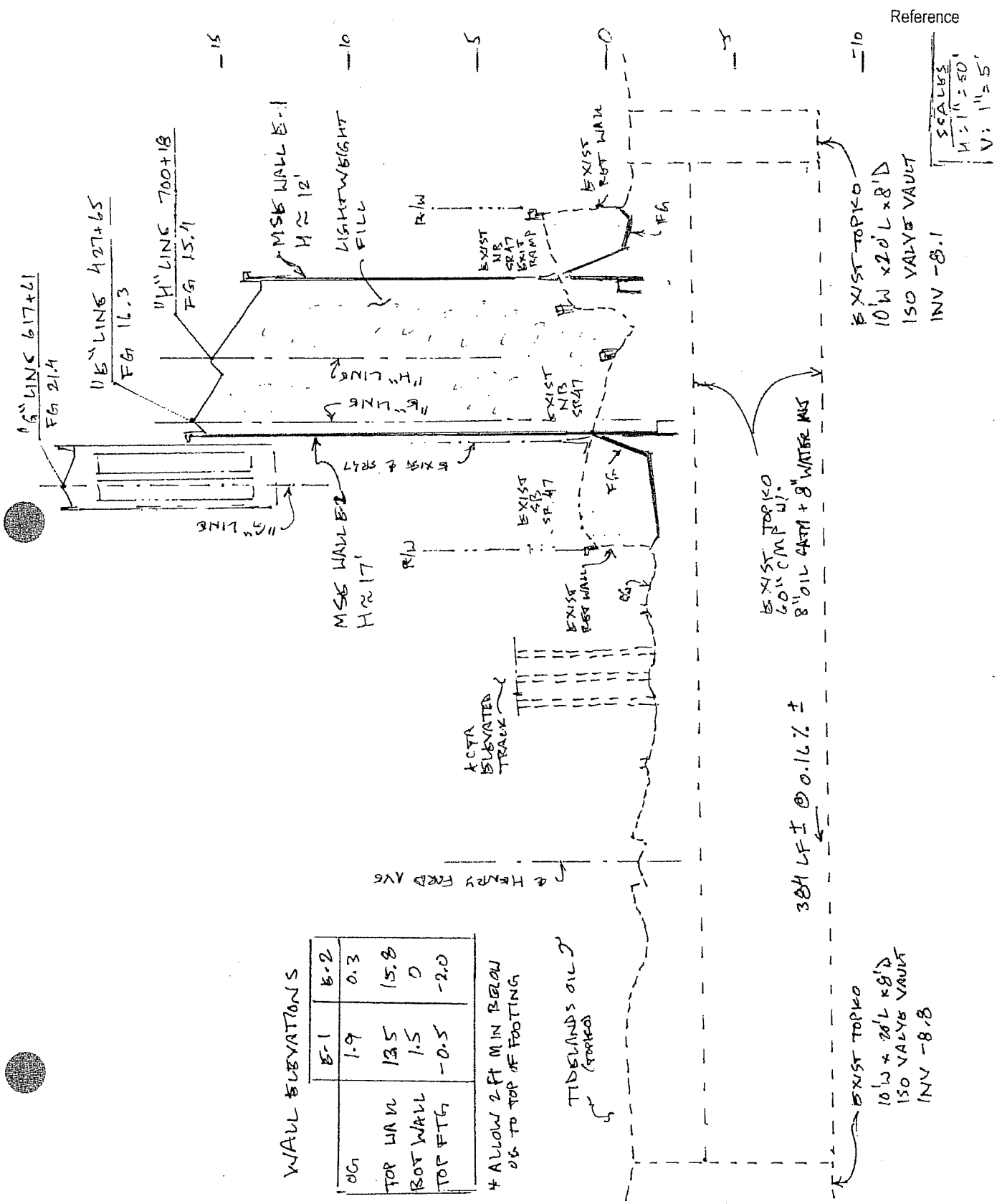
PROVIDED BY URS

URS

Job SR 47 - HEIM BRIDGE | Project No. | Page ___ of ___

Description RET WALL & UTILITIES CONFLICT SECTION EXHIBIT | Computed by CGP | Date 11-9-09

Checked by | Date



WALL ELEVATIONS

	E-1	E-2
OG	1.9	0.3
TOP WALL	13.5	15.8
BOT WALL	1.5	0
TOP FTG	-0.5	-2.0

* ALLOW 2 FT MIN BELOW OG TO TOP OF FOOTING

URS

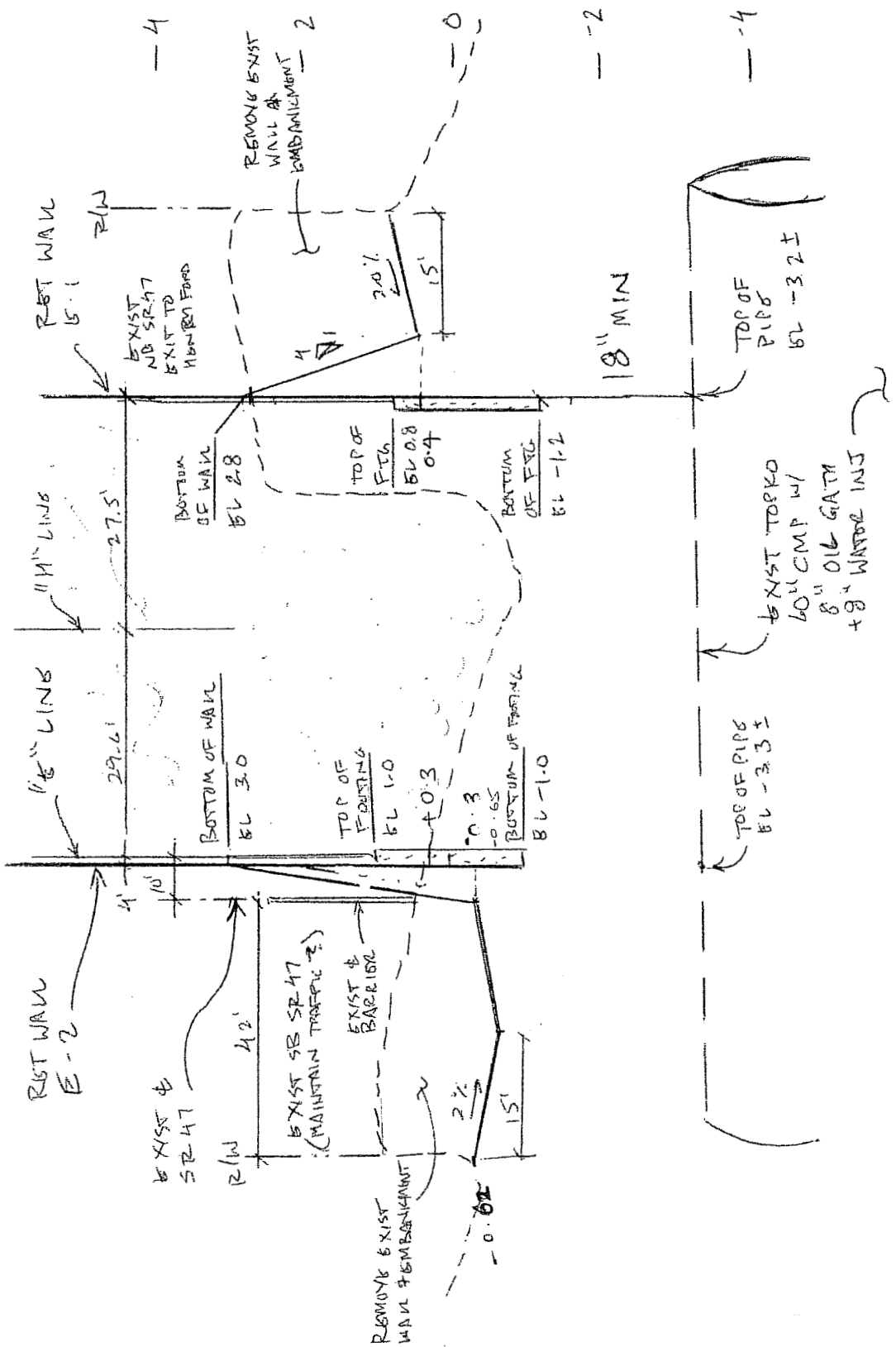
Job SR 47 - HEIM BRIDGE Project No. _____ Page ____ of ____

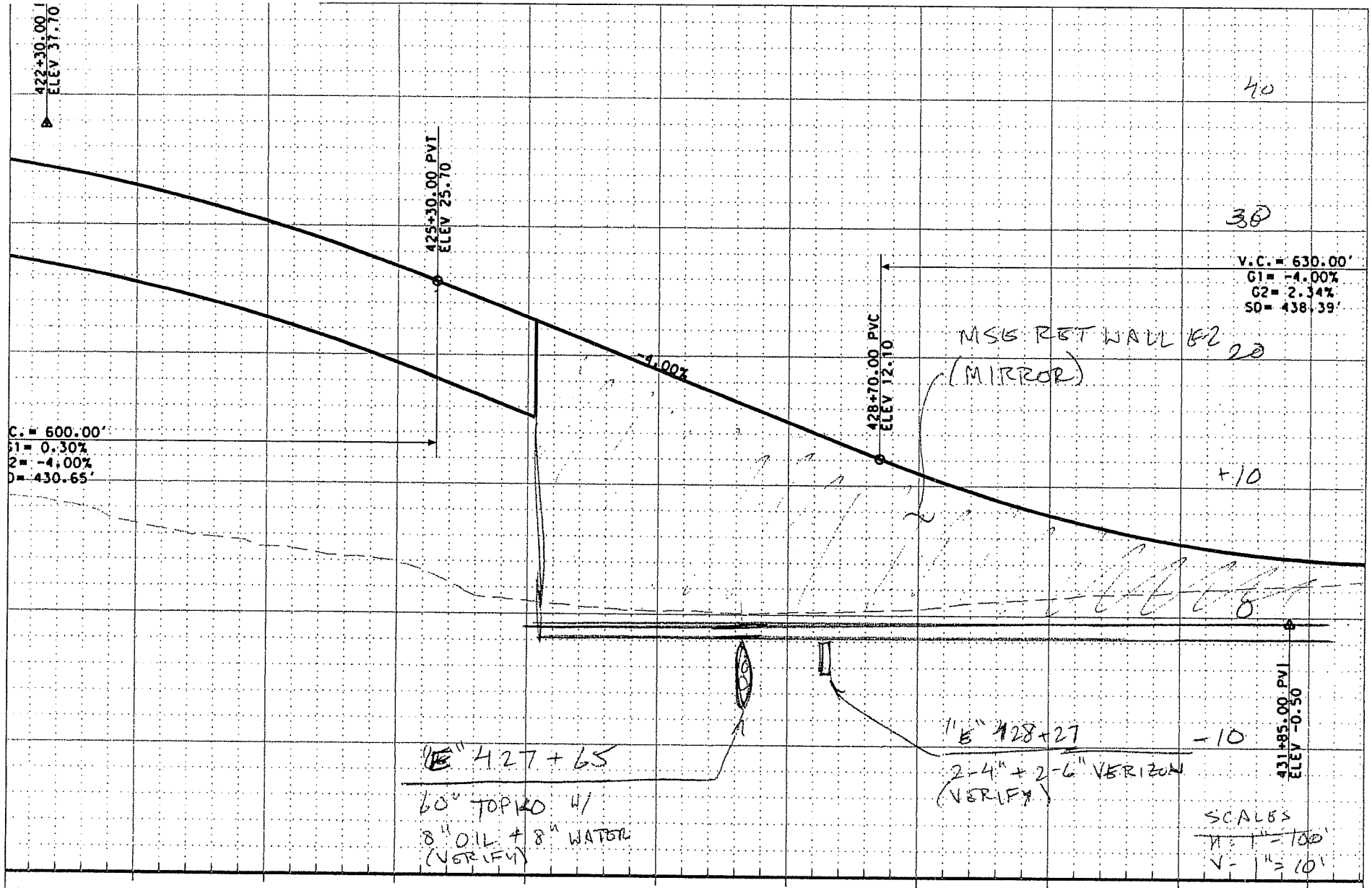
Description RET WALL & UTILITIES CONFLICT Computed by CGP Sheet 2 of ____

SECTION EXHIBIT Checked by _____ Date 11-9-09 Date _____

Reference

SCALES
H: 1" = 20'
V: 1" = 2'





RETAINING WALL & UTILITIES
CONFLICT EXHIBIT
LINE "E" PROFILE W/ TOPKO, VERIZON

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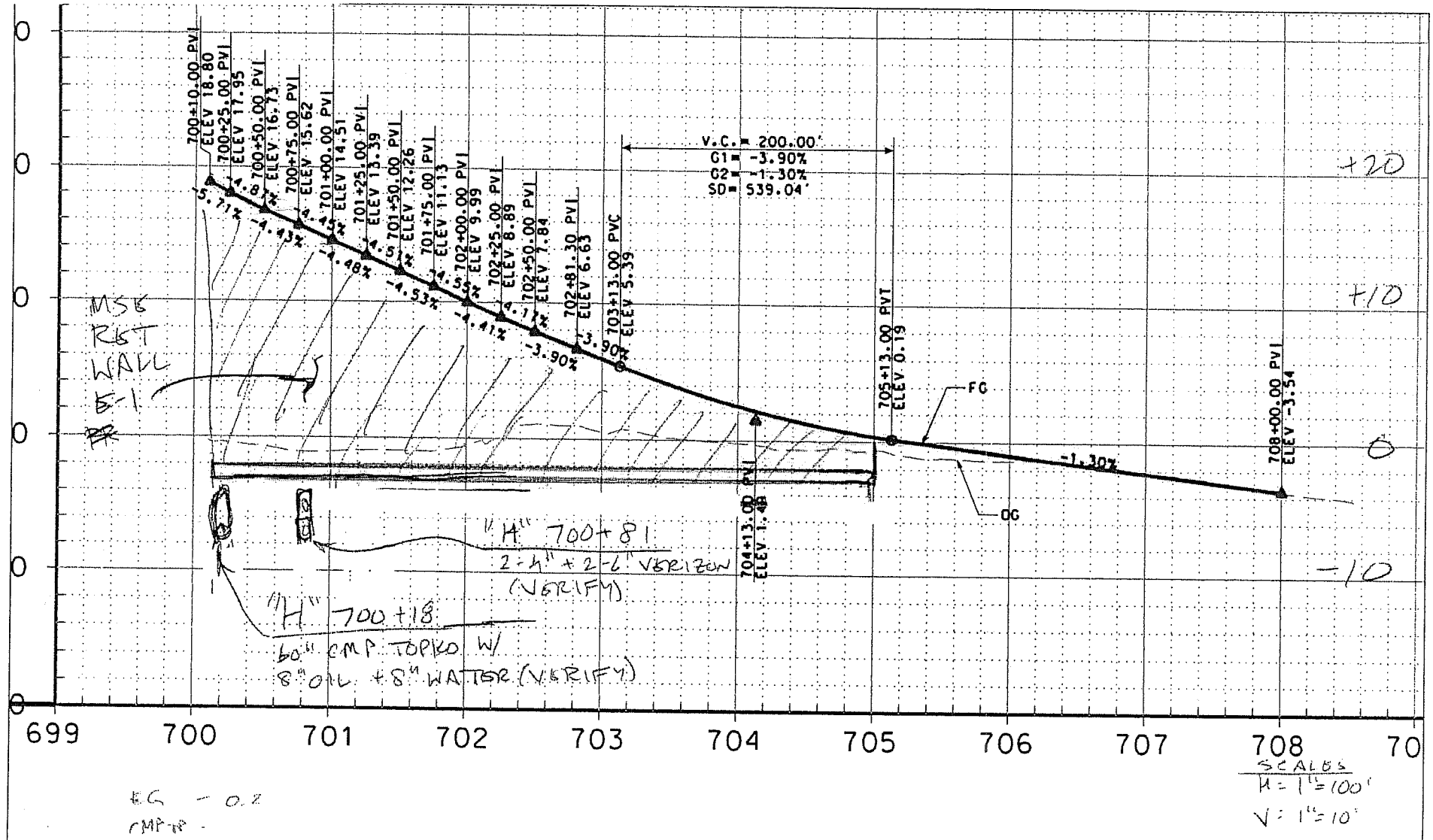

RETAINING WALL & UTILITIES
CONFLICT EXHIBIT

LINE "H" PROFILE
W/ TOPKO, VERIZON
CROSSINGS EXHIBIT
3 OF 3

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Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report***
Retaining Wall G1, Wall No. 53E0151
Retaining Wall G2
Los Angeles County, California, (7-LA-47, PM 0.17, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining walls. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining walls.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix E. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL G1, WALL NO. 53E0151
RETAINING WALL G2
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.17, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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End of Text – Log-of-Test-Borings (LOTB) Sheets and As-Built LOTB Sheets

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Appendix A. EarthSpectives SPT Hammer Energy Measurement Report
Appendix B. GeoVision Geophysical Investigation Report
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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall G1 and G2 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Retaining Wall G1 and G2 located on the west and east side, respectively, of the approach embankment for the SR-103 On-Ramp (Figure 2).

Retaining Wall G1, located along the western edge of the SR-103 On-Ramp approach embankment between Sta. 618+33 and Sta. 622+22 ("G" Line) is proposed to be a mechanically stabilized embankment (MSE) wall and will be approximately 389 ft long with retained heights varying from 24 ft at the southern end of the wall to about 6 ft at the northern end of the wall. Retaining Wall G2, located along the eastern edge of the SR-103 On-Ramp approach embankment between Sta. 618+33 and Sta. 621+00 ("G" Line) is proposed to be a Caltrans

standard Type 1 cantilever retaining wall and will be approximately 267 ft long with retained heights varying from 12 ft at the southern end of the wall to 8 ft at the northern end of the wall.

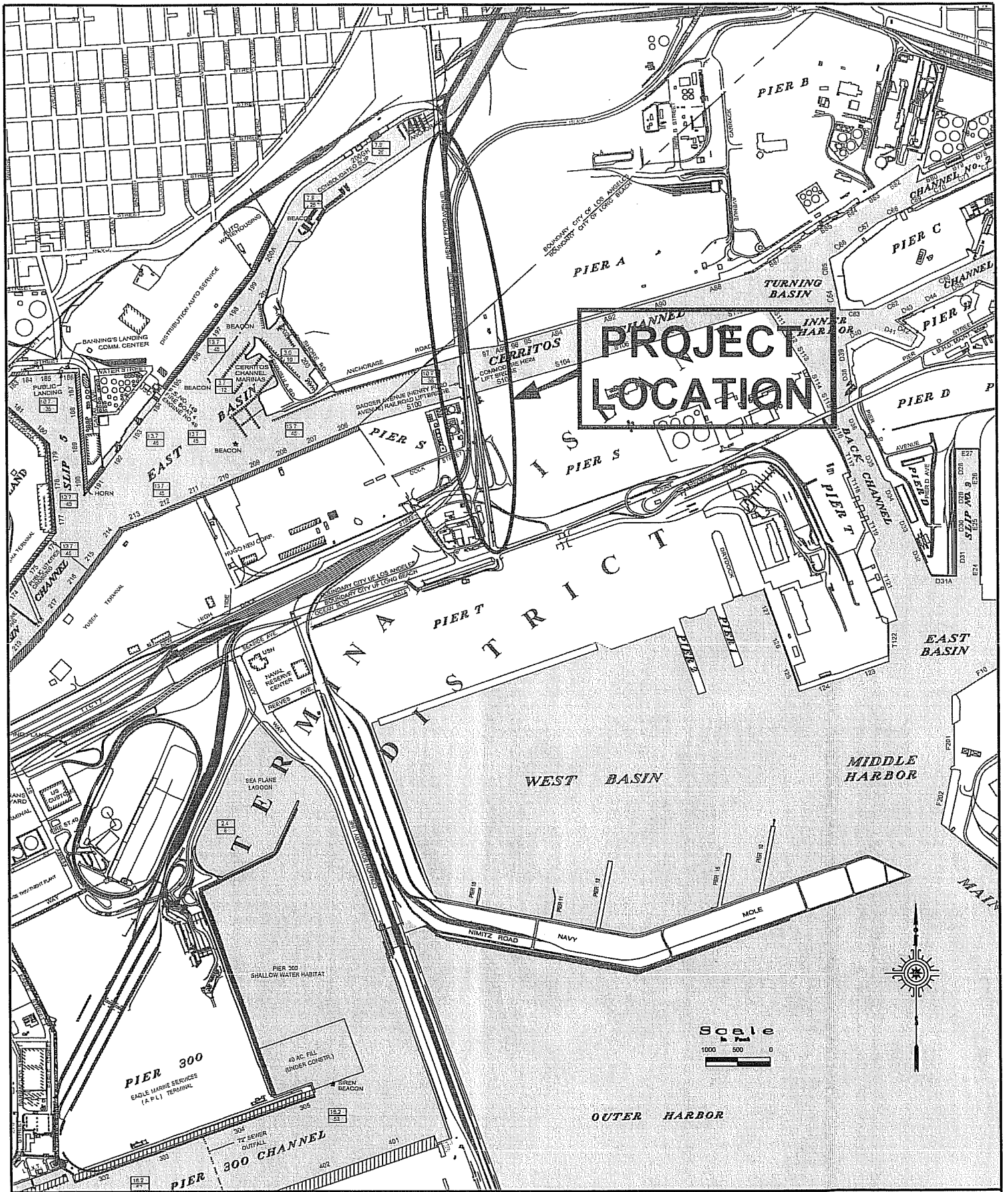
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Retaining Wall G1 and G2. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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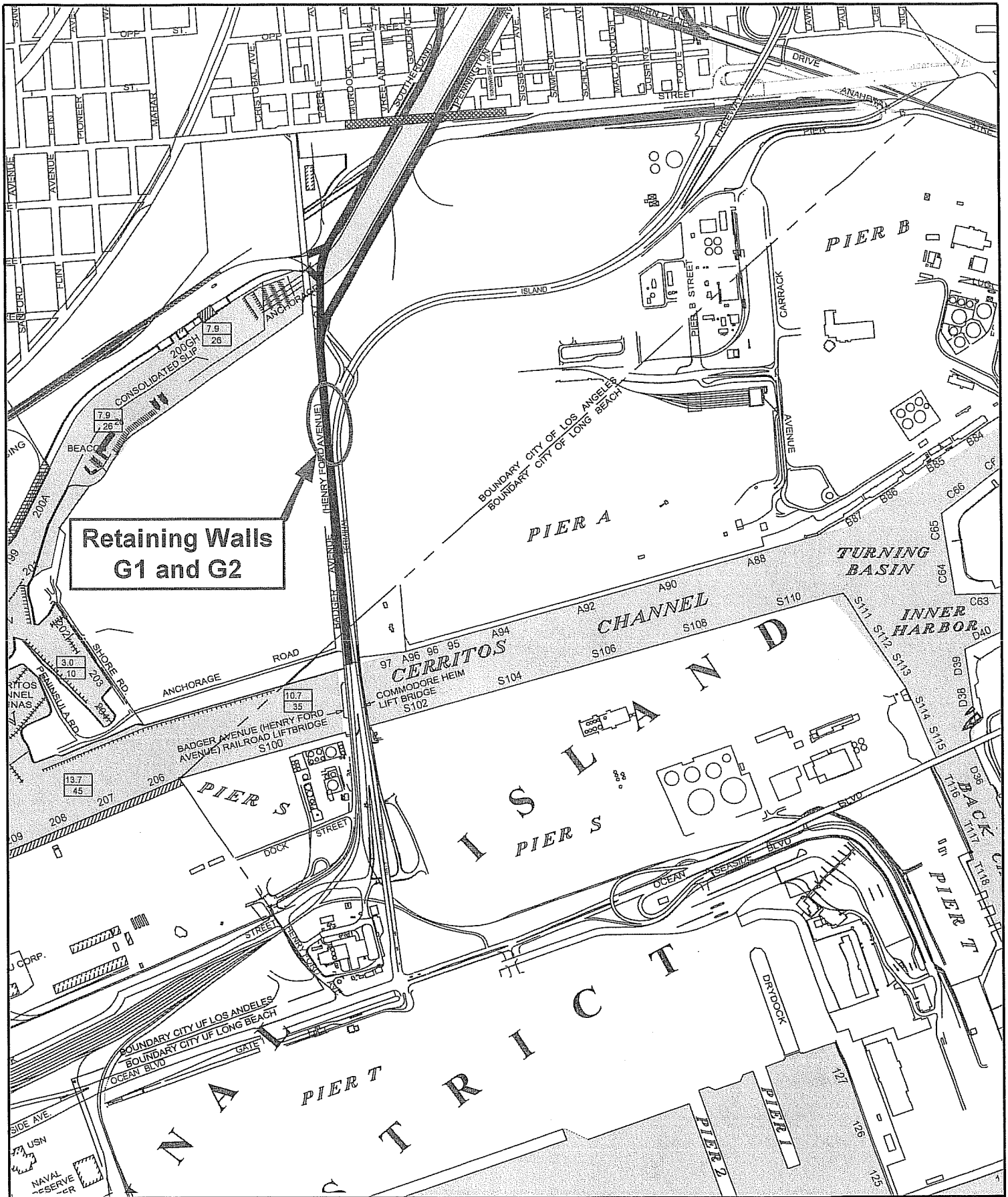
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 5-10-10



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structure Location Map

Figure 2

Project No. 06-123	Date: 5-10-10

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the nearest boring to Retaining Wall G1 and G2 is shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge and is approximately 800 ft south of the southern end of the proposed wall pair.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, two rotary wash borings, two hollow-stem auger borings and one CPT sounding were performed in the vicinity of Retaining Wall G1 and G2. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed walls. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings and CPT soundings surrounding the proposed retaining wall pair were performed at grade on the shoulder of the existing SR-103/SR47 ramps. The deepest boring penetrated down to about elevation -96.9 ft, approximately 102 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix B.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix C.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-035[2]	"G" Line	618+39.2	28.5 Lt	+2.1	-11.9	-74.4	RW
R-09-036[1]		619+74.9	30.8 Lt.	+3.4	-11.6	-72.6	RW
A-09-058[3]		620+78.1	39.0 Lt.	+4.2	-8.8	-47.3	HSA
A-09-059[3]		622+73.0	65.3 Lt.	+5.6	-1.6	-46.0	HSA
CPT-09-099		622+73.8	63.4 Lt.	+5.6	NR	-96.9	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2 Boring performed by SoCalDrilling Co.
3.Boring performed by 2R Drilling Co.
4. GWE = Groundwater Elevation.
5. GSE = Ground Surface Elevation (estimated from topographic plans).
6. Top of Boring Elevation Based on NAVD88.
7. RW = Rotary Wash, HSA = Hollow Stem Auger, CPT = Cone Penetration Test.
8. NR = Not Recorced.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -102.7 ft, approximately 103.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance

during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

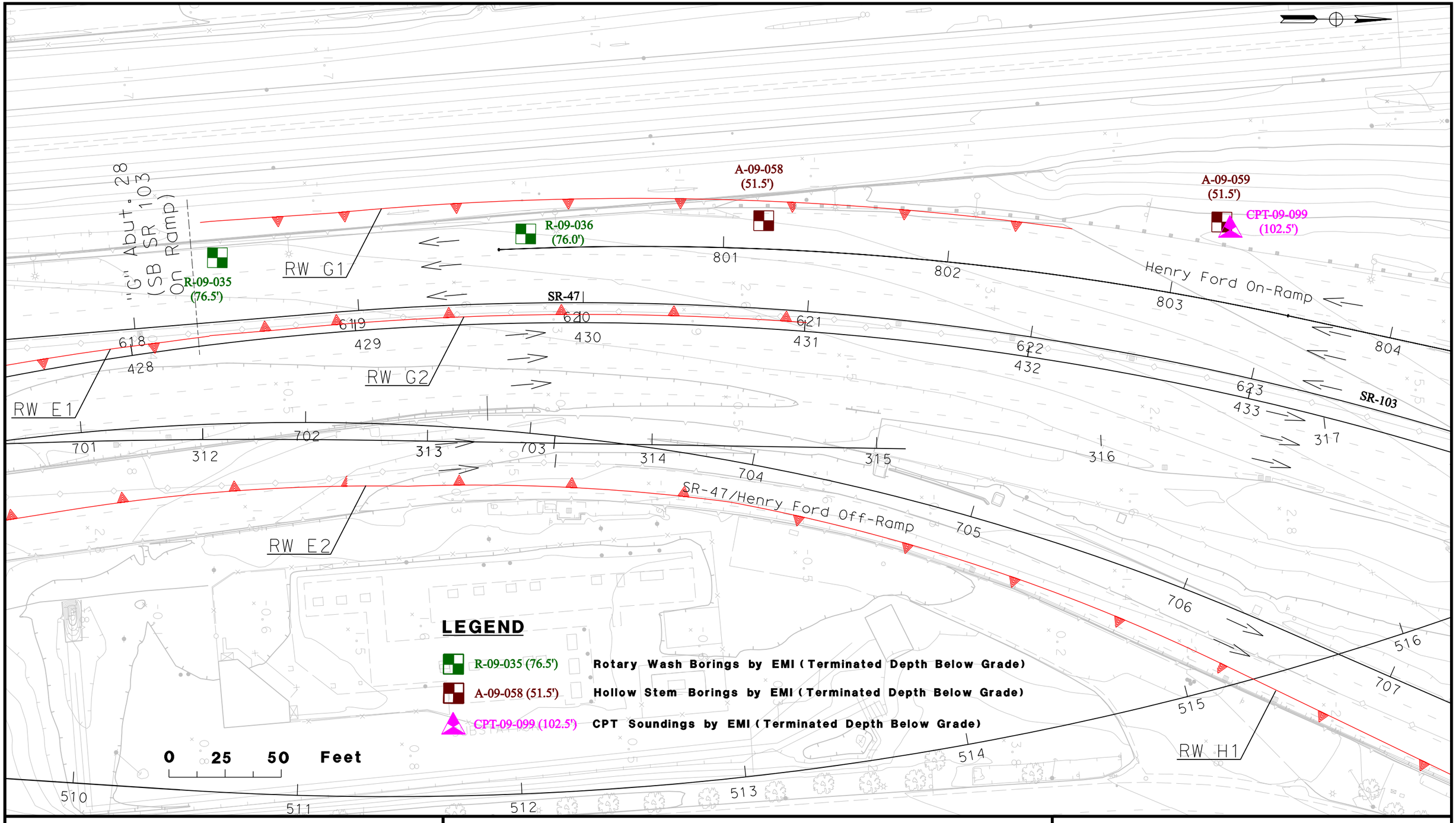
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix C.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-10-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department

(LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

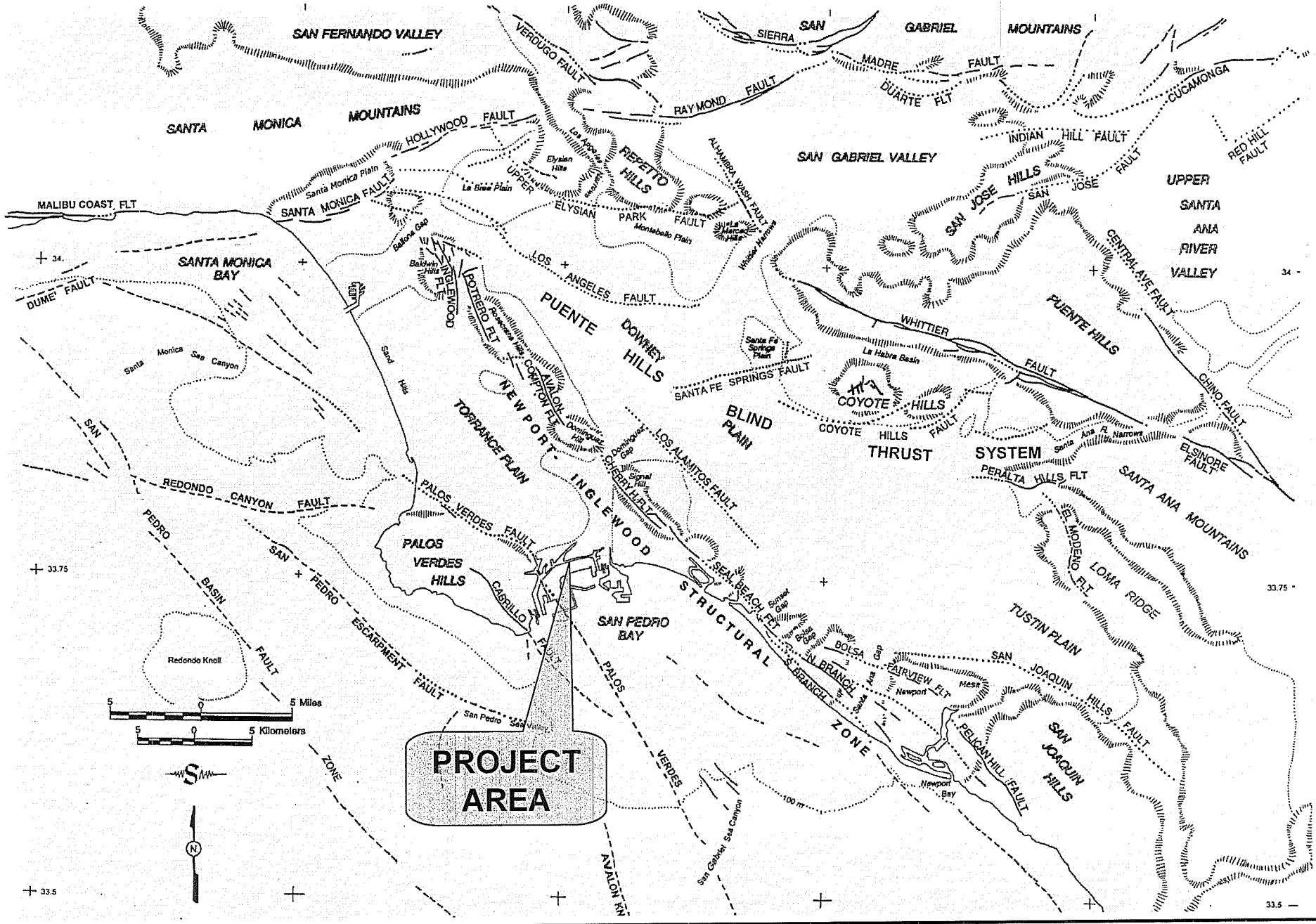
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

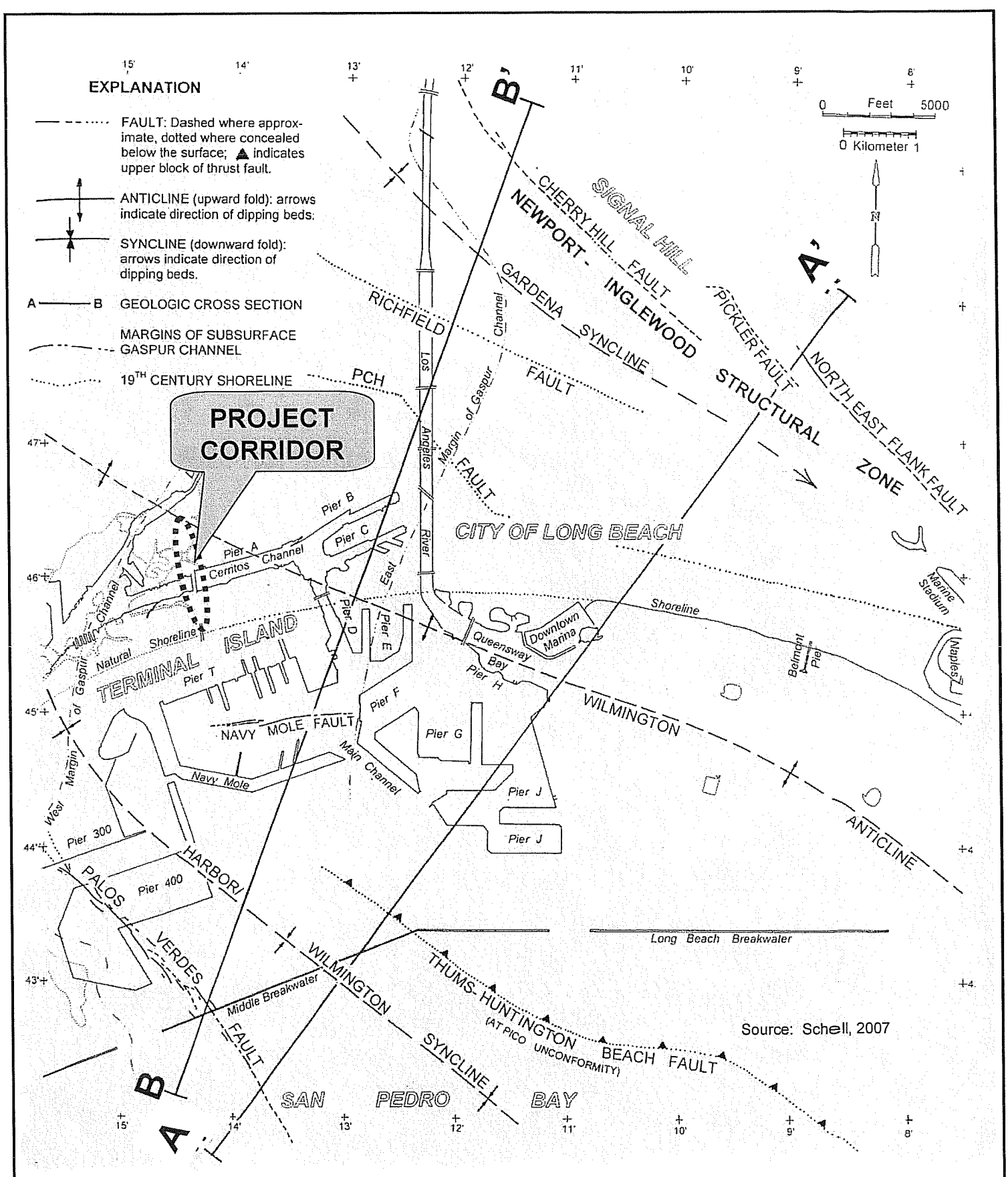
California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at

Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 5-10-10	Figure 4



Source: Schell, 2007

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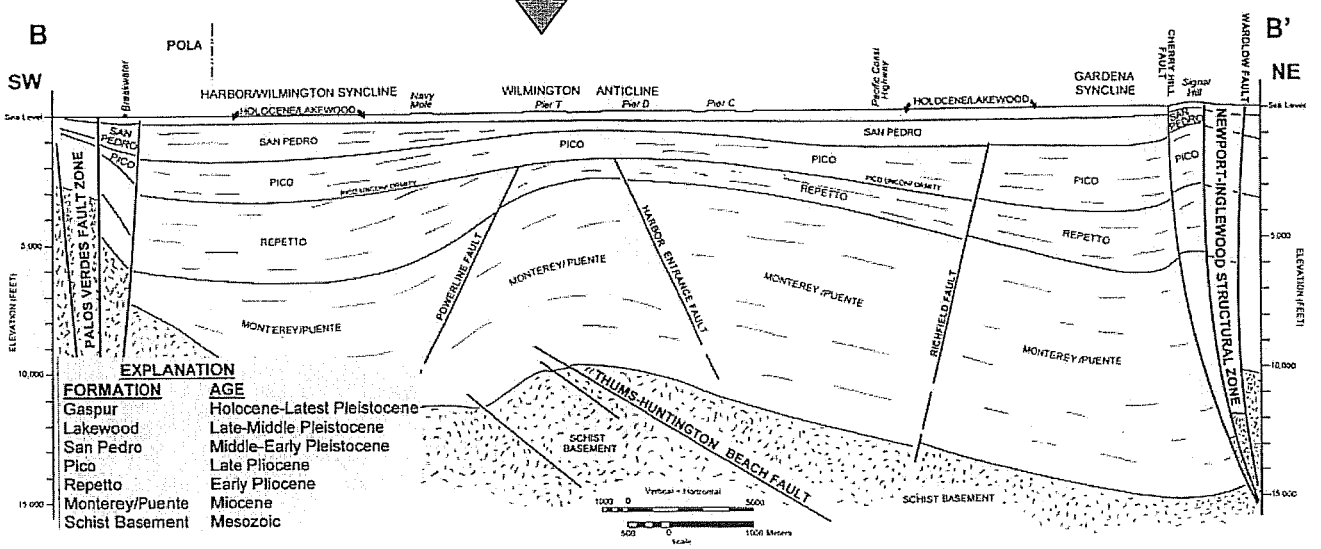
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structural Geology Map, Long Beach Harbor

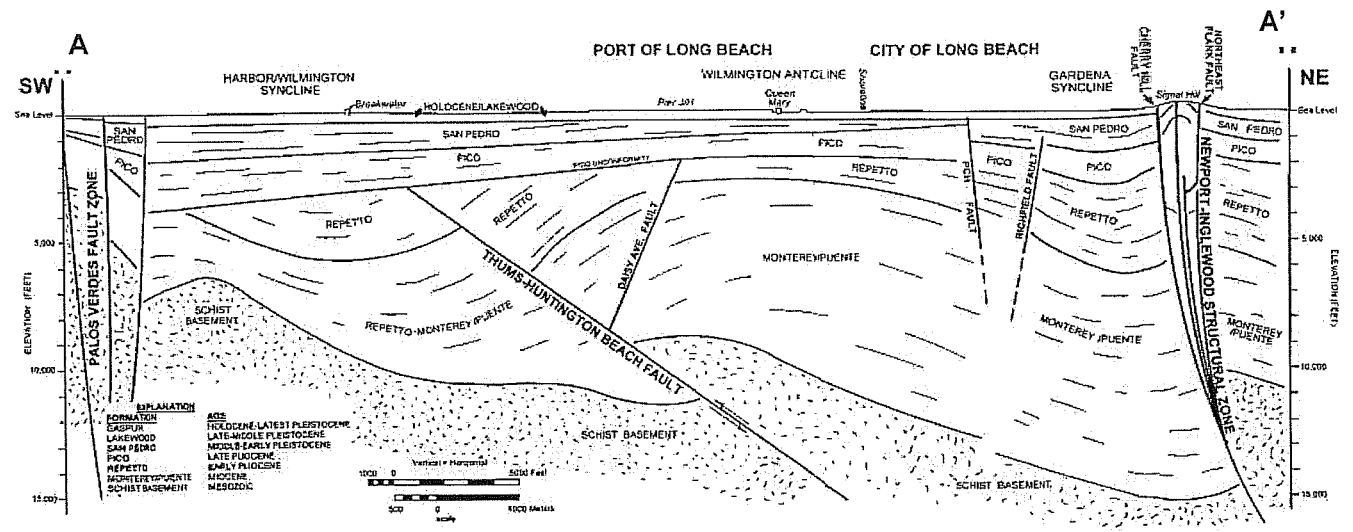
Figure 5

Project No. 06-123 | Date: 5-10-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

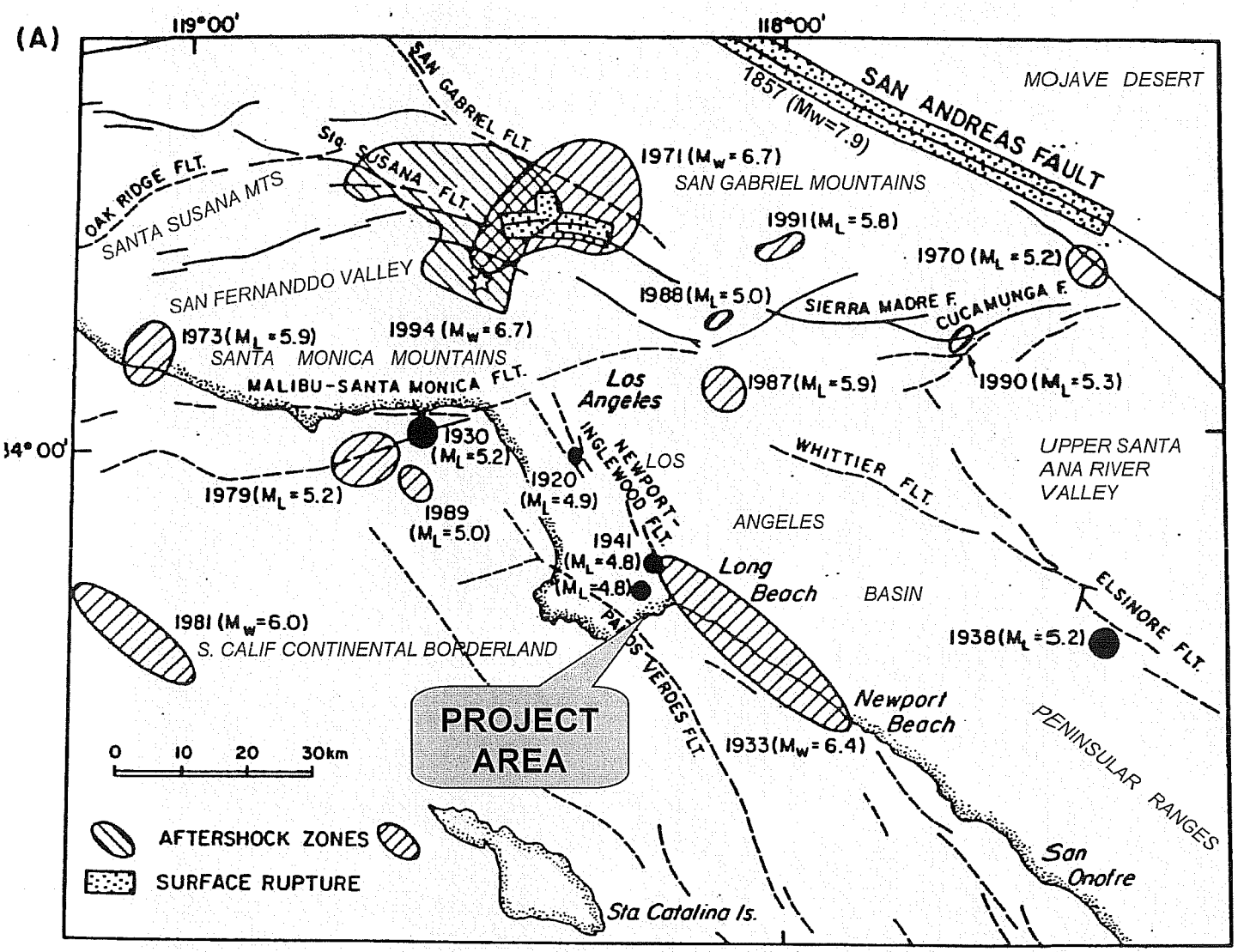


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

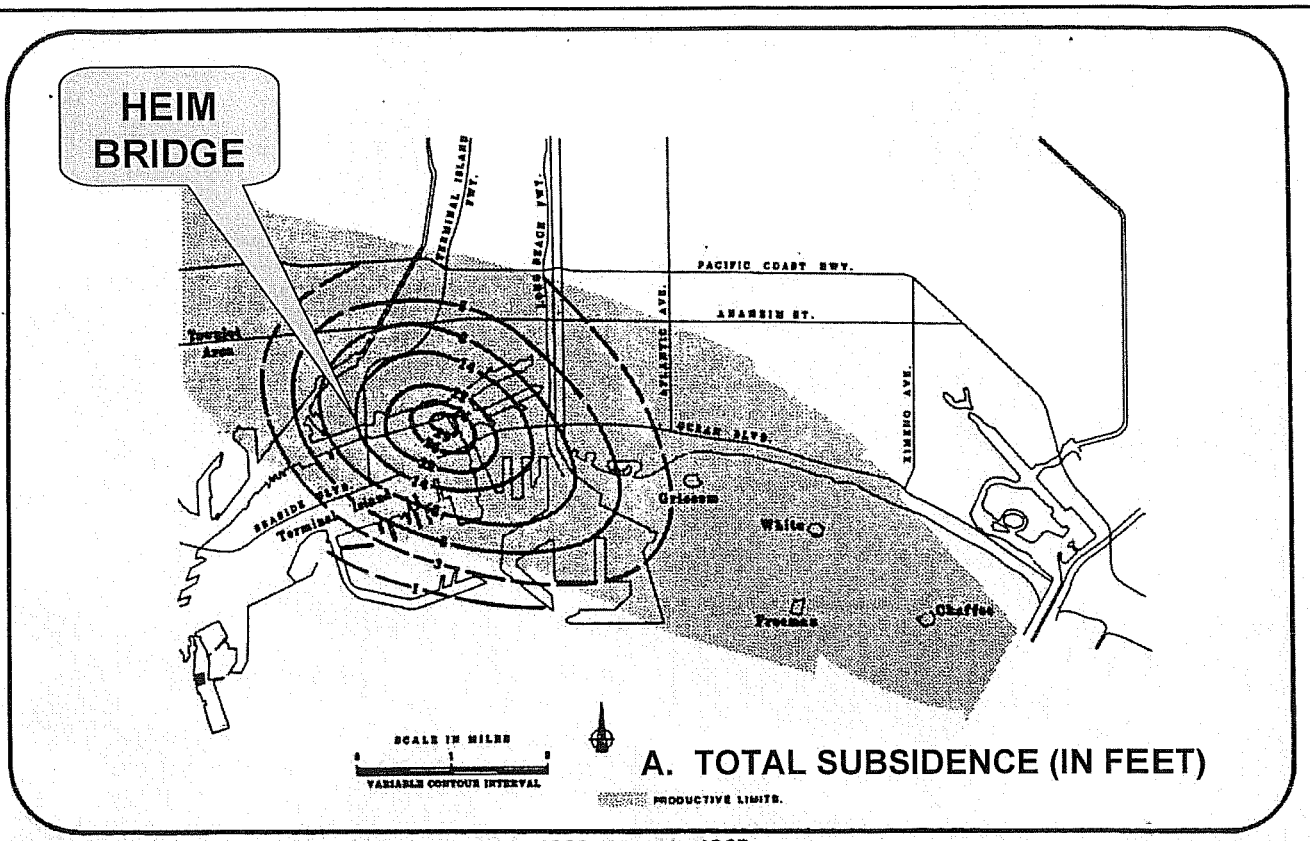
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-10-10	Geologic Cross-Sections, LA Harbor Figure 6

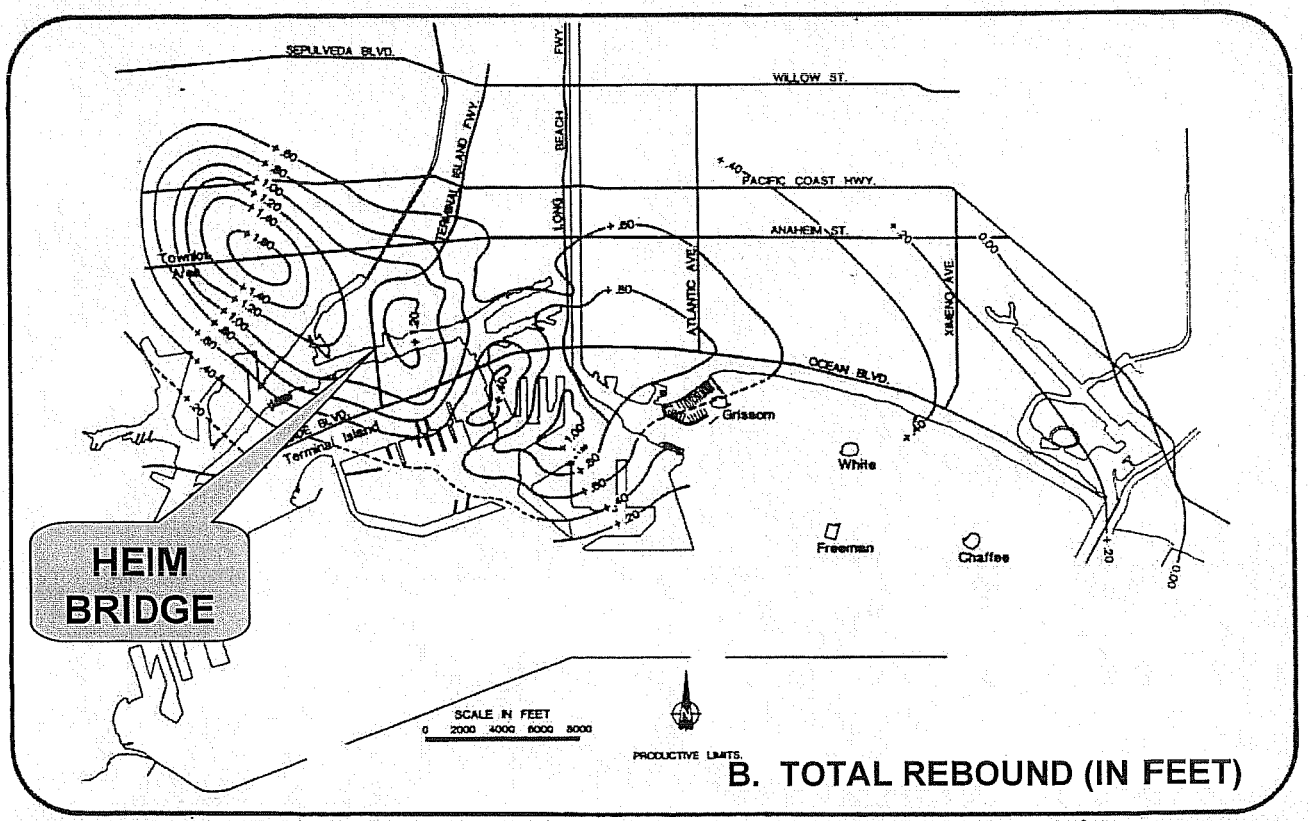


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-10-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-10-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -149 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about zero, with a few feet of import fill for the existing northern approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +6 ft along the proposed alignment of the two walls. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -4 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -55 ft. Below elevation -55 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in all four of the borings performed near the proposed walls between elevation -1.6 ft and -11.9 feet. The elevation that groundwater was encountered in each boring is listed in Table 2 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

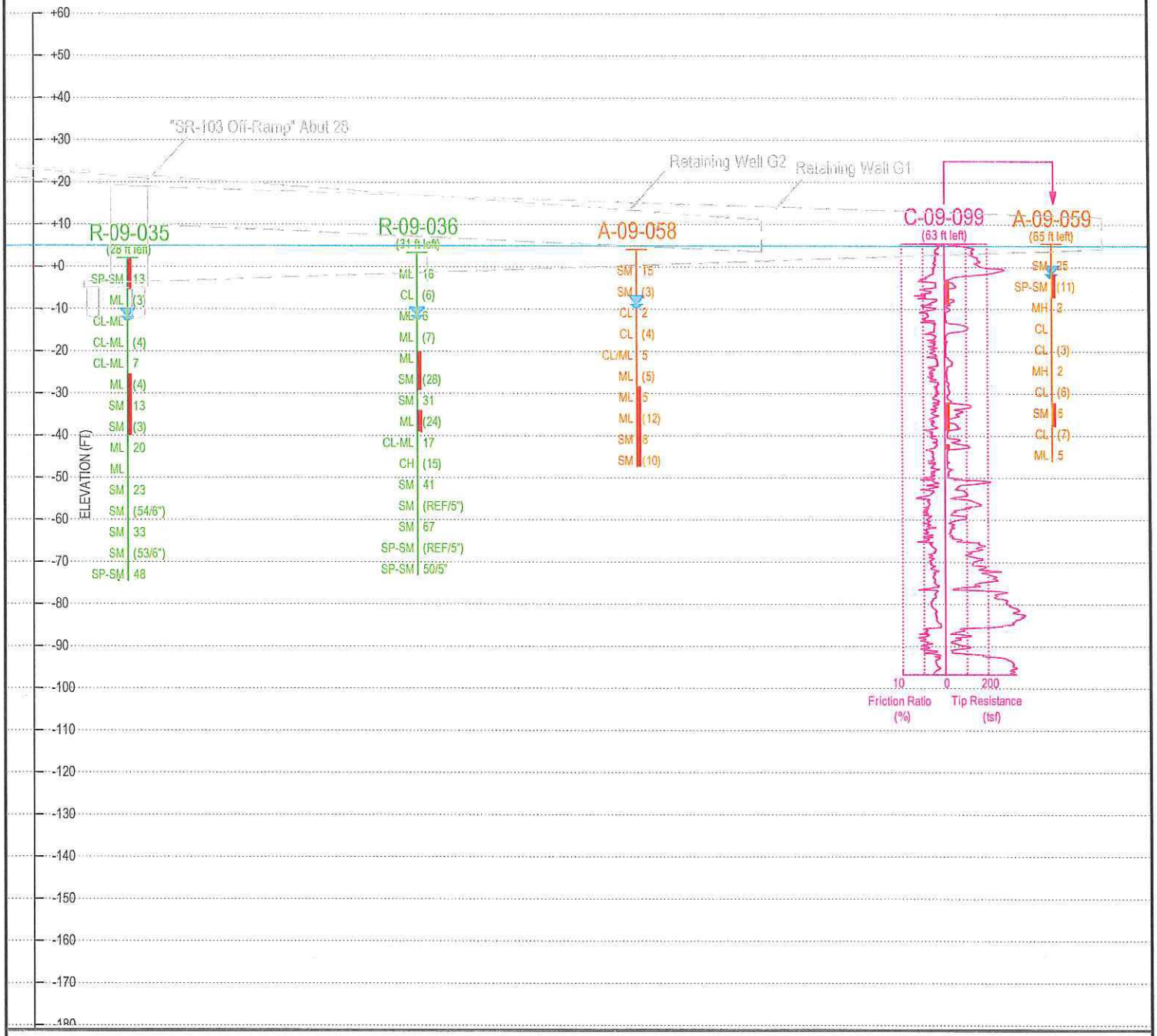
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

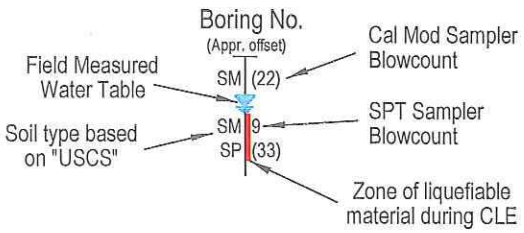
Based on information collected from borings R-09-035, R-09-036, A-09-058, A-09-059 and CPT sounding CPT-09-099 an idealized soil profile for foundation analysis and design was developed along the alignment of the proposed walls. The subsurface profile beneath the proposed structures is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+2.0 to -5.0	Silty Sand / Sandy Silt	120	0	32
-5.0 to -30.0	Clayey Silt / Sandy Silt	120	650	0
-30.0 to -40.0	Silty Sand / Sandy Silt	120	0	30
-40.0 to -50.0	Clayey Silt / Lean Clay / Silty Clay	120	2,500	0
-50.0 to -65.0	Silty Sand	120	0	34
-65.0 to -100.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Figure 9

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5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance to with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix E.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -55 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-035	+2 to -5	0.7	6.3
	-25 to -40	5.6	
R-09-036	-19 to -29	1.4	2.4
	-34 to -39	1.0	
A-09-058	-28 to -48	5.6	5.6
A-09-059	-2 to -7	1.4	2.9
	-32 to -37	1.5	
CPT-09-099	-3.0 to -8.6	0.7	1.1
	-32.1 to -38.5	0.3	
	-42.0 to -43.0	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.7 and 8.7, the minimum resistivities were 150 and 9,300 ohm-cm, soluble chloride contents were 248 and 12,774 parts per million (ppm) and soluble sulfate contents were 30 and 1,187 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Mechanically Stabilized Earth Wall Recommendations – Retaining Wall G1

As described in Section 1.2, Proposed Retaining Wall G1 is located between approximate Stations 618+33 and 622+22 ("G" Line). The retaining wall is approximately 389 ft long and will vary in design height from 6 to 24 ft. Due to the presence of compressible soil, construction

of the proposed SR-103 On-Ramp embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 24 ft and base width of 24 ft near the southern end of the wall at Sta. 618+40 ("G" Line), the bearing pressure induced on the underlying foundation soil is 3.5 ksf. Using a base width of 24 ft and a remedial excavation of 2 ft (see Section 5.4.8), the allowable bearing capacity of the soil directly beneath the MSE wall is greater than 3.5 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 2 ft below lowest adjacent grade. Using a remedial excavation of 2 ft below the leveling pad, the allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL G1 STABILITY ANALYSES

Approx. "E" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety		Global Stability Factor of Safety		
			During Surcharge	Permanent	During Surcharge	Static[1]	Psuedo-Static[1]
426+06	24	24	1.25	2.2	1.25	1.7	1.3

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1.

(4) A remedial overexcavation of 2 ft below the leveling pad and the MSE was considered in the analysis.

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed wall approximately 40 ft from the southern terminus of the wall near "G" Line Sta. 618+75.

Based on cross-sections provided by the roadway designers, the proposed embankment at "G" Line Sta. 618+75 will be approximately 50 feet wide at the crest and the embankment height is approximately 16 feet above existing grade. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 9 inches. The settlement period is estimated to be about 28 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied across the full proposed roadway width, the settlement period is reduced to about 17 weeks. For a 7-ft embankment surcharge across the full proposed roadway width, the settlement periods is reduced to about 16 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of

subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

Along the proposed wall alignment, the base of the MSE structure will be founded on native soils. EMI recommends remedial grading consisting of a 2-ft overexcavation. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted according to Caltrans Standard Specifications (2006c). The overexcavation should be backfilled using granular, non-expansive soils. In the event the bottom of remedial excavations become saturated due to the presence of shallow groundwater or seepage, self compacting material such as gravel or lean concrete slurry can be placed within the limits of the overexcation. The overexcavation should extend at least 2 ft beyond the outer edge of the leveling pad and 2 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Wall Stability

The "global" stability of the Retaining Wall G1 was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "G" Line Sta. 618+75.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and no cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

5.5 Cantilever Retaining Wall Recommendations – Retaining Wall G2

As described in Section 1.2, Proposed Retaining Wall G2 is a Caltrans Type I Retaining Wall located between approximate Stations 618+33 and 621+00 ("G" Line). The retaining wall is approximately 266 ft long and will vary in design height from 8 to 12 ft. Based upon the preliminary cross sections provided by the wall designers, the proposed wall will be embedded in embankment fill placed as part of the project. Due to the limited wall heights and corresponding demand toe pressures, spread footings are suitable for support of the proposed wall.

5.5.1 Lateral Earth Pressures

The proposed retaining wall will retain embankment fill material to be placed as part of the project. Material placed behind the proposed retaining wall will be required to conform to Section 19-3.06 of Caltrans Standard Specifications for structure backfill. A static active lateral earth pressure of 36 psf per ft of depth is recommended for design of cantilever retaining walls with a uniform lateral pressure of at least 72 psf due to vehicle surcharge load. This static active lateral earth pressure is applicable for a free-draining and level backfill.

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.5.2 Spread Footings

Allowable Bearing Capacity: The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. Based on the assumed soil parameters for the fill material, the allowable soil bearing capacity is estimated to be 2.8 ksf. The ultimate bearing capacity (for seismic design) is three times the allowable bearing capacity.

Fill placed in the upper 2 ft below the footing should be compacted to at least 95% relative compaction. The lateral extent of the 95% relative compaction should be at least 2 ft beyond the edges of the footing.

Lateral active loads can be resisted by passive lateral earth pressure (against the side of buried stem walls and spread footings) and friction acting along the base of footings. The passive lateral

earth pressure can be determined using an average passive pressure of 3.0 ksf against the face of the footing, assuming level ground in front of the retaining wall. The full passive resistance against the face of the footing will be mobilized at a displacement equal to 4 percent of the footing thickness. To determine the frictional resistance along the base of a footing, a coefficient of friction of 0.35 between the concrete footing and the soil below the footing is recommended. The sliding resistance of footings may be determined using 50% of the passive pressure and 100% of the friction along the base of the footing.

Settlement: Maximum total settlement under the allowable bearing capacity is estimated to be no more than 1 inch.

5.5.3 Static Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed wall approximately 40 ft from the southern terminus of the wall near "G" Line Sta. 618+75.

Based on cross-sections provided by the roadway designers, the existing embankment at "G" Line Sta. 618+75 will be approximately 50 feet at the crest and the embankment fill height is approximately 16 feet above existing grade. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 12 inches. However, since Caltrans Type 1 retaining walls have a limited settlement allowance, the surcharge and settlement period recommended for the MSE wall G1 embankment (see section Section 5.4.3) should be completed prior to construction of Retaining Wall G2. MSE Wall G1 should be constructed and the surcharge placed across the entire embankment roadway width. Once the settlement period has elapsed or the surcharge has been released, the portion of the embankment near Retaining Wall G2 can be excavated down to the footing elevation, and Retaining Wall G2 can be constructed.

Settlement Monitoring Recommendations: Surcharge placement and monitoring of settlement will occur following the embankment and MSE Wall G1 construction, prior to construction of Retaining Wall G2. Refer to Section 5.4.3 for settlement monitoring recommendations.

5.5.4 Global Wall Stability

The "global" stability of the Retaining Wall G2 was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for

the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "G" Line Sta. 618+75.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and 200 psf cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all four of the borings performed near the proposed wall pair between elevation -9.9 and -11.9 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad varies between about elevation +2 and -4 ft. The deepest excavation for the proposed MSE wall is expected to be a few feet above the observed groundwater elevations. However, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

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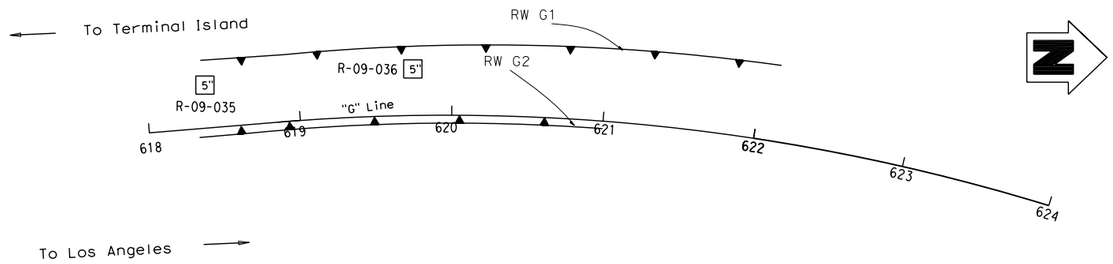

PLAN

1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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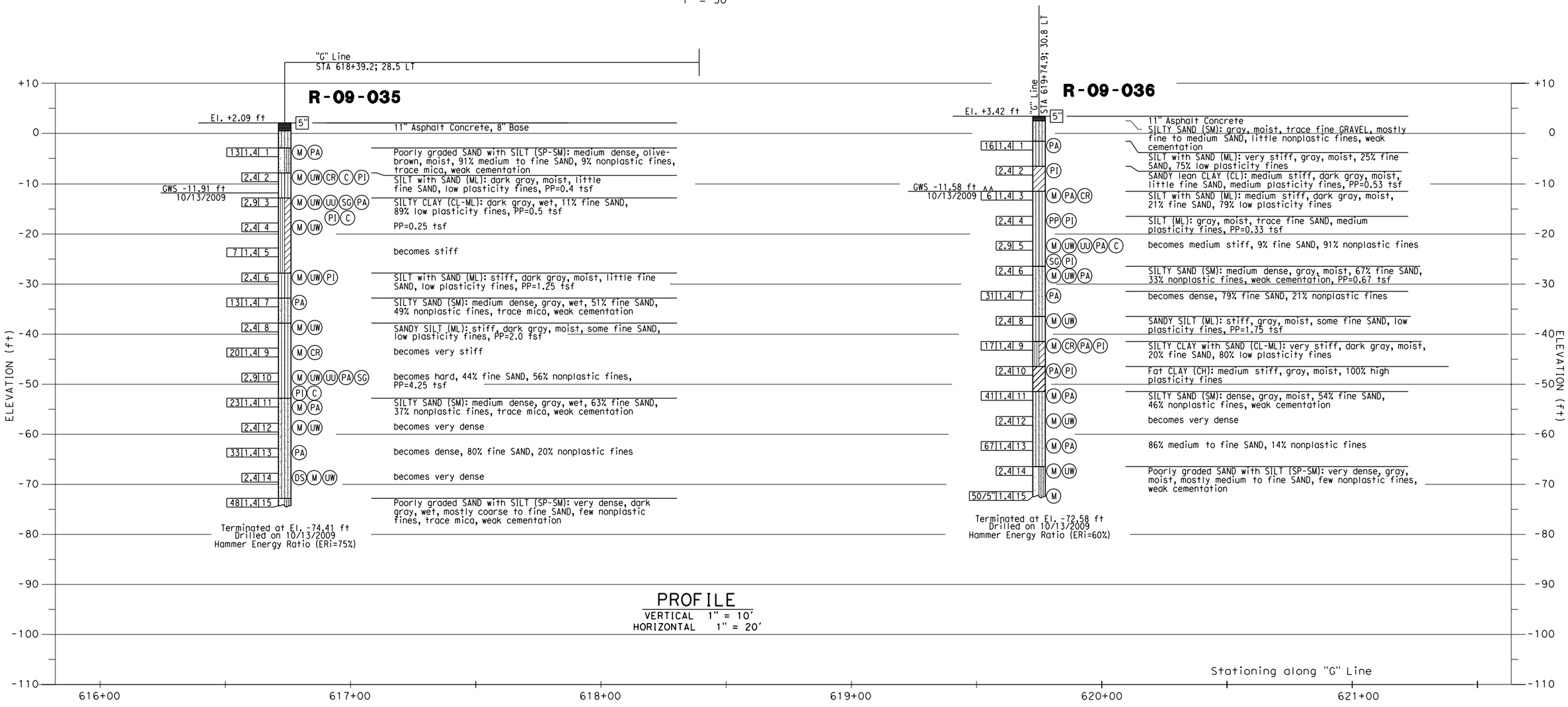
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0151	MSE RETAINING WALL NO. G1
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.17	LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/26/10	04/14/10									X	X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

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BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
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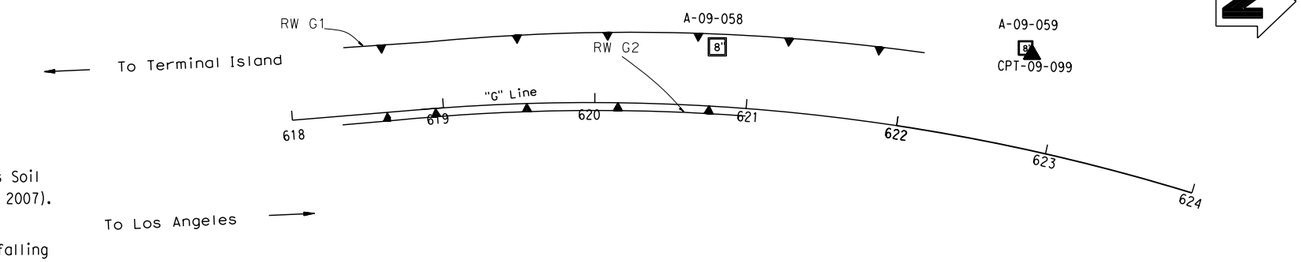

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17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

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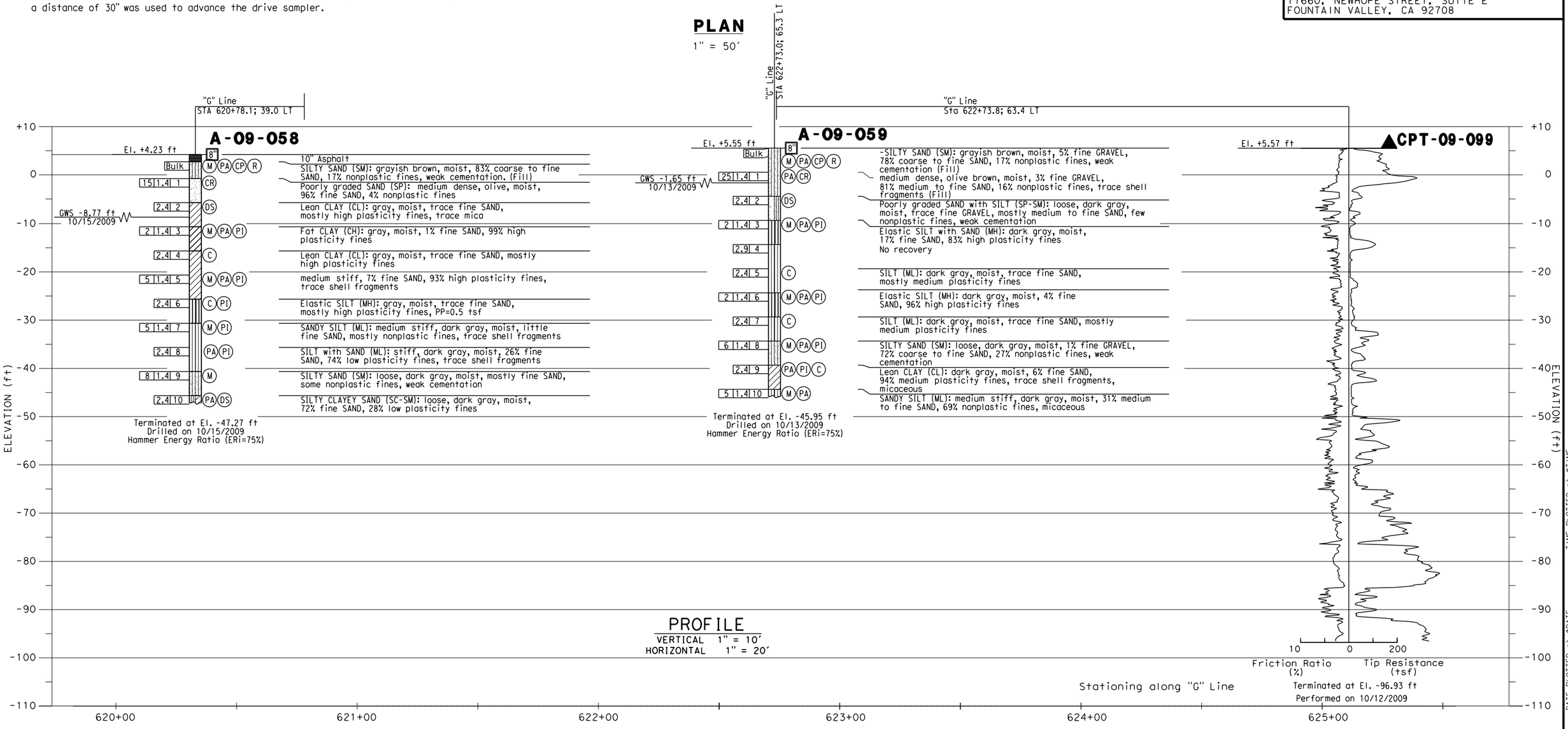

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.17	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

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02/08/10	04/14/10								X	X

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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

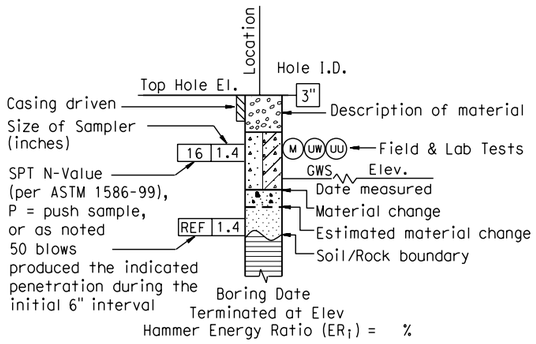
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

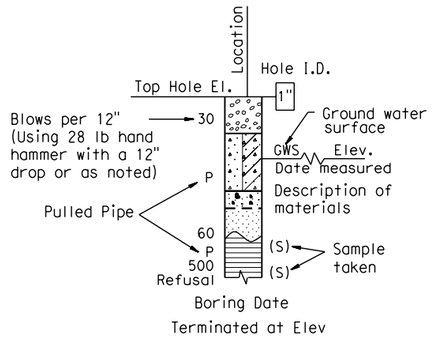
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

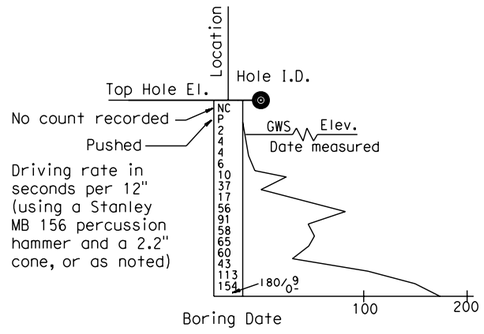
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



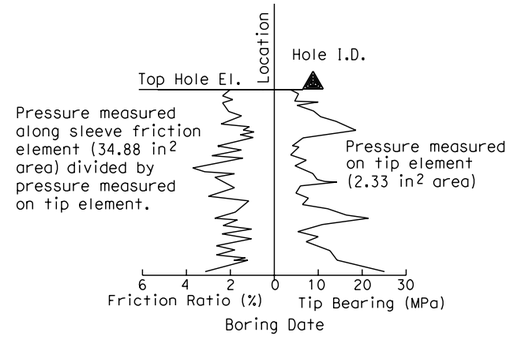
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0151 POST MILE 0.17

MSE RETAINING WALL NO. G1

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

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02/08/10	04/14/10									X	X

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0151
POST MILE 0.17

MSE RETAINING WALL NO. G1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

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SHEET X OF X

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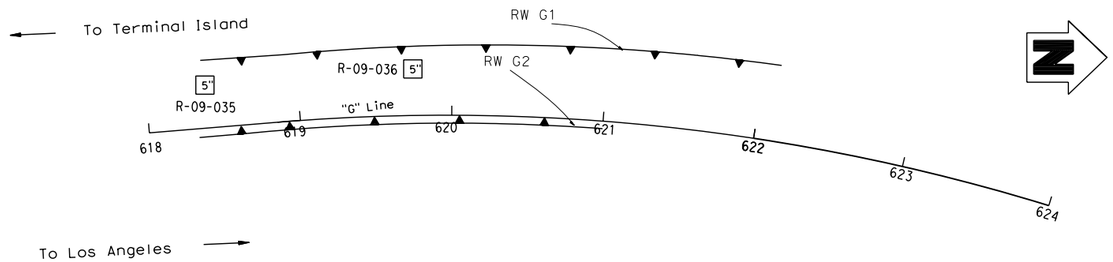

PLAN

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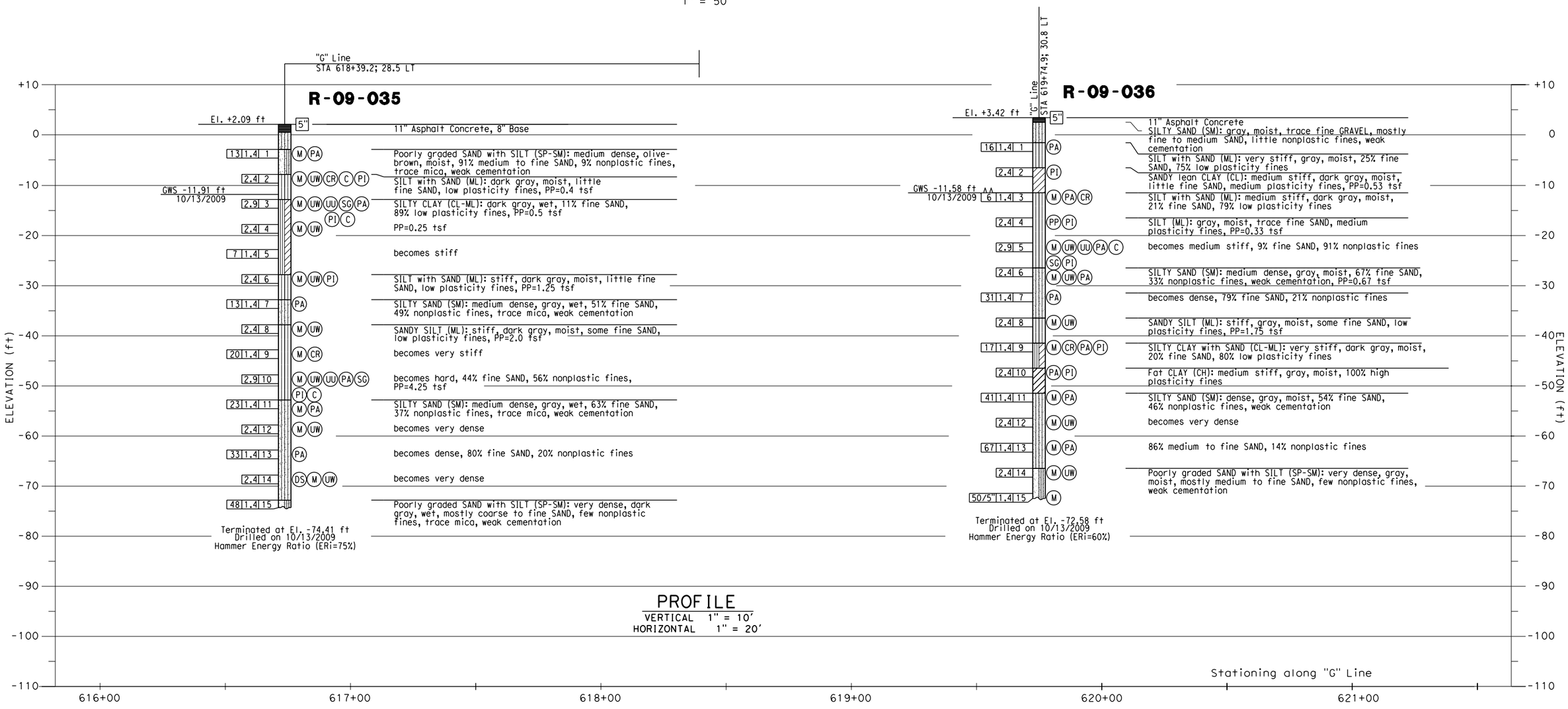

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			

MSE RETAINING WALL NO. G2

LOG OF TEST BORINGS NO. 1 OF 4

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CU 07
EA 238501

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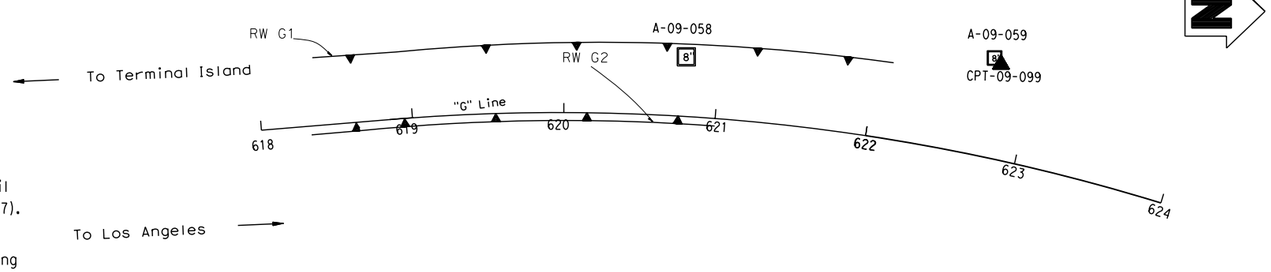

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PLAN

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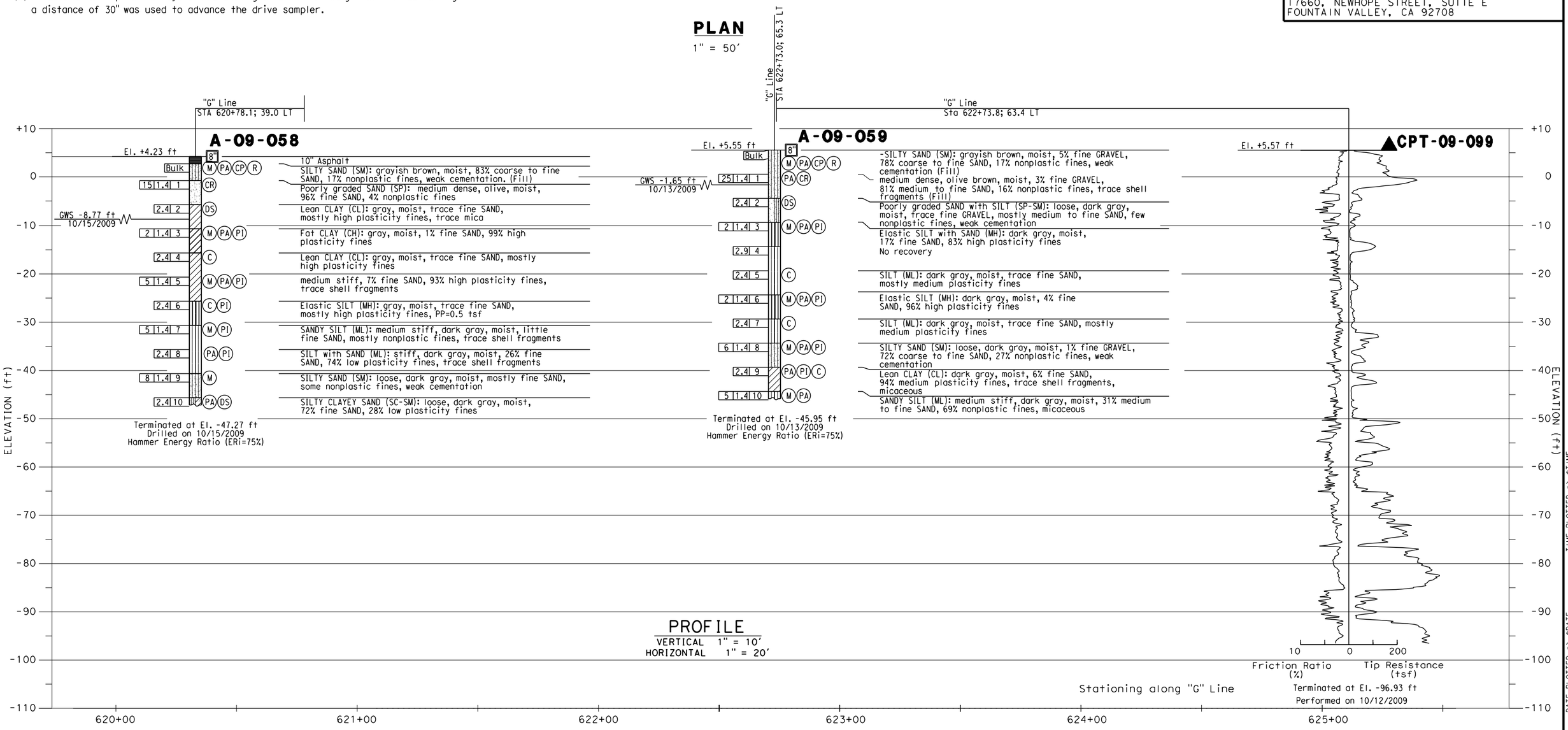

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.17	LOG OF TEST BORINGS NO. 2 OF 4

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USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

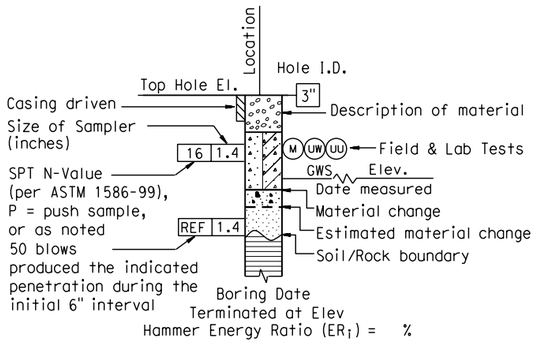
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

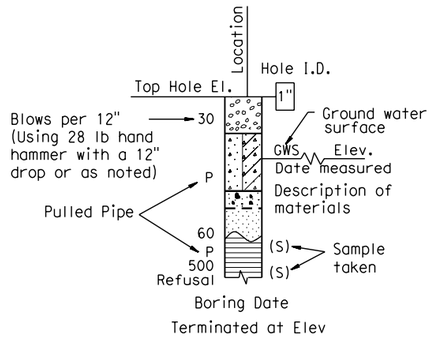
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

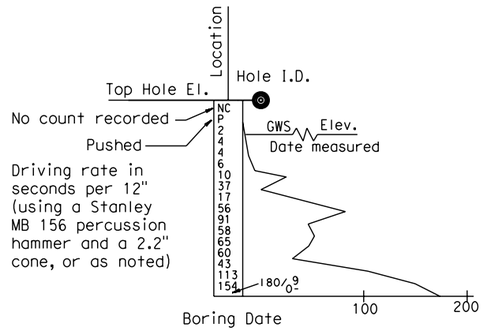
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



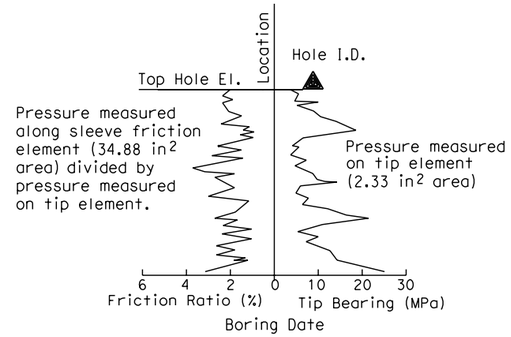
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. - POST MILE 0.17

MSE RETAINING WALL NO. G2

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	04/14/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. -

POST MILE 0.17

MSE RETAINING WALL NO. G2

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10, 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A. EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

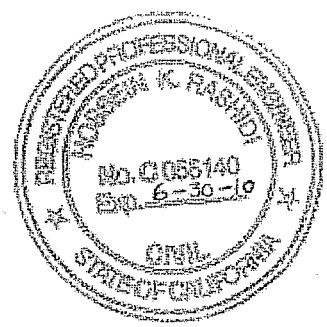
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

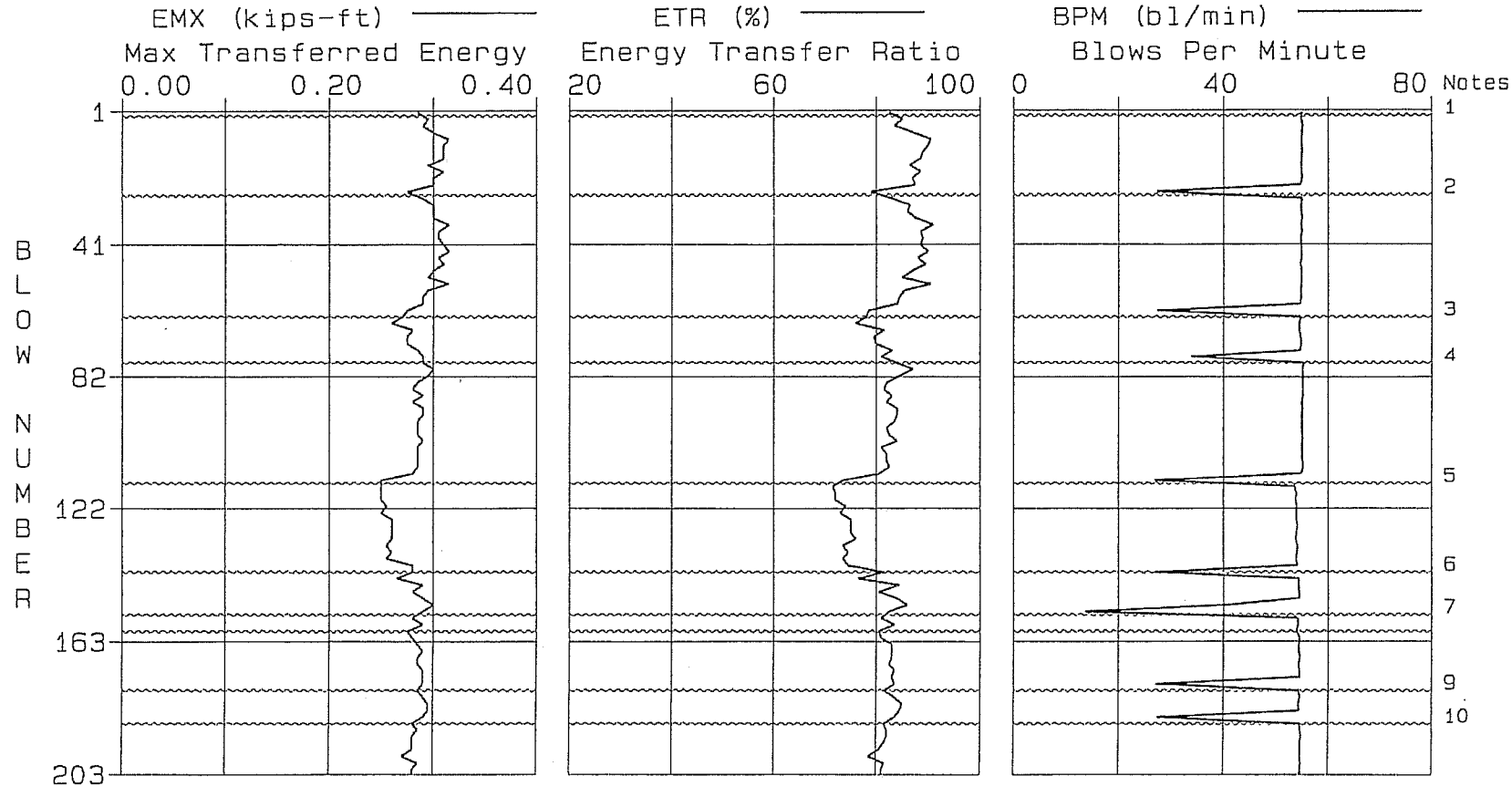
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

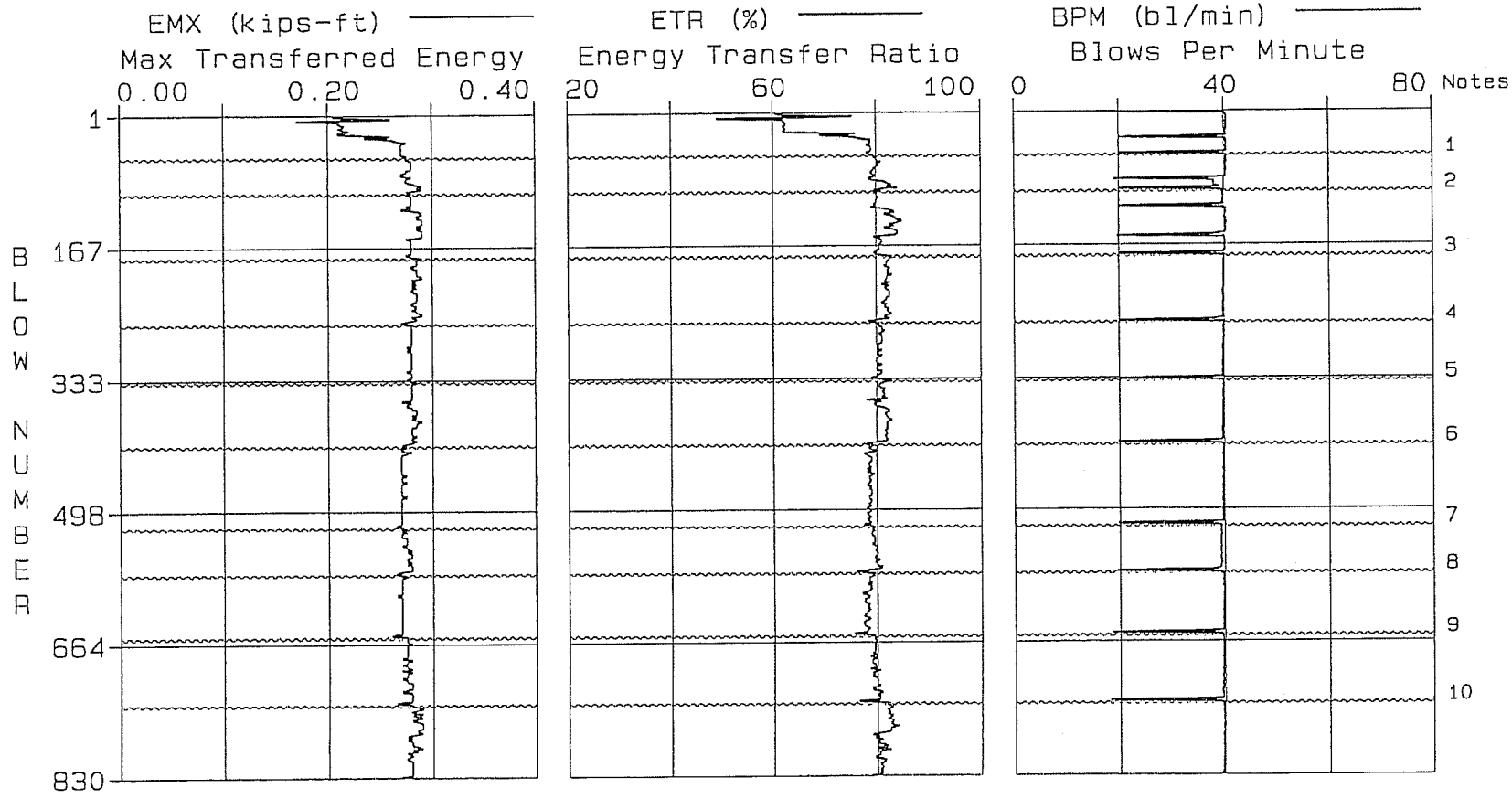
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

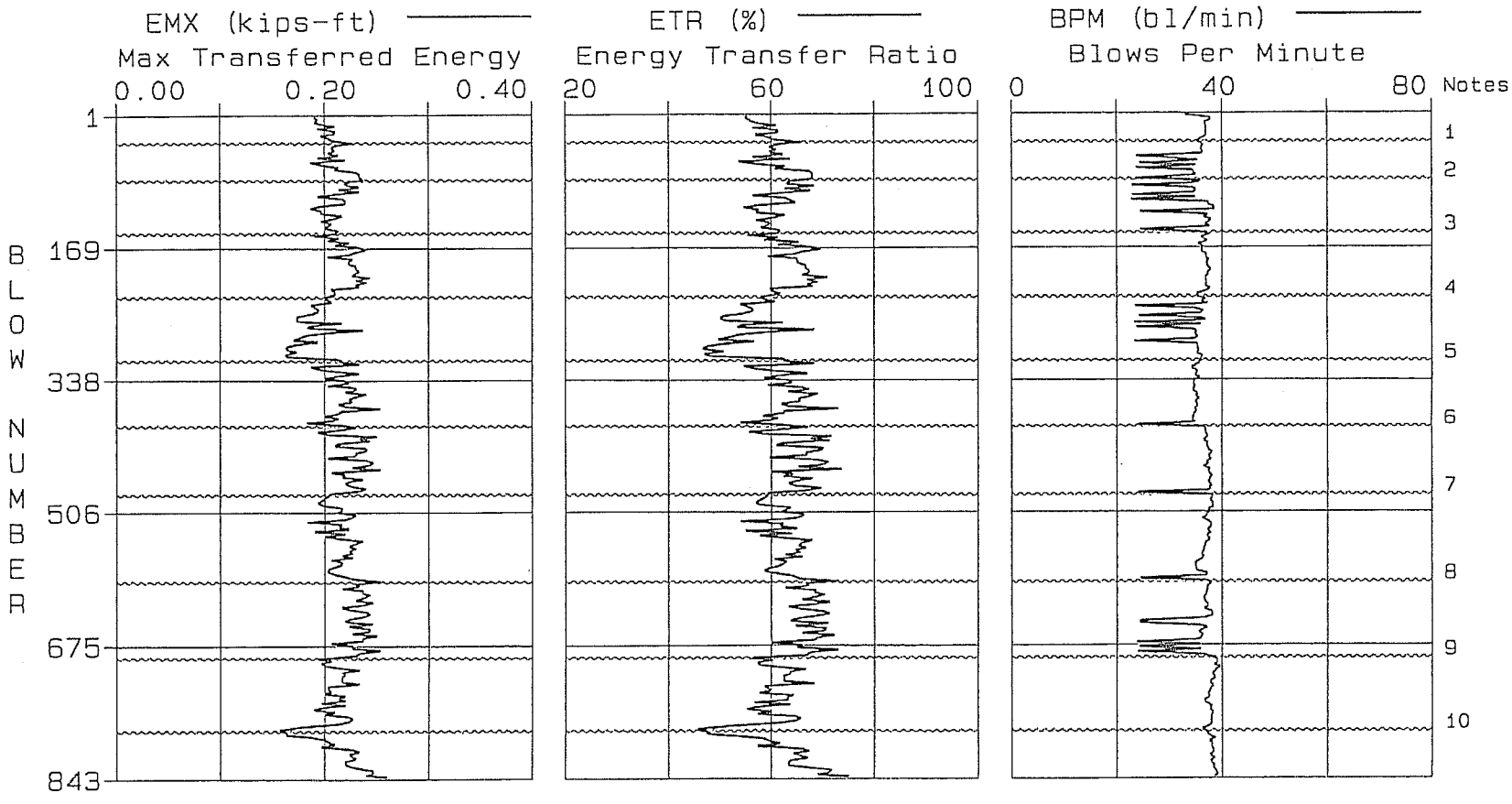
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX B. GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

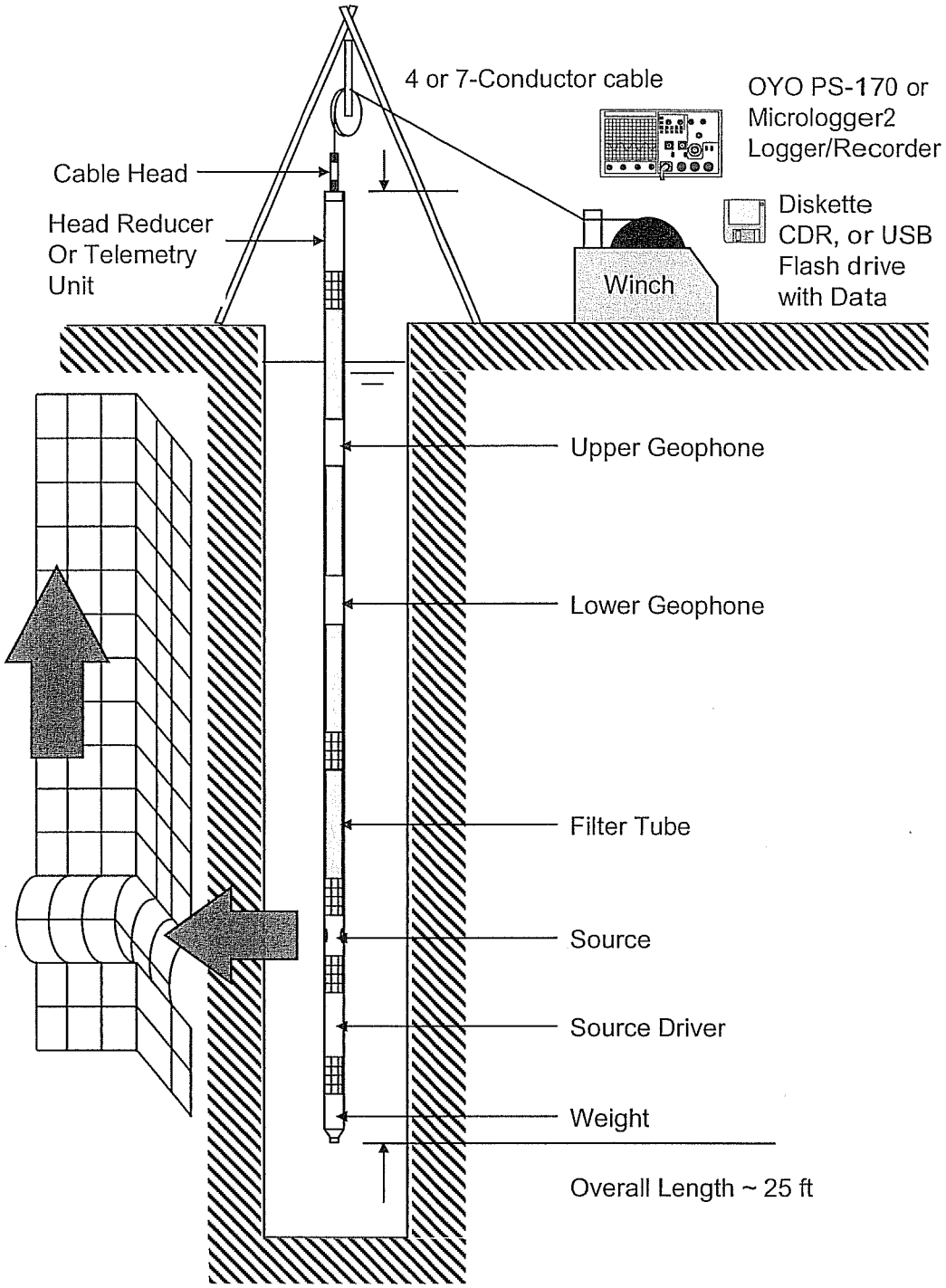

Figure 1: Concept illustration of P-S logging system

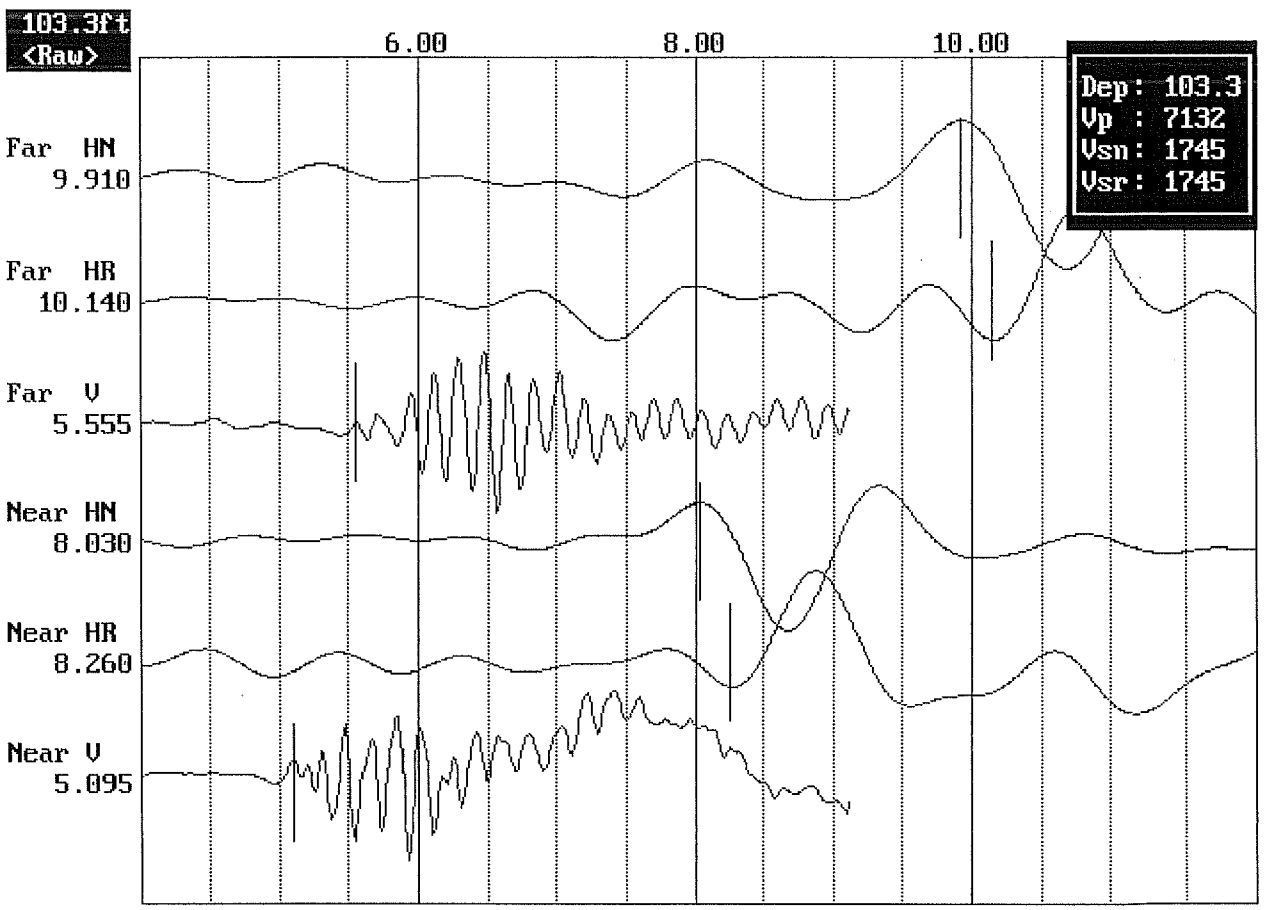

Figure 2: Example of filtered (1400 Hz lowpass) record

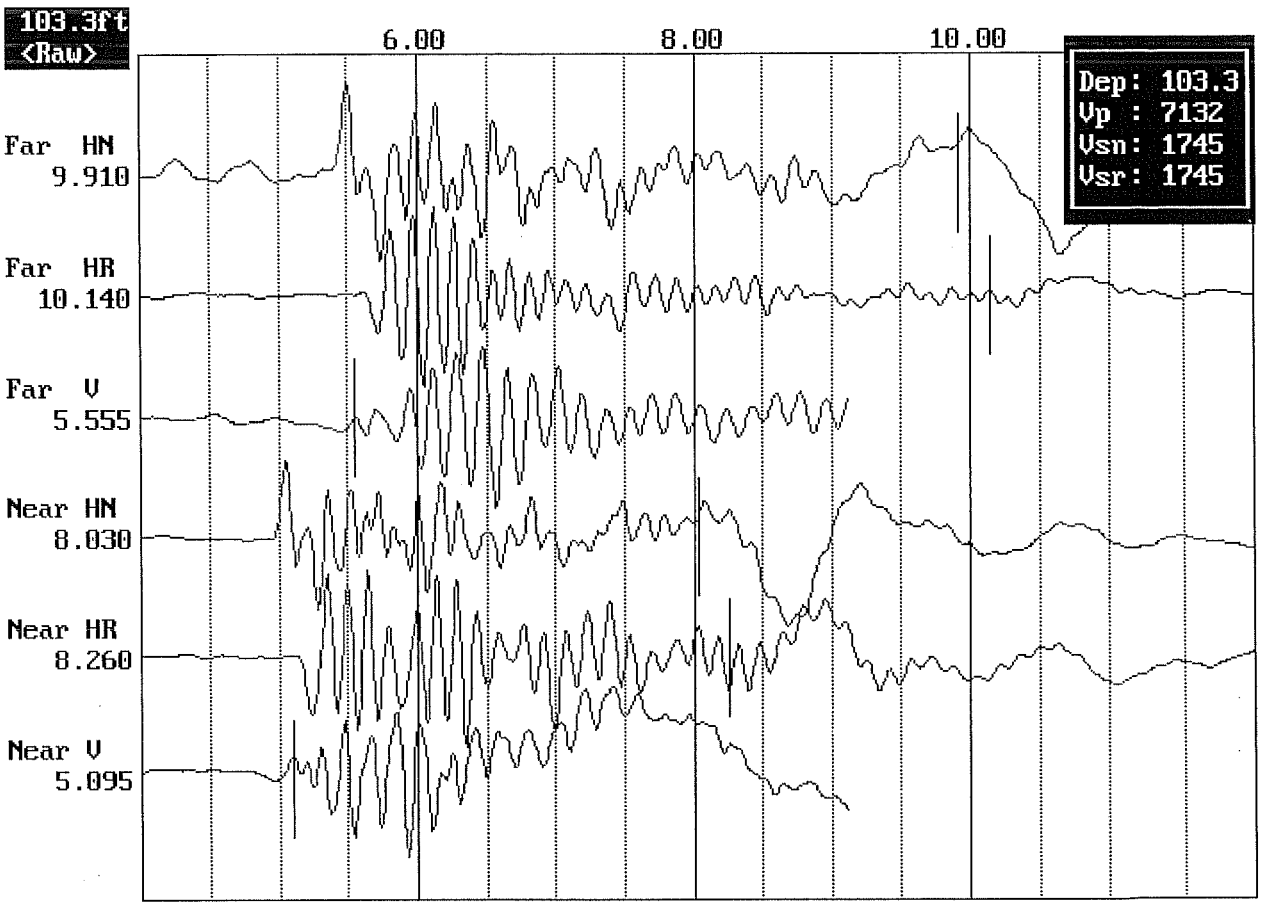

Figure 3. Example of unfiltered record

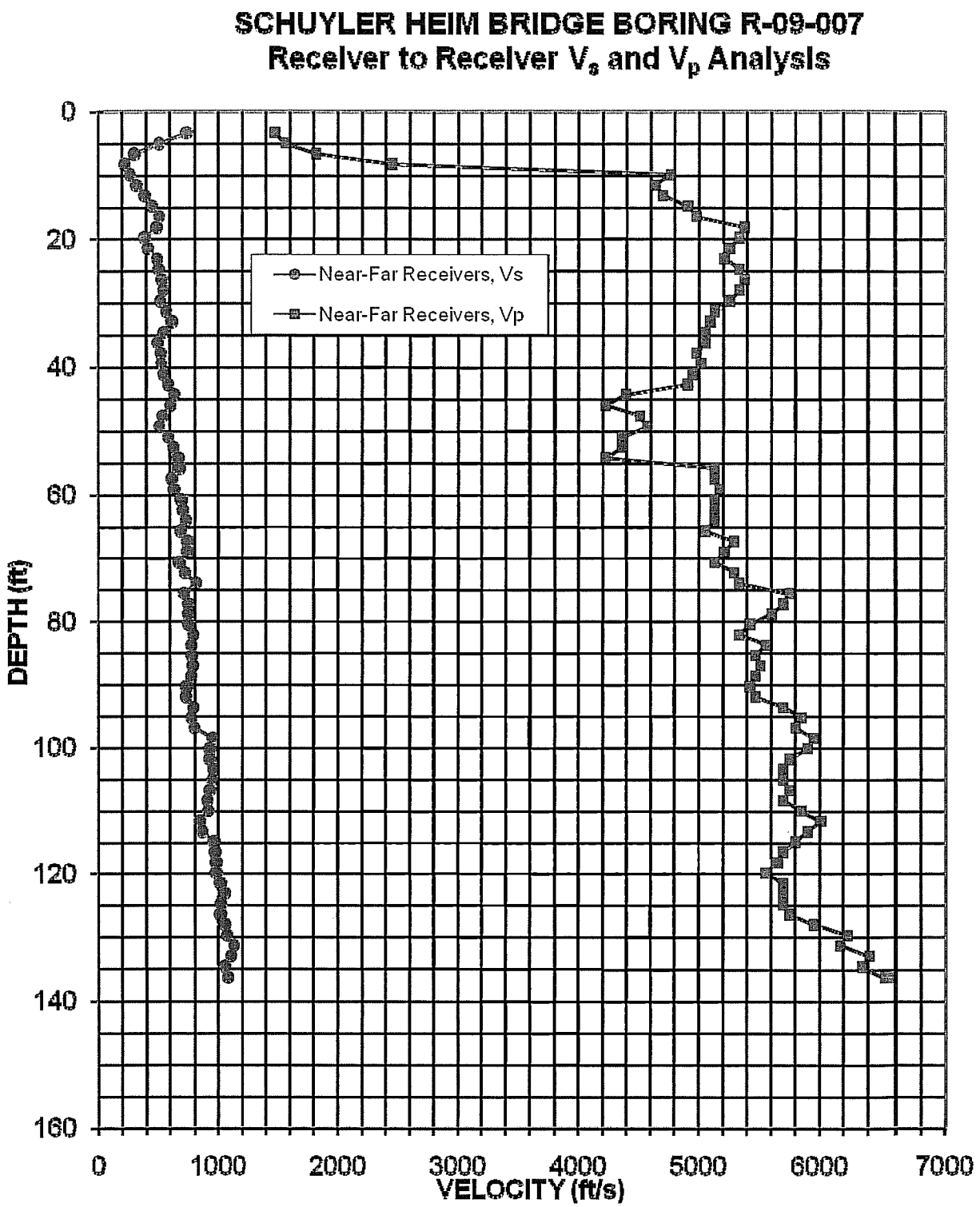

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

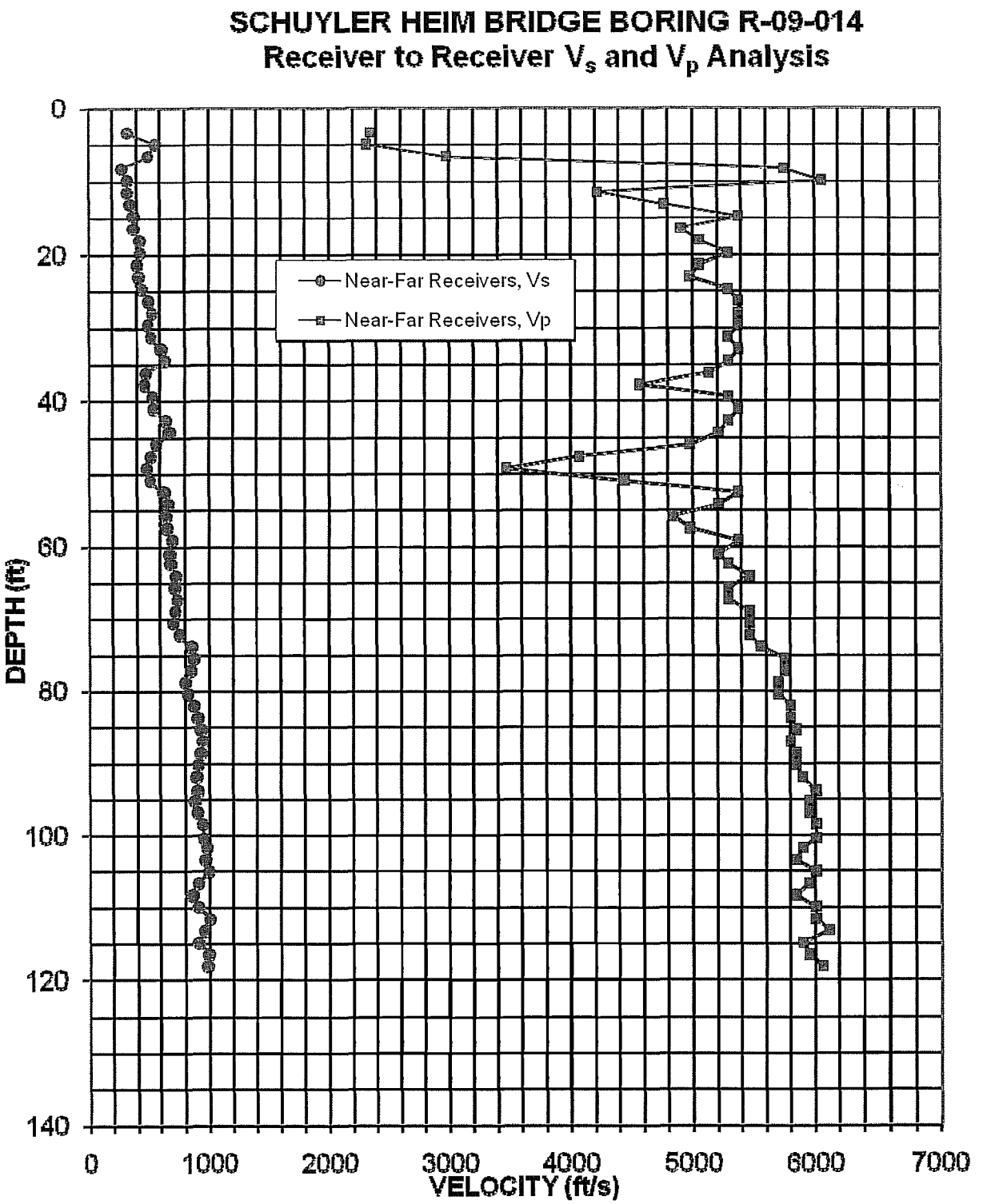

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

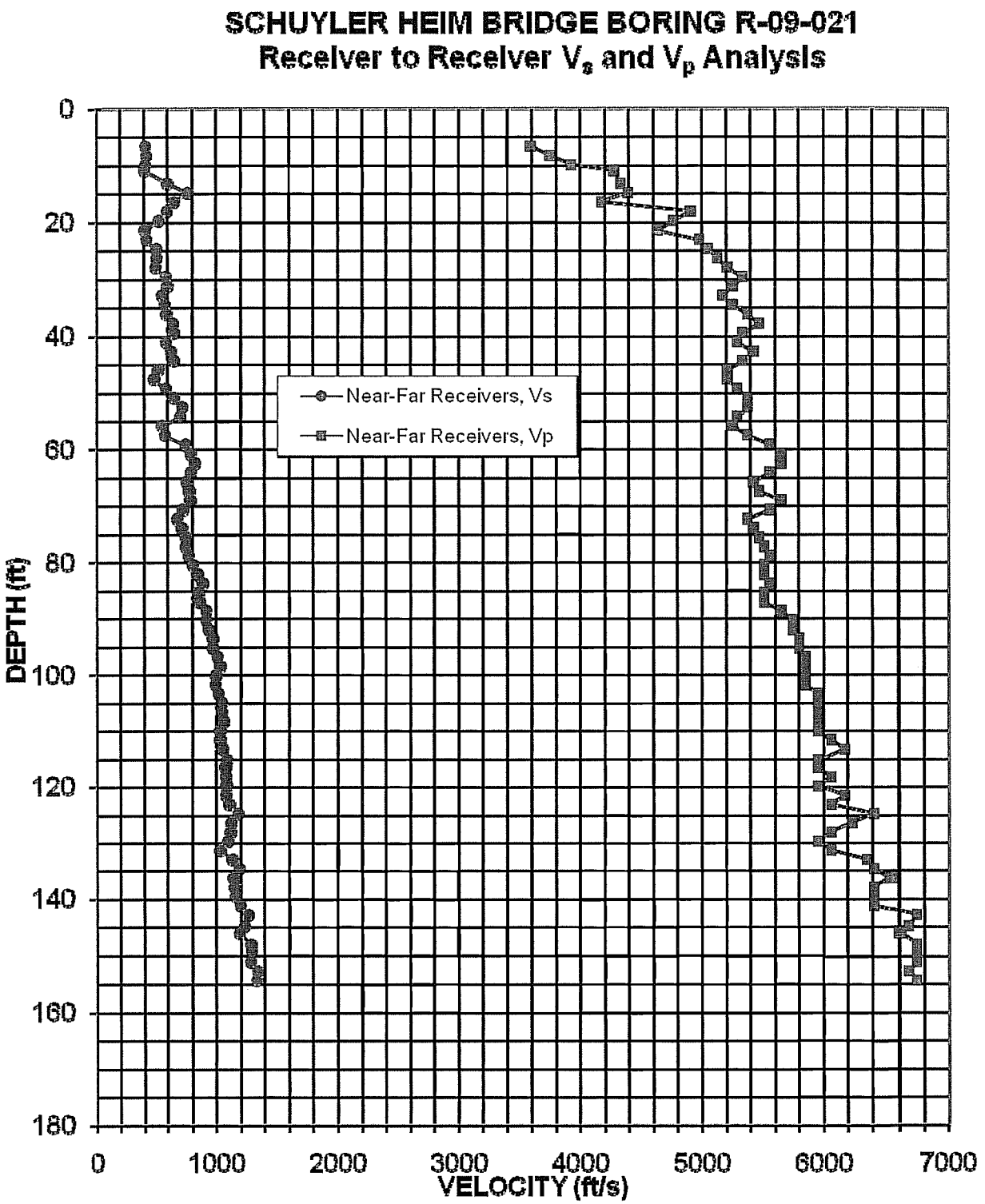

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

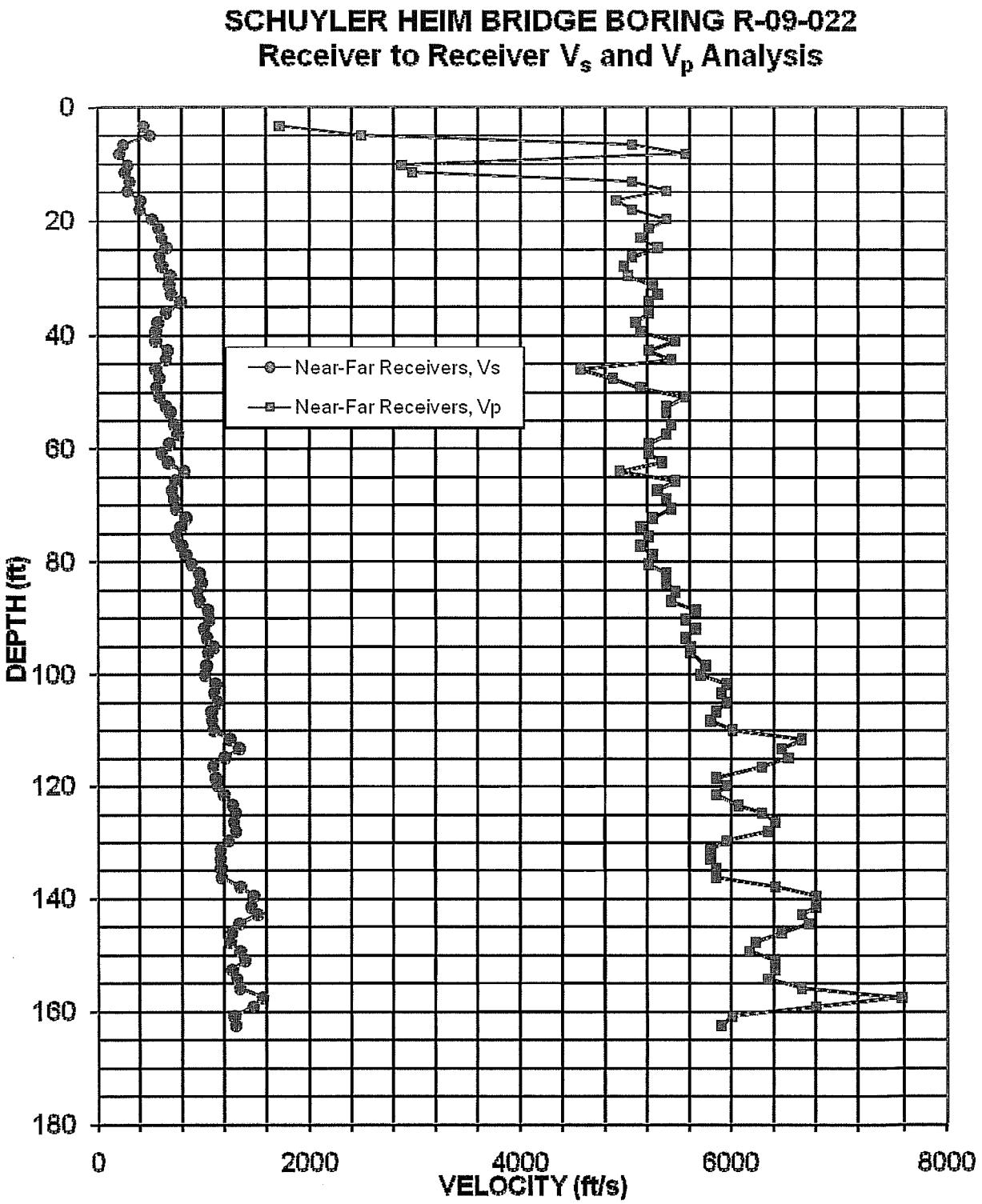

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

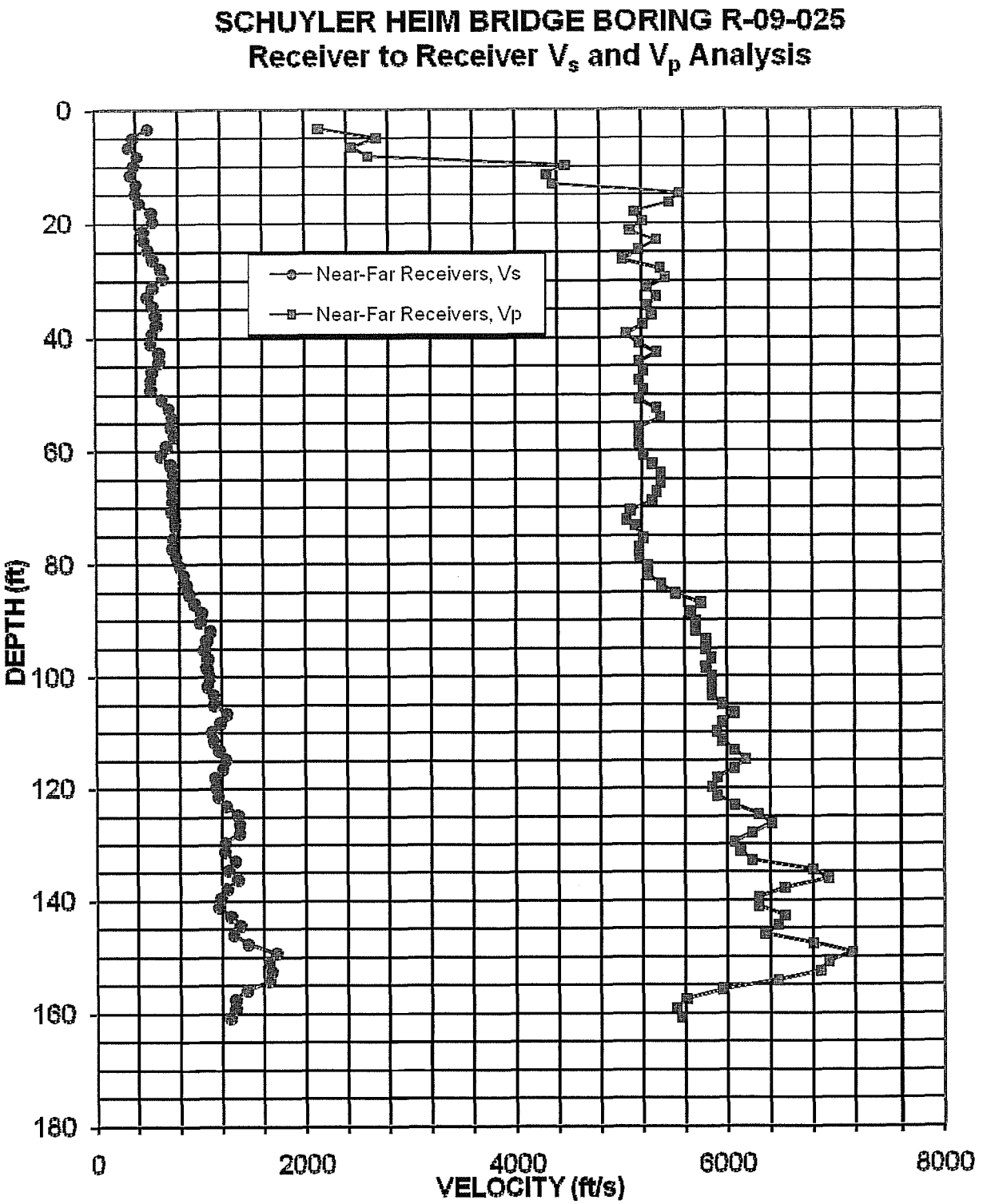

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

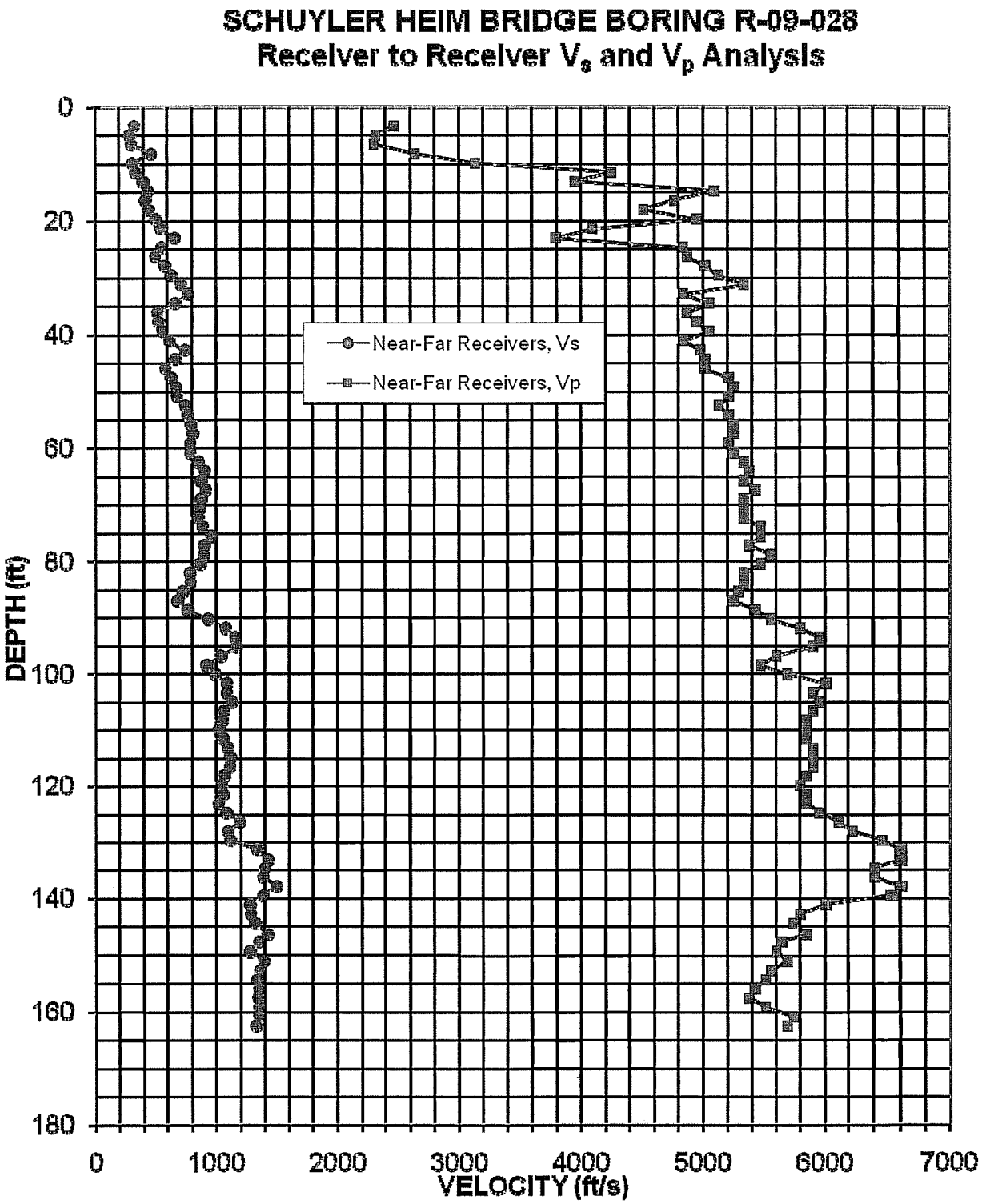

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

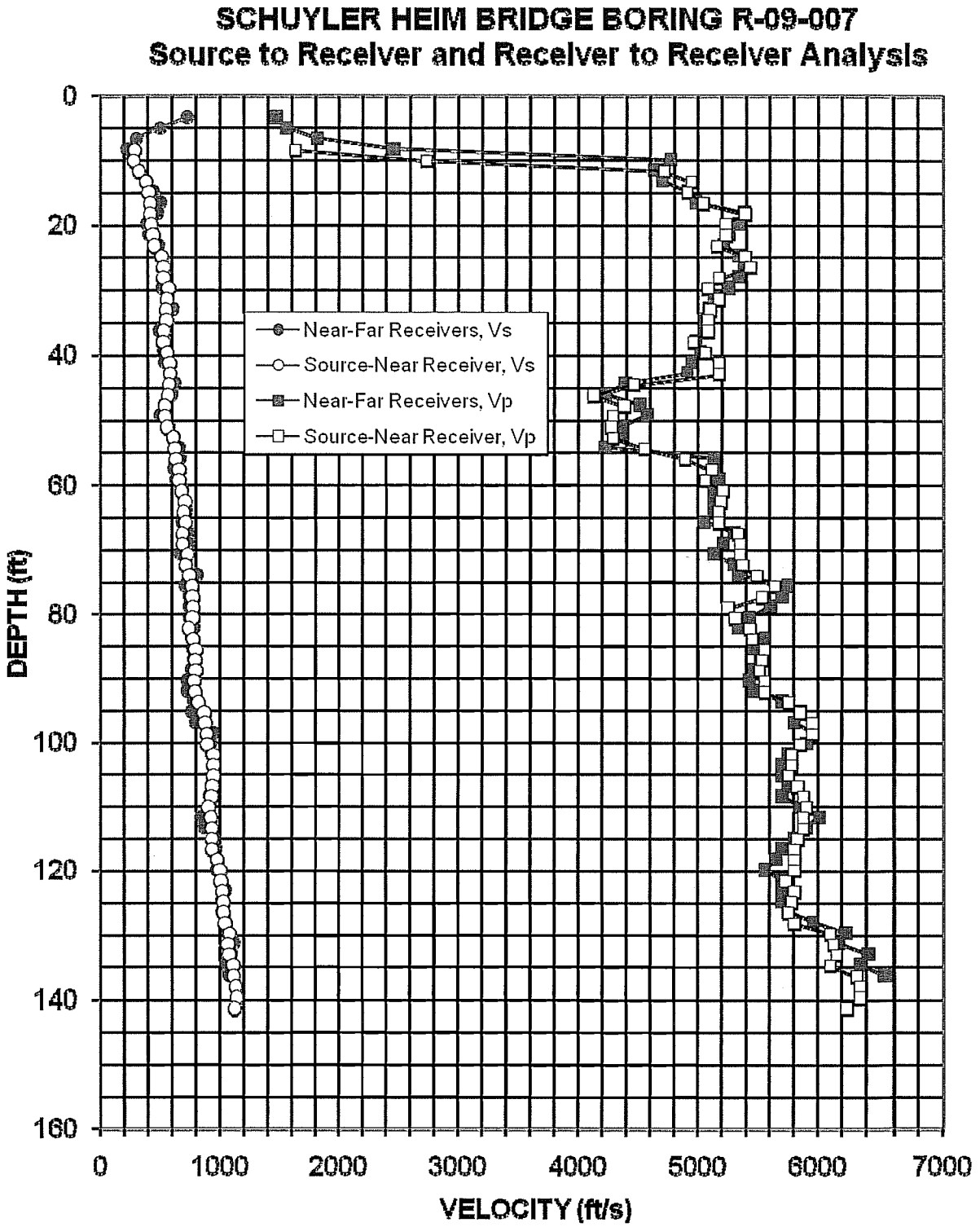

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

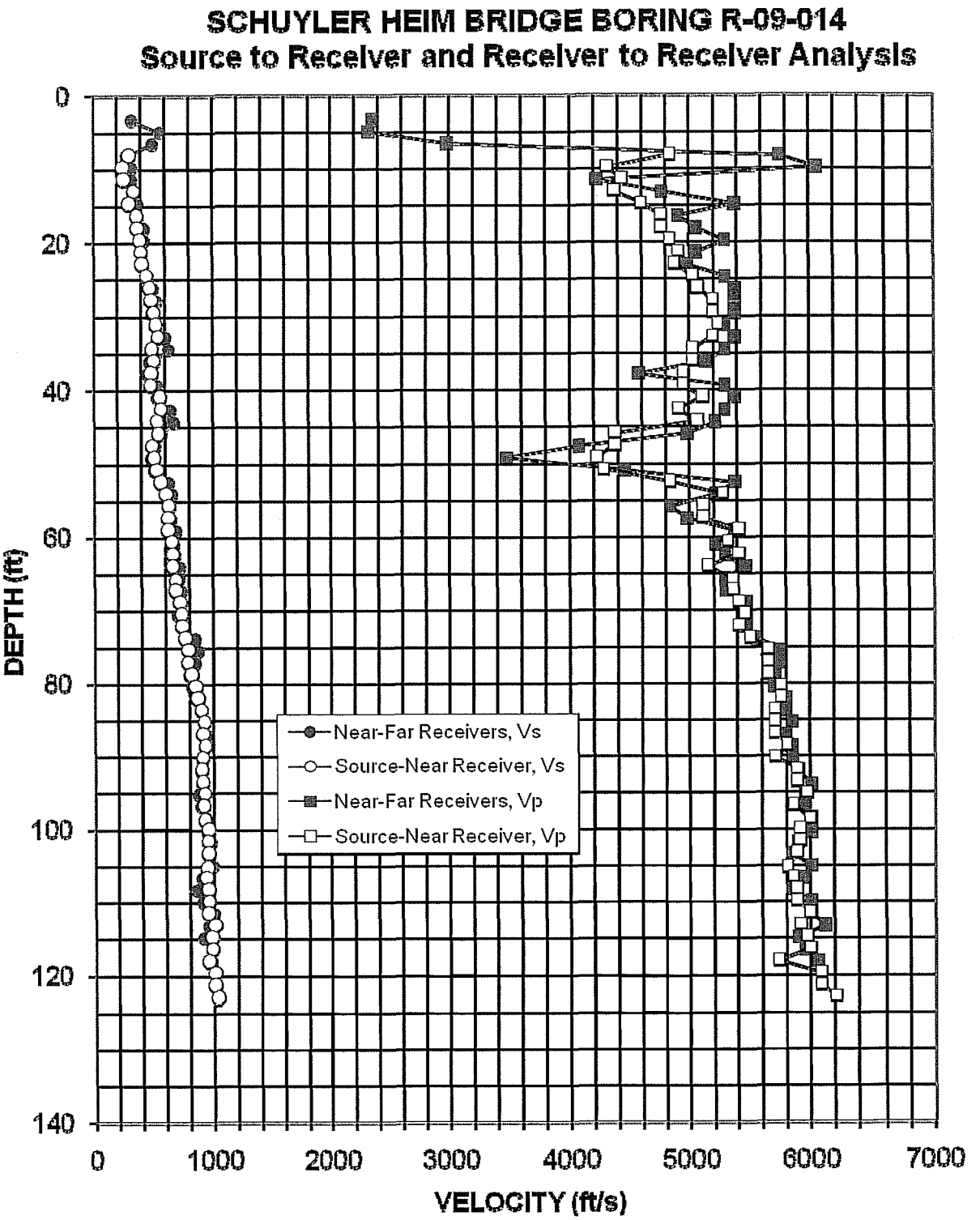

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

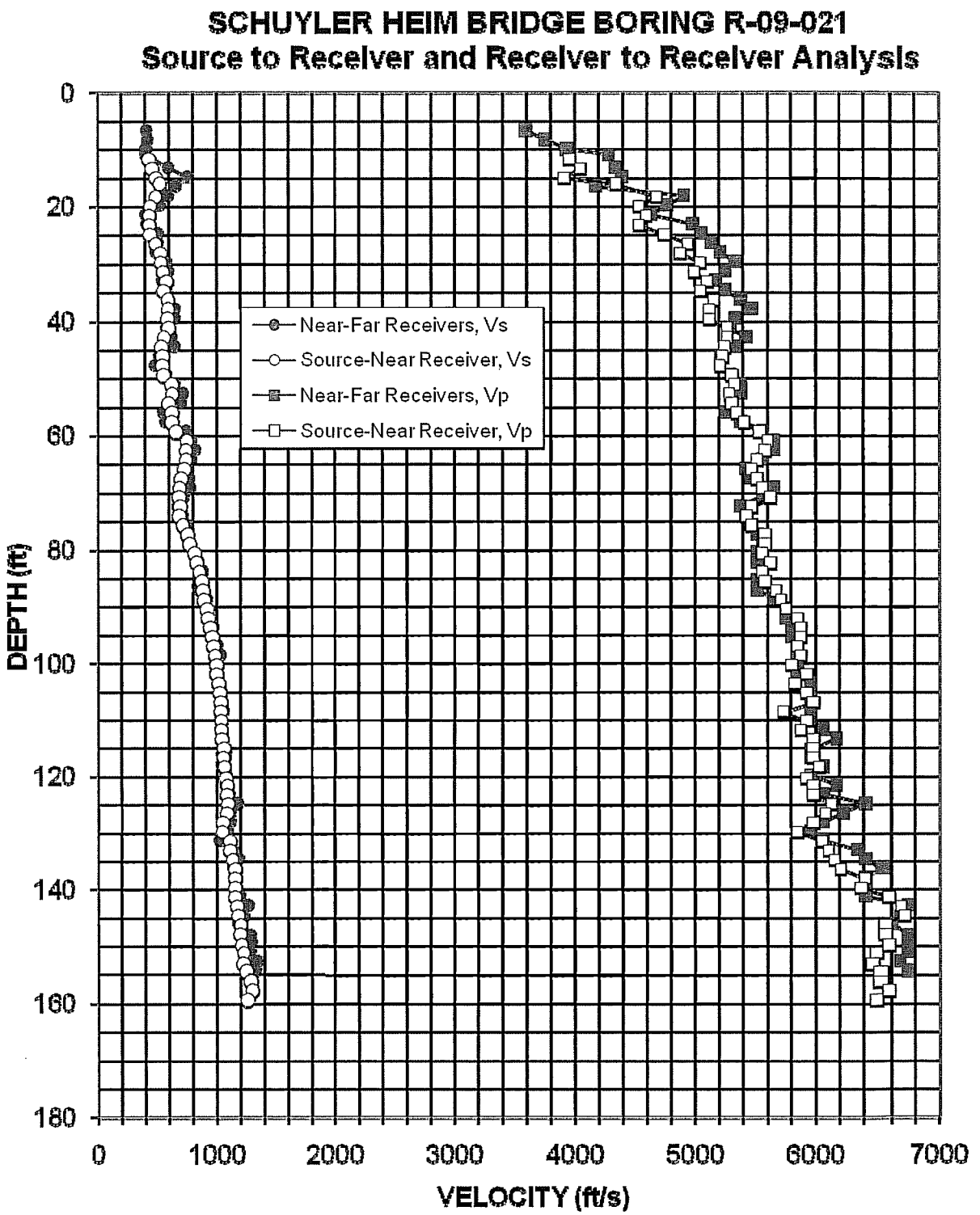

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

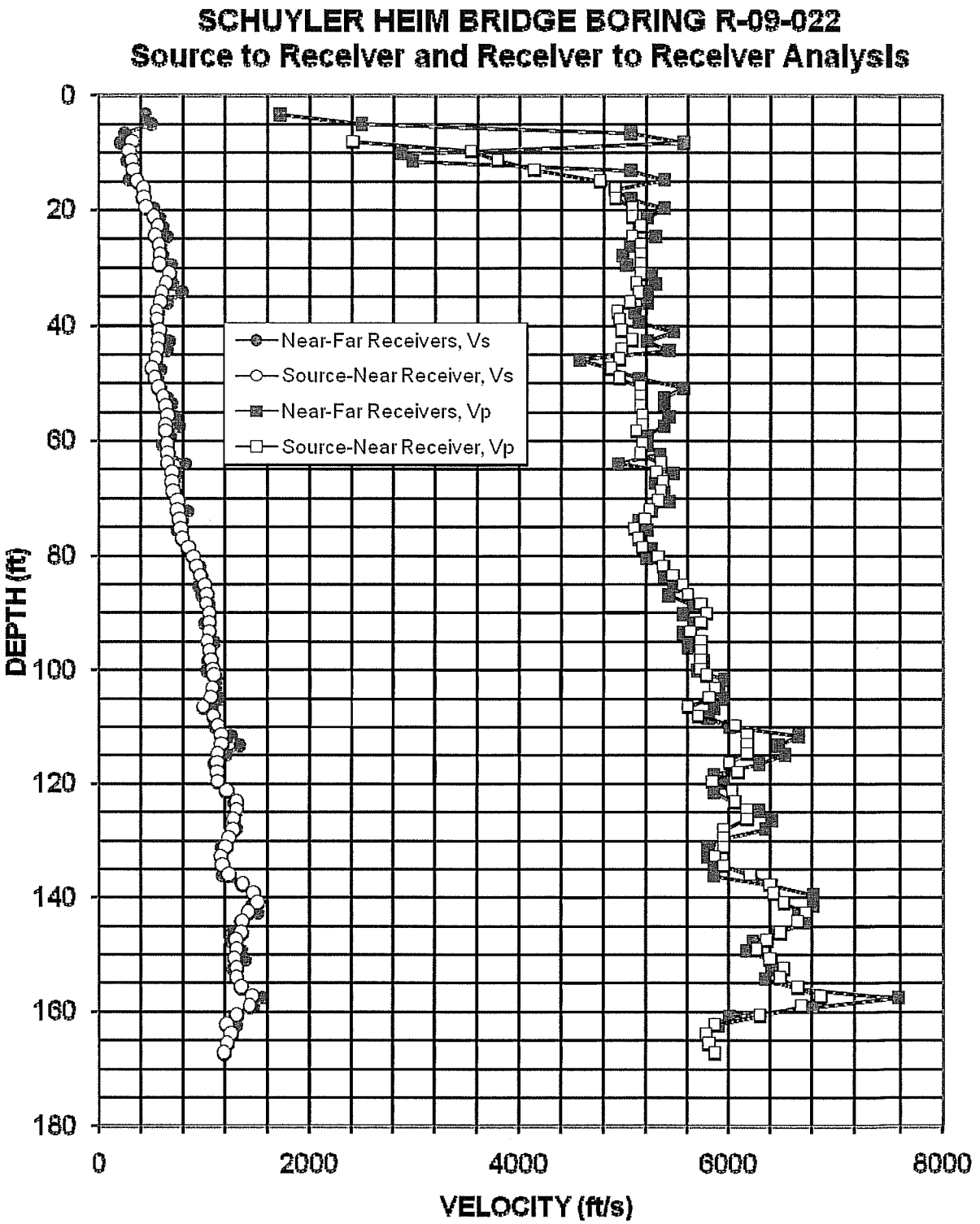

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

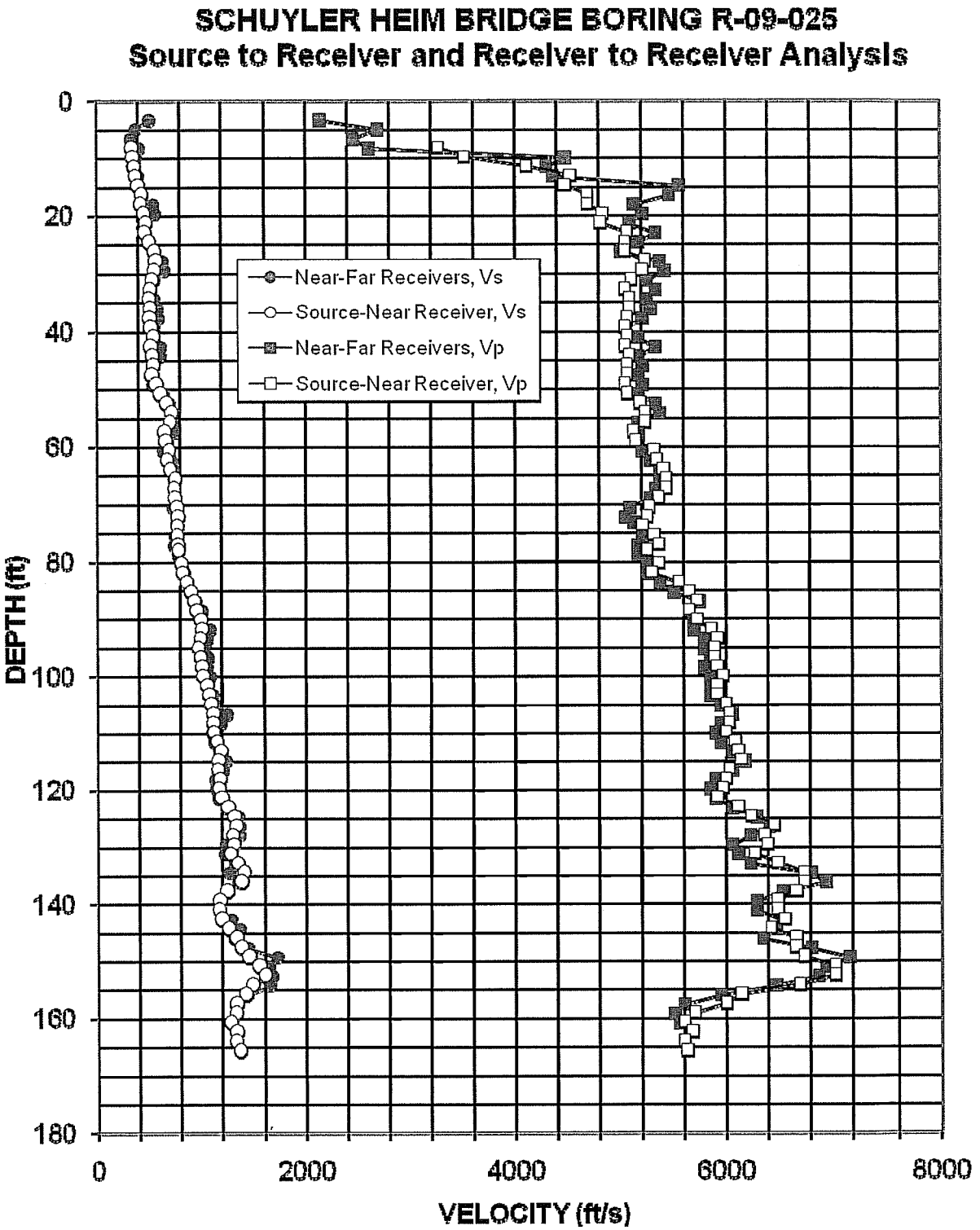

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

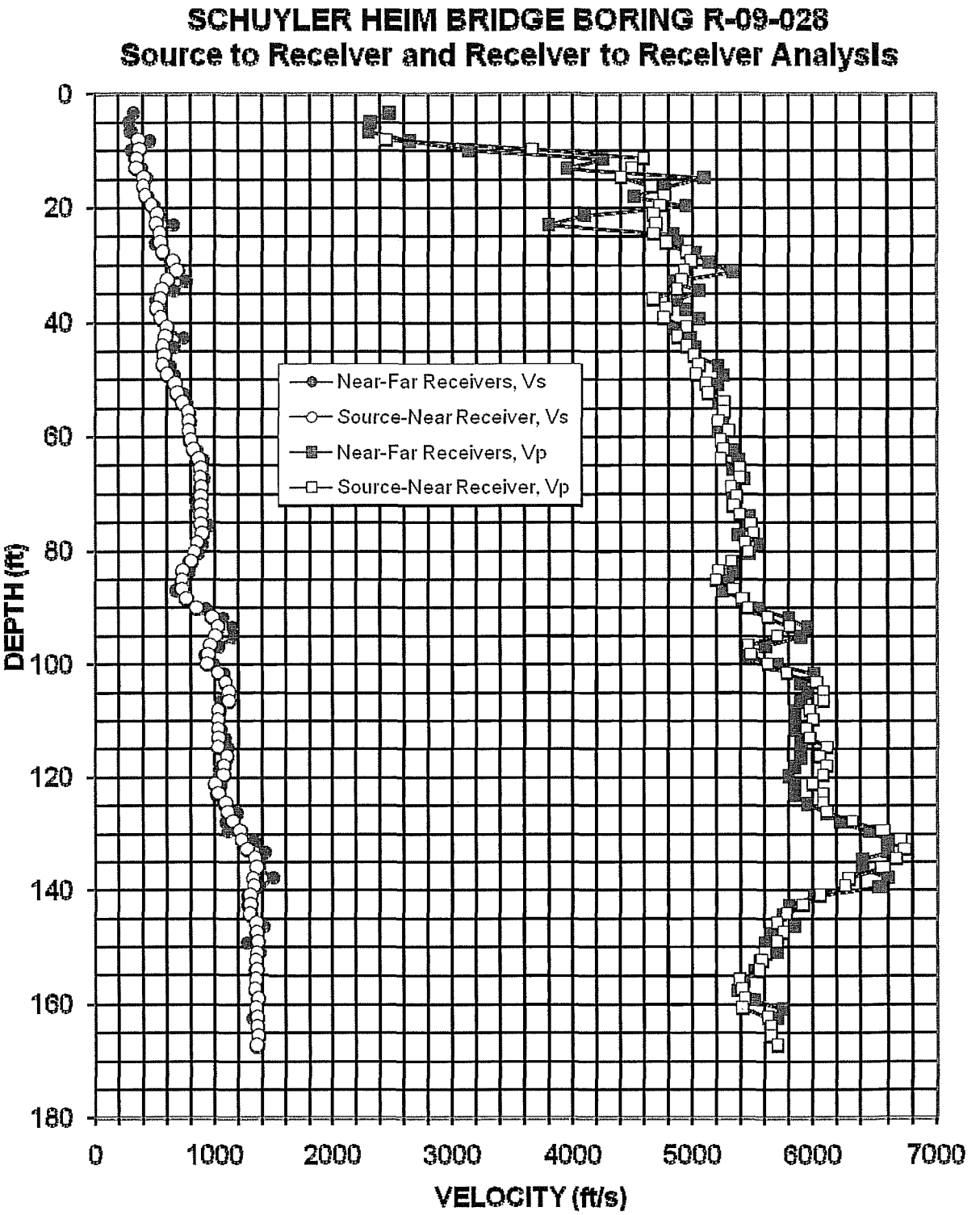

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
		2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No:	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 ~~160024~~ CH2
573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C. LABORATORY SOIL TEST RESULTS

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-035	S-01	5.0	25.4		9.3	
R-09-035	D-02	10.0				38,29,10
R-09-035	U-03	15.0				28,23,5
R-09-035	D-04	20.0	43.1	80.0		
R-09-035	D-06	30.0	33.3	90.2		24,22,2
R-09-035	S-07	35.0			48.8	
R-09-035	D-08	40.0	31.1	92.7		
R-09-035	S-09	45.0	39.7			
R-09-035	U-10	50.0				NP
R-09-035	S-11	55.0	33.4		37.0	
R-09-035	D-12	60.0	21.9	105.4		
R-09-035	S-13	65.0			19.9	
R-09-035	D-14	70.0	27.0	98.7		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-035	D-02	10	7.88	465	0.051	610
R-09-035	S-09	45	8.65	2215	0.056	230

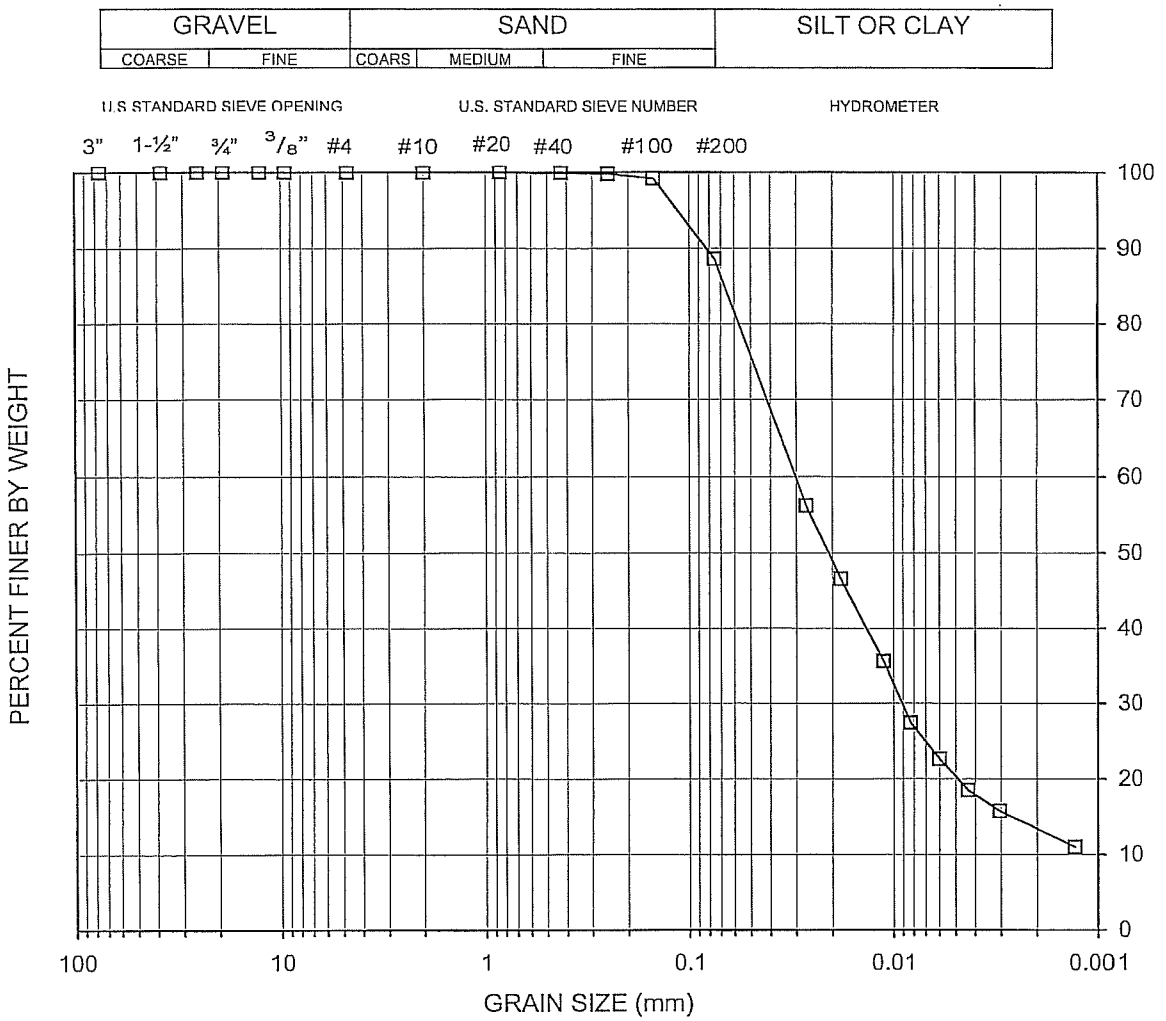
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-035	U-03	15	2.763
R-09-035	U-10	50	2.742



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-03	15	Shelby Tube	ML	28	5

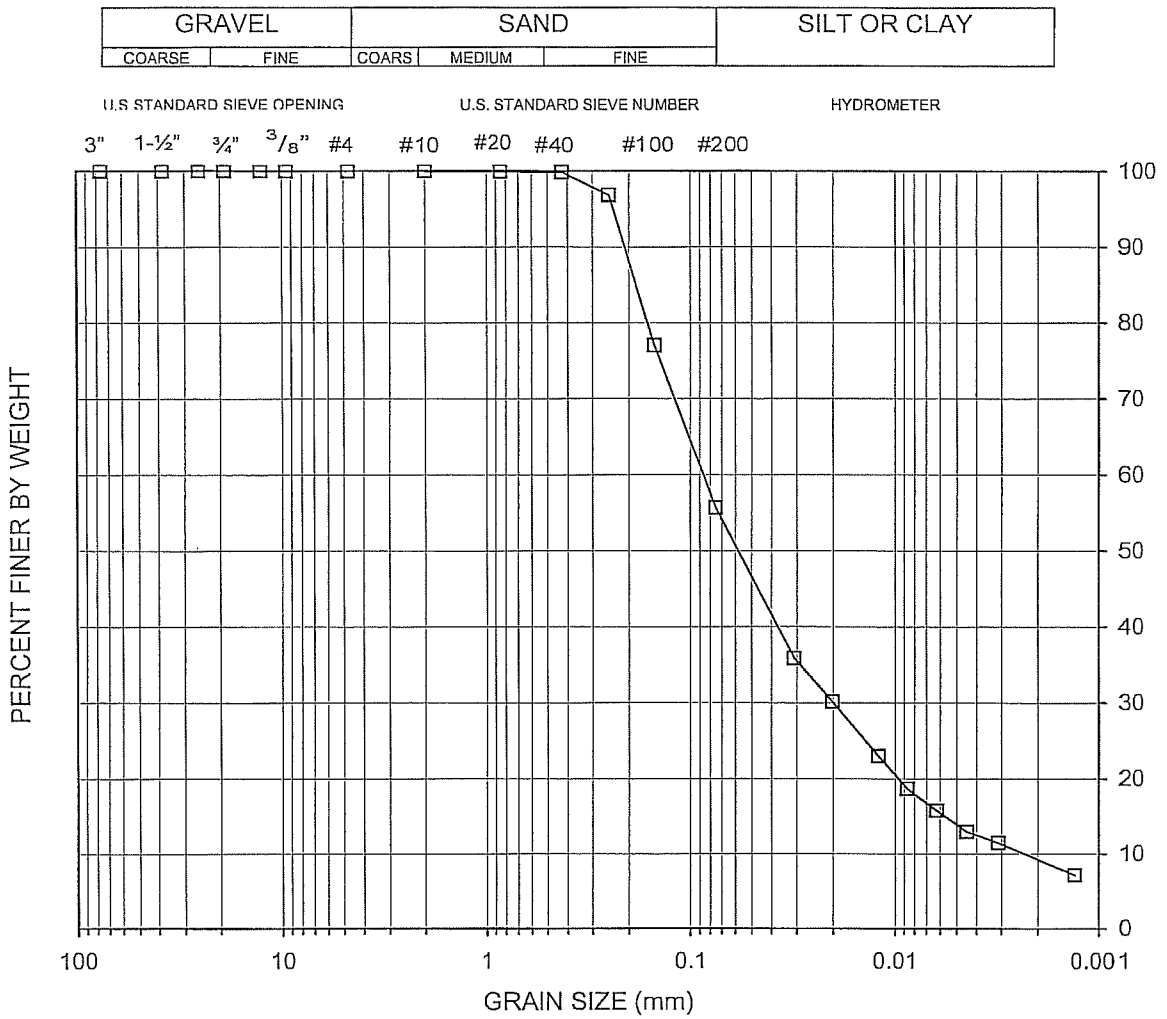
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-10	50	Shelby Tube	ML	NP	N/A

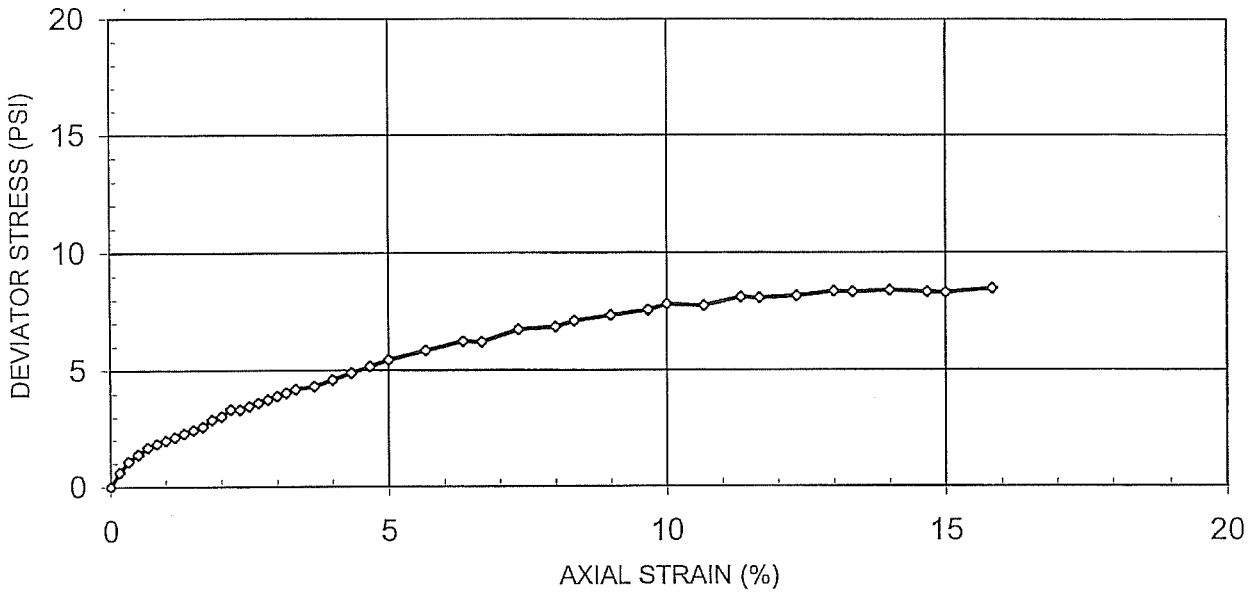
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

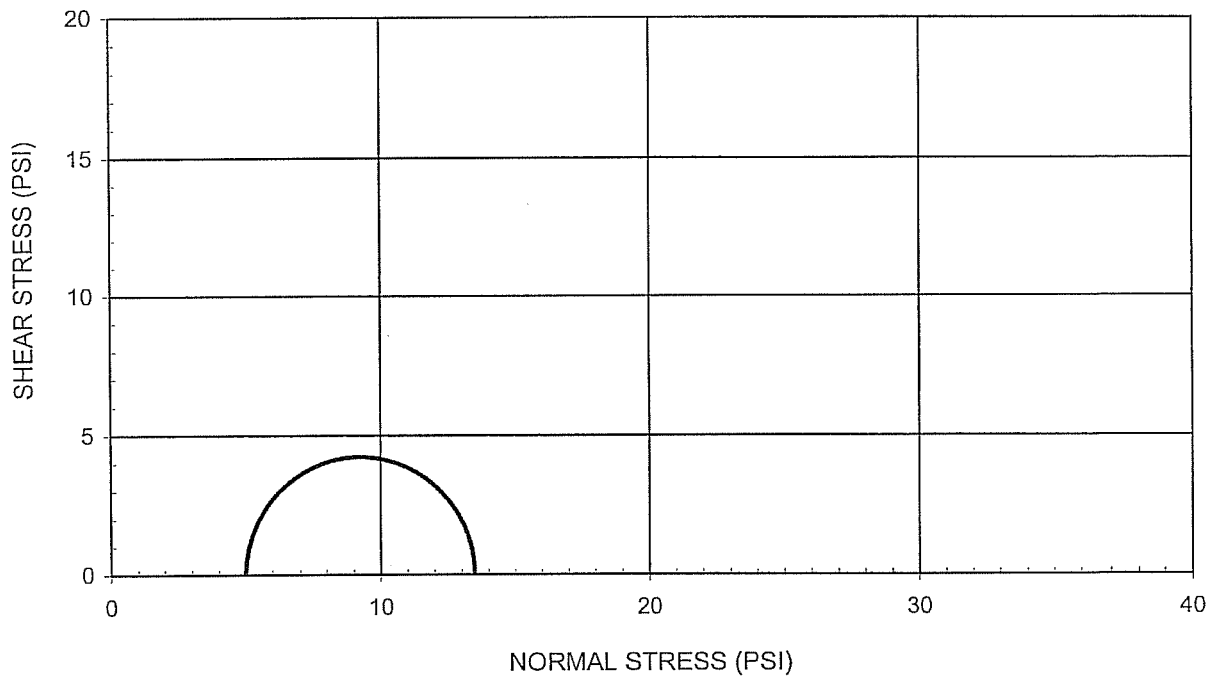
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	15	U-03	ML	Shelby Tube	41.01	80.0	5.0	8.5	0.06	100.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

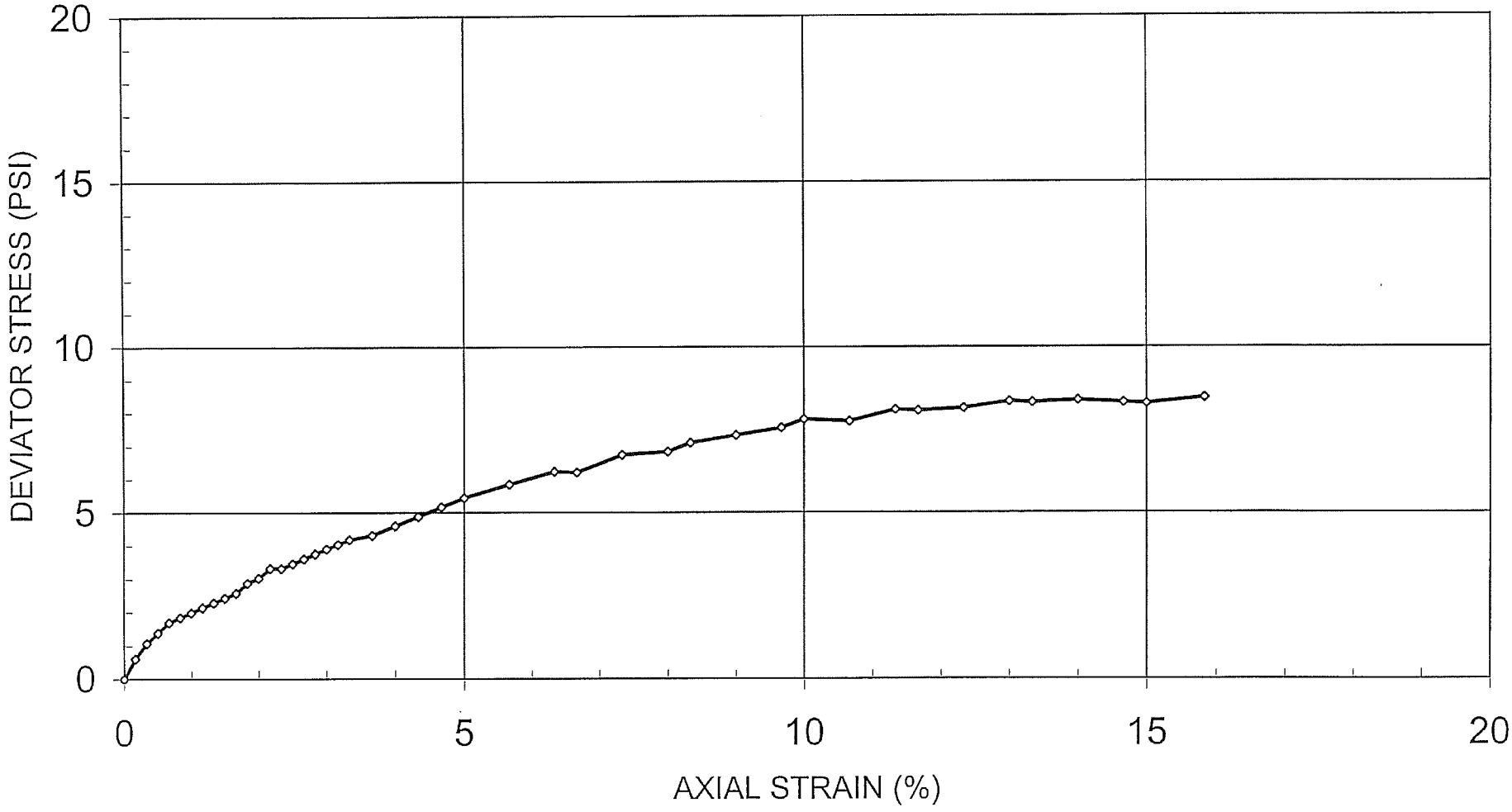
(ASTM D2850)

11/29/09

Figure

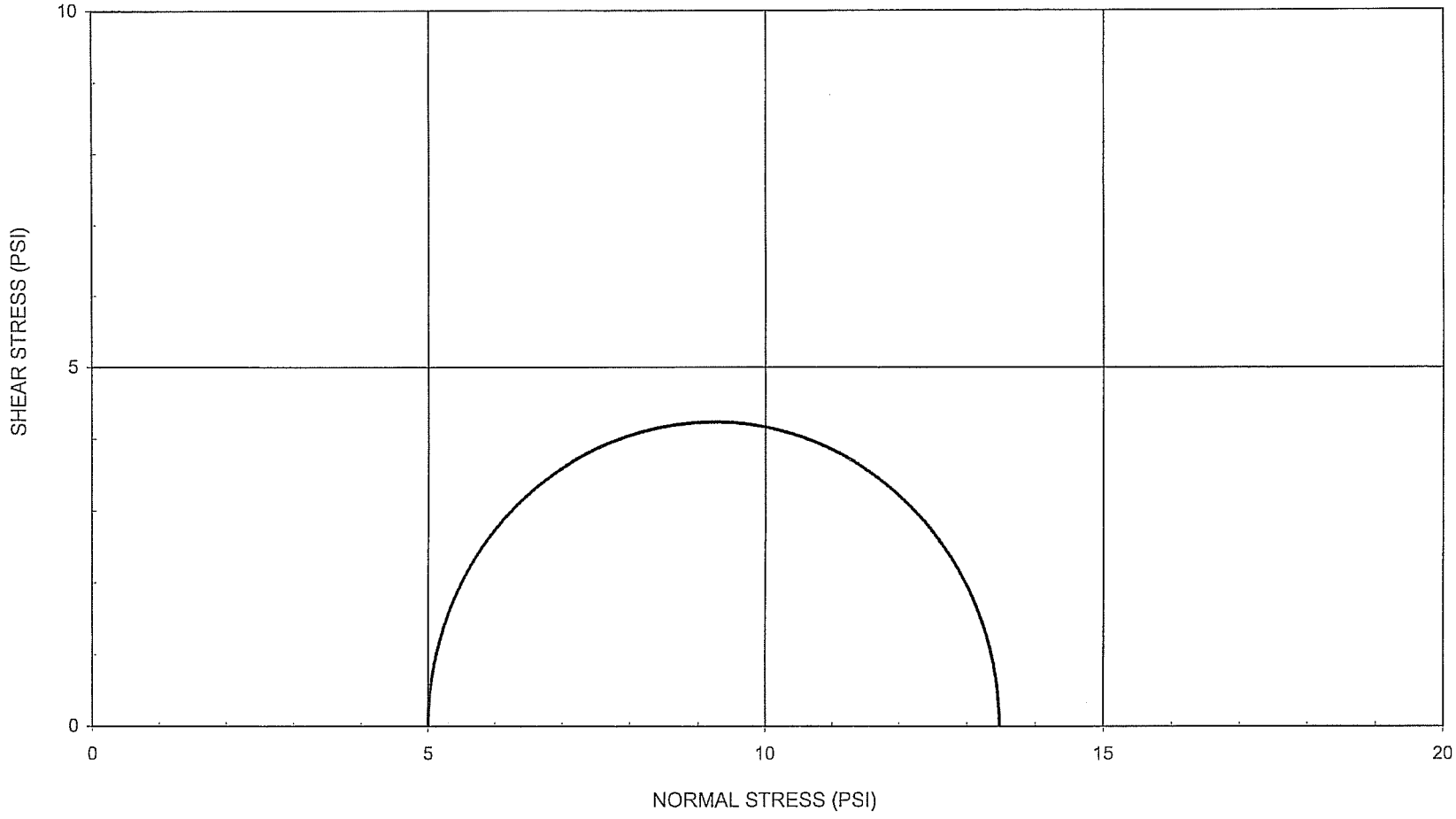
Project Name: ACTA Heim Bridge Replacement

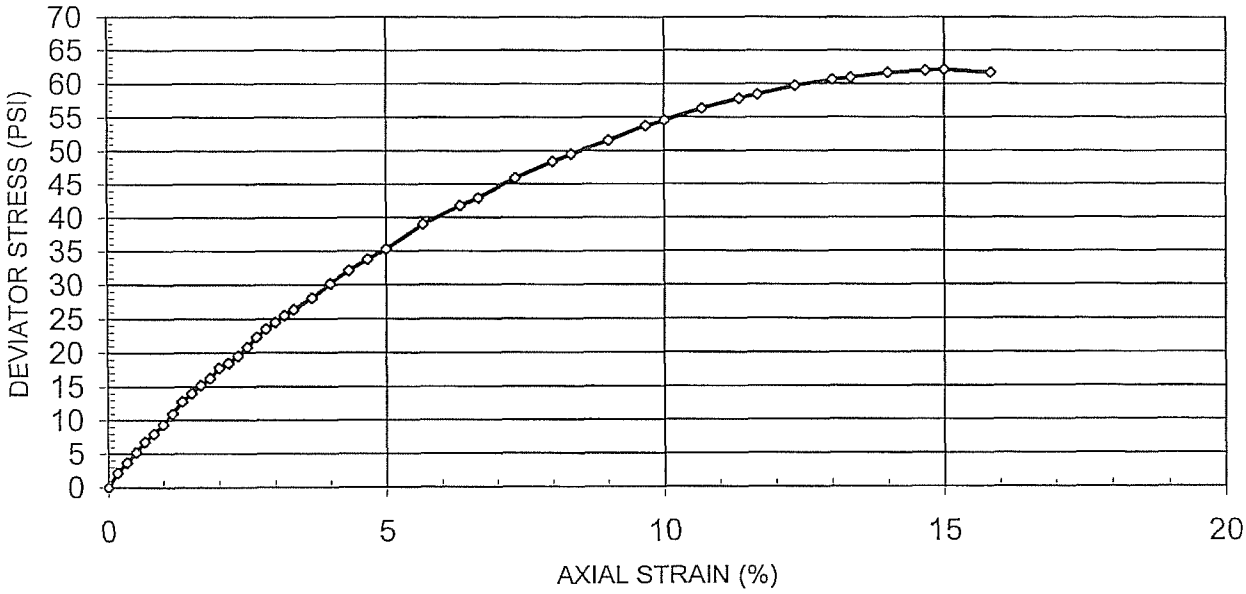
Boring: R-09-035 Sample ID: U-03 Depth (ft): 15

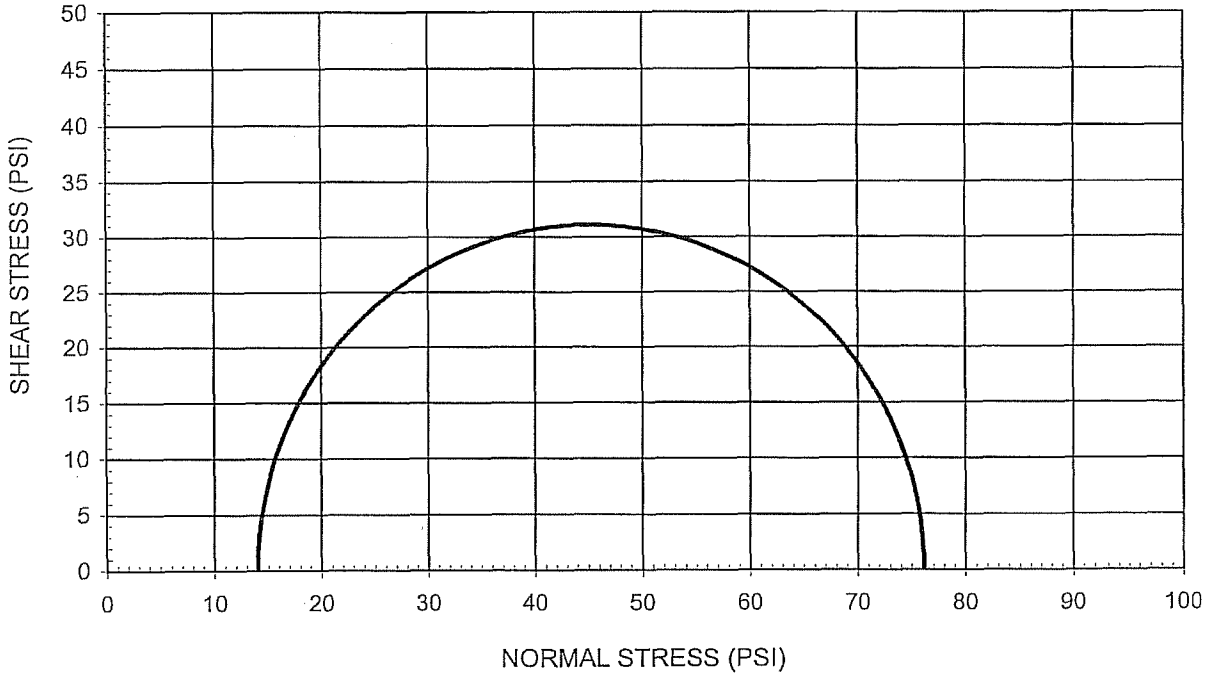


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-03 Depth (ft): 15







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	50	U-10	ML	Shelby Tube	22.25	106.6	14.0	62.1	0.06	103.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

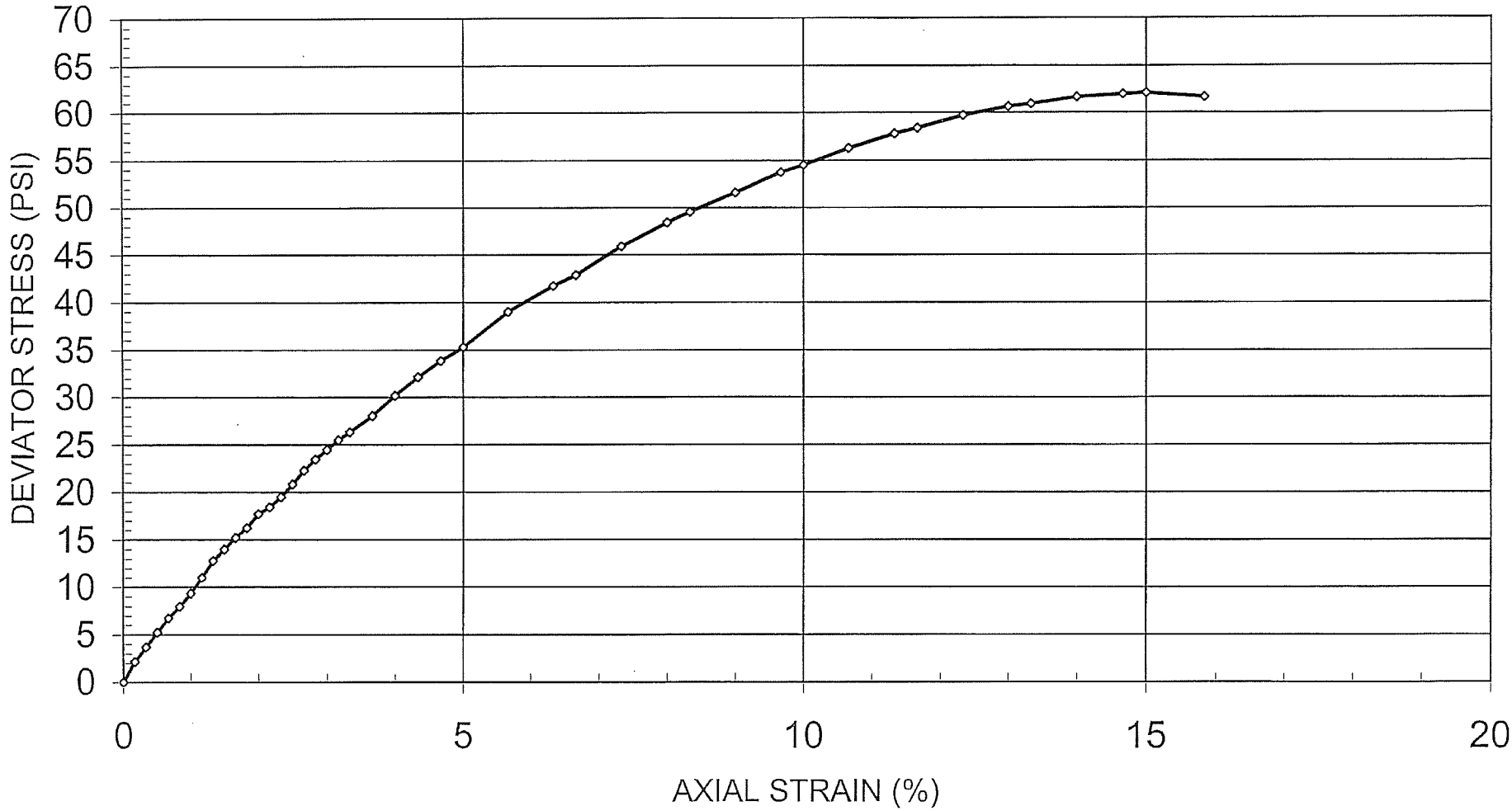
(ASTM D2850)

11/29/09

Figure

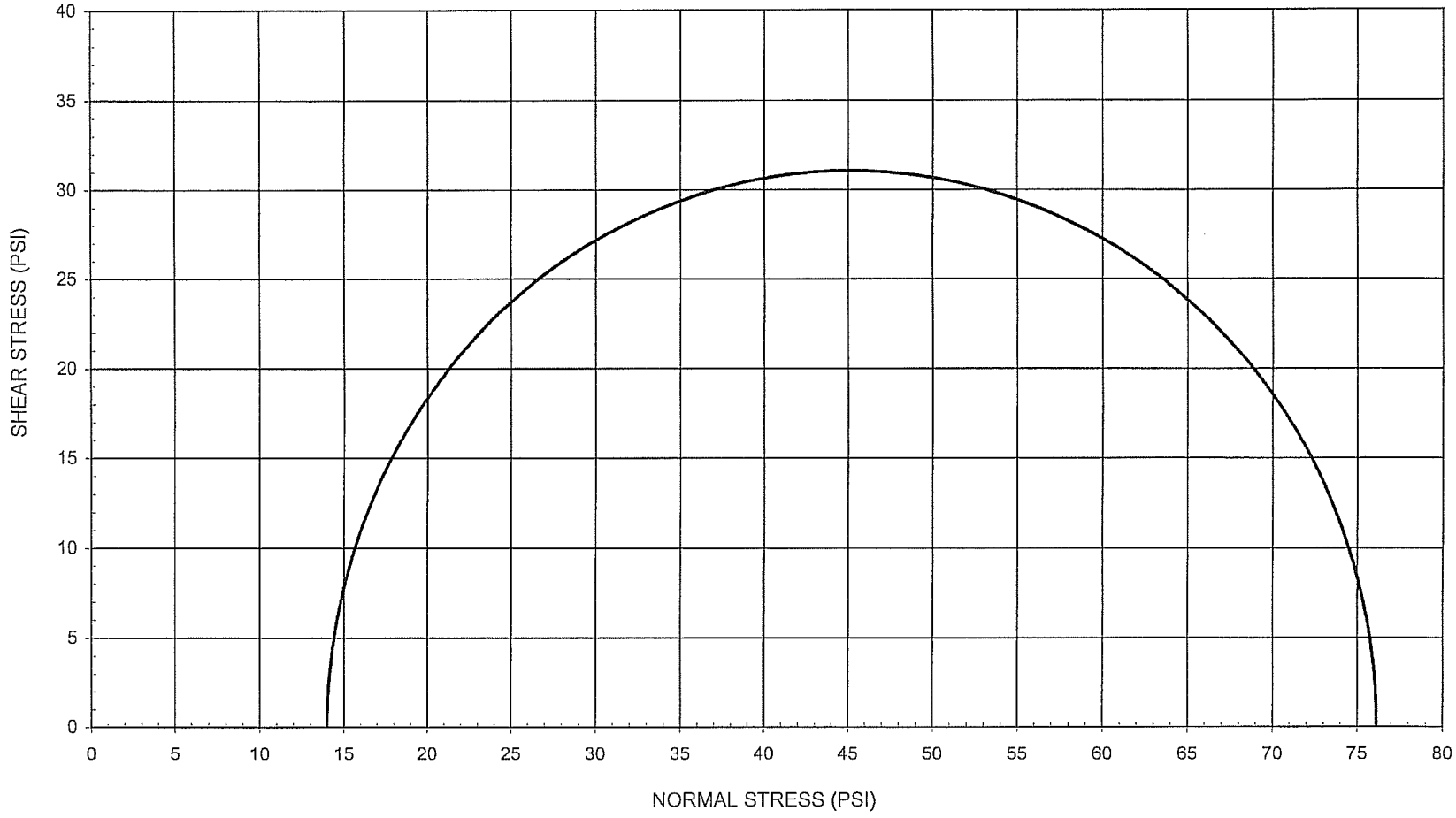
Project Name: ACTA Heim Bridge Replacement

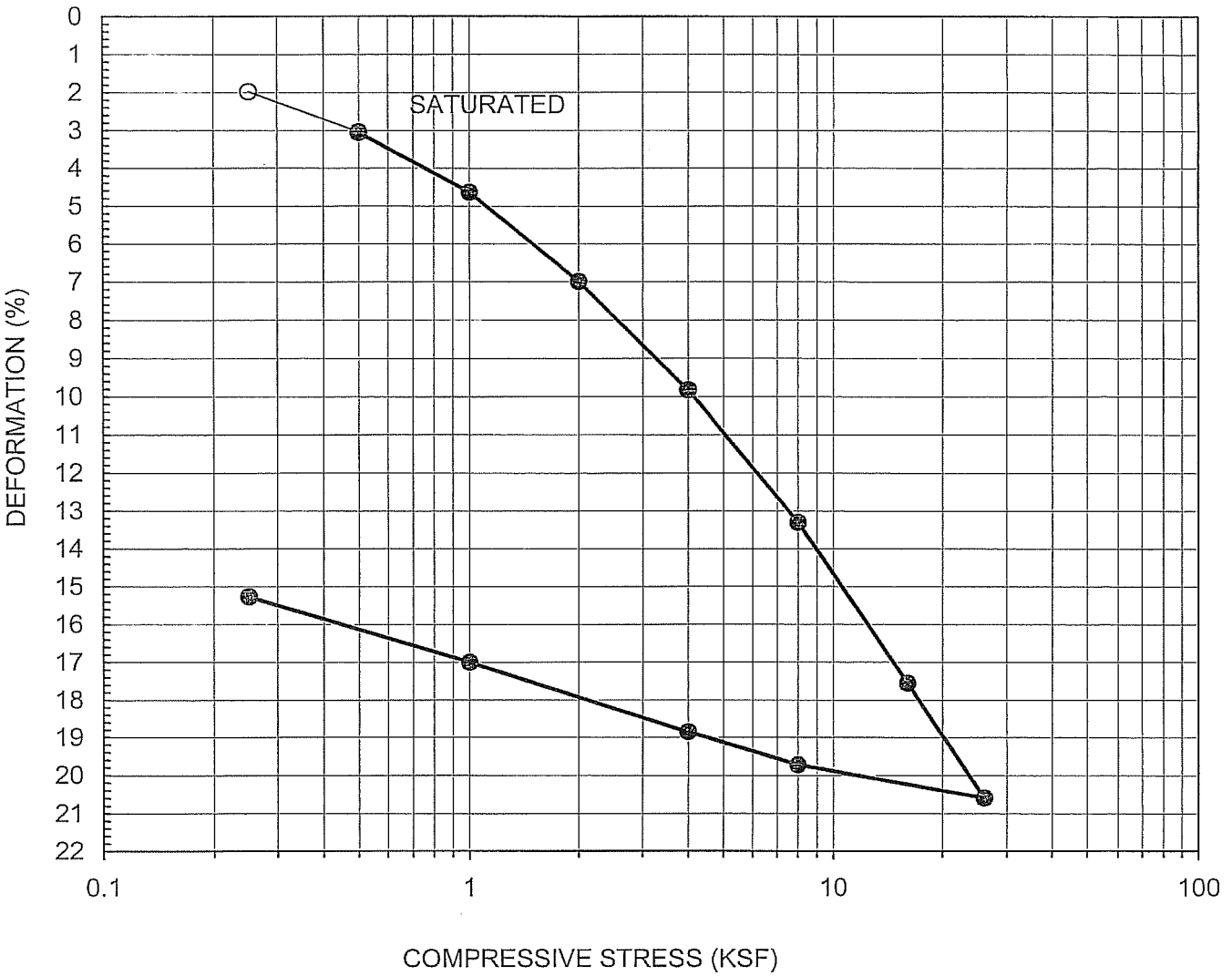
Boring: R-09-035 Sample ID: U-10 Depth (ft): 50



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-10 Depth (ft): 50





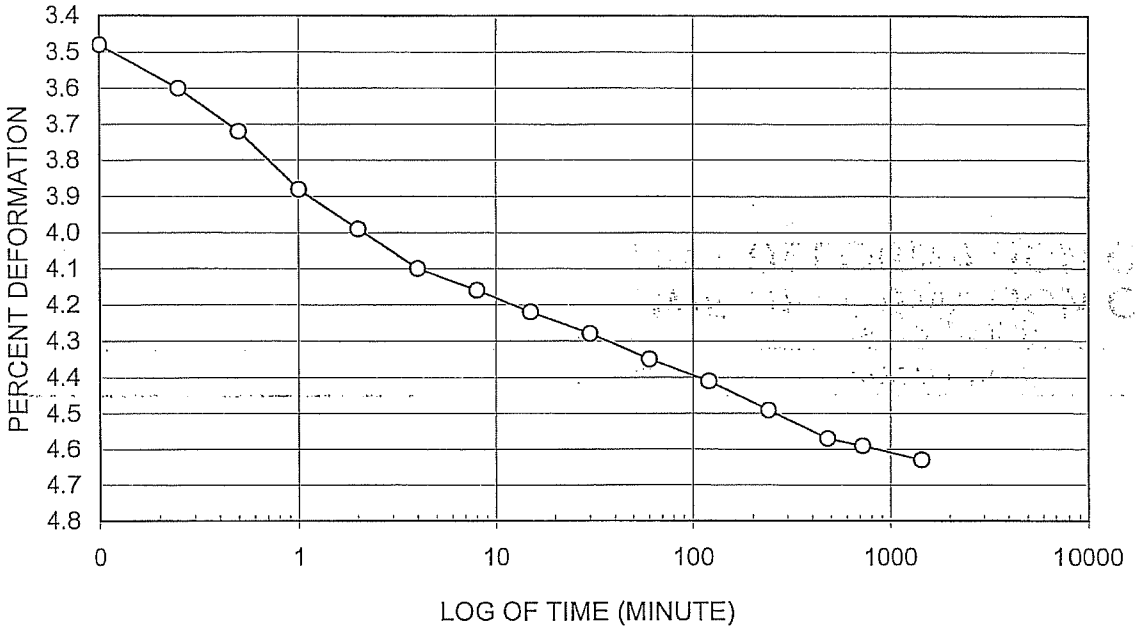
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	D-02	10.0	ML	48.0	73.9	1.279

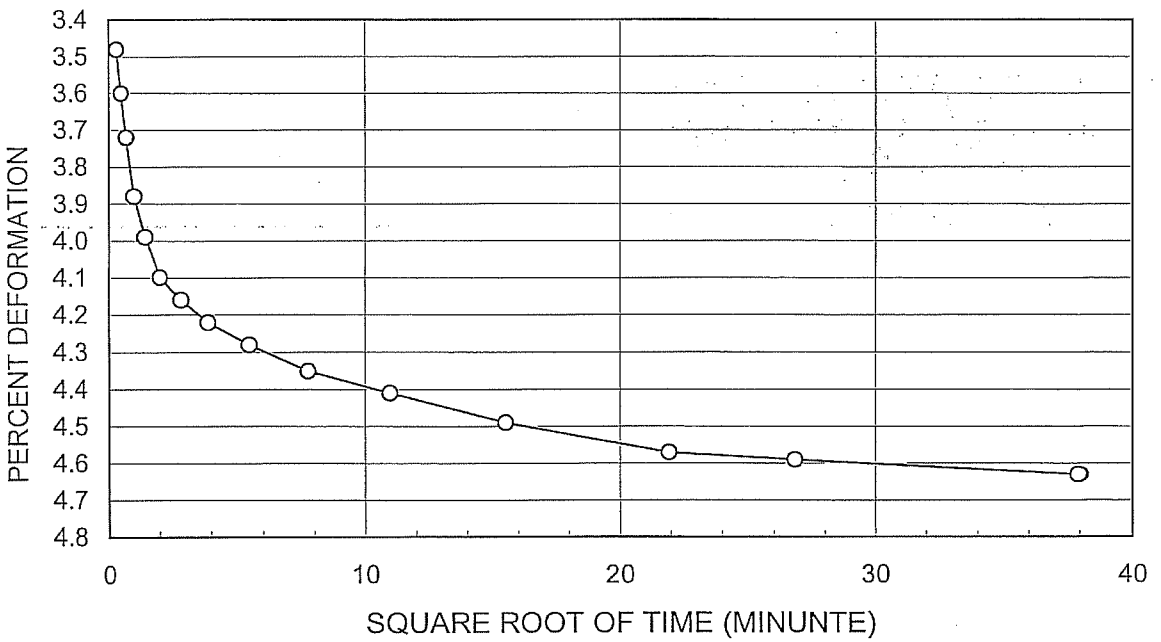
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





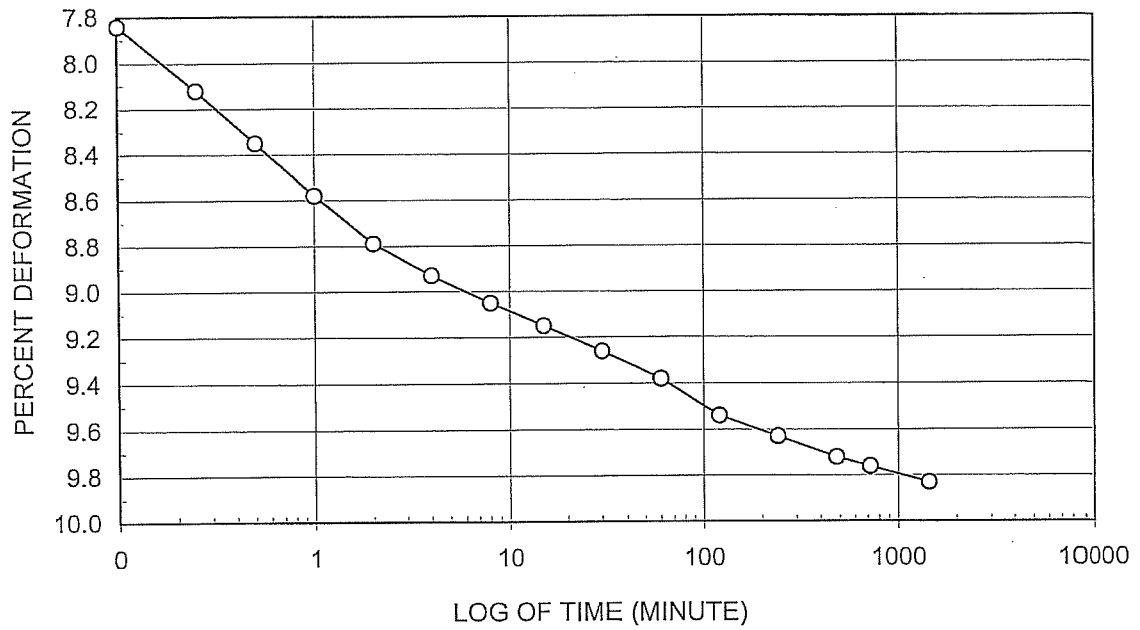
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 1.0 ksf

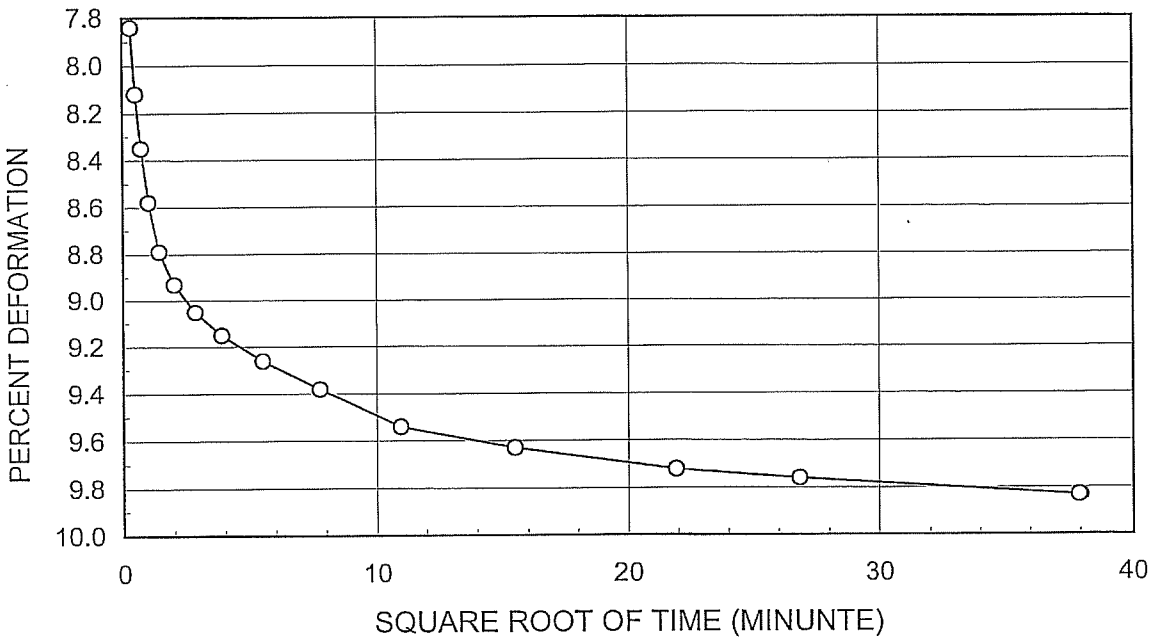
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





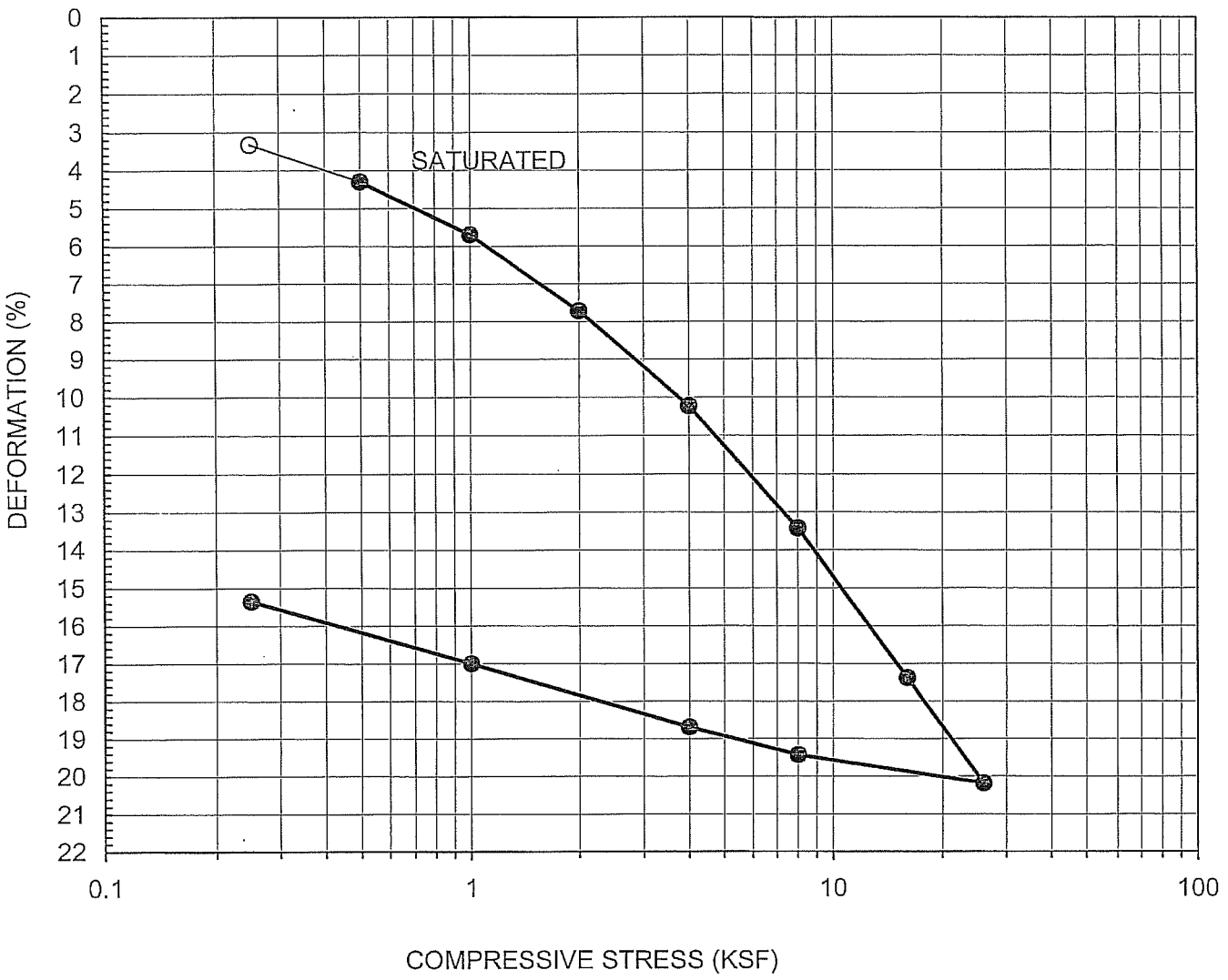
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



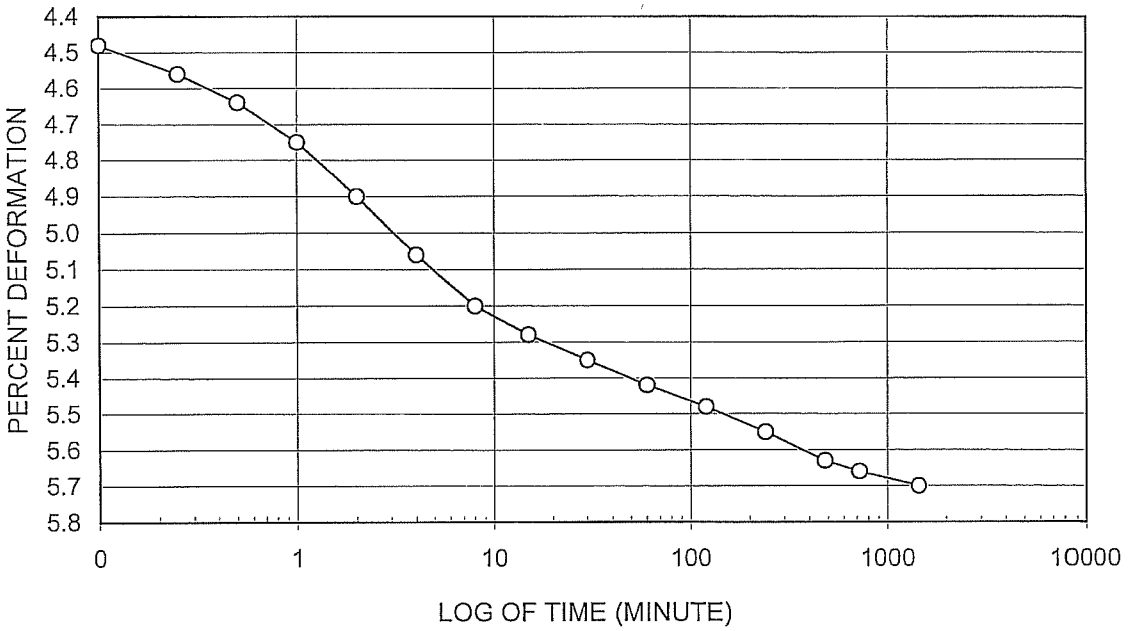
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-03	15.0	ML	40.8	78.1	1.157

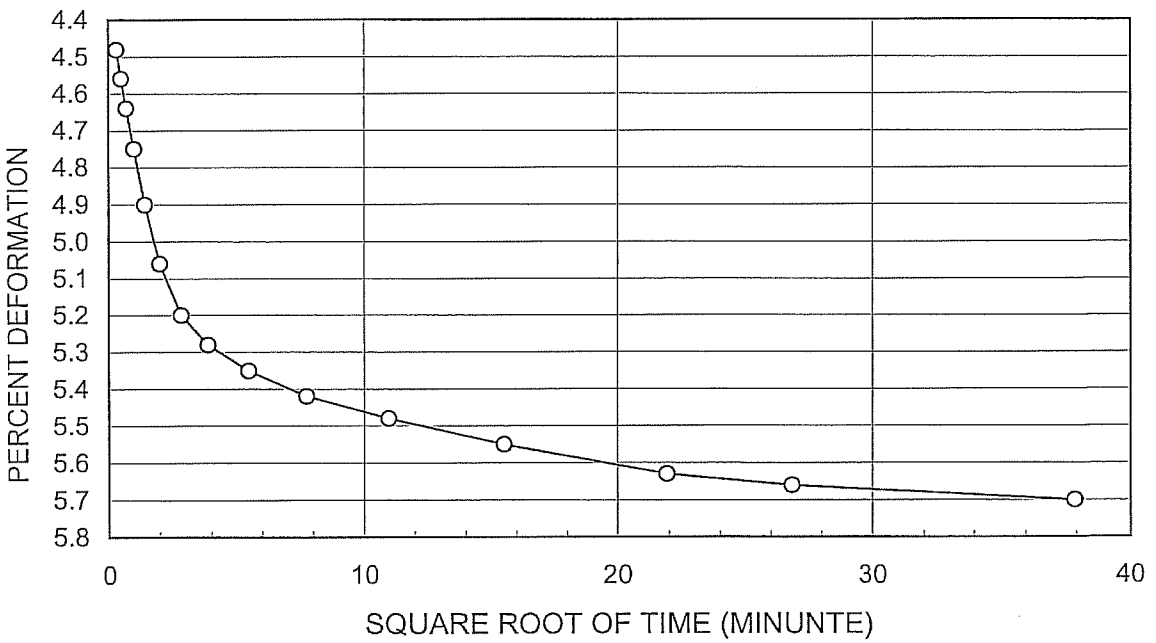
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





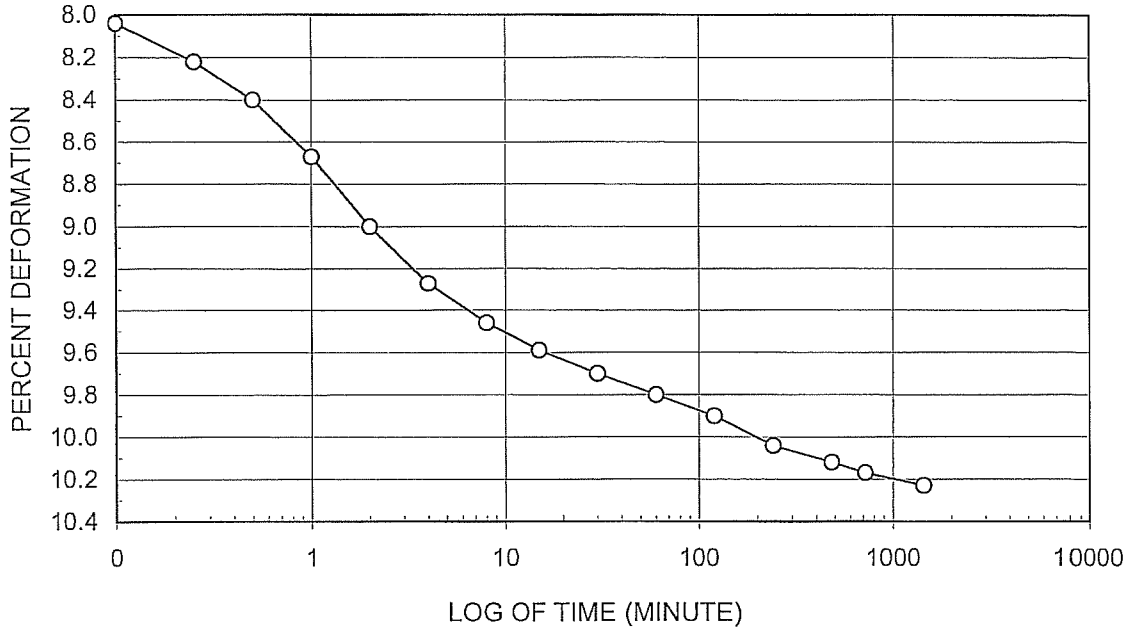
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 1.0 ksf

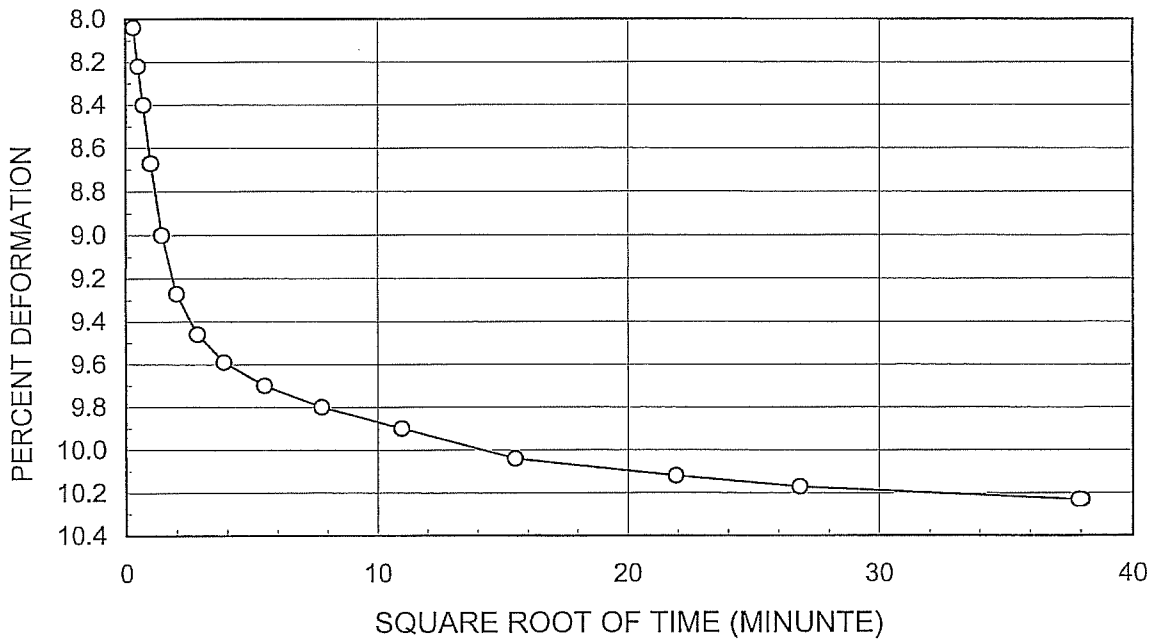
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





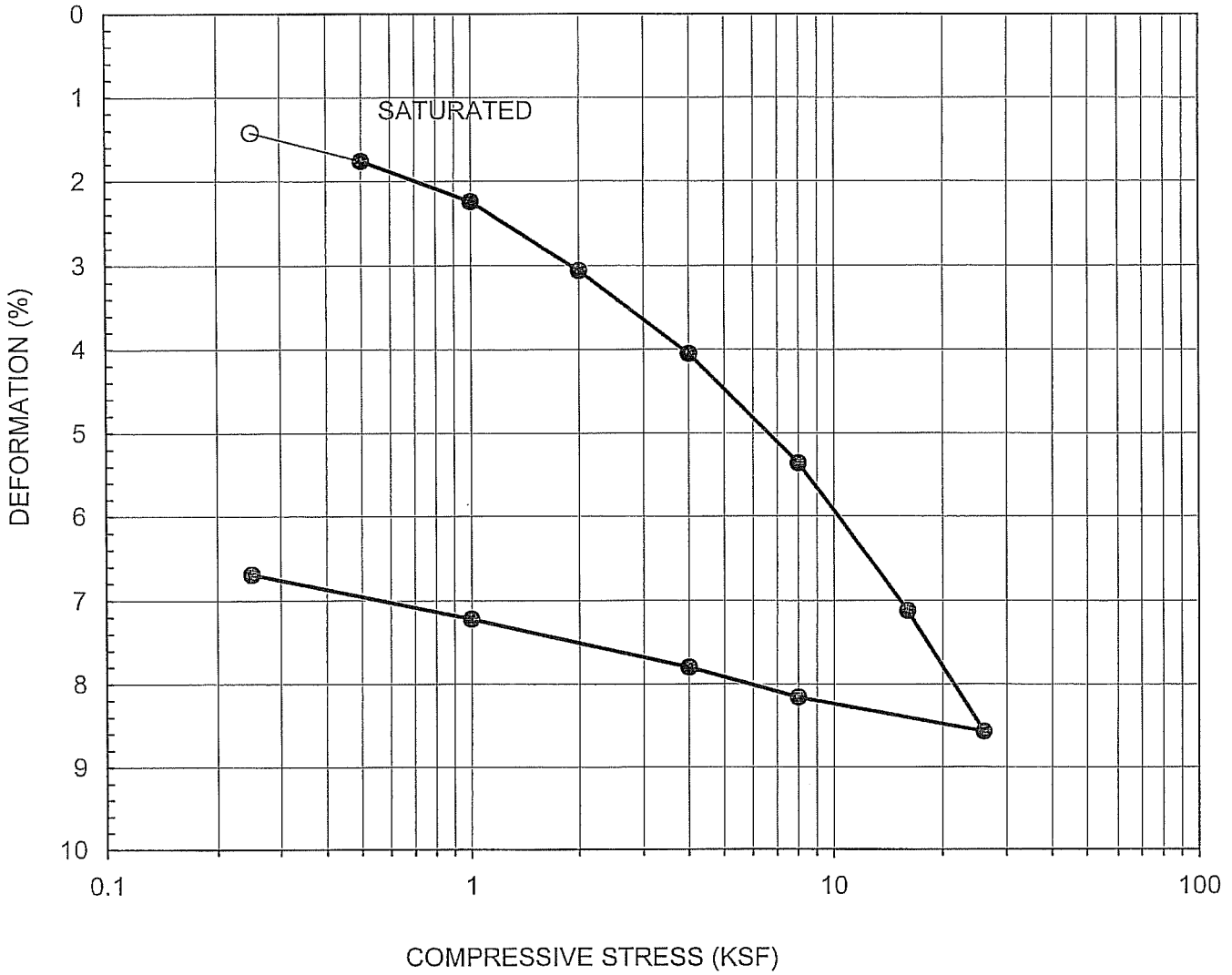
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



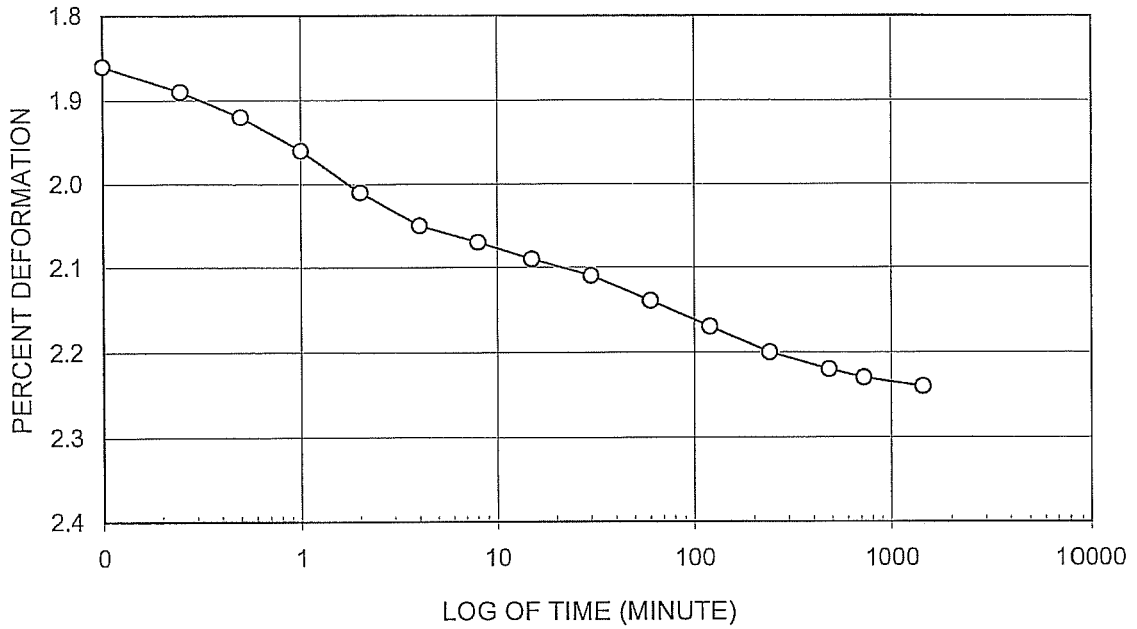
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-10	50.0	ML	21.6	109.1	0.544

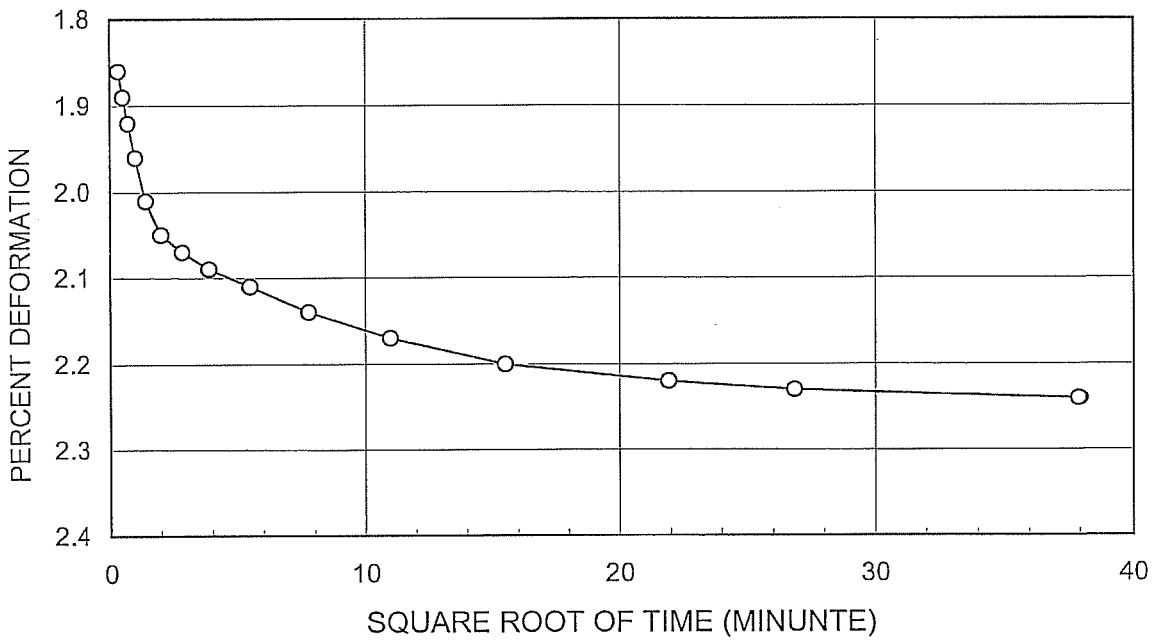
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





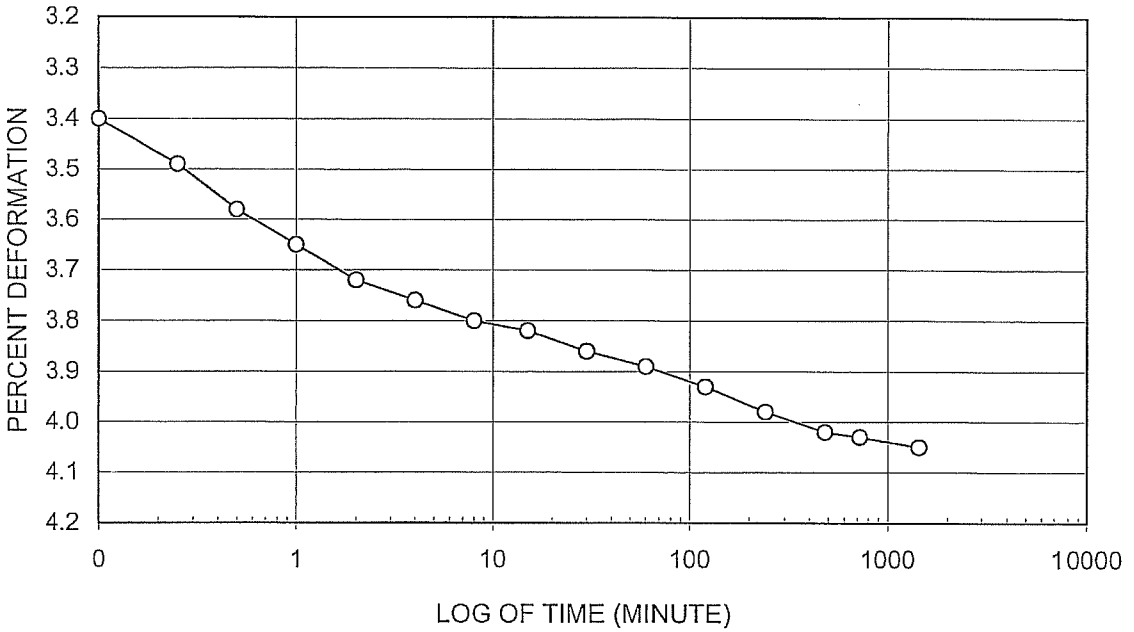
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 1.0 ksf

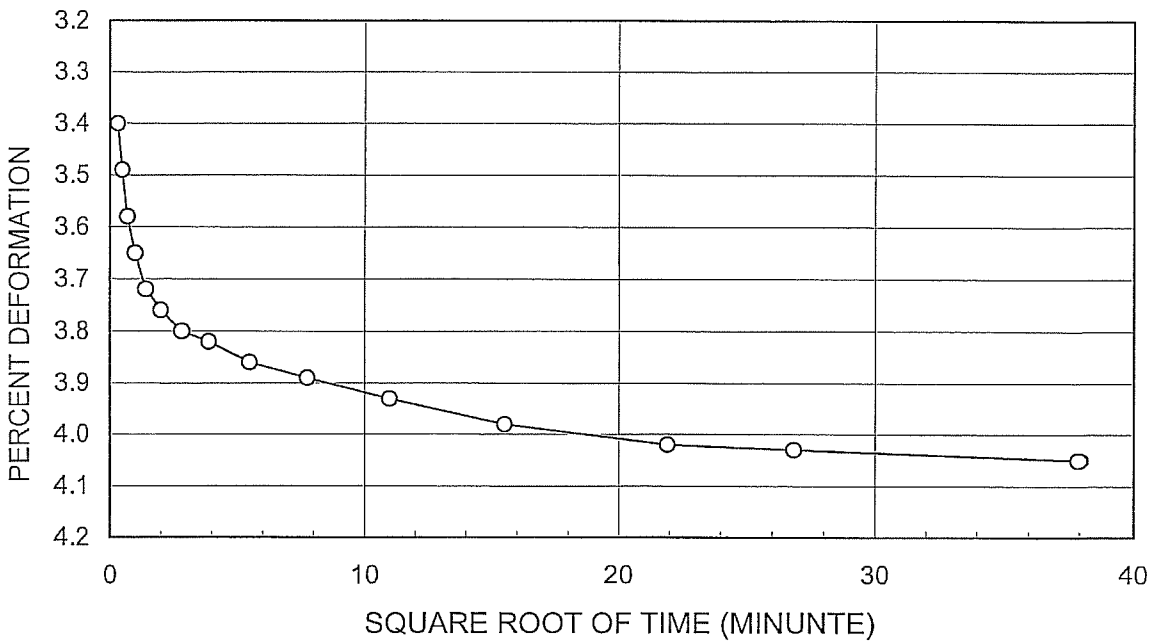
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





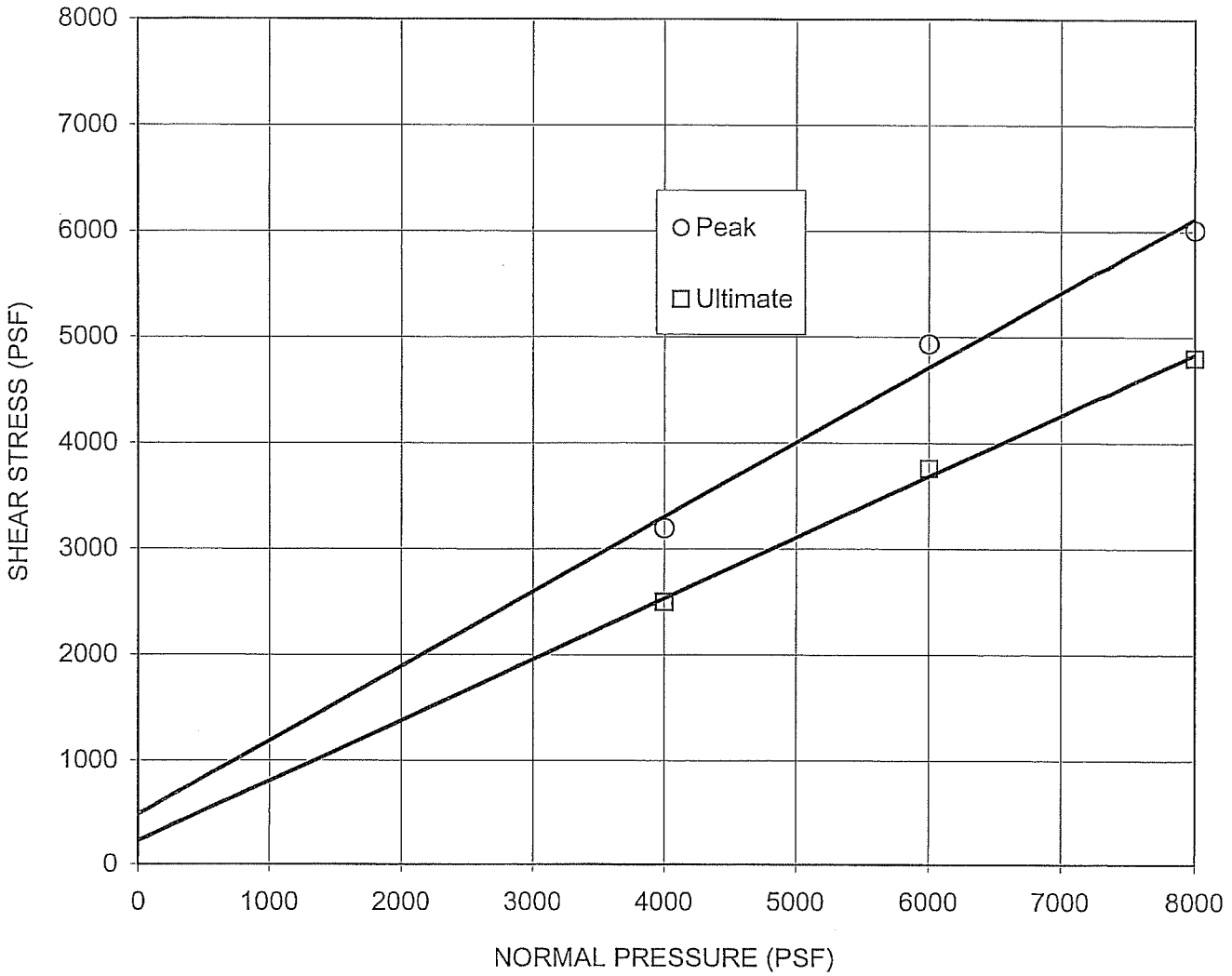
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-035	D-14	70	Ring	SM	○	484	35
					□	228	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	27.0	30.7
6000	27.0	29.3
8000	27.0	29.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/18/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-036	S-03	15	43.6	NA
R-09-036	D-06	30	32.2	91.8
R-09-036	D-08	40	32.8	89.5
R-09-036	S-09	45	38.7	NA
R-09-036	S-11	55	28.4	NA
R-09-036	D-12	60	36.7	91.0
R-09-036	S-13	65	25.2	NA
R-09-036	D-14	70	36.9	97.2
R-09-036	S-15	75	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-036	D-02	10	0.53
R-09-036	D-04	20	0.33
R-09-036	U-05	25	1.00
R-09-036	D-06	30	0.67
R-09-036	D-08	40	1.75

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/18/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-036	S-01	5	75.38
R-09-036	S-03	15	79.26
R-09-036	D-06	30	32.51
R-09-036	S-07	35	21.13
R-09-036	S-09	45	80.15
R-09-036	S-11	55	45.51
R-09-036	S-13	65	14.11

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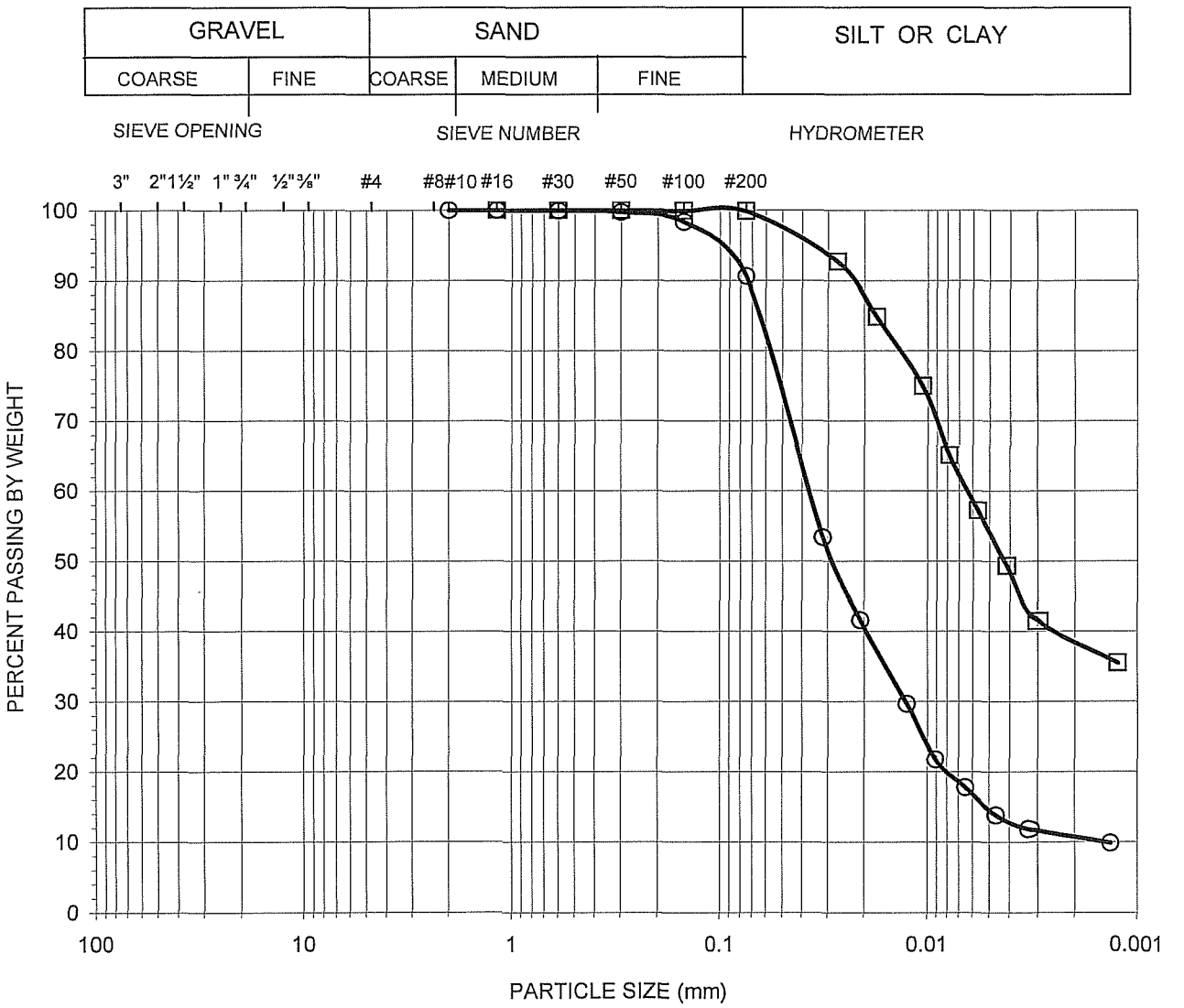
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-036	U-05	25	0.00	9.35	90.65	N/P	ML
□	R-09-036	D-10	50	0.00	0.16	99.84	56:29:27	CH

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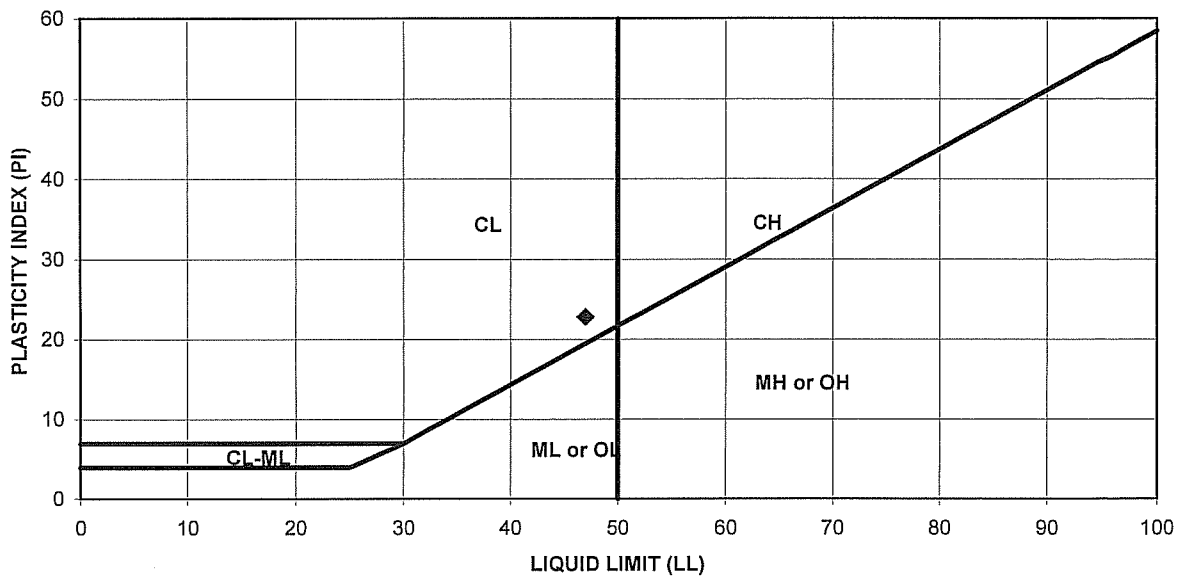
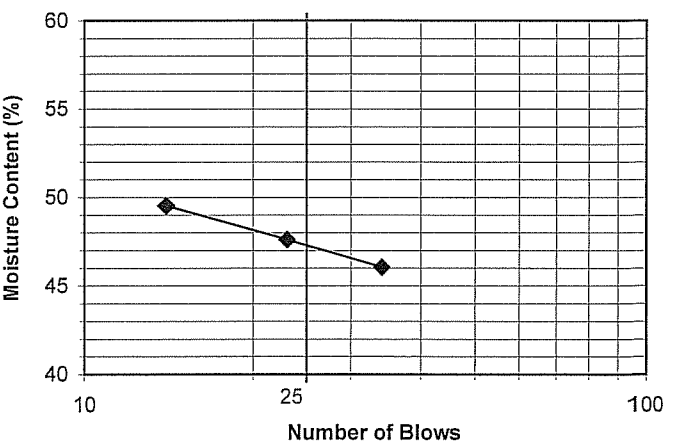
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



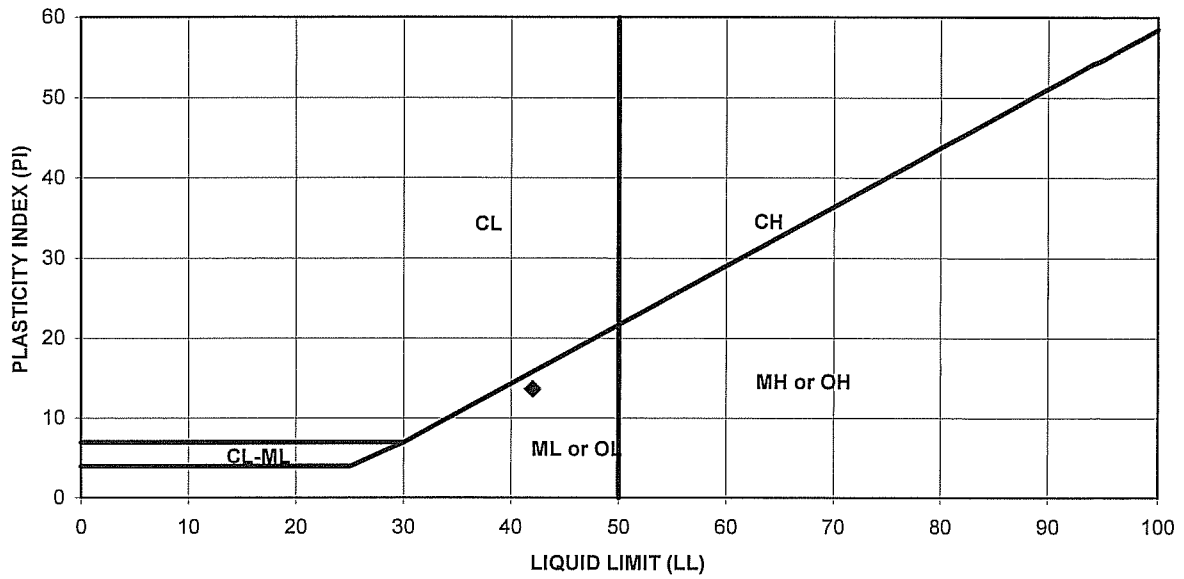
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-036	D-02	10	47	24	23	CL
	R-09-036	U-05	25	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

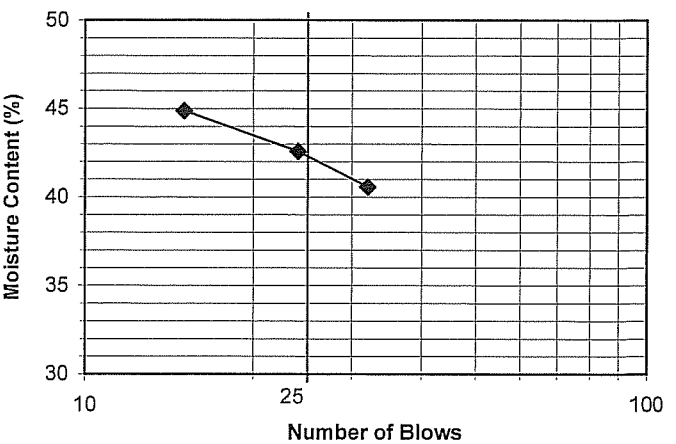
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Tested By: DK
Checked By: AP
Date: 01/06/10
Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



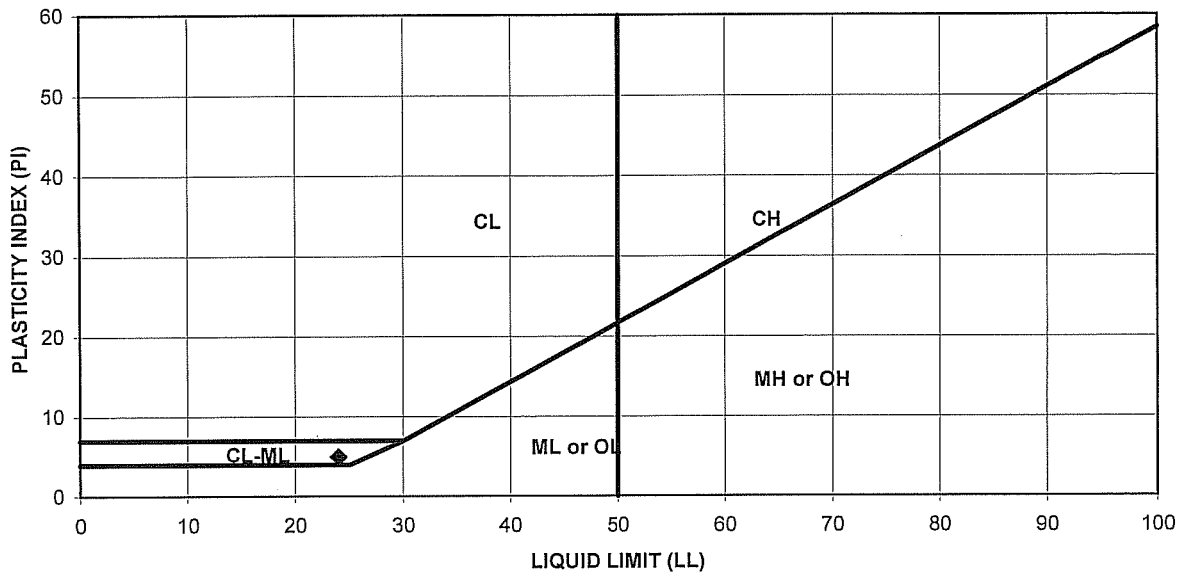
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-04	20	42	28	14	ML

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

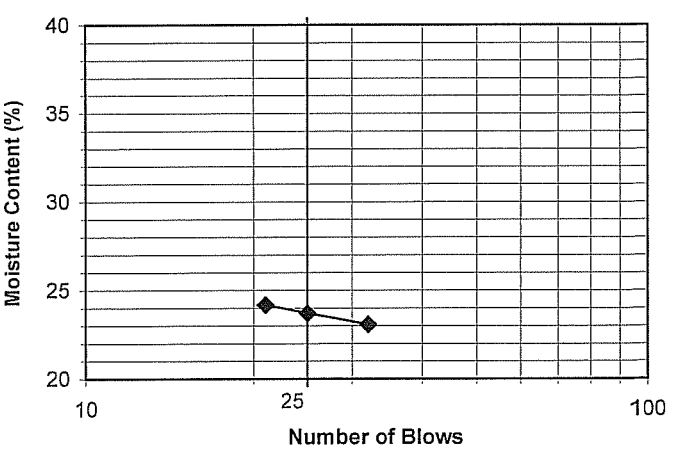
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



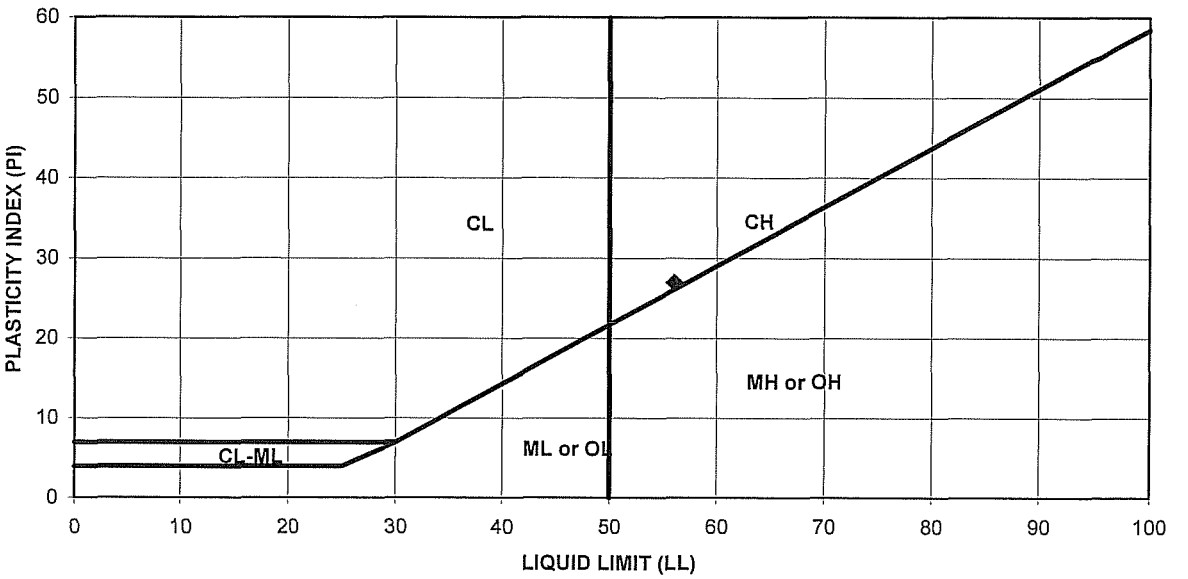
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-036	S-09	45	24	19	5	CL-ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

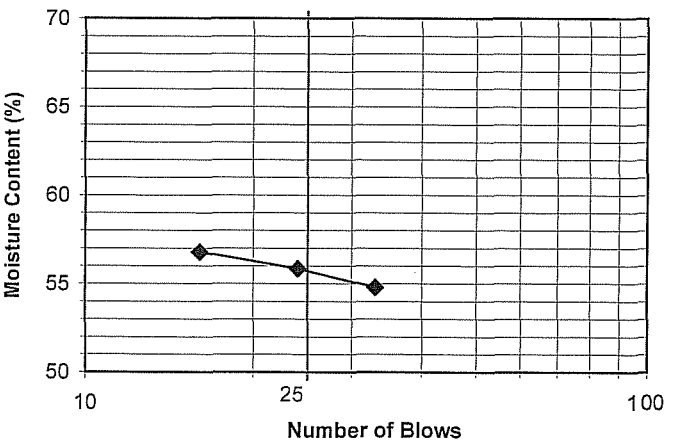
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Tested By: DK
Checked By: AP
Date: 11/24/09
Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-10	50	56	29	27	CH

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-036					
SAMPLE NUMBER	U-05					
DEPTH (FT)	25					
SOIL CLASSIFICATION	Silt					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	385.76					
TEMPERATURE, °C	19.5					
CORRECTION FACTOR	1.0001					
WT. DRY SOIL, g	37.81					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.68**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/18/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-036	S-03	15	ML	150	8.0	1187	12774
R-09-036	S-09	45	ML	190	7.7	680	9790

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

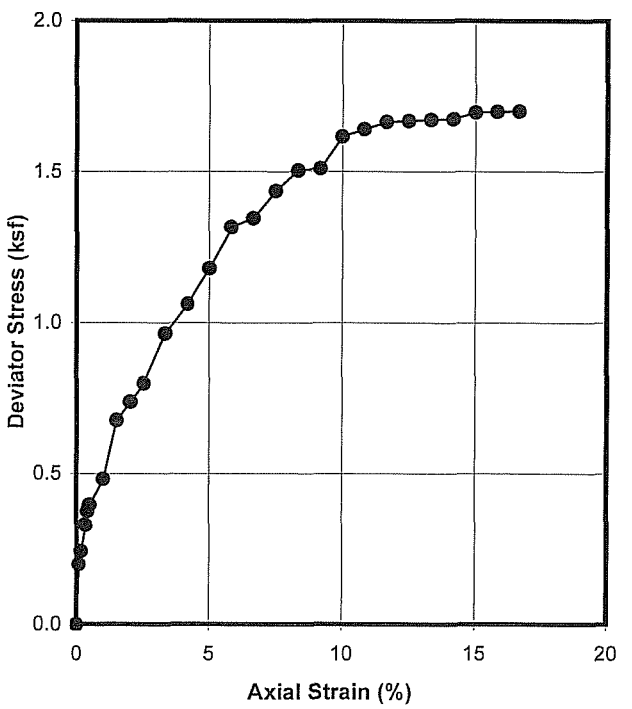
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-036		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silt w/shell	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	111.7
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	78.6
Sample Weight (gms):	1142.84	Moisture Content (%):	42.1
Wt. Wet Soil+Container(gms)	1351.61	Void Ratio for Gs=2.7:	1.14
Wt. Dry Soil+Container(gms)	1010.90	% Saturation:	99.5
Wt. Container (gms)	202.38		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.7
Ultimate Deviator Stress (ksf):	1.7
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
9	0.005	6.50	0.20	0.08
11	0.010	6.50	0.24	0.17
15	0.020	6.51	0.33	0.33
17	0.025	6.52	0.38	0.42
18	0.030	6.52	0.40	0.50
22	0.060	6.56	0.48	1.00
31	0.090	6.59	0.68	1.50
34	0.120	6.62	0.74	2.00
37	0.150	6.66	0.80	2.50
45	0.200	6.72	0.96	3.33
50	0.250	6.77	1.06	4.17
56	0.300	6.83	1.18	5.00
63	0.350	6.89	1.32	5.83
65	0.400	6.96	1.35	6.67
70	0.450	7.02	1.44	7.50
74	0.500	7.08	1.50	8.33
75	0.550	7.15	1.51	9.17
81	0.600	7.21	1.62	10.00
83	0.650	7.28	1.64	10.83
85	0.700	7.35	1.67	11.67
86	0.750	7.42	1.67	12.50
87	0.800	7.49	1.67	13.33
88	0.850	7.56	1.68	14.17
90	0.900	7.64	1.70	15.00
91	0.950	7.71	1.70	15.83
92	1.000	7.79	1.70	16.67

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : *06-123-3* **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-055	*S-1*	5	SP-SM	23.1				37:52:11						
A-09-055	*D-2*	10	0								2100	7.7	50	380
A-09-055	*S-3*	15	SP	24.3				0:99:1						
A-09-055	*D-4*	20	SP-SM	21.8	122.9									
A-09-055	*S-5*	25	SP	24.9				0:96:4						
A-09-055	*S-7-2*	35.5	CL	36.6										
A-09-055	*S-9*	45	CH	31.3				0:6:94		59/29/30				
A-09-055	*D-10*	50	CL			1.0								
A-09-055	*S-11*	55	ML	33.0				0:6:94		32/27/5				
A-09-055	*D-12*	60	ML			2.0				22/20/2				
A-09-056	*S-1*	5	SM					13:46:41			670	7.8	580	514
A-09-056	*D-2*	10	ML			<0.25				49/32/17				
A-09-056	*S-3*	15	CL	44.9				0:13:87		41/25/16				
A-09-056	*D-4*	20	SM							N.P.				
A-09-056	*S-5*	25	SP-SM	29.4				0:93:7						
A-09-058	*S-1*	5	SP					0:96:4			9300	8.6	30	248
A-09-058	*S-3*	15	CH	65.2				0:1:99		93/34/59				
A-09-058	*S-5*	25	CL	34.2				0:7:93		47/24/23				
A-09-058	*D-6*	30	ML			0.5								
A-09-058	*S-7*	35	ML	23.9						N.P.				
A-09-058	*D-8*	40	ML			1.5		0:26:74						
A-09-058	*S-9*	45	SM	29.5										
A-09-058	*D-10*	50	SC-SM					0:72:28						
A-09-059	*S-1*	5	SM					3:81:16			1300	8.1	380	542
A-09-059	*S-3*	15	MH	47.0				0:17:83		98/49/49				
A-09-059	*S-6*	30	MH	37.2				0:4:96		50/30/20				
A-09-059	*S-8*	40	SM	28.2				1:72:27		N.P.				
A-09-059	*D-9*	45	CL			0.5		0:6:94		40/24/16				
A-09-059	*S-10*	50	ML	37.3				0:31:69						

ATTERBERG LIMITS

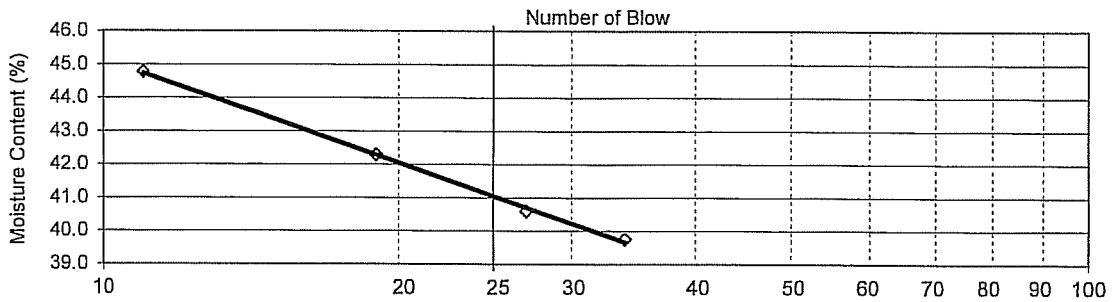
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-054	Depth (ft/m): 50 ft	15 m				1	
Sample Number: D-10	Description: ML						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air: G-2	
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		34	27	19	11		
Can Number		25	26	27	28	29	30
Wt. Wet Soil +Can (gm)		43.96	47.29	46.84	46.84	35.59	34.37
Wt. Dry Soil +Can (gm)		40.06	42.63	41.69	41.49	33.90	32.62
Weight of Can (gm)		30.25	31.15	29.51	29.54	27.50	25.97
Water Content (%)		39.8	40.6	42.3	44.8	26.4	26.3

Liquid Limit (LL, %):	41	Plastic Limit (PL, %):	26	Plastic Index (PI, %):	15

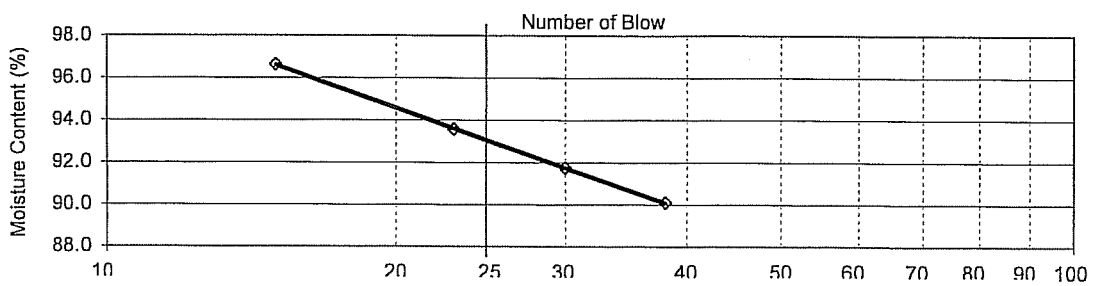


Remark:

Boring Number: A-09-058	Depth (ft/m): 15 ft	4.5 m				1	
Sample Number: S-3	Description: CH						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air: G-9	
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		38	30	23	15		
Can Number		1	2	3	4	5	6
Wt. Wet Soil +Can (gm)		38.99	36.47	37.57	38.48	31.22	34.01
Wt. Dry Soil +Can (gm)		33.08	30.47	31.31	31.62	29.44	32.38
Weight of Can (gm)		26.52	23.93	24.62	24.52	24.26	27.59
Water Content (%)		90.1	91.7	93.6	96.6	34.4	34.0

Liquid Limit (LL,%)	93	Plastic Limit PL,%)	34	Plastic Index (PI,%)	59



Remark:

ATTERBERG LIMITS

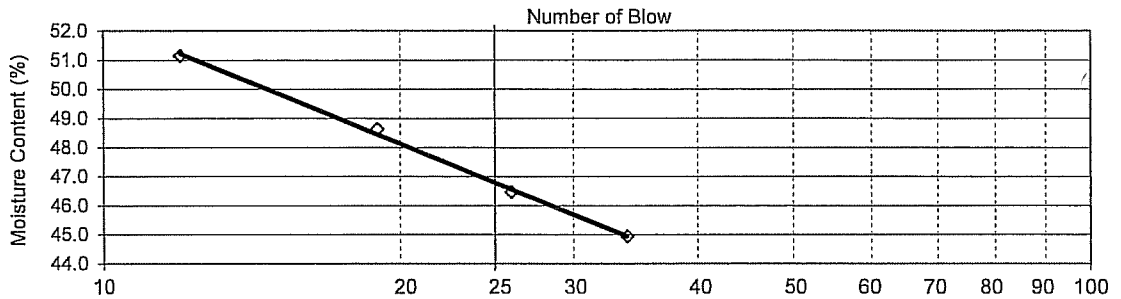
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-058	Depth (ft/m): 15 ft	4.5 m					1
Sample Number: S-5	Description: CL						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-2
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		34	26	19	12		
Can Number		13	14	15	16	17	18
Wt. Wet Soil +Can (gm)		43.50	38.34	38.46	40.16	34.03	33.30
Wt. Dry Soil +Can (gm)		38.71	33.61	33.69	34.54	32.39	31.64
Weight of Can (gm)		28.05	23.43	23.88	23.55	25.46	24.55
Water Content (%)		44.9	46.5	48.6	51.1	23.7	23.4

Liquid Limit (LL, %):	47	Plastic Limit (PL, %):	24	Plastic Index (PI, %):	23

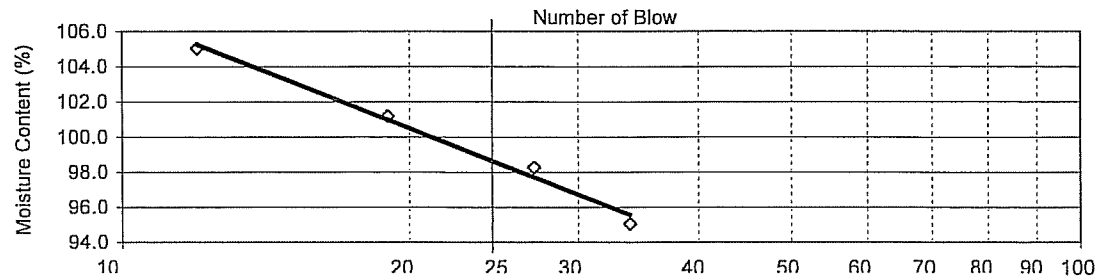


Remark:

Boring Number: A-09-059	Depth (ft/m): 15 ft	4.5 m					1
Sample Number: S-3	Description: MH						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-9
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		34	27	19	12		
Can Number		1	2	3	4	5	6
Wt. Wet Soil +Can (gm)		42.27	39.83	40.01	39.22	32.25	34.79
Wt. Dry Soil +Can (gm)		34.60	31.95	32.27	31.69	29.61	32.42
Weight of Can (gm)		26.53	23.93	24.62	24.52	24.26	27.59
Water Content (%)		95.0	98.3	101.2	105.0	49.3	49.1

Liquid Limit (LL,%)	98	Plastic Limit PL,%)	49	Plastic Index (PI,%)	49



Remark:

ATTERBERG LIMITS

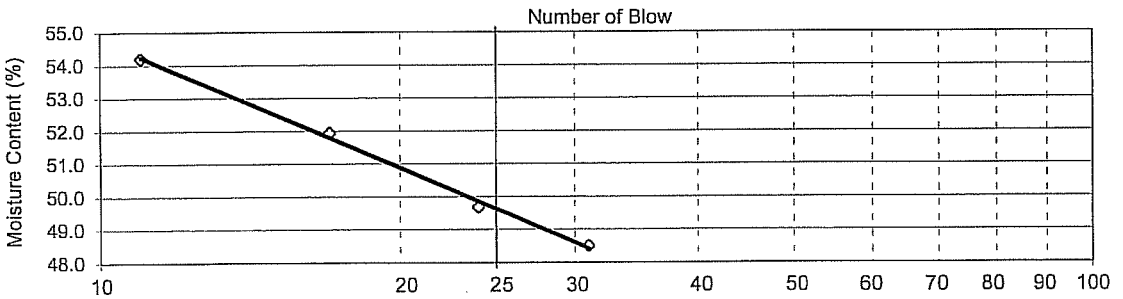
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-059	Depth (ft/m): 30 ft	9 m		1
Sample Number: S-6	Description: MH			
Prepared By: PA	Date:	Checked By: R.J.	Date:	
Pulverized By: PA	Date:		Container Number	
Tested By: PA	Date:		Air: G-2	
Computed By: JF	Date:		Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		31	24	17	11		
Can Number		13	14	15	16	17	18
Wt. Wet Soil +Can (gm)		43.42	39.58	39.94	40.82	34.89	33.98
Wt. Dry Soil +Can (gm)		38.40	34.22	34.45	34.75	32.71	31.81
Weight of Can (gm)		28.05	23.43	23.88	23.55	25.46	24.55
Water Content (%)		48.5	49.7	51.9	54.2	30.1	29.9

Liquid Limit (LL, %):	50	Plastic Limit (PL, %):	30	Plastic Index (PI, %):	20

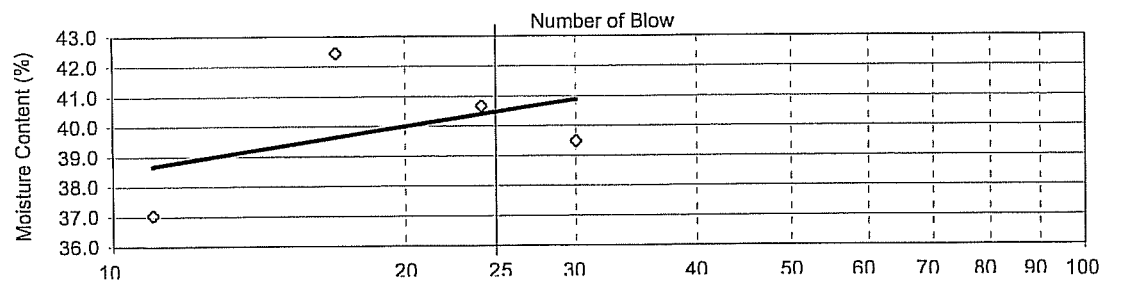


Remark:

Boring Number: A-09-059	Depth (ft/m): 45 ft	13.5 m		1
Sample Number: D-9	Description: CL			
Prepared By: PA	Date:	Checked By: R.J.	Date:	
Pulverized By: PA	Date:		Container Number	
Tested By: PA	Date:		Air: G-9	
Computed By: JF	Date:		Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		30	24	17	11		
Can Number		25	26	27	28	29	30
Wt. Wet Soil +Can (gm)		46.96	49.31	46.36	47.78	37.38	35.36
Wt. Dry Soil +Can (gm)		42.23	44.06	41.34	42.85	35.44	33.52
Weight of Can (gm)		30.25	31.15	29.51	29.54	27.50	25.97
Water Content (%)		39.5	40.7	42.4	37.0	24.4	24.4

Liquid Limit (LL,%)	40	Plastic Limit PL,%)	24	Plastic Index (PI,%)	16



Remark:

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-056		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 5.0		**Tested By :** PA	**Date :**	**13**	**46**	**41**	3/8"
Depth (m)	: 1.53		**Checked By :**	**Date :**				
Description	: Olive, SILTY SAND (SM)				**Sample**		**Retained On**	
X	**Method (A)** - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-5	S-5	S-5	S-5
Wet Weight of Soil + Container (gm)					308.92	308.92		
Dry Weight of Soil + Container (gm)						282.16	214.06	
Weight of Container (gm)					117.80	117.8	117.8	
Weight of Dry Soil (gm)					164.36	164.36	96.26	22.15
Moisture Content (%)						16.28		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							41.43	13.48
Remark :								1

Boring No.	: A-09-056		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-5		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 25.0		**Tested By :** PA	**Date :**	**0**	**93**	**7**	#30
Depth (m)	:		**Checked By :**	**Date :**				
Description	: Olive-gray, Poorly graded SAND with SILT (SP-SM)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-6	S-6	S-6	S-6
Wet Weight of Soil + Container (gm)					365.39	365.39		
Dry Weight of Soil + Container (gm)						308.86	295.04	
Weight of Container (gm)					116.77	116.77	116.77	
Weight of Dry Soil (gm)					192.09	192.09	178.27	0.00
Moisture Content (%)						29.43		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							7.19	0.00
Remark :								2

Boring No.	: A-09-058		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 25.0		**Tested By :** PA	**Date :**	**0**	**96**	**4**	#10
Depth (m)	: 7.63		**Checked By :**	**Date :**				
Description	: Olive-gray, Poorly graded SAND (SP)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-8	S-8	S-8	S-8
Wet Weight of Soil + Container (gm)					358.92	358.92		
Dry Weight of Soil + Container (gm)						351.07	341.94	
Weight of Container (gm)					118.29	118.29	118.29	
Weight of Dry Soil (gm)					232.78	232.78	223.65	0.00
Moisture Content (%)						3.37		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							3.92	0.00
Remark :								3

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-058		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: D-8		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 40.0		**Tested By :** PA	**Date :**	**0**	**26**	**74**	#40
Depth (m)	: 12.20		**Checked By :**	**Date :**				
Description	: Dark olive-gray, SILT with SAND (ML)				**Sample**		**Retained On**	
X	**Method (A)** - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-22	S-22	S-22	S-22
Wet Weight of Soil + Container (gm)					261.42	261.42		
Dry Weight of Soil + Container (gm)						226.09	143.5	
Weight of Container (gm)					115.19	115.19	115.19	
Weight of Dry Soil (gm)					110.9	110.9	28.31	0.00
Moisture Content (%)						31.86		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							74.47	0.00
Remark :								1

Boring No.	: A-09-059		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 5.0		**Tested By :** PA	**Date :**	**3**	**81**	**16**	1/2"
Depth (m)	:		**Checked By :**	**Date :**				
Description	: Olive-brown, SILTY SAND (SM)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-23	S-23	S-23	S-23
Wet Weight of Soil + Container (gm)					331.49	331.49		
Dry Weight of Soil + Container (gm)						322.28	289.74	
Weight of Container (gm)					113.82	113.82	113.82	
Weight of Dry Soil (gm)					208.46	208.46	175.92	5.25
Moisture Content (%)						4.42		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							15.61	2.52
Remark :								2

Boring No.	: A-058		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: D-10		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 50.0		**Tested By :** PA	**Date :**	**0**	**72**	**28**	#40
Depth (m)	: 15.25		**Checked By :**	**Date :**				
Description	: Dark gray, SILTY CLAYEY SAND (SC-SM)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-13	S-13	S-13	S-13
Wet Weight of Soil + Container (gm)					264.26	264.26		
Dry Weight of Soil + Container (gm)						233.18	199.92	
Weight of Container (gm)					113.62	113.62	113.62	
Weight of Dry Soil (gm)					119.56	119.56	86.3	0.00
Moisture Content (%)						26.00		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							27.82	0.00
Remark :								3

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-059		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-10		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 50.0		**Tested By :** PA	**Date :**	**0**	**31**	**69**	#40
Depth (m)	: 15.25		**Checked By :**	**Date :**				
Description	: Dark olive-gray, SANDY lean CLAY (CL)				**Sample**		**Retained On**	
X	**Method (A)** - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-24	S-24	S-24	S-24
Wet Weight of Soil + Container (gm)					348.65	348.65		
Dry Weight of Soil + Container (gm)						284.67	165.52	
Weight of Container (gm)					113.10	113.1	113.1	
Weight of Dry Soil (gm)					171.57	171.57	52.42	0.00
Moisture Content (%)						37.29		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							69.45	0.00
Remark :								1

Boring No.	: A-09-059		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: D-9		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 45.0		**Tested By :** PA	**Date :**	**0**	**6**	**94**	1/2"
Depth (m)	:		**Checked By :**	**Date :**				
Description	: Dark gray, SILT (ML)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-16	S-16	S-16	S-16
Wet Weight of Soil + Container (gm)					258.23	258.23		
Dry Weight of Soil + Container (gm)						221.97	120.2	
Weight of Container (gm)					114.22	114.22	114.22	
Weight of Dry Soil (gm)					107.75	107.75	5.98	0.00
Moisture Content (%)						33.65		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							94.45	0.00
Remark :								2

Boring No.	:		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	:		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	:		**Tested By :** PA	**Date :**				#40
Depth (m)	:		**Checked By :**	**Date :**				
Description	:				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number								
Wet Weight of Soil + Container (gm)								
Dry Weight of Soil + Container (gm)								
Weight of Container (gm)								
Weight of Dry Soil (gm)								
Moisture Content (%)								
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve								
Remark :								3

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-058	Prepared By : PA	Date :
Sample No.	: S-3	Tested By : PA	Date :
Depth below Deck	: 15.0	Sieved By : RJ	Date :
Description	: darkolive-gray, Fat CLAY (CH)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

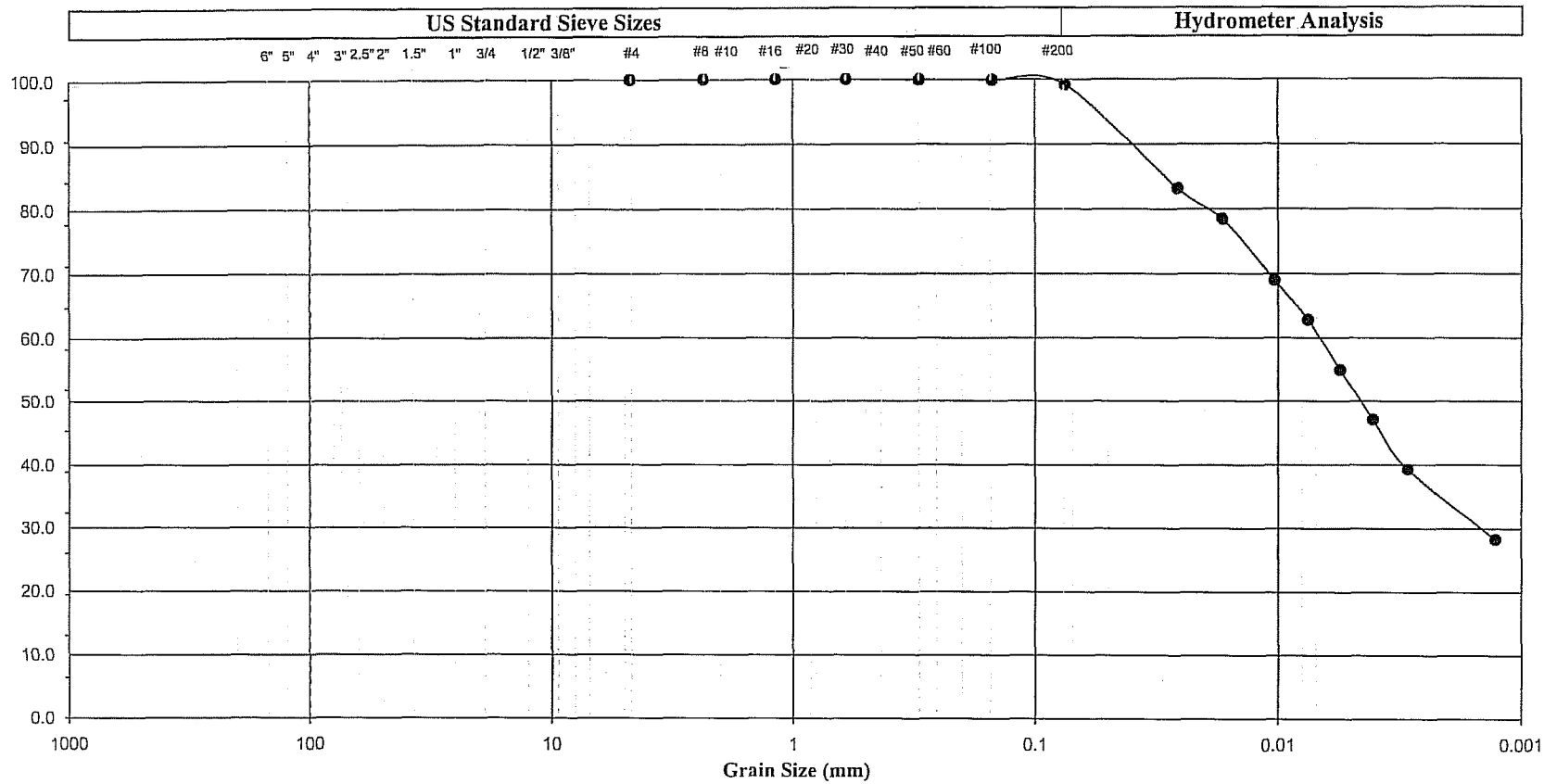
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-17	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	8	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-26		S-17	74		S-29		
Wt. of Wet Soil + Container (gm)		197.22		64.20	123.39			0.99	
Wt. of Dry Soil + Container (gm)					122.31		112.98	Hydrometer Type	
Wt. of Container (gm)					59.31		112.39	152H	
Wt. of Dry Soil (gm)		193.90		63.12			0.59	(K) Value	Temp. °C
Moisture Content (%)					1.71			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				93	No. 16	0.00		100.00	100.00
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.00		100.00	100.00
1.0"					No. 40				
3/4"				34	No. 50	0.05		99.92	99.92
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.10		99.84	99.84
No. 4	0.00		100.00		No. 140				
No. 8	0.00		100.00	59	No. 200	0.56		99.11	99.11
No. 10					Pan	0.61			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
13:34	0:00:00			6.0							
	2	21.0	59.0	6.0	53.0	83.13	83.13	0.05500	0.01328	7.6	0.02590
	5	21.0	56.0	6.0	50.0	78.42	78.42	0.03500	0.01328	8.1	0.01690
	15	21.0	50.0	6.0	44.0	69.01	69.01	0.02000	0.01328	9.1	0.01033
	30	21.0	46.0	6.0	40.0	62.74	62.74	0.01400	0.01328	9.7	0.00757
	60	21.0	41.0	6.0	35.0	54.90	54.90	0.01000	0.01328	10.6	0.00557
	120	21.5	36.0	6.0	30.0	47.05	47.05	0.00700	0.01328	11.4	0.00409
	240	22.0	31.0	6.0	25.0	39.21	39.21	0.00500	0.01328	12.2	0.00293
	1440	21.5	24.0	6.0	18.0	28.23	28.23	0.00100	0.01328	13.3	0.00128

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	0	1	99



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-058	S-3	15.0	dark olive-gray	Fat clay	CH
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-058	Prepared By : PA	Date :
Sample No.	: S-5	Tested By : PA	Date :
Depth below Deck	: 25.0	Sieved By : RJ	Date :
Description	: dark olive-gray, Lean CLAY (CL)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

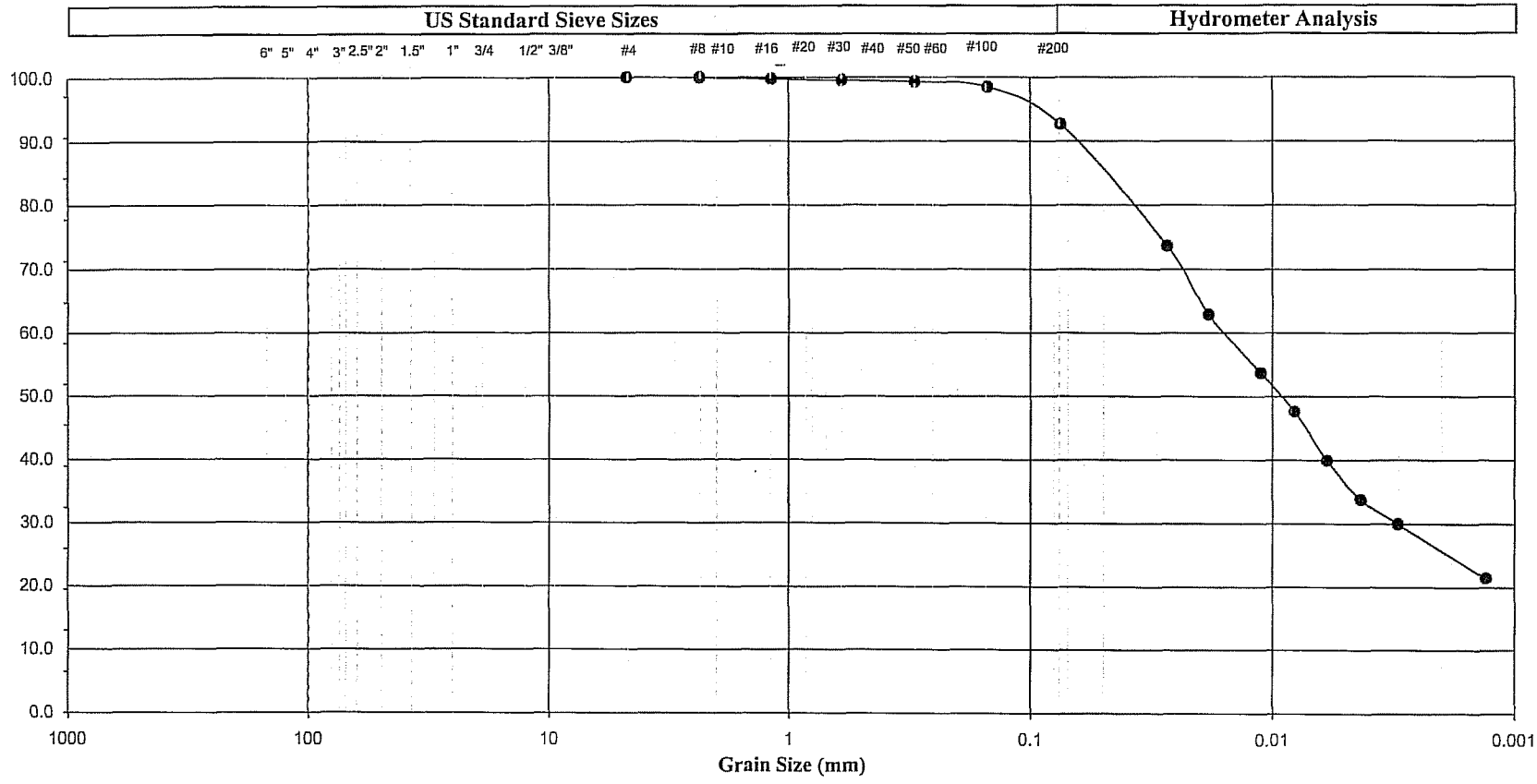
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-2	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	1	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-26		S-2	75		S-30		
Wt. of Wet Soil + Container (gm)		191.69		65.42	121.47			0.99	
Wt. of Dry Soil + Container (gm)					120.62		119.46	Hydrometer Type	
Wt. of Container (gm)					60.09		114.29	152H	
Wt. of Dry Soil (gm)		189.04		64.51			5.17	(K) Value	Temp. °C
Moisture Content (%)					1.40			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				47	No. 16	0.17		99.74	99.74
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.31		99.52	99.52
1.0"					No. 40				
3/4"				24	No. 50	0.44		99.32	99.32
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.99		98.47	98.47
No. 4	0.00		100.00		No. 140				
No. 8	0.02		99.97	23	No. 200	4.71		92.70	92.70
No. 10					Pan	5.16			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
13:38	0:00:00			6.0							
	2	21.0	54.0	6.0	48.0	73.66	73.66	0.05500	0.01328	8.4	0.02726
	5	21.0	47.0	6.0	41.0	62.92	62.92	0.03500	0.01328	9.6	0.01838
	15	21.0	41.0	6.0	35.0	53.71	53.71	0.02000	0.01328	10.6	0.01114
	30	21.0	37.0	6.0	31.0	47.57	47.57	0.01400	0.01328	11.2	0.00812
	60	21.0	32.0	6.0	26.0	39.90	39.90	0.01000	0.01328	12.0	0.00595
	120	21.5	28.0	6.0	22.0	33.76	33.76	0.00700	0.01328	12.7	0.00432
	240	22.0	25.5	6.0	19.5	29.92	29.92	0.00500	0.01328	13.1	0.00304
	1440	21.5	20.0	6.0	14.0	21.48	21.48	0.00100	0.01328	14.0	0.00131

Remark :	above #30 are shell fragments	Cu :	Gravel	Sand	Fine
		Cc :	0	7	93



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-058	S-5	25.0	dark olive-gray	Lean clay	CL
Remark	above #30 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *A-09-059*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-3*	**Tested By :** *PA*	**Date :**
Depth below Decl	: *15.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark olive-gray, Elastic SILT with SAND (MH)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

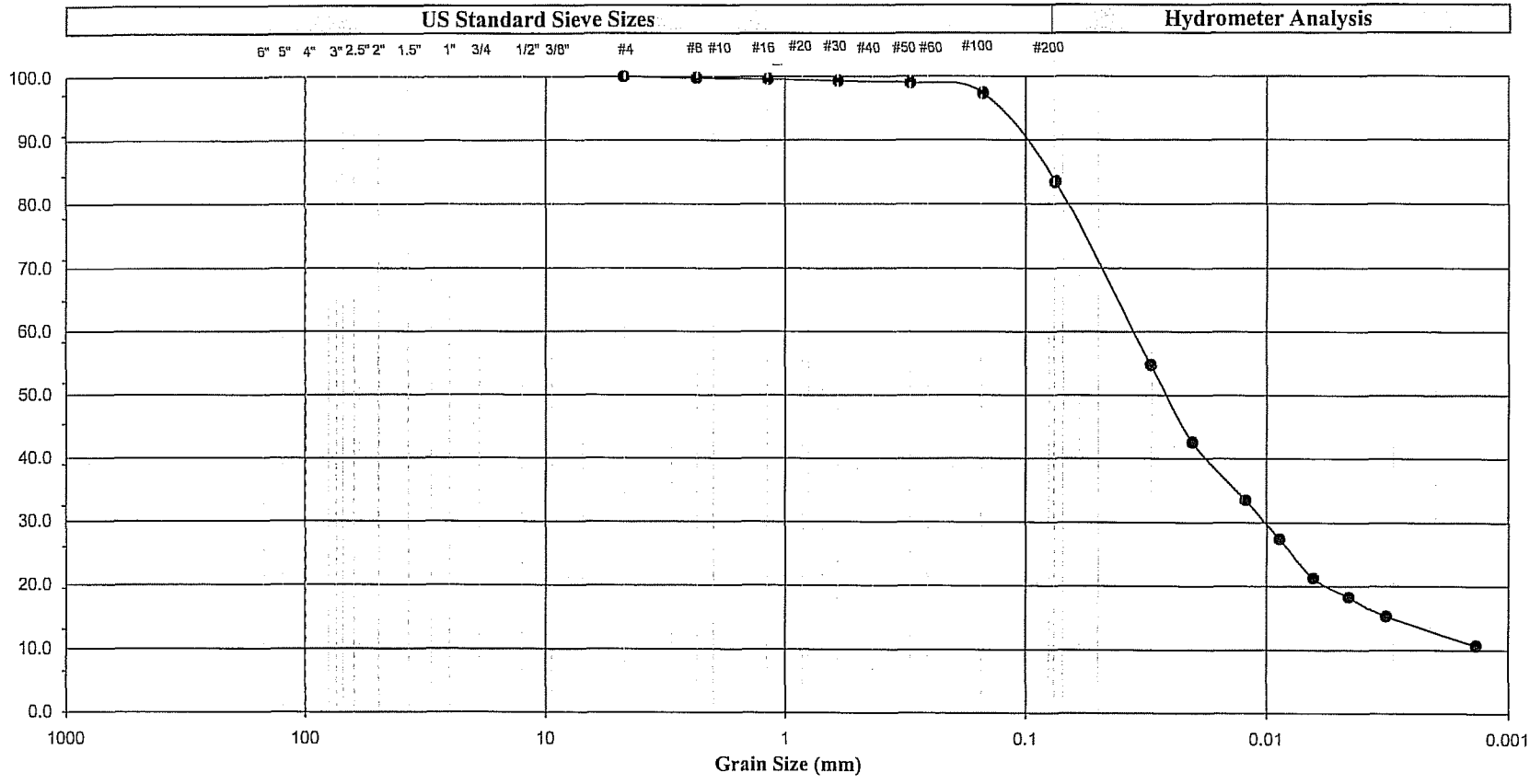
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

Setup Container No. :	*J-4*	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	*2*	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	*2.70*	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor	
Container No.		*S-26*		*J-4*	*76*		*S-1*	for difference S.G.	
Wt. of Wet Soil + Container (gm)		*226.43*		*65.84*	*126.75*			*0.99*	
Wt. of Dry Soil + Container (gm)					*126.09*		*132.04*	Hydrometer Type	
Wt. of Container (gm)					*59.80*		*118.79*	*152H*	
Wt. of Dry Soil (gm)		*224.20*		*65.19*			*13.25*	(K) Value	Temp. °C
Moisture Content (%)					*1.00*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***98***	No. 16	*0.26*		*99.60*	***99.60***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.46*		*99.29*	***99.29***
1.0"					No. 40				
3/4"				***49***	No. 50	*0.67*		*98.97*	***98.97***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*1.71*		*97.38*	***97.38***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.16*		***99.75***	***49***	No. 200	*10.85*		*83.36*	***83.36***
No. 10					Pan	*13.25*			

Obsersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	W		(mm)	(K)	(L)	(D)
0:01	(T)										
13:42	*0:00:00*			*6.0*							
	2	*21.0*	*42.0*	*6.0*	*36.0*	*54.67*	***54.67***	*0.05500*	*0.01328*	*10.4*	***0.03027***
	5	*21.0*	*34.0*	*6.0*	*28.0*	*42.52*	***42.52***	*0.03500*	*0.01328*	*11.7*	***0.02032***
	15	*21.0*	*28.0*	*6.0*	*22.0*	*33.41*	***33.41***	*0.02000*	*0.01328*	*12.7*	***0.01222***
	30	*21.0*	*24.0*	*6.0*	*18.0*	*27.34*	***27.34***	*0.01400*	*0.01328*	*13.3*	***0.00886***
	60	*21.0*	*20.0*	*6.0*	*14.0*	*21.26*	***21.26***	*0.01000*	*0.01328*	*14.0*	***0.00642***
	120	*21.5*	*18.0*	*6.0*	*12.0*	*18.22*	***18.22***	*0.00700*	*0.01328*	*14.3*	***0.00459***
	240	*22.0*	*16.0*	*6.0*	*10.0*	*15.19*	***15.19***	*0.00500*	*0.01328*	*14.7*	***0.00322***
	1440	*21.5*	*13.0*	*6.0*	*7.0*	*10.63*	***10.63***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***0***	***17***	***83***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-059	S-3	15.0	dark olive-gray	Elastic silt with sand	MH
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-059	Prepared By : PA	Date :
Sample No.	: S-6	Tested By : PA	Date :
Depth below Deck	: 30.0	Sieved By : RJ	Date :
Description	: dark olive-gray, Elastic SILT (MH)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

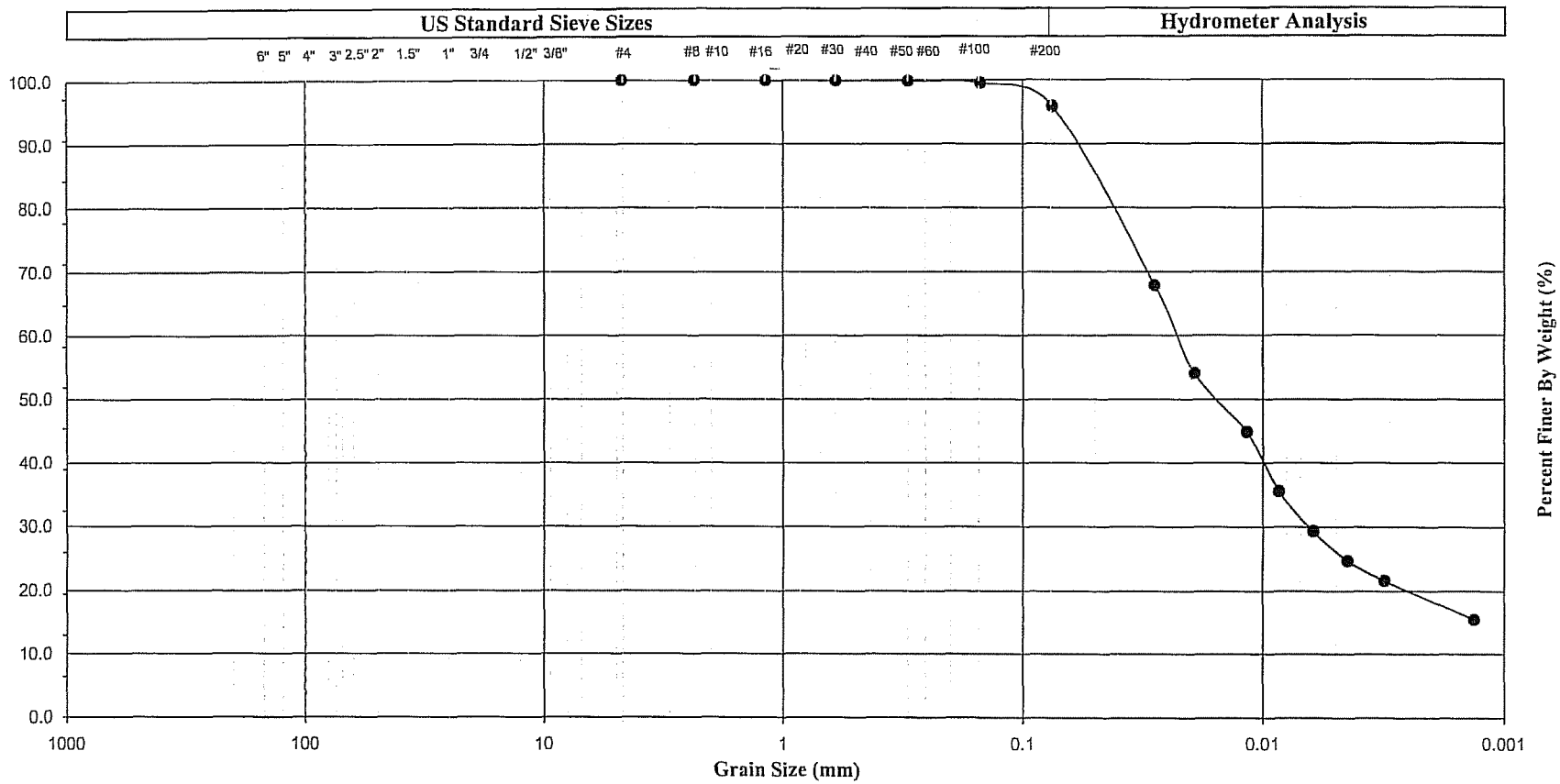
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-19	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	6	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-26		S-19	77		S-2		
Wt. of Wet Soil + Container (gm)		228.47		65.19	125.48			0.99	
Wt. of Dry Soil + Container (gm)					124.44		120.50	Hydrometer Type	
Wt. of Container (gm)					59.10		116.88	152H	
Wt. of Dry Soil (gm)		224.89		64.17			3.62	(K) Value	Temp. °C
Moisture Content (%)					1.59			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				50	No. 16	0.04		99.94	99.94
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.06		99.91	99.91
1.0"					No. 40				
3/4"				30	No. 50	0.11		99.83	99.83
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.34		99.47	99.47
No. 4	0.00		100.00		No. 140				
No. 8	0.00		100.00	20	No. 200	2.65		95.87	95.87
No. 10					Pan	3.63			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / W	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01											
13:46	0:00:00			6.0							
	2	21.0	50.0	6.0	44.0	67.88	67.88	0.05500	0.01328	9.1	0.02830
	5	21.0	41.0	6.0	35.0	54.00	54.00	0.03500	0.01328	10.6	0.01930
	15	21.0	35.0	6.0	29.0	44.74	44.74	0.02000	0.01328	11.5	0.01165
	30	21.0	29.0	6.0	23.0	35.48	35.48	0.01400	0.01328	12.5	0.00858
	60	21.0	25.0	6.0	19.0	29.31	29.31	0.01000	0.01328	13.2	0.00622
	120	21.5	22.0	6.0	16.0	24.68	24.68	0.00700	0.01328	13.7	0.00448
	240	22.0	20.0	6.0	14.0	21.60	21.60	0.00500	0.01328	14.0	0.00314
	1440	21.5	16.0	6.0	10.0	15.43	15.43	0.00100	0.01328	14.7	0.00134

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	0	4	96



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-059	S-6	30.0	dark olive-gray	Elastic silt	MH
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/07/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ **ASTM** ☑ **CAL. TRANS.**	
Boring No.	: *A-09-059*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-8*	**Tested By :** *PA*	**Date :**
Depth below Decl	: *40.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark greenish gray, SILTY SAND (SM)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

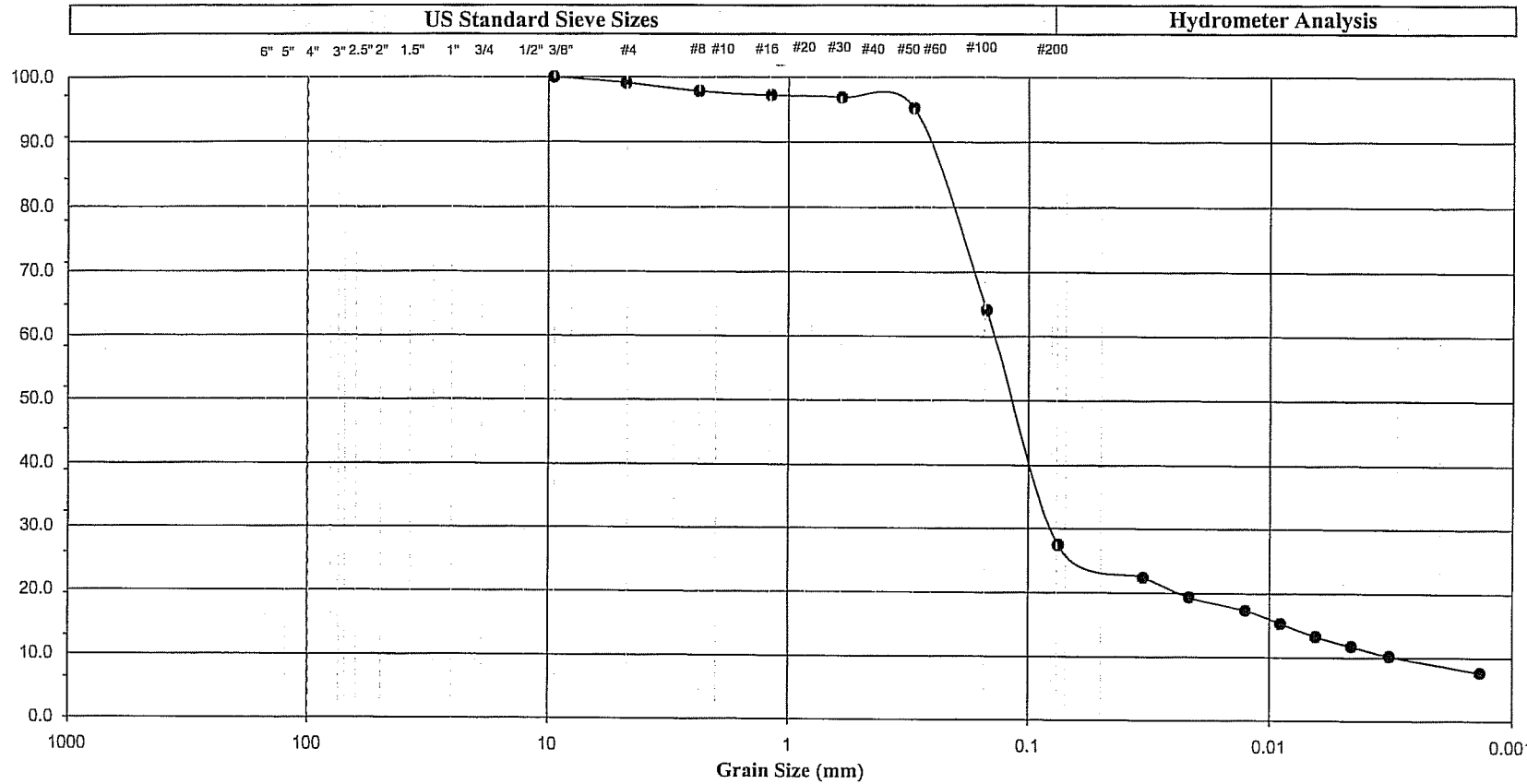
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

Setup Container No. :	*J-13*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*4*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-26*		*J-13*	*78*		*S-3*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*255.53*		*97.03*	*209.35*			*0.99*	
Wt. of Dry Soil + Container (gm)					*208.37*		*189.52*	**Hydrometer Type**	
Wt. of Container (gm)					*58.94*		*118.19*	*152H*	
Wt. of Dry Soil (gm)		*253.87*		*96.40*			*71.33*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.66*			*0.01328*	*21.0*

U.S. Sieve Size	**Cumulative Wt. of Dry Soil (gm)**	**Wt. of Dry Soil (gm)**	**% Finer Than**	**Liquid Limit**	**U.S. Sieve Size**	**Cumulative Weight of Dry Soil (gm)**	**Wt. of Dry Soil (gm)**	**% Finer Than**	**% Total Sample**
2.5"				-	**No. 16**	*1.79*		*98.14*	***97.27***
2.0"					**No. 20**				
1.5"				**Plastic Limit**	**No. 30**	*2.14*		*97.78*	***96.91***
1.0"					**No. 40**				
3/4"				-	**No. 50**	*3.73*		*96.13*	***95.28***
1/2"					**No. 60**				
3/8"	*0.00*		***100.00***	**Plastic Index**	**No. 100**	*34.09*		*64.64*	***64.06***
No. 4	*2.25*		***99.11***		**No. 140**				
No. 8	*1.21*		***97.87***	-	**No. 200**	*69.74*		*27.65*	***27.41***
No. 10					**Pan**	*71.27*			

Obersved Time	**EL. Time (min.) (T)**	**Temp. (oC)**	**Hydrometer Reading**			**100 Ra / W**	**% Total Sample**	**Grain Diameter (mm)**	**Correction Coefficient**		**Correction Dia. (mm)**
			Orginal	**Composite Correction**	**Correction (R)**				**(K)**	**(L)**	**(D)**
13:50	*0:00:00*			*6.0*							
0:01	*2*	*21.0*	*28.0*	*6.0*	*22.0*	*22.59*	***22.39***	*0.05500*	*0.01328*	*12.7*	***0.03345***
	5	*21.0*	*25.0*	*6.0*	*19.0*	*19.51*	***19.34***	*0.03500*	*0.01328*	*13.2*	***0.02156***
	15	*21.0*	*23.0*	*6.0*	*17.0*	*17.46*	***17.30***	*0.02000*	*0.01328*	*13.5*	***0.01260***
	30	*21.0*	*21.0*	*6.0*	*15.0*	*15.40*	***15.27***	*0.01400*	*0.01328*	*13.8*	***0.00902***
	60	*21.0*	*19.0*	*6.0*	*13.0*	*13.35*	***13.23***	*0.01000*	*0.01328*	*14.2*	***0.00645***
	120	*21.5*	*17.5*	*6.0*	*11.5*	*11.81*	***11.71***	*0.00700*	*0.01328*	*14.4*	***0.00460***
	240	*22.0*	*16.0*	*6.0*	*10.0*	*10.27*	***10.18***	*0.00500*	*0.01328*	*14.7*	***0.00322***
	1440	*21.5*	*13.5*	*6.0*	*7.5*	*7.70*	***7.63***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :	*Above #30 are shell fragments*	**Cu :** *45.9*	**Gravel**	**Sand**	**Fine**
		Cc : *14.8*	***1***	***72***	***27***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-059	S-8	40.0	dark greenish gray	Silty sand	SM

Remark: Above #30 are shell fragments

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/07/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Boring No. : A-09-058

Sample No. : D-4

Depth (ft / m) : 20.0 | 6.10

File No. :

Soil Description : Dark gray, SANDY SILT (ML)

Set up By : J.F Date : 12/3/2009

Tested By : J.F/R.J. Date : 12/3/09-12/13/09

Time Rate Took By : J.F Date : 12/6/09, 12/8/09

Computer By : JF Date : 12/9/2009

Checked By : R.J. Date :

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9565	24.30	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

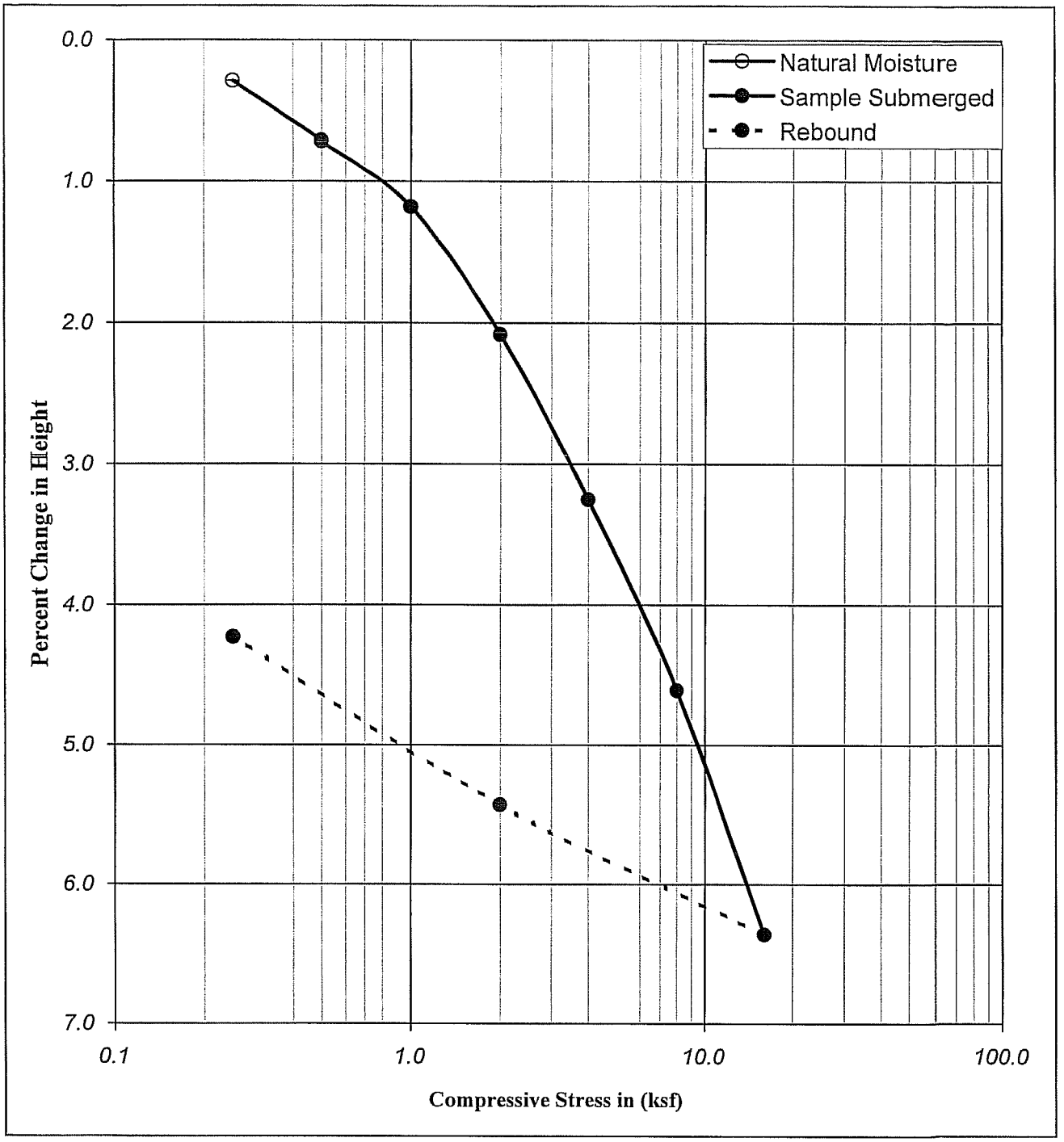
	Before	After
Weight of wet soil + ring (gm)	187.21	
Weight of ring (gm)	44.00	
Weight of wet soil + ring + container (gm)		244.97
Weight of dry soil + ring + container (gm)		210.28
No. 85 Weight of container (gm)		59.31
Weight of ring + container (gm)		103.31
Moisture Content (%)	33.88	32.43
Dial Reading (inch)	0.05	0.04
Sample Volume (ft³)	0.0027	0.0025
Wet Density (pcf)	118.6	122.7
Dry Density (pcf)	88.60	92.62

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04880	1.24		
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	
12/4/2009	8:10	0:00:00	0.25	12.0	0.05290	1.34	0.29	
12/5/2009	9:44	0:00:00	0.50	23.9	0.05710	1.45	0.71	
			Add Water					
12/6/2009	8:40	0:00:00	0.50	23.9	0.05720	1.45	0.72	
12/6/2009	8:43	0:00:00	1.00	47.9	0.05720	1.45	0.72	0.00
		0.10	1.0	47.9	0.05970	1.52	0.97	0.32
		0.25	1.0	47.9	0.05990	1.52	0.99	0.50
		0.50	1.0	47.9	0.0600	1.52	1.00	0.71
		1	1.0	47.9	0.06020	1.53	1.02	1.00
		2	1.0	47.9	0.06030	1.53	1.03	1.41
		4	1.0	47.9	0.06040	1.53	1.04	2.00
		8	1.0	47.9	0.06060	1.54	1.06	2.83
		15	1.0	47.9	0.06085	1.55	1.08	3.87
		30	1.0	47.9	0.06090	1.55	1.09	5.48
		60	1.0	47.9	0.06100	1.55	1.10	7.75
		120	1.0	47.9	0.06120	1.55	1.12	10.95
		240	1.0	47.9	0.06140	1.56	1.14	15.49
		480	1.0	47.9	0.06150	1.56	1.15	21.91
12/7/2009		1440	1.0	47.9	0.06180	1.57	1.18	37.95
12/8/2009	8:28	0	2.0	95.8	0.07080	1.80	2.08	
12/8/2009	8:29	0	4.0	191.5	0.0708	1.80	2.08	
		0.10	4.0	191.5	0.0785	1.99	2.85	
		0.25	4.0	191.5	0.0787	2.00	2.87	
		0.50	4.0	191.5	0.0790	2.01	2.90	
		1	4.0	191.5	0.0791	2.01	2.91	
		2	4.0	191.5	0.0794	2.02	2.94	
		4	4.0	191.5	0.0797	2.02	2.97	
		8	4.0	191.5	0.0801	2.03	3.01	
		15	4.0	191.5	0.0803	2.04	3.03	
		30	4.0	191.5	0.0806	2.05	3.06	
		60	4.0	191.5	0.0809	2.05	3.09	
		120	4.0	191.5	0.0812	2.06	3.12	
		240	4.0	191.5	0.0816	2.07	3.16	
		480	4.0	191.5	0.0822	2.09	3.22	
12/09/09		1440	4.0	191.5	0.0825	2.10	3.25	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.0961	2.44	4.61
12/11/2009	8:23		**16.00**	766.1	0.1136	2.89	6.36
12/12/2009	8:40		**2.00**	95.8	0.1043	2.65	5.43
12/13/2009	9:15		0.25	12.0	0.0923	2.34	4.23

Remark

Final Dial Reading 0.0923



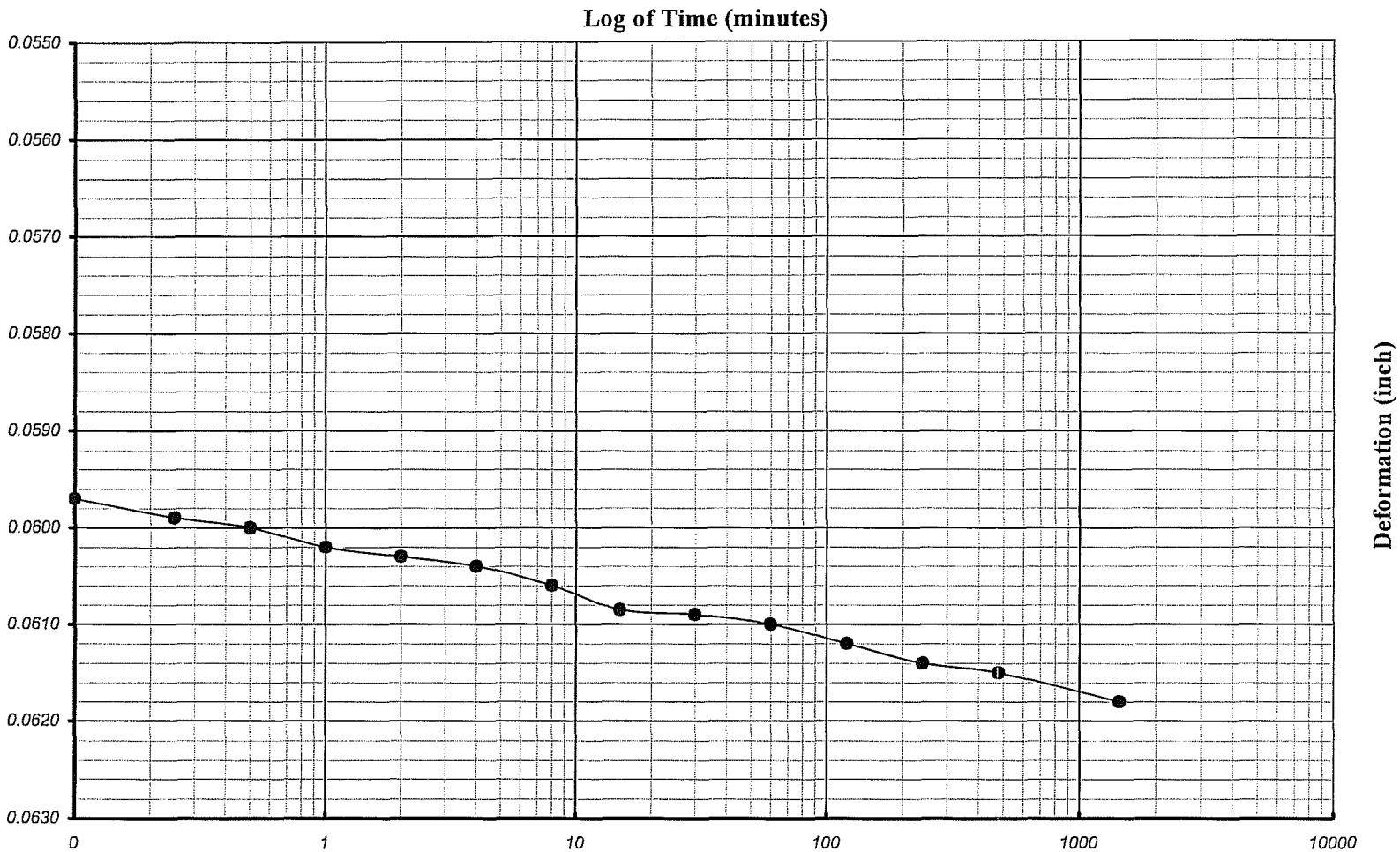
Boring No.	: A-09-058		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No.	: D-4		Plastic Limit :	-						
Depth (ft)	: 20.0	21.5	Plastic Index :	-	Initial	33.88	88.60	13.94	101.34	0.90
Depth (m)	: 6.10	6.56	Specific Gravity :	2.70	Final	32.43	92.62	14.58	106.80	0.82
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

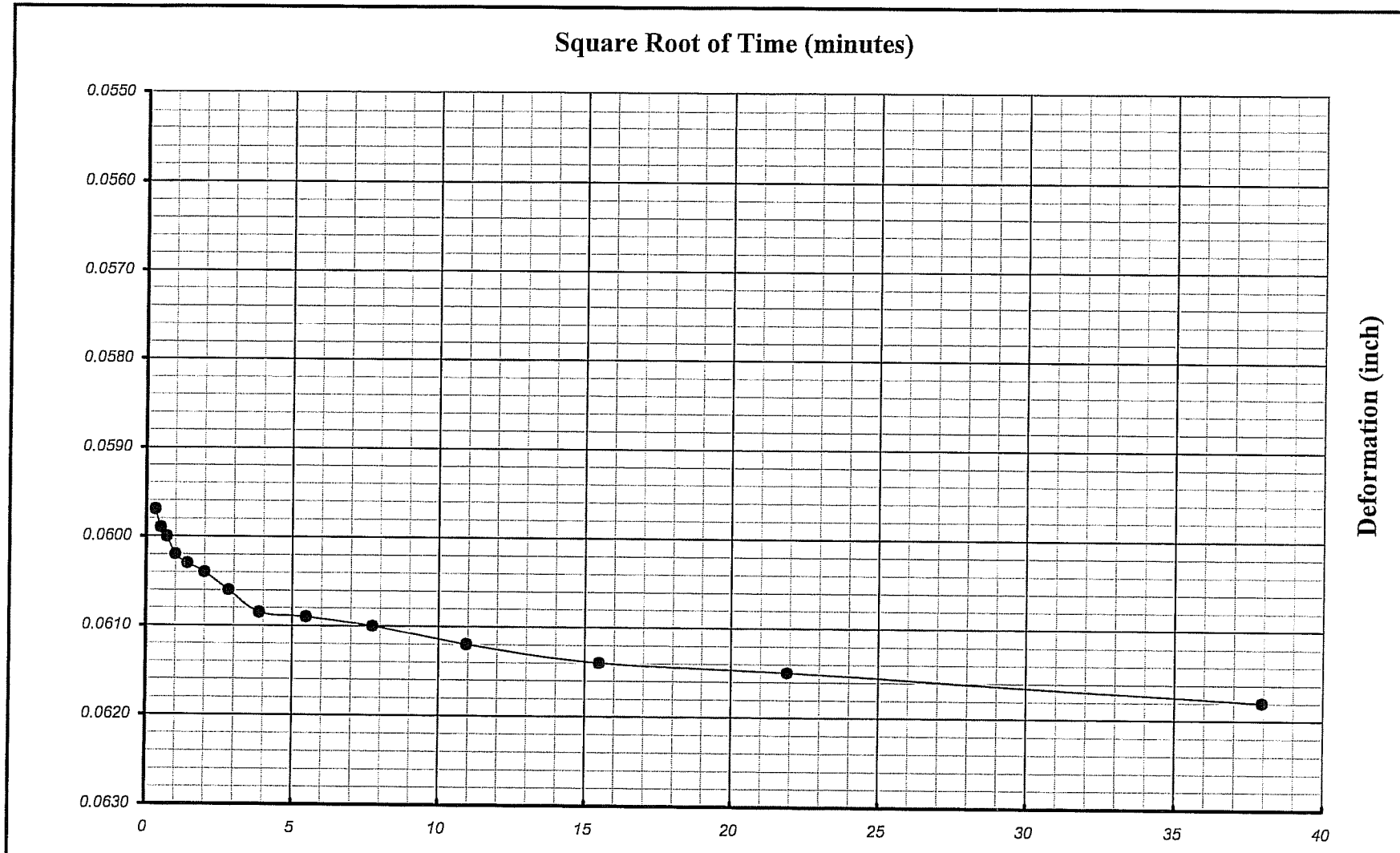
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 12/09/09

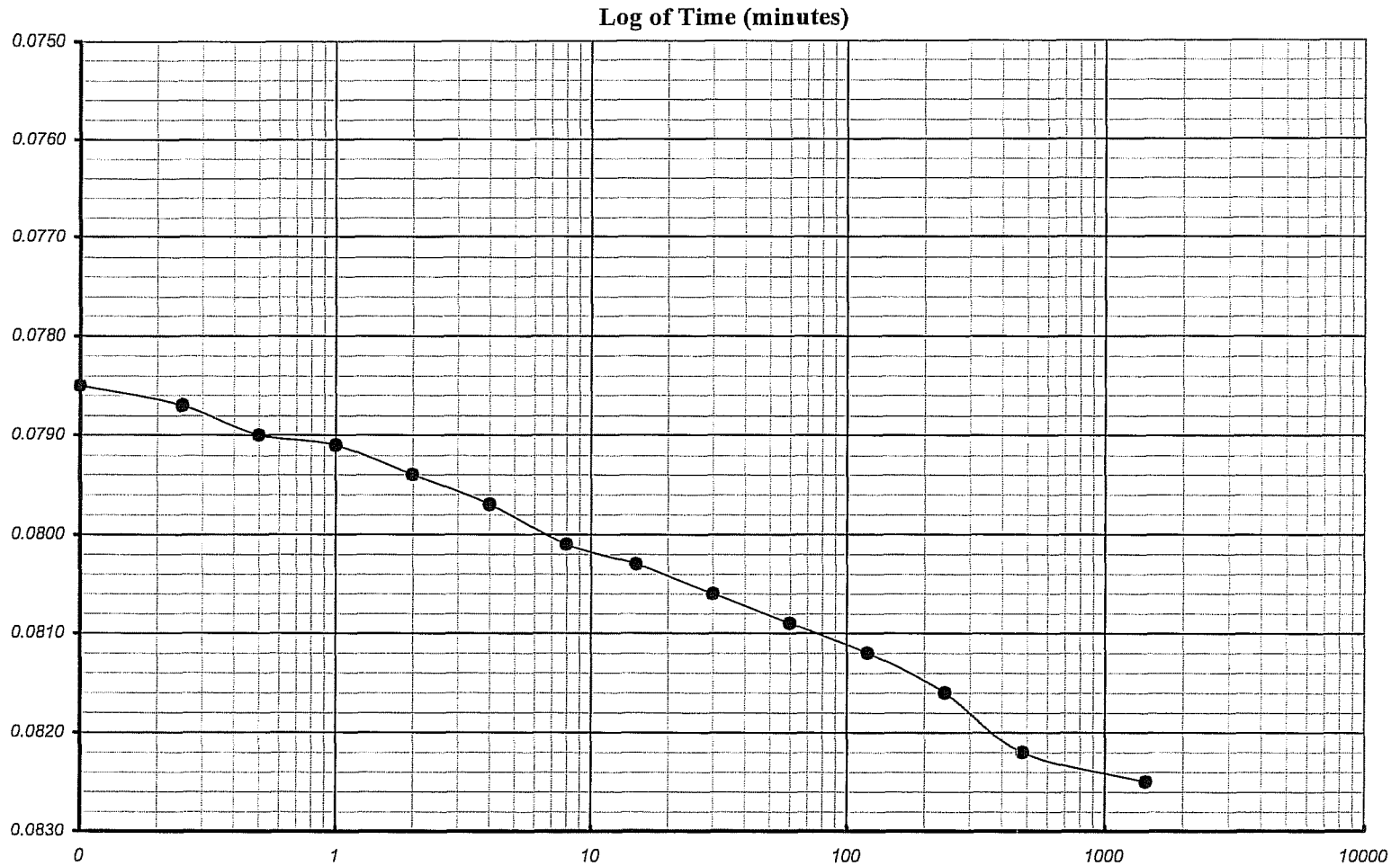
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



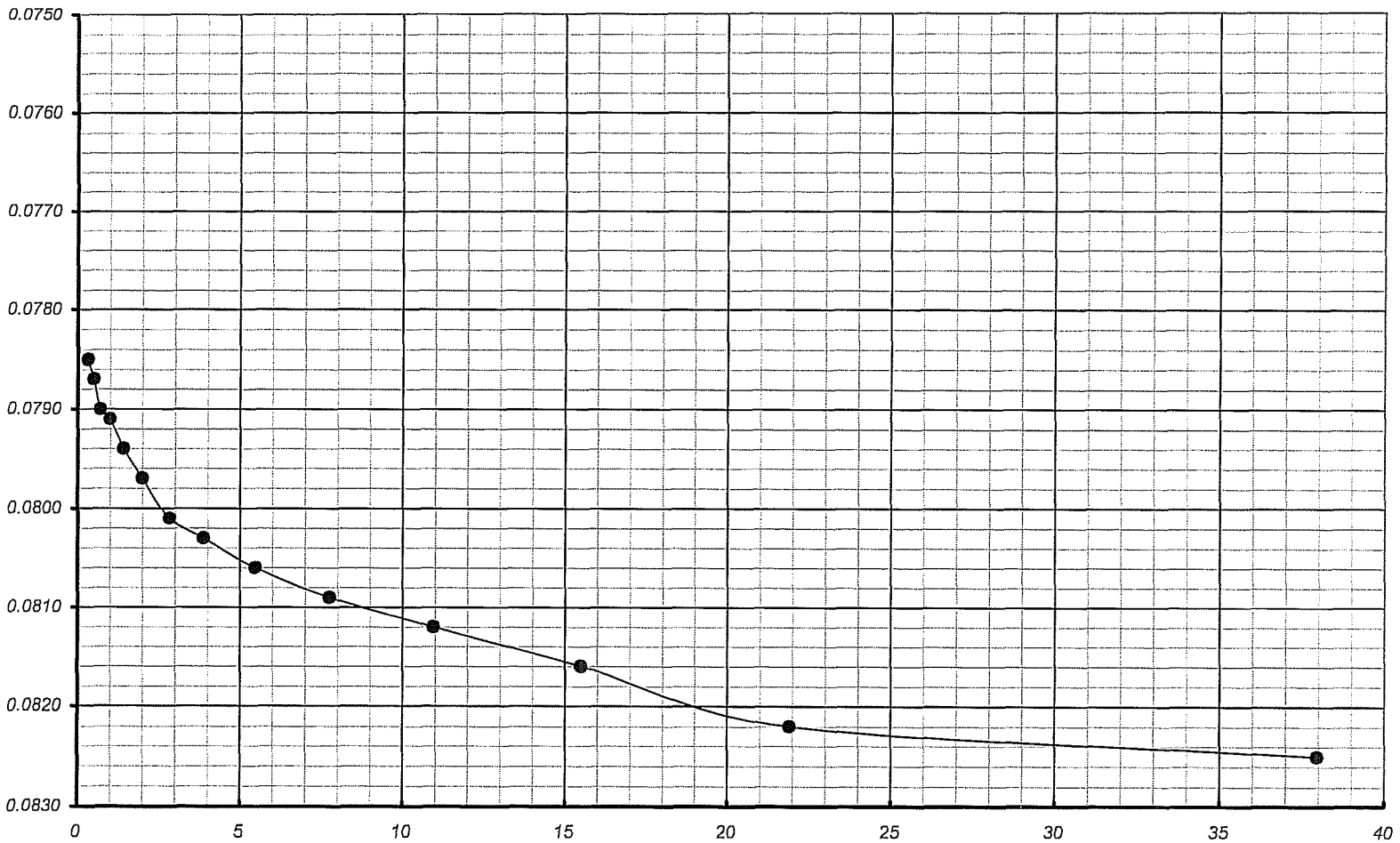
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* | *6.1*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-058	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 6.1	Veritcal Load (ksf/kpa) : 1.0 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-058	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 6.1	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* / *6.1*	Veritcal Load (ksf/kpa) : *4.0* / *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 5

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-058
Sample No. : D-6
Depth (ft / m) : 30.0 | 9.15
File No. :
Soil Description : Dark gray, SILT with SAND (ML)

Set up By : J.F Date : 12/3/2009
Tested By : J.F/R.J. Date : 12/3/09-12/13/09
Time Rate Took By : J.F Date : 12/6/09,12/8/09
Computer By : JF Date : 12/9/2009
Checked By : R.J. Date :

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)
Internal Diameter	2.42	61.47
Height (Intial)	1.00	25.40
Height (Final)	0.9128	23.19

Vertical Load	(ksf)	(kPa)
Add Water at	0.50	23.94
Load to	16.00	766.08
Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

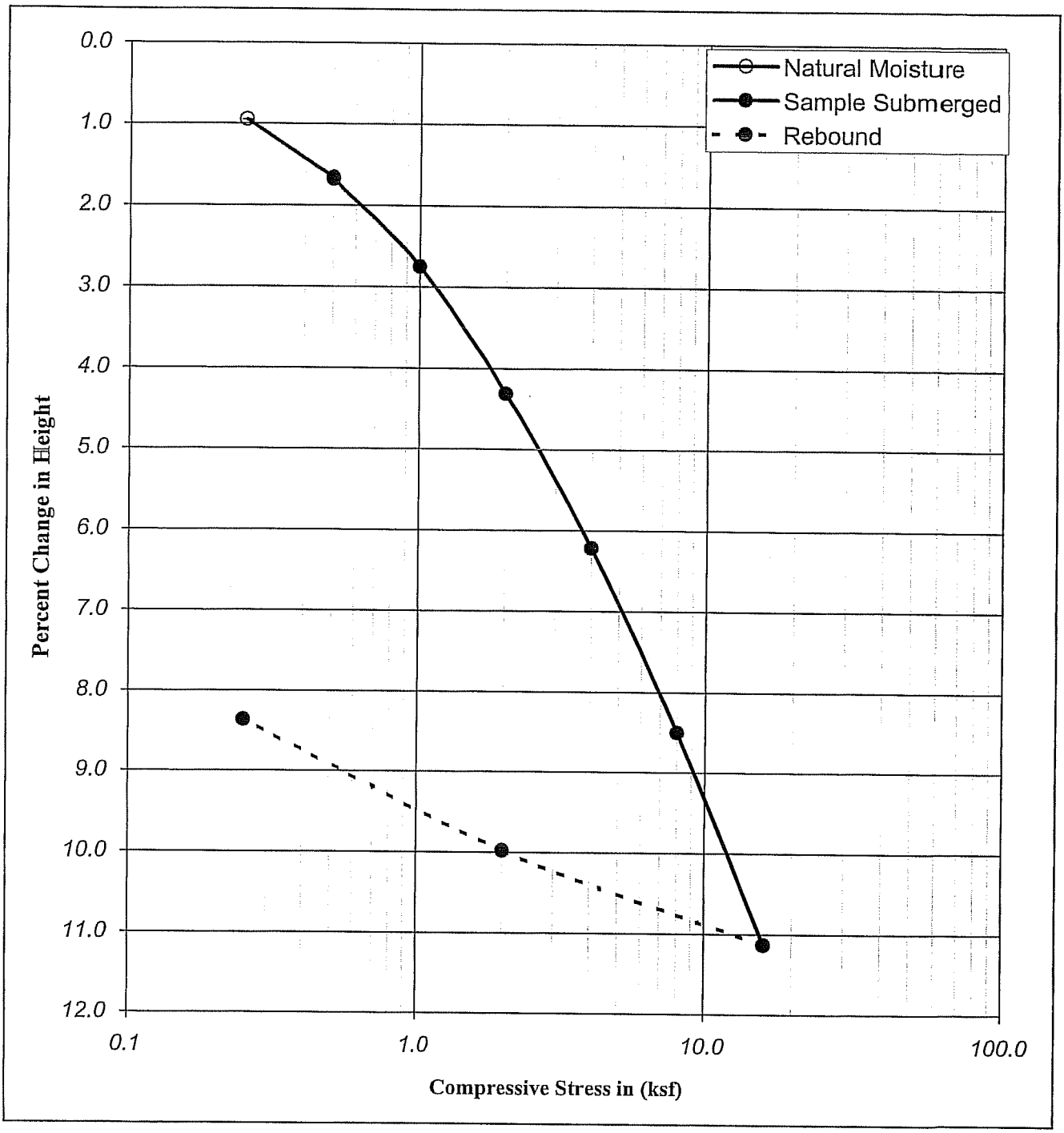
	Before	After
Weight of wet soil + ring (gm)	188.31	
Weight of ring (gm)	43.71	
Weight of wet soil + ring + container (gm)		242.33
Weight of dry soil + ring + container (gm)		211.80
No. 86 Weight of container (gm)		60.05
Weight of ring + container (gm)		103.76
Moisture Content (%)	33.84	28.26
Dial Reading (inch)	0.05	0.04
Sample Volume (ft³)	0.0027	0.0024
Wet Density (pcf)	119.8	125.7
Dry Density (pcf)	89.48	98.03

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04640	1.18		0.00
			Load					0.32
	15:14		0.1	4.8	0.05000	1.27	0.00	0.50
								0.71
12/4/2009	8:10	0:00:00	0.25	12.0	0.05950	1.51	0.95	1.00
								1.41
12/5/2009	9:44	0:00:00	0.50	23.9	0.06660	1.69	1.66	2.00
			Add Water					2.83
12/6/2009	8:40	0:00:00	0.50	23.9	0.06680	1.70	1.68	3.87
								5.48
12/6/2009	8:43	0:00:00	1.00	47.9	0.06680	1.70	1.68	0.00
		0.10	1.0	47.9	0.07030	1.79	2.03	0.32
		0.25	1.0	47.9	0.07110	1.81	2.11	0.50
		0.50	1.0	47.9	0.0717	1.82	2.17	0.71
		1	1.0	47.9	0.07240	1.84	2.24	1.00
		2	1.0	47.9	0.07310	1.86	2.31	1.41
		4	1.0	47.9	0.07380	1.87	2.38	2.00
		8	1.0	47.9	0.07430	1.89	2.43	2.83
		15	1.0	47.9	0.07460	1.89	2.46	3.87
		30	1.0	47.9	0.07510	1.91	2.51	5.48
		60	1.0	47.9	0.07560	1.92	2.56	7.75
		120	1.0	47.9	0.07590	1.93	2.59	10.95
		240	1.0	47.9	0.07640	1.94	2.64	15.49
		480	1.0	47.9	0.07700	1.96	2.70	21.91
12/7/2009		1440	1.0	47.9	0.07750	1.97	2.75	37.95
12/8/2009	8:28	0	2.0	95.8	0.09310	2.36	4.31	
12/8/2009	8:29	0	4.0	191.5	0.0931	2.36	4.31	
		0.10	4.0	191.5	0.1019	2.59	5.19	
		0.25	4.0	191.5	0.1025	2.60	5.25	
		0.50	4.0	191.5	0.1046	2.66	5.46	
		1	4.0	191.5	0.1053	2.67	5.53	
		2	4.0	191.5	0.1062	2.70	5.62	
		4	4.0	191.5	0.1069	2.72	5.69	
		8	4.0	191.5	0.1075	2.73	5.75	
		15	4.0	191.5	0.1080	2.74	5.80	
		30	4.0	191.5	0.1087	2.76	5.87	
		60	4.0	191.5	0.1093	2.78	5.93	
		120	4.0	191.5	0.1100	2.79	6.00	
		240	4.0	191.5	0.1109	2.82	6.09	
		480	4.0	191.5	0.1118	2.84	6.18	
12/09/09		1440	4.0	191.5	0.1122	2.85	6.22	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.1350	3.43	8.50
12/11/2009	8:23		16.00	766.1	0.1613	4.10	11.13
12/12/2009	8:40		2.00	95.8	0.1498	3.80	9.98
12/13/2009	9:15		0.25	12.0	0.1336	3.39	8.36

Remark

Final Dial Reading 0.1336



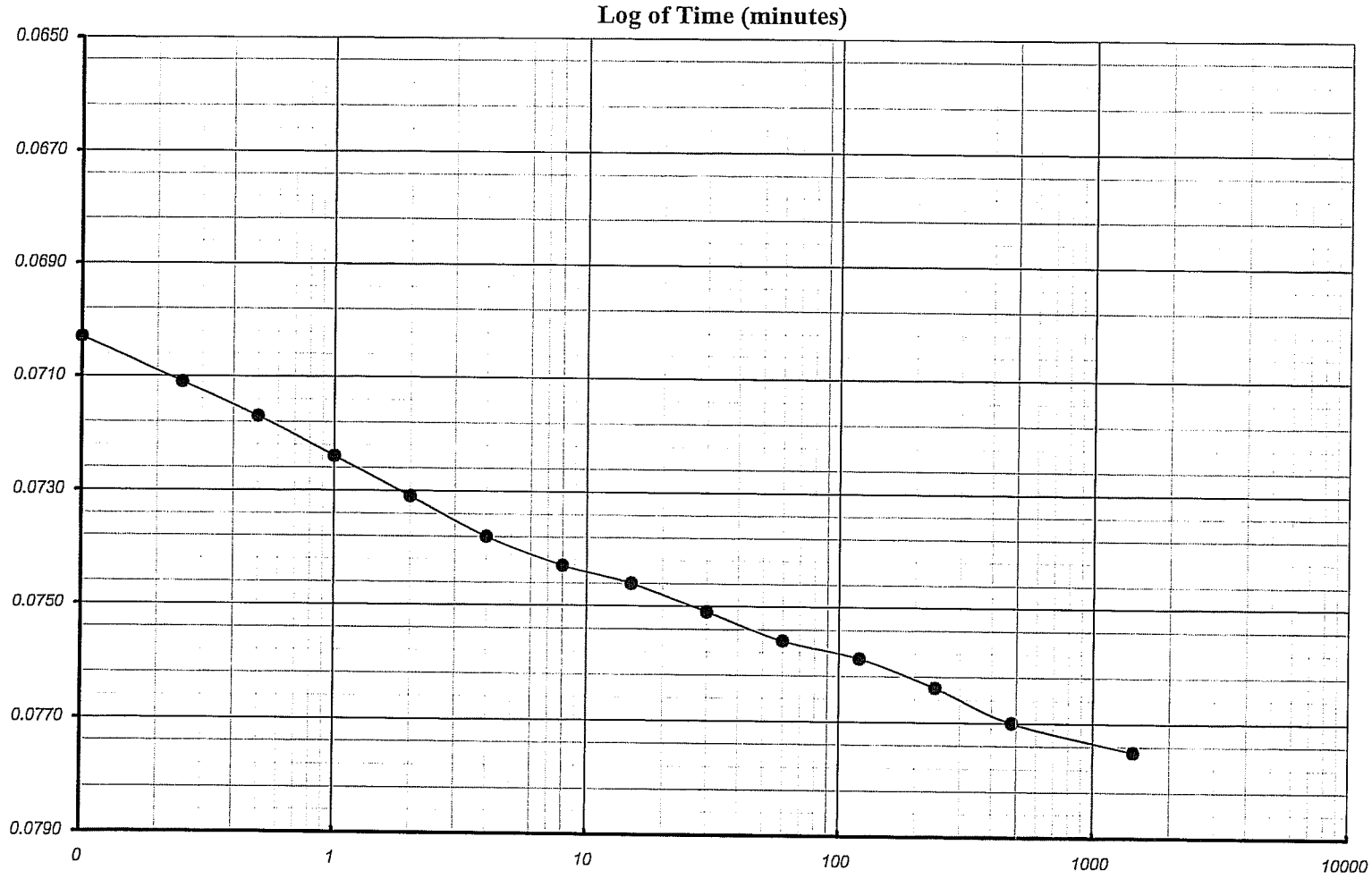
Boring No.	: A-09-058		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-6		Plastic Limit :	-						
Depth (ft)	: 30.0	31.5	Plastic Index :	-	Initial	33.84	89.48	14.08	103.38	0.88
Depth (m)	: 9.15	9.61	Specific Gravity :	2.70	Final	28.26	98.03	15.43	106.04	0.72
Description	: Dark gray, SILT with SAND (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

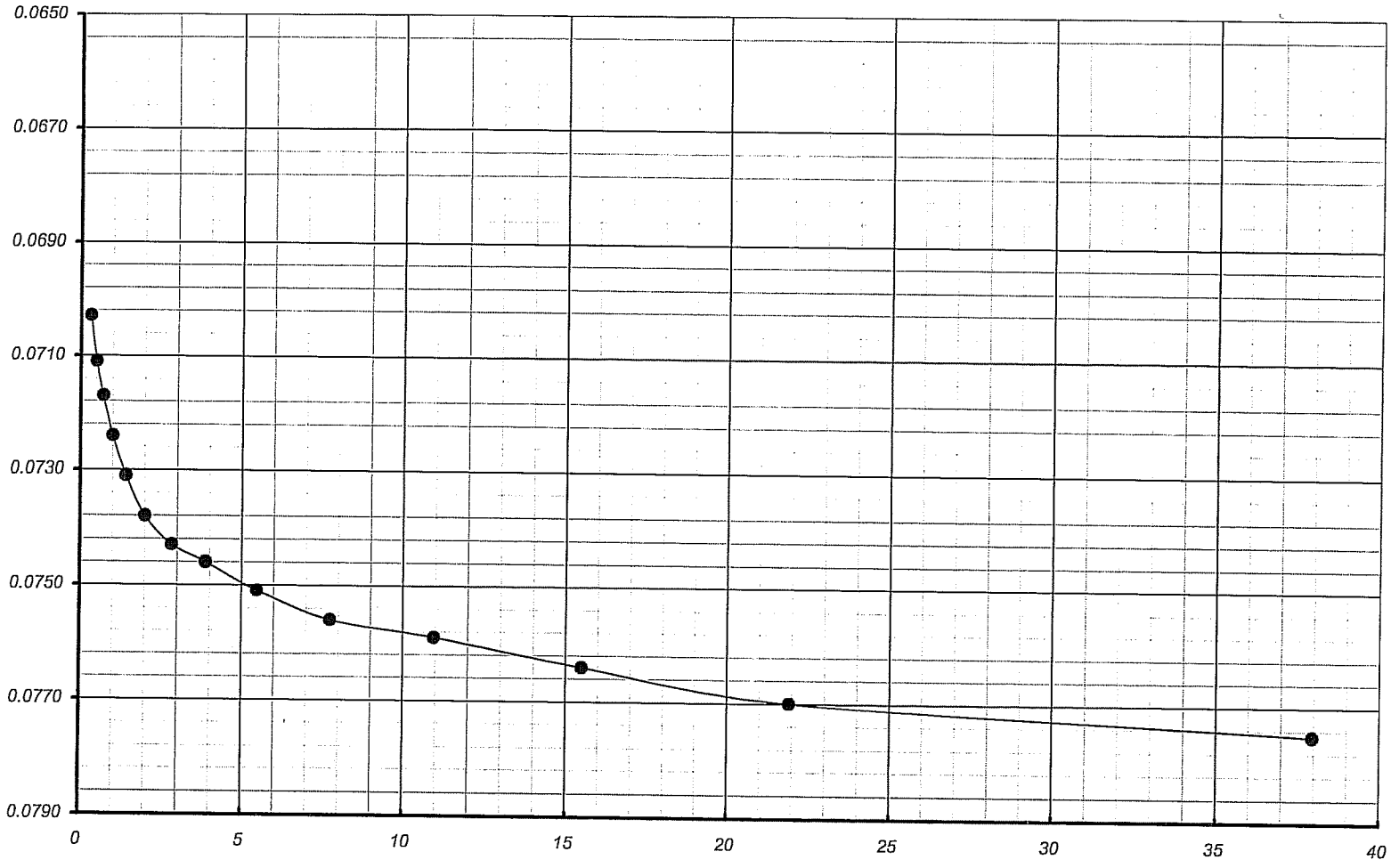
ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3* *12/09/09*

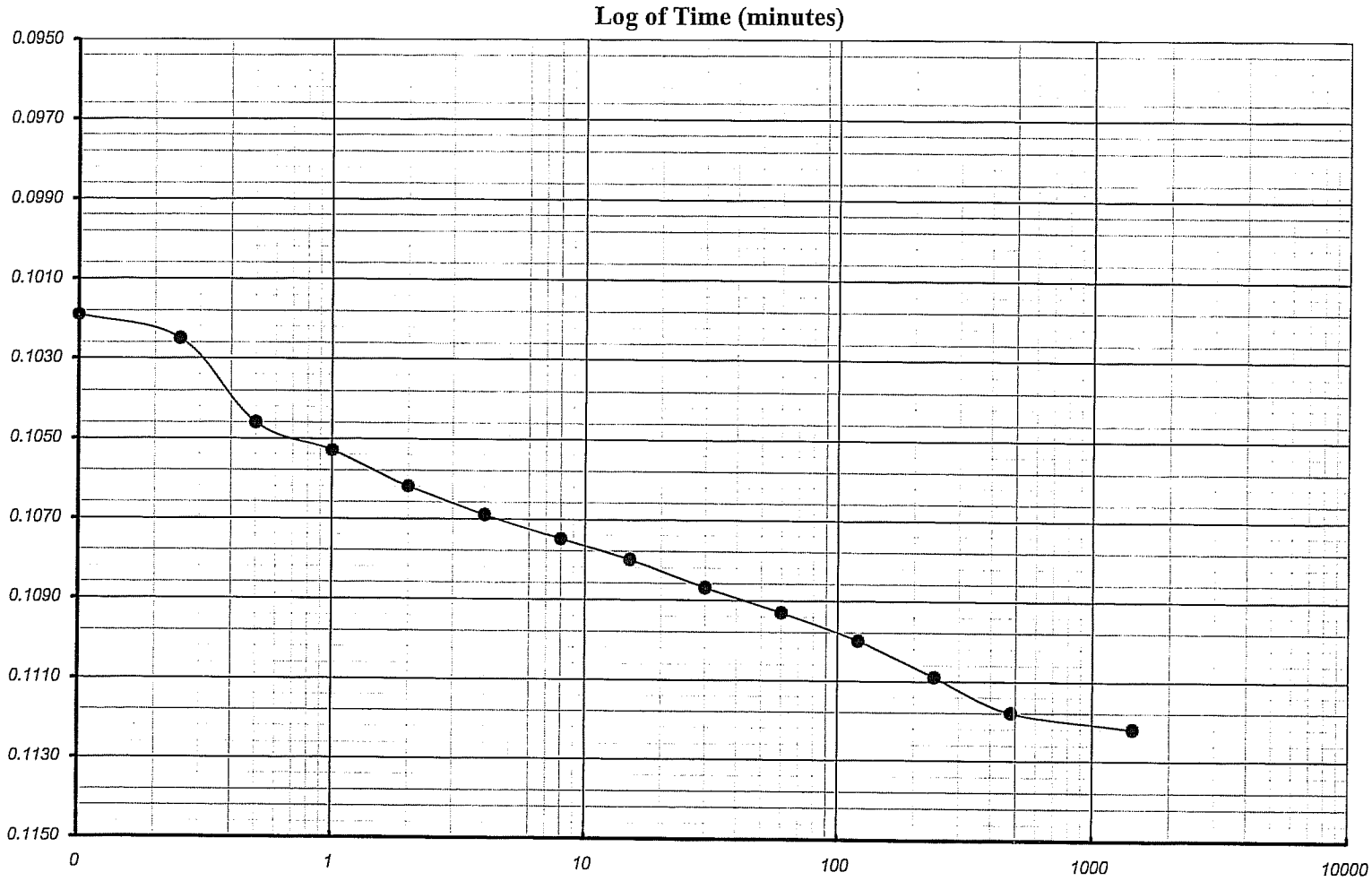
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



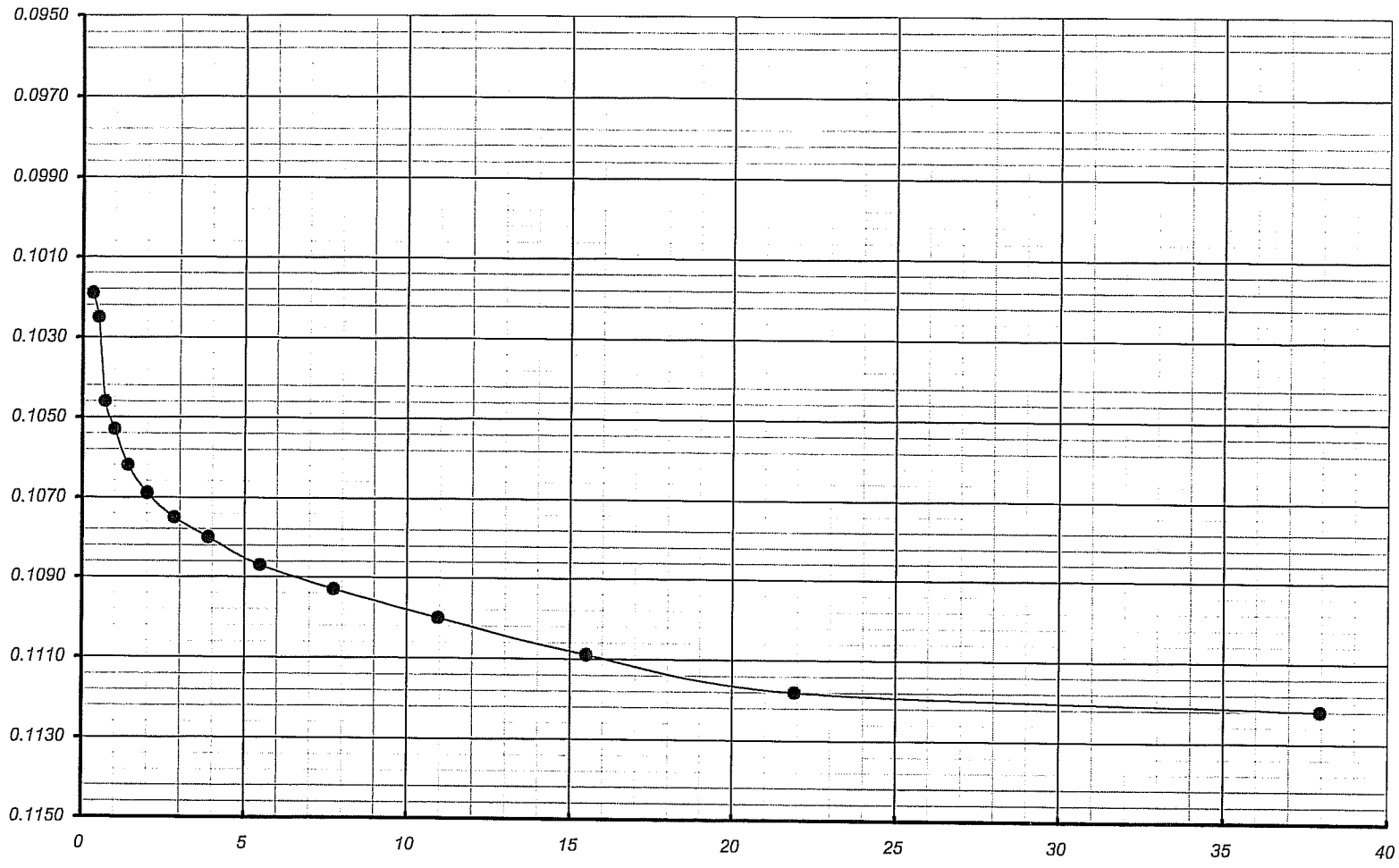
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* | *9.2*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve(Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-058		**Saturated**		**Field Moisiture**	X	**Inundated**		**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-2	X	**Undisturbed**		**Remolded**		**Consolidated-Drained**		**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 10.0	x	**Shear Once**		**Reshear**		**Residual**		**Data File Number :** 0911810	
Description : Dark gray, Lean CLAY (CL)									

Percent Saturation (%)	98.69	**File No. :** 0911810 1																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09																			
Computed By : JF	**Date :** 12/11/09	1.00	(ksf)																	
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		172.68																		
Weight of Ring (gm)		44.91																		
Weight of Wet Soil + Cont. (gm)				126.51																
Weight of Dry Soil + Cont. (gm)				84.71																
Weight of Cont. (gm) No.	4			4.12																
Moisture Content (%)				51.87																
Wet Density (pcf / kN/m³)		105.82	16.66																	
Dry Density (pcf / kN/m³)		69.68	10.97																	
Percent Saturation (%)	94.84	**File No. :** 0911810 2																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	2.00	(ksf)																	
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		171.10																		
Weight of Ring (gm)		46.45																		
Weight of Wet Soil + Cont. (gm)				121.65																
Weight of Dry Soil + Cont. (gm)				81.37																
Weight of Cont. (gm) No.	5			4.08																
Moisture Content (%)				52.12																
Wet Density (pcf / kN/m³)		103.24	16.25																	
Dry Density (pcf / kN/m³)		67.87	10.68																	
Percent Saturation (%)	91.64	**File No. :** 0911810 3																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	4.00	(ksf)																	
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		168.66																		
Weight of Ring (gm)		43.87																		
Weight of Wet Soil + Cont. (gm)				118.54																
Weight of Dry Soil + Cont. (gm)				81.39																
Weight of Cont. (gm) No.	6			3.93																
Moisture Content (%)				47.96																
Wet Density (pcf / kN/m³)		103.35	16.27																	
Dry Density (pcf / kN/m³)		69.85	10.99																	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.56	27.00	0.95	45.39	2.14	102.27
Ultimate	0.52	24.71	0.71	33.90	1.91	91.36

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	156	0.16	7.5	156	0.16	7.5	396	0.40	18.9
0.020	0.05	216	0.22	10.3	228	0.23	10.9	588	0.59	28.0
0.030	0.08	264	0.26	12.6	300	0.30	14.4	804	0.80	38.4
0.040	0.10	300	0.30	14.4	348	0.35	16.7	972	0.97	46.4
0.050	0.13	336	0.34	16.1	396	0.40	19.0	1116	1.12	53.2
0.060	0.15	360	0.36	17.2	444	0.44	21.3	1248	1.25	59.5
0.070	0.18	396	0.40	19.0	480	0.48	23.0	1356	1.36	64.7
0.080	0.20	420	0.42	20.1	516	0.52	24.7	1464	1.46	69.8
0.090	0.23	444	0.44	21.3	552	0.55	26.4	1536	1.54	73.3
0.100	0.25	456	0.46	21.8	588	0.59	28.2	1620	1.62	77.3
0.110	0.28	468	0.47	22.4	612	0.61	29.3	1692	1.69	80.7
0.120	0.30	492	0.49	23.6	636	0.64	30.5	1752	1.75	83.6
0.130	0.33	492	0.49	23.6	660	0.66	31.6	1800	1.80	85.9
0.140	0.36	516	0.52	24.7	684	0.68	32.7	1860	1.86	88.7
0.150	0.38	516	0.52	24.7	708	0.71	33.9	1908	1.91	91.0
0.160	0.41	528	0.53	25.3	744	0.74	35.6	1944	1.94	92.7
0.170	0.43	540	0.54	25.9	756	0.76	36.2	1968	1.97	93.9
0.180	0.46	540	0.54	25.9	780	0.78	37.3	2004	2.00	95.6
0.190	0.48	540	0.54	25.9	792	0.79	37.9	2028	2.03	96.7
0.200	0.51	552	0.55	26.4	816	0.82	39.1	2052	2.05	97.9
0.210	0.53	552	0.55	26.4	828	0.83	39.6	2076	2.08	99.0
0.220	0.56	552	0.55	26.4	840	0.84	40.2	2100	2.10	100.2
0.230	0.58	564	0.56	27.0	852	0.85	40.8	2100	2.10	100.2
0.240	0.61	564	0.56	27.0	852	0.85	40.8	2124	2.12	101.3
0.250	0.64	564	0.56	27.0	852	0.85	40.8	2112	2.11	100.7
0.260	0.66	564	0.56	27.0	864	0.86	41.4	2124	2.12	101.3
0.270	0.69	552	0.55	26.4	876	0.88	41.9	2124	2.12	101.3
0.280	0.71	552	0.55	26.4	888	0.89	42.5	2136	2.14	101.9
0.290	0.74	552	0.55	26.4	900	0.90	43.1	2136	2.14	101.9
0.300	0.76	552	0.55	26.4	912	0.91	43.7	2124	2.12	101.3
0.310	0.79	552	0.55	26.4	912	0.91	43.7	2124	2.12	101.3
0.320	0.81	552	0.55	26.4	924	0.92	44.2	2124	2.12	101.3
0.330	0.84	552	0.55	26.4	924	0.92	44.2	2124	2.12	101.3
0.340	0.86	552	0.55	26.4	936	0.94	44.8	2124	2.12	101.3
0.350	0.89	552	0.55	26.4	936	0.94	44.8	2112	2.11	100.7
0.360	0.91	552	0.55	26.4	936	0.94	44.8	2112	2.11	100.7
0.370	0.94	552	0.55	26.4	948	0.95	45.4	2100	2.10	100.2
0.380	0.97	540	0.54	25.9	948	0.95	45.4	2112	2.11	100.7
0.390	0.99	552	0.55	26.4	948	0.95	45.4	2112	2.11	100.7
0.400	1.02	540	0.54	25.9	948	0.95	45.4	2112	2.11	100.7
	0.00									
	0.00									
	0.00									
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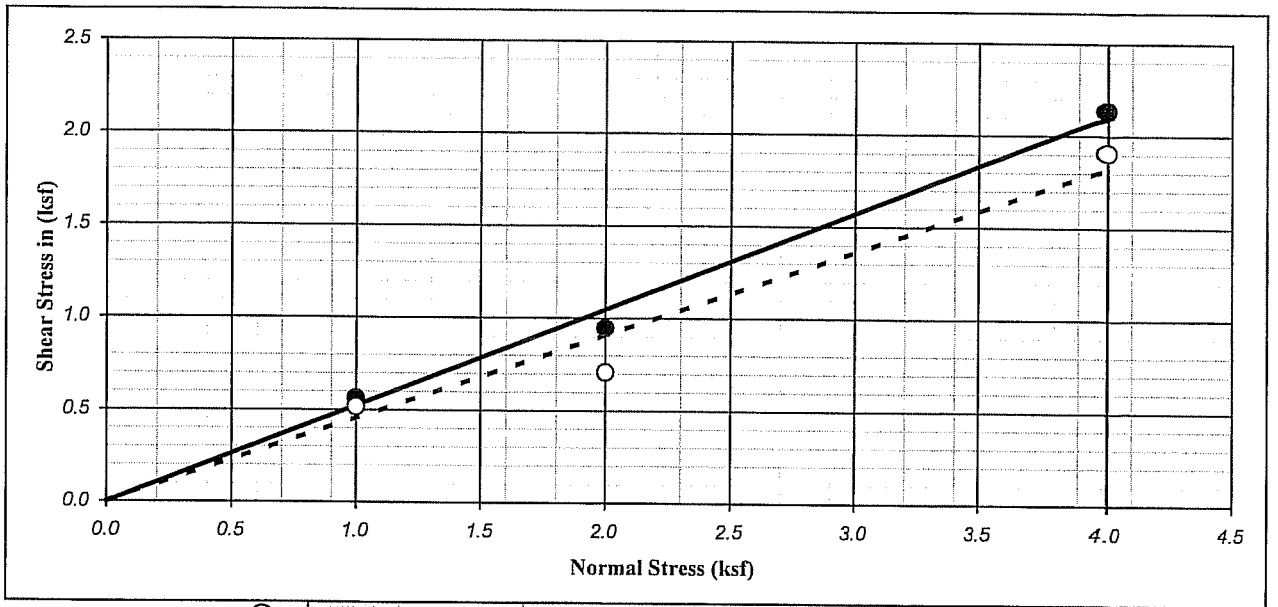
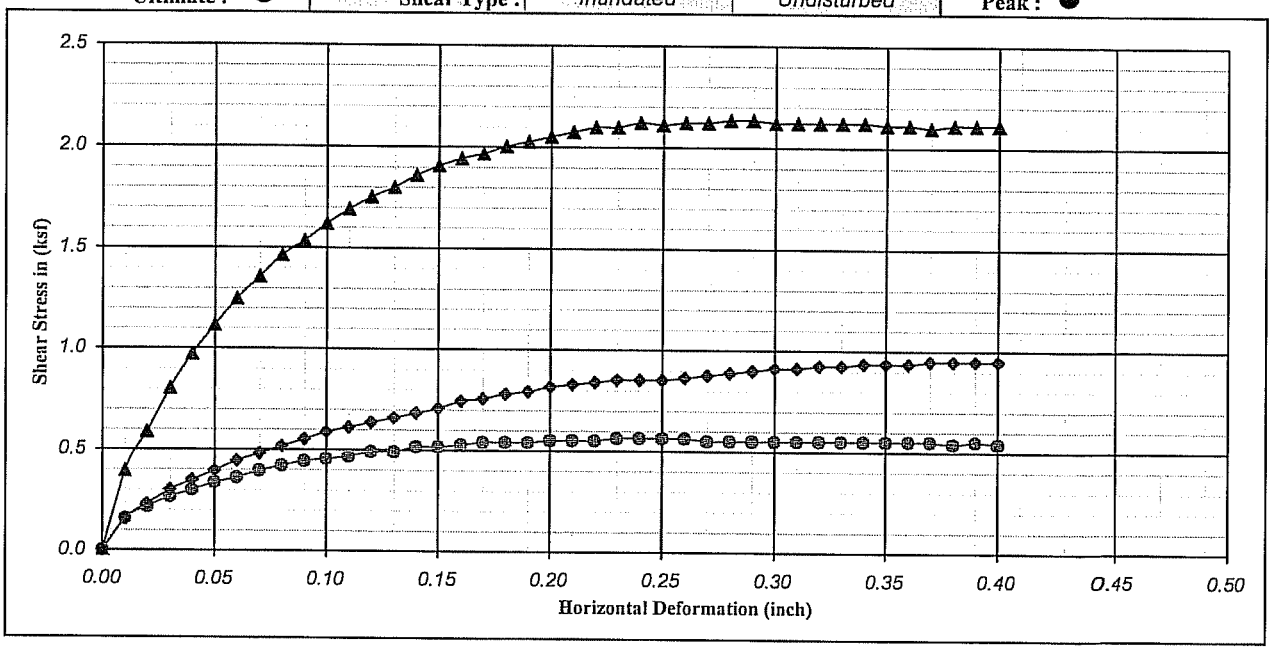
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-058		Strength Intercept (C) :	0.00	(ksf)	Peak	0.00	(ksf)	Ultimate
Sample No. : D-2			0.00	(kPa)		0.00	(kPa)	
Depth (ft/m) : 10.0	0.00	Friction Angle (ϕ) :	27.65	Degree		24.49	Degree	
Description : Dark gray, Lean CLAY (CL)					Shear Rate (inch/minute) :			0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	51.87	69.68	10.97	1.42	1.00	47.88	0.56	27.00	0.52	24.71
◆	52.12	67.87	10.68	1.48	2.00	95.76	0.95	45.39	0.71	33.90
▲	47.96	69.85	10.99	1.41	4.00	191.52	2.14	102.27	1.91	91.36

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-04

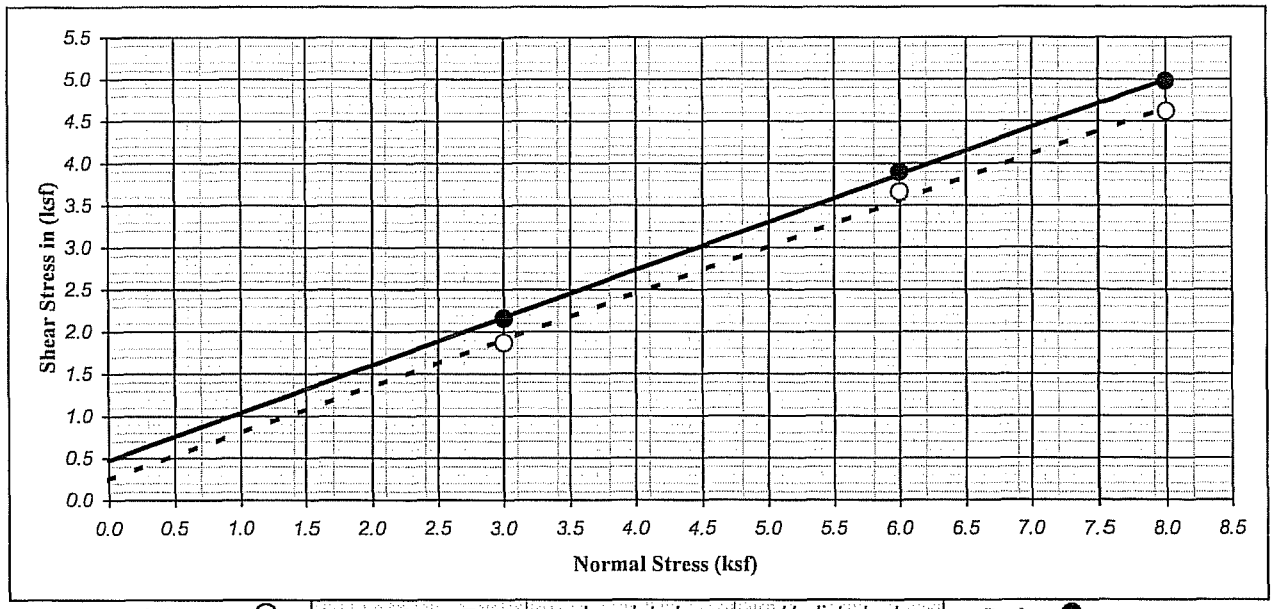
Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-058		**Saturated**		**Field Moisture**	X	**Inundated**		**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-10	X	**Undisturbed**		**Remolded**		**Consolidated-Drained**		**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 50.0	x	**Shear Once**		**Reshear**		**Residual**		**Data File Number :** 0612311	
Description : Dark gray, SILTY CLAYEY SAND (SC-SM)									

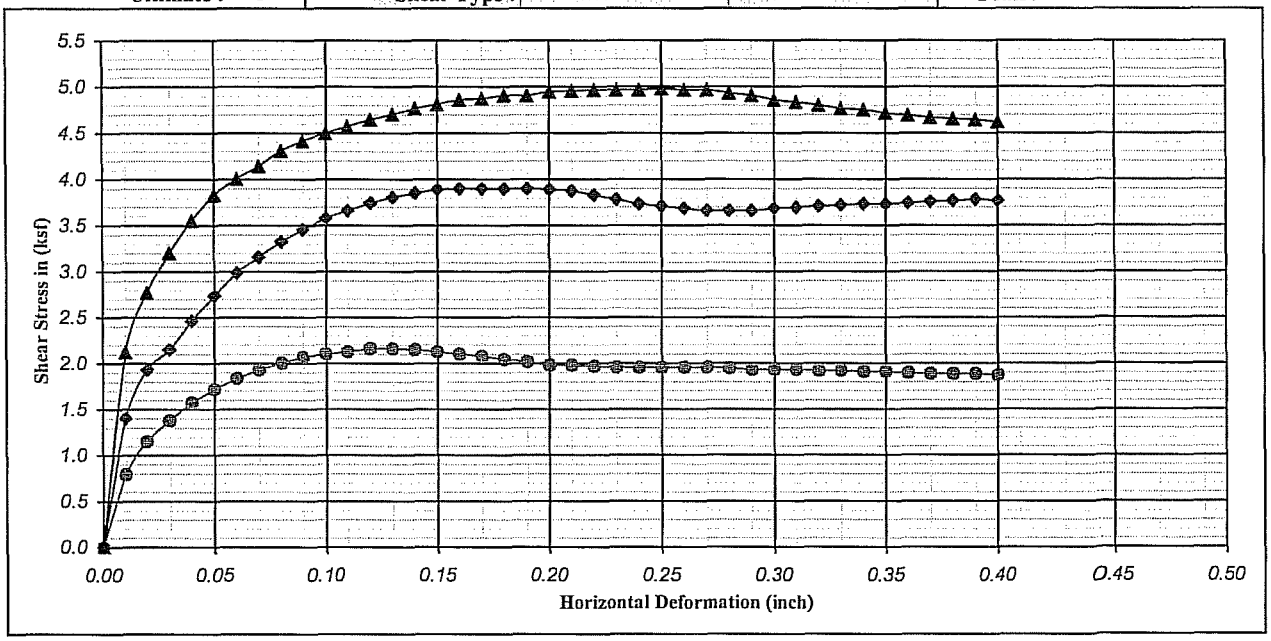
Percent Saturation (%)	95.59	**File No. :** 0612311 1																					
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																					
Tested By : JF	**Date :** 11/30/09																						
Computed By : JF	**Date :** 12/11/09	**3.00** (ksf)																					
Checked By :	**Date :**																						
Percent Consolidation (%)		**Before**		**After**																			
Height of Sample (inch)		1.00		1.0000																			
Diameter of Sample (inch)		2.42		2.42																			
Dial Reading-Consolidation (inch)																							
Weight of Soil + Ring (gm)		188.06																					
Weight of Ring (gm)		38.44																					
Weight of Wet Soil + Cont. (gm)				151.88																			
Weight of Dry Soil + Cont. (gm)				122.65																			
Weight of Cont. (gm) No.	1			3.84																			
Moisture Content (%)				24.60																			
Wet Density (pcf / kN/m³)		123.92	19.50																				
Dry Density (pcf / kN/m³)		99.45	15.65																				
Percent Saturation (%)	95.03	**File No. :** 0612311 2																					
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																					
Tested By : JF	**Date :** 11/30/09	**6.00** (ksf)																					
Percent Consolidation (%)		**Before**		**After**																			
Height of Sample (inch)		1.00		1.0000																			
Diameter of Sample (inch)		2.42		2.42																			
Dial Reading-Consolidation (inch)																							
Weight of Soil + Ring (gm)		194.82																					
Weight of Ring (gm)		46.15																					
Weight of Wet Soil + Cont. (gm)				149.51																			
Weight of Dry Soil + Cont. (gm)				120.34																			
Weight of Cont. (gm) No.	2			3.93																			
Moisture Content (%)				25.06																			
Wet Density (pcf / kN/m³)		123.13	19.38																				
Dry Density (pcf / kN/m³)		98.46	15.50																				
Percent Saturation (%)	101.33	**File No. :** 0612311 3																					
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																					
Tested By : JF	**Date :** 11/30/09	**8.00** (ksf)																					
Percent Consolidation (%)		**Before**		**After**																			
Height of Sample (inch)		1.00		1.0000																			
Diameter of Sample (inch)		2.42		2.42																			
Dial Reading-Consolidation (inch)																							
Weight of Soil + Ring (gm)		190.63																					
Weight of Ring (gm)		43.52																					
Weight of Wet Soil + Cont. (gm)				148.62																			
Weight of Dry Soil + Cont. (gm)				115.24																			
Weight of Cont. (gm) No.	3			3.73																			
Moisture Content (%)				29.93																			
Wet Density (pcf / kN/m³)		121.84	19.18																				
Dry Density (pcf / kN/m³)		93.77	14.76																				

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	2.16	103.42	3.90	186.73	4.98	238.44
Ultimate	1.87	89.63	3.66	175.24	4.62	221.21

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		3000	3.00	143.6	6000	6.0	287.3	8000	8.0	383.0
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	792	0.79	37.9	1404	1.40	67.2	2124	2.12	101.3
0.020	0.05	1152	1.15	55.2	1932	1.93	92.5	2772	2.77	132.2
0.030	0.08	1380	1.38	66.1	2148	2.15	102.8	3204	3.20	152.8
0.040	0.10	1572	1.57	75.3	2460	2.46	117.8	3552	3.55	169.4
0.050	0.13	1716	1.72	82.2	2736	2.74	131.0	3828	3.83	182.6
0.060	0.15	1836	1.84	87.9	2988	2.99	143.1	4008	4.01	191.2
0.070	0.18	1932	1.93	92.5	3156	3.16	151.1	4140	4.14	197.5
0.080	0.20	2004	2.00	96.0	3324	3.32	159.2	4308	4.31	205.5
0.090	0.23	2064	2.06	98.8	3456	3.46	165.5	4416	4.42	210.7
0.100	0.25	2100	2.10	100.5	3576	3.58	171.2	4500	4.50	214.7
0.110	0.28	2124	2.12	101.7	3660	3.66	175.2	4572	4.57	218.1
0.120	0.30	2160	2.16	103.4	3744	3.74	179.3	4644	4.64	221.5
0.130	0.33	2160	2.16	103.4	3804	3.80	182.1	4704	4.70	224.4
0.140	0.36	2148	2.15	102.8	3852	3.85	184.4	4764	4.76	227.3
0.150	0.38	2124	2.12	101.7	3888	3.89	186.2	4812	4.81	229.5
0.160	0.41	2100	2.10	100.5	3900	3.90	186.7	4860	4.86	231.8
0.170	0.43	2076	2.08	99.4	3900	3.90	186.7	4872	4.87	232.4
0.180	0.46	2040	2.04	97.7	3900	3.90	186.7	4908	4.91	234.1
0.190	0.48	2016	2.02	96.5	3900	3.90	186.7	4908	4.91	234.1
0.200	0.51	1980	1.98	94.8	3888	3.89	186.2	4944	4.94	235.8
0.210	0.53	1980	1.98	94.8	3876	3.88	185.6	4956	4.96	236.4
0.220	0.56	1968	1.97	94.2	3828	3.83	183.3	4968	4.97	237.0
0.230	0.58	1956	1.96	93.7	3780	3.78	181.0	4968	4.97	237.0
0.240	0.61	1956	1.96	93.7	3732	3.73	178.7	4968	4.97	237.0
0.250	0.64	1956	1.96	93.7	3708	3.71	177.5	4980	4.98	237.6
0.260	0.66	1956	1.96	93.7	3684	3.68	176.4	4968	4.97	237.0
0.270	0.69	1956	1.96	93.7	3660	3.66	175.2	4968	4.97	237.0
0.280	0.71	1944	1.94	93.1	3660	3.66	175.2	4932	4.93	235.3
0.290	0.74	1932	1.93	92.5	3660	3.66	175.2	4908	4.91	234.1
0.300	0.76	1932	1.93	92.5	3684	3.68	176.4	4860	4.86	231.8
0.310	0.79	1932	1.93	92.5	3696	3.70	177.0	4836	4.84	230.7
0.320	0.81	1920	1.92	91.9	3708	3.71	177.5	4800	4.80	229.0
0.330	0.84	1920	1.92	91.9	3720	3.72	178.1	4764	4.76	227.3
0.340	0.86	1908	1.91	91.4	3732	3.73	178.7	4752	4.75	226.7
0.350	0.89	1908	1.91	91.4	3732	3.73	178.7	4716	4.72	225.0
0.360	0.91	1896	1.90	90.8	3744	3.74	179.3	4692	4.69	223.8
0.370	0.94	1884	1.88	90.2	3756	3.76	179.8	4668	4.67	222.7
0.380	0.97	1884	1.88	90.2	3768	3.77	180.4	4656	4.66	222.1
0.390	0.99	1884	1.88	90.2	3780	3.78	181.0	4644	4.64	221.5
0.400	1.02	1872	1.87	89.6	3768	3.77	180.4	4620	4.62	220.4
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No. : *A-09-058*		**Strength Intercept (C) :**	*0.48*	(ksf)		*0.25*	(ksf)	
Sample No. : *D-10*			*22.83*	(kPa)	**Peak**	*11.91*	(kPa)	**Ultimate**
Depth (ft/m) : *50.0*	*0.00*	**Friction Angle (ϕ) :**	*29.48*	Degree		*28.95*	Degree	

Description : *Dark gray, SILTY CLAYEY SAND (SC-SM)* **Shear Rate** (inch/minute) : *0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*24.60*	*99.45*	*15.65*	*0.69*	*3.00*	*143.64*	*2.16*	*103.42*	*1.87*	*89.63*
◆	*25.06*	*98.46*	*15.50*	*0.71*	*6.00*	*287.28*	*3.90*	*186.73*	*3.66*	*175.24*
▲	*29.93*	*93.77*	*14.76*	*0.80*	*8.00*	*383.04*	*4.98*	*238.44*	*4.62*	*221.21*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* **Date :** *11/30/09*

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

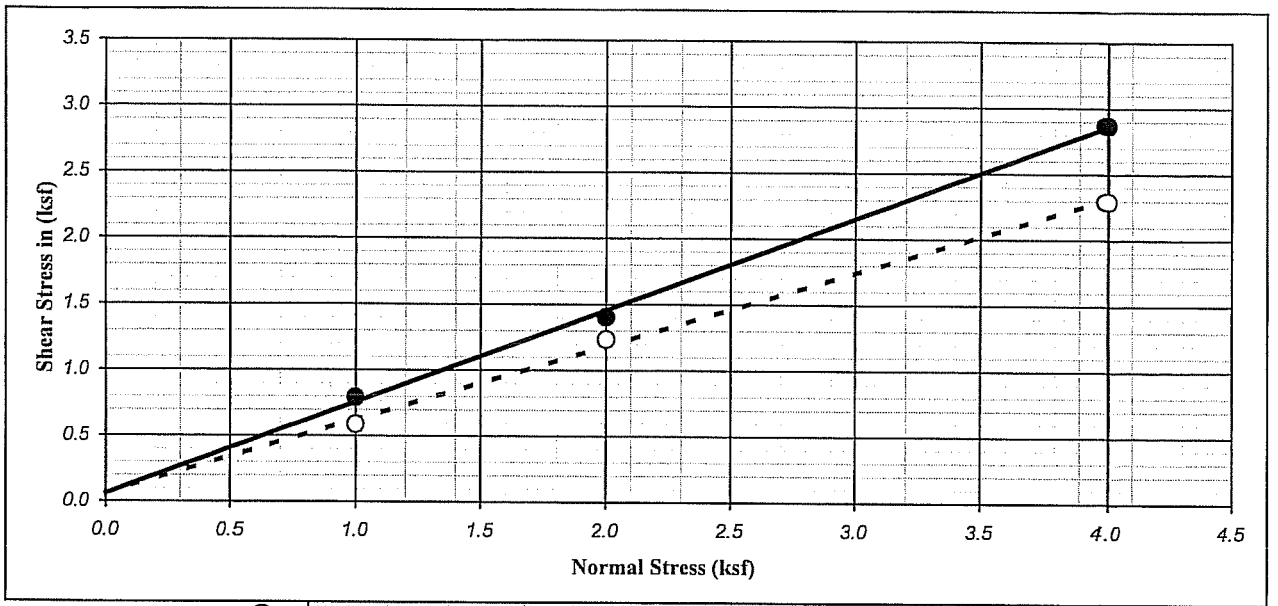
Boring No. : A-09-059		**Saturated**		**Field Moisture**	X	**Inundated**		**Specific Gravity** (Assumed) :	2.70
Sample No. : D-2	X	**Undisturbed**		**Remolded**		**Consolidated-Drained**		**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 10.0	x	**Shear Once**		**Reshear**		**Residual**		**Data File Number :**	0911812

Description : Dark grayish brown, Poorly graded SAND with SILT (SP-SM)

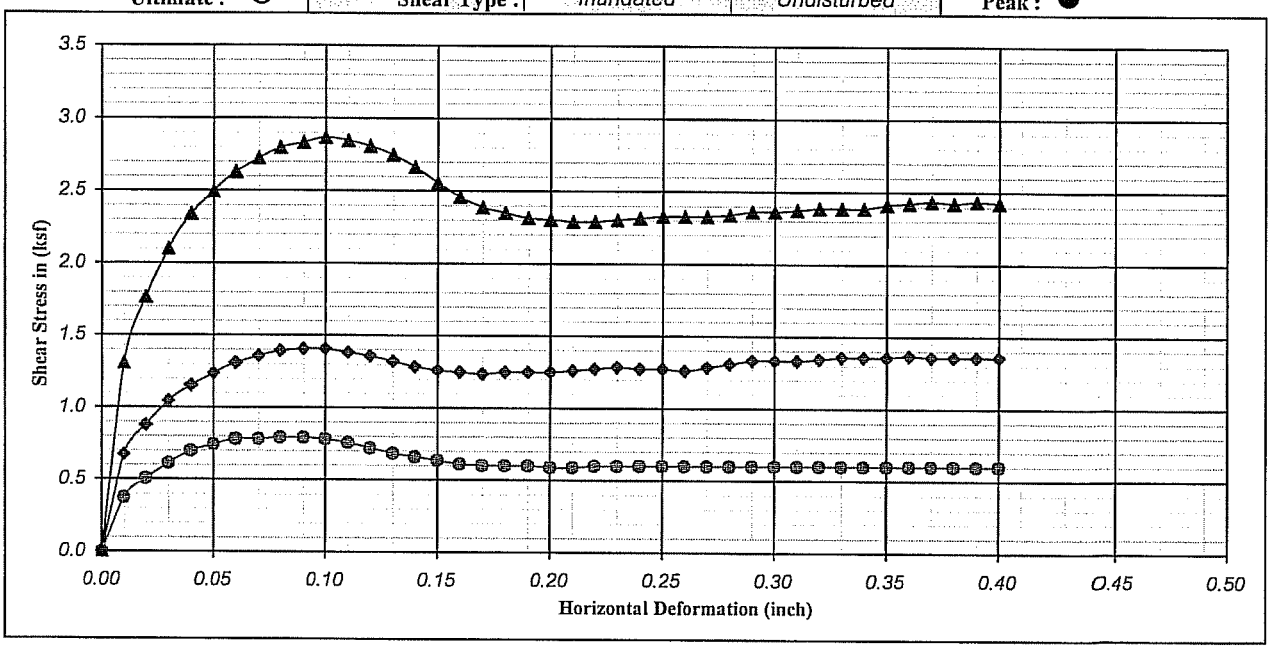
Percent Saturation (%)	90.33		**File No. :** 0911812 1																		
Prepared By : JF	**Date :** 11/30/09		**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09																				
Computed By : JF	**Date :** 12/11/09		**1.00**	(ksf)																	
Checked By :	**Date :**																				
Percent Consolidation (%)		**Before**	**After**																		
Height of Sample (inch)		1.00	1.0000																		
Diameter of Sample (inch)		2.42	2.42																		
Dial Reading-Consolidation (inch)																					
Weight of Soil + Ring (gm)		187.47																			
Weight of Ring (gm)		45.05																			
Weight of Wet Soil + Cont. (gm)			144.89																		
Weight of Dry Soil + Cont. (gm)			114.45																		
Weight of Cont. (gm) **No.**	4		3.77																		
Moisture Content (%)			27.50																		
Wet Density (pcf / kN/m³)		117.96	18.57																		
Dry Density (pcf / kN/m³)		92.51	14.56																		
Percent Saturation (%)	82.64		**File No. :** 0911812 2																		
Prepared By : JF	**Date :** 11/30/09		**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09		**2.00**	(ksf)																	
Percent Consolidation (%)		**Before**	**After**																		
Height of Sample (inch)		1.00	1.0000																		
Diameter of Sample (inch)		2.42	2.42																		
Dial Reading-Consolidation (inch)																					
Weight of Soil + Ring (gm)		182.44																			
Weight of Ring (gm)		45.07																			
Weight of Wet Soil + Cont. (gm)			141.48																		
Weight of Dry Soil + Cont. (gm)			112.22																		
Weight of Cont. (gm) **No.**	5		3.71																		
Moisture Content (%)			26.97																		
Wet Density (pcf / kN/m³)		113.77	17.91																		
Dry Density (pcf / kN/m³)		89.61	14.10																		
Percent Saturation (%)	90.88		**File No. :** 0911812 3																		
Prepared By : JF	**Date :** 11/30/09		**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09		**4.00**	(ksf)																	
Percent Consolidation (%)		**Before**	**After**																		
Height of Sample (inch)		1.00	1.0000																		
Diameter of Sample (inch)		2.42	2.42																		
Dial Reading-Consolidation (inch)																					
Weight of Soil + Ring (gm)		188.05																			
Weight of Ring (gm)		45.06																			
Weight of Wet Soil + Cont. (gm)			146.51																		
Weight of Dry Soil + Cont. (gm)			115.84																		
Weight of Cont. (gm) **No.**	6		3.72																		
Moisture Content (%)			27.35																		
Wet Density (pcf / kN/m³)		118.43	18.64																		
Dry Density (pcf / kN/m³)		92.99	14.64																		

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.79	37.92	1.40	67.22	2.87	137.32
Ultimate	0.59	28.15	1.24	59.18	2.29	109.74

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)** 1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
		Shear Stress (psf/ksf/kPa) 0.00	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	372	0.37	17.8	672	0.67	32.2	1308	1.31	62.4
0.020	0.05	504	0.50	24.1	876	0.88	41.9	1764	1.76	84.1
0.030	0.08	612	0.61	29.3	1044	1.04	50.0	2100	2.10	100.2
0.040	0.10	696	0.70	33.3	1152	1.15	55.2	2340	2.34	111.6
0.050	0.13	744	0.74	35.6	1236	1.24	59.2	2496	2.50	119.1
0.060	0.15	780	0.78	37.3	1308	1.31	62.6	2628	2.63	125.4
0.070	0.18	780	0.78	37.3	1356	1.36	64.9	2724	2.72	129.9
0.080	0.20	792	0.79	37.9	1392	1.39	66.6	2796	2.80	133.4
0.090	0.23	792	0.79	37.9	1404	1.40	67.2	2832	2.83	135.1
0.100	0.25	780	0.78	37.3	1404	1.40	67.2	2868	2.87	136.8
0.110	0.28	756	0.76	36.2	1380	1.38	66.1	2844	2.84	135.7
0.120	0.30	720	0.72	34.5	1356	1.36	64.9	2808	2.81	133.9
0.130	0.33	684	0.68	32.7	1320	1.32	63.2	2748	2.75	131.1
0.140	0.36	660	0.66	31.6	1284	1.28	61.5	2664	2.66	127.1
0.150	0.38	636	0.64	30.5	1260	1.26	60.3	2556	2.56	121.9
0.160	0.41	612	0.61	29.3	1248	1.25	59.8	2460	2.46	117.3
0.170	0.43	600	0.60	28.7	1236	1.24	59.2	2388	2.39	113.9
0.180	0.46	600	0.60	28.7	1248	1.25	59.8	2352	2.35	112.2
0.190	0.48	600	0.60	28.7	1248	1.25	59.8	2316	2.32	110.5
0.200	0.51	588	0.59	28.2	1248	1.25	59.8	2304	2.30	109.9
0.210	0.53	588	0.59	28.2	1260	1.26	60.3	2292	2.29	109.3
0.220	0.56	600	0.60	28.7	1272	1.27	60.9	2292	2.29	109.3
0.230	0.58	600	0.60	28.7	1284	1.28	61.5	2304	2.30	109.9
0.240	0.61	600	0.60	28.7	1272	1.27	60.9	2316	2.32	110.5
0.250	0.64	600	0.60	28.7	1272	1.27	60.9	2328	2.33	111.1
0.260	0.66	600	0.60	28.7	1260	1.26	60.3	2328	2.33	111.1
0.270	0.69	600	0.60	28.7	1284	1.28	61.5	2328	2.33	111.1
0.280	0.71	600	0.60	28.7	1308	1.31	62.6	2340	2.34	111.6
0.290	0.74	600	0.60	28.7	1332	1.33	63.8	2364	2.36	112.8
0.300	0.76	600	0.60	28.7	1332	1.33	63.8	2364	2.36	112.8
0.310	0.79	600	0.60	28.7	1332	1.33	63.8	2376	2.38	113.3
0.320	0.81	600	0.60	28.7	1344	1.34	64.4	2388	2.39	113.9
0.330	0.84	600	0.60	28.7	1356	1.36	64.9	2388	2.39	113.9
0.340	0.86	600	0.60	28.7	1356	1.36	64.9	2388	2.39	113.9
0.350	0.89	600	0.60	28.7	1356	1.36	64.9	2412	2.41	115.1
0.360	0.91	600	0.60	28.7	1368	1.37	65.5	2424	2.42	115.6
0.370	0.94	600	0.60	28.7	1356	1.36	64.9	2436	2.44	116.2
0.380	0.97	600	0.60	28.7	1356	1.36	64.9	2424	2.42	115.6
0.390	0.99	600	0.60	28.7	1356	1.36	64.9	2436	2.44	116.2
0.400	1.02	600	0.60	28.7	1356	1.36	64.9	2424	2.42	115.6
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-059		Strength Intercept (C) :	0.06	(ksf)	Peak	0.06	(ksf)	Ultimate
Sample No. : D-2			2.87	(kPa)		2.87	(kPa)	
Depth (ft/m) : 10.0	0.00	Friction Angle (ϕ) :	34.90	Degree		29.35	Degree	

Description : Dark grayish brown, Poorly graded SAND with SILT (SP-SM) — Shear Rate (inch/minute) : 0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	27.50	92.51	14.56	0.82	1.00	47.88	0.79	37.92	0.59	28.15
◆	26.97	89.61	14.10	0.88	2.00	95.76	1.40	67.22	1.24	59.18
▲	27.35	92.99	14.64	0.81	4.00	191.52	2.87	137.32	2.29	109.74

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

MEASUREMENT OF SOIL CORROSIVITY

Project No.	: 06-123-3	Project Name : ACTA/Schuyler Heim Bridge Project	
Boring No.	: A-09-058	Depth (ft/m) : 5.00	1.53
Sample No.	: S-1	Description : Dark olive-gray, Poorly graded SAND (SP)	

*** Sample for Corrosivity tests must screen through No. 8 Sieve

Measurement of Soil Resistivity (ASTM G-57-78 / CT- 643)

Test Standard	ASTM	X	CAL. TRAN.	Wt of Wet Soil + Cont. (gm)	122.08	Weight of Total Sample for Test (gm)
Soil Box Diamension (cm)	22.86 X 3.81 X 2.54		15.31 X 10.04 X4.41	Wt of Dry Soil + Cont. (gm)	120.09	
(L X W X H) / (inch)	9.0 X 1.5 X 1.0		6.04X 3.95 X 1.74	Wt. of Cont. No. 2	58.66	101.22
Soil Box Constant (C)	1.0		6.72	Setup Moisture Content (%)	3.24	

Trial	Resistivity Meter Reading (ohm-cm)							
	As received	1	2	3	4	5		
Water added	0.0	5.00	5.00	5.00	5.00	5.00	Prepared By : PA	Date : 12/14/09
Meter reading	81000	31000	18000	10000	9300	9300	Tested By : PA	Date : 12/15/09
Resistivity	81000.0	31000.0	18000.0	10000.0	9300.0	9300.0	Calculated By : JF	Date : 12/17/09
							Checked By :	Date :
							Minimum Resistivity :	9300.0

Measurement of Soil pH (ASTM G-51-77 / CT- 643)

Weight 30 gm soil sample and add 30 ml distilled water, stir to a soil slurry and settle at least 1 hr.

Prepared By :	Date : 12/14/09	Time : 14:48	Beaker No. : 29	pH Reading					
Tested By :	Date : 12/15/09	Weigh of Wetsoil (gm)	30.03	Trial	1	2	3	Average	
Calculated By :	Date : 12/17/09	Distilled Water added (ml)	30.04	Test Time	13:40:00	13:42:00	13:44:00		
Checked By :	Date :	Moisture Content (%)	3.24	Reading	8.57	8.63	8.67	8.62	

Measurement of Soil Soluble Sulfate Content (CT - 417)

Weight 100.0 gm of sample soil & add 300 ml. of distilled water. Stopper and shake well. Allow to settle overnight. Prepare two 30 (ml.) of water layer into a 150 (ml.) beaker, dilute to 100 (ml.), add 5 (ml.) conditioning reagent. Turbidity Blank - Adjust the stirrer to the maximum speed, add 1 spoonfull Barium Chloride & start timing. Stir for exactly 1 minute.

Flask No. :	8	Prepared By :		Date :	12/14/09
Weight of Soil (gm) :	100.01	Tested By :		Date :	12/15/09
Distilled Water (ml.) :	300.05	Calculated By :		Date :	12/17/09
Shaking at :	14:49:00	Checked By :		Date :	
Reshaking at :					

Total Water Sample Prepared	60.07	With BaCL		18	< Beaker Number >			19	Blank
Distilled Water added to (ml)	200.18			100.08	Tested Sample Volume			100.1	
Time Intervals	0:00:00	0:00:30	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:04:00	Maximum
With BaCL (time)	14:23:00	14:23:30	14:24:00	14:24:30	14:25:00	14:25:30	14:26:00	14:27:00	
Turbidity with BaCL (NTV)		29.30	29.20	29.20	28.90	28.70	28.70	28.90	29.30
Blank (time)	14:18:00	14:18:30	14:19:00	14:19:30	14:20:00	14:20:30	14:21:00	14:22:00	
Turbidity Blank (NTV)		18.10	17.60	17.10	17.00	16.70	16.50	16.40	18.10
Difference (ppm)		11.20	11.60	12.10	11.90	12.00	12.20	12.50	11.20
SO_4 (from graph) (ppm)									30

Measurement of Soil Chloride Content (CT - 422)

1. Weight 100.0 gm sample soil & add 300 ml. of distilled water. Stopper and shake vigorously for 20 seconds, reshaking after one hour and let it settle over night. 2. Pour 30 ml aliquot of filtered solution into a 150 ml beaker, then check pH. If pH is in the range 6 through 8, go to step 4. If ph below 6, add Sodium Hydroxide and if above 8, add Acetic Acid to adjust to the range. 4. Add two drops of Potassium Chromate solution before titrate with Silver Nitrate and change color from Yellow to Red. ** If the titration is over 30 ml., take a smaller sample. Dilute any smaller sample to about 50 ml..

Flask No. :	8	Prepared By :		Date :	12/14/09
Wt. of Soil (gm) :	100.01	Tested By :		Date :	12/15/09
Distilled Water (ml) :	300.05	Calculated By :		Date :	12/17/09
Shaking at :	14:49:00	Checked By :		Date :	
Reshaking at :		Vaccum & Filter at :			
Remark :					

Titration of (I ml.) Sample Diluted to (F ml.)	5	< Beaker No.			8	
Total Sample Prepared : 60.13	Initial	Final	Total	Initial	Final	Total
Sample Volume (ml)	30.06	30.06		30.07	30.07	
pH of Liquid Sample	7.57	7.57		7.57	7.57	
Sodium Hydroxide added (ml)	-	-	-	-	-	-
Acetic Acid added (ml)	-	-	-	-	-	-
Silver Nitrate added (ml)	14.20	16.80	2.60	16.80	19.40	2.60
ppm CL= 100x(ml of Sil.Ni.-0.2 ml blank)*F/I			240.00			240.00
Moisture - Free CL = ppm CL X 100 / (100 - w)			248.03			248.03

Average
240.00
248

MEASUREMENT OF SOIL CORROSIVITY

Project No.	: 06-123-3	**Project Name :** ACTA/Schuyler Heim Bridge Project	
Boring No.	: A-09-059	**Depth (ft/m) :** 5.00	1.53
Sample No.	: S-1	**Description :** Dark olive-gray, SILTY SAND (SM)	

*** Sample for Corrosivity tests must screen through No. 8 Sieve

Measurement of Soil Resistivity (ASTM G-57-78 / CT- 643)

Test Standard	ASTM	X	CAL. TRAN.	Wt of Wet Soil + Cont. (gm)	145.53	Weight of Total
Soil Box Diamension (cm)	22.86 X 3.81 X 2.54		15.31 X 10.04 X4.41	Wt of Dry Soil + Cont. (gm)	142.15	Sample for Test (gm)
(L X W X H) / (inch)	9.0 X 1.5 X 1.0		6.04X 3.95 X 1.74	Wt. of Cont. No. 1	57.24	101.24
Soil Box Constant (C)	1.0		6.72	Setup Moisture Content (%)	3.98	

Trial	Resistivity Meter Reading (ohm-cm)							
	As received	1	2	3	4	5		
Water added	0.0	5.00	5.00	5.00	5.00	5.00	Prepared By : PA	Date : 12/14/09
Meter reading	21000	4600	2800	1700	1300	1400	Tested By : PA	Date : 12/15/09
Resistivity	21000.0	4600.0	2800.0	1700.0	1300.0	1400.0	Calculated By : JF	Date : 12/17/09
							Checked By :	Date :
							Minimum Resistivity :	1300.0

Measurement of Soil pH (ASTM G-51-77 / CT- 643)

Weight 30 gm soil sample and add 30 ml distilled water, stir to a soil slurry and settle at least 1 hr.

Prepared By :	Date : 12/14/09	Time : 14:57	Beaker No. : 37	pH Reading				
Tested By :	Date : 12/15/09	Weigh of Wetsoil (gm)	30.03	Trial	1	2	3	Average
Calculated By :	Date : 12/17/09	Distilled Water added (ml)	30.01	Test Time	13:34:00	13:36:00	13:38:00	
Checked By :	Date :	Moisture Content (%)	3.98	Reading	8.07	8.05	8.05	8.06

Measurement of Soil Soluble Sulfate Content (CT - 417)

Weight 100.0 gm of sample soil & add 300 ml. of distilled water. Stopper and shake well. Allow to settle overnight. Prepare two 30 (ml.) of water layer into a 150 (ml.) beaker, dilute to 100 (ml.), add 5 (ml.) conditioning reagent. Turbidity Blank - Adjust the stirrer to the maximum speed, add 1 spoonfull Barium Chloride & start timing. Stir for exactly 1 minute.

Flask No. : 38	Prepared By :	Date :	12/14/09
Weight of Soil (gm) : 100.02	Tested By :	Date :	12/15/09
Distilled Water (ml.) : 300.08	Calculated By :	Date :	12/17/09
Shaking at : 15:11:00	Checked By :	Date :	
Reshaking at :			

Total Water Sample Prepared	60.03	With BaCL		16	< Beaker Number >			17	Blank
Distilled Water added to (ml)	200.1			100.04	Tested Sample Volume			100.06	
Time Intervals	0:00:00	0:00:30	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:04:00	Maximum
With BaCL (time)	14:44:00	14:44:30	14:45:00	14:45:30	14:46:00	14:46:30	14:47:00	14:48:00	
Turbidity with BaCL (NTV)		225.00	222.00	220.00	214.00	212.00	212.00	210.00	225.00
Blank (time)	14:39:00	14:39:30	14:40:00	14:40:30	14:41:00	14:41:30	14:42:00	14:43:00	
Turbidity Blank (NTV)		41.20	35.60	31.70	28.30	26.10	24.30	23.70	41.20
Difference (ppm)		183.80	186.40	188.30	185.70	185.90	187.70	186.30	183.80
SO_4 (from graph) (ppm)									380

Measurement of Soil Chloride Content (CT - 422)

*1. Weight 100.0 gm sample soil & add 300 ml. of distilled water. Stopper and shake vigorously for 20 seconds, reshaking after one hour and let it settle over night. 2. Pour 30 ml aliquot of filtered solution into a 150 ml beaker, then check pH. If pH is in the range 6 through 8, go to step 4. If ph below 6, add Sodium Hydroxide and if above 8, add Acetic Acid to adjust to the range. 4. Add two drops of Potassium Chromate solution before titrate with Silver Nitrate and change color from Yellow to Red. ** If the titration is over 30 ml., take a smaller sample. Dilute any smaller sample to about 50 ml..*

Flask No. : 38	Prepared By :	Date :	12/14/09
Wt. of Soil (gm) : 100.02	Tested By :	Date :	12/15/09
Distilled Water (ml.) : 300.08	Calculated By :	Date :	12/17/09
Shaking at : 15:11:00	Checked By :	Date :	
Reshaking at :	Vaccum & Filter at :		

Remark :

Titration of (I ml.) Sample Diluted to (F ml.)		16	< Beaker No.			20	
Total Sample Prepared :	60.07	Initial	Final	Total	Initial	Final	Total	
Sample Volume (ml)		30.03	30.03		30.04	30.04		
pH of Liquid Sample		7.24	7.24		7.24	7.24		
Sodium Hydroxide added (ml)		-	-	-	-	-	-	
Acetic Acid added (ml)		-	-	-	-	-	-	Average
Silver Nitrate added (ml)		19.40	24.80	5.40	24.80	30.20	5.40	
ppm CL= 100x(ml of Sil.Ni.-0.2 ml blank)*F/I				520.00			520.00	520.00
Moisture - Free CL = ppm CL X 100 / (100 - w)				541.56			541.56	542

APPENDIX D. SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

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COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
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Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

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——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

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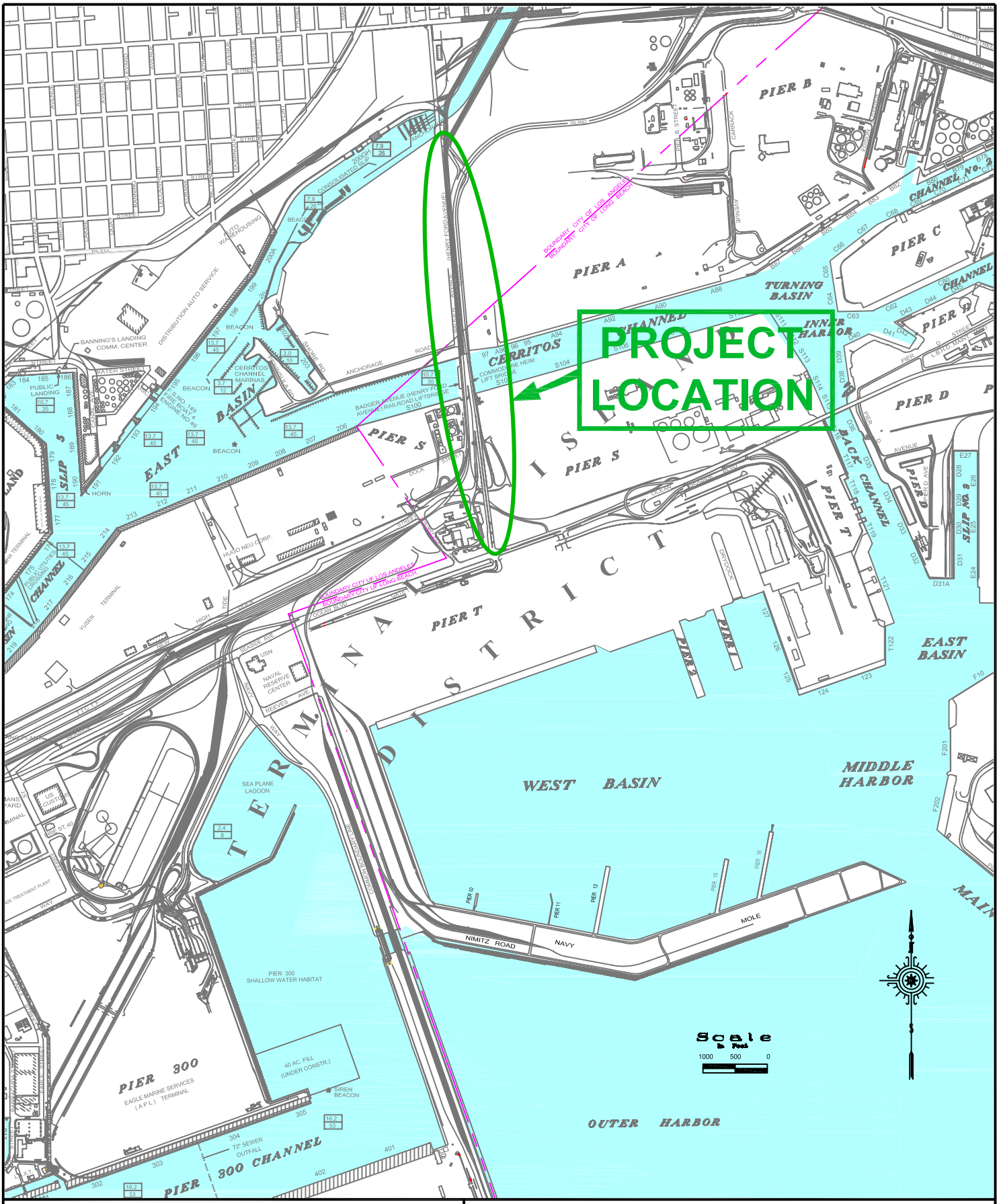


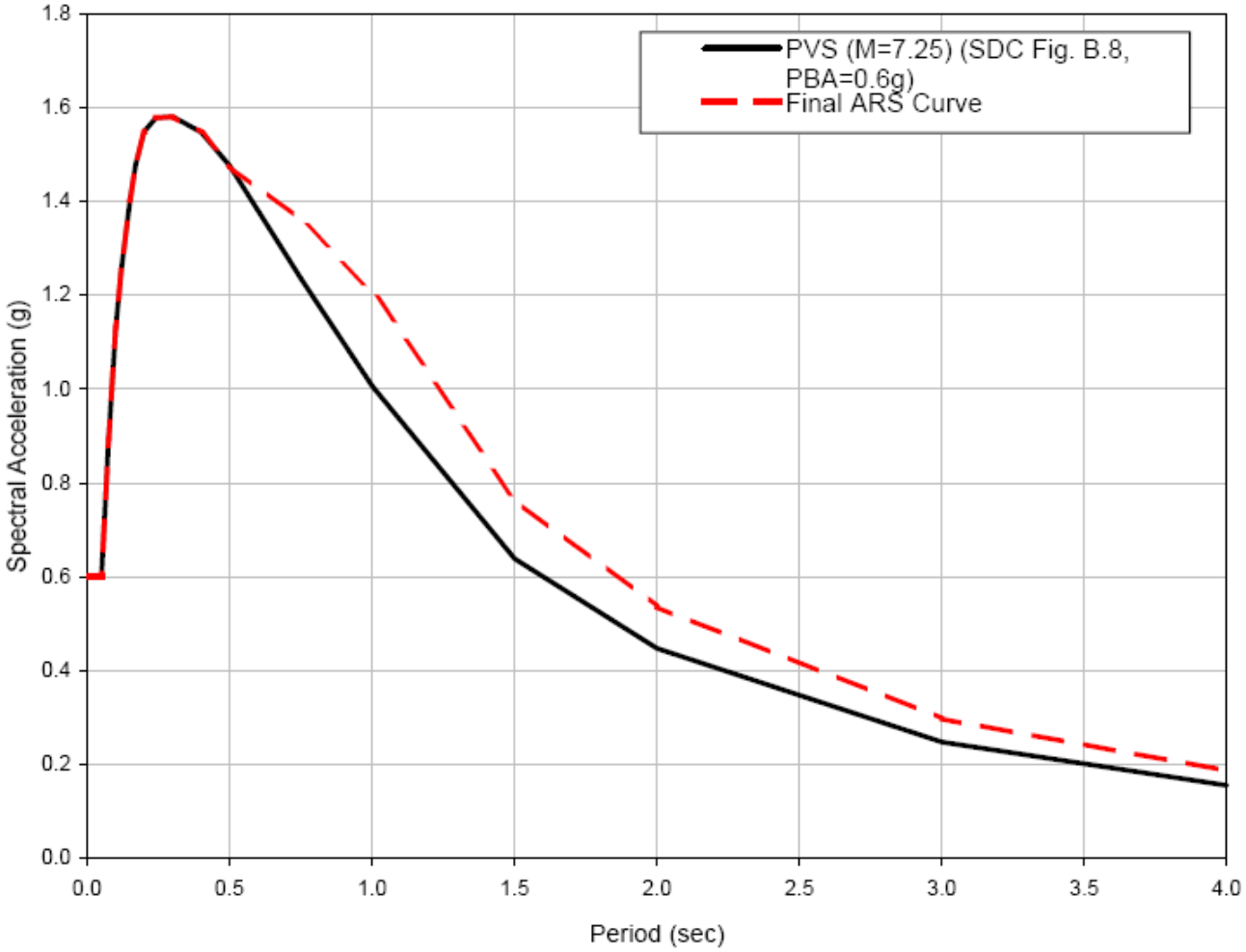
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

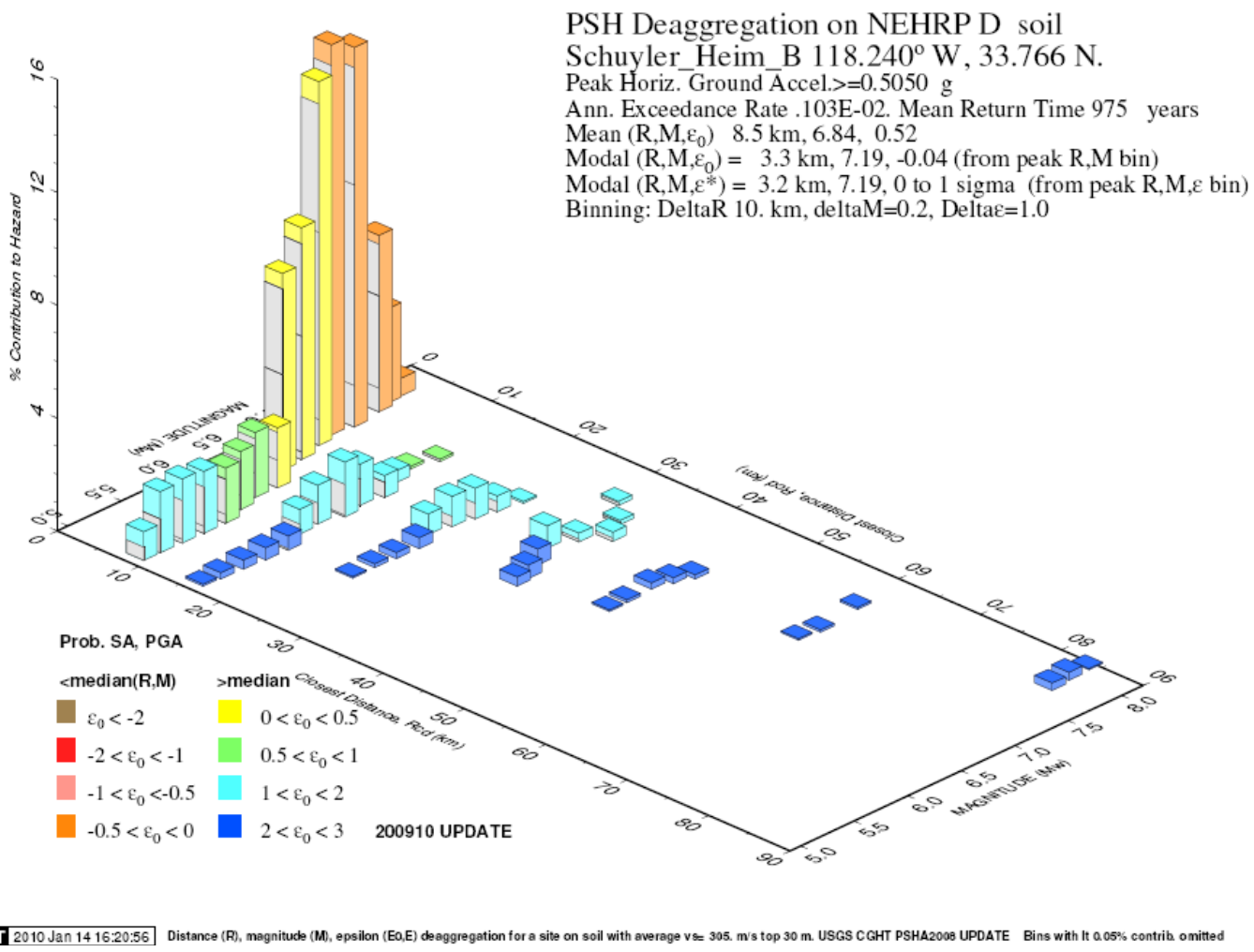


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

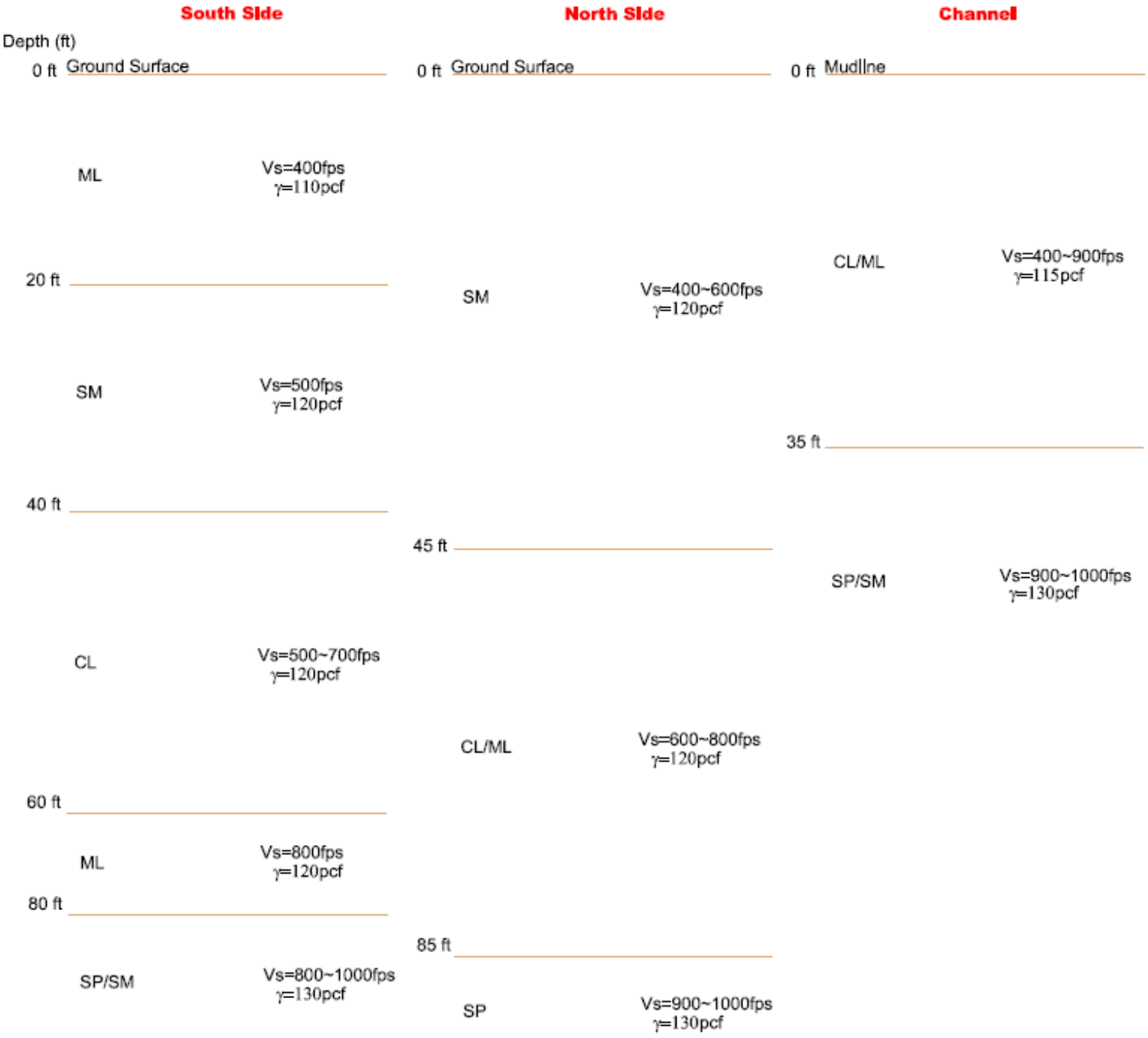
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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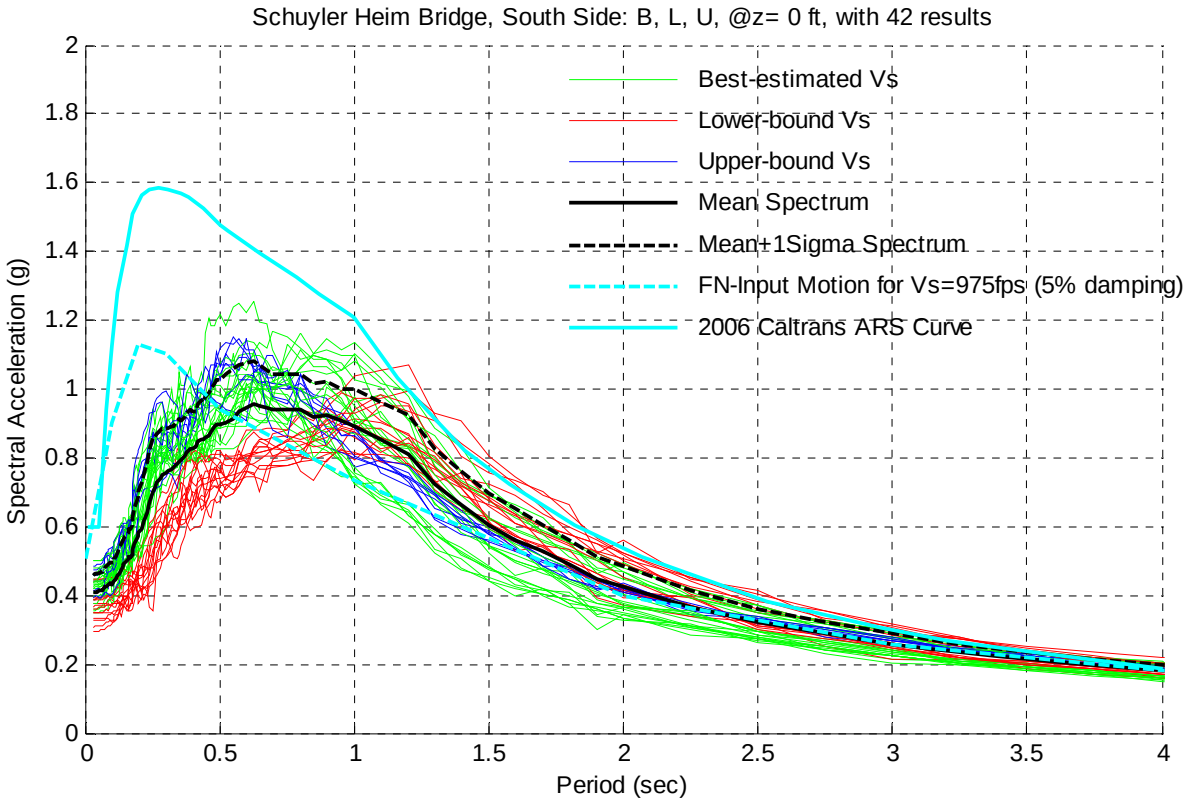
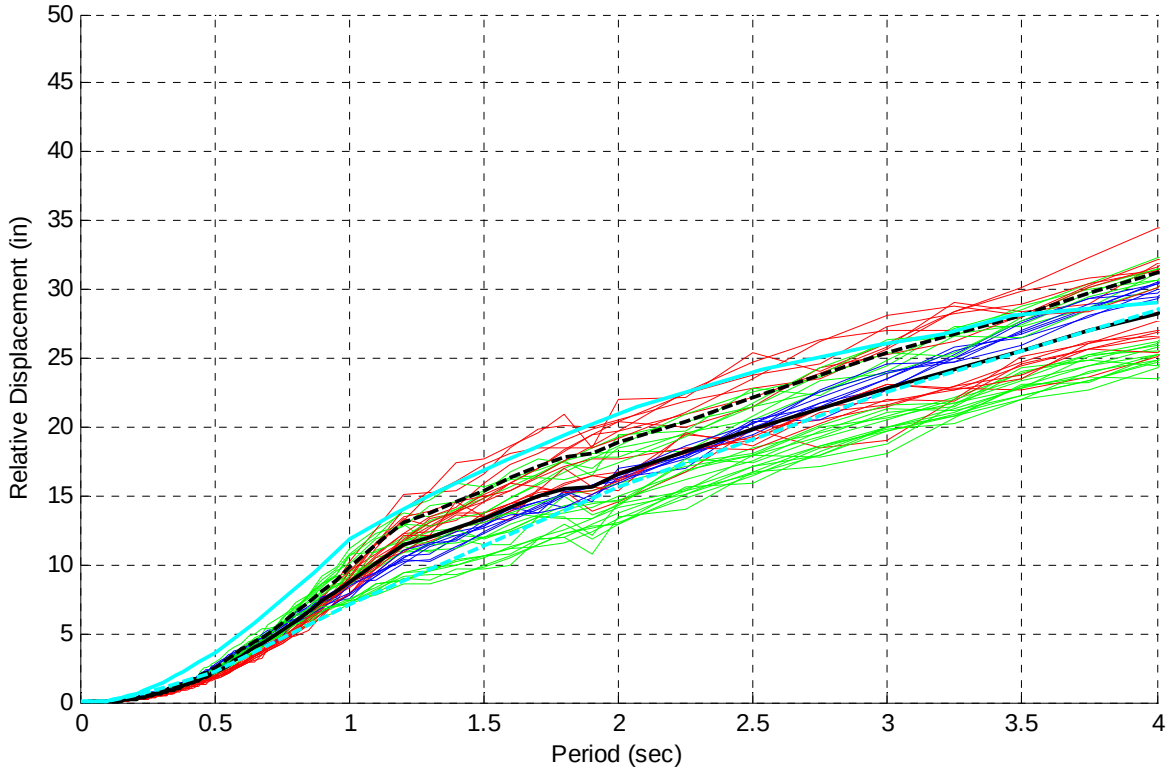
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





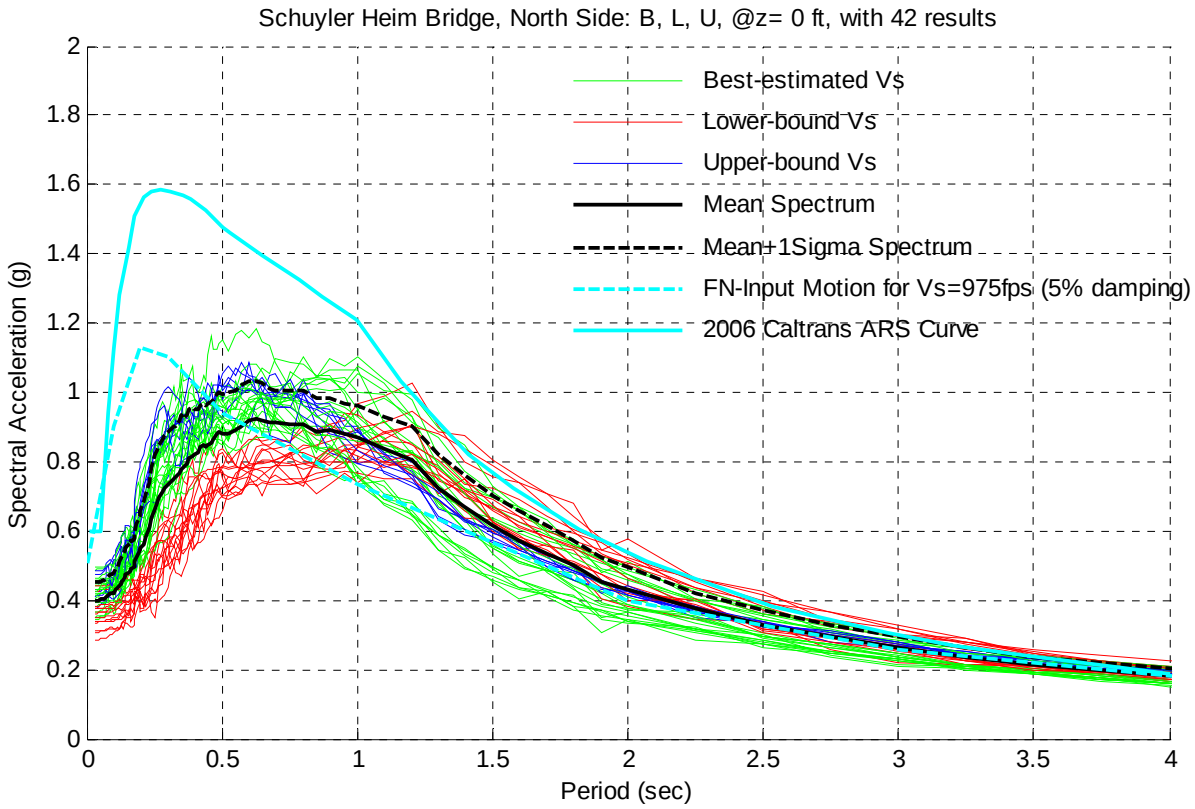
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

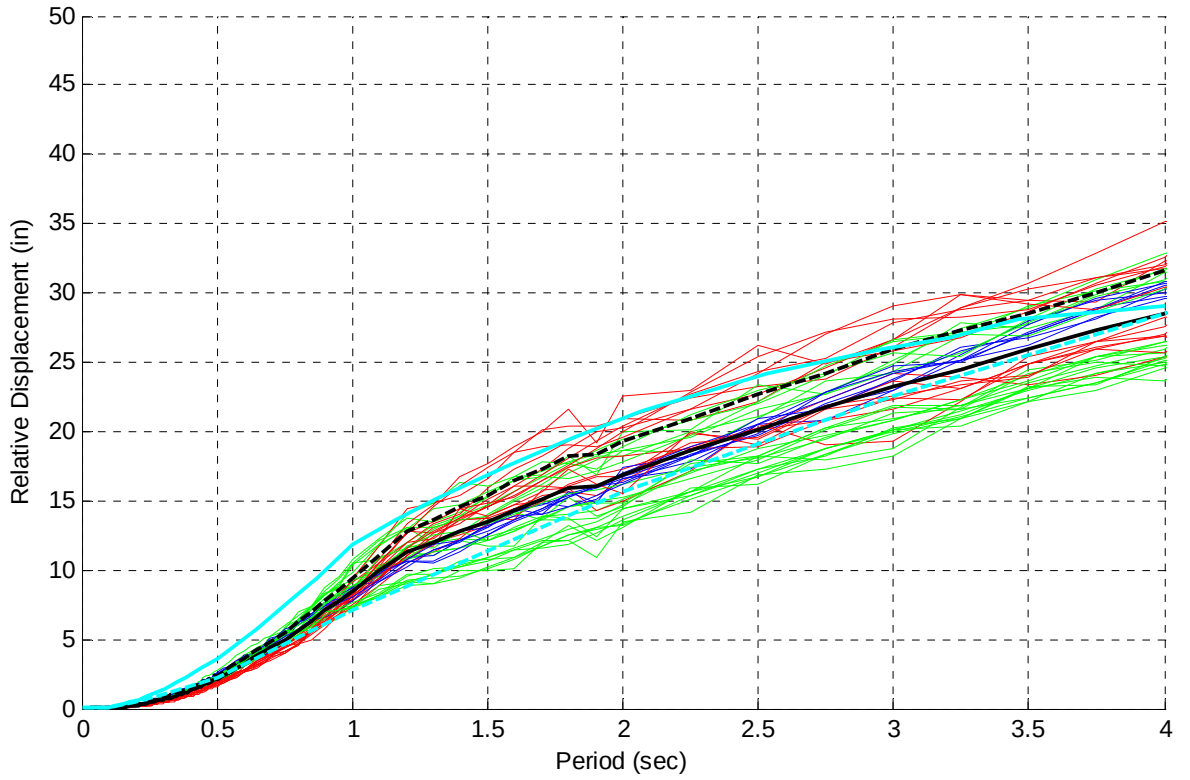
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





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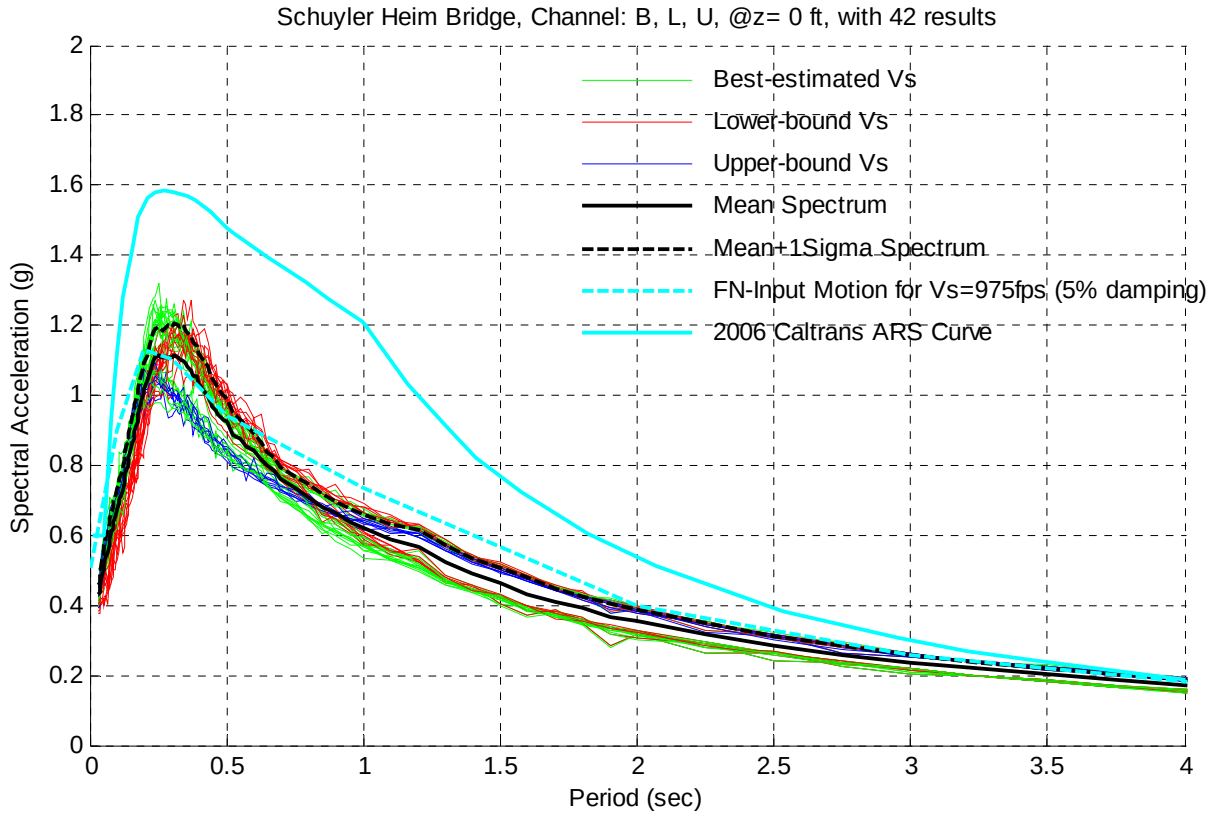
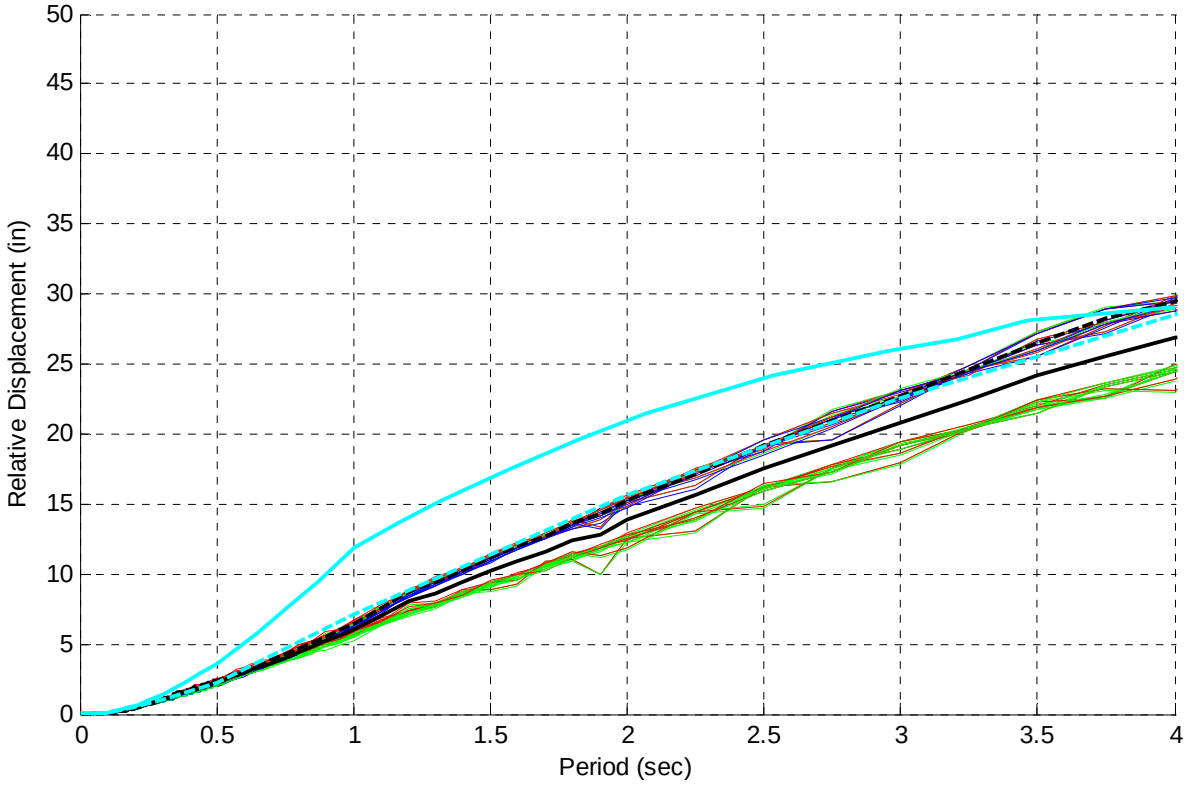
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





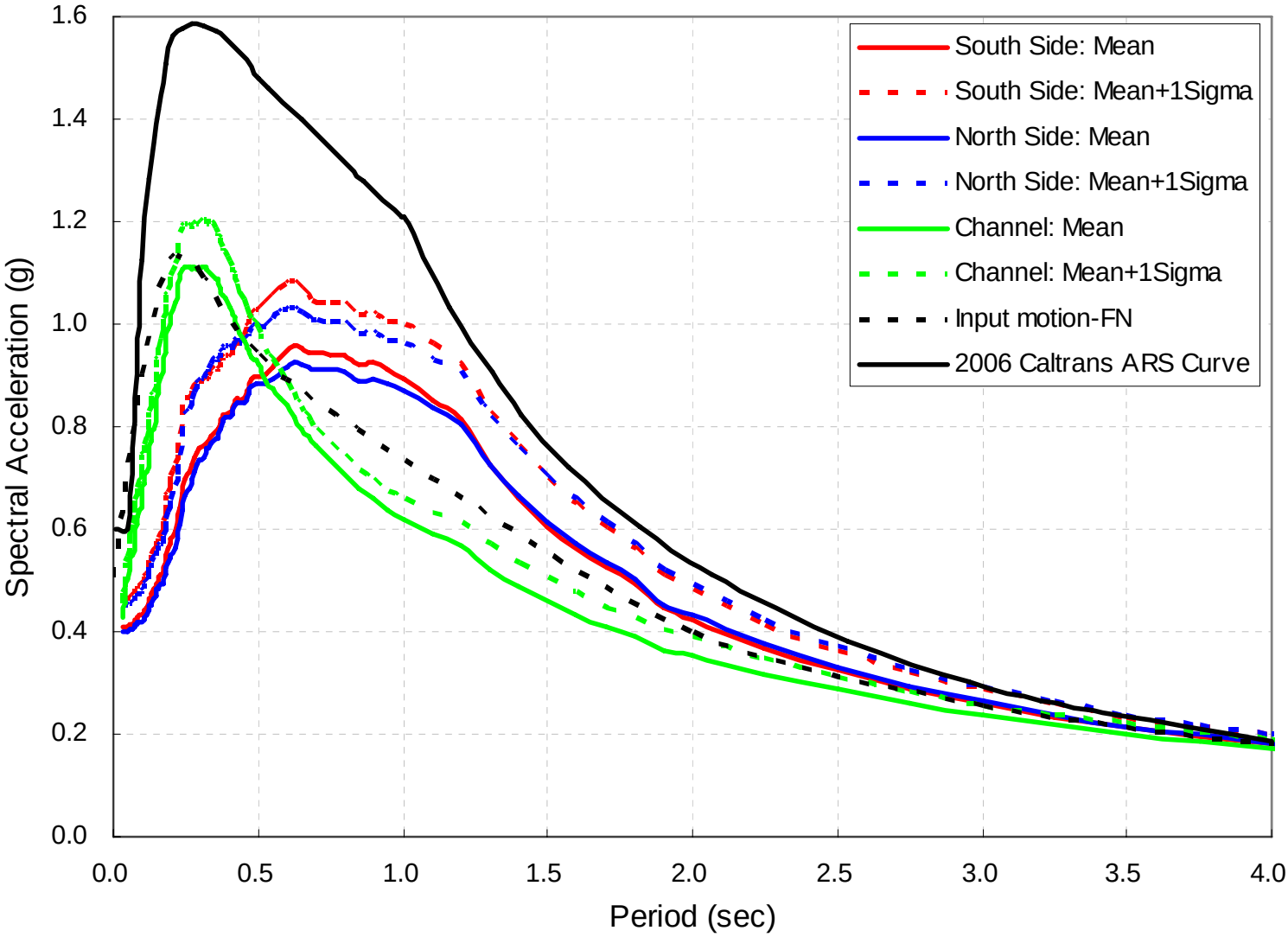
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

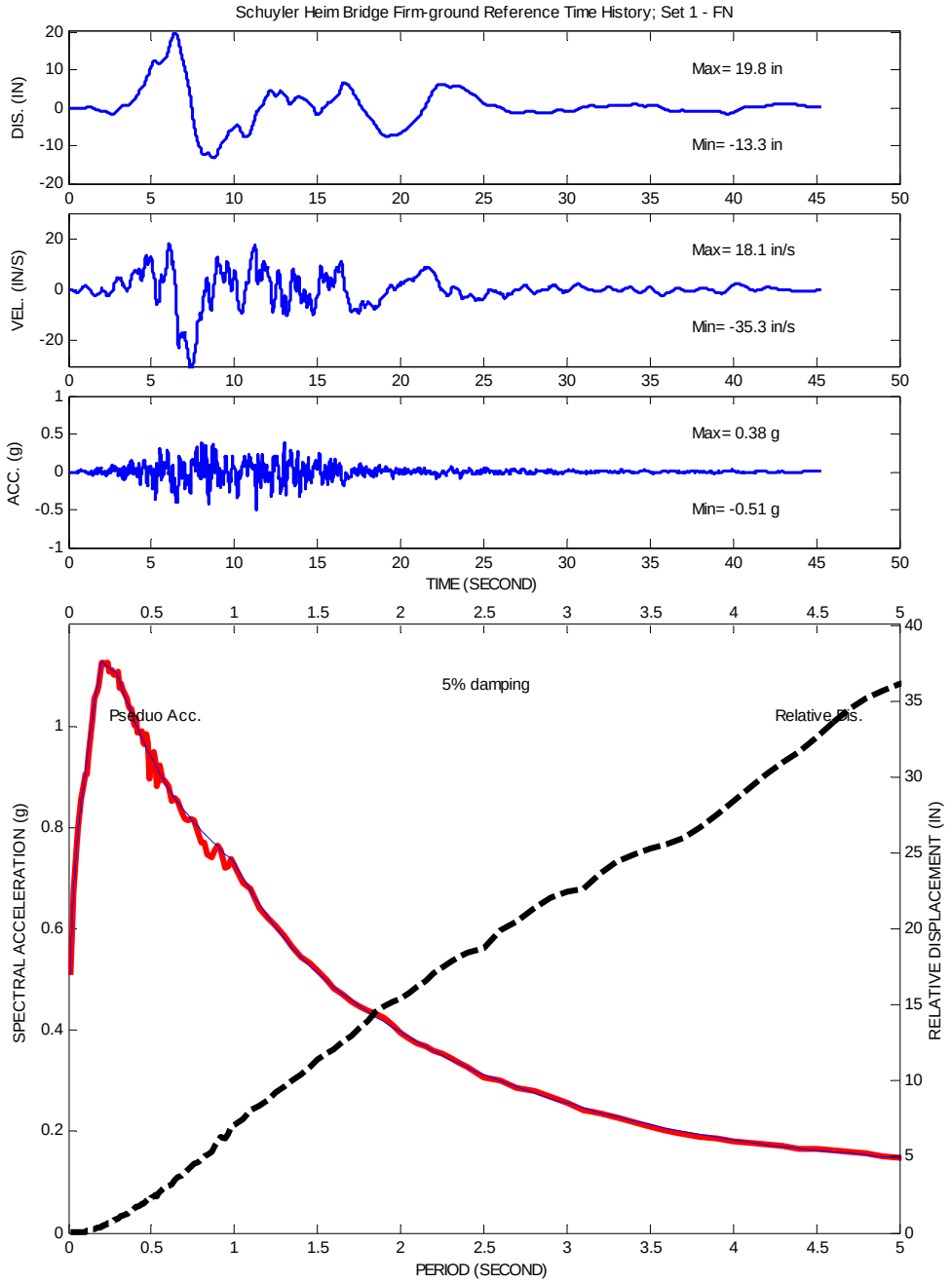


Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

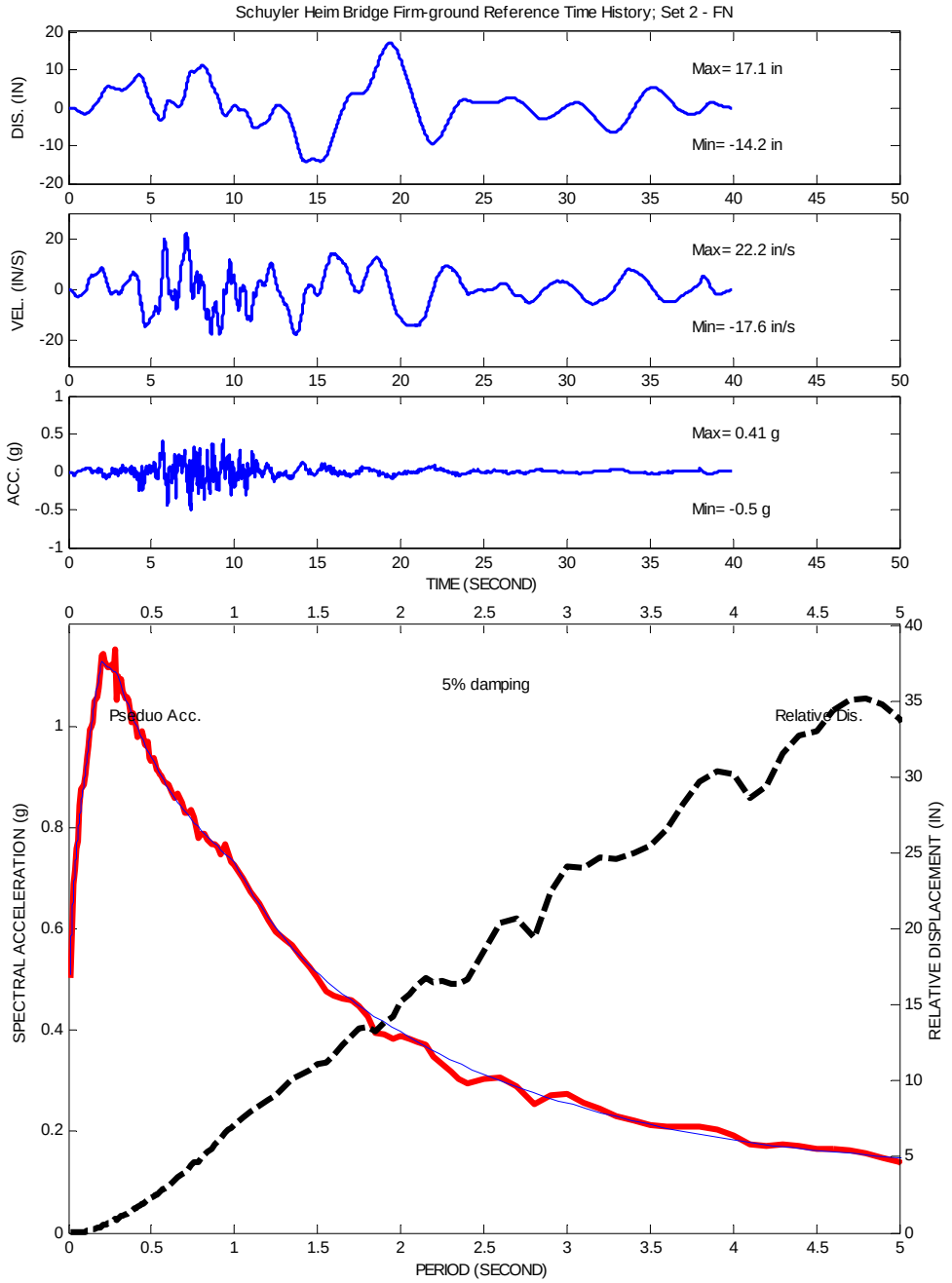


Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

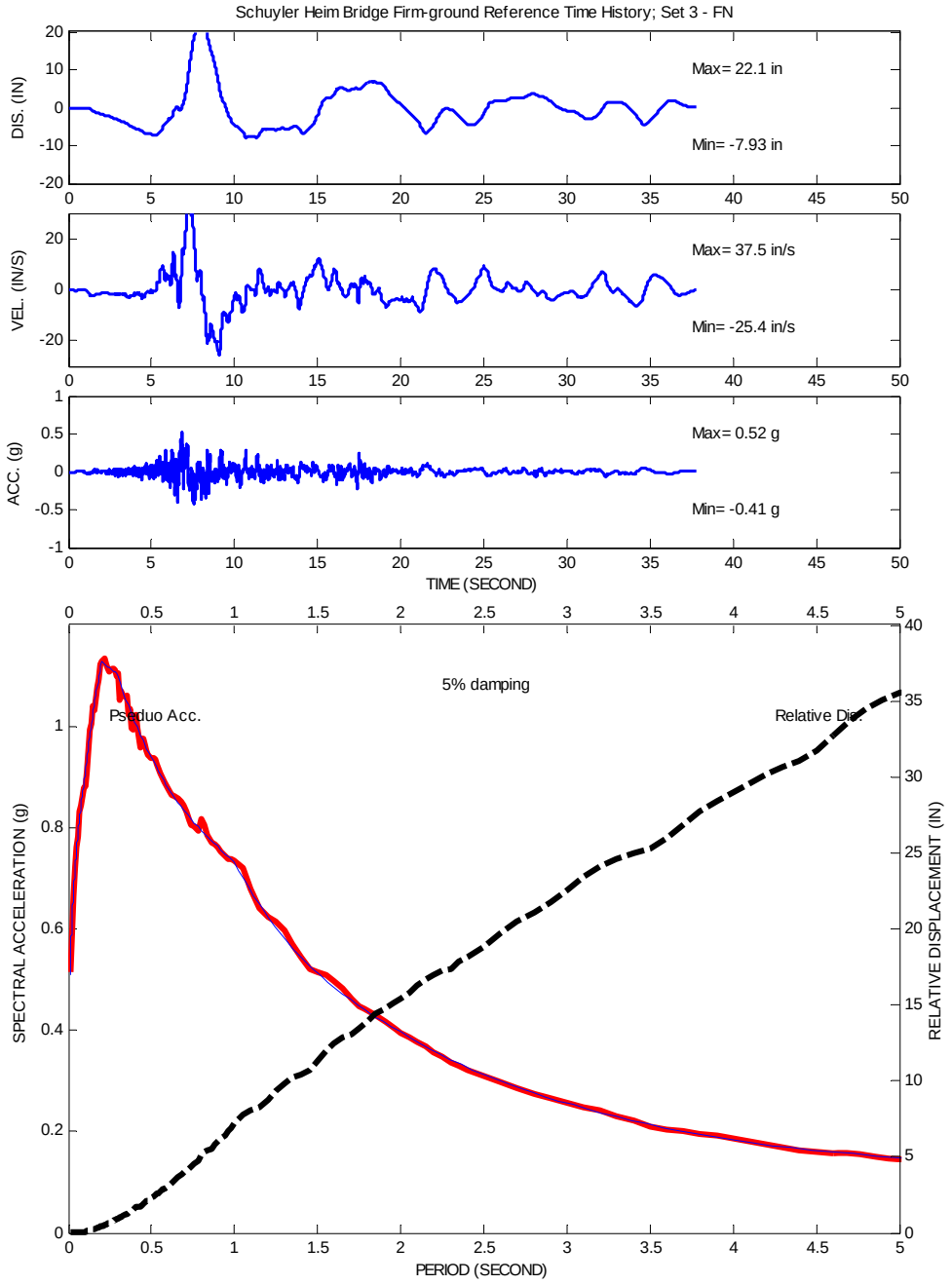


Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

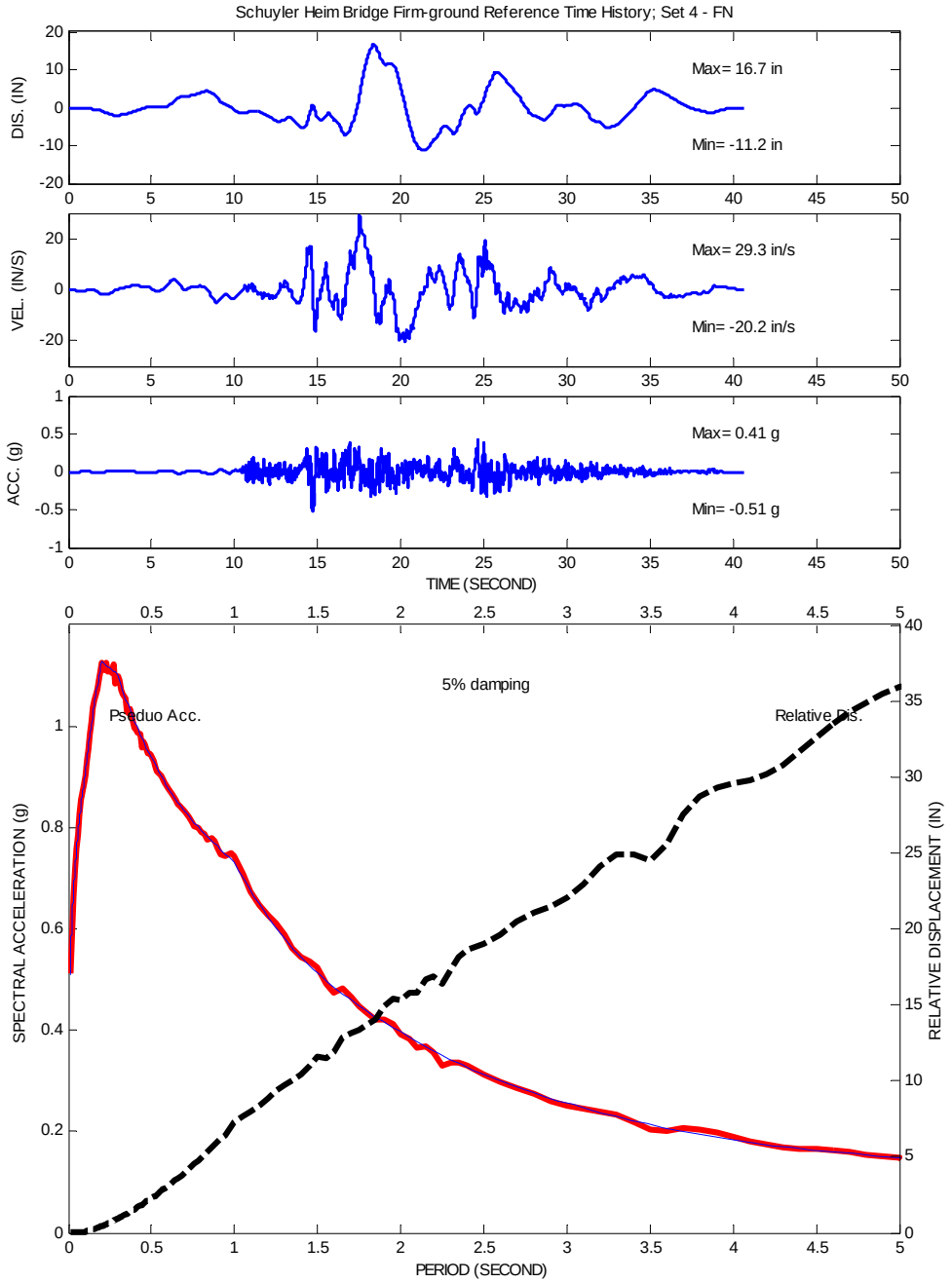


Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

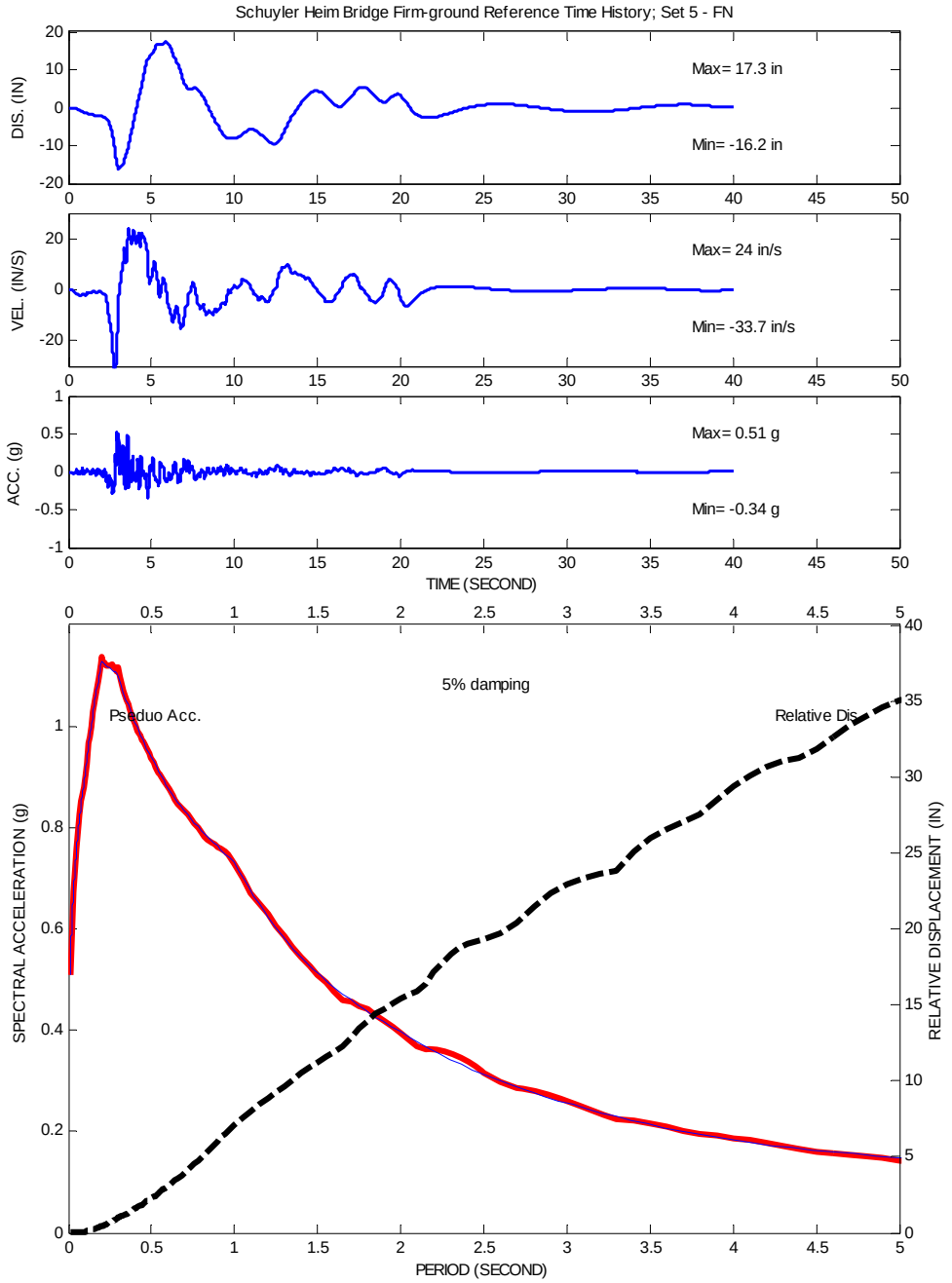


Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

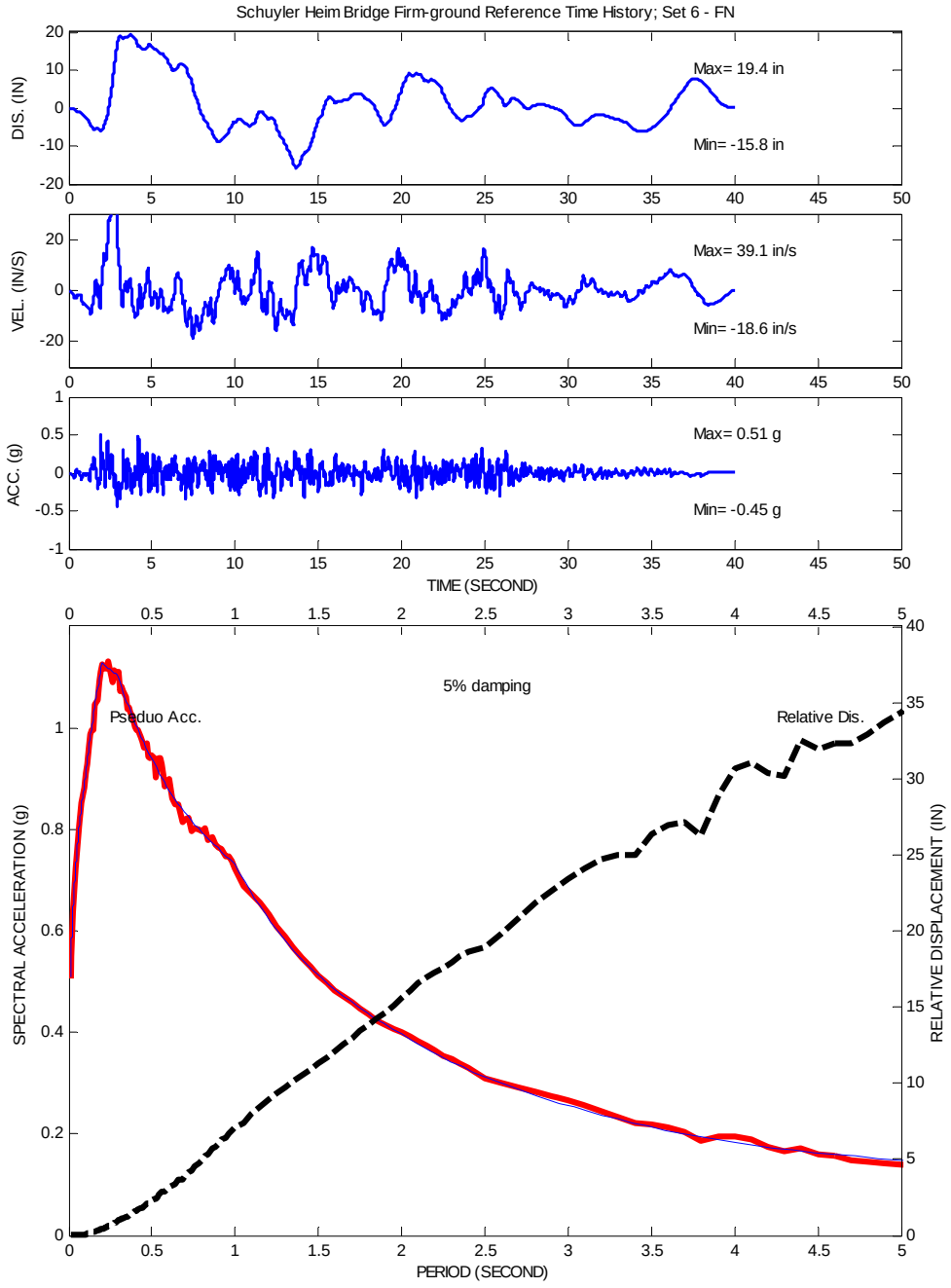


Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

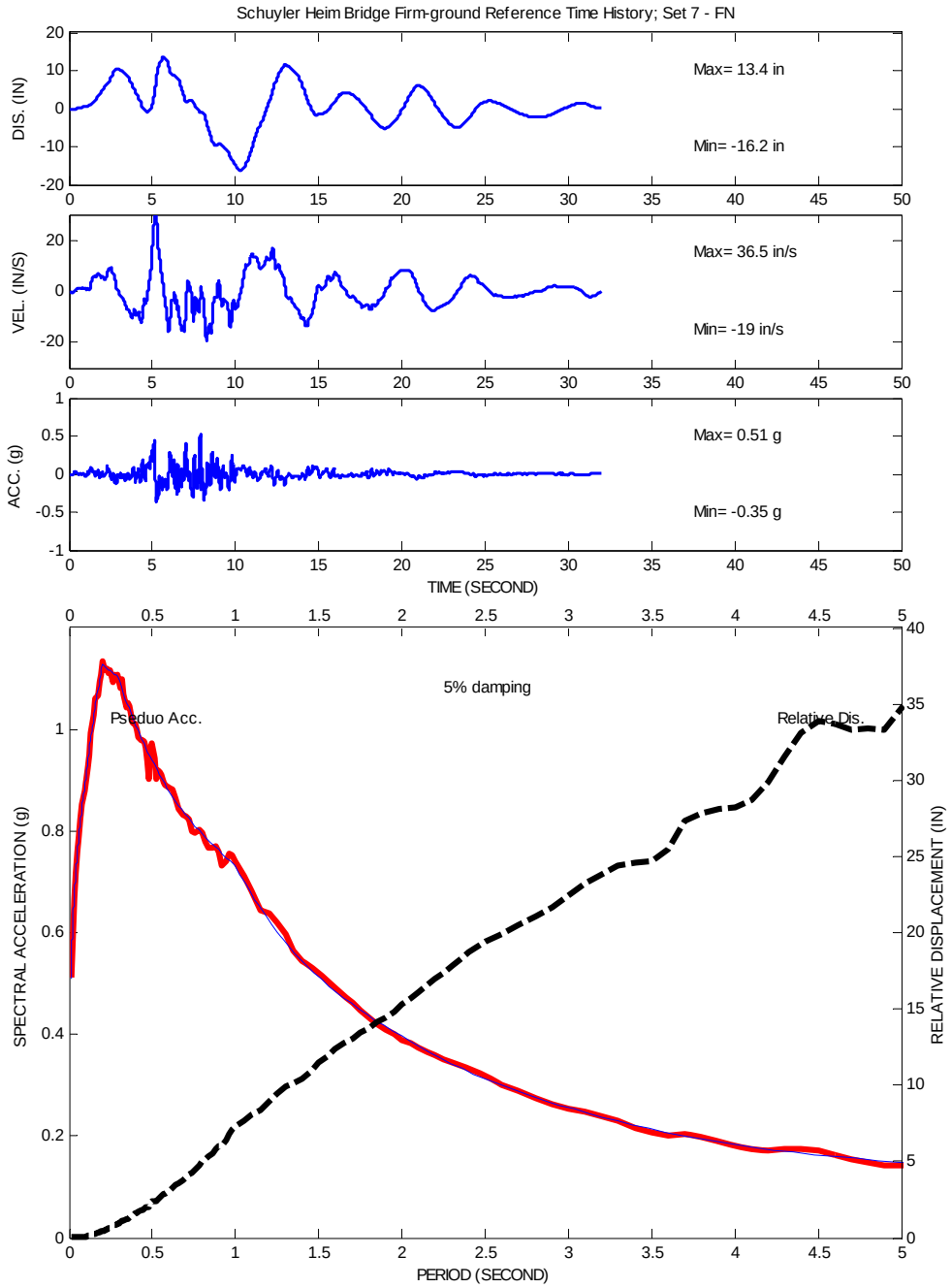


Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

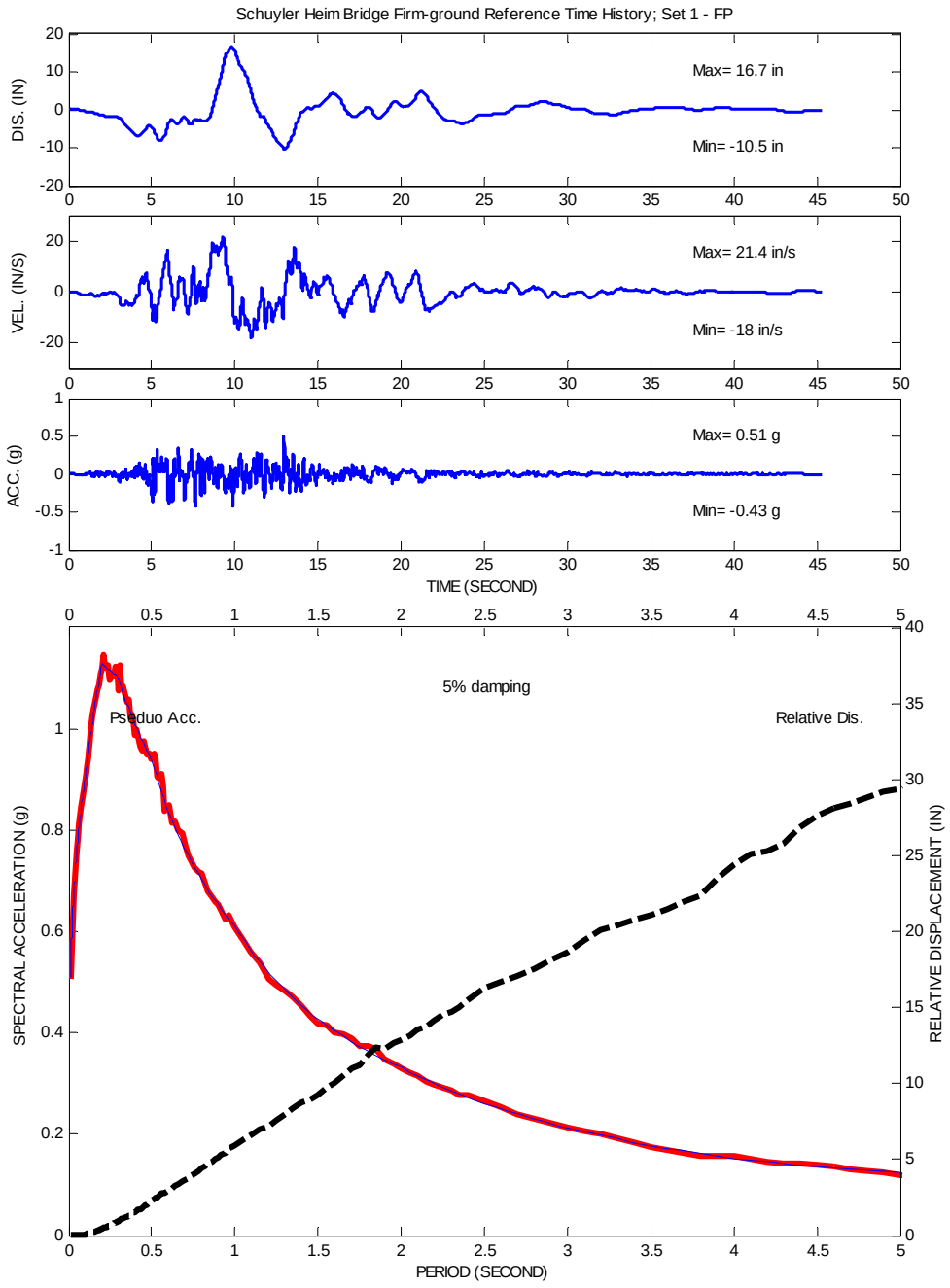


Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

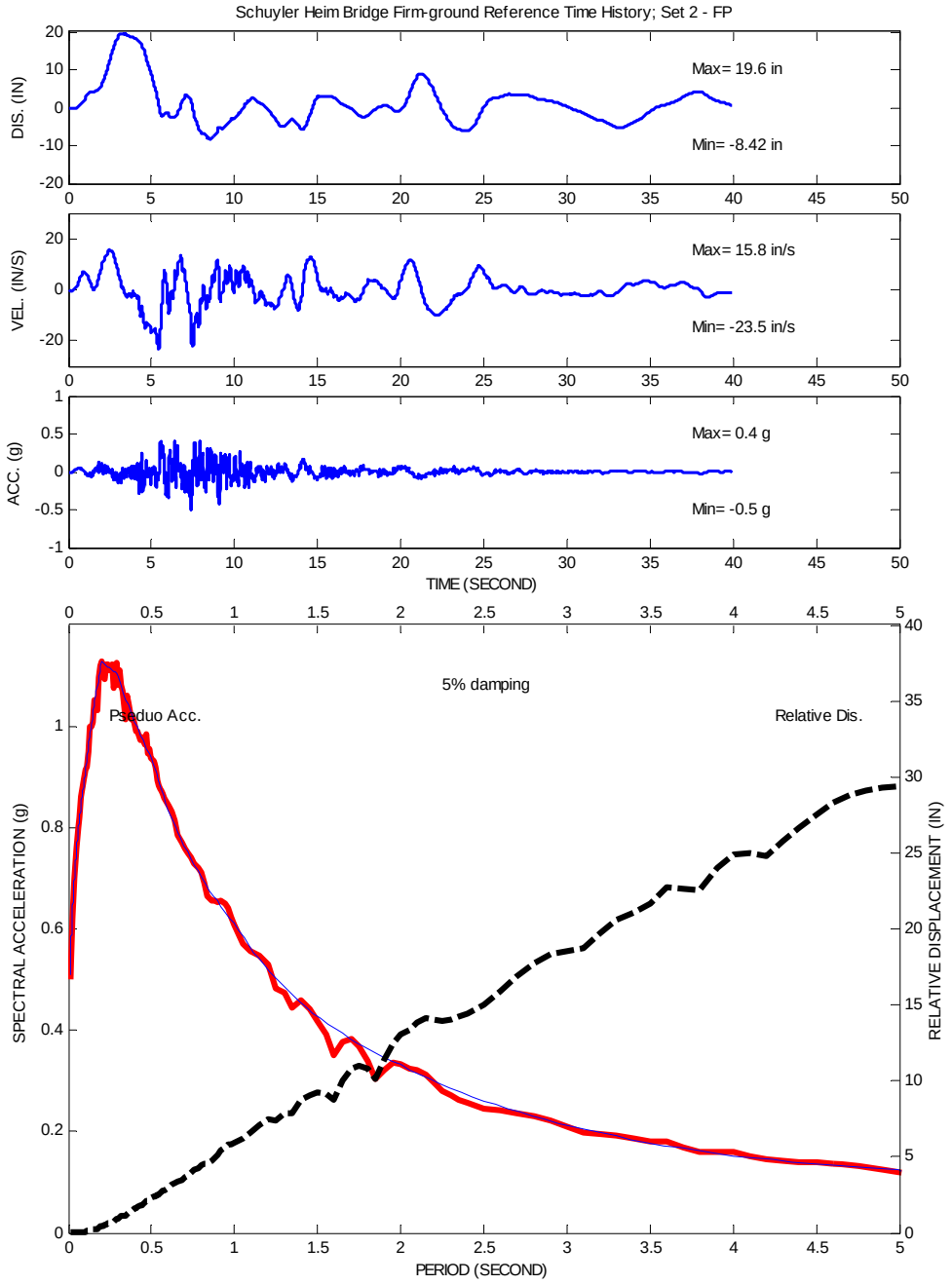


Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

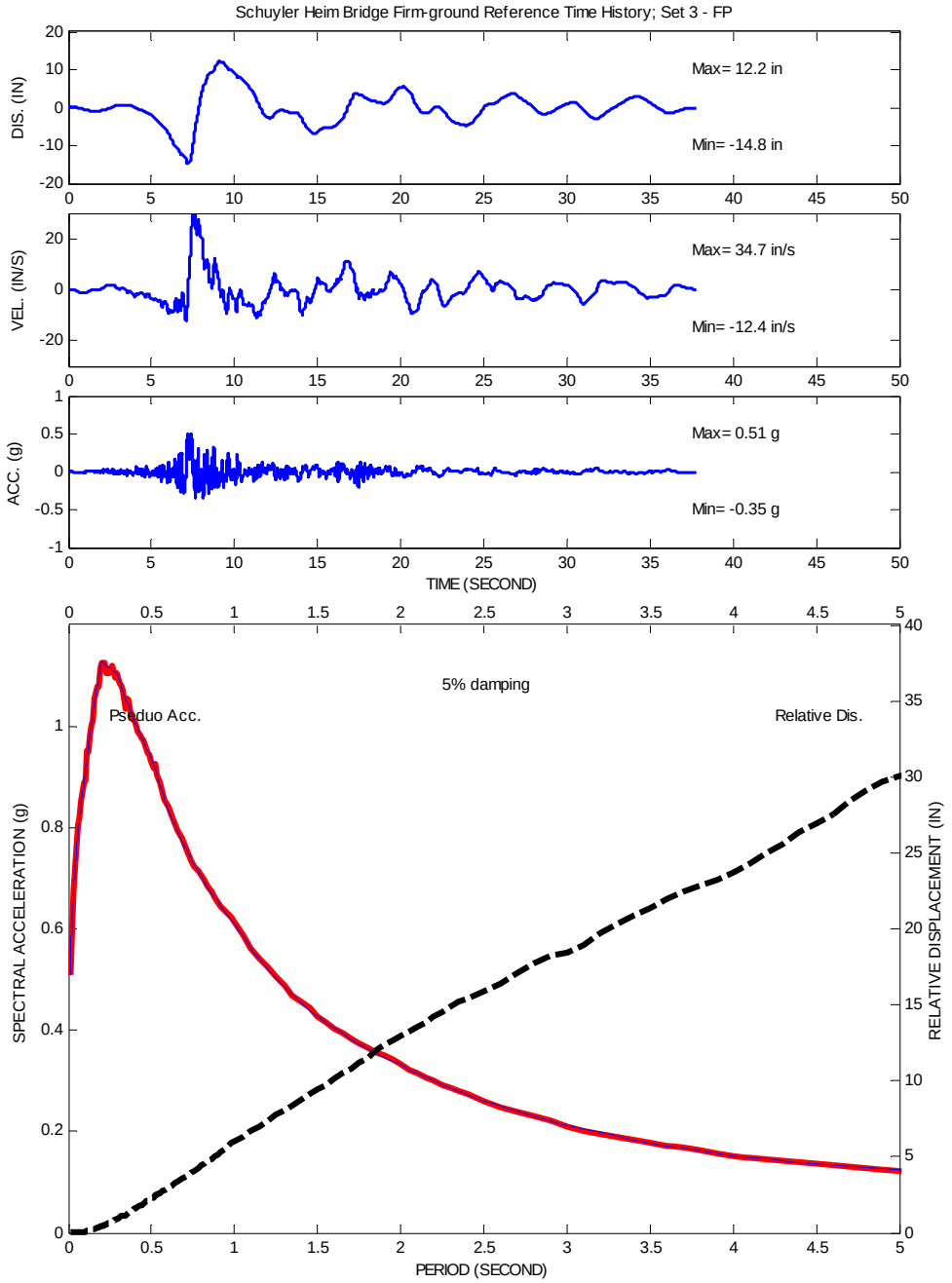


Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

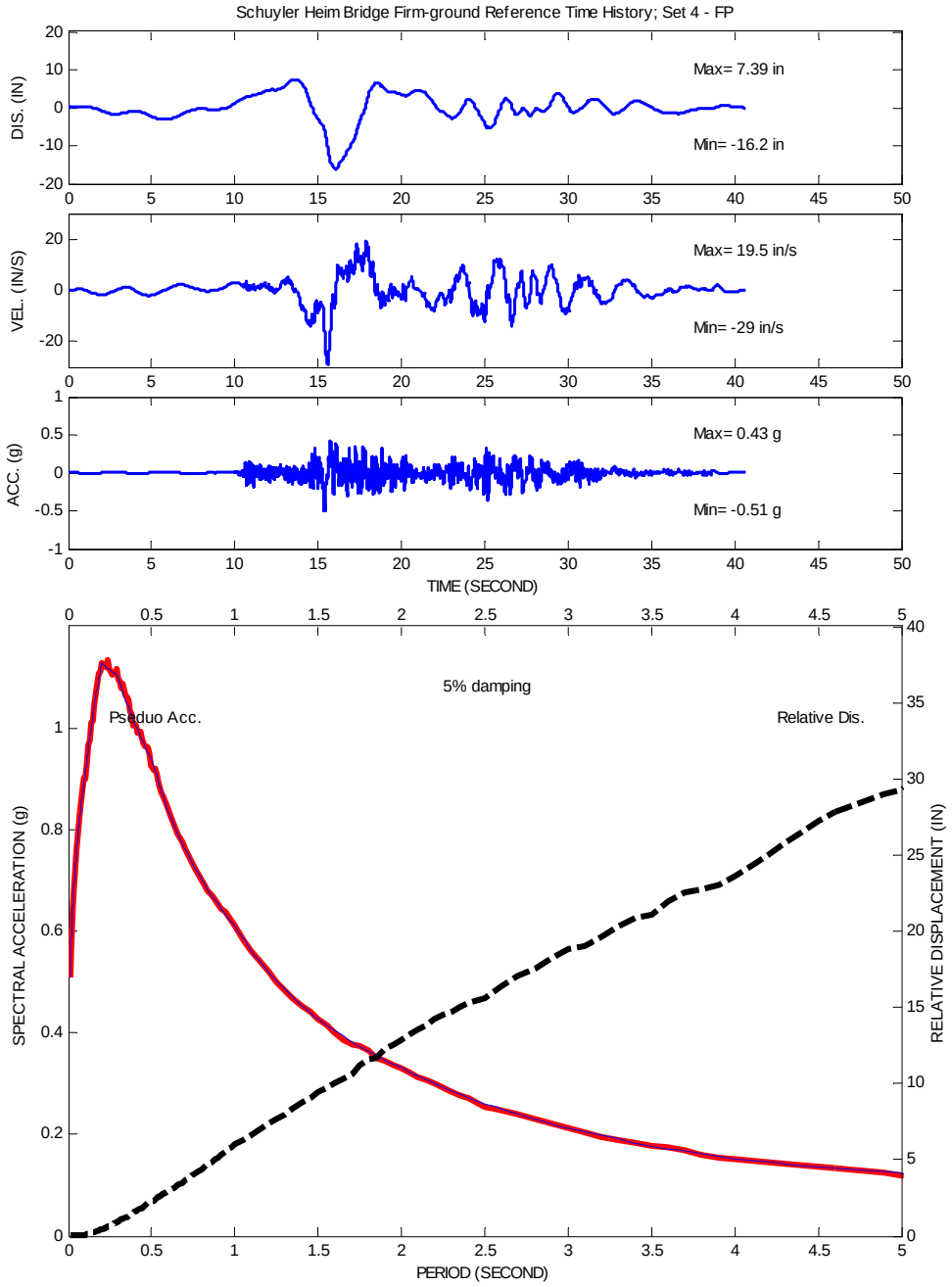


Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

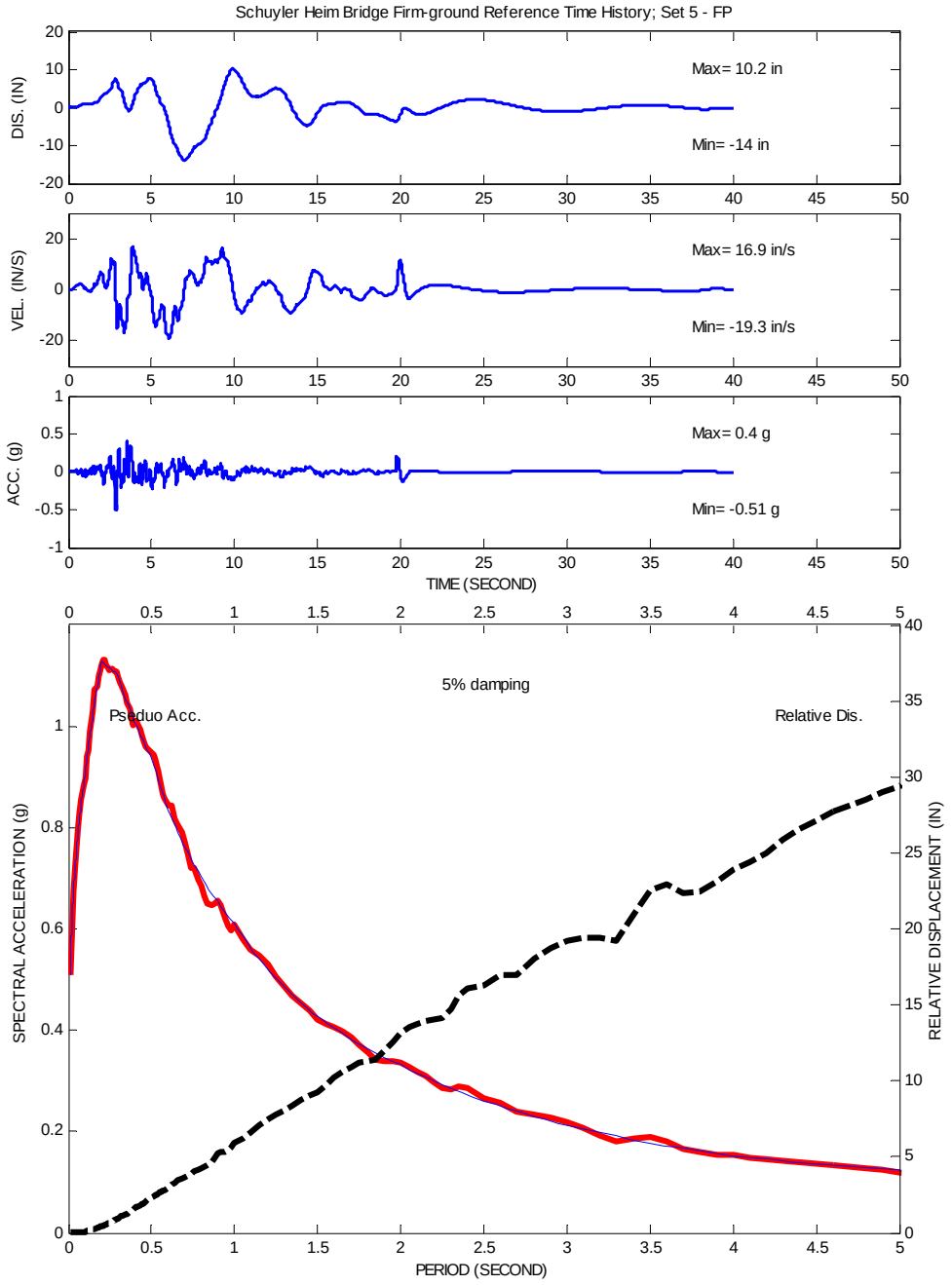


Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

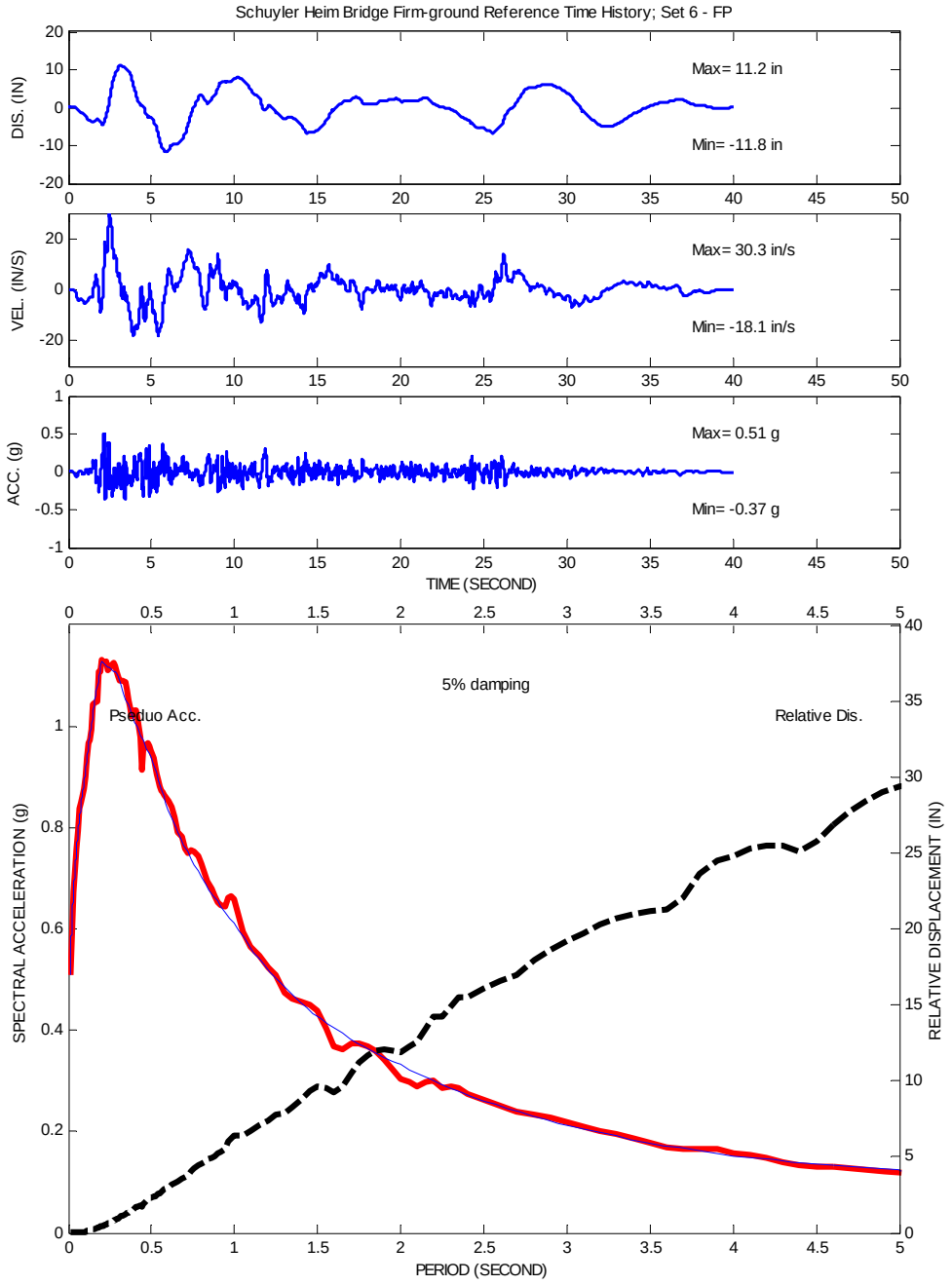


Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

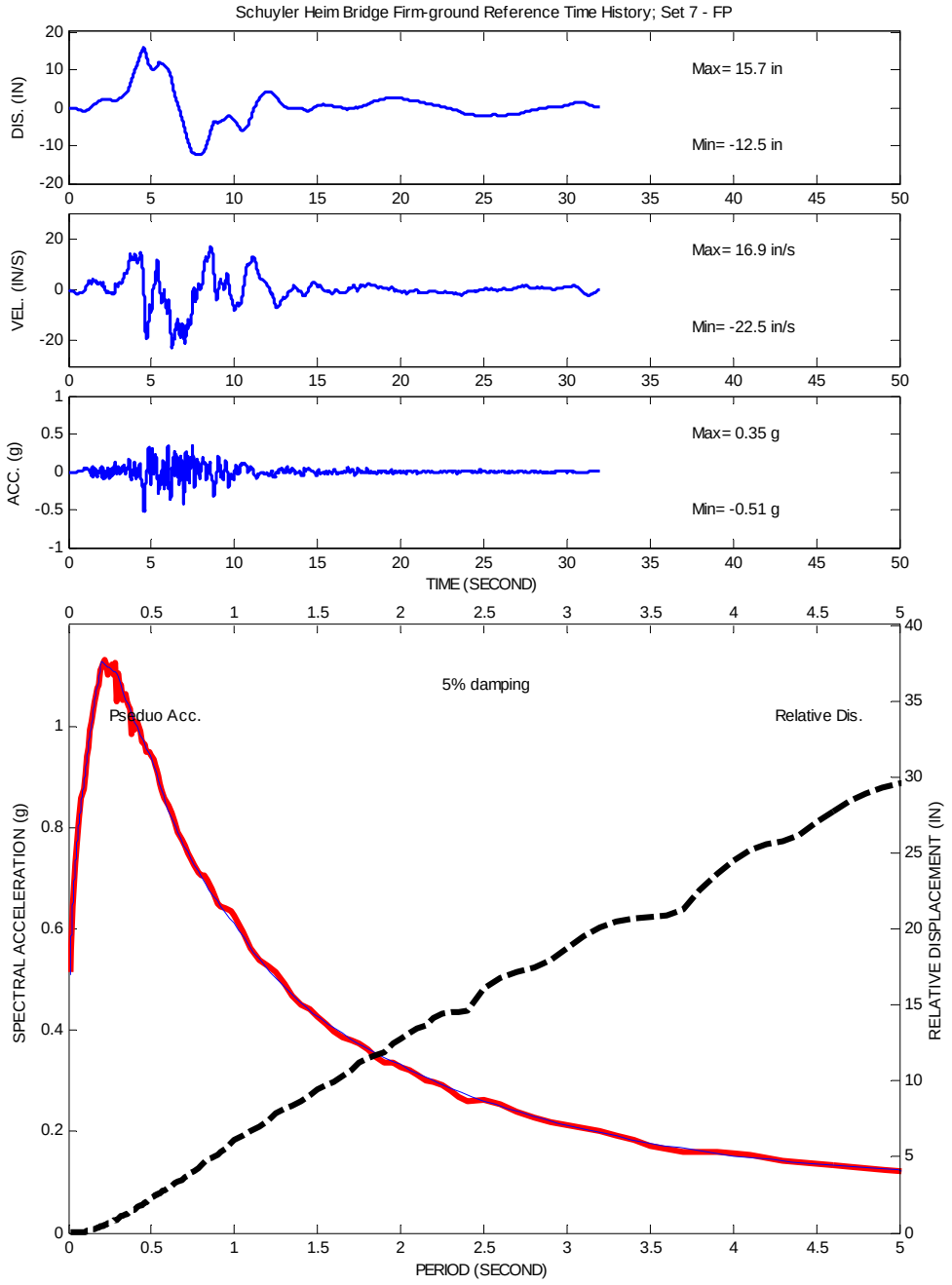


Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX E. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

RECEIVED
ACTA DCC
JUL 19 '10
10036 04 01 000
0165615
C-NELSON

TETRA TECH

Heather Benfield, P.E.
Project Manager

Ms. Elaine Silvestro
Alameda Corridor Engineering Team
One Civic Plaza, Suite 350
Carson, CA 90745

July 15, 2010

Subject: **Final Baseline Hydroacoustic Survey Plan for Commodore Schuyler F. Heim Bridge, Demolition and Replacement Project, Long Beach, California**

Dear Elaine:

Enclosed are three (3) copies of the above reference plan. The final workplan is the same as the revised final workplan (with a few minor typo corrections) which incorporated comments from ACTA. Upon review of the plan by the National Marine and Fisheries Service (NMFS), Tetra Tech will prepare responses to comments, if necessary.

If you have any questions or need additional information, do not hesitate to contact me at (626) 470-2415.

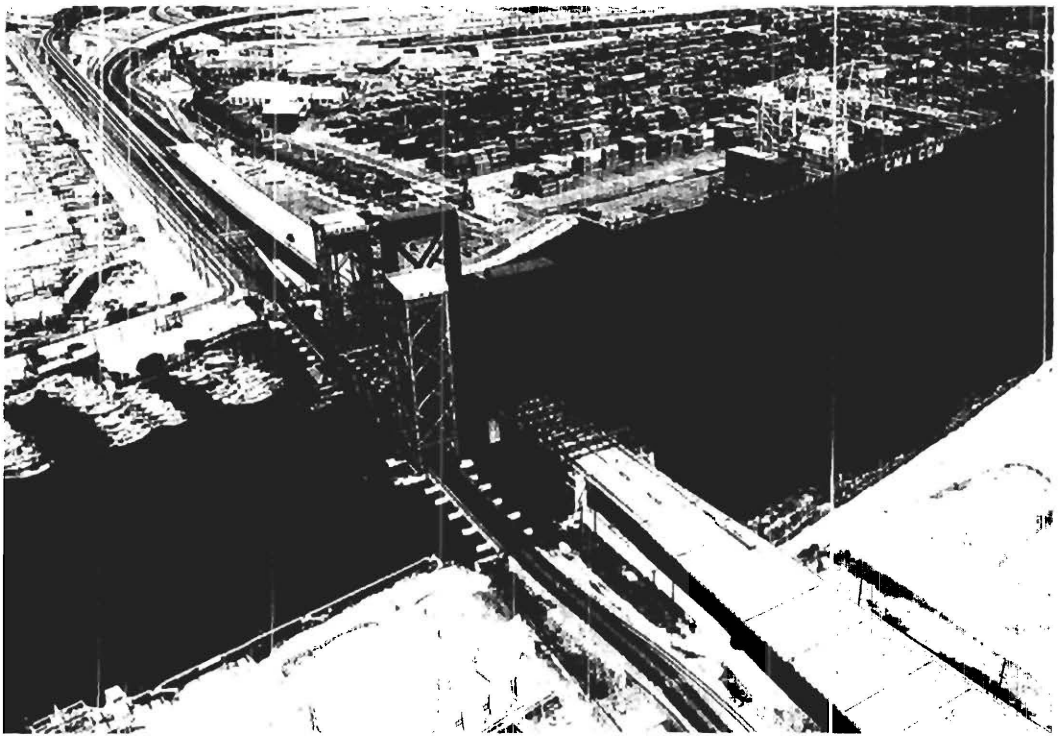
Sincerely,

Heather Benfield

Enclosure: 3

Tetra Tech, Inc.
3475 E. Foothill Boulevard Suite 700, Pasadena, CA 91107-5024
Tel 626.470.2415 Fax 626.470.2515 www.tetratech.com

FINAL
BASELINE HYDROACOUSTIC SURVEY PLAN



COMMODORE SCHUYLER HEIM BRIDGE DEMOLITION AND REPLACEMENT PROJECT LONG BEACH, CA

Prepared For:
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1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has been retained by the Alameda Corridor Transportation Authority (ACTA) to conduct baseline hydroacoustic monitoring in support of the environmental studies required during replacement of the Commodore Schuyler F. Heim Bridge, located in the city of Long Beach, California, hereafter referred to as the "Bridge" or the "Site". Figure 1 presents the location of the Bridge and surrounding area. This workplan has been prepared to describe the work procedures that will be adhered to while conducting the survey. Determining local baseline or ambient noise levels are necessary for quantifying potential harassment take of marine mammals, and for developing mitigation measures, such as safety zones, for avoiding or minimizing take.

2.0 PROJECT BACKGROUND

The Schuyler Heim Bridge was built between 1946 and 1948 and connects Terminal Island to the mainland. The California Department of Transportation (Caltrans) has been the operator of the Bridge since 1974. The bridge requires replacement because it does not meet current seismic safety standards. The project consists of replacing the existing bridge with a fixed-span bridge along and east of the existing bridge alignment. The Project will also reconstruct the northerly and southerly approaches to the bridge and maintain connectivity to State Route (SR) 103 and Ocean Boulevard. The width of the navigable channel (distance between bridge support columns and fenders) will be 180 feet, the same as the existing width. Construction is expected to take approximately two to three years and is scheduled to begin in 2011 with pile driving to be conducted in Fall of 2011.

Both impact and vibratory pile driving will be required for the installation of piles necessary for construction of the temporary trestles for access, the falsework for placing the forms to pour concrete, and the coffer dams used to isolate each of the four existing piers for removal. Because pile driving generates underwater noise at levels potentially harmful or disturbing to marine mammals, a number of measures have been identified (Section B-2 Protecting Aquatic Communities in the Project Record of Decision [ROD]) that would avoid, minimize, or mitigate these effects to marine mammals. These measures include using bubble curtains and caps to attenuate noise generated by pile driving, and establishing safety zones whereby noise-generating activity is shutdown at the approach of a marine mammal to these safety zones. Subsequently, in order to determine effective safety zones, both the existing ambient noise levels in the absence of pile driving and the maximum noise levels generated by the two pile driving methods (impact and vibratory) during construction shall be identified.

To meet the objectives of the measures identified in the ROD, there are three work elements to be completed: 1) development and implementation of a baseline hydroacoustic survey plan, 2) development and implementation of a pile driving (construction) hydroacoustic monitoring work plan, and 3) development and implementation of a detailed marine mammal monitoring and mitigation plan. This document addresses only the baseline hydroacoustic survey workplan; the pile driving (construction) hydroacoustic monitoring workplan and the marine mammal monitoring and mitigation plan will be prepared by Caltrans upon completion of the baseline hydroacoustic monitoring. However, a conceptual marine mammal monitoring and mitigation plan has been prepared and provided in Appendix A.

The objective of the baseline hydroacoustic survey plan is to describe the methodology to be used to document the existing underwater acoustic environment of the Cerritos Channel, in proximity to the Bridge. The results of the survey will be used to identify an appropriate marine mammal harassment safety zone during vibratory pile driving activities.

3.0 HYDROACOUSTIC PLAN OBJECTIVE

Although marine mammal use in the vicinity of the Bridge is very low, limited to primarily the occasional California sea lion (*Zalophus californianus*) or Pacific harbor seal (*Phoca vitulina richardii*), both non-Endangered Species Act-listed marine mammals, exposing marine mammals to continuous underwater construction noises exceeding 120 dB or impulse noises exceeding 160 dB represents a Level B take (harassment) violation of the Marine Mammal Protection Act (MMPA). According to the NMFS, sounds introduced into the sea by man-made devices could have deleterious effect on marine mammals by causing stress or injury, interfering with communication and predator/prey detection, and changing behavior. NMFS is currently determining safety criteria/guidelines for marine species exposed to underwater sound, and has determined that 180 dB re 1 μPa_{RMS} (190 dB for pinnipeds) is the impulse sound presser level that can be received by marine mammals without injury. In otherwords, exposing cetaceans to noise levels exceeding 180 dB and pinnipeds exceeding 190 dB represents a more serious Level A injury or lethal take. The Project commitment is to avoid any level of take by establishing effective safety zones whereby noise-generating activity (pile driving) is shutdown in the event of a marine mammal approaching a safety zone.

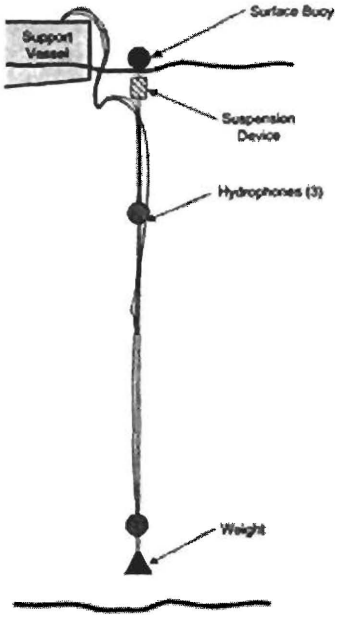
Noise generated from pile driving activities is often loud enough to harm (Level A take) or harass (Level B take) local populations of marine mammals. As noise attenuates as a function of the distance from source, at some point the noise declines to levels no longer of concern to marine mammals. For vibratory pile driving, a continuous noise source, the threshold for Level B take is the 120 dB isopleth. To avoid Level B take, the water surface area extending to the 120 dB isopleth will be monitored (by trained marine mammal biologists), and pile driving activity will be shutdown at the observed approach of a marine mammal. However, if the estimated distance (based on previous studies) to the 120 dB isopleth is relatively great (a large zone of influence, ZOI), then many marine mammal observers may be needed to effectively monitor the harassment safety zone. Reducing the size of the ZOI (and therefore the number of observers) can be accomplished by 1) attenuating the noise levels using techniques such as caps or bubble curtains (which is not conducted for vibratory pile driving), 2) determining the actual distance to the 120 dB isopleth from field measurements (which cannot be conducted prior to construction) and 3) determining whether the ambient noise levels already exceed 120 dB (which can be conducted prior to construction).

In marine environments where the background or ambient noise levels are already higher than 120 dB, the threshold of concern becomes the ambient level, and only areas ensonified by noise louder than ambient need to be monitored. Therefore, assessing local ambient or background noise levels in the vicinity of the pile driving construction activities is important to determine the actual areas that need to be monitored for marine mammals, especially in high energy industrial environments where ambient noise levels are high. Thus, the purpose of this workplan is to identify protocols to collect and report baseline (ambient) underwater noise levels at the Schuyler Heim Bridge project site. The results of the survey will be used during development of the marine mammal monitoring and mitigation plan to identify the initial safety zone that will be monitored during all pile driving activities.

3.1 BASELINE MONITORING PROCEDURES

Tetra Tech will design and execute an underwater sound monitoring survey to collect, analyze, and record underwater acoustic data to characterize preconstruction background sound levels and residual ambient sound levels in areas of proposed activities that have the potential to injure or disturb marine mammals. In order to quantify the underwater sound, three main measurement instrumentation components are required: (1) hydrophones and signal conditioning, (2) data acquisition and processing, digital recording, and a real-time display system, and (3) geographic positioning system.

Tetra Tech will measure and record underwater sound levels by collecting short-term data at set distances and hydrophone water depths. Figure 2 presents the area for the proposed sampling program. The Cerritos Channel and the adjacent basins (East Basin to the west and Turning Basin to the east) are well traveled by commercial vessels and recreational boats, and are expected to be relatively homogenous acoustically, with similar underwater background sound levels and exposure to noise sources. To maximize the number of spot measurement locations and reduce the effects of hydrostatic pressures and resulting extraneous noise from a stationary fixed system due to current flow, the hydrophones will be deployed over the side of a workboat such that the hydrophones drift away from the vessel as it moves freely along a transect. The hydrophones will be suspended in the water column and secured to an anti-heave buoy, which will position the sensors at a constant distance below the surface of the water. In addition, the line will be weighted at the lower end to maintain a vertical profile. At a minimum, two hydrophones will be deployed per measurement period. One hydrophone will be situated at the approximated 1/3 of the average depth of the water column at the test locations and the second will be placed at 2/3 of the average depth to sample the variation in the sound field with depth. To assess spatial variations, measurement locations will be completed along radial transects from a vessel, which traverses the channel at set linear distances from the Bridge. Measurement extents are shown in Figure 2 and consistent with where construction monitoring is anticipated will take place and at depths that are assumed to cover the behavior of the species considered. Typically, the work-boat starts at a minimum of 100 feet away from the future area of future pile driving and then a series of measurements completed using a sprint/stop/measure procedure. Typical measured sequences will last for a period of 5 to 10 minutes, depending on current strength. The vessel then moves to a new position along the transect. Using this methodology, it is anticipated that multiple measurements can be completed in 200 to 300 foot intervals at distances of up to one mile in the principal channel east-west directions.



Reference: Draft ANSI Standard S12.64- 200X
Revision 12, May 21, 2009

Immediately prior to the fieldwork program, a sound velocity profile will be collected using a current-temperature-depth (CTD) sounder. In the shallow coastal waters and coastal inlets, the water column is typically well-mixed and isothermal, but seasonal variations may occur. It will be required that the vessel's engines, depth sounder, generator, and other equipment that may contaminate the sound signal will be shut down prior to hydrophone deployment. The position of the vessel will be monitored by GPS over the entire duration of the measurement period.

Tetra Tech will utilize three (3) Bruel & Kjaer model BK8104 or Reson model TC4040 broadband hydrophones. Factory calibration certificates and sensitivity specifications will be submitted with the baseline sampling report. The TC4040 and BK8104 hydrophones are more sensitive than most other hydrophones, even at the extremes of its frequency range. With a dynamic range in excess of 90 decibels (dB), these hydrophones are of the few that are suitable for the measurement of noise with a highly sloped spectrum, such as shallow water background noise. The hydrophones will be equipped with extended length integrated water blocked cables suitable for use in the general area of the Bridge. These units will have waterproof connectors for signal input following conditioning directly to multichannel real time frequency analyzers capable of 1/3 octave and Fast Fourier Transform spectra analysis with data measured in the frequency range of 20 to 20 kilohertz (kHz). The underwater sound levels will also be recorded with calibration tones recorded immediately prior to each measurement period, for reference purposes. The sampling rate will be set to a minimum of 12,000 (12k) samples per second (sps). A general rule of thumb is that the playback of a digital sound recording will provide accurate reproduction

of frequency content up to 0.48 times the recording sample rate. Thus, a 12k sample rate would provide a recording having good fidelity over the entire range of pile driving sound, with principal sound energy generally found below 2,000 hertz (Hz).

3.2 BASELINE SAMPLING SCHEDULE

The target mobilization date for the Bridge reconstruction has not been finalized. Baseline monitoring will be completed during the same season that pile driving is anticipated. Following completion of the sound survey, sound measurement data and recordings will be immediately downloaded in the field for subsequent analysis at the Tetra Tech acoustics lab. Sound levels will be correlated to field logbooks and all data analysis including engineering calculations will be conducted for inclusion in the report.

3.3 DATA ANALYSIS

Tetra Tech will report the background noise levels in terms of root-mean-square decibels (dB_{RMS}) for a daytime 10-hour period, which is sufficient based on our experience to capture the temporal variation in sound levels that occur at the Site. The spectral composition and overall broadband sound levels vary relatively slowly, so that a high level of temporal resolution is not necessary. The RMS sound values will be calculated using 30-second averages for each period of data collected. The 30-second RMS averages will then be calculated as energy averages and reported for cumulative hourly and ten-minute intervals. Measurements identified as absent of obvious human influence, i.e. ship movements within visual sight, will be reported as ambient sound levels as a separate subset of the entire measurement program, to the extent that these conditions occur. The full range of measurement data will be compared to NMFS thresholds and plotted as a cumulative distribution function. Measured background frequencies in one-third octave band levels will also be presented. The one-third octave band data may be useful in the analysis of potential impacts pertaining to species of concern to establish species-specific acoustic impact thresholds. Relevant phases for a detailed acoustic analysis are defined as times of typical and extreme acoustic noise emission. For each relevant time period, third octave spectra of the single event sound pressure level shall be evaluated for frequencies ranging from 10 Hz to 20 kHz which spans the entire frequency range over which pile driving sounds are of interest, with principal sound energy found below 2000 Hz.

4.0 HEALTH AND SAFETY PROCEDURES

A separate site specific health and safety plan has been prepared and is provided as Appendix B. All work will be conducted according to provisions of this plan. A daily tailgate safety meeting will be conducted at the beginning of each work day. During this meeting, the field lead will discuss the tasks to be conducted, the equipment to be used, any special procedures to be followed, protective devices that will be used, and the potential physical, chemical, and biological hazards that may be encountered. This meeting will be documented on a standard Tetra Tech tailgate safety meeting form that will be signed by all attendees. All Tetra Tech personnel will have current first aid and cardiopulmonary resuscitation (CPR) training. Personnel will be trained to use all equipment and any protective devices.

5.0 REPORT PREPARATION

The report will provide full documentation of methods and monitoring protocols for the underwater baseline measurements. Items to be documented within the technical report include:

- Time and date stamped time histories for all relevant datasets;

- Names of personnel conducting testing;
- Name, manufacturer and model number of equipment including hydrophone type, directionality, and nominal sensitivity;
- Map of monitoring locations based upon GPS data
- National Institute of Standards and Technology (NIST) equipment calibration certifications and field calibration methods and results;
- Any unusual conditions that could have affected measured noise levels, including a description of any excessive extraneous noises;
- 1/3 frequency spectra of all relevant time periods including mean, L_{90} residual background, and maxima values and a table of significant highest tones;
- Position of hydrophones in the water column during tests;
- Weather, wave height, and sea state conditions;
- A calculation of overall uncertainties evaluated from a combination of measurement components that describe random errors estimated from the measurement repeatability and errors caused by effects that may introduce a systematic bias.

The results of the baseline data analysis will include interpretation of results and conclusions including any implications related to methodology for the subsequent marine mammal monitoring and mitigation plan (MMMP) and the pile driving (construction) hydroacoustic workplan.

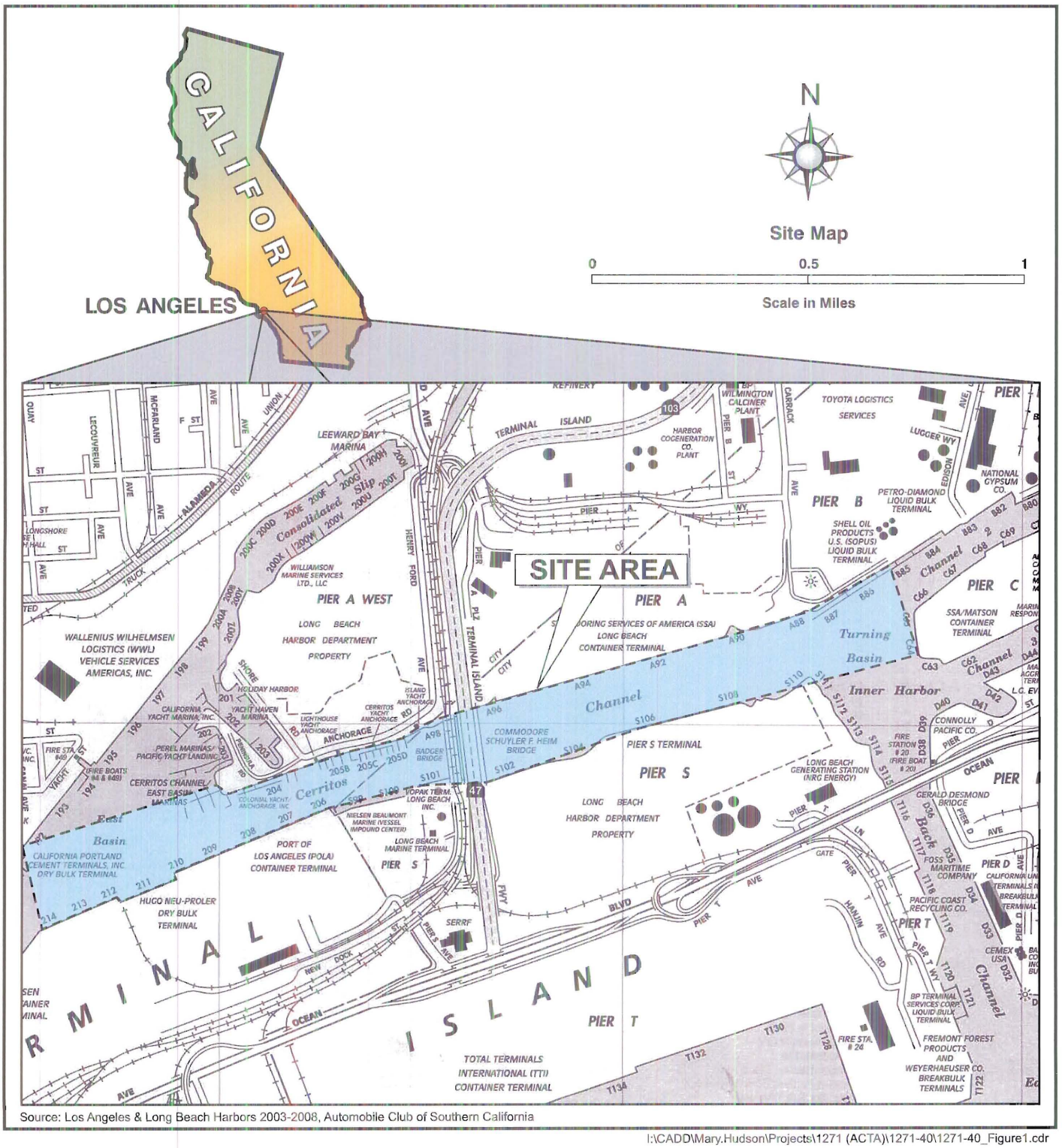
6.0 REFERENCES

Caltrans, Essential Fish Habitat Assessment, Commodore Schuyler Heim Bridge (BR. NO. 53-2618) in the Ports of Long Beach and Los Angeles, Los Angeles County, California, January 2010.

MEC Analytical Systems, Inc., Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay, June 2002.

Correspondence from National Marine Fisheries Service, Southwest Region, Long Beach CA, Mr. Robert S. Hoffman, to Caltrans, District 7, Division of Environmental Planning Los Angeles, CA, Mr. Karl Price, February 12, 2010.

FIGURE 1
SITE LOCATION MAP



Source: Los Angeles & Long Beach Harbors 2003-2008, Automobile Club of Southern California

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A.1 INTRODUCTION

Marine mammals are protected under the Marine Mammal Protection Act, which is administered by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, NMFS. Construction-related impacts such as high underwater noise levels and turbidity could affect marine mammals in the vicinity of the action area. However, mammalian species occurrence within Los Angeles harbor is limited to California sea lions (*Zalophus californianus*) and occasionally Pacific harbor seals (*Phoca vitulina richardii)*. These are non-Endangered Species Act-listed marine mammal species which inhabit the harbor in low numbers (and probably very low numbers in the industrialized Cerritos Channel), but could be present during construction. Other mammal species found within the region but have been determined in the Project Final Environmental Impact Statement/Environmental Impact Report (FEIS/FEIR) to be absent within the action area, include the Northern elephant seal (*Mirounga angustirostris*), common bottlenose dolphin (*Tursiops truncatus)*, Pacific white-sided dolphin (*Lagenorhynchus obliquidens)*, and gray whale (*Eschrichtius robustus)*. Therefore, potential effects to marine mammals from the Project are limited to sea lions and harbor seals.

Observations during pile-driving for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project showed sea lions rapidly swam out of the area when piles were being driven. Thus, sea lions would be expected to avoid areas and activities associated with the Project that could affect them. Harbor seals are unlikely to be present as few individuals have been observed in the Project area. Any sea lions or harbor seals present during construction activities would likely avoid the area. Construction activities would also not adversely interfere with foraging activities because impacts would be limited to portions of Cerritos Channel and large foraging areas within the Harbor would remain available to marine mammals. Therefore, any adverse effects to marine mammals from elevated underwater noise levels would be short term and very minimal. In addition, there are no pinniped haulout sites in the Project vicinity, so in-air noise impacts are not expected.

To reduce the effects of elevated underwater sound levels on marine mammals species during construction activities, the following measures, as identified in the Project Record of Decision (ROD), August 2009, would be implemented:

- Attenuation of pile driving sound via contained air bubble curtain on larger pile installations and dewatering casings for smaller piles. Performance criteria for sound attenuation will be developed to achieve maximum practicable reductions in underwater sound levels.

- A hydroacoustic monitoring plan will be developed, which would include appropriate sampling point locations, frequency, and methods to be implemented during pile driving. The results of the hydroacoustic monitoring would be analyzed in real time to identify appropriate safety isopleths and monitoring zones for biological (sensitive) resources.

- Evaluate potential to modify pile driving operational procedures to reduce noise effects, such as ramping up of pile driving energy levels to allow mobile organisms to exit the area; evaluating potential use of vibratory versus impact hammers under certain conditions; using less force of the hydraulic impact hammer; and limiting pile driving to no more than 2 piles per day with a minimum 12 hour interval between daily driving, to minimize cumulative exposure levels (SEL).

- A detailed marine mammal monitoring/protection plan will be developed in coordination with NMFS; this would include use of biological monitors with authority to suspend activities should sensitive organisms be present or enter the action area. Details of the plan will be developed, and will include methods to identify safety zone limits, numbers and locations of

monitors, and conditions when Project activities would be suspended to protect biological resources.

NMFS requested that information on baseline or ambient noise levels be collected prior to construction to help establish effective safety zones for vibratory pile driving activity. The baseline hydroacoustic study plan has been prepared separately.

The Marine Mammal Monitoring and Mitigation Plan (MMMMP) will include the first three mitigation measures identified above: noise attenuation, construction hydroacoustic monitoring, and modification of operational procedures. The approaches to completing these tasks are addressed below. The MMMP will be prepared by Caltrans and will be submitted to NMFS.

A.2 MARINE MAMMAL MONITORING AND MITIGATION PLAN

Caltrans (or their representative) will be responsible for developing and implementing the MMMMP and the subtasks identified within the plan. There are six elements to the MMMMP that will be developed:

- Coordination
- Safety Zone Establishment
- Noise Attenuation
- Visual Monitoring
- Startup and Shutdown Procedures
- Hydroacoustic Monitoring

Each element is briefly described below.

Coordination

This section of the MMMMP will detail the communication network that will be established to ensure coordination not only between the marine mammal observers/monitors and the construction crew, but among the marine mammal observers, Caltrans, and NMFS, especially in the unlikely event of a take. In an event of a watercraft collision with a marine mammal, Caltrans (or their representative with authority) must immediately contact the NMFS Stranding Coordinator, Mr. Joseph Cordaro at (562) 980-4017. This section of the MMMP may also describe any coordination opportunities with other marine mammal observation programs working in Los Angeles Harbor.

Safety Zone Establishment

Since Caltrans will not be requesting Incidental Harassment Authorization from NMFS, it is critical that accurate or conservative safety zones be established that ensure harassment or injury take of marine mammals does not occur. However, establishment of an overly conservative safety zone will lead to excessive manpower to monitor an area more than actually needed. Overly large safety zones can also lead to diluted observation of the more critical injury zones (where noise levels are greater than 190 dB).

Separate safety zones will be established for each vibratory pile driving (extending to the 120 dB isopleth) and impact pile driving (extending to the 180 dB isopleth). Distances to the threshold isopleths will be estimated by applying sound source data from similar hammers collected by Caltrans in California and WSDOT/WSF in Puget Sound to various transmission loss models available in the literature. The vibratory hammer safety zone estimate will take into account baseline noise levels, while the impact hammer estimate will account for any employed attenuation method (such as bubble curtains). All these

zones will be verified, and modified as needed, during the real time collection of hydroacoustic data during construction (refer to Hydroacoustic Monitoring below).

Noise Attenuation

The noise attenuation procedures planned to be used during impact pile driving will be described in this section of the MMMMP. The description will focus upon the use of bubble curtains following NMFS' Impact Pile Driving Sound Attenuation Specification (revised October 31, 2006). Studies by Jim Laughlin (WSDOT/WSF) in Puget Sound have shown on average about a 10 dB decline in noise levels at source can be achieved with bubble curtains for pile driving in shallow water. Until actual measurements are taken during pile driving, an average 10 dB reduction will likely be used in estimating distance to NMFS thresholds for initial establishment of safety zones.

However, bubble curtains are not always effective leaving other techniques to consider to achieve appropriate levels of attenuation. These include using cofferdams around piles or using wood or synthetic material caps on the pile surfaces to cushion hammer blows. The pros and cons of these methods will be described in the MMMP.

Visual Monitoring

The visual monitoring section of the MMMP will include the following: 1) minimum qualifications for biological/marine mammal monitors, 2) location and number of monitors, 3) data collection procedures, including forms and equipment to be used, and 4) survey periods before, during, and after pile driving activity. The latter will be identified based on the established safety zones. Monitoring locations must consider that marine mammals need to be observed prior to reaching the safety zone such that pile driving operations can be shutdown before the animal crosses the safety threshold (thereby avoiding take).

Startup and Shutdown Procedures

Soft startups of pile driving serve as a warning to marine mammals of pending loud noise levels, providing them an opportunity to leave the Project vicinity before hammering commences at full force. For vibratory hammers, this generally means operating the hammer at reduced energy for 15 seconds, waiting a minute, and then repeating this sequence twice more. For impact hammers, the pile is often struck three times at 40 percent of the planned energy force, followed by a one-minute waiting period, then followed by two subsequent three-strike sets.

The shutdown procedures will identify under what conditions pile driving will not occur, such as fog or night conditions where the safety zone is not entirely visible. In addition, the shutdown procedures will identify the chain of communication leading to an immediate shutdown of pile driving in the event of a marine mammal approaching the safety zone. Biological monitors will have the authority to suspend activities should sensitive mammals be present or enter the action area; therefore the monitors will need to be in full contact with construction personnel that have the authority to shutdown an active operation.

Hydroacoustic Monitoring

The hydroacoustic monitoring plan will identify the requisite instruments, methods, and reporting requirements for the measurement of underwater sound pressure and particle movement during pile driving activities. The workplan will be similar to the baseline hydroacoustic survey plan, but will focus on both vibratory and impact pile driving, possibly with and without attenuation depending on whether there is also a research focus to the hydroacoustic monitoring. The results of the hydroacoustic

monitoring will be analyzed in real time to identify whether existing (estimated) safety zones need to be modified to ensure that a marine mammal take is avoided.

A.3 REFERENCES

Caltrans, Essential Fish Habitat Assessment, Commodore Schuyler Heim Bridge (BR. NO. 53-2618) in the Ports of Long Beach and Los Angeles, Los Angeles County, California, January 2010.

MEC Analytical Systems, Inc., Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay, June 2002.

Correspondence from National Marine Fisheries Service, Southwest Region, Long Beach CA, Mr. Robert S. Hoffman, to Caltrans, District 7, Division of Environmental Planning Los Angeles, CA, Mr. Karl Price, February 12, 2010.

Site Name: Commodore Schuyler F. Heim Bridge, Long Beach, CA

Key Personnel And Responsibilities

Project Manager: Heather Benfield
The PM shall approve the health and safety plan and ensure its implementation in the field.

Site Manager: Rafael Holcombe
The SM will be responsible for the overall coordination and management of the field activities.

Site Health and Safety Officer: Rafael Holcombe
The Site Health and Safety Officer is responsible for developing and enforcing the health & safety plan (HASP), to periodically inspect the work area to ensure HASP compliance, and to verify that all project personnel have met the training and medical surveillance requirements.

Alternate Field Health and Safety Officer: Erik Kalapinski

Plan Prepared by: Rafael Holcombe Date: 6/10/10
Plan Approved by: Heather Benfield Date: 6/11/10

Training And Medical Surveillance Requirements

All Tetra Tech personnel assigned to the project have, or will have, completed all training and medical surveillance requirements as required by 29 CFR 1910.120 and company policy. A tailgate meeting will be conducted at the start of each field workday for all Tetra Tech personnel and recorded on a tailgate safety meeting field form (Attachment A).

Site Description

Type: Spill ☐ Fire ☐ HW Site ☐ Industrial Facility ☐ Other ☑

Physical Description:
The Commodore Schuyler F. Heim Bridge (the "Bridge") is a motor vehicle bridge that serves to connect Terminal Island with Long Beach crossing the Cerritos Channel. The work conducted under this HASP will take place within the Cerritos Channel directly underneath the Bridge and in surrounding waters.

Location:
The Bridge is located on Highway 47 at the crossing of the Cerritos Channel in Long Beach, California. The Site area for the hydroacoustic surveying activities is the Cerritos Channel within the Port of Los Angeles and the Port of Long Beach.

Size:
N/A

History:
The Bridge was built in 1948 and is being readied for demolition. The project purpose is to conduct a baseline hydroacoustic survey of the water surrounding the Bridge.

Status: Active ☑ Inactive ☐

Surrounding Population: Industrial Usage

Surrounding Buildings/Homes: Industrial buildings in adjacent areas.

Have Nearby People Been Evacuated? Yes ☐ No ☑ Evacuation Initiated By: N/A

Evacuation Distance: N/A Topography: Low Relief

Receiving Waters: Cerritos Channel Site Plan/Sketch Attached: Yes ☐ No ☑

Background Material Attached: Yes ☐ No ☑

Work Objectives

Conduct a hydroacoustic survey of the Cerritos Channel located directly beneath and adjacent to the Schuyler Heim bridge.

Hazard Evaluation

Hazard Level: High ☐ Moderate ☐ Low ☑

Hazard Type: Liquid ☐ Solid ☐ Sludge ☐ Vapor/Gas ☐ Unknown ☑

Known or Suspected Hazardous Materials: N/A

Characteristics: Corrosive ☐ Ignitable ☐ Toxic ☐ Reactive ☐
Volatile ☐ Radioactive ☐ Bio. Agent ☐

Exposure Routes: Inhalation ☐ Ingestion ☐ Contact ☐

MSDS Sheets attached for informational purposes only: Yes ☐ No ☑

HAZARD EVALUATION

Task	Hazards	Preventive Measures
Boating/Sampling	Boating safety, mechanical, noise, fall potential	Trained experienced boat operator, equipment inspected prior to use; PPE and life vests worn at all times. Establish traffic and Site control protocols. Observe safe boating guidelines.
General	Slip/trip/fall, vehicles	Good housekeeping practices. Clear area before working. Level D PPE at all times, equipment and working personnel will not be allowed to encroach the control boundary at all times. Place orange cones/floats when working in traffic areas and a person to direct traffic around the work zone if necessary.

Tetra Tech personnel will adhere to the Safe Working Practices for Working Over or Near Water (Attachment B) with the exception of a look-out. Due to the large project area as well as limited access to the shorelines and security issues within both Port of Los Angles and Port of Long Beach, it is not possible to have a third person onshore during work activities. However, Tetra Tech field personnel will complete the Float Plan provided in Attachment C and give a copy to the project manager (or designee) prior to launching the boat. Tetra Tech field crew (FC)/HSO will notify the PM upon return to shore.

The Vessel Safety Check (Attachment D) will be conducted prior to launch the boat into the Channel.

Personnel Protection – Sampling Operations

Level of Protection: A ☐ B ☐ C ☐ D ☑ plus life vests

Suit Type: Work Clothes Boot Type: Steel-Toe

Protection Type: Level D Eye Protection Type: Safety Glasses

Glove Type(s): Work gloves for general protection, nitrile gloves while collecting samples.

Other Protective Dress: Life vest.

Justification for Level of Protection (state decision criteria): Based on hazard level.

Change in Level of Protection: Upgraded ☐ Downgraded ☐ Not applicable ☑

Up or Downgraded to: B ☐ C ☐ D ☐
Reason (state decision criteria): Upgrade of protection level is not anticipated to be needed.

Specific Changes Made: N/A

Heat/Cold Stress Monitoring: Yes ☐ No ☑

Decontamination / Site Control Procedures – N/A

Residuals Management – N/A

Emergency Information

Emergency Contact Resources

Police/Fire Department	911
U.S. Coast Guard Sector Los Angeles-Long Beach	(310) 521-3815
	Channel 22
Non-emergency	(310) 521-3805
Los Angeles Port Police	(310) 732-3500
Long Beach Port Police	(562) 590-4185
National Response Center	(800) 424-8802
St. Mary Medical Center	(562) 491-9000

A cellular phone will be available at the Site for notifying emergency resources.

Directions/Map to Hospital Attached:
St. Mary Medical Center
1050 Linden Avenue
Long Beach, CA 90813
(562) 491 - 9000

(From Berth 205C – Colonial Yacht Anchorage)

1. Head east on Anchorage Road for 0.4 miles
2. Turn left (north) on Henry Ford Avenue for 1 mile (at the traffic light, bear left to continue on Henry Ford Avenue)
3. Turn Right (east) on Anaheim Street. Travel for 3.1 miles
4. Turn right (south) onto Linden Avenue. Entrance is on left side (east) of Linden.

Tetra Tech Resources

Tetra Tech, Inc. ..... (626) 351-4664
Heather Benfield (Project Manager) ..... (626) 470-2415
Cell: (310) 990-9524
Rafael Holcombe (Site Manager, Site Health and Safety Officer) ..... (562) 257-1589
Cell: (626) 255-1924
Christine McClain CIH (Corporate Health and Safety Manager) ..... (626) 470-2542
Michael Ridosh, CIH (Health and Safety Consultant) ..... (818) 888-5894
Erik Kalapinski (Alternate Site Health and Safety Officer) ..... (617) 443-7538
Cell: (857) 272-6276

ACTA Resources

Elaine Silvestro. ..... (310) 816-0460 x 175
Cell: (310) 650-3359

Other Resources

Marine Exchange ..... (310) 832-6411
Long Beach Pilots ..... (562) 432-0664
Los Angeles Pilots ..... (310) 732-3805
Coast Maritime Services ..... (310) 521-0484
U.S. EPA-ERT. ..... (201) 321-6660
Centers for Disease Control (Day) ..... (404) 639-3534
Centers for Disease Control (Night) ..... (404) 639-2888
National Response Center ..... (800) 424-8802
Bureau of Alcohol, Tobacco, and Firearms (Explosives) ..... (800) 424-9555
National Weather Service Forecast Office ..... (805) 955-6611

Contingency Plan for Emergencies

Emergency routes and meeting locations are on-site and will be finalized by the Site Safety Officer/Manager in the field and conveyed to all field personnel during a tailgate safety meeting prior to the start of work.

All field personnel will be instructed regarding the use of all field safety equipment prior to the start of work.

All personnel will be instructed of emergency communication procedures appropriate to the project.

A first aid kit and portable fire extinguisher will be on-site (on board) during any field operations.

A cellular phone will be available on the boat along with a working radio.

At least one of the field crew (Site Safety Officer/Manager) will be trained to perform First Aid and CPR.

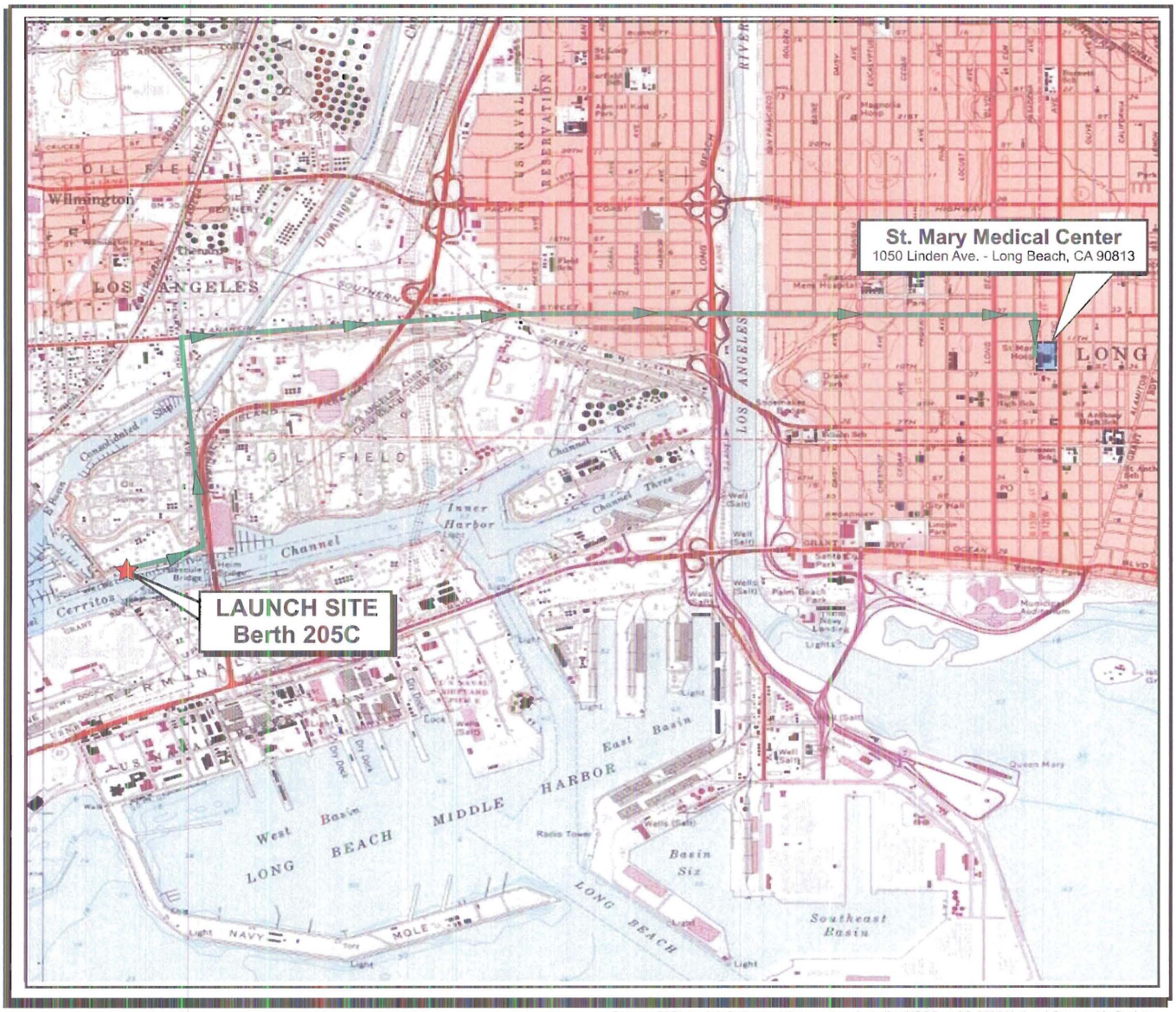
Confined-space Entry

Confined-space entry procedures applicable? Yes ☐ No ☑
If yes, attach copy of confined-space entry procedures and permit.

Prepared for
Alameda Corridor
Transportation Authority

HYDROACOUSTIC MONITORING PLAN
Health and Safety Plan

Hospital Route from Launch Site, Colonial Yacht Anchorage



Source: ESRI ArcGIS Online and data partners including USGS and © 2007 National Geographic Society

Directions:

1. Head East on Anchorage Road for 0.4 miles
2. Turn left (north) on Henry Ford Avenue for 1 mile
3. Turn right (east) on Anaheim Street. Travel for 3.1 miles
4. Turn right (south) onto Linden Avenue
   Entrance on the left side (east) of Linden Avenue

St. Mary Medical Center
1050 Linden Avenue, Long Beach, CA 90813 (562) 491-9000

NORTH
Not to Scale

I:\CADD\Mary.Hudson\Projects\1271 (ACTA)\1271-39_Route to hospital_6_4_10.cdr

TETRA TECH

ATTACHMENT A
TAILGATE SAFETY MEETING FORM

TAILGATE SAFETY MEETING

3475 East Foothill Blvd.
Pasadena, CA 91107
(626) 351-4664

DATE _____ **TIME** _____ **JOB NUMBER** _____

CLIENT _____

SPECIFIC LOCATION: _____

TYPE OF WORK _____

SAFETY TOPICS PRESENTED

PROTECTIVE CLOTHING/EQUIPMENT _____

CHEMICAL HAZARDS _____

PHYSICAL HAZARDS _____

EMERGENCY PROCEDURES:

CALL 911

_____

HOSPITAL/CLINIC _____ **ADDRESS** _____

PHONE NUMBER _____ **PARAMEDIC** 911 _____

SPECIAL EQUIPMENT _____

OTHER _____

ATTENDEES

PRINT NAME	SIGNATURE	PRINT NAME	SIGNATURE

MEETING CONDUCTED BY: **TASK LEADER**

SIGNATURE _____ _____

PRINTED NAME _____

ATTACHMENT B

SAFE WORKING PRACTICES FOR WORKING OVER OR NEAR WATER

The following sections discuss general procedures for working over or near water, underwater work, and cold water procedures.

1.0 SCOPE

This safe work practice (SWP) provides guidelines for all Tetra Tech employees and subcontractors who work over or near bodies of water three (3) or more feet deep or swiftly moving water. This SWP was developed in accordance with the Occupational Safety and Health Administration (OSHA) standard specified in Title 29 of the *Code of Federal Regulations* (CFR), Part 1926.106, "Working Over or Near Water."

2.0 RESPONSIBILITIES

The project manager (PM) is responsible for identifying all health and safety requirements of each project, including all tasks that may involve worker exposure to hazards or working in or near bodies of water. The PM will appoint a site safety coordinator (SSC) to ensure that this SWP is followed in the field. Workers will follow this SWP whenever working near or in any body of water that is over three (3) feet deep or swiftly moving.

3.0 GENERAL PROCEDURES

When working over or near water, the following precautions will be taken:

- All staff and team members must wear a personal flotation device (PFD) when working within 15 feet of a water body. Personnel will be provided with U.S. Coast Guard (USCG)-approved life jackets or work vests. The PFD should be Class III, which will support the head of an unconscious person above water.
- Life jackets and work vests will be inspected before and after each use.
- Ring buoys with at least 90 feet of line shall be provided and readily available for employee rescue operations.
- The distance between ring buoys shall not exceed 200 feet.

The online version of this document supersedes all other versions. Paper copies of this document are uncontrolled. The controlled version of this document can be found on the Tetra Tech Intranet.

accelerate shock. Drinks no warmer than normal body temperature are acceptable. If symptoms are severe and evacuation to a medical facility cannot be quickly conducted, any wet clothing should be removed, the victim should be placed in blankets or sleeping bags in a sheltered location, and the rescuer should climb into the blankets or sleeping bag with victim to provide additional warmth. The victim should also be treated continuously for shock, elevating feet and monitoring the victim's pulse and breathing rate.

If a team member falls into cold water, he or she should not remove any clothing while in the water because clothing provides additional insulation. Although clothing creates an added drag while swimming, the insulation outweighs the disadvantage of the additional drag. Each team member should carry a wool hat to place on his or her head in case he or she falls into the water. A wool hat, even when wet, provides good insulation for the head, where a large amount of body heat is lost.

Disclaimer: This safe work practice (SWP) is the property of Tetra Tech, Inc. (Tetra Tech). Any reuse of the SWP without Tetra Tech's permission is at the sole risk of the user. The user will hold harmless Tetra Tech for any damages that result from unauthorized reuse of this SWP. Authorized users are responsible for obtaining proper training and qualification from their employer before performing operations described in this SWP.

Revision Date	Document Authorizer	Revision Details
10/1/2008	Chris McClain	Update from 1998 format

ATTACHMENT C

FLOAT PLAN

TETRA TECH, INC. – FLOAT PLAN

*(This information will be called in **daily** and recorded by the FC or HSO for each **sampling site**)*

TODAY'S DATE:_____

VESSEL NAME:_____

OPERATOR: _____

DEPARTURE TIME: _____

EXPECTED TIME OF RETURN:_____

CELL PHONE NUMBER: _____

If your return will be after 4:30 p.m., with whom will you be in contact with upon your return? _____

DESTINATION/SAMPLING PLAN:_____
_____
_____
_____
_____

NAMES OF PERSONNEL ON BOARD:

_____
_____
_____
_____

NAMES (AND CELL CONTACT IF APPLICABLE) OF PERSONNEL ON SHORE:

_____
_____
_____

If expected time of return is exceeded by 3 hours, the following steps will be taken in a logical order:

1. HSO/FC will contact each other (If someone other than the FC has the float plan, that person will contact the FC)
2. Attempt to contact on-shore crew member
3. If known, hotel where crew is staying will be contacted
4. PM will be notified
5. Local hospitals and emergency centers will be contacted
6. Local search and rescue will be notified

ATTACHMENT D

VESSEL SAFETY CHECK

VESSEL SAFETY CHECK (VSC)

To be completed by a U.S. Coast Guard approved Vessel Examiner.
See the back of this form for a brief explanation of required items.
A Federal Requirements pamphlet is also available.

Date of VSC: _____

Decal Awarded: Yes ☐ No ☐

Owner/Operator Name:

_____

Owner/Operator has attended a CGAUX, USPS, State or _____ Boating Safety Class: Yes ☐ No ☐

Location of VSC - County: _____ State: _____

Replaced decal was: Last Year ☐ Outdated ☐ First time ☐

VESSEL INFORMATION:

Registration or
Documentation Number: _____

HIN: _____

Length: <16 ☐ 16-25 ☐ 26-39 ☐ 40-65 ☐ >65 ☐

Powered by: Gas ☐ Diesel ☐ Sail ☐ Other ☐

Area of Operations: Inland ☐ Coastal ☐

Type: PWC ☐ Open ☐ Cabin ☐ Other ☐

VESSEL SAFETY CHECK DECAL REQUIREMENTS

Item	Yes	No	N/A
1. Display of Numbers			
2. Registration/Documentation			
3. Personal Flotation Devices (PFD)			
4. Visual Distress Signals (VDS)			
5. Fire Extinguishers			
6. Ventilation			
7. Backfire Flame Control			
8. Sound Producing Devices/Bell			
9. Navigation Lights			
10. Pollution Placard			
11. MARPOL Trash Placard			
12. Marine Sanitation Devices			
13. Navigation Rules			
14. State and/or Local Requirements			
15. Overall Vessel Condition: **as applies**			
a. Deck Free of Hazards / Clean Bilge			
b. Electrical - Fuel Systems			
c. Galley - Heating Systems			

RECOMMENDED AND DISCUSSION ITEMS

(While encouraged, items below are not VSC requirements)

Item	Yes	No
I. Marine Radio		
II. Dewatering Device & Backup		
III. Mounted Fire Extinguishers		
IV. Anchor & Line for Area		
V. First Aid and PIW Kits (**over)		
VI. Inland Visual Distress Signals		
VII. Capacity/Certificate of Compliance		
VIII. Discussion Items: **as applies**		
a. Accident Reporting - Owner Responsibility		
b. Offshore Operations		
c. Nautical Charts / Navigation Aids		
d. Survival Tips / First Aid		
e. Fueling / Fuel Management		
f. Float Plan / Weather & Sea Conditions		
g. Insurance Considerations		
h. Boating Check List		
i. Safe Boating Classes		
j. Maritime Domain Awarness		

I certify that I have personally examined this vessel and find it meets the above requirements at the time of this Vessel Safety Check. I am a qualified Vessel Examiner of the: CGAUX ☐, USPS ☐, State of _____ ☐, or _____ ☐.

Printed Name of the Examiner _____ Examiner Number _____

Examiner Signature _____ Telephone Number _____

Additional Comments: *This is not an official boarding for law enforcement purposes. It is recommended that you correct any deficiencies noted. This checklist is furnished for your information. There is no assumption of liability of any kind for advice given or opinions expressed in connection to this examination. By accepting the Vessel Safety Check decal you are pledging to maintain your boat and equipment to the standard of safety exhibited during this examination.* **Please remove the Vessel Safety Check decal if the boat is sold or no longer meets these requirements.**

I am consenting to this Vessel Safety Check of my watercraft with full knowledge that it is provided to me as a public service on a volunteer basis without cost, and I understand and agree that my receipt of a Vessel Safety Check shall not constitute or be construed as a warranty or guarantee as to either the qualification, knowledge, or skills of the operator; the seaworthiness of the vessel; or the serviceability or adequacy of any equipment on board.

Owner/Operator Signature: _____ **Date:** _____

Back of ANSC7012 (4/08)

Brief Explanation of VSC Required Items:

❑ **1. NUMBERING:** The boat's registration number must be permanently attached to each side of the forward half of the boat characters must be plain, vertical, block style, not less than three (3) inches high, and in a color contrasting with the background. A space or hyphen must separate the letters from the numbers. Place State validation sticker according to State policy. (e.g. **FL 1234 AB or FL-4234-AB)**

❑ **2. REGISTRATION/DOCUMENTATION:** Registration or Documentation papers must be on board and available. Documentation numbers must be permanently marked on a visible part of the interior structure. The documented boat's name and hailing Port must be displayed on the exterior hull in letters not less than 4 inches in height.

❑ **3. PERSONAL FLOTATION DEVICES (PFDs):** Acceptable PFDs (also known as Life Jackets) must be U.S. Coast Guard approved and in good, serviceable condition. A wearable PFD of suitable size is required for the each person on the boat. Children must have properly fitted PFDs designed for children. Wearable PFDs shall be *"readily accessible."* Boats 16 Feet or longer, must also have one Type IV (throwable) device, which shall be *"immediately available."* PFDs shall NOT be stored in unopened plastic packaging. For Personal Watercraft riders, the PFD must be worn. An impact rating is recommended, but not required.

❑ **4. VISUAL DISTRESS SIGNALS:** Recreational boats 16 feet and over used on coast waters or the Great Lakes are required to carry a minimum of either 1) three day and three night pyrotechnic devices, 2) one day non-pyrotechnic device (flag) and one night non-pyrotechnic device (auto SOS light) or 3) a combination of 1) and 2). Recreational boats less than 16 feet on coastal waters or the Great Lakes need only carry night visual distress signals when operating from sunset to sunrise.

It is recommended, but not required, that boats operating on inland waters could have some means of making a suitable day and night distress signal. The number and type of signals is best judged by considering conditions under which the boat will be operating.

❑ **5. FIRE EXTINGUISHERS:** Fire extinguishers are required if one of the following conditions exists: 1) Inboard engine(s); 2) Double bottom hulls not completely sealed or not completely filled with flotation materials 3) Closed living space 4) Closed stowage compartments that contain flammable materials or 5) Permanently installed fuel tanks. Recreational boats less than 26 feet, and propelled by outboard motors are NOT required to have fire extinguishers unless one or more of the conditions (2-5) listed above applies. *NOTE: Fire extinguishers must be readily accessible and verified as serviceable.*

Minimum number of extinguishers required

Boat Length	*No Fixed System*	*With Fixed System*
Less than 26'	**one B-1**	**0**
26' to less than 40'	**two B-1 or one B-2**	**one B-1**
40' to 65'	**three B-1 or one B-1 & one B-2**	**two B-1 or one B-2**

❑ **6. VENTILATION:** Boats with gasoline engines in closed compartments, built after 1 August 1980 must have a powered ventilation system. Those built prior to that date must have natural or powered ventilation. Boats with closed fuel tank compartments built after 1 August 1978 must meet requirements by displaying a "certificate of compliance." Boats built before that date must have either natural or powered ventilation in the fuel tank compartment.

❑ **7. BACKFIRE FLAME ARRESTER:** All gasoline powered inboard/outboard or inboard motor boats must be equipped with an approved backfire flame control device.

❑ **8. SOUND PRODUCING DEVICES:** To comply with Navigation Rules and for distress signaling purposes all boats must carry a sound producing device (whistle, horn, siren, etc.) capable of a 4-second blast audible for ½ mile. Boats larger than 39.4 ft. are also required to have a bell (see Navigation Rules.)

❑ **9. NAVIGATION LIGHTS:** All boats must be able to display navigation lights between sunset and sunrise and in conditions of reduced visibility. Boats 16 feet or more in length must have properly installed, working navigation lights and an all- around anchor light capable of being lit independently from the red/green/white "running" lights.

❑ **10. POLLUTION PLACARD:** Boats 26 feet and over with a machinery compartment must display an oily waste "pollution" placard.

❑ **11. MARPOL TRASH PLACARD:** Boats 26 feet and over in length, operating in U.S. navigable waters, must display a "MARPOL" trash placard. Oceangoing boats 40 feet and over must also have a written trash disposal plan available onboard.

❑ **12. MARINE SANITATION DEVICE:** Any installed toilet must be a Coast Guard approved device. Overboard discharge outlets must be capable of being sealed.

❑ **13. NAVIGATION RULES:** Boats 39.4 feet and over must have on board a current copy of the Navigation Rules.

❑ **14. STATE AND LOCAL REQUIREMENTS:** These requirements must be met before the "Vessel Safety Check" decal can be awarded. A boat must meet the requirements of the state in which it is being examined.

❑ **15. OVERALL BOAT CONDITION: As it applies to this Vessel. Including, but not limited to:**

a. Deck free of hazards and clean bilge - The boat must be free from fire hazards, in good overall condition, with bilges reasonably clean and visible hull structure generally sound. The use of automobile parts on boat engines is not acceptable. The engine horsepower must not exceed that shown on the capacity plate.

b. Electrical and Fuel Systems: The electrical system must be protected by fuses or manual reset circuit breakers. Switches and fuse panels must be protected from rain or water spray. Wiring must be in good condition, properly installed and with no exposed areas or deteriorated insulation. Batteries must be secured and terminals covered to prevent accidental arcing.. **If installed,** self-circling or kill switch mechanism must be in proper working order. All PWCs **require** an operating self circling or kill switch mechanism.

Fuel Systems - Portable fuel tanks (normally 7 gallon capacity or less) must be constructed of non-breakable material and free of corrosion and leaks. All vents must be capable of being closed. The tank must be secured and have a vapor-tight, leak-proof cap. Each permanent fuel tank must be properly ventilated.

c. Galley and Heating Systems - System and fuel tanks must be properly secured with no flammable materials nearby.

I - VIII. RECOMMENDED AND DISCUSSION ITEMS: (Not required for the award of the "Vessel Safety Check" decal). For the very best boaters, we recommend these additional items. Meeting these requirements reflects your concern for Boating Safety.

**** Person in the Water (PIW) kit consists of one extra wearable PFD and a throwable type IV PFD w/line.**

For more information: Ask your Vessel Examiner,
Visit http://SafetySeal.net

Schuyler Heim Bridge Replacement Project
Air Quality Information Handout

The following mitigation measures have been identified in the "Schuyler Heim Bridge Replacement and SR-47 Expressway Project Final Environmental Impact Statement/Environmental Impact Report and Section 4(f) Evaluation" to reduce air quality effects during project construction and provide the noted potential efficiencies as determined by SCAQMD:

AQ-1 Apply nontoxic soil stabilizers to all inactive construction areas (previously graded areas inactive for 10 days), and areas anticipated to be inactive for 10 days. Nontoxic soil stabilizers can reduce PM_{10}/$PM_{2.5}$ emissions from these areas by 30 to65 percent.

AQ-2 Replace ground cover in disturbed areas as quickly as possible. A reduction of 15 to 49 percent in PM_{10}/$PM_{2.5}$ emissions for disturbed areas could be achieved.

AQ-3 Reduce traffic speed on all unpaved roads to 15 mph or less. PM10/PM2.5 emissions from travel on unpaved roads can be reduced by 40 to 70 percent by managing vehicle speeds.

AQ-4 Develop and implement a trip reduction plan to achieve a 1.5 average vehicle ridership for construction employees. A trip reduction plan can reduce emissions of ROG, NOX, CO, and PM_{10} from worker commutes by 0.1 to 2.2 percent, 0.1 to 2.9 percent, 0.1 to 2.9 percent, and 0.1 to 2.9 percent, respectively (SCAQMD, 1993).

AQ-5 Implement a shuttle service for construction workers to and from retail services and food establishments during lunch hours. A shuttle service can reduce emissions of ROG, NOX, CO, and PM10 from lunch hour trips by 0.1 to 1.0 percent, 0.1 to 1.3 percent, 0.1 to 1.3 percent, and 0.1 to 1.3 percent, respectively (SCAQMD, 1993).

AQ-6 Prohibit truck idling in excess of 2 minutes. Employ periodic, unscheduled inspections to limit unnecessary idling. The SCAQMD has not quantified the efficiency of this mitigation measure.

AQ-7 Suspend use of all construction equipment operations during second-stage smog alerts. The SCAQMD has not quantified the efficiency of this measure.

AQ-8 Use electricity, if feasible, from power poles rather than temporary diesel- or gasoline-powered generators. Using electricity from power poles is an effective measure to reduce emissions of ROG, NOX, CO, and PM_{10} from generators. Reduction efficiencies for these compounds are 97 to 99 percent.

AQ-9 Does not apply.

AQ-10 To the extent feasible, utilize construction equipment equipped with Tier 2 or newer engines.

AQ-11 Maintain and tune engines per manufacturer's specifications to perform at EPA certification levels and to perform at verified standards applicable to retrofit technologies. Employ periodic, unscheduled inspections to ensure that construction equipment is properly maintained, tuned, and modified to established specifications.

AQ-12 Prohibit tampering with engines, and require continuing adherence to manufacturer's recommendations.

INFORMATION HANDOUT

BATTERY BACKUP SYSTEM CONNECTION DIAGRAMS AND FOUNDATION DETAILS

EA 07-138201

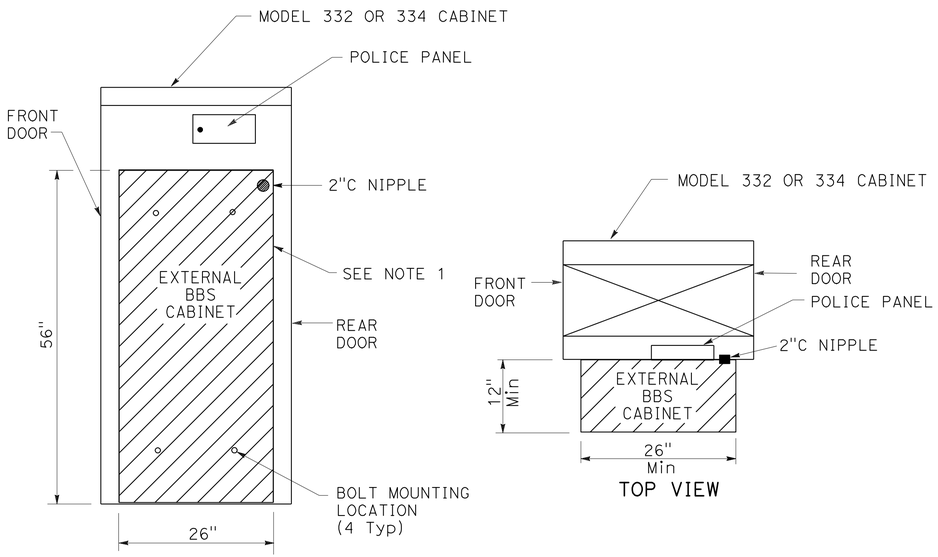
Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Theresa Gabriel — 12-20-07
REGISTERED CIVIL ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER
Theresa A. Gabriel
No. E15129
Exp. 6-30-10
ELECT
STATE OF CALIFORNIA

PLANS APPROVAL DATE

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

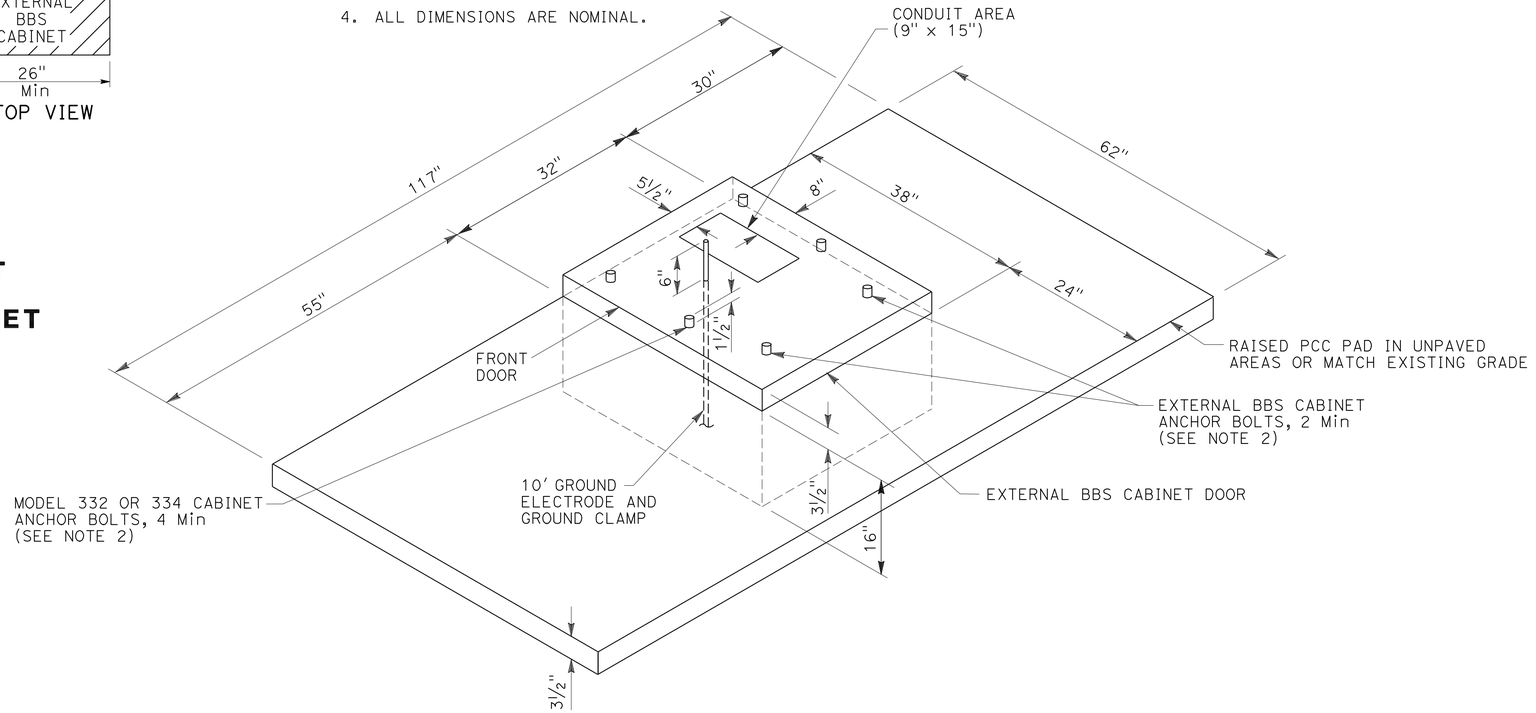


SIDE VIEW

EXTERNAL BBS CABINET MOUNTED TO THE MODEL 332 OR 334 CABINET

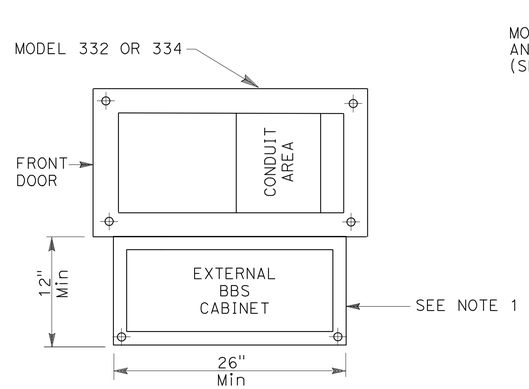
NOTE: (THIS SHEET ONLY)

1. THE EXTERNAL BBS CABINET SHALL BE MOUNTED TO THE MODEL 332 OR 334 CABINET WITH FOUR 18-8 STAINLESS STEEL HEX HEAD, FULLY-THREADED, $\frac{3}{8}$"-16 X 1" BOLTS; TWO WASHERS PER BOLT, DESIGNED FOR $\frac{3}{8}$" BOLTS AND ARE 18-8 STAINLESS STEEL, 1" OUTSIDE DIAMETER, ROUND, AND FLAT; AND ONE K-LOCK NUT PER BOLT THAT IS 18-8 STAINLESS STEEL AND A HEX-NUT. THE ENGINEER WILL HAVE TO APPROVE THE BOLT MOUNTING LOCATION PRIOR TO INSTALLATION.
2. THE ANCHOR BOLTS SHALL BE $\frac{3}{4}$" Dia X 15" WITH A 2"-90° BEND. THE CABINET MANUFACTURER'S SPECIFICATION SHALL DETERMINE THE LOCATION OF THE ANCHOR BOLTS IN THE FOUNDATION. THE ENGINEER WILL HAVE TO APPROVE THE ANCHOR BOLTS AND ITS LOCATION IN THE FOUNDATION PRIOR TO CONSTRUCTION.
3. THE CONTRACTOR SHALL VERIFY THE DIMENSIONS OF THE BBS CABINET PRIOR TO CONSTRUCTING THE FOUNDATION OF THE MODIFIED PORTION OF THE Std MODEL 332 AND 334 CABINET FOUNDATION. THE ENGINEER WILL HAVE TO APPROVE ANY NECESSARY DEVIATIONS PRIOR TO CONSTRUCTION.
4. ALL DIMENSIONS ARE NOMINAL.



MODIFIED MODEL 332 AND 334 CABINET FOUNDATION DETAIL FOR BATTERY BACKUP SYSTEM (BBS)

(FOR DIMENSIONS AND DETAILS NOT SHOWN AND ADDITIONAL NOTES, SEE SHEET ES-3C OF THE STANDARD PLANS FOR MODEL 332 AND 334 CABINETS)



BASE PLAN FOR BBS MOUNTED TO THE MODEL 332 OR 334 CABINET

(FOR DIMENSIONS AND DETAILS NOT SHOWN, SEE SHEET A6-1 TO A6-4, CABINET HOUSING DETAILS OF THE TRANSPORTATION ELECTRICAL EQUIPMENT SPECIFICATION (TEES))

ELECTRICAL SYSTEMS
(BBS FOUNDATION DETAILS)

NO SCALE

THIS PLAN IS ACCURATE FOR ELECTRICAL WORK ONLY.

REVISED BY | DATE REVISED
CALCULATED-DESIGNED BY | CHECKED BY
FUNCTIONAL SUPERVISOR
STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans

LAST REVISION 2-2-09
DATE PLOTTED => 13-APR-2010
TIME PLOTTED => 11:41

BORDER LAST REVISED 4/11/2008
RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3
USERNAME => trpierce
DGN FILE => BBS Foundation.dgn
CU 00000
EA 000000

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Theresa Gabriel — REGISTERED CIVIL ENGINEER — 12-20-07 DATE

REGISTERED PROFESSIONAL ENGINEER — Theresa A. Gabriel — No. E15129 — Exp. 6-30-10 — ELECT — STATE OF CALIFORNIA

PLANS APPROVAL DATE

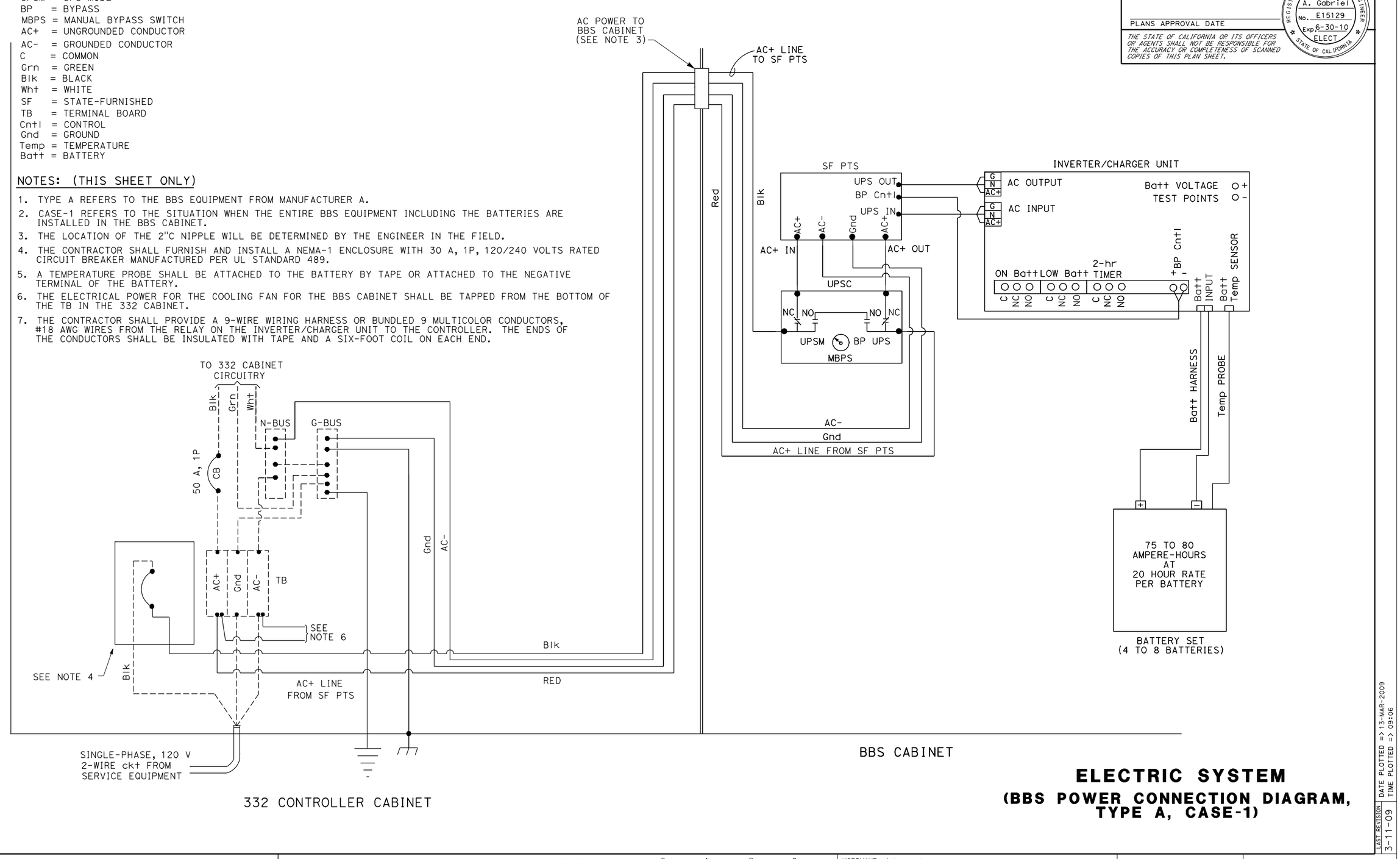
THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

LEGEND: (THIS SHEET ONLY)

PTS = POWER TRANSFER SWITCH
UPS = UNINTERRUPTIBLE POWER SUPPLY
UPSC = UNINTERRUPTIBLE POWER SUPPLY CONTROLLER
UPSM = UPS MODE
BP = BYPASS
MBPS = MANUAL BYPASS SWITCH
AC+ = UNGROUNDED CONDUCTOR
AC- = GROUNDED CONDUCTOR
C = COMMON
Grn = GREEN
Blk = BLACK
Wht = WHITE
SF = STATE-FURNISHED
TB = TERMINAL BOARD
Cntl = CONTROL
Gnd = GROUND
Temp = TEMPERATURE
Batt = BATTERY

NOTES: (THIS SHEET ONLY)

1. TYPE A REFERS TO THE BBS EQUIPMENT FROM MANUFACTURER A.
2. CASE-1 REFERS TO THE SITUATION WHEN THE ENTIRE BBS EQUIPMENT INCLUDING THE BATTERIES ARE INSTALLED IN THE BBS CABINET.
3. THE LOCATION OF THE 2"C NIPPLE WILL BE DETERMINED BY THE ENGINEER IN THE FIELD.
4. THE CONTRACTOR SHALL FURNISH AND INSTALL A NEMA-1 ENCLOSURE WITH 30 A, 1P, 120/240 VOLTS RATED CIRCUIT BREAKER MANUFACTURED PER UL STANDARD 489.
5. A TEMPERATURE PROBE SHALL BE ATTACHED TO THE BATTERY BY TAPE OR ATTACHED TO THE NEGATIVE TERMINAL OF THE BATTERY.
6. THE ELECTRICAL POWER FOR THE COOLING FAN FOR THE BBS CABINET SHALL BE TAPPED FROM THE BOTTOM OF THE TB IN THE 332 CABINET.
7. THE CONTRACTOR SHALL PROVIDE A 9-WIRE WIRING HARNESS OR BUNDLED 9 MULTICOLOR CONDUCTORS, #18 AWG WIRES FROM THE RELAY ON THE INVERTER/CHARGER UNIT TO THE CONTROLLER. THE ENDS OF THE CONDUCTORS SHALL BE INSULATED WITH TAPE AND A SIX-FOOT COIL ON EACH END.



ELECTRIC SYSTEM
(BBS POWER CONNECTION DIAGRAM, TYPE A, CASE-1)

LAST REVISION 3-11-09 | DATE PLOTTED => 13-MAR-2009 | TIME PLOTTED => 09:06

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION | FUNCTIONAL SUPERVISOR | CALCULATED-DESIGNED BY | CHECKED BY | REVISED BY | DATE REVISED

BORDER LAST REVISED 4/11/2008 | RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3 | USERNAME => trcarol | DGN FILE => BBS 1250FSM.dgn | CU 00000 | EA 000000

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Theresa Gabriel — REGISTERED CIVIL ENGINEER — 12-20-07 DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — Theresa A. Gabriel — No. E15129 — Exp 6-30-10 — ELECT — STATE OF CALIFORNIA

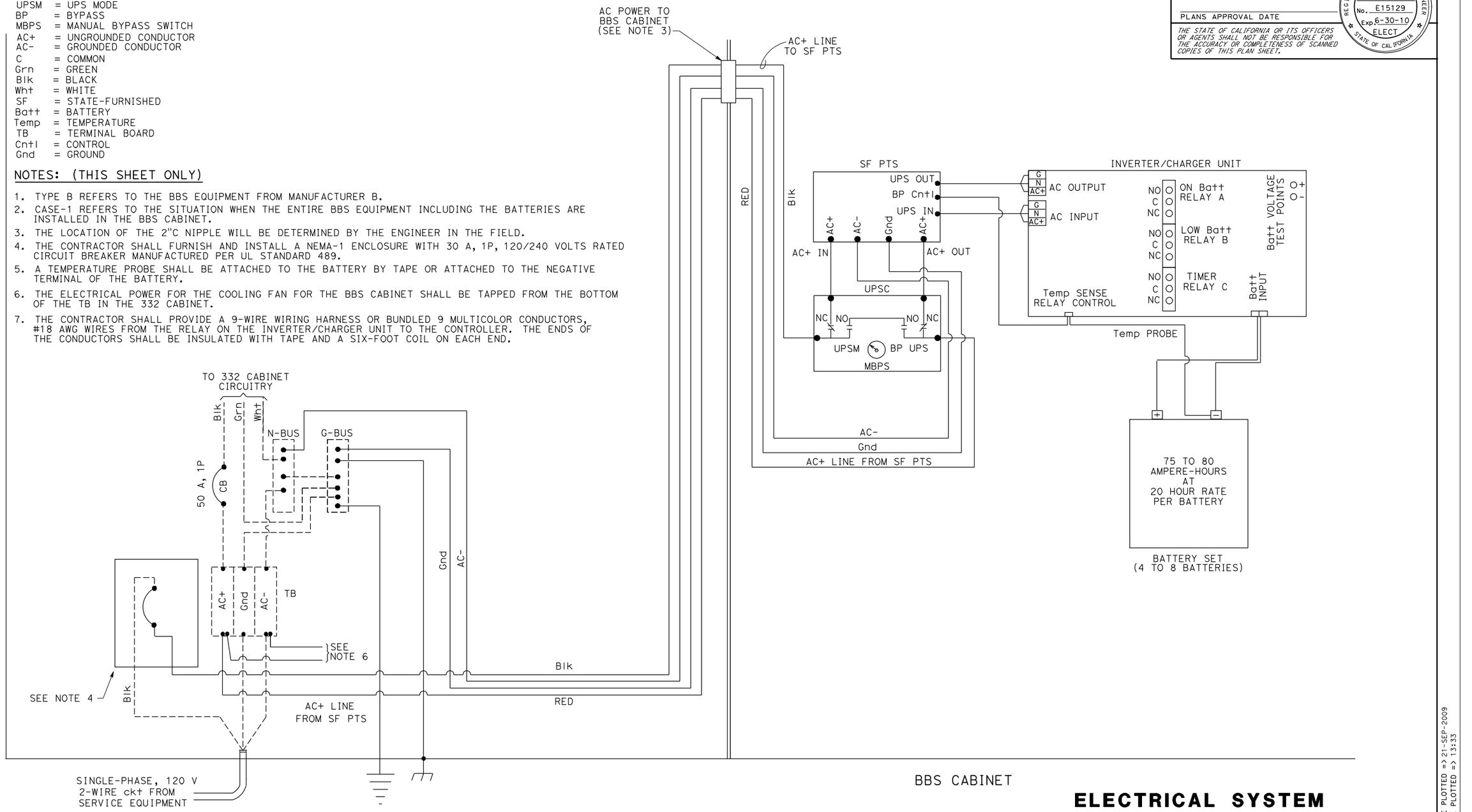
THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

LEGEND: (THIS SHEET ONLY)

PTS = POWER TRANSFER SWITCH
UPS = UNINTERRUPTIBLE POWER SUPPLY
UPSC = UNINTERRUPTIBLE POWER SUPPLY CONTROLLER
UPSM = UPS MODE
BP = BYPASS
MBPS = MANUAL BYPASS SWITCH
AC+ = UNGROUNDED CONDUCTOR
AC- = GROUNDED CONDUCTOR
C = COMMON
Grn = GREEN
Blk = BLACK
Wht = WHITE
SF = STATE-FURNISHED
Batt = BATTERY
Temp = TEMPERATURE
TB = TERMINAL BOARD
Cntl = CONTROL
Gnd = GROUND

NOTES: (THIS SHEET ONLY)

1. TYPE B REFERS TO THE BBS EQUIPMENT FROM MANUFACTURER B.
2. CASE-1 REFERS TO THE SITUATION WHEN THE ENTIRE BBS EQUIPMENT INCLUDING THE BATTERIES ARE INSTALLED IN THE BBS CABINET.
3. THE LOCATION OF THE 2"C NIPPLE WILL BE DETERMINED BY THE ENGINEER IN THE FIELD.
4. THE CONTRACTOR SHALL FURNISH AND INSTALL A NEMA-1 ENCLOSURE WITH 30 A, 1P, 120/240 VOLTS RATED CIRCUIT BREAKER MANUFACTURED PER UL STANDARD 489.
5. A TEMPERATURE PROBE SHALL BE ATTACHED TO THE BATTERY BY TAPE OR ATTACHED TO THE NEGATIVE TERMINAL OF THE BATTERY.
6. THE ELECTRICAL POWER FOR THE COOLING FAN FOR THE BBS CABINET SHALL BE TAPPED FROM THE BOTTOM OF THE TB IN THE 332 CABINET.
7. THE CONTRACTOR SHALL PROVIDE A 9-WIRE WIRING HARNESS OR BUNDLED 9 MULTICOLOR CONDUCTORS, #18 AWG WIRES FROM THE RELAY ON THE INVERTER/CHARGER UNIT TO THE CONTROLLER. THE ENDS OF THE CONDUCTORS SHALL BE INSULATED WITH TAPE AND A SIX-FOOT COIL ON EACH END.



ELECTRICAL SYSTEM

(BBS POWER CONNECTION DIAGRAM, TYPE B, CASE-1)

LAST REVISION 3-11-09
DATE PLOTTED => 21-SEP-2009
TIME PLOTTED => 13:33

REVISED BY | DATE REVISED
CALCULATED-DESIGNED BY | CHECKED BY
FUNCTIONAL SUPERVISOR
STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans

BORDER LAST REVISED 4/11/2008

RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

USERNAME => trcarol
DGN FILE => BBS DUIFSM.dgn

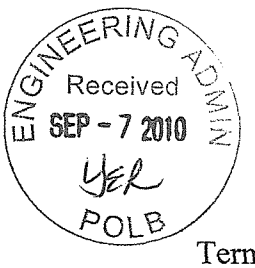
CU 00000

EA 000000

CC: CT

STATE OF CALIFORNIA ARNOLD SCHWARZENEGGER, *Governor*

PUBLIC UTILITIES COMMISSION
180 Promenade Circle, Suite 115
Sacramento, CA 95834



August 31, 2010

File Number: G.10-07-021
Terminal Island Fwy/New Dock St off ramp
City of Long Beach

Al Moro, P.E.
Chief Harbor Engineer
The Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Re: General Order 88-B Request for Authority to Grade Separate the Terminal Island Fwy/New Dock St off ramp At-Grade Highway-Rail crossing across the tracks of the Port of Long Beach, in City of Long Beach, Los Angeles County.

Dear Mr. Moro:

This refers to your letter, dated July 15, 2010, received July 16, 2010, requesting authorization, pursuant to Commission General Order (GO) 88-B, to alter the Terminal Island Fwy/New Dock St off ramp at-grade highway-rail crossing (crossing), CPUC Crossing No. 120AT-18.57, of the Port of Long Beach's (POLB) Alameda Corridor Subdivision tracks in City of Long Beach (City), County of Los Angeles.

POLB owns the railroad right of way and Pacific Harbor Line (PHL) operates freight service on the rail corridor. POLB, a City of Long Beach agency, also controls the street system within the port. The alterations proposed for this crossing are part of a larger project to reconstruct and widen the Terminal Island Freeway (SR-47).

The proposed SR-47 reconstruction will realign and grade separate the existing at-grade crossing. The existing tracks will be shifted north with the new SR-47 southbound off ramp structure passing over the tracks. The ramp structure will intersect with a newly elevated New Dock Street.

The Commission's Rail Crossings Engineering Section (RCES) investigated the request by POLA and finds it adequately addresses compliance and safety. As POLA, PHL and City are in agreement as to the design and apportionments of the cost under the provisions of GO 88-B, the improvements as described in your letter dated July 15, 2010, and summarized above are authorized. Improvements shall comply with all applicable Commission General Orders and the California Manual on Uniform Traffic Control Devices published by the California Department of Transportation.

This project is statutorily exempt from the requirements of the California Environment Quality Act of 1970, as amended. [California Pubic Resources Code 21080.13]

This authorization shall expire if the above conditions are not complied with or if the work is not completed within three years of the date of this letter. Upon written request to this office, the time to complete the project may be extended. Any written request for a time extension must include concurrence letters by involved parties in support of the time extension. If an extension is requested, the Commission's RCES may reevaluate the crossings prior to granting an extension.

Within 30 days after completion of this project, POLA shall notify RCES that the authorized work is completed, by submitting a completed Commission Standard Form G title *Report of Changes at Highway Grade Crossings and Separation.* Form G requirements and forms can be obtained at the CPUC web site Form G page at http://www.cpuc.ca.gov/formg. This report may be submitted electronically to rces@cpuc.ca.gov as outlined on the web page.

If you have any questions, please contact Jose Pereyra at (213-576-7083) or jfp@cpuc.ca.gov .

Sincerely,

Daren Gilbert, Supervisor
Rail Crossings Engineering Section
Consumer Protection and Safety Division

C: Carlo Luzzi, Port of Long Beach
Robert Giannoble, Pacific Harbor Line

CC: CT

STATE OF CALIFORNIA ARNOLD SCHWARZENEGGER, *Governor*

PUBLIC UTILITIES COMMISSION
180 Promenade Circle, Suite 115
Sacramento, CA 95834

August 31, 2010

File Number: G.10-07-022
New Dock St
City of Long Beach

Al Moro, P.E.
Chief Harbor Engineer
The Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Re: General Order 88-B Request for Authority to Modify the New Dock St At-Grade Highway-Rail crossing across the tracks of the Port of Long Beach, in City of Long Beach, Los Angeles County.

Dear Mr. Moro:

This refers to your letter, dated July 15, 2010, received July 16, 2010, requesting authorization, pursuant to Commission General Order (GO) 88-B, to alter the New Dock St at-grade highway-rail crossing (crossing), CPUC Crossing No. 120AT-18.60, of the Port of Long Beach's (POLB) Alameda Corridor Subdivision tracks in City of Long Beach (City), County of Los Angeles.

POLB owns the railroad right of way and Pacific Harbor Line (PHL) operates freight service on the rail corridor. POLB, a City of Long Beach agency, also controls the street system within the port. The alterations proposed for this crossing are part of a larger project to reconstruct and widen the Terminal Island Fwy (SR-47).

The proposed SR-47 reconstruction will realign the existing tracks and shift the existing crossing. POLB proposes to shift the existing tracks east and raise the elevation to match the elevations of the reconstructed New Dock St. New Dock St will have two vehicular lanes for each direction of travel (east/west). Specifically, POLB will perform the following modifications:

- Construct new raised medians on both approaches to the crossing,
- Install one curb mounted Commission Standard 9A (flashing light signals with gate and cantilever, per GO 75-D) on west approach to crossing,
- Install one curb mounted Commission Standard 9 (flashing light signals with gate, per GO 75-D) and one median mounted Commission Standard 9 on east approach to crossing,
- Replace all existing flashers with LEDs,
- Install new railroad signage, pavement markings and striping as indicated in letter and plans.

The Commission's Rail Crossings Engineering Section (RCES) investigated the request by POLB and finds it adequately addresses compliance and safety. As POLB, PHL and City are in agreement as to the design and apportionments of the cost under the provisions of GO 88-B, the improvements as described in your letter dated July 15, 2010, and summarized above are authorized. Improvements shall comply with all applicable Commission General Orders and the California Manual on Uniform Traffic Control Devices published by the California Department of Transportation.

This project is categorically exempt from the requirements of the California Environment Quality Act of 1970, as amended. [California Pubic Resources Code 21084]

This authorization shall expire if the above conditions are not complied with or if the work is not completed within two years of the date of this letter. Upon written request to this office, the time to complete the project may be extended. Any written request for a time extension must include concurrence letters by involved parties in support of the time extension. If an extension is requested, the Commission's RCES may reevaluate the crossings prior to granting an extension.

Within 30 days after completion of this project, POLB shall notify RCES that the authorized work is completed, by submitting a completed Commission Standard Form G title *Report of Changes at Highway Grade Crossings and Separation.* Form G requirements and forms can be obtained at the CPUC web site Form G page at http://www.cpuc.ca.gov/formg. This report may be submitted electronically to rces@cpuc.ca.gov as outlined on the web page.

If you have any questions, please contact Jose Pereyra at (213-576-7083) or jfp@cpuc.ca.gov .

Sincerely,

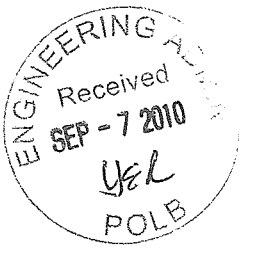
Daren Gilbert, Supervisor
Rail Crossings Engineering Section
Consumer Protection and Safety Division

C: Carlo Luzzi, Port of Long Beach
Robert Giannoble, Pacific Harbor Line

CC: CT

STATE OF CALIFORNIA ARNOLD SCHWARZENEGGER, *Governor*

PUBLIC UTILITIES COMMISSION
180 Promenade Circle, Suite 115
Sacramento, CA 95834



August 31, 2010

File Number: G.10-07-023
Terminal Island Fwy Overhead
City of Long Beach

Al Moro, P.E.
Chief Harbor Engineer
The Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Re: General Order 88-B Request for Authority to modify the Terminal Island Fwy Grade Separated Highway-Rail crossing over the tracks of the Port of Long Beach, in City of Long Beach, Los Angeles County.

Dear Mr. Moro:

This refers to your letter, dated July 15, 2010, received July 16, 2010, requesting authorization, pursuant to Commission General Order (GO) 88-B, to alter the Terminal Island Fwy Grade Separated Highway-Rail crossing (crossing), CPUC Crossing No. 120AT-18.64-A, of the Port of Long Beach's (POLB) Alameda Corridor Subdivision tracks in City of Long Beach (City), County of Los Angeles.

POLB owns the railroad right of way and Pacific Harbor Line (PHL) operates freight service on the rail corridor. POLB, a City of Long Beach agency, also controls the street system within the port. The alterations proposed for this crossing are part of a larger project to reconstruct and widen the Terminal Island Fwy (SR-47).

The proposed SR-47 reconstruction will realign the existing northerly track and raise its elevation to match that of the adjacent New Dock St. The existing southerly track and turnout will remain unchanged. The existing SR-47 overhead structure will be removed and replaced with a new structure located at approximately the same horizontal location but at a higher elevation.

The Commission's Rail Crossings Engineering Section (RCES) investigated the request by POLA and finds it adequately addresses compliance and safety. As POLA, PHL and City are in agreement as to the design and apportionments of the cost under the provisions of GO 88-B, the improvements as described in your letter dated July 15, 2010, and summarized above are authorized. Improvements shall comply with all applicable Commission General Orders and the California Manual on Uniform Traffic Control Devices published by the California Department of Transportation.

This project is categorically exempt from the requirements of the California Environment Quality Act of 1970, as amended. [California Pubic Resources Code 21084]

This authorization shall expire if the above conditions are not complied with or if the work is not completed within three years of the date of this letter. Upon written request to this office, the time to complete the project may be extended. Any written request for a time extension must include concurrence letters by involved parties in support of the time extension. If an extension is requested, the Commission's RCES may reevaluate the crossings prior to granting an extension.

Within 30 days after completion of this project, POLA shall notify RCES that the authorized work is completed, by submitting a completed Commission Standard Form G title *Report of Changes at Highway Grade Crossings and Separation.* Form G requirements and forms can be obtained at the CPUC web site Form G page at http://www.cpuc.ca.gov/formg. This report may be submitted electronically to rces@cpuc.ca.gov as outlined on the web page.

If you have any questions, please contact Jose Pereyra at (213-576-7083) or jfp@cpuc.ca.gov .

Sincerely,

Daren Gilbert, Supervisor
Rail Crossings Engineering Section
Consumer Protection and Safety Division

C: Carlo Luzzi, Port of Long Beach
Robert Giannoble, Pacific Harbor Line

HARBOR DEVELOPMENT PERMIT (RAILROAD GUIDELINES SECTION)

WORK REQUIREMENTS WHEN WORKING WITHIN RAILROAD RIGHT-OF-WAY

The requirements stated in this section relate to any work within the railroad right-of-way. For construction purposes, the railroad right-of-way is defined as 20 feet from track centerline. The minimum vertical clearance above top of rail is 25 feet. The minimum depth for any utility construction below grade shall be five (5) feet – six (6) inches from base of rail for mainline track and four (4) feet – six (6) inches from base of rail for other than mainline track in accordance with the Engineering Division railroad standard plans. Any work within the railroad right-of-way shall include a Port inspector paid by the Contractor.

The Contractor shall not enter any location, perform any work, or locate any piece of equipment within ten (10) feet of the nearest rail of any railroad track without prior authorization from the Engineering Division and Pacific Harbor Line (PHL). The PHL contact is Bob Giannoble at (310) 420-8116. All work shall be performed in accordance with the provisions of Title 49, Part 214 of the Code of Federal Regulations.

The Contractor shall submit a written Work Plan to the Engineering Division for approval not less than fourteen (14) days prior to beginning work. The Work Plan shall include the location, starting and stopping times, a description of the work to be performed, the work crews involved, and the track outages and/or railroad safety protection (Flagmen). All flagging shall be by PHL. No work may be performed, nor any piece of equipment moved within ten (10) feet of the nearest rail of any railroad track until the Engineering Division approves the Work Plan. The Contractor, if required, will pay Flagmen, to PHL.

The Contractor shall provide a qualified train Watchperson when working within 20 feet of the track centerline for the safety and protection of the Contractor's personnel and equipment during construction operations. Watchperson shall be properly trained and equipped in accordance with Title 49, Part 214 of the Code of Federal Regulations. The Contractor shall pay the cost of Watchperson. The PHL will qualify the Watchperson for the project. The Contractor shall submit an approved list of PHL trained watchperson to the Engineering Division prior to working within 20 feet of the track centerline.

Crossing of tracks by the Contractor's equipment at unpaved railroad crossings is prohibited. A temporary timber railroad crossing shall be required for construction access over the tracks.

The Contractor shall report any accidents, injuries, track defects, or any unusual track conditions, which may affect the safe and efficient operation of the railroad to the Engineering Division and PHL by the first available means of communication.

The Contractor shall be responsible for the prevention or damage to railroad facilities, equipment and operating trains due to its activities. In the event the Contractor damages railroad facilities or equipment, the Contractor shall immediately report the damage to the Engineering Division and PHL. Repair of damage caused by Contractor's operations shall be at the expense of the Contractor and accomplished immediately in accordance with the Engineering Division and PHL supervision.

Upon completion of the work, the Contractor shall promptly remove all materials, tools, equipment, and leave the right-of-way in a clean, presentable condition.

Port Standard Utility Casing Requirements

The approved method for utility installation under the railroad tracks is by boring or jacking and shall be in accordance to the Engineering Division railroad standards casing plans. All ballast and sub-ballast replacements shall be with new material. The tracks shall be restored to original alignment by an experienced railroad contractor.

Utility Work on Railroad Right-of-Way

Trenching and/or tunneling under the tracks may be permitted for non-mainline track where boring cannot be accomplished as approved by the Engineering Division for each specific site. Shoring plans, engineering calculations and detailed cross sections shall be required for both utility crossings under the railroad tracks and longitudinal trenching within 20 feet from track centerline. The shoring plan shall include a support beam in order to prevent a sag in the tracks.

Open cut trenching under unpaved track sections shall include delineators or fencing after work hours. New ballast shall be placed 12 inches (six inch lifts) from bottom of tie to a distance two feet beyond edge of tie. A two (2) - sack slurry (quick hardening mix) shall be placed from bottom of new ballast to a distance 15 feet from each side of track centerline. Backfill for longitudinal work within 20 feet from track centerline shall be required and placed in six (6) inch layers with 95 percent compaction in accordance with the American Society for Testing and Materials (ASTM) Designation D 1556 and D 1557.

For tunneling work under paved tracks, the Contractor shall saw cut pavement at a distance of five (5) feet from track centerline (or beyond end of tie). The Contractor shall fill any voids between the proposed steel casing and tunneling hole with a two (2)-sack slurry mix (quick hardening mix). If a cave in occurs within the area from the base of rail to a distance four (4) feet below base of rail at any point along the tunneling operation, then the Contractor shall be required to continue as an open cut trench with complete asphalt and soil removal.

Ballast and Sub-ballast

Sub-ballast material shall be Crushed Miscellaneous Base (CMB) and shall conform to Section 200-2.4 (Fine Gradation), per SSPWC. Placement of the sub-ballast shall conform to Section 301-2.2 "Spreading" and 301-2.3 "Compacting" per SSPWC

Ballast material shall consist of clean crushed stone, tough, durable fragments free of any detrimental quantity of soft, friable, thin, elongated or laminated pieces, disintegrated material, pieces coated with dirt, oil or other deleterious substance. Ballast shall be crushed granite, quarry stone or slag.

Ballast gradation shall be gradation No. 4A as outlined in Chapter 1, Part 2, Section 2 of the AREMA Manual. The ballast gradation shall be determined by ASTM C136 with laboratory sieves having square openings conforming to ASTM E11.

Gradation No. 4A:

Nominal Sieve Size	Percent Passing By Weight (No. 4A)
2 – 1/2 inch	100 percent
2 inch	90 - 100 percent
1-1/2 inch	60 - 90 percent
1 inch	10 - 35 percent
3/4 inch	0 - 10 percent
1/2 inch	----------
3/8 inch	0 – 3 percent

The Contractor shall provide certification that ballast delivered to the job site is typical of ballast which passed acceptance and production tests. If material at the job site does not conform to these specifications, the Contractor shall stop further deliveries until the fault has been corrected. The Engineering Division will reject ballast arriving at the site for unloading that does not conform to the specifications. Defective material shall be promptly removed and replaced at the Contractors expense.

The ballast shall be hand tamped by mechanical method from a point twelve (12) inches inside each rail on both sides of the ties to the ends of the ties for short rail lengths (less than 20 feet). For larger areas (greater than 20 linear feet), mobile tampers will be required. The mobile tampers shall be started from a nearly vertical position and used directly against the sides of the tie to be tamped, and worked downward past the bottom corner, after which the tool may be tipped down to force the ballast directly under the tie. Switch ties shall be heavy tamped under each rail to a point twelve (12) inches on either side of each rail. Light tamping only shall be permitted between the above – stated limits. Each tie shall be thoroughly inspected as to compactness of ballast under the tie by means of sounding devices, and any tie found not to be solidly embedded in ballast shall be re-tamped.

In paved areas, the ballast shall be dressed one (1) inch above top of tie.

Track Testing and Acceptance

The track shall be surveyed by the Contractor upon completion of the work to ensure no differential settlement has occurred over the affected work area. Upon completion of work the Contractor shall coordinate a test engine with PHL and the Engineering Division over the affected track work for inspection and acceptance of the work.

RAILROAD WORK PLAN – DATE:_____

REQUIREMENTS WHEN WORKING WITHIN, ADJACENT TO, ABOVE, OR BENEATH RAILROAD RIGHT-OF-WAY

START DATE: _____

DURATION (Start & End Date): Start on _____ and Ending on _____

TRACK LOCATION: Track number _____ track located _____ (See attached plan).

START & STOP TIMES: Begin each day at _____ and end at _____

DESCRIPTION OF WORK: The work includes

_____

_____

_____ (see attached plan).

WORK CREW: The work will be performed by _____. The equipment used will be _____.

SAFETY PROTECTION:

The work plan is submitted ten (10) days in advance of any work within twenty (20) feet of track centerline. Prior to start of work, _____ will request a watch person training session from Pacific Harbor Line (PHL) for all work-crew working within 20 feet of the railroad track for the safety of the contractor's personnel only. Watch persons are not an approved method of protection for working equipment. Once the watch person training is completed, we will submit an approved list to the Engineer prior to working within 20 Feet of the track centerline.

If equipment is within ten (10) feet from the track centerline, then a flag person will be required. Flagging to be provided by Pacific Harbor Line (PHL) only. When a Flag Person is required, a new work plan request will be submitted to the Engineer and PHL a minimum of ten (10) working days prior to any work being performed. If a full track closure/outage is necessary, a minimum notice of ten (10) working days will be provided to the Engineer and PHL for each track closure. The Railroad track closure will be at the full discretion of the Engineer and PHL. The PHL contact is Bob Giannoble (310-834-4594).

Note: The Contractor shall submit the Railroad Work Plan to the Ports Construction Manager for approval by the Manager of Rail Transportation Systems (562-590-4140). All related permits shall be obtained prior to submitting the work plan.

RAILROAD
SPECIAL PROVISIONS

RAILROAD TRACK CONSTRUCTION

1.0 **GENERAL**
1.1 Track materials and special trackwork shall conform to recommendations set forth in the most current AREMA Manuals.

1.2 Track components design shall be standardized to facilitate maintenance and minimize the inventory of materials.

2.0 **EARTHWORK**
2.1 The material to be used for embankment fill shall be provided by the Contractor from a suitable source. Fill material shall be approved by the Engineer prior to being placed on site.

2.2 The material to be used for fill shall be relatively non-expansive soils with an Expansion Index of less than 35. The on-site soils (including non-contaminated ballast) less any debris or organic matter may be used.

2.3 Material for structural backfill shall be provided by the Contractor from an off-site borrow site. Structural backfill shall conform to Caltrans Standard Specifications, Section 19-3, except that jetting of material shall not be allowed.

2.4 Material for pervious backfill shall be provided by the Contractor from an off-site source, and conform to Caltrans Standard Specification Section 19-3.06.

2.5 Sub-drains and geotextile filter fabric are required for drainage of all track systems.

2.6 The exposed bottom of all excavations or surface to receive fill shall be scarified to a depth of six (6) inches, moisture conditioned to optimum moisture content, and compacted to at least ninety (90) percent relative compaction per ASTM 1557.

2.7 The uppermost of two (2) feet of railroad subgrade, and all subballast, shall be compacted to at least ninety five (95) percent of the maximum dry density as determined in accordance with ASTM D1557. 2.8 Fill shall be placed in layers not exceeding eight (8) inches in thickness and conform to Caltrans Specification 19-3.

3.0 **TRENCH EXCAVATION AND BACKFILL**
3.1 Excavation and backfill shall be in accordance with the SSPWC subsection 306-1.1 "Trench Excavation" and 306.1.3 "Backfill and Densification" and Los Angeles Standard Plan No. S-610-21, unless otherwise specified on the plans.

3.2 Excavations for pipe laying or conduit shall be per City of Los Angeles Standard Plan No. S-251-1, unless otherwise noted on the plans.

3.3 Prior to excavating adjacent to and within six (6) feet. of a subsurface installation, excavate potholes per Section 62.03.1 of the Los Angeles Municipal Code and positively determine the elevation and location of the subsurface installation.

4.0 GEOTEXTILE REINFORCING

Geotextile material shall be required for drainage between the subballast and the subgrade.

4.1 Geotextile material type shall be as follows:

- MIRAFI type 140N for under drains
- MIRAFI type 600X for subgrade crossing areas.
- MIRAFI type 1160N for track subgrade areas.

4.2 Geotextile material shall conform to section 213-2 "Geotextiles" of the latest edition of the SSPWC.

4.3 Geogrid shall be placed on geotextile or between subballast and subgrade to increase subgrade strength for railyard and crossing areas. Geogrid material shall be Tensar SS1. Geogrid material shall conform to section 213-2 "Geotextiles"of SSPWC.

5.0 STORM DRAIN SYSTEM- UNDERDRAINS

All trackage shall be designed with adequate sub-drainage.

The following shall apply in the design of track drainage:

a. The design storm shall be a ten (10) year storm for all trackage except SUMPs and SAG areas where a fifty (50) year storm shall be used.
b. All sub-drains shall be the level of the water below the level of the ballast.
c. No ponding of water will be allowed.
d. All sub drain systems shall be designed using perforated PVC piping, a permeable drainage material and a filter fabric.

The following criteria shall be used for the drainage piping.

a. All under drain pipe and fittings shall be eight (8) inches in diameter schedule eighty (80) PVC with elastomatic asphalt joints and fittings in accordance with ASTM F578. Perforated pipe shall be used for all underdrains with solid wall pipe being used only as connector piping.
b. PVC piping shall be in accordance with ASTM D1758. Schedule eighty (80) pipe compounds shall be in accordance with ASTM 1784.
c. Joint material shall be a solvent cement in accordance with ASTM D2564.
d. Underdrain outlets and risers shall be fabricated of ductile iron or corrugated metal. They shall be painted blue and marked "POLB" and "O". and spaced evenly three hundred (300) feet.

Sub-drains pipe shall have geotextile filter fabric wrapped in crushed filter rock. The filter rock shall conform to the following gradation:

Sieve Size	**Percentage Passing**
3/4"	100
3/8"	30-100
No. 4	0-30

Filter fabric for subdrains shall be manufactured from polyester, nylon, or polypropylene material, or

any combination thereof. The fabric shall be permeable, non-woven, shall not act as a wicking agent and shall conform to the following:

Weight, ounces per square yard min. ASTM Designation D3776	4.0
Grab tensile strength (1 inch grip) lbs. Min. each direction ASTM D 4632	90
Elongation at Break, percent min. ASTM D 4632	30
Toughness, pounds, min. (%elongation x grab tensile strength)	6000
Permittivity, 1/sec., min. ASTM D4491	0.5

If filter fabric is to be exposed for more than seventy two (72) hours, all fabric shall be treated with Ultraviolet Ray (UV) Protection. The treated fabric shall provide a minimum of seventy (70) percent breaking strength retention after five hundred (500) hours exposure when tested in accordance with ASTM D4355.

7.0 DEMOLITION AND REMOVAL OF EXISTING TRACK

Track removal shall consist of removing all material from the bottom of the subballast to the top of rail for the length as shown on the project plans. All material removed will be the contractor's for disposal/salvage except for special track work such as turnouts, railroad grade crossings and signal systems. For disposal of these items, the contractor shall contact the POLB Manager of Railroads for direction. Demolition work shall not interfere with the operation of existing railroad or vehicular traffic.

8.0 SUBBALLAST

8.1 Subballast material shall be in accordance with SSPWC Section 200.24, Crushed Miscellaneous Base, subsection 200-2.4.2, "Grading", Table 200-2.4.2 (A) Fine Gradation. The gradation shall be as follows:

Sieve Size	Percent Passing (Fine)
1" – 11/2"	100
3/4"	85-100
3/8	55-75
No. 4	30-50
No. 30	12-28
No. 200	2-10

8.2 Subballast material must be submitted to the Engineer for approval prior to use.

8.3 Placing, spreading and compaction of crushed aggregate base subballast material shall be in accordance with SSPWC subsection 301-2.2, "Spreading" and 301-2.3. "Compacting". Compaction shall be ninety five (95) percent relative compaction.

8.4 A geotextile filter fabric shall be placed at the base of the subballast throughout areas of all tracks including turnouts and grade crossings.

8.5 Subballast depth shall be as follows:

a. Subballast shoulder width shall be twelve (12) inches below ballast on mainline tracks, intermodal container stack train storage yard tracks, intermodal container stack train loading/unloading tracks, and mainline yard tracks. Use as required for industrial service tracks and other yard tracks.
b. Subballast material shall conform to section 200.2.4 (CMB), per SSPWC fine gradation.
c. A geotextile filter fabric shall be placed at base of Subballast throughout areas of all tracks including turnouts and grade crossings.
d. Subballast shall conform to AREMA Chapter 1 – Roadway and Ballast; Part 2 – Ballast; Section 2.11 – Subballast specifications for site specific calculation of total/subballast thickness.

8.6 Subballast shoulder width shall be as follows:
a. Subballast shoulder width shall be thirteen (13) feet from centerline on mainline tracks and twelve (12) feet from centerline elsewhere.

9.0 **BALLAST**
Ballast material shall be in accordance with the following:

9.1 Ballast material shall be in accordance with AREMA specifications excluding slag and limestone.

9.2 Ballast shall consist of crushed stone with angular fragments resulting from crushing by mechanical means using the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar igneous rocks; extrusive igneous rocks; or massive metamorphic quartzite or similar rocks. Crushed gravel is not acceptable.

9.3 Gradation testing shall be in accordance with ASTM C-136, utilizing square opening sieves in accordance with ASTM E-11. When testing the ballast material show a loss of not more than five (5) percent at the end of one hundred (100) revolutions and not more than thirty (30) percent at the end of five hundred (500) revolutions.

9.4 Ballast material shall meet the requirements of AREMA number 4A in all track areas.

9.5 For typical track construction provide ballast foundation with percentage passing each sieve falling within the following limits (Ballast size 4A).

Sieve Size **Sieve Opening**	**Percent Passing** **by Weight**
2½" 2.50"	100
2" 2.0"	90 - 100
1½" 1.50"	60 - 90
1" 1.0"	10 - 35
¾" 0.75"	0 - 10
½" 0.50"	-
3/8" 0.375"	0 - 3
No. 4 0.187"	-

9.6 Property requirements as indicated in AREMA Table 2-1 for "Quartzite"
Percent by Weight

Soft and friable pieces	0.5
Materials finer than No. 200 sieve	1.0
Clay lumps	0.5

9.7 Determination of ballast bulk density shall be in accordance with the ASTM C29, using three (3) inch nominal maximum size.

9.8 Particles of the ballast shall have been broken by the crusher and have at least two (2) broken surfaces.

9.9 Boulders which will pass through a five (5) inch circular opening before crushing shall be rejected.

9.10 Ballast depth shall be as follows:

a. Timber and/or Concrete Ties – Ballast depth shall extend not less than twelve (12) inches below bottom of tie for the full length of the tie and shoulders.

9.11 Ballast shoulder width shall be as follows:

a. Ballast shoulder width shall be a minimum of twelve (12) inches beyond the edge of the tie.
b. Ballast shoulder width shall be twelve (12) inches on mainline tracks, intermodal container stack train storage yard tracks, mainline sidings, and mainline yard tracks.

9.12 Ballast Source Control

a. Representative samples of ballast, of not less than one hundred fifty (150) lbs. for gradation and other required tests shall be taken from each source of ballast and tested as specified herein. Each shipment of ballast to the site shall be accompanied by a certification as specified.
b. Certified results of the tests required to demonstrate conformance with this Design Criteria shall be provided prior to any material being used for the work.
c. The ballast delivered to the site shall be from the same source from which samples were tested and found to be in accordance with this criteria and shall be of the same type and quality of that which was tested.

9.13 Ballasting

Ballasting is the spreading, watering, rolling, tamping, and dressing of ballast rock to bring the rails to grade and alignment. Ballast shall be installed as follows:

a. Ballast shall be placed in two (2) lifts. Each lift shall be compacted with a minimum ten (10) ton roller until no waving or creeping occurs.
b. Ballast shall be tamped with an eight (8) head tamping machine, using not less than three (3) insertions per tie.
c. Ballast shall be placed one (1) inch higher than the top of tie to provide a separate lining between asphalt and the tie.

10.0 CRUSHED WALKWAY ROCK

a. Walkway Rock shall be of the same quality material specified for ballast shall conform to the gradation requirements for size No. 5 Table 2-2 Section 2.4, of the AREMA manual.
b. Crushed Walkway Rock shall be placed two (2) inches in depth where required.
c. The percent passing each sieve shall be as follows:

Sieve Size	Percent Passing by Weight
1" – 1/2"	100
1"	90-100
3/4"	40-75
1/2"	15-35
3/8"	0-15
No. 4	0-5

11.0 PERMANENT TRACK CONSTRUCTION

Trackwork for projects will be typical ballasted track construction.

11.1 BALLASTED TRACK

a. Ballasted track shall be the primary type used for track work constructed at grade. It shall consist of subballast, ballast, cross-ties, rails, and rail fasteners.

b. The top of ballast elevation shall be one (1) inch below top of tie, except in the area six (6) inches on either side of the rail where the ballast shall be cribbed to maintain one (1) inch of clearance between the bottom of the rail and the top of ballast.

c. Ballast conforming to AREMA size No. 4A shall be used for all track areas.

d. At locations where subgrade material is unsuitable, a stabilizing course of compacted fill or asphalt shall be utilized.

11.2 TRACK GAUGE

a. The standard track gauge shall be four (4) feet eight and one half (8½) inches. Track gauge shall be measured between the gauge sides of the heads of rails at a distance of 5/8 inch below the top of rails. Wider gauges shall be used in some curves, depending upon the degree of curvature. Track gauges shall follow AREMA tables of practical gauges and flangeways for curved track, plan no. 791-59.

b. Gauge widening shall be distributed through the spiral curve for a spiral-circular-spiral type curve. For circular curves without spirals, the gauge widening distance shall be distributed by placing half the distance on the tangent and half on the circular curve. c. Gauges for special trackwork shall be as recommended in the AREMA portfolio of trackwork plans except as modified to reflect the physical and operational characteristics of the system.

11.3 TRACK CONSTRUCTION TOLERANCES

a. Track construction tolerances are determined by taking into consideration safety, speed of operation and type of service to be provided. All new track construction shall be constructed as class 5 in accordance with FRA Title 49, Part 213. Track shall be constructed to the tolerances shown in the following table:

	Vertical Track Alignment			Horizontal Track Alignment		
Type of Track	Gauge Variation	Cross Level Variation	Total Deviation	Middle Ordinate in 62' Chord	Total Deviation	Middle Ordinate In 62' Chord
Mainline Track	+/- 1/8"	+/- 1/8"	+/- 1/2"	+/- 1/8"	+/- 1/2"	+/- 1/4"
Yard Track	+1.4" -1/8"	+/- 1/4"	+/- 1/2"	+/- 1/4"	+/- 1/2"	+/- 1/4"

Notes:

(1) Variations of gauge and cross level shall not exceed 1/8" per 31' of track.

(2) Total deviation is measured between the theoretical and actual alignment at any point in the track.

b. Maintenance of existing track shall be Class 3 in accordance with FRA Title 49, part 213.

11.4 RAIL

a. The standard rail section shall be new 136 RE pound Continuous Welded Rail (CWR), meeting AREMA material requirements on mainline tracks, intermodal container stack train storage yard tracks, intermodal container stack train loading/unloading tracks, and yard tracks.
b. Jointed rail may be used only for temporary track construction or as approved by the Chief Harbor Engineer. Second hand (relay) rail may be used providing it meets the requirements of AREMA grading for Class 1 and passes ultrasonic testing for the entire length of the rail. Rails shall be either control-cooled carbon steel or special alloy rails as manufactured in accordance with the requirements of AREMA.
c. Rail Hardness – Brinell Hardness Number (BHN)
    1. For standard strength rail used in tangent track and curves of less than five (5) degrees the minimum BHN shall be three hundred (300).
    2. For high strength rail used in curves of greater than five (5) degrees and all turnouts the minimum BHN shall be three hundred sixty (360).

11.5 TURNOUTS

a. Turnout rail size shall be the same as the track size. See Design Criteria for turnout size.
b. All new turnouts shall be constructed of 136-RE rail.
c. Turnouts shall be continuously welded rail except at specific areas indicating a thirty six (36) inch whole joint bar bonded insulated which shall be a poly-insulated type.
d. Switch points, stock rails, closure rails, guard rails, and frog wing rails and all associated components shall be fabricated from new, high strength (Head Hardened) Rail.
e. All turnouts shall be equipped with floating heel blocks and adjustable rail braces. Rail braces shall be Bethlehem boltless adjustable braces with boltless adjustable clamps.
f. All turnouts shall be insulated and utilize resilient rail fasteners throughout.
g. All turnouts shall have electrical conduits and pull boxes for installation of automated power switching in the future.
h. All vertical switch rods and gauge plates shall be insulated.

11.6 FROGS

a. Frogs for open-track turnouts shall be AREMA Railbound Manganese (RBM) high integrity heavy wall three shot explosion hardened steel castings with mitered heel, extended heel and rail wings with frog base plate and gauge plates utilizing a resilient fastening system.
b. Frogs for tracks embedded in pavement shall be one-piece, solid cast manganese with frog base plate and gauge plates utilizing a resilient fastening system.
c. Frogs shall be radiographed tested in accordance with AREMA.
d. Frogs shall have extended legs for thermite welding.

11.7 SWITCH POINTS

a. Switch points shall be Samson undercut type with Manganese steel tips in accordance with AREMA Specifications.
    1. Manganese steel tips lengths shall be as follows:
    2. Two (2) feet eight (8) inches for No. 8 turnouts
    3. Three (3) foot six (6) inches for Nos. 9, 10, 15, and 20 turnouts.

b. Switch points shall have adjustable braces.
c. Switch points shall be straight points with a uniform riser bolted in Manganese steel switch point guard.
d. Switch points, rods, and gauge plates shall all be insulated.
e. Switch point lengths shall be as follows:
    1. Sixteen (16) feet six (6) inches for Nos. 8, 9 and 10 turnouts.
    2. Nineteen (19) feet six (6) inches for No. 11 turnouts.
    3. Twenty six (26) feet zero (0) inches for No. 15 turnout.
    4. Thirty-nine (39) feet zero (0) inches for No. 20 turnouts fabricated from rail fifty-six (56) feet long for field welding.
f. Switch point rollers shall be required for all turnouts.
g. Switch point throw shall be four and three quarters (4-¾) inch with a tolerance of plus or minus one quarter (¼) inch.

11.8 GUARD RAILS

a. Guard rails shall be raised one (1) inch above top of running rail for all turnouts.
    1. Guard rails shall be boltless and adjustable with a hardened ABC U69 type guard bar in accordance with AREMA specifications.
b. Guard rails shall be hook-flange or boltless-adjustable for Nos. 15 and 20 turnouts.
c. Guard rail lengths shall be as follows:
    1. Fifteen (15) feet for Nos. 8, 9, 10 and 11 turnouts.
    2. Twenty six (26) feet for Nos. 15 and 20 turnouts.
d. Guard rails shall be Bethlehem hook flange raised guard rail with plates or an engineer approved equal.
e. Switch point guard shall be adjustable Manganese steel type.

11.9 SWITCH STANDS

Switch stands shall be located on the diverging side of the turnout. For parallel tracks, the switch stand shall be located on the outside of the track. All switch stands shall have switch rods and connections that can be retrofitted to remote – controlled power operation.

For open ballasted track the following shall apply:

a. Switch stand shall be high-star, lockable, non-trailable on mainline tracks.
b. Adjustable switch stand shall be ABC Tri-Glide 22-E.
c. Target shall be low mast fastened sturdy and highly reflective with green and red colors.
d. Headblock ties shall be sixteen and a half (16.5) feet for switch stands located on outside of track and have a minimum clearance of eight and a half (8.5) feet from track centerline to switch stand.
e. Headblock ties shall be fourteen (14) feet for switch stands located between tracks and have a minimum clearance of six (6) feet from track centerline to switch stand.

For track embedded in pavement the following shall apply:

a. Switch stands shall be enclosed, parallel-throw in-pavement type such as Racor 336-EC flush with pavement.
b. Switch throw assemblies shall be supplied with all boxes and components for use in pavement. The lid shall open to a position that provides convenient access to the switch throw handle, and

that allows the open lid to rest in a position that it will not inadvertently slam shut while the train person is operating the switch throw lever.

c. Paved switch shall have a spring connecting rod.
d. Vertical switch rods shall be enclosed with steel box cover with ability to support H-25 loading (125.000 lb. Axle load) spread over five (5) square feet.
e. Steel box covers shall be flush with pavement and top of rail.

11.10 TURNOUT SUPPLEMENT FOR PAVED AREAS

a. All turnouts imbedded in pavement shall utilize special fabricated switch rod access boxes and fabricated switch point flangeway guards.
b. Pavements guards are required for switch points.
c. Switch points protectors shall be required and located on the inside running rail web area on the right side for a right hand turnout or the left side for a left hand turnout.
d. Turnouts in paved areas shall be welded with thirty six (36) inch six (6) hole joint bar for jointed areas.
e. Paved switches shall have a spring connecting rod.
f. Guard rails shall be flush with the running rail.
g. Switch and connecting rod boxes shall be flush with the pavement with ability to support H-25 loading (125,000 lb. Axle load) spread owner five (5) square feet

11.11 RAIL ANCHORING

a. In conventional ballasted track construction, where timber ties and track spikes are used, rail anchors shall be applied. Details shall be in accordance with AREMA standard plans.
b. Rail joints shall be used where rail welding is not practical or where required by signal track circuits.
c. Thirty-six (36) inch long, six (6) hole joint bars shall be used at rail joints. Drilling, punching, and track bolts shall be as specified by AREMA standard plans.

11.12 INSULATED JOINTS

Where required by the track signal circuits, insulated rail joints shall be installed. These shall be prefabricated bonded joints and shall meet the following track requirements:

a. Insulated joints shall be six (6) hole Allegheny-type, epoxy bonded, field fabricated.
b. For installation in CWR (I-bonds) shall be six (6) hole Allegheny-type, epoxy-bonded, pre-fabricated from new rail twenty (20) feet long for field welding in place.
c. For installation in jointed rail I-bonds shall be six (6) whole bolted Allegheny-types for field installation.

The following shall apply for electrical continuity testing of bonded insulated joints:

a. Perform separate tests between the running rails, and between the bar and the running rails.
b. Individual tests of the electrical resistance between each of the running rails and the bar shall be greater than ten thousand (10,000) ohms.
c. The electrical resistance between the running rails shall be greater than thirty thousand (30,000) ohms.

11.13 INSULATED RESILIENT FASTENERS (IRF) FOR CONCRETE TIES

The following shall apply for IRF for concrete ties:

a. Insulated resilient fasteners with rail seat abrasion pads and iron shoulders shall be used on all

trackage with concrete ties.

b. Pandrol E-2055 clips, Safelok or an Engineer approved equal shall be used as clips to concrete ties. POLB prefers the use of Safelock clips.
c. Two (2) clips shall be used on each base plate
d. When IRF are used with wood ties, the plates and hold-down screws shall be of a type approved for use with IRF by the IRF manufacturer.

11.14 ANCHORS ON TIMBER TIES

The following shall apply for anchors on timber ties:

a. Anchors shall be sixteen (16) per each thirty-nine (39) feet of rail.
b. Box anchor every other tie on CWR.
c. All anchors shall be in accordance with AREMA standards.

11.15 TIE PLATES

The following shall apply for tie plates:

a. Tie plates for timber ties with resilient fasteners shall be seven and three-quarters (7.75) inch by sixteen (16) inch for six (6) inch base rail with screw spikes for plate hold-downs and be of a type approved for use with resilient fasteners by the resilient fastener manufacturer.
b. Hole punching shall be six (6) with four (4) to be one (1) inch holes and two-eleven sixteenth (11/16) inch holes.
c. Tie plates shall be fastened evenly on wood ties within one eighth (1/8) inch alignment.

11.16 JOINT BARS

The following shall apply to joint bars:

a. Bars shall be thirty-six (36) inch bars with six (6) holes utilizing six (6) inch long one and one eighth (1-1/8) inch diameter bolts with four (4) inch thread length. Joint bars are to match the rail section. Joint bars are to be insulated.
b. Hole punching spacing shall be : Two and seven sixteenths (2-7/16) inches; six (6) inches; six (6) inches; six (6) inches, seven and one eighth (7-1/8) inches; six (6) inches; six (6) inches; and two and seven sixteenths (2-7/16) inches in accordance with Chapter 4 of AREMA.
c. Joint bars shall be six (6) hole bars appropriate for the rail size in accordance with AREMA.

11.17 SPIKES

The following shall apply for screw spikes:

a. Screw spikes shall be used for all newly constructed track with timber ties and turnouts.
b. Screw spikes shall be six (6) inches long and be able to fit one (1) inch diameter pandrol plates.

The following shall apply to cut spikes:

a. Cut spikes can be used for shoofly track, temporary track construction and maintenance as necessary.
b. Rail spikes shall be five –eighths (5/8) inch x six (6) inch.
c. Each tie plate in a turnout or horizontal curve shall have two (2) plate holding spikes and two (2) rail holding spikes.
d. Tangent track shall have a minimum of two (2) spikes per tie plate.
e. Cut spikes shall not be used on curves over six (6) degrees. For curves over six (6) degrees, a resilient fastening system shall be used.

12.0 TEMPORARY TRACK CONSTRUCTION (SHOOFLY TRACK)

a. Temporary track construction may be required in order to stage some of the site construction work while maintaining rail service. This temporary track work may be accomplished with timber ties and relay rail. Relay rail shall be Class 1 in accordance with AREMA standards.
b. If timber ties are to be used, the tie spacing shall be nineteen and one half (19.5) inches, center to center. Jointed rail sticks shall not be less than thirty-three (33) feet in length.
c. Tolerances shall be the same as permanent track construction.
d. It is the responsibility of the Contractor to remove this temporary work at the appropriate time and to dispose/salvage all materials.

13.0 CONTINUOUSLY WELDED RAIL (CWR)

The Work specified in this section consists of providing rails, fabricating rails into continuous welded rail (CWR) strings using the electric flash butt welding method, inspecting, testing, shipping and delivering the CWR strings to the project work site.

13.1 RAIL

a. Rail shall be 136 CWR per AREMA.
b. Procedures, material testing and other submittals listed in AREMA standards and herein are to be made to the Engineer and approved prior to iniation of the specific activity.
c. All new rail shall be 136 RE lb meeting the requirements of Chapter 4, Part 2 "Specifications for Steel Rails" of AREMA and Supplementary Requirements S2 "Manual Ultrasonic Testing".
d. Prior to the start of welding, a CWR schedule shall be submitted listing the lengths of CWR strings to be fabricated and the location of each string in the finished track. Also included in the submittal shall be a schedule of CWR lengths and the CWR string designation system.
e. Prior to the start of welding submit drawings and specifications of the proposed equipment, materials, methods and procedures to be used for the electric flash butt welding process for joining of the rail. Include layouts of the welding line showing locations of welding components.
f. Prior to transportation of the rail, submit procedures for transportation of the CWR to work site, proposed off-load locations and timing, stockpiling and handling procedures.
g. Perform flash butt welding and testing of the rail to the requirements of Chapter 4, Part 2 "Specifications for Fabrication on Continuous Welded Rail".
h. The fabrication of the CWR shall be done offsite.
i. Weld CWR strings to minimum delivered lengths at work site of. At grade crossings, strings equal to the width of the crossing plus forty (40) feet twenty (20) feet on each side of crossing measured along the center line of track) will be permitted. A minimum of twenty (20) feet is required between the end of the crossing panel and the first weld.
j. Cut out and reweld rejected welds with a minimum of nineteen (19) feet - 6 inch plugs. This work shall be at the Contractor's expense.
k. Bolt holes are not permitted except for insulated joints.

13.2 RAIL CUTTING AND PREPARATION OF ENDS

a. Saw cut or abrasive disc-cut rails used for electric flash butt welds square and clean by means of accepted equipment.
b. Torch cutting of rail is prohibited.
c. Prepare the head and base of rails prior to welding by removing mill scale down to bright metal for a length of approximately six (6) inches from the welding end.

d. Remove all burrs from the rail end area where the welding current carrying electrodes contact the head and base of the rail.
e. Holes are not permitted in the rail.
f. Torch cut rails at the end of CWR strings must be saw cut a minimum of six (6) inches from the torch cut end or three (3) feet from a shop weld prior to welding.

13.3 RAIL DESTRESSING PROCEDURE (BY MECHANICAL PULLING)

Rail Destressing shall be in accordance with AREMA and the following:

a. Upon track construction at the proposed alignment, place joint bars between each four hundred eighty (480) foot length of ribbon rail.
b. Place ballast material in and around track tie cribs and surface track to its alignment and grade.
c. Weld rail lengths to nine hundred sixty (960) feet each.
d. Calculate the elongation required to bring the rail into equilibrium using the thermal expansion equation:

$$\Delta L = a(T)L = (TD - TA)L$$

Coefficient of thermal expansion = 6.5x0.000001/F°
TD = design temperature (F°)
TA = actual temperature (F°)
L = rail length (ft.)

e. Unclip the rail on each side of the joint. The amount of rail to unclip is based on the amount of elongation required. For each inch of rail to pull a minimum of one hundred (100) feet of track shall be unclipped on each side of the joint.
f. The rail to be cut shall be equivalent to the calculated rail equilibrium distance plus one (1) inch required for the welding procedure.
g. Rail pullers will be used to pull the rail to the desired distance.
h. The rail shall be welded and the pullers will be released once the rail is cooled less than six hundred (600) F°.
i. The clips shall be replaced and the welds ground flush.

13.4 WELDING

The following method procedures, equipment and materials shall be used for welding CWR.

a. Thermite welding, materials and equipment shall be as manufactured by "Boutet", "Orgotherm", "Elektro-Thermite", or other Engineer approved equal for standard rail.
b. Thermite welding, methods and procedures shall comply with the AREMA Manual, Chapter 4, "Thermite Welding-Rail Joints-1980," and with the welding kit manufacturer's recommendations and as specified herein.
c. Rail ends for thermite welding shall be prepared in accordance with the recommendations of the welding kit manufacturer.
d. For thermite welding, the rail ends shall be preheated prior to welding to a sufficient temperature and for sufficient time to ensure full fusion of the weld metal to the rail ends without cracking of the rail or weld.
e. The completed weld shall be finished by mechanically controlled grinding to conform to the same requirements specified for shop welding.
f. Welds shall not be made within six (6) inches of bolt holes, or pin holes, or within three (3) feet of plant weld.
g. Manufacturers recommendations shall be used for compromise welds.
h. For welding heat treated or high strength rails, the recommendations of the rail manufacturer

shall be followed.

i. Welds must be in cribs between ties and located no closer than four (4) inches to nearest tie.
j. Torch cut rails at the end of CWR strings must be saw cut a minimum of six (6) inches from the saw cut end or within three (3) feet of a factory weld prior to welding.

13.5 FIELD WELDING RECORDS

a. Field welding records shall be continuously maintained and furnished bi-weekly to the Engineer. Records shall include the following details:
   - Date and time of weld(s)
   - Location by station, stating track and rail
   - Contractor's foreman
   - Weather, air and rail temperature
   - Track condition, anchorage and rail stress

b. Rail shall be painted in legible characters at least one and one half (1-1/2) inches high at each field weld with the following information:
   - Date of Weld (MO/DAY/YR)
   - Initials of welder performing weld
   - Air temperature at time of weld (AT XXX)
   - Rail temperature at time of weld (RT XXX)

Example: 5/5/93 ABC AT90 RT120

13.6 TOLERANCES OF FIELD WELDS

a. Using a straight edge thirty six (36) inches in length, and placing the straight against the welded joint area the following tolerances must not be exceeded:

Rail Head:

- Vertical Offset 0.020 inches
- Horizontal Offset 0.040 inches
- Vertical Crown 0.030 - 0.045 inches
- Horizontal Kink 0.020 inches

Rail Base

- Horizontal Offset 0.060 inches
- Offset Bending 0.010 per inch

13.7 FINISHING OF FIELD WELDS

The following shall apply to the finishing of welds:

a. Sharp edges and burrs are to be removed, including chimneys from all welds. All welds shall be ground smooth.
b. Weld joints shall be smooth on top and sides and straight in line. No over grinding is permitted.
c. Weld joints shall be smooth on sides and bottom. Offset blending permitted at rate of one hundredth (0.010) per inch.
d. Weld joints shall be smooth on both sides to within approximately one eighth (1/8) inch of original contour. Width of remaining upset will be between one half (½) inch and five eighths (5/8) inch.

13.8 FIELD WELD TESTING

The following shall apply to the field testing of welds:

a. Rail welds shall be tested through the use of a testing agency using the Ultrasonic Testing Method in accordance with ASTM E 164.
b. Each completed weld shall have full penetration and complete fusion and be entirely free of cracks. Total area of internal defects such as porosity and slag inclusions shall not exceed six hundredths (0.060) square inch and the largest single porosity or slag defect permitted shall not exceed one eighth (1/8) inch in diameter.
c. Other causes for rejection of welds shall be:
    - Cracks that show in the finished weld are cause to reject the weld.
    - Pit holes that show in the web and base of the weld after finish grinding are cause to reject the weld. Pit holes in head not exceeding one quarter (1/4) inch in depth may be repaired by gas welding or as approved by the Engineer.
    - Welded joints not meeting these technical provisions and tolerances will replaced at no additional cost. The defective weld shall be cut out, and a new section of rail not less than thirteen (13) feet long shall be inserted welded and retested at no additional cost.

13.9 CUTTING IN SHORT SECTION RAIL AND THERMITE WELDING THE ENDS

The following procedure shall be used in cutting in short section rail and the thermite welding of rail ends.

a. A short section of rail shall be cut in the CWR, as approved by the Engineer, for the following reasons:
    - To repair defective rail
    - To repair defective welds
b. Before cutting out rail in CWR, prevent remaining CWR from further movement by applying anchors. After cutting CWR, rail expander/puller or other means shall be used to prevent rail movement.
c. The ends of the short rail section and the CWR shall be sawed or abrasive cut.
d. Follow procedures specified for completing field welding by the thermite process.
e. Repair of rail due to damage by the Contractor shall be at Contractor's expense.
f. When repairing defective rail or welds, new rail shall be the same length as rail being replaced, or as required to achieve thermal adjustment.
g. If secondhand rail was originally installed, replacement is to be in kind.

13.10 TOLERANCES IN ELECTRIC FLASH BUTT WELDS

Tolerance in electric flash butt welds shall be in accordance with tolerances set forth in the AREMA Manual, Chapter 4, Part 2, Section "Specifications for Fabrication of Continuous Welded Rail - 1983."

13.11 ULTRASONIC TESTING OF PRODUCTION WELDS

The following shall apply for the Ultasonic Testing of Production Welds:

a. Test all welds ultrasonically at the welding plant for defects in accordance with ASTM E164 using an inspection team approved by POLB. The cost for testing is to be borne by the Vendor.
b. The POLB will perform weld testing on field welds through the use of an inspection agency conducting ultrasonic testing.

13.12 REPLACEMENT OF DEFECTIVE WELDS

Defective flash both production welds giving fault indications in Magnetic Particle or Ultrasonic Inspection during production shall be cut-out, rewelded and retested. These repairs shall be done in the

shop and not left for field repair.

14.0 **CONCRETE TIES** All track construction shall utilize concrete ties for regular track and timber ties for turnouts. The following criteria shall apply for concrete ties:

a. Concrete ties shall be spaced at a maximum of twenty four (24) inches and not less than twenty (20) inches, center to center. On curves of radius less than three hundred (300) feet concrete ties shall be used and spaced a maximum of twenty (20) inches and not less than eighteen inches (18), center to center.
b. For road crossings the tie spacing shall be in accordance with manufacturers' specifications for paving material, for both timber and concrete ties.
c. Concrete ties shall be of the type referred to as the "Union Pacific Scallop Style" with dimensions as follows:
    - Length: Eight (8) foot six (6) inches +/- one eighth (1/8) inch.
    - Height, at rail seat: Eight and three quarters (8 ¾) inches +/- three sixteenths (3/16) inches
    - Base width: Ten and one half (10-1/2) inches +/- one eighth (1/8) inch.
    - The rail seat shall provide for a cant of one (1) in forty (40) toward the centerline of the tie.
    - Weight: Maximum weight shall be seven hundred fifty (750) pounds.
    - Height, at center of tie: Six and one quarter (6-1/4) inches, +/- three sixteenths 3/16 inches.
    - Rail pad: Pandrol three (3) part assembly with six point five (6.5) mid polyurethane pad in double dimple studded configuration including a nine tenths (0.9) mm steel plate.
    - All concrete ties must be imprinted with the letters POLB on top of the tie.
d. Standard concrete ties shall be designed to the following bending moment capacities:
    - Rail positive seat bending: 300 in-kips
    - Center negative bending –200- in-kips
e. Concrete grade crossing ties shall be ten (10) foot long, flat top, prestressed, in accordance with AREMA standards.
f. Maximum weight for grade crossing ties shall be nine hundred (900) lbs.
g. Guard rail ties shall be eight (8) foot six (6) inches long
h. Concrete Tie Materials: Wire shall conform to ASTM A881. Strand shall conform to ASTM A886. Cement shall comply with ASTM C150 type III. Aggregate shall be non-reactive. Ductile castings shall comply with ASTM A53665-45-12. Concrete admixtures shall comply with ASTM C494 (no fly ash or silica fume may be used)
i. Concrete Material Qualification Testing: Aggregates shall be tested to ASTM C227 and C1260 prior to use. Cement shall be tested to ASTM C112 and C150. Total alkali level of cement shall not exceed four tenths (0.4) percent
j. Concrete Tie Qualification testing:" Six (6) ties shall be taken at random from the first (3) three casts and tested for RS+, RS-, C+, C-, and Bond development. Ties shall be tested for dimensional compliance. Two (2) ties shall be jointly picked by the supplier and the Port's representative to show acceptable surface finish, air voids, and spalling/breakage.
k. Concrete tie Production testing: Concrete ties shall be tested for compressive strength using four (4) x eight (8) or six (6) x twelve (12) cylinders. A minimum of two (2) concrete cylinders shall achieve forty five hundred (4500) psi prior to detensioning.. Concrete twenty eight (28) day compressive strength shall exceed seven thousand (7000) psi (average of three (3) cylinders) with no individual cylinder less than six thousand five hundred (6500) psi. For each

production day, at least one (1) tie shall be tested for dimensional conformance, RS+, and C-bending. All ties produced shall be inspected visually for defects and certified.

l. Concrete tie shall be prestressed, mono-block type.
m. Concrete tie fasteners shall be Safelok Clip 36800. Other components shall include Insulators (type 38249), Rail pads (type 38280) and Assembly (type 36192-A1). For curves over two (2) degrees shall include insulators type 36180. For curves over four (4) degrees include Rail, Pad Assembly type 38319.
n. Protrusion of Pretensioning Tendons - One eighth (1/8) inch maximum beyond the ends of the ties.
o. Markings - Mark on top of the ties with indented or raised letters to indicate the manufacturer, type of tie and year of manufacture and POLB.

15.0 TIMBER TIES

a. Timber ties shall have dimensions as follows:
    - Length: Nine (9) feet
    - Height: Seven (7) inches
    - Width: Nine (9) inches
b. Timber ties shall be in accordance with Chapter 3 of AREMA.
c. Timber tie spacing shall be a maximum of nineteen and one half (19.5) inches and a minimum of eighteen (18) inches, center to center.
d. All wood ties shall have steel end plates.
e. Timber tie fasteners shall be Pandrol E-2055 clips.
f. Timber tie wood treatment shall be in accordance with AREMA.
g. Switch ties shall have the dimensions for height and width as previously stated, but the length shall vary as required.

16.0 SPECIAL TRACKWORK MATERIALS

16.1 GENERAL

This section specifies the material requirements for complete special trackwork materials including, turnouts and crossovers with ties, derails, bolts, lock washers, bumping posts and wheel stops to be furnished in accordance with Plans and these technical provisions.

16.2 TURNOUTS AND CROSSOVERS

a. Turnouts and crossovers shall have switch points with uniform risers.
b. There shall be no "Laced Ties", use appropriate "Long Ties".
c. Electric switches shall be of Model M23A as manufactured by Union Switch, or approved equal.
d. Manual switches shall be of Model T-20 as manufactured by Union Switch, or approved equal.
e. Electric Locks shall be of Model SL-21 or SL-25 as manufactured by Union Switch, or approved equal.
f. Pandrol Type "E" fasteners or an Engineer approved equal, shall be used on all timber turnout ties.
g. Switch ties shall be timber,with Pandrol Type "E" Fasteners or Engineer approved equivalent.

17.0 DERAILS

a. The Engineer shall provide a positive method to protect individuals working on rail equipment located on other than mainline track. Consideration shall be given to locations of derails,

grades, on tracks and other derail installation requirements.

b. Derail type shall be Western-Cullen-Hayes model HBX double end sliding derail, size Nos. 8, with standard two (2) tie operated stand with connecting rods and reflectorized low target.

18.0 BUMPING POSTS

a. Bolt material and coatings shall be per AREMA Class B specification for rail fastening size.
b. All bolts shall be new.

19.0 WHEEL STOPS

Wheel stops shall be site specific. Wheel stops shall be Western Cullen Hayes type SH, hinged wheel stop.

20.0 CONCRETE GRADE CROSSINGS

20.1 GENERAL

No field welds shall be allowed through crossings or within twenty (20) feet of the end of the crossing.

20.2 MODULE CROSSINGS

Concrete grade crossing on POLB main roadways four (4) lanes or more with heavy truck traffic and loading shall be as follows:

a. Grade crossing shall be eleven (11) feet wide by five (5) feet long Star Track II HD module or eight (8) feet wide by five (5) feet long Star Track II module with grout holes or ten (10) feet wide by eight (8) feet long CXT PTS Prestressed Track Slab System or Engineer approved equal.
b. Module shall sit on twelve (12) inches of CAB on twenty-four (24) inches of granular fill compacted to ninety five (95) percent, Geogrid to be placed between layers. Geotextile to be placed below the granular fill.
c. The roadway approaches to the grade crossing systems shall include a ten (10) feet wide concrete reinforced approach slab. The track approaches shall include an eight (8) to one (1) approach.

Concrete grade crossing on POLB secondary roadway with minor truck traffic shall be as follows:

a. Grade crossings shall be Railroad Common Standard Type 10W manufactured by OMNI or CXT full depth concrete crossing panel or engineer approved equal. The crossing panels shall be prestressed, full depth with steel frame and pre-attached flangeway filler with precast end restraints.
b. Grade crossing panels shall sit flush evenly to one another with zero gap for tangent track. For curved track over four (4) degrees, the gap between panels shall not exceed one-quarter (1/4) inch maximum gap between panels.
c. Concrete panels to sit on ten (10) foot long wood ties, on eighteen (18) inch track centers with lag bolts.
d. The roadway approaches to the grade crossing system shall include a ten (10) feet wide concrete reinforced approach slab. The track approach shall include an eight (8) to one (1) approach.
e. Geotextile filter fabric shall be placed under all grade crossings between the subballast and the ballast.
f. Tamping of ballast shall not be performed until a minimum of eight (8) inches of ballast is below the base of cross ties and then precaution shall be taken in setting the tamping feet to

prevent driving the ballast through the geotextile. Probes of any type, including alignment probes, will not be used where geotextile is installed.

g. Construction of track through a grade crossing shall be completed to finish line and grade, surfaced, and ballast compacted and dressed before grade crossing panels are installed.
h. Concrete grade crossing panels shall be installed in accordance with manufacturer's instructions.
i. Grade subgrade to drain away from ballast section at completion of crossing work.
j. Flange way filler shall be as recommended by manufacturer. Asphalt paving filler shall be AR 8000 class B mix per SSPWC.
k. Wearing surface shall be diamond mark "POLB".
l. Each crossing shall have a four (4) feet minimum reinforced concrete approach. The concrete shall be type II Portland concrete cement 520-C-3250 minimum strength with four (4) inch slump per Section 201, "Concrete Mortar and Related Materials" and 203, "Bituminous Materials" of the SSPWC.
m. The manufacturers warranty for the grade crossing shall be for a minimum of five (5) years.

24.0 RAILROAD CROSSING SIGNAL SYSTEM

The following shall apply to railroad crossing systems used within the POLB system:

a. The design shall be in accordance with both FRA and PUC regulations.
b. Signal system bungalow shall be six (6) feet by six (6) feet aluminum with outside lights. The bungalow shall state "The Port of Long Beach","Pier #", and Milepost, CPUC #, and a PHL emergency phone number. The area outside the bungalow shall be paved.
c. Two (2) sets of backup batteries and rectifiers. The batteries shall be rated at four hundred (400) amp hours and the rectifier being twelve (12) volt forty (40) amps.

25.0 RAILROAD SAFETY WARNING SYSTEM

All railyard facilities shall have a positive method to warn employees of train movement, which shall include audio and visual signals in keeping with the Pacific Coast Marine Safety Code.

26.0 REQUIREMENTS WHEN WORKING WITHIN, ADJACENT OR ABOVE RAILROAD TRACKS

The following shall apply when working in the vicinity of railroad tracks:

a. The Contractor shall not enter any location, perform any work, or locate any piece of equipment within ten (10) feet of the nearest rail of any railroad track without prior authorization from the Engineer. All work shall be performed in accordance with the provisions of Title 49, Part 214 of the Code of Federal Regulations.
b. The Contractor shall submit a written Work Plan to the Engineer not less than ten (10) days prior to beginning work. The Work Plan shall include the location, starting and stopping times, a description of the work to be performed, the work crews involved, and the Contractor's recommendations regarding track outages and railroad safety protection (Flagmen). No work may be performed, nor any piece of equipment moved within ten (10) feet of the nearest rail of any railroad track until the Work Plan in approved by the Engineer. Flagmen, if required, will be provided by the City at no cost to the Contractor for days which the City deems necessary for the project. If the number of flagging days are exceeded due to the Contractor's actions the Contractor shall pay for the flagging services beyond the days paid by the Port. The flagging charges paid by the Contractor will be withheld from payment due. The flagging charges are five hundred fifty ($550) day for Pacific Harbor Line flagging services. The Contractor may

cancel scheduled Flagmen with written notice to the Engineer at least forty-eight (48) hours prior to the start of the work. However, if the Contractor fails to provide such notice of cancellation within the required time, any cost to the City for scheduled Flagmen will be withheld from payment due to the Contractor.

c. The Contractor shall provide qualified Watchmen when working within twenty (20) feet of the track centerline for the safety and protection of the Contractor's personnel and equipment during construction operations. Watchmen shall be properly trained and equipped in accordance with Title 49, Part 214 of the Code of Federal Regulations. The cost of Watchmen shall be included within the cost of related bid items for such work. The Pacific Harbor Line (PHL) will qualify the Watchmen for the project. The Contractor shall submit an approved list of PHL trained watchmen to the Engineer prior to working within twenty (20) feet of the track centerline.
d. Crossing of tracks by the Contractor's equipment other than at public or private road crossings is prohibited without specific authorization by the Engineer.
e. The Contractor shall report any accidents, injuries, track defects, or any unusual track conditions which may affect the safe and efficient operation of the railroad to the Engineer by the first available means of communication.
f. The Contractor shall be responsible for the prevention of damage to railroad facilities, equipment and operating trains due to his activities. In the event the Contractor damages railroad facilities or equipment, he shall immediately report the damage to the Engineer. Repair of damage caused by Contractor's operations shall be at the expense of the Contractor and accomplished to the satisfaction of the Engineer.
g. The Contractor shall be responsible for compliance with the requirements of the Roadway Worker Protection Act (the Act) issued by the FRA.

The Port of LONG BEACH / **The Port of Los Angeles**

Insurance Requirements for Joint Revocable Permit/Joint Temporary Entry & Use License

Requestor: C. Tsai

Name of Licensee/Permitee: Cal Trans

Division: Engineering

Division Reference Number: TBD

Description of Operations/Project: Heim Bridge Replacement

Based upon the information provided, the following types/limits of insurance are required of the entity listed above. Please refer to the applicable permit/license document for complete insurance wording requirements.

☒ **General Liability Insurance** with minimum limits of $10,000,000 and if written with an aggregate, the aggregate shall be double the per occurrence limit.

- ☒ ISO Form CG 0001 or CG 0002
- ☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured
- ☒ Include Products/Completed Operations
- ☒ Include Contractual Liability – Railroads
- ☒ Include Explosion, Collapse, Underground Hazards (XCU)

☒ **Automobile Liability Insurance** with minimum limits of $5,000,000 per accident

- ☒ ISO Form CA 0001
- ☒ Symbol 1 ☐ Symbol 2 ☐ Symbol 8 ☐ Symbol 9
- ☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☒ **Workers' Compensation Insurance (Statutory)**

- ☒ $1,000,000 Employer's Liability Insurance
- ☒ Statutory U.S.L. & H. Insurance ☒ Statutory Jones Act Insurance
- ☐ Statutory FELA Insurance
- ☒ Waiver of Subrogation in favor of the Port of Long Beach and the Port of Los Angeles (required for all coverage checked)

The Port of LONG BEACH / **The Port of Los Angeles**

Insurance Requirements for Joint Revocable Permit/Joint Temporary Entry & Use License

☒ **Watercraft Liability Insurance** including Protection & Indemnity and Water Pollution Liability with minimum limits of $5,000,000 per loss and $10,000,000 total all losses.

☒ Bodily Injury ☒ Death ☒ Mental Anguish
☒ Cleanup Costs ☒ Property Damage ☒ Defense Costs

☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Environmental Impairment Liability Insurance** with minimum limits of _____per loss and _____ total all losses.

☐ On-site Coverage ☐ Off-site Coverage ☐ Bodily Injury
☐ Death ☐ Mental Anguish ☐ Property Damage
☐ Defense Costs ☐ Clean-up Costs ☐ Sudden & Accidental

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☒ **Contractor's Pollution Liability Insurance** covering all of the contractor's operations minimum limits of $5,000,000 per loss and $10,000,000 total all losses.

☒ On-site coverage ☒ Off-site Coverage ☒ Bodily Injury
☒ Death ☒ Mental Anguish ☒ Property Damage
☒ Defense costs ☒ Clean-up Costs

☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Professional Liability Insurance** with minimum limits of _____.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Producers Professional Liability Insurance** with minimum limits of _____.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Aircraft Liability Insurance** with minimum limits of _____ per occurrence.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

The Port of LONG BEACH / **The Port of Los Angeles**

Insurance Requirements for Joint Revocable Permit/Joint Temporary Entry & Use License

☐ **Garagekeepers Liability Insurance** with minimum limits of _____ per loss.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Property Insurance** with no coinsurance clause.

☐ All Risk ☐ Full Replacement Cost

☐ **Builder's Risk Insurance** for property constructed on behalf of the City, maintained until full acceptance of the work.

☐ All Risk ☐ 100% of completed Contract costs
☐ Loss Payee (POLB) ☐ Collapse (including resulting from design error)

☒ **30-day notice of cancellation to both Ports for all insurance policies (10 days for non-payment of premium).**

☒ **Miscellaneous**: Insurance required to be provided by general contractor selected by Cal Trans to replace Heim Bridge.

Port of Long Beach Risk Management Division Contact Information

Name R. Baratta Phone # 562-901-1775 Date 8/6/10

Signature: _____

Port of Los Angeles Risk Management Division Contact Information

Name K. Merkovsky Phone # 310-732-3971 Date _____

Signature: _____

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Retaining Wall A1, Bridge No. 53E0147***
Mechanically Stabilized Earth (MSE) Wall
Los Angeles County, California, (7-LA-47, PM 3.55, EA 238501)

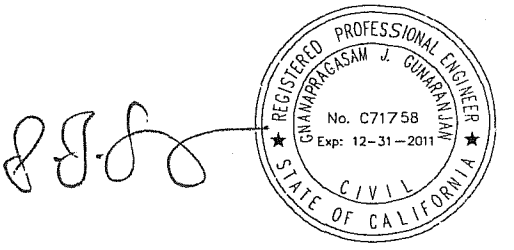
Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining wall. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining wall.

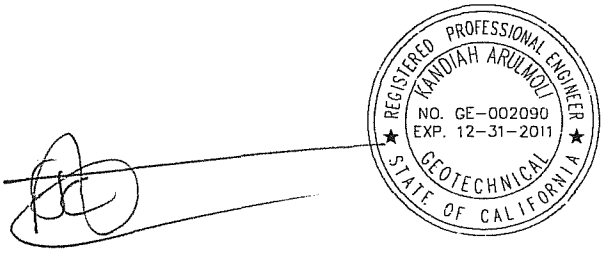
The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix G. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

(Pratheep) K. Pratheepan
Staff Engineer



(Ranjan) G.J. Gunaranjan, PE
Senior Staff Engineer



(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL A1, BRIDGE NO. 53E0147
MECHANICALLY STABILIZED EARTH (MSE) WALL
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 3.55, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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Appendix A. Schuyler Heim Bridge Seismic Retrofit LOTB Sheets Prepared by LKR (1998)
Appendix B. Site-Specific Boring And CPT logs
Appendix C. EarthSpectives SPT Hammer Energy Measurement Report
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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Approach Embankment and Retaining Wall A1 (Bridge No 53E0147) in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Approach Embankment for the Schuyler Heim Bridge from the Ocean Boulevard and Retaining Wall A1 (Bridge No 53E0147) located on the west side of the approach embankment (Figure 2).

The proposed approach embankment has a maximum height of 17 ft at abutment 1, which is about 2 ft more than the existing embankment. Proposed width of the embankment varies approximately from 120 ft to 150 ft, which requires some fills and cuts to the existing embankment. The proposed approach embankment has a 2:1 slope on the east side and a MSE Wall (A1) on the west side. Retaining Wall A1, located between Sta. 2+38 and Sta. 4+20 ("A"

Line), will be approximately 185 ft long with retained heights varying from 10 ft at the southern end of the wall to a maximum height of 20 ft at the northern end of the wall where it terminates at the Abutment 1 of the Schuyler Heim Bridge. Recommendations for Abutment 1 of the Schuyler Heim Bridge are provided in a separate foundation report prepared by EMI (2010).

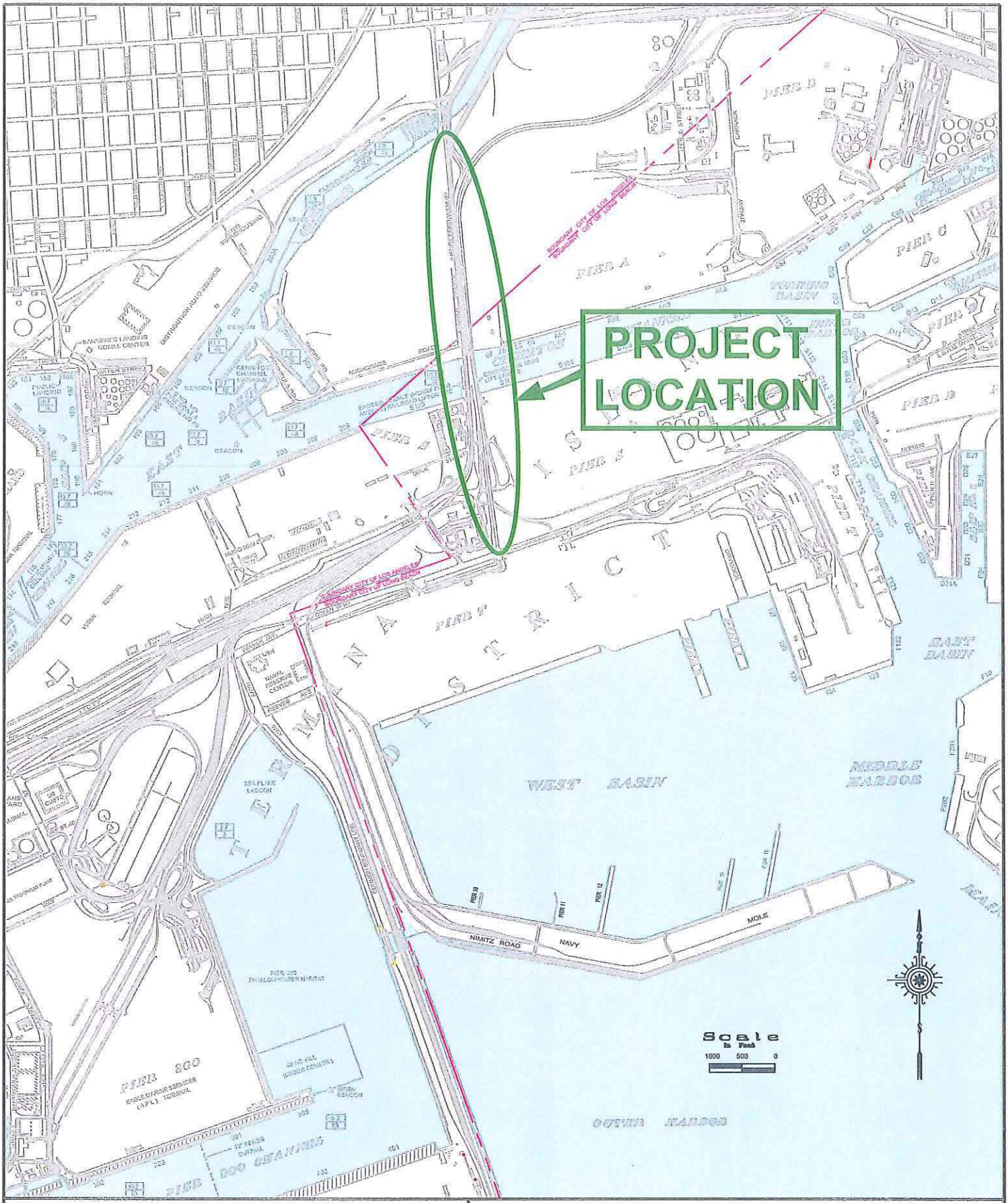
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Approach Embankment and Retaining Wall A1. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



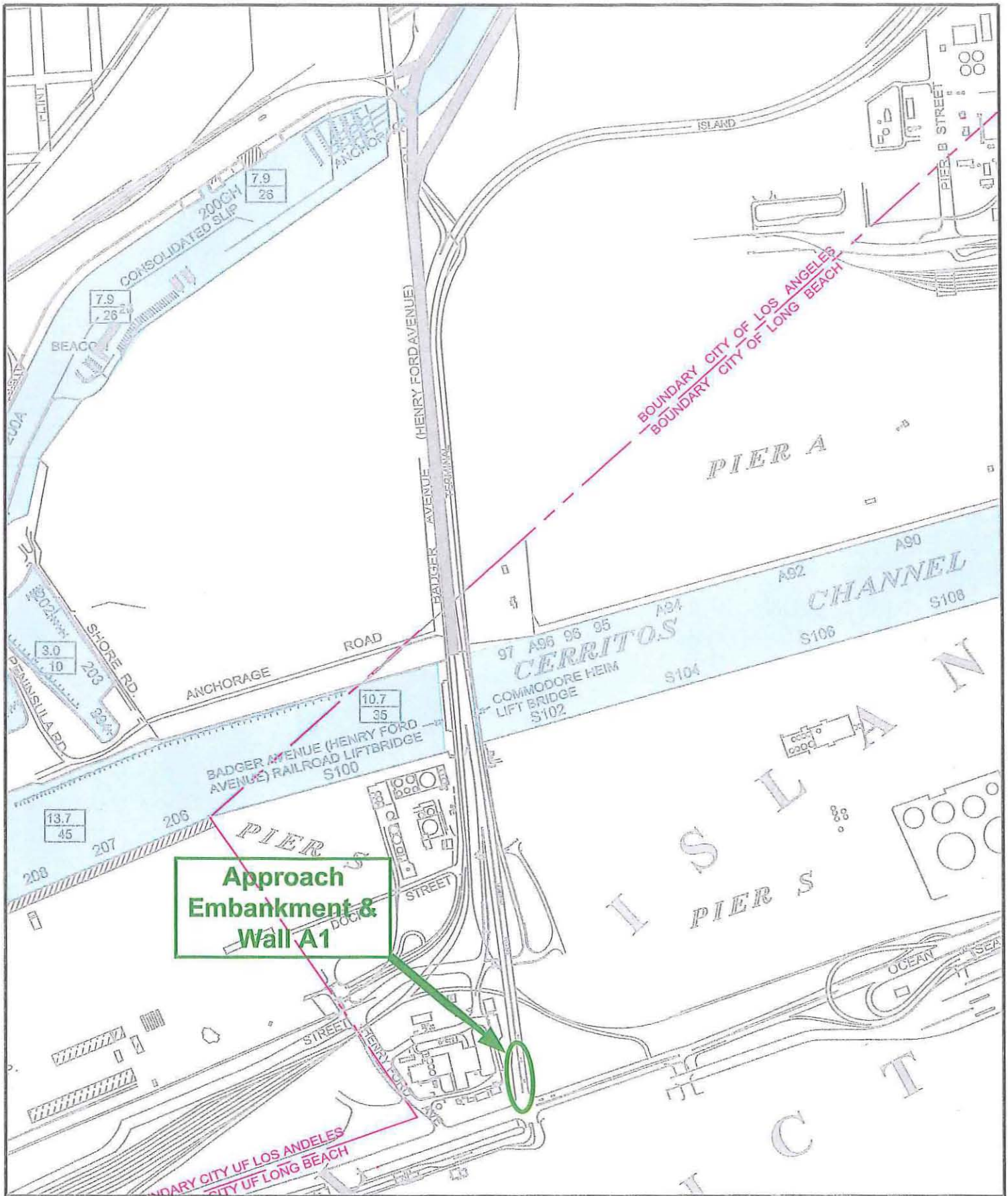
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 2-08-10

Project Location Map

Figure 1



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structure Location Map — Figure 2

Project No. 06-123 | Date: 2-08-10

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of Approach Embankment and Retaining Wall A1 were those shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and, boring B-1 and CPT sounding CPT-1 were performed near the proposed wall site. The boring penetrated to a depth of 176 ft and CPT sounding penetrated to depth of 137 ft below existing grade with a deepest penetration to an elevation of -176 ft.

Copy of the as-built LOTB sheet prepared by LKR for the seismic retrofit study is provided in Appendix A.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, three hollow-stem auger borings, three rotary wash borings and three CPT soundings were performed in the vicinity of Approach Embankment and Retaining Wall A1. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed wall and bridge support locations. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI. Log-of-Test-Borings (LOTBs) for the borings and CPTs used to characterize the subsurface soil for the Retaining wall A1 are provided at the end of the text and Boring/CPT logs for the borings and CPT soundings used to characterize the subsurface soil for the east side embankment are provided in Appendix B.

2.2.1 Soil Borings

All of the borings surrounding the proposed embankment and wall were performed at grade in the undeveloped area near the existing Schuyler Heim Bridge. The deepest boring penetrated down to about elevation -112 ft, approximately 120 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a

subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of thin wall Shelby tubes and split-spoon drive samplers. Thin wall Shelby tubes (2.9 inch ID, 3.0 inch OD) were pushed into soft soils to collect undisturbed samples. Split-spoon drive samplers; Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix C.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix D.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
A-09-051	"A" Line	1+64.8	128.1 Lt	+5.7	-1.3	-45.8	HS
A-09-052		3+29.0	87.8 Lt	+3.2	-5.3	-48.3	HS
A-09-053		2+86.8	88.7 Rt	+6.0	-2.4	-45.5	HS
R-09-001		4+56.8	73.6 Lt	+2.4	NR	-74.1	RW
R-09-002		4+57.4	110.0 Rt	+3.6	NR	-72.9	RW
R-09-038		1+89.2	80.3 Rt	+8.8	+2.3	-111.7	RW
CPT-09-093		1+72.0	129.2 Lt	+5.7	NR	-105.2	CPT
CPT-09-094		3+35.2	89.1 Lt	+3.2	NR	-112.3	CPT
CPT-09-095		2+95.4	89.0 Rt	+5.9	NR	-104.3	CPT

Notes: 1. Top of boring elevations based upon NAVD88.
2. GSE = Ground Surface Elevation.
3. GWE = Groundwater Elevation.
4. HS= Hollow-Stem Auger, RW = Rotary Wash, CPT = Cone Penetration Test.
5. NR = Not Recorded.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near the existing Schuyler Heim Bridge. The deepest sounding was advanced down to elevation -112.3 ft, approximately 115.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in^2 (10 cm^2) and a cylindrical friction sleeve with a surface area of 23.25 in^2 (150 cm^2). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

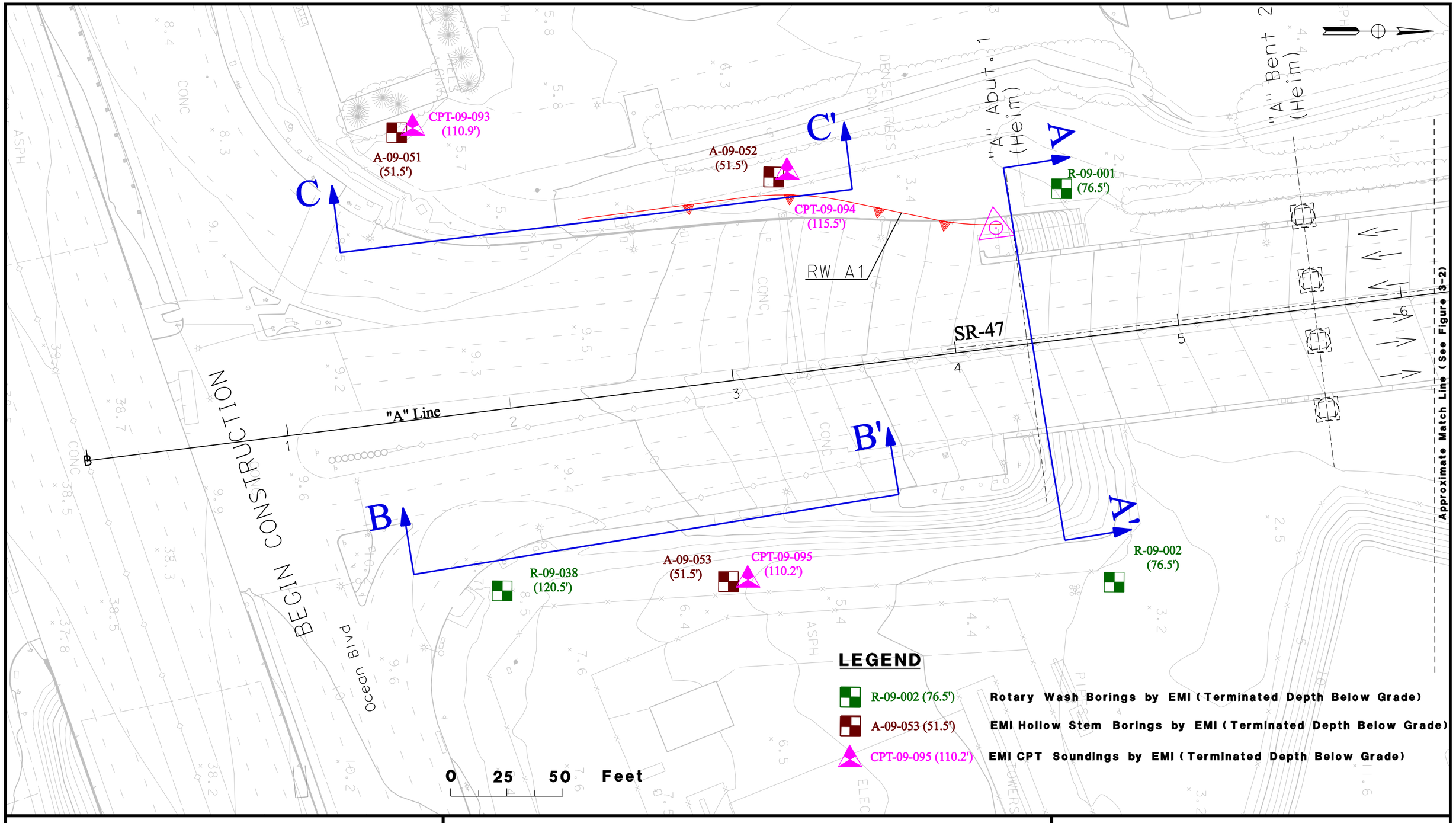
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix E.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department

(LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

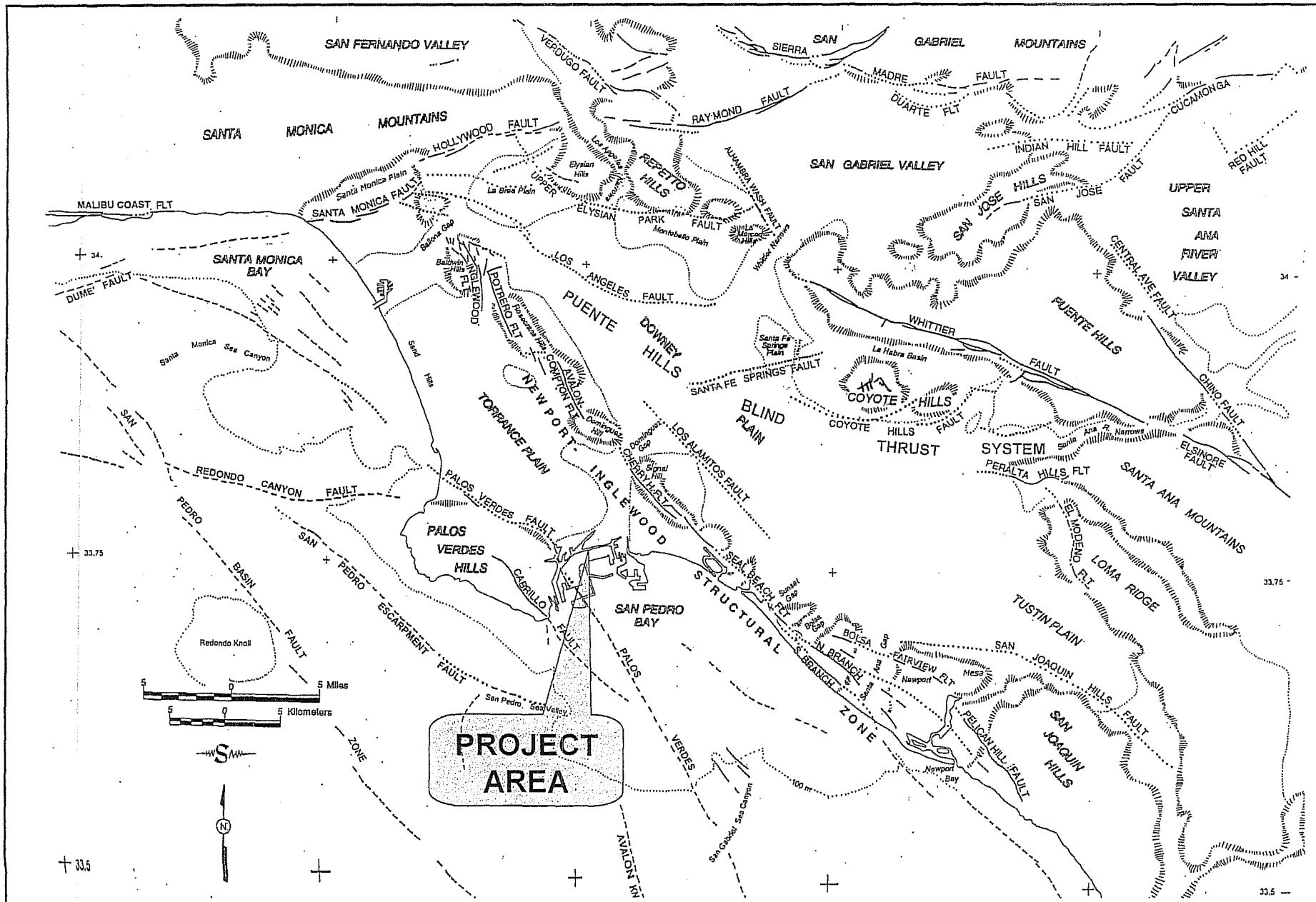
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

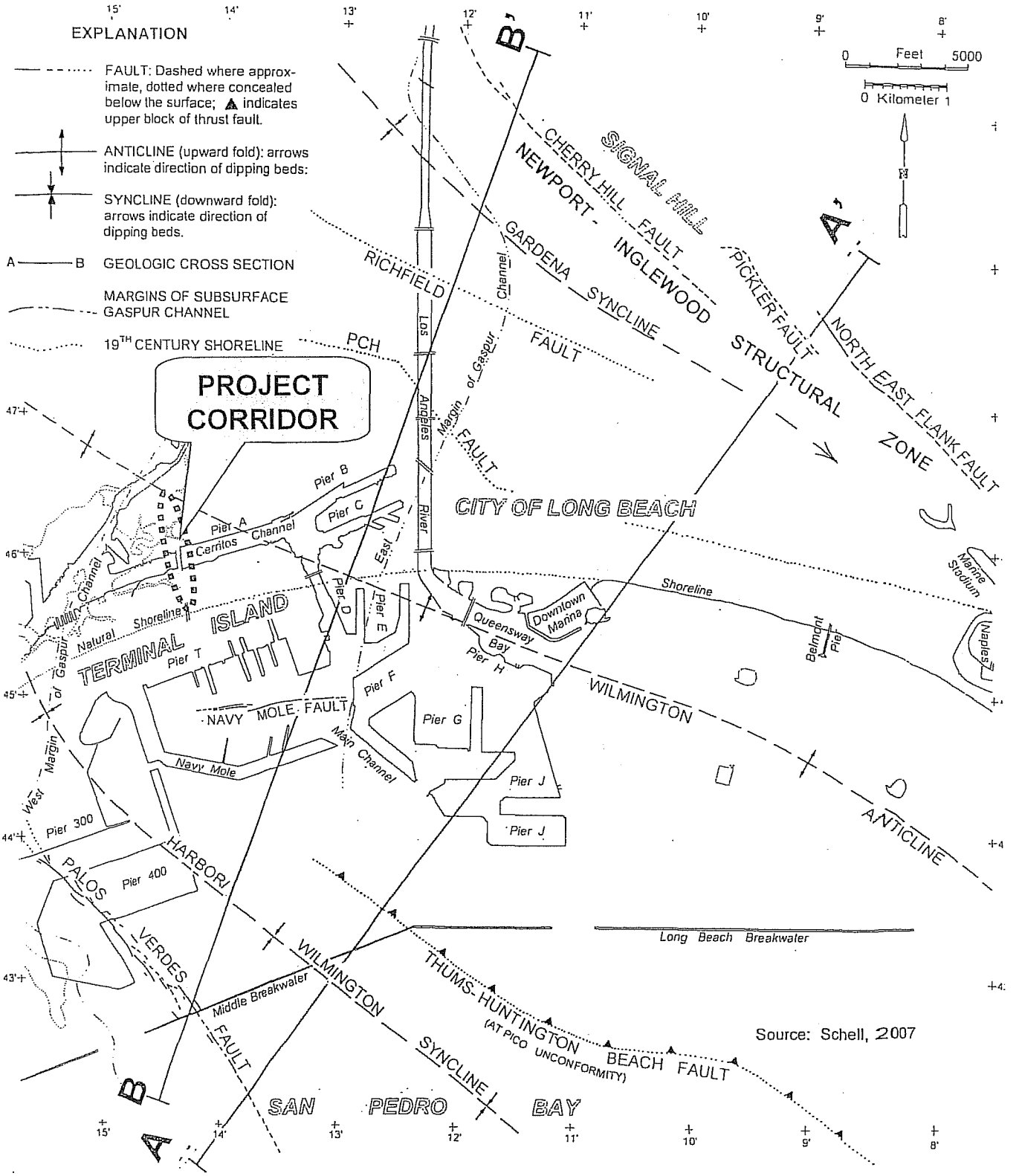
California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at

Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 2-08-10	Figure 4



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ACTA SCHUYLER HEIM B RIDGE REPLACEMENT PROJECT

Structural Geology Map, Long Beach Harbor

Figure 5

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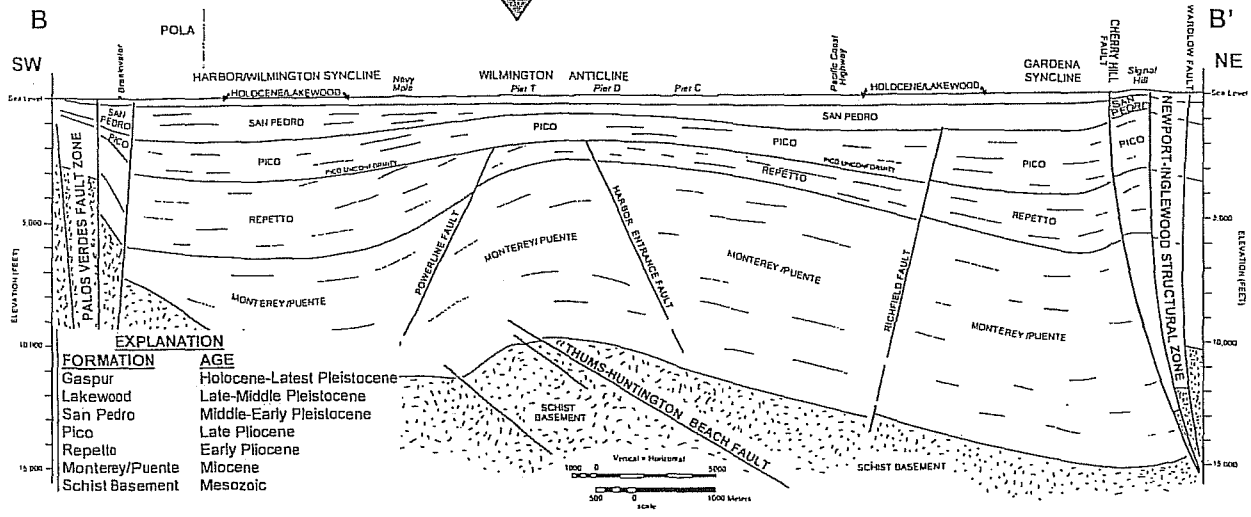
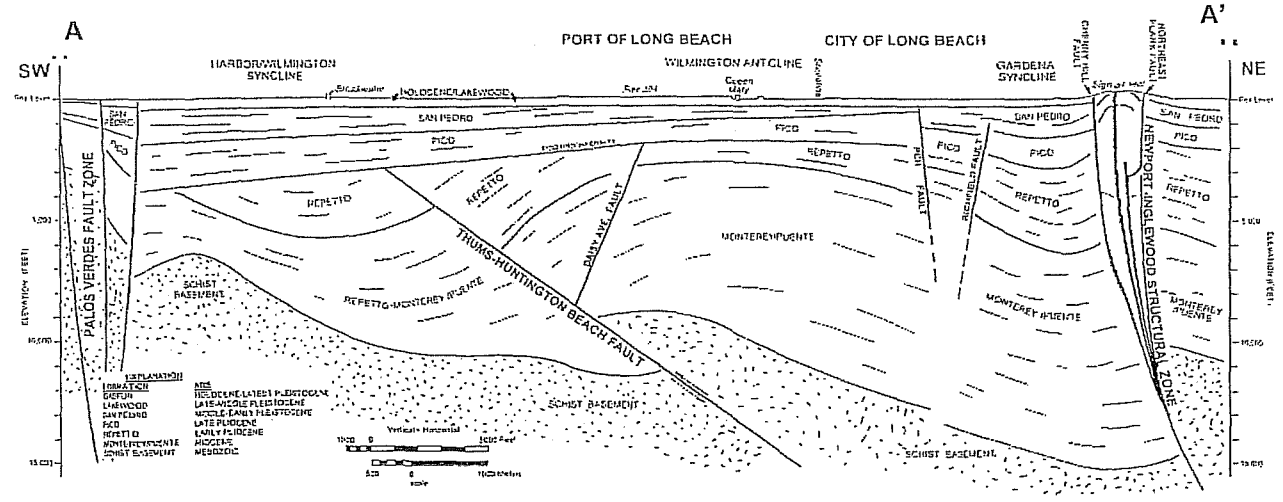
APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

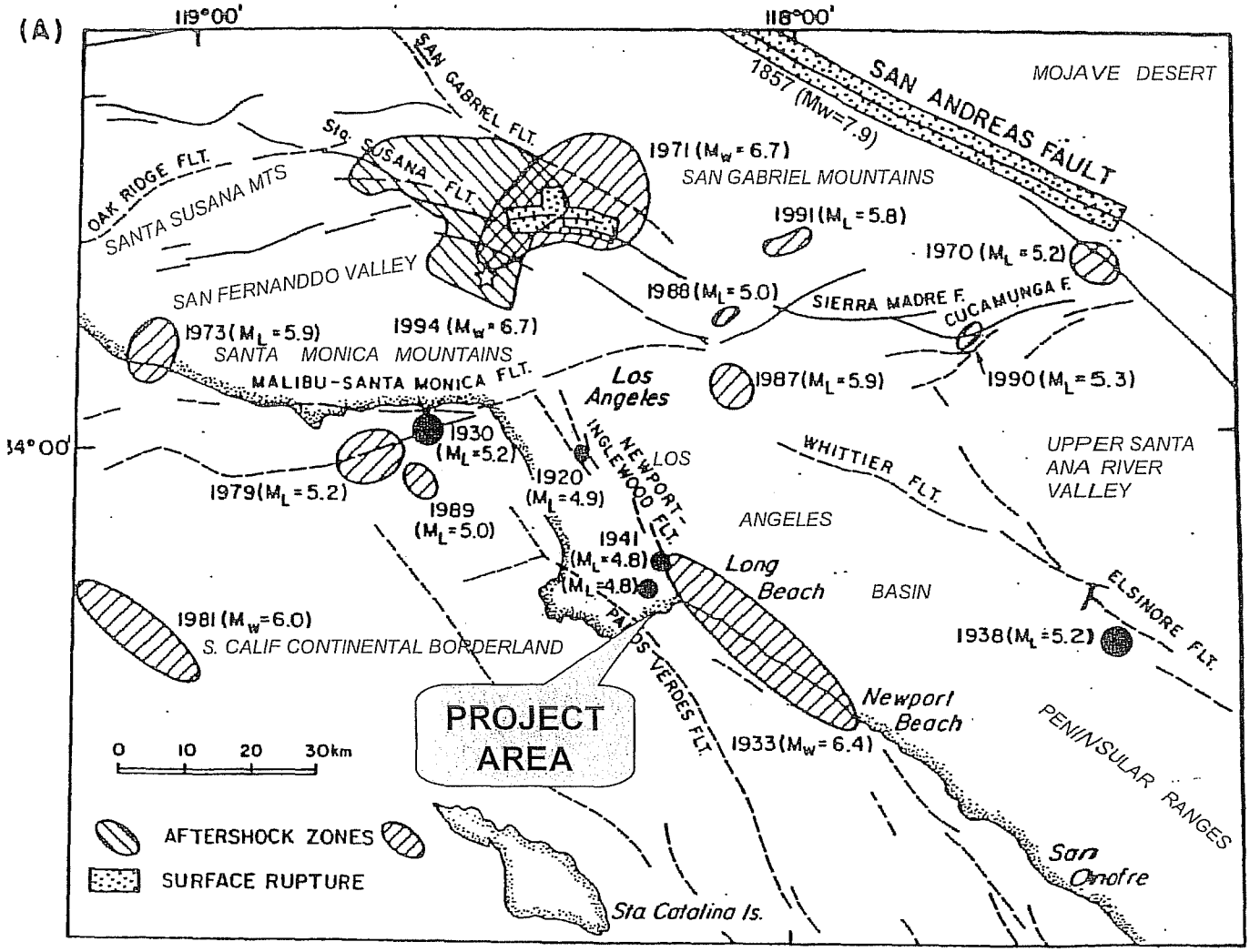


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

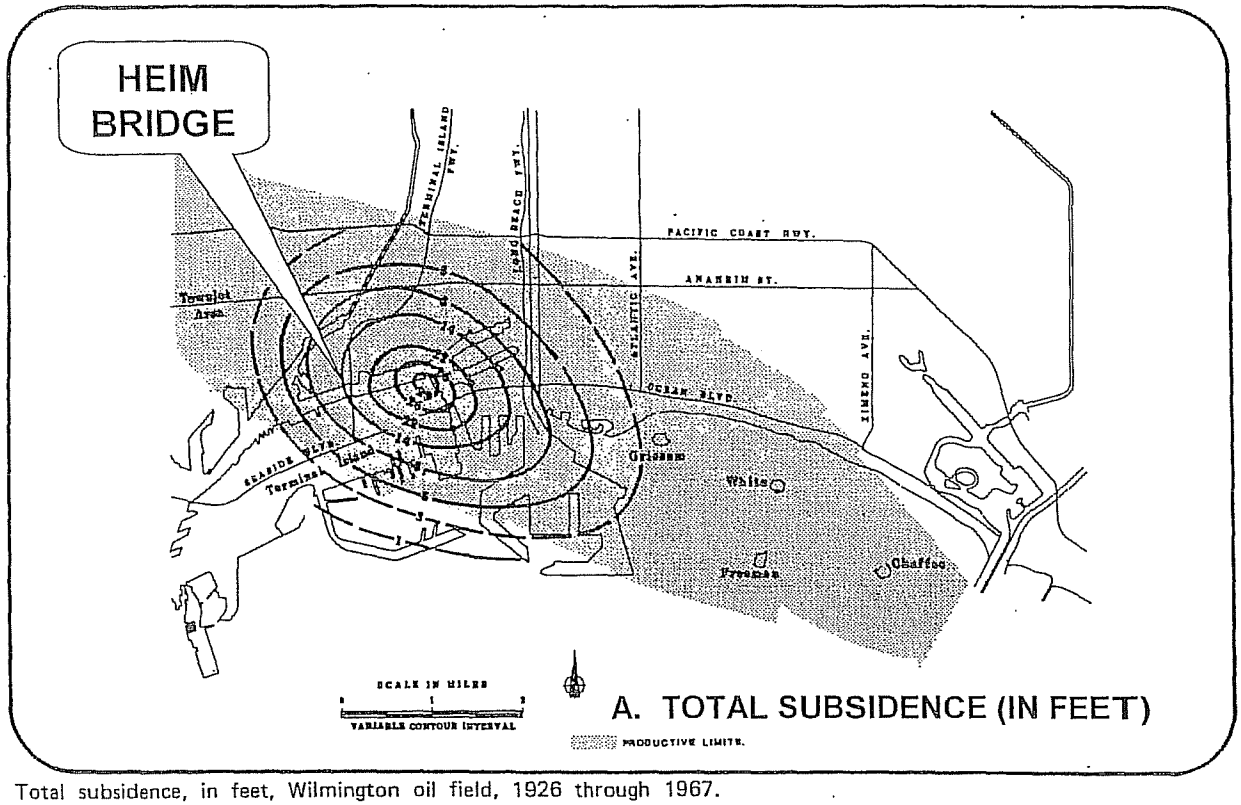
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 2-08-10	Geologic Cross-Sections, LA Harbor Figure 6

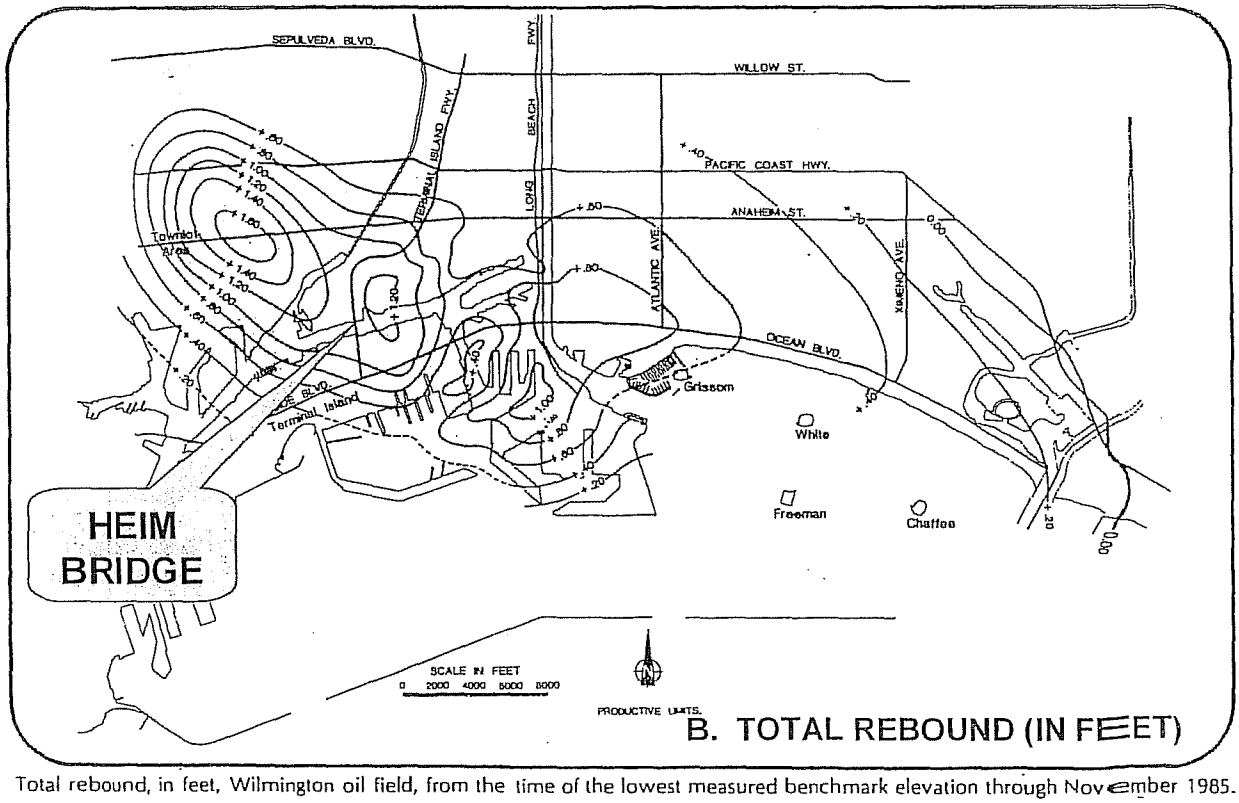


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 2-08-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM B RIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -112 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about 3 ft, with a few feet of import fill for the existing approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +18 ft near the northern end of the proposed wall. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -25 ft. The near surface deposits are underlain by a thick strata of inter-layered soft to stiff clay, silt, sandy silt, and loose to medium dense silty sand down to about elevation -70 ft. Below elevation -70 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB and Log of Boring sheets.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in four of the borings performed near the proposed approach embankment and wall, between elevation +2.3 ft and -5.3 ft. The elevation that groundwater was encountered in each boring is listed in Table 2 and also on LOTB/Log of Boring sheets attached with this report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

Based on the observed high water elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

Based on information collected from borings A-09-051, A-09-052, A-09-053, R-09-001, R-09-02, R-09-038 and CPT soundings CPT-09-093, CPT-09-094 and CPT-09-095 three separate sections of idealized soil profiles for foundation analysis and design were developed (A-A' for Abutment 1, B-B' for East Embankment and C-C' for Wall A1, See Figure 3). The subsurface profiles beneath the proposed structures are shown in Figures 9 through 11. The soil profiles and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

SECTION A-A' (FROM STA 3+75 TO 4+27)

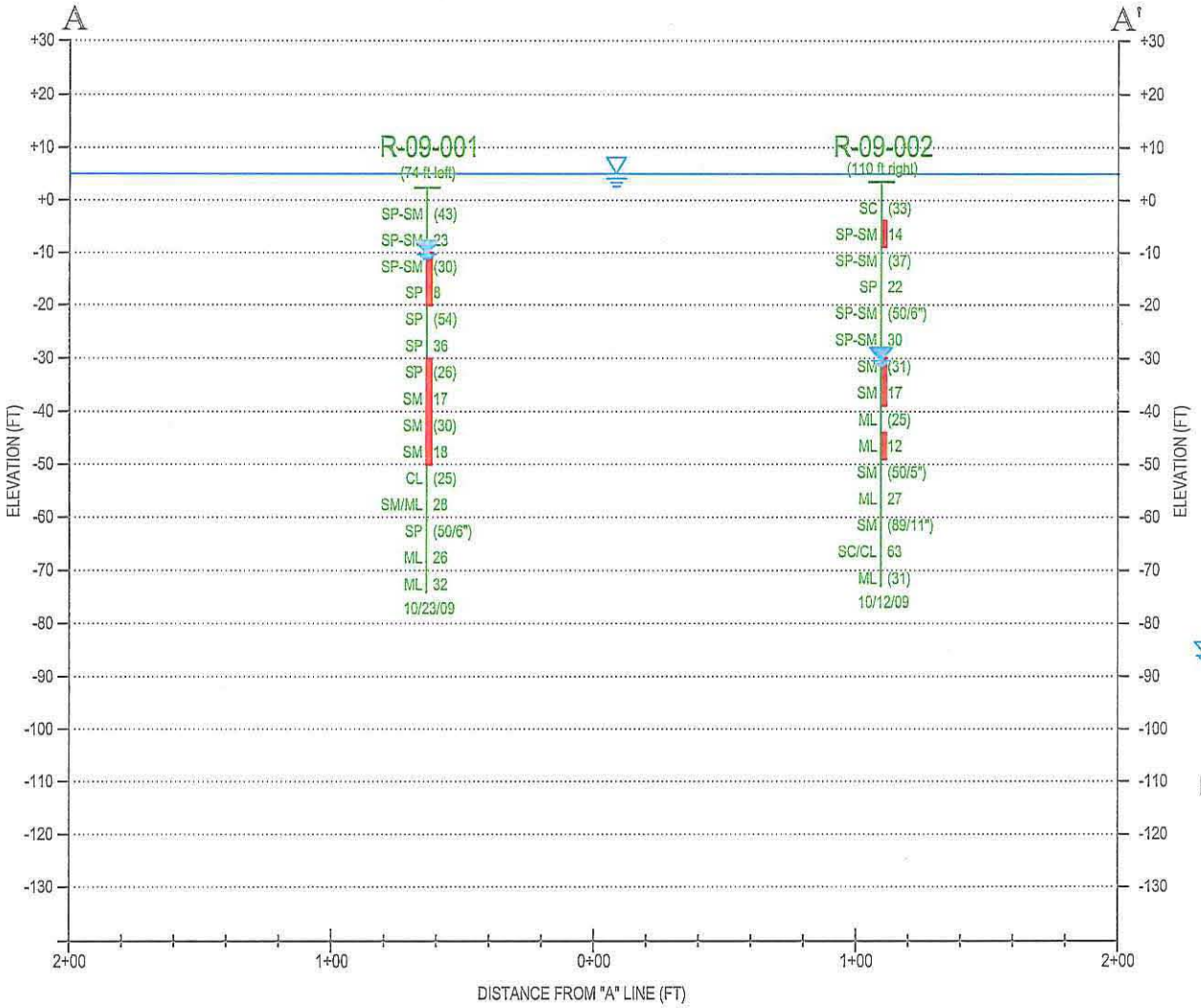
Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -20.0	Sand / Sand with Silt	120	100	32
-20.0 to -30.0	Sand / Sand with Silt	120	100	34
-30.0 to -50.0	Silty Sand / Sandy Silt	120	100	33
-50.0 to -68.0	Silty Sand / Sandy Silt / Lean Clay	120	100	36
-68.0 to -75.0	Silt / Silt with Sand	120	3,000	0
-75.0 to -110.0	Sand / Sand with Silt / Silty Sand	125	0	38

SECTION B-B' (FROM STA 1+00 TO 3+75, EAST SIDE)

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -5.0	Silty Sand	120	100	34
-5.0 to -25.0	Sand / Sand with Silt / Silty Sand	120	100	30
-25.0 to -35.0	Sandy Silt / Silt / Lean Clay / Fat Clay	120	700	0
-35.0 to -48.0	Clayey Silt / Silt / Sandy Silt	120	1,750	0
-48.0 to -72.0	Silt / Sandy Silt / Silty Sand	120	100	34
-75.0 to -110.0	Sand / Sand with Silt / Silty Sand	125	0	38

SECTION C-C' (FROM STA 1+00 TO 3+75, WEST SIDE)

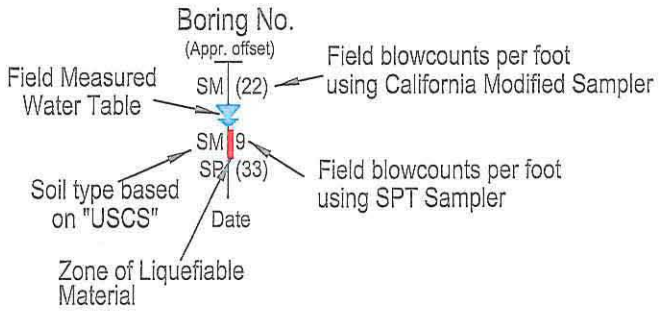
Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+20 to Grade	Silty Sand (assumed embankment fill)	120	200	32
Grade to -5.0	Silty Sand	120	100	34
-5.0 to -22.0	Sand / Sand with Silt / Silty Sand	120	100	30
-22.0 to -40.0	Sandy Silt / Silt / Lean Clay	120	1,250	0
-40.0 to -50.0	Silt / Sandy Silt / Silty Sand	120	100	32
-50.0 to -70.0	Silt / Sandy Silt / Silty Sand	120	100	34
-70.0 to -110.0	Sand / Sand with Silt / Silty Sand	125	0	38



LEGEND

R-09-001 Rotary Wash Boring (2009)

Assumed Design Water Table at +5 ft MLLW



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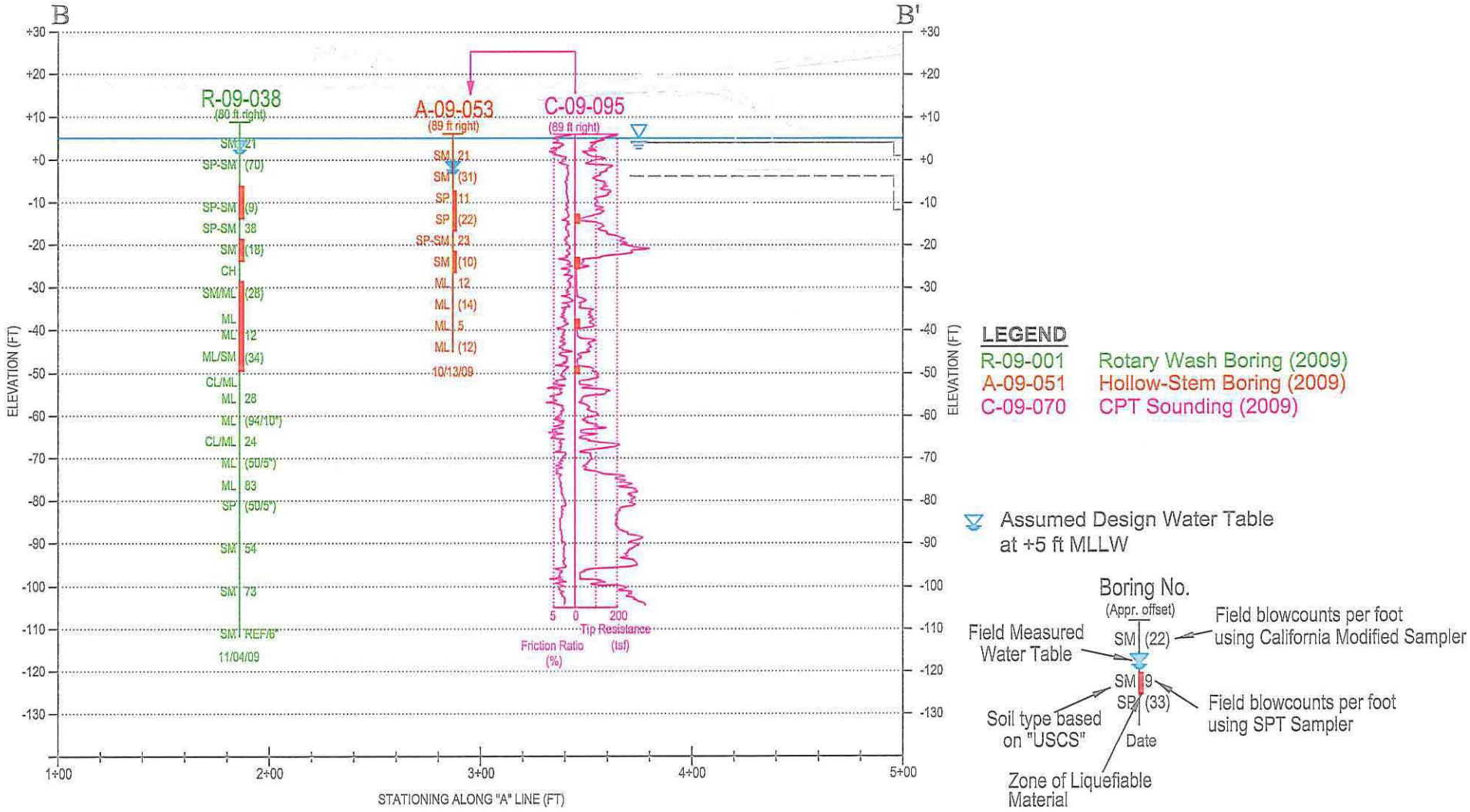
Idealized Soil Profile along Section A-A'

Figure 9



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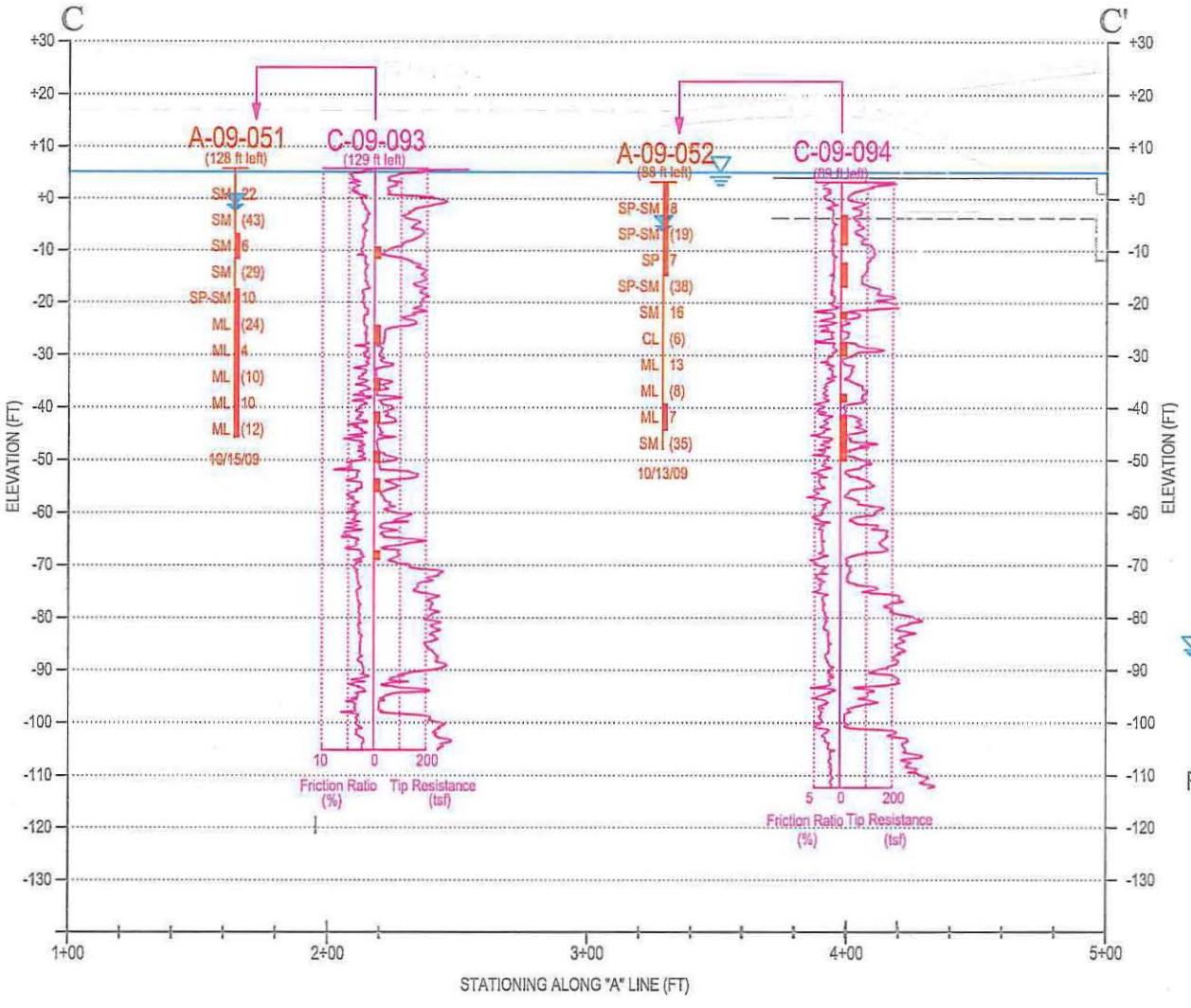
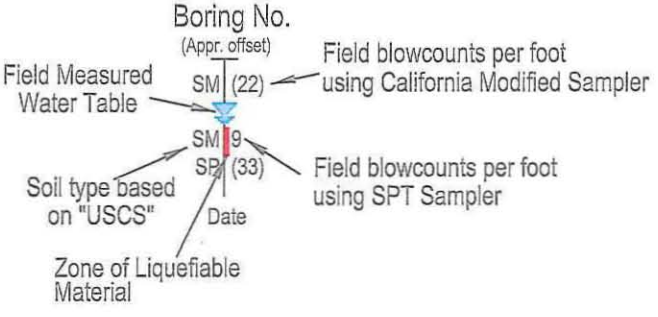


LEGEND

A-09-051 Hollow-Stem Boring (2009)

C-09-070 CPT Sounding (2009)

Assumed Design Water Table at +5 ft MLLW



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EMI Project No. 06-123 | Date: 02-08-10

Idealized Soil Profile along Section C-C'

Figure 11

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance to with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix F.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the approximate elevation -50 ft are expected to be susceptible to liquefaction. Seismically induced-settlements up to 9 inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake event is also identified in the subsurface profiles shown in Figures 9 through 11.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
A-09-051	-6.8 to -11.8	1.5	8.5
	-16.8 to -45.8	7.0	
A-09-052	+3.2 to -14.3	3.2	4.5
	-39.3 to -44.3	1.3	
A-09-053	-6.5 to -16.5	1.7	3.2
	-21.5 to -26.5	1.5	
R-09-001	-10.0 to -20.0	2.0	5.5
	-30.0 to -50.0	3.5	
R-09-002	-4.0 to -9.0	0.7	3.4
	-29.0 to -39.0	1.5	
	-44.0 to -49.0	-1.2	
R-09-038	-6.2 to -13.7	2.8	8.5
	-18.7 to -23.7	1.3	
	-28.7 to -50.0	4.4	
CPT-09-093	-9.5 to -11.4	0.1	1.3
	-24.5 to -27.8	0.6	
	-34.7 to -36.7	0.2	
	-41.0 to -43.0	0.1	
	-48.4 to -50.4	0.1	
	-53.8 to -56.0	0.1	
	-67.4 to -68.8	0.1	
CPT-09-094	-3.2 to -8.7	<0.1	0.5
	-12.4 to -16.8	<0.1	
	-21.8 to -22.8	<0.1	
	-27.6 to -30.0	0.1	
	-37.5 to -38.8	<0.1	
	-41.5 to -50.0	0.3	
CPT-09-095	-12.8 to -14.8	0.1	0.8
	-23.0 to -25.5	0.5	
	-37.5 to -39.5	0.1	
	-48.5 to -50	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. In the vicinity of the subject site six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.4 and 8.4, the minimum resistivities were between 390 and 2,000 ohm-cm, soluble

chloride contents were between 267 and 1,809 parts per million (ppm) and soluble sulfate contents were between 20 and 1,380 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Approach Embankment and Mechanically Stabilized Earth Wall Recommendations

As discussed in Section 1.2, the maximum design height of the approach embankment is about 17 ft. Due to the presence of compressible soil; construction of the proposed Schuyler Heim Bridge approach embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected to retain the soil on the west side of the approach embankment because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 20 ft and base width of 14 ft at Sta. 3+50 ("A" Line), the bearing pressure induced on the underlying foundation soil is 3.4 ksf. Using a base width of 14 ft, the allowable bearing capacity of the soil directly beneath

the MSE wall is greater than 3.4 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads supporting the wall face may be supported on the in-situ soil. They should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 2 ft below lowest adjacent grade. The allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL A1 STABILITY ANALYSES

Approx. "A" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety [3]	Global Stability Factor of Safety	
				Static[1]	Psuedo-Static[1],[2]
3+50	20	14	2.1	2.40	1.18

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1. Bearing capacity factor of safety is 2.1 for end of construction also

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

Based on cross-sections provided by the roadway designers, the potential settlement beneath the proposed embankment was evaluated at "A" Line Stations 2+50, 3+50, and 4+27. The results for settlement analysis at Sta. 4+27 are discussed in a separate foundation report prepared by EMI (2010) for the Schuyler Heim Bridge.

Based on cross-sections provided by roadway designers, the existing embankment will be widened as much as 3 feet on the east side and 9 ft on the west side and the embankment height is increased by up to about 2 feet. Based on our calculations, the maximum settlement of soils underlying the proposed approach embankment is estimated to be about 1.5 inch and the differential settlement along the wall is estimated to be less than 1 inch per 100 ft. The settlement period is estimated to be about 6 weeks to reduce the remaining long-term settlement to less than ½-inch.

Utilities: An existing 12-inch diameter high pressure gas line is located about 33 ft west of Abutment 1. Between Sta. 2+50 and 3+50 ("A" Line), this gas line is becoming as close as about 5 to 10 ft west of Retaining Wall A1. The maximum settlement below the gas line is estimated to be about 1.1 inch and the differential settlement along the pipe is on the order of 1 inch per 100 feet.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

The base of the MSE structure will be founded on native soils. EMI recommends remedial grading consisting of 1-ft overexcavation for the section founded on native soil. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted to a minimum 90 percent relative compaction. The overexcavation should be backfilled using granular, non-expansive soils. In the event the bottom of remedial excavations become saturated due to the presence of shallow groundwater or seepage, self compacting material such as gravel or lean concrete slurry can be placed within the limits of the overexcation. The overexcavation should extend at least 3 ft beyond the outer edge of the leveling pad and 3 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Stability

The "global" stabilities of the MSE and east slope were evaluated for both static and pseudo-static conditions using the computer program SLIDE 5.0 (Rocscience, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-sections selected for stability analysis were near "A" Line Sta. 4+27 and Sta. 3+50. The results for the global stability analysis at Sta. 4+27 are discussed in a separate foundation report prepared by EMI (2010) for the Schuyler Heim Bridge.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 12 inches is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans show removal of existing retaining wall on the west side of the approach embankment is necessary to achieve finish grades. Temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all of the borings performed near the proposed approach embankment and wall A1 between Elevation +2.3 ft and -5.3 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad varies between about elevation +1 and +2.5 ft. The deepest excavation for the proposed MSE wall is expected to be below the observed groundwater elevations; therefore, groundwater is expected to be encountered during construction of the proposed MSE wall. Due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, even higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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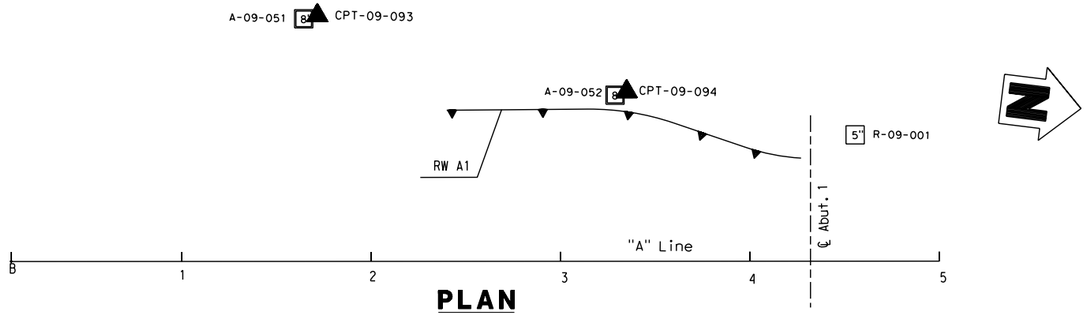
BENCHMARKS:

PT-503	PT-531065
REBAR	PK NAIL IN LEAD
18.51'Lt ℄ "A" Line	53.55'Lt ℄ "A" Line
Sta. 8+8.66	Sta. 4+24.53
N 1735350.13	N 1734960.02
E 6489075.70	E 6489051.67
Elev. = -0.53	Elev. = 17.75

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).
(2) 2.4" samples were taken using a California Modified Sampler.
(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8/8/10 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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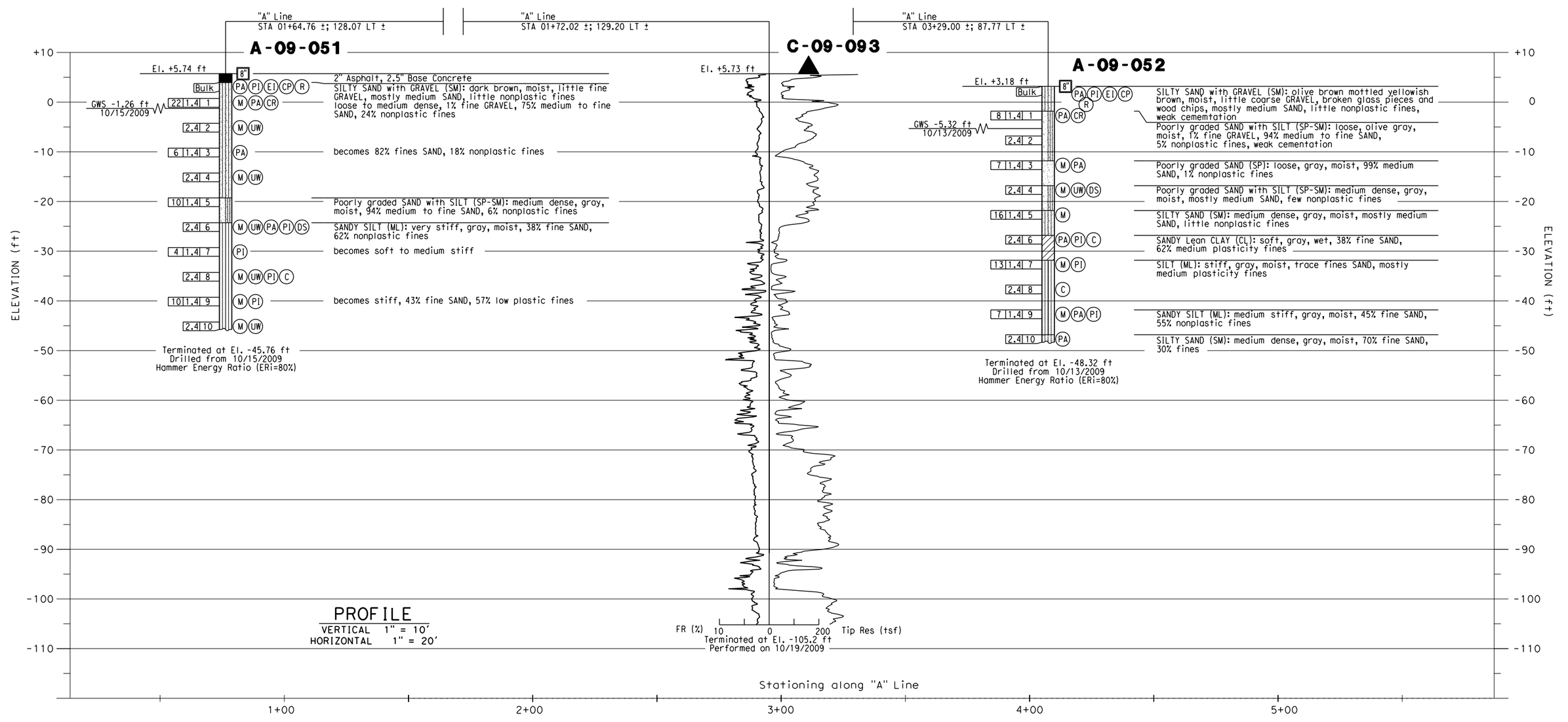
REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY: K. Thant	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53E0147
SIGN OFF DATE	CHECKED BY: K. Pratheepan				POST MILE 3.55

MSE RETAINING WALL NO. A1

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCHMARKS:

PT-503	PT-531065
REBAR	PK NAIL IN LEAD
18.51'Lt ℄ "A" Line	53.55'Lt ℄ "A" Line
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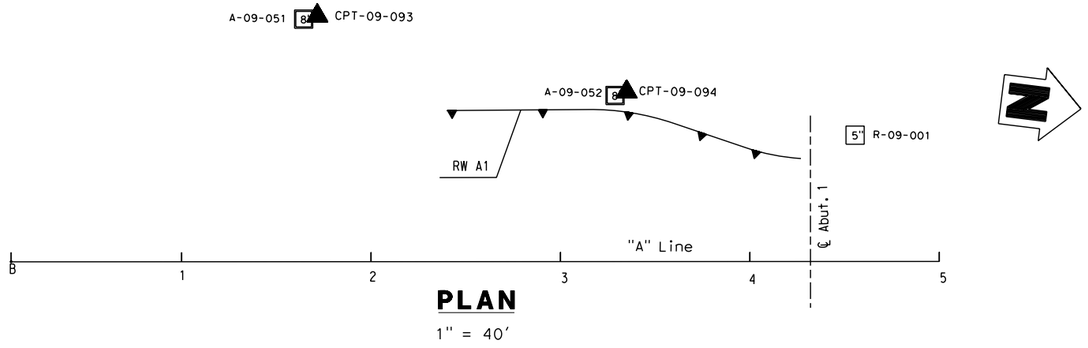
(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8.886 04/19/10
REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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CARSON, CA 90745

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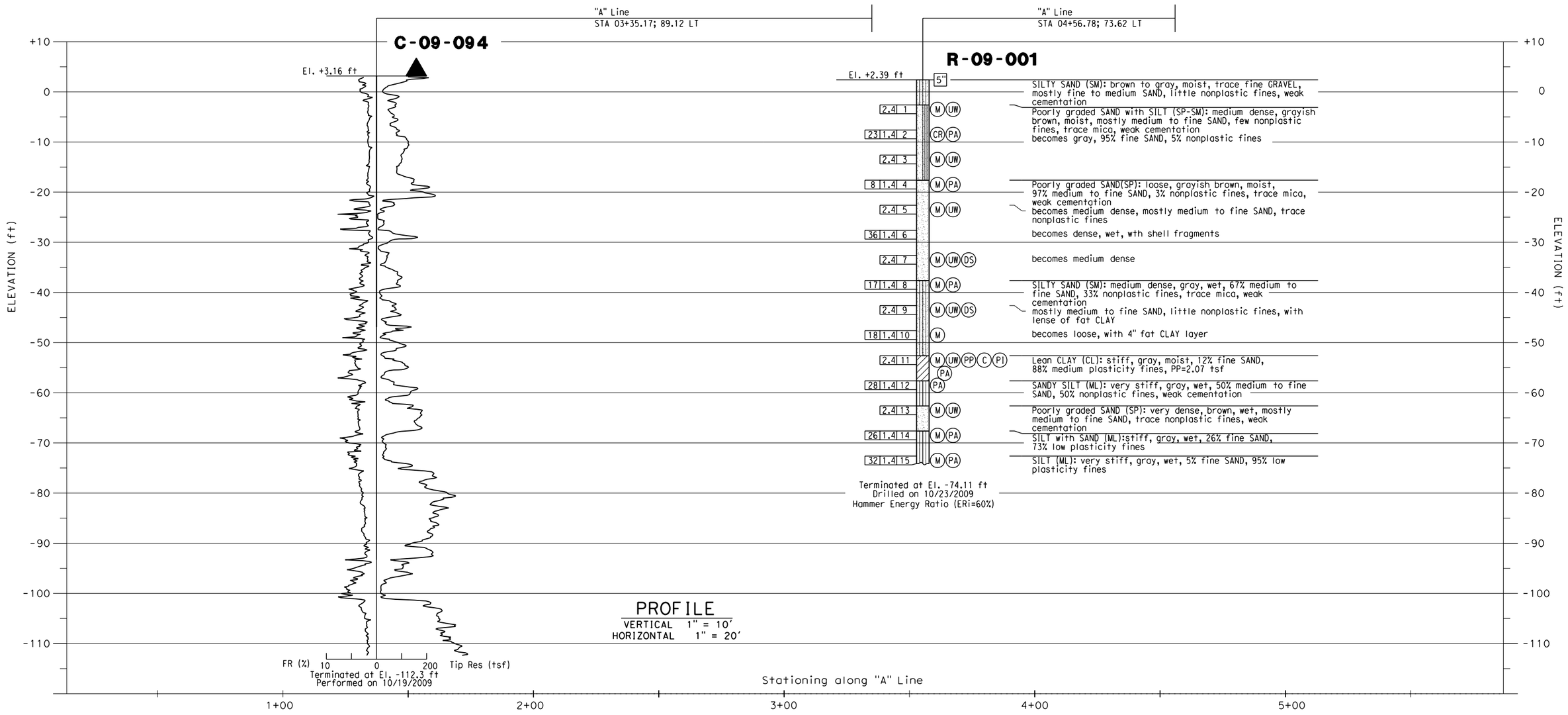
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. J. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53E0147	MSE RETAINING WALL NO. A1
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.55	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/14/10

SHEET X OF X

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8880 04/19/10
REGISTERED ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER
G. J. Gunaranjan
No. C71758
Exp. 12-31-11
CIVIL
STATE OF CALIFORNIA

PLANS APPROVAL DATE

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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

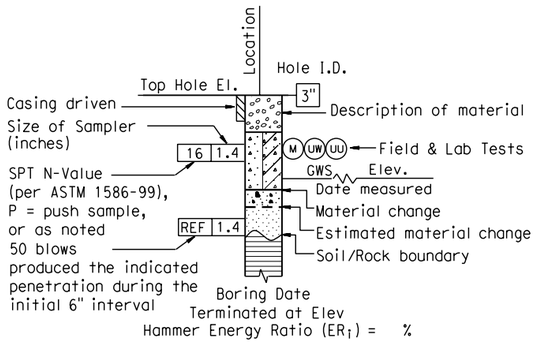
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

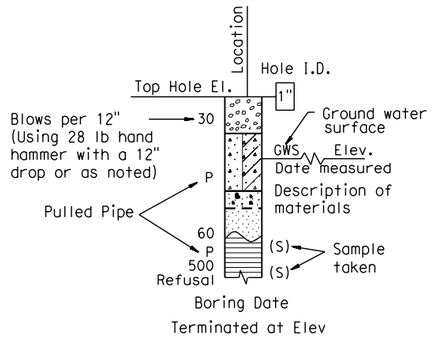
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

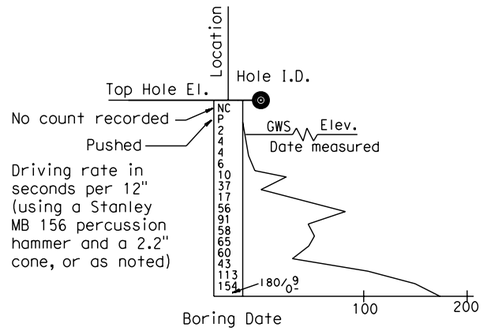
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



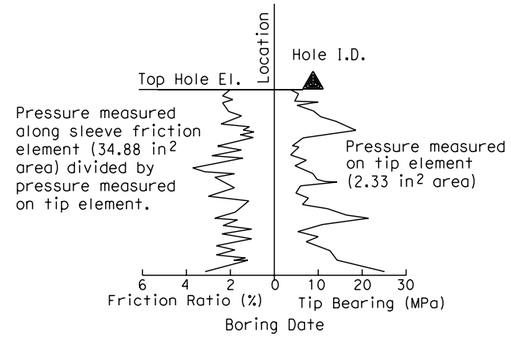
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: R. Jie/K. Thant	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	G. G. Gunaranjan PROJECT ENGINEER	BRIDGE NO. 53E0147 POST MILE 3.55	MSE RETAINING WALL NO. A1 LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 120301

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
04/06/09	04/14/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

8880 04/19/10
REGISTERED ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — G. J. Gunaranjan — No. C71758 — Exp. 12-31-11 — CIVIL — STATE OF CALIFORNIA

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CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:

R. Jie/K. Thant

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

G. J. Gunaranjan
PROJECT ENGINEER

BRIDGE NO. 53E0147
POST MILE 3.55

MSE RETAINING WALL NO. A1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 120301

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 04/06/09, 03/18/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A. SCHUYLER HEIM BRIDGE SEISMIC RETROFIT LOTB SHEETS PREPARED BY LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Laboratory Testing

- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RS) Minimum Resistivity

N.S.R.= No sample recovery

OVM8608 Gas Readings

PLAN

SCALE: 1"=40'

NORTH

ABUT. 0, BENT 1, BENT 2, BENT 3, BENT 4, BENT 5, BENT 6, BENT 7, BENT 8, BENT 9

B-1, CPT-1, CPT-2, CPT-3, CPT-4

℄ EXISTING R.R.

5, 6, 7, 8, 9, 10, 11, 12

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 24, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

PROFILE

HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

45° Lt. STA. 5+94.00 — ELEV.= 0.21

B-1

FILL-(SM)Brown fine to medium SILTY SAND w/GRAVEL, vegetation, w/shell fragments

GWS ELEV.= 4.71 08-26-96

NATIVE:(ML)Gray SILT, very stiff grades to SANDY soft

(ML)Gray SANDY SILT w/mica & shell fragments

(ML)Gray to dark gray SILT w/traces of SAND, stiff

(SP)Gray fine SAND w/mica, compact

(ML)Gray SILT w/CLAY, very stiff

(SP)Gray fine SAND, very dense

(ML)Gray CLAYEY SILT, very stiff, less CLAYEY grades to CLAYEY

(SP)Gray fine SAND, very dense, w/GRAVEL grades to fine to medium w/1" gravel

grades to medium

traces of gravel

Grades to fine w/traces of SILT w/decomposed wood fragments & mica

Grades to medium to coarse w/traces of GRAVEL less SILT

Grades to medium

Grades to fine to medium

Grades to medium w/traces of 3/4" GRAVEL

(ML)Gray SANDY SILT

(GP)Gray poorly graded GRAVEL w/SAND, very dense

(ML)Gray SANDY SILT

08-26-96

17° Lt. STA. 6+02.50 — ELEV.= -0.06 — Vs (ft/s) — CPT-1 — N[blows/foot] — 08-19-96

STA. 7+63.50 — ELEV.= -2.01 — CPT-2 — 08-15-96

STA. 9+08.00 — ELEV.= -0.18 — CPT-3 — 08-15-96

STA. 11+12.00 — ELEV.= 2.46 — CPT-4 — 08-15-96

ELEVATION

LEGEND OF EARTH MATERIALS: GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, GRANULAR ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK, SANDY CLAY or CLAYEY SAND, SILTY SAND or SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS (According to the Standard Penetration Test)

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
4-10	Loose	Soft
10-30	Slightly compact	Stiff
30-50	Compact	Very stiff
50-90	Dense	Hard
>90	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERSIGHT	DRAWN BY	NL	CB-LH-MC		PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	PROJECT ENGINEER	BRIDGE NO. 53-2618
	CHECKED BY	MR	FIELD INVESTIGATION				POST MILE 3.58
			DATE 09-15-96				

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS: 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO. 1

SHEET 141 OF 148

J:\JOB\LKR\LT8\BOR 9-15-96 11:45:15 on EST

APPENDIX B. SITE-SPECIFIC BORING AND CPT LOGS

SITE-SPECIFIC BORING LOGS

LOG OF BORING NO. A-09-053

Grade Elevation:	+8.80 feet			
Boring Depth:	51.5 feet	Driller:	2R Drilling Inc.	SHEET 1 OF 2
Borehole Diameter:	8 inches	Type of Rig:	Hollow-Stem Auger	Comments: 1. CME 75 with automatic hammer
Date Drilled:	10-12-09	Drive Wt. (lbs):	140	2. 3.25" O.D. ring sampler
Logged By:	K.K	Drop (inches):	30	3. "A" Line STA 02+86.77±; 88.67 RT ±

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	Tests/ Results
0	D	1	15		SILTY SAND (SM): medium dense, brown, moist, fine-grained sand, trace of medium-grained sand, nonplastic	CR
5	S	2	Push		CLAYEY SAND (SC): medium dense, olive, moist, fine-grained sand, trace of medium-grained sand, slightly plasticity	PA
	D	3	50/6"		very dense	DS
10	S	4	21		SANDY SILT (ML): hard, olive, moist, fine-grained sand, trace of mica, nonplastic	PA

1. 'Sample Type' - Graphical representation of sample type as shown below.
   - S: Split Spoon - Standard Penetration Test Sample (SPT)
   - D: Drive Sample - California Drive Sampler
   - H: Hand Auger Sample - Obtained by collecting hand auger cuttings in a plastic bag
   - B: Bulk Sample - Obtained by collecting cuttings in a plastic bag
   - T: Tube Sample - Thin-walled Tube Sample
   - P: Thin-walled Pitcher Core Sample
2. 'Sample' - Sample Number
3. 'Blows/foot' - Number of blows required to advance sampler one foot (unless a distance is specified). Samplers in general were driven into the soil at the bottom of the hole with an automatic drop type 140-lb hammer dropping a standard 30 inches (as specified in header).

   'REC/RQD' - Sample Core Recovery (REC) in percent (%) and Rock Quality Designation (RQD) in percent (%). RQD is defined as the percentage of core in each run in which the spacing between natural fractures is greater than 4 inches. Mechanical breaks of the core are not considered.
4. 'Graphic Log' - Standard symbols for soil and rock types, as shown in Note B, Sheet 2 of 2
5. ▼ Encountered groundwater depth while drilling.
6. 'Geotechnical Description' (See also Note A, Sheet 2 of 2)
   Soil - Soil classifications are in general accordance with the American Society for Testing and Materials (ASTM) D2488.84. Designations include consistency, moisture, and color. Field description have been modified to reflect results of laboratory analyses where deemed appropriate.

   Rock - Rock classifications generally include a rock type, color, moisture, mineral constituents, degree of weathering, alteration and the mechanical properties of the rock.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 Date: 02-08-10

LEGEND FOR GEOTECHNICAL BORING LOGS

(SHEET 1 OF 2)

7. 'Moisture Content' and 'Dry Density' determined by laboratory testing.

8. 'Tests/Results' - Identify types of laboratory tests performed on samples collected from the field investigation. Abbreviations of tests are provided below:

PI	Atterberg Limits	PP	Pocket Penetrometer
CR	Corrosivity	R	R-Value
CBR	California Bearing Ratio	SE	Sand Equivalent
CP	Compaction Test	SG	Specific Gravity
C	Consolidation	TV	Torvane
CU	Consolidated-Undrained Triaxial	UC	Unconfined Compression
DS	Direct Shear	UU	Unconsolidated-Undrained Triaxial
EI	Expansion Index	VS	Vane Shear
PA	Particle Size Analysis		

Pocket penetrometer and Torvane Shear measurements are given on the boring logs directly as the reading taken from the measuring instrument.

NOTE A

Criteria for Describing Moisture Condition

Description	Criteria (After ASTM D 2488)
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Relative Density of Coarse-Grained Soil

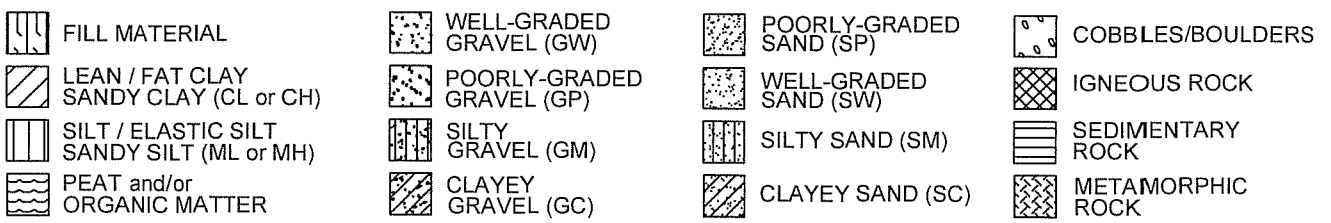
Blows/foot	Relative Density	Field Test (After Sowers, 1979)
0 - 4	Very Loose	Easily penetrated 12" with 0.5-inch steel rod pushed by hand
5 - 10	Loose	Easily penetrated with 0.5-inch steel rod pushed by hand
11 - 30	Medium Dense	Easily penetrated with 0.5-inch steel rod driven by 5-lb hammer
31 - 50	Dense	Penetrated a foot with 0.5-inch steel rod driven by 5-lb hammer
> 50	Very Dense	Penetrated a few inches with 0.5-inch steel rod driven by 5-lb hammer

Relative Density of Fine-Grained Soil

Unconfined Compressive Strength (tsf)	Consistency	Field Test (After Sowers, 1979)
< 0.25	Very Soft	Easily penetrated several inches by fist
0.25 - 0.5	Soft	Easily penetrated by thumb
0.5 - 1.0	Medium Stiff	Can be penetrated several inches by thumb with moderate effort
1.0 - 2.0	Stiff	Readily indented by thumb, but penetrated only with great effort
2.0 - 4.0	Very Stiff	Readily Indented by thumbnail
> 4.0	Hard	Indented with difficulty by thumbnail

NOTE B

Legend of Earth Materials



Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 | Date: 02-08-10

LEGEND FOR GEOTECHNICAL BORING LOGS

(SHEET 2 OF 2)

LOG OF BORING NO. A-09-053

Grade Elevation:	+ 6.05 ft			
Boring Depth:	51.5 feet	Driller:	2R Drilling Inc.	SHEET 1 OF 2
Borehole Diameter:	8 inches	Type of Rig:	Hollow-Stem Auger	Comments: 1. CME 75 with automatic hammer 2. 3.25" O.D. ring sampler 3. "A" Line STA 02+86.77±; 88.67 RT ±
Date Drilled:	10-13-09	Drive Wt. (lbs):	140	
Logged By:	K.T	Drop (inches):	30	

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	Tests/ Results
0	B	0			SILTY SAND with GRAVEL (SM): dark brown to gray, moist, little GRAVEL, mostly medium to fine SAND, some nonplastic fines	PA, PI, EI, CP, R
5	S	1	21		medium dense, 20% fine GRAVEL, 49% medium to fine SAND, 31% nonplastic fines	PA, CR
10	D	2	31		becomes mostly medium to fine SAND, some nonplastic fines	M, UW, DS
15	S	3	11		Poorly graded SAND (SP): medium dense, olive gray, moist, 97% medium SAND, 3% nonplastic fines	M, PA
20	D	4	22			M, UW
25	S	5	23		Poorly graded SAND with SILT (SP-SM): medium dense, light gray, moist, 95% medium SAND, 5% nonplastic fines	M, PA
30	D	6	10		SILTY SAND (SM): loose, gray, moist, mostly fine SAND, some nonplastic fines	DS
35						

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123 Date: 02-08-10

CONTINUED LOG OF BORING NO. A-09-053

Date Drilled: 10-13-09

Logged By: K.T

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	Tests/ Results
35	S	7	12		SILT (ML): stiff, gray, moist, 13% fine SAND, 87% medium plasticity fines, trace shell fragments	M, PA, PI
40	D	8	14			C
45	S	9	5			M, PA, PI
50	D	10	12			C
					Terminated Boring at 51.5 feet depth. Groundwater encountered at 8.5 feet depth. Hammer Energy Ratio (ER=75%).	
55						
60						
65						
70						

LOG OF BORING NO. R-09-002

Grade Elevation:	+ 3.55 ft				
Boring Depth:	76.5 feet	Driller:	C&L Drilling Co.	SHEET 1 OF 3	
Borehole Diameter:	5 inches	Type of Rig:	Mud Rotary	Comments: 1. Mayhew 1000 with rope and cat-head hammer	
Date Drilled:	10-12-09	Drive Wt. (lbs):	140	2. 3.25" O.D. ring sampler	
Logged By:	R.J	Drop (inches):	30	3. "A" Line STA 04+57.38 ±; 110.03RT ±	

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
0						
5	D	1	42		CLAYEY SAND (SC): medium dense grayish brown, moist, trace fine GRAVEL, mostly fine to medium SAND, little non to low plasticity fines, weak cementation	M, UW
10	S	2	14		Poorly graded SAND with SILT (SP-SM): medium dense, gray, wet, 90% fine SAND, 10% nonplastic fines, trace mica, weak cementation	M, PA, CR
15	D	3	37			M, UW, DS
20	S	4	22		Poorly graded SAND (SP): medium dense, gray, wet, 97% fine SAND, 3% nonplastic fines, with shell fragments, weak cementation	PA
25	D	5	50/6"		Poorly graded SAND with SILT (SP-SM): very dense, gray, wet, mostly fine SAND, few nonplastic fines, with shell fragments, weak cementation	M, UW
30	S	6	30		becomes medium dense	
35						

CONTINUED LOG OF BORING NO. R-09-002

Date Drilled: 10-12-09
Logged By: R.J

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
35	D	7	31		SILTY SAND (SM): medium dense, gray, wet, mostly medium to fine SAND, some nonplastic fines, trace mica and shell fragments, weak cementation	M, UW, DS
40	S	8	17		54% fine SAND, 46% fines	M, PA
45	D	9	25		SILT with SAND (ML): stiff, gray, wet, little fine SAND, low plasticity fines, trace mica	M, UW, C, PI
50	S	10	12		SANDY SILT (ML): stiff, gray, wet, 3% fine GRAVEL, 36% fine SAND, 61% low plasticity fines	M, PA
55	D	11	50/5"		SILTY SAND (SM): very dense, gray, wet, mostly fine SAND, little nonplastic fines, weak cementation	M, UW
60	S	12	27		SANDY SILT (ML): very stiff, gray, moist, some fine SAND, low plasticity fines, trace mica	M
65	D	13	89/11"		SILTY SAND (SM): very dense, gray, wet, mostly fine SAND, some nonplastic fines, weak cementation	
70	S	14	63		CLAYEY SAND (SC): very dense, gray, wet, mostly fine SAND, some low plasticity fines, weak cementation, with 8" lean CLAY layer	M, PI

CONTINUED LOG OF BORING NO. R-09-002

Date Drilled: 10-12-09

Logged By: R.J

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
75	S	15	31		SILT (ML): very stiff, gray, moist, 1% fine GRAVEL, 13% fine SAND, 86% low plasticity fines	M, PA
					Terminated Boring at 76.5 feet depth. Groundwater Table was not measured. Hammer Energy Ratio (ER=60%).	
80						
85						
90						
95						
100						
105						
110						

LOG OF BORING NO. R-09-038

Grade Elevation:	+ 8.80 ft MLLW				
Boring Depth:	120.5 feet	Driller:	C&L Drilling Co.	SHEET 1 OF 4	
Borehole Diameter:	5 inches	Type of Rig:	Mud Rotary	Comments: 1. Mayhew 1000 with rope and cat-head hammer 2. 3.25" O.D. ring sampler 3. "A" Line STA 01+86.19±; 80.30 RT±	
Date Drilled:	11-04-09	Drive Wt. (lbs):	140		
Logged By:	K.T/K.P	Drop (inches):	30		

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
0	B	0			SILTY SAND (SM): medium dense, moist, olive gray, 10% fine GRAVEL, 55% medium to fine SAND, 35% nonplastic fines, weak cementation	CR, CP, PA
5	S	2	21		mostly medium to fine SAND, somenonplastic fines	
10	D	2	60		Poorly SAND with SILT (SP-SM): dense, moist, olive gray, 95% medium to fine SAND, 5% nonplastic fines, weak cementation	M, UW, PA
15						
20	D	3	9		becomes loose, mostly fine SAND, few nonplastic fines	
25	S	4	38		becomes dense, gray, 88% fine SAND, 12% nonplastic fines	PA
30	D	5	18		SILTY SAND (SM): medium dense, moist, gray, mostly fine SAND, some nonplastic fines, weak cementation	M, DS
35						

CONTINUED LOG OF BORING NO. R-09-038

Date Drilled: 11-04-09	Comments:	SHEET 2 OF 4
Logged By: K.T/K.P	1. Drillhole was backfilled with soil-cement mixture.	

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
35	U	6			Fat CLAY (CH): medium stiff, gray, moist, 1% fine SAND, 99% high plasticity fines, PP=0.8 tsf	M, UW, UU, SG, PA, PI, PP
40	D	7-1 7-2	28		SILTY SAND (SM): medium dense, moist, 86% fine SAND, 14% nonplastic fines, trace shell fragments, weak cementation	M, UW, PA PI
					SANDY SILT (ML): very stiff, gray, moist, some fine SAND, nonplastic fines	
45	U	8			SILT with SAND (ML): stiff, gray, moist, 24% fine SAND, 76% low plasticity fines	M, UW, UU, SG, PA, PI, PP
50	S	9	12		SANDY SILT (ML): stiff, gray, moist, 42% fine SAND, 58% nonplastic fines	M, PA, PI
55	D	10-1 10-2	34			M, UW, C, PI M, UW
					SILTY SAND (SM): medium dense, moist, mostly fine SAND, some nonplastic fines, weak cementation	
60	U	11			SILT with SAND (ML): very stiff, dark gray, moist, 28% fine SAND, 72% low plasticity fines	M, UW, UU, SG, PA, PI, PP
65	S	12	24		SILT (ML): very stiff, gray, moist, 13% fine SAND, 72% nonplastic fines	M, PA, PI
70	D	13	94/10"		becomes hard	M, UW

CONTINUED LOG OF BORING NO. R-09-038

Date Drilled: 11-04-09
Logged By: K.T/K.P

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION	
75	S	14-1 14-2	24		Lean CLAY with SAND (CL): very stiff, moist, dark gray, trace fine SAND, mostly medium plasticity fines	M, Pi
					SILT with SAND (ML): very stiff, dark gray, moist, little fine SAND, moslty nonplastic fines	
80	D	15	50/5"		SANDY SILT (ML): hard, gray, moist, 41% fine SAND, 59% nonplastic fines	M, UW, PA, PI
85	S	16	83			
90	D	17	50/5"		Poorly graded SAND (SP): very dense, moist, gray, 96% medium to fine SAND, 4% low plasticity fines, weak cementation	M, UW, PA
95						
100	S	18	54		SILTY SAND (SM): very dense, moist, mostly medium to fine SAND, little nonplastic fines, weak cementation	
105						
110	S	19	73		81% medium to fine SAND, 19% nonplastic fines	M, PA

CONTINUED LOG OF BORING NO. R-09-038

Date Drilled: 11-04-09

Logged By: K.T/K.P

Comments:
1. Drillhole was backfilled with soil-cement mixture.

Depth (feet)	Sampler Type	Sample	Blows/foot	Graphic Log	GEOTECHNICAL DESCRIPTION
115					
120	S	20	REF/6"		No Recovery
					Terminated Boring at 120.5 feet depth.
					Groundwater encountered at 6.5 feet depth.
					Hammer Energy Ratio (ER=60%).
125					
130					
135					
140					
145					
150					

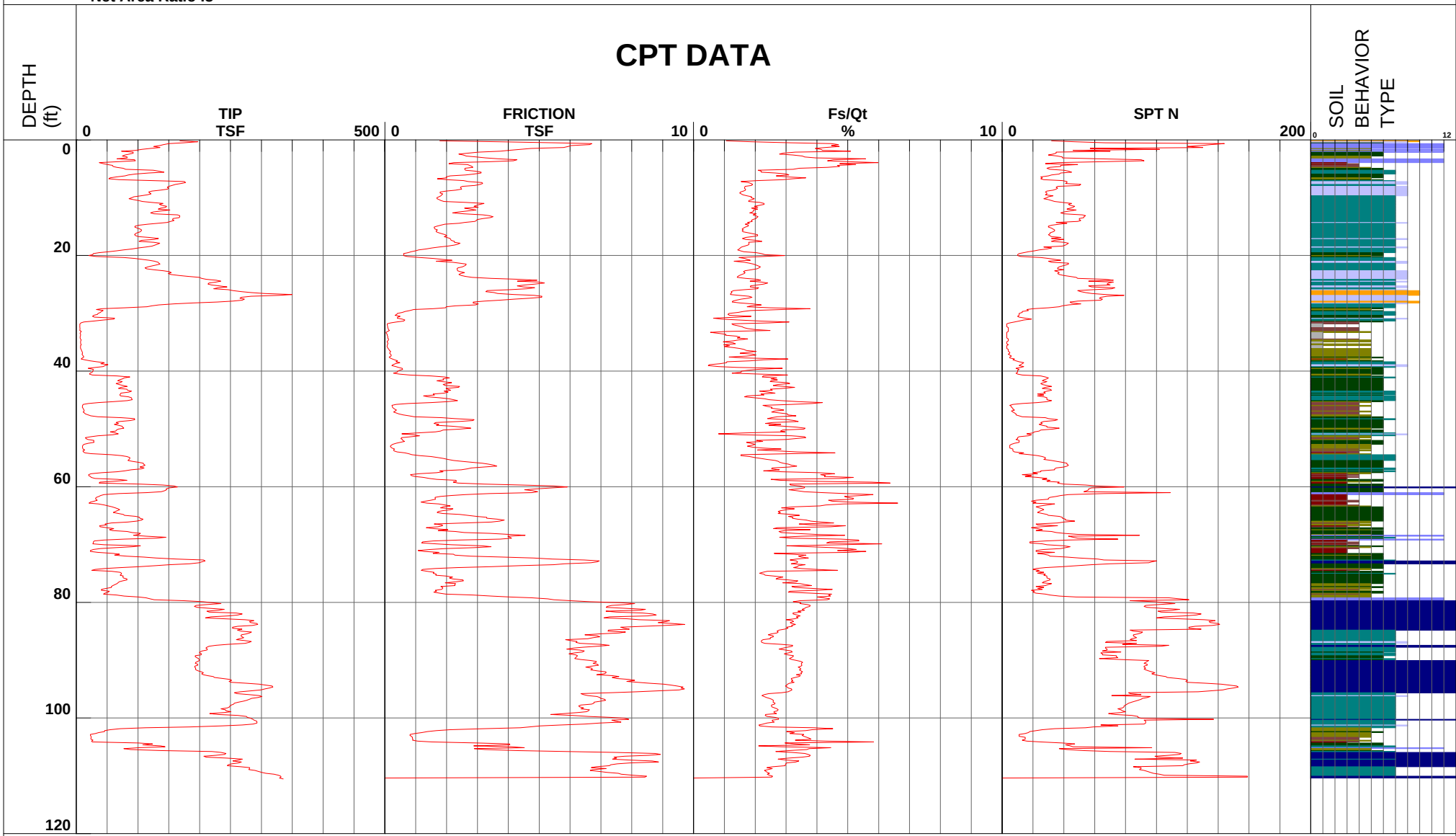
SITE-SPECIFIC CPT SOUNDING LOG

Earth Mechanics

Project	Schuyler Heim Bridge	Operator	DK-ML	Filename	SDF(297).cpt
Job Number	06-123	Cone Number	DSG1023	GPS	
Hole Number	C-09-095	Date and Time	10/20/2009 7:07:16 AM	Maximum Depth	110.56 ft
Water Table Depth	10.00 ft				

Net Area Ratio .8

CPT DATA



1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

Cone Size 10cm squared

*Soil behavior type and SPT based on data from UBC-1983

APPENDIX C. EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

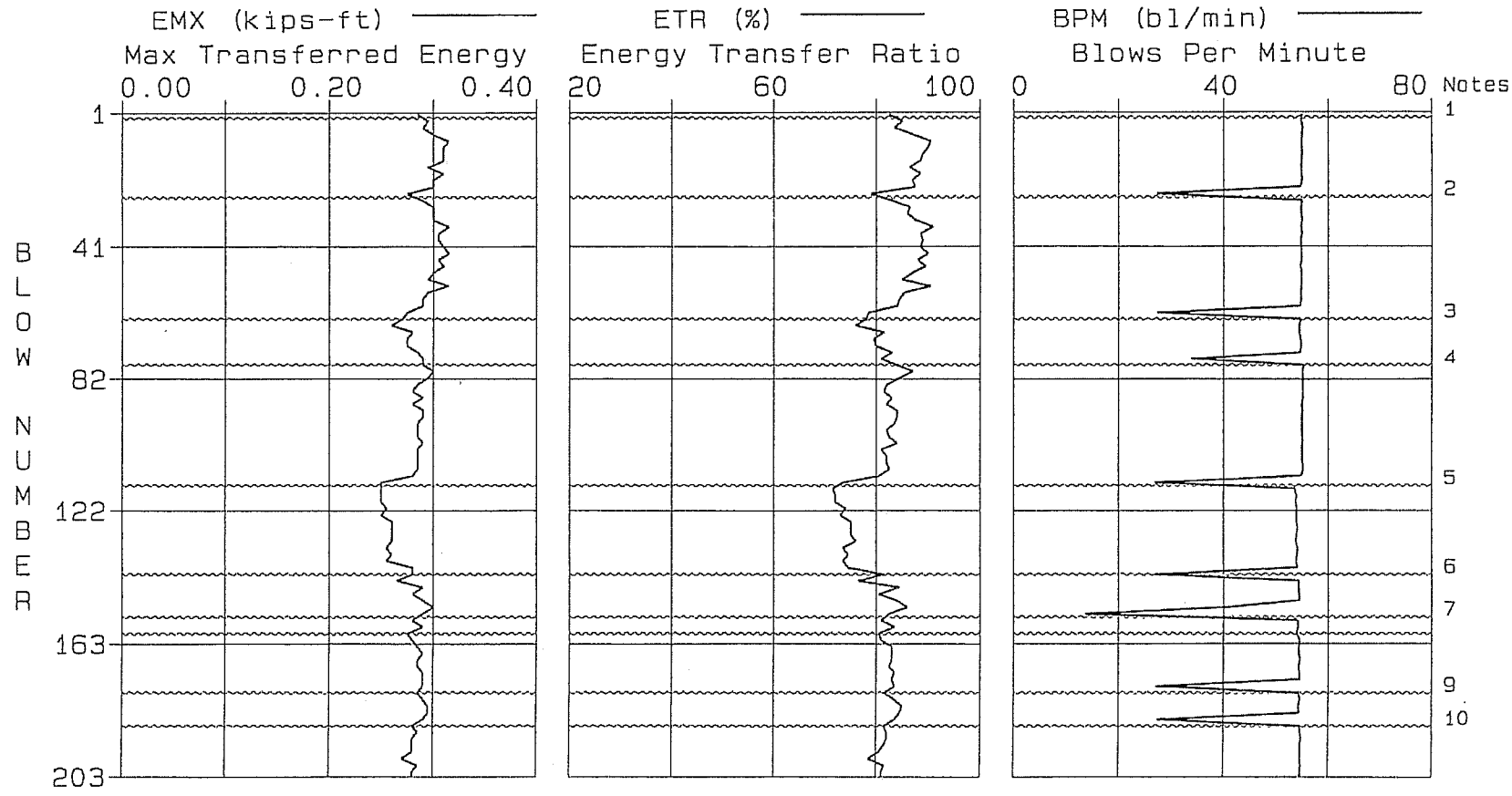
Sincerely Submitted for EarthSpectives

Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer

EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

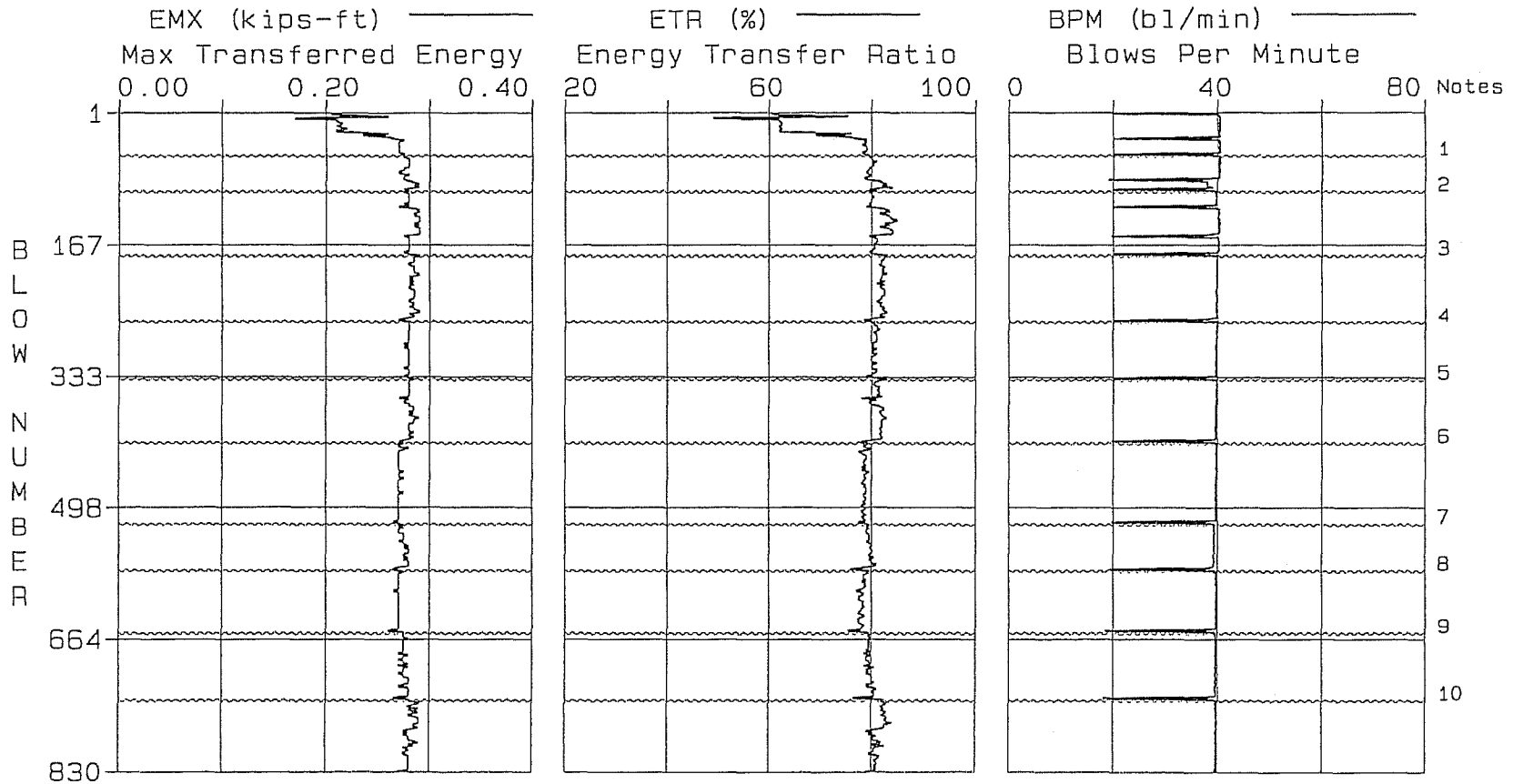
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

Info: MUD ROTARY

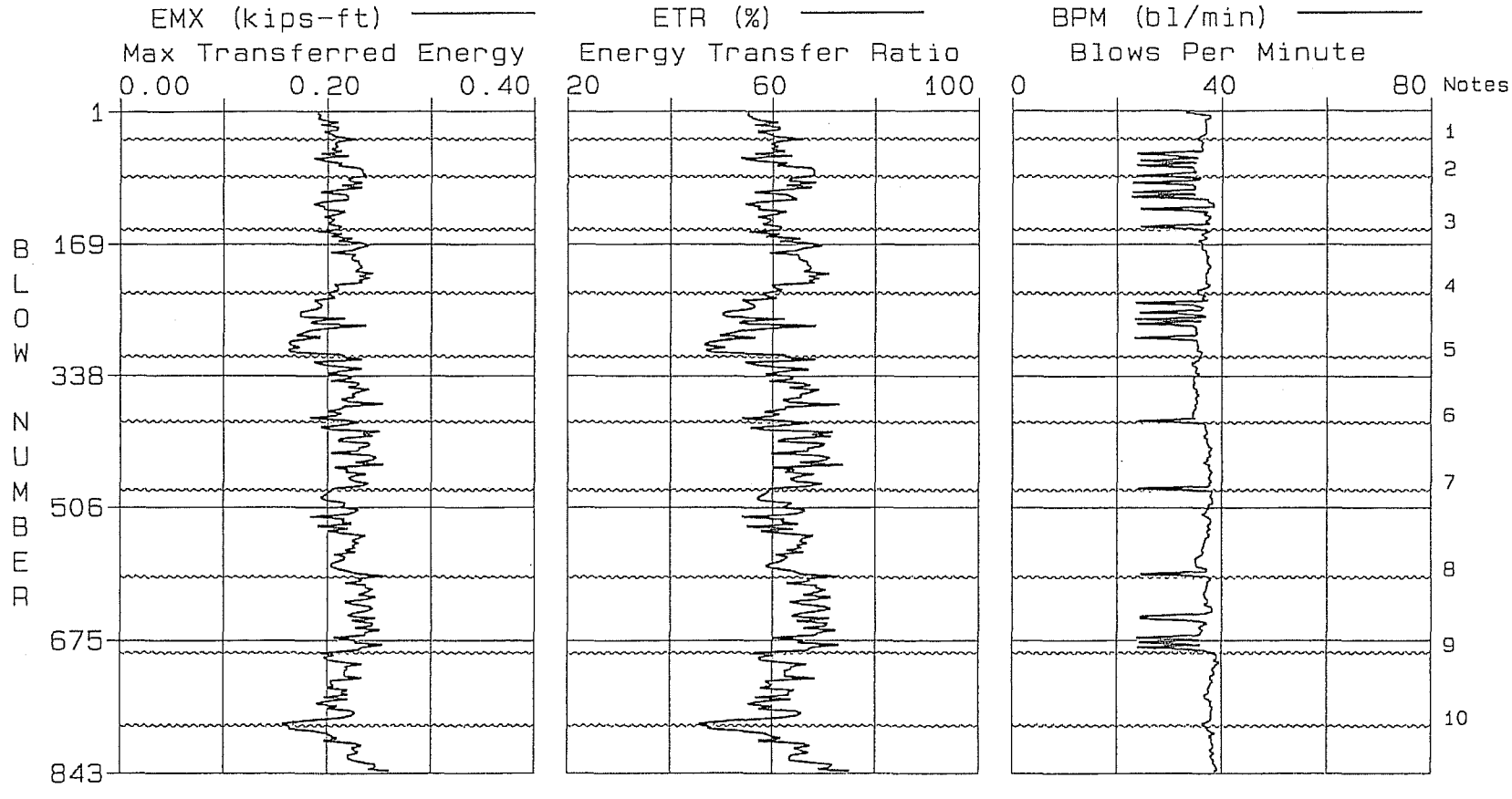
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009 Proj: ACTA HEIM BRIDGE PROJECT Pg1
Info: MUD ROTARY- rope and cathead SP: 0.492 k/ft^3
AR: 1.4 in^2 WS: 16808 ft/s
LE: 165.0 ft EM: 30000 KSI

EMX: Max Transferred Energy BPM: Blows Per Minute
ETR: Energy Transfer Ratio CSX: Max Measured C-Stress
E2F: UNDEFINED CSI: Max F1 or F2 C-Stress
EF2: Energy by F^2 Method TSX: Max Computed T-Stress
EV2: UNDEFINED

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX D. GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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EMI Project Number 06-123

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

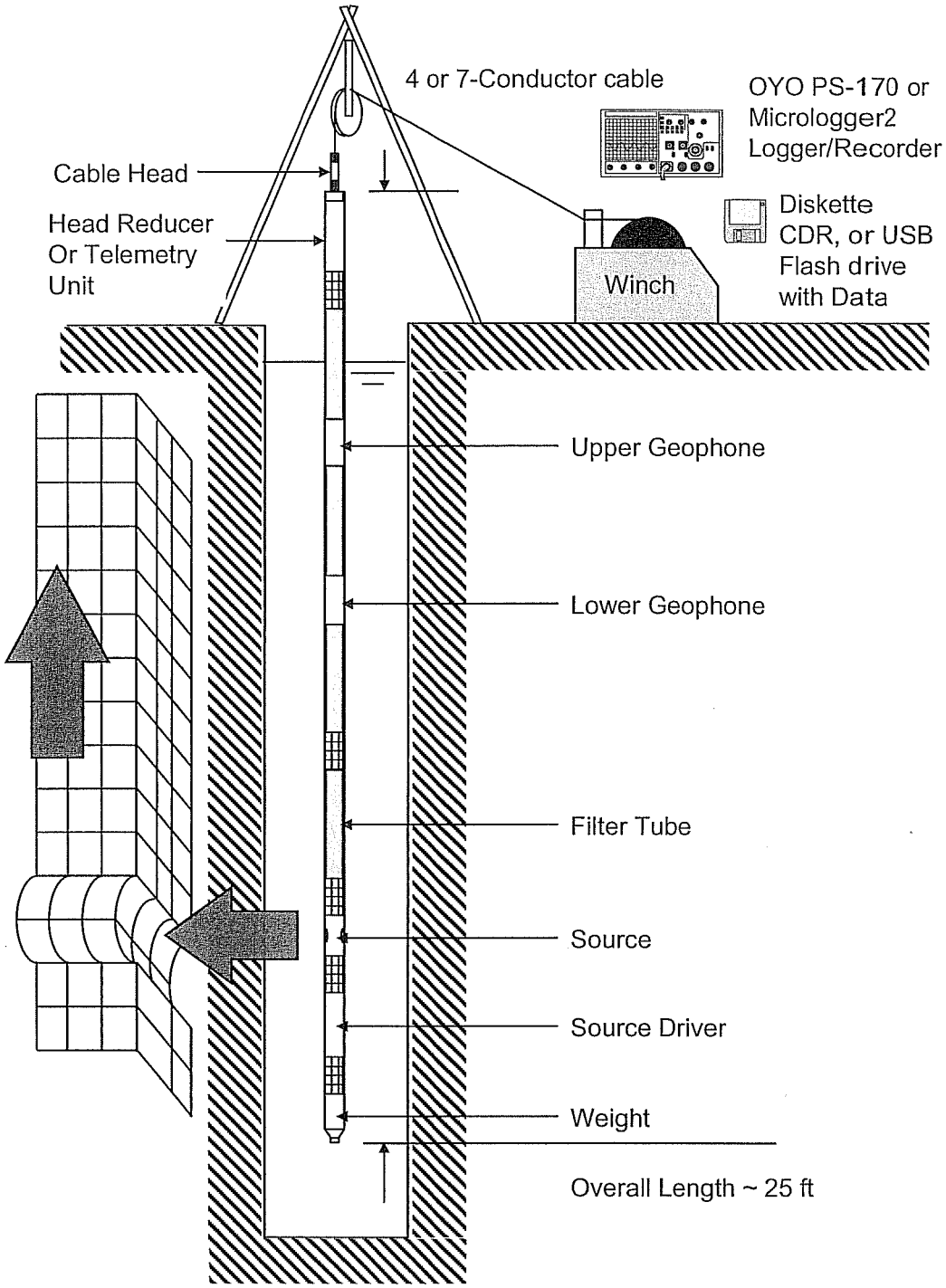

Figure 1: Concept illustration of P-S logging system

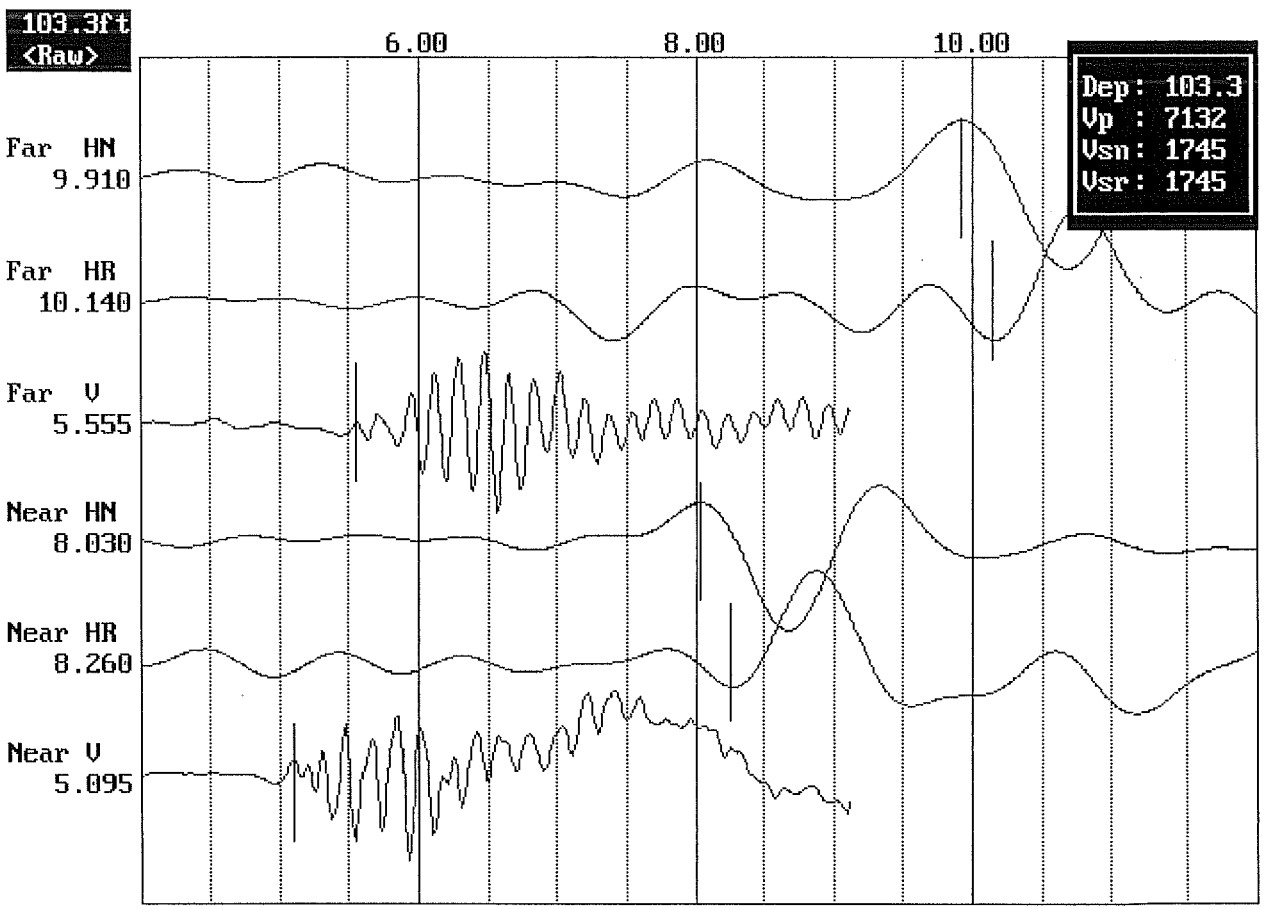

Figure 2: Example of filtered (1400 Hz lowpass) record

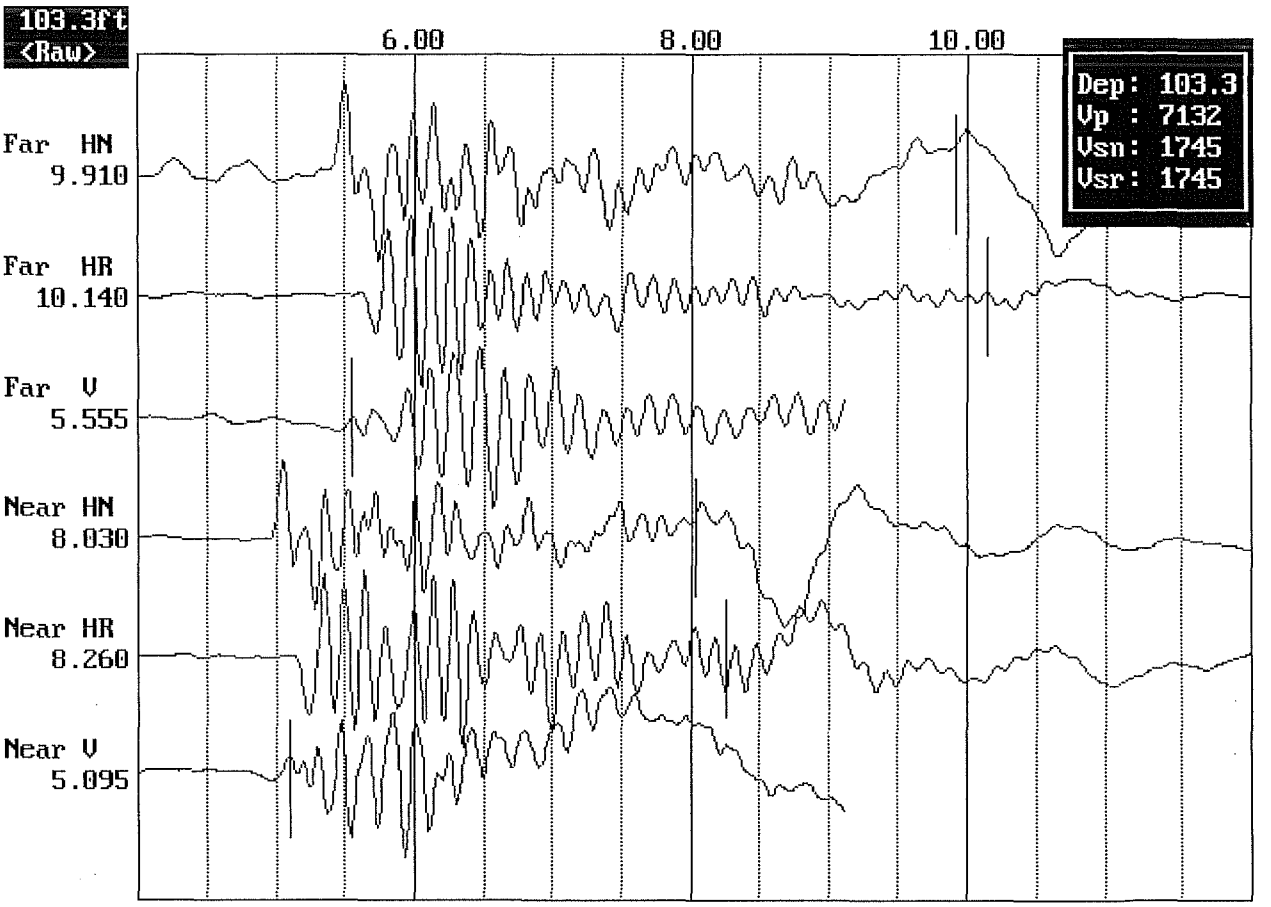

Figure 3. Example of unfiltered record

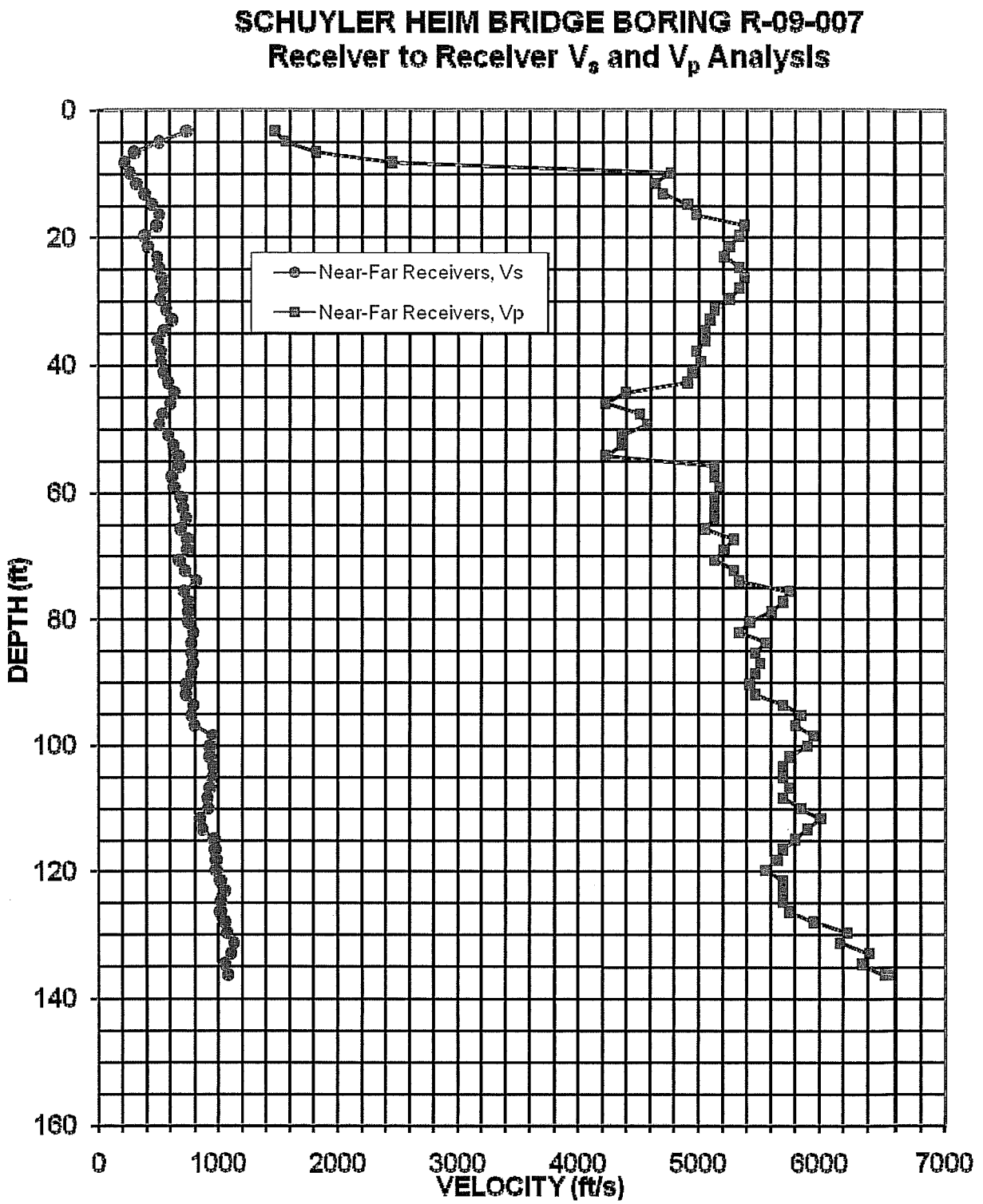

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

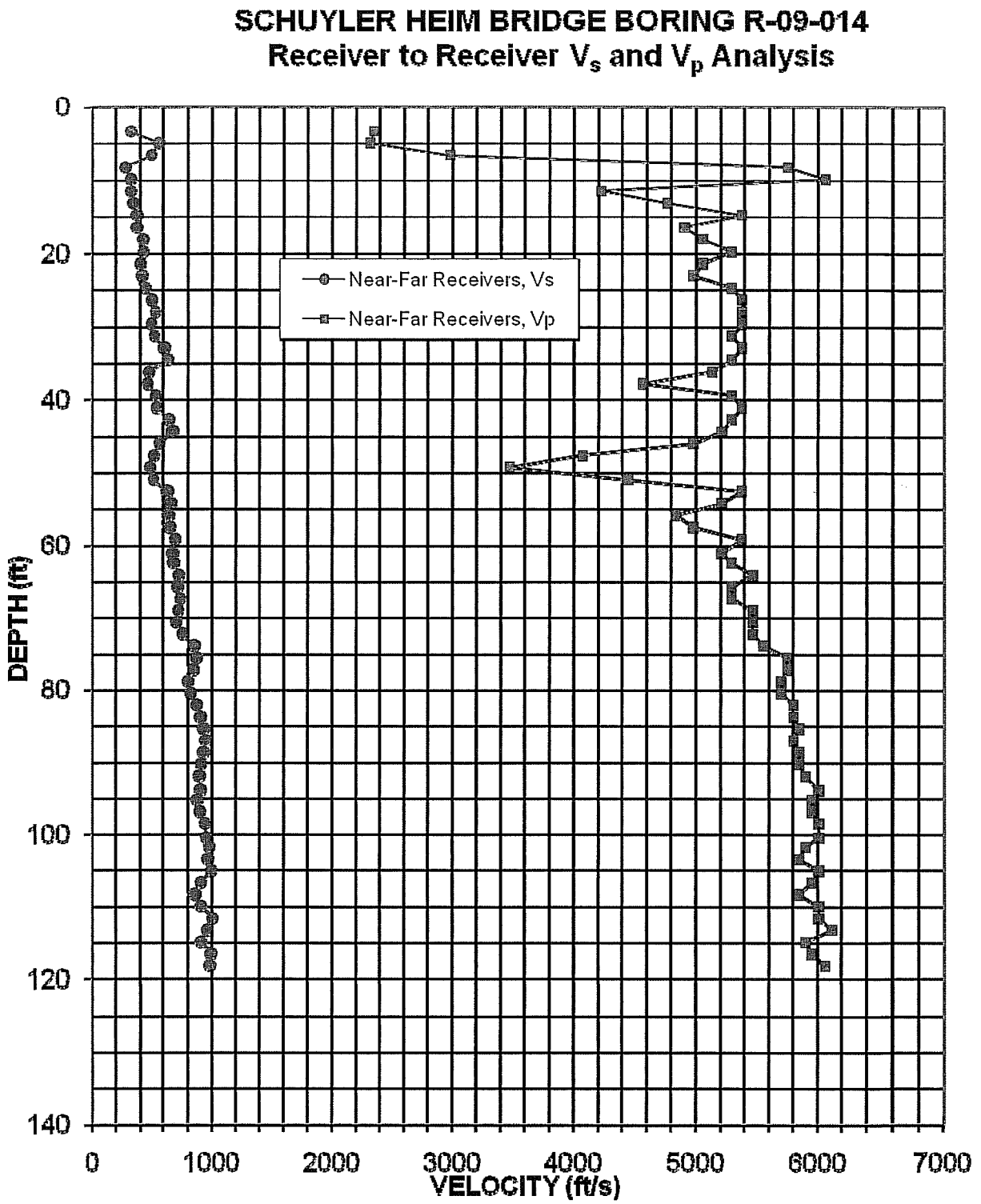

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

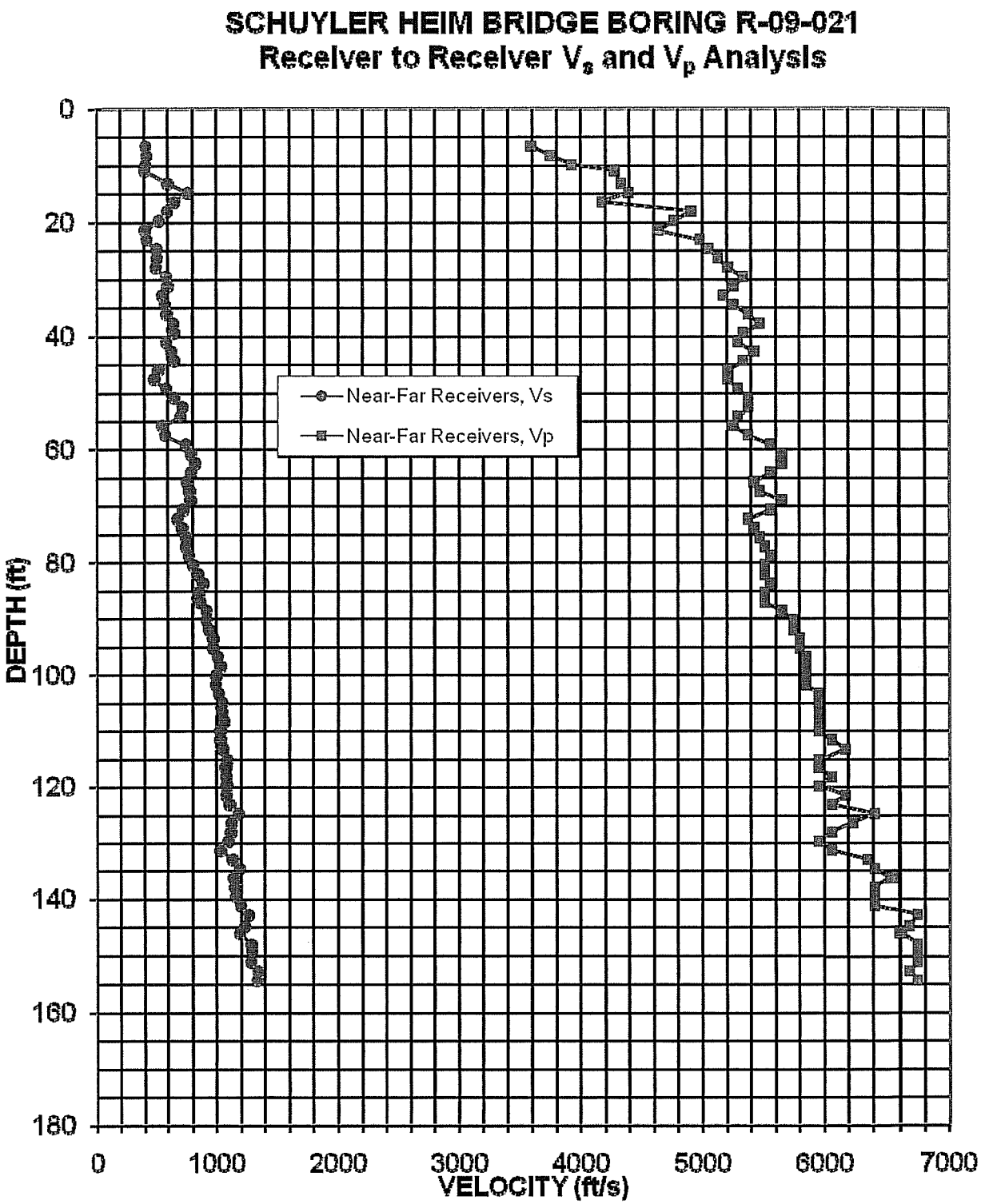

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

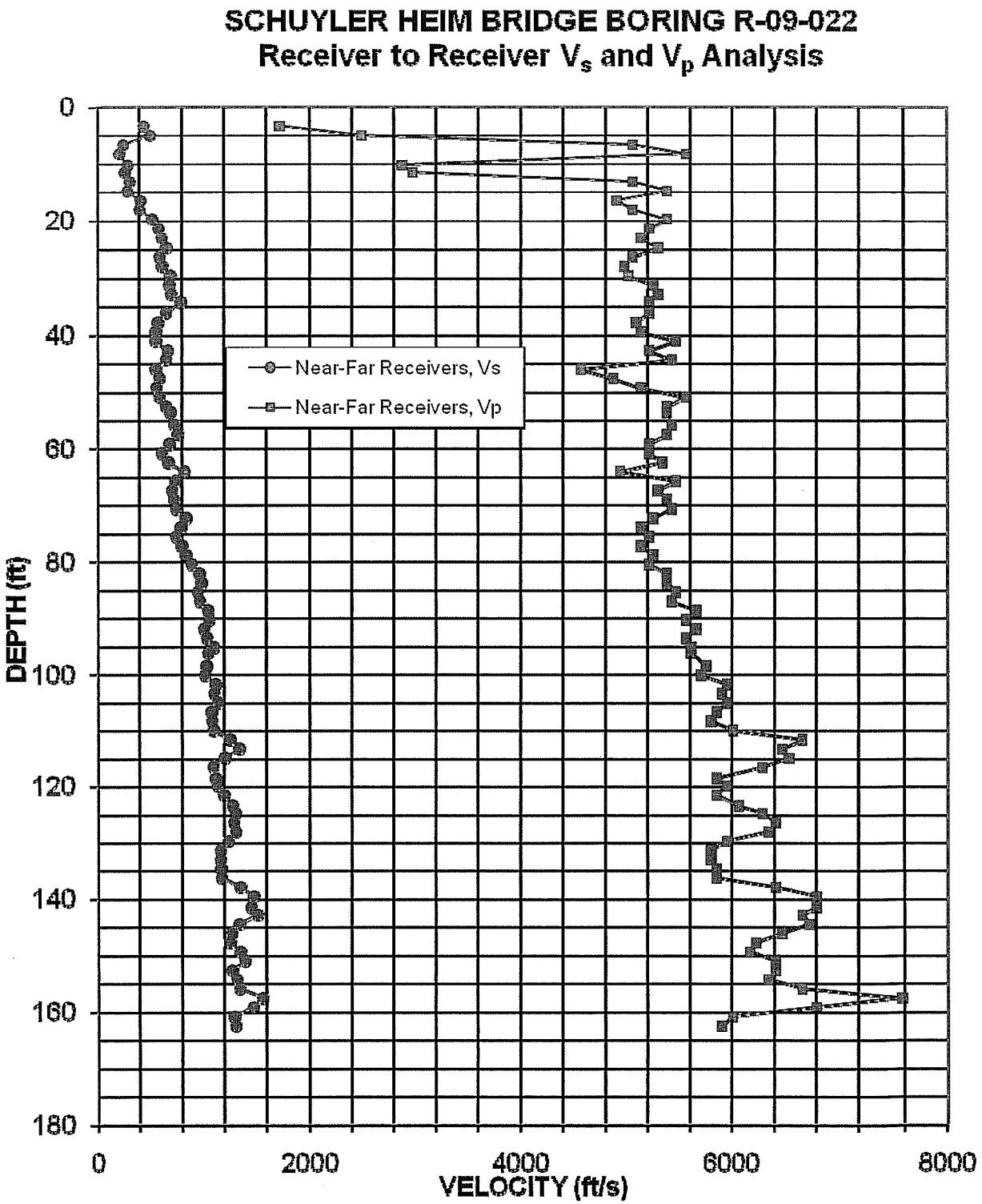

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

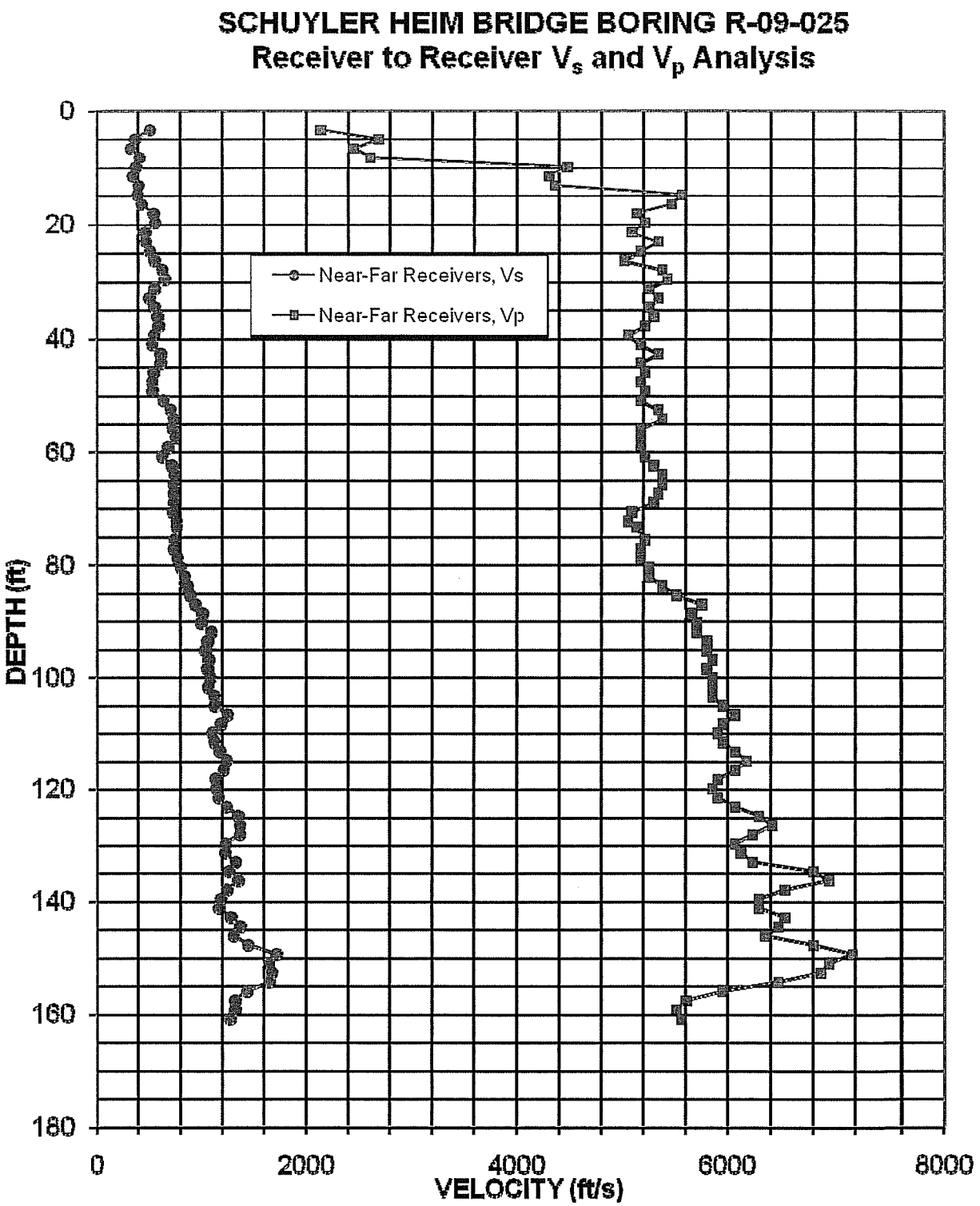

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

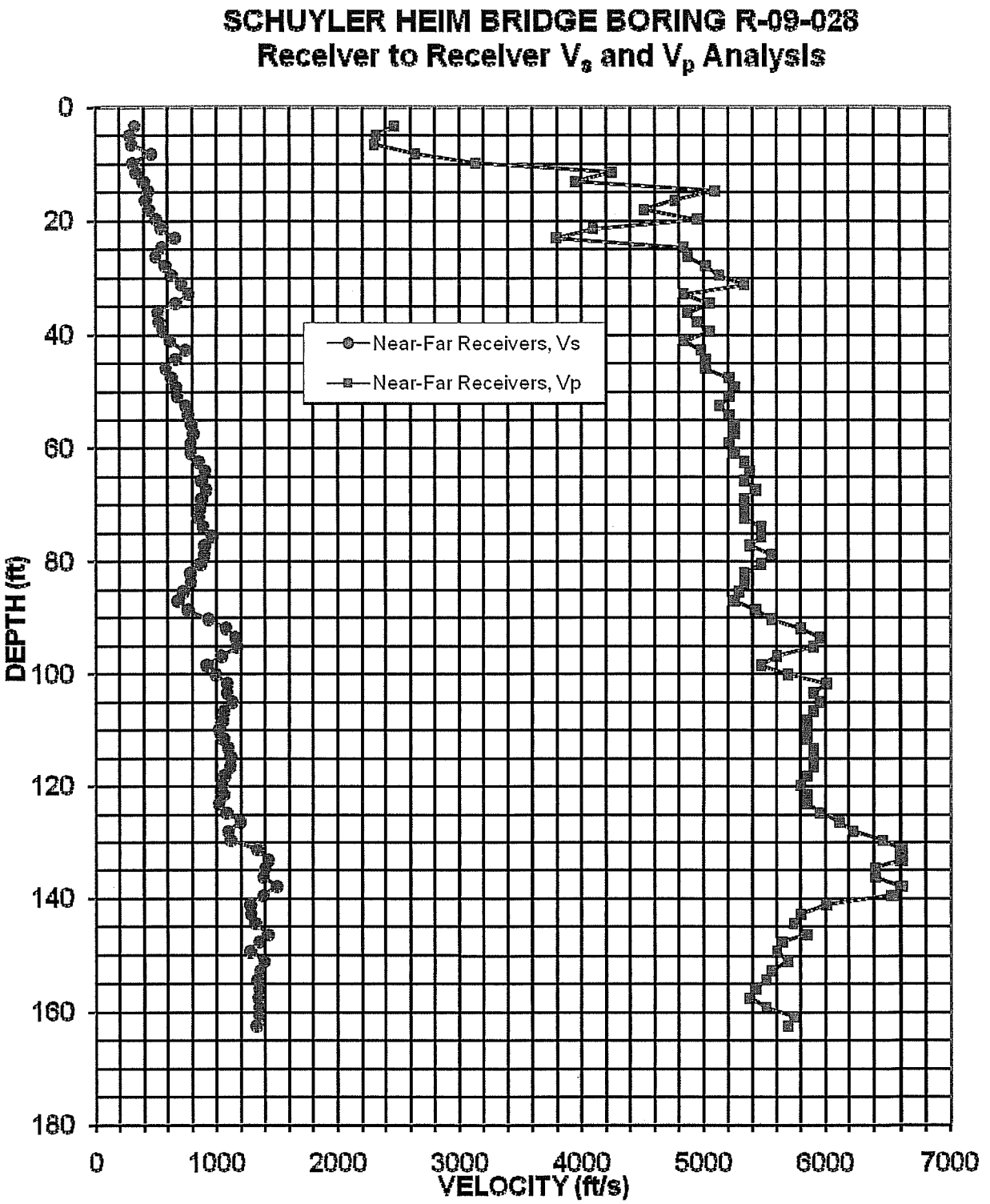

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

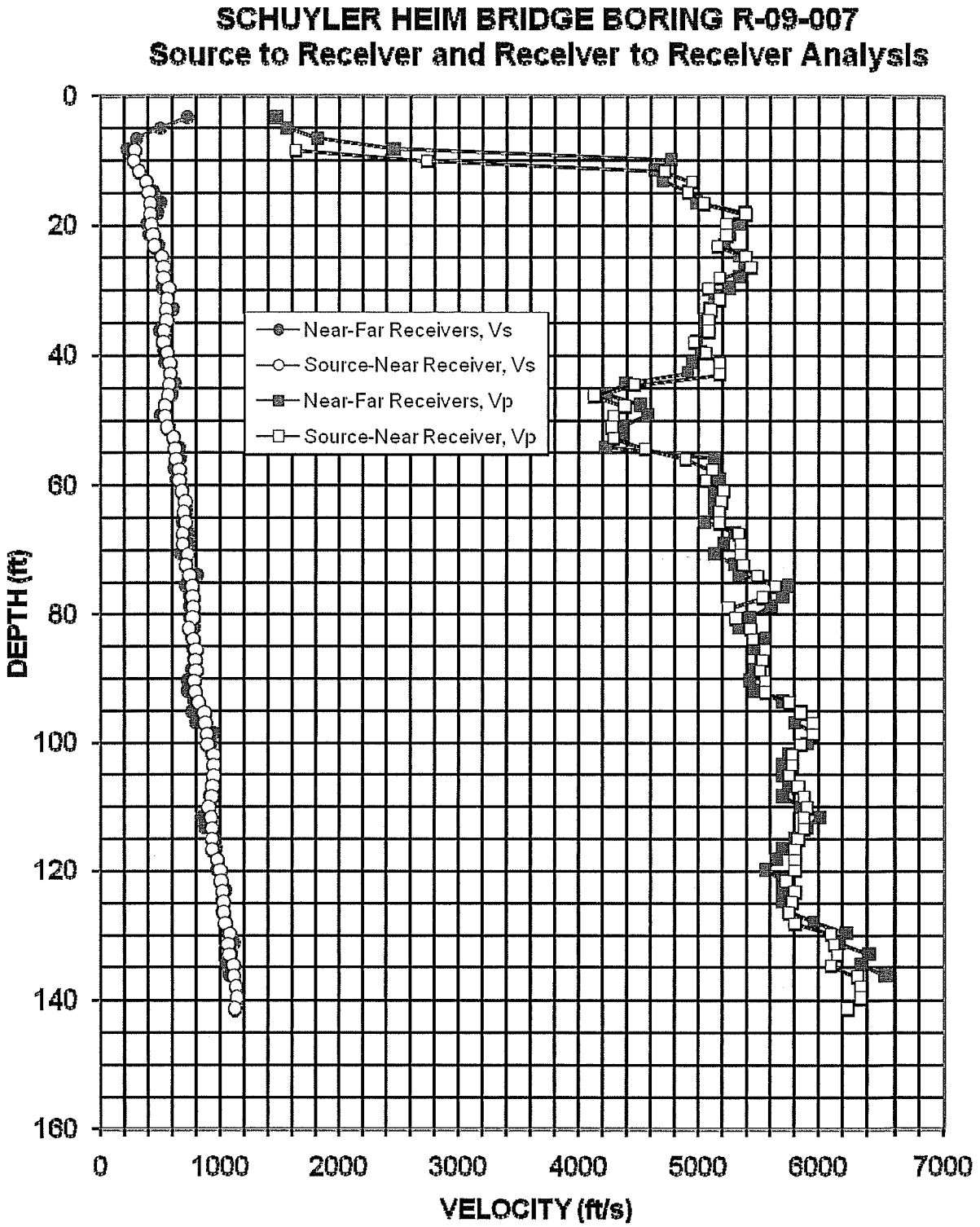

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

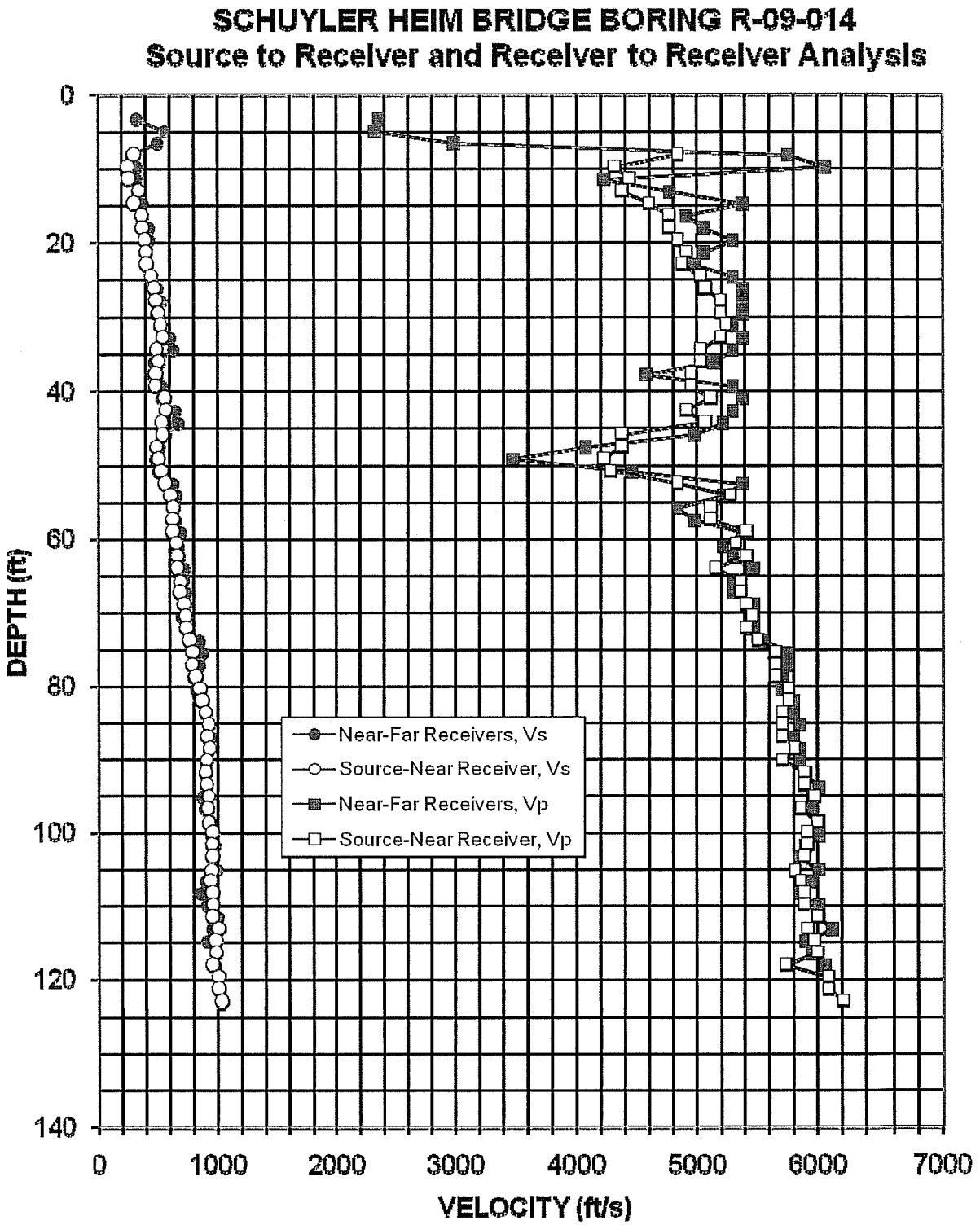

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

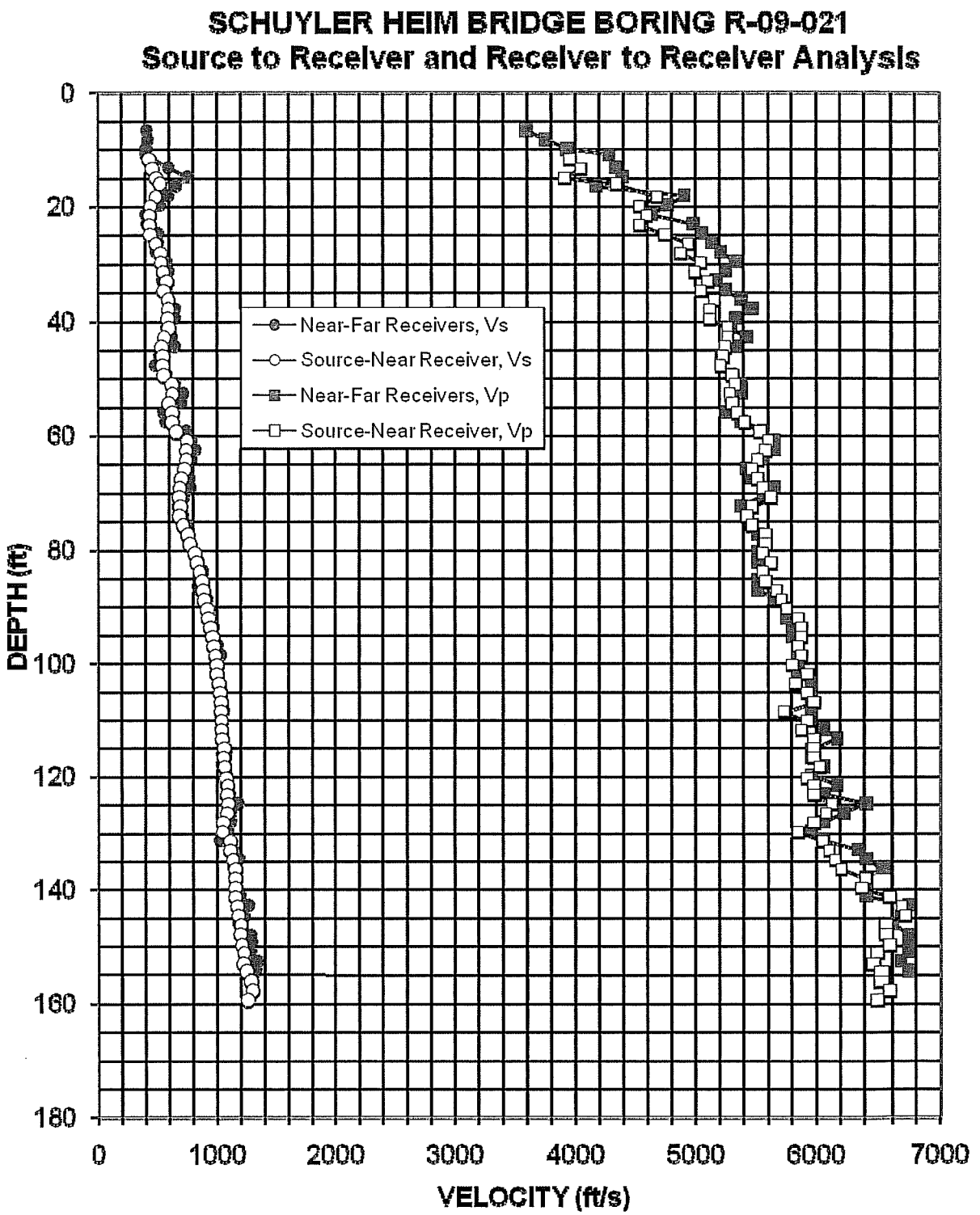

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

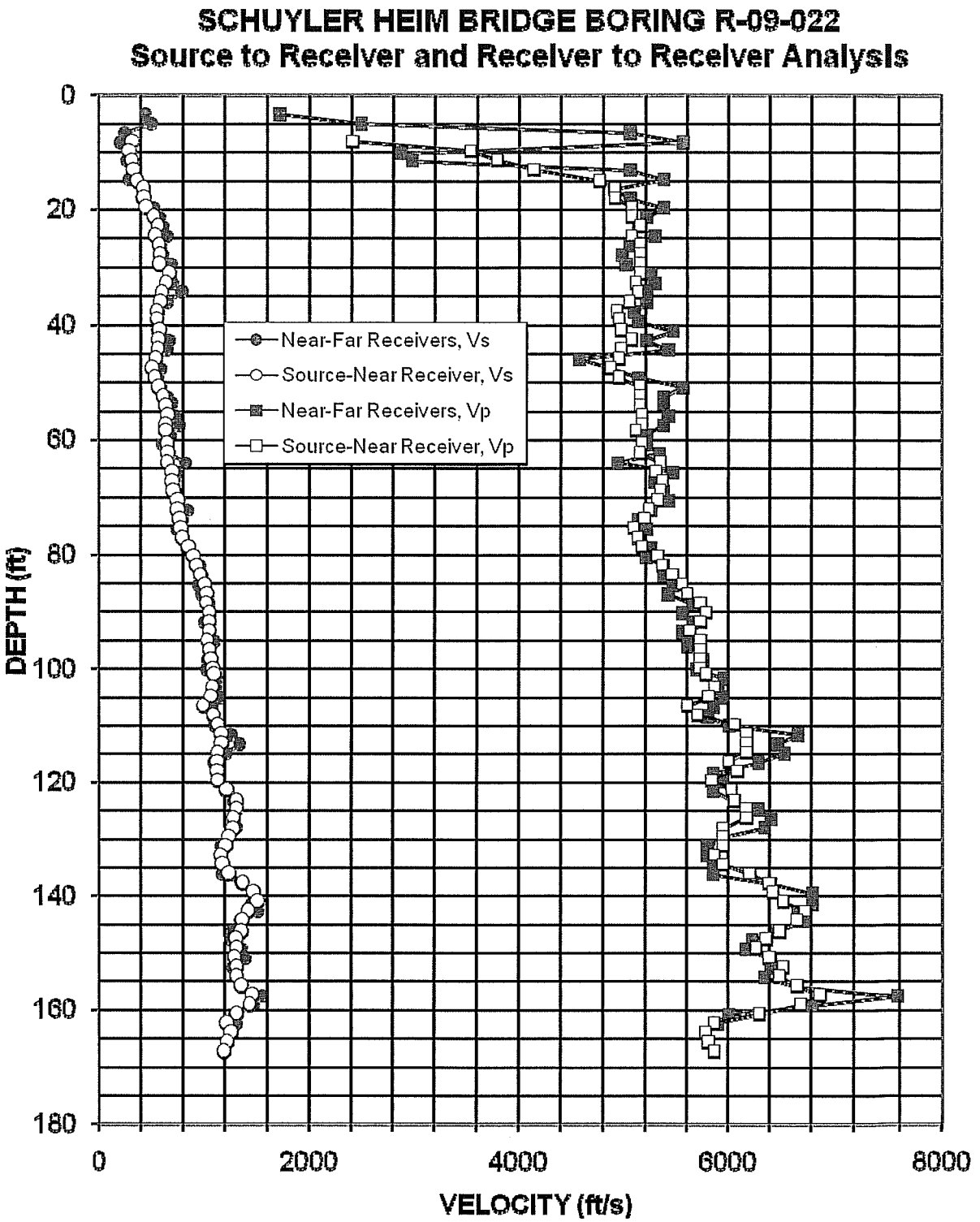

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

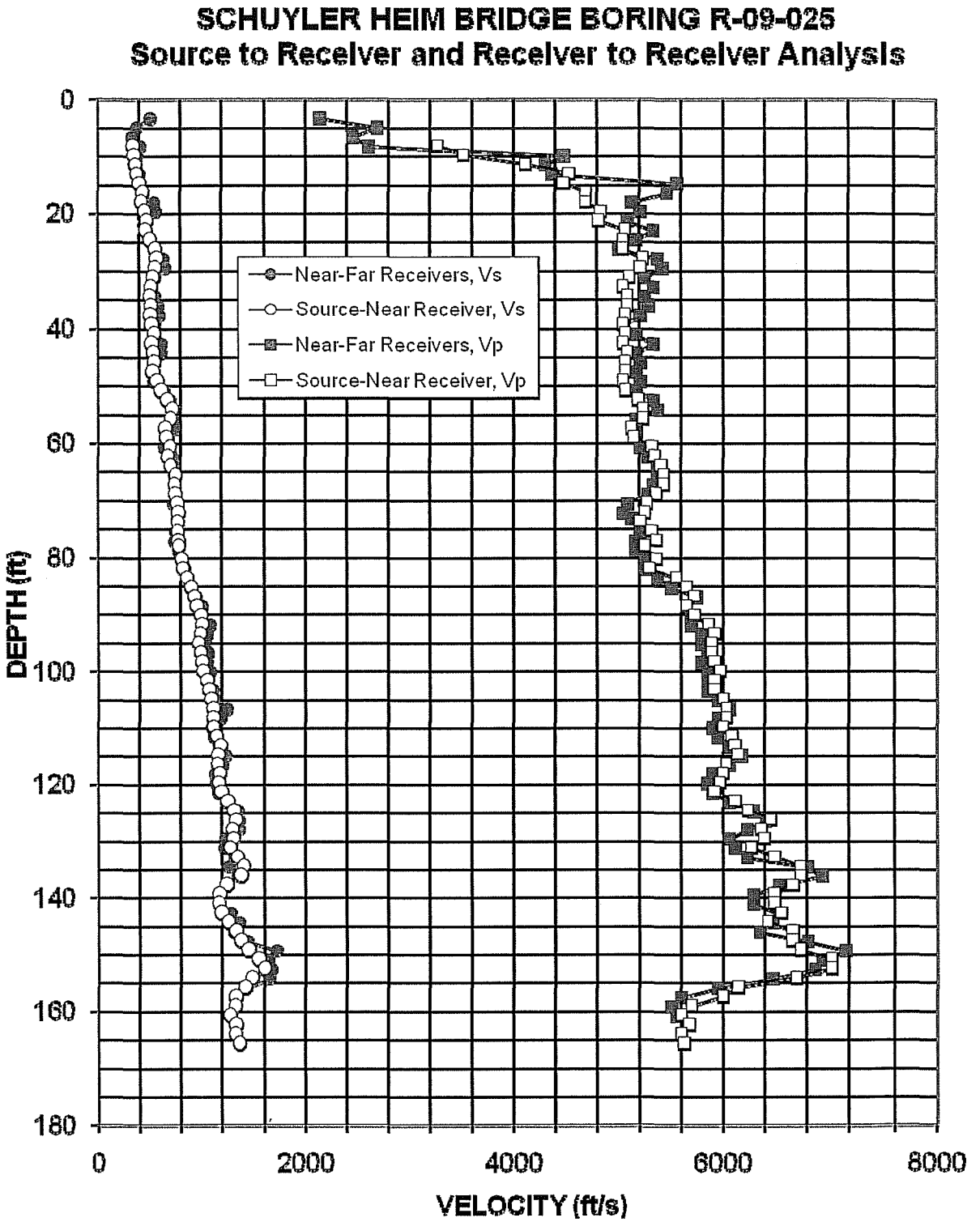

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

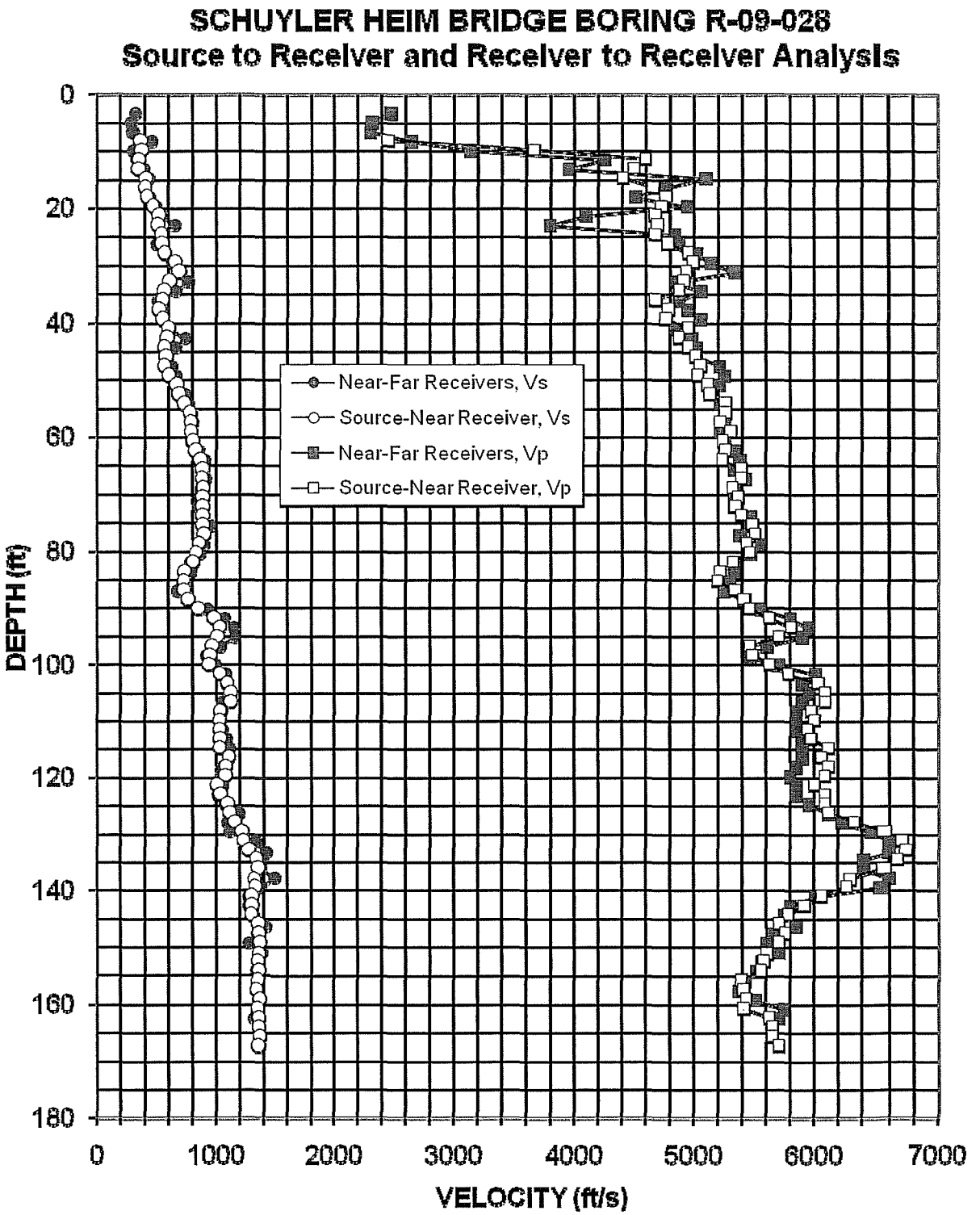

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CXB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Test No. 573794
Asset No. 160023

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573794
Asset No. 160023

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 ~~160024~~ 573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX E. LABORATORY SOIL TEST RESULTS

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-051	S-1	5	SM	11.3				1:75:24			2000	8.4	300	400
A-09-051	D-2	10	SM	24.1	127.8									
A-09-051	S-3	15	SM					0:82:18						
A-09-051	D-4	20	SM	22.6	127.5									
A-09-051	S-5	25	SP-SM					0:94:6						
A-09-051	D-6	30	ML	22.8	125.9					N.P				
A-09-051	D-7	35	ML							N.P				
A-09-051	D-8	40	ML	26.0	124.5					N.P				
A-09-051	S-9	45	ML	30.8				0:43:57		28/24/4				
A-09-051	D-10	50	ML	26.7	122.5									
A-09-052	S-1	5	SP-SM					1:94:5			1400	8.4	20	873
A-09-052	S-3	15	SP	21.6				0:99:1						
A-09-052	D-4	20	SP-SM	22.7	125.4									
A-09-052	S-5	25	SM	27.8										
A-09-052	D-6	30	CL					0:38:62		41/24/17				
A-09-052	S-7	35	ML	33.5						49/30/19				
A-09-052	S-9	45	ML	31.0				0:45:55		26/26/0				
A-09-052	D-10	50	SM			<0.25		0:70:30						
A-09-053	S-1	5	SM					20:49:31			430	7.8	730	1809
A-09-053	D-2	10	SP-SM	27.4	124.5									
A-09-053	S-3	15	SP	24.5				0:97:3						
A-09-053	D-4	20	SM	19.5	127.8									
A-09-053	S-5	25	SP-SM	26.2				0:95:5						
A-09-053	S-7	35	ML	32.7				0:13:87		42/27/15				
A-09-053	S-9	45	ML	29.9				0:7:93		46/29/17				
A-09-054	S-1	5	ML					0:45:55			780	7.9	420	817
A-09-054	S-3	15	SP	27.3				0:98:2						
A-09-054	S-5	25	SP	22.0				0:98:2						
A-09-054	S-7	35	ML	30.7				0:30:70		28/24/4				
A-09-054	D-8	40	ML			1.25								
A-09-054	S-9	45	ML	42.8						N.P.				
A-09-054	D-10	50	ML					0:10:90		41/26/15				

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 1

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3

Boring No. : A-09-051

Sample No. : D-8

Depth (ft / m) : 40.0 | 12.20

File No. :

Soil Description : Dark gray, SANDY SILT (ML)

Set up By : J.F Date : 11/13/2009

Tested By : J.F/R.J. Date : 11/13/09-11/23/09

Time Rate Took By : J.F Date : 11/16/09,11/18/09

Computer By : JF Date : 11/24/2009

Checked By : R.J. Date :

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9537	24.22	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

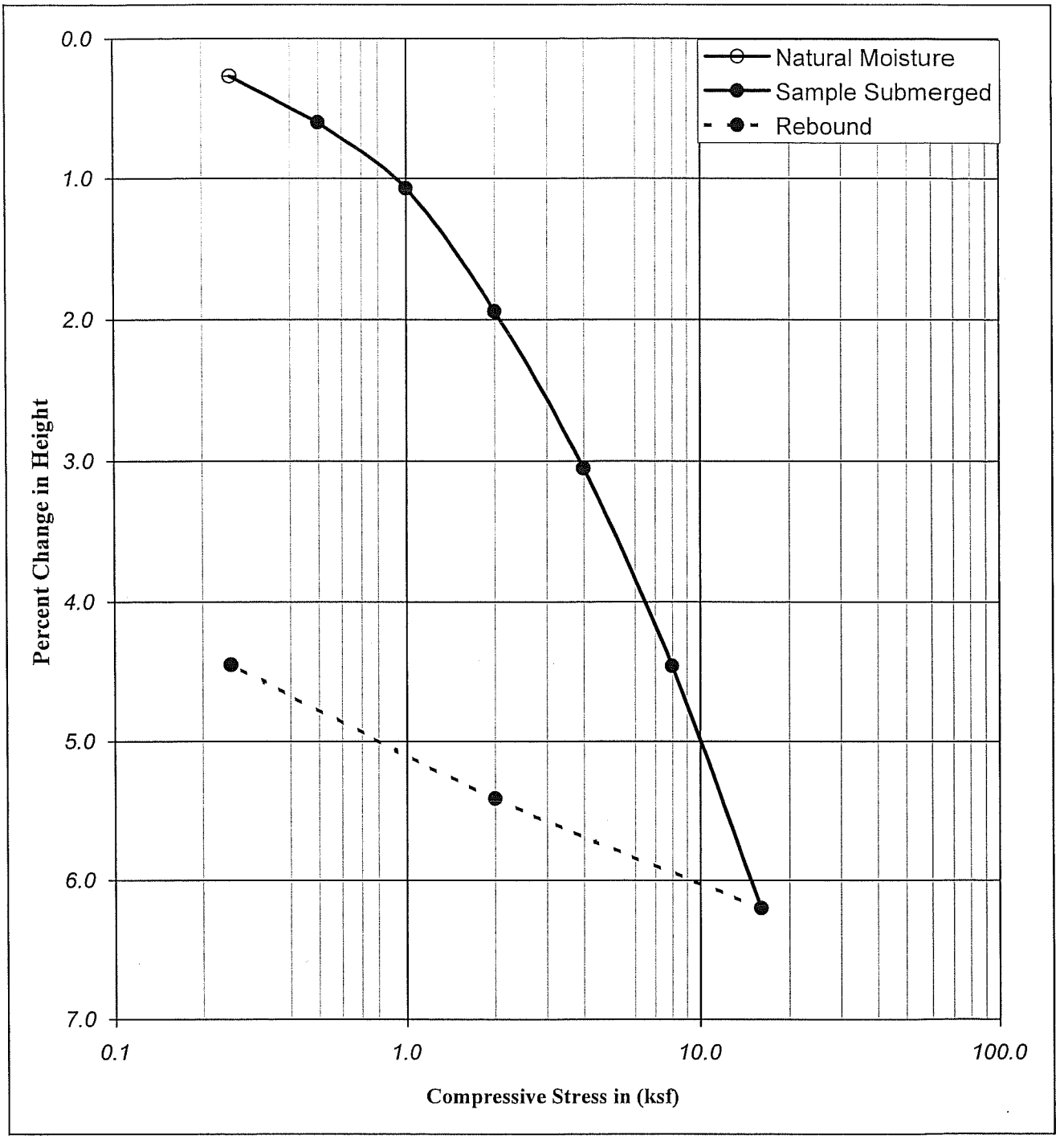
	Before	After
Weight of wet soil + ring (gm)	199.15	
Weight of ring (gm)	42.95	
Weight of wet soil + ring + container (gm)		255.03
Weight of dry soil + ring + container (gm)		226.83
No. 83 Weight of container (gm)		58.80
Weight of ring + container (gm)		101.75
Moisture Content (%)	24.88	22.55
Dial Reading (inch)	0.05	0.04
Sample Volume (ft^3)	0.0027	0.0025
Wet Density (pcf)	129.4	133.1
Dry Density (pcf)	103.59	108.62

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
11/13/2009	14:42	0:00:00	Seating		0.04820	1.22		
			Load					
	14:55		0.1	4.8	0.05000	1.27	0.00	
11/14/2009	9:10	0:00:00	0.25	12.0	0.05270	1.34	0.27	
11/15/2009	9:42	0:00:00	0.50	23.9	0.05600	1.42	0.60	
			Add Water					
11/16/2009	8:35	0:00:00	0.50	23.9	0.05600	1.42	0.60	
11/16/2009	8:38	0:00:00	1.00	47.9	0.05600	1.42	0.60	0.00
		0.10	1.0	47.9	0.05750	1.46	0.75	0.32
		0.25	1.0	47.9	0.0577	1.47	0.77	0.50
		0.50	1.0	47.9	0.05800	1.47	0.80	0.71
		1	1.0	47.9	0.05820	1.48	0.82	1.00
		2	1.0	47.9	0.05840	1.48	0.84	1.41
		4	1.0	47.9	0.05860	1.49	0.86	2.00
		8	1.0	47.9	0.05880	1.49	0.88	2.83
		15	1.0	47.9	0.05890	1.50	0.89	3.87
		30	1.0	47.9	0.05900	1.50	0.90	5.48
		60	1.0	47.9	0.05930	1.51	0.93	7.75
		120	1.0	47.9	0.05950	1.51	0.95	10.95
		240	1.0	47.9	0.05990	1.52	0.99	15.49
		480	1.0	47.9	0.06040	1.53	1.04	21.91
11/17/2009		1440	1.0	47.9	0.06070	1.54	1.07	37.95
11/18/2009	8:34	0	2.0	95.8	0.06940	1.76	1.94	
11/18/2009	8:42	0	4.0	191.5	0.0694	1.76	1.94	
		0.10	4.0	191.5	0.0752	1.91	2.52	
		0.25	4.0	191.5	0.0757	1.92	2.57	
		0.50	4.0	191.5	0.0764	1.94	2.64	
		1	4.0	191.5	0.0767	1.95	2.67	
		2	4.0	191.5	0.0771	1.96	2.71	
		4	4.0	191.5	0.0774	1.97	2.74	
		8	4.0	191.5	0.0777	1.97	2.77	
		15	4.0	191.5	0.0779	1.98	2.79	
		30	4.0	191.5	0.0783	1.99	2.83	
		60	4.0	191.5	0.0787	2.00	2.87	
		120	4.0	191.5	0.0792	2.01	2.92	
		240	4.0	191.5	0.0796	2.02	2.96	
		480	4.0	191.5	0.0802	2.04	3.02	
11/19/09		1440	4.0	191.5	0.0805	2.04	3.05	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.0946	2.40	4.46
11/21/2009	8:36		16.00	766.1	0.1120	2.84	6.20
11/22/2009	8:42		2.00	95.8	0.1041	2.64	5.41
11/23/2009	8:40		0.25	12.0	0.0945	2.40	4.45

Remark :

Final Dial Reading 0.0945



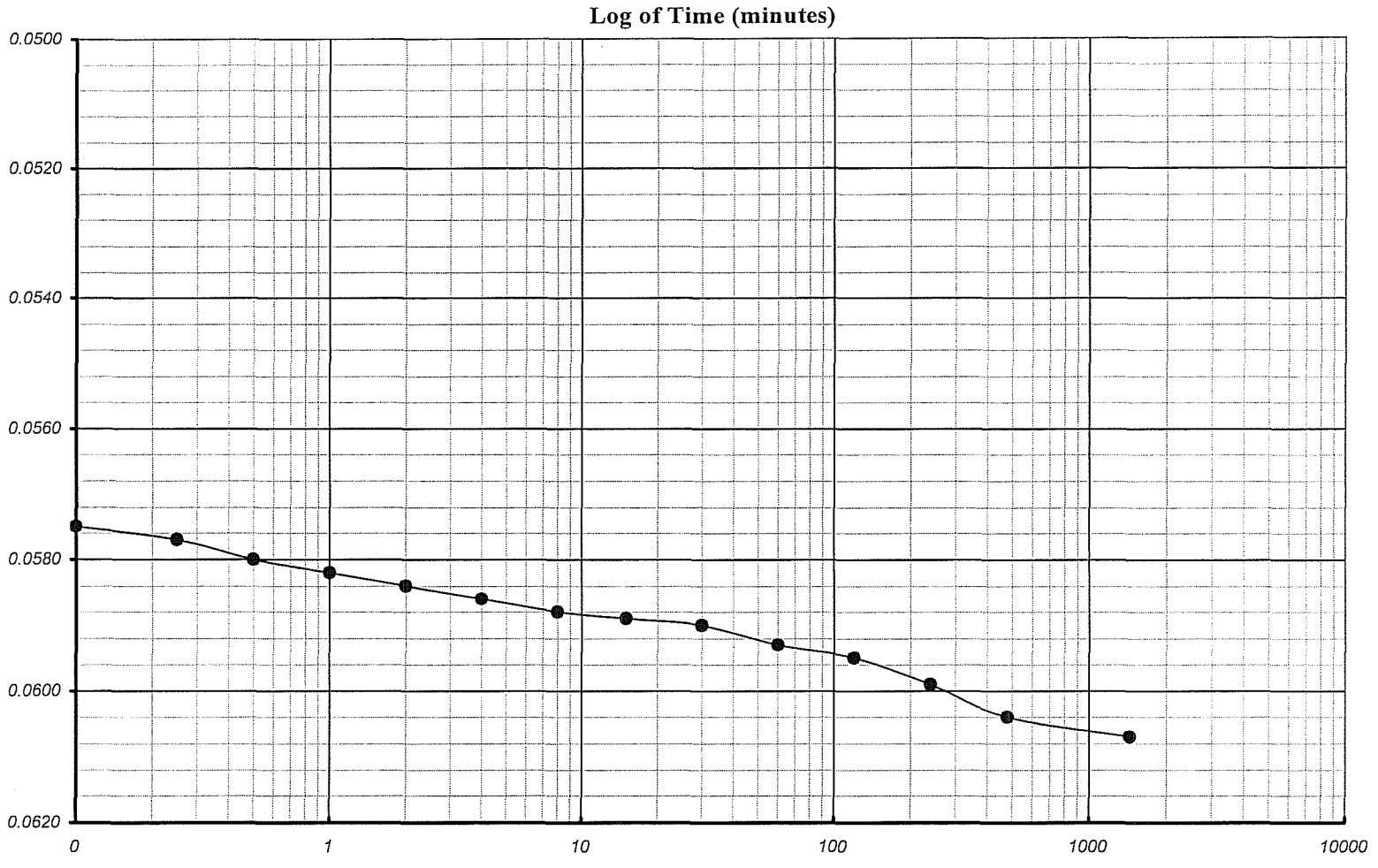
Boring No.	: A-09-051		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	24.88	103.59	16.31	107.12	0.63
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	22.55	108.62	17.10	110.32	0.55
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

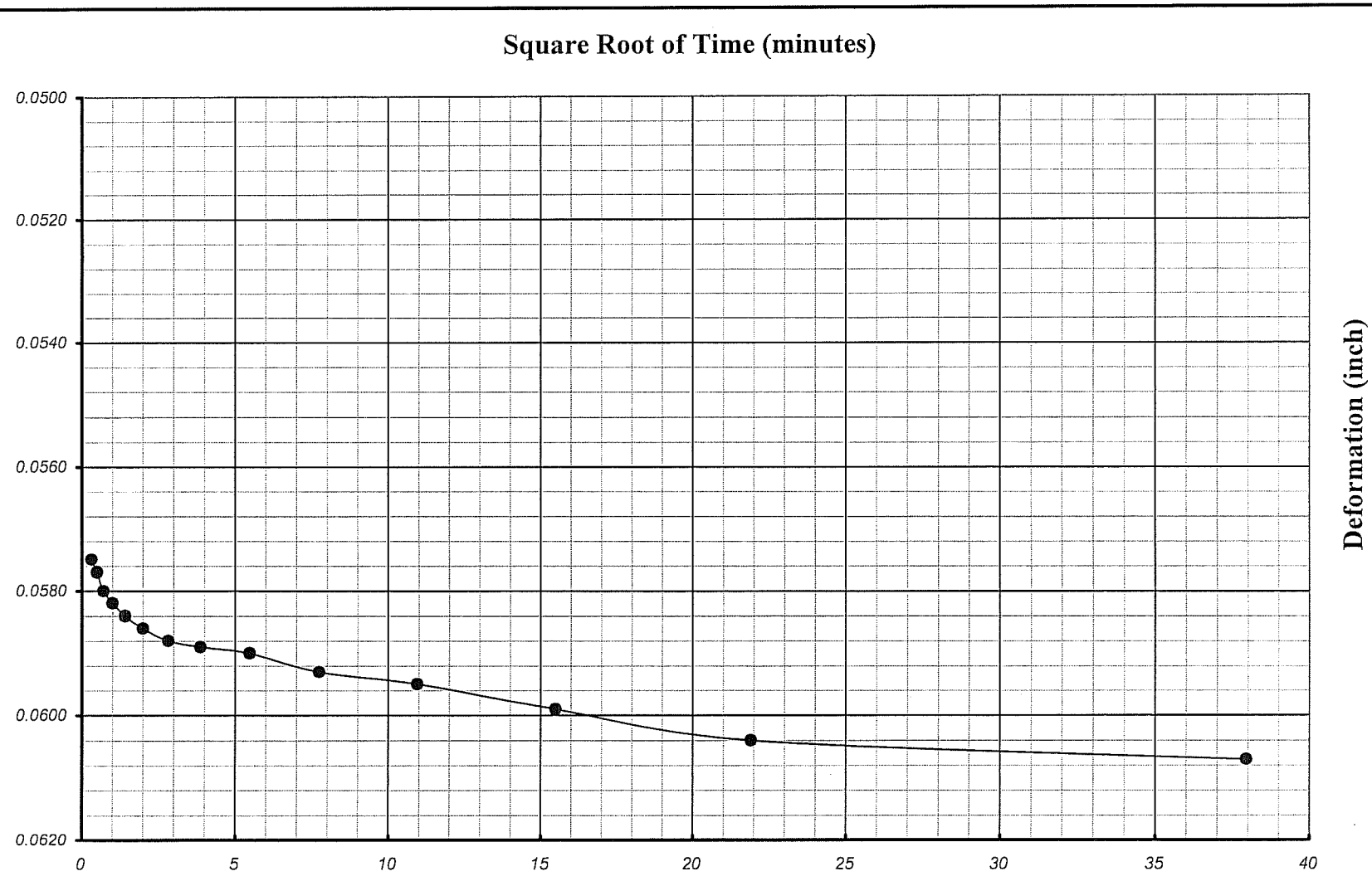
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

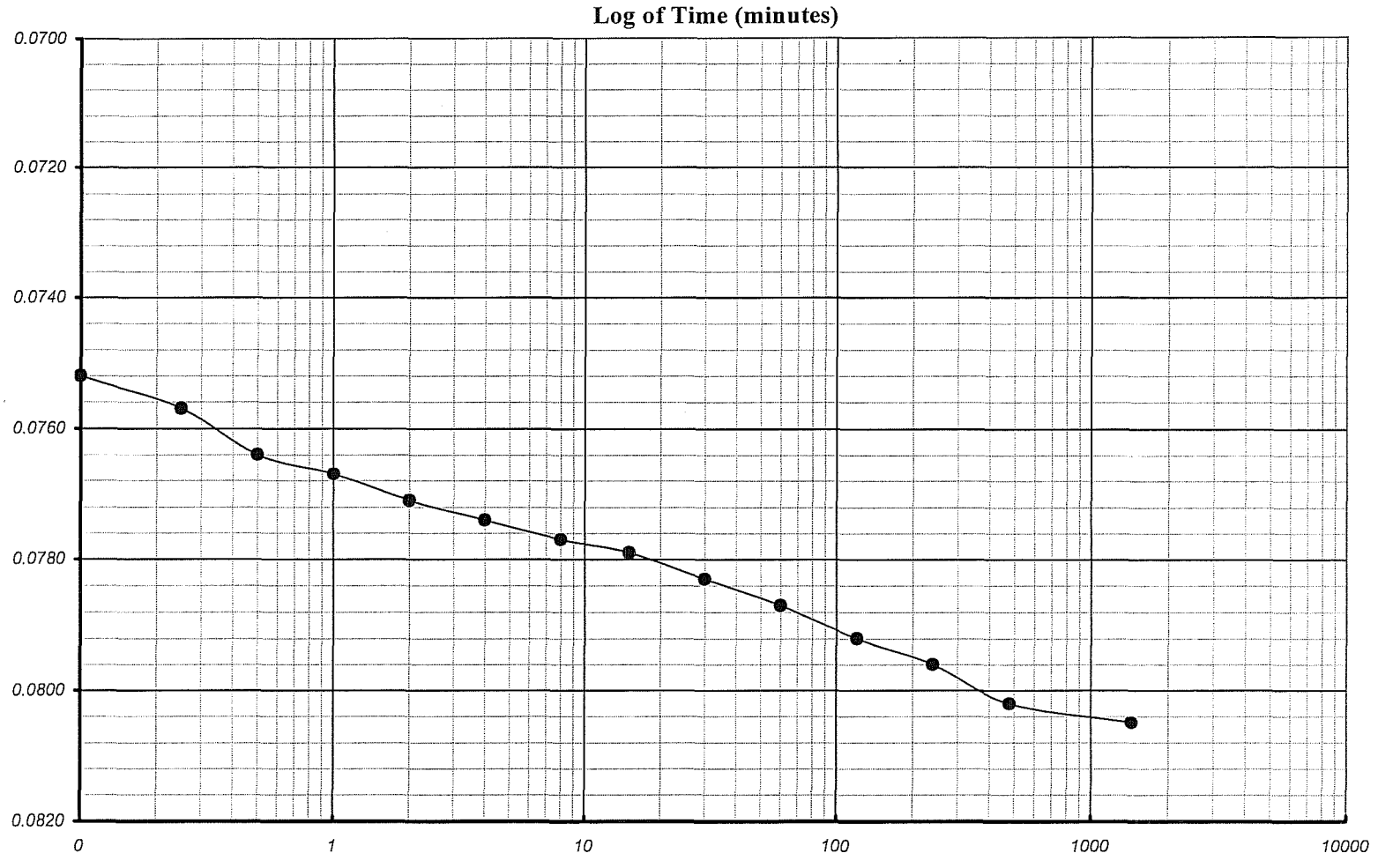
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



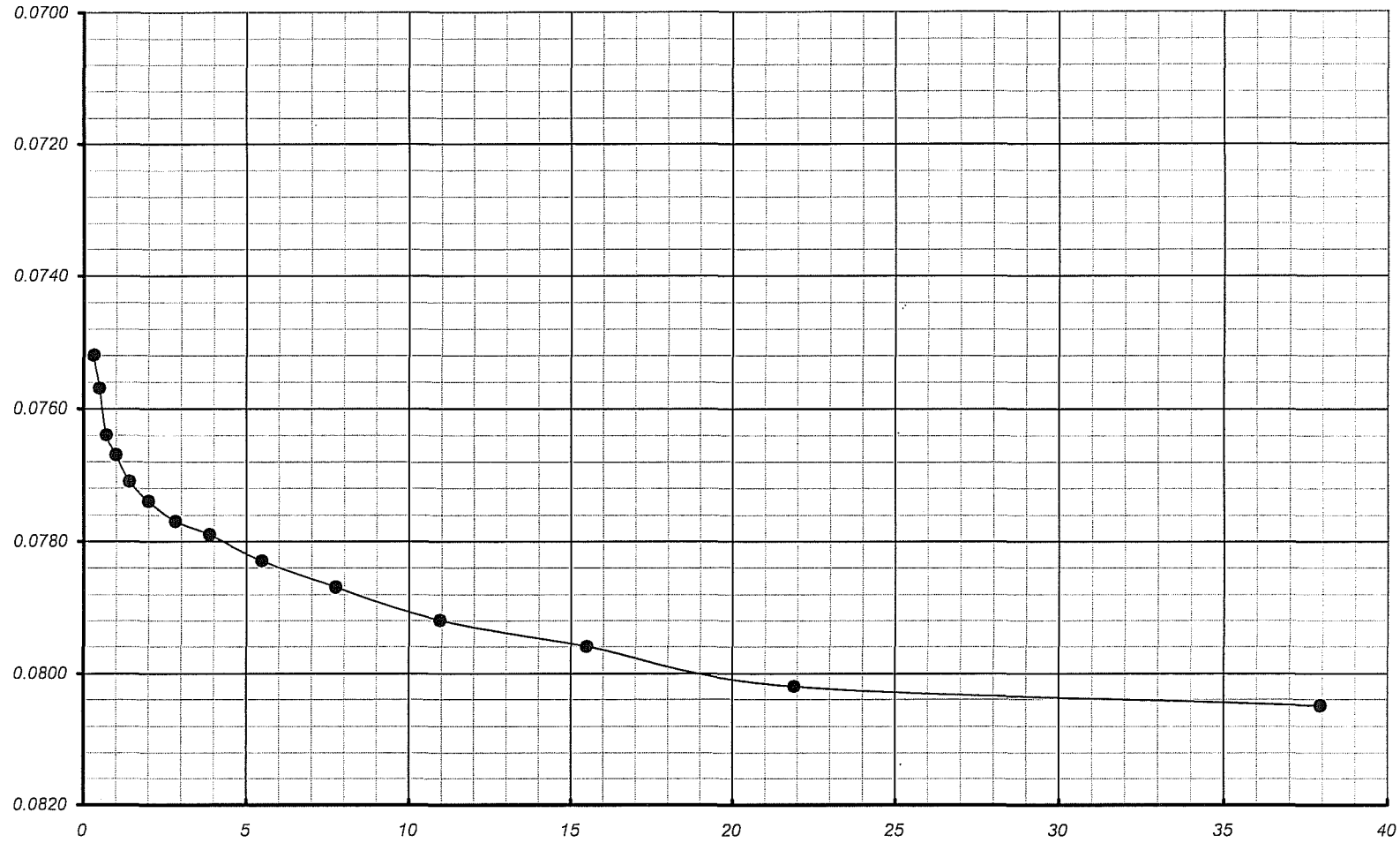
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-051	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 1.00 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-051*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-051*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-051*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

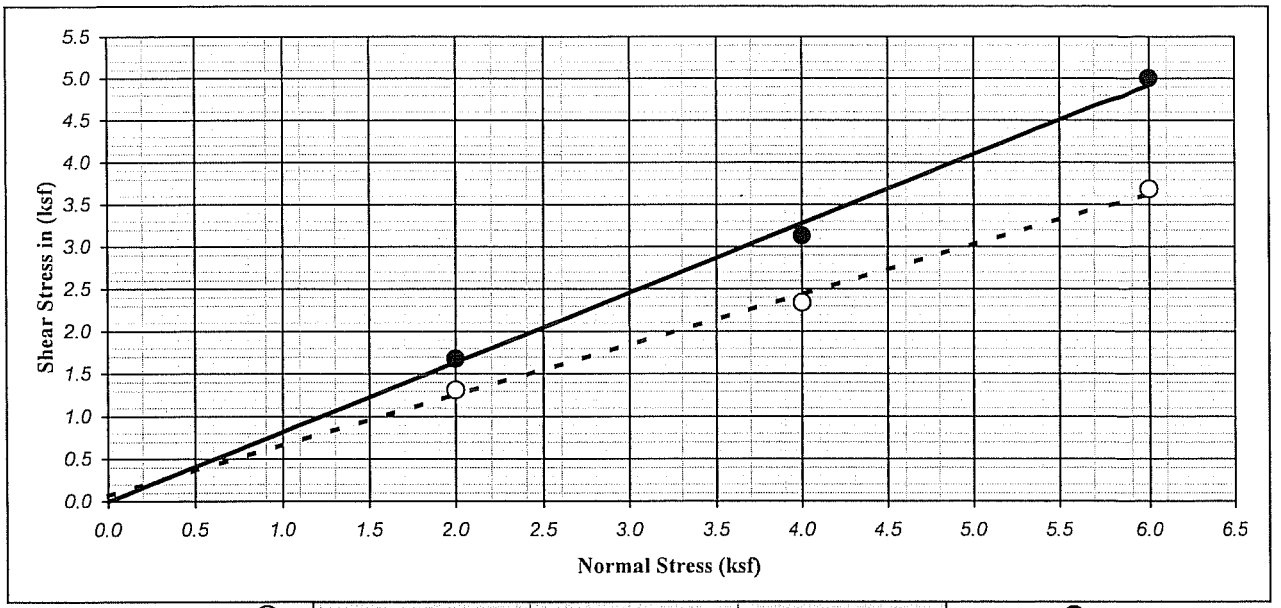
Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-051		**Saturated**		**Field Moisture**	X	**Inundated**		**Specific Gravity** (Assumed) :	2.70
Sample No. : D-6	X	**Undisturbed**		**Remolded**		**Consolidated-Drained**		**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 30.0	x	**Shear Once**		**Reshear**		**Residual**		**Data File Number :**	0612301
Description : Dark olive-gray, Poorly graded SAND with SILT (SP-SM)									

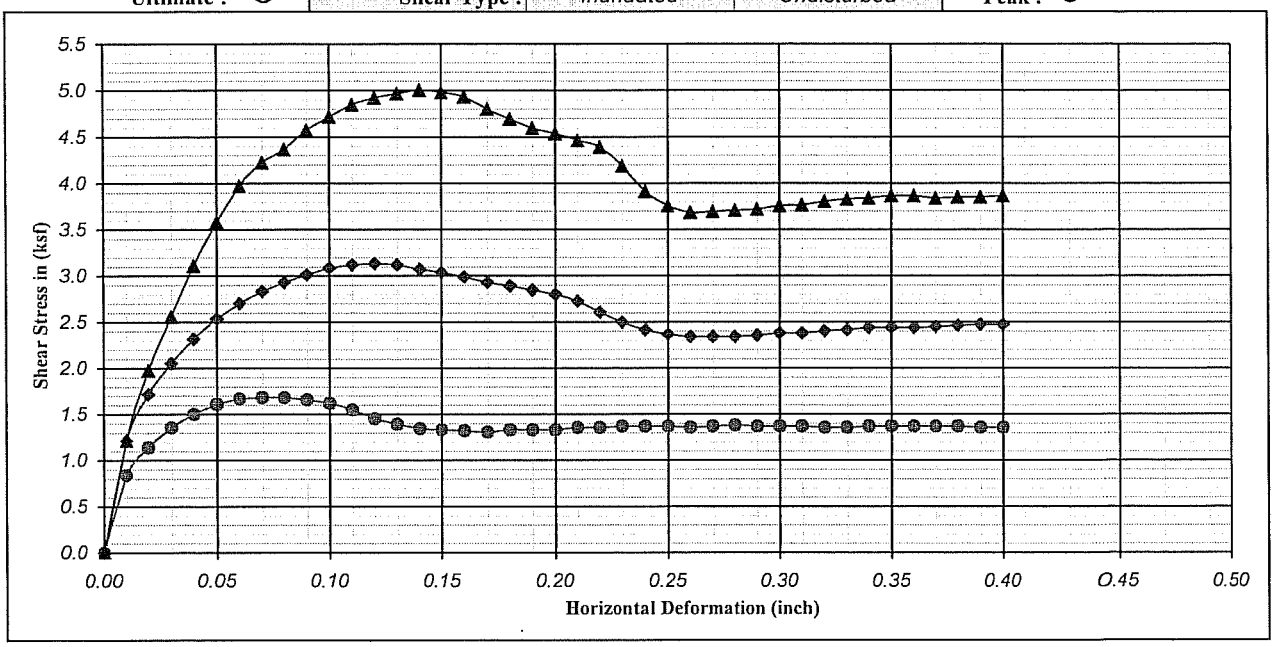
Percent Saturation (%)	99.22	**File No. :** 0612301	1																	
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09																			
Computed By : JF	**Date :** 12/11/09	**2.00**	(ksf)																	
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		195.32																		
Weight of Ring (gm)		45.25																		
Weight of Wet Soil + Cont. (gm)			151.92																	
Weight of Dry Soil + Cont. (gm)			121.28																	
Weight of Cont. (gm) **No.**	1		3.84																	
Moisture Content (%)			26.09																	
Wet Density (pcf / kN/m^3)	124.29	19.56																		
Dry Density (pcf / kN/m^3)	98.57	15.52																		
Percent Saturation (%)	98.30	**File No. :** 0612301	2																	
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	**4.00**	(ksf)																	
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		193.80																		
Weight of Ring (gm)		44.24																		
Weight of Wet Soil + Cont. (gm)			151.83																	
Weight of Dry Soil + Cont. (gm)			121.25																	
Weight of Cont. (gm) **No.**	2		3.78																	
Moisture Content (%)			26.03																	
Wet Density (pcf / kN/m^3)	123.87	19.50																		
Dry Density (pcf / kN/m^3)	98.28	15.47																		
Percent Saturation (%)	103.78	**File No. :** 0612301	3																	
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	**6.00**	(ksf)																	
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		199.77																		
Weight of Ring (gm)		45.20																		
Weight of Wet Soil + Cont. (gm)			157.56																	
Weight of Dry Soil + Cont. (gm)			127.13																	
Weight of Cont. (gm) **No.**	3		3.66																	
Moisture Content (%)			24.65																	
Wet Density (pcf / kN/m^3)	128.02	20.15																		
Dry Density (pcf / kN/m^3)	102.71	16.17																		

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.68	80.44	3.13	149.96	5.00	239.59
Ultimate	1.31	62.63	2.34	112.04	3.68	176.39

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		2000	2.00	95.8	4000	4.0	191.5	6000	6.0	287.3
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	840	0.84	40.2	1212	1.21	58.0	1220	1.22	58.2
0.020	0.05	1140	1.14	54.6	1716	1.72	82.2	1976	1.98	94.3
0.030	0.08	1356	1.36	64.9	2052	2.05	98.2	2556	2.56	121.9
0.040	0.10	1500	1.50	71.8	2316	2.32	110.9	3108	3.11	148.3
0.050	0.13	1608	1.61	77.0	2532	2.53	121.2	3576	3.58	170.6
0.060	0.15	1668	1.67	79.9	2700	2.70	129.3	3972	3.97	189.5
0.070	0.18	1680	1.68	80.4	2832	2.83	135.6	4224	4.22	201.5
0.080	0.20	1680	1.68	80.4	2928	2.93	140.2	4368	4.37	208.4
0.090	0.23	1656	1.66	79.3	3012	3.01	144.2	4572	4.57	218.1
0.100	0.25	1620	1.62	77.6	3084	3.08	147.7	4716	4.72	225.0
0.110	0.28	1548	1.55	74.1	3120	3.12	149.4	4848	4.85	231.3
0.120	0.30	1452	1.45	69.5	3132	3.13	150.0	4920	4.92	234.7
0.130	0.33	1392	1.39	66.6	3120	3.12	149.4	4968	4.97	237.0
0.140	0.36	1344	1.34	64.4	3072	3.07	147.1	5004	5.00	238.7
0.150	0.38	1332	1.33	63.8	3036	3.04	145.4	4980	4.98	237.6
0.160	0.41	1320	1.32	63.2	2988	2.99	143.1	4932	4.93	235.3
0.170	0.43	1308	1.31	62.6	2928	2.93	140.2	4800	4.80	229.0
0.180	0.46	1332	1.33	63.8	2892	2.89	138.5	4692	4.69	223.8
0.190	0.48	1332	1.33	63.8	2844	2.84	136.2	4596	4.60	219.2
0.200	0.51	1332	1.33	63.8	2796	2.80	133.9	4536	4.54	216.4
0.210	0.53	1356	1.36	64.9	2724	2.72	130.4	4464	4.46	212.9
0.220	0.56	1356	1.36	64.9	2604	2.60	124.7	4392	4.39	209.5
0.230	0.58	1368	1.37	65.5	2496	2.50	119.5	4188	4.19	199.8
0.240	0.61	1368	1.37	65.5	2412	2.41	115.5	3912	3.91	186.6
0.250	0.64	1368	1.37	65.5	2364	2.36	113.2	3756	3.76	179.2
0.260	0.66	1356	1.36	64.9	2340	2.34	112.0	3684	3.68	175.7
0.270	0.69	1368	1.37	65.5	2340	2.34	112.0	3696	3.70	176.3
0.280	0.71	1380	1.38	66.1	2340	2.34	112.0	3708	3.71	176.9
0.290	0.74	1368	1.37	65.5	2352	2.35	112.6	3720	3.72	177.5
0.300	0.76	1368	1.37	65.5	2376	2.38	113.8	3756	3.76	179.2
0.310	0.79	1368	1.37	65.5	2376	2.38	113.8	3768	3.77	179.7
0.320	0.81	1356	1.36	64.9	2400	2.40	114.9	3804	3.80	181.5
0.330	0.84	1356	1.36	64.9	2412	2.41	115.5	3828	3.83	182.6
0.340	0.86	1368	1.37	65.5	2436	2.44	116.6	3840	3.84	183.2
0.350	0.89	1368	1.37	65.5	2436	2.44	116.6	3864	3.86	184.3
0.360	0.91	1368	1.37	65.5	2436	2.44	116.6	3864	3.86	184.3
0.370	0.94	1368	1.37	65.5	2448	2.45	117.2	3840	3.84	183.2
0.380	0.97	1368	1.37	65.5	2460	2.46	117.8	3852	3.85	183.7
0.390	0.99	1356	1.36	64.9	2472	2.47	118.4	3852	3.85	183.7
0.400	1.02	1356	1.36	64.9	2472	2.47	118.4	3864	3.86	184.3
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○	Shear Type :	Inundated	Undisturbed	Peak : ●



Boring No. : A-09-051		Strength Intercept (C) :	0.00	(ksf)	Peak	0.07	(ksf)	Ultimate
Sample No. : D-6			0.00	(kPa)		3.26	(kPa)	
Depth (ft/m) : 30.0	0.00	Friction Angle (ϕ) :	39.35	Degree		30.71	Degree	
Description : Dark olive-gray, Poorly graded SAND with SILT (SP-SM)					Shear Rate (inch/minute) :			0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	26.09	98.57	15.52	0.71	2.00	95.76	1.68	80.44	1.31	62.63
◆	26.03	98.28	15.47	0.72	4.00	191.52	3.13	149.96	2.34	112.04
▲	24.65	102.71	16.17	0.64	6.00	287.28	5.00	239.59	3.68	176.39

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3

Date : 11/30/09

Figure No. :

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-051	S-1	5	SM	11.3				1:75:24			2000	8.4	300	400
A-09-051	D-2	10	SM	24.1	127.8									
A-09-051	S-3	15	SM					0:82:18						
A-09-051	D-4	20	SM	22.6	127.5									
A-09-051	S-5	25	SP-SM					0:94:6						
A-09-051	D-6	30	ML	22.8	125.9					N.P				
A-09-051	D-7	35	ML							N.P				
A-09-051	D-8	40	ML	26.0	124.5					N.P				
A-09-051	S-9	45	ML	30.8				0:43:57		28/24/4				
A-09-051	D-10	50	ML	26.7	122.5									
A-09-052	S-1	5	SP-SM					1:94:5			1400	8.4	20	673
A-09-052	S-3	15	SP	21.6				0:99:1						
A-09-052	D-4	20	SP-SM	22.7	125.4									
A-09-052	S-5	25	SM	27.8										
A-09-052	D-6	30	CL					0:38:62		41/24/17				
A-09-052	S-7	35	ML	33.5						49/30/19				
A-09-052	S-9	45	ML	31.0				0:45:55		26/26/0				
A-09-052	D-10	50	SM			<0.25		0:70:30						
A-09-053	S-1	5	SM					20:49:31			430	7.8	730	1809
A-09-053	D-2	10	SP-SM	27.4	124.5									
A-09-053	S-3	15	SP	24.5				0:97:3						
A-09-053	D-4	20	SM	19.5	127.8									
A-09-053	S-5	25	SP-SM	26.2				0:95:5						
A-09-053	S-7	35	ML	32.7				0:13:87		42/27/15				
A-09-053	S-9	45	ML	29.9				0:7:93		46/29/17				
A-09-054	S-1	5	ML					0:45:55			780	7.9	420	817
A-09-054	S-3	15	SP	27.3				0:98:2						
A-09-054	S-5	25	SP	22.0				0:98:2						
A-09-054	S-7	35	ML	30.7				0:30:70		28/24/4				
A-09-054	D-8	40	ML			1.25								
A-09-054	S-9	45	ML	42.8						N.P.				
A-09-054	D-10	50	ML					0:10:90		41/26/15				

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-052	Prepared By : PA	Date :
Sample No.	: D-6	Tested By : PA	Date :
Depth below Deck	: 30.0	Sieved By : RJ	Date :
Description	: Olive gray, SANDY Lean CLAY (CL)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

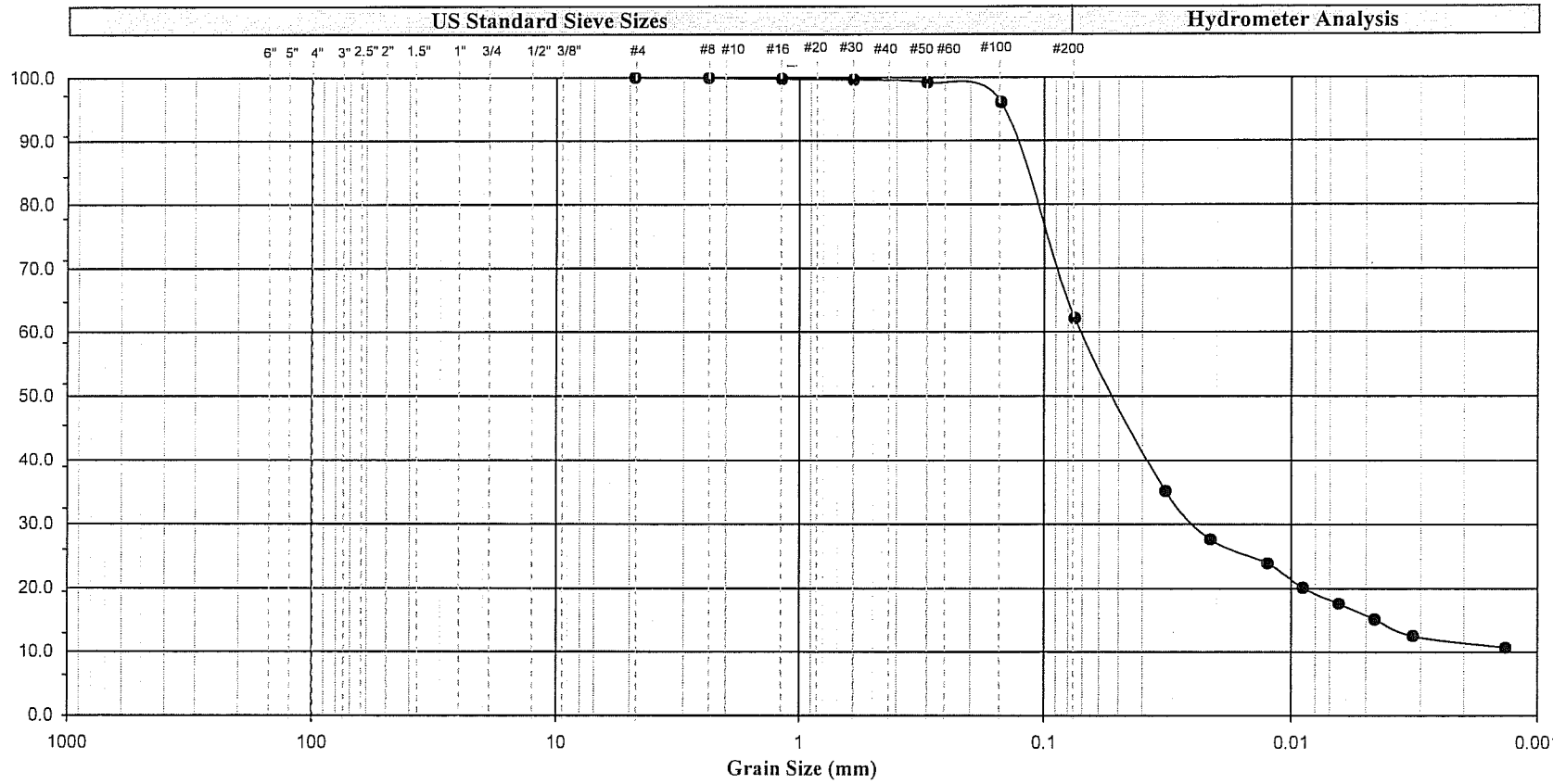
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-19	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	7	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-11		S-19	26		S-13		
Wt. of Wet Soil + Container (gm)		236.54		79.20	173.60			0.99	
Wt. of Dry Soil + Container (gm)					173.10		152.75	Hydrometer Type	
Wt. of Container (gm)					58.41		113.63	152H	
Wt. of Dry Soil (gm)		235.51		78.86			39.12	(K) Value	Temp. °C
Moisture Content (%)					0.44			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				41	No. 16	0.18		99.77	**99.77**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.29		99.63	**99.63**
1.0"					No. 40				
3/4"				24	No. 50	0.61		99.23	**99.23**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	3.04		96.14	**96.14**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.04		**99.95**	17	No. 200	29.84		62.16	**62.16**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	W		(mm)	(K)	(L)	(D)
13:34	0:00:00			5.0							
	2	21.0	33.0	5.0	28.0	35.15	**35.15**	0.05500	0.01328	11.7	**0.03213**
	5	21.0	27.0	5.0	22.0	27.62	**27.62**	0.03500	0.01328	12.7	**0.02116**
	15	21.0	24.0	5.0	19.0	23.85	**23.85**	0.02000	0.01328	13.2	**0.01245**
	30	22.0	21.0	5.0	16.0	20.09	**20.09**	0.01400	0.01328	13.7	**0.00897**
	60	23.0	19.0	5.0	14.0	17.58	**17.58**	0.01000	0.01328	14.0	**0.00642**
	120	23.0	17.0	5.0	12.0	15.07	**15.07**	0.00700	0.01328	14.3	**0.00459**
	240	23.5	15.0	5.0	10.0	12.55	**12.55**	0.00500	0.01328	14.7	**0.00322**
	1440	21.5	13.5	5.0	8.5	10.67	**10.67**	0.00100	0.01328	14.9	**0.00135**

Remark :	Retaining on #4 are shell fragments	Cu :	Gravel	Sand	Fine
		Cc :	**0**	**38**	**62**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth below (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-052	D-6	30.0	olive gray	Sandy lean clay	CL
Remark	Retaining on #4 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *A-09-052*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-9*	**Tested By :** *PA*	**Date :**
Depth below Decl	: *45.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark greenish gray, SANDY SILT (ML)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

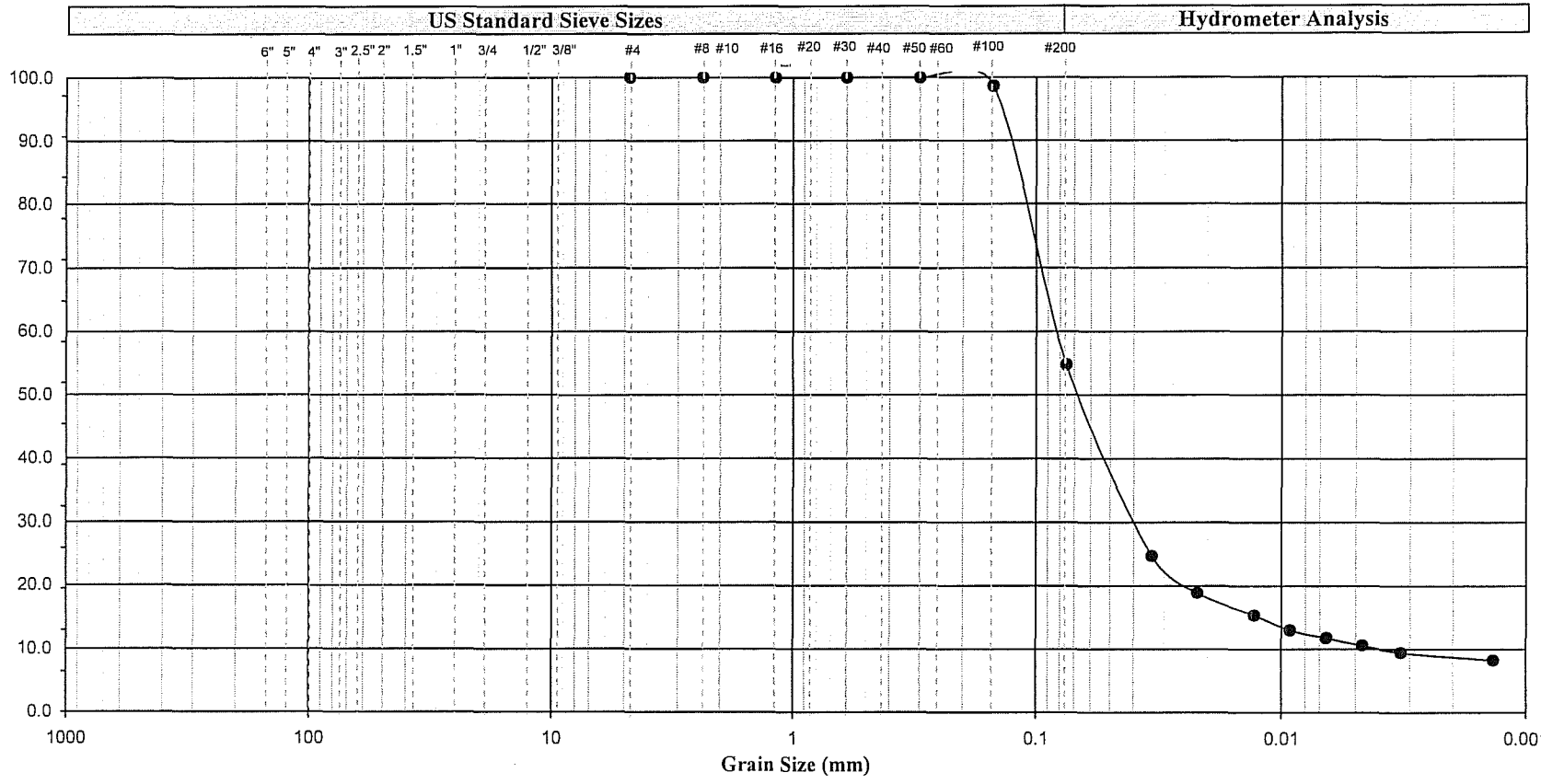
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. **1**

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*S-17*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Test Cylinder No. :	*1*								
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-11*		*S-17*	*27*		*S-14*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*401.03*		*84.37*	*190.34*			*0.99*	
Wt. of Dry Soil + Container (gm)					*189.83*		*162.84*	**Hydrometer Type**	
Wt. of Container (gm)					*57.54*		*115.82*	*152H*	
Wt. of Dry Soil (gm)		*399.49*		*84.05*			*47.02*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.39*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				**26**	No. 16	*0.02*		*99.98*	***99.98***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.04*		*99.95*	***99.95***
1.0"					No. 40				
3/4"				**26**	No. 50	*0.09*		*99.89*	***99.89***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*1.14*		*98.64*	***98.64***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.00*		***100.00***	**0**	No. 200	*38.05*		*54.73*	***54.73***
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
13:38	*0:00:00*			*5.0*							
	2	*21.0*	*26.0*	*5.0*	*21.0*	*24.74*	***24.74***	*0.05500*	*0.01328*	*12.9*	***0.03367***
	5	*21.0*	*21.0*	*5.0*	*16.0*	*18.85*	***18.85***	*0.03500*	*0.01328*	*13.7*	***0.02196***
	15	*21.0*	*18.0*	*5.0*	*13.0*	*15.31*	***15.31***	*0.02000*	*0.01328*	*14.2*	***0.01291***
	30	*22.0*	*16.0*	*5.0*	*11.0*	*12.96*	***12.96***	*0.01400*	*0.01328*	*14.5*	***0.00923***
	60	*23.0*	*15.0*	*5.0*	*10.0*	*11.78*	***11.78***	*0.01000*	*0.01328*	*14.7*	***0.00656***
	120	*23.0*	*14.0*	*5.0*	*9.0*	*10.60*	***10.60***	*0.00700*	*0.01328*	*14.8*	***0.00467***
	240	*23.5*	*13.0*	*5.0*	*8.0*	*9.42*	***9.42***	*0.00500*	*0.01328*	*15.0*	***0.00325***
	1440	*21.5*	*12.0*	*5.0*	*7.0*	*8.25*	***8.25***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :	*Retaining on #4 are shell fragments*	Cu : *21.3*	**Gravel**	**Sand**	**Fine**
		Cc : *5.1*	***0***	***45***	***55***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-052	S-9	45.0	dark greenish gray	Sandy silt	ML
Remark	Retaining on #4 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 | Set up By : J.F | Date : 11/13/2009

Boring No. : A-09-052 | Tested By : J.F/R.J. | Date : 11/13/09-11/23/09

Sample No. : D-6 | Time Rate Took By : J.F | Date : 11/16/09,11/18/09

Depth (ft / m) : 30.0 | 9.15 | Computer By : JF | Date : 11/24/2009

File No. : | Checked By : R.J. | Date :

Soil Description : Gray, SANDY lean CLAY (CL)

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.9039	22.96	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

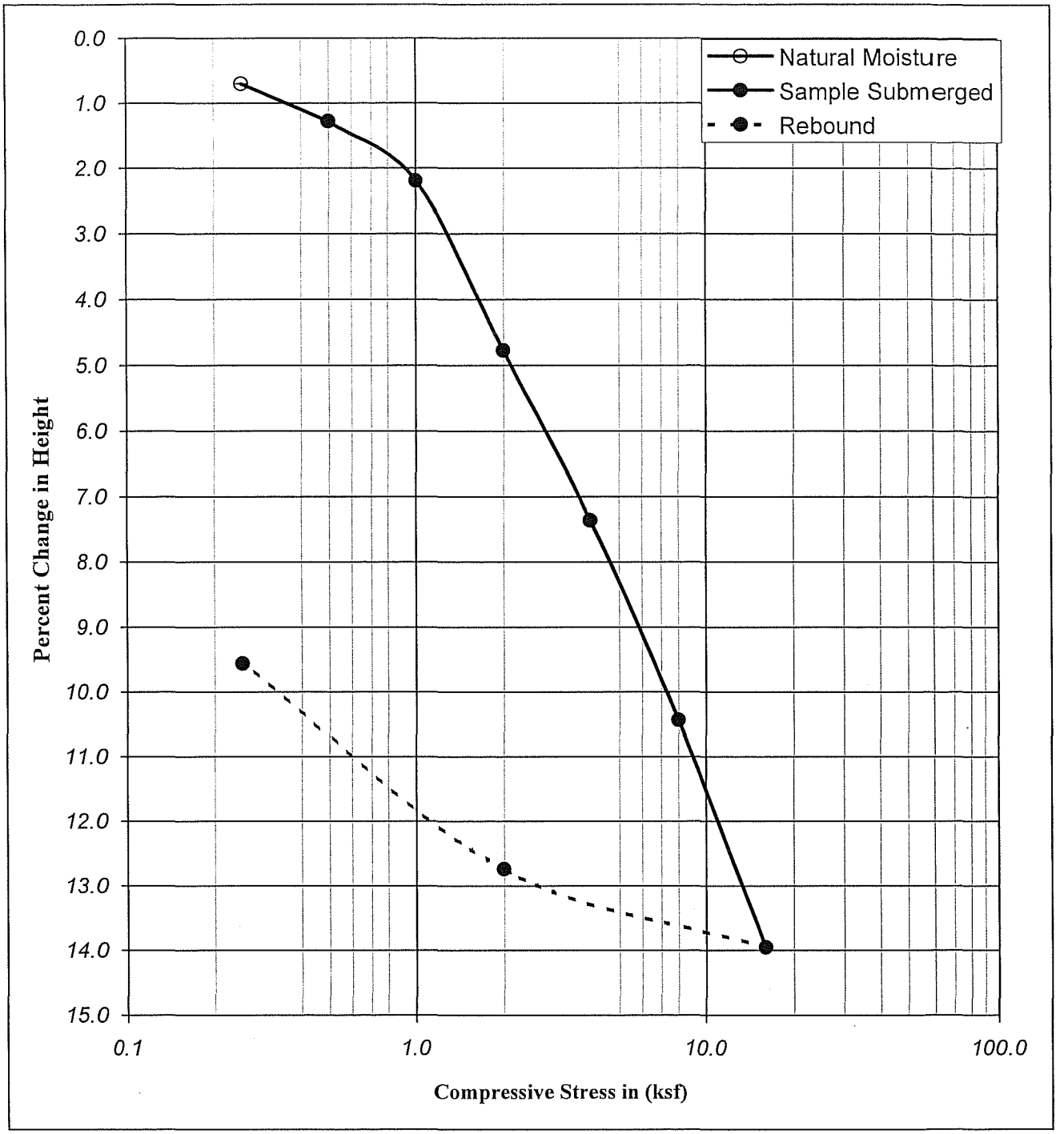
Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/13/2009	14:43	0:00:00	Seating		0.04950	1.26	
			Load				
	14:55		0.1	4.8	0.05000	1.27	0.00
11/14/2009	9:10	0:00:00	0.25	12.0	0.05700	1.45	0.70
11/15/2009	9:42	0:00:00	0.50	23.9	0.06280	1.60	1.28
			Add Water				
11/16/2009	8:35	0:00:00	0.50	23.9	0.06280	1.60	1.28
11/16/2009	8:38	0:00:00	1.00	47.9	0.06280	1.60	1.28
		0.10	1.0	47.9	0.06450	1.64	1.45
		0.25	1.0	47.9	0.0650	1.65	1.50
		0.50	1.0	47.9	0.06560	1.67	1.56
		1	1.0	47.9	0.06640	1.69	1.64
		2	1.0	47.9	0.06680	1.70	1.68
		4	1.0	47.9	0.06710	1.70	1.71
		8	1.0	47.9	0.06770	1.72	1.77
		15	1.0	47.9	0.06805	1.73	1.80
		30	1.0	47.9	0.06845	1.74	1.85
		60	1.0	47.9	0.06910	1.76	1.91
		120	1.0	47.9	0.06970	1.77	1.97
		240	1.0	47.9	0.07050	1.79	2.05
		480	1.0	47.9	0.07130	1.81	2.13
11/17/2009		1440	1.0	47.9	0.07190	1.83	2.19
11/18/2009	8:34	0	2.0	95.8	0.09770	2.48	4.77
11/18/2009	8:42	0	4.0	191.5	0.0977	2.48	4.77
		0.10	4.0	191.5	0.1053	2.67	5.53
		0.25	4.0	191.5	0.1068	2.71	5.68
		0.50	4.0	191.5	0.1106	2.81	6.06
		1	4.0	191.5	0.1130	2.87	6.30
		2	4.0	191.5	0.1149	2.92	6.49
		4	4.0	191.5	0.1161	2.95	6.61
		8	4.0	191.5	0.1169	2.97	6.69
		15	4.0	191.5	0.1176	2.99	6.76
		30	4.0	191.5	0.1186	3.01	6.86
		60	4.0	191.5	0.1197	3.04	6.97
		120	4.0	191.5	0.1208	3.07	7.08
		240	4.0	191.5	0.1219	3.10	7.19
		480	4.0	191.5	0.1229	3.12	7.29
11/19/09		1440	4.0	191.5	0.1236	3.14	7.36

		Before	After
Weight of wet soil + ring (gm)		179.23	
Weight of ring (gm)		42.97	
Weight of wet soil + ring + container (gm)			232.23
Weight of dry soil + ring + container (gm)			198.94
No. 84 — Weight of container (gm)			60.32
Weight of ring + container (gm)			103.29
Moisture Content (%)		42.46	34.80
Dial Reading (inch)		0.05	0.04
Sample Volume (ft³)		0.0027	0.0024
Wet Density (pcf)		112.9	118.1
Dry Density (pcf)		79.22	87.64

SQRT Time	Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
0.00								
0.32								
0.50	11/20/2009	8:30		8.00	383.0	0.1543	3.92	10.43
0.71								
1.00	11/21/2009	8:36		16.00	766.1	0.1895	4.81	13.95
1.41								
2.00	11/22/2009	8:42		2.00	95.8	0.1774	4.51	12.74
2.83								
3.87	11/23/2009	8:40		0.25	12.0	0.1456	3.70	9.56
5.48								
7.75								
10.95								
15.49								
21.91								
37.95								

Remark :

Final Dial Reading 0.1456



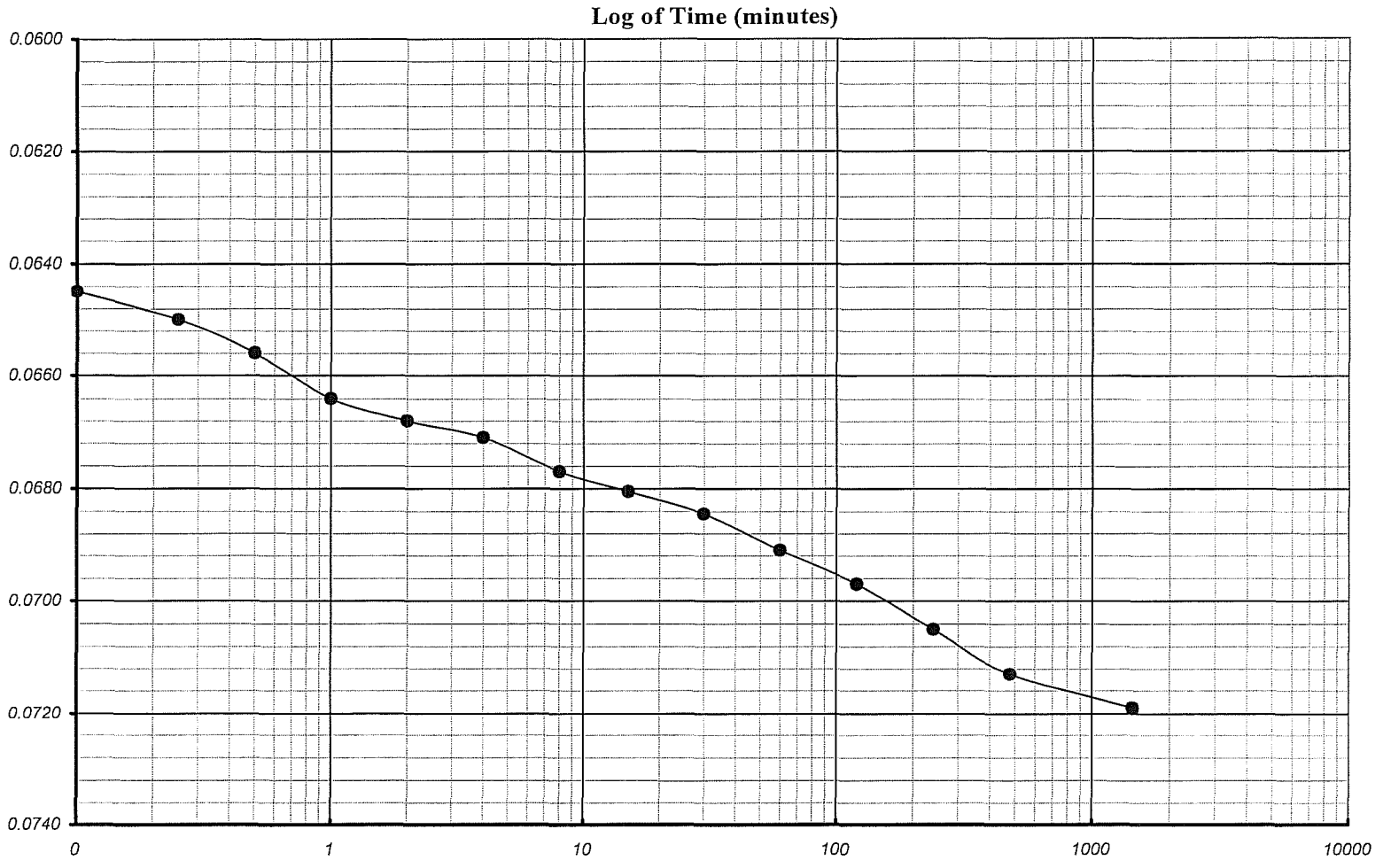
Boring No.	: A-09-052		Liquid Limit :	-		Moisture Content (%)	Dry Density		Percent Saturation	Void Ratio
Sample No.	: D-6		Plastic Limit :	-			(pcf)	(kN/m³)		
Depth (ft)	: 30.0	31.5	Plastic Index :	-	Initial	42.46	79.22	12.47	101.65	1.13
Depth (m)	: 9.15	9.61	Specific Gravity :	2.70	Final	34.80	87.64	13.79	101.78	0.92
Description	: Gray, SANDY lean CLAY (CL)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

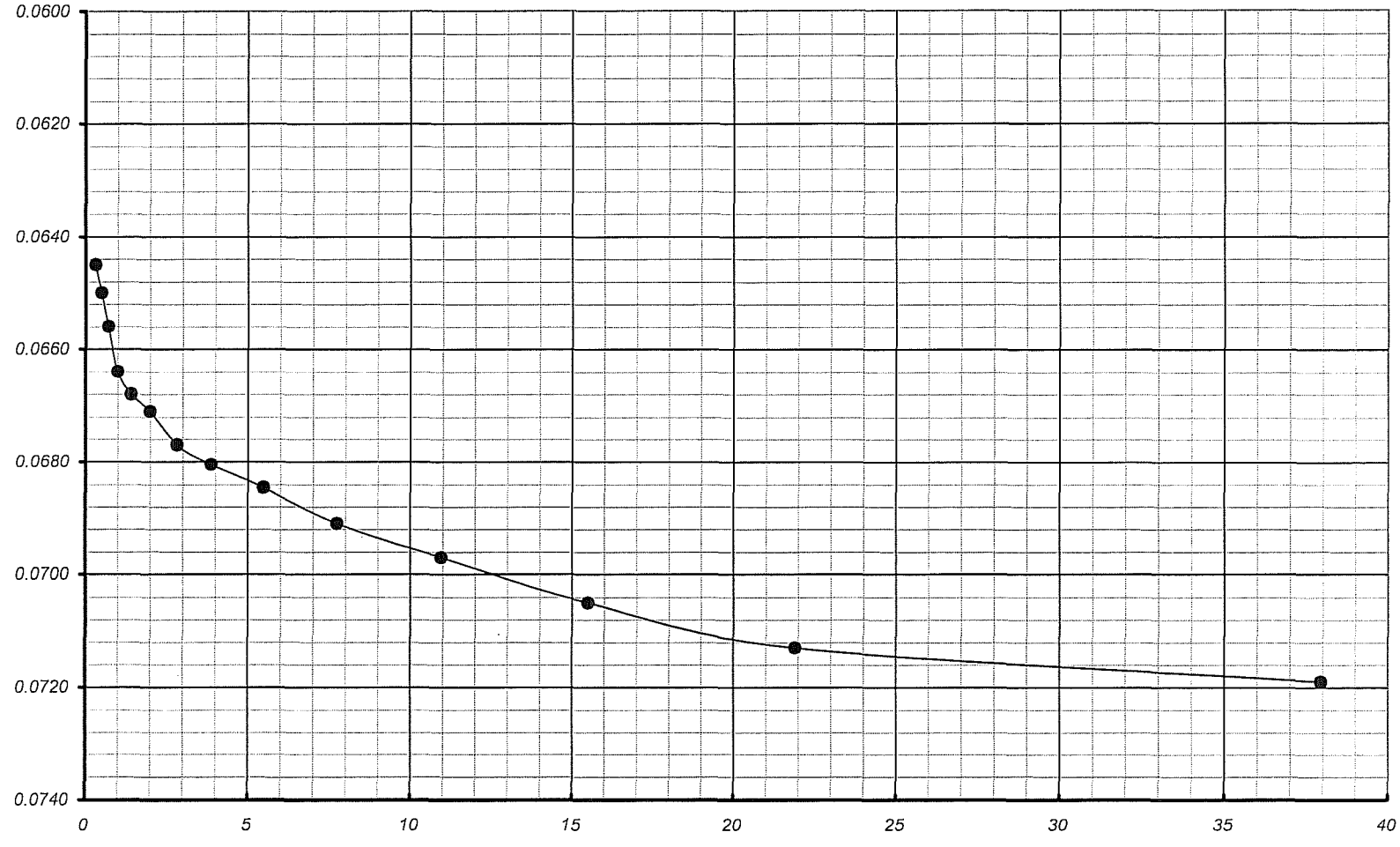
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

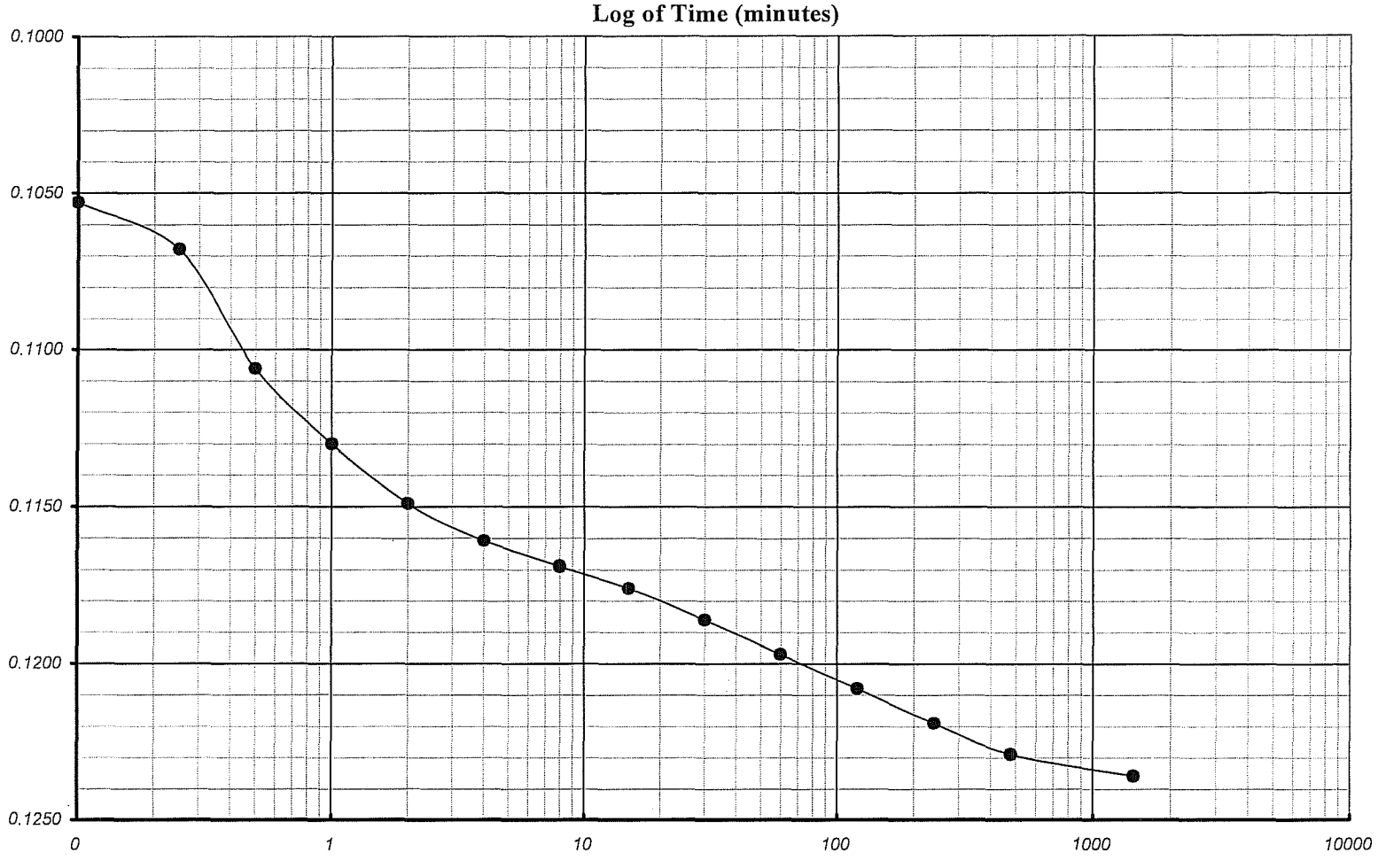
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



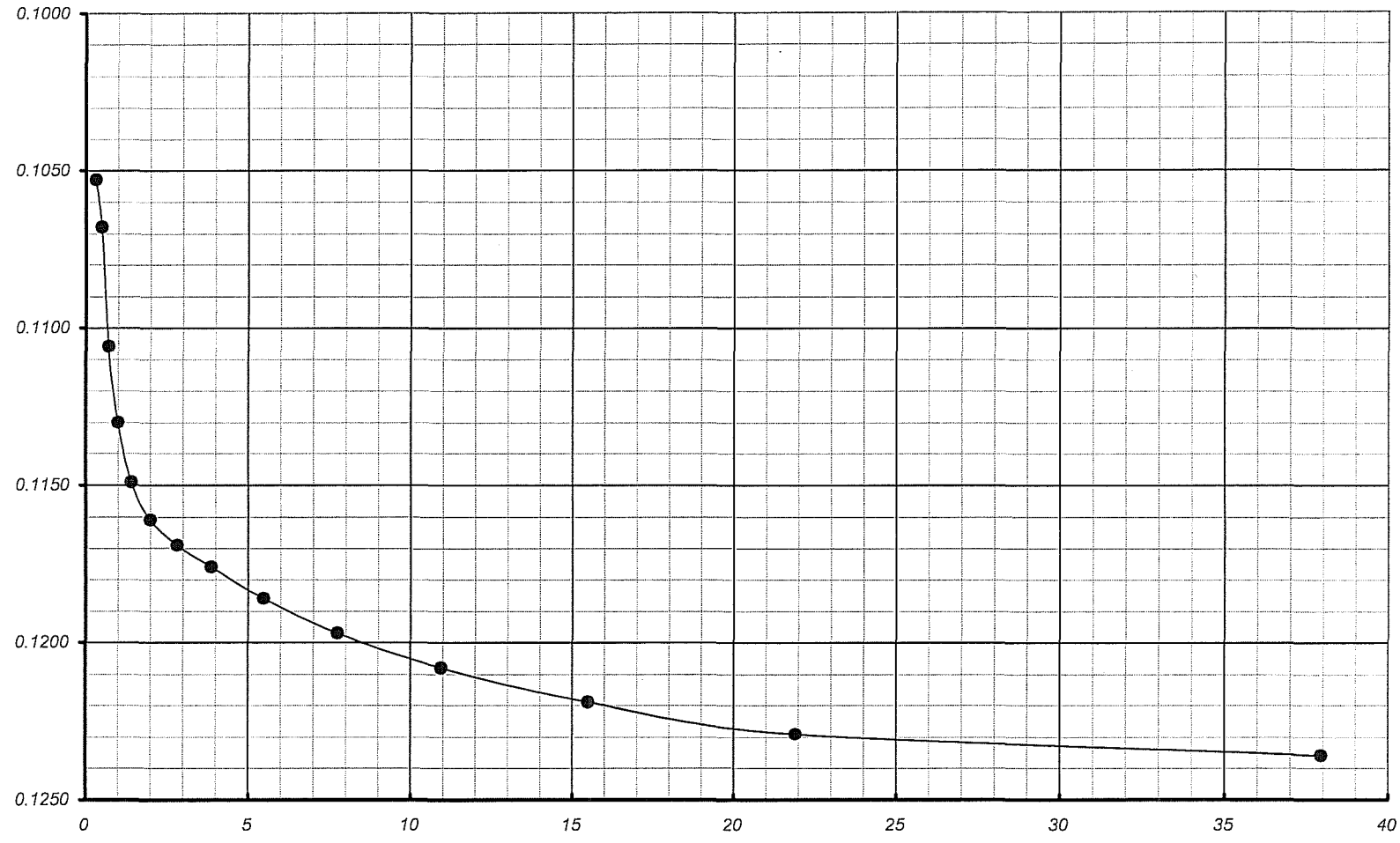
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* | *9.2*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 | Set up By : J.F | Date : 11/13/2009

Boring No. : A-09-052 | Tested By : J.F/R.J. | Date : 11/13/09-11/23/09

Sample No. : D-8 | Time Rate Took By : J.F | Date : 11/16/09,11/18/09

Depth (ft / m) : 40.0 | 12.20 | Computer By : JF | Date : 11/24/2009

File No. : | Checked By : R.J. | Date :

Soil Description : Dark gray, SANDY SILT (ML)

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9678	24.58	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/13/2009	14:43	0:00:00	Seating		0.04990	1.27	
			Load				
	14:55		0.1	4.8	0.05000	1.27	0.00
11/14/2009	9:10	0:00:00	0.25	12.0	0.05190	1.32	0.19
11/15/2009	9:42	0:00:00	0.50	23.9	0.05420	1.38	0.42
			Add Water				
11/16/2009	8:35	0:00:00	0.50	23.9	0.05430	1.38	0.43
11/16/2009	8:38	0:00:00	1.00	47.9	0.05430	1.38	0.43
		0.10	1.0	47.9	0.05620	1.43	0.62
		0.25	1.0	47.9	0.0563	1.43	0.63
		0.50	1.0	47.9	0.05640	1.43	0.64
		1	1.0	47.9	0.05650	1.44	0.65
		2	1.0	47.9	0.05670	1.44	0.67
		4	1.0	47.9	0.05680	1.44	0.68
		8	1.0	47.9	0.05690	1.45	0.69
		15	1.0	47.9	0.05700	1.45	0.70
		30	1.0	47.9	0.05710	1.45	0.71
		60	1.0	47.9	0.05730	1.46	0.73
		120	1.0	47.9	0.05740	1.46	0.74
		240	1.0	47.9	0.05770	1.47	0.77
		480	1.0	47.9	0.05810	1.48	0.81
11/17/2009		1440	1.0	47.9	0.05830	1.48	0.83
11/18/2009	8:34	0	2.0	95.8	0.06570	1.67	1.57
11/18/2009	8:42	0	4.0	191.5	0.0657	1.67	1.57
		0.10	4.0	191.5	0.0705	1.79	2.05
		0.25	4.0	191.5	0.0708	1.80	2.08
		0.50	4.0	191.5	0.0711	1.81	2.11
		1	4.0	191.5	0.0712	1.81	2.12
		2	4.0	191.5	0.0714	1.81	2.14
		4	4.0	191.5	0.0716	1.82	2.16
		8	4.0	191.5	0.0718	1.82	2.18
		15	4.0	191.5	0.0720	1.83	2.20
		30	4.0	191.5	0.0722	1.83	2.22
		60	4.0	191.5	0.0724	1.84	2.24
		120	4.0	191.5	0.0728	1.85	2.28
		240	4.0	191.5	0.0731	1.86	2.31
		480	4.0	191.5	0.0734	1.86	2.34
11/19/09		1440	4.0	191.5	0.0736	1.87	2.36

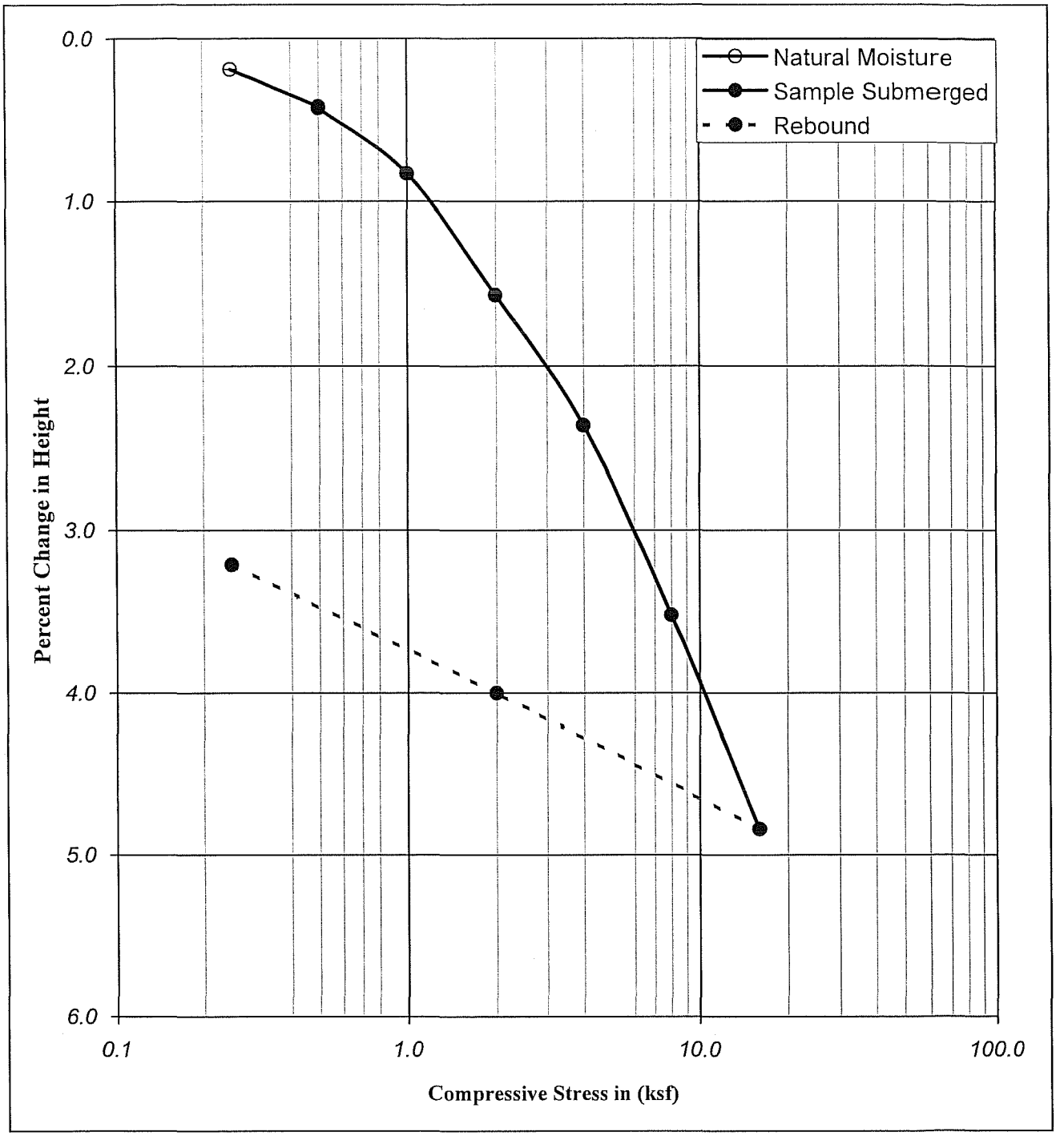
	Before	After
Weight of wet soil + ring (gm)	185.69	
Weight of ring (gm)	42.22	
Weight of wet soil + ring + container (gm)		243.21
Weight of dry soil + ring + container (gm)		209.42
No. 85 Weight of container (gm)		59.32
Weight of ring + container (gm)		101.54
Moisture Content (%)	32.99	31.32
Dial Reading (inch)	0.05	0.04
Sample Volume (ft^3)	0.0027	0.0026
Wet Density (pcf)	118.8	121.2
Dry Density (pcf)	89.35	92.32

SQRT Time
0.00
0.32
0.50
0.71
1.00
1.41
2.00
2.83
3.87
5.48
7.75
10.95
15.49
21.91
37.95

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.0852	2.16	3.52
11/21/2009	8:36		16.00	766.1	0.0984	2.50	4.84
11/22/2009	8:42		2.00	95.8	0.0900	2.29	4.00
11/23/2009	8:40		0.25	12.0	0.0821	2.09	3.21

Remark :

Final Dial Reading 0.0821



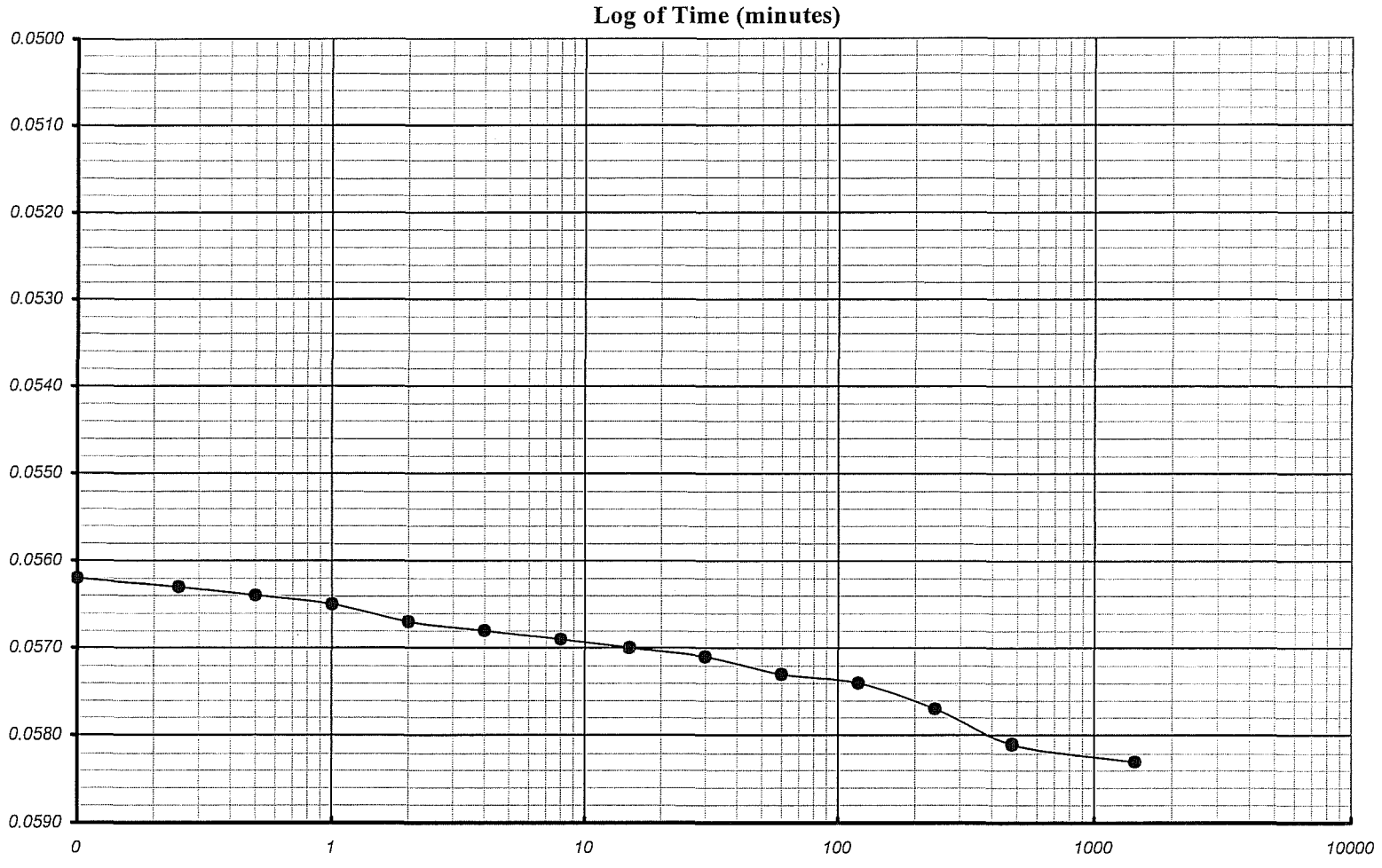
Boring No.	: A-09-052		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	32.99	89.35	14.06	100.47	0.89
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	31.32	92.32	14.53	102.41	0.83
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

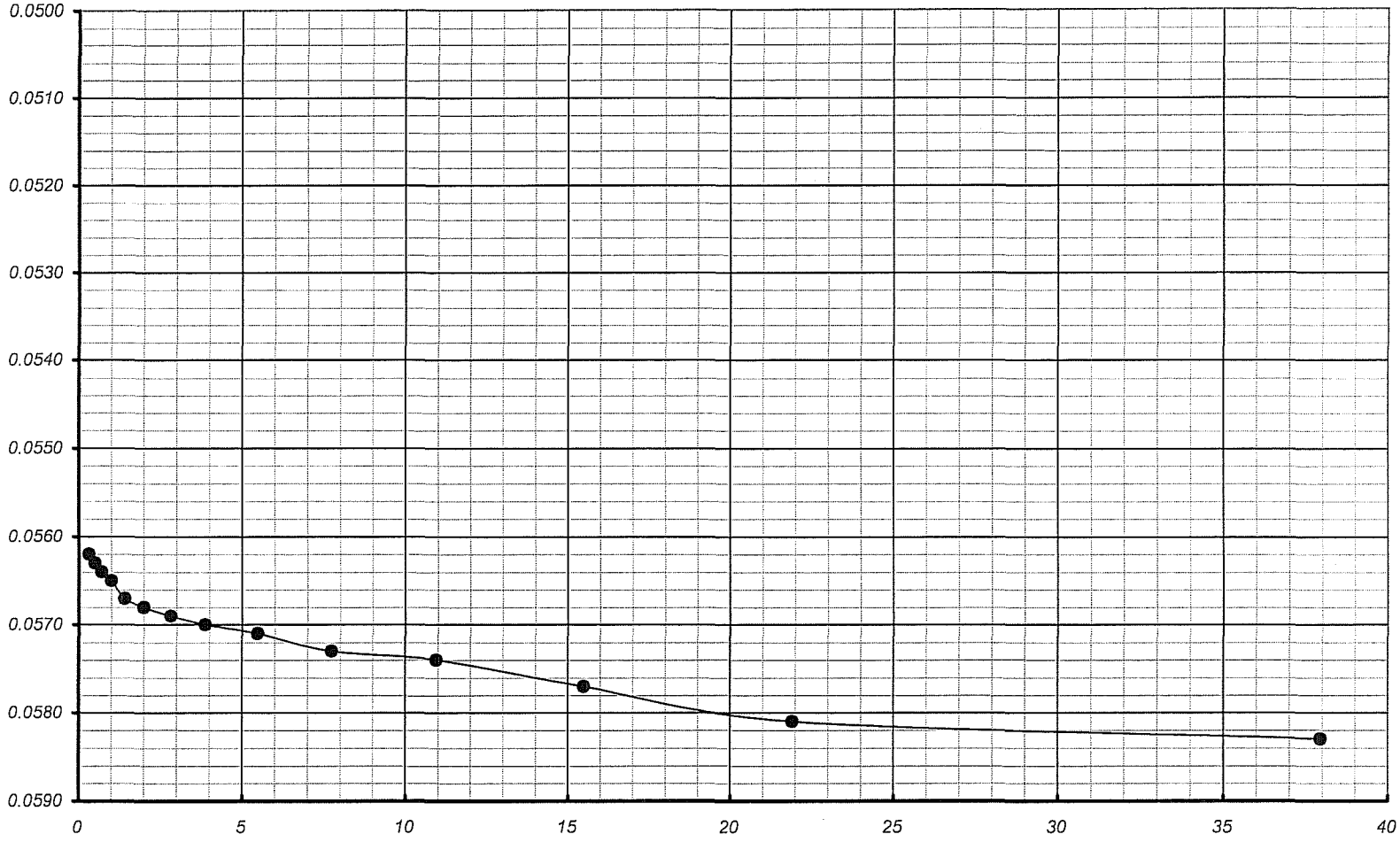
Project No. : 06-123-3 11/24/09

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

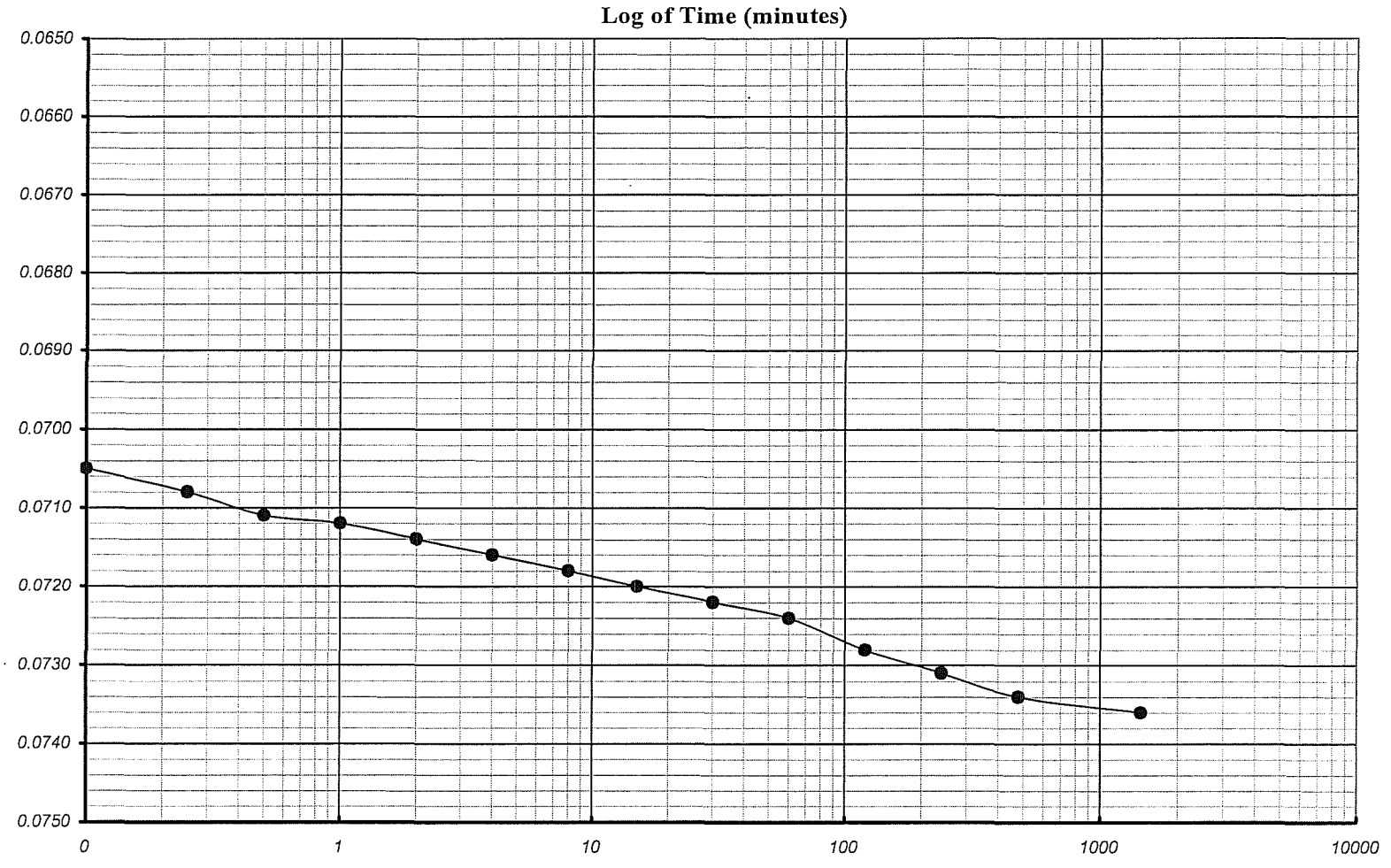


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-052	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 1.00 47.9

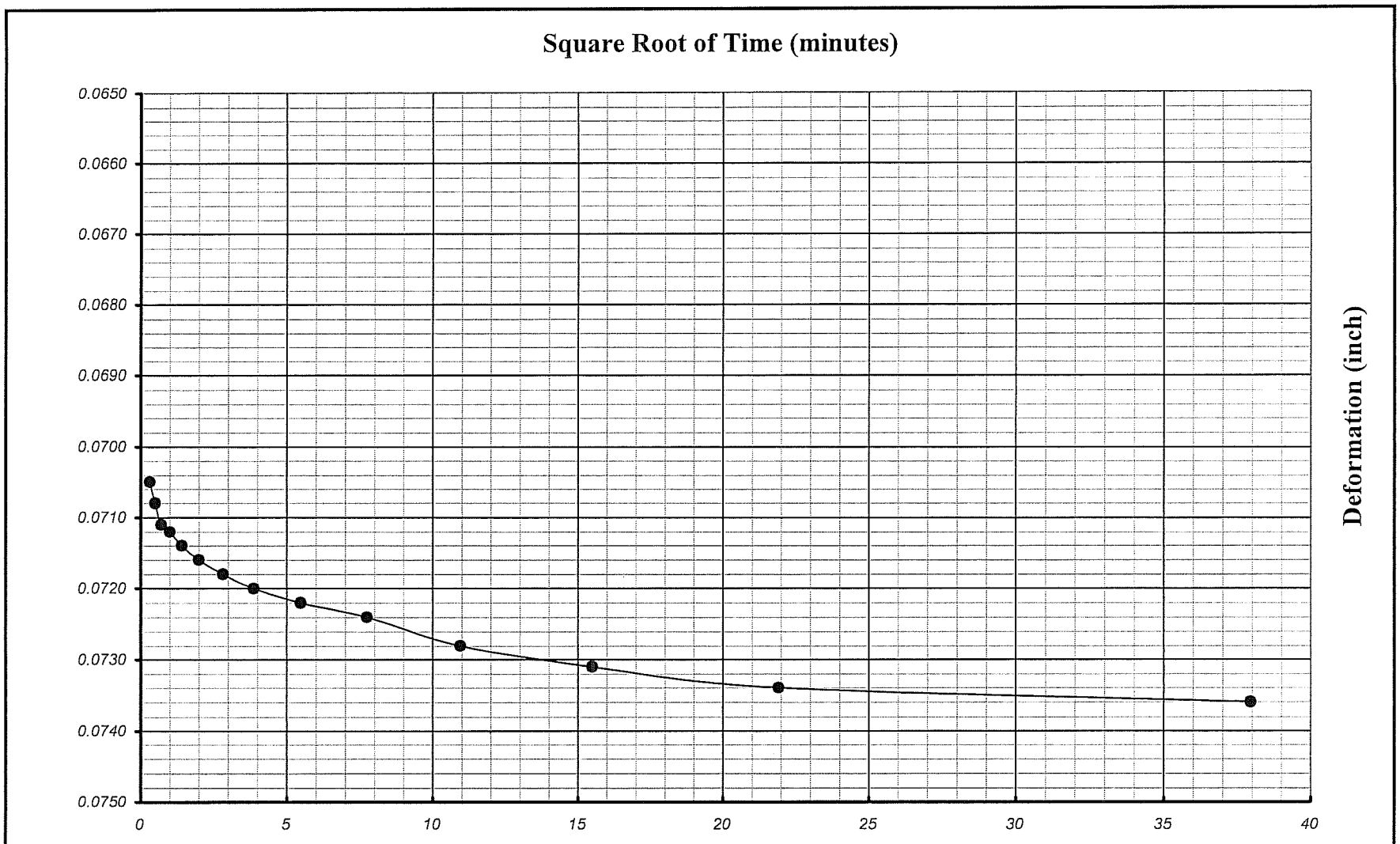
Square Root of Time (minutes)



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-052	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-8	
EMI Project No. : 06-123-3		Depth (ft/m) : 40.0 12.2	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-052*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. :	A-09-052		Saturated		Field Moisture	X	Inundated — **Specific Gravity (Assumed) :** 2.70
Sample No. :	D-4	X	Undisturbed		Remolded		Consolidated-Drained — **Shear Rate (inch/min) :** 0.02
Depth (ft/m) :	20.0	x	Shear Once		Reshear		Residual — **Data File Number :** 0612302
Description :	Gray, Poorly graded SAND with SILT (SP-SM)						

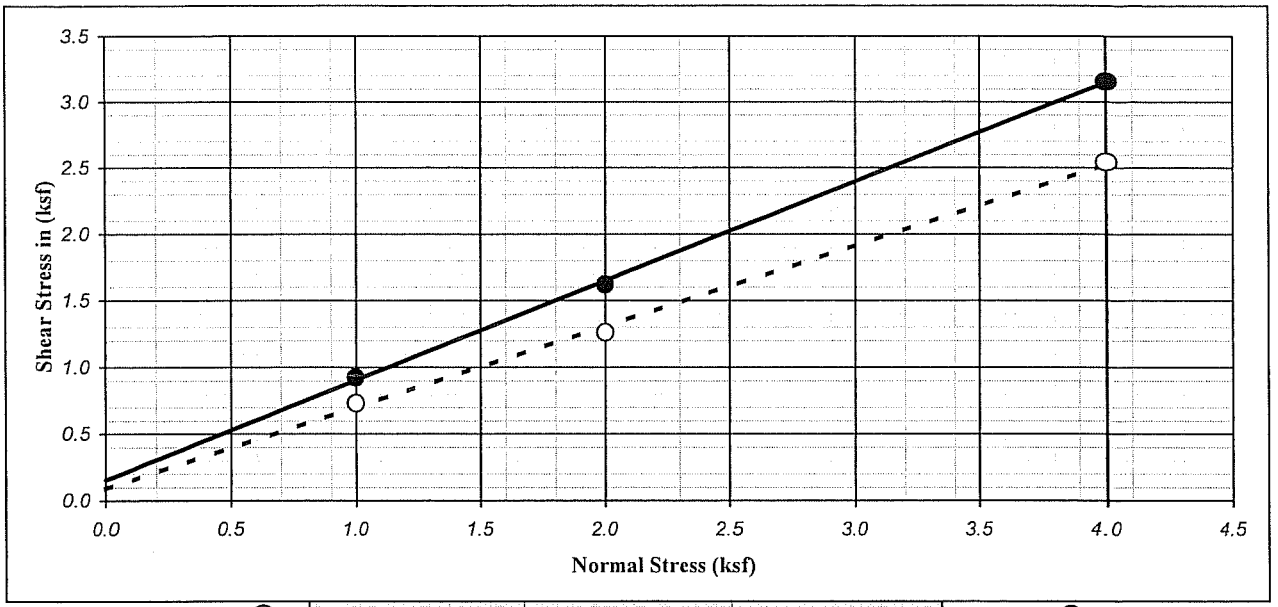
Percent Saturation (%)	101.61	**File No. :** 0612302	1	
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**		
Tested By : JF	**Date :** 11/30/09			
Computed By : JF	**Date :** 12/11/09	1.00	(ksf)	
Checked By :	**Date :**			
Percent Consolidation (%)		**Before**		**After**
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		194.51		
Weight of Ring (gm)		43.45		
Weight of Wet Soil + Cont. (gm)				152.47
Weight of Dry Soil + Cont. (gm)				121.35
Weight of Cont. (gm) No.	4			3.97
Moisture Content (%)				26.51
Wet Density (pcf / kN/m³)		125.11	19.69	
Dry Density (pcf / kN/m³)		98.89	15.57	

Percent Saturation (%)	104.82	**File No. :** 0612302	2	
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**		
Tested By : JF	**Date :** 11/30/09	2.00	(ksf)	
Percent Consolidation (%)		**Before**		**After**
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		196.09		
Weight of Ring (gm)		43.22		
Weight of Wet Soil + Cont. (gm)				154.22
Weight of Dry Soil + Cont. (gm)				122.61
Weight of Cont. (gm) No.	5			3.89
Moisture Content (%)				26.63
Wet Density (pcf / kN/m³)		126.61	19.93	
Dry Density (pcf / kN/m³)		99.99	15.74	

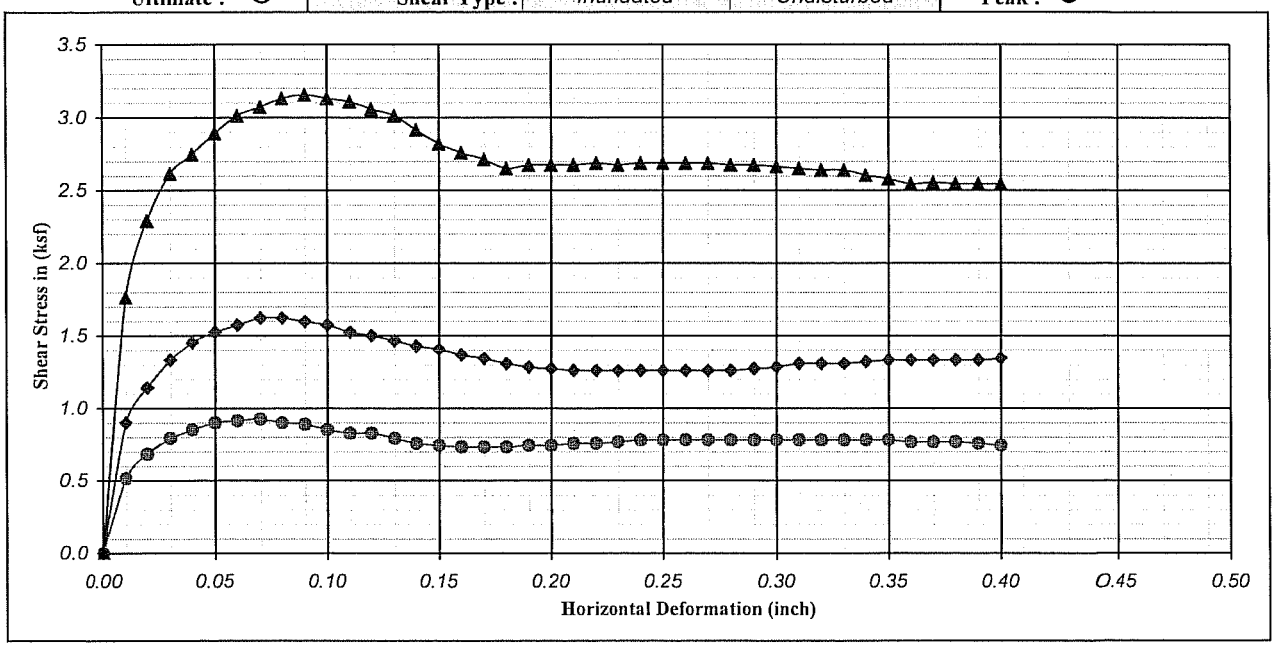
Percent Saturation (%)	100.15	**File No. :** 0612302	3	
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**		
Tested By : JF	**Date :** 11/30/09	4.00	(ksf)	
Percent Consolidation (%)		**Before**		**After**
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		195.00		
Weight of Ring (gm)		43.98		
Weight of Wet Soil + Cont. (gm)				151.53
Weight of Dry Soil + Cont. (gm)				121.28
Weight of Cont. (gm) No.	6			3.95
Moisture Content (%)				25.78
Wet Density (pcf / kN/m³)		125.08	19.69	
Dry Density (pcf / kN/m³)		99.44	15.65	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.92	44.24	1.62	77.57	3.16	151.11
Ultimate	0.73	35.05	1.26	60.33	2.54	121.81

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	516	0.52	24.7	900	0.90	43.1	1764	1.76	84.1
0.020	0.05	684	0.68	32.7	1140	1.14	54.6	2292	2.29	109.3
0.030	0.08	792	0.79	37.9	1332	1.33	63.8	2616	2.62	124.8
0.040	0.10	852	0.85	40.8	1452	1.45	69.5	2748	2.75	131.1
0.050	0.13	900	0.90	43.1	1524	1.52	73.0	2892	2.89	138.0
0.060	0.15	912	0.91	43.7	1572	1.57	75.3	3012	3.01	143.7
0.070	0.18	924	0.92	44.2	1620	1.62	77.6	3072	3.07	146.5
0.080	0.20	900	0.90	43.1	1620	1.62	77.6	3132	3.13	149.4
0.090	0.23	888	0.89	42.5	1596	1.60	76.4	3156	3.16	150.5
0.100	0.25	852	0.85	40.8	1572	1.57	75.3	3132	3.13	149.4
0.110	0.28	828	0.83	39.6	1524	1.52	73.0	3108	3.11	148.3
0.120	0.30	828	0.83	39.6	1500	1.50	71.8	3060	3.06	146.0
0.130	0.33	792	0.79	37.9	1464	1.46	70.1	3012	3.01	143.7
0.140	0.36	756	0.76	36.2	1428	1.43	68.4	2916	2.92	139.1
0.150	0.38	744	0.74	35.6	1404	1.40	67.2	2820	2.82	134.5
0.160	0.41	732	0.73	35.0	1368	1.37	65.5	2760	2.76	131.7
0.170	0.43	732	0.73	35.0	1344	1.34	64.4	2712	2.71	129.4
0.180	0.46	732	0.73	35.0	1308	1.31	62.6	2652	2.65	126.5
0.190	0.48	744	0.74	35.6	1284	1.28	61.5	2676	2.68	127.7
0.200	0.51	744	0.74	35.6	1272	1.27	60.9	2676	2.68	127.7
0.210	0.53	756	0.76	36.2	1260	1.26	60.3	2676	2.68	127.7
0.220	0.56	756	0.76	36.2	1260	1.26	60.3	2688	2.69	128.2
0.230	0.58	768	0.77	36.8	1260	1.26	60.3	2676	2.68	127.7
0.240	0.61	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.250	0.64	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.260	0.66	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.270	0.69	780	0.78	37.3	1260	1.26	60.3	2688	2.69	128.2
0.280	0.71	780	0.78	37.3	1260	1.26	60.3	2676	2.68	127.7
0.290	0.74	780	0.78	37.3	1272	1.27	60.9	2676	2.68	127.7
0.300	0.76	780	0.78	37.3	1284	1.28	61.5	2664	2.66	127.1
0.310	0.79	780	0.78	37.3	1308	1.31	62.6	2652	2.65	126.5
0.320	0.81	780	0.78	37.3	1308	1.31	62.6	2640	2.64	125.9
0.330	0.84	780	0.78	37.3	1308	1.31	62.6	2640	2.64	125.9
0.340	0.86	780	0.78	37.3	1320	1.32	63.2	2604	2.60	124.2
0.350	0.89	780	0.78	37.3	1332	1.33	63.8	2580	2.58	123.1
0.360	0.91	768	0.77	36.8	1332	1.33	63.8	2544	2.54	121.4
0.370	0.94	768	0.77	36.8	1332	1.33	63.8	2556	2.56	121.9
0.380	0.97	768	0.77	36.8	1332	1.33	63.8	2544	2.54	121.4
0.390	0.99	756	0.76	36.2	1332	1.33	63.8	2544	2.54	121.4
0.400	1.02	744	0.74	35.6	1344	1.34	64.4	2544	2.54	121.4
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No. : *A-09-052*		**Strength Intercept (C) :**	*0.16*	(ksf)	**Peak**	*0.09*	(ksf)	**Ultimate**
Sample No. : *D-4*			*7.47*	(kPa)		*4.31*	(kPa)	
Depth (ft/m) : *20.0*	*0.00*	**Friction Angle (ϕ) :**	*36.78*	Degree		*31.36*	Degree	
Description : *Gray, Poorly graded SAND with SILT (SP-SM)*						**Shear Rate** (inch/minute) :		*0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*26.51*	*98.89*	*15.57*	*0.70*	*1.00*	*47.88*	*0.92*	*44.24*	*0. 73*	*35.05*
◆	*26.63*	*99.99*	*15.74*	*0.69*	*2.00*	*95.76*	*1.62*	*77.57*	*1. 26*	*60.33*
▲	*25.78*	*99.44*	*15.65*	*0.70*	*4.00*	*191.52*	*3.16*	*151.11*	*2. 54*	*121.81*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* | **Date :** *11/30/09*

Figure No. :

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-051	S-1	5	SM	11.3				1:75:24			2000	8.4	300	400
A-09-051	D-2	10	SM	24.1	127.8									
A-09-051	S-3	15	SM					0:82:18						
A-09-051	D-4	20	SM	22.6	127.5									
A-09-051	S-5	25	SP-SM					0:94:6						
A-09-051	D-6	30	ML	22.8	125.9					N.P				
A-09-051	D-7	35	ML							N.P				
A-09-051	D-8	40	ML	26.0	124.5					N.P				
A-09-051	S-9	45	ML	30.8				0:43:57		28/24/4				
A-09-051	D-10	50	ML	26.7	122.5									
A-09-052	S-1	5	SP-SM					1:94:5			1400	8.4	20	673
A-09-052	S-3	15	SP	21.6				0:99:1						
A-09-052	D-4	20	SP-SM	22.7	125.4									
A-09-052	S-5	25	SM	27.8										
A-09-052	D-6	30	CL					0:38:62		41/24/17				
A-09-052	S-7	35	ML	33.5						49/30/19				
A-09-052	S-9	45	ML	31.0				0:45:55		26/26/0				
A-09-052	D-10	50	SM			<0.25		0:70:30						
A-09-053	S-1	5	SM					20:49:31			430	7.8	730	1809
A-09-053	D-2	10	SP-SM	27.4	124.5									
A-09-053	S-3	15	SP	24.5				0:97:3						
A-09-053	D-4	20	SM	19.5	127.8									
A-09-053	S-5	25	SP-SM	26.2				0:95:5						
A-09-053	S-7	35	ML	32.7				0:13:87		42/27/15				
A-09-053	S-9	45	ML	29.9				0:7:93		46/29/17				
A-09-054	S-1	5	ML					0:45:55			780	7.9	420	847
A-09-054	S-3	15	SP	27.3				0:98:2						
A-09-054	S-5	25	SP	22.0				0:98:2						
A-09-054	S-7	35	ML	30.7				0:30:70		28/24/4				
A-09-054	D-8	40	ML			1.25								
A-09-054	S-9	45	ML	42.8						N.P.				
A-09-054	D-10	50	ML					0:10:90		41/26/15				

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: A-09-053	Prepared By : PA	Date :
Sample No.	: S-7	Tested By : PA	Date :
Depth below Deck	: 35.0	Sieved By : RJ	Date :
Description	: dark greenish gray, SILT (ML)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

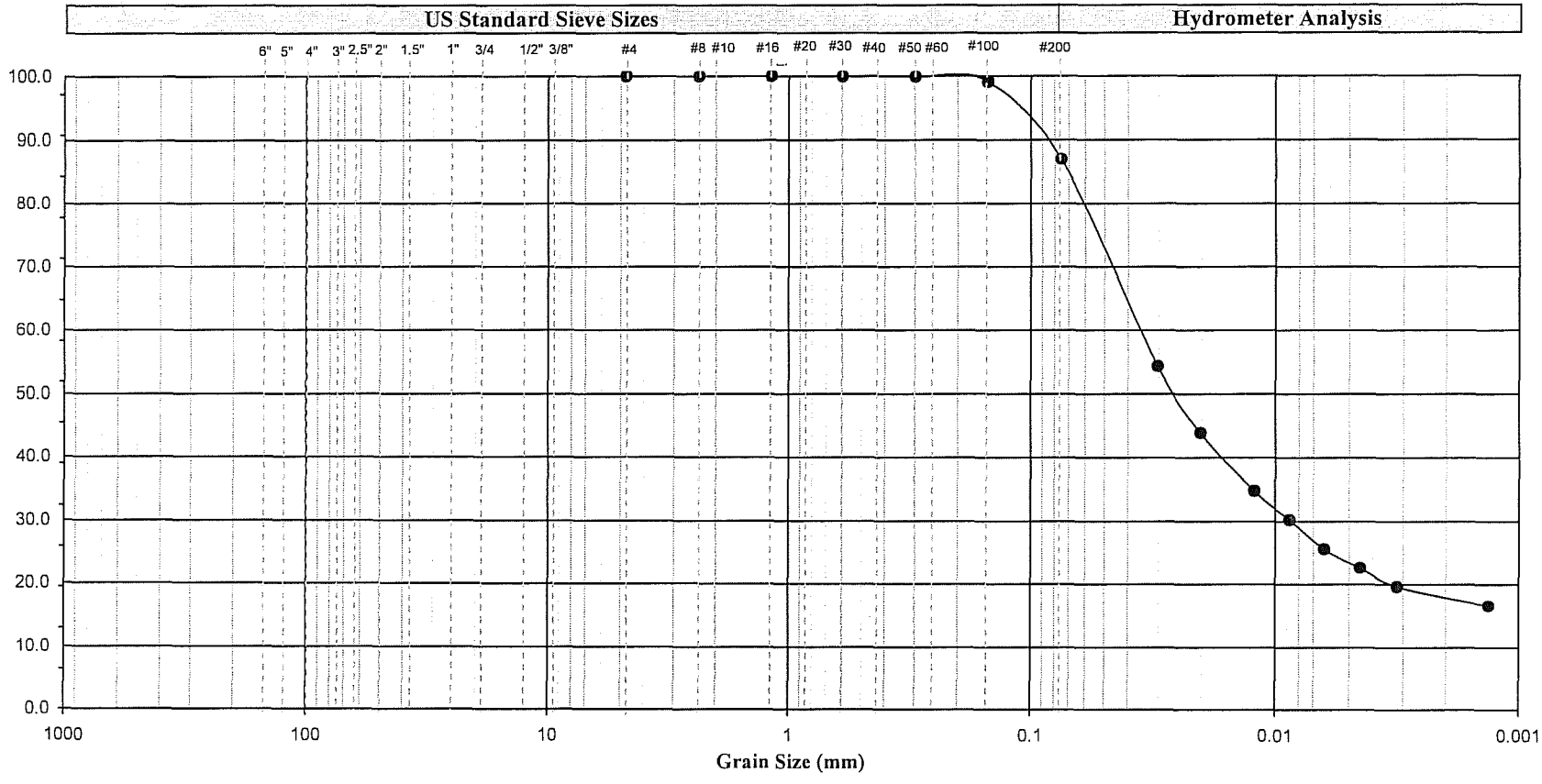
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-14	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	3	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-11		S-17	27		S-15		
Wt. of Wet Soil + Container (gm)		287.08		66.09	177.80			0.99	
Wt. of Dry Soil + Container (gm)					176.85		129.96	Hydrometer Type	
Wt. of Container (gm)					57.68		114.75	152H	
Wt. of Dry Soil (gm)		284.81		65.57			15.21	(K) Value	Temp. °C
Moisture Content (%)					0.80			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				42	No. 16	0.01		99.98	**99.98**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.02		99.97	**99.97**
1.0"					No. 40				
3/4"				27	No. 50	0.07		99.89	**99.89**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.59		99.10	**99.10**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.00		**100.00**	15	No. 200	8.54		86.98	**86.98**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)	w			(K)	(L)	
0:01	(T)							(mm)			(D)
13:42	0:00:00			5.0							
	2	21.0	41.0	5.0	36.0	54.36	**54.36**	0.05500	0.01328	10.4	**0.03027**
	5	21.0	34.0	5.0	29.0	43.79	**43.79**	0.03500	0.01328	11.5	**0.02018**
	15	21.0	28.0	5.0	23.0	34.73	**34.73**	0.02000	0.01328	12.5	**0.01214**
	30	22.0	25.0	5.0	20.0	30.20	**30.20**	0.01400	0.01328	13.0	**0.00875**
	60	23.0	22.0	5.0	17.0	25.67	**25.67**	0.01000	0.01328	13.5	**0.00630**
	120	23.0	20.0	5.0	15.0	22.65	**22.65**	0.00700	0.01328	13.8	**0.00451**
	240	23.5	18.0	5.0	13.0	19.63	**19.63**	0.00500	0.01328	14.2	**0.00316**
	1440	21.5	16.0	5.0	11.0	16.61	**16.61**	0.00100	0.01328	14.5	**0.00133**

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	**0**	**13**	**87**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-053	S-7	35.0	dark greenish gray	Silt	ML
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-053	Prepared By : PA	Date :
Sample No.	: S-9	Tested By : PA	Date :
Depth below Deck	: 45.0	Sieved By : RJ	Date :
Description	: dark olive gray, SILT (ML)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

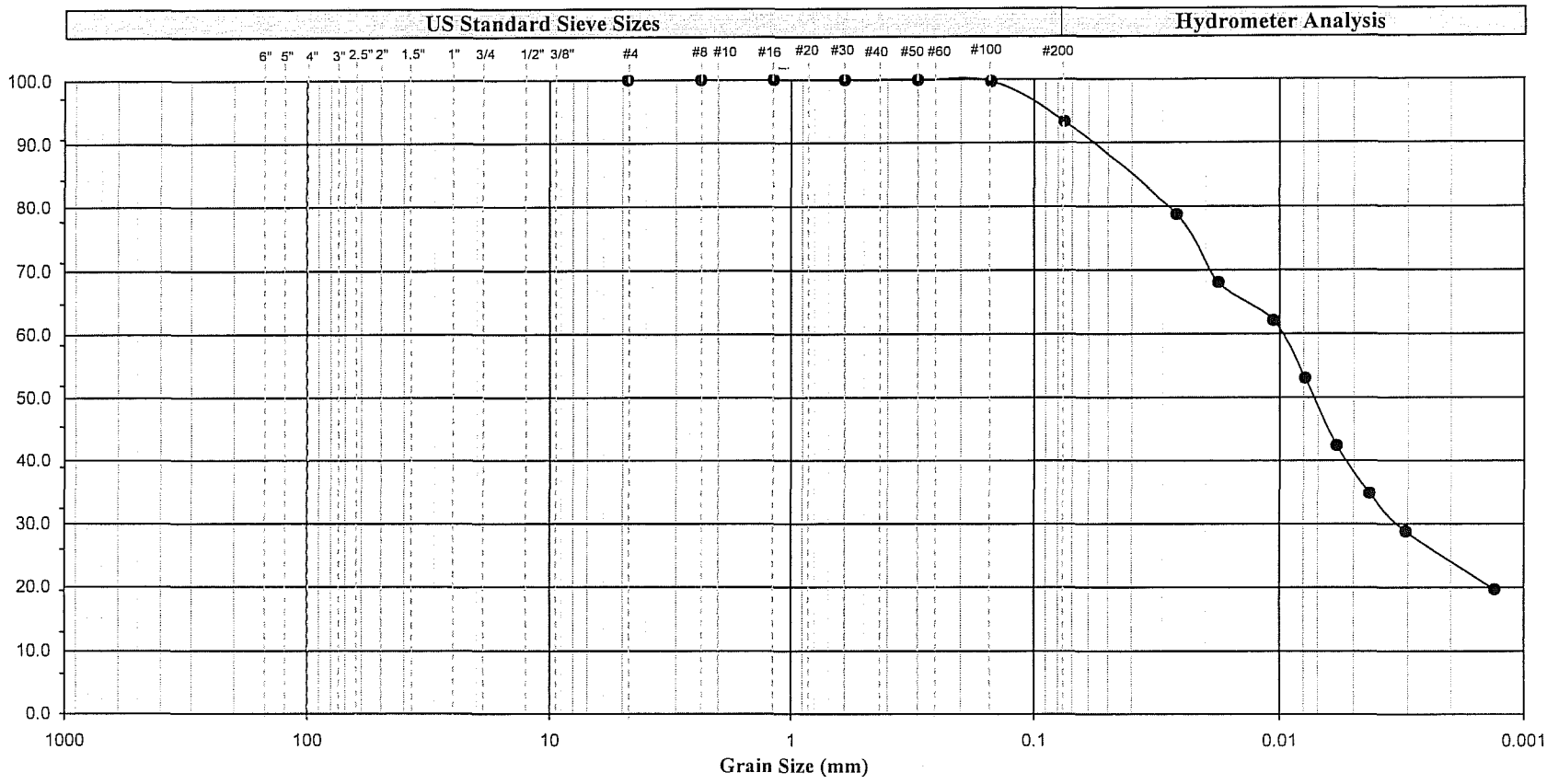
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	J-18	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Test Cylinder No. :	6							Correction factor	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	for difference S.G.	
Container No.		S-11		S-18	29		S-16	0.99	
Wt. of Wet Soil + Container (gm)		225.62		66.06	172.34			Hydrometer Type	
Wt. of Dry Soil + Container (gm)					171.19		119.01	152H	
Wt. of Container (gm)					56.80		114.20	(K) Value	Temp. °C
Wt. of Dry Soil (gm)		223.37		65.40			4.81	0.01328	21.0
Moisture Content (%)					1.01				

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				46	No. 16	0.01		99.98	**99.98**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.03		99.95	**99.95**
1.0"					No. 40				
3/4"				29	No. 50	0.05		99.92	**99.92**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.21		99.68	**99.68**
No. 4	0.00		**100.00**		No. 140				
No. 8	0.00		**100.00**	17	No. 200	4.31		93.41	**93.41**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)	w		(mm)	(K)	(L)	(D)
13:46	0:00:00			5.0							
	2	21.0	57.0	5.0	52.0	78.71	**78.71**	0.05500	0.01328	7.8	**0.02617**
	5	21.0	50.0	5.0	45.0	68.12	**68.12**	0.03500	0.01328	8.9	**0.01774**
	15	21.0	46.0	5.0	41.0	62.06	**62.06**	0.02000	0.01328	9.6	**0.01061**
	30	22.0	40.0	5.0	35.0	52.98	**52.98**	0.01400	0.01328	10.6	**0.00788**
	60	23.0	33.0	5.0	28.0	42.38	**42.38**	0.01000	0.01328	11.7	**0.00587**
	120	23.0	28.0	5.0	23.0	34.82	**34.82**	0.00700	0.01328	12.5	**0.00429**
	240	23.5	24.0	5.0	19.0	28.76	**28.76**	0.00500	0.01328	13.2	**0.00305**
	1440	21.5	18.0	5.0	13.0	19.68	**19.68**	0.00100	0.01328	14.2	**0.00132**

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	**0**	**7**	**93**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-053	S-9	45.0	dark olive gray	Silt	ML
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name	: ACTA/Schuyler Heim Bridge Project				
Project No.	: 06-123-3	Set up By :	J.F	Date :	11/13/2009
Boring No.	: A-09-053	Tested By :	J.F/R.J.	Date :	11/13/09-11/23/09
Sample No.	: D-8	Time Rate Took By :	J.F	Date :	11/16/09,11/18/09
Depth (ft / m)	: 40.0 | 12.20	Computer By :	JF	Date :	11/24/2009
File No.	:	Checked By :	R.J.	Date :	
Soil Description	: Dark gray, SANDY SILT (ML)				

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

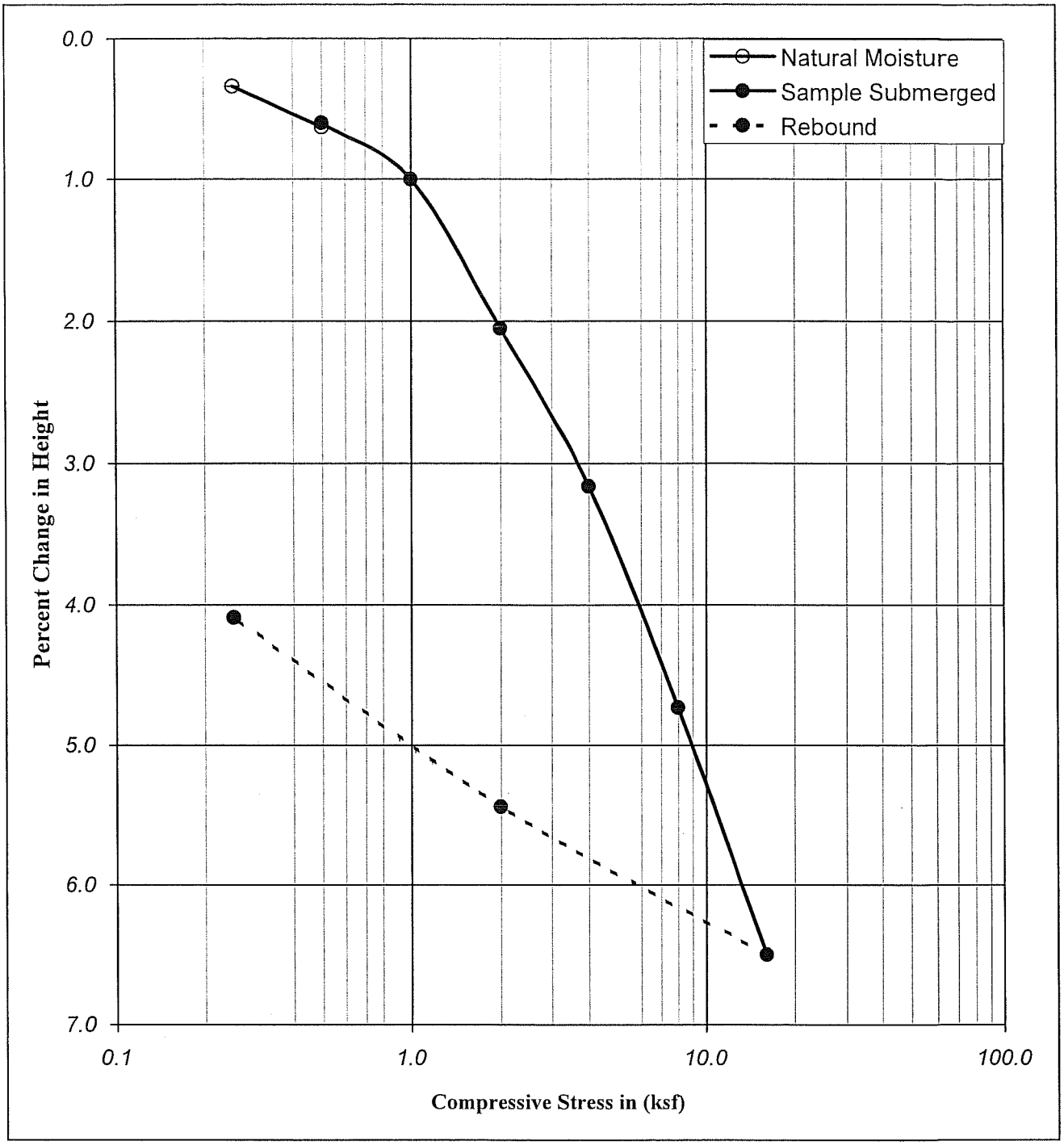
Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.9588	24.35	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
11/13/2009	14:50	0:00:00	Seating		0.04970	1.26		
			Load					
	15:03:00 PM		0.1	4.8	0.05000	1.27	0.00	
11/14/2009	9:10	0:00:00	0.25	12.0	0.05340	1.36	0.34	
11/15/2009	9:42	0:00:00	0.50	23.9	0.05630	1.43	0.63	
			Add Water					
11/16/2009	8:35	0:00:00	0.50	23.9	0.05600	1.42	0.60	
11/16/2009	8:38	0:00:00	1.00	47.9	0.05600	1.42	0.60	0.00
		0.10	1.0	47.9	0.05770	1.47	0.77	0.32
		0.25	1.0	47.9	0.0579	1.47	0.79	0.50
		0.50	1.0	47.9	0.05810	1.48	0.81	0.71
		1	1.0	47.9	0.05820	1.48	0.82	1.00
		2	1.0	47.9	0.05840	1.48	0.84	1.41
		4	1.0	47.9	0.05850	1.49	0.85	2.00
		8	1.0	47.9	0.05860	1.49	0.86	2.83
		15	1.0	47.9	0.05870	1.49	0.87	3.87
		30	1.0	47.9	0.05880	1.49	0.88	5.48
		60	1.0	47.9	0.05890	1.50	0.89	7.75
		120	1.0	47.9	0.05910	1.50	0.91	10.95
		240	1.0	47.9	0.05930	1.51	0.93	15.49
		480	1.0	47.9	0.05950	1.51	0.95	21.91
11/17/2009		1440	1.0	47.9	0.06000	1.52	1.00	37.95
11/18/2009	8:34	0	2.0	95.8	0.07050	1.79	2.05	
11/18/2009	8:42	0	4.0	191.5	0.0705	1.79	2.05	
		0.10	4.0	191.5	0.0759	1.93	2.59	
		0.25	4.0	191.5	0.0769	1.95	2.69	
		0.50	4.0	191.5	0.0777	1.97	2.77	
		1	4.0	191.5	0.0781	1.98	2.81	
		2	4.0	191.5	0.0784	1.99	2.84	
		4	4.0	191.5	0.0787	2.00	2.87	
		8	4.0	191.5	0.0791	2.01	2.91	
		15	4.0	191.5	0.0793	2.01	2.93	
		30	4.0	191.5	0.0796	2.02	2.96	
		60	4.0	191.5	0.0799	2.03	2.99	
		120	4.0	191.5	0.0802	2.04	3.02	
		240	4.0	191.5	0.0807	2.05	3.07	
		480	4.0	191.5	0.0812	2.06	3.12	
11/19/09		1440	4.0	191.5	0.0816	2.07	3.16	

		Before	After
Weight of wet soil + ring (gm)		193.94	
Weight of ring (gm)		43.63	
Weight of wet soil + ring + container (gm)			252.39
Weight of dry soil + ring + container (gm)			219.19
No. 86	Weight of container (gm)		60.06
Weight of ring + container (gm)			103.69
Moisture Content (%)		30.14	28.74
Dial Reading (inch)		0.05	0.04
Sample Volume (ft^3)		0.0027	0.0026
Wet Density (pcf)		124.5	128.4
Dry Density (pcf)		95.66	99.77

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.0973	2.47	4.73
11/21/2009	8:36		16.00	766.1	0.1150	2.92	6.50
11/22/2009	8:42		2.00	95.8	0.1044	2.65	5.44
11/23/2009	8:40		0.25	12.0	0.0909	2.31	4.09

Remark : Final Dial Reading 0.0909



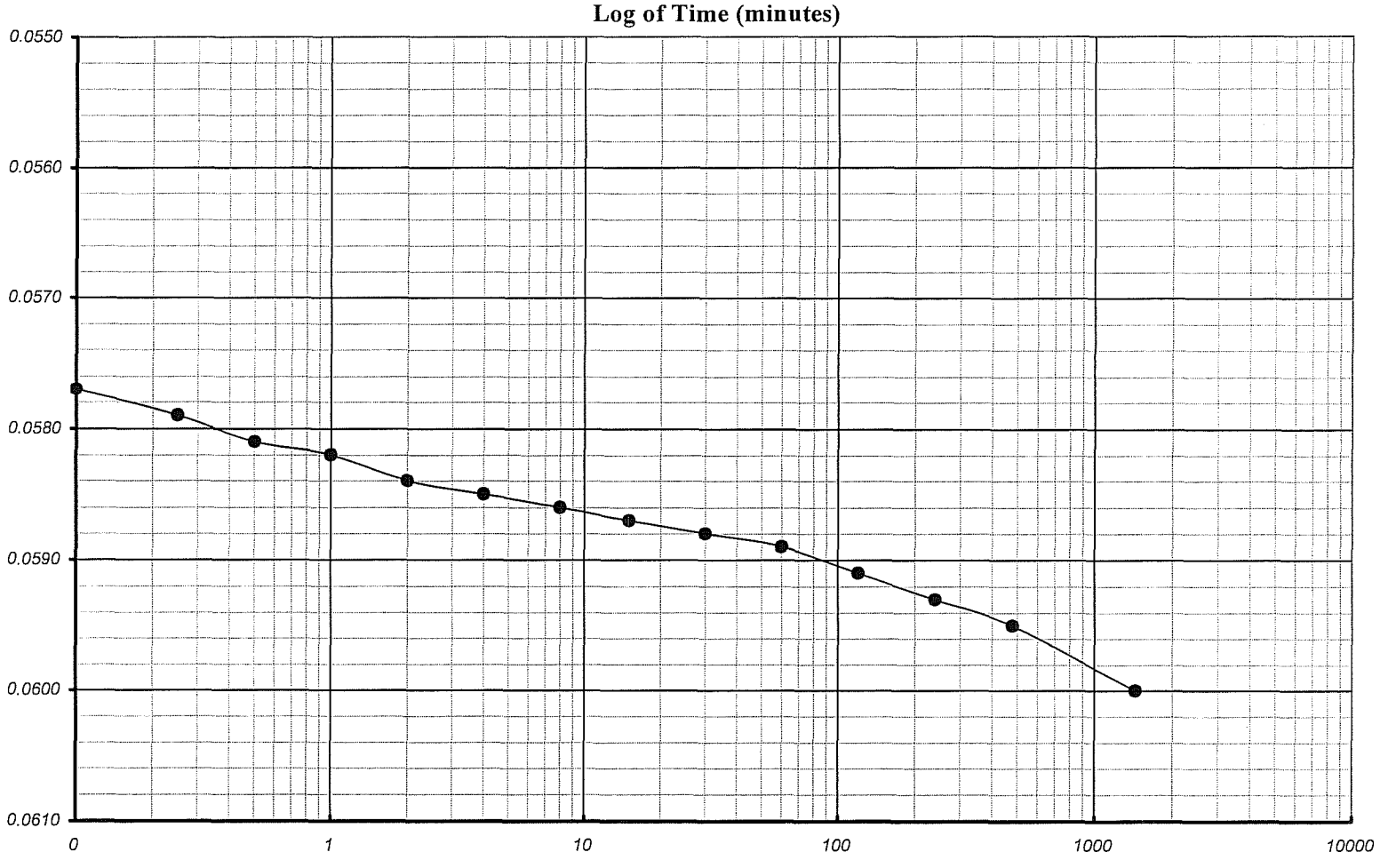
Boring No.	: A-09-053		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	30.14	95.66	15.06	106.78	0.76
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	28.74	99.77	15.70	112.56	0.69
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

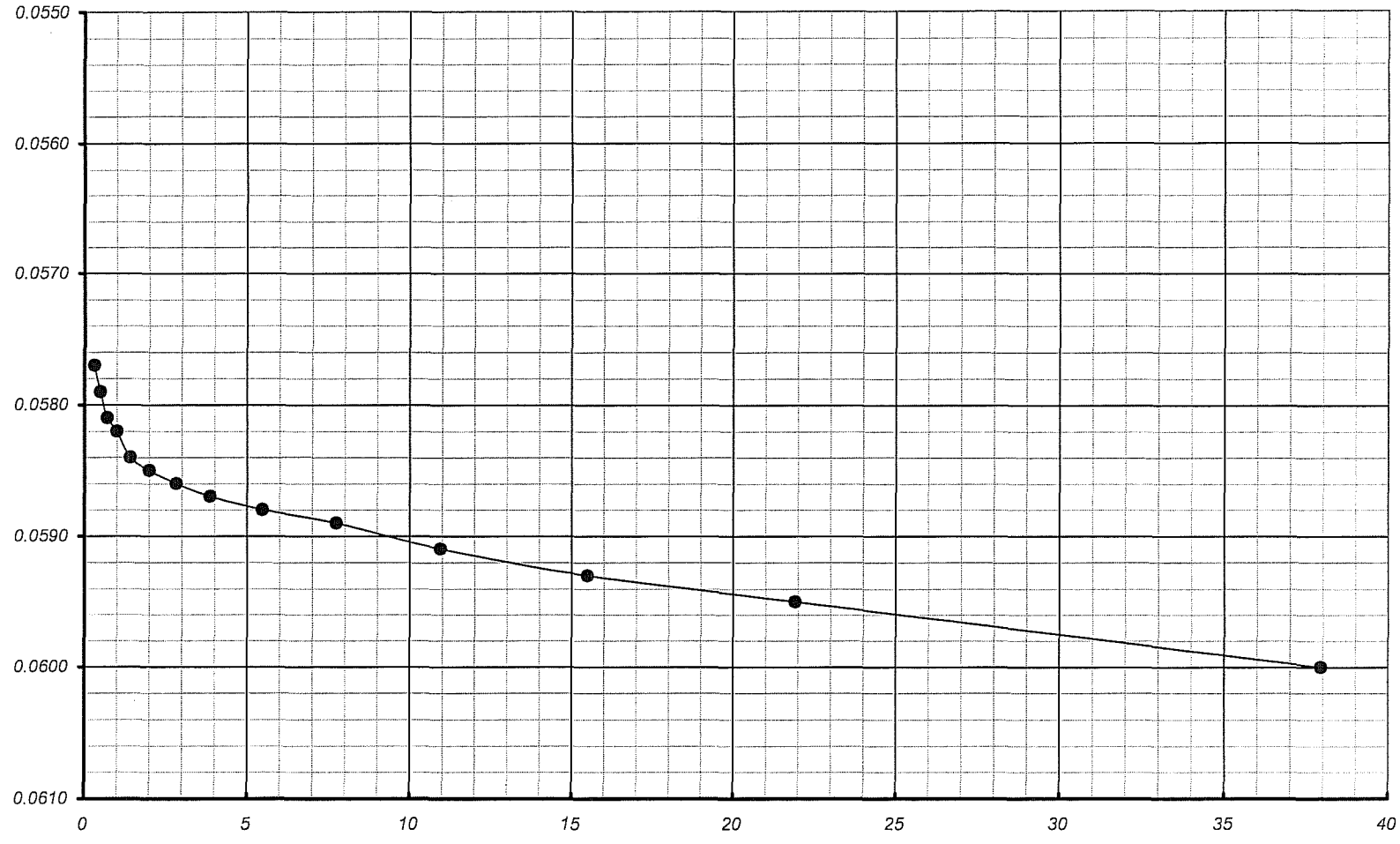
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

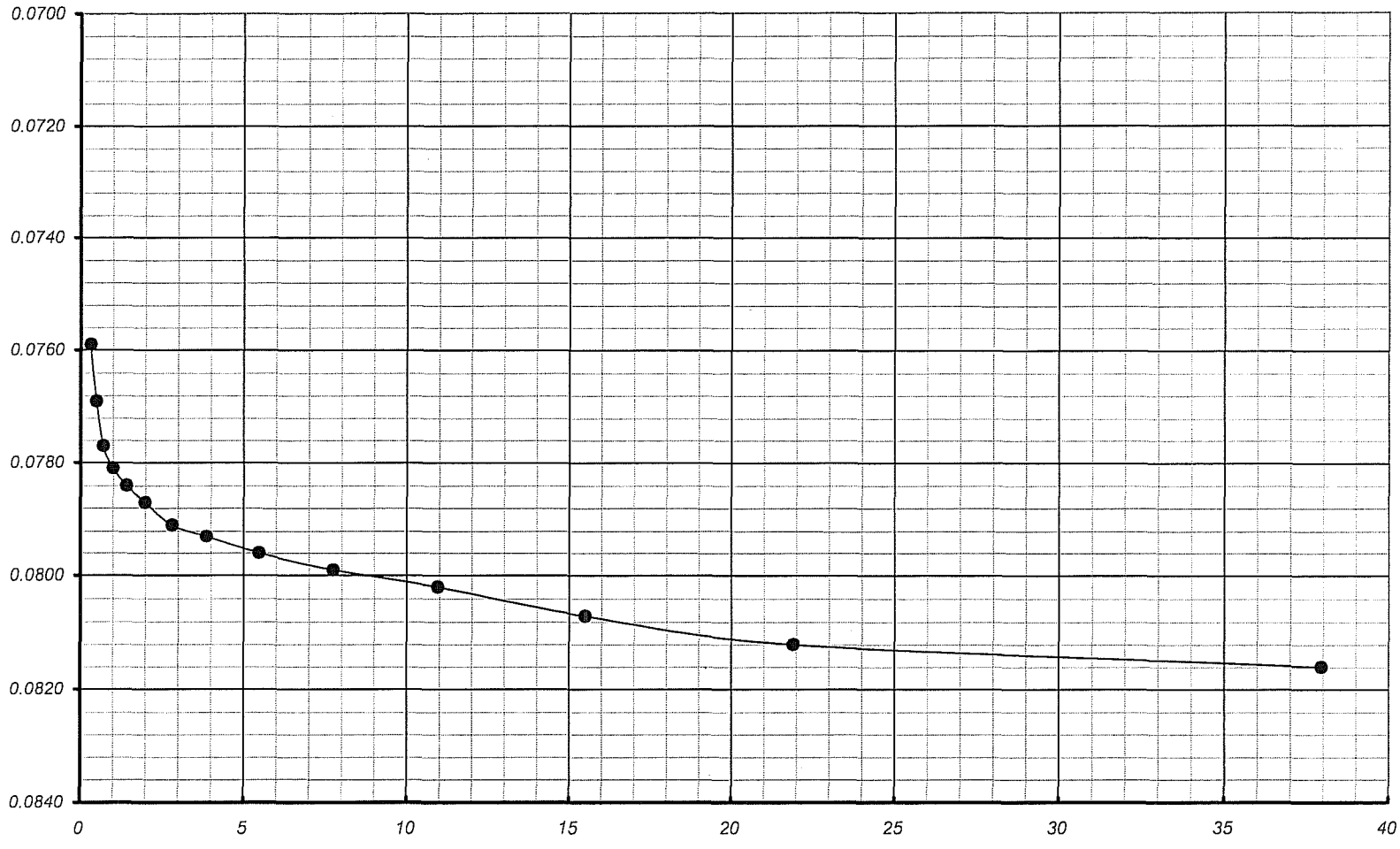


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	***ACTA/Schuyler Heim Bridge Project***	Boring No. : *A-09-053*	**One-Dimensional Consolidation of Soil** **Time-Deformation Curve (Log of Time Method)**
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 1

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-053
Sample No. : D-10
Depth (ft / m) : 50.0 | 15.25
File No. :
Soil Description : Dark gray, SILT with SAND (ML)

Set up By : J.F Date : 11/13/2009
Tested By : J.F/R.J. Date : 11/13/09-11/23/09
Time Rate Took By : J.F Date : 11/16/09, 11/18/09
Computer By : JF Date : 11/24/2009
Checked By : R.J. Date :

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.
Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94	Reload to		
Height (Intial)	1.00	25.40	Load to	16.00	766.08	Rebound to		
Height (Final)	0.9297	23.61	Rebound to	0.25	11.97	Time rate taking at	1.00	47.70

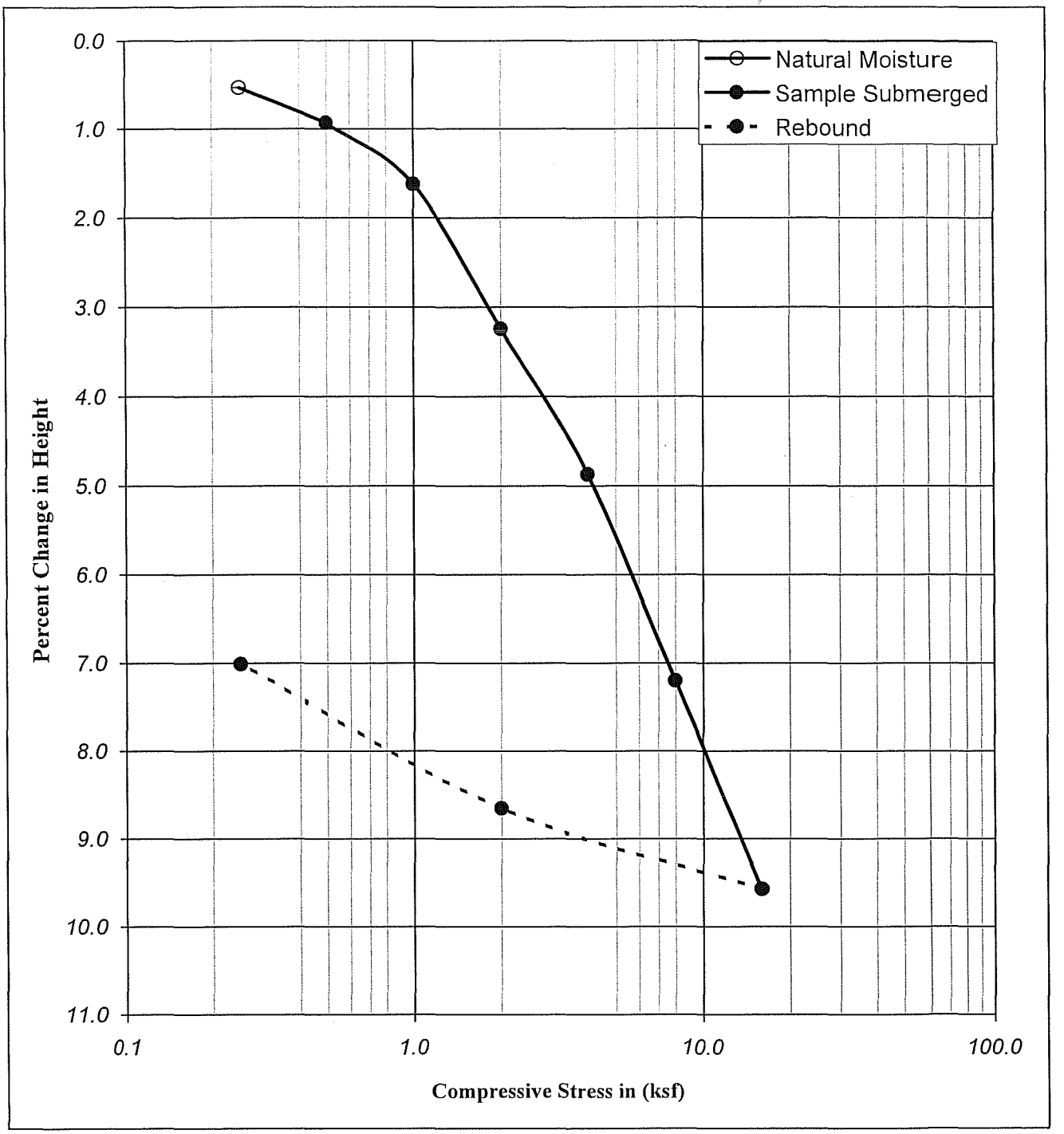
Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/13/2009	14:55	0:00:00	Seating Load		0.04980	1.26	
	15:05		0.1	4.8	0.05000	1.27	0.00
11/14/2009	9:10	0:00:00	0.25	12.0	0.05530	1.40	0.53
11/15/2009	9:42	0:00:00	0.50	23.9	0.05930	1.51	0.93
			Add Water				
11/16/2009	8:35	0:00:00	0.50	23.9	0.05930	1.51	0.93
11/16/2009	8:44	0:00:00	1.00	47.9	0.05930	1.51	0.93
		0.10	1.0	47.9	0.05950	1.51	0.95
		0.25	1.0	47.9	0.0597	1.52	0.97
		0.50	1.0	47.9	0.06000	1.52	1.00
		1	1.0	47.9	0.06040	1.53	1.04
		2	1.0	47.9	0.06080	1.54	1.08
		4	1.0	47.9	0.06120	1.55	1.12
		8	1.0	47.9	0.06160	1.56	1.16
		15	1.0	47.9	0.06210	1.58	1.21
		30	1.0	47.9	0.06260	1.59	1.26
		60	1.0	47.9	0.06310	1.60	1.31
		120	1.0	47.9	0.06360	1.62	1.36
		240	1.0	47.9	0.06460	1.64	1.46
		480	1.0	47.9	0.06570	1.67	1.57
11/17/2009		1440	1.0	47.9	0.06620	1.68	1.62
11/18/2009	8:34	0	2.0	95.8	0.08240	2.09	3.24
11/18/2009	8:42	0	4.0	191.5	0.0824	2.09	3.24
		0.10	4.0	191.5	0.0831	2.11	3.31
		0.25	4.0	191.5	0.0860	2.18	3.60
		0.50	4.0	191.5	0.0885	2.25	3.85
		1	4.0	191.5	0.0897	2.28	3.97
		2	4.0	191.5	0.0908	2.31	4.08
		4	4.0	191.5	0.0923	2.34	4.23
		8	4.0	191.5	0.0928	2.36	4.28
		15	4.0	191.5	0.0935	2.37	4.35
		30	4.0	191.5	0.0945	2.40	4.45
		60	4.0	191.5	0.0953	2.42	4.53
		120	4.0	191.5	0.0961	2.44	4.61
		240	4.0	191.5	0.0972	2.47	4.72
		480	4.0	191.5	0.0980	2.49	4.80
11/19/09		1440	4.0	191.5	0.0987	2.51	4.87

	Before	After
Weight of wet soil + ring (gm)	191.36	
Weight of ring (gm)	43.40	
Weight of wet soil + ring + container (gm)		246.58
Weight of dry soil + ring + container (gm)		216.82
No. 87 Weight of container (gm)		59.79
Weight of ring + container (gm)		103.19
Moisture Content (%)	30.21	26.19
Dial Reading (inch)	0.05	0.04
Sample Volume (ft^3)	0.0027	0.0025
Wet Density (pcf)	122.5	127.7
Dry Density (pcf)	94.11	101.23

SQRT Time
0.00
0.32
0.50
0.71
1.00
1.41
2.00
2.83
3.87
5.48
7.75
10.95
15.49
21.91
37.95

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
11/20/2009	8:30		8.00	383.0	0.1220	3.10	7.20
11/21/2009	8:36		16.00	766.1	0.1457	3.70	9.57
11/22/2009	8:42		2.00	95.8	0.1365	3.47	8.65
11/23/2009	8:40		0.25	12.0	0.1201	3.05	7.01

Remark : Final Dial Reading 0.1201



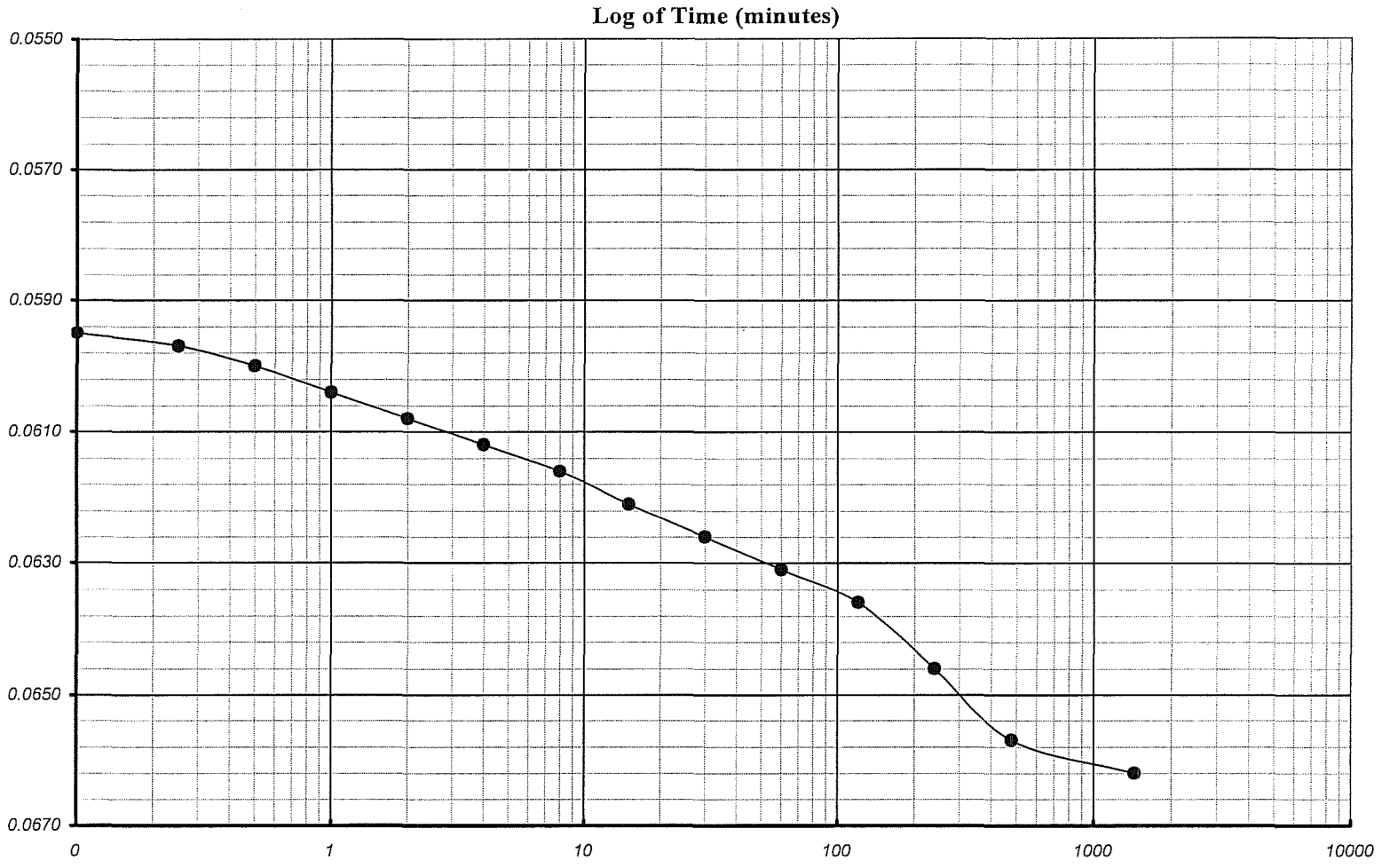
Boring No. : A-09-053			Liquid Limit :	-		Moisture Content (%)	Dry Density		Percent Saturation	Void Ratio
Sample No. : D-10			Plastic Limit :	-			(pcf)	(kN/m³)		
Depth	(ft) : 50.0	51.5	Plastic Index :	-	Initial	30.21	94.11	14.81	103.12	0.79
	(m) : 15.25	15.71	Specific Gravity :	2.70	Final	26.19	101.23	15.93	106.31	0.67
Description : Dark gray, SILT with SAND (ML)										

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

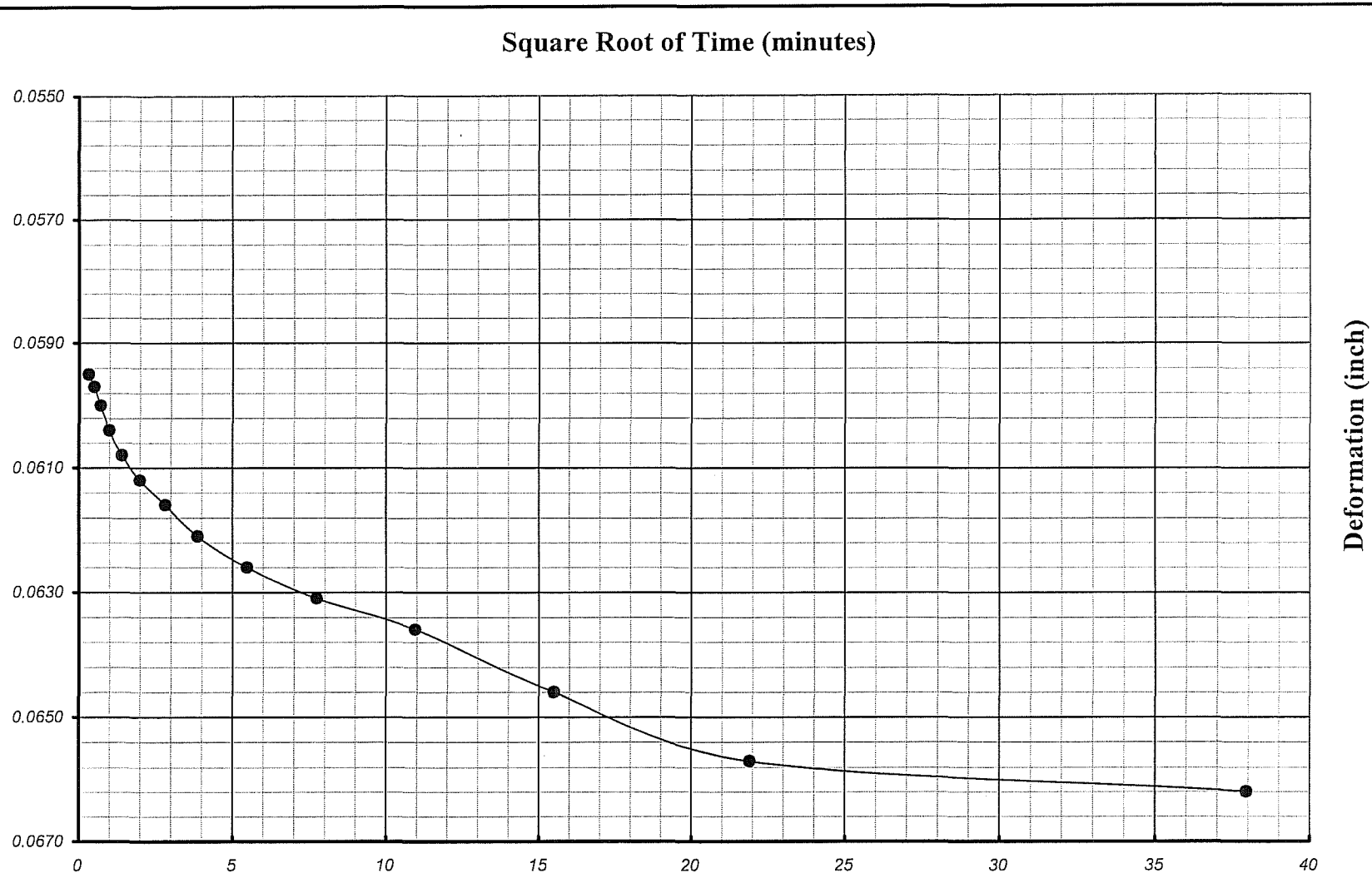
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 11/24/09

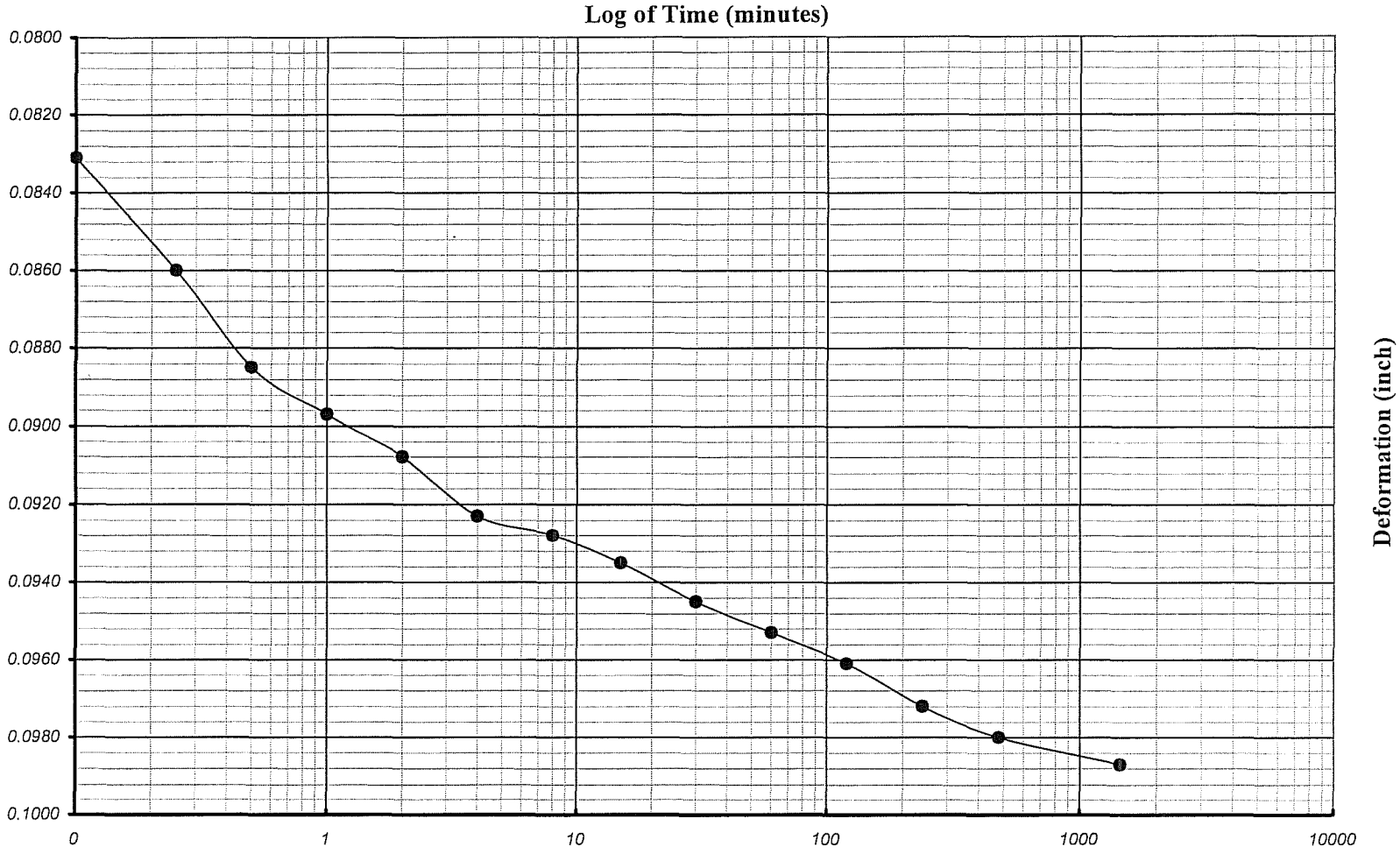
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



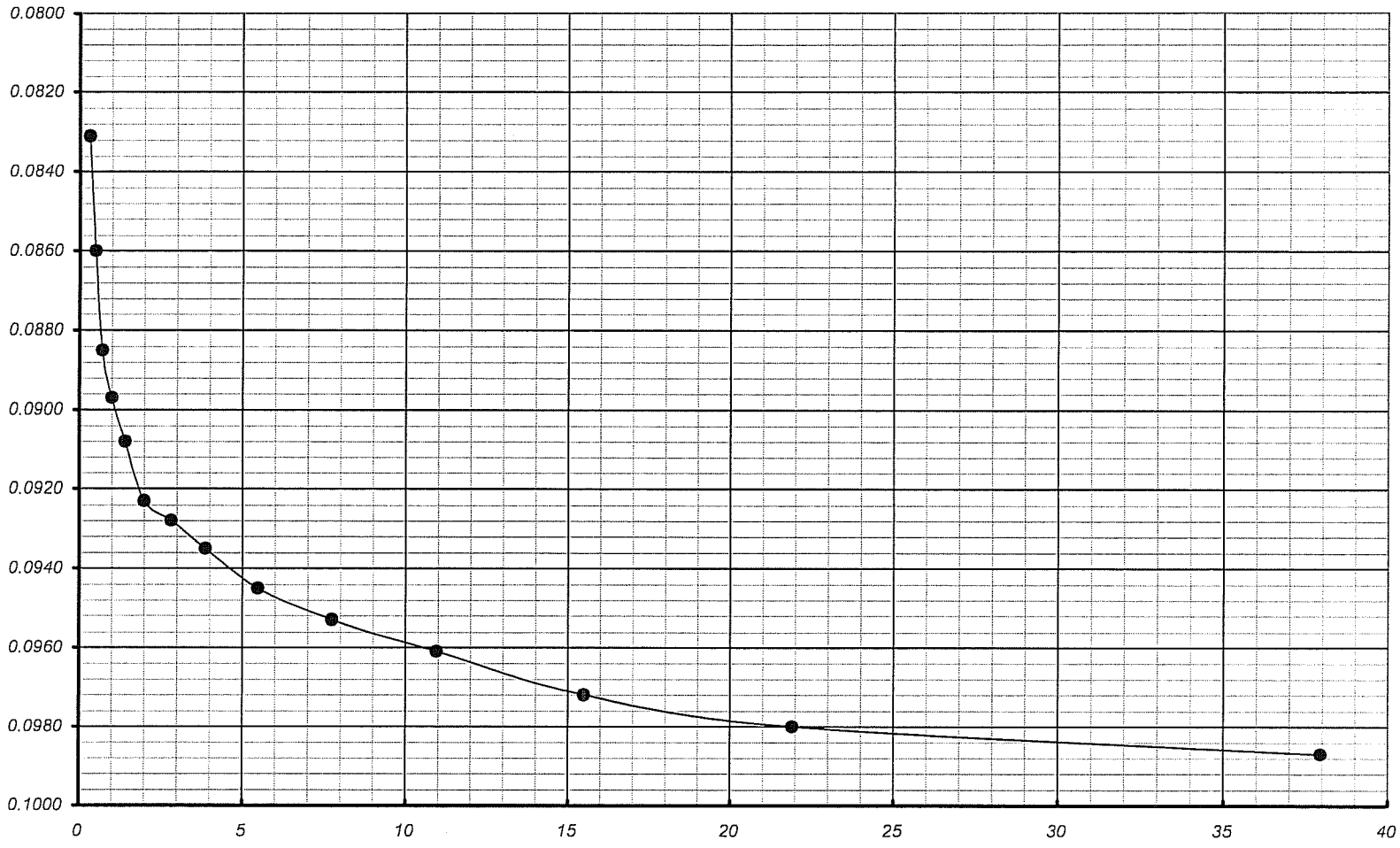
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-053	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-10	
EMI Project No. : 06-123-3		Depth (ft/m) : 50.0 15.3	Veritcal Load (ksf/kpa) : 1.00 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-10*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *50.0* *15.3*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-053	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-10	
EMI Project No. : 06-123-3		Depth (ft/m) : 50.0 15.3	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-053*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-10*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *50.0* *15.3*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-053		Saturated		Field Moisiture	X	Inundated		**Specific Gravity** (Assumed) :	2.70
Sample No. : D-2	X	Undisturbed		Remolded		Consolidated-Drained		**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 10.0	x	Shear Once		Reshear		Residual		**Data File Number :**	0612303
Description : Dark grayish brown, Poorly graded SAND with SILT (SP-SM)									

Percent Saturation (%)	106.86	**File No. :** 0612303 1																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09																			
Computed By : JF	**Date :** 12/11/09	**1.00** (ksf)																		
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		197.84																		
Weight of Ring (gm)		44.68																		
Weight of Wet Soil + Cont. (gm)				154.63																
Weight of Dry Soil + Cont. (gm)				122.13																
Weight of Cont. (gm) **No.**	7			3.72																
Moisture Content (%)				27.45																
Wet Density (pcf / kN/m³)		126.85	19.97																	
Dry Density (pcf / kN/m³)		99.53	15.67																	
Percent Saturation (%)	69.29	**File No. :** 0612303 2																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	**2.00** (ksf)																		
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		210.42																		
Weight of Ring (gm)		44.83																		
Weight of Wet Soil + Cont. (gm)				146.39																
Weight of Dry Soil + Cont. (gm)				135.11																
Weight of Cont. (gm) **No.**	8			3.74																
Moisture Content (%)				8.59																
Wet Density (pcf / kN/m³)		137.15	21.59																	
Dry Density (pcf / kN/m³)		126.30	19.88																	
Percent Saturation (%)	104.96	**File No. :** 0612303 3																		
Prepared By : JF	**Date :** 11/30/09	**Normal Stress**																		
Tested By : JF	**Date :** 11/30/09	**4.00** (ksf)																		
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		193.60																		
Weight of Ring (gm)		42.47																		
Weight of Wet Soil + Cont. (gm)				152.52																
Weight of Dry Soil + Cont. (gm)				119.73																
Weight of Cont. (gm) **No.**	9			3.78																
Moisture Content (%)				28.28																
Wet Density (pcf / kN/m³)		125.17	19.70																	
Dry Density (pcf / kN/m³)		97.58	15.36																	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.86	41.37	1.68	80.44	3.11	148.81
Ultimate	0.68	32.75	1.26	60.33	2.64	126.40

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)**								
		1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	588	0.59	28.2	972	0.97	46.5	1500	1.50	71.6
0.020	0.05	732	0.73	35.0	1308	1.31	62.6	2016	2.02	96.2
0.030	0.08	828	0.83	39.6	1500	1.50	71.8	2340	2.34	111.6
0.040	0.10	864	0.86	41.4	1632	1.63	78.1	2544	2.54	121.4
0.050	0.13	864	0.86	41.4	1680	1.68	80.4	2684	2.68	128.0
0.060	0.15	852	0.85	40.8	1680	1.68	80.4	2772	2.77	132.2
0.070	0.18	816	0.82	39.1	1620	1.62	77.6	2904	2.90	138.5
0.080	0.20	792	0.79	37.9	1572	1.57	75.3	3000	3.00	143.1
0.090	0.23	780	0.78	37.3	1500	1.50	71.8	3060	3.06	146.0
0.100	0.25	780	0.78	37.3	1428	1.43	68.4	3108	3.11	148.3
0.110	0.28	780	0.78	37.3	1380	1.38	66.1	3108	3.11	148.3
0.120	0.30	768	0.77	36.8	1344	1.34	64.4	3060	3.06	146.0
0.130	0.33	780	0.78	37.3	1308	1.31	62.6	2940	2.94	140.2
0.140	0.36	756	0.76	36.2	1296	1.30	62.1	2772	2.77	132.2
0.150	0.38	768	0.77	36.8	1272	1.27	60.9	2688	2.69	128.2
0.160	0.41	768	0.77	36.8	1260	1.26	60.3	2664	2.66	127.1
0.170	0.43	756	0.76	36.2	1260	1.26	60.3	2676	2.68	127.7
0.180	0.46	756	0.76	36.2	1260	1.26	60.3	2676	2.68	127.7
0.190	0.48	756	0.76	36.2	1260	1.26	60.3	2700	2.70	128.8
0.200	0.51	756	0.76	36.2	1260	1.26	60.3	2712	2.71	129.4
0.210	0.53	744	0.74	35.6	1260	1.26	60.3	2724	2.72	129.9
0.220	0.56	744	0.74	35.6	1260	1.26	60.3	2724	2.72	129.9
0.230	0.58	744	0.74	35.6	1260	1.26	60.3	2724	2.72	129.9
0.240	0.61	732	0.73	35.0	1260	1.26	60.3	2712	2.71	129.4
0.250	0.64	732	0.73	35.0	1260	1.26	60.3	2724	2.72	129.9
0.260	0.66	732	0.73	35.0	1260	1.26	60.3	2724	2.72	129.9
0.270	0.69	720	0.72	34.5	1260	1.26	60.3	2724	2.72	129.9
0.280	0.71	708	0.71	33.9	1260	1.26	60.3	2712	2.71	129.4
0.290	0.74	708	0.71	33.9	1260	1.26	60.3	2724	2.72	129.9
0.300	0.76	708	0.71	33.9	1260	1.26	60.3	2700	2.70	128.8
0.310	0.79	708	0.71	33.9	1260	1.26	60.3	2712	2.71	129.4
0.320	0.81	708	0.71	33.9	1260	1.26	60.3	2712	2.71	129.4
0.330	0.84	708	0.71	33.9	1272	1.27	60.9	2700	2.70	128.8
0.340	0.86	708	0.71	33.9	1272	1.27	60.9	2676	2.68	127.7
0.350	0.89	696	0.70	33.3	1272	1.27	60.9	2676	2.68	127.7
0.360	0.91	708	0.71	33.9	1272	1.27	60.9	2676	2.68	127.7
0.370	0.94	696	0.70	33.3	1272	1.27	60.9	2652	2.65	126.5
0.380	0.97	696	0.70	33.3	1272	1.27	60.9	2652	2.65	126.5
0.390	0.99	696	0.70	33.3	1260	1.26	60.3	2652	2.65	126.5
0.400	1.02	684	0.68	32.7	1260	1.26	60.3	2640	2.64	125.9
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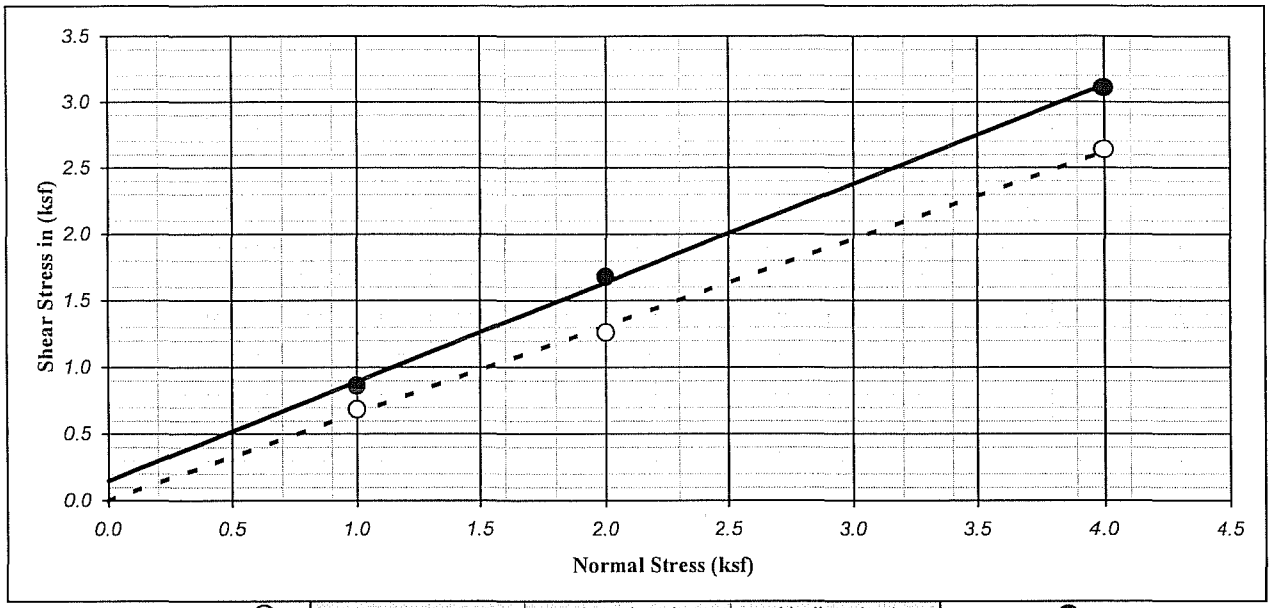
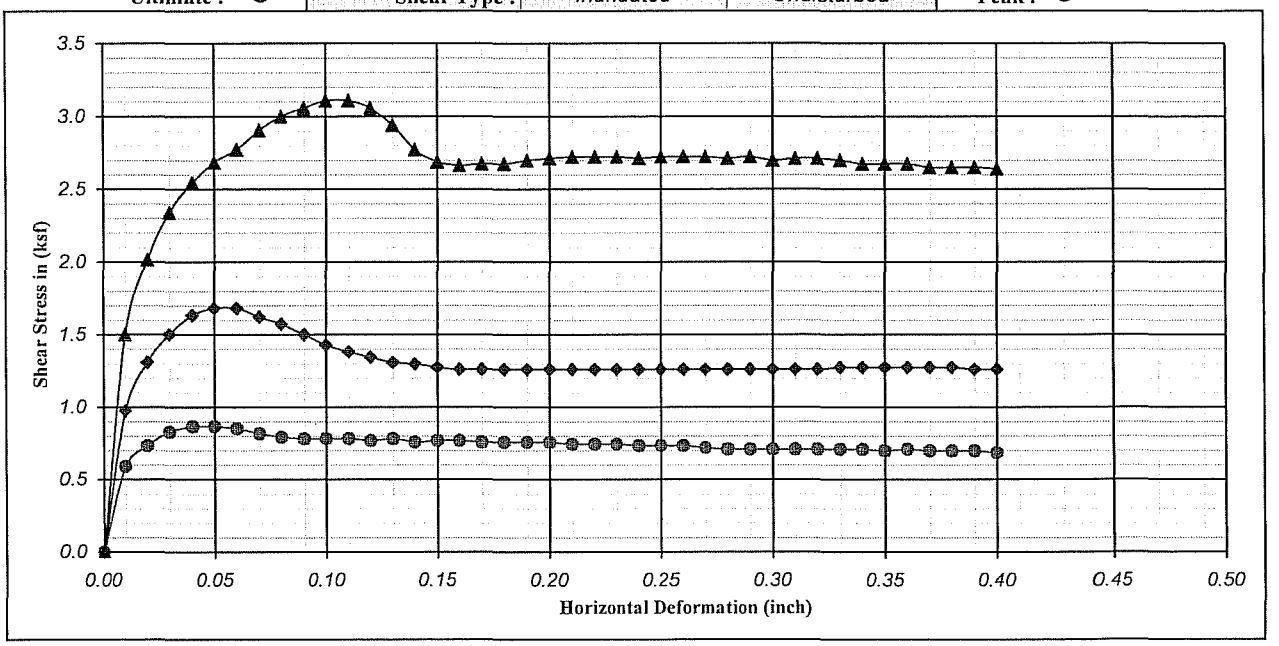
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No. : *A-09-053*	**Strength Intercept (C) :**	*0.15*	(ksf)		*0.00*	(ksf)	
Sample No. : *D-2*		*7.18*	(kPa)	**Peak**	*0.00*	(kPa)	**Ultimate**
Depth (ft/m) : *10.0* | *0.00*	**Friction Angle (ϕ) :**	*36.62*	Degree		*33.24*	Degree	

Description : *Dark grayish brown, Poorly graded SAND with SILT (SP-SM)* **Shear Rate** (inch/minute) : *0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*27.45*	*99.53*	*15.67*	*0.69*	*1.00*	*47.88*	*0.86*	*41.37*	*0.68*	*32.75*
◆	*8.59*	*126.30*	*19.88*	*0.33*	*2.00*	*95.76*	*1.68*	*80.44*	*1.26*	*60.33*
▲	*28.28*	*97.58*	*15.36*	*0.73*	*4.00*	*191.52*	*3.11*	*148.81*	*2.64*	*126.40*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* **Date :** *11/30/09*

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. :	A-09-053		Saturated		Field Moisture	X	Inundated	**Specific Gravity (Assumed) :** 2.70
Sample No. :	D-6	X	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate (inch/min) :** 0.02
Depth (ft/m) :	30.0	x	Shear Once		Reshear		Residual	**Data File Number :** 0911804

Description : Gray, SILTY SAND (SM)

Specimen 1

Percent Saturation (%)	100.95	File No. : 0911804	1
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09		
Computed By : JF	Date : 12/11/09	2.00	(ksf)
Checked By :	Date :		

Percent Consolidation (%)		Before		After
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		190.81		
Weight of Ring (gm)		44.91		
Weight of Wet Soil + Cont. (gm)				149.76
Weight of Dry Soil + Cont. (gm)				115.30
Weight of Cont. (gm) No.	10			3.65
Moisture Content (%)				30.86
Wet Density (pcf / kN/m³)		120.84	19.02	
Dry Density (pcf / kN/m³)		92.34	14.53	

Specimen 2

Percent Saturation (%)	104.25	File No. : 0911804	2
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09	4.00	(ksf)

Percent Consolidation (%)		Before		After
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		190.63		
Weight of Ring (gm)		43.63		
Weight of Wet Soil + Cont. (gm)				149.90
Weight of Dry Soil + Cont. (gm)				114.53
Weight of Cont. (gm) No.	11			3.65
Moisture Content (%)				31.90
Wet Density (pcf / kN/m³)		121.75	19.16	
Dry Density (pcf / kN/m³)		92.30	14.53	

Specimen 3

Percent Saturation (%)	103.92	File No. : 0911804	3
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09	6.00	(ksf)

Percent Consolidation (%)		Before		After
Height of Sample (inch)		1.00		1.0000
Diameter of Sample (inch)		2.42		2.42
Dial Reading-Consolidation (inch)				
Weight of Soil + Ring (gm)		190.38		
Weight of Ring (gm)		43.43		
Weight of Wet Soil + Cont. (gm)				149.40
Weight of Dry Soil + Cont. (gm)				114.29
Weight of Cont. (gm) No.	12			3.65
Moisture Content (%)				31.73
Wet Density (pcf / kN/m³)		121.71	19.16	
Dry Density (pcf / kN/m³)		92.39	14.54	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.54	73.54	2.69	128.70	3.95	189.03
Ultimate	1.31	62.63	2.44	116.64	3.67	175.82

Shear Data

Shear Deflection		Normal Stress (psf/ksf/kPa)								
		2000	2.00	95.8	4000	4.0	191.5	6000	6.0	287.3
(inch)	(mm)	Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	780	0.78	37.3	920	0.92	44.0	1312	1.31	62.6
0.020	0.05	1020	1.02	48.8	1200	1.20	57.5	1956	1.96	93.3
0.030	0.08	1152	1.15	55.2	1608	1.61	77.0	2376	2.38	113.3
0.040	0.10	1272	1.27	60.9	1860	1.86	89.1	2760	2.76	131.7
0.050	0.13	1356	1.36	64.9	2076	2.08	99.4	3060	3.06	146.0
0.060	0.15	1416	1.42	67.8	2220	2.22	106.3	3276	3.28	156.3
0.070	0.18	1464	1.46	70.1	2340	2.34	112.0	3456	3.46	164.9
0.080	0.20	1500	1.50	71.8	2436	2.44	116.6	3588	3.59	171.2
0.090	0.23	1524	1.52	73.0	2520	2.52	120.7	3684	3.68	175.7
0.100	0.25	1536	1.54	73.5	2580	2.58	123.5	3768	3.77	179.7
0.110	0.28	1536	1.54	73.5	2616	2.62	125.3	3840	3.84	183.2
0.120	0.30	1524	1.52	73.0	2640	2.64	126.4	3876	3.88	184.9
0.130	0.33	1464	1.46	70.1	2676	2.68	128.1	3900	3.90	186.0
0.140	0.36	1416	1.42	67.8	2688	2.69	128.7	3924	3.92	187.2
0.150	0.38	1368	1.37	65.5	2688	2.69	128.7	3948	3.95	188.3
0.160	0.41	1344	1.34	64.4	2676	2.68	128.1	3948	3.95	188.3
0.170	0.43	1320	1.32	63.2	2664	2.66	127.6	3948	3.95	188.3
0.180	0.46	1308	1.31	62.6	2628	2.63	125.8	3948	3.95	188.3
0.190	0.48	1308	1.31	62.6	2580	2.58	123.5	3948	3.95	188.3
0.200	0.51	1308	1.31	62.6	2556	2.56	122.4	3936	3.94	187.8
0.210	0.53	1308	1.31	62.6	2520	2.52	120.7	3900	3.90	186.0
0.220	0.56	1308	1.31	62.6	2520	2.52	120.7	3864	3.86	184.3
0.230	0.58	1308	1.31	62.6	2496	2.50	119.5	3828	3.83	182.6
0.240	0.61	1308	1.31	62.6	2496	2.50	119.5	3792	3.79	180.9
0.250	0.64	1308	1.31	62.6	2496	2.50	119.5	3756	3.76	179.2
0.260	0.66	1308	1.31	62.6	2508	2.51	120.1	3732	3.73	178.0
0.270	0.69	1320	1.32	63.2	2508	2.51	120.1	3720	3.72	177.5
0.280	0.71	1320	1.32	63.2	2508	2.51	120.1	3708	3.71	176.9
0.290	0.74	1320	1.32	63.2	2496	2.50	119.5	3708	3.71	176.9
0.300	0.76	1332	1.33	63.8	2484	2.48	118.9	3708	3.71	176.9
0.310	0.79	1332	1.33	63.8	2484	2.48	118.9	3708	3.71	176.9
0.320	0.81	1332	1.33	63.8	2484	2.48	118.9	3696	3.70	176.3
0.330	0.84	1332	1.33	63.8	2472	2.47	118.4	3696	3.70	176.3
0.340	0.86	1332	1.33	63.8	2472	2.47	118.4	3696	3.70	176.3
0.350	0.89	1332	1.33	63.8	2448	2.45	117.2	3684	3.68	175.7
0.360	0.91	1332	1.33	63.8	2436	2.44	116.6	3684	3.68	175.7
0.370	0.94	1332	1.33	63.8	2448	2.45	117.2	3684	3.68	175.7
0.380	0.97	1332	1.33	63.8	2448	2.45	117.2	3684	3.68	175.7
0.390	0.99	1332	1.33	63.8	2460	2.46	117.8	3684	3.68	175.7
0.400	1.02	1332	1.33	63.8	2472	2.47	118.4	3672	3.67	175.2
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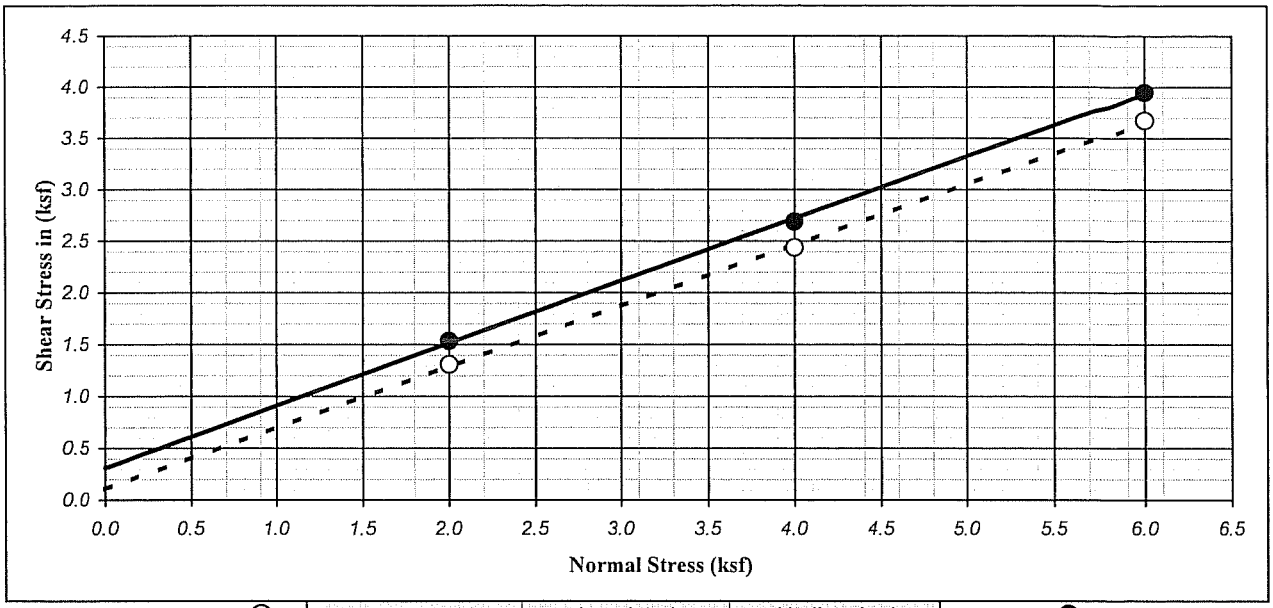
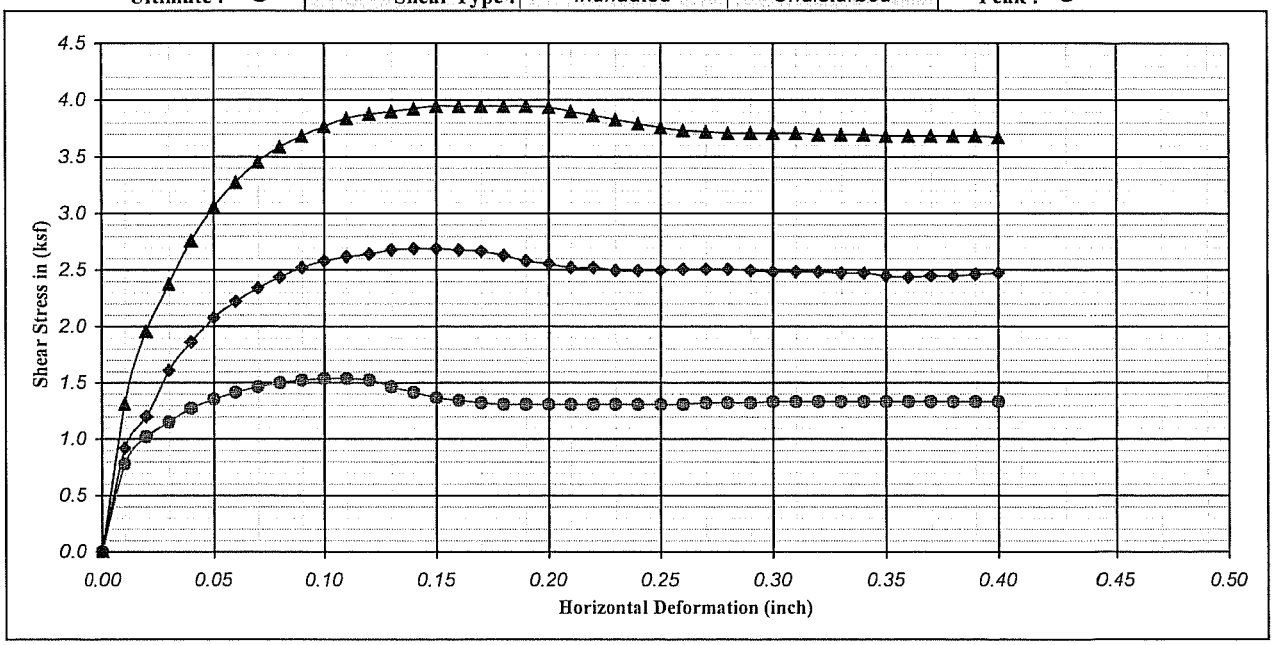


Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No. : *A-09-053*		**Strength Intercept (C) :**	*0.31*	(ksf)		*0.11*	(ksf)	
Sample No. : *D-6*			*14.94*	(kPa)	**Peak**	*5.17*	(kPa)	**Ultimate**
Depth (ft/m) : *30.0*	*0.00*	**Friction Angle (ϕ) :**	*31.09*	Degree		*30.58*	Degree	
Description : *Gray, SILTY SAND (SM)*						**Shear Rate** (inch/minute) :		*0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*30.86*	*92.34*	*14.53*	*0.83*	*2.00*	*95.76*	*1.54*	*73.54*	*1.31*	*62.63*
◆	*31.90*	*92.30*	*14.53*	*0.83*	*4.00*	*191.52*	*2.69*	*128.70*	*2.44*	*116.64*
▲	*31.73*	*92.39*	*14.54*	*0.82*	*6.00*	*287.28*	*3.95*	*189.03*	*3.67*	*175.82*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* | **Date :** *11/30/09*

Figure No. :

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/12/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-001	S-02	10	5.03
R-09-001	S-04	20	3.29
R-09-001	S-08	40	32.62
R-09-001	S-12	60	49.91

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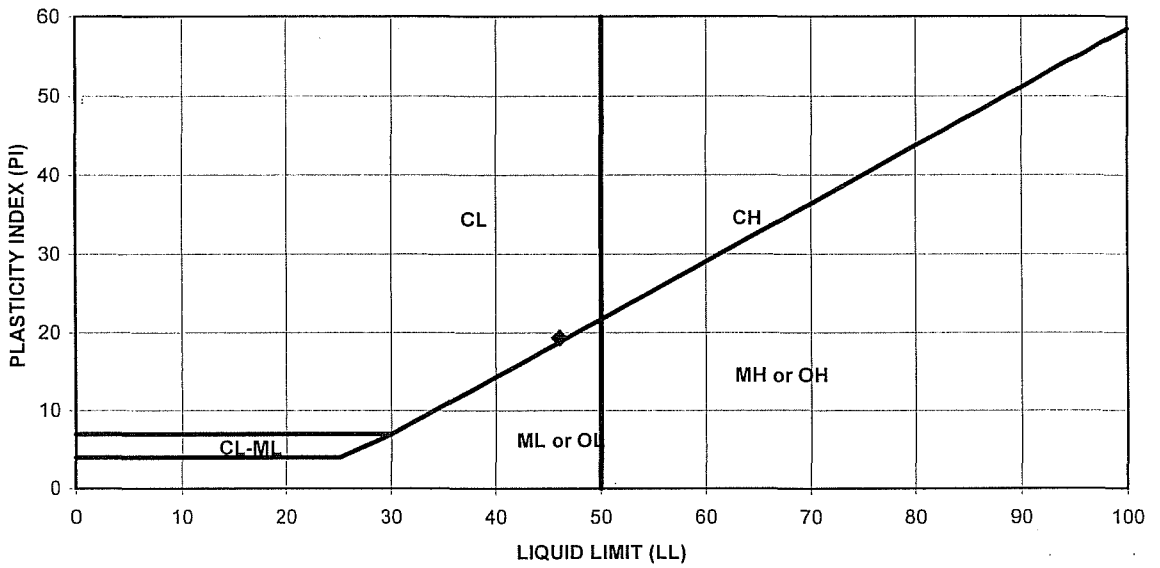
AP Engineering & Testing, Inc.

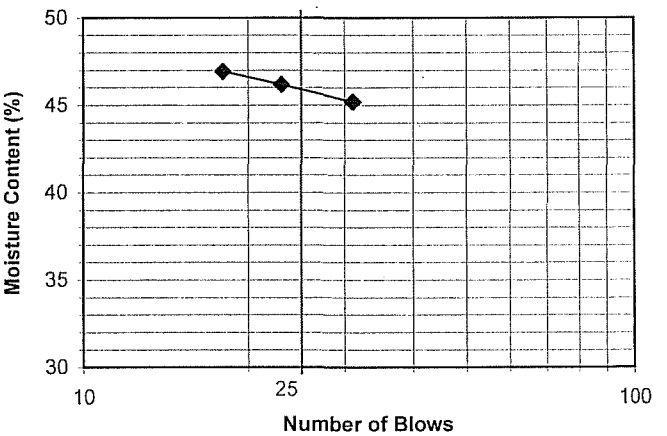
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/12/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-001	D-11	55	46	27	19	CL

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/12/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-001	S-02	10	SP-SM	1400	7.4	158	407

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/13/09

Boring No.: R-09-001 Checked By: AP Date: 12/01/09

Sample No.: D-07 Depth (ft): 35

Description: Dark Gray Poorly-Graded w/silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	574.89
Total Ring Weight (g)	135.20
Wet Density (pcf)	121.89
Dry Density (pcf)	95.26

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.11	104.07
Wet Soil+Cont. (g)	203.51	524.35
Dry Soil+Cont. (g)	170.00	427.51
Moisture Content (%)	28.0	29.9
Degree Saturation	98.1	100.4

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

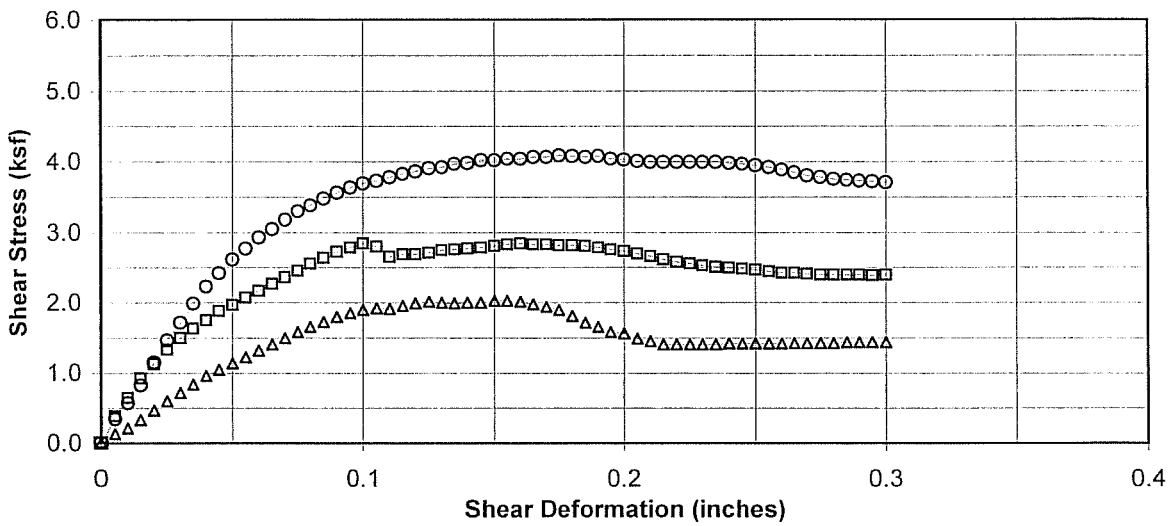
Shear Distance (in): **0.3**

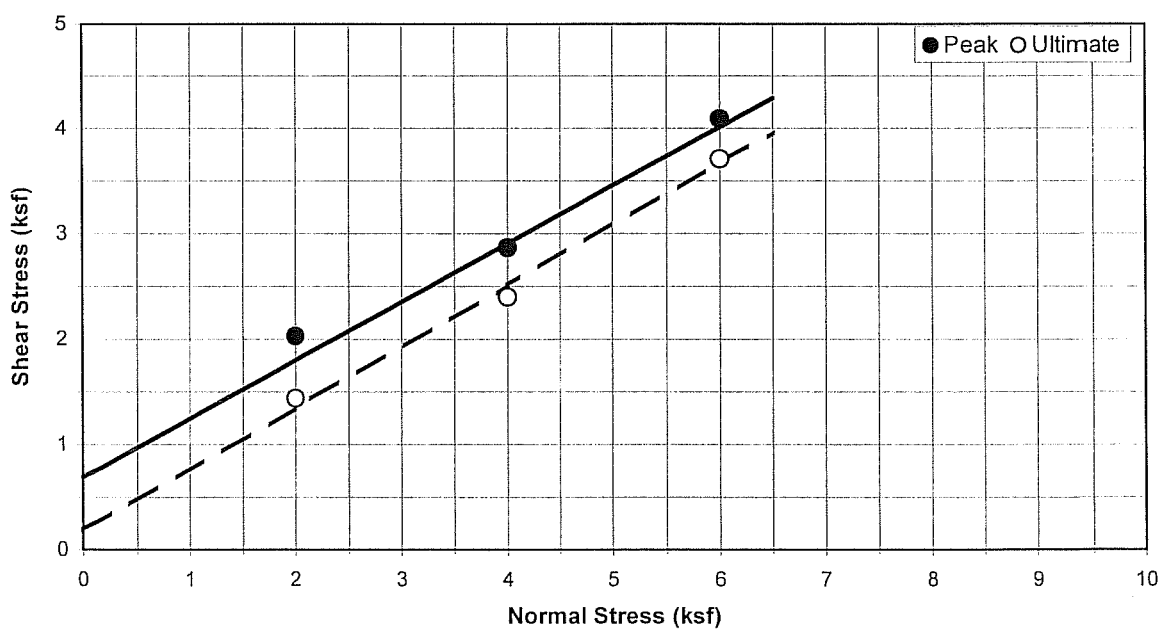
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**194.47**	**46.59**	**2.0**	**2028**	**1440**	
2	**188.74**	**43.43**	**4.0**	**2868**	**2400**	
3	**191.68**	**45.18**	**6.0**	**4092**	**3708**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	95.3	pcf
Boring No.:	R-09-001	Moisture Content (before):	28.0	%
Sample No.:	D-07	Moisture Content (after):	29.9	%
Depth (ft):	35			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Poorly-Graded w/silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	700	200
Friction Angle:	29 °	30 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/13/09

Boring No.: R-09-001 Checked By: AP Date: 11/27/09

Sample No.: D-09 Depth (ft): 45

Description: Dark Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	575.62
Total Ring Weight (g)	134.81
Wet Density (pcf)	122.20
Dry Density (pcf)	94.37

Moisture Determination	Before Test	After Test
Cont. Weight (g)	49.37	197.75
Wet Soil+Cont. (g)	208.71	612.93
Dry Soil+Cont. (g)	172.43	517.48
Moisture Content (%)	29.5	29.9
Degree Saturation	100.3	100.2

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

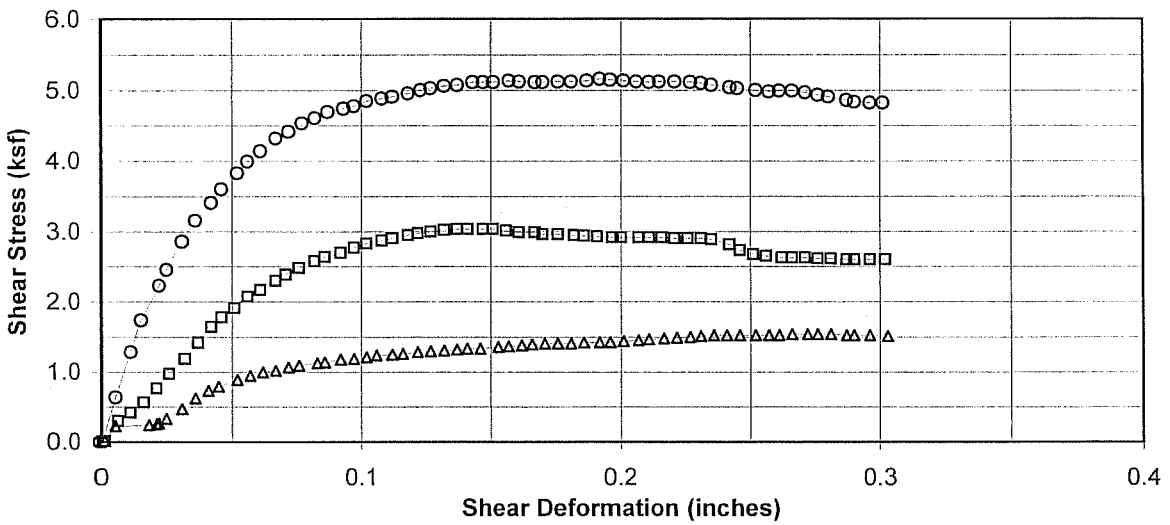
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

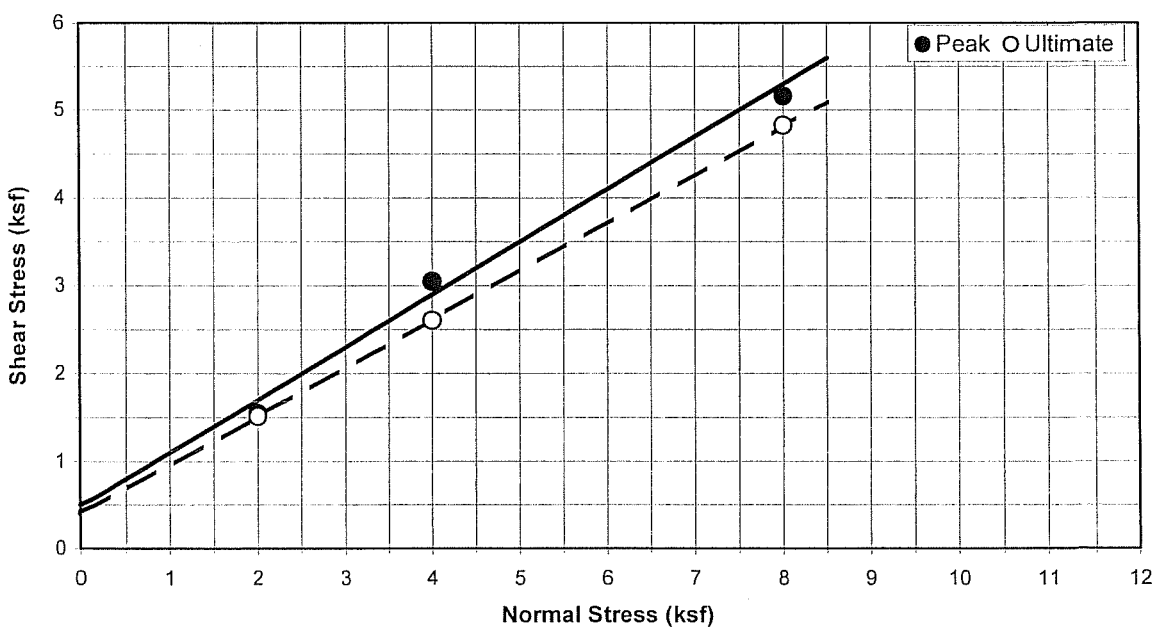
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**190.67**	**43.48**	**2.0**	**1548**	**1512**	
2	**192.52**	**44.89**	**4.0**	**3048**	**2604**	
3	**192.43**	**46.44**	**8.0**	**5160**	**4824**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.4	pcf
Boring No.:	R-09-001	Moisture Content (before):	29.5	%
Sample No.:	D-09	Moisture Content (after):	29.9	%
Depth (ft):	45			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	500	400
Friction Angle:	31 °	29 °

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/12/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-001	D-01	5	21.1	107.2
R-09-001	D-03	15	26.7	96.3
R-09-001	S-04	20	26.7	NA
R-09-001	D-05	25	24.6	101.6
R-09-001	S-08	40	29.9	NA
R-09-001	S-10	50	57.0	NA
R-09-001	D-11	55	30.9	90.9
R-09-001	D-13	65	27.5	98.2
R-09-001	S-14	70	29.6	NA
R-09-001	S-15	75	35.5	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc. Laboratory No.: 29-1121

Project Name: ACTA Heim Bridge Replacement Date: 11/17/09

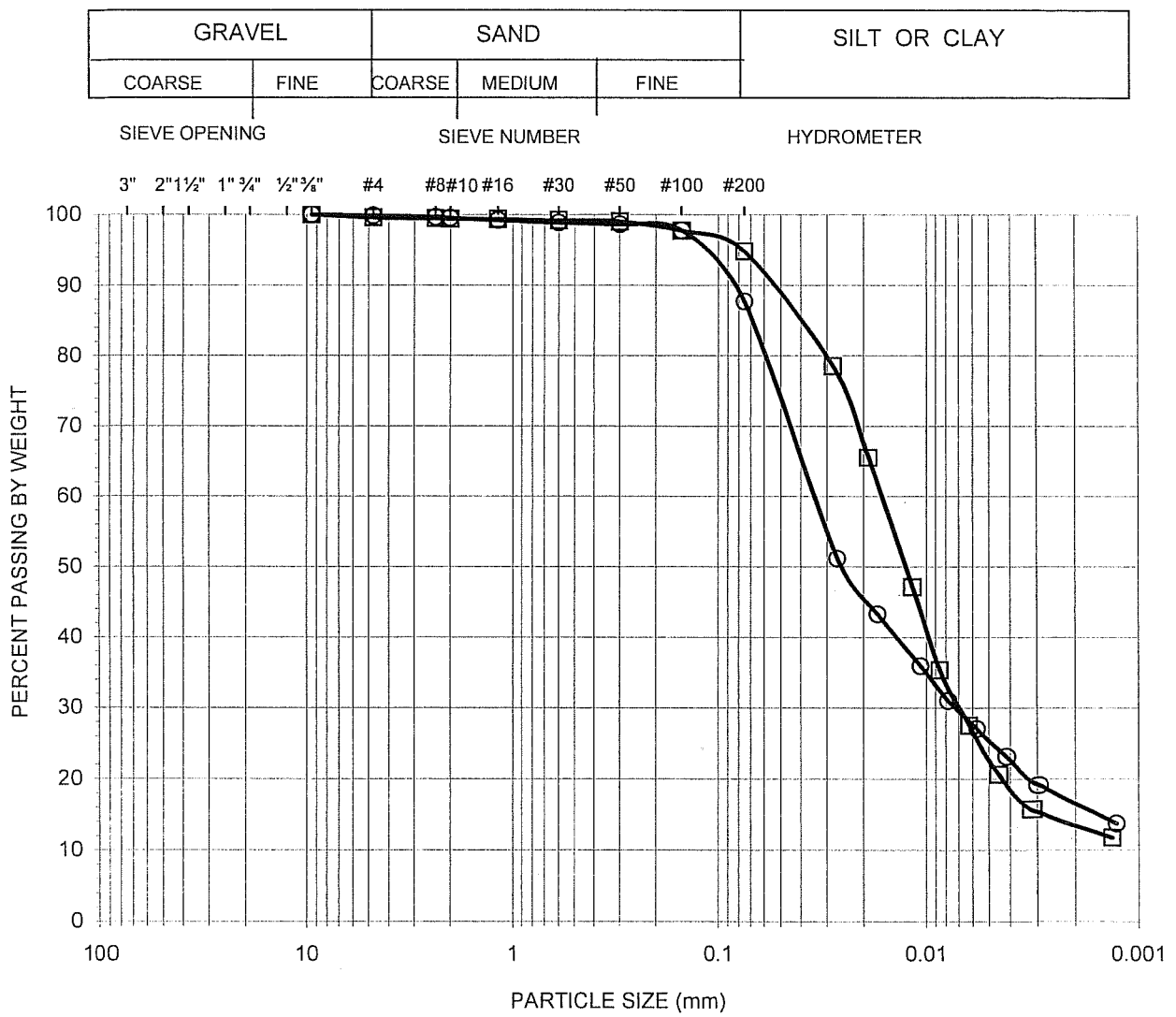
Project Number: 06-123-03

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-001	D-11	55	2.07

AP Engineering & Testing, Inc.

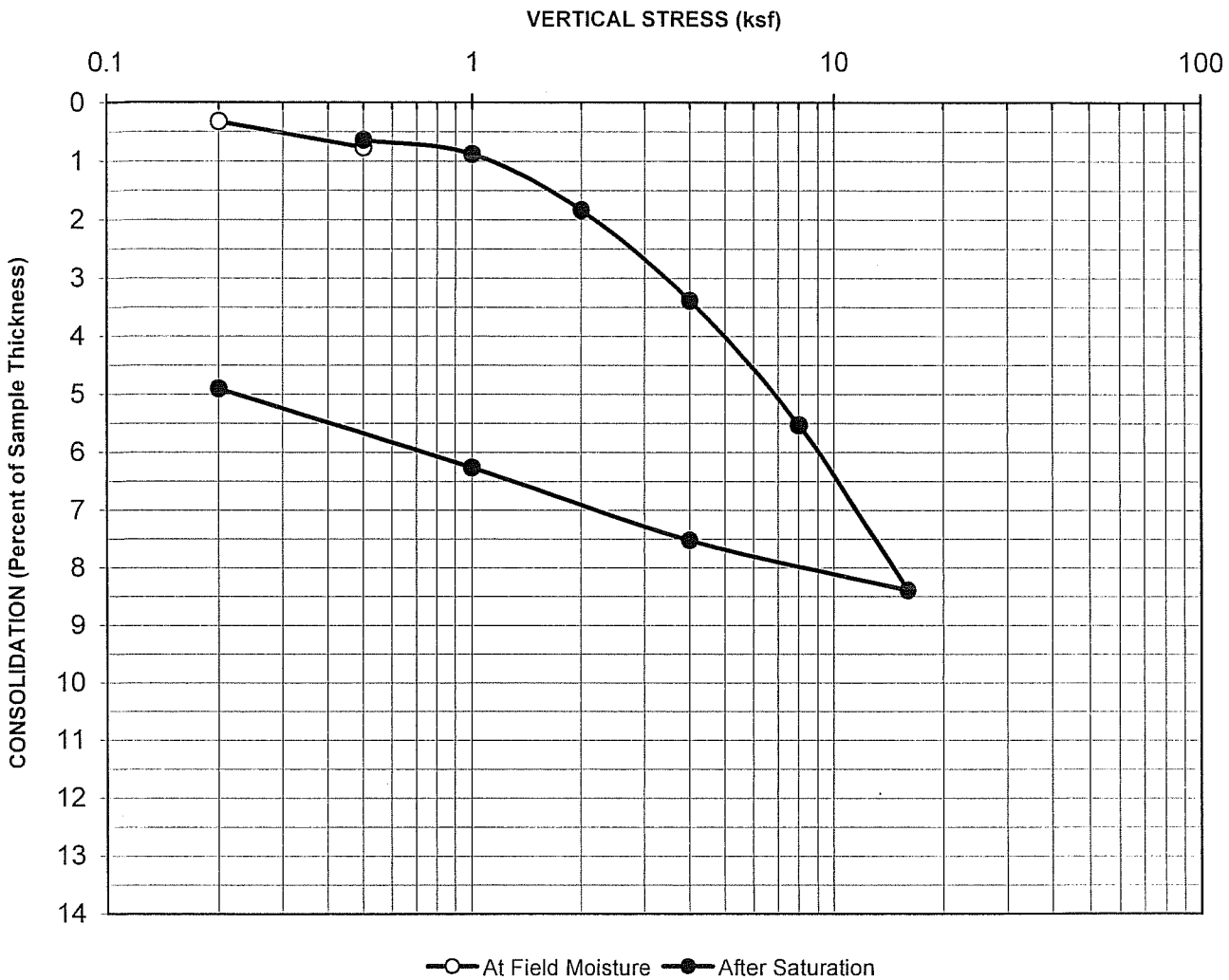
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/12/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-001	D-11	55	0.18	12.08	87.74	46:27:19	CL
□	R-09-001	S-15	75	0.46	4.73	94.81	N/A	CL

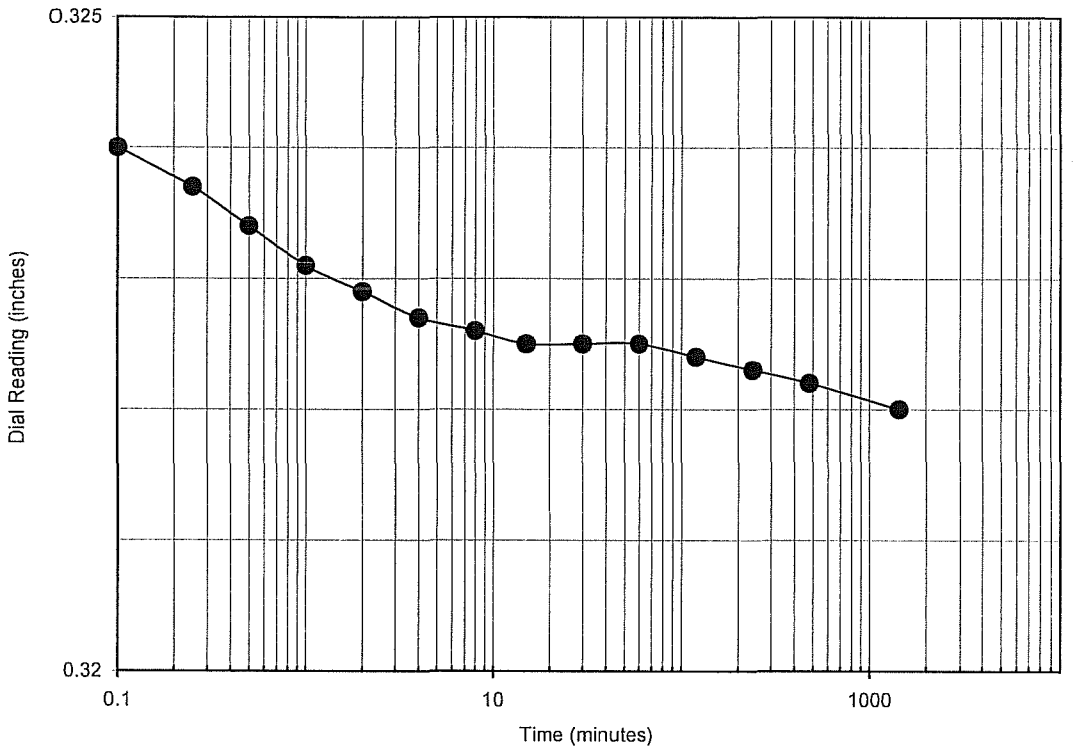
AP Engineering & Testing, Inc.



Boring No. :	R-09-001	Initial Dry Unit Weight (pcf):	90.6
Sample No.:	D-11	Initial Moisture Content (%):	30.9
Depth (feet):	55	Final Moisture Content (%):	33.9
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Lean Clay with fine sand	Initial Void Ratio:	0.86
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/27/2009
AP No:	29-1121

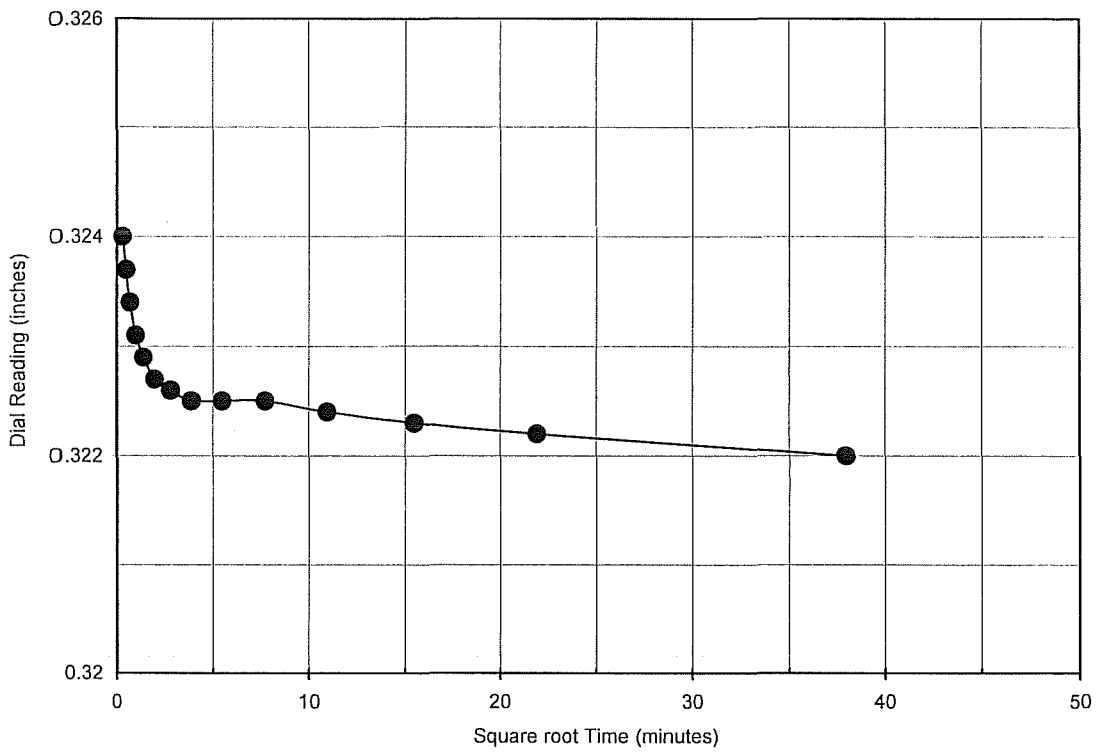


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.324
0.25	0.3237
0.5	0.3234
1	0.3231
2	0.3229
4	0.3227
8	0.3226
15	0.3225
30	0.3225
60	0.3225
120	0.3224
240	0.3223
480	0.3222
1440	0.322

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

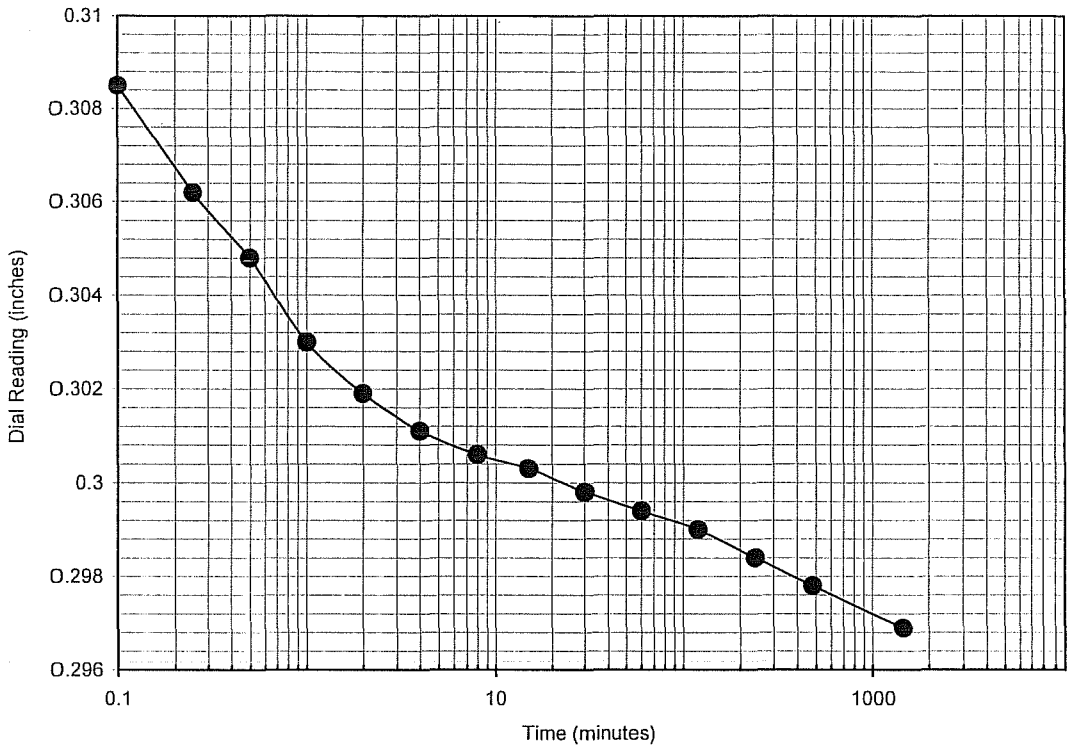


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3240
0.5000	0.3237
0.7071	0.3234
1.0000	0.3231
1.4142	0.3229
2.0000	0.3227
2.8284	0.3226
3.8730	0.3225
5.4772	0.3225
7.7460	0.3225
10.9545	0.3224
15.4919	0.3223
21.9089	0.3222
37.9473	0.3220

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

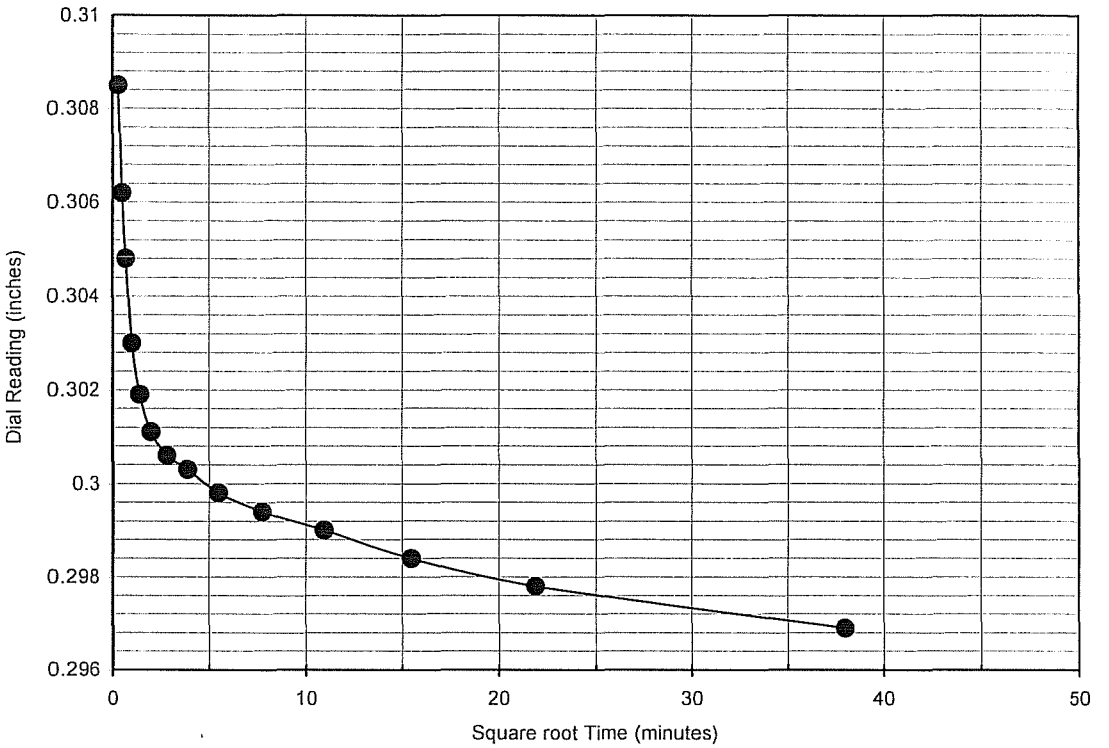


Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3085
0.25	0.3062
0.5	0.3048
1	0.303
2	0.3019
4	0.3011
8	0.3006
15	0.3003
30	0.2998
60	0.2994
120	0.299
240	0.2984
480	0.2978
1440	0.2969

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-001	Sample Type:	Cal. Mod.
Sample No.:	D-11	Soil Description:	Lean Clay with fine sand
Depth (feet):	55	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3085
0.5000	0.3062
0.7071	0.3048
1.0000	0.3030
1.4142	0.3019
2.0000	0.3011
2.8284	0.3006
3.8730	0.3003
5.4772	0.2998
7.7460	0.2994
10.9545	0.2990
15.4919	0.2984
21.9089	0.2978
37.9473	0.2969

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/12/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/13/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-002	S-02	10	10.37
R-09-002	S-04	20	3.44
R-09-002	S-08	40	46.23

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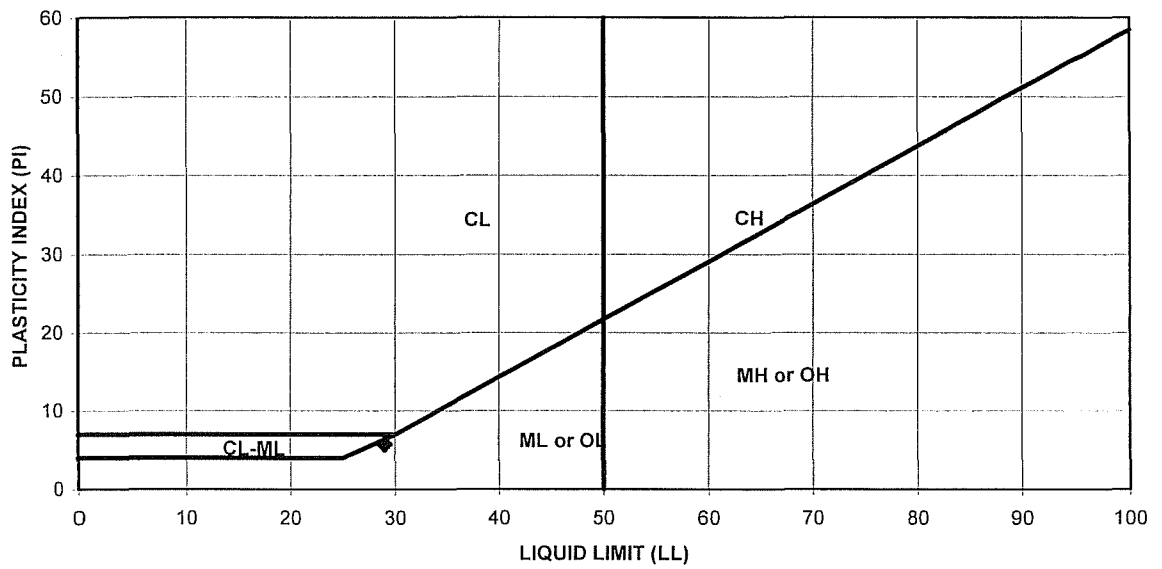
AP Engineering & Testing, Inc.

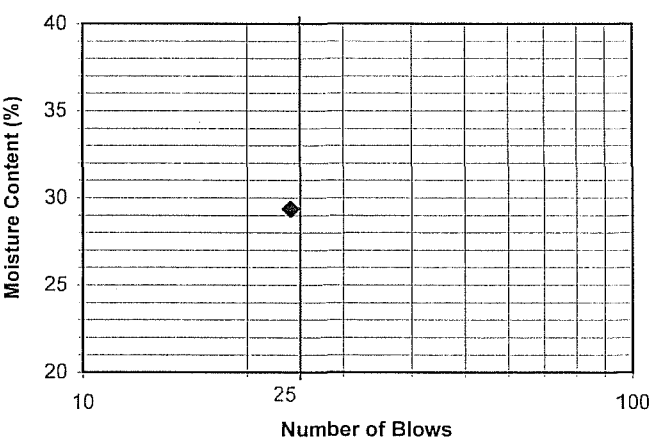
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/12/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-002	S-10	50	29	23	6	ML
	R-09-002	S-12	60	NP	NP	NP	

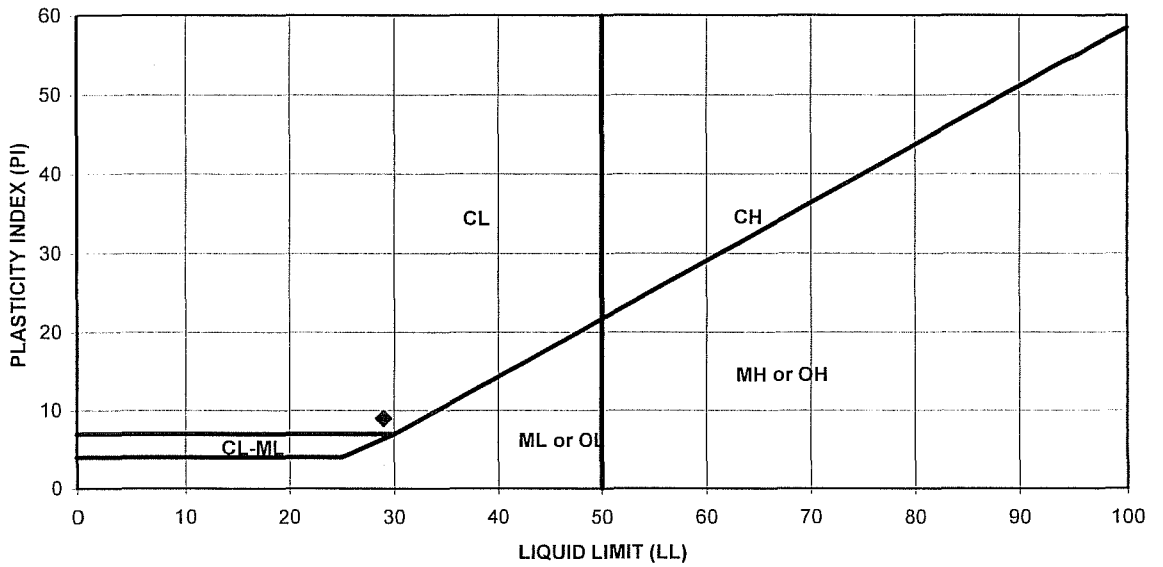
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

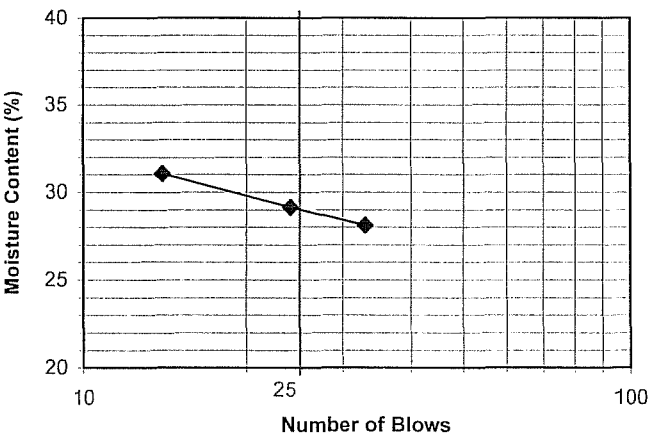
Tested By: DK
Checked By: AP

Date: 11/12/09
Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-002	S-14	70	29	20	9	CL

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/12/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-002	S-02	10	SP-SM	1100	7.7	325	267

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/14/09

Boring No.: R-09-002 Checked By: AP Date: 12/01/09

Sample No.: D-03 Depth (ft): 15

Description: Dark Gray Sand with silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	570.48
Total Ring Weight (g)	134.68
Wet Density (pcf)	120.81
Dry Density (pcf)	95.07

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.13	157.94
Wet Soil+Cont. (g)	193.93	570.94
Dry Soil+Cont. (g)	163.29	473.95
Moisture Content (%)	27.1	30.7
Degree Saturation	94.6	102.5

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

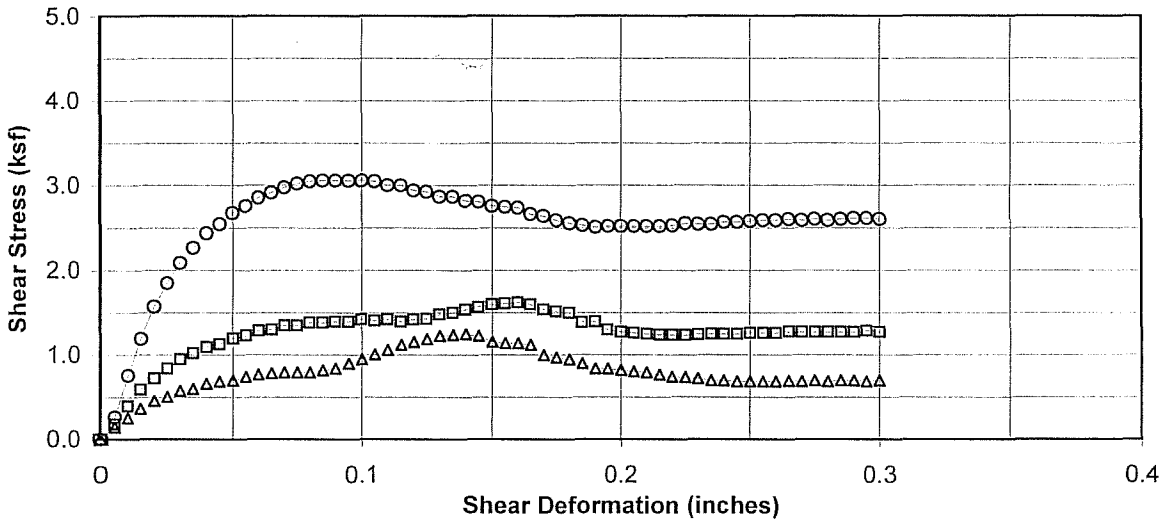
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

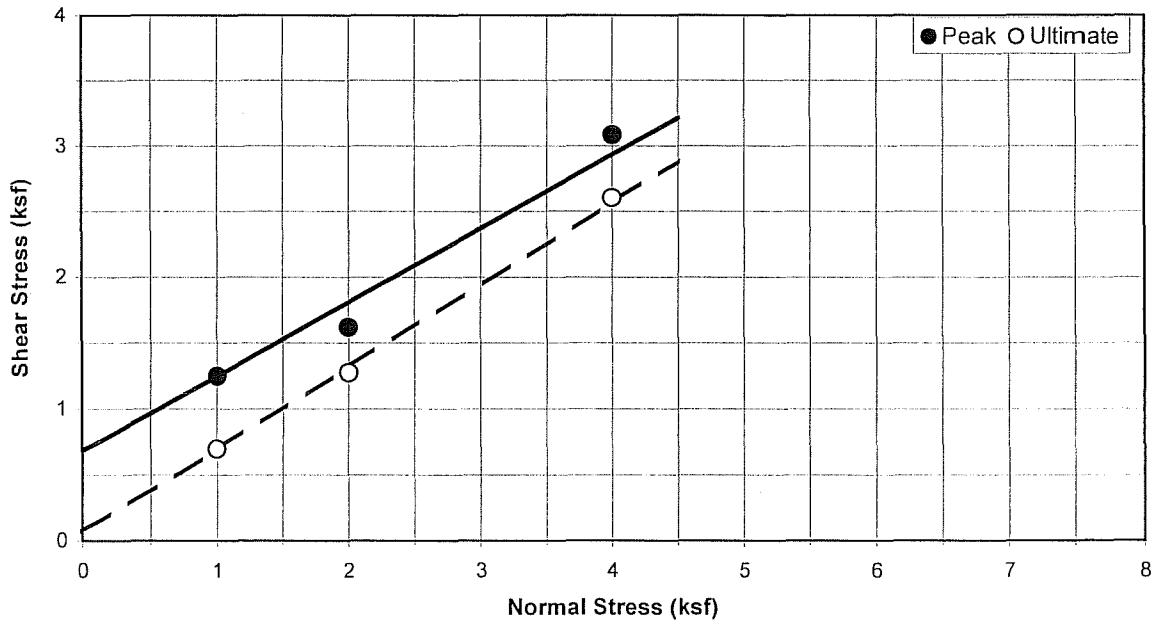
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**191.90**	**45.15**	**1.0**	**1248**	**696**	
2	**188.64**	**43.81**	**2.0**	**1620**	**1272**	
3	**189.94**	**45.72**	**4.0**	**3084**	**2604**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	95.1	pcf
Boring No.:	R-09-002	Moisture Content (before):	27.1	%
Sample No.:	D-03	Moisture Content (after):	30.7	%
Depth (ft):	15			
Sample Type:	Cal. Mod.			
Soil Description:	Dark Gray Sand with silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	700	50
Friction Angle:	29 °	32 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/14/09

Boring No.: R-09-002 Checked By: AP Date: 12/01/09

Sample No.: D-07 Depth (ft): 35

Description: Gray Sitly Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	571.64
Total Ring Weight (g)	135.52
Wet Density (pcf)	120.90
Dry Density (pcf)	91.52

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.39	195.18
Wet Soil+Cont. (g)	192.89	616.91
Dry Soil+Cont. (g)	158.27	513.85
Moisture Content (%)	32.1	32.3
Degree Saturation	100.3	101.1

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

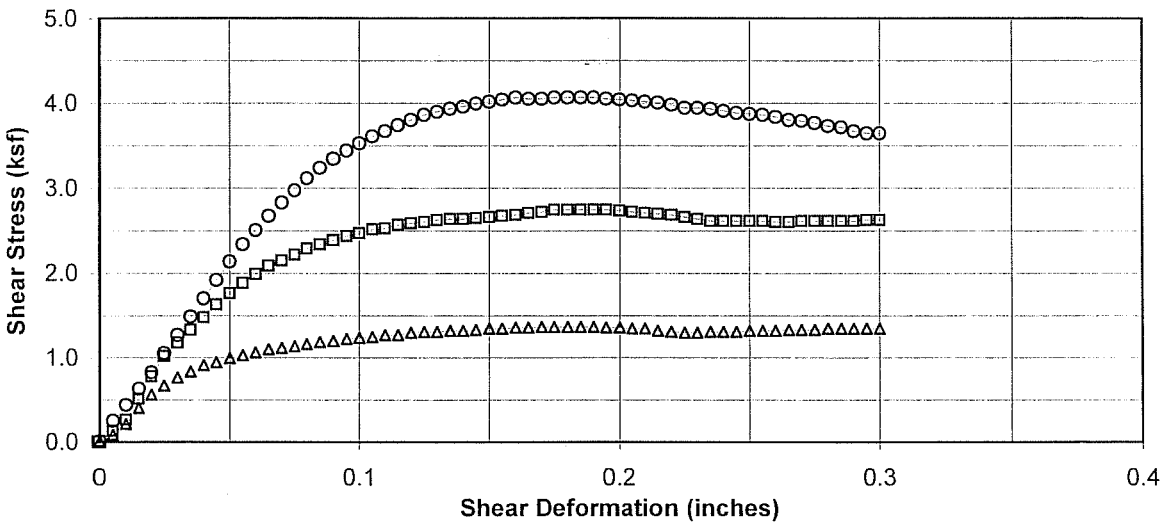
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

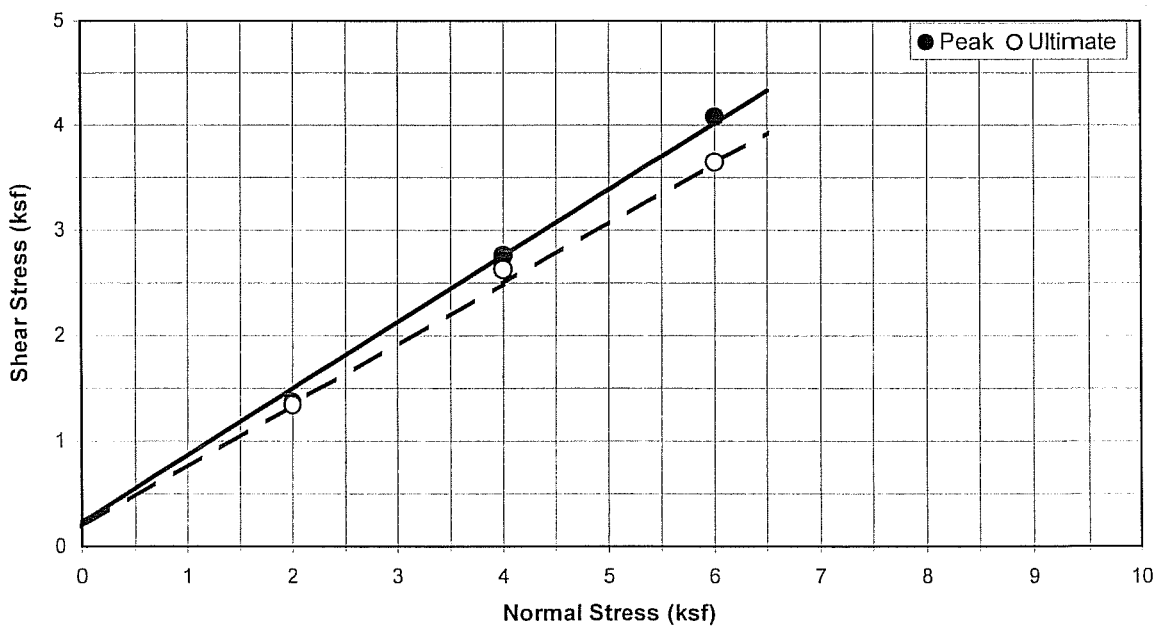
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**190.53**	**45.39**	**2.0**	**1368**	**1344**	
2	**188.75**	**44.69**	**4.0**	**2760**	**2628**	
3	**192.36**	**45.44**	**6.0**	**4080**	**3648**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	91.5	pcf
Boring No.:	R-09-002	Moisture Content (before):	32.1	%
Sample No.:	D-07	Moisture Content (after):	32.3	%
Depth (ft):	35			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sitly Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	200
Friction Angle:	32 °	30 °

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

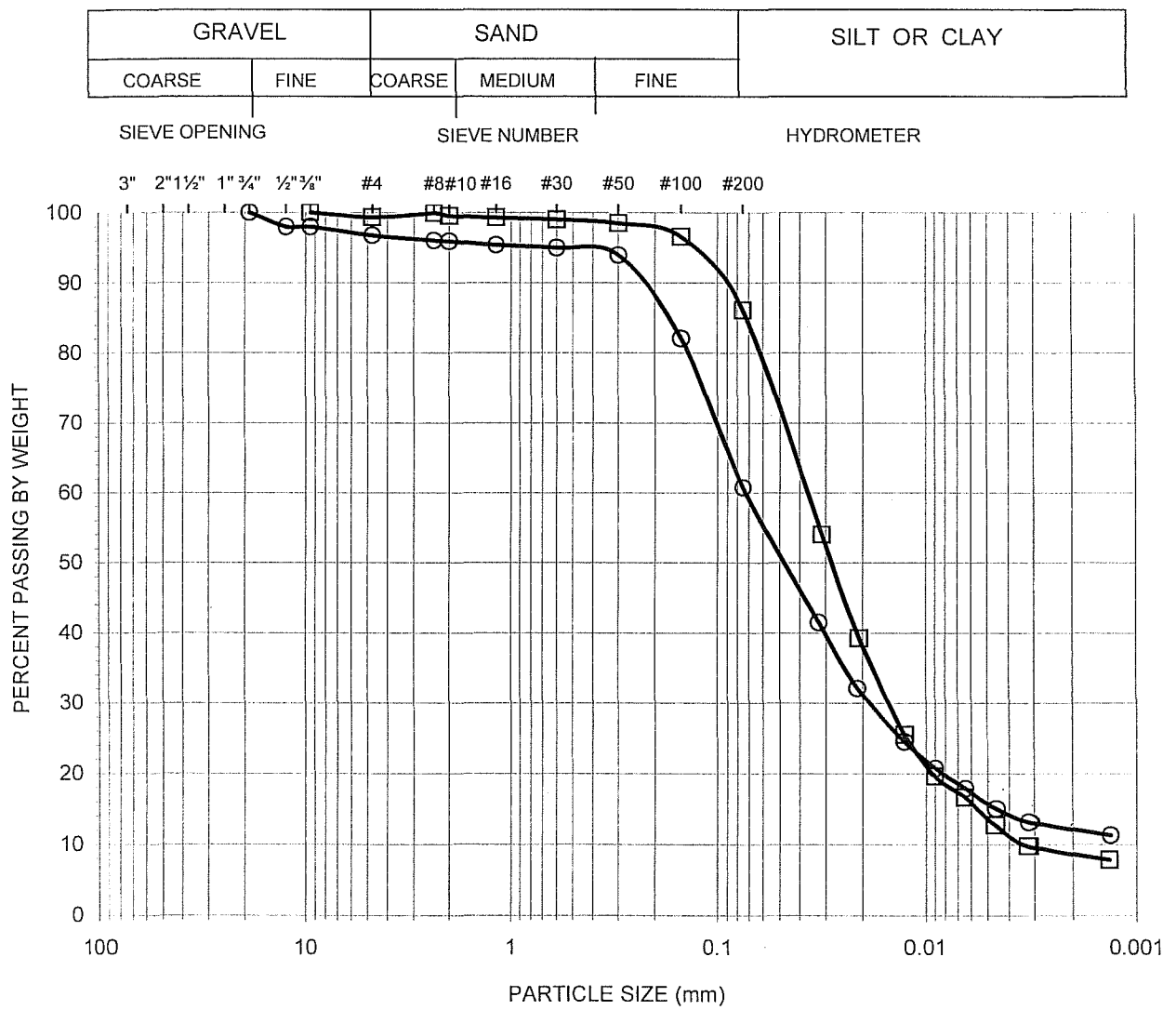
Laboratory No.: 29-1121
Date: 11/12/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-002	D-01	5	17.3	109.8
R-09-002	S-02	10	32.7	NA
R-09-002	D-05	25	13.9	114.6
R-09-002	S-08	40	31.0	NA
R-09-002	S-10	50	35.2	NA
R-09-002	D-11	55	35.7	93.8
R-09-002	S-12	60	26.1	NA
R-09-002	S-14	70	35.0	NA
R-09-002	S-15	75	33.7	NA

AP Engineering & Testing, Inc.

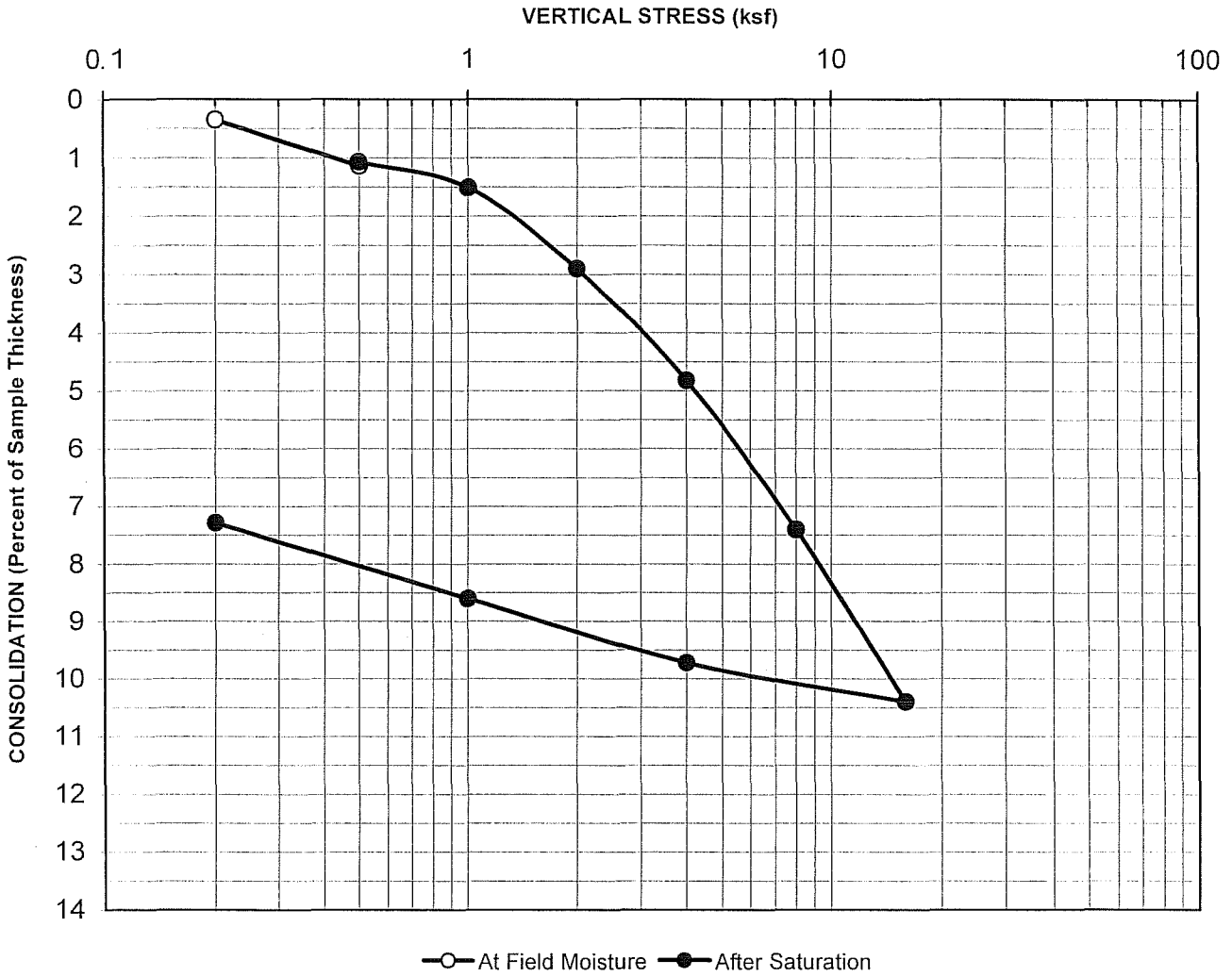
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-002	S-10	50	3.23	36.02	60.75	29:23:6	ML
□	R-09-002	S-15	75	0.68	13.21	86.11	N/A	ML

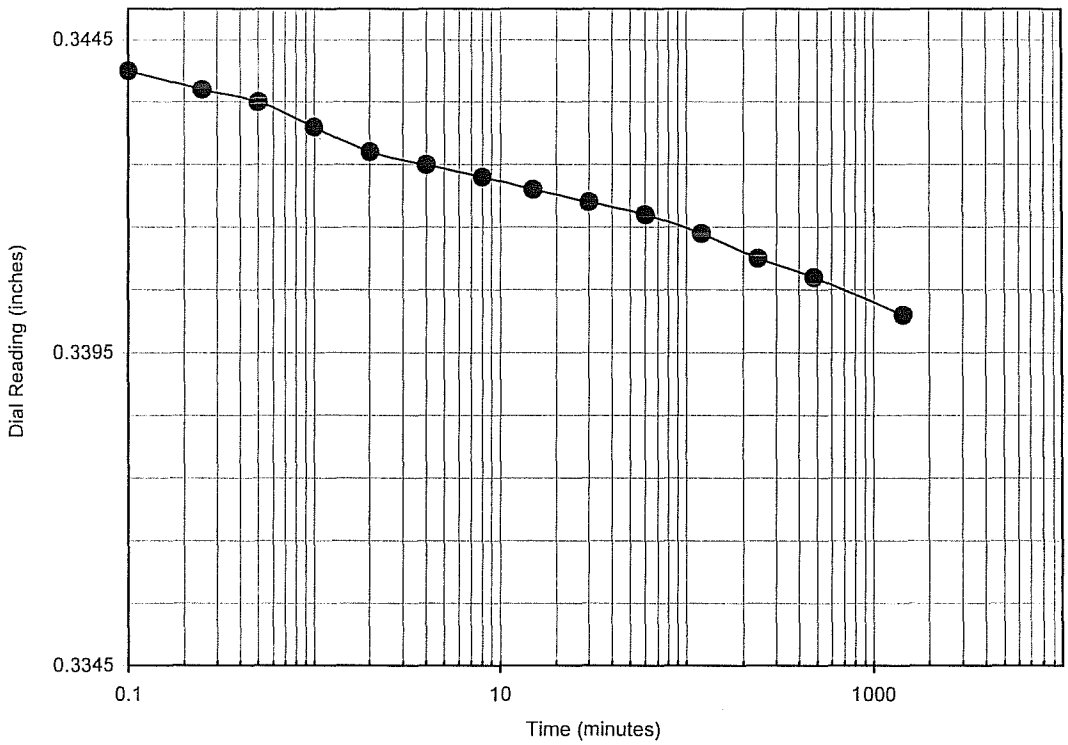
AP Engineering & Testing, Inc.



Boring No. :	R-09-002	Initial Dry Unit Weight (pcf):	89.1
Sample No.:	D-09	Initial Moisture Content (%):	35.7
Depth (feet):	45	Final Moisture Content (%):	28.4
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Silt with sand	Initial Void Ratio:	0.89
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/27/2009
AP No:	29-1121

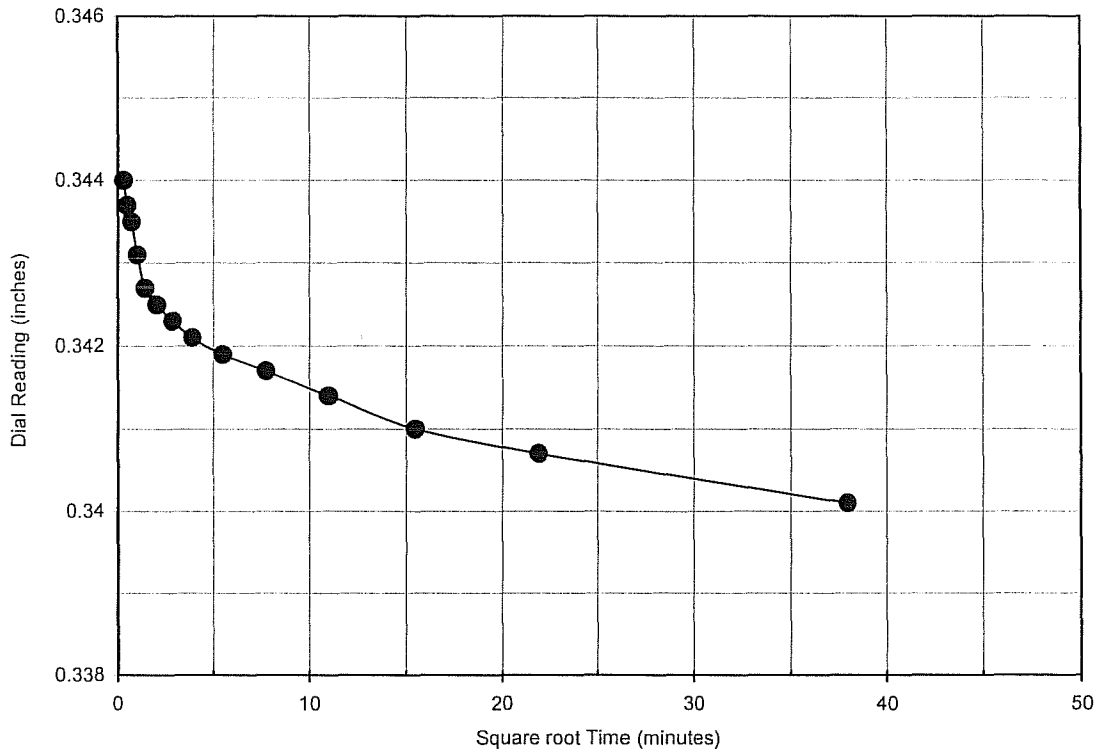


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.344
0.25	0.3437
0.5	0.3435
1	0.3431
2	0.3427
4	0.3425
8	0.3423
15	0.3421
30	0.3419
60	0.3417
120	0.3414
240	0.341
480	0.3407
1440	0.3401

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

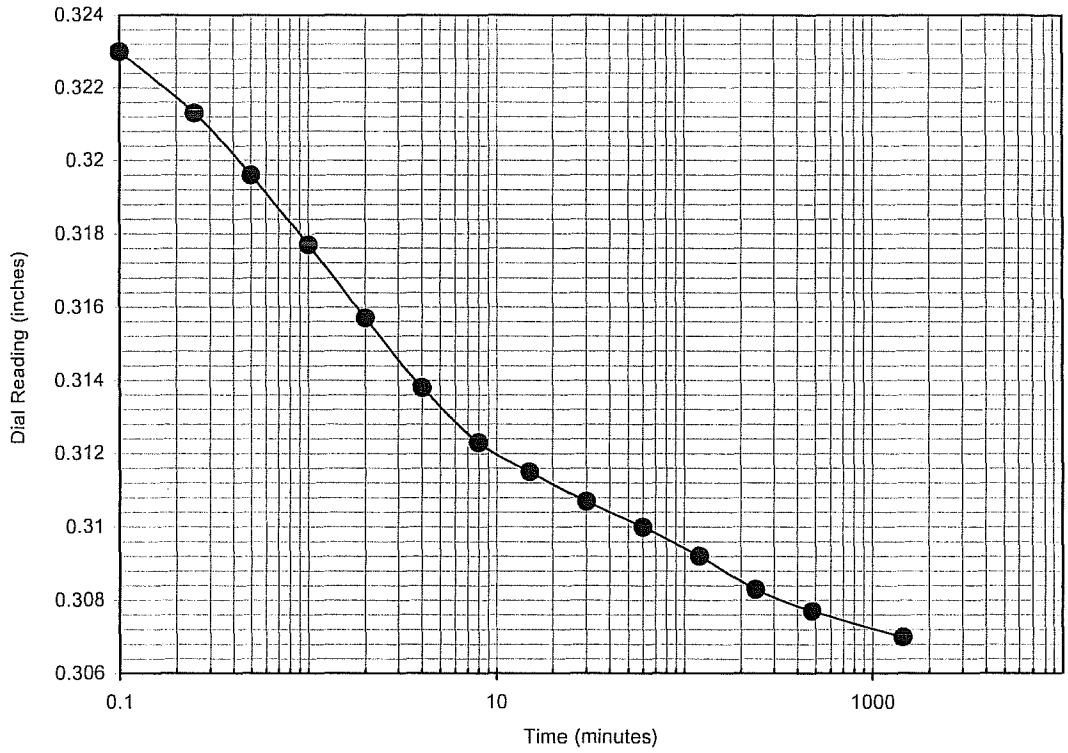


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3440
0.5000	0.3437
0.7071	0.3435
1.0000	0.3431
1.4142	0.3427
2.0000	0.3425
2.8284	0.3423
3.8730	0.3421
5.4772	0.3419
7.7460	0.3417
10.9545	0.3414
15.4919	0.3410
21.9089	0.3407
37.9473	0.3401

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

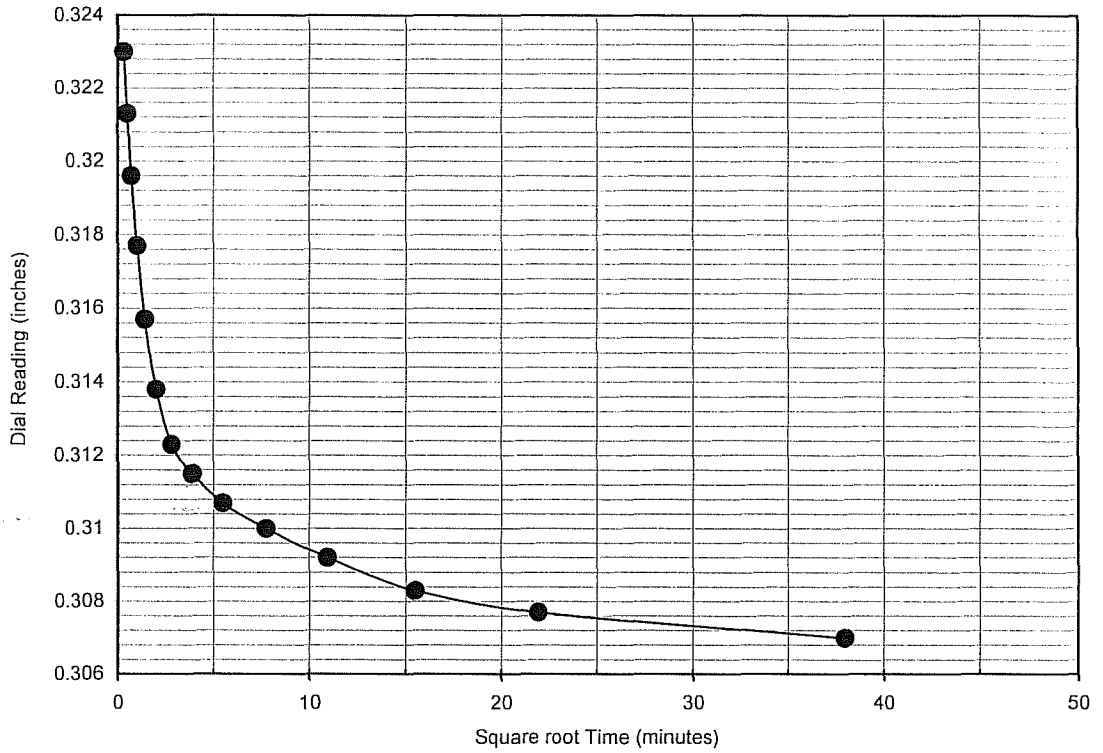


Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.323
0.25	0.3213
0.5	0.3196
1	0.3177
2	0.3157
4	0.3138
8	0.3123
15	0.3115
30	0.3107
60	0.31
120	0.3092
240	0.3083
480	0.3077
1440	0.307

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-002	Sample Type:	Cal. Mod.
Sample No.:	D-09	Soil Description:	Silt with sand
Depth (feet):	45	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3230
0.5000	0.3213
0.7071	0.3196
1.0000	0.3177
1.4142	0.3157
2.0000	0.3138
2.8284	0.3123
3.8730	0.3115
5.4772	0.3107
7.7460	0.3100
10.9545	0.3092
15.4919	0.3083
21.9089	0.3077
37.9473	0.3070

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/13/09
AP No: 29-1121 **Figure No:**

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008A

PROJECT NO.: 06-123-03

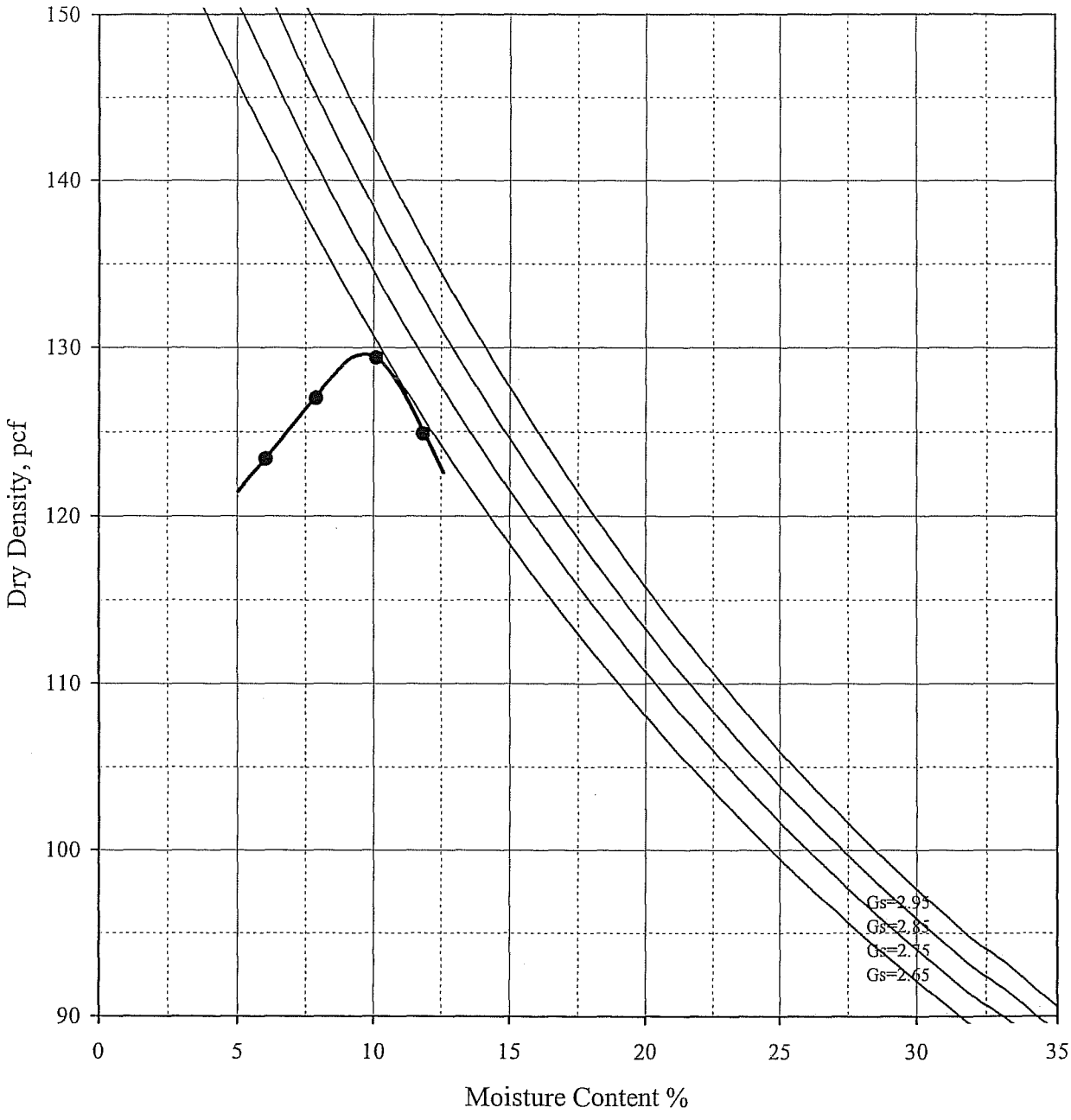
CLIENT: Earth Mechanics, Inc.

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-038	B-0	0-2.0	9.7			
R-09-038	D-02	10.0	24.8	100.8	4.8	
R-09-038	S-04	25.0			12.0	
R-09-038	U-06	35.0				58,28,30
R-09-038	D-07-1	40.0	21.9	106.7	14.4	
R-09-038	U-08	46.0				26,24,2
R-09-038	S-09	50.0	33.1			NP
R-09-038	D-10-2	55.5	26.6	100.3		
R-09-038	U-11	61.0				25,23,2
R-09-038	S-12	65.0	36.9			26,24,2
R-09-038	D-13	70.0	28.0	97.9		
R-09-038	S-14-1	75.0	40.8			48,25,23
R-09-038	D-15	80.0	27.0	99.7		NP
R-09-038	D-17	90.0	25.3	100.9		
R-09-038	S-19	110.0	18.6			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index



	Boring No: R-09-038
Maximum Dry Density = 129.5 pcf	Sample: B-0
	Depth : 0-2 feet
Optimum Moisture Content = 10 %	Description : SM

Environmental Geotechnology Laboratory

Modified Proctor

(ASTM D1557)

Project Name:	ACTA Heim Bridge Replacement	
Client Name:	Earth Mechanics, Inc.	
Job No:	06-123-03	
EGL Project No.:		09-230-008A
Date :	Dec-09	Figure

SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
~~R-09-027~~	~~U-01~~	~~11~~	~~2.736~~
R-09-027	U-09	45	2.77
R-09-033	U-04	20	2.697
~~R-09-033~~	~~U-09~~	~~45~~	~~2.746~~
R-09-038	U-06	35	2.768
R-09-038	U-08	46	2.737
R-09-038	U-11	61	2.741

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

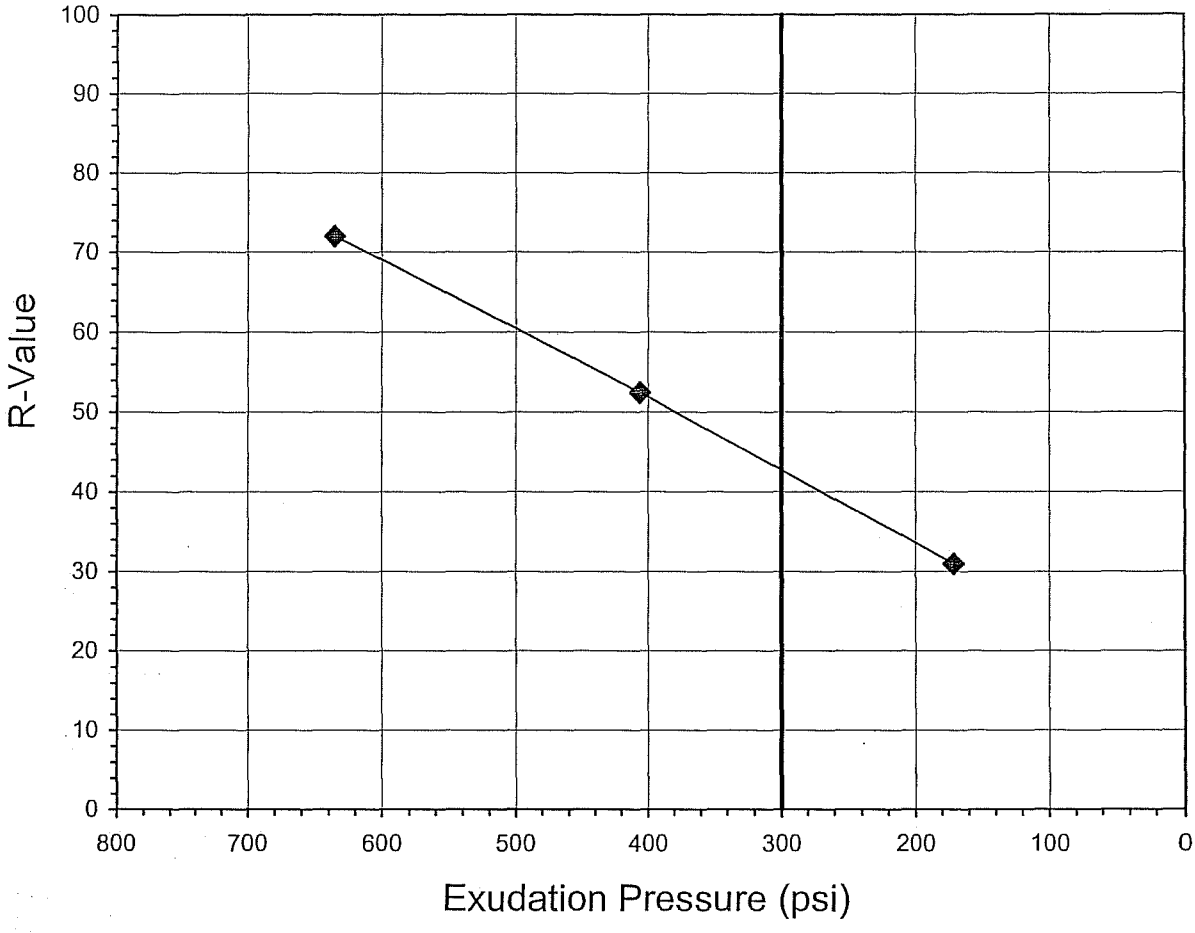
DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
~~R-09-027~~	~~U-01~~	~~11~~	~~0.2~~
R-09-027	U-09	45	1.25
R-09-033	U-04	20	0.5
~~R-09-033~~	~~U-09~~	~~45~~	~~1.75~~
R-09-038	U-06	35	0.8
R-09-038	U-08	46	1.75
R-09-038	U-11	61	4

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008A
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	12/18/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
~~R-09-027~~	~~D-2-2~~	~~15.5~~	~~8.05~~	~~10,655~~	~~0.106~~	~~72~~
~~R-09-033~~	~~T-3~~	~~15~~	~~8.40~~	~~605~~	~~0.018~~	~~630~~
R-09-038	B-0	0 - 2	8.11	710	0.138	390



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	150	121.3	12.2	0.00	92	2.52	171	31	31
2	200	122.9	11.3	0.00	59	2.52	406	52	52
3	250	124.6	10.4	0.48	34	2.49	635	72	72

Boring No: R-09-038
Sample No: B-0 @ 0-2'
Sample Type: Bulk
Sample Description: Silty sand (SM)
Test Date: 12/7/09

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008A

Test Results: R-Value at 300 psi
Exudation Pressure: 43

R-VALUE TEST REPORT

12/30/09

FIGURE 1

Resistance R - Value Testing Results

(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008A
Test Date:	12/7/2009
Boring No:	R-09-038
Sample No:	B-0 @ 0-2'
Sample Type:	Bulk
Sample Description:	Silty sand (SM), dark brown
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	150	200	250
Wet Weight (gms)	1230	1220	1210
Dry Weight (gms)	1096	1096	1096
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	2150	5100	7970
Total Weight (gms)	2915	3058	3002
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1132	1138	1130
Sample Height (in)	2.52	2.52	2.49
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0000	0.0000	0.0016
Expansion Pressure (psi)	0.0000	0.0000	0.4848
Ph @ 2000 lbs	92	59	34
D turns	4.12	3.88	3.6
R-Value from Exudation	31	52	72
Density (pcf)	121.3	122.9	124.6
Moisture (%)	12.2	11.3	10.4
Exudation Pressure (psi)	171	406	635
Corrected R-Value from Exudation:	31	52	72
Exudation Pressure (psi)	171	406	635

R-Value at 300 psi exudation pressure = 43

Note:
0.91% Retained on 3/4-inch Sieve

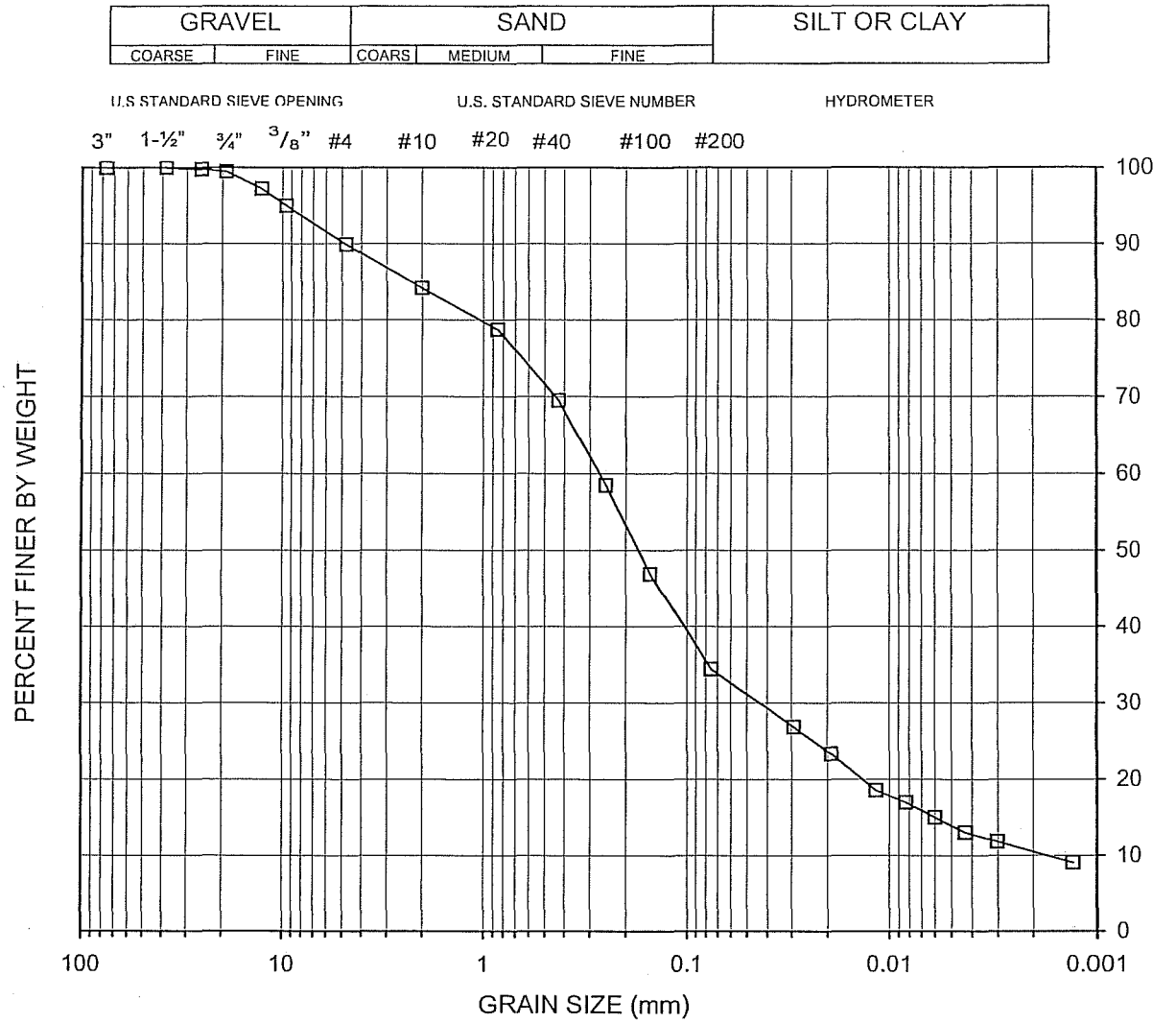
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008A

R-VALUE TEST RESULTS

12/30/09

FIGURE 2



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	B-0	0 - 2	Bulk	SM	N/A	N/A

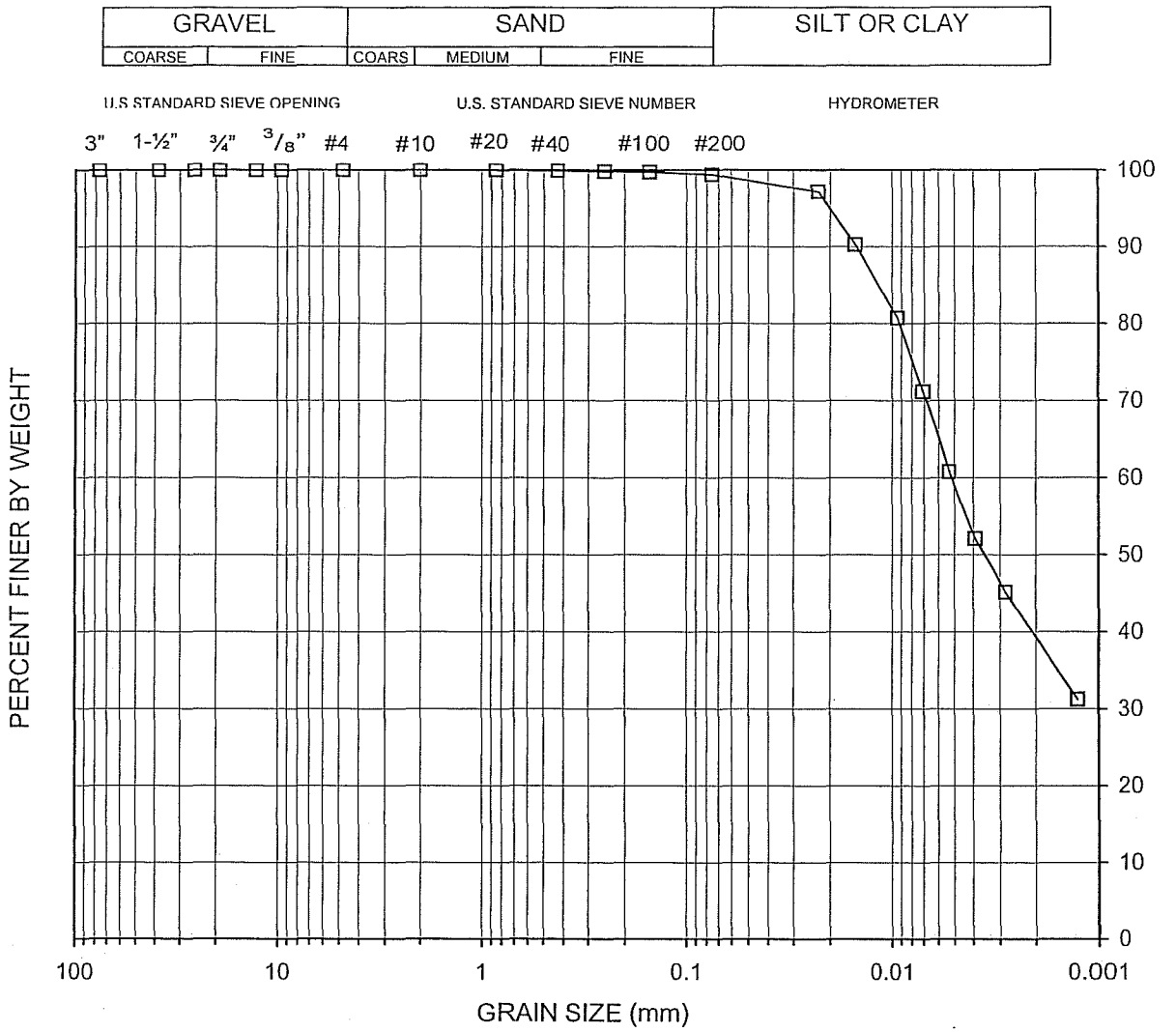
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	U-06	35	Shelby Tube	CH	58	30

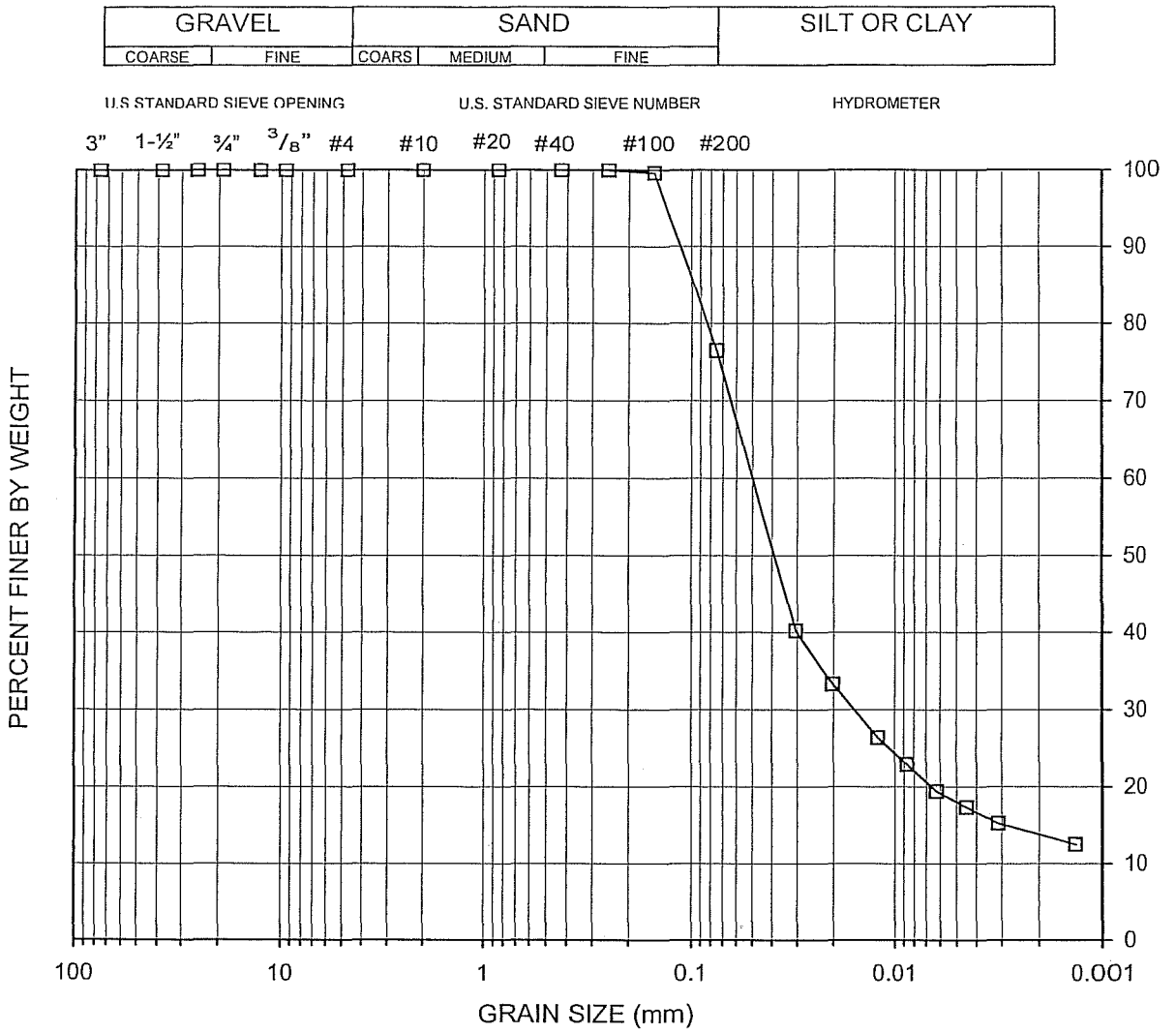
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	U-08	46	Shelby Tube	ML	26	2

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

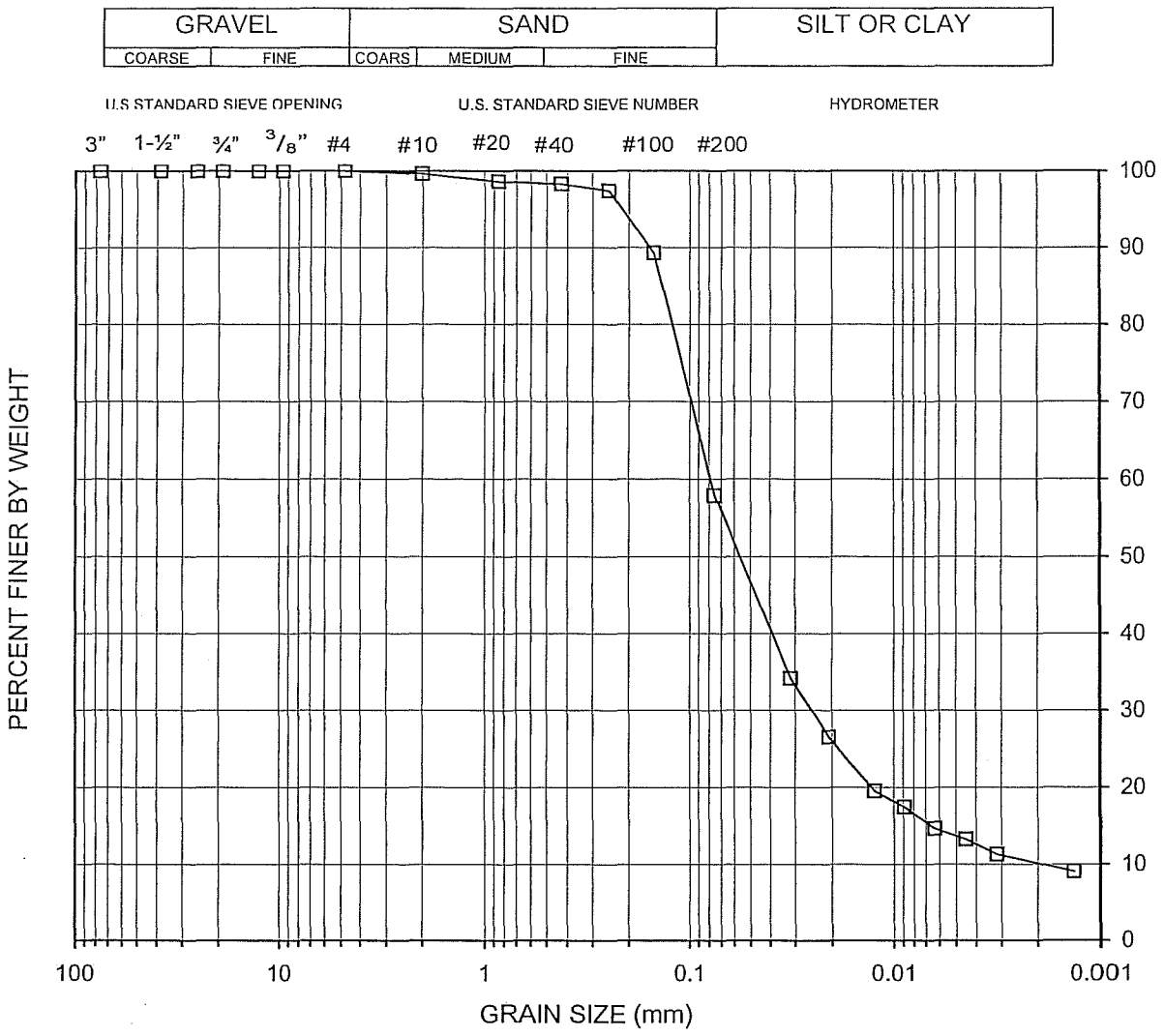
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	S-09	50	Bag	ML	NP	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

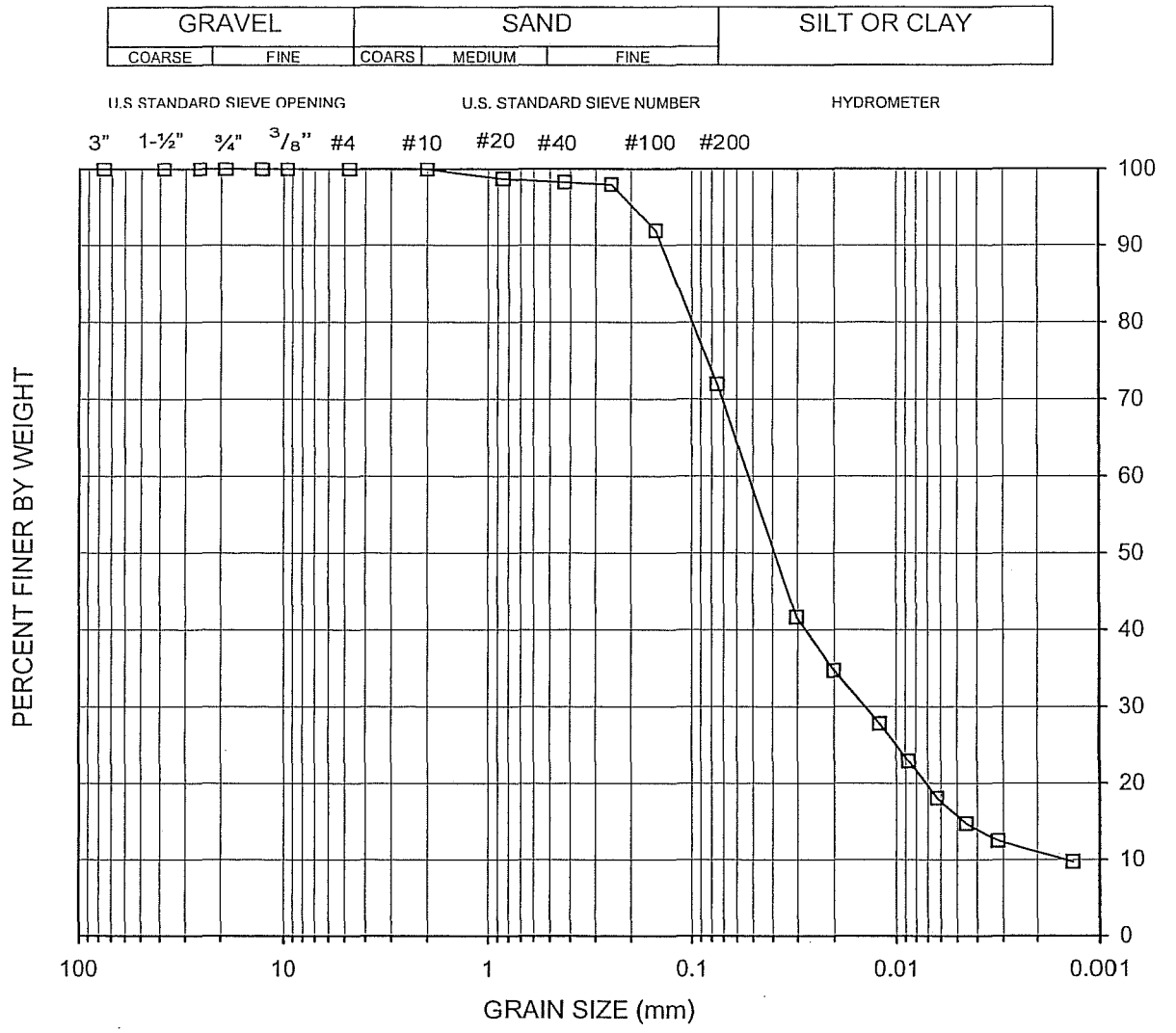
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/22/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	U-11	61	Shelby Tube	ML	25	2

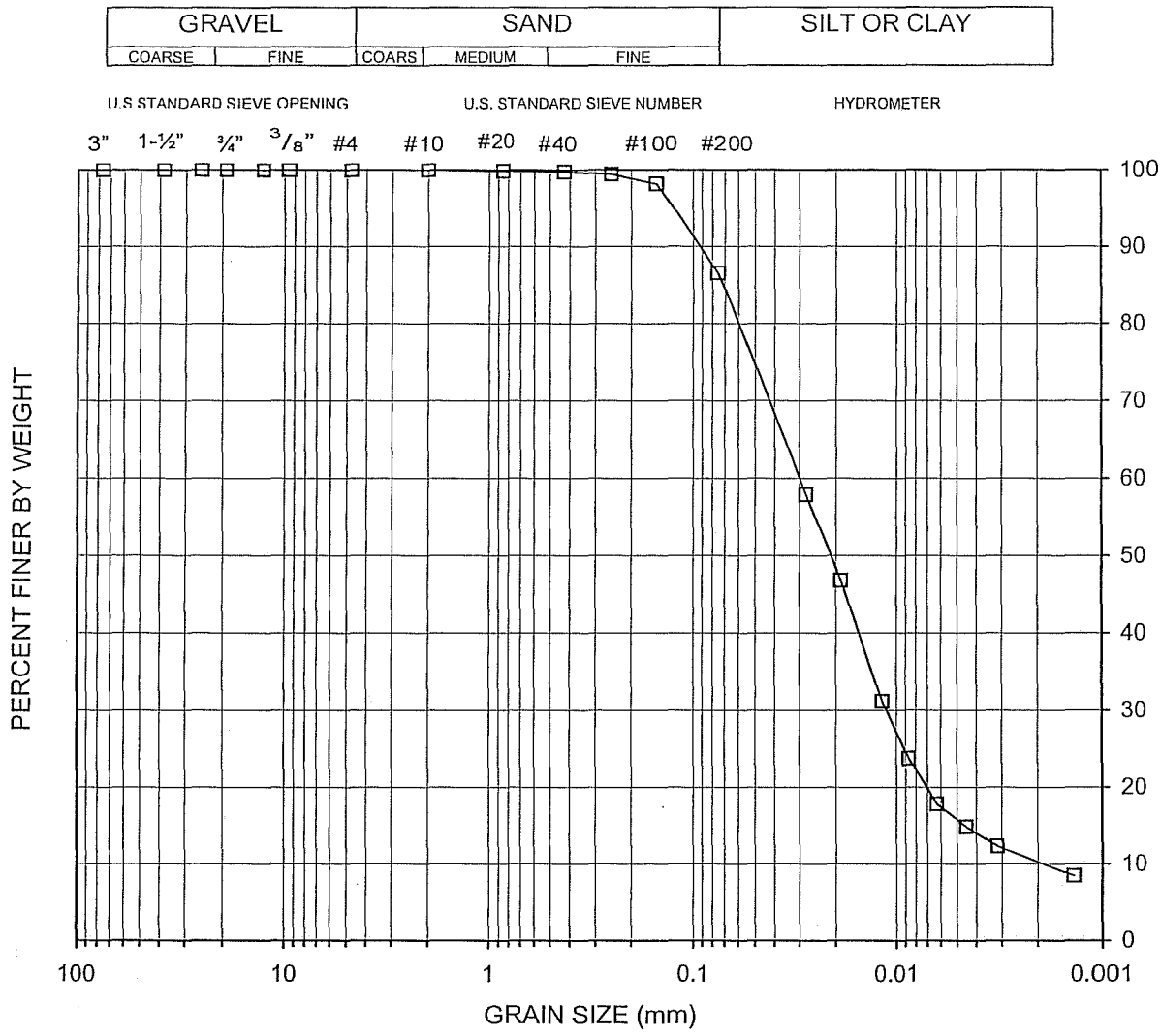
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	S-12	65	Bag	ML	26	2

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

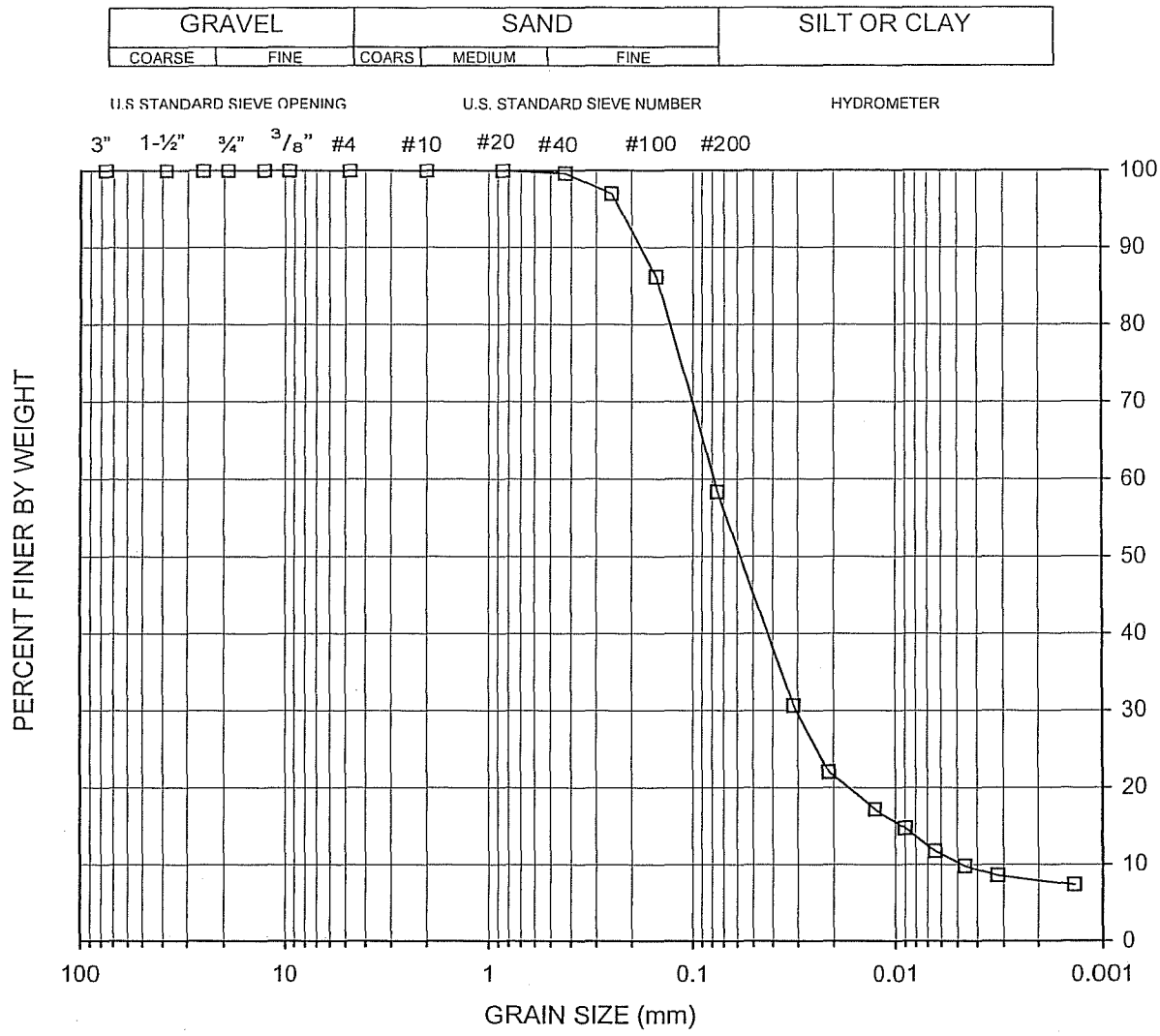
Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/21/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-038	D-15	80	Ring	ML	NP	N/A

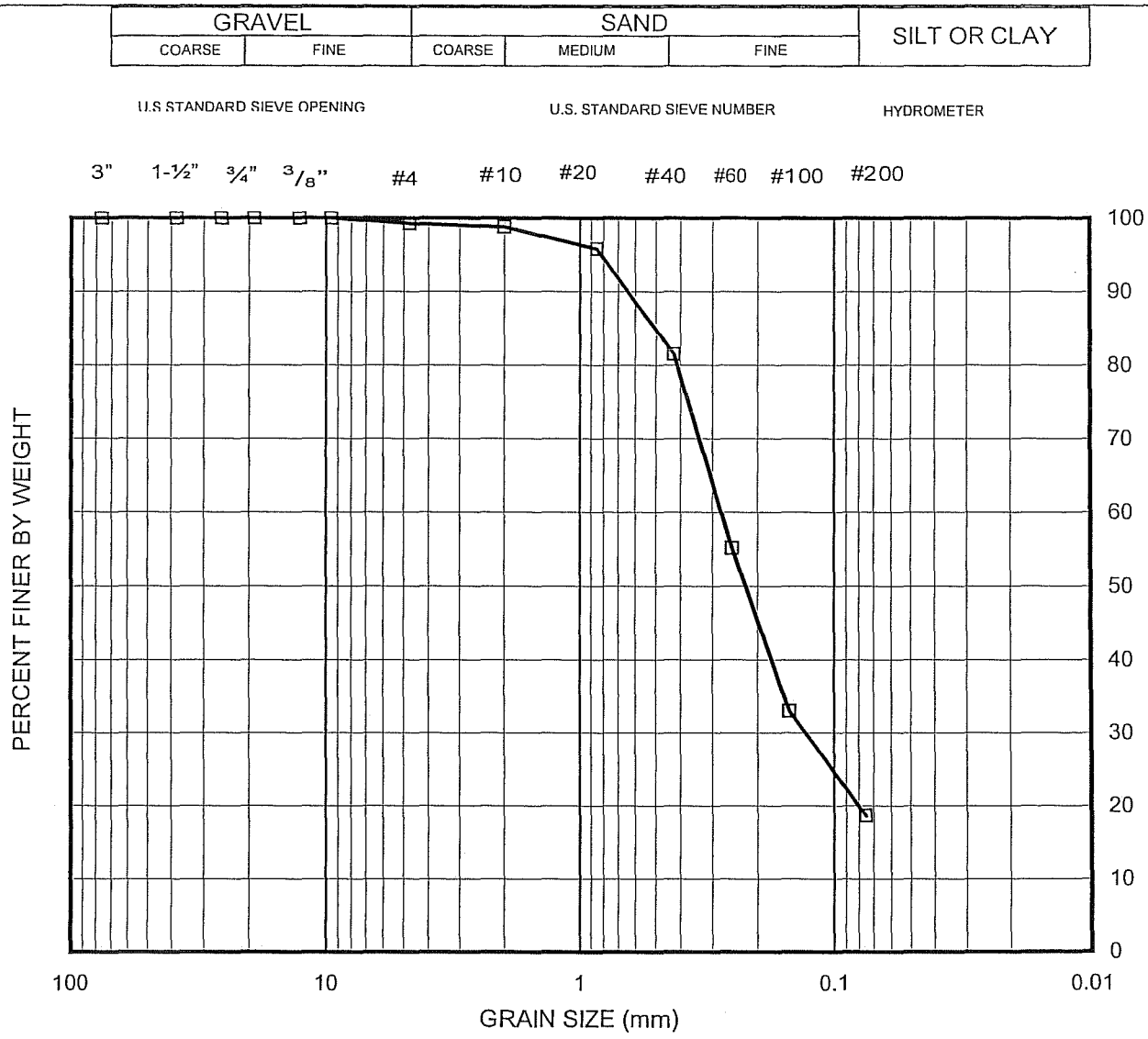
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE

12/22/09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-038	S-19	110	Bag	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

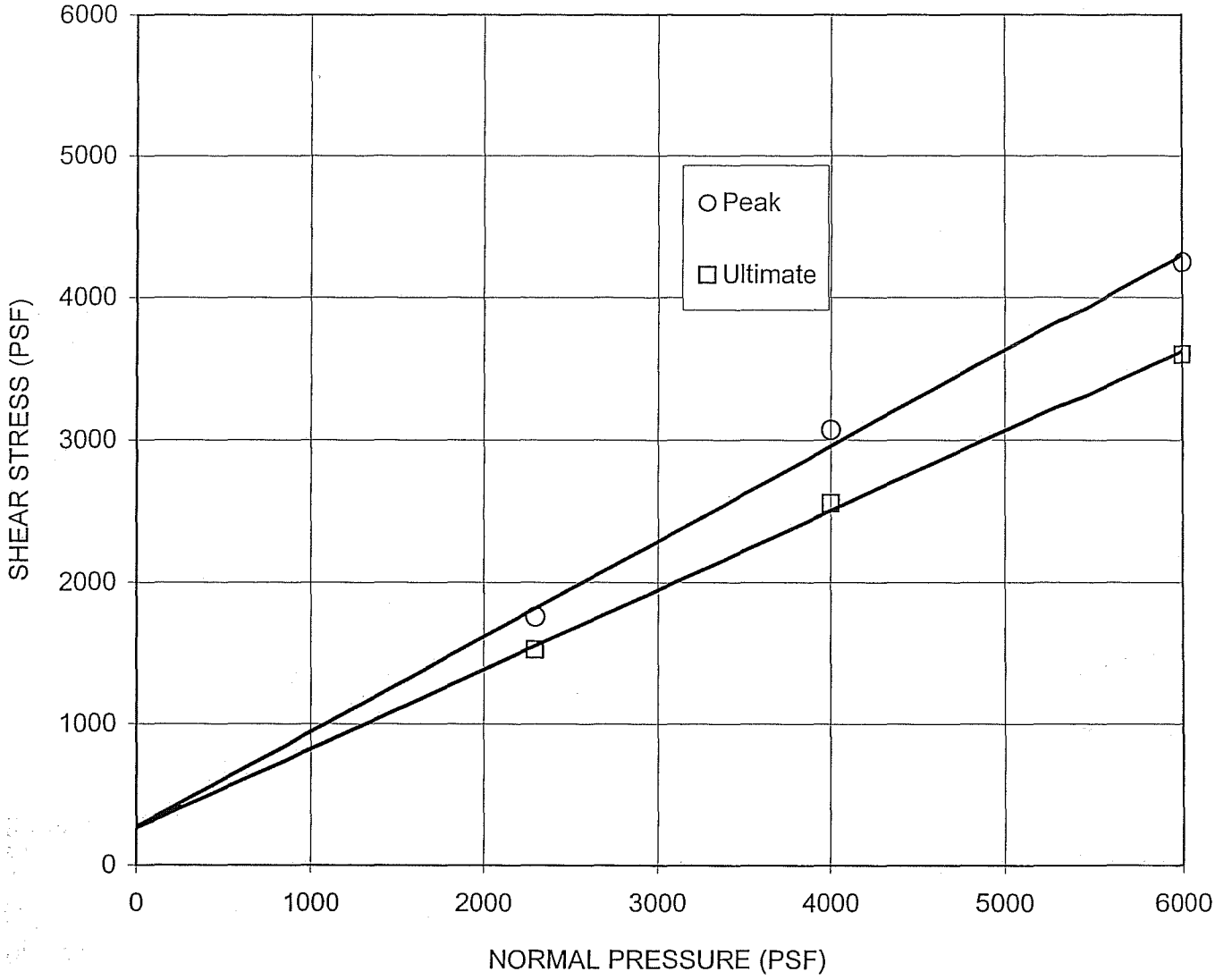
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-038	D-05	30	Ring	SM	○	275	34
					□	265	29

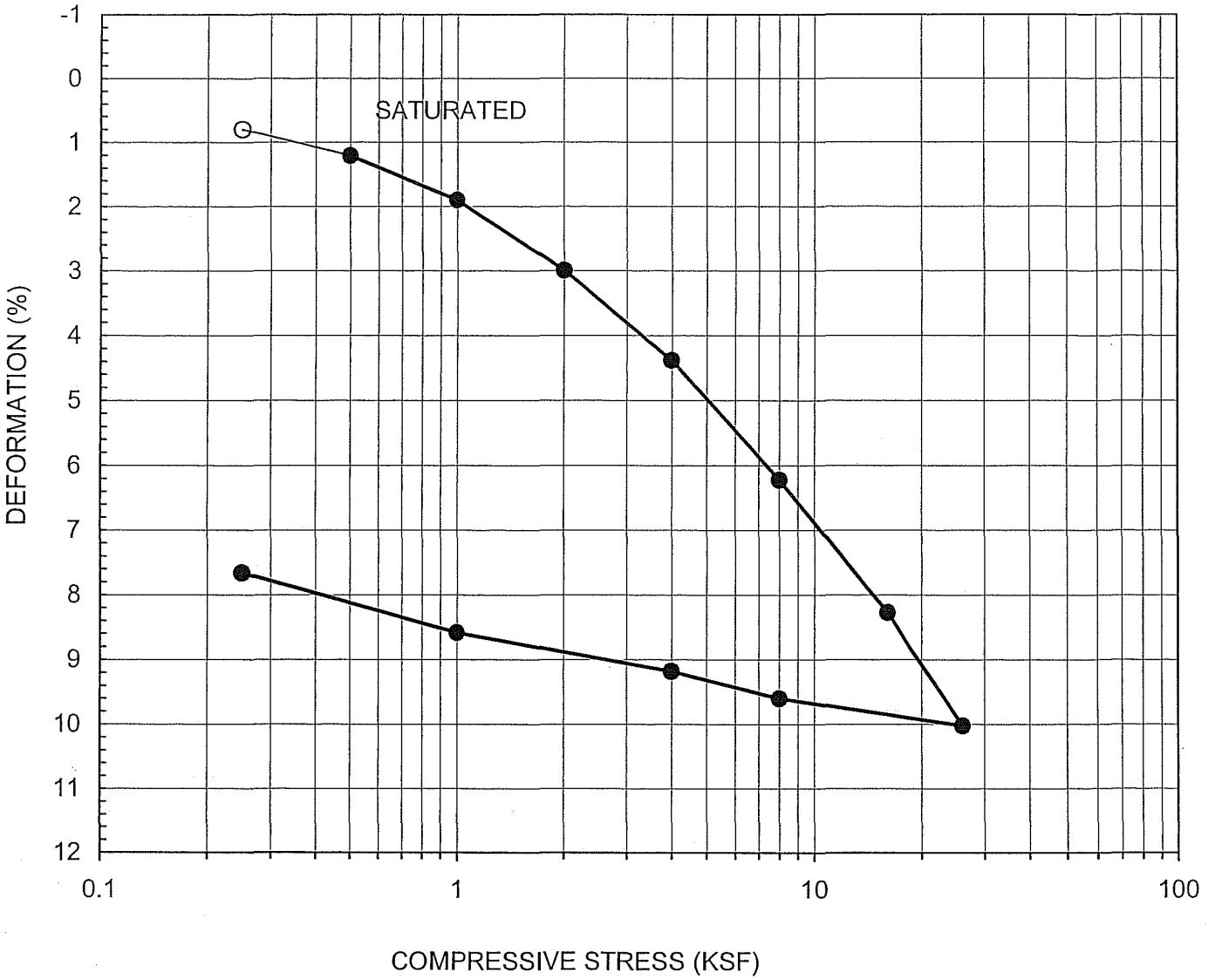
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2300	26.5	29.8
4000	26.5	28.3
6000	26.5	27.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



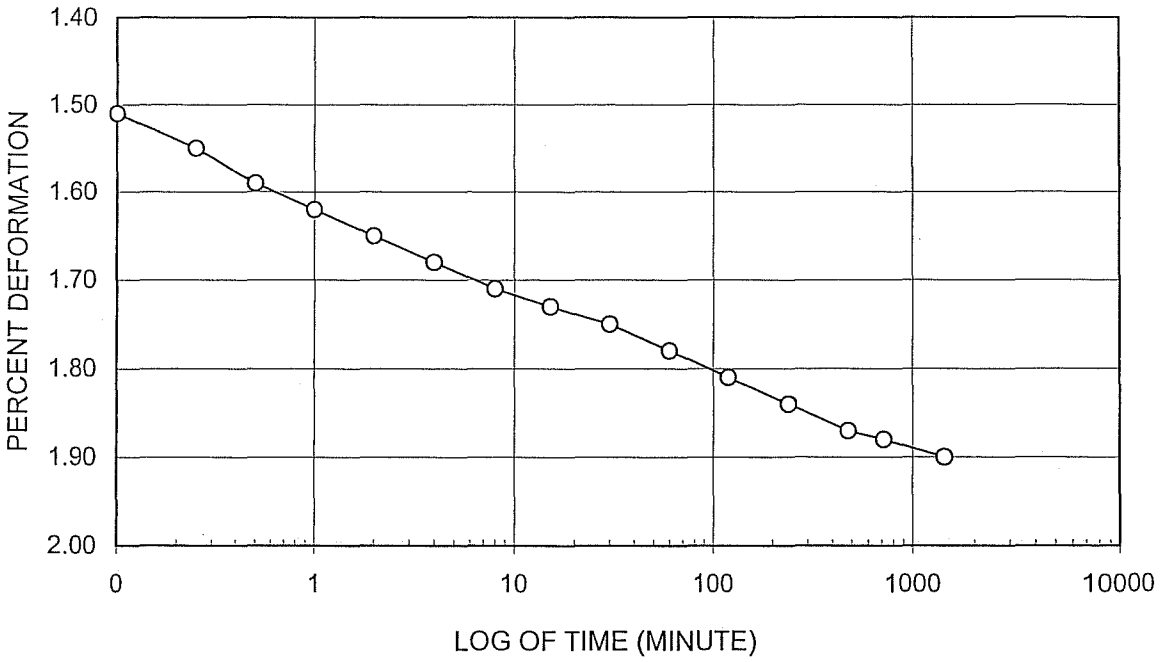
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-038	D-10-1	55.0	ML	26.1	96.9	0.738

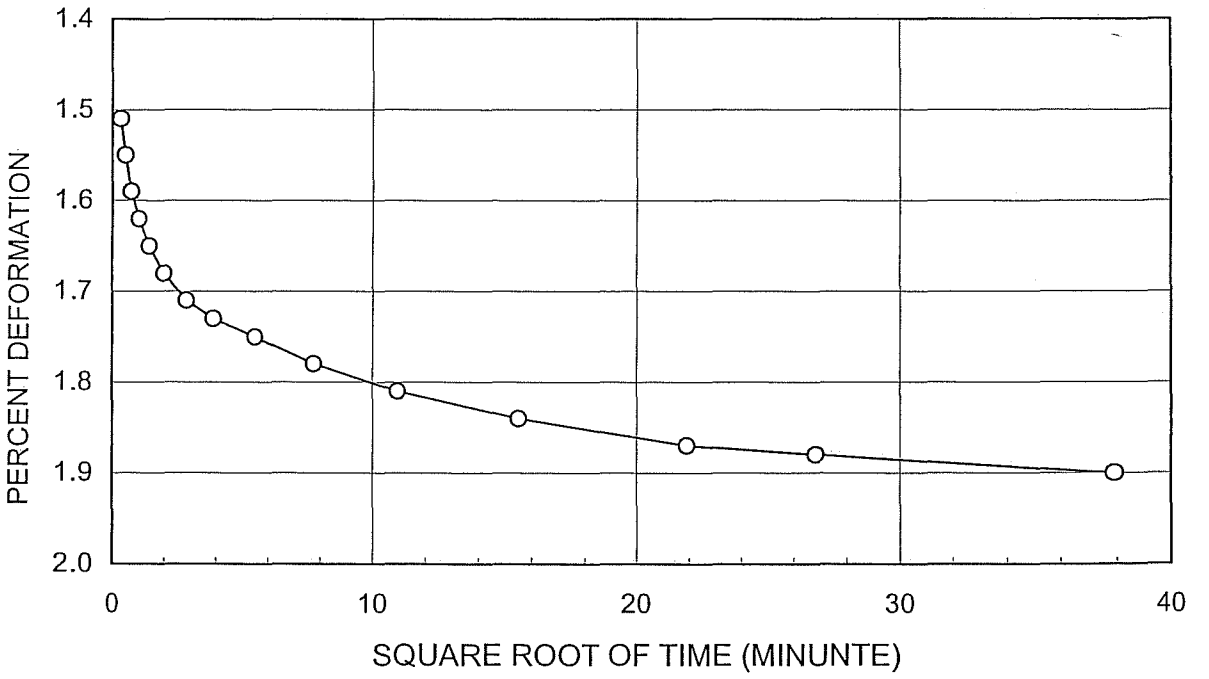
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





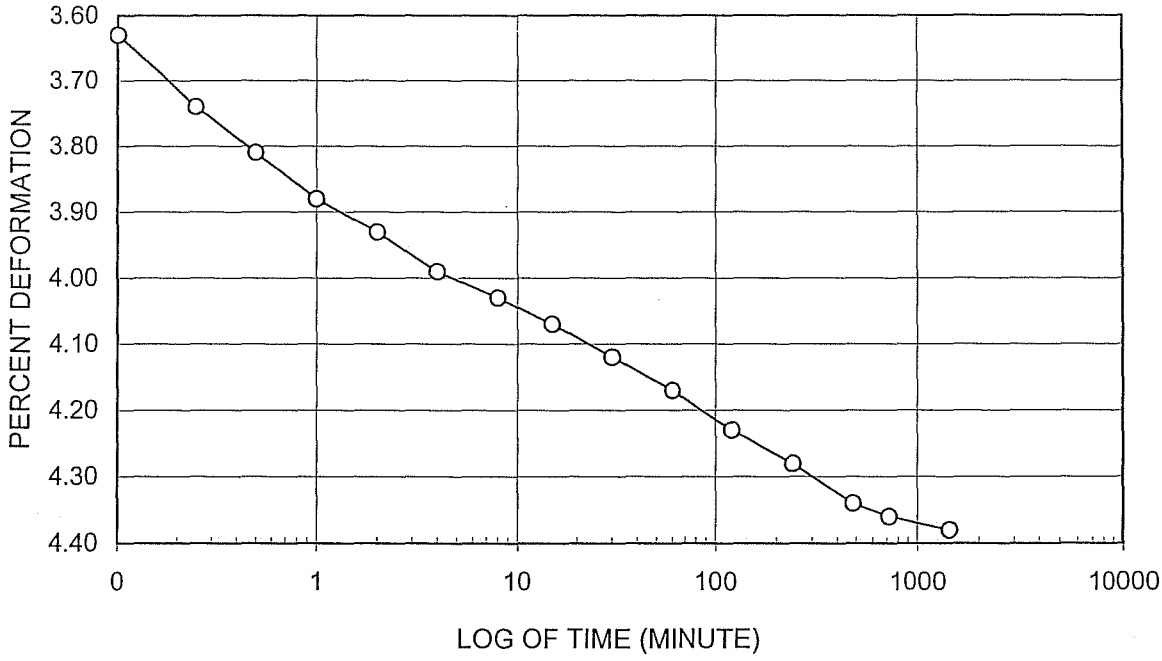
Boring No: R-09-038
Sample No: D-10-1
Depth (ft): 55
Soil Type: ML
Normal Stress: 1.0 ksf

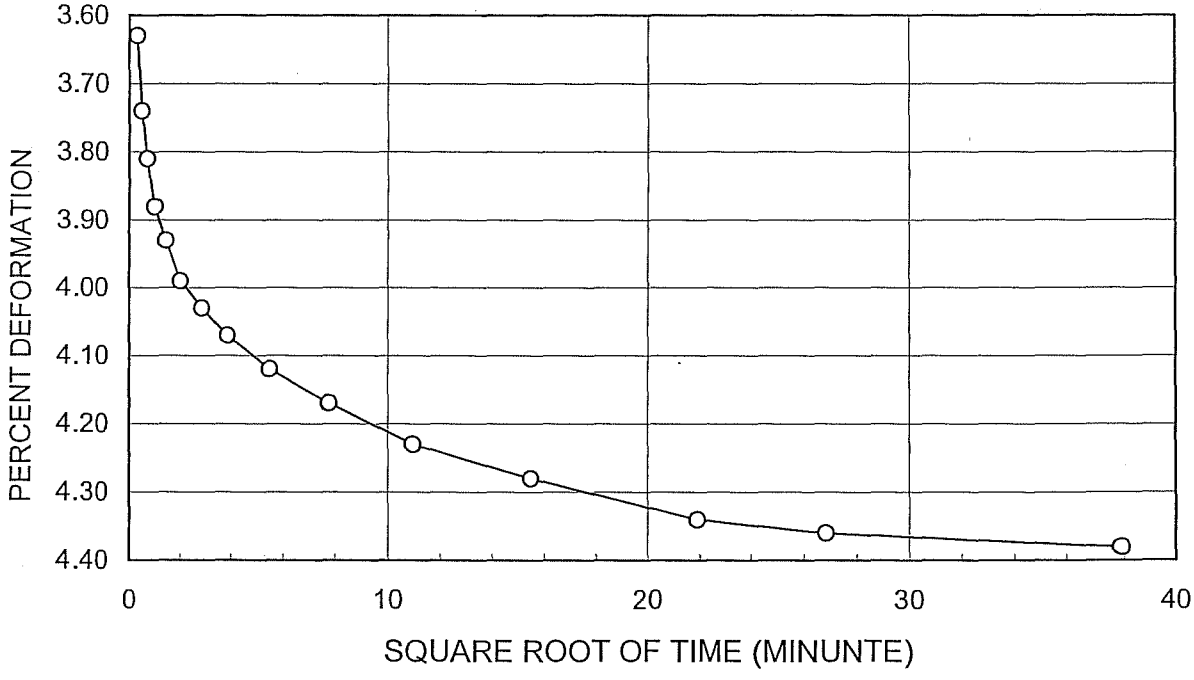
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





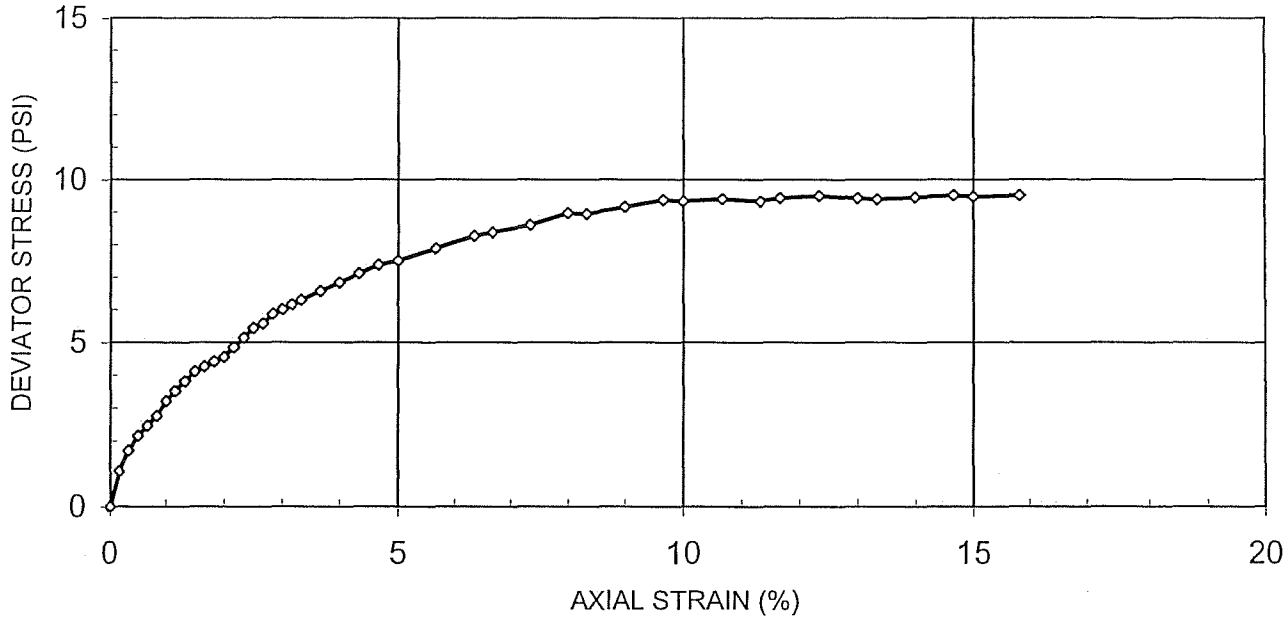
Boring No: R-09-038
Sample No: D-10-1
Depth (ft): 55
Soil Type: ML
Normal Stress: 4.0 ksf

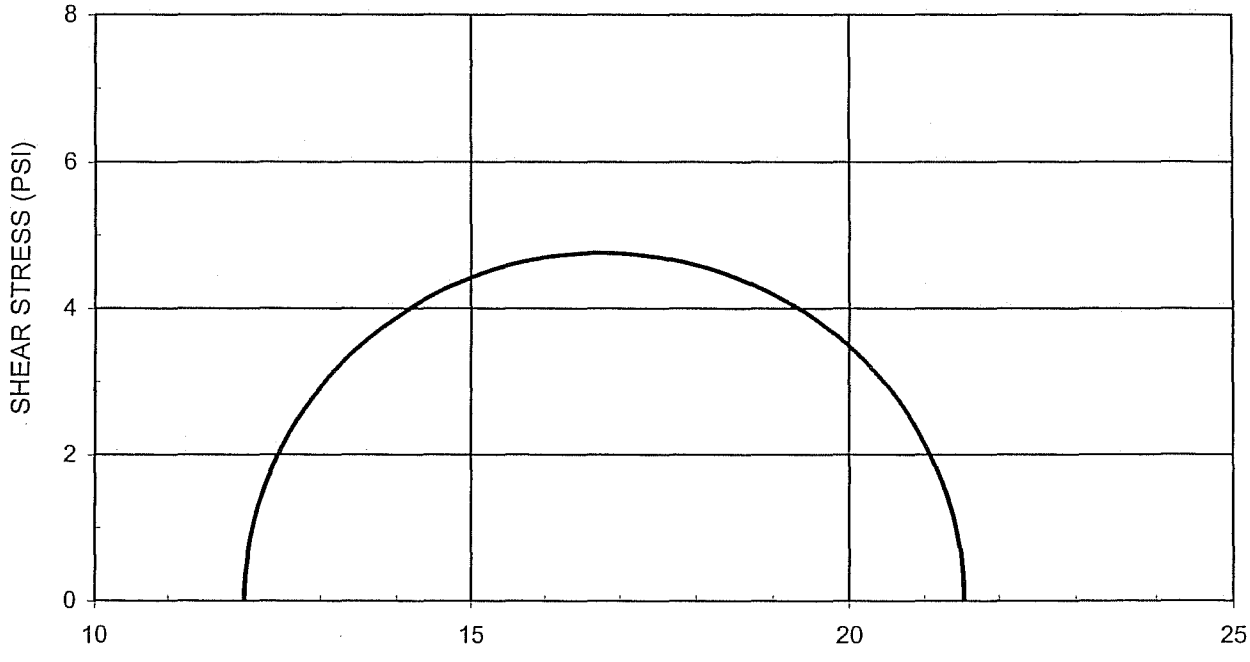
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-038	35	U-06	CH	Shelby Tube	57.95	66.5	12.0	9.5	0.06	102.2

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

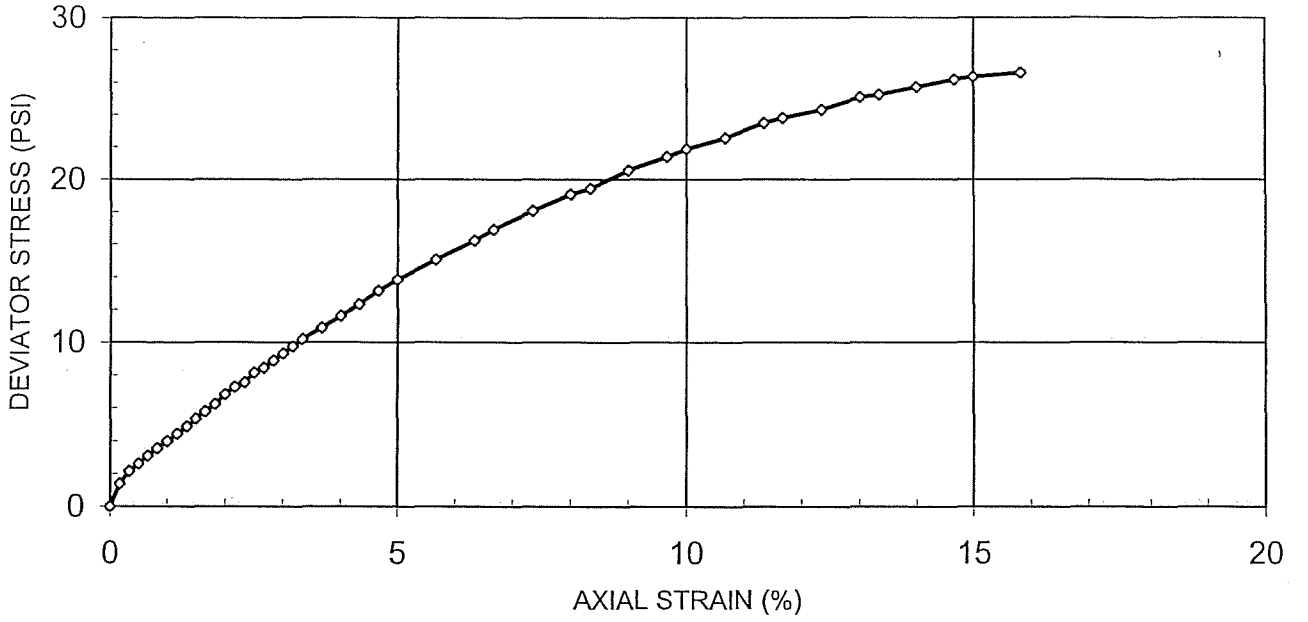
EGL Project No: 09-230-008A

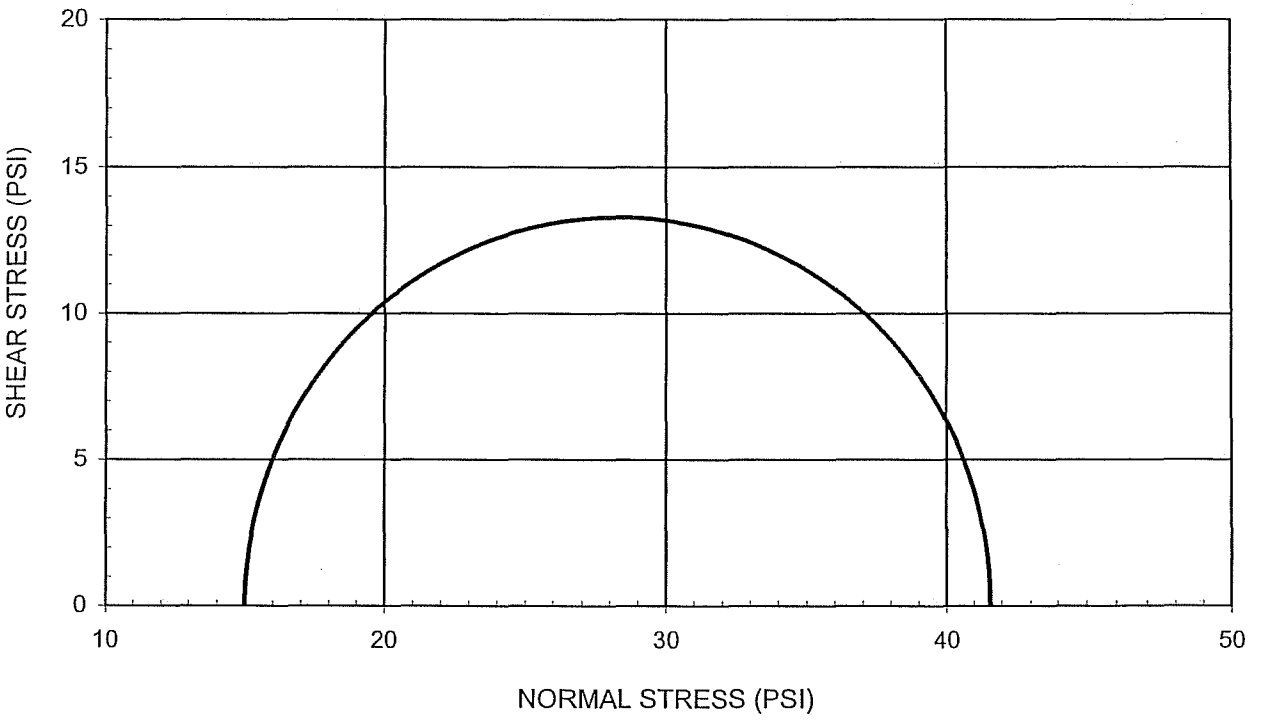
UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-038	46	U-08	ML	Shelby Tube	31.14	91.7	15.0	26.6	0.06	100.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

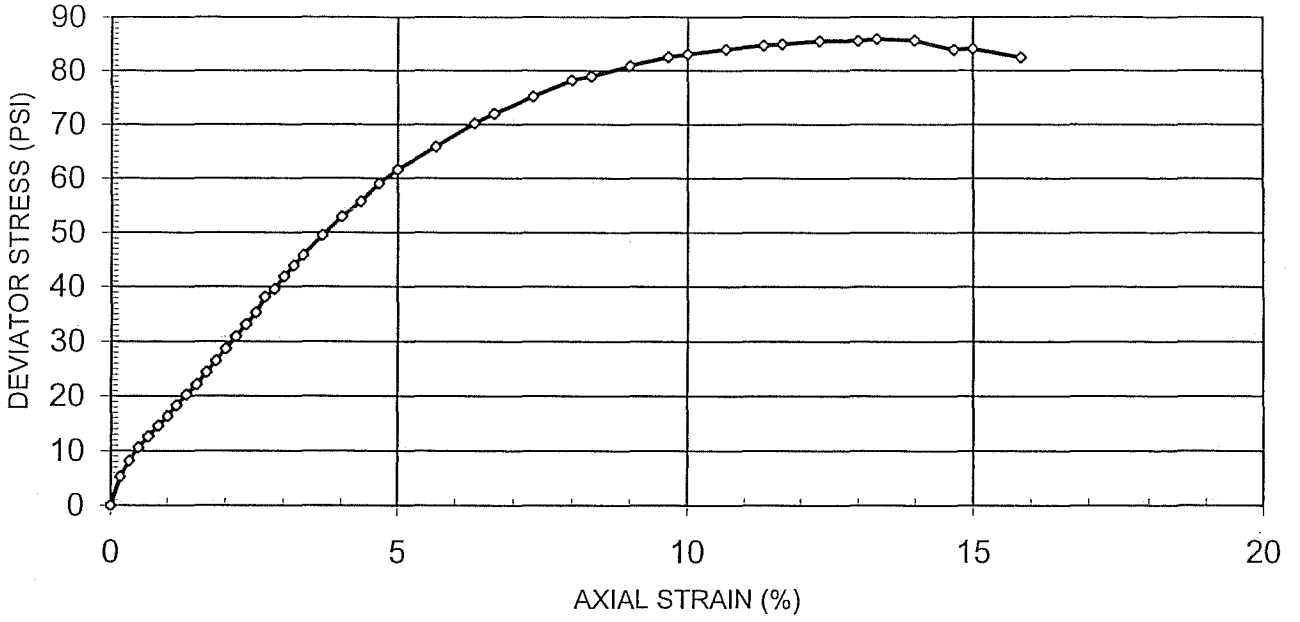
Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

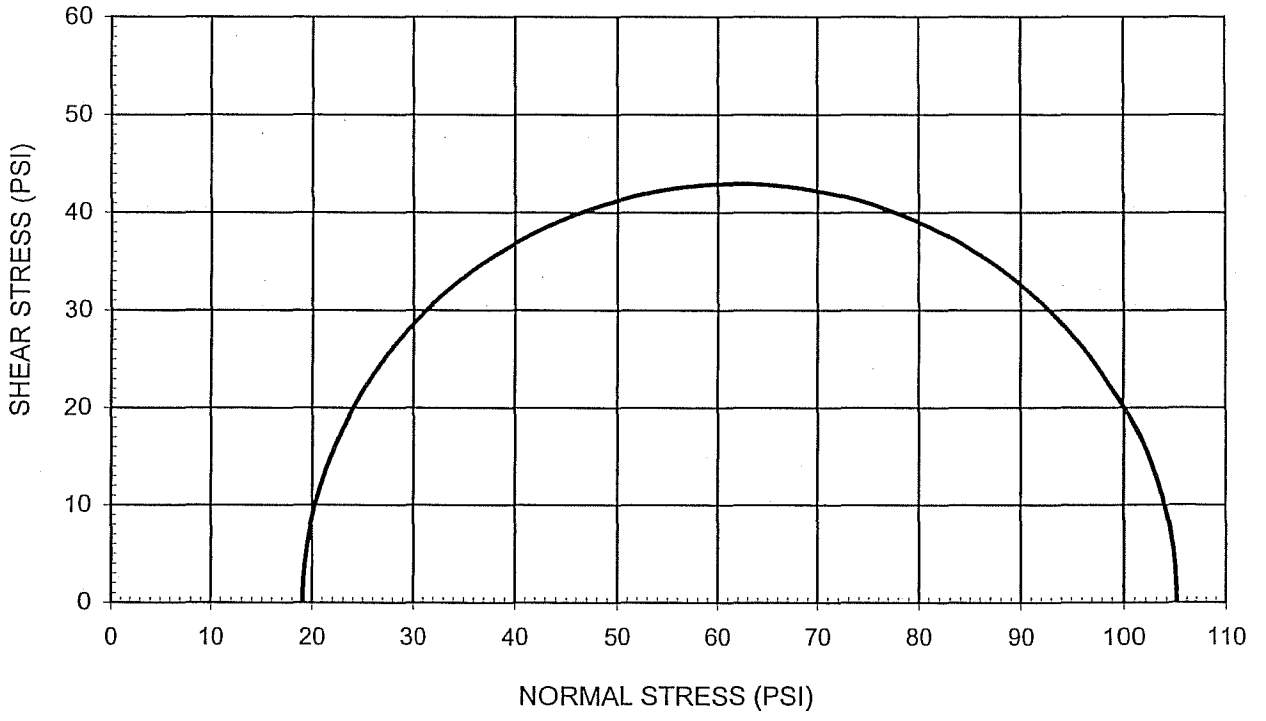
UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-038	61	U-11	ML	Shelby Tube	21.61	105.2	19.0	85.9	0.06	97.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

(ASTM D2850)

12/21/09

Figure

APPENDIX F. SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

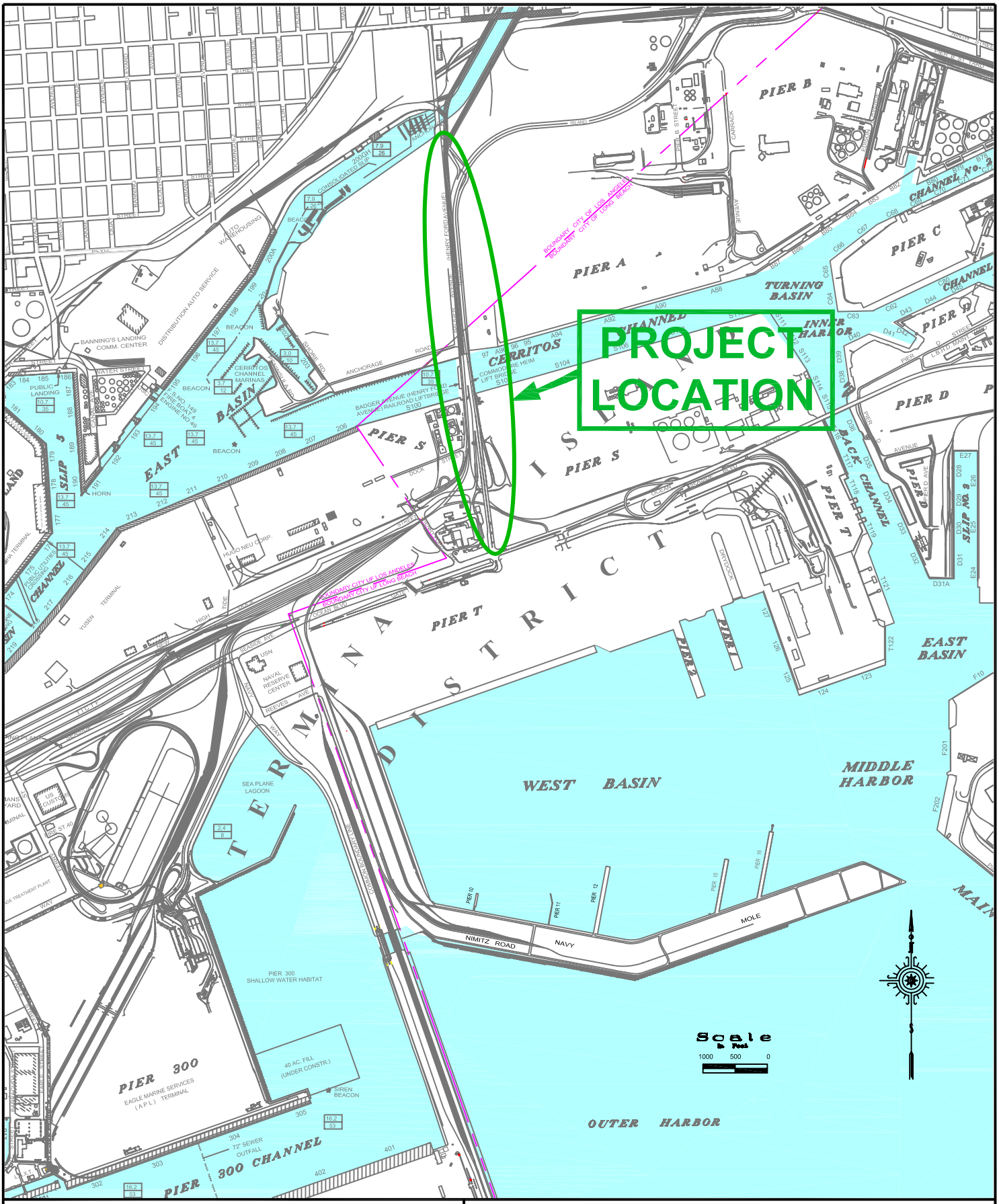
California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

Earth Mechanics, Inc., 2006a, "Preliminary Foundation Report, ACTA Schuyler Heim Bridge (Replace), Los Angeles, California," Report Prepared for Alameda Corridor Transportation Authority, EMI Project No. 06-123, June 23.

——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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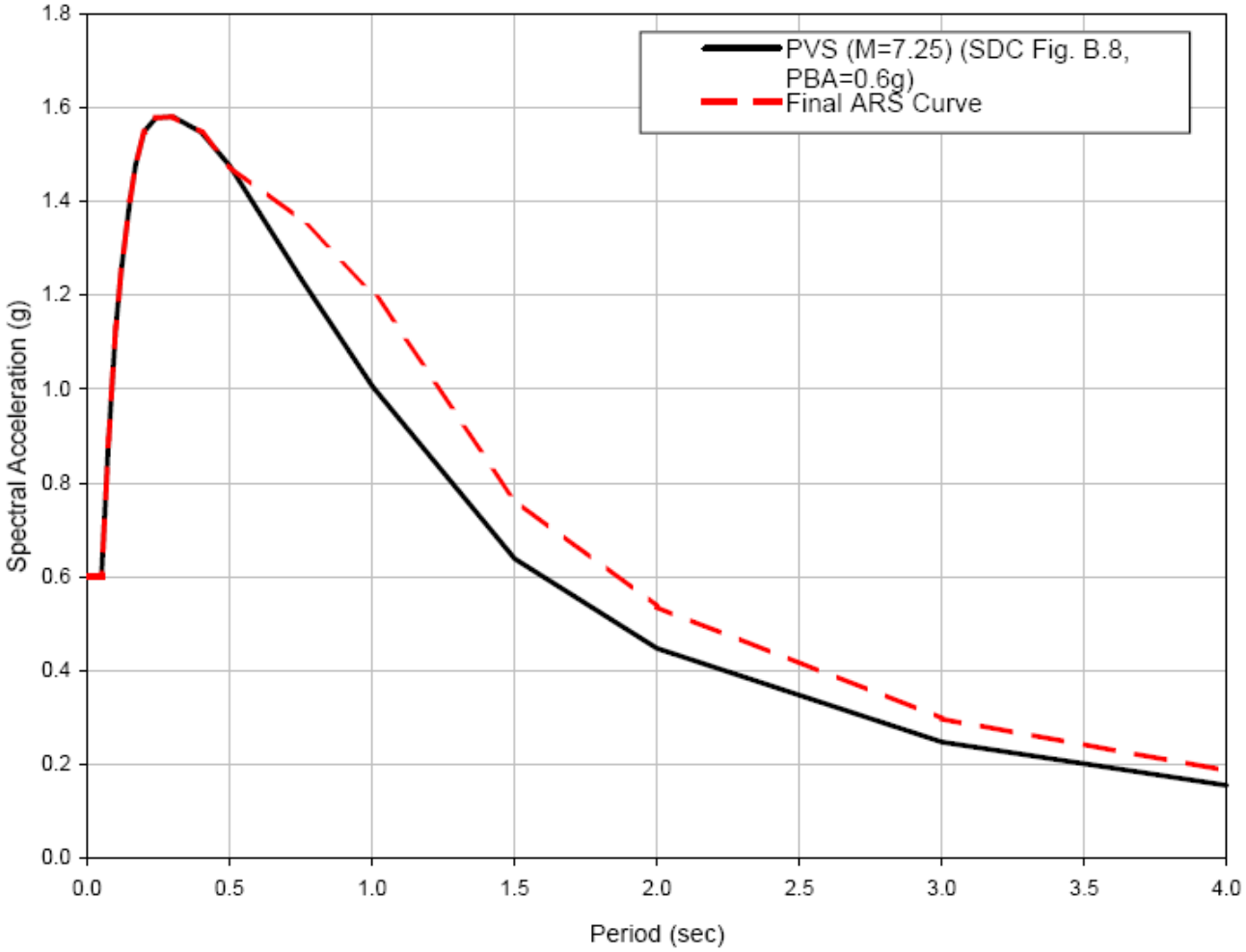
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

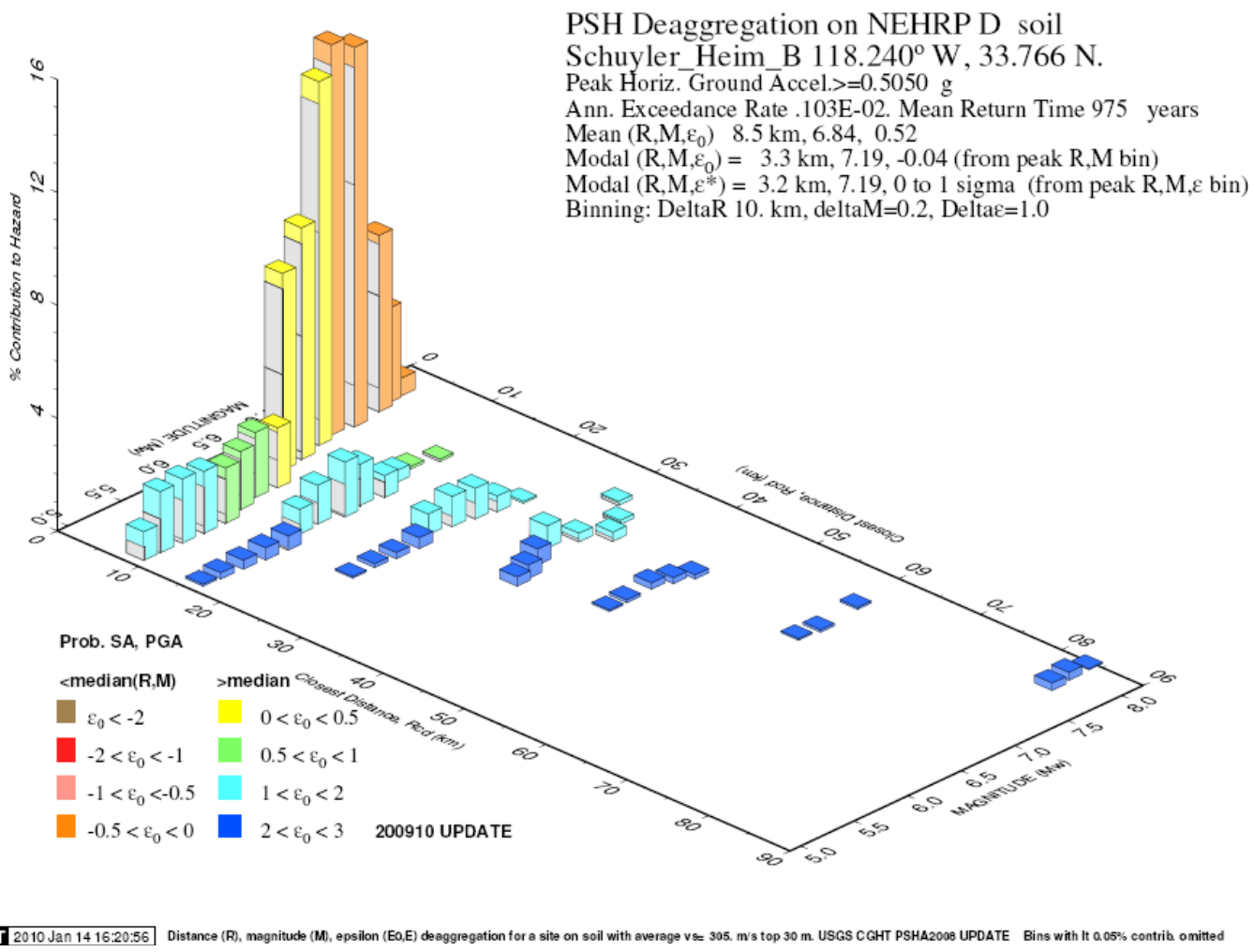


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

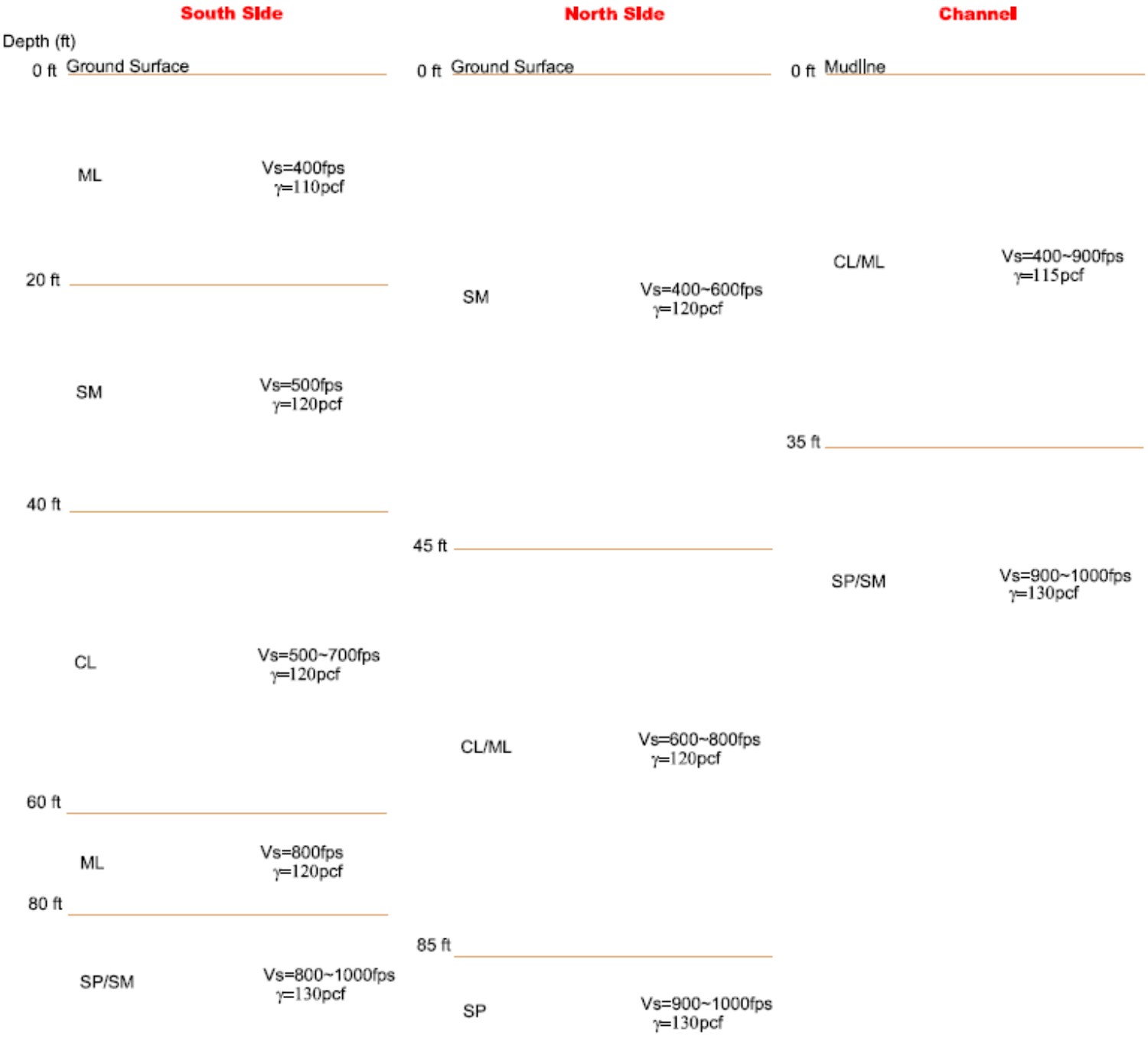
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



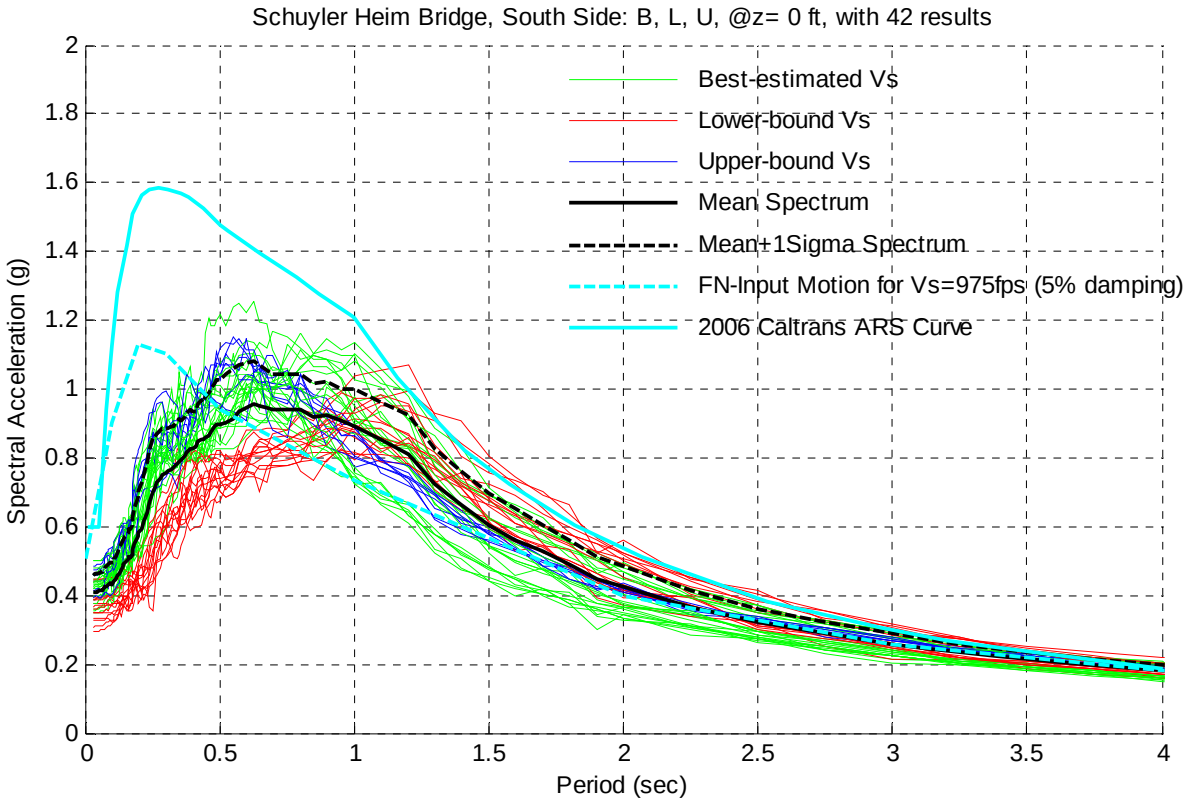
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

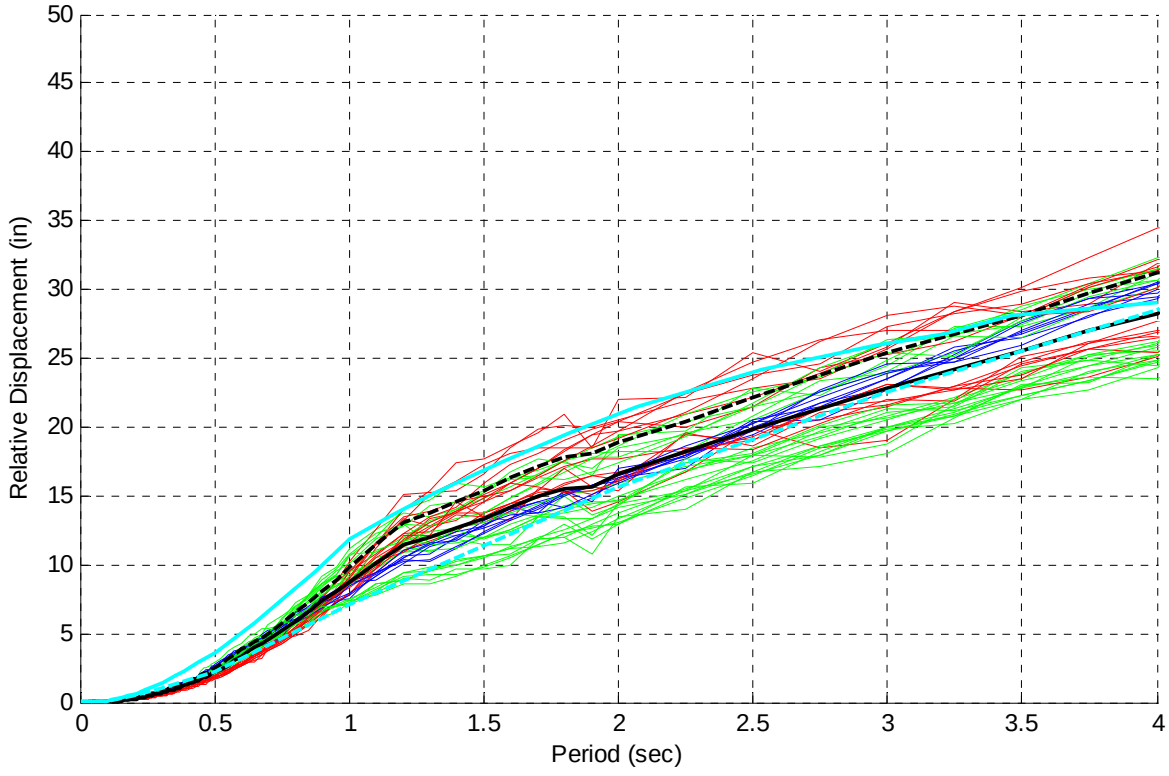
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





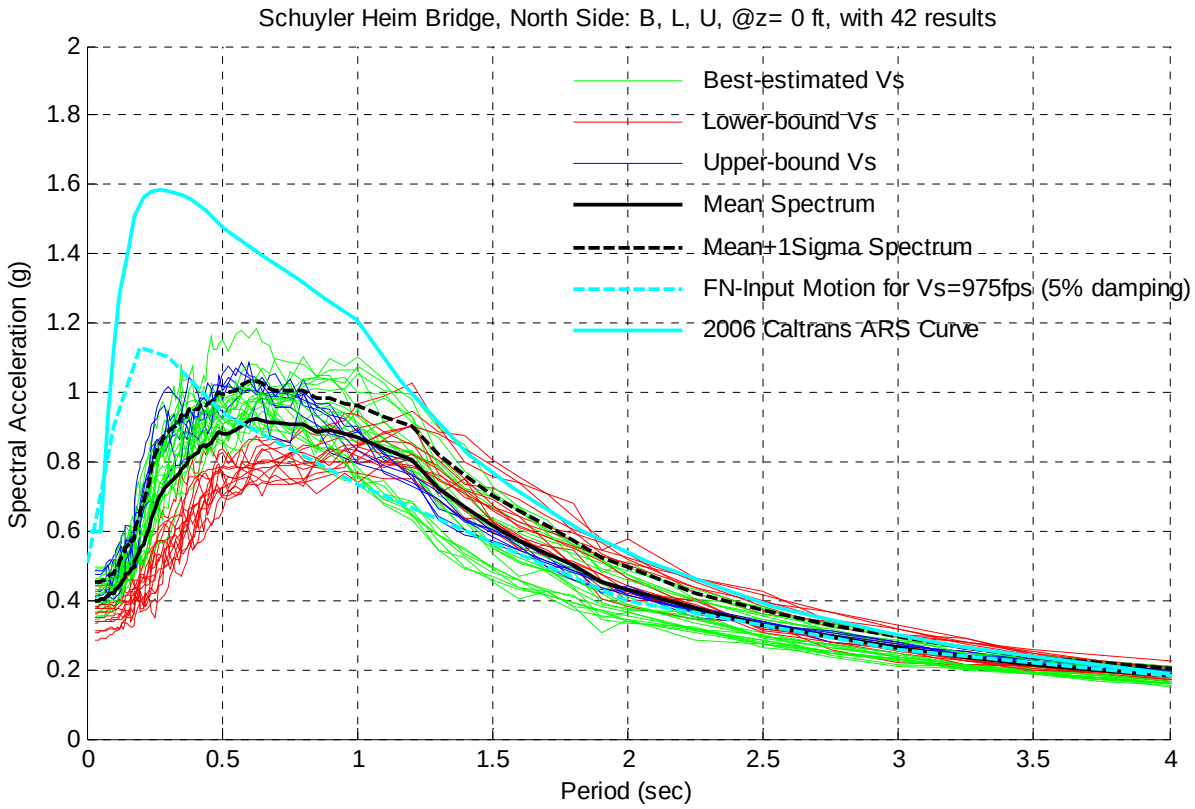
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

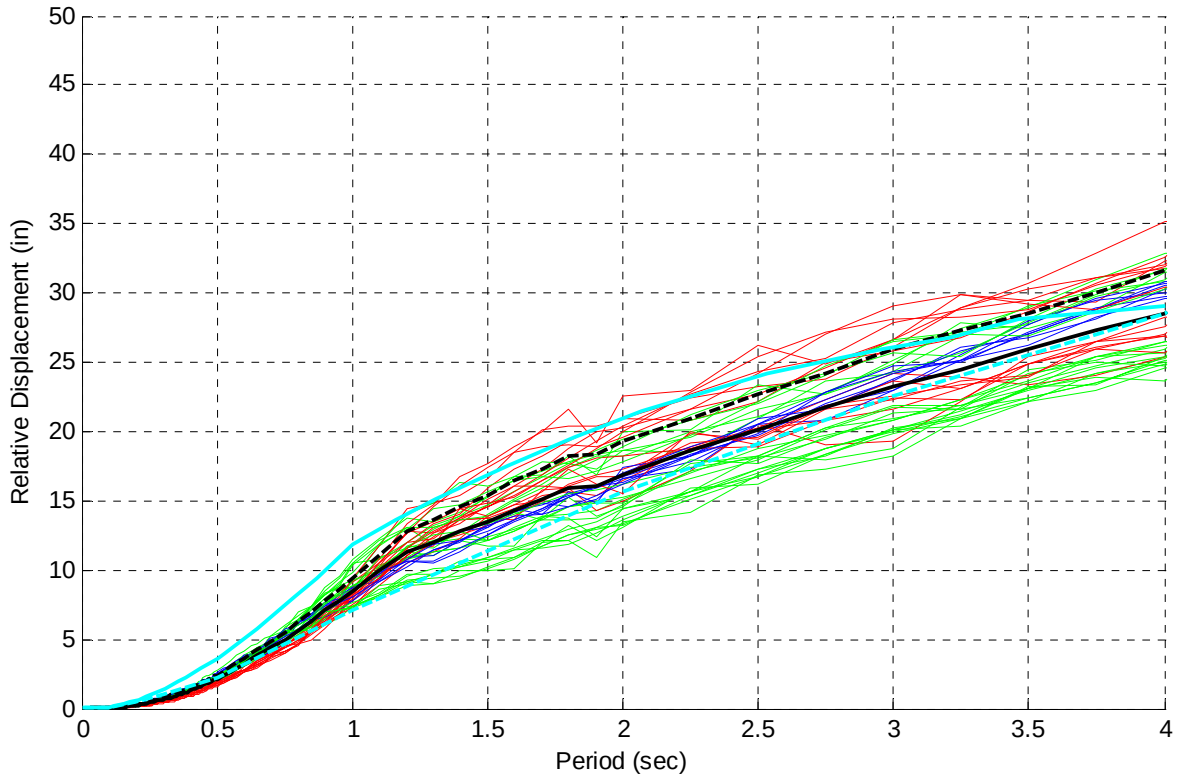
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





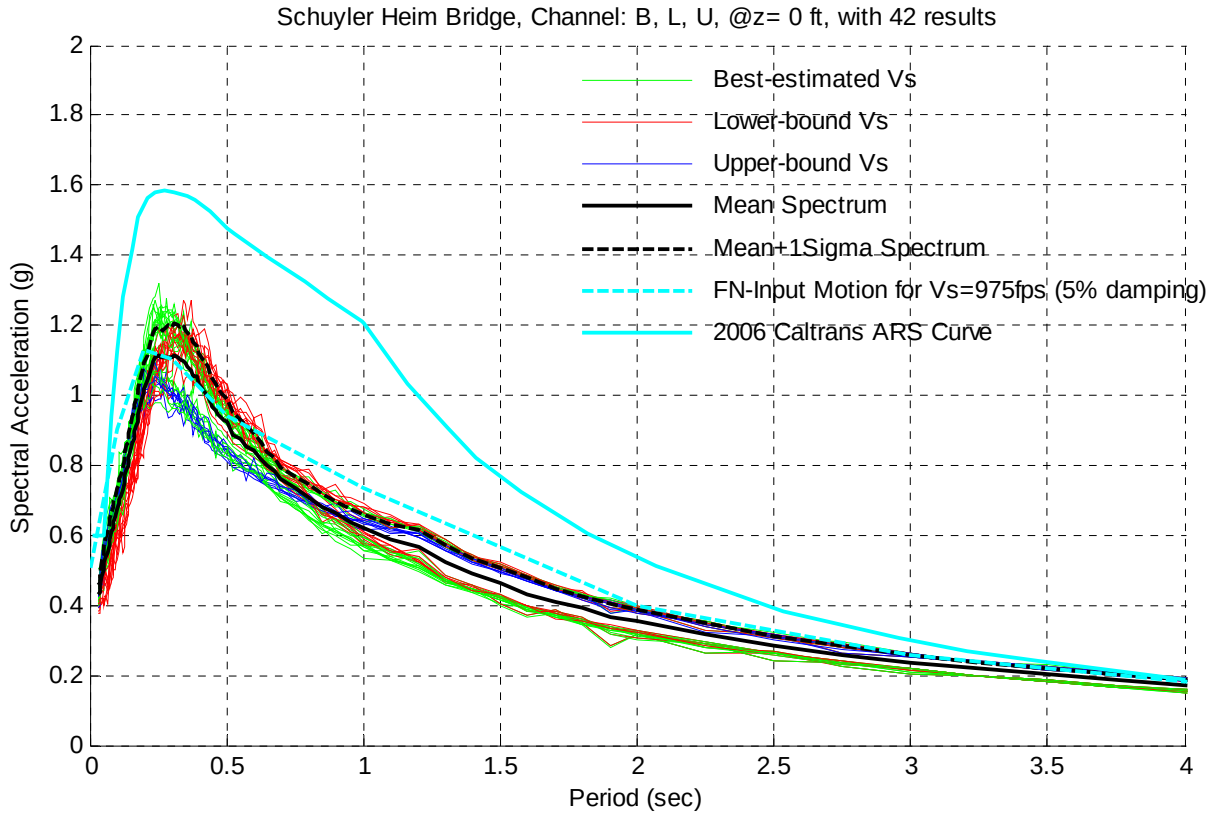
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

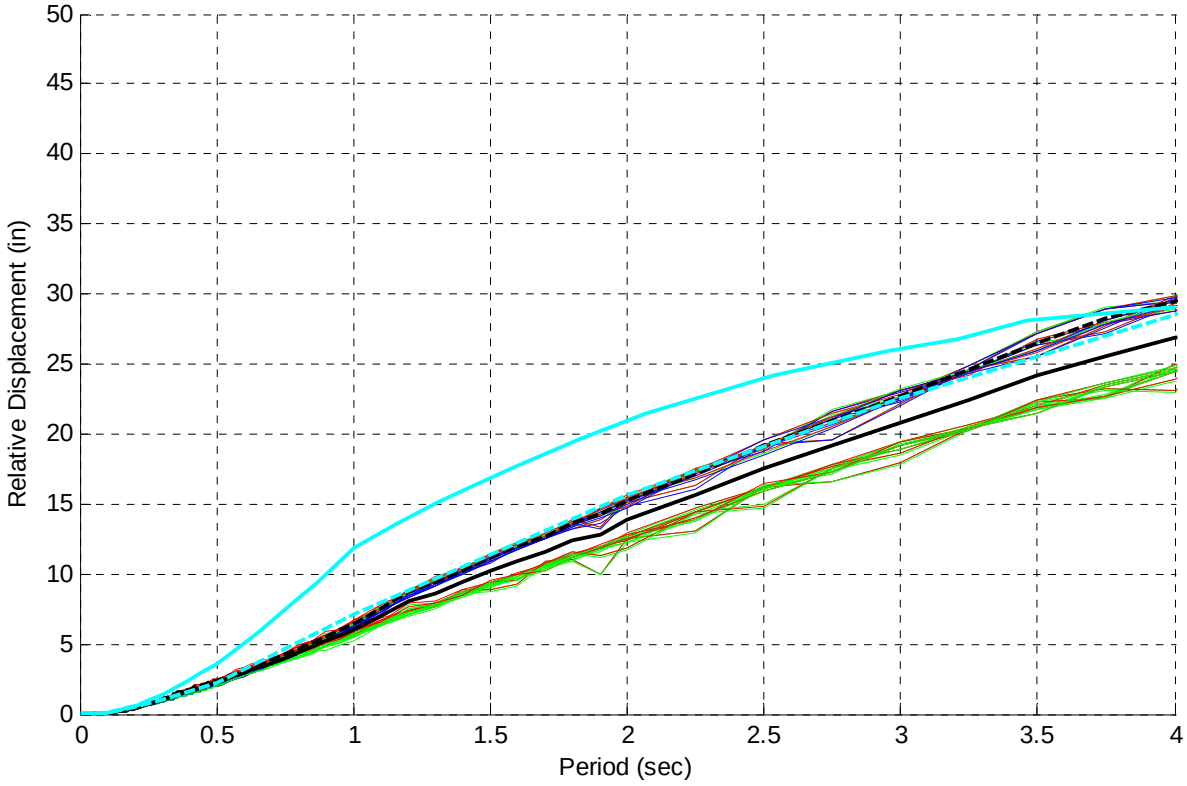
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





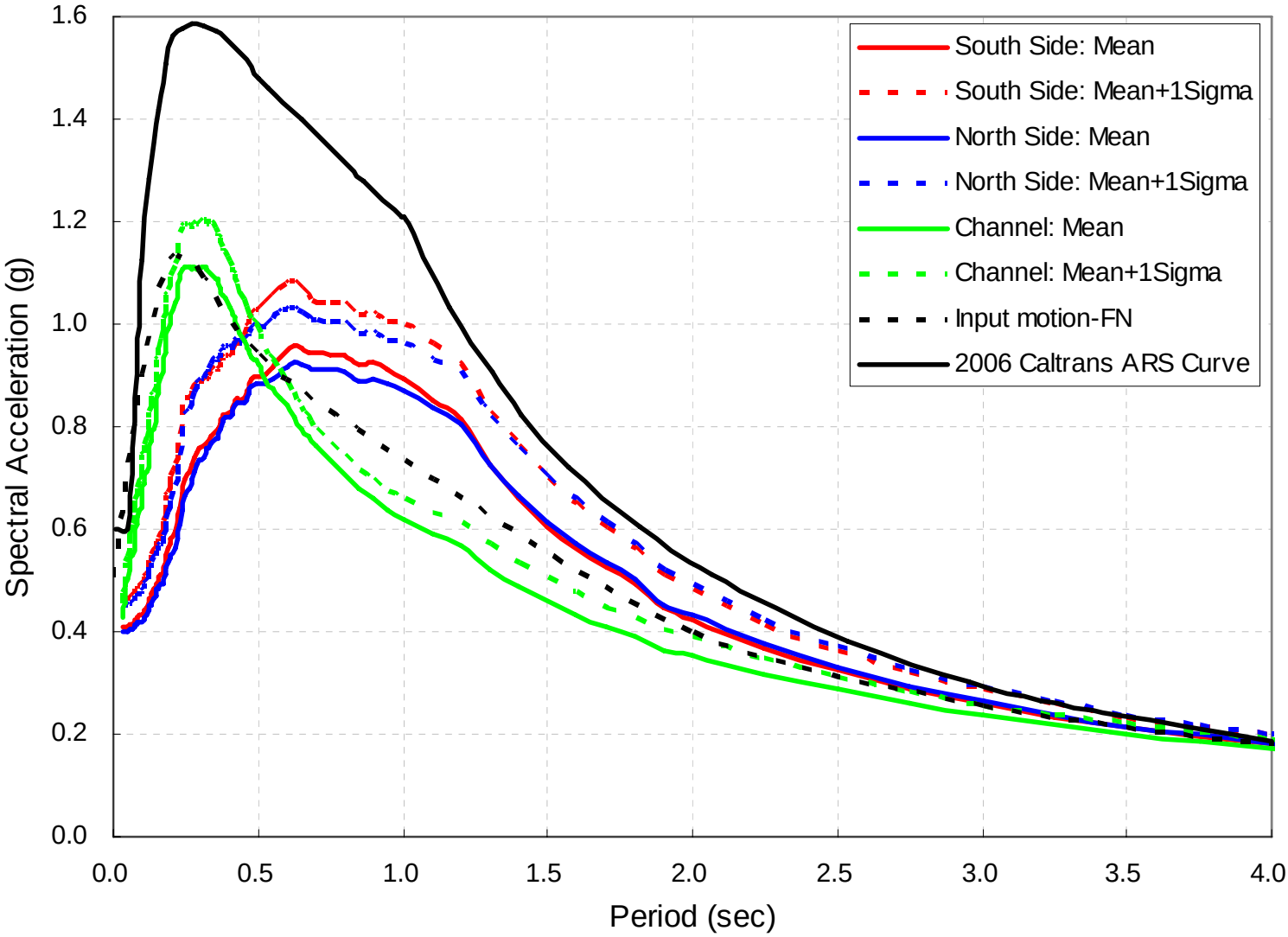
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

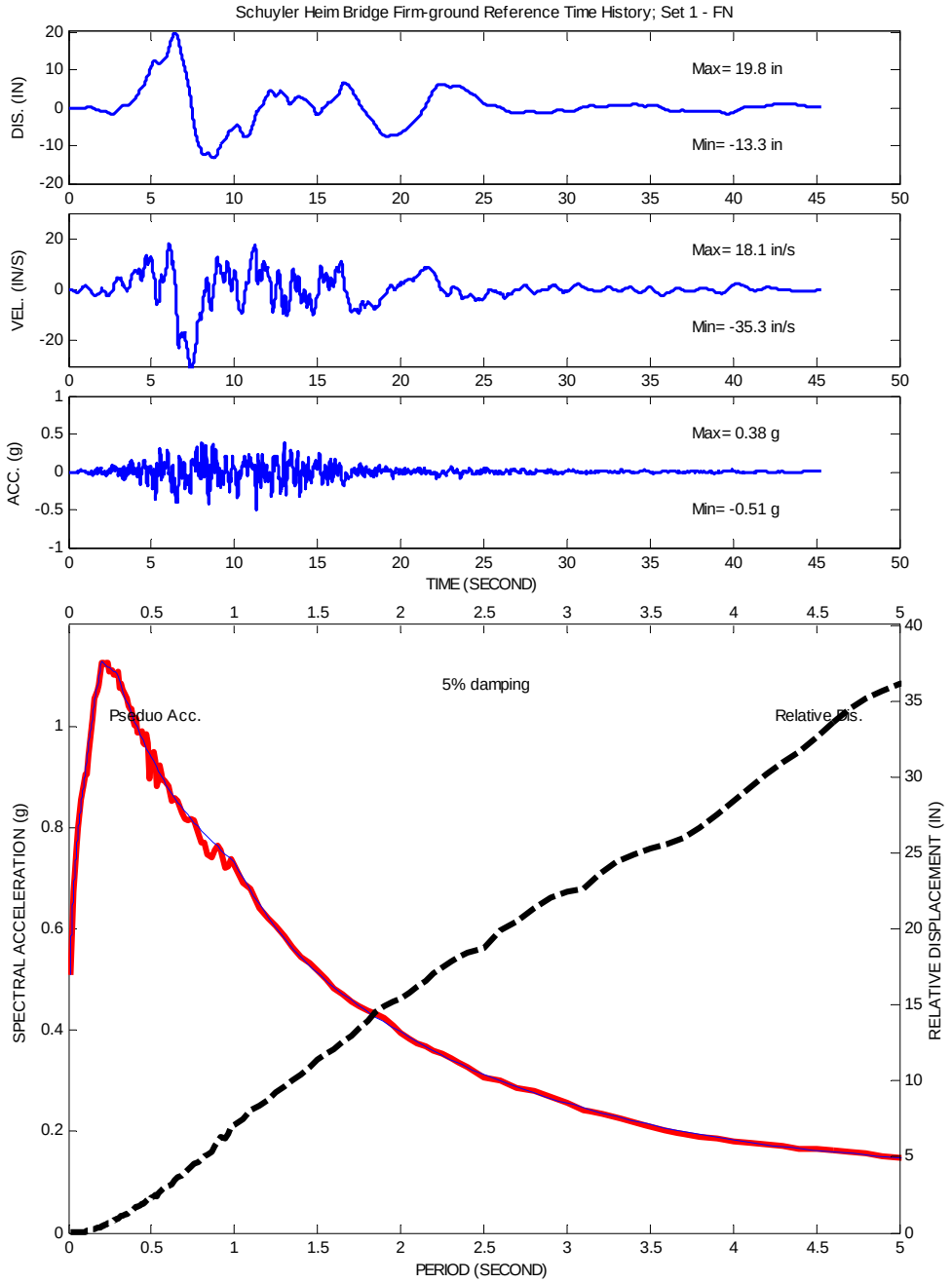

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

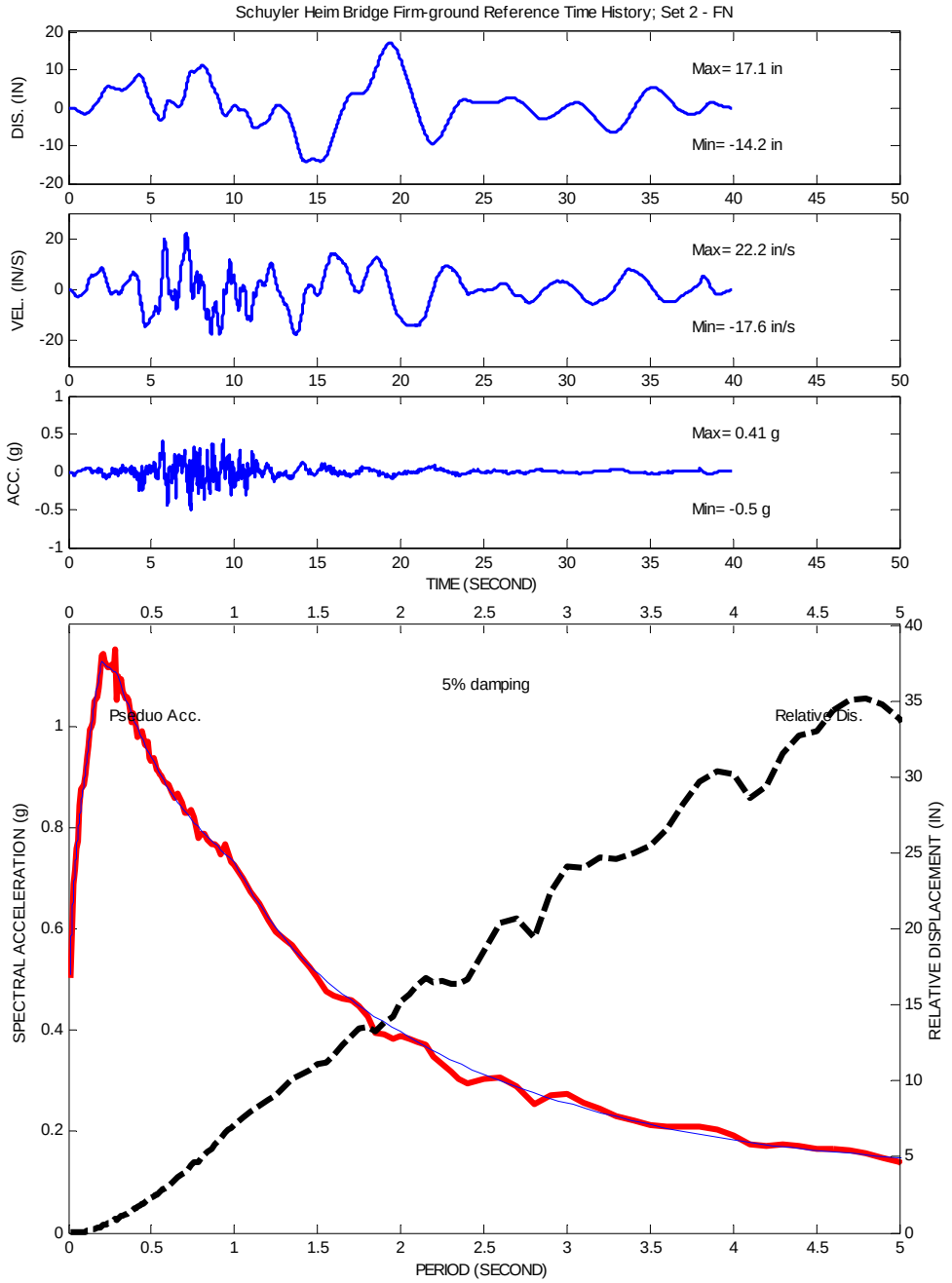

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

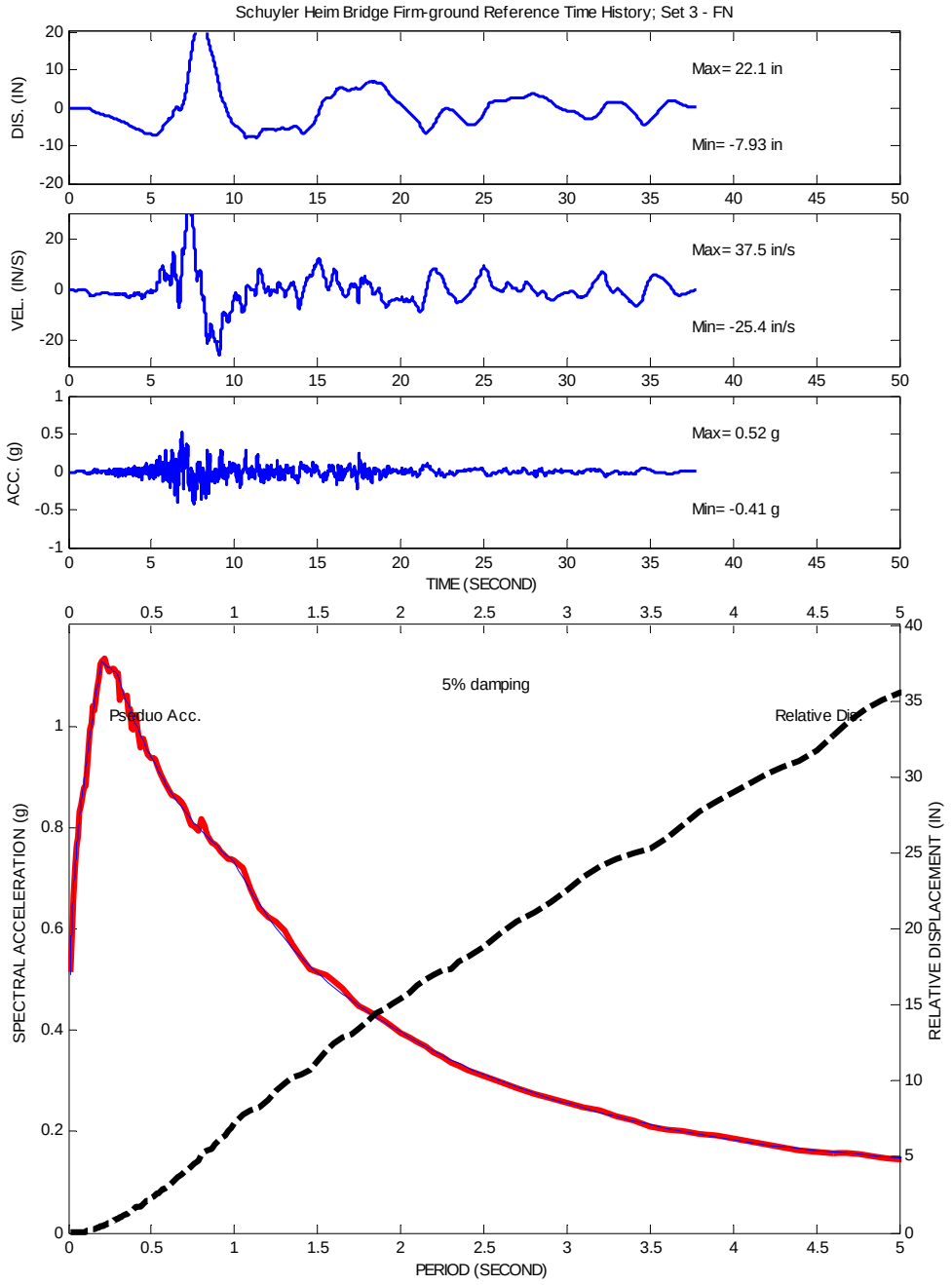

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

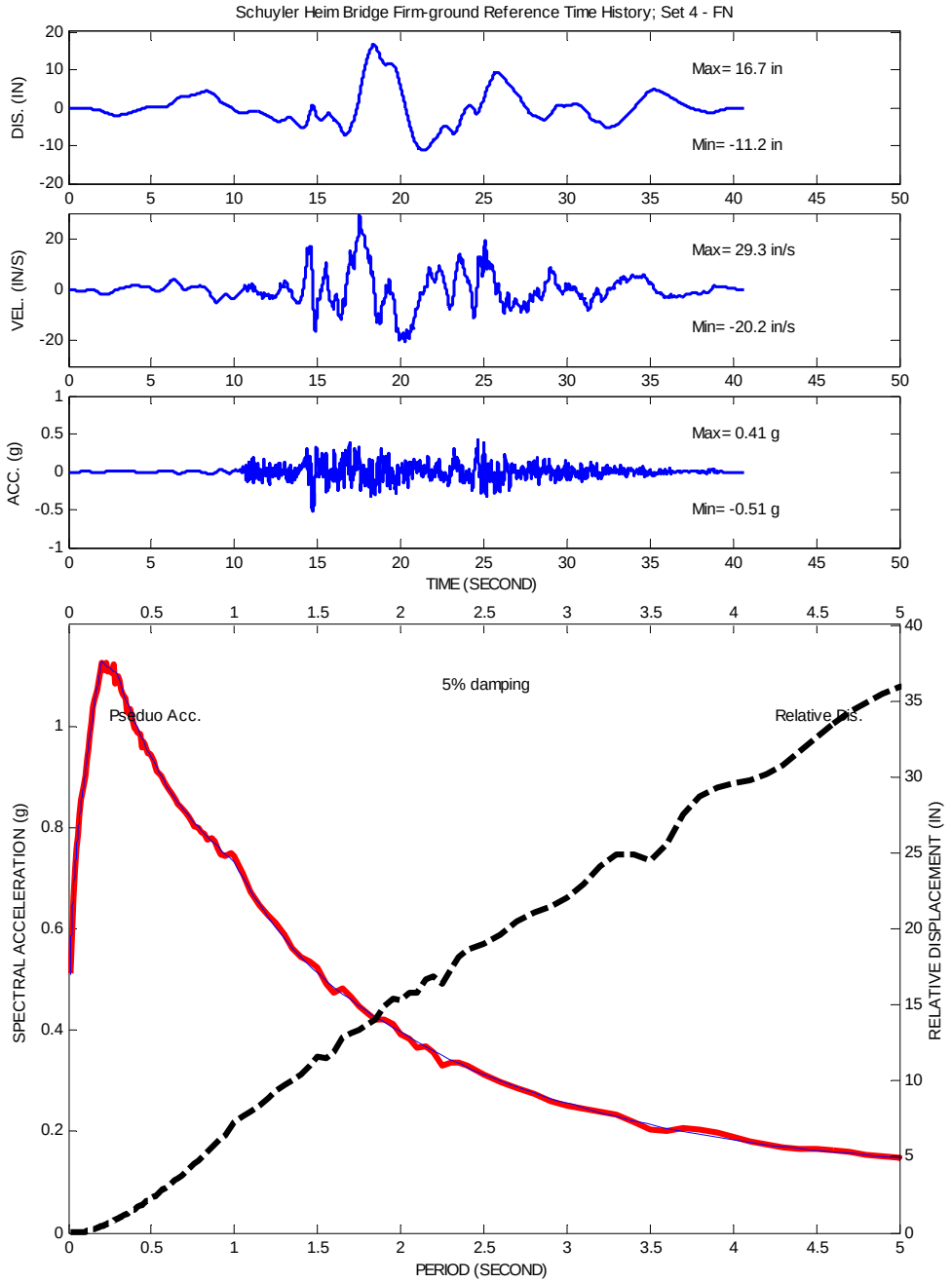

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

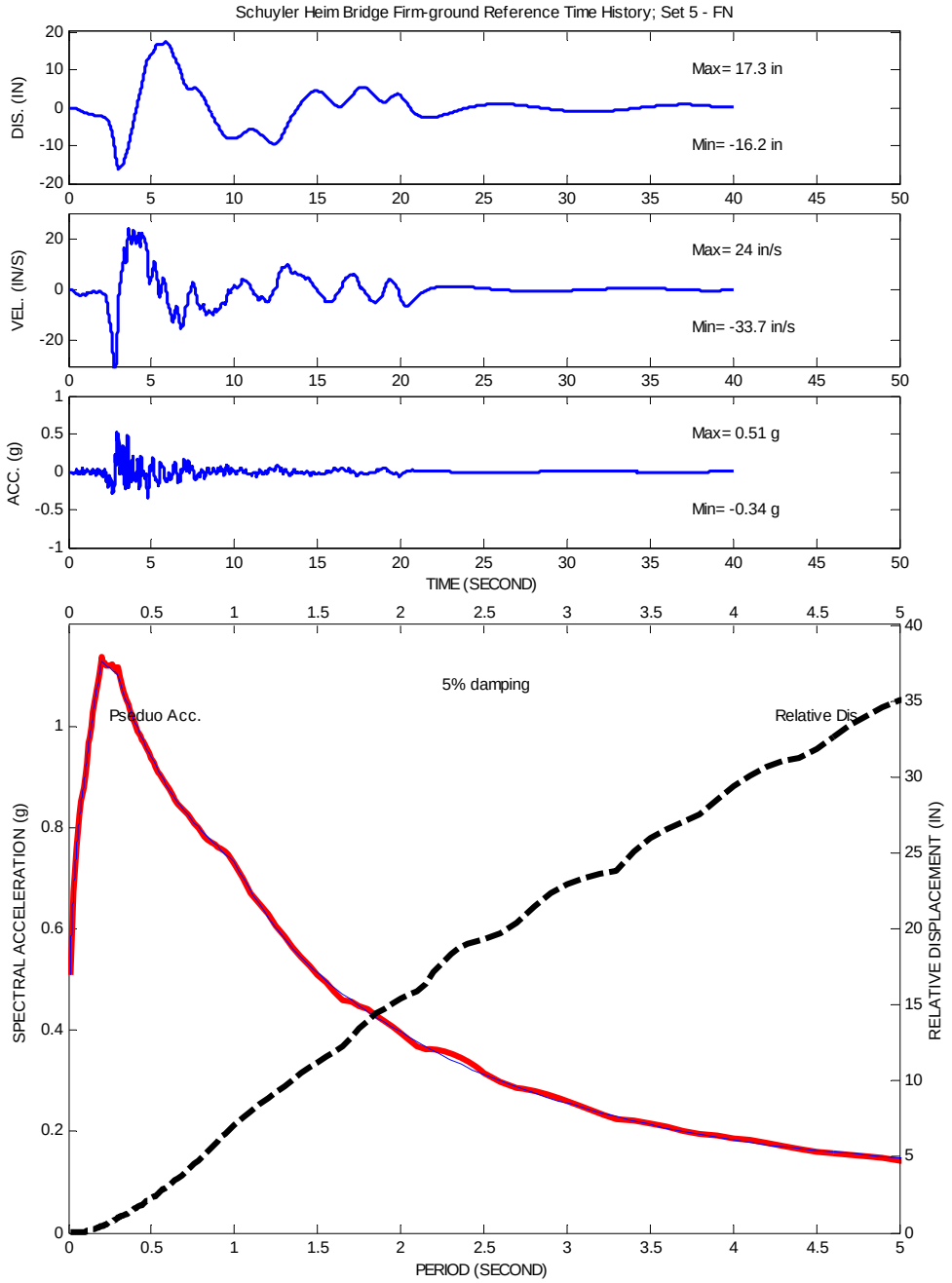

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

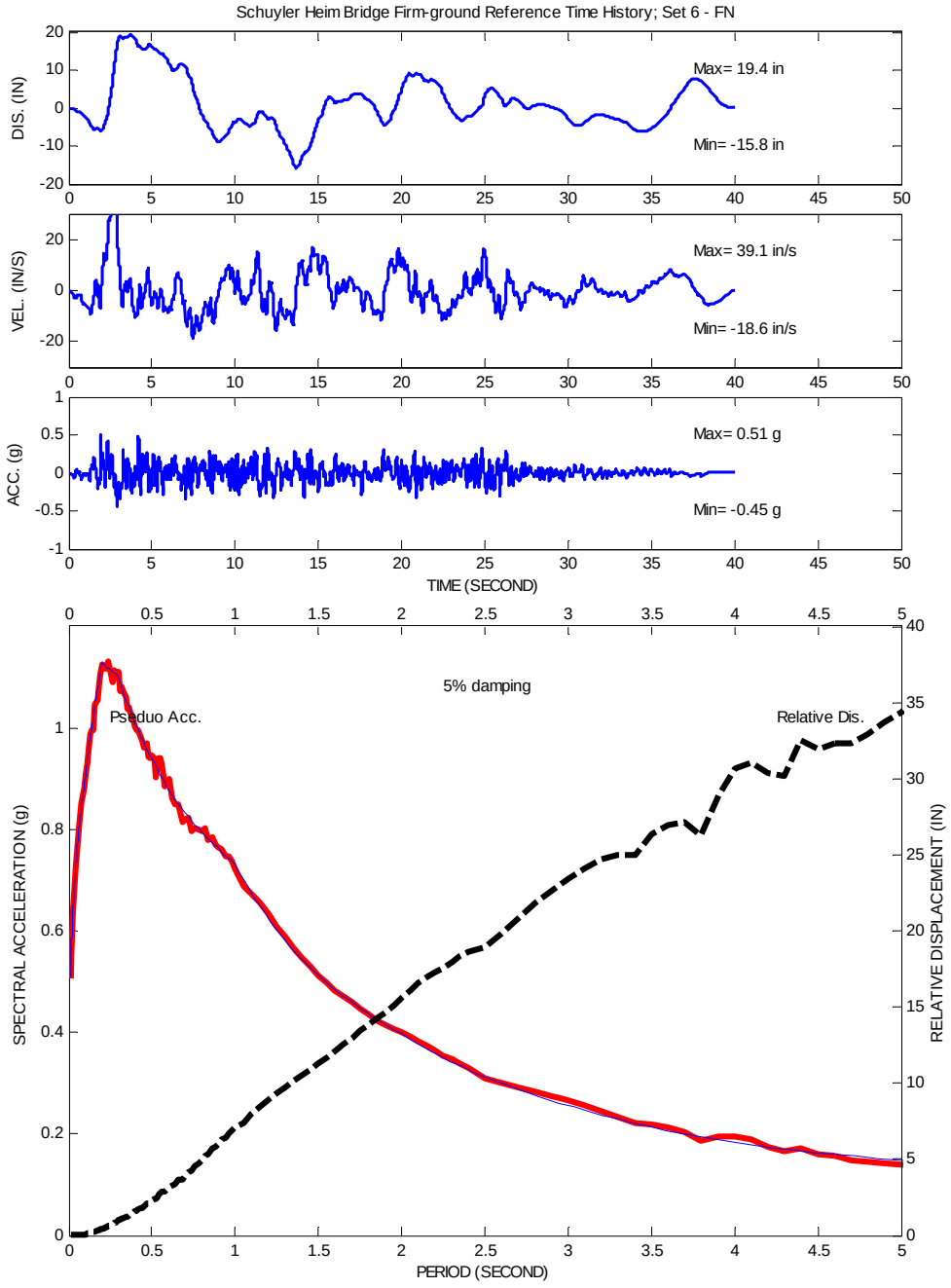

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

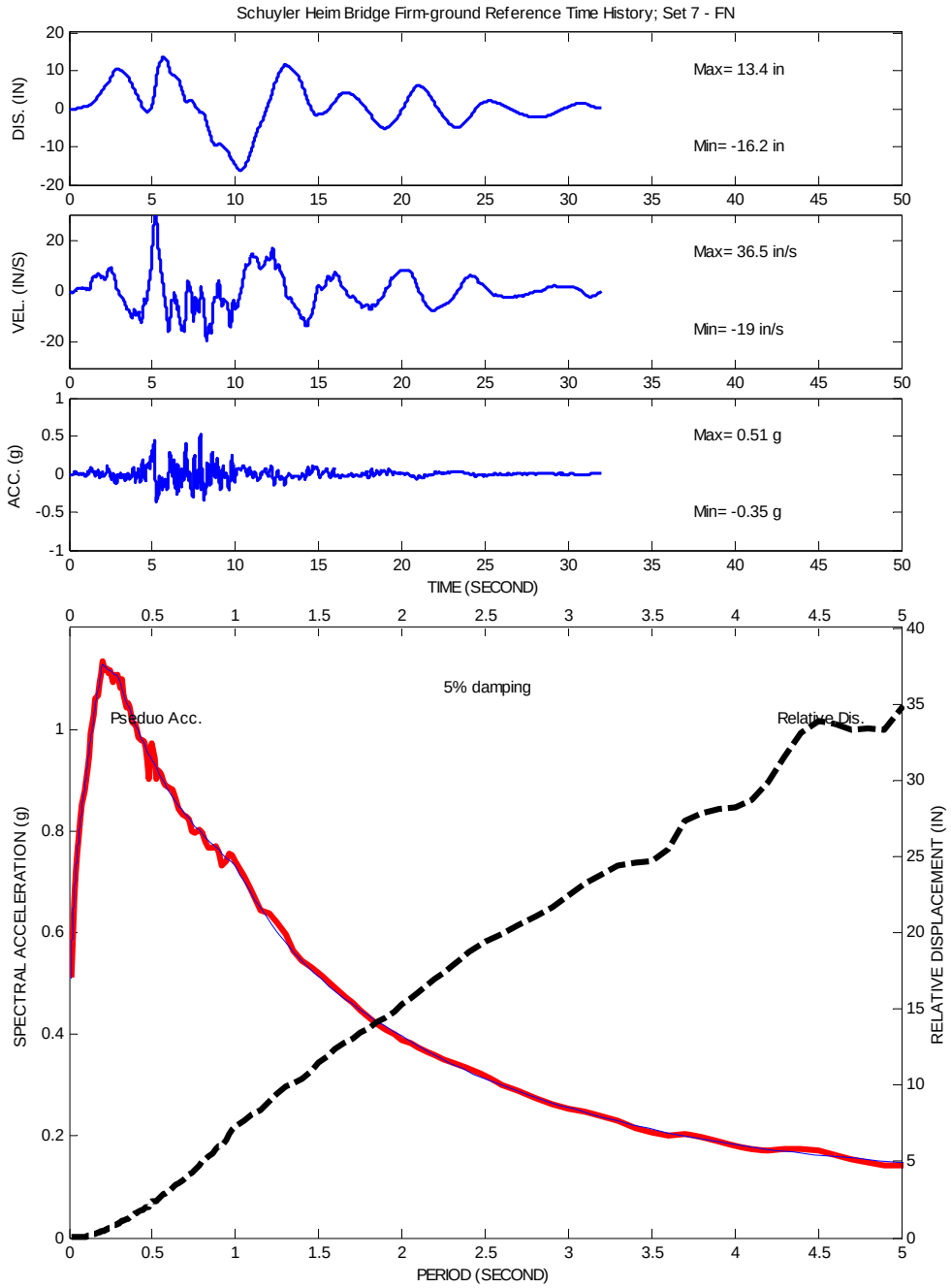

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

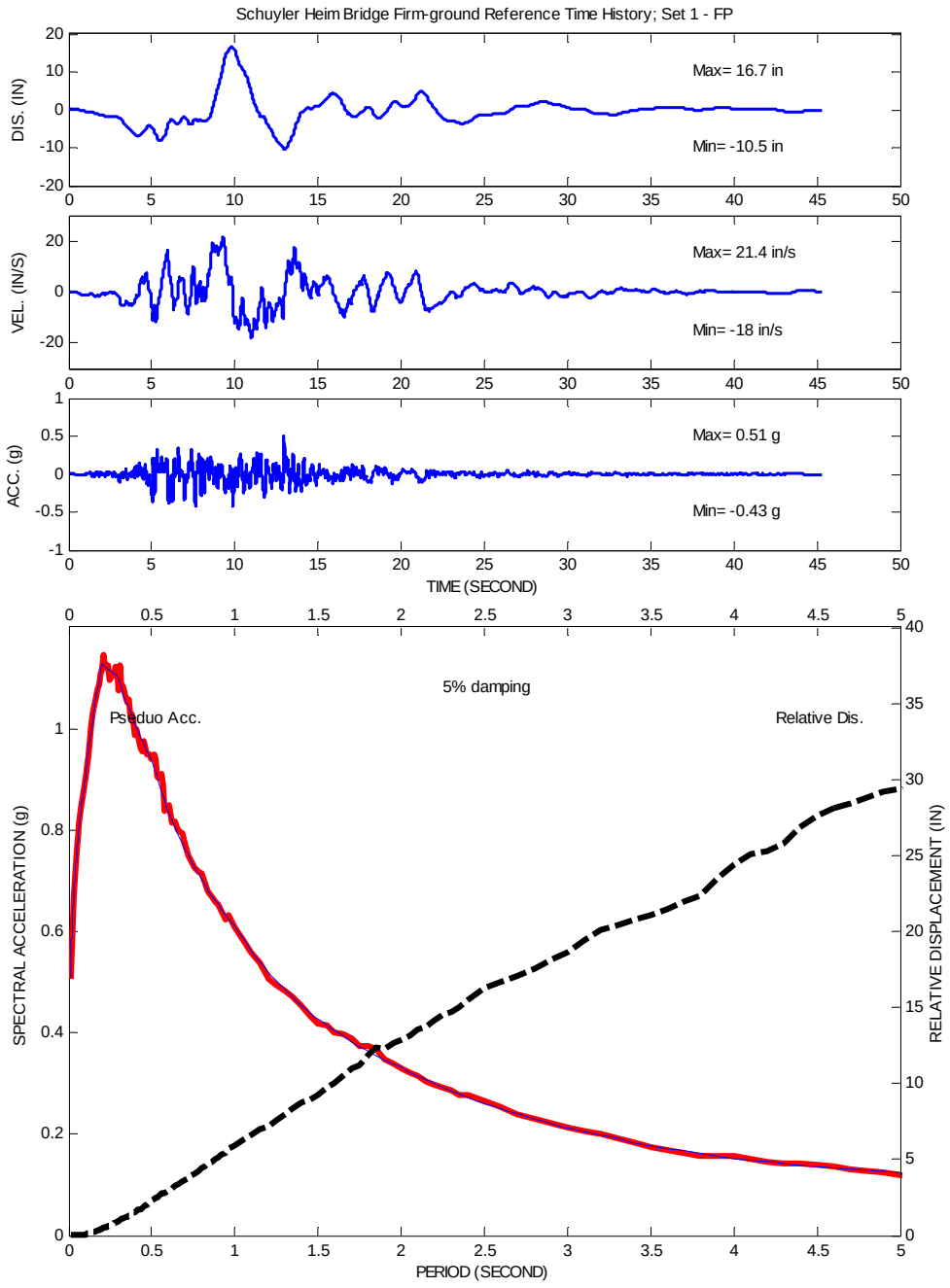

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

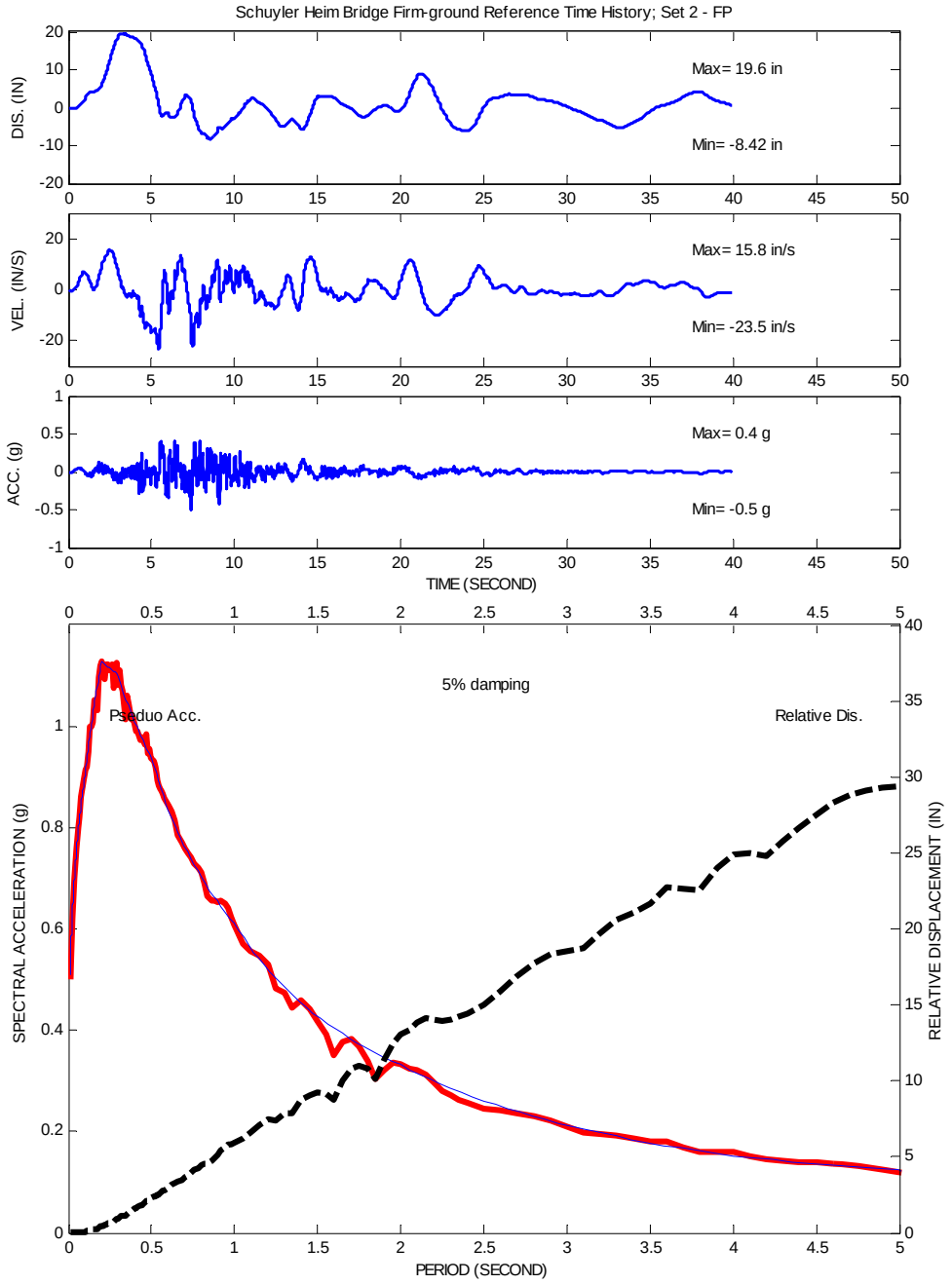

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

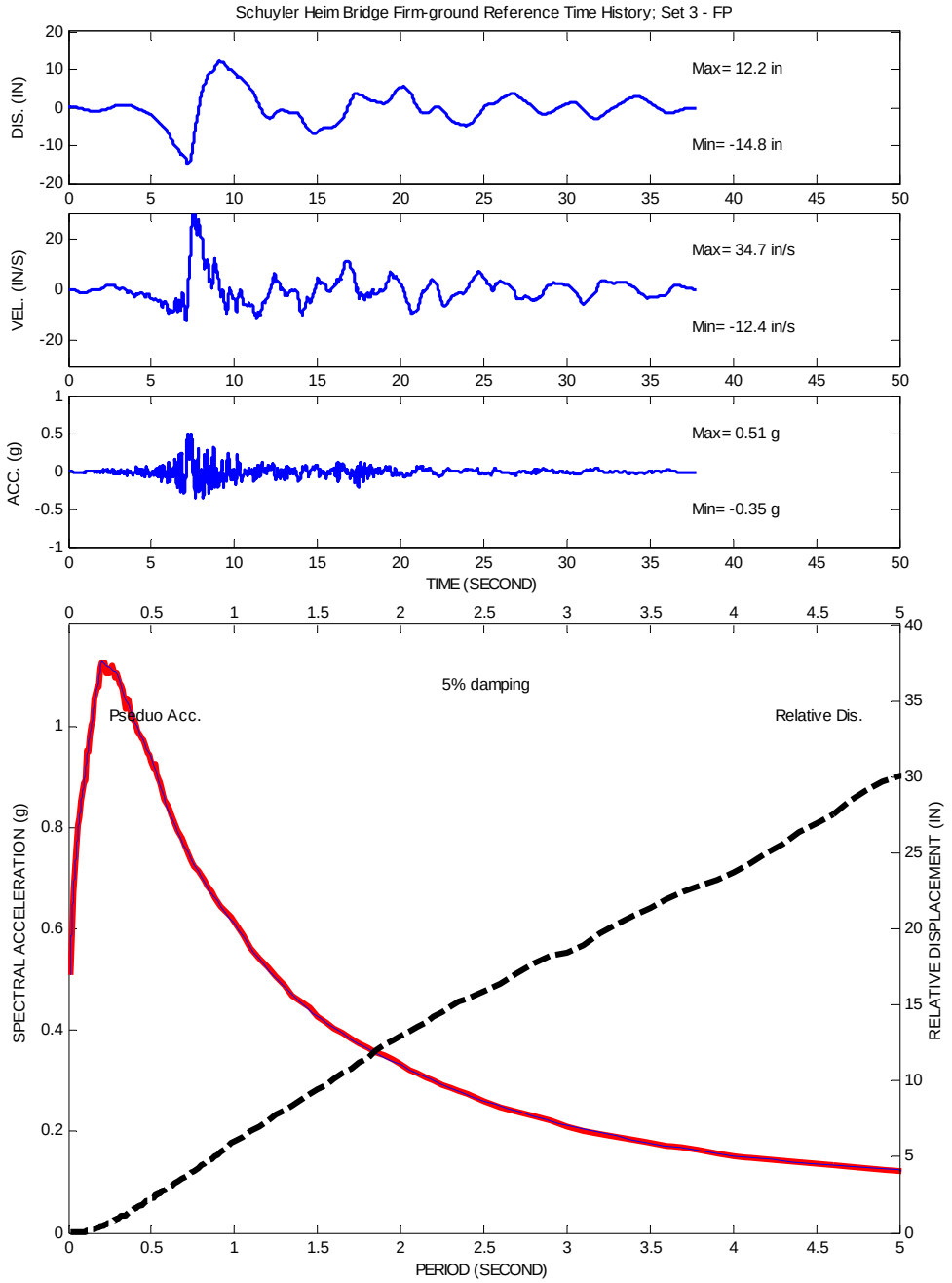

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

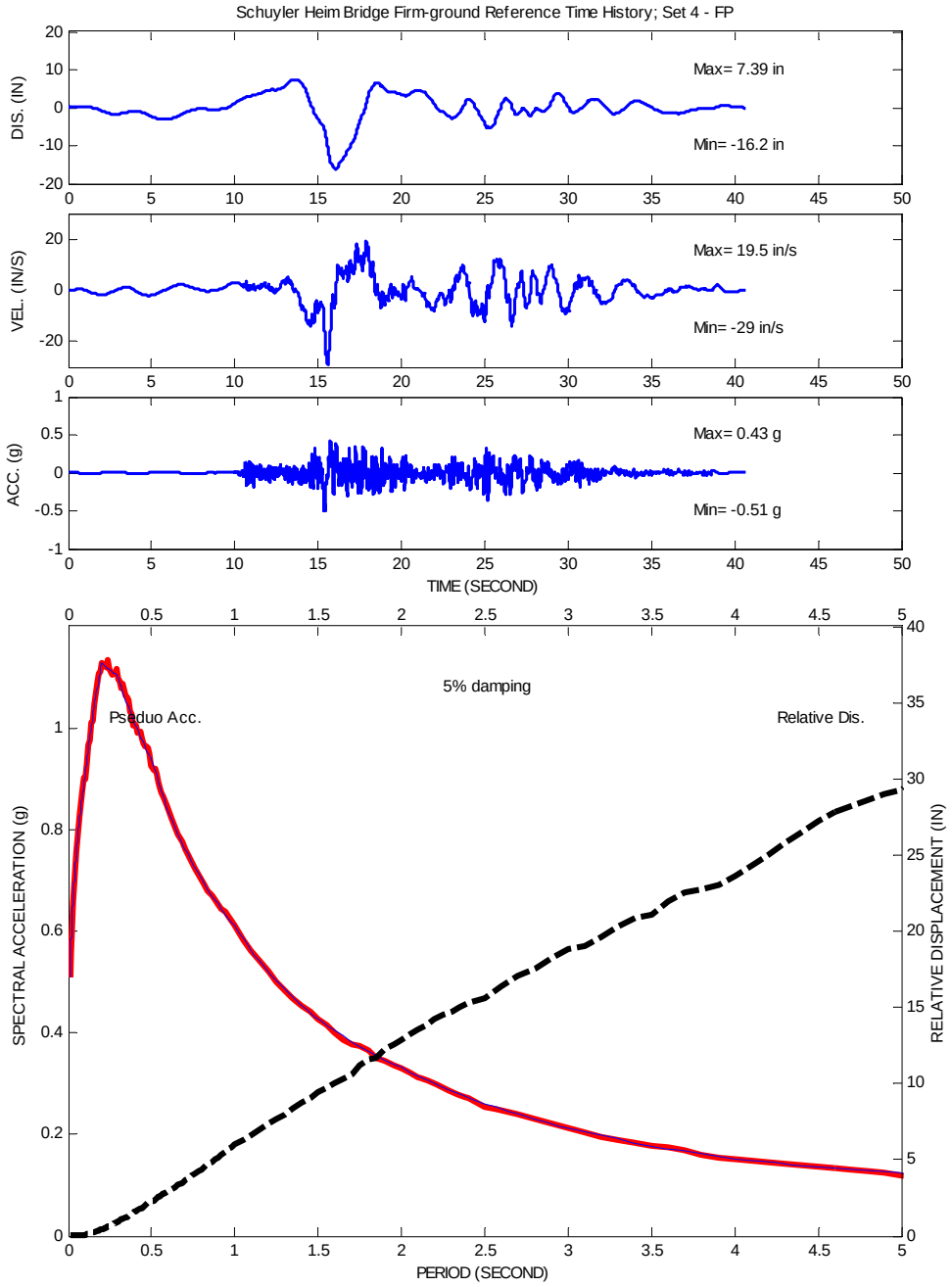

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

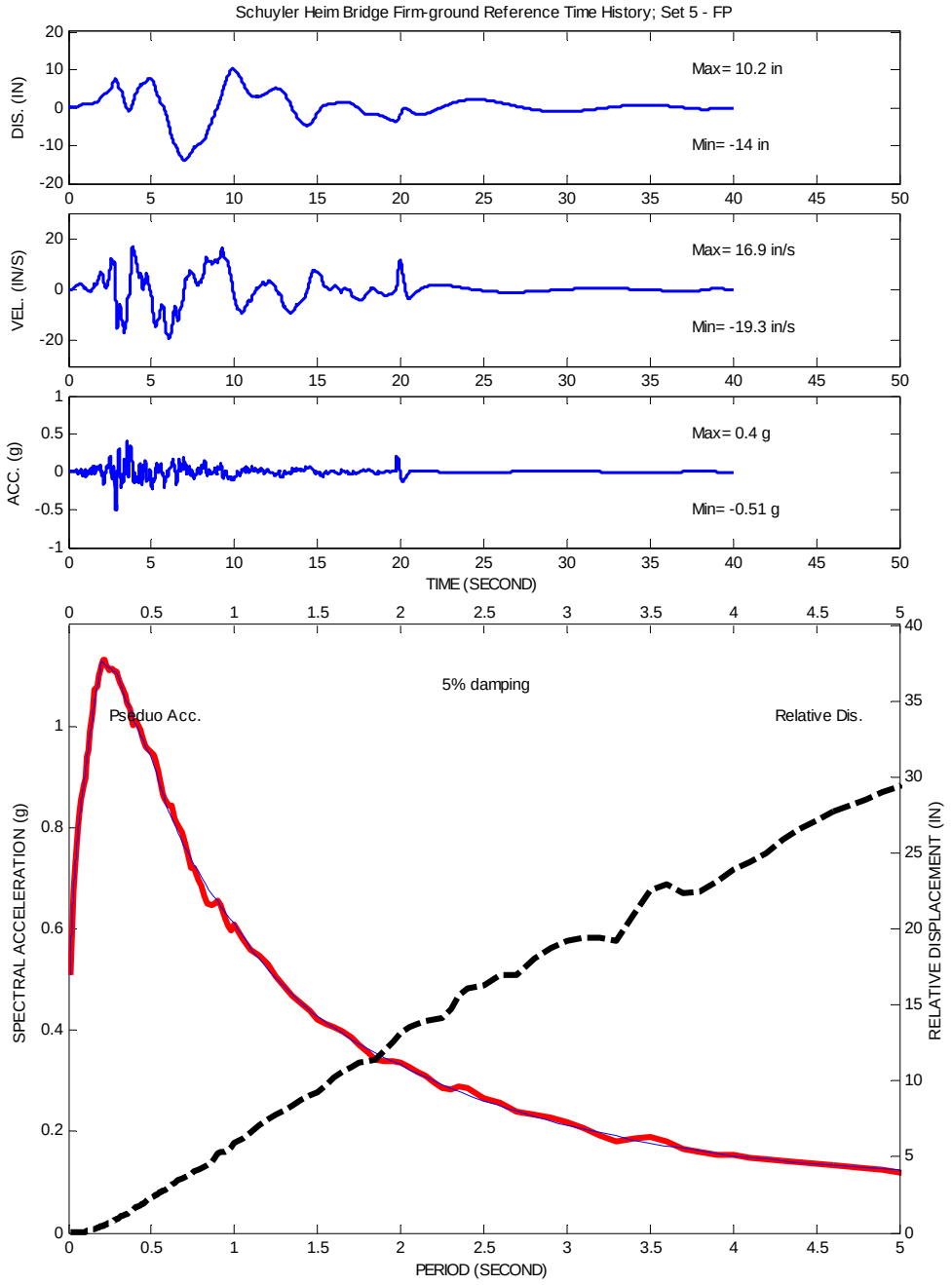

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

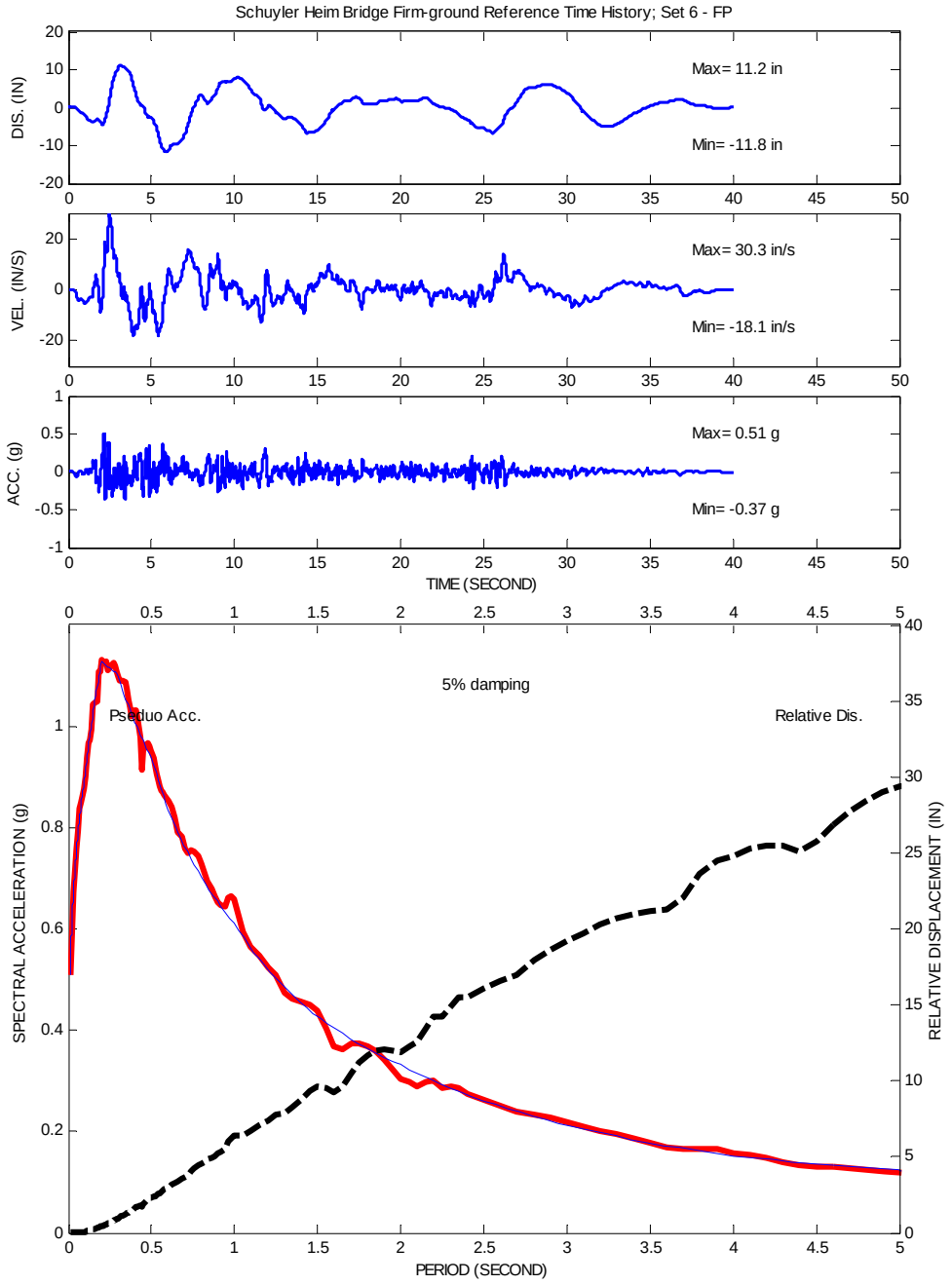

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

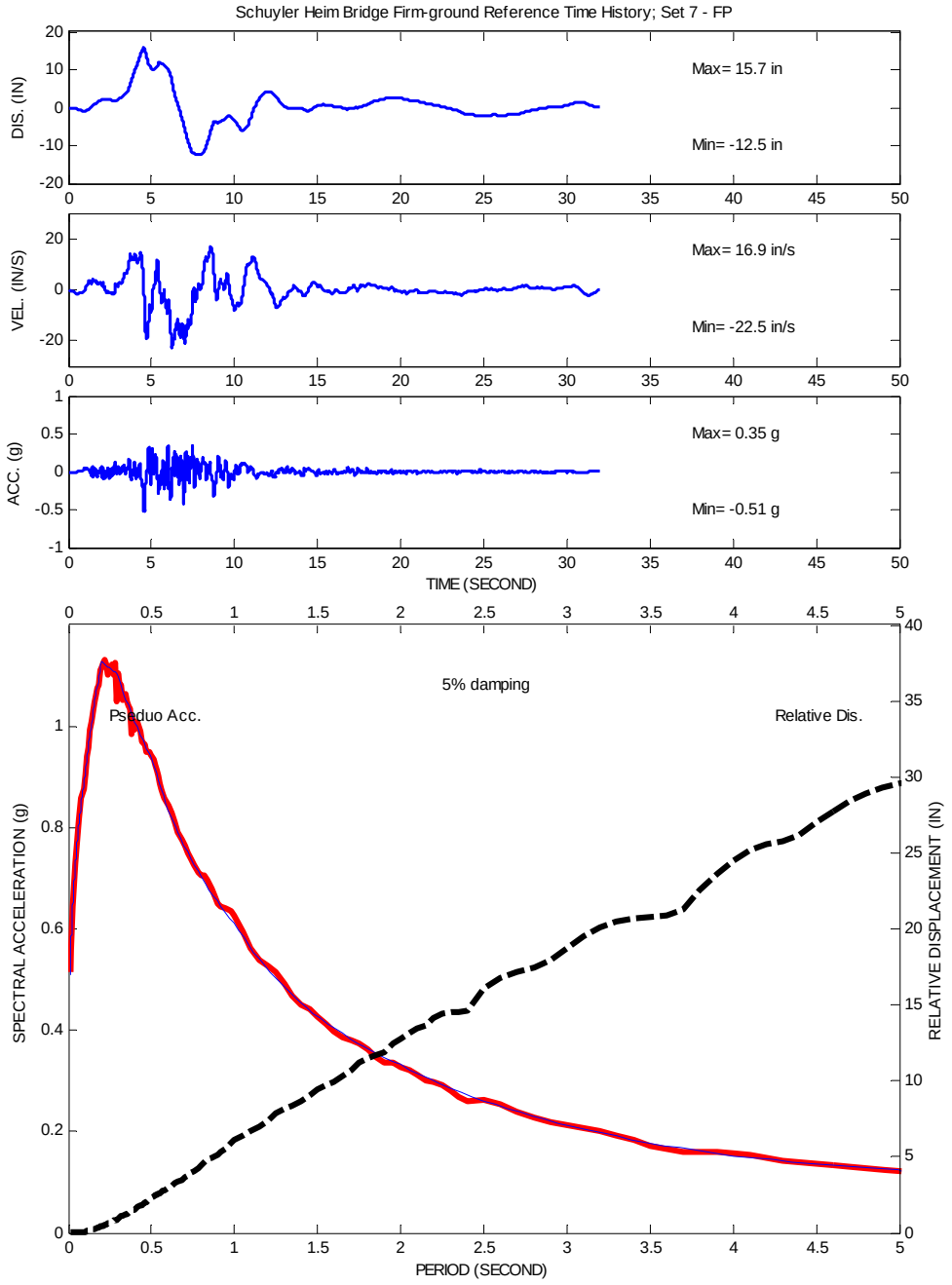

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX G. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)

SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQD
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Retaining Wall C1, Wall No. 53E0148***
Mechanically Stabilized Earth (MSE) Wall
Los Angeles County, California (7-LA-47, PM 3.74, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining wall. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining wall.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix F. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,

EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL C1, WALL NO. 53E0148
MECHANICALLY STABILIZED EARTH (MSE) WALL
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 3.72, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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Appendix B. EarthSpectives SPT Hammer Energy Measurement Report
Appendix C. GeoVision Geophysical Investigation Report
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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall C1 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Retaining Wall C1 located on the east side of the approach embankment for the New Dock Street On-Ramp (Figure 2).

The proposed wall, located on the east side of the New Dock Street On-Ramp approach embankment between about Sta. 212+42 and Sta. 213+73 ("C" Line), will be approximately 131 ft long with retained heights varying from about 2 ft at the southern end of the wall to about 16 ft at the northern end of the wall where it terminates at Abutment 6 of the New Dock Street On-Ramp. The wall is proposed to be a mechanically stabilized embankment (MSE) wall.

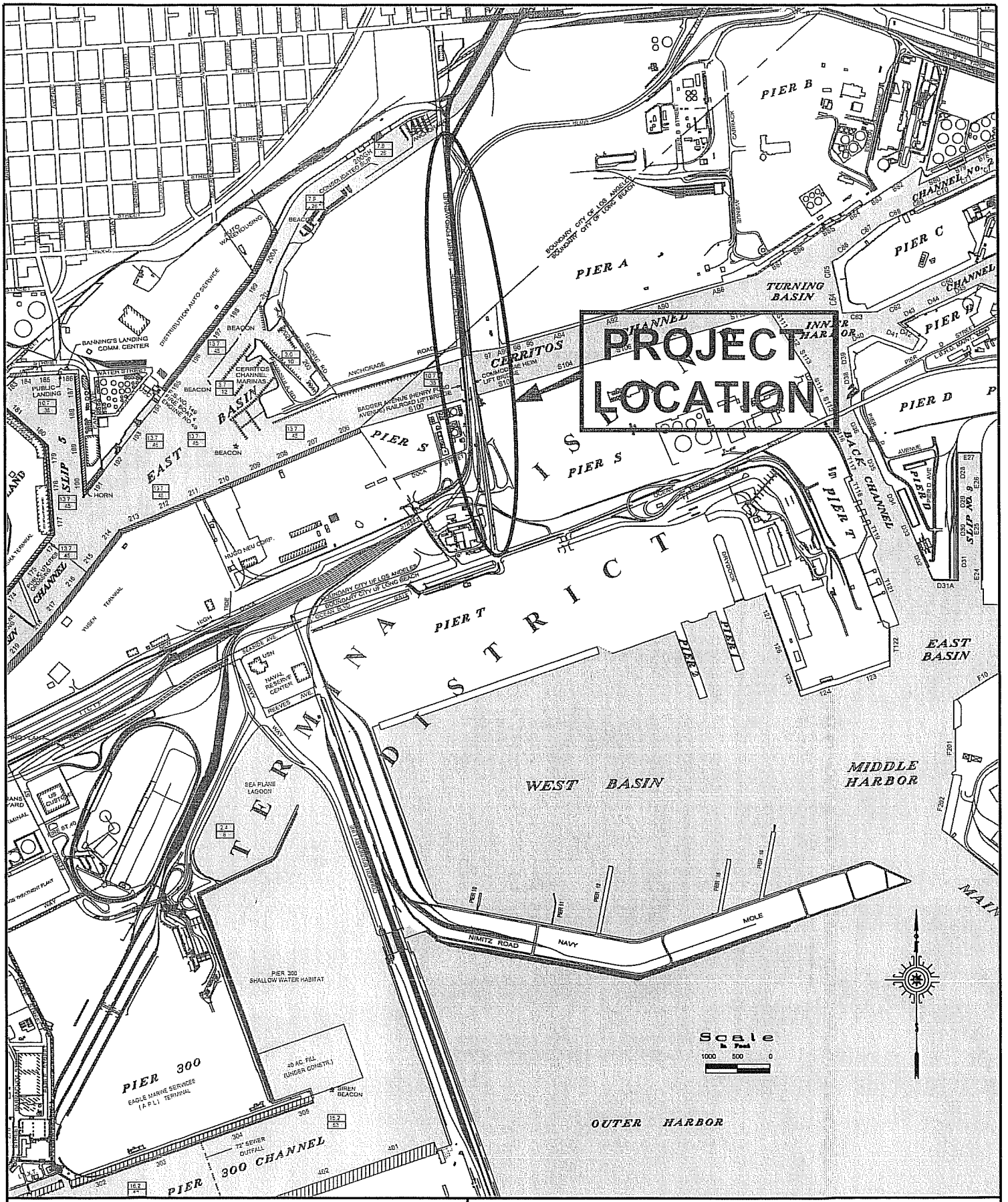
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Retaining Wall C1. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



Earth Mechanics, Inc.
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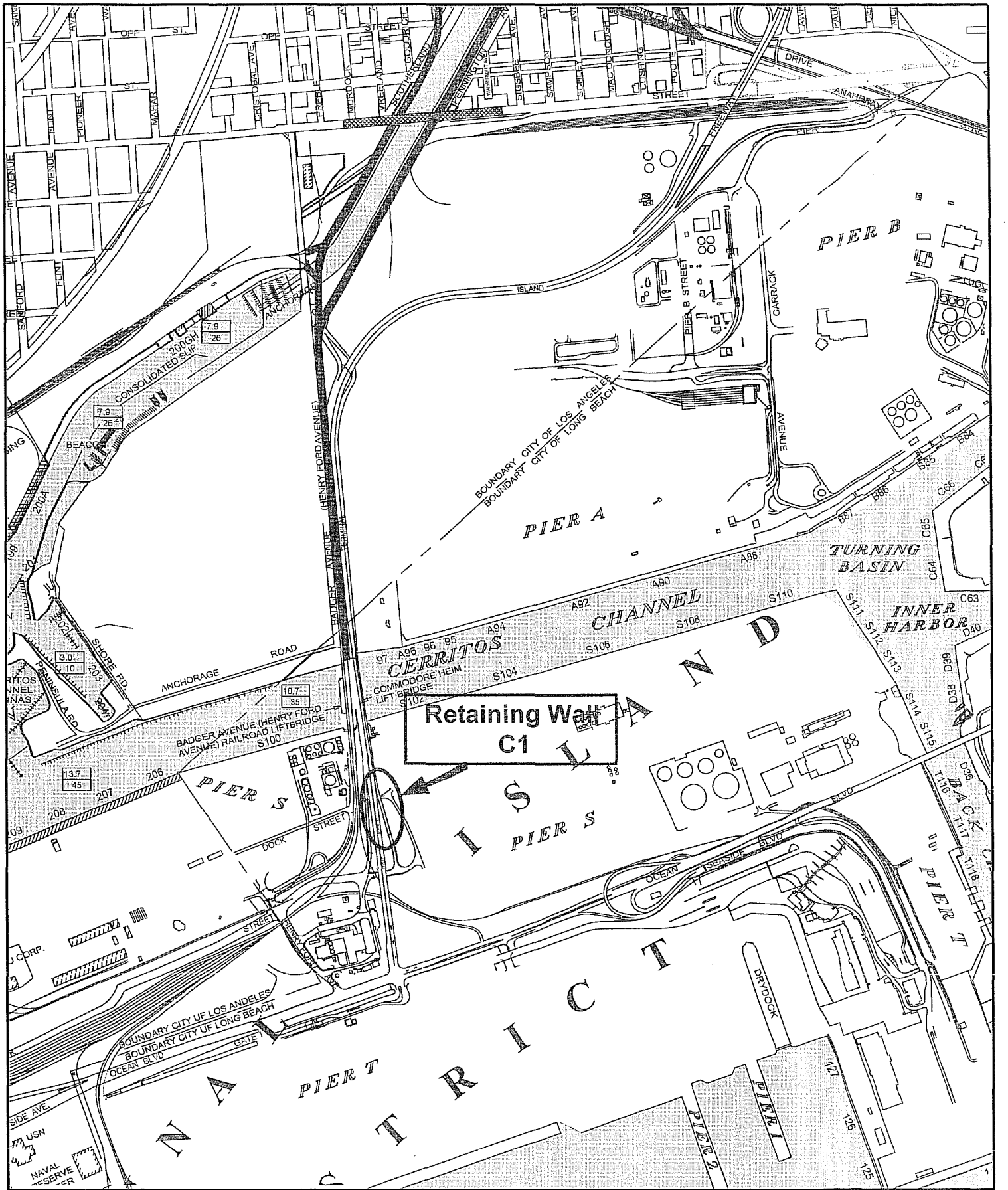
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 5-10-10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-10-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information beneath the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the only borings in the vicinity of Retaining Wall C1 were those shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge.

For the seismic retrofit project, a total of 20 cone penetration test (CPT) soundings and five rotary wash borings were performed along the entire Schuyler Heim Bridge alignment. Of those CPT's and borings, three CPTs were performed near the proposed wall site. The CPT soundings penetrated to depths between 100 and 133 ft below existing grade with a deepest penetration to an elevation of -134 ft.

Copies of the as-built LOTB sheets prepared by LKR the seismic retrofit study are provided in Appendix A.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of 22 hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, two rotary wash borings and two CPT soundings were performed in the vicinity of Retaining Wall C1. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed wall. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

All of the borings surrounding the proposed wall were performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp bridge, east of the mainline structure. The deepest boring penetrated down to about elevation -156 ft, approximately 155 ft below ground surface.

The borings were performed by C&L Drilling Co. (C&L), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California

Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the C&L borings. A copy of the ES report is provided in Appendix B.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix C.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-009	"C" Line	212+16.9	61.0 Lt	-0.9	-4.9	-156.3	RW
R-09-011		213+81.5	61.5 Lt	-1.0	-10.0	-151.3	RW
CPT-09-076		212+22.4	60.0 Lt	-0.9	NR	-92.1	CPT
CPT-09-077		213+86.4	61.3 Lt	-0.8	NR	-103.2	CPT

Notes: 1. Top of boring elevations based upon NAVD88.
2. GSE = Ground Surface Elevation (estimated from topographic plans).
3. GWE = Groundwater Elevation.
4. RW = Rotary Wash, CPT = Cone Penetration Test.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -103.2 ft, approximately 102.4 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance

during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

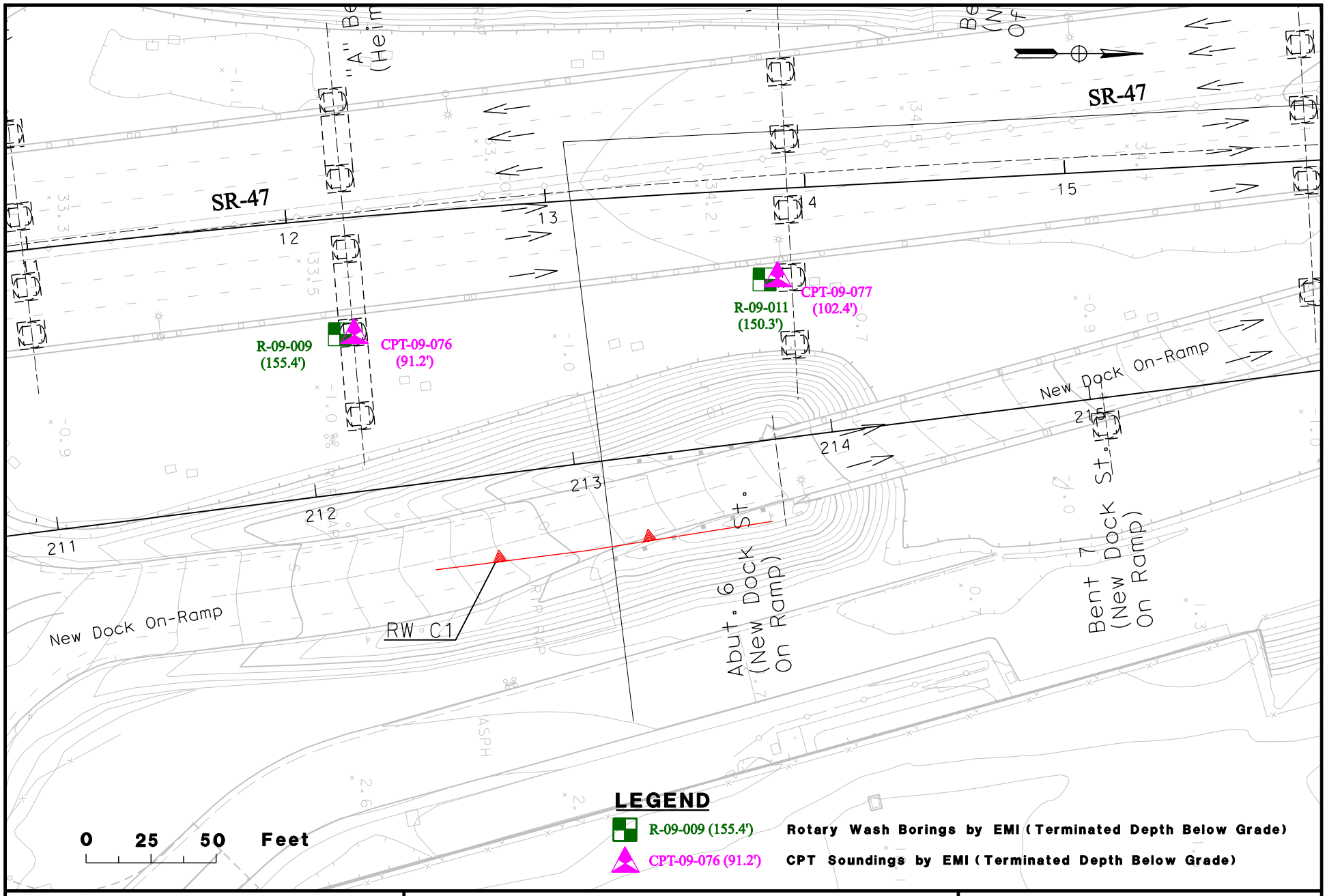
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix D.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Direct Shear	ASTM D 3080	Estimate strength parameters of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-10-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 4 and 5). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (M_W) of about 6.7 (M_S = 6.8, M_L = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (M_W = 6.7, M_S = 6.4, M_L = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about M_W = 6.4 (M_L = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (M_L = 5.9, M_W = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1987; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas

are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

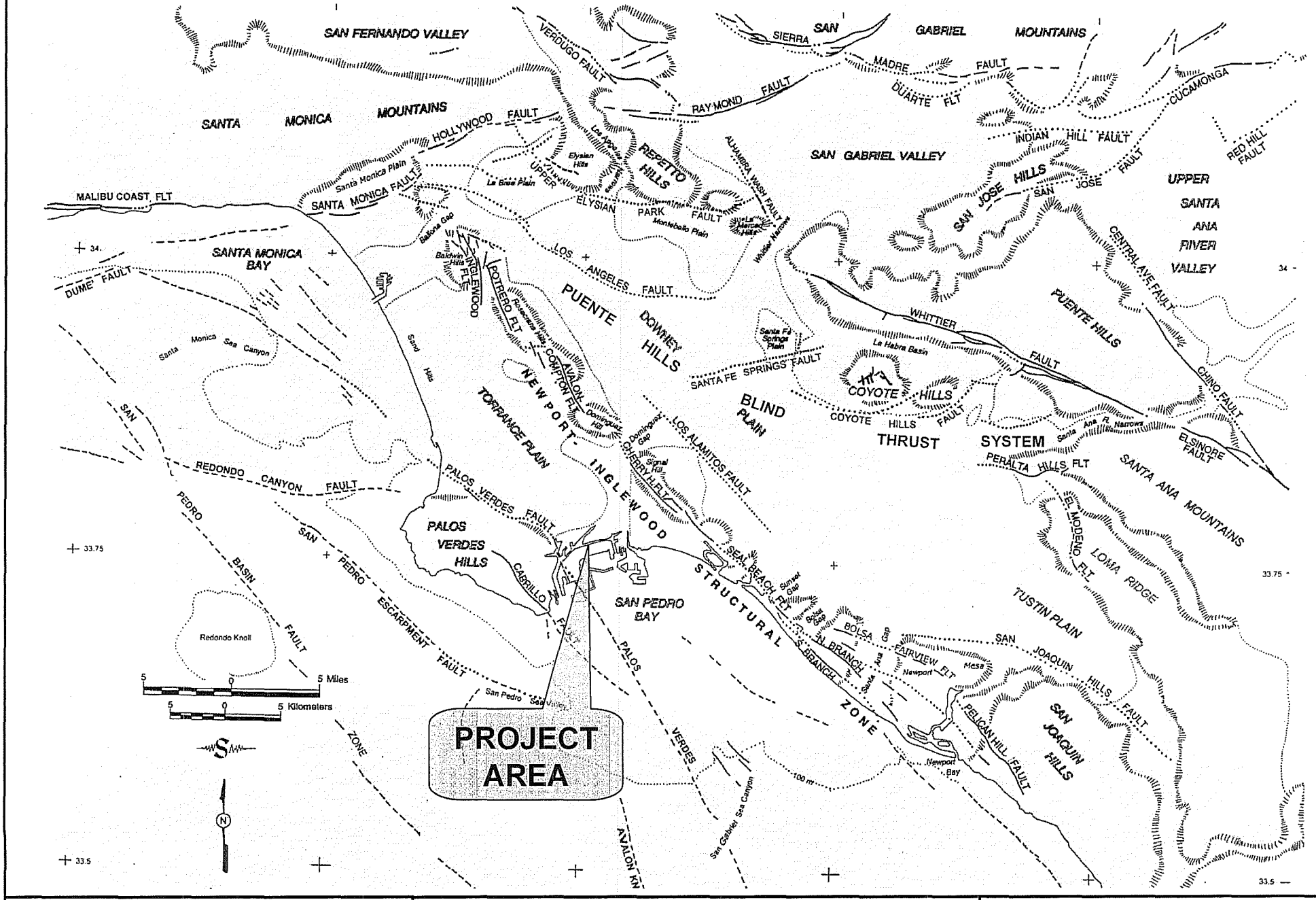
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of $M_w = 7.8$ and 1964 Alaska event of $M_w = 9.2$); and in the southern Pacific (1922 Chile earthquake of $M_w = 8.4$ and the 1960 Chile event of $M_w = 9.5$). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats

and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



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Project No. 06-123

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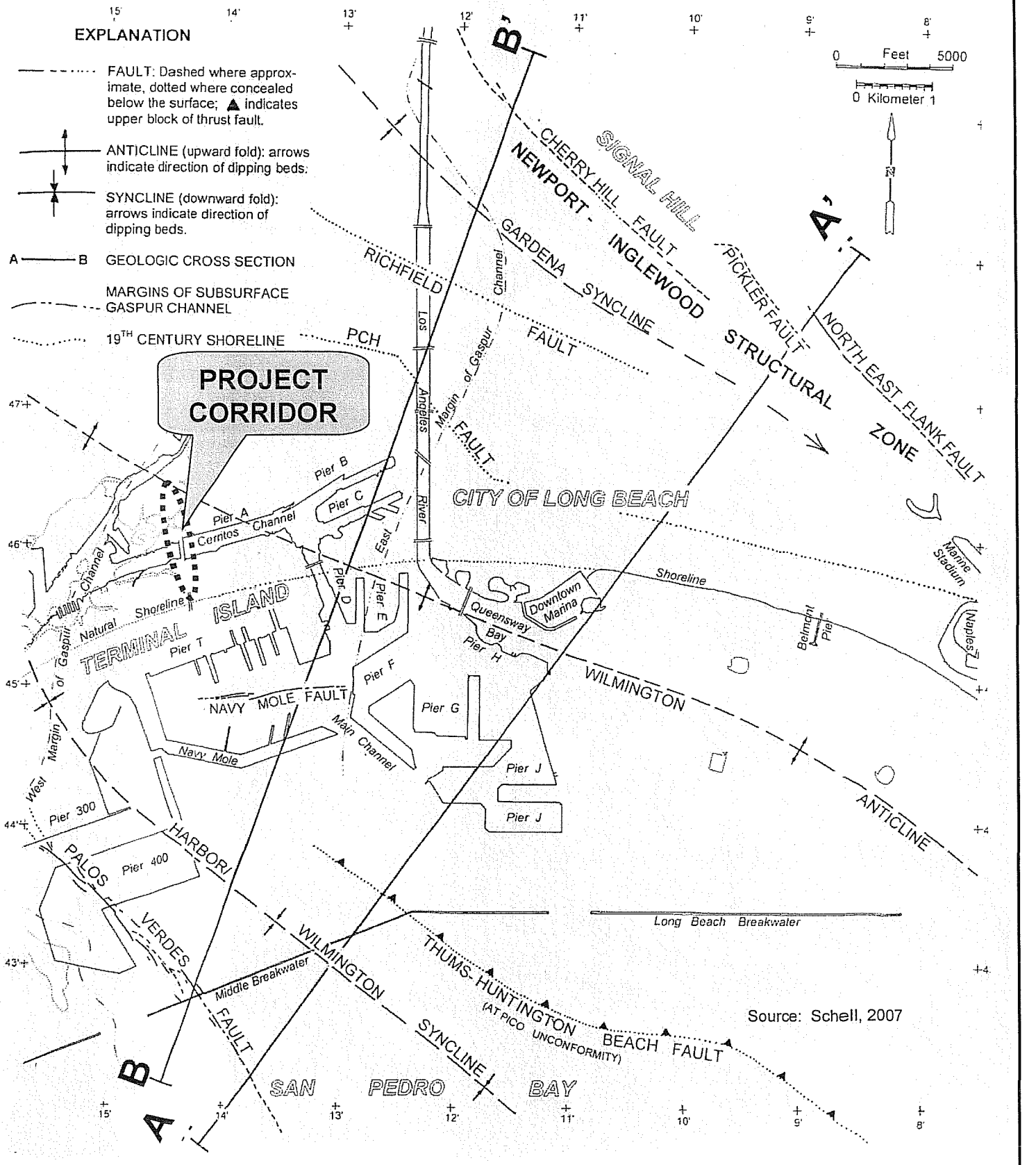
Map of Active Faults and Physiography, LA Basin

Figure 4



Source: Schell, 2007

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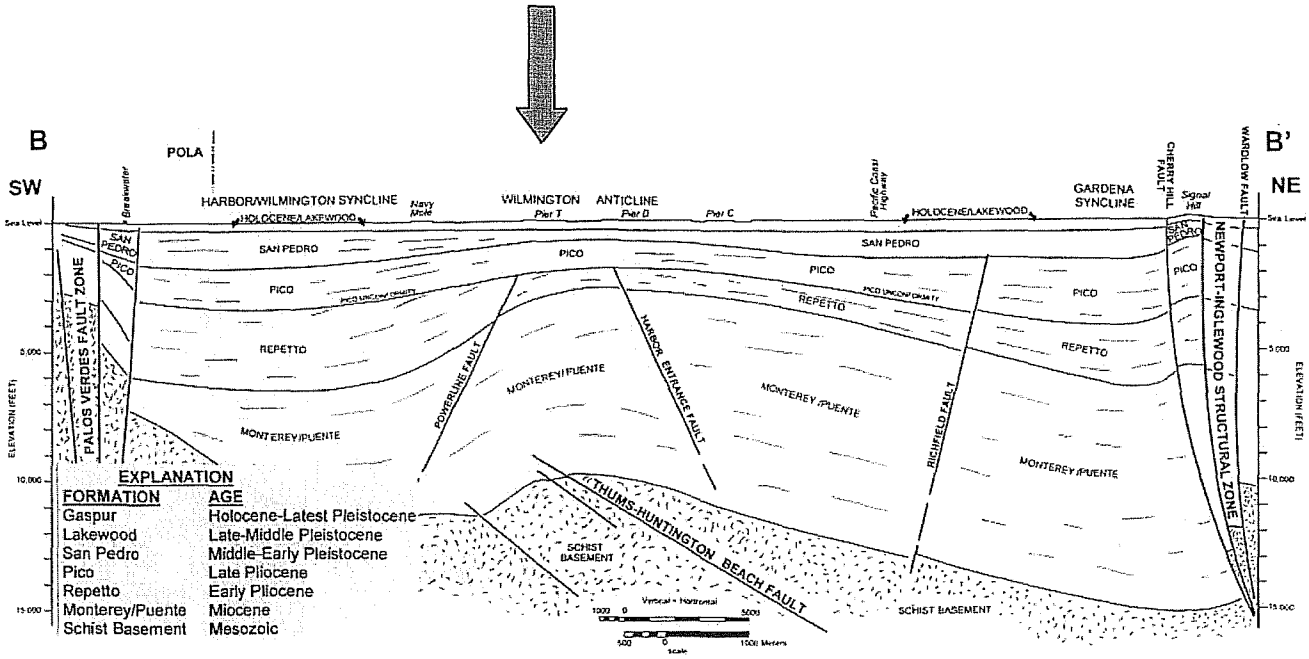
Structural Geology Map, Long Beach Harbor

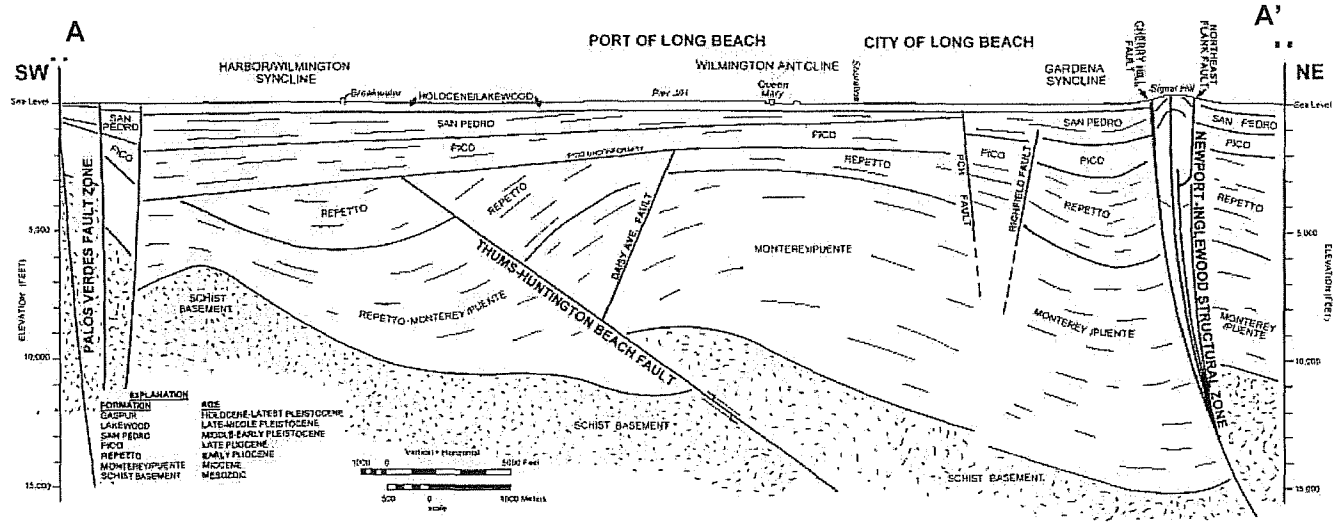
Figure 5

Project No. 06-123 | Date: 5-10-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH



A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

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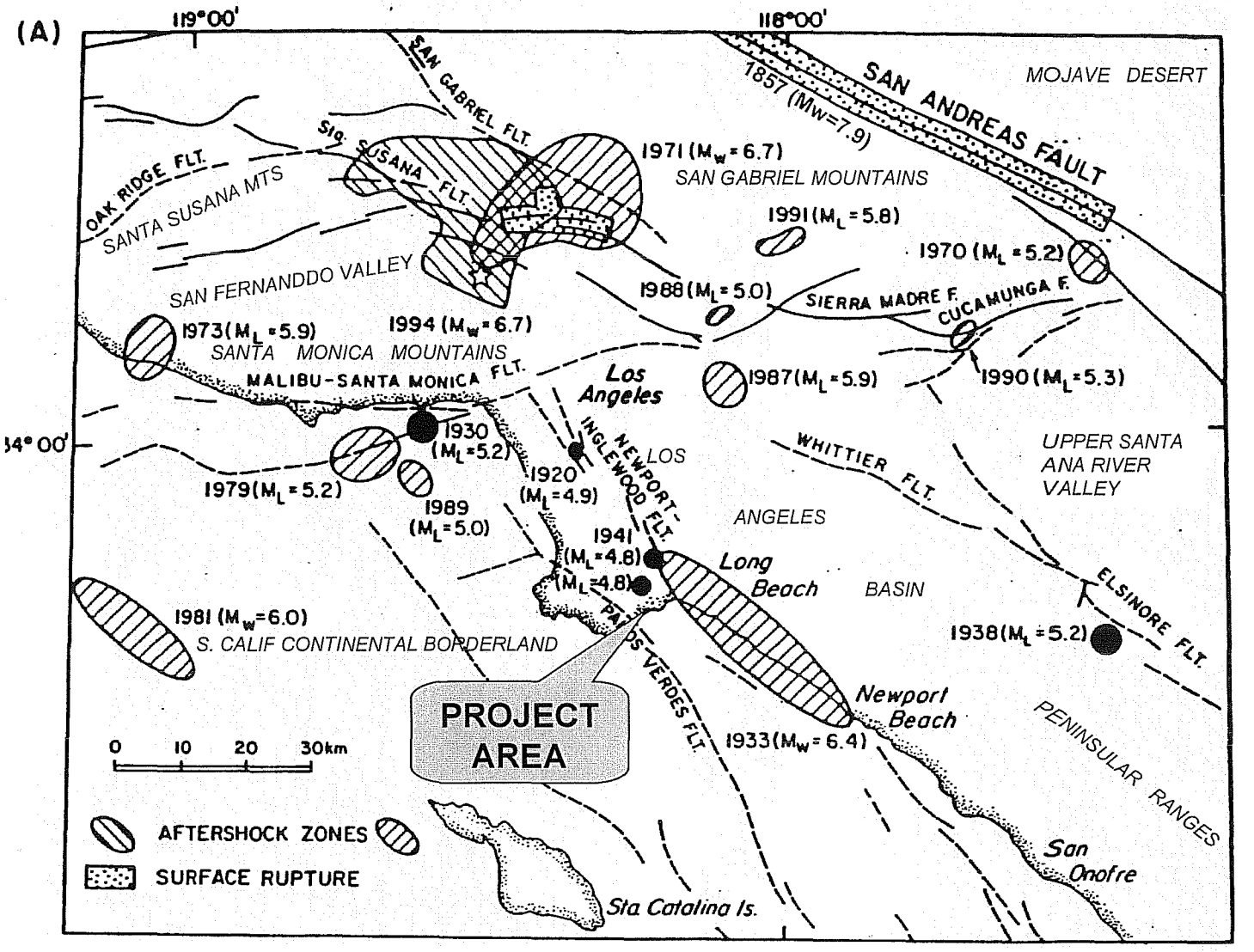
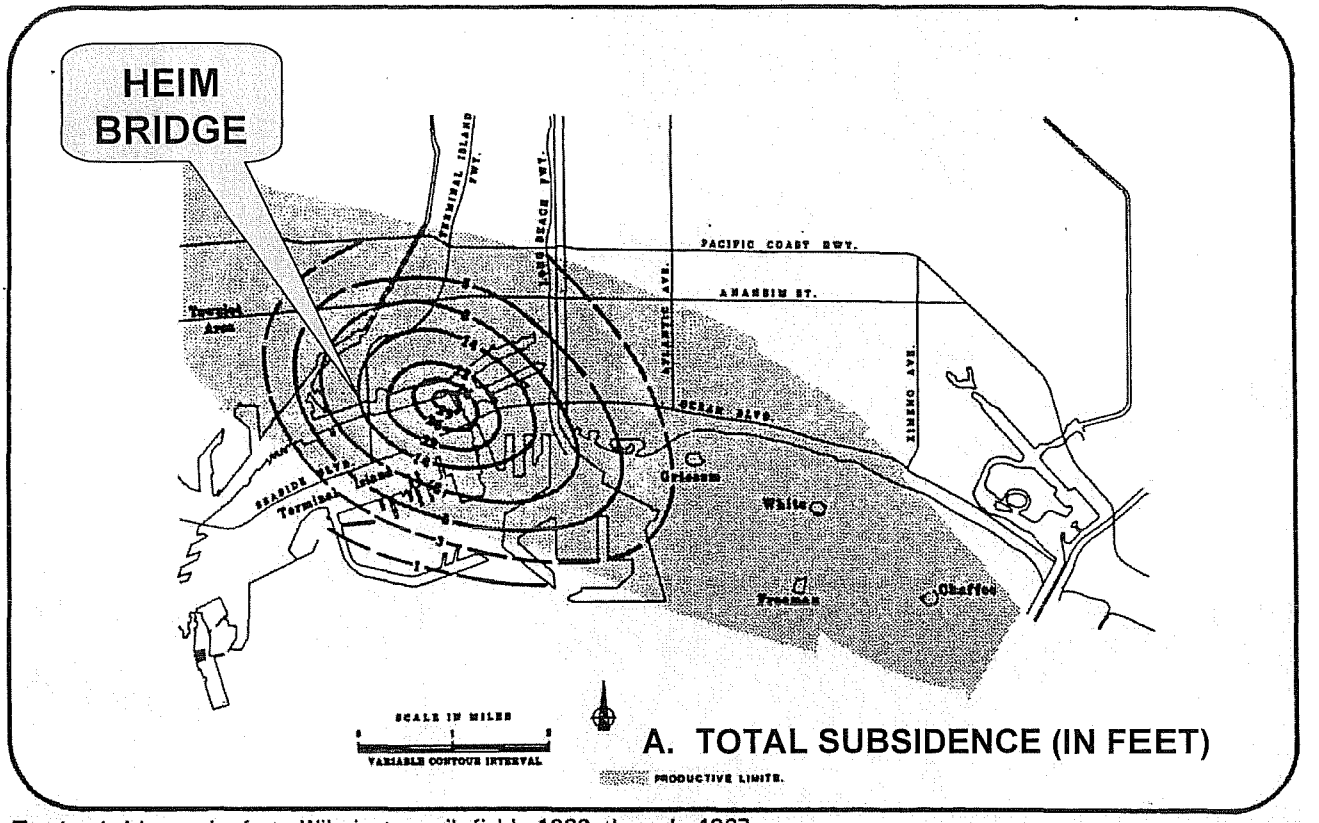
	Geologic Cross-Sections, LA Harbor	
Project No. 06-123	Date: 5-10-10	Figure 6

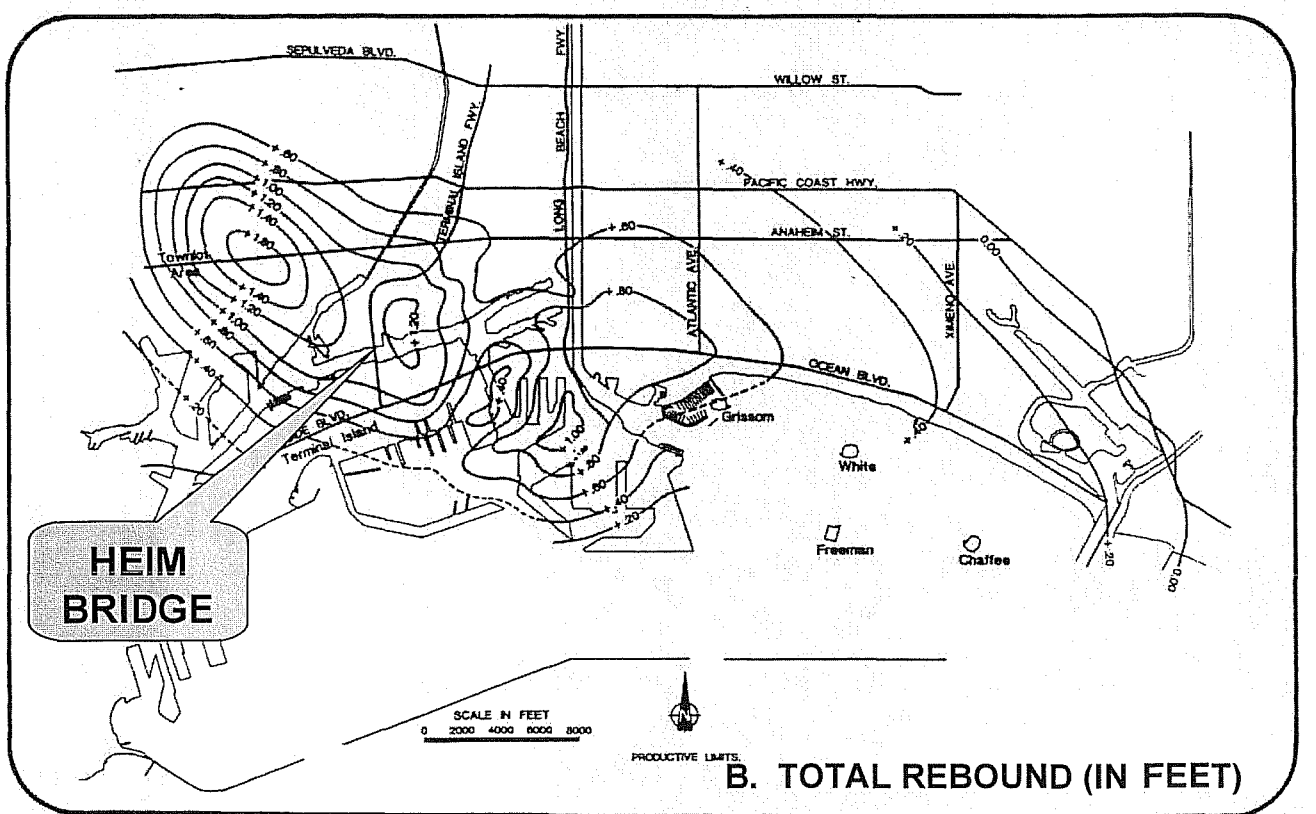


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-10-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

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Project No. 06-123	Date: 5-10-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -155.9 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject wall site, natural grade lies at an elevation of about zero, with the approach embankment for the existing New Dock Street On-Ramp consisting of import fill extending to a maximum elevation of about +15 ft. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -25 ft. The near surface deposits are underlain by a thick strata of inter-layered soft to stiff silt, sandy silt, clay, and loose silty sand down to about elevation -75 ft. Below elevation -75 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

Groundwater was not recorded in any of the CPT soundings performed in 1996 for the Geotechnical Investigation by LKR (LKR, 1998). During the EMI investigation in 2009, groundwater was recorded in both of the borings performed near the proposed wall between elevation -5.0 ft and -10.0 feet. The elevation that groundwater was encountered in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

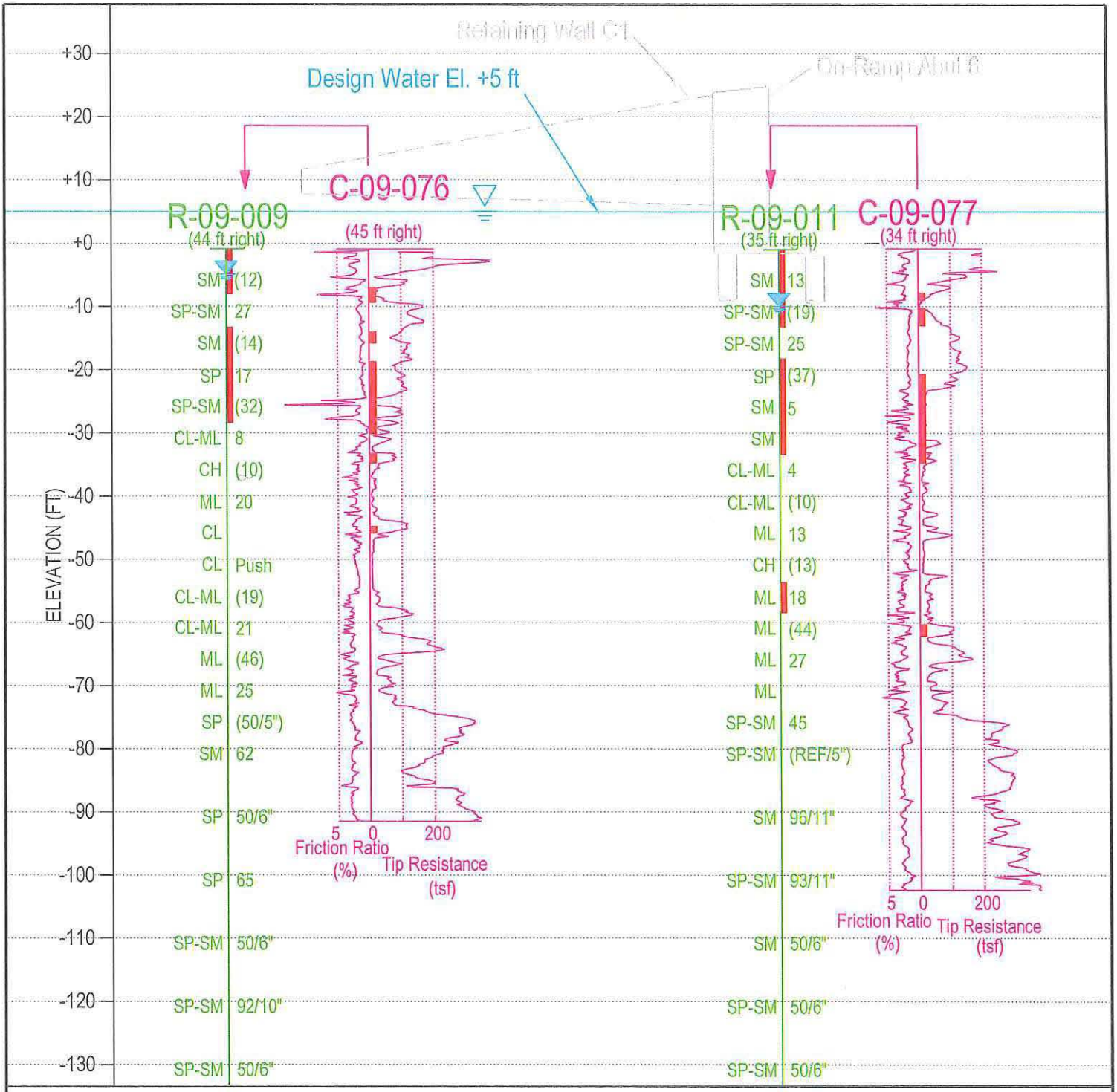
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

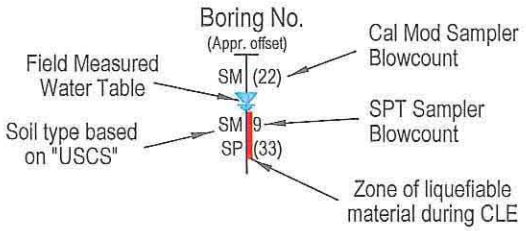
Based on information collected from borings R-09-009, R-09-011and CPT soundings CPT-09-076 and CPT-09-077 an idealized soil profile for foundation analysis and design was developed along the proposed wall alignment. The subsurface profile beneath the propose structure is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+23.0 to +0.0	Silty Sand (assumed embankment fill)	120	200	32
+0.0 to -11.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-11.0 to -20.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	32
-20.0 to -25.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	30
-25.0 to -47.0	Sandy Silt / Silty Clay / Lean Clay	120	1,000	0
-47.0 to -62.0	Clayey Silt / Clay with Silt / Clay with Sand	120	2,000	0
-62.0 to -75.0	Clayey Silt / Silt with Sand / Silt with Clay	120	1,500	0
-75.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Subsurface Profile

Project No. 06-123 | Date: 5-10-10 | Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix E.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -75 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-009	-1 to -8	1.4	3.7
	-13 to -28	2.3	
R-09-011	-1 to -13	2.0	6.5
	-18 to -33	3.7	
	-53 to -58	0.8	
CPT-09-076	-7.0 to -9.3	0.1	1.0
	-14.0 to -15.7	0.1	
	-18.7 to -30.1	0.5	
	-33.2 to -34.7	0.2	
	-44.8 to -45.8	0.1	
CPT-09-077	-7.9 to -8.9	0.1	3.2
	-10.3 to -13.0	0.1	
	-20.7 to -34.7	2.9	
	-60.3 to -62.1	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Two soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to be 7.4 and 7.5, the minimum resistivities were 200 and 2,200 ohm-cm, soluble chloride contents were 152 and 568 parts per million (ppm) and soluble sulfate contents were 116 and 514 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Mechanically Stabilized Earth Wall Recommendations

As discussed in Section 1.2, the maximum design height of the MSE is about 16 ft. Due to the presence of compressible soil, construction of the proposed New Dock Street On-Ramp embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall does not need to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 16 ft and base width of 12 ft near the northern end of the wall at Sta. 213+70 ("C" Line), the bearing pressure induced on the underlying foundation soil is 2.7 ksf. Using a base width of 12 ft and a remedial excavation of 1 ft (see Section 5.4.8), the allowable bearing capacity of the sand directly beneath the MSE wall is greater than 2.7 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads supporting the wall face may be supported on the in-situ soil. They should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 2 ft below lowest adjacent grade. The allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL C1 STABILITY ANALYSES

Approx. "E" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety		Global Stability Factor of Safety		
			During Surcharge	Permanent	During Surcharge	Static[1]	Psuedo-Static[1]
426+06	16	12	5.7	6.6	1.56	1.75	1.12

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1.

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

Based on cross-sections provided by the roadway designers, the potential settlement beneath the proposed wall was evaluated at "C" Line Stations 212+50, 213+00, and 213+50. The provided cross-sections indicate that the existing embankment will be widened by as much as 5 feet at the crest and the embankment height will be increased by up to about 7 feet. Based on our calculations, settlement of soils underlying the proposed retaining wall is estimated to be about 2 to 3 inches along the length of the wall, with a differential settlement of about 1 inch over a 100 feet long section. The settlement period is estimated to be about 30 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 13 weeks. For a 7-ft embankment surcharge, the settlement period is reduced to about 10 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

Along the proposed wall alignment, the base of the MSE structure will be founded on the existing approach embankment fill. EMI recommends remedial grading consisting of a 1 ft overexcavation. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted to a minimum 90 percent relative compaction. The overexcavation should be backfilled using granular, non-expansive soils. The overexcavation should extend at least 1 ft beyond the outer edge of the leveling pad and 1 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Wall Stability

The "global" stability of the western embankment side slope was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "C" Line Sta. 213+60.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and 200 psf cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix E) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in both of the borings performed near the proposed wall between Elevation -5.0 and -10.0 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad is at approximate El. +5 ft. The deepest excavation for the proposed MSE wall is expected to be several feet above the observed groundwater elevations. However, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

7.0 REFERENCES

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BENCHMARKS:

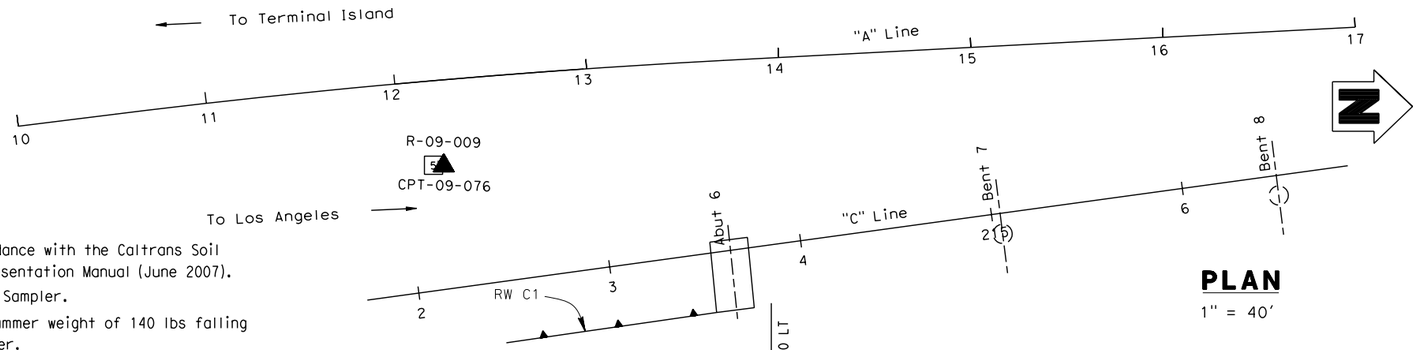
PT-501	PT-15001
SET + FOOTING 23.25'Rt ℄ "A" Line	STK601061 MAG NAIL IN LEAD CUT 113.09'Lt ℄ "A" Line
Sta. 10+59.08	Sta. 10+42.39
N 1735599.25	N 1735565.80
E 6489049.69	E 6488916.52
Elev. = -0.91	Elev. = 3.42

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED CIVIL ENGINEER DATE

REGISTERED PROFESSIONAL ENGINEER ERIC BROWN NO. GE-2806 EXP. 06-30-2010 GEOTECHNICAL STATE OF CALIFORNIA

PLANS APPROVAL DATE

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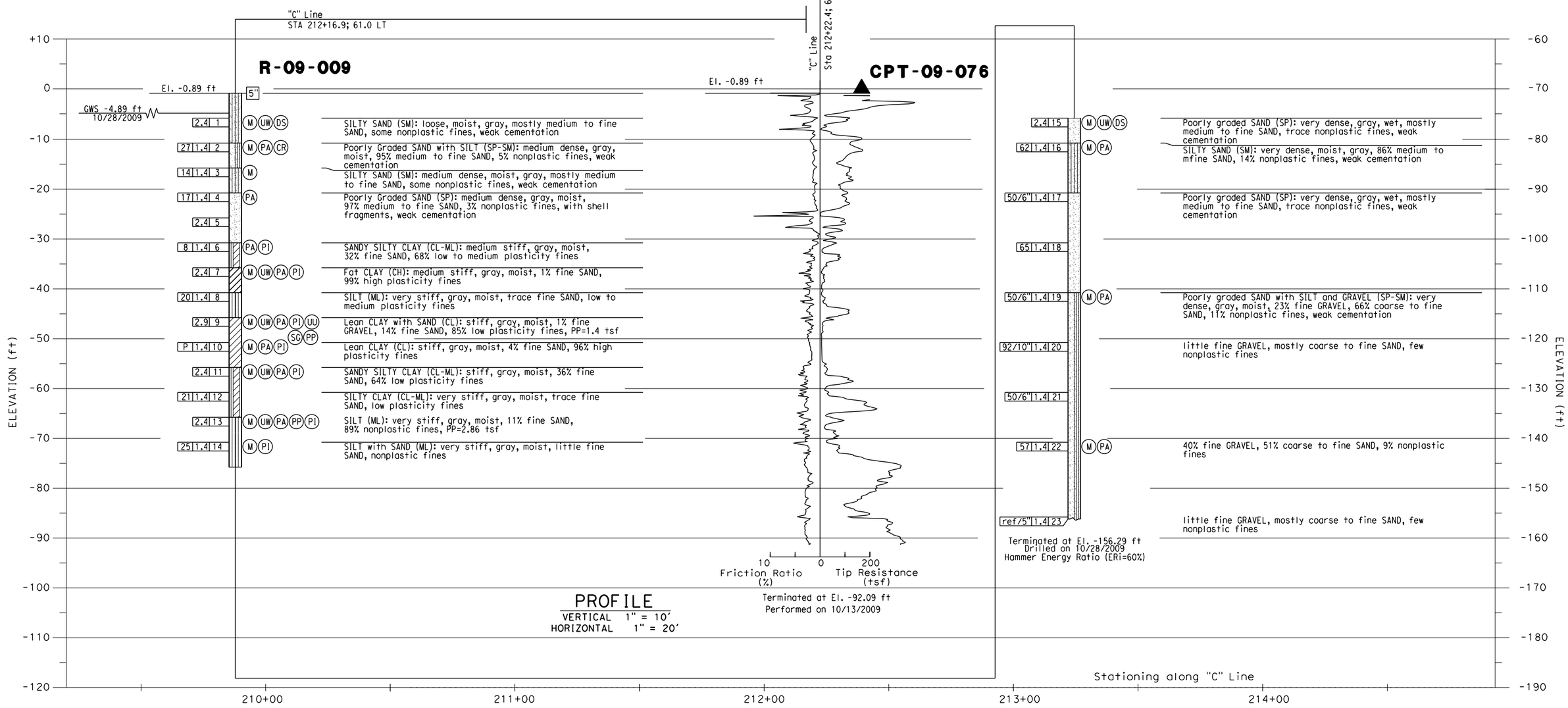
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown	BRIDGE NO. 53E0148	MSE RETAINING WALL NO. C1	
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie		PROJECT ENGINEER	POST MILE 3.72	LOG OF TEST BORINGS NO. 1 OF 4	

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
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ACTA
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CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-524	PT-525
SET REBAR	SET + VLT
19.536'Lt ℄ Line SR 47	34.81'Lt ℄ "A" Line
Sta. 16+00.56	Sta. 14+00.95
N 1736134.90	N 1735941.10
E 6488978.91	E 6489032.50
Elev. = -0.51	Elev. = 0.12

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

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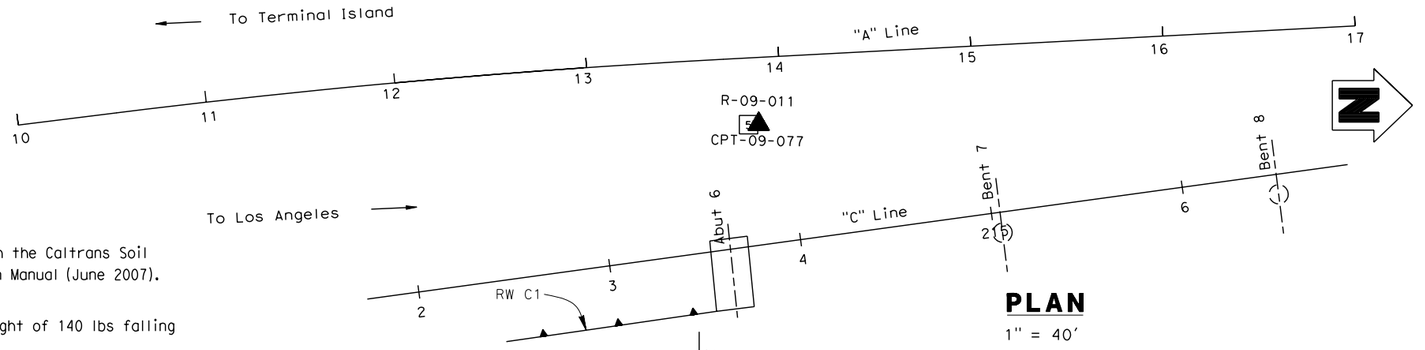
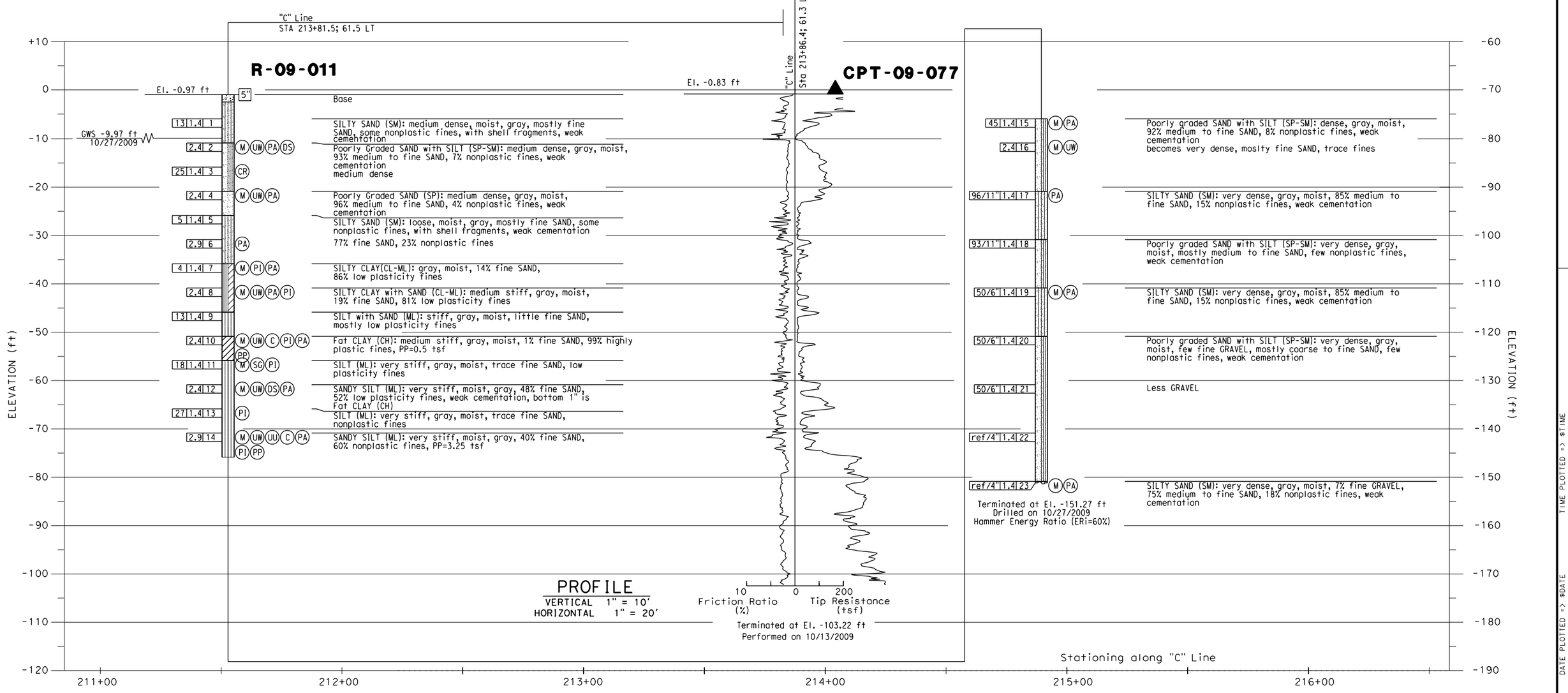
(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 40'



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0148	MSE RETAINING WALL NO. C1
SIGN OFF DATE	CHECKED BY: K. Pratheepan	R. Jie			POST MILE 3.72	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

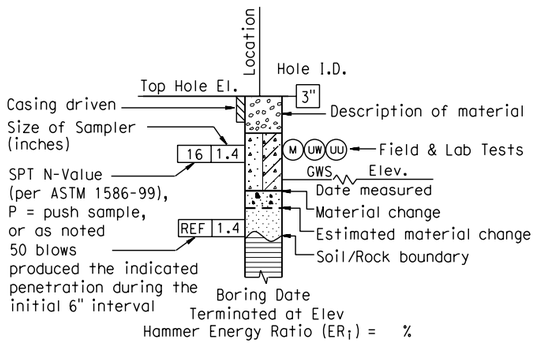
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

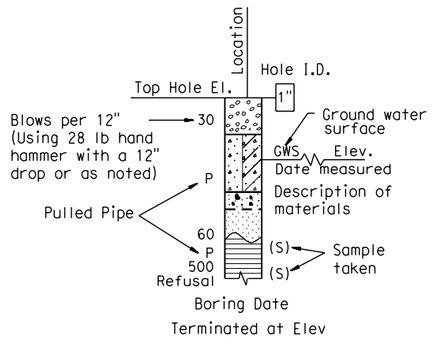
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

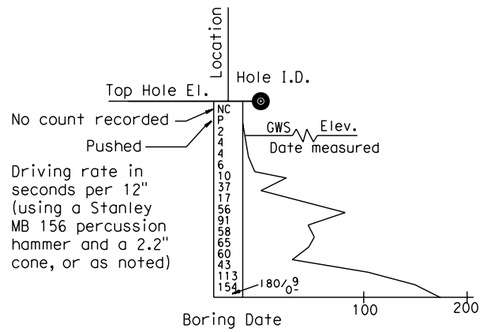
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



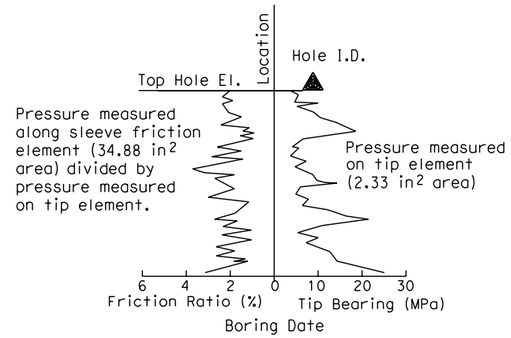
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0148 POST MILE 3.72	MSE RETAINING WALL NO. C1 LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90) Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166); Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0148
POST MILE 3.72

MSE RETAINING WALL NO. C1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10, 04/19/10

SHEET X OF X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

APPENDIX A.

SCHUYLER HEIM BRIDGE SEISMIC RETROFIT LOTB SHEETS

PREPARED BY LKR (1998)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th Street, Suite 103
Torrance, California 90501
Project No.:96-1005

PLAN
SCALE 1"=40' NORTH

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate .
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity
- N.S.R.= No sample recovery
- OVM5808 Gas Readings

ABUT. 0 4+93 · BENT 1 · B-1 · CPT-1 · BENT 2 · BENT 3 · CPT-2 · BENT 4 · BENT 5 · CPT-3 · BENT 6 · BENT 7 · BENT 8 · CPT-4 · BENT 9

℄ EXISTING R.R.

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

45° LT. STA. 5+94.00 · ELEV.= 0.21 · B-1

FILL-(SM)Brown fine to medium SILTY SAND w/GRAVEL, vegetation, w/shell fragments

CWS ELEV.= 4.71 08-26-96

NATIVE:(ML)Gray SILT, very stiff grades to SANDY soft

(ML)Gray SANDY SILT w/mica & shell fragments

(ML)Gray to dark gray SILT w/traces of SAND, stiff

(SP)Gray fine SAND w/mica, compact

(ML)Gray SILT w/CLAY, very stiff

(SP)Gray fine SAND, very dense

(ML)Gray CLAYEY SILT, very stiff, less CLAYEY grades to CLAYEY

(SP)Gray fine SAND, very dense, w/GRAVEL grades to fine to medium w/1" gravel

grades to medium

traces of gravel

Grades to fine w/traces of SILT w/decomposed wood fragments & mica

Grades to medium to coarse w/traces of GRAVEL less SILT

Grades to medium

Grades to fine to medium

Grades to medium w/traces of 3/4" GRAVEL

(ML)Gray SANDY SILT

(GP)Gray poorly graded GRAVEL w/SAND, very dense

(ML)Gray SANDY SILT

08-26-96

17' LT. STA. 6+02.50 · ELEV.= -0.06 · CPT-1 · 08-19-96

STA. 7+63.50 · ELEV.= -2.01 · CPT-2 · 08-15-96

STA. 9+08.00 · ELEV.= -0.18 · CPT-3 · 08-15-96

STA. 11+12.00 · ELEV.= 2.46 · CPT-4 · 08-15-96

Vs (ft/s) 1400 1200 1000 800 600 400 200

N (blows/foot) 10 20 30 40 50

ELEVATION 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200

PROFILE
HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

5 6 7 8 9 10 11 12

LEGEND OF EARTH MATERIALS: GRAVEL · SAND · SILT · CLAY · CLAYEY SILT · PEAT and/or ORGANIC MATTER · FILL MATERIAL · IGNEOUS ROCK · SEDIMENTARY ROCK · METAMORPHIC ROCK · SANDY CLAY or CLAYEY SAND · SANDY SILT or SILTY SAND · SILTY CLAY

2nd " CONE PENETROMETER (SAMPLE DRY) · 2 1/2" CONE PENETROMETER (SAMPLE DRY) · ROTARY SAMPLE BORING (WET) · AUGER BORING (DRY) · TEST PIT · DIAMOND CORE BORING · JET BORING · ELECTRONIC CONE PENETROMETER

ASCE CLASSIFICATION FOR SOILS (According to the Standard Penetration Test)

	Penetration Index (Blows/Ft.)	Granular	Cohesive
	0-4	Very loose	Very soft
	5-9	Loose	Soft
	10-19	Slightly compact	Firm
	20-34	Compact	Very stiff
	35-69	Dense	Hard
	>70	Very dense	Very hard

NOTE: Classification of earth materials as shown on this sheet is based upon field inspection and is not to be construed as being mechanical analysis

PENETRATION BORING · PENETROMETER TEST

ROTARY SAMPLE BORING (WET) · AUGER BORING (DRY)

Penetrometer Hammer (Using a 140 lb. hammer with a 30" free fall, or as noted) · Boring Data · Penetration Index (Blows/Ft.) · Unconfined compressive strength (Tons/Sq.Ft.) · Dry Density (Lbs/Cu.Ft.) · Moisture Content (%) · Liquid Limit (%) · Plasticity Index (%) · Passing No. 200 Sieve (%) · Description of material · Unit weight (Lbs/Cu.Ft.) · % moisture · consolidation test · Sample No. · Core · Conformable material change · Estimated material change · Unconformable material change

Top Hole El. · Cased · Drilling driven · Size of Sample · Rotary Sample Boring · Auger Boring · Vane shear · Pushed · Rocky Data · Fluid pipe · Blows per foot, Using a 140 lb. hammer with a 30" free fall · Pushed with hydraulic pressure · Pressure measured during steady motion · Pressure measured during steady motion divided by pressure required on 10 cm² piston · Pressure measured during steady motion divided by pressure required on 10 cm² piston

DESIGN OVERSIGHT	DRAWN BY	NL	CS-LN-MC
BRIDGE ENGINEER DATE	CHECKED BY	MH	FIELD INVESTIGATOR 08-15-96 DATE

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

BRIDGE NO.	53-2618
POST MILE	3.58

SEISMIC RETROFIT PROJECT No. 627

SCHUYLER HEIM BRIDGE

LOG OF TEST BORINGS NO. 1

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET 141 OF 148

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
07	LA	47			

Michael D Reader
GEOTECHNICAL PROFESSIONAL

PLANS APPROVAL DATE

THE LKR GROUP
2341 205th. Street, Suite 103
Torrance, California 90501
Project No.:96-1005

Note - 1. Boring elevations were surveyed by Psomas & Associates on August 21, 1996
2. Vs, Shear Wave Velocity
3. N values on CPTs are correlated from tip resistance data

Laboratory Testing
- (DS) Direct Shear
- (SS) Soluble Sulfate
- (SC) Soluble Chloride
- (R) R- Value
- (MD) Maximum Dry Density
- (RE) Minimum Resistivity
- N.S.R= No sample recovery
- OVM5808 Gas Readings

PLAN
SCALE: 1"=40'

NORTH

BENT 9, CPT-5, BENT 11, BENT 12, "OFF ABUT. 5", "OFF BENT 4", "OFF BENT 3", "OFF BENT 2", "OFF BENT 1", BENT 18, BENT 10, "ON ABUT. 6", "ON BENT 5", BENT 13, CPT-6, CPT-7, B-2, BENT 14, BENT 15, CPT-8, BENT 16, BENT 17

14+05.00

PROFILE
HORIZONTAL: 1"=40'
VERTICAL: 1"=20'

45° Lt. STA. 12+82.50 — ELEV.= -0.68 — CPT-5 — 08-15-96

STA. 14+05.00 — ELEV.= -1.78 — CPT-6 — 08-15-96

STA. 15+63.50 — ELEV.= -1.66 — CPT-7 — 08-15-96

5° Lt. STA. 15+51.50 — ELEV.= -1.54 — GWS ELEV.= -5.54' 08-23-96 — B-2 — 08-21-96

STA. 17+23.00 — ELEV.= -0.02 — CPT-8 — 08-15-96

FILL-(SM)Brown fine SILTY SAND w/GRAVEL & shell fragments
(ML)Dark gray CLAYEY SILT w/roots, very soft
NATIVE-(SP)Gray fine SAND w/mica, slightly compact
(ML)Gray SILT w/traces of SAND, stiff -
grades to SANDY, very soft
grades to w/SAND and shells
grades to SANDY
increasing shells, stiff
grades to CLAYEY w/traces of mica
Decreasing in CLAY, soft
grades to CLAYEY w/mica
Decreasing in mica, very stiff
stiff
w/traces of SAND -
interbedded w/ SANDY SILT
(SP)Gray fine SAND, dense
(ML/SM)Gray SANDY SILT
(SP)Gray fine SAND w/traces of SILT
grades to w/mica, decreasing in SILT, very dense
traces of SILT
traces of GRAVEL, 0.5" dia.
w/o GRAVEL
grades to fine to medium
grades to fine to medium w/traces of GRAVEL
grades to w/traces of SILT
(ML)Gray SANDY SILT
(SP)Gray fine SAND, very dense
grades to medium to coarse w/GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND, 3/8" max. dia.
(SP)Gray fine SAND w/GRAVEL
Decreasing in GRAVEL
(ML)Dark gray SILT w/decomposed wood & mica
(SP)Gray fine to medium SAND w/1.5" GRAVEL
(GP)Gray poorly graded GRAVEL w/SAND
(ML)Dark gray SILT w/SAND
(SM)Dark gray fine to medium SILTY SAND w/traces of CLAY
(ML)Gray SILT w/SAND

2½" I.D. CONE PENETROMETER
SPT SAMPLE DRIVE (DRY)
RCK ROTARY SAMPLE BORING (WET)
AUGER BORING (DRY)
TP TEST PIT
DIAMOND CORE BORING
JET BORING
ECP ELECTRONIC CONE PENETROMETER

LEGEND OF EARTH MATERIALS
GRAVEL, SAND, SILT, CLAY, CLAYEY SILT, PEAT and/or ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK, SANDY CLAY or CLAYEY SAND, SANDY SILT or SILTY SAND, SILTY CLAY

CONSISTENCY CLASSIFICATION FOR SOILS According to the Standard Penetration Test

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
70	Very dense	Very hard

NOTE: Classification of earth material as shown on the chart is based upon field inspection and is not to be construed to imply mechanical analysis

DESIGN OVERNIGHT
SIGN OFF DATE

DRAWN BY: NL
CHECKED BY: MR

CS-LN-MC
FIELD INVESTIGATOR
DATE 09-15-96

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
PROJECT ENGINEER

BRIDGE NO. 53-2618
POST MILE 9.58

SEISMIC RETROFIT PROJECT No. 627
SCHUYLER HEIM BRIDGE
LOG OF TEST BORINGS NO.2

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 138201

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 4/17/97 9/12/97

SHEET 142 OF 148

C:\CADDWG\JOB\LKR\LTBBDR 8-15-96 11:45:15 am EST

APPENDIX B.

EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

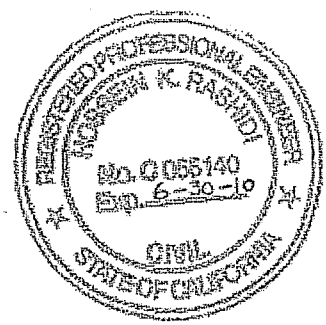
Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

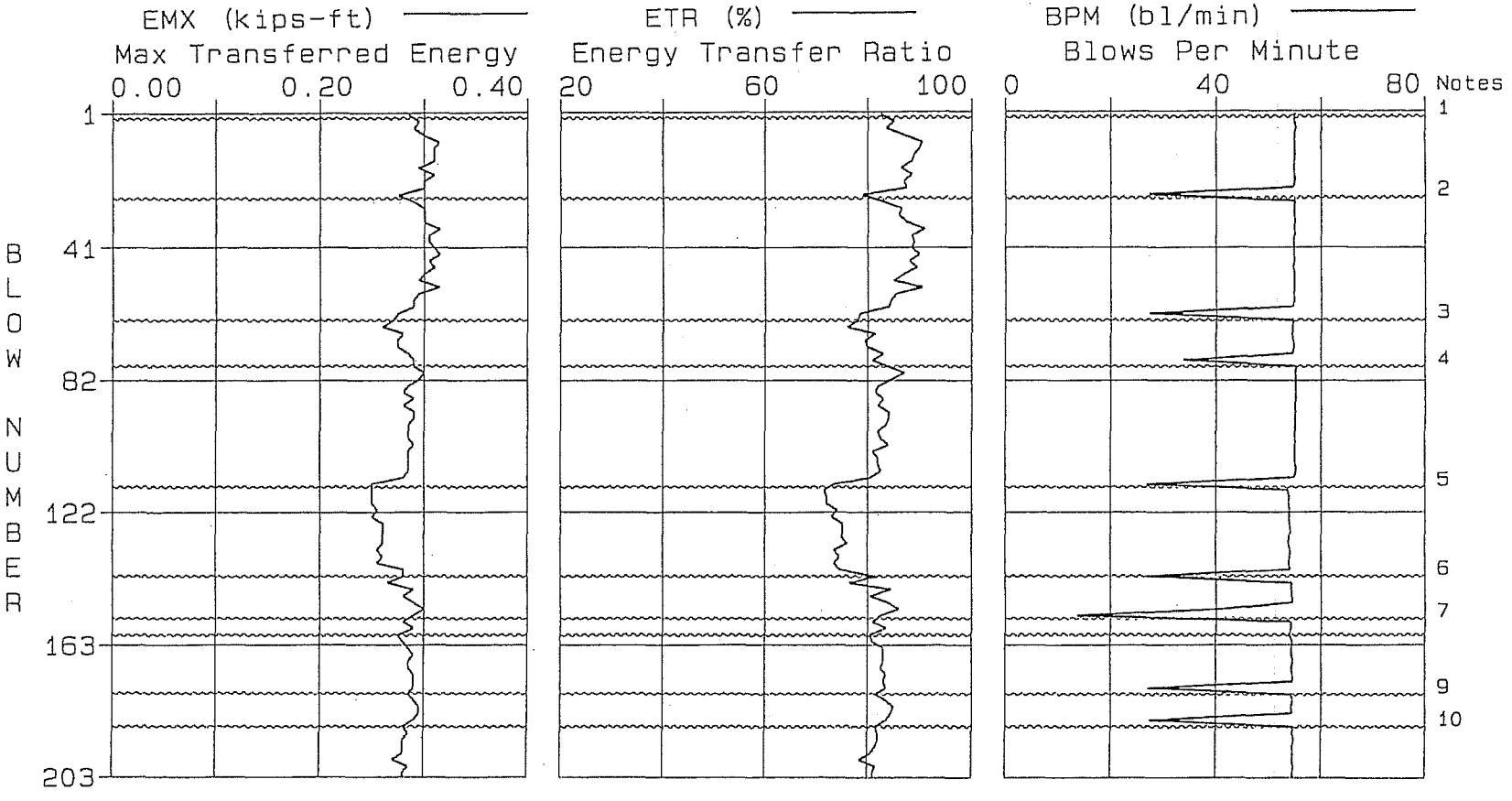
Sincerely Submitted for EarthSpectives

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

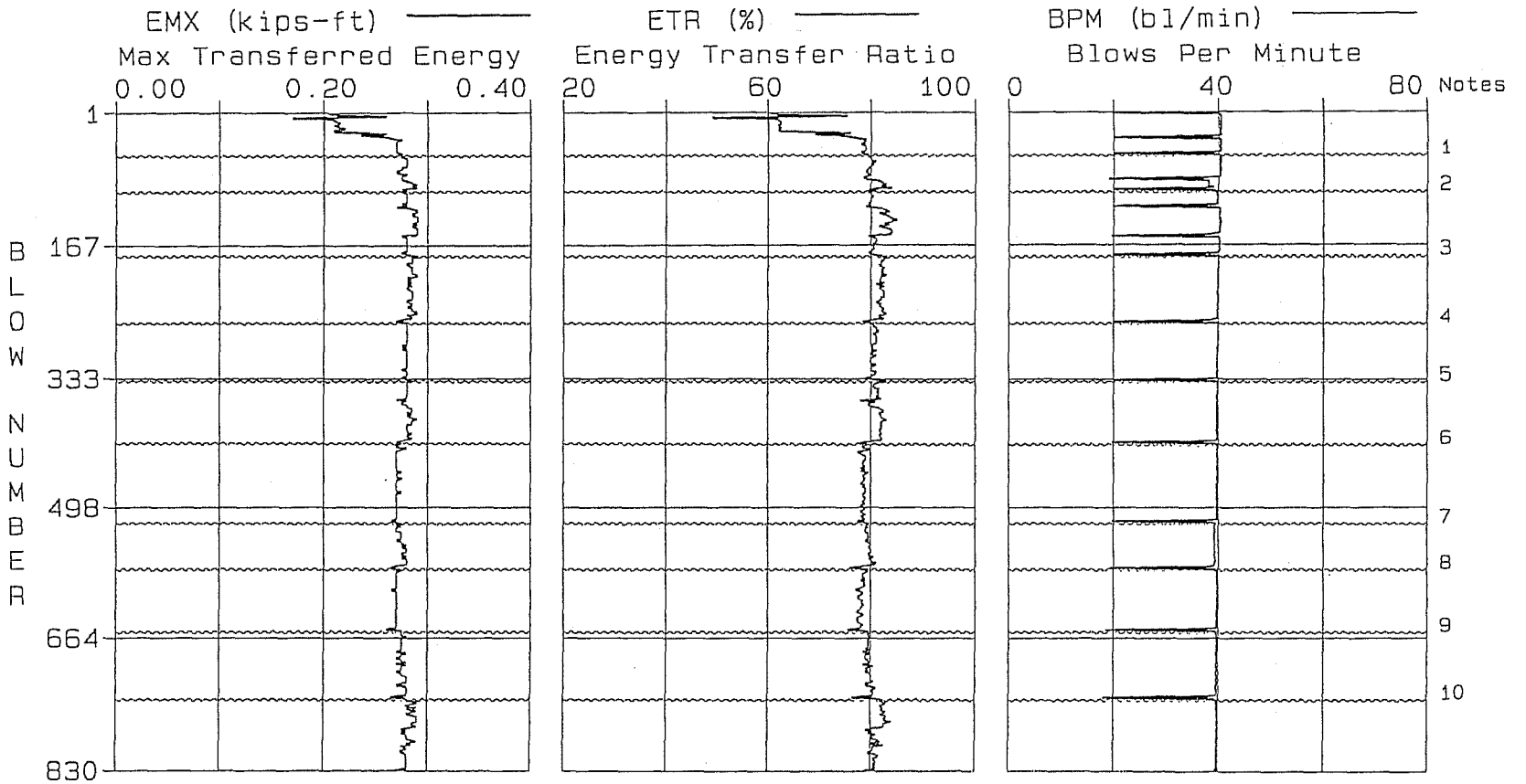
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

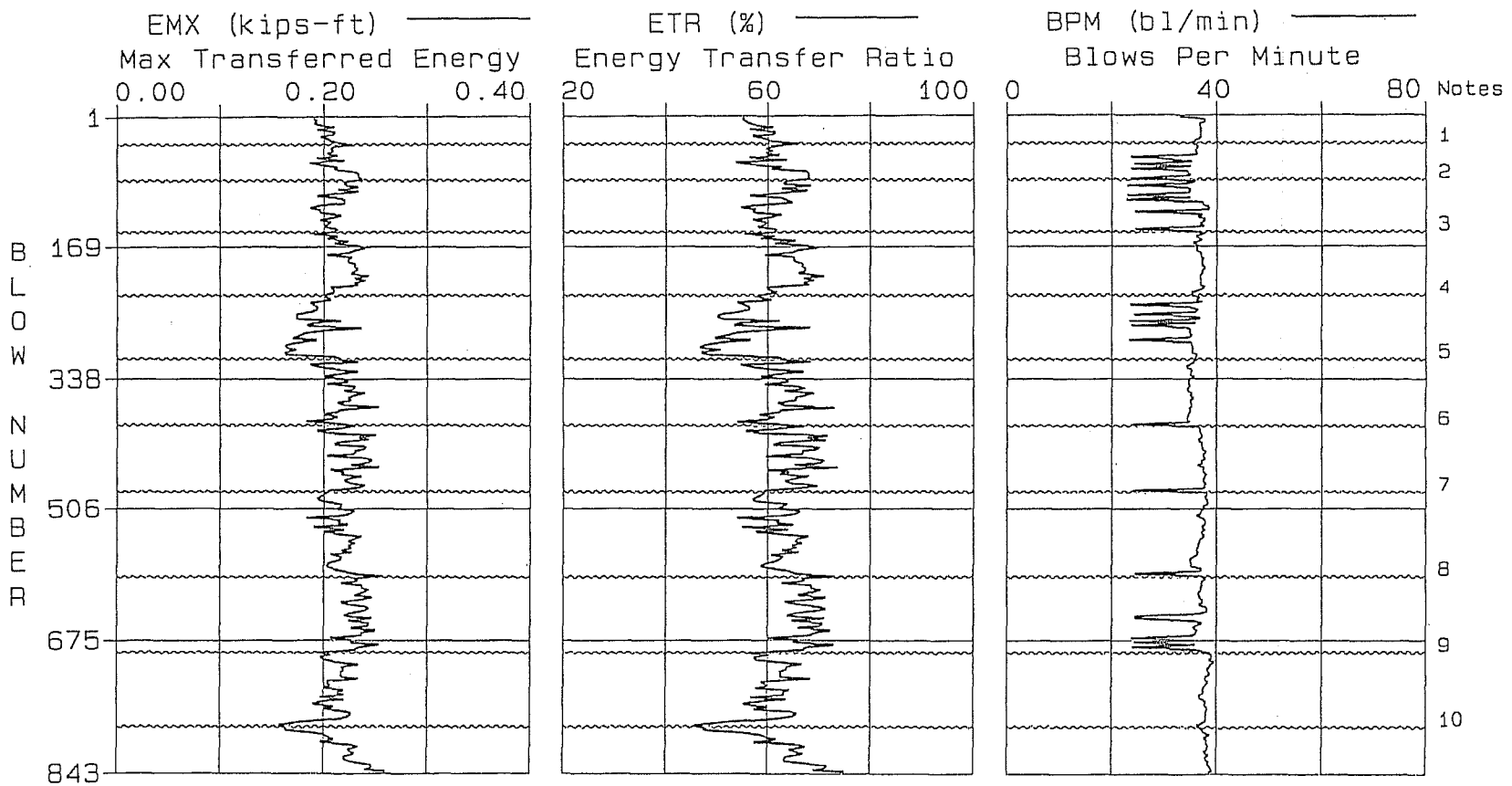
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009 Proj: ACTA HEIM BRIDGE PROJECT Pg1
Info: MUD ROTARY- rope and cathead SP: 0.492 k/ft^3
AR: 1.4 in^2 WS: 16808 ft/s
LE: 165.0 ft EM: 30000 KSI

EMX: Max Transferred Energy BPM: Blows Per Minute
ETR: Energy Transfer Ratio CSX: Max Measured C-Stress
E2F: UNDEFINED CSI: Max F1 or F2 C-Stress
EF2: Energy by F^2 Method TSX: Max Computed T-Stress
EV2: UNDEFINED

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX C.

GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

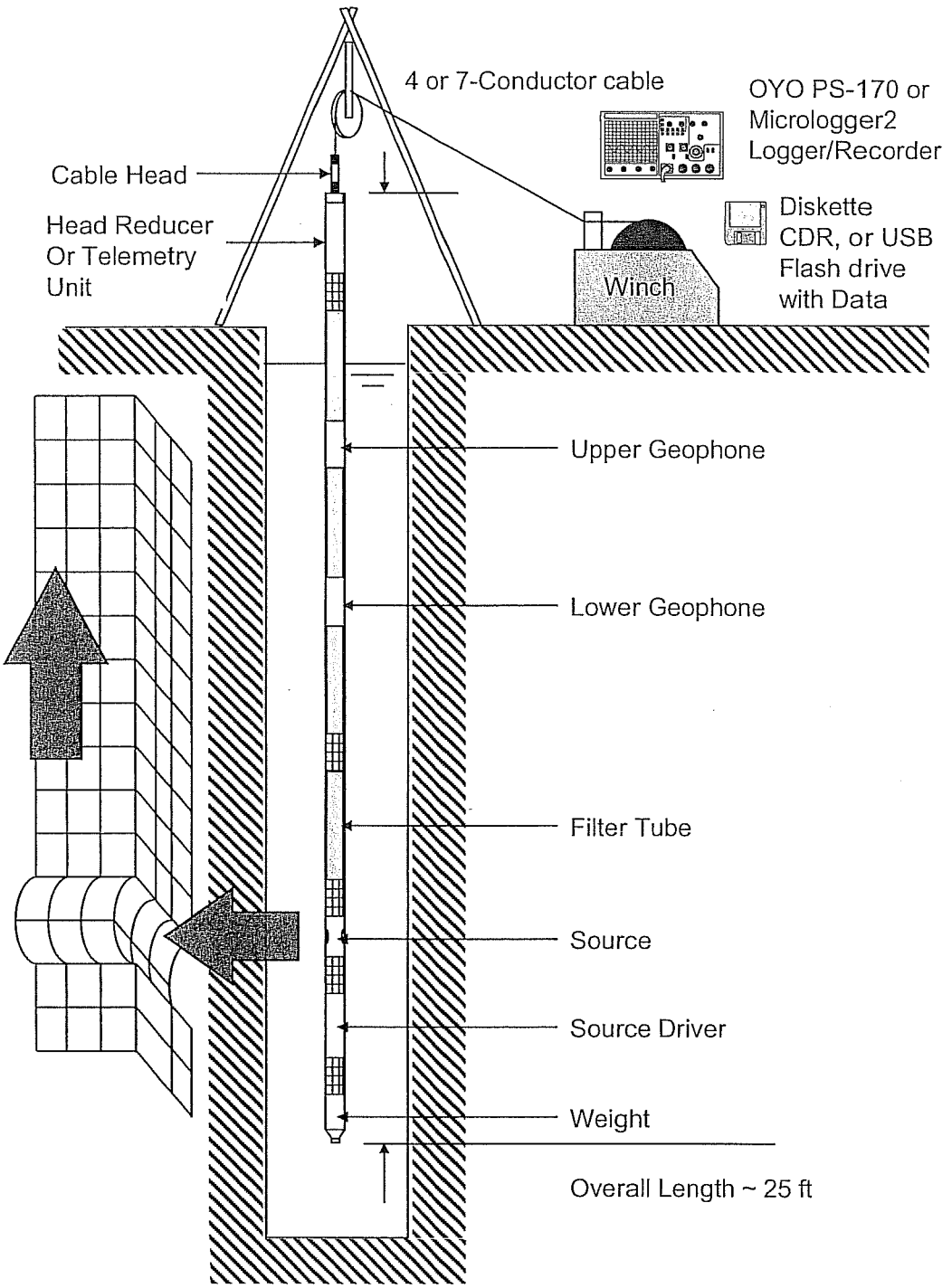

Figure 1: Concept illustration of P-S logging system

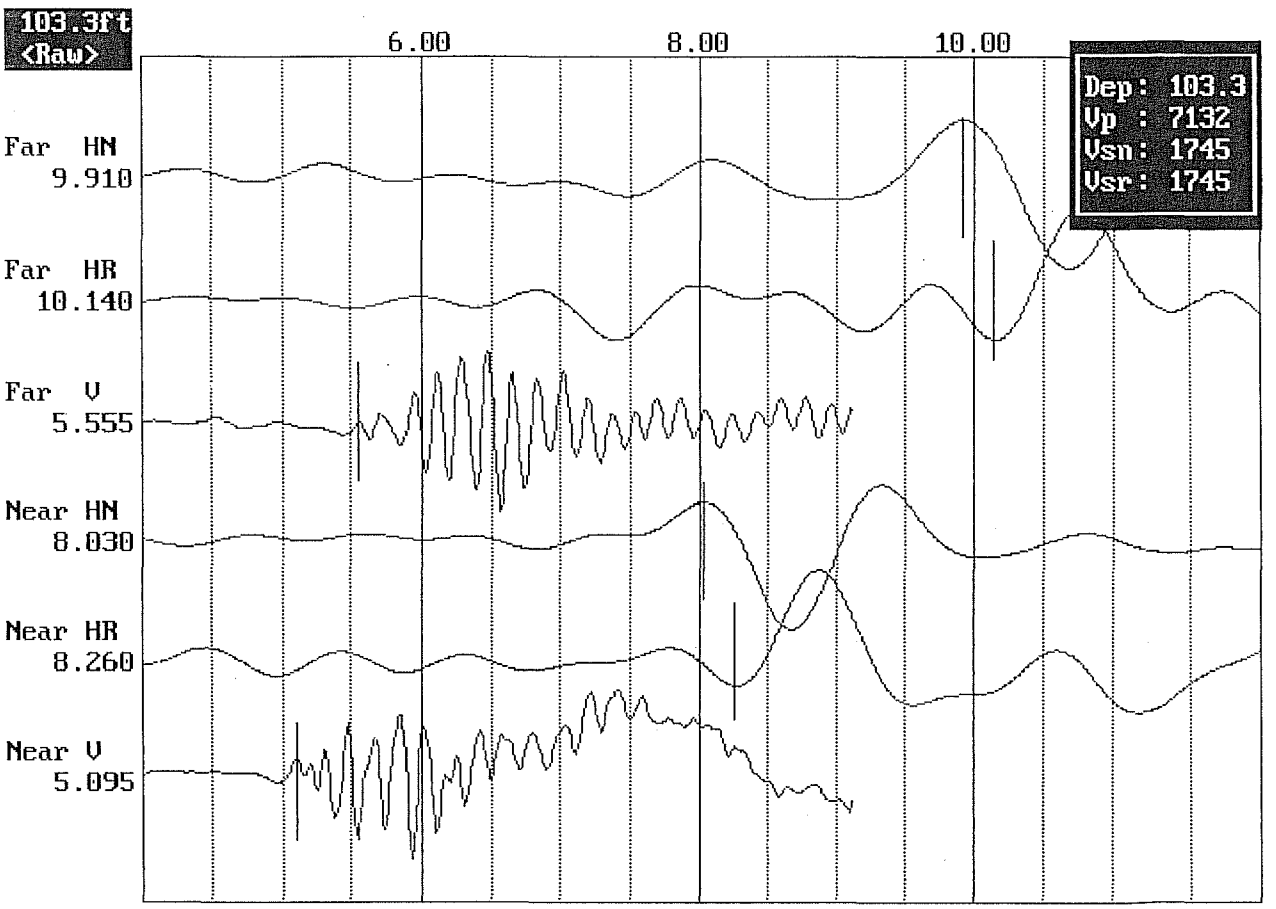

Figure 2: Example of filtered (1400 Hz lowpass) record

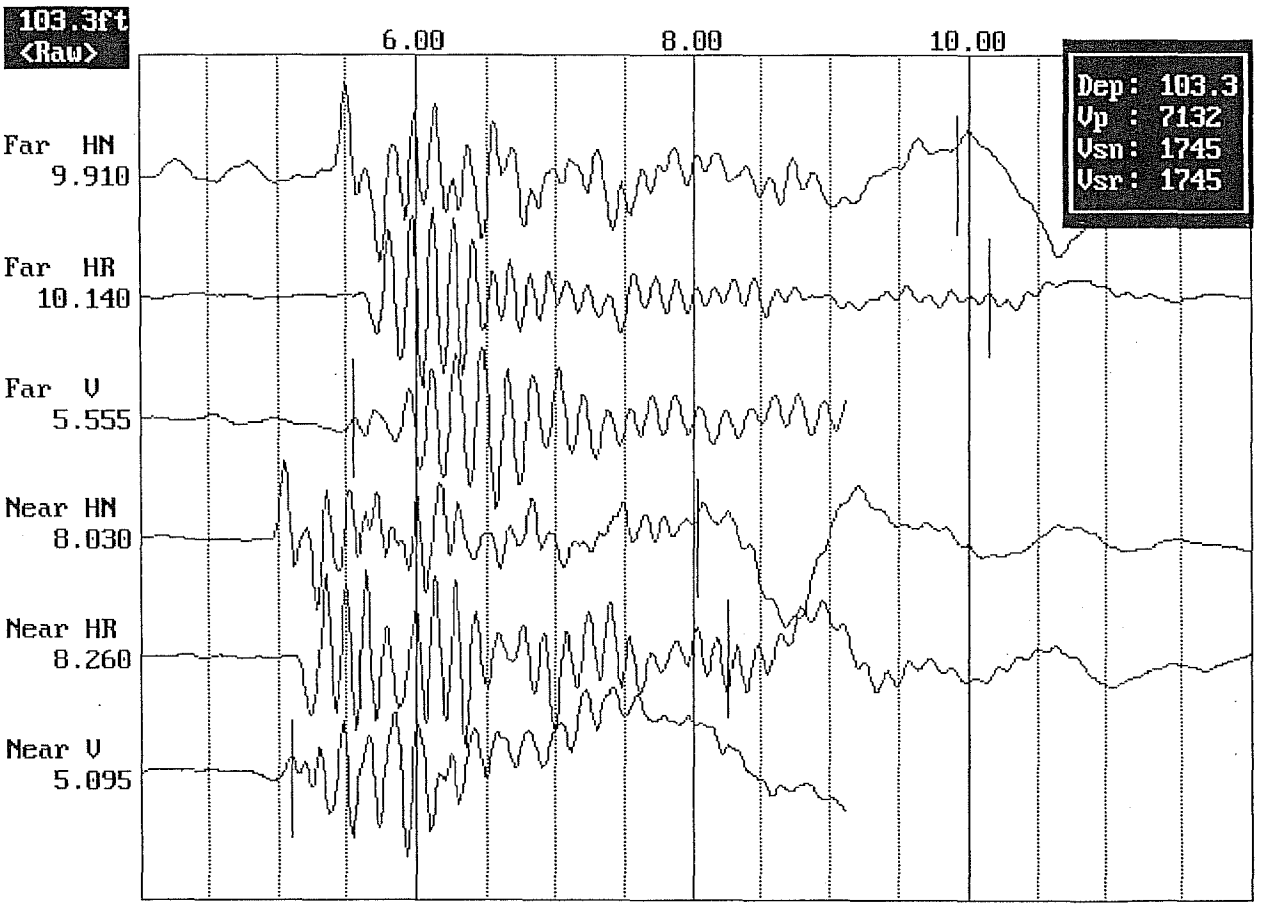

Figure 3. Example of unfiltered record

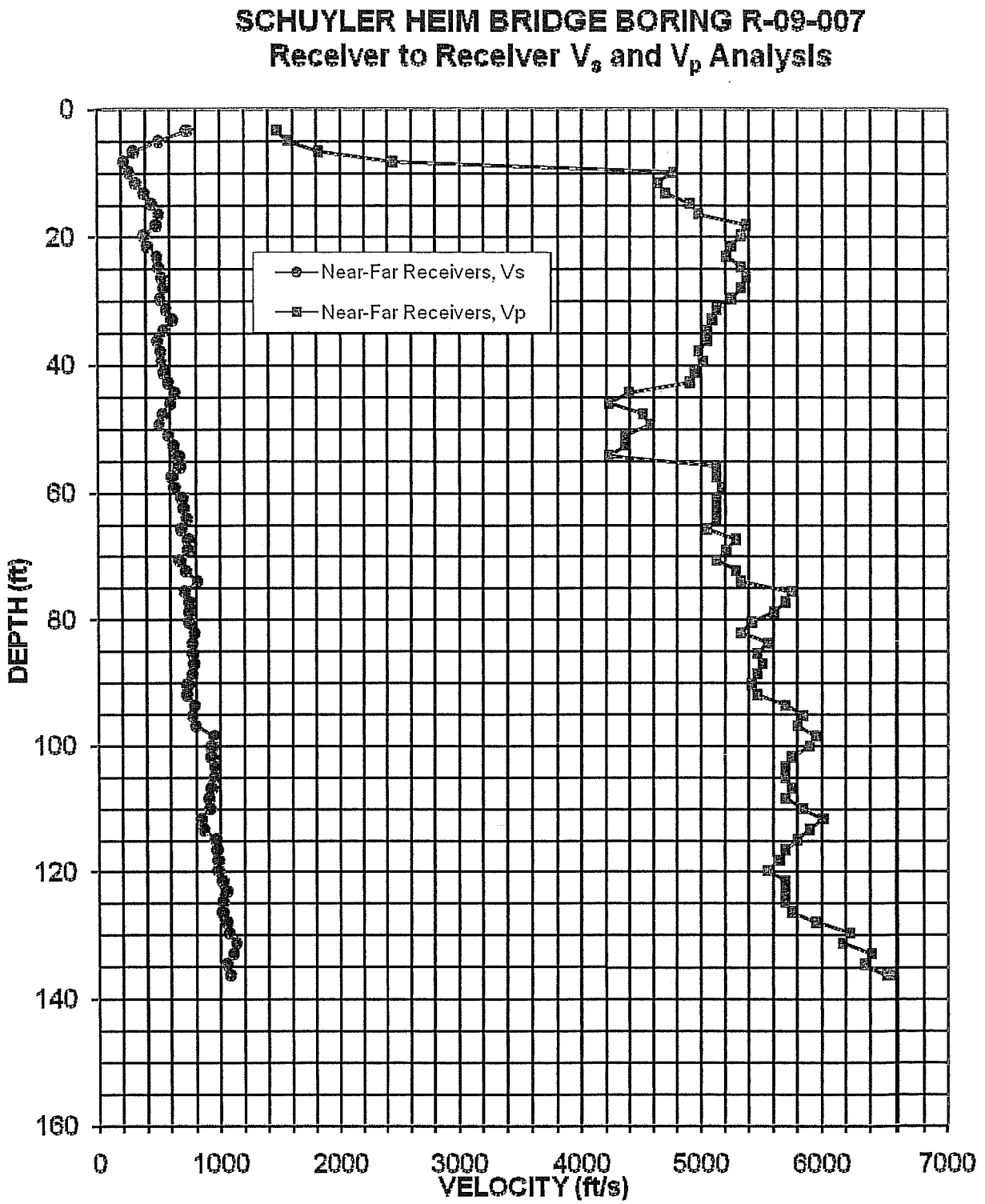

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

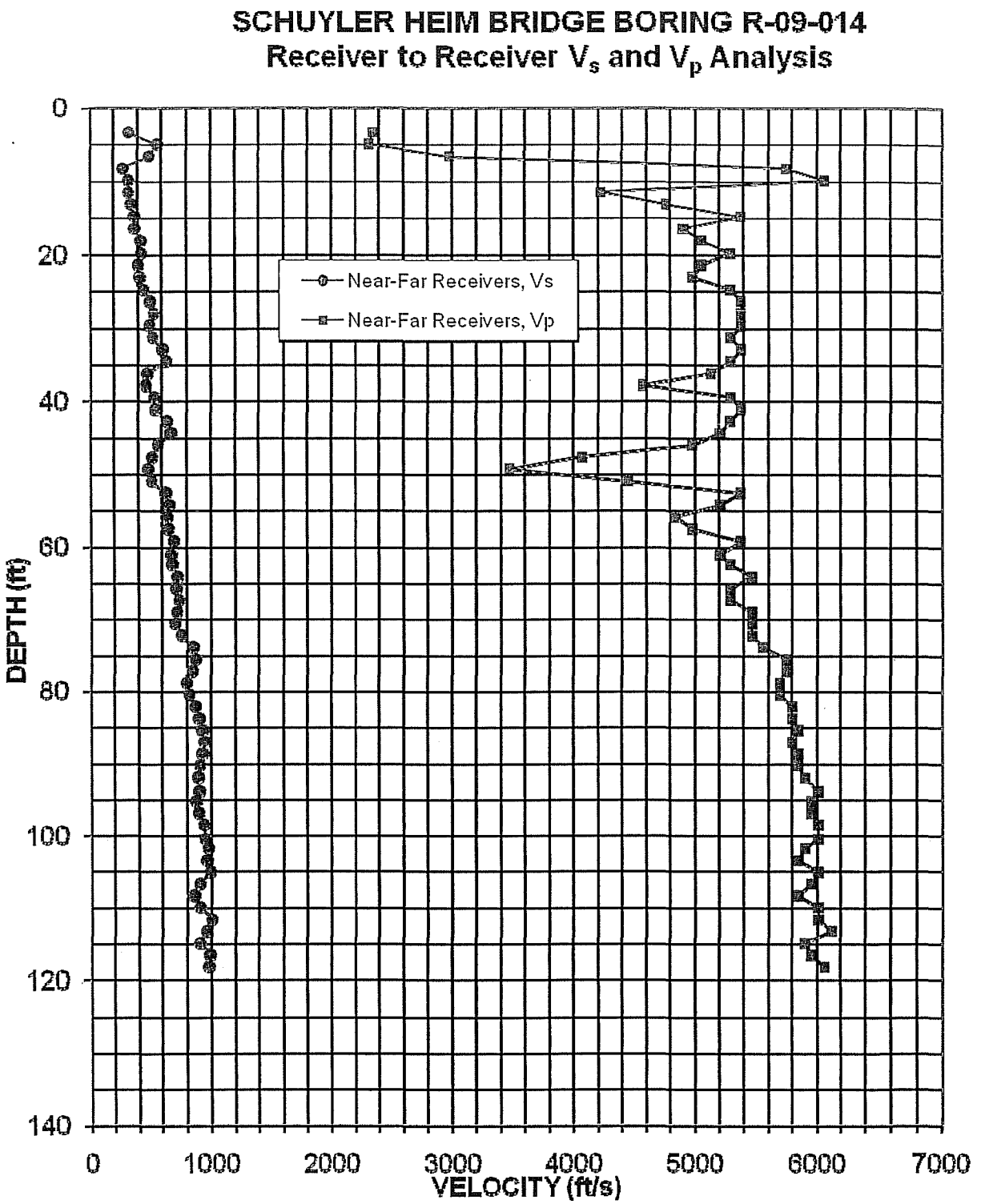

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

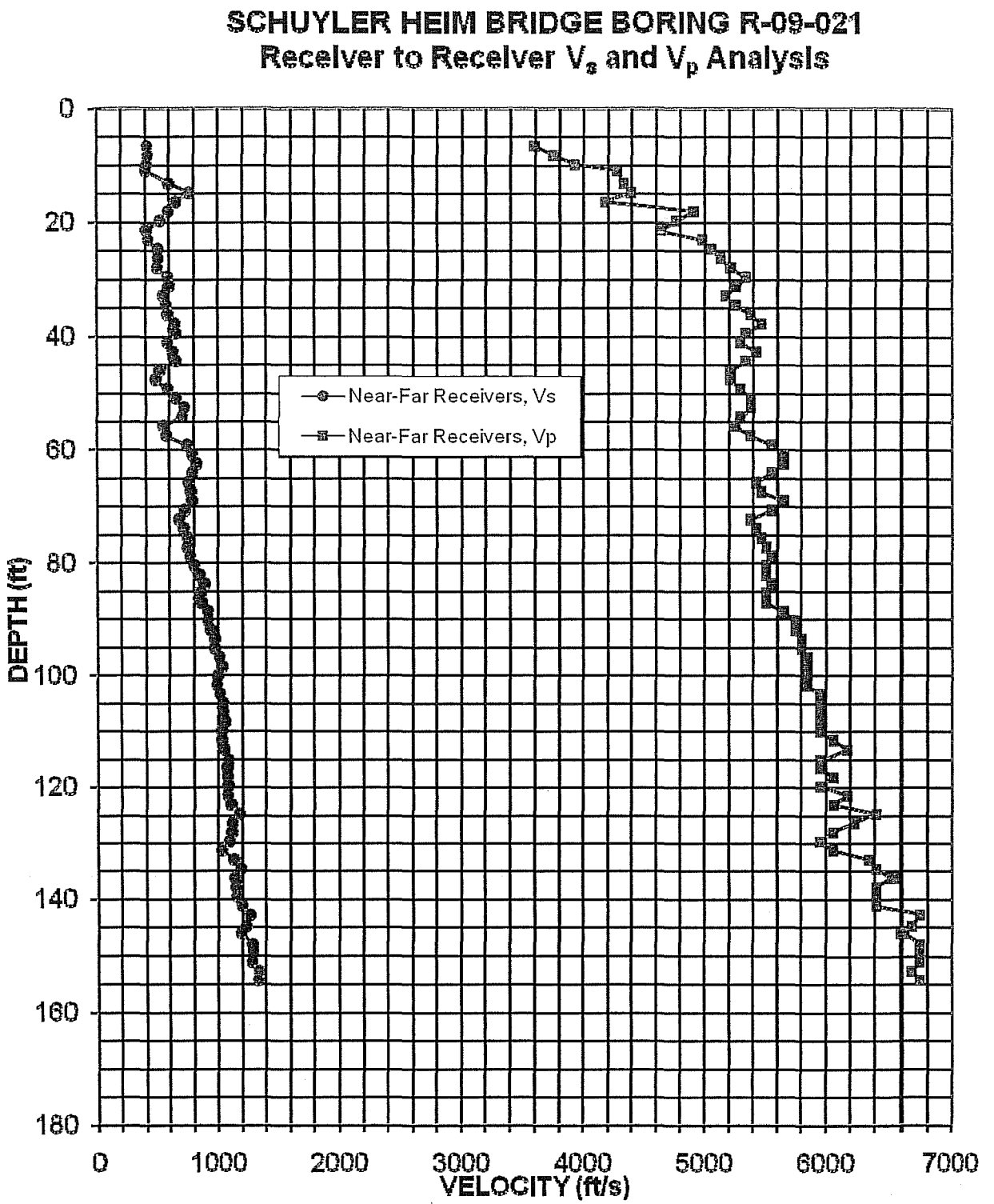

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

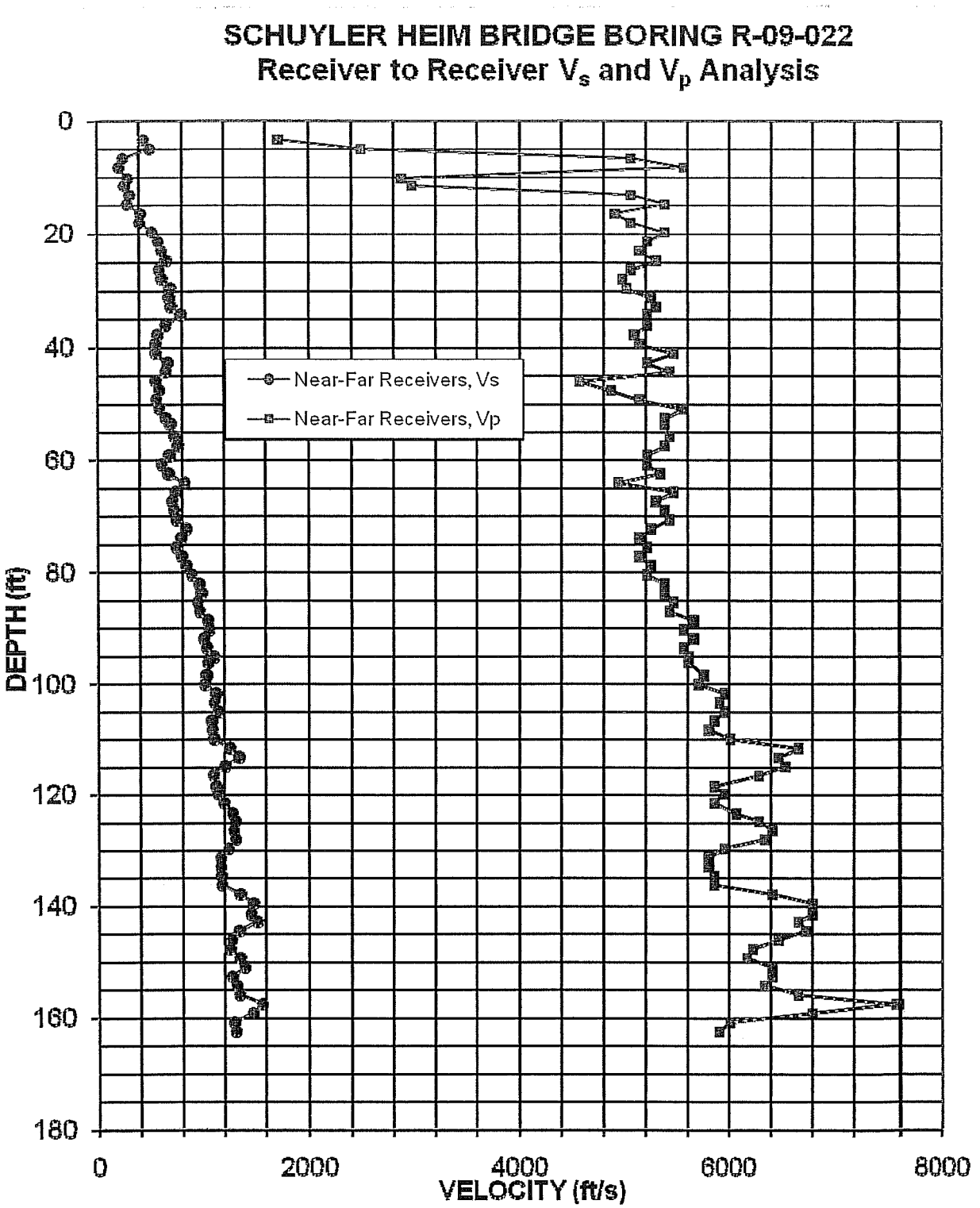

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

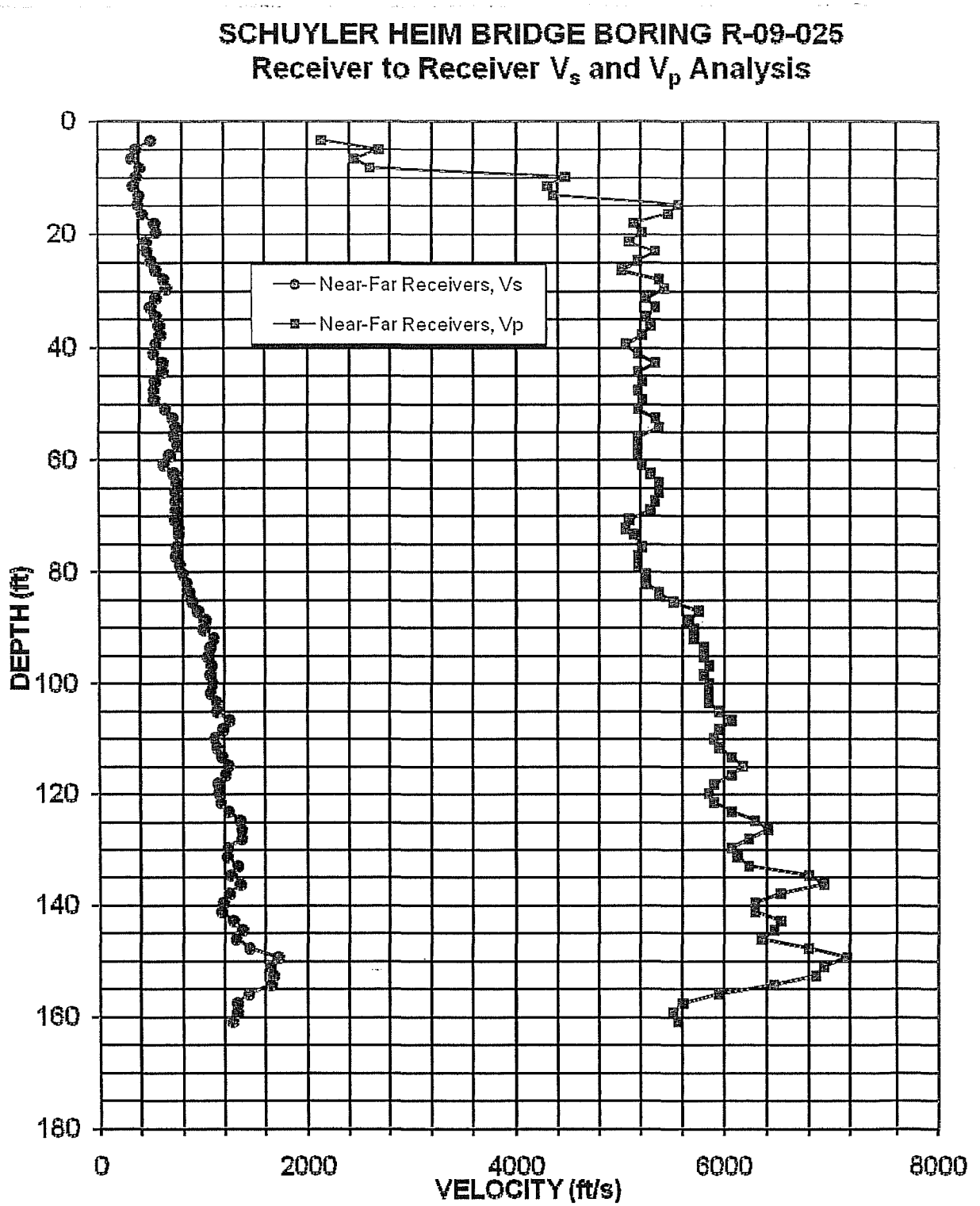

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

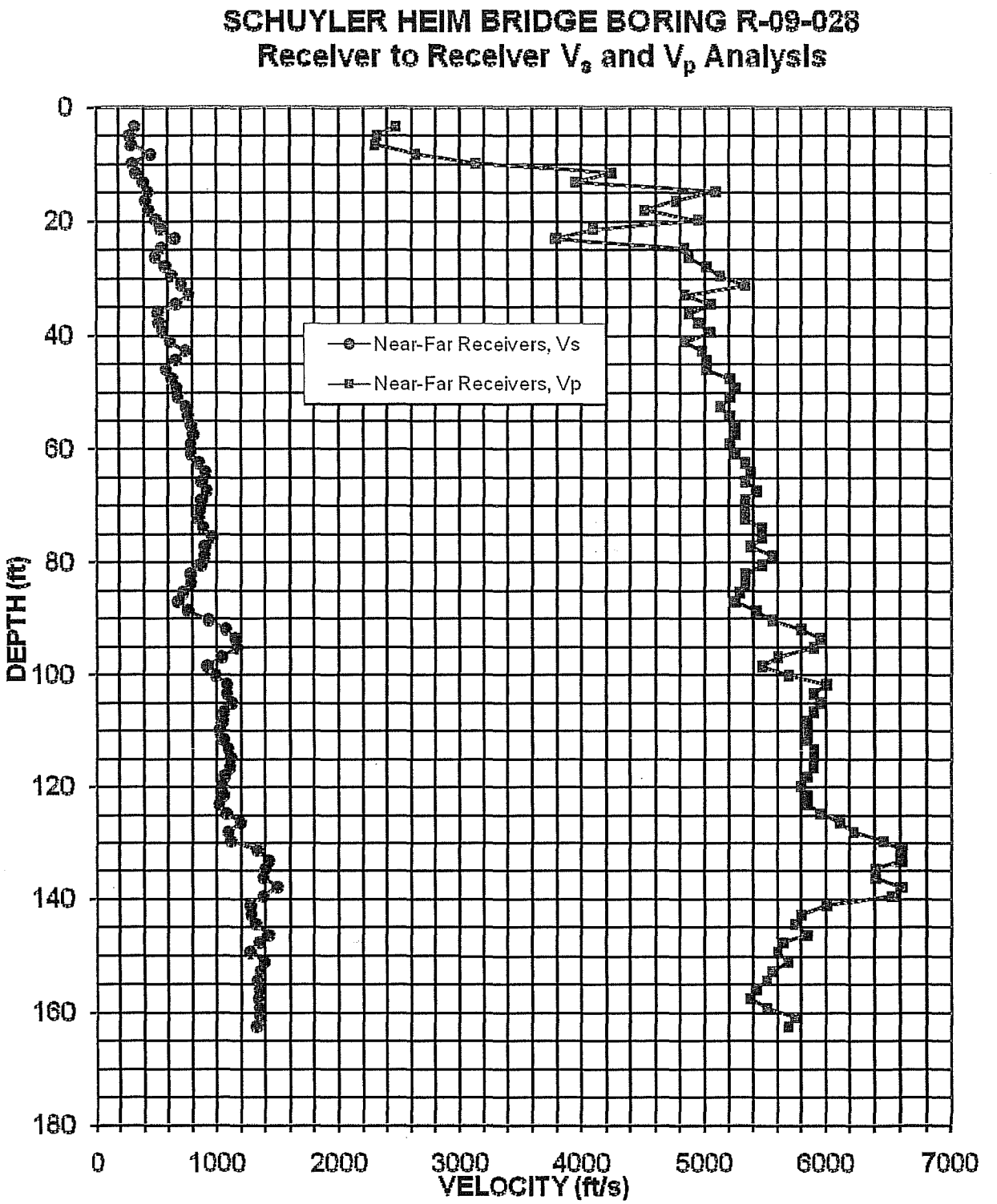

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

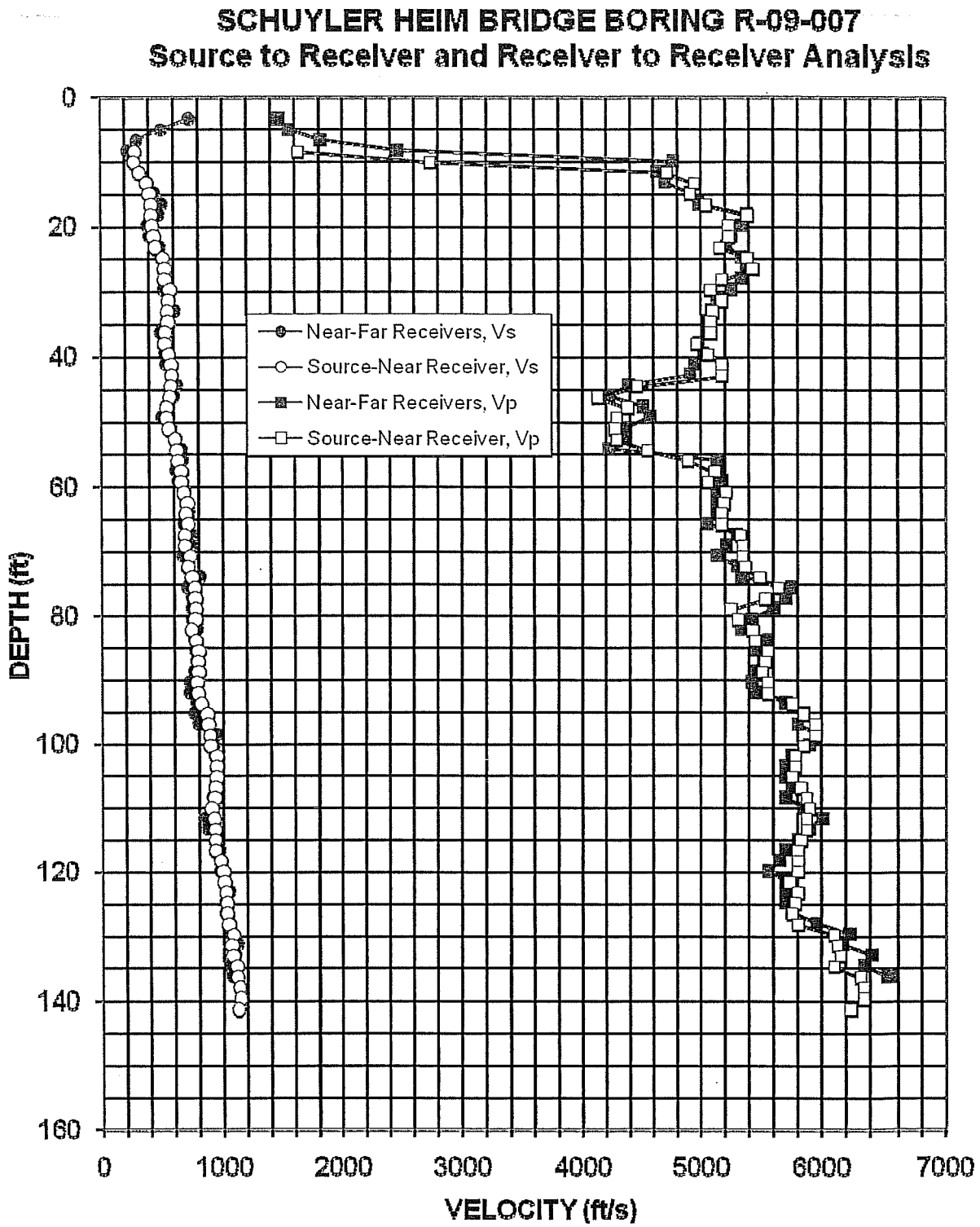

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

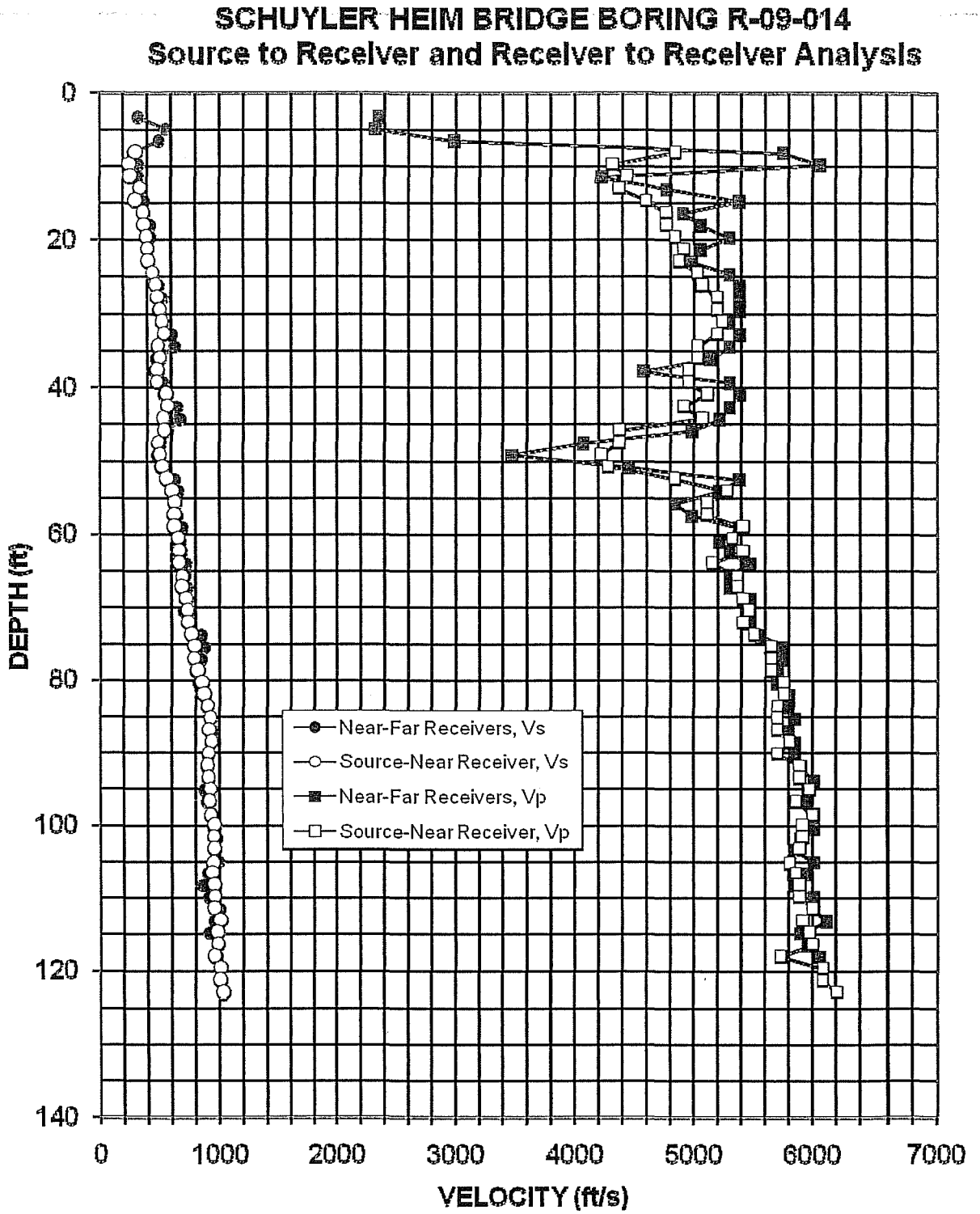

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

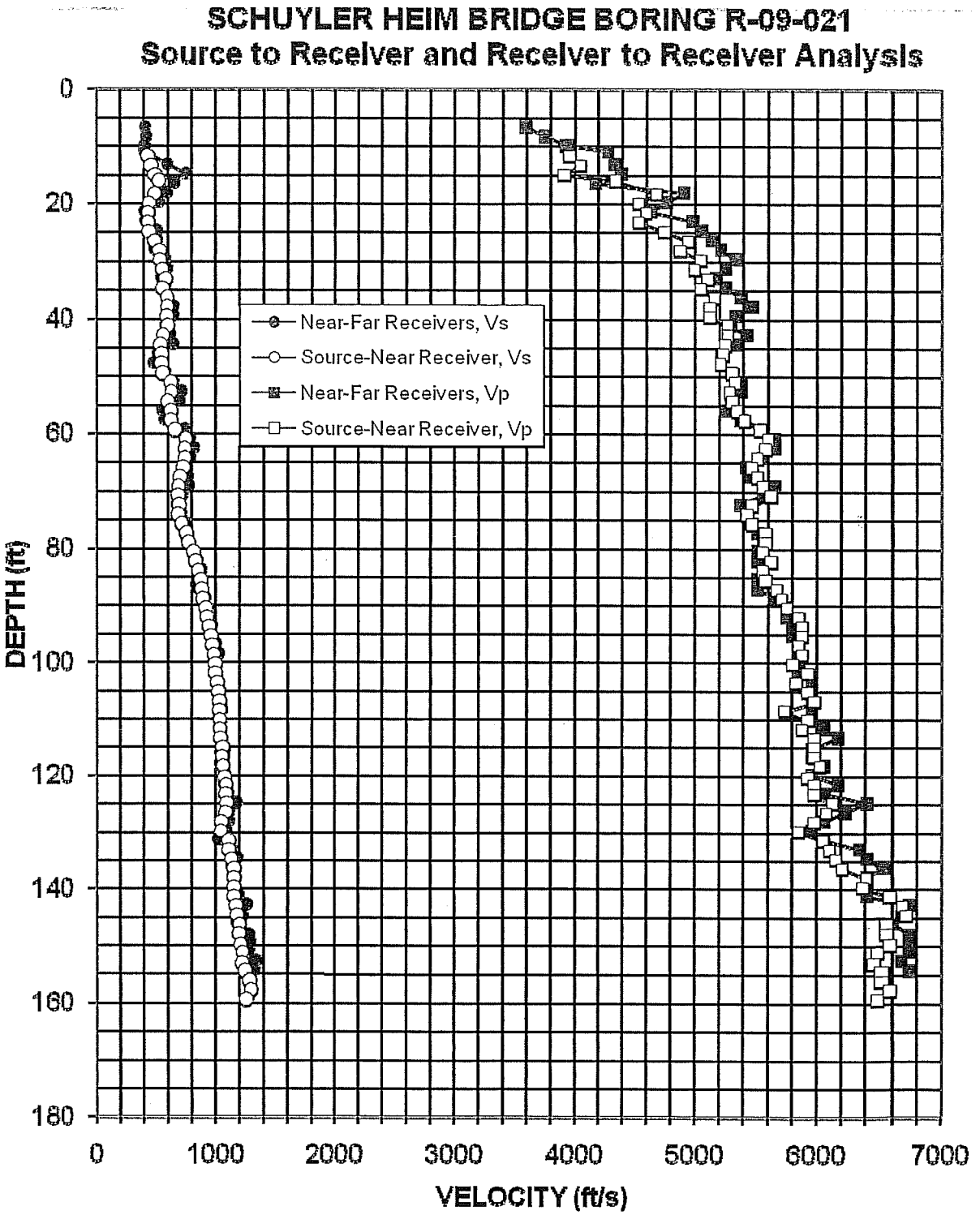

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

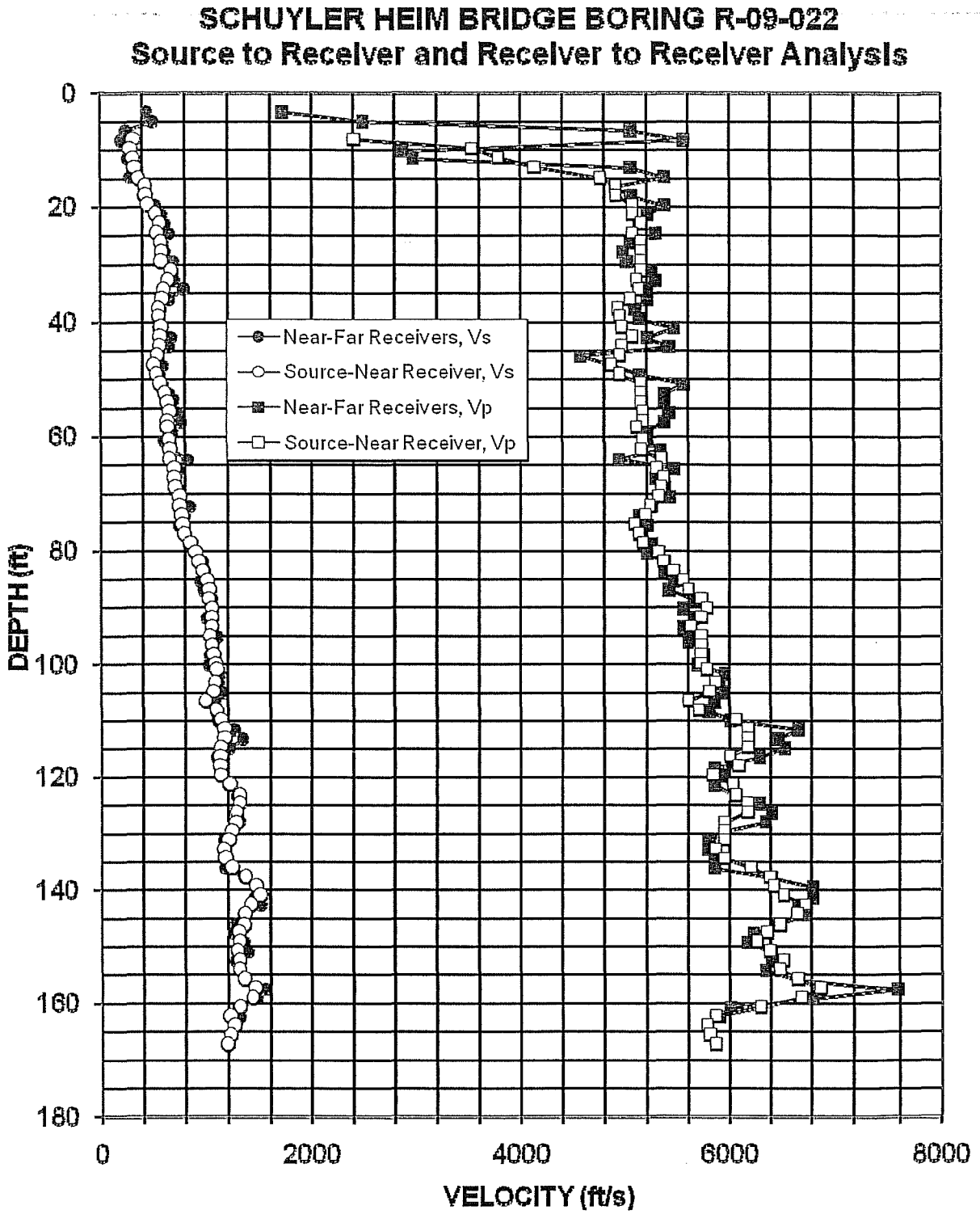

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

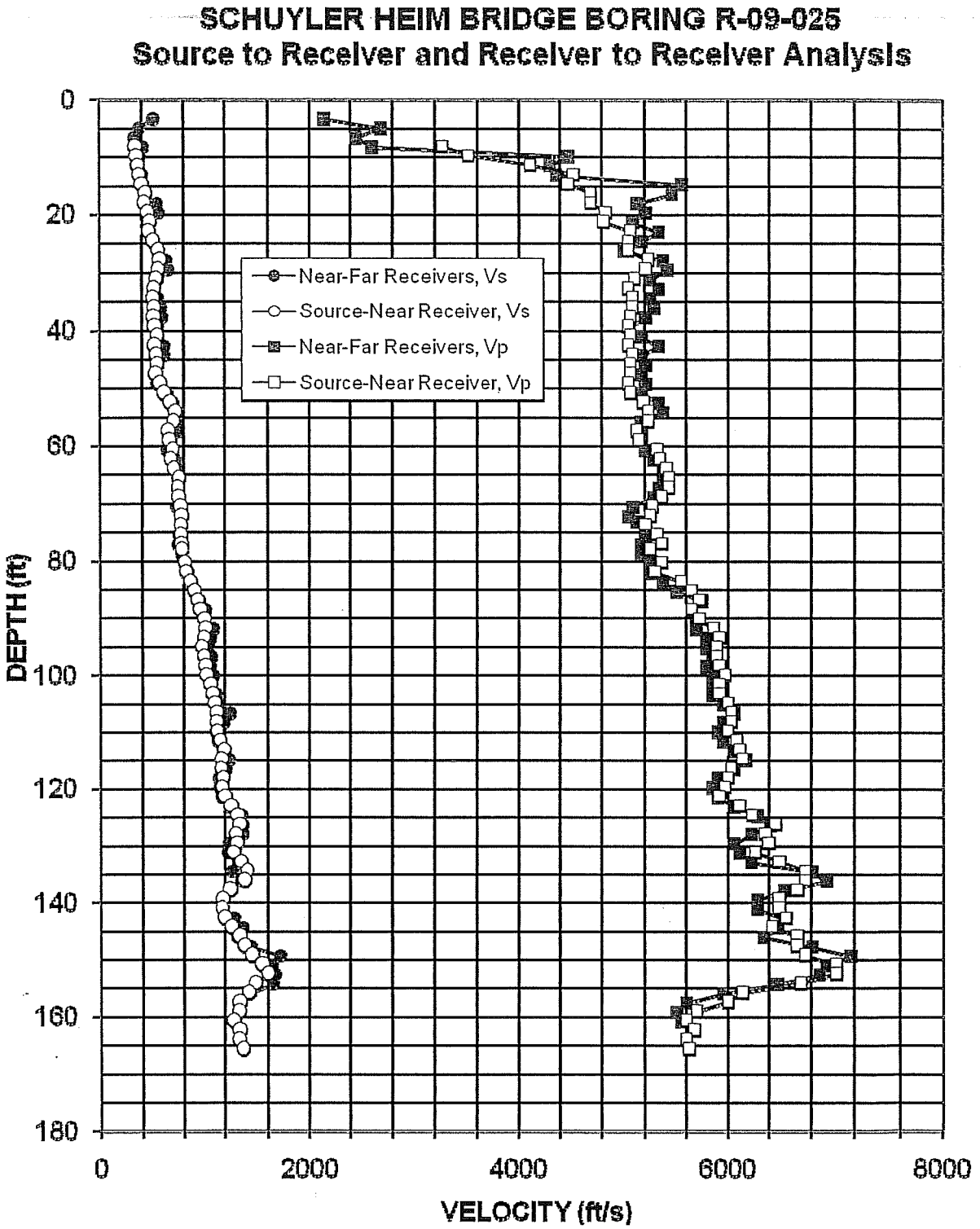

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

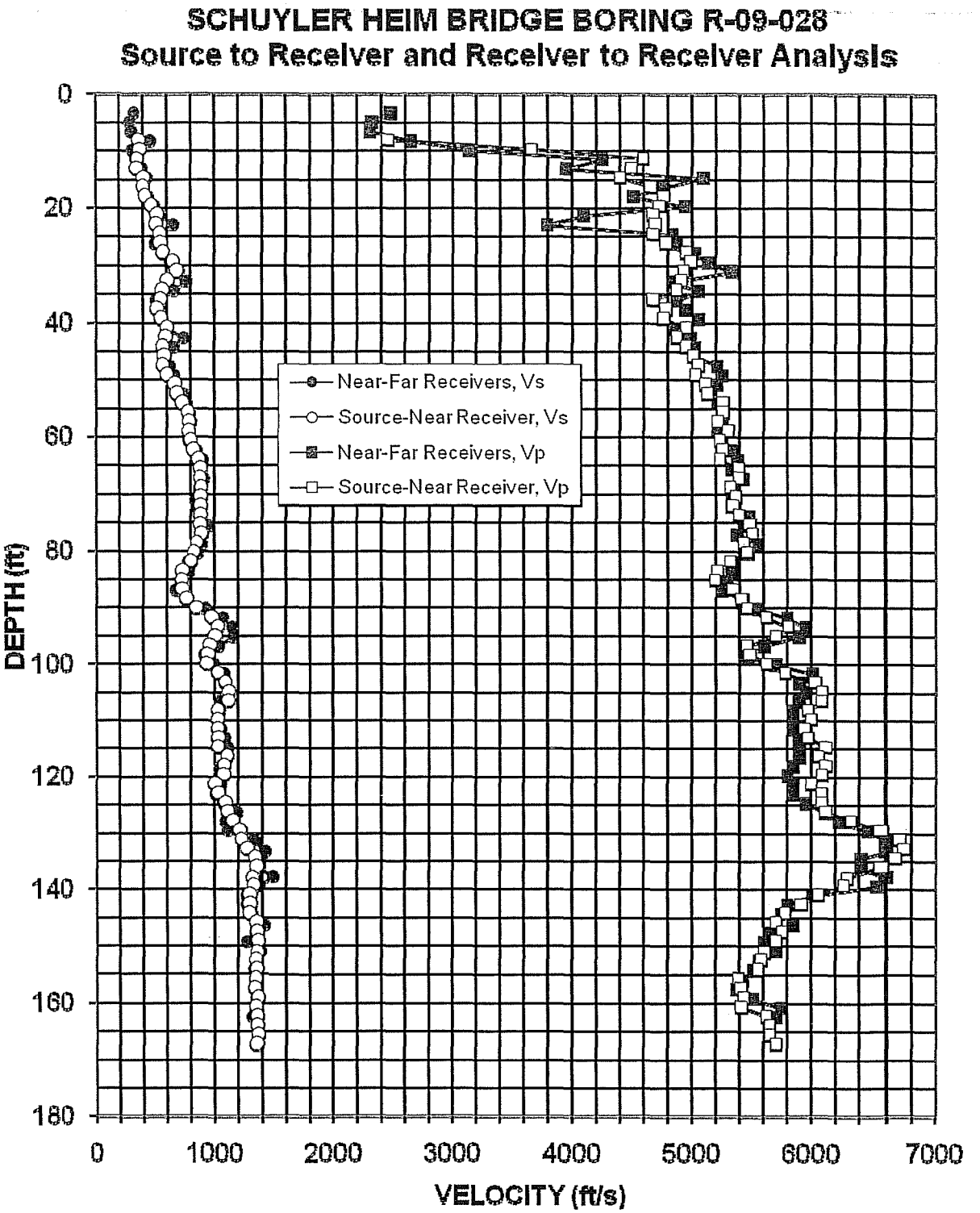

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®

Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:

The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11% As left -0.11%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®

Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:

The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573795
Asset No. 160024

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160824 Project Number 06-123 7-17 CT

~~160024~~

573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX D.

LABORATORY SOIL TEST RESULTS

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/01/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-009	D-01	5	24.5	94.3
R-09-009	S-03	15	24.7	NA
R-09-009	D-07	35	52.9	72.3
R-09-009	S-10	50	52.6	NA
R-09-009	D-11	55	28.6	92.9
R-09-009	D-13	65	32.0	89.6
R-09-009	S-14	70	29.2	NA
R-09-009	S-16	80	26.6	NA
R-09-009	S-19	110	12.0	NA
R-09-009	S-22	140	9.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-009	U-09	45	1.38
R-09-009	D-13	65	2.86

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03
Laboratory No.: 29-1121
Date: 12/04/09

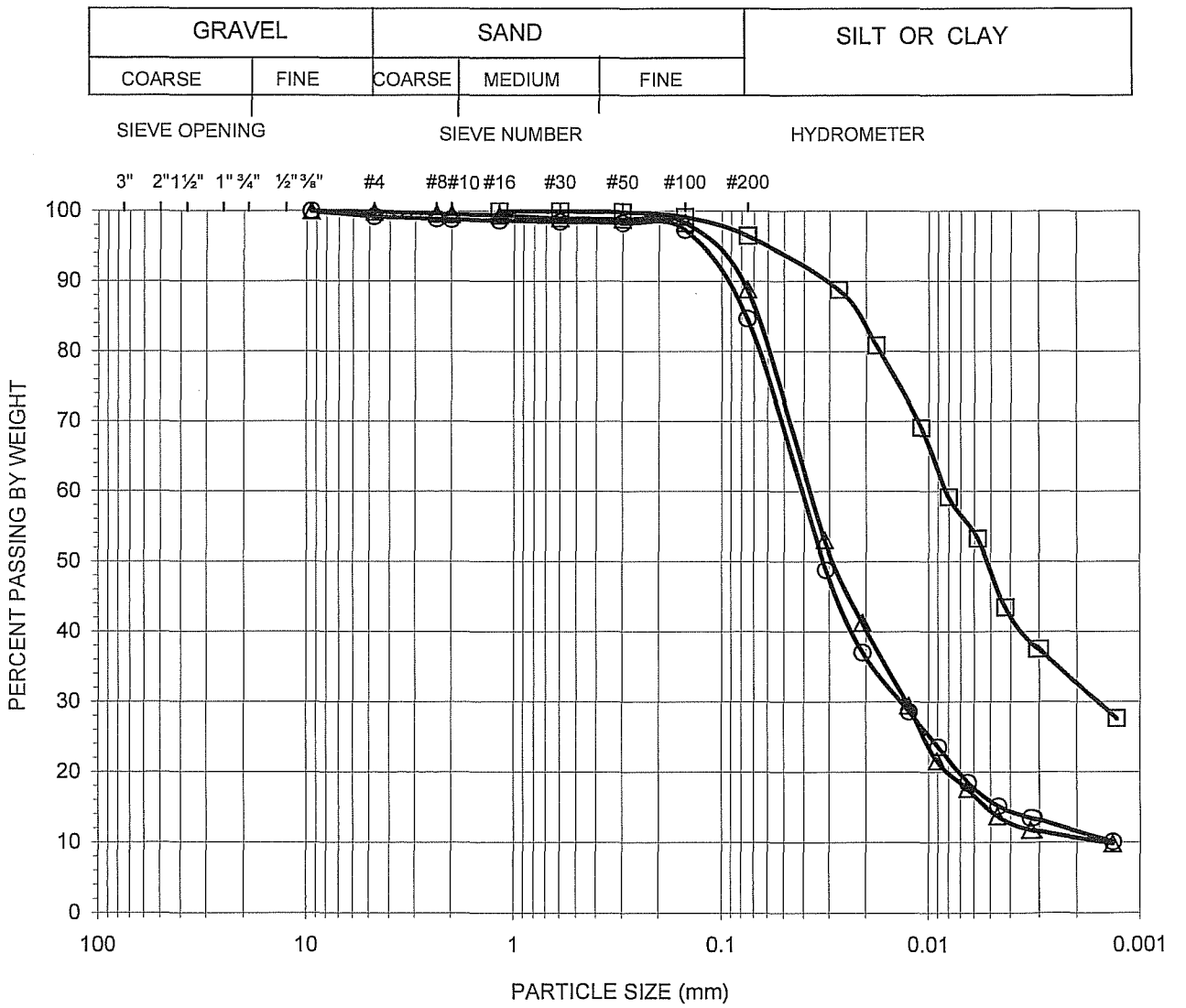
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-009	S-02	10	5.44
R-09-009	S-04	20	3.42
R-09-009	S-06	30	67.93
R-09-009	S-07	35	99.15
R-09-009	D-11	55	63.85

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

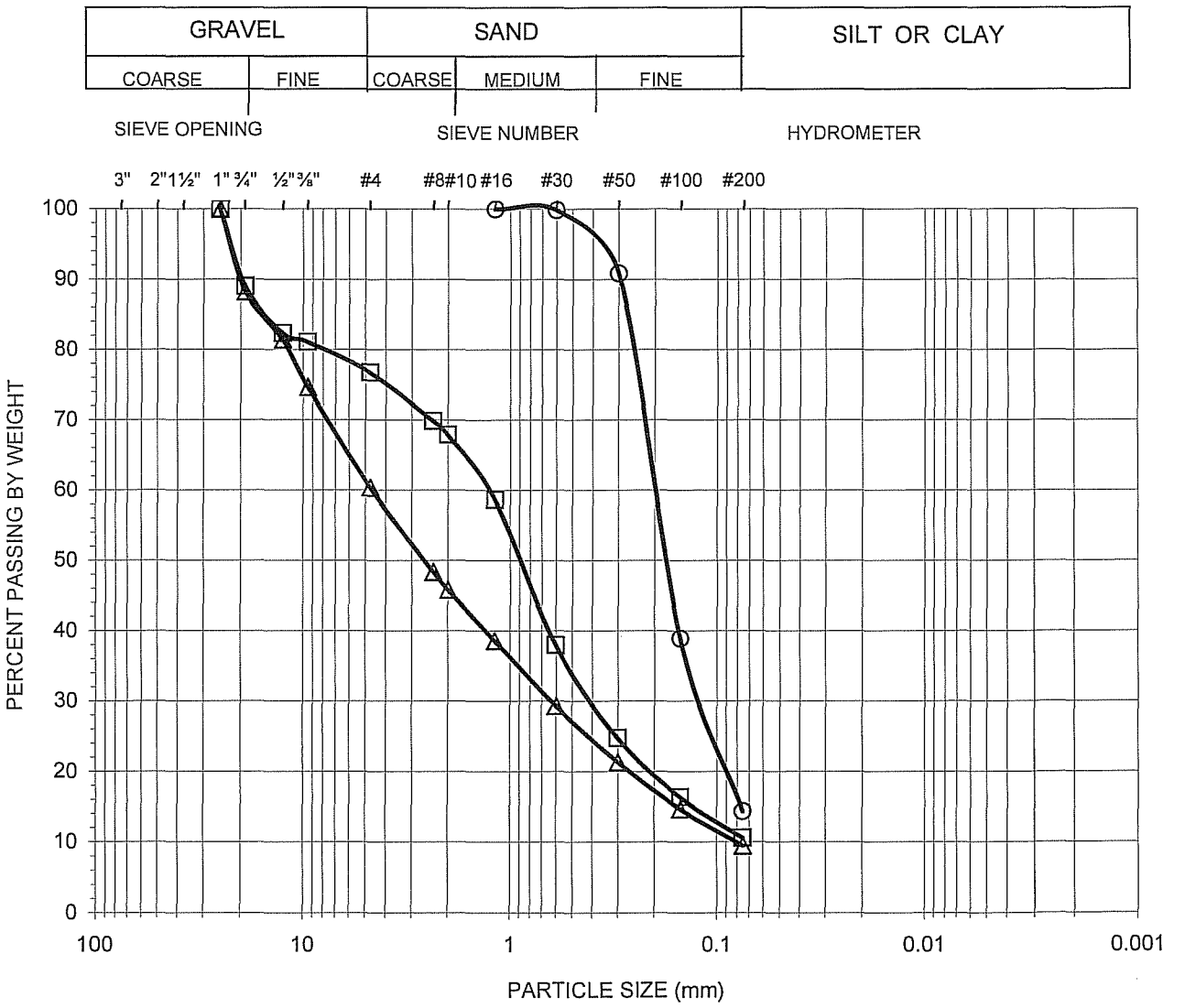


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-009	U-09	45	0.77	14.53	84.70	31:22:9	CL
□	R-09-009	S-10	50	0.00	3.55	96.45	49:27:22	CL
△	R-09-009	D-13	65	0.14	10.96	88.90	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

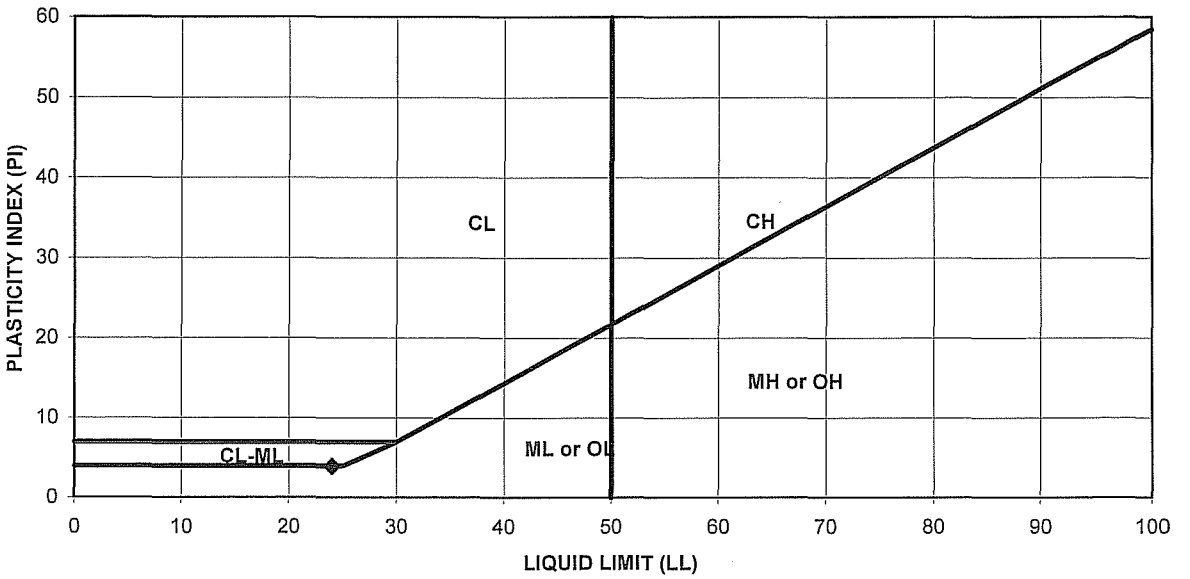


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-009	S-16	80	0.00	85.64	14.36	N/A	SM
□	R-09-009	S-19	110	23.28	66.13	10.59	N/A	SW-SM
△	R-09-009	S-22	140	39.61	50.88	9.51	N/A	SW-SM

AP Engineering & Testing, Inc.

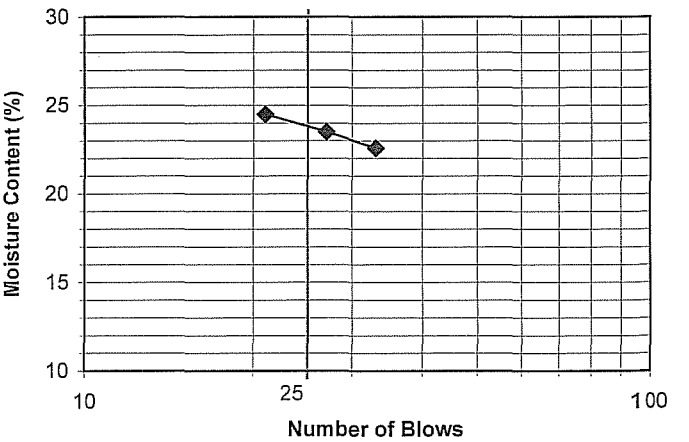
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Tested By: WJO
Checked By: AP
Date: 01/05/10
Date: 01/07/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test

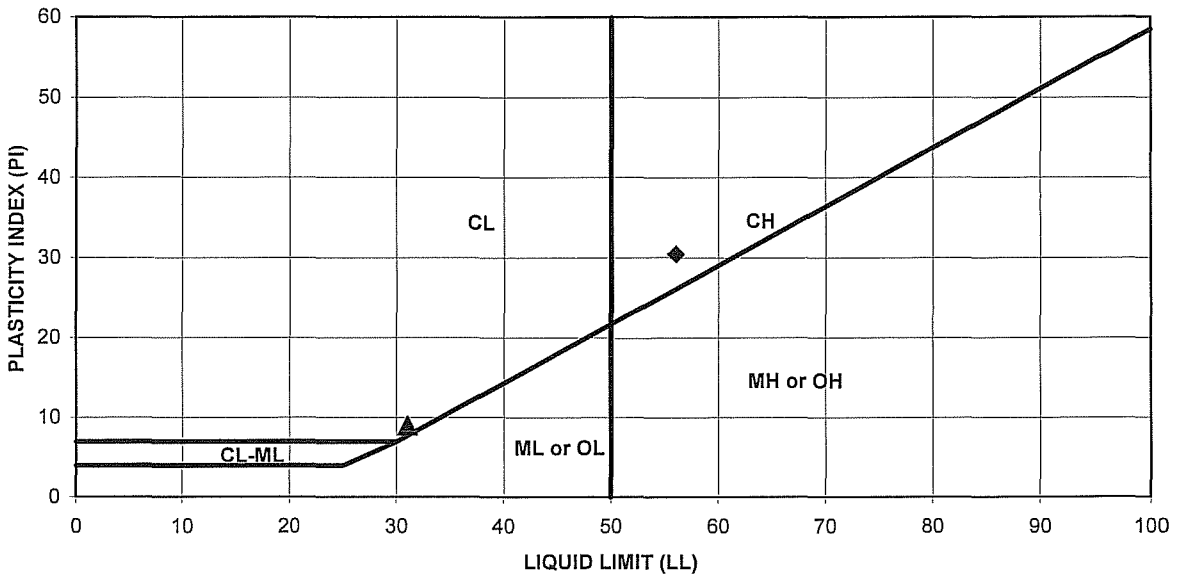


Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	S-06	30	24	20	4	CL-ML

AP Engineering & Testing, Inc.

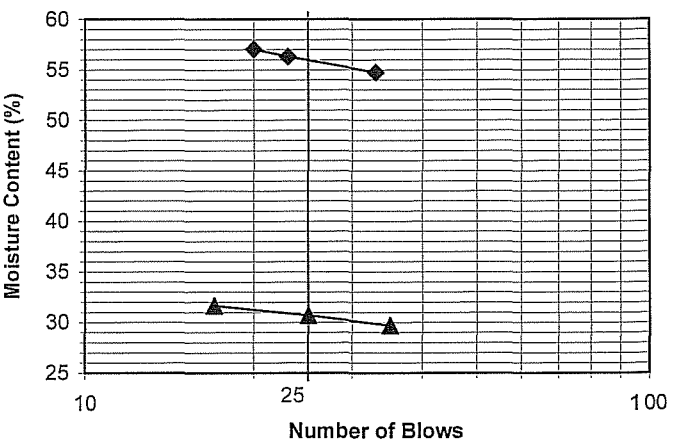
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Tested By: WJO
Checked By: AP
Date: 12/01/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	D-07	35	56	25	31	CH
▲	R-09-009	U-09	45	31	22	9	CL

* NP denotes "non-plastic"

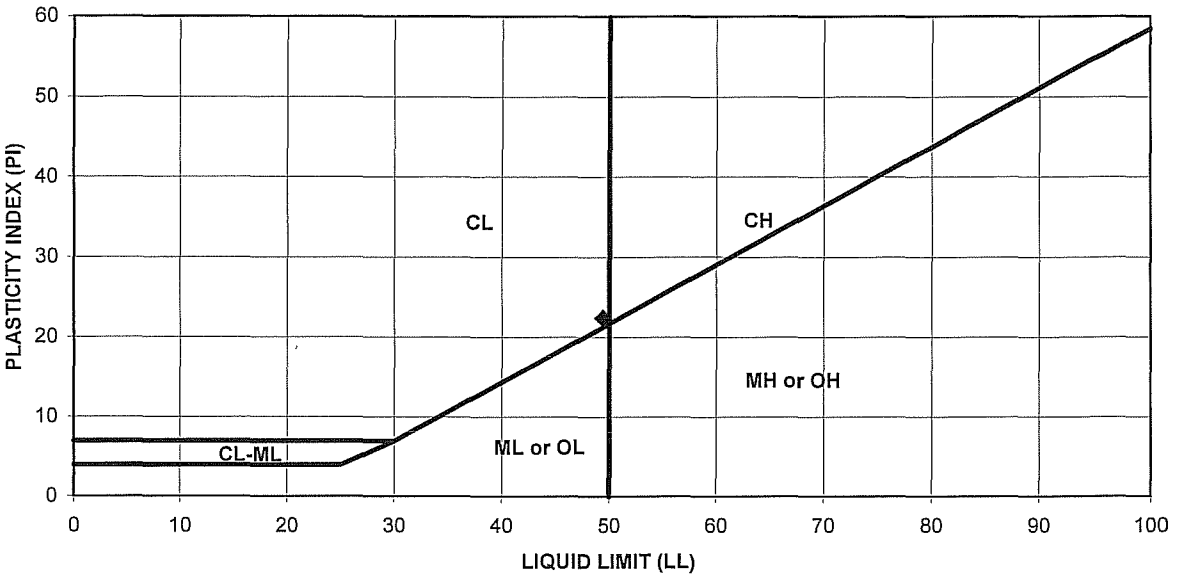
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

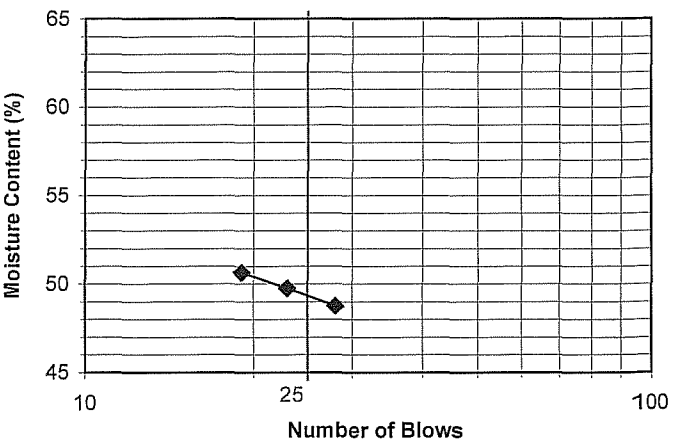
Tested By: WJO
Checked By: AP

Date: 12/01/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	S-10	50	49	27	22	CL
	R-09-009	D-13	65	NP	NP	NP	

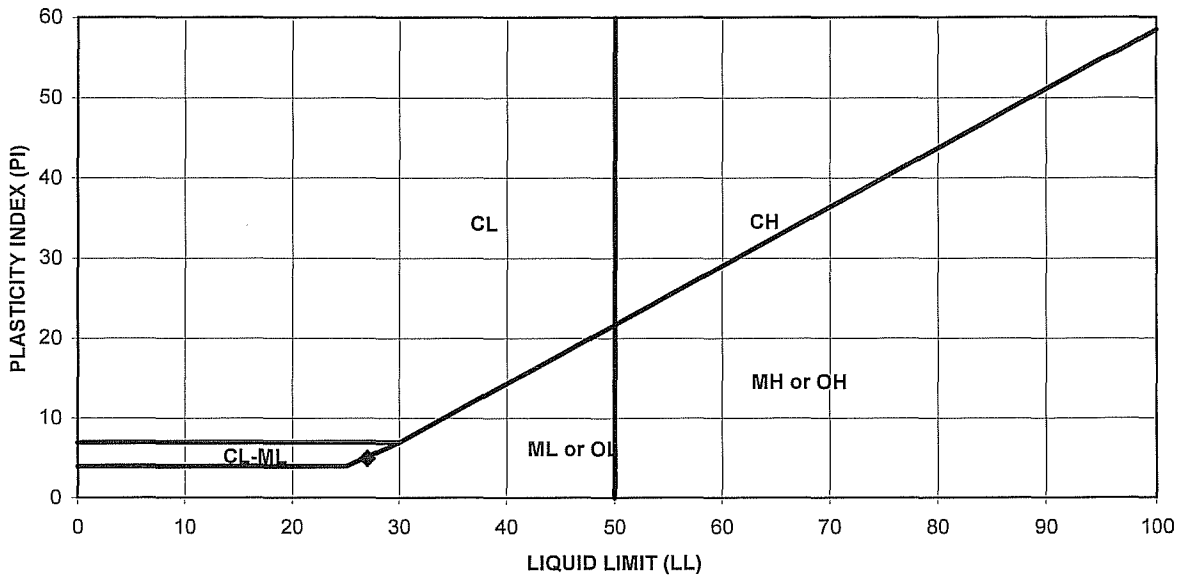
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

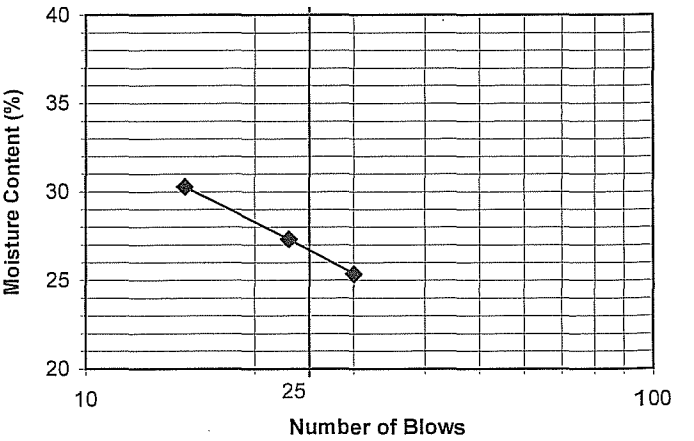
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 01/05/10
Checked By: AP Date: 01/07/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-009	D-11	55	27	22	5	ML

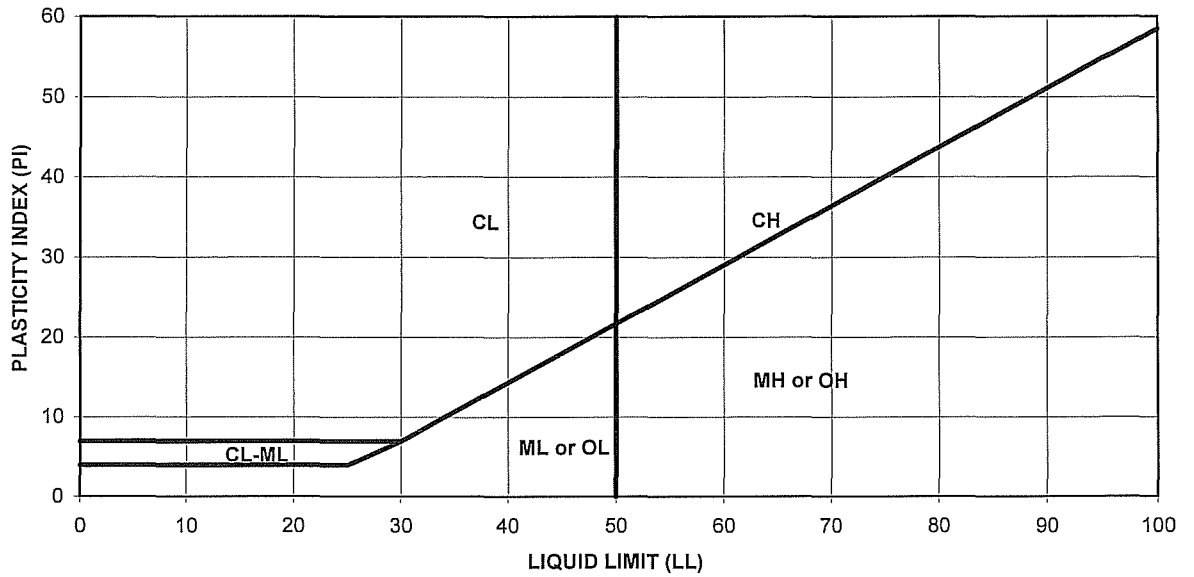
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

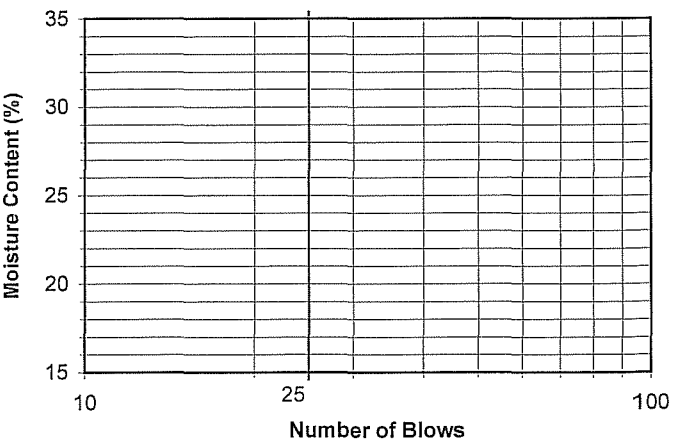
Tested By: WJO
Checked By: AP

Date: 12/01/09
Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-009	S-14	70	NP	NP	NP	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/30/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/11/09

Project No. : 06-123-03 Checked By: AP Date: 12/11/09

BORING NUMBER	R-09-009					
SAMPLE NUMBER	U-09					
DEPTH (FT)	45					
SOIL CLASSIFICATION	Lean Clay with sand					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	387.65					
TEMPERATURE, °C	20.3					
CORRECTION FACTOR	0.9999					
WT. DRY SOIL, g	40.91					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.68**					

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/30/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-009	S-02	10	SP-SM	2200	7.4	116	152

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 11/22/09

Boring No.: R-09-009 Checked By: AP Date: 12/11/09

Sample No.: D-01 Depth (ft): 5

Description: Olive Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	558.28
Total Ring Weight (g)	139.33
Wet Density (pcf)	116.14
Dry Density (pcf)	93.31

Moisture Determination	Before Test	After Test
Cont. Weight (g)	49.87	195.04
Wet Soil+Cont. (g)	172.46	600.12
Dry Soil+Cont. (g)	148.37	508.61
Moisture Content (%)	24.5	29.2
Degree Saturation	78.4	97.7

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

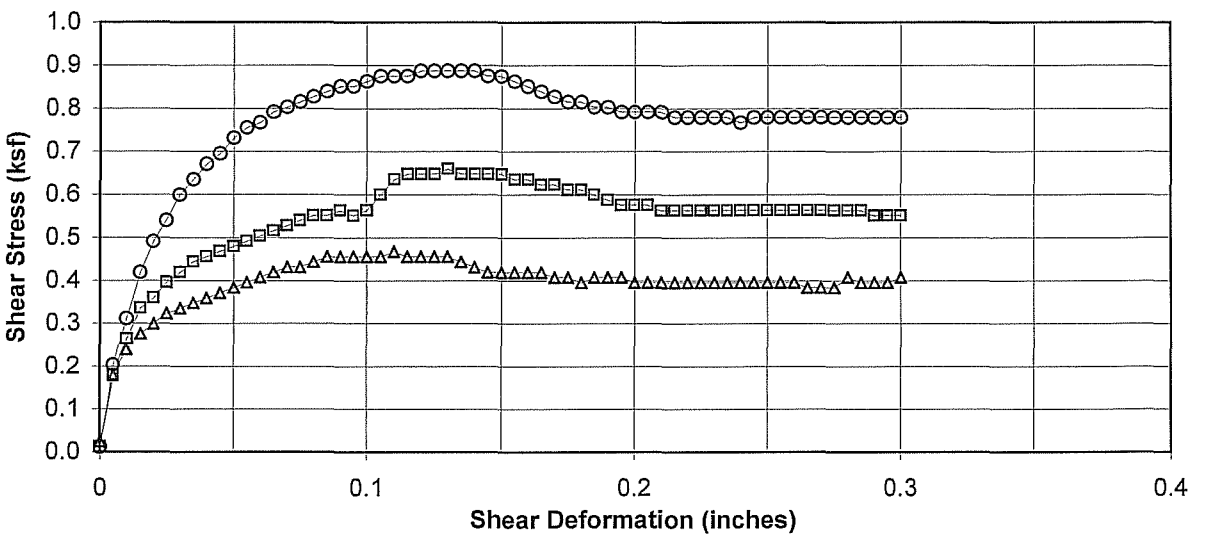
Shear Distance (in): **0.3**

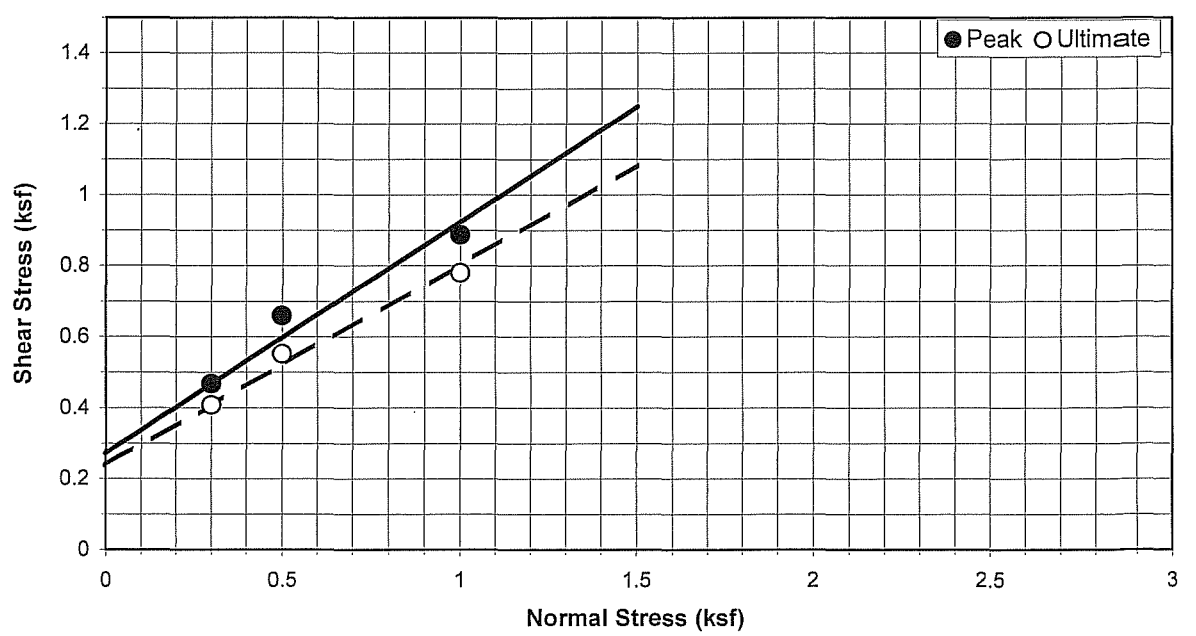
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**187.24**	**45.73**	**0.3**	**468**	**408**	
2	**185.57**	**46.01**	**0.5**	**660**	**552**	
3	**185.47**	**47.59**	**1.0**	**888**	**780**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.3	pcf
Boring No.:	R-09-009	Moisture Content (before):	24.5	%
Sample No.:	D-01	Moisture Content (after):	29.2	%
Depth (ft):	5			
Sample Type:	Cal. Mod.			
Soil Description:	Olive Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	250	250
Friction Angle:	33 °	29 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 11/22/09

Boring No.: R-09-009 Checked By: AP Date: 12/11/09

Sample No.: D-15 Depth (ft): 75

Description: Gray Poorly-Graded Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	590.70
Total Ring Weight (g)	130.88
Wet Density (pcf)	127.47
Dry Density (pcf)	104.77

Moisture Determination	Before Test	After Test
Cont. Weight (g)	49.48	191.28
Wet Soil+Cont. (g)	206.21	623.91
Dry Soil+Cont. (g)	178.30	540.24
Moisture Content (%)	21.7	24.0
Degree Saturation	90.7	103.2

METHOD OF SHEARING

[X] Regular Shearing

[ ] Residual Shearing 5 Passes

Shear Rate (in/min): **0.005**

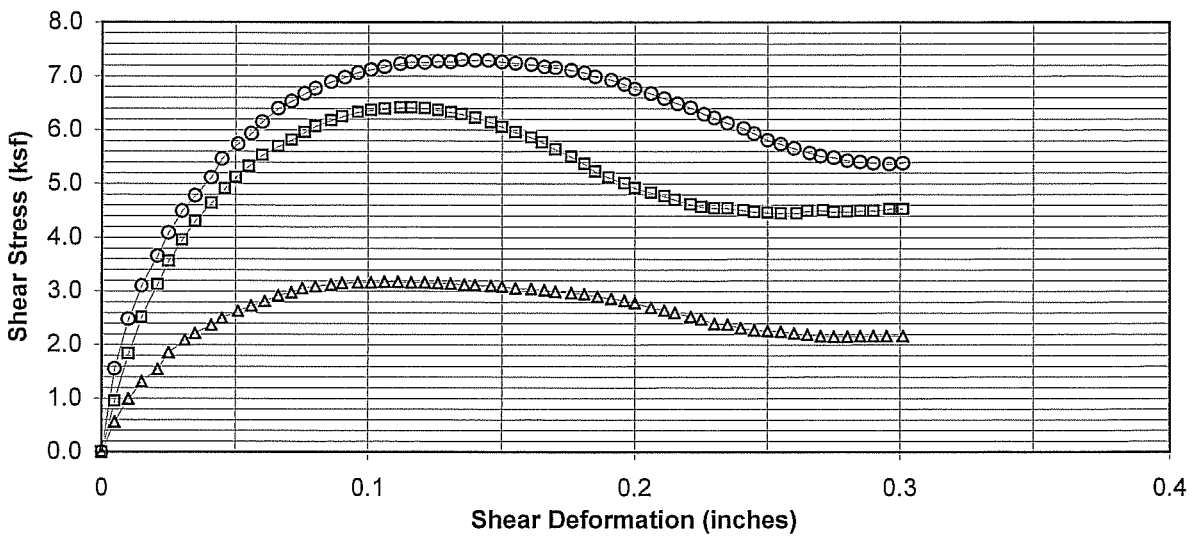
Shear Distance (in): **0.3**

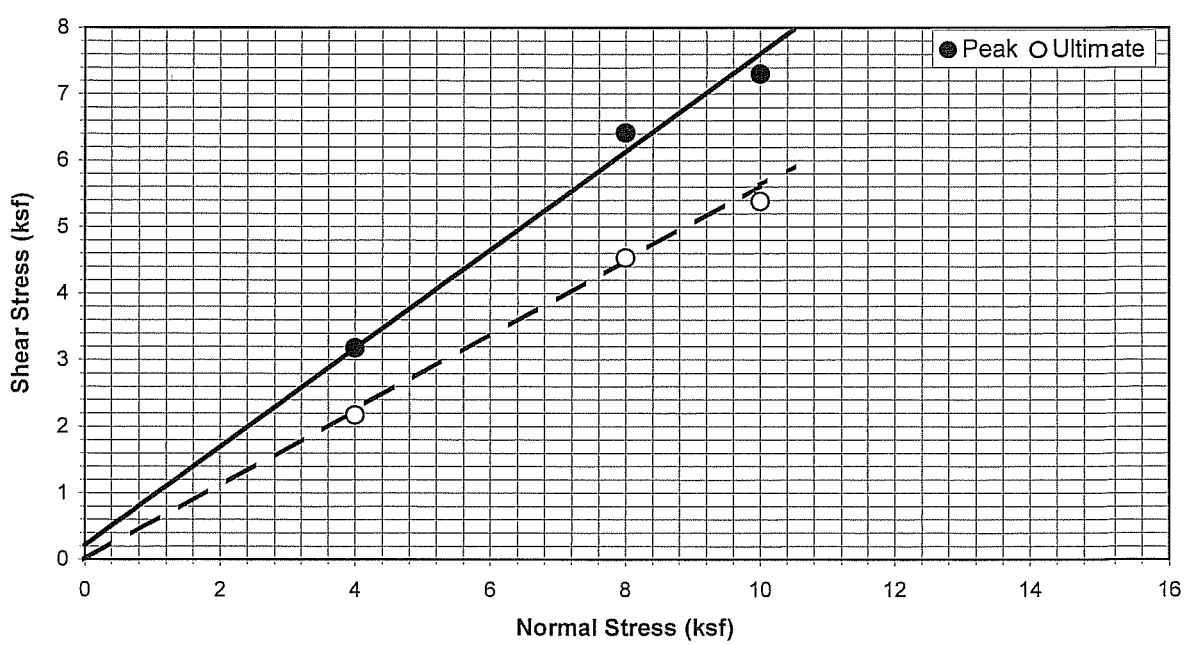
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**196.88**	**44.13**	**4.0**	**3180**	**2172**	
2	**196.90**	**43.86**	**8.0**	**6419**	**4536**	
3	**196.92**	**42.89**	**10.0**	**7307**	**5388**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	104.8	pcf
Boring No.:	R-09-009	Moisture Content (before):	21.7	%
Sample No.:	D-15	Moisture Content (after):	24.0	%
Depth (ft):	75			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	200	0
Friction Angle:	36 °	29 °

AP Engineering & Testing, Inc.

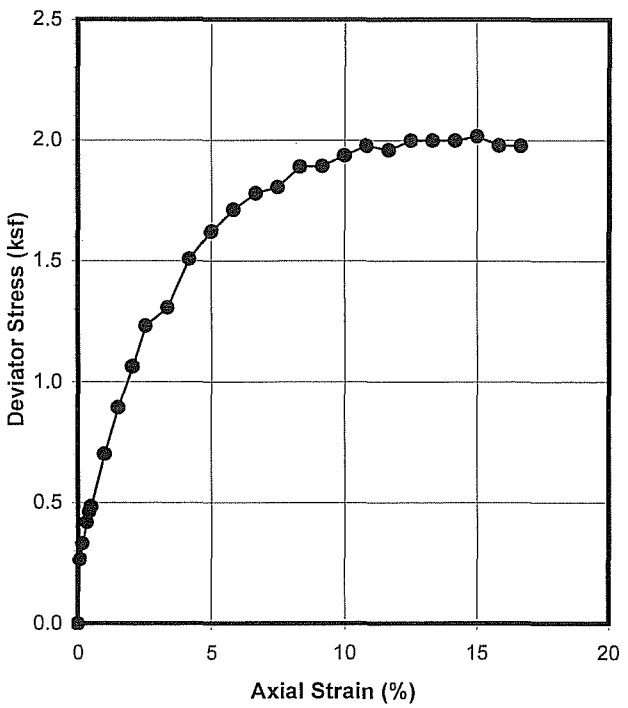
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/20/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/12/09
Project No.:	06-123-03				
Boring No.:	R-09-009				
Sample No.:	U-09	Depth (feet): 45			
Soil Description	Gray Lean Clay w/sand and shell fragments		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	118.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	89.1
Sample Weight (gms):	1216.40	Moisture Content (%):	33.5
Wt. Wet Soil+Container(gms)	1327.82	Void Ratio for Gs=2.7:	0.89
Wt. Dry Soil+Container(gms)	1020.96	% Saturation:	101.4
Wt. Container (gms)	104.89		

TEST DATA

Cell Pressure (ksf):	1.73
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.73
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	2.0
Ultimate Deviator Stress (ksf):	2.0
Ultimate Undrained Shear Strength (ksf):	1.0
Axial Strain @ Maximum Stress (%)	15.00



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
15	0.010	6.50	0.33	0.17
19	0.020	6.51	0.42	0.33
21	0.025	6.52	0.46	0.42
22	0.030	6.52	0.49	0.50
32	0.060	6.56	0.70	1.00
41	0.090	6.59	0.90	1.50
49	0.120	6.62	1.07	2.00
57	0.150	6.66	1.23	2.50
61	0.200	6.72	1.31	3.33
71	0.250	6.77	1.51	4.17
77	0.300	6.83	1.62	5.00
82	0.350	6.89	1.71	5.83
86	0.400	6.96	1.78	6.67
88	0.450	7.02	1.81	7.50
93	0.500	7.08	1.89	8.33
94	0.550	7.15	1.89	9.17
97	0.600	7.21	1.94	10.00
100	0.650	7.28	1.98	10.83
100	0.700	7.35	1.96	11.67
103	0.750	7.42	2.00	12.50
104	0.800	7.49	2.00	13.33
105	0.850	7.56	2.00	14.17
107	0.900	7.64	2.02	15.00
106	0.950	7.71	1.98	15.83
107	1.000	7.79	1.98	16.67

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/01/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-011	D-02	10	27.2	91.4
R-09-011	D-04	20	26.6	97.2
R-09-011	S-07	35	39.1	NA
R-09-011	D-08	40	35.1	87.9
R-09-011	D-10	50	39.8	78.5
R-09-011	S-11	55	38.8	NA
R-09-011	S-13	65	32.2	NA
R-09-011	S-15	75	21.8	NA
R-09-011	D-16	80	28.9	97.1
R-09-011	S-19	110	22.1	NA
R-09-011	S-23	150	18.7	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/20/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-011	D-10	50	0.50
R-09-011	U-14	70	3.25

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	12/04/09
Project Number:	06-123-03		

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-011	D-02	10	6.60
R-09-011	D-04	20	4.17
R-09-011	U-06	30	23.02

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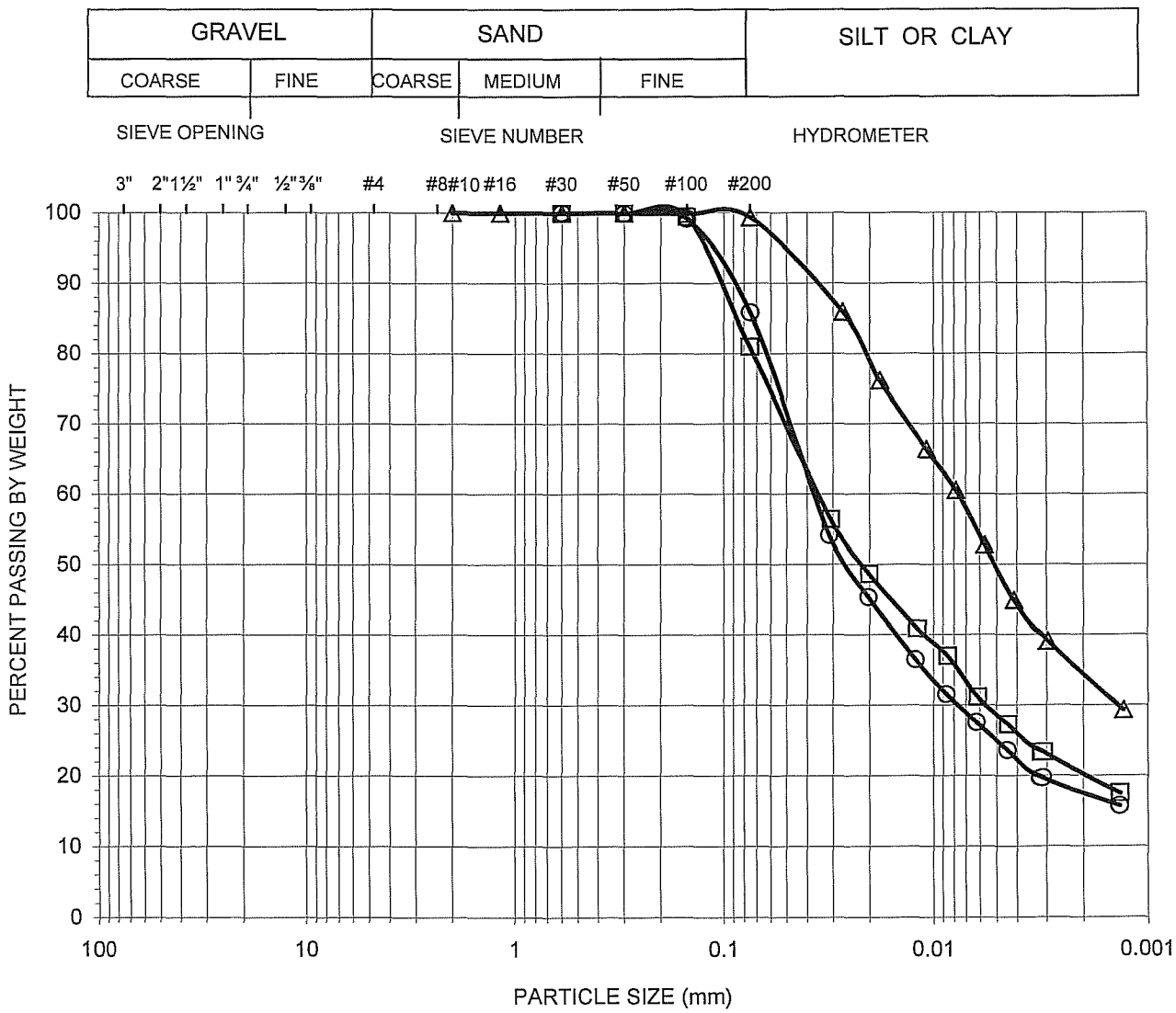
GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

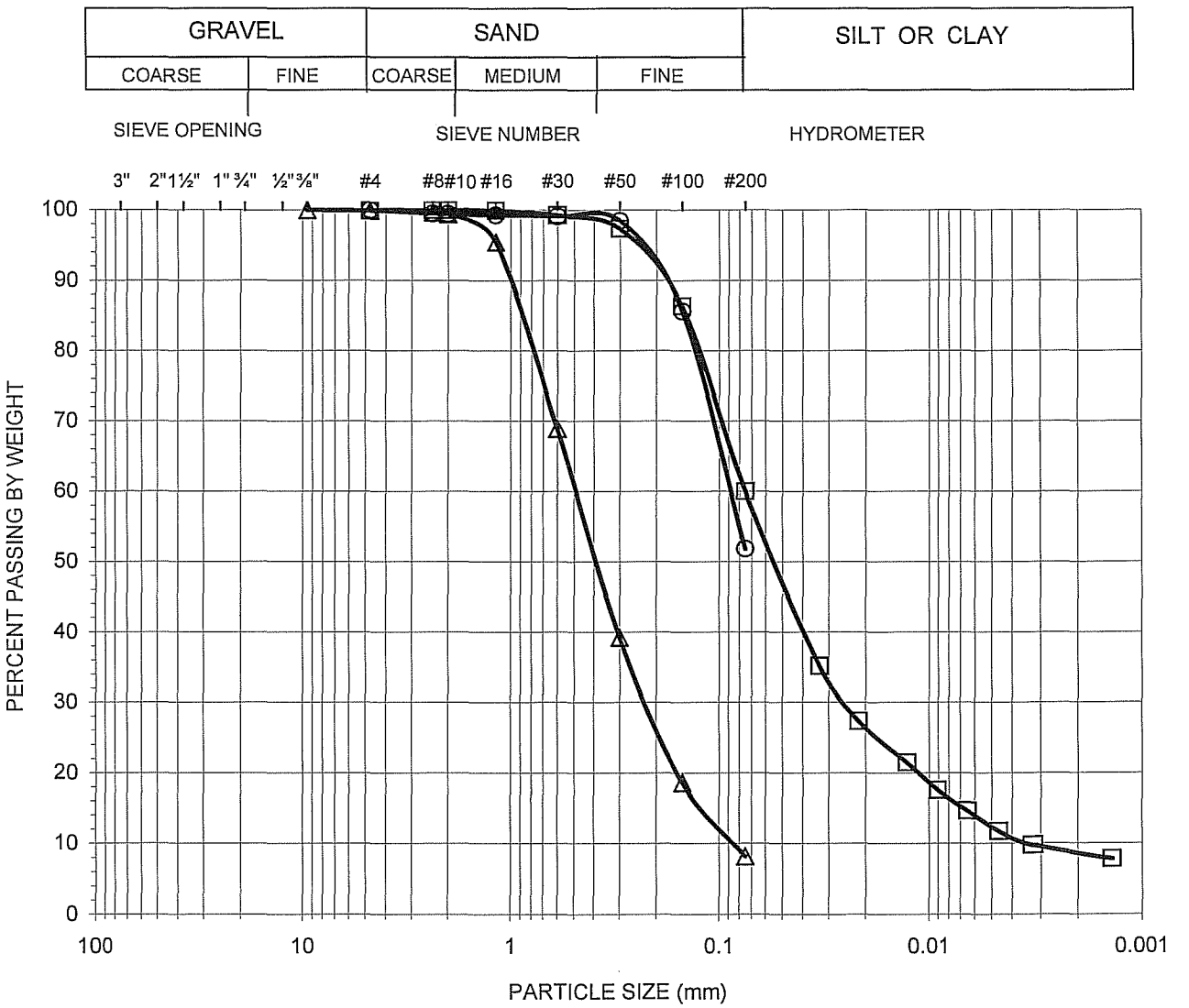


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-07	35	0.00	14.12	85.88	29:23:6	CL-ML
□	R-09-011	D-08	40	0.00	19.09	80.91	29:22:7	CL-ML
△	R-09-011	D-10	50	0.00	0.65	99.35	51:23:28	CH

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09

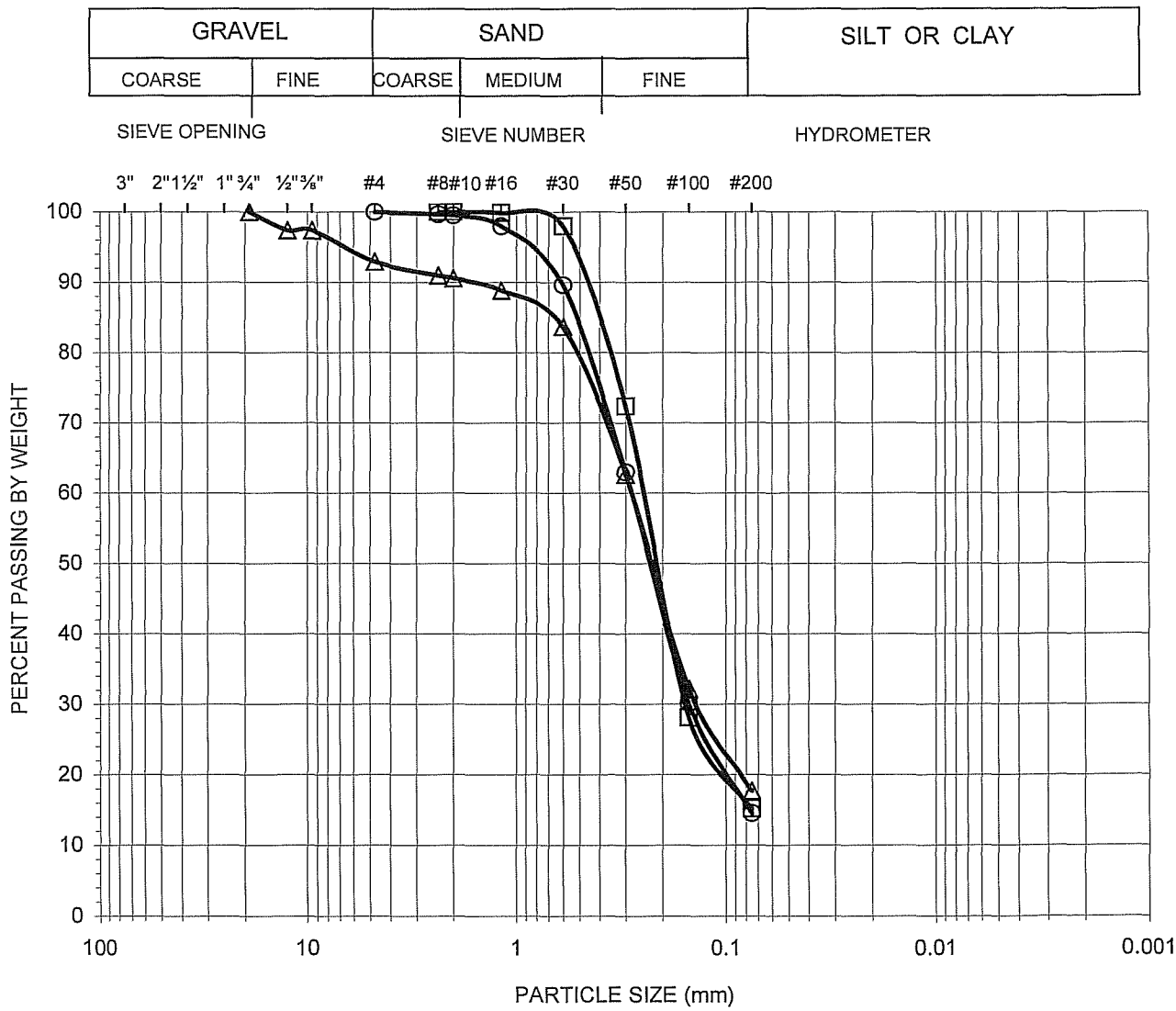


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	D-12	60	0.00	48.16	51.84	N/A	ML
□	R-09-011	U-14	70	0.00	40.02	59.98	N/P	ML
△	R-09-011	S-15	75	0.07	91.69	8.24	N/A	SP-SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	DK	Date:	12/08/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/11/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/12/09



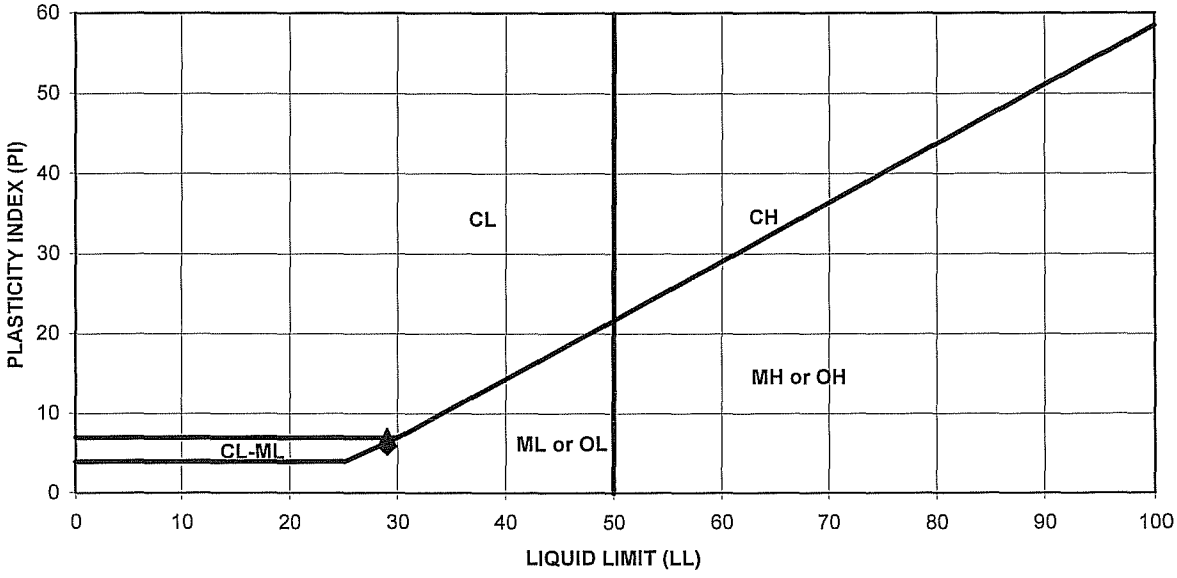
Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-011	S-17	90	0.00	85.42	14.58	N/A	SM
□	R-09-011	S-19	110	0.00	84.84	15.16	N/A	SM
△	R-09-011	S-23	150	7.02	75.27	17.71	N/A	SM

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

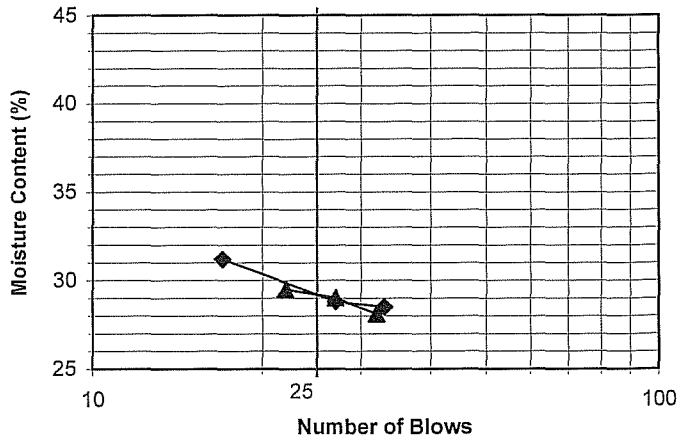
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 11/24/09
Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



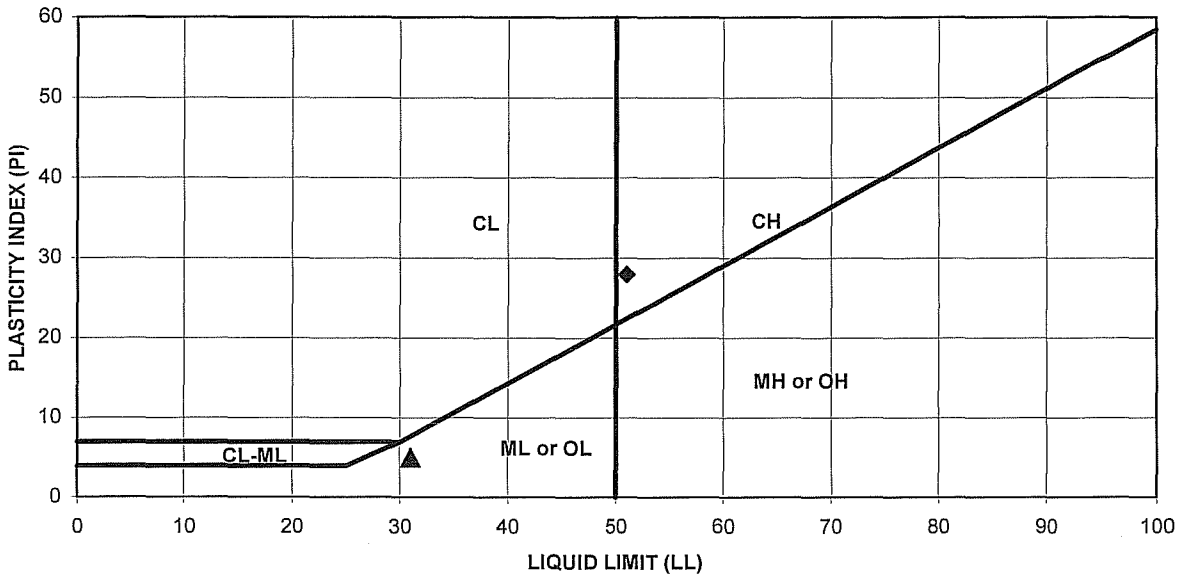
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-011	S-07	35	29	23	6	CL-ML
▲	R-09-011	D-08	40	29	22	7	CL-ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

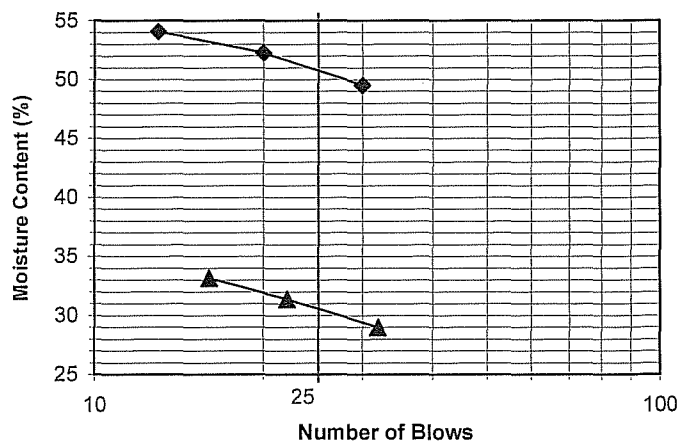
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



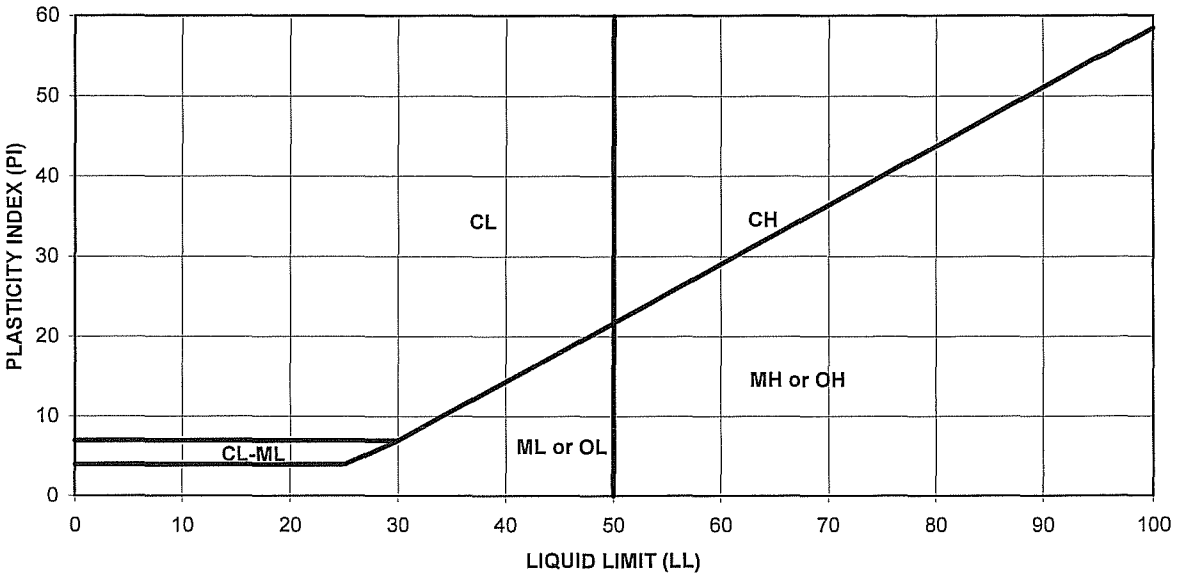
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-011	D-10	50	51	23	28	CH
▲	R-09-011	S-11	55	31	26	5	ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

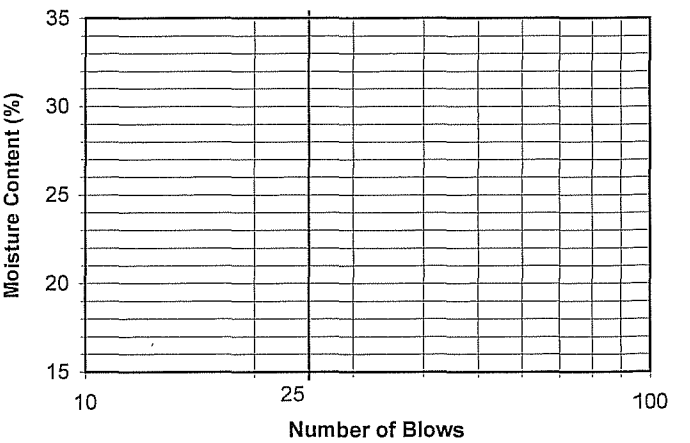
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/12/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-011	S-13	65	NP	NP	NP	
	R-09-011	U-14	70	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/30/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-011	S-03	15	SP-SM	200	7.5	514	568

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/11/09

Project No. : 06-123-03 Checked By: AP Date: 12/11/09

BORING NUMBER	R-09-011					
SAMPLE NUMBER	U-14					
DEPTH (FT)	70					
SOIL CLASSIFICATION	Sandy Silt					
METHOD (A OR B)	B					
FLASK NUMBER	2					
WT. FLASK+WATER+SOIL, g	368.25					
TEMPERATURE, °C	19.8					
CORRECTION FACTOR	1.0000					
WT. DRY SOIL, g	46.78					
WT. FLASK + WATER, g	249.30					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.69**					

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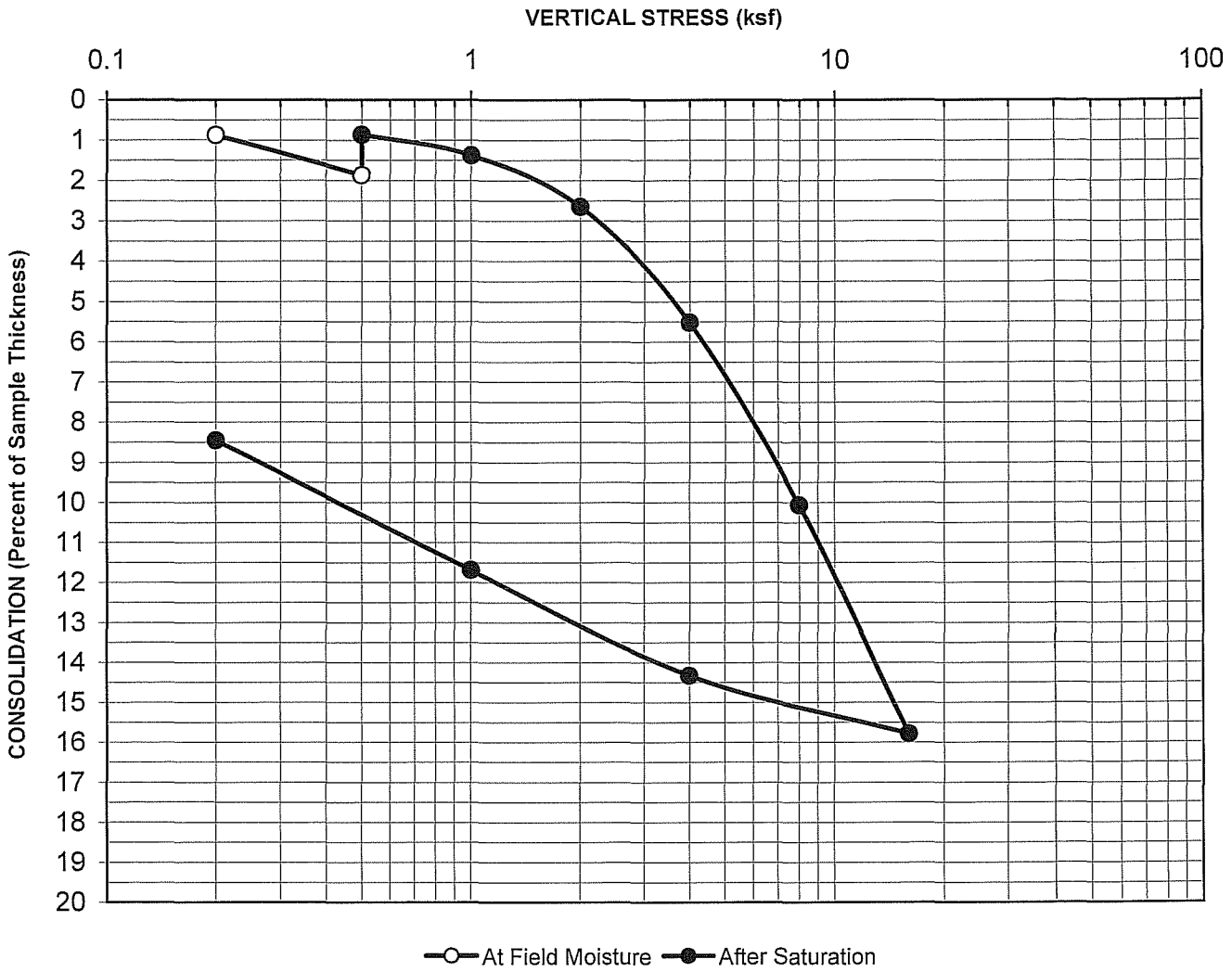
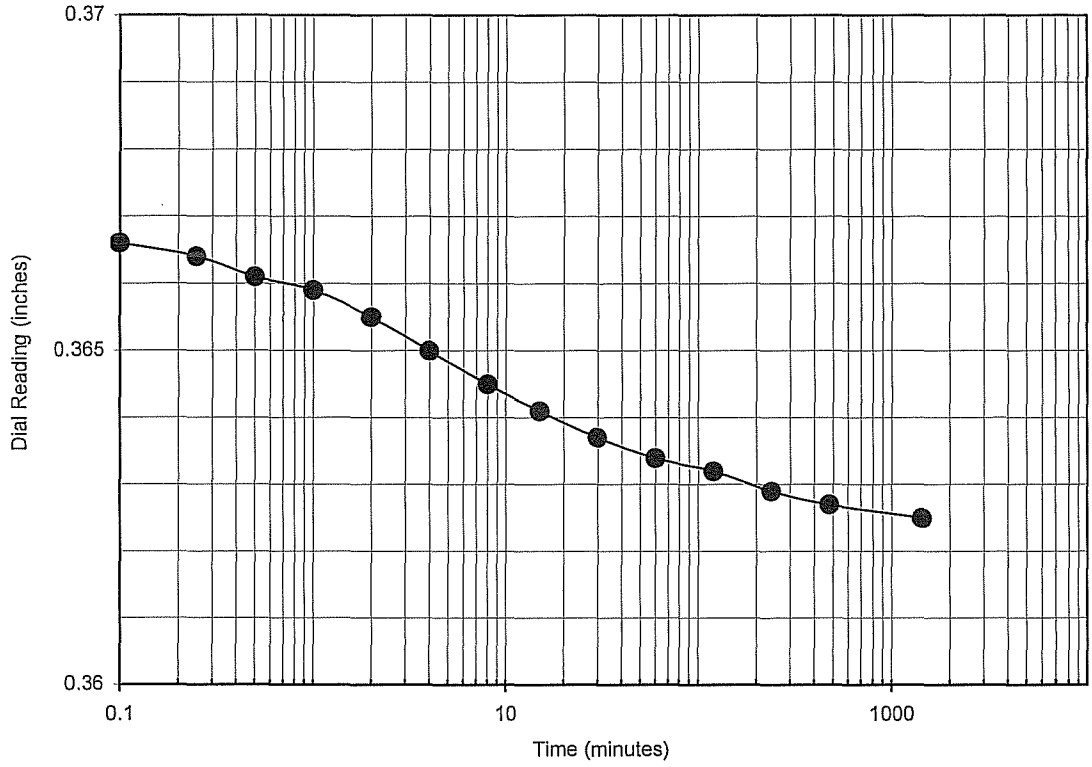


Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	77.3
Sample No.:	D-10	Initial Moisture Content (%):	39.8
Depth (feet):	50	Final Moisture Content (%):	39.1
Sample Type:	Mod. Cal.	Assumed Specific Gravity:	2.7
Soil Description:	Fat Clay	Initial Void Ratio:	1.18
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

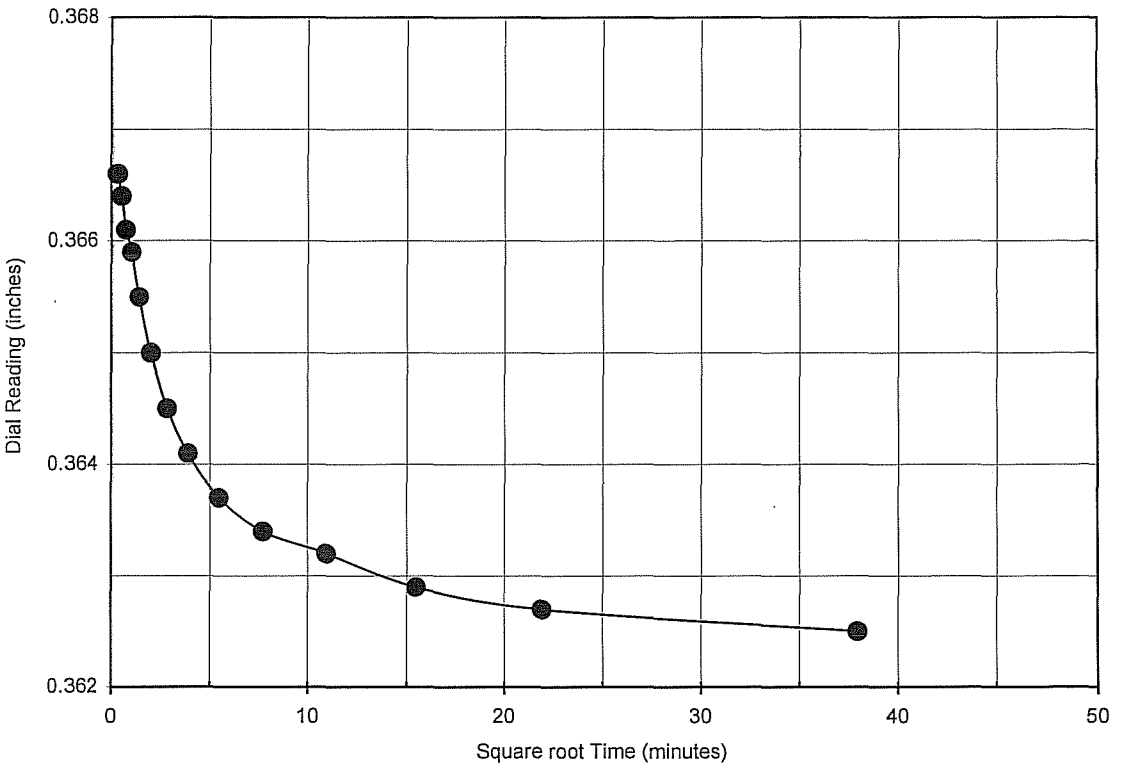


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3666
0.25	0.3664
0.5	0.3661
1	0.3659
2	0.3655
4	0.365
8	0.3645
15	0.3641
30	0.3637
60	0.3634
120	0.3632
240	0.3629
480	0.3627
1440	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

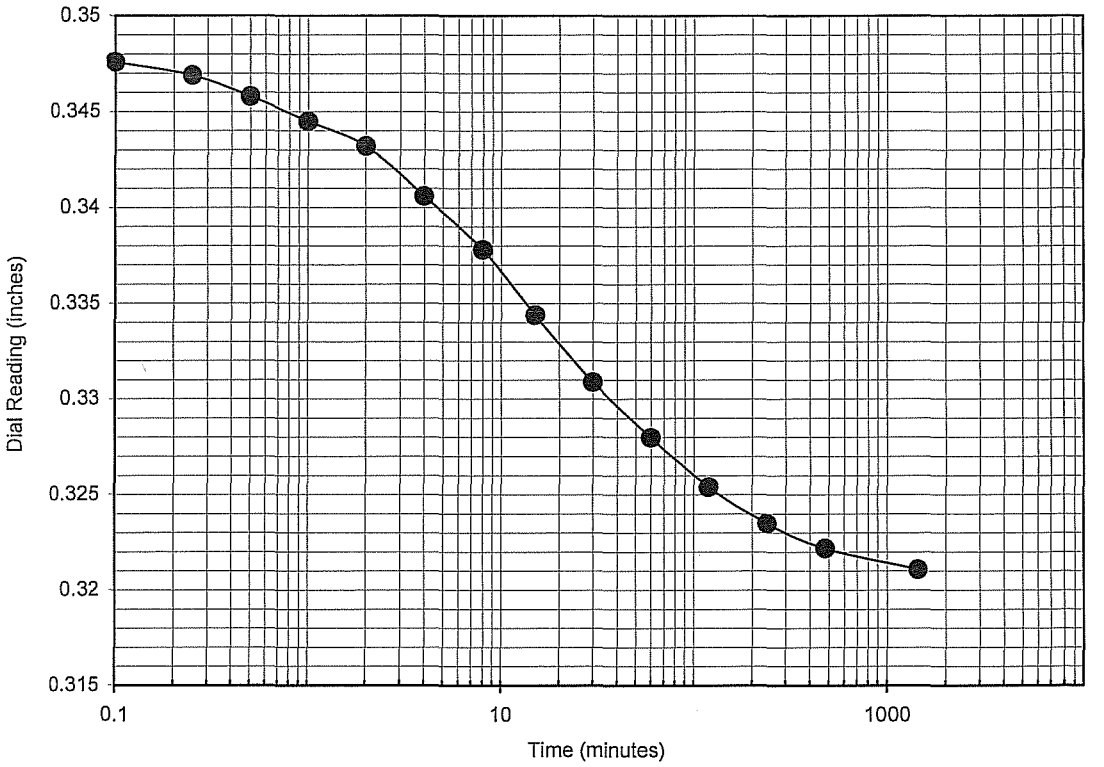


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3666
0.5000	0.3664
0.7071	0.3661
1.0000	0.3659
1.4142	0.3655
2.0000	0.3650
2.8284	0.3645
3.8730	0.3641
5.4772	0.3637
7.7460	0.3634
10.9545	0.3632
15.4919	0.3629
21.9089	0.3627
37.9473	0.3625

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

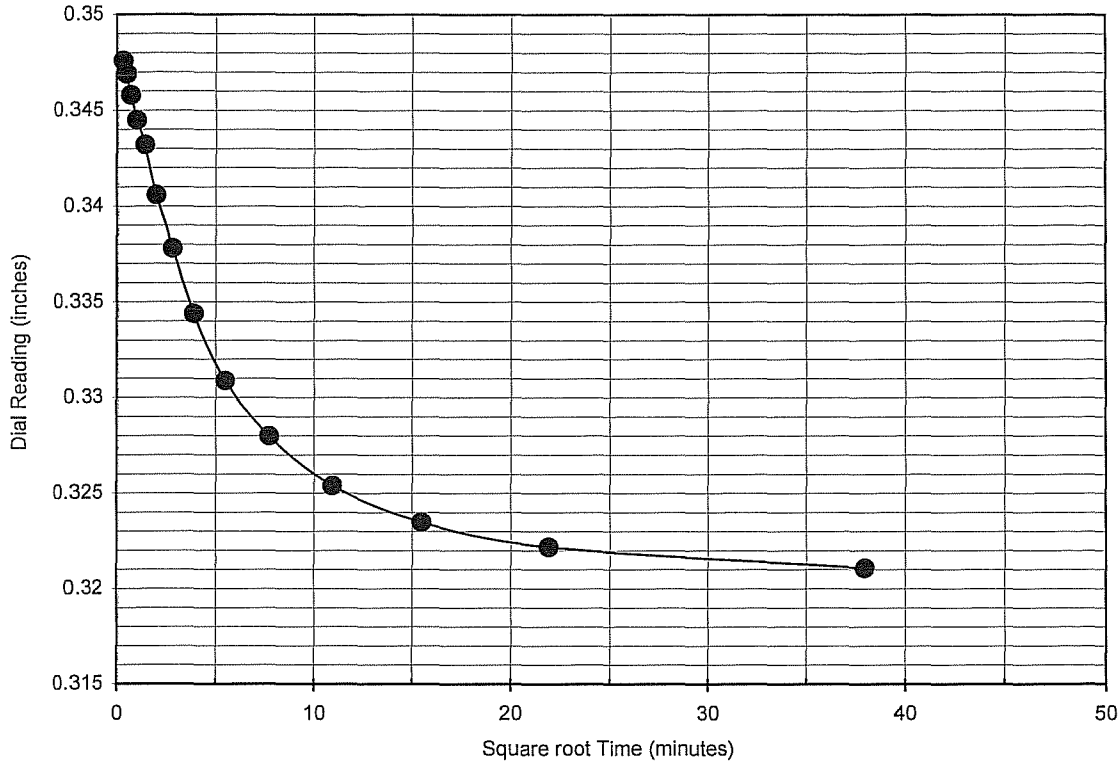


Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3476
0.25	0.3469
0.5	0.3458
1	0.3445
2	0.3432
4	0.3406
8	0.3378
15	0.3344
30	0.3309
60	0.328
120	0.3254
240	0.3235
480	0.3222
1440	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Mod. Cal.
Sample No.:	D-10	Soil Description:	Fat Clay
Depth (feet):	50	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3476
0.5000	0.3469
0.7071	0.3458
1.0000	0.3445
1.4142	0.3432
2.0000	0.3406
2.8284	0.3378
3.8730	0.3344
5.4772	0.3309
7.7460	0.3280
10.9545	0.3254
15.4919	0.3235
21.9089	0.3222
37.9473	0.3211

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/01/09

Boring No.: R-09-011 Checked By: AP Date: 12/11/09

Sample No.: D-02 Depth (ft): 10

Description: Gray Poorly-Graded Sand w/ silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	554.38
Total Ring Weight (g)	126.64
Wet Density (pcf)	118.57
Dry Density (pcf)	93.24

Moisture Determination	Before Test	After Test
Cont. Weight (g)	194.13	104.46
Wet Soil+Cont. (g)	478.24	511.68
Dry Soil+Cont. (g)	417.54	416.03
Moisture Content (%)	27.2	30.7
Degree Saturation	87.0	100.3

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

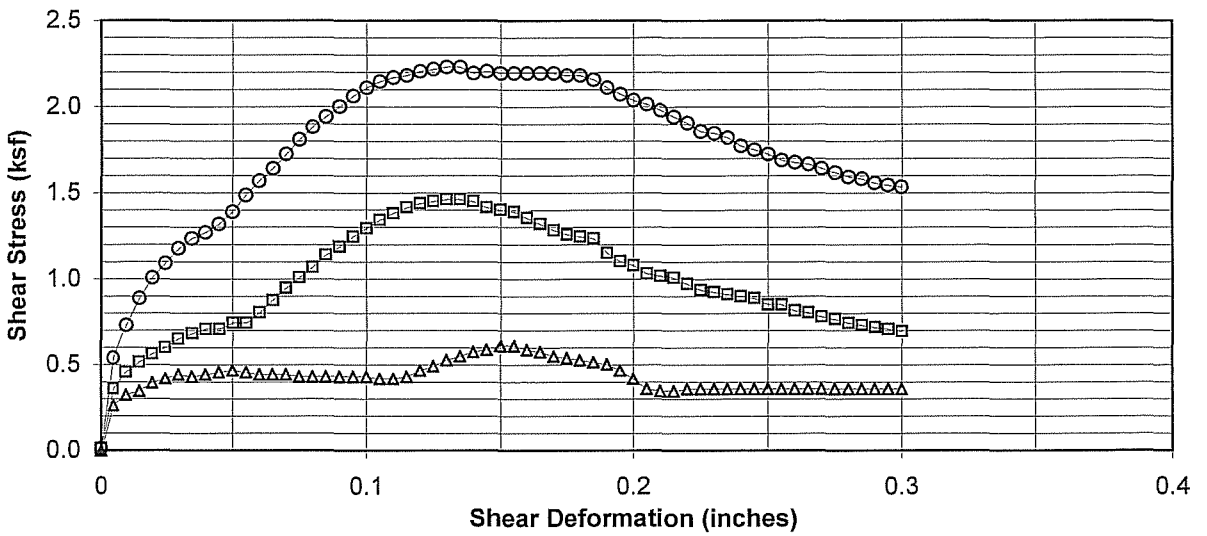
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

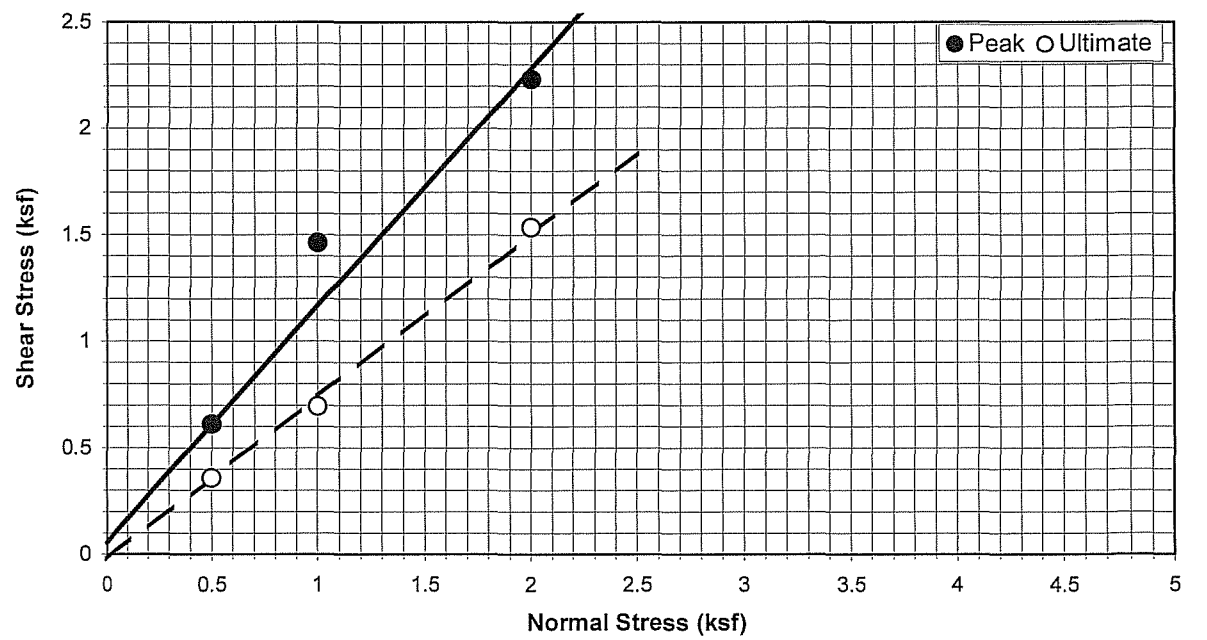
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**187.49**	**42.13**	**0.5**	**612**	**360**	
2	**184.75**	**42.70**	**1.0**	**1464**	**696**	
3	**182.14**	**41.81**	**2.0**	**2232**	**1536**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	93.2	pcf
Boring No.:	R-09-011	Moisture Content (before):	27.2	%
Sample No.:	D-02	Moisture Content (after):	30.7	%
Depth (ft):	10			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/ silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	48 °	37 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: KM Date: 12/01/09

Boring No.: R-09-011 Checked By: AP Date: 12/11/09

Sample No.: D-12 Depth (ft): 60

Description: Gray Sandy Silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	586.40
Total Ring Weight (g)	131.26
Wet Density (pcf)	126.17
Dry Density (pcf)	97.30

Moisture Determination	Before Test	After Test
Cont. Weight (g)	198.19	104.12
Wet Soil+Cont. (g)	480.64	542.99
Dry Soil+Cont. (g)	416.01	448.93
Moisture Content (%)	29.7	27.3
Degree Saturation	104.3	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

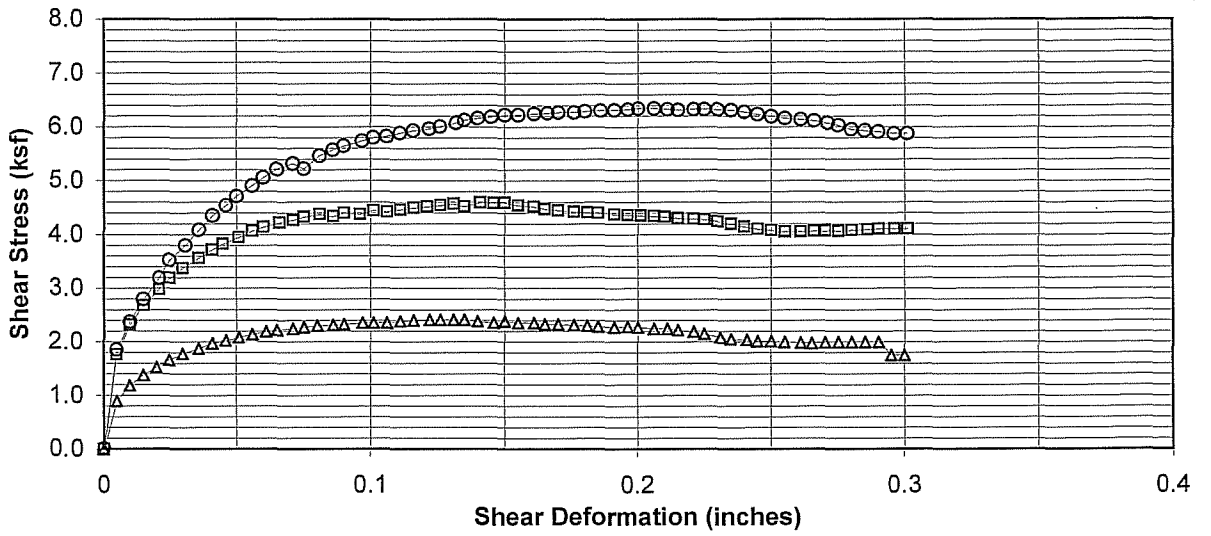
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

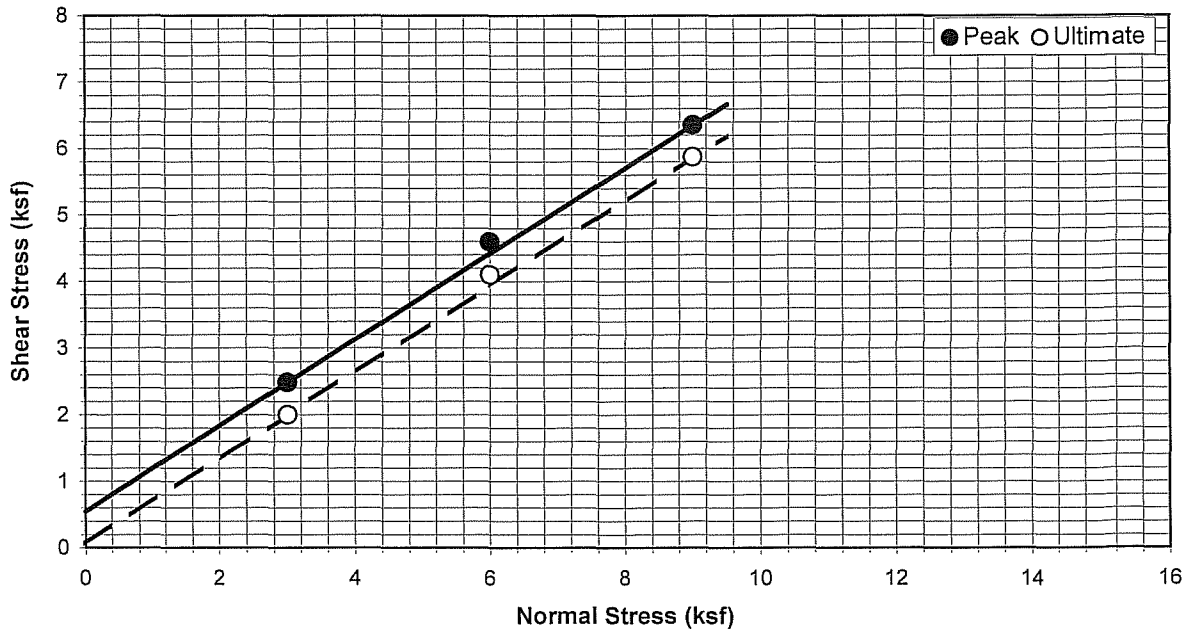
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**197.56**	**43.02**	**3.0**	**2487**	**2003**	
2	**196.67**	**44.97**	**6.0**	**4596**	**4104**	
3	**192.17**	**43.27**	**9.0**	**6359**	**5879**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

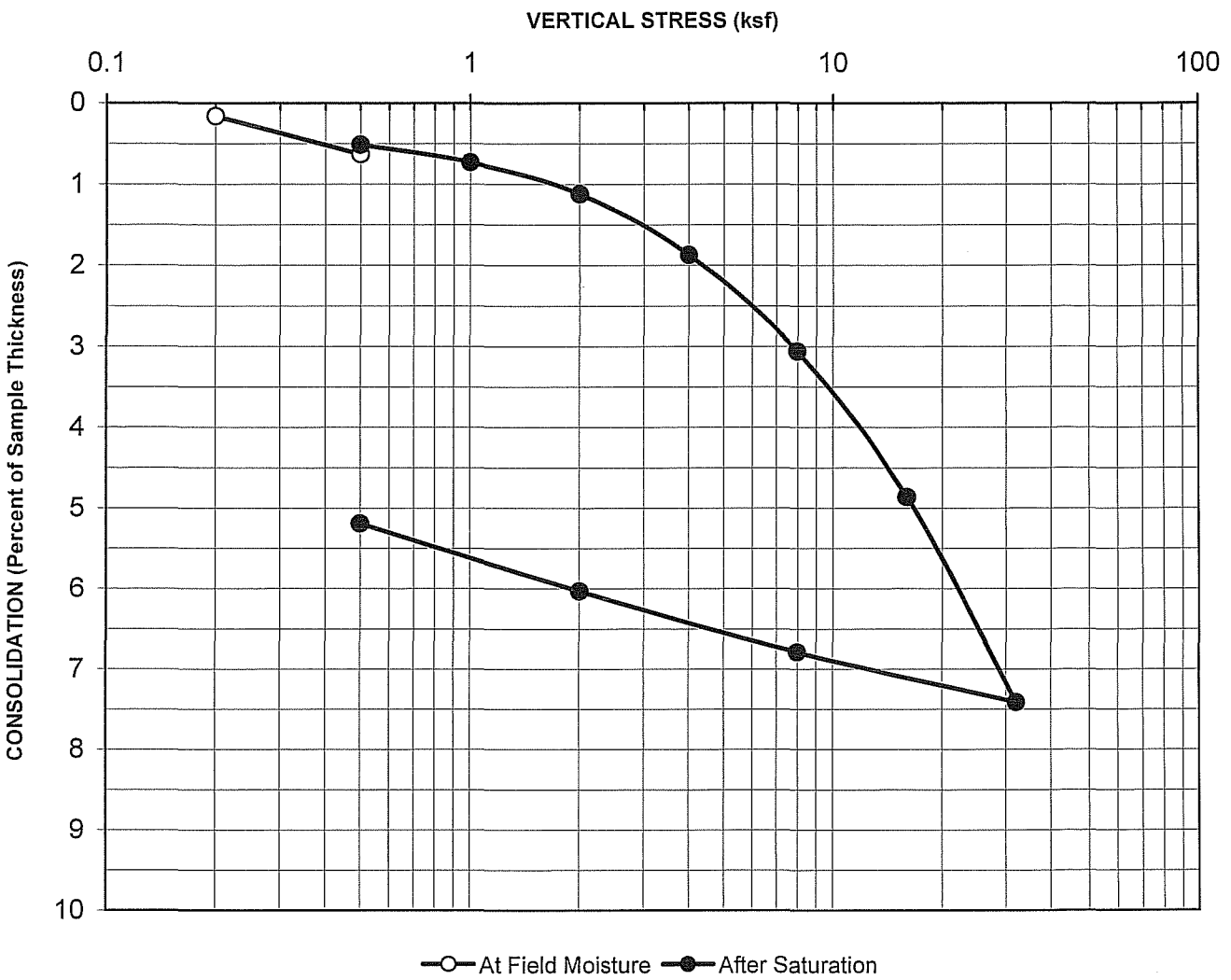
Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	97.3	pcf
Boring No.:	R-09-011	Moisture Content (before):	29.7	%
Sample No.:	D-12	Moisture Content (after):	27.3	%
Depth (ft):	60			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Sandy Silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	550	50
Friction Angle:	33 °	33 °

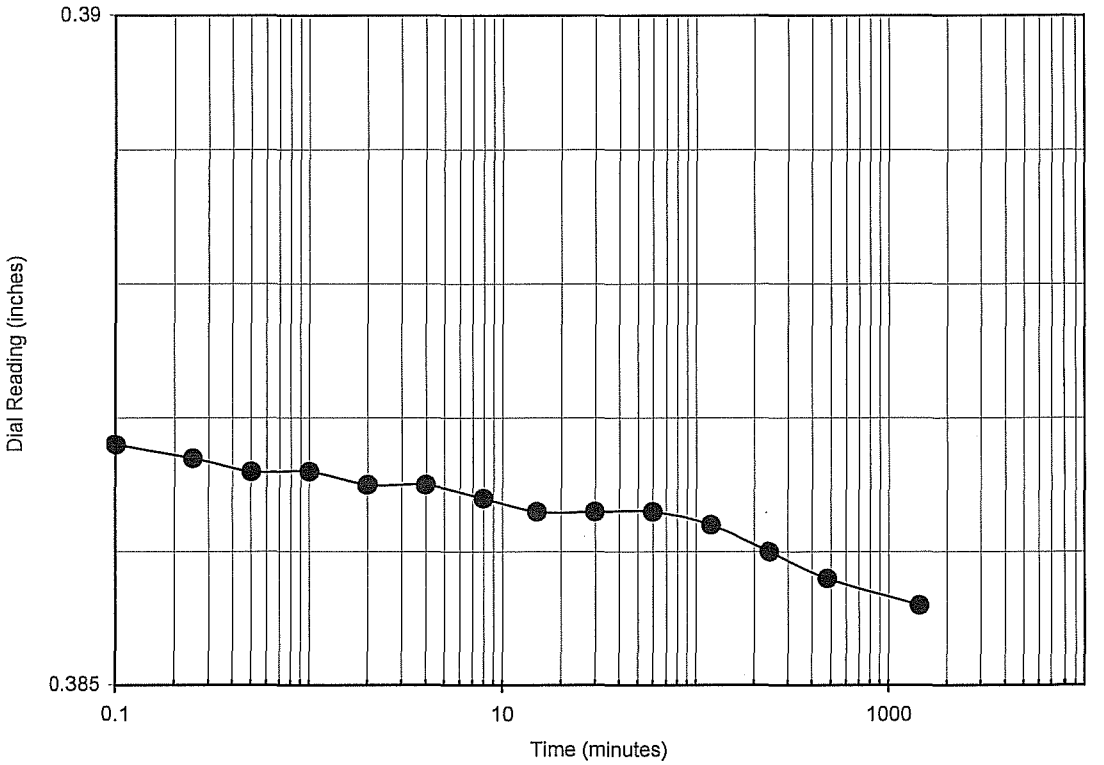
AP Engineering & Testing, Inc.



Boring No. :	R-09-011	Initial Dry Unit Weight (pcf):	104.2
Sample No.:	U-14	Initial Moisture Content (%):	22.0
Depth (feet):	70	Final Moisture Content (%):	20.4
Sample Type:	Shelby	Assumed Specific Gravity:	2.7
Soil Description:	Sandy Silt	Initial Void Ratio:	0.62
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	11/17/2009
AP No:	29-1121

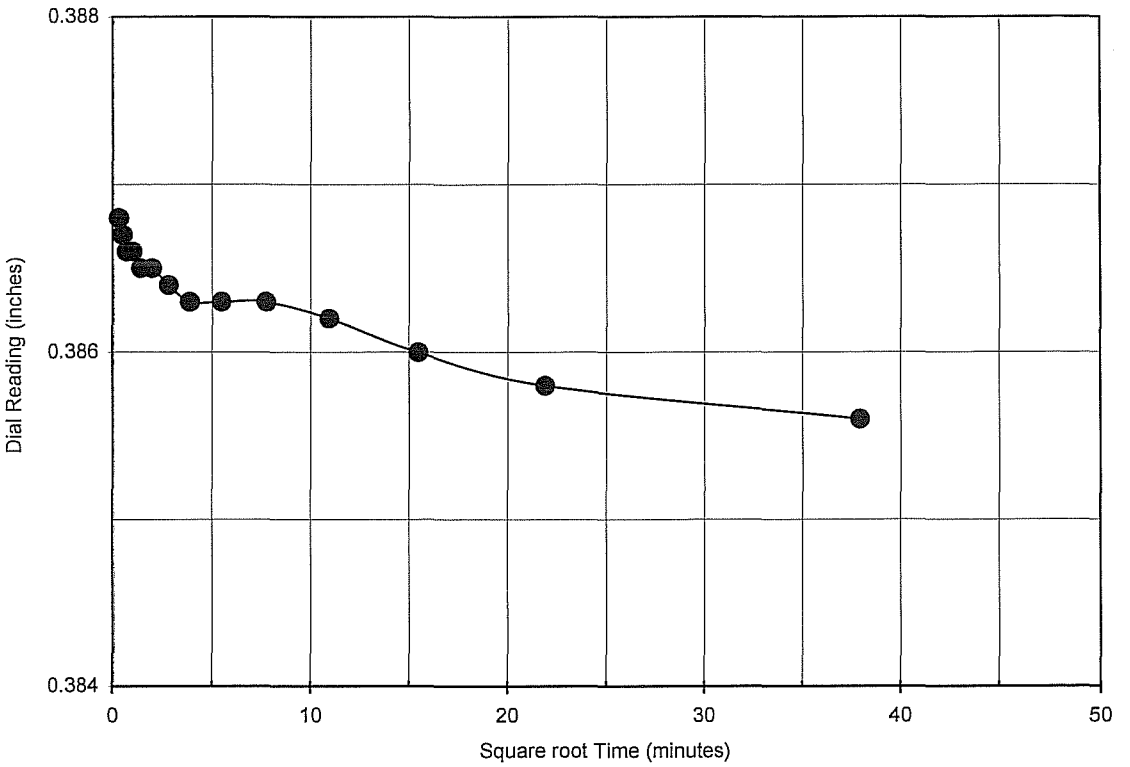


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3868
0.25	0.3867
0.5	0.3866
1	0.3866
2	0.3865
4	0.3865
8	0.3864
15	0.3863
30	0.3863
60	0.3863
120	0.3862
240	0.386
480	0.3858
1440	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

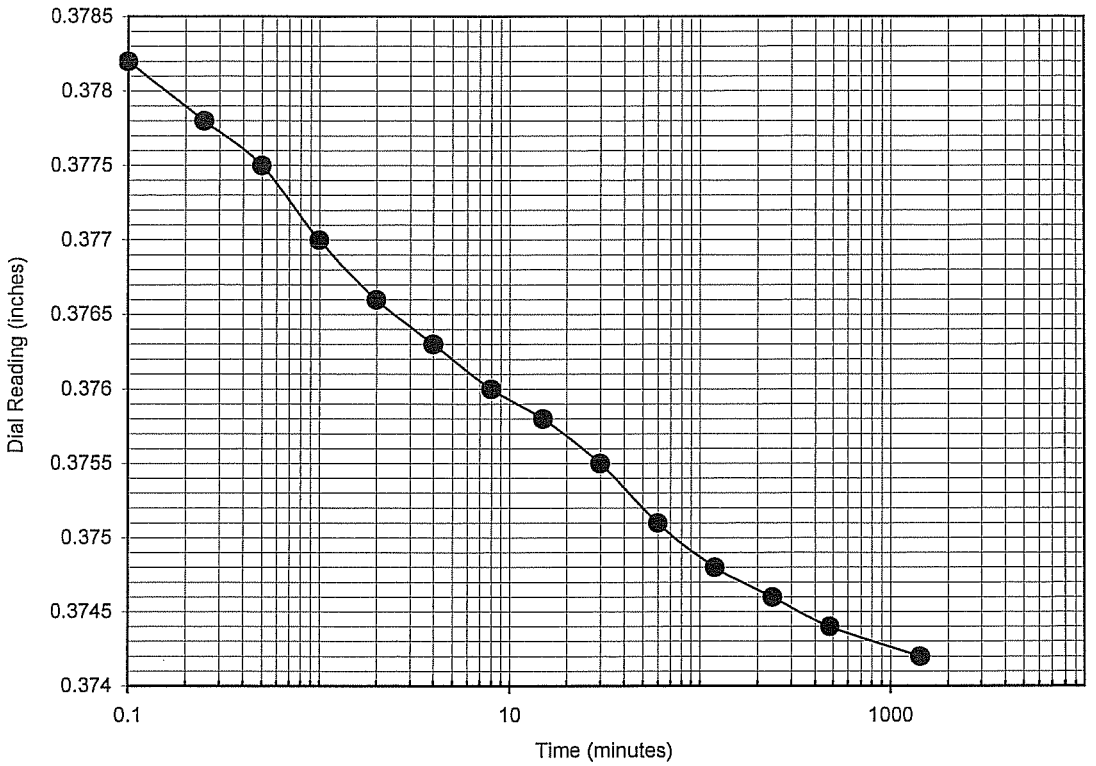


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3868
0.5000	0.3867
0.7071	0.3866
1.0000	0.3866
1.4142	0.3865
2.0000	0.3865
2.8284	0.3864
3.8730	0.3863
5.4772	0.3863
7.7460	0.3863
10.9545	0.3862
15.4919	0.3860
21.9089	0.3858
37.9473	0.3856

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

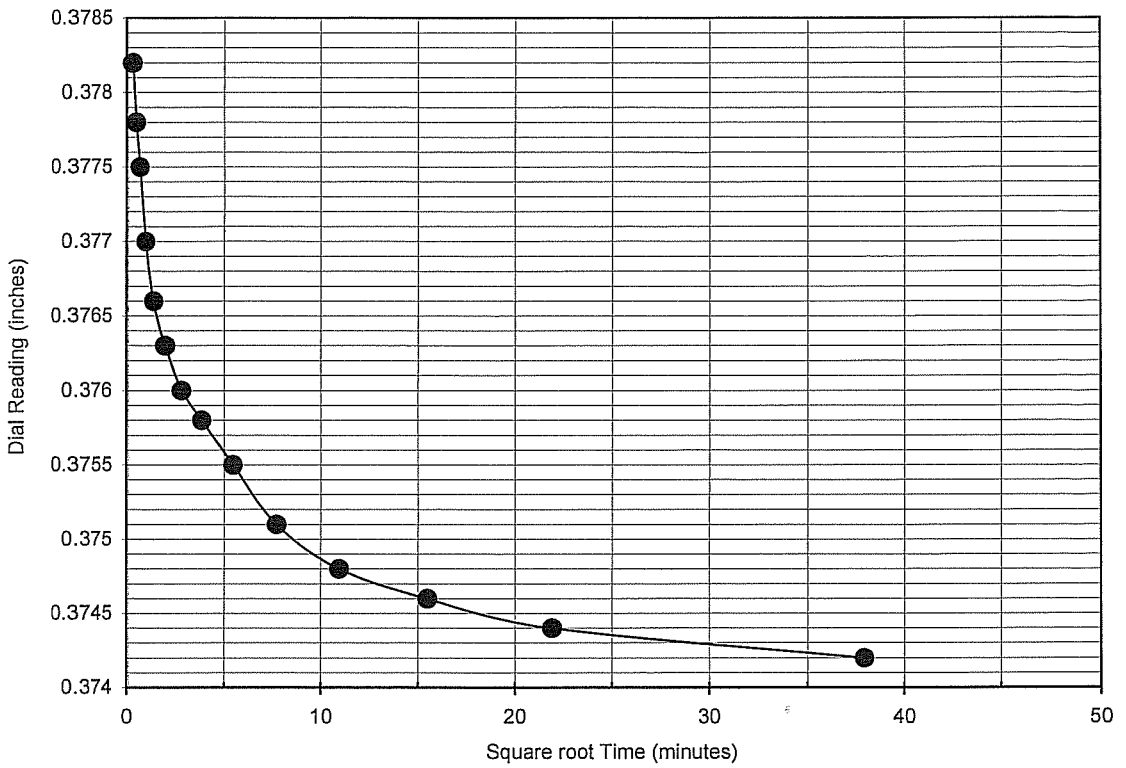


Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3782
0.25	0.3778
0.5	0.3775
1	0.377
2	0.3766
4	0.3763
8	0.376
15	0.3758
30	0.3755
60	0.3751
120	0.3748
240	0.3746
480	0.3744
1440	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-011	Sample Type:	Shelby
Sample No.:	U-14	Soil Description:	Sandy Silt
Depth (feet):	70	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3782
0.5000	0.3778
0.7071	0.3775
1.0000	0.3770
1.4142	0.3766
2.0000	0.3763
2.8284	0.3760
3.8730	0.3758
5.4772	0.3755
7.7460	0.3751
10.9545	0.3748
15.4919	0.3746
21.9089	0.3744
37.9473	0.3742

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/17/09
AP No: 29-1121 **Figure No:**

AP Engineering & Testing, Inc.

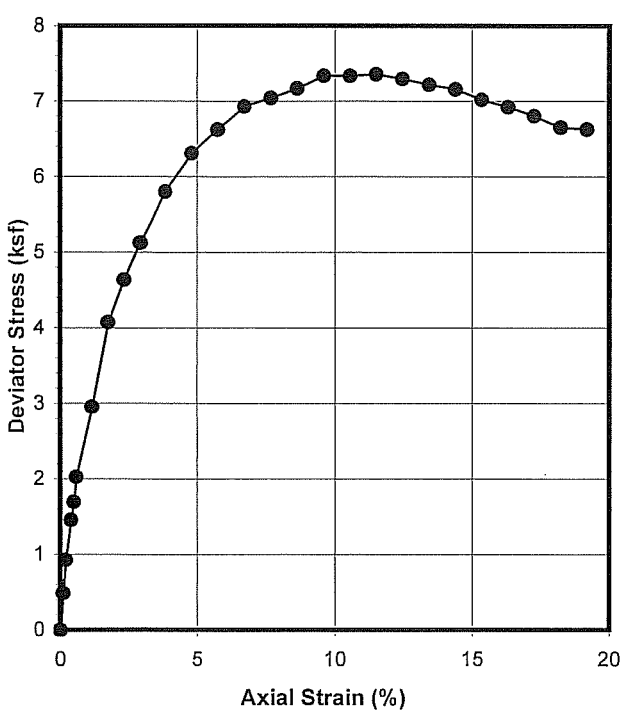
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/12/09
Project No.:	06-123-03		
Boring No.:	R-09-011		
Sample No.:	U-14 Depth (feet): 70		
Soil Description	Gray Sandy Silt	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	129.4
Sample Hieght (inch):	5.2	Dry Unit Weight (pcf):	106.1
Sample Weight (gms):	1149.87	Moisture Content (%):	22.0
Wt. Wet Soil+Container(gms)	1310.19	Void Ratio for Gs=2.7:	0.59
Wt. Dry Soil+Container(gms)	1101.86	% Saturation:	101.0
Wt. Container (gms)	154.83		

TEST DATA

Cell Pressure (ksf):	2.74
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	2.74
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	7.4
Ultimate Deviator Stress (ksf):	6.9
Ultimate Undrained Shear Strength (ksf):	3.5
Axial Strain @ Maximum Stress (%)	11.52



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
22	0.005	6.50	0.49	0.10
42	0.010	6.50	0.93	0.19
66	0.020	6.52	1.46	0.38
77	0.025	6.52	1.70	0.48
92	0.030	6.53	2.03	0.58
135	0.060	6.57	2.96	1.15
187	0.090	6.61	4.08	1.73
214	0.120	6.64	4.64	2.30
238	0.150	6.68	5.13	2.88
272	0.200	6.75	5.80	3.84
299	0.250	6.82	6.31	4.80
317	0.300	6.89	6.63	5.76
335	0.350	6.96	6.93	6.72
344	0.400	7.03	7.04	7.68
354	0.450	7.11	7.17	8.64
366	0.500	7.18	7.34	9.60
370	0.550	7.26	7.34	10.56
375	0.600	7.34	7.36	11.52
376	0.650	7.42	7.30	12.48
376	0.700	7.50	7.22	13.44
377	0.750	7.58	7.16	14.40
374	0.800	7.67	7.02	15.36
373	0.850	7.76	6.92	16.31
371	0.900	7.85	6.81	17.27
367	0.950	7.94	6.66	18.23
370	1.000	8.03	6.63	19.19

APPENDIX E.

SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

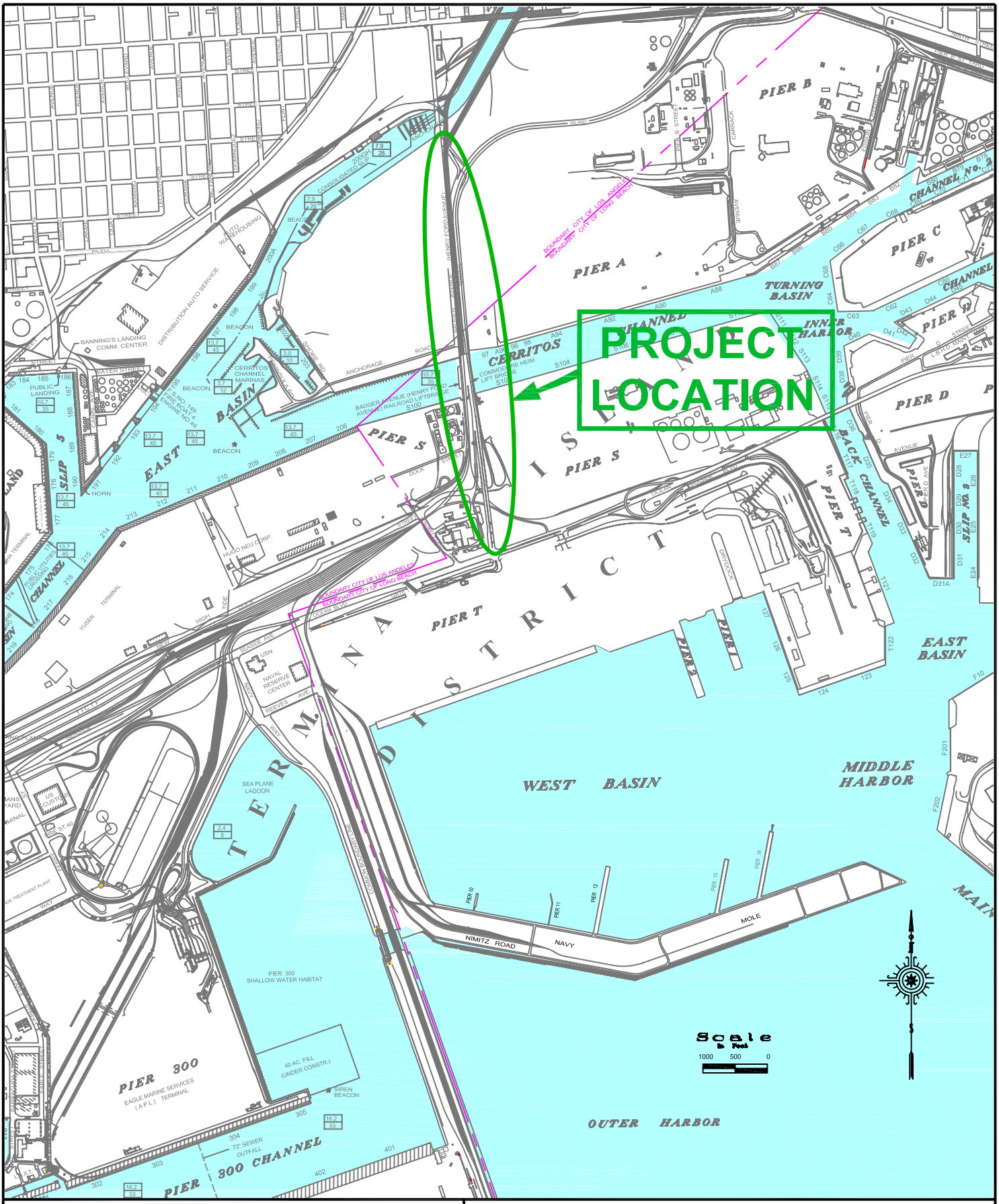
California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

Earth Mechanics, Inc., 2006a, "Preliminary Foundation Report, ACTA Schuyler Heim Bridge (Replace), Los Angeles, California," Report Prepared for Alameda Corridor Transportation Authority, EMI Project No. 06-123, June 23.

——, 2006b, "Port-Wide Ground Motion Study, Port of Long Beach, California," Report Prepared for Port of Long Beach, August 7.

Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



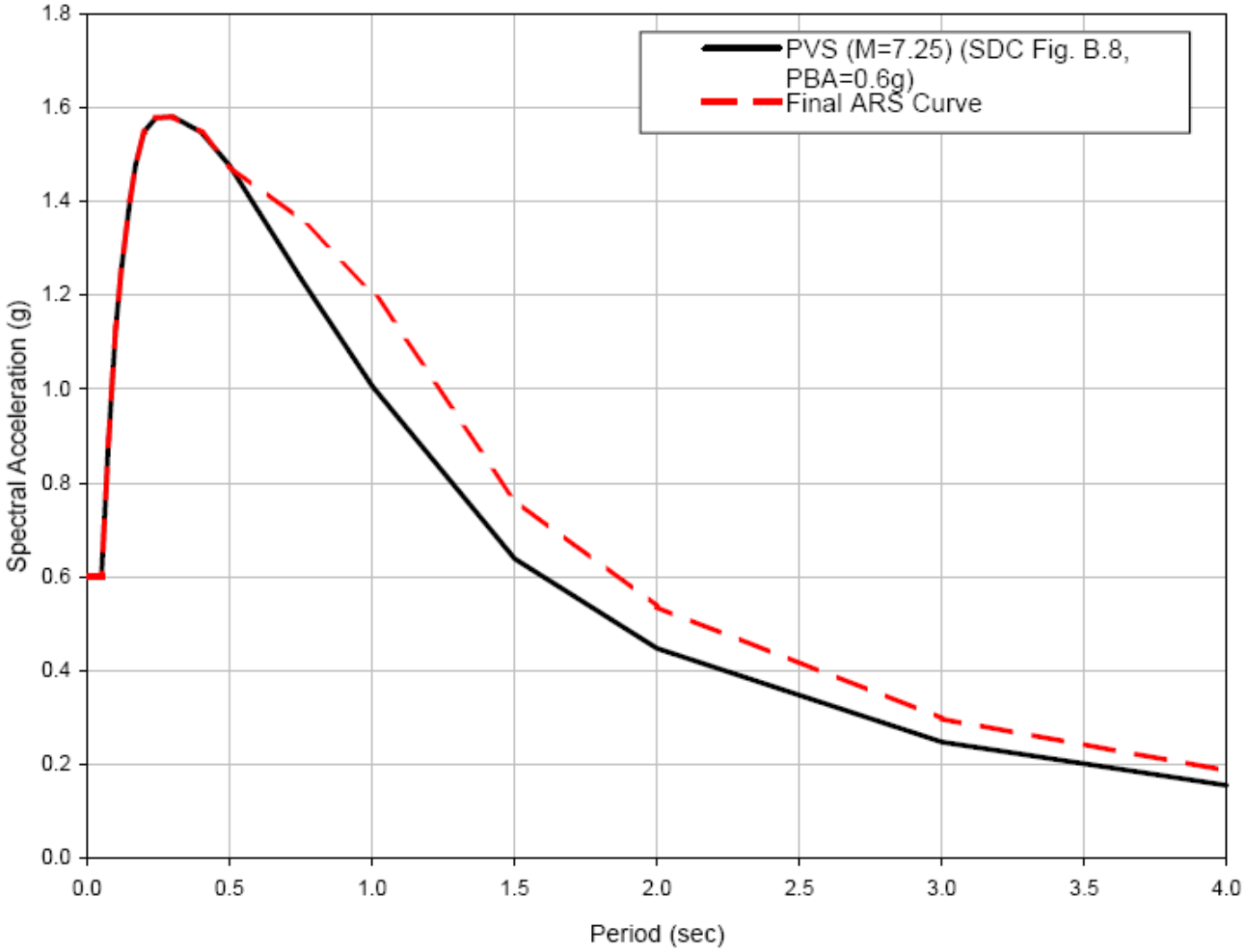
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

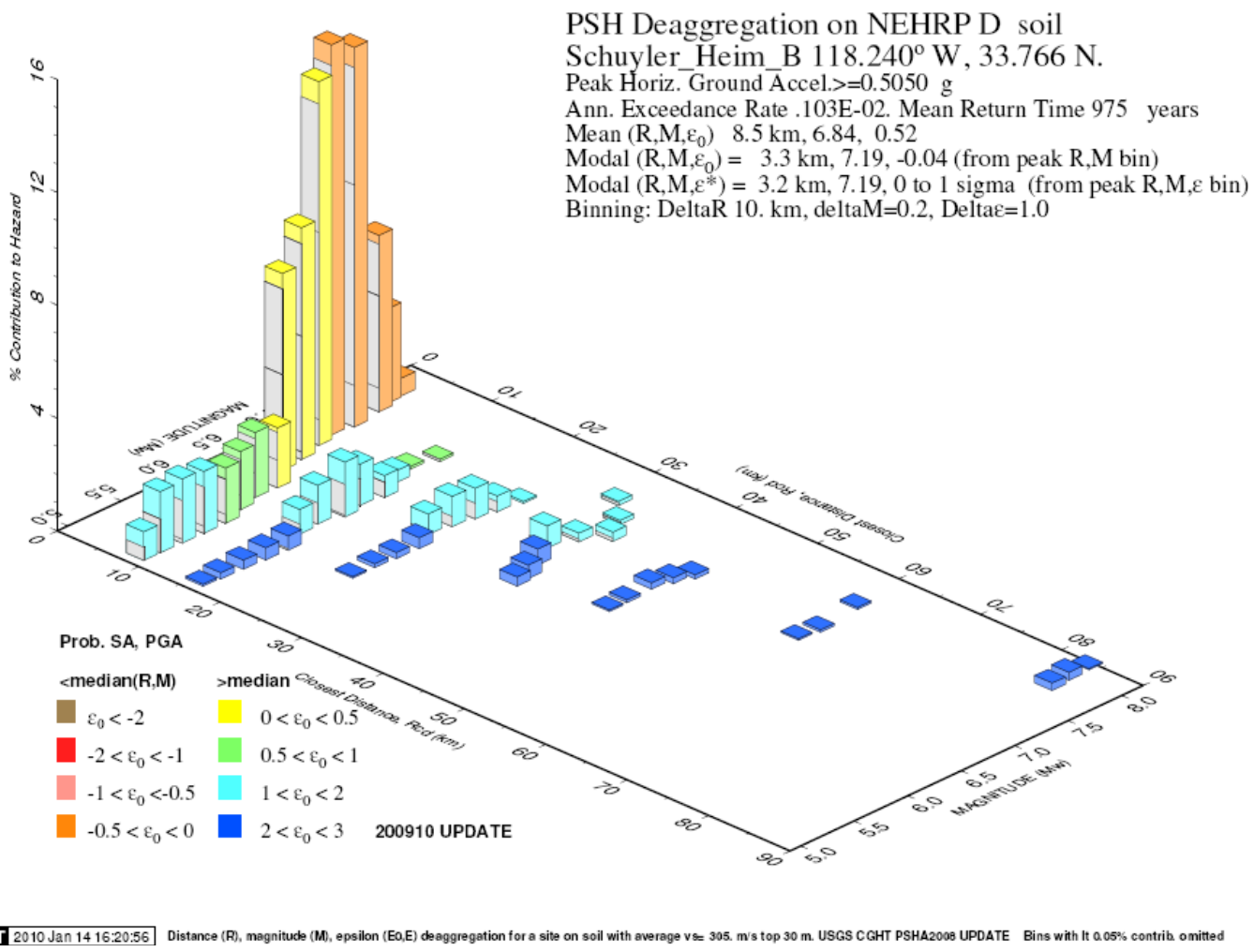


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

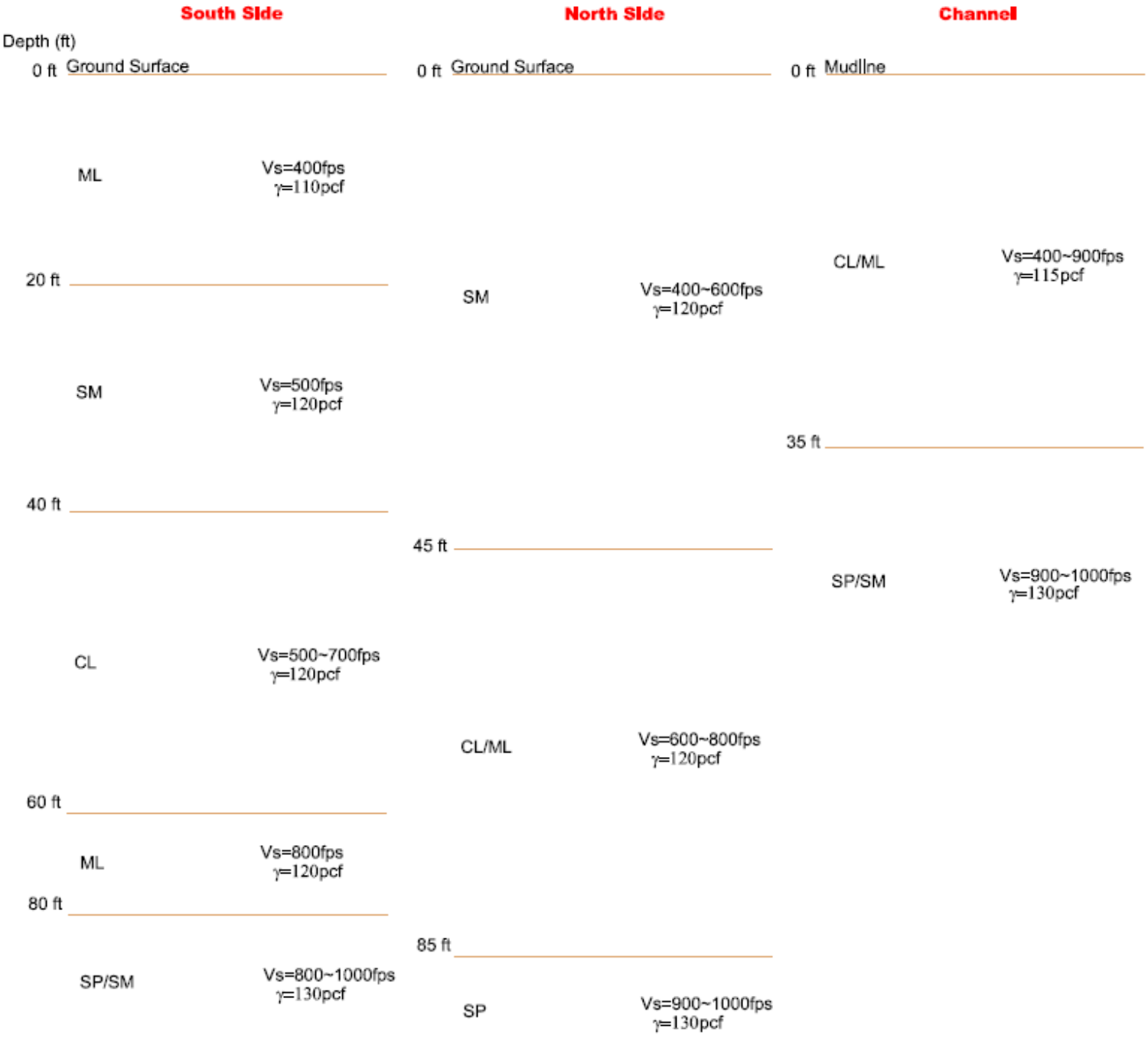
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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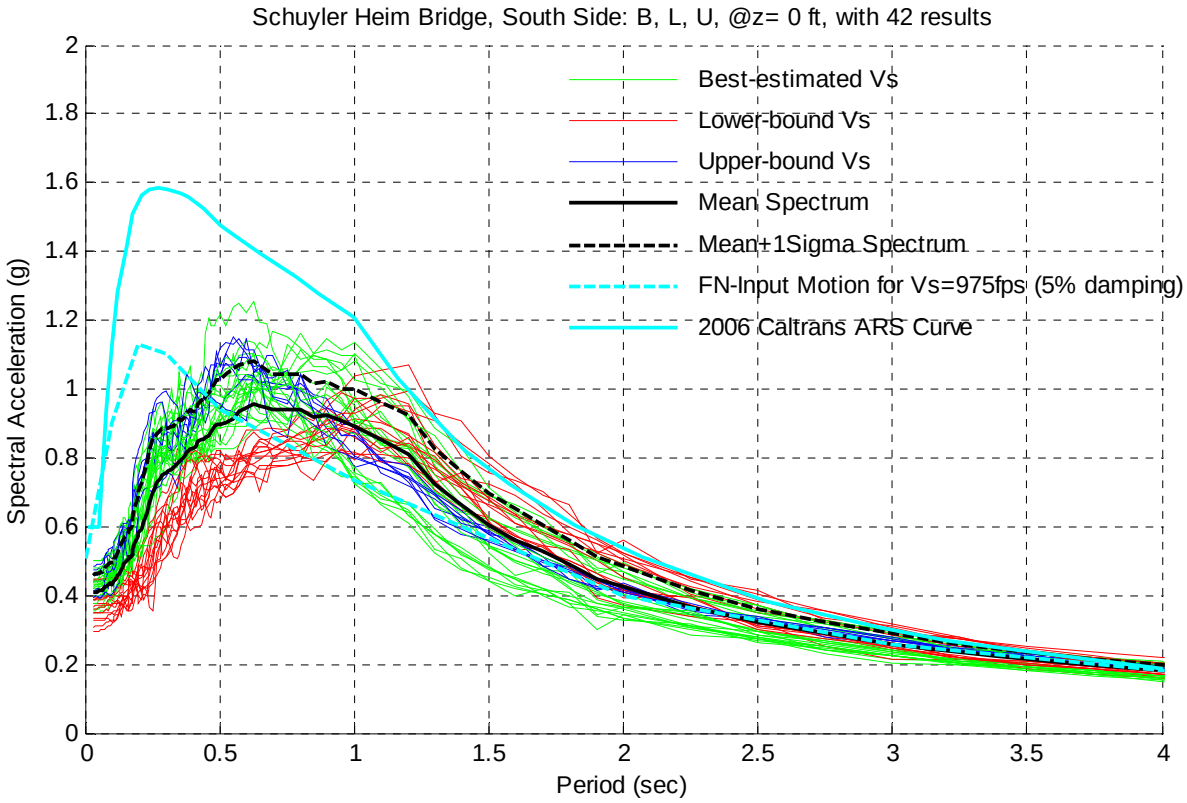
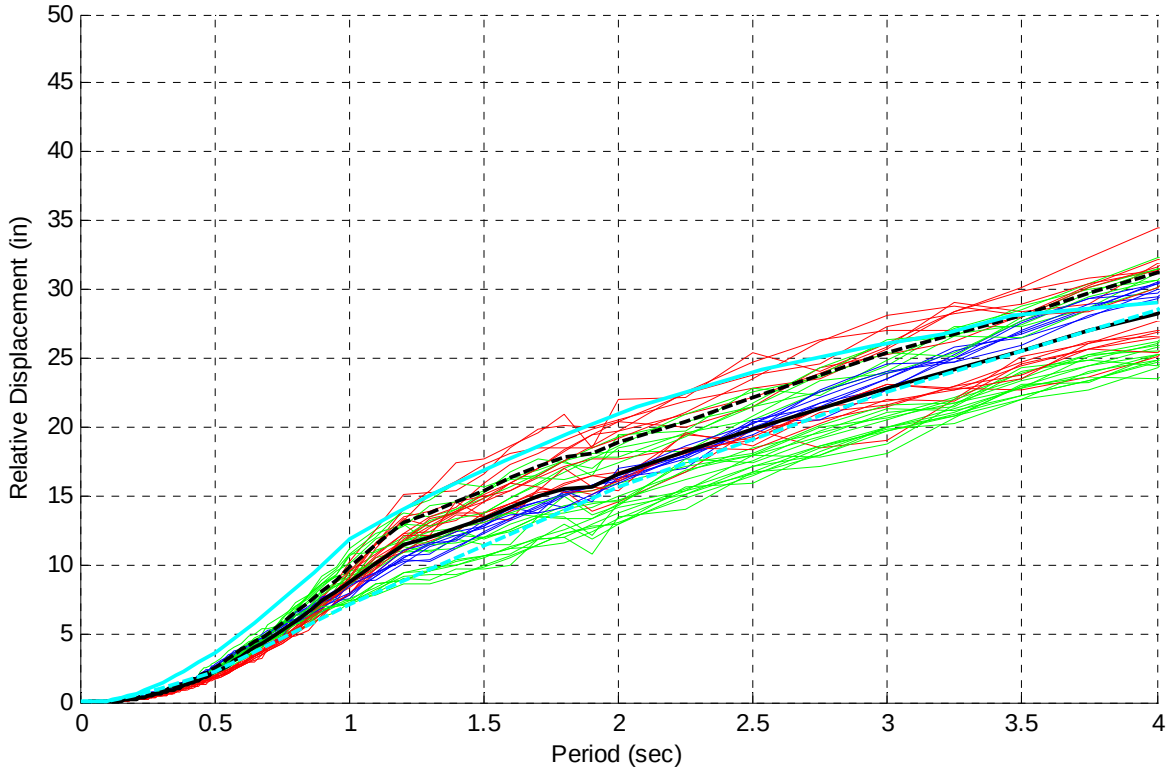
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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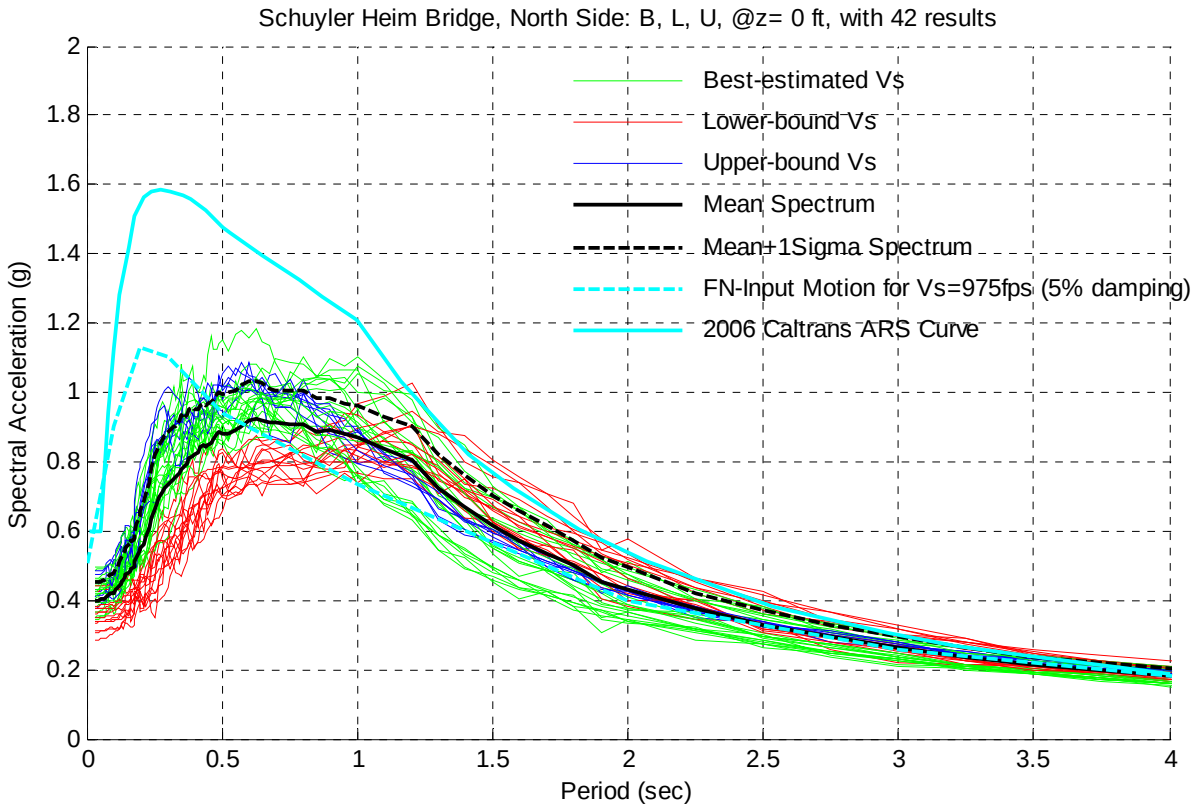
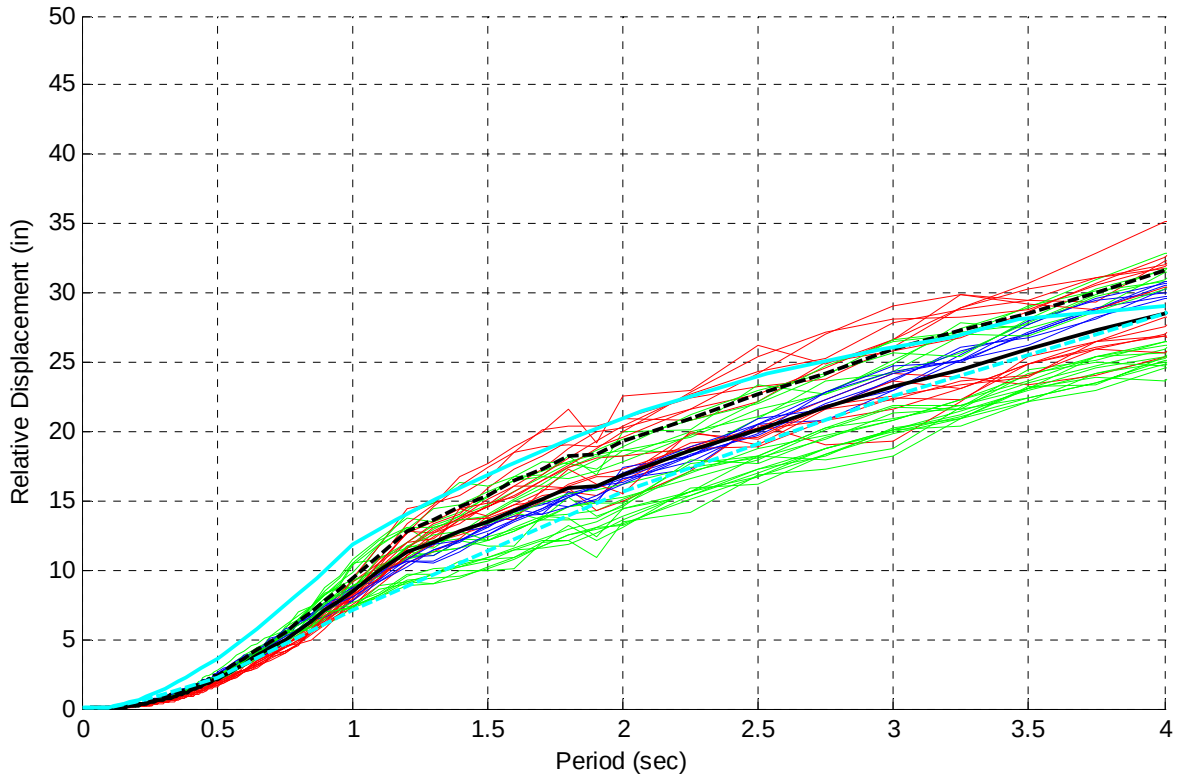
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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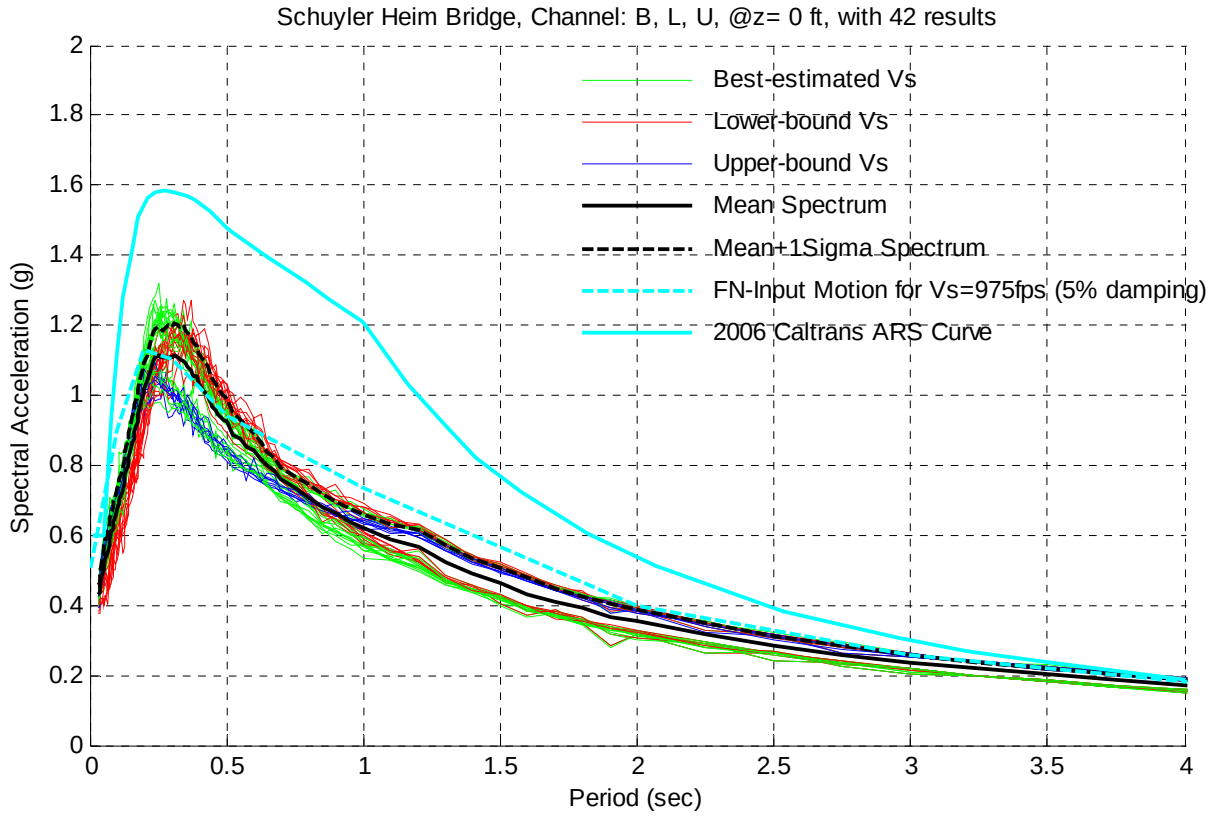
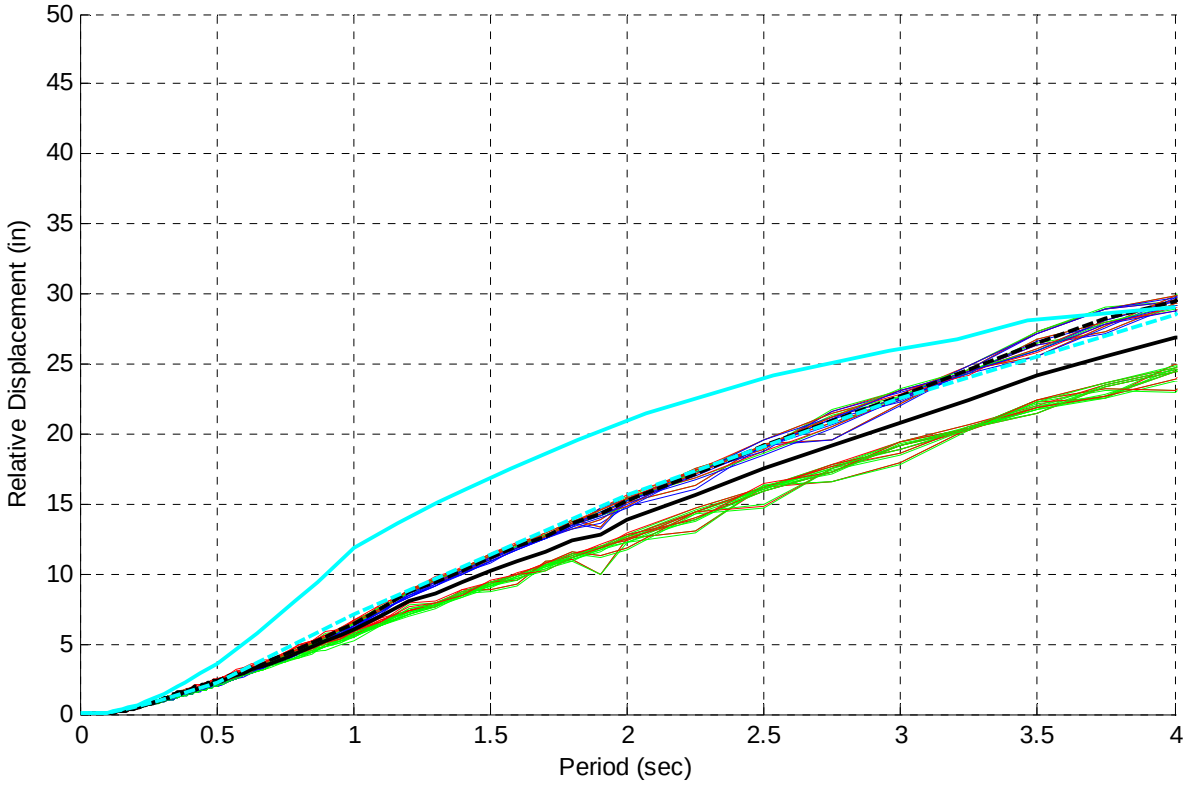
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





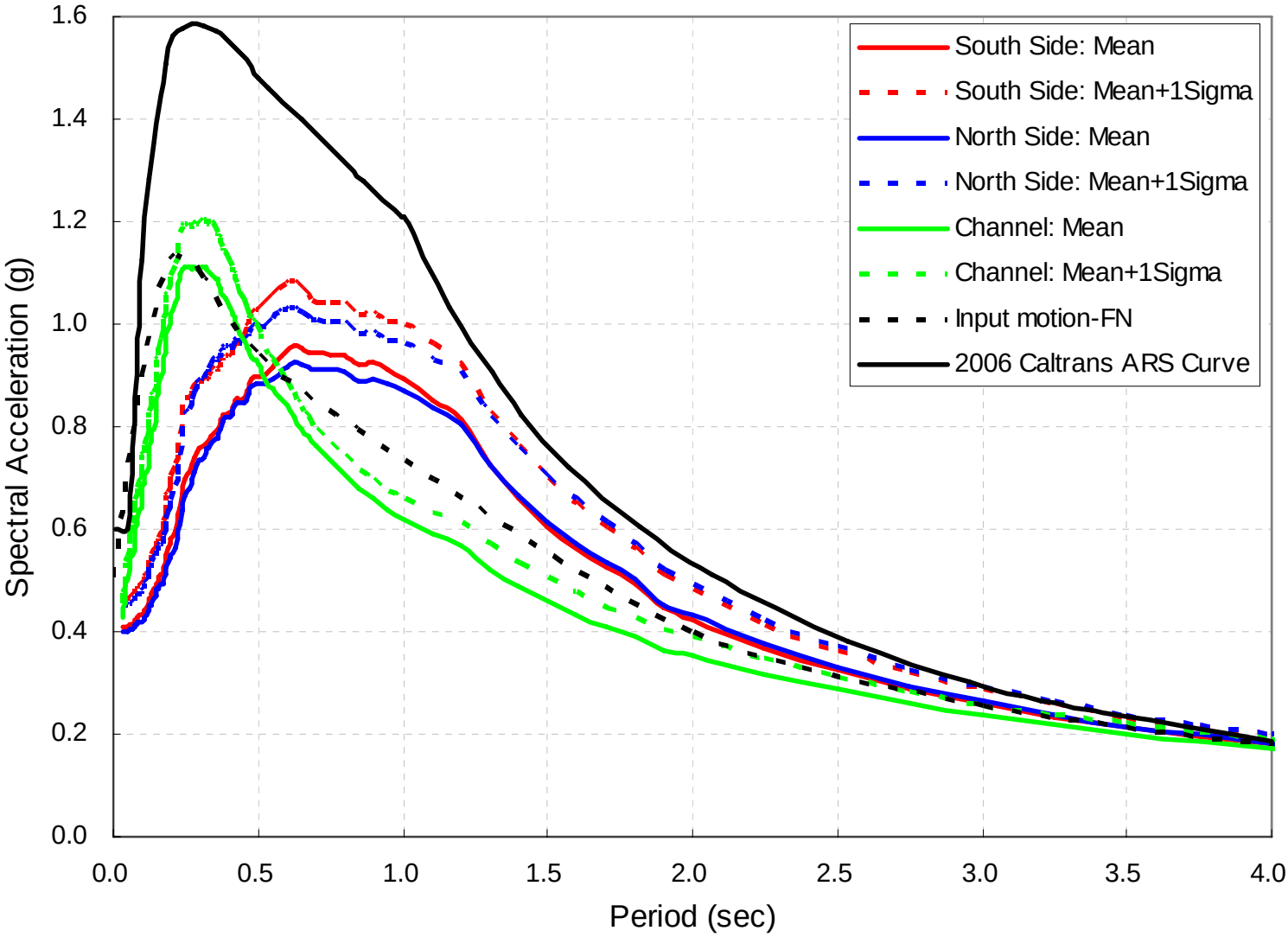
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

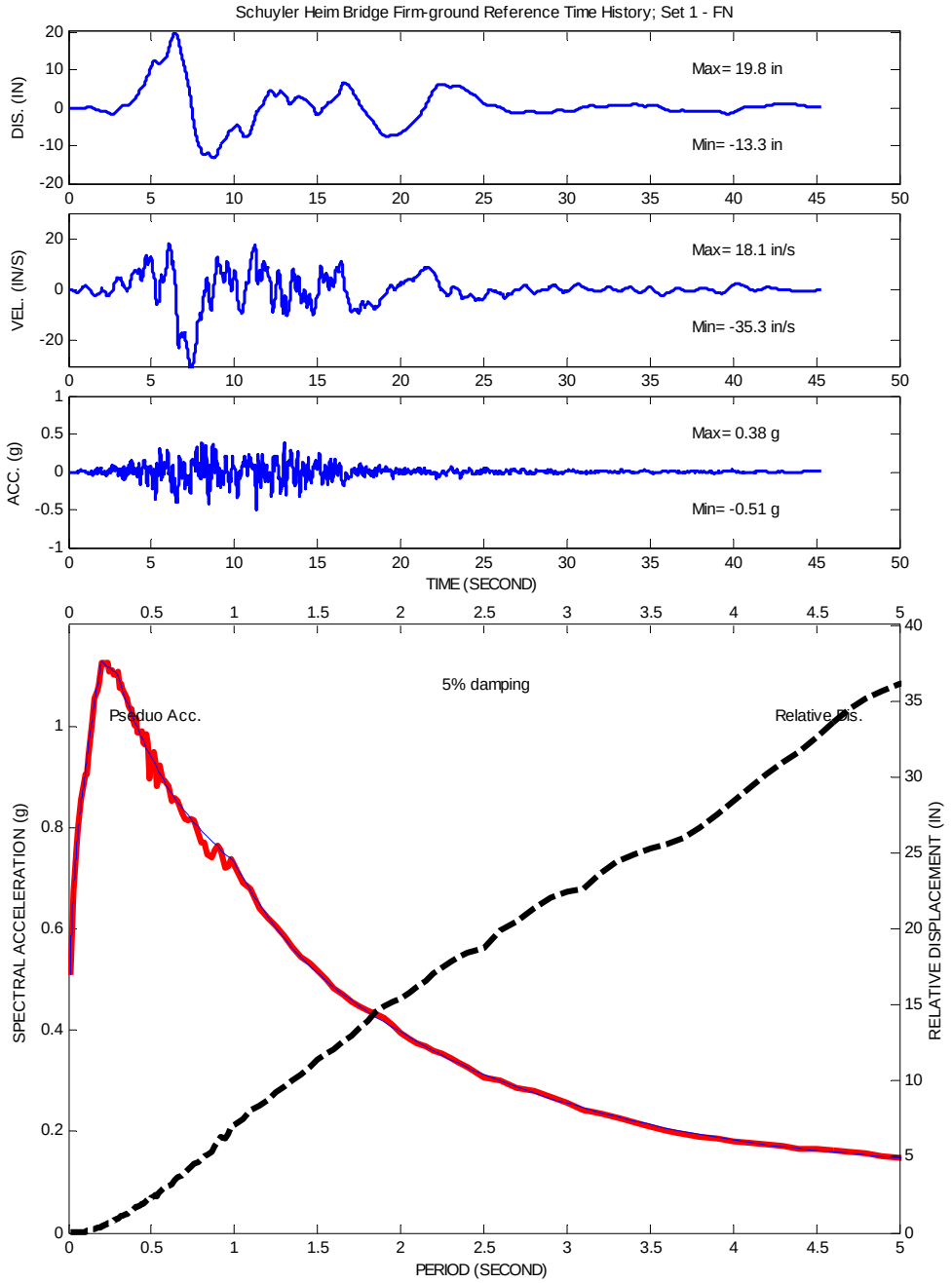

Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

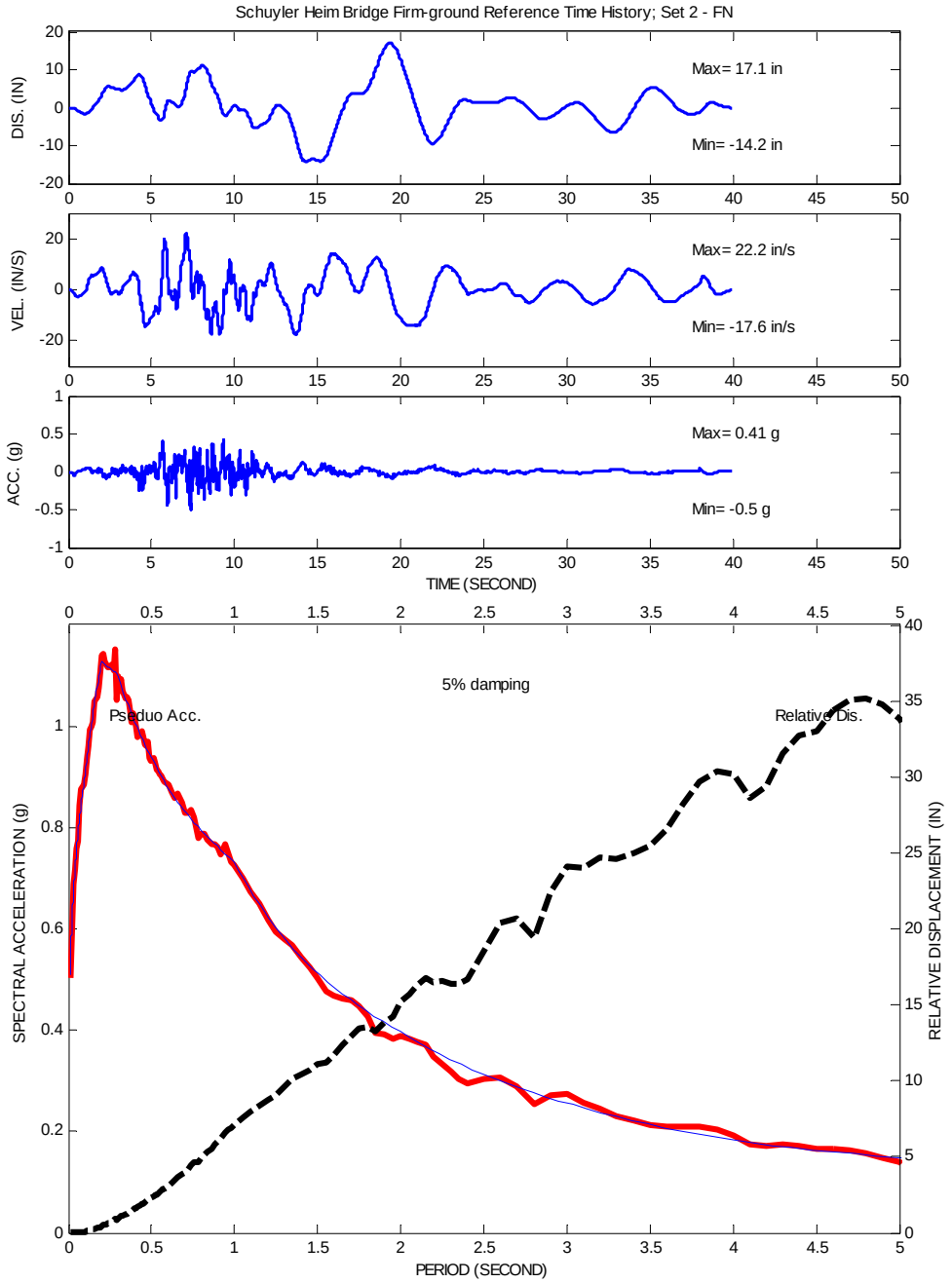

Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

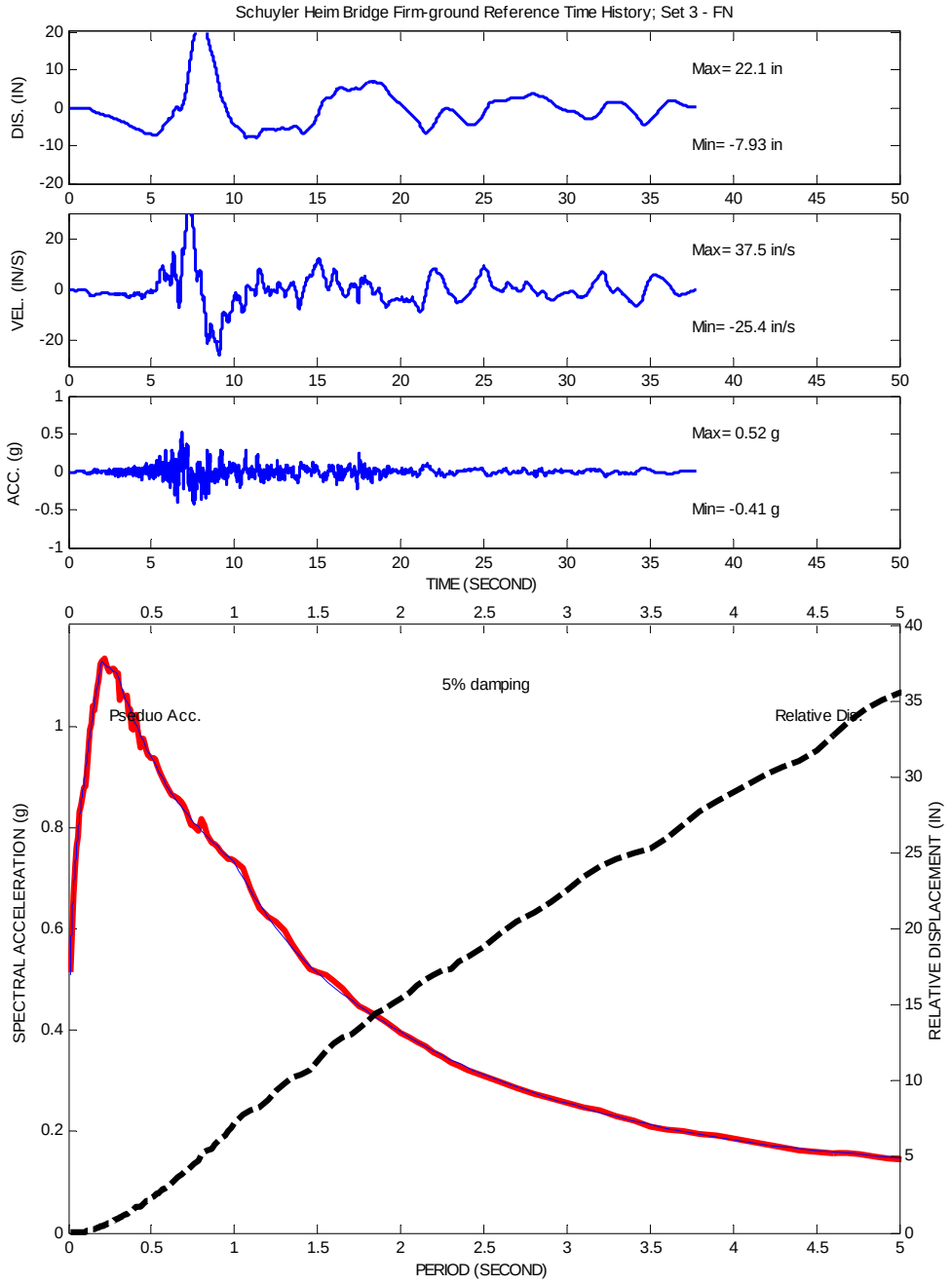

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

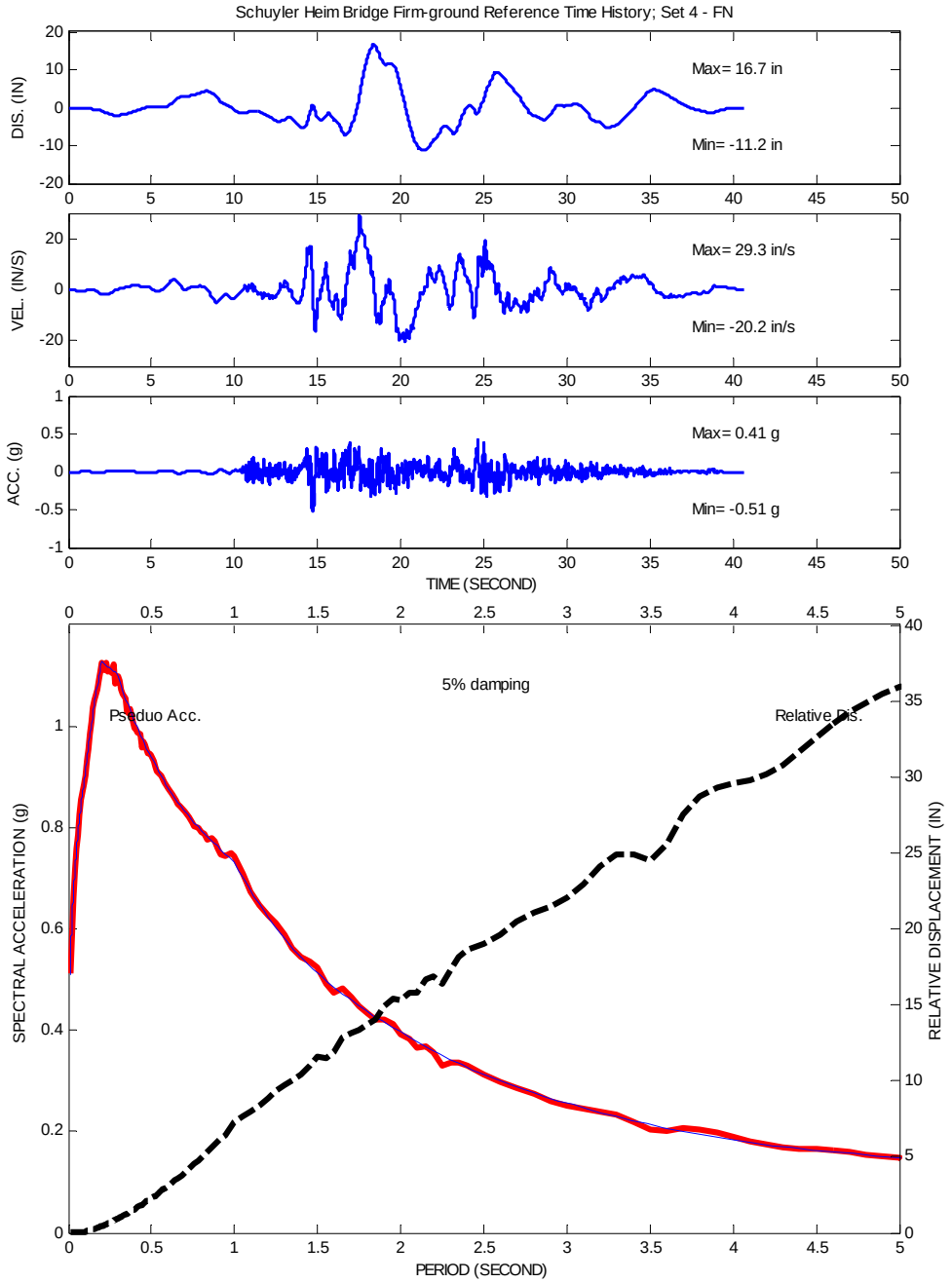

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

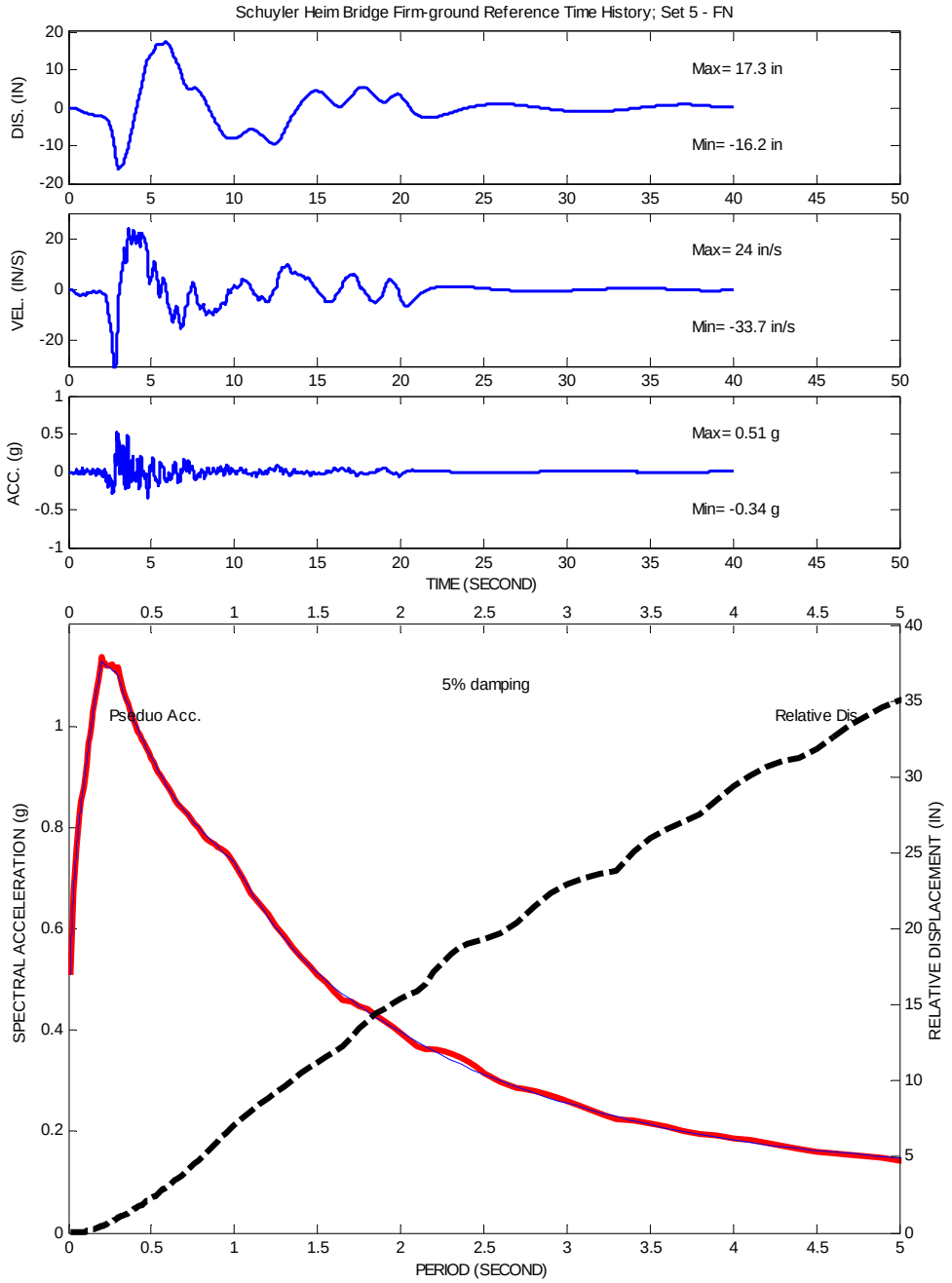

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

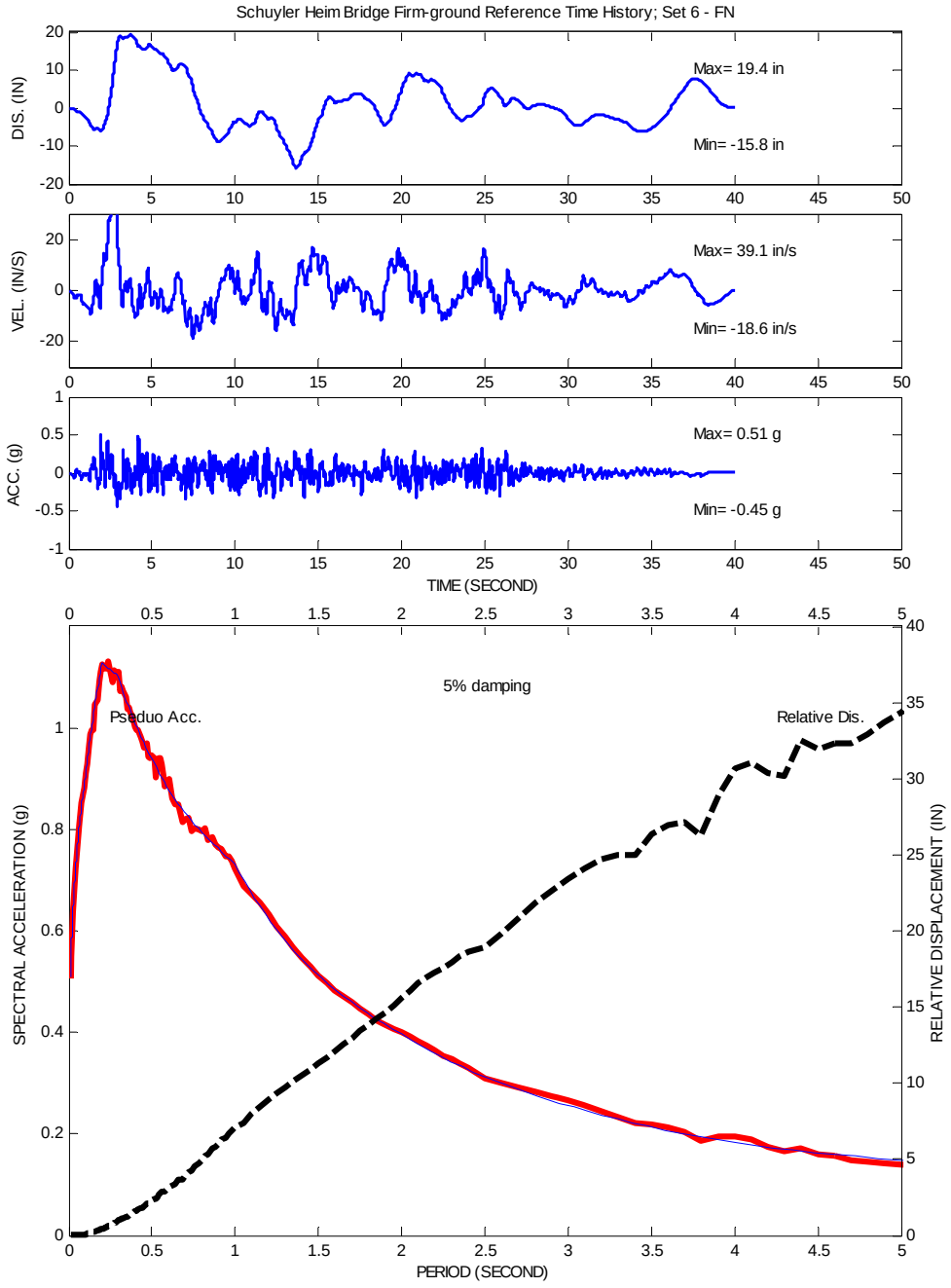

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

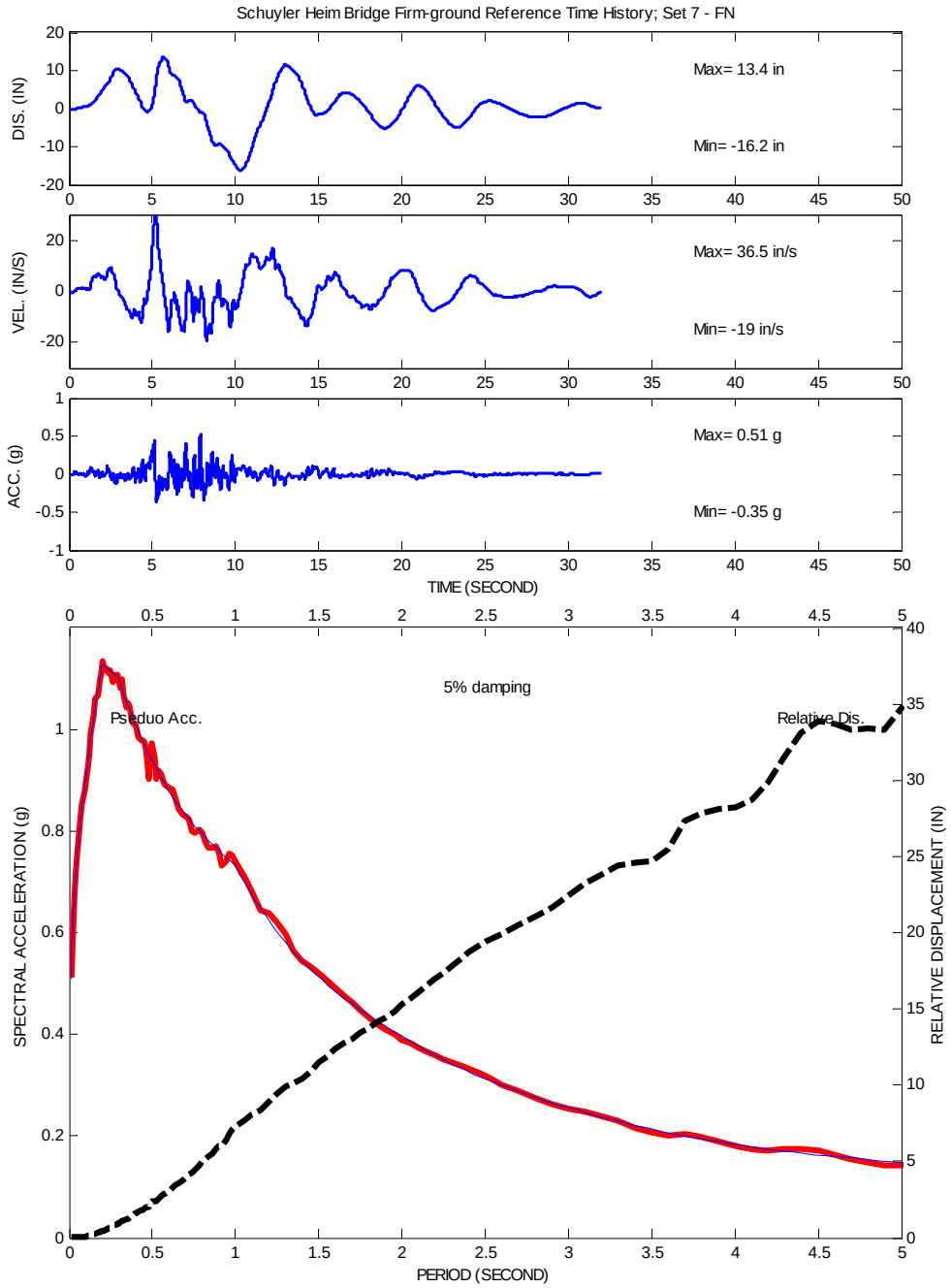

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

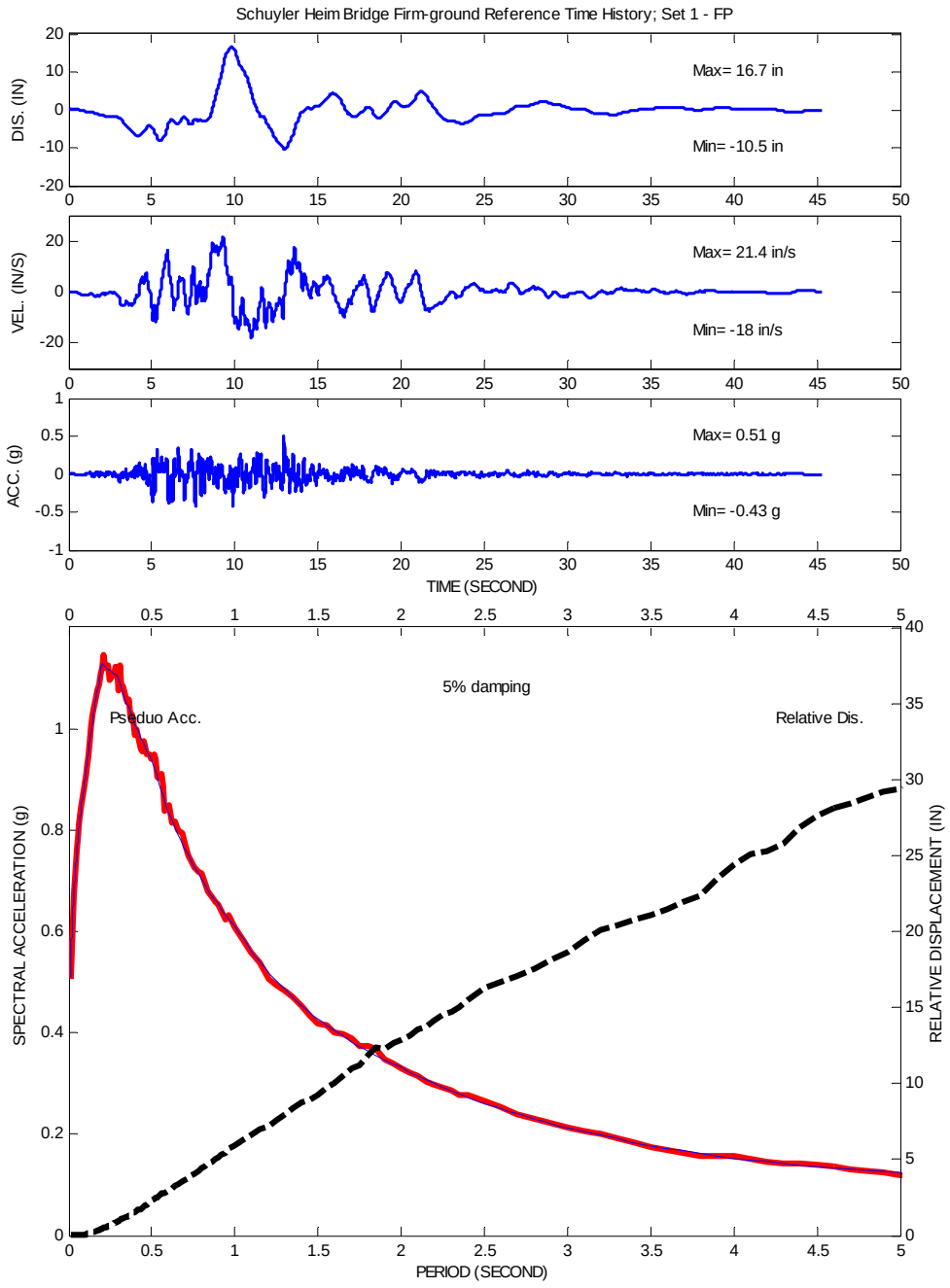

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

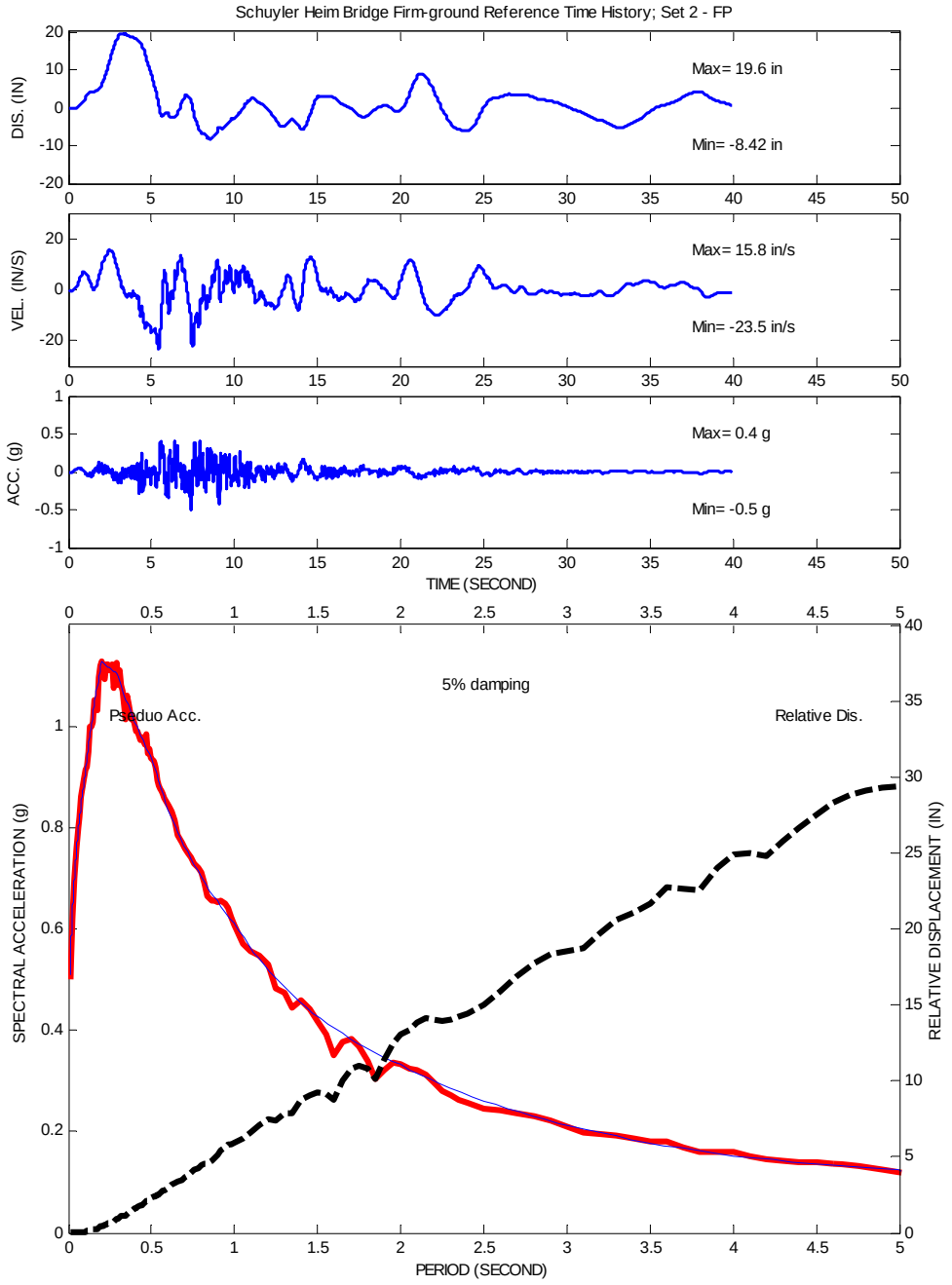

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

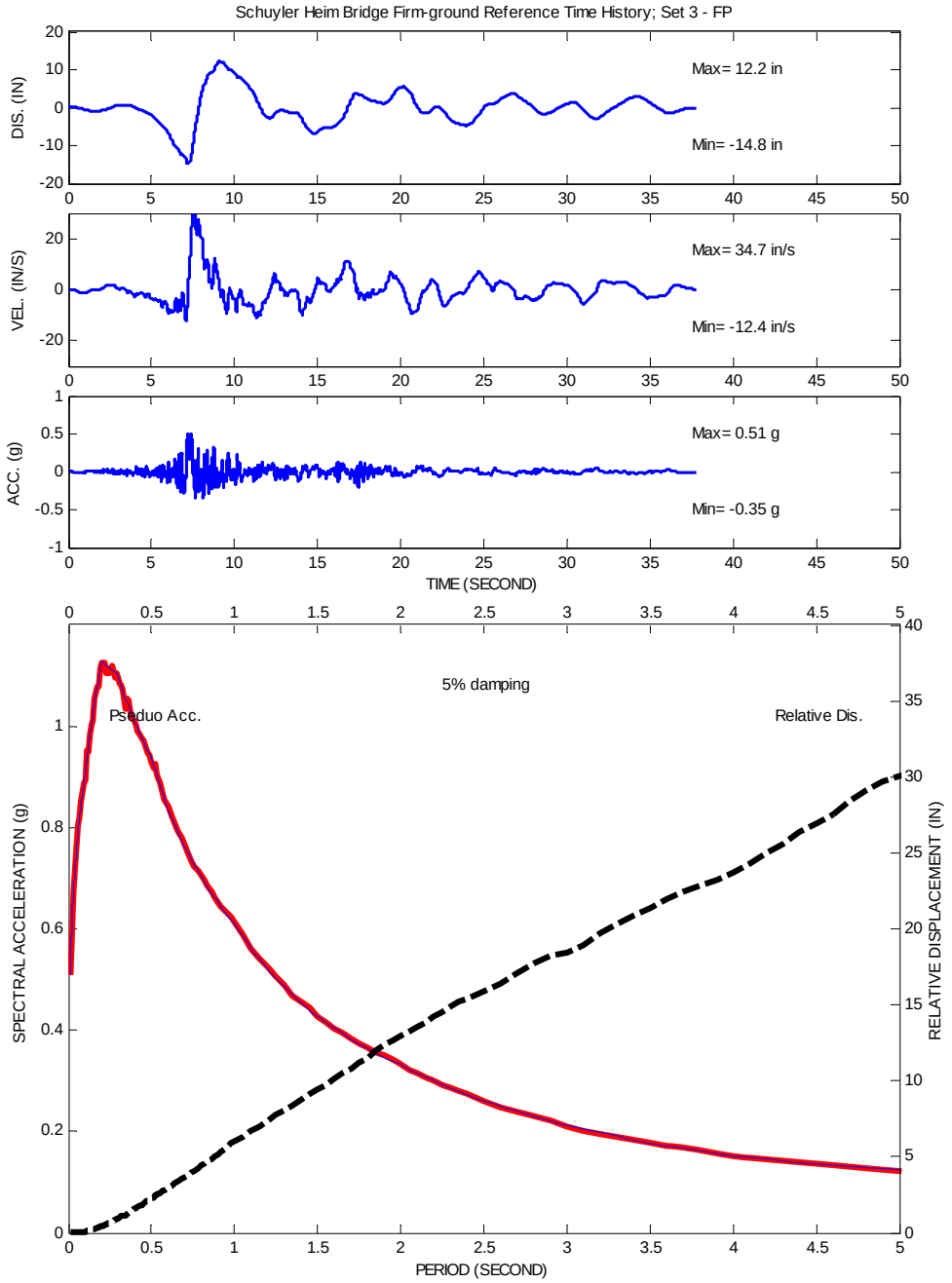

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

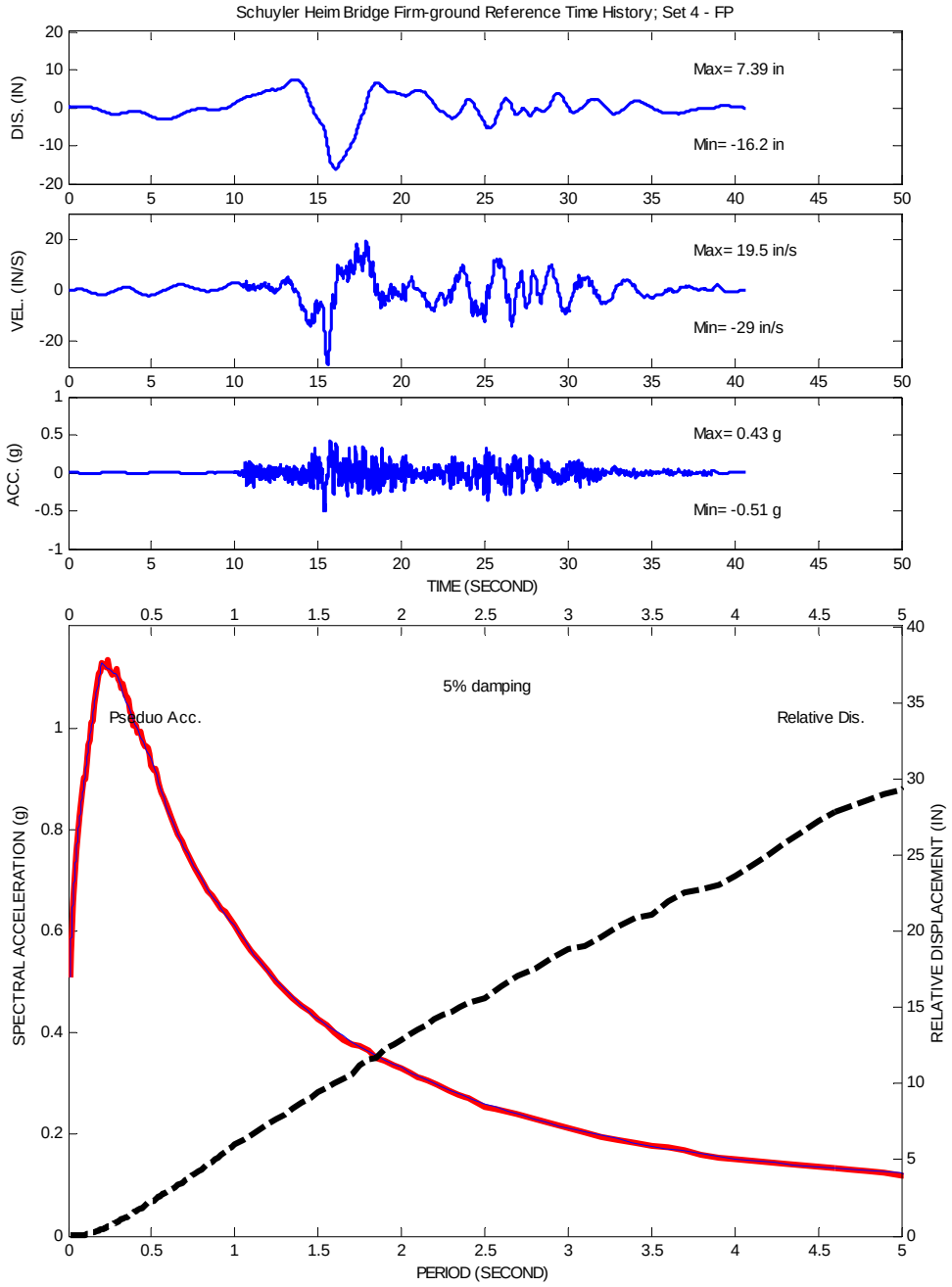

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

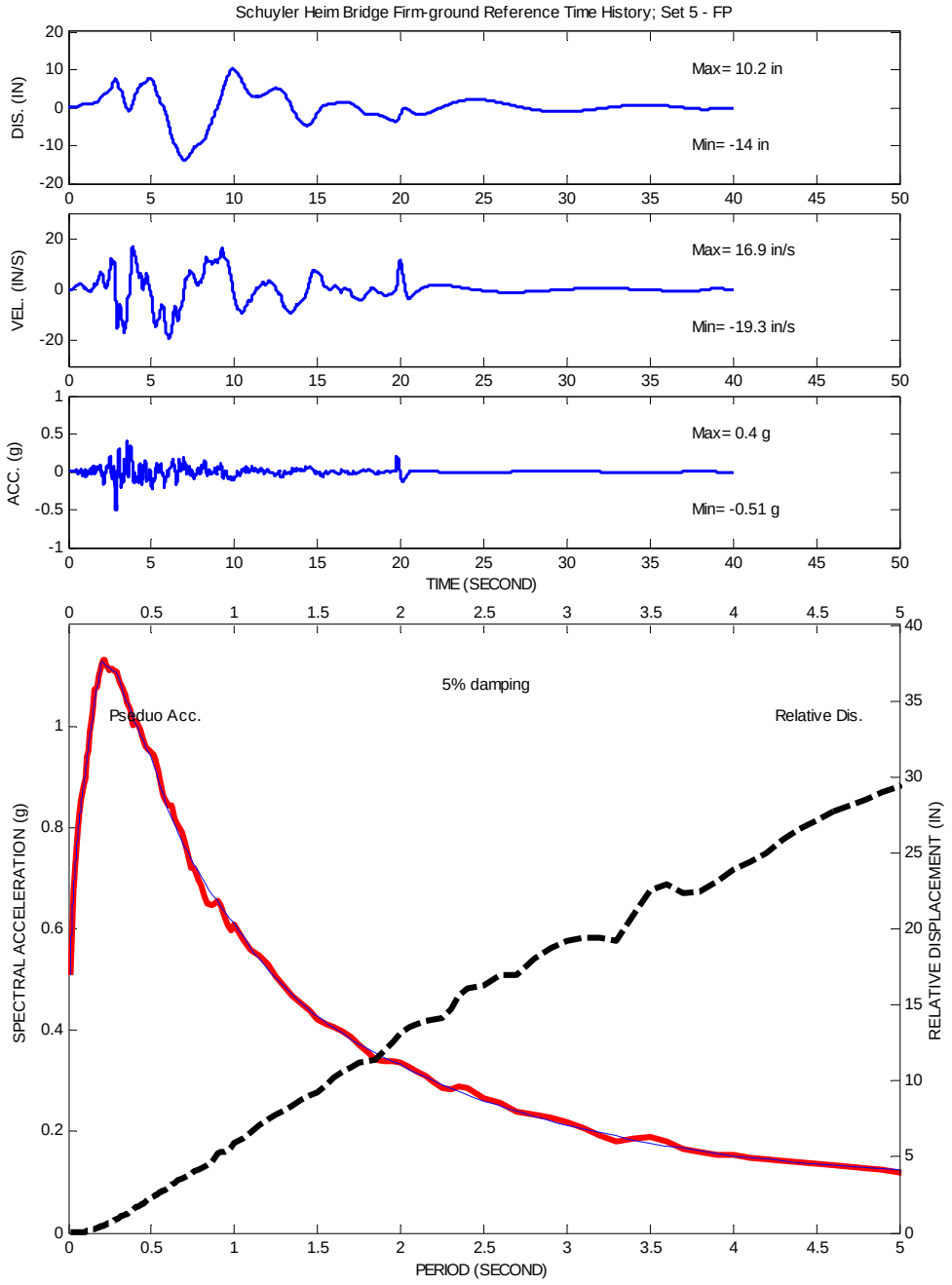

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

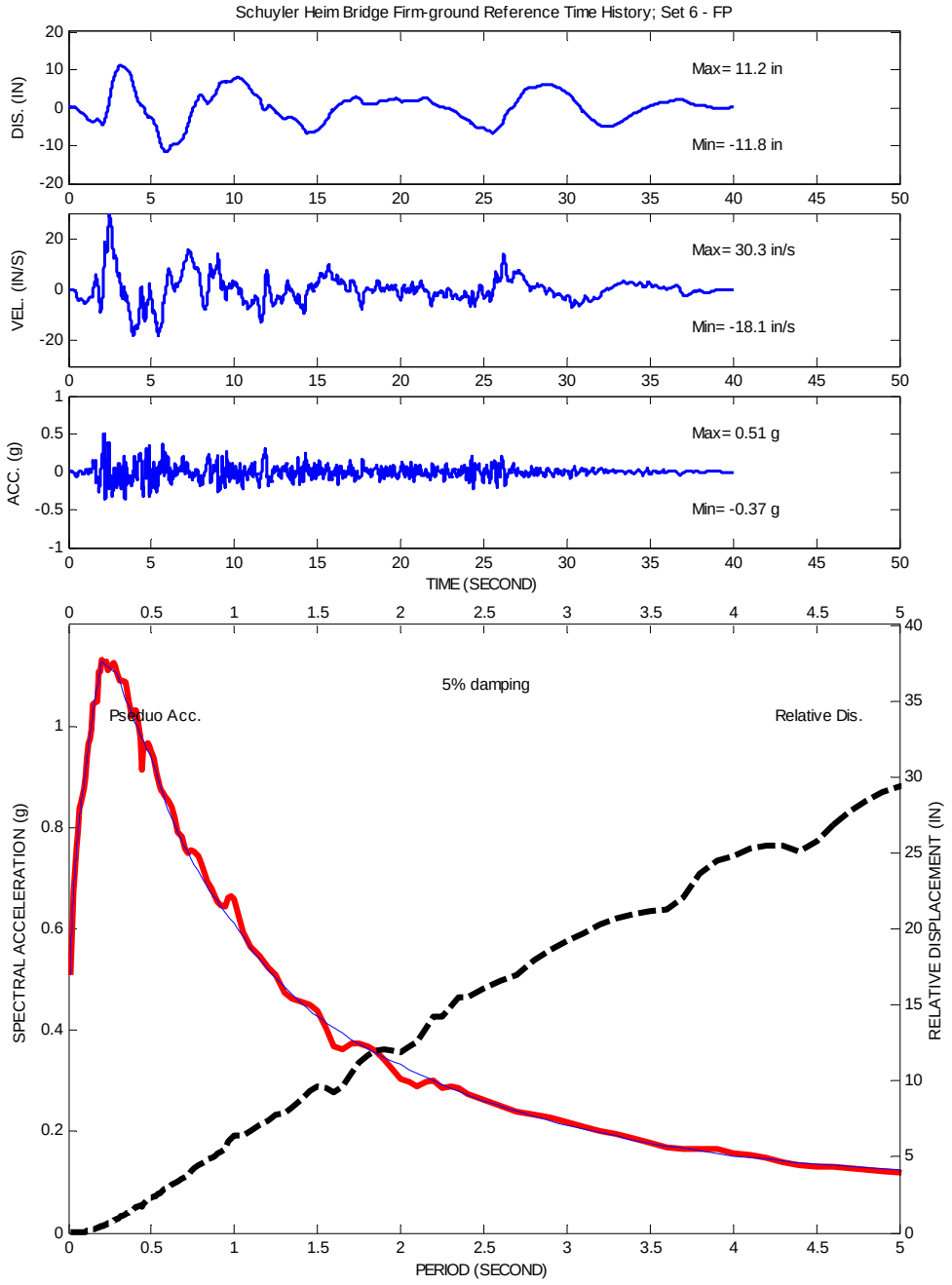

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

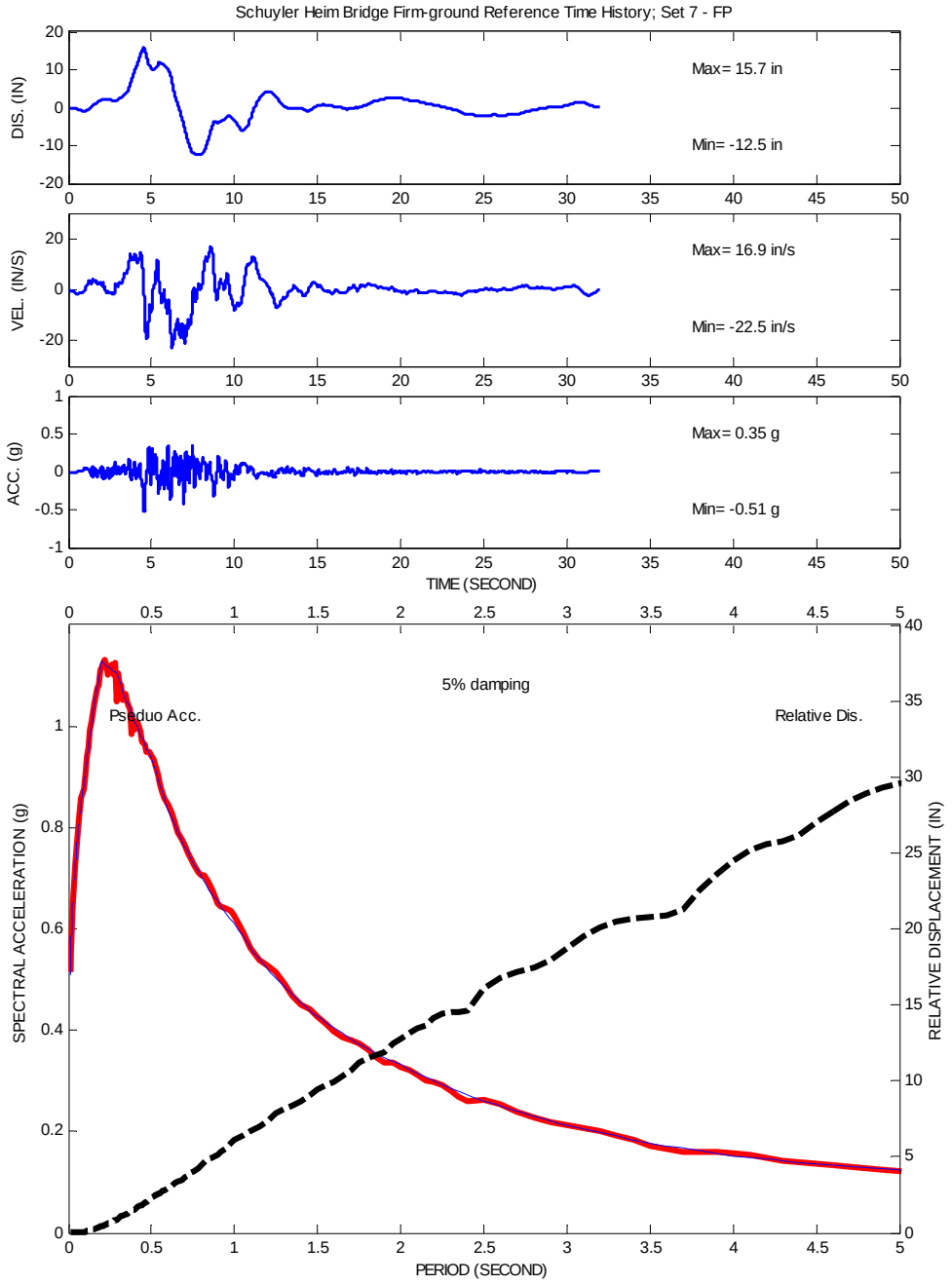

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX F. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)

SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQD
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report, Retaining Wall H1***
Los Angeles County, California, (7-LA-47, PM 0.18, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining wall. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining wall.

The Foundation Report for the subject wall, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix E. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,

EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
ERIC BROWN
NO. GE 2806
EXP. 6-30-2010
GEOTECHNICAL
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
KANDIAH ARULMOLI
NO. 2090
EXP. 12-31-2011
GEOTECHNICAL
STATE OF CALIFORNIA

(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL H1
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.18, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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APPENDICES

Appendix A. EarthSpectives SPT Hammer Energy Measurement Report
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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall H1 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for the proposed Retaining Wall H1 located on the east side of the SR-47/Henry Ford Avenue connector ramp (Figure 2).

Retaining Wall H1, located along the eastern edge of the SR-47/Henry Ford Avenue connector ramp between Sta. 702+90 and Sta. 707+25 ("H" Line) is proposed to be a Caltrans Type 1 retaining wall and will be approximately 428 ft long with retained heights varying from 4 ft to 10 ft.

1.3 Limitations

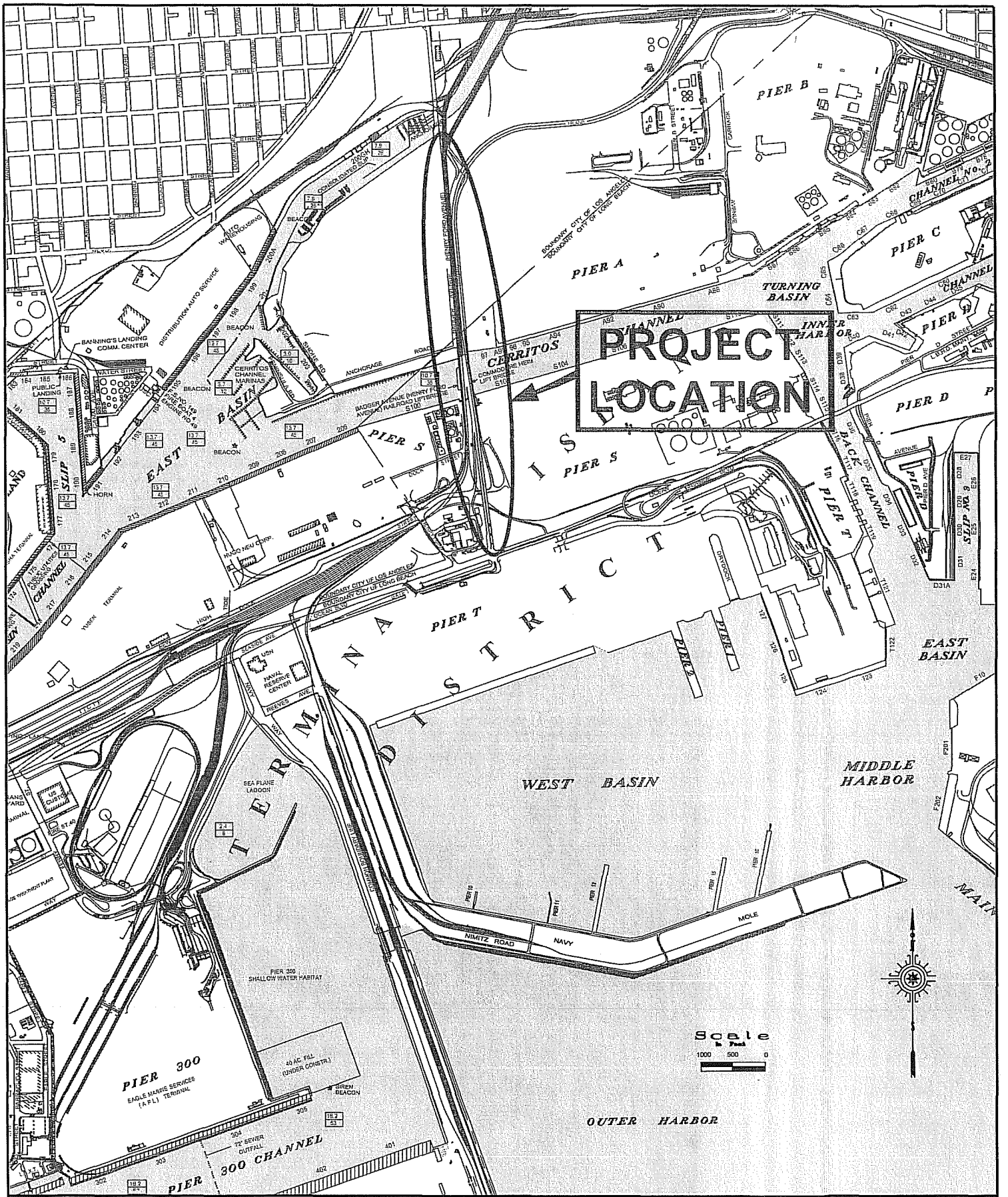
This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members, and the California Department of Transportation (Caltrans) for the

proposed Retaining Wall H1. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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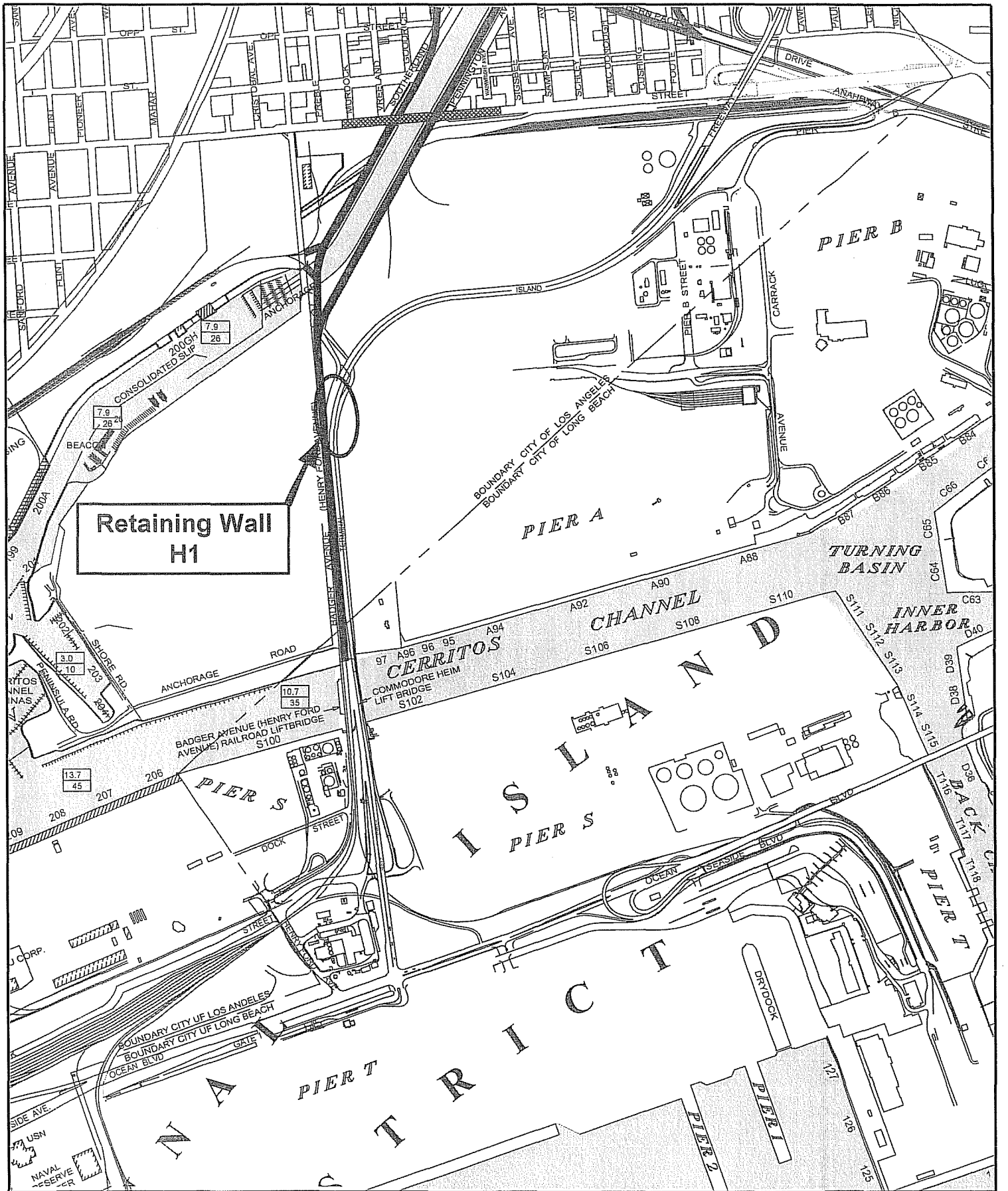
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 5-10-10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-10-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the nearest boring to Retaining Wall H1 is shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge and is approximately 950 ft south of the southern end of the proposed wall pair.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of 22 hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings for embankments and structures and 14 additional hollow-stem auger borings for pavement. From that exploration program, two rotary wash borings, one CPT sounding and three hollow-stem auger borings were performed in the vicinity of Retaining Wall H1. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed wall. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings surrounding the proposed retaining wall were performed at grade on the shoulder of the existing SR-47/Henry Ford Avenue Off-Ramp. The deepest boring penetrated down to about elevation -100.0 ft, approximately 99.2 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer

falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix A.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix B.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-036[1]	"H" Line	702+90.6	88.2 Lt	+3.4	-11.6	-72.6	RW
R-09-037[2]		704+03.1	48.5 Rt	-0.9	-8.4	-82.4	RW
A-09-106[3]		704+28.8	22.2 Lt	+1.0	NE	-10.5	HSA
A-09-109[3]		705+91.0	37.0 Rt	+0.9	NE	-10.6	HSA
A-09-110[3]		707+76.3	39.2 Rt	+1.2	NE	-10.3	HSA
CPT-09-066		702+17.7	51.1 Rt	-0.8	NR	-100.0	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3.Boring performed by 2R Drilling Co.
4. GWE = Groundwater Elevation.
5. GSE = Ground Surface Elevation (estimated from topographic plans).
6. Top of Boring Elevation Based on NAVD88.
7. RW = Rotary Wash, HSA = Hollow Stem Auger, CPT = Cone Penetration Test.
8. NR = Not Recorced, NE = Not Encountered.

2.2.2 CPT Soundings

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set

of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

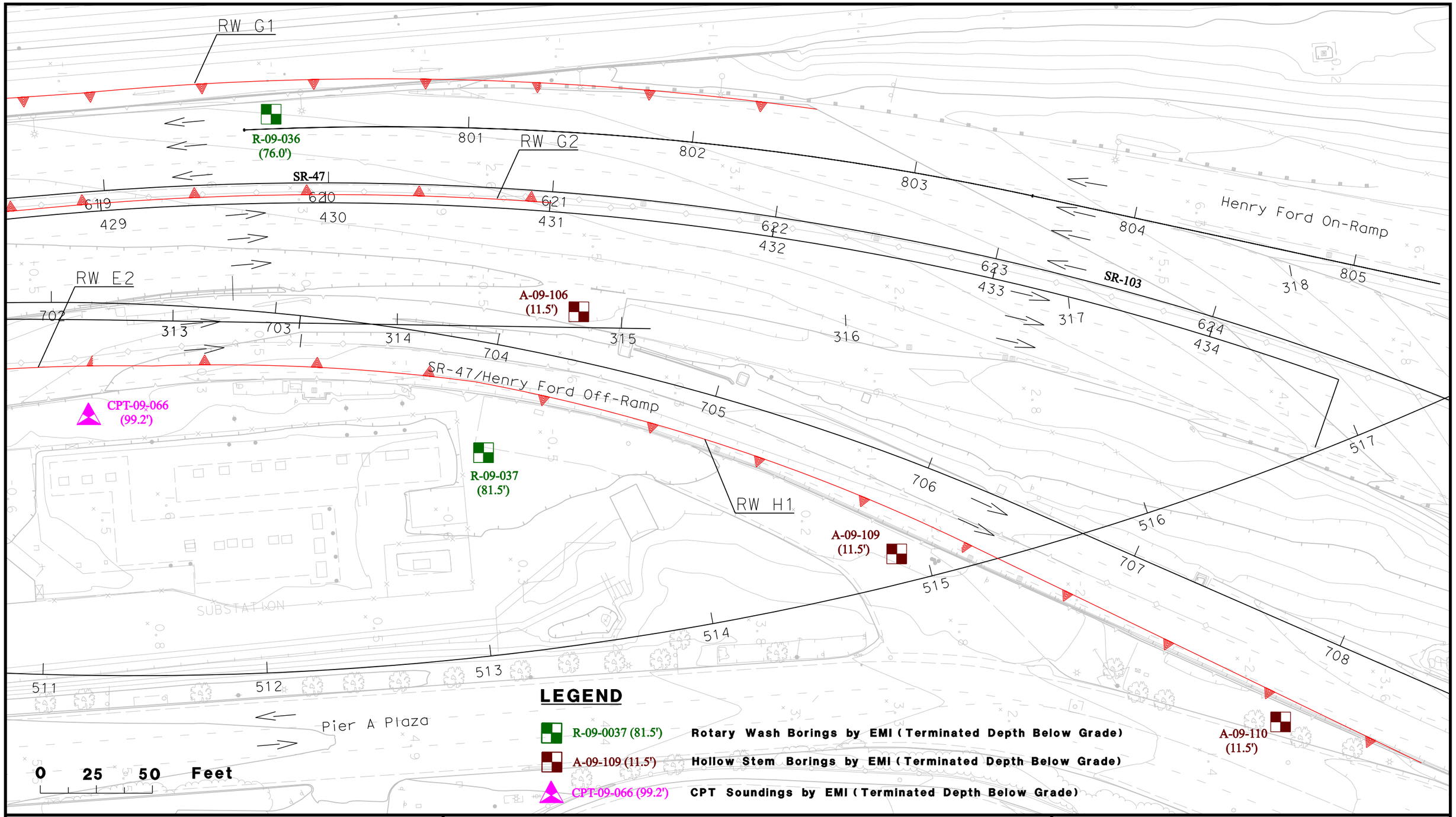
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix C.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



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Project No. 06-123

Date: 05-10-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 4 and 5). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department (LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas

are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

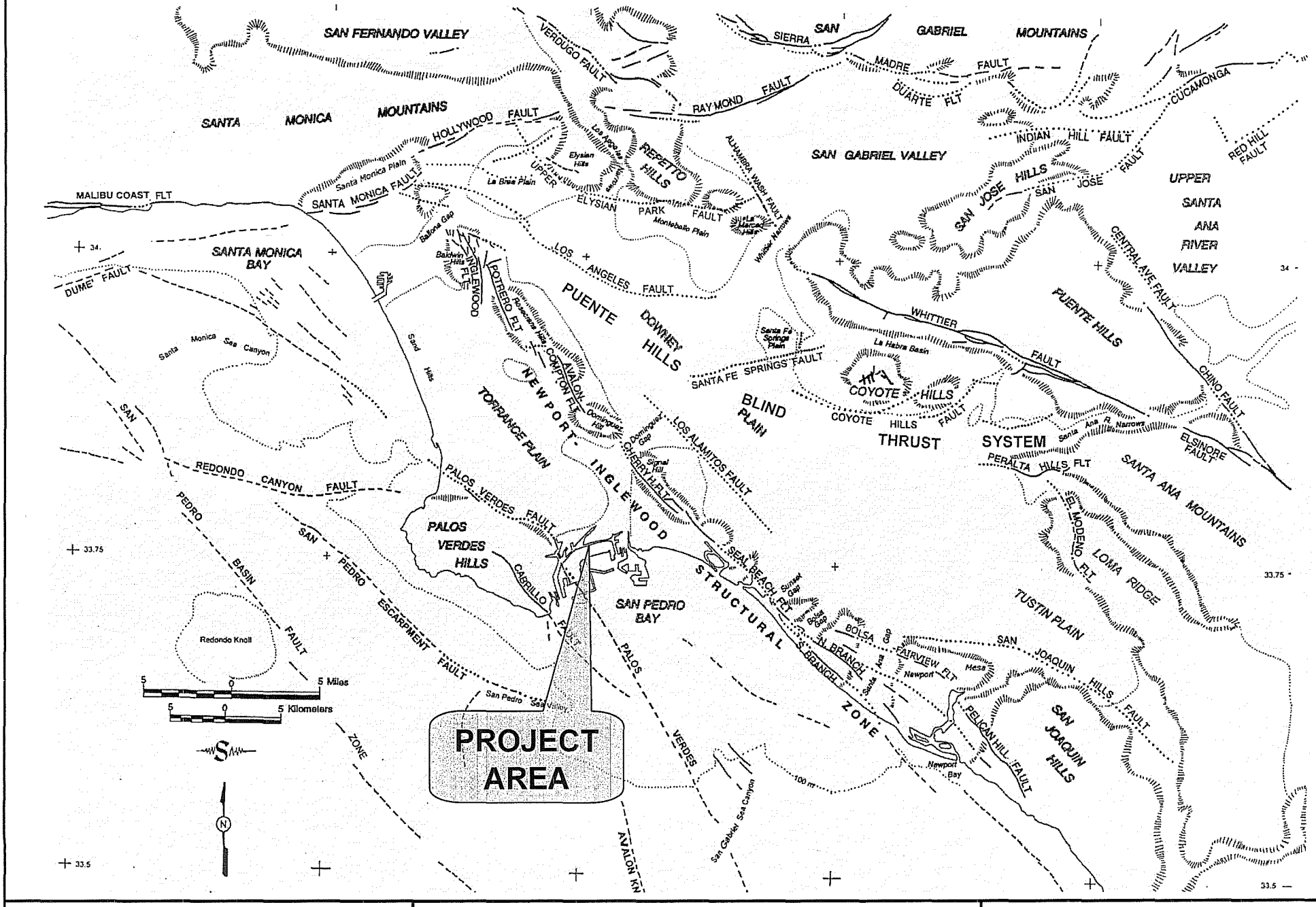
3.5.4 Tsunami and Seiche

Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



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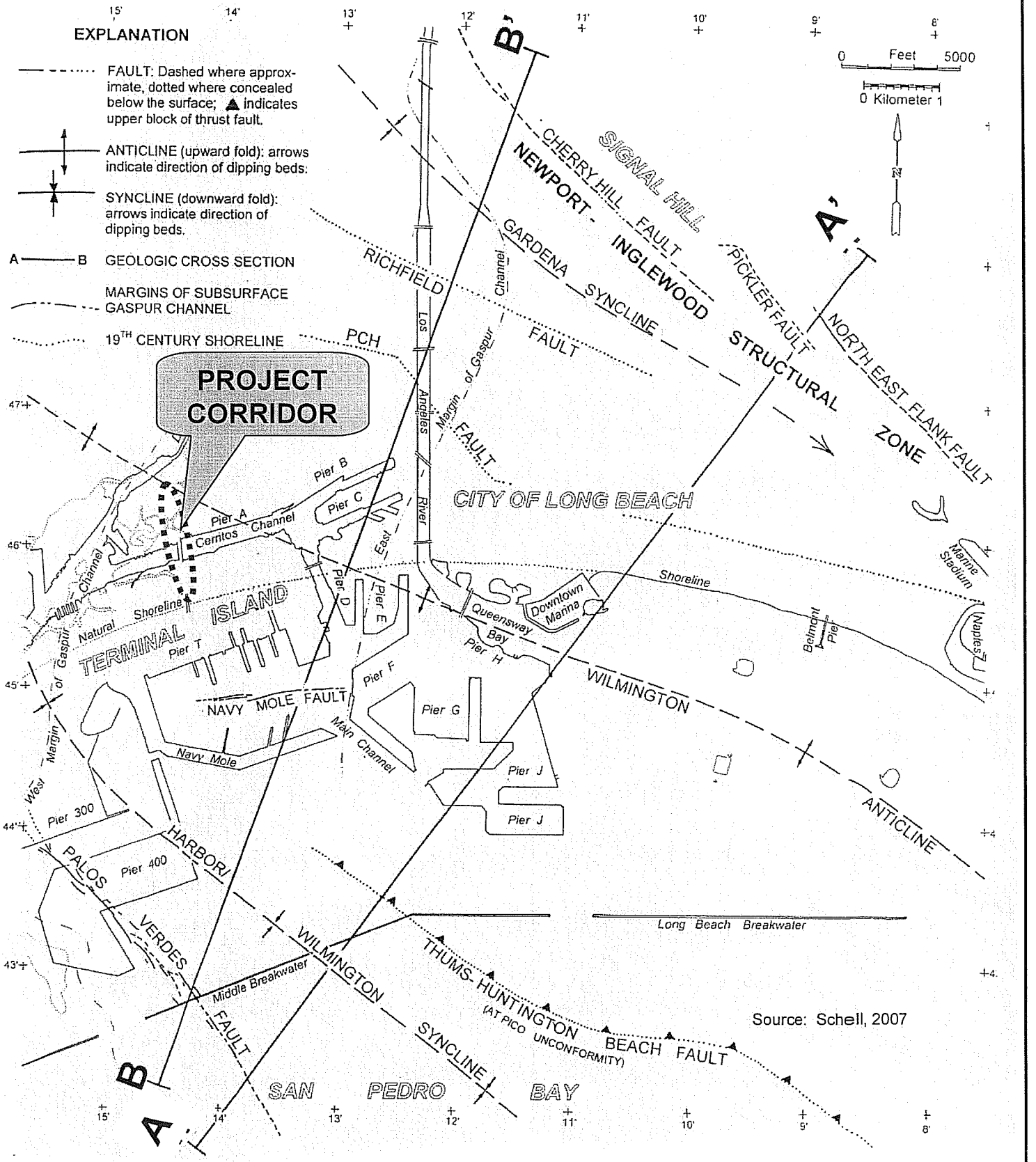
Map of Active Faults and Physiography, LA Basin

Figure 4



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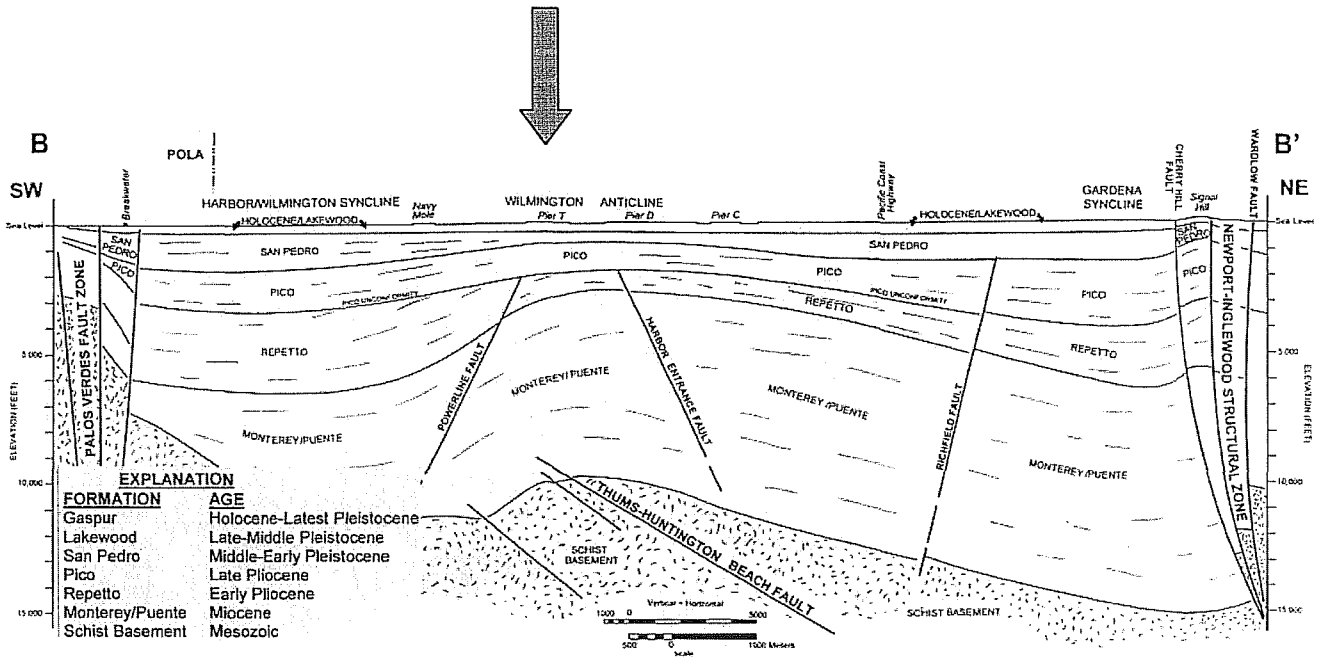
Structural Geology Map, Long Beach Harbor

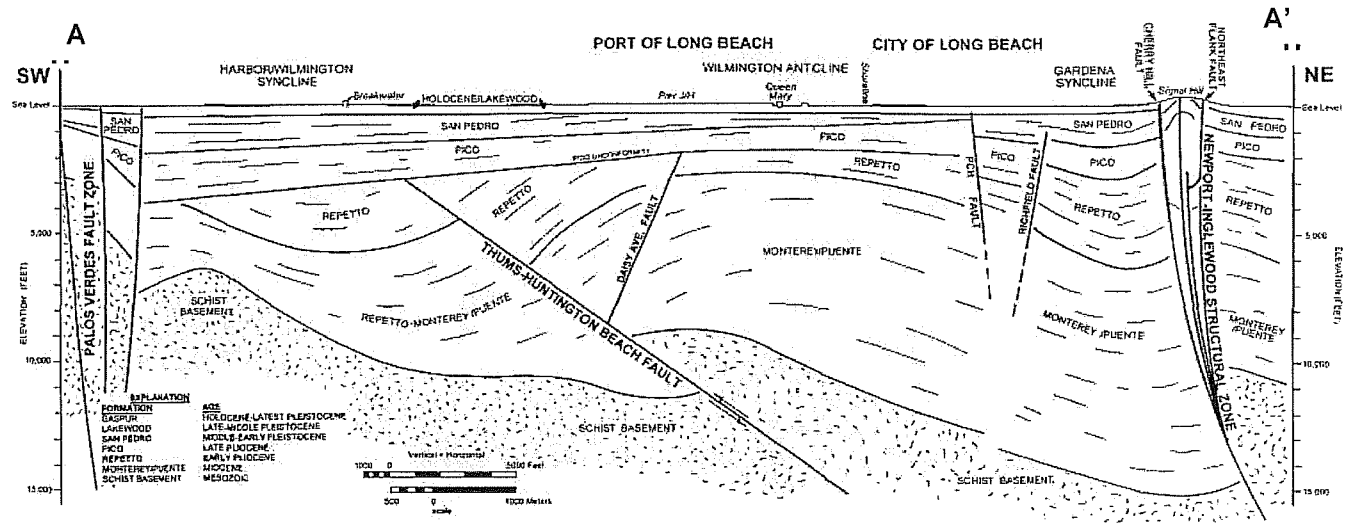
Figure 5

Project No. 06-123 | Date: 5-10-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH



A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

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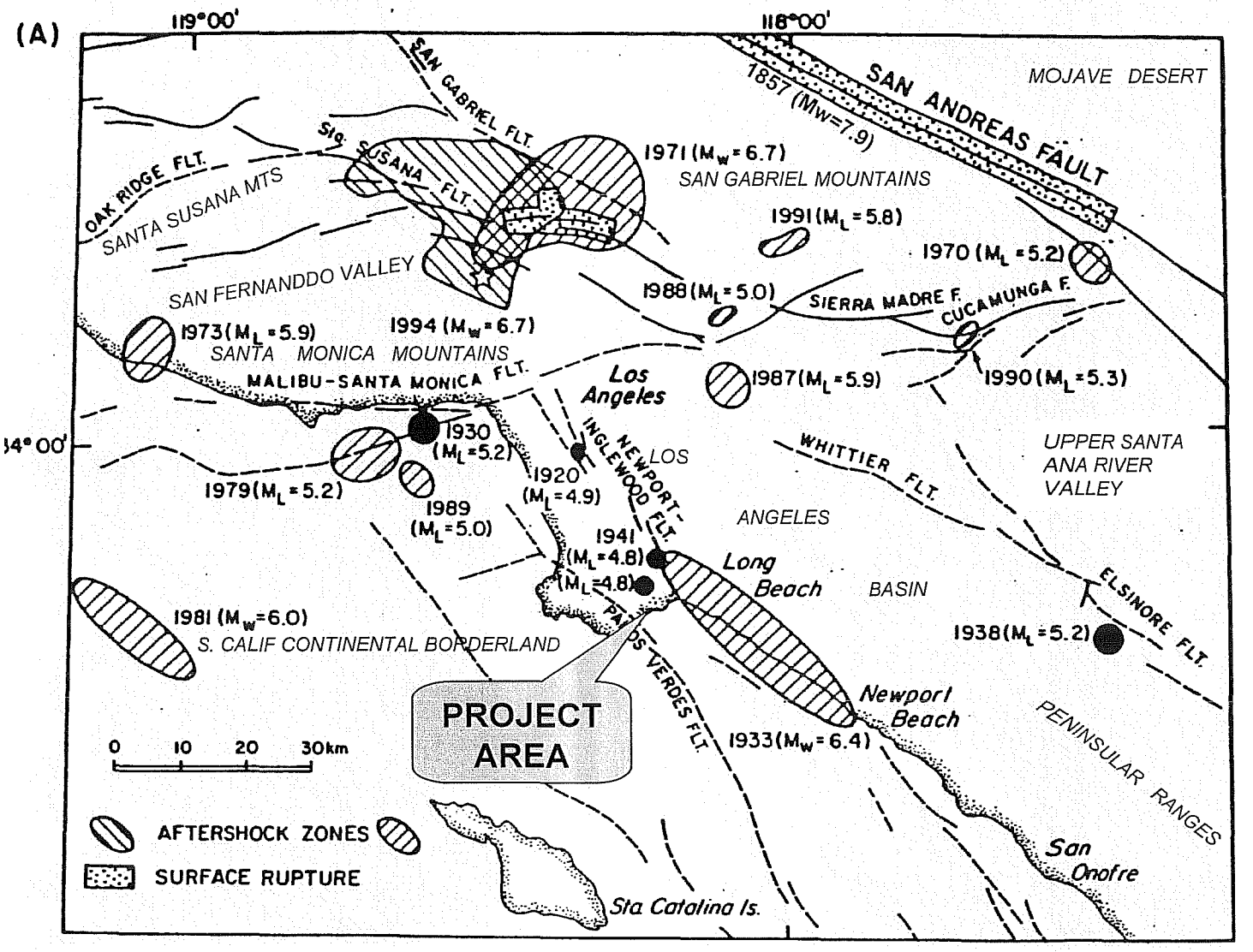
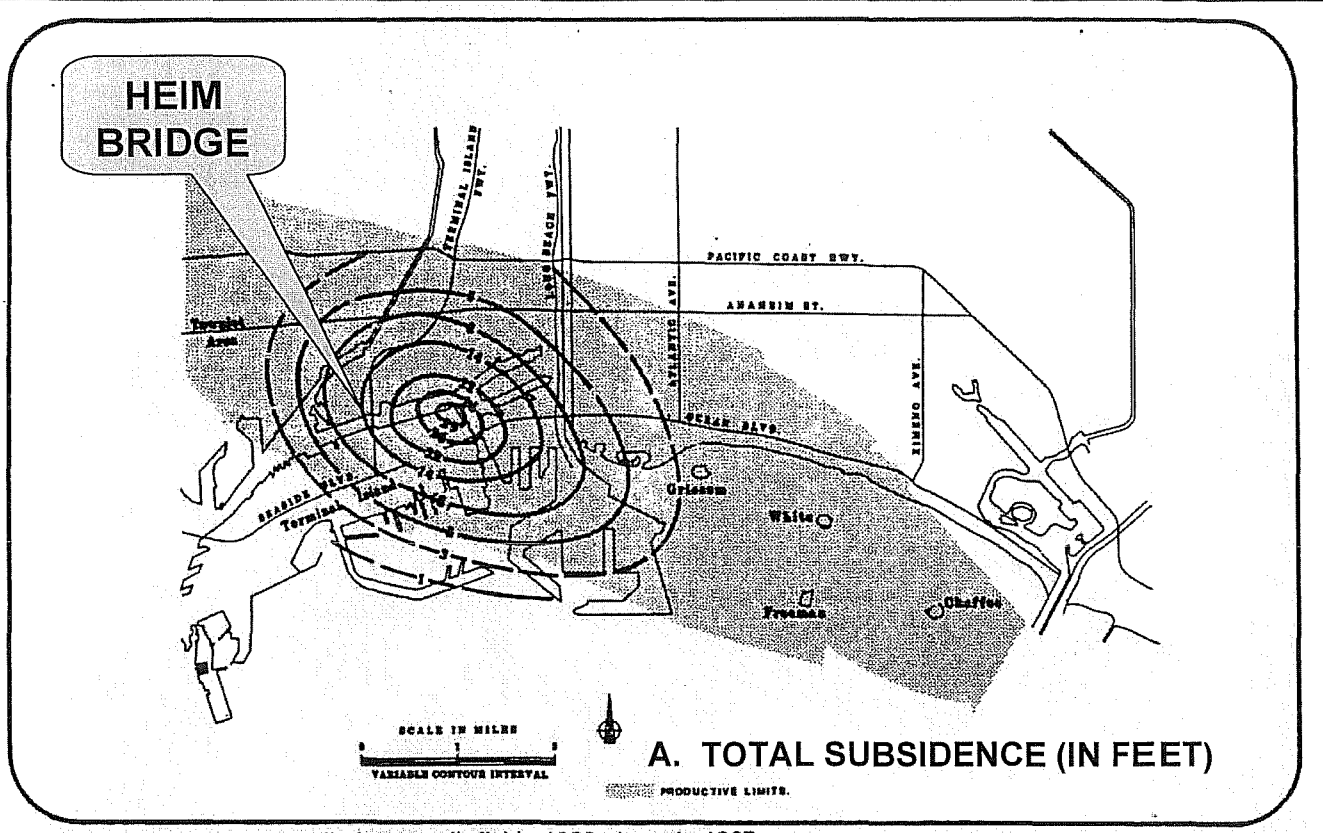
Project No. 06-123	Date: 5-10-10	Geologic Cross-Sections, LA Harbor Figure 6

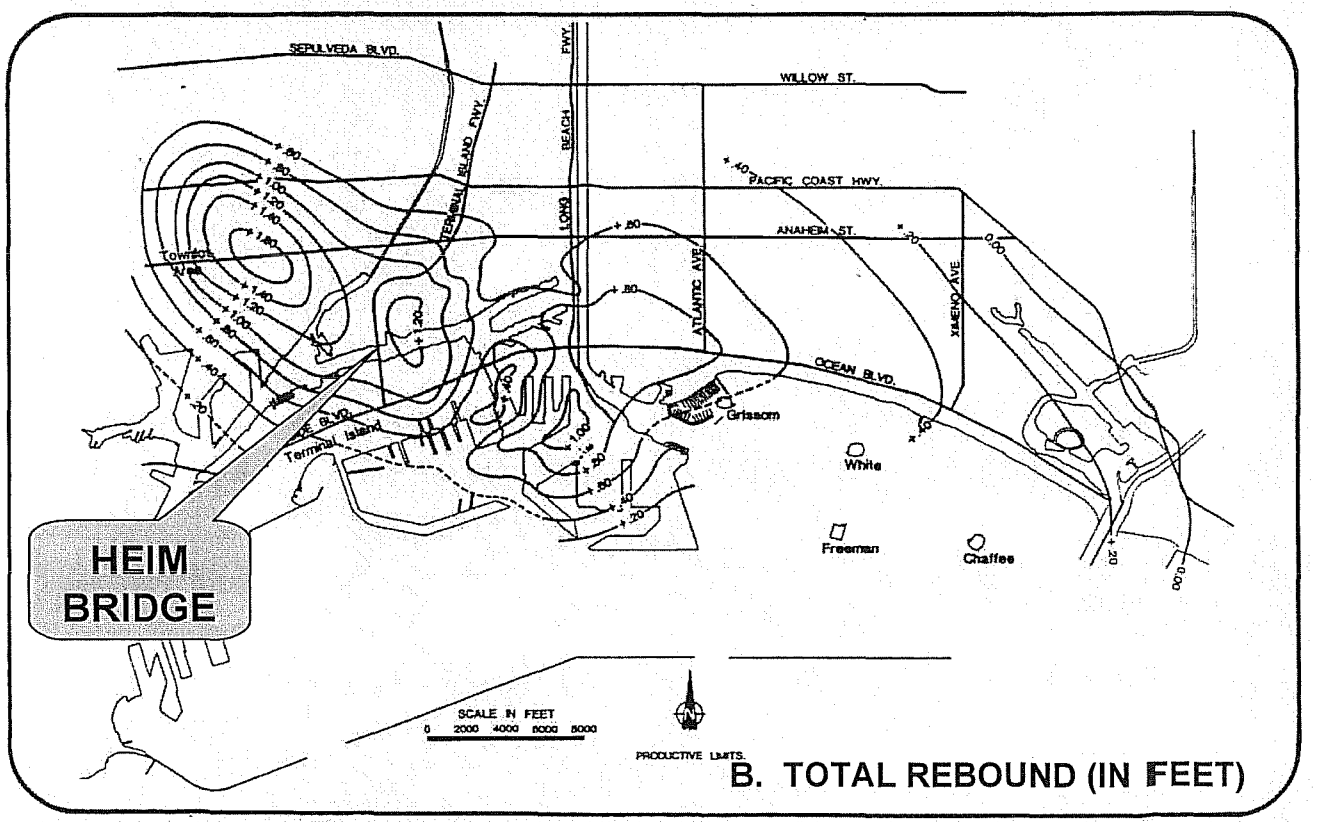


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-10-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

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Project No. 06-123 | Date: 5-10-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -100 ft), the subsurface profile consists of about 55 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about zero. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -5 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -55 ft. Below elevation -55 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in both of the deep borings performed near the proposed wall at elevation -8.4 ft and -11.6 feet. The elevation that groundwater was encountered in each boring is listed in Table 1 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

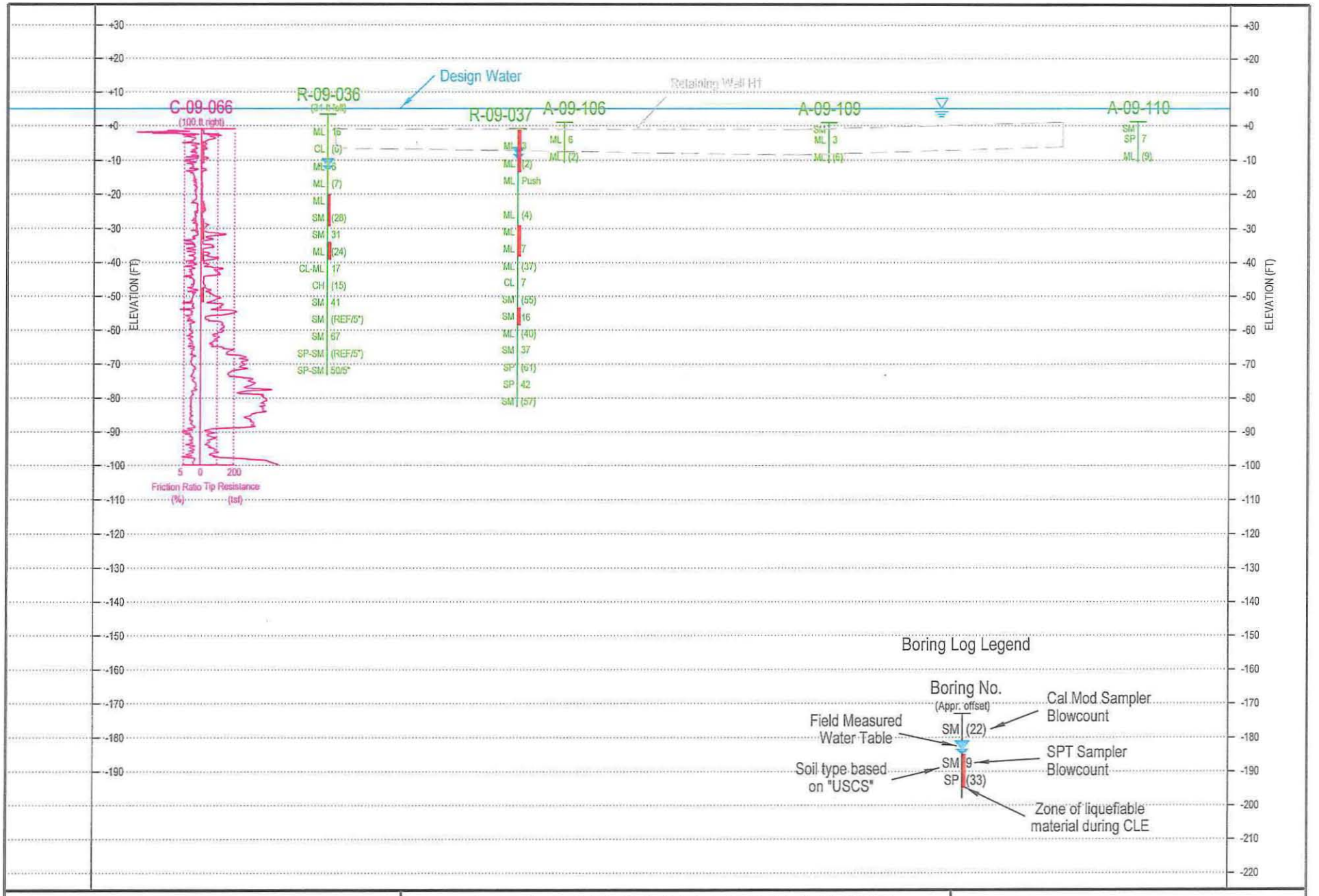
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

Based on information collected from borings R-09-036, R-09-037, A-09-106, A-09-109, A-09-110 and CPT sounding CPT-09-066, an idealized soil profile for foundation analysis and design was developed along the alignment of the proposed wall. The subsurface profile beneath the proposed structures is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+2.0 to -5.0	Silty Sand / Sandy Silt	120	0	30
-5.0 to -30.0	Clayey Silt / Sandy Silt	120	700	0
-30.0 to -40.0	Silty Sand / Sandy Silt	120	0	30
-40.0 to -50.0	Clayey Silt / Lean Clay / Silty Clay	120	2,500	0
-50.0 to -65.0	Silty Sand	120	0	34
-65.0 to -100.0	Sand / Sand with Silt / Silty Sand	125	0	38



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Subsurface Profile

Figure 9

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix D.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -55 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-036	-19 to -29	1.4	2.4
	-34 to -39	1.0	
R-09-037	-1 to -12	3.4	6.1
	-28 to -38	1.9	
	-53 to -58	0.8	
CPT-09-066	-4.0 to -10.0	0.5	2.0
	-22.6 to -24.8	0.6	
	-28.5 to -33.5	0.6	
	-37.0 to -39.3	0.3	
	-47.8 to -52.2	0.2	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Three soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.5 and 8.0, the minimum resistivities were found to vary between 65 and 190 ohm-cm, soluble chloride contents varied between 2,257 and 12,774 parts per million (ppm) and soluble sulfate contents varied between 518 and 1,187 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

5.4 Retaining Wall Recommendations

As described in Section 1.2, Proposed Retaining Wall H1 is a Caltrans Type I Retaining Wall located between approximate Stations 702+90 and Sta. 707+25 ("H" Line). The retaining wall is approximately 428 ft long and will vary in design height from 4 to 10 ft.

Based upon the preliminary cross sections provided by the wall designers, the proposed wall will have a footing bottom between approximately elevation -6 to -10 ft. Due to the soft to loose consistency of the near surface deposits along the proposed wall, spread footings are not suitable for support of the proposed wall. While both driven piles and Cast-In-Drilled-Hole (CIDH) piles are feasible foundation alternatives, it is our understanding that pile driving restrictions for the project make driven piles a less desireable foundation alternative compared to CIDH piles. Due

to the presence of shallow groundwater which will require "wet" construction methods and pile integrity testing, 24-inch diameter CIDH piles are recommended for support of the proposed structure.

5.4.1 Lateral Earth Pressures

The proposed retaining wall will be a "cut" wall and will retain the native, near-surface alluvium. A static active lateral earth pressure of 40 psf per ft of depth is recommended for design of cantilever retaining walls with a uniform lateral pressure of at least 80 psf due to vehicle surcharge load. This static active lateral earth pressure is applicable for a free-draining and level backfill.

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the subject wall need not to be designed for seismic earth pressures.

5.4.2 Pile Foundations

Axial Pile Capacity: Axial pile analyses were performed using the computer program SHAFT 6.0 (Ensoft 2007). The calculated axial geotechnical capacities and pile tip elevations for a single 24-inch CIDH pile is presented in Table 6. For the extreme event limit case, negative skin friction due to seismic settlement was estimated using residual strengths for liquefiable soils based upon the method outlined in Seed and Harder (1990). The bottom of the liquefiable layer contributing to negative skin friction was determined to be at elevation -40 ft based upon the seismic settlement analysis performed on boring C-09-066.

The maximum pile-head settlement due to the nominal resistance is estimated to be less than 1-inch. For axial loading, a group effect reduction factor of 0.8 was included in determining the tip elevation shown in Table 6.

TABLE 6. RECOMMENDED PILE TIP ELEVATIONS

Approx. Wall Station; "H" Line	Approx. Pile Cutoff El. (ft)	Design Loading (Service) (kip)	Nominal Resistance (kip)		Design Tip El. (ft)[1]	Specified Tip El. (ft)
			Compr.	Tension		
702+90 to 707+25	-3.5 to -7.0	90	180	0	-61.0 (a) -45.0 (b)	-61.0

Note: (1) Design tip elevation is controlled by the following demands: (a) Compression, (b) Lateral Loads.

Lateral Pile Capacity: Pile-head shear capacity and maximum bending moment caused by lateral pile-head deflections for a free-head connection with the pile cap are provided in Table 7. The design tip elevation for lateral loading is given in Table 6.

Lateral pile analyses were performed using the computer program LPILE (Ensoft 2007). The internally generated p-y curves for sandy soils were estimated using the API criteria (API, 2000). The internally generated p-y curves for stiff fine-grained soils were estimated using the method proposed by Reese (Reese et al., 1975), and the internally generated p-y curves for soft fine-grained soils were estimated using the method proposed by Matlock (Matlock, 1970). A group reduction factor of 0.9 was used in the analysis based a staggered pile layout with an average pile spacing of 6 ft along the length of the wall and the procedures outlined in the Ensoft Group 7.0 software Technical Manual (Ensoft 2006). Liquefied soils were modeled using a p-multiplier to degrade the static strength (Ashford et al., 2008).

The solutions presented are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and other connection details.

TABLE 7. 24-IN CIDH PILE "FREE" HEAD SOLUTION

Pile Head Deflection (in)	Pile Head Shear (k)	Maximum Moment (k-in)
0.25	19	928
0.5	27	1,484
1.0	38	2,380
2.0	55	3,839
3.0	68	5,091

Notes: 1. Group effects considered with a reduction factor of 0.9 on "p."

5.4.3 Global Wall Stability

The "global" stability of the Retaining Wall H1 was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The cross-section selected for stability analysis was near "H" Line Sta. 705+75 where the retained wall height is greatest.

Slope stability analyses were conducted for the static condition. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix D) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in both of the borings performed near the proposed wall between elevation -8.4 and -11.6 ft. Based on the latest cross sections provided by the designers, the bottom of proposed footing bottom varies between about elevation -6 and -10 ft. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

Due to the proposed footing bottom elevations, the contractor should anticipate encountering groundwater during construction. The contractor should be prepared to manage groundwater and conduct construction activities in soft ground conditions. The groundwater should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 CIDH Pile Construction

Loose soils should be cleaned from the bottom of the borings. Pile borings should be inspected and approved by the geotechnical engineer prior to the installation of reinforcement. Extreme care in drilling, placement of steel, and the pouring of concrete is essential to avoid excessive disturbance of pile boring walls. Concrete placement by pumping or tremie tube to the bottom of the pile borings is recommended. Specifications should require that sufficient space be provided in the pile reinforcing cage during fabrication to allow the insertion of a tremie tube for concrete placement.

The pile reinforcing cage should be installed and the concrete pumped immediately after drilling is completed. No boring should be drilled immediately adjacent to another pile until the concrete in the other pile has attained its initial set.

Groundwater was encountered between elevation -8.4 and -11.6 feet in October and November 2009. Actual groundwater elevation may be different during construction due to seasonal rainfall, surface runoff and other man-made conditions. In addition, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely. Therefore, contractors should be prepared to use a "wet" method of construction. As a standard Caltrans practice for "wet" construction, PVC tubings must be installed within the reinforcement cage of the CIDH pile for gamma-ray testing.

Pockets and lenses of loose sandy material and very soft to soft fine-grained material were encountered in our soil borings and these materials are susceptible to caving. If caving occurs, a temporary casing may be required during construction. Casings should have an outer diameter equal to or exceeding the pile diameter. Temporary casing should be pulled as the concrete is

being poured while always maintaining at least a 5 ft head of concrete inside the casing. Contractor can choose to use a "wet" method of construction to control caving.

In the event that any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

6.3 Backfill Requirements for Walls

Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2006c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned or dried to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the walls in order to avoid damaging the walls due to large lateral earth pressures.

6.4 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.5 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Shoring installation.
- Footing excavations.
- CIDH pile construction.
- CIDH pile integrity testing.
- Backdrain installation and backfilling of retaining wall.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

7.0 REFERENCES

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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

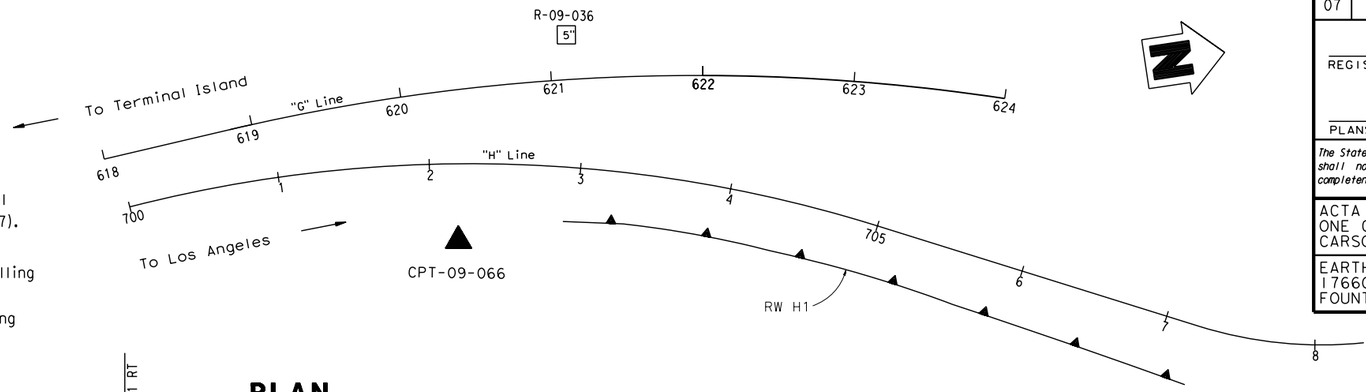
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

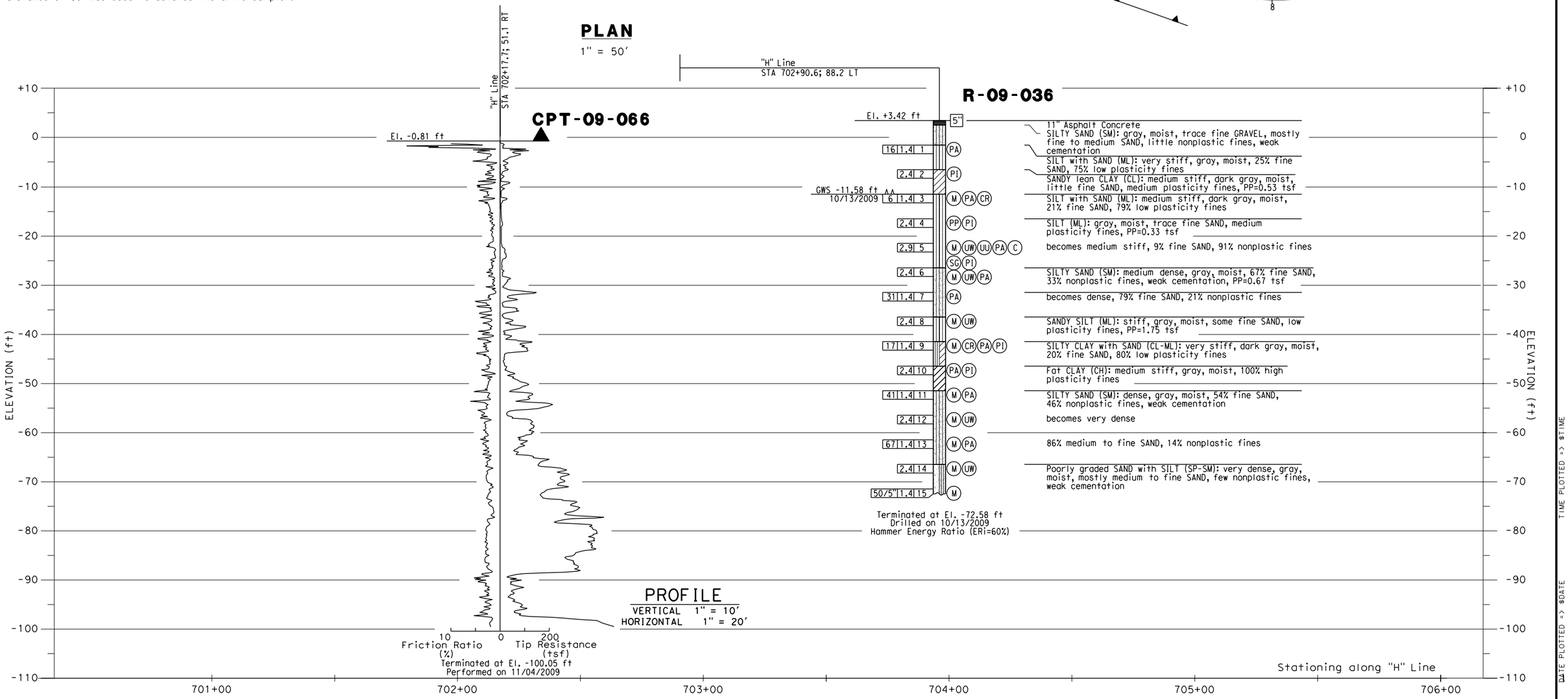
(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 50'



DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. - / POST MILE 0.18
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			

RETAINING WALL NO. H1

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10, 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER — DATE PLOTTED => $DATE — TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

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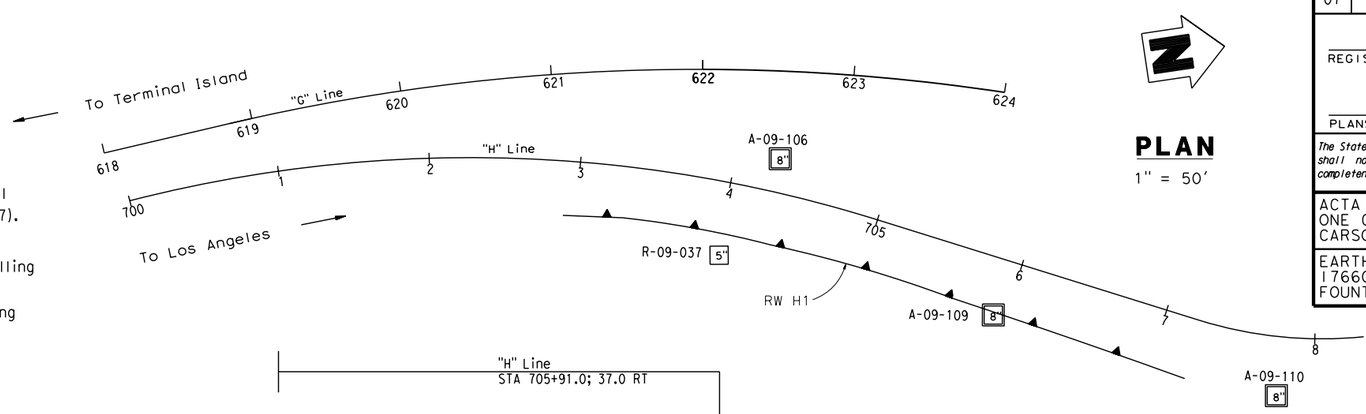
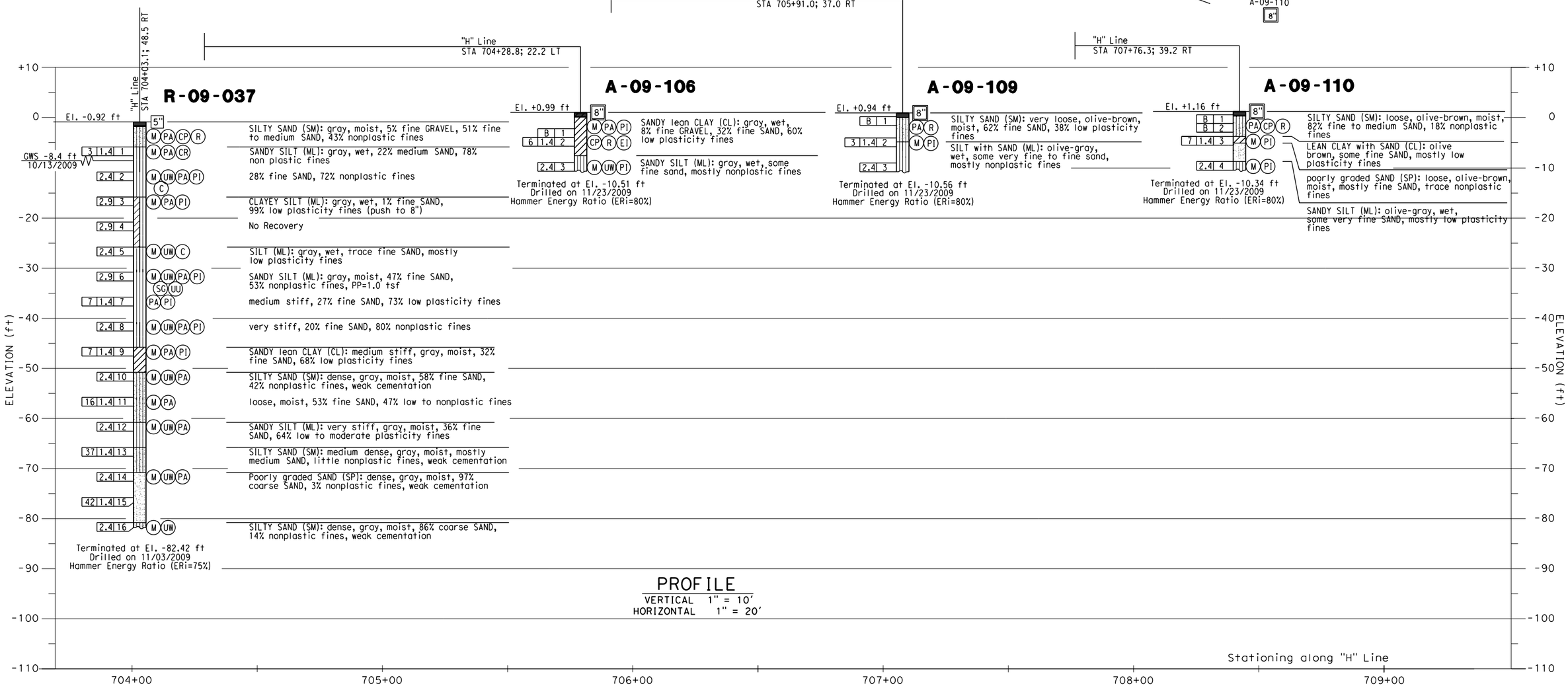


PLAN

1" = 50'



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. -	RETAINING WALL NO. H1
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.18	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER · ERIC BROWN · NO. GE-2806 EXP. 06-30-2010 · GEOTECHNICAL · STATE OF CALIFORNIA

PLANS APPROVAL DATE

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

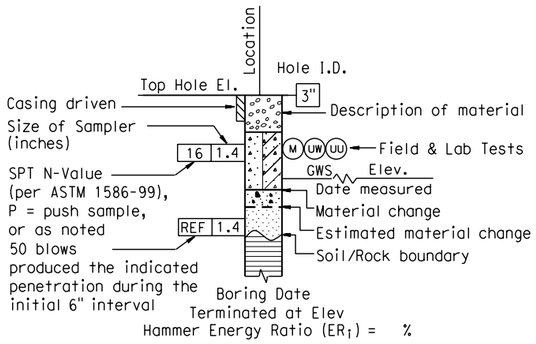
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

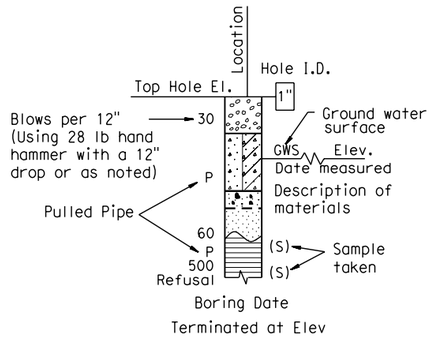
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

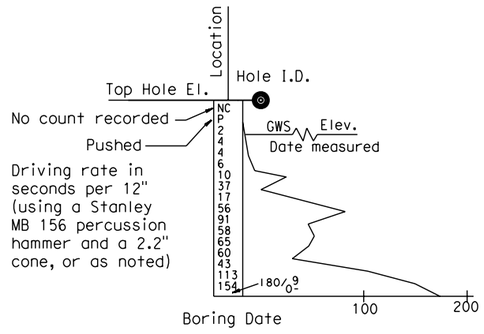
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



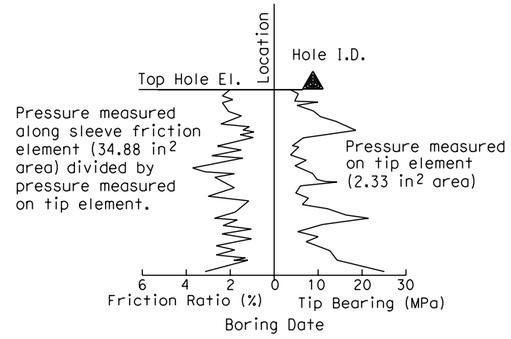
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. - POST MILE 0.18

RETAINING WALL NO. H1

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)									SHEET	OF
03/01/10	04/14/10								X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. -

POST MILE 0.18

RETAINING WALL NO. H1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 03/01/10, 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A.

EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

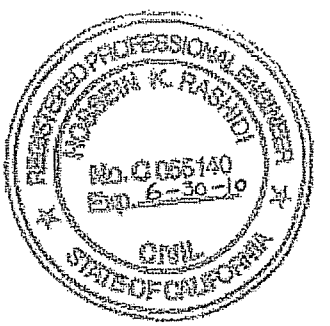
CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

Sincerely Submitted for EarthSpectives

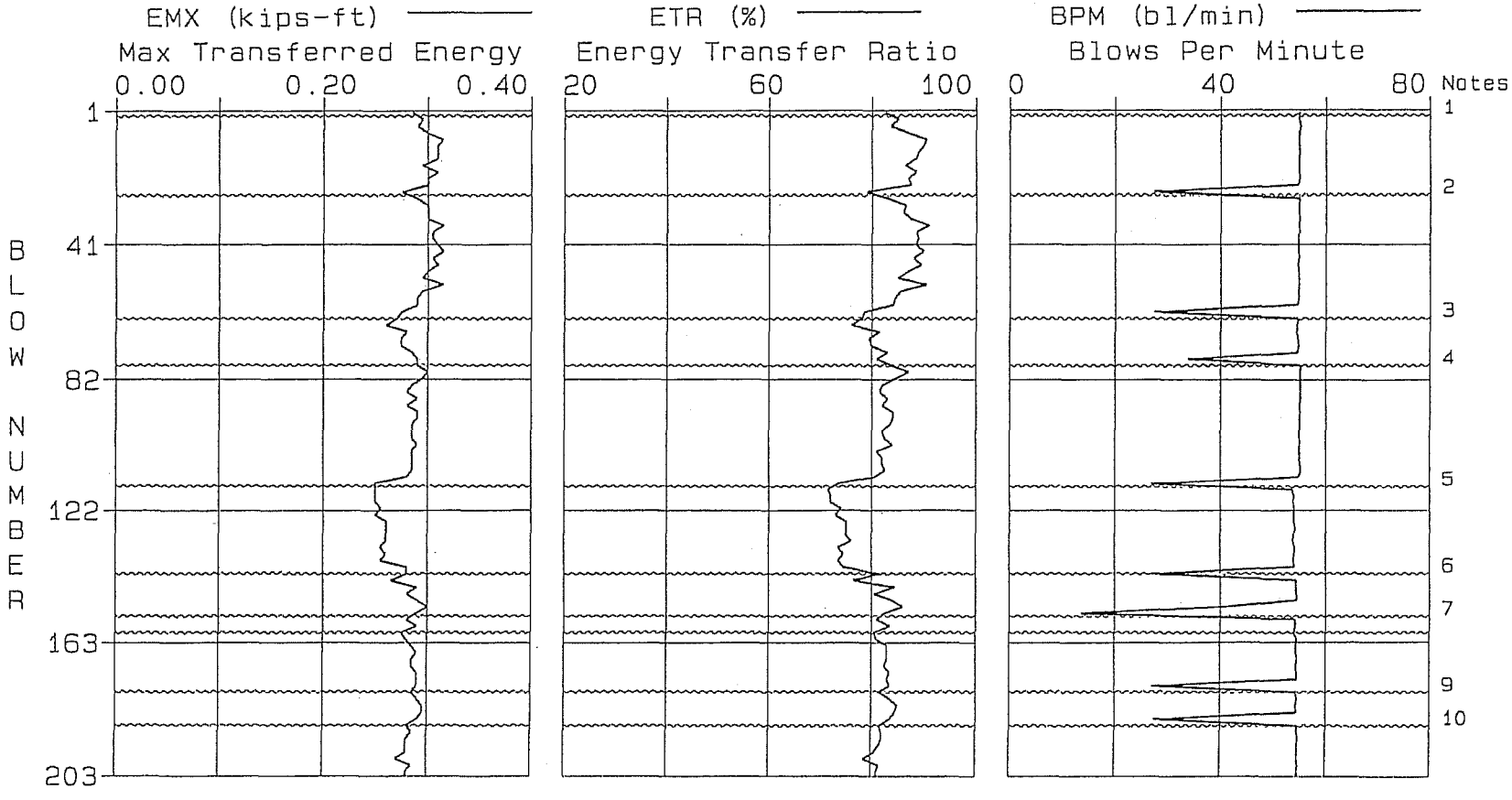
Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

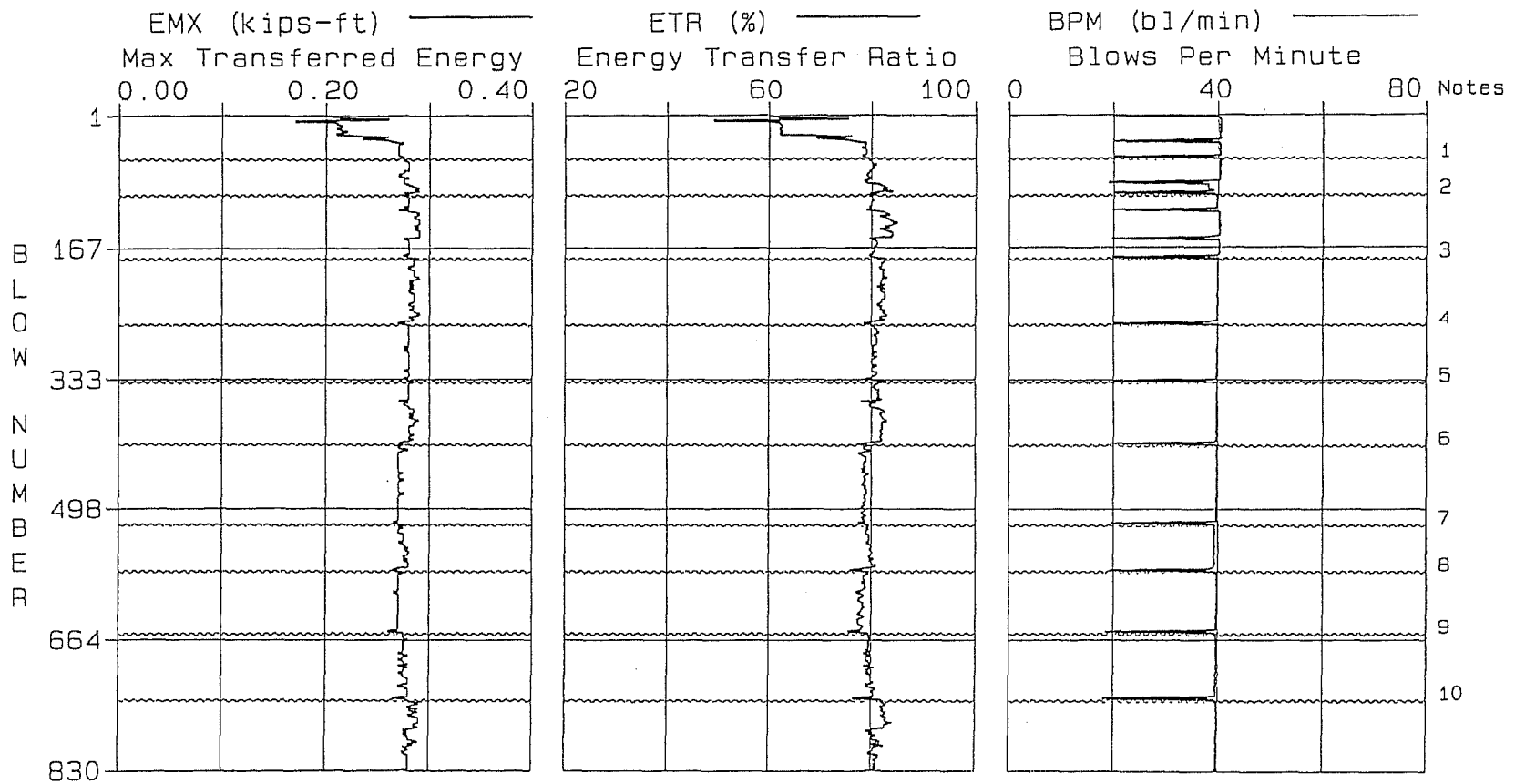
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

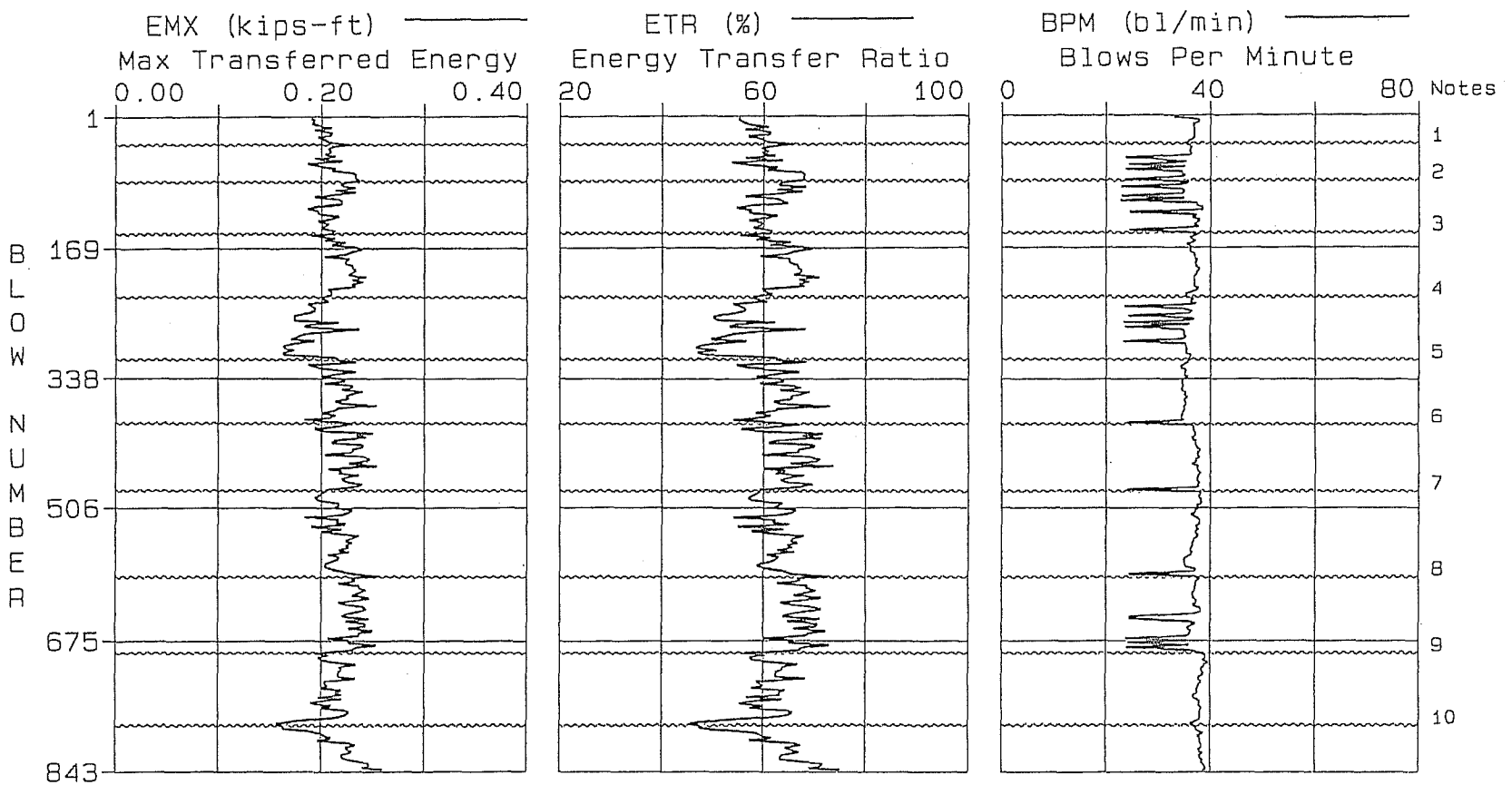
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX B.

GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

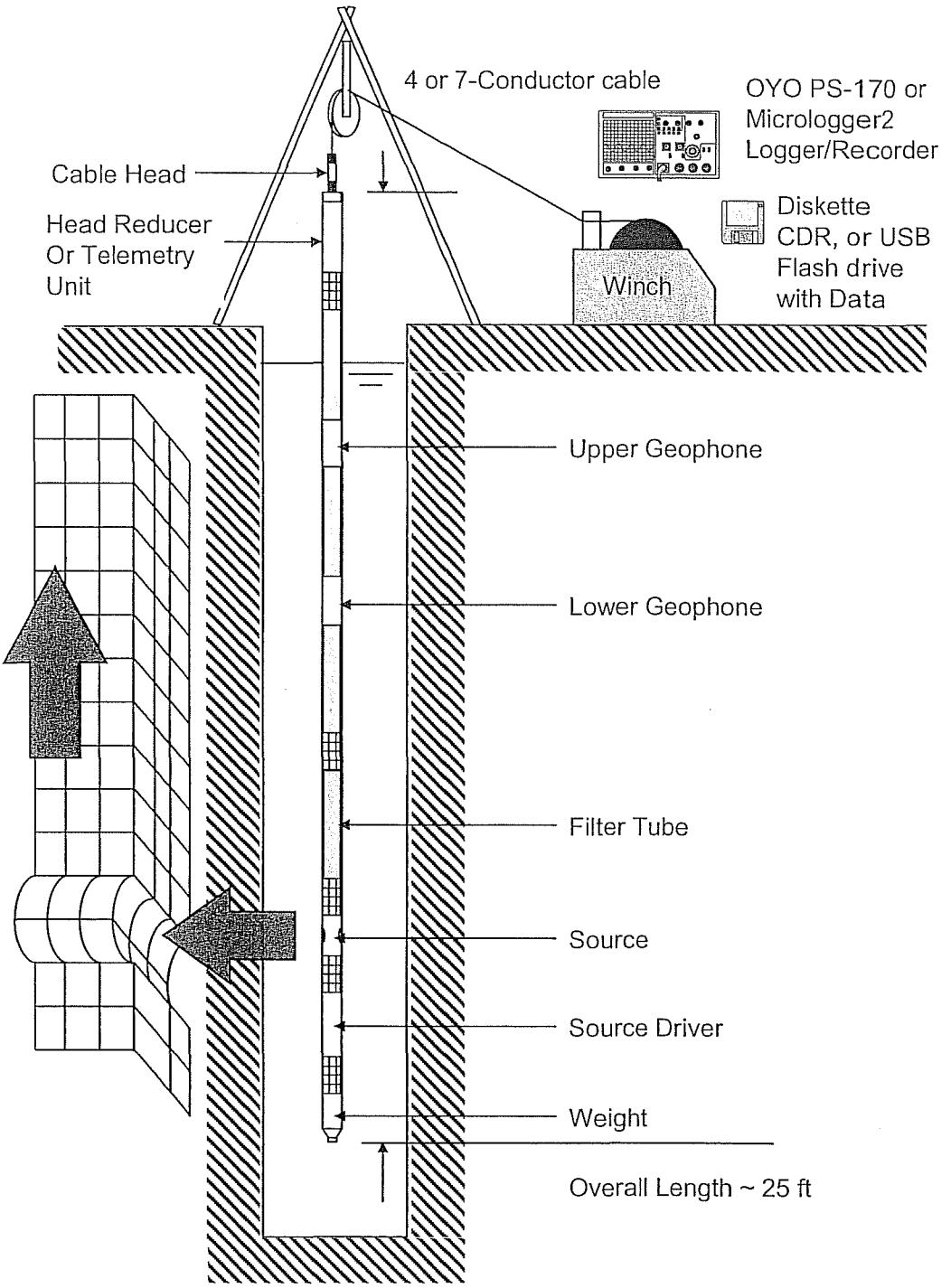

Figure 1: Concept illustration of P-S logging system

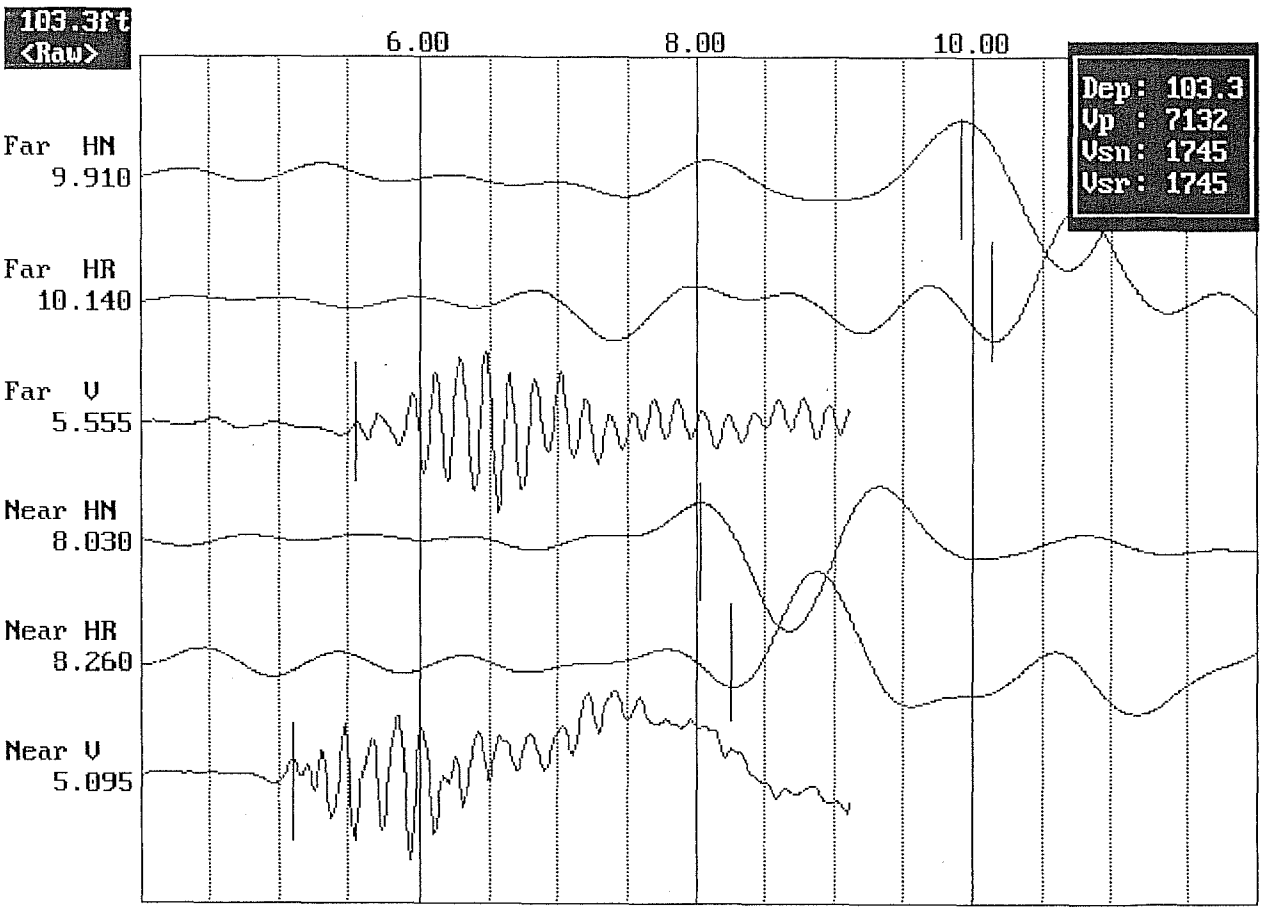

Figure 2: Example of filtered (1400 Hz lowpass) record

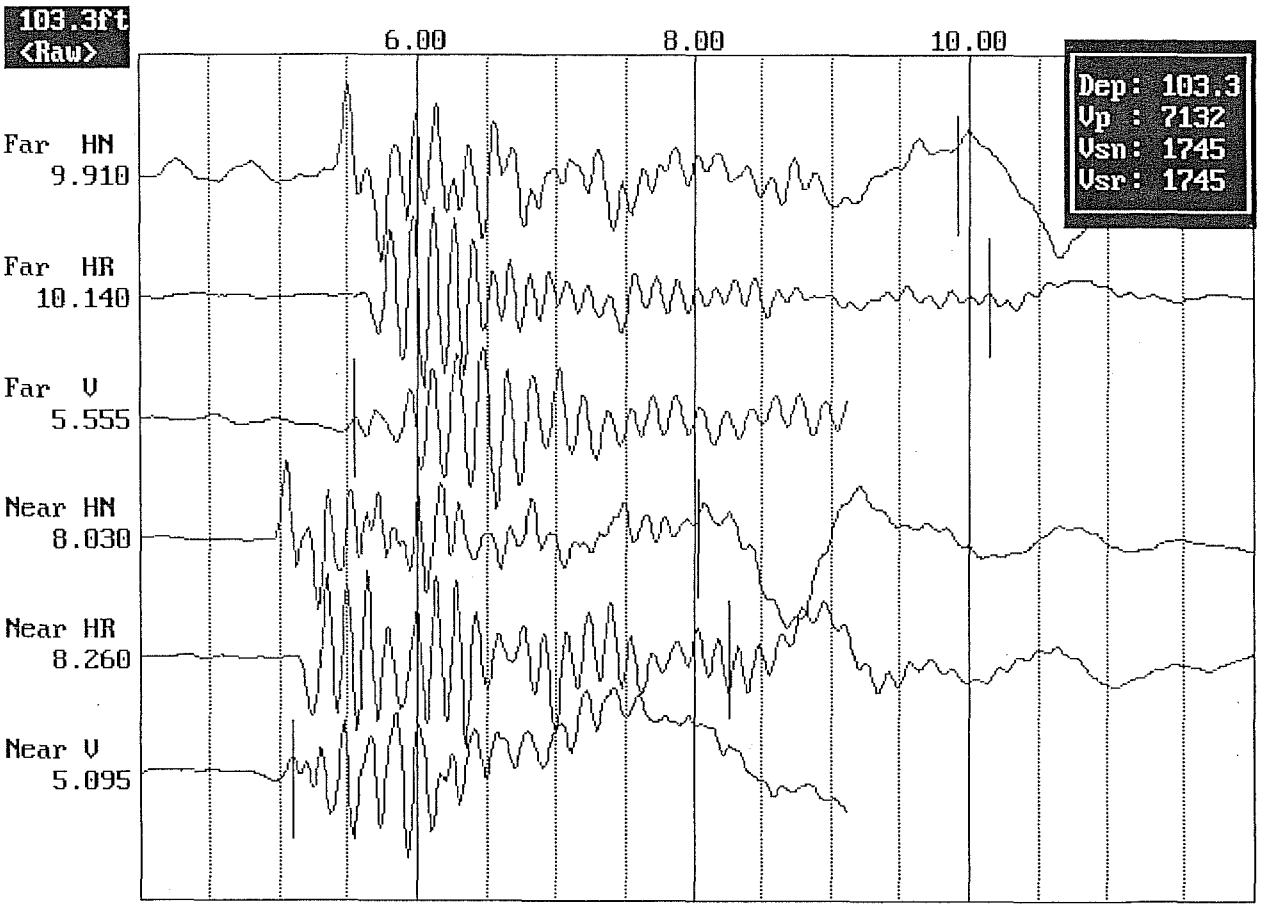

Figure 3. Example of unfiltered record

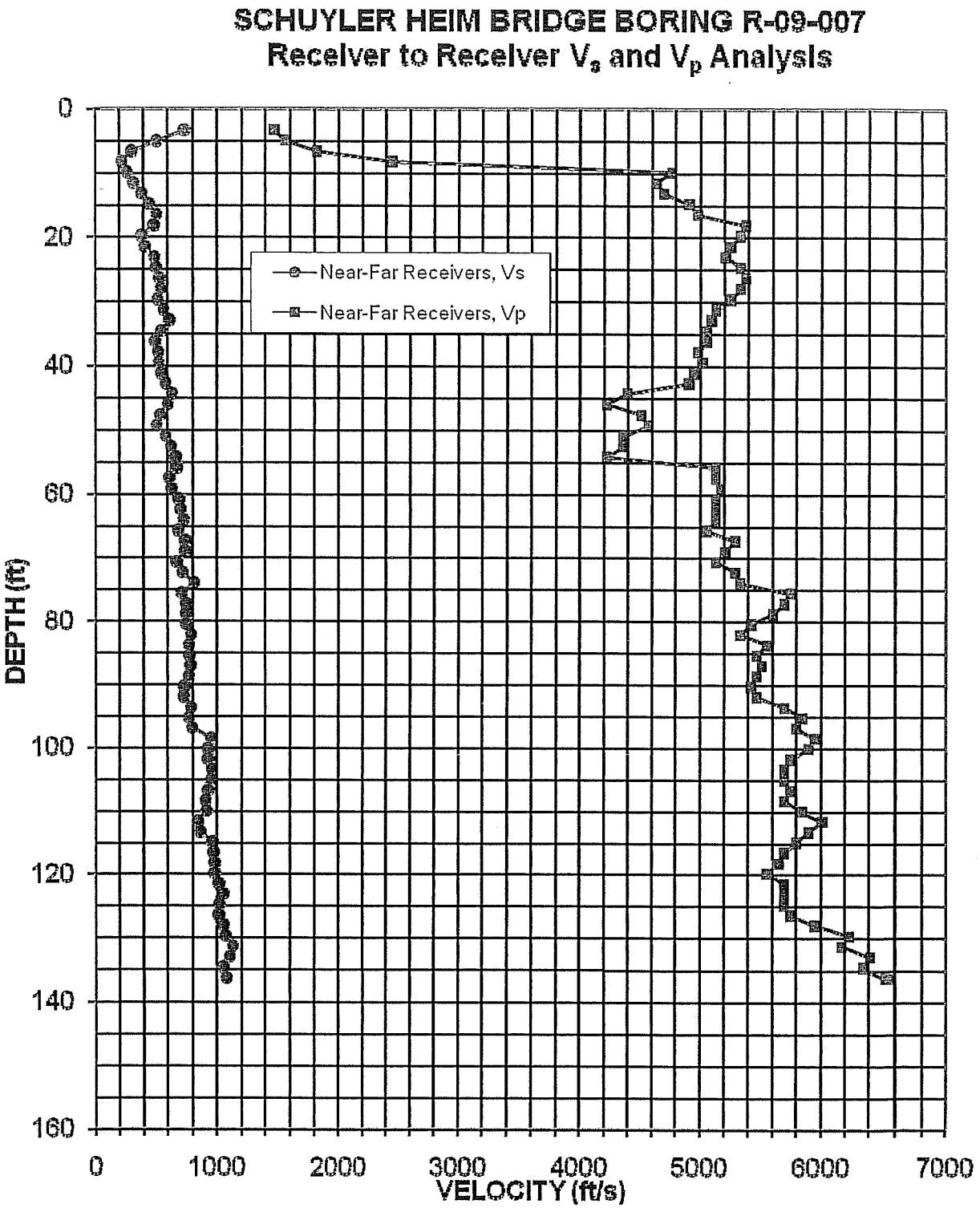

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

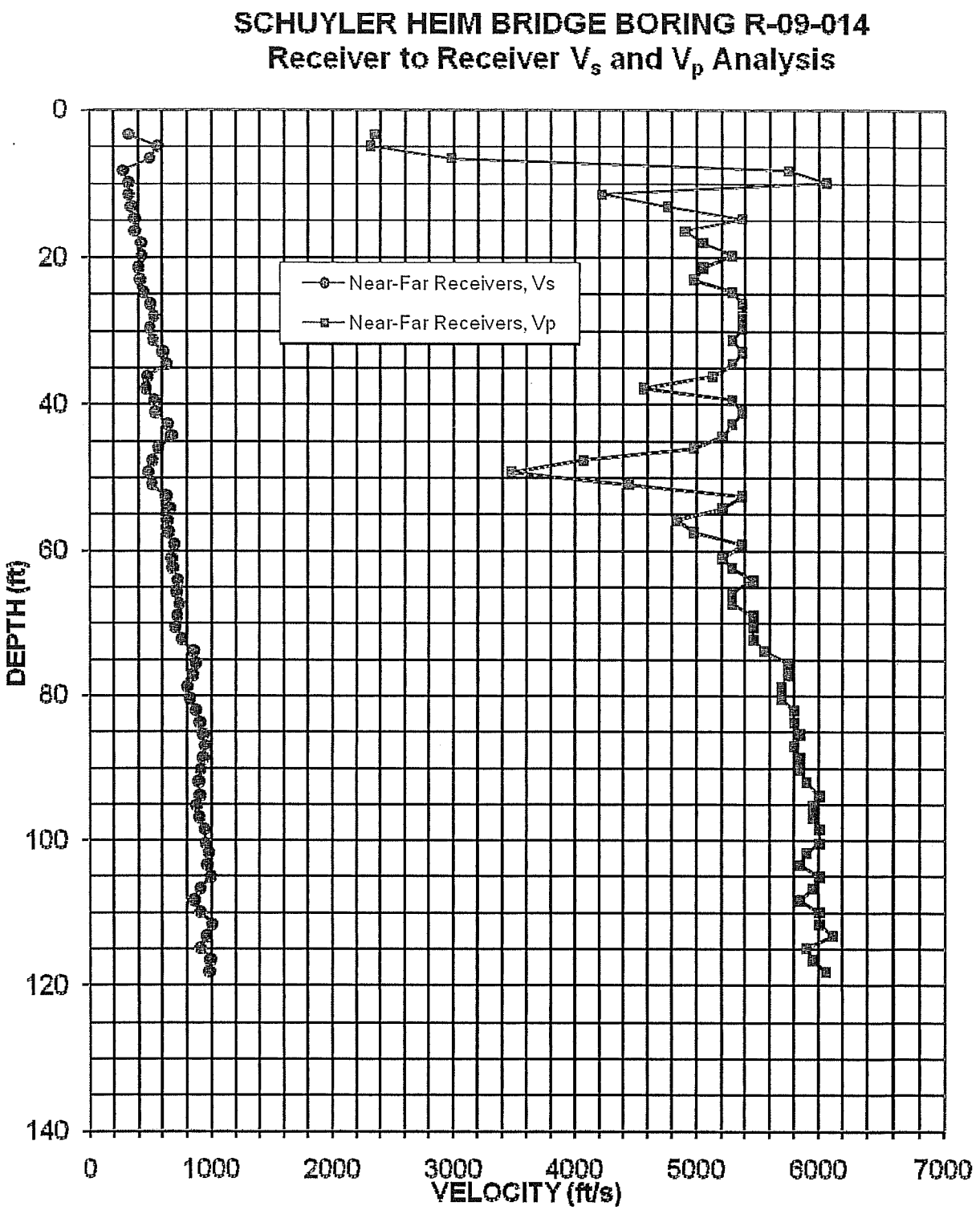

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

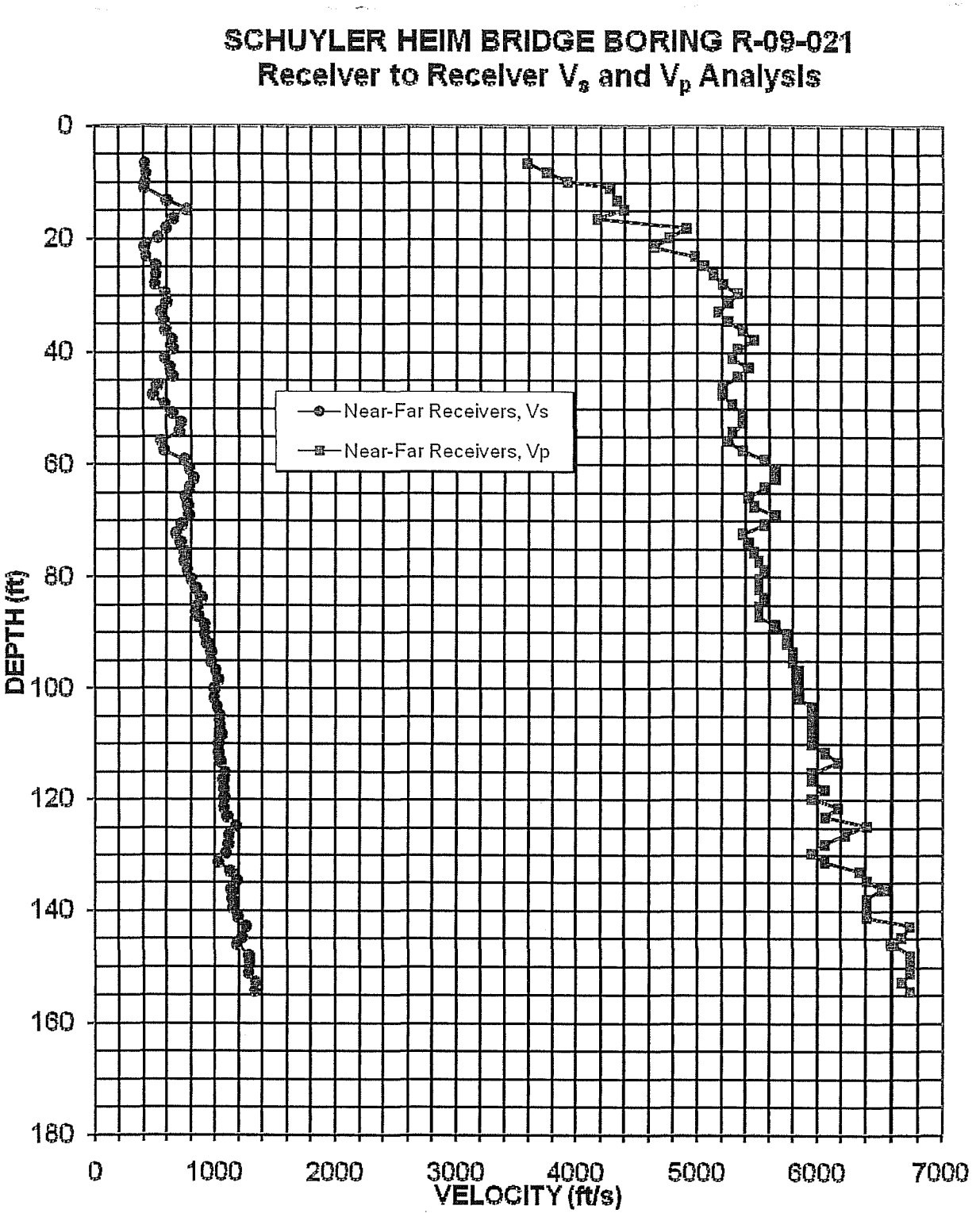

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

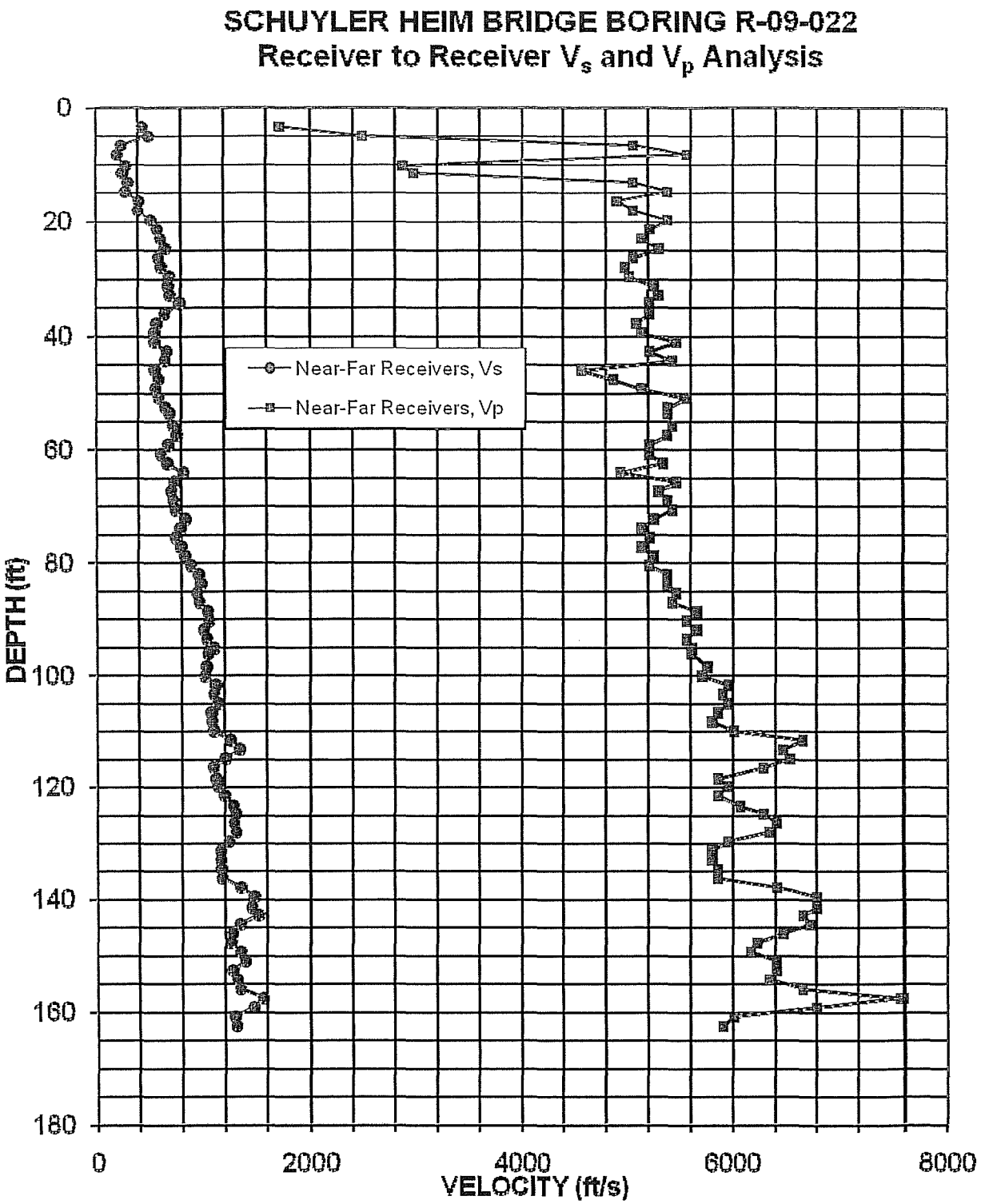

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

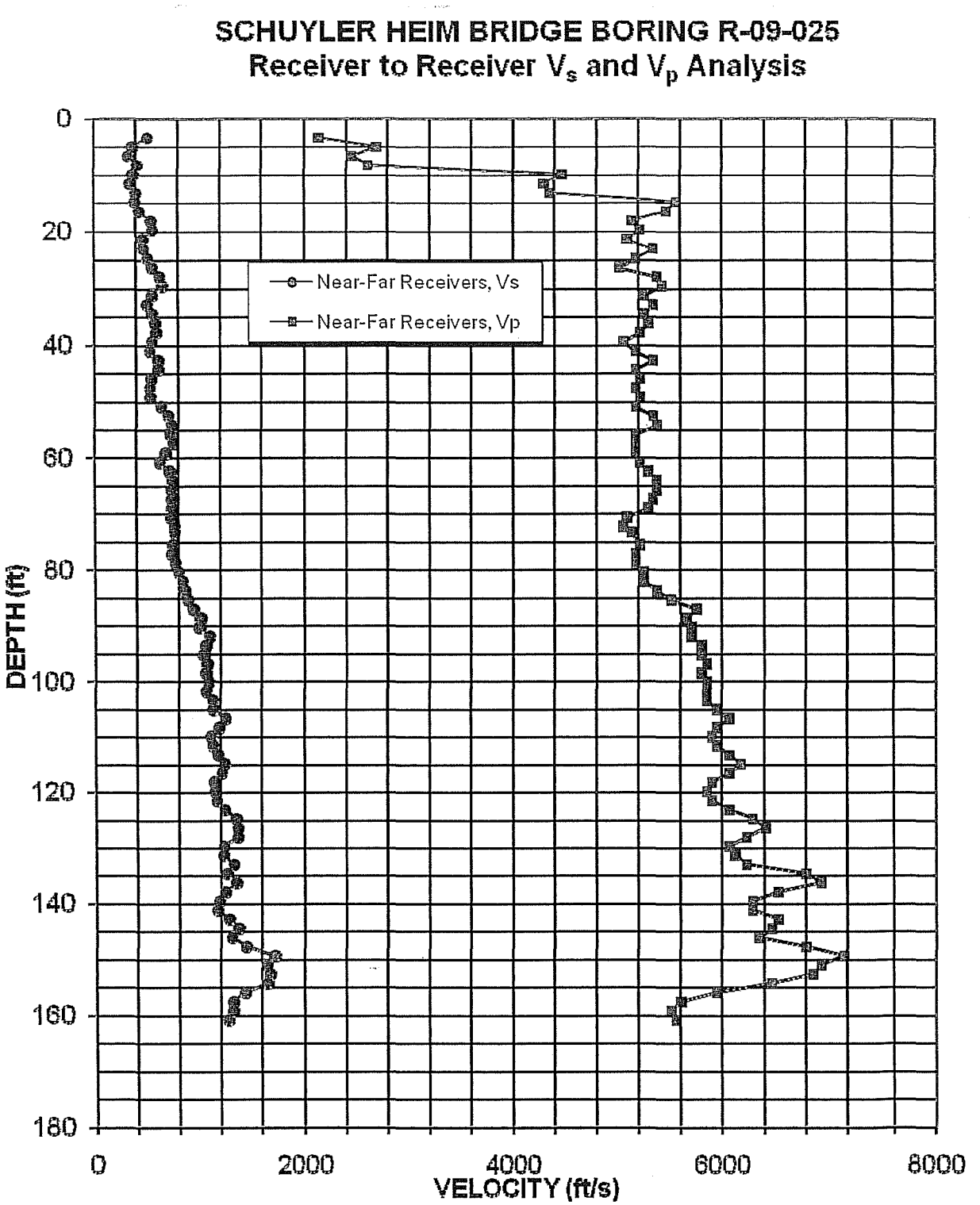

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

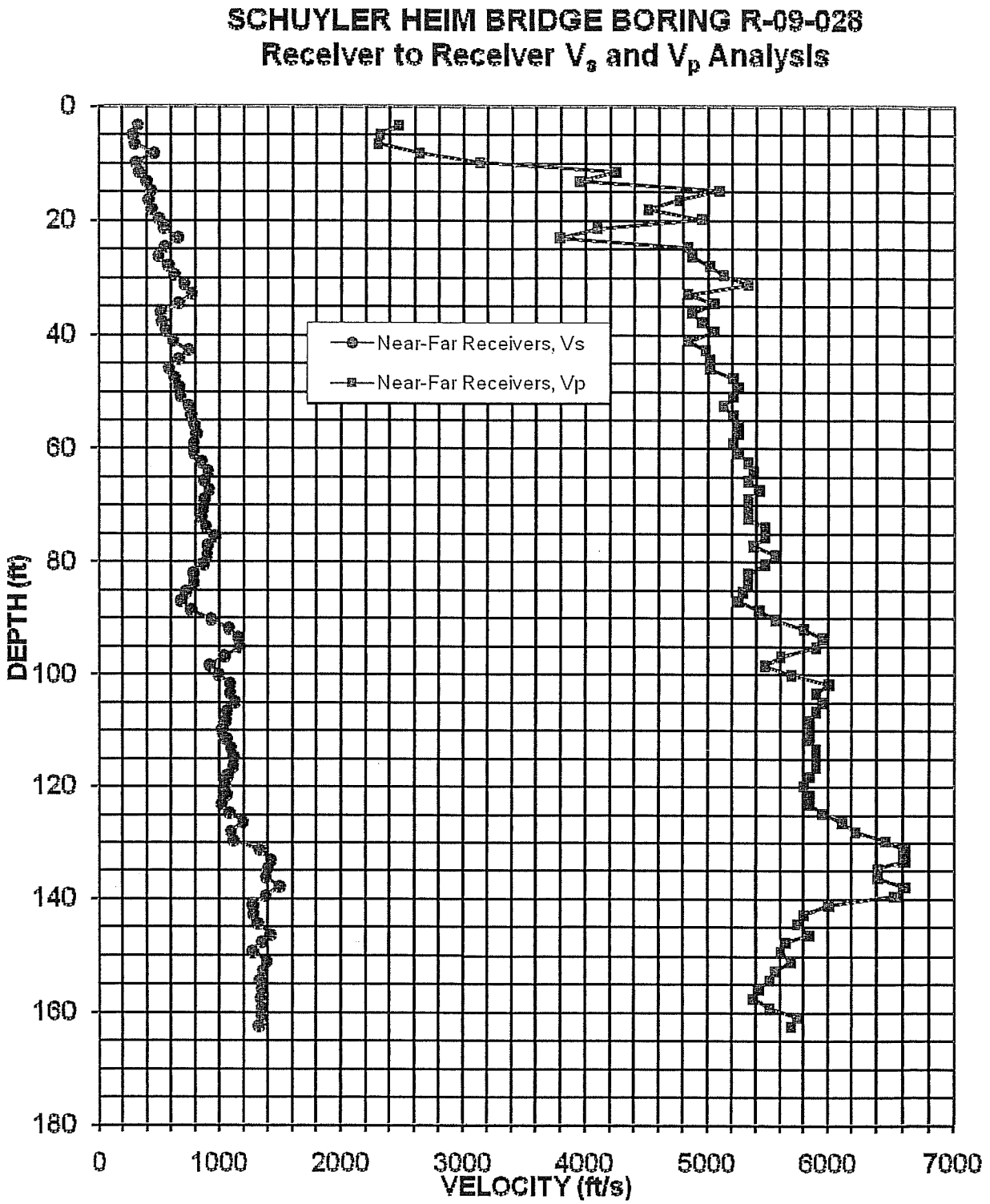

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

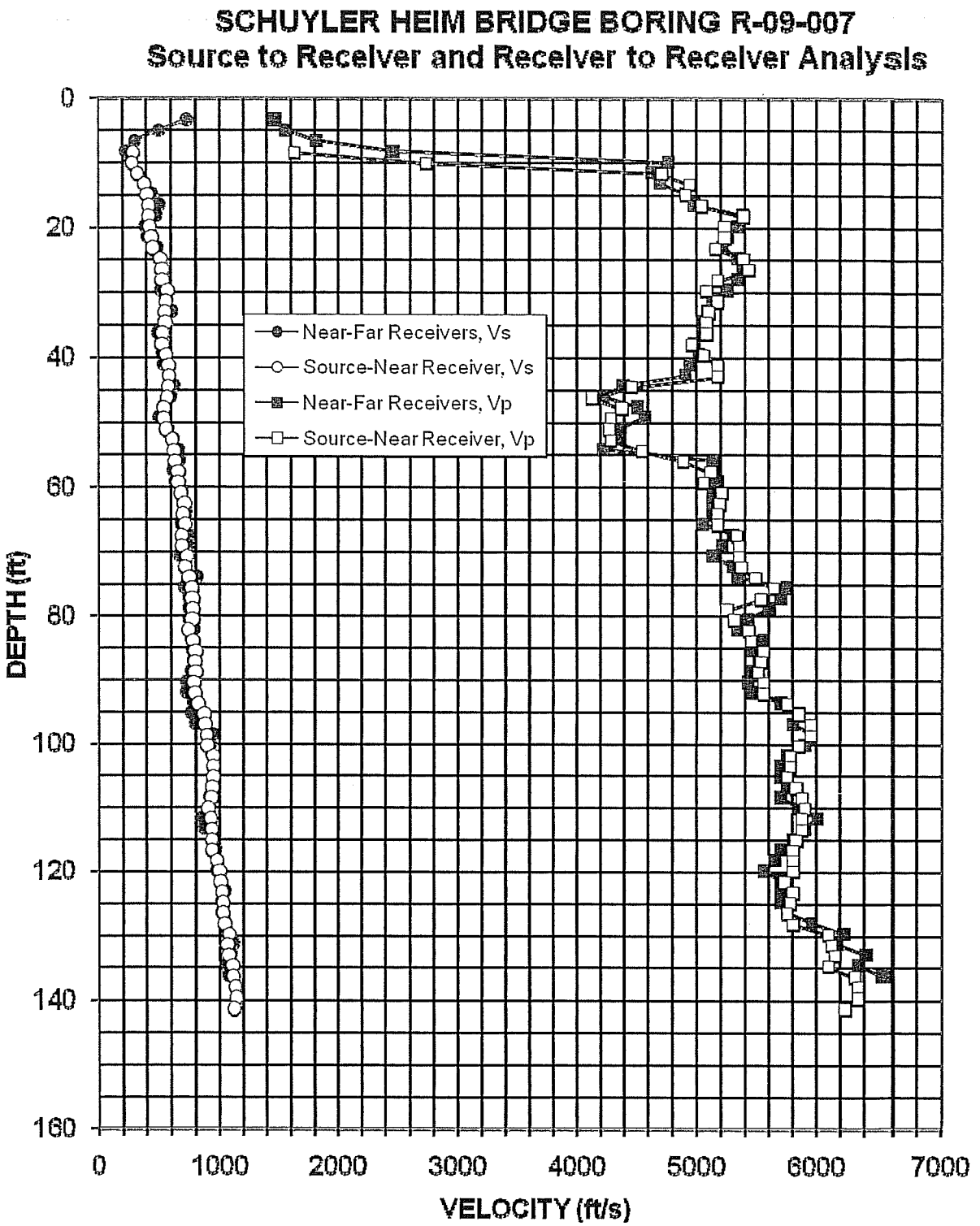

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

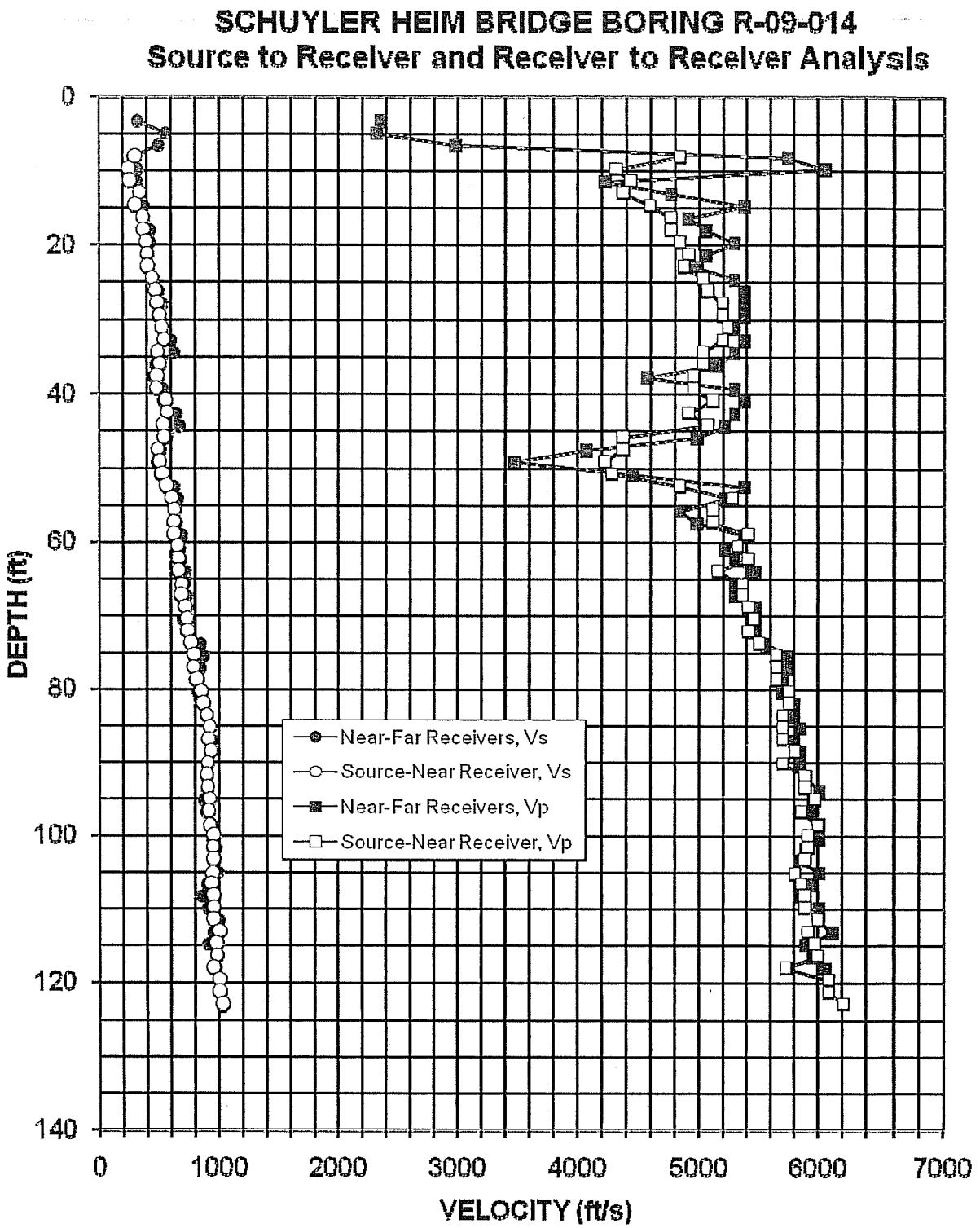

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

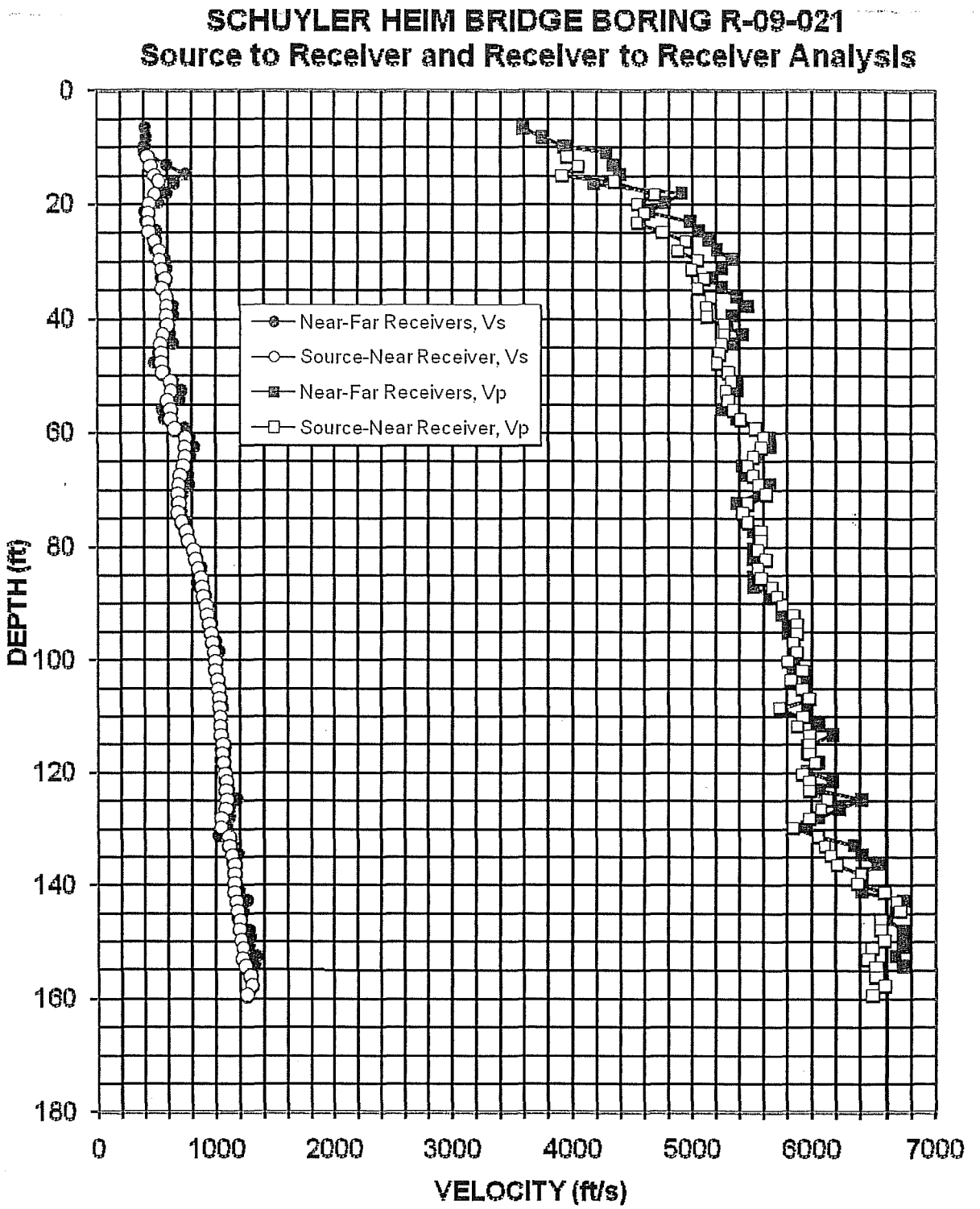

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S-- R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

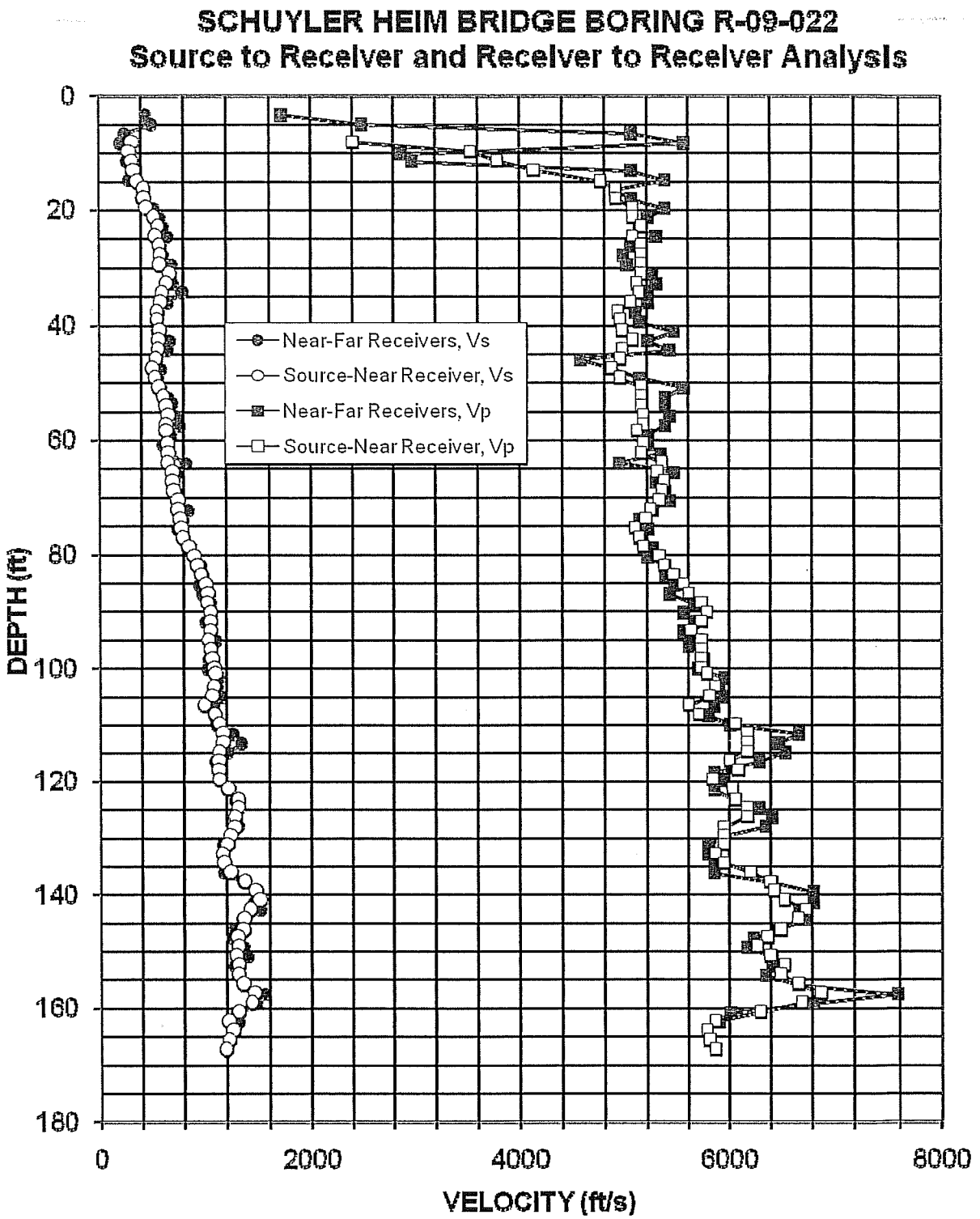

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5080	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

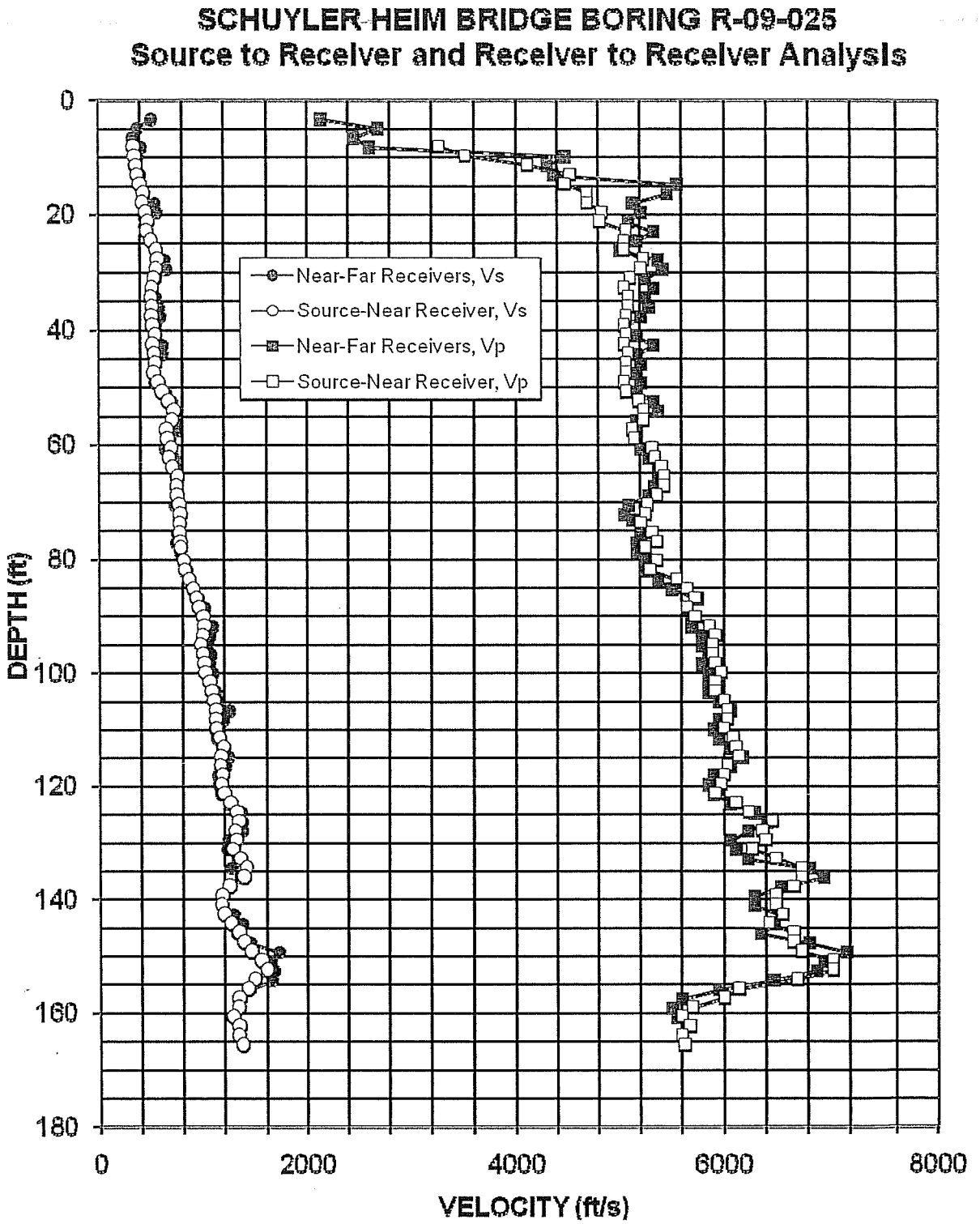

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

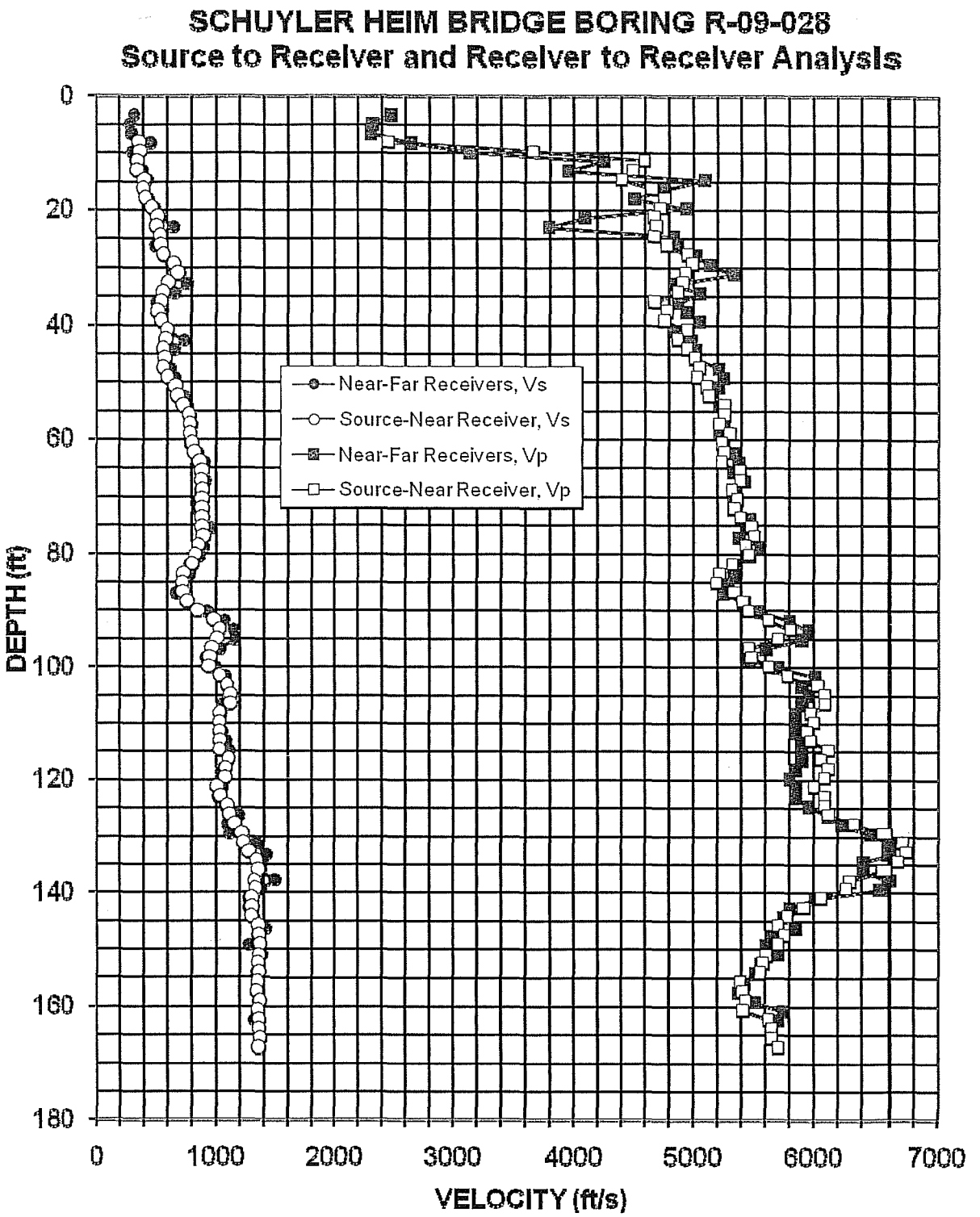

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Test No. 573794
Asset No. 160023

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573794
Asset No. 160023

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11% As left -0.11%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 CH1
160024
573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C.

LABORATORY SOIL TEST RESULTS

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/18/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-036	S-03	15	43.6	NA
R-09-036	D-06	30	32.2	91.8
R-09-036	D-08	40	32.8	89.5
R-09-036	S-09	45	38.7	NA
R-09-036	S-11	55	28.4	NA
R-09-036	D-12	60	36.7	91.0
R-09-036	S-13	65	25.2	NA
R-09-036	D-14	70	36.9	97.2
R-09-036	S-15	75	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Laboratory No.: 29-1121
Project Name: ACTA Heim Bridge Replacement
Date: 11/17/09
Project Number: 06-123-03

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-036	D-02	10	0.53
R-09-036	D-04	20	0.33
R-09-036	U-05	25	1.00
R-09-036	D-06	30	0.67
R-09-036	D-08	40	1.75

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name:	Earth Mechanics, Inc.	Laboratory No.:	29-1121
Project Name:	ACTA Heim Bridge Replacement	Date:	11/18/09
Project Number:	06-123-03		

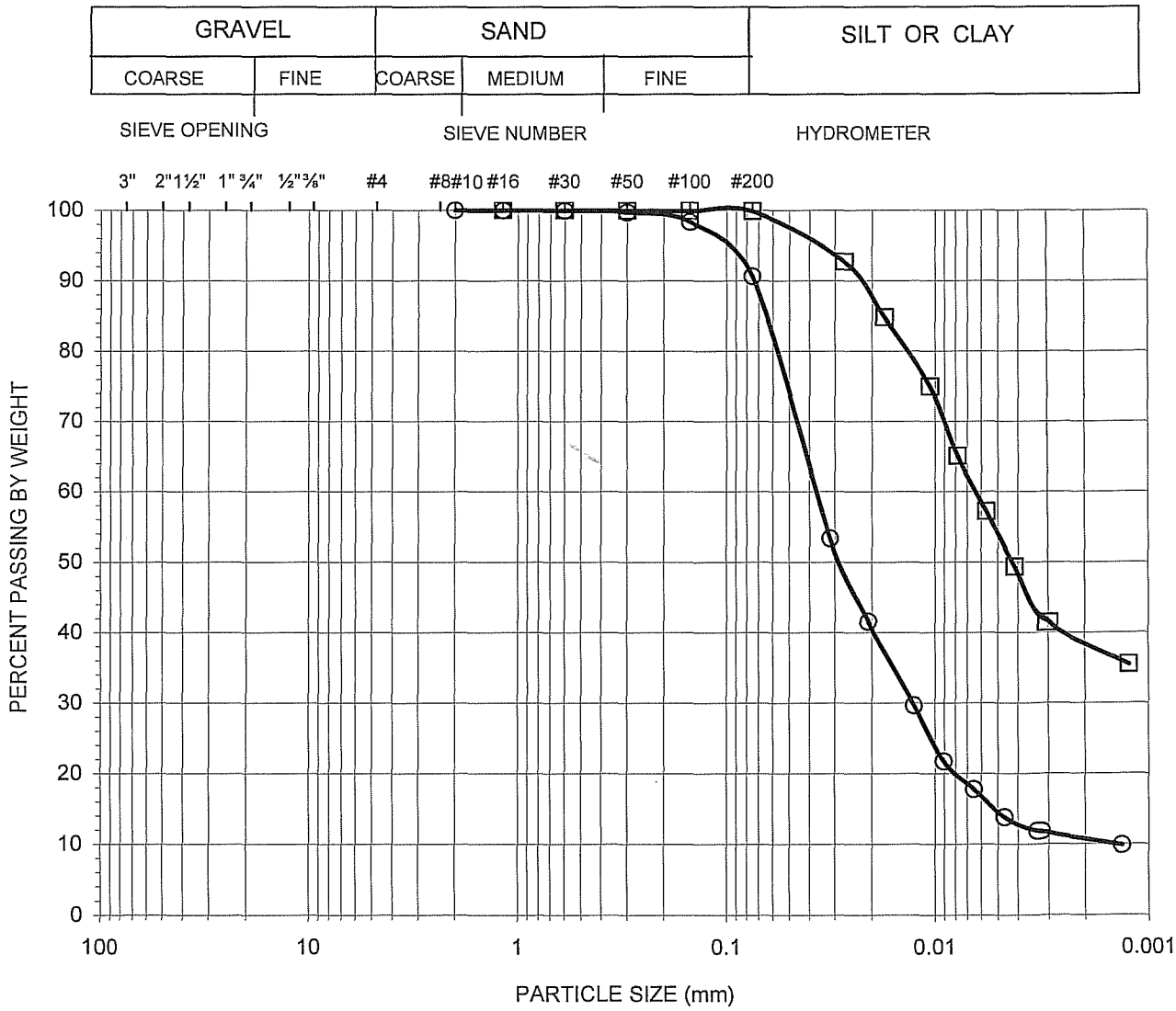
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-036	S-01	5	75.38
R-09-036	S-03	15	79.26
R-09-036	D-06	30	32.51
R-09-036	S-07	35	21.13
R-09-036	S-09	45	80.15
R-09-036	S-11	55	45.51
R-09-036	S-13	65	14.11

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

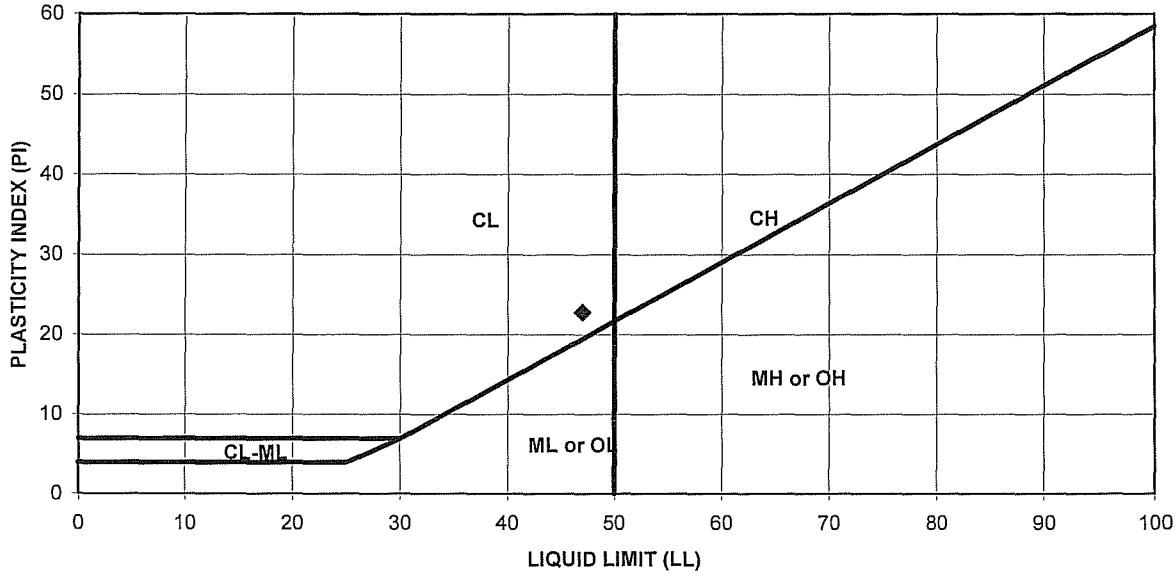


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-036	U-05	25	0.00	9.35	90.65	N/P	ML
□	R-09-036	D-10	50	0.00	0.16	99.84	56:29:27	CH

AP Engineering & Testing, Inc.

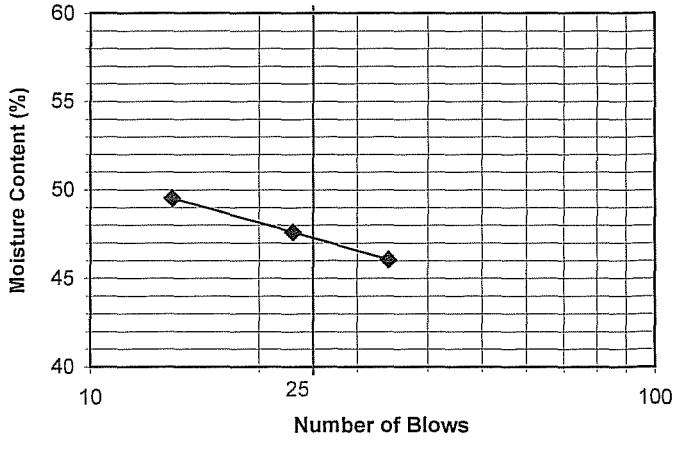
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-02	10	47	24	23	CL
	R-09-036	U-05	25	NP	NP	NP	

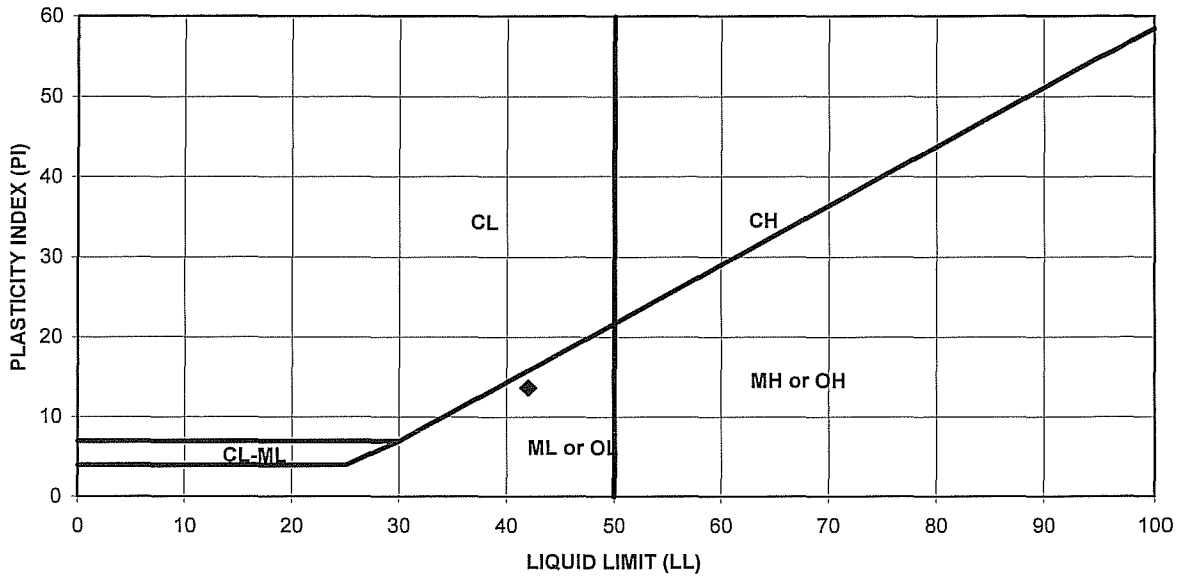
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

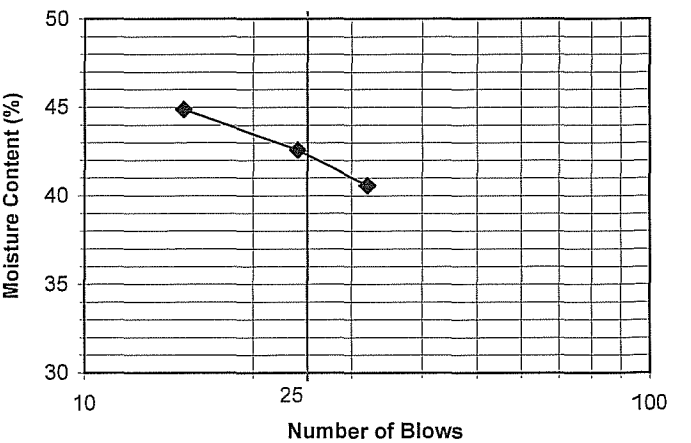
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 01/06/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test

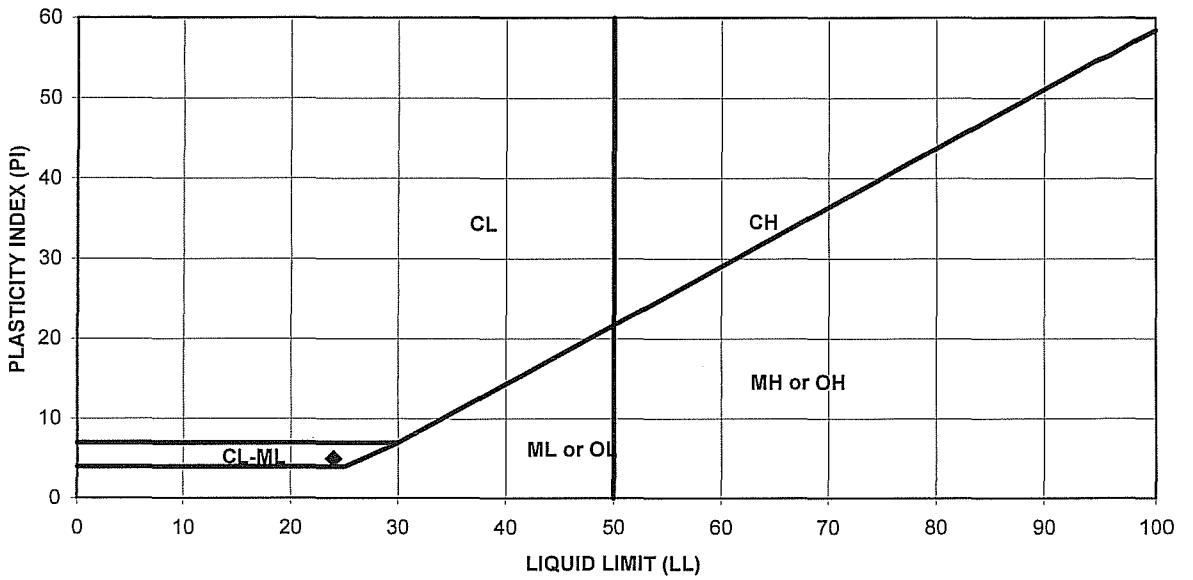


Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-04	20	42	28	14	ML

AP Engineering & Testing, Inc.

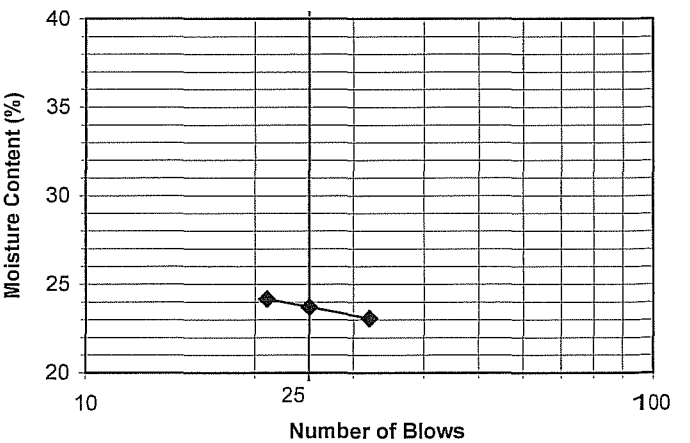
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: WJO Date: 01/05/10
Project No.: 06-123-03 Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



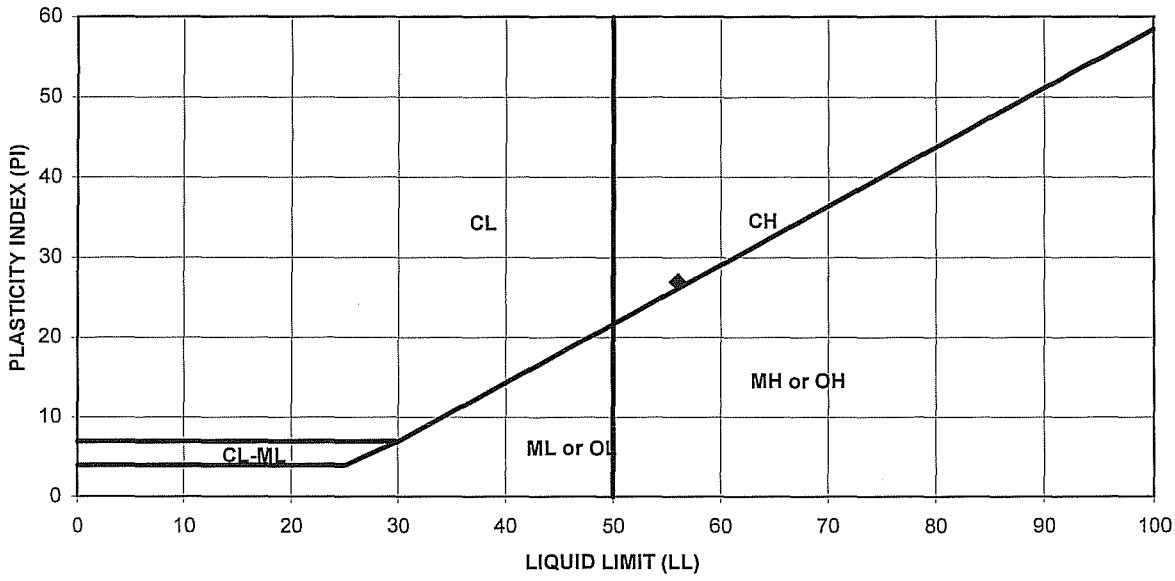
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-036	S-09	45	24	19	5	CL-ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

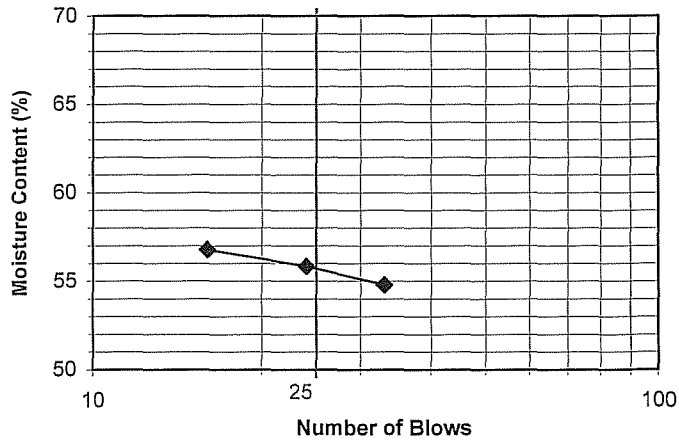
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- ☐ Wet Preparation
- ☒ Dry Preparation
- ☒ Procedure A Multipoint Test
- ☐ Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-10	50	56	29	27	CH

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-036					
SAMPLE NUMBER	U-05					
DEPTH (FT)	25					
SOIL CLASSIFICATION	Silt					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	385.76					
TEMPERATURE, °C	19.5					
CORRECTION FACTOR	1.0001					
WT. DRY SOIL, g	37.81					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.68**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/18/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-036	S-03	15	ML	150	8.0	1187	12774
R-09-036	S-09	45	ML	190	7.7	680	9790

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

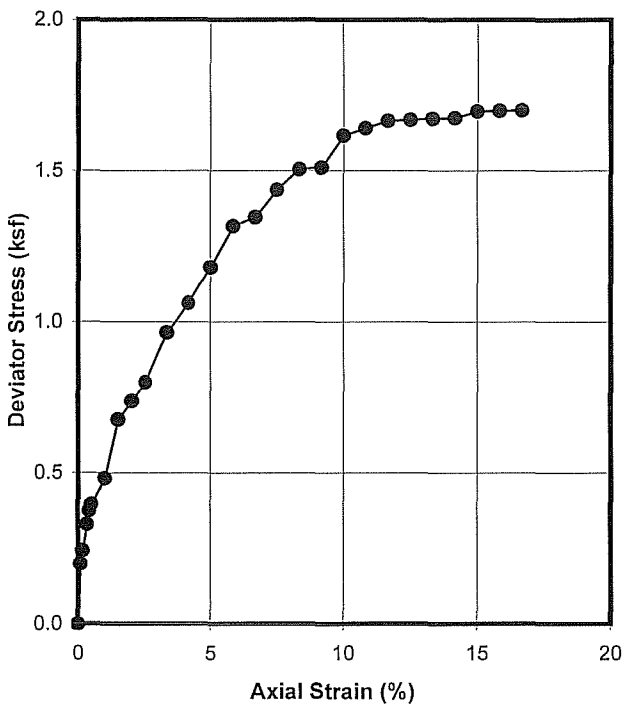
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-036				
Sample No.:	U-05	Depth (feet): 25			
Soil Description	Gray Silt w/shell		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	111.7
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	78.6
Sample Weight (gms):	1142.84	Moisture Content (%):	42.1
Wt. Wet Soil+Container(gms)	1351.61	Void Ratio for Gs=2.7:	1.14
Wt. Dry Soil+Container(gms)	1010.90	% Saturation:	99.5
Wt. Container (gms)	202.38		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.7
Ultimate Deviator Stress (ksf):	1.7
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
9	0.005	6.50	0.20	0.08
11	0.010	6.50	0.24	0.17
15	0.020	6.51	0.33	0.33
17	0.025	6.52	0.38	0.42
18	0.030	6.52	0.40	0.50
22	0.060	6.56	0.48	1.00
31	0.090	6.59	0.68	1.50
34	0.120	6.62	0.74	2.00
37	0.150	6.66	0.80	2.50
45	0.200	6.72	0.96	3.33
50	0.250	6.77	1.06	4.17
56	0.300	6.83	1.18	5.00
63	0.350	6.89	1.32	5.83
65	0.400	6.96	1.35	6.67
70	0.450	7.02	1.44	7.50
74	0.500	7.08	1.50	8.33
75	0.550	7.15	1.51	9.17
81	0.600	7.21	1.62	10.00
83	0.650	7.28	1.64	10.83
85	0.700	7.35	1.67	11.67
86	0.750	7.42	1.67	12.50
87	0.800	7.49	1.67	13.33
88	0.850	7.56	1.68	14.17
90	0.900	7.64	1.70	15.00
91	0.950	7.71	1.70	15.83
92	1.000	7.79	1.70	16.67

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/17/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-037	B-00	0-2	13.7	NA
R-09-037	S-01	5	46.8	NA
R-09-037	D-02-2	10.5	61.1	61.8
R-09-037	S-03	15	49.2	NA
R-09-037	D-05-2	25.5	42.3	78.4
R-09-037	D-08-2	40.5	32.1	90.3
R-09-037	S-09	45	34.9	NA
R-09-037	D-10-1	50	25.0	100.1
R-09-037	S-11	55	32.3	NA
R-09-037	D-12-1	60	32.9	89.0
R-09-037	D-14	70	23.2	78.2
R-09-037	D-16-1	80	23.5	100.2

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 12/18/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-037	U-06	30	1.00

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03
Laboratory No.: 29-1121
Date: 12/21/09

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-037	S-01	5	77.72
R-09-037	D-02-2	10.5	72.38
R-09-037	S-7	35	71.57
R-09-037	D-10-1	50	41.77

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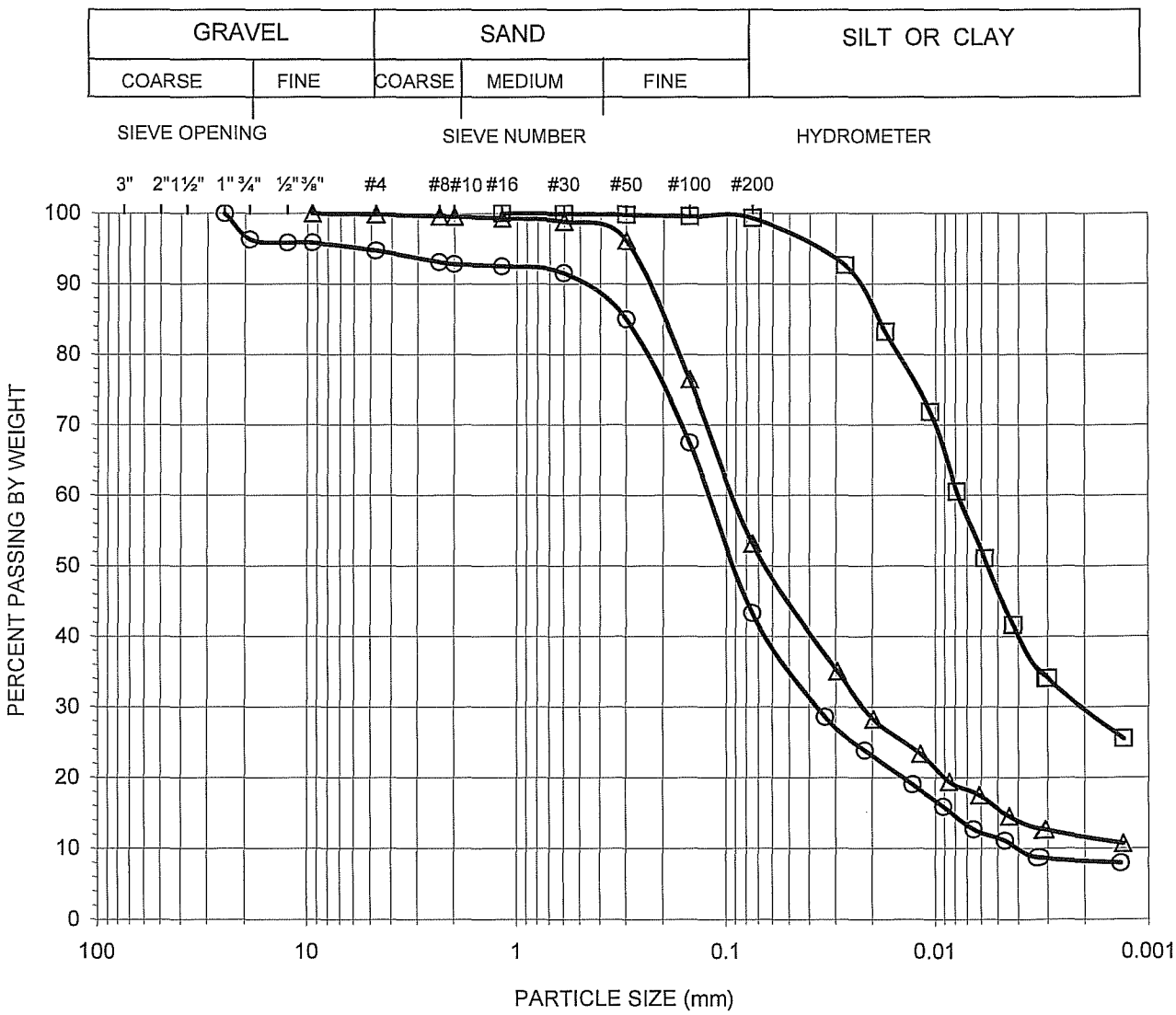
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

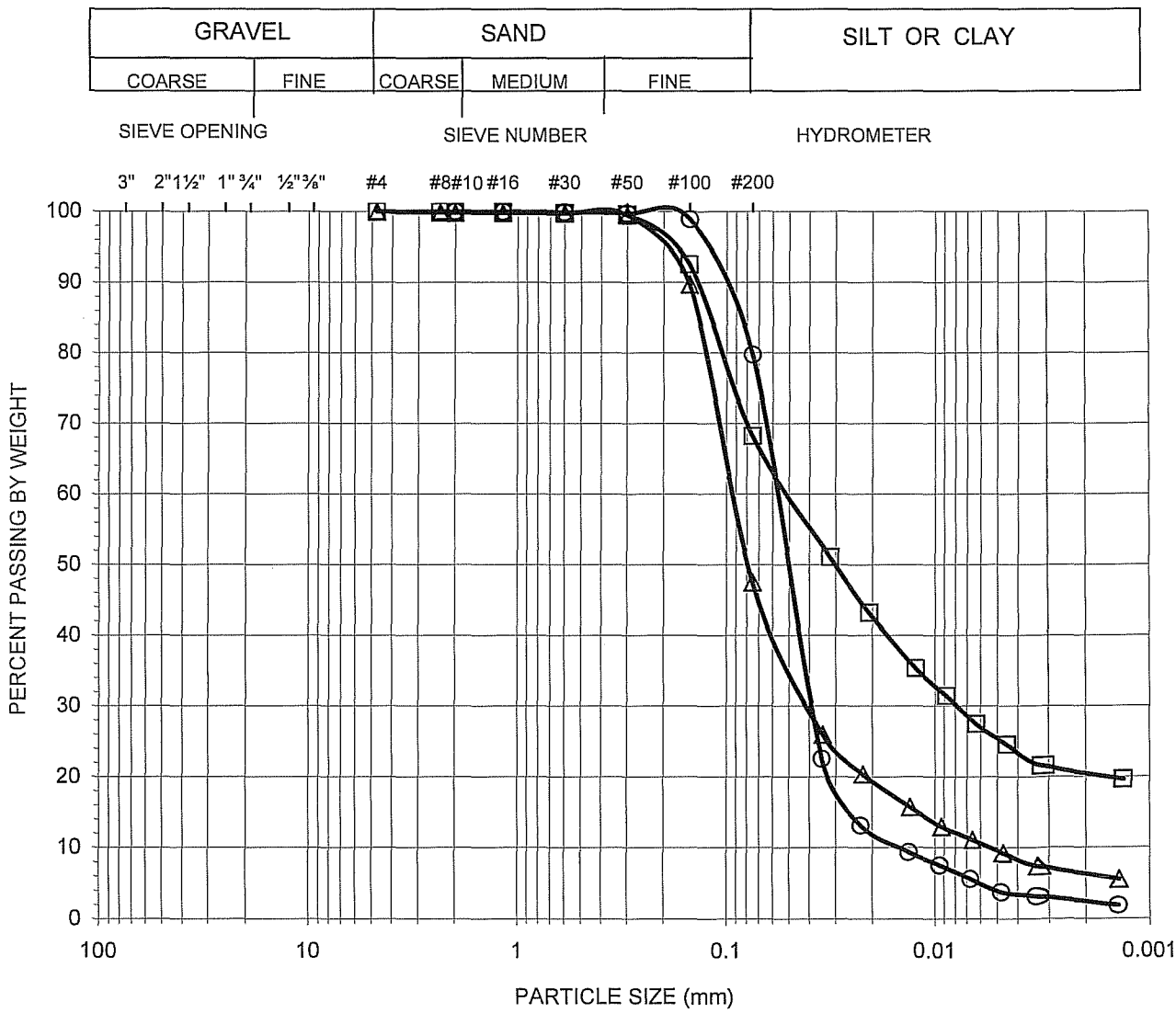


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-037	B-00	0-2	5.22	51.45	43.33	N/A	SM
□	R-09-037	S-03	15	0.00	0.67	99.33	48:29:19	ML
△	R-09-037	U-06	30	0.12	46.69	53.19	N/P	ML

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/31/09

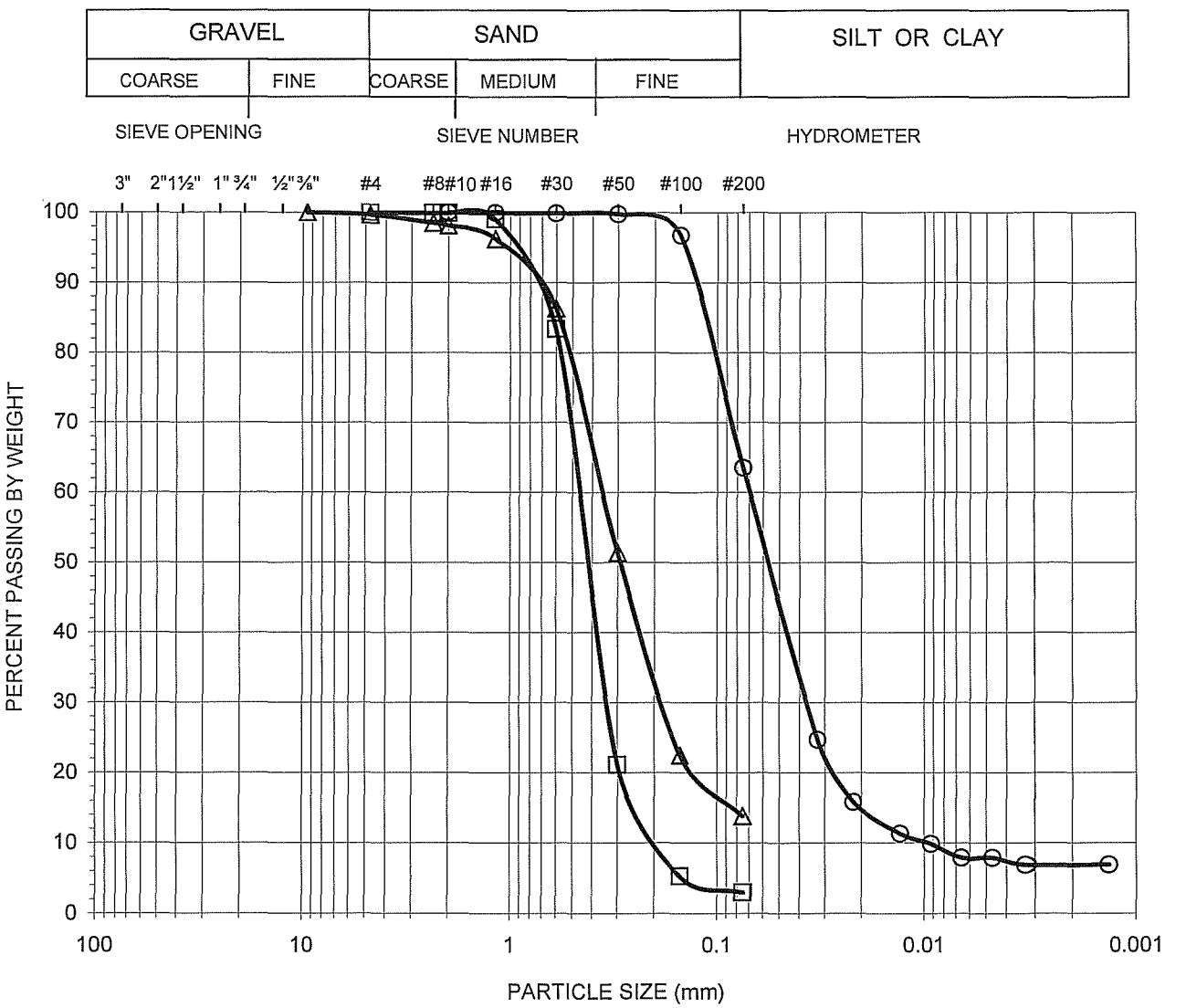


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-037	D-08-2	40	0.00	20.21	79.79	N/P	ML
□	R-09-037	S-09	45	0.00	31.82	68.18	28:20:8	CL
△	R-09-037	S-11	55	0.00	52.51	47.49	N/A	SM

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	12/28/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	12/31/09
Project No.:	06-123-03	Checked by:	AP	Date:	01/01/10

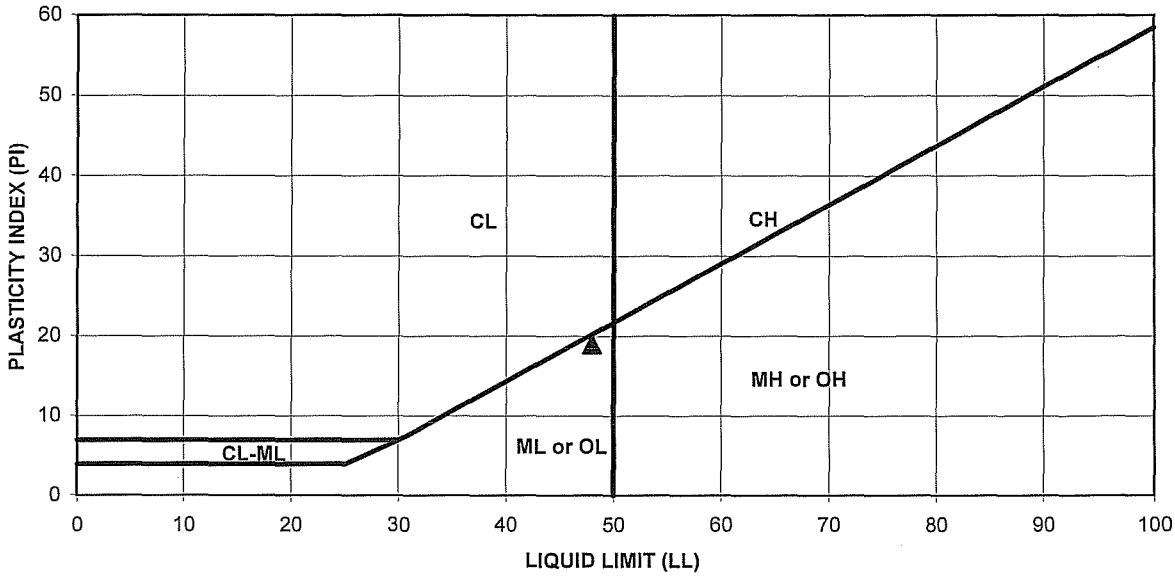


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-037	D-12-1	60	0.00	36.44	63.56	N/A	ML
□	R-09-037	D-14	70	0.00	97.04	2.96	N/A	SP
△	R-09-037	D-16-1	80	0.32	85.82	13.86	N/A	SM

AP Engineering & Testing, Inc.

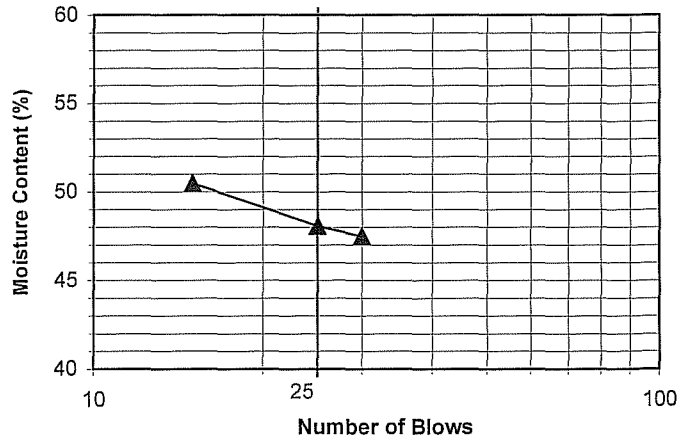
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: WJO Date: 12/18/09
Project No.: 06-123-03 Checked By: AP Date: 12/31/09



PROCEDURE USED

- ☐ Wet Preparation
- ☒ Dry Preparation
- ☒ Procedure A Multipoint Test
- ☐ Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-037	D-02-2	10.5	NP	NP	NP	
▲	R-09-037	S-03	15	48	29	19	ML

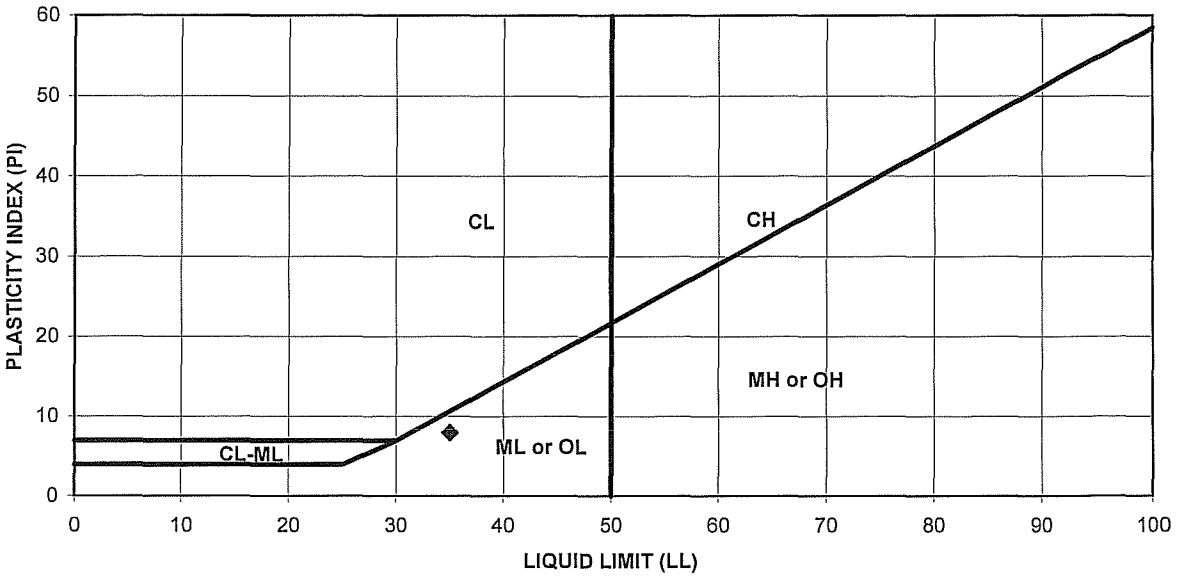
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

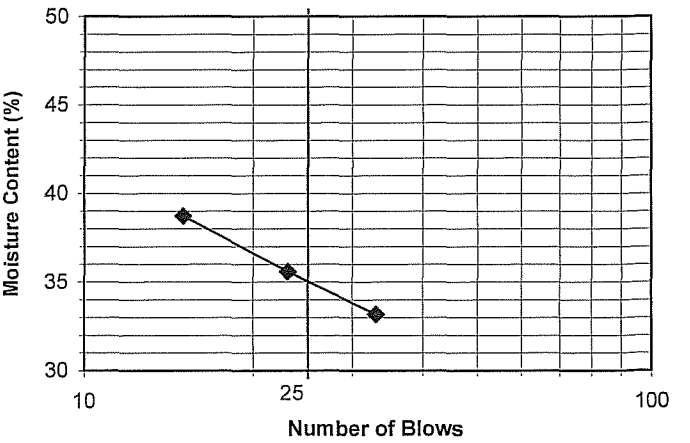
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: WJO Date: 12/18/09
Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



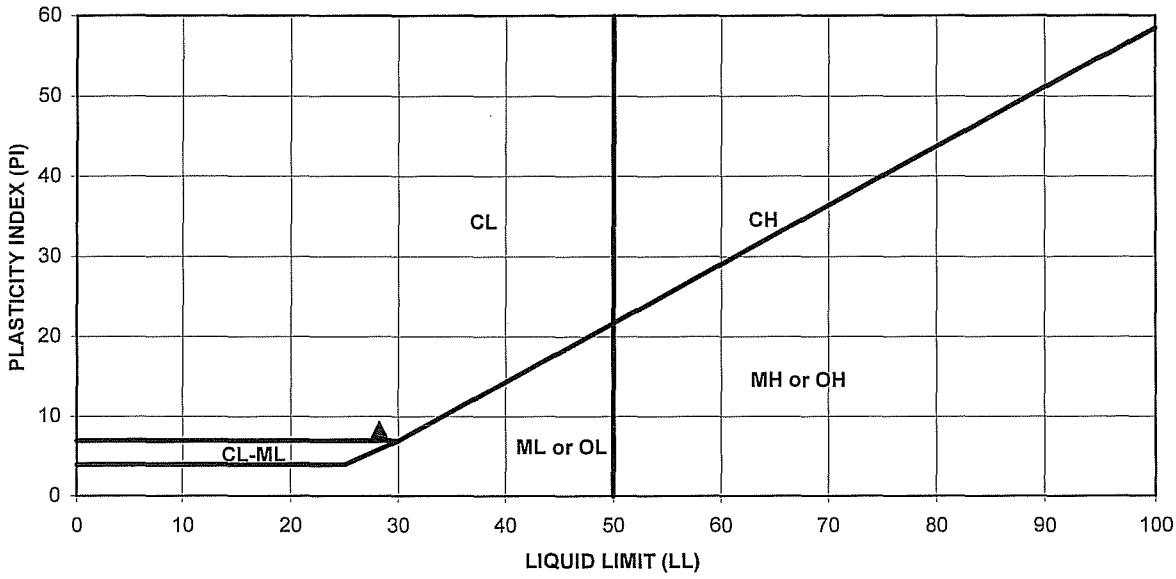
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-037	D-05-2	35.5	35	27	8	ML
	R-09-037	U-06	30	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

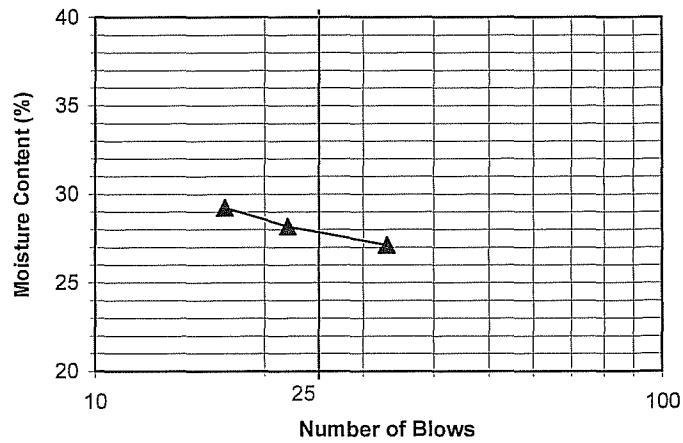
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: WJO Date: 12/18/09
Project No.: 06-123-03 Checked By: AP Date: 12/31/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-037	D-08-2	40.5	NP	NP	NP	
▲	R-09-037	S-09	45	28	20	8	CL

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 12/23/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 12/26/09

Project No. : 06-123-03 Checked By: AP Date: 12/26/09

BORING NUMBER	R-09-037					
SAMPLE NUMBER	U-06					
DEPTH (FT)	30					
SOIL CLASSIFICATION	Sandy Silt (ML)					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	393.20					
TEMPERATURE, °C	18.4					
CORRECTION FACTOR	1.0003					
WT. DRY SOIL, g	47.95					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.85**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 12/09/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-037	D-01	5	ML	65	7.5	518	2257

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

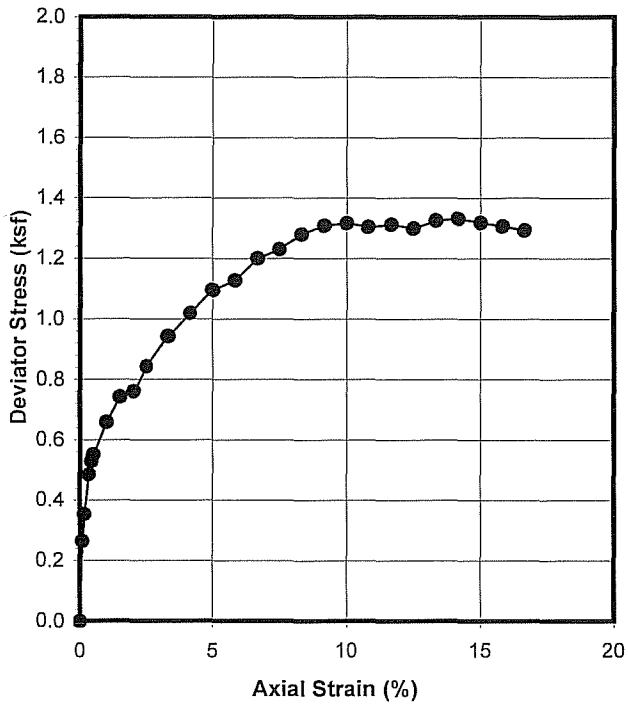
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 12/18/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 01/01/10
Project No.:	06-123-03				
Boring No.:	R-09-037				
Sample No.:	U-06	Depth (feet): 30			
Soil Description	Gray Sandy Silt w/shell		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	121.9
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	93.3
Sample Weight (gms):	1247.25	Moisture Content (%):	30.7
Wt. Wet Soil+Container(gms)	1348.76	Void Ratio for Gs=2.7:	0.81
Wt. Dry Soil+Container(gms)	1056.77	% Saturation:	102.8
Wt. Container (gms)	105.01		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.3
Ultimate Deviator Stress (ksf):	1.3
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	14.17



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
12	0.005	6.50	0.27	0.08
16	0.010	6.50	0.35	0.17
22	0.020	6.51	0.49	0.33
24	0.025	6.52	0.53	0.42
25	0.030	6.52	0.55	0.50
30	0.060	6.56	0.66	1.00
34	0.090	6.59	0.74	1.50
35	0.120	6.62	0.76	2.00
39	0.150	6.66	0.84	2.50
44	0.200	6.72	0.94	3.33
48	0.250	6.77	1.02	4.17
52	0.300	6.83	1.10	5.00
54	0.350	6.89	1.13	5.83
58	0.400	6.96	1.20	6.67
60	0.450	7.02	1.23	7.50
63	0.500	7.08	1.28	8.33
65	0.550	7.15	1.31	9.17
66	0.600	7.21	1.32	10.00
66	0.650	7.28	1.31	10.83
67	0.700	7.35	1.31	11.67
67	0.750	7.42	1.30	12.50
69	0.800	7.49	1.33	13.33
70	0.850	7.56	1.33	14.17
70	0.900	7.64	1.32	15.00
70	0.950	7.71	1.31	15.83
70	1.000	7.79	1.29	16.67

AP Engineering & Testing, Inc.

COMPACTION TEST

Client: Earth Mechanics, Inc. AP Number: 29-1121
Project Name: ACTA Heim Bridge Replacement Tested By: ST Date: 12/29/09
Project No. : 06-123-03 Calculated By: KM Date: 12/31/09
Boring No.: R-09-037 Checked By: AP Date: 01/01/10
Sample No. : BB-00 Depth (ft.): 0.5-3.5
Visual Sample Description: Grayish Brown Silty Sand

Compaction Method: [X] ASTM D1557 [ ] ASTM D698
Preparation Method: [ ] Moist [X] Dry

METHOD: A
MOLD VOLUME (CU.FT): 0.0333

Trial No.	1	2	3	4	5	6
Wt. Comp. Soil + Mold (gm.)	3781	3856	3777	3649		
Wt. of Mold (gm.)	1762	1762	1762	1762		
Net Wt. of Soil (gm.)	2019	2094	2015	1887		
Container No.						
Wt. of Container (gm.)	103.90	103.80	104.60	104.80		
Wet Wt. of Soil + Cont. (gm.)	1103.00	1207.90	904.90	873.83		
Dry Wt. of Soil + Cont. (gm.)	1029.49	1096.36	805.79	831.81		
Moisture Content (%)	7.94	11.24	14.13	5.78		
Wet Density (pcf)	133.50	138.49	133.27	124.82		
Dry Density (pcf)	123.68	124.50	116.76	118.00		

Maximum Dry Density (pcf): **126.0**
Maximum Dry Density w/ Rock Correction (pcf): **127.9**
Optimum Moisture Content (%): **10.0**
Optimum Moisture Content w/ Rock Correction (%): **10.2**

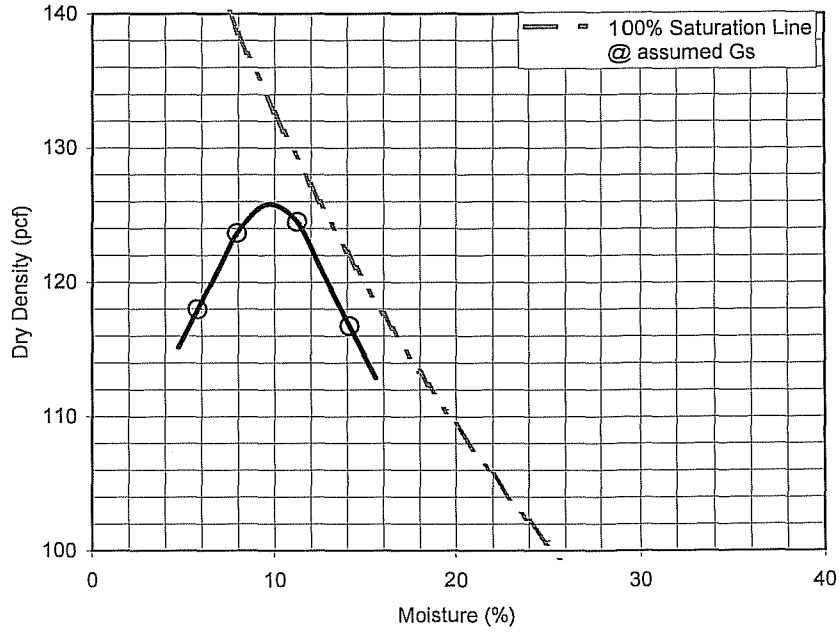
Assumed Specific Gravity = 2.7

PROCEDURE USED

[X] *METHOD A: Percent of Oversize:* *5.9%*
Soil Passing No. 4 (4.75 mm) Sieve
Mold : 4 in. (101.6 mm) diameter
Layers : 5 (Five)
Blows per layer : 25 (twenty-five)
May be used if No.4 retained < 20%

[ ] *METHOD B: Percent of Oversize:* *NA*
Soil Passing 3/8 in. (9.5 mm) Sieve
Mold : 4 in. (101.6 mm) diameter
Layers : 5 (Five)
Blows per layer : 25 (twenty-five)
Use if + No.4 > 20% and - 3/8 in < 20%

[ ] *METHOD C: Percent of Oversize:* *NA*
Soil Passing 3/4 in. (19.0 mm) Sieve
Mold : 6 in. (152.4 mm) diameter
Layers : 5 (Five)
Blows per layer : 56 (fifty-six)
Use if + 3/8 in >20% and +3/4 in <30%



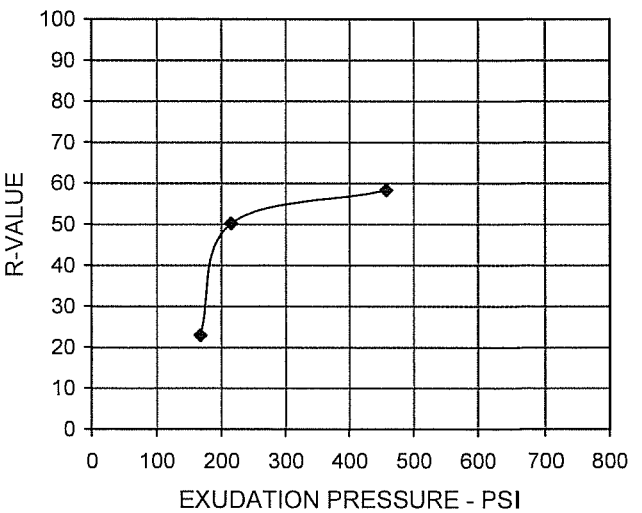
AP Engineering & Testing, Inc.

R-VALUE TEST DATA

ASTM D2844

Project Name:	ACTA Heim Bridge Replaceme	Tested By:	ST	Date:	12/29/09
Project Number:	06-123-03	Computed By:	KM	Date:	12/31/09
Boring No.:	R-09-037	Checked By:	AP	Date:	12/31/09
Sample No.:	BB-00	Depth (ft.):	0.5-3.5		
Location:					
Soil Description:	Grayish Brown Silty Sand				

Mold Number	A	B	D		
Water Added, g	40	35	45		
Compact Moisture(%)	18.0	17.5	18.5		
Compaction Gage Pressure, psi	160	200	120		
Exudation Pressure, psi	216	458	168		
Sample Height, Inches	2.5	2.5	2.5		
Gross Weight Mold, g	3078	3074	3081		
Tare Weight Mold, g	1970	1969	1971		
Net Sample Weight, g	1108	1105	1110		
Expansion, inches$x10^{-4}$	6	12	0		
Stability 2,000 (160 psi)	29/60	23/50	47/108		
Turns Displacement	4.14	3.95	4.06		
R-Value Uncorrected	50	58	23		
R-Value Corrected	50	58	23		
Dry Density, pcf	113.8	114.0	113.5		
Traffic Index	8.0	8.0	8.0		
G.E. by Stability	0.84	0.71	1.31		
G.E. by Expansion	0.20	0.40	0.00		

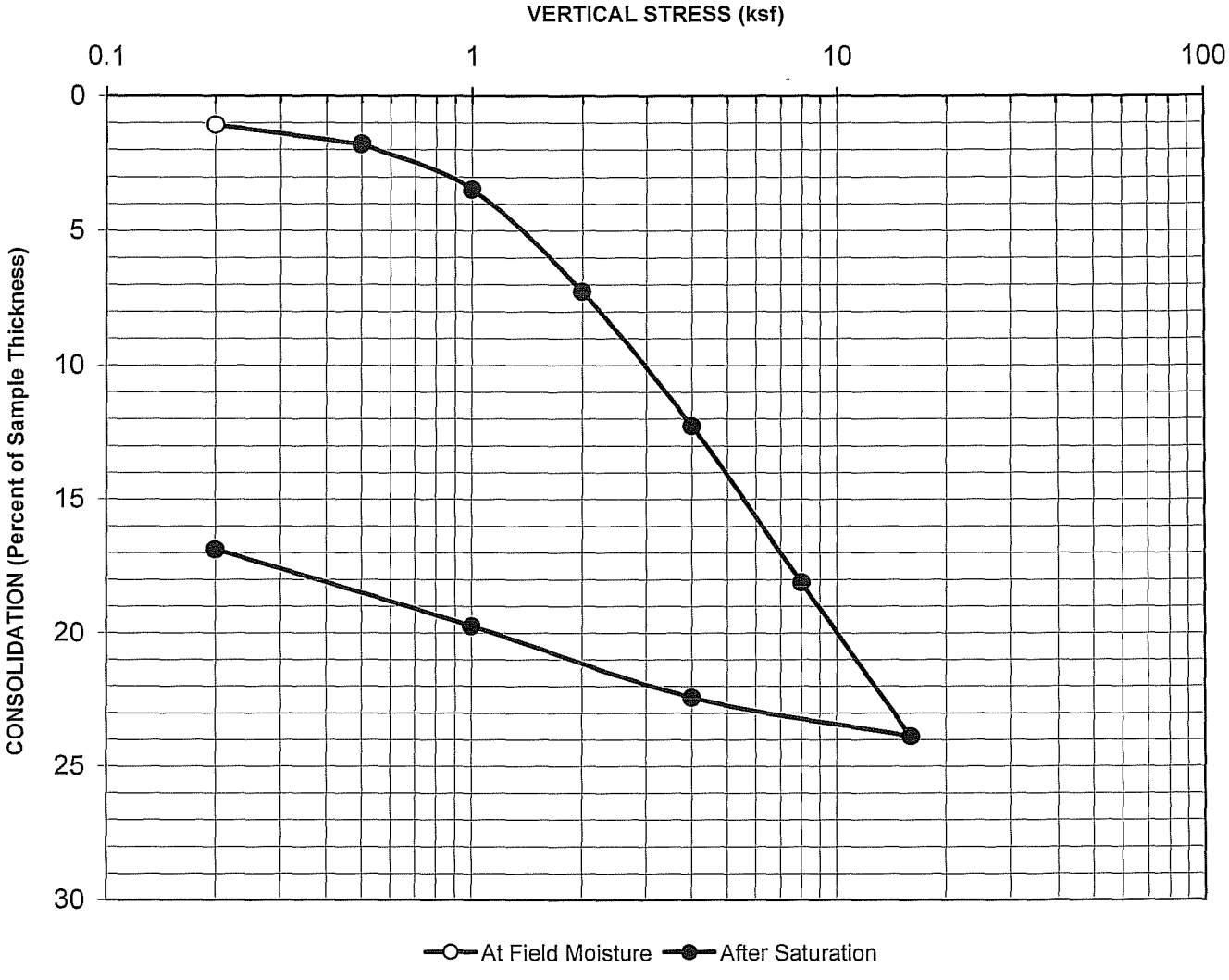


R-Value by Exudation = 54
R-Value by Expansion = N/A
Equilibrium R- Value = 54
(by Exudation)

Remarks: G_f = 1.5
3.7 % Retained on the ¾"

2607 Pomona Blvd, Pomona, CA 91768, Tel (909)869-6316 Fax (909) 869-6318

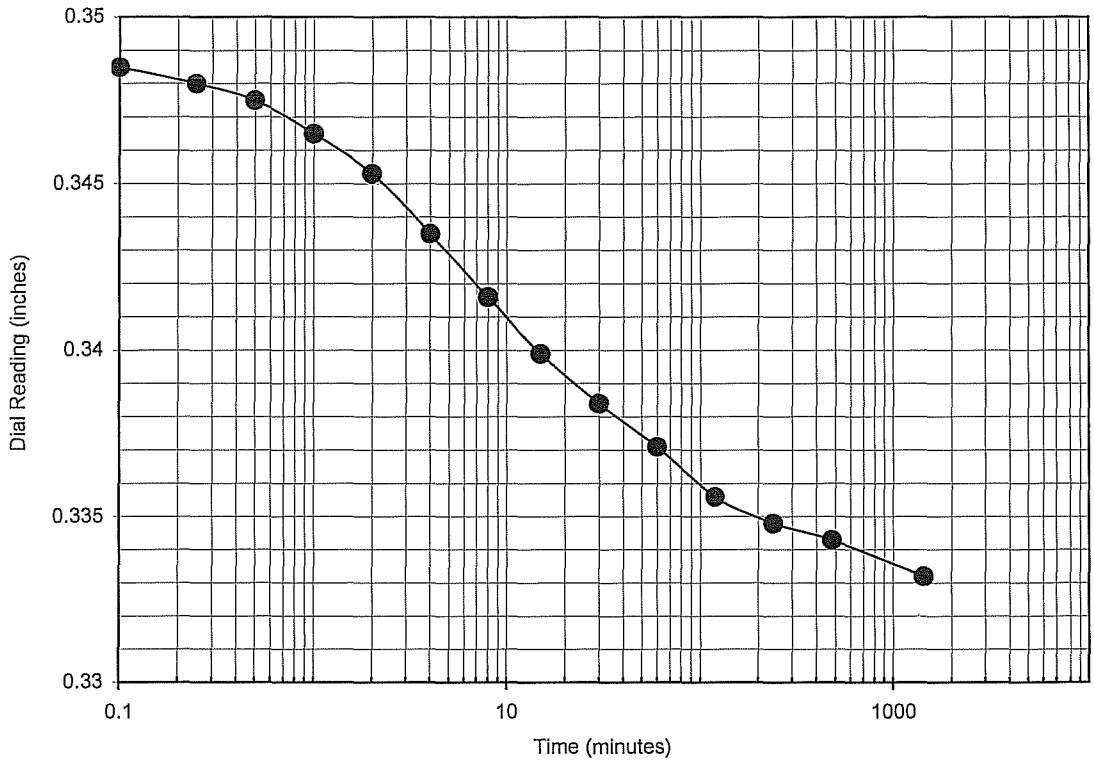
AP Engineering & Testing, Inc.



Boring No. :	R-09-037	Initial Dry Unit Weight (pcf):	68.6
Sample No.:	D-02-1	Initial Moisture Content (%):	54.2
Depth (feet):	10	Final Moisture Content (%):	44.8
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Silt with sand	Initial Void Ratio:	1.46
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	12/28/2009
AP No:	29-1121

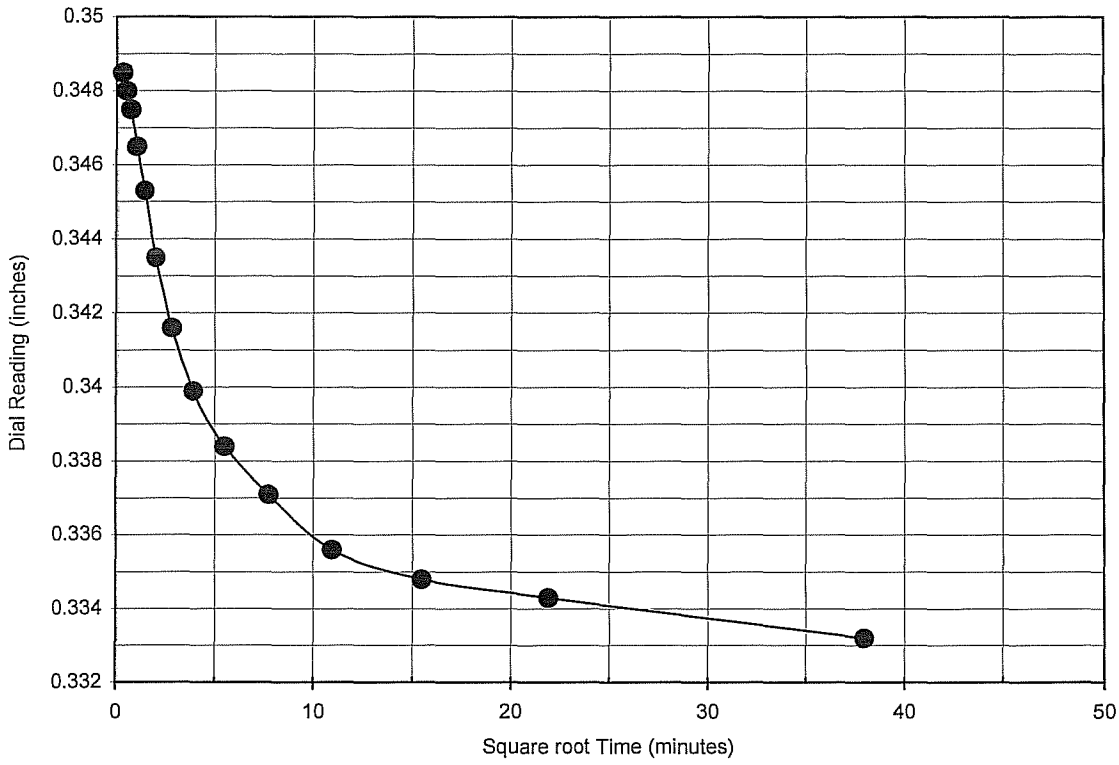


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3485
0.25	0.348
0.5	0.3475
1	0.3465
2	0.3453
4	0.3435
8	0.3416
15	0.3399
30	0.3384
60	0.3371
120	0.3356
240	0.3348
480	0.3343
1440	0.3332

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

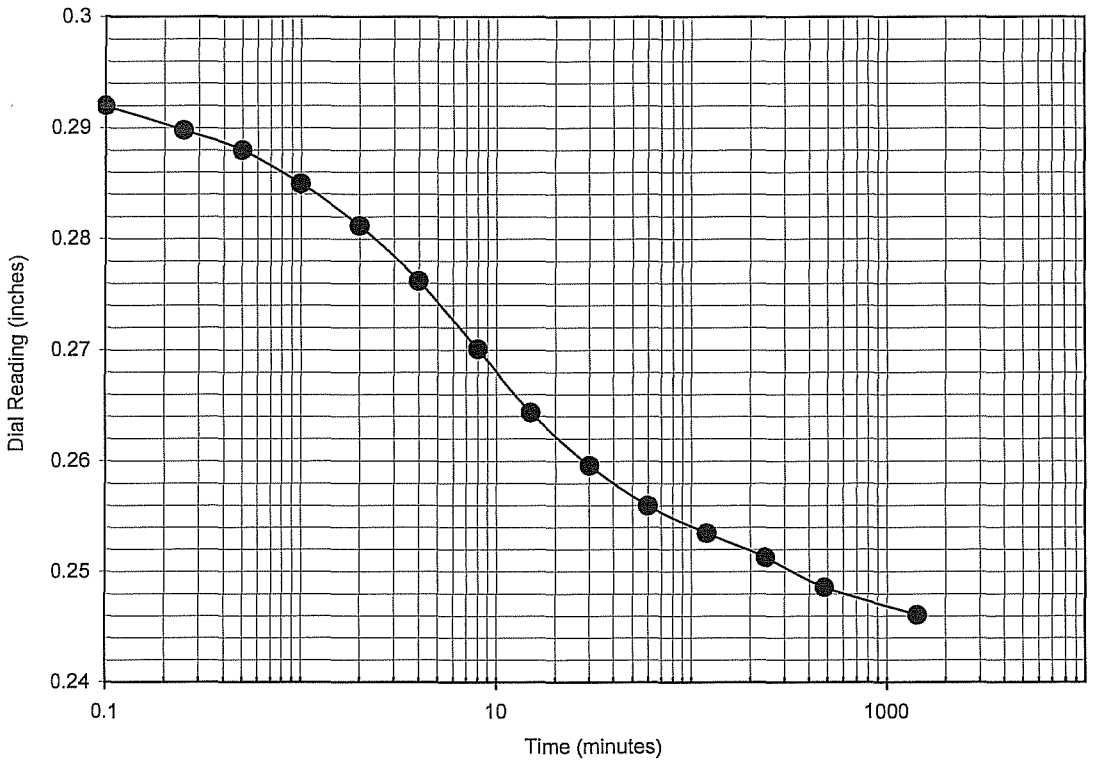


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3485
0.5000	0.3480
0.7071	0.3475
1.0000	0.3465
1.4142	0.3453
2.0000	0.3435
2.8284	0.3416
3.8730	0.3399
5.4772	0.3384
7.7460	0.3371
10.9545	0.3356
15.4919	0.3348
21.9089	0.3343
37.9473	0.3332

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

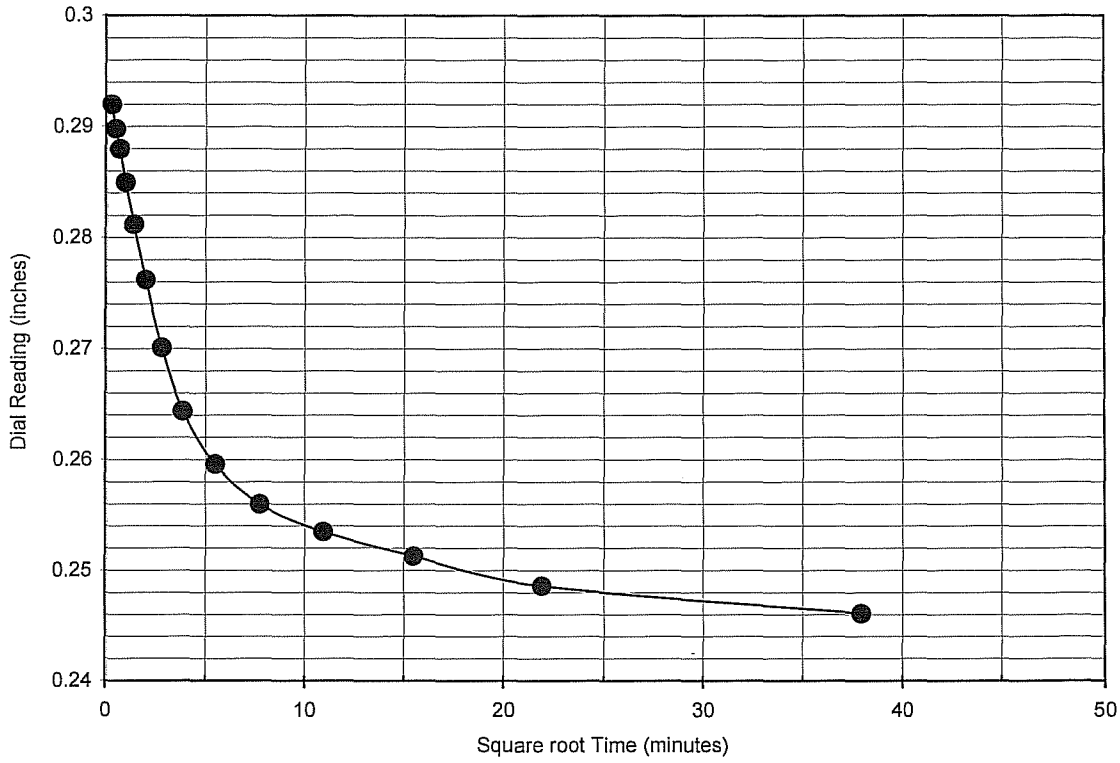


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.292
0.25	0.2898
0.5	0.288
1	0.285
2	0.2812
4	0.2762
8	0.2701
15	0.2644
30	0.2596
60	0.256
120	0.2535
240	0.2513
480	0.2486
1440	0.2461

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**



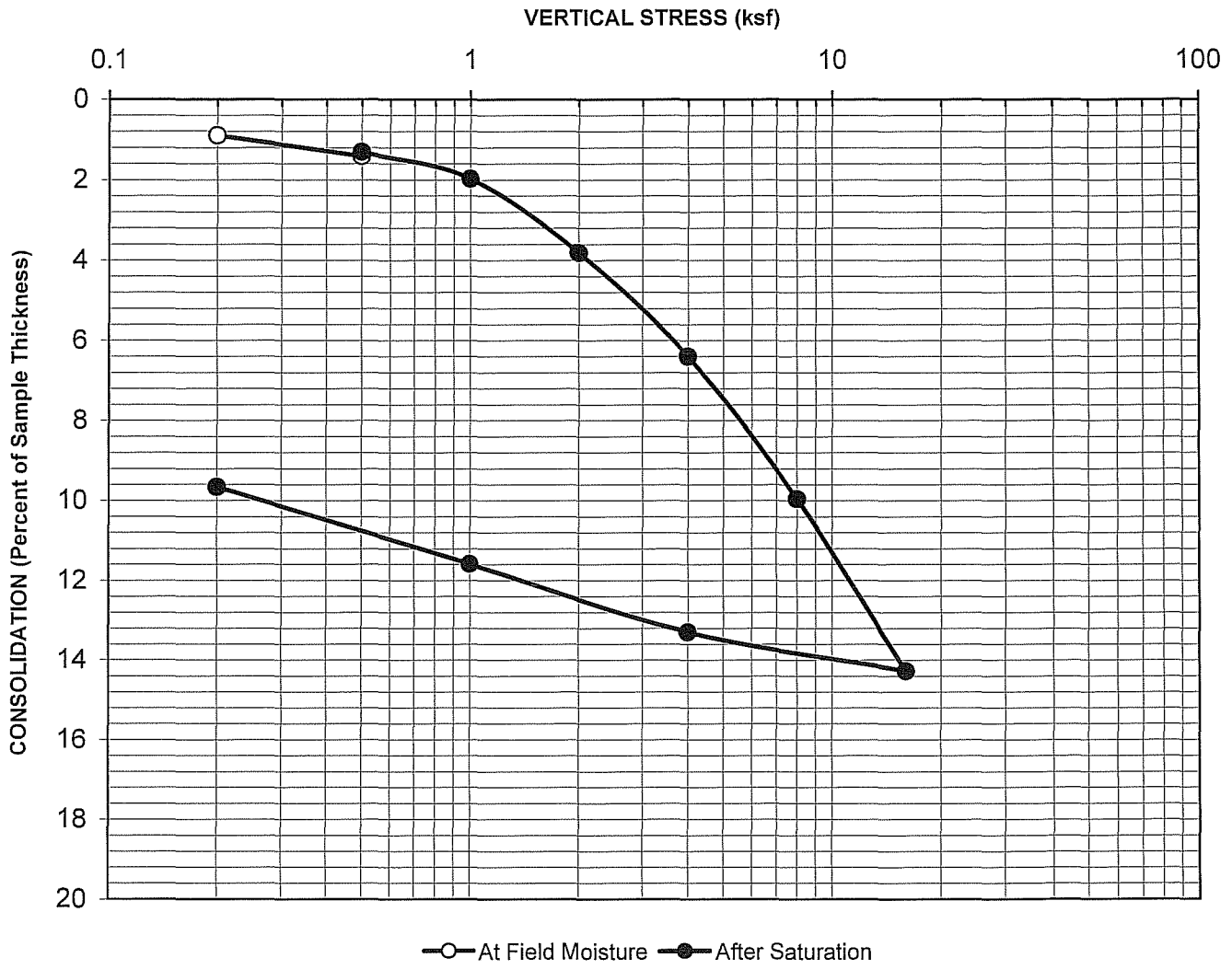
Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-02-1	Soil Description:	Silt with sand
Depth (feet):	10	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.2920
0.5000	0.2898
0.7071	0.2880
1.0000	0.2850
1.4142	0.2812
2.0000	0.2762
2.8284	0.2701
3.8730	0.2644
5.4772	0.2596
7.7460	0.2560
10.9545	0.2535
15.4919	0.2513
21.9089	0.2486
37.9473	0.2461

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

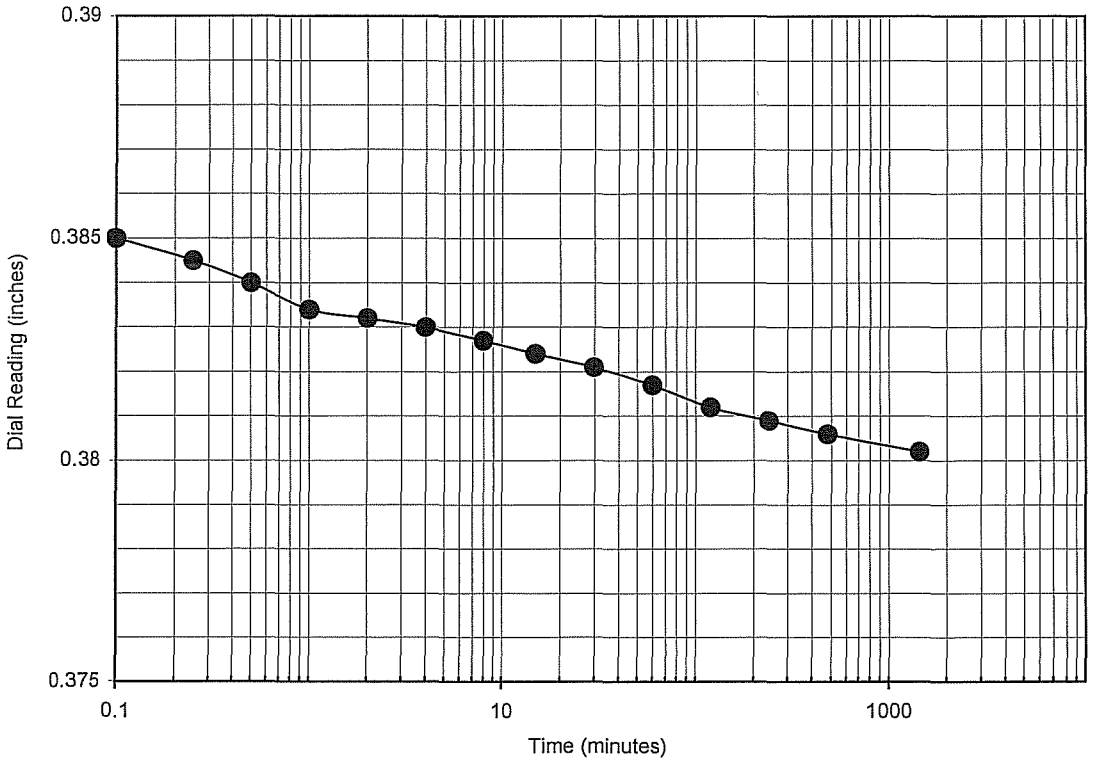
AP Engineering & Testing, Inc.



Boring No. :	R-09-037	Initial Dry Unit Weight (pcf):	78.3
Sample No.:	D-5A	Initial Moisture Content (%):	44.3
Depth (feet):	25	Final Moisture Content (%):	38.8
Sample Type:	Cal. Mod.	Assumed Specific Gravity:	2.7
Soil Description:	Sandy Silt	Initial Void Ratio:	1.15
Remarks:			

CONSOLIDATION CURVE
ASTM D 2435

Project Name:	ACTA Heim Bridge Replacement
Project No.:	06-123-03
Date:	12/28/2009
AP No:	29-1121

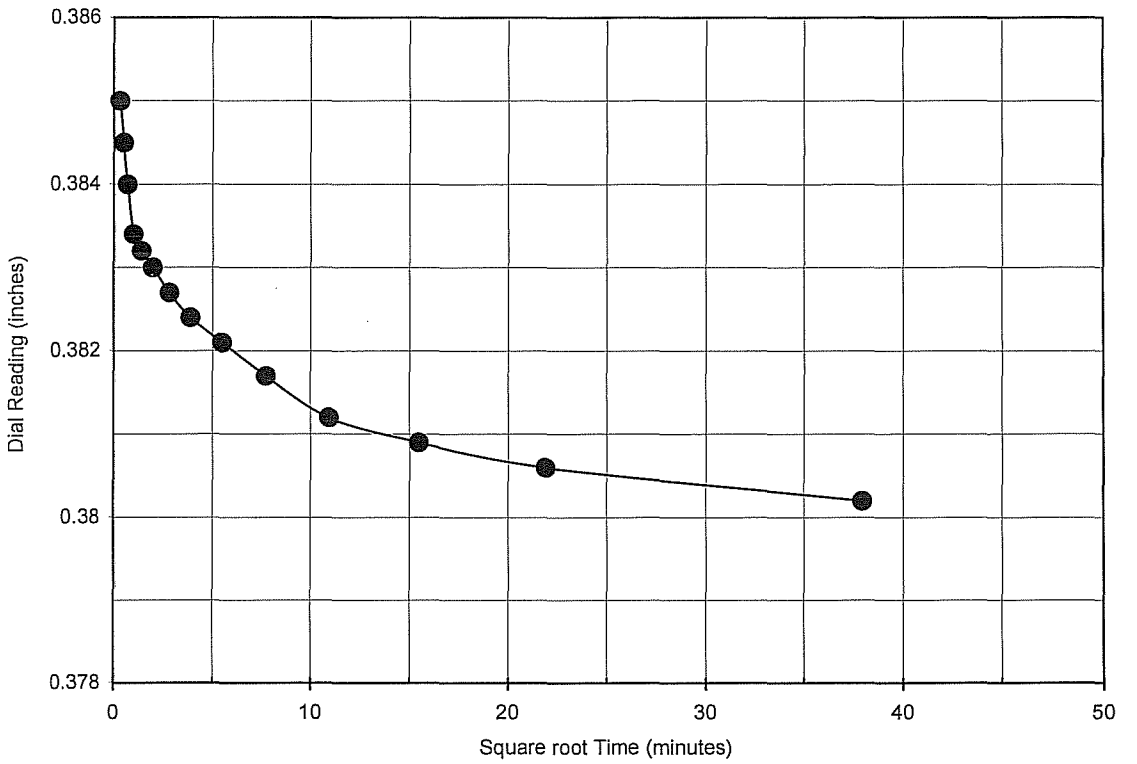


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.385
0.25	0.3845
0.5	0.384
1	0.3834
2	0.3832
4	0.383
8	0.3827
15	0.3824
30	0.3821
60	0.3817
120	0.3812
240	0.3809
480	0.3806
1440	0.3802

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

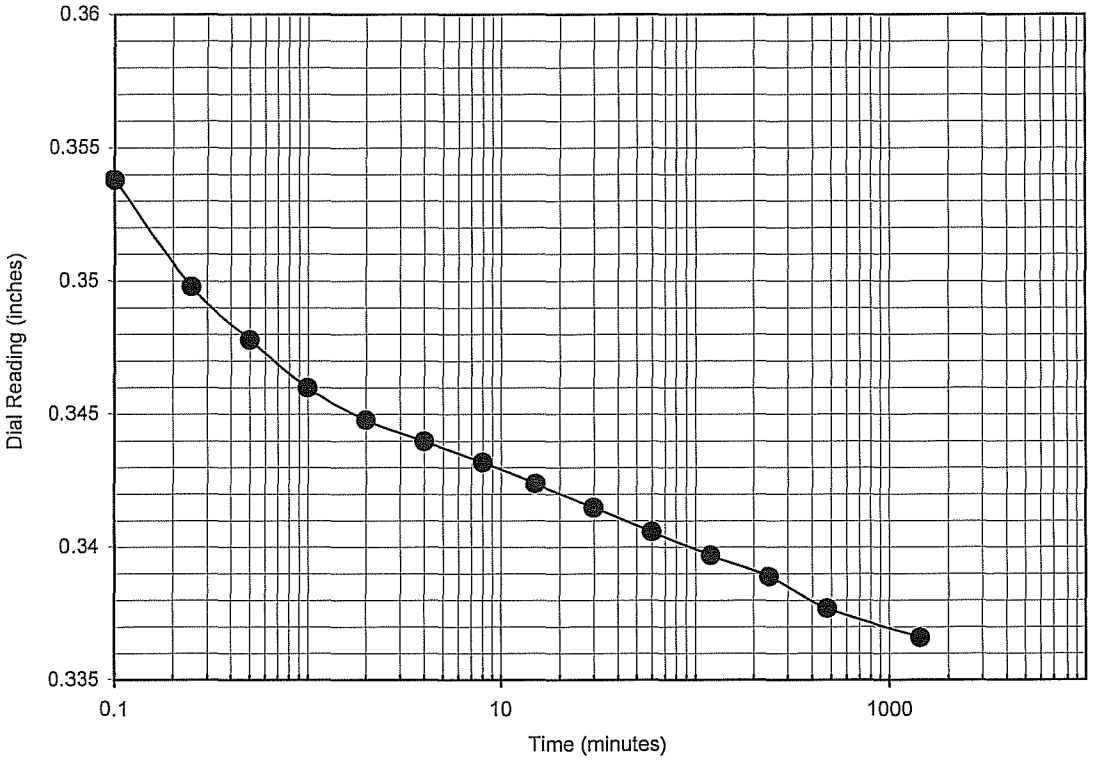


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	1
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3850
0.5000	0.3845
0.7071	0.3840
1.0000	0.3834
1.4142	0.3832
2.0000	0.3830
2.8284	0.3827
3.8730	0.3824
5.4772	0.3821
7.7460	0.3817
10.9545	0.3812
15.4919	0.3809
21.9089	0.3806
37.9473	0.3802

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

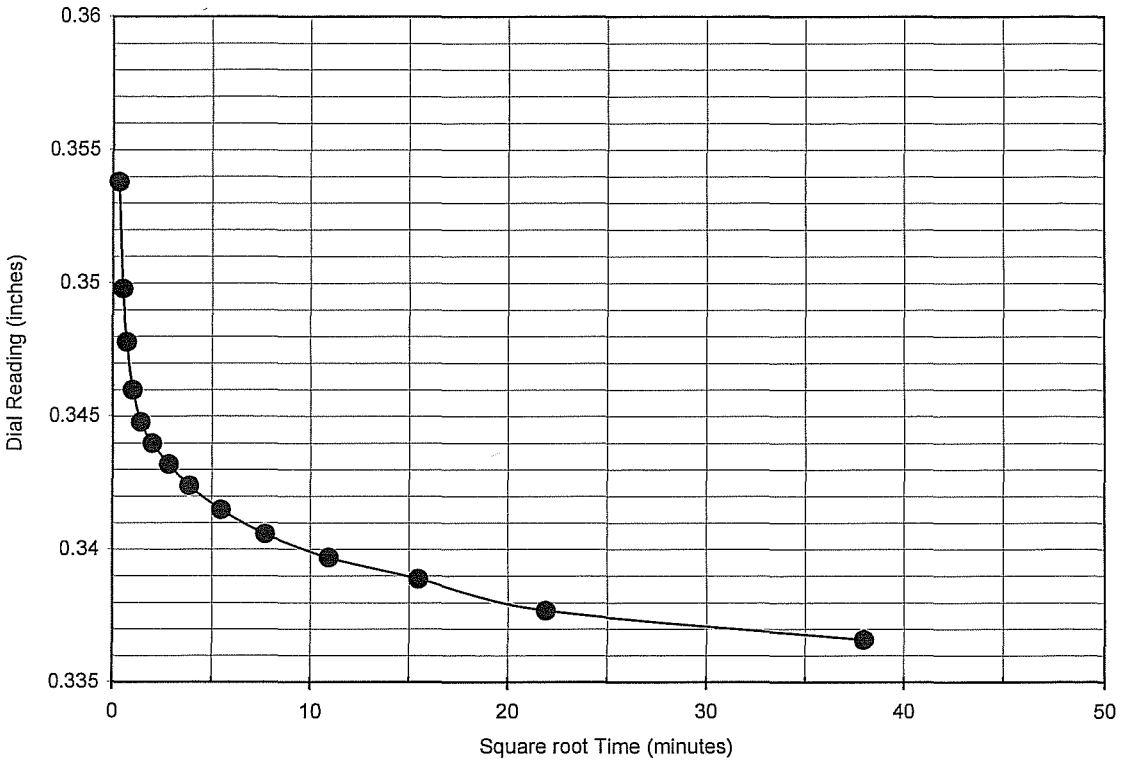


Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

Time (minutes)	Dial Reading (inches)
0.1	0.3538
0.25	0.3498
0.5	0.3478
1	0.346
2	0.3448
4	0.344
8	0.3432
15	0.3424
30	0.3415
60	0.3406
120	0.3397
240	0.3389
480	0.3377
1440	0.3366

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**



Boring No. :	R-09-037	Sample Type:	Cal. Mod.
Sample No.:	D-5A	Soil Description:	Sandy Silt
Depth (feet):	25	Vertical Pressure (ksf):	4
		Test Condition:	Saturated

SQRT Time (minutes)	Dial Reading (inches)
0.3162	0.3538
0.5000	0.3498
0.7071	0.3478
1.0000	0.3460
1.4142	0.3448
2.0000	0.3440
2.8284	0.3432
3.8730	0.3424
5.4772	0.3415
7.7460	0.3406
10.9545	0.3397
15.4919	0.3389
21.9089	0.3377
37.9473	0.3366

CONSOLIDATION CURVE
ASTM D 2435

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03
Date: 11/30/09
AP No: 29-1121 **Figure No:**

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008B

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc.

DATE: 12/29/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
A-09-101	B-01	2.0			14.6	
A-09-101	D-03	10.0	6.5	116.0		
A-09-102	B-01	0.0	5.1		27.6	
A-09-102	D-04	10.0	10.3	113.7		
A-09-103	B-01	2.0			16.7	
A-09-103	S-02-2	5.5	41.4			29,25,4
A-09-104	B-01	2.0			11.0	
A-09-104	D-03	10.0	15.7	103.4		
A-09-105	B-01	0.0			13.5	
A-09-106	B-01	4.0	28.7			30,20,10
A-09-106	D-03	10.0	33.8	87.8		NP
A-09-107	B-01	0.0			27.1	
A-09-107	S-03	5.0	23.1			
A-09-108	B-01	0.0			29.4	
A-09-108	D-04	10.0	41.3	77.4		43,24,19
A-09-109	B-01	1.0			38.2	
A-09-109	S-02	5.0	34.3			25,24,1
A-09-110	B-01	0.0			18.4	
A-09-110	S-03-1	5.0	19.0			41,20,21
A-09-110	D-04	10.0	31.3			30,19,11
A-09-111	B-01	0.0			14.8	
A-09-111	D-04	10.0	11.8	93.2		
A-09-112	B-01	0.0			22.8	
A-09-112	S-03	5.0	8.2			NP
A-09-113	B-01	0.0			20.7	
A-09-113	D-04-2	10.6	47.9			38,24,14
A-09-114	B-01	0.0			20.2	
A-09-114	S-03	5.0	9.7			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

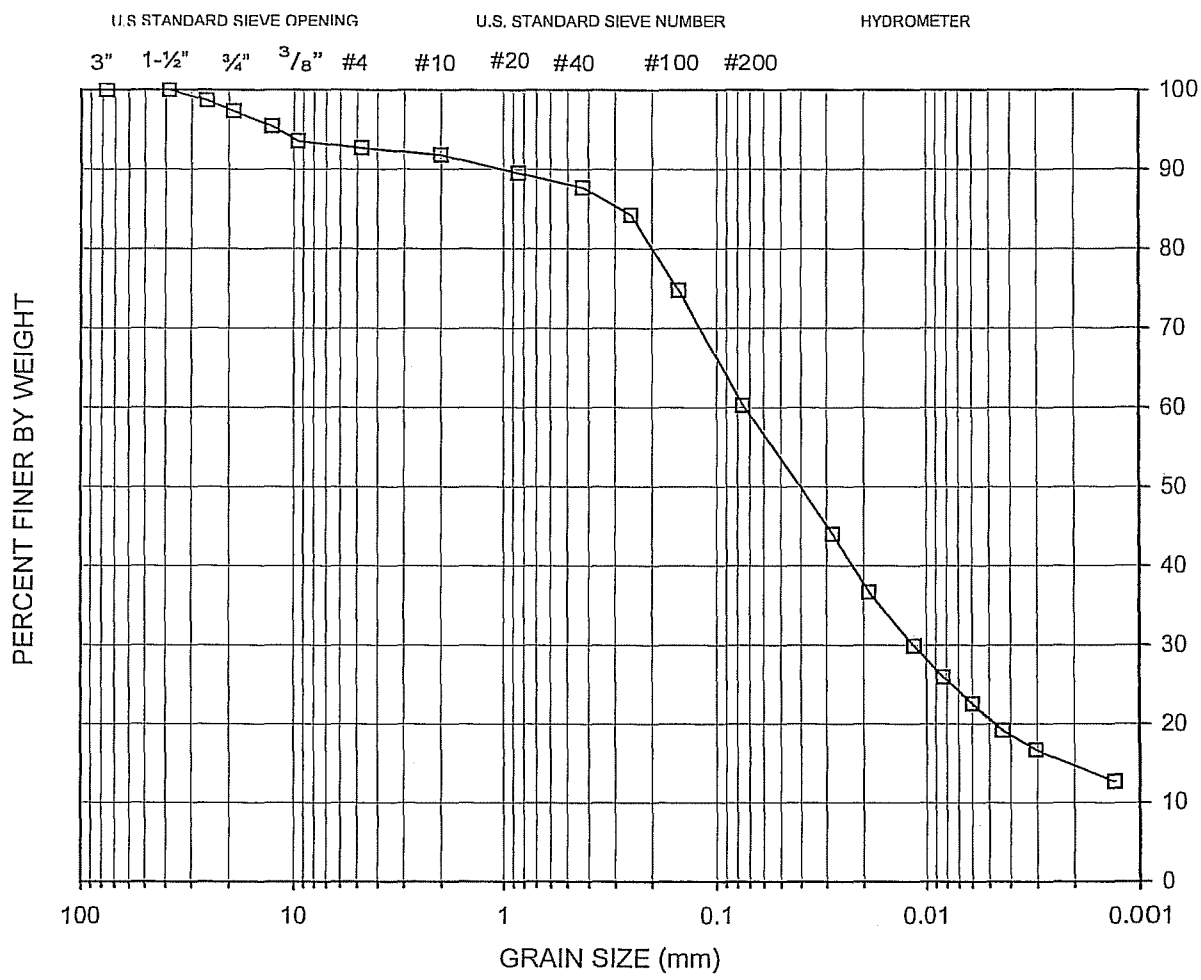
SUMMARY OF LABORATORY TEST RESULTS
EXPANSION INDEX

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008B

PROJECT NO.: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/18/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	EXPANSION INDEX ASTM D 4829
A-09-106	B-01	4	44



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	A-09-106	B-01	4	Bulk	CL	30	10

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

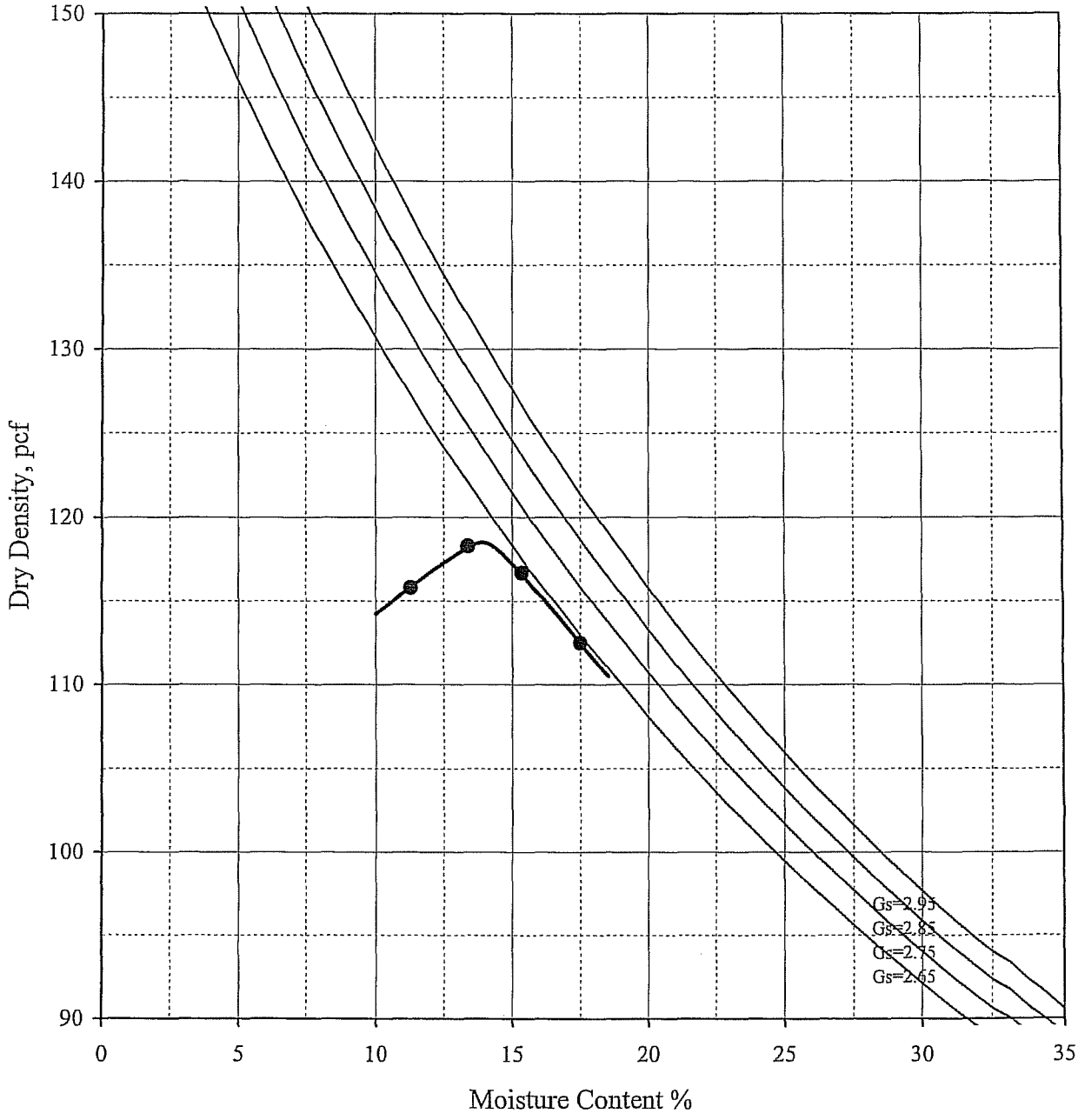
EGL Project No: 09-230-008B

GRAINSIZE DISTRIBUTION CURVE

12/29/09

(ASTM D422)

FIGURE



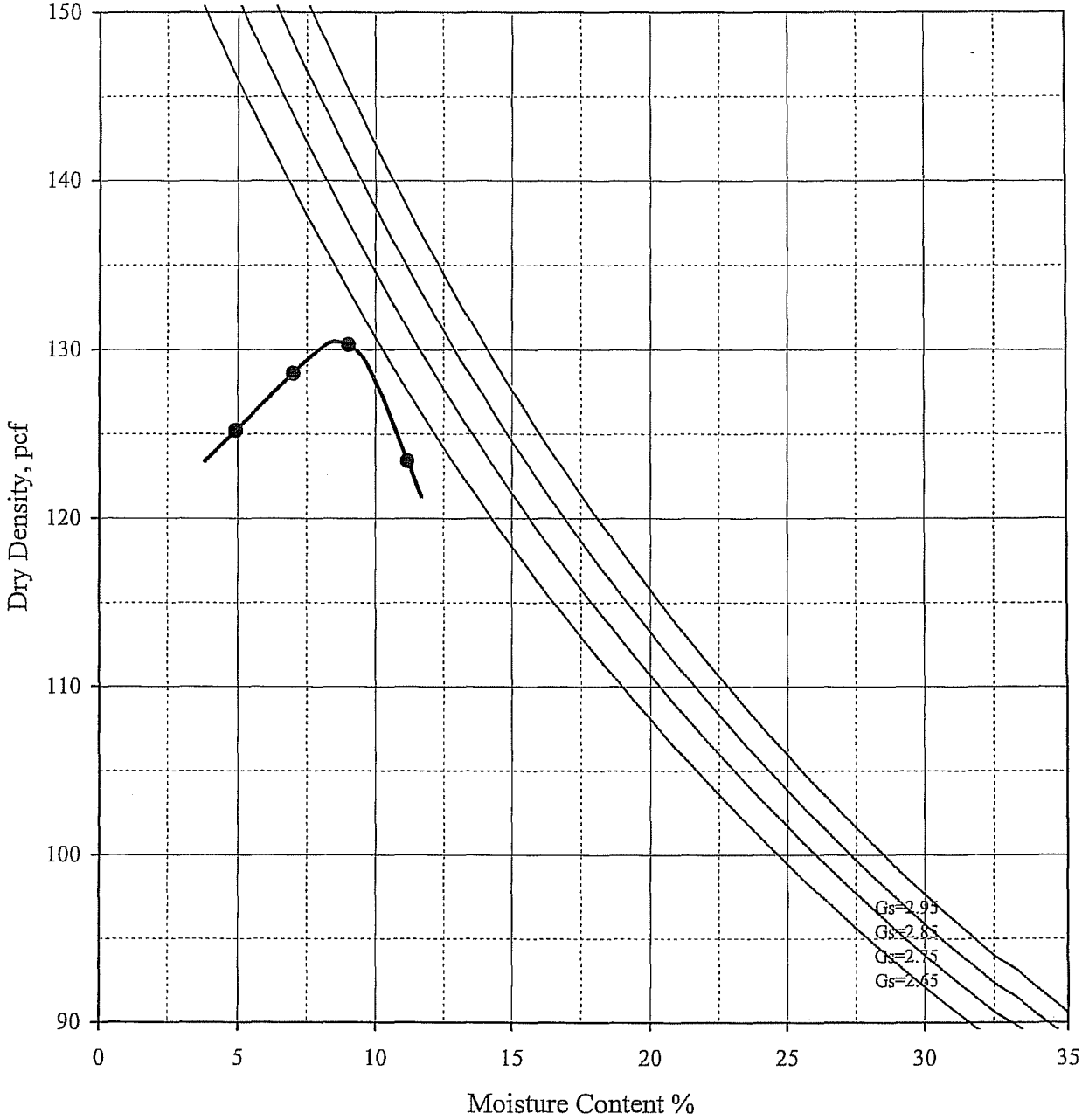
Maximum Dry Density = 118.5 pcf	Boring No: A-09-106
Optimum Moisture Content = 14 %	Sample: B-01
	Depth : 4 feet
	Description : Sandy clay (CL), dark brown

Environmental Geotechnology Laboratory

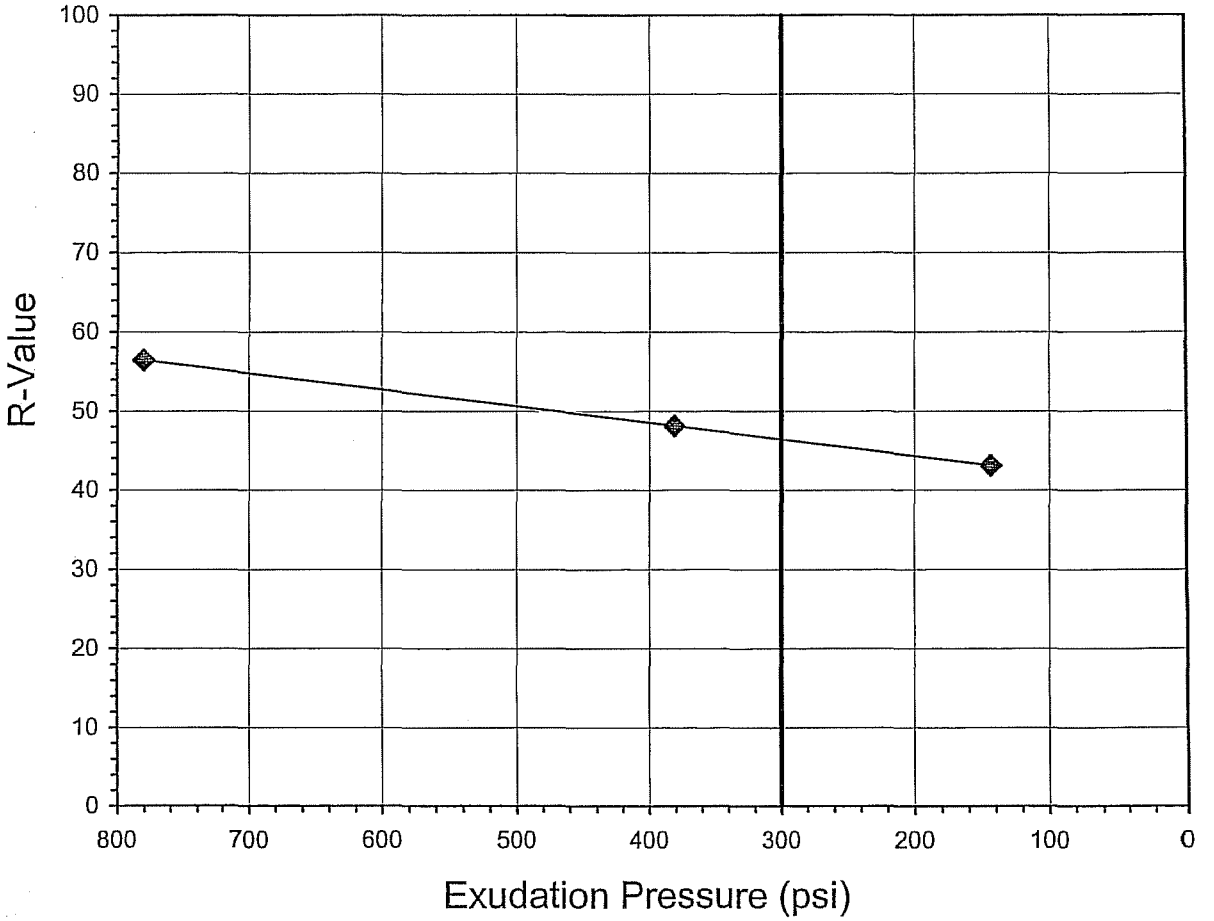
Modified Proctor

(ASTM D1557)

Project Name:		ACTA Heim Bridge Replacement
Client Name:		Earth Mechanics, Inc.
Job No:		06-123-03
EGL Project No.:		09-230-O08B
Date :	Dec-09	Figure



Maximum Dry Density = 130.5 pcf	Boring No: A-09-110
	Sample: B-01
Optimum Moisture Content = 8.5 %	Depth : 0 feet
	Description : Silty sand (SM), brown with some gravel
Environmental Geotechnology Laboratory	Project Name: ACTA Heim Bridge Replacement
	Client Name: Earth Mechanics, Inc.
Modified Proctor	Job No: 06-123-03
	EGL Project No.: 09-230-008B
(ASTM D1557)	Date : Dec-09 Figure



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	150	111.3	16.1	0.45	67	2.57	143	42	43
2	200	112.5	15.2	1.27	60	2.53	381	48	48
3	220	113.8	14.3	2.09	51	2.51	780	56	56

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

Boring No: A-09-106
Sample No: B-01 @ 4'
Sample Type: Bulk
Sample Description: Sandy clay (CL)
Test Date: 12/29/09

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

Test Results: R-Value at 300 psi
Exudation Pressure: 46

R-VALUE TEST REPORT

12/31/09

FIGURE 1

Resistance R - Value Testing Results
(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008B
Test Date:	12/29/2009
Boring No:	A-09-106
Sample No:	B-01 @ 4'
Sample Type:	Bulk
Sample Description:	Sandy clay (CL), dark brown
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	150	200	220
Wet Weight (gms)	1230	1220	1210
Dry Weight (gms)	1059	1059	1059
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	1800	4785	9800
Total Weight (gms)	2879	3002	2949
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1096	1082	1077
Sample Height (in)	2.57	2.53	2.51
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0015	0.0042	0.0069
Expansion Pressure (psi)	0.4545	1.2726	2.0907
Ph @ 2000 lbs	67	60	51
D turns	4.88	4.48	4.12
R-Value from Exudation	42	48	56
Density (pcf)	111.3	112.5	113.8
Moisture (%)	16.1	15.2	14.3
Exudation Pressure (psi)	143	381	780
Corrected R-Value from Exudation:	43	48	56
Exudation Pressure (psi)	143	381	780

R-Value at 300 psi exudation pressure = 46

Note:
0.87% Retained on 3/4-inch Sieve

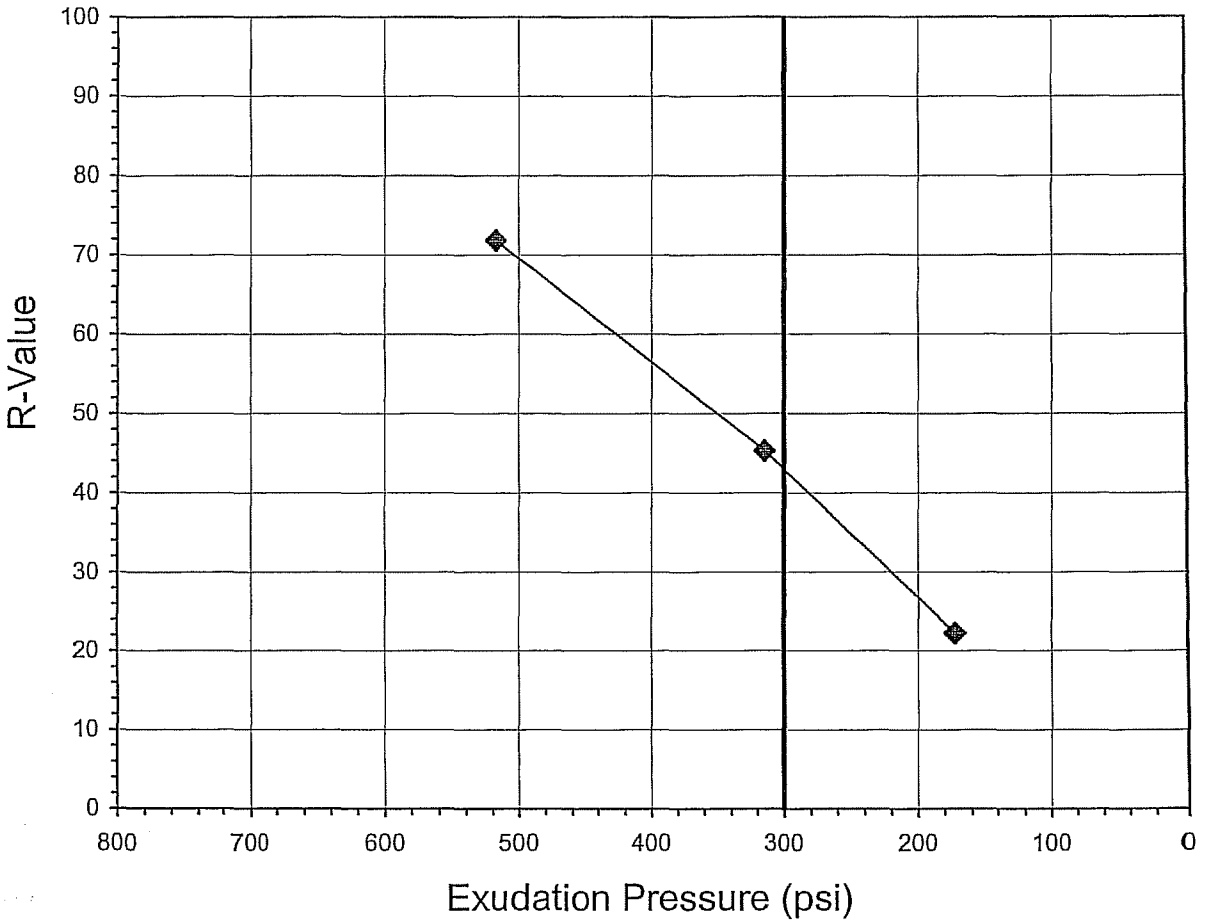
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

R-VALUE TEST RESULTS

12/31/09

FIGURE 2



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	250	122.2	11.1	0.79	35	2.53	518	72	72
2	120	119.5	12.9	0.00	109	2.50	172	22	22
3	200	121.0	12.0	0.52	70	2.52	314	45	45

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

Boring No: A-09-109
Sample No: B-01 @ 1'
Sample Type: Bulk
Sample Description: Clayey sand (SC)
Test Date: 12/14/09

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

Test Results: R-Value at 300 psi
Exudation Pressure: 42

R-VALUE TEST REPORT

12/30/09

FIGURE 1

Resistance R - Value Testing Results
(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008B
Test Date:	12/14/2009
Boring No:	A-09-109
Sample No:	B-01 @ 1'
Sample Type:	Bulk
Sample Description:	Clayey sand (SC), dark brown
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	250	120	200
Wet Weight (gms)	1210	1230	1220
Dry Weight (gms)	1089	1089	1089
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	6500	2161	3950
Total Weight (gms)	2917	3034	2999
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1134	1114	1127
Sample Height (in)	2.53	2.50	2.52
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0026	0.0000	0.0017
Expansion Pressure (psi)	0.7878	0.0000	0.5151
Ph @ 2000 lbs	35	109	70
D turns	3.5	4.09	3.88
R-Value from Exudation	72	22	45
Density (pcf)	122.2	119.5	121.0
Moisture (%)	11.1	12.9	12.0
Exudation Pressure (psi)	518	172	314
Corrected R-Value from Exudation:	72	22	45
Exudation Pressure (psi)	518	172	314

R-Value at 300 psi exudation pressure = 42

Note:
0.00% Retained on 3/4-inch Sieve

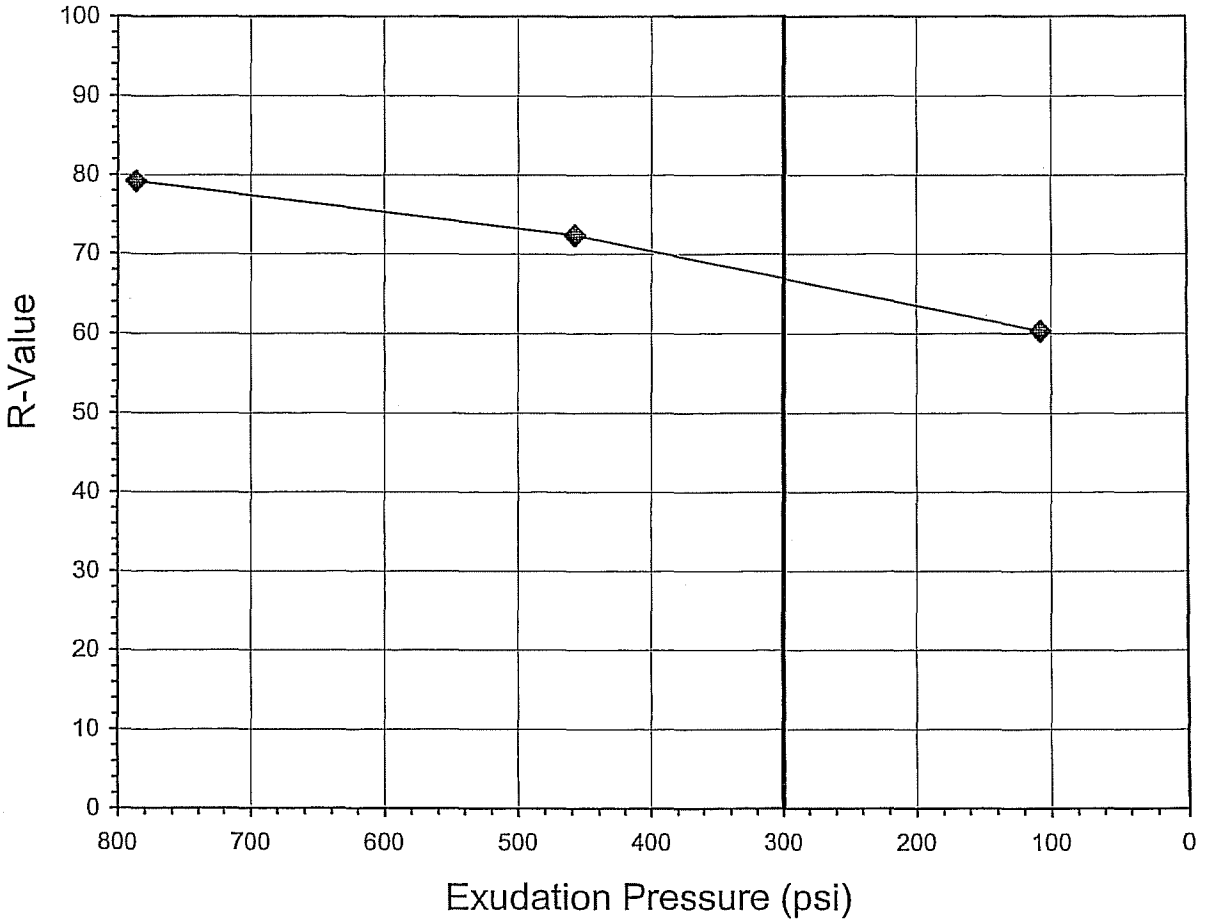
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

R-VALUE TEST RESULTS

12/30/09

FIGURE 2



Test No.	Compaction Pressure (psi)	Density (pcf)	Moisture (%)	Expansion Pressure (psi)	Horizontal Pressure (psi) @ 160 psi	Sample Height (in)	Exudation Pressure (psi)	R-Value	R-Value Correction
1	350	125.0	9.3	0.00	31	2.55	458	72	72
2	250	123.8	10.1	0.00	42	2.50	107	60	60
3	350	126.2	8.4	0.39	25	2.50	786	79	79

Test Name and Method:
Resistance R-Value and Expansion Pressure - Cal Test 301

Boring No: A-09-110
Sample No: B-01 @ 0'
Sample Type: Bulk
Sample Description: Silty sand (SM)
Test Date: 12/11/09

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

Test Results: R-Value at 300 psi
Exudation Pressure: 66

R-VALUE TEST REPORT

12/30/09

FIGURE 1

Resistance R - Value Testing Results
(Cal Test 301)

Project Name:	ACTA Heim Bridge Replacement
Job No.:	06-123-03
Client:	Earth Mechanics, Inc.
EGL Project No:	09-230-008B
Test Date:	12/11/2009
Boring No:	A-09-110
Sample No:	B-01 @ 0'
Sample Type:	Bulk
Sample Description:	Silty sand (SM), brown with some gravel
Tested by:	JT
Checked by:	HJ

Test Specimen Number	1	2	3
Compaction Pressure (psi)	350	250	350
Wet Weight (gms)	1240	1250	1230
Dry Weight (gms)	1135	1135	1135
Tare Weight (gms)	0	0	0
Exudation Load (lbs.)	5750	1350	9870
Total Weight (gms)	2932	3045	3000
Mold Weight (gms)	1783	1920	1872
Sample Weight (gms)	1149	1125	1128
Sample Height (in)	2.55	2.50	2.50
Initial Expansion (x 10,000)	0.0000	0.0000	0.0000
Final Expansion (x 10,000)	0.0000	0.0000	0.0013
Expansion Pressure (psi)	0.0000	0.0000	0.3939
Ph @ 2000 lbs	31	42	25
D turns	3.97	4.62	3.54
R-Value from Exudation	72	60	79
Density (pcf)	125.0	123.8	126.2
Moisture (%)	9.3	10.1	8.4
Exudation Pressure (psi)	458	107	786
Corrected R-Value from Exudation:	72	60	79
Exudation Pressure (psi)	458	107	786

R-Value at 300 psi exudation pressure = 66

Note:
6.74% Retained on 3/4-inch Sieve

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008B

R-VALUE TEST RESULTS

12/30/09

FIGURE 2

APPENDIX D.

SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

PREPARED FOR: Haitao Liu, P. E. / Caltrans
Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

California Department of Transportation (Caltrans), 2006, "Seismic Design Criteria," Version 1.4, June.

——, 2009, "Seismic Design Criteria," Version 1.5, Appendix B, September.

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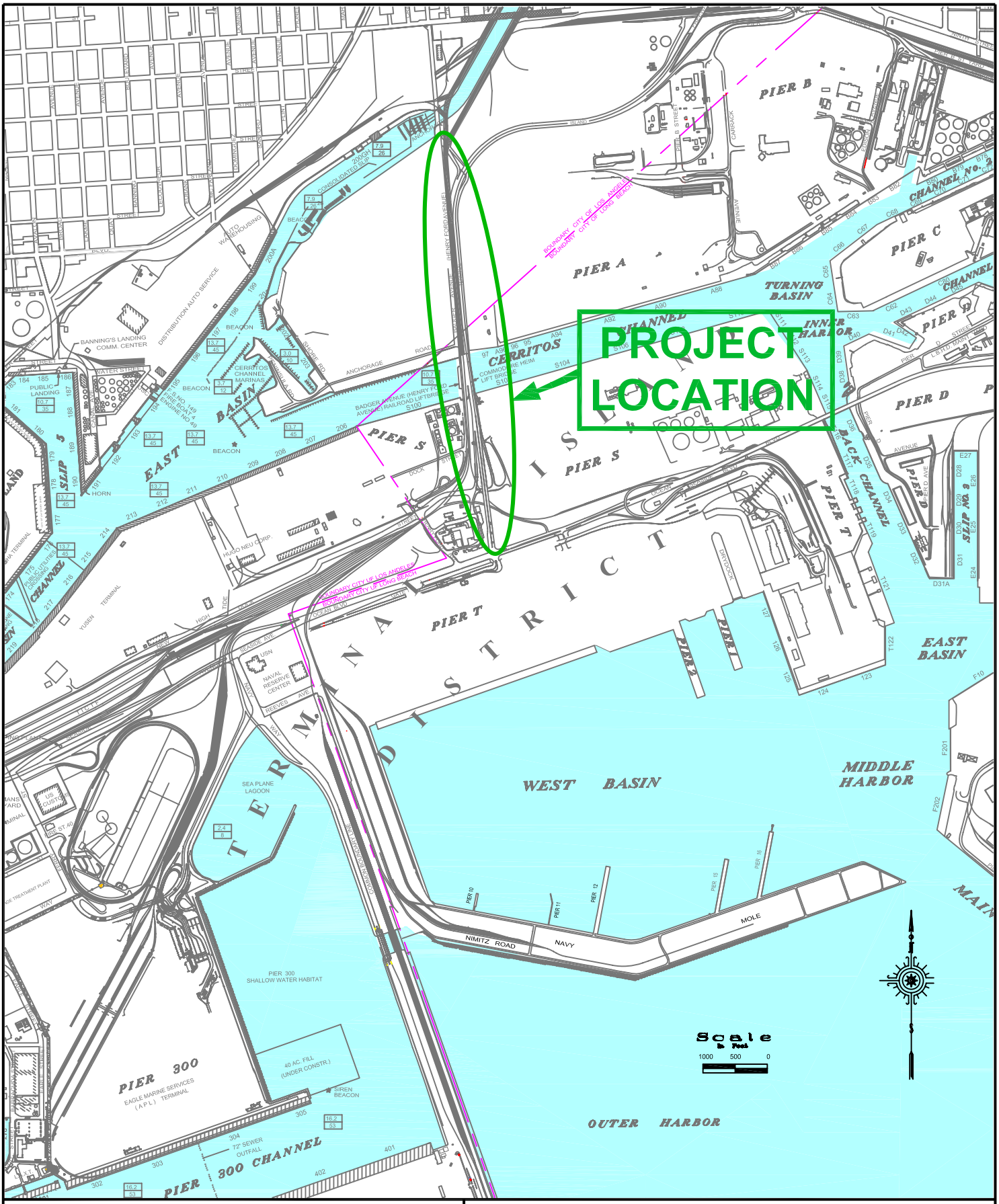
Idriss, I. M. and Sun, J. I., 1992, "User's Manual for SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Department of Civil and Environmental Engineering, University of California, Davis, Report Prepared for National Institute of Standards and Technology, Gaithersburg, Maryland, August.



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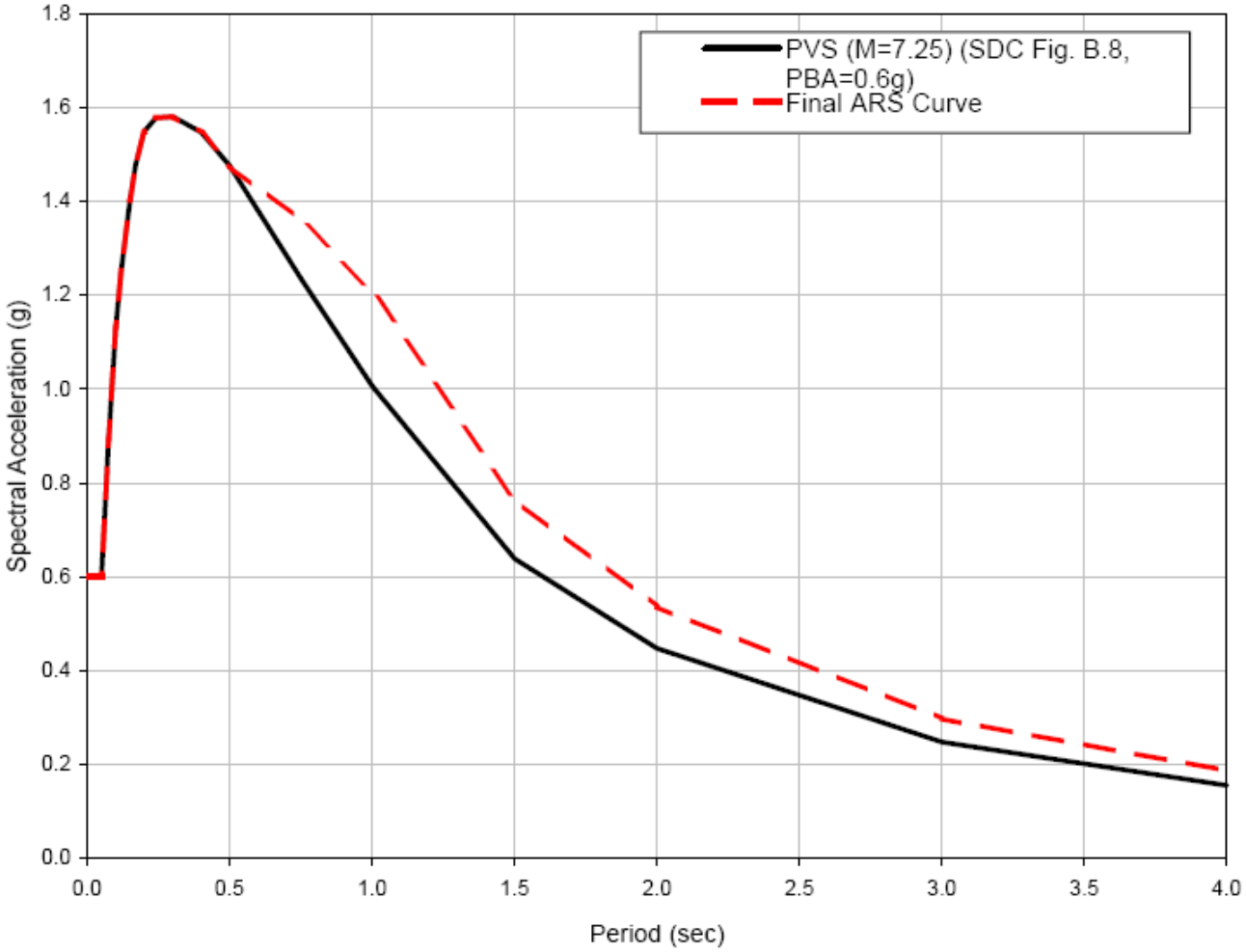
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

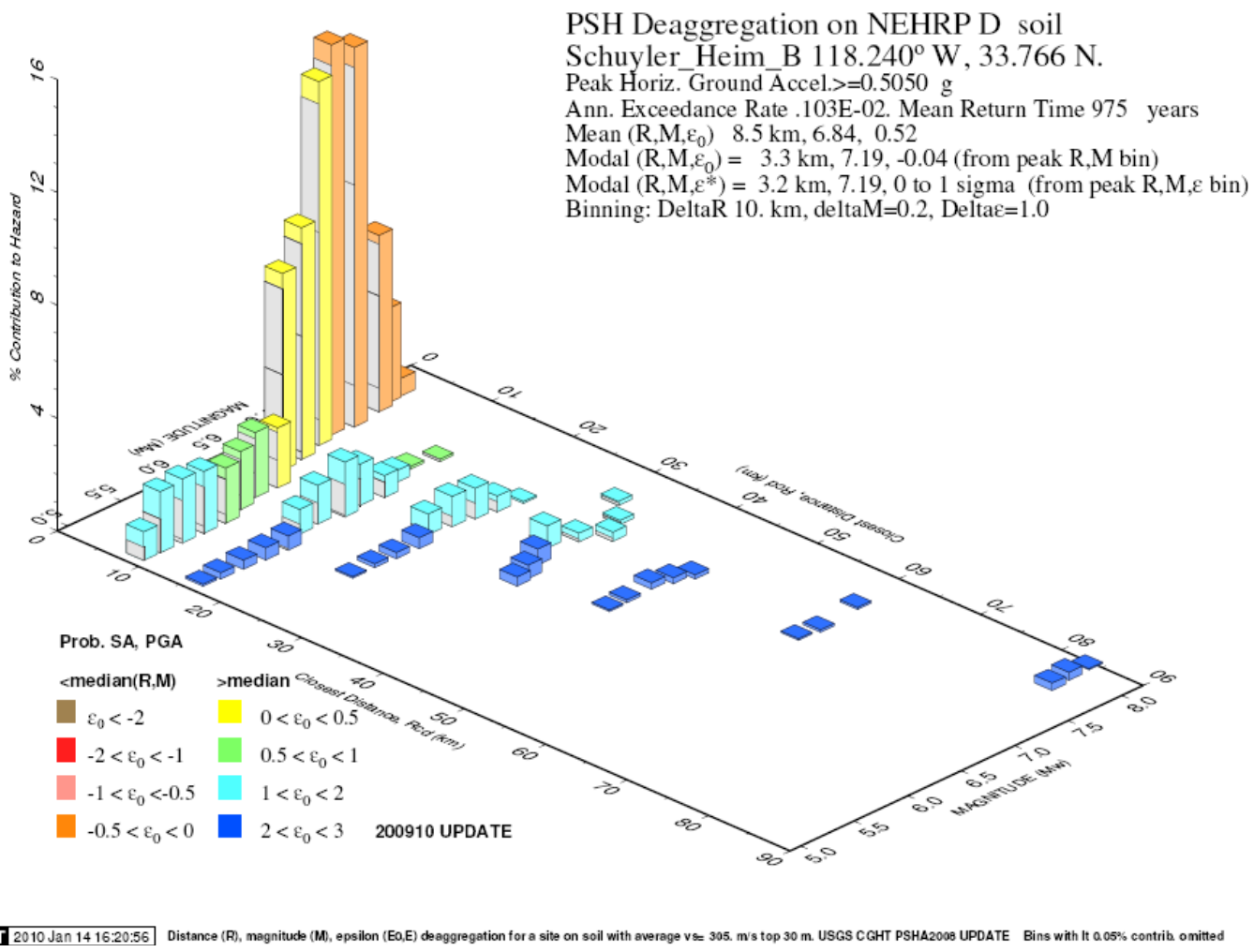


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

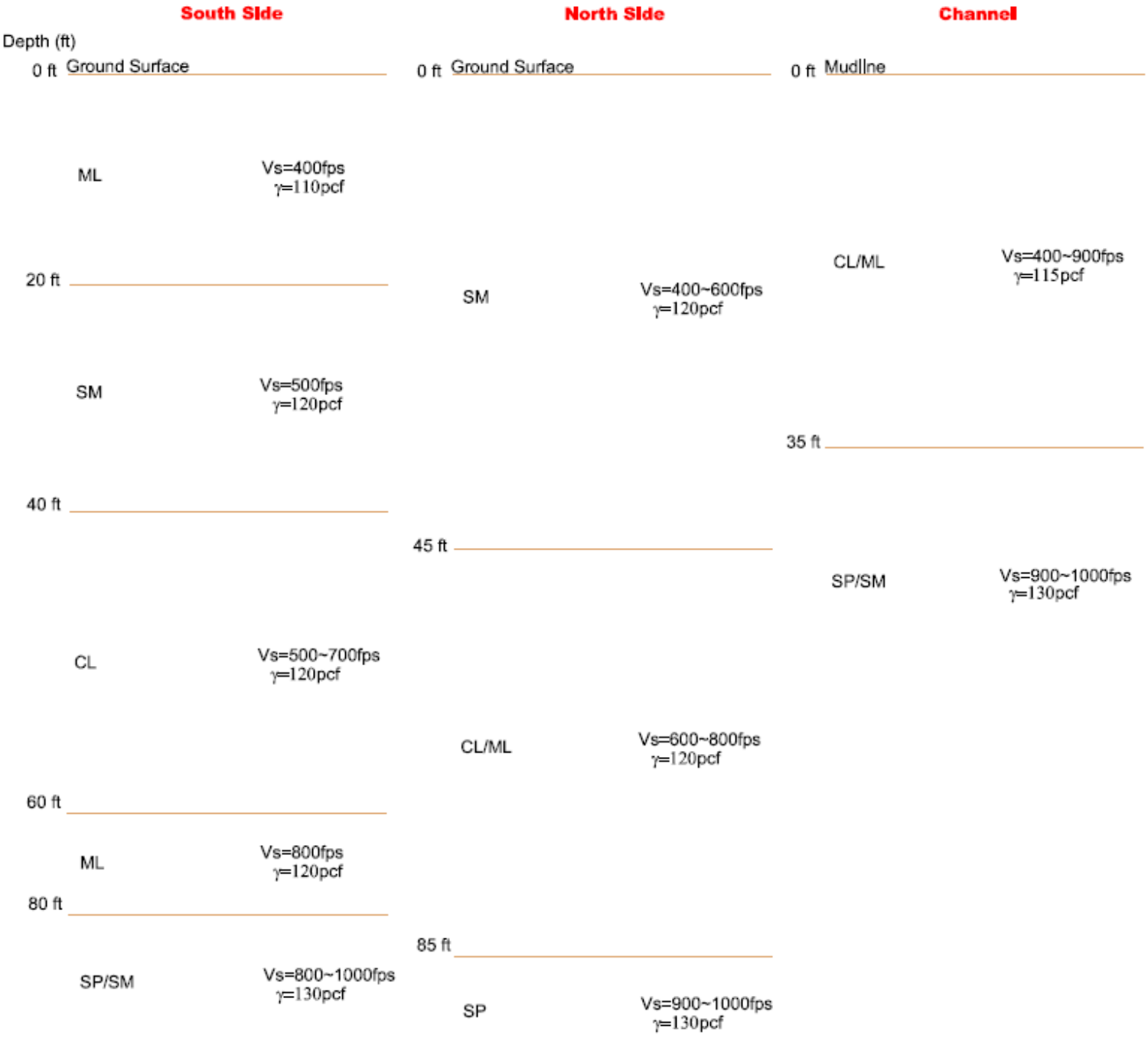
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



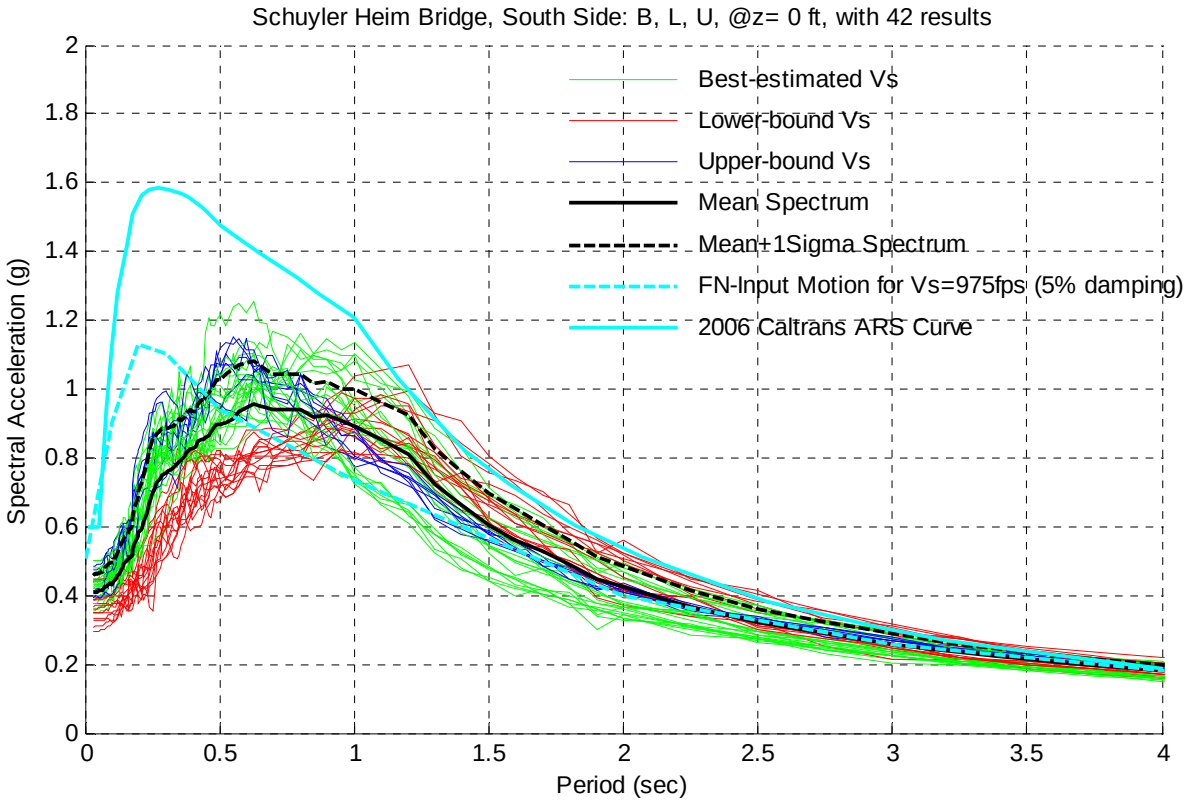
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

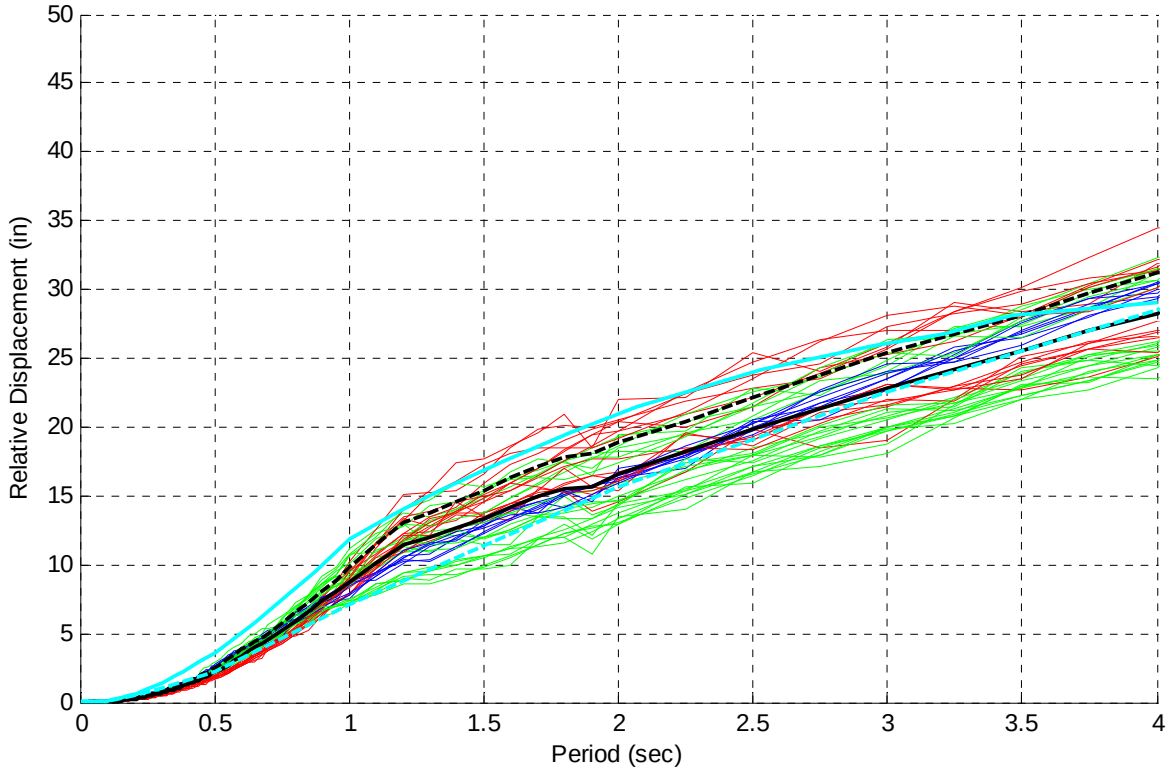
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





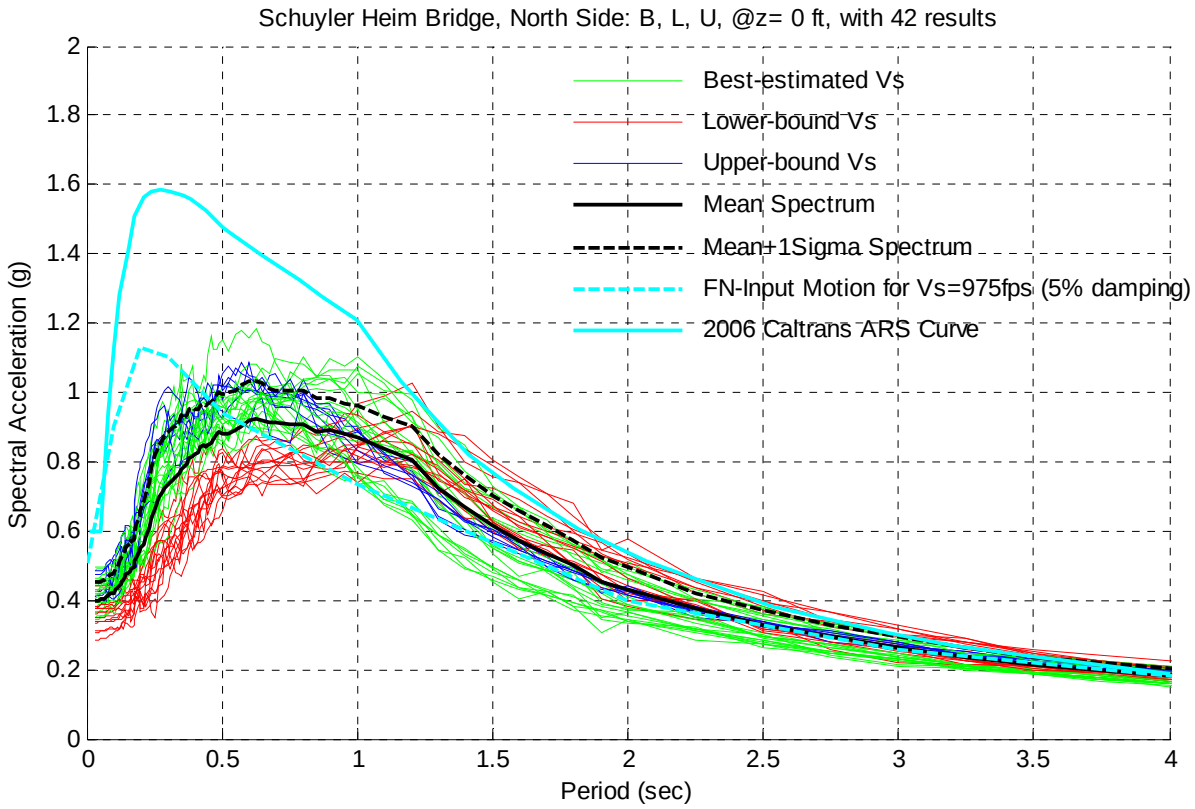
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

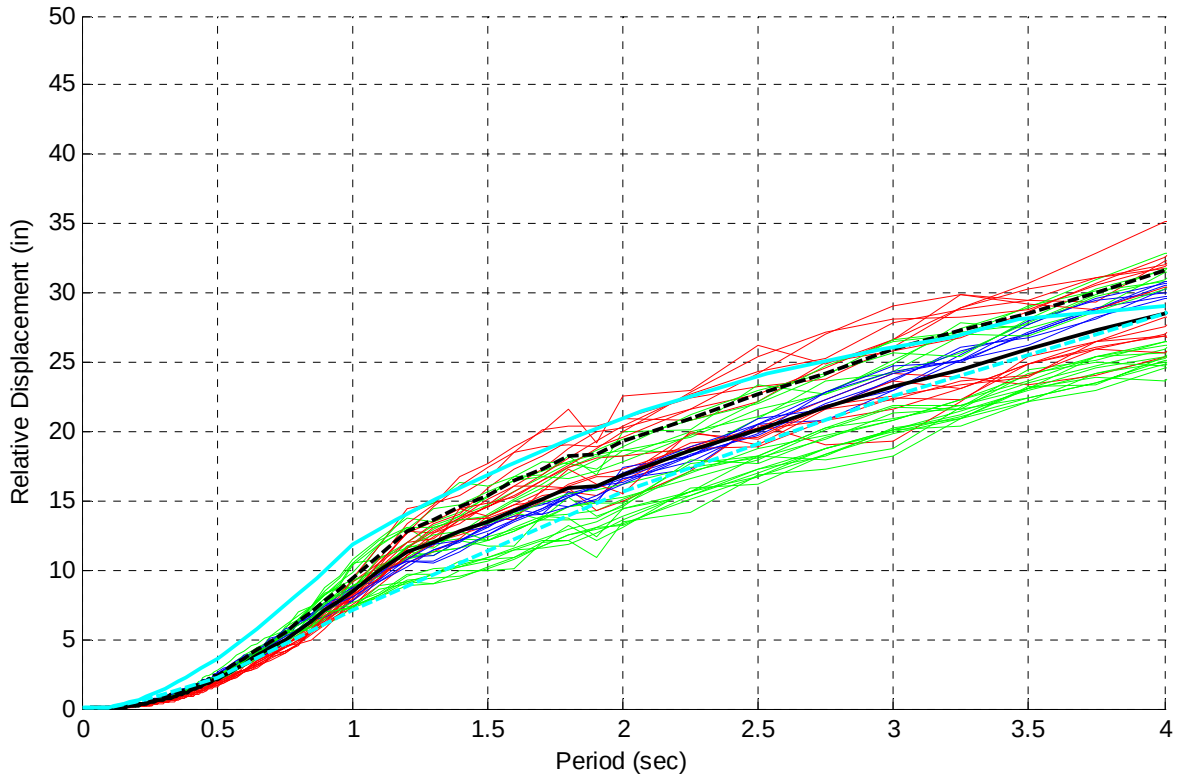
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





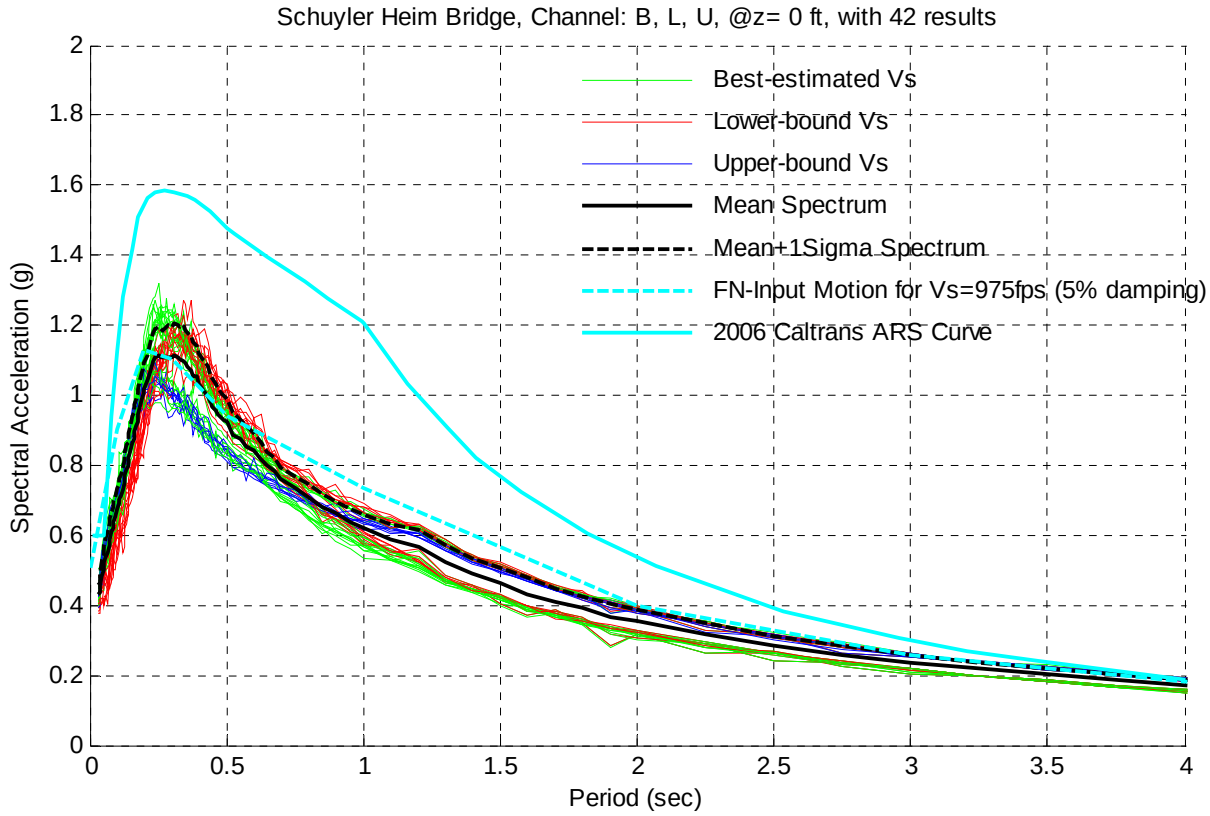
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

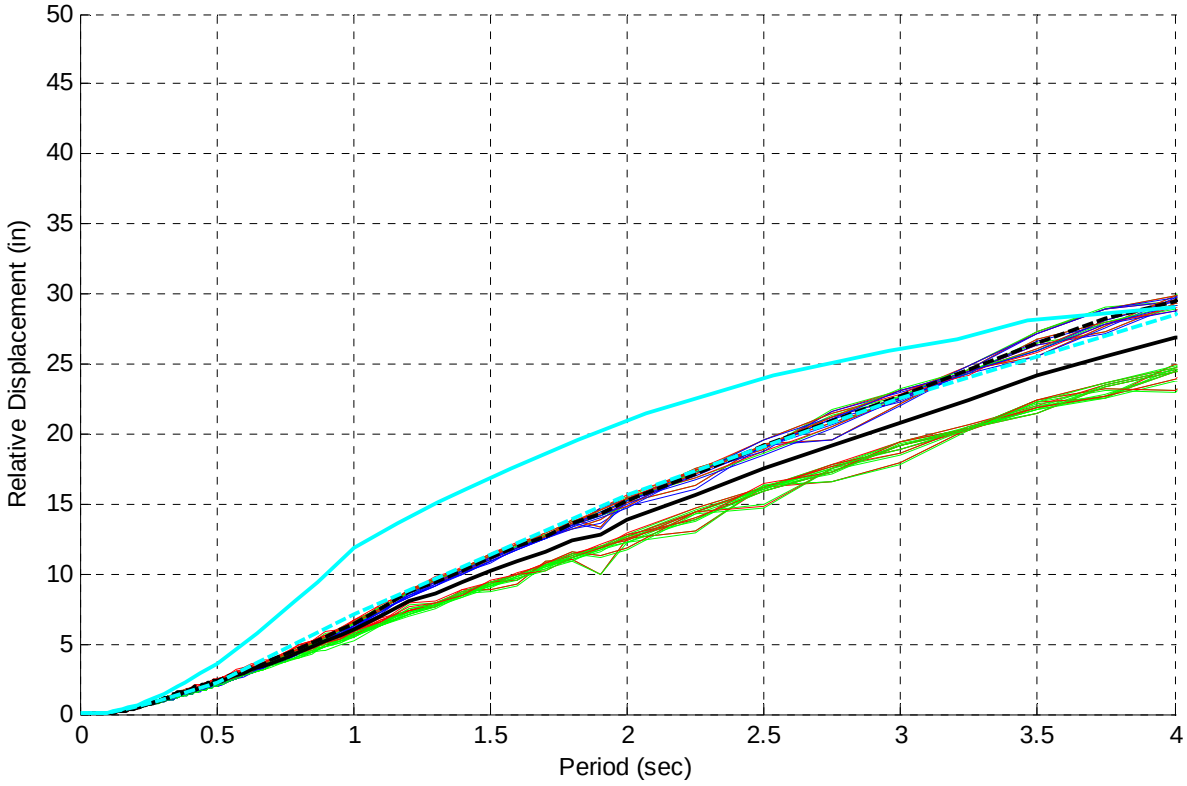
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





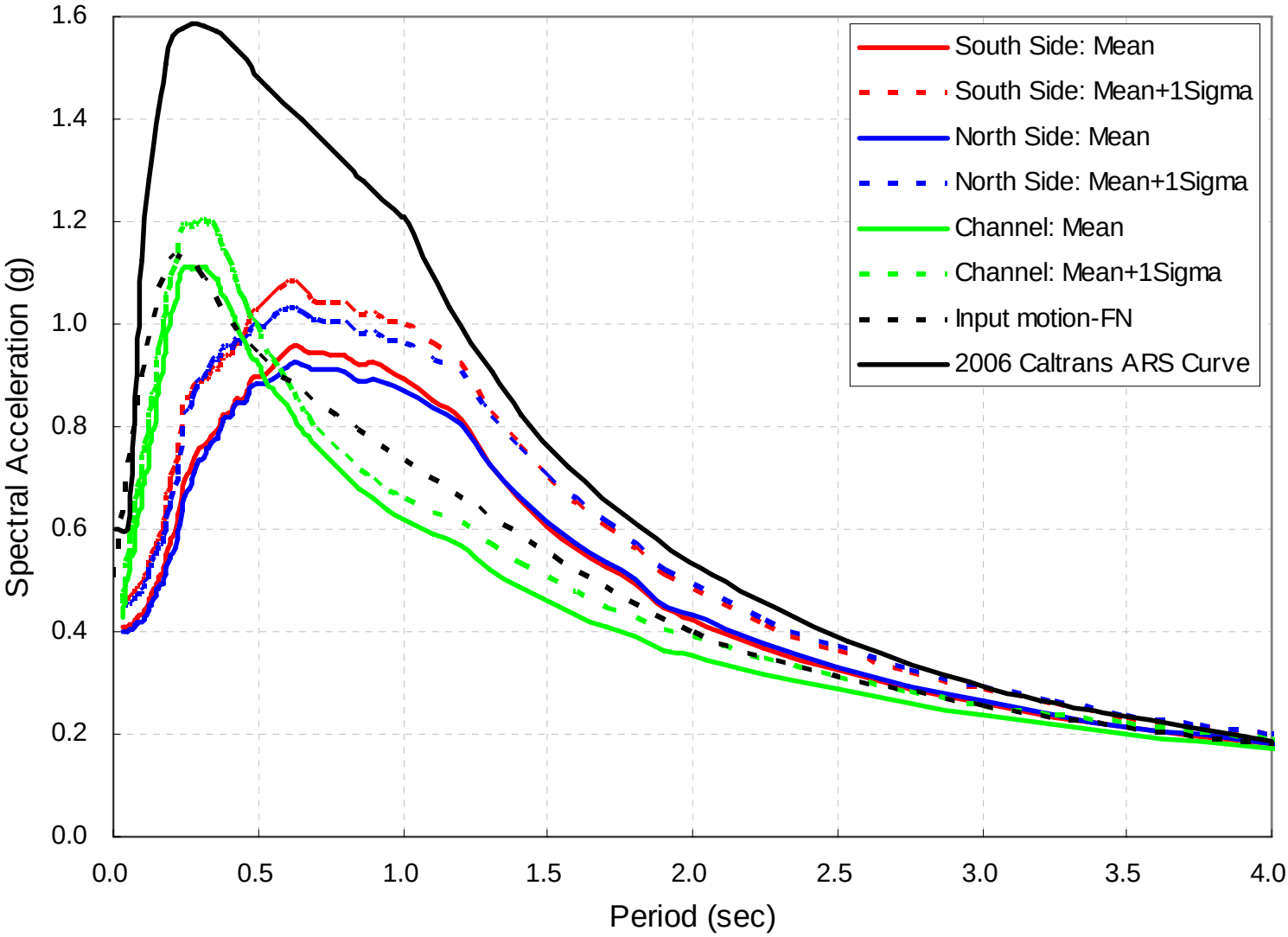
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

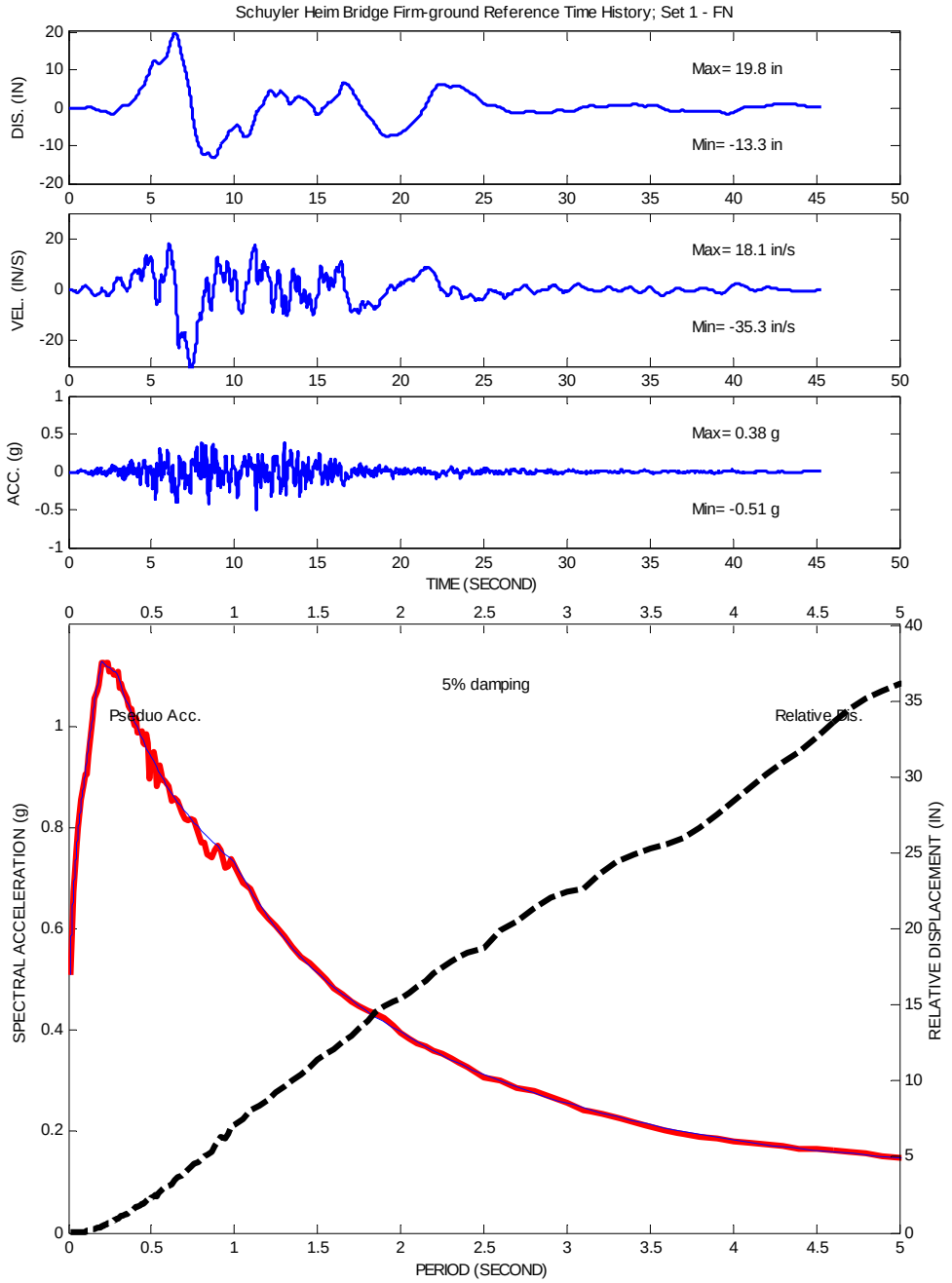
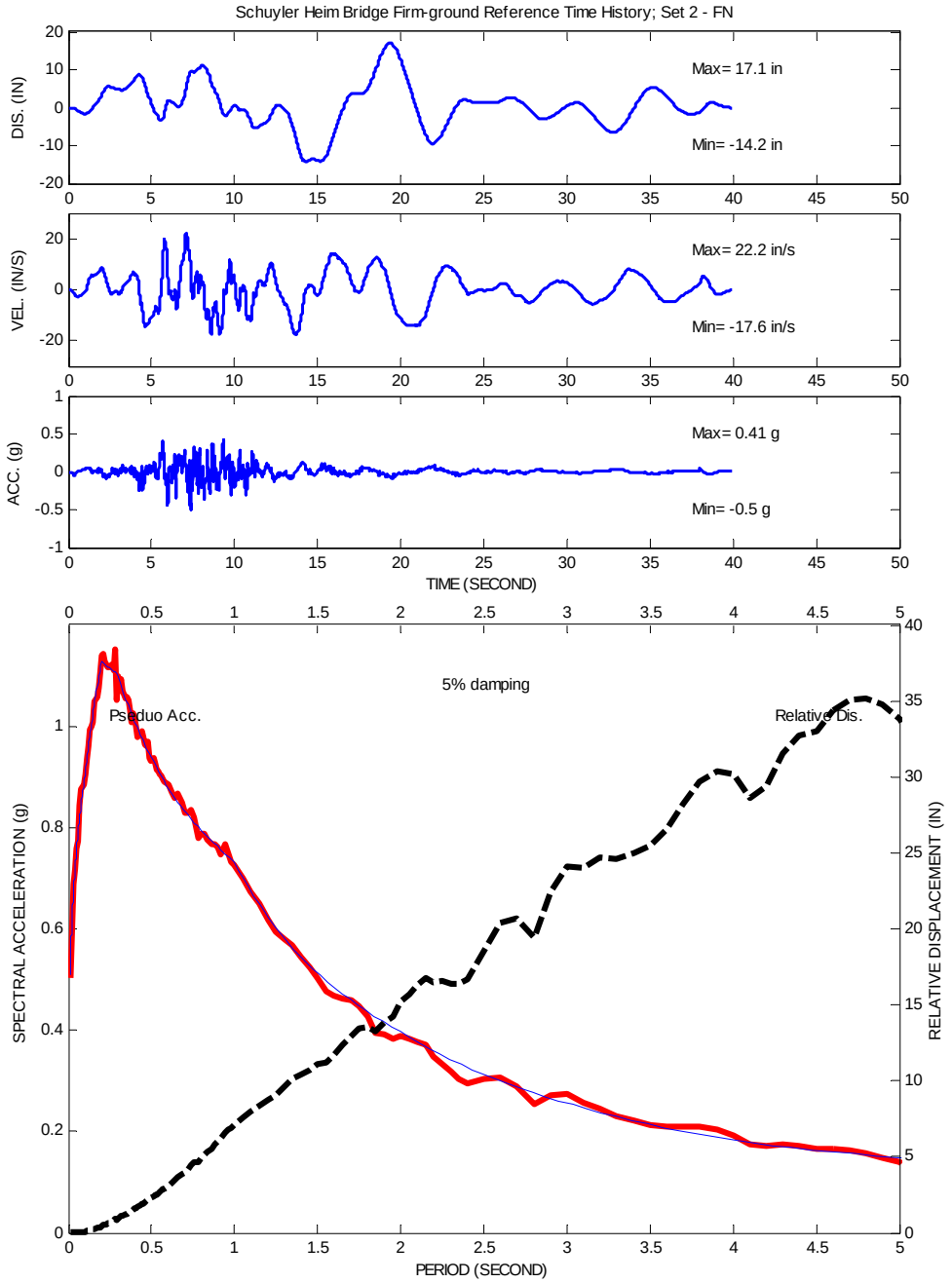


Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN



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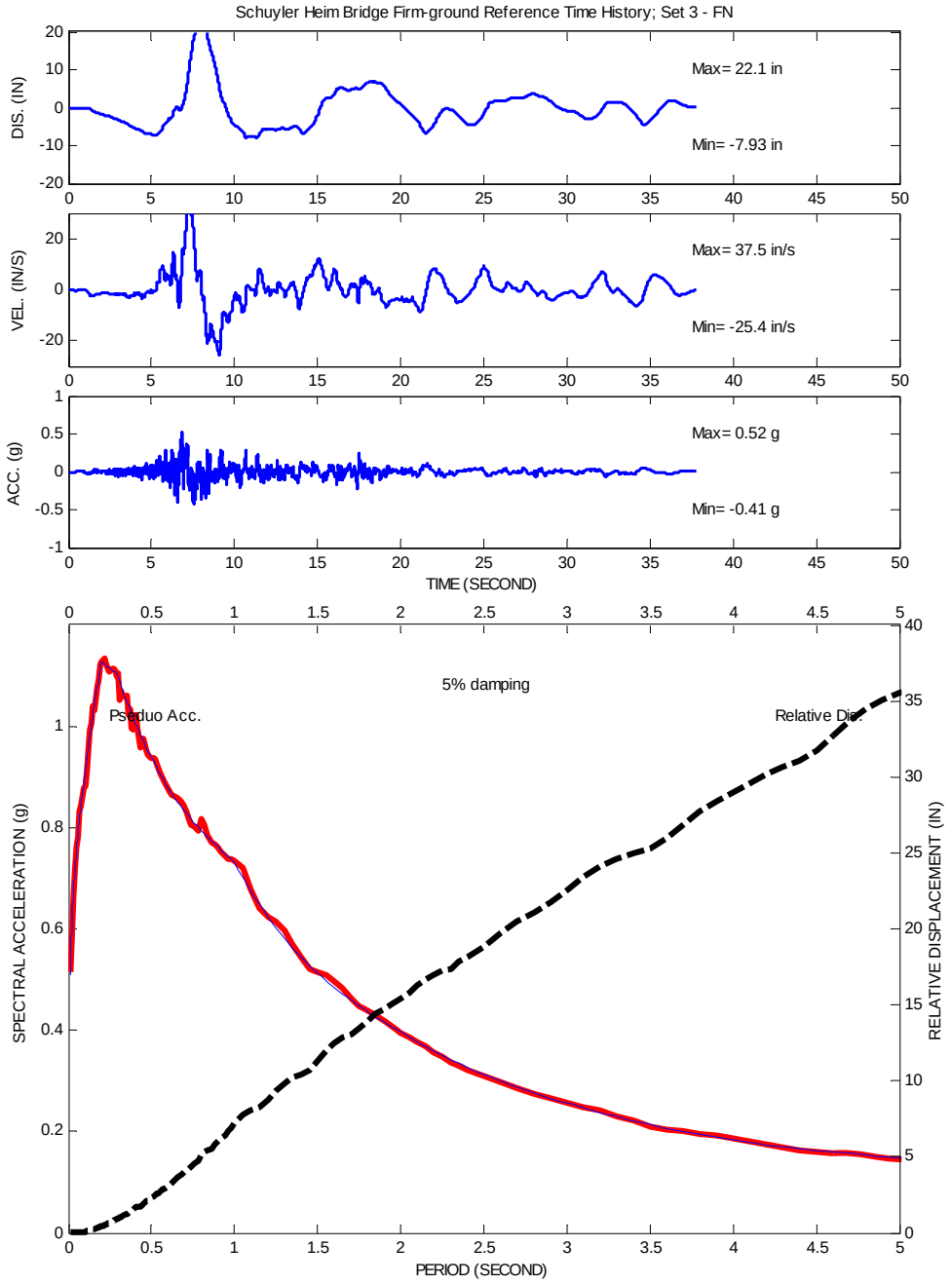

Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

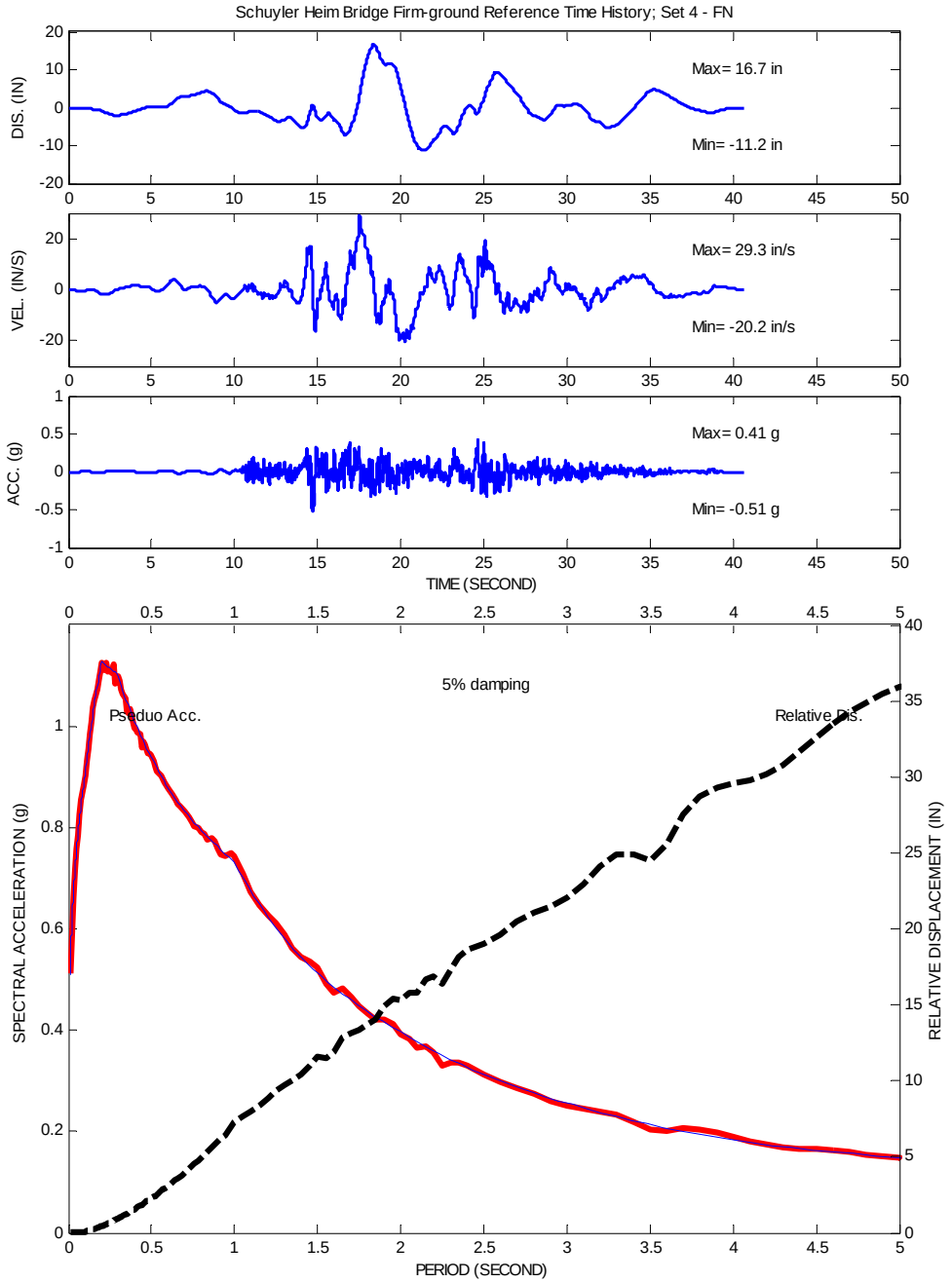

Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

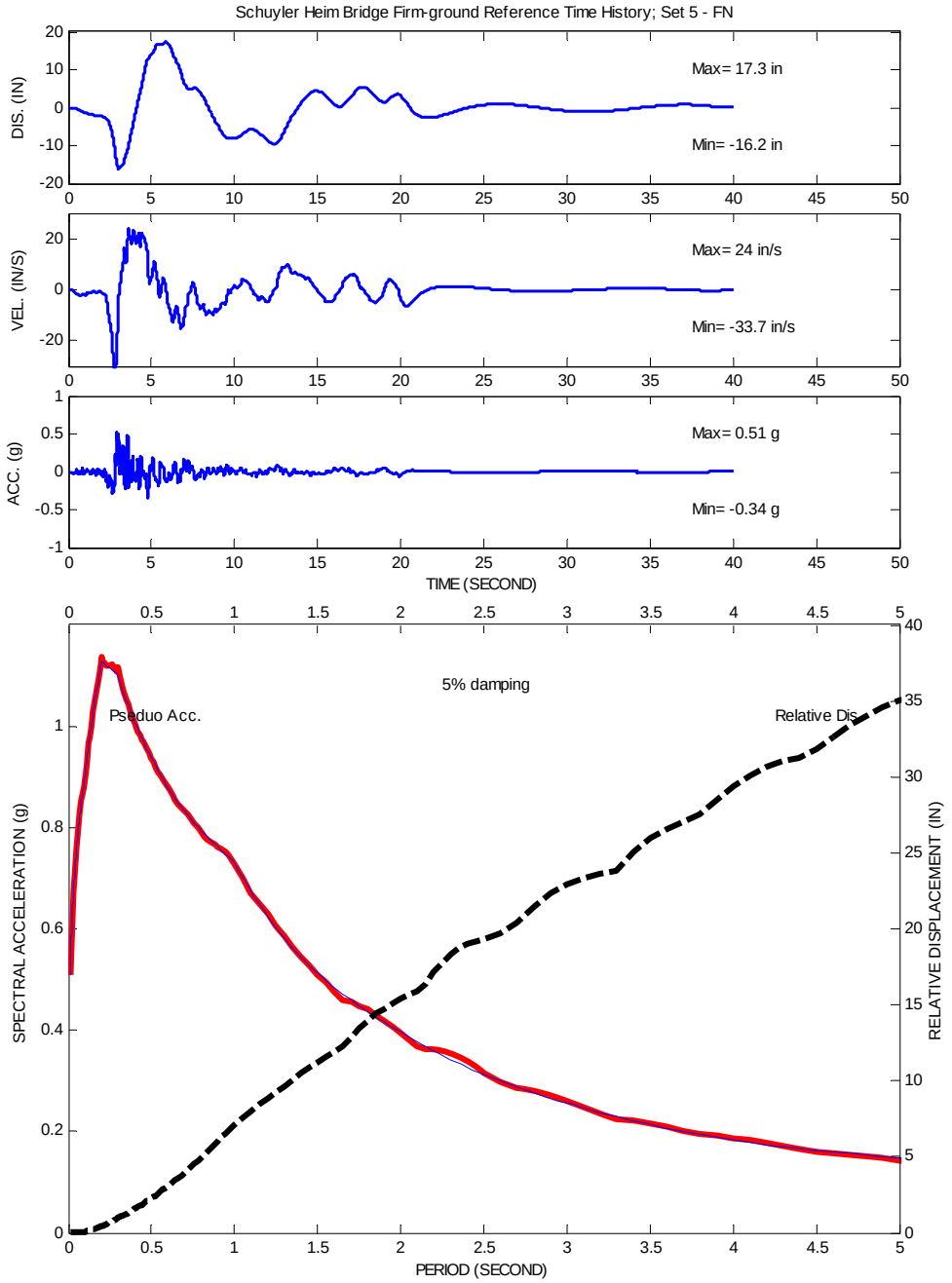

Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

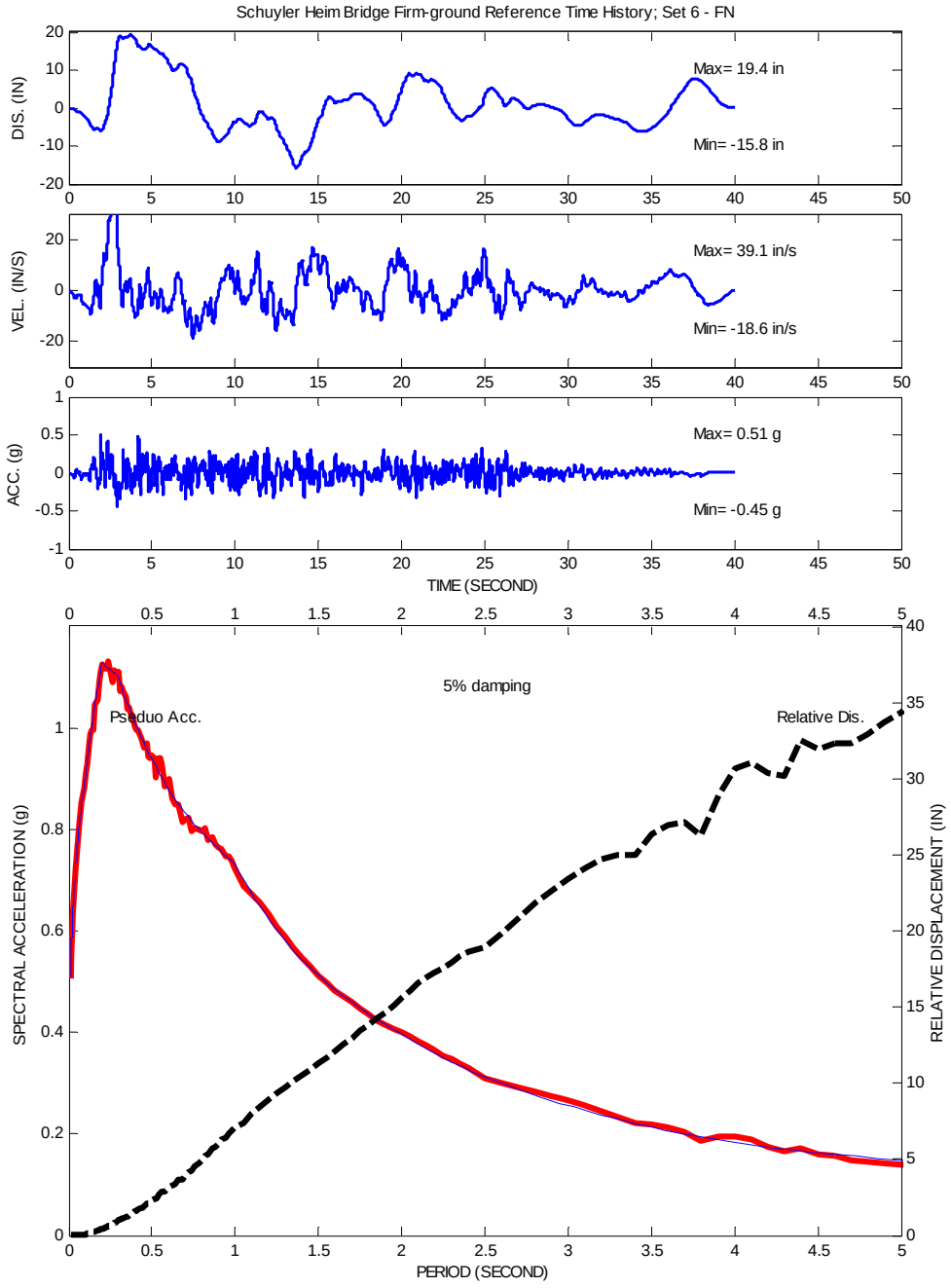

Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

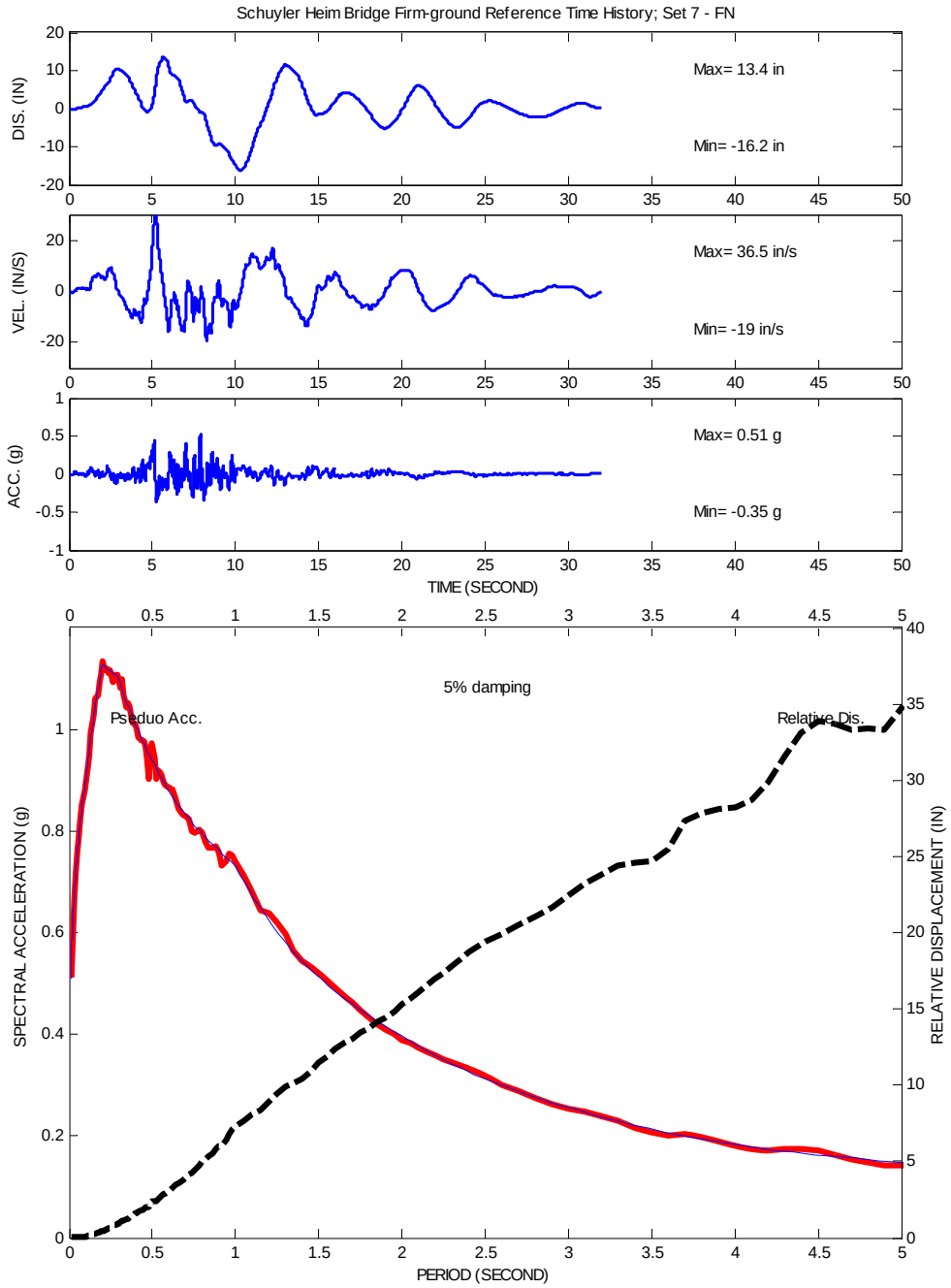

Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

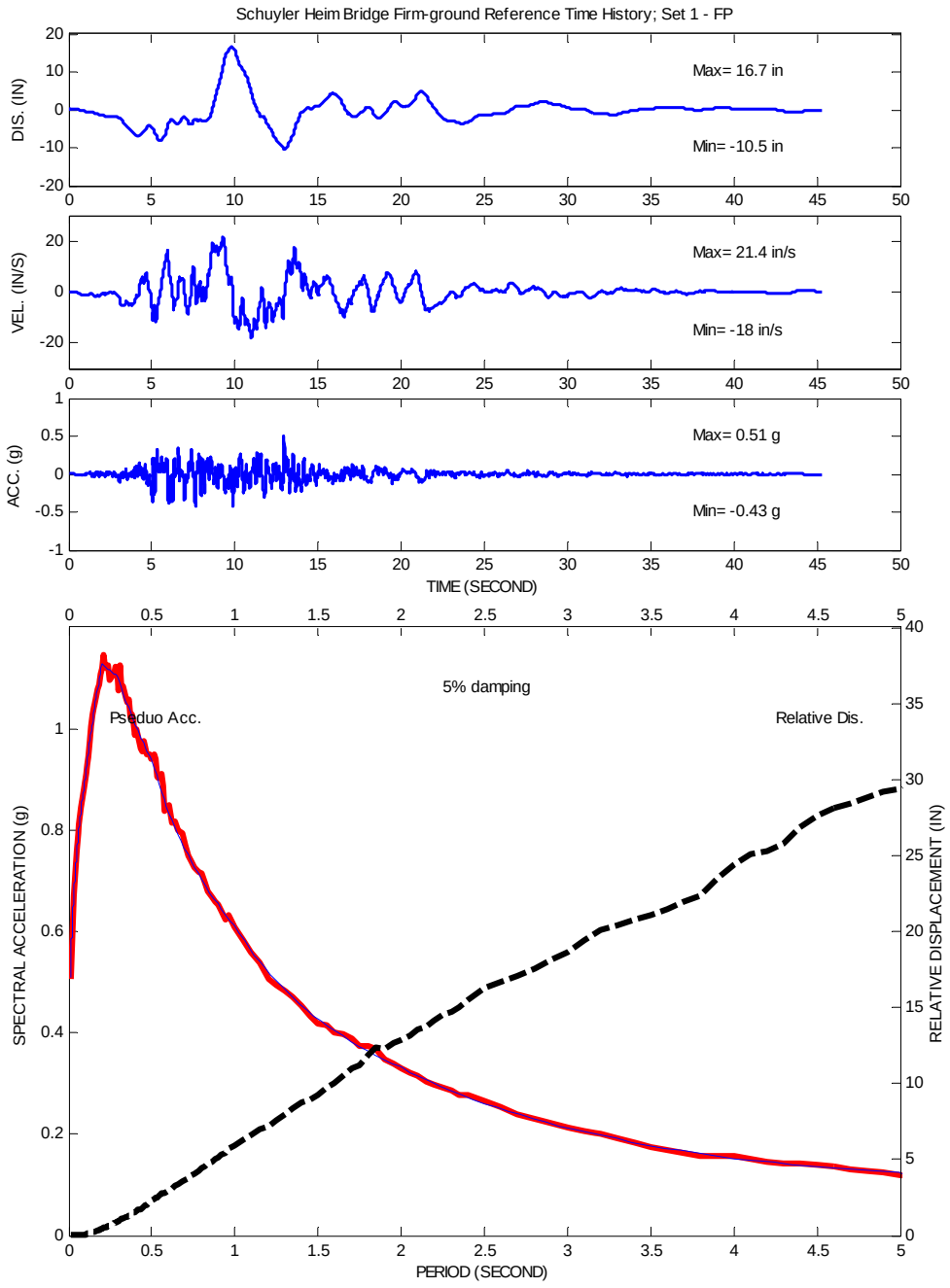

Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

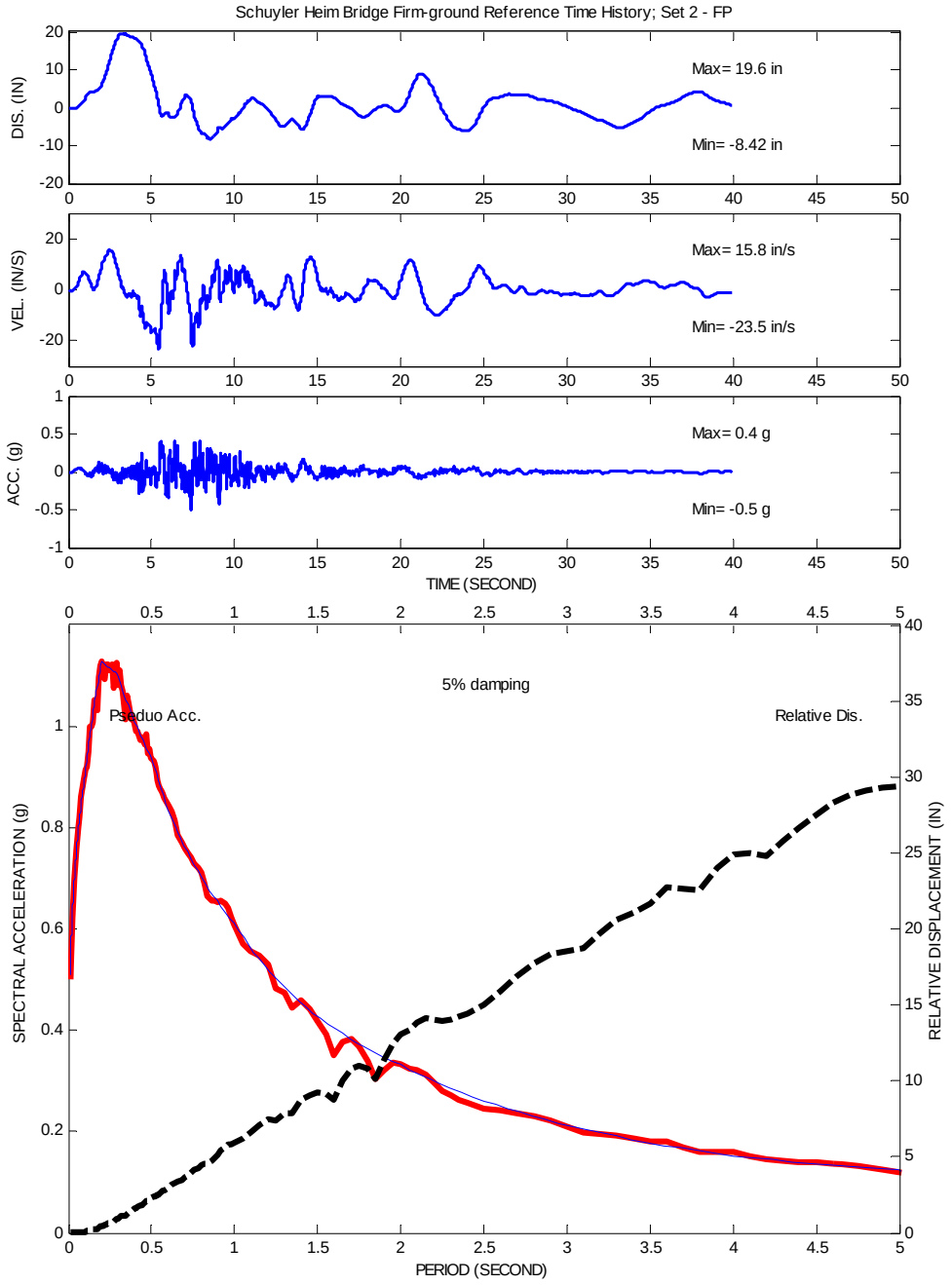

Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

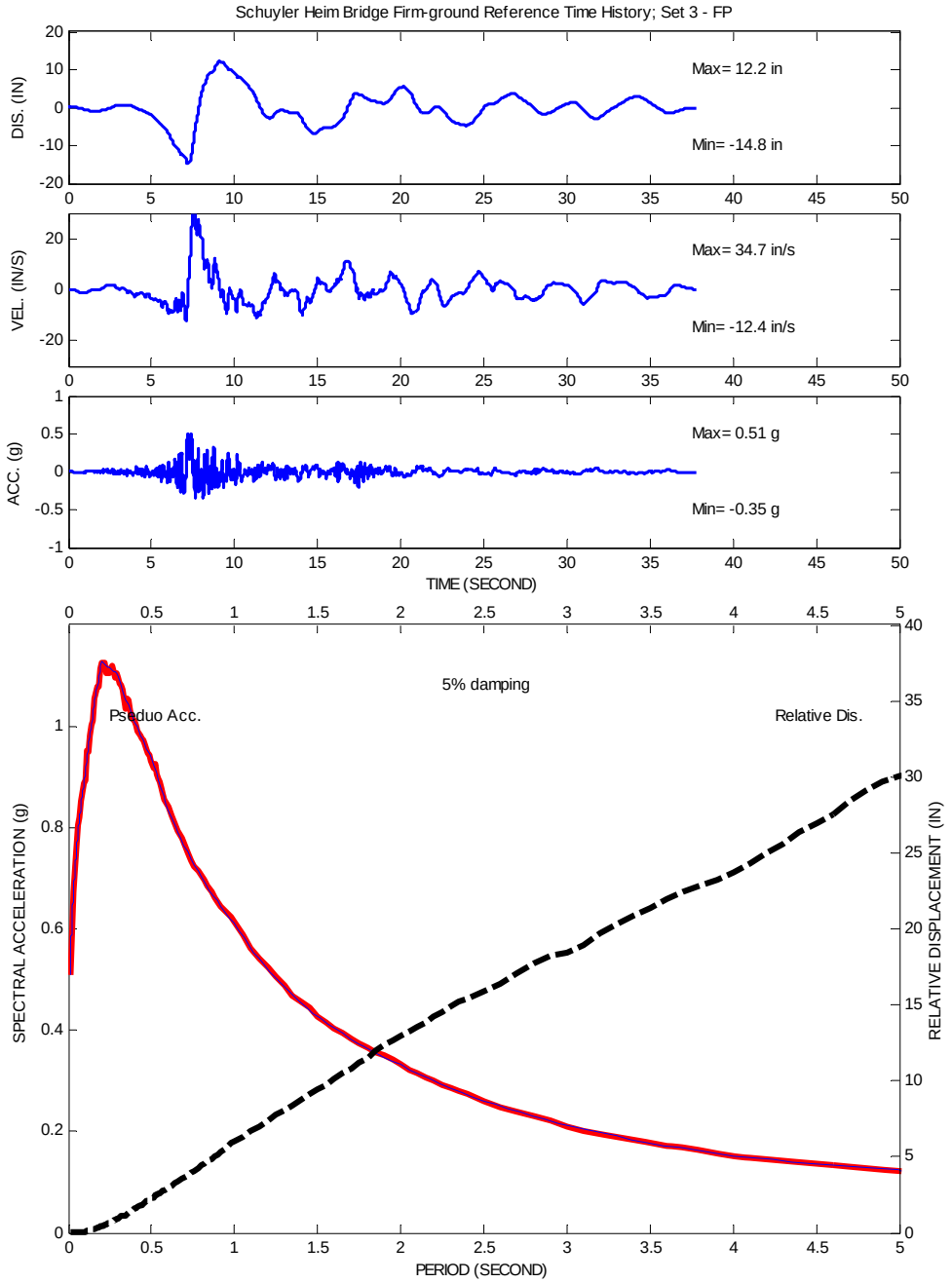

Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

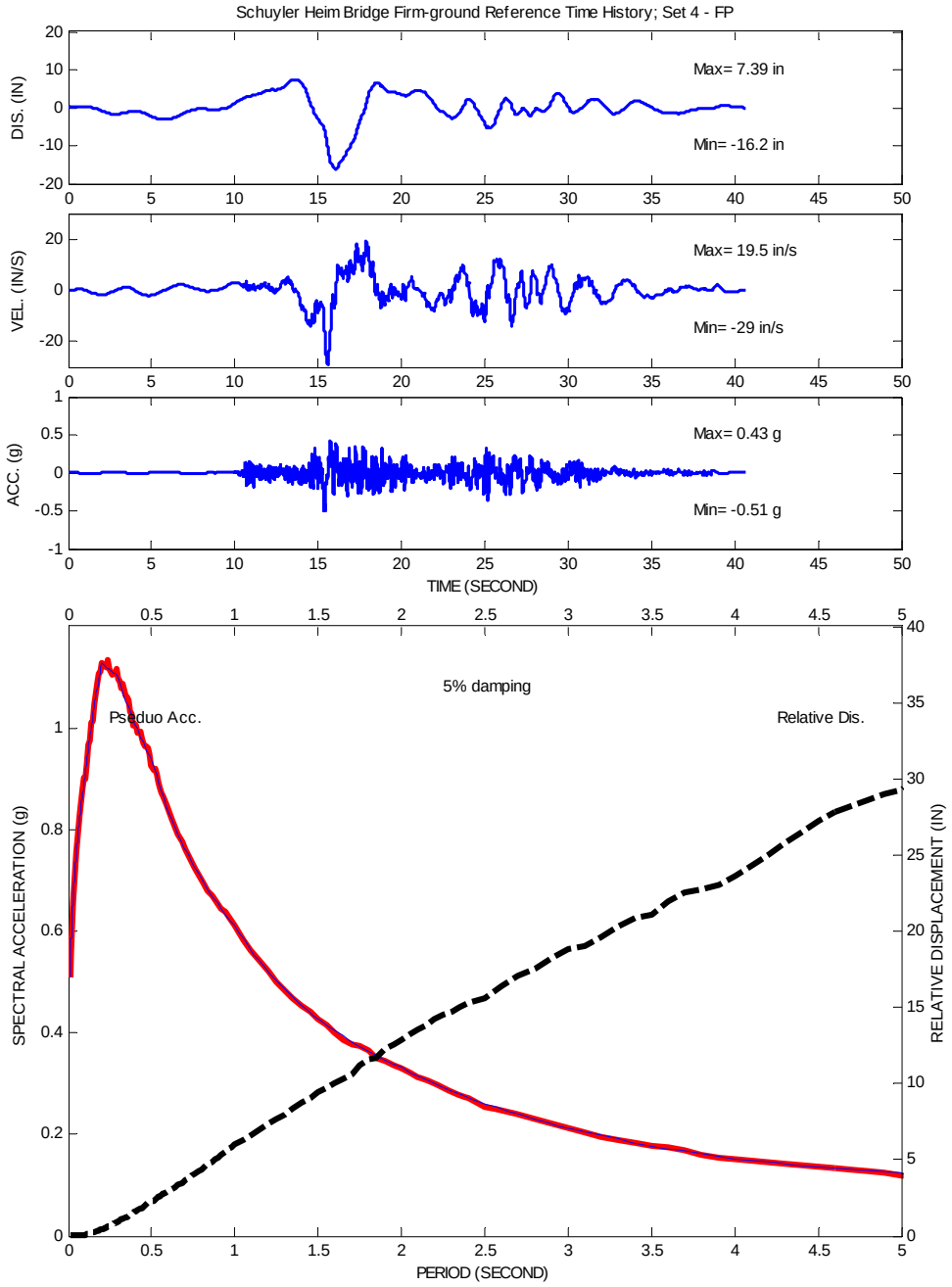

Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

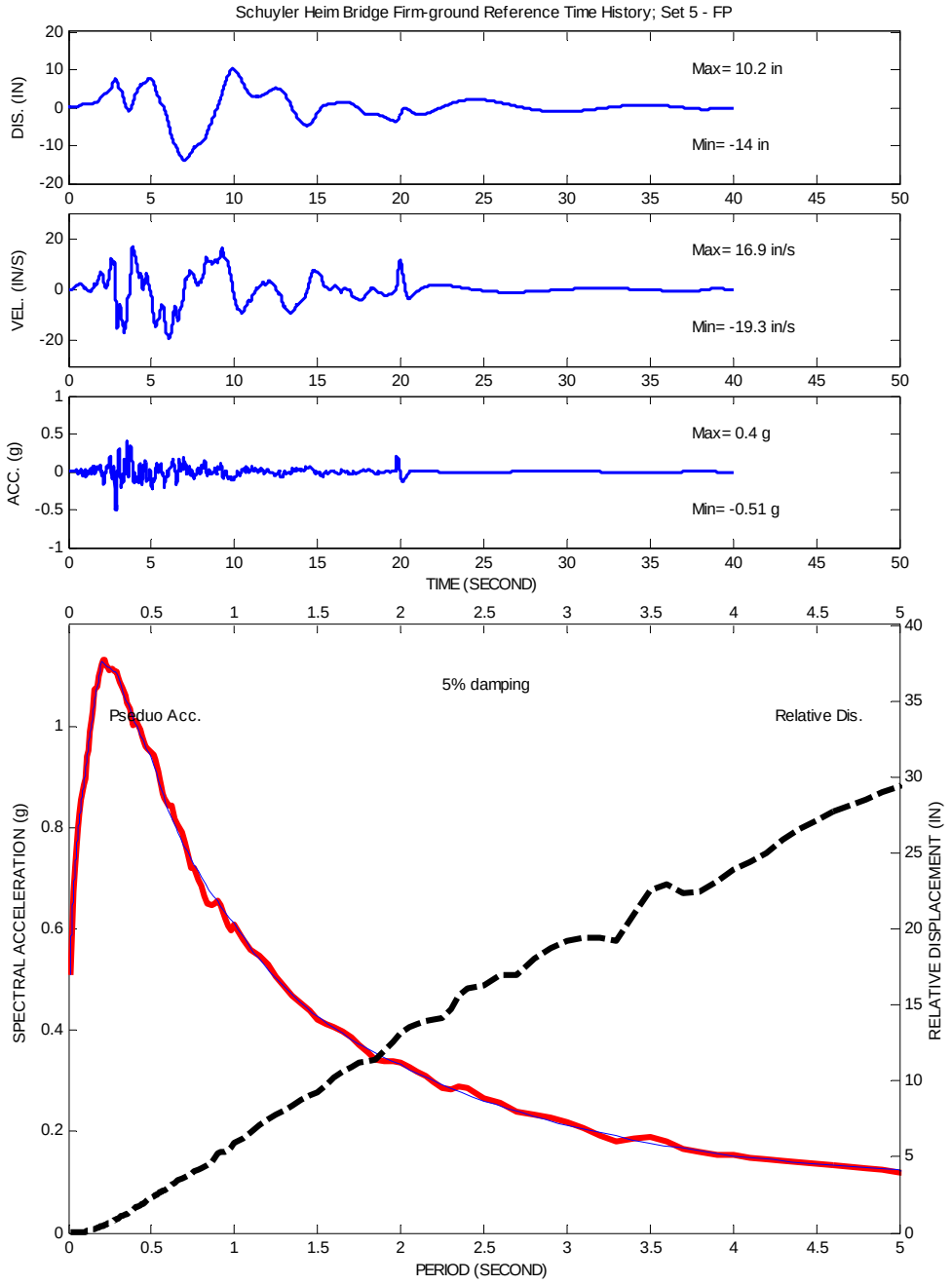

Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

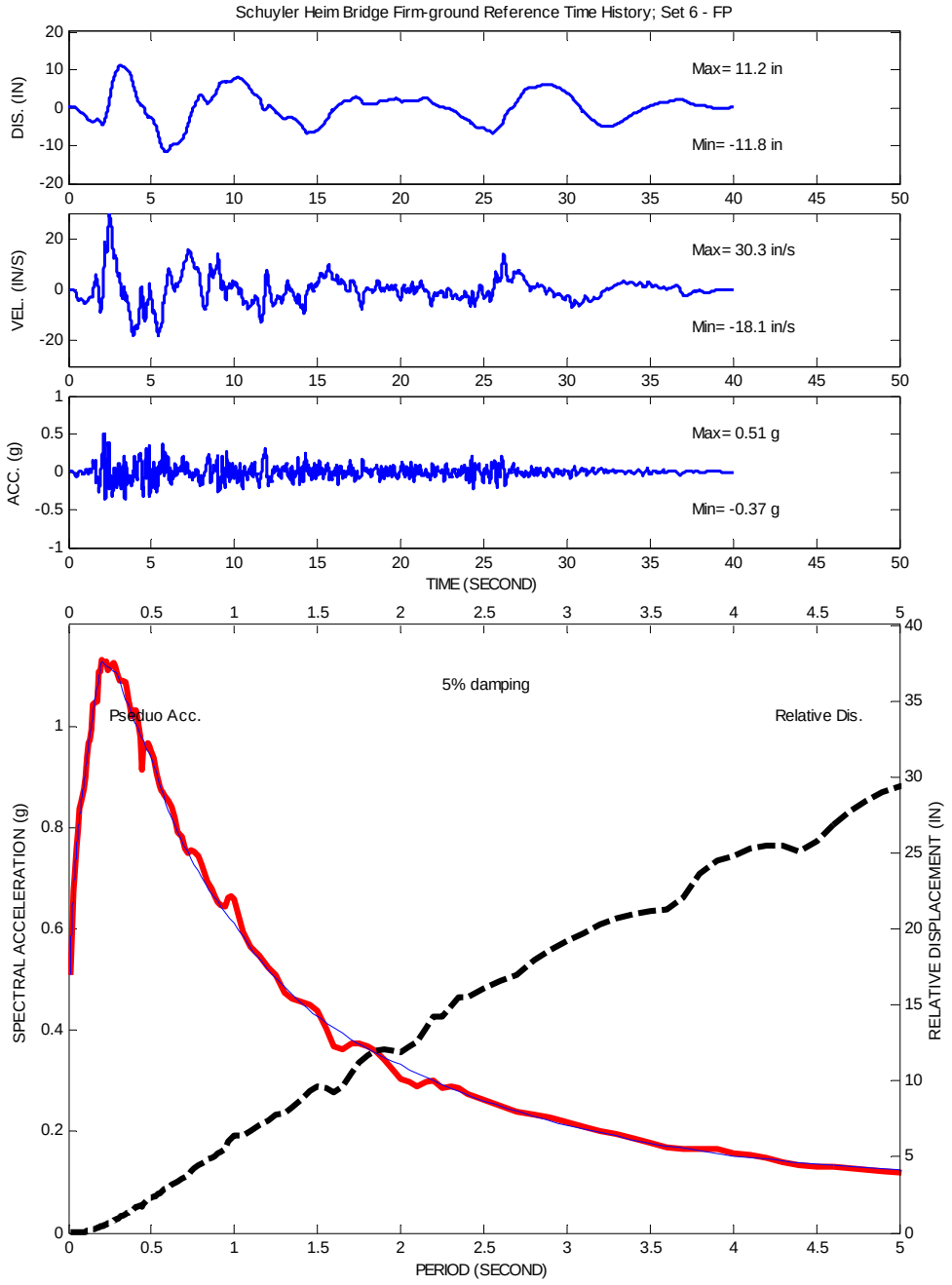

Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

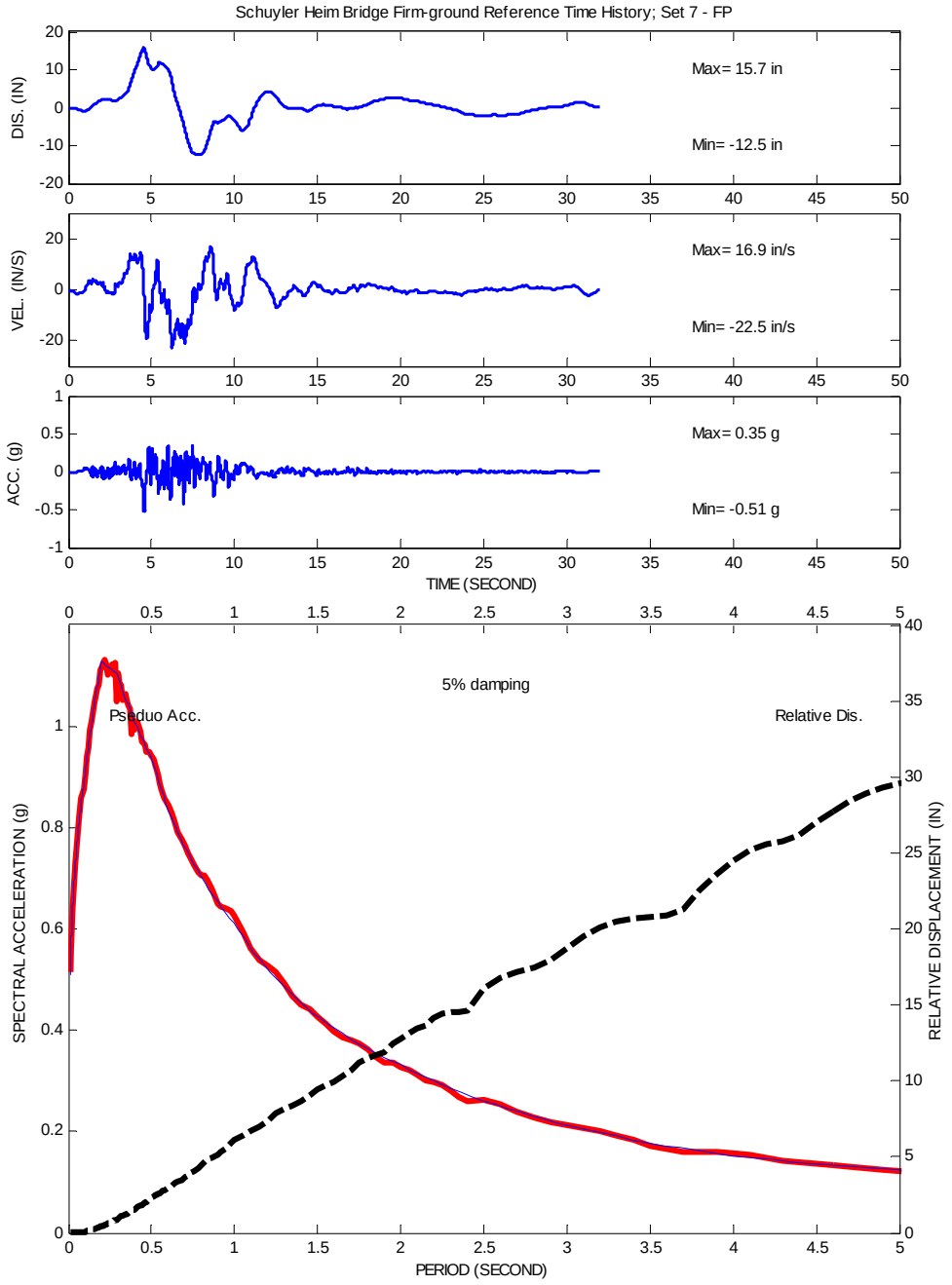

Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX E. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)

SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQD
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 17, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report***
Retaining Wall E1, Wall No. 53E0149
Retaining Wall E2, Wall No. 53E0150
Mechanically Stabilized Earth (MSE) Walls
Los Angeles County, California, (7-LA-47, PM 0.10, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining walls. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining walls.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix E. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
ERIC BROWN
NO. GE 2806
EXP. 6-30-2010
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STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
KANDIAH ARULMOLI
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(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL E1, WALL NO. 53E0149
RETAINING WALL E2, WALL NO. 53E0150
MECHANICALLY STABILIZED EARTH (MSE) WALLS
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.10, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 17, 2010

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APPENDICES

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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall E1 and E2 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Retaining Wall E1 and E2 located on the west and east side, respectively, of the approach embankment for the SR-103 Off-Ramp (Figure 2).

Retaining Wall E1, located along the western edge of the SR-103 Off-Ramp approach embankment between Sta. 426+06 and Sta. 428+35 ("E" Line), will be approximately 230 ft long with retained heights varying from 24 ft at the southern end of the wall to 16 ft at the northern end of the wall where it terminates at the southern end of Retaining Wall G2. Recommendations for Retaining Wall G2 and the SR-103 Off-Ramp bridge are provided in separate foundation reports prepared by EMI (2010a, 2010b). Retaining Wall E2, located along the eastern edge of the SR-103 Off-Ramp approach embankment between Sta. 426+06 and Sta.

429+95 ("E" Line), will be approximately 475 ft long with retained heights varying from 22 ft at the southern end of the wall to 4 ft at the northern end of the wall. Both walls are proposed to be mechanically stabilized embankment (MSE) walls.

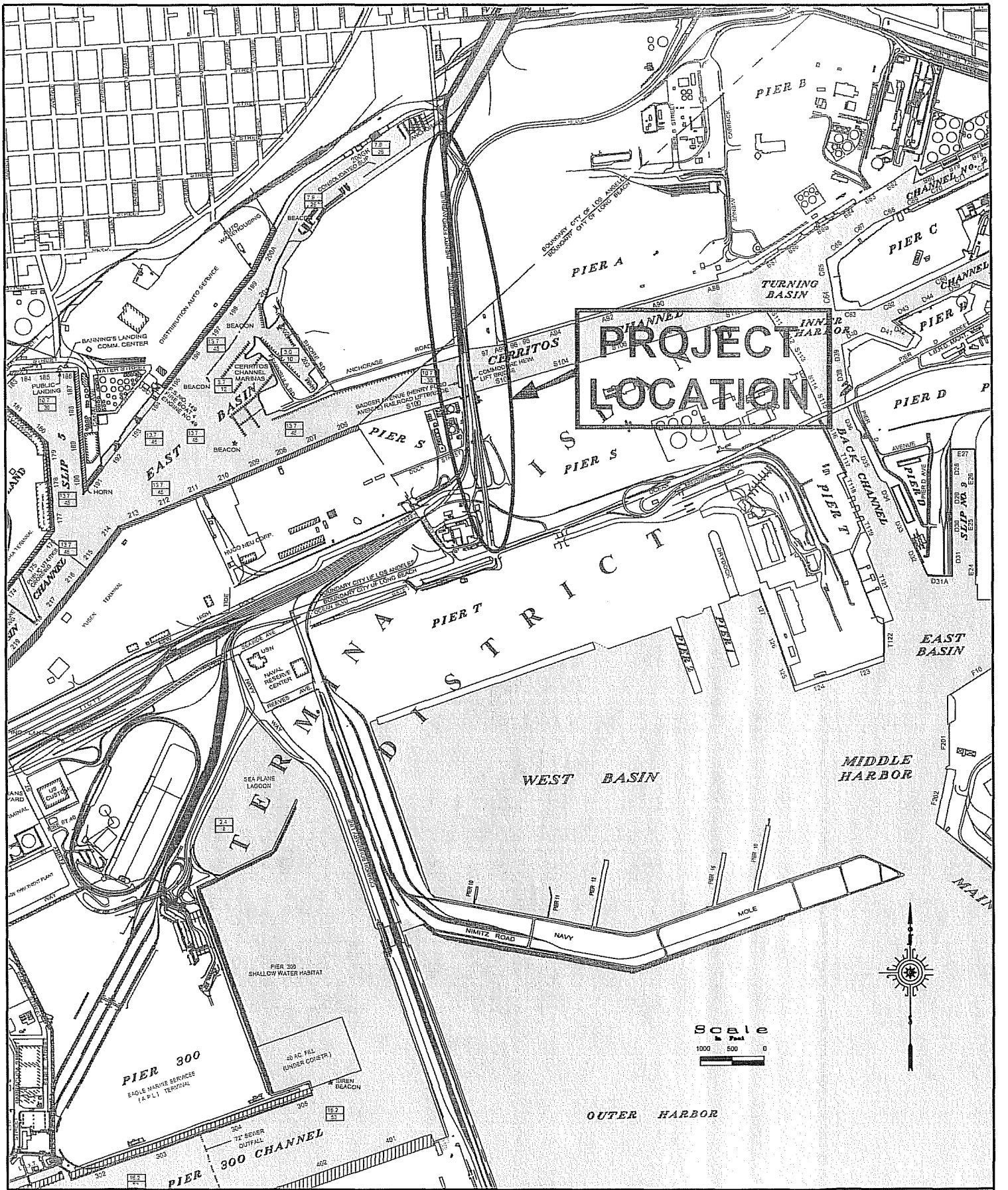
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Retaining Wall E1 and E2. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



Earth Mechanics, Inc.
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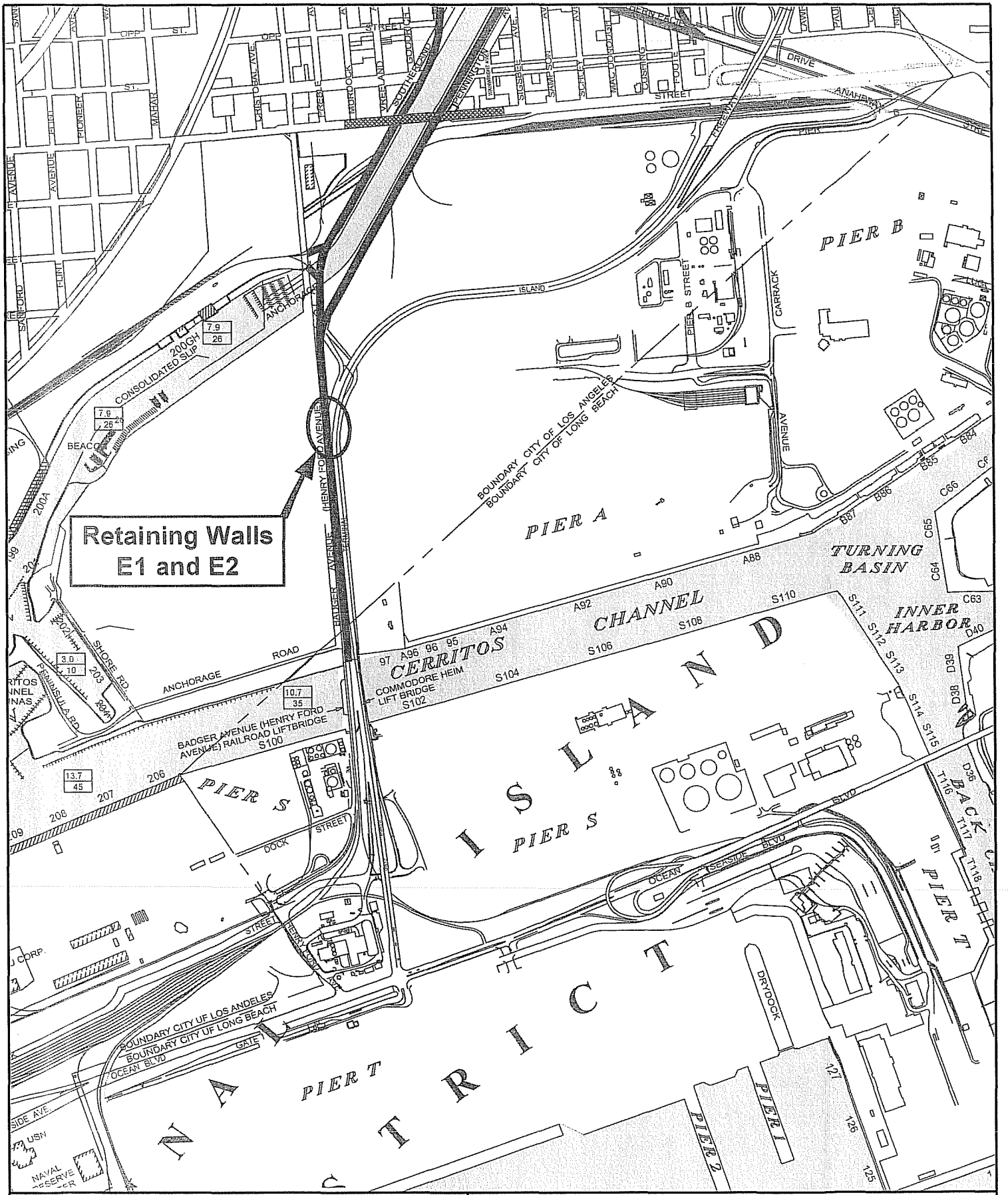
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123 | Date: 5-17-10



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-17-10	Structure Location Map — Figure 2

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the nearest boring to Retaining Wall E1 and E2 is shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge and is approximately 600 ft south of the southern end of the proposed wall pair.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, three rotary wash borings, two hollow-stem auger borings and two CPT soundings were performed in the vicinity of Retaining Wall E1 and E2. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed walls. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings and CPT soundings surrounding the proposed retaining wall pair were performed at grade on the shoulder of the existing SR-103/SR47 ramps. The deepest boring penetrated down to about elevation -149 ft, approximately 150 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix B.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix C.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-033[1]	"E" Line	425+87.5	84.7 Rt	+6.1	-9.9	-94.9	RW
R-09-034[1]		426+74.1	55.2 Lt	+1.3	-9.7	-149.0	RW
R-09-035[2]		428+42.7	38.1 Lt	+2.1	-11.9	-74.4	RW
A-09-056[3]		427+15.6	36.3 Rt	+0.2	-11.0	-36.3	HSA
CPT-09-066		428+87.0	91.4 Rt	-0.8	NR	-100.1	RW
CPT-09-098		427+19.4	36.4 Rt	+0.1	NR	-92.3	RW

Notes: *1. Boring performed by C&L. Drilling Co.*
2. Boring performed by SoCalDrilling Co.
3.Boring performed by 2R Drilling Co.
4. GWE = Groundwater Elevation.
5. GSE = Ground Surface Elevation (estimated from topographic plans).
6. Top of Boring Elevation Based on NAVD88.
7. RW = Rotary Wash, HSA = Hollow Stem Auger, CPT = Cone Penetration Test.
8. NR = Not Recorced.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -102.7 ft, approximately 103.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle

and a projected cross sectional area of 1.55 in^2 (10 cm^2) and a cylindrical friction sleeve with a surface area of 23.25 in^2 (150 cm^2). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

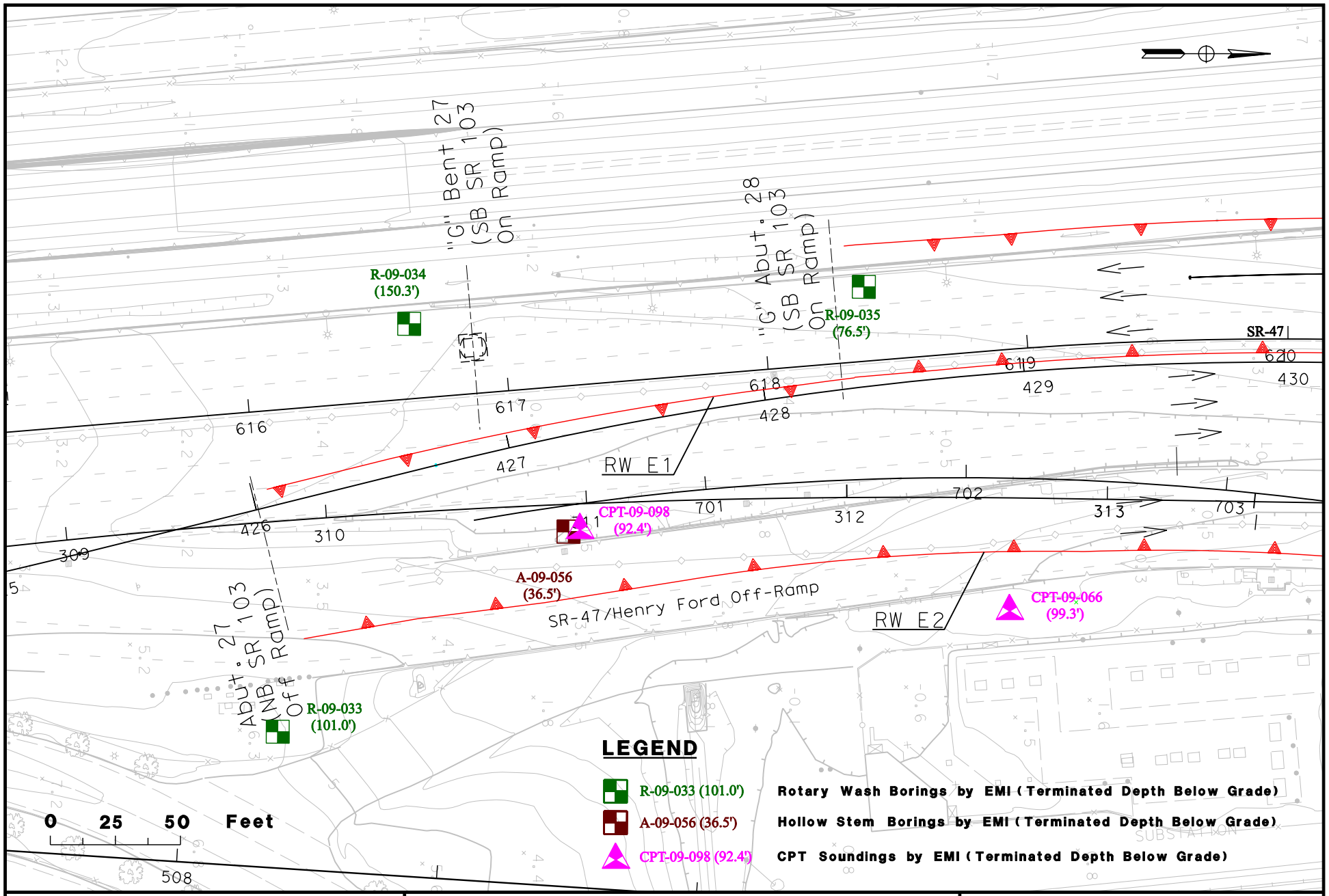
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix C.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



Earth Mechanics, Inc.
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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-17-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department

(LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

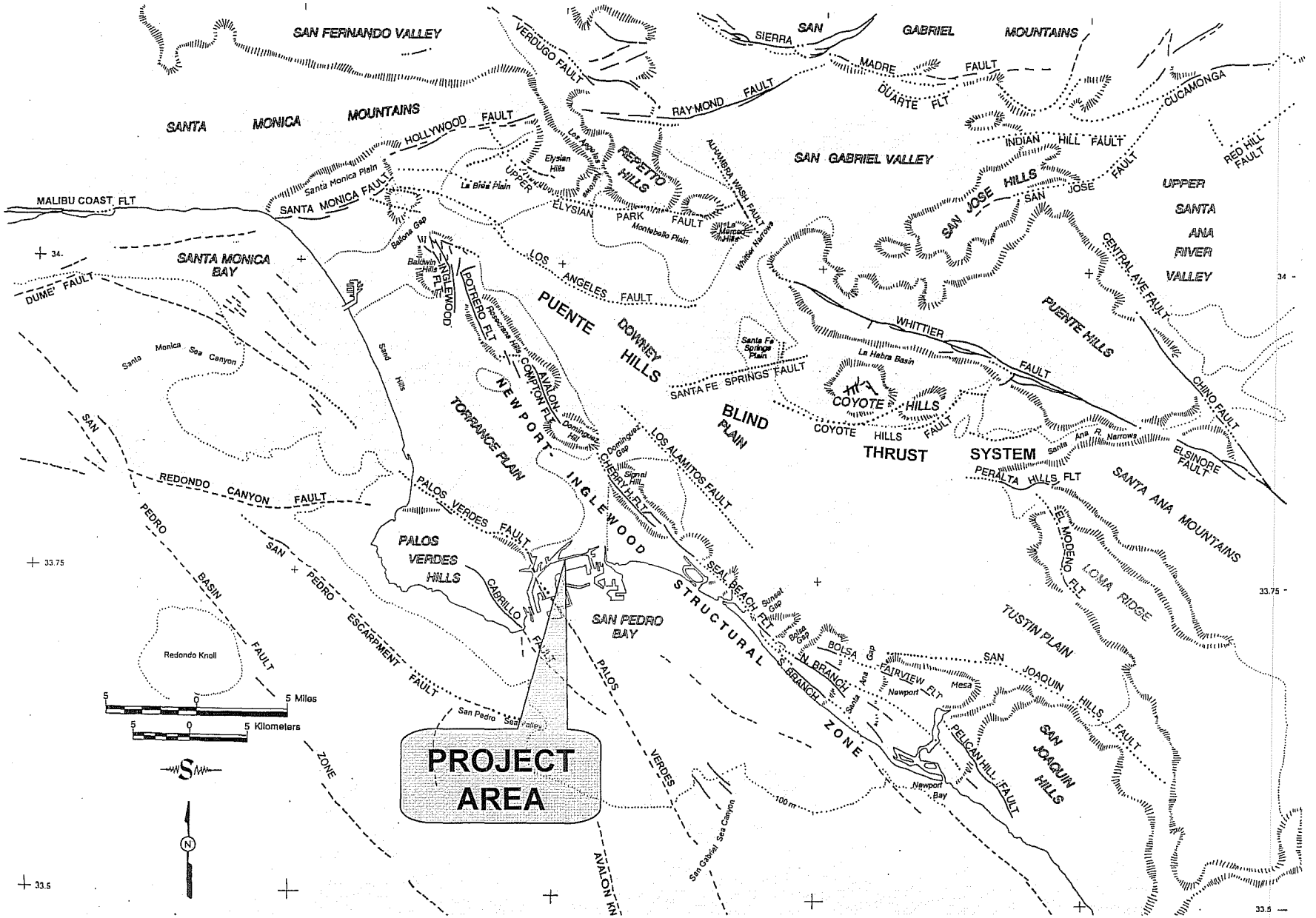
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at

Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.



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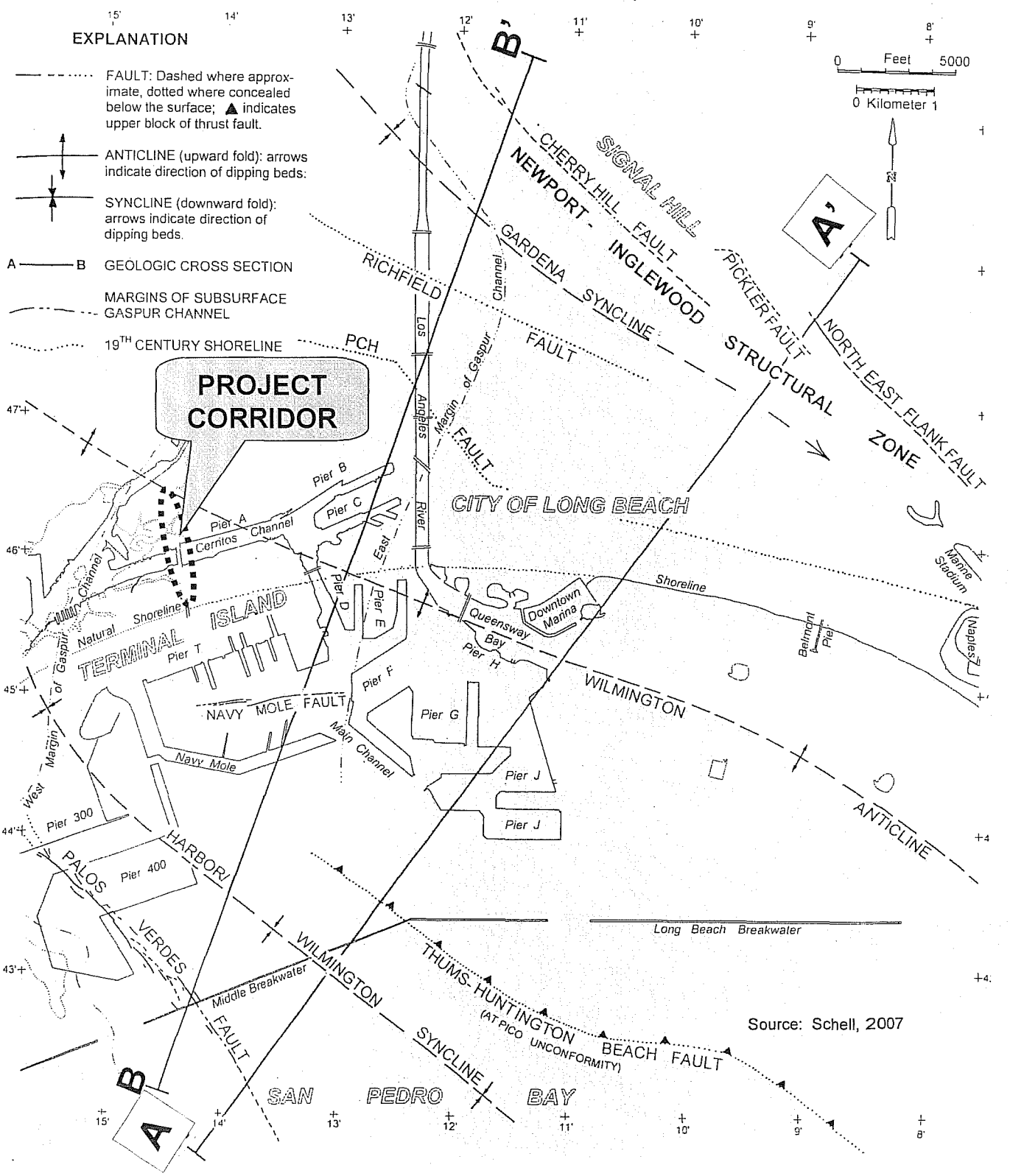
Map of Active Faults and Physiography, LA Basin

Figure 4



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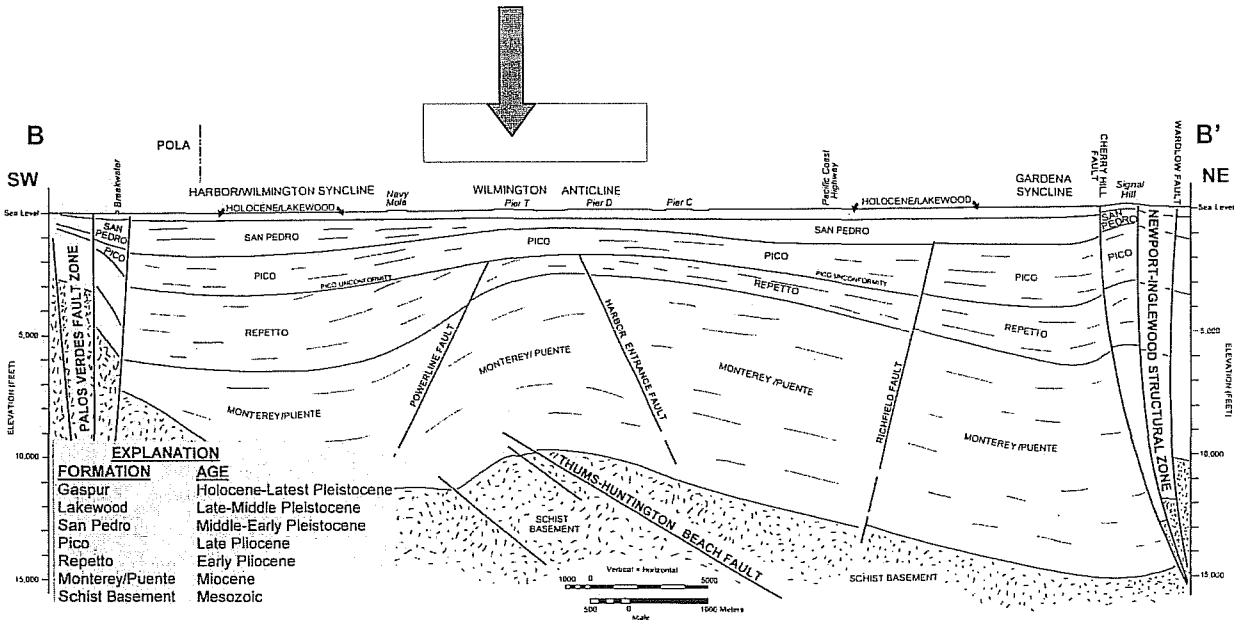
Structural Geology Map, Long Beach Harbor

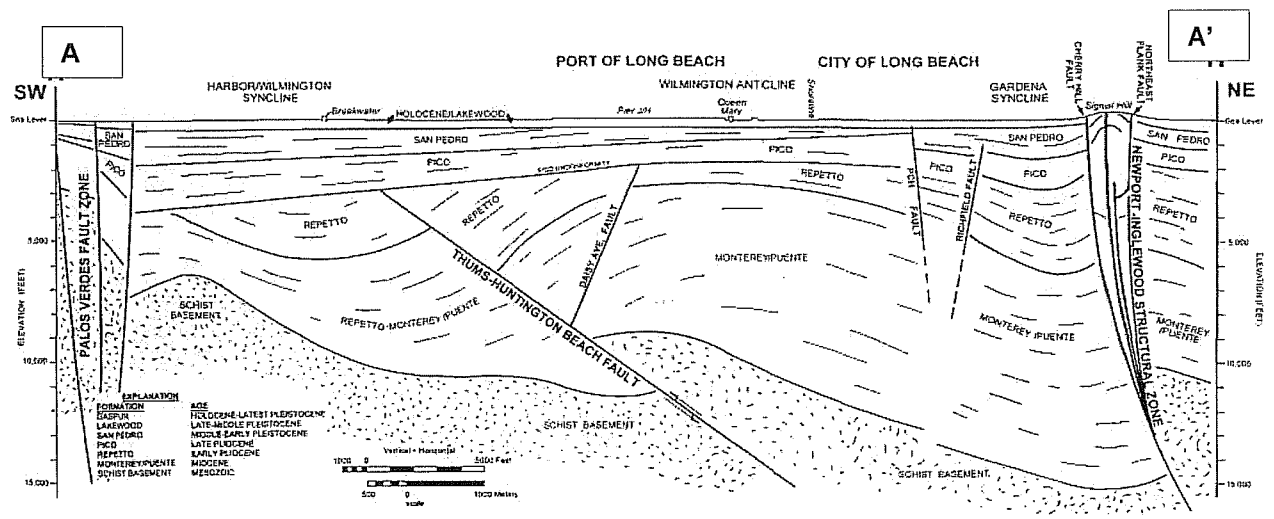
Figure 5

Project No. 06-123 | Date: 5-17-10

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH



A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

2) Source: Schell, 2007

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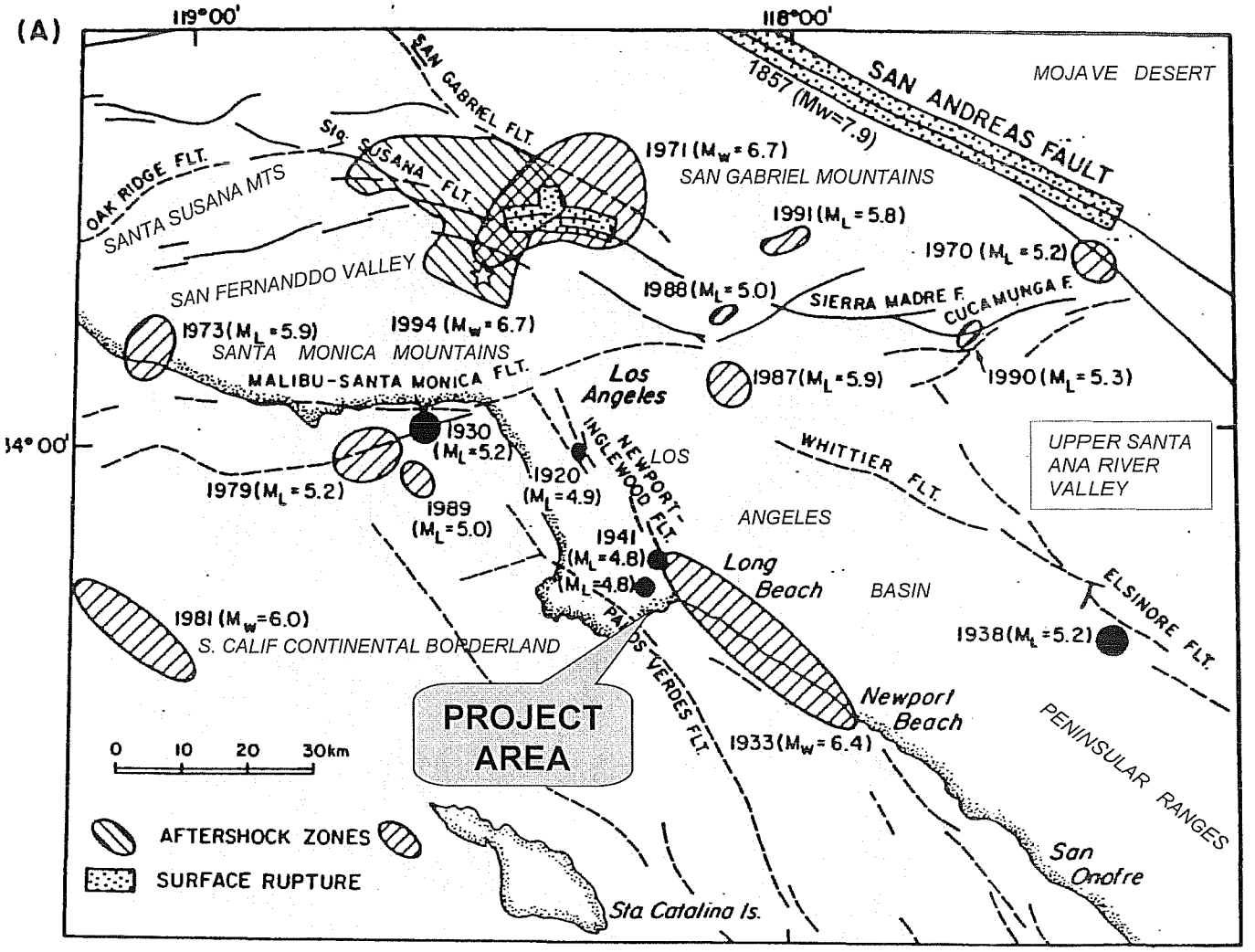
	Geologic Cross-Sections, LA Harbor	
Project No. 06-123	Date: 5-17-10	Figure 6



Source: Modified from Hauksson, 1995

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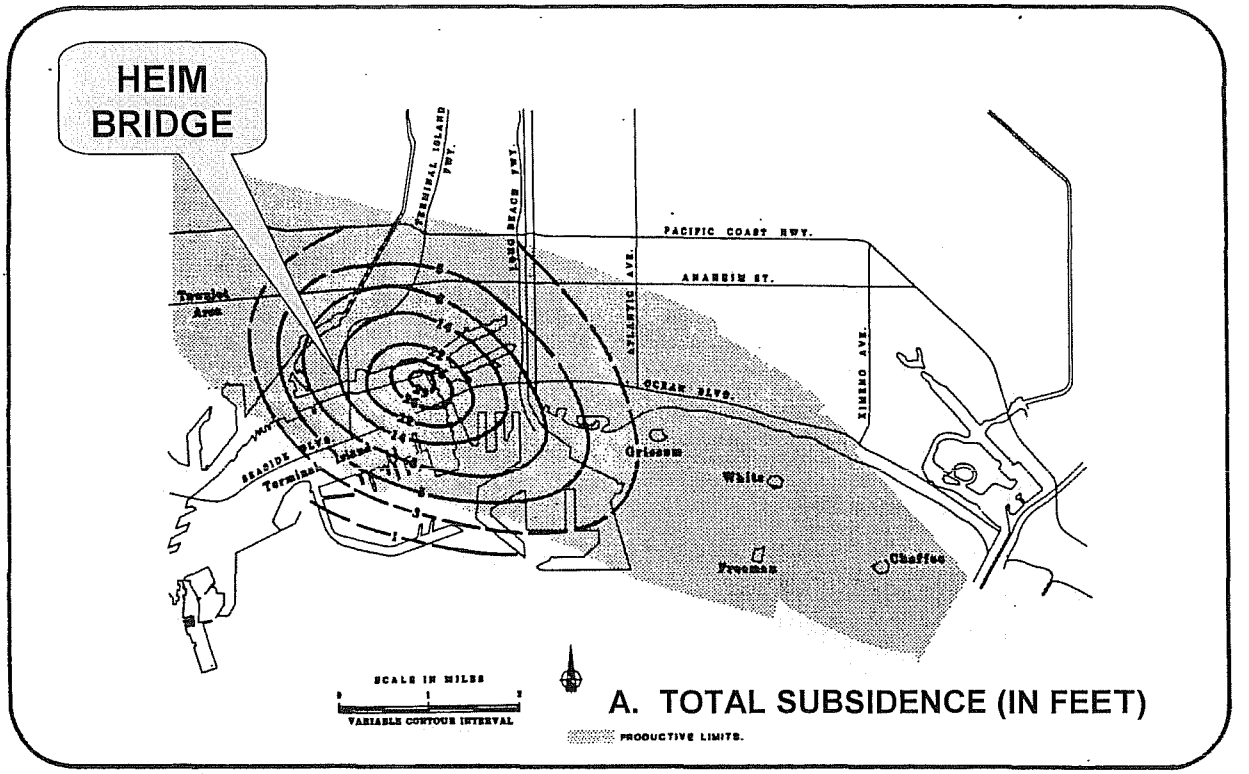
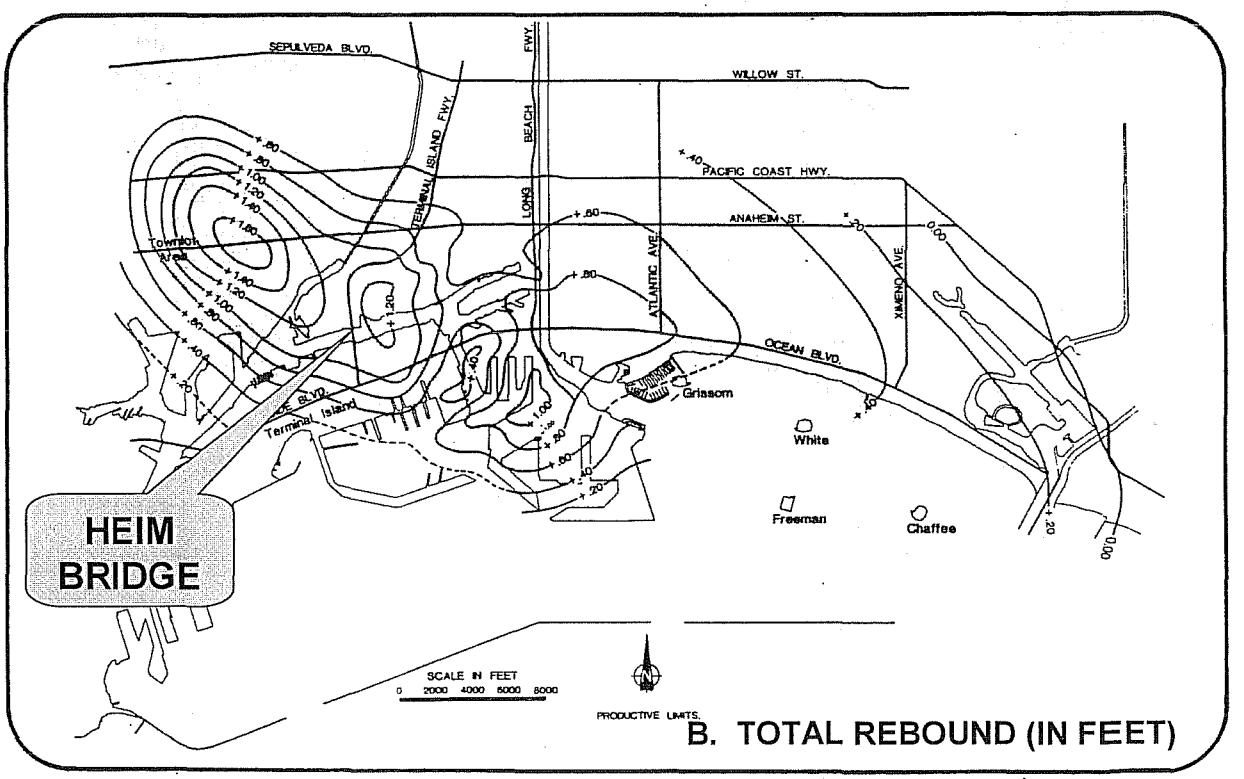
Project No. 06-123 | Date: 5-17-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 / Date: 5-17-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -149 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about zero, with a few feet of import fill for the existing northern approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +2 ft near the southern end of the two walls. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -5 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -60 ft. Below elevation -60 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in all four of the borings performed near the proposed walls between elevation -9.9 ft and -11.9 feet. The elevation that groundwater was encountered in each boring is listed in Table 2 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

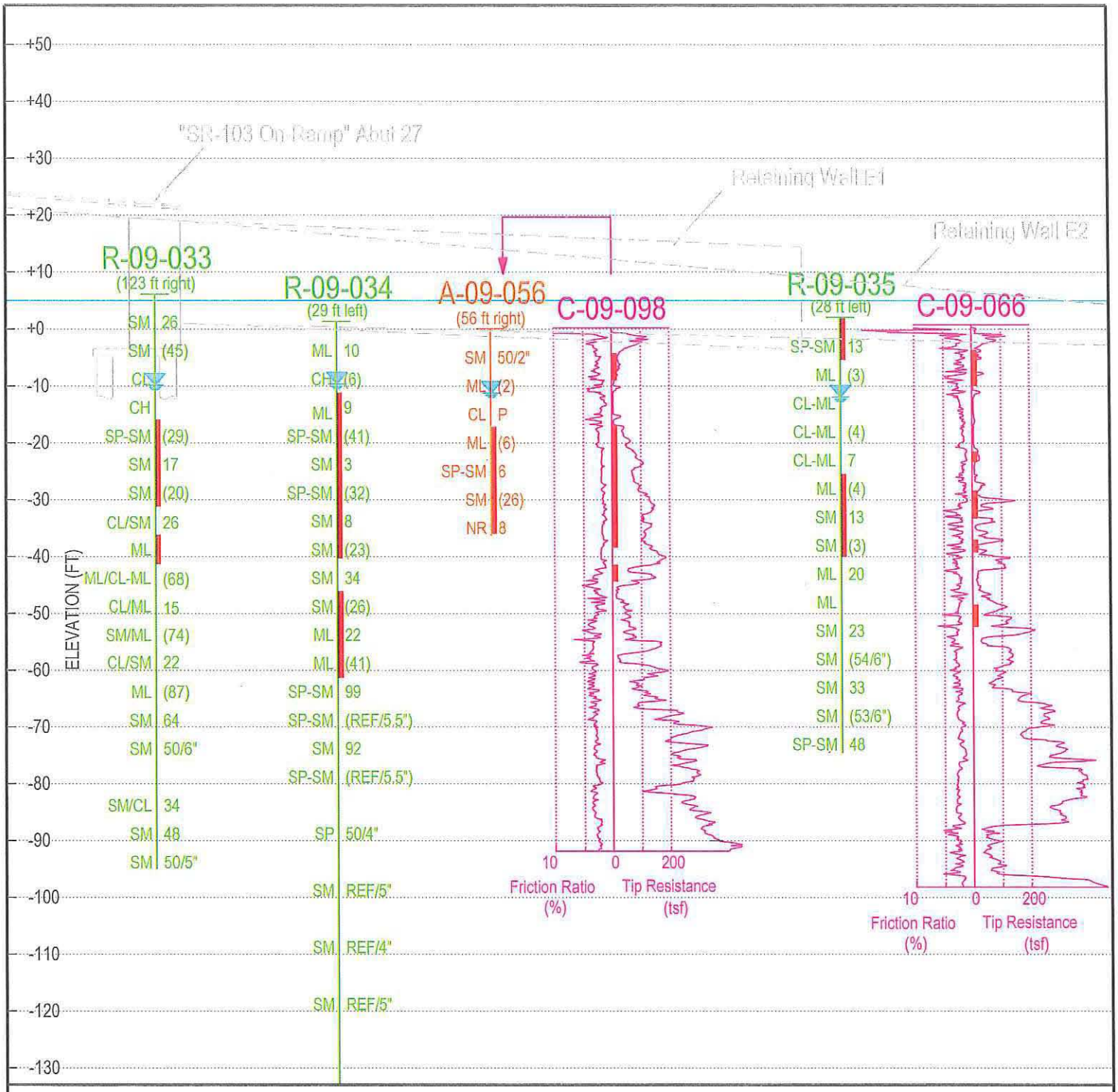
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

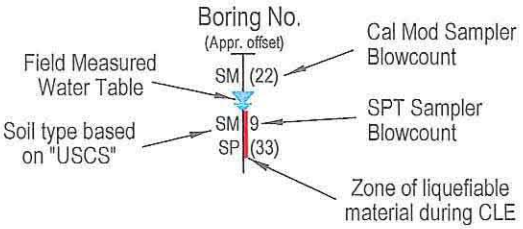
Based on information collected from borings R-09-033, R-09-034, R-09-035, A-09-056 and CPT soundings CPT-09-066 and CPT-09-098 an idealized soil profile for foundation analysis and design was developed along the alignment of the proposed walls. The subsurface profile beneath the proposed structures is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+24 to +2.0	Silty Sand (assumed MSE fill)	120	0	34
+2.0 to -5.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	32
-5.0 to -17.0	Sandy Silt / Silty Clay / Lean Clay	120	600	0
-17.0 to -25.0	Clayey Silt / Sandy Silt / Silty Sand	120	800	0
-25.0 to -43.0	Silty Sand / Sand with Silt / Sandy Silt	120	0	32
-43.0 to -55.0	Clayey Silt / Sandy Silt / Silty Sand	120	2,500	0
-55.0 to -65.0	Sand with Silt / Silty Sand / Sandy Silt	120	0	34
-65.0 to -150.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Figure 9

Project No. 06-123 | Date: 5-17-10

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance to with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix E.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -65 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-033	-16 to -31	3.1	3.2
	-37 to -42	0.1	
R-09-034	-10 to -40	7.7	9.5
	-45 to -55	1.8	
R-09-035	+2 to -5	0.7	6.3
	-25 to -40	5.6	
A-09-056	-17 to -27	3.4	4.7
	-32 to -37	1.3	
CPT-09-066	-4.0 to -10.0	0.5	2.0
	-22.6 to -24.8	0.6	
	-28.5 to -33.5	0.6	
	-37.0 to -39.3	0.3	
	-47.8 to -52.2	0.2	
CPT-09-098	-3.8 to -7.4	0.3	0.5
	-17.1 to -38.7	0.1	
	-41.3 to -43.1	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.7 and 8.7, the minimum resistivities were 230 and 670 ohm-cm, soluble chloride contents were 514 and 6,316 parts per million (ppm) and soluble sulfate contents were 107 and 915 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Mechanically Stabilized Earth Wall Recommendations

As discussed in Section 1.2, the maximum design height of the MSE is about 22 ft. Due to the presence of compressible soil, construction of the proposed SR-103 Off-Ramp embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 26 ft and base width of 26 ft near the southern end of the walls at Sta. 426+06 ("E" Line), the bearing pressure induced on the underlying foundation soil is 3.8 ksf. Using a base width of 26 ft and a remedial excavation of 3 ft (see Section 5.4.8), the allowable bearing capacity of the soil directly beneath the MSE wall is greater than 3.8 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 3 ft below lowest adjacent grade. Using a remedial excavation of 3 ft below the leveling pad, the allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL E1/E2 STABILITY ANALYSES

Approx. "E" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety		Global Stability Factor of Safety		
			During Surcharge	Permanent	During Surcharge	Static[1]	Psuedo-Static[1]
426+25	26	26	1.26	2.40	1.26	1.57	1.13

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1.

(4) A remedial overexcavation of 3 ft below the leveling pad and the MSE was considered in the analysis.

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed wall approximately 25 ft from the southern terminus of the wall near "E" Line Sta. 426+25.

Based on cross-sections provided by the roadway designers, the existing embankment at "E" Line Sta. 426+25 will be approximately 57 feet wide at the crest and the embankment height is approximately 20 feet above existing grade. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 10 inches. The settlement period is estimated to be about 20 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is reduced to about 11 weeks. For a 7-ft embankment surcharge, the settlement periods is reduced to about 9 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

Along the proposed wall alignment, the base of the MSE structure will be founded on native soils. EMI recommends remedial grading consisting of a 3-ft overexcavation. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted according to Caltrans Standard Specifications (2006c). The overexcavation should be backfilled using granular, non-expansive soils. In the event the bottom of remedial excavations become saturated due to the presence of shallow groundwater or seepage, self compacting material such as gravel or lean concrete slurry can be placed within the limits of the overexcation. The overexcavation should extend at least 3 ft beyond the outer edge of the leveling pad and 3 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Wall Stability

The "global" stability of the MSE was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "E" Line Sta. 426+25.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and zero cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

5.5 Settlement of Adjacent Utilities

Topko Pipe. An existing 60-inch Corrugated Metal Pipe (CMP), which contains an 8-inch diameter Topko oil line and 8-inch diameter water line inside, crosses beneath the proposed MSE at approximate "E" Line Sta. 427+65. At the location where the CMP crosses beneath the proposed embankment, the embankment height is approximately 16 ft and the width of the proposed embankment is approximately 57 ft.

Settlement of compressible fine-grained soils underlying the Topko pipe is estimated to be about 5 inches, 2.5 inches and 0.25 inches at the centerline of the embankment, beneath Retaining Walls E1/E2 and about 25 ft beyond the toe of Retaining Walls E1/E2, respectively.

A Technical Memorandum was prepared by EMI (EMI, 2009) that specifically addresses settlement of foundation soils underlying the Topko Pipe. The memorandum includes cross-sections of locations where the CMP line crosses beneath the proposed embankment, and the estimated settlement profile of the CMP at those locations. This memorandum is included in Appendix F.

Proposed Drainage Structure No. 34. A 24-inch diameter reinforced concrete pipe (RCP) storm drain, which runs in a north-south direction beneath the proposed MSE, will be abandoned due to the proposed improvements. The existing storm drain will be capped and replaced with proposed Drainage Structure No. 34 (DS 34) that will consist of a 24-inch diameter RCP that will connect to another existing storm drain located to the east of proposed Retaining Wall E2. DS 34 will run in an east-west direction crossing the "E" Line about 35 ft south of the proposed MSE (in front of Abutment 27 of the SR-103 Off-Ramp) and then turn north, running parallel to the "E" Line approximately 10 ft west of the toe of Retaining Wall E1.

Settlement estimates along the proposed alignment of DS 34 are anticipated to vary from less than 0.5-inch to a maximum of about 3-inches adjacent to Retaining Wall E1. The estimated maximum differential settlement along the alignment of DS 34 is approximately 2.5-inches over a 100-ft of length of pipe.

The proposed storm drain is expected to be sensitive to differential and total settlement due to gravity flow within the RCP. If the proposed settlement magnitudes are determined to be outside the tolerable limits of the storm drain, construction of DS 34 should not be initiated until after the settlement period for the proposed MSE is complete or the surcharge has been released

Settlement recommendations including embankment surcharge and settlement period estimates for the proposed MSE are included in Section 5.4.7.

5.6 Pier A Development

As part of its future development plans, the Port of Long Beach is considering expanding Pier A beneath the proposed Schuyler Heim Bridge Replacement south of the subject MSE walls. A Technical Memorandum has been prepared by EMI (EMI, 2010c) that details the potential development plans and the impact of the proposed development on the storm drain and sewer lines and recommends appropriate mitigation measures.

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all four of the borings performed near the proposed wall pair between elevation -9.9 and -11.9 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad varies between about elevation +0 and -5 ft. The deepest excavation for the proposed MSE wall is expected to be a couple of feet above the observed groundwater elevations. However, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER ★ ERIC BROWN ★ NO. GE-2806 EXP. 06-30-2010 ★ GEOTECHNICAL ★ STATE OF CALIFORNIA

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

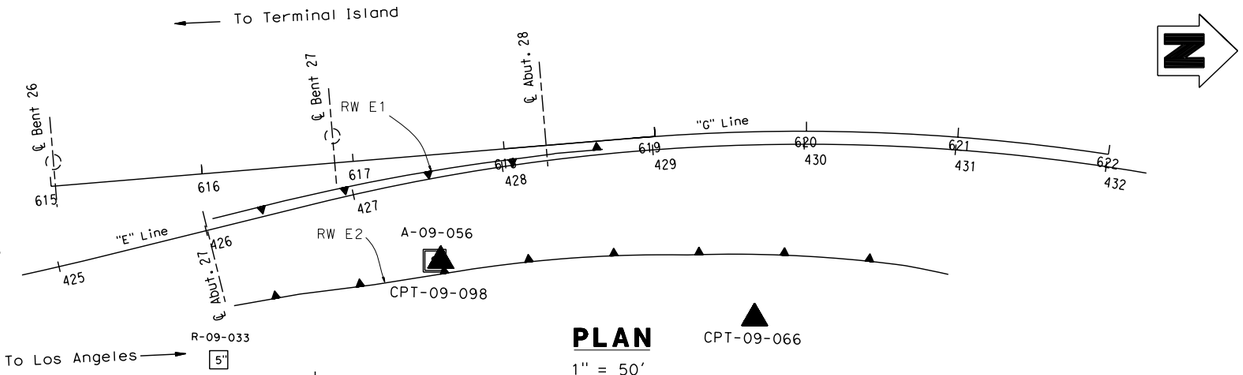
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) For A-09-056, an automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(3) For R-09-033, a rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



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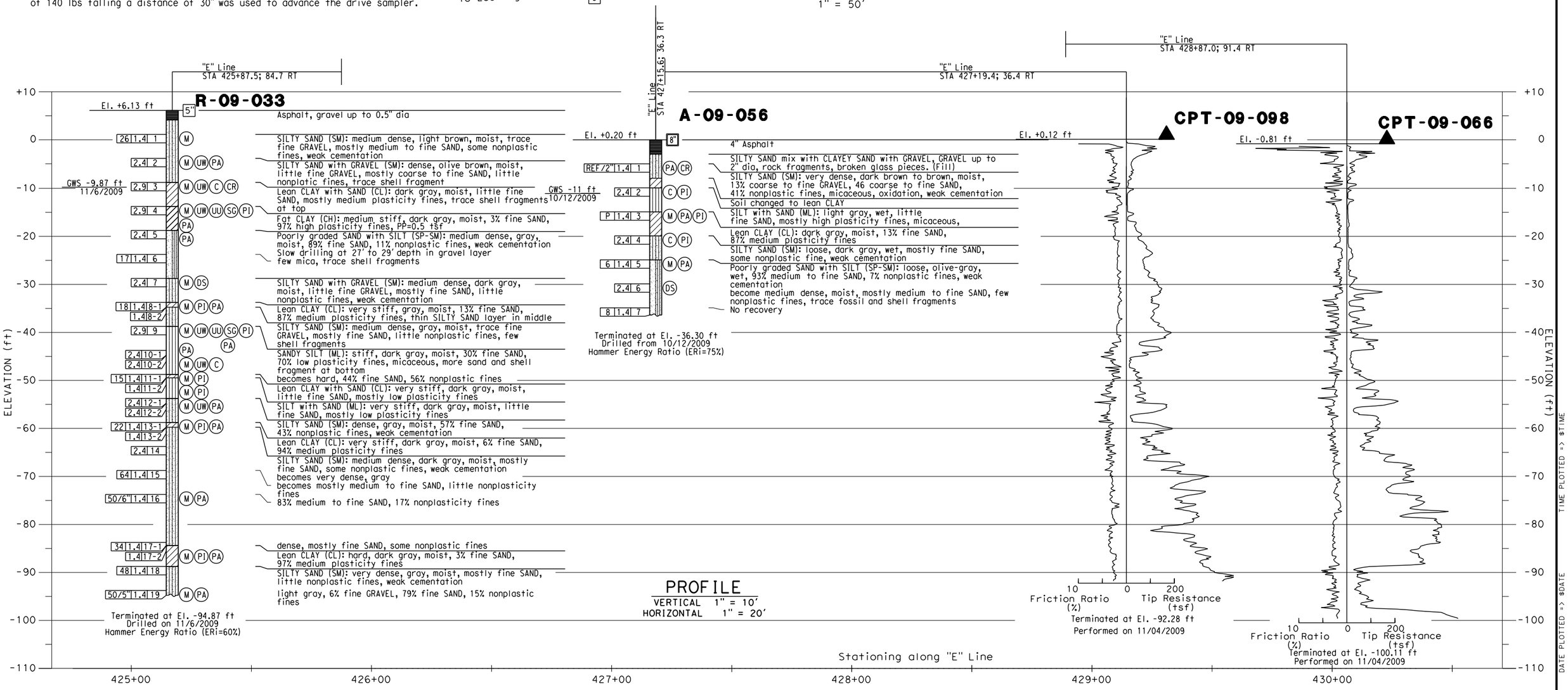

PROFILE
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HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0149
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.10

MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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CU 07
EA 238501

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Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
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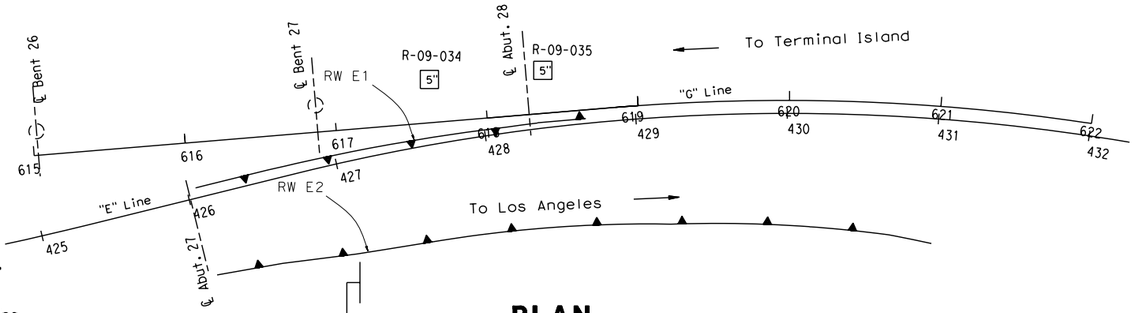

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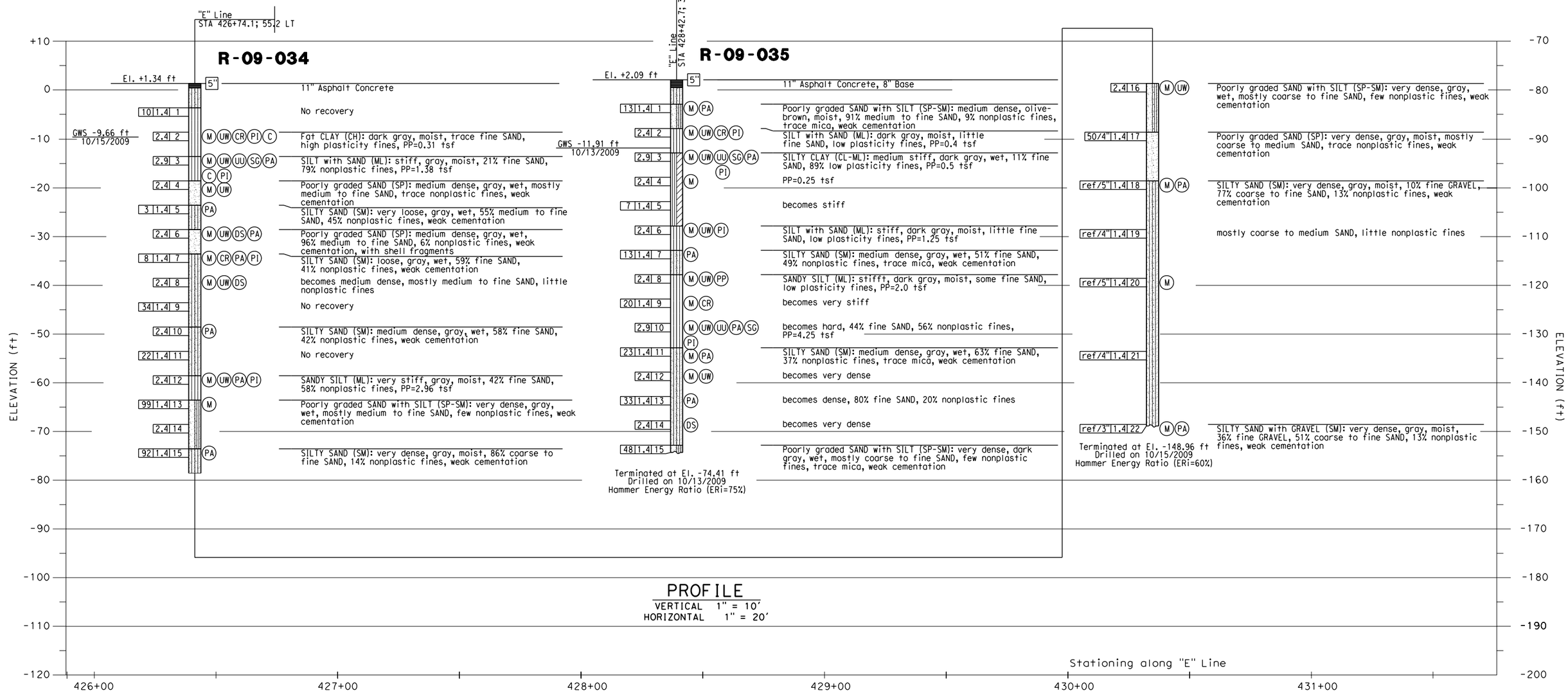

PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

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REGISTERED ENGINEER — DATE 04/19/10

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DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J.Fang

CHECKED BY: K.Pratheepan

FIELD INVESTIGATION BY:
E.Brown

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0149
POST MILE 0.10

MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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CU 07
EA 23850I

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04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER · ERIC BROWN · NO. GE-2806 EXP. 06-30-2010 · GEOTECHNICAL · STATE OF CALIFORNIA

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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R	Rotary drilled boring
	P	Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

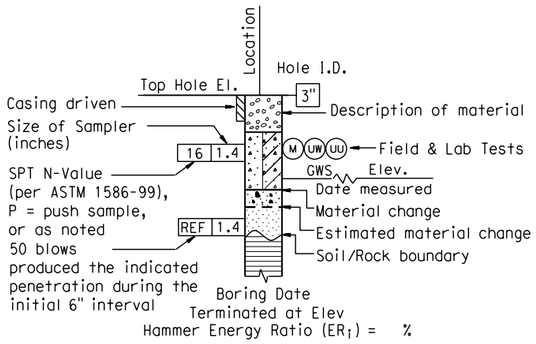
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



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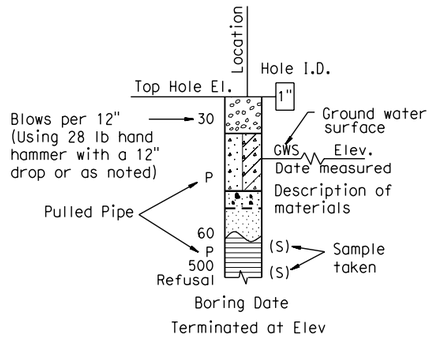
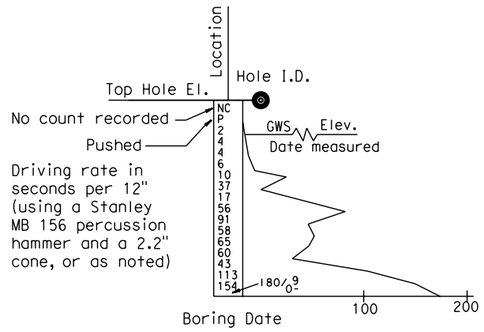
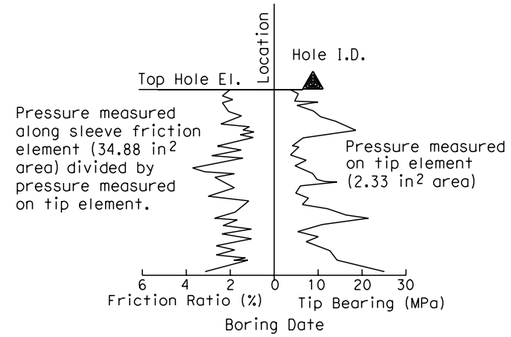


HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.10

MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 23850I

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90) Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166) Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

PLANS APPROVAL DATE

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ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0149
POST MILE 0.10

MSE RETAINING WALL NO. E1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/14/10

SHEET X OF X

FILE => $REQUEST

DATE PLOTTED => $DATE TIME PLOTTED => $TIME USERNAME => $USER

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

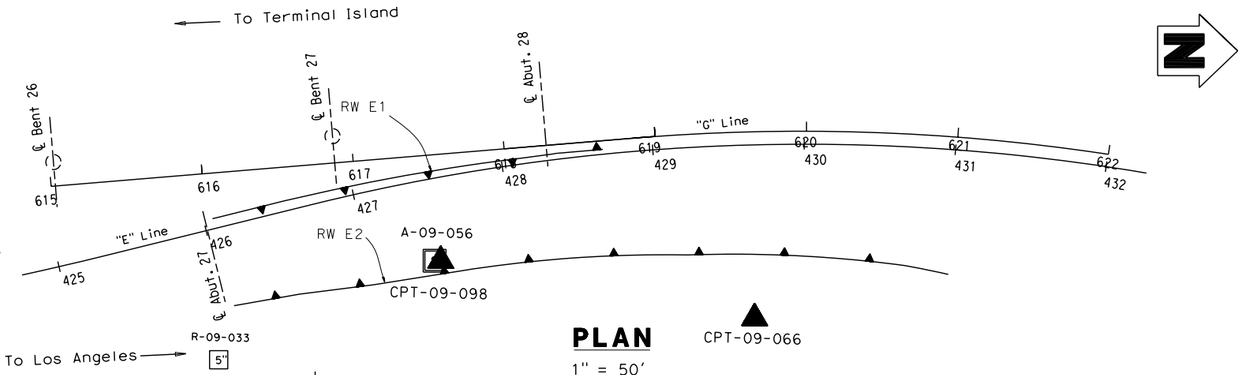
NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) For A-09-056, an automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(3) For R-09-033, a rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN
1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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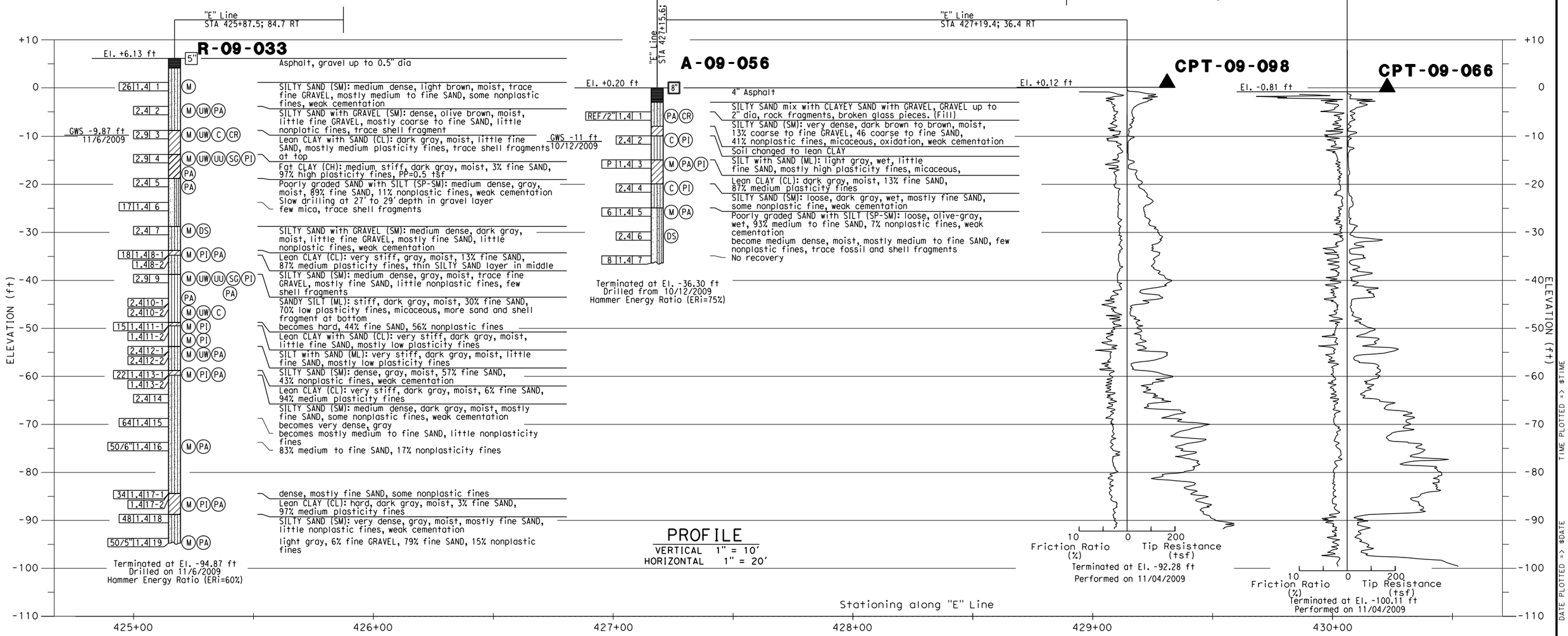
EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



DESIGN OVERSIGHT / SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53E0150 POST MILE 0.10

MSE RETAINING WALL NO. E2

LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

FILE => $REQUEST

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES (PRELIMINARY STAGE ONLY): 03/08/10 04/14/10

SHEET X OF X

BENCHMARKS:

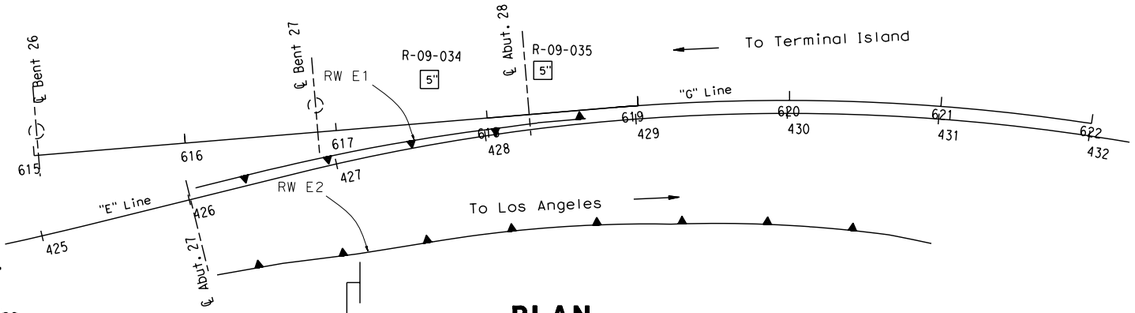
PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

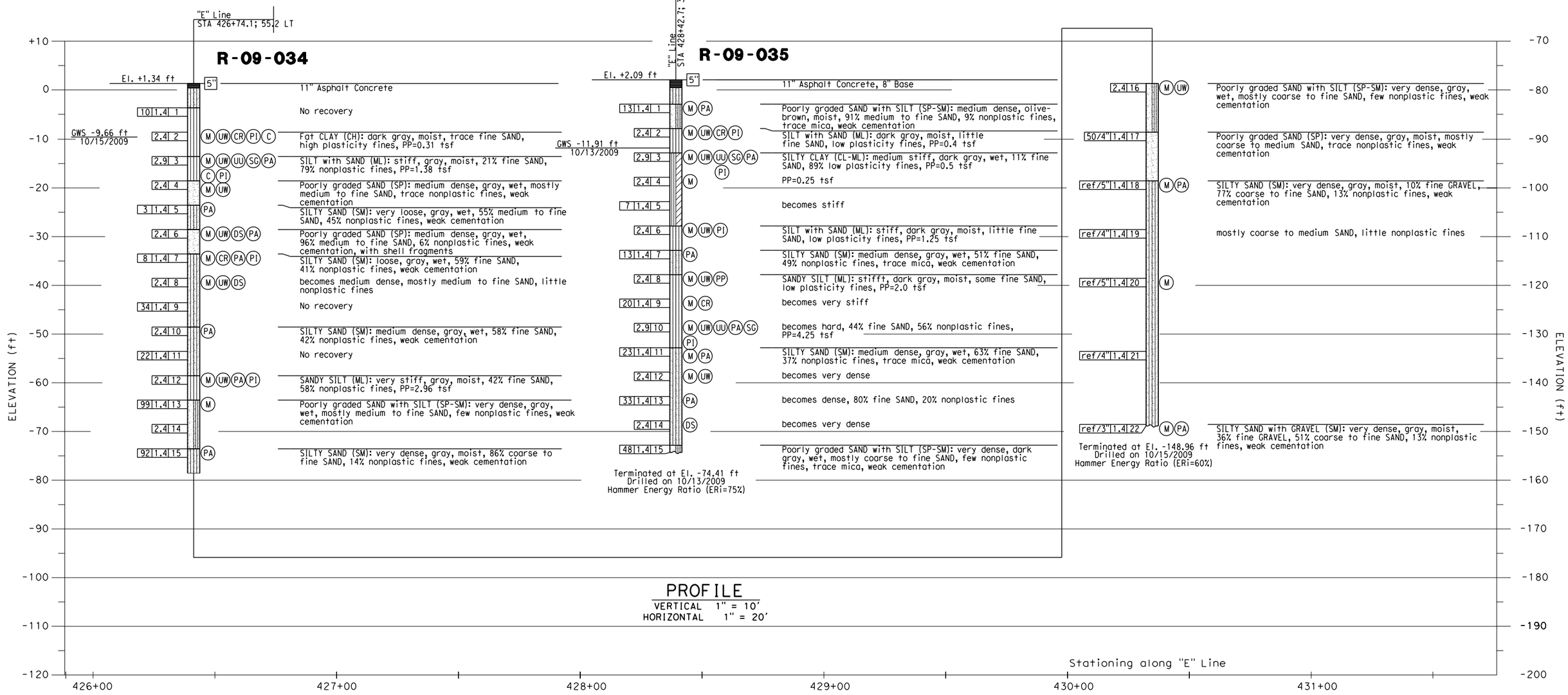
(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) A rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.



PLAN

1" = 50'



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER ERIC BROWN NO. GE-2806 EXP. 06-30-2010 GEOTECHNICAL STATE OF CALIFORNIA

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CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY:
E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0150
POST MILE 0.10

MSE RETAINING WALL NO. E2

LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 23850I

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

04/19/10
REGISTERED ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER · ERIC BROWN · NO. GE-2806 EXP. 06-30-2010 · GEOTECHNICAL · STATE OF CALIFORNIA

PLANS APPROVAL DATE

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R	Rotary drilled boring
	P	Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD	Hand driven (1-inch soil tube)
	HA	Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

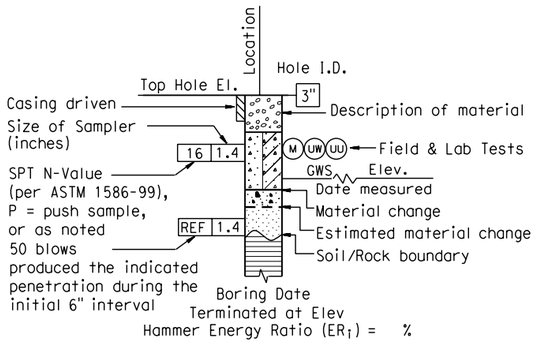
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

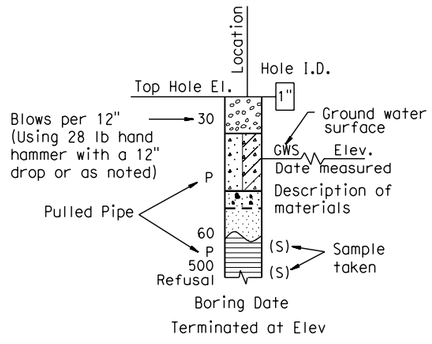
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

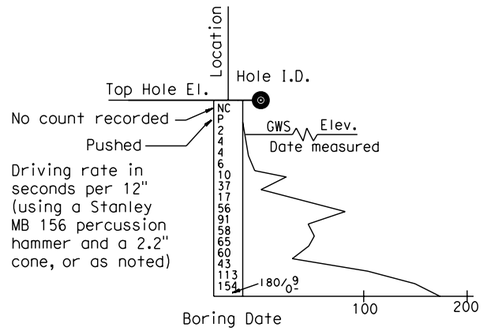
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



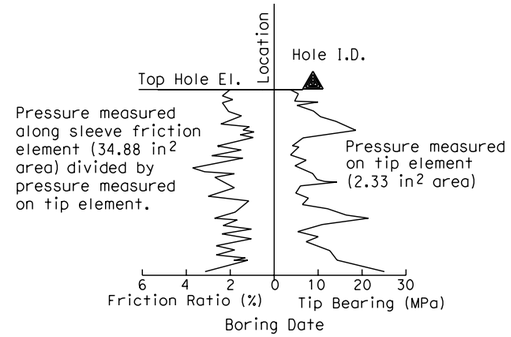
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown, PROJECT ENGINEER	BRIDGE NO. 53E0150	MSE RETAINING WALL NO. E2
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.10	LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	04/14/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
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- (OC) Organic Content-% (ASTM D 2974)
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- (PM) Pressure Meter
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- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
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- (TV) Pocket Torvane
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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

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CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0150
POST MILE 0.10

MSE RETAINING WALL NO. E2

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

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SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A. EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

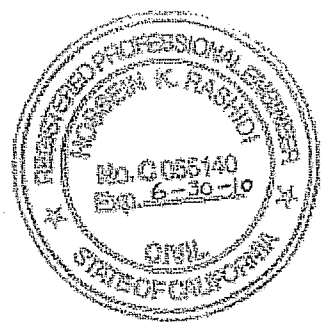
Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

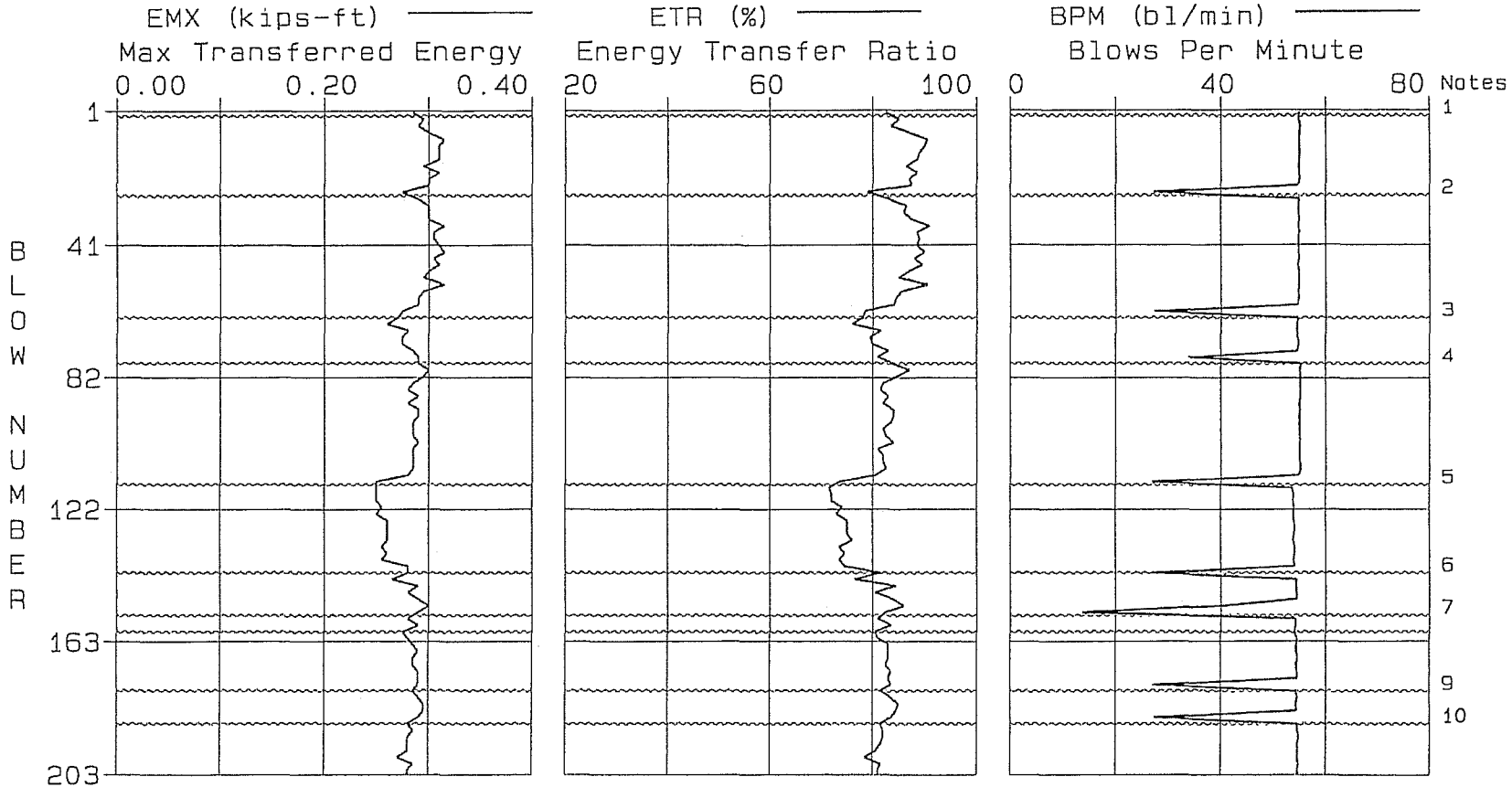
Sincerely Submitted for EarthSpectives

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer



EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

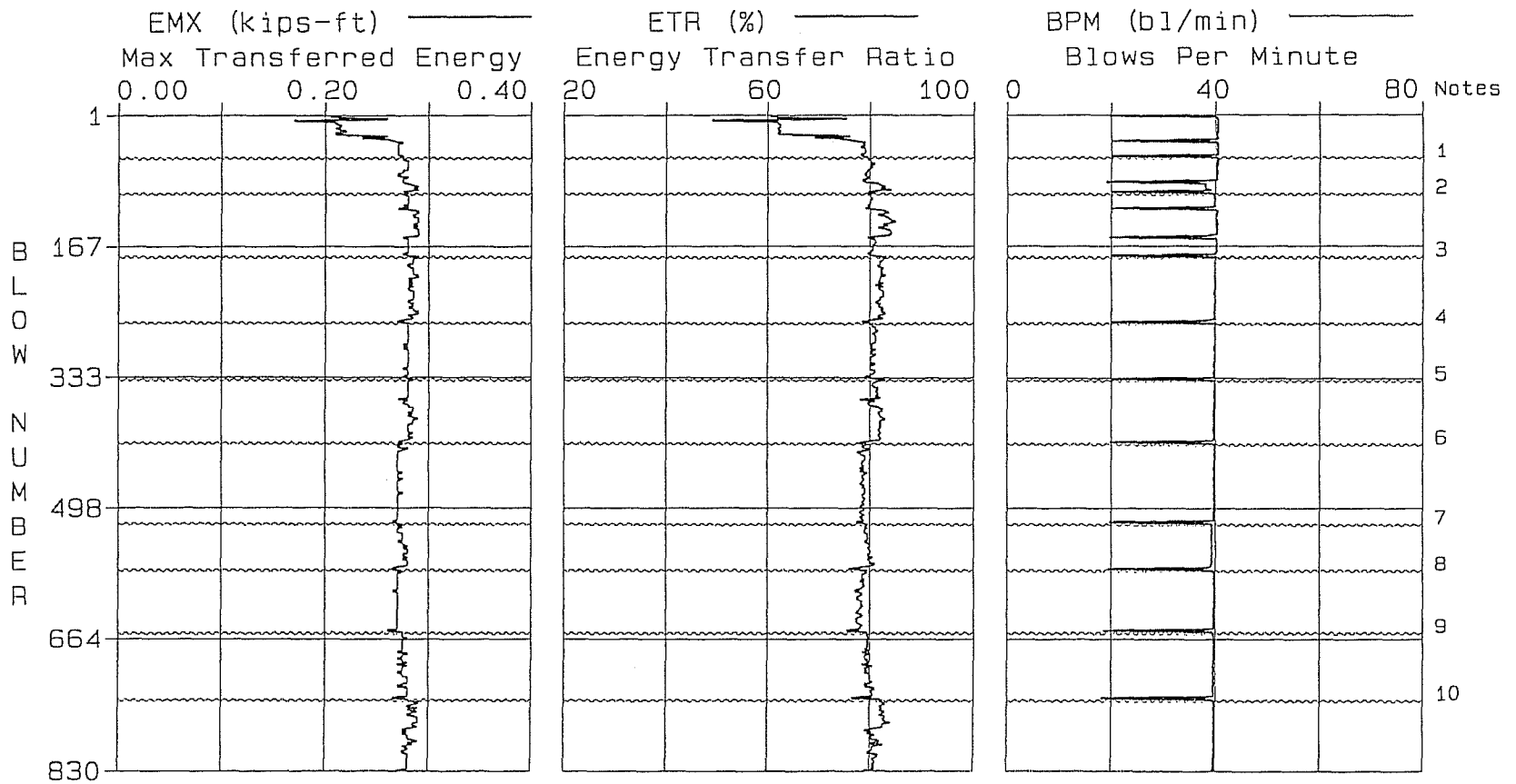
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

Info: MUD ROTARY

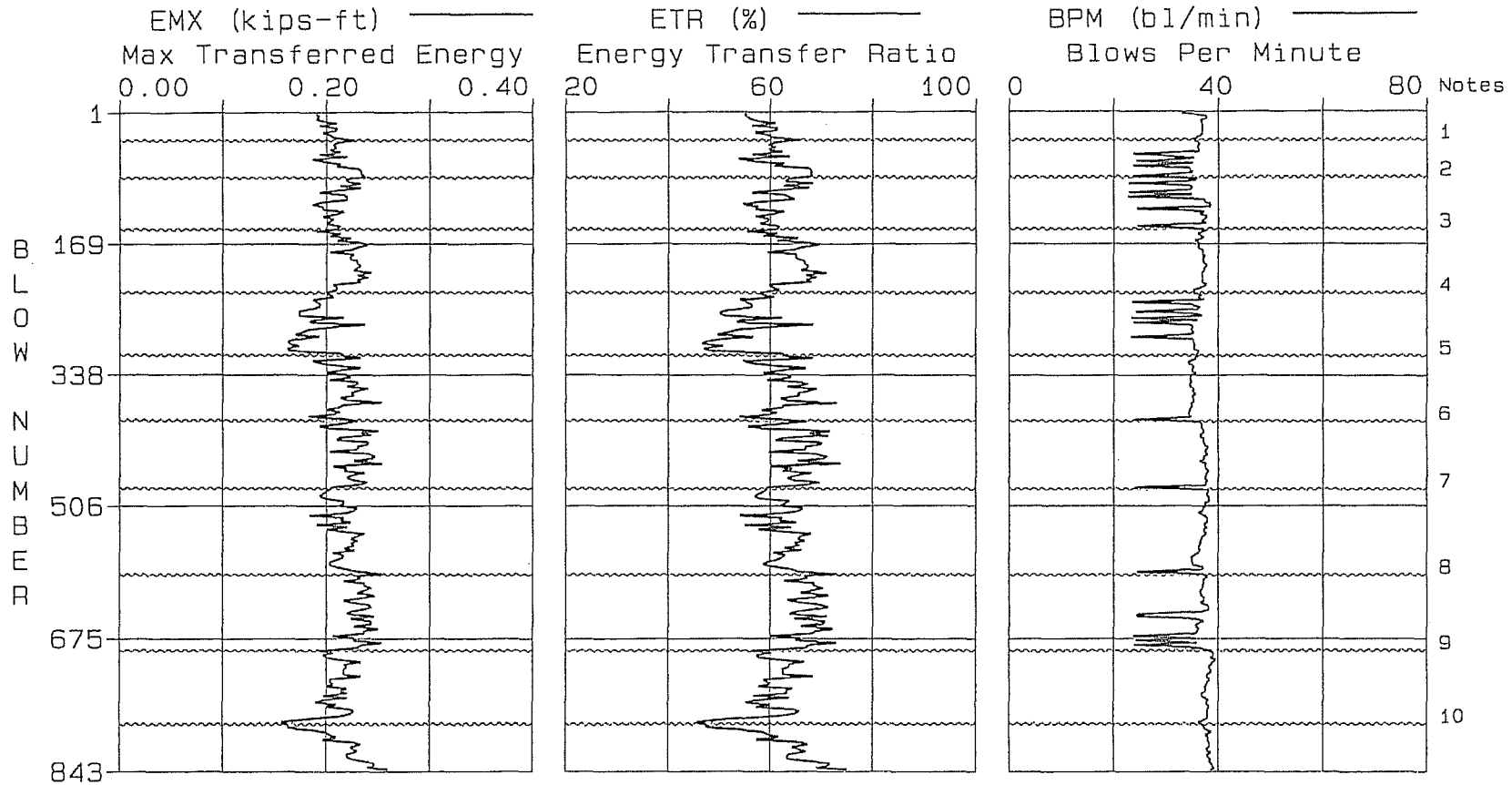
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009
Info: MUD ROTARY- rope and cathead
AR: 1.4 in^2
LE: 165.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX B. GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

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EMI Project Number 06-123

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

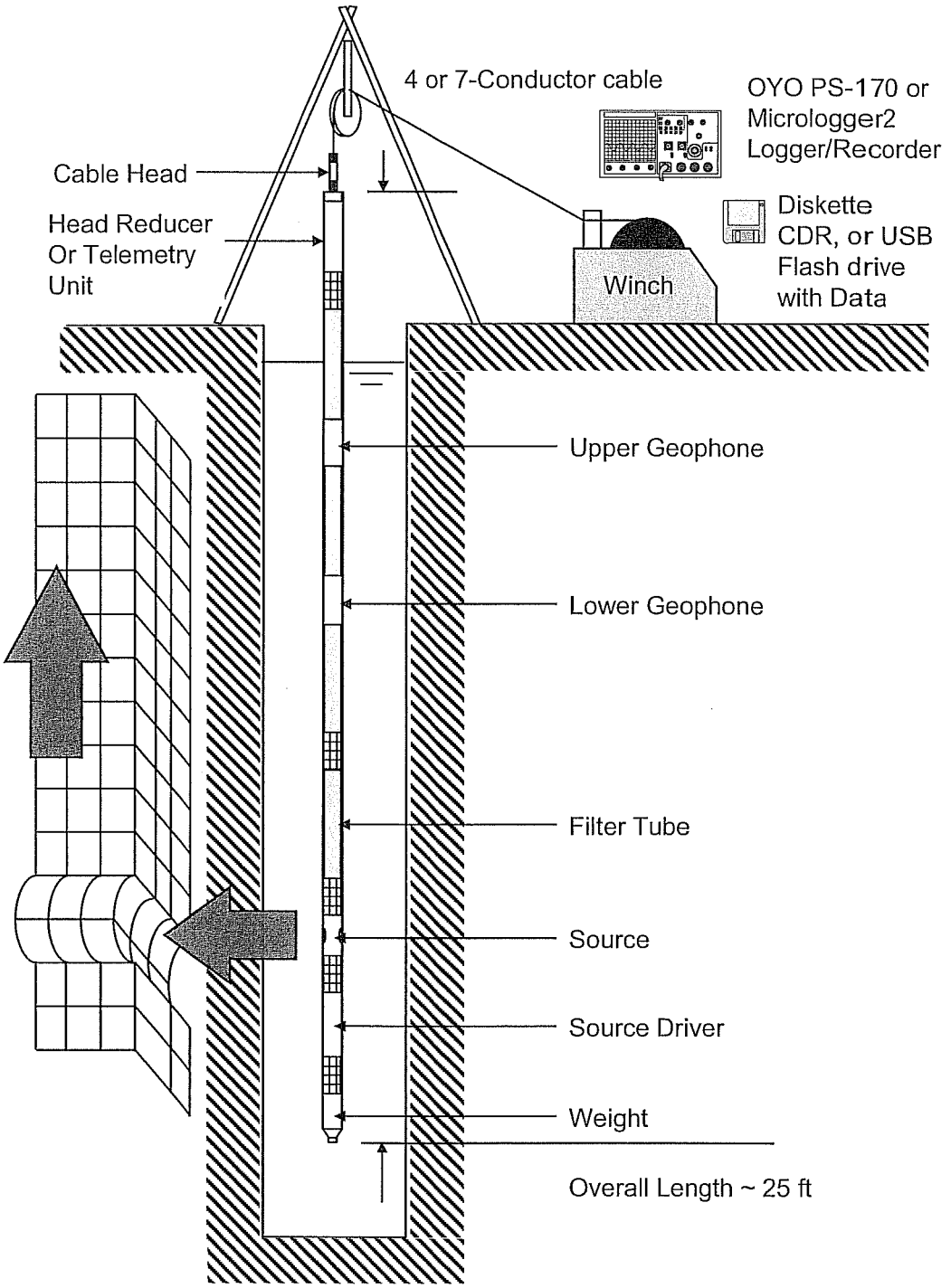

Figure 1: Concept illustration of P-S logging system

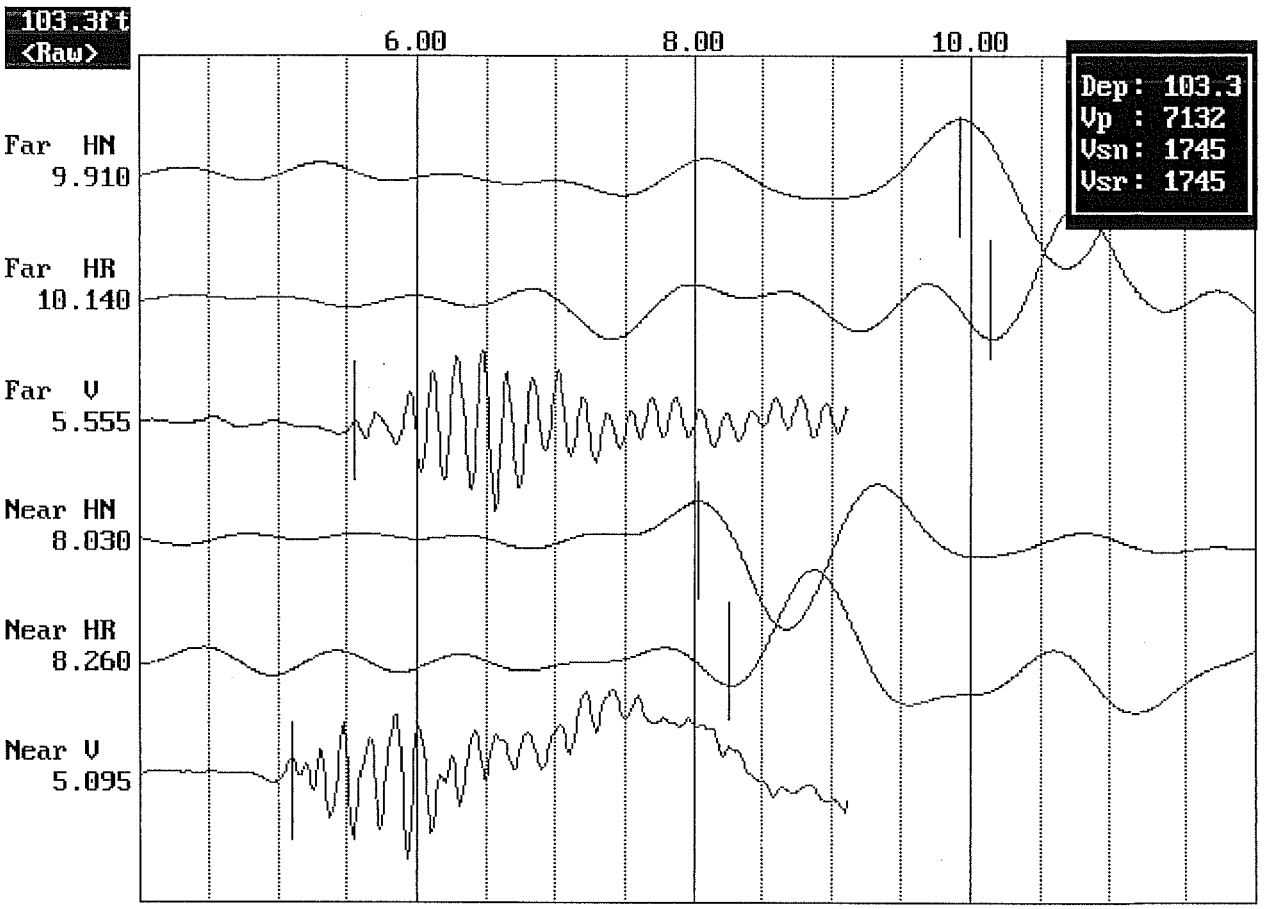

Figure 2: Example of filtered (1400 Hz lowpass) record

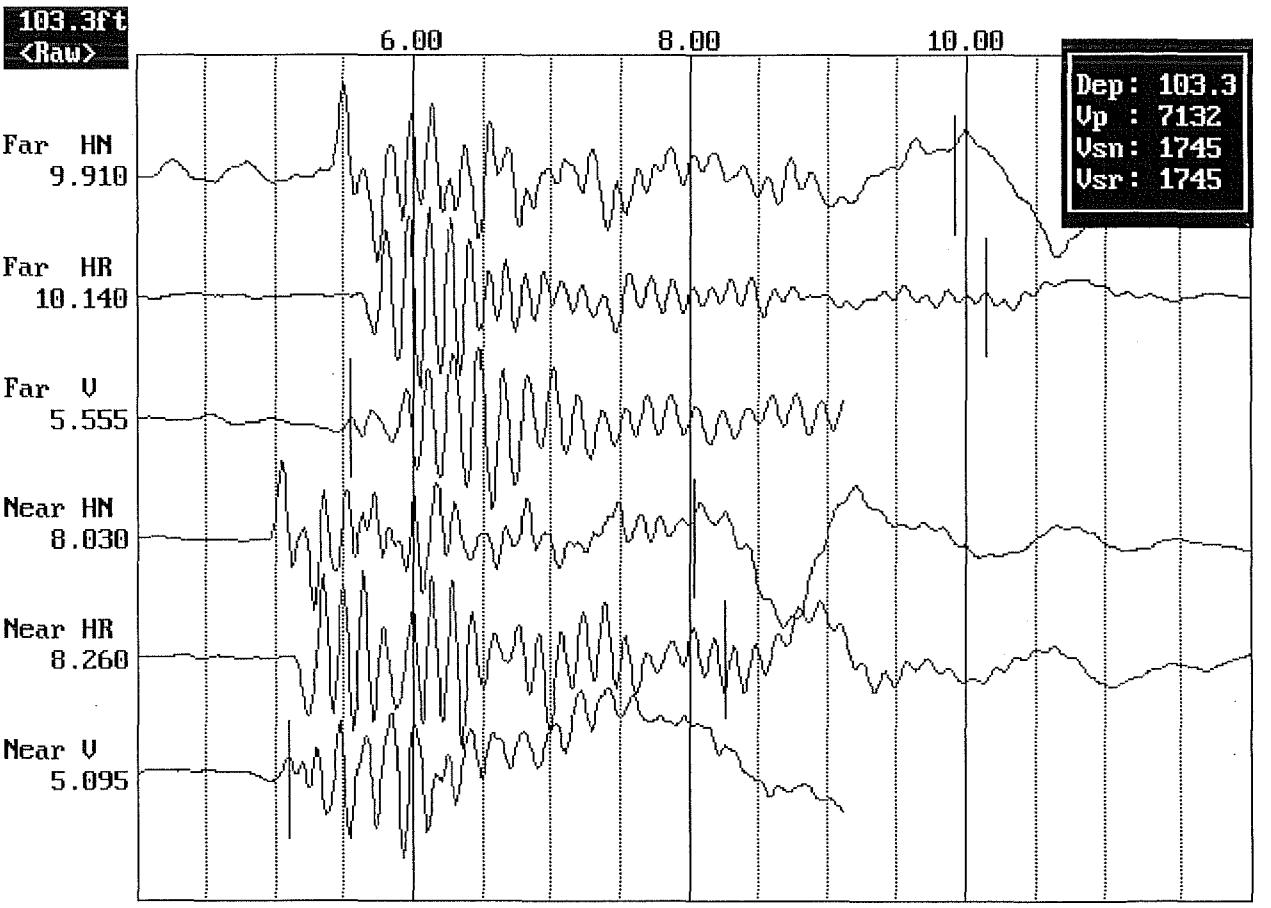

Figure 3. Example of unfiltered record

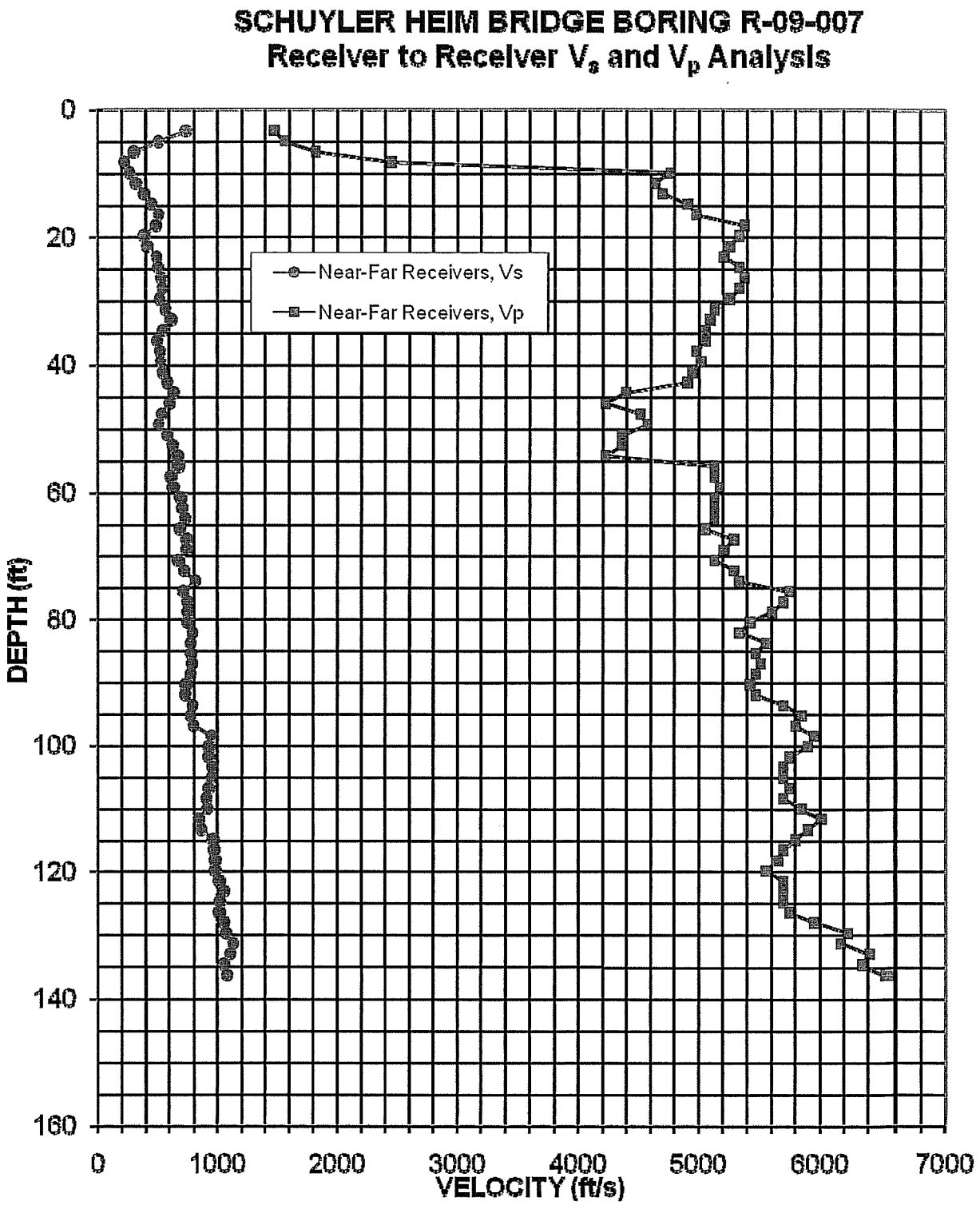

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

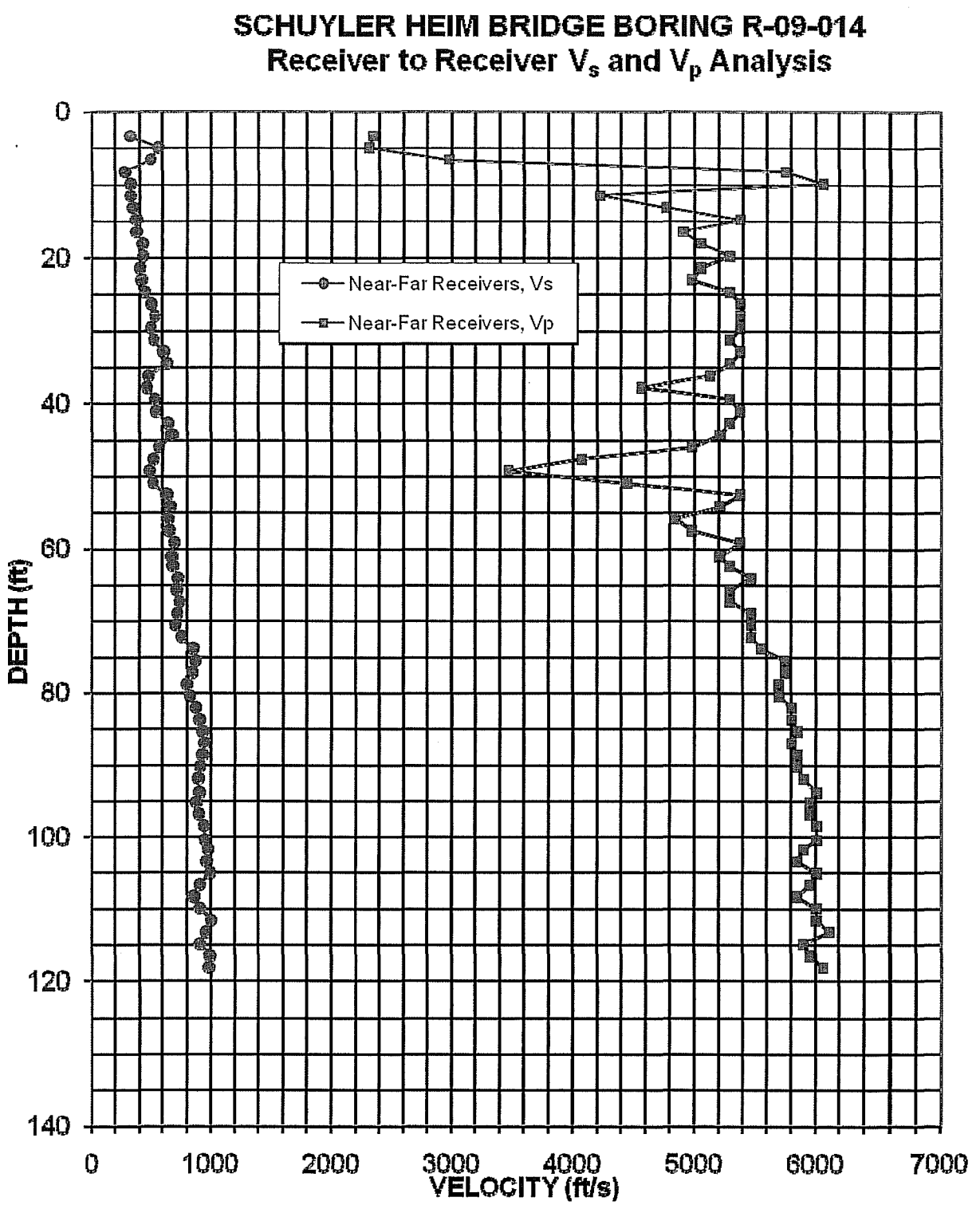

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

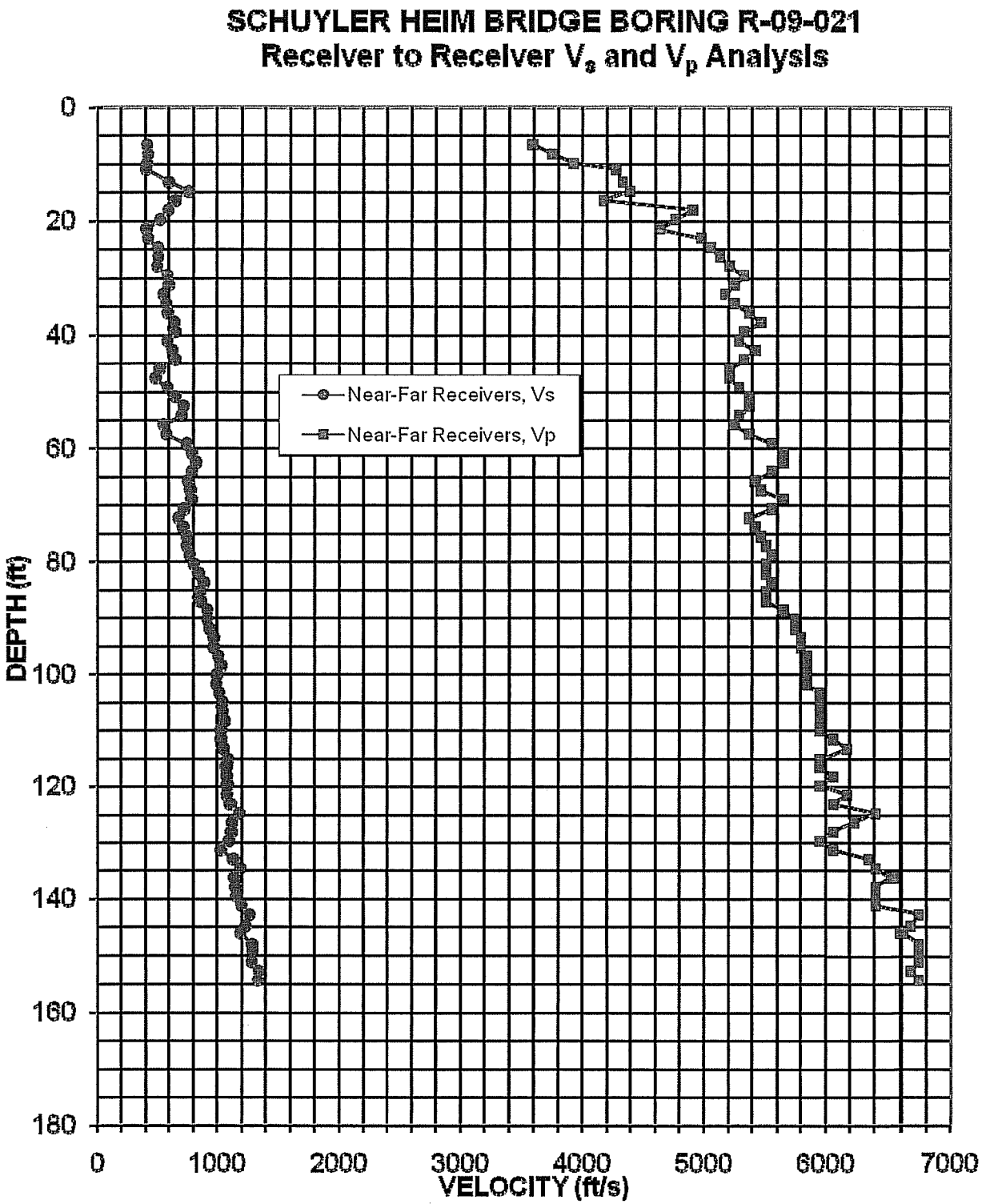

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

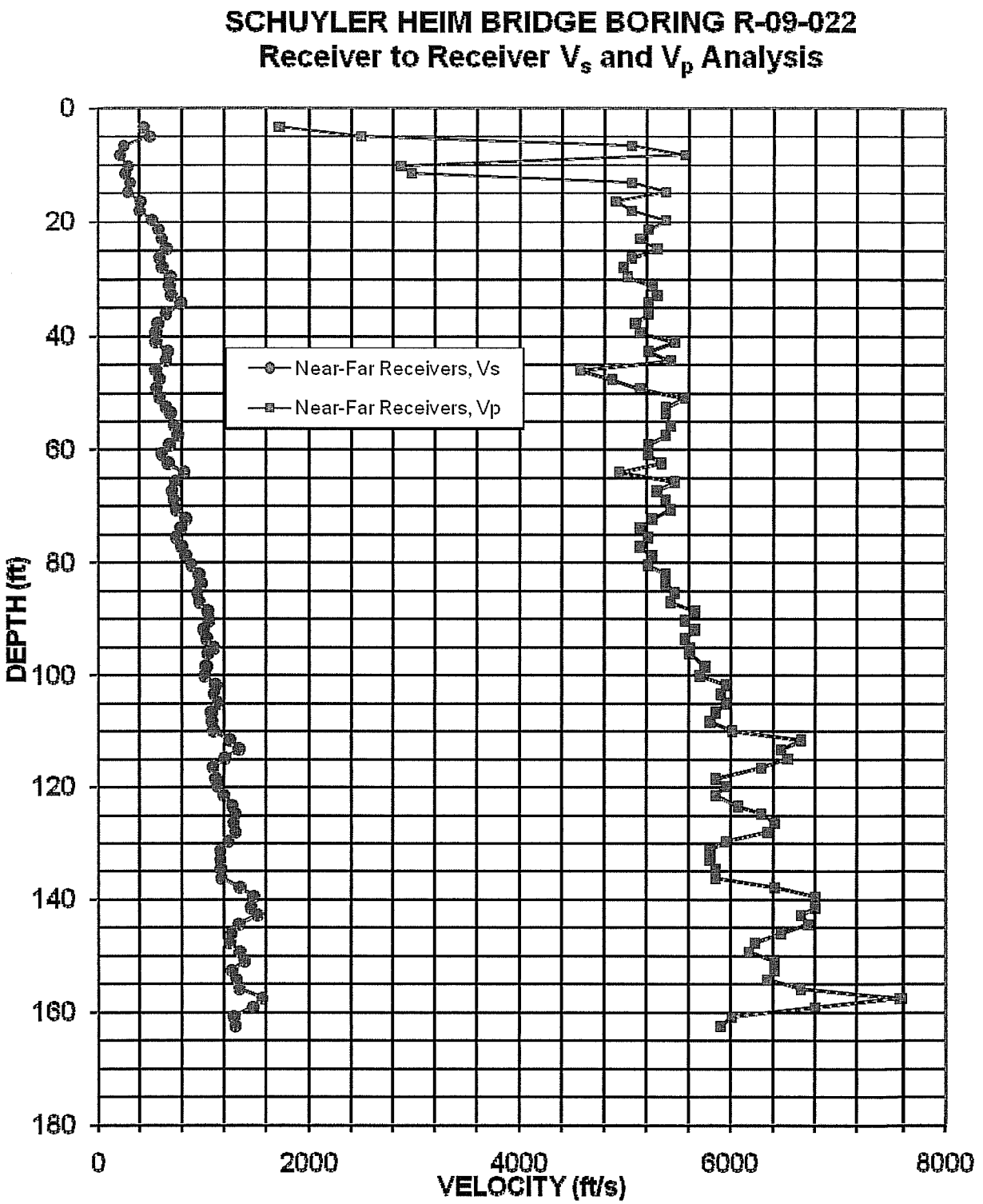

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

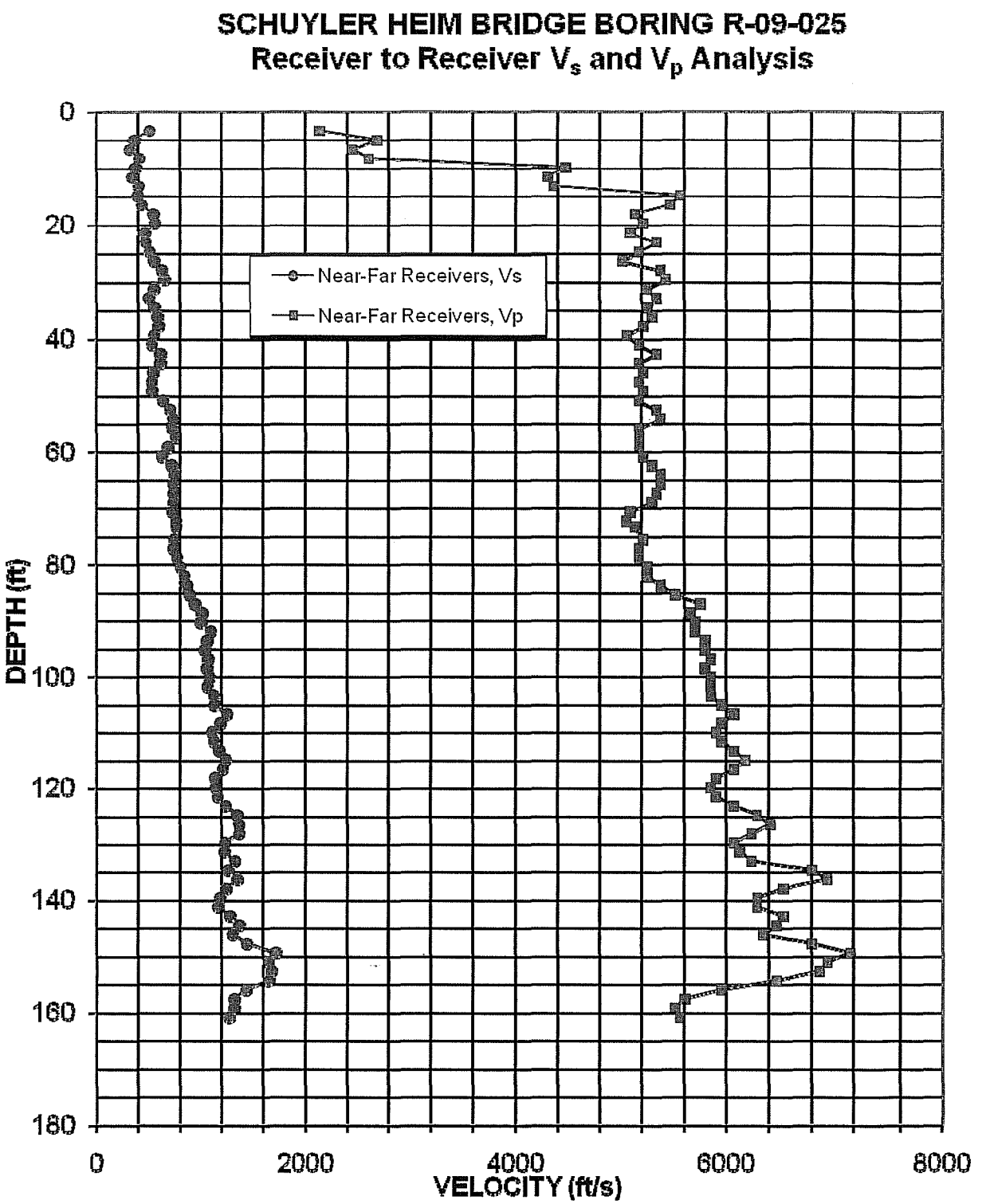

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

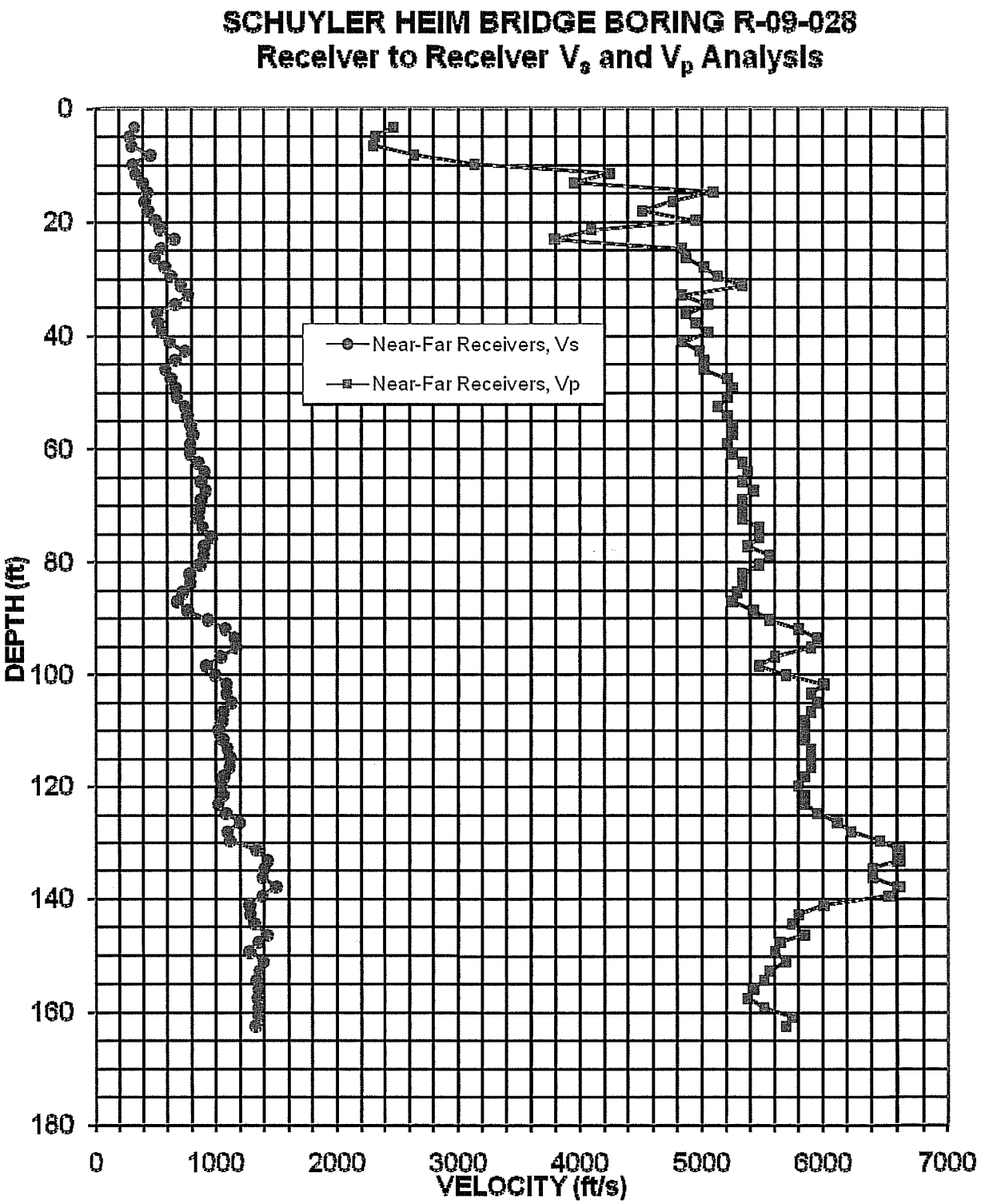

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

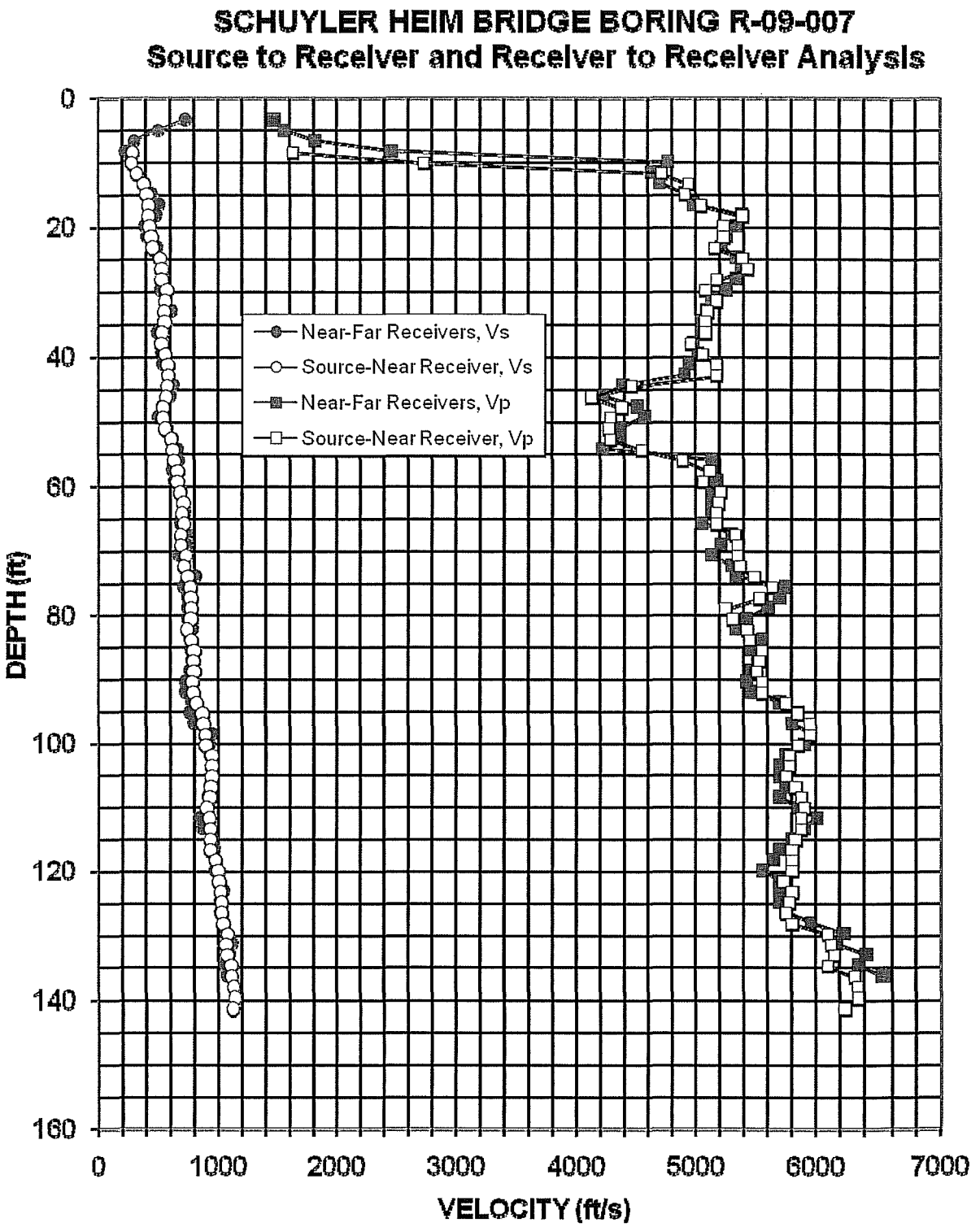

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

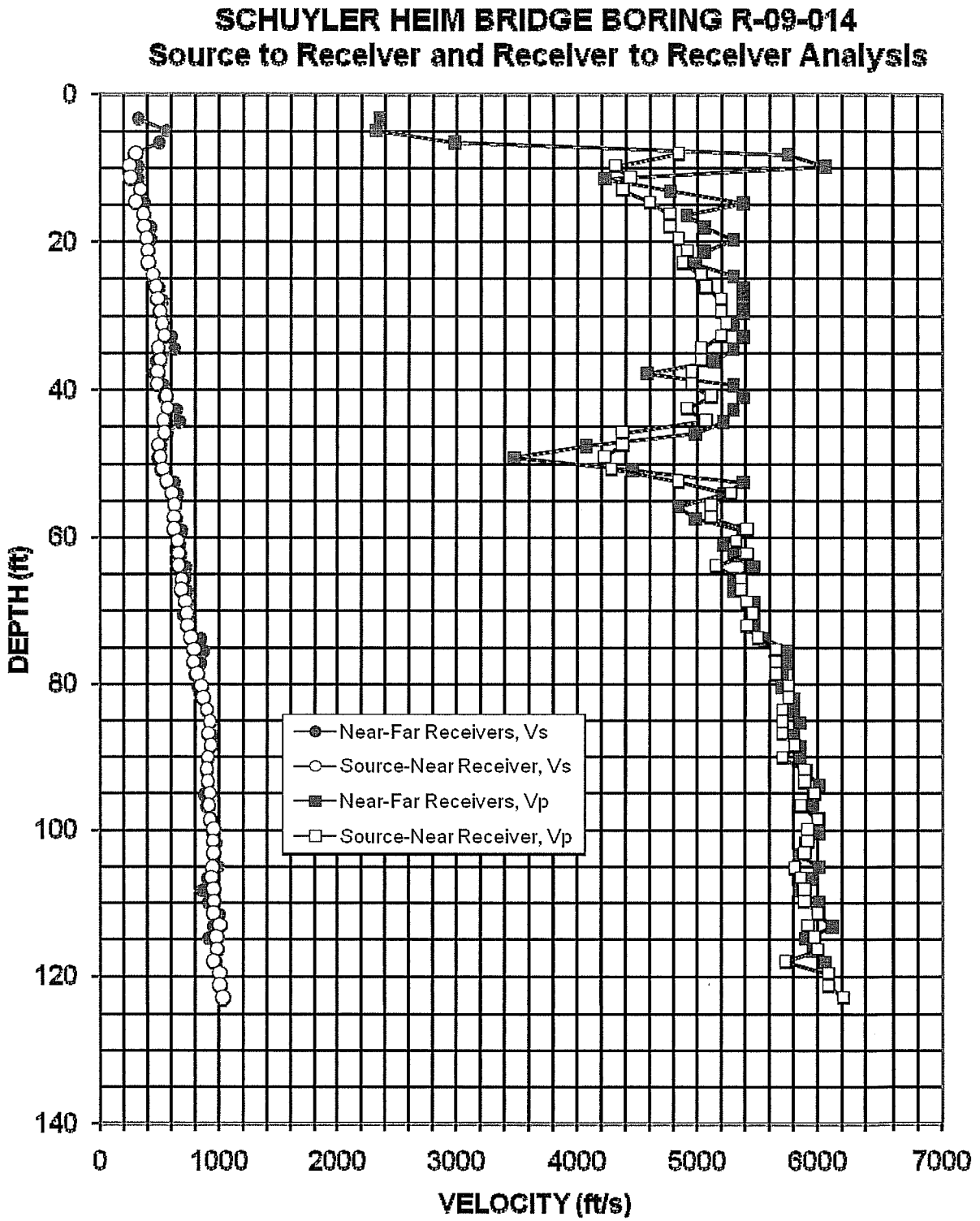

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

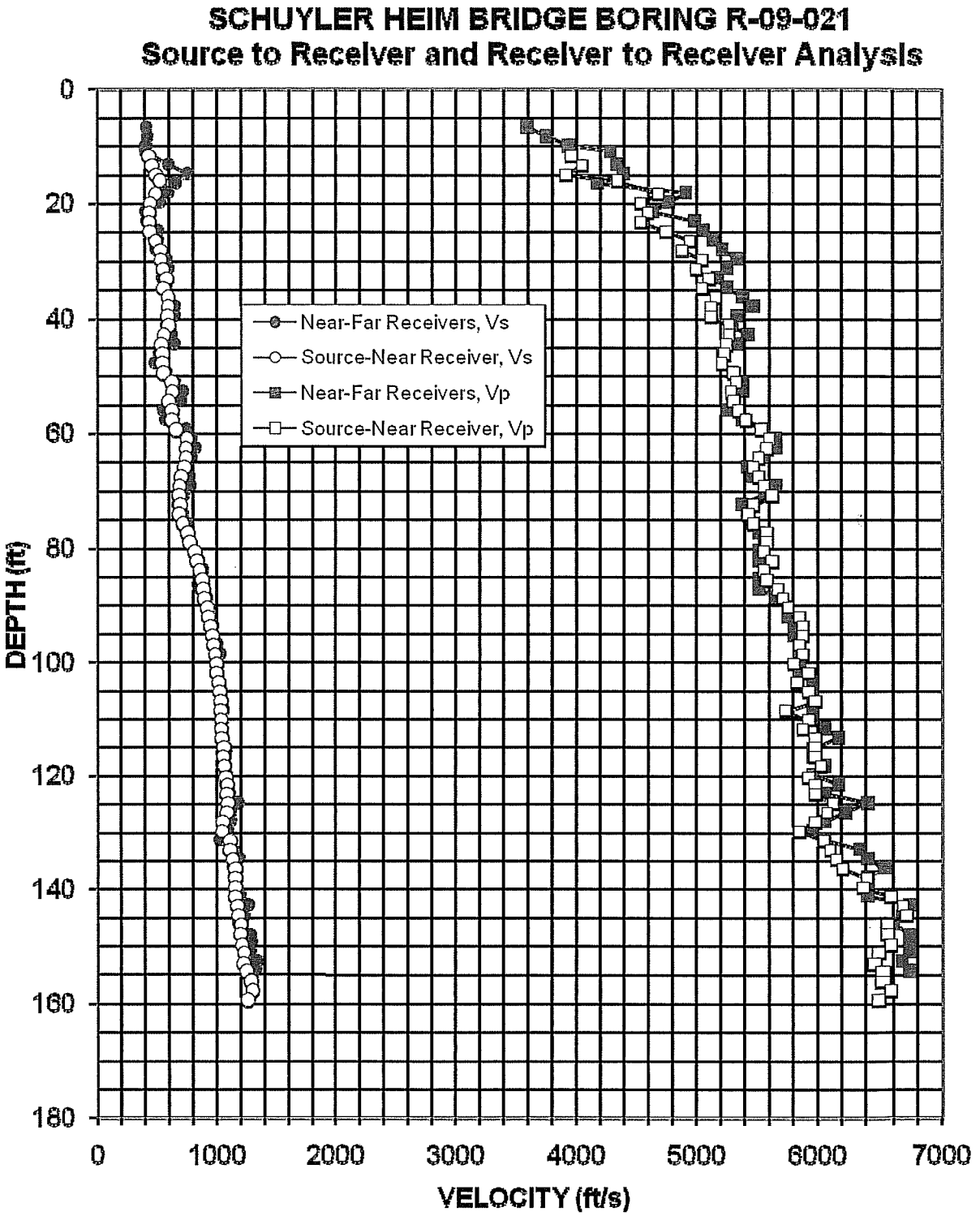

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

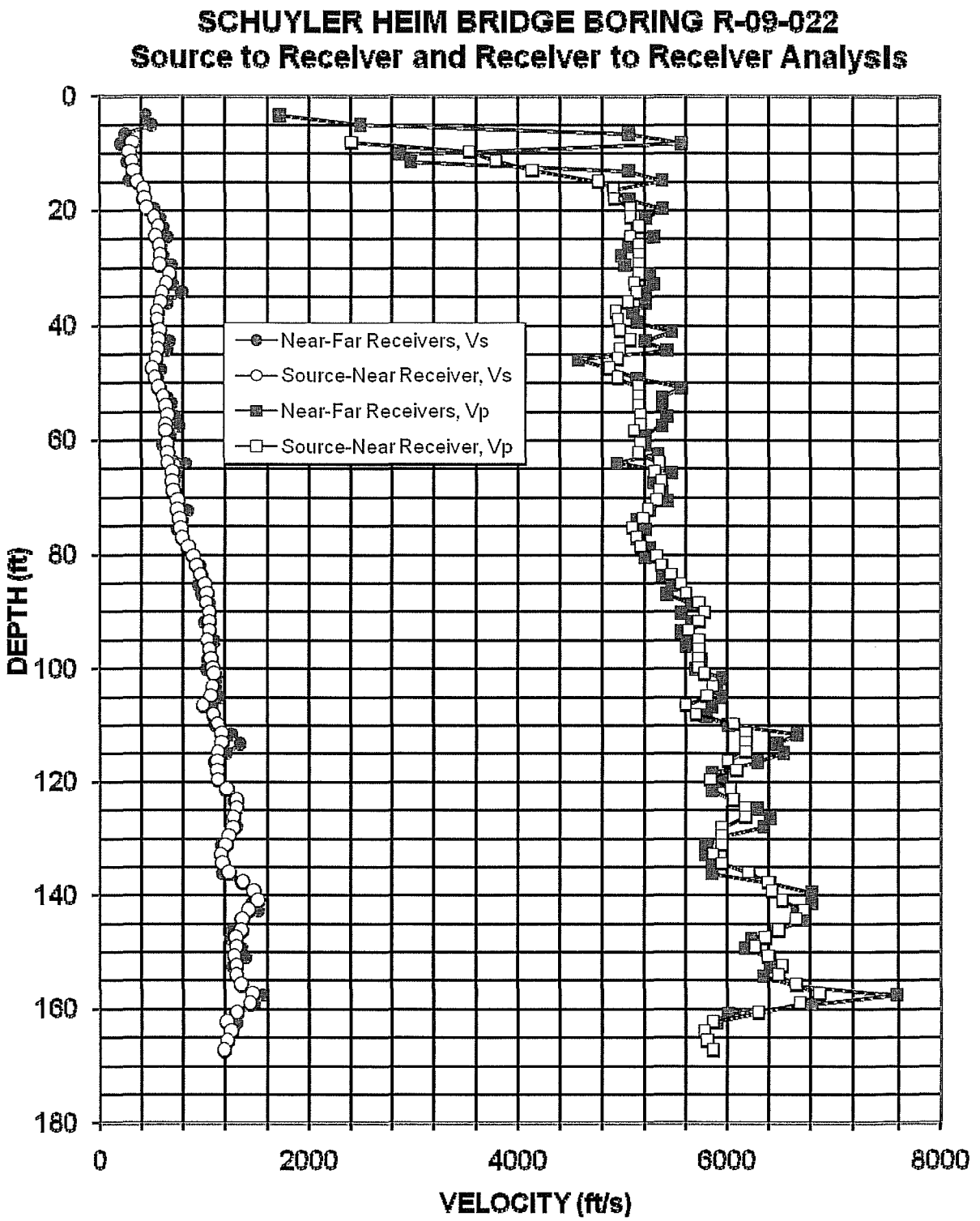

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

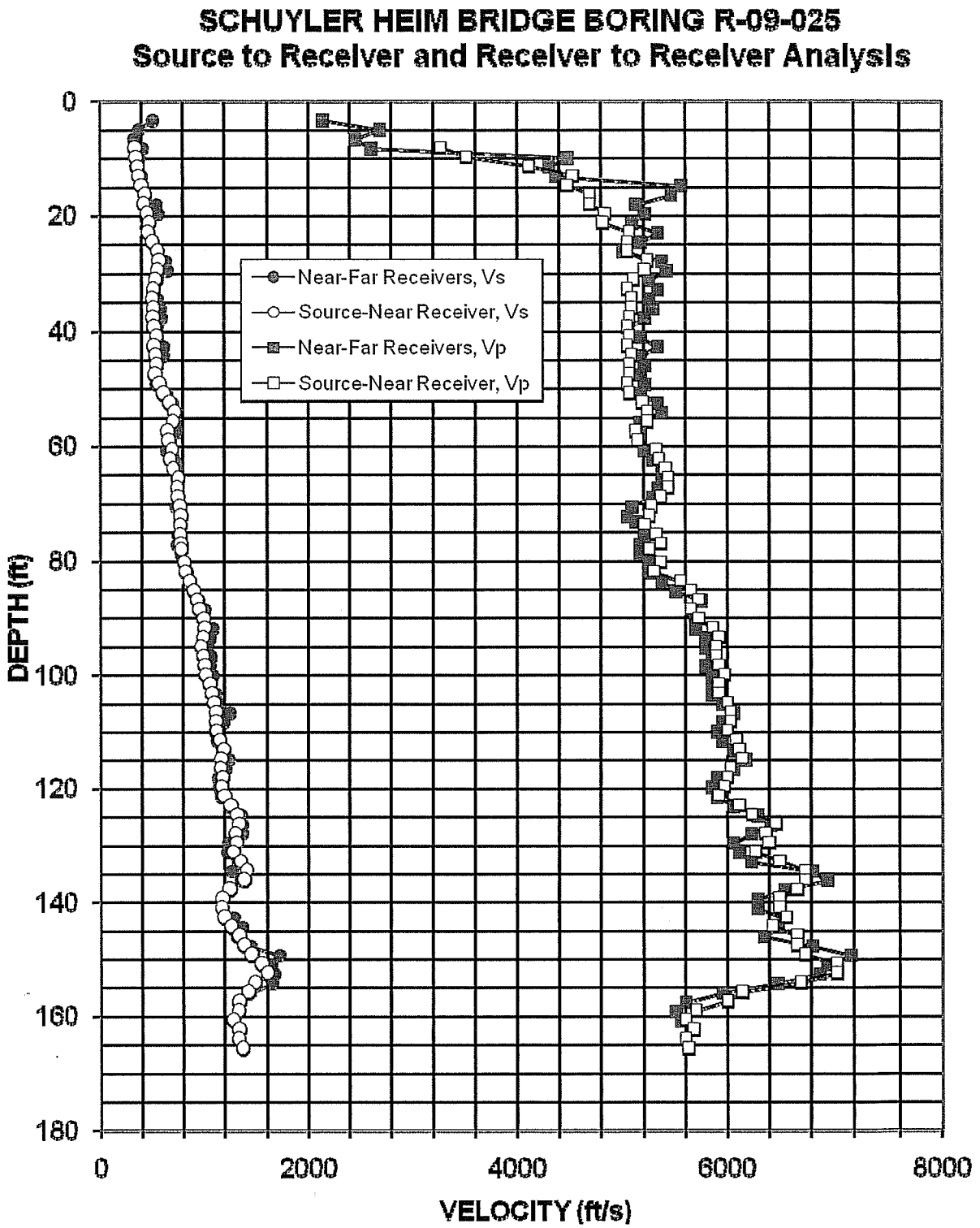

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

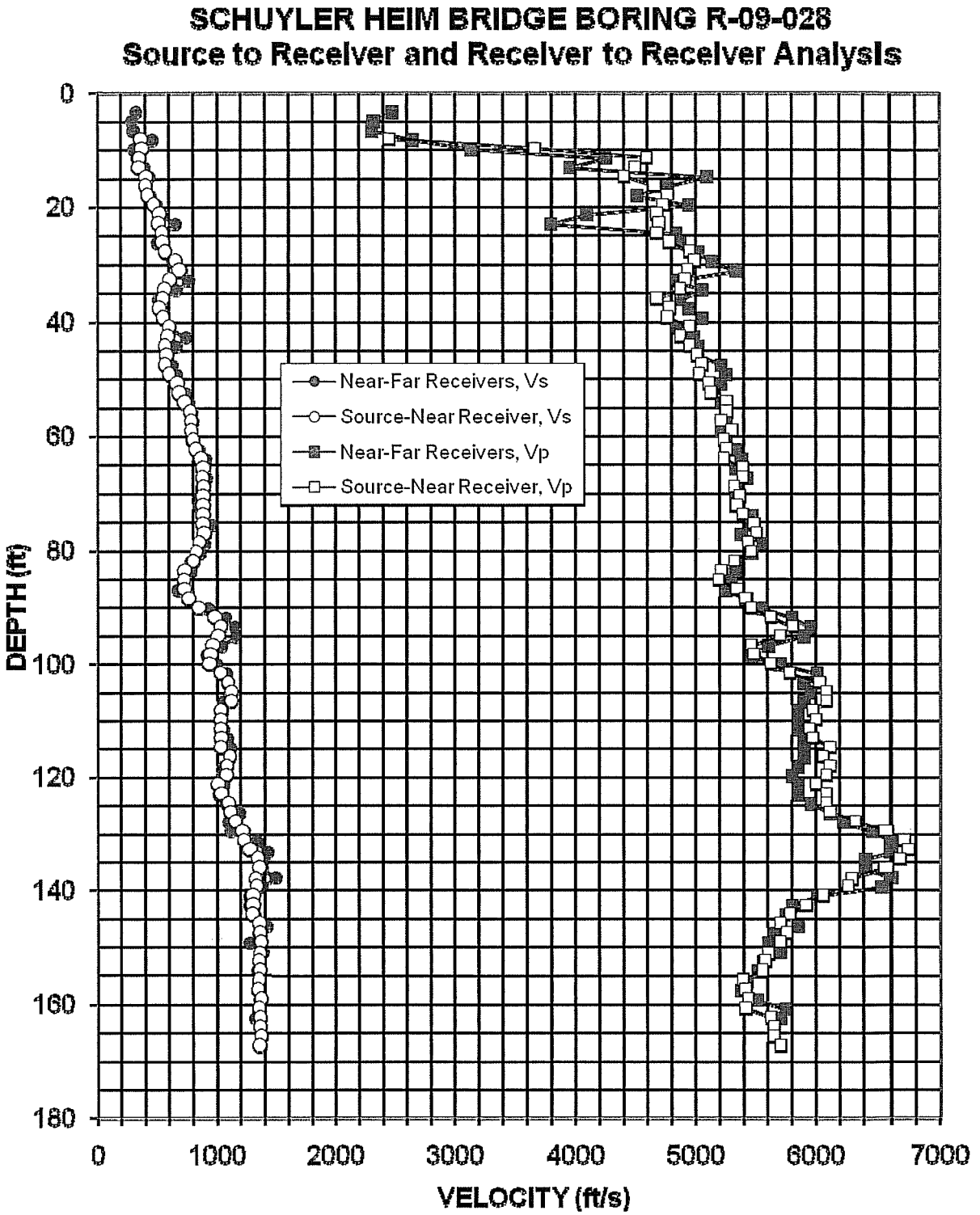

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠ Calibration Report

A SOUTHERN CALIFORNIA EDISON® Company

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
		2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 160024 573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C. LABORATORY SOIL TEST RESULTS

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

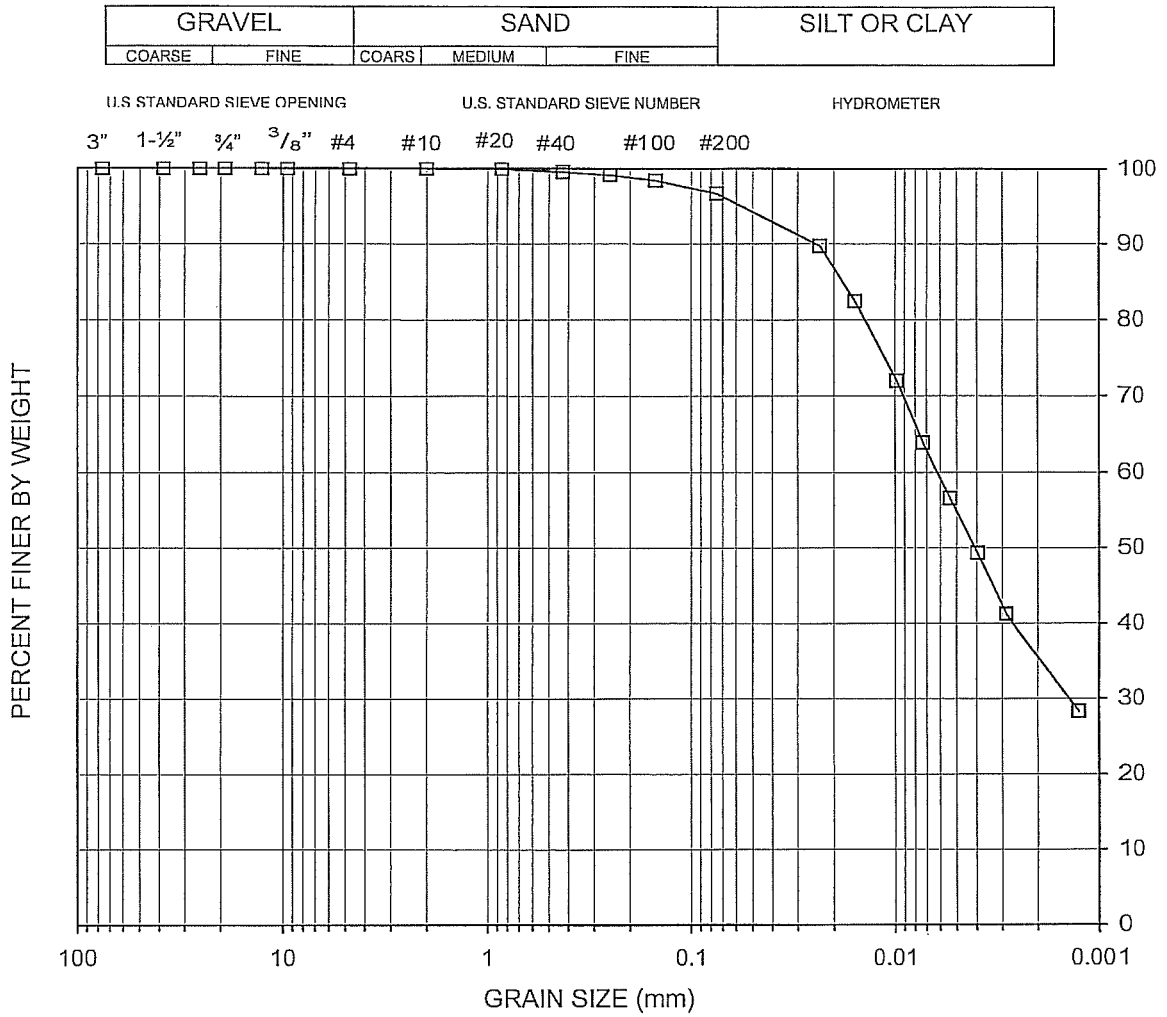
CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-033	S-01	5.0	12.7			
R-09-033	D-02	10.0	12.7	104.6	21.4	
R-09-033	U-04	20.0				61,26,35
R-09-033	D-05	25.0			10.9	
R-09-033	S-08-1	40.0	47.8			41,23,18
R-09-033	U-09	45.0				25,24,1
R-09-033	D-10-1	50.0			55.5	
R-09-033	S-11-1	55.0	31.9			29,28,1
R-09-033	S-11-2	55.8	30.5			24,23,1
R-09-033	D-12-1	60.0	25.5	100.4		
R-09-033	S-13-1	65.0	38.6			38,24,14
R-09-033	S-16	80.0	20.7			
R-09-033	S-17-2	90.6	35.5			33,22,11
R-09-033	S-19	100.0	14.2			

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	U-04	20	Shelby Tube	CH	61	35

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

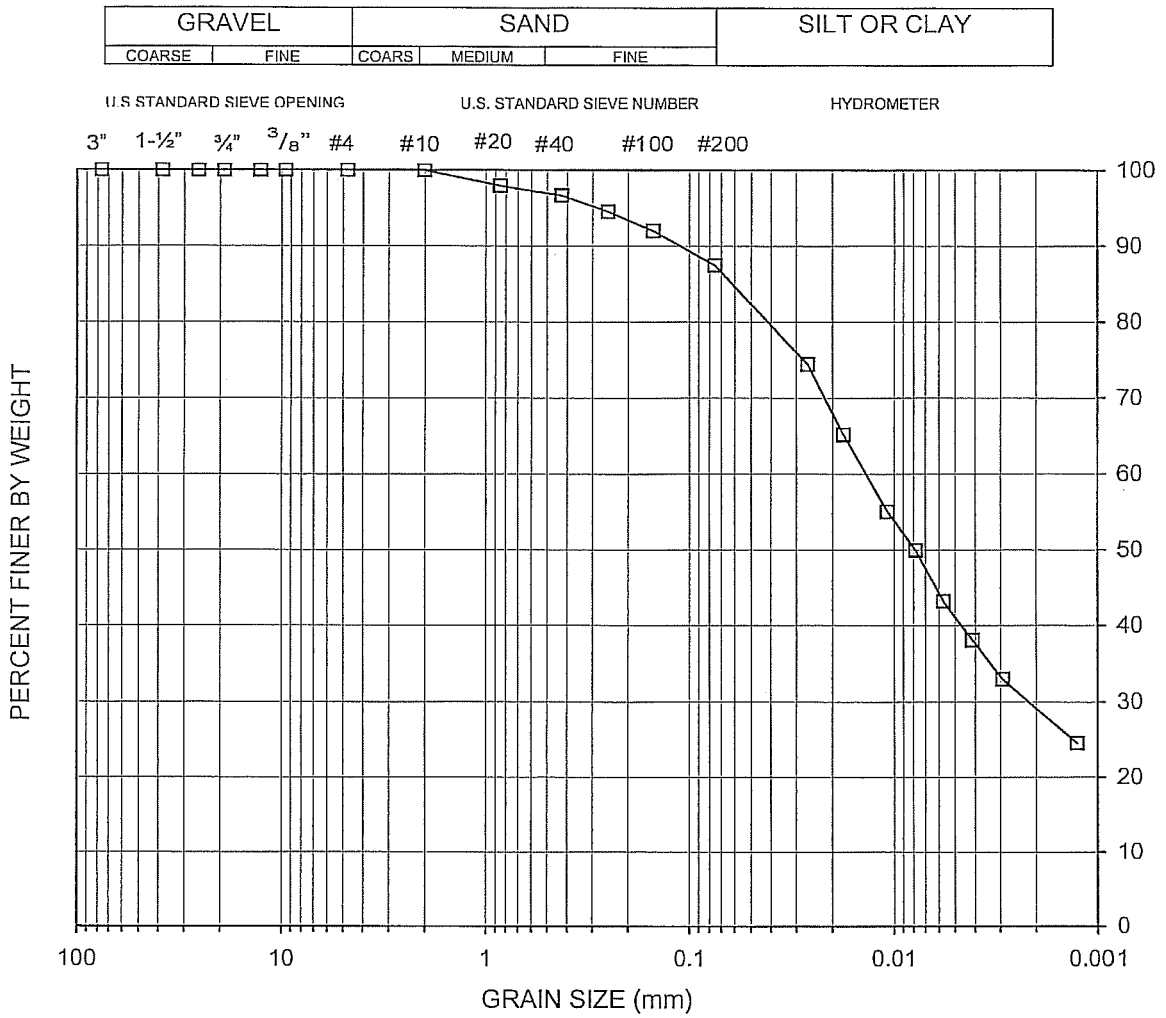
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-08-1	40	Bag	CL	41	18

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

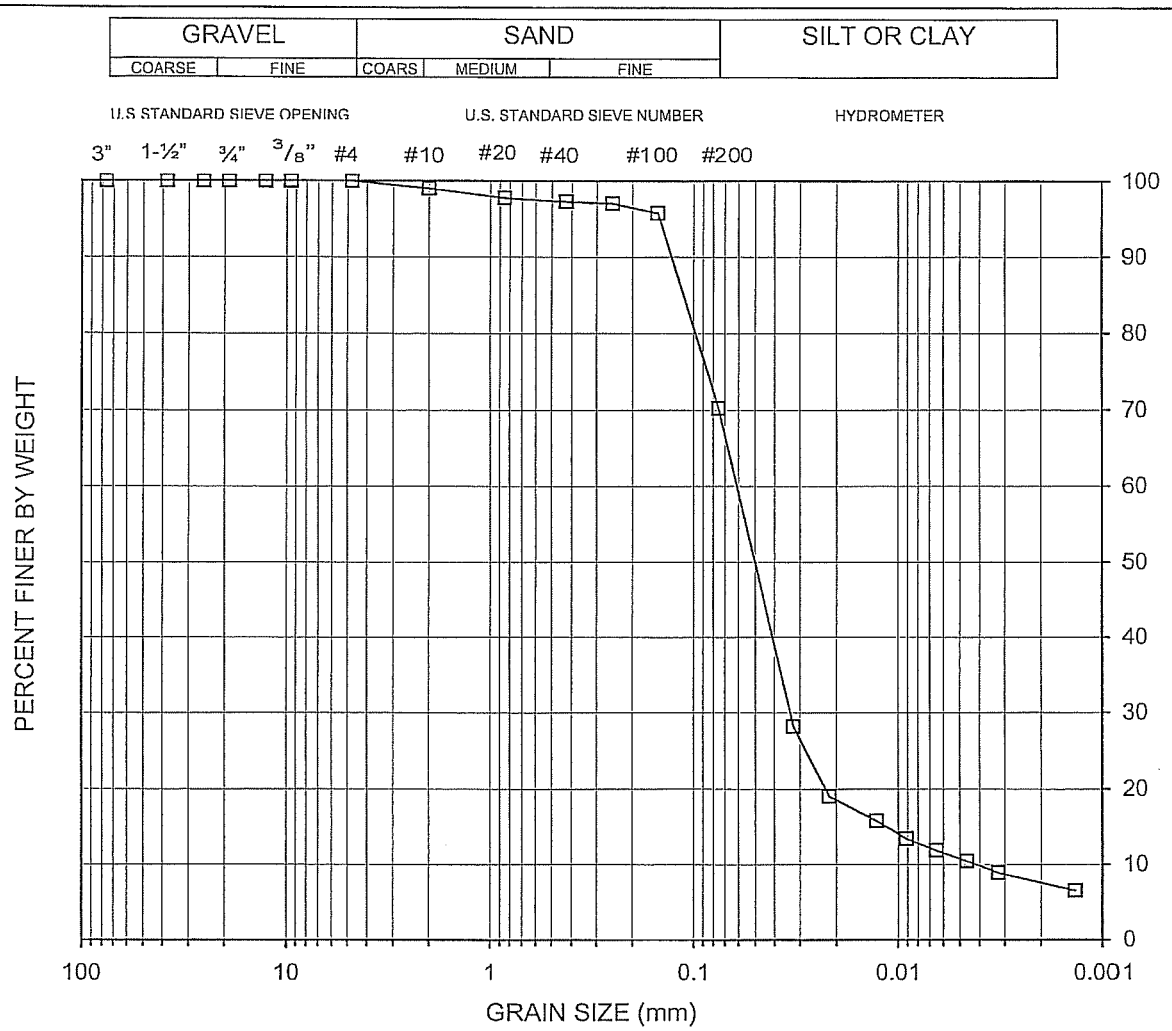
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	U-09	45	Shelby Tube	ML	24	1

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

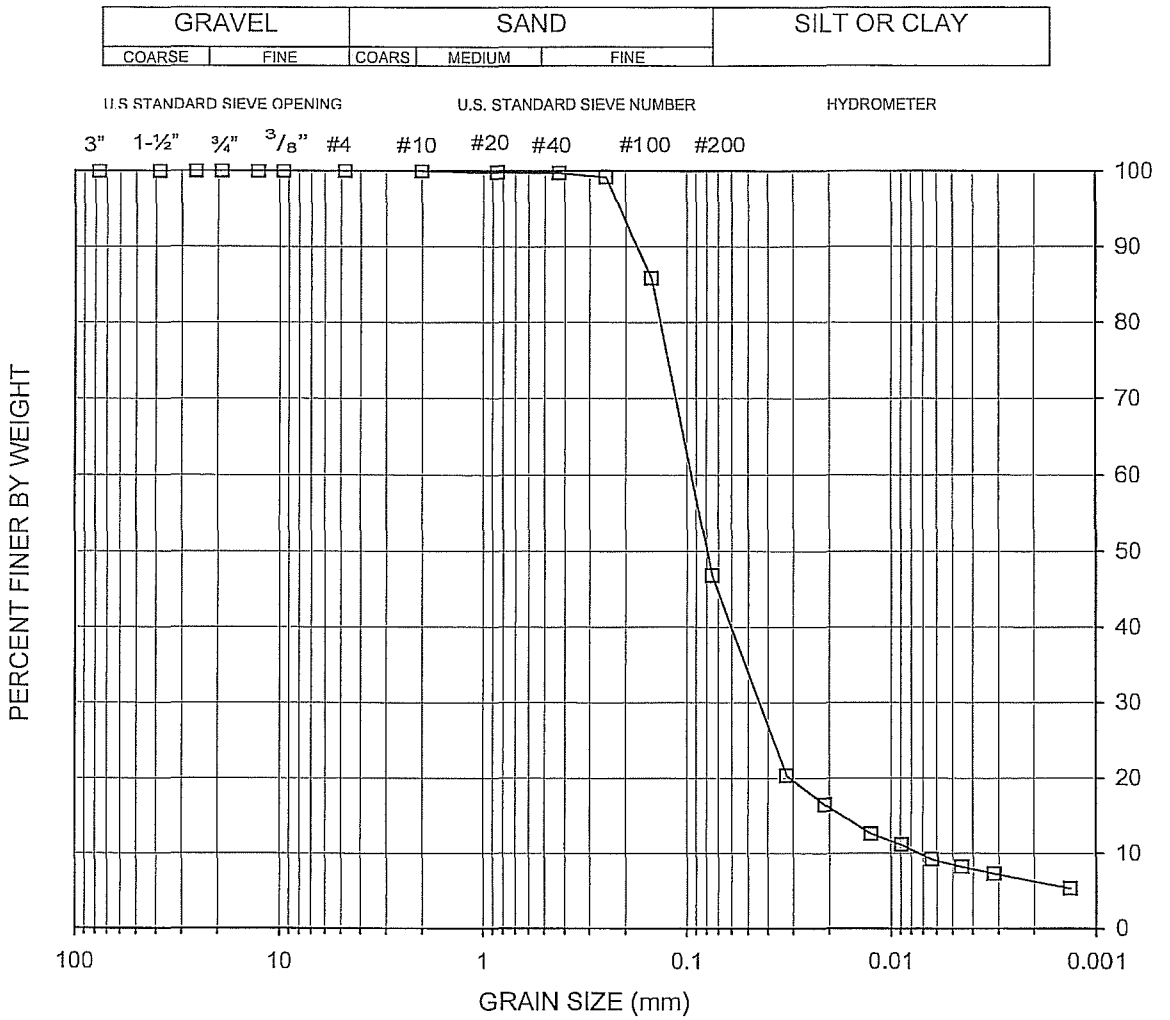
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/22/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	D-12-1	60	Ring	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

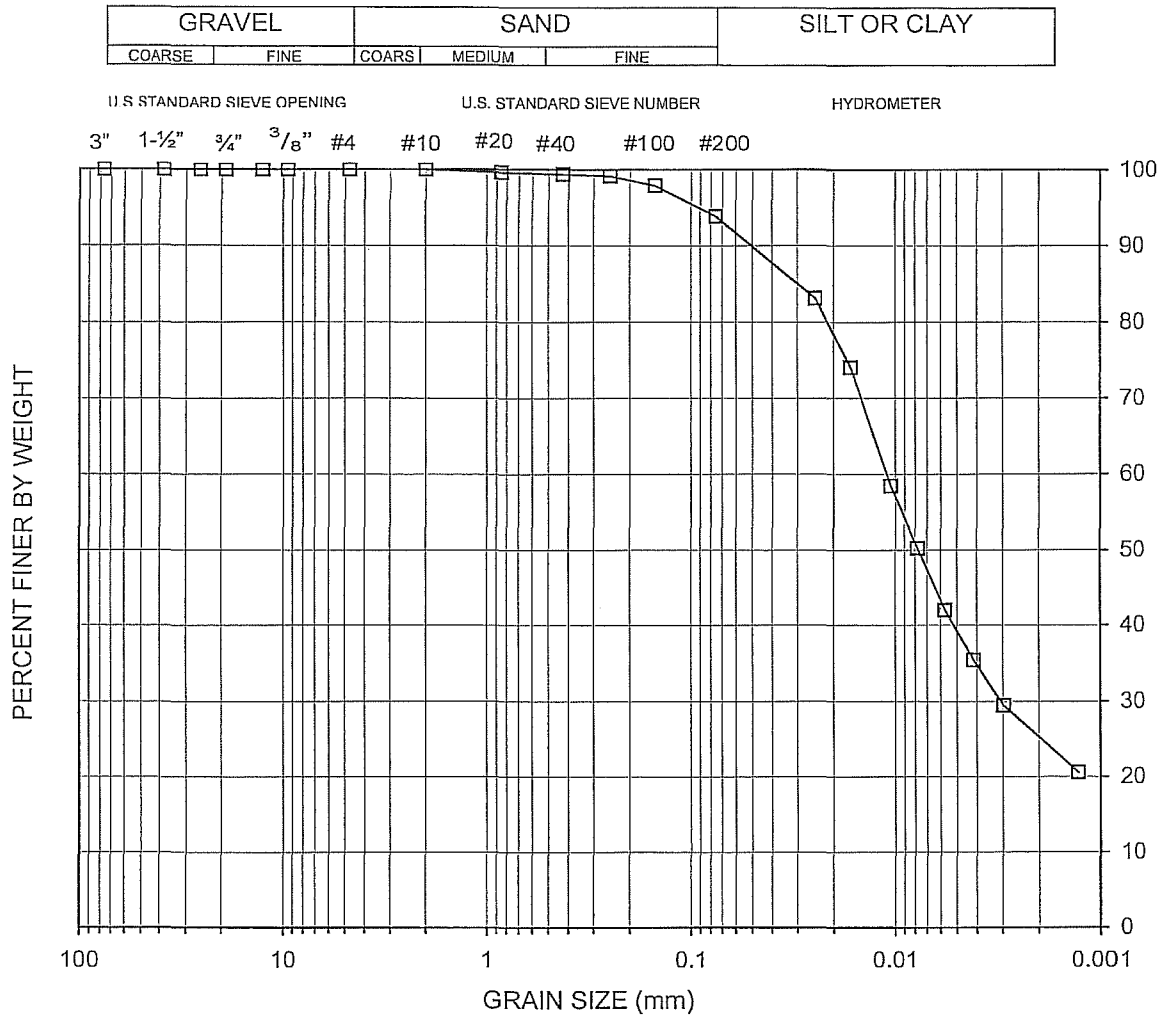
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-13-1	65	Bag	CL	38	14

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

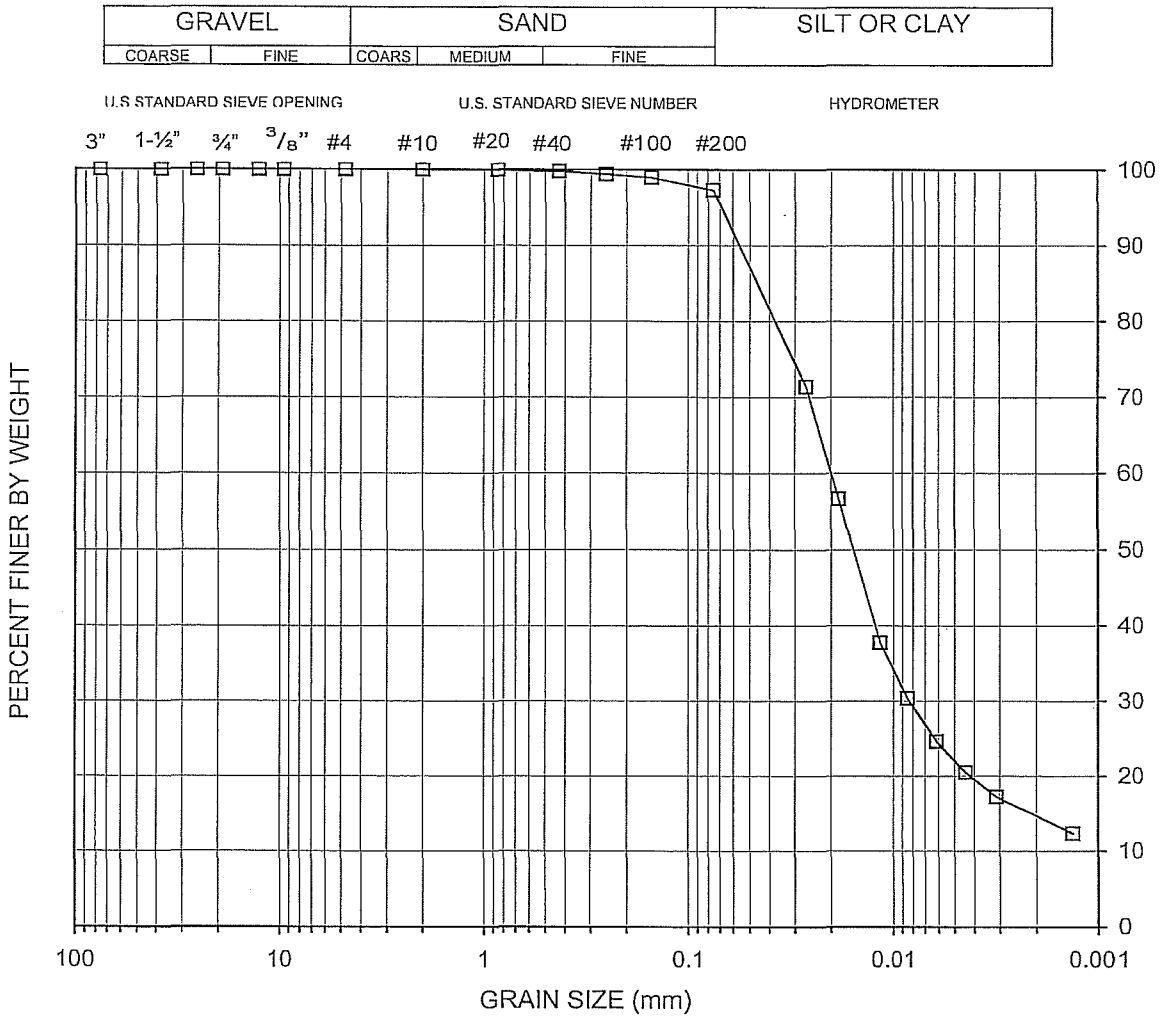
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-033	S-17-2	90.6	Bag	CL	33	11

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

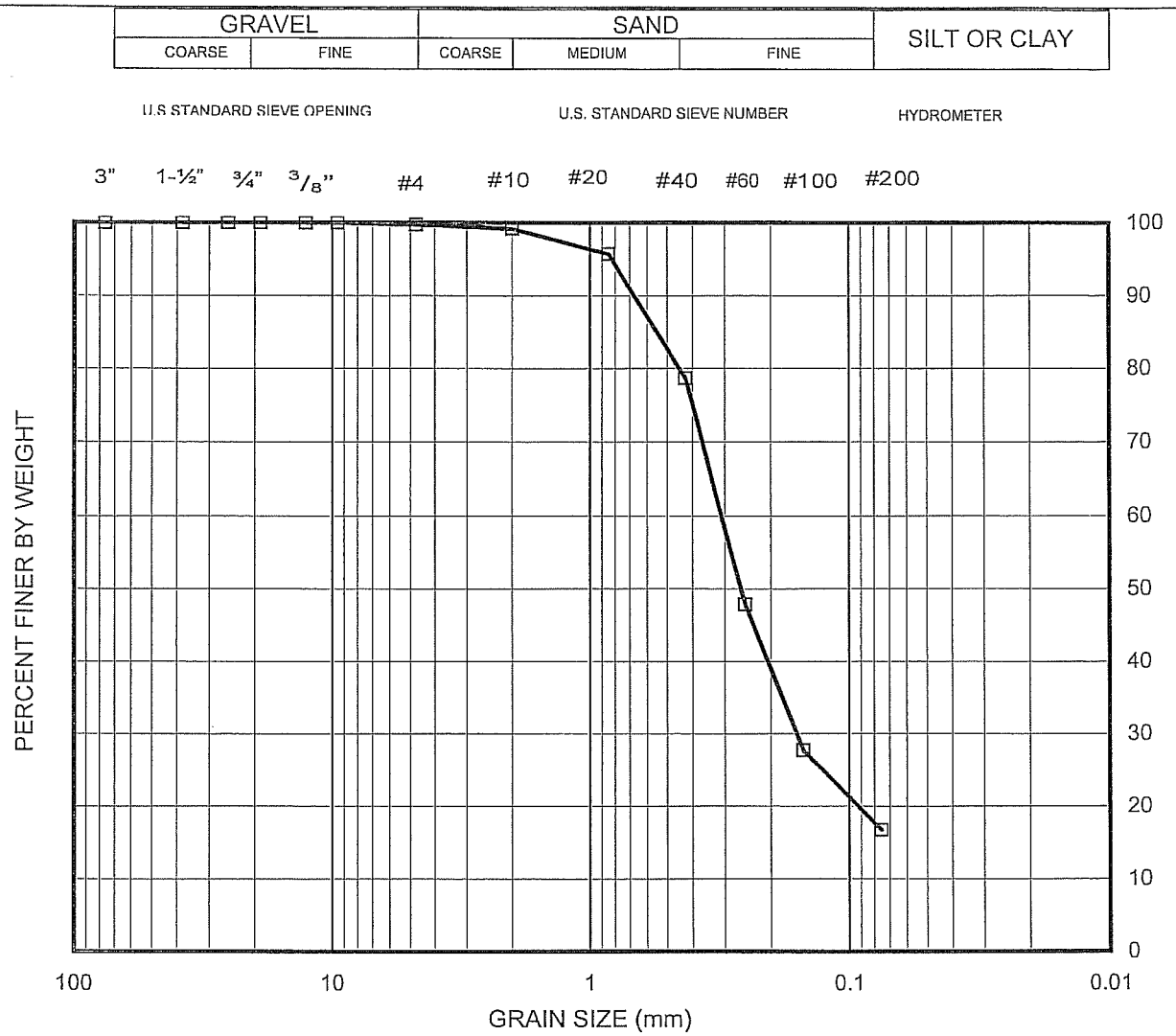
Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

GRAINSIZE DISTRIBUTION CURVE
(ASTM D422)

12/21/09

FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-033	S-16	80	Bag	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

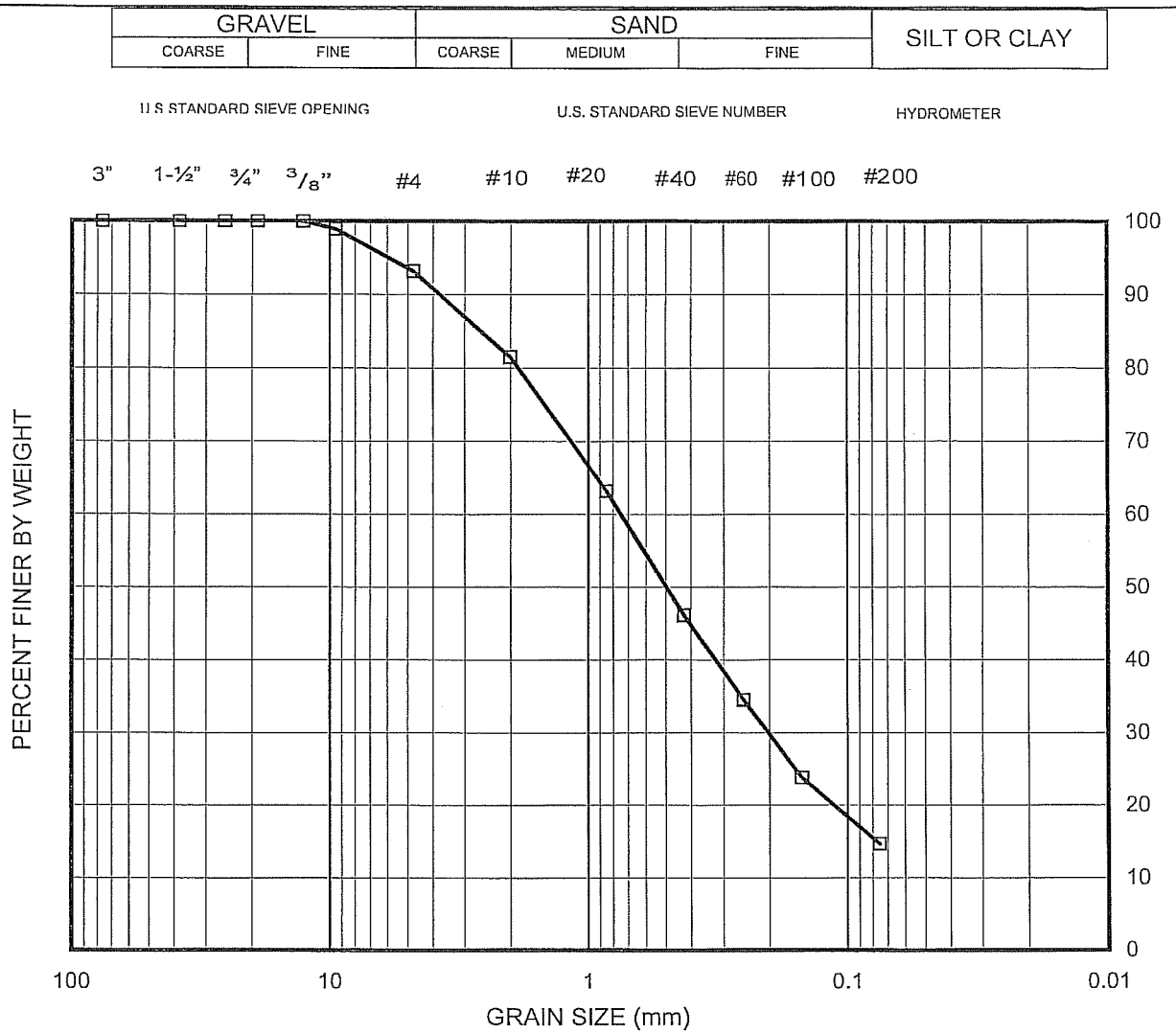
Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	R-09-033	S-19	100	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

Client Job No.: 06-123-03

Client Name: Earth Mechanics, Inc.

EGL Project No: 09-230-008A

GRAIN SIZE DISTRIBUTION CURVE

Dec-09 (ASTM D422) FIGURE

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008A
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	12/18/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-033	U-03	15	8.40	605	0.018	630

SUMMARY OF LABORATORY TEST RESULTS
POCKET PENETROMETER

PROJECT NAME ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	POCKET PENETROMETER Ton/ft*2 (TSF)
R-09-033	U-04	20	0.5
R-09-033	U-09	45	1.75

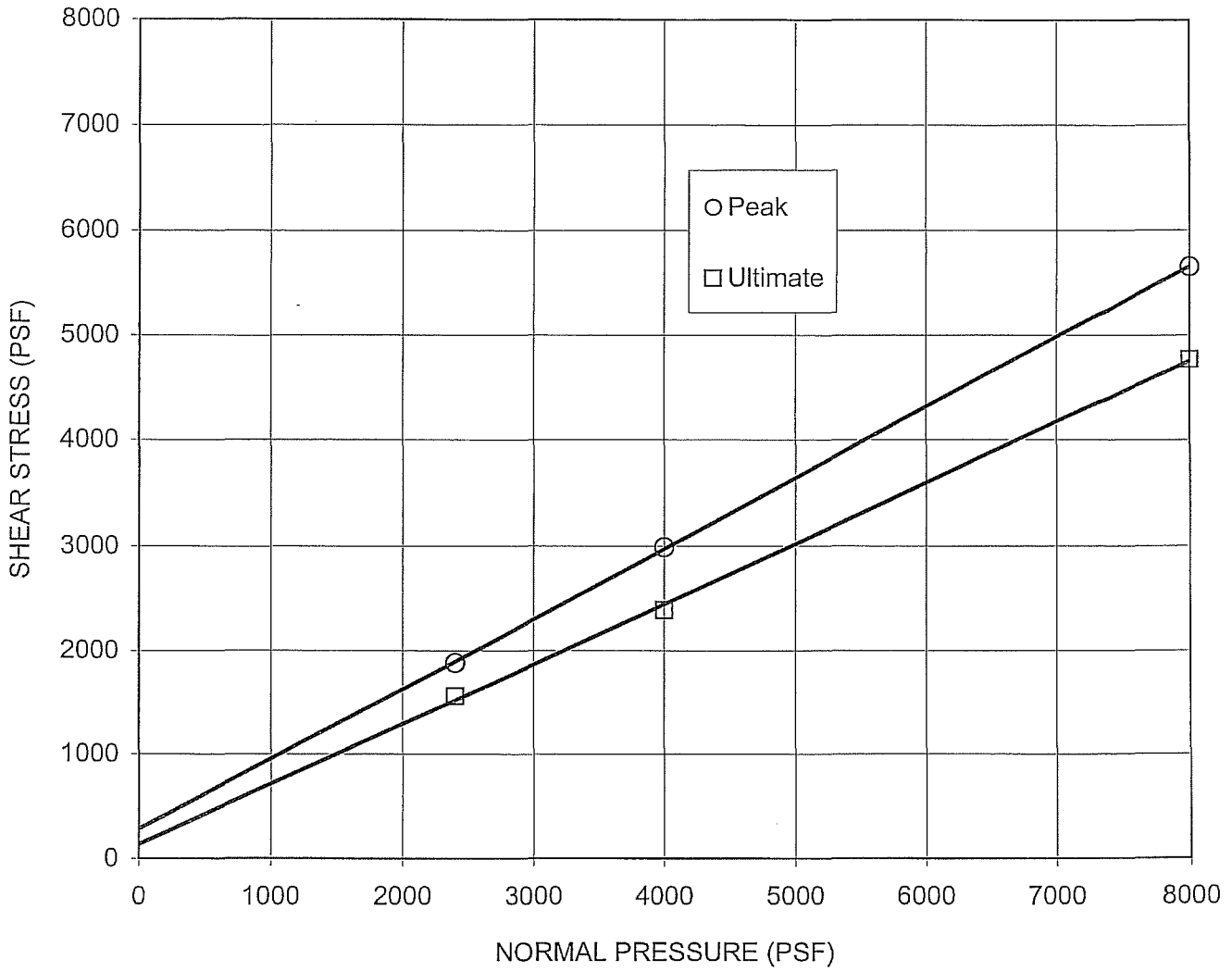
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008A

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/22/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-033	U-04	20	2.697
R-09-033	U-09	45	2.746



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-033	D-07	35	Ring	SP-SM	○	286	34
					□	138	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
2400	21.4	26.4
4000	21.4	25.8
8000	21.4	25.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

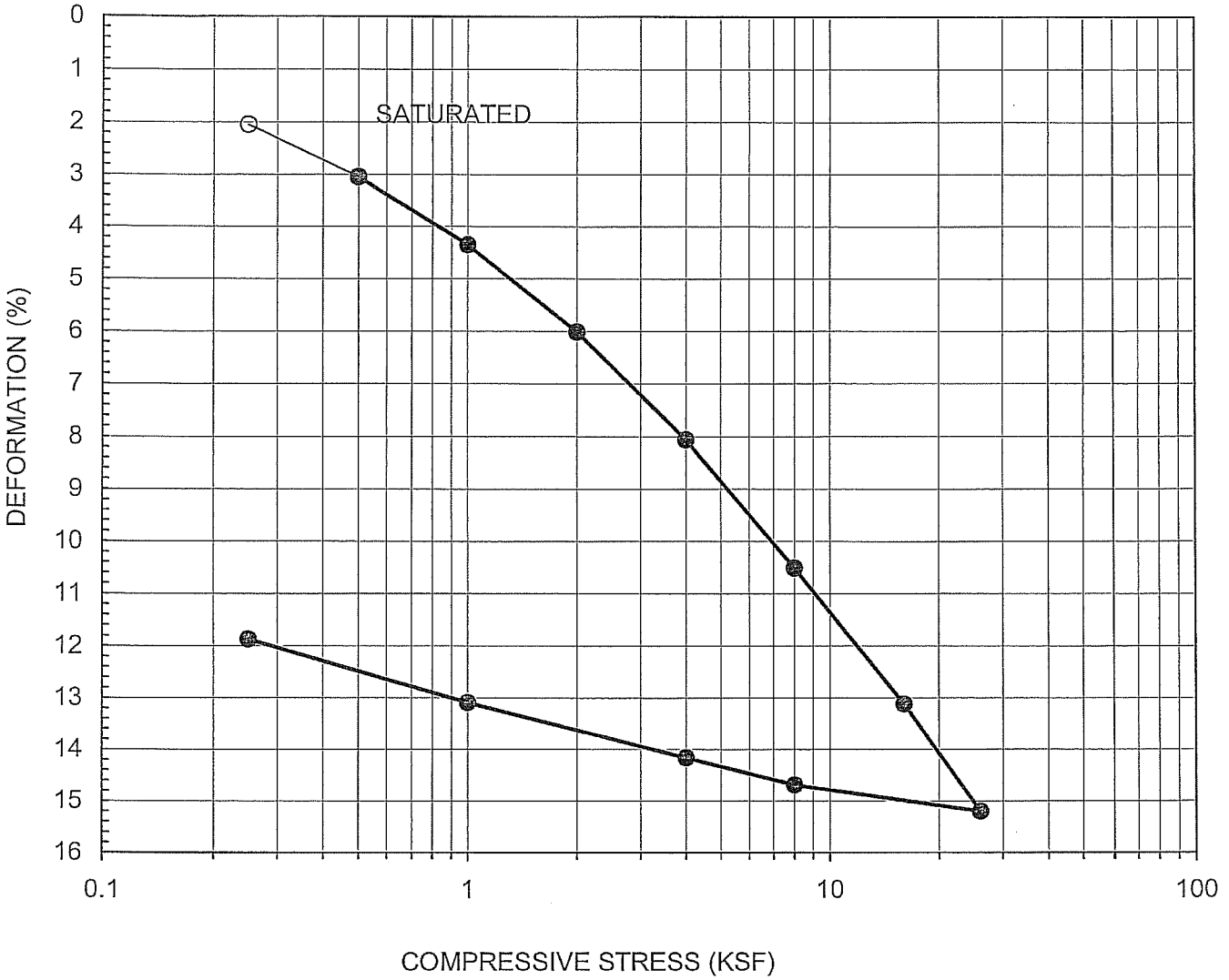
Client: Earth Mechanics, Inc.

Project No: 06-123-03

EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure



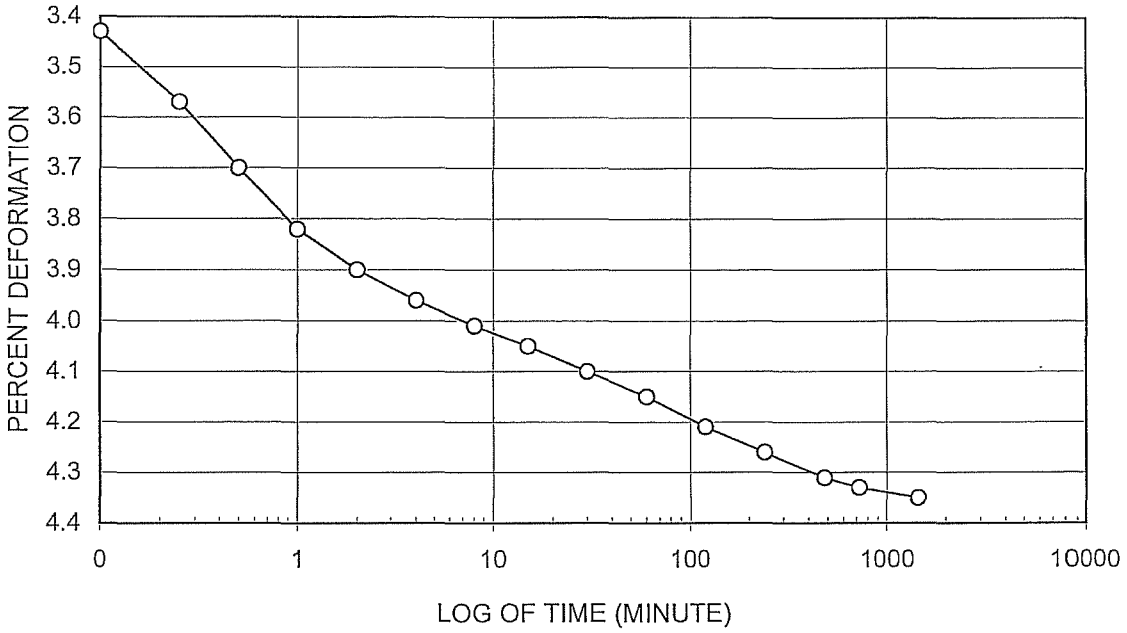
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-033	U-03	15.0	CL-ML	47.8	77.3	1.179

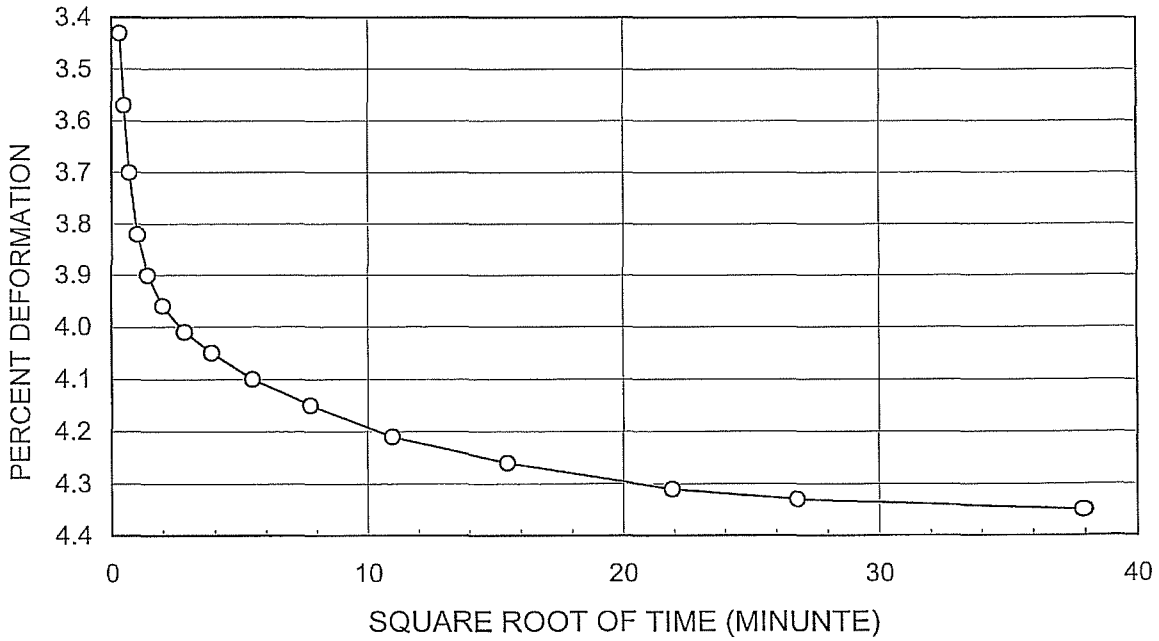
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





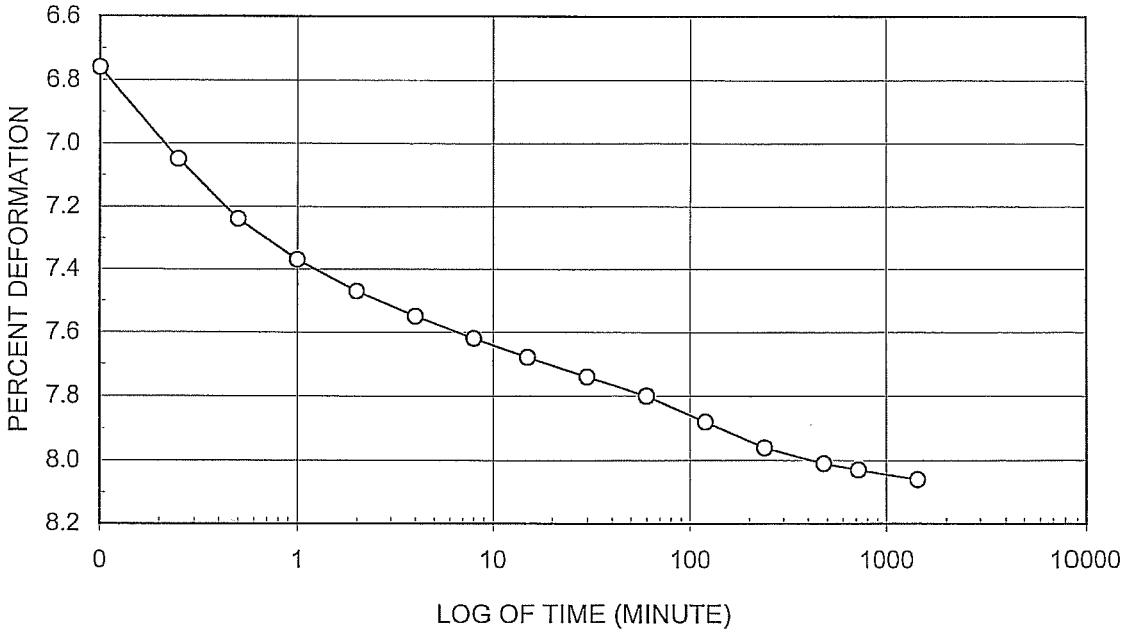
Boring No: R-09-033
Sample No: U-03
Depth (ft): 15
Soil Type: CL-ML
Normal Stress: 1.0 ksf

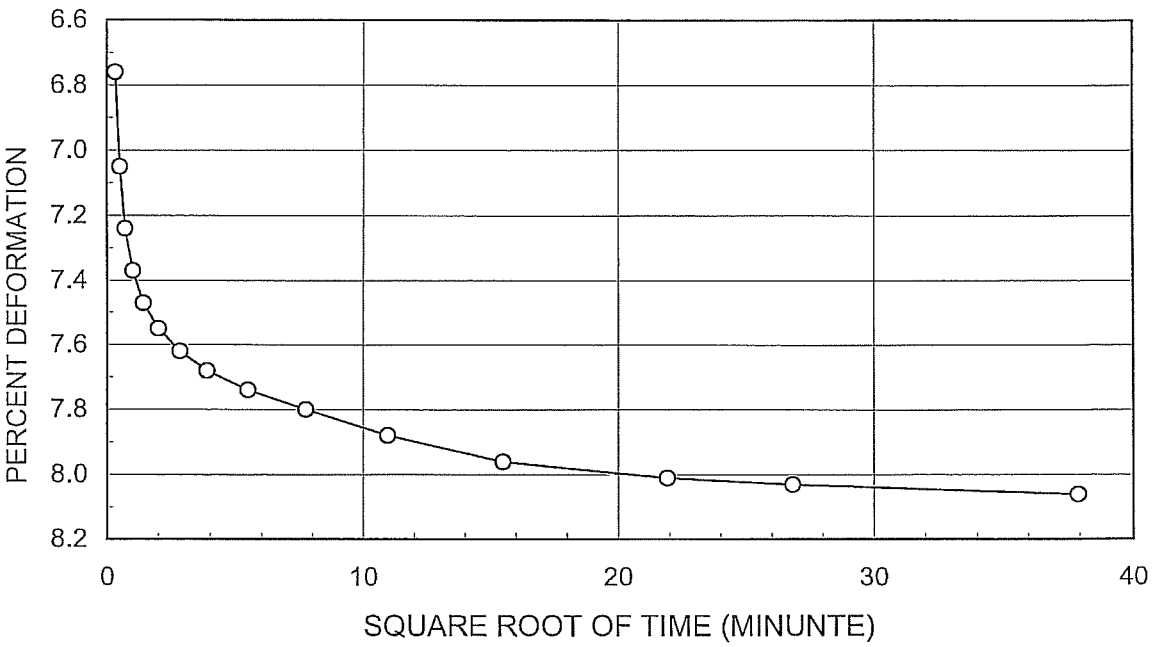
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





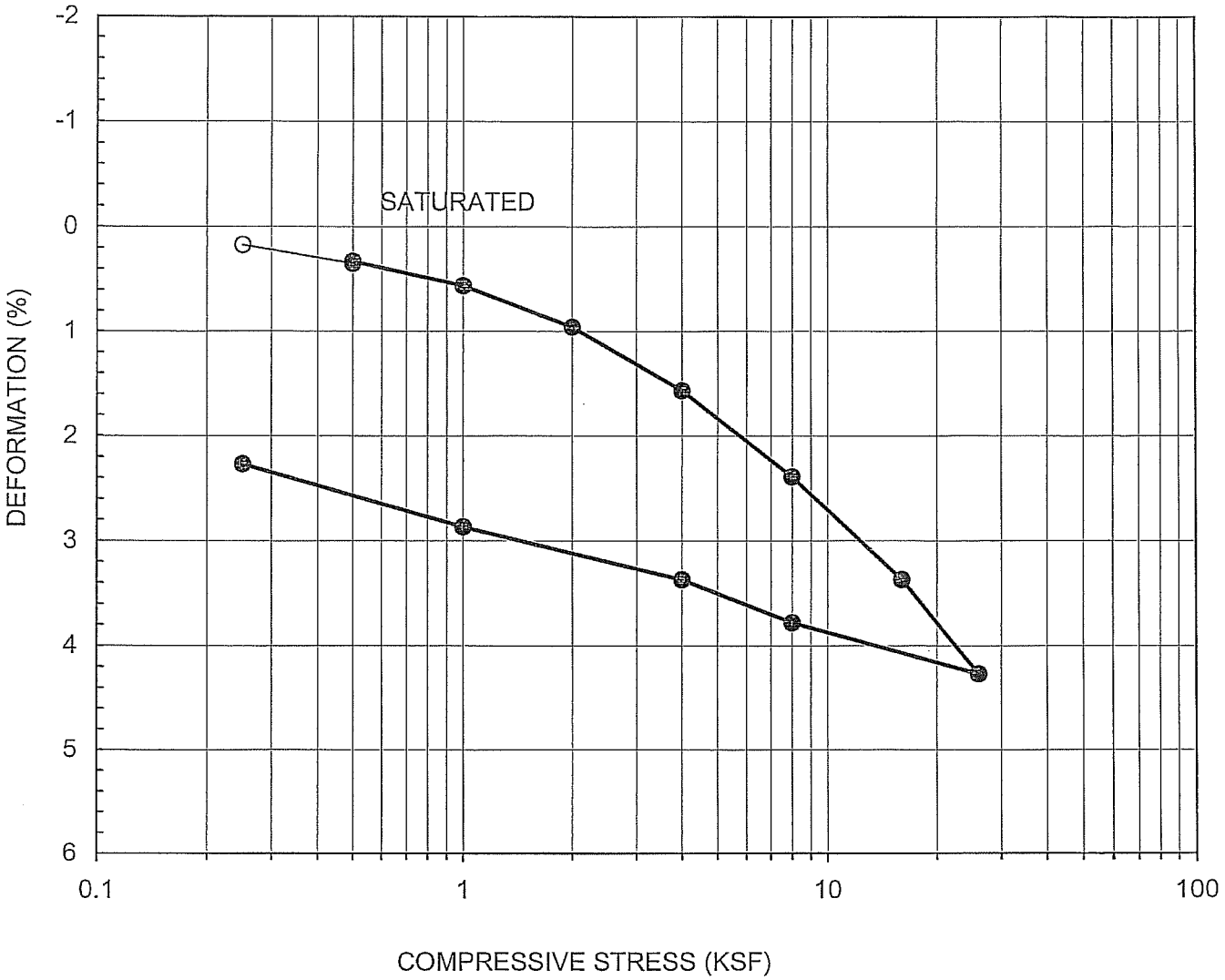
Boring No: R-09-033
Sample No: U-03
Depth (ft): 15
Soil Type: CL-ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



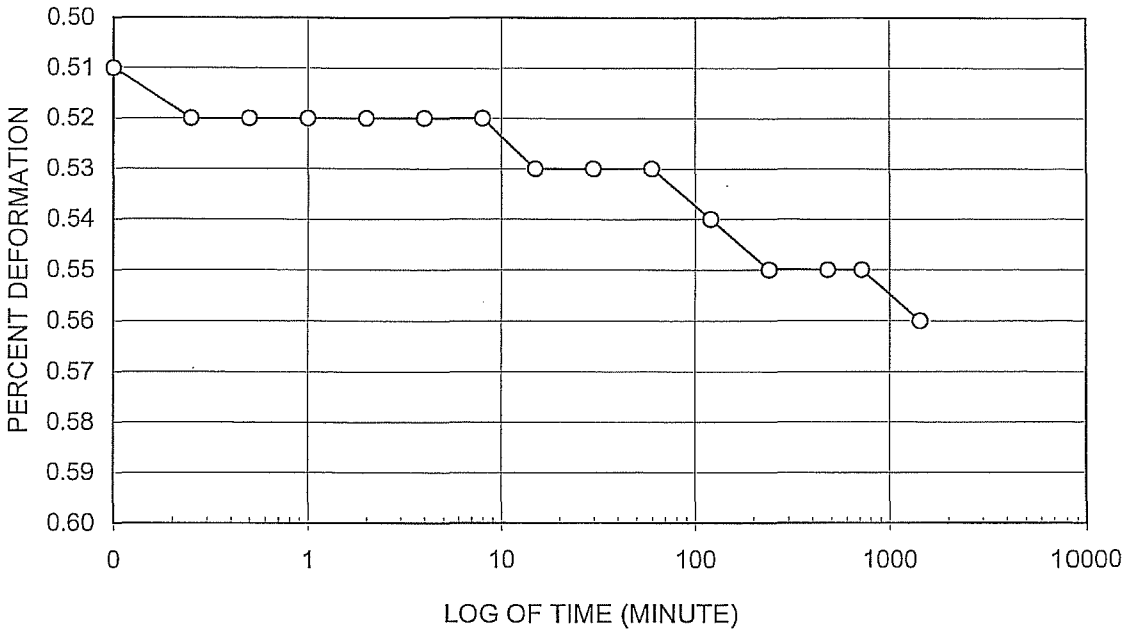
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
O	R-09-033	D-10-2	50.5	ML	27.1	95.7	0.761

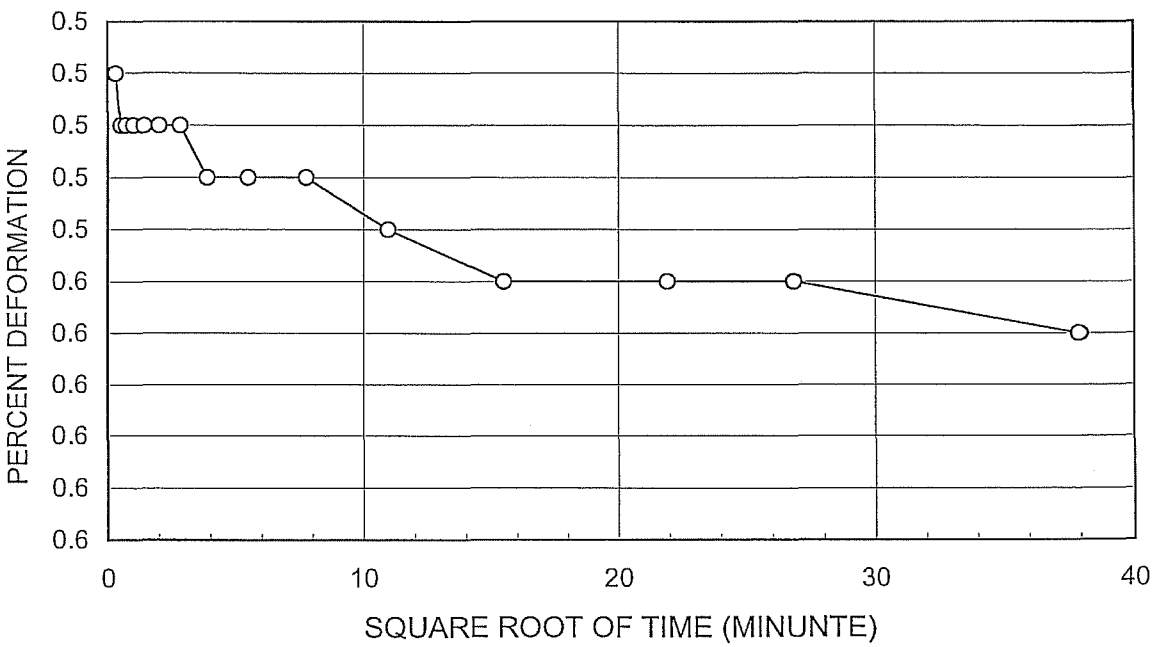
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008A

CONSOLIDATION

12/09 (ASTM D2435) Figure





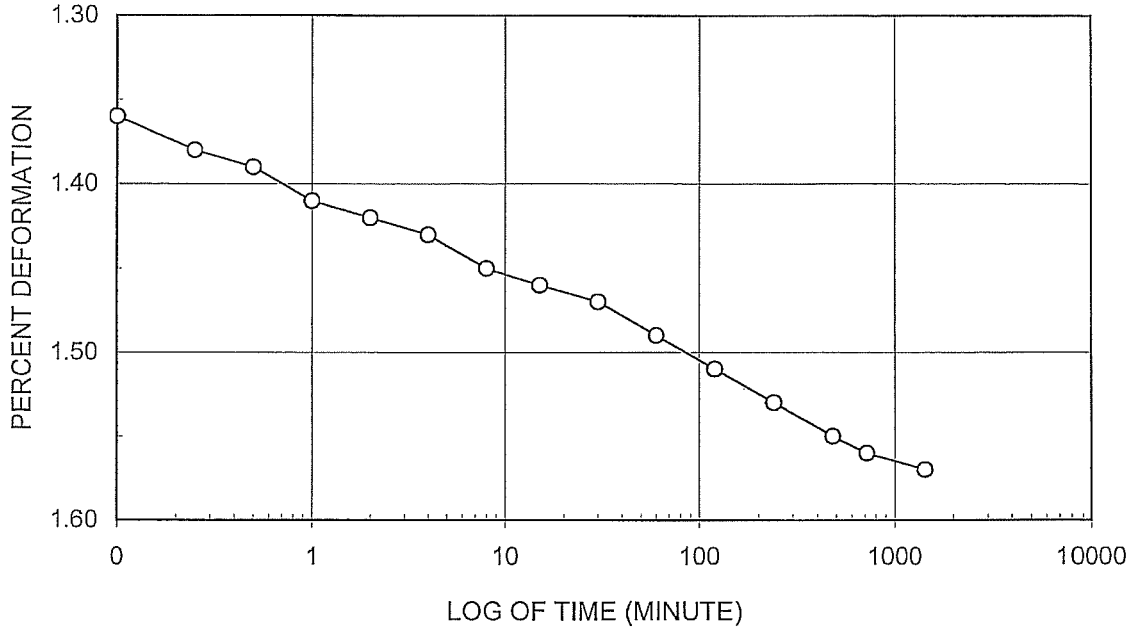
Boring No: R-09-033
Sample No: D-10-2
Depth (ft): 50.5
Soil Type: ML
Normal Stress: 1.0 ksf

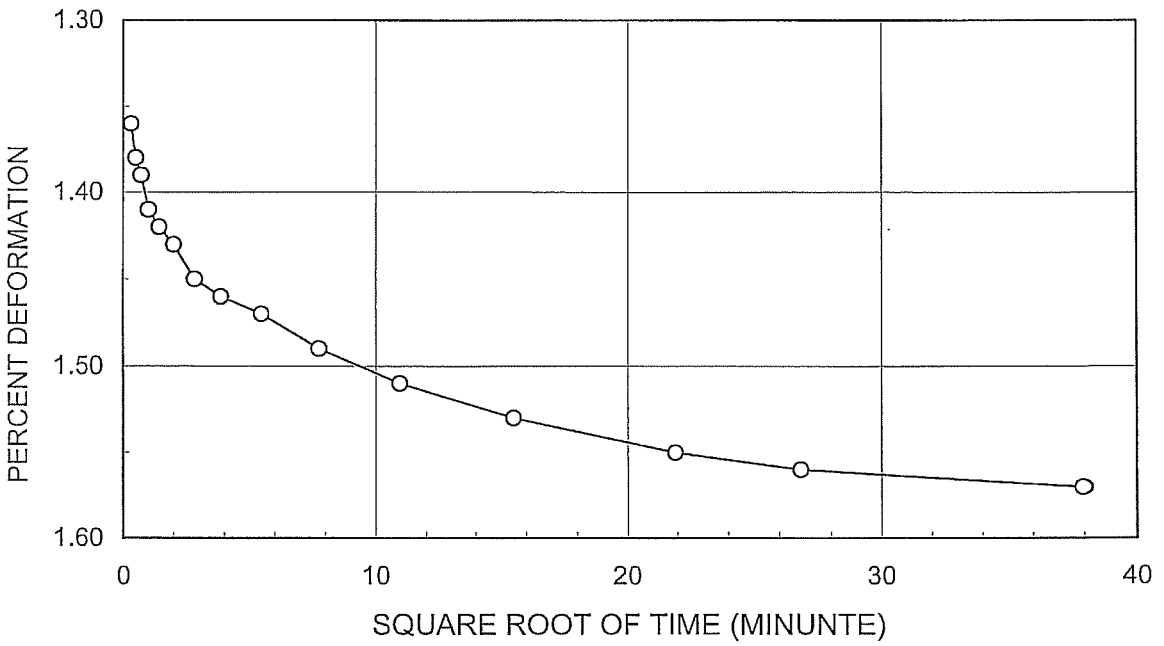
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





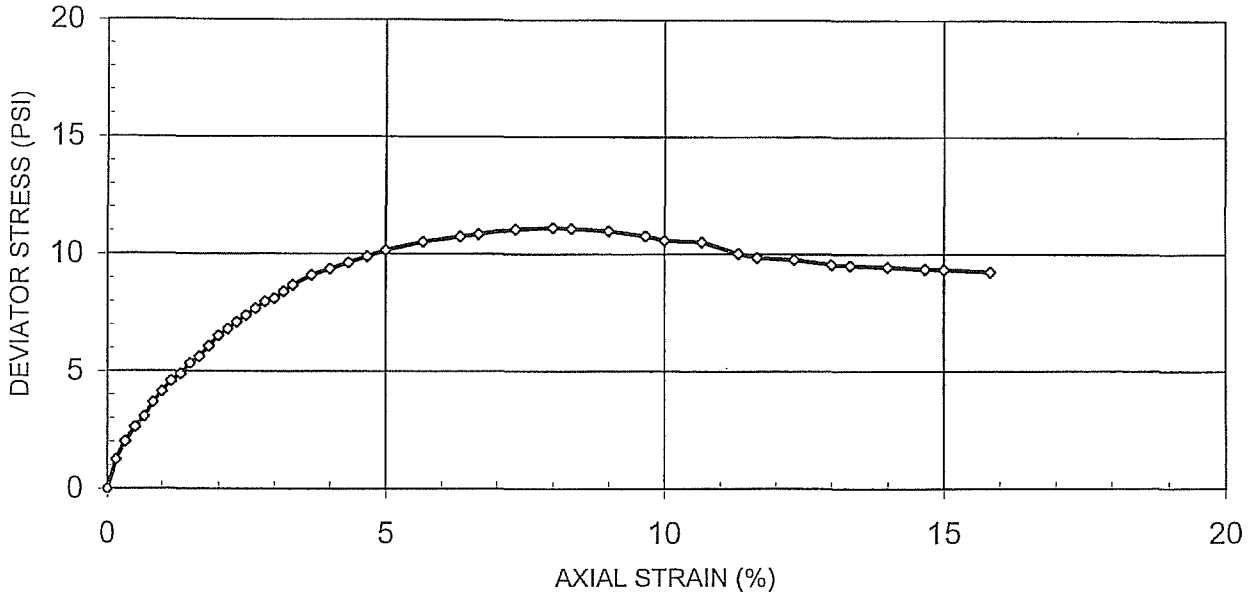
Boring No: R-09-033
Sample No: D-10-2
Depth (ft): 50.5
Soil Type: ML
Normal Stress: 4.0 ksf

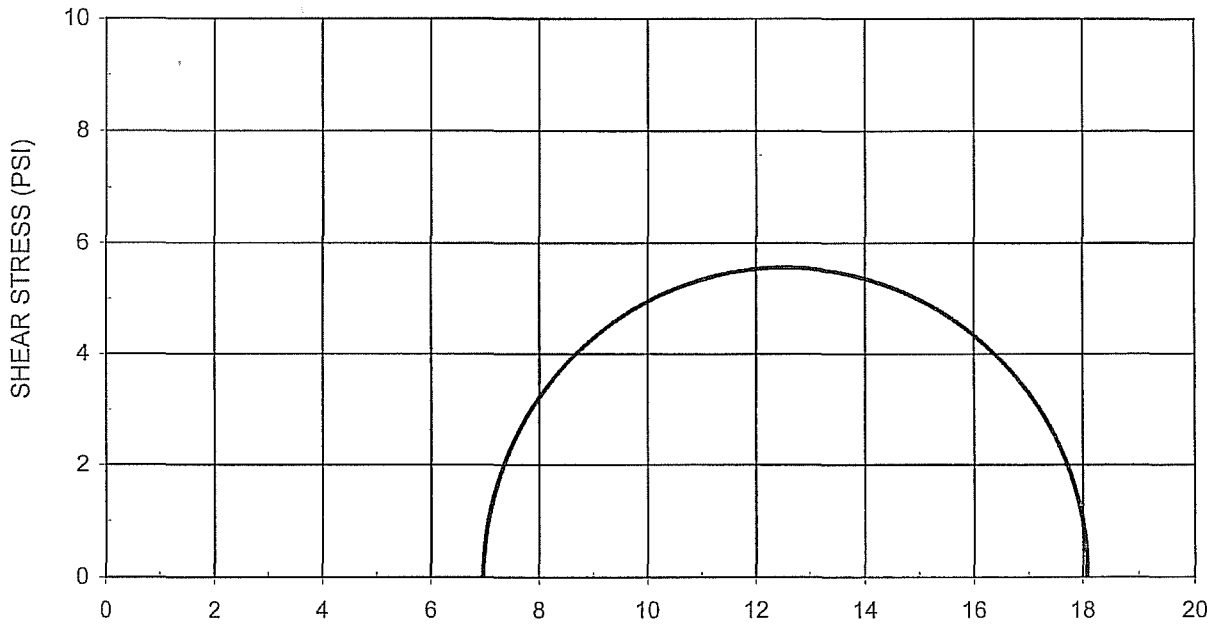
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008A

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-033	20	U-04	CH	Shelby Tube	59.44	64.1	7.0	11.1	0.06	98.4

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008A

UNCONSOLIDATED UNDRAINED

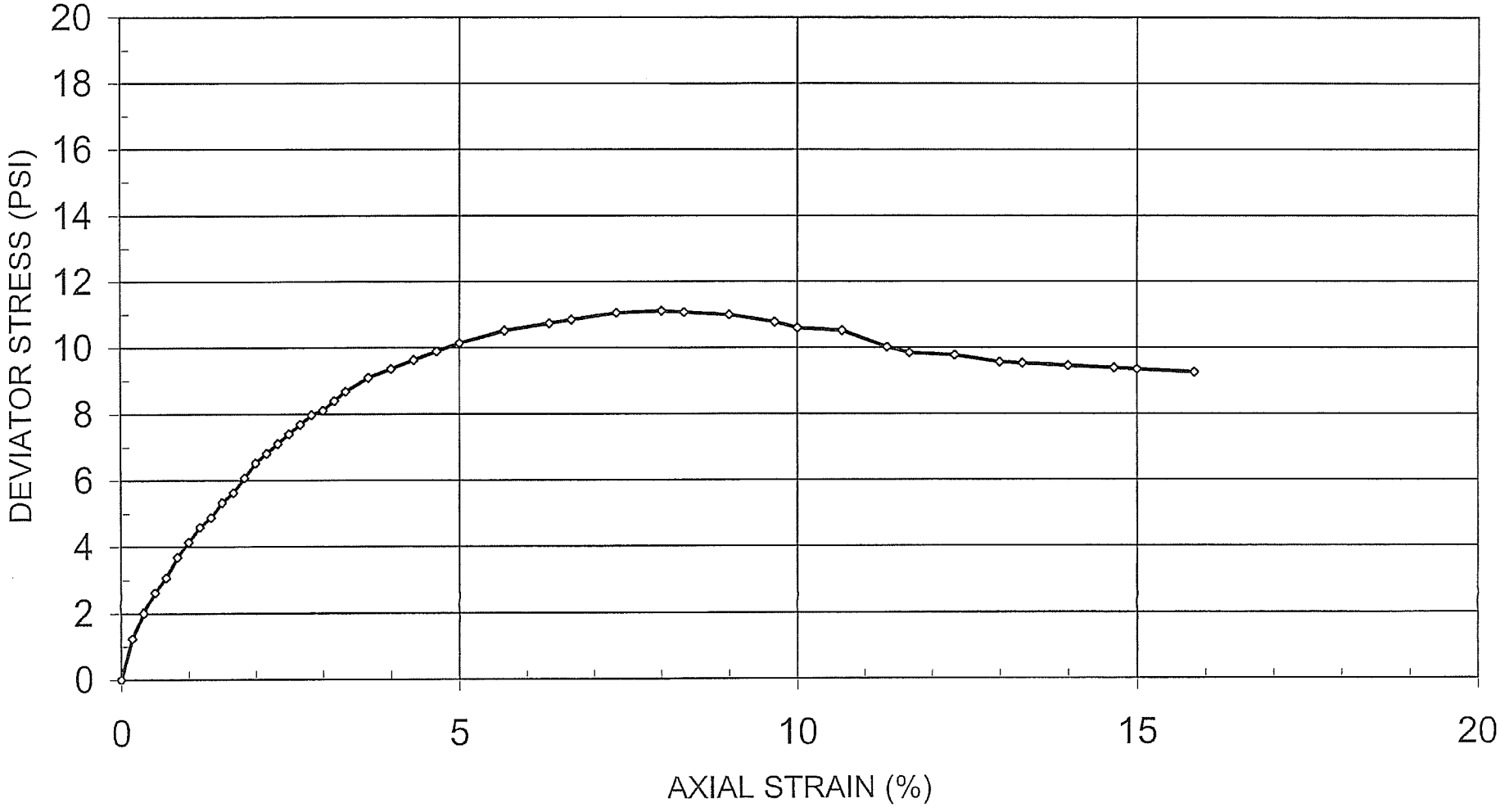
(ASTM D2850)

12/21/09

Figure

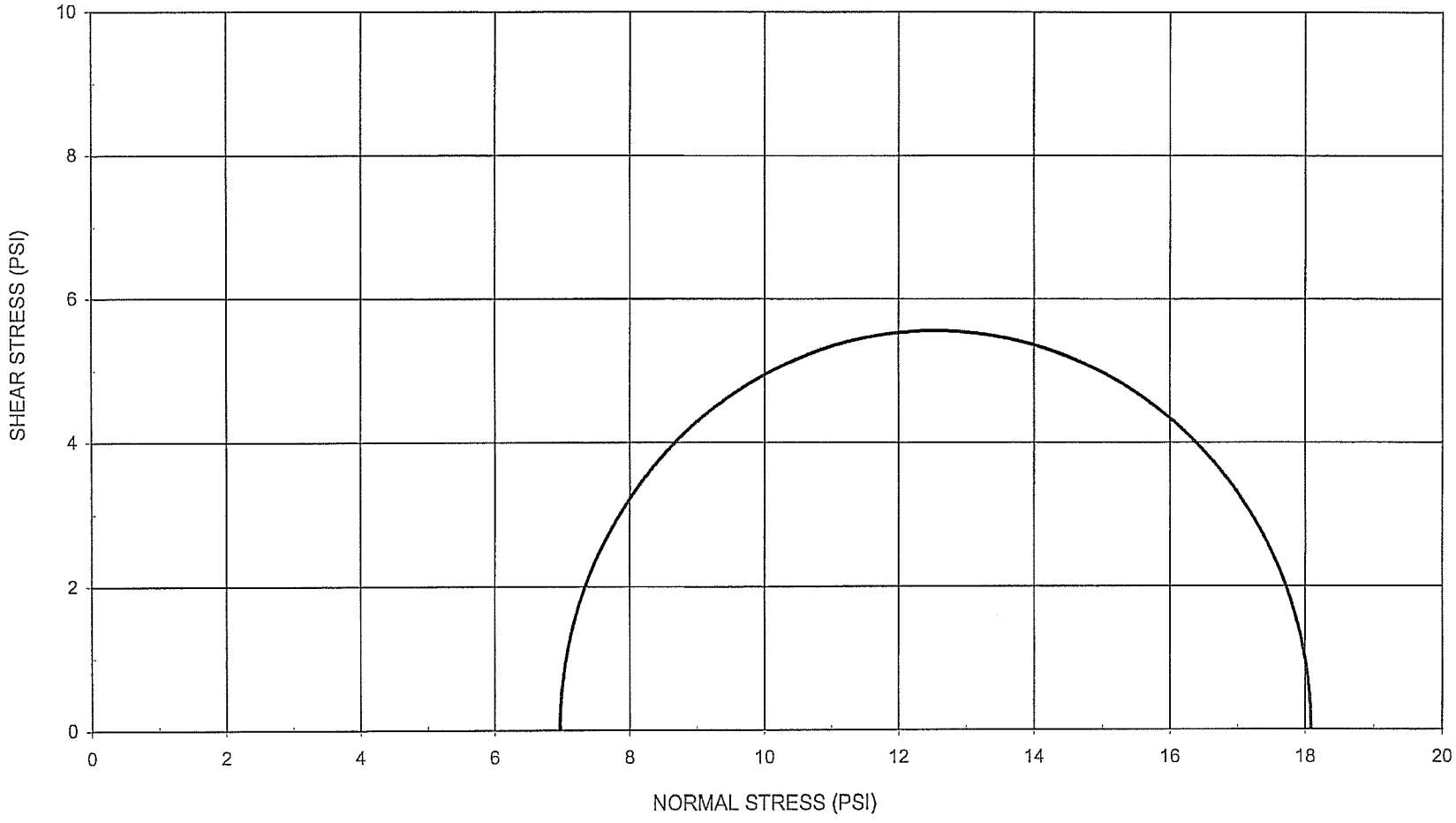
Project Name: ACTA Heim Bridge Replacement

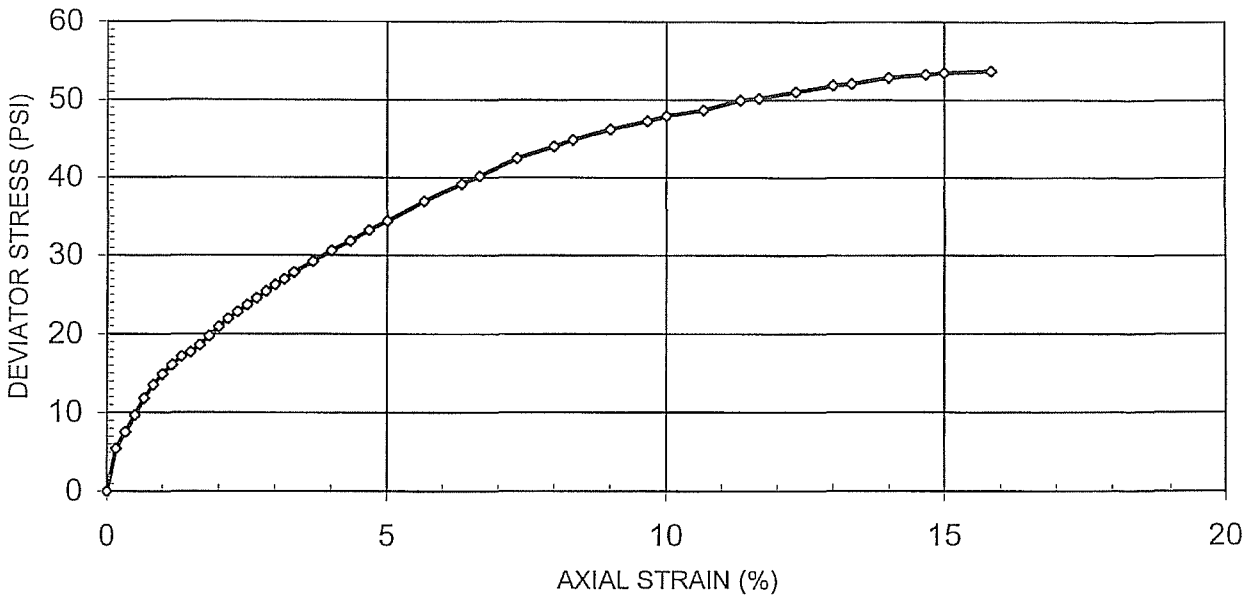
Boring: R-09-033 Sample ID: U-04 Depth (ft): 20

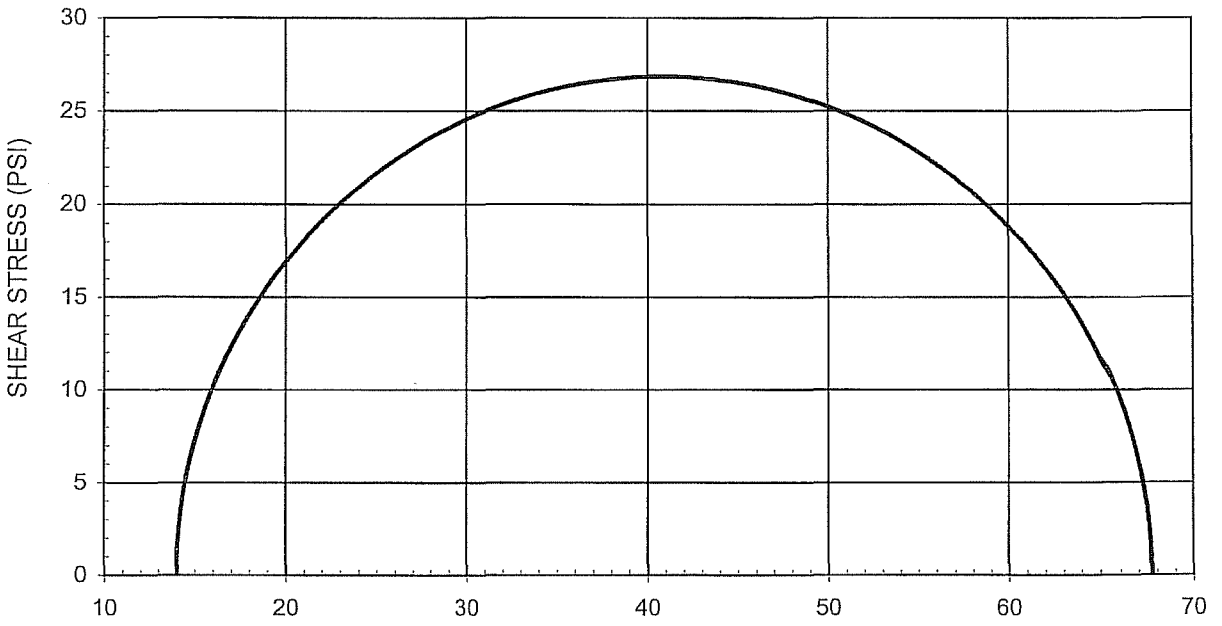


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-04 Depth (ft): 20







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-033	45	U-09	ML	Shelby Tube	30.47	92.2	14.0	53.7	0.06	99.3

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address: ACTA Heim Bridge Replacement

Client: Earth Mechanics, Inc.

Job No: 06-123-03

EGL Project No: 09-230-008A

UNCONSOLIDATED UNDRAINED

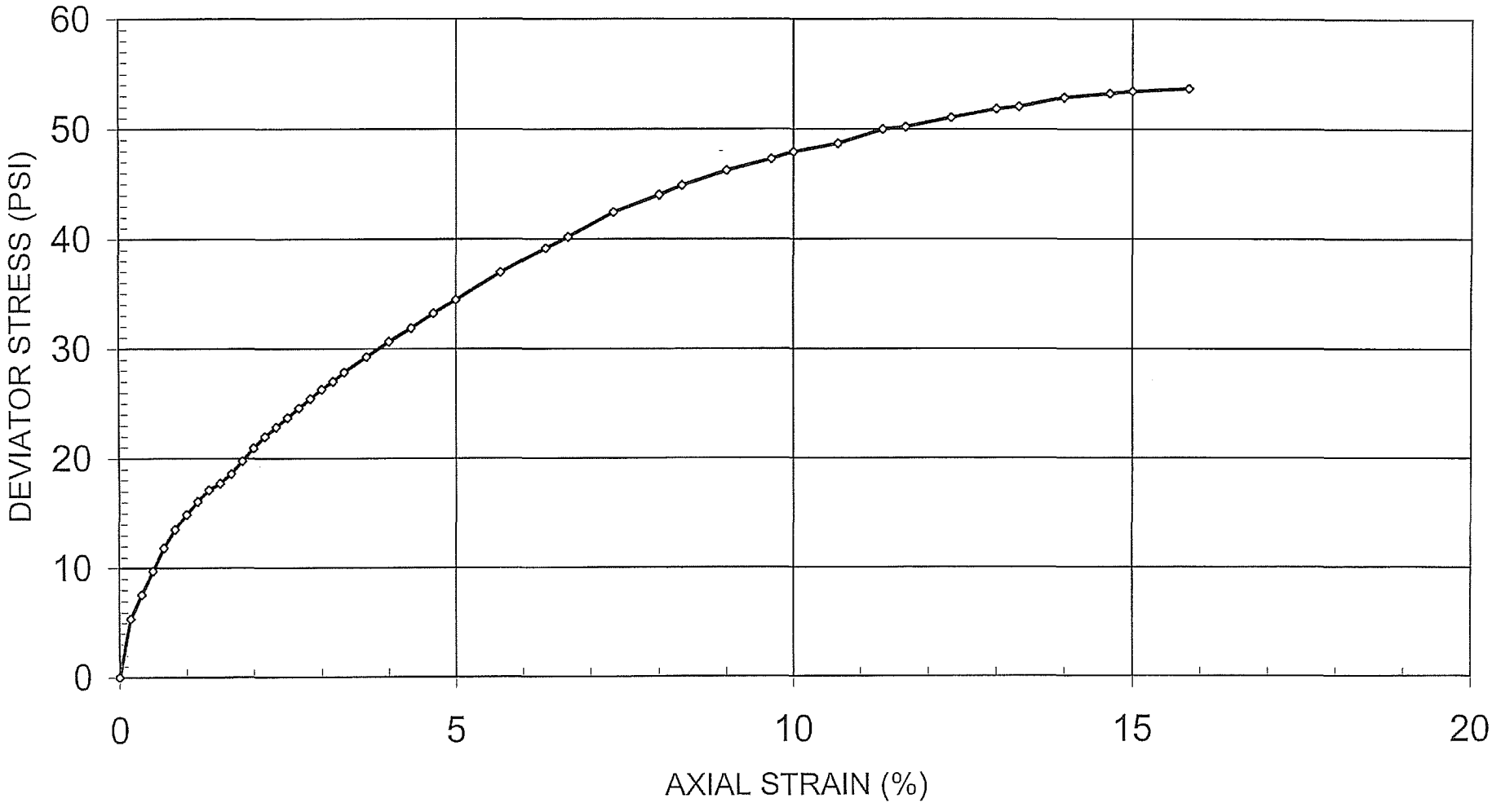
(ASTM D2850)

12/21/09

Figure

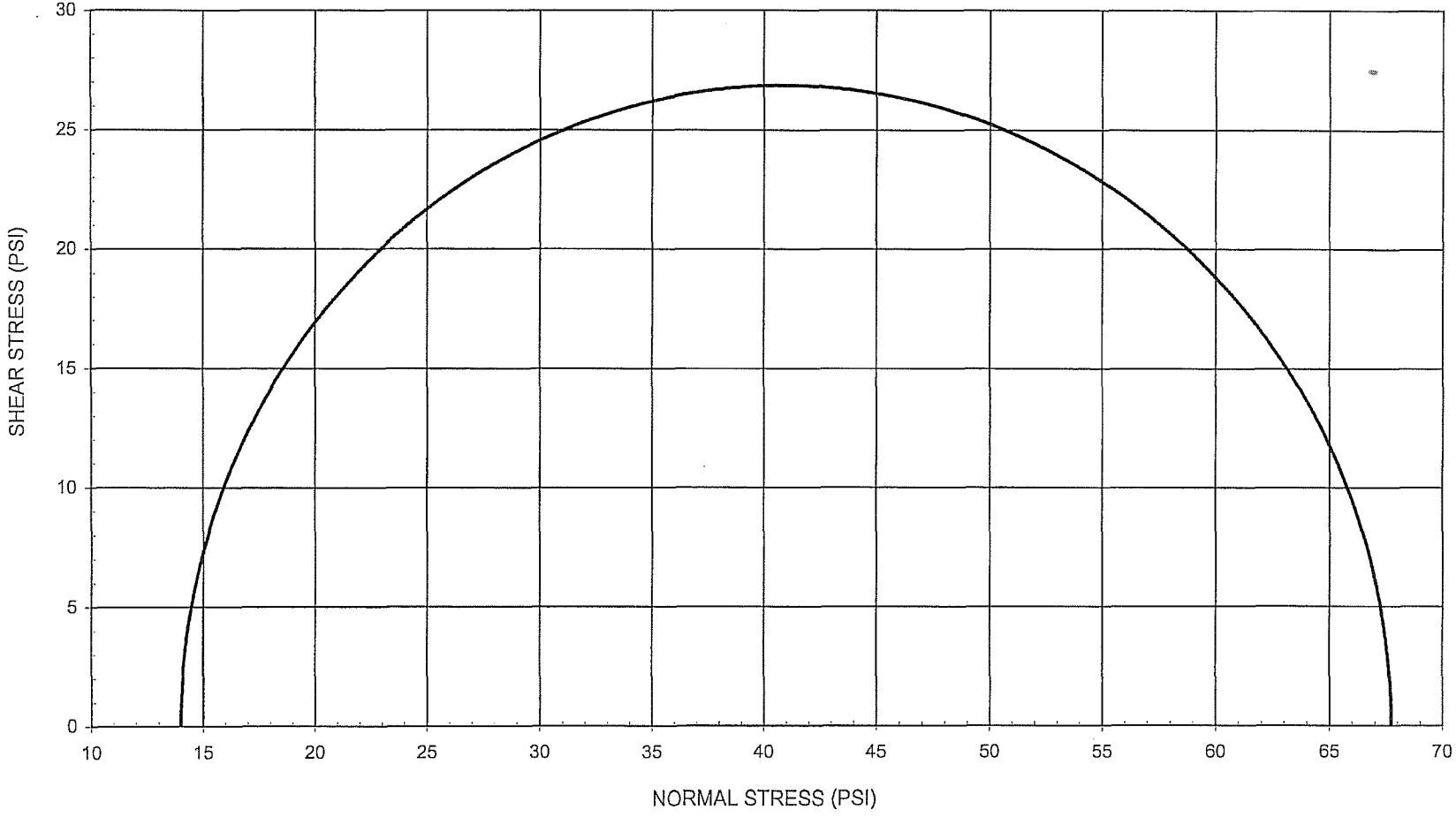
Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-09 Depth (ft): 45



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-033 Sample ID: U-09 Depth (ft): 45



AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-034	D-04	20	24.1	98.5
R-09-034	S-05	25	26.6	NA
R-09-034	S-07	35	33.5	NA
R-09-034	D-12	60	26.7	117.8
R-09-034	S-13	65	26.6	NA
R-09-034	D-16	80	21.1	98.3
R-09-034	S-18	100	34.9	NA
R-09-034	S-20	120	13.3	NA
R-09-034	S-22	150	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-034	D-02	10	0.31
R-09-034	U-03	16	1.38
R-09-034	D-12	60	2.96

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/17/09

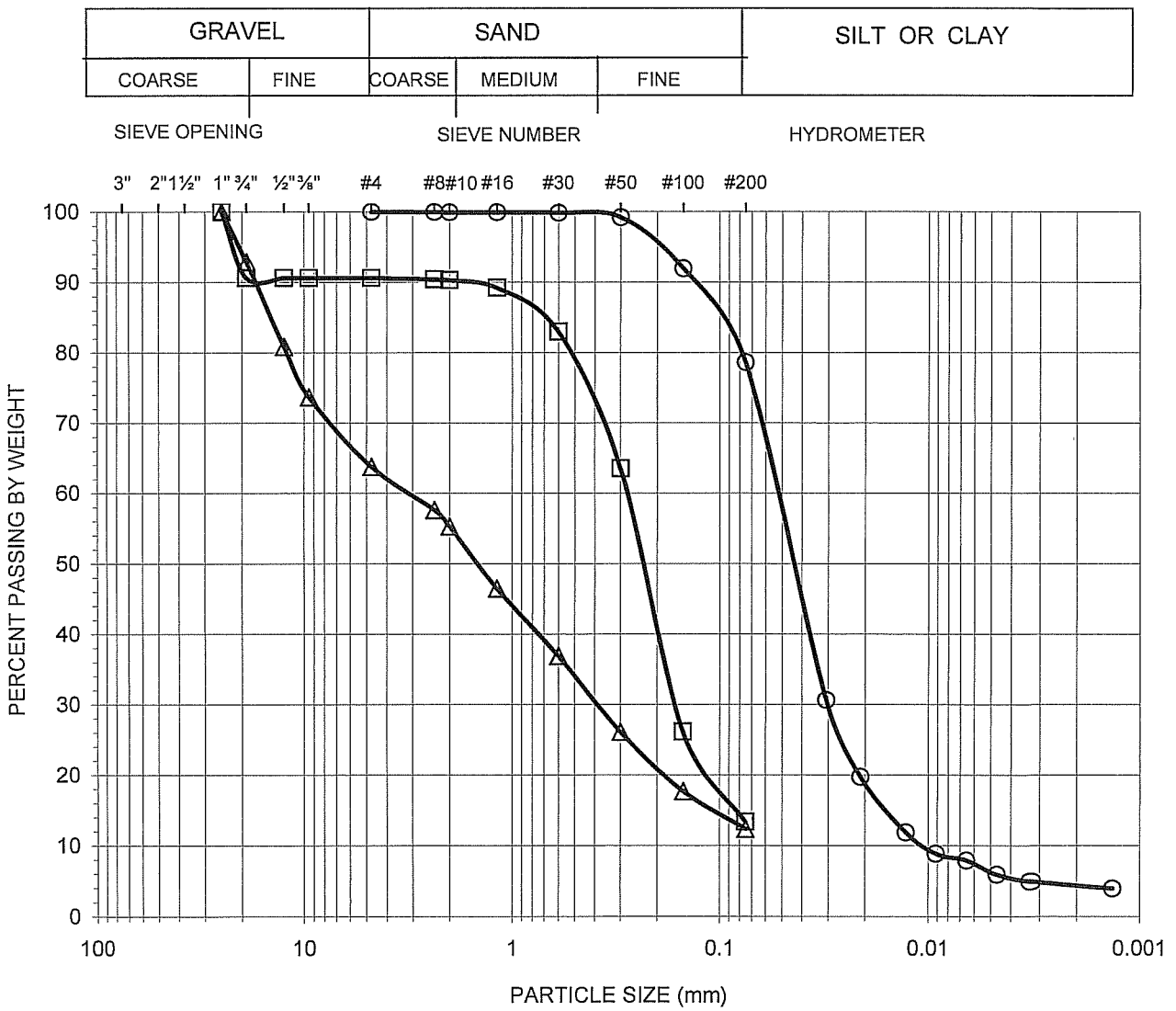
Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-034	S-05	25	45.21
R-09-034	D-06	30	5.96
R-09-034	S-07	35	41.20
R-09-034	D-10	50	42.15
R-09-034	D-12	60	58.30
R-09-034	S-15	75	13.73

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09

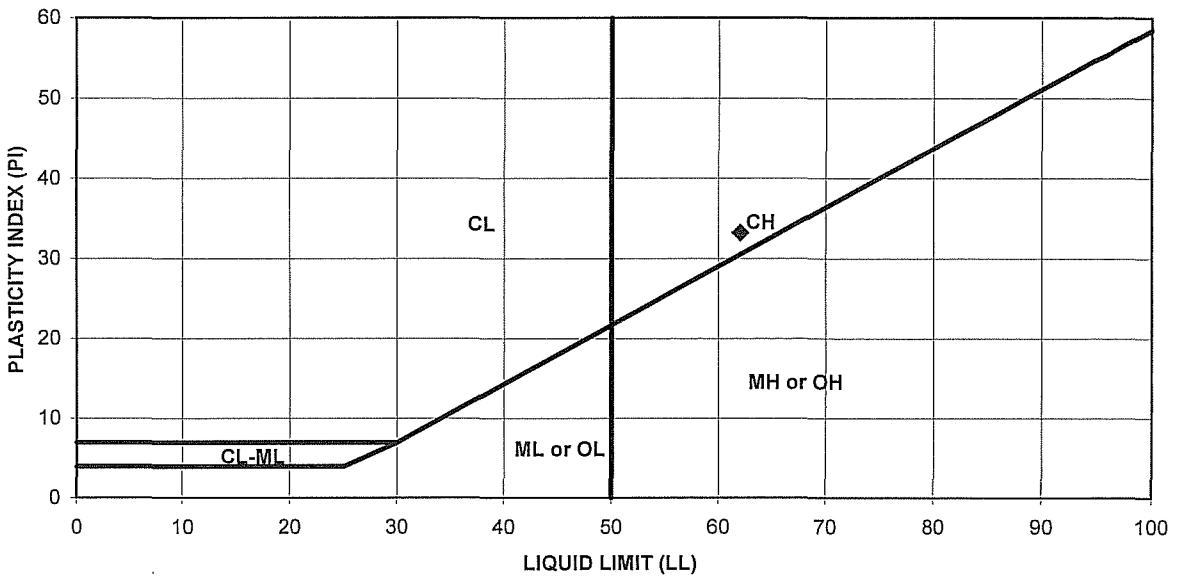


Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-034	U-03	16	0.00	21.36	78.64	N/P	ML
□	R-09-034	S-18	100	9.40	77.23	13.37	N/A	SM
△	R-09-034	S-22	150	36.20	51.38	12.42	N/A	SM

AP Engineering & Testing, Inc.

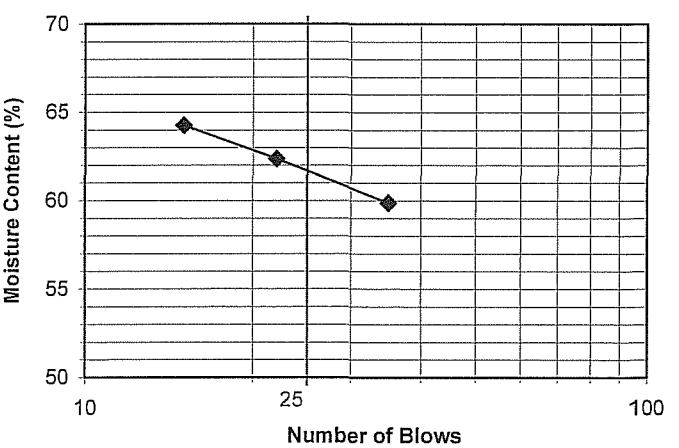
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



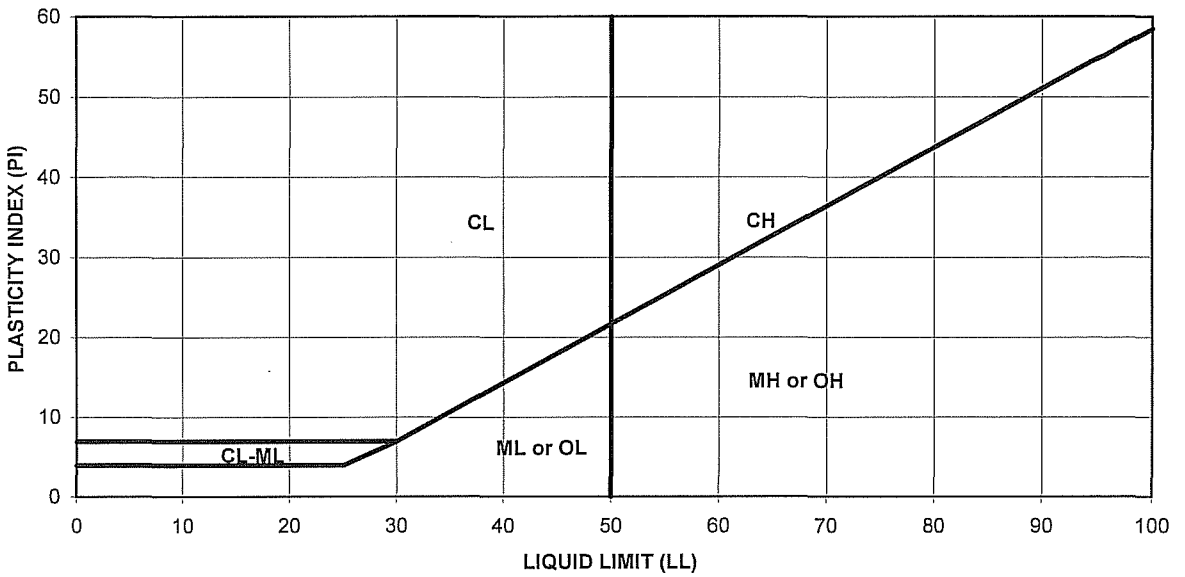
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-034	D-02	10	62	29	33	CH
	R-09-034	U-03	16	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

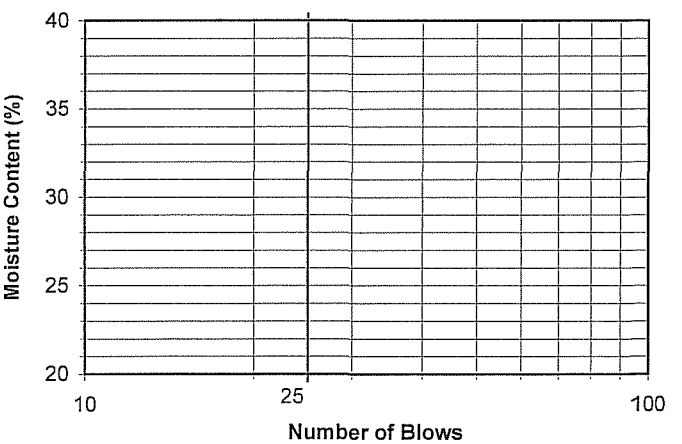
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



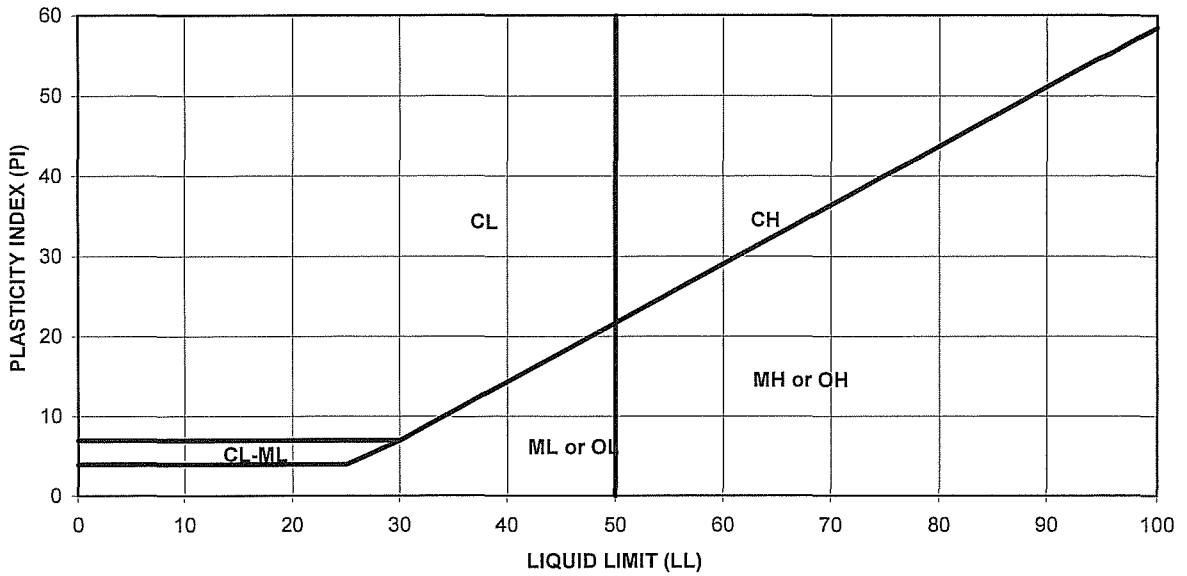
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-034	S-07	35	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

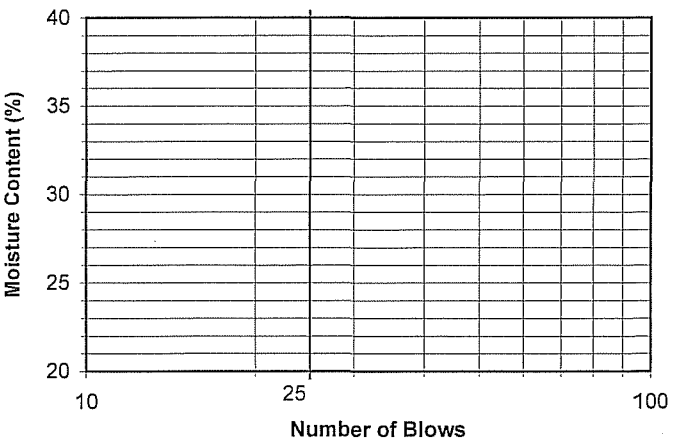
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: WJO Date: 01/06/10
Project No.: 06-123-03 Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
	R-09-034	D-12	60	NP	NP	NP	

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/25/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-034					
SAMPLE NUMBER	U-03					
DEPTH (FT)	16					
SOIL CLASSIFICATION	Silt with sand					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	388.13					
TEMPERATURE, °C	20.0					
CORRECTION FACTOR	1.0000					
WT. DRY SOIL, g	41.27					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.72**					

2607 Pomona Boulevard. Pomona, California 91768
Tel. (909) 869-6316, Fax (909) 869-6318

AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/16/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-034	D-02	10	CH	470	7.7	107	1281
R-09-034	S-07	35	SM	620	7.7	915	6316

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

2607 Pomona Boulevard, Pomona, CA 91768
Tel. (909) 869-6316 Fax. (909)869-6318

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/19/09

Boring No.: R-09-034 Checked By: AP Date: 12/01/09

Sample No.: D-06 Depth (ft): 30

Description: Gray Poorly-Graded Sand w/silt

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	586.70
Total Ring Weight (g)	139.93
Wet Density (pcf)	123.85
Dry Density (pcf)	99.64

Moisture Determination	Before Test	After Test
Cont. Weight (g)	179.16	104.26
Wet Soil+Cont. (g)	346.93	532.23
Dry Soil+Cont. (g)	314.13	439.98
Moisture Content (%)	24.3	27.5
Degree Saturation	94.8	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

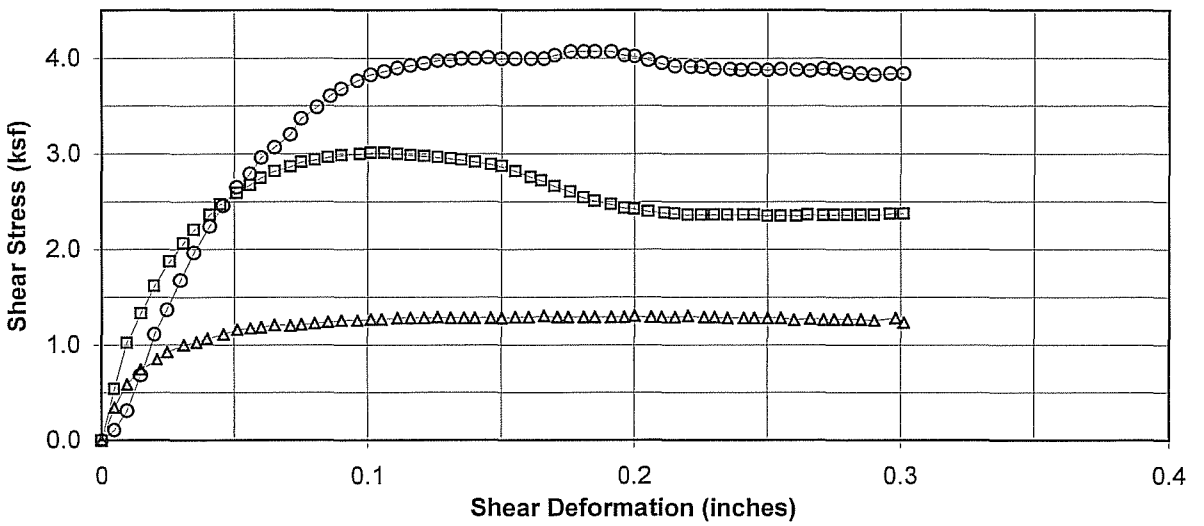
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

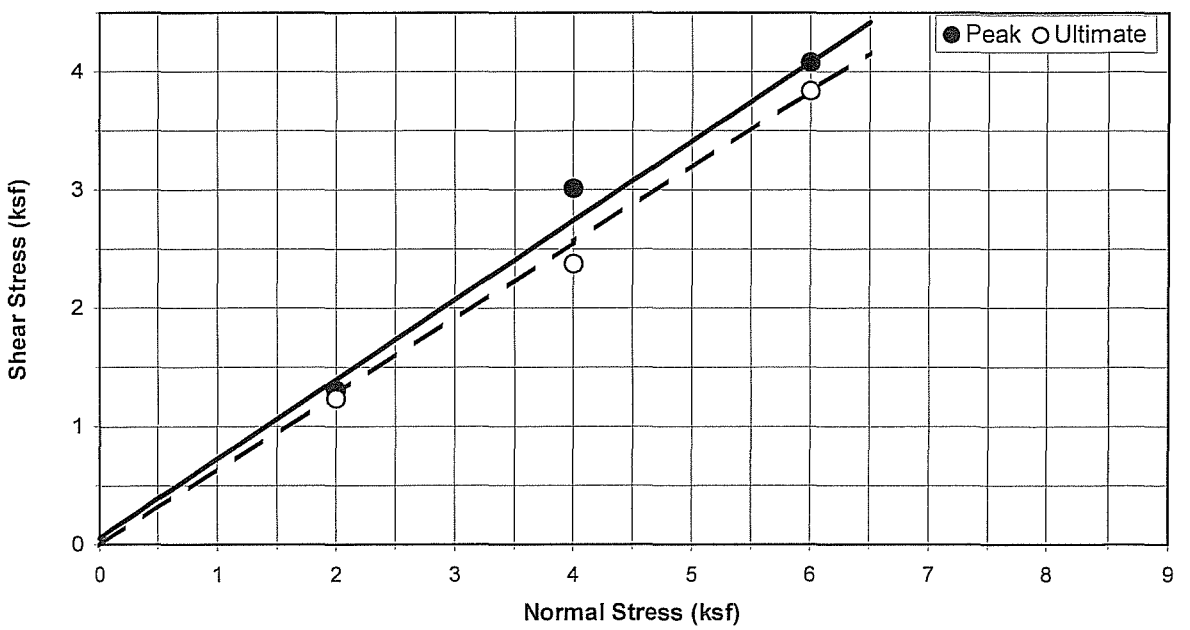
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**196.74**	**47.59**	**2.0**	**1308**	**1236**	
2	**194.81**	**46.29**	**4.0**	**3012**	**2376**	
3	**195.15**	**46.05**	**6.0**	**4080**	**3840**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	99.6	pcf
Boring No.:	R-09-034	Moisture Content (before):	24.3	%
Sample No.:	D-06	Moisture Content (after):	27.5	%
Depth (ft):	30			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Poorly-Graded Sand w/silt			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	50	0
Friction Angle:	34 °	33 °

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST DATA
ASTM D 3080

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/19/09

Boring No.: R-09-034 Checked By: AP Date: 12/01/09

Sample No.: D-08 Depth (ft): 40

Description: Gray Silty Sand

Sample Type: Cal. Mod.

Test Condition: Saturated

Sample Diameter (in)	2.415
Sample Height (in)	1.00
Total Soil+Ring Weight(g)	576.23
Total Ring Weight (g)	133.93
Wet Density (pcf)	122.61
Dry Density (pcf)	94.17

Moisture Determination	Before Test	After Test
Cont. Weight (g)	50.44	104.78
Wet Soil+Cont. (g)	201.97	530.31
Dry Soil+Cont. (g)	166.82	431.86
Moisture Content (%)	30.2	30.1
Degree Saturation	98.8	100.6

METHOD OF SHEARING

[X] Regular Shearing Shear Rate (in/min): **0.005**

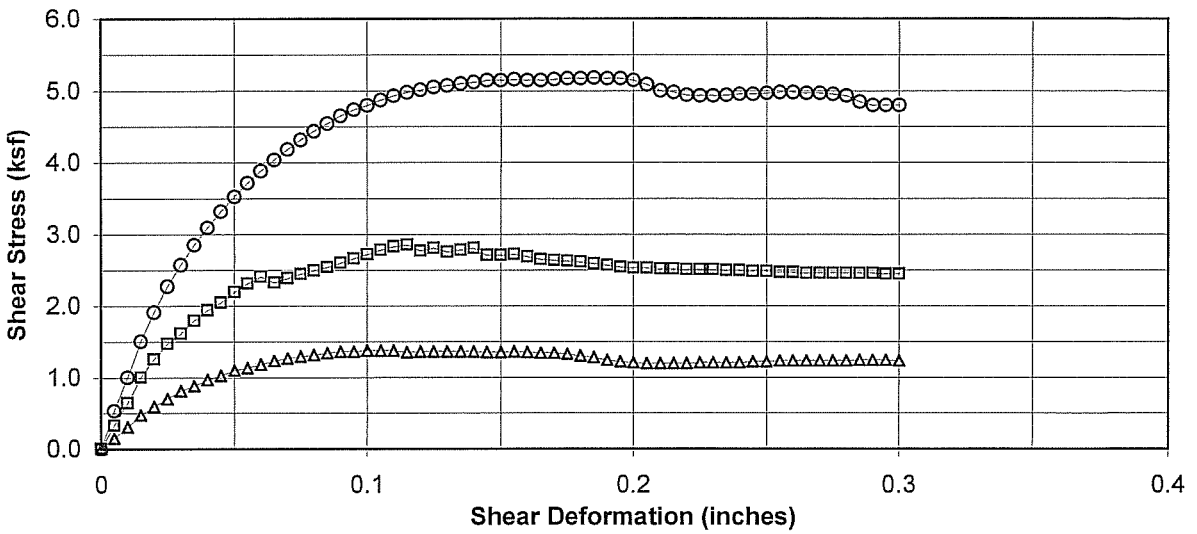
[ ] Residual Shearing 5 Passes Shear Distance (in): **0.3**

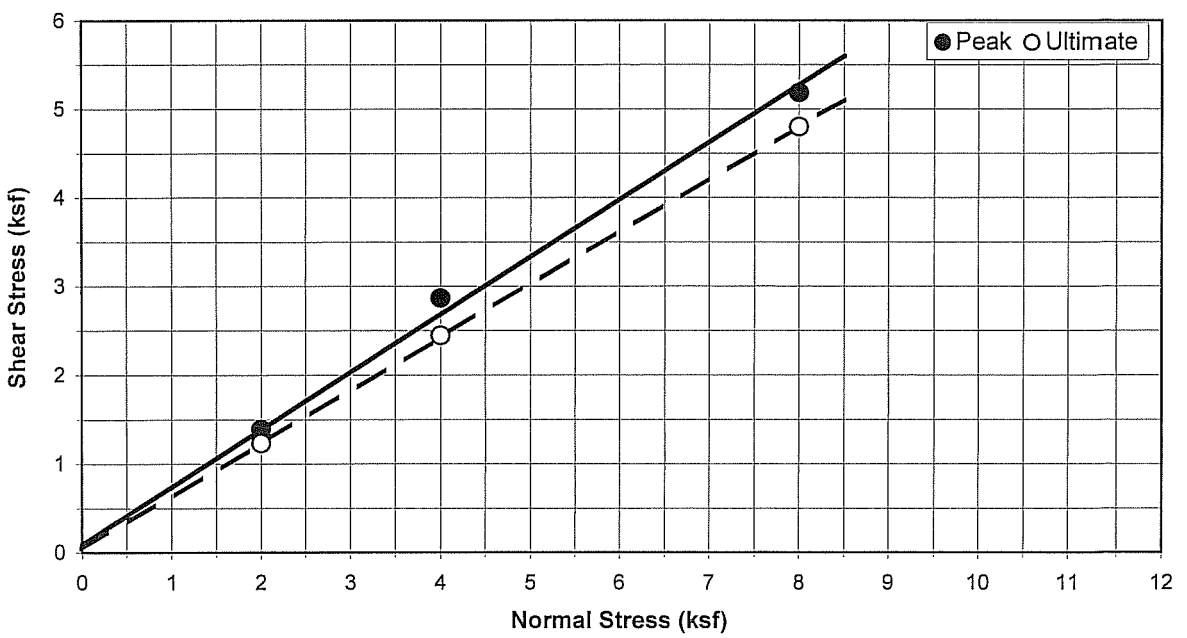
Sample Number	Sample + Ring Wt.	Ring Wt.	Normal Load (ksf)	Max. Shear Reading (psf)	Ultimate Shear Reading (psf)	Remarks
1	**192.96**	**43.62**	**2.0**	**1392**	**1236**	
2	**193.96**	**46.65**	**4.0**	**2868**	**2448**	
3	**189.31**	**43.66**	**8.0**	**5184**	**4800**	

AP Engineering & Testing, Inc.

DIRECT SHEAR TEST RESULTS
ASTM D 3080

Project Name:	ACTA Heim Bridge Replacement	Initial Dry Density:	94.2	pcf
Boring No.:	R-09-034	Moisture Content (before):	30.2	%
Sample No.:	D-08	Moisture Content (after):	30.1	%
Depth (ft):	40			
Sample Type:	Cal. Mod.			
Soil Description:	Gray Silty Sand			
Test Condition:	Saturated			





Strength Parameters	Peak	Ultimate
Cohesion (psf):	100	50
Friction Angle:	33 °	31 °

AP Engineering & Testing, Inc.

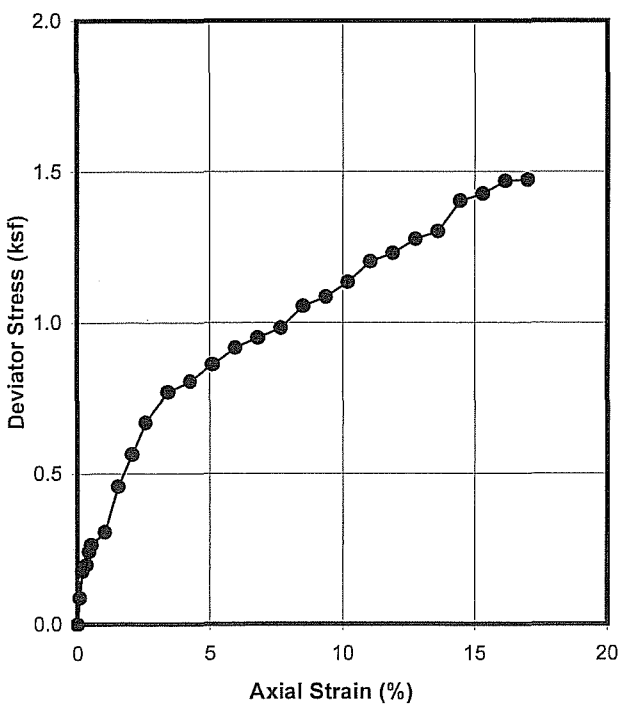
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.		Tested By:	KK	Date: 11/17/09
Project Name:	ACTA Heim Bridge Replacement		Checked by:	AP	Date: 12/02/09
Project No.:	06-123-03				
Boring No.:	R-09-034				
Sample No.:	U-03	Depth (feet): 16			
Soil Description	Gray Silt with sand		Sample Type:	Shelby	

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	117.9
Sample Hieght (inch):	5.9	Dry Unit Weight (pcf):	87.7
Sample Weight (gms):	1182.02	Moisture Content (%):	34.4
Wt. Wet Soil+Container(gms)	1373.35	Void Ratio for Gs=2.7:	0.92
Wt. Dry Soil+Container(gms)	1071.47	% Saturation:	100.9
Wt. Container (gms)	194.37		

TEST DATA

Cell Pressure (ksf):	0.72
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	0.72
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.5
Ultimate Deviator Stress (ksf):	1.4
Ultimate Undrained Shear Strength (ksf):	0.7
Axial Strain @ Maximum Stress (%)	17.01



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
4	0.005	6.50	0.09	0.09
8	0.010	6.50	0.18	0.17
9	0.020	6.51	0.20	0.34
11	0.025	6.52	0.24	0.43
12	0.030	6.53	0.26	0.51
14	0.060	6.56	0.31	1.02
21	0.090	6.59	0.46	1.53
26	0.120	6.63	0.56	2.04
31	0.150	6.66	0.67	2.55
36	0.200	6.72	0.77	3.40
38	0.250	6.78	0.81	4.25
41	0.300	6.84	0.86	5.10
44	0.350	6.90	0.92	5.95
46	0.400	6.97	0.95	6.80
48	0.450	7.03	0.98	7.65
52	0.500	7.10	1.06	8.50
54	0.550	7.16	1.09	9.35
57	0.600	7.23	1.14	10.20
61	0.650	7.30	1.20	11.05
63	0.700	7.37	1.23	11.90
66	0.750	7.44	1.28	12.76
68	0.800	7.51	1.30	13.61
74	0.850	7.59	1.40	14.46
76	0.900	7.67	1.43	15.31
79	0.950	7.74	1.47	16.16
80	1.000	7.82	1.47	17.01

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-035	S-01	5.0	25.4		9.3	
R-09-035	D-02	10.0				38,29,10
R-09-035	U-03	15.0				28,23,5
R-09-035	D-04	20.0	43.1	80.0		
R-09-035	D-06	30.0	33.3	90.2		24,22,2
R-09-035	S-07	35.0			48.8	
R-09-035	D-08	40.0	31.1	92.7		
R-09-035	S-09	45.0	39.7			
R-09-035	U-10	50.0				NP
R-09-035	S-11	55.0	33.4		37.0	
R-09-035	D-12	60.0	21.9	105.4		
R-09-035	S-13	65.0			19.9	
R-09-035	D-14	70.0	27.0	98.7		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-035	D-02	10	7.88	465	0.051	610
R-09-035	S-09	45	8.65	2215	0.056	230

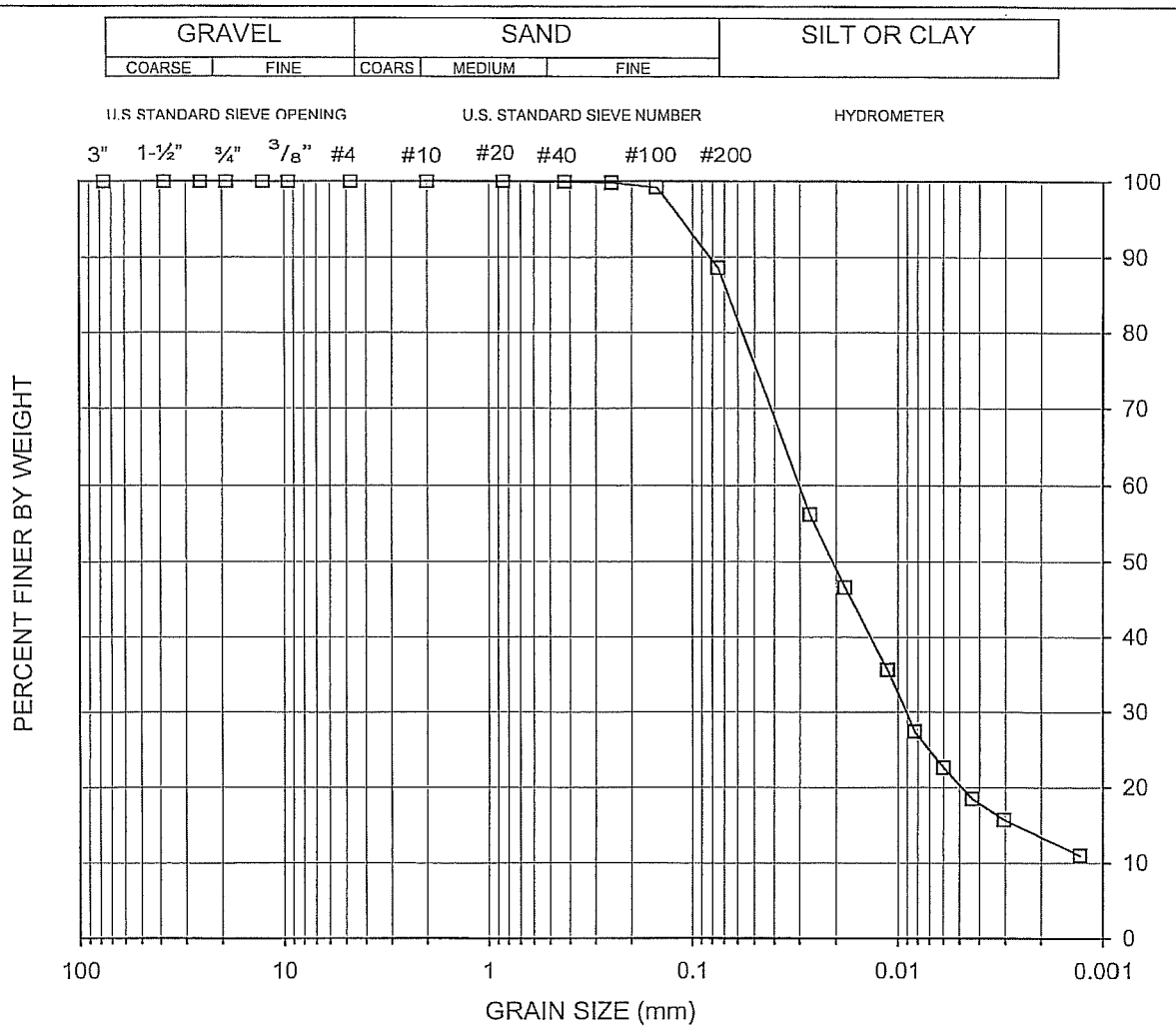
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-035	U-03	15	2.763
R-09-035	U-10	50	2.742



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-03	15	Shelby Tube	ML	28	5

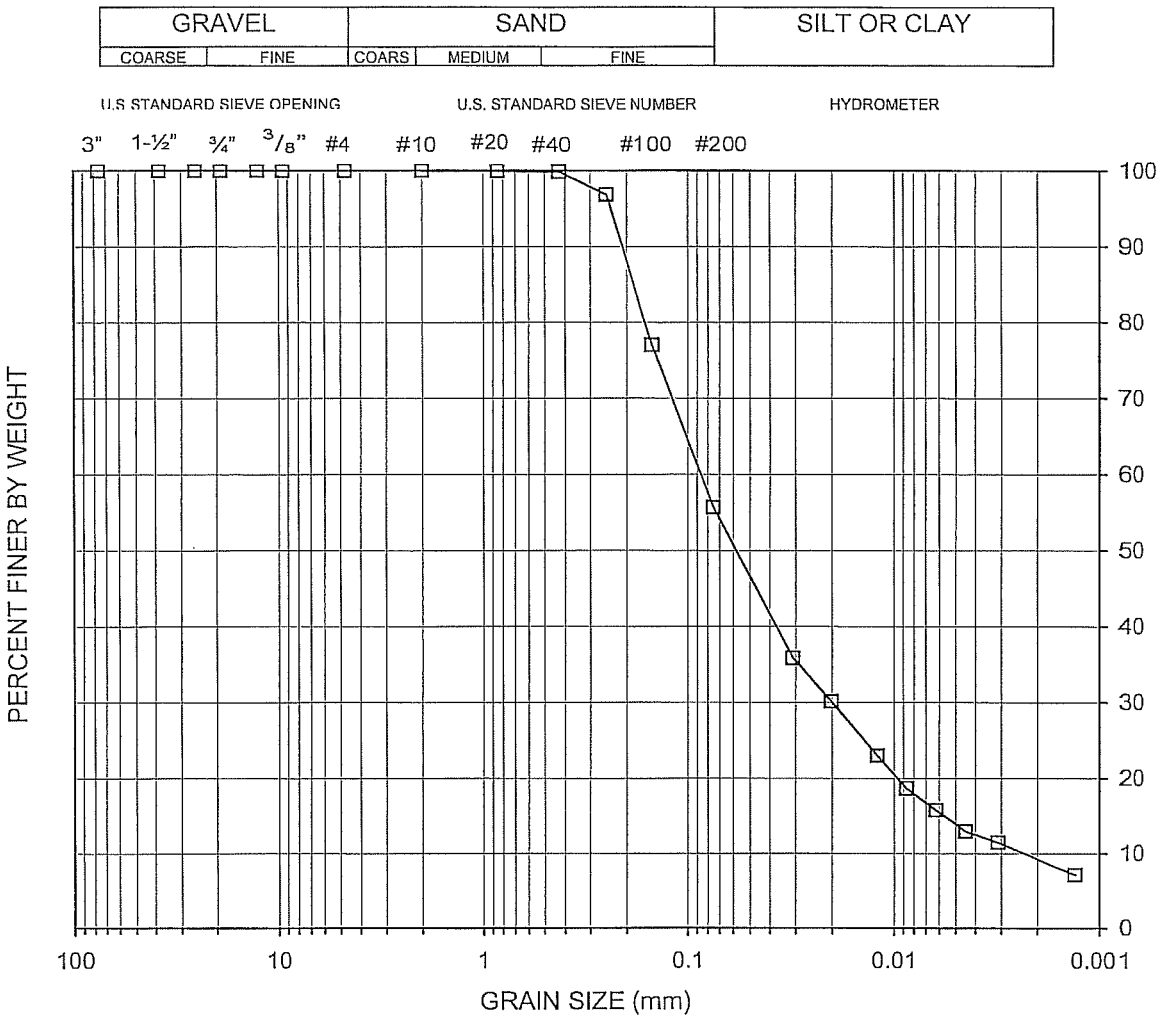
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-10	50	Shelby Tube	ML	NP	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

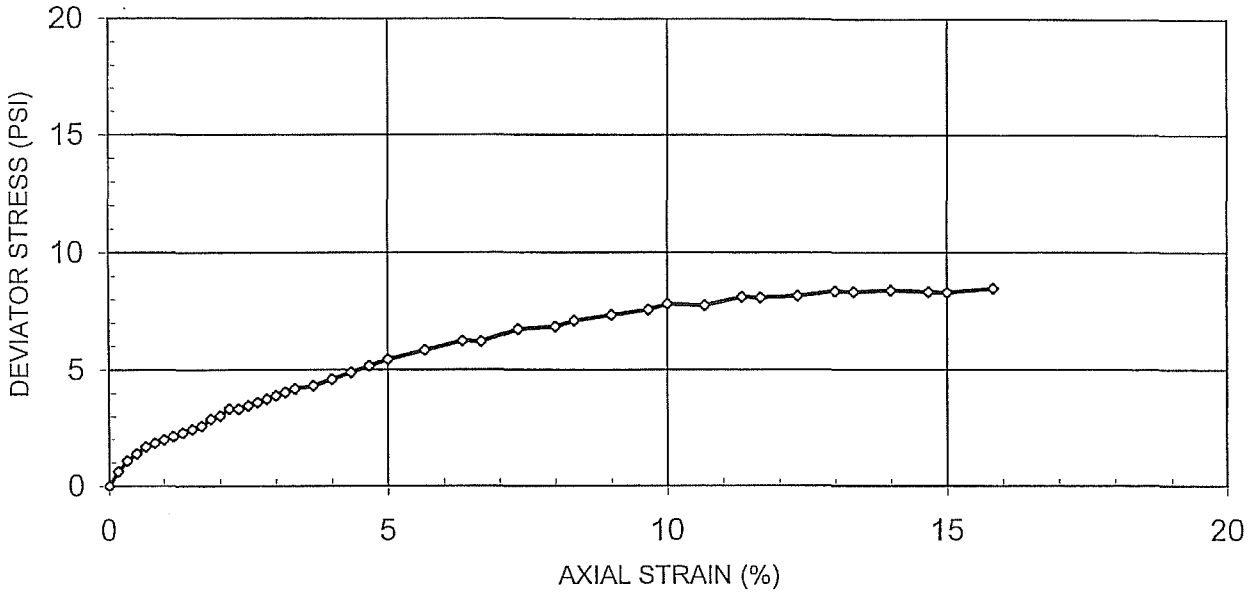
Client: Earth Mechanic, Inc.

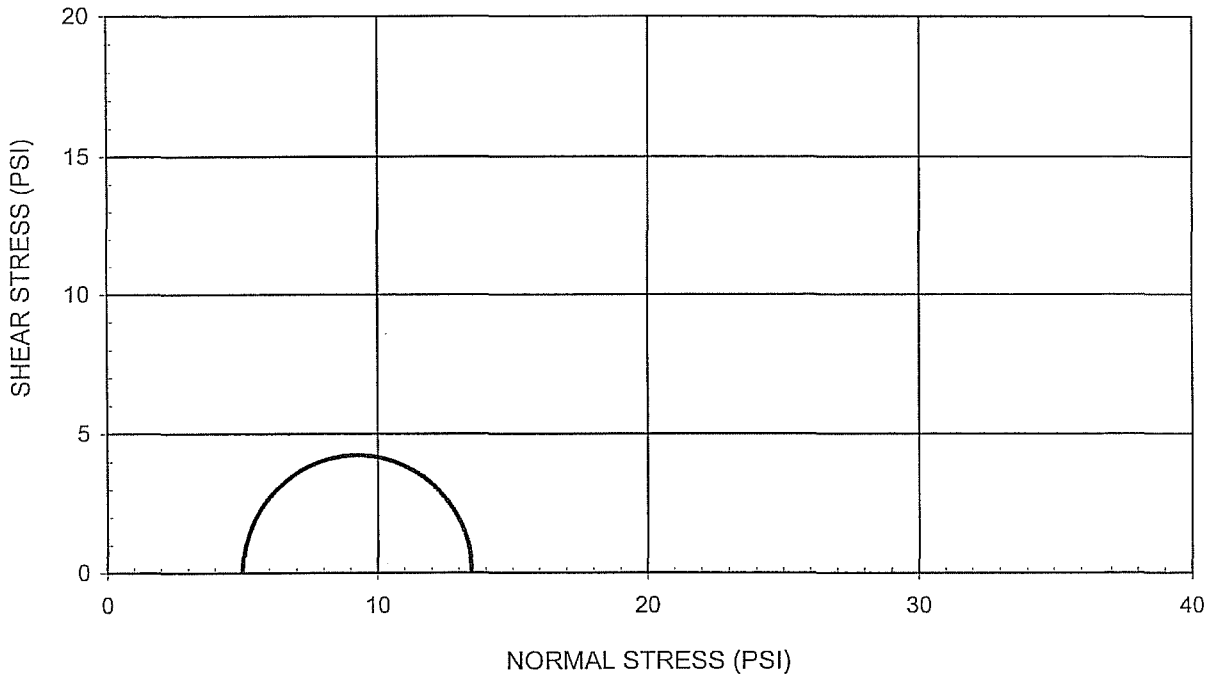
Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	15	U-03	ML	Shelby Tube	41.01	80.0	5.0	8.5	0.06	100.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

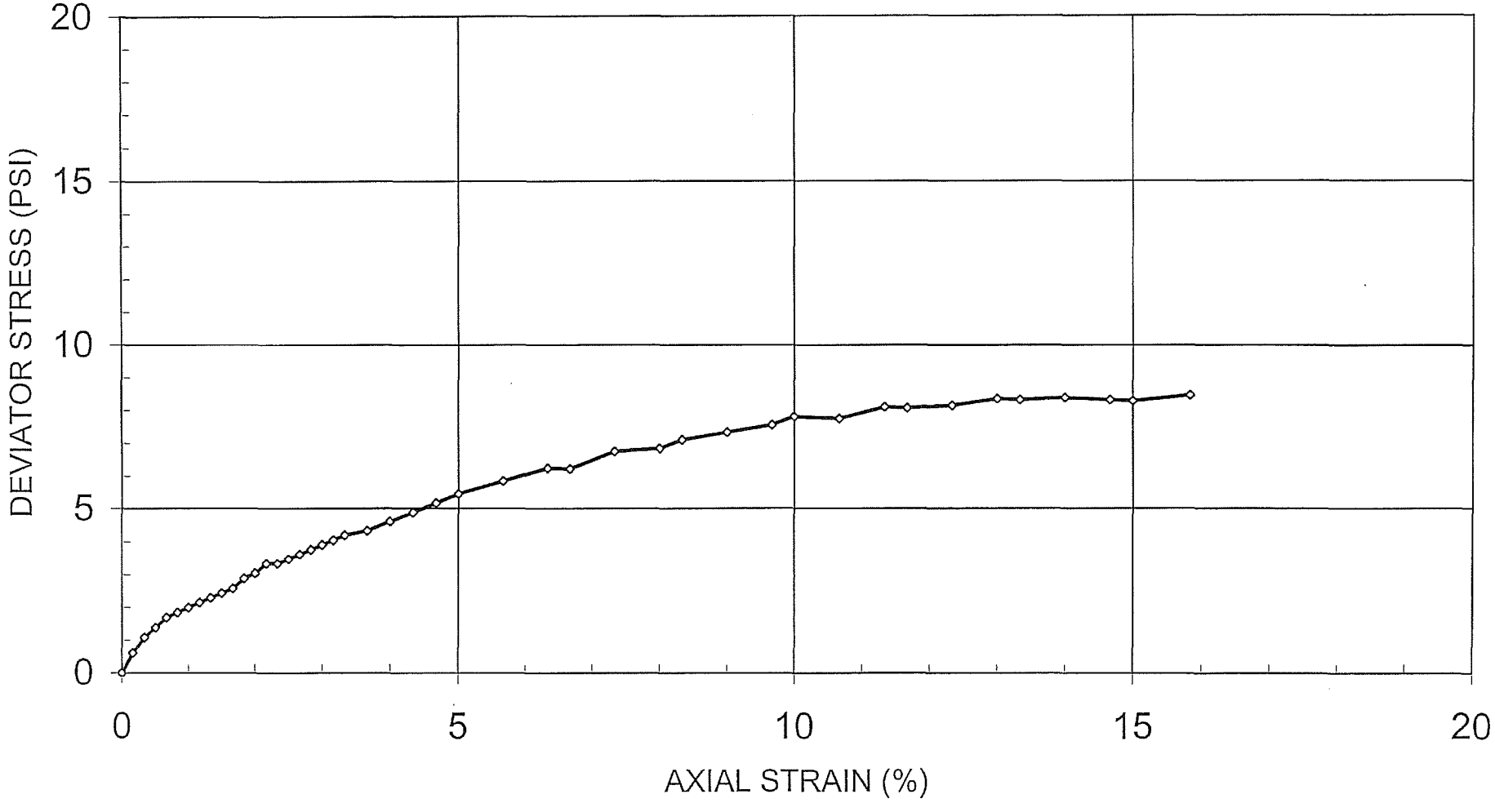
(ASTM D2850)

11/29/09

Figure

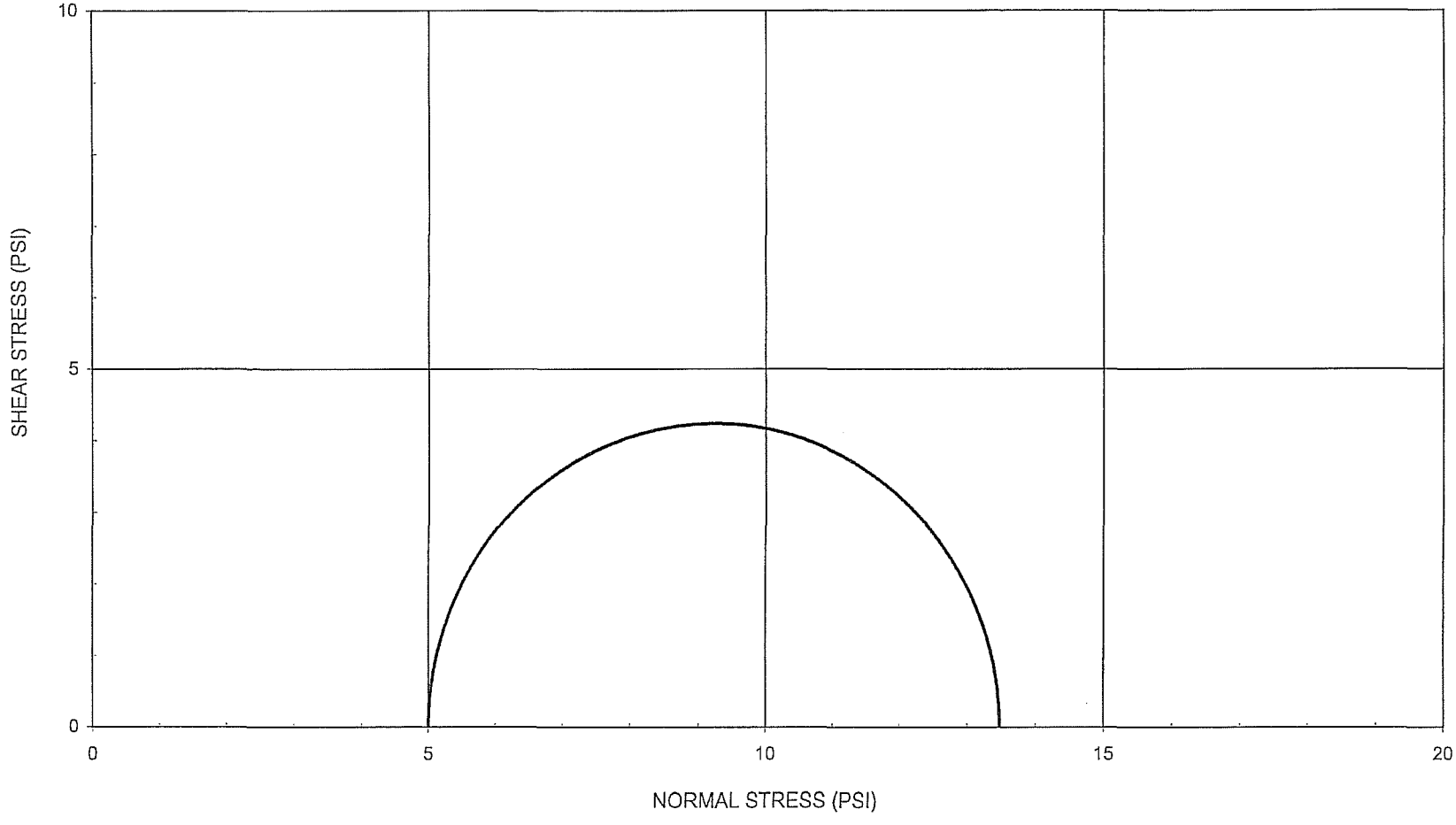
Project Name: ACTA Heim Bridge Replacement

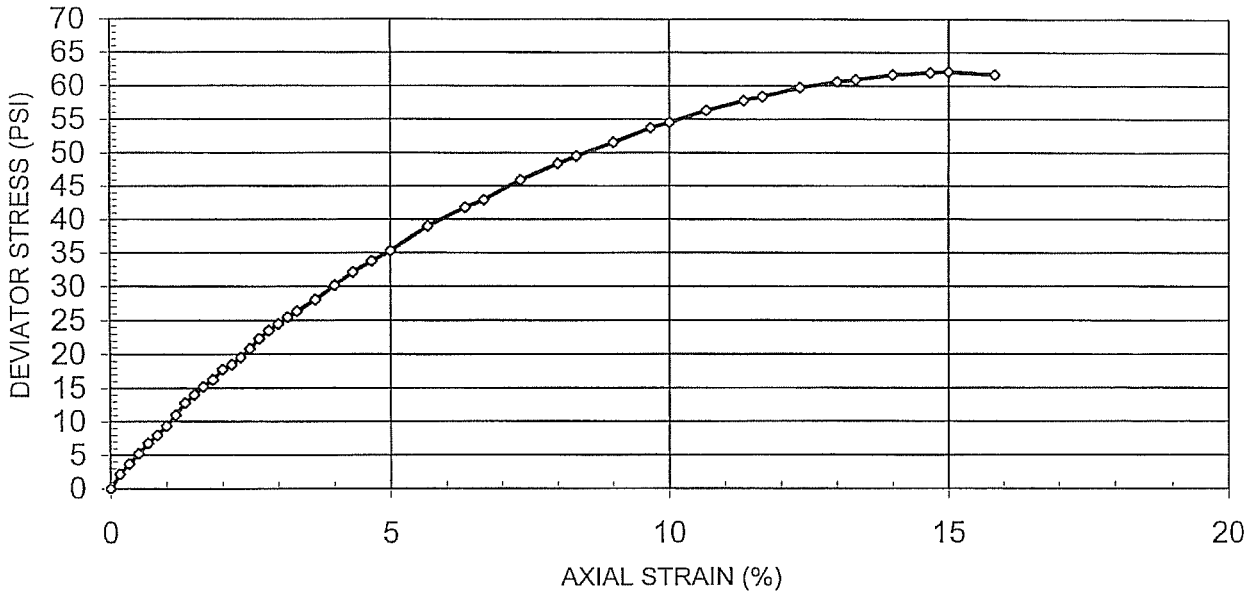
Boring: R-09-035 Sample ID: U-03 Depth (ft): 15

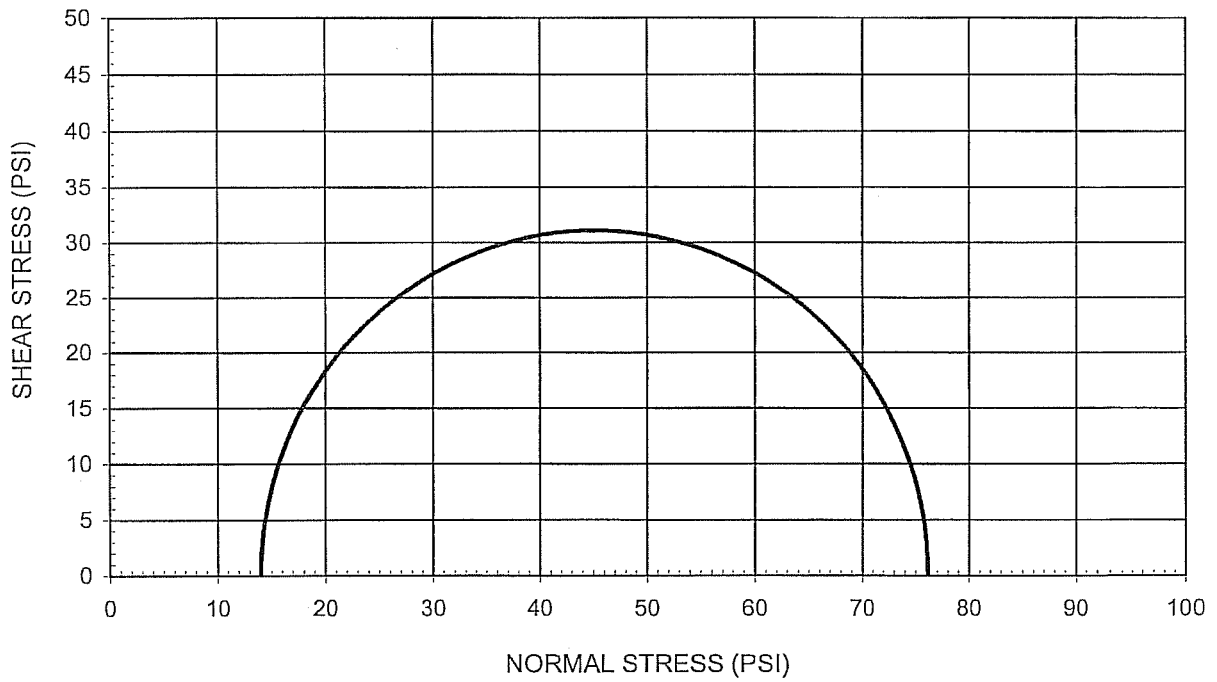


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-03 Depth (ft): 15







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	50	U-10	ML	Shelby Tube	22.25	106.6	14.0	62.1	0.06	103.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

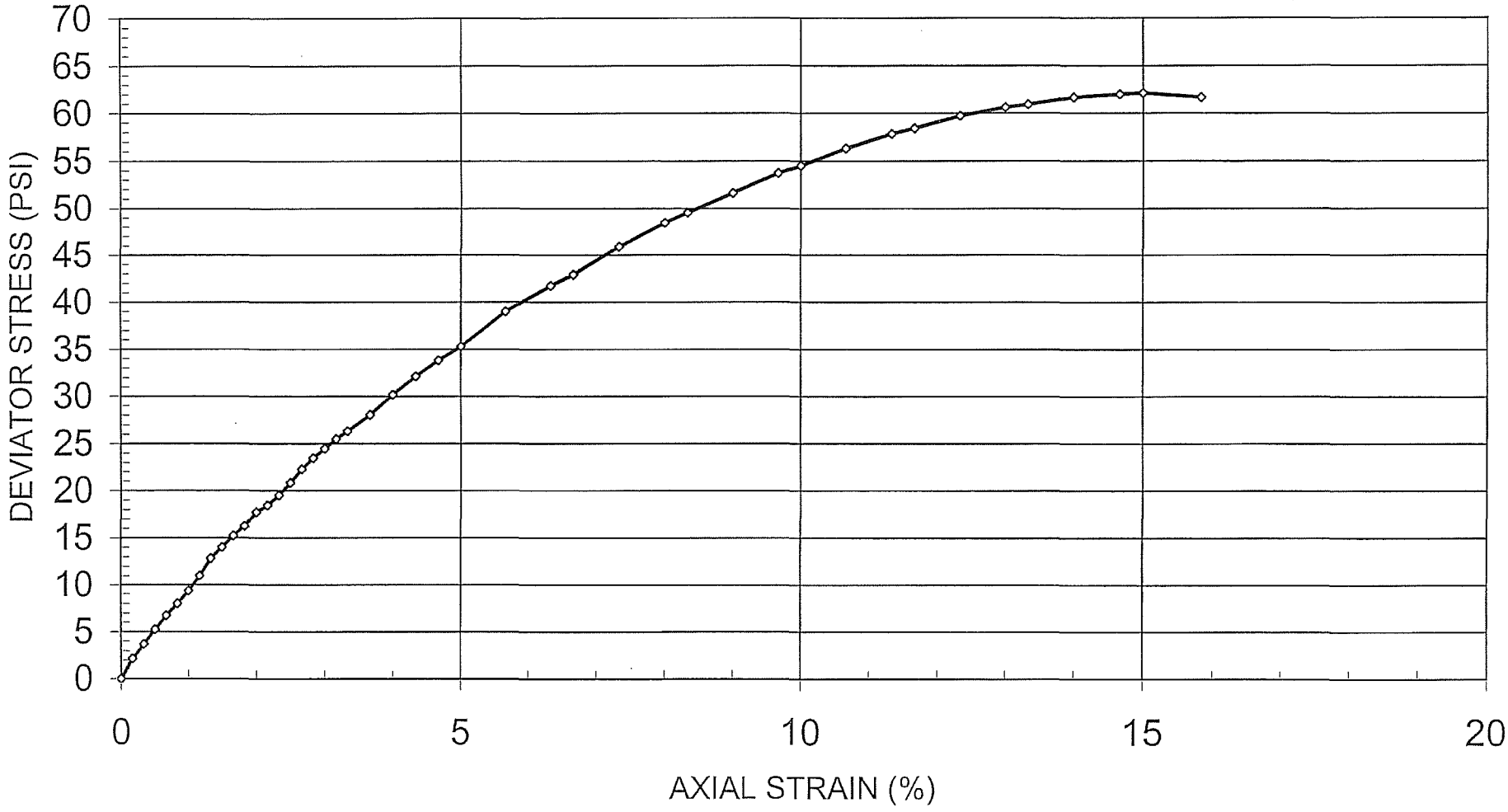
(ASTM D2850)

11/29/09

Figure

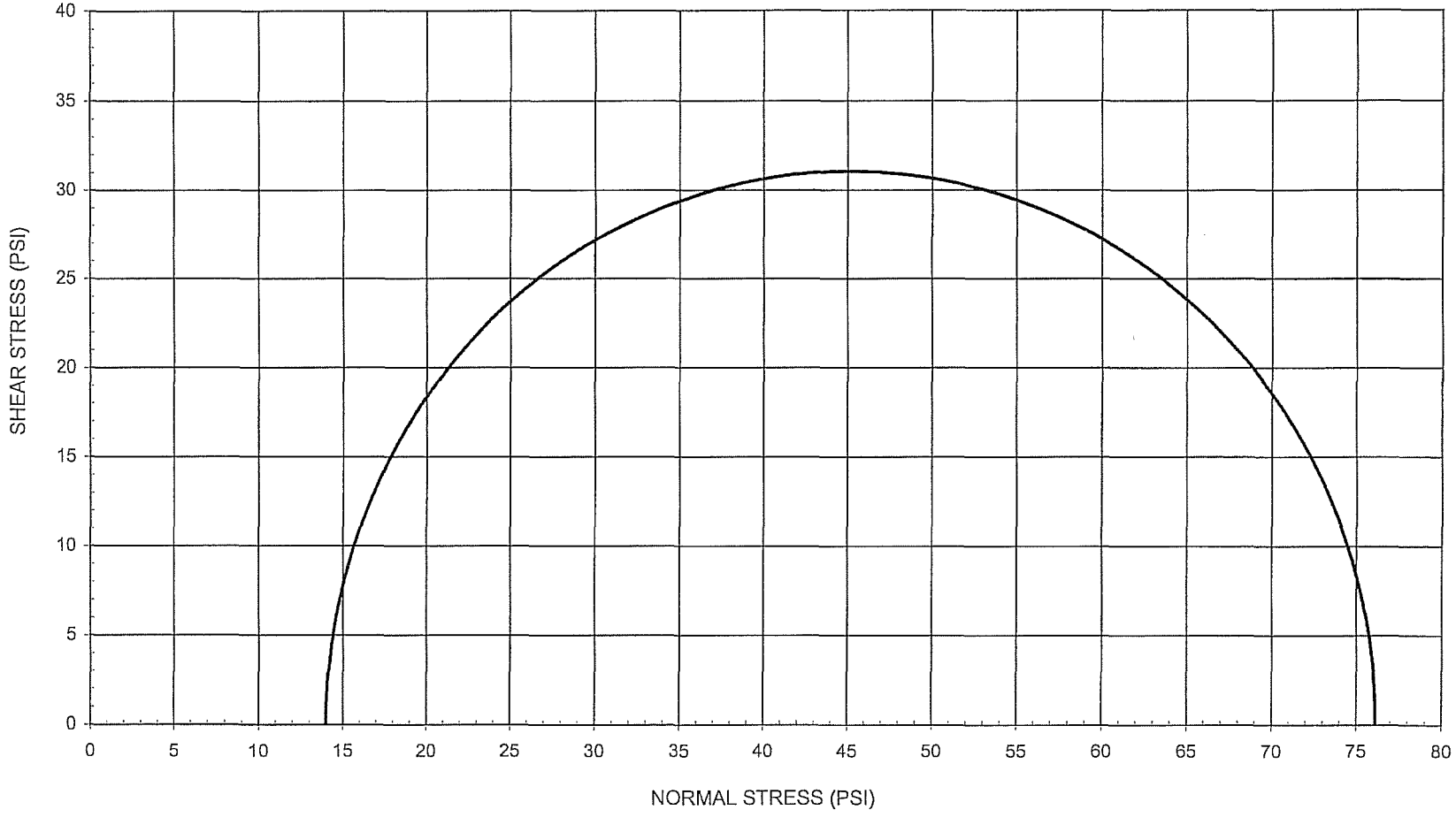
Project Name: ACTA Heim Bridge Replacement

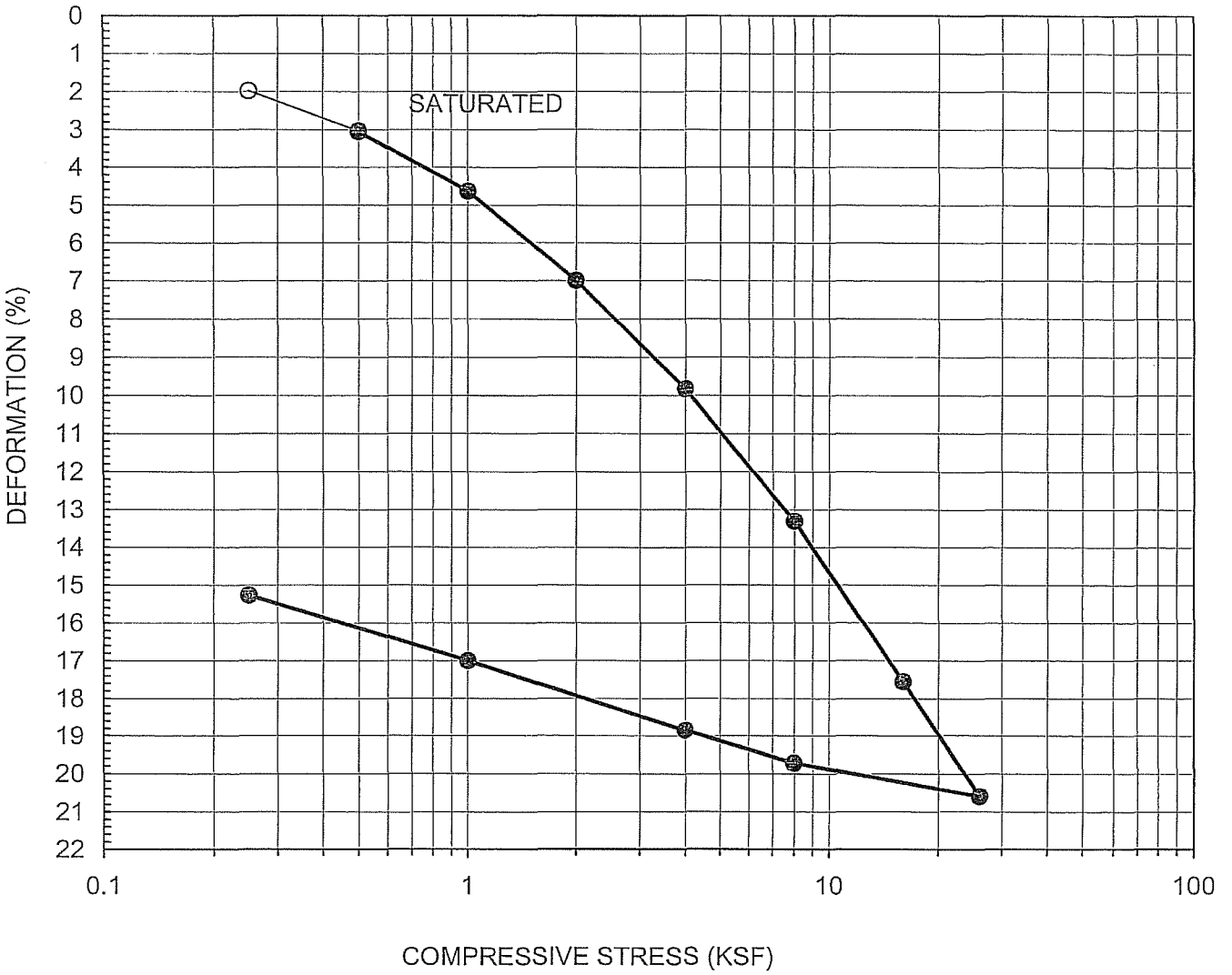
Boring: R-09-035 Sample ID: U-10 Depth (ft): 50



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-10 Depth (ft): 50





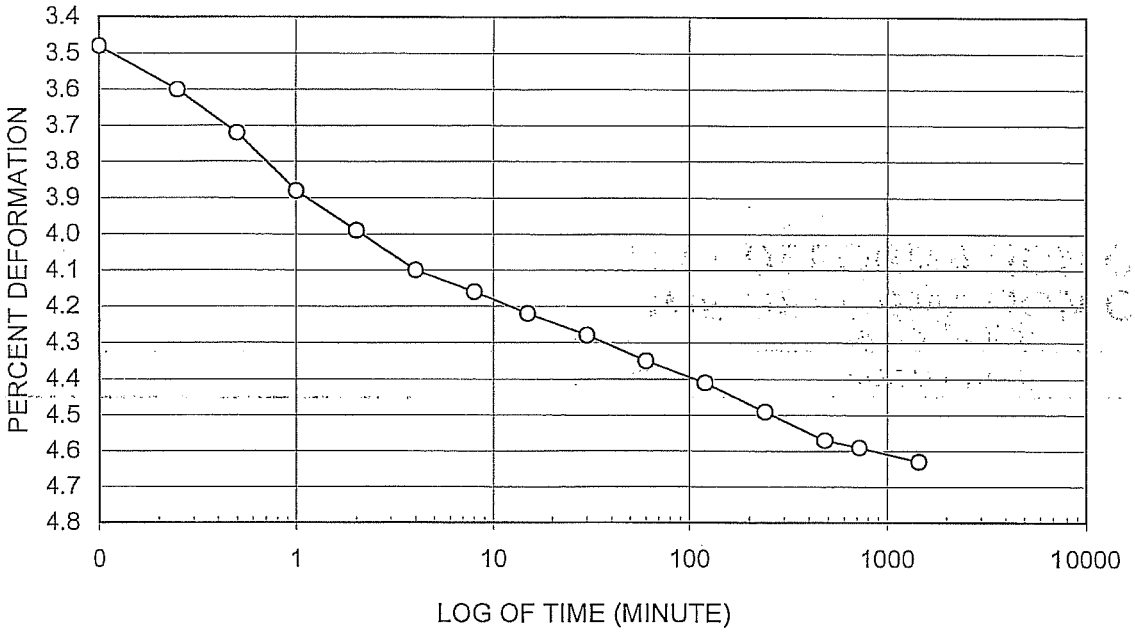
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	D-02	10.0	ML	48.0	73.9	1.279

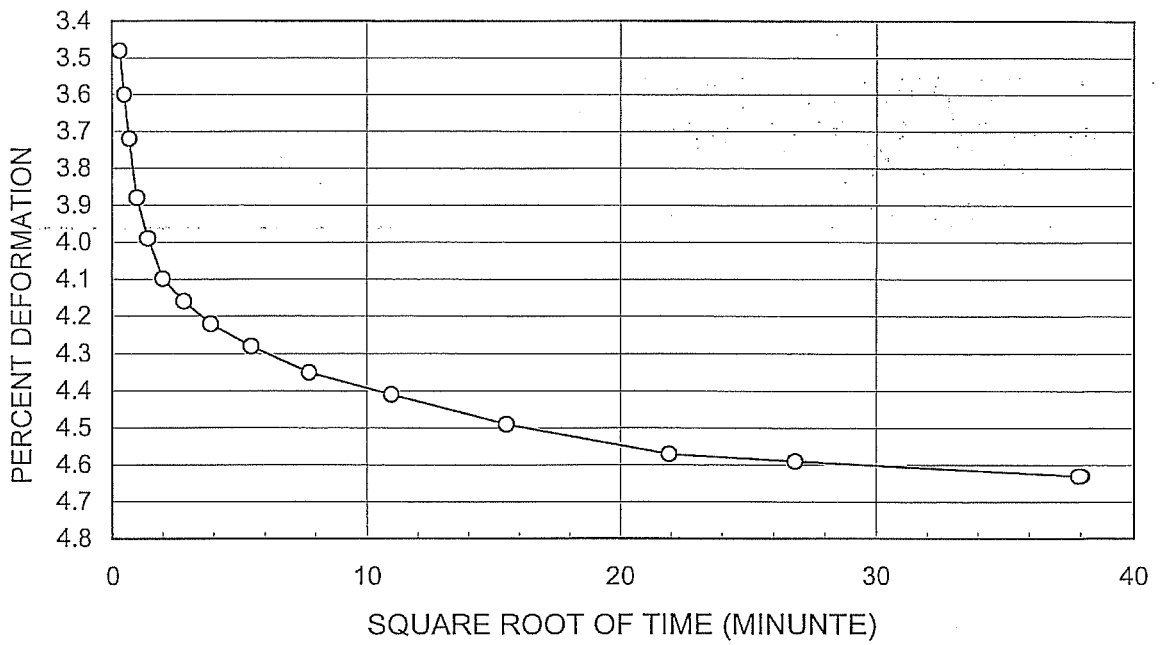
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





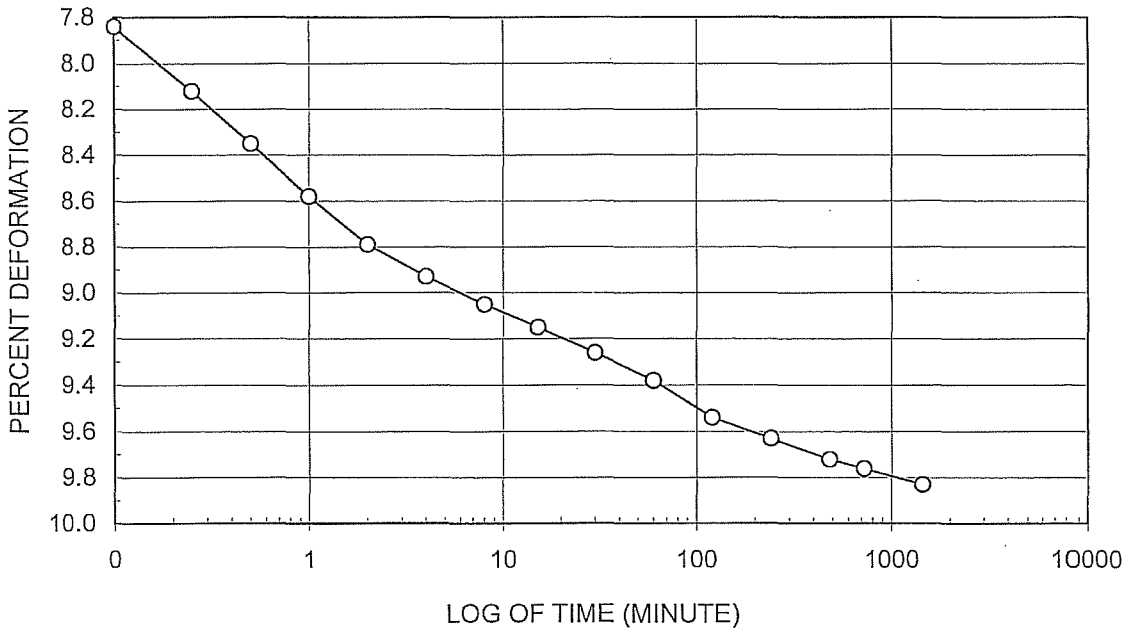
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 1.0 ksf

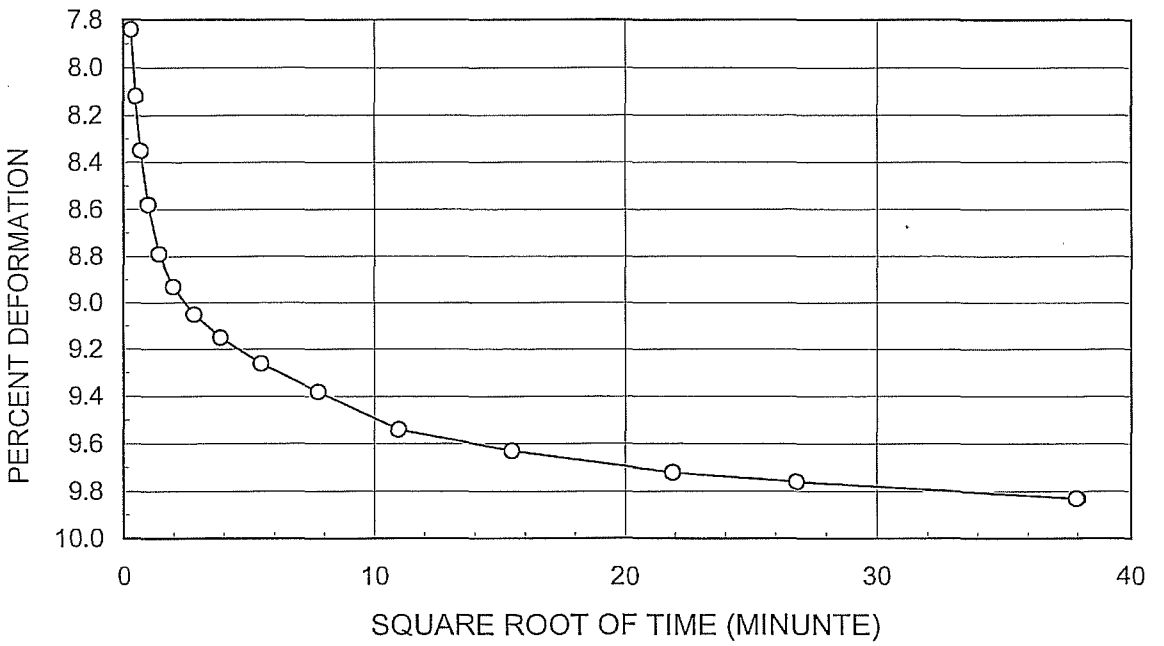
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





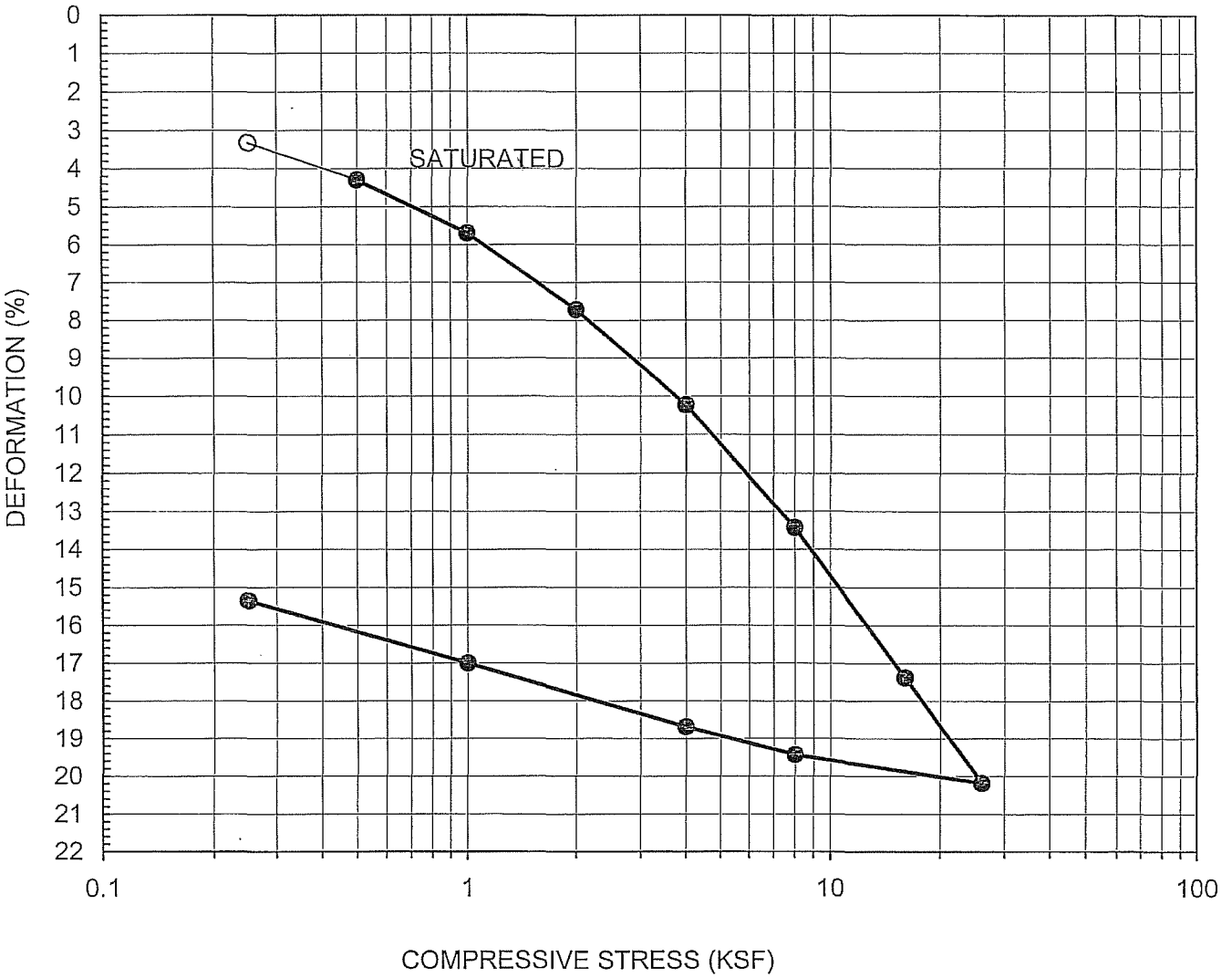
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



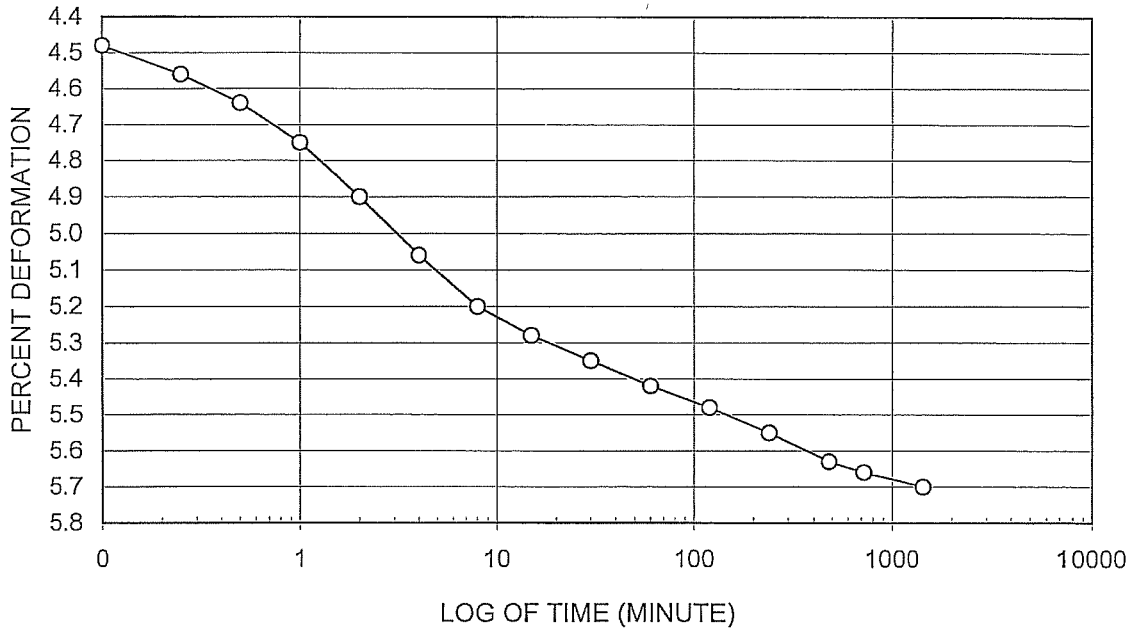
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-03	15.0	ML	40.8	78.1	1.157

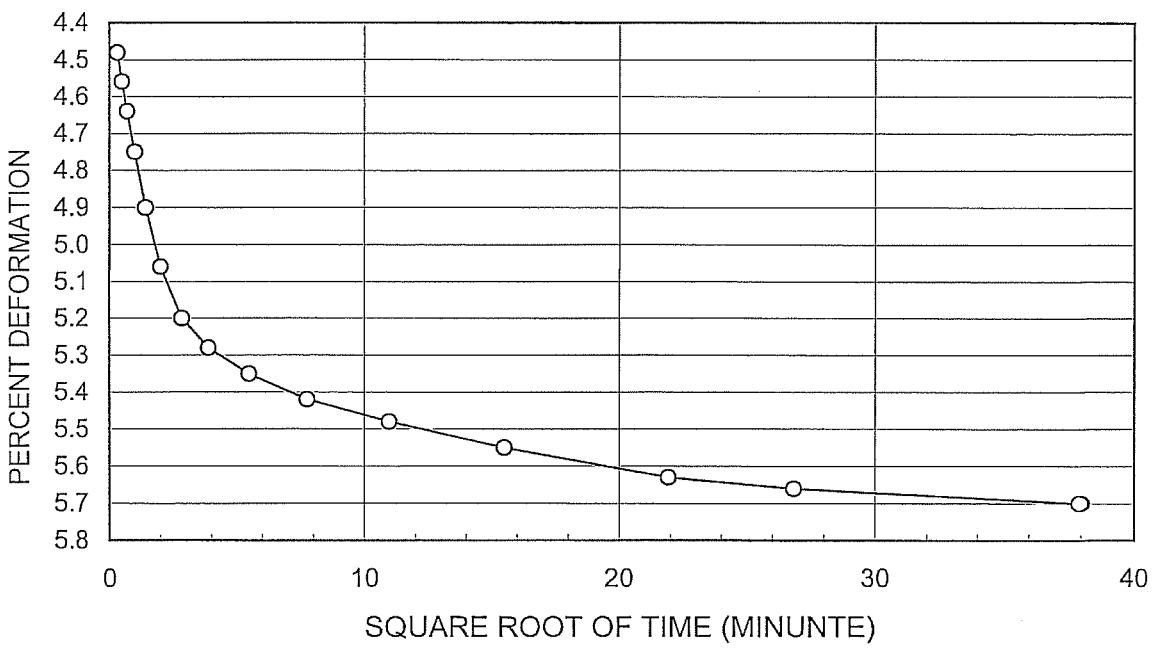
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





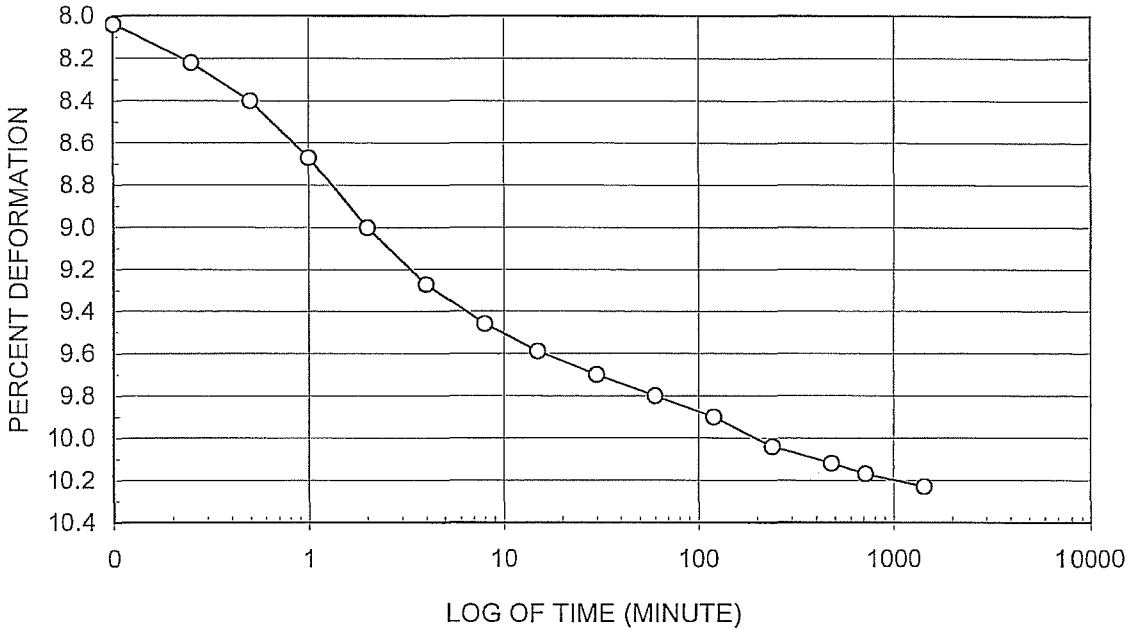
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 1.0 ksf

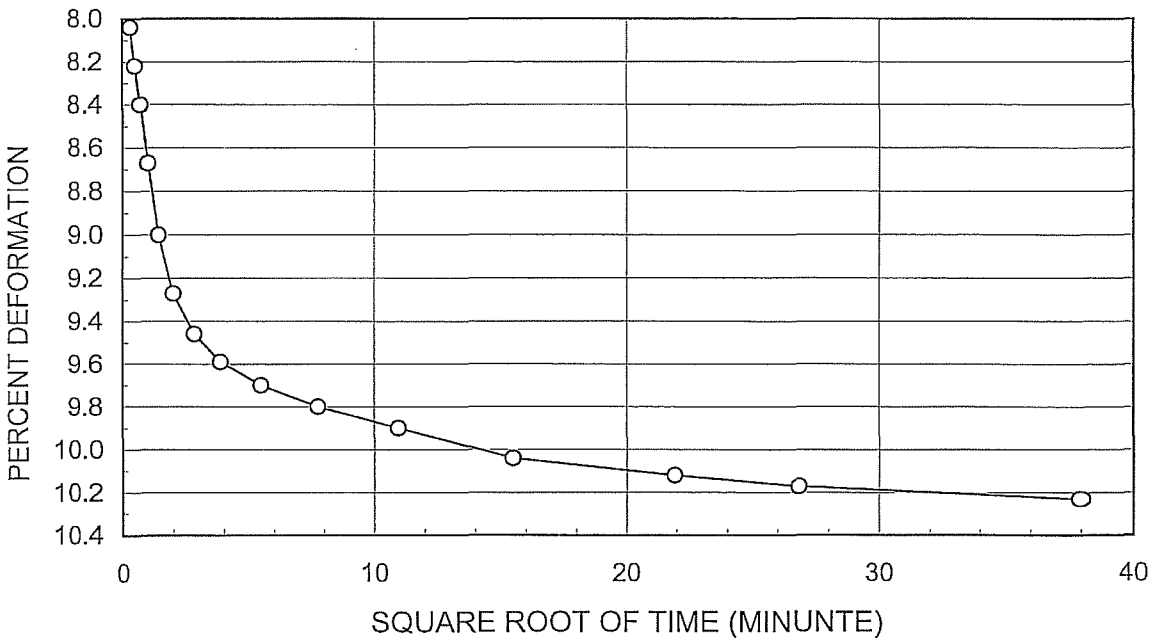
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





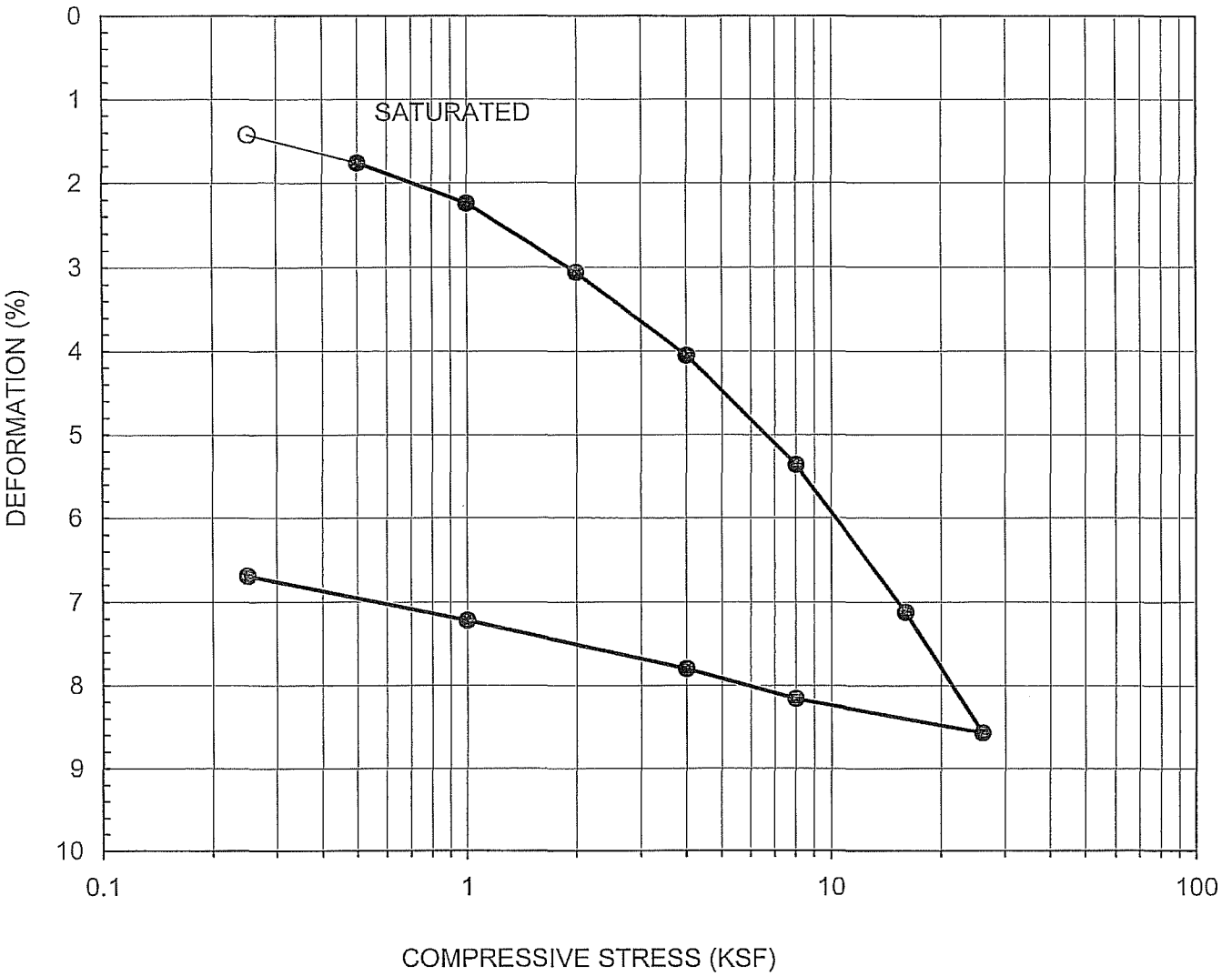
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



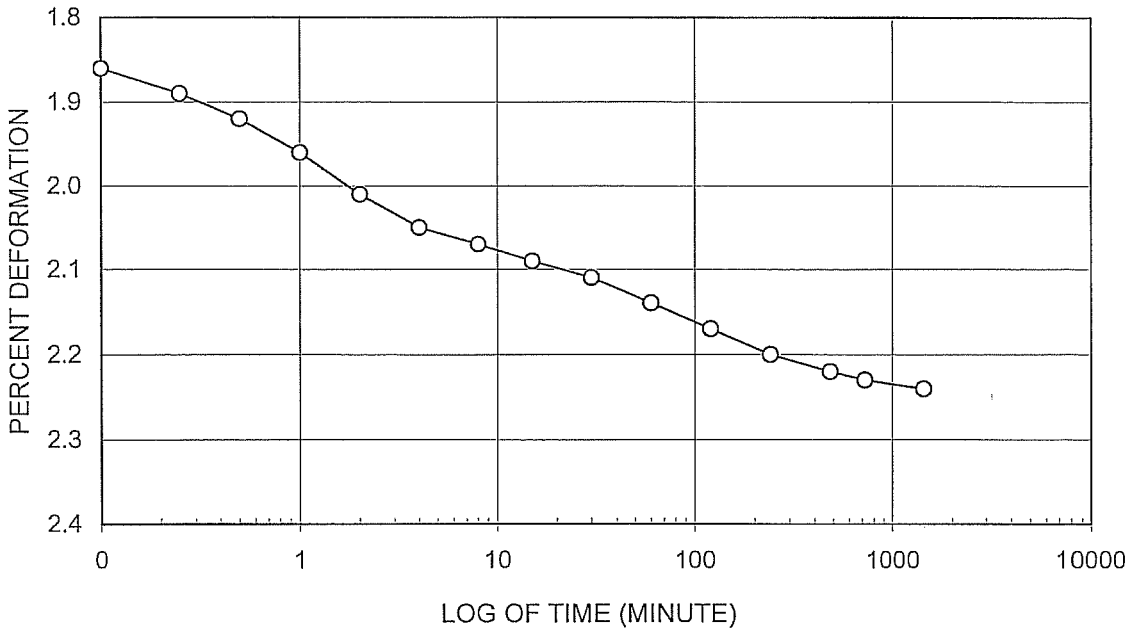
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-10	50.0	ML	21.6	109.1	0.544

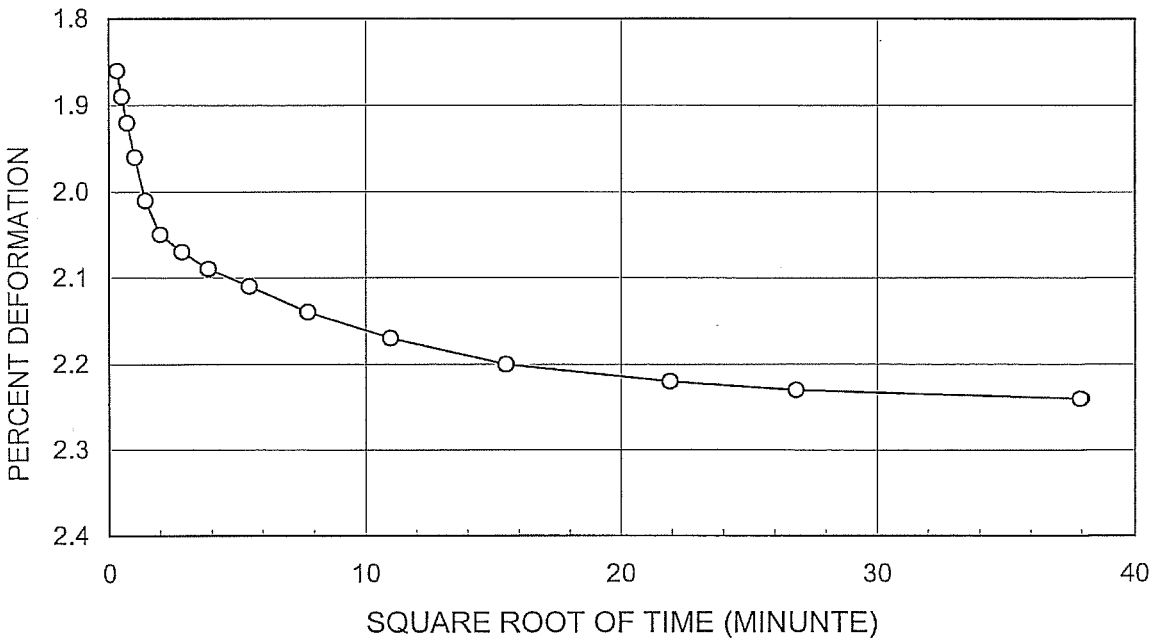
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





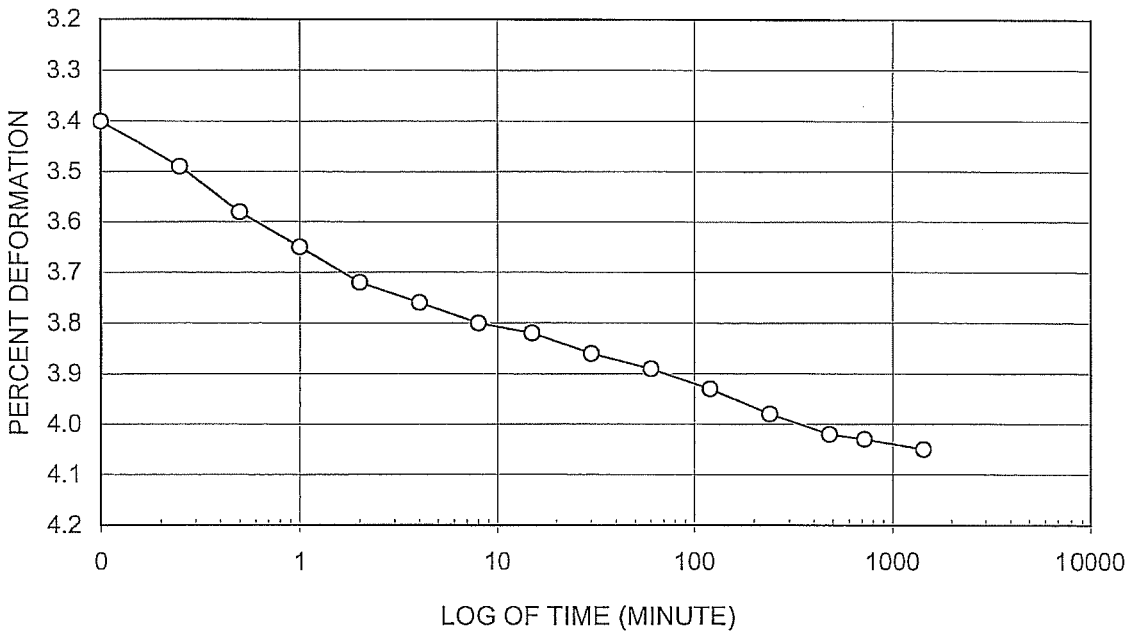
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 1.0 ksf

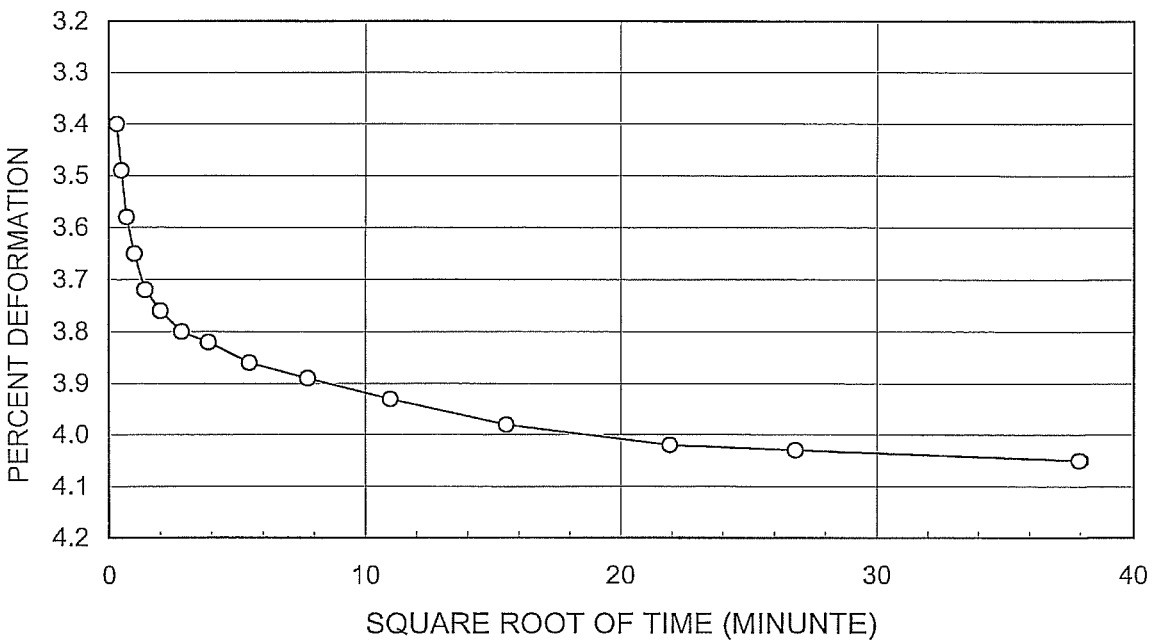
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





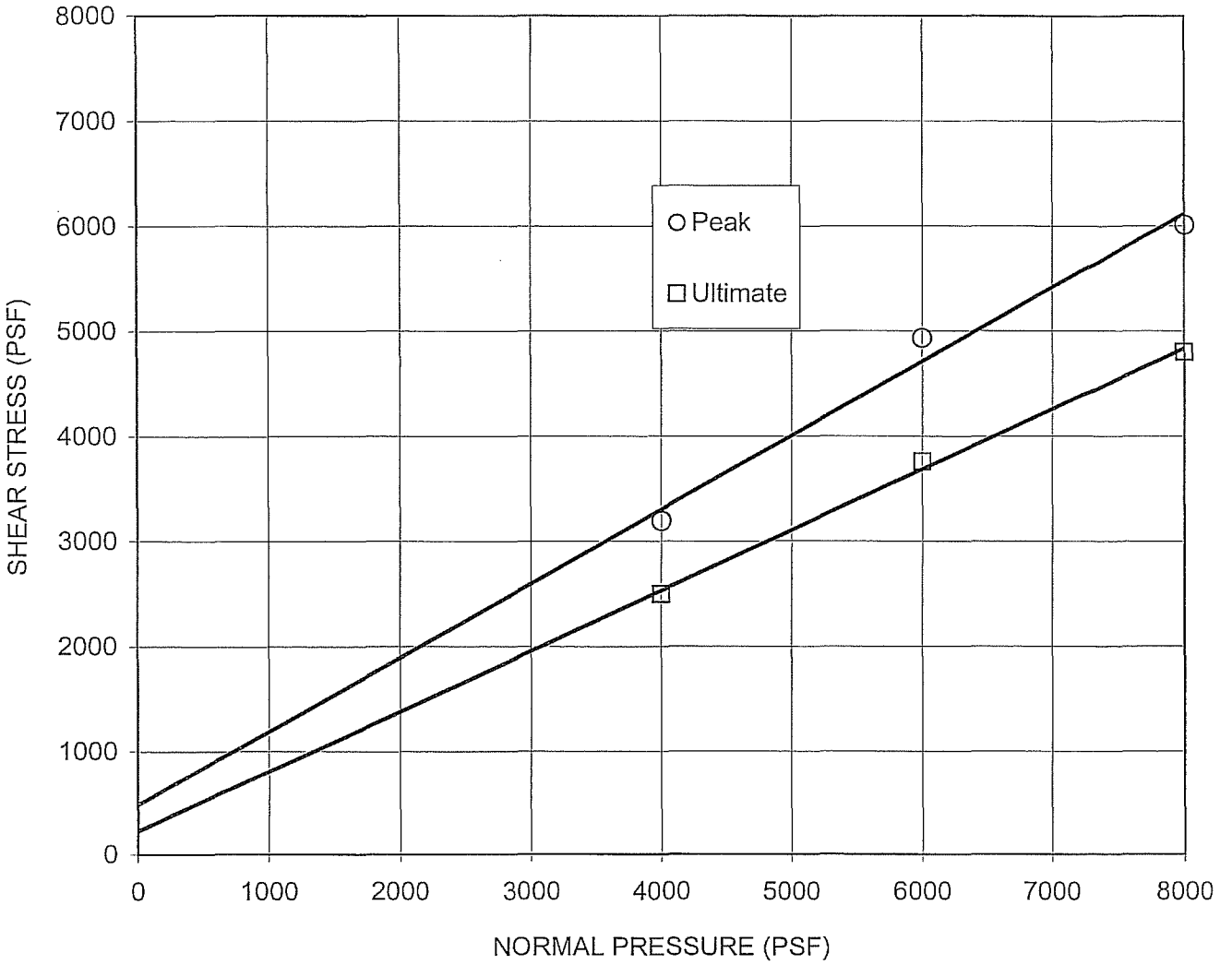
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-035	D-14	70	Ring	SM	○	484	35
					□	228	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	27.0	30.7
6000	27.0	29.3
8000	27.0	29.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-055	S-1	5	SP-SM	23.1				37:52:11						
A-09-055	D-2	10	0								2100	7.7	50	380
A-09-055	S-3	15	SP	24.3				0:99:1						
A-09-055	D-4	20	SP-SM	21.8	122.9									
A-09-055	S-5	25	SP	24.9				0:96:4						
A-09-055	S-7-2	35.5	CL	36.6										
A-09-055	S-9	45	CH	31.3				0:6:94		59/29/30				
A-09-055	D-10	50	CL			1.0								
A-09-055	S-11	55	ML	33.0				0:6:94		32/27/5				
A-09-055	D-12	60	ML			2.0				22/20/2				
A-09-056	S-1	5	SM					13:46:41			670	7.8	580	514
A-09-056	D-2	10	ML			<0.25				49/32/17				
A-09-056	S-3	15	CL	44.9				0:13:87		41/25/16				
A-09-056	D-4	20	SM							N.P.				
A-09-056	S-5	25	SP-SM	29.4				0:93:7						
A-09-058	S-1	5	SP					0:96:4			9300	8.6	30	248
A-09-058	S-3	15	CH	65.2				0:1:99		93/34/59				
A-09-058	S-5	25	CL	34.2				0:7:93		47/24/23				
A-09-058	D-6	30	ML			0.5								
A-09-058	S-7	35	ML	23.9						N.P.				
A-09-058	D-8	40	ML			1.5		0:26:74						
A-09-058	S-9	45	SM	29.5										
A-09-058	D-10	50	SC-SM					0:72:28						
A-09-059	S-1	5	SM					3:81:16			1300	8.1	380	542
A-09-059	S-3	15	MH	47.0				0:17:83		98/49/49				
A-09-059	S-6	30	MH	37.2				0:4:96		50/30/20				
A-09-059	S-8	40	SM	28.2				1:72:27		N.P.				
A-09-059	D-9	45	CL			0.5		0:6:94		40/24/16				
A-09-059	S-10	50	ML	37.3				0:31:69						

ATTERBERG LIMITS

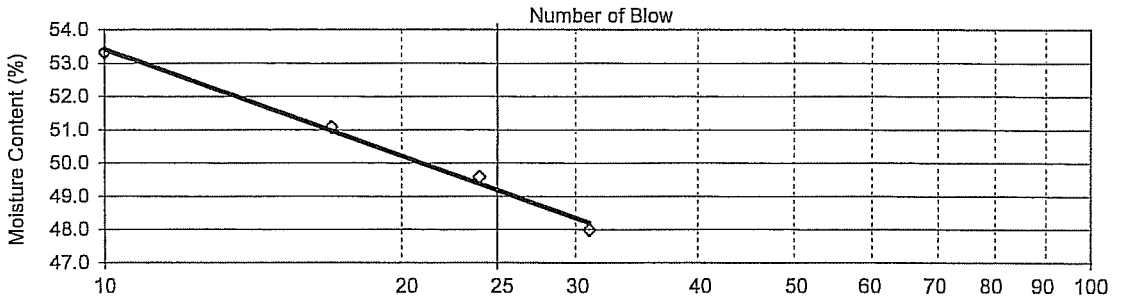
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-056	Depth (ft/m): 10 ft	3 m			1
Sample Number: D-2	Description: ML				
Prepared By: PA	Date:		Checked By: R.J.	Date:	
Pulverized By: PA	Date:			Container Number	
Tested By: PA	Date:			Air: G-2	
Computed By: JF	Date:			Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		31	24	17	10		
Can Number		13	14	15	16	17	18
Wt. Wet Soil +Can (gm)		43.87	41.20	39.38	40.44	34.01	33.00
Wt. Dry Soil +Can (gm)		38.74	35.31	34.14	34.57	31.93	30.96
Weight of Can (gm)		28.05	23.43	23.88	23.56	25.46	24.55
Water Content (%)		48.0	49.6	51.1	53.3	32.1	31.8

Liquid Limit (LL, %):	49	Plastic Limit (PL, %):	32	Plastic Index (PI, %):	17

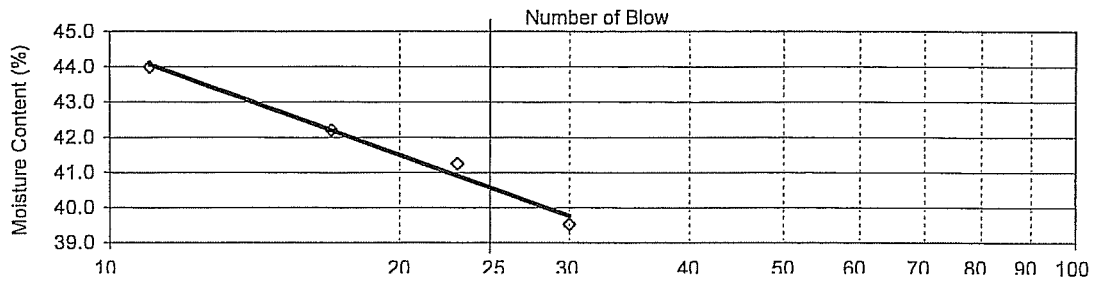


Remark:

Boring Number: A-09-056	Depth (ft/m): 15 ft	4.5 m			1
Sample Number: S-3	Description: CL				
Prepared By: PA	Date:		Checked By: R.J.	Date:	
Pulverized By: PA	Date:			Container Number	
Tested By: PA	Date:			Air: G-9	
Computed By: JF	Date:			Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		30	23	17	11		
Can Number		31	32	33	34	35	36
Wt. Wet Soil +Can (gm)		41.51	38.51	37.85	38.97	29.60	31.26
Wt. Dry Soil +Can (gm)		36.06	33.78	32.96	33.93	27.91	29.60
Weight of Can (gm)		22.27	22.31	21.37	22.47	21.14	22.94
Water Content (%)		39.5	41.2	42.2	44.0	25.0	24.9

Liquid Limit (LL,%)	41	Plastic Limit PL,%)	25	Plastic Index (PI,%)	16



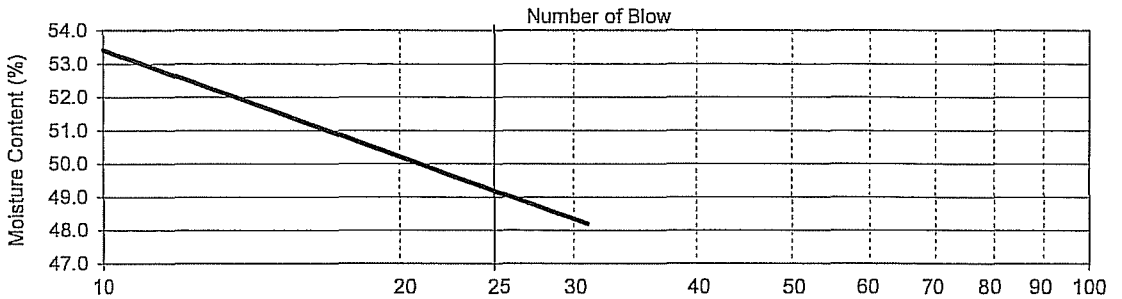
Remark:

ATTERBERG LIMITS

ASTM D-4318-84 / CT-204

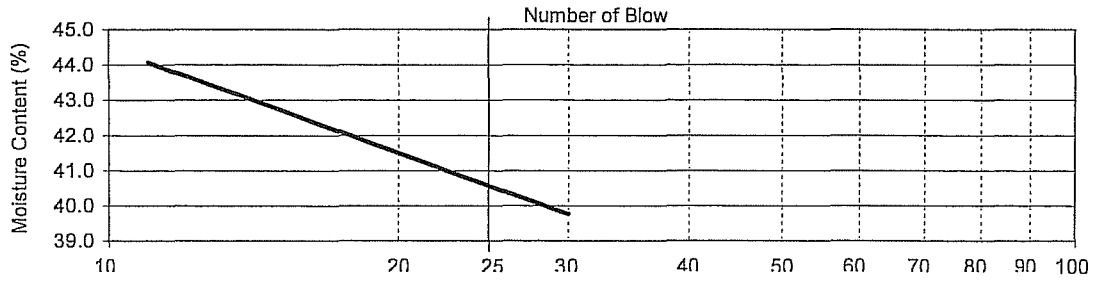
Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-056	Depth (ft/m): 20	3 m							1
Sample Number: D-4	Description: SM								
Prepared By: PA	Date:		Checked By: R.J.				Date:		
Pulverized By: PA	Date:						Container Number		
Tested By: PA	Date:						Air:	G-2	
Computed By: JF	Date:		NO PLASTIC				Field:		
Trial Number	Field Moisture	1	2	3	4		Plastic Limit 1	2	
Number of Blow									
Can Number									
Wt. Wet Soil +Can (gm)									
Wt. Dry Soil +Can (gm)									
Weight of Can (gm)									
Water Content (%)									
Liquid Limit (LL, %):		**Plastic Limit (PL, %):**				**Plastic Index (PI, %):**			



Remark:

Boring Number: A-09-054	Depth (ft/m): 45	4.5 m							1
Sample Number: S-9	Description: ML								
Prepared By: PA	Date:		Checked By: R.J.				Date:		
Pulverized By: PA	Date:						Container Number		
Tested By: PA	Date:						Air:	G-9	
Computed By: JF	Date:		NO PLASTIC				Field:		
Trial Number	Field Moisture	1	2	3	4		Plastic Limit 1	2	
Number of Blow									
Can Number									
Wt. Wet Soil +Can (gm)									
Wt. Dry Soil +Can (gm)									
Weight of Can (gm)									
Water Content (%)									
Liquid Limit (LL, %):		**Plastic Limit (PL, %):**				**Plastic Index (PI, %):**			



Remark:

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-056		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 5.0		**Tested By :** PA	**Date :**	**13**	**46**	**41**	3/8"
Depth (m)	: 1.53		**Checked By :**	**Date :**				
Description	: Olive, SILTY SAND (SM)				**Sample**		**Retained On**	
X	**Method (A)** - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-5	S-5	S-5	S-5
Wet Weight of Soil + Container (gm)					308.92	308.92		
Dry Weight of Soil + Container (gm)						282.16	214.06	
Weight of Container (gm)					117.80	117.8	117.8	
Weight of Dry Soil (gm)					164.36	164.36	96.26	22.15
Moisture Content (%)						16.28		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							41.43	13.48
Remark :								1

Boring No.	: A-09-056		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-5		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 25.0		**Tested By :** PA	**Date :**	**0**	**93**	**7**	#30
Depth (m)	:		**Checked By :**	**Date :**				
Description	: Olive-gray, Poorly graded SAND with SILT (SP-SM)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-6	S-6	S-6	S-6
Wet Weight of Soil + Container (gm)					365.39	365.39		
Dry Weight of Soil + Container (gm)						308.86	295.04	
Weight of Container (gm)					116.77	116.77	116.77	
Weight of Dry Soil (gm)					192.09	192.09	178.27	0.00
Moisture Content (%)						29.43		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							7.19	0.00
Remark :								2

Boring No.	: A-09-058		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**
Sample No.	: S-1		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	
Depth (ft)	: 25.0		**Tested By :** PA	**Date :**	**0**	**96**	**4**	#10
Depth (m)	: 7.63		**Checked By :**	**Date :**				
Description	: Olive-gray, Poorly graded SAND (SP)				**Sample**		**Retained On**	
	Method (A) - Soaked by Water						**No. 200**	**No. 4**
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number					S-8	S-8	S-8	S-8
Wet Weight of Soil + Container (gm)					358.92	358.92		
Dry Weight of Soil + Container (gm)						351.07	341.94	
Weight of Container (gm)					118.29	118.29	118.29	
Weight of Dry Soil (gm)					232.78	232.78	223.65	0.00
Moisture Content (%)						3.37		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							3.92	0.00
Remark :								3

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-056	Prepared By : PA	Date :
Sample No.	: S-3	Tested By : PA	Date :
Depth below Deck	: 15.0	Sieved By : RJ	Date :
Description	: darkolive-gray, Lean CLAY (CL)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

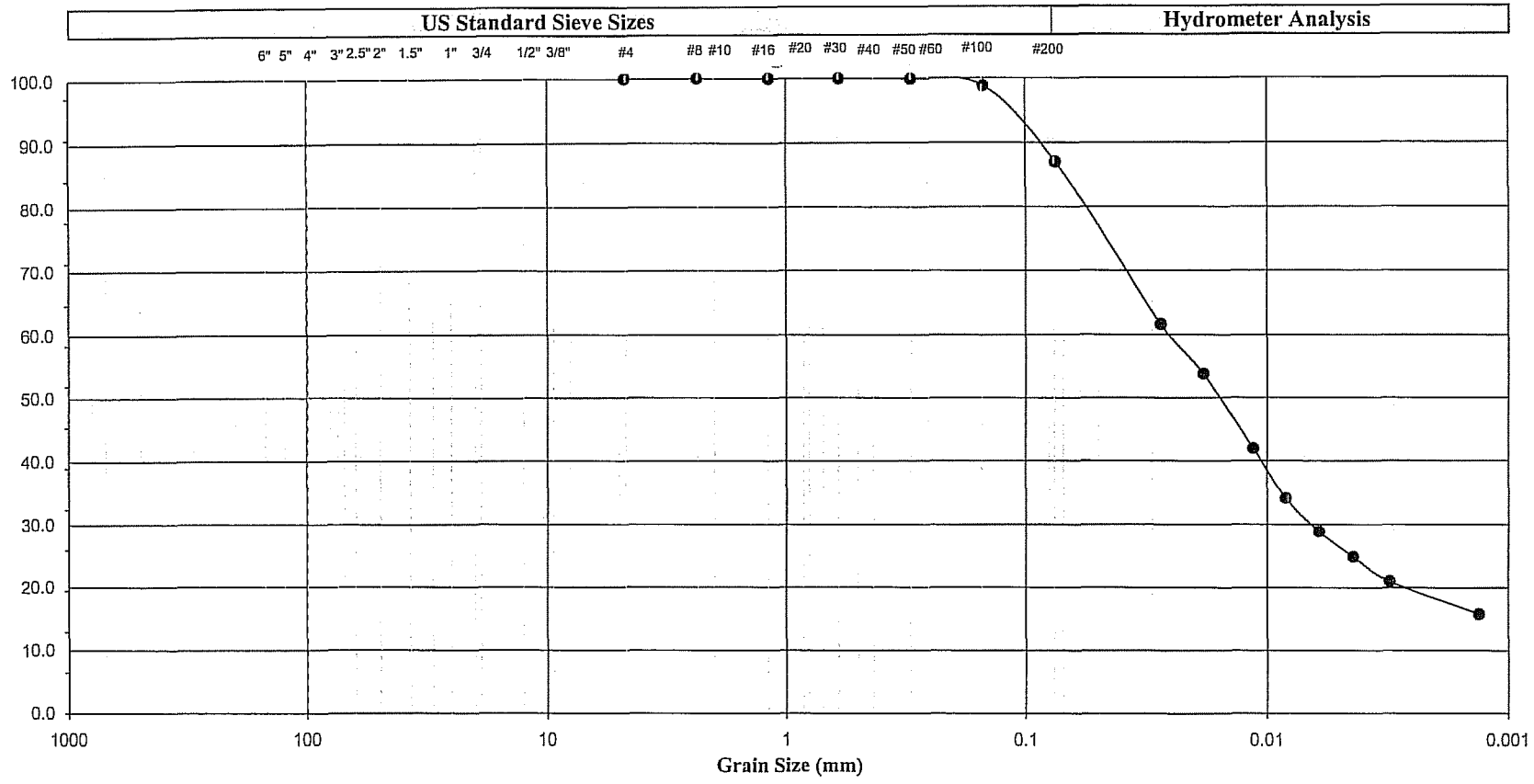
Sample for Hydrometer should passing (No.10-ASTM) & (No.4-Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-15	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	3	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-11		S-15	34		S-21		
Wt. of Wet Soil + Container (gm)		228.27		76.25	154.19			0.99	
Wt. of Dry Soil + Container (gm)					153.31		128.30	Hydrometer Type	
Wt. of Container (gm)					57.35		114.62	152H	
Wt. of Dry Soil (gm)		226.20		75.56			13.68	(K) Value	Temp. °C
Moisture Content (%)					0.92			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				41	No. 16	0.02		99.97	**99.97**
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.04		99.95	**99.95**
1.0"					No. 40				
3/4"				25	No. 50	0.10		99.87	**99.87**
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.92		98.78	**98.78**
No. 4	0.00		100.00		No. 140				
No. 8	0.00		100.00	16	No. 200	9.84		86.98	**86.98**
No. 10					Pan				

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01	(T)							(mm)			(D)
14:06	0:00:00			5.0							
	2	21.0	52.0	5.0	47.0	61.58	**61.58**	0.05500	0.01328	8.6	**0.02752**
	5	21.0	46.0	5.0	41.0	53.72	**53.72**	0.03500	0.01328	9.6	**0.01838**
	15	21.0	37.0	5.0	32.0	41.93	**41.93**	0.02000	0.01328	11.0	**0.01140**
	30	22.0	31.0	5.0	26.0	34.07	**34.07**	0.01400	0.01328	12.0	**0.00841**
	60	23.0	27.0	5.0	22.0	28.83	**28.83**	0.01000	0.01328	12.7	**0.00611**
	120	23.0	24.0	5.0	19.0	24.90	**24.90**	0.00700	0.01328	13.2	**0.00440**
	240	23.5	21.0	5.0	16.0	20.96	**20.96**	0.00500	0.01328	13.7	**0.00311**
	1440	21.5	17.0	5.0	12.0	15.72	**15.72**	0.00100	0.01328	14.3	**0.00132**

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	**0**	**13**	**87**



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-056	S-3	15.0	dark olive-gray	Lean clay	CL
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 2

Project Name : ACTA/Schuyler Heim Bridge Project
Project No. : 06-123-3
Boring No. : A-09-056
Sample No. : D-2
Depth (ft / m) : 10.0 | 3.05
File No. :
Soil Description : Dark gray, SILT (ML)

Set up By : J.F Date : 12/3/2009
Tested By : J.F/R.J. Date : 12/3/09-12/13/09
Time Rate Took By : J.F Date : 12/6/09,12/8/09
Computer By : JF Date : 12/9/2009
Checked By : R.J. Date :

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.8455	21.48	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

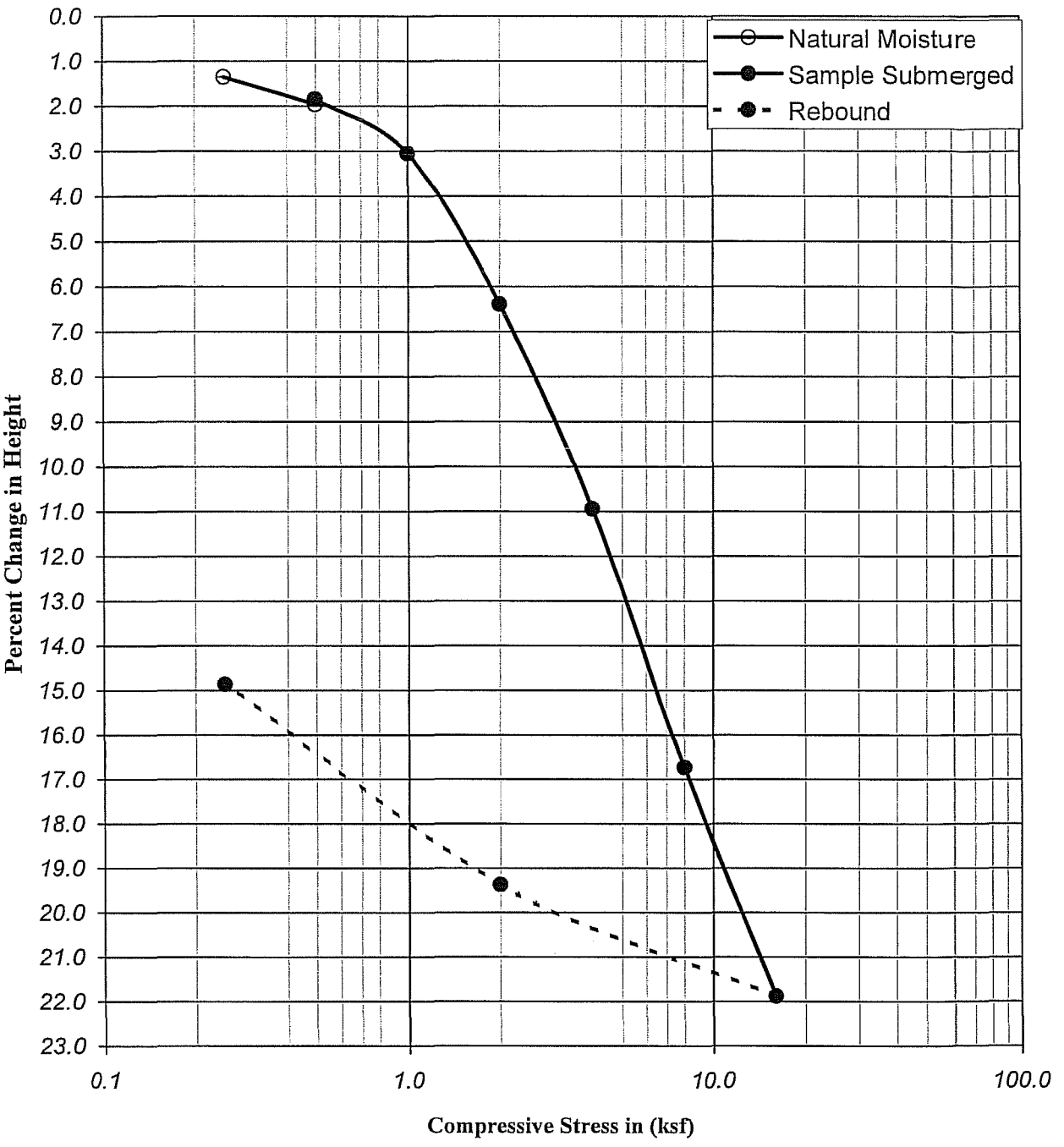
	Before	After
Weight of wet soil + ring (gm)	172.47	
Weight of ring (gm)	44.21	
Weight of wet soil + ring + container (gm)		220.58
Weight of dry soil + ring + container (gm)		186.69
No. 93 Weight of container (gm)		58.81
Weight of ring + container (gm)		103.02
Moisture Content (%)	53.29	40.50
Dial Reading (inch)	0.05	0.04
Sample Volume (ft³)	0.0027	0.0023
Wet Density (pcf)	106.2	115.2
Dry Density (pcf)	69.30	81.96

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04410	1.12		
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	
12/4/2009	8:10	0:00:00	0.25	12.0	0.06350	1.61	1.35	
12/5/2009	9:44	0:00:00	0.50	23.9	0.06960	1.77	1.96	
			Add Water					
12/6/2009	8:40	0:00:00	0.50	23.9	0.06840	1.74	1.84	
12/6/2009	8:43	0:00:00	1.00	47.9	0.06840	1.74	1.84	0.00
		0.10	1.0	47.9	0.06990	1.78	1.99	0.32
		0.25	1.0	47.9	0.07050	1.79	2.05	0.50
		0.50	1.0	47.9	0.0711	1.81	2.11	0.71
		1	1.0	47.9	0.07200	1.83	2.20	1.00
		2	1.0	47.9	0.07310	1.86	2.31	1.41
		4	1.0	47.9	0.07420	1.88	2.42	2.00
		8	1.0	47.9	0.07530	1.91	2.53	2.83
		15	1.0	47.9	0.07610	1.93	2.61	3.87
		30	1.0	47.9	0.07680	1.95	2.68	5.48
		60	1.0	47.9	0.07750	1.97	2.75	7.75
		120	1.0	47.9	0.07820	1.99	2.82	10.95
		240	1.0	47.9	0.07890	2.00	2.89	15.49
		480	1.0	47.9	0.07960	2.02	2.96	21.91
12/7/2009		1440	1.0	47.9	0.08050	2.04	3.05	37.95
12/8/2009	8:28	0	2.0	95.8	0.11390	2.89	6.39	
12/8/2009	8:29	0	4.0	191.5	0.1139	2.89	6.39	
		0.10	4.0	191.5	0.1200	3.05	7.00	
		0.25	4.0	191.5	0.1217	3.09	7.17	
		0.50	4.0	191.5	0.1248	3.17	7.48	
		1	4.0	191.5	0.1267	3.22	7.67	
		2	4.0	191.5	0.1312	3.33	8.12	
		4	4.0	191.5	0.1355	3.44	8.55	
		8	4.0	191.5	0.1403	3.56	9.03	
		15	4.0	191.5	0.1446	3.67	9.46	
		30	4.0	191.5	0.1472	3.74	9.72	
		60	4.0	191.5	0.1495	3.80	9.95	
		120	4.0	191.5	0.1518	3.86	10.18	
		240	4.0	191.5	0.1545	3.92	10.45	
		480	4.0	191.5	0.1575	4.00	10.75	
12/09/09		1440	4.0	191.5	0.1594	4.05	10.94	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.2173	5.52	16.73
12/11/2009	8:23		16.00	766.1	0.2688	6.83	21.88
12/12/2009	8:40		2.00	95.8	0.2437	6.19	19.37
12/13/2009	9:15		0.25	12.0	0.1986	5.04	14.86

Remark

Final Dial Reading 0.1986



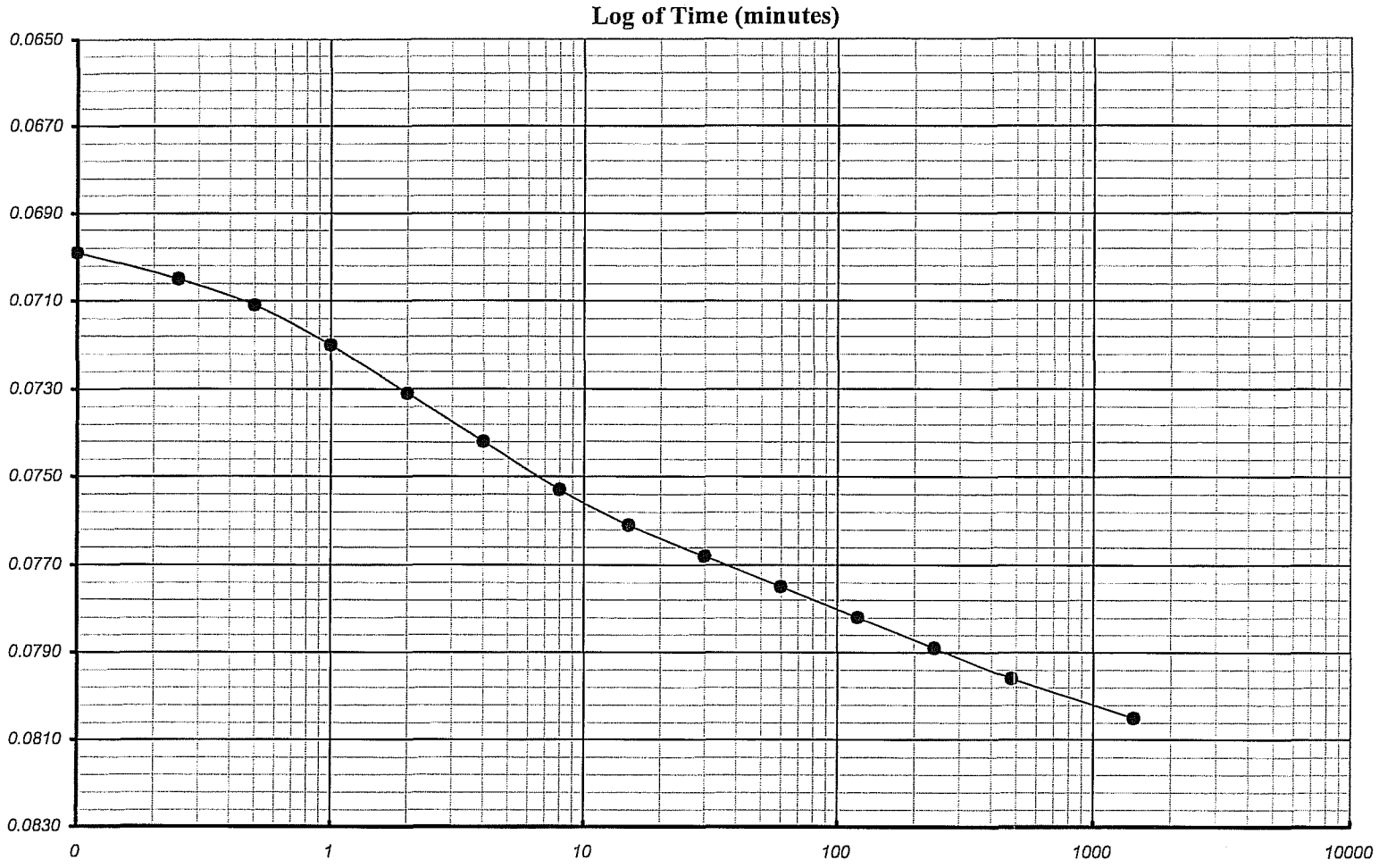
Boring No.	: A-09-056		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-2		Plastic Limit :	-						
Depth (ft)	: 10.0	11.5	Plastic Index :	-	Initial	53.29	69.30	10.91	100.45	1.43
Depth (m)	: 3.05	3.51	Specific Gravity :	2.70	Final	40.50	81.96	12.90	103.50	1.06
Description	: Dark gray, SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

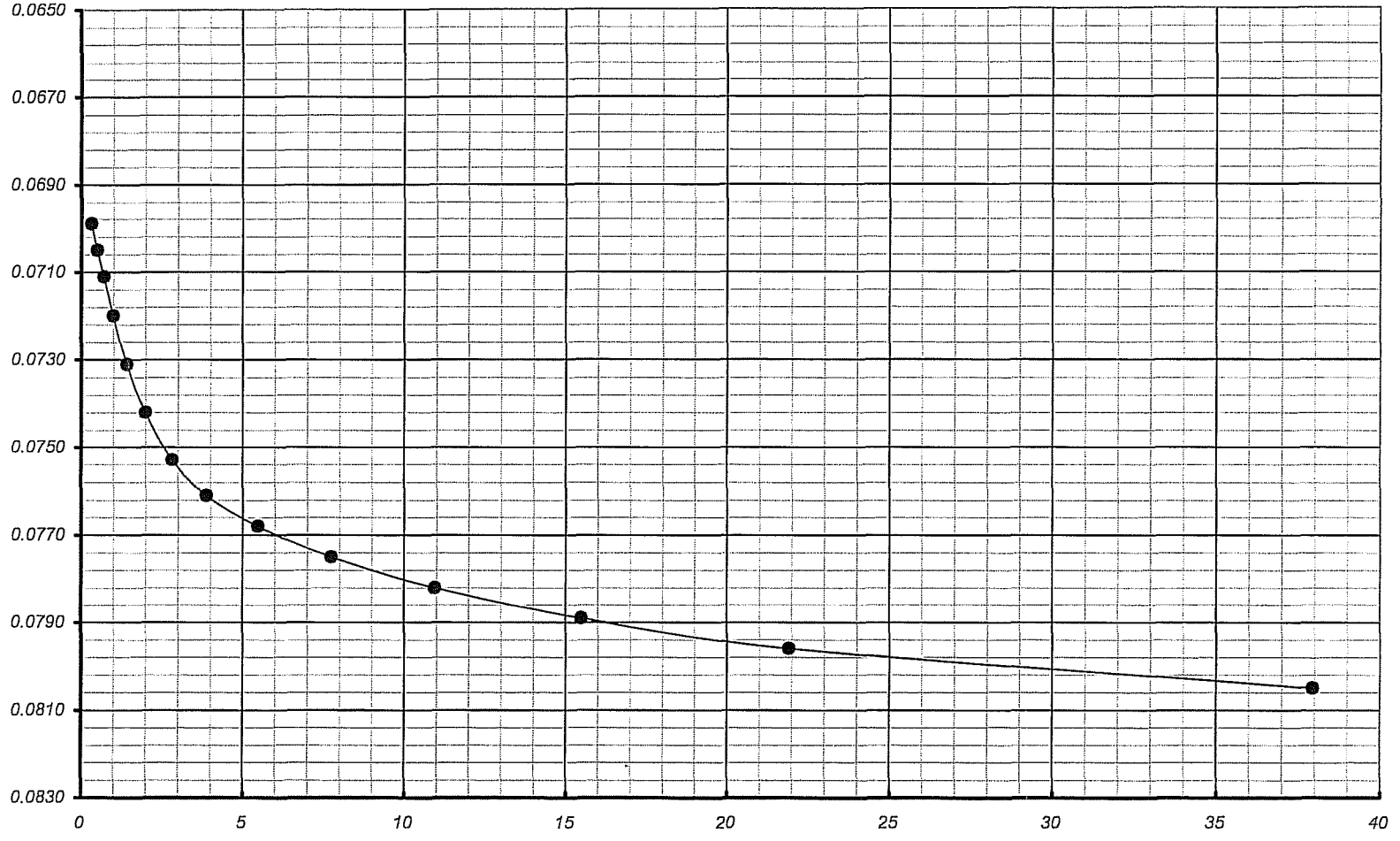
Project No. : 06-123-3 12/09/09

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

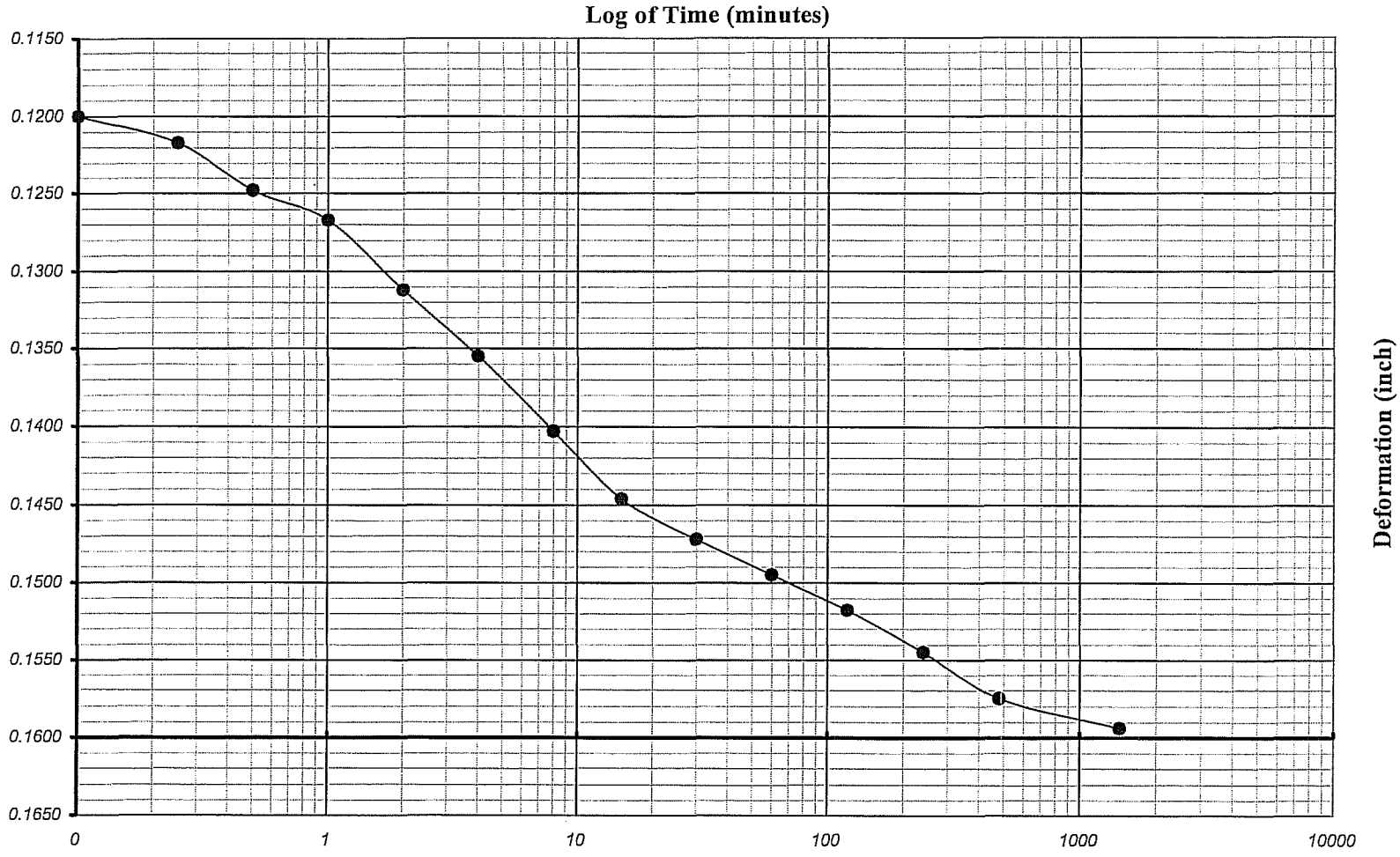


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-2*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *10.0* *3.1*	Veritcal Load (ksf/kpa) : *1.00* *47.9*

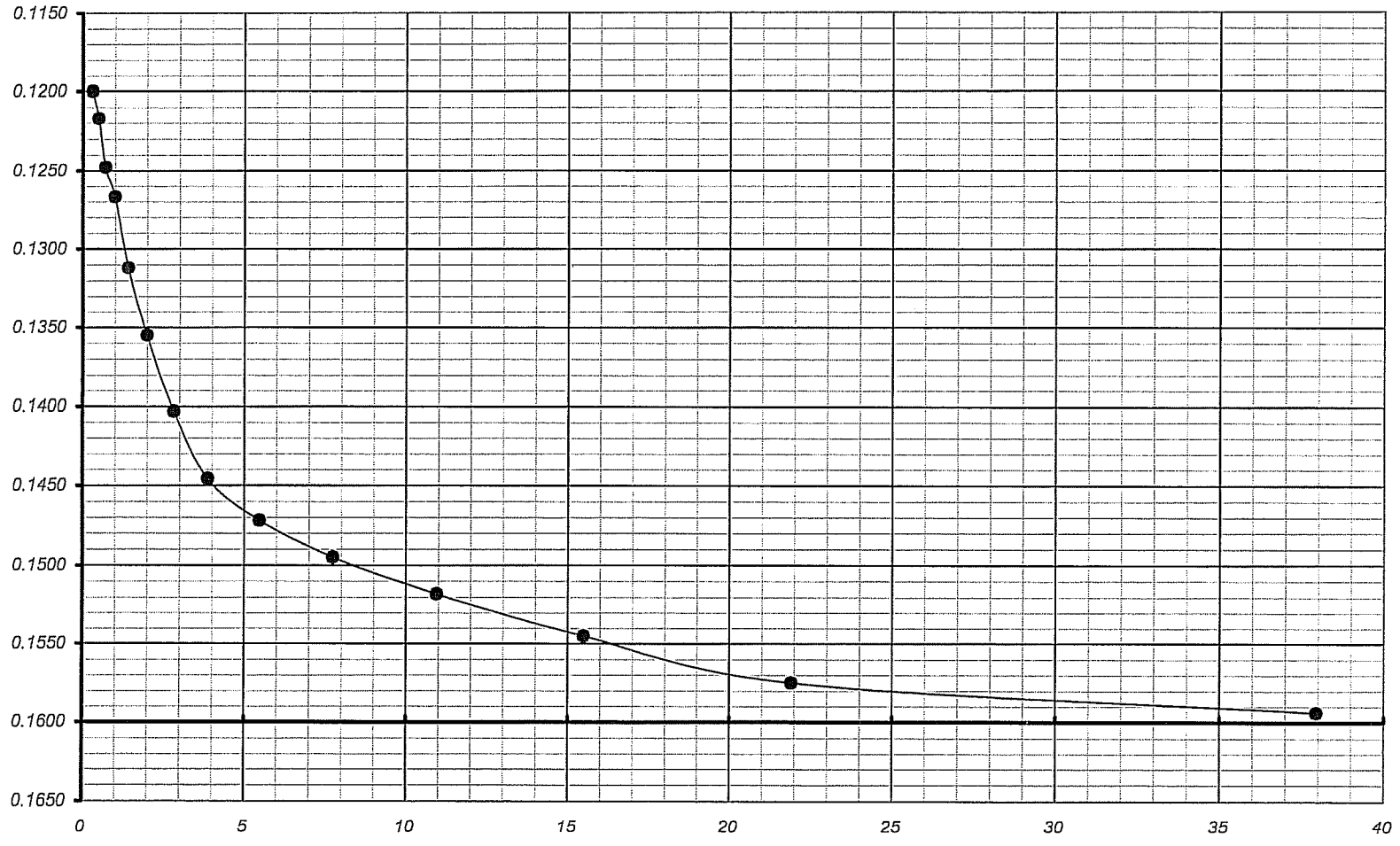
Square Root of Time (minutes)



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-056	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : D-2	
EMI Project No. : 06-123-3		Depth (ft/m) : 10.0 3.1	Veritcal Load (ksf/kpa) : 1.0 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-056	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-2	
EMI Project No. : 06-123-3		Depth (ft/m) : 10.0 3.1	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-2*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *10.0* *3.1*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 2

Project Name : *ACTA/Schuyler Heim Bridge Project*
Project No. : *06-123-3*
Boring No. : *A-09-056*
Sample No. : *D-4*
Depth (ft / m) : *20.0* | *6.10*
File No. :
Soil Description : *Dark gray, SILTY SAND (SM)*

Set up By : *J.F* Date : *12/3/2009*
Tested By : *J.F/R.J.* Date : *12/3/09-12/13/09*
Time Rate Took By : *J.F* Date : *12/6/09,12/8/09*
Computer By : *JF* Date : *12/9/2009*
Checked By : *R.J.* Date :

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.
Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9728	24.71	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

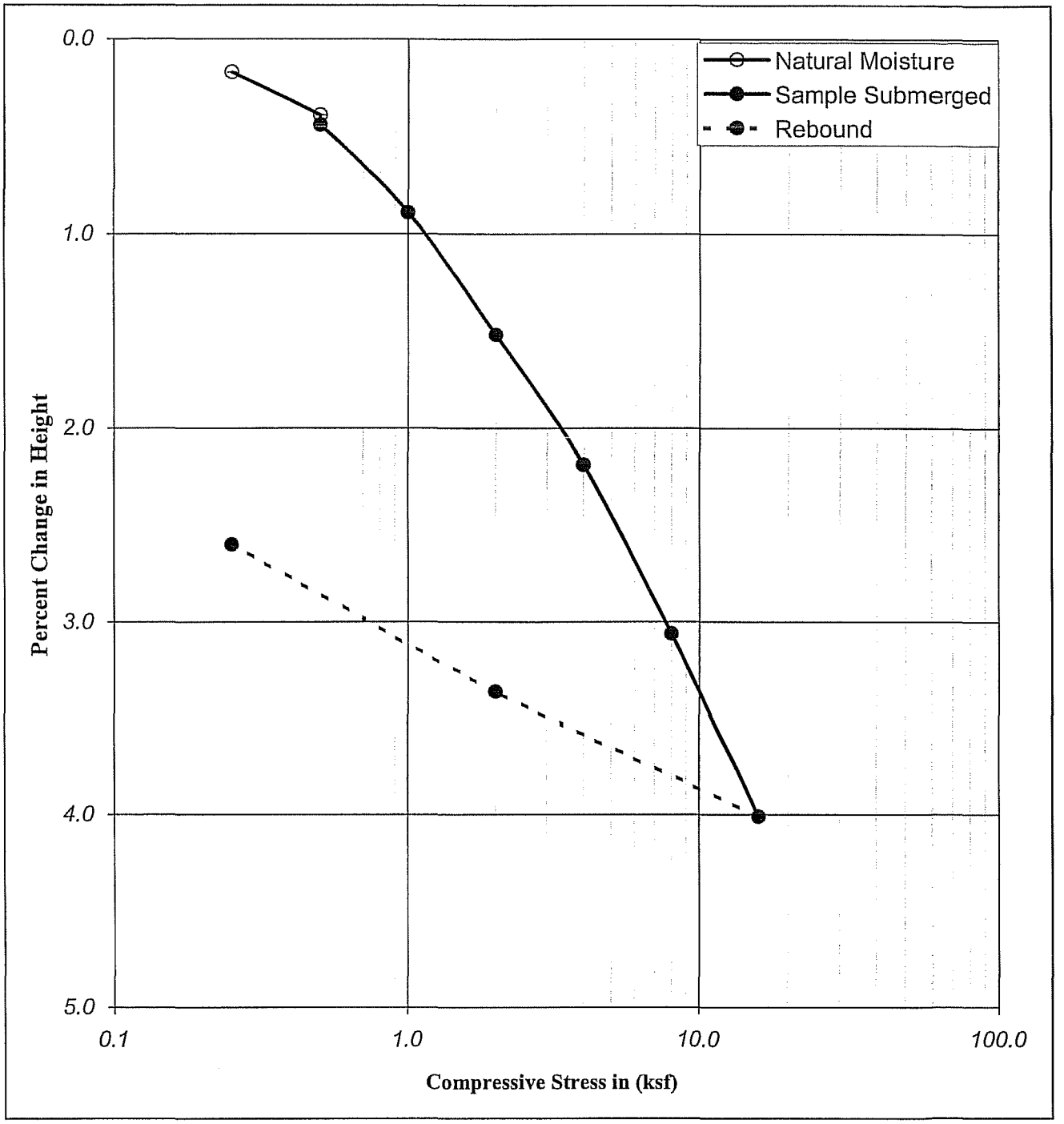
			Before	After
Weight of wet soil + ring (gm)			193.90	
Weight of ring (gm)			45.94	
Weight of wet soil + ring + container (gm)				252.92
Weight of dry soil + ring + container (gm)				220.84
No. 84	Weight of container (gm)			60.33
	Weight of ring + container (gm)			106.27
	Moisture Content (%)		29.14	28.00
	Dial Reading (inch)		0.05	0.04
	Sample Volume (ft³)		0.0027	0.0026
	Wet Density (pcf)		122.5	124.9
	Dry Density (pcf)		94.89	97.54

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04880	1.24		
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	
12/4/2009	8:10	0:00:00	0.25	12.0	0.05170	1.31	0.17	
12/5/2009	9:44	0:00:00	0.50	23.9	0.05390	1.37	0.39	
			Add Water					
12/6/2009	8:40	0:00:00	0.50	23.9	0.05440	1.38	0.44	
12/6/2009	8:43	0:00:00	1.00	47.9	0.05440	1.38	0.44	0.00
		0.10	1.0	47.9	0.05720	1.45	0.72	0.32
		0.25	1.0	47.9	0.05730	1.46	0.73	0.50
		0.50	1.0	47.9	0.0574	1.46	0.74	0.71
		1	1.0	47.9	0.05750	1.46	0.75	1.00
		2	1.0	47.9	0.05760	1.46	0.76	1.41
		4	1.0	47.9	0.05770	1.47	0.77	2.00
		8	1.0	47.9	0.05790	1.47	0.79	2.83
		15	1.0	47.9	0.05800	1.47	0.80	3.87
		30	1.0	47.9	0.05810	1.48	0.81	5.48
		60	1.0	47.9	0.05820	1.48	0.82	7.75
		120	1.0	47.9	0.05840	1.48	0.84	10.95
		240	1.0	47.9	0.05850	1.49	0.85	15.49
		480	1.0	47.9	0.05870	1.49	0.87	21.91
12/7/2009		1440	1.0	47.9	0.05890	1.50	0.89	37.95
12/8/2009	8:28	0	2.0	95.8	0.06520	1.66	1.52	
12/8/2009	8:29	0	4.0	191.5	0.0652	1.66	1.52	
		0.10	4.0	191.5	0.0697	1.77	1.97	
		0.25	4.0	191.5	0.0698	1.77	1.98	
		0.50	4.0	191.5	0.0700	1.78	2.00	
		1	4.0	191.5	0.0701	1.78	2.01	
		2	4.0	191.5	0.0702	1.78	2.02	
		4	4.0	191.5	0.0703	1.79	2.03	
		8	4.0	191.5	0.0705	1.79	2.05	
		15	4.0	191.5	0.0706	1.79	2.06	
		30	4.0	191.5	0.0708	1.80	2.08	
		60	4.0	191.5	0.0709	1.80	2.09	
		120	4.0	191.5	0.0712	1.81	2.12	
		240	4.0	191.5	0.0714	1.81	2.14	
		480	4.0	191.5	0.0717	1.82	2.17	
12/09/09		1440	4.0	191.5	0.0719	1.83	2.19	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.0806	2.05	3.06
12/11/2009	8:23		16.00	766.1	0.0901	2.29	4.01
12/12/2009	8:40		2.00	95.8	0.0836	2.12	3.36
12/13/2009	9:15		0.25	12.0	0.0760	1.93	2.60

Remark

Final Dial Reading 0.0760



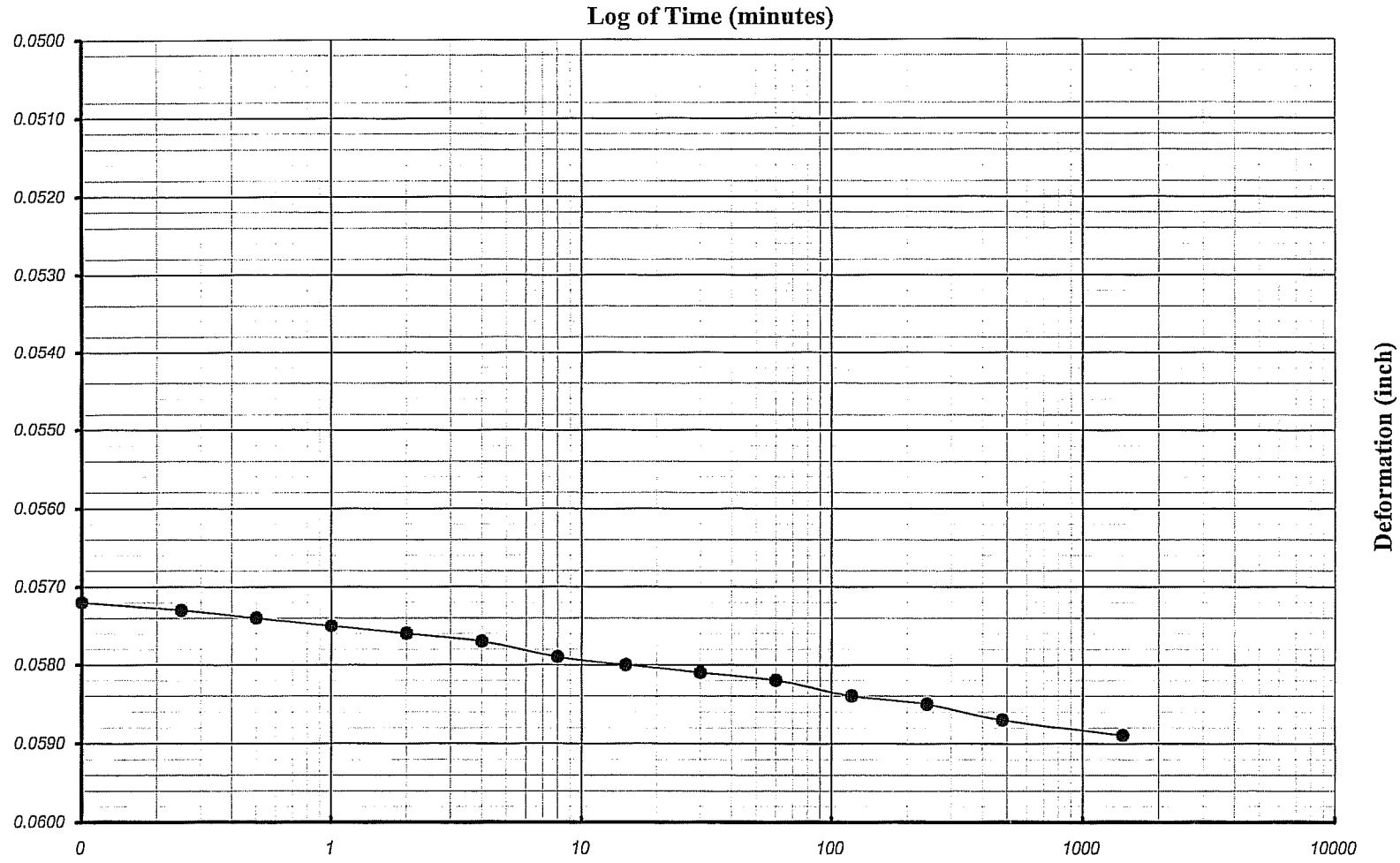
Boring No.		: A-09-056		Liquid Limit :	-		Moisture Content (%)	Dry Density		Percent Saturation	Void Ratio
Sample No.		: D-4		Plastic Limit :	-			(pcf)	(kN/m³)		
Depth	(ft)	: 20.0	21.5	Plastic Index :	-	Initial	29.14	94.89	14.94	101.35	0.78
	(m)	: 6.10	6.56	Specific Gravity :	2.70	Final	28.00	97.54	15.35	103.84	0.73
Description		: Dark gray, SILTY SAND (SM)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

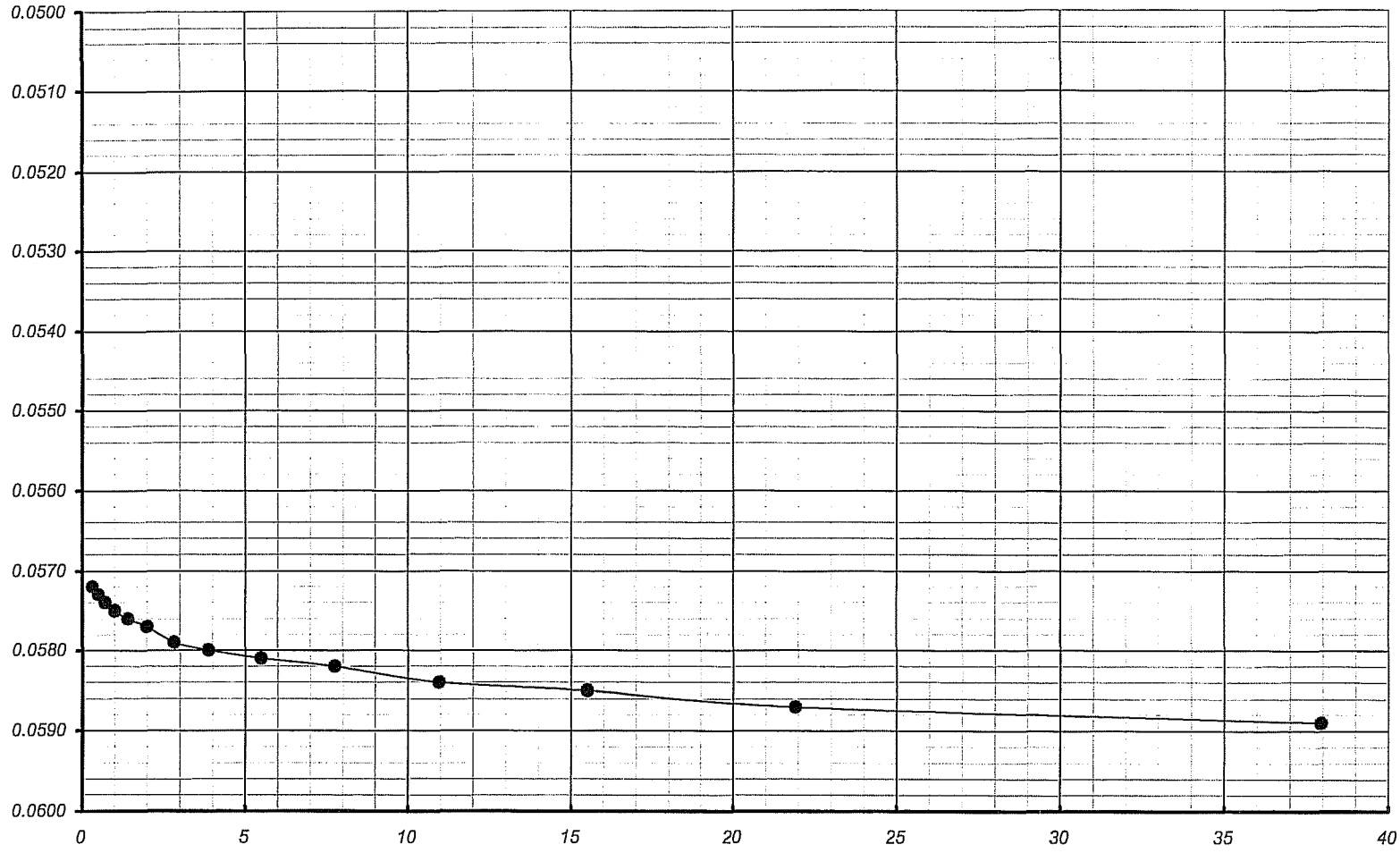
Project No. : 06-123-3 12/09/09

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

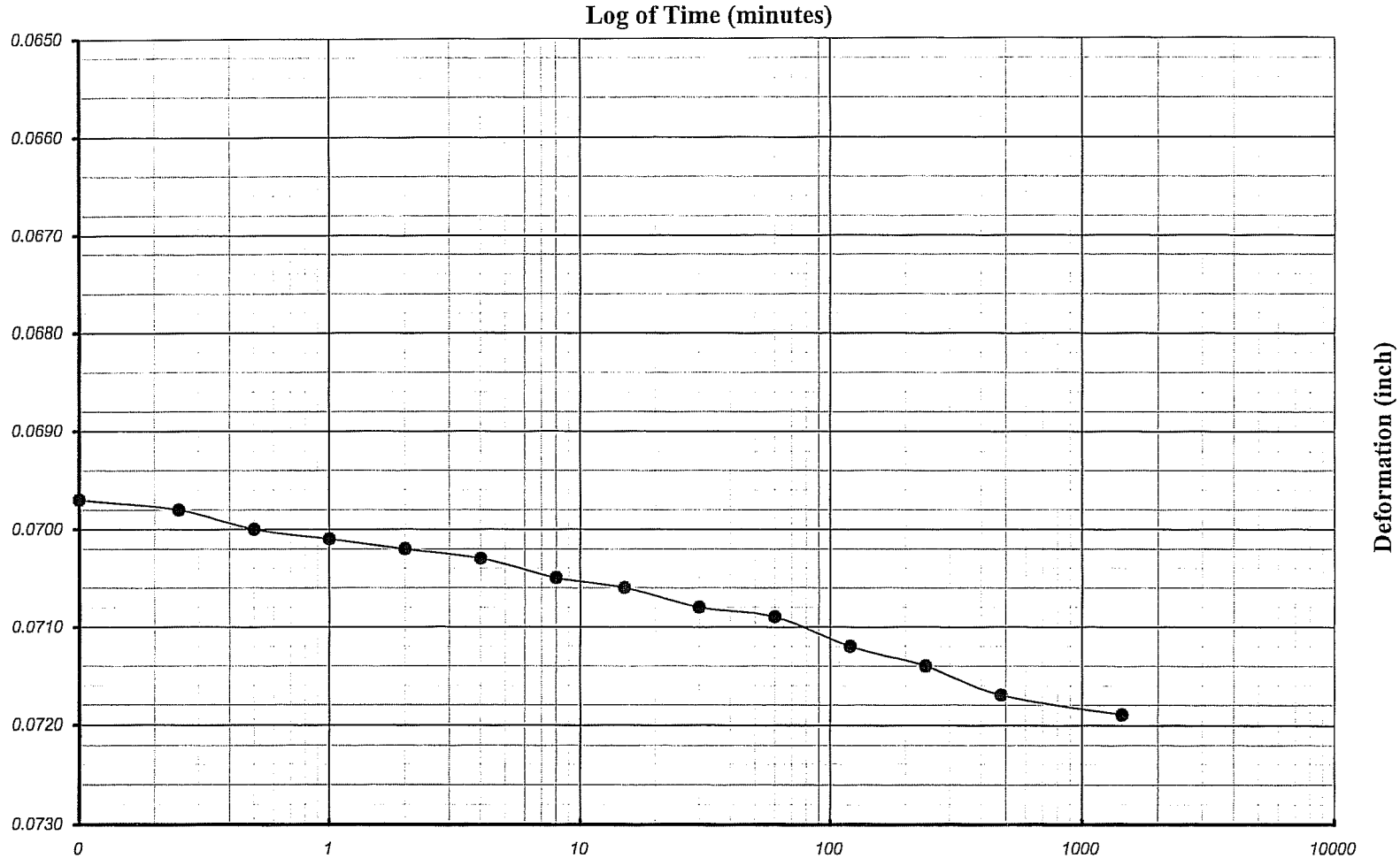


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-056	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 | 6.1	Veritcal Load (ksf/kpa) : 1.00 47.9

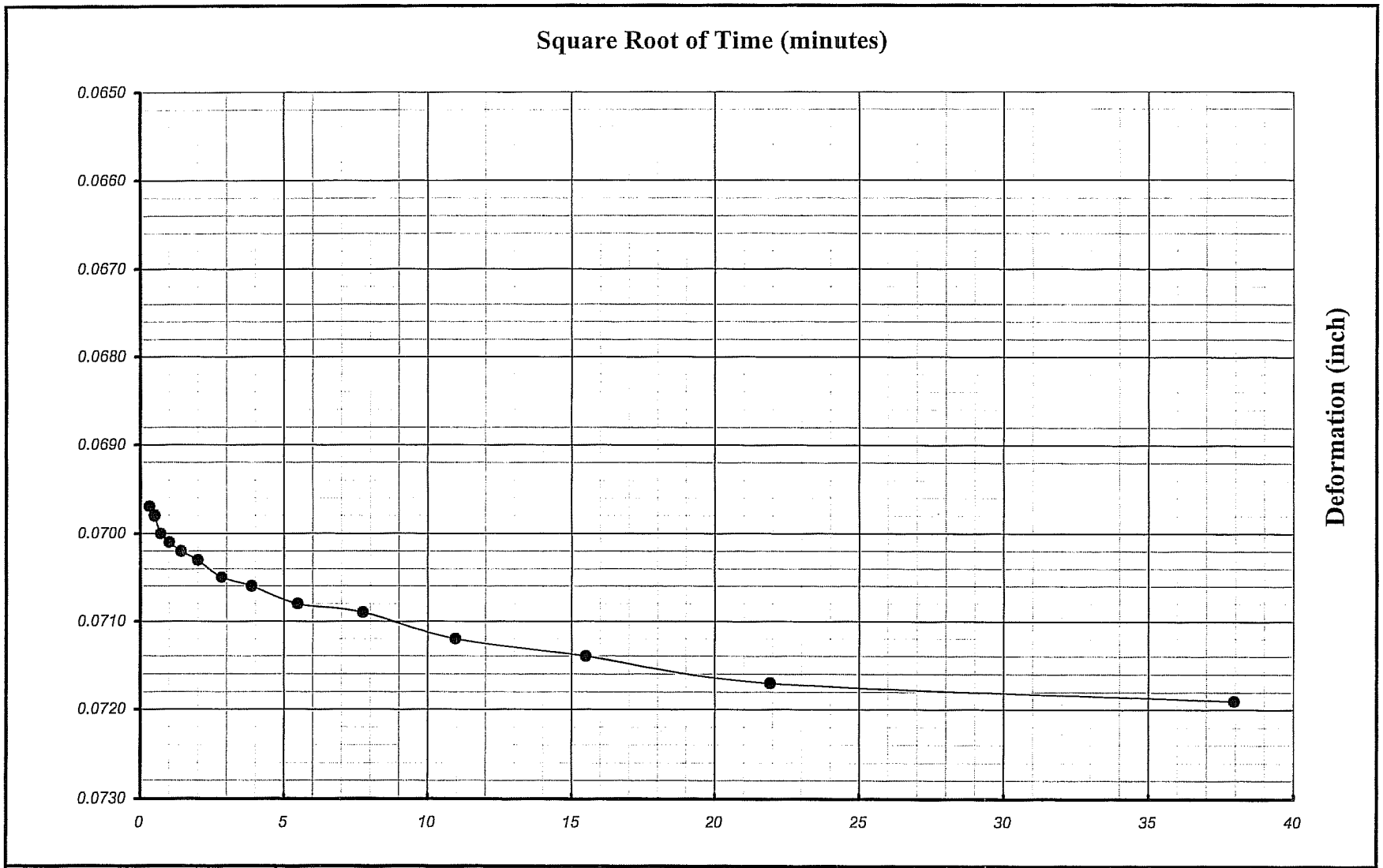
Square Root of Time (minutes)



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-056	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 6.1	Veritcal Load (ksf/kpa) : 1.0 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	**One-Dimensional Consolidation of Soil** **Time-Deformation Curve (Log of Time Method)**
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		**Depth** (ft/m) : *20.0* *6.1*	**Veritcal Load (ksf/kpa) :** *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-056*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve(Square Root of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* *6.1*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

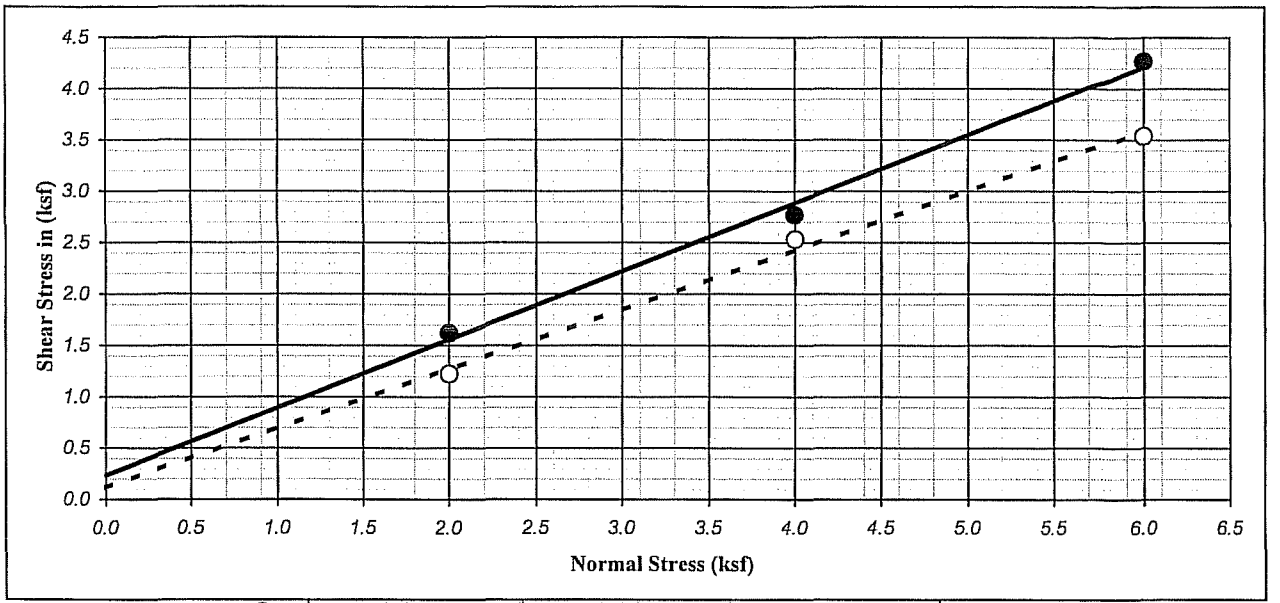
Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-056		Saturated		Field Moisiture	X	Inundated		**Specific Gravity** (Assumed) :	2.70
Sample No. : D-6	X	Undisturbed		Remolded		Consolidated-Drained		**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 30.0	x	Shear Once		Reshear		Residual		**Data File Number :**	0612309
Description : Gray, Poorly graded SAND with SILT (SP-SM)									

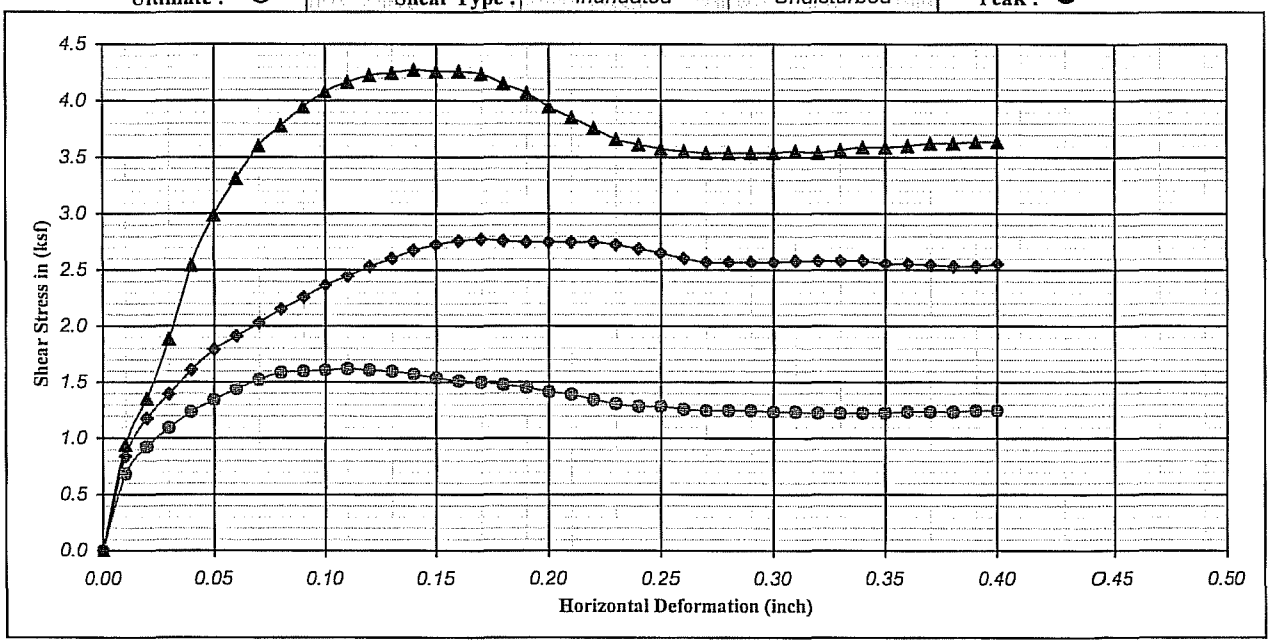
Percent Saturation (%)	98.94		**File No. :** 0612309	1																
Prepared By : JF	**Date :** 11/30/09		**Normal Stress**																	
Tested By : JF	**Date :** 11/30/09																			
Computed By : JF	**Date :** 12/11/09		**2.00**	(ksf)																
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		192.35																		
Weight of Ring (gm)		43.45																		
Weight of Wet Soil + Cont. (gm)			149.74																	
Weight of Dry Soil + Cont. (gm)			118.75																	
Weight of Cont. (gm) **No.**	7		3.67																	
Moisture Content (%)			26.93																	
Wet Density (pcf / kN/m^3)		123.32	19.41																	
Dry Density (pcf / kN/m^3)		97.16	15.29																	
Percent Saturation (%)	99.59		**File No. :** 0612309	2																
Prepared By : JF	**Date :** 11/30/09		**Normal Stress**																	
Tested By : JF	**Date :** 11/30/09		**4.00**	(ksf)																
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		198.03																		
Weight of Ring (gm)		46.92																		
Weight of Wet Soil + Cont. (gm)			153.44																	
Weight of Dry Soil + Cont. (gm)			123.08																	
Weight of Cont. (gm) **No.**	8		3.66																	
Moisture Content (%)			25.42																	
Wet Density (pcf / kN/m^3)		125.15	19.70																	
Dry Density (pcf / kN/m^3)		99.79	15.71																	
Percent Saturation (%)	101.13		**File No. :** 0612309	3																
Prepared By : JF	**Date :** 11/30/09		**Normal Stress**																	
Tested By : JF	**Date :** 11/30/09		**6.00**	(ksf)																
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		201.08																		
Weight of Ring (gm)		47.03																		
Weight of Wet Soil + Cont. (gm)			156.49																	
Weight of Dry Soil + Cont. (gm)			127.10																	
Weight of Cont. (gm) **No.**	9		3.67																	
Moisture Content (%)			23.81																	
Wet Density (pcf / kN/m^3)		127.59	20.08																	
Dry Density (pcf / kN/m^3)		103.05	16.22																	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.62	77.57	2.77	132.72	4.27	204.54
Ultimate	1.22	58.61	2.53	121.23	3.54	169.50

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)**								
		2000	2.00	95.8	4000	4.0	191.5	6000	6.0	287.3
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	684	0.68	32.7	840	0.84	40.2	940	0.94	44.8
0.020	0.05	924	0.92	44.2	1176	1.18	56.3	1352	1.35	64.5
0.030	0.08	1092	1.09	52.3	1392	1.39	66.6	1884	1.88	89.9
0.040	0.10	1236	1.24	59.2	1608	1.61	77.0	2544	2.54	121.4
0.050	0.13	1344	1.34	64.4	1788	1.79	85.6	2988	2.99	142.5
0.060	0.15	1440	1.44	68.9	1908	1.91	91.4	3312	3.31	158.0
0.070	0.18	1524	1.52	73.0	2028	2.03	97.1	3600	3.60	171.7
0.080	0.20	1584	1.58	75.8	2148	2.15	102.8	3780	3.78	180.3
0.090	0.23	1596	1.60	76.4	2256	2.26	108.0	3948	3.95	188.3
0.100	0.25	1608	1.61	77.0	2364	2.36	113.2	4080	4.08	194.6
0.110	0.28	1620	1.62	77.6	2448	2.45	117.2	4164	4.16	198.6
0.120	0.30	1608	1.61	77.0	2532	2.53	121.2	4224	4.22	201.5
0.130	0.33	1596	1.60	76.4	2604	2.60	124.7	4248	4.25	202.6
0.140	0.36	1572	1.57	75.3	2676	2.68	128.1	4272	4.27	203.8
0.150	0.38	1536	1.54	73.5	2724	2.72	130.4	4260	4.26	203.2
0.160	0.41	1512	1.51	72.4	2760	2.76	132.1	4260	4.26	203.2
0.170	0.43	1500	1.50	71.8	2772	2.77	132.7	4236	4.24	202.1
0.180	0.46	1476	1.48	70.7	2760	2.76	132.1	4152	4.15	198.1
0.190	0.48	1452	1.45	69.5	2748	2.75	131.6	4068	4.07	194.1
0.200	0.51	1416	1.42	67.8	2748	2.75	131.6	3948	3.95	188.3
0.210	0.53	1392	1.39	66.6	2748	2.75	131.6	3852	3.85	183.7
0.220	0.56	1344	1.34	64.4	2748	2.75	131.6	3756	3.76	179.2
0.230	0.58	1308	1.31	62.6	2724	2.72	130.4	3660	3.66	174.6
0.240	0.61	1284	1.28	61.5	2688	2.69	128.7	3612	3.61	172.3
0.250	0.64	1284	1.28	61.5	2652	2.65	127.0	3576	3.58	170.6
0.260	0.66	1260	1.26	60.3	2604	2.60	124.7	3552	3.55	169.4
0.270	0.69	1248	1.25	59.8	2568	2.57	123.0	3540	3.54	168.9
0.280	0.71	1248	1.25	59.8	2568	2.57	123.0	3540	3.54	168.9
0.290	0.74	1248	1.25	59.8	2568	2.57	123.0	3540	3.54	168.9
0.300	0.76	1236	1.24	59.2	2568	2.57	123.0	3540	3.54	168.9
0.310	0.79	1236	1.24	59.2	2580	2.58	123.5	3552	3.55	169.4
0.320	0.81	1224	1.22	58.6	2580	2.58	123.5	3540	3.54	168.9
0.330	0.84	1224	1.22	58.6	2580	2.58	123.5	3564	3.56	170.0
0.340	0.86	1224	1.22	58.6	2580	2.58	123.5	3588	3.59	171.2
0.350	0.89	1224	1.22	58.6	2556	2.56	122.4	3588	3.59	171.2
0.360	0.91	1236	1.24	59.2	2556	2.56	122.4	3600	3.60	171.7
0.370	0.94	1236	1.24	59.2	2544	2.54	121.8	3624	3.62	172.9
0.380	0.97	1236	1.24	59.2	2532	2.53	121.2	3624	3.62	172.9
0.390	0.99	1248	1.25	59.8	2532	2.53	121.2	3636	3.64	173.4
0.400	1.02	1248	1.25	59.8	2556	2.56	122.4	3636	3.64	173.4
	0.00									
	0.00									
	0.00									
	0.00									
	0.00									



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-056		Strength Intercept (C) :	0.24	(ksf)	Peak	0.12	(ksf)	Ultimate
Sample No. : D-6			11.30	(kPa)		5.55	(kPa)	
Depth (ft/m) : 30.0	0.00	Friction Angle (ϕ) :	33.54	Degree		30.07	Degree	
Description : Gray, Poorly graded SAND with SILT (SP-SM)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	26.93	97.16	15.29	0.73	2.00	95.76	1.62	77.57	1.22	58.61
◆	25.42	99.79	15.71	0.69	4.00	191.52	2.77	132.72	2.53	121.23
▲	23.81	103.05	16.22	0.64	6.00	287.28	4.27	204.54	3.54	169.50

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

MEASUREMENT OF SOIL CORROSIVITY

Project No. : 06-123-3	Project Name : ACTA/Schuyler Heim Bridge Project		
Boring No. : A-09-056	Depth (ft/m) : 5.00		1.53
Sample No. : S-1	Description : Olive, SILTY SAND (SM)		

*** Sample for Corrosivity tests must screen through No. 8 Sieve

Measurement of Soil Resistivity (ASTM G-57-78 / CT- 643)

Test Standard	ASTM	X	CAL. TRAN.	Wt of Wet Soil + Cont. (gm)		118.91	Weight of Total
Soil Box Diamension (cm)	22.86 X 3.81 X 2.54		15.31 X 10.04 X4.41	Wt of Dry Soil + Cont. (gm)		111.34	Sample for Test (gm)
(L X W X H) / (inch)	9.0 X 1.5 X 1.0		6.04X 3.95 X 1.74	Wt. of Cont. No.	3	58.47	100.19
Soil Box Constant (C)	1.0		6.72	Setup Moisture Content (%)		14.32	

Trial	Resistivity Meter Reading (ohm-cm)					
	As received	1	2	3	4	5
Water added	0.0	5.00	5.00	5.00	5.00	5.00
Meter reading	2200	1000	990	720	670	680
Resistivity	2200.0	1000.0	990.0	720.0	670.0	680.0

Prepared By : PA	Date : 12/14/09
Tested By : PA	Date : 12/15/09
Calculated By : JF	Date : 12/17/09
Checked By :	Date :
Minimum Resistivity :	670.0

Measurement of Soil pH (ASTM G-51-77 / CT- 643)

Weight 30 gm soil sample and add 30 ml distilled water, stir to a soil slurry and settle at least 1 hr.

Prepared By :	Date : 12/14/09	Time : 14:40	Beaker No. :	40	
Tested By :	Date : 12/15/09	Weigh of Wetsoil (gm)		30.01	
Calculated By :	Date : 12/17/09	Distilled Water added (ml)		30.03	
Checked By :	Date :	Moisture Content (%)		14.32	

pH Reading				
Trial	1	2	3	Average
Test Time	13:46:00	13:48:00	13:50:00	
Reading	7.81	7.85	7.87	7.84

Measurement of Soil Soluble Sulfate Content (CT - 417)

Weight 100.0 gm of sample soil & add 300 ml. of distilled water. Stopper and shake well. Allow to settle overnight. Prepare two 30 (ml.) of water layer into a 150 (ml.) beaker, dilute to 100 (ml.), add 5 (ml.) conditioning reagent. Turbidity Blank - Adjust the stirrer to the maximum speed, add 1 spoonfull Barium Chloride & start timing. Stir for exactly 1 minute.

Flask No. : 3	Prepared By :	Date :	12/14/09
Weight of Soil (gm) : 100.01	Tested By :	Date :	12/15/09
Distilled Water (ml.) : 300.07	Calculated By :	Date :	12/17/09
Shaking at : 14:41:00	Checked By :	Date :	
Reshaking at :			

Total Water Sample Prepared	60.03	With BaCL		14	< Beaker Number >			15	Blank
Distilled Water added to (ml)	200.04			100.01	Tested Sample Volume			100.03	
Time Intervals	0:00:00	0:00:30	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:04:00	Maximum
With BaCL (time)	14:02:00	14:02:30	14:03:00	14:03:30	14:04:00	14:04:30	14:05:00	14:06:00	
Turbidity with BaCL (NTV)		335.00	333.00	333.00	332.00	332.00	332.00	331.00	335.00
Blank (time)	16:03:00	16:03:30	16:04:00	16:04:30	16:05:00	16:05:30	16:06:00	16:07:00	
Turbidity Blank (NTV)		46.40	41.00	34.40	29.40	28.50	27.40	24.90	46.40
Difference (ppm)		288.60	292.00	298.60	302.60	303.50	304.60	306.10	288.60
SO_4 (from graph) (ppm)									580

Measurement of Soil Chloride Content (CT - 422)

1. Weight 100.0 gm sample soil & add 300 ml. of distilled water. Stopper and shake vigorously for 20 seconds, reshaking after one hour and let it settle over night. 2. Pour 30 ml aliquot of filtered solution into a 150 ml beaker, then check pH. If pH is in the range 6 through 8, go to step 4. If ph below 6, add Sodium Hydroxide and if above 8, add Acetic Acid to adjust to the range. 4. Add two drops of Potassium Chromate solution before titrate with Silver Nitrate and change color from Yellow to Red. ** If the titration is over 30 ml., take a smaller sample. Dilute any smaller sample to about 50 ml..

Flask No. : 3	Prepared By :	Date :	12/14/09
Wt. of Soil (gm) : 100.01	Tested By :	Date :	12/15/09
Distilled Water (mL) : 300.07	Calculated By :	Date :	12/17/09
Shaking at : 14:41:00	Checked By :	Date :	
Reshaking at :	Vaccum & Filter at :		

Remark :

Titration of (I ml.) Sample Diluted to (F ml.)	15	< Beaker No.		24	>		
Total Sample Prepared : 60.09	Initial	Final	Total	Initial	Final	Total	
Sample Volume (ml)	30.04	30.04		30.05	30.05		
pH of Liquid Sample	7.84	7.84		7.84	7.84		
Sodium Hydroxide added (ml)	-	-	-	-	-	-	
Acetic Acid added (ml)	-	-	-	-	-	-	Average
Silver Nitrate added (ml)	5.00	9.60	4.60	9.60	14.20	4.60	
ppm CL= 100x(ml of Sil.Ni.-0.2 ml blank)*F/I			440.00			440.00	440.00
Moisture - Free CL = ppm CL X 100 / (100 - w)			513.53			513.53	514

APPENDIX D. SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

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Seungwoon Han, Ph. D., P. E. / Caltrans

COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
Lucien Hersh, P. E. / Alameda Corridor Transportation Authority
Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

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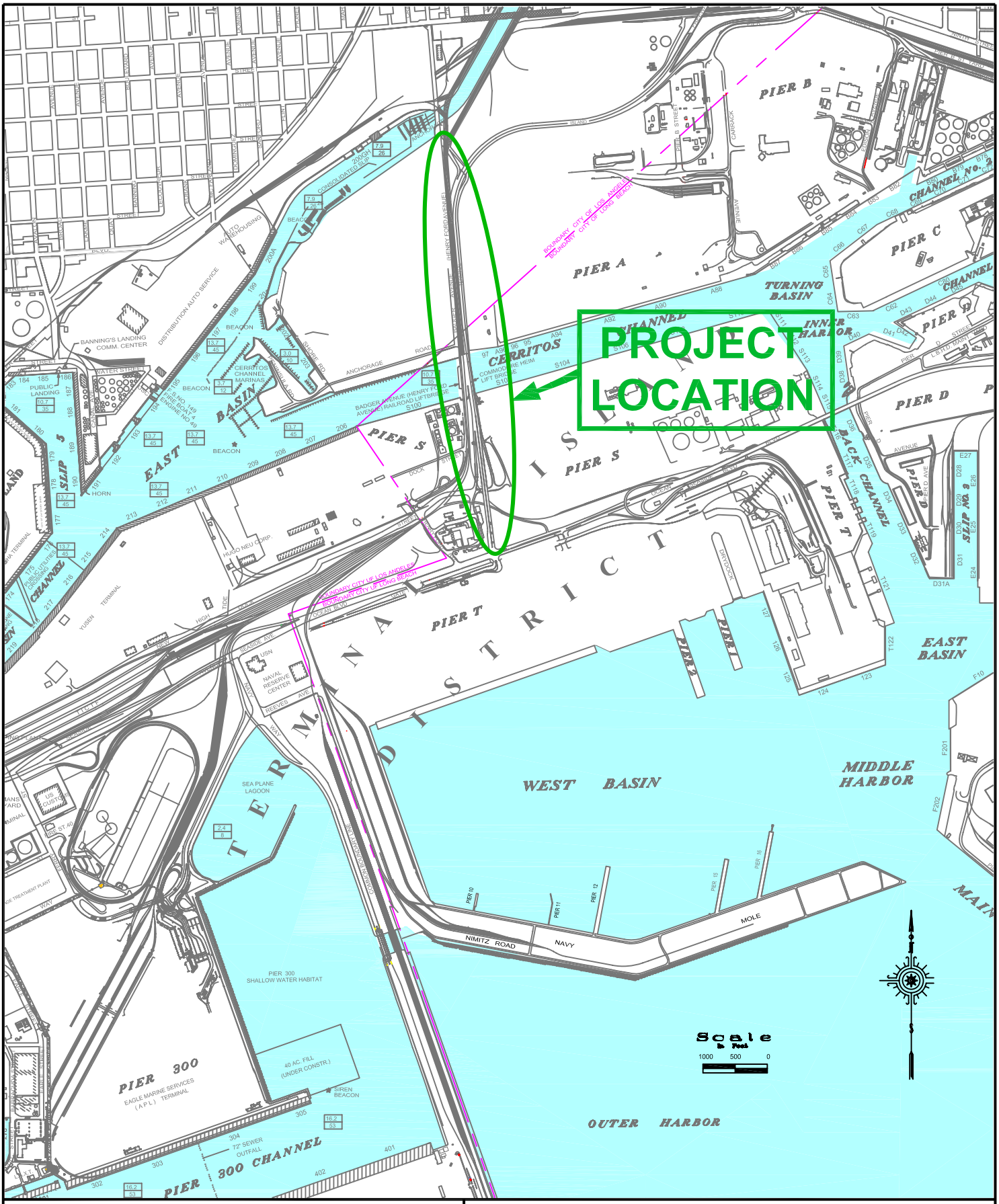

Earth Mechanics, Inc.
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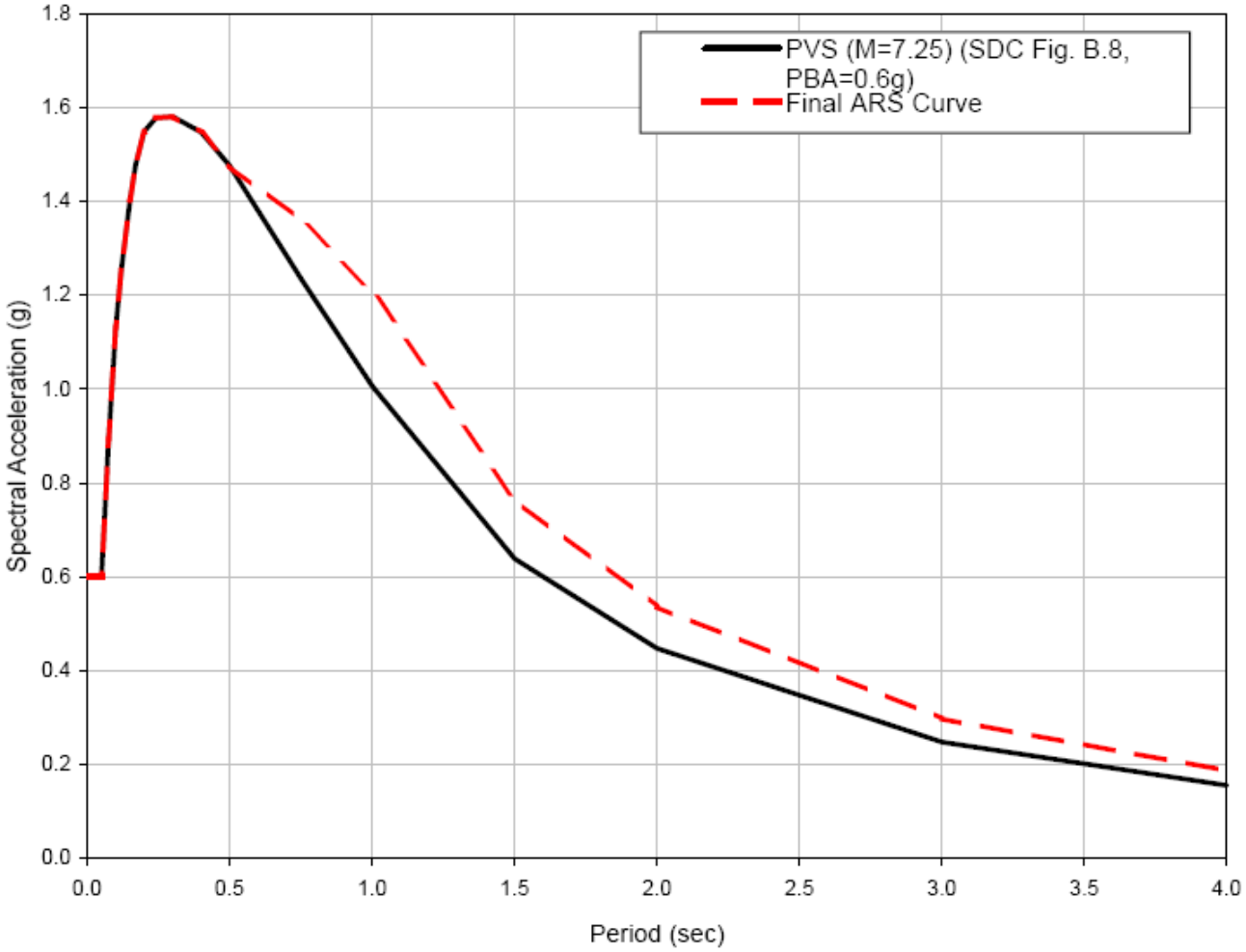
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

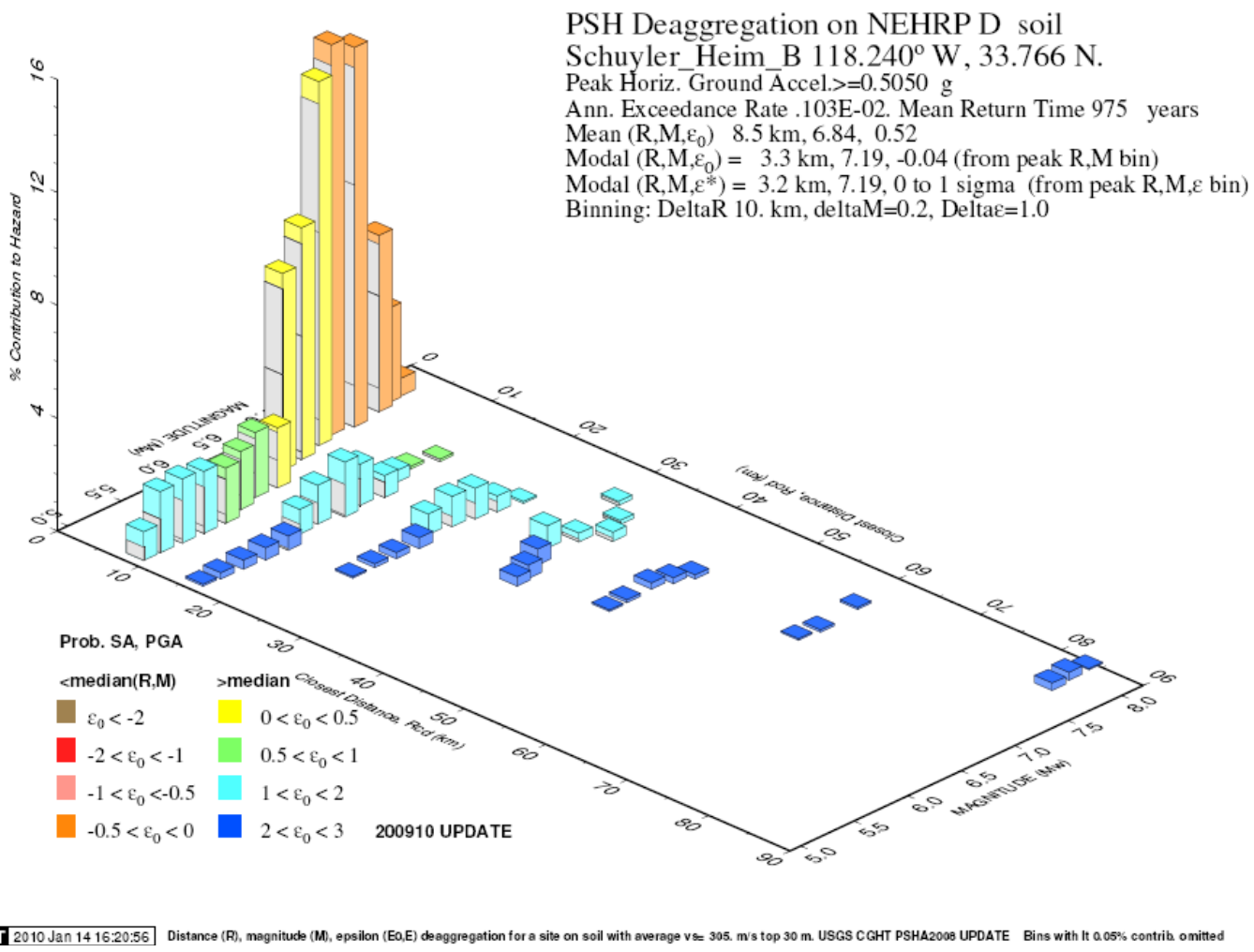


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

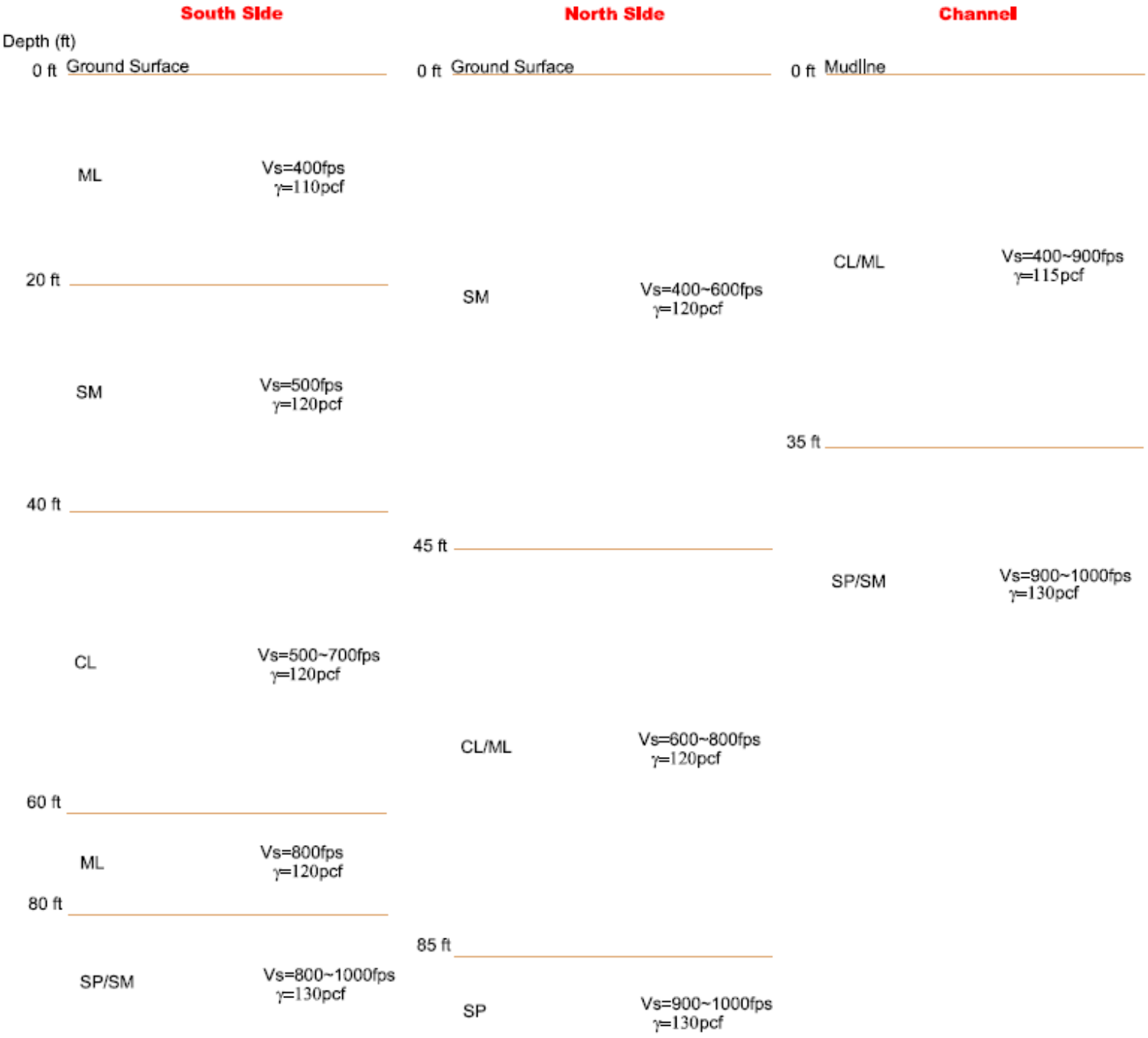
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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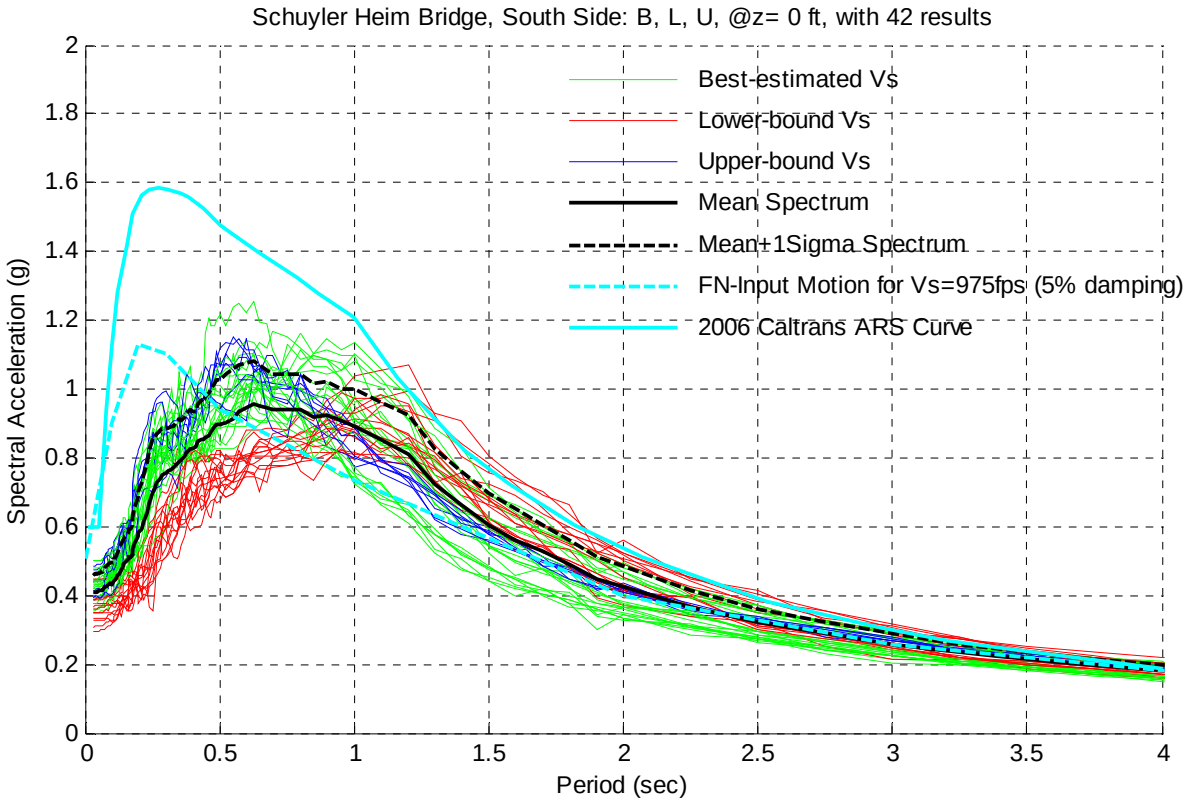
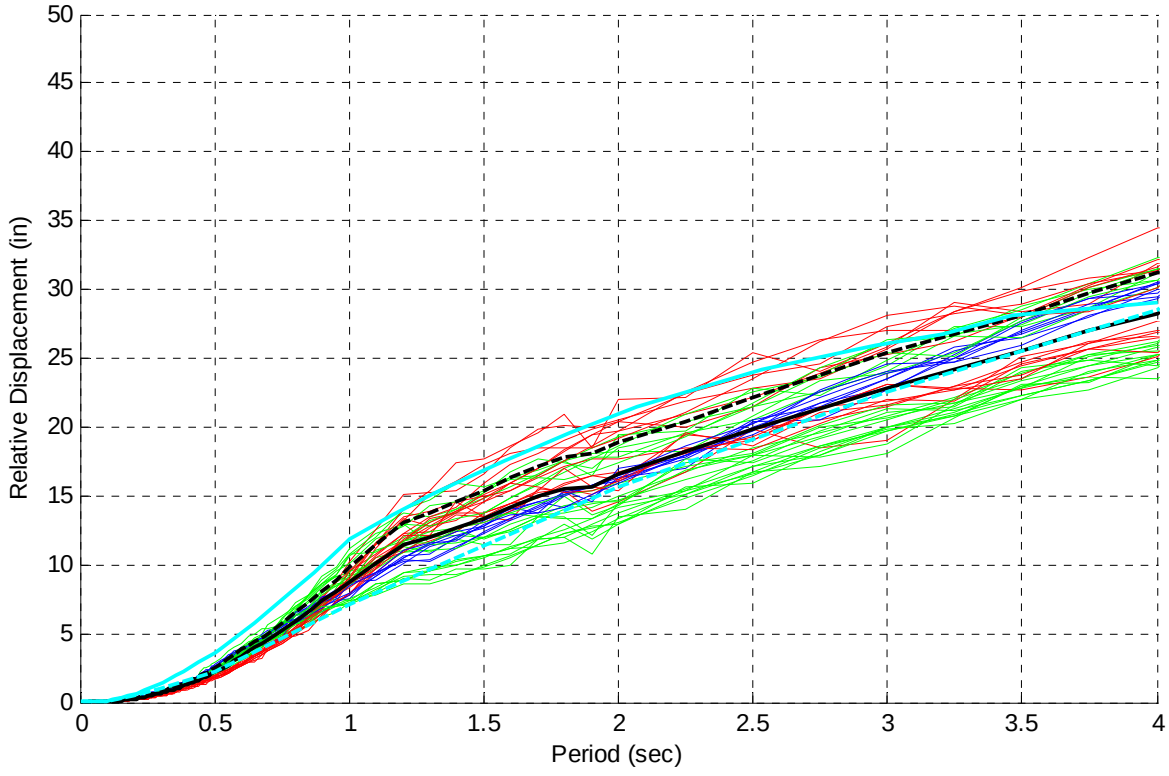
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





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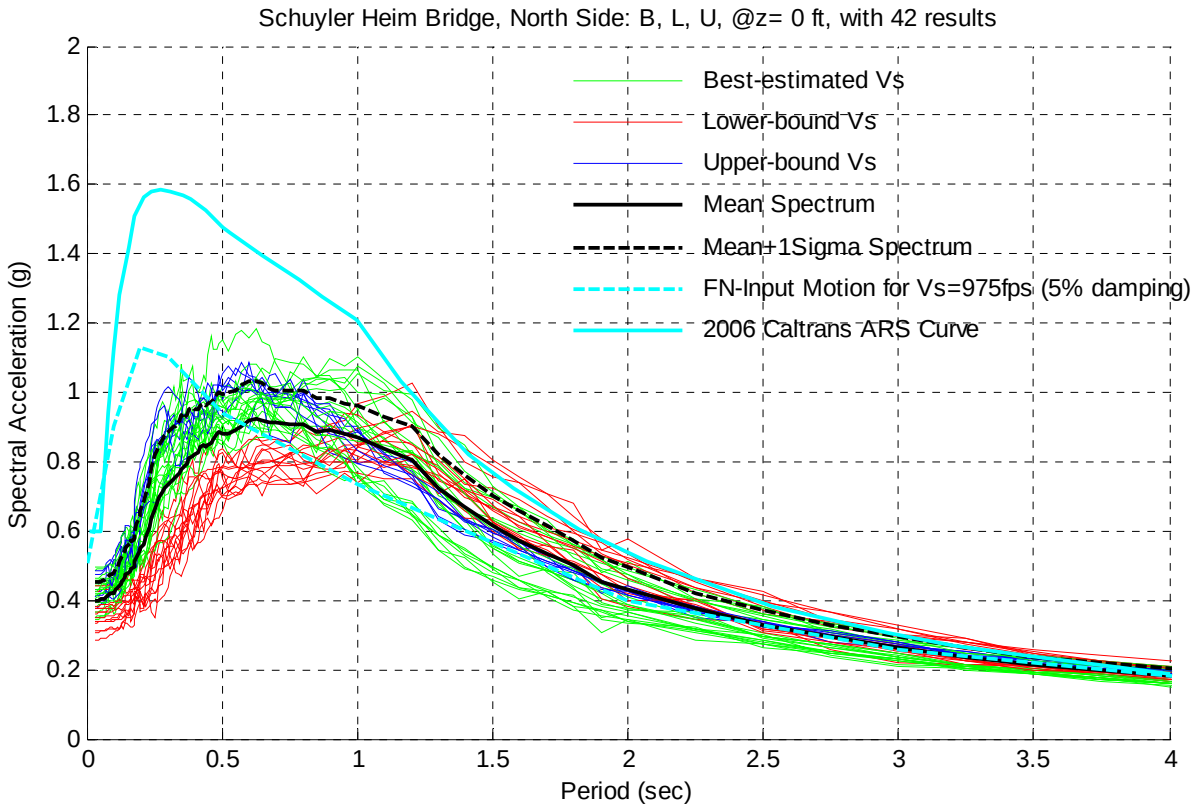
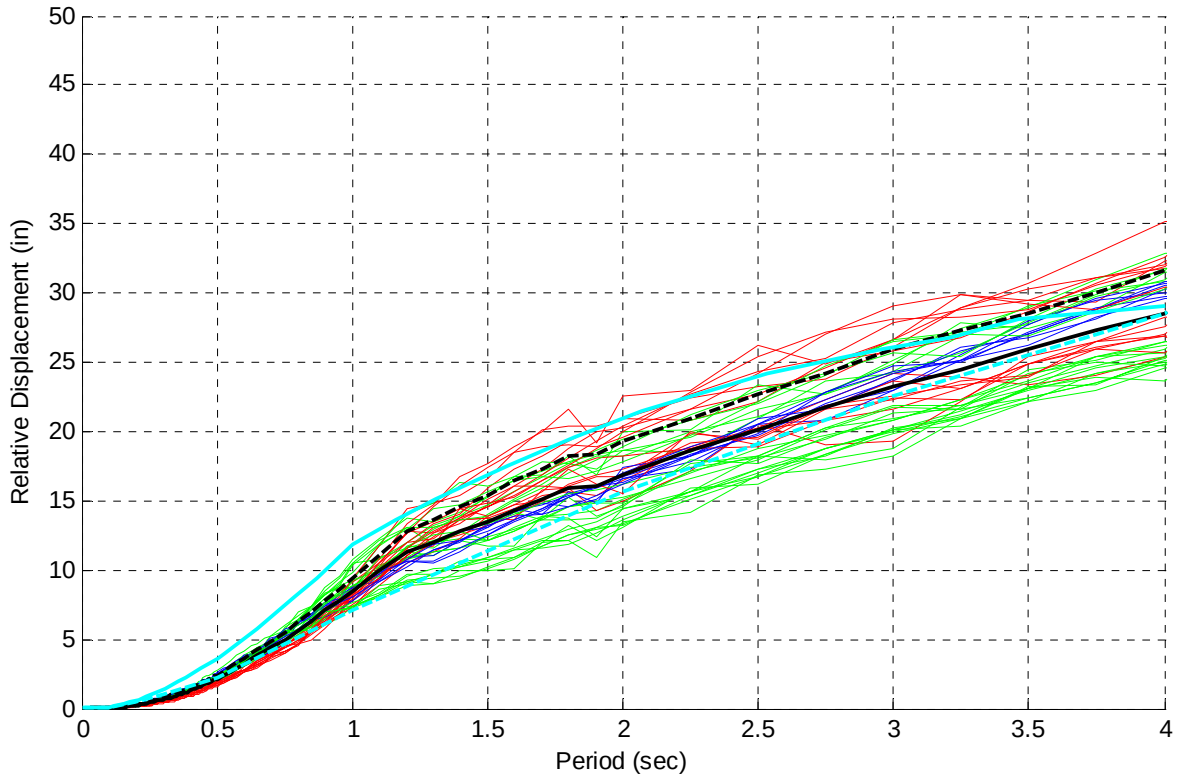
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





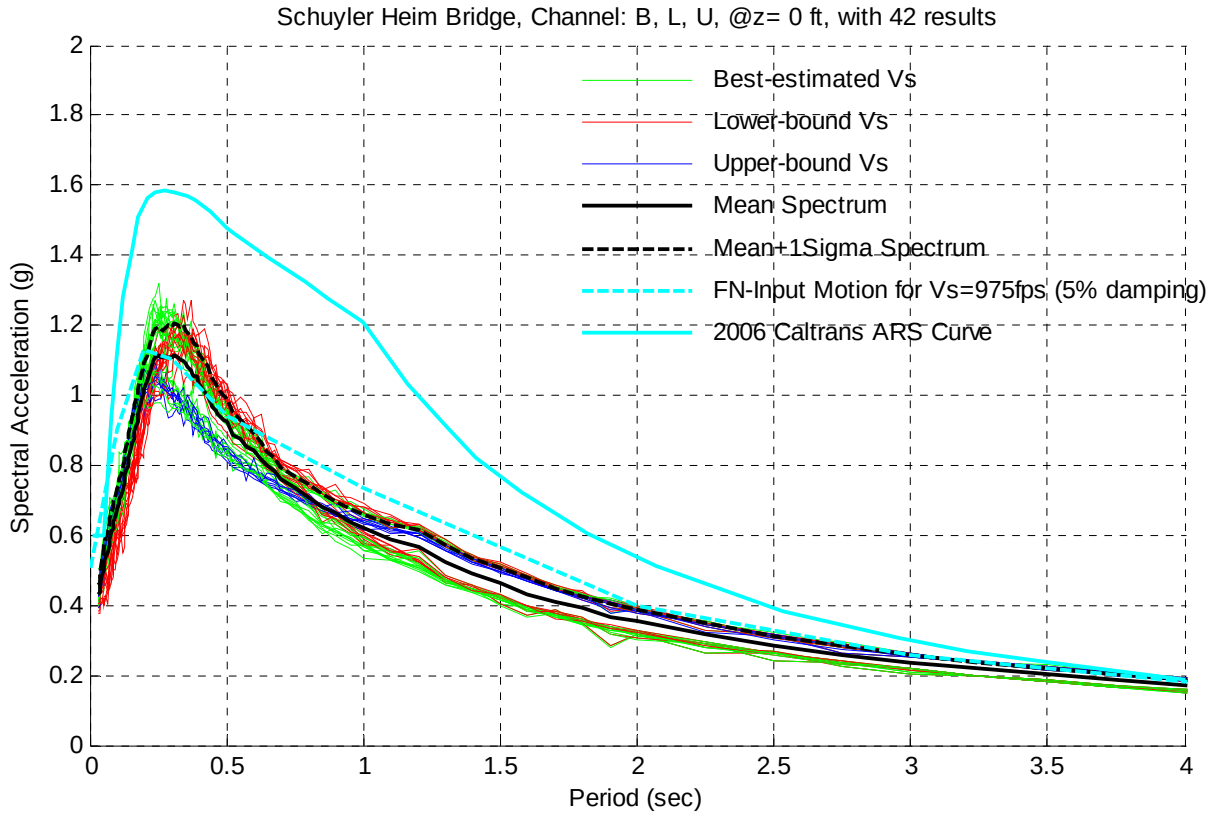
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

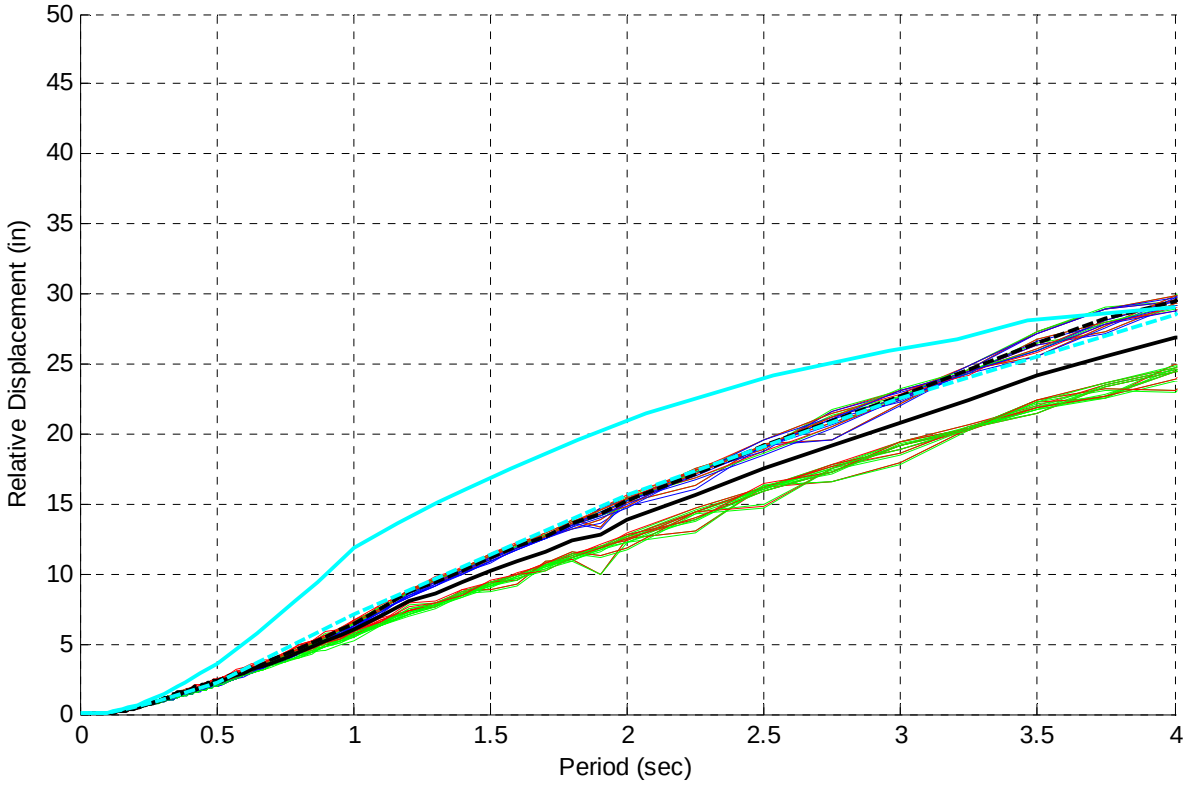
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





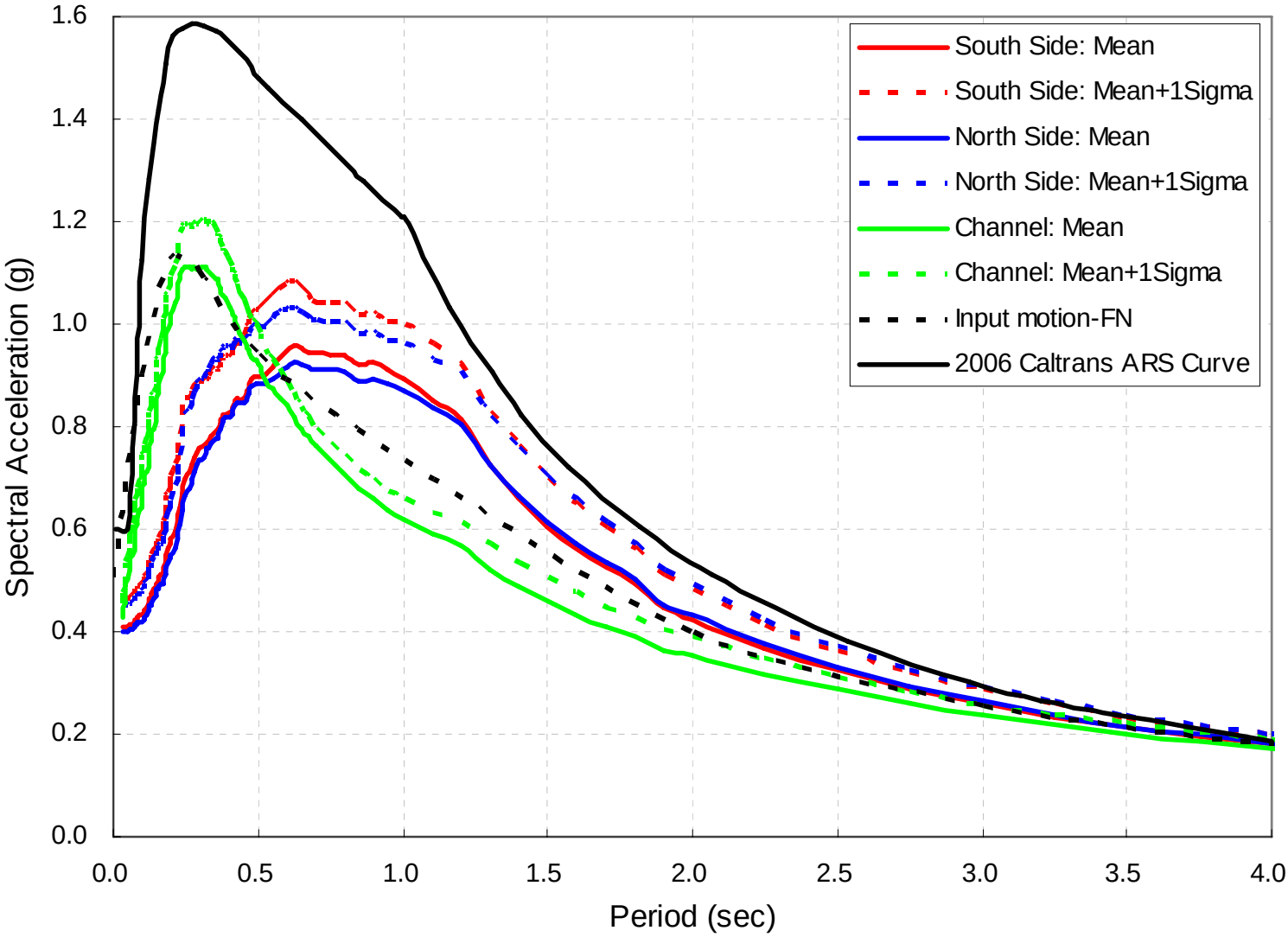
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



Earth Mechanics, Inc.
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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

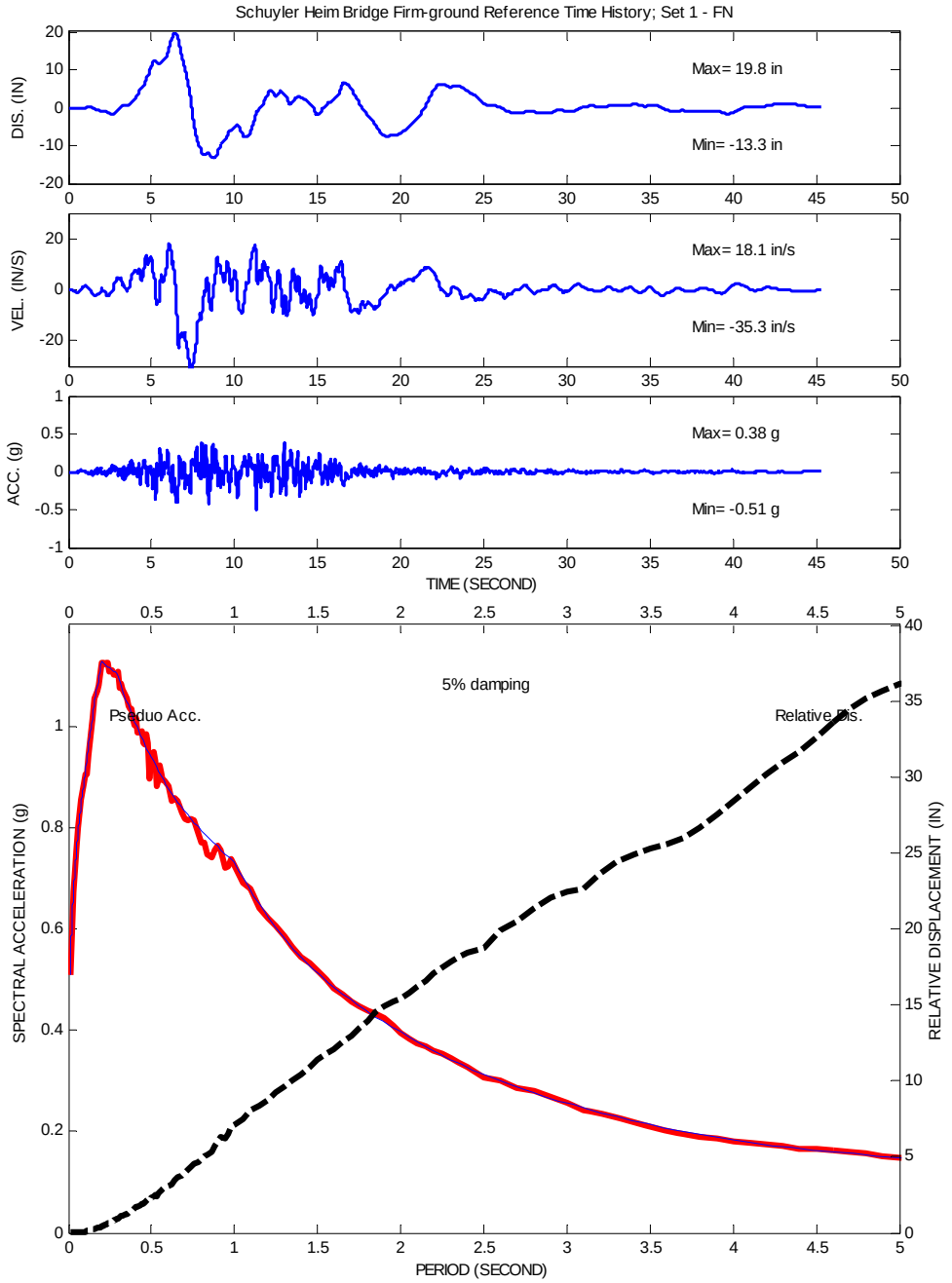


Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

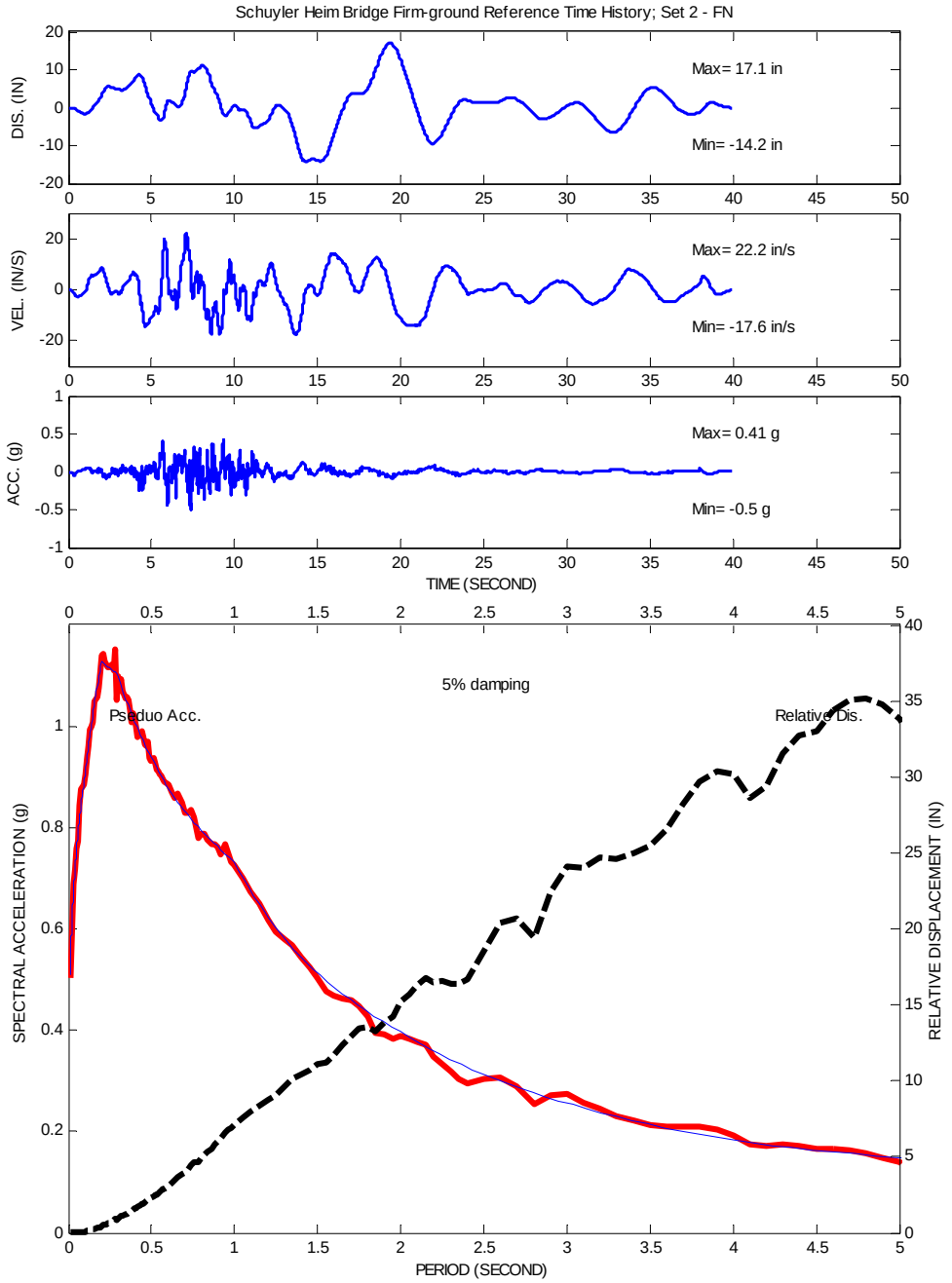


Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

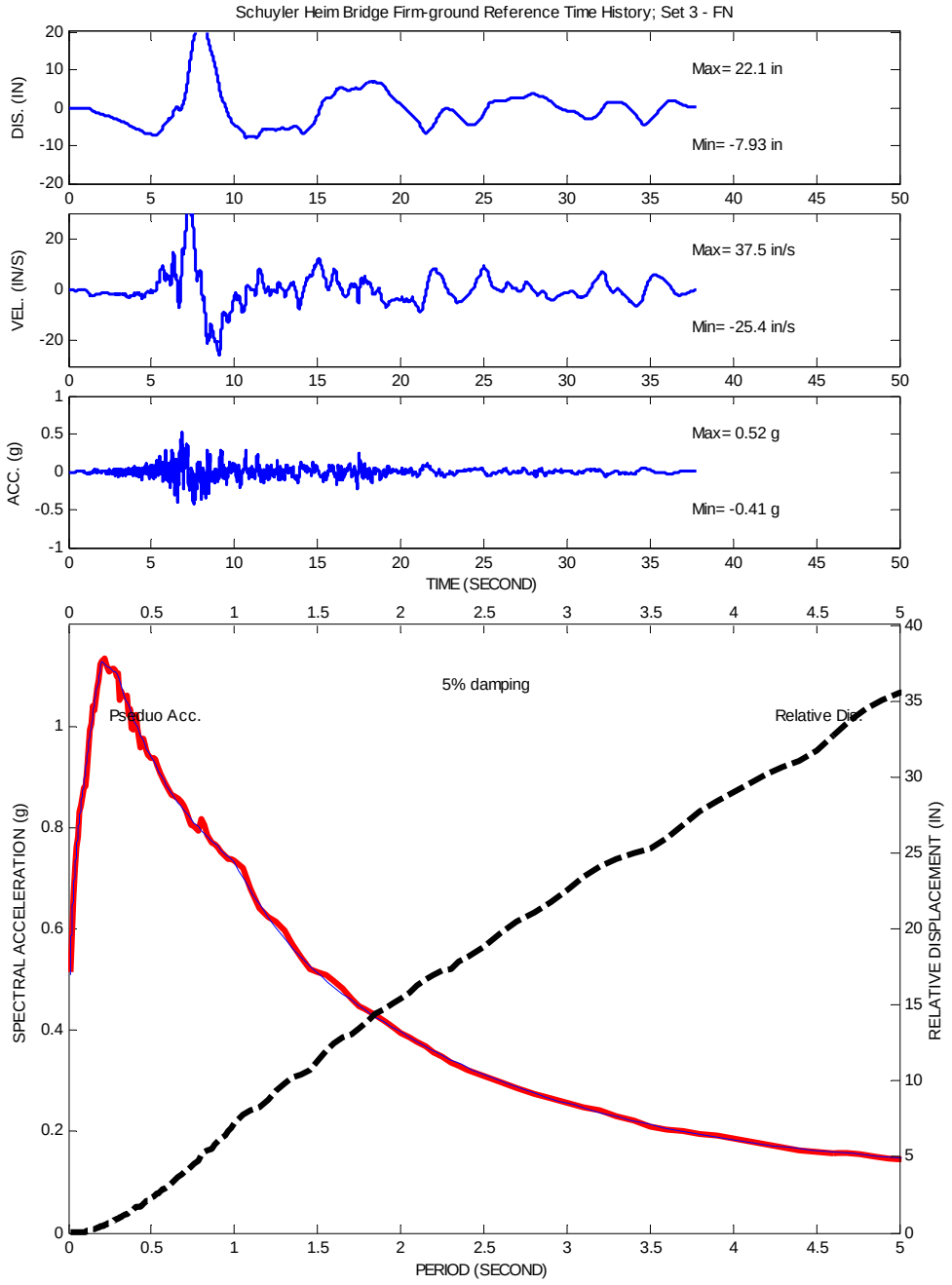


Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

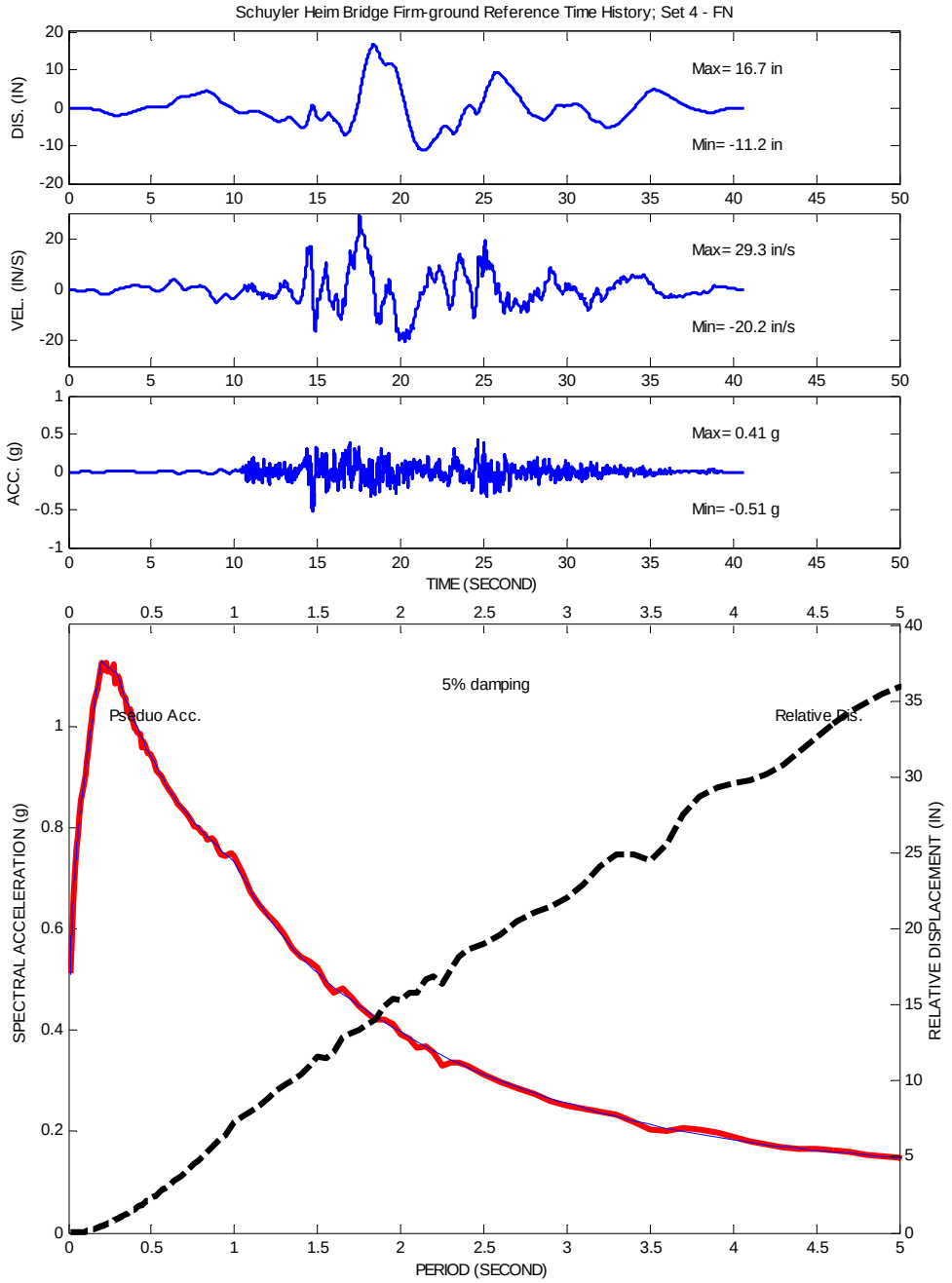


Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

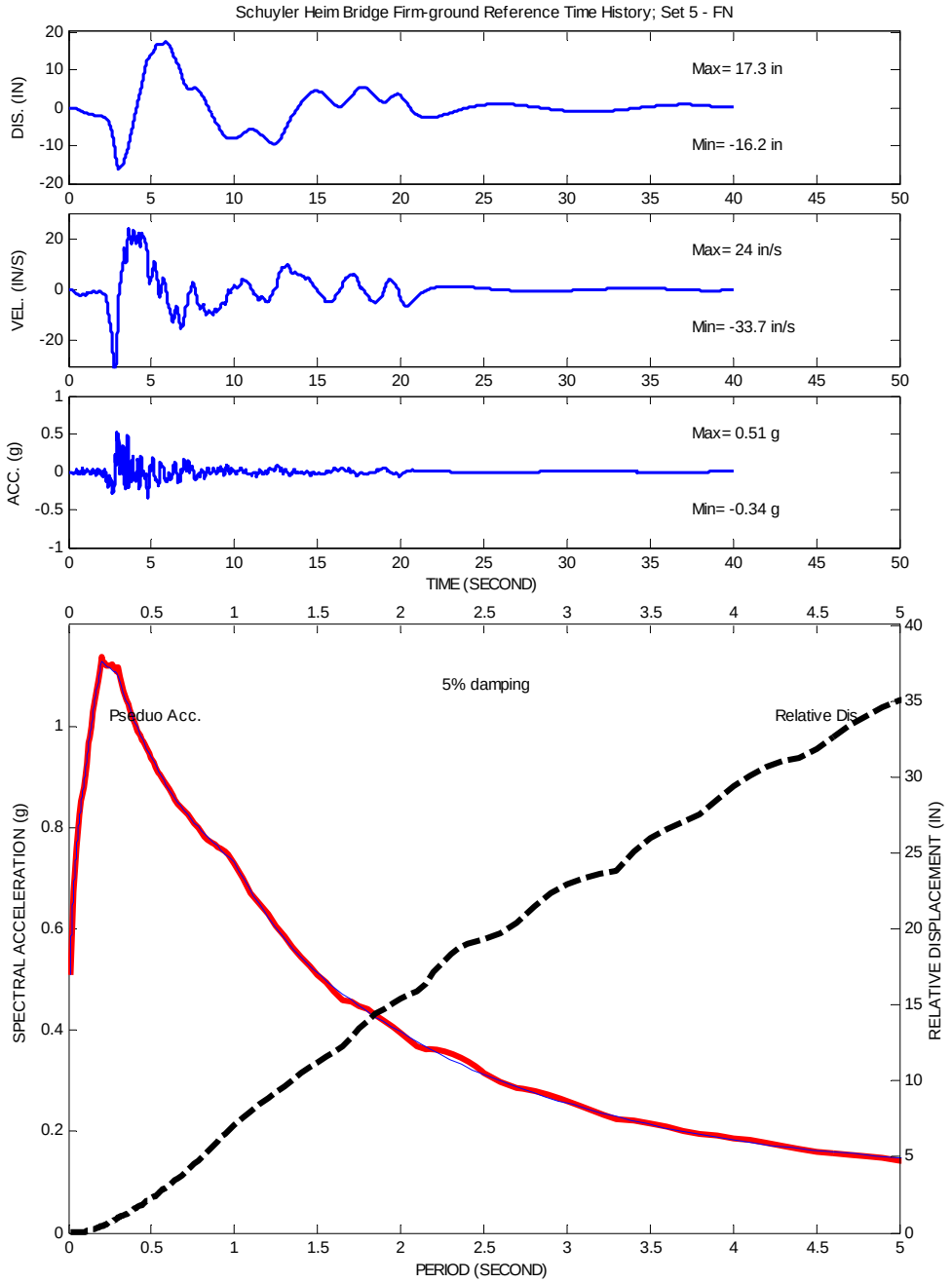


Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

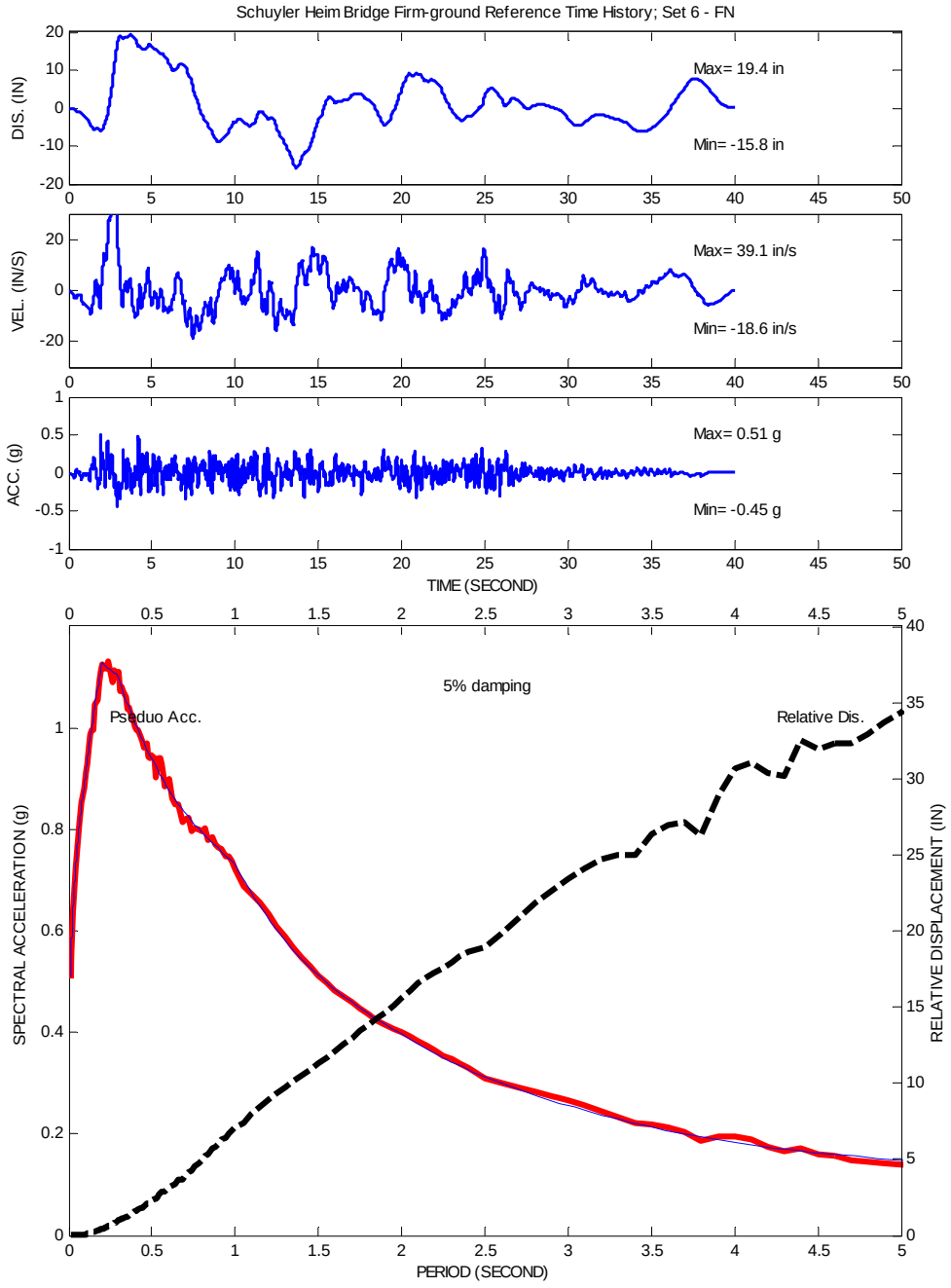


Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

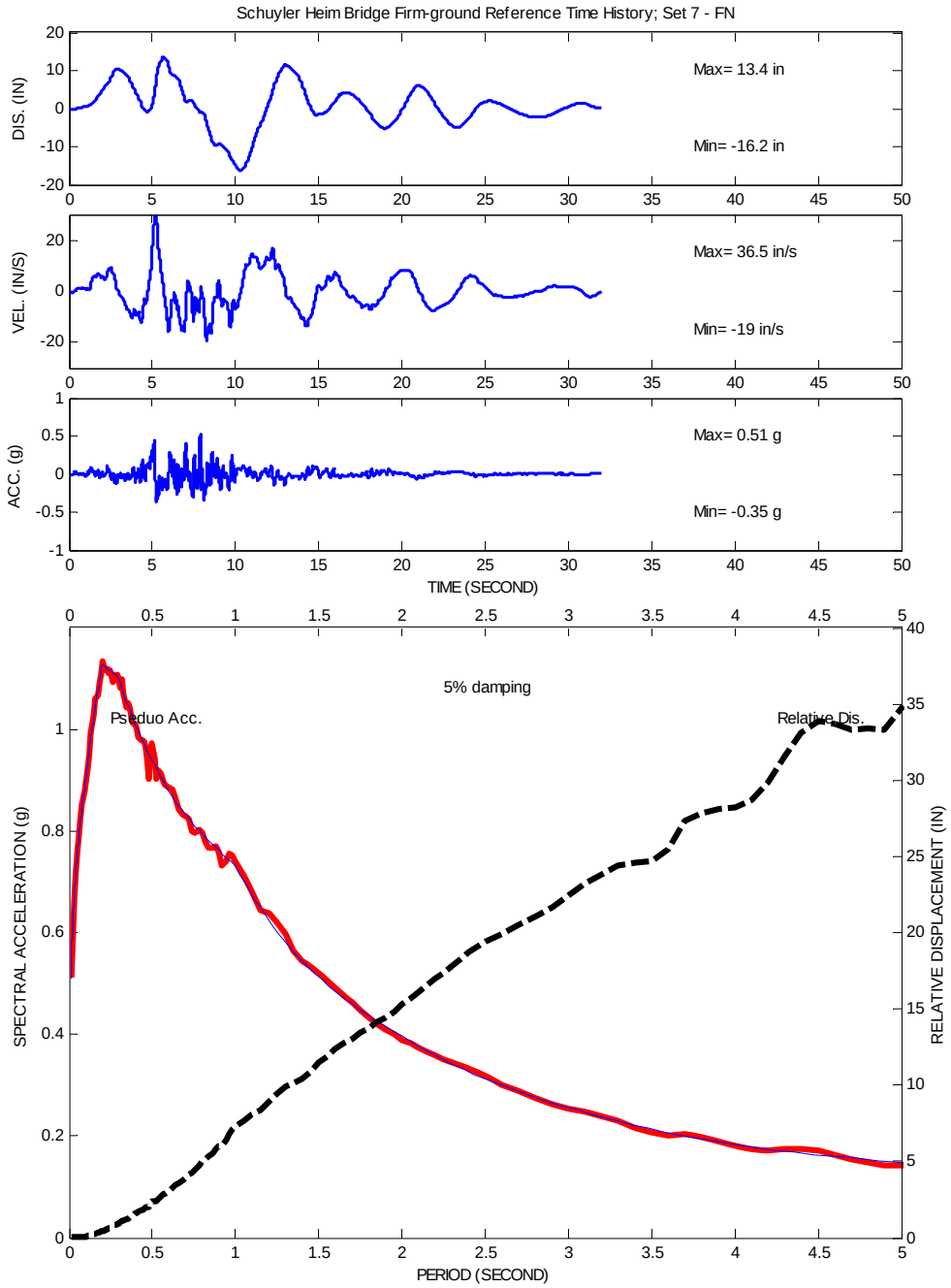


Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

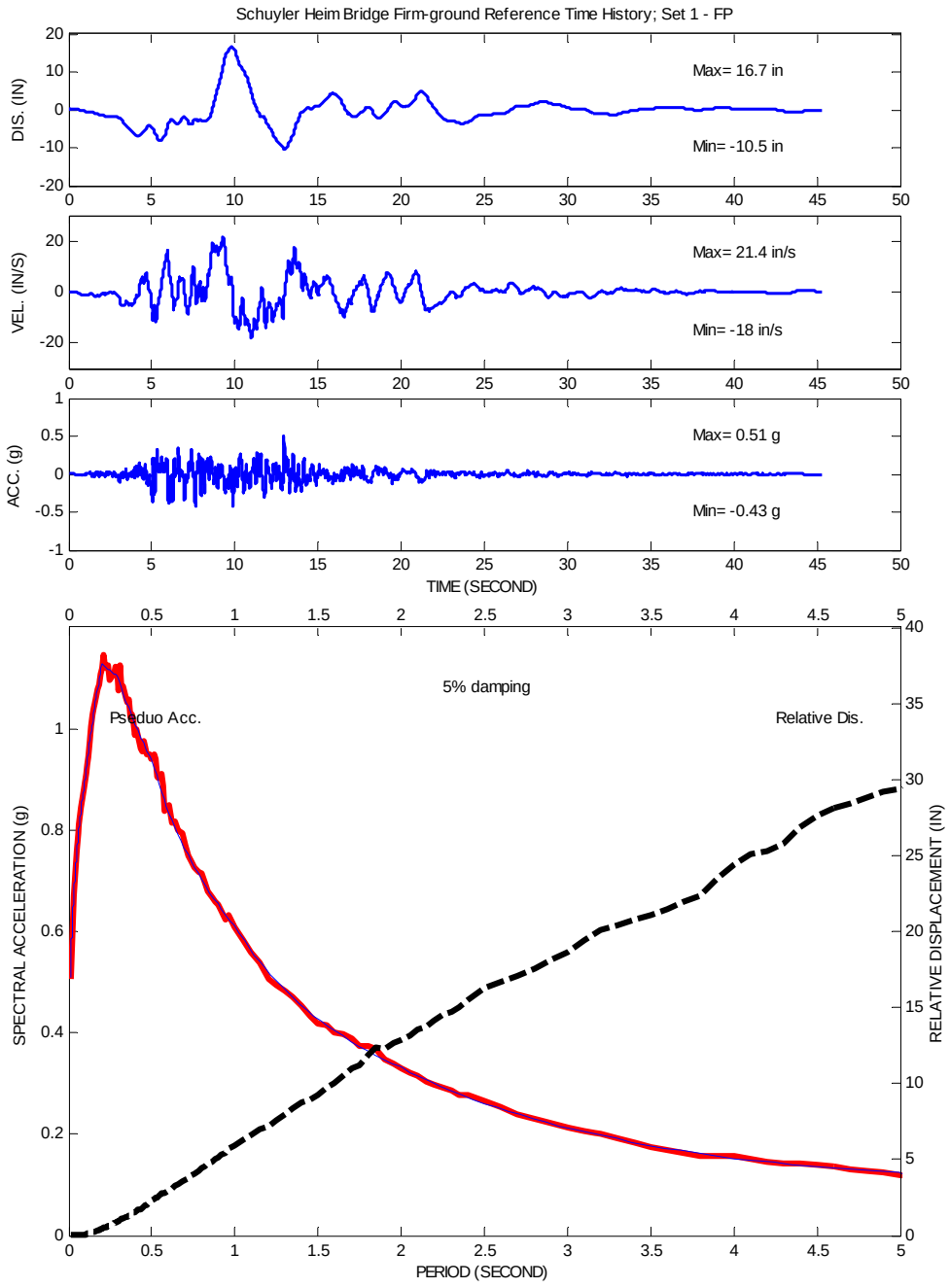


Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

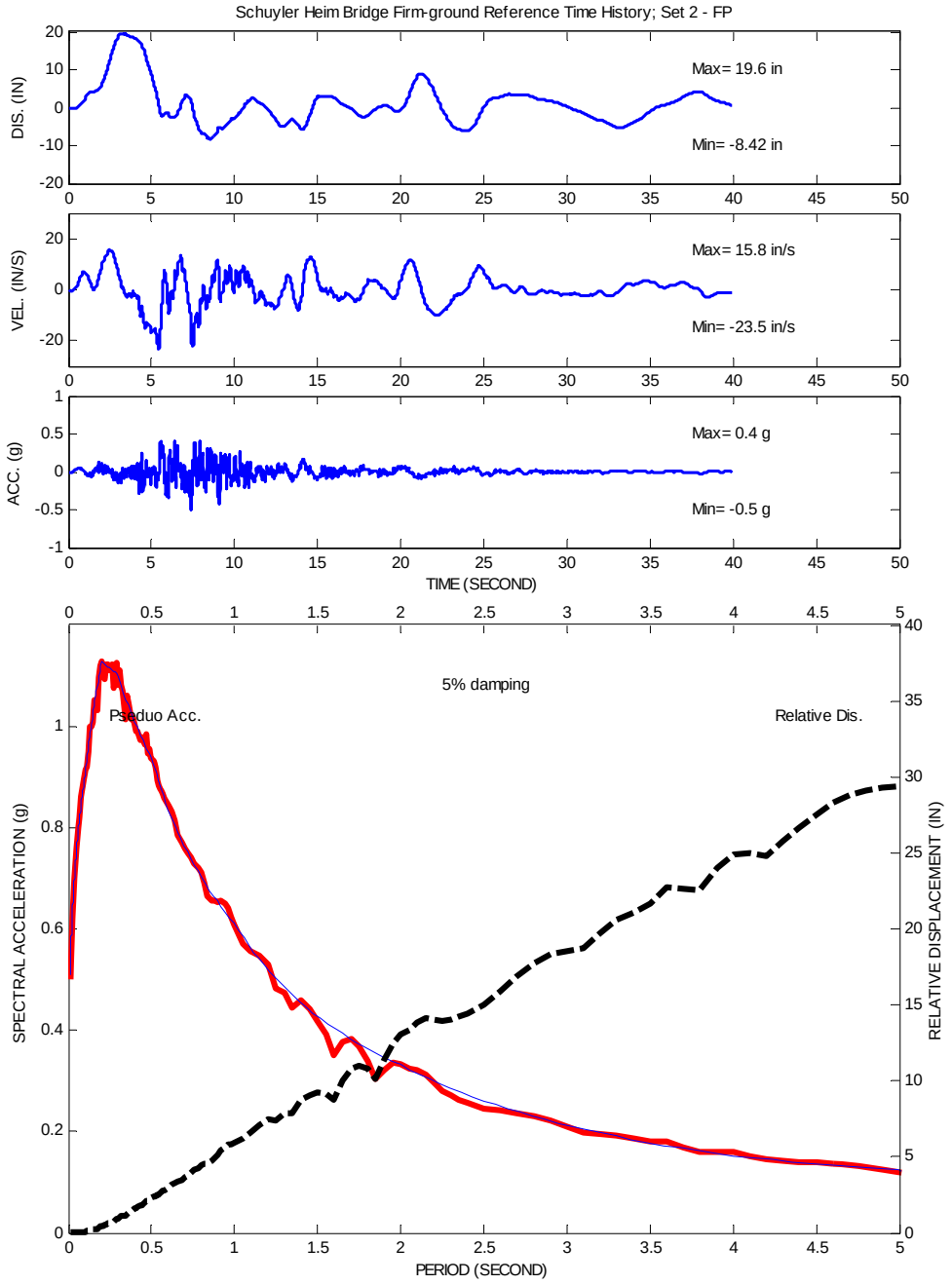


Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

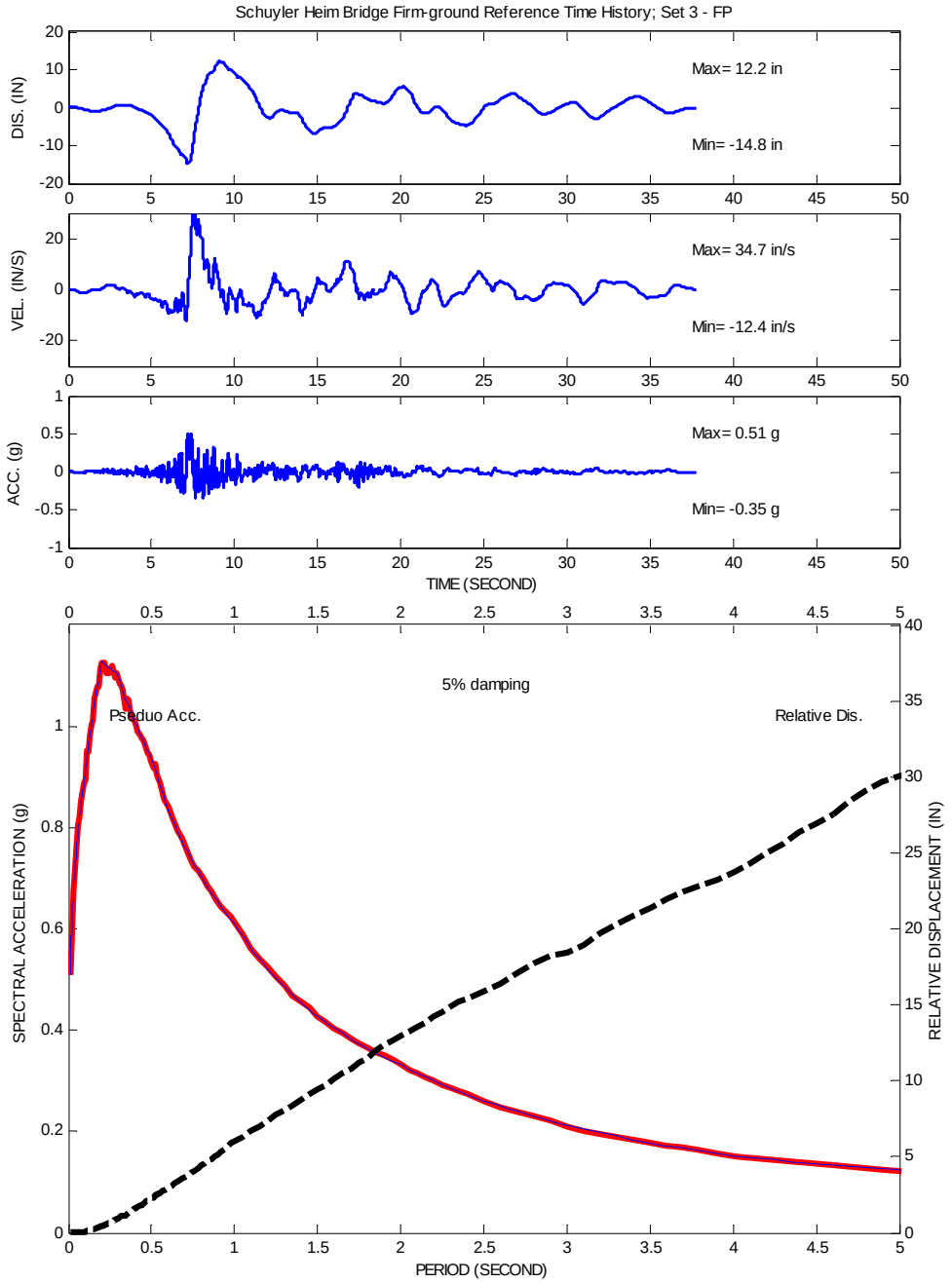


Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

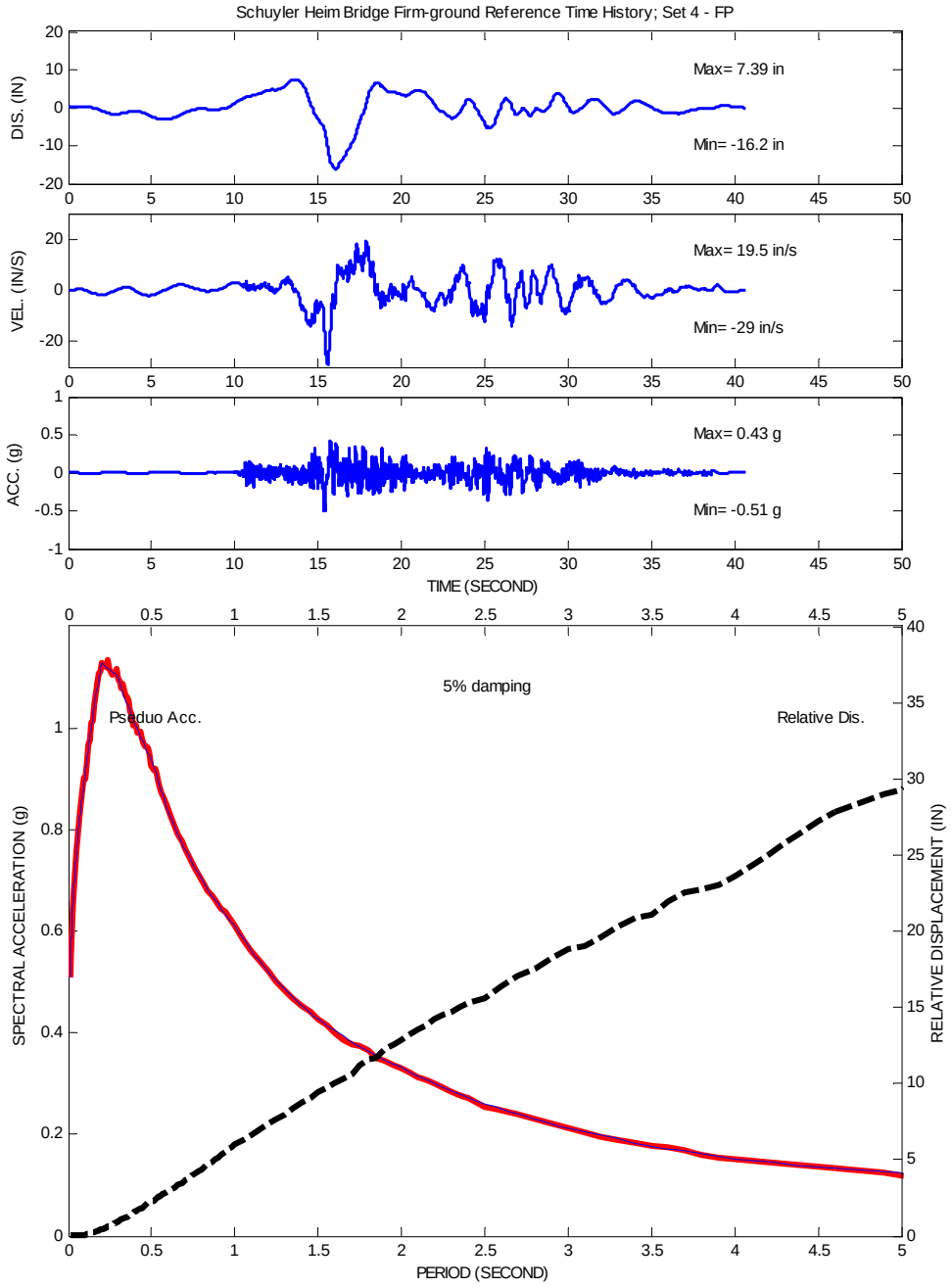


Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

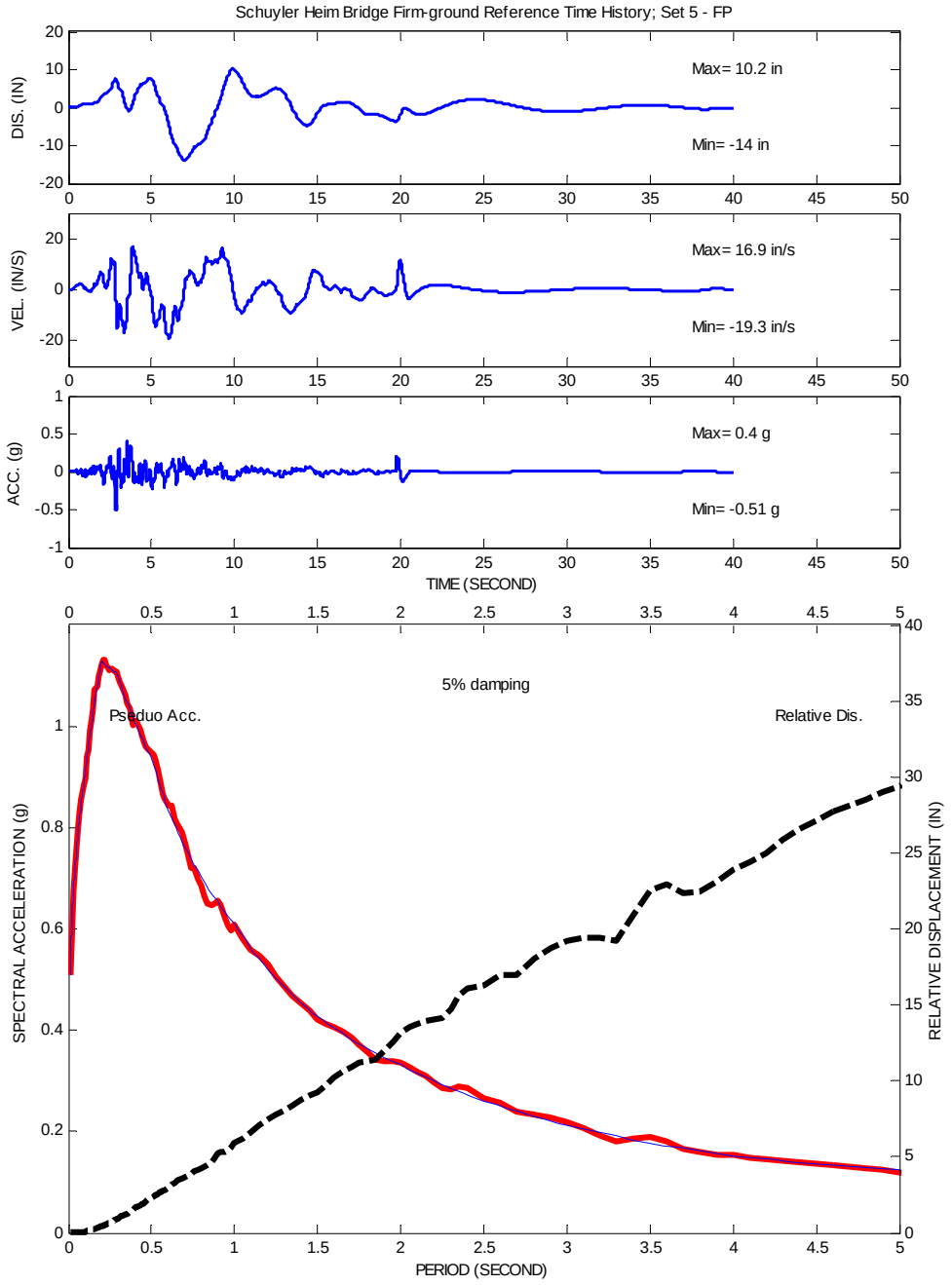


Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

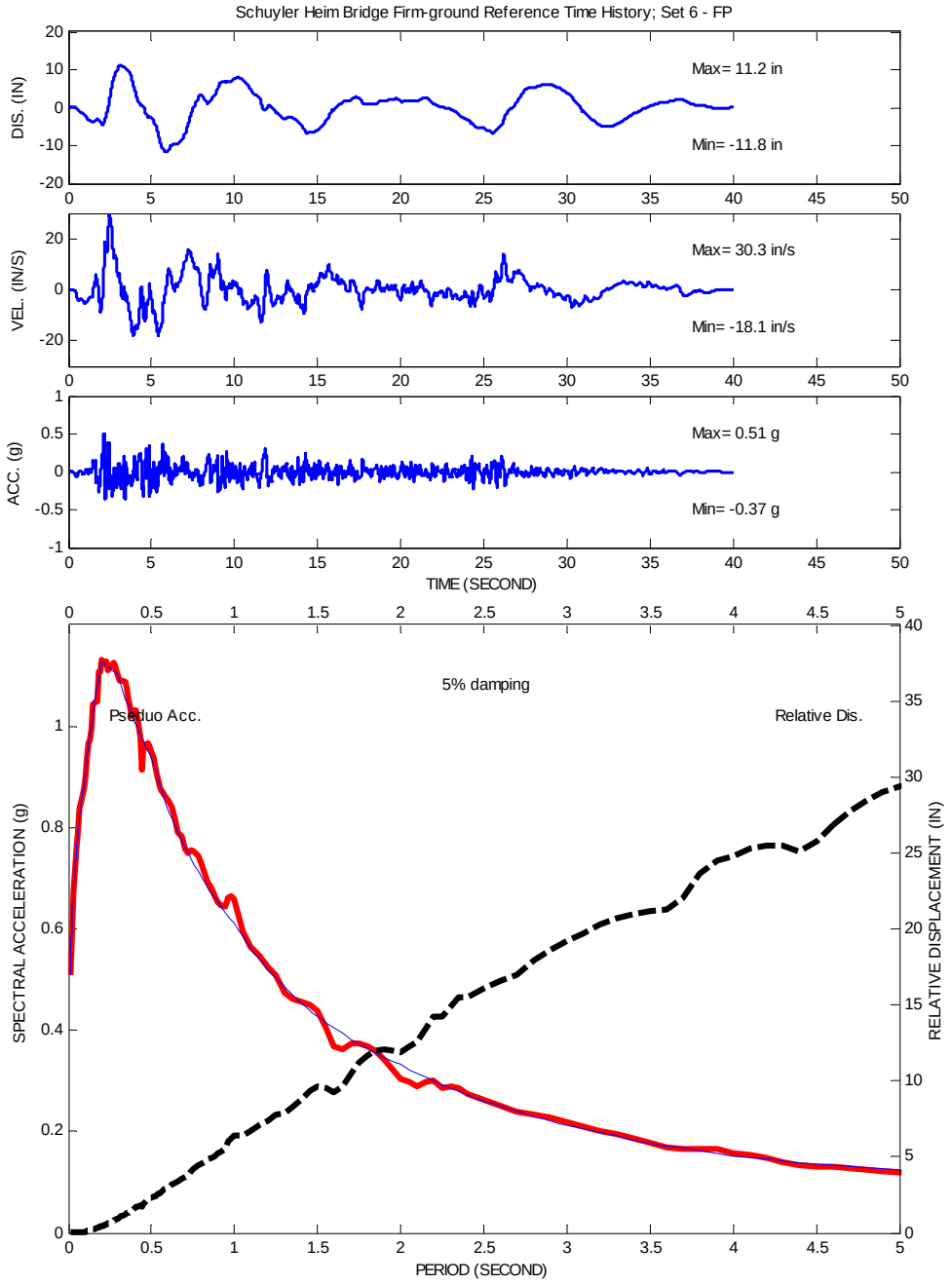


Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

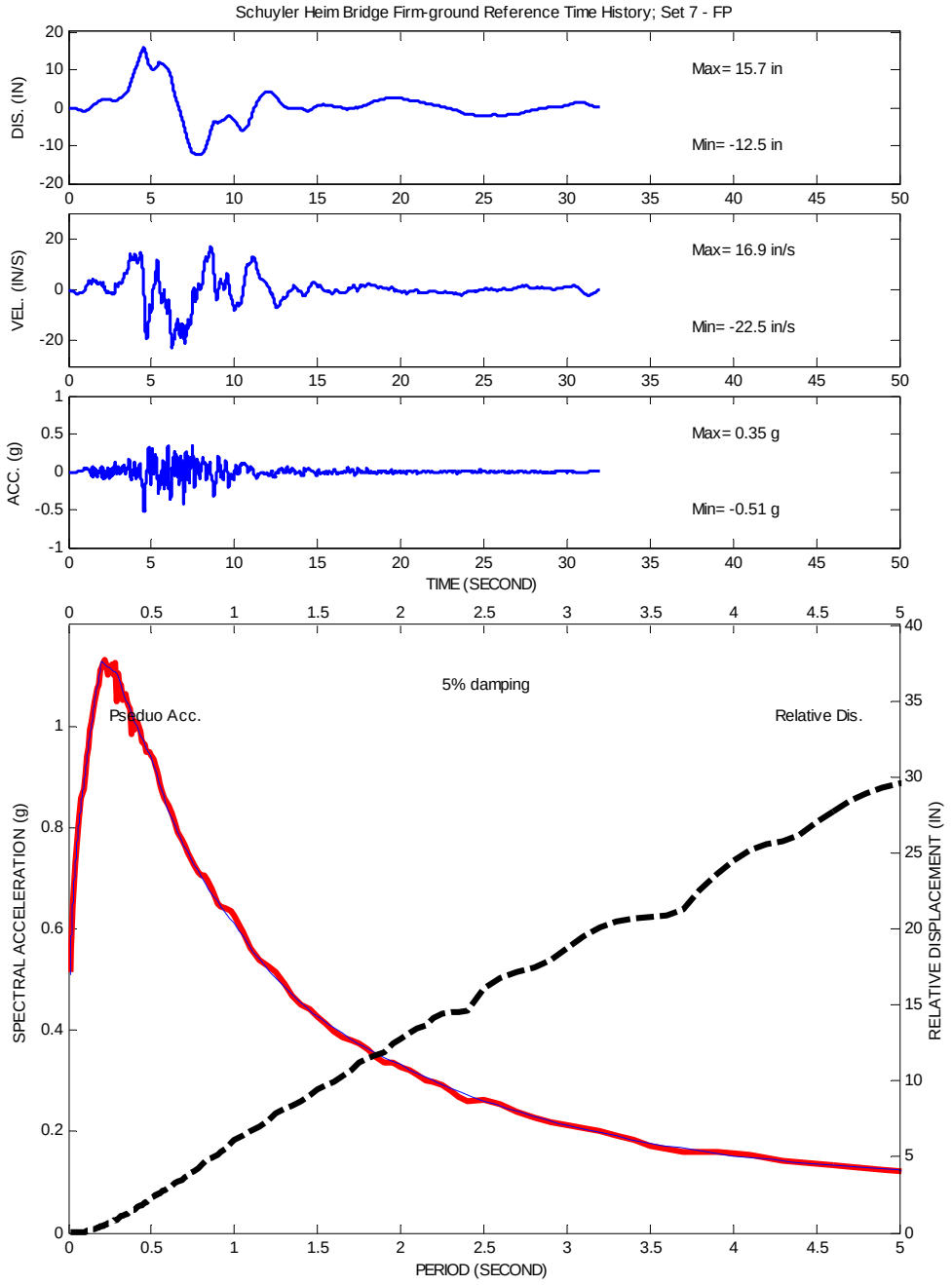


Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX E. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQD
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)

SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B. AGREE PARTLY SEE NOTED EXCEPTIONS.
C. DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

APPENDIX F. TOPKO PIPE SETTLEMENT ESTIMATES MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: December 31, 2009 **EMI PROJECT NO:** 06-123-03

TO: Lucien Hersh / Alameda Corridor Engineering Team (ACET)

COPY: Richard Norton / URS Corporation (URS)
Jeff Mills / URS

FROM: Arul Arulmoli / Earth Mechanics, Inc. (EMI)
Ranjan Gunaranjan / EMI

SUBJECT: Schuyler Heim Bridge Replacement Project, Geotechnical Memorandum for Settlement Estimates below Topko Pipe due to Proposed Retaining Wall Nos. E1 and E2.

Earth Mechanics, Inc. (EMI) has been requested by URS Corporation (URS) to estimate settlements below the existing Topko pipe due to the proposed embankment fill of Retaining Wall (RW) Nos. E1 and E2. This memorandum is prepared to provide settlement estimates below the Topko pipe due to the proposed RW Nos. E1 and E2 embankment fill.

Project Description

As a part of the Schuyler Heim Bridge Replacement Project, Retaining Wall (RW) Nos. E1 and E2 are proposed to be built at east and west sides of the northern approach embankment (Abutment 27) of Northbound SR-103 Off-Ramp Bridge to retain an approximately 57-ft wide approach embankment (Figure 1). Per plans provided by the designers, Wall No. E1, located on the west side of the approach between approximate Sta. 426+13 and Sta. 428+29 (“E” Line), will be approximately 216 ft long with a maximum design height of 23.5 ft at the south end of the wall while Wall No. E2, located on the east side of the approach between approximate Sta. 426+13 and Sta. 429+83 (“E” Line), will be approximately 370 ft long. The bottom elevation of the subject wall footings vary between -1.0 ft and -1.2 ft. Based on the information provided by URS, an existing 60-inch diameter Corrugated Metal Pipe (CMP), which contains an 8-inch diameter Topko oil line and 8-inch diameter water line inside, crosses the RW Nos. E1 and E2 at approximate Sta. 427+65 (“E” Line) (See Attachment 1 and Figure 1). The top elevations of the CMP line vary between -3.2 ft and -3.3 ft. At the location where the CMP line crosses the walls, the top elevation of the proposed wall will be approximately at +16 ft. The existing grade is at about El. 0 ft.

Settlement Estimates

Standard procedures were used to evaluate ground settlement underneath the Topko pipe due to the proposed wall and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and configuration (thicknesses and locations) of fine-grained soil layers. Immediate settlement is estimated to be negligible in this case (less than 0.25 inches) and is expected to occur during grading. Consolidation settlement is expected to occur over varying time periods.

Soil Parameters: The wall section provided by URS was used to evaluate potential settlement at approximate Sta. 427+65 ("E" Line), where the Topko pipe crosses the subject retaining walls. Using the subsurface information collected from site-specific soil borings A-09-056, R-09-034 and R-09-035 and Cone Penetration Test (CPT) soundings CPT-09-066 and CPT-09-098 (See Figure 1 for boring and CPT locations) and laboratory test results, an idealized soil profile was developed along the subject utility line for settlement estimates. The idealized soil profile and soil parameters used in the analyses are shown graphically in Figure 2. The design groundwater table was selected to be at El. +0 ft.

The consolidation parameters were estimated using laboratory test data. The compression index (C_c) was determined by measuring the slope of the virgin portion of the consolidation curves developed from laboratory consolidation tests. The Casagrande procedure was used to estimate the pre-consolidation pressure (σ_p). And, Taylor's square-root-of-time method and Casagrande's logarithm-of-time method were used to estimate the coefficient of consolidation (C_v). The methods for determining the compression index, recompression index, the pre-consolidation pressure, and the coefficient of consolidation are described in Holtz and Kovacs (2004).

Settlement Magnitudes: Based on our settlement calculations, settlement of soils underlying the Topko pipe is estimated to be about 5 inches, 2.5 inches, 0.25 inches at the centerline of the MSE embankment (*i.e.,* Point A, see Figure 2), at the edges of RW Nos. E1 and E2 locations (*i.e.,* Point B or B', see Figure 2), and about 25 ft away from the walls (*i.e.,* Point E or E', see Figure 2), respectively. The approximate settlement profile of the soil underlying the Topko pipe is shown in Figure 3.

Settlement Periods: The settlement period without any surcharge is estimated to be about 25 weeks to reduce the long-term post-construction settlement below the CMP to be less than ½-inch. If a 5-ft embankment surcharge is applied, the settlement period is expected to be reduced to about 12 weeks. For a 7-ft embankment surcharge, the settlement period is expected to be reduced to about 9 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade. Settlement periods with surcharge begin once the full surcharge height is completed.

Closure

We appreciate the opportunity to work with you on this project to provide geotechnical recommendations for the project. If you have any questions, please do not hesitate to call us.

(Ranjan) G.J. Gunaranjan, PE 71758
Senior Staff Engineer

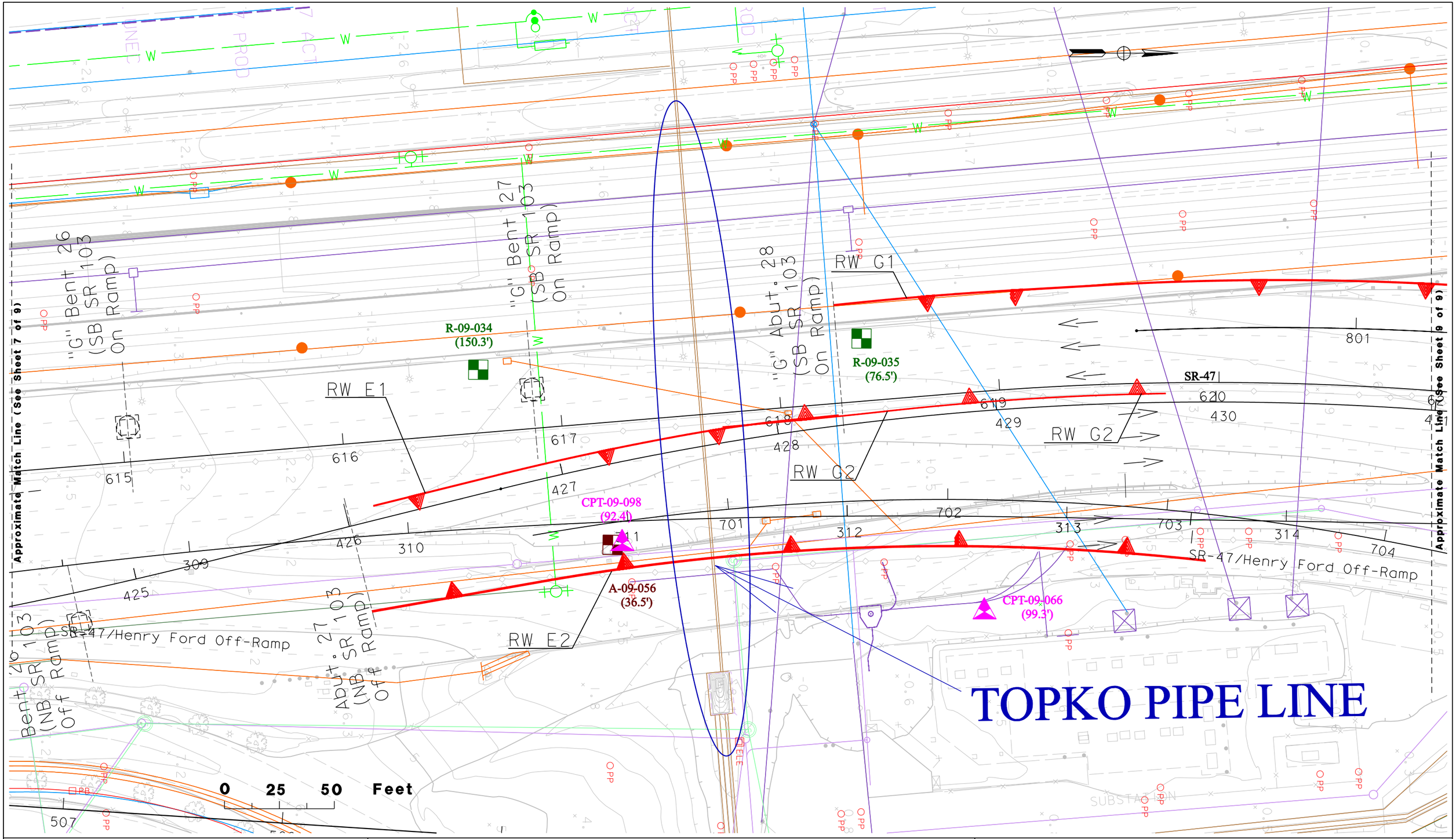
(Arul) K. Arulmoli, GE 2090
Project Manager

Reference

Holtz, R.D. and Kovacs, W.D., 2004, "An Introduction to Geotechnical Engineering", Prentice Hall Civil Engineering and Engineering Mechanics Series, September.

Attachments

Attachment 1 – Wall Section and Topko Pipe Location Information Provided by URS



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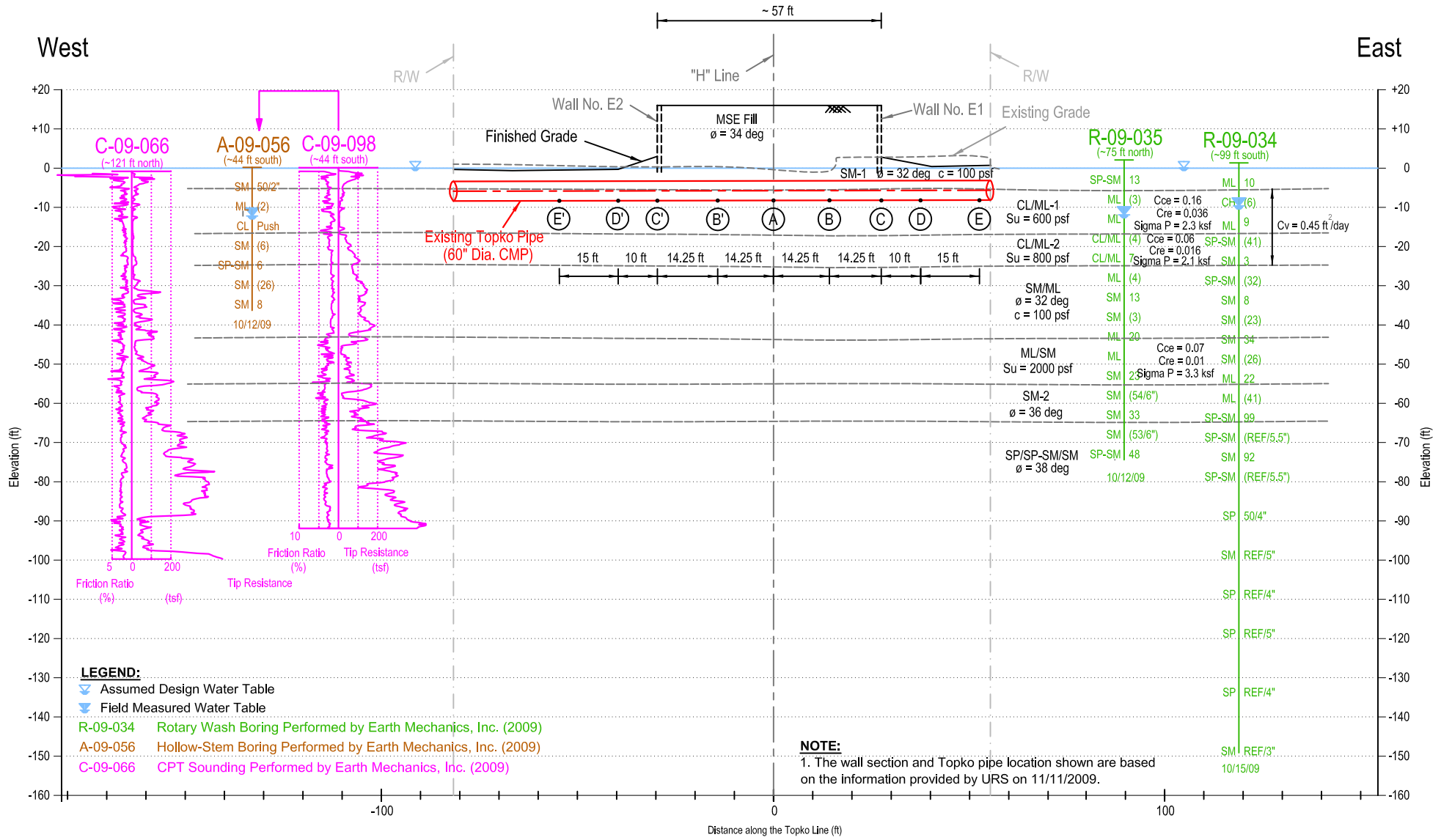
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No.: 06-123-03 | **Date: 12-22-09**

Site-Specific Exploration and Topko Pipe Location Map

Figure 1



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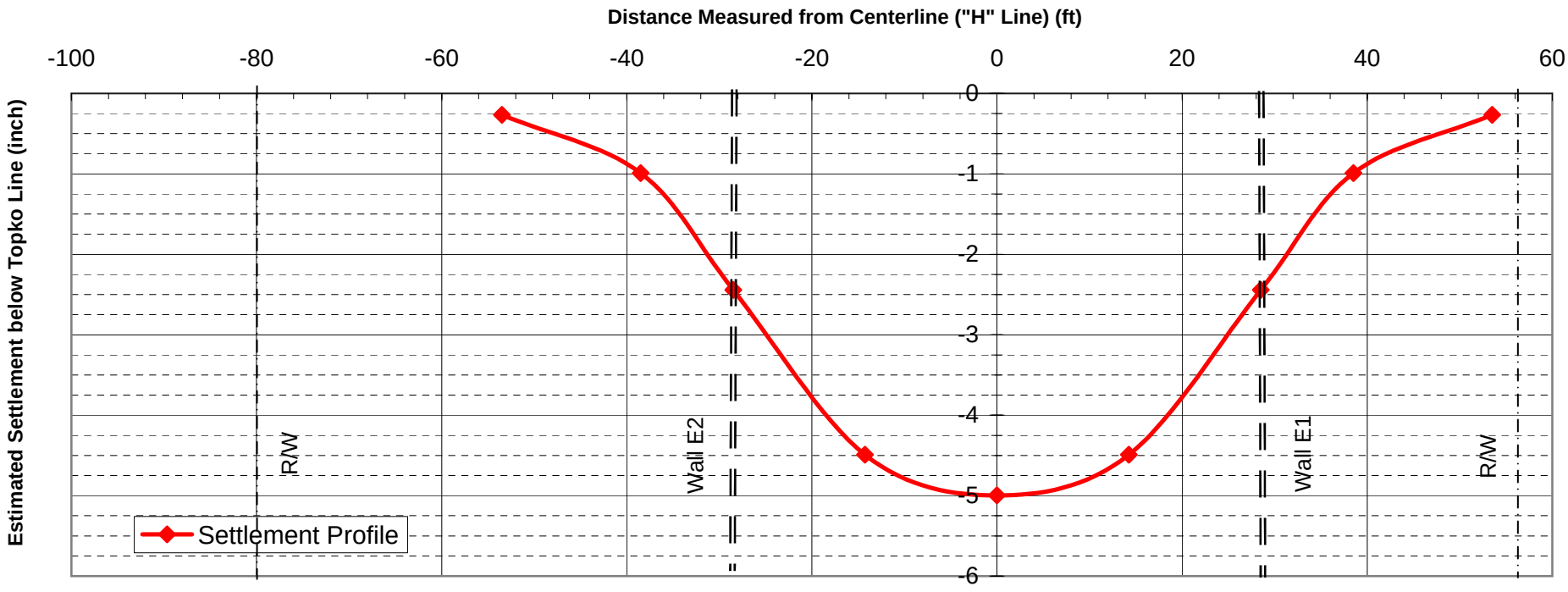
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

EMI Project No. 06-123-03 | Date: 12-21-09

Idealized Soil Profile along Topko Pipe at Approximate Sta. 427+65 ("E" Line)

Figure 2

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT



Consolidation Settlement Profile along Topko Pipe Line

ATTACHMENT 1

WALL SECTION AND TOPKO PIPE LOCATION INFORMATION

PROVIDED BY URS

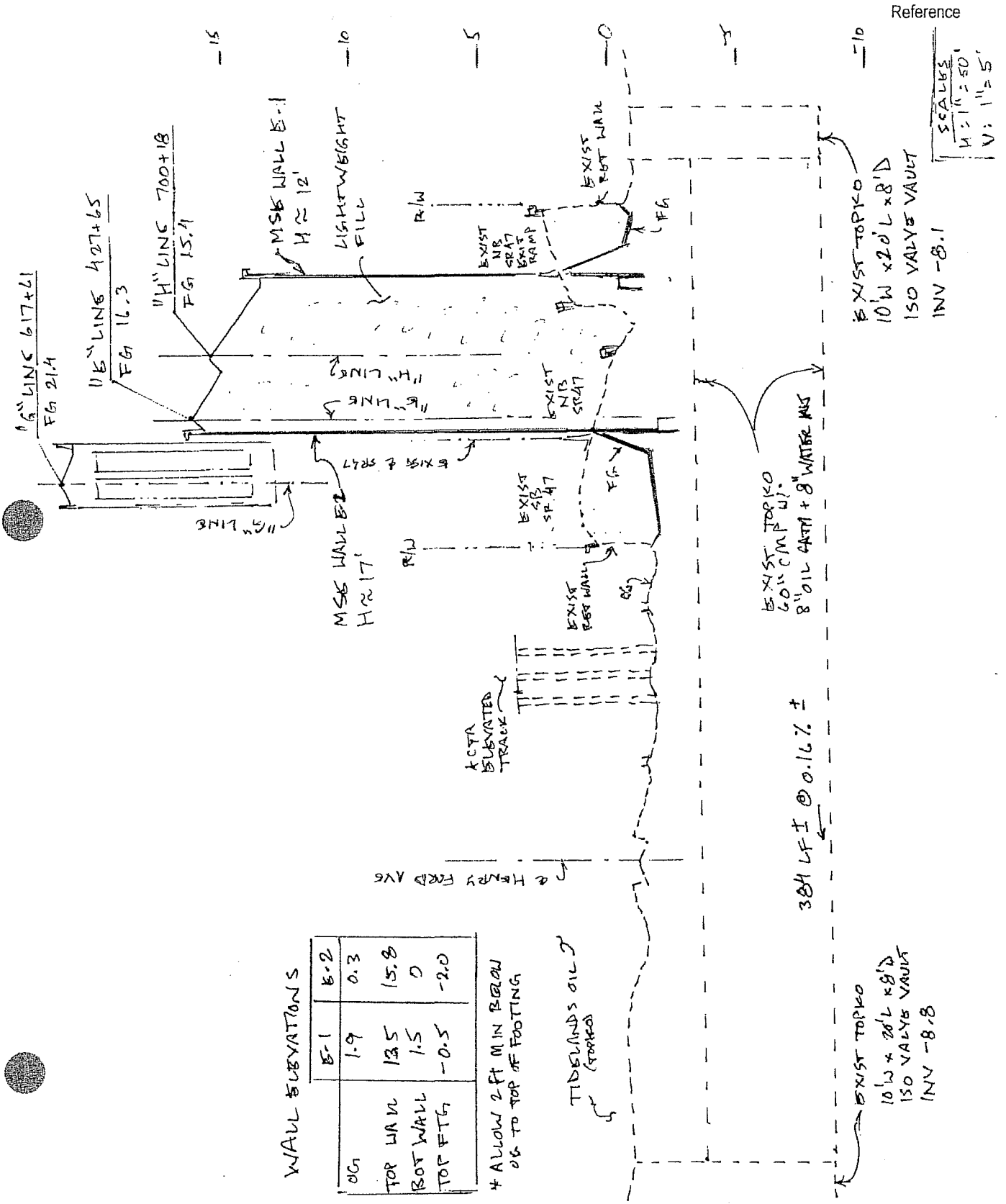
URS

Page ____ of ____

Job SR 47 - HEIM BRIDGE | Project No. ____ | Sheet 1 of 3

Description RET WALL & UTILITIES CONFLICT SECTION EXHIBIT | Computed by CGP | Date 11-9-09

Checked by ____ | Date ____



WALL ELEVATIONS

	E-1	E-2
OG	1.9	0.3
TOP WALL	13.5	15.8
BOT WALL	1.5	0
TOP FTG	-0.5	-2.0

* ALLOW 2 FT MIN BELOW OG TO TOP OF FOOTING

URS

Job SR 47 - HEIM BRIDGE Project No.

Description RET WALL & UTILITIES CONFLICT Computed by CGP

SECTION EXHIBIT Checked by

Page ____ of ____

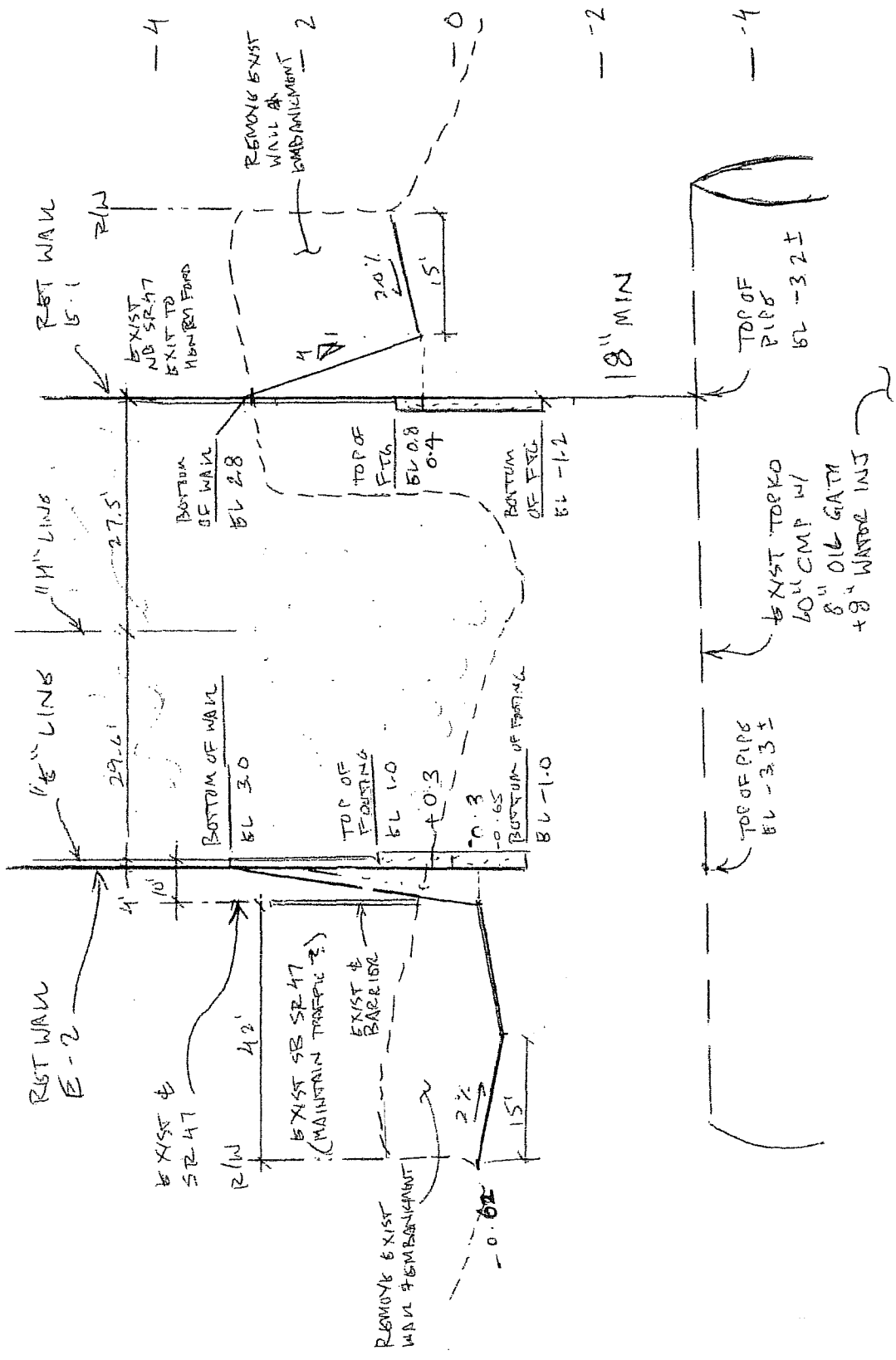
Sheet 2 of ____

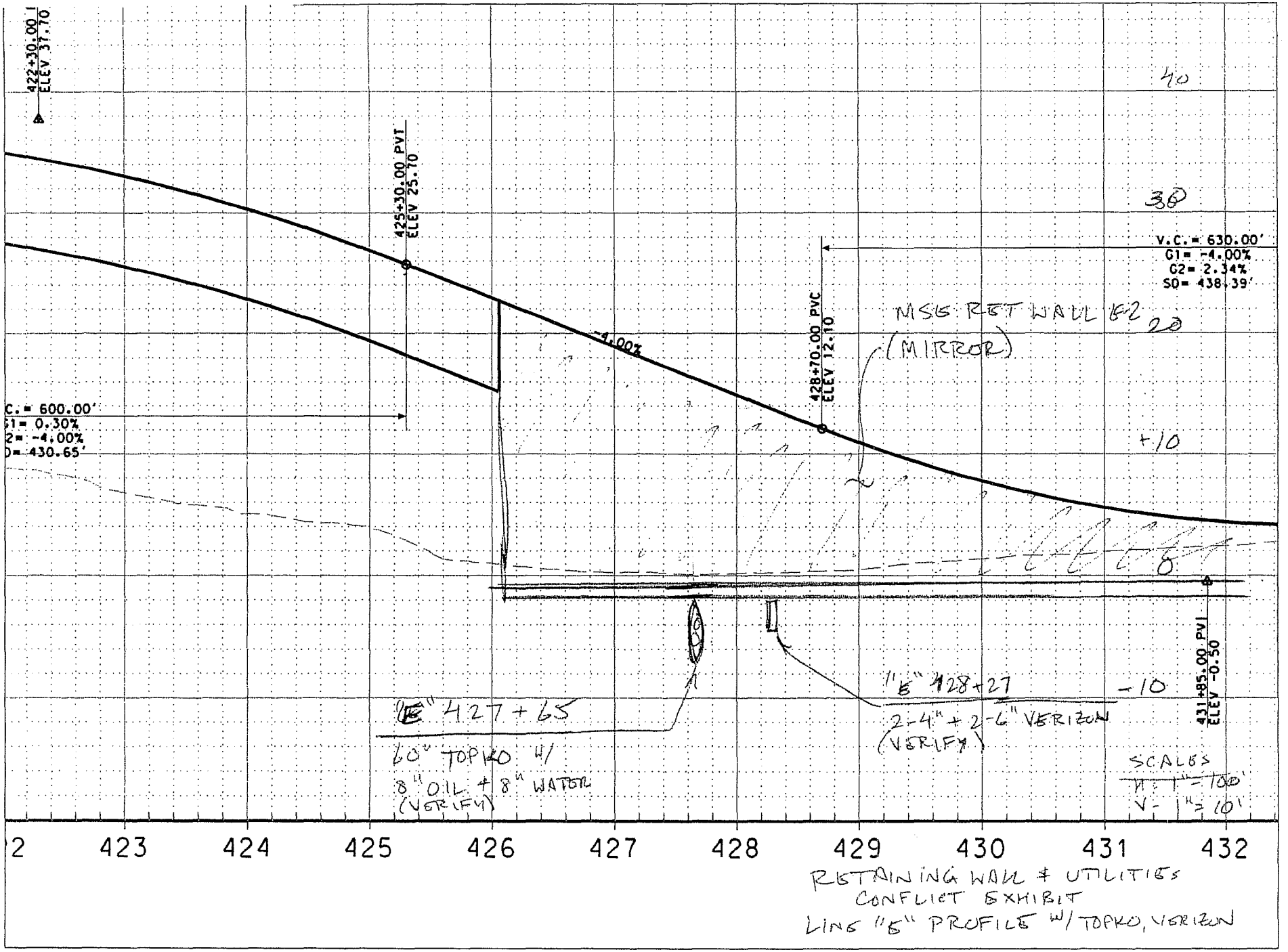
Date 11-9-09

Date ____

Reference

SCALES
H: 1" = 20'
V: 1" = 2'





RETAINING WALL & UTILITIES
CONFLICT EXHIBIT
LINE "E" PROFILE W/ TOPKO, VERIZON

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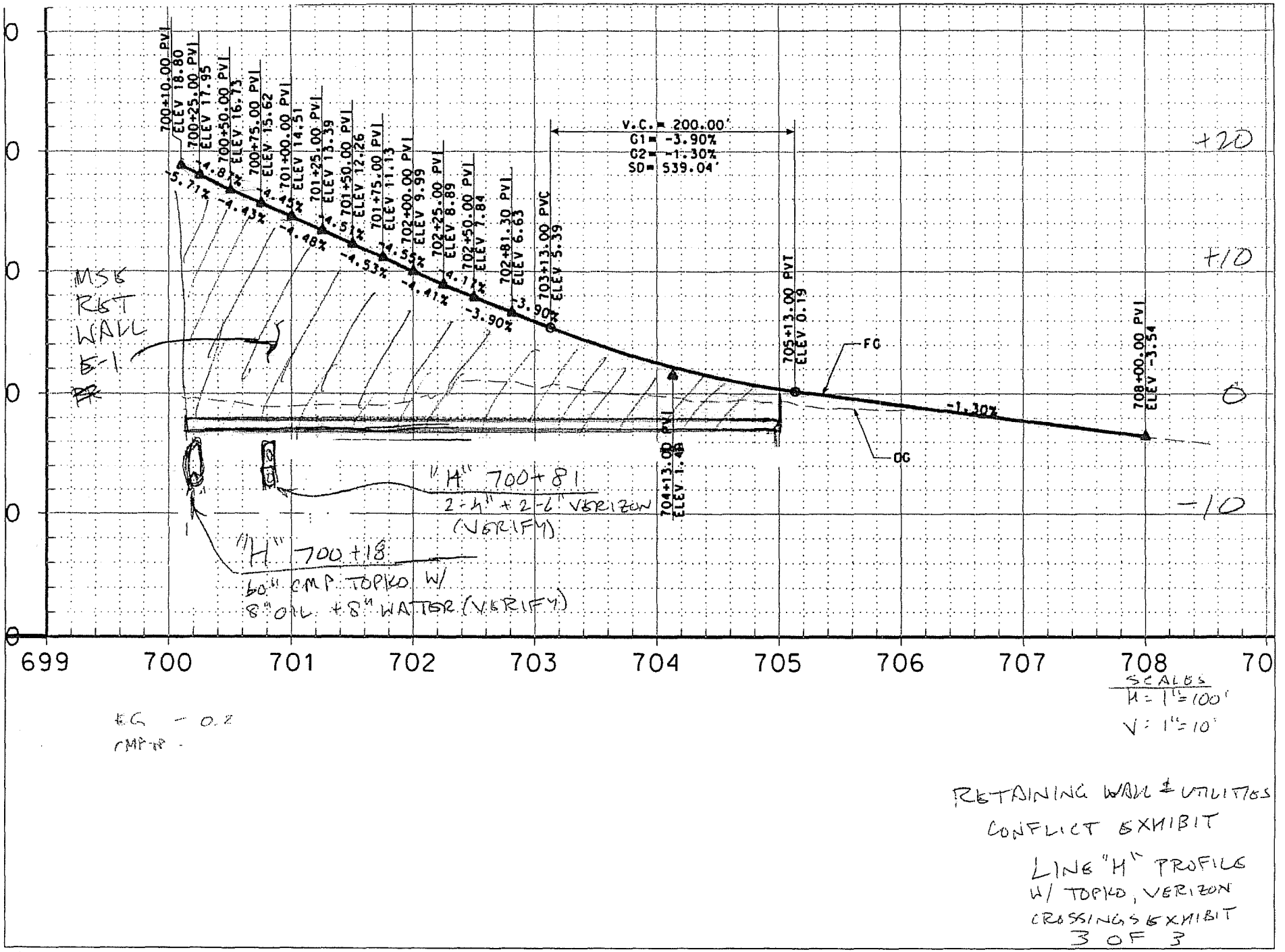

E.G. - 0.2
CMP "H"

RETAINING WALL & UTILITIES
CONFLICT EXHIBIT

LINE "H" PROFILE
W/ TOPKO, VERIZON
CROSSINGS EXHIBIT
3 OF 3

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Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

May 10, 2010

EMI Project No. 06-123-03

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Attention: Mr. Lucien Hersh, P.E.
Project Manager

Subject: ***Final Foundation Report***
Retaining Wall G1, Wall No. 53E0151
Retaining Wall G2
Los Angeles County, California, (7-LA-47, PM 0.17, EA 238501)

Dear Mr. Hersh:

Attached is our Final Foundation Report for the subject retaining walls. This report presents the findings and conclusions of our geotechnical investigation as well as analyses results and recommendations for design and construction of the subject retaining walls.

The Foundation Report for the subject walls, dated February 10, 2010, was submitted to Caltrans. The Caltrans Office of Geotechnical Design South 1 (OGDS-1) reviewed the report and provided their comments on April 12, 2010. EMI developed responses to the OGDS-1 review comments and submitted them on May 4, 2010. OGDS-1 review comments and EMI responses are included in Appendix E. The responses to these review comments have been incorporated into this Final Foundation Report. We appreciate the opportunity to provide geotechnical services for this project. If you have any questions please call us.

Sincerely,
EARTH MECHANICS, INC.

Patrick Wilson, PhD
Staff Engineer

Eric Brown, GE
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
ERIC BROWN
NO. GE 2806
EXP. 6-30-2010
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STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
KANDIAH ARULMOLI
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(Arul) K. Arulmoli, PhD, GE
Project Manager

17660 Newhope Street, Suite E, Fountain Valley, California 92708 Tel: (714) 751-3826 Fax: (714) 751-3928

FINAL FOUNDATION REPORT
RETAINING WALL G1, WALL NO. 53E0151
RETAINING WALL G2
LOS ANGELES COUNTY, CALIFORNIA
(7-LA-47, PM 0.17, EA 238501)

Prepared for:

Alameda Corridor Transportation Authority
One Civic Plaza, Suite 350
Carson, California 90745

Prepared by:

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, California 92708

EMI Project No. 06-123-03

May 10, 2010

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1.0 INTRODUCTION

1.1 Purpose Scope of Work

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI) for the proposed Retaining Wall G1 and G2 in Los Angeles County, California. The report has been prepared in general accordance with Caltrans Guidelines for Foundation Investigation and Reports (Caltrans, 2006e). It presents results of our foundation analyses and provides design and construction recommendations to assist the bridge designers in preparing the project Plans, Specifications, and Estimates (PS&E) for the project.

The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling, sampling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering analysis to develop foundation design and construction recommendations;
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 Project Description

The Schuyler Heim Bridge Replacement and State Route-47 (SR-47) Expressway Project is a joint partnership between Caltrans and the Alameda Corridor Transportation Authority (ACTA). The project proposes to replace the seismically deficient Schuyler Heim Bridge over Cerritos Channel and add a four-lane elevated roadway connection to Alameda Street that will bypass three signalized intersections and five at-grade railroad crossings. The location of the project is shown in Figure 1.

The proposed Schuyler Heim Bridge replacement consists of replacing the existing vertical-lift bridge with a fixed bridge with an elevated profile to provide a minimum vertical clearance of 47 ft in the Cerritos Channel and maintain a navigable width of 180 ft within the channel. The proposed bridge replacement project includes bridge structures along the southbound exit ramps and northbound entrance ramps at New Dock Street and State Route-103 (SR-103). This report is prepared for proposed Retaining Wall G1 and G2 located on the west and east side, respectively, of the approach embankment for the SR-103 On-Ramp (Figure 2).

Retaining Wall G1, located along the western edge of the SR-103 On-Ramp approach embankment between Sta. 618+33 and Sta. 622+22 ("G" Line) is proposed to be a mechanically stabilized embankment (MSE) wall and will be approximately 389 ft long with retained heights varying from 24 ft at the southern end of the wall to about 6 ft at the northern end of the wall. Retaining Wall G2, located along the eastern edge of the SR-103 On-Ramp approach embankment between Sta. 618+33 and Sta. 621+00 ("G" Line) is proposed to be a Caltrans

standard Type 1 cantilever retaining wall and will be approximately 267 ft long with retained heights varying from 12 ft at the southern end of the wall to 8 ft at the northern end of the wall.

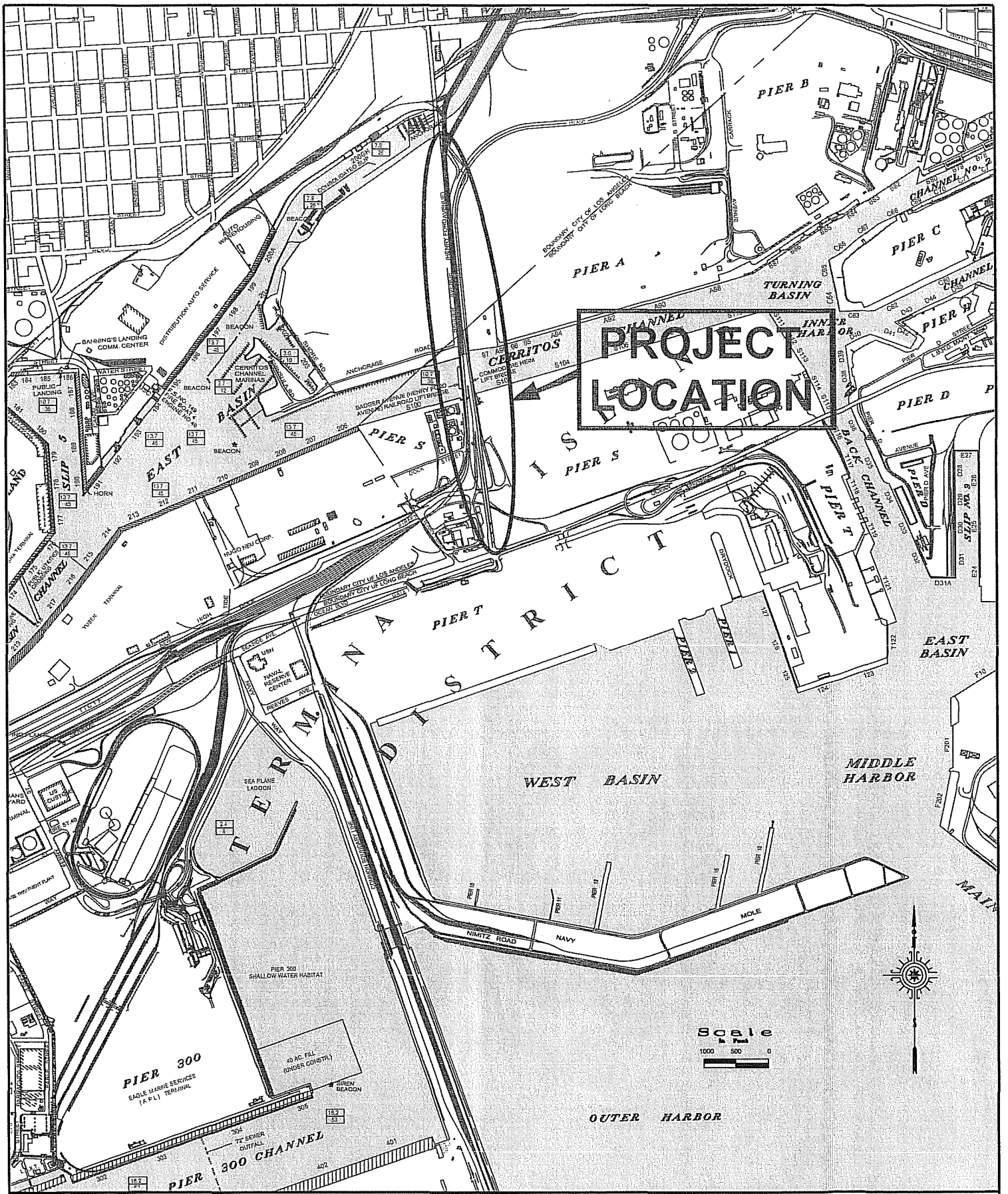
1.3 Limitations

This report is intended for use by Alameda Corridor Transportation Authority (ACTA), its design team members and the California Department of Transportation (Caltrans) for the proposed Retaining Wall G1 and G2. This report is based on the project as described herein and the information obtained from the exploratory borings at the approximate locations indicated on the attached plans. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. Also, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site; however, subsurface conditions and characteristics of soils between exploratory borings can vary. Findings reflect an interpretation of the direct evidence obtained. Recommendations presented herein are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Modifications to the project plans or variations in subsurface conditions may require re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained herein are applicable to the specific design elements and locations which are the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI is not responsible for construction means, methods, techniques, sequences, or procedures, or for safety precautions or programs in connection with the construction, for the acts or omissions of the Contractor, or any other person performing any of the construction, or for the failure of any worker to carry out the construction in accordance with the Final construction drawings and specifications.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.



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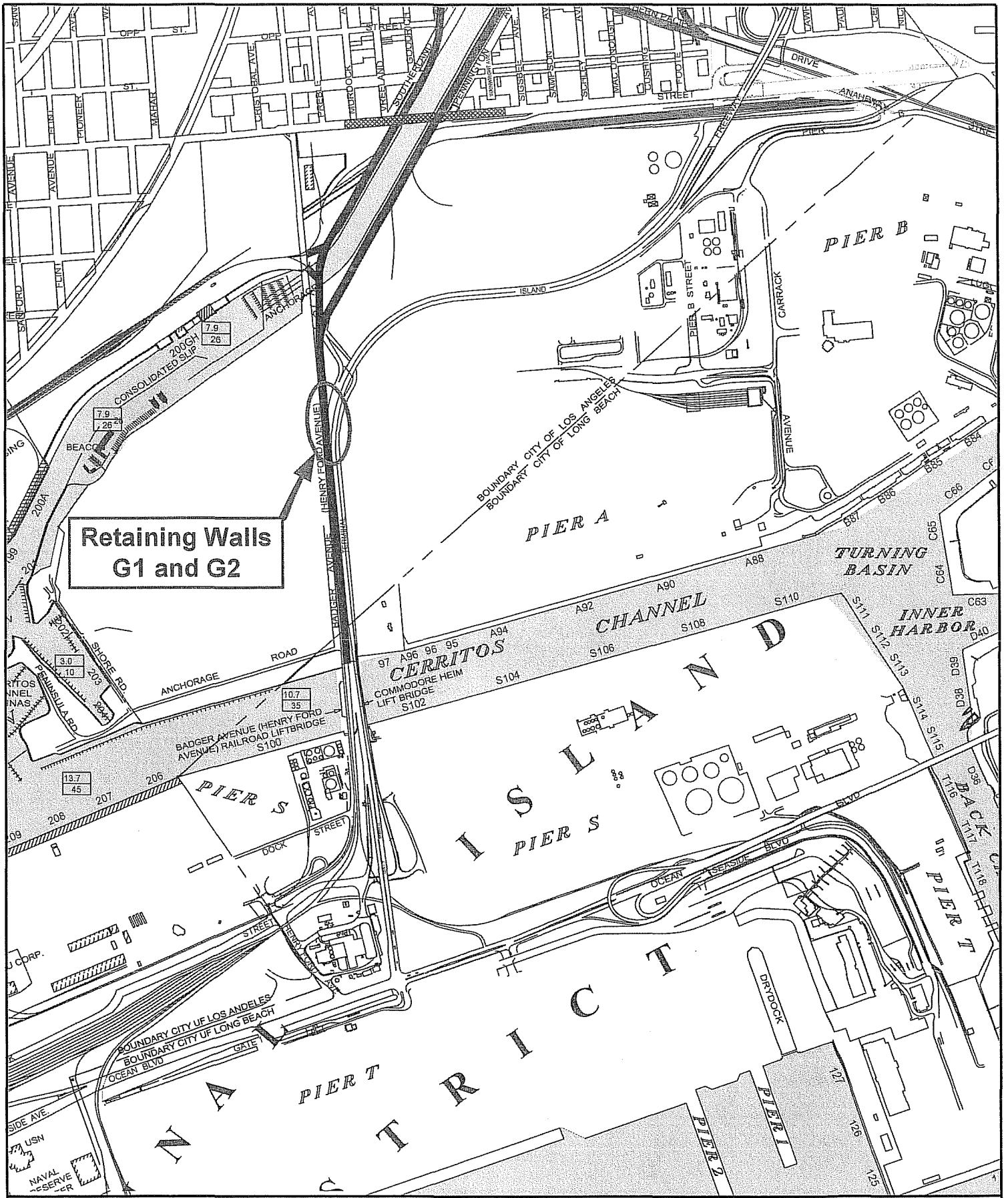
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Project No. 06-123 | Date: 5-10-10 | Figure 1



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ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Structure Location Map

Figure 2

Project No. 06-123	Date: 5-10-10

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Existing Information

Existing subsurface information surrounding the Schuyler Heim Bridge is available from reports prepared by LKR Group, Inc. (LKR, 1998), MAA Engineering Consultants, Inc. (MAA, 1993) and Diaz-Yourman and Associates (DYA, 2000) for seismic retrofit of the existing Schuyler Heim Bridge, rehabilitation of the Badger Avenue Bridge, and Henry Ford Avenue Grade Separation Project, respectively. From these three sources, the nearest boring to Retaining Wall G1 and G2 is shown on the as-built Logs-of-Test-Boring (LOTB) sheets prepared by LKR for the seismic retrofit of the Schuyler Heim Bridge and is approximately 800 ft south of the southern end of the proposed wall pair.

2.2 Supplemental Field Exploration

A geotechnical field investigation was conducted by EMI for the entire project between October and November, 2009 which included a total of eight hollow-stem auger borings, 42 rotary wash borings and 38 CPT soundings. Of that exploration program, two rotary wash borings, two hollow-stem auger borings and one CPT sounding were performed in the vicinity of Retaining Wall G1 and G2. The purpose of the explorations was to log subsurface conditions and collect soil samples from locations near the proposed walls. Soil exploration information is summarized in Table 1. Approximate locations of the explorations performed by EMI for this project are shown on Figure 3 and on the LOTB sheets included at the end of this report. Upon completion, the exploration locations were surveyed by Wagner Engineering & Survey, Inc. (WES) under a subcontract with EMI.

2.2.1 Soil Borings

The borings and CPT soundings surrounding the proposed retaining wall pair were performed at grade on the shoulder of the existing SR-103/SR47 ramps. The deepest boring penetrated down to about elevation -96.9 ft, approximately 102 ft below ground surface.

Rotary borings were performed by C&L Drilling Co. (C&L) and SoCal Drilling Co. (SoCal), under a subcontract with EMI, using a truck-mounted drill rig equipped with 5-in diameter tri-cone drill bit and a mud-rotary circulation drill system. Auger borings were performed by 2R Drilling Co. (2R), under a subcontract with EMI, using a truck-mounted hollow-stem auger drill rig equipped with 8-inch diameter augers. Subsurface soils and conditions were logged and samples of soils were collected for laboratory testing. Large bulk samples of near-surface soils were logged and collected. Smaller soil samples were collected from borings generally at 5 ft vertical intervals by means of split-spoon drive samplers; the Standard Penetration Test (SPT) sampler and the Modified California Drive (MCD) sampler were used to collect small disturbed and relatively undisturbed samples, respectively. The MCD is a split-barrel sampler with a tapered cutting tip and lined with a series of 1 inch tall brass rings. The SPT sampler (1.4 inch ID) and MCD sampler (2.4 inch ID, 3.25 inch OD) were driven using a 140 pound hammer falling 30 inches down a total depth of 18 inches or until refusal. The blowcounts for the last ft of penetration were recorded on the boring logs.

As part of the field investigation, SPT hammer energy measurements were performed by EarthSpectives (ES) under a subcontract with EMI. Based on those measurements, the average hammer efficiency was 62 percent in the borings performed by C&L, and 79 percent in the borings performed by SoCal and 80 percent in the borings performed by 2R. A copy of the ES report is provided in Appendix B.

Boring geophysical measurements were also collected by GeoVision under a subcontract with EMI in six uncased borings as part of the project. Compression (P) and shear (S) wave velocities were measured along the entire boring depth at the six selected boring locations. A copy of the GeoVision report is provided in Appendix C.

TABLE 1. SOIL EXPLORATION INFORMATION

Boring	Line	Approx. Station	Approx. Offset (ft)	Approx. GSE (ft)	Approx. GWE (ft)	Approx. Bottom of Boring Elevation (ft)	Method
R-09-035[2]	"G" Line	618+39.2	28.5 Lt	+2.1	-11.9	-74.4	RW
R-09-036[1]		619+74.9	30.8 Lt.	+3.4	-11.6	-72.6	RW
A-09-058[3]		620+78.1	39.0 Lt.	+4.2	-8.8	-47.3	HSA
A-09-059[3]		622+73.0	65.3 Lt.	+5.6	-1.6	-46.0	HSA
CPT-09-099		622+73.8	63.4 Lt.	+5.6	NR	-96.9	CPT

Notes: *1. Boring performed by C&L. Drilling Co.*
2 Boring performed by SoCalDrilling Co.
3.Boring performed by 2R Drilling Co.
4. GWE = Groundwater Elevation.
5. GSE = Ground Surface Elevation (estimated from topographic plans).
6. Top of Boring Elevation Based on NAVD88.
7. RW = Rotary Wash, HSA = Hollow Stem Auger, CPT = Cone Penetration Test.
8. NR = Not Recorced.

2.2.2 CPT Soundings

The CPT soundings were also performed at grade in the undeveloped area near or beneath the existing New Dock Street on-ramp structure, east of the main bridge structure. The deepest sounding was advanced down to elevation -102.7 ft, approximately 103.5 ft below ground surface.

Cone Penetration Test (CPT) soundings were performed by Middle Earth Geo Testing, Inc. (Middle Earth) under a subcontract with EMI, using an electronic cone penetrometer in general accordance with the current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance

during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the test equipment. The computer generated graphical logs include cone resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.3 Laboratory Testing

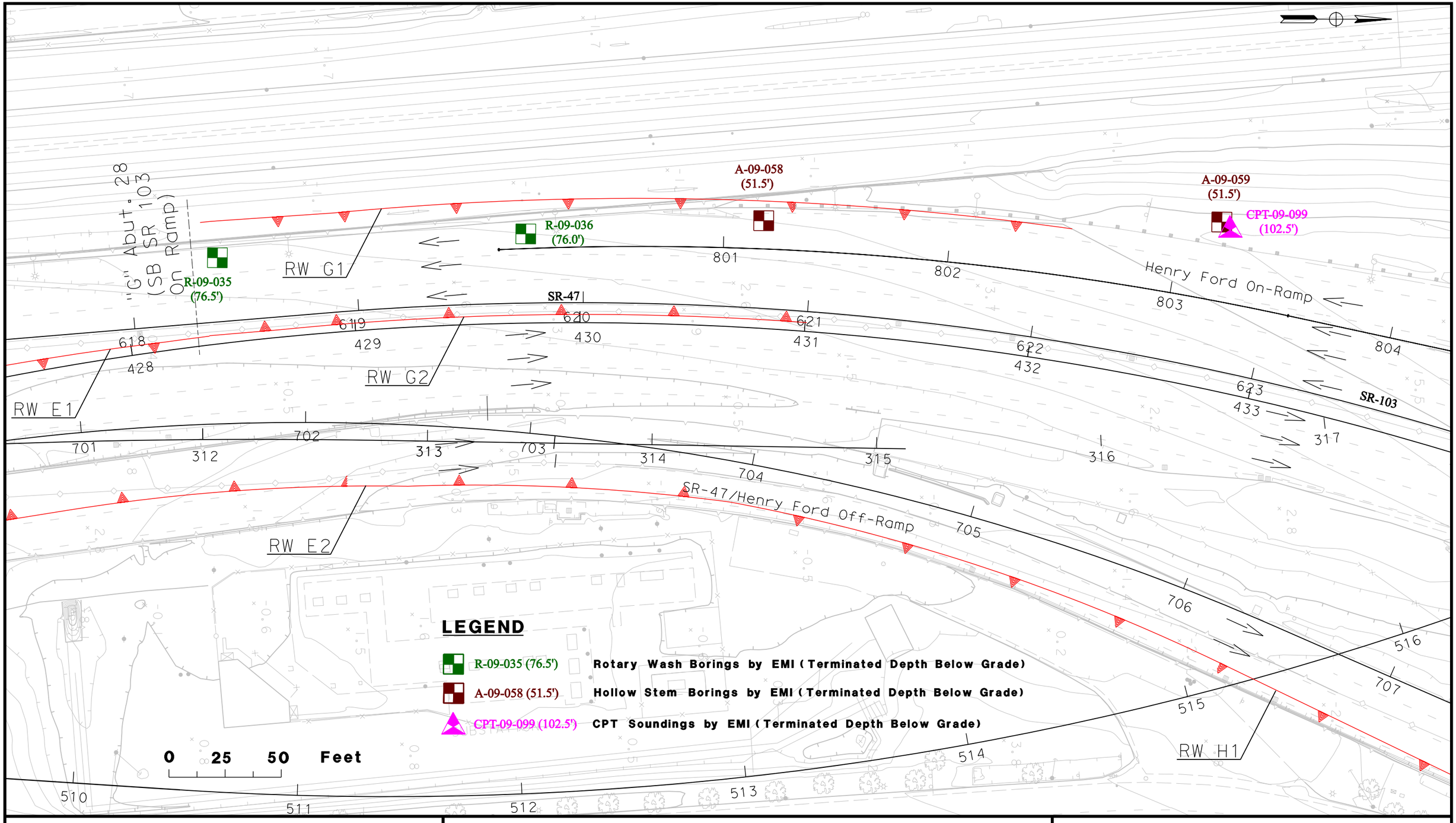
Laboratory tests were performed to determine relevant physical characteristics and engineering properties of the in-situ soils at the site. Selected soil samples were tested to determine soil type and other physical and engineering properties. A list of tests performed, the corresponding test methods, and purpose of testing is presented in Table 2.

The laboratory soil tests were conducted in general accordance with California Test (CT) methods or American Society for Testing and Materials (ASTM) standards. The distribution of laboratory tests is shown on the LOTB sheets at the end of the report and test results are given in Appendix C.

TABLE 2. EXPLANATION OF LABORATORY TESTS PERFORMED

Type of Test	Applicable Test Method	Purpose
Dry Density	ASTM D 2937	Estimate in-situ dry soil density
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
No. 200 Wash	ASTM D 1140	Determine the percentage of fine-grained particles of soil
Sieve Analysis & Hydrometer	ASTM D 422	Determine particle size distribution of soil
Atterberg Limits	ASTM D 4318	Determine plasticity of fine-grained soil
Specific Gravity	ASTM D 854	Determine specific gravity of soil grains
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
UU Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Compaction	CT 216	Determine maximum density and optimum moisture of soil
R-Value	CT 301	Determine R-value of soil
Soil pH	CT 643	Determine pH of soil for corrosion potential evaluation
Minimum Resistivity	CT 643	Determine resistivity of soil for corrosion potential evaluation
Sulfate Content	CT 417	Determine sulfate in soil for corrosion potential evaluation
Chloride Content	CT 422	Determine chloride in soil for corrosion potential evaluation

Notes: 1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project No. 06-123

Date: 05-10-10

Boring/CPT Sounding Location Map

Figure 3

3.0 GEOLOGY

3.1 Physiography

The Schuyler Heim Bridge spans the Cerritos Channel in the Port of Long Beach. Like most of the shipping channels within the port, the Cerritos channel is a man-made channel that was dredged into the former Wilmington Lagoon which was a coastal marshland with abundant tidal channels, estuaries, and small marshy islands. The site area is in the coastal area of San Pedro Bay within Los Angeles Basin (Figure 4). Los Angeles Basin is a large low-lying coastal plain bordered by the Santa Monica Mountains on the north, the Repetto and Puente Hills on the northeast, the Santa Ana Mountains on the east, and the San Joaquin Hills on the south (Figure 4). The western margin of the basin is open to the Pacific Ocean except for one prominent hill, the Palos Verdes Hills which is a peninsula separating Santa Monica Bay on the north from San Pedro Bay. The Palos Verdes Hills are a result of uplift along the Palos Verdes fault zone (Schell, 2007).

The floor of the Los Angeles Basin is a relatively flat surface rising gently from sea level along the coastline to the surrounding mountains which then rise abruptly to a few thousand feet above the plain. The margins of the hills and mountains surrounding the basin are commonly elevated somewhat above the general level of these major plains by an apron of uplifted sediments such as the La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and the Coyote Hills.

The flat basin floor of the Los Angeles basin is interrupted in a few localities by small hills such as the northwesterly alignment of hills and mesas called the Newport-Inglewood Structural Zone-NISZ (Figure 4). The NISZ extends from the Newport Bay area on the south to the Beverly Hills area on the north, and is a result of geologically recent folding and earthquake fault displacements. The NISZ divides the basin floor into two major plains, The Downey-Tustin Plain on the northeast and the Torrance plain (including the Long Beach Plain) on the southwest. The part of the NISZ nearest the site is at Signal Hill to the northeast (Figure 5).

Major Rivers in the Los Angeles basin are the Los Angeles, San Gabriel, and Santa Ana Rivers. These rivers enter the basin through valleys or canyons in the surrounding mountains such as Los Angeles Narrows, Whittier Narrows, and Santa Ana Canyon, and flow southerly across the basin floor, through gaps in the NISZ, to the coast. At present these rivers along with nearly all minor tributaries in the Basin are confined within concrete-or rip-rap-lined channels but in the natural state they meandered back and forth across the Basin floor, commonly shifting outlets. For example, the Los Angeles River at one time flowed westerly into Santa Monica Bay through Ballona gap and the San Gabriel River flowed into Wilmington Lagoon which is now occupied by the Port of Los Angeles. At present, the Los Angeles River flows to the Port of Long Beach-Los Angeles area.

The floor of the Los Angeles Basin is directly underlain by unconsolidated Quaternary-age sandy sediments. These generally can be subdivided into loose unconsolidated Holocene-age sediments which cover the bulk of the basin, and the underlying Pleistocene-age materials of the Lakewood and San Pedro formations which are only exposed in some of the uplifts of the NISZ and the marginal plains. Hard rocks occur only in the mountains surrounding the basin and at depths ranging from a few thousand feet to as much as 30,000 feet in the deepest part of the central Los Angeles Basin.

Except for the Newport-Inglewood and the Palos Verdes fault zones, most surface geological faults such as the Santa Monica, Hollywood, and Whittier faults occur along the basin margins (Figure 4). In Addition to these known surface faults, the Los Angeles region is underlain by buried thrust and reverse faults. These are poorly understood features with poorly known locations and orientations. The Los Angeles, Santa Fe Springs, and Coyote Hills faults which make up the Puente Hills blind thrust fault system, are examples (Figure 4). However, any large earthquakes associated with these subsurface features are most likely to originate at great depths (e.g. about 10 to 12 miles), and thus these should not impact the subject site significantly more than similar-sized earthquakes on the nearer Newport Inglewood or Palos Verdes faults. The 1987 Whittier earthquake occurred on one of these subsurface faults (either the Santa Fe Springs or the Coyote Hills faults) dipping northerly under the Repetto-Puente hills and the San Gabriel Valley northeast of the site. The 1994 Northridge earthquake occurred on a southerly dipping buried fault below the San Fernando Valley.

3.2 Stratigraphy

The project area is underlain by a sequence of geologic strata consistent with the general stratigraphy of the Los Angeles Basin. Table 3 is a regional stratigraphic and correlation chart showing the upper part of the stratigraphic sequence in the ports of Long Beach and Los Angeles area. Review of the borehole logs drilled for this project, along with existing boring logs from other geotechnical studies and from published sources (e.g. Zielbauer, et al., 1962; Wright 1991; U.S. Geological Survey, 2007; Schell, 2007), indicates similar strata.

The uppermost deposits of most significance to the project were deposited during the last ice age and the period directly thereafter, i.e. the past 15,000-20,000 years or so. The rise in sea level was not constant but comprised several fluctuations. Interaction between the fluctuating sea level and sedimentary deposition from inland streams resulted in a complex association of irregular and discontinuous beds and lenses of marine and non-marine sedimentary strata. The major stratigraphic units underlying the project corridor are summarized below:

1) The surficial strata consist of sandy alluvium deposited by streams of the Los Angeles River system flowing into the coastal marsh, near-shore-marine, and beach deposits along the coast during the past few thousand years (~ past 5,000 to 7,000 years). These are about 20 to 30 feet thick.
2) The surficial strata overlie early Holocene-age transgressive marine silts and clays deposited between about 4,500-7,500 years ago to about 10,000 years ago. These deposits occur at depths of about 25 ±5 to 70 ±10 feet and represent primarily marine sediments deposited during the later stages of the most recent rise in sea level that began about 15,000 to 20,000 years ago. However, these deposits commonly contain sand and fine gravel lenses deposited by seasonal river flooding during intermittent wetter periods and storms inland.
3) These are underlain by the Gaspur Formation which is coarser grained sand and gravel material deposited in a relict channel of the Los Angeles River that was cut when sea level was lower during the last ice age. As the climate warmed, sea level rose due to melting ice at the Polar ice caps and the shore line retreated inland. The Gaspur is about 70 ±10 feet to about 190 feet deep and consists of an upper primarily sandy unit and a

deeper coarser sand and gravel unit. The gravels of the Gaspur channel extend far inland and comprise a major aquifer in the Los Angeles area.

4) The Gaspur channel was cut into older Pleistocene material of the Lakewood Formation which is about 160 to 300 thousand years old. The Lakewood is partially marine and partially non marine that was deposited during previous Pleistocene ice ages. Lakewood sediments were intermittently exposed to surficial weathering resulting in desiccation, oxidation, and soil-profile development. At the site, the Lakewood is about 190 feet to about 250-300 feet deep and overlies the Pleistocene-age, marine San Pedro Formation.
5) The San Pedro Formation extends to about 1100 ±50 feet depth and comprises gently tilted marine silts and sands overlying the folded Tertiary-age marine deposits (Pico, Repetto, Fernando formations), and the ancient igneous and metamorphic basement rocks at a depth of about 10,000 feet.

TABLE 3. STRATIGRAPHY AND CORRELATION CHART, LONG BEACH AREA

Geologic Series	Formation	Sequence (USGS, 2007)	Age Estimate	Zielbauer and others (1962)	CA Dept. of Water Resources (1961)
Holocene	Dune/Beach Sand, Coastal Marsh, Transgressive Marine, Stream Alluvium	Dominguez	<15 ka	Gaspur	Gaspur
Upper Pleistocene	Older Dune Sand, Stream Alluvium, Near-shore Marine, Lakewood Fm (Marine and Non Marine)	Mesa	Latest Pleistocene (~30-80 ka)	200 ft sand	Gage
		Pacific	Early O stage 5 (110-130 ka)		
		Harbor	Constrained between O stage 5 and 9 (~160-300 ka)		
Lower Pleistocene	San Pedro Formation	Bent Spring	O stage 9-11 (~300-450 ka)	400 ft gravel	Lynwood
		Upper Wilmington	O stage 12-14 (~475-580 ka)		
		Lower Wilmington	O stage 15-17+ (~580-<780 ka)	Upper Silverado	Silverado
		Pliocene A	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology		
		Pliocene B	~2.0 Ma or >2.6 Ma from magnetic polarity and paleontology	Lower Silverado	
Upper Pliocene	Pico/Fernando Formation	Pliocene C	>2.6 Ma from magnetic polarity and paleontology	Pico	Pico

Units 1 through 3 were penetrated by many of the deeper on-land borings drilled for this investigation. Most of the recovered gravel and the sandy gravel/gravelly sand samples are from the Gaspur Formation. The over-water borings generally penetrated deeper and extended through the Gaspur into the upper part of the Lakewood Formation. Other units of the stratigraphic succession (e.g. the Mesa and Pacific parts of the Lakewood Formation) are present in areas adjacent to the project area but were eroded away by the erosion that accompanied deposition of the Gaspur sediments and therefore are not important to the project. Likewise, the San Pedro formation is deep below the site and is not important to the project.

3.3 Geologic Structure

The regional geological structure was introduced above in the geological Setting. The project area is near the crest of the Wilmington Anticline (Figure 5) which is a west-northwest trending fold in the Tertiary-age strata (Figure 6). As shown on Figure 6, the Holocene and late Pleistocene strata (Lakewood Formation) form a thin veneer across the Wilmington fold and appear to be unaffected by the deeper folding and faulting.

There are no known active faults at the project site. The nearest major active faults are the Palos Verdes fault to the southwest and the Newport-Inglewood (Cherry Hill segment) to the northeast (Figures 5 and 6). The Thums-Huntington Beach fault is deep below the surface (Figure 6). This fault is a thrust fault dipping northeasterly at about 25-35 degrees. Some geoscientists suspect the fault is a potentially active blind thrust fault but high-resolution geophysical data clearly show the fault does not displace sediments younger than 3 or 4 million years old (Schell, 2007). Furthermore, the fault displacement diminishes toward the northwest and is virtually nil under the project area (Figures 5 and 6).

3.4 Seismicity

The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. The larger earthquakes are shown on Figure 7. Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, along the northern side of the San Fernando Valley, the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. Although historical earthquakes have occurred in proximity to known faults, they are often difficult to directly associate with mapped faults unless there was a surface rupture or a robust sequence of aftershocks. Ward (1994) estimated that about 40 percent of seismic moment can not be correlated with known faults. Part of the correlation difficulty is due to the fact that the basin is underlain by the subsurface blind thrust faults that are not likely to be discovered until they rupture during an earthquake.

The largest historical earthquakes in the region were the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred north of the Los Angeles Basin (Figure 7). The 1994 earthquake had a moment magnitude (MW) of about 6.7 (MS = 6.8, ML = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles below the community of Reseda in the San Fernando Valley. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1 or 2 miles to 14 miles (Hauksson, 1995). The causative fault was never identified with certainty, but it may have been on the eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping fault bounding the Ventura Basin and dipping under the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW = 6.7, MS = 6.4, ML = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults such as the Sylmar fault, Tujunga fault, and Lakeview fault were involved. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly along the southern margin of the San Gabriel Mountains from the San Fernando Valley to the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The largest historical earthquake in the Los Angeles region to have a major impact on the site area was the 1933 Long Beach event which had a magnitude of about MW = 6.4 (ML = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone because of the distribution of aftershocks and the abundance of ground disturbances in proximity to the fault zone (Figure 7). Although ground failures were abundant along the NISZ trend, no unequivocal surface rupture was identified (Benioff, 1938). Reevaluation of the seismicity data by Hauksson and Gross (1991) led to relocation of the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

The 1987 Whittier earthquake (ML = 5.9, MW = 5.9) occurred on subsurface faults dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This zone of faults is referred to as the Puente Hills blind thrust fault system (Figure 4). This event did not rupture the ground surface.

Another significant earthquake in the Los Angeles region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1988; Weldon et al., 2004) postulated that it did not occur in the Los Angeles Basin area, but rather, was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Spanish Portola' expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, the 1812 or 1992 Landers events).

3.5 Geologic Hazards

3.5.1 Surface Fault Rupture

No surficial faults are known at the site, therefore the potential for ground rupture due to faulting is negligible. The nearest major faults with a known potential for surface rupture are the Newport-Inglewood zone to the northeast and the Palos Verdes Hill fault to the southwest (Figures 4, 5, and 6).

3.5.2 Subsidence

The ground surface in the Long Beach Harbor area has undergone substantial lowering during the 20th century due to subsidence of the sediments and rocks underlying the area. Some of this subsidence may have been due to natural causes (e.g. natural ground-water decline, sediment compaction, tectonics, 1933 Long Beach earthquake). Harris (1945) estimated natural subsidence of about half an inch per year. The principal cause of the subsidence has been attributed to withdrawal of oil and gas (Allen, 1984; Strehle, 1987), but ground-water extraction undoubtedly contributed, perhaps 2 feet out of the 29 feet (7%), to the total subsidence.

Subsidence accelerated with development of the Wilmington oil field in 1936. The area of subsidence forms a circular or bowl-shaped area centered on the northeast corner of Terminal Island (Figure 8A). The maximum subsidence in the center of the subsidence bowl is about 29 feet. Subsidence along the Heim Bridge project corridor in the western part of the subsidence bowl was about 14 feet (Figure 8A). The maximum rate of subsidence reached about 2.4 feet per year by 1951. The subsidence was so great that dikes had to be built within the harbor area to prevent flooding by sea water. Some of the subsided areas behind the dikes have recently been filled bringing the ground surface back to above sea level (~ +15 feet).

Subsidence was arrested by restoring pressure to the oil zones through injection of water into the oil wells. This has not only stopped subsidence but has resulted in some rebound, and also has been of economic benefit by driving more oil to the producing wells. Initial injection began in 1953 but was not fully established until about 1958; by 1961 injection was widespread. Cessation of subsidence occurred within a couple years. Elevation rebound was noticed in 1958 and reached a maximum by about 1964 with only minor fluctuations since. Maximum elevation rebound has been about 1.6 feet along Anaheim Street, and at the Heim bridge about 1.2 feet (Figure 8B).

The subsidence did not cause significant damage to most surface facilities but it did damage oil wells at about 1,500-2,000 feet depth, and induced several small earthquakes. In all, about 500 wells were damaged. Some of the oil well casings were sheared off or so severely damaged that the wells had to be abandoned and redrilled.

Mathematical calculations indicate that up to 66 feet of subsidence could occur if allowed to continue unchecked. To prevent and control further subsidence, injection must be maintained even after cessation of fluid withdrawals. The City of Long Beach Gas and Oil Department

(LBGOD) surveys elevation changes twice a year, and monitors oil field fluid injection designed to correct elevation changes. The LBGOD estimates survey accuracy of about 0.24 inches; areas are considered to be stable if elevation changes are less than that (LBGOD, 2009). Bench marks rise and fall in a somewhat random manner that is not completely understood but injections do seem to correct elevation changes. The correlation between injection and elevation rebound appears to be good, but it may take a few months to a year or so to be fully realized.

There are 3 "index" bench marks near the Heim Bridge; one at the north abutment and two more a little farther to the north. Several other bench marks are scattered around the bridge area. Based on measurements of these benchmarks, it appears that subsidence of the Heim Bridge area has resumed since 1995 and total subsidence of about 2 feet has been observed in the Heim Bridge area since 1995. During the recent years, the annual subsidence rate seems to have decreased; Measurements were approximately 0.6 in. during the period between May 2007 and April 2008 and about 0.2 in during the period between November 2008 and April 2009 (LBGOD, 2009).

3.5.3 Flooding

The flood inundation map in the Los Angeles County safety element of the General Plan (1990) indicates there is a flooding potential at the project site from failure of Hansen Dam which is in the San Fernando Valley. However, the reservoir volume, even in the extremely rare case of when it is full, is quite small and it is difficult to imagine that a significant flood surge could be maintained across the flat open terrain for the 30 + miles across the San Fernando Valley and Los Angeles Basin; therefore, the potential for flooding of the site is considered low.

3.5.4 Tsunami and Seiche

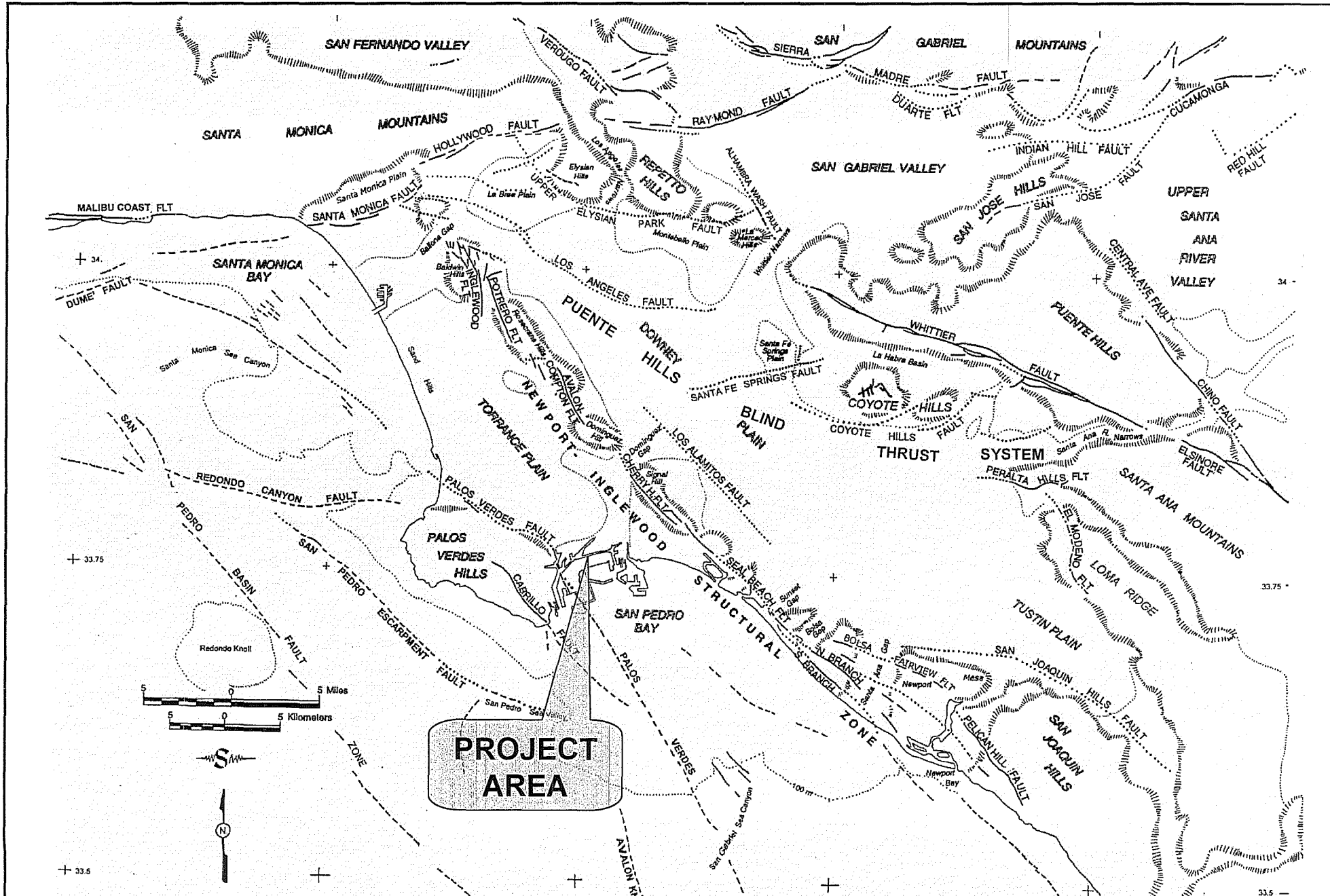
Tsunamis are sea waves generated by submarine earthquakes, landslides, and volcanic eruptions. Seiches are waves internal to an enclosed or highly restricted body of water that wash back and forth across the basin. Smaller tsunamis may be common but their run-ups are no more than typical tidal fluctuations so they do not cause significant damage. Generally, damaging tsunamis are caused by submarine earthquakes with a magnitude of about 7 or larger.

Most tsunamis to affect the Los Angeles-Long Beach harbor areas have been generated by distant earthquakes although California has had few locally generated, historic tsunamis, namely the 1812 Santa Barbara earthquake and the 1927 Point Arguello earthquake. According to Houston (1979), the Los Angeles Harbor is within Tsunami Zone 2 (out of 5 zones with 5 being the worst) indicating a potential for water run-ups of 5 to 15 feet.

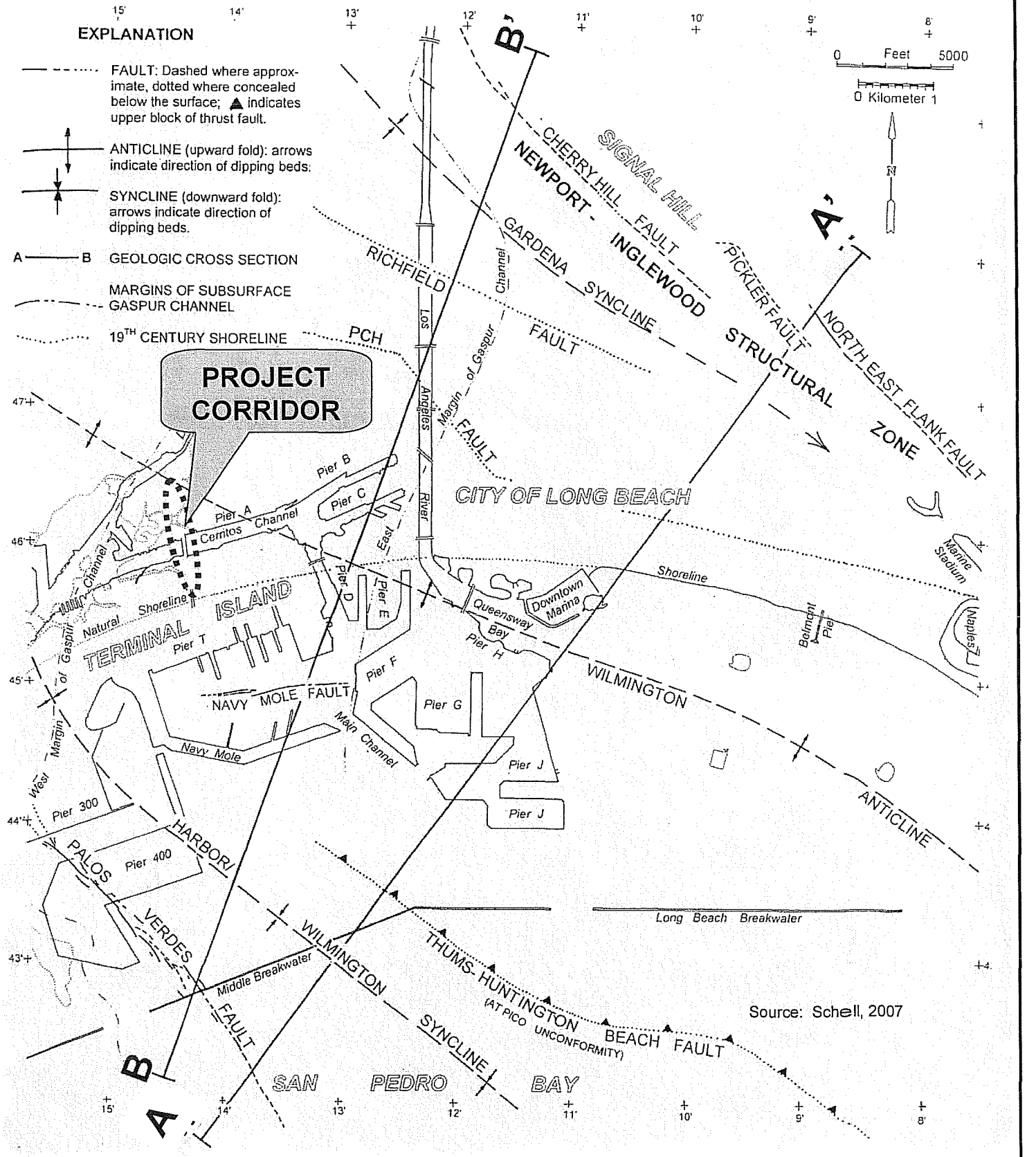
California has been struck by several other significant tsunamis generated in the northern Pacific (for example, the 1946 Aleutian earthquake of Mw = 7.8 and 1964 Alaska event of Mw = 9.2); and in the southern Pacific (1922 Chile earthquake of Mw = 8.4 and the 1960 Chile event of Mw = 9.5). The 1964 Alaska earthquake caused severe damage and 15 fatalities in northern California. In southern California, the most serious recorded tsunami was generated by the 1960 Chile earthquake. The greatest damage occurred in the Long Beach-Los Angeles Harbor where 5-foot-high seiche waves surged back and forth in the channels. Currents of 12 knots were reported as the water rose and fell rapidly. A 6-foot drop in water level occurred in 1 minute at

Long Beach and 3 foot drop in 5 minutes along the Cerritos Channel. The currents tore some 300 small boats and yachts from the slips and as many as 30 were sunk. Damage was estimated at between $500,000 to over $1,000,000.

A comprehensive tsunami analysis for the ports of Long Beach and Los Angeles by Moffat & Nichol (2007) basically confirmed the tsunami hazard from distant events. The analysis included tsunamis generated by local sources such an earthquakes in the nearby offshore Southern California Continental Borderland, and by landslides off the Palos Verdes shelf. No tsunamis have been documented from such local events during historical times. These events are extremely rare with recurrence intervals up to about 10,000 years. The results of the analysis indicate that the maximum water level within the Cerritos channel near Heim bridge could be as high as about 11 feet. Current speeds should be less than about 3 ft/sec.

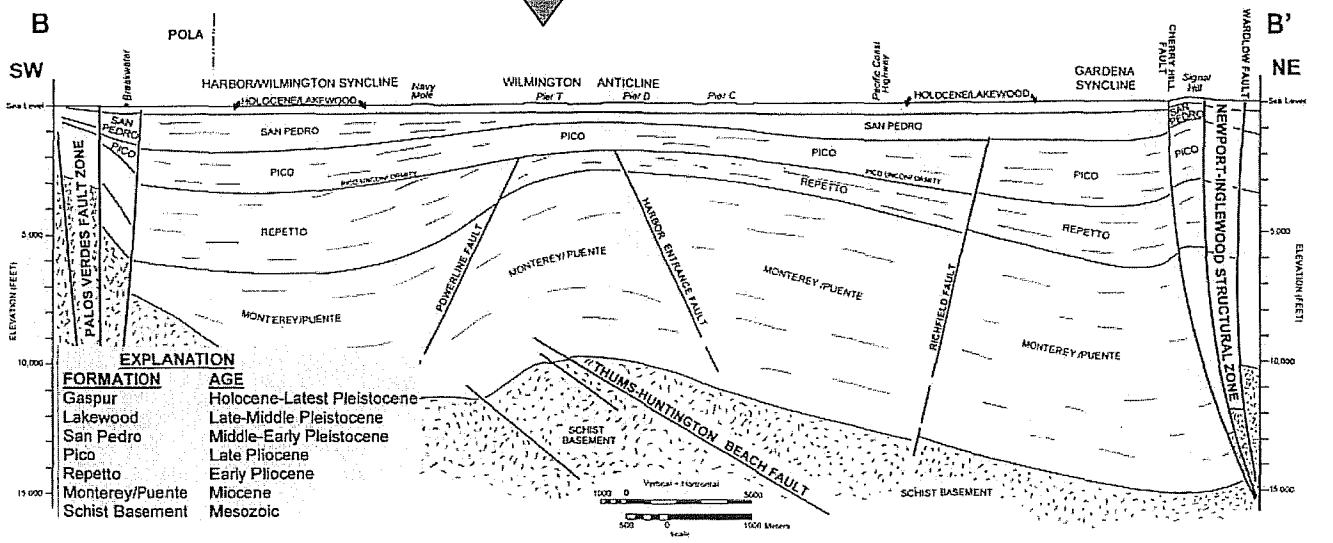


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	Map of Active Faults and Physiography, LA Basin
	Project No. 06-123 / Date: 5-10-10	Figure 4

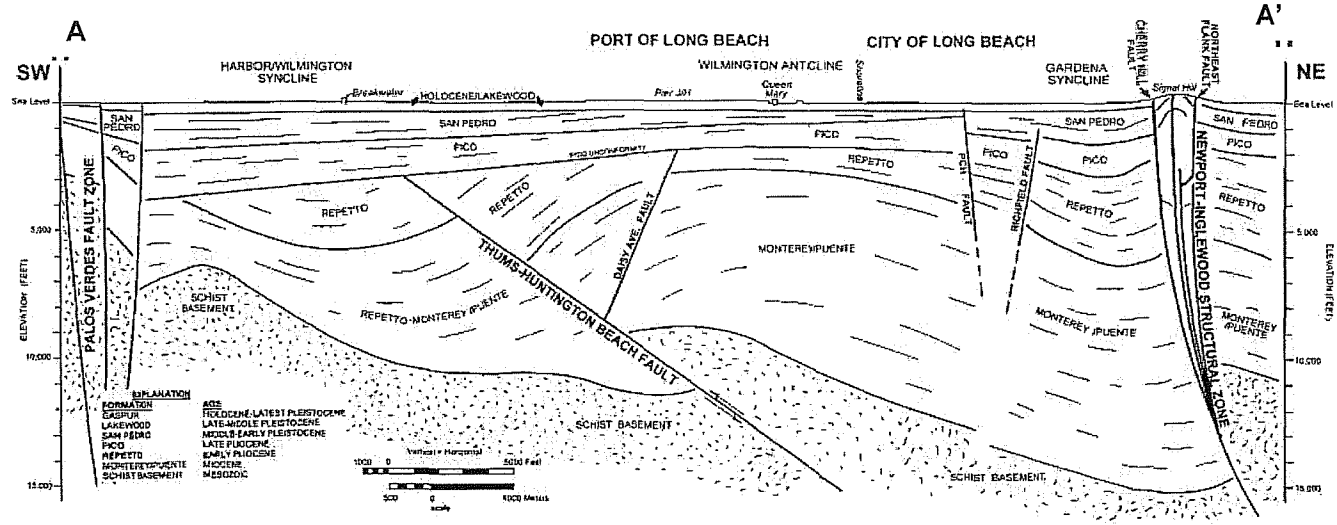


Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT	
	Structural Geology Map, Long Beach Harbor	
Project No. 06-123	Date: 5-10-10	Figure 5

APPROXIMATE
PROJECTED LOCATION
OF PROJECT CORRIDOR



B. GEOLOGIC CROSS SECTION B THROUGH WESTERN PORT OF LONG BEACH

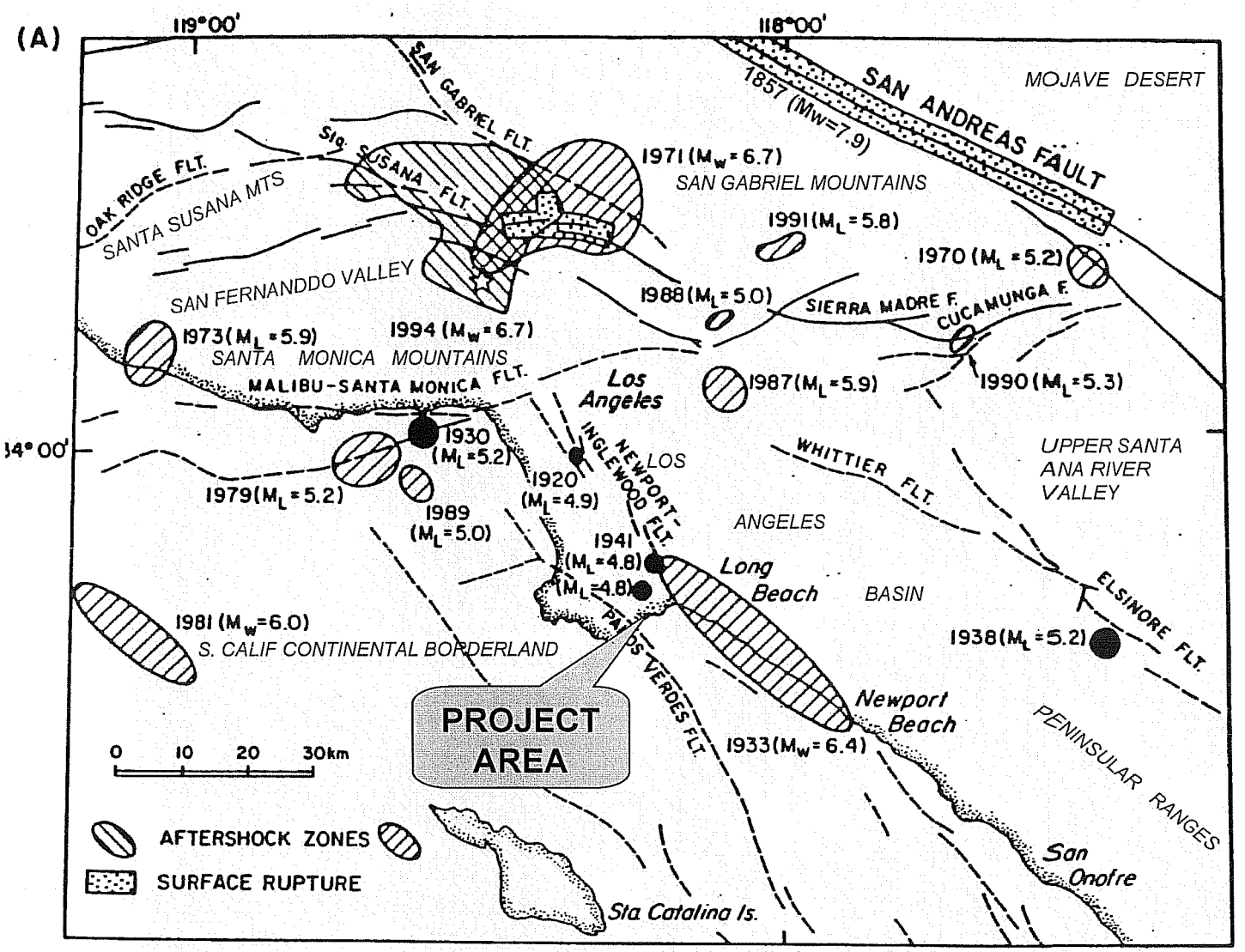


A. GEOLOGIC CROSS SECTION A THROUGH EASTERN PORT OF LONG BEACH

Notes 1) See Figure 5 For Location Of Cross Section Lines

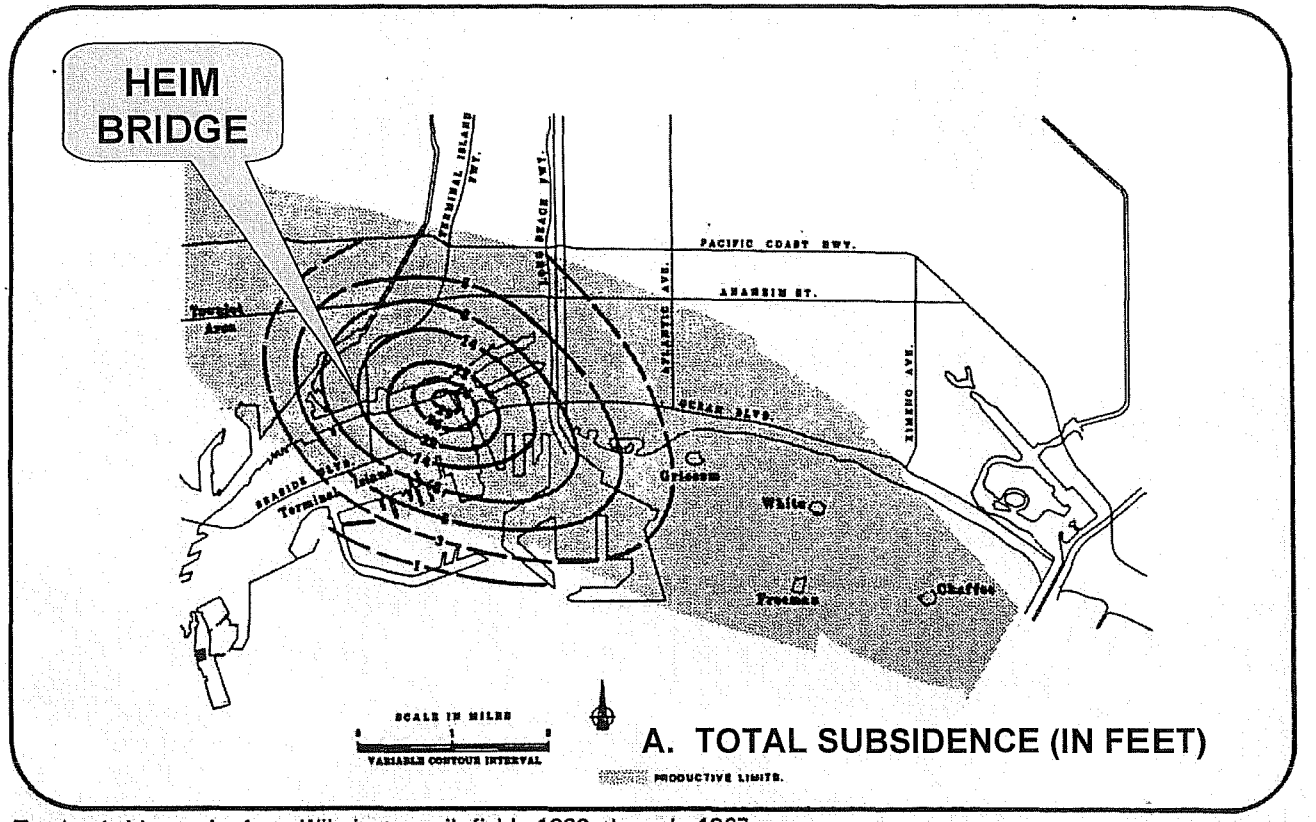
2) Source: Schell, 2007

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 5-10-10	Geologic Cross-Sections, LA Harbor Figure 6

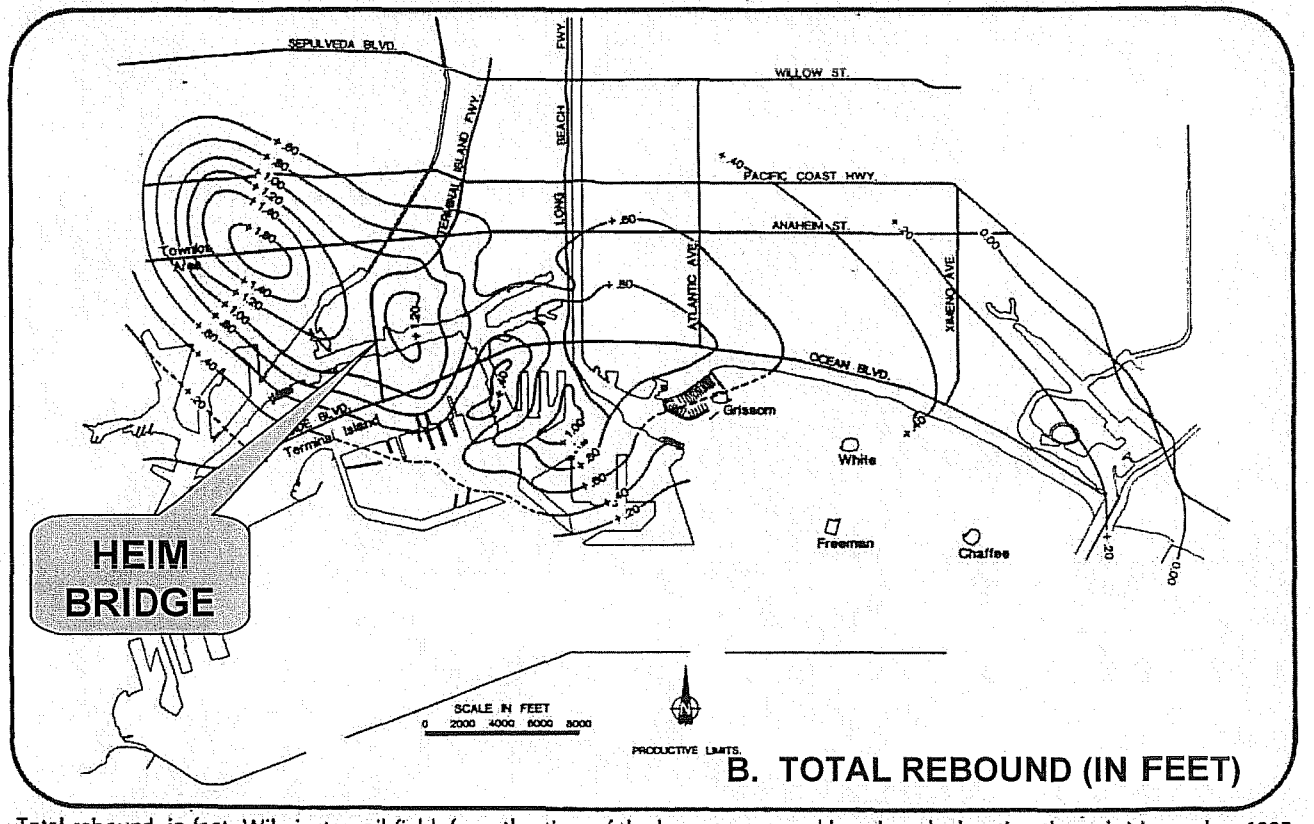


Source: Modified from Hauksson, 1995

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-10-10	Map of Notable Earthquakes, LA Region Figure 7



Total subsidence, in feet, Wilmington oil field, 1926 through 1967.



Total rebound, in feet, Wilmington oil field, from the time of the lowest measured benchmark elevation through November 1985.

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123 | Date: 5-10-10	Map of Subsidence and Rebound, Long Beach Harbor Figure 8

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

Soil stratigraphy is defined by the available soils information and the exploratory borings and CPT soundings (described in Section 2) performed under the supervision of EMI personnel for the project. Within the depths explored (down to about elevation -149 ft), the subsurface profile consists of about 75 ft of interlayered alluvial deposits overlying Gaspur Formation sand.

At the subject site, natural grade lies at an elevation of about zero, with a few feet of import fill for the existing northern approach embankment to Schuyler Heim Bridge extending to a maximum elevation of about +6 ft along the proposed alignment of the two walls. The near surface deposits consist of silty sand and sandy silt between natural grade and about elevation -4 ft. The near surface deposits are underlain by a thick strata of inter-layered medium stiff to stiff silt, sandy silt, and some clay and loose to medium dense silty sand down to about elevation -55 ft. Below elevation -55 ft, lies the Gaspur Formation which consists of dense to very dense sand and silty sand within the depths explored.

It should be noted that the above soil description is general and is intended to describe the subsurface in very broad terms. The soil descriptions above should not be construed to mean that the subsurface profile is uniform and that soil is homogeneous within the project area. For details on the stratigraphy at each borehole location, refer to the LOTB sheets at the end of the report.

4.2 Groundwater Conditions

During the EMI investigation in 2009, groundwater was recorded in all four of the borings performed near the proposed walls between elevation -1.6 ft and -11.9 feet. The elevation that groundwater was encountered in each boring is listed in Table 2 and also on LOTB sheets at the end of the report. However, due to the proximity of the site to the Cerritos Channel, where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely.

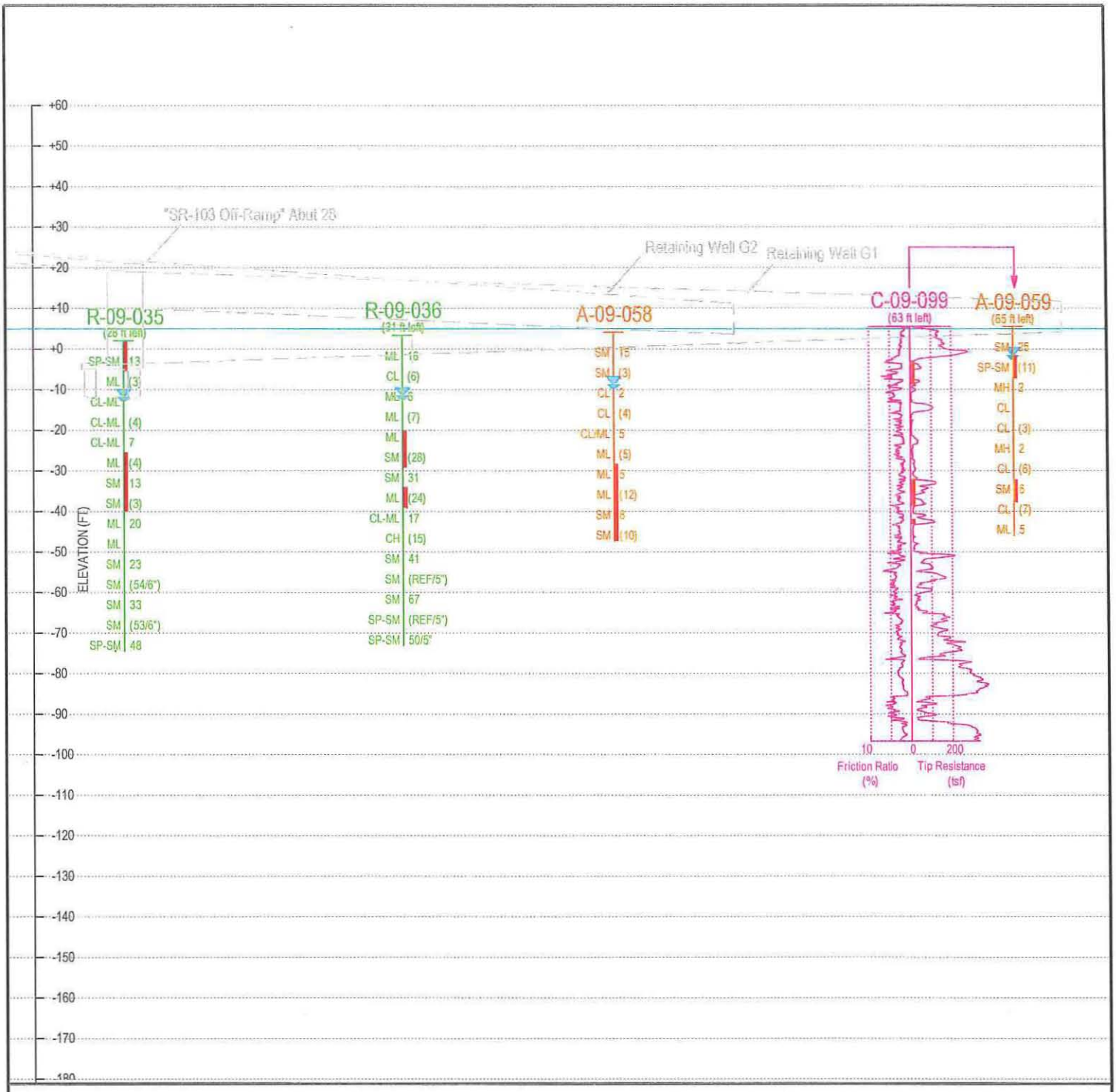
Based on the observed high water groundwater elevation for the Cerritos Channel, the design groundwater was placed conservatively at elevation +5 ft or the ground surface in locations where finished grade is proposed to be below elevation +5 ft.

4.3 Idealized Soil Profile

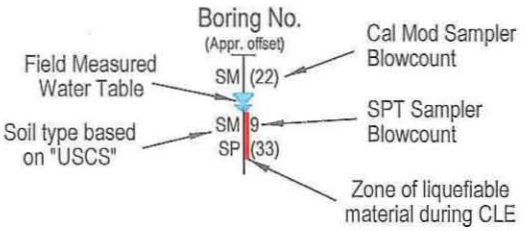
Based on information collected from borings R-09-035, R-09-036, A-09-058, A-09-059 and CPT sounding CPT-09-099 an idealized soil profile for foundation analysis and design was developed along the alignment of the proposed walls. The subsurface profile beneath the proposed structures is shown in Figure 9. The soil profile and design strength parameters are presented below in Table 4.

TABLE 4. IDEALIZED SOIL PROFILE AND PARAMETERS

Approx. Elev. (ft)	Predominant Soil Type	Total Unit Weight (lb/ft^3)	Cohesion (lb/ft^2)	Friction Angle (degree)
+2.0 to -5.0	Silty Sand / Sandy Silt	120	0	32
-5.0 to -30.0	Clayey Silt / Sandy Silt	120	650	0
-30.0 to -40.0	Silty Sand / Sandy Silt	120	0	30
-40.0 to -50.0	Clayey Silt / Lean Clay / Silty Clay	120	2,500	0
-50.0 to -65.0	Silty Sand	120	0	34
-65.0 to -100.0	Sand / Sand with Silt / Silty Sand	125	0	38



Boring Log Legend



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Subsurface Profile

Figure 9

Project No. 06-123 | Date: 5-10-10

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Seismic Evaluation

As part of EMI's scope of work for the Schuyler Heim Bridge (Replace) project, a ground motion study was performed in accordance to with the 2009 Caltrans Seismic Design Criteria (Caltrans, 2009). Due to the weak near surface deposits encountered throughout the project area, a site response analysis was performed to develop the design acceleration response spectra.

As described in Section 2, down-hole shear wave velocity measurements were taken in six of the rotary wash borings performed along the mainline bridge alignment. Shear wave velocity profiles were generated for the upper 30 meters (100 ft) of the soil profile and input into the program SHAKE91 along with the seven sets of spectrum compatible time histories to develop a site specific ARS spectrum. The design ARS spectrum was generated by enveloping the mean plus one standard deviation surface ground accelerations from the SHAKE analysis. Details of the site specific ground motion study are summarized in a memorandum prepared by EMI, which is included in Appendix E.

The site response analysis, performed in accordance with the 2009 SDC, results in a peak ground acceleration (PGA) of 0.5g for the site. Liquefaction potential and seismic settlement analysis were performed using a PGA of 0.5g resulting from a magnitude 7.0 event. Pseudo-static global stability analyses were performed using a seismic coefficient of 0.17 equal to one-third the PGA in accordance with Caltrans guidelines (Caltrans, 2006e).

Ground Rupture: No known active surface faults traverse the project area. The California Division of Mines and Geology has not identified Alquist-Priolo Fault Zones through or in the proximity of the site. Therefore, the risk of ground surface rupture and related hazards is considered low.

5.2 Soil Liquefaction Potential and Seismically-Induced Settlement

The liquefaction potential of the saturated, granular materials below the water table was evaluated using the procedures outlined by Seed et al. (1983) and updated by NCEER (1997) and Youd et al. (2001). For liquefaction potential evaluation of clayey soils, the procedure outlined in Boulanger and Idriss (2006) was used. The seismically-induced soil settlement was estimated using the procedures outlined by Tokimatsu and Seed (1987). As discussed in Section 4.2, the design groundwater was assumed to be at the lower of elevation +5 ft or the ground surface for the liquefaction potential evaluation.

Layers, pockets and lenses of saturated coarse-grained alluvial deposits above the dense Gaspur Formation (located below approximate elevation -55 ft) are expected to be susceptible to liquefaction. Seismically induced-settlements of a few to several inches are anticipated. The elevations of the potentially liquefiable material and the corresponding anticipated seismic settlements are shown in Table 5. The location of the potentially liquefiable material during the design earthquake is also identified in the subsurface profile shown in Figure 9.

TABLE 5. LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS RESULTS

Boring/CPT Sounding No.	Approximate Elevations of Liquefiable Zones (ft)[1]	Layer Approximate Seismically induced Settlement (inches)	Total Approximate Seismically induced Settlement (inches)
R-09-035	+2 to -5	0.7	6.3
	-25 to -40	5.6	
R-09-036	-19 to -29	1.4	2.4
	-34 to -39	1.0	
A-09-058	-28 to -48	5.6	5.6
A-09-059	-2 to -7	1.4	2.9
	-32 to -37	1.5	
CPT-09-099	-3.0 to -8.6	0.7	1.1
	-32.1 to -38.5	0.3	
	-42.0 to -43.0	0.1	

Notes: 1. Elevations are based on NAVD88.

5.3 Soil Corrosivity

Samples representative of soils throughout the project area were tested to determine corrosivity including minimum resistivity, pH, soluble sulfate content, and soluble chloride content. Six soil samples were tested for corrosivity using the procedures described in California Test methods 417, 422, 532, and 643. The pH was determined to vary between 7.7 and 8.7, the minimum resistivities were 150 and 9,300 ohm-cm, soluble chloride contents were 248 and 12,774 parts per million (ppm) and soluble sulfate contents were 30 and 1,187 ppm.

According to Caltrans corrosion guidelines (Caltrans, 2003), soils are corrosive if the pH is 5.5 or less, or the chloride concentration is 500 parts per million (ppm) or greater, or the sulfate concentration is 2,000 ppm or greater. Based on the test results, the on-site soils are considered to be corrosive.

The backfill for the reinforced soil mass should conform to the corrosion requirements per Caltrans Standard Special Provision (SSP) for MSE walls. For MSE walls with metallic soil reinforcement, the permeable backfill material should meet the following requirements: minimum resistivity of 2,000 ohm-cm, chlorides less than 250 ppm, sulfates less than 500 ppm, and pH between 5.5 and 10. Permeable material with geosynthetic soil reinforcement should have a pH between 4.5 and 9.0.

5.4 Mechanically Stabilized Earth Wall Recommendations – Retaining Wall G1

As described in Section 1.2, Proposed Retaining Wall G1 is located between approximate Stations 618+33 and 622+22 ("G" Line). The retaining wall is approximately 389 ft long and will vary in design height from 6 to 24 ft. Due to the presence of compressible soil, construction

of the proposed SR-103 On-Ramp embankment is expected to induce long-term consolidation settlement within the footprint of the proposed approach. Several wall alternatives were considered, and ultimately an MSE wall was selected because of its ability to tolerate substantial amount of total and differential settlements.

The MSE wall should be designed based on Section 5 of the Caltrans BDS (Caltrans, 2004).

5.4.1 Lateral Earth Pressures

Using Section 5.5.5.8 of the Caltrans BDS (Caltrans, 2004), an active earth pressure coefficient of 0.3 and a soil unit weight of 120 pcf is recommended for the proposed MSE wall (i.e., 36 pcf equivalent fluid pressure), which retains level backfill. An additional lateral uniform pressure of 75 psf due to a traffic surcharge equivalent to a vertical pressure of 250 psf should be added to the above lateral earth pressure values, where applicable. The lateral active earth pressure resultant should be applied to the back of the MSE wall at H/3 ft above the bottom of the wall (H is the wall height in ft).

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.4.2 Bearing Capacity

Bearing Capacity of MSE Structure: Using the maximum wall height of 24 ft and base width of 24 ft near the southern end of the wall at Sta. 618+40 ("G" Line), the bearing pressure induced on the underlying foundation soil is 3.5 ksf. Using a base width of 24 ft and a remedial excavation of 2 ft (see Section 5.4.8), the allowable bearing capacity of the soil directly beneath the MSE wall is greater than 3.5 ksf. Therefore, the allowable bearing capacities exceed the bearing pressures induced by the wall.

Bearing Capacity of Leveling Pad: Leveling pads should be embedded to a depth of 0.1H (where H = height of wall in feet), but not less than 2 ft below lowest adjacent grade. Using a remedial excavation of 2 ft below the leveling pad, the allowable bearing capacity for the leveling pad is recommended to be 2.5 ksf.

TABLE 6. MSE WALL G1 STABILITY ANALYSES

Approx. "E" Line Station	Max Wall Height (ft)	MSE Strap Length (ft)	Bearing Capacity Factor of Safety		Global Stability Factor of Safety		
			During Surcharge	Permanent	During Surcharge	Static[1]	Psuedo-Static[1]
426+06	24	24	1.25	2.2	1.25	1.7	1.3

Notes:

(1) Factor of safety based upon level backfill and 240 psf equivalent vehicle surcharge for static condition. No vehicle surcharge for psueudo-static condition.

(2) Governing psuedo-static factor of safety based upon static horizontal inertial force equal to one-third the peak design ground acceleration; 0.17g per Caltrans guidelines (2006e).

(3) Demand bearing pressures for MSE walls as shown in Catrans Bridge Design Aids, 2002 for Loading Condition 1.

(4) A remedial overexcavation of 2 ft below the leveling pad and the MSE was considered in the analysis.

5.4.3 Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed wall approximately 40 ft from the southern terminus of the wall near "G" Line Sta. 618+75.

Based on cross-sections provided by the roadway designers, the proposed embankment at "G" Line Sta. 618+75 will be approximately 50 feet wide at the crest and the embankment height is approximately 16 feet above existing grade. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 9 inches. The settlement period is estimated to be about 28 weeks to reduce the remaining long-term settlement to less than ½-inch. If a 5-ft embankment surcharge is applied across the full proposed roadway width, the settlement period is reduced to about 17 weeks. For a 7-ft embankment surcharge across the full proposed roadway width, the settlement periods is reduced to about 16 weeks.

The surcharge heights referred to in these recommendations are measured relative to the finished grade of the proposed embankments. Settlement periods with surcharge begin once the full surcharge height is completed. Waiting periods without surcharge begin once the project grade is constructed to the top of the finished subgrade.

Settlement Monitoring Recommendations: Based on our experience, the calculated settlements and settlement periods are approximations of actual field observations. Due to the variability of

subsurface conditions and the thinly layered nature of soil deposits, settlement monitoring is recommended.

A settlement monitoring program should be implemented for the proposed MSE wall. Surface monuments should be placed on the face of the MSE wall to measure any vertical or lateral movement. In addition, surface settlement monuments, constructed in accordance with Caltrans Standard Plan Sheet A74 or equivalent (Caltrans, 2006b), should be placed at the maximum wall heights and at every 100 ft along the length of the MSE wall. The settlement monuments should be installed in a timely manner upon completion of wall construction. Special care should be exercised in the field to survey and protect these settlement devices. The monuments should be monitored at the time of installation, on a weekly basis for a month, and then once every 2 weeks thereafter until it has been verified by the Engineer that the remaining settlement for the embankment is acceptable. The uppermost levels of wall facing, coping, roadway pavement, hardscape, and any other improvements should not be constructed until the remaining settlement is within acceptable limits (i.e., ½-inch or less).

5.4.4 Overexcavation

Along the proposed wall alignment, the base of the MSE structure will be founded on native soils. EMI recommends remedial grading consisting of a 2-ft overexcavation. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted according to Caltrans Standard Specifications (2006c). The overexcavation should be backfilled using granular, non-expansive soils. In the event the bottom of remedial excavations become saturated due to the presence of shallow groundwater or seepage, self compacting material such as gravel or lean concrete slurry can be placed within the limits of the overexcation. The overexcavation should extend at least 2 ft beyond the outer edge of the leveling pad and 2 ft beyond the back of the reinforced zone behind the wall.

5.4.5 Global Wall Stability

The "global" stability of the Retaining Wall G1 was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "G" Line Sta. 618+75.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and no cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

5.4.6 Drainage

Sufficient drainage should be provided at the roadway surface of the embankment and between the pavement structure and the top of the MSE Wall to minimize accumulation of water within the MSE mass during the life of the structure.

5.5 Cantilever Retaining Wall Recommendations – Retaining Wall G2

As described in Section 1.2, Proposed Retaining Wall G2 is a Caltrans Type I Retaining Wall located between approximate Stations 618+33 and 621+00 ("G" Line). The retaining wall is approximately 266 ft long and will vary in design height from 8 to 12 ft. Based upon the preliminary cross sections provided by the wall designers, the proposed wall will be embedded in embankment fill placed as part of the project. Due to the limited wall heights and corresponding demand toe pressures, spread footings are suitable for support of the proposed wall.

5.5.1 Lateral Earth Pressures

The proposed retaining wall will retain embankment fill material to be placed as part of the project. Material placed behind the proposed retaining wall will be required to conform to Section 19-3.06 of Caltrans Standard Specifications for structure backfill. A static active lateral earth pressure of 36 psf per ft of depth is recommended for design of cantilever retaining walls with a uniform lateral pressure of at least 72 psf due to vehicle surcharge load. This static active lateral earth pressure is applicable for a free-draining and level backfill.

Per Section 5.5.4 of the Caltrans BDS (Caltrans, 2004), the effects of earthquakes need to be considered in the design of retaining walls which support bridge abutments, soundwalls, or other installations for which there is a low tolerance for failure. Since the subject MSE wall does not support any structure for which there is a low tolerance for failure, per Caltrans practice, the MSE wall need not to be designed for seismic earth pressures.

5.5.2 Spread Footings

Allowable Bearing Capacity: The material used for the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. Based on the assumed soil parameters for the fill material, the allowable soil bearing capacity is estimated to be 2.8 ksf. The ultimate bearing capacity (for seismic design) is three times the allowable bearing capacity.

Fill placed in the upper 2 ft below the footing should be compacted to at least 95% relative compaction. The lateral extent of the 95% relative compaction should be at least 2 ft beyond the edges of the footing.

Lateral active loads can be resisted by passive lateral earth pressure (against the side of buried stem walls and spread footings) and friction acting along the base of footings. The passive lateral

earth pressure can be determined using an average passive pressure of 3.0 ksf against the face of the footing, assuming level ground in front of the retaining wall. The full passive resistance against the face of the footing will be mobilized at a displacement equal to 4 percent of the footing thickness. To determine the frictional resistance along the base of a footing, a coefficient of friction of 0.35 between the concrete footing and the soil below the footing is recommended. The sliding resistance of footings may be determined using 50% of the passive pressure and 100% of the friction along the base of the footing.

Settlement: Maximum total settlement under the allowable bearing capacity is estimated to be no more than 1 inch.

5.5.3 Static Settlement

Standard procedures were used to evaluate ground settlement of the underlying foundation soils due to the proposed MSE and associated embankment fill placement. Generally, fills induce immediate and consolidation settlement of underlying soils. Immediate settlement occurs during grading and consolidation settlement occurs over varying time periods. Consolidation settlement (magnitude and time period) is directly related to the depth of fill placed over compressible soil and the thickness of compressible soil layers. Immediate settlement which is estimated to be negligible in this case occurs during grading or shortly thereafter, while consolidation settlement, which in this case is considerable, occurs over varying time periods.

One cross-section was selected to evaluate the potential settlement beneath the proposed wall approximately 40 ft from the southern terminus of the wall near "G" Line Sta. 618+75.

Based on cross-sections provided by the roadway designers, the existing embankment at "G" Line Sta. 618+75 will be approximately 50 feet at the crest and the embankment fill height is approximately 16 feet above existing grade. Based on our calculations, the maximum settlement of soils underlying the proposed embankment is estimated to be about 12 inches. However, since Caltrans Type 1 retaining walls have a limited settlement allowance, the surcharge and settlement period recommended for the MSE wall G1 embankment (see section Section 5.4.3) should be completed prior to construction of Retaining Wall G2. MSE Wall G1 should be constructed and the surcharge placed across the entire embankment roadway width. Once the settlement period has elapsed or the surcharge has been released, the portion of the embankment near Retaining Wall G2 can be excavated down to the footing elevation, and Retaining Wall G2 can be constructed.

Settlement Monitoring Recommendations: Surcharge placement and monitoring of settlement will occur following the embankment and MSE Wall G1 construction, prior to construction of Retaining Wall G2. Refer to Section 5.4.3 for settlement monitoring recommendations.

5.5.4 Global Wall Stability

The "global" stability of the Retaining Wall G2 was evaluated for both static and pseudo-static conditions using the computer program GSTABLE7 (Gregory, 2006). Strengths of liquefiable soils were estimated using the method outlined in Seed and Harder (1990). The material used for

the fill is assumed to have a friction angle of 32 degrees and minimum cohesion of 200 psf. The cross-section selected for stability analysis was near "G" Line Sta. 618+75.

The soil strength within the reinforced earth zone is assumed to have a friction angle of 34 degrees and 200 psf cohesion. The in-situ shear strengths of existing fill material and in-situ native soils vary and are provided in Table 4.

Slope stability analyses were conducted for the static condition including a 2 ft soil surcharge to represent traffic loading. In accordance with Caltrans Guidelines (2006e), stability analysis for the seismic condition was performed using the pseudo-static approach with a seismic coefficient of 0.17; Caltrans guidelines require a seismic coefficient equal to one-third the peak horizontal acceleration (0.5 g, based on the site specific ground motion study, see Appendix F) but not exceeding 0.2.

According to the results of the analyses and Caltrans guidelines, the slopes meet the minimum required factor-of-safety for deep-seated failure of 1.5 for the static condition and 1.1 for the seismic condition per Caltrans Foundation Design Guidelines (2006e).

6.0 CONSTRUCTION CONSIDERATIONS

All work should be performed in accordance with the Caltrans Standard Specifications (Caltrans, 2006c) except as indicated in the Special Provisions prepared for the project improvements.

6.1 Earthwork

6.1.1 General

Earthwork should be performed in accordance with Section 19 of the Caltrans Standard Specifications (Caltrans, 2006c). Appropriate measures should be taken to prevent damage to adjacent existing structures and utilities. Design and construction of temporary slopes or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational safety and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

Heavy construction equipment should not be used immediately adjacent to shoring due to large lateral pressures induced by such equipment unless the shoring is designed to accommodate resulting pressures. Excavated soil or construction materials should not be stockpiled adjacent to shoring or open excavations. Stockpiled soil and construction materials should be set back a distance at least equal to the height of the excavation.

In fill areas, complete removal of compressible surficial materials including vegetation, topsoil, loose or soft alluvium, and otherwise unsuitable material is required prior to fill placement. A minimum overexcavation of 2 ft is recommended within all areas to receive compacted fill; the overexcavation should extend horizontally a minimum distance of 2 ft from edges of new fills or structures. Actual depths and extent of the required removals should be determined in the field by qualified geotechnical personnel. Overexcavated areas should be cleaned of loose soils and debris and should be observed to be firm and unyielding before receiving fill. The bottom of the overexcavation should be scarified to a minimum depth of 8 inches, moisture conditioned to near optimum moisture content, and compacted in place to at least 90 percent relative compaction.

6.1.2 Cuts and Excavations

Preliminary plans do not show any permanent cuts necessary to achieve finish grades. However, temporary cuts may be required to facilitate the construction of proposed improvements. Temporary excavations, including temporary sloping or shoring, will need to be designed by the contractor for local and global stability, once the means and methods of construction are determined.

6.1.3 Groundwater Control

Groundwater was encountered in all four of the borings performed near the proposed wall pair between elevation -9.9 and -11.9 ft. Based on latest cross sections provided by the designers, the bottom of proposed leveling pad varies between about elevation +2 and -4 ft. The deepest excavation for the proposed MSE wall is expected to be a few feet above the observed groundwater elevations. However, due to the proximity of the site to the Cerritos Channel where the water elevation is dictated by tidal fluctuations, higher groundwater elevations than those encountered during the field investigation are likely; therefore, the contractor should be prepared to control groundwater during footing construction. Any groundwater encountered during footing construction should be controlled in accordance with Section 19-3.04 of the Caltrans Standard Specifications (2006c). Any seepage or groundwater removed from an excavation should be tested and disposed of in compliance with all applicable local, state and federal requirements. Free water should not be allowed to stand in any excavations. If excavations become flooded, at least the bottom 6 inches of soil should be removed and replaced or re-compacted to 95 percent relative compaction. Additional removals may be required at the discretion of the Engineer.

6.2 Review of Construction Plans

Recommendations contained herein are based on current design information. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents.

6.3 Geotechnical Observation and Testing

Qualified geotechnical personnel should perform inspections and testing during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill.
- Placement of reinforcing elements for the MSE structure.
- Shoring installation.
- Removal or installation of support of buried utilities or structures.
- When any unusual subsurface conditions are encountered.

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BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

(1) This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil and Rock Classification Logging, Classification and Presentation Manual (June 2007).

(2) 2.4" samples were taken using a California Split-spoon Sampler.

(3) For R-09-036, a rope and cat-head hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

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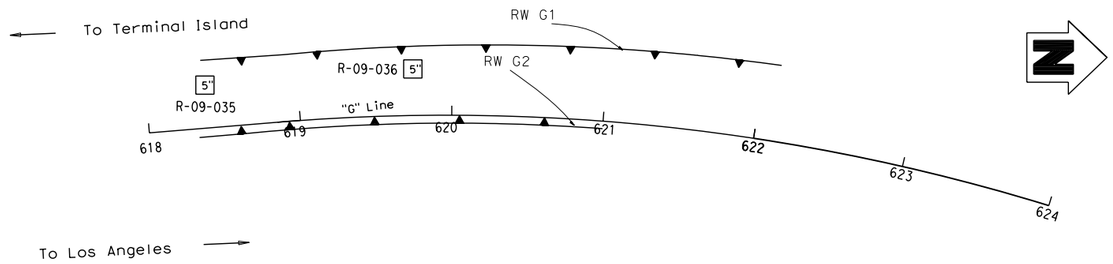

PLAN

1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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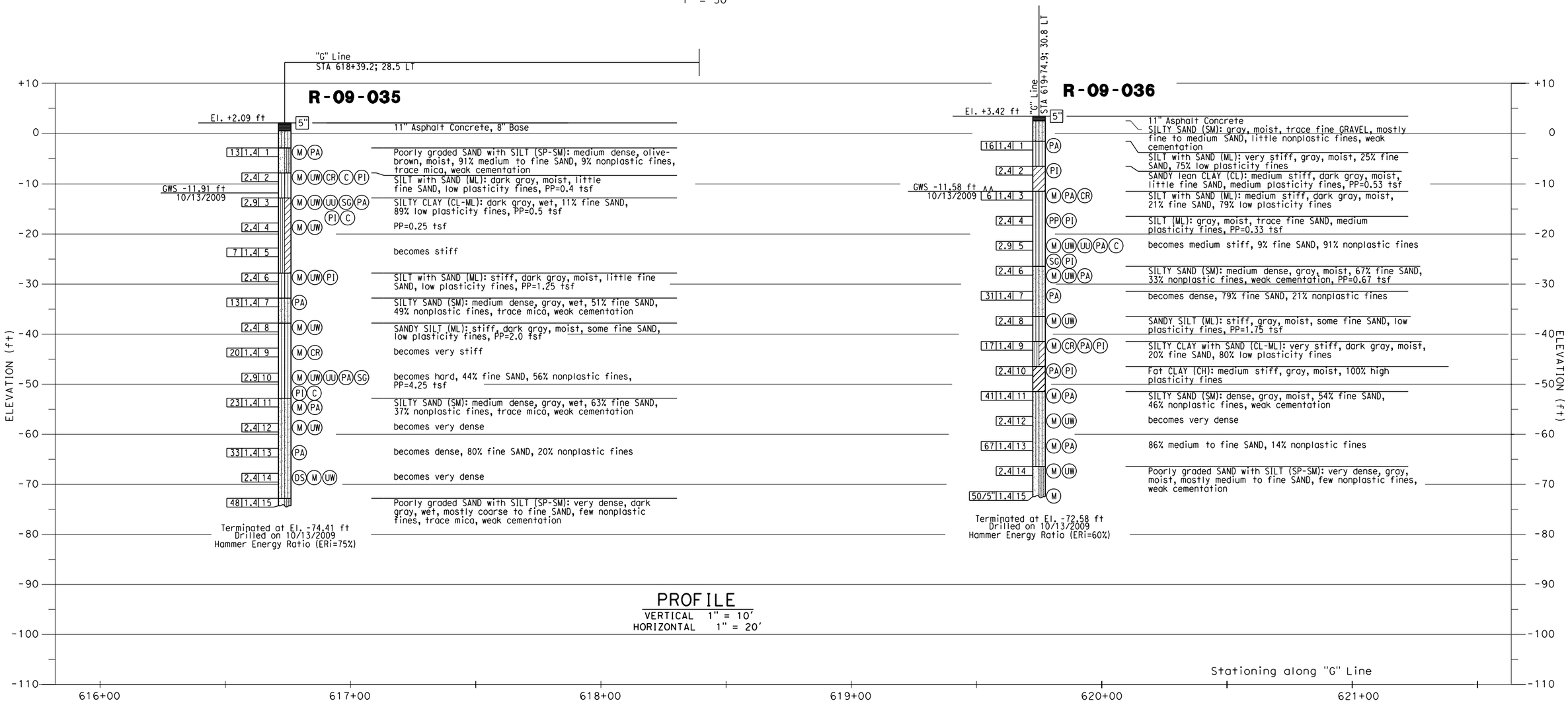
ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY: J. Fang	FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0151	MSE RETAINING WALL NO. G1
SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.17	LOG OF TEST BORINGS NO. 1 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/26/10	04/14/10									X	X

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

FILE => $REQUEST

BENCHMARKS:

PT-PMHV509	PT-PMHV515
SET MAG NAIL	SET MAG NAIL
26.671' Lt ℄ "G"Line	28.517' Rt ℄ "G" Line
Sta. 604+968.70	Sta. 600+995.50
N 1738366.89	N 1737997.51
E 6488728.36	E 6488779.52
Elev. = -3.61	Elev. = -2.21

NOTES:

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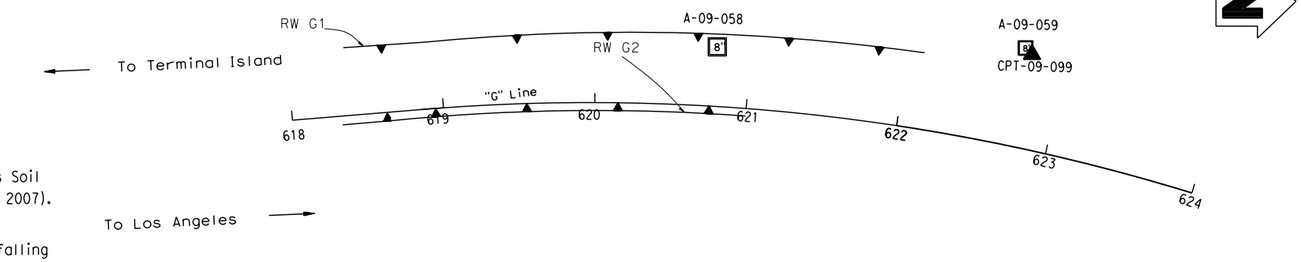

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
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REGISTERED ENGINEER — DATE 04/19/10

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EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

PLAN

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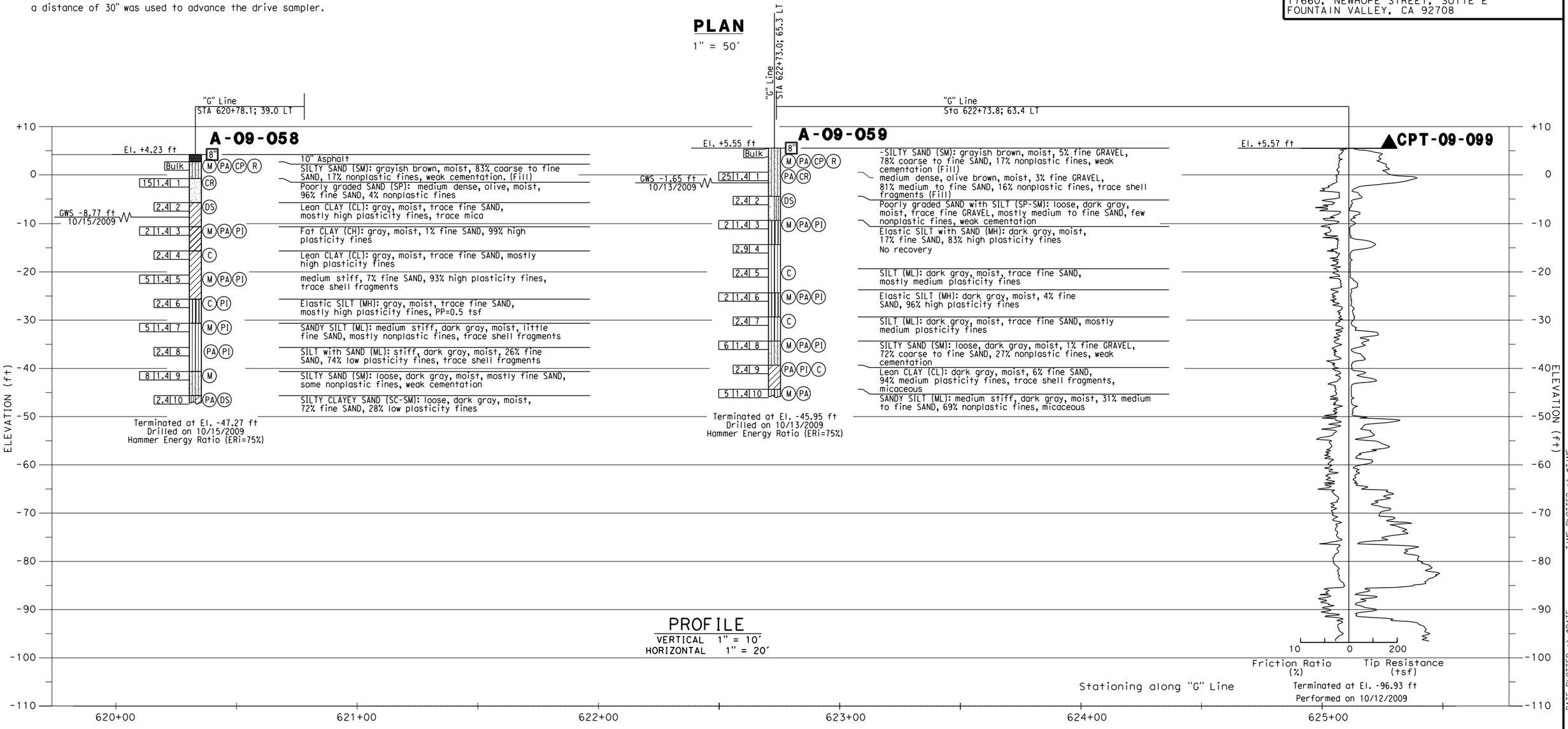

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.17	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

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02/08/10	04/14/10								X	X

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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

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FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

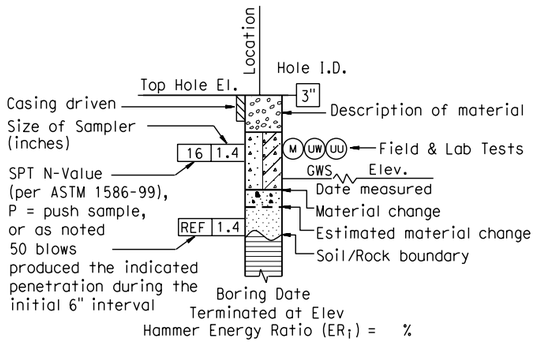
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

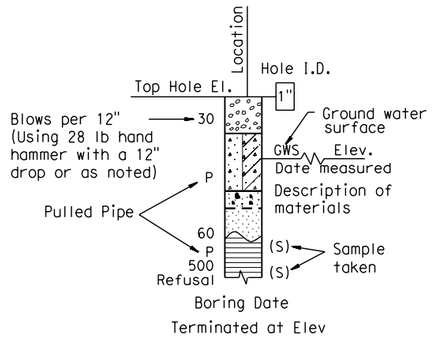
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

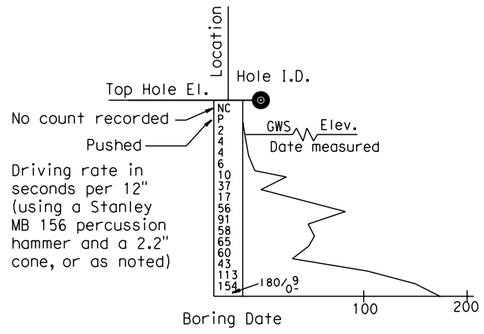
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



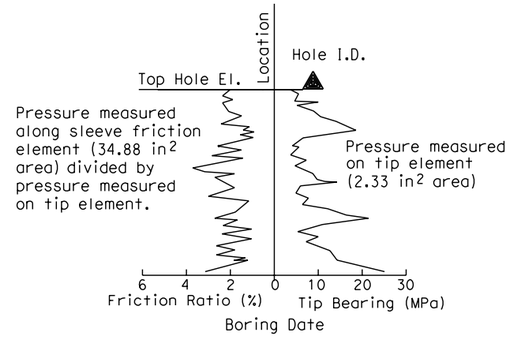
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. 53E0151 POST MILE 0.17

MSE RETAINING WALL NO. G1

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	04/14/10									X	X

FILE => $REQUEST

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REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. 53E0151
POST MILE 0.17

MSE RETAINING WALL NO. G1

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

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SHEET X OF X

FILE => $REQUEST

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Sta. 604+968.70	Sta. 600+995.50
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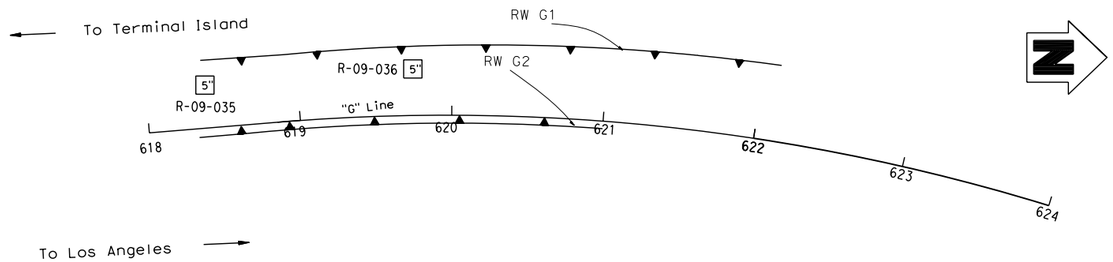

PLAN

1" = 50'

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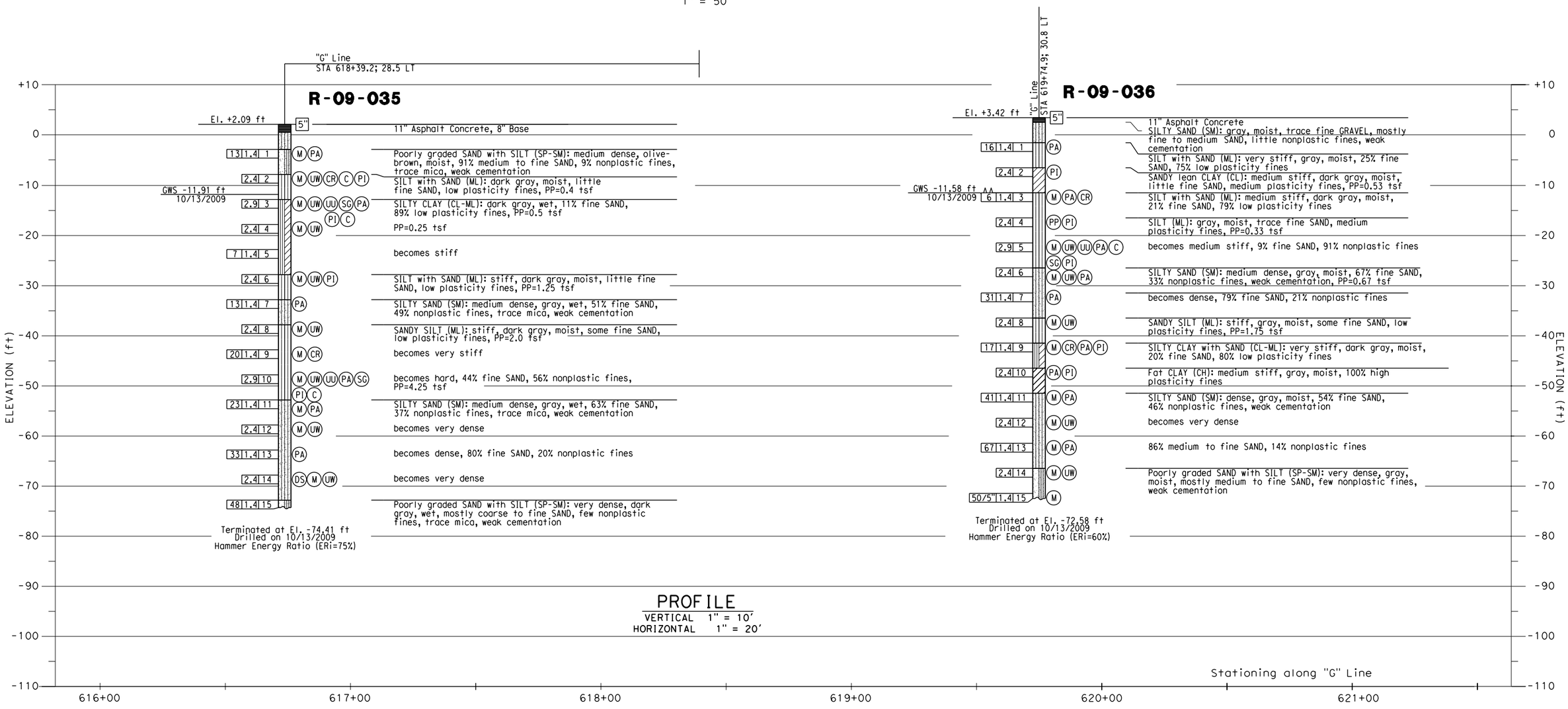

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			

MSE RETAINING WALL NO. G2

LOG OF TEST BORINGS NO. 1 OF 4

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CU 07
EA 238501

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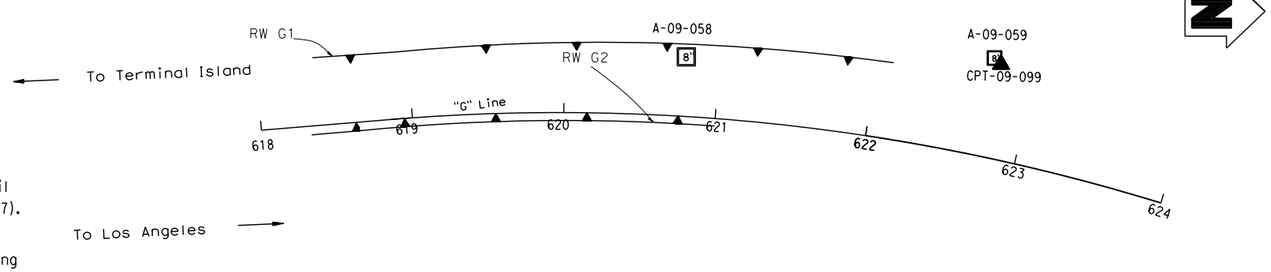

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PLAN

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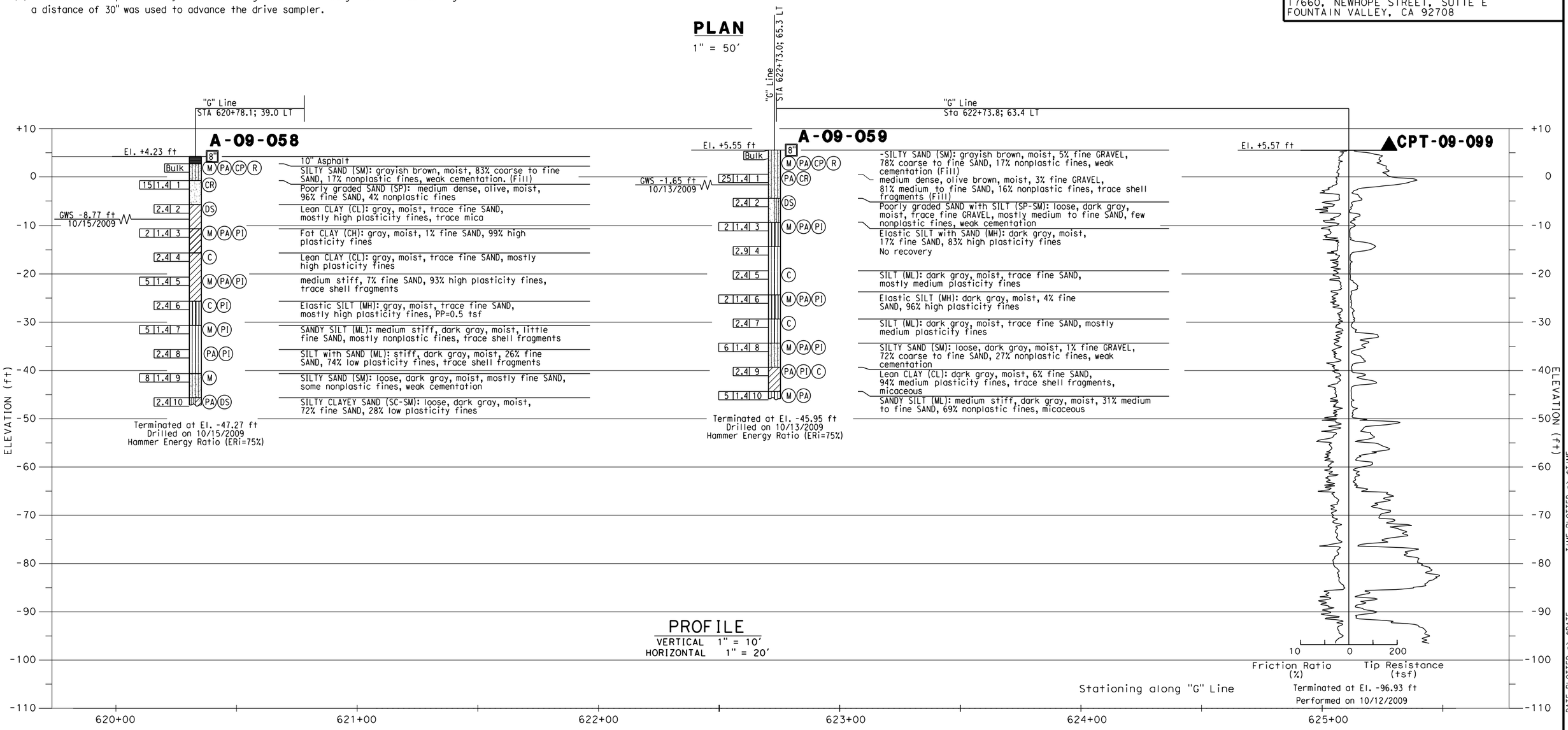

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SIGN OFF DATE	CHECKED BY: K. Pratheepan	E. Brown			POST MILE 0.17	LOG OF TEST BORINGS NO. 2 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

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REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ACTA
ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

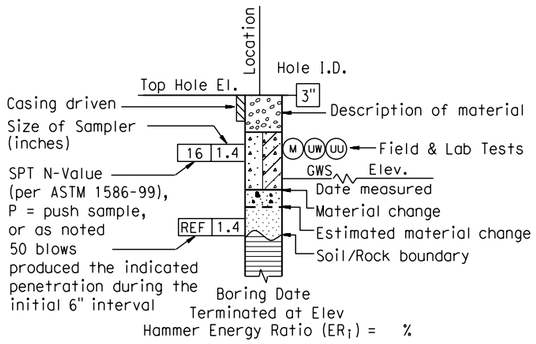
Note: Size in inches.

CONSISTENCY OF COHESIVE SOILS

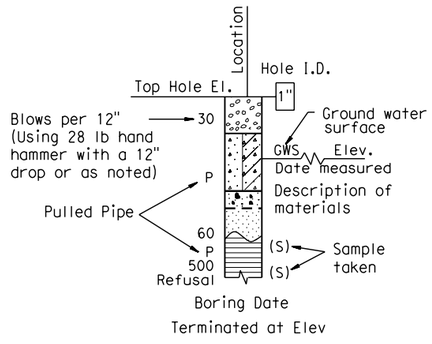
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

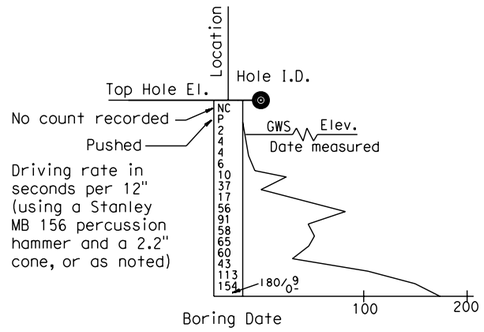
Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.



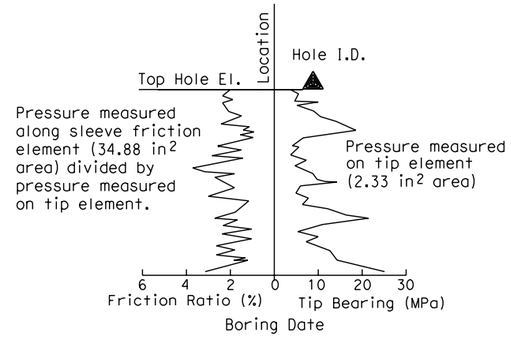
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT SIGN OFF DATE	DRAWN BY: J. Fang CHECKED BY: K. Pratheepan	FIELD INVESTIGATION BY: E. Brown	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	E. Brown PROJECT ENGINEER	BRIDGE NO. - POST MILE 0.17

MSE RETAINING WALL NO. G2

LOG OF TEST BORINGS NO. 3 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)										SHEET	OF
02/08/10	04/14/10									X	X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Triaxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90)
Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166)
Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	47			

REGISTERED ENGINEER — DATE 04/19/10

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — ERIC BROWN — NO. GE-2806 EXP. 06-30-2010 — GEOTECHNICAL — STATE OF CALIFORNIA

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ONE CIVIC PLAZA, SUITE 350,
CARSON, CA 90745

EARTH MECHANICS, INC.
17660, NEWHOPE STREET, SUITE E
FOUNTAIN VALLEY, CA 92708

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY: J. Fang

CHECKED BY: K. Pratheepan

FIELD INVESTIGATION BY: E. Brown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

E. Brown
PROJECT ENGINEER

BRIDGE NO. -

POST MILE 0.17

MSE RETAINING WALL NO. G2

LOG OF TEST BORINGS NO. 4 OF 4

OGS CIVIL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 07
EA 238501

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY): 02/08/10, 04/14/10

SHEET X OF X

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX A. EARTHSPECTIVES SPT HAMMER ENERGY MEASUREMENT REPORT

EARTHSPECTIVES
250 Goddard
Irvine, California 92618

Phone: (949) 777-1270
Fax: (949) 777-1283

November 12, 2009

EarthMechanic, Inc.
17660 Newhope, Suite E
Fountain Valley, California 92708

Attention: Mr. Ranjan Guneranjan

Dear Ranjan:

SPT Hammer Energy Measurement
Borings A-09-053, R-09-004, and R-09-009
ACTA Schuyler Heim Bridge Replacement
Long Beach, California
ES Project No. 09095-141

INTRODUCTION

This letter report summarizes the results of EarthSpectives' (ES) SPT hammer energy measurements performed at the subject site during subsurface soil exploration on October 13, 22, and 28, 2009. It provides a description of the test program and results.

SPT energy measurements were accomplished using a Pile Driving Analyzer (PDA) system manufactured by Pile Dynamics, Inc. and was conducted in general accordance with ASTM 4945 and 6066 test standards. Results are summarized in Table 1, while more details regarding energy records are provided in Appendix A.

TESTING CONDITIONS

Test Borings

SPT hammer energy measurements were performed at three boring locations drilled by three different drilling contractors. Hollow Stem Auger (HSA) drilling was performed at boring location A-09-053 by 2R Drilling and samplers were advanced using a drill rig equipped with a Automatic trip hammer and NWJ drill rod. Mud Rotary drilling was performed at both boring locations R-09-004 and R-09-009 by SoCal Drilling and C&L Drilling, respectively. SoCal Drilling samplers were advanced using a drill rig equipped with a Automatic trip hammer and HF2-5/8 drill rod, while C&L Drilling samplers were advanced using a drill rig equipped with a Rope and Cat-Head hammer and unknown custom made drill rod.

Instrumentation

SPT energy measurements were performed by placing a 2 ft instrumented section of drill rod at the top of the drill string between the hammer and the existing sampling rods. The instruments consist of two

sets of accelerometers and strain transducers, mounted on opposite sides of the drill rod, with a view to evaluate normal and eccentric effects. The analyzer acquired and processed the signals during sampling, and provided real-time evaluations of the maximum SPT hammer transferred energy. The raw data were stored directly on a portable field computer for subsequent analysis in the office.

RESULTS

Results from SPT hammer energy measurements are summarized in Tables 1. It shows the Energy Transfer Ratio (ETR) for every sampling depth. ETR is the ratio of the measured maximum transferred energy to rated energy of the hammer which is the product of the weight of the hammer times the height of fall (140 lb x 30 inches = 4200 lb-in = 0.35 kip-ft).

TABLE 1 – SUMMARY OF SPT HAMMER ENERGY MEASUREMTS

SAMPLING DEPTH (FT)	AVERAGE SPT HAMMER EFFICIENCY (ENERGY TRANSFER RATIO)		
	BORING A-09-053 2R Drilling, Inc. Hollow Stem Automatic Trip hammer	BORING R-09-004 So Cal drilling, Inc. Mud Rotary Automatic Trip hammer	BORING R-09-009 C&L Drilling, Inc. Mud Rotary Rope and Cat-Head Manual Hammer
5	77%, 92%, 87%	--	--
10	72%, 95%, 87%	49%, 76%, 65%	50%, 64%, 58%
15	75%, 84%, 80%	--	--
20	73%, 88%, 83%	--	48%, 69%, 61%
21	--	77%, 80%, 79%	--
25	71%, 76%, 74%	--	--
30	70%, 86%, 82%	77%, 81%, 80%	49%, 69%, 58%
35	80%, 84%, 82%	--	--
40	79%, 85%, 83%	77%, 84%, 82%	56%, 73%, 65%
45	81%, 86%, 84%	--	--
50	78%, 83%, 81%	--	--
56	--	79%, 82%, 80%	--
60	--	78%, 85%, 83%	49%, 74%, 64%
70	--	78%, 81%, 80%	51%, 73%, 59%
80	--	76%, 83%, 82%	47%, 78%, 65%
90	--	78%, 82%, 80%	41%, 76%, 54%
100	--	--	51%, 76%, 63%
105	--	75%, 84%, 81%	--
110	--	--	51%, 81%, 66%
115	--	76%, 80%, 79%	--
120	--	--	36%, 78%, 62%
125	--	75%, 81%, 80%	--
130	--	--	51%, 80%, 68%
135	--	73%, 80%, 78%	--
140	--	--	43%, 70%, 61%
145	--	75%, 81%, 80%	--
155	--	78%, 84%, 81%	36%, 75%, 62%

NOTE: Numbers in each cell are Min, Max, and Avg efficiency for that sampling depth

Plot of the maximum transferred energy, energy transfer ratio, and blow rate is provided as function of blow number in Appendix A. Table immediately following the plot also provides the minimum, maximum, and average values at each sampling depth in addition to raw data.

In general, average ETR values over each sampling depth ranged between 74 and 87 percent with an overall average of 82 percent for boring hole A-09-053, between 65 and 83 percent with an overall average of 79 percent for boring hole R-09-004, and between 54 and 68 percent with an overall average of 62 percent for boring hole R-09-009.

LIMITATIONS

Professional judgments represented in this report are based on evaluations of the technical information gathered, our understanding of the proposed construction, and our general experience in the geotechnical field. We do not guarantee the performance of the project in any respect, only that our engineering work and judgments are rendered while striving to meet the standard of care of our profession at this time.

CLOSURE

It has been a pleasure serving you on this project and we look forward to working with you again. Please call if you have any questions.

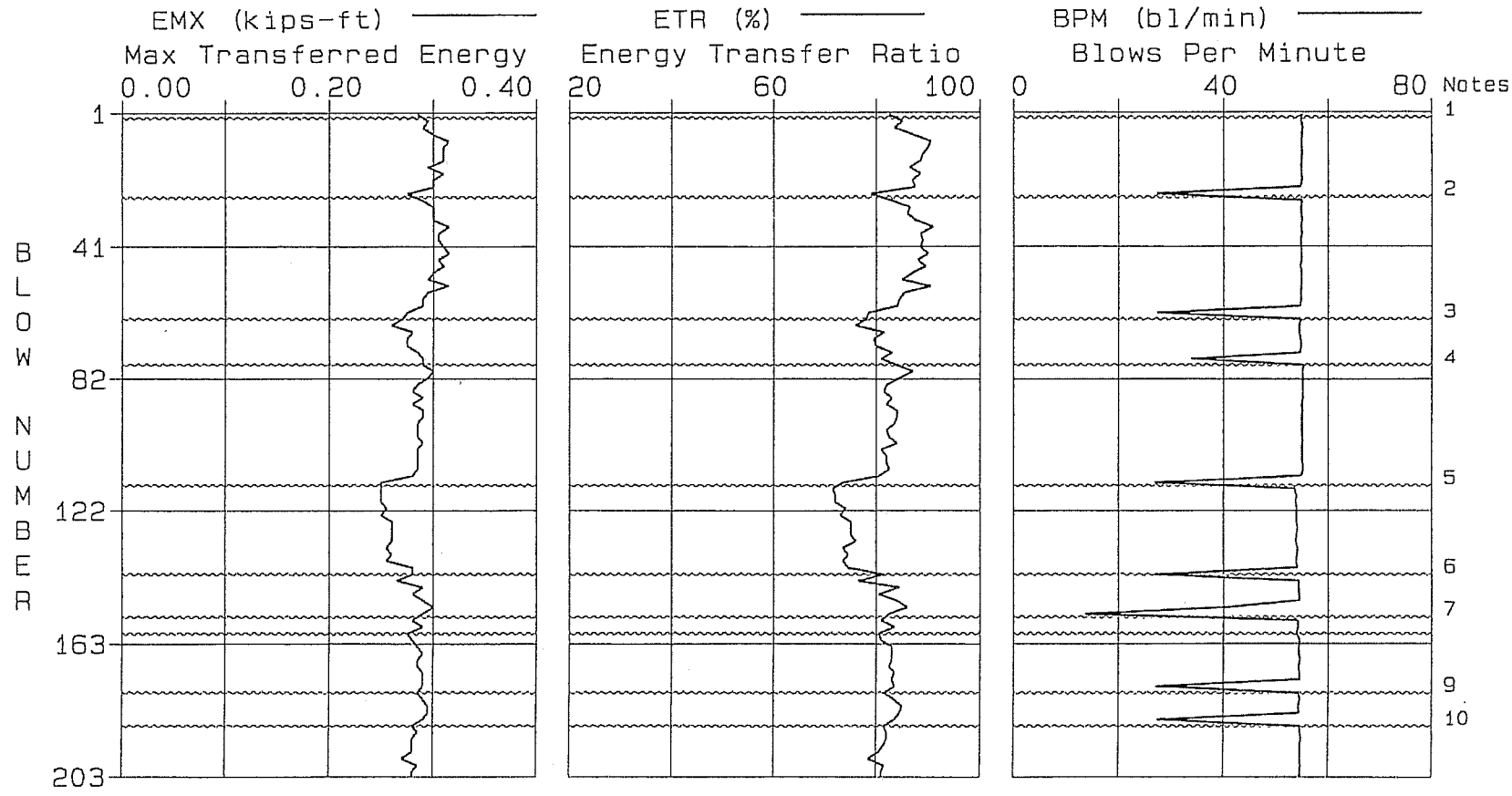
Sincerely Submitted for EarthSpectives

Hossein Rashidi

Hossein K. Rashidi, Ph.D., P.E.
Principal Engineer

EarthSpectives 2009-Oct-13

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE A-09-053, 2R DRILLING



Notes
1. Sample at 5 ft
2. Sample at 10 ft
3. Sample at 15 ft
4. Sample at 20 ft
5. Sample at 25 ft

Notes
6. Sample at 30 ft
7. Sample at 35 ft
8. (BN159), Sample at 40 ft
9. Sample at 45 ft
10. Sample at 50 ft

Pile: A-09-053
Info: HOLLOW STEM
AR: 1.2 in^2
LE: 56.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

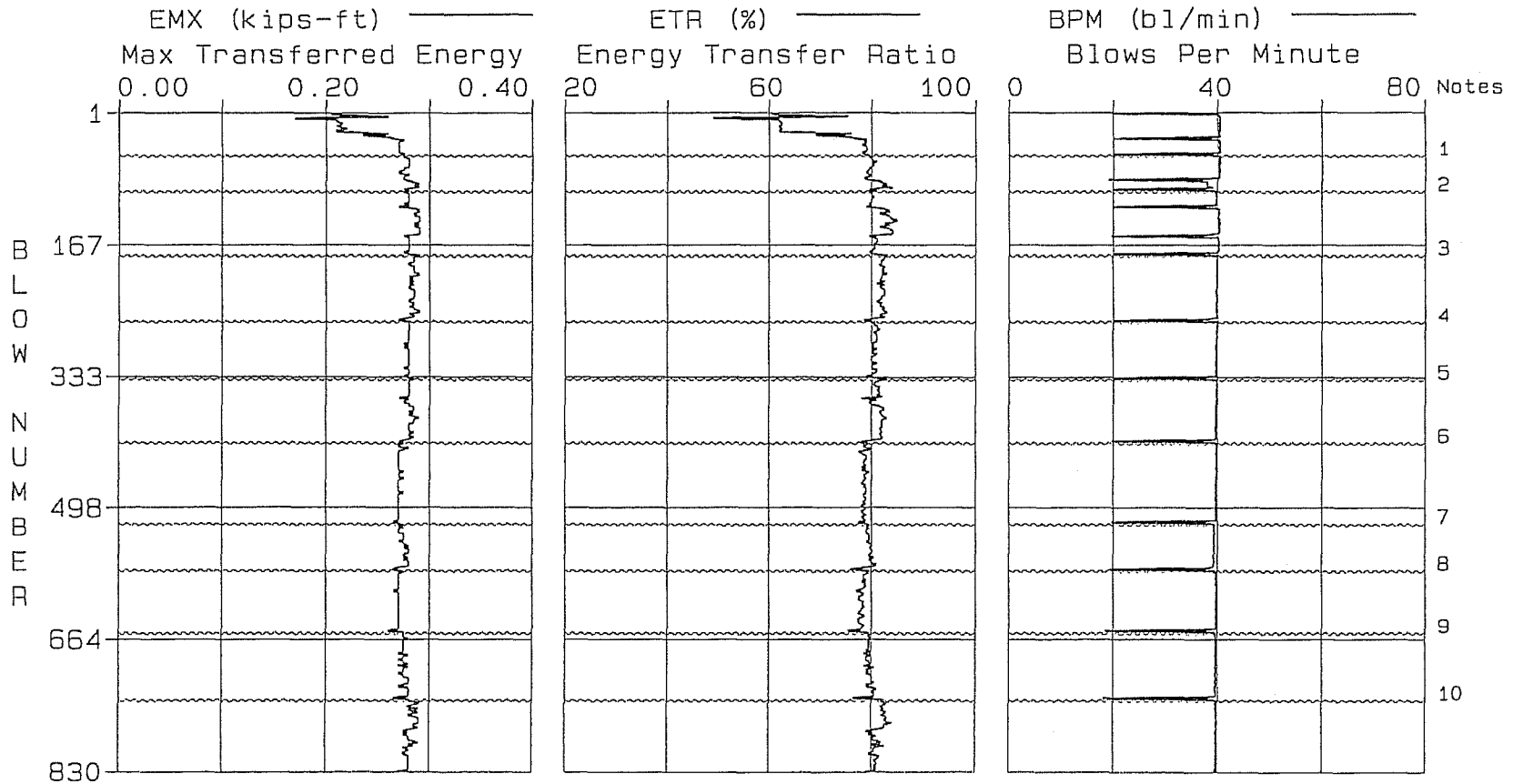
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	4	5.00	AV	0.28	82	0	1.50	204	54.7	20.06	20.13	6.81
25	4	10.00	AV	0.30	87	0	1.54	216	52.6	20.27	20.36	5.80
			MX	0.32	92	0	2.70	261	55.2	24.00	24.26	9.85
			MN	0.27	77	0	1.41	204	0.0	19.70	19.82	3.41
62	7	15.00	AV	0.30	87	0	2.83	266	53.3	24.22	24.36	5.75
			MX	0.33	95	0	2.92	299	55.2	24.79	25.01	14.34
			MN	0.25	72	0	2.16	252	0.0	22.26	22.28	3.10
76	2	20.00	AV	0.28	80	0	2.22	314	51.6	21.17	21.22	11.75
			MX	0.30	84	0	2.32	324	55.0	22.68	22.69	14.29
			MN	0.26	75	0	2.16	299	33.8	5.01	5.05	1.41
113	7	25.00	AV	0.29	83	0	3.02	318	53.6	22.28	22.49	5.85
			MX	0.30	88	0	3.24	332	55.4	22.69	22.94	14.43
			MN	0.25	73	0	2.27	303	0.0	21.51	21.70	2.08
140	5	30.00	AV	0.26	74	0	2.18	309	53.9	21.03	21.10	9.06
			MX	0.30	76	0	2.29	319	54.2	22.26	22.37	12.58
			MN	0.25	71	0	2.10	298	53.3	4.68	4.70	1.80
153	2	35.00	AV	0.29	82	0	3.14	338	46.0	21.50	21.63	7.73
			MX	0.30	86	0	3.19	354	54.7	23.23	23.37	9.57
			MN	0.24	70	0	3.01	261	0.0	4.52	4.57	2.90
158	1	40.00	AV	0.28	82	0	2.62	351	43.3	22.84	22.99	13.57
			MX	0.29	84	0	3.16	361	54.4	23.20	23.33	15.32
			MN	0.28	80	0	2.46	345	0.0	22.64	22.86	9.31
176	3	45.00	AV	0.29	83	0	2.98	360	51.4	22.73	22.89	8.15
			MX	0.29	85	0	3.11	372	54.7	23.06	23.25	16.15
			MN	0.27	79	0	2.50	347	0.0	22.24	22.29	7.37
186	2	50.00	AV	0.29	84	0	2.57	363	49.0	22.94	23.10	14.04
			MX	0.30	86	0	2.89	375	54.6	23.38	23.42	15.32
			MN	0.28	81	0	2.50	348	0.0	22.71	22.83	10.26
203	2	58.50	AV	0.28	81	0	2.82	362	54.6	22.13	22.34	8.10
			MX	0.29	83	0	2.87	372	55.0	22.71	22.82	9.99
			MN	0.27	78	0	2.74	349	54.2	21.74	21.93	7.46

BL#	COMMENTS
1	JC = 0.70
1	Sample at 5 ft
25	Sample at 10 ft
62	Sample at 15 ft
76	Sample at 20 ft
113	Sample at 25 ft
140	Sample at 30 ft
153	Sample at 35 ft
158	Sample at 40 ft
176	Sample at 45 ft
186	Sample at 50 ft

DRIVEN (2009-Oct-13 : A-09-053.MDF)

EarthSpectives 2009-Oct-22

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-004, SOCAL DRILLING



Notes
1. Sample at 30 ft
2. Sample at 56 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 105 ft

Notes
6. Sample at 115 ft
7. Sample at 125 ft
8. Sample at 135 ft
9. Sample at 145 ft
10. Sample at 155 ft

Pile: R-09-004
Info: MUD ROTARY
AR: 1.4 in^2
LE: 163.0 ft

Proj: ACTA HEIM BRIDGE PROJECT Pg1
SP: 0.492 k/ft^3
WS: 16808 ft/s
EM: 30000 KSI

EMX: Max Transferred Energy
ETR: Energy Transfer Ratio
E2F: UNDEFINED
EF2: Energy by F^2 Method
EV2: UNDEFINED

BPM: Blows Per Minute
CSX: Max Measured C-Stress
CSI: Max F1 or F2 C-Stress
TSX: Max Computed T-Stress

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	2	10.00	AV	0.20	59	0	2.79	164	0.0	26.20	32.04	11.83
33	2	21.00	AV	0.22	65	0	3.39	171	39.1	29.39	33.69	12.31
			MX	0.26	76	0	4.97	176	40.6	35.16	35.16	18.20
			MN	0.17	49	0	1.90	156	0.0	21.85	21.85	10.73
53	2	30.00	AV	0.27	79	0	5.19	163	38.4	33.90	33.90	18.14
			MX	0.28	80	0	5.33	181	40.7	35.25	35.25	20.04
			MN	0.27	77	0	4.95	156	0.0	31.94	31.94	16.83
85	3	40.00	AV	0.28	80	0	5.06	189	39.1	34.43	34.43	17.43
			MX	0.28	81	0	5.14	192	40.5	35.24	35.24	20.17
			MN	0.27	77	0	4.67	182	0.0	32.26	32.26	15.43
98	1	56.00	AV	0.28	82	0	4.69	207	35.4	32.93	32.93	19.77
			MX	0.29	84	0	4.82	213	39.9	33.84	33.84	20.65
			MN	0.27	77	0	4.52	184	0.0	32.31	32.31	16.68
120	5	60.00	AV	0.28	80	0	4.82	191	37.9	34.55	34.55	15.49
			MX	0.28	82	0	4.93	202	39.9	35.30	35.30	21.62
			MN	0.27	79	0	4.47	187	0.0	32.44	32.44	14.43
155	3	70.00	AV	0.29	83	0	4.53	215	39.0	32.96	32.96	18.89
			MX	0.29	85	0	4.68	223	40.4	33.99	33.99	21.51
			MN	0.27	78	0	4.06	206	0.0	31.25	31.25	15.91
177	2	80.00	AV	0.28	80	0	4.19	216	38.2	32.36	32.36	14.68
			MX	0.28	81	0	4.28	223	40.4	33.53	33.53	17.11
			MN	0.27	78	0	4.09	206	0.0	31.54	31.54	13.13
261	8	90.00	AV	0.28	82	0	4.30	238	39.4	32.11	32.11	13.60
			MX	0.29	83	0	4.44	246	40.1	33.19	33.19	16.14
			MN	0.26	76	0	4.12	212	0.0	31.38	31.38	11.96
333	4	105.00	AV	0.28	80	0	4.28	235	39.3	32.88	32.88	11.18
			MX	0.28	82	0	4.89	242	40.1	34.28	34.28	14.93
			MN	0.27	78	0	4.19	202	0.0	31.69	31.69	9.08
414	8	115.00	AV	0.28	81	0	5.01	208	39.2	32.54	32.54	12.80
			MX	0.29	84	0	5.27	223	40.0	35.90	35.90	14.87
			MN	0.26	75	0	4.60	150	0.0	28.91	28.91	10.42
516	10	125.00	AV	0.27	79	0	5.39	163	39.3	36.22	36.22	12.06
			MX	0.28	80	0	5.48	226	40.0	37.09	37.09	14.79
			MN	0.26	76	0	4.70	157	0.0	32.53	32.53	9.07

Info: MUD ROTARY

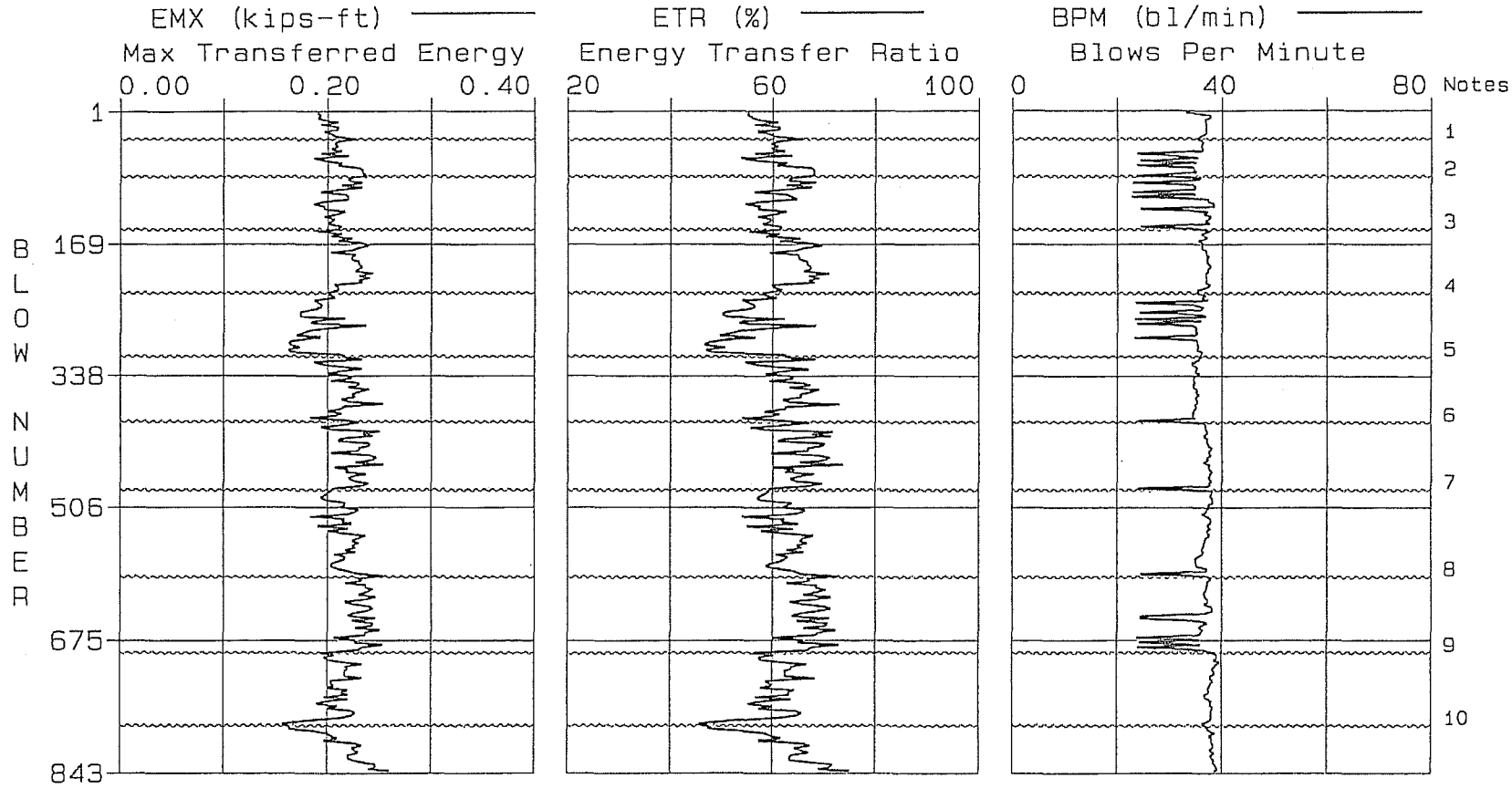
BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
575	5	135.00	AV	0.28	80	0	5.14	210	38.6	35.68	35.68	12.65
			MX	0.28	81	0	5.38	222	39.4	36.75	36.75	14.02
			MN	0.26	75	0	4.96	154	0.0	34.28	34.28	11.15
654	7	145.00	AV	0.27	78	0	5.48	156	39.1	35.48	35.48	8.50
			MX	0.28	80	0	5.57	190	39.9	36.26	36.26	11.96
			MN	0.25	73	0	5.01	142	0.0	34.11	34.11	5.84
738	8	155.00	AV	0.28	80	0	5.11	194	39.0	34.13	34.13	7.09
			MX	0.28	81	0	5.29	213	39.7	35.36	35.36	9.97
			MN	0.26	75	0	4.02	185	0.0	32.39	32.39	4.89
830	8	165.95	AV	0.28	81	0	4.07	221	39.7	32.50	32.50	6.57
			MX	0.29	84	0	4.26	232	39.8	34.26	34.26	9.64
			MN	0.27	78	0	3.82	207	39.2	30.05	30.05	4.79

BL#	COMMENTS
1	JC = 0.70
53	Sample at 30 ft
98	Sample at 56 ft
177	Sample at 80 ft
261	Sample at 90 ft
333	Sample at 105 ft
414	Sample at 115 ft
516	Sample at 125 ft
575	Sample at 135 ft
654	Sample at 145 ft
738	Sample at 155 ft

DRIVEN (2009-Oct-22 : R-09-004.MDF)

EarthSpectives 2009-Oct-28

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT, BORING HOLE R-09-009, C&L DRILLING



Notes
1. Sample at 20 ft
2. Sample at 60 ft
3. Sample at 80 ft
4. Sample at 90 ft
5. Sample at 100 ft

Notes
6. Sample at 110 ft
7. Sample at 120 ft
8. Sample at 130 ft
9. Sample at 140 ft
10. Sample at 155 ft

Pile: R-09-009 Proj: ACTA HEIM BRIDGE PROJECT Pg1
Info: MUD ROTARY- rope and cathead SP: 0.492 k/ft^3
AR: 1.4 in^2 WS: 16808 ft/s
LE: 165.0 ft EM: 30000 KSI

EMX: Max Transferred Energy BPM: Blows Per Minute
ETR: Energy Transfer Ratio CSX: Max Measured C-Stress
E2F: UNDEFINED CSI: Max F1 or F2 C-Stress
EF2: Energy by F^2 Method TSX: Max Computed T-Stress
EV2: UNDEFINED

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
1	3	10.00	AV	0.20	55	0	2.10	0	24.0	28.27	28.27	0.00
34	3	20.00	AV	0.20	58	0	1.94	127	36.6	18.84	18.84	4.18
			MX	0.22	64	0	2.67	178	38.2	21.77	21.77	6.58
			MN	0.17	50	0	0.00	0	24.0	6.34	6.34	0.55
56	2	30.00	AV	0.21	61	0	2.26	194	34.2	18.69	18.69	6.31
			MX	0.24	69	0	2.96	247	37.1	23.57	23.57	8.24
			MN	0.16	48	0	0.00	0	0.0	14.23	14.23	0.51
65	1	40.00	AV	0.20	58	0	1.89	164	30.2	19.71	19.71	7.25
			MX	0.24	69	0	2.60	231	36.5	21.02	21.02	10.52
			MN	0.17	49	0	0.00	0	0.0	18.44	18.44	0.90
81	1	60.00	AV	0.22	65	0	2.65	212	32.7	18.96	18.96	7.92
			MX	0.25	73	0	3.57	263	36.2	27.82	27.82	9.45
			MN	0.19	56	0	0.00	2	0.0	3.14	3.14	0.46
110	2	70.00	AV	0.22	64	0	2.88	219	30.1	21.46	21.46	7.54
			MX	0.26	74	0	3.81	262	36.1	29.54	29.54	8.88
			MN	0.17	49	0	0.00	0	0.0	17.26	17.26	3.92
147	3	80.00	AV	0.20	59	0	2.23	187	36.3	20.16	20.16	7.94
			MX	0.25	73	0	3.15	253	39.1	25.27	25.27	10.30
			MN	0.05	51	0	0.00	0	0.0	8.30	8.30	2.89
229	8	90.00	AV	0.22	64	0	2.62	234	36.4	19.28	19.28	5.25
			MX	0.27	78	0	3.46	306	38.6	27.34	27.34	7.73
			MN	0.16	47	0	0.00	16	0.0	3.27	3.27	0.37
310	8	100.00	AV	0.19	54	0	2.71	245	33.4	21.08	21.08	2.78
			MX	0.26	76	0	3.57	351	37.7	26.83	26.83	7.62
			MN	0.14	41	0	2.20	22	0.0	5.52	5.52	0.89
394	8	110.00	AV	0.22	63	0	2.83	231	34.5	20.95	20.95	4.04
			MX	0.26	76	0	3.90	287	36.8	29.25	29.25	7.67
			MN	0.17	51	0	0.00	184	0.0	15.45	15.45	1.54
481	8	120.00	AV	0.23	66	0	2.72	246	36.9	20.99	20.99	3.31
			MX	0.28	81	0	3.48	308	39.7	26.42	26.42	5.42
			MN	0.18	51	0	0.00	178	0.0	15.88	15.88	1.42
591	11	130.00	AV	0.21	62	0	2.87	214	36.6	21.08	21.08	2.77
			MX	0.27	78	0	4.16	259	38.7	30.51	30.51	7.35
			MN	0.12	36	0	0.00	123	0.0	13.80	13.80	1.12

Info: MUD ROTARY- rope and cathead

BL# end	bl/ft	depth ft	TY	EMX K-ft	ETR %	E2F	EF2 K-ft	EV2	BPM bl/min	CSX ksi	CSI ksi	TSX ksi
687	9	140.00	AV	0.24	68	0	3.01	236	34.8	23.31	23.31	2.79
			MX	0.30	80	0	3.69	303	38.8	28.09	28.09	5.59
			MN	0.18	51	0	0.00	13	0.0	3.80	3.80	0.47
780	6	155.00	AV	0.21	60	0	2.86	188	38.0	20.27	20.27	3.95
			MX	0.24	70	0	3.77	264	39.8	28.67	28.67	5.87
			MN	0.15	43	0	0.00	1	36.0	4.85	4.85	0.56
840	6	164.57	AV	0.21	62	0	2.91	211	38.1	20.71	20.71	1.88
			MX	0.26	75	0	3.72	291	39.5	28.13	28.13	3.30
			MN	0.12	36	0	1.60	121	35.6	13.42	13.42	0.77

BL#	COMMENTS
1	JC = 0.70
34	Sample at 20 ft
81	Sample at 60 ft
147	Sample at 80 ft
229	Sample at 90 ft
310	Sample at 100 ft
394	Sample at 110 ft
481	Sample at 120 ft
591	Sample at 130 ft
687	Sample at 140 ft
780	Sample at 155 ft

DRIVEN (2009-Oct-28 : R-09-009.MDF)

APPENDIX B. GEOVISION GEOPHYSICAL INVESTIGATION REPORT

GEOVision
geophysical services

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
BORINGS R-09-007, R-09-014, R-09-021, R-09-022, R-09-025 and R-09-028

Report 9375-01 rev a

November 11, 2009

SCHUYLER HEIM BRIDGE PROJECT
PORT OF LOS ANGELES, CALIFORNIA

SUSPENSION PS VELOCITIES
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Report 9375-01 rev a

November 11, 2009

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INTRODUCTION

Boring geophysical measurements were collected in six uncased borings for the Schuyler Heim Bridge Project at the Port of Los Angeles, California. Geophysical data acquisition was performed between October 19 to November 6, 2009 by Victor Gonzalez and Charles Carter of **GEO***Vision*. Data analysis was performed by Victor Gonzalez and reviewed by Robert Steller of **GEO***Vision*. Report preparation was performed by Victor Gonzalez and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Earth Mechanics, Inc. (EMI) with G. J. Gunaranjan serving as the point of contact for EMI.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 19 and November 6, 2009 in six 4 7/8 -inch uncased borings, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during EMI's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	ELEVATION - FEET MLLW [1]	COORDINATES – FEET [1]	
			NORTHING	EASTING
R-09-007	10/19/2009	-0.79	1,735,625	6,488,980
R-09-014	10/20 – 10/21/2009	-1.33	1,736,114	6,489,009
R-09-021	10/21/2009	7.31	1,736,864	6,488,921
R-09-022	11/02 – 11/03/2009	-4.11	1,737,853	6,488,768
R-09-025	11/05/2009	-3.90	1,738,368	6,488,737
R-09-028	11/06/2009	-3.32	1,738,869	6,488,698

[1] Coordinates and elevations provided by EMI

Table 1 Boring locations and logging dates

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in all borings using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil

waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received SH-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Six 4 7/8-inch uncased borings filled with freshwater drilling mud were logged. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.4. Prior to each logging run, the probe was positioned with the top of the probe at the top of the drilling mud tub, ground surface, or other stationary reference point. Subsequently, the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring or until the probe descent was inhibited (i.e., R-09-014), stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive each day upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
R-09-007	SUSPENSION PS 1	3.3 – 136.2	150	1.6	10/19/2009
R-09-014	SUSPENSION PS 1	3.3 – 118.1	165	1.6	10/20/2009
R-09-021	SUSPENSION PS 1	6.6 – 154.2	170	1.6	10/21/2009
R-09-022	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/02/2009
R-09-025	SUSPENSION PS 1	3.3 – 160.8	175	1.6	11/05/2009
R-09-028	SUSPENSION PS 1	3.3 – 162.4	175	1.6	11/06/2009

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.33-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity

determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.53 feet to correspond to the mid-point of the 6.33-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by Robert Steller as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4, 5, 6, 7, 8, and 9. The suspension velocity data presented in these figures are presented in Table 3, 4, 5, 6, 7, and 8, respectively. These plots and data are included in the EXCEL analysis files transmitted separately.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-6 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.33 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-6, and included in the EXCEL analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as were these borings. Thus data collected in these uncased borings was of very good quality.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show good correlation between R1 – R2 and S – R1. Additionally, there is a good correlation between P-wave and S_H-wave velocities, as both show similar velocity inflections. Data from adjacent depth intervals are generally similar. P-wave and S_H-wave onsets are clear and later oscillations are well damped.

Velocity profiles between borings in the study area are generally similar. All borings exhibit S_H-wave velocities ranging from approximately 200 – 300 fps near the surface, increasing to over 1,000 fps at depth. All borings show an increase to water velocities in the P-wave profiles at 10 – 20 feet below ground surface (bgs). Adjacent borings R-09-007 and R-09-014 show a similar decrease in P-wave velocity at approximately 45 – 55 feet bgs which typically indicates an organic-rich zone.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

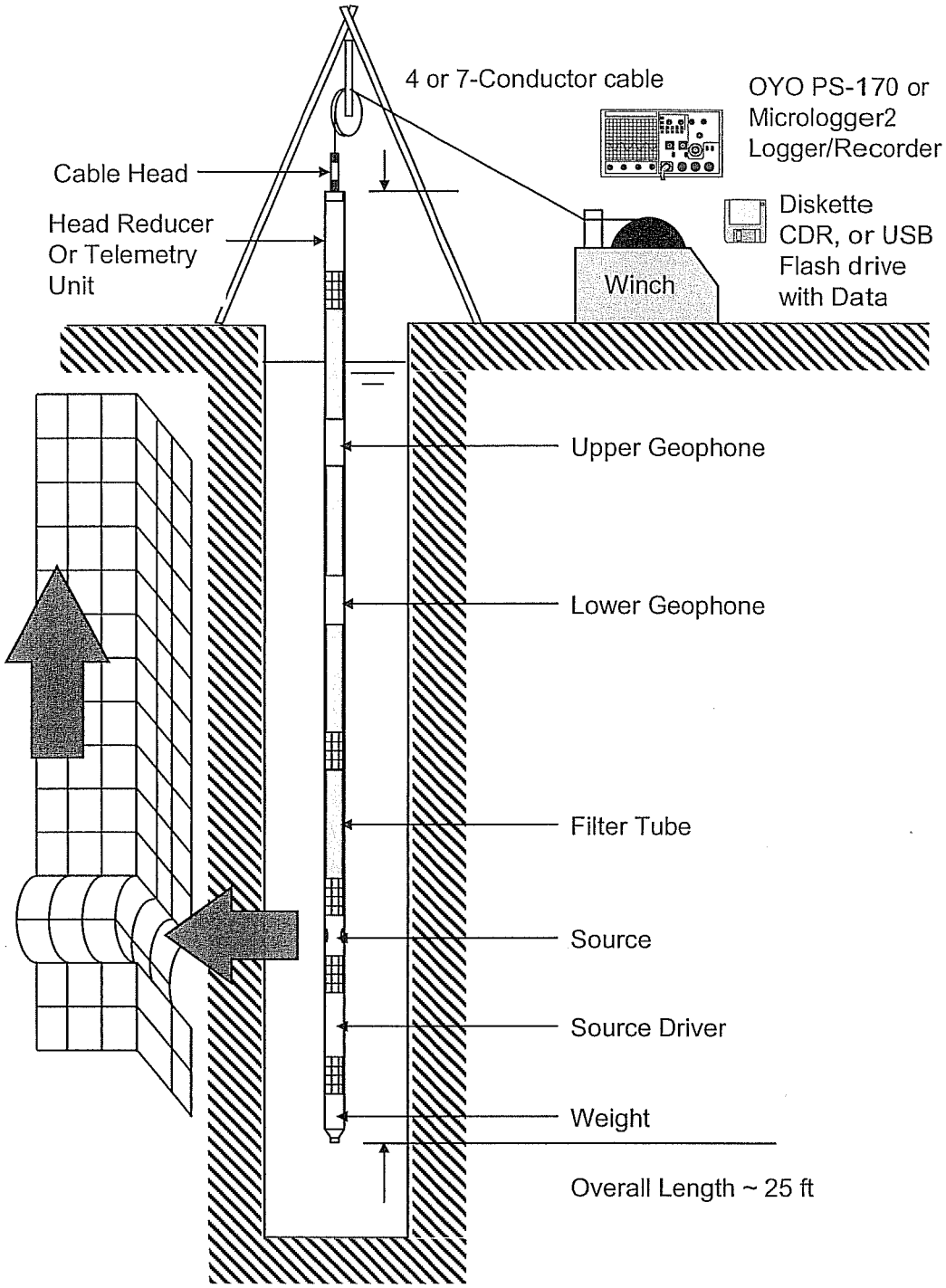

Figure 1: Concept illustration of P-S logging system

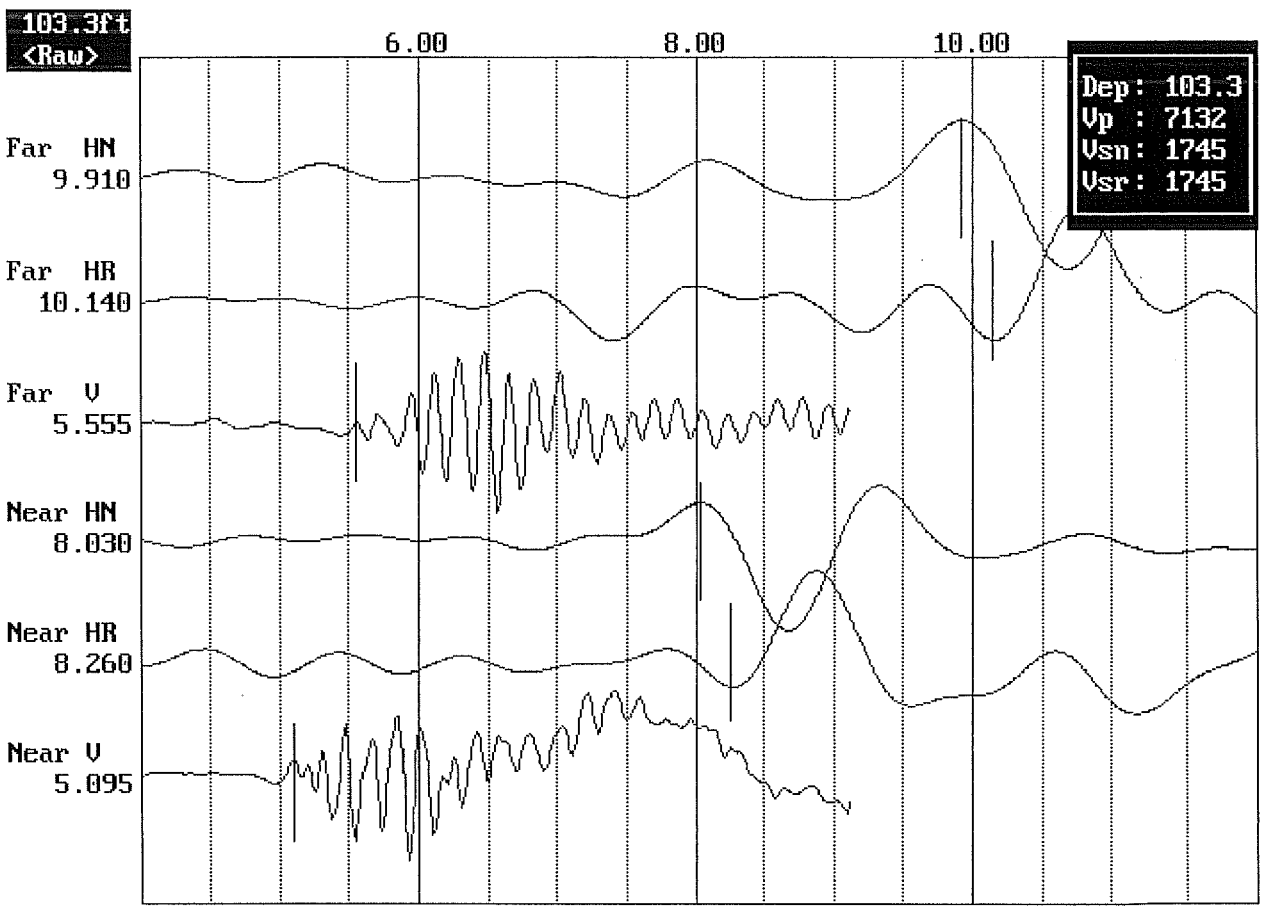

Figure 2: Example of filtered (1400 Hz lowpass) record

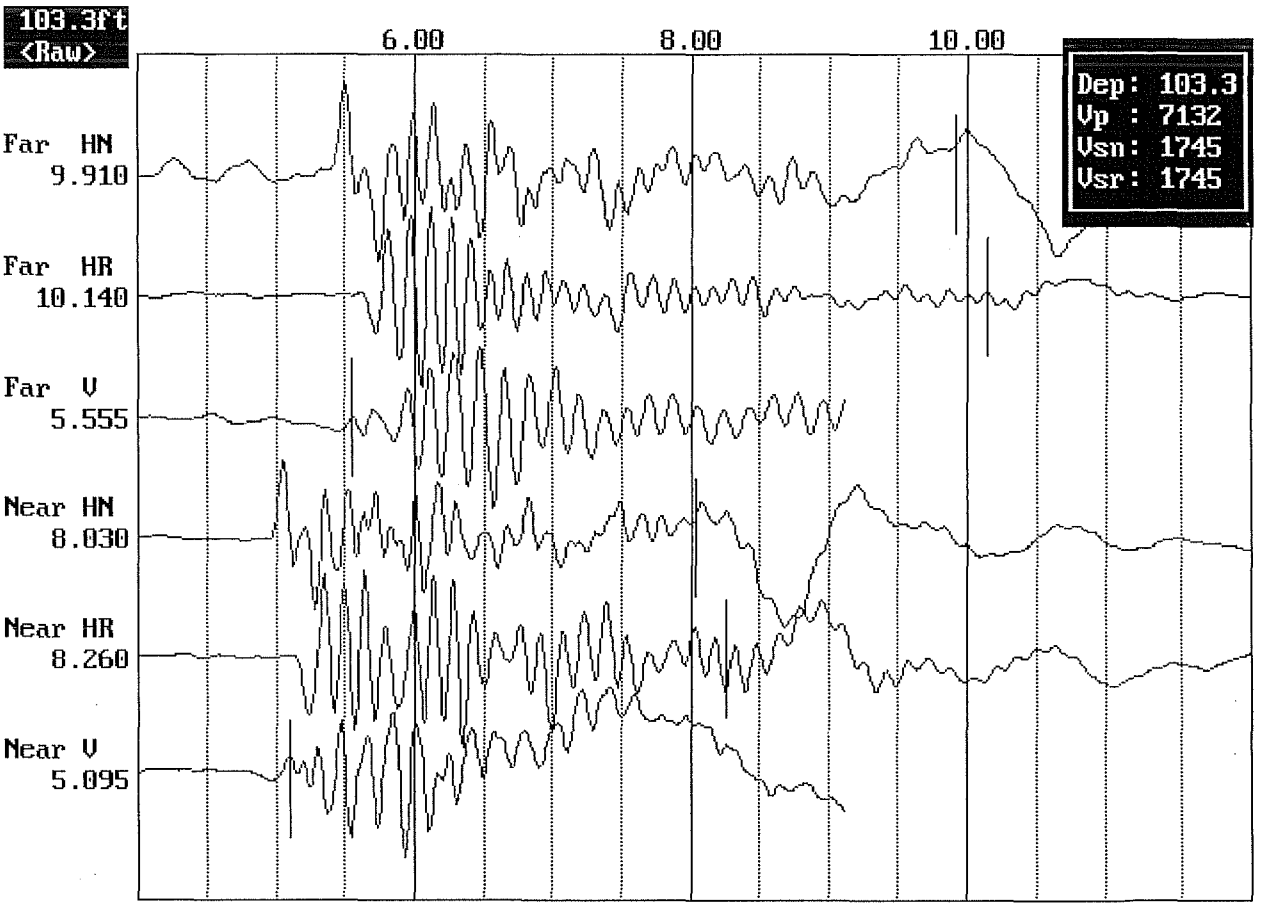

Figure 3. Example of unfiltered record

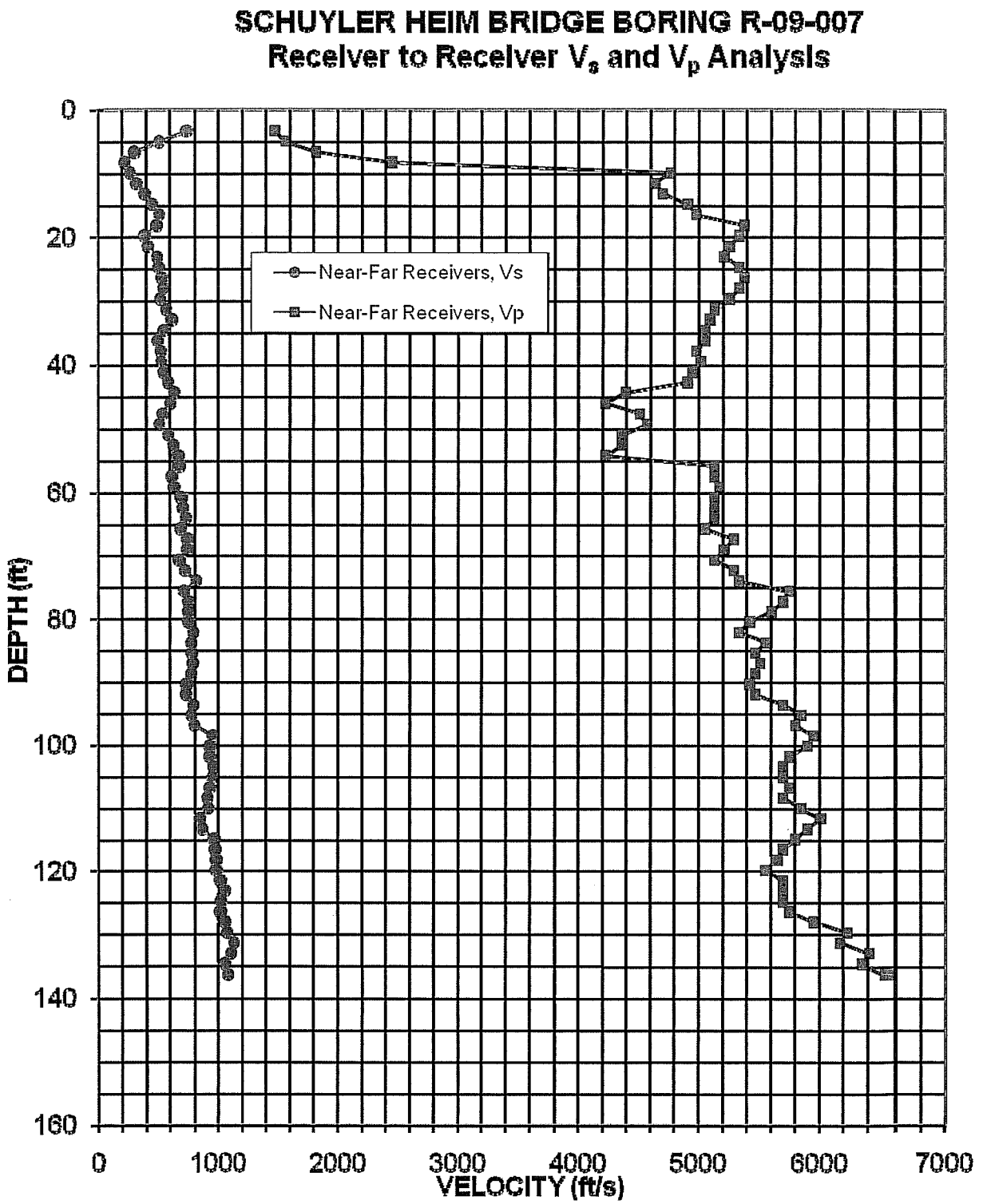

Figure 4: Boring R-09-007, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring R-09-007, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	730	1470	0.34
4.9	510	1560	0.44
6.6	310	1810	0.49
8.2	220	2450	0.50
9.8	270	4760	0.50
11.5	320	4630	0.50
13.1	390	4690	0.50
14.8	450	4900	0.50
16.4	510	4980	0.49
18.0	480	5380	0.50
19.7	390	5330	0.50
21.3	410	5250	0.50
23.0	490	5210	0.50
24.6	500	5330	0.50
26.3	520	5380	0.50
27.9	540	5330	0.49
29.5	510	5250	0.50
31.2	560	5130	0.49
32.8	610	5090	0.49
34.5	540	5050	0.49
36.1	490	5050	0.50
37.7	520	4980	0.49
39.4	520	5010	0.49
41.0	540	4940	0.49
42.7	580	4900	0.49
44.3	630	4390	0.49
45.9	600	4220	0.49
47.6	530	4500	0.49
49.2	500	4570	0.49
50.9	580	4360	0.49
52.5	620	4360	0.49
54.1	660	4220	0.49
55.8	670	5130	0.49
57.4	610	5130	0.49
59.1	630	5170	0.49
60.7	690	5130	0.49
62.3	700	5130	0.49
64.0	720	5130	0.49
65.6	680	5050	0.49
67.3	740	5290	0.49
68.9	740	5210	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	220	450	0.34
1.5	150	470	0.44
2.0	90	550	0.49
2.5	70	750	0.50
3.0	80	1450	0.50
3.5	100	1410	0.50
4.0	120	1430	0.50
4.5	140	1490	0.50
5.0	150	1520	0.49
5.5	150	1640	0.50
6.0	120	1630	0.50
6.5	120	1600	0.50
7.0	150	1590	0.50
7.5	150	1630	0.50
8.0	160	1640	0.50
8.5	160	1630	0.49
9.0	160	1600	0.50
9.5	170	1560	0.49
10.0	190	1550	0.49
10.5	170	1540	0.49
11.0	150	1540	0.50
11.5	160	1520	0.49
12.0	160	1530	0.49
12.5	160	1510	0.49
13.0	180	1490	0.49
13.5	190	1340	0.49
14.0	180	1290	0.49
14.5	160	1370	0.49
15.0	150	1390	0.49
15.5	180	1330	0.49
16.0	190	1330	0.49
16.5	200	1290	0.49
17.0	200	1560	0.49
17.5	190	1560	0.49
18.0	190	1580	0.49
18.5	210	1560	0.49
19.0	210	1560	0.49
19.5	220	1560	0.49
20.0	210	1540	0.49
20.5	220	1610	0.49
21.0	220	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	670	5130	0.49
72.2	720	5290	0.49
73.8	810	5330	0.49
75.5	710	5750	0.49
77.1	740	5700	0.49
78.7	740	5600	0.49
80.4	740	5420	0.49
82.0	780	5330	0.49
83.7	770	5560	0.49
85.3	770	5460	0.49
86.9	780	5510	0.49
88.6	770	5460	0.49
90.2	730	5420	0.49
91.9	720	5460	0.49
93.5	780	5700	0.49
95.1	770	5850	0.49
96.8	800	5800	0.49
98.4	950	5950	0.49
100.1	920	5900	0.49
101.7	920	5750	0.49
103.4	950	5700	0.49
105.0	940	5700	0.49
106.6	930	5750	0.49
108.3	910	5700	0.49
109.9	910	5850	0.49
111.6	840	6010	0.49
113.2	860	5900	0.49
114.8	960	5800	0.49
116.5	970	5700	0.49
118.1	970	5650	0.48
119.8	970	5560	0.48
121.4	1010	5700	0.48
123.0	1040	5700	0.48
124.7	1010	5700	0.48
126.3	1010	5750	0.48
128.0	1050	5950	0.48
129.6	1060	6230	0.48
131.2	1120	6170	0.48
132.9	1100	6410	0.48
134.5	1050	6350	0.49
136.2	1080	6540	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	200	1560	0.49
22.0	220	1610	0.49
22.5	250	1630	0.49
23.0	220	1750	0.49
23.5	230	1740	0.49
24.0	230	1710	0.49
24.5	230	1650	0.49
25.0	240	1630	0.49
25.5	230	1690	0.49
26.0	230	1670	0.49
26.5	240	1680	0.49
27.0	230	1670	0.49
27.5	220	1650	0.49
28.0	220	1670	0.49
28.5	240	1740	0.49
29.0	230	1780	0.49
29.5	240	1770	0.49
30.0	290	1810	0.49
30.5	280	1800	0.49
31.0	280	1750	0.49
31.5	290	1740	0.49
32.0	290	1740	0.49
32.5	280	1750	0.49
33.0	280	1740	0.49
33.5	280	1780	0.49
34.0	260	1830	0.49
34.5	260	1800	0.49
35.0	290	1770	0.49
35.5	290	1740	0.49
36.0	300	1720	0.48
36.5	300	1690	0.48
37.0	310	1740	0.48
37.5	320	1740	0.48
38.0	310	1740	0.48
38.5	310	1750	0.48
39.0	320	1810	0.48
39.5	320	1900	0.48
40.0	340	1880	0.48
40.5	340	1950	0.48
41.0	320	1940	0.49
41.5	330	1990	0.49

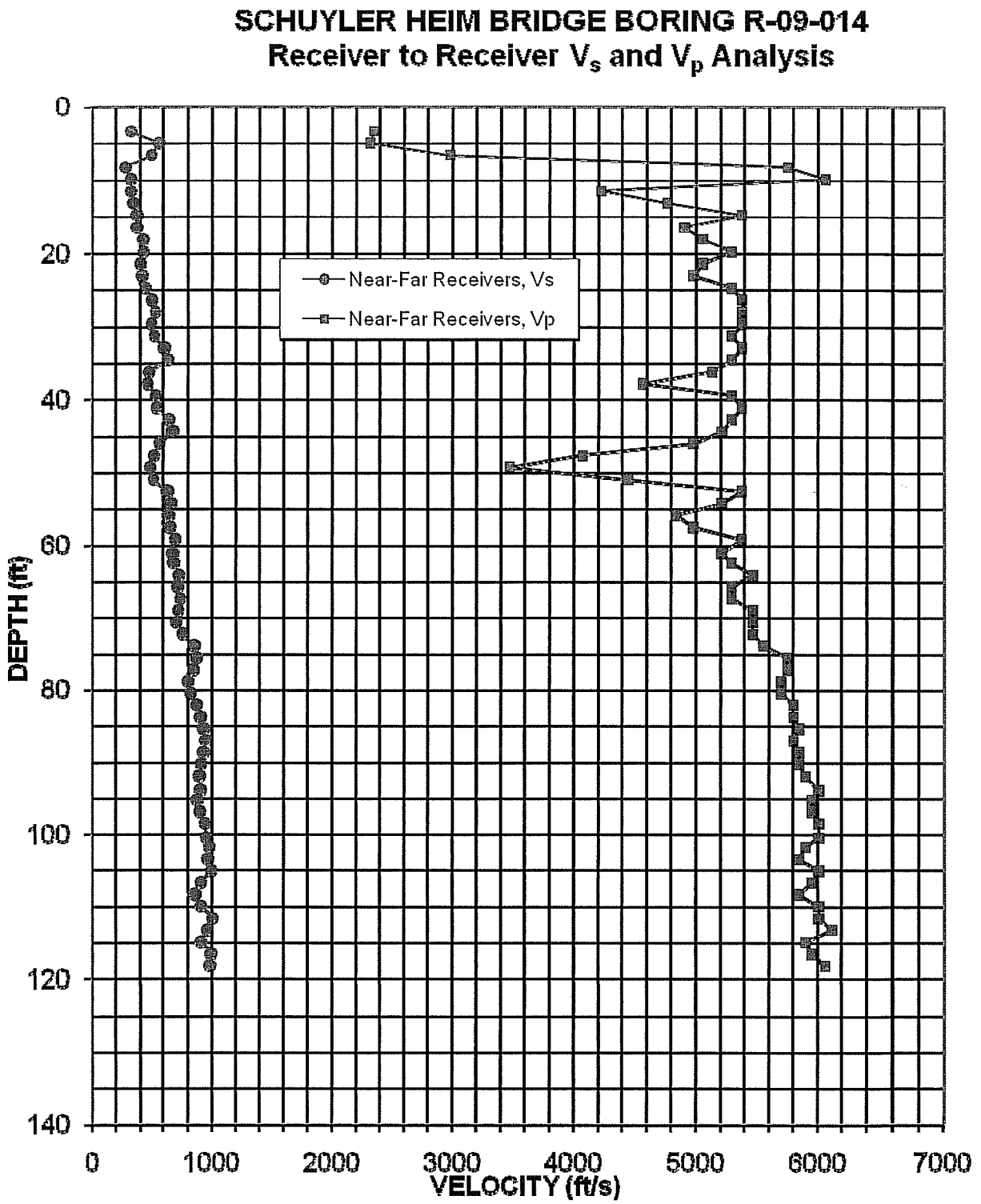

Figure 5: Boring R-09-014, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring R-09-014, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2350	0.49
4.9	560	2310	0.47
6.6	500	2980	0.49
8.2	280	5750	0.50
9.8	320	6060	0.50
11.5	330	4220	0.50
13.1	350	4760	0.50
14.8	370	5380	0.50
16.4	370	4900	0.50
18.0	420	5050	0.50
19.7	430	5290	0.50
21.3	400	5050	0.50
23.0	410	4980	0.50
24.6	450	5290	0.50
26.3	500	5380	0.50
27.9	530	5380	0.50
29.5	500	5380	0.50
31.2	520	5290	0.50
32.8	600	5380	0.49
34.5	630	5290	0.49
36.1	480	5130	0.50
37.7	460	4570	0.49
39.4	530	5290	0.49
41.0	540	5380	0.49
42.7	640	5290	0.49
44.3	670	5210	0.49
45.9	560	4980	0.49
47.6	520	4070	0.49
49.2	480	3470	0.49
50.9	510	4440	0.49
52.5	630	5380	0.49
54.1	650	5210	0.49
55.8	630	4830	0.49
57.4	650	4980	0.49
59.1	690	5380	0.49
61.0	670	5210	0.49
62.3	680	5290	0.49
64.0	720	5460	0.49
65.6	710	5290	0.49
67.3	730	5290	0.49
68.9	720	5460	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	720	0.49
1.5	170	710	0.47
2.0	150	910	0.49
2.5	90	1750	0.50
3.0	100	1850	0.50
3.5	100	1290	0.50
4.0	110	1450	0.50
4.5	110	1640	0.50
5.0	110	1490	0.50
5.5	130	1540	0.50
6.0	130	1610	0.50
6.5	120	1540	0.50
7.0	130	1520	0.50
7.5	140	1610	0.50
8.0	150	1640	0.50
8.5	160	1640	0.50
9.0	150	1640	0.50
9.5	160	1610	0.50
10.0	180	1640	0.49
10.5	190	1610	0.49
11.0	150	1560	0.50
11.5	140	1390	0.49
12.0	160	1610	0.49
12.5	160	1640	0.49
13.0	200	1610	0.49
13.5	200	1590	0.49
14.0	170	1520	0.49
14.5	160	1240	0.49
15.0	150	1060	0.49
15.5	160	1350	0.49
16.0	190	1640	0.49
16.5	200	1590	0.49
17.0	190	1470	0.49
17.5	200	1520	0.49
18.0	210	1640	0.49
18.6	200	1590	0.49
19.0	210	1610	0.49
19.5	220	1670	0.49
20.0	220	1610	0.49
20.5	220	1610	0.49
21.0	220	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	700	5460	0.49
72.2	750	5460	0.49
73.8	850	5560	0.49
75.5	870	5750	0.49
77.1	840	5750	0.49
78.7	800	5700	0.49
80.4	820	5700	0.49
82.0	870	5800	0.49
83.7	900	5800	0.49
85.3	920	5850	0.49
86.9	940	5800	0.49
88.6	920	5850	0.49
90.2	900	5850	0.49
91.9	890	5900	0.49
93.8	900	6010	0.49
95.1	870	5950	0.49
96.8	900	5950	0.49
98.4	940	6010	0.49
100.4	950	6010	0.49
101.7	970	5900	0.49
103.4	960	5850	0.49
105.0	990	6010	0.49
106.6	900	5950	0.49
108.3	860	5850	0.49
109.9	910	6010	0.49
111.6	1000	6010	0.49
113.2	960	6120	0.49
114.8	910	5900	0.49
116.5	980	5950	0.49
118.1	980	6060	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	210	1670	0.49
22.0	230	1670	0.49
22.5	260	1690	0.49
23.0	270	1750	0.49
23.5	260	1750	0.49
24.0	240	1740	0.49
24.5	250	1740	0.49
25.0	260	1770	0.49
25.5	270	1770	0.49
26.0	280	1780	0.49
26.5	290	1770	0.49
27.0	280	1780	0.49
27.5	280	1780	0.49
28.0	270	1800	0.49
28.6	270	1830	0.49
29.0	270	1810	0.49
29.5	270	1810	0.49
30.0	290	1830	0.49
30.6	290	1830	0.49
31.0	300	1800	0.49
31.5	290	1780	0.49
32.0	300	1830	0.49
32.5	280	1810	0.49
33.0	260	1780	0.49
33.5	280	1830	0.49
34.0	300	1830	0.49
34.5	290	1860	0.49
35.0	280	1800	0.49
35.5	300	1810	0.49
36.0	300	1850	0.49

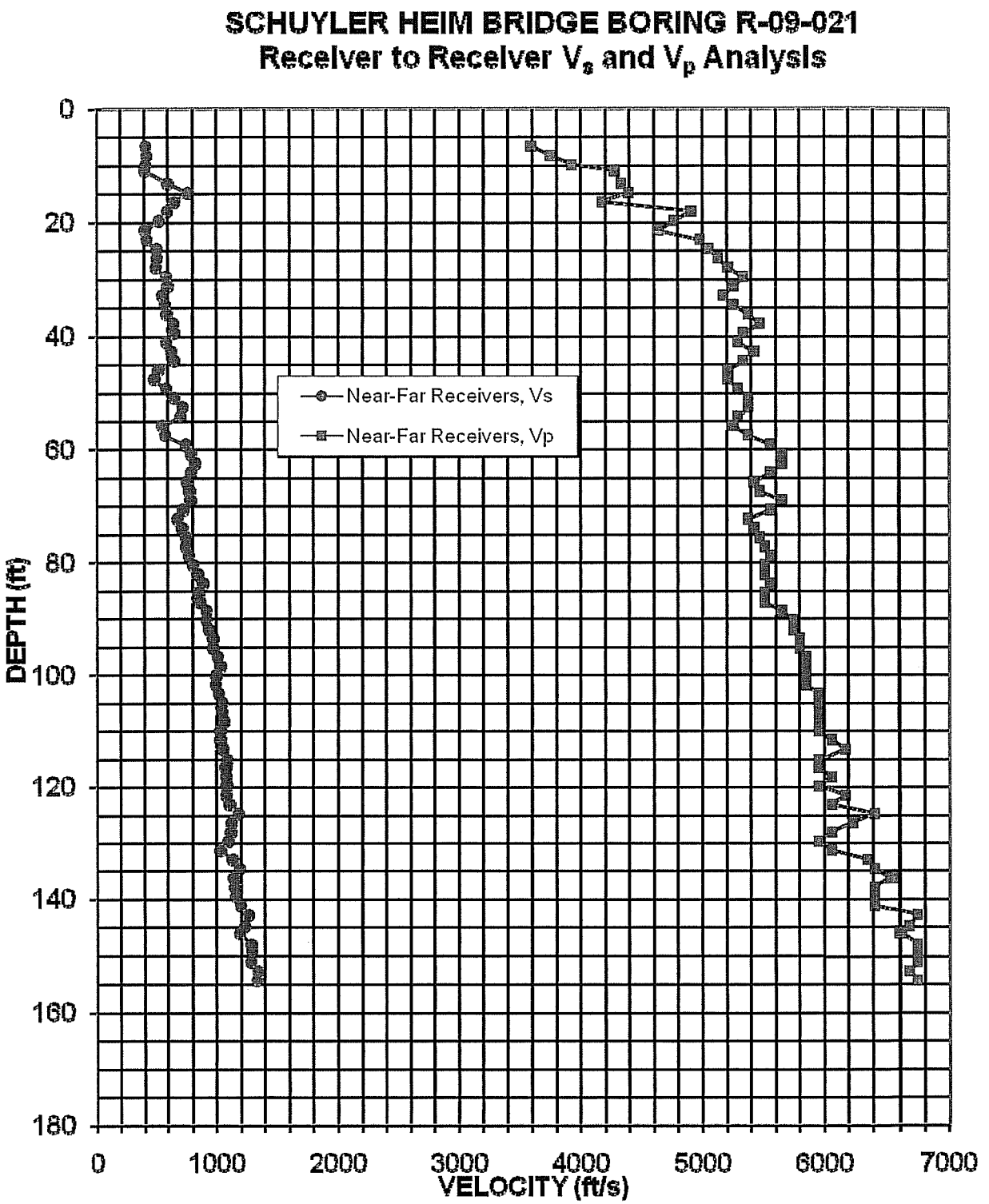

Figure 6: Boring R-09-021, Suspension R1-R2 P- and S_H-wave velocities

Table 5. Boring R-09-021, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.6	410	3580	0.49
8.2	420	3750	0.49
9.8	410	3920	0.49
10.8	400	4270	0.50
13.1	600	4330	0.49
14.8	760	4390	0.48
16.4	650	4170	0.49
18.0	590	4900	0.49
19.7	520	4760	0.49
21.3	410	4630	0.50
23.0	420	4980	0.50
24.6	500	5050	0.49
26.3	510	5130	0.50
27.9	490	5210	0.50
29.5	580	5330	0.49
31.2	600	5250	0.49
32.8	550	5170	0.49
34.5	570	5250	0.49
36.1	580	5380	0.49
37.7	640	5460	0.49
39.4	650	5330	0.49
41.0	580	5290	0.49
42.7	620	5420	0.49
44.3	650	5330	0.49
45.9	520	5210	0.49
47.6	480	5210	0.50
49.2	580	5290	0.49
50.9	650	5380	0.49
52.5	720	5380	0.49
54.1	700	5290	0.49
55.8	550	5250	0.49
57.4	570	5380	0.49
59.1	740	5560	0.49
60.7	780	5650	0.49
62.3	820	5650	0.49
64.0	780	5560	0.49
65.6	750	5420	0.49
67.3	770	5460	0.49
68.9	780	5650	0.49
70.5	720	5560	0.49
72.2	670	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	130	1090	0.49
2.5	130	1140	0.49
3.0	120	1200	0.49
3.3	120	1300	0.50
4.0	180	1320	0.49
4.5	230	1340	0.48
5.0	200	1270	0.49
5.5	180	1490	0.49
6.0	160	1450	0.49
6.5	120	1410	0.50
7.0	130	1520	0.50
7.5	150	1540	0.49
8.0	150	1560	0.50
8.5	150	1590	0.50
9.0	180	1630	0.49
9.5	180	1600	0.49
10.0	170	1580	0.49
10.5	180	1600	0.49
11.0	180	1640	0.49
11.5	200	1670	0.49
12.0	200	1630	0.49
12.5	180	1610	0.49
13.0	190	1650	0.49
13.5	200	1630	0.49
14.0	160	1590	0.49
14.5	150	1590	0.50
15.0	180	1610	0.49
15.5	200	1640	0.49
16.0	220	1640	0.49
16.5	210	1610	0.49
17.0	170	1600	0.49
17.5	170	1640	0.49
18.0	230	1690	0.49
18.5	240	1720	0.49
19.0	250	1720	0.49
19.5	240	1690	0.49
20.0	230	1650	0.49
20.5	230	1670	0.49
21.0	240	1720	0.49
21.5	220	1690	0.49
22.0	210	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
73.8	710	5420	0.49
75.5	750	5460	0.49
77.1	740	5510	0.49
78.7	770	5560	0.49
80.4	800	5510	0.49
82.0	840	5510	0.49
83.7	880	5560	0.49
85.3	850	5510	0.49
86.9	860	5510	0.49
88.6	910	5650	0.49
90.2	910	5750	0.49
91.9	930	5750	0.49
93.5	970	5800	0.49
95.1	970	5800	0.49
96.8	1000	5850	0.48
98.4	1030	5850	0.48
100.1	990	5850	0.49
101.7	990	5850	0.49
103.4	1020	5950	0.48
105.0	1040	5950	0.48
106.6	1040	5950	0.48
108.3	1050	5950	0.48
109.9	1030	5950	0.48
111.6	1030	6060	0.49
113.2	1050	6170	0.49
115.2	1080	5950	0.48
116.5	1070	5950	0.48
118.1	1080	6060	0.48
119.8	1080	5950	0.48
121.4	1080	6170	0.48
123.0	1100	6060	0.48
124.7	1180	6410	0.48
126.3	1120	6230	0.48
128.0	1110	6060	0.48
129.6	1090	5950	0.48
131.2	1030	6060	0.49
132.9	1130	6350	0.48
134.5	1180	6410	0.48
136.2	1140	6540	0.48
137.8	1150	6410	0.48
139.4	1150	6410	0.48
141.1	1190	6410	0.48
142.7	1260	6730	0.48
144.7	1230	6670	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
22.5	220	1650	0.49
23.0	230	1670	0.49
23.5	230	1680	0.49
24.0	230	1690	0.49
24.5	240	1680	0.49
25.0	260	1680	0.49
25.5	270	1690	0.49
26.0	260	1680	0.49
26.5	260	1680	0.49
27.0	280	1720	0.49
27.5	280	1750	0.49
28.0	280	1750	0.49
28.5	290	1770	0.49
29.0	300	1770	0.49
29.5	310	1780	0.48
30.0	310	1780	0.48
30.5	300	1780	0.49
31.0	300	1780	0.49
31.5	310	1810	0.48
32.0	320	1810	0.48
32.5	320	1810	0.48
33.0	320	1810	0.48
33.5	310	1810	0.48
34.0	310	1850	0.49
34.5	320	1880	0.49
35.1	330	1810	0.48
35.5	330	1810	0.48
36.0	330	1850	0.48
36.5	330	1810	0.48
37.0	330	1880	0.48
37.5	340	1850	0.48
38.0	360	1950	0.48
38.5	340	1900	0.48
39.0	340	1850	0.48
39.5	330	1810	0.48
40.0	310	1850	0.49
40.5	340	1940	0.48
41.0	360	1950	0.48
41.5	350	1990	0.48
42.0	350	1950	0.48
42.5	350	1950	0.48
43.0	360	1950	0.48
43.5	380	2050	0.48
44.1	370	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
146.0	1180	6600	0.48
148.0	1280	6730	0.48
149.3	1290	6730	0.48
150.9	1280	6730	0.48
152.6	1340	6670	0.48
154.2	1330	6730	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
44.5	360	2010	0.48
45.1	390	2050	0.48
45.5	390	2050	0.48
46.0	390	2050	0.48
46.5	410	2030	0.48
47.0	400	2050	0.48

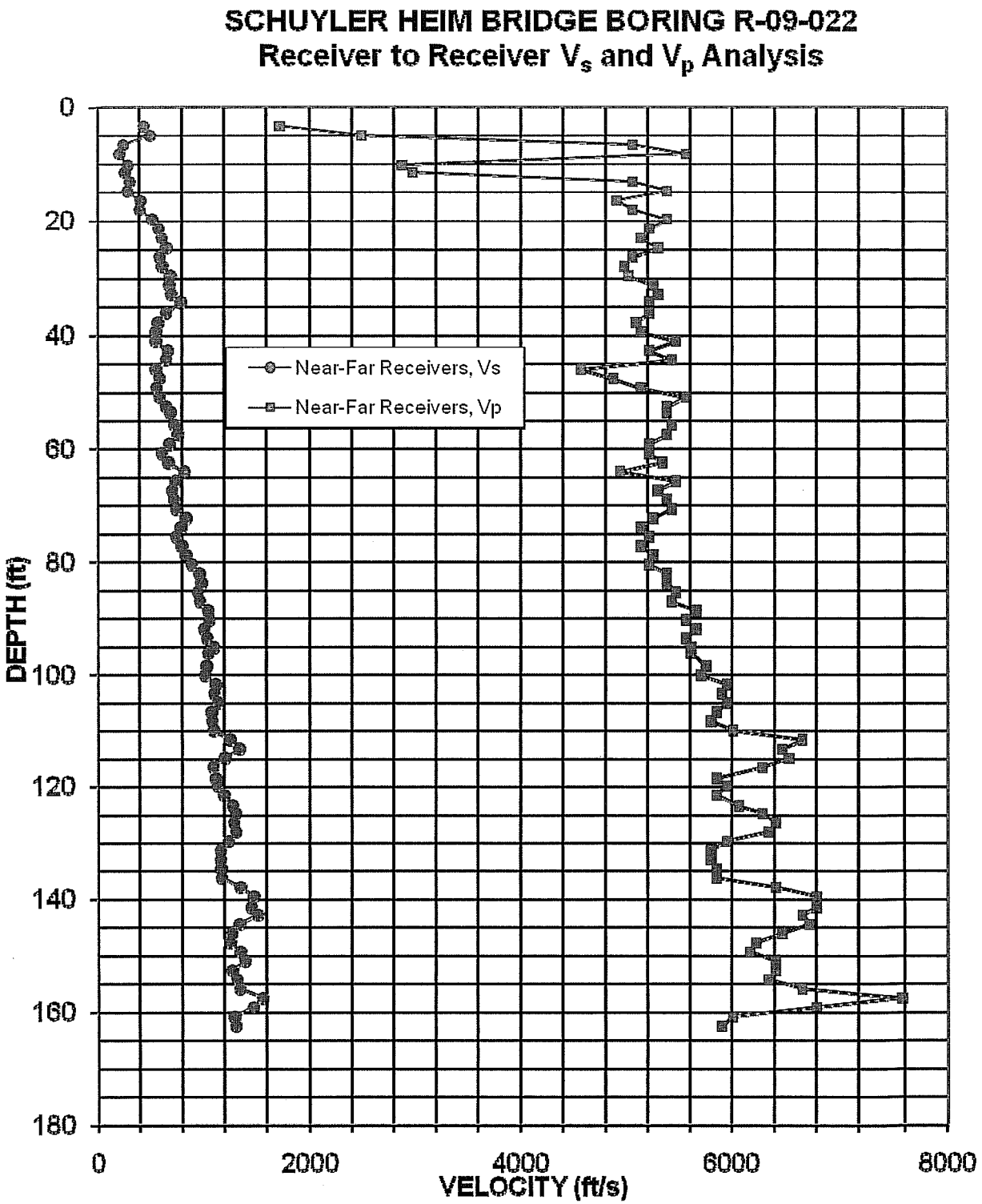

Figure 7: Boring R-09-022, Suspension R1-R2 P- and S_H-wave velocities

Table 6. Boring R-09-022, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	440	1720	0.47
4.9	500	2490	0.48
6.6	250	5050	0.50
8.2	210	5560	0.50
10.2	290	2870	0.49
11.5	260	2980	0.50
13.1	310	5050	0.50
14.8	290	5380	0.50
16.4	410	4900	0.50
18.0	400	5050	0.50
19.7	520	5380	0.50
21.3	570	5210	0.49
23.0	600	5130	0.49
24.6	650	5290	0.49
26.3	580	5050	0.49
27.9	610	4980	0.49
29.5	690	5010	0.49
31.2	680	5250	0.49
32.8	700	5290	0.49
34.1	780	5210	0.49
36.1	640	5210	0.49
37.7	570	5090	0.49
39.4	550	5130	0.49
41.0	550	5460	0.49
42.7	660	5210	0.49
44.3	650	5420	0.49
45.9	550	4570	0.49
47.6	590	4870	0.49
49.2	560	5130	0.49
50.9	580	5560	0.49
52.5	650	5380	0.49
53.5	690	5380	0.49
55.8	730	5420	0.49
57.4	760	5380	0.49
59.1	680	5210	0.49
60.7	610	5210	0.49
62.3	670	5330	0.49
64.0	820	4940	0.49
65.6	740	5460	0.49
67.3	700	5290	0.49
68.9	720	5380	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	130	520	0.47
1.5	150	760	0.48
2.0	80	1540	0.50
2.5	60	1690	0.50
3.1	90	880	0.49
3.5	80	910	0.50
4.0	90	1540	0.50
4.5	90	1640	0.50
5.0	130	1490	0.50
5.5	120	1540	0.50
6.0	160	1640	0.50
6.5	180	1590	0.49
7.0	180	1560	0.49
7.5	200	1610	0.49
8.0	180	1540	0.49
8.5	190	1520	0.49
9.0	210	1530	0.49
9.5	210	1600	0.49
10.0	210	1610	0.49
10.4	240	1590	0.49
11.0	200	1590	0.49
11.5	170	1550	0.49
12.0	170	1560	0.49
12.5	170	1670	0.49
13.0	200	1590	0.49
13.5	200	1650	0.49
14.0	170	1390	0.49
14.5	180	1480	0.49
15.0	170	1560	0.49
15.5	180	1690	0.49
16.0	200	1640	0.49
16.3	210	1640	0.49
17.0	220	1650	0.49
17.5	230	1640	0.49
18.0	210	1590	0.49
18.5	180	1590	0.49
19.0	200	1630	0.49
19.5	250	1510	0.49
20.0	220	1670	0.49
20.5	210	1610	0.49
21.0	220	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	740	5420	0.49
72.2	830	5250	0.49
73.8	780	5130	0.49
75.5	740	5210	0.49
77.1	800	5130	0.49
78.7	840	5250	0.49
80.4	890	5210	0.48
82.0	960	5380	0.48
83.7	980	5380	0.48
85.3	940	5460	0.48
86.9	970	5420	0.48
88.6	1040	5650	0.48
90.2	1050	5560	0.48
91.9	1000	5650	0.48
93.5	1040	5560	0.48
95.1	1100	5600	0.48
96.1	1040	5600	0.48
98.4	1030	5750	0.48
100.1	1020	5700	0.48
101.7	1110	5950	0.48
103.4	1100	5900	0.48
105.0	1150	5950	0.48
106.6	1080	5850	0.48
108.3	1080	5800	0.48
109.9	1100	6010	0.48
111.6	1250	6670	0.48
113.2	1340	6470	0.48
114.8	1200	6540	0.48
116.5	1090	6290	0.48
118.4	1110	5850	0.48
119.8	1130	5950	0.48
121.4	1190	5850	0.48
123.4	1280	6060	0.48
124.7	1310	6290	0.48
126.3	1290	6410	0.48
128.0	1310	6350	0.48
129.6	1240	5950	0.48
131.2	1160	5800	0.48
132.9	1160	5800	0.48
134.5	1170	5850	0.48
136.2	1170	5850	0.48
137.8	1350	6410	0.48
139.4	1470	6800	0.48
141.4	1450	6800	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	230	1650	0.49
22.0	250	1600	0.49
22.5	240	1560	0.49
23.0	230	1590	0.49
23.5	240	1560	0.49
24.0	250	1600	0.49
24.5	270	1590	0.48
25.0	290	1640	0.48
25.5	300	1640	0.48
26.0	290	1670	0.48
26.5	290	1650	0.48
27.0	320	1720	0.48
27.5	320	1690	0.48
28.0	310	1720	0.48
28.5	320	1690	0.48
29.0	340	1710	0.48
29.3	320	1710	0.48
30.0	310	1750	0.48
30.5	310	1740	0.48
31.0	340	1810	0.48
31.5	340	1800	0.48
32.0	350	1810	0.48
32.5	330	1780	0.48
33.0	330	1770	0.48
33.5	330	1830	0.48
34.0	380	2030	0.48
34.5	410	1970	0.48
35.0	370	1990	0.48
35.5	330	1920	0.48
36.1	340	1780	0.48
36.5	340	1810	0.48
37.0	360	1780	0.48
37.6	390	1850	0.48
38.0	400	1920	0.48
38.5	390	1950	0.48
39.0	400	1940	0.48
39.5	380	1810	0.48
40.0	350	1770	0.48
40.5	350	1770	0.48
41.0	360	1780	0.48
41.5	360	1780	0.48
42.0	410	1950	0.48
42.5	450	2070	0.48
43.1	440	2070	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1520	6670	0.47
144.4	1340	6730	0.48
146.0	1270	6470	0.48
147.6	1250	6230	0.48
149.3	1350	6170	0.47
150.9	1390	6410	0.48
152.6	1270	6410	0.48
154.2	1310	6350	0.48
155.8	1340	6670	0.48
157.5	1560	7580	0.48
159.1	1470	6800	0.48
160.8	1290	6010	0.48
162.4	1310	5900	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	460	2030	0.47
44.0	410	2050	0.48
44.5	390	1970	0.48
45.0	380	1900	0.48
45.5	410	1880	0.47
46.0	430	1950	0.48
46.5	390	1950	0.48
47.0	400	1940	0.48
47.5	410	2030	0.48
48.0	470	2310	0.48
48.5	450	2070	0.48
49.0	390	1830	0.48
49.5	400	1800	0.47

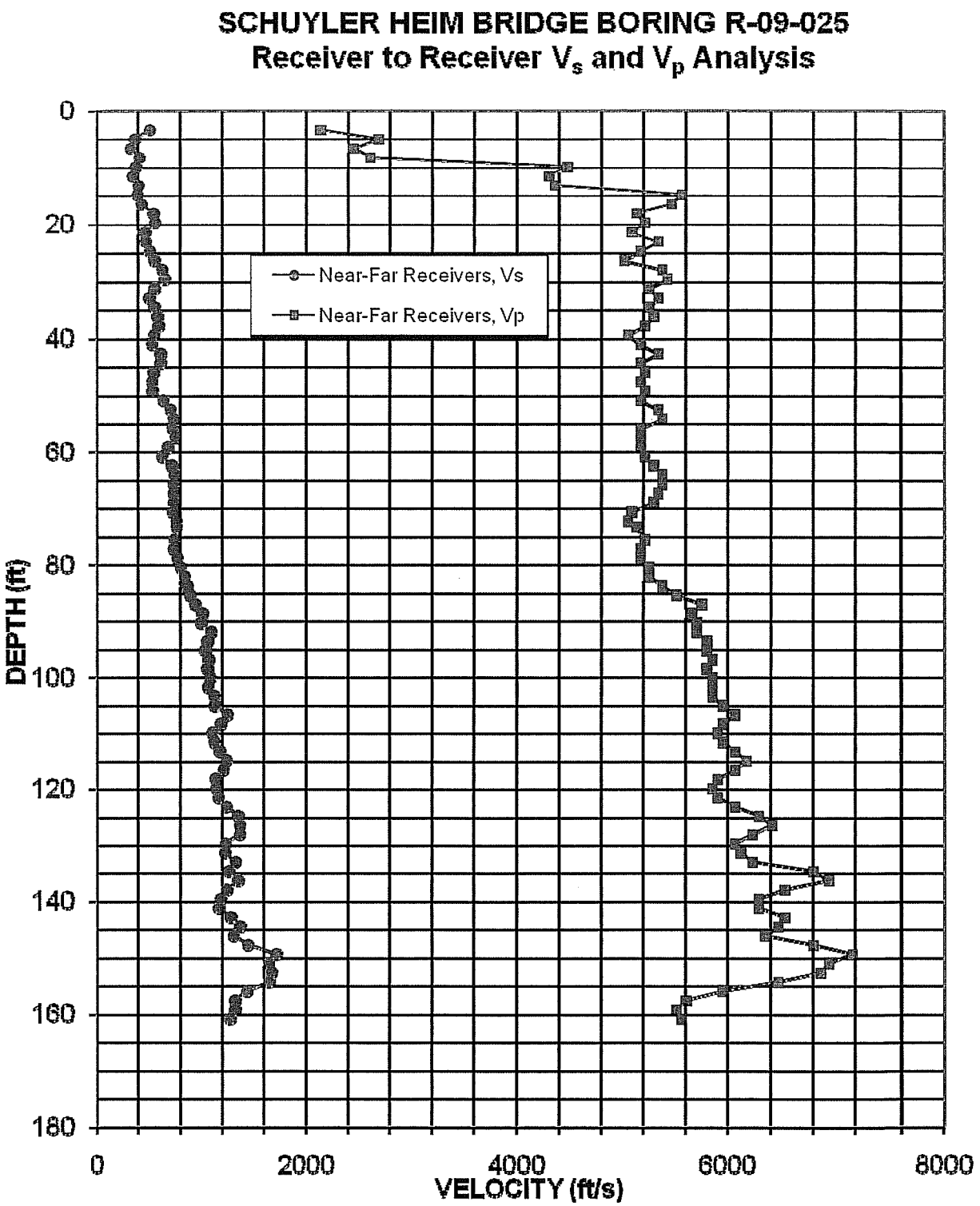

Figure 8: Boring R-09-025, Suspension R1-R2 P- and S_H-wave velocities

Table 7. Boring R-09-025, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	510	2140	0.47
4.9	370	2690	0.49
6.6	330	2450	0.49
8.2	410	2600	0.49
9.8	380	4470	0.50
11.5	340	4300	0.50
13.1	400	4360	0.50
14.8	390	5560	0.50
16.4	430	5460	0.50
18.0	540	5130	0.49
19.7	560	5210	0.49
21.3	460	5090	0.50
23.0	470	5330	0.50
24.6	510	5170	0.50
26.3	550	5010	0.49
27.9	620	5380	0.49
29.5	650	5420	0.49
31.2	550	5250	0.49
32.8	500	5330	0.50
34.5	550	5250	0.49
36.1	580	5290	0.49
37.7	590	5210	0.49
39.4	550	5050	0.49
41.0	530	5170	0.49
42.7	610	5330	0.49
44.3	610	5170	0.49
45.9	540	5210	0.49
47.6	530	5170	0.49
49.2	530	5210	0.49
50.9	630	5170	0.49
52.5	700	5330	0.49
54.1	730	5380	0.49
55.8	720	5170	0.49
57.4	750	5170	0.49
59.1	680	5170	0.49
60.7	630	5210	0.49
62.3	720	5290	0.49
64.0	750	5380	0.49
65.6	730	5380	0.49
67.3	730	5330	0.49
68.9	740	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	150	650	0.47
1.5	110	820	0.49
2.0	100	750	0.49
2.5	130	790	0.49
3.0	120	1360	0.50
3.5	100	1310	0.50
4.0	120	1330	0.50
4.5	120	1690	0.50
5.0	130	1670	0.50
5.5	170	1560	0.49
6.0	170	1590	0.49
6.5	140	1550	0.50
7.0	140	1630	0.50
7.5	160	1580	0.50
8.0	170	1530	0.49
8.5	190	1640	0.49
9.0	200	1650	0.49
9.5	170	1600	0.49
10.0	150	1630	0.50
10.5	170	1600	0.49
11.0	180	1610	0.49
11.5	180	1590	0.49
12.0	170	1540	0.49
12.5	160	1580	0.49
13.0	190	1630	0.49
13.5	190	1580	0.49
14.0	170	1590	0.49
14.5	160	1580	0.49
15.0	160	1590	0.49
15.5	190	1580	0.49
16.0	210	1630	0.49
16.5	220	1640	0.49
17.0	220	1580	0.49
17.5	230	1580	0.49
18.0	210	1580	0.49
18.5	190	1590	0.49
19.0	220	1610	0.49
19.5	230	1640	0.49
20.0	220	1640	0.49
20.5	220	1630	0.49
21.0	220	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	730	5090	0.49
72.2	760	5050	0.49
73.2	760	5130	0.49
75.5	740	5210	0.49
77.1	740	5170	0.49
78.7	770	5170	0.49
80.4	800	5250	0.49
82.0	840	5250	0.49
83.7	860	5380	0.49
85.3	890	5510	0.49
86.9	940	5750	0.49
88.6	1010	5650	0.48
90.2	1000	5700	0.48
91.9	1090	5700	0.48
93.5	1060	5800	0.48
95.1	1040	5800	0.48
96.8	1060	5850	0.48
98.4	1060	5800	0.48
100.1	1080	5850	0.48
101.7	1060	5850	0.48
103.4	1120	5850	0.48
105.0	1130	5950	0.48
106.6	1250	6060	0.48
108.3	1180	5950	0.48
109.9	1100	5900	0.48
111.6	1120	5950	0.48
113.2	1170	6060	0.48
114.8	1230	6170	0.48
116.5	1210	6060	0.48
118.1	1130	5900	0.48
119.8	1140	5850	0.48
121.4	1160	5900	0.48
123.0	1240	6060	0.48
124.7	1350	6290	0.48
126.3	1360	6410	0.48
128.0	1360	6230	0.47
129.6	1230	6060	0.48
131.2	1220	6120	0.48
132.9	1320	6230	0.48
134.5	1260	6800	0.48
136.2	1350	6940	0.48
137.8	1240	6540	0.48
139.4	1180	6290	0.48
141.1	1170	6290	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	220	1550	0.49
22.0	230	1540	0.49
22.3	230	1560	0.49
23.0	230	1590	0.49
23.5	220	1580	0.49
24.0	230	1580	0.49
24.5	240	1600	0.49
25.0	260	1600	0.49
25.5	260	1640	0.49
26.0	270	1680	0.49
26.5	290	1750	0.49
27.0	310	1720	0.48
27.5	310	1740	0.48
28.0	330	1740	0.48
28.5	320	1770	0.48
29.0	320	1770	0.48
29.5	320	1780	0.48
30.0	320	1770	0.48
30.5	330	1780	0.48
31.0	320	1780	0.48
31.5	340	1780	0.48
32.0	340	1810	0.48
32.5	380	1850	0.48
33.0	360	1810	0.48
33.5	340	1800	0.48
34.0	340	1810	0.48
34.5	360	1850	0.48
35.0	380	1880	0.48
35.5	370	1850	0.48
36.0	350	1800	0.48
36.5	350	1780	0.48
37.0	350	1800	0.48
37.5	380	1850	0.48
38.0	410	1920	0.48
38.5	410	1950	0.48
39.0	410	1900	0.47
39.5	370	1850	0.48
40.0	370	1860	0.48
40.5	400	1900	0.48
41.0	380	2070	0.48
41.5	410	2120	0.48
42.0	380	1990	0.48
42.5	360	1920	0.48
43.0	360	1920	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	6540	0.48
144.4	1370	6470	0.48
146.0	1310	6350	0.48
147.6	1440	6800	0.48
149.3	1720	7170	0.47
150.9	1640	6940	0.47
152.6	1680	6870	0.47
154.2	1650	6470	0.47
155.8	1430	5950	0.47
157.5	1320	5600	0.47
159.1	1320	5510	0.47
160.8	1270	5560	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1990	0.48
44.0	420	1970	0.48
44.5	400	1940	0.48
45.0	440	2070	0.48
45.5	520	2180	0.47
46.0	500	2120	0.47
46.5	510	2090	0.47
47.0	500	1970	0.47
47.5	440	1810	0.47
48.0	400	1710	0.47
48.5	400	1680	0.47
49.0	390	1690	0.47

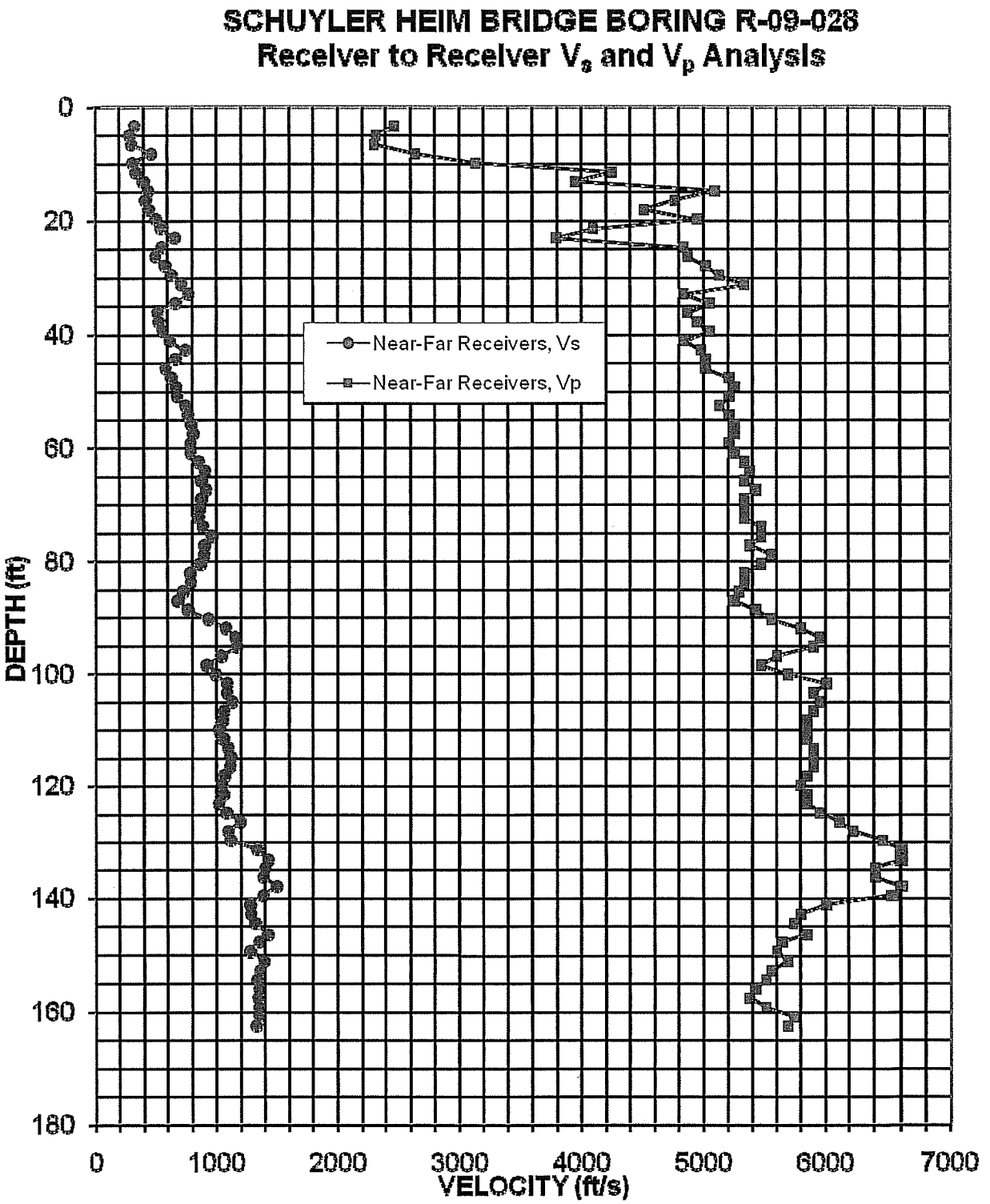

Figure 9: Boring R-09-028, Suspension R1-R2 P- and S_H-wave velocities

Table 8. Boring R-09-028, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.3	330	2470	0.49
4.9	290	2310	0.49
6.6	300	2300	0.49
8.2	460	2640	0.48
9.8	310	3130	0.49
11.5	340	4250	0.50
13.1	400	3940	0.49
14.8	430	5090	0.50
16.4	410	4760	0.50
18.0	440	4500	0.50
19.7	500	4940	0.49
21.3	540	4090	0.49
23.0	660	3790	0.48
24.6	550	4830	0.49
26.3	500	4870	0.49
27.9	580	5010	0.49
29.5	630	5130	0.49
31.2	710	5330	0.49
32.8	770	4830	0.49
34.5	660	5050	0.49
36.1	510	4870	0.49
37.7	520	4940	0.49
39.4	560	5050	0.49
41.0	610	4830	0.49
42.7	740	4980	0.49
44.3	660	5010	0.49
45.9	580	5010	0.49
47.6	630	5210	0.49
49.2	670	5250	0.49
50.9	670	5210	0.49
52.5	740	5130	0.49
54.1	760	5210	0.49
55.8	790	5250	0.49
57.4	810	5250	0.49
59.1	790	5210	0.49
60.7	790	5250	0.49
62.3	850	5330	0.49
64.0	910	5380	0.49
65.6	870	5330	0.49
67.3	910	5420	0.49
68.9	870	5330	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	750	0.49
1.5	90	710	0.49
2.0	90	700	0.49
2.5	140	800	0.48
3.0	100	950	0.49
3.5	100	1290	0.50
4.0	120	1200	0.49
4.5	130	1550	0.50
5.0	130	1450	0.50
5.5	130	1370	0.50
6.0	150	1510	0.49
6.5	170	1250	0.49
7.0	200	1150	0.48
7.5	170	1470	0.49
8.0	150	1480	0.49
8.5	180	1530	0.49
9.0	190	1560	0.49
9.5	220	1630	0.49
10.0	230	1470	0.49
10.5	200	1540	0.49
11.0	160	1480	0.49
11.5	160	1510	0.49
12.0	170	1540	0.49
12.5	190	1470	0.49
13.0	230	1520	0.49
13.5	200	1530	0.49
14.0	180	1530	0.49
14.5	190	1590	0.49
15.0	200	1600	0.49
15.5	200	1590	0.49
16.0	230	1560	0.49
16.5	230	1590	0.49
17.0	240	1600	0.49
17.5	250	1600	0.49
18.0	240	1590	0.49
18.5	240	1600	0.49
19.0	260	1630	0.49
19.5	280	1640	0.49
20.0	270	1630	0.49
20.5	280	1650	0.49
21.0	270	1630	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
70.5	860	5330	0.49
72.2	850	5330	0.49
73.8	890	5460	0.49
75.5	960	5460	0.48
77.1	900	5380	0.49
78.7	890	5560	0.49
80.4	870	5460	0.49
82.0	780	5330	0.49
83.7	790	5330	0.49
85.3	720	5290	0.49
86.9	680	5250	0.49
88.6	760	5420	0.49
90.2	930	5560	0.49
91.9	1080	5800	0.48
93.5	1150	5950	0.48
95.1	1160	5900	0.48
96.8	1040	5600	0.48
98.4	920	5460	0.49
100.1	990	5700	0.48
101.7	1080	6010	0.48
103.4	1080	5900	0.48
105.0	1120	5950	0.48
106.6	1050	5900	0.48
108.3	1050	5850	0.48
109.9	1020	5850	0.48
111.6	1050	5850	0.48
113.2	1090	5900	0.48
114.8	1110	5900	0.48
116.5	1110	5900	0.48
118.1	1060	5850	0.48
119.8	1040	5800	0.48
121.4	1050	5850	0.48
123.0	1010	5850	0.48
124.7	1080	5950	0.48
126.3	1190	6120	0.48
128.0	1090	6230	0.48
129.6	1110	6470	0.48
131.2	1330	6600	0.48
133.2	1420	6600	0.48
134.5	1390	6410	0.48
136.2	1380	6410	0.48
137.8	1490	6600	0.47
139.4	1380	6540	0.48
141.1	1270	6010	0.48

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.5	260	1630	0.49
22.0	260	1630	0.49
22.5	270	1670	0.49
23.0	290	1670	0.48
23.5	270	1640	0.49
24.0	270	1690	0.49
24.5	260	1670	0.49
25.0	240	1630	0.49
25.5	240	1630	0.49
26.0	220	1610	0.49
26.5	210	1600	0.49
27.0	230	1650	0.49
27.5	280	1690	0.49
28.0	330	1770	0.48
28.5	350	1810	0.48
29.0	350	1800	0.48
29.5	320	1710	0.48
30.0	280	1670	0.49
30.5	300	1740	0.48
31.0	330	1830	0.48
31.5	330	1800	0.48
32.0	340	1810	0.48
32.5	320	1800	0.48
33.0	320	1780	0.48
33.5	310	1780	0.48
34.0	320	1780	0.48
34.5	330	1800	0.48
35.0	340	1800	0.48
35.5	340	1800	0.48
36.0	320	1780	0.48
36.5	320	1770	0.48
37.0	320	1780	0.48
37.5	310	1780	0.48
38.0	330	1810	0.48
38.5	360	1860	0.48
39.0	330	1900	0.48
39.5	340	1970	0.48
40.0	410	2010	0.48
40.6	430	2010	0.48
41.0	430	1950	0.48
41.5	420	1950	0.48
42.0	460	2010	0.47
42.5	420	1990	0.48
43.0	390	1830	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
142.7	1280	5800	0.47
144.4	1320	5750	0.47
146.3	1420	5850	0.47
147.6	1340	5650	0.47
149.3	1270	5600	0.47
150.9	1390	5700	0.47
152.6	1360	5560	0.47
154.2	1330	5510	0.47
155.8	1340	5420	0.47
157.5	1340	5380	0.47
159.1	1350	5510	0.47
160.8	1340	5750	0.47
162.4	1320	5700	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
43.5	390	1770	0.47
44.0	400	1750	0.47
44.6	430	1780	0.47
45.0	410	1720	0.47
45.5	390	1710	0.47
46.0	420	1740	0.47
46.5	410	1690	0.47
47.0	410	1680	0.47
47.5	410	1650	0.47
48.0	410	1640	0.47
48.5	410	1680	0.47
49.0	410	1750	0.47
49.5	400	1740	0.47

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

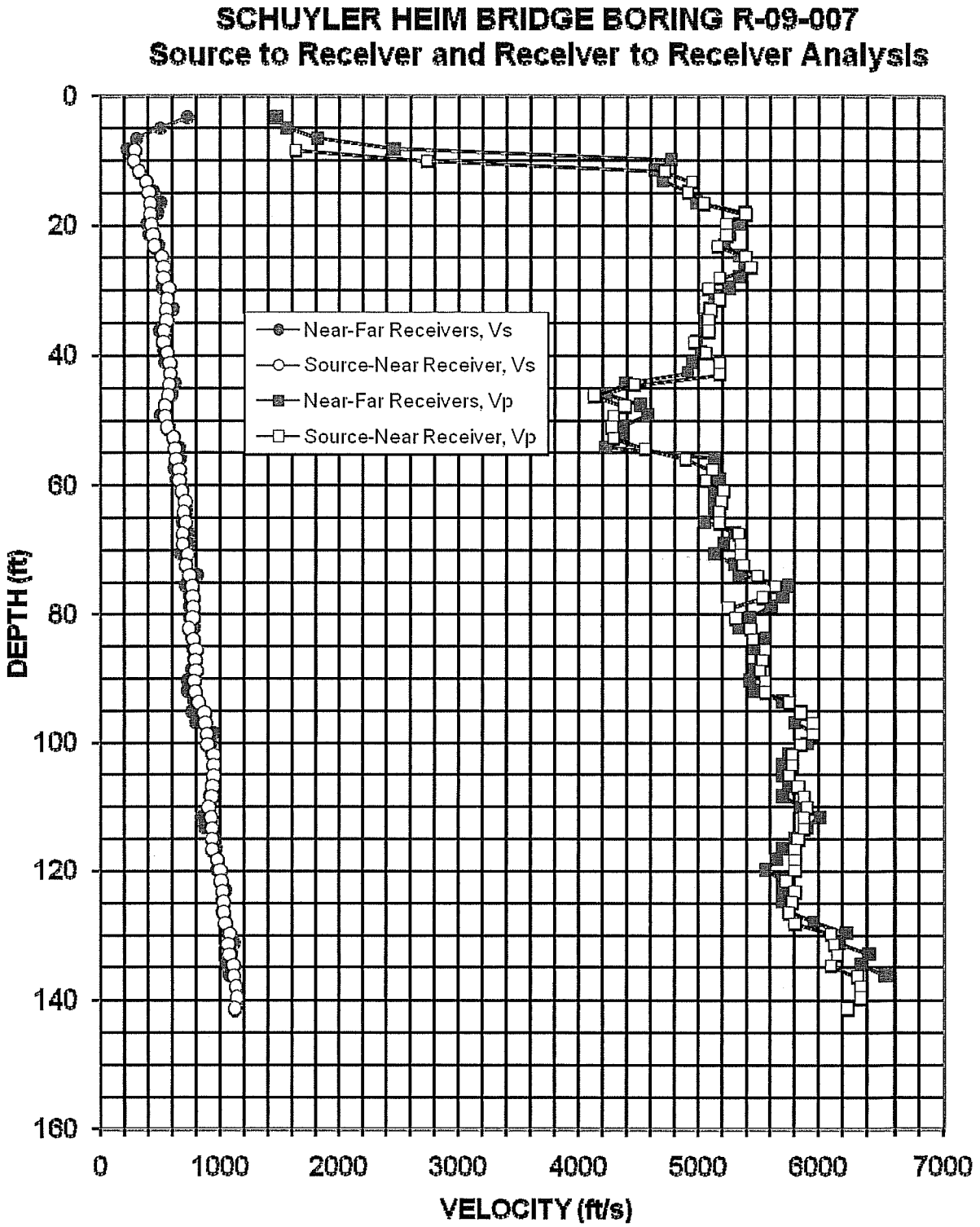

Figure A-1. Boring R-09-007, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring R-09-007, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.5	290	1630	0.48
10.1	280	2720	0.49
11.8	330	4710	0.50
13.4	390	4940	0.50
15.1	410	4900	0.50
16.7	420	5040	0.50
18.3	420	5390	0.50
20.0	430	5230	0.50
21.6	440	5230	0.50
23.3	460	5150	0.50
24.9	520	5390	0.50
26.6	530	5430	0.50
28.2	530	5170	0.49
29.8	570	5080	0.49
31.5	560	5170	0.49
33.1	550	5100	0.49
34.8	560	5080	0.49
36.4	530	5080	0.49
38.0	530	4950	0.49
39.7	560	5060	0.49
41.3	580	5170	0.49
43.0	590	5170	0.49
44.6	580	4460	0.49
46.2	570	4120	0.49
47.9	540	4380	0.49
49.5	540	4280	0.49
51.2	560	4270	0.49
52.8	610	4280	0.49
54.4	620	4540	0.49
56.1	630	4890	0.49
57.7	660	5120	0.49
59.4	660	5060	0.49
61.0	680	5210	0.49
62.6	710	5190	0.49
64.3	700	5170	0.49
65.9	720	5170	0.49
67.6	690	5330	0.49
69.2	690	5350	0.49
70.8	730	5350	0.49
72.5	720	5370	0.49
74.1	750	5490	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	90	500	0.48
3.1	90	830	0.49
3.6	100	1440	0.50
4.1	120	1500	0.50
4.6	120	1490	0.50
5.1	130	1540	0.50
5.6	130	1640	0.50
6.1	130	1590	0.50
6.6	140	1590	0.50
7.1	140	1570	0.50
7.6	160	1640	0.50
8.1	160	1650	0.50
8.6	160	1580	0.49
9.1	170	1550	0.49
9.6	170	1580	0.49
10.1	170	1550	0.49
10.6	170	1550	0.49
11.1	160	1550	0.49
11.6	160	1510	0.49
12.1	170	1540	0.49
12.6	180	1580	0.49
13.1	180	1580	0.49
13.6	180	1360	0.49
14.1	170	1260	0.49
14.6	170	1330	0.49
15.1	160	1310	0.49
15.6	170	1300	0.49
16.1	190	1310	0.49
16.6	190	1380	0.49
17.1	190	1490	0.49
17.6	200	1560	0.49
18.1	200	1540	0.49
18.6	210	1590	0.49
19.1	220	1580	0.49
19.6	210	1580	0.49
20.1	220	1580	0.49
20.6	210	1620	0.49
21.1	210	1630	0.49
21.6	220	1630	0.49
22.1	220	1640	0.49
22.6	230	1670	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-007

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.8	770	5640	0.49
77.4	770	5530	0.49
79.0	780	5250	0.49
80.7	770	5310	0.49
82.3	740	5430	0.49
84.0	780	5450	0.49
85.6	800	5550	0.49
87.2	790	5530	0.49
88.9	800	5510	0.49
90.5	790	5550	0.49
92.2	790	5550	0.49
93.8	820	5760	0.49
95.4	870	5850	0.49
97.1	880	5950	0.49
98.7	890	5950	0.49
100.4	890	5850	0.49
102.0	950	5780	0.49
103.7	950	5780	0.49
105.3	950	5760	0.49
106.9	940	5830	0.49
108.6	930	5880	0.49
110.2	900	5900	0.49
111.9	920	5880	0.49
113.5	930	5880	0.49
115.1	940	5830	0.49
116.8	930	5800	0.49
118.4	980	5800	0.49
120.1	1000	5800	0.48
121.7	1010	5730	0.48
123.3	1020	5800	0.48
125.0	1030	5780	0.48
126.6	1030	5760	0.48
128.3	1040	5800	0.48
129.9	1080	6100	0.48
131.5	1070	6130	0.48
133.2	1080	6160	0.48
134.8	1110	6100	0.48
136.5	1120	6320	0.48
138.1	1140	6350	0.48
139.7	1140	6350	0.48
141.4	1130	6240	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.1	230	1720	0.49
23.6	240	1690	0.49
24.1	240	1600	0.49
24.6	240	1620	0.49
25.1	230	1650	0.49
25.6	240	1660	0.49
26.1	240	1690	0.49
26.6	240	1690	0.49
27.1	240	1680	0.49
27.6	240	1690	0.49
28.1	240	1690	0.49
28.6	250	1750	0.49
29.1	260	1780	0.49
29.6	270	1810	0.49
30.1	270	1810	0.49
30.6	270	1780	0.49
31.1	290	1760	0.49
31.6	290	1760	0.49
32.1	290	1750	0.49
32.6	290	1780	0.49
33.1	280	1790	0.49
33.6	280	1800	0.49
34.1	280	1790	0.49
34.6	280	1790	0.49
35.1	290	1780	0.49
35.6	280	1770	0.49
36.1	300	1770	0.49
36.6	300	1770	0.48
37.1	310	1750	0.48
37.6	310	1770	0.48
38.1	310	1760	0.48
38.6	310	1750	0.48
39.1	320	1770	0.48
39.6	330	1860	0.48
40.1	330	1870	0.48
40.6	330	1880	0.48
41.1	340	1860	0.48
41.6	340	1930	0.48
42.1	350	1930	0.48
42.6	350	1930	0.48
43.1	340	1900	0.48

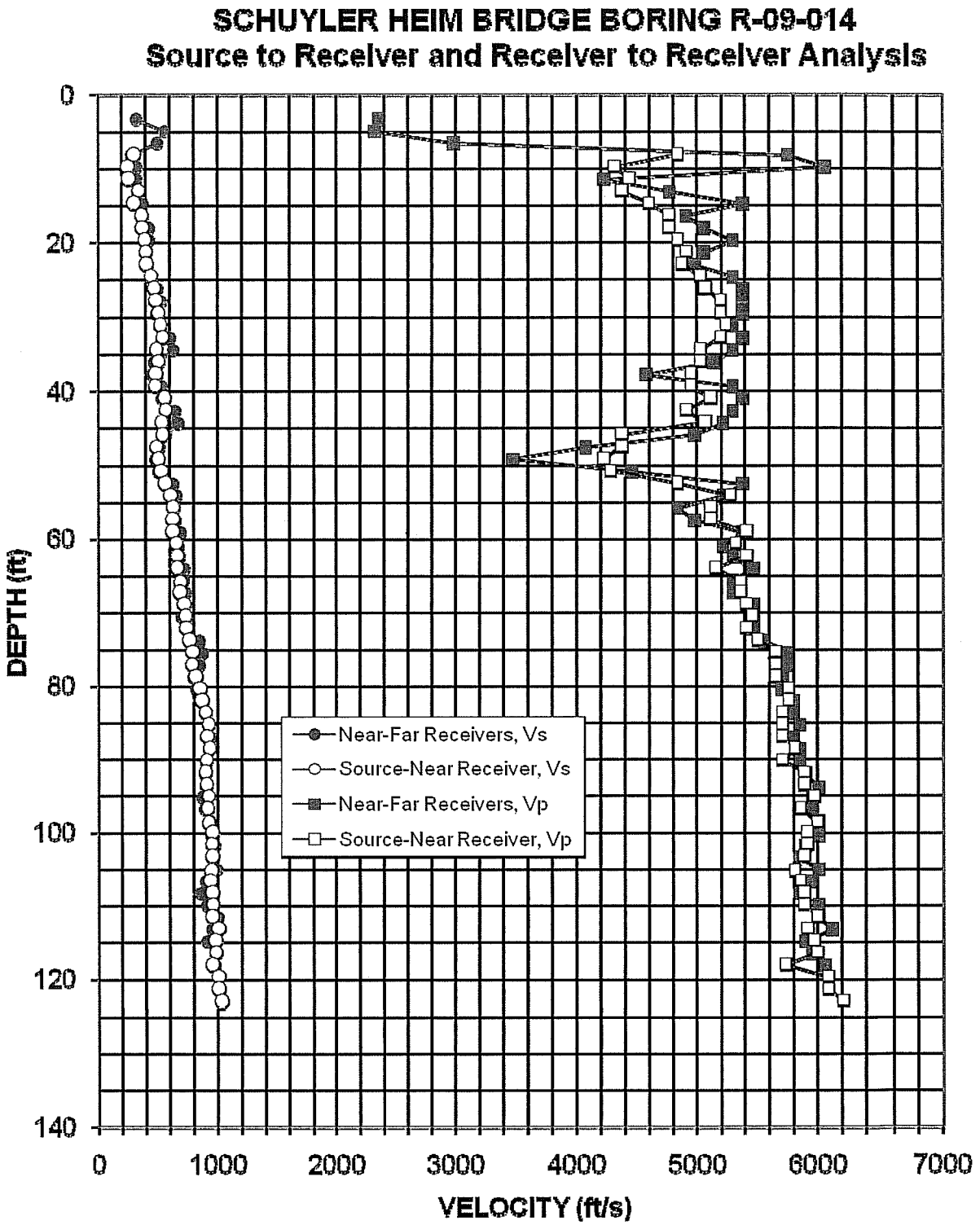

Figure A-2. Boring R-09-014, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring R-09-014, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	300	4830	0.50
9.8	250	4310	0.50
11.4	260	4430	0.50
13.0	340	4370	0.50
14.7	300	4590	0.50
16.3	370	4760	0.50
18.0	370	4760	0.50
19.6	400	4830	0.50
21.2	400	4910	0.50
22.9	410	4870	0.50
24.5	450	5020	0.50
26.2	470	5060	0.50
27.8	490	5190	0.50
29.4	510	5190	0.50
31.1	520	5230	0.49
32.7	540	5190	0.49
34.4	490	5020	0.50
36.0	510	5020	0.49
37.6	490	4950	0.50
39.3	480	4950	0.50
40.9	560	5100	0.49
42.6	570	4910	0.49
44.2	530	5060	0.49
45.8	540	4370	0.49
47.5	490	4370	0.49
49.1	510	4220	0.49
50.8	530	4280	0.49
52.4	560	4830	0.49
54.0	610	5280	0.49
55.7	630	5100	0.49
57.3	630	5100	0.49
59.0	620	5410	0.49
60.6	660	5320	0.49
62.2	660	5410	0.49
63.9	670	5150	0.49
65.9	690	5360	0.49
67.2	690	5360	0.49
68.8	720	5410	0.49
70.5	740	5460	0.49
72.1	740	5410	0.49
73.7	760	5500	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	90	1470	0.50
3.0	80	1310	0.50
3.5	80	1350	0.50
4.0	100	1330	0.50
4.5	90	1400	0.50
5.0	110	1450	0.50
5.5	110	1450	0.50
6.0	120	1470	0.50
6.5	120	1500	0.50
7.0	120	1480	0.50
7.5	140	1530	0.50
8.0	140	1540	0.50
8.5	150	1580	0.50
9.0	150	1580	0.50
9.5	160	1590	0.49
10.0	160	1580	0.49
10.5	150	1530	0.50
11.0	150	1530	0.49
11.5	150	1510	0.50
12.0	150	1510	0.50
12.5	170	1560	0.49
13.0	170	1500	0.49
13.5	160	1540	0.49
14.0	160	1330	0.49
14.5	150	1330	0.49
15.0	150	1290	0.49
15.5	160	1300	0.49
16.0	170	1470	0.49
16.5	190	1610	0.49
17.0	190	1560	0.49
17.5	190	1560	0.49
18.0	190	1650	0.49
18.5	200	1620	0.49
19.0	200	1650	0.49
19.5	200	1570	0.49
20.1	210	1640	0.49
20.5	210	1640	0.49
21.0	220	1650	0.49
21.5	220	1660	0.49
22.0	230	1650	0.49
22.5	230	1680	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-014

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	790	5650	0.49
77.0	790	5650	0.49
78.7	820	5650	0.49
80.3	850	5750	0.49
81.9	870	5750	0.49
83.6	900	5700	0.49
85.2	920	5700	0.49
86.9	910	5700	0.49
88.5	940	5810	0.49
90.1	910	5700	0.49
91.8	900	5890	0.49
93.4	910	5890	0.49
95.1	920	5970	0.49
96.7	920	5860	0.49
98.7	930	6000	0.49
100.0	960	5920	0.49
101.6	950	5920	0.49
103.3	960	5890	0.49
105.2	950	5810	0.49
106.5	940	5860	0.49
108.2	950	5890	0.49
109.8	960	5890	0.49
111.5	960	6000	0.49
113.1	1010	5920	0.49
114.7	980	5970	0.49
116.4	980	6000	0.49
118.0	960	5730	0.49
119.7	1010	6090	0.49
121.3	1010	6090	0.49
122.9	1030	6210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1720	0.49
23.5	240	1720	0.49
24.0	250	1720	0.49
24.5	260	1750	0.49
25.0	260	1750	0.49
25.5	270	1740	0.49
26.0	280	1740	0.49
26.5	280	1740	0.49
27.0	280	1770	0.49
27.5	280	1740	0.49
28.0	270	1790	0.49
28.5	280	1790	0.49
29.0	280	1820	0.49
29.5	280	1790	0.49
30.1	280	1830	0.49
30.5	290	1800	0.49
31.0	290	1800	0.49
31.5	290	1790	0.49
32.1	290	1770	0.49
32.5	290	1790	0.49
33.0	290	1790	0.49
33.5	290	1790	0.49
34.0	290	1830	0.49
34.5	310	1800	0.49
35.0	300	1820	0.49
35.5	300	1830	0.49
36.0	290	1750	0.49
36.5	310	1860	0.49
37.0	310	1860	0.49
37.5	310	1890	0.49

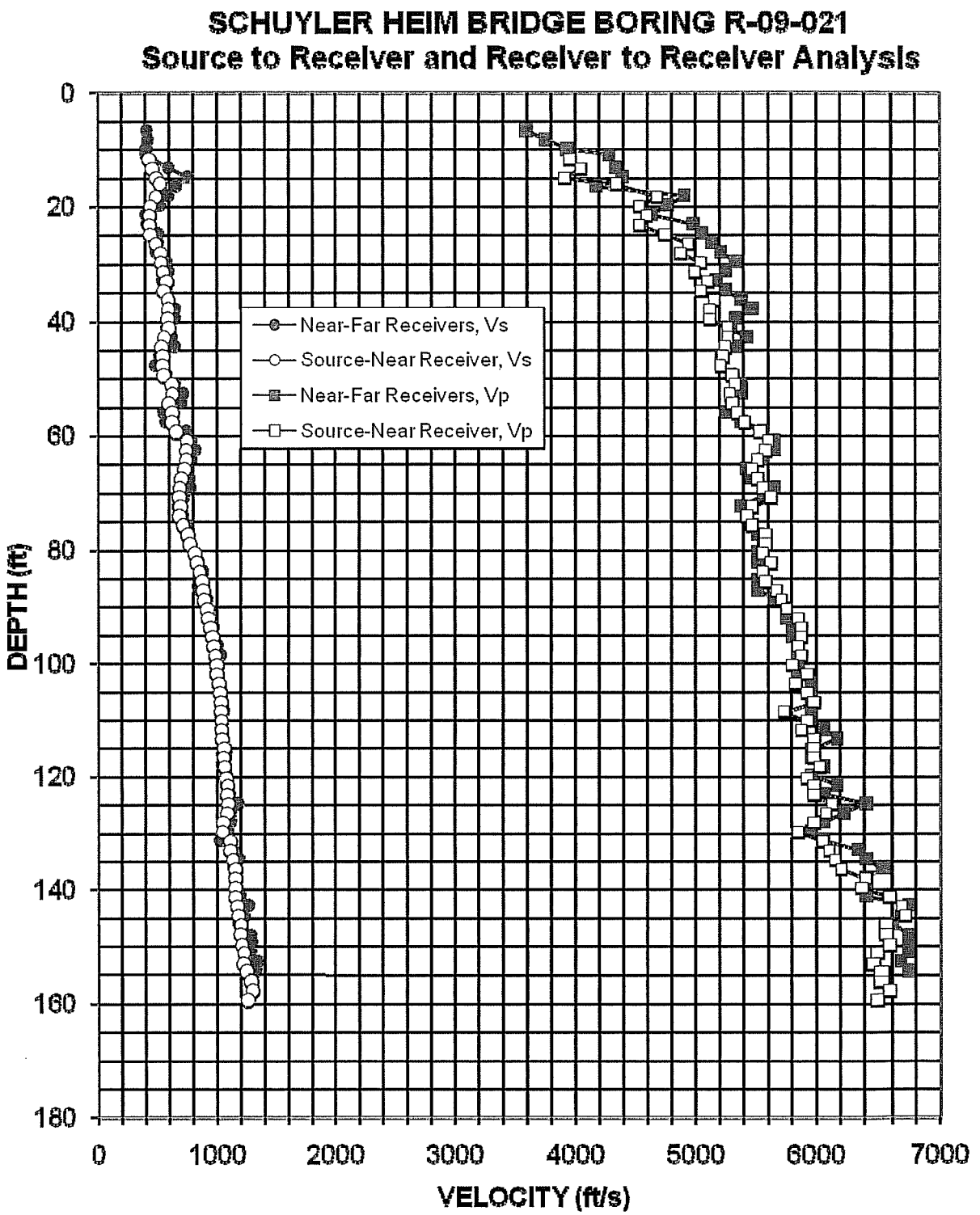

Figure A-3. Boring R-09-021, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-3. Boring R-09-021, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
11.8	430	3950	0.49
13.4	460	4040	0.49
15.1	490	3910	0.49
16.1	530	4340	0.49
18.3	490	4680	0.49
20.0	450	4530	0.50
21.6	440	4590	0.50
23.3	440	4530	0.50
24.9	440	4740	0.50
26.6	490	4940	0.50
28.2	530	4870	0.49
29.8	530	5040	0.49
31.5	550	4990	0.49
33.1	580	5100	0.49
34.8	560	5040	0.49
36.4	590	5150	0.49
38.0	590	5120	0.49
39.7	590	5120	0.49
41.3	600	5270	0.49
43.0	560	5270	0.49
44.6	540	5250	0.49
46.2	540	5230	0.49
47.9	540	5210	0.49
49.5	560	5310	0.49
51.2	630	5330	0.49
52.8	630	5290	0.49
54.4	600	5310	0.49
56.1	630	5350	0.49
57.7	630	5410	0.49
59.4	660	5530	0.49
61.0	750	5600	0.49
62.6	740	5580	0.49
64.3	740	5510	0.49
65.9	730	5470	0.49
67.6	700	5510	0.49
69.2	690	5550	0.49
70.8	690	5620	0.49
72.5	690	5470	0.49
74.1	690	5430	0.49
75.8	710	5470	0.49
77.4	760	5580	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
3.6	130	1200	0.49
4.1	140	1230	0.49
4.6	150	1190	0.49
4.9	160	1320	0.49
5.6	150	1430	0.49
6.1	140	1380	0.50
6.6	130	1400	0.50
7.1	130	1380	0.50
7.6	130	1440	0.50
8.1	150	1500	0.50
8.6	160	1480	0.49
9.1	160	1540	0.49
9.6	170	1520	0.49
10.1	180	1550	0.49
10.6	170	1540	0.49
11.1	180	1570	0.49
11.6	180	1560	0.49
12.1	180	1560	0.49
12.6	180	1610	0.49
13.1	170	1610	0.49
13.6	160	1600	0.49
14.1	170	1590	0.49
14.6	170	1590	0.49
15.1	170	1620	0.49
15.6	190	1620	0.49
16.1	190	1610	0.49
16.6	180	1620	0.49
17.1	190	1630	0.49
17.6	190	1650	0.49
18.1	200	1690	0.49
18.6	230	1710	0.49
19.1	230	1700	0.49
19.6	230	1680	0.49
20.1	220	1670	0.49
20.6	210	1680	0.49
21.1	210	1690	0.49
21.6	210	1710	0.49
22.1	210	1670	0.49
22.6	210	1650	0.49
23.1	220	1670	0.49
23.6	230	1700	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
79.0	770	5580	0.49
80.7	820	5550	0.49
82.3	830	5620	0.49
84.0	850	5550	0.49
85.6	880	5580	0.49
87.2	880	5670	0.49
88.9	890	5710	0.49
90.5	920	5760	0.49
92.2	930	5850	0.49
93.8	950	5880	0.49
95.4	960	5880	0.49
97.1	970	5850	0.49
98.7	980	5880	0.49
100.4	1000	5800	0.48
102.0	1000	5930	0.49
103.7	1020	5830	0.48
105.3	1020	5930	0.48
106.9	1030	5970	0.48
108.6	1030	5730	0.48
110.2	1040	5930	0.48
111.9	1040	5880	0.48
113.5	1040	5970	0.48
115.1	1060	5970	0.48
116.8	1060	5970	0.48
118.4	1060	6030	0.48
120.4	1080	5930	0.48
121.7	1090	5970	0.48
123.3	1090	5970	0.48
125.0	1100	6130	0.48
126.6	1090	6080	0.48
128.3	1050	5970	0.48
129.9	1050	5850	0.48
131.5	1110	6050	0.48
133.2	1110	6100	0.48
134.8	1140	6160	0.48
136.5	1150	6210	0.48
138.1	1160	6410	0.48
139.7	1160	6380	0.48
141.4	1160	6580	0.48
143.0	1170	6680	0.48
144.7	1180	6710	0.48
146.3	1210	6550	0.48
147.9	1200	6550	0.48
149.9	1210	6580	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
24.1	240	1700	0.49
24.6	250	1690	0.49
25.1	250	1710	0.49
25.6	260	1690	0.49
26.1	270	1700	0.49
26.6	270	1730	0.49
27.1	270	1740	0.49
27.6	280	1750	0.49
28.1	280	1780	0.49
28.6	290	1790	0.49
29.1	290	1790	0.49
29.6	300	1780	0.49
30.1	300	1790	0.49
30.6	300	1770	0.48
31.1	310	1810	0.49
31.6	310	1780	0.48
32.1	310	1810	0.48
32.6	310	1820	0.48
33.1	310	1750	0.48
33.6	320	1810	0.48
34.1	320	1790	0.48
34.6	320	1820	0.48
35.1	320	1820	0.48
35.6	320	1820	0.48
36.1	320	1840	0.48
36.7	330	1810	0.48
37.1	330	1820	0.48
37.6	330	1820	0.48
38.1	330	1870	0.48
38.6	330	1850	0.48
39.1	320	1820	0.48
39.6	320	1780	0.48
40.1	340	1840	0.48
40.6	340	1860	0.48
41.1	350	1880	0.48
41.6	350	1890	0.48
42.1	350	1950	0.48
42.6	350	1940	0.48
43.1	350	2010	0.48
43.6	360	2030	0.48
44.1	360	2040	0.48
44.6	370	2000	0.48
45.1	370	2000	0.48
45.7	370	2010	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-021

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
151.2	1230	6490	0.48
153.2	1230	6460	0.48
154.5	1250	6520	0.48
156.1	1290	6520	0.48
157.8	1300	6580	0.48
159.4	1260	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
46.1	370	1980	0.48
46.7	370	1970	0.48
47.1	380	1990	0.48
47.6	390	1990	0.48
48.1	400	2010	0.48
48.6	380	1980	0.48

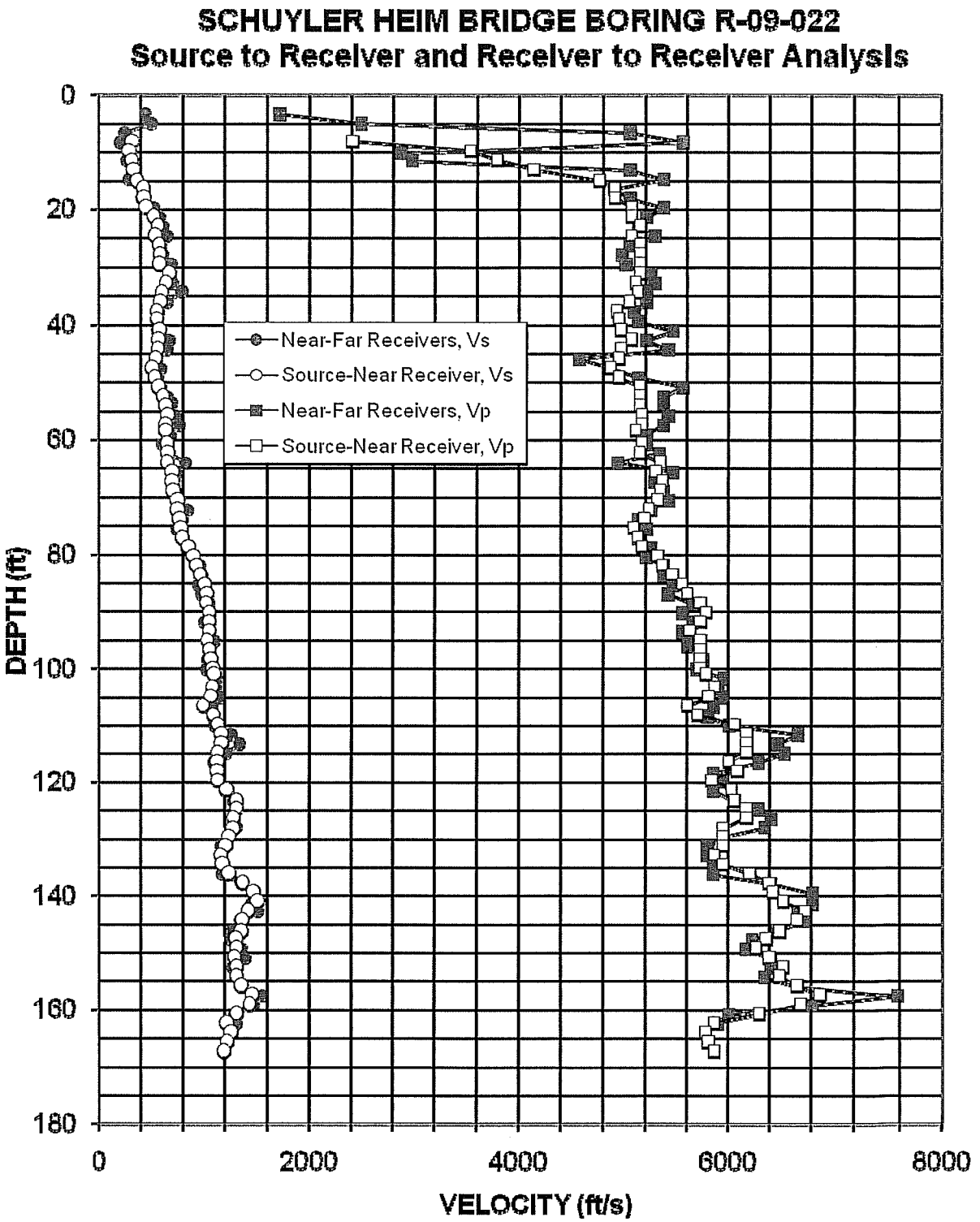

Figure A-4. Boring R-09-022, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-4. Boring R-09-022, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	320	2410	0.49
9.8	290	3540	0.50
11.4	310	3790	0.50
13.0	330	4140	0.50
15.0	360	4760	0.50
16.3	420	4910	0.50
18.0	430	4910	0.50
19.6	450	5060	0.50
21.2	520	5060	0.49
22.9	560	5150	0.49
24.5	540	5060	0.49
26.2	570	5150	0.49
27.8	580	5150	0.49
29.4	580	5150	0.49
31.1	670	5150	0.49
32.7	640	5100	0.49
34.4	600	5130	0.49
36.0	590	5040	0.49
37.6	550	4930	0.49
39.0	550	4950	0.49
40.9	570	4960	0.49
42.6	560	5060	0.49
44.2	560	4960	0.49
45.8	540	4950	0.49
47.5	510	4870	0.49
49.1	530	4950	0.49
50.8	560	5150	0.49
52.4	610	5150	0.49
54.0	640	5150	0.49
55.7	650	5170	0.49
57.3	640	5170	0.49
58.3	630	5100	0.49
60.6	650	5170	0.49
62.2	650	5150	0.49
63.9	650	5340	0.49
65.5	690	5300	0.49
67.2	690	5360	0.49
68.8	700	5340	0.49
70.5	750	5320	0.49
72.1	740	5230	0.49
73.7	760	5190	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	730	0.49
3.0	90	1080	0.50
3.5	90	1160	0.50
4.0	100	1260	0.50
4.6	110	1450	0.50
5.0	130	1500	0.50
5.5	130	1500	0.50
6.0	140	1540	0.50
6.5	160	1540	0.49
7.0	170	1570	0.49
7.5	160	1540	0.49
8.0	170	1570	0.49
8.5	180	1570	0.49
9.0	180	1570	0.49
9.5	200	1570	0.49
10.0	200	1560	0.49
10.5	180	1560	0.49
11.0	180	1540	0.49
11.5	170	1500	0.49
11.9	170	1510	0.49
12.5	170	1510	0.49
13.0	170	1540	0.49
13.5	170	1510	0.49
14.0	170	1510	0.49
14.5	150	1480	0.49
15.0	160	1510	0.49
15.5	170	1570	0.49
16.0	190	1570	0.49
16.5	190	1570	0.49
17.0	200	1580	0.49
17.5	190	1580	0.49
17.8	190	1560	0.49
18.5	200	1580	0.49
19.0	200	1570	0.49
19.5	200	1630	0.49
20.0	210	1610	0.49
20.5	210	1640	0.49
21.0	210	1630	0.49
21.5	230	1620	0.49
22.0	230	1590	0.49
22.5	230	1580	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5080	0.49
77.0	790	5130	0.49
78.7	850	5170	0.49
80.3	890	5320	0.49
81.9	920	5360	0.48
83.6	960	5460	0.48
85.2	1000	5550	0.48
86.9	1020	5600	0.48
88.5	1020	5730	0.48
90.1	1050	5780	0.48
91.8	1050	5730	0.48
93.4	1050	5630	0.48
95.1	1030	5730	0.48
96.7	1050	5730	0.48
98.3	1060	5730	0.48
100.0	1080	5730	0.48
101.0	1090	5780	0.48
103.3	1080	5860	0.48
104.9	1060	5810	0.48
106.5	990	5600	0.48
108.2	1090	5700	0.48
109.8	1130	6060	0.48
111.5	1160	6180	0.48
113.1	1160	6180	0.48
114.7	1130	6180	0.48
116.4	1120	6000	0.48
118.0	1120	6090	0.48
119.7	1130	5830	0.48
121.3	1210	6030	0.48
123.3	1310	6060	0.48
124.6	1310	6180	0.48
126.2	1280	6180	0.48
128.2	1270	5940	0.48
129.5	1230	5940	0.48
131.1	1200	5940	0.48
132.8	1160	5860	0.48
134.4	1170	5940	0.48
136.1	1230	6210	0.48
137.7	1370	6390	0.48
139.3	1470	6430	0.47
141.0	1510	6530	0.47
142.6	1420	6730	0.48
144.3	1360	6660	0.48
146.2	1350	6490	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	240	1550	0.49
23.5	240	1560	0.49
24.0	260	1580	0.49
24.5	270	1620	0.49
25.0	280	1640	0.48
25.5	290	1660	0.48
26.0	310	1690	0.48
26.5	310	1710	0.48
27.0	310	1750	0.48
27.5	320	1760	0.48
28.0	320	1750	0.48
28.5	320	1720	0.48
29.0	310	1750	0.48
29.5	320	1750	0.48
30.0	320	1750	0.48
30.5	330	1750	0.48
30.8	330	1760	0.48
31.5	330	1790	0.48
32.0	320	1770	0.48
32.5	300	1710	0.48
33.0	330	1740	0.48
33.5	340	1850	0.48
34.0	350	1880	0.48
34.5	350	1880	0.48
35.0	340	1880	0.48
35.5	340	1830	0.48
36.0	340	1860	0.48
36.5	340	1780	0.48
37.0	370	1840	0.48
37.6	400	1850	0.48
38.0	400	1880	0.48
38.5	390	1880	0.48
39.1	390	1810	0.48
39.5	380	1810	0.48
40.0	370	1810	0.48
40.5	350	1790	0.48
41.0	360	1810	0.48
41.5	380	1890	0.48
42.0	420	1950	0.48
42.5	450	1960	0.47
43.0	460	1990	0.47
43.5	430	2050	0.48
44.0	410	2030	0.48
44.6	410	1980	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-022

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1300	6360	0.48
149.2	1310	6270	0.48
150.8	1280	6390	0.48
152.5	1310	6530	0.48
154.1	1310	6490	0.48
155.8	1350	6660	0.48
157.4	1460	6880	0.48
159.0	1440	6700	0.48
160.7	1310	6300	0.48
162.3	1210	5860	0.48
164.0	1250	5780	0.48
165.6	1210	5810	0.48
167.2	1190	5860	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	400	1940	0.48
45.5	400	1910	0.48
46.0	390	1950	0.48
46.5	400	1990	0.48
47.0	400	1980	0.48
47.5	410	2030	0.48
48.0	450	2100	0.48
48.5	440	2040	0.48
49.0	400	1920	0.48
49.5	370	1790	0.48
50.0	380	1760	0.48
50.5	370	1770	0.48
51.0	360	1790	0.48

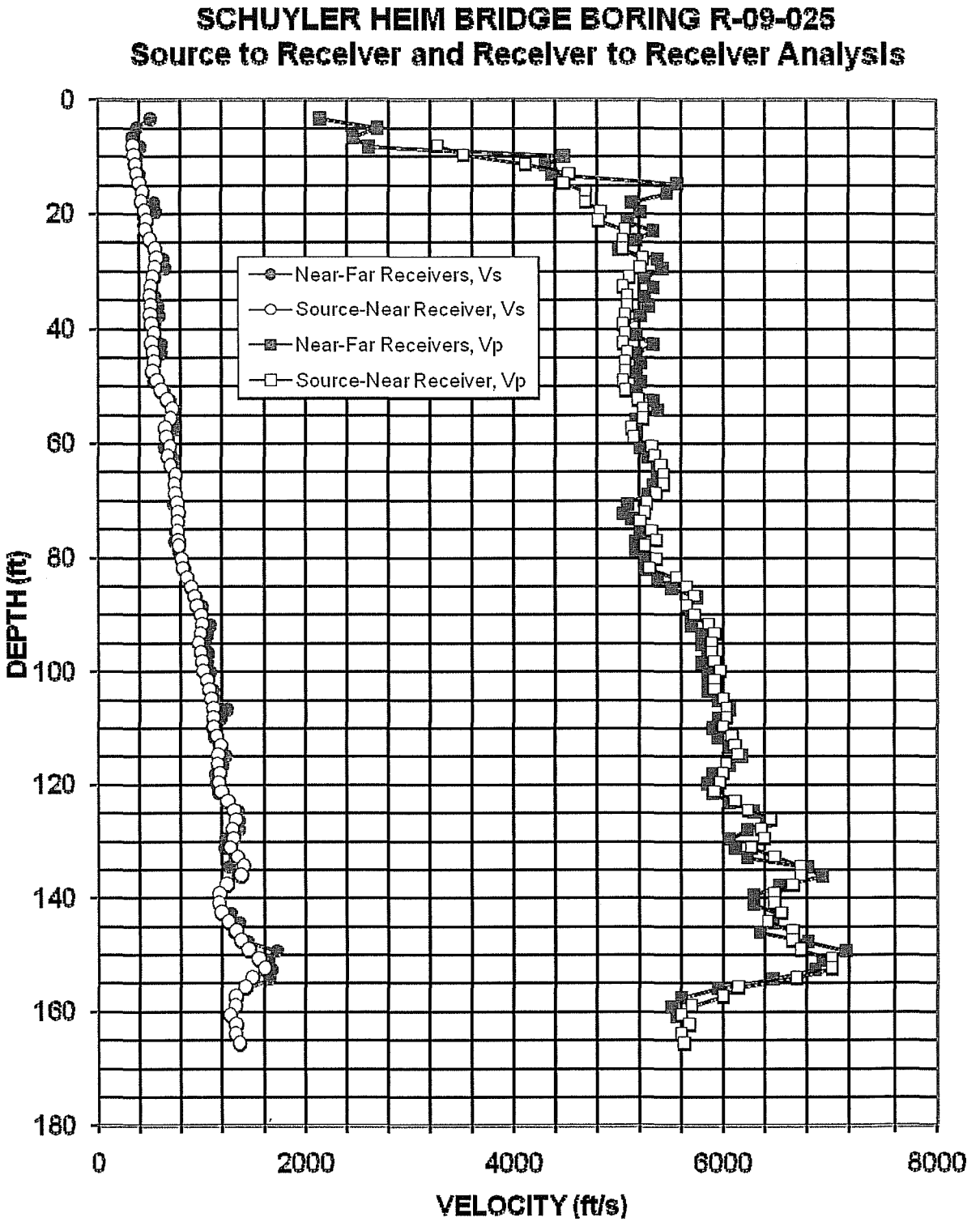

Figure A-5. Boring R-09-025, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-5. Boring R-09-025, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	340	3260	0.49
9.8	340	3520	0.50
11.4	360	4110	0.50
13.0	370	4520	0.50
14.7	400	4470	0.50
16.3	430	4690	0.50
18.0	420	4690	0.50
19.6	450	4830	0.50
21.2	470	4810	0.50
22.9	460	5060	0.50
24.5	500	5040	0.50
26.2	550	5040	0.49
27.8	570	5230	0.49
29.4	550	5210	0.49
31.1	530	5100	0.49
32.7	510	5040	0.49
34.4	500	5080	0.50
36.0	510	5080	0.49
37.6	510	5060	0.49
39.3	510	5040	0.49
40.9	540	5060	0.49
42.6	510	5040	0.49
44.2	530	5080	0.49
45.8	540	5060	0.49
47.5	530	5060	0.49
49.1	570	5040	0.49
50.8	600	5060	0.49
52.4	660	5190	0.49
54.0	710	5230	0.49
55.7	700	5230	0.49
57.3	640	5130	0.49
59.0	660	5150	0.49
60.6	690	5320	0.49
62.2	670	5340	0.49
63.9	700	5410	0.49
65.5	750	5430	0.49
67.2	740	5430	0.49
68.8	750	5360	0.49
70.5	760	5280	0.49
72.1	780	5250	0.49
73.7	770	5210	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	100	990	0.49
3.0	110	1070	0.50
3.5	110	1250	0.50
4.0	110	1380	0.50
4.5	120	1360	0.50
5.0	130	1430	0.50
5.5	130	1430	0.50
6.0	140	1470	0.50
6.5	140	1470	0.50
7.0	140	1540	0.50
7.5	150	1540	0.50
8.0	170	1540	0.49
8.5	170	1590	0.49
9.0	170	1590	0.49
9.5	160	1560	0.49
10.0	160	1540	0.49
10.5	150	1550	0.50
11.0	150	1550	0.49
11.5	150	1540	0.49
12.0	160	1540	0.49
12.5	160	1540	0.49
13.0	160	1540	0.49
13.5	160	1550	0.49
14.0	160	1540	0.49
14.5	160	1540	0.49
15.0	170	1540	0.49
15.5	180	1540	0.49
16.0	200	1580	0.49
16.5	220	1590	0.49
17.0	210	1590	0.49
17.5	200	1560	0.49
18.0	200	1570	0.49
18.5	210	1620	0.49
19.0	200	1630	0.49
19.5	210	1650	0.49
20.0	230	1660	0.49
20.5	230	1660	0.49
21.0	230	1640	0.49
21.5	230	1610	0.49
22.0	240	1600	0.49
22.5	230	1590	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	770	5320	0.49
77.0	770	5360	0.49
78.0	780	5250	0.49
80.3	810	5360	0.49
81.9	820	5300	0.49
83.6	860	5550	0.49
85.2	900	5650	0.49
86.9	930	5730	0.49
88.5	950	5650	0.49
90.1	990	5730	0.48
91.8	1000	5860	0.48
93.4	990	5920	0.49
95.1	970	5890	0.49
96.7	990	5890	0.49
98.3	1000	5920	0.49
100.0	1010	5970	0.49
101.6	1050	5920	0.48
103.3	1070	5920	0.48
104.9	1090	6000	0.48
106.5	1110	6030	0.48
108.2	1110	6030	0.48
109.8	1120	6000	0.48
111.5	1150	6090	0.48
113.1	1190	6120	0.48
114.7	1160	6150	0.48
116.4	1160	6030	0.48
118.0	1180	6000	0.48
119.7	1170	5970	0.48
121.3	1190	5920	0.48
122.9	1250	6120	0.48
124.6	1310	6240	0.48
126.2	1330	6460	0.48
127.9	1300	6360	0.48
129.5	1310	6390	0.48
131.1	1280	6270	0.48
132.8	1350	6490	0.48
134.4	1410	6730	0.48
136.1	1380	6730	0.48
137.7	1240	6660	0.48
139.3	1170	6490	0.48
141.0	1170	6490	0.48
142.6	1190	6560	0.48
144.3	1260	6430	0.48
145.9	1330	6660	0.48

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	230	1620	0.49
23.5	240	1640	0.49
23.8	240	1600	0.49
24.5	250	1640	0.49
25.0	250	1610	0.49
25.5	260	1690	0.49
26.0	270	1720	0.49
26.5	280	1750	0.49
27.0	290	1720	0.49
27.5	300	1750	0.48
28.0	310	1790	0.48
28.5	300	1800	0.49
29.0	300	1790	0.49
29.5	300	1790	0.49
30.0	310	1800	0.49
30.5	310	1820	0.49
31.0	320	1800	0.48
31.5	330	1800	0.48
32.0	330	1830	0.48
32.5	340	1840	0.48
33.0	340	1840	0.48
33.5	340	1830	0.48
34.0	350	1860	0.48
34.5	360	1860	0.48
35.0	350	1870	0.48
35.5	350	1840	0.48
36.0	360	1830	0.48
36.5	360	1820	0.48
37.0	360	1800	0.48
37.5	380	1860	0.48
38.0	400	1900	0.48
38.5	410	1970	0.48
39.0	400	1940	0.48
39.5	400	1950	0.48
40.0	390	1910	0.48
40.5	410	1980	0.48
41.0	430	2050	0.48
41.5	420	2050	0.48
42.0	380	2030	0.48
42.5	360	1980	0.48
43.0	360	1980	0.48
43.5	360	2000	0.48
44.0	380	1960	0.48
44.5	410	2030	0.48

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-025

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1380	6660	0.48
149.2	1450	6730	0.48
150.8	1550	7030	0.47
152.5	1610	7030	0.47
154.1	1490	6700	0.47
155.8	1420	6150	0.47
157.4	1330	6000	0.47
159.0	1320	5700	0.47
160.7	1280	5600	0.47
162.3	1330	5680	0.47
164.0	1320	5600	0.47
165.6	1360	5630	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	420	2030	0.48
45.5	440	2050	0.48
46.0	470	2140	0.47
46.5	490	2140	0.47
47.0	450	2040	0.47
47.5	430	1870	0.47
48.0	410	1830	0.47
48.5	400	1740	0.47
49.0	390	1710	0.47
49.5	410	1730	0.47
50.0	400	1710	0.47
50.5	420	1720	0.47

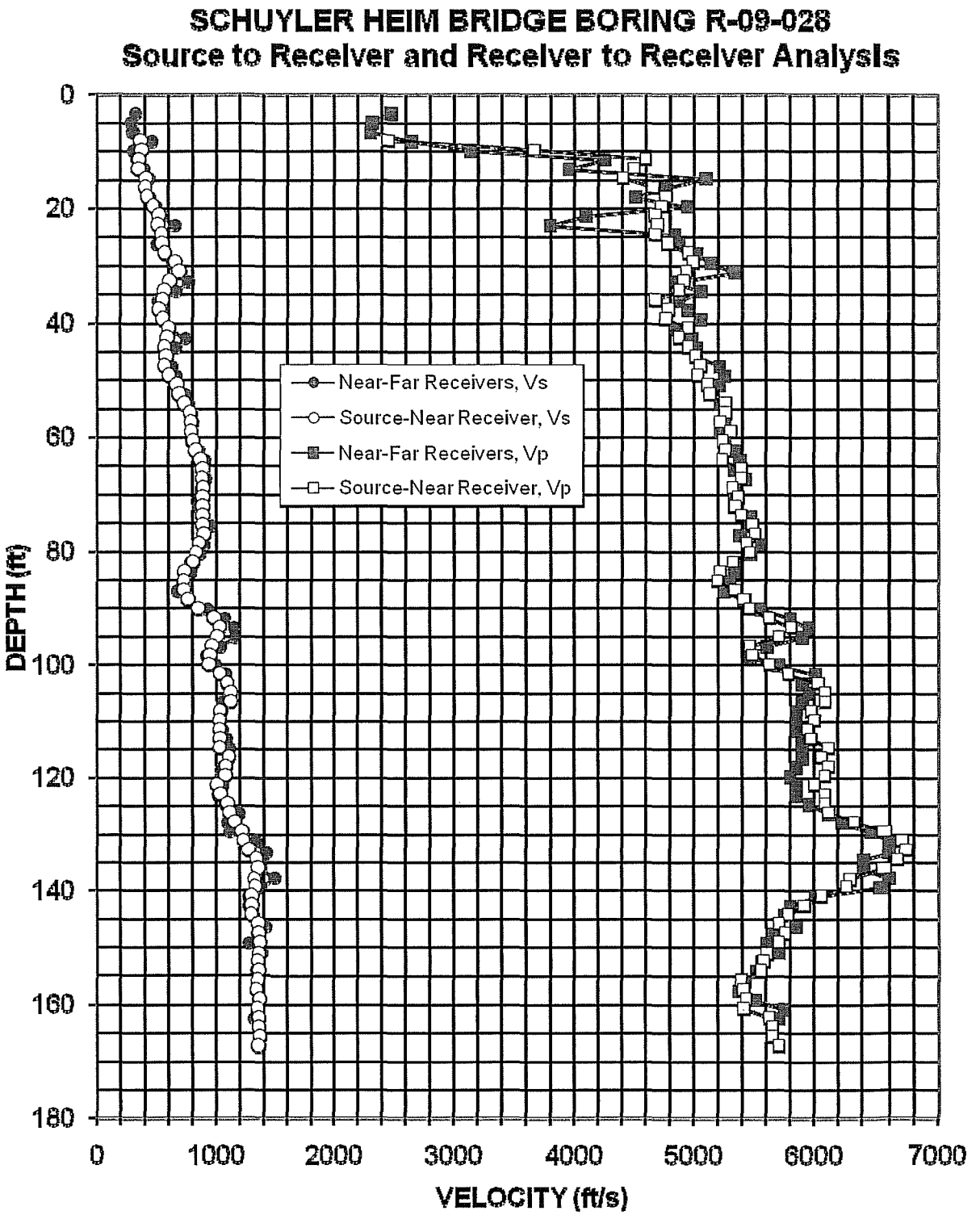

Figure A-6. Boring R-09-028, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-6. Boring R-09-028, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.1	370	2440	0.49
9.8	370	3660	0.49
11.4	350	4590	0.50
13.0	350	4490	0.50
14.7	410	4400	0.50
16.3	400	4650	0.50
18.0	420	4760	0.50
19.6	470	4720	0.49
21.2	520	4670	0.49
22.9	510	4690	0.49
24.5	540	4670	0.49
26.2	550	4780	0.49
27.8	570	4950	0.49
29.4	660	4980	0.49
31.1	690	4930	0.49
32.7	610	4910	0.49
34.4	570	4870	0.49
36.0	550	4670	0.49
37.6	520	4780	0.49
39.3	550	4760	0.49
40.9	600	4950	0.49
42.6	590	4870	0.49
44.2	570	4950	0.49
45.8	580	5000	0.49
47.5	570	5040	0.49
49.1	600	5020	0.49
50.8	670	5100	0.49
52.4	690	5130	0.49
54.0	730	5250	0.49
55.7	780	5250	0.49
57.3	780	5210	0.49
59.0	790	5300	0.49
60.6	800	5230	0.49
62.2	830	5250	0.49
63.9	870	5230	0.49
65.5	890	5390	0.49
67.2	880	5390	0.49
68.8	890	5320	0.49
70.5	890	5360	0.49
72.1	890	5340	0.49
73.7	890	5390	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.5	110	740	0.49
3.0	110	1120	0.49
3.5	110	1400	0.50
4.0	110	1370	0.50
4.5	120	1340	0.50
5.0	120	1420	0.50
5.5	130	1450	0.50
6.0	140	1440	0.49
6.5	160	1420	0.49
7.0	160	1430	0.49
7.5	160	1420	0.49
8.0	170	1460	0.49
8.5	170	1510	0.49
9.0	200	1520	0.49
9.5	210	1500	0.49
10.0	190	1500	0.49
10.5	170	1480	0.49
11.0	170	1420	0.49
11.5	160	1460	0.49
12.0	170	1450	0.49
12.5	180	1510	0.49
13.0	180	1480	0.49
13.5	170	1510	0.49
14.0	180	1530	0.49
14.5	170	1540	0.49
15.0	180	1530	0.49
15.5	200	1560	0.49
16.0	210	1560	0.49
16.5	220	1600	0.49
17.0	240	1600	0.49
17.5	240	1590	0.49
18.0	240	1610	0.49
18.5	250	1590	0.49
19.0	250	1600	0.49
19.5	260	1590	0.49
20.0	270	1640	0.49
20.5	270	1640	0.49
21.0	270	1620	0.49
21.5	270	1640	0.49
22.0	270	1630	0.49
22.5	270	1640	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
75.4	890	5480	0.49
77.0	900	5500	0.49
78.7	860	5430	0.49
80.3	830	5460	0.49
81.9	800	5320	0.49
83.6	730	5210	0.49
85.2	730	5190	0.49
86.9	730	5340	0.49
88.5	760	5410	0.49
90.1	850	5460	0.49
91.8	980	5630	0.48
93.4	1030	5810	0.48
95.1	1010	5700	0.48
96.7	960	5460	0.48
98.3	950	5480	0.48
100.0	940	5630	0.49
101.6	1030	5780	0.48
103.3	1090	6030	0.48
104.9	1120	6090	0.48
106.5	1120	6090	0.48
108.2	1030	5970	0.48
109.8	1030	6000	0.48
111.5	1030	5940	0.48
113.1	1030	5970	0.48
114.7	1030	6120	0.49
116.4	1110	6060	0.48
118.0	1080	6120	0.48
119.7	1080	6090	0.48
121.3	1010	6000	0.49
122.9	1030	6090	0.49
124.6	1090	6090	0.48
126.2	1110	6120	0.48
127.9	1160	6330	0.48
129.5	1210	6560	0.48
131.1	1230	6700	0.48
132.8	1280	6730	0.48
134.4	1340	6660	0.48
136.1	1360	6560	0.48
138.0	1330	6300	0.48
139.3	1330	6270	0.48
141.0	1310	6060	0.48
142.6	1310	5920	0.47
144.3	1300	5780	0.47
145.9	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.0	270	1670	0.49
23.5	270	1680	0.49
24.0	260	1660	0.49
24.5	250	1660	0.49
25.0	250	1620	0.49
25.5	220	1590	0.49
26.0	220	1580	0.49
26.5	220	1630	0.49
27.0	230	1650	0.49
27.5	260	1660	0.49
28.0	300	1720	0.48
28.5	310	1770	0.48
29.0	310	1740	0.48
29.5	290	1660	0.48
30.0	290	1670	0.48
30.5	290	1720	0.49
31.0	310	1760	0.48
31.5	330	1840	0.48
32.0	340	1860	0.48
32.5	340	1860	0.48
33.0	310	1820	0.48
33.5	310	1830	0.48
34.0	310	1810	0.48
34.5	310	1820	0.48
35.0	310	1860	0.49
35.5	340	1850	0.48
36.0	330	1860	0.48
36.5	330	1860	0.48
37.0	310	1830	0.49
37.5	310	1860	0.49
38.0	330	1860	0.48
38.5	340	1860	0.48
39.0	350	1930	0.48
39.5	370	2000	0.48
40.0	370	2040	0.48
40.5	390	2050	0.48
41.0	410	2030	0.48
41.5	410	2000	0.48
42.1	400	1920	0.48
42.5	410	1910	0.48
43.0	400	1850	0.48
43.5	400	1800	0.47
44.0	400	1760	0.47
44.5	410	1740	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole R-09-028

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
147.6	1360	5750	0.47
149.2	1370	5700	0.47
151.2	1360	5600	0.47
152.5	1350	5580	0.47
154.1	1360	5550	0.47
155.8	1350	5390	0.47
157.4	1340	5410	0.47
159.0	1370	5430	0.47
160.7	1350	5410	0.47
162.3	1360	5630	0.47
164.0	1360	5650	0.47
165.6	1370	5650	0.47
167.2	1360	5700	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
45.0	410	1750	0.47
45.5	420	1740	0.47
46.1	410	1710	0.47
46.5	410	1700	0.47
47.0	410	1690	0.47
47.5	410	1640	0.47
48.0	410	1650	0.47
48.5	420	1660	0.47
49.0	410	1650	0.47
49.5	410	1720	0.47
50.0	410	1720	0.47
50.5	420	1720	0.47
51.0	410	1740	0.47

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION PROCEDURES AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER 573794

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160023	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160023	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CXB	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

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Test No. 573794
Asset No. 160023

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573794
Asset No. 160023

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	998.9	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160023
573794

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1019

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.11%. As left -0.11%.

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	401	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	402	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	403	45.00	200.0	45.00	200.0	45.00	200.0
500.0	500.0	20	404	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	405	9.000	1000	9.000	1000	9.010	998.9
2000	2000	5	406	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Calibration Report

TEST NUMBER
573795

Metrology

7300 Fenwick Lane
Westminster, CA 92683
Toll Free: 866-723-2257

GEOVision Geophysical Services

1124 Olympic Drive
Corona, CA 92881-3390

NVLAP®
Lab Code: 105014-0

Manufacturer:	Oyo	**Ambient Temperature:**	23° C
Model Number:	3403	**Ambient Humidity:**	56% RH
Description:	Unit, Suspension Telemetry	**Condition As Found:**	In Tolerance
Asset Number:	160024	**Condition As Left:**	In Tolerance - No Adjustment
Serial Number:	160024	**Calibration Date:**	07/17/2009
Cal. Procedure:	Customer	**Calibration Due Date:**	07/17/2010
PO Number:	9200-090716-01	**Calibration Interval:**	12 Months

Remarks:
The unit was calibrated with the customer's procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 2 and 3 of this report with the original observation data on page 4.

Standards Utilized

I.D. No.	Manufacturer	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal	01/29/2009	07/29/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	05/04/2009	11/04/2009
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/24/2009	01/24/2010

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A	Metrologist	714-895-0714		7/17/09
Name	Title	Phone	Name	Date

This report may not be reproduced, except in full, without written permission of this laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. The results stated in this report relate only to the items tested or calibrated. Measurements reported herein are traceable to SI units via national standards maintained by NIST. This laboratory and calibration are in compliance with NVLAP laboratory accreditation criteria established by NIST/NVLAP under the specific scope of accreditation for lab code 105014-0, and in compliance with ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 and 10CFR50, Appendix B. Where uncertainties are provided, the uncertainty stated is the expanded uncertainty of the measurement, where k=2.

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.2	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	"	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	"	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	"	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	"	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Test No. 573795
Asset No. 160024

Custom Specification Report

Oyo 3403 Unit, Suspension Telemetry,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	"	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

160024 ~~160024~~ 573795

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	7/17/2009
By:	Craig Branson	Due date:	7/17/2010
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	1/29/2009
By:	SCE #S1-01252	Due date:	7/29/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	5/4/2009
By:	SCE #S1-01347	Due date:	11/4/2009

SYSTEM SETTINGS:

Gain:	8
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/17/2009 1037

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10%. As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	501	180.00	50.00	180.00	50.00	180.00	50.00
100.0	100.0	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.0	50	503	44.95	200.2	45.00	200.0	45.00	200.0
500.0	500.0	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000	10	505	9.000	1000	8.990	1001	9.000	1000
2000	2000	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Craig Branson	7/17/2009	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/17/2009	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C. LABORATORY SOIL TEST RESULTS

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: ACTA Heim Bridge Replacement

EGL JOB NO. : 09-230-008

PROJECT NO.: 06-123-03

CLIENT: Earth Mechanics, Inc

DATE: 11/23/2009

SUMMARIZED BY: JT

BORING No.	SAMPLE No.	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	%PASSING #200 ASTM D1140 (%)	ATTERBERG LIMIT ASTM D4318 (LL,PL,PI)*
R-09-035	S-01	5.0	25.4		9.3	
R-09-035	D-02	10.0				38,29,10
R-09-035	U-03	15.0				28,23,5
R-09-035	D-04	20.0	43.1	80.0		
R-09-035	D-06	30.0	33.3	90.2		24,22,2
R-09-035	S-07	35.0			48.8	
R-09-035	D-08	40.0	31.1	92.7		
R-09-035	S-09	45.0	39.7			
R-09-035	U-10	50.0				NP
R-09-035	S-11	55.0	33.4		37.0	
R-09-035	D-12	60.0	21.9	105.4		
R-09-035	S-13	65.0			19.9	
R-09-035	D-14	70.0	27.0	98.7		

*LL,PL,PI = Liquid Limit, Plastic Limit, Plasticity Index

SUMMARY OF CORROSION TEST RESULTS

PROJECT NAME:	ACTA Heim Bridge Replacement	EGL JOB NO:	09-230-008
PROJECT NO.:	06-123-03	CLIENT:	Earth Mechanics, Inc.
DATE:	11/30/2009	Summarized By:	RJ

BORING NO	SAMPLE NO	DEPTH (ft)	pH CalTrans 643	Chloride Content CalTrans 422 (ppm)	Sulfate Content CalTrans 417 (% by weight)	Minimum Resistivity CalTrans 643 (ohm-cm)
R-09-035	D-02	10	7.88	465	0.051	610
R-09-035	S-09	45	8.65	2215	0.056	230

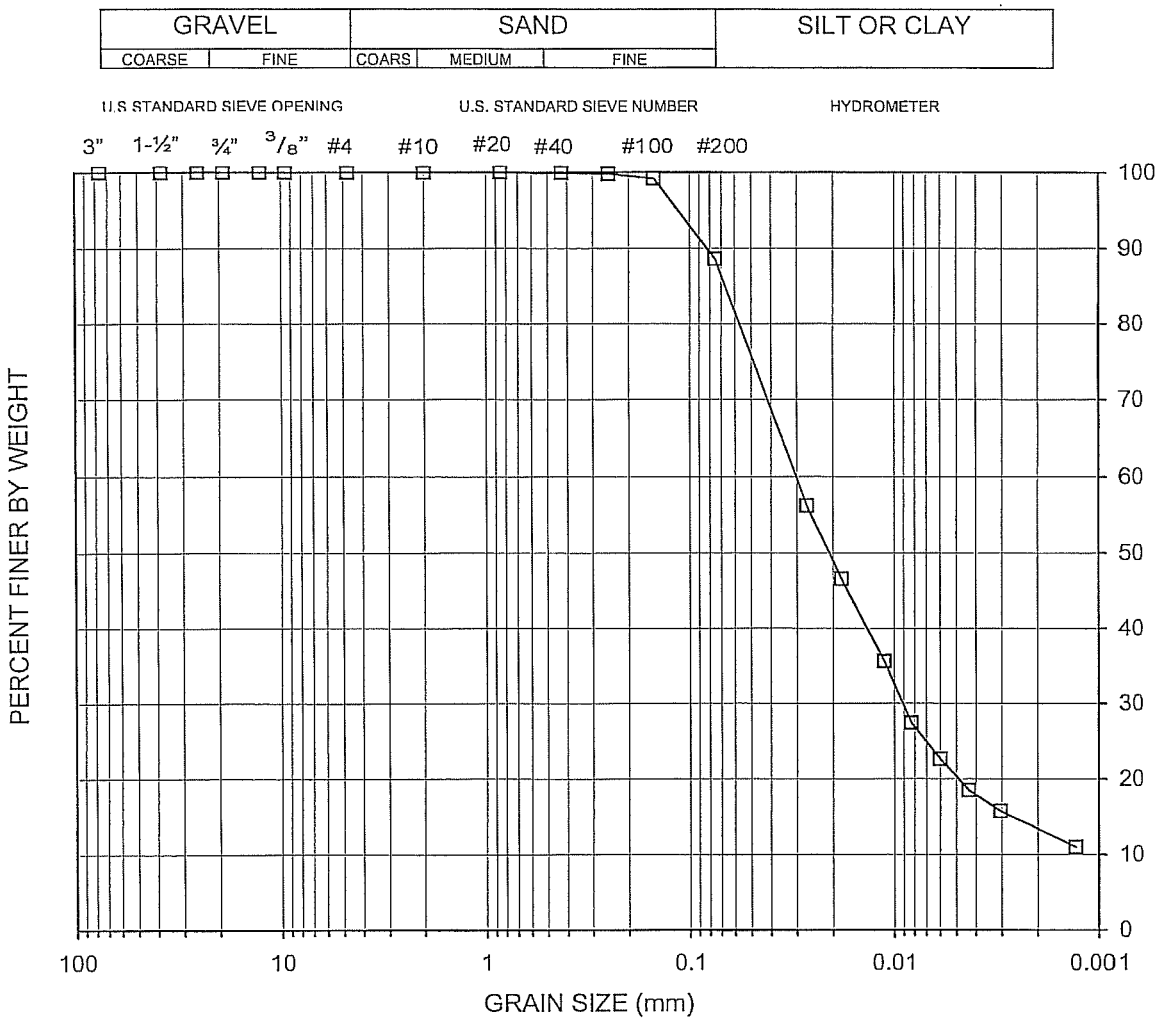
SUMMARY OF LABORATORY TEST RESULTS
SPECIFIC GRAVITY

PROJECT NAME: ACTA Heim Bridge Replacement EGL JOB NO.: 09-230-008

PROJECT NO: 06-123-03 CLIENT: Earth Mechanics, Inc.

DATE: 12/1/2009 SUMMARIZED BY: JT

BORING NO	SAMPLE NO	DEPTH (ft)	SPECIFIC GRAVITY ASTM D 854
R-09-035	U-03	15	2.763
R-09-035	U-10	50	2.742



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-03	15	Shelby Tube	ML	28	5

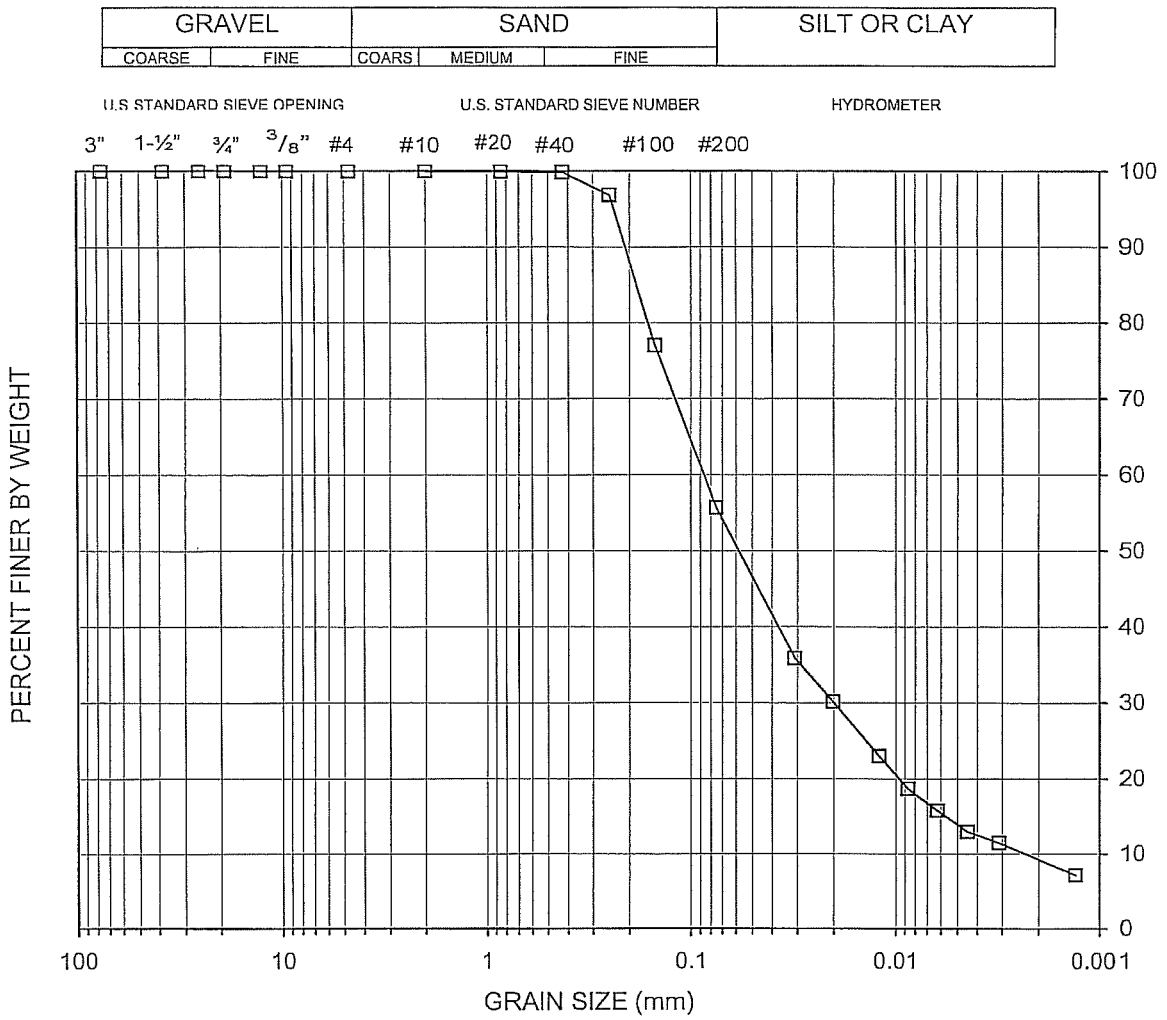
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement

Client: Earth Mechanic, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	R-09-035	U-10	50	Shelby Tube	ML	NP	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement

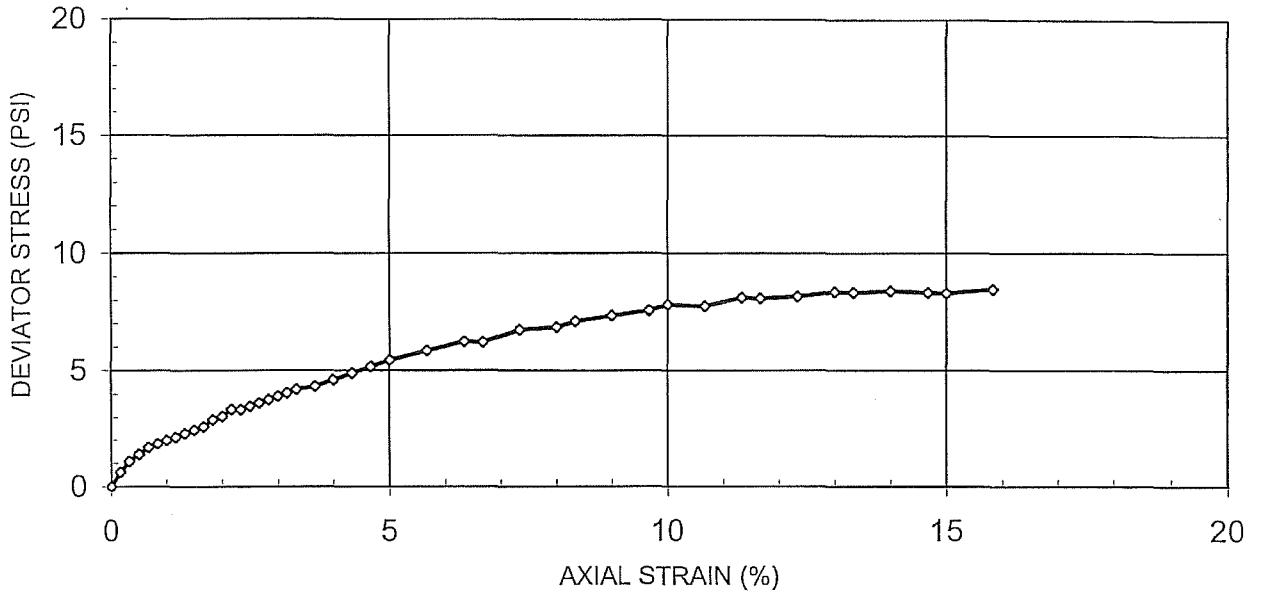
Client: Earth Mechanic, Inc.

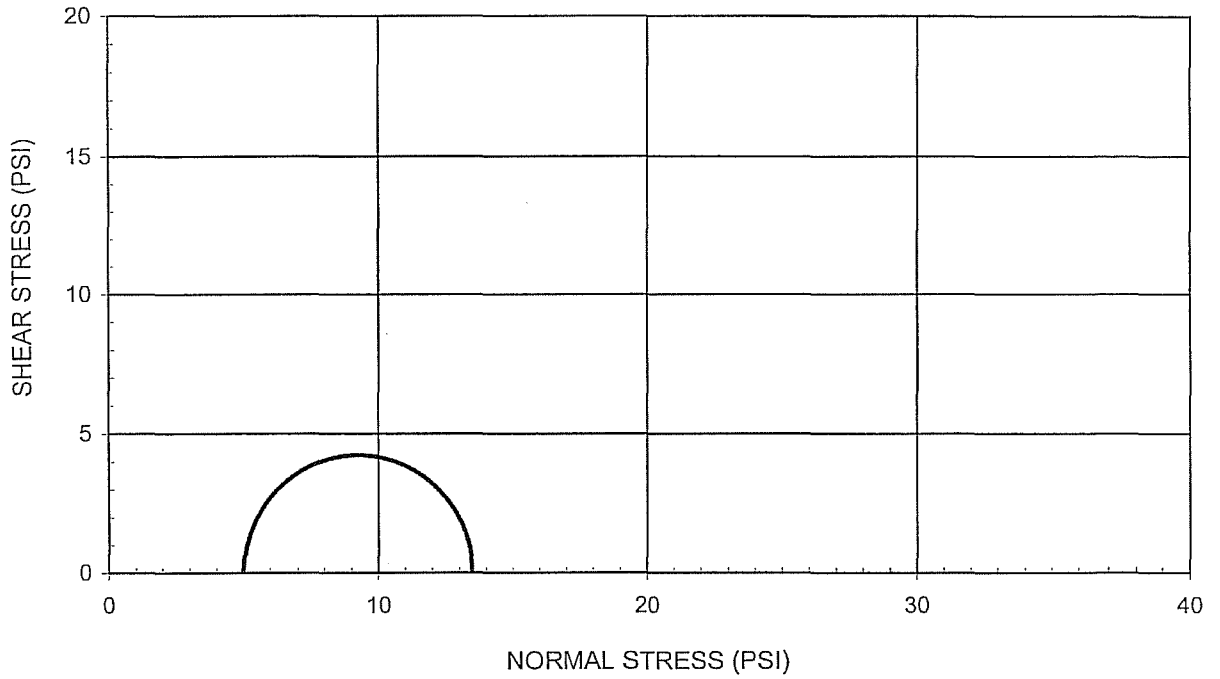
Job No: 06-123-03

EGL Project No: 09-230-008

GRAINSIZE DISTRIBUTION CURVE

11/29/09 (ASTM D422) FIGURE





Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	15	U-03	ML	Shelby Tube	41.01	80.0	5.0	8.5	0.06	100.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

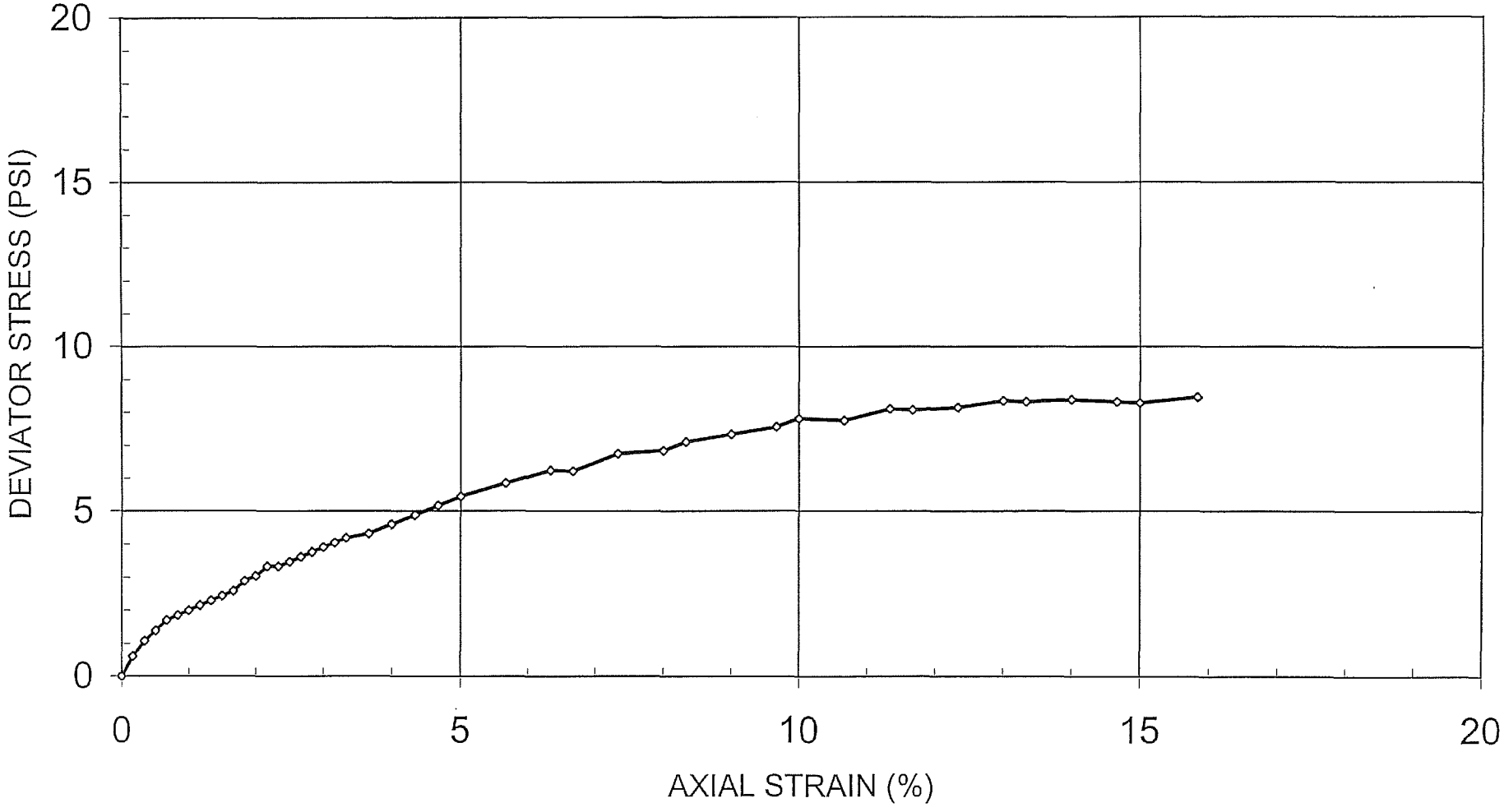
(ASTM D2850)

11/29/09

Figure

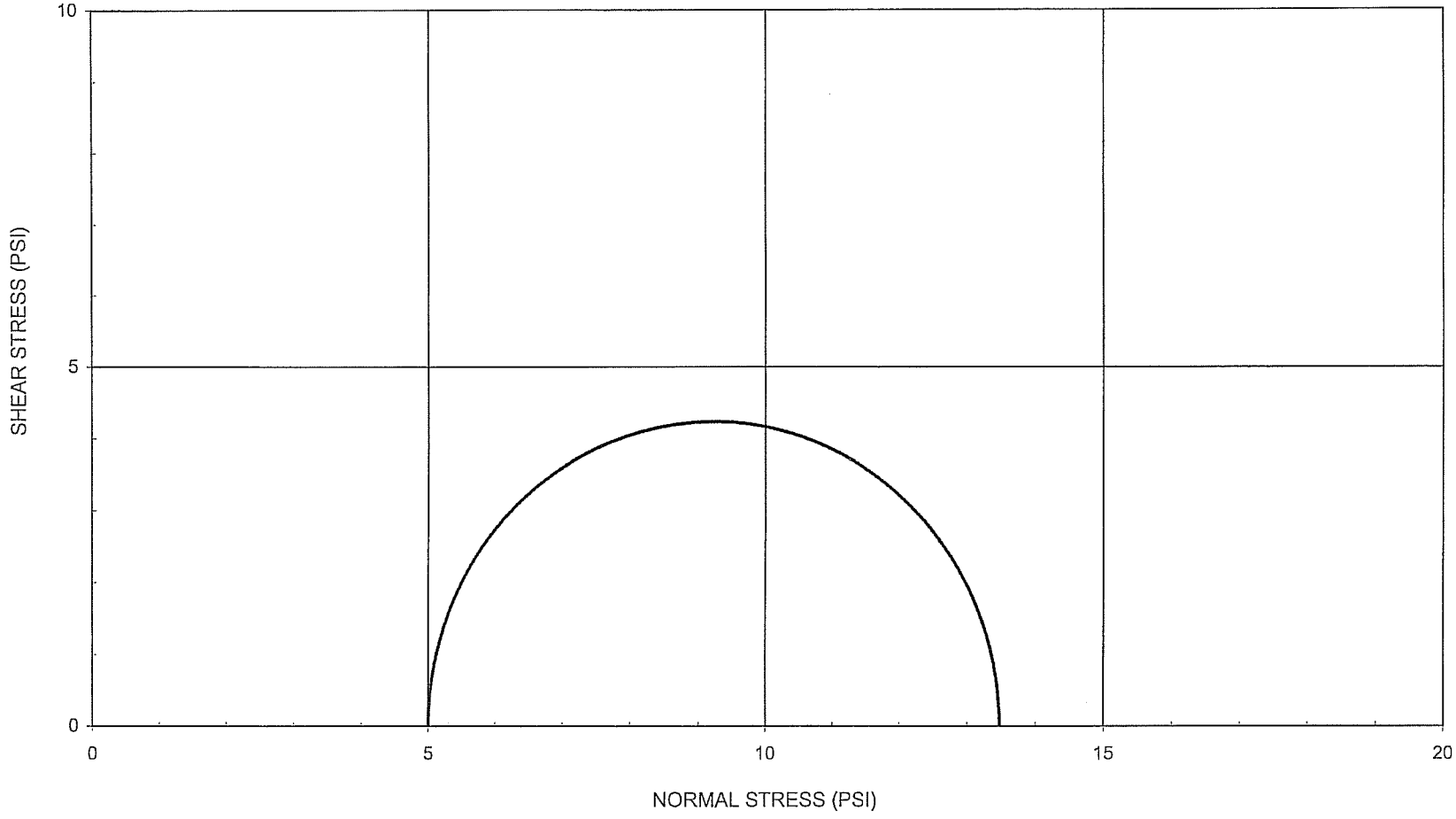
Project Name: ACTA Heim Bridge Replacement

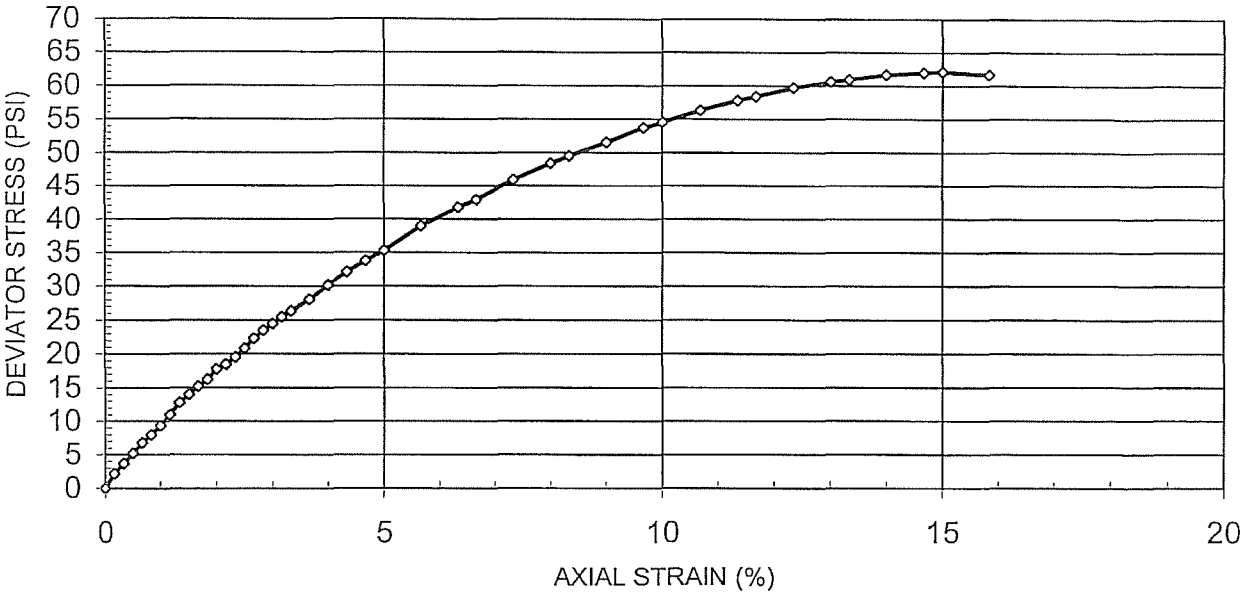
Boring: R-09-035 Sample ID: U-03 Depth (ft): 15

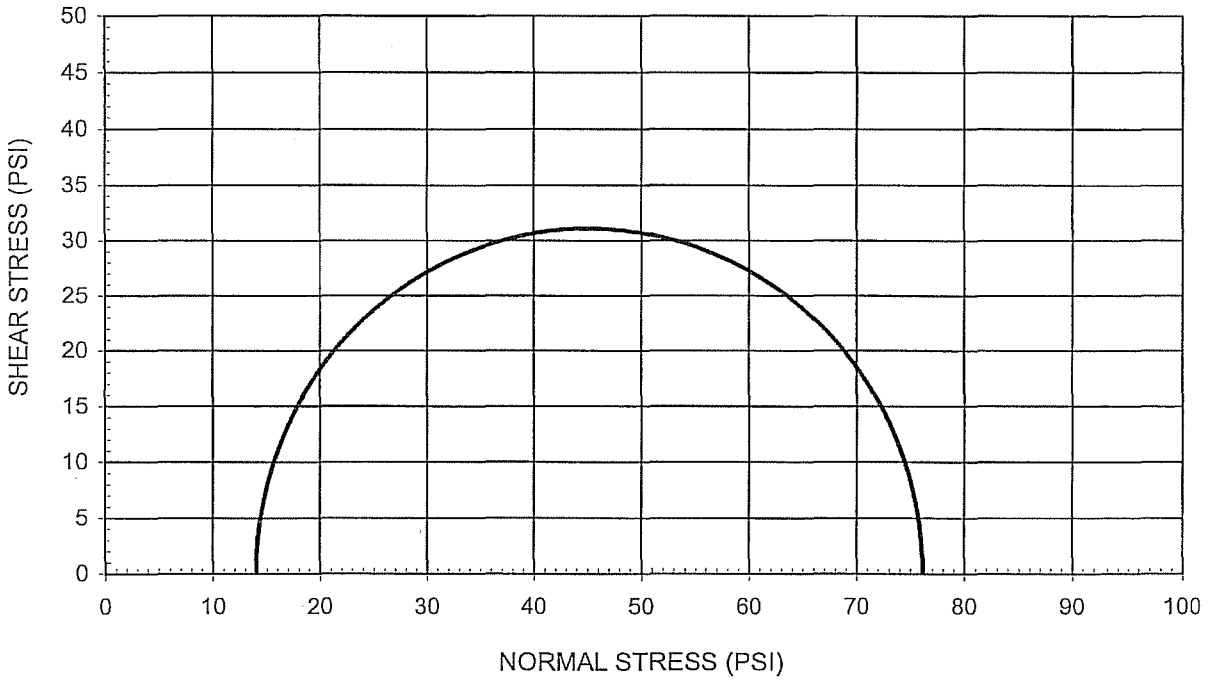


Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-03 Depth (ft): 15







Boring No	Depth (ft)	Sample No	Soil Type	Sample Type	Moisture Content (%)	Dry Density (pcf)	Effective Confined Pressure (psi)	Maximum Deviator Stress (psi)	Strain Rate (in/min)	Initial Saturation (%)
R-09-035	50	U-10	ML	Shelby Tube	22.25	106.6	14.0	62.1	0.06	103.5

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc.
Job No:	06-123-03
EGL Project No:	09-230-008

UNCONSOLIDATED UNDRAINED

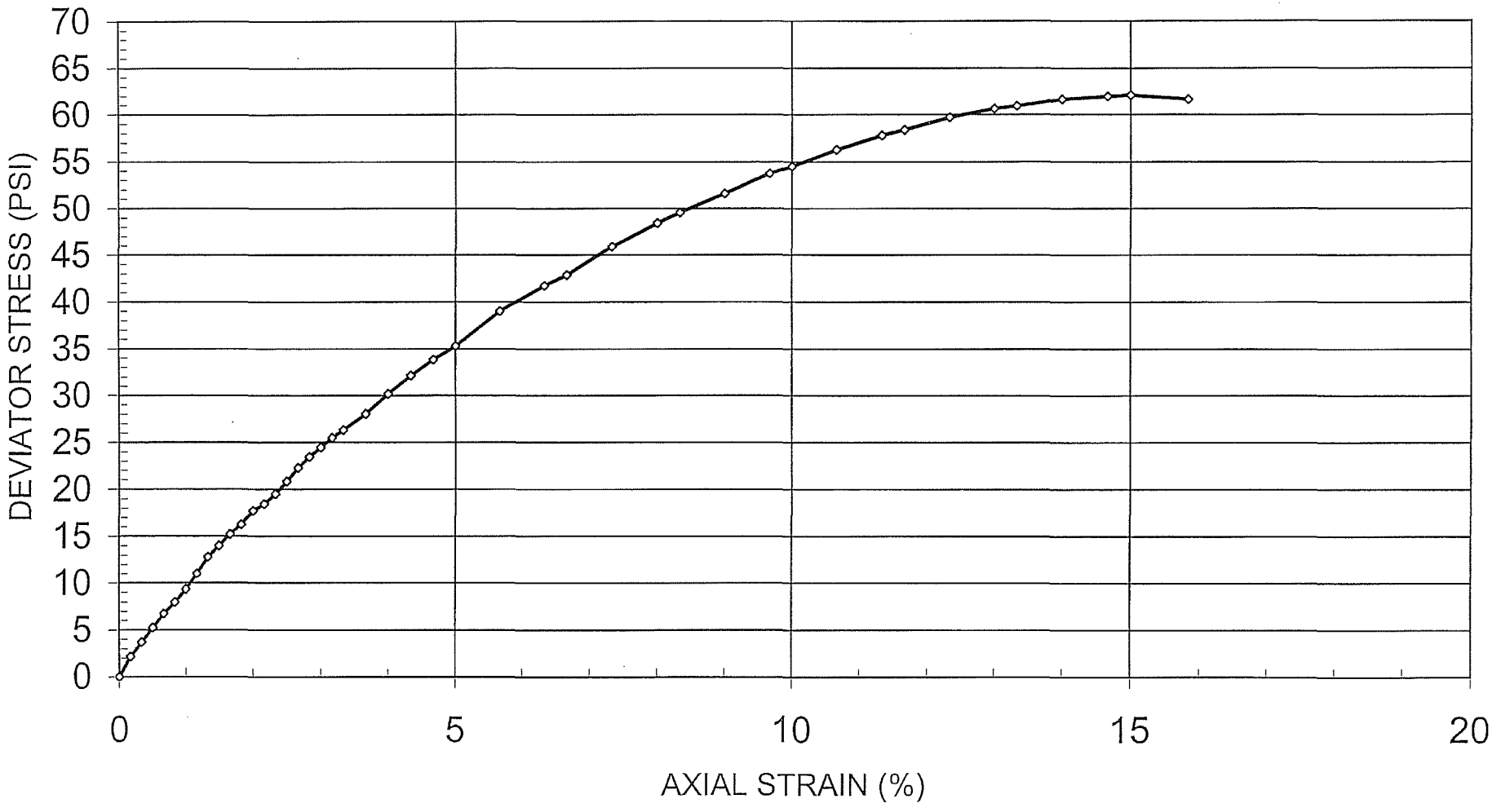
(ASTM D2850)

11/29/09

Figure

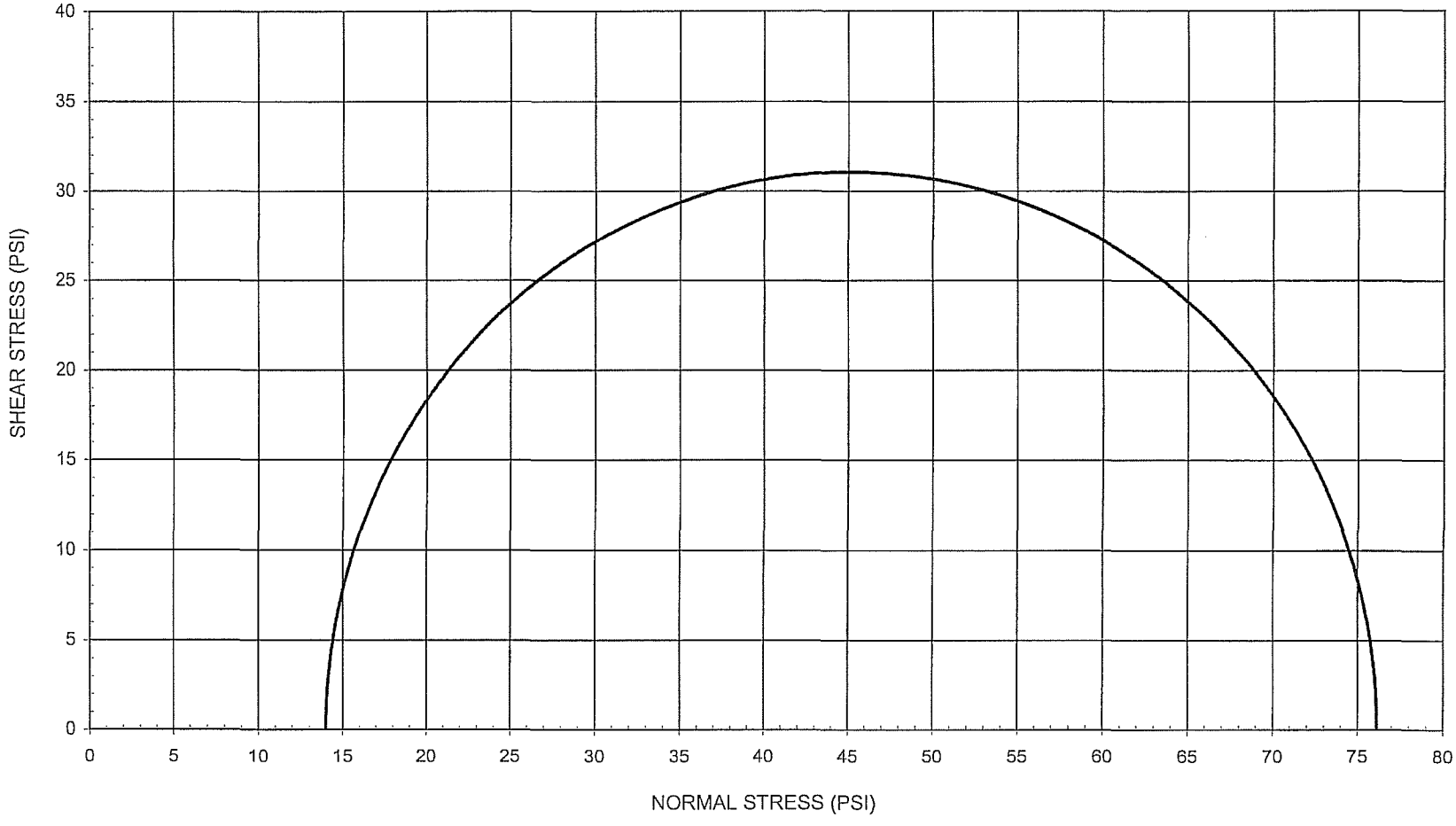
Project Name: ACTA Heim Bridge Replacement

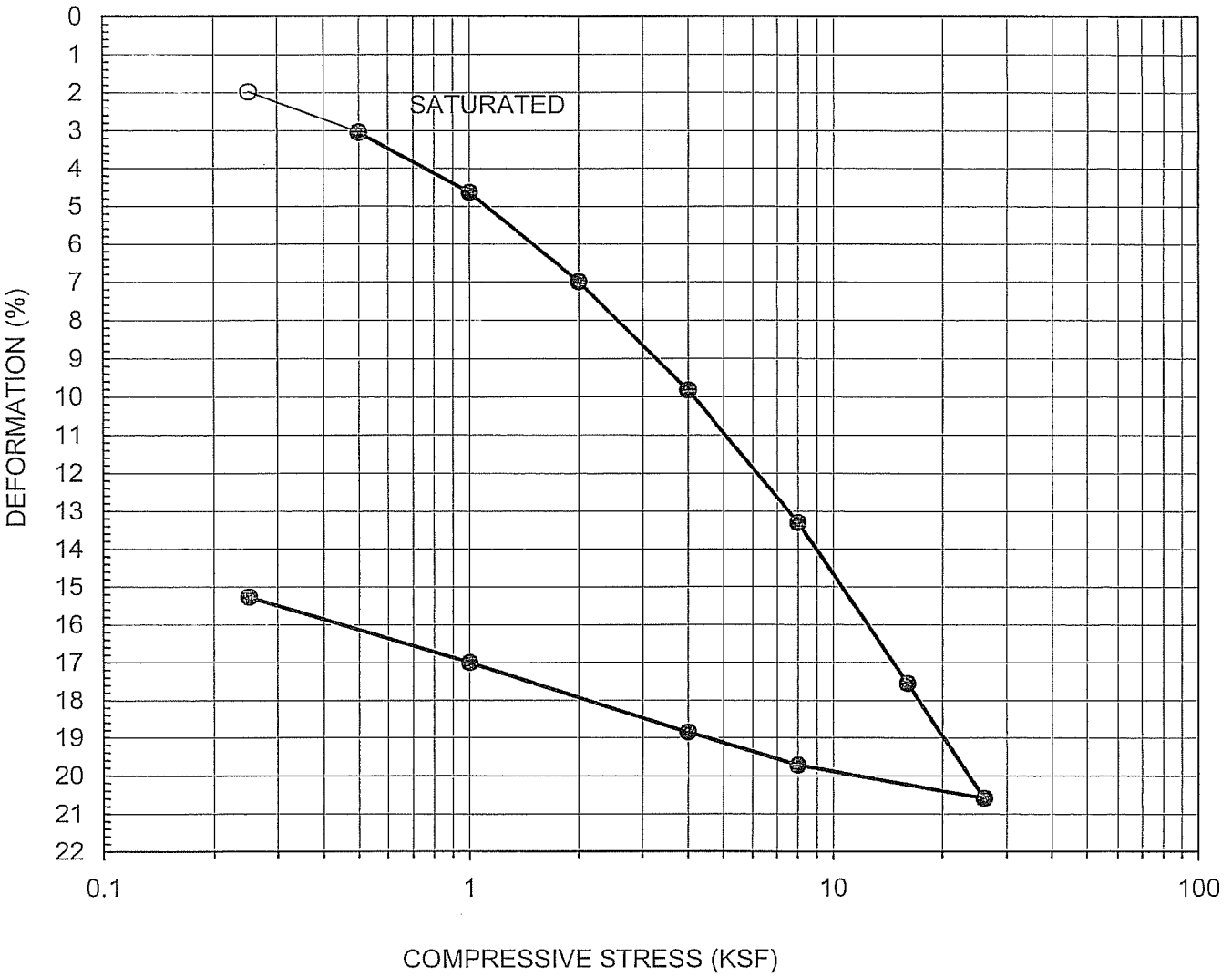
Boring: R-09-035 Sample ID: U-10 Depth (ft): 50



Project Name: ACTA Heim Bridge Replacement

Boring: R-09-035 Sample ID: U-10 Depth (ft): 50





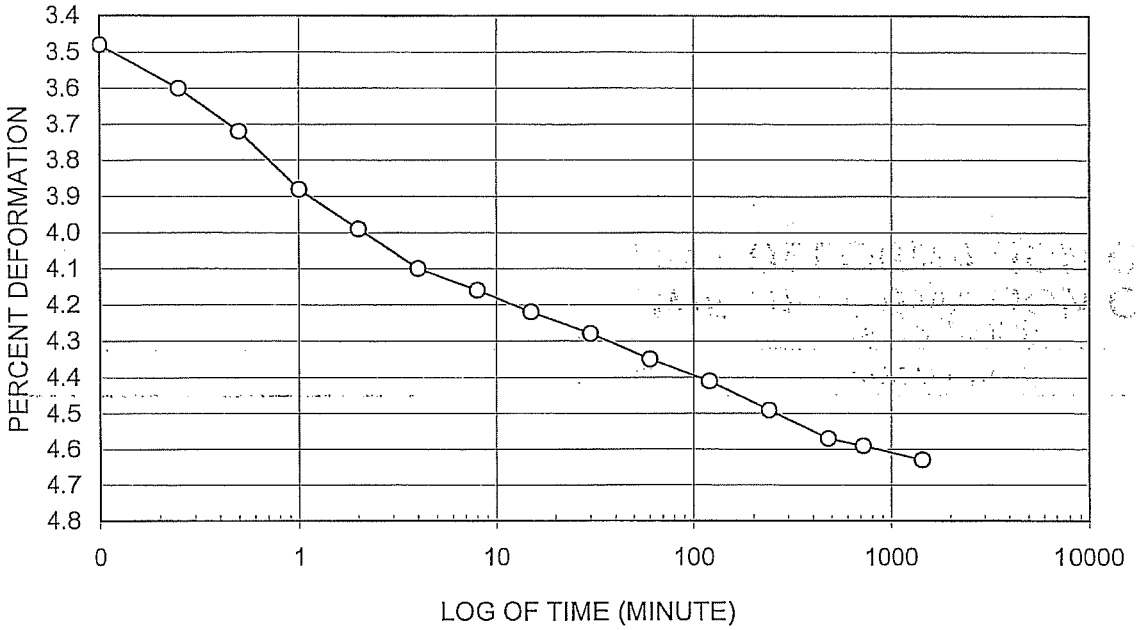
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	D-02	10.0	ML	48.0	73.9	1.279

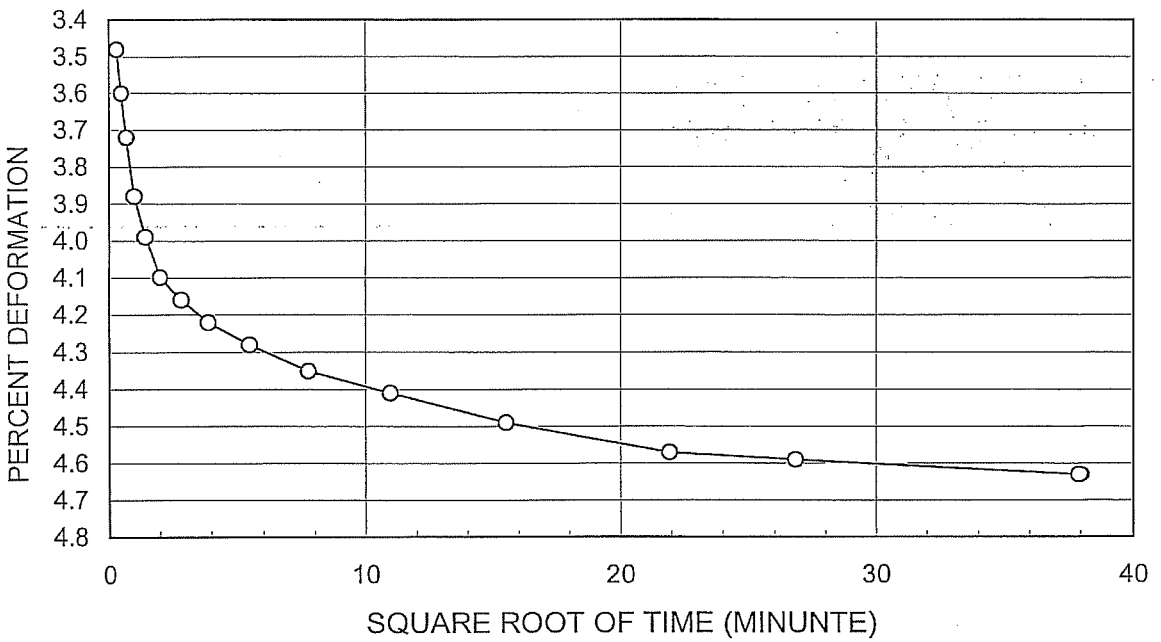
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





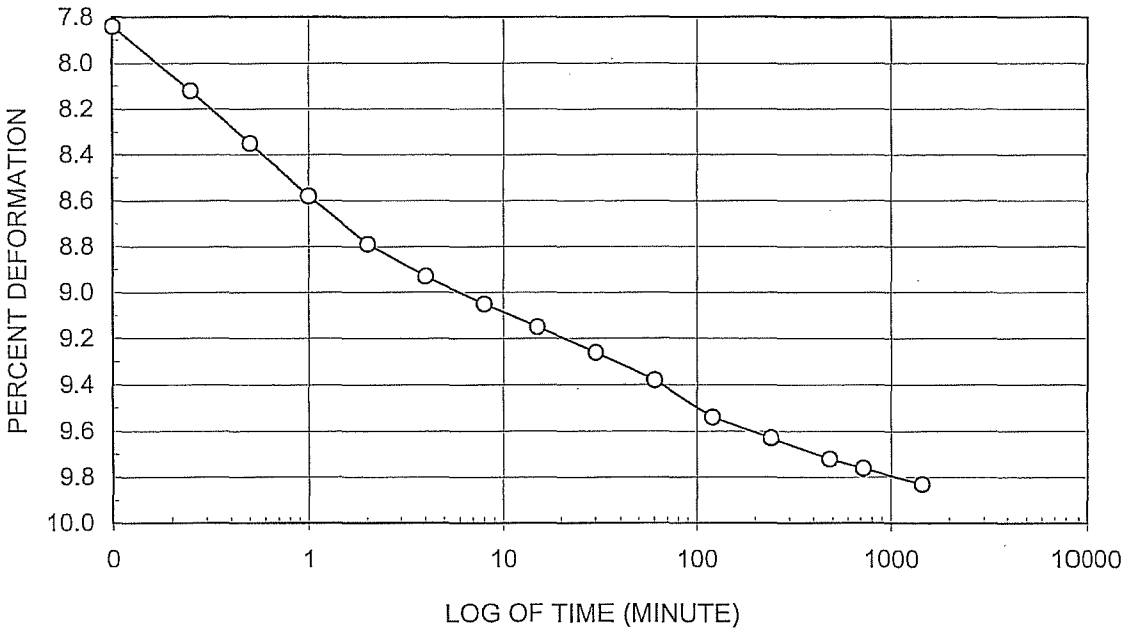
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 1.0 ksf

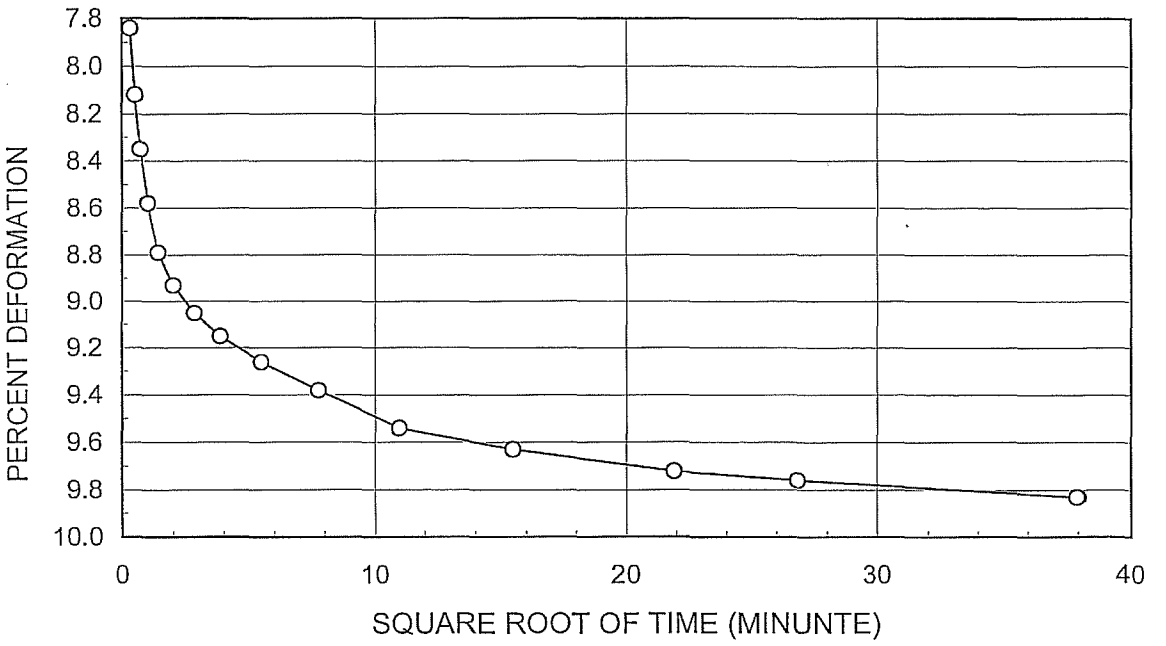
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





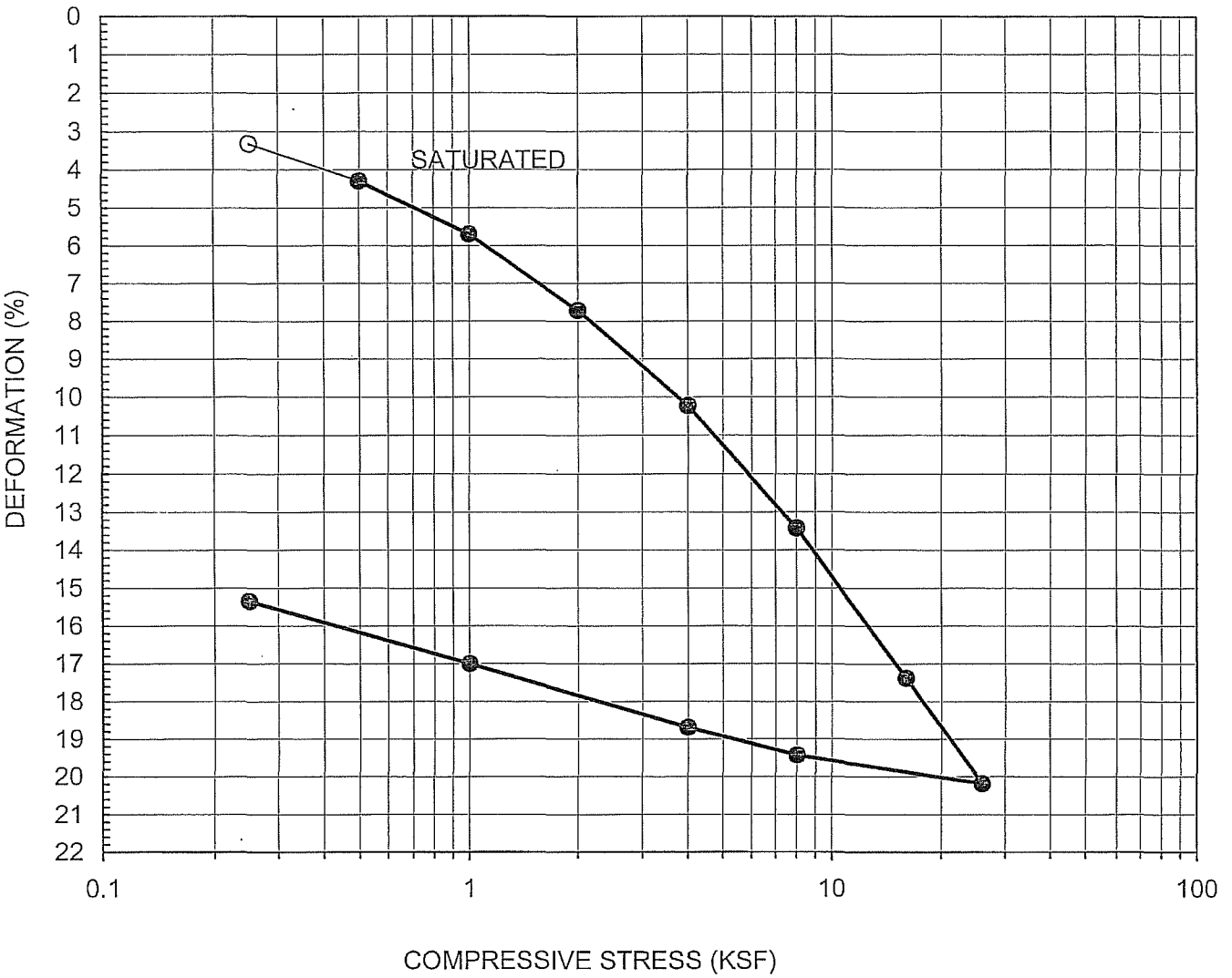
Boring No: R-09-035
Sample No: D-02
Depth (ft): 10
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



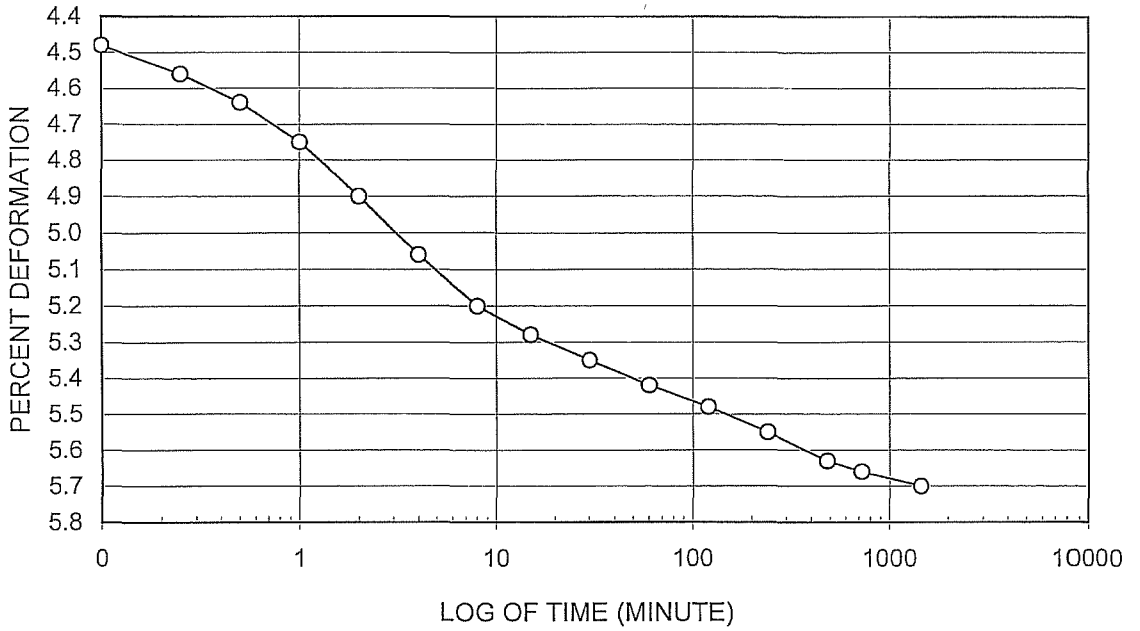
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
O	R-09-035	U-03	15.0	ML	40.8	78.1	1.157

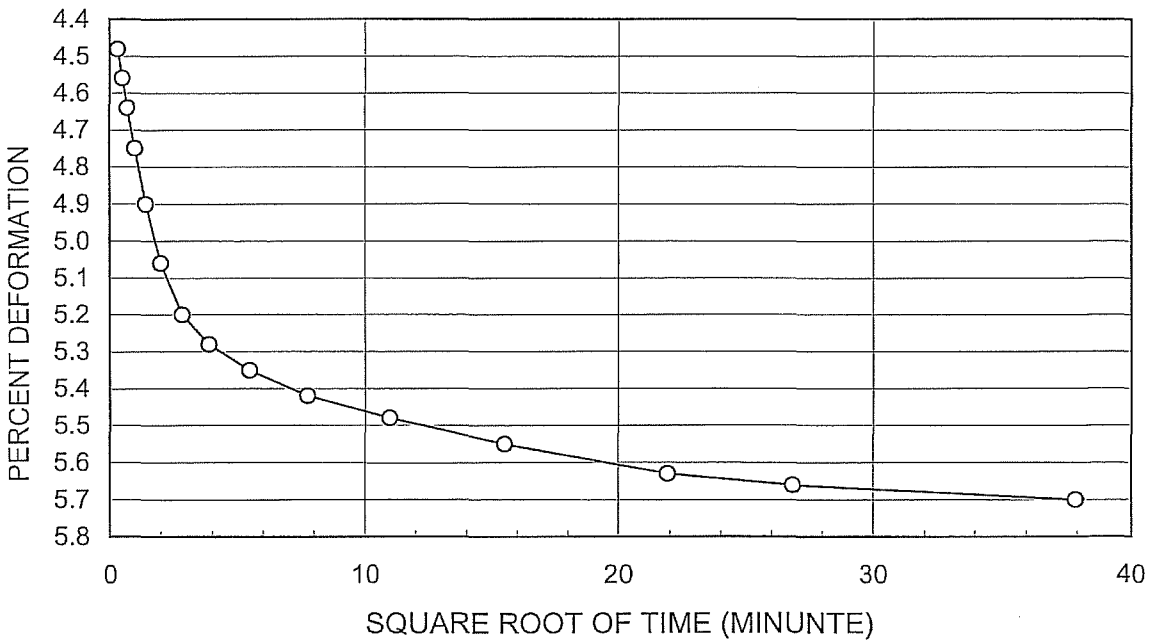
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





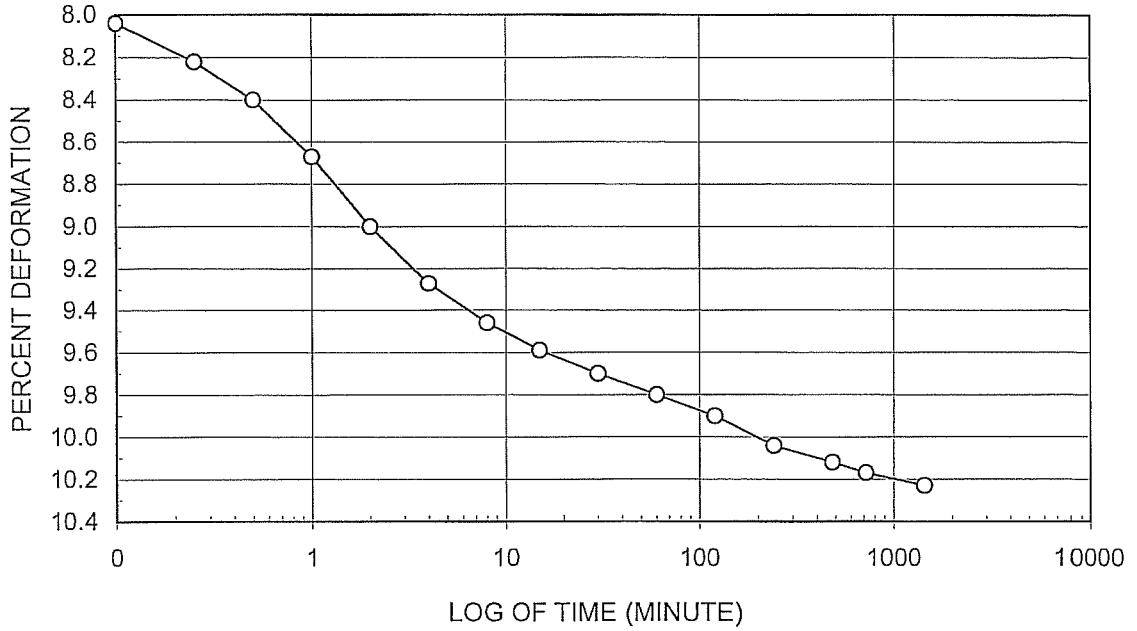
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 1.0 ksf

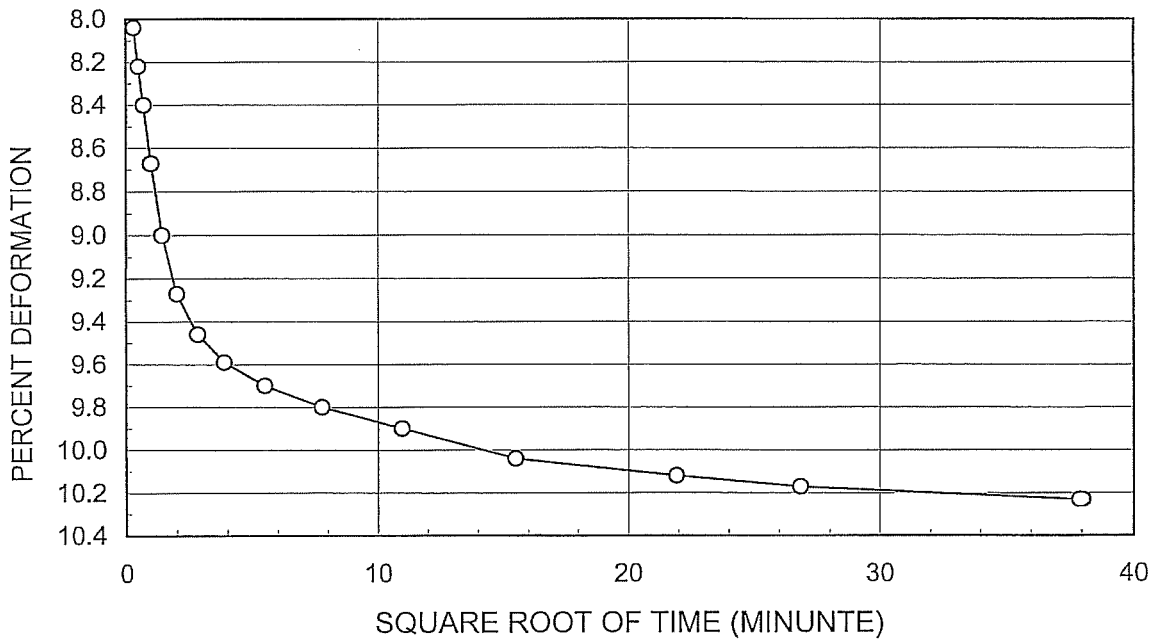
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





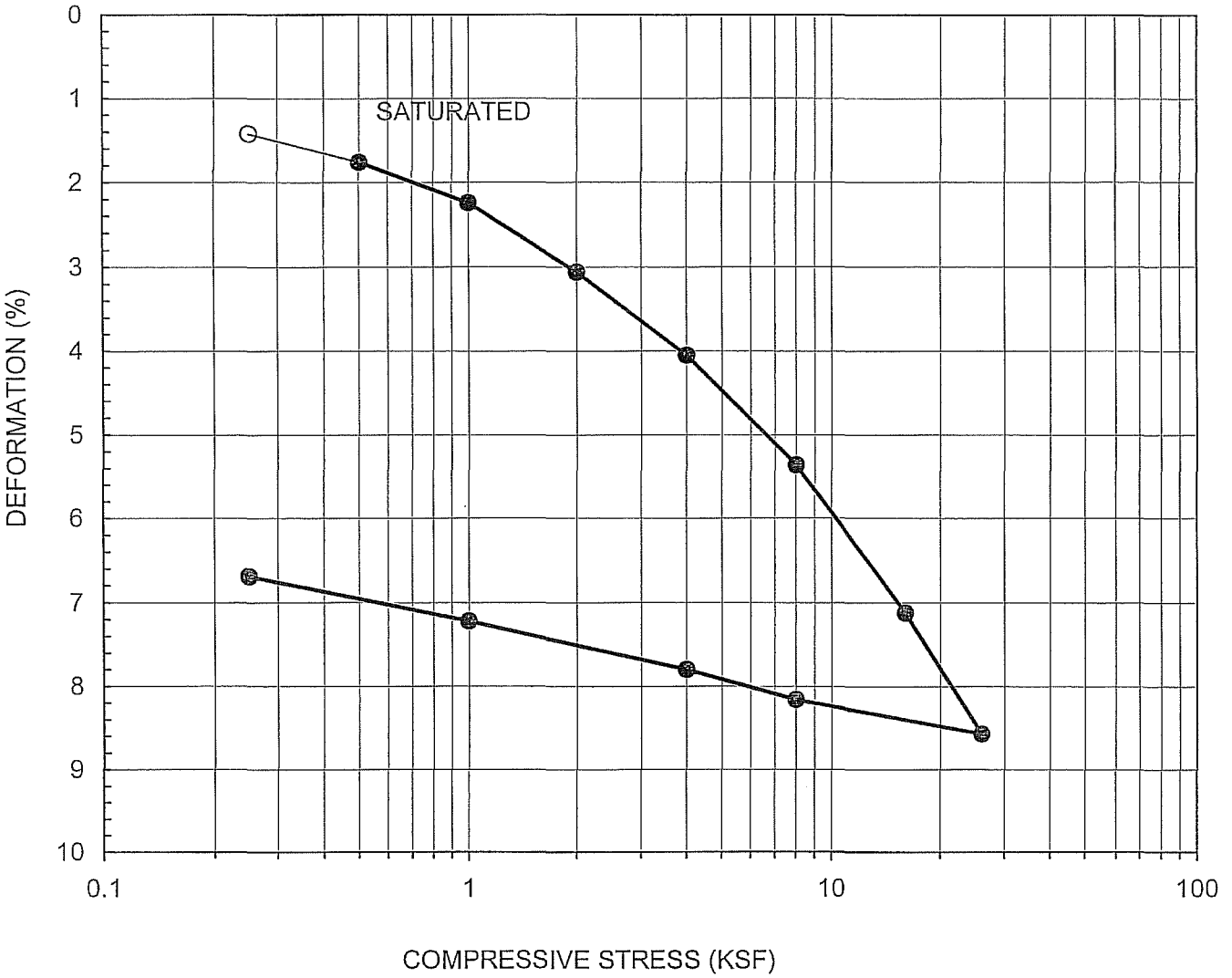
Boring No: R-09-035
Sample No: U-03
Depth (ft): 15
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc
Project No: 06-123-03
EGL Project No: 09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



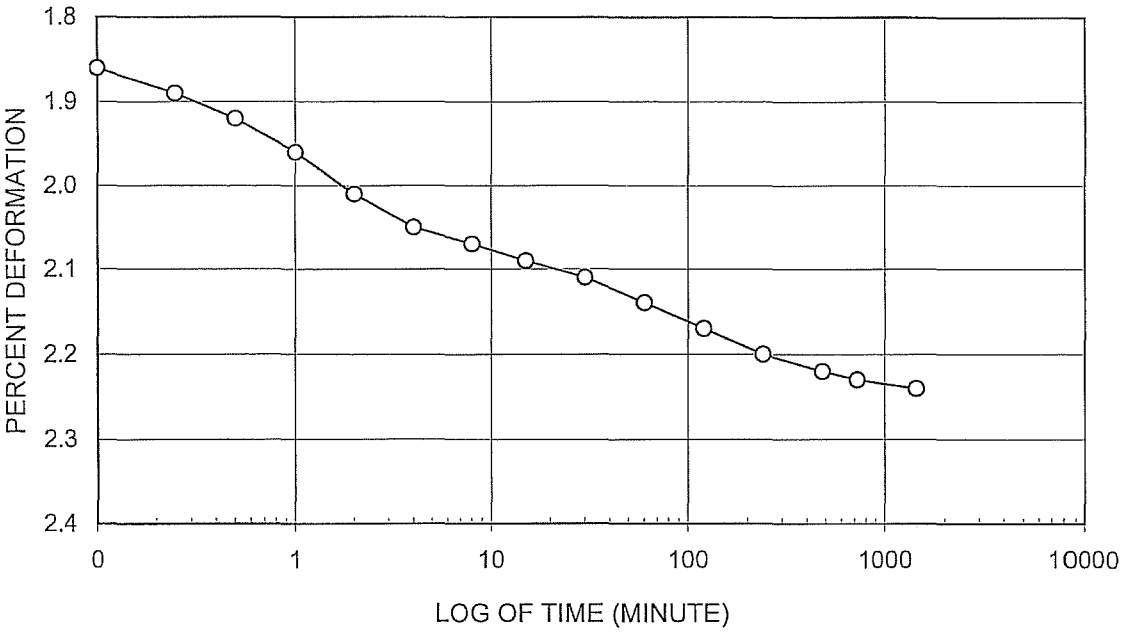
Symbol	Boring No.	Sample No.	Depth (Ft.)	Soil Type	Init. Moisture Content (%)	Init. Dry Density (PCF)	Init. Void Ratio
○	R-09-035	U-10	50.0	ML	21.6	109.1	0.544

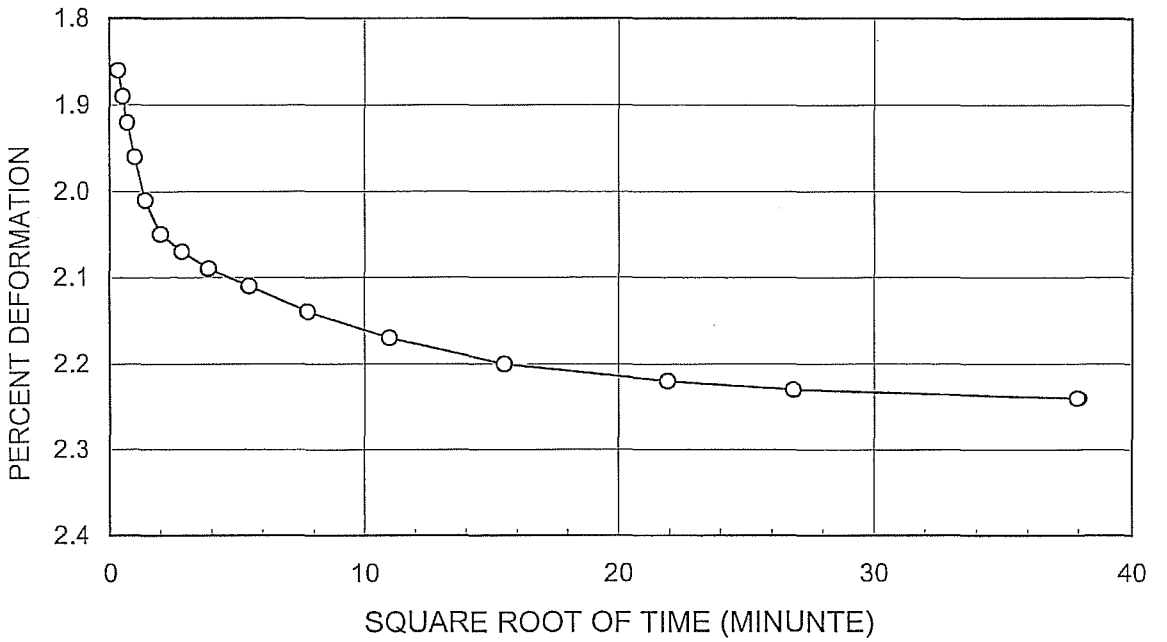
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Job No: 06-123-03
EGL Project No: 09-230-008

CONSOLIDATION

12/09 (ASTM D2435) Figure





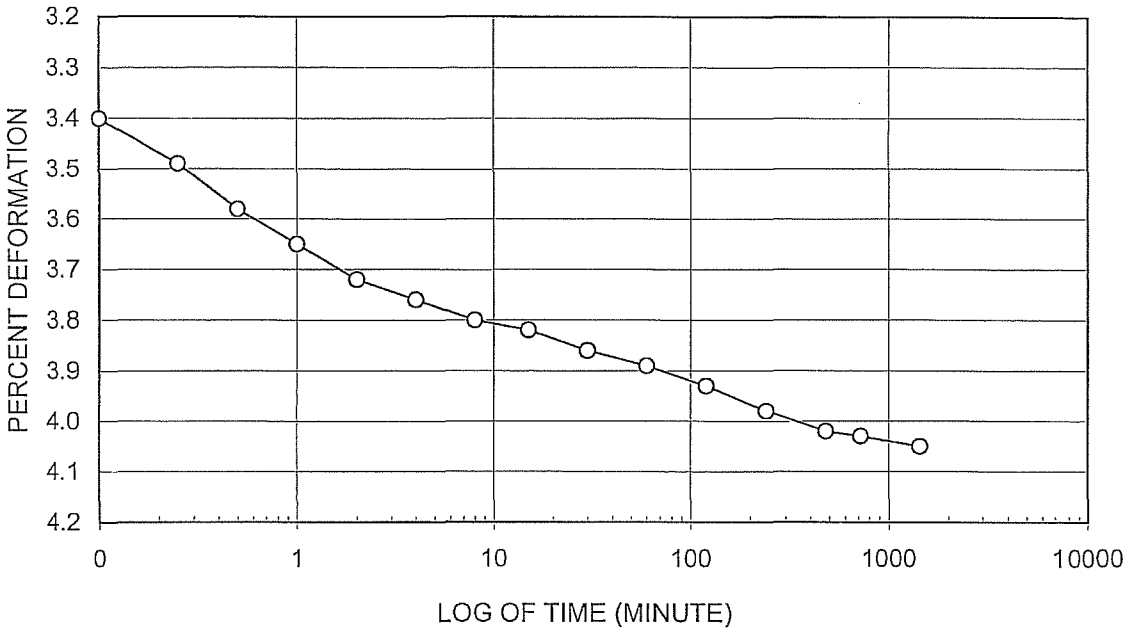
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 1.0 ksf

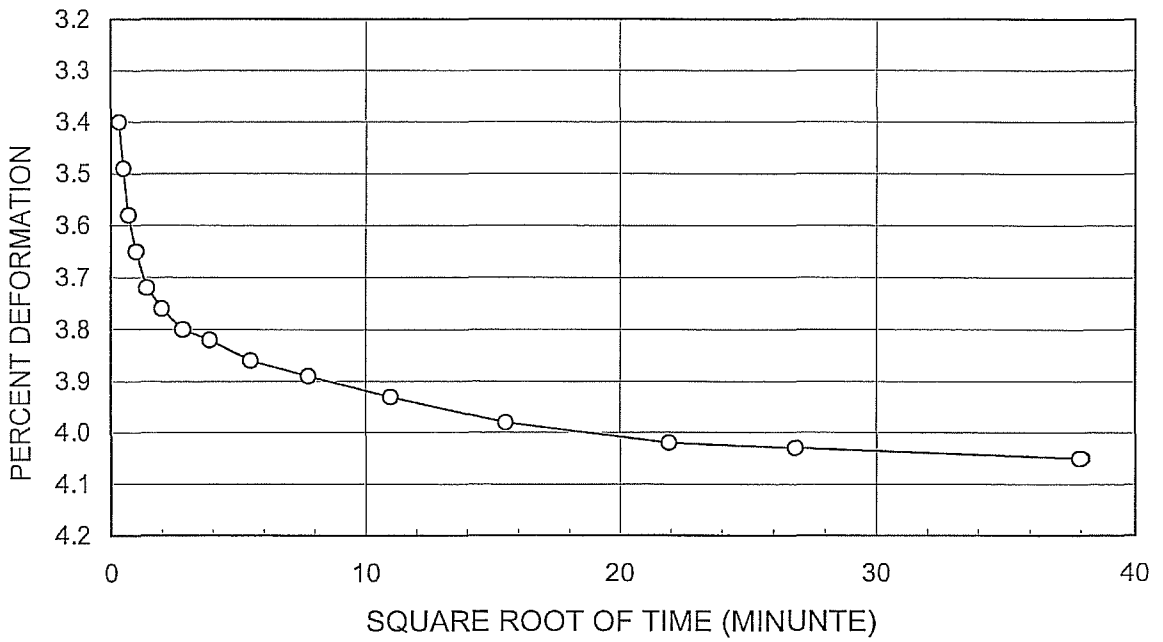
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure





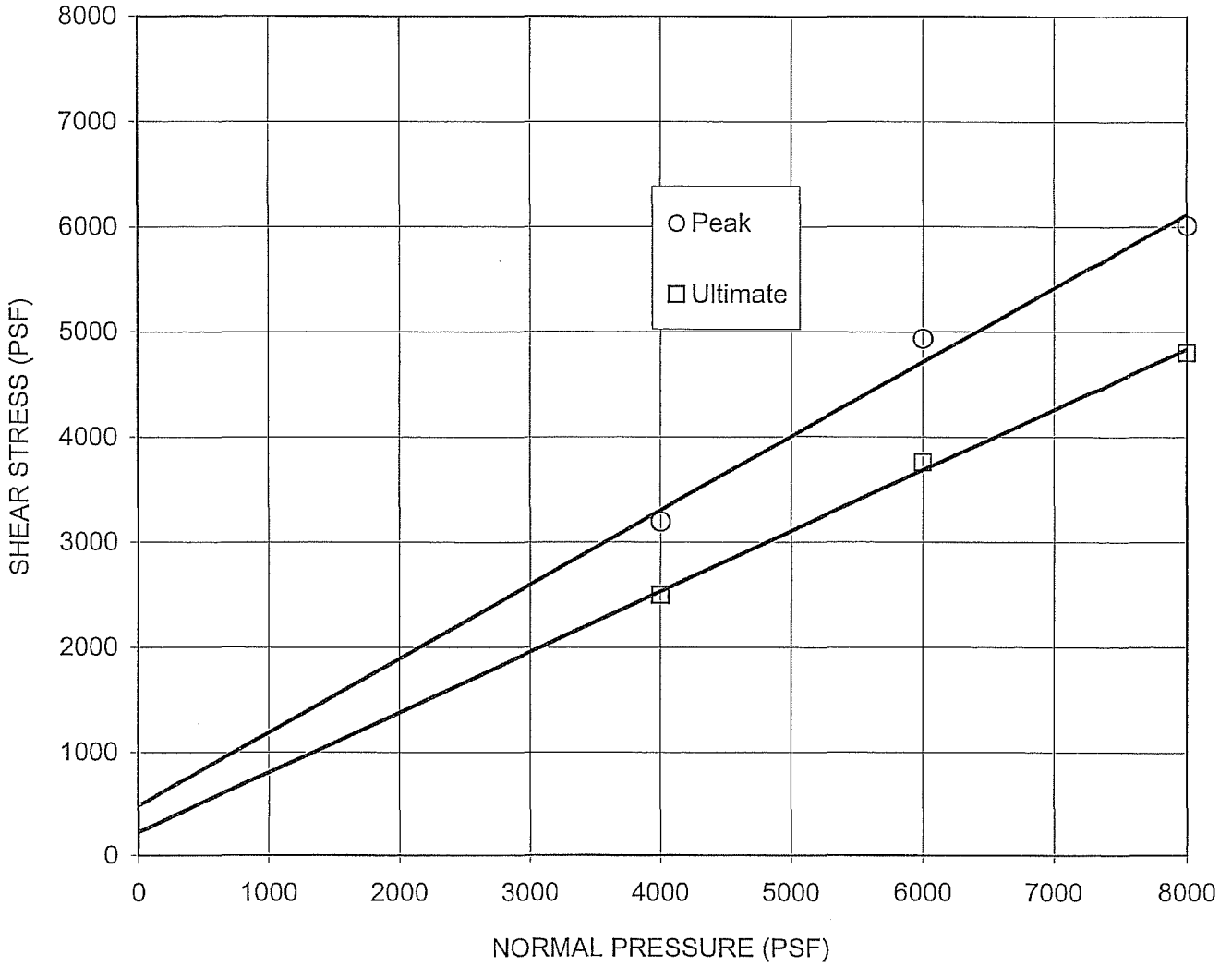
Boring No: R-09-035
Sample No: U-10
Depth (ft): 50
Soil Type: ML
Normal Stress: 4.0 ksf

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:	ACTA Heim Bridge Replacement
Client:	Earth Mechanics, Inc
Project No:	06-123-03
EGL Project No:	09-230-008

TIME DEFORMATION CURVE

12/09 (ASTM D2435) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
R-09-035	D-14	70	Ring	SM	○	484	35
					□	228	30

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
4000	27.0	30.7
6000	27.0	29.3
8000	27.0	29.3

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
ACTA Heim Bridge Replacement
Client: Earth Mechanics, Inc.
Project No: 06-123-03
EGL Project No: 09-230-008

DIRECT SHEAR

12/09 (ASTM D3080) Figure

AP Engineering & Testing, Inc.

MOISTURE AND DENSITY TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/18/09

Boring No.	Sample No.	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)
R-09-036	S-03	15	43.6	NA
R-09-036	D-06	30	32.2	91.8
R-09-036	D-08	40	32.8	89.5
R-09-036	S-09	45	38.7	NA
R-09-036	S-11	55	28.4	NA
R-09-036	D-12	60	36.7	91.0
R-09-036	S-13	65	25.2	NA
R-09-036	D-14	70	36.9	97.2
R-09-036	S-15	75	14.6	NA

AP Engineering & Testing, Inc.

POCKET PENETROMETER DATA

Client Name: Earth Mechanics, Inc. — Laboratory No.: 29-1121

Project Name: ACTA Heim Bridge Replacement — Date: 11/17/09

Project Number: 06-123-03

Boring No.	Sample No.	Depth (feet)	Pocket Penetrometer (tsf)
R-09-036	D-02	10	0.53
R-09-036	D-04	20	0.33
R-09-036	U-05	25	1.00
R-09-036	D-06	30	0.67
R-09-036	D-08	40	1.75

AP Engineering & Testing, Inc.

PERCENT PASSING NO. 200 SIEVE

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project Number: 06-123-03

Laboratory No.: 29-1121
Date: 11/18/09

Boring No.	Sample No.	Sample Depth (ft)	Percent Fines (%)
R-09-036	S-01	5	75.38
R-09-036	S-03	15	79.26
R-09-036	D-06	30	32.51
R-09-036	S-07	35	21.13
R-09-036	S-09	45	80.15
R-09-036	S-11	55	45.51
R-09-036	S-13	65	14.11

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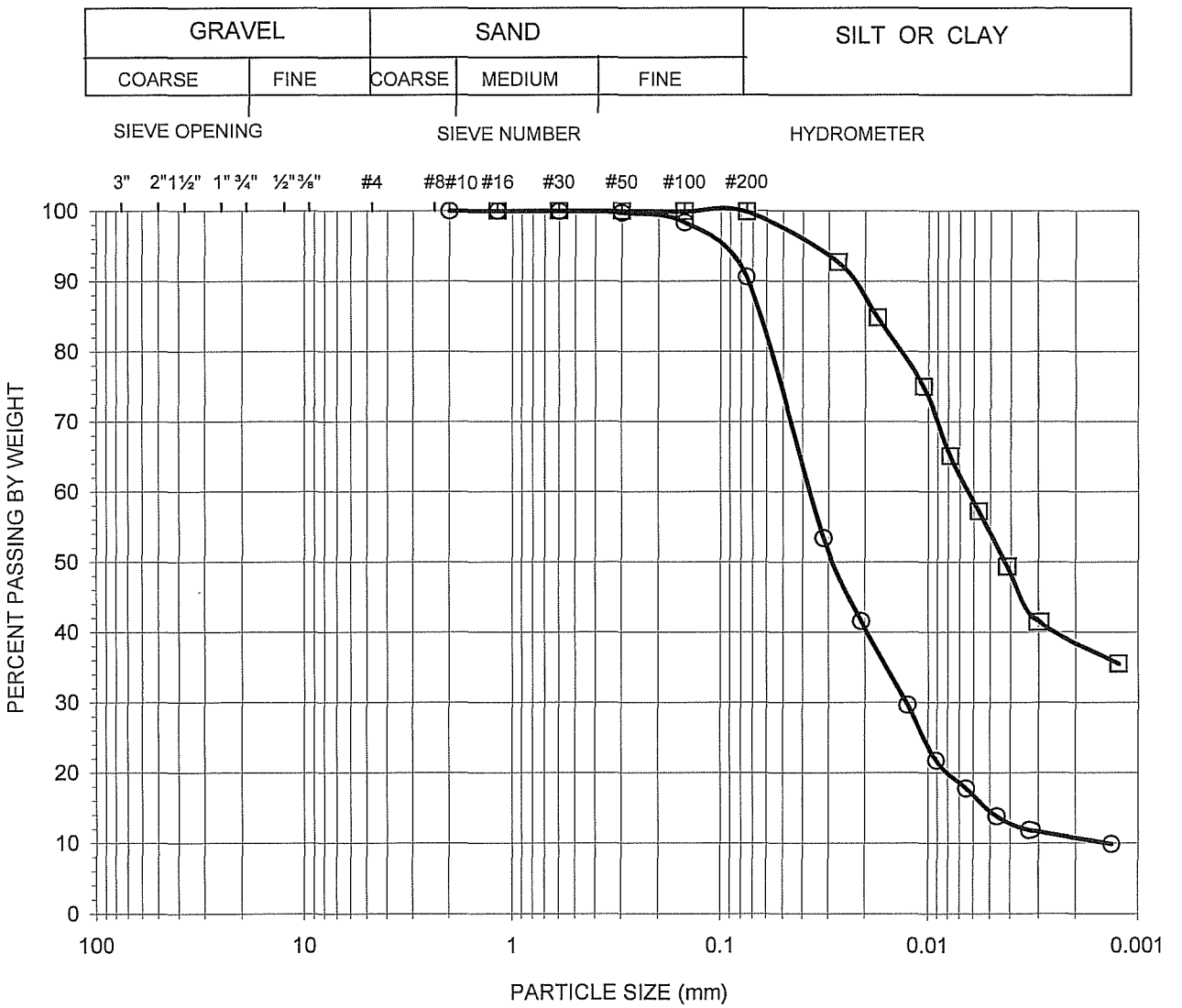
AP Engineering & Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Earth Mechanics, Inc.	Tested by:	ST	Date:	11/19/09
Project Name:	ACTA Heim Bridge Replacement	Computed by:	KM	Date:	11/24/09
Project No.:	06-123-03	Checked by:	AP	Date:	12/01/09



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type ASTM D 2487
				Gravel	Sand	Fines		
○	R-09-036	U-05	25	0.00	9.35	90.65	N/P	ML
□	R-09-036	D-10	50	0.00	0.16	99.84	56:29:27	CH

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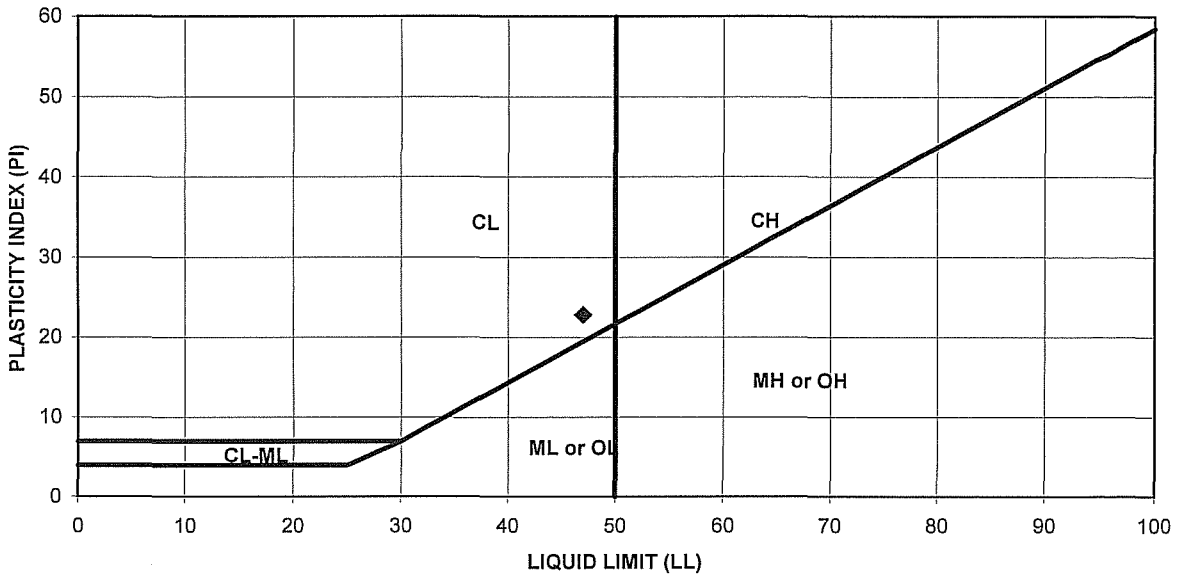
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

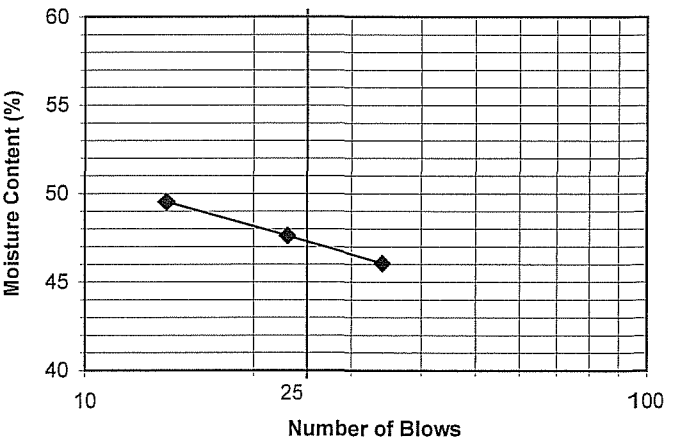
Tested By: DK
Checked By: AP

Date: 11/24/09
Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-036	D-02	10	47	24	23	CL
	R-09-036	U-05	25	NP	NP	NP	

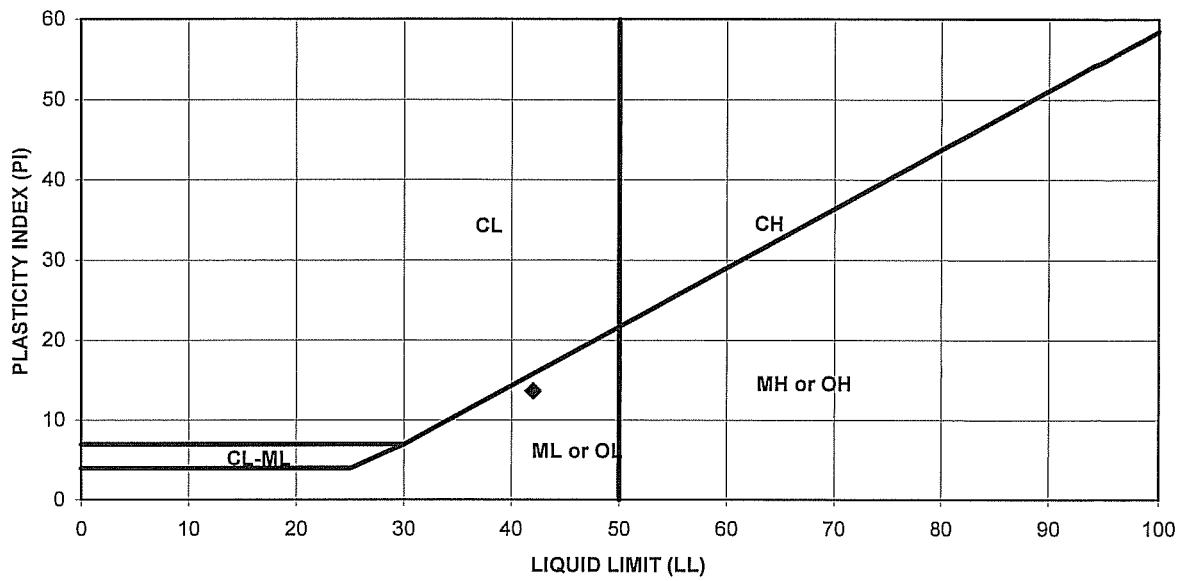
* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

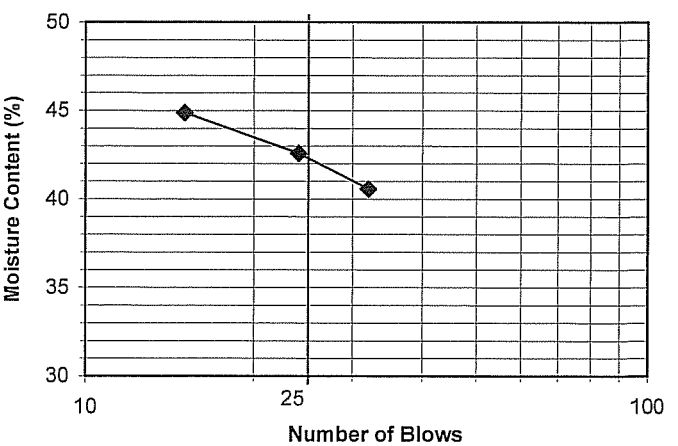
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

Tested By: DK Date: 01/06/10
Checked By: AP Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-04	20	42	28	14	ML

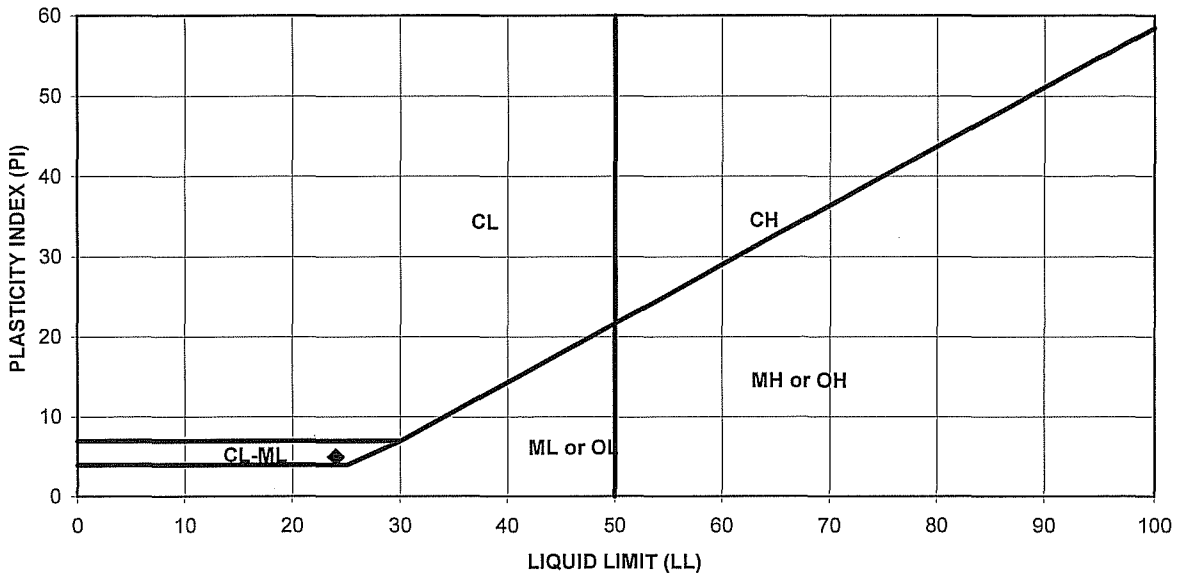
AP Engineering & Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

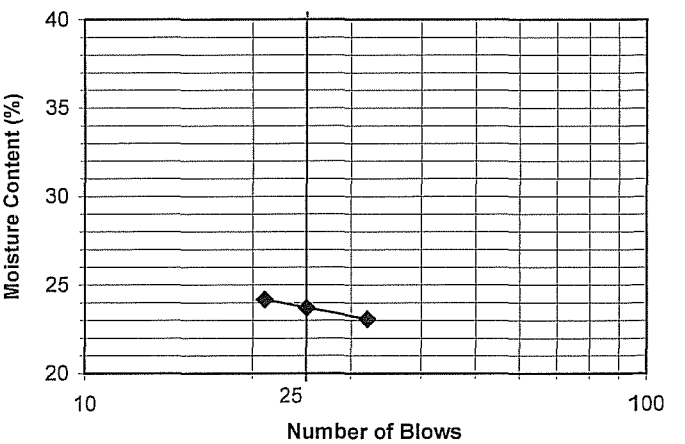
Tested By: WJO
Checked By: AP

Date: 01/05/10
Date: 01/08/10



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



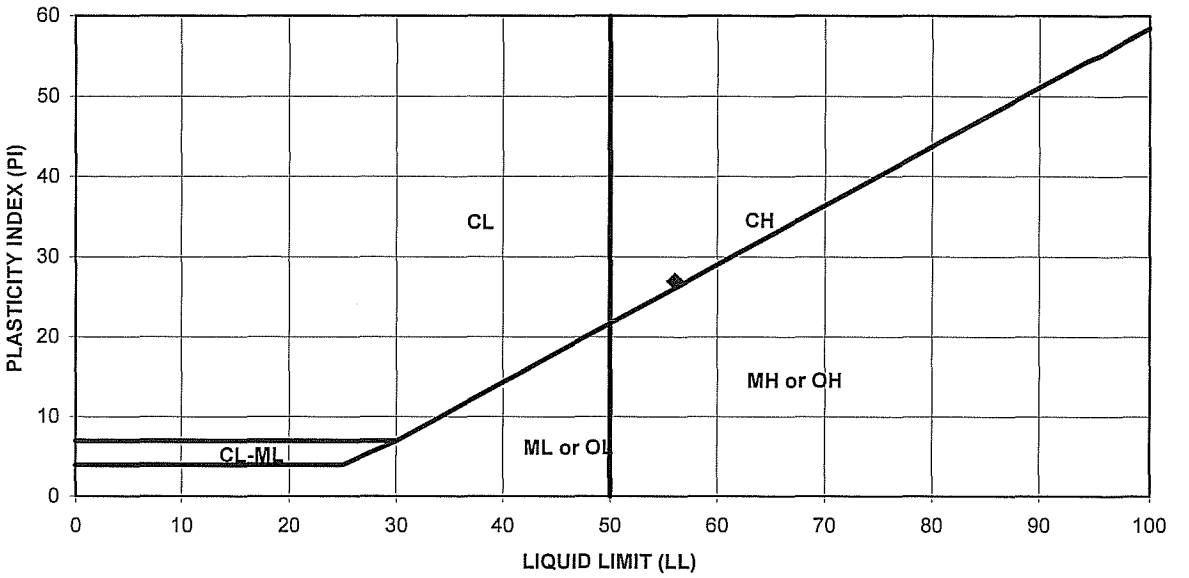
Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
◆	R-09-036	S-09	45	24	19	5	CL-ML

* NP denotes "non-plastic"

AP Engineering & Testing, Inc.

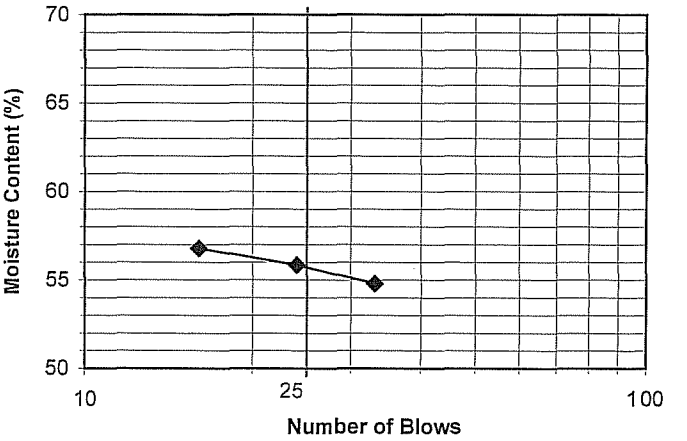
ATTERBERG LIMITS
ASTM D 4318

Project Name: ACTA Heim Bridge Replacement Tested By: DK Date: 11/24/09
Project No.: 06-123-03 Checked By: AP Date: 12/01/09



PROCEDURE USED

- [ ] Wet Preparation
- [X] Dry Preparation
- [X] Procedure A Multipoint Test
- [ ] Procedure B One-point Test



Symbol	Boring Number	Sample Number	Depth (feet)	LL	PL	PI	U.S.C.S Symbol
♦	R-09-036	D-10	50	56	29	27	CH

AP Engineering & Testing, Inc.

SPECIFIC GRAVITY

ASTM D854

AP Number: 29-1121

Client: Name: Earth Mechanics, Inc. Tested By: KM Date: 11/24/09

Project Name: ACTA Heim Bridge Replacement Data Input By: KM Date: 11/30/09

Project No. : 06-123-03 Checked By: AP Date: 11/30/09

BORING NUMBER	R-09-036					
SAMPLE NUMBER	U-05					
DEPTH (FT)	25					
SOIL CLASSIFICATION	Silt					
METHOD (A OR B)	B					
FLASK NUMBER	1					
WT. FLASK+WATER+SOIL, g	385.76					
TEMPERATURE, °C	19.5					
CORRECTION FACTOR	1.0001					
WT. DRY SOIL, g	37.81					
WT. FLASK + WATER, g	249.36					
% RETAINED #4	0.00					
% PASSING #4	100.00					
MATERIAL EXCLUDED	None					
SPECIFIC GRAVITY ($G_{S,20°C}$)	**2.68**					

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AP Engineering & Testing, Inc.

CORROSION TEST RESULTS

Client Name: Earth Mechanics, Inc.
Project Name: ACTA Heim Bridge Replacement
Project No.: 06-123-03

AP Job No.: 29-1121
Date 11/18/09

Boring No.	Sample No.	Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
R-09-036	S-03	15	ML	150	8.0	1187	12774
R-09-036	S-09	45	ML	190	7.7	680	9790

NOTES: Resistivity Test and pH: California Test Methods 532 and 643
Sulfate Content : California Test Method 417
Chloride Content : California Test Method 422
ND = Not Detectable
NA = Not Sufficient Sample
NR = Not Requested

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AP Engineering & Testing, Inc.

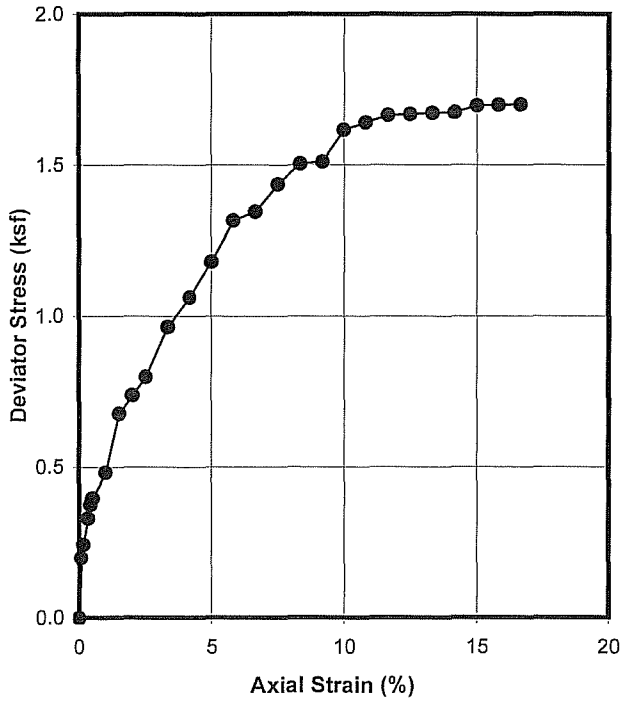
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST (UU,Q)
ASTM D 2850

Client Name:	Earth Mechanics, Inc.	Tested By:	KK Date: 11/18/09
Project Name:	ACTA Heim Bridge Replacement	Checked by:	AP Date: 12/02/09
Project No.:	06-123-03		
Boring No.:	R-09-036		
Sample No.:	U-05 Depth (feet): 25		
Soil Description	Gray Silt w/shell	Sample Type:	Shelby

Sample Diameter (inch):	2.875	Wet Unit Weight (pcf):	111.7
Sample Hieght (inch):	6.0	Dry Unit Weight (pcf):	78.6
Sample Weight (gms):	1142.84	Moisture Content (%):	42.1
Wt. Wet Soil+Container(gms)	1351.61	Void Ratio for Gs=2.7:	1.14
Wt. Dry Soil+Container(gms)	1010.90	% Saturation:	99.5
Wt. Container (gms)	202.38		

TEST DATA

Cell Pressure (ksf):	1.15
Back Pressure (ksf):	0.0
Eff. Confining Pressure (ksf):	1.15
Shear Rate (%/min):	0.3
Maximum Deviator Stress (ksf):	1.7
Ultimate Deviator Stress (ksf):	1.7
Ultimate Undrained Shear Strength (ksf):	0.8
Axial Strain @ Maximum Stress (%)	16.67



Load (lbs)	Def. (inch)	Area (sq.in)	Deviator Stress (ksf)	Axial Strain (%)
0	0.000	6.49	0.00	0.00
9	0.005	6.50	0.20	0.08
11	0.010	6.50	0.24	0.17
15	0.020	6.51	0.33	0.33
17	0.025	6.52	0.38	0.42
18	0.030	6.52	0.40	0.50
22	0.060	6.56	0.48	1.00
31	0.090	6.59	0.68	1.50
34	0.120	6.62	0.74	2.00
37	0.150	6.66	0.80	2.50
45	0.200	6.72	0.96	3.33
50	0.250	6.77	1.06	4.17
56	0.300	6.83	1.18	5.00
63	0.350	6.89	1.32	5.83
65	0.400	6.96	1.35	6.67
70	0.450	7.02	1.44	7.50
74	0.500	7.08	1.50	8.33
75	0.550	7.15	1.51	9.17
81	0.600	7.21	1.62	10.00
83	0.650	7.28	1.64	10.83
85	0.700	7.35	1.67	11.67
86	0.750	7.42	1.67	12.50
87	0.800	7.49	1.67	13.33
88	0.850	7.56	1.68	14.17
90	0.900	7.64	1.70	15.00
91	0.950	7.71	1.70	15.83
92	1.000	7.79	1.70	16.67

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 06-123-3 **Project Name :** ACTA Schuyler Heim Bridge Project

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (Kg/cm2)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil- pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-09-055	S-1	5	SP-SM	23.1				37:52:11						
A-09-055	D-2	10	0								2100	7.7	50	380
A-09-055	S-3	15	SP	24.3				0:99:1						
A-09-055	D-4	20	SP-SM	21.8	122.9									
A-09-055	S-5	25	SP	24.9				0:96:4						
A-09-055	S-7-2	35.5	CL	36.6										
A-09-055	S-9	45	CH	31.3				0:6:94		59/29/30				
A-09-055	D-10	50	CL			1.0								
A-09-055	S-11	55	ML	33.0				0:6:94		32/27/5				
A-09-055	D-12	60	ML			2.0				22/20/2				
A-09-056	S-1	5	SM					13:46:41			670	7.8	580	514
A-09-056	D-2	10	ML			<0.25				49/32/17				
A-09-056	S-3	15	CL	44.9				0:13:87		41/25/16				
A-09-056	D-4	20	SM							N.P.				
A-09-056	S-5	25	SP-SM	29.4				0:93:7						
A-09-058	S-1	5	SP					0:96:4			9300	8.6	30	248
A-09-058	S-3	15	CH	65.2				0:1:99		93/34/59				
A-09-058	S-5	25	CL	34.2				0:7:93		47/24/23				
A-09-058	D-6	30	ML			0.5								
A-09-058	S-7	35	ML	23.9						N.P.				
A-09-058	D-8	40	ML			1.5		0:26:74						
A-09-058	S-9	45	SM	29.5										
A-09-058	D-10	50	SC-SM					0:72:28						
A-09-059	S-1	5	SM					3:81:16			1300	8.1	380	542
A-09-059	S-3	15	MH	47.0				0:17:83		98/49/49				
A-09-059	S-6	30	MH	37.2				0:4:96		50/30/20				
A-09-059	S-8	40	SM	28.2				1:72:27		N.P.				
A-09-059	D-9	45	CL			0.5		0:6:94		40/24/16				
A-09-059	S-10	50	ML	37.3				0:31:69						

ATTERBERG LIMITS

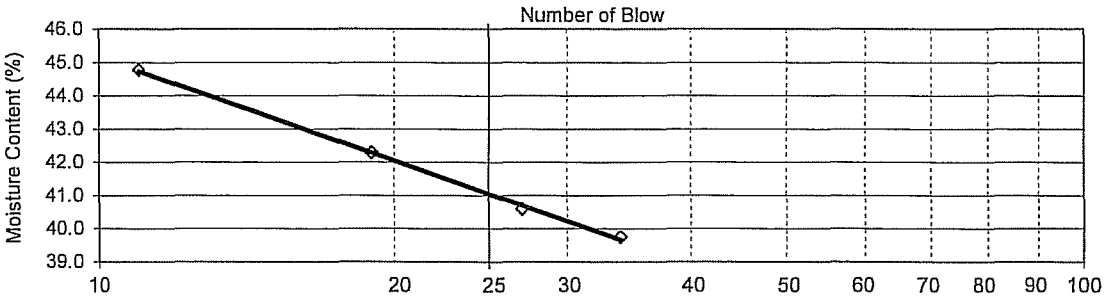
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-054	Depth (ft/m): 50 ft	15 m					1
Sample Number: D-10	Description: ML						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-2
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		34	27	19	11		
Can Number		25	26	27	28	29	30
Wt. Wet Soil +Can (gm)		43.96	47.29	46.84	46.84	35.59	34.37
Wt. Dry Soil +Can (gm)		40.06	42.63	41.69	41.49	33.90	32.62
Weight of Can (gm)		30.25	31.15	29.51	29.54	27.50	25.97
Water Content (%)		39.8	40.6	42.3	44.8	26.4	26.3

Liquid Limit (LL, %):	41	Plastic Limit (PL, %):	26	Plastic Index (PI, %):	15

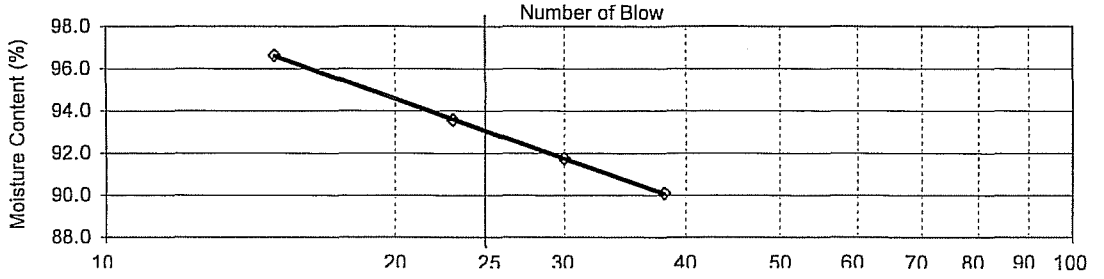


Remark:

Boring Number: A-09-058	Depth (ft/m): 15 ft	4.5 m					1
Sample Number: S-3	Description: CH						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-9
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		38	30	23	15		
Can Number		1	2	3	4	5	6
Wt. Wet Soil +Can (gm)		38.99	36.47	37.57	38.48	31.22	34.01
Wt. Dry Soil +Can (gm)		33.08	30.47	31.31	31.62	29.44	32.38
Weight of Can (gm)		26.52	23.93	24.62	24.52	24.26	27.59
Water Content (%)		90.1	91.7	93.6	96.6	34.4	34.0

Liquid Limit (LL,%)	93	Plastic Limit PL,%)	34	Plastic Index (PI,%)	59



Remark:

ATTERBERG LIMITS

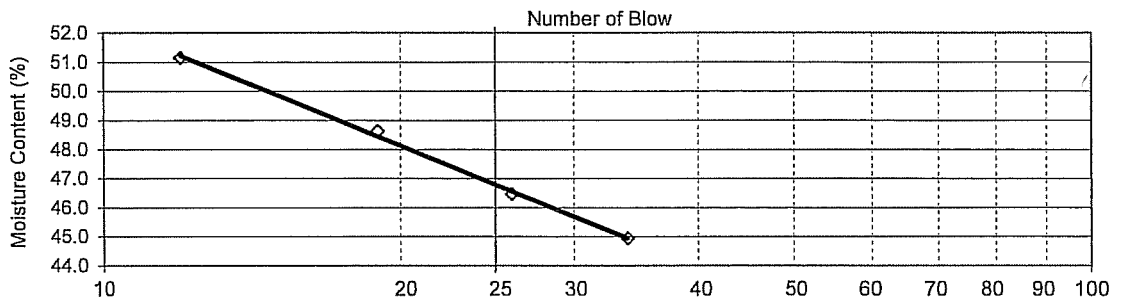
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-058	Depth (ft/m): 15 ft	4.5 m					1
Sample Number: S-5	Description: CL						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-2
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		34	26	19	12		
Can Number		13	14	15	16	17	18
Wt. Wet Soil +Can (gm)		43.50	38.34	38.46	40.16	34.03	33.30
Wt. Dry Soil +Can (gm)		38.71	33.61	33.69	34.54	32.39	31.64
Weight of Can (gm)		28.05	23.43	23.88	23.55	25.46	24.55
Water Content (%)		44.9	46.5	48.6	51.1	23.7	23.4

Liquid Limit (LL, %):	47	Plastic Limit (PL, %):	24	Plastic Index (PI, %):	23

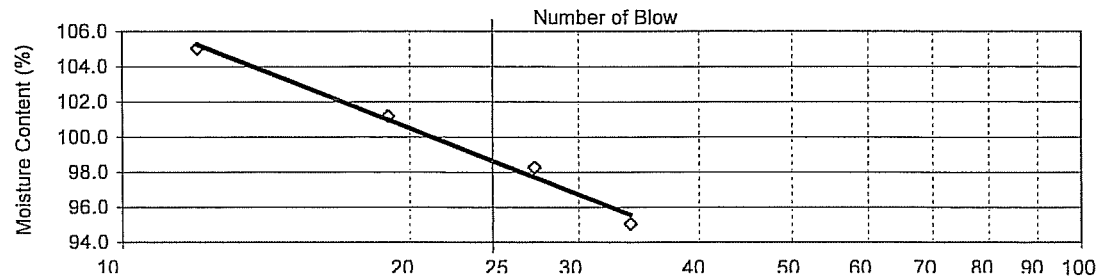


Remark:

Boring Number: A-09-059	Depth (ft/m): 15 ft	4.5 m					1
Sample Number: S-3	Description: MH						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-9
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		34	27	19	12		
Can Number		1	2	3	4	5	6
Wt. Wet Soil +Can (gm)		42.27	39.83	40.01	39.22	32.25	34.79
Wt. Dry Soil +Can (gm)		34.60	31.95	32.27	31.69	29.61	32.42
Weight of Can (gm)		26.53	23.93	24.62	24.52	24.26	27.59
Water Content (%)		95.0	98.3	101.2	105.0	49.3	49.1

Liquid Limit (LL,%)	98	Plastic Limit PL,%)	49	Plastic Index (PI,%)	49



Remark:

ATTERBERG LIMITS

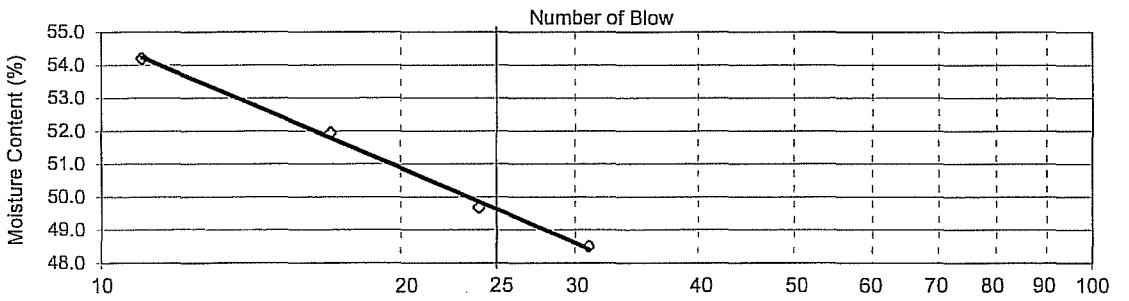
ASTM D-4318-84 / CT-204

Project No: 06-123-3 Project Name: ACTA/Schuyler Heim Bridge Project

Boring Number: A-09-059	Depth (ft/m): 30 ft	9 m					1
Sample Number: S-6	Description: MH						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-2
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		31	24	17	11		
Can Number		13	14	15	16	17	18
Wt. Wet Soil +Can (gm)		43.42	39.58	39.94	40.82	34.89	33.98
Wt. Dry Soil +Can (gm)		38.40	34.22	34.45	34.75	32.71	31.81
Weight of Can (gm)		28.05	23.43	23.88	23.55	25.46	24.55
Water Content (%)		48.5	49.7	51.9	54.2	30.1	29.9

Liquid Limit (LL, %):	50	Plastic Limit (PL, %):	30	Plastic Index (PI, %):	20

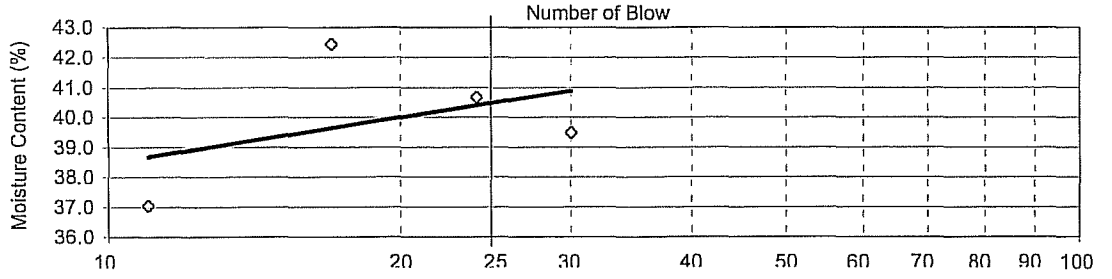


Remark:

Boring Number: A-09-059	Depth (ft/m): 45 ft	13.5 m					1
Sample Number: D-9	Description: CL						
Prepared By: PA	Date:		Checked By: R.J.			Date:	
Pulverized By: PA	Date:					Container Number	
Tested By: PA	Date:					Air:	G-9
Computed By: JF	Date:					Field:	

Trial Number	Field Moisture	1	2	3	4	Plastic Limit 1	Plastic Limit 2
Number of Blow		30	24	17	11		
Can Number		25	26	27	28	29	30
Wt. Wet Soil +Can (gm)		46.96	49.31	46.36	47.78	37.38	35.36
Wt. Dry Soil +Can (gm)		42.23	44.06	41.34	42.85	35.44	33.52
Weight of Can (gm)		30.25	31.15	29.51	29.54	27.50	25.97
Water Content (%)		39.5	40.7	42.4	37.0	24.4	24.4

Liquid Limit (LL,%)	40	Plastic Limit PL,%)	24	Plastic Index (PI,%)	16



Remark:

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-056	**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**		
Sample No.	: S-1	**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**			
Depth (ft)	: 5.0	**Tested By :** PA	**Date :**	**13**	**46**	**41**	3/8"		
Depth (m)	: 1.53	**Checked By :**	**Date :**						
Description	: Olive, SILTY SAND (SM)			**Sample**		**Retained On**			
X	**Method (A)** - Soaked by Water					**No. 200**	**No. 4**		
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)			**Tested**	**Moisture**	**Sieve**			
Container Number				S-5	S-5	S-5	S-5		
Wet Weight of Soil + Container (gm)				308.92	308.92				
Dry Weight of Soil + Container (gm)					282.16	214.06			
Weight of Container (gm)				117.80	117.8	117.8			
Weight of Dry Soil (gm)				164.36	164.36	96.26	22.15		
Moisture Content (%)					16.28				
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						41.43	13.48		
Remark :									1

Boring No.	: A-09-056	**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**		
Sample No.	: S-5	**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**			
Depth (ft)	: 25.0	**Tested By :** PA	**Date :**	**0**	**93**	**7**	#30		
Depth (m)	:	**Checked By :**	**Date :**						
Description	: Olive-gray, Poorly graded SAND with SILT (SP-SM)			**Sample**		**Retained On**			
	Method (A) - Soaked by Water					**No. 200**	**No. 4**		
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)			**Tested**	**Moisture**	**Sieve**			
Container Number				S-6	S-6	S-6	S-6		
Wet Weight of Soil + Container (gm)				365.39	365.39				
Dry Weight of Soil + Container (gm)					308.86	295.04			
Weight of Container (gm)				116.77	116.77	116.77			
Weight of Dry Soil (gm)				192.09	192.09	178.27	0.00		
Moisture Content (%)					29.43				
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						7.19	0.00		
Remark :									2

Boring No.	: A-09-058	**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum Size**		
Sample No.	: S-1	**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**			
Depth (ft)	: 25.0	**Tested By :** PA	**Date :**	**0**	**96**	**4**	#10		
Depth (m)	: 7.63	**Checked By :**	**Date :**						
Description	: Olive-gray, Poorly graded SAND (SP)			**Sample**		**Retained On**			
	Method (A) - Soaked by Water					**No. 200**	**No. 4**		
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)			**Tested**	**Moisture**	**Sieve**			
Container Number				S-8	S-8	S-8	S-8		
Wet Weight of Soil + Container (gm)				358.92	358.92				
Dry Weight of Soil + Container (gm)					351.07	341.94			
Weight of Container (gm)				118.29	118.29	118.29			
Weight of Dry Soil (gm)				232.78	232.78	223.65	0.00		
Moisture Content (%)					3.37				
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						3.92	0.00		
Remark :									3

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name** : ACTA/Schuyler Heim Bridge Project

Boring No.	: A-09-058	Prepared By : PA	Date :	Percentage of			Maximum Size	
Sample No.	: D-8	Washed By : PA	Date :	Gravel	Sand	Fine		
Depth (ft)	: 40.0	Tested By : PA	Date :	0	26	74	#40	
Depth (m)	: 12.20	Checked By :	Date :					
Description	: Dark olive-gray, SILT with SAND (ML)			Sample		Retained On		
X	Method (A) - Soaked by Water					No. 200	No. 4	
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)			Tested	Moisture	Sieve		
Container Number				S-22	S-22	S-22	S-22	
Wet Weight of Soil + Container (gm)				261.42	261.42			
Dry Weight of Soil + Container (gm)					226.09	143.5		
Weight of Container (gm)				115.19	115.19	115.19		
Weight of Dry Soil (gm)				110.9	110.9	28.31	0.00	
Moisture Content (%)					31.86			
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						74.47	0.00	
Remark :								1

Boring No.	: A-09-059	Prepared By : PA	Date :	Percentage of			Maximum Size	
Sample No.	: S-1	Washed By : PA	Date :	Gravel	Sand	Fine		
Depth (ft)	: 5.0	Tested By : PA	Date :	3	81	16	1/2"	
Depth (m)	:	Checked By :	Date :					
Description	: Olive-brown, SILTY SAND (SM)			Sample		Retained On		
	Method (A) - Soaked by Water					No. 200	No. 4	
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)			Tested	Moisture	Sieve		
Container Number				S-23	S-23	S-23	S-23	
Wet Weight of Soil + Container (gm)				331.49	331.49			
Dry Weight of Soil + Container (gm)					322.28	289.74		
Weight of Container (gm)				113.82	113.82	113.82		
Weight of Dry Soil (gm)				208.46	208.46	175.92	5.25	
Moisture Content (%)					4.42			
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						15.61	2.52	
Remark :								2

Boring No.	: A-058	Prepared By : PA	Date :	Percentage of			Maximum Size	
Sample No.	: D-10	Washed By : PA	Date :	Gravel	Sand	Fine		
Depth (ft)	: 50.0	Tested By : PA	Date :	0	72	28	#40	
Depth (m)	: 15.25	Checked By :	Date :					
Description	: Dark gray, SILTY CLAYEY SAND (SC-SM)			Sample		Retained On		
	Method (A) - Soaked by Water					No. 200	No. 4	
	Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)			Tested	Moisture	Sieve		
Container Number				S-13	S-13	S-13	S-13	
Wet Weight of Soil + Container (gm)				264.26	264.26			
Dry Weight of Soil + Container (gm)					233.18	199.92		
Weight of Container (gm)				113.62	113.62	113.62		
Weight of Dry Soil (gm)				119.56	119.56	86.3	0.00	
Moisture Content (%)					26.00			
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						27.82	0.00	
Remark :								3

Amount of Material in Soil Finer Than No. 200 Sieve
(ASTM D-1140-97)

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. : A-09-059		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum**
Sample No. : S-10		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	**Size**
Depth (ft) : 50.0		**Tested By :** PA	**Date :**	**0**	**31**	**69**	#40
Depth (m) : 15.25		**Checked By :**	**Date :**				
Description : Dark olive-gray, SANDY lean CLAY (CL)				**Sample**		**Retained On**	
X **Method (A)** - Soaked by Water						**No. 200**	**No. 4**
Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number				S-24	S-24	S-24	S-24
Wet Weight of Soil + Container (gm)				348.65	348.65		
Dry Weight of Soil + Container (gm)					284.67	165.52	
Weight of Container (gm)				113.10	113.1	113.1	
Weight of Dry Soil (gm)				171.57	171.57	52.42	0.00
Moisture Content (%)					37.29		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						69.45	0.00
Remark :							1

Boring No. : A-09-059		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum**
Sample No. : D-9		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	**Size**
Depth (ft) : 45.0		**Tested By :** PA	**Date :**	**0**	**6**	**94**	1/2"
Depth (m) :		**Checked By :**	**Date :**				
Description : Dark gray, SILT (ML)				**Sample**		**Retained On**	
Method (A) - Soaked by Water						**No. 200**	**No. 4**
Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number				S-16	S-16	S-16	S-16
Wet Weight of Soil + Container (gm)				258.23	258.23		
Dry Weight of Soil + Container (gm)					221.97	120.2	
Weight of Container (gm)				114.22	114.22	114.22	
Weight of Dry Soil (gm)				107.75	107.75	5.98	0.00
Moisture Content (%)					33.65		
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve						94.45	0.00
Remark :							2

Boring No. :		**Prepared By :** PA	**Date :**	**Percentage of**			**Maximum**
Sample No. :		**Washed By :** PA	**Date :**	**Gravel**	**Sand**	**Fine**	**Size**
Depth (ft) :		**Tested By :** PA	**Date :**				#40
Depth (m) :		**Checked By :**	**Date :**				
Description :				**Sample**		**Retained On**	
Method (A) - Soaked by Water						**No. 200**	**No. 4**
Method (B) - Soaked by Deflocculating Agent (Minimum 2 Hours)				**Tested**	**Moisture**	**Sieve**	
Container Number							
Wet Weight of Soil + Container (gm)							
Dry Weight of Soil + Container (gm)							
Weight of Container (gm)							
Weight of Dry Soil (gm)							
Moisture Content (%)							
(%) of Soil Passing No. 200 Sieve and Retained on No. 4 Sieve							
Remark :							3

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-058	Prepared By : PA	Date :
Sample No.	: S-3	Tested By : PA	Date :
Depth below Deck	: 15.0	Sieved By : RJ	Date :
Description	: darkolive-gray, Fat CLAY (CH)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

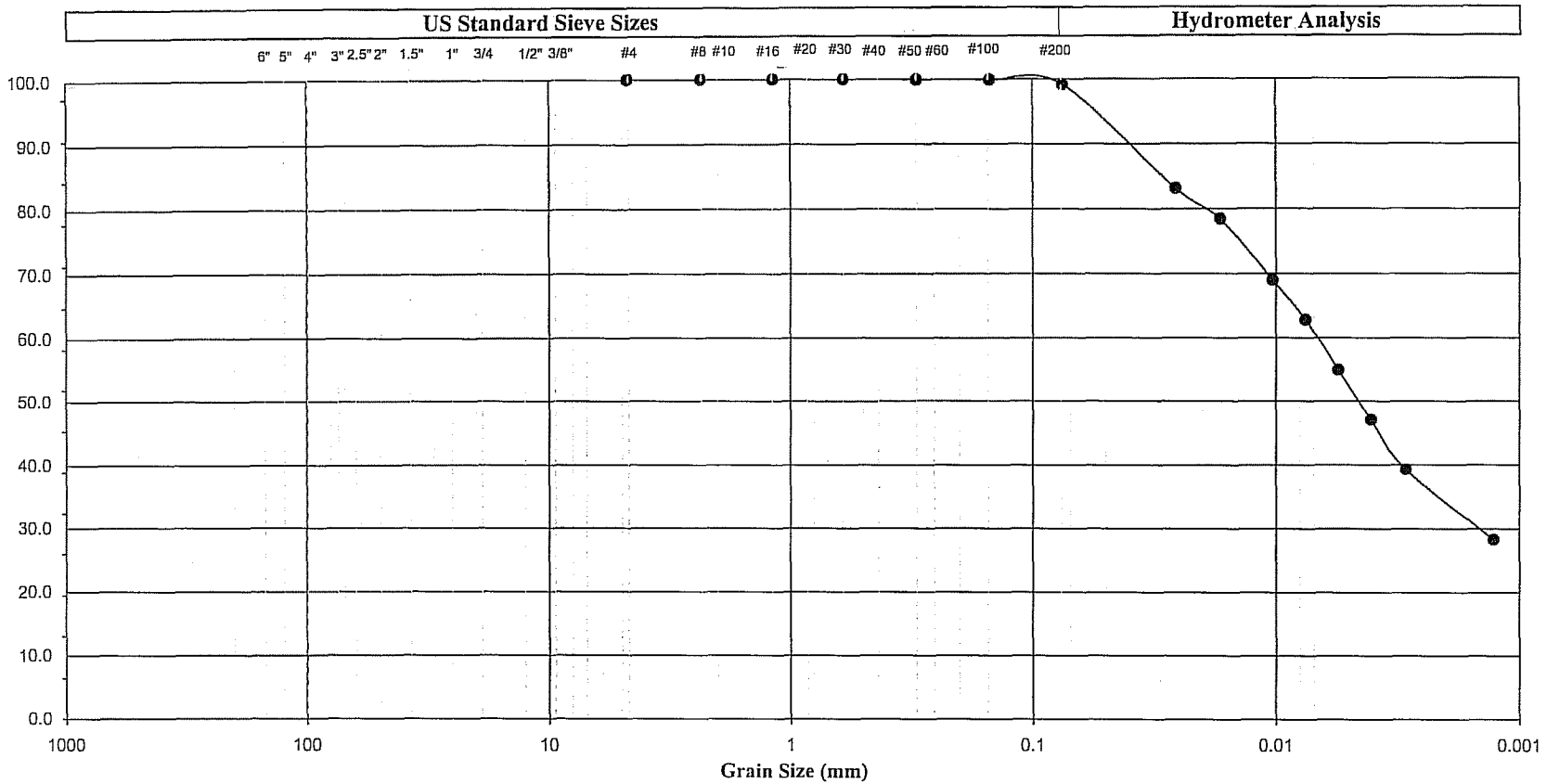
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-17	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	8	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-26		S-17	74		S-29		
Wt. of Wet Soil + Container (gm)		197.22		64.20	123.39			0.99	
Wt. of Dry Soil + Container (gm)					122.31		112.98	Hydrometer Type	
Wt. of Container (gm)					59.31		112.39	152H	
Wt. of Dry Soil (gm)		193.90		63.12			0.59	(K) Value	Temp. °C
Moisture Content (%)					1.71			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				93	No. 16	0.00		100.00	100.00
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.00		100.00	100.00
1.0"					No. 40				
3/4"				34	No. 50	0.05		99.92	99.92
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.10		99.84	99.84
No. 4	0.00		100.00		No. 140				
No. 8	0.00		100.00	59	No. 200	0.56		99.11	99.11
No. 10					Pan	0.61			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / W	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
13:34	0:00:00			6.0							
	2	21.0	59.0	6.0	53.0	83.13	83.13	0.05500	0.01328	7.6	0.02590
	5	21.0	56.0	6.0	50.0	78.42	78.42	0.03500	0.01328	8.1	0.01690
	15	21.0	50.0	6.0	44.0	69.01	69.01	0.02000	0.01328	9.1	0.01033
	30	21.0	46.0	6.0	40.0	62.74	62.74	0.01400	0.01328	9.7	0.00757
	60	21.0	41.0	6.0	35.0	54.90	54.90	0.01000	0.01328	10.6	0.00557
	120	21.5	36.0	6.0	30.0	47.05	47.05	0.00700	0.01328	11.4	0.00409
	240	22.0	31.0	6.0	25.0	39.21	39.21	0.00500	0.01328	12.2	0.00293
	1440	21.5	24.0	6.0	18.0	28.23	28.23	0.00100	0.01328	13.3	0.00128

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	0	1	99



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-058	S-3	15.0	dark olive-gray	Fat clay	CH
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: ACTA/Schuyler Heim Bridge Project		
Project No.	: 06-123-3	Tested Standard : ☐ ASTM ☑	CAL. TRANS.

Boring No.	: A-09-058	Prepared By : PA	Date :
Sample No.	: S-5	Tested By : PA	Date :
Depth below Deck	: 25.0	Sieved By : RJ	Date :
Description	: dark olive-gray, Lean CLAY (CL)	Calculated By : JF	Date : 12/07/09
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		Checked By: R.J.	Date :

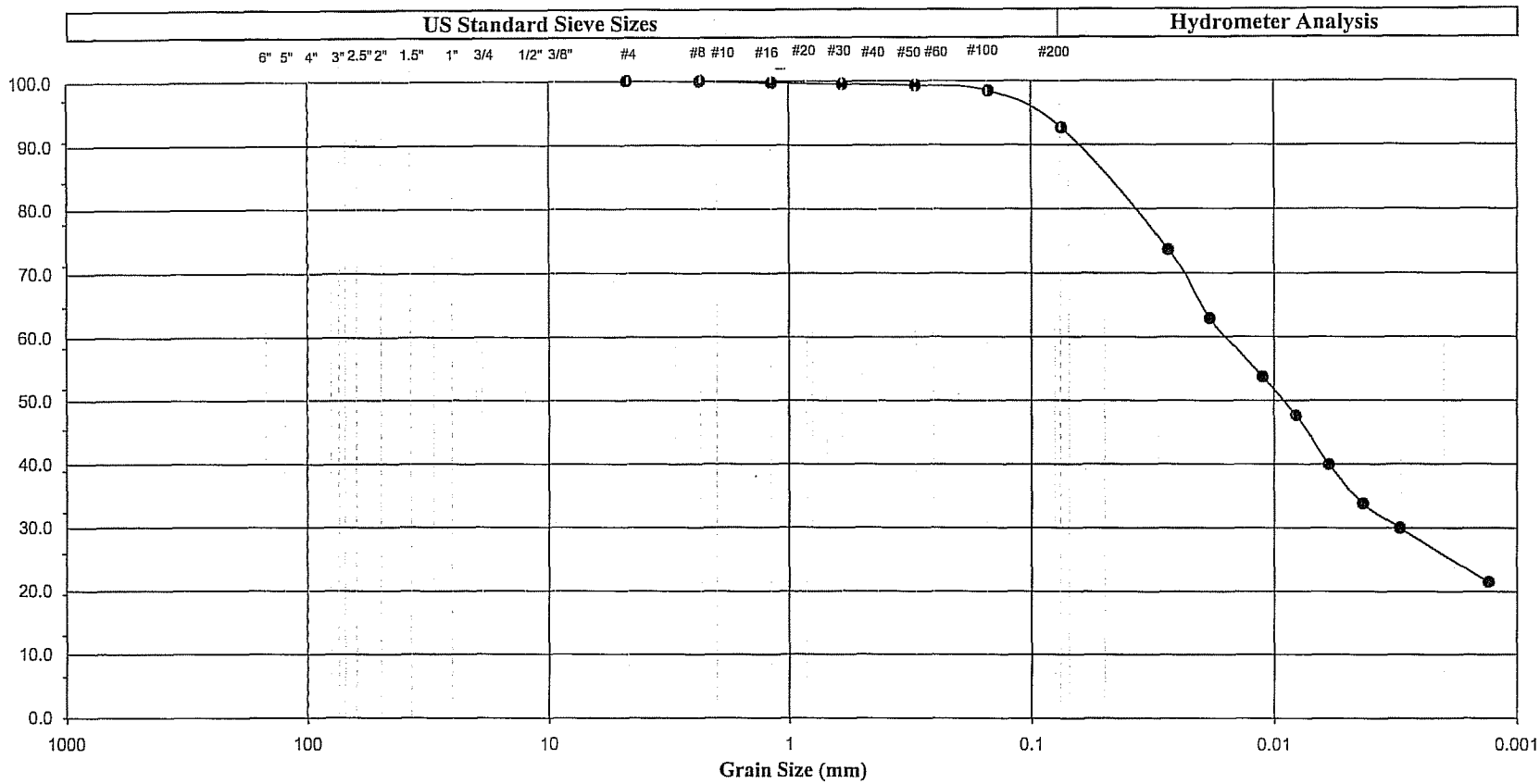
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	S-2	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	1	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	2.70	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		S-26		S-2	75		S-30		
Wt. of Wet Soil + Container (gm)		191.69		65.42	121.47			0.99	
Wt. of Dry Soil + Container (gm)					120.62		119.46	Hydrometer Type	
Wt. of Container (gm)					60.09		114.29	152H	
Wt. of Dry Soil (gm)		189.04		64.51			5.17	(K) Value	Temp. °C
Moisture Content (%)					1.40			0.01328	21.0

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				47	No. 16	0.17		99.74	99.74
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	0.31		99.52	99.52
1.0"					No. 40				
3/4"				24	No. 50	0.44		99.32	99.32
1/2"					No. 60				
3/8"				Plastic Index	No. 100	0.99		98.47	98.47
No. 4	0.00		100.00		No. 140				
No. 8	0.02		99.97	23	No. 200	4.71		92.70	92.70
No. 10					Pan	5.16			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / W	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
0:01	(T)		Orginal	Composite Correction	Correction (R)			(mm)	(K)	(L)	(D)
13:38	0:00:00			6.0							
	2	21.0	54.0	6.0	48.0	73.66	73.66	0.05500	0.01328	8.4	0.02726
	5	21.0	47.0	6.0	41.0	62.92	62.92	0.03500	0.01328	9.6	0.01838
	15	21.0	41.0	6.0	35.0	53.71	53.71	0.02000	0.01328	10.6	0.01114
	30	21.0	37.0	6.0	31.0	47.57	47.57	0.01400	0.01328	11.2	0.00812
	60	21.0	32.0	6.0	26.0	39.90	39.90	0.01000	0.01328	12.0	0.00595
	120	21.5	28.0	6.0	22.0	33.76	33.76	0.00700	0.01328	12.7	0.00432
	240	22.0	25.5	6.0	19.5	29.92	29.92	0.00500	0.01328	13.1	0.00304
	1440	21.5	20.0	6.0	14.0	21.48	21.48	0.00100	0.01328	14.0	0.00131

Remark :	above #30 are shell fragments	Cu :	Gravel	Sand	Fine
		Cc :	0	7	93



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-058	S-5	25.0	dark olive-gray	Lean clay	CL
Remark	above #30 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 Date : 12/07/09

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *A-09-059*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-3*	**Tested By :** *PA*	**Date :**
Depth below Deck	: *15.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark olive-gray, Elastic SILT with SAND (MH)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

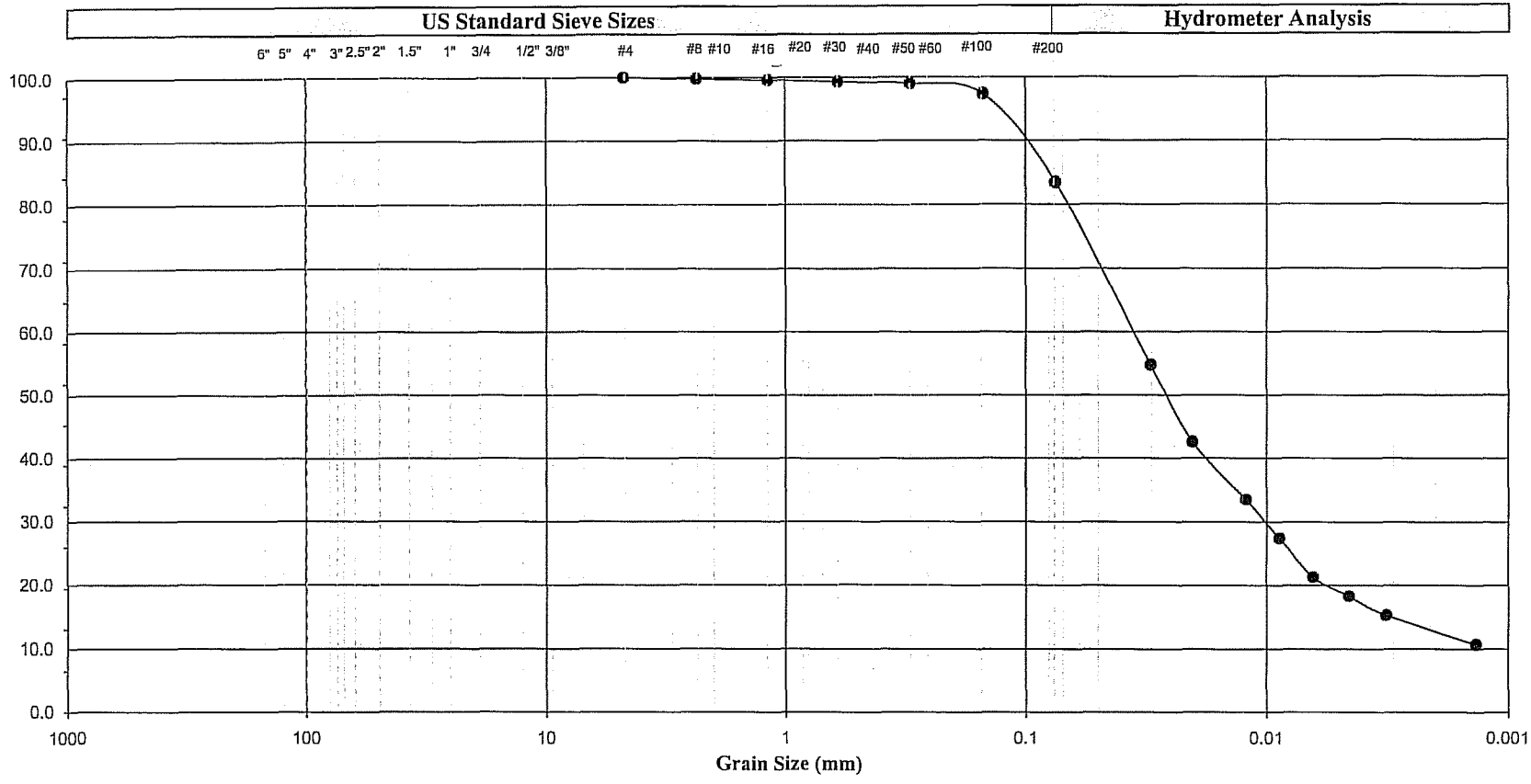
Sample for Hydrometer should passing (No.10-ASTM) & (No.4-Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

Setup Container No. :	*J-4*	Sample Before Washing				After Washing		Specific Gravity	
Test Cylinder No. :	*2*	No. 8 & 10 Retained		Hydrometer		Retained	Hydrometer	*2.70*	
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		*S-26*		*J-4*	*76*		*S-1*		
Wt. of Wet Soil + Container (gm)		*226.43*		*65.84*	*126.75*			*0.99*	
Wt. of Dry Soil + Container (gm)					*126.09*		*132.04*	Hydrometer Type	
Wt. of Container (gm)					*59.80*		*118.79*	*152H*	
Wt. of Dry Soil (gm)		*224.20*		*65.19*			*13.25*	(K) Value	Temp. °C
Moisture Content (%)					*1.00*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				***98***	No. 16	*0.26*		*99.60*	***99.60***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*0.46*		*99.29*	***99.29***
1.0"					No. 40				
3/4"				***49***	No. 50	*0.67*		*98.97*	***98.97***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*1.71*		*97.38*	***97.38***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*0.16*		***99.75***	***49***	No. 200	*10.85*		*83.36*	***83.36***
No. 10					Pan	*13.25*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / W	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01	(T)							(mm)			(D)
13:42	*0:00:00*			*6.0*							
	2	*21.0*	*42.0*	*6.0*	*36.0*	*54.67*	***54.67***	*0.05500*	*0.01328*	*10.4*	***0.03027***
	5	*21.0*	*34.0*	*6.0*	*28.0*	*42.52*	***42.52***	*0.03500*	*0.01328*	*11.7*	***0.02032***
	15	*21.0*	*28.0*	*6.0*	*22.0*	*33.41*	***33.41***	*0.02000*	*0.01328*	*12.7*	***0.01222***
	30	*21.0*	*24.0*	*6.0*	*18.0*	*27.34*	***27.34***	*0.01400*	*0.01328*	*13.3*	***0.00886***
	60	*21.0*	*20.0*	*6.0*	*14.0*	*21.26*	***21.26***	*0.01000*	*0.01328*	*14.0*	***0.00642***
	120	*21.5*	*18.0*	*6.0*	*12.0*	*18.22*	***18.22***	*0.00700*	*0.01328*	*14.3*	***0.00459***
	240	*22.0*	*16.0*	*6.0*	*10.0*	*15.19*	***15.19***	*0.00500*	*0.01328*	*14.7*	***0.00322***
	1440	*21.5*	*13.0*	*6.0*	*7.0*	*10.63*	***10.63***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***0***	***17***	***83***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-059	S-3	15.0	dark olive-gray	Elastic silt with sand	MH
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑	CAL. TRANS.

Boring No.	: *A-09-059*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-6*	**Tested By :** *PA*	**Date :**
Depth below Deck	: *30.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark olive-gray, Elastic SILT (MH)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

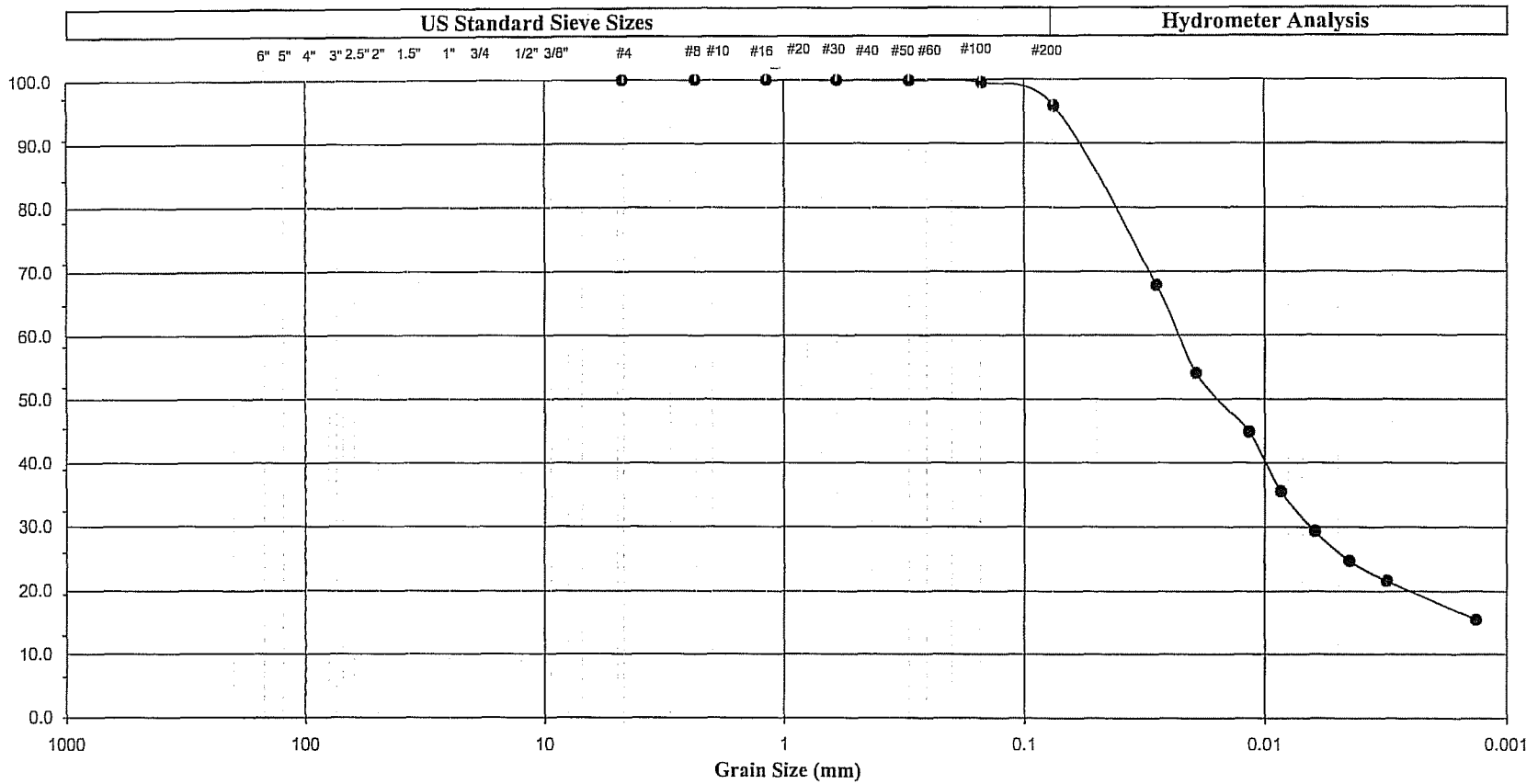
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*S-19*							*2.70*	
Test Cylinder No. :	*6*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**		
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*S-26*		*S-19*	*77*		*S-2*		
Wt. of Wet Soil + Container (gm)		*228.47*		*65.19*	*125.48*			*0.99*	
Wt. of Dry Soil + Container (gm)					*124.44*		*120.50*	**Hydrometer Type**	
Wt. of Container (gm)					*59.10*		*116.88*	*152H*	
Wt. of Dry Soil (gm)		*224.89*		*64.17*			*3.62*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*1.59*			*0.01328*	*21.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"					No. 16	*0.04*		*99.94*	***99.94***
2.0"				***50***	No. 20				
1.5"					No. 30	*0.06*		*99.91*	***99.91***
1.0"				**Plastic Limit**	No. 40				
3/4"					No. 50	*0.11*		*99.83*	***99.83***
1/2"				***30***	No. 60				
3/8"					No. 100	*0.34*		*99.47*	***99.47***
No. 4	*0.00*		***100.00***	**Plastic Index**	No. 140				
No. 8	*0.00*		***100.00***		No. 200	*2.65*		*95.87*	***95.87***
No. 10				***20***	Pan	*3.63*			

Obersved Time	EL. Time (min.)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
0:01	(T)							(mm)			(D)
13:46	*0:00:00*			*6.0*							
	2	*21.0*	*50.0*	*6.0*	*44.0*	*67.88*	***67.88***	*0.05500*	*0.01328*	*9.1*	***0.02830***
	5	*21.0*	*41.0*	*6.0*	*35.0*	*54.00*	***54.00***	*0.03500*	*0.01328*	*10.6*	***0.01930***
	15	*21.0*	*35.0*	*6.0*	*29.0*	*44.74*	***44.74***	*0.02000*	*0.01328*	*11.5*	***0.01165***
	30	*21.0*	*29.0*	*6.0*	*23.0*	*35.48*	***35.48***	*0.01400*	*0.01328*	*12.5*	***0.00858***
	60	*21.0*	*25.0*	*6.0*	*19.0*	*29.31*	***29.31***	*0.01000*	*0.01328*	*13.2*	***0.00622***
	120	*21.5*	*22.0*	*6.0*	*16.0*	*24.68*	***24.68***	*0.00700*	*0.01328*	*13.7*	***0.00448***
	240	*22.0*	*20.0*	*6.0*	*14.0*	*21.60*	***21.60***	*0.00500*	*0.01328*	*14.0*	***0.00314***
	1440	*21.5*	*16.0*	*6.0*	*10.0*	*15.43*	***15.43***	*0.00100*	*0.01328*	*14.7*	***0.00134***

Remark :		Cu :	Gravel	Sand	Fine
		Cc :	***0***	***4***	***96***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-059	S-6	30.0	dark olive-gray	Elastic silt	MH
Remark	0.00					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *ACTA/Schuyler Heim Bridge Project*		
Project No.	: *06-123-3*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	

Boring No.	: *A-09-059*	**Prepared By :** *PA*	**Date :**
Sample No.	: *S-8*	**Tested By :** *PA*	**Date :**
Depth below Decl	: *40.0*	**Sieved By :** *RJ*	**Date :**
Description	: *dark greenish gray, SILTY SAND (SM)*	**Calculated By :** *JF*	**Date :** *12/07/09*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:** *R.J.*	**Date :**

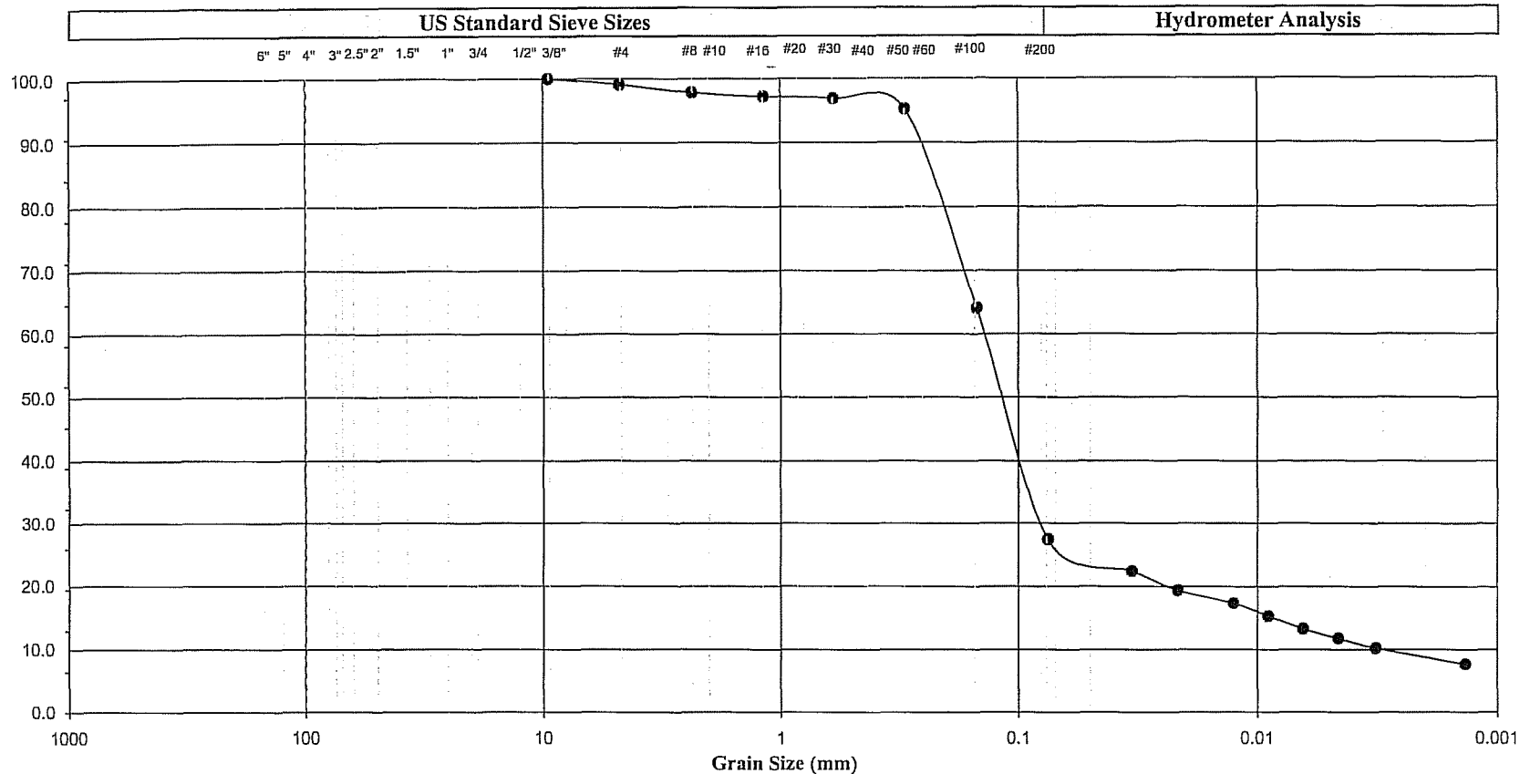
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. *1*

Setup Container No. :	*J-13*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*4*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-26*		*J-13*	*78*		*S-3*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*255.53*		*97.03*	*209.35*			*0.99*	
Wt. of Dry Soil + Container (gm)					*208.37*		*189.52*	**Hydrometer Type**	
Wt. of Container (gm)					*58.94*		*118.19*	*152H*	
Wt. of Dry Soil (gm)		*253.87*		*96.40*			*71.33*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*0.66*			*0.01328*	*21.0*

U.S. Sieve Size	**Cumulative Wt. of Dry Soil (gm)**	**Wt. of Dry Soil (gm)**	**% Finer Than**	**Liquid Limit**	**U.S. Sieve Size**	**Cumulative Weight of Dry Soil (gm)**	**Wt. of Dry Soil (gm)**	**% Finer Than**	**% Total Sample**
2.5"				-	**No. 16**	*1.79*		*98.14*	***97.27***
2.0"					**No. 20**				
1.5"				**Plastic Limit**	**No. 30**	*2.14*		*97.78*	***96.91***
1.0"					**No. 40**				
3/4"				-	**No. 50**	*3.73*		*96.13*	***95.28***
1/2"					**No. 60**				
3/8"	*0.00*		***100.00***	**Plastic Index**	**No. 100**	*34.09*		*64.64*	***64.06***
No. 4	*2.25*		***99.11***		**No. 140**				
No. 8	*1.21*		***97.87***	-	**No. 200**	*69.74*		*27.65*	***27.41***
No. 10					**Pan**	*71.27*			

Obersved Time	**EL. Time (min.)**	**Temp. (oC)**	**Hydrometer Reading**			**100 Ra**	**% Total Sample**	**Grain Diameter**	**Correction Coefficient**		**Correction Dia. (mm)**
			Orginal	**Composite Correction**	**Correction (R)**	**W**		**(mm)**	**(K)**	**(L)**	**(D)**
13:50	*0:00:00*			*6.0*							
0:01	*2*	*21.0*	*28.0*	*6.0*	*22.0*	*22.59*	***22.39***	*0.05500*	*0.01328*	*12.7*	***0.03345***
	5	*21.0*	*25.0*	*6.0*	*19.0*	*19.51*	***19.34***	*0.03500*	*0.01328*	*13.2*	***0.02156***
	15	*21.0*	*23.0*	*6.0*	*17.0*	*17.46*	***17.30***	*0.02000*	*0.01328*	*13.5*	***0.01260***
	30	*21.0*	*21.0*	*6.0*	*15.0*	*15.40*	***15.27***	*0.01400*	*0.01328*	*13.8*	***0.00902***
	60	*21.0*	*19.0*	*6.0*	*13.0*	*13.35*	***13.23***	*0.01000*	*0.01328*	*14.2*	***0.00645***
	120	*21.5*	*17.5*	*6.0*	*11.5*	*11.81*	***11.71***	*0.00700*	*0.01328*	*14.4*	***0.00460***
	240	*22.0*	*16.0*	*6.0*	*10.0*	*10.27*	***10.18***	*0.00500*	*0.01328*	*14.7*	***0.00322***
	1440	*21.5*	*13.5*	*6.0*	*7.5*	*7.70*	***7.63***	*0.00100*	*0.01328*	*15.1*	***0.00136***

Remark :	*Above #30 are shell fragments*	**Cu :** *45.9*	**Gravel**	**Sand**	**Fine**
		Cc : *14.8*	***1***	***72***	***27***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)	Soil Color	Soil Description	U.S.C.S.
●	A-09-059	S-8	40.0	dark greenish gray	Silty sand	SM
Remark	Above #30 are shell fragments					

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

Project No. : *06-123-3*

Date : *12/07/09*

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 4

Project Name : ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 | Set up By : J.F | Date : 12/3/2009

Boring No. : A-09-058 | Tested By : J.F/R.J. | Date : 12/3/09-12/13/09

Sample No. : D-4 | Time Rate Took By : J.F | Date : 12/6/09, 12/8/09

Depth (ft / m) : 20.0 | 6.10 | Computer By : JF | Date : 12/9/2009

File No. : | Checked By : R.J. | Date :

Soil Description : Dark gray, SANDY SILT (ML)

Method (A) : ☑ Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : ☐ Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9565	24.30	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

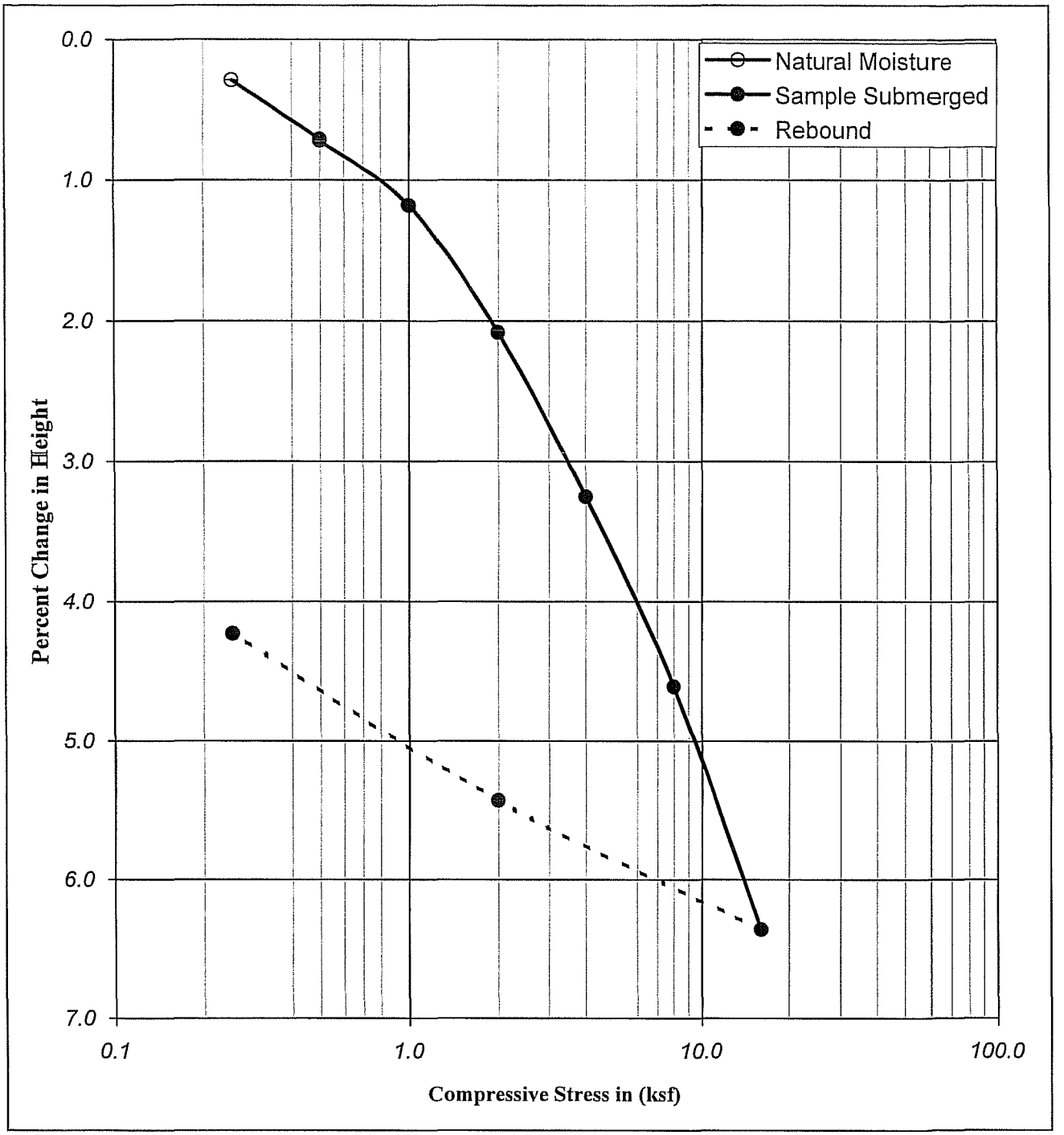
		Before	After
Weight of wet soil + ring (gm)		187.21	
Weight of ring (gm)		44.00	
Weight of wet soil + ring + container (gm)			244.97
Weight of dry soil + ring + container (gm)			210.28
No. 85 — Weight of container (gm)			59.31
Weight of ring + container (gm)			103.31
Moisture Content (%)		33.88	32.43
Dial Reading (inch)		0.05	0.04
Sample Volume (ft^3)		0.0027	0.0025
Wet Density (pcf)		118.6	122.7
Dry Density (pcf)		88.60	92.62

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04880	1.24		
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	
12/4/2009	8:10	0:00:00	0.25	12.0	0.05290	1.34	0.29	
12/5/2009	9:44	0:00:00	0.50	23.9	0.05710	1.45	0.71	
			Add Water					
12/6/2009	8:40	0:00:00	0.50	23.9	0.05720	1.45	0.72	
12/6/2009	8:43	0:00:00	1.00	47.9	0.05720	1.45	0.72	0.00
		0.10	1.0	47.9	0.05970	1.52	0.97	0.32
		0.25	1.0	47.9	0.05990	1.52	0.99	0.50
		0.50	1.0	47.9	0.0600	1.52	1.00	0.71
		1	1.0	47.9	0.06020	1.53	1.02	1.00
		2	1.0	47.9	0.06030	1.53	1.03	1.41
		4	1.0	47.9	0.06040	1.53	1.04	2.00
		8	1.0	47.9	0.06060	1.54	1.06	2.83
		15	1.0	47.9	0.06085	1.55	1.08	3.87
		30	1.0	47.9	0.06090	1.55	1.09	5.48
		60	1.0	47.9	0.06100	1.55	1.10	7.75
		120	1.0	47.9	0.06120	1.55	1.12	10.95
		240	1.0	47.9	0.06140	1.56	1.14	15.49
		480	1.0	47.9	0.06150	1.56	1.15	21.91
12/7/2009		1440	1.0	47.9	0.06180	1.57	1.18	37.95
12/8/2009	8:28	0	2.0	95.8	0.07080	1.80	2.08	
12/8/2009	8:29	0	4.0	191.5	0.0708	1.80	2.08	
		0.10	4.0	191.5	0.0785	1.99	2.85	
		0.25	4.0	191.5	0.0787	2.00	2.87	
		0.50	4.0	191.5	0.0790	2.01	2.90	
		1	4.0	191.5	0.0791	2.01	2.91	
		2	4.0	191.5	0.0794	2.02	2.94	
		4	4.0	191.5	0.0797	2.02	2.97	
		8	4.0	191.5	0.0801	2.03	3.01	
		15	4.0	191.5	0.0803	2.04	3.03	
		30	4.0	191.5	0.0806	2.05	3.06	
		60	4.0	191.5	0.0809	2.05	3.09	
		120	4.0	191.5	0.0812	2.06	3.12	
		240	4.0	191.5	0.0816	2.07	3.16	
		480	4.0	191.5	0.0822	2.09	3.22	
12/09/09		1440	4.0	191.5	0.0825	2.10	3.25	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.0961	2.44	4.61
12/11/2009	8:23		16.00	766.1	0.1136	2.89	6.36
12/12/2009	8:40		2.00	95.8	0.1043	2.65	5.43
12/13/2009	9:15		0.25	12.0	0.0923	2.34	4.23

Remark

Final Dial Reading 0.0923



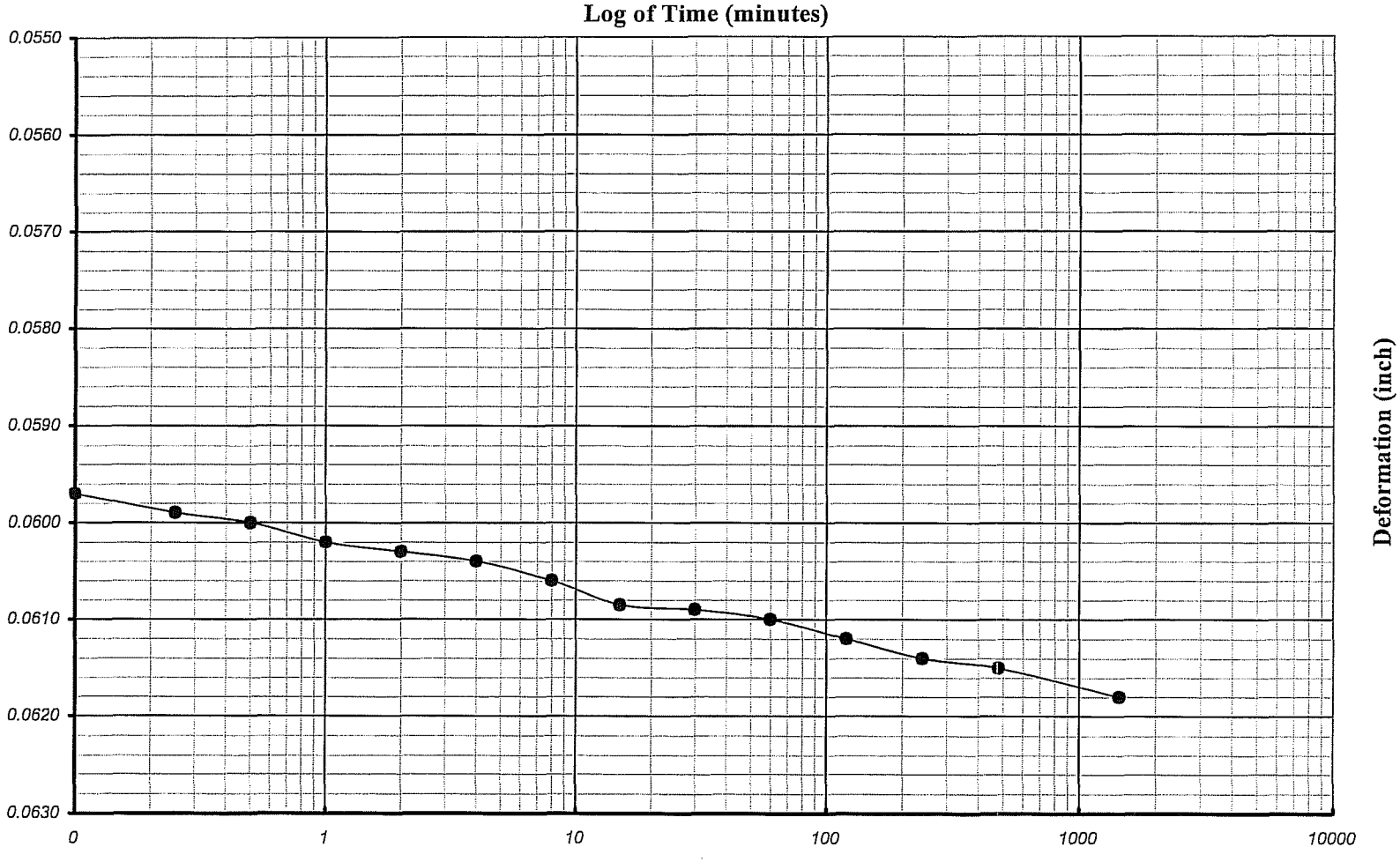
Boring No.	: A-09-058		Liquid Limit :	-		Moisture Content (%)	Dry Density		Percent Saturation	Void Ratio
Sample No.	: D-4		Plastic Limit :	-			(pcf)	(kN/m³)		
Depth (ft)	: 20.0	21.5	Plastic Index :	-	Initial	33.88	88.60	13.94	101.34	0.90
(m)	: 6.10	6.56	Specific Gravity :	2.70	Final	32.43	92.62	14.58	106.80	0.82
Description	: Dark gray, SANDY SILT (ML)									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

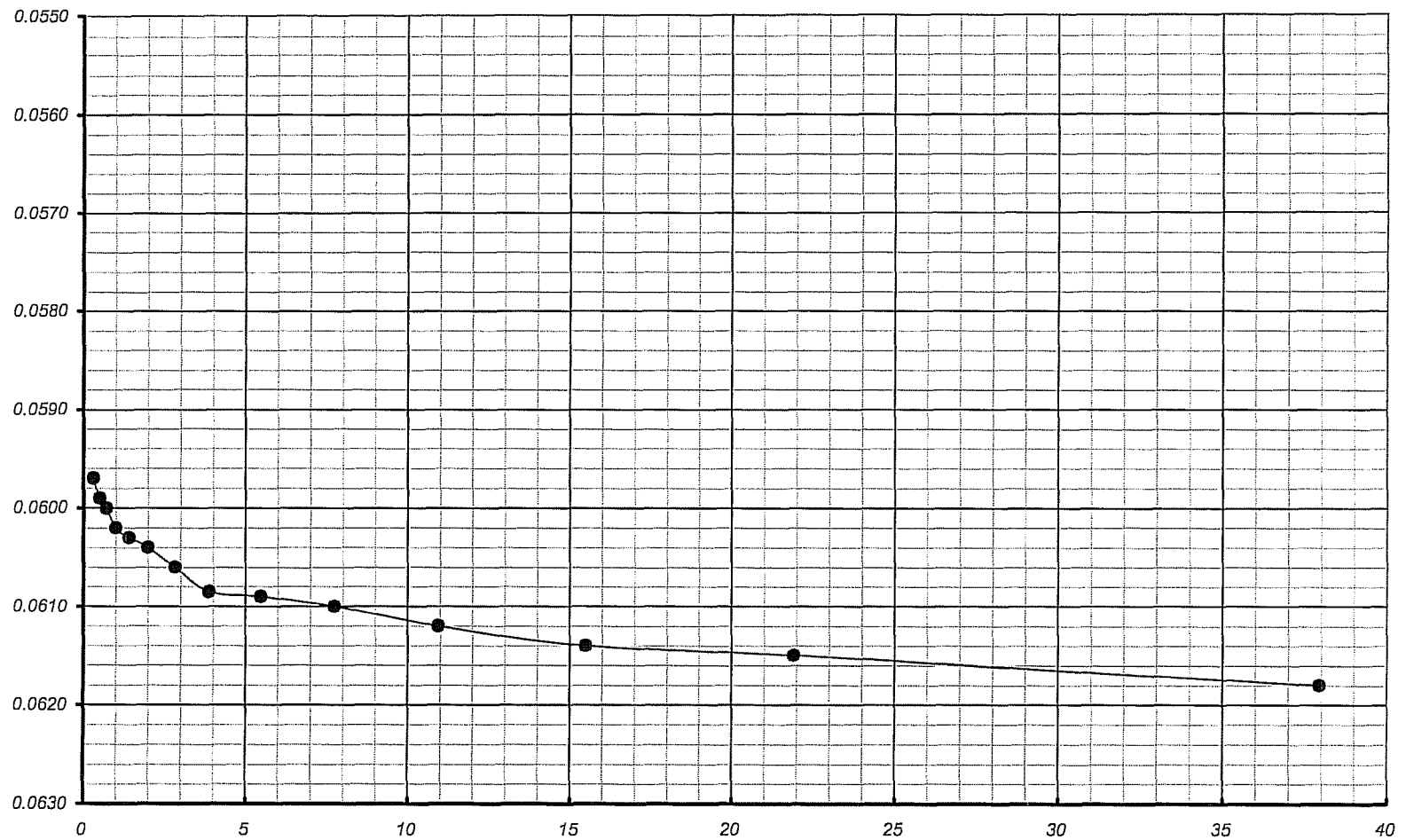
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 12/09/09

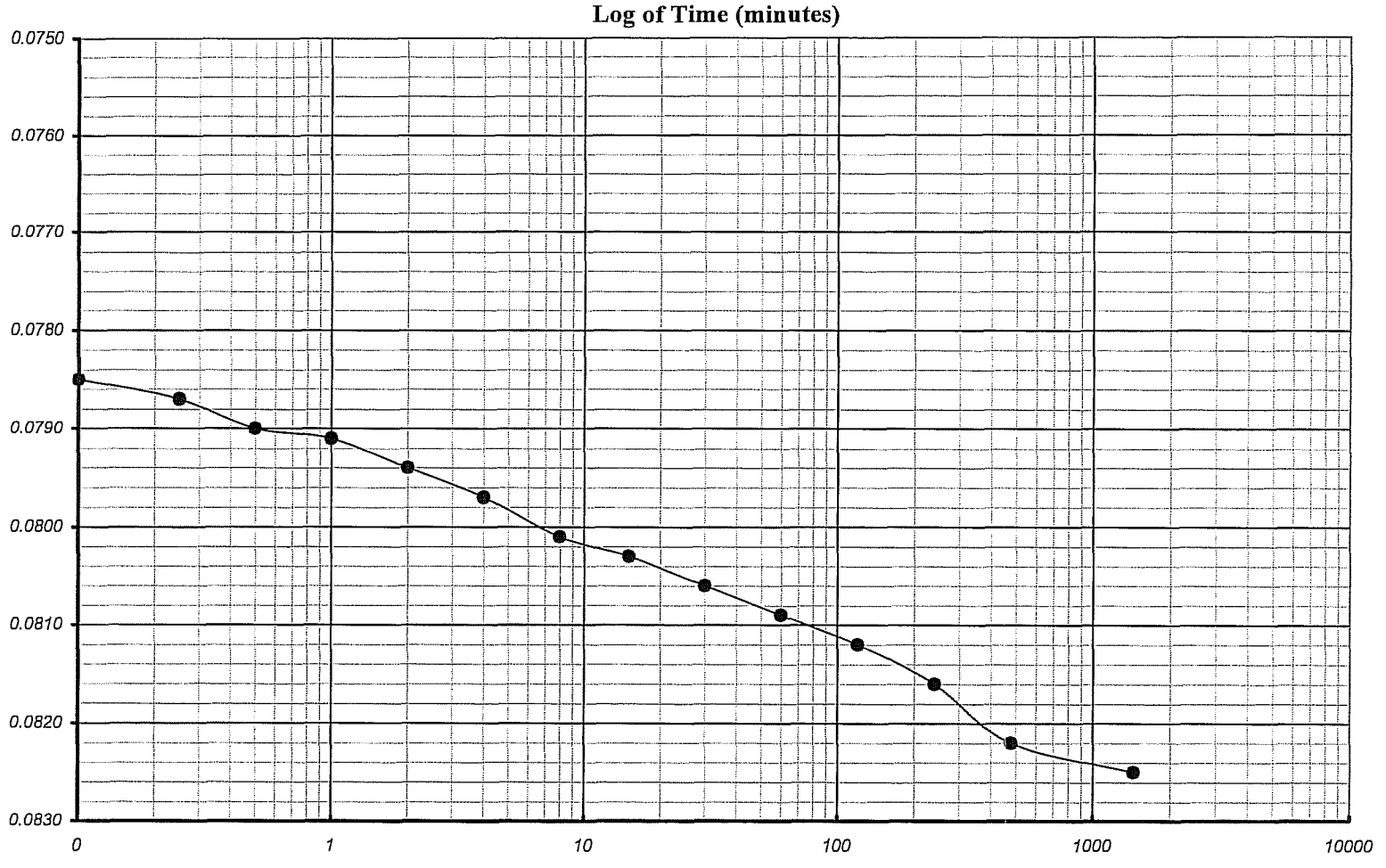
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



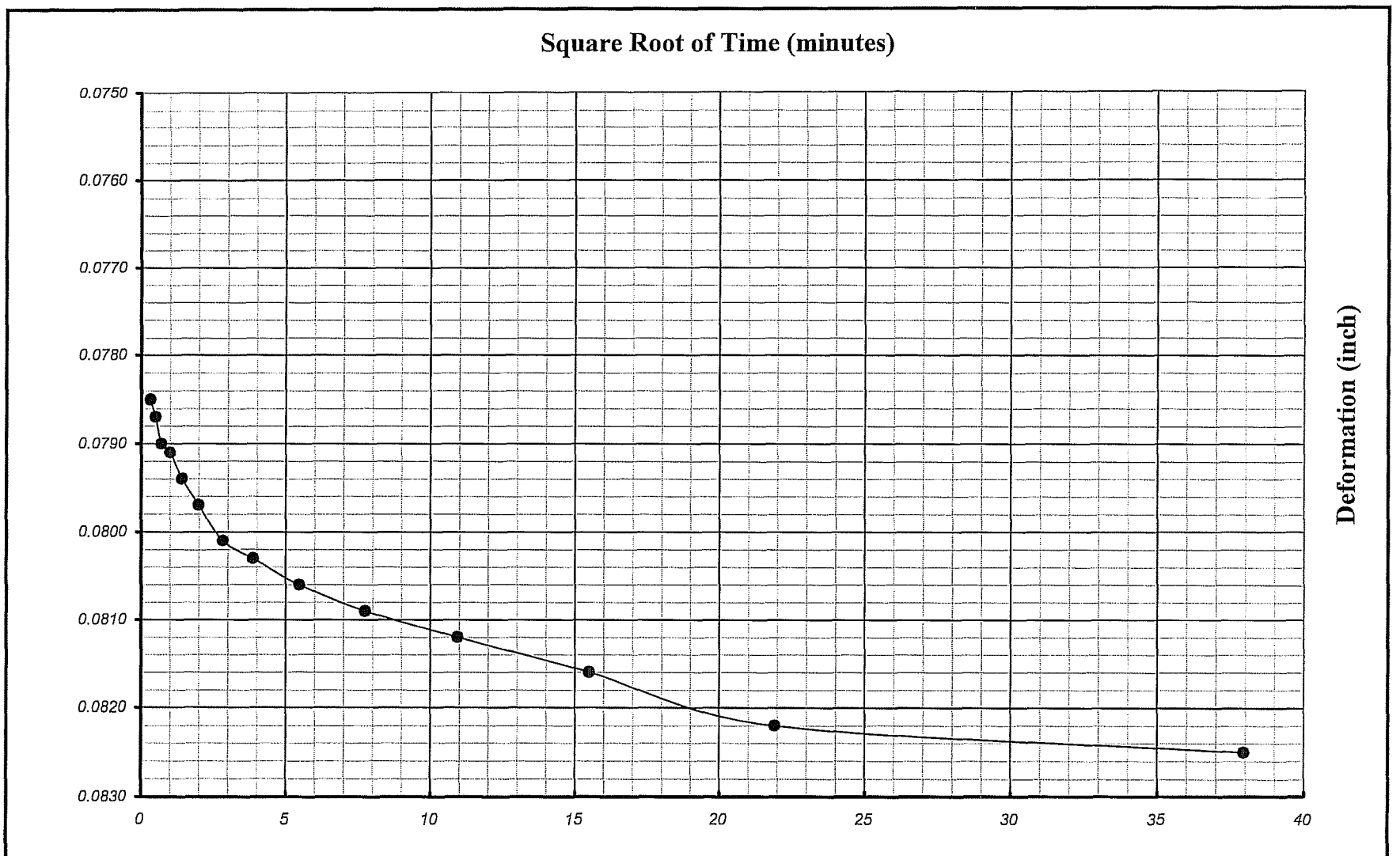
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* | *6.1*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-058	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 6.1	Veritcal Load (ksf/kpa) : 1.0 47.9



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	ACTA/Schuyler Heim Bridge Project	Boring No. : A-09-058	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : D-4	
EMI Project No. : 06-123-3		Depth (ft/m) : 20.0 6.1	Veritcal Load (ksf/kpa) : 4.00 191.5



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-4*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *20.0* *6.1*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

ONE-DIMENSIONAL CONSOLIDATION OF SOIL

ASTM D-2435 / CT-219

Device No. : 5

Project Name : ACTA/Schuyler Heim Bridge Project

Project No.	: 06-123-3	Set up By :	J.F	Date :	12/3/2009
Boring No.	: A-09-058	Tested By :	J.F/R.J.	Date :	12/3/09-12/13/09
Sample No.	: D-6	Time Rate Took By :	J.F	Date :	12/6/09,12/8/09
Depth (ft / m)	: 30.0 / 9.15	Computer By :	JF	Date :	12/9/2009
File No.	:	Checked By :	R.J.	Date :	

Soil Description : Dark gray, SILT with SAND (ML)

Method (A) : [✓] Constant load increment duration of 24 hours or multiples there for. Minium of two Time -deformation reading are required.

Method (B) : [ ] Time-deformation reading are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments are described in Test Method (A)

1

Sample	(inch)	(mm)	Vertical Load	(ksf)	(kPa)
Internal Diameter	2.42	61.47	Add Water at	0.50	23.94
Height (Intial)	1.00	25.40	Load to	16.00	766.08
Height (Final)	0.9128	23.19	Rebound to	0.25	11.97

Vertical Load	(ksf)	(kPa)
Reload to		
Rebound to		
Time rate taking at	1.00	47.70

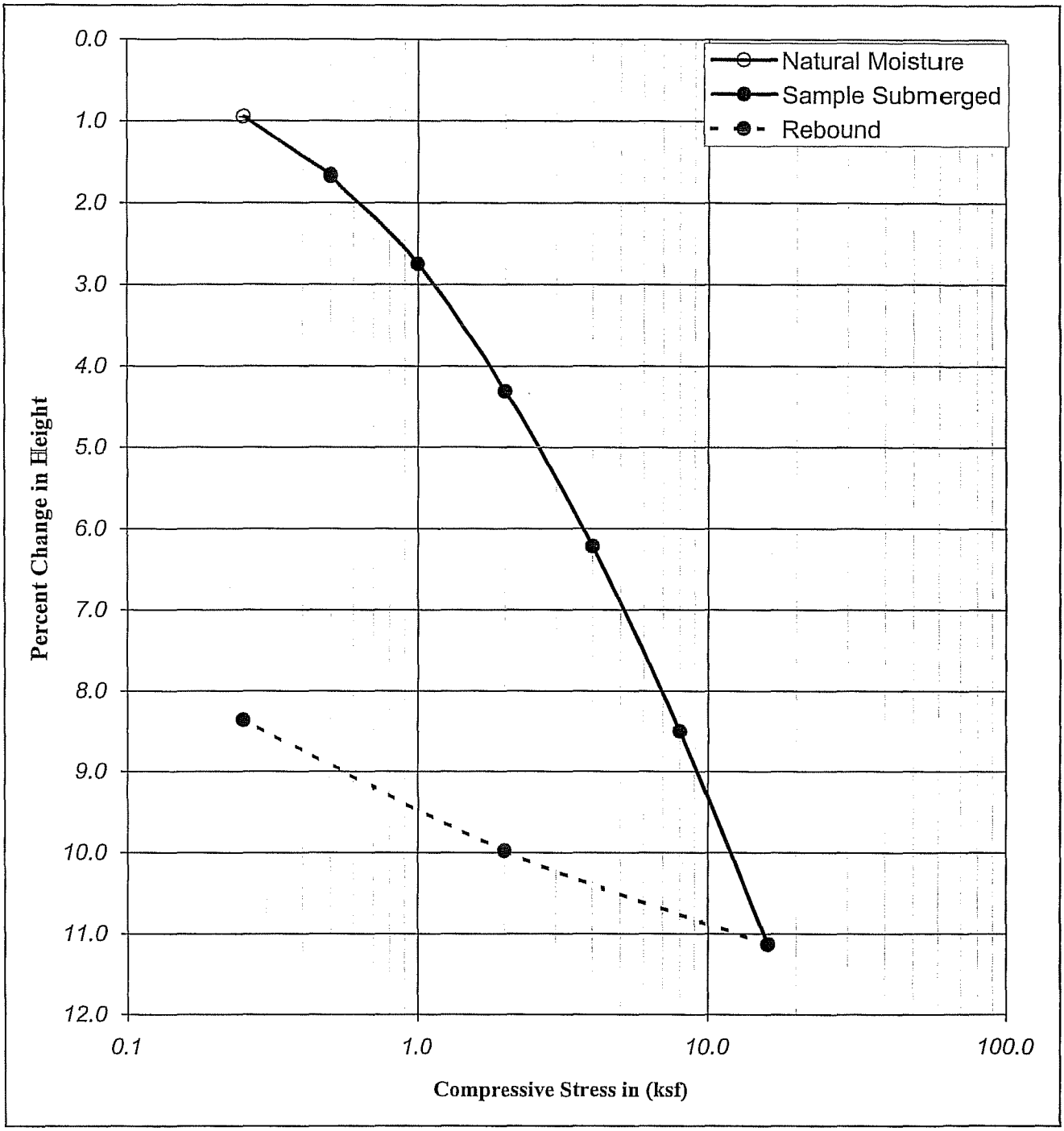
			Before	After
Weight of wet soil + ring (gm)			188.31	
Weight of ring (gm)			43.71	
Weight of wet soil + ring + container (gm)				242.33
Weight of dry soil + ring + container (gm)				211.80
No. 86	Weight of container (gm)			60.05
Weight of ring + container (gm)				103.76
Moisture Content (%)			33.84	28.26
Dial Reading (inch)			0.05	0.04
Sample Volume (ft³)			0.0027	0.0024
Wet Density (pcf)			119.8	125.7
Dry Density (pcf)			89.48	98.03

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)	SQRT Time
12/3/2009	15:04	0:00:00	Seating		0.04640	1.18		0.00
			Load					
	15:14		0.1	4.8	0.05000	1.27	0.00	0.32
								0.50
12/4/2009	8:10	0:00:00	0.25	12.0	0.05950	1.51	0.95	0.71
								1.00
12/5/2009	9:44	0:00:00	0.50	23.9	0.06660	1.69	1.66	1.41
			Add Water					2.00
12/6/2009	8:40	0:00:00	0.50	23.9	0.06680	1.70	1.68	2.83
								3.87
12/6/2009	8:43	0:00:00	1.00	47.9	0.06680	1.70	1.68	5.48
		0.10	1.0	47.9	0.07030	1.79	2.03	7.75
		0.25	1.0	47.9	0.07110	1.81	2.11	10.95
		0.50	1.0	47.9	0.0717	1.82	2.17	15.49
		1	1.0	47.9	0.07240	1.84	2.24	21.91
		2	1.0	47.9	0.07310	1.86	2.31	37.95
		4	1.0	47.9	0.07380	1.87	2.38	
		8	1.0	47.9	0.07430	1.89	2.43	
		15	1.0	47.9	0.07460	1.89	2.46	
		30	1.0	47.9	0.07510	1.91	2.51	
		60	1.0	47.9	0.07560	1.92	2.56	
		120	1.0	47.9	0.07590	1.93	2.59	
		240	1.0	47.9	0.07640	1.94	2.64	
		480	1.0	47.9	0.07700	1.96	2.70	
12/7/2009		1440	1.0	47.9	0.07750	1.97	2.75	
12/8/2009	8:28	0	2.0	95.8	0.09310	2.36	4.31	
12/8/2009	8:29	0	4.0	191.5	0.0931	2.36	4.31	
		0.10	4.0	191.5	0.1019	2.59	5.19	
		0.25	4.0	191.5	0.1025	2.60	5.25	
		0.50	4.0	191.5	0.1046	2.66	5.46	
		1	4.0	191.5	0.1053	2.67	5.53	
		2	4.0	191.5	0.1062	2.70	5.62	
		4	4.0	191.5	0.1069	2.72	5.69	
		8	4.0	191.5	0.1075	2.73	5.75	
		15	4.0	191.5	0.1080	2.74	5.80	
		30	4.0	191.5	0.1087	2.76	5.87	
		60	4.0	191.5	0.1093	2.78	5.93	
		120	4.0	191.5	0.1100	2.79	6.00	
		240	4.0	191.5	0.1109	2.82	6.09	
		480	4.0	191.5	0.1118	2.84	6.18	
12/09/09		1440	4.0	191.5	0.1122	2.85	6.22	

Date	Time	Elapsed Time (min.)	Load (ksf)	Load (kPa)	Dial Reading (in)	Dial Reading (mm)	Consol. (%)
12/10/2009	8:22		8.00	383.0	0.1350	3.43	8.50
12/11/2009	8:23		16.00	766.1	0.1613	4.10	11.13
12/12/2009	8:40		2.00	95.8	0.1498	3.80	9.98
12/13/2009	9:15		0.25	12.0	0.1336	3.39	8.36

Remark

Final Dial Reading 0.1336



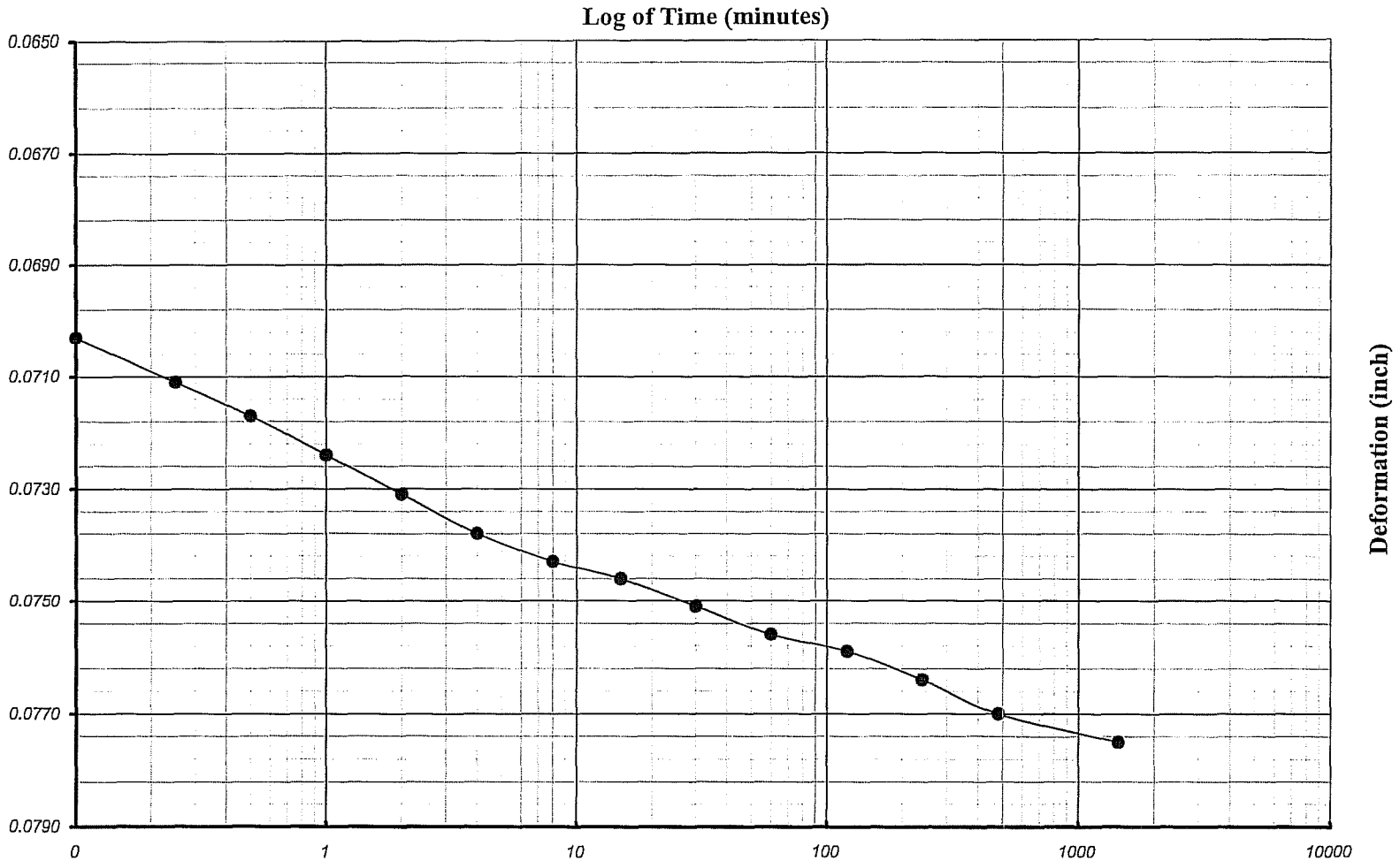
Boring No.	: A-09-058			Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-6			Plastic Limit :	-						
Depth (ft)	: 30.0		31.5	Plastic Index :	-	Initial	33.84	89.48	14.08	103.38	0.88
Depth (m)	: 9.15		9.61	Specific Gravity :	2.70	Final	28.26	98.03	15.43	106.04	0.72
Description	: Dark gray, SILT with SAND (ML)										

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

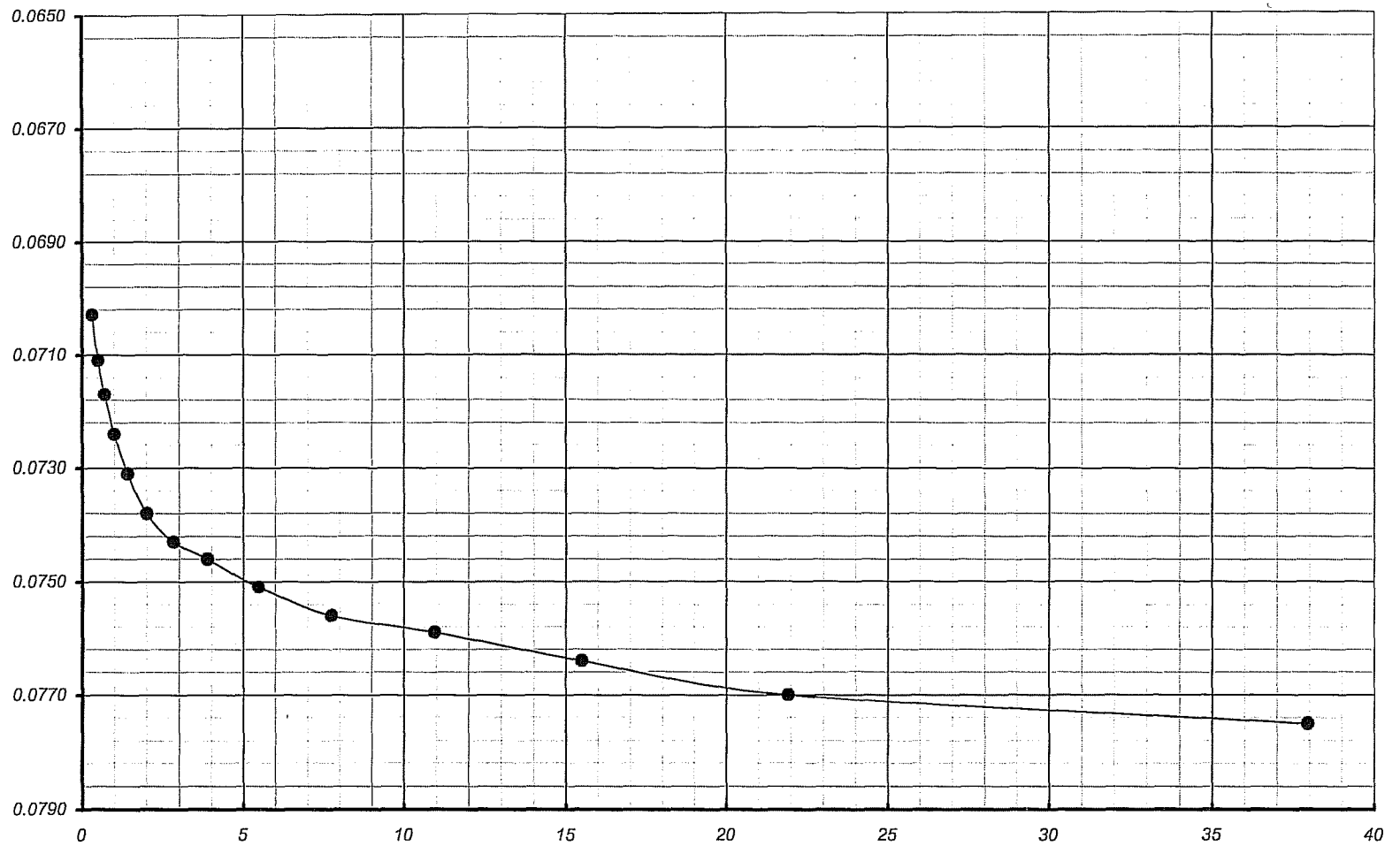
ACTA/Schuyler Heim Bridge Project

Project No. : 06-123-3 12/09/09

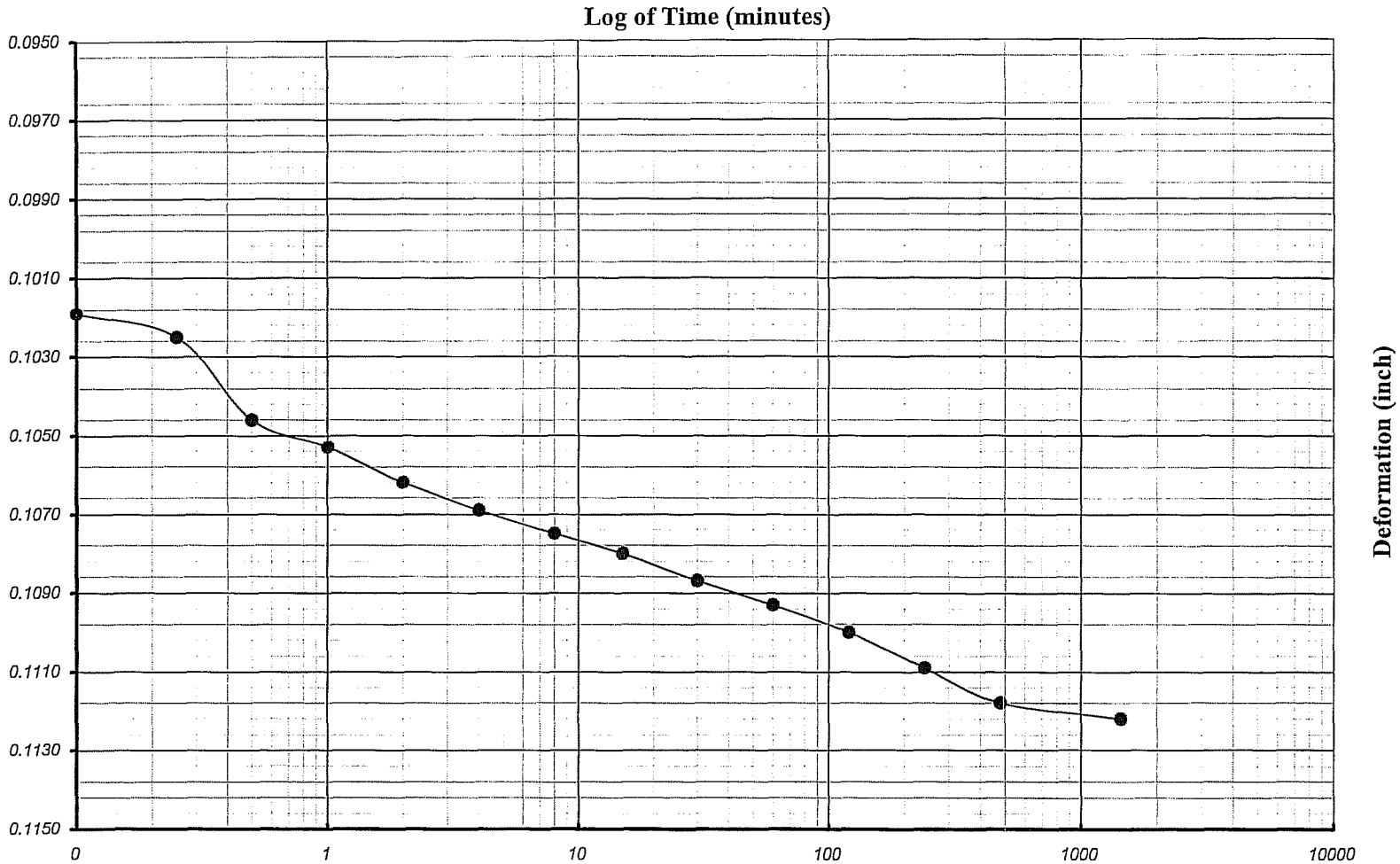
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



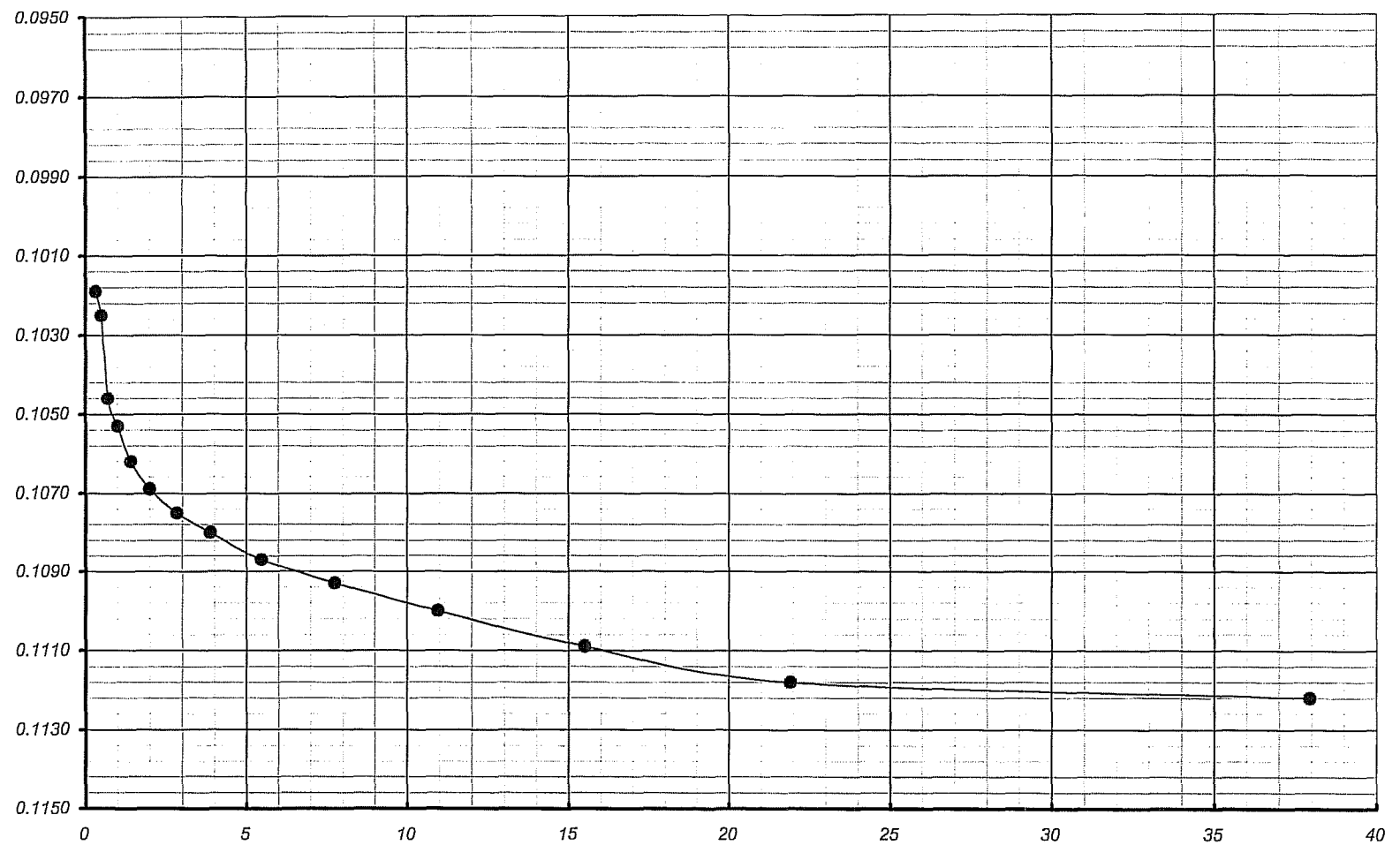
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *1.00* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve(Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *1.0* *47.9*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*ACTA/Schuyler Heim Bridge Project*	Boring No. : *A-09-058*	**One-Dimensional Consolidation of Soil** Time-Deformation Curve(Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *06-123-3*		Depth (ft/m) : *30.0* *9.2*	Veritcal Load (ksf/kpa) : *4.0* *191.5*

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. :	A-09-058		Saturated		Field Moisture	X	Inundated	**Specific Gravity** (Assumed) :	2.70
Sample No. :	D-2	X	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min) :	0.02
Depth (ft/m) :	10.0	x	Shear Once		Reshear		Residual	**Data File Number :**	0911810
Description :	Dark gray, Lean CLAY (CL)								

Percent Saturation (%)	98.69	**File No. :**	0911810	1																
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**																	
Tested By : JF	**Date :**	11/30/09																		
Computed By : JF	**Date :**	12/11/09	1.00	(ksf)																
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		172.68																		
Weight of Ring (gm)		44.91																		
Weight of Wet Soil + Cont. (gm)			126.51																	
Weight of Dry Soil + Cont. (gm)			84.71																	
Weight of Cont. (gm) **No.**	4		4.12																	
Moisture Content (%)			51.87																	
Wet Density (pcf / kN/m³)		105.82	16.66																	
Dry Density (pcf / kN/m³)		69.68	10.97																	
Percent Saturation (%)	94.84	**File No. :**	0911810	2																
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**																	
Tested By : JF	**Date :**	11/30/09	2.00	(ksf)																
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		171.10																		
Weight of Ring (gm)		46.45																		
Weight of Wet Soil + Cont. (gm)			121.65																	
Weight of Dry Soil + Cont. (gm)			81.37																	
Weight of Cont. (gm) **No.**	5		4.08																	
Moisture Content (%)			52.12																	
Wet Density (pcf / kN/m³)		103.24	16.25																	
Dry Density (pcf / kN/m³)		67.87	10.68																	
Percent Saturation (%)	91.64	**File No. :**	0911810	3																
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**																	
Tested By : JF	**Date :**	11/30/09	4.00	(ksf)																
Percent Consolidation (%)		**Before**	**After**																	
Height of Sample (inch)		1.00	1.0000																	
Diameter of Sample (inch)		2.42	2.42																	
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		168.66																		
Weight of Ring (gm)		43.87																		
Weight of Wet Soil + Cont. (gm)			118.54																	
Weight of Dry Soil + Cont. (gm)			81.39																	
Weight of Cont. (gm) **No.**	6		3.93																	
Moisture Content (%)			47.96																	
Wet Density (pcf / kN/m³)		103.35	16.27																	
Dry Density (pcf / kN/m³)		69.85	10.99																	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.56	27.00	0.95	45.39	2.14	102.27
Ultimate	0.52	24.71	0.71	33.90	1.91	91.36

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)** 1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	156	0.16	7.5	156	0.16	7.5	396	0.40	18.9
0.020	0.05	216	0.22	10.3	228	0.23	10.9	588	0.59	28.0
0.030	0.08	264	0.26	12.6	300	0.30	14.4	804	0.80	38.4
0.040	0.10	300	0.30	14.4	348	0.35	16.7	972	0.97	46.4
0.050	0.13	336	0.34	16.1	396	0.40	19.0	1116	1.12	53.2
0.060	0.15	360	0.36	17.2	444	0.44	21.3	1248	1.25	59.5
0.070	0.18	396	0.40	19.0	480	0.48	23.0	1356	1.36	64.7
0.080	0.20	420	0.42	20.1	516	0.52	24.7	1464	1.46	69.8
0.090	0.23	444	0.44	21.3	552	0.55	26.4	1536	1.54	73.3
0.100	0.25	456	0.46	21.8	588	0.59	28.2	1620	1.62	77.3
0.110	0.28	468	0.47	22.4	612	0.61	29.3	1692	1.69	80.7
0.120	0.30	492	0.49	23.6	636	0.64	30.5	1752	1.75	83.6
0.130	0.33	492	0.49	23.6	660	0.66	31.6	1800	1.80	85.9
0.140	0.36	516	0.52	24.7	684	0.68	32.7	1860	1.86	88.7
0.150	0.38	516	0.52	24.7	708	0.71	33.9	1908	1.91	91.0
0.160	0.41	528	0.53	25.3	744	0.74	35.6	1944	1.94	92.7
0.170	0.43	540	0.54	25.9	756	0.76	36.2	1968	1.97	93.9
0.180	0.46	540	0.54	25.9	780	0.78	37.3	2004	2.00	95.6
0.190	0.48	540	0.54	25.9	792	0.79	37.9	2028	2.03	96.7
0.200	0.51	552	0.55	26.4	816	0.82	39.1	2052	2.05	97.9
0.210	0.53	552	0.55	26.4	828	0.83	39.6	2076	2.08	99.0
0.220	0.56	552	0.55	26.4	840	0.84	40.2	2100	2.10	100.2
0.230	0.58	564	0.56	27.0	852	0.85	40.8	2100	2.10	100.2
0.240	0.61	564	0.56	27.0	852	0.85	40.8	2124	2.12	101.3
0.250	0.64	564	0.56	27.0	852	0.85	40.8	2112	2.11	100.7
0.260	0.66	564	0.56	27.0	864	0.86	41.4	2124	2.12	101.3
0.270	0.69	552	0.55	26.4	876	0.88	41.9	2124	2.12	101.3
0.280	0.71	552	0.55	26.4	888	0.89	42.5	2136	2.14	101.9
0.290	0.74	552	0.55	26.4	900	0.90	43.1	2136	2.14	101.9
0.300	0.76	552	0.55	26.4	912	0.91	43.7	2124	2.12	101.3
0.310	0.79	552	0.55	26.4	912	0.91	43.7	2124	2.12	101.3
0.320	0.81	552	0.55	26.4	924	0.92	44.2	2124	2.12	101.3
0.330	0.84	552	0.55	26.4	924	0.92	44.2	2124	2.12	101.3
0.340	0.86	552	0.55	26.4	936	0.94	44.8	2124	2.12	101.3
0.350	0.89	552	0.55	26.4	936	0.94	44.8	2112	2.11	100.7
0.360	0.91	552	0.55	26.4	936	0.94	44.8	2112	2.11	100.7
0.370	0.94	552	0.55	26.4	948	0.95	45.4	2100	2.10	100.2
0.380	0.97	540	0.54	25.9	948	0.95	45.4	2112	2.11	100.7
0.390	0.99	552	0.55	26.4	948	0.95	45.4	2112	2.11	100.7
0.400	1.02	540	0.54	25.9	948	0.95	45.4	2112	2.11	100.7
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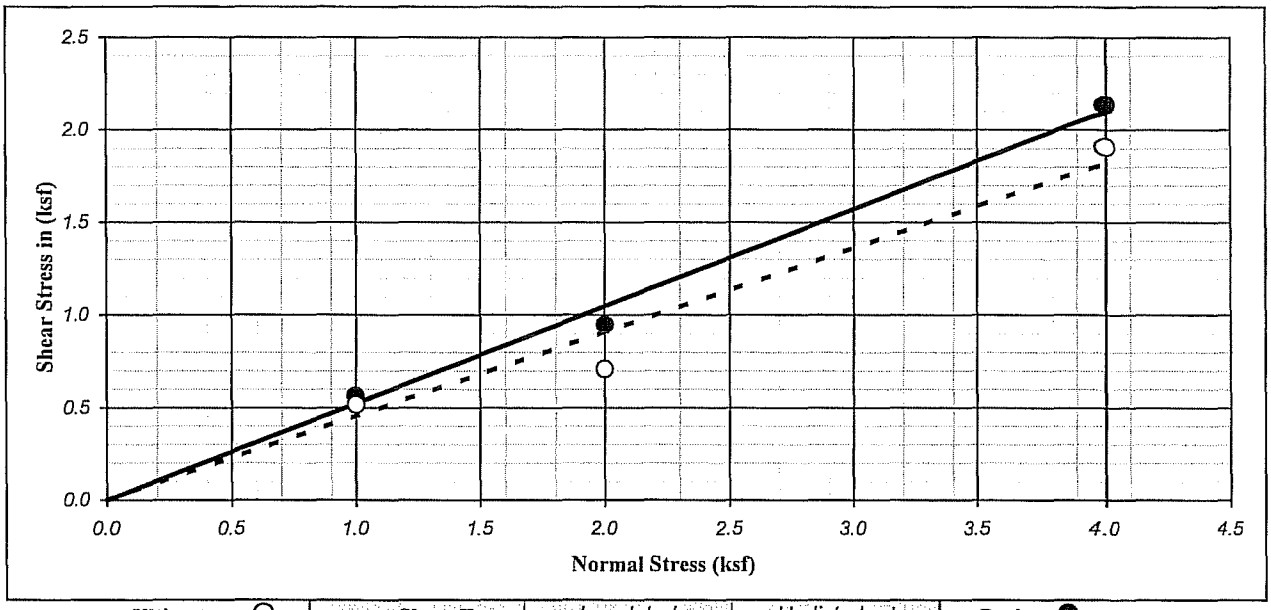
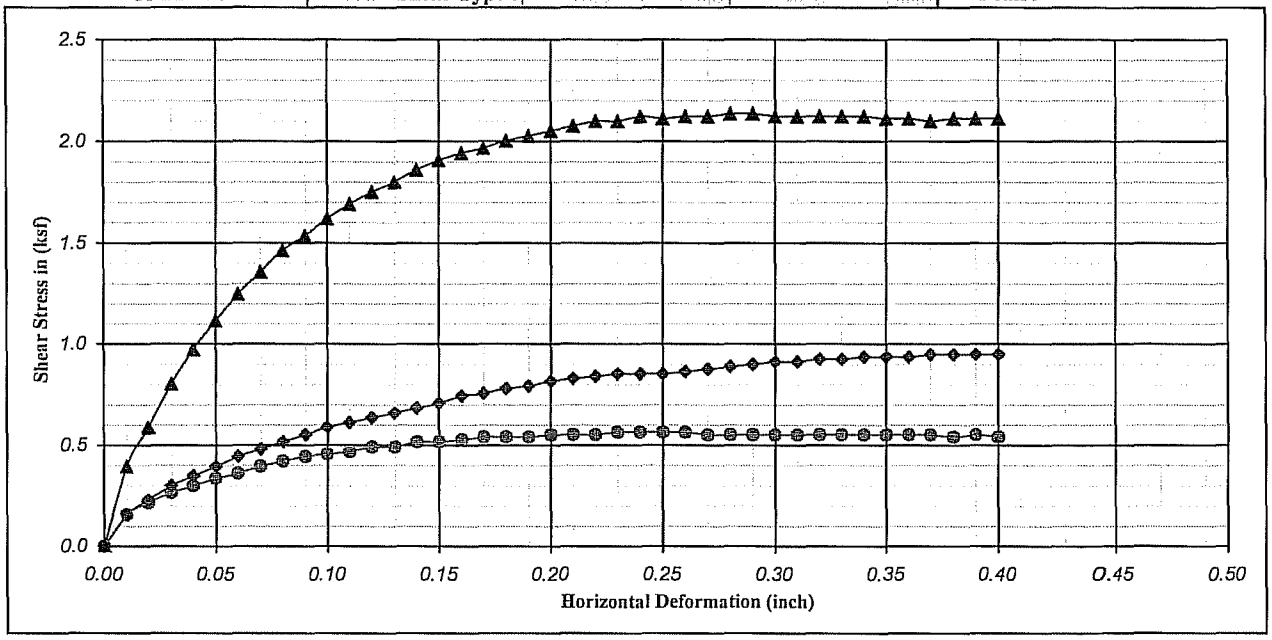


Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-058		Strength Intercept (C) :	0.00	(ksf)	Peak	0.00	(ksf)	Ultimate
Sample No. : D-2			0.00	(kPa)		0.00	(kPa)	
Depth (ft/m) : 10.0	0.00	Friction Angle (ϕ) :	27.65	Degree		24.49	Degree	

Description : Dark gray, Lean CLAY (CL) — Shear Rate (inch/minute) : 0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	51.87	69.68	10.97	1.42	1.00	47.88	0.56	27.00	0.52	24.71
◆	52.12	67.87	10.68	1.48	2.00	95.76	0.95	45.39	0.71	33.90
▲	47.96	69.85	10.99	1.41	4.00	191.52	2.14	102.27	1.91	91.36

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

Boring No. :	A-09-058		Saturated		Field Moisture	X	Inundated — Specific Gravity (Assumed) : 2.70
Sample No. :	D-10	X	Undisturbed		Remolded		Consolidated-Drained — Shear Rate (inch/min) : 0.02
Depth (ft/m) :	50.0	x	Shear Once		Reshear		Residual — Data File Number : 0612311
Description :	Dark gray, SILTY CLAYEY SAND (SC-SM)						

Sample 1

Percent Saturation (%)	95.59	File No. : 0612311	1
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09		
Computed By : JF	Date : 12/11/09	3.00	(ksf)
Checked By :	Date :		

	Before	After
Percent Consolidation (%)		
Height of Sample (inch)	1.00	1.0000
Diameter of Sample (inch)	2.42	2.42
Dial Reading-Consolidation (inch)		
Weight of Soil + Ring (gm)	188.06	
Weight of Ring (gm)	38.44	
Weight of Wet Soil + Cont. (gm)		151.88
Weight of Dry Soil + Cont. (gm)		122.65
Weight of Cont. (gm) No. 1		3.84
Moisture Content (%)		24.60
Wet Density (pcf / kN/m³)	123.92 / 19.50	
Dry Density (pcf / kN/m³)	99.45 / 15.65	

Sample 2

Percent Saturation (%)	95.03	File No. : 0612311	2
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09	6.00	(ksf)

	Before	After
Percent Consolidation (%)		
Height of Sample (inch)	1.00	1.0000
Diameter of Sample (inch)	2.42	2.42
Dial Reading-Consolidation (inch)		
Weight of Soil + Ring (gm)	194.82	
Weight of Ring (gm)	46.15	
Weight of Wet Soil + Cont. (gm)		149.51
Weight of Dry Soil + Cont. (gm)		120.34
Weight of Cont. (gm) No. 2		3.93
Moisture Content (%)		25.06
Wet Density (pcf / kN/m³)	123.13 / 19.38	
Dry Density (pcf / kN/m³)	98.46 / 15.50	

Sample 3

Percent Saturation (%)	101.33	File No. : 0612311	3
Prepared By : JF	Date : 11/30/09	Normal Stress	
Tested By : JF	Date : 11/30/09	8.00	(ksf)

	Before	After
Percent Consolidation (%)		
Height of Sample (inch)	1.00	1.0000
Diameter of Sample (inch)	2.42	2.42
Dial Reading-Consolidation (inch)		
Weight of Soil + Ring (gm)	190.63	
Weight of Ring (gm)	43.52	
Weight of Wet Soil + Cont. (gm)		148.62
Weight of Dry Soil + Cont. (gm)		115.24
Weight of Cont. (gm) No. 3		3.73
Moisture Content (%)		29.93
Wet Density (pcf / kN/m³)	121.84 / 19.18	
Dry Density (pcf / kN/m³)	93.77 / 14.76	

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	2.16	103.42	3.90	186.73	4.98	238.44
Ultimate	1.87	89.63	3.66	175.24	4.62	221.21

Shear Data

Shear Deflection (inch)	(mm)	Normal Stress (psf/ksf/kPa) 3000	3.00	143.6	6000	6.0	287.3	8000	8.0	383.0
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0
0.010	0.03	792	0.79	37.9	1404	1.40	67.2	2124	2.12	101.3
0.020	0.05	1152	1.15	55.2	1932	1.93	92.5	2772	2.77	132.2
0.030	0.08	1380	1.38	66.1	2148	2.15	102.8	3204	3.20	152.8
0.040	0.10	1572	1.57	75.3	2460	2.46	117.8	3552	3.55	169.4
0.050	0.13	1716	1.72	82.2	2736	2.74	131.0	3828	3.83	182.6
0.060	0.15	1836	1.84	87.9	2988	2.99	143.1	4008	4.01	191.2
0.070	0.18	1932	1.93	92.5	3156	3.16	151.1	4140	4.14	197.5
0.080	0.20	2004	2.00	96.0	3324	3.32	159.2	4308	4.31	205.5
0.090	0.23	2064	2.06	98.8	3456	3.46	165.5	4416	4.42	210.7
0.100	0.25	2100	2.10	100.5	3576	3.58	171.2	4500	4.50	214.7
0.110	0.28	2124	2.12	101.7	3660	3.66	175.2	4572	4.57	218.1
0.120	0.30	2160	2.16	103.4	3744	3.74	179.3	4644	4.64	221.5
0.130	0.33	2160	2.16	103.4	3804	3.80	182.1	4704	4.70	224.4
0.140	0.36	2148	2.15	102.8	3852	3.85	184.4	4764	4.76	227.3
0.150	0.38	2124	2.12	101.7	3888	3.89	186.2	4812	4.81	229.5
0.160	0.41	2100	2.10	100.5	3900	3.90	186.7	4860	4.86	231.8
0.170	0.43	2076	2.08	99.4	3900	3.90	186.7	4872	4.87	232.4
0.180	0.46	2040	2.04	97.7	3900	3.90	186.7	4908	4.91	234.1
0.190	0.48	2016	2.02	96.5	3900	3.90	186.7	4908	4.91	234.1
0.200	0.51	1980	1.98	94.8	3888	3.89	186.2	4944	4.94	235.8
0.210	0.53	1980	1.98	94.8	3876	3.88	185.6	4956	4.96	236.4
0.220	0.56	1968	1.97	94.2	3828	3.83	183.3	4968	4.97	237.0
0.230	0.58	1956	1.96	93.7	3780	3.78	181.0	4968	4.97	237.0
0.240	0.61	1956	1.96	93.7	3732	3.73	178.7	4968	4.97	237.0
0.250	0.64	1956	1.96	93.7	3708	3.71	177.5	4980	4.98	237.6
0.260	0.66	1956	1.96	93.7	3684	3.68	176.4	4968	4.97	237.0
0.270	0.69	1956	1.96	93.7	3660	3.66	175.2	4968	4.97	237.0
0.280	0.71	1944	1.94	93.1	3660	3.66	175.2	4932	4.93	235.3
0.290	0.74	1932	1.93	92.5	3660	3.66	175.2	4908	4.91	234.1
0.300	0.76	1932	1.93	92.5	3684	3.68	176.4	4860	4.86	231.8
0.310	0.79	1932	1.93	92.5	3696	3.70	177.0	4836	4.84	230.7
0.320	0.81	1920	1.92	91.9	3708	3.71	177.5	4800	4.80	229.0
0.330	0.84	1920	1.92	91.9	3720	3.72	178.1	4764	4.76	227.3
0.340	0.86	1908	1.91	91.4	3732	3.73	178.7	4752	4.75	226.7
0.350	0.89	1908	1.91	91.4	3732	3.73	178.7	4716	4.72	225.0
0.360	0.91	1896	1.90	90.8	3744	3.74	179.3	4692	4.69	223.8
0.370	0.94	1884	1.88	90.2	3756	3.76	179.8	4668	4.67	222.7
0.380	0.97	1884	1.88	90.2	3768	3.77	180.4	4656	4.66	222.1
0.390	0.99	1884	1.88	90.2	3780	3.78	181.0	4644	4.64	221.5
0.400	1.02	1872	1.87	89.6	3768	3.77	180.4	4620	4.62	220.4
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	0.00									
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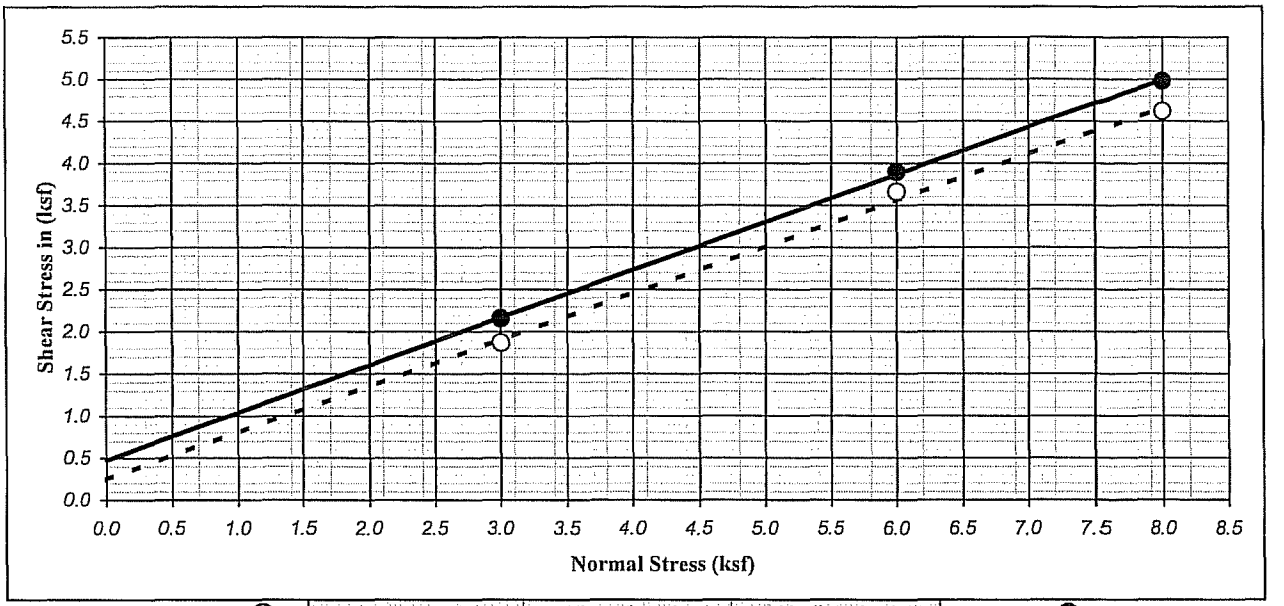
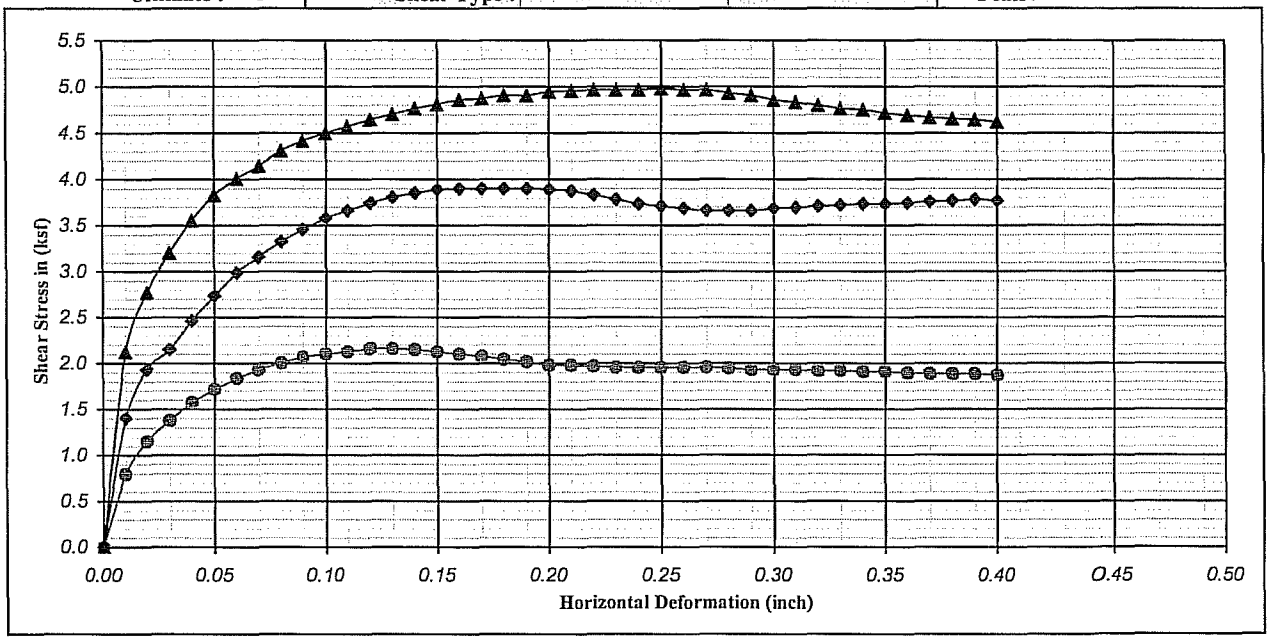


Ultimate : ○ | Shear Type : *Inundated* | *Undisturbed* | Peak : ●



Boring No.	: *A-09-058*	**Strength Intercept (C) :**	*0.48*	(ksf)		*0.25*	(ksf)	
Sample No.	: *D-10*		*22.83*	(kPa)	**Peak**	*11.91*	(kPa)	**Ultimate**
Depth (ft/m)	: *50.0* | *0.00*	**Friction Angle (ϕ) :**	*29.48*	Degree		*28.95*	Degree	
Description	: *Dark gray, SILTY CLAYEY SAND (SC-SM)*					**Shear Rate** (inch/minute) :		*0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	*24.60*	*99.45*	*15.65*	*0.69*	*3.00*	*143.64*	*2.16*	*103.42*	*1.87*	*89.63*
◆	*25.06*	*98.46*	*15.50*	*0.71*	*6.00*	*287.28*	*3.90*	*186.73*	*3.66*	*175.24*
▲	*29.93*	*93.77*	*14.76*	*0.80*	*8.00*	*383.04*	*4.98*	*238.44*	*4.62*	*221.21*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *06-123-3* | **Date :** *11/30/09*

Figure No. :

DIRECT SHEAR TEST

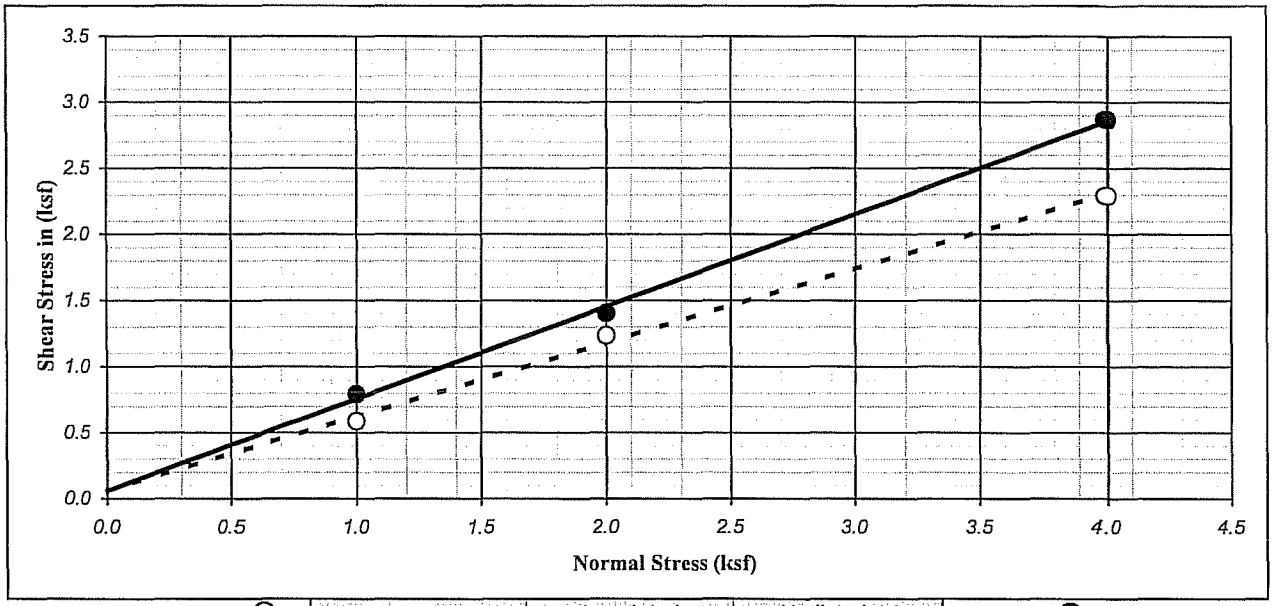
ASTM D-3080-04

Project No. : 06-123-3 **Project Name :** ACTA/Schuyler Heim Bridge Project

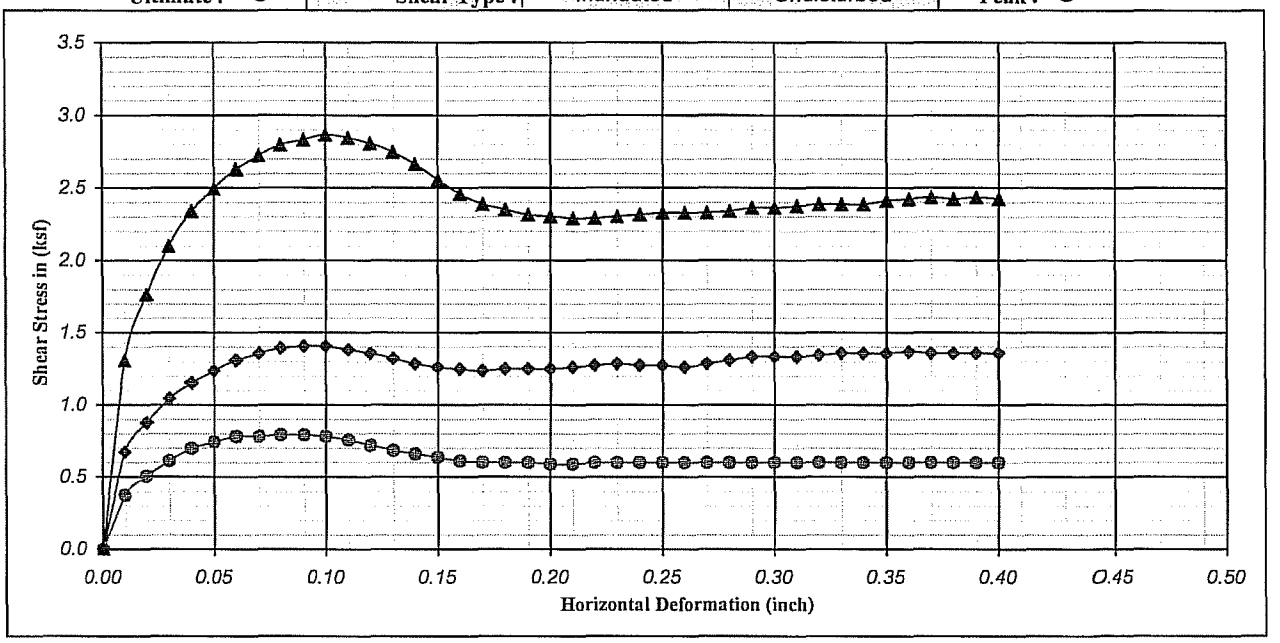
Boring No. : A-09-059		**Saturated**		**Field Moisture**	X	**Inundated**		**Specific Gravity** (Assumed) :	2.70
Sample No. : D-2	X	**Undisturbed**		**Remolded**		**Consolidated-Drained**		**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 10.0	x	**Shear Once**		**Reshear**		**Residual**		**Data File Number :**	0911812
Description : Dark grayish brown, Poorly graded SAND with SILT (SP-SM)									

Percent Saturation (%)	90.33	**File No. :**	0911812	1		**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**												
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**					1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5				
Tested By : JF	**Date :**	11/30/09				(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**												
Computed By : JF	**Date :**	12/11/09	**1.00**	(ksf)		0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0				
Checked By :	**Date :**					0.010	0.03	372	0.37	17.8	672	0.67	32.2	1308	1.31	62.4				
Percent Consolidation (%)		**Before**	**After**			0.020	0.05	504	0.50	24.1	876	0.88	41.9	1764	1.76	84.1				
Height of Sample (inch)		1.00	1.0000			0.030	0.08	612	0.61	29.3	1044	1.04	50.0	2100	2.10	100.2				
Diameter of Sample (inch)		2.42	2.42			0.040	0.10	696	0.70	33.3	1152	1.15	55.2	2340	2.34	111.6				
Dial Reading-Consolidation (inch)						0.050	0.13	744	0.74	35.6	1236	1.24	59.2	2496	2.50	119.1				
Weight of Soil + Ring (gm)		187.47				0.060	0.15	780	0.78	37.3	1308	1.31	62.6	2628	2.63	125.4				
Weight of Ring (gm)		45.05				0.070	0.18	780	0.78	37.3	1356	1.36	64.9	2724	2.72	129.9				
Weight of Wet Soil + Cont. (gm)			144.89			0.080	0.20	792	0.79	37.9	1392	1.39	66.6	2796	2.80	133.4				
Weight of Dry Soil + Cont. (gm)			114.45			0.090	0.23	792	0.79	37.9	1404	1.40	67.2	2832	2.83	135.1				
Weight of Cont. (gm) **No.**	4		3.77			0.100	0.25	780	0.78	37.3	1404	1.40	67.2	2868	2.87	136.8				
Moisture Content (%)			27.50			0.110	0.28	756	0.76	36.2	1380	1.38	66.1	2844	2.84	135.7				
Wet Density (pcf / kN/m³)		117.96	18.57			0.120	0.30	720	0.72	34.5	1356	1.36	64.9	2808	2.81	133.9				
Dry Density (pcf / kN/m³)		92.51	14.56			0.130	0.33	684	0.68	32.7	1320	1.32	63.2	2748	2.75	131.1				
Percent Saturation (%)	82.64	**File No. :**	0911812	2		0.140	0.36	660	0.66	31.6	1284	1.28	61.5	2664	2.66	127.1				
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**			0.150	0.38	636	0.64	30.5	1260	1.26	60.3	2556	2.56	121.9				
Tested By : JF	**Date :**	11/30/09	**2.00**	(ksf)		0.160	0.41	612	0.61	29.3	1248	1.25	59.8	2460	2.46	117.3				
Percent Consolidation (%)		**Before**	**After**			0.170	0.43	600	0.60	28.7	1236	1.24	59.2	2388	2.39	113.9				
Height of Sample (inch)		1.00	1.0000			0.180	0.46	600	0.60	28.7	1248	1.25	59.8	2352	2.35	112.2				
Diameter of Sample (inch)		2.42	2.42			0.190	0.48	600	0.60	28.7	1248	1.25	59.8	2316	2.32	110.5				
Dial Reading-Consolidation (inch)						0.200	0.51	588	0.59	28.2	1248	1.25	59.8	2304	2.30	109.9				
Weight of Soil + Ring (gm)		182.44				0.210	0.53	588	0.59	28.2	1260	1.26	60.3	2292	2.29	109.3				
Weight of Ring (gm)		45.07				0.220	0.56	600	0.60	28.7	1272	1.27	60.9	2292	2.29	109.3				
Weight of Wet Soil + Cont. (gm)			141.48			0.230	0.58	600	0.60	28.7	1284	1.28	61.5	2304	2.30	109.9				
Weight of Dry Soil + Cont. (gm)			112.22			0.240	0.61	600	0.60	28.7	1272	1.27	60.9	2316	2.32	110.5				
Weight of Cont. (gm) **No.**	5		3.71			0.250	0.64	600	0.60	28.7	1272	1.27	60.9	2328	2.33	111.1				
Moisture Content (%)			26.97			0.260	0.66	600	0.60	28.7	1260	1.26	60.3	2328	2.33	111.1				
Wet Density (pcf / kN/m³)		113.77	17.91			0.270	0.69	600	0.60	28.7	1284	1.28	61.5	2328	2.33	111.1				
Dry Density (pcf / kN/m³)		89.61	14.10			0.280	0.71	600	0.60	28.7	1308	1.31	62.6	2340	2.34	111.6				
Percent Saturation (%)	90.88	**File No. :**	0911812	3		0.290	0.74	600	0.60	28.7	1332	1.33	63.8	2364	2.36	112.8				
Prepared By : JF	**Date :**	11/30/09	**Normal Stress**			0.300	0.76	600	0.60	28.7	1332	1.33	63.8	2364	2.36	112.8				
Tested By : JF	**Date :**	11/30/09	**4.00**	(ksf)		0.310	0.79	600	0.60	28.7	1332	1.33	63.8	2376	2.38	113.3				
Percent Consolidation (%)		**Before**	**After**			0.320	0.81	600	0.60	28.7	1344	1.34	64.4	2388	2.39	113.9				
Height of Sample (inch)		1.00	1.0000			0.330	0.84	600	0.60	28.7	1356	1.36	64.9	2388	2.39	113.9				
Diameter of Sample (inch)		2.42	2.42			0.340	0.86	600	0.60	28.7	1356	1.36	64.9	2388	2.39	113.9				
Dial Reading-Consolidation (inch)						0.350	0.89	600	0.60	28.7	1356	1.36	64.9	2412	2.41	115.1				
Weight of Soil + Ring (gm)		188.05				0.360	0.91	600	0.60	28.7	1368	1.37	65.5	2424	2.42	115.6				
Weight of Ring (gm)		45.06				0.370	0.94	600	0.60	28.7	1356	1.36	64.9	2436	2.44	116.2				
Weight of Wet Soil + Cont. (gm)			146.51			0.380	0.97	600	0.60	28.7	1356	1.36	64.9	2424	2.42	115.6				
Weight of Dry Soil + Cont. (gm)			115.84			0.390	0.99	600	0.60	28.7	1356	1.36	64.9	2436	2.44	116.2				
Weight of Cont. (gm) **No.**	6		3.72			0.400	1.02	600	0.60	28.7	1356	1.36	64.9	2424	2.42	115.6				
Moisture Content (%)			27.35				0.00													
Wet Density (pcf / kN/m³)		118.43	18.64				0.00													
Dry Density (pcf / kN/m³)		92.99	14.64				0.00													

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)		0.00
Peak	0.79	37.92	1.40	67.22	2.87	137.32		0.00
Ultimate	0.59	28.15	1.24	59.18	2.29	109.74		0.00



Ultimate : ○ | Shear Type : Inundated | Undisturbed | Peak : ●



Boring No. : A-09-059	Strength Intercept (C) :	0.06	(ksf)	Peak	0.06	(ksf)	Ultimate
Sample No. : D-2		2.87	(kPa)		2.87	(kPa)	
Depth (ft/m) : 10.0 | 0.00	Friction Angle (ϕ) :	34.90	Degree		29.35	Degree	
Description : Dark grayish brown, Poorly graded SAND with SILT (SP-SM)					Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	27.50	92.51	14.56	0.82	1.00	47.88	0.79	37.92	0.59	28.15
◆	26.97	89.61	14.10	0.88	2.00	95.76	1.40	67.22	1.24	59.18
▲	27.35	92.99	14.64	0.81	4.00	191.52	2.87	137.32	2.29	109.74

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA/Schuyler Heim Bridge Project

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 06-123-3 | Date : 11/30/09

Figure No. :

MEASUREMENT OF SOIL CORROSIVITY

Project No.	: 06-123-3	**Project Name :** ACTA/Schuyler Heim Bridge Project	
Boring No.	: A-09-058	**Depth (ft/m) :** 5.00	1.53
Sample No.	: S-1	**Description :** Dark olive-gray, Poorly graded SAND (SP)	

**** Sample for Corrosivity tests must screen through No. 8 Sieve*

Measurement of Soil Resistivity (ASTM G-57-78 / CT- 643)

Test Standard	ASTM	X	CAL. TRAN.	**Wt of Wet Soil + Cont. (gm)**	122.08	**Weight of Total**
Soil Box Diamension (cm)	22.86 X 3.81 X 2.54		15.31 X 10.04 X4.41	**Wt of Dry Soil + Cont. (gm)**	120.09	**Sample for Test (gm)**
(L X W X H) / (inch)	9.0 X 1.5 X 1.0		6.04X 3.95 X 1.74	**Wt. of Cont. No.** 2	58.66	101.22
Soil Box Constant (C)	1.0		6.72	**Setup Moisture Content (%)**	3.24	

Trial	**Resistivity Meter Reading (ohm-cm)**					
	As received	**1**	**2**	**3**	**4**	**5**
Water added	**0.0**	5.00	5.00	5.00	5.00	5.00
Meter reading	81000	31000	18000	10000	9300	9300
Resistivity	81000.0	31000.0	18000.0	10000.0	9300.0	9300.0

Prepared By : PA	**Date :** 12/14/09
Tested By : PA	**Date :** 12/15/09
Calculated By : JF	**Date :** 12/17/09
Checked By :	**Date :**
Minimum Resistivity :	**9300.0**

Measurement of Soil pH (ASTM G-51-77 / CT- 643)

*Weight **30 gm** soil sample and add **30 ml** distilled water, stir to a soil slurry and settle at least **1 hr**.*

Prepared By	:	**Date :** 12/14/09	**Time :** 14:48	**Beaker No. :** 29		**pH Reading**			
Tested By	:	**Date :** 12/15/09	**Weigh of Wetsoil (gm)**		30.03	**Trial**	**1**	**2**	**3**	**Average**
Calculated By	:	**Date :** 12/17/09	**Distilled Water added (ml)**		30.04	**Test Time**	13:40:00	13:42:00	13:44:00	
Checked By	:	**Date :**	**Moisture Content (%)**		3.24	**Reading**	8.57	8.63	8.67	**8.62**

Measurement of Soil Soluble Sulfate Content (CT - 417)

*Weight **100.0 gm** of sample soil & add **300 ml.** of distilled water. Stopper and shake well. Allow to settle overnight. Prepare two **30 (ml.)** of water layer into a **150 (ml.)** beaker, dilute to **100 (ml.)**, add **5 (ml.)** conditioning reagent. Turbidity Blank - Adjust the stirrer to the maximum speed, add **1** spoonfull Barium Chloride & start timing. Stir for exactly **1** minute.*

Flask No. : 8	**Prepared By :**	**Date :** 12/14/09
Weight of Soil (gm) : 100.01	**Tested By :**	**Date :** 12/15/09
Distilled Water (ml.) : 300.05	**Calculated By :**	**Date :** 12/17/09
Shaking at : 14:49:00	**Checked By :**	**Date :**
Reshaking at :		

Total Water Sample Prepared	60.07	**With BaCL**		18	**<** **Beaker Number** **>**			19	**Blank**
Distilled Water added to (ml)	200.18			100.08	**Tested Sample Volume**			100.1	
Time Intervals	0:00:00	0:00:30	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:04:00	**Maximum**
With BaCL (time)	14:23:00	14:23:30	14:24:00	14:24:30	14:25:00	14:25:30	14:26:00	14:27:00	
Turbidity with BaCL (NTV)		29.30	29.20	29.20	28.90	28.70	28.70	28.90	29.30
Blank (time)	14:18:00	14:18:30	14:19:00	14:19:30	14:20:00	14:20:30	14:21:00	14:22:00	
Turbidity Blank (NTV)		18.10	17.60	17.10	17.00	16.70	16.50	16.40	18.10
Difference (ppm)		11.20	11.60	12.10	11.90	12.00	12.20	12.50	11.20
SO_4 (from graph) (ppm)									**30**

Measurement of Soil Chloride Content (CT - 422)

*1. Weight **100.0 gm** sample soil & add **300 ml** of distilled water. Stopper and shake vigorously for **20** seconds, reshaking after one hour and let it settle over night. 2. Pour **30 ml** aliquot of filtered solution into a **150 ml** beaker, then check pH. If pH is in the range **6** through **8**, go to step **4**. If ph below **6**, add Sodium Hydroxide and if above **8**, add Acetic Acid to adjust to the range. 4. Add two drops of Potassium Chromate solution before titrate with Silver Nitrate and change color from Yellow to Red. ** If the titration is over **30 ml**., take a smaller sample. Dilute any smaller sample to about **50 ml**..*

Flask No. : 8	**Prepared By :**	**Date :** 12/14/09
Wt. of Soil (gm) : 100.01	**Tested By :**	**Date :** 12/15/09
Distilled Water (ml.) : 300.05	**Calculated By :**	**Date :** 12/17/09
Shaking at : 14:49:00	**Checked By :**	**Date :**
Reshaking at :	**Vaccum & Filter at :**	
Remark :		

Titration of (I ml.) Sample Diluted to (F ml.)	5	**<** **Beaker No.** **>**		8	
Total Sample Prepared : 60.13	**Initial**	**Final**	**Total**	**Initial**	**Final**	**Total**	
Sample Volume (ml)	30.06	30.06		30.07	30.07		
pH of Liquid Sample	7.57	7.57		7.57	7.57		
Sodium Hydroxide added (ml)	-	-	-	-	-	-	
Acetic Acid added (ml)	-	-	-	-	-	-	**Average**
Silver Nitrate added (ml)	14.20	16.80	2.60	16.80	19.40	2.60	
ppm CL= 100x(ml of Sil.Ni.-0.2 ml blank)*F/I			240.00			240.00	240.00
Moisture - Free CL = ppm CL X 100 / (100 - w)			**248.03**			**248.03**	**248**

MEASUREMENT OF SOIL CORROSIVITY

Project No.	: 06-123-3	**Project Name :** ACTA/Schuyler Heim Bridge Project	
Boring No.	: A-09-059	**Depth (ft/m) :** 5.00	1.53
Sample No.	: S-1	**Description :** Dark olive-gray, SILTY SAND (SM)	

*** Sample for Corrosivity tests must screen through No. 8 Sieve

Measurement of Soil Resistivity (ASTM G-57-78 / CT- 643)

Test Standard	ASTM	X	CAL. TRAN.	Wt of Wet Soil + Cont. (gm)	145.53	Weight of Total
Soil Box Diamension (cm)	22.86 X 3.81 X 2.54		15.31 X 10.04 X4.41	Wt of Dry Soil + Cont. (gm)	142.15	Sample for Test (gm)
(L X W X H) / (inch)	9.0 X 1.5 X 1.0		6.04X 3.95 X 1.74	Wt. of Cont. No. 1	57.24	101.24
Soil Box Constant (C)	1.0		6.72	Setup Moisture Content (%)	3.98	

Trial	Resistivity Meter Reading (ohm-cm)						Prepared By : PA	Date : 12/14/09
	As received	1	2	3	4	5	Tested By : PA	Date : 12/15/09
Water added	0.0	5.00	5.00	5.00	5.00	5.00	Calculated By : JF	Date : 12/17/09
Meter reading	21000	4600	2800	1700	1300	1400	Checked By :	Date :
Resistivity	21000.0	4600.0	2800.0	1700.0	1300.0	1400.0	Minimum Resistivity :	**1300.0**

Measurement of Soil pH (ASTM G-51-77 / CT- 643)

Weight 30 gm soil sample and add 30 ml distilled water, stir to a soil slurry and settle at least 1 hr.

							pH Reading				
Prepared By	:	Date : 12/14/09	Time : 14:57	Beaker No. :	37		Trial	1	2	3	Average
Tested By	:	Date : 12/15/09	Weigh of Wetsoil (gm)		30.03		Test Time	13:34:00	13:36:00	13:38:00	
Calculated By	:	Date : 12/17/09	Distilled Water added (ml)		30.01		Reading	8.07	8.05	8.05	**8.06**
Checked By	:	Date :	Moisture Content (%)		3.98						

Measurement of Soil Soluble Sulfate Content (CT - 417)

Weight 100.0 gm of sample soil & add 300 ml. of distilled water. Stopper and shake well. Allow to settle overnight. Prepare two 30 (ml.) of water layer into a 150 (ml.) beaker, dilute to 100 (ml.), add 5 (ml.) conditioning reagent. Turbidity Blank - Adjust the stirrer to the maximum speed, add 1 spoonfull Barium Chloride & start timing. Stir for exactly 1 minute.

Flask No. : 38	Prepared By :	Date :	12/14/09
Weight of Soil (gm) : 100.02	Tested By :	Date :	12/15/09
Distilled Water (ml.) : 300.08	Calculated By :	Date :	12/17/09
Shaking at : 15:11:00	Checked By :	Date :	
Reshaking at :			

Total Water Sample Prepared	60.03	With BaCL		16	< Beaker Number >			17	Blank
Distilled Water added to (ml)	200.1			100.04	Tested Sample Volume			100.06	
Time Intervals	0:00:00	0:00:30	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:04:00	Maximum
With BaCL (time)	14:44:00	14:44:30	14:45:00	14:45:30	14:46:00	14:46:30	14:47:00	14:48:00	
Turbidity with BaCL (NTV)		225.00	222.00	220.00	214.00	212.00	212.00	210.00	225.00
Blank (time)	14:39:00	14:39:30	14:40:00	14:40:30	14:41:00	14:41:30	14:42:00	14:43:00	
Turbidity Blank (NTV)		41.20	35.60	31.70	28.30	26.10	24.30	23.70	41.20
Difference (ppm)		183.80	186.40	188.30	185.70	185.90	187.70	186.30	183.80
SO_4 (from graph) (ppm)									**380**

Measurement of Soil Chloride Content (CT - 422)

*1. Weight 100.0 gm sample soil & add 300 ml. of distilled water. Stopper and shake vigorously for 20 seconds, reshaking after one hour and let it settle over night. 2. Pour 30 ml aliquot of filtered solution into a 150 ml beaker, then check pH. If pH is in the range 6 through 8, go to step 4. If ph below 6, add Sodium Hydroxide and if above 8, add Acetic Acid to adjust to the range. 4. Add two drops of Potassium Chromate solution before titrate with Silver Nitrate and change color from Yellow to Red. ** If the titration is over 30 ml., take a smaller sample. Dilute any smaller sample to about 50 ml..*

Flask No. : 38	Prepared By :	Date :	12/14/09
Wt. of Soil (gm) : 100.02	Tested By :	Date :	12/15/09
Distilled Water (ml.) : 300.08	Calculated By :	Date :	12/17/09
Shaking at : 15:11:00	Checked By :	Date :	
Reshaking at :	Vaccum & Filter at :		
Remark :			

Titration of (I ml.) Sample Diluted to (F ml.)	16	< Beaker No.			> 20	
Total Sample Prepared : 60.07	Initial	Final	Total	Initial	Final	Total	
Sample Volume (ml)	30.03	30.03		30.04	30.04		
pH of Liquid Sample	7.24	7.24		7.24	7.24		
Sodium Hydroxide added (ml)	-	-	-	-	-	-	
Acetic Acid added (ml)	-	-	-	-	-	-	Average
Silver Nitrate added (ml)	19.40	24.80	5.40	24.80	30.20	5.40	
ppm CL= 100x(ml of Sil.Ni.-0.2 ml blank)*F/I			520.00			520.00	520.00
Moisture - Free CL = ppm CL X 100 / (100 - w)			**541.56**			**541.56**	**542**

APPENDIX D. SITE SPECIFIC GROUND MOTION MEMORANDUM

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TECHNICAL MEMORANDUM

DATE: February 8, 2010 **EMI PROJECT NO:** 06-123-03

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COPY TO: David Jang, Ph. D., P. E., G. E. / Caltrans
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Foued Zayati, P. E. / Caltrans

PREPARED BY: Arul Arulmoli, Te-Chih Ke and Chien-Tai Yang / Earth Mechanics, Inc.

SUBJECT: ACTA Schuyler Heim Bridge Replacement Project
Los Angeles and Long Beach, CA
Site-Specific Ground Motion Study (ARS Comparison)

Introduction

This memorandum has been prepared to assist the structural designers for the Schuyler Heim Bridge Replacement Project, located in the cities of Los Angeles and Long Beach, California, by addressing the methodology used in the seismic design of the proposed structure.

All five bridges that are a part of the Schuyler Heim Bridge Replacement Project were originally designed by Caltrans designers in 2008 based on the Acceleration Response Spectrum (ARS) selected according to the 2006 Seismic Design Criteria (SDC). In 2009, Caltrans released an updated version of the SDC. This memorandum first describes the development of new ARS curves based on the updated 2009 Caltrans SDC. Next, the two sets of ARS curves (those developed based on Catrans, 2006, and Caltrans, 2009) are compared. Based on that comparison, it is finally determined that the bridge seismic design, which was based on the 2006 Caltrans ARS, is conservative and acceptable for final design.

Project Description

The Schuyler Heim Bridge provides vehicle access to Terminal Island and is located immediately south of the junction of SR-47 and SR-103 in the cities of Long Beach and Los Angeles, California (Figure 1). The bridge is located on SR-47 and spans the Cerritos Channel generally between Pier A Way on the north side and West Ocean Boulevard on the south side.

The proposed project consists of replacing the existing vertical-lift Schuyler Heim Bridge with a fixed structure. The new alignment shifts to the east along the existing bridge. The proposed 23 span main bridge structure will be approximately 4,100 feet in length will have an elevated profile to provide a vertical clearance of about 47 feet over a mean high water level (MHWL) of +4.7 feet in the Cerritos Channel and maintain a navigable channel width of 180 feet. The proposed bridge replacement will also include replacement of on- and off-ramps at New Dock Street and State Route (SR) 103.

Seismic Evaluation Background

The Preliminary Foundation Report (PFR) for the project was prepared in 2006 by Earth Mechanics, Inc. (EMI, 2006a) based on existing subsurface information available at the time. The PFR included an ARS design curve (Figure 2) based on Caltrans SDC (2006). The controlling fault was the Palos Verdes fault about 2.7 km from the site, with peak bedrock acceleration (PBA) of 0.6g and a MCE Magnitude of 7.25.

It is our understanding that due to time constraints, certain aspects of the Schuyler Heim Bridge Replacement Project seismic design needed to proceed based on the Caltrans (2006) ARS curve described above. As such, it is necessary to determine if those aspects of the design remain conservative under the new (Caltrans, 2009) seismic criteria. To that end, a new ground motion study was performed in accordance to with the 2009 Caltrans SDC (Caltrans, 2009), using information from an extensive subsurface exploration performed by EMI, including down-hole shear wave velocity measurements, as described in the sections below.

New Input Motion for "Firm-Ground" Condition

The 2009 Caltrans ARS on-line tool is a by-product of the 2009 update to the Caltrans SDC. Given the location and V_{S30} of a site, it can produce the horizontal probabilistic hazard spectrum of 975-year return period and the deterministic hazard spectra of some controlling faults at the site. The use of 2008 USGS Beta on-line tool is required for checking the result of 2009 Caltrans SDC, especially when the site has a V_{S30} less than 300 m/sec.

For the Schuyler Heim Bridge, latitude and longitude are 33.7660^0 N and 118.2397^0 W, respectively and V_{S30} of 1,000 ft/sec (~300 m/sec) was used to represent "firm-ground" condition. Because the assumed value of V_{S30} is about 300 m/sec, the difference between the 2009 Caltrans spectrum and 2008 USGS Beta spectrum is less than about 5%. Figure 3 presents the PSH de-aggregation plot at PGA generated by 2008 USGS Beta, which indicates that the modal values of the distance and moment magnitude of the controlling fault are 3.2 km and 7.19, respectively, i.e., a scenario of Palos Verdes fault as expected.

The final generated spectrum with adjustment for both basin and near-fault effects is taken as the fault normal (FN) motion, while that with adjustment for the basin effect only is regarded to be the fault parallel (FP) motion. The coordinates of these two input motion spectra (acceleration and displacement) for "firm" ground condition are tabulated in Table 1 for 5% damping.

During the recent field investigations conducted by EMI and its subconsultants, down-hole shear wave velocities were measured in several borings to depths of more than 160 ft. Based on the shear wave velocity profiles, the V_{S30} from the surface is significantly less than 1,000 ft/sec (~300 m/sec) and therefore, seismic site response analyses must be performed to develop design response spectrum corresponding to the new SDC criteria.

"Firm-Ground" Spectrum Compatible Time Histories

In order to perform seismic site response analysis, seven sets of "firm-ground" spectrum compatible time histories were developed by modifying seed motions (usually actual earthquake

records) so that their spectra are similar to the reference rock spectra. Various methods have been developed to perform the spectrum matching. A commonly used method adjusts the Fourier amplitude spectrum based on the ratio of the target response spectrum to the time history response spectrum while keeping the Fourier phase of the reference history fixed. An alternative approach for spectral matching adjusts the time history in the time domain by adding wavelets to the reference time history. In this project, the time domain method was used.

As part of the spectral matching procedure, a baseline correction is applied to the ground motions. The baseline is computed by fitting the displacement time history to a high order polynomial (order 4 to 7) and excluding the constant and linear terms. The second derivative of this displacement baseline is computed and it is subtracted from the acceleration ground motion. The resulting ground motion is baseline corrected in acceleration, velocity, and displacement.

Table 2 lists the basic information of seven seed motions selected for spectrum matching. These seed motions were developed by EMI as a part of the Port of Long Beach Port-wide Ground Motion Study (EMI, 2006b). The seven sets of time histories that are spectrum matched to the FN and FP input motions are presented in Appendix A.

Idealized Soil Profiles

Three idealized soil profiles for the seismic response analyses were developed for the seismic site response analyses. The down-hole shear wave velocity (V_S) data obtained during the field investigation, using PS logging, were used to generate simplified shear wave velocity profiles. Three profiles were used to represent the length of the bridge. The first soil profile, denoted as "South Side", represents the area south of Cerritos Channel. The second soil profile, denoted as "North Side", represents the area north of Cerritos Channel. The third soil profile, denoted as "Channel", is representative of the profile within the channel. Figure 4 shows the three idealized soil profiles and Table 3 summarizes the corresponding soil parameters of these three soil profiles. To account for potential variations in V_S, the lower bound (LB) case and the upper bound (UB) case were also considered. Scaling factors of 0.85 and 1.15 were used on the shear wave velocities as multiplication factors on the best-estimate (BE) V_S for the LB and UB bound scenarios.

Seismic Site Response Analysis

Seismic site response analyses were conducted using the computer program SHAKE91, with the input motion given at the "firm-ground" elevations, which are assumed to be at 100, 90, and 60 feet below the ground surface (or mudline) for the three profiles, respectively. The input motions adopted are the seven sets of "firm-ground' spectrum compatible time histories, each with two components (FN and FP), as described earlier. Considering three V_S variations (BE, LB, and UB), seven ground motion sets and two components, a total of 42 runs were made for each soil profile. The computed free-field motions at the ground surface were obtained. Figure 5 shows the spectral plots of free-field ground motions for "South Side", which include the "firm-ground" input motion spectrum for the bridge, the free-field motions for BE, LB, and UB V_S profiles, the mean and the mean plus one standard deviation spectra of the 42 runs. The 2006 Caltrans ARS deign curve is also plotted in this figure. Similarly, the spectral plots of free-field ground motions for "North Side" and "Channel" are presented in Figures 6 and 7, respectively. These analyses also show that the peak ground acceleration (PGA) is less than 0.5g.

Comparison of Caltrans 2006 and 2009 ARS Design Curves

Figure 8 shows the mean and the mean plus one standard deviation spectra for the three profiles as well as the 2006 Caltrans ARS deign curve. A conservative 2009 ARS design curve for this bridge can be generated by enveloping the mean plus one standard deviation spectra of the three profiles in Figure 8. It can be seen from Figure 8 that the envelope of all three mean plus one standard deviation spectra is expected to be well below the 2006 Caltrans ARS design curve. The PGA from the 2009 Caltrans design curve is less than 0.5g.

Conclusions

Based on the above analyses, we conclude that the use of the 2006 Caltrans ARS curve in the design of the proposed Schuyler Heim Bridge is conservative and acceptable. For geotechnical evaluations, a PGA value of 0.5g is considered appropriate.

Table 1. New Input Motion Spectra for a 5% damping

Period (sec)	FN		FP	
	Acceleration (g)	Displacement (in)	Acceleration (g)	Displacement (in)
0.000	0.5050	0.0000	0.5050	0.0000
0.100	0.9028	0.0884	0.9028	0.0884
0.200	1.1278	0.4415	1.1278	0.4415
0.300	1.1027	0.9714	1.1027	0.9714
0.500	0.9393	2.2984	0.9393	2.2984
1.000	0.7333	7.1770	0.6111	5.9808
2.000	0.3980	15.5830	0.3317	12.9858
3.000	0.2558	22.5314	0.2132	18.7761
4.000	0.1825	28.5751	0.1521	23.8126
5.000	0.1479	36.1932	0.1233	30.1610

Table 2. Ground Motion Sets Selected for Spectral Matching

Set	Earthquake	Station	Magnitude	Distance (km)
1	1999 Hector mine	Hector	7.1	12
2	1989 Loma Prieta	Gilroy 03	6.9	13
3	1979 Imperial Valley	Brawley	6.5	10
4	1999 Duzce	Lamont 1059	7.1	4
5	1992 Erzikan	Erzikan	6.7	4
6	1940 Imperial Valley	El Centro	7.0	6
7	1995 Kobe	Kobe University	6.9	1

Table 3. Idealized Soil Profiles and Properties for Seismic Response Analyses

a) "South Side" (Boring R09-014 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-20	ML	110	400
20-40	SM	120	500
40-70	CL	120	500~700
70-80	ML	120	800
80-100	SP/SM	130	800~1000

b) "North Side" (Boring R09-025 and PS logging)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-45	SM	120	400~600
45-85	CL/ML	120	600~800
85-90	SP	130	900~1000

c) "Channel" (Boring WR09-043 and nearby PS loggings)

Depth Range (ft)	Soil Type	Unit Weight, γ (pcf)	Best-estimated Shear Wave Velocity, V_S (ft/sec)
0-35	CL/ML	115	400~900
35-50	SP/SM	130	900~1000

Note: Ground surface elevation was assumed to be +5 feet for both "South Side" and "North Side", and mudline elevation for "Channel" was assumed to be -45 feet.

References

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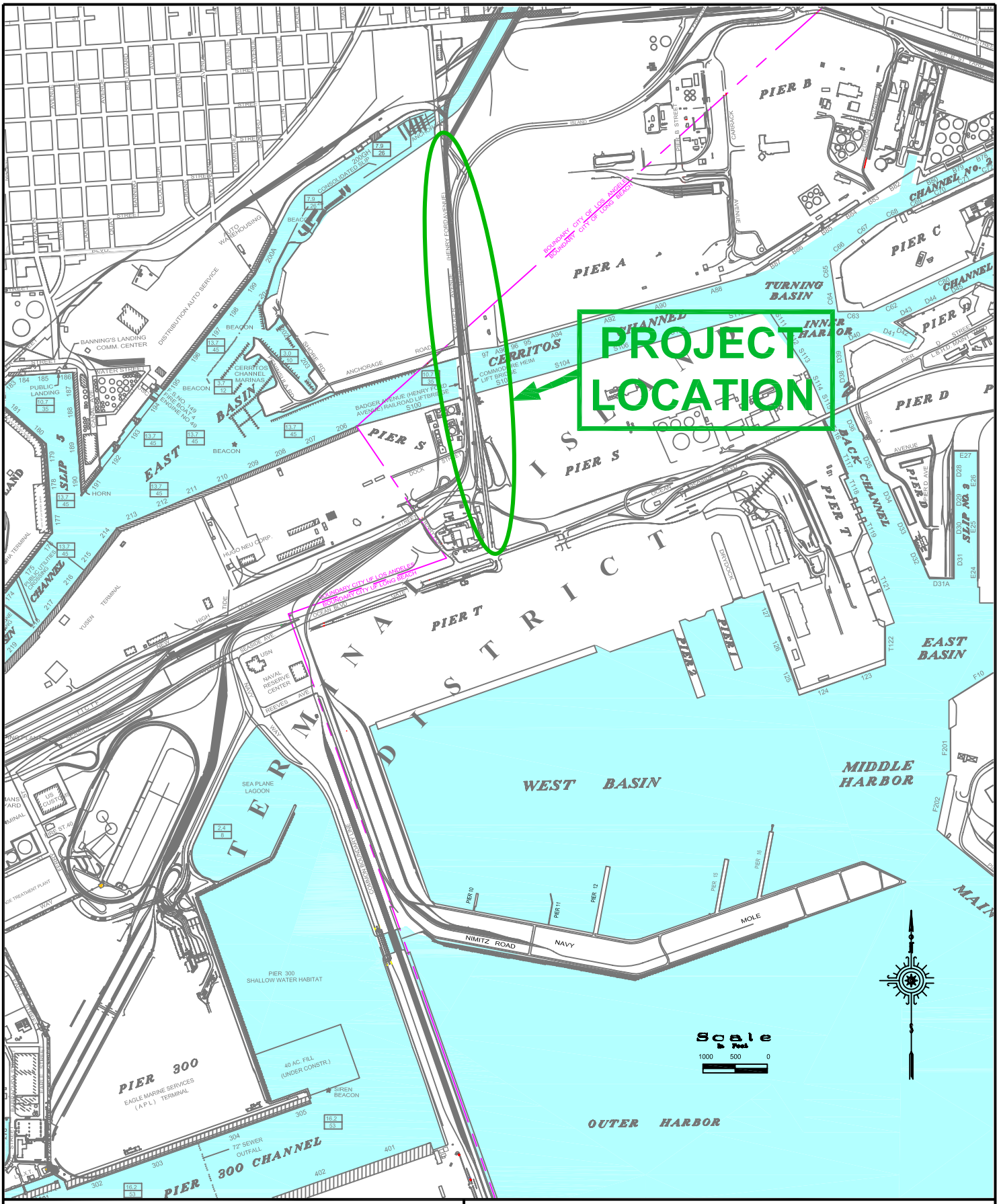

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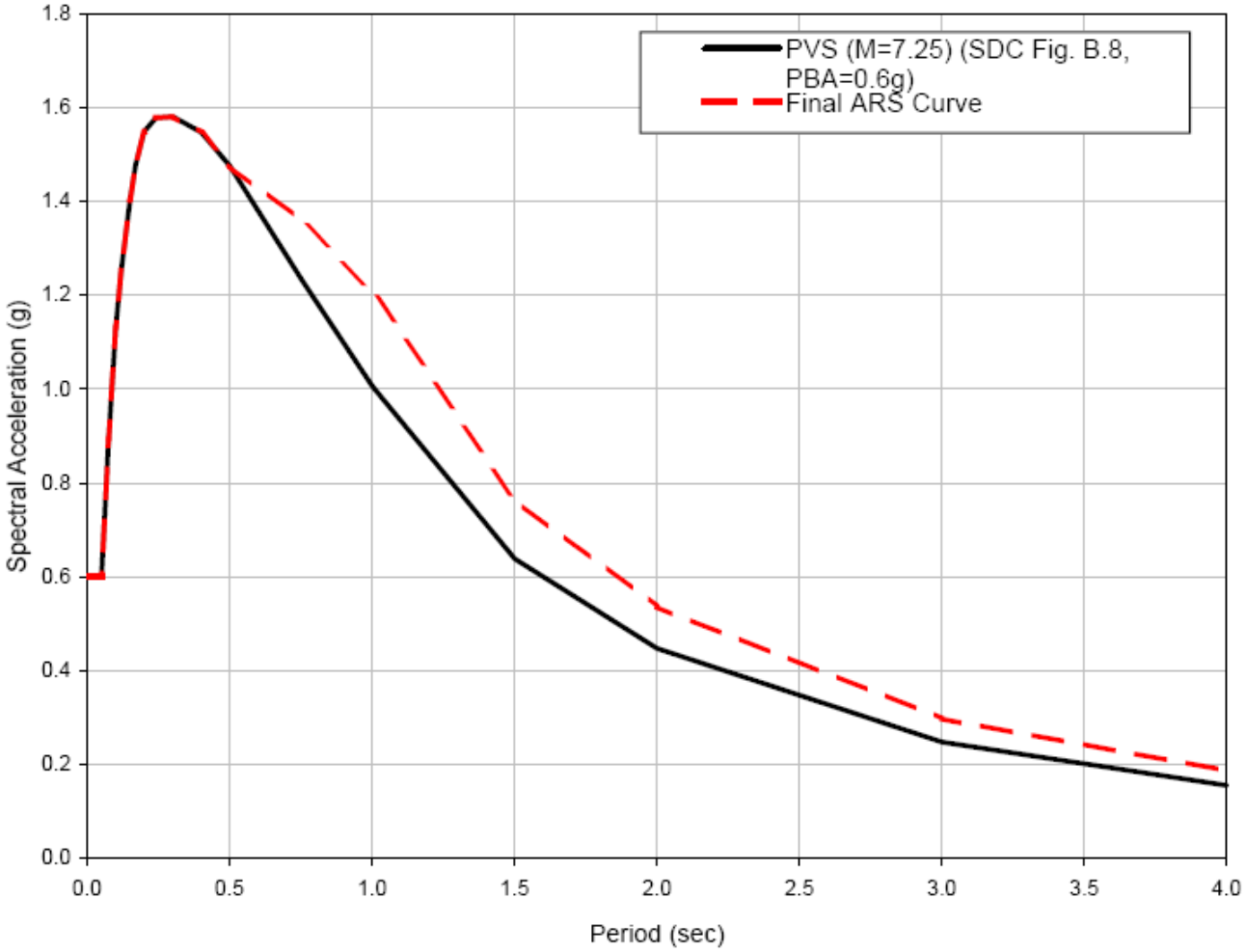
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Project Location Map

Figure 1

Project No. 06-123	Date: 2-08-10

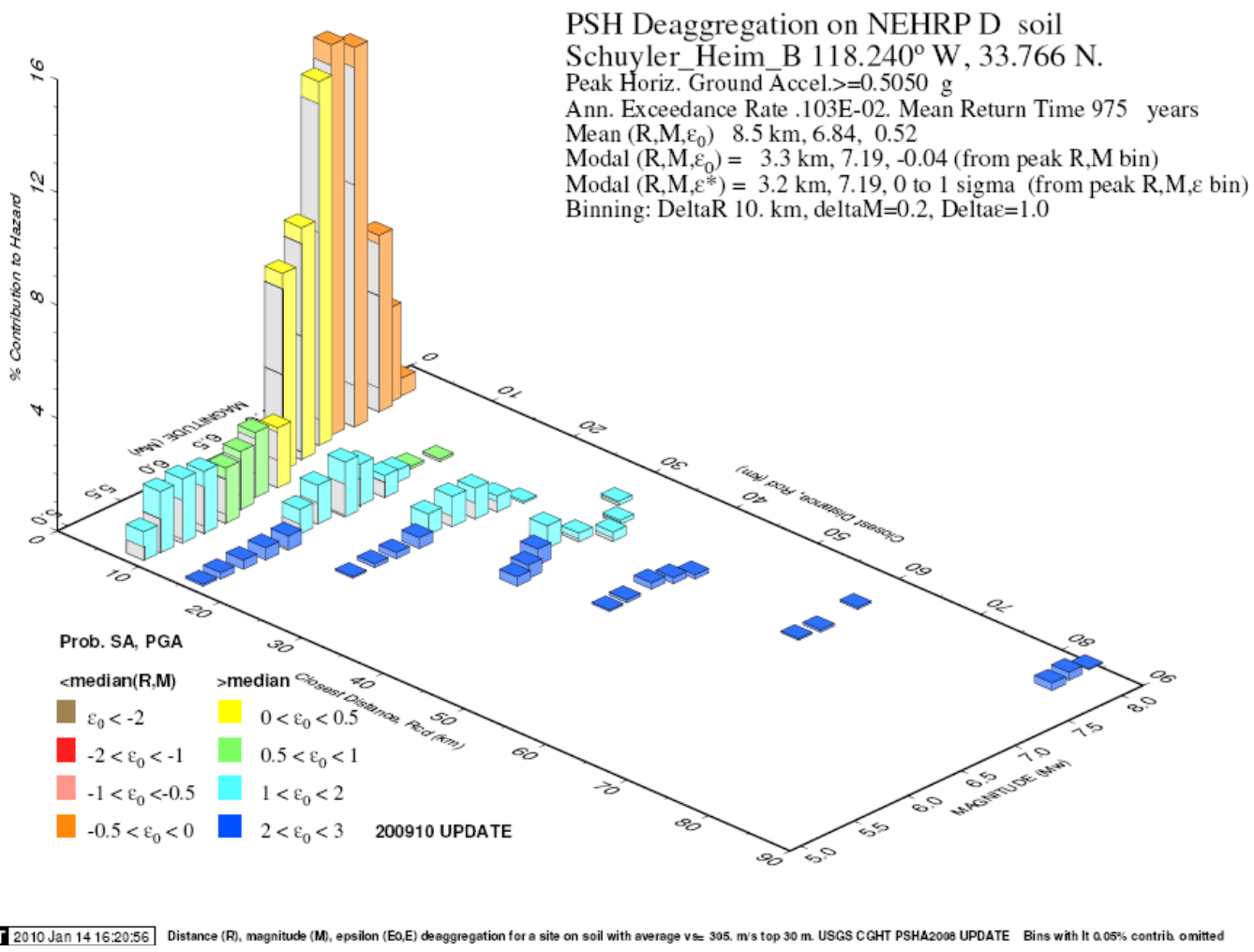


PVS (M=7.25) (M 7.25)
Peak Bedrock Acceleration (PBA)=0.6g
Soil Type D

Spectral Coordinates

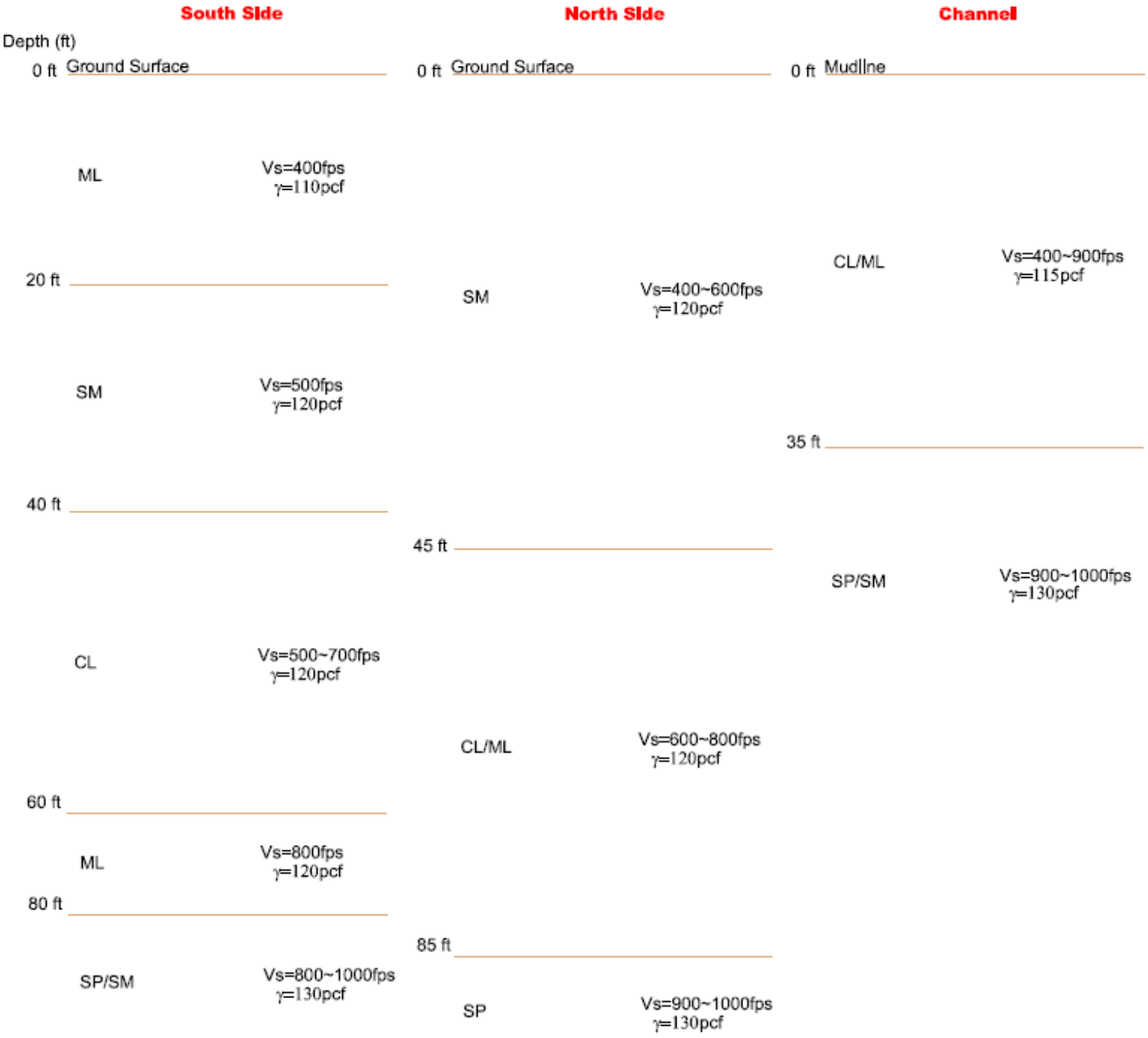
Period (sec)	Acc. (g)
0.010	0.600
0.020	0.600
0.030	0.600
0.050	0.600
0.075	0.893
0.100	1.132
0.120	1.259
0.150	1.403
0.170	1.480
0.200	1.550

Period (sec)	Acc. (g)
0.240	1.578
0.300	1.581
0.400	1.548
0.500	1.477
0.750	1.360
1.000	1.207
1.500	0.765
2.000	0.536
3.000	0.296
4.000	0.186



GMT 2010 Jan 14 16:20:56 Distance (R), magnitude (M), epsilon (Eo,E) deaggregation for a site on soil with average vs= 395. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT
Project No. 06-123	Date: 2-08-10	PSH De-aggregation Plot at PGA (USGS Beta) Figure 3



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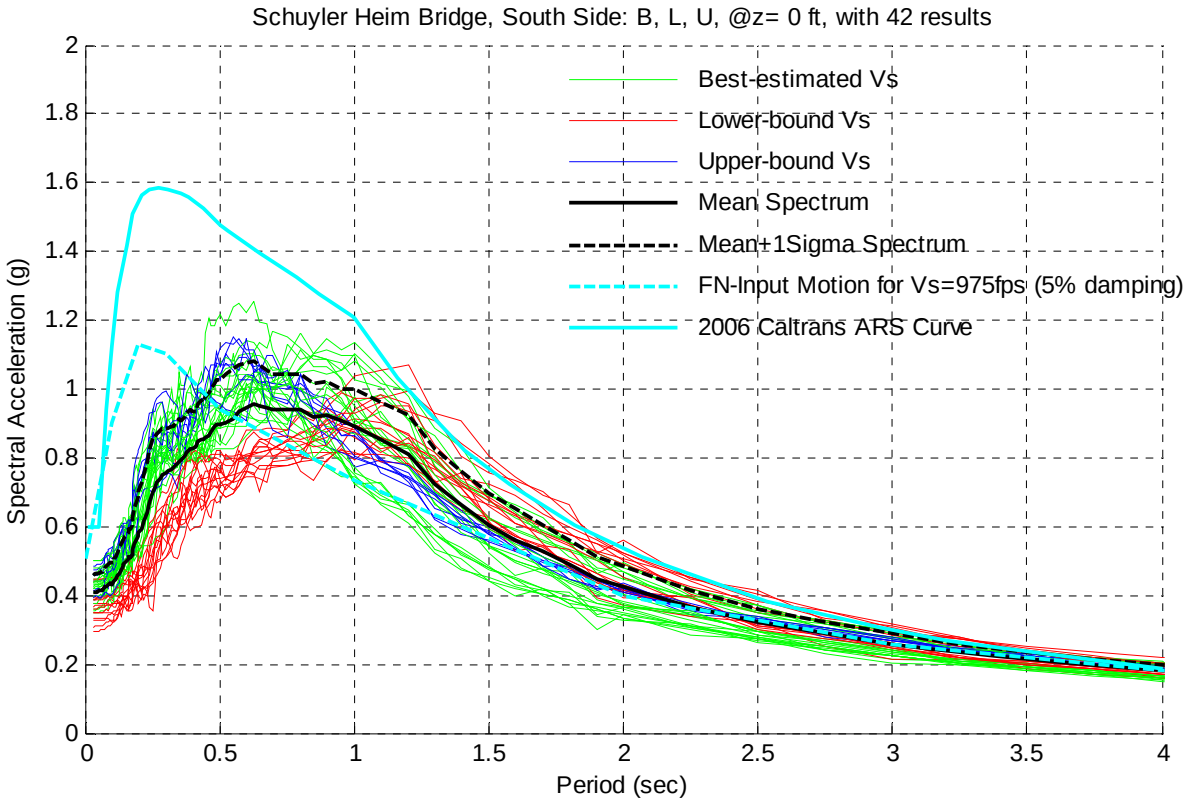
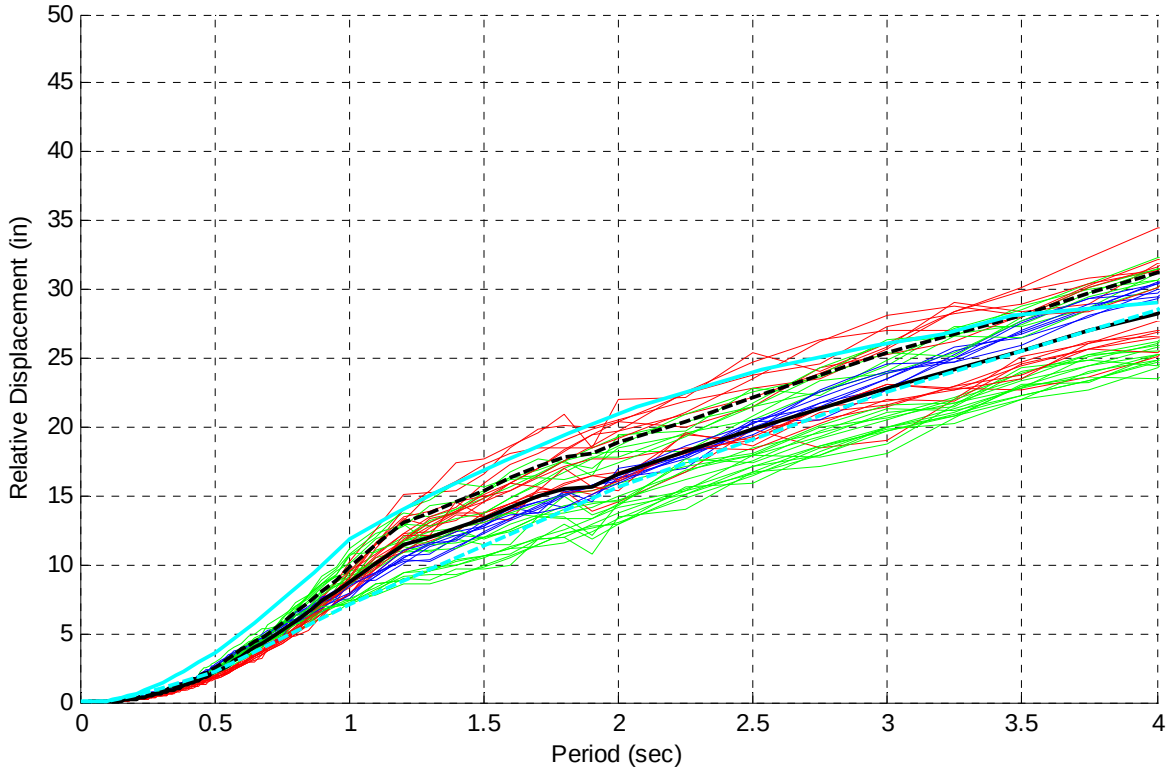
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Idealized Soil Profiles for Site Response Analyses

Project No. 06-123 | Date: 2-08-10

Figure 4





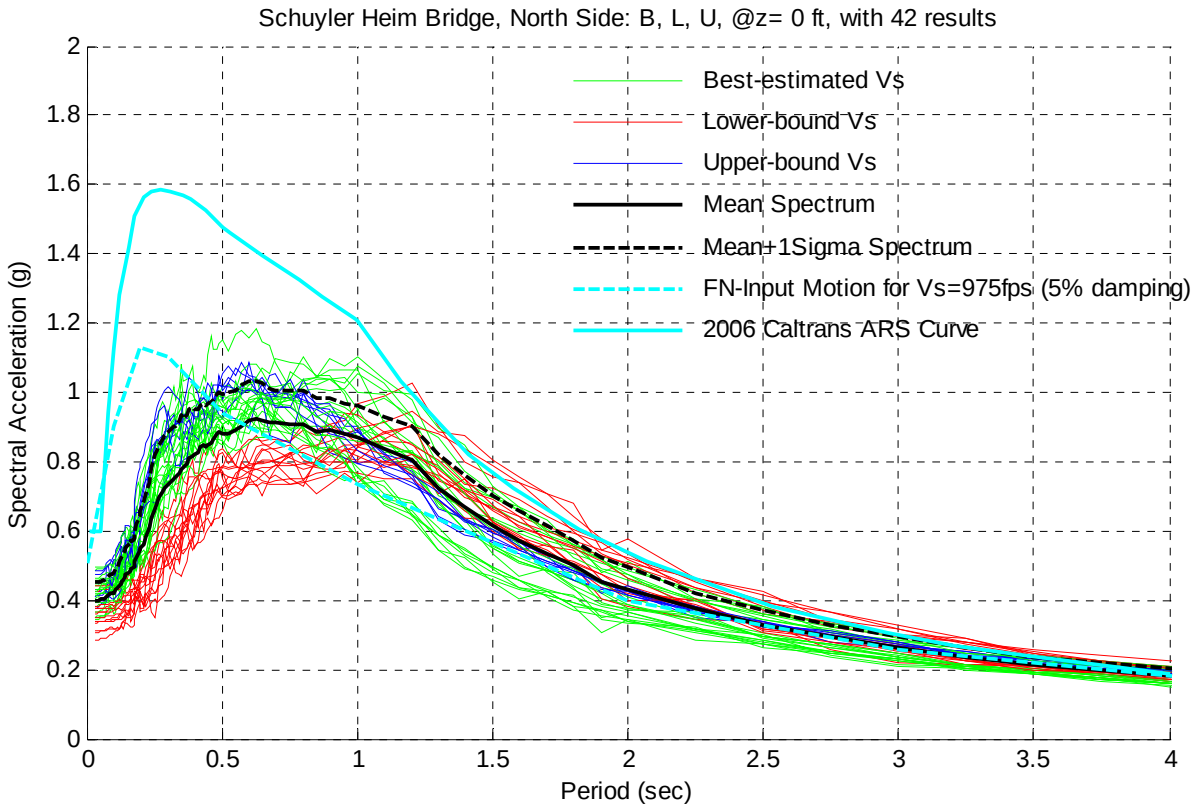
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

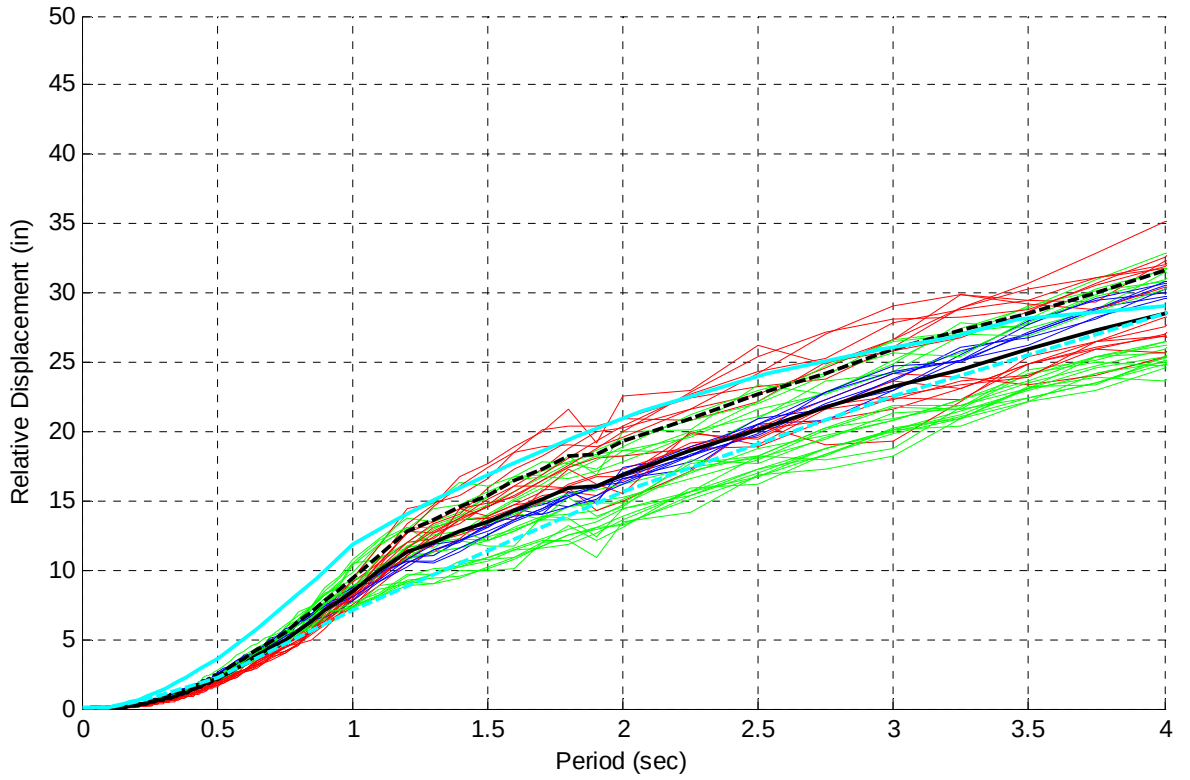
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of South Side at z=0 ft

Figure 5

Project No. 06-123 | Date: 2-08-10





Earth Mechanics, Inc.
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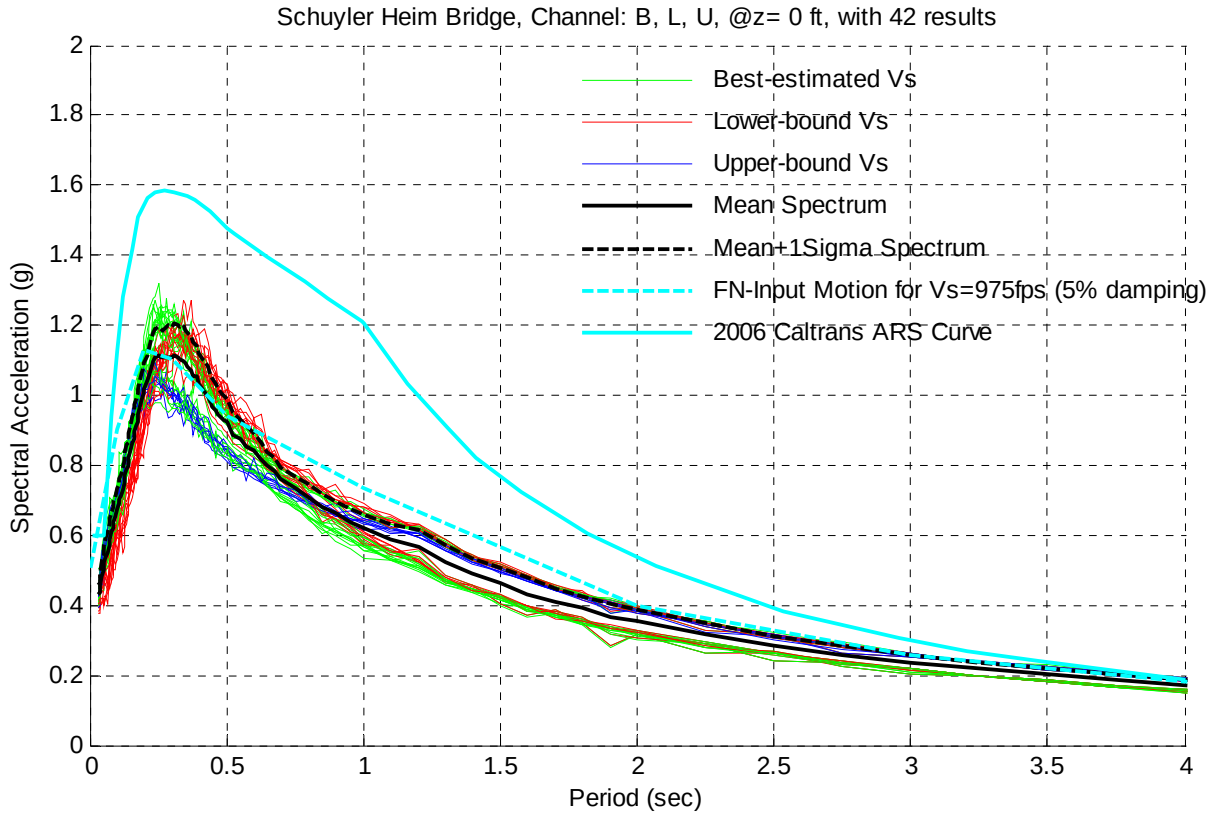
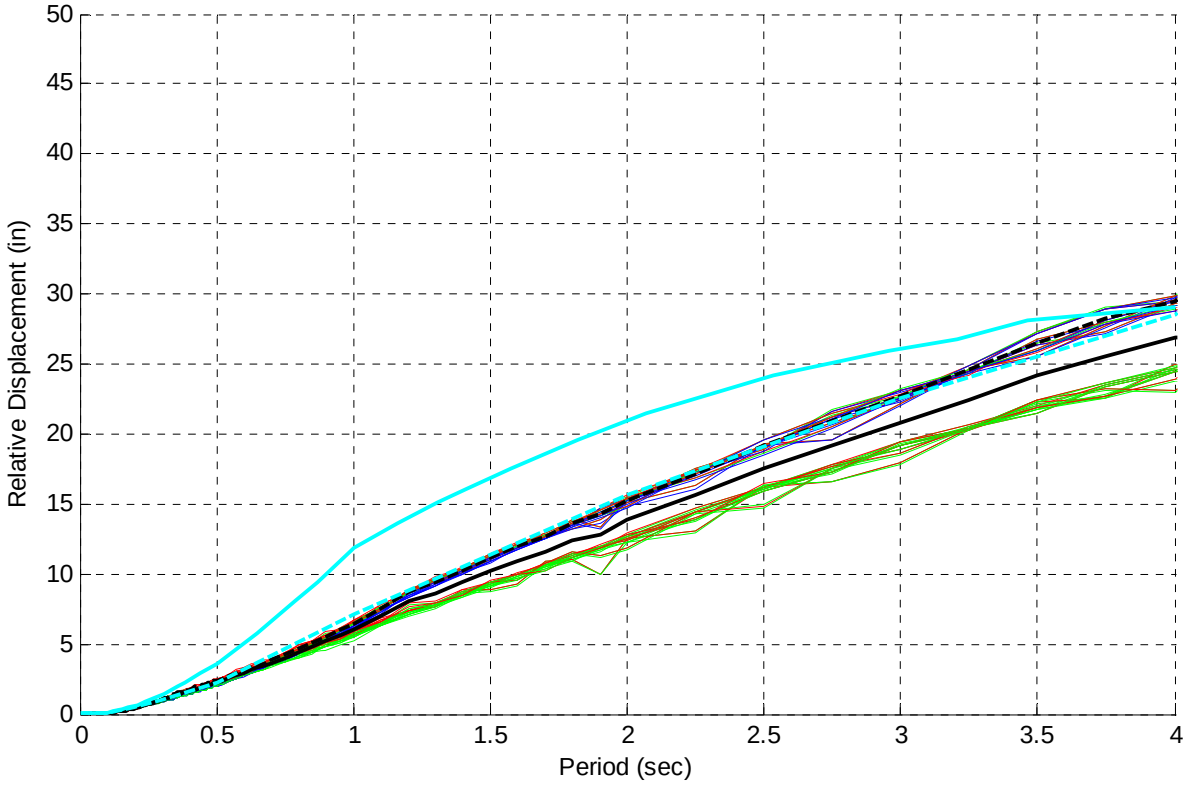
ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of North Side at z=0 ft

Figure 6

Project No. 06-123 | Date: 2-08-10





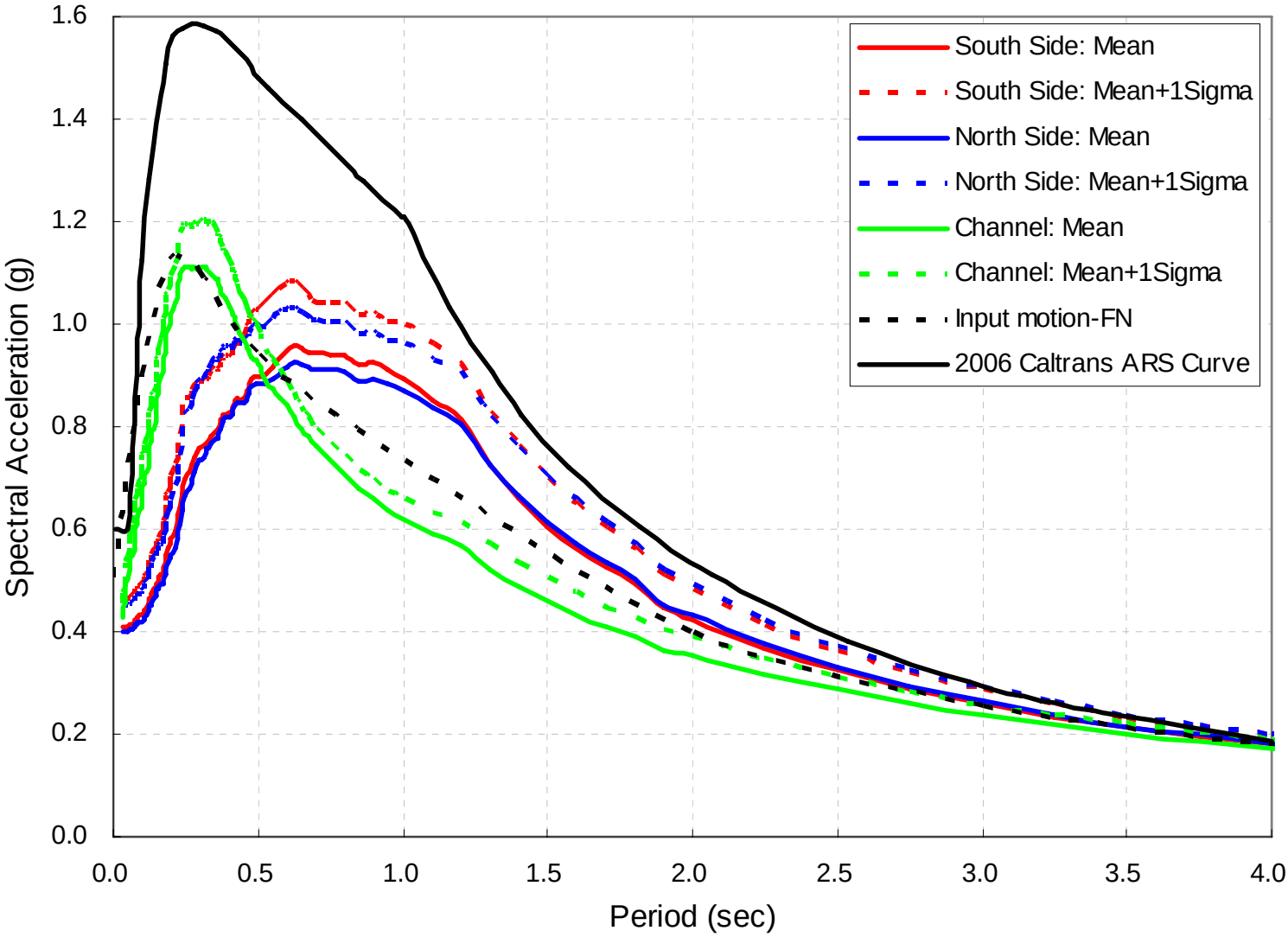
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Spectral Plots of Free-Field Motions of Channel at z=0 ft

Figure 7

Project No. 06-123 | Date: 2-08-10



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

ACTA SCHUYLER HEIM BRIDGE REPLACEMENT PROJECT

Comparison of Caltrans SDC 2006 and 2009 ARS Curves

Figure 8

Project No. 06-123

Date: 2-08-10

APPENDIX A: Seven Sets of "Firm-Ground" Spectrum Compatible Time Histories

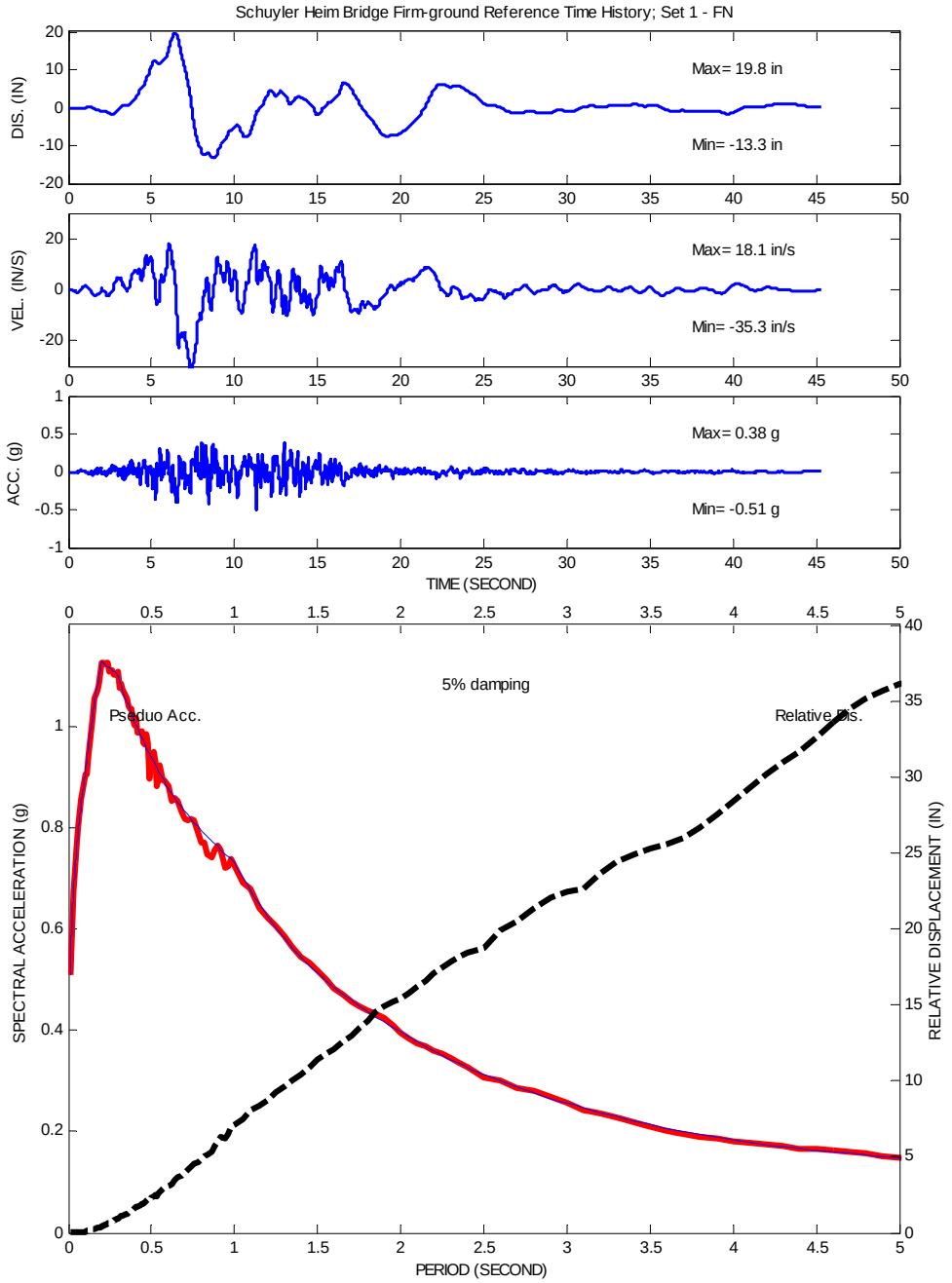


Figure A1. Schuyler Heim Bridge Reference Time History; Set 1 - FN

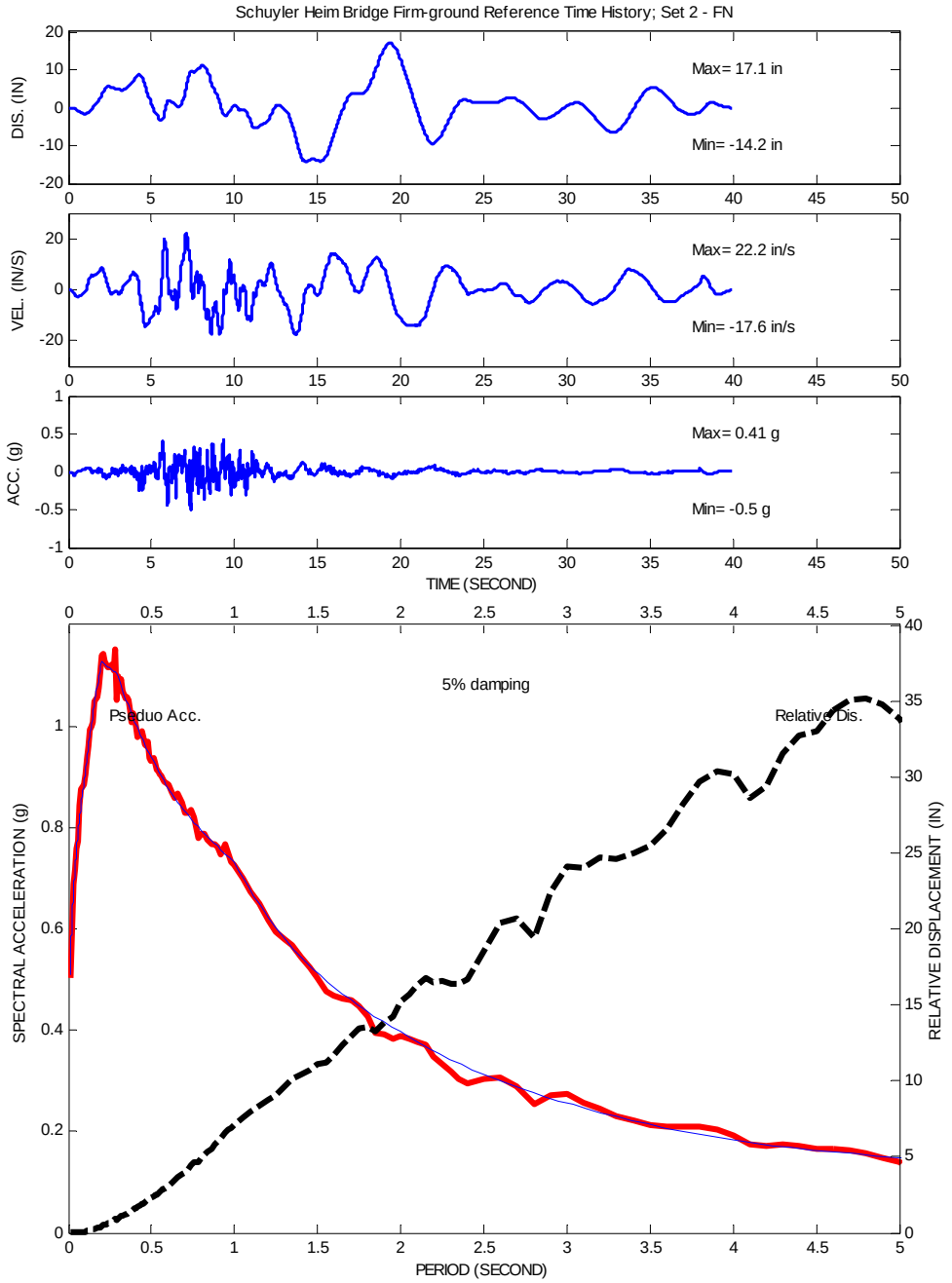


Figure A2. Schuyler Heim Bridge Reference Time History; Set 2 - FN

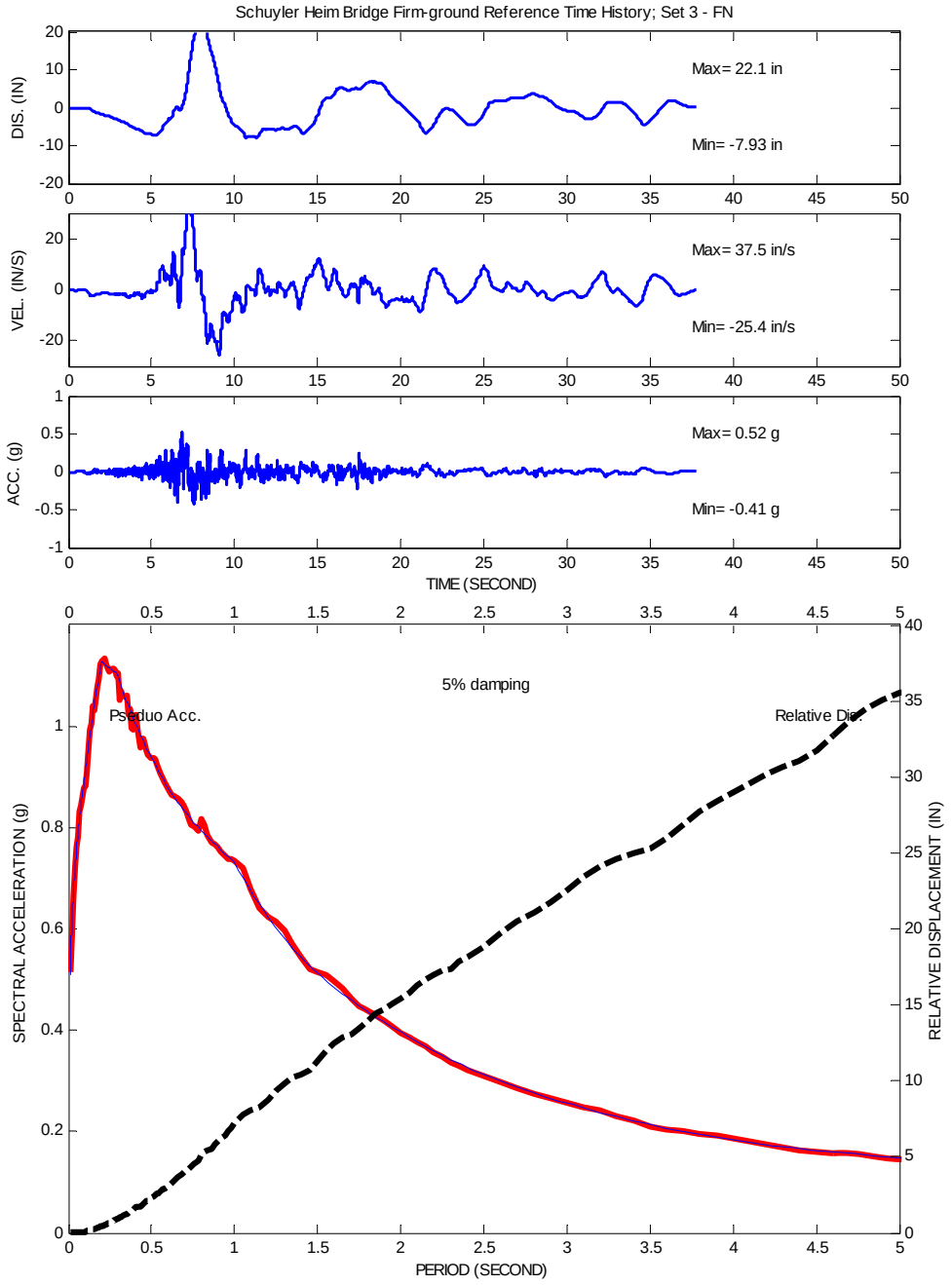


Figure A3. Schuyler Heim Bridge Reference Time History; Set 3 - FN

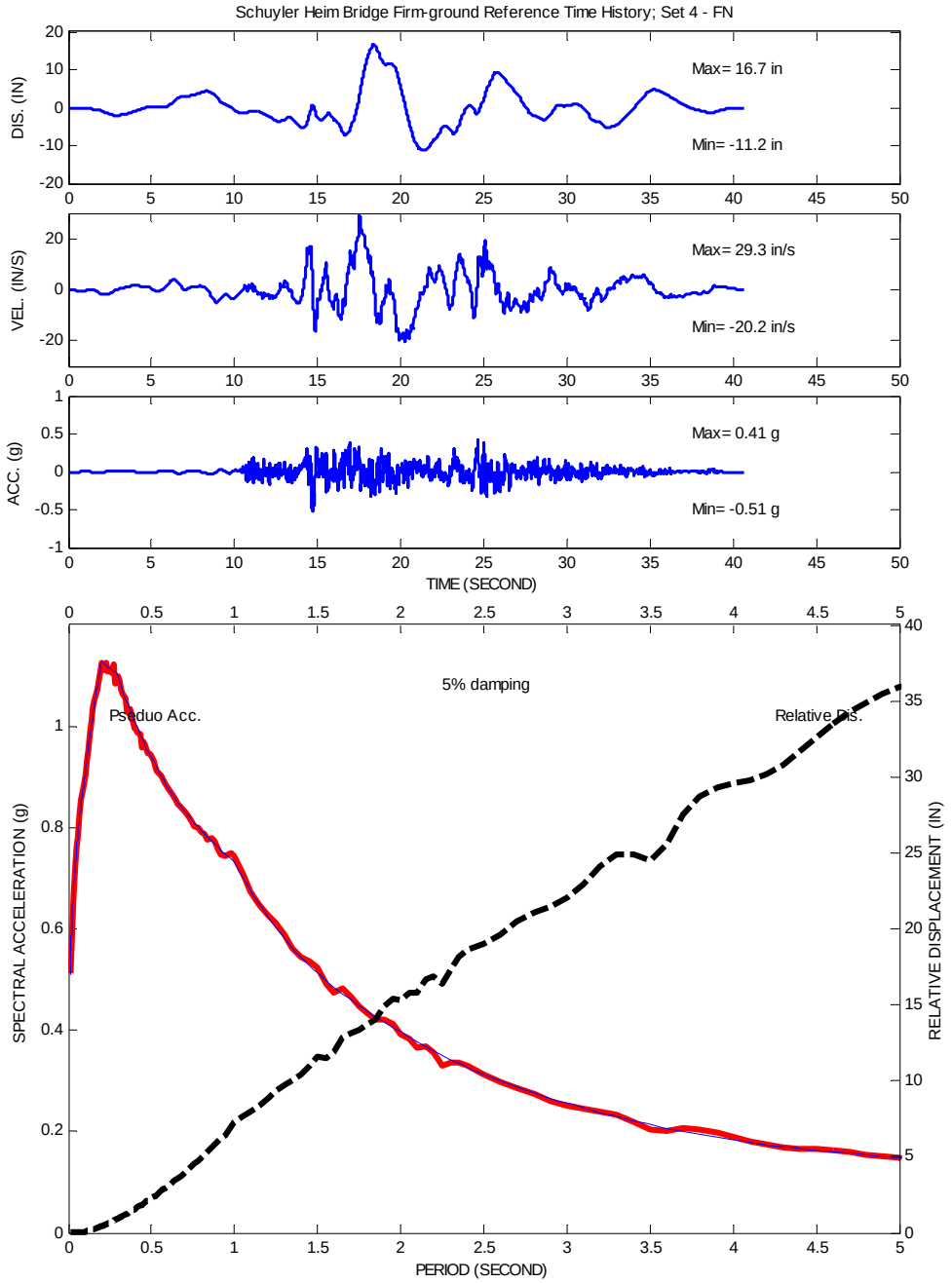


Figure A4. Schuyler Heim Bridge Reference Time History; Set 4 - FN

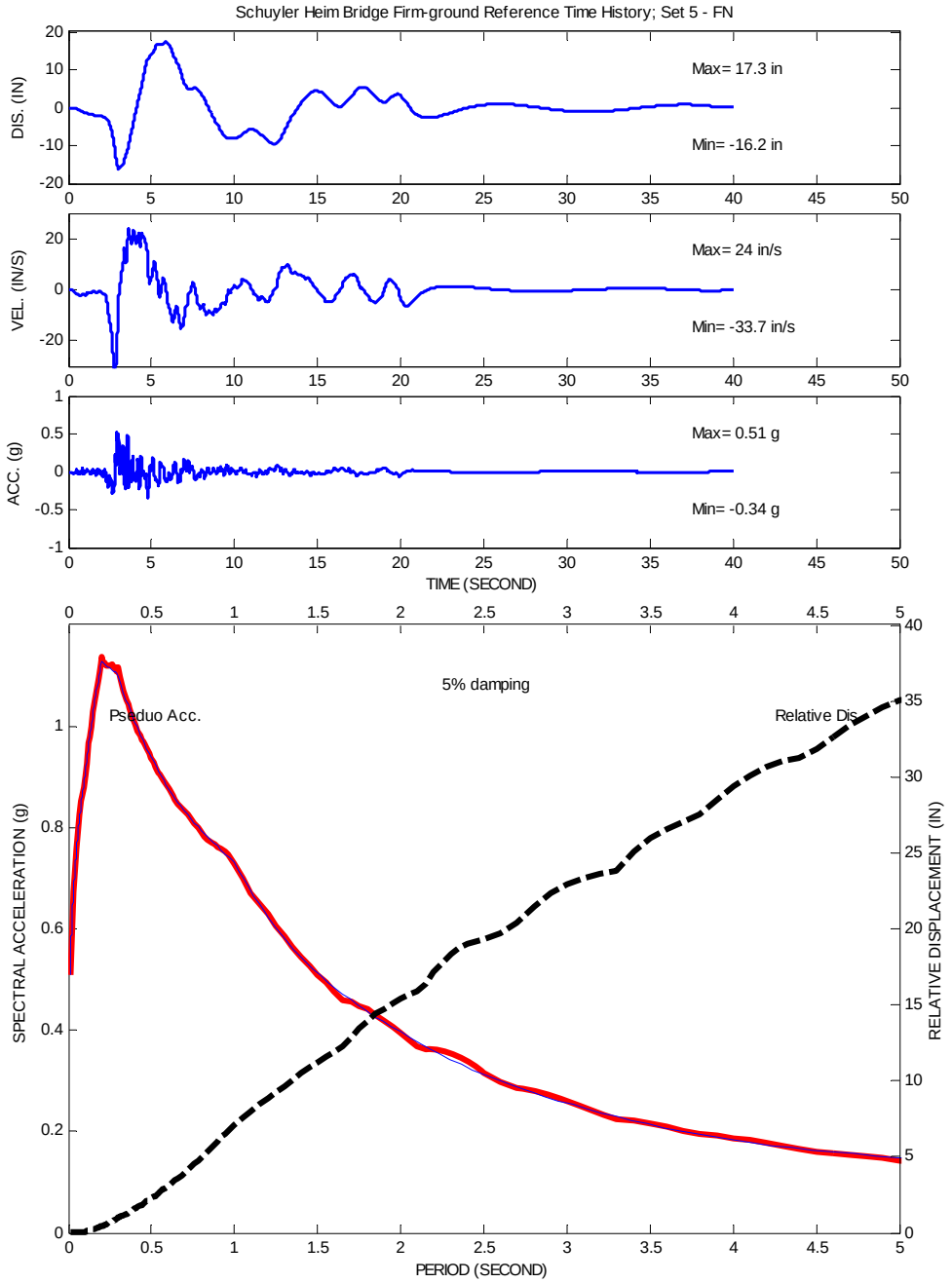


Figure A5. Schuyler Heim Bridge Reference Time History; Set 5 - FN

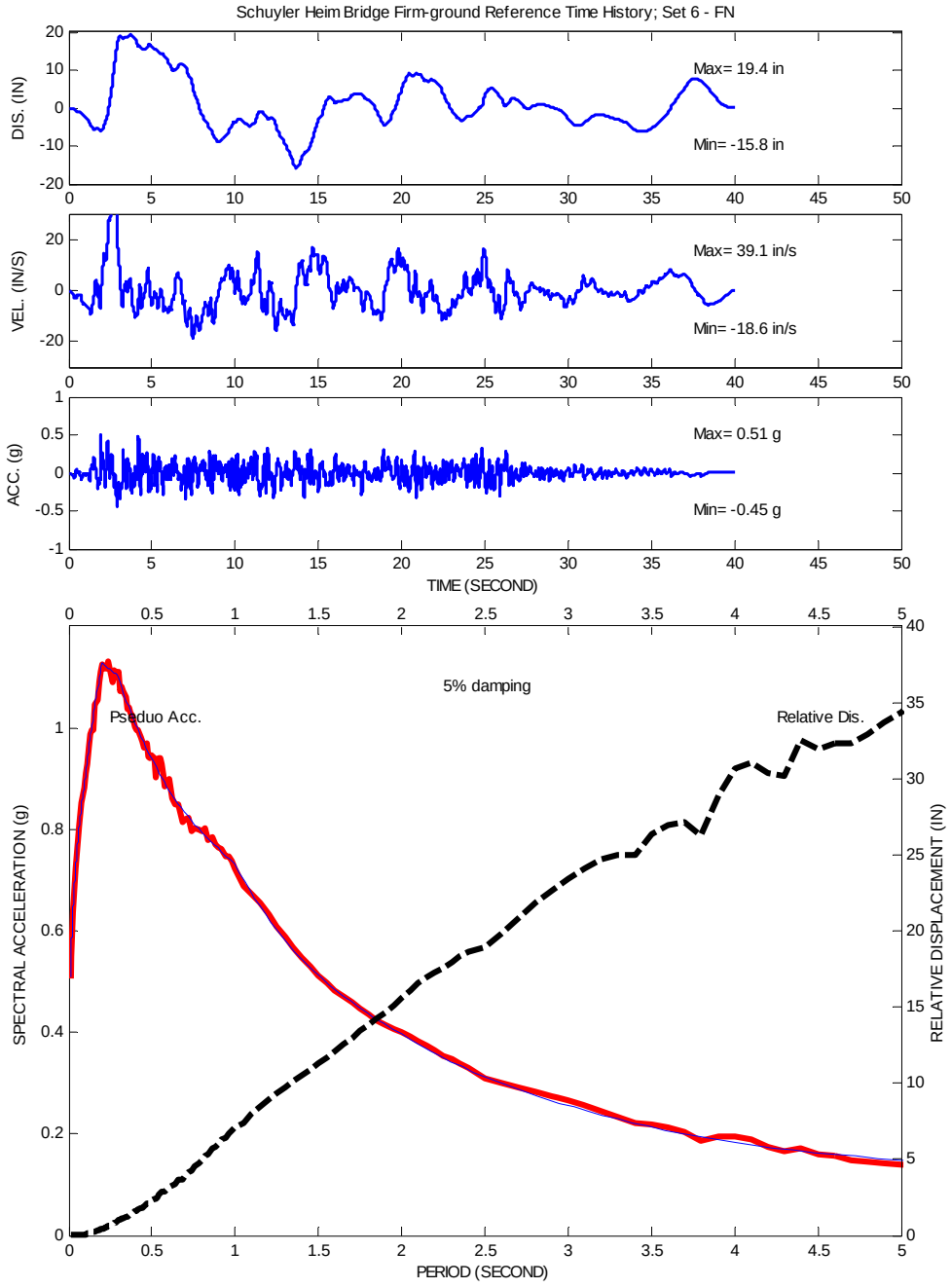


Figure A6. Schuyler Heim Bridge Reference Time History; Set 6 - FN

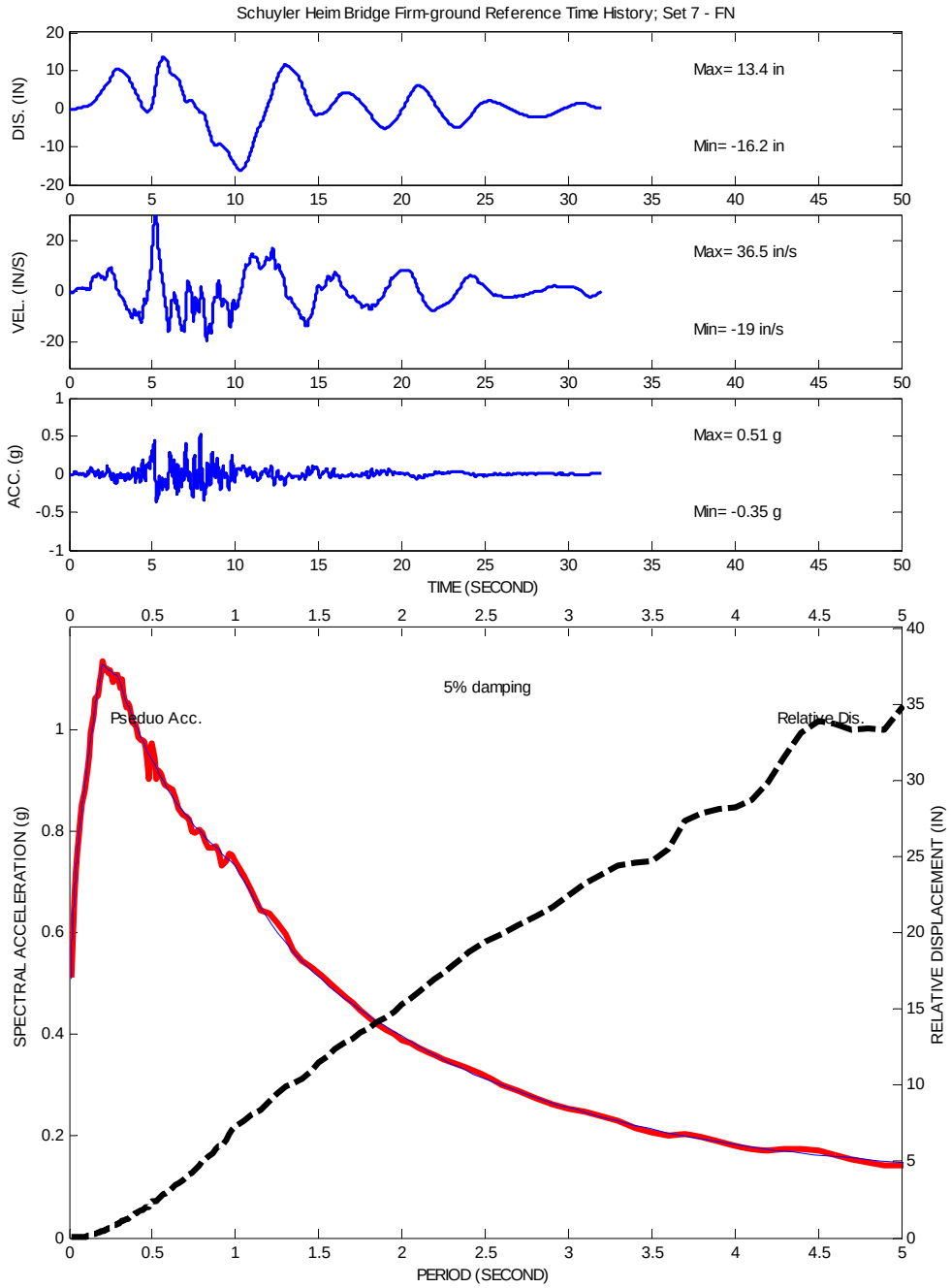


Figure A7. Schuyler Heim Bridge Reference Time History; Set 7 - FN

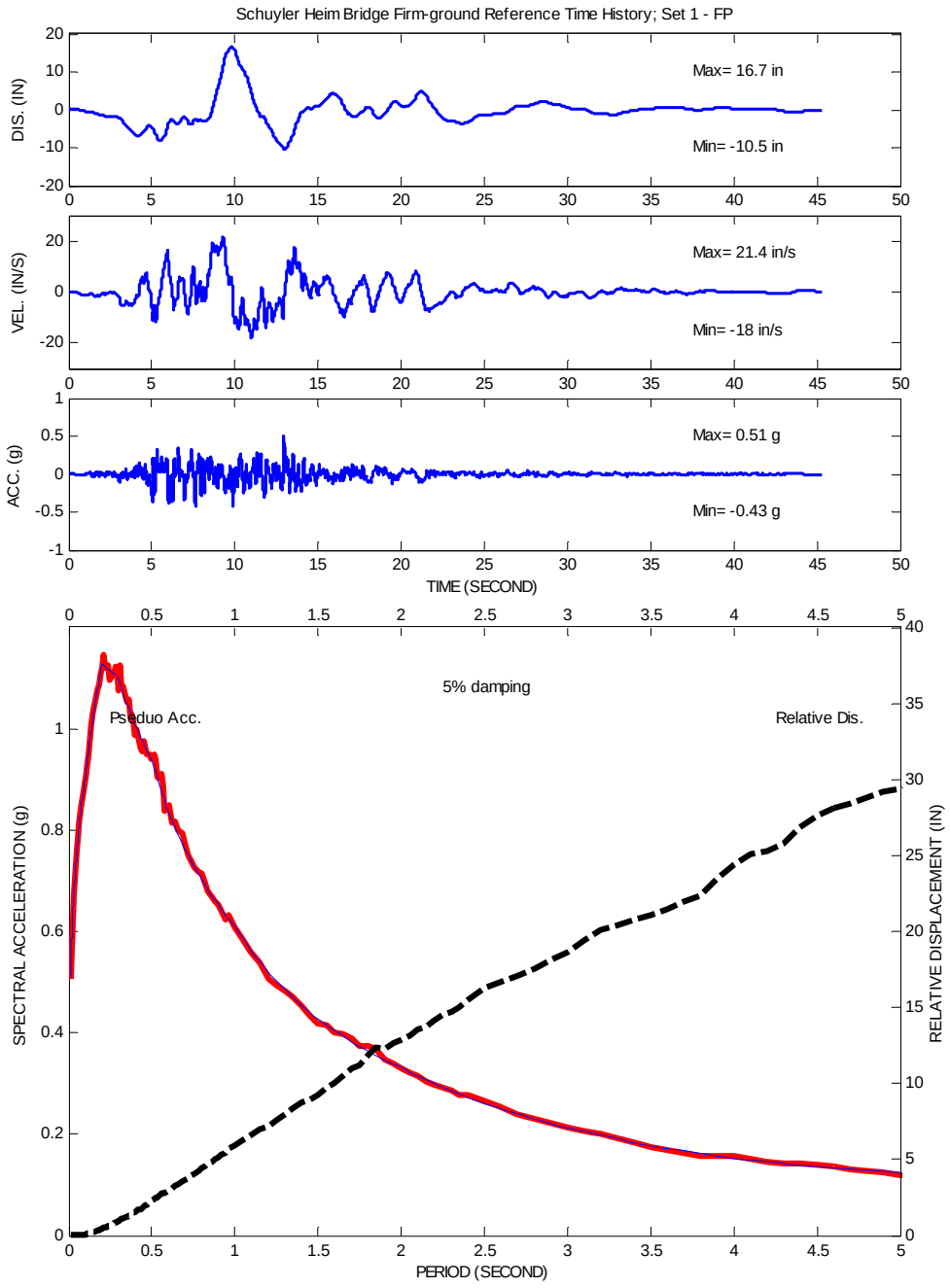


Figure A8. Schuyler Heim Bridge Reference Time History; Set 1 - FP

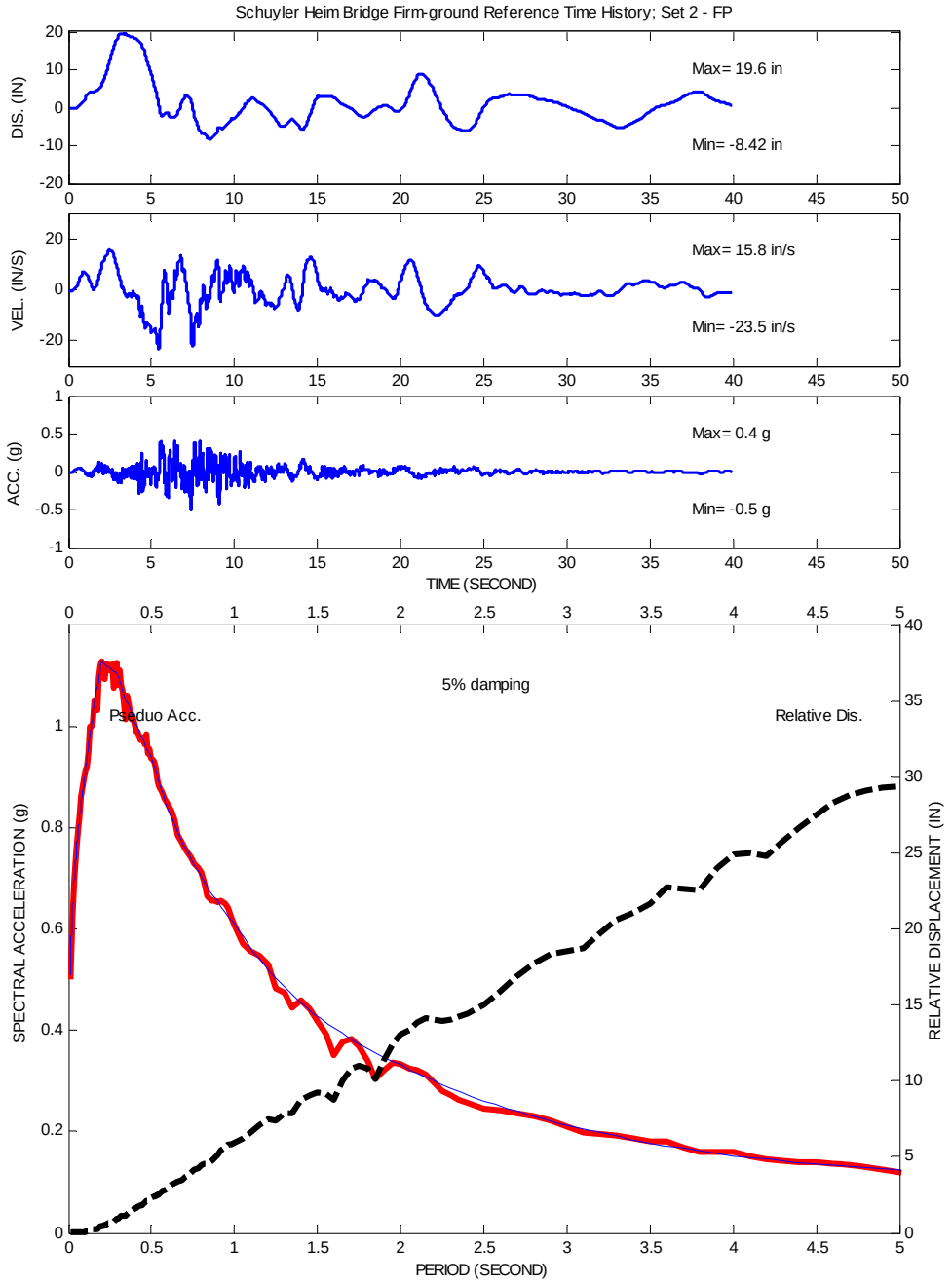


Figure A9. Schuyler Heim Bridge Reference Time History; Set 2 - FP

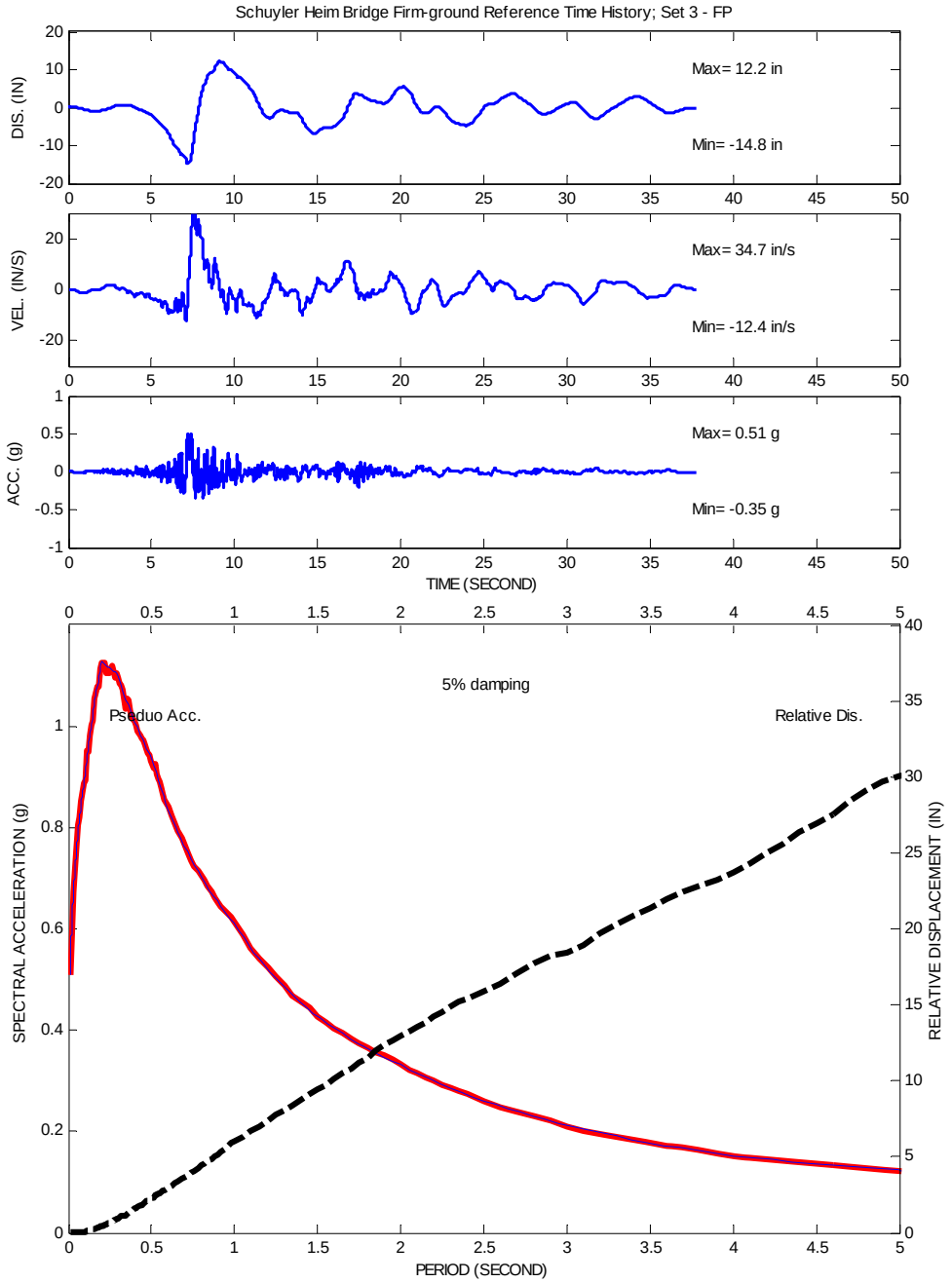


Figure A10. Schuyler Heim Bridge Reference Time History; Set 3 - FP

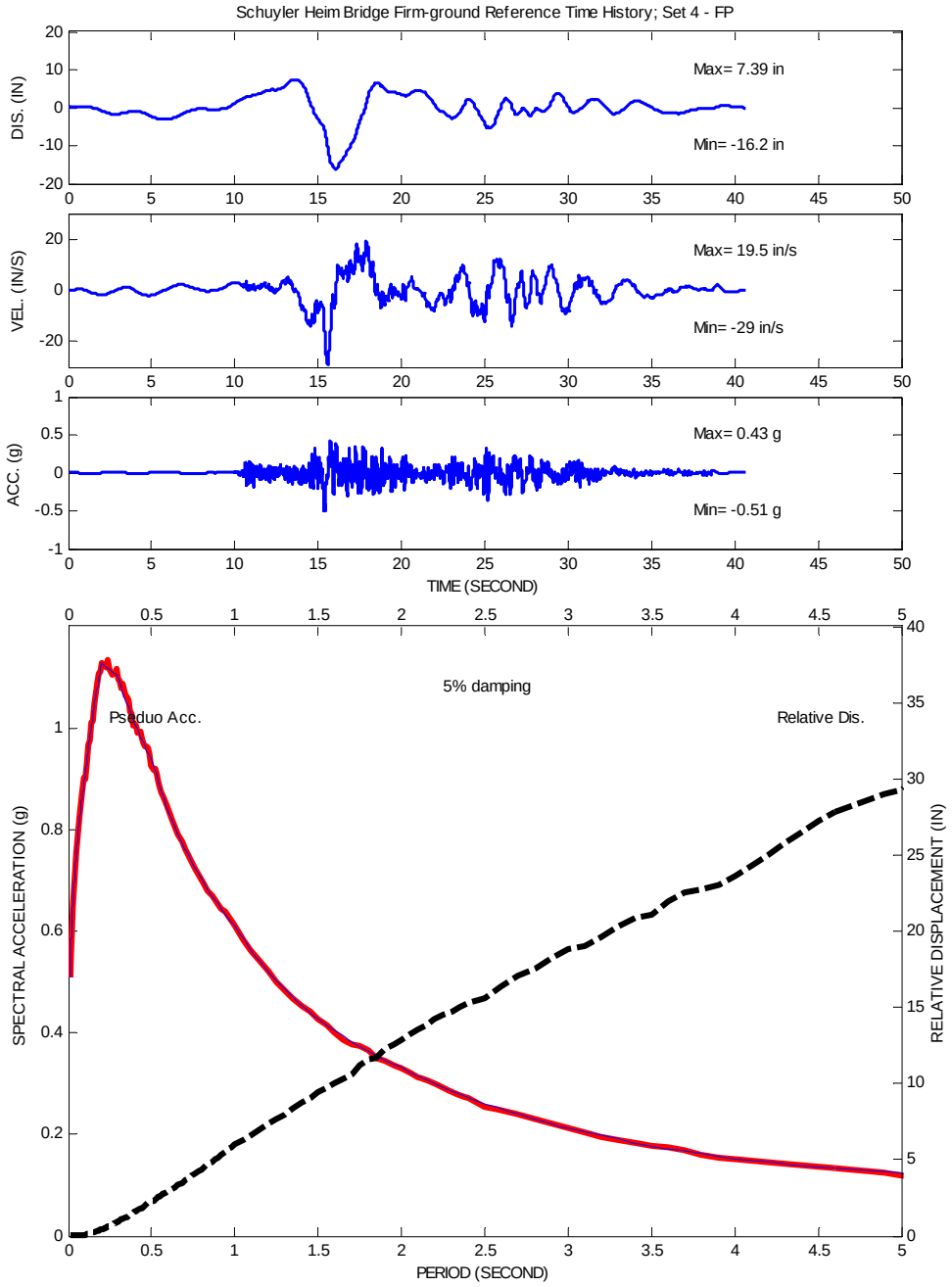


Figure A11. Schuyler Heim Bridge Reference Time History; Set 4 - FP

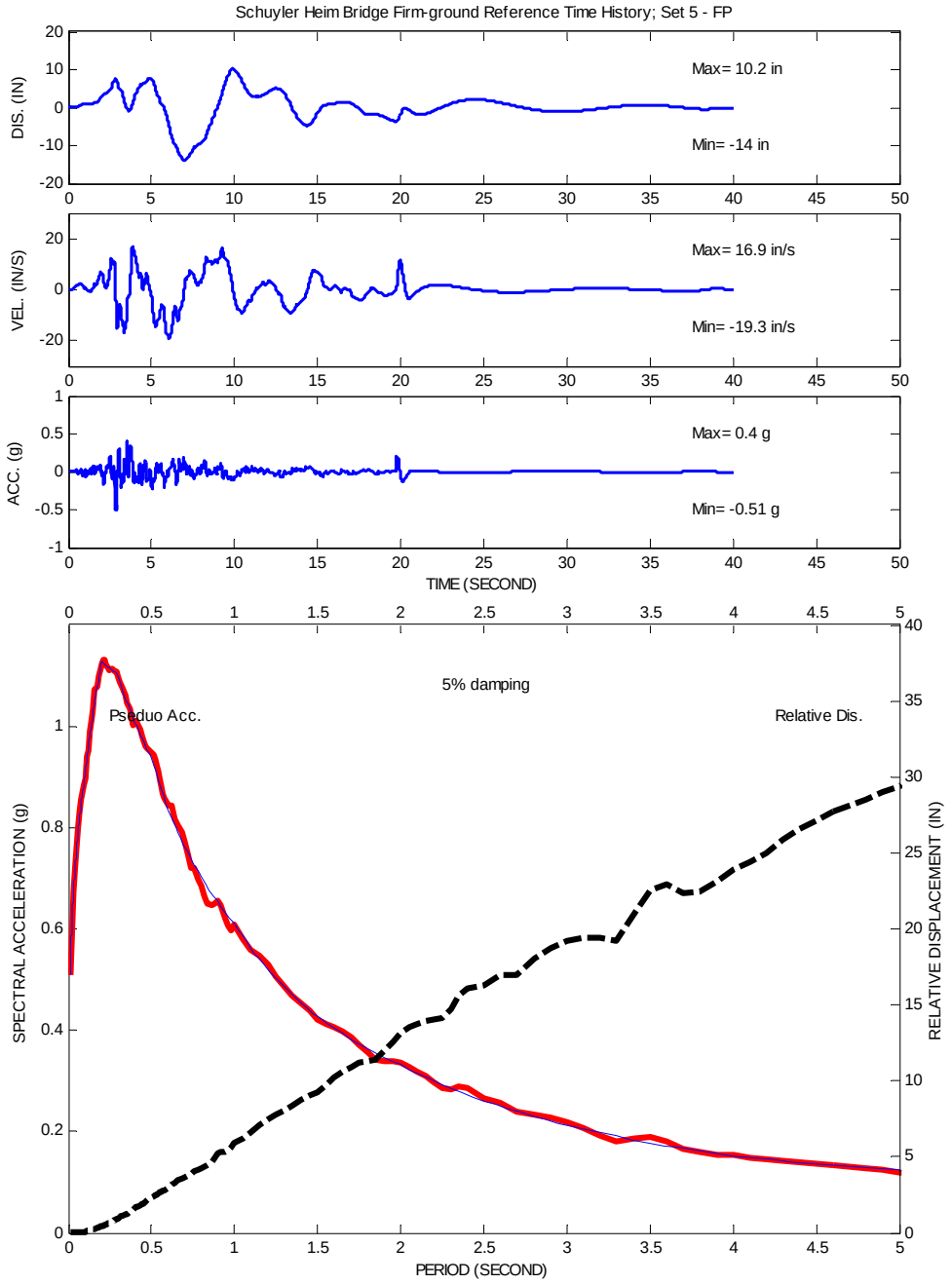


Figure A12. Schuyler Heim Bridge Reference Time History; Set 5 - FP

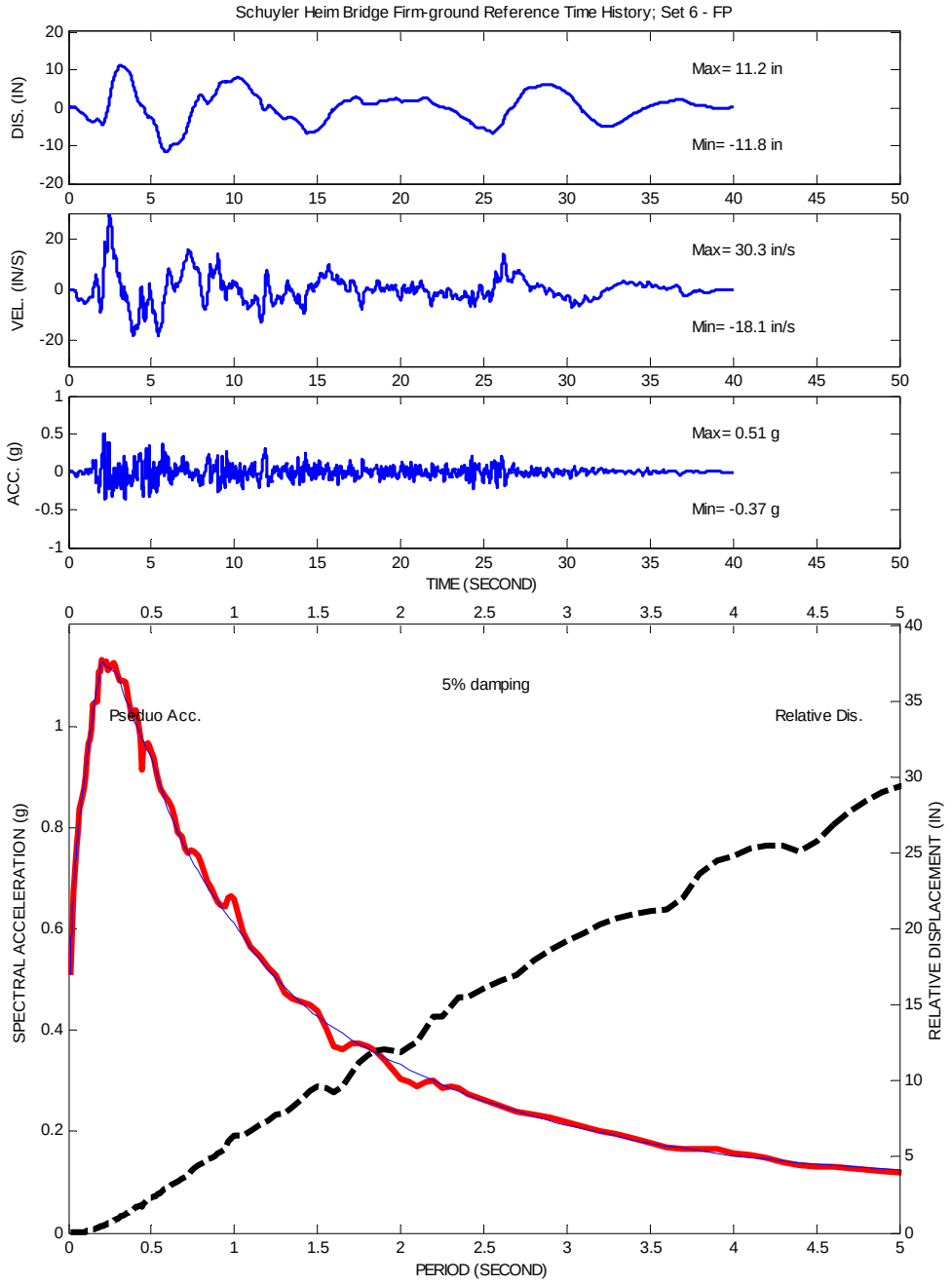


Figure A13. Schuyler Heim Bridge Reference Time History; Set 6 - FP

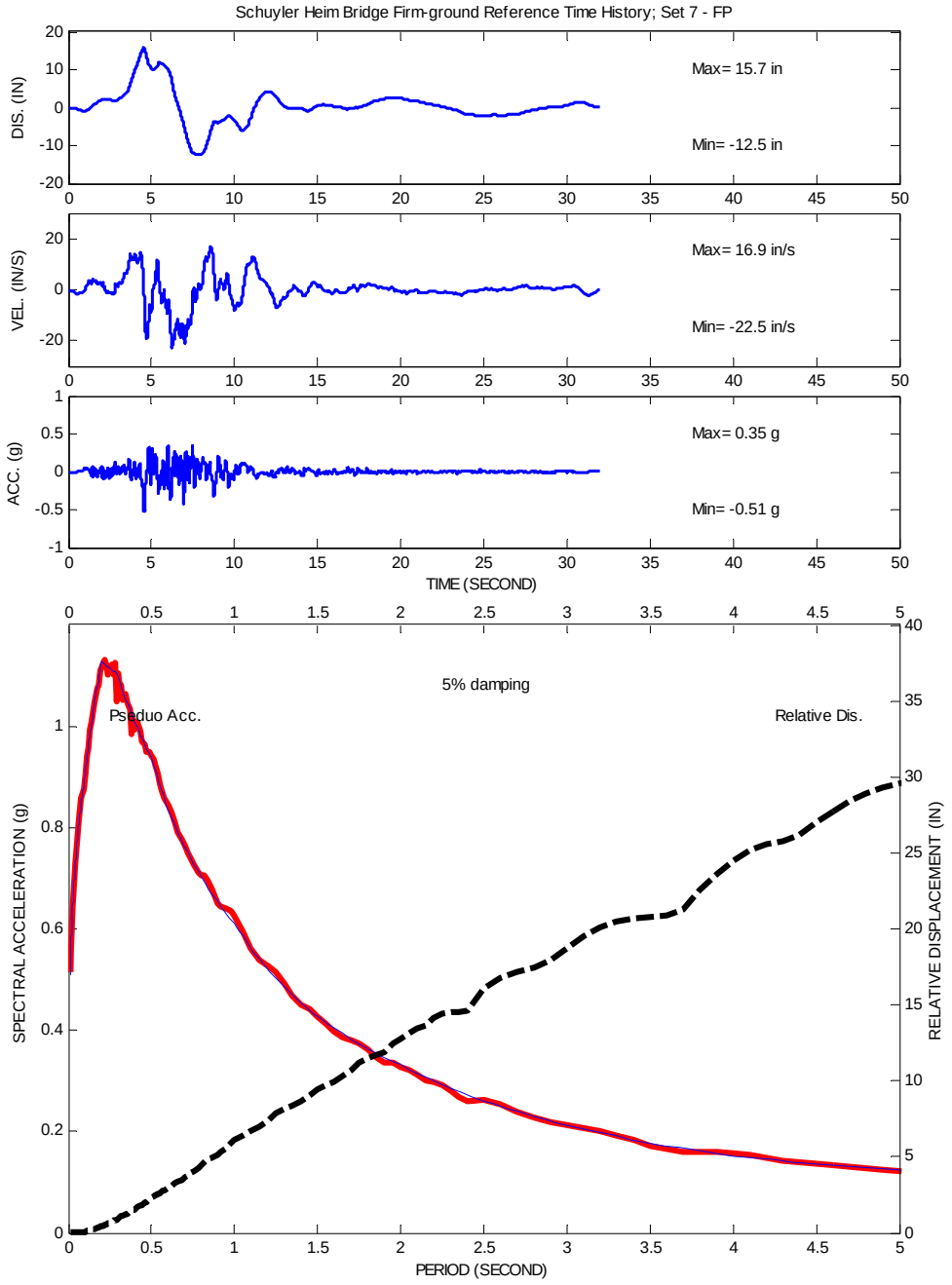


Figure A14. Schuyler Heim Bridge Reference Time History; Set 7 - FP

APPENDIX E. REVIEW COMMENTS AND RESPONSES

Subject: Re: MSE Wall BDA Section
From: Seungwoon Han <seungwoon_han@dot.ca.gov>
Date: Mon, 12 Apr 2010 12:09:05 -0400
To: Arul Arulmoli <arulmoli@earthmech.com>
CC: Eric Brown <e.brown@earthmech.com>, "Haitao_Liu@dot.ca.gov" <Haitao_Liu@dot.ca.gov>, Pat Wilson <P.Wilson@earthmech.com>, Ranjan Gunaranjan <ranjan@earthmech.com>, Deh-Jeng Jang <deh-jeng_jang@dot.ca.gov>

Arul,

As we discussed over the phone, I summarized our comments below. Please note that all comments below, and our previous comments on the bridges are applicable to all the wall reports. Also, I removed some of comments that we resolved during discussion. If you have any questions, Please contact us.

Comments on retaining wall reports

1. Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.

2. Please provide stability analysis for each phase construction if strength increase is considered with phase construction.

3. Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.

4. Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.

5. Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.

6. Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.

7. For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.

8. Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.

9.For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
1			Please revisit idealized soil profile and parameters, and revise them if necessary. Especially when global slope and external stability is considered, a failure tend to develop through a weak layer, which should be considered in the design. Therefore, layers with averaged parameters may not represent the weak layers. Also confirm undrained residual strength of liquefiable layers.	Patrick Wilson (PW), Eric Brown (EB), K. Arul Arulmoli (KA), Kandiah Pratheepan (KP)	A	I. Wall A1. The residual shear strength for the liquefiable material between El. -5 ft and -22 ft was revised to be 700 psf consistent with the lowest N1(60-CS) blowcount in that layer; 13 bpf for R-09-038/ D-4. Revised global stability analysis indicates a pseudo-static factor of safety greater than 1.1, meeting Caltrans requirements. Revised global stability calculations are attached. II. Wall C1. The residual shear strength for the liquefiable material between El. -11 ft and -25 ft was discretized into two layers (1) the material between El. -11 ft to -20 ft revised to be 1200 psf consistent with the lowest N1(60-CS) blowcount in that layer of 24 bpf for R-09-009/S-4 and (2) material between El. -20 ft to -25 ft revised to be 600 psf consistent with the lowest N1(60-CS) blowcount in that layer of 10 bpf for sample R-09-011/S-5. Revised global stability calculations are attached. III. Walls E1/E2. The critical layer in the global stability analysis is the material between El. -5 ft and -17 ft and is modeled as 600 psf, which is supported by triaxial test results performed on three different samples; R-09-033/U-4, R-09-034/U-3 and R-09-035/U-3. IV. Walls G1/G2. The idealized soil profile beneath walls G1/G2 has been revised. The critical revision was the reduction of the undrained shear strength in the layer from -6 to -23 ft to 650 psf, which was verified as the most conservative strength in that layer, according to the lab test data. V. Wall H1. The undrained shear strength of material between El. -5 ft and -30 ft was reduced from 750 psf to 700 psf, which is supported by triaxial test results performed on samples R-09-036/U-5 and R-09-037/U-6.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)

SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
2			Please provide stability analysis for each phase construction if strength increase is considered with phase construction.	PW / EB / KA	A	Will comply. Strength increase due to consolidation of fine grained layers was considered in the global stability analysis of MSE walls E1-E2 and MSE wall G1. Global stability analysis for the temporary condition during construction for these walls indicate a factor of safety greater than 1.25 for all walls. Global stability calculations for the temporary condition for these walls are attached.		
3			Please check allowable static long-term and short-term settlement, and seismic induced settlement with the Structure. Especially, caltrans standard cantilever walls may not carry the settlement estimated in the report. Also, when calculating bearing capacity of the standard wall, settlement should be considered since settlement will control the footing design for most sandy soils.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with wall contractors, the allowable differential settlement for an MSE Wall is 1% along the wall length. Static and seismic settlement calculations indicate the anticipated differential settlements are within the tolerable limits for MSE walls. For retaining wall G2 (standard cantilever wall) the settlement analysis has been revised to account for the proposed staged construction and indicates the anticipated static settlement beneath the proposed wall after footing construction is less than 4 inches with a maximum differential settlement of 2 inches along the wall length; which is considered within the tolerable limits of a Caltrans Standard Type 1 wall. The recommendations in the report have been revised to require that wall G2 should not be constucted until the settlment period for the embankment is complete (a temporary shoring wall will be required to retain the embankment during the settlement period). The revised settlement calculations are attached. The bearing capacity calculations for retaining wall G2 have been revised according to the methodology proposed by Meyerhoff (1956) considering that the footing will be embedded in granular fill material compacted to 90% relative density. The revised bearing		
4			Backfill material and soil corrosivity requirement should conform to our standard special provision (SSP) for MSE wall. The requirement in SSP is more stringent than that in BDS.	PW / EB / KA / KP	A	Will comply. The corrosion requirements for MSE backfill will be revised and are attached.		
5			Please provide a table showing bearing capacity FOS and minimum strap length to meet external stability, global stability and settlement.	PW / EB / KA / KP	A	Will comply. A table will be added to the "Bearing Capacity" section that will list the FOS for bearing capacity and global stability for a range of strap lengths. A sample table for MSE Walls E1-E2 is attached.		

RESPONSES FOR ACTION REQ'D
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

MSE Wall A1 (Bridge No. 53-E0147), MSE Wall C1 (Bridge No. 53-E0148), MSE Wall E1 (Bridge No. 53-E0149), MSE Wall E2 (Bridge No. 53-E0150), MSE Wall G1 (Bridge No. 53-E0151), Retaining Wall G2 (Bridge No. 53-EXXXX) and Retaining Wall H1 (Bridge No. 53-XXXX)
SUBMITTAL REVIEW COMMENTS FORM

District-Co-Rte-PM:	07-LA-47-PM (Varies)	Reviewing Agency:	Caltrans District 7
EA No.:	238501	Functional Unit:	Geotechnical Design South - 2
Milestone:	65% PS&E	Review Date:	April 12, 2010
Consultant:	Earth Mechanics, Inc.		

NO.	DWG NO./ SPEC NO./ SECTION NO., ETC.	Reviewed By:	COMMENTS	RESPONSE BY:	ACTION REQ'D	RESPONSE	DATE	CURRENT STATUS (OPEN / CLOSED)
6			Structural backfill is assumed to have a friction angle of 34 degree with zero cohesion, and compacted to a minimum 95 percent.	PW / EB / KA / KP	A	Will comply. Idealized soil profiles and global stability analyses have been revised to reflect a 34 degree/zero cohesion material for structural backfill.		
7			For Wall A1, please check inputs regarding a spreadsheet, "Stress at Various Points Below an Earth Embankment." The Inputs for embankment geometry is not consistent with real embankment geometry.	PW / EB / KA / KP	A	Will comply. The stress calculations as part of the settlement analysis beneath MSE Wall A1 which now reflect the current geometry of the proposed embankment are attached.		
8			Please verify bearing pressure of MSE wall. Caltran will also check BDA provided by EMI.	PW / EB / KA / KP	A	Will comply. Based upon our conversations with the designers, the demand bearing pressures listed in the Caltrans BDA (2002) are suitable for use in determining demand bearing pressures for walls with a level backfill and equivalent vehicle surcharge.		
9			For Wall H1, end bearing of CIDH pile for retaining wall should be limited to consider potential defect at the pile bottom during construction. Also, CIDH pile construction should comply to Caltrans SSP.	PW / EB / KA	A	Will comply. Axial capacity calculations have been revised to limit the end bearing to no more than 20% of the nominal resistance. Revised axial pile capacity calculations are attached. Also, the recommendations provided in Section 6.2 "CIDH Pile Construction" have been confirmed to be in compliance with Caltrans SSP's.		
10			From Review of Bridge Foundation Reports - Log of Test Borings. Except for the standard split sampler, blowcounts recorded by driving any other sampler should not be shown in the LOTBs.	PW / EB / KA / KP	A	Will comply. LOTB's have been revised to only show SPT blowcounts.		
11			From Review of Bridge Foundation Reports - Consolidation Coefficient (CV) is a function of the effective overburden and pre-consolidation stress for a given soil. Please present the correlation curve between consolidation coefficient and applied vertical pressure, and select the lowest coefficient, or the coefficient value under the actual effective overburden by the end of construction for the settlement evaluation.	PW / EB / KA / KP	A	Will comply. Settlement rate calculations have been revised to use the lowest consolidation coefficient determined from lab testing. Revised settlement calculations are attached.		
12			Settlement of adjacent utilities.	PW / EB / KA / KP	A	A section will be included to each report that addresses the settlment benath adjacent utilities.		

RESPONSES FOR ACTION REQD
A: AGREE FULLY WILL COMPLY.
B: AGREE PARTLY SEE NOTED EXCEPTIONS.
C: DISAGREE. REASONS ARE NOTED.
D: COMMENT HAS BEEN SUPERCEDED BY DESIGN DEVELOPMENT.
E: QUESTION ONLY. ANSWER THE QUESTION.

RECEIVED
ACTA DCC
JUL 19 '10
10036 04 01 000
0165615
C-NELSON

TETRA TECH

Heather Benfield, P.E.
Project Manager

Ms. Elaine Silvestro
Alameda Corridor Engineering Team
One Civic Plaza, Suite 350
Carson, CA 90745

July 15, 2010

Subject: **Final Baseline Hydroacoustic Survey Plan for Commodore Schuyler F. Heim Bridge, Demolition and Replacement Project, Long Beach, California**

Dear Elaine:

Enclosed are three (3) copies of the above reference plan. The final workplan is the same as the revised final workplan (with a few minor typo corrections) which incorporated comments from ACTA. Upon review of the plan by the National Marine and Fisheries Service (NMFS), Tetra Tech will prepare responses to comments, if necessary.

If you have any questions or need additional information, do not hesitate to contact me at (626) 470-2415.

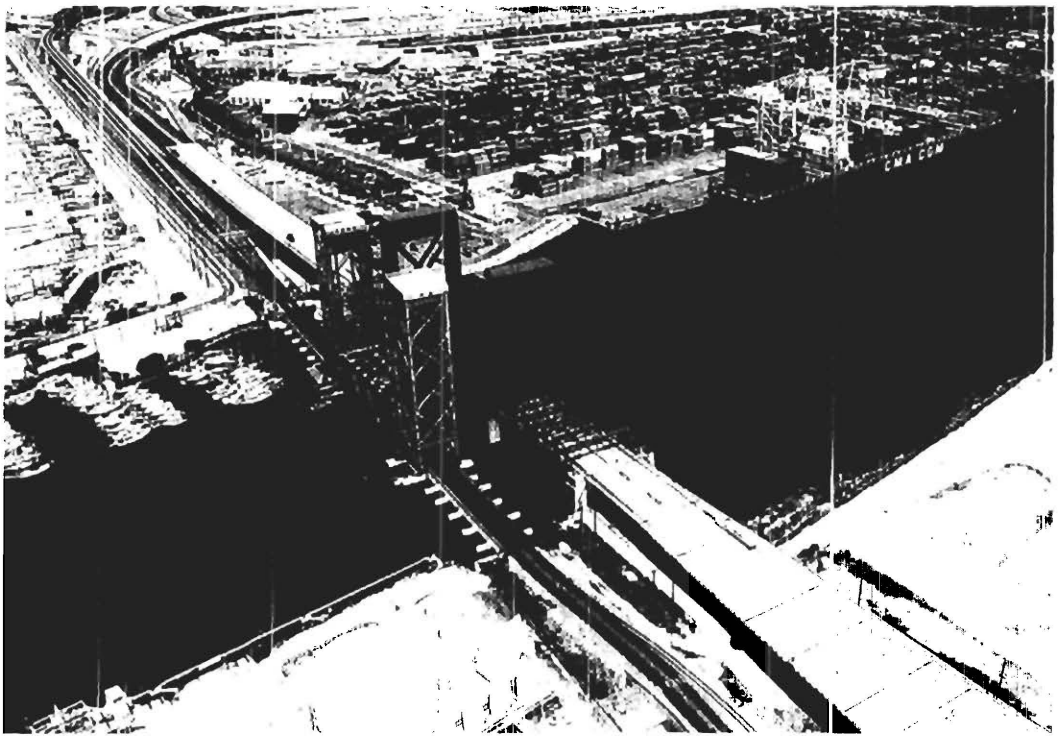
Sincerely,

Heather Benfield

Enclosure: 3

Tetra Tech, Inc.
3475 E. Foothill Boulevard Suite 700, Pasadena, CA 91107-5024
Tel 626.470.2415 Fax 626.470.2515 www.tetratech.com

FINAL
BASELINE HYDROACOUSTIC SURVEY PLAN



COMMODORE SCHUYLER HEIM BRIDGE DEMOLITION AND REPLACEMENT PROJECT LONG BEACH, CA

Prepared For:
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1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has been retained by the Alameda Corridor Transportation Authority (ACTA) to conduct baseline hydroacoustic monitoring in support of the environmental studies required during replacement of the Commodore Schuyler F. Heim Bridge, located in the city of Long Beach, California, hereafter referred to as the "Bridge" or the "Site". Figure 1 presents the location of the Bridge and surrounding area. This workplan has been prepared to describe the work procedures that will be adhered to while conducting the survey. Determining local baseline or ambient noise levels are necessary for quantifying potential harassment take of marine mammals, and for developing mitigation measures, such as safety zones, for avoiding or minimizing take.

2.0 PROJECT BACKGROUND

The Schuyler Heim Bridge was built between 1946 and 1948 and connects Terminal Island to the mainland. The California Department of Transportation (Caltrans) has been the operator of the Bridge since 1974. The bridge requires replacement because it does not meet current seismic safety standards. The project consists of replacing the existing bridge with a fixed-span bridge along and east of the existing bridge alignment. The Project will also reconstruct the northerly and southerly approaches to the bridge and maintain connectivity to State Route (SR) 103 and Ocean Boulevard. The width of the navigable channel (distance between bridge support columns and fenders) will be 180 feet, the same as the existing width. Construction is expected to take approximately two to three years and is scheduled to begin in 2011 with pile driving to be conducted in Fall of 2011.

Both impact and vibratory pile driving will be required for the installation of piles necessary for construction of the temporary trestles for access, the falsework for placing the forms to pour concrete, and the coffer dams used to isolate each of the four existing piers for removal. Because pile driving generates underwater noise at levels potentially harmful or disturbing to marine mammals, a number of measures have been identified (Section B-2 Protecting Aquatic Communities in the Project Record of Decision [ROD]) that would avoid, minimize, or mitigate these effects to marine mammals. These measures include using bubble curtains and caps to attenuate noise generated by pile driving, and establishing safety zones whereby noise-generating activity is shutdown at the approach of a marine mammal to these safety zones. Subsequently, in order to determine effective safety zones, both the existing ambient noise levels in the absence of pile driving and the maximum noise levels generated by the two pile driving methods (impact and vibratory) during construction shall be identified.

To meet the objectives of the measures identified in the ROD, there are three work elements to be completed: 1) development and implementation of a baseline hydroacoustic survey plan, 2) development and implementation of a pile driving (construction) hydroacoustic monitoring work plan, and 3) development and implementation of a detailed marine mammal monitoring and mitigation plan. This document addresses only the baseline hydroacoustic survey workplan; the pile driving (construction) hydroacoustic monitoring workplan and the marine mammal monitoring and mitigation plan will be prepared by Caltrans upon completion of the baseline hydroacoustic monitoring. However, a conceptual marine mammal monitoring and mitigation plan has been prepared and provided in Appendix A.

The objective of the baseline hydroacoustic survey plan is to describe the methodology to be used to document the existing underwater acoustic environment of the Cerritos Channel, in proximity to the Bridge. The results of the survey will be used to identify an appropriate marine mammal harassment safety zone during vibratory pile driving activities.

3.0 HYDROACOUSTIC PLAN OBJECTIVE

Although marine mammal use in the vicinity of the Bridge is very low, limited to primarily the occasional California sea lion (*Zalophus californianus*) or Pacific harbor seal (*Phoca vitulina richardii*), both non-Endangered Species Act-listed marine mammals, exposing marine mammals to continuous underwater construction noises exceeding 120 dB or impulse noises exceeding 160 dB represents a Level B take (harassment) violation of the Marine Mammal Protection Act (MMPA). According to the NMFS, sounds introduced into the sea by man-made devices could have deleterious effect on marine mammals by causing stress or injury, interfering with communication and predator/prey detection, and changing behavior. NMFS is currently determining safety criteria/guidelines for marine species exposed to underwater sound, and has determined that 180 dB re 1 μPa_{RMS} (190 dB for pinnipeds) is the impulse sound presser level that can be received by marine mammals without injury. In otherwords, exposing cetaceans to noise levels exceeding 180 dB and pinnipeds exceeding 190 dB represents a more serious Level A injury or lethal take. The Project commitment is to avoid any level of take by establishing effective safety zones whereby noise-generating activity (pile driving) is shutdown in the event of a marine mammal approaching a safety zone.

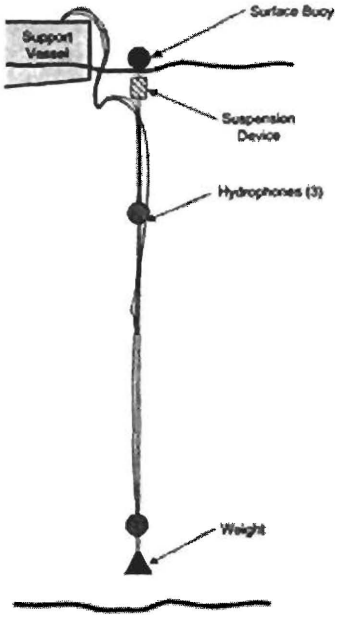
Noise generated from pile driving activities is often loud enough to harm (Level A take) or harass (Level B take) local populations of marine mammals. As noise attenuates as a function of the distance from source, at some point the noise declines to levels no longer of concern to marine mammals. For vibratory pile driving, a continuous noise source, the threshold for Level B take is the 120 dB isopleth. To avoid Level B take, the water surface area extending to the 120 dB isopleth will be monitored (by trained marine mammal biologists), and pile driving activity will be shutdown at the observed approach of a marine mammal. However, if the estimated distance (based on previous studies) to the 120 dB isopleth is relatively great (a large zone of influence, ZOI), then many marine mammal observers may be needed to effectively monitor the harassment safety zone. Reducing the size of the ZOI (and therefore the number of observers) can be accomplished by 1) attenuating the noise levels using techniques such as caps or bubble curtains (which is not conducted for vibratory pile driving), 2) determining the actual distance to the 120 dB isopleth from field measurements (which cannot be conducted prior to construction) and 3) determining whether the ambient noise levels already exceed 120 dB (which can be conducted prior to construction).

In marine environments where the background or ambient noise levels are already higher than 120 dB, the threshold of concern becomes the ambient level, and only areas ensonified by noise louder than ambient need to be monitored. Therefore, assessing local ambient or background noise levels in the vicinity of the pile driving construction activities is important to determine the actual areas that need to be monitored for marine mammals, especially in high energy industrial environments where ambient noise levels are high. Thus, the purpose of this workplan is to identify protocols to collect and report baseline (ambient) underwater noise levels at the Schuyler Heim Bridge project site. The results of the survey will be used during development of the marine mammal monitoring and mitigation plan to identify the initial safety zone that will be monitored during all pile driving activities.

3.1 BASELINE MONITORING PROCEDURES

Tetra Tech will design and execute an underwater sound monitoring survey to collect, analyze, and record underwater acoustic data to characterize preconstruction background sound levels and residual ambient sound levels in areas of proposed activities that have the potential to injure or disturb marine mammals. In order to quantify the underwater sound, three main measurement instrumentation components are required: (1) hydrophones and signal conditioning, (2) data acquisition and processing, digital recording, and a real-time display system, and (3) geographic positioning system.

Tetra Tech will measure and record underwater sound levels by collecting short-term data at set distances and hydrophone water depths. Figure 2 presents the area for the proposed sampling program. The Cerritos Channel and the adjacent basins (East Basin to the west and Turning Basin to the east) are well traveled by commercial vessels and recreational boats, and are expected to be relatively homogenous acoustically, with similar underwater background sound levels and exposure to noise sources. To maximize the number of spot measurement locations and reduce the effects of hydrostatic pressures and resulting extraneous noise from a stationary fixed system due to current flow, the hydrophones will be deployed over the side of a workboat such that the hydrophones drift away from the vessel as it moves freely along a transect. The hydrophones will be suspended in the water column and secured to an anti-heave buoy, which will position the sensors at a constant distance below the surface of the water. In addition, the line will be weighted at the lower end to maintain a vertical profile. At a minimum, two hydrophones will be deployed per measurement period. One hydrophone will be situated at the approximated 1/3 of the average depth of the water column at the test locations and the second will be placed at 2/3 of the average depth to sample the variation in the sound field with depth. To assess spatial variations, measurement locations will be completed along radial transects from a vessel, which traverses the channel at set linear distances from the Bridge. Measurement extents are shown in Figure 2 and consistent with where construction monitoring is anticipated will take place and at depths that are assumed to cover the behavior of the species considered. Typically, the work-boat starts at a minimum of 100 feet away from the future area of future pile driving and then a series of measurements completed using a sprint/stop/measure procedure. Typical measured sequences will last for a period of 5 to 10 minutes, depending on current strength. The vessel then moves to a new position along the transect. Using this methodology, it is anticipated that multiple measurements can be completed in 200 to 300 foot intervals at distances of up to one mile in the principal channel east-west directions.



Reference: Draft ANSI Standard S12.64- 200X
Revision 12, May 21, 2009

Immediately prior to the fieldwork program, a sound velocity profile will be collected using a current-temperature-depth (CTD) sounder. In the shallow coastal waters and coastal inlets, the water column is typically well-mixed and isothermal, but seasonal variations may occur. It will be required that the vessel's engines, depth sounder, generator, and other equipment that may contaminate the sound signal will be shut down prior to hydrophone deployment. The position of the vessel will be monitored by GPS over the entire duration of the measurement period.

Tetra Tech will utilize three (3) Bruel & Kjaer model BK8104 or Reson model TC4040 broadband hydrophones. Factory calibration certificates and sensitivity specifications will be submitted with the baseline sampling report. The TC4040 and BK8104 hydrophones are more sensitive than most other hydrophones, even at the extremes of its frequency range. With a dynamic range in excess of 90 decibels (dB), these hydrophones are of the few that are suitable for the measurement of noise with a highly sloped spectrum, such as shallow water background noise. The hydrophones will be equipped with extended length integrated water blocked cables suitable for use in the general area of the Bridge. These units will have waterproof connectors for signal input following conditioning directly to multichannel real time frequency analyzers capable of 1/3 octave and Fast Fourier Transform spectra analysis with data measured in the frequency range of 20 to 20 kilohertz (kHz). The underwater sound levels will also be recorded with calibration tones recorded immediately prior to each measurement period, for reference purposes. The sampling rate will be set to a minimum of 12,000 (12k) samples per second (sps). A general rule of thumb is that the playback of a digital sound recording will provide accurate reproduction

of frequency content up to 0.48 times the recording sample rate. Thus, a 12k sample rate would provide a recording having good fidelity over the entire range of pile driving sound, with principal sound energy generally found below 2,000 hertz (Hz).

3.2 BASELINE SAMPLING SCHEDULE

The target mobilization date for the Bridge reconstruction has not been finalized. Baseline monitoring will be completed during the same season that pile driving is anticipated. Following completion of the sound survey, sound measurement data and recordings will be immediately downloaded in the field for subsequent analysis at the Tetra Tech acoustics lab. Sound levels will be correlated to field logbooks and all data analysis including engineering calculations will be conducted for inclusion in the report.

3.3 DATA ANALYSIS

Tetra Tech will report the background noise levels in terms of root-mean-square decibels (dB_{RMS}) for a daytime 10-hour period, which is sufficient based on our experience to capture the temporal variation in sound levels that occur at the Site. The spectral composition and overall broadband sound levels vary relatively slowly, so that a high level of temporal resolution is not necessary. The RMS sound values will be calculated using 30-second averages for each period of data collected. The 30-second RMS averages will then be calculated as energy averages and reported for cumulative hourly and ten-minute intervals. Measurements identified as absent of obvious human influence, i.e. ship movements within visual sight, will be reported as ambient sound levels as a separate subset of the entire measurement program, to the extent that these conditions occur. The full range of measurement data will be compared to NMFS thresholds and plotted as a cumulative distribution function. Measured background frequencies in one-third octave band levels will also be presented. The one-third octave band data may be useful in the analysis of potential impacts pertaining to species of concern to establish species-specific acoustic impact thresholds. Relevant phases for a detailed acoustic analysis are defined as times of typical and extreme acoustic noise emission. For each relevant time period, third octave spectra of the single event sound pressure level shall be evaluated for frequencies ranging from 10 Hz to 20 kHz which spans the entire frequency range over which pile driving sounds are of interest, with principal sound energy found below 2000 Hz.

4.0 HEALTH AND SAFETY PROCEDURES

A separate site specific health and safety plan has been prepared and is provided as Appendix B. All work will be conducted according to provisions of this plan. A daily tailgate safety meeting will be conducted at the beginning of each work day. During this meeting, the field lead will discuss the tasks to be conducted, the equipment to be used, any special procedures to be followed, protective devices that will be used, and the potential physical, chemical, and biological hazards that may be encountered. This meeting will be documented on a standard Tetra Tech tailgate safety meeting form that will be signed by all attendees. All Tetra Tech personnel will have current first aid and cardiopulmonary resuscitation (CPR) training. Personnel will be trained to use all equipment and any protective devices.

5.0 REPORT PREPARATION

The report will provide full documentation of methods and monitoring protocols for the underwater baseline measurements. Items to be documented within the technical report include:

- Time and date stamped time histories for all relevant datasets;

- Names of personnel conducting testing;
- Name, manufacturer and model number of equipment including hydrophone type, directionality, and nominal sensitivity;
- Map of monitoring locations based upon GPS data
- National Institute of Standards and Technology (NIST) equipment calibration certifications and field calibration methods and results;
- Any unusual conditions that could have affected measured noise levels, including a description of any excessive extraneous noises;
- 1/3 frequency spectra of all relevant time periods including mean, L_{90} residual background, and maxima values and a table of significant highest tones;
- Position of hydrophones in the water column during tests;
- Weather, wave height, and sea state conditions;
- A calculation of overall uncertainties evaluated from a combination of measurement components that describe random errors estimated from the measurement repeatability and errors caused by effects that may introduce a systematic bias.

The results of the baseline data analysis will include interpretation of results and conclusions including any implications related to methodology for the subsequent marine mammal monitoring and mitigation plan (MMMP) and the pile driving (construction) hydroacoustic workplan.

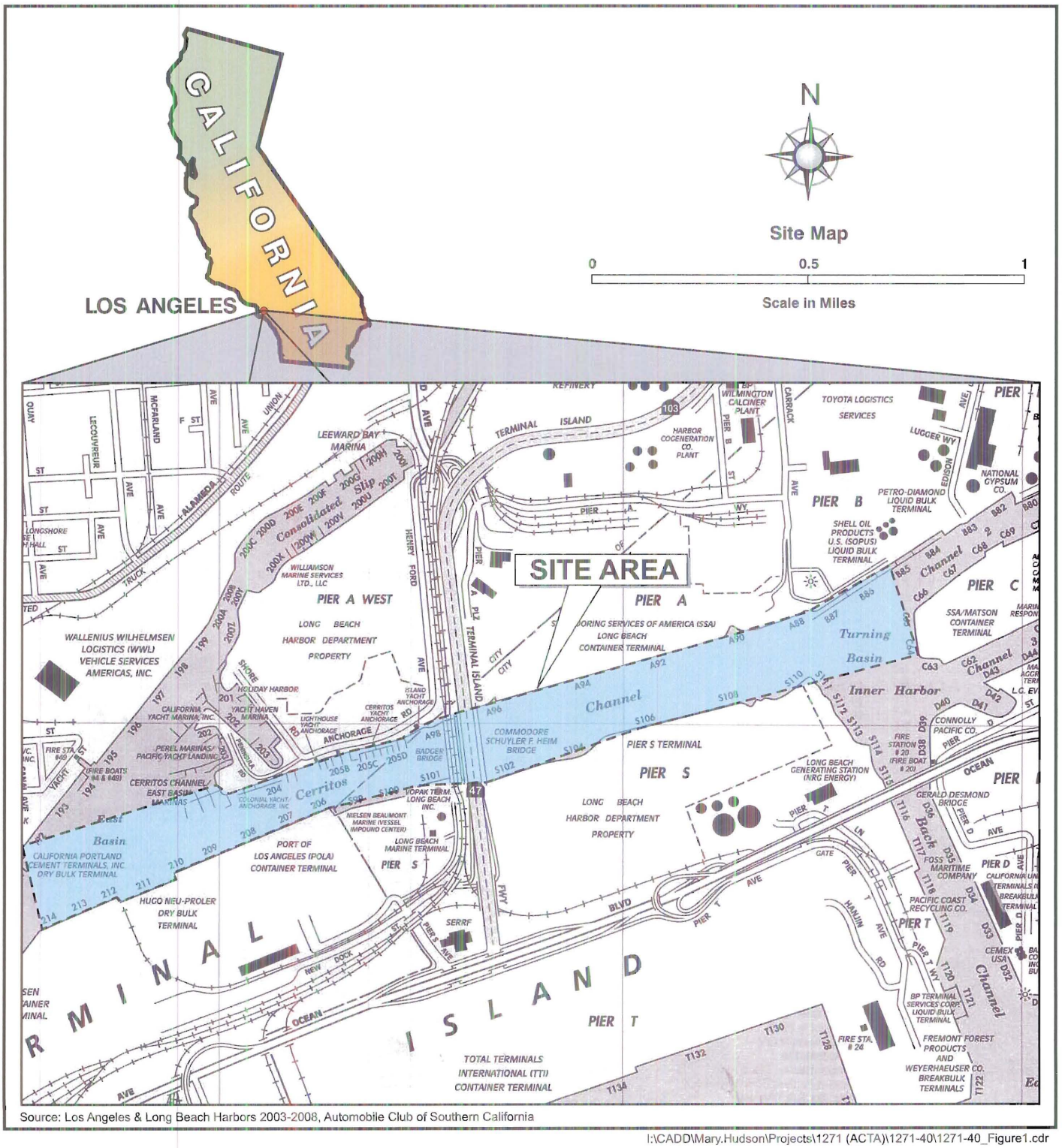
6.0 REFERENCES

Caltrans, Essential Fish Habitat Assessment, Commodore Schuyler Heim Bridge (BR. NO. 53-2618) in the Ports of Long Beach and Los Angeles, Los Angeles County, California, January 2010.

MEC Analytical Systems, Inc., Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay, June 2002.

Correspondence from National Marine Fisheries Service, Southwest Region, Long Beach CA, Mr. Robert S. Hoffman, to Caltrans, District 7, Division of Environmental Planning Los Angeles, CA, Mr. Karl Price, February 12, 2010.

FIGURE 1
SITE LOCATION MAP



Source: Los Angeles & Long Beach Harbors 2003-2008, Automobile Club of Southern California

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A.1 INTRODUCTION

Marine mammals are protected under the Marine Mammal Protection Act, which is administered by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, NMFS. Construction-related impacts such as high underwater noise levels and turbidity could affect marine mammals in the vicinity of the action area. However, mammalian species occurrence within Los Angeles harbor is limited to California sea lions (*Zalophus californianus*) and occasionally Pacific harbor seals (*Phoca vitulina richardii)*. These are non-Endangered Species Act-listed marine mammal species which inhabit the harbor in low numbers (and probably very low numbers in the industrialized Cerritos Channel), but could be present during construction. Other mammal species found within the region but have been determined in the Project Final Environmental Impact Statement/Environmental Impact Report (FEIS/FEIR) to be absent within the action area, include the Northern elephant seal (*Mirounga angustirostris*), common bottlenose dolphin (*Tursiops truncatus)*, Pacific white-sided dolphin (*Lagenorhynchus obliquidens)*, and gray whale (*Eschrichtius robustus)*. Therefore, potential effects to marine mammals from the Project are limited to sea lions and harbor seals.

Observations during pile-driving for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project showed sea lions rapidly swam out of the area when piles were being driven. Thus, sea lions would be expected to avoid areas and activities associated with the Project that could affect them. Harbor seals are unlikely to be present as few individuals have been observed in the Project area. Any sea lions or harbor seals present during construction activities would likely avoid the area. Construction activities would also not adversely interfere with foraging activities because impacts would be limited to portions of Cerritos Channel and large foraging areas within the Harbor would remain available to marine mammals. Therefore, any adverse effects to marine mammals from elevated underwater noise levels would be short term and very minimal. In addition, there are no pinniped haulout sites in the Project vicinity, so in-air noise impacts are not expected.

To reduce the effects of elevated underwater sound levels on marine mammals species during construction activities, the following measures, as identified in the Project Record of Decision (ROD), August 2009, would be implemented:

- Attenuation of pile driving sound via contained air bubble curtain on larger pile installations and dewatering casings for smaller piles. Performance criteria for sound attenuation will be developed to achieve maximum practicable reductions in underwater sound levels.

- A hydroacoustic monitoring plan will be developed, which would include appropriate sampling point locations, frequency, and methods to be implemented during pile driving. The results of the hydroacoustic monitoring would be analyzed in real time to identify appropriate safety isopleths and monitoring zones for biological (sensitive) resources.

- Evaluate potential to modify pile driving operational procedures to reduce noise effects, such as ramping up of pile driving energy levels to allow mobile organisms to exit the area; evaluating potential use of vibratory versus impact hammers under certain conditions; using less force of the hydraulic impact hammer; and limiting pile driving to no more than 2 piles per day with a minimum 12 hour interval between daily driving, to minimize cumulative exposure levels (SEL).

- A detailed marine mammal monitoring/protection plan will be developed in coordination with NMFS; this would include use of biological monitors with authority to suspend activities should sensitive organisms be present or enter the action area. Details of the plan will be developed, and will include methods to identify safety zone limits, numbers and locations of

monitors, and conditions when Project activities would be suspended to protect biological resources.

NMFS requested that information on baseline or ambient noise levels be collected prior to construction to help establish effective safety zones for vibratory pile driving activity. The baseline hydroacoustic study plan has been prepared separately.

The Marine Mammal Monitoring and Mitigation Plan (MMMMP) will include the first three mitigation measures identified above: noise attenuation, construction hydroacoustic monitoring, and modification of operational procedures. The approaches to completing these tasks are addressed below. The MMMP will be prepared by Caltrans and will be submitted to NMFS.

A.2 MARINE MAMMAL MONITORING AND MITIGATION PLAN

Caltrans (or their representative) will be responsible for developing and implementing the MMMMP and the subtasks identified within the plan. There are six elements to the MMMMP that will be developed:

- Coordination
- Safety Zone Establishment
- Noise Attenuation
- Visual Monitoring
- Startup and Shutdown Procedures
- Hydroacoustic Monitoring

Each element is briefly described below.

Coordination

This section of the MMMMP will detail the communication network that will be established to ensure coordination not only between the marine mammal observers/monitors and the construction crew, but among the marine mammal observers, Caltrans, and NMFS, especially in the unlikely event of a take. In an event of a watercraft collision with a marine mammal, Caltrans (or their representative with authority) must immediately contact the NMFS Stranding Coordinator, Mr. Joseph Cordaro at (562) 980-4017. This section of the MMMP may also describe any coordination opportunities with other marine mammal observation programs working in Los Angeles Harbor.

Safety Zone Establishment

Since Caltrans will not be requesting Incidental Harassment Authorization from NMFS, it is critical that accurate or conservative safety zones be established that ensure harassment or injury take of marine mammals does not occur. However, establishment of an overly conservative safety zone will lead to excessive manpower to monitor an area more than actually needed. Overly large safety zones can also lead to diluted observation of the more critical injury zones (where noise levels are greater than 190 dB).

Separate safety zones will be established for each vibratory pile driving (extending to the 120 dB isopleth) and impact pile driving (extending to the 180 dB isopleth). Distances to the threshold isopleths will be estimated by applying sound source data from similar hammers collected by Caltrans in California and WSDOT/WSF in Puget Sound to various transmission loss models available in the literature. The vibratory hammer safety zone estimate will take into account baseline noise levels, while the impact hammer estimate will account for any employed attenuation method (such as bubble curtains). All these

zones will be verified, and modified as needed, during the real time collection of hydroacoustic data during construction (refer to Hydroacoustic Monitoring below).

Noise Attenuation

The noise attenuation procedures planned to be used during impact pile driving will be described in this section of the MMMMP. The description will focus upon the use of bubble curtains following NMFS' Impact Pile Driving Sound Attenuation Specification (revised October 31, 2006). Studies by Jim Laughlin (WSDOT/WSF) in Puget Sound have shown on average about a 10 dB decline in noise levels at source can be achieved with bubble curtains for pile driving in shallow water. Until actual measurements are taken during pile driving, an average 10 dB reduction will likely be used in estimating distance to NMFS thresholds for initial establishment of safety zones.

However, bubble curtains are not always effective leaving other techniques to consider to achieve appropriate levels of attenuation. These include using cofferdams around piles or using wood or synthetic material caps on the pile surfaces to cushion hammer blows. The pros and cons of these methods will be described in the MMMP.

Visual Monitoring

The visual monitoring section of the MMMP will include the following: 1) minimum qualifications for biological/marine mammal monitors, 2) location and number of monitors, 3) data collection procedures, including forms and equipment to be used, and 4) survey periods before, during, and after pile driving activity. The latter will be identified based on the established safety zones. Monitoring locations must consider that marine mammals need to be observed prior to reaching the safety zone such that pile driving operations can be shutdown before the animal crosses the safety threshold (thereby avoiding take).

Startup and Shutdown Procedures

Soft startups of pile driving serve as a warning to marine mammals of pending loud noise levels, providing them an opportunity to leave the Project vicinity before hammering commences at full force. For vibratory hammers, this generally means operating the hammer at reduced energy for 15 seconds, waiting a minute, and then repeating this sequence twice more. For impact hammers, the pile is often struck three times at 40 percent of the planned energy force, followed by a one-minute waiting period, then followed by two subsequent three-strike sets.

The shutdown procedures will identify under what conditions pile driving will not occur, such as fog or night conditions where the safety zone is not entirely visible. In addition, the shutdown procedures will identify the chain of communication leading to an immediate shutdown of pile driving in the event of a marine mammal approaching the safety zone. Biological monitors will have the authority to suspend activities should sensitive mammals be present or enter the action area; therefore the monitors will need to be in full contact with construction personnel that have the authority to shutdown an active operation.

Hydroacoustic Monitoring

The hydroacoustic monitoring plan will identify the requisite instruments, methods, and reporting requirements for the measurement of underwater sound pressure and particle movement during pile driving activities. The workplan will be similar to the baseline hydroacoustic survey plan, but will focus on both vibratory and impact pile driving, possibly with and without attenuation depending on whether there is also a research focus to the hydroacoustic monitoring. The results of the hydroacoustic

monitoring will be analyzed in real time to identify whether existing (estimated) safety zones need to be modified to ensure that a marine mammal take is avoided.

A.3 REFERENCES

Caltrans, Essential Fish Habitat Assessment, Commodore Schuyler Heim Bridge (BR. NO. 53-2618) in the Ports of Long Beach and Los Angeles, Los Angeles County, California, January 2010.

MEC Analytical Systems, Inc., Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay, June 2002.

Correspondence from National Marine Fisheries Service, Southwest Region, Long Beach CA, Mr. Robert S. Hoffman, to Caltrans, District 7, Division of Environmental Planning Los Angeles, CA, Mr. Karl Price, February 12, 2010.

Site Name: Commodore Schuyler F. Heim Bridge, Long Beach, CA

Key Personnel And Responsibilities

Project Manager: Heather Benfield
The PM shall approve the health and safety plan and ensure its implementation in the field.

Site Manager: Rafael Holcombe
The SM will be responsible for the overall coordination and management of the field activities.

Site Health and Safety Officer: Rafael Holcombe
The Site Health and Safety Officer is responsible for developing and enforcing the health & safety plan (HASP), to periodically inspect the work area to ensure HASP compliance, and to verify that all project personnel have met the training and medical surveillance requirements.

Alternate Field Health and Safety Officer: Erik Kalapinski

Plan Prepared by: Rafael Holcombe Date: 6/10/10
Plan Approved by: Heather Benfield Date: 6/11/10

Training And Medical Surveillance Requirements

All Tetra Tech personnel assigned to the project have, or will have, completed all training and medical surveillance requirements as required by 29 CFR 1910.120 and company policy. A tailgate meeting will be conducted at the start of each field workday for all Tetra Tech personnel and recorded on a tailgate safety meeting field form (Attachment A).

Site Description

Type: Spill ☐ Fire ☐ HW Site ☐ Industrial Facility ☐ Other ☑

Physical Description:
The Commodore Schuyler F. Heim Bridge (the "Bridge") is a motor vehicle bridge that serves to connect Terminal Island with Long Beach crossing the Cerritos Channel. The work conducted under this HASP will take place within the Cerritos Channel directly underneath the Bridge and in surrounding waters.

Location:
The Bridge is located on Highway 47 at the crossing of the Cerritos Channel in Long Beach, California. The Site area for the hydroacoustic surveying activities is the Cerritos Channel within the Port of Los Angeles and the Port of Long Beach.

Size:
N/A

History:
The Bridge was built in 1948 and is being readied for demolition. The project purpose is to conduct a baseline hydroacoustic survey of the water surrounding the Bridge.

Status: Active ☑ Inactive ☐

Surrounding Population: Industrial Usage

Surrounding Buildings/Homes: Industrial buildings in adjacent areas.

Have Nearby People Been Evacuated? Yes ☐ No ☑ Evacuation Initiated By: N/A

Evacuation Distance: N/A Topography: Low Relief

Receiving Waters: Cerritos Channel Site Plan/Sketch Attached: Yes ☐ No ☑

Background Material Attached: Yes ☐ No ☑

Work Objectives

Conduct a hydroacoustic survey of the Cerritos Channel located directly beneath and adjacent to the Schuyler Heim bridge.

Hazard Evaluation

Hazard Level: High ☐ Moderate ☐ Low ☑

Hazard Type: Liquid ☐ Solid ☐ Sludge ☐ Vapor/Gas ☐ Unknown ☑

Known or Suspected Hazardous Materials: N/A

Characteristics: Corrosive ☐ Ignitable ☐ Toxic ☐ Reactive ☐
Volatile ☐ Radioactive ☐ Bio. Agent ☐

Exposure Routes: Inhalation ☐ Ingestion ☐ Contact ☐

MSDS Sheets attached for informational purposes only: Yes ☐ No ☑

HAZARD EVALUATION

Task	Hazards	Preventive Measures
Boating/Sampling	Boating safety, mechanical, noise, fall potential	Trained experienced boat operator, equipment inspected prior to use; PPE and life vests worn at all times. Establish traffic and Site control protocols. Observe safe boating guidelines.
General	Slip/trip/fall, vehicles	Good housekeeping practices. Clear area before working. Level D PPE at all times, equipment and working personnel will not be allowed to encroach the control boundary at all times. Place orange cones/floats when working in traffic areas and a person to direct traffic around the work zone if necessary.

Tetra Tech personnel will adhere to the Safe Working Practices for Working Over or Near Water (Attachment B) with the exception of a look-out. Due to the large project area as well as limited access to the shorelines and security issues within both Port of Los Angles and Port of Long Beach, it is not possible to have a third person onshore during work activities. However, Tetra Tech field personnel will complete the Float Plan provided in Attachment C and give a copy to the project manager (or designee) prior to launching the boat. Tetra Tech field crew (FC)/HSO will notify the PM upon return to shore.

The Vessel Safety Check (Attachment D) will be conducted prior to launch the boat into the Channel.

Personnel Protection – Sampling Operations

Level of Protection: A ☐ B ☐ C ☐ D ☑ plus life vests

Suit Type: Work Clothes Boot Type: Steel-Toe

Protection Type: Level D Eye Protection Type: Safety Glasses

Glove Type(s): Work gloves for general protection, nitrile gloves while collecting samples.

Other Protective Dress: Life vest.

Justification for Level of Protection (state decision criteria): Based on hazard level.

Change in Level of Protection: Upgraded ☐ Downgraded ☐ Not applicable ☑

Up or Downgraded to: B ☐ C ☐ D ☐
Reason (state decision criteria): Upgrade of protection level is not anticipated to be needed.

Specific Changes Made: N/A

Heat/Cold Stress Monitoring: Yes ☐ No ☑

Decontamination / Site Control Procedures – N/A

Residuals Management – N/A

Emergency Information

Emergency Contact Resources

Police/Fire Department	911
U.S. Coast Guard Sector Los Angeles-Long Beach	(310) 521-3815
	Channel 22
Non-emergency	(310) 521-3805
Los Angeles Port Police	(310) 732-3500
Long Beach Port Police	(562) 590-4185
National Response Center	(800) 424-8802
St. Mary Medical Center	(562) 491-9000

A cellular phone will be available at the Site for notifying emergency resources.

Directions/Map to Hospital Attached:
St. Mary Medical Center
1050 Linden Avenue
Long Beach, CA 90813
(562) 491 - 9000

(From Berth 205C – Colonial Yacht Anchorage)

1. Head east on Anchorage Road for 0.4 miles
2. Turn left (north) on Henry Ford Avenue for 1 mile (at the traffic light, bear left to continue on Henry Ford Avenue)
3. Turn Right (east) on Anaheim Street. Travel for 3.1 miles
4. Turn right (south) onto Linden Avenue. Entrance is on left side (east) of Linden.

Tetra Tech Resources

Tetra Tech, Inc. ..... (626) 351-4664
Heather Benfield (Project Manager) ..... (626) 470-2415
Cell: (310) 990-9524
Rafael Holcombe (Site Manager, Site Health and Safety Officer) ..... (562) 257-1589
Cell: (626) 255-1924
Christine McClain CIH (Corporate Health and Safety Manager) ..... (626) 470-2542
Michael Ridosh, CIH (Health and Safety Consultant) ..... (818) 888-5894
Erik Kalapinski (Alternate Site Health and Safety Officer) ..... (617) 443-7538
Cell: (857) 272-6276

ACTA Resources

Elaine Silvestro. ..... (310) 816-0460 x 175
Cell: (310) 650-3359

Other Resources

Marine Exchange ..... (310) 832-6411
Long Beach Pilots ..... (562) 432-0664
Los Angeles Pilots ..... (310) 732-3805
Coast Maritime Services ..... (310) 521-0484
U.S. EPA-ERT. ..... (201) 321-6660
Centers for Disease Control (Day) ..... (404) 639-3534
Centers for Disease Control (Night) ..... (404) 639-2888
National Response Center ..... (800) 424-8802
Bureau of Alcohol, Tobacco, and Firearms (Explosives) ..... (800) 424-9555
National Weather Service Forecast Office ..... (805) 955-6611

Contingency Plan for Emergencies

Emergency routes and meeting locations are on-site and will be finalized by the Site Safety Officer/Manager in the field and conveyed to all field personnel during a tailgate safety meeting prior to the start of work.

All field personnel will be instructed regarding the use of all field safety equipment prior to the start of work.

All personnel will be instructed of emergency communication procedures appropriate to the project.

A first aid kit and portable fire extinguisher will be on-site (on board) during any field operations.

A cellular phone will be available on the boat along with a working radio.

At least one of the field crew (Site Safety Officer/Manager) will be trained to perform First Aid and CPR.

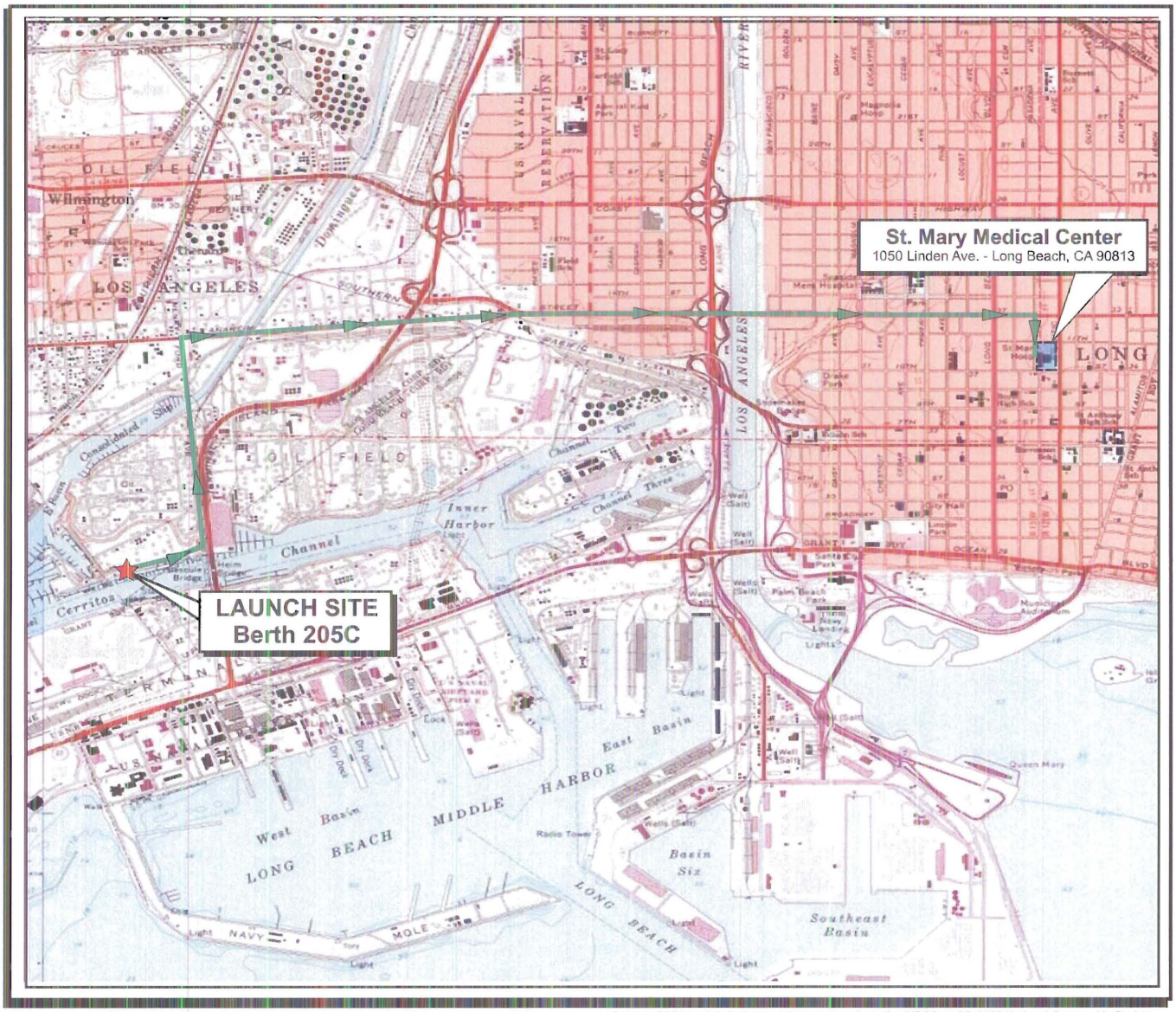
Confined-space Entry

Confined-space entry procedures applicable? Yes ☐ No ☑
If yes, attach copy of confined-space entry procedures and permit.

Prepared for
Alameda Corridor
Transportation Authority

HYDROACOUSTIC MONITORING PLAN
Health and Safety Plan

Hospital Route from Launch Site, Colonial Yacht Anchorage



Source: ESRI ArcGIS Online and data partners including USGS and © 2007 National Geographic Society

Directions:

1. Head East on Anchorage Road for 0.4 miles
2. Turn left (north) on Henry Ford Avenue for 1 mile
3. Turn right (east) on Anaheim Street. Travel for 3.1 miles
4. Turn right (south) onto Linden Avenue
   Entrance on the left side (east) of Linden Avenue

St. Mary Medical Center
1050 Linden Avenue, Long Beach, CA 90813 (562) 491-9000

NORTH
Not to Scale

I:\CADD\Mary.Hudson\Projects\1271 (ACTA)\1271-39_Route to hospital_6_4_10.cdr

TETRA TECH

ATTACHMENT A
TAILGATE SAFETY MEETING FORM

TAILGATE SAFETY MEETING

3475 East Foothill Blvd.
Pasadena, CA 91107
(626) 351-4664

DATE _____ **TIME** _____ **JOB NUMBER** _____

CLIENT _____

SPECIFIC LOCATION: _____

TYPE OF WORK _____

SAFETY TOPICS PRESENTED

PROTECTIVE CLOTHING/EQUIPMENT _____

CHEMICAL HAZARDS _____

PHYSICAL HAZARDS _____

EMERGENCY PROCEDURES:

CALL 911

_____

HOSPITAL/CLINIC _____ **ADDRESS** _____

PHONE NUMBER _____ **PARAMEDIC** 911 _____

SPECIAL EQUIPMENT _____

OTHER _____

ATTENDEES

PRINT NAME	SIGNATURE	PRINT NAME	SIGNATURE

MEETING CONDUCTED BY: **TASK LEADER**

SIGNATURE _____ _____

PRINTED NAME _____

ATTACHMENT B

SAFE WORKING PRACTICES FOR WORKING OVER OR NEAR WATER

The following sections discuss general procedures for working over or near water, underwater work, and cold water procedures.

1.0 SCOPE

This safe work practice (SWP) provides guidelines for all Tetra Tech employees and subcontractors who work over or near bodies of water three (3) or more feet deep or swiftly moving water. This SWP was developed in accordance with the Occupational Safety and Health Administration (OSHA) standard specified in Title 29 of the *Code of Federal Regulations* (CFR), Part 1926.106, "Working Over or Near Water."

2.0 RESPONSIBILITIES

The project manager (PM) is responsible for identifying all health and safety requirements of each project, including all tasks that may involve worker exposure to hazards or working in or near bodies of water. The PM will appoint a site safety coordinator (SSC) to ensure that this SWP is followed in the field. Workers will follow this SWP whenever working near or in any body of water that is over three (3) feet deep or swiftly moving.

3.0 GENERAL PROCEDURES

When working over or near water, the following precautions will be taken:

- All staff and team members must wear a personal flotation device (PFD) when working within 15 feet of a water body. Personnel will be provided with U.S. Coast Guard (USCG)-approved life jackets or work vests. The PFD should be Class III, which will support the head of an unconscious person above water.
- Life jackets and work vests will be inspected before and after each use.
- Ring buoys with at least 90 feet of line shall be provided and readily available for employee rescue operations.
- The distance between ring buoys shall not exceed 200 feet.

The online version of this document supersedes all other versions. Paper copies of this document are uncontrolled. The controlled version of this document can be found on the Tetra Tech Intranet.

accelerate shock. Drinks no warmer than normal body temperature are acceptable. If symptoms are severe and evacuation to a medical facility cannot be quickly conducted, any wet clothing should be removed, the victim should be placed in blankets or sleeping bags in a sheltered location, and the rescuer should climb into the blankets or sleeping bag with victim to provide additional warmth. The victim should also be treated continuously for shock, elevating feet and monitoring the victim's pulse and breathing rate.

If a team member falls into cold water, he or she should not remove any clothing while in the water because clothing provides additional insulation. Although clothing creates an added drag while swimming, the insulation outweighs the disadvantage of the additional drag. Each team member should carry a wool hat to place on his or her head in case he or she falls into the water. A wool hat, even when wet, provides good insulation for the head, where a large amount of body heat is lost.

Disclaimer: This safe work practice (SWP) is the property of Tetra Tech, Inc. (Tetra Tech). Any reuse of the SWP without Tetra Tech's permission is at the sole risk of the user. The user will hold harmless Tetra Tech for any damages that result from unauthorized reuse of this SWP. Authorized users are responsible for obtaining proper training and qualification from their employer before performing operations described in this SWP.

Revision Date	Document Authorizer	Revision Details
10/1/2008	Chris McClain	Update from 1998 format

ATTACHMENT C

FLOAT PLAN

TETRA TECH, INC. – FLOAT PLAN

*(This information will be called in **daily** and recorded by the FC or HSO for each **sampling site**)*

TODAY'S DATE:_____

VESSEL NAME:_____

OPERATOR: _____

DEPARTURE TIME: _____

EXPECTED TIME OF RETURN:_____

CELL PHONE NUMBER: _____

If your return will be after 4:30 p.m., with whom will you be in contact with upon your return? _____

DESTINATION/SAMPLING PLAN:_____
_____
_____
_____
_____

NAMES OF PERSONNEL ON BOARD:

_____
_____
_____
_____

NAMES (AND CELL CONTACT IF APPLICABLE) OF PERSONNEL ON SHORE:

_____
_____
_____

If expected time of return is exceeded by 3 hours, the following steps will be taken in a logical order:

1. HSO/FC will contact each other (If someone other than the FC has the float plan, that person will contact the FC)
2. Attempt to contact on-shore crew member
3. If known, hotel where crew is staying will be contacted
4. PM will be notified
5. Local hospitals and emergency centers will be contacted
6. Local search and rescue will be notified

ATTACHMENT D

VESSEL SAFETY CHECK

VESSEL SAFETY CHECK (VSC)

To be completed by a U.S. Coast Guard approved Vessel Examiner.
See the back of this form for a brief explanation of required items.
A Federal Requirements pamphlet is also available.

Date of VSC: _____

Decal Awarded: Yes ☐ No ☐

Owner/Operator Name:

_____

Owner/Operator has attended a CGAUX, USPS, State or _____ Boating Safety Class: Yes ☐ No ☐

Location of VSC - County: _____ State: _____

Replaced decal was: Last Year ☐ Outdated ☐ First time ☐

VESSEL INFORMATION:

Registration or
Documentation Number: _____

HIN: _____

Length: <16 ☐ 16-25 ☐ 26-39 ☐ 40-65 ☐ >65 ☐

Powered by: Gas ☐ Diesel ☐ Sail ☐ Other ☐

Area of Operations: Inland ☐ Coastal ☐

Type: PWC ☐ Open ☐ Cabin ☐ Other ☐

VESSEL SAFETY CHECK DECAL REQUIREMENTS

Item	Yes	No	N/A
1. Display of Numbers			
2. Registration/Documentation			
3. Personal Flotation Devices (PFD)			
4. Visual Distress Signals (VDS)			
5. Fire Extinguishers			
6. Ventilation			
7. Backfire Flame Control			
8. Sound Producing Devices/Bell			
9. Navigation Lights			
10. Pollution Placard			
11. MARPOL Trash Placard			
12. Marine Sanitation Devices			
13. Navigation Rules			
14. State and/or Local Requirements			
15. Overall Vessel Condition: **as applies**			
a. Deck Free of Hazards / Clean Bilge			
b. Electrical - Fuel Systems			
c. Galley - Heating Systems			

RECOMMENDED AND DISCUSSION ITEMS

(While encouraged, items below are not VSC requirements)

Item	Yes	No
I. Marine Radio		
II. Dewatering Device & Backup		
III. Mounted Fire Extinguishers		
IV. Anchor & Line for Area		
V. First Aid and PIW Kits (**over)		
VI. Inland Visual Distress Signals		
VII. Capacity/Certificate of Compliance		
VIII. Discussion Items: **as applies**		
a. Accident Reporting - Owner Responsibility		
b. Offshore Operations		
c. Nautical Charts / Navigation Aids		
d. Survival Tips / First Aid		
e. Fueling / Fuel Management		
f. Float Plan / Weather & Sea Conditions		
g. Insurance Considerations		
h. Boating Check List		
i. Safe Boating Classes		
j. Maritime Domain Awarness		

I certify that I have personally examined this vessel and find it meets the above requirements at the time of this Vessel Safety Check. I am a qualified Vessel Examiner of the: CGAUX ☐, USPS ☐, State of _____ ☐, or _____ ☐.

Printed Name of the Examiner _____ Examiner Number _____

Examiner Signature _____ Telephone Number _____

Additional Comments: *This is not an official boarding for law enforcement purposes. It is recommended that you correct any deficiencies noted. This checklist is furnished for your information. There is no assumption of liability of any kind for advice given or opinions expressed in connection to this examination. By accepting the Vessel Safety Check decal you are pledging to maintain your boat and equipment to the standard of safety exhibited during this examination.* **Please remove the Vessel Safety Check decal if the boat is sold or no longer meets these requirements.**

I am consenting to this Vessel Safety Check of my watercraft with full knowledge that it is provided to me as a public service on a volunteer basis without cost, and I understand and agree that my receipt of a Vessel Safety Check shall not constitute or be construed as a warranty or guarantee as to either the qualification, knowledge, or skills of the operator; the seaworthiness of the vessel; or the serviceability or adequacy of any equipment on board.

Owner/Operator Signature: _____ **Date:** _____

Back of ANSC7012 (4/08)

Brief Explanation of VSC Required Items:

❑ **1. NUMBERING:** The boat's registration number must be permanently attached to each side of the forward half of the boat characters must be plain, vertical, block style, not less than three (3) inches high, and in a color contrasting with the background. A space or hyphen must separate the letters from the numbers. Place State validation sticker according to State policy. (e.g. **FL 1234 AB or FL-4234-AB)**

❑ **2. REGISTRATION/DOCUMENTATION:** Registration or Documentation papers must be on board and available. Documentation numbers must be permanently marked on a visible part of the interior structure. The documented boat's name and hailing Port must be displayed on the exterior hull in letters not less than 4 inches in height.

❑ **3. PERSONAL FLOTATION DEVICES (PFDs):** Acceptable PFDs (also known as Life Jackets) must be U.S. Coast Guard approved and in good, serviceable condition. A wearable PFD of suitable size is required for the each person on the boat. Children must have properly fitted PFDs designed for children. Wearable PFDs shall be *"readily accessible."* Boats 16 Feet or longer, must also have one Type IV (throwable) device, which shall be *"immediately available."* PFDs shall NOT be stored in unopened plastic packaging. For Personal Watercraft riders, the PFD must be worn. An impact rating is recommended, but not required.

❑ **4. VISUAL DISTRESS SIGNALS:** Recreational boats 16 feet and over used on coast waters or the Great Lakes are required to carry a minimum of either 1) three day and three night pyrotechnic devices, 2) one day non-pyrotechnic device (flag) and one night non-pyrotechnic device (auto SOS light) or 3) a combination of 1) and 2). Recreational boats less than 16 feet on coastal waters or the Great Lakes need only carry night visual distress signals when operating from sunset to sunrise.

It is recommended, but not required, that boats operating on inland waters could have some means of making a suitable day and night distress signal. The number and type of signals is best judged by considering conditions under which the boat will be operating.

❑ **5. FIRE EXTINGUISHERS:** Fire extinguishers are required if one of the following conditions exists: 1) Inboard engine(s); 2) Double bottom hulls not completely sealed or not completely filled with flotation materials 3) Closed living space 4) Closed stowage compartments that contain flammable materials or 5) Permanently installed fuel tanks. Recreational boats less than 26 feet, and propelled by outboard motors are NOT required to have fire extinguishers unless one or more of the conditions (2-5) listed above applies. *NOTE: Fire extinguishers must be readily accessible and verified as serviceable.*

Minimum number of extinguishers required

Boat Length	*No Fixed System*	*With Fixed System*
Less than 26'	**one B-1**	**0**
26' to less than 40'	**two B-1 or one B-2**	**one B-1**
40' to 65'	**three B-1 or one B-1 & one B-2**	**two B-1 or one B-2**

❑ **6. VENTILATION:** Boats with gasoline engines in closed compartments, built after 1 August 1980 must have a powered ventilation system. Those built prior to that date must have natural or powered ventilation. Boats with closed fuel tank compartments built after 1 August 1978 must meet requirements by displaying a "certificate of compliance." Boats built before that date must have either natural or powered ventilation in the fuel tank compartment.

❑ **7. BACKFIRE FLAME ARRESTER:** All gasoline powered inboard/outboard or inboard motor boats must be equipped with an approved backfire flame control device.

❑ **8. SOUND PRODUCING DEVICES:** To comply with Navigation Rules and for distress signaling purposes all boats must carry a sound producing device (whistle, horn, siren, etc.) capable of a 4-second blast audible for ½ mile. Boats larger than 39.4 ft. are also required to have a bell (see Navigation Rules.)

❑ **9. NAVIGATION LIGHTS:** All boats must be able to display navigation lights between sunset and sunrise and in conditions of reduced visibility. Boats 16 feet or more in length must have properly installed, working navigation lights and an all- around anchor light capable of being lit independently from the red/green/white "running" lights.

❑ **10. POLLUTION PLACARD:** Boats 26 feet and over with a machinery compartment must display an oily waste "pollution" placard.

❑ **11. MARPOL TRASH PLACARD:** Boats 26 feet and over in length, operating in U.S. navigable waters, must display a "MARPOL" trash placard. Oceangoing boats 40 feet and over must also have a written trash disposal plan available onboard.

❑ **12. MARINE SANITATION DEVICE:** Any installed toilet must be a Coast Guard approved device. Overboard discharge outlets must be capable of being sealed.

❑ **13. NAVIGATION RULES:** Boats 39.4 feet and over must have on board a current copy of the Navigation Rules.

❑ **14. STATE AND LOCAL REQUIREMENTS:** These requirements must be met before the "Vessel Safety Check" decal can be awarded. A boat must meet the requirements of the state in which it is being examined.

❑ **15. OVERALL BOAT CONDITION: As it applies to this Vessel. Including, but not limited to:**

a. Deck free of hazards and clean bilge - The boat must be free from fire hazards, in good overall condition, with bilges reasonably clean and visible hull structure generally sound. The use of automobile parts on boat engines is not acceptable. The engine horsepower must not exceed that shown on the capacity plate.

b. Electrical and Fuel Systems: The electrical system must be protected by fuses or manual reset circuit breakers. Switches and fuse panels must be protected from rain or water spray. Wiring must be in good condition, properly installed and with no exposed areas or deteriorated insulation. Batteries must be secured and terminals covered to prevent accidental arcing.. **If installed,** self-circling or kill switch mechanism must be in proper working order. All PWCs **require** an operating self circling or kill switch mechanism.

Fuel Systems - Portable fuel tanks (normally 7 gallon capacity or less) must be constructed of non-breakable material and free of corrosion and leaks. All vents must be capable of being closed. The tank must be secured and have a vapor-tight, leak-proof cap. Each permanent fuel tank must be properly ventilated.

c. Galley and Heating Systems - System and fuel tanks must be properly secured with no flammable materials nearby.

I - VIII. RECOMMENDED AND DISCUSSION ITEMS: (Not required for the award of the "Vessel Safety Check" decal). For the very best boaters, we recommend these additional items. Meeting these requirements reflects your concern for Boating Safety.

**** Person in the Water (PIW) kit consists of one extra wearable PFD and a throwable type IV PFD w/line.**

For more information: Ask your Vessel Examiner,
Visit http://SafetySeal.net

Schuyler Heim Bridge Replacement Project
Air Quality Information Handout

The following mitigation measures have been identified in the "Schuyler Heim Bridge Replacement and SR-47 Expressway Project Final Environmental Impact Statement/Environmental Impact Report and Section 4(f) Evaluation" to reduce air quality effects during project construction and provide the noted potential efficiencies as determined by SCAQMD:

AQ-1 Apply nontoxic soil stabilizers to all inactive construction areas (previously graded areas inactive for 10 days), and areas anticipated to be inactive for 10 days. Nontoxic soil stabilizers can reduce PM_{10}/$PM_{2.5}$ emissions from these areas by 30 to65 percent.

AQ-2 Replace ground cover in disturbed areas as quickly as possible. A reduction of 15 to 49 percent in PM_{10}/$PM_{2.5}$ emissions for disturbed areas could be achieved.

AQ-3 Reduce traffic speed on all unpaved roads to 15 mph or less. PM10/PM2.5 emissions from travel on unpaved roads can be reduced by 40 to 70 percent by managing vehicle speeds.

AQ-4 Develop and implement a trip reduction plan to achieve a 1.5 average vehicle ridership for construction employees. A trip reduction plan can reduce emissions of ROG, NOX, CO, and PM_{10} from worker commutes by 0.1 to 2.2 percent, 0.1 to 2.9 percent, 0.1 to 2.9 percent, and 0.1 to 2.9 percent, respectively (SCAQMD, 1993).

AQ-5 Implement a shuttle service for construction workers to and from retail services and food establishments during lunch hours. A shuttle service can reduce emissions of ROG, NOX, CO, and PM10 from lunch hour trips by 0.1 to 1.0 percent, 0.1 to 1.3 percent, 0.1 to 1.3 percent, and 0.1 to 1.3 percent, respectively (SCAQMD, 1993).

AQ-6 Prohibit truck idling in excess of 2 minutes. Employ periodic, unscheduled inspections to limit unnecessary idling. The SCAQMD has not quantified the efficiency of this mitigation measure.

AQ-7 Suspend use of all construction equipment operations during second-stage smog alerts. The SCAQMD has not quantified the efficiency of this measure.

AQ-8 Use electricity, if feasible, from power poles rather than temporary diesel- or gasoline-powered generators. Using electricity from power poles is an effective measure to reduce emissions of ROG, NOX, CO, and PM_{10} from generators. Reduction efficiencies for these compounds are 97 to 99 percent.

AQ-9 Does not apply.

AQ-10 To the extent feasible, utilize construction equipment equipped with Tier 2 or newer engines.

AQ-11 Maintain and tune engines per manufacturer's specifications to perform at EPA certification levels and to perform at verified standards applicable to retrofit technologies. Employ periodic, unscheduled inspections to ensure that construction equipment is properly maintained, tuned, and modified to established specifications.

AQ-12 Prohibit tampering with engines, and require continuing adherence to manufacturer's recommendations.

INFORMATION HANDOUT

BATTERY BACKUP SYSTEM CONNECTION DIAGRAMS AND FOUNDATION DETAILS

EA 07-138201

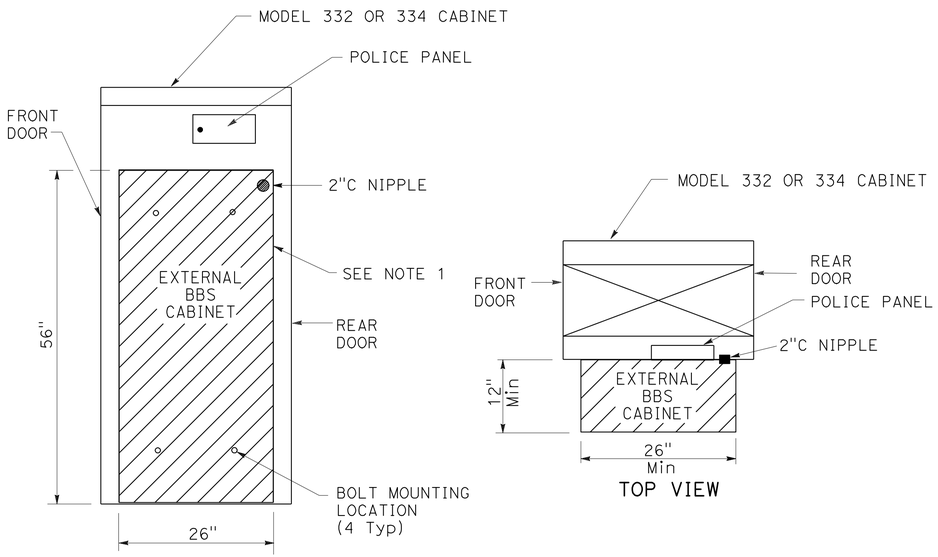
Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Theresa Gabriel — 12-20-07
REGISTERED CIVIL ENGINEER — DATE

REGISTERED PROFESSIONAL ENGINEER
Theresa A. Gabriel
No. E15129
Exp. 6-30-10
ELECT
STATE OF CALIFORNIA

PLANS APPROVAL DATE

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

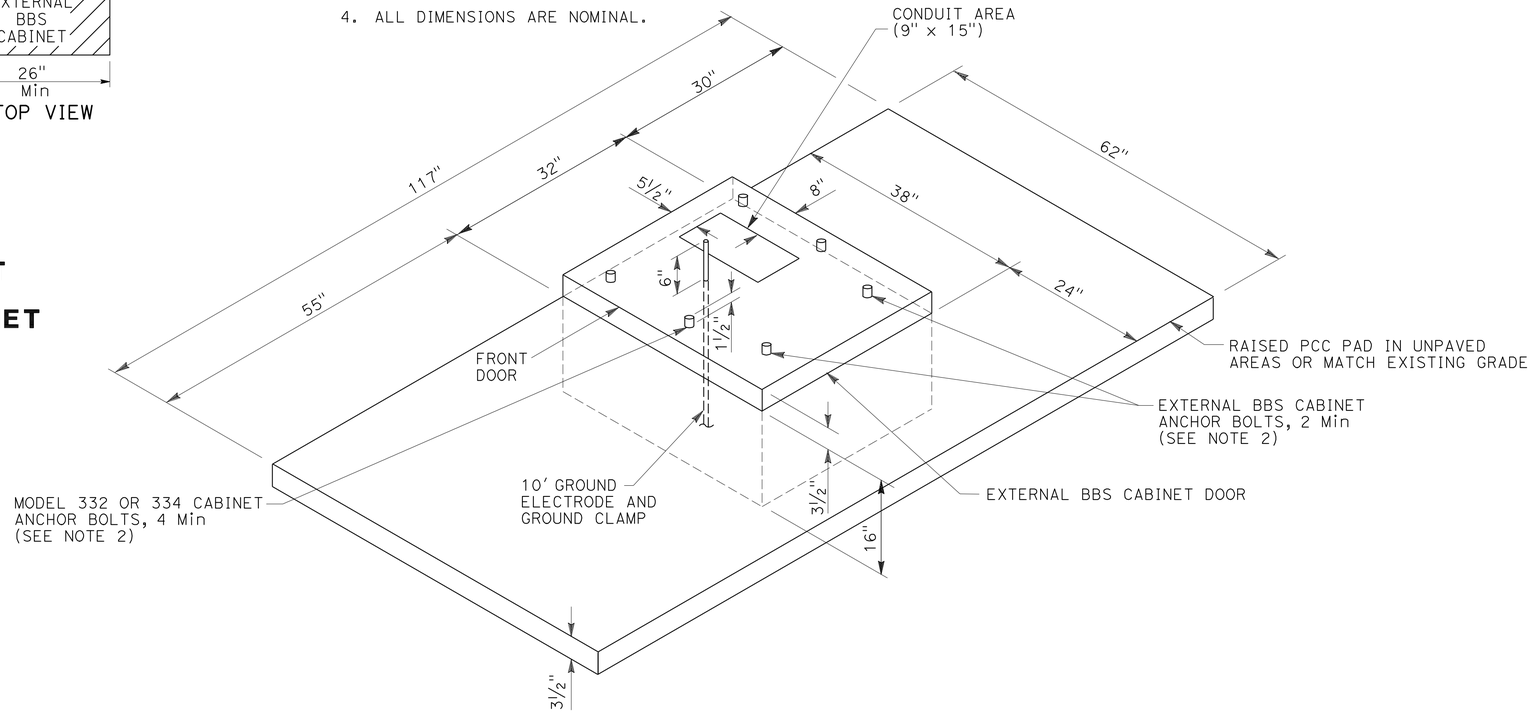


SIDE VIEW

EXTERNAL BBS CABINET MOUNTED TO THE MODEL 332 OR 334 CABINET

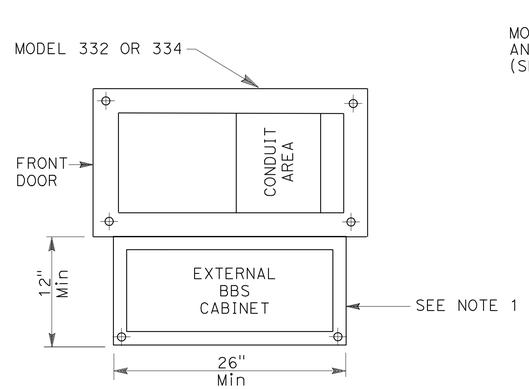
NOTE: (THIS SHEET ONLY)

1. THE EXTERNAL BBS CABINET SHALL BE MOUNTED TO THE MODEL 332 OR 334 CABINET WITH FOUR 18-8 STAINLESS STEEL HEX HEAD, FULLY-THREADED, $\frac{3}{8}$"-16 X 1" BOLTS; TWO WASHERS PER BOLT, DESIGNED FOR $\frac{3}{8}$" BOLTS AND ARE 18-8 STAINLESS STEEL, 1" OUTSIDE DIAMETER, ROUND, AND FLAT; AND ONE K-LOCK NUT PER BOLT THAT IS 18-8 STAINLESS STEEL AND A HEX-NUT. THE ENGINEER WILL HAVE TO APPROVE THE BOLT MOUNTING LOCATION PRIOR TO INSTALLATION.
2. THE ANCHOR BOLTS SHALL BE $\frac{3}{4}$" Dia X 15" WITH A 2"-90° BEND. THE CABINET MANUFACTURER'S SPECIFICATION SHALL DETERMINE THE LOCATION OF THE ANCHOR BOLTS IN THE FOUNDATION. THE ENGINEER WILL HAVE TO APPROVE THE ANCHOR BOLTS AND ITS LOCATION IN THE FOUNDATION PRIOR TO CONSTRUCTION.
3. THE CONTRACTOR SHALL VERIFY THE DIMENSIONS OF THE BBS CABINET PRIOR TO CONSTRUCTING THE FOUNDATION OF THE MODIFIED PORTION OF THE Std MODEL 332 AND 334 CABINET FOUNDATION. THE ENGINEER WILL HAVE TO APPROVE ANY NECESSARY DEVIATIONS PRIOR TO CONSTRUCTION.
4. ALL DIMENSIONS ARE NOMINAL.



MODIFIED MODEL 332 AND 334 CABINET FOUNDATION DETAIL FOR BATTERY BACKUP SYSTEM (BBS)

(FOR DIMENSIONS AND DETAILS NOT SHOWN AND ADDITIONAL NOTES, SEE SHEET ES-3C OF THE STANDARD PLANS FOR MODEL 332 AND 334 CABINETS)



BASE PLAN FOR BBS MOUNTED TO THE MODEL 332 OR 334 CABINET

(FOR DIMENSIONS AND DETAILS NOT SHOWN, SEE SHEET A6-1 TO A6-4, CABINET HOUSING DETAILS OF THE TRANSPORTATION ELECTRICAL EQUIPMENT SPECIFICATION (TEES))

ELECTRICAL SYSTEMS
(BBS FOUNDATION DETAILS)

NO SCALE

THIS PLAN IS ACCURATE FOR ELECTRICAL WORK ONLY.

REVISED BY | DATE REVISED
CALCULATED-DESIGNED BY | CHECKED BY
FUNCTIONAL SUPERVISOR
STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans

LAST REVISION 2-2-09
DATE PLOTTED => 13-APR-2010
TIME PLOTTED => 11:41

BORDER LAST REVISED 4/11/2008
RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3
USERNAME => trpierce
DGN FILE => BBS Foundation.dgn
CU 00000
EA 000000

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Theresa Gabriel — REGISTERED CIVIL ENGINEER — 12-20-07 DATE

REGISTERED PROFESSIONAL ENGINEER — Theresa A. Gabriel — No. E15129 — Exp. 6-30-10 — ELECT — STATE OF CALIFORNIA

PLANS APPROVAL DATE

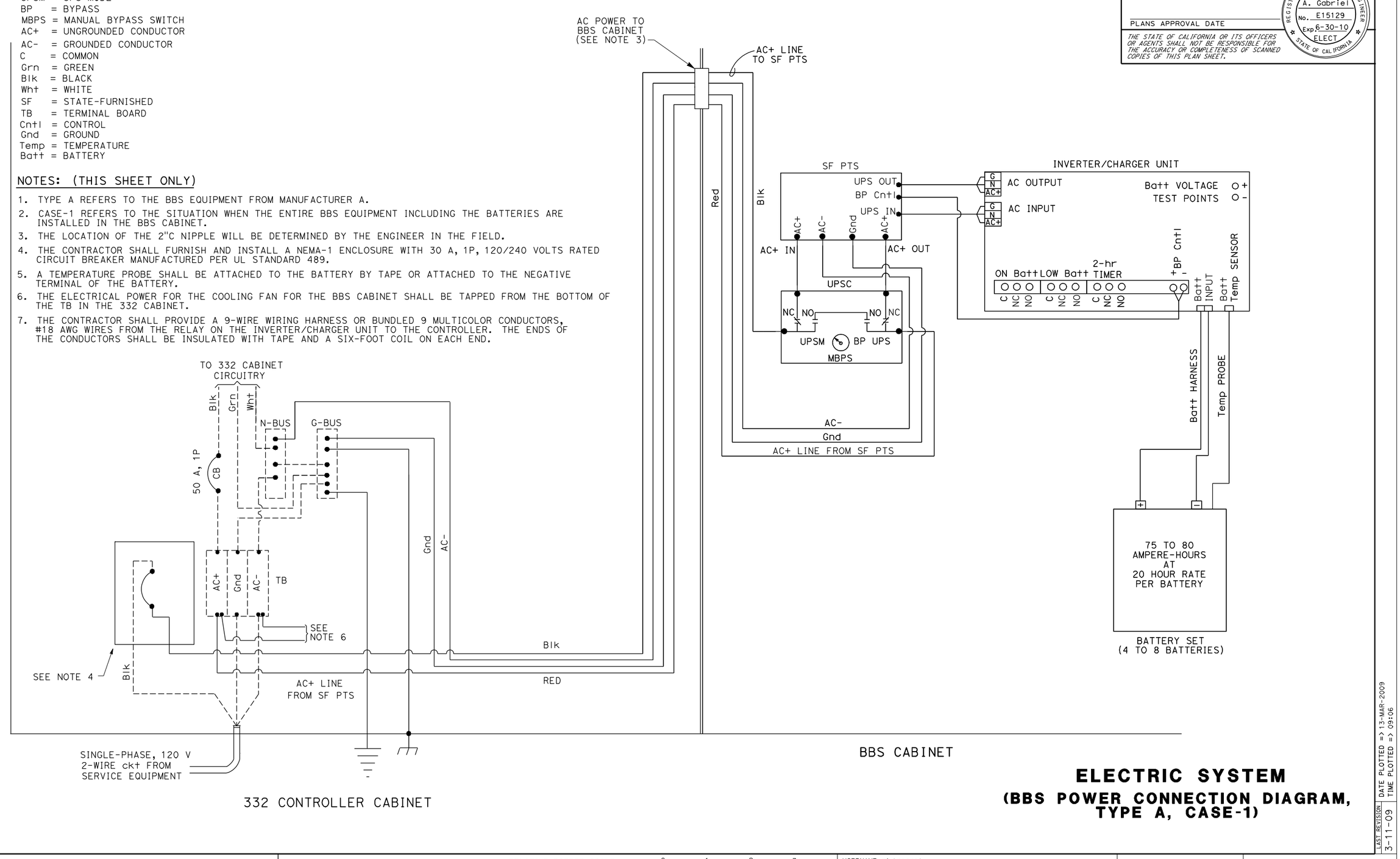
THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

LEGEND: (THIS SHEET ONLY)

PTS = POWER TRANSFER SWITCH
UPS = UNINTERRUPTIBLE POWER SUPPLY
UPSC = UNINTERRUPTIBLE POWER SUPPLY CONTROLLER
UPSM = UPS MODE
BP = BYPASS
MBPS = MANUAL BYPASS SWITCH
AC+ = UNGROUNDED CONDUCTOR
AC- = GROUNDED CONDUCTOR
C = COMMON
Grn = GREEN
Blk = BLACK
Wht = WHITE
SF = STATE-FURNISHED
TB = TERMINAL BOARD
Cntl = CONTROL
Gnd = GROUND
Temp = TEMPERATURE
Batt = BATTERY

NOTES: (THIS SHEET ONLY)

1. TYPE A REFERS TO THE BBS EQUIPMENT FROM MANUFACTURER A.
2. CASE-1 REFERS TO THE SITUATION WHEN THE ENTIRE BBS EQUIPMENT INCLUDING THE BATTERIES ARE INSTALLED IN THE BBS CABINET.
3. THE LOCATION OF THE 2"C NIPPLE WILL BE DETERMINED BY THE ENGINEER IN THE FIELD.
4. THE CONTRACTOR SHALL FURNISH AND INSTALL A NEMA-1 ENCLOSURE WITH 30 A, 1P, 120/240 VOLTS RATED CIRCUIT BREAKER MANUFACTURED PER UL STANDARD 489.
5. A TEMPERATURE PROBE SHALL BE ATTACHED TO THE BATTERY BY TAPE OR ATTACHED TO THE NEGATIVE TERMINAL OF THE BATTERY.
6. THE ELECTRICAL POWER FOR THE COOLING FAN FOR THE BBS CABINET SHALL BE TAPPED FROM THE BOTTOM OF THE TB IN THE 332 CABINET.
7. THE CONTRACTOR SHALL PROVIDE A 9-WIRE WIRING HARNESS OR BUNDLED 9 MULTICOLOR CONDUCTORS, #18 AWG WIRES FROM THE RELAY ON THE INVERTER/CHARGER UNIT TO THE CONTROLLER. THE ENDS OF THE CONDUCTORS SHALL BE INSULATED WITH TAPE AND A SIX-FOOT COIL ON EACH END.



ELECTRIC SYSTEM
(BBS POWER CONNECTION DIAGRAM, TYPE A, CASE-1)

LAST REVISION 3-11-09 | DATE PLOTTED => 13-MAR-2009 | TIME PLOTTED => 09:06

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION | FUNCTIONAL SUPERVISOR | CALCULATED-DESIGNED BY | CHECKED BY | REVISED BY | DATE REVISED

BORDER LAST REVISED 4/11/2008 | RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3 | USERNAME => trcarol | DGN FILE => BBS 1250FSM.dgn | CU 00000 | EA 000000

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Theresa Gabriel — REGISTERED CIVIL ENGINEER — 12-20-07 DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — Theresa A. Gabriel — No. E15129 — Exp 6-30-10 — ELECT — STATE OF CALIFORNIA

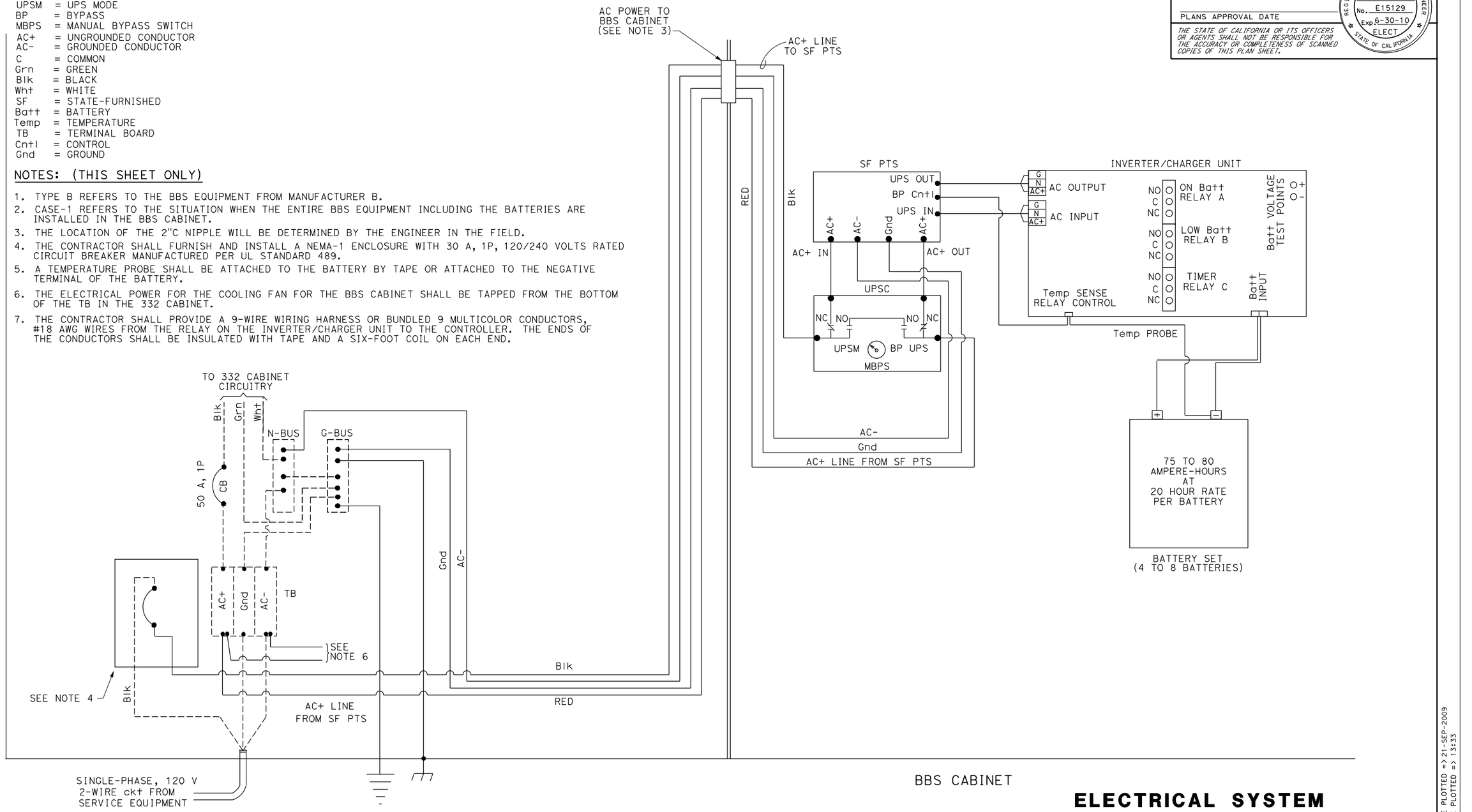
THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

LEGEND: (THIS SHEET ONLY)

PTS = POWER TRANSFER SWITCH
UPS = UNINTERRUPTIBLE POWER SUPPLY
UPSC = UNINTERRUPTIBLE POWER SUPPLY CONTROLLER
UPSM = UPS MODE
BP = BYPASS
MBPS = MANUAL BYPASS SWITCH
AC+ = UNGROUNDED CONDUCTOR
AC- = GROUNDED CONDUCTOR
C = COMMON
Grn = GREEN
Blk = BLACK
Wht = WHITE
SF = STATE-FURNISHED
Batt = BATTERY
Temp = TEMPERATURE
TB = TERMINAL BOARD
Cntl = CONTROL
Gnd = GROUND

NOTES: (THIS SHEET ONLY)

1. TYPE B REFERS TO THE BBS EQUIPMENT FROM MANUFACTURER B.
2. CASE-1 REFERS TO THE SITUATION WHEN THE ENTIRE BBS EQUIPMENT INCLUDING THE BATTERIES ARE INSTALLED IN THE BBS CABINET.
3. THE LOCATION OF THE 2"C NIPPLE WILL BE DETERMINED BY THE ENGINEER IN THE FIELD.
4. THE CONTRACTOR SHALL FURNISH AND INSTALL A NEMA-1 ENCLOSURE WITH 30 A, 1P, 120/240 VOLTS RATED CIRCUIT BREAKER MANUFACTURED PER UL STANDARD 489.
5. A TEMPERATURE PROBE SHALL BE ATTACHED TO THE BATTERY BY TAPE OR ATTACHED TO THE NEGATIVE TERMINAL OF THE BATTERY.
6. THE ELECTRICAL POWER FOR THE COOLING FAN FOR THE BBS CABINET SHALL BE TAPPED FROM THE BOTTOM OF THE TB IN THE 332 CABINET.
7. THE CONTRACTOR SHALL PROVIDE A 9-WIRE WIRING HARNESS OR BUNDLED 9 MULTICOLOR CONDUCTORS, #18 AWG WIRES FROM THE RELAY ON THE INVERTER/CHARGER UNIT TO THE CONTROLLER. THE ENDS OF THE CONDUCTORS SHALL BE INSULATED WITH TAPE AND A SIX-FOOT COIL ON EACH END.



ELECTRICAL SYSTEM

(BBS POWER CONNECTION DIAGRAM, TYPE B, CASE-1)

LAST REVISION 3-11-09
DATE PLOTTED => 21-SEP-2009
TIME PLOTTED => 13:33

REVISED BY | DATE REVISED
CALCULATED-DESIGNED BY | CHECKED BY
FUNCTIONAL SUPERVISOR
STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans

BORDER LAST REVISED 4/11/2008

RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

USERNAME => trcarol
DGN FILE => BBS DUIFSM.dgn

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EA 000000

Schuyler Heim Bridge Replacement Project
Air Quality Information Handout

The following measures have been identified in the "Schuyler Heim Bridge Replacement and SR-47 Expressway Project Final Environmental Impact Statement/Environmental Impact Report and Section 4(f) Evaluation" to reduce air quality effects during project construction:

1 Apply nontoxic soil stabilizers to all inactive construction areas (previously graded areas inactive for 10 days), and areas anticipated to be inactive for 10 days. Nontoxic soil stabilizers can reduce PM_{10}/$PM_{2.5}$ emissions from these areas by 30 to65 percent.

2 Replace ground cover in disturbed areas as quickly as possible. A reduction of 15 to 49 percent in PM_{10}/$PM_{2.5}$ emissions for disturbed areas could be achieved.

3 Reduce traffic speed on all unpaved roads to 15 mph or less. PM10/PM2.5 emissions from travel on unpaved roads can be reduced by 40 to 70 percent by managing vehicle speeds.

4 Prohibit truck idling in excess of 2 minutes. Employ periodic, unscheduled inspections to limit unnecessary idling. The SCAQMD has not quantified the efficiency of this mitigation measure.

5 Suspend use of all construction equipment operations during second-stage smog alerts. The SCAQMD has not quantified the efficiency of this measure.

6 Use electricity, if feasible, from power poles rather than temporary diesel- or gasoline-powered generators. Using electricity from power poles is an effective measure to reduce emissions of ROG, NOX, CO, and PM_{10} from generators. Reduction efficiencies for these compounds are 97 to 99 percent.

7 To the extent feasible, utilize construction equipment equipped with Tier 2 or newer engines.

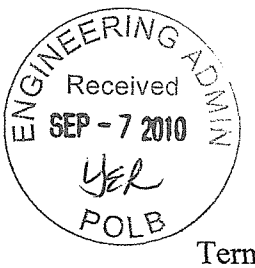
8 Maintain and tune engines per manufacturer's specifications to perform at EPA certification levels and to perform at verified standards applicable to retrofit technologies. Employ periodic, unscheduled inspections to ensure that construction equipment is properly maintained, tuned, and modified to established specifications.

9 Prohibit tampering with engines, and require continuing adherence to manufacturer's recommendations.

CC: CT

STATE OF CALIFORNIA ARNOLD SCHWARZENEGGER, *Governor*

PUBLIC UTILITIES COMMISSION
180 Promenade Circle, Suite 115
Sacramento, CA 95834



August 31, 2010

File Number: G.10-07-021
Terminal Island Fwy/New Dock St off ramp
City of Long Beach

Al Moro, P.E.
Chief Harbor Engineer
The Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Re: General Order 88-B Request for Authority to Grade Separate the Terminal Island Fwy/New Dock St off ramp At-Grade Highway-Rail crossing across the tracks of the Port of Long Beach, in City of Long Beach, Los Angeles County.

Dear Mr. Moro:

This refers to your letter, dated July 15, 2010, received July 16, 2010, requesting authorization, pursuant to Commission General Order (GO) 88-B, to alter the Terminal Island Fwy/New Dock St off ramp at-grade highway-rail crossing (crossing), CPUC Crossing No. 120AT-18.57, of the Port of Long Beach's (POLB) Alameda Corridor Subdivision tracks in City of Long Beach (City), County of Los Angeles.

POLB owns the railroad right of way and Pacific Harbor Line (PHL) operates freight service on the rail corridor. POLB, a City of Long Beach agency, also controls the street system within the port. The alterations proposed for this crossing are part of a larger project to reconstruct and widen the Terminal Island Freeway (SR-47).

The proposed SR-47 reconstruction will realign and grade separate the existing at-grade crossing. The existing tracks will be shifted north with the new SR-47 southbound off ramp structure passing over the tracks. The ramp structure will intersect with a newly elevated New Dock Street.

The Commission's Rail Crossings Engineering Section (RCES) investigated the request by POLA and finds it adequately addresses compliance and safety. As POLA, PHL and City are in agreement as to the design and apportionments of the cost under the provisions of GO 88-B, the improvements as described in your letter dated July 15, 2010, and summarized above are authorized. Improvements shall comply with all applicable Commission General Orders and the California Manual on Uniform Traffic Control Devices published by the California Department of Transportation.

This project is statutorily exempt from the requirements of the California Environment Quality Act of 1970, as amended. [California Pubic Resources Code 21080.13]

This authorization shall expire if the above conditions are not complied with or if the work is not completed within three years of the date of this letter. Upon written request to this office, the time to complete the project may be extended. Any written request for a time extension must include concurrence letters by involved parties in support of the time extension. If an extension is requested, the Commission's RCES may reevaluate the crossings prior to granting an extension.

Within 30 days after completion of this project, POLA shall notify RCES that the authorized work is completed, by submitting a completed Commission Standard Form G title *Report of Changes at Highway Grade Crossings and Separation.* Form G requirements and forms can be obtained at the CPUC web site Form G page at http://www.cpuc.ca.gov/formg. This report may be submitted electronically to rces@cpuc.ca.gov as outlined on the web page.

If you have any questions, please contact Jose Pereyra at (213-576-7083) or jfp@cpuc.ca.gov .

Sincerely,

Daren Gilbert, Supervisor
Rail Crossings Engineering Section
Consumer Protection and Safety Division

C: Carlo Luzzi, Port of Long Beach
Robert Giannoble, Pacific Harbor Line

CC: CT

STATE OF CALIFORNIA ARNOLD SCHWARZENEGGER, *Governor*

PUBLIC UTILITIES COMMISSION
180 Promenade Circle, Suite 115
Sacramento, CA 95834

August 31, 2010

File Number: G.10-07-022
New Dock St
City of Long Beach

Al Moro, P.E.
Chief Harbor Engineer
The Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Re: General Order 88-B Request for Authority to Modify the New Dock St At-Grade Highway-Rail crossing across the tracks of the Port of Long Beach, in City of Long Beach, Los Angeles County.

Dear Mr. Moro:

This refers to your letter, dated July 15, 2010, received July 16, 2010, requesting authorization, pursuant to Commission General Order (GO) 88-B, to alter the New Dock St at-grade highway-rail crossing (crossing), CPUC Crossing No. 120AT-18.60, of the Port of Long Beach's (POLB) Alameda Corridor Subdivision tracks in City of Long Beach (City), County of Los Angeles.

POLB owns the railroad right of way and Pacific Harbor Line (PHL) operates freight service on the rail corridor. POLB, a City of Long Beach agency, also controls the street system within the port. The alterations proposed for this crossing are part of a larger project to reconstruct and widen the Terminal Island Fwy (SR-47).

The proposed SR-47 reconstruction will realign the existing tracks and shift the existing crossing. POLB proposes to shift the existing tracks east and raise the elevation to match the elevations of the reconstructed New Dock St. New Dock St will have two vehicular lanes for each direction of travel (east/west). Specifically, POLB will perform the following modifications:

- Construct new raised medians on both approaches to the crossing,
- Install one curb mounted Commission Standard 9A (flashing light signals with gate and cantilever, per GO 75-D) on west approach to crossing,
- Install one curb mounted Commission Standard 9 (flashing light signals with gate, per GO 75-D) and one median mounted Commission Standard 9 on east approach to crossing,
- Replace all existing flashers with LEDs,
- Install new railroad signage, pavement markings and striping as indicated in letter and plans.

The Commission's Rail Crossings Engineering Section (RCES) investigated the request by POLB and finds it adequately addresses compliance and safety. As POLB, PHL and City are in agreement as to the design and apportionments of the cost under the provisions of GO 88-B, the improvements as described in your letter dated July 15, 2010, and summarized above are authorized. Improvements shall comply with all applicable Commission General Orders and the California Manual on Uniform Traffic Control Devices published by the California Department of Transportation.

This project is categorically exempt from the requirements of the California Environment Quality Act of 1970, as amended. [California Pubic Resources Code 21084]

This authorization shall expire if the above conditions are not complied with or if the work is not completed within two years of the date of this letter. Upon written request to this office, the time to complete the project may be extended. Any written request for a time extension must include concurrence letters by involved parties in support of the time extension. If an extension is requested, the Commission's RCES may reevaluate the crossings prior to granting an extension.

Within 30 days after completion of this project, POLB shall notify RCES that the authorized work is completed, by submitting a completed Commission Standard Form G title *Report of Changes at Highway Grade Crossings and Separation.* Form G requirements and forms can be obtained at the CPUC web site Form G page at http://www.cpuc.ca.gov/formg. This report may be submitted electronically to rces@cpuc.ca.gov as outlined on the web page.

If you have any questions, please contact Jose Pereyra at (213-576-7083) or jfp@cpuc.ca.gov .

Sincerely,

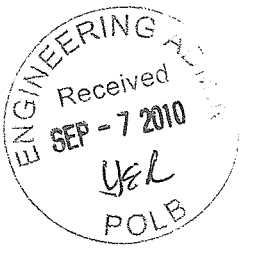
Daren Gilbert, Supervisor
Rail Crossings Engineering Section
Consumer Protection and Safety Division

C: Carlo Luzzi, Port of Long Beach
Robert Giannoble, Pacific Harbor Line

CC: CT

STATE OF CALIFORNIA ARNOLD SCHWARZENEGGER, *Governor*

PUBLIC UTILITIES COMMISSION
180 Promenade Circle, Suite 115
Sacramento, CA 95834



August 31, 2010

File Number: G.10-07-023
Terminal Island Fwy Overhead
City of Long Beach

Al Moro, P.E.
Chief Harbor Engineer
The Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Re: General Order 88-B Request for Authority to modify the Terminal Island Fwy Grade Separated Highway-Rail crossing over the tracks of the Port of Long Beach, in City of Long Beach, Los Angeles County.

Dear Mr. Moro:

This refers to your letter, dated July 15, 2010, received July 16, 2010, requesting authorization, pursuant to Commission General Order (GO) 88-B, to alter the Terminal Island Fwy Grade Separated Highway-Rail crossing (crossing), CPUC Crossing No. 120AT-18.64-A, of the Port of Long Beach's (POLB) Alameda Corridor Subdivision tracks in City of Long Beach (City), County of Los Angeles.

POLB owns the railroad right of way and Pacific Harbor Line (PHL) operates freight service on the rail corridor. POLB, a City of Long Beach agency, also controls the street system within the port. The alterations proposed for this crossing are part of a larger project to reconstruct and widen the Terminal Island Fwy (SR-47).

The proposed SR-47 reconstruction will realign the existing northerly track and raise its elevation to match that of the adjacent New Dock St. The existing southerly track and turnout will remain unchanged. The existing SR-47 overhead structure will be removed and replaced with a new structure located at approximately the same horizontal location but at a higher elevation.

The Commission's Rail Crossings Engineering Section (RCES) investigated the request by POLA and finds it adequately addresses compliance and safety. As POLA, PHL and City are in agreement as to the design and apportionments of the cost under the provisions of GO 88-B, the improvements as described in your letter dated July 15, 2010, and summarized above are authorized. Improvements shall comply with all applicable Commission General Orders and the California Manual on Uniform Traffic Control Devices published by the California Department of Transportation.

This project is categorically exempt from the requirements of the California Environment Quality Act of 1970, as amended. [California Pubic Resources Code 21084]

This authorization shall expire if the above conditions are not complied with or if the work is not completed within three years of the date of this letter. Upon written request to this office, the time to complete the project may be extended. Any written request for a time extension must include concurrence letters by involved parties in support of the time extension. If an extension is requested, the Commission's RCES may reevaluate the crossings prior to granting an extension.

Within 30 days after completion of this project, POLA shall notify RCES that the authorized work is completed, by submitting a completed Commission Standard Form G title *Report of Changes at Highway Grade Crossings and Separation.* Form G requirements and forms can be obtained at the CPUC web site Form G page at http://www.cpuc.ca.gov/formg. This report may be submitted electronically to rces@cpuc.ca.gov as outlined on the web page.

If you have any questions, please contact Jose Pereyra at (213-576-7083) or jfp@cpuc.ca.gov .

Sincerely,

Daren Gilbert, Supervisor
Rail Crossings Engineering Section
Consumer Protection and Safety Division

C: Carlo Luzzi, Port of Long Beach
Robert Giannoble, Pacific Harbor Line

HARBOR DEVELOPMENT PERMIT (RAILROAD GUIDELINES SECTION)

WORK REQUIREMENTS WHEN WORKING WITHIN RAILROAD RIGHT-OF-WAY

The requirements stated in this section relate to any work within the railroad right-of-way. For construction purposes, the railroad right-of-way is defined as 20 feet from track centerline. The minimum vertical clearance above top of rail is 25 feet. The minimum depth for any utility construction below grade shall be five (5) feet – six (6) inches from base of rail for mainline track and four (4) feet – six (6) inches from base of rail for other than mainline track in accordance with the Engineering Division railroad standard plans. Any work within the railroad right-of-way shall include a Port inspector paid by the Contractor.

The Contractor shall not enter any location, perform any work, or locate any piece of equipment within ten (10) feet of the nearest rail of any railroad track without prior authorization from the Engineering Division and Pacific Harbor Line (PHL). The PHL contact is Bob Giannoble at (310) 420-8116. All work shall be performed in accordance with the provisions of Title 49, Part 214 of the Code of Federal Regulations.

The Contractor shall submit a written Work Plan to the Engineering Division for approval not less than fourteen (14) days prior to beginning work. The Work Plan shall include the location, starting and stopping times, a description of the work to be performed, the work crews involved, and the track outages and/or railroad safety protection (Flagmen). All flagging shall be by PHL. No work may be performed, nor any piece of equipment moved within ten (10) feet of the nearest rail of any railroad track until the Engineering Division approves the Work Plan. The Contractor, if required, will pay Flagmen, to PHL.

The Contractor shall provide a qualified train Watchperson when working within 20 feet of the track centerline for the safety and protection of the Contractor's personnel and equipment during construction operations. Watchperson shall be properly trained and equipped in accordance with Title 49, Part 214 of the Code of Federal Regulations. The Contractor shall pay the cost of Watchperson. The PHL will qualify the Watchperson for the project. The Contractor shall submit an approved list of PHL trained watchperson to the Engineering Division prior to working within 20 feet of the track centerline.

Crossing of tracks by the Contractor's equipment at unpaved railroad crossings is prohibited. A temporary timber railroad crossing shall be required for construction access over the tracks.

The Contractor shall report any accidents, injuries, track defects, or any unusual track conditions, which may affect the safe and efficient operation of the railroad to the Engineering Division and PHL by the first available means of communication.

The Contractor shall be responsible for the prevention or damage to railroad facilities, equipment and operating trains due to its activities. In the event the Contractor damages railroad facilities or equipment, the Contractor shall immediately report the damage to the Engineering Division and PHL. Repair of damage caused by Contractor's operations shall be at the expense of the Contractor and accomplished immediately in accordance with the Engineering Division and PHL supervision.

Upon completion of the work, the Contractor shall promptly remove all materials, tools, equipment, and leave the right-of-way in a clean, presentable condition.

Port Standard Utility Casing Requirements

The approved method for utility installation under the railroad tracks is by boring or jacking and shall be in accordance to the Engineering Division railroad standards casing plans. All ballast and sub-ballast replacements shall be with new material. The tracks shall be restored to original alignment by an experienced railroad contractor.

Utility Work on Railroad Right-of-Way

Trenching and/or tunneling under the tracks may be permitted for non-mainline track where boring cannot be accomplished as approved by the Engineering Division for each specific site. Shoring plans, engineering calculations and detailed cross sections shall be required for both utility crossings under the railroad tracks and longitudinal trenching within 20 feet from track centerline. The shoring plan shall include a support beam in order to prevent a sag in the tracks.

Open cut trenching under unpaved track sections shall include delineators or fencing after work hours. New ballast shall be placed 12 inches (six inch lifts) from bottom of tie to a distance two feet beyond edge of tie. A two (2) - sack slurry (quick hardening mix) shall be placed from bottom of new ballast to a distance 15 feet from each side of track centerline. Backfill for longitudinal work within 20 feet from track centerline shall be required and placed in six (6) inch layers with 95 percent compaction in accordance with the American Society for Testing and Materials (ASTM) Designation D 1556 and D 1557.

For tunneling work under paved tracks, the Contractor shall saw cut pavement at a distance of five (5) feet from track centerline (or beyond end of tie). The Contractor shall fill any voids between the proposed steel casing and tunneling hole with a two (2)-sack slurry mix (quick hardening mix). If a cave in occurs within the area from the base of rail to a distance four (4) feet below base of rail at any point along the tunneling operation, then the Contractor shall be required to continue as an open cut trench with complete asphalt and soil removal.

Ballast and Sub-ballast

Sub-ballast material shall be Crushed Miscellaneous Base (CMB) and shall conform to Section 200-2.4 (Fine Gradation), per SSPWC. Placement of the sub-ballast shall conform to Section 301-2.2 "Spreading" and 301-2.3 "Compacting" per SSPWC

Ballast material shall consist of clean crushed stone, tough, durable fragments free of any detrimental quantity of soft, friable, thin, elongated or laminated pieces, disintegrated material, pieces coated with dirt, oil or other deleterious substance. Ballast shall be crushed granite, quarry stone or slag.

Ballast gradation shall be gradation No. 4A as outlined in Chapter 1, Part 2, Section 2 of the AREMA Manual. The ballast gradation shall be determined by ASTM C136 with laboratory sieves having square openings conforming to ASTM E11.

Gradation No. 4A:

Nominal Sieve Size	Percent Passing By Weight (No. 4A)
2 – 1/2 inch	100 percent
2 inch	90 - 100 percent
1-1/2 inch	60 - 90 percent
1 inch	10 - 35 percent
3/4 inch	0 - 10 percent
1/2 inch	----------
3/8 inch	0 – 3 percent

The Contractor shall provide certification that ballast delivered to the job site is typical of ballast which passed acceptance and production tests. If material at the job site does not conform to these specifications, the Contractor shall stop further deliveries until the fault has been corrected. The Engineering Division will reject ballast arriving at the site for unloading that does not conform to the specifications. Defective material shall be promptly removed and replaced at the Contractors expense.

The ballast shall be hand tamped by mechanical method from a point twelve (12) inches inside each rail on both sides of the ties to the ends of the ties for short rail lengths (less than 20 feet). For larger areas (greater than 20 linear feet), mobile tampers will be required. The mobile tampers shall be started from a nearly vertical position and used directly against the sides of the tie to be tamped, and worked downward past the bottom corner, after which the tool may be tipped down to force the ballast directly under the tie. Switch ties shall be heavy tamped under each rail to a point twelve (12) inches on either side of each rail. Light tamping only shall be permitted between the above – stated limits. Each tie shall be thoroughly inspected as to compactness of ballast under the tie by means of sounding devices, and any tie found not to be solidly embedded in ballast shall be re-tamped.

In paved areas, the ballast shall be dressed one (1) inch above top of tie.

Track Testing and Acceptance

The track shall be surveyed by the Contractor upon completion of the work to ensure no differential settlement has occurred over the affected work area. Upon completion of work the Contractor shall coordinate a test engine with PHL and the Engineering Division over the affected track work for inspection and acceptance of the work.

RAILROAD WORK PLAN – DATE:_____

REQUIREMENTS WHEN WORKING WITHIN, ADJACENT TO, ABOVE, OR BENEATH RAILROAD RIGHT-OF-WAY

START DATE: _____

DURATION (Start & End Date): Start on _____ and Ending on _____

TRACK LOCATION: Track number _____ track located _____ (See attached plan).

START & STOP TIMES: Begin each day at _____ and end at _____

DESCRIPTION OF WORK: The work includes

_____

_____

_____ (see attached plan).

WORK CREW: The work will be performed by _____. The equipment used will be _____.

SAFETY PROTECTION:

The work plan is submitted ten (10) days in advance of any work within twenty (20) feet of track centerline. Prior to start of work, _____ will request a watch person training session from Pacific Harbor Line (PHL) for all work-crew working within 20 feet of the railroad track for the safety of the contractor's personnel only. Watch persons are not an approved method of protection for working equipment. Once the watch person training is completed, we will submit an approved list to the Engineer prior to working within 20 Feet of the track centerline.

If equipment is within ten (10) feet from the track centerline, then a flag person will be required. Flagging to be provided by Pacific Harbor Line (PHL) only. When a Flag Person is required, a new work plan request will be submitted to the Engineer and PHL a minimum of ten (10) working days prior to any work being performed. If a full track closure/outage is necessary, a minimum notice of ten (10) working days will be provided to the Engineer and PHL for each track closure. The Railroad track closure will be at the full discretion of the Engineer and PHL. The PHL contact is Bob Giannoble (310-834-4594).

Note: The Contractor shall submit the Railroad Work Plan to the Ports Construction Manager for approval by the Manager of Rail Transportation Systems (562-590-4140). All related permits shall be obtained prior to submitting the work plan.

RAILROAD
SPECIAL PROVISIONS

RAILROAD TRACK CONSTRUCTION

1.0 **GENERAL**
1.1 Track materials and special trackwork shall conform to recommendations set forth in the most current AREMA Manuals.

1.2 Track components design shall be standardized to facilitate maintenance and minimize the inventory of materials.

2.0 **EARTHWORK**
2.1 The material to be used for embankment fill shall be provided by the Contractor from a suitable source. Fill material shall be approved by the Engineer prior to being placed on site.

2.2 The material to be used for fill shall be relatively non-expansive soils with an Expansion Index of less than 35. The on-site soils (including non-contaminated ballast) less any debris or organic matter may be used.

2.3 Material for structural backfill shall be provided by the Contractor from an off-site borrow site. Structural backfill shall conform to Caltrans Standard Specifications, Section 19-3, except that jetting of material shall not be allowed.

2.4 Material for pervious backfill shall be provided by the Contractor from an off-site source, and conform to Caltrans Standard Specification Section 19-3.06.

2.5 Sub-drains and geotextile filter fabric are required for drainage of all track systems.

2.6 The exposed bottom of all excavations or surface to receive fill shall be scarified to a depth of six (6) inches, moisture conditioned to optimum moisture content, and compacted to at least ninety (90) percent relative compaction per ASTM 1557.

2.7 The uppermost of two (2) feet of railroad subgrade, and all subballast, shall be compacted to at least ninety five (95) percent of the maximum dry density as determined in accordance with ASTM D1557. 2.8 Fill shall be placed in layers not exceeding eight (8) inches in thickness and conform to Caltrans Specification 19-3.

3.0 **TRENCH EXCAVATION AND BACKFILL**
3.1 Excavation and backfill shall be in accordance with the SSPWC subsection 306-1.1 "Trench Excavation" and 306.1.3 "Backfill and Densification" and Los Angeles Standard Plan No. S-610-21, unless otherwise specified on the plans.

3.2 Excavations for pipe laying or conduit shall be per City of Los Angeles Standard Plan No. S-251-1, unless otherwise noted on the plans.

3.3 Prior to excavating adjacent to and within six (6) feet. of a subsurface installation, excavate potholes per Section 62.03.1 of the Los Angeles Municipal Code and positively determine the elevation and location of the subsurface installation.

4.0 GEOTEXTILE REINFORCING

Geotextile material shall be required for drainage between the subballast and the subgrade.

4.1 Geotextile material type shall be as follows:

- MIRAFI type 140N for under drains
- MIRAFI type 600X for subgrade crossing areas.
- MIRAFI type 1160N for track subgrade areas.

4.2 Geotextile material shall conform to section 213-2 "Geotextiles" of the latest edition of the SSPWC.

4.3 Geogrid shall be placed on geotextile or between subballast and subgrade to increase subgrade strength for railyard and crossing areas. Geogrid material shall be Tensar SS1. Geogrid material shall conform to section 213-2 "Geotextiles"of SSPWC.

5.0 STORM DRAIN SYSTEM- UNDERDRAINS

All trackage shall be designed with adequate sub-drainage.

The following shall apply in the design of track drainage:

a. The design storm shall be a ten (10) year storm for all trackage except SUMPs and SAG areas where a fifty (50) year storm shall be used.
b. All sub-drains shall be the level of the water below the level of the ballast.
c. No ponding of water will be allowed.
d. All sub drain systems shall be designed using perforated PVC piping, a permeable drainage material and a filter fabric.

The following criteria shall be used for the drainage piping.

a. All under drain pipe and fittings shall be eight (8) inches in diameter schedule eighty (80) PVC with elastomatic asphalt joints and fittings in accordance with ASTM F578. Perforated pipe shall be used for all underdrains with solid wall pipe being used only as connector piping.
b. PVC piping shall be in accordance with ASTM D1758. Schedule eighty (80) pipe compounds shall be in accordance with ASTM 1784.
c. Joint material shall be a solvent cement in accordance with ASTM D2564.
d. Underdrain outlets and risers shall be fabricated of ductile iron or corrugated metal. They shall be painted blue and marked "POLB" and "O". and spaced evenly three hundred (300) feet.

Sub-drains pipe shall have geotextile filter fabric wrapped in crushed filter rock. The filter rock shall conform to the following gradation:

Sieve Size	**Percentage Passing**
3/4"	100
3/8"	30-100
No. 4	0-30

Filter fabric for subdrains shall be manufactured from polyester, nylon, or polypropylene material, or

any combination thereof. The fabric shall be permeable, non-woven, shall not act as a wicking agent and shall conform to the following:

Weight, ounces per square yard min. ASTM Designation D3776	4.0
Grab tensile strength (1 inch grip) lbs. Min. each direction ASTM D 4632	90
Elongation at Break, percent min. ASTM D 4632	30
Toughness, pounds, min. (%elongation x grab tensile strength)	6000
Permittivity, 1/sec., min. ASTM D4491	0.5

If filter fabric is to be exposed for more than seventy two (72) hours, all fabric shall be treated with Ultraviolet Ray (UV) Protection. The treated fabric shall provide a minimum of seventy (70) percent breaking strength retention after five hundred (500) hours exposure when tested in accordance with ASTM D4355.

7.0 DEMOLITION AND REMOVAL OF EXISTING TRACK

Track removal shall consist of removing all material from the bottom of the subballast to the top of rail for the length as shown on the project plans. All material removed will be the contractor's for disposal/salvage except for special track work such as turnouts, railroad grade crossings and signal systems. For disposal of these items, the contractor shall contact the POLB Manager of Railroads for direction. Demolition work shall not interfere with the operation of existing railroad or vehicular traffic.

8.0 SUBBALLAST

8.1 Subballast material shall be in accordance with SSPWC Section 200.24, Crushed Miscellaneous Base, subsection 200-2.4.2, "Grading", Table 200-2.4.2 (A) Fine Gradation. The gradation shall be as follows:

Sieve Size	Percent Passing (Fine)
1" – 11/2"	100
3/4"	85-100
3/8	55-75
No. 4	30-50
No. 30	12-28
No. 200	2-10

8.2 Subballast material must be submitted to the Engineer for approval prior to use.

8.3 Placing, spreading and compaction of crushed aggregate base subballast material shall be in accordance with SSPWC subsection 301-2.2, "Spreading" and 301-2.3. "Compacting". Compaction shall be ninety five (95) percent relative compaction.

8.4 A geotextile filter fabric shall be placed at the base of the subballast throughout areas of all tracks including turnouts and grade crossings.

8.5 Subballast depth shall be as follows:

a. Subballast shoulder width shall be twelve (12) inches below ballast on mainline tracks, intermodal container stack train storage yard tracks, intermodal container stack train loading/unloading tracks, and mainline yard tracks. Use as required for industrial service tracks and other yard tracks.
b. Subballast material shall conform to section 200.2.4 (CMB), per SSPWC fine gradation.
c. A geotextile filter fabric shall be placed at base of Subballast throughout areas of all tracks including turnouts and grade crossings.
d. Subballast shall conform to AREMA Chapter 1 – Roadway and Ballast; Part 2 – Ballast; Section 2.11 – Subballast specifications for site specific calculation of total/subballast thickness.

8.6 Subballast shoulder width shall be as follows:
a. Subballast shoulder width shall be thirteen (13) feet from centerline on mainline tracks and twelve (12) feet from centerline elsewhere.

9.0 **BALLAST**
Ballast material shall be in accordance with the following:

9.1 Ballast material shall be in accordance with AREMA specifications excluding slag and limestone.

9.2 Ballast shall consist of crushed stone with angular fragments resulting from crushing by mechanical means using the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar igneous rocks; extrusive igneous rocks; or massive metamorphic quartzite or similar rocks. Crushed gravel is not acceptable.

9.3 Gradation testing shall be in accordance with ASTM C-136, utilizing square opening sieves in accordance with ASTM E-11. When testing the ballast material show a loss of not more than five (5) percent at the end of one hundred (100) revolutions and not more than thirty (30) percent at the end of five hundred (500) revolutions.

9.4 Ballast material shall meet the requirements of AREMA number 4A in all track areas.

9.5 For typical track construction provide ballast foundation with percentage passing each sieve falling within the following limits (Ballast size 4A).

Sieve Size **Sieve Opening**	**Percent Passing** **by Weight**
2½" 2.50"	100
2" 2.0"	90 - 100
1½" 1.50"	60 - 90
1" 1.0"	10 - 35
¾" 0.75"	0 - 10
½" 0.50"	-
3/8" 0.375"	0 - 3
No. 4 0.187"	-

9.6 Property requirements as indicated in AREMA Table 2-1 for "Quartzite"
Percent by Weight

Soft and friable pieces	0.5
Materials finer than No. 200 sieve	1.0
Clay lumps	0.5

9.7 Determination of ballast bulk density shall be in accordance with the ASTM C29, using three (3) inch nominal maximum size.

9.8 Particles of the ballast shall have been broken by the crusher and have at least two (2) broken surfaces.

9.9 Boulders which will pass through a five (5) inch circular opening before crushing shall be rejected.

9.10 Ballast depth shall be as follows:

a. Timber and/or Concrete Ties – Ballast depth shall extend not less than twelve (12) inches below bottom of tie for the full length of the tie and shoulders.

9.11 Ballast shoulder width shall be as follows:

a. Ballast shoulder width shall be a minimum of twelve (12) inches beyond the edge of the tie.
b. Ballast shoulder width shall be twelve (12) inches on mainline tracks, intermodal container stack train storage yard tracks, mainline sidings, and mainline yard tracks.

9.12 Ballast Source Control

a. Representative samples of ballast, of not less than one hundred fifty (150) lbs. for gradation and other required tests shall be taken from each source of ballast and tested as specified herein. Each shipment of ballast to the site shall be accompanied by a certification as specified.
b. Certified results of the tests required to demonstrate conformance with this Design Criteria shall be provided prior to any material being used for the work.
c. The ballast delivered to the site shall be from the same source from which samples were tested and found to be in accordance with this criteria and shall be of the same type and quality of that which was tested.

9.13 Ballasting

Ballasting is the spreading, watering, rolling, tamping, and dressing of ballast rock to bring the rails to grade and alignment. Ballast shall be installed as follows:

a. Ballast shall be placed in two (2) lifts. Each lift shall be compacted with a minimum ten (10) ton roller until no waving or creeping occurs.
b. Ballast shall be tamped with an eight (8) head tamping machine, using not less than three (3) insertions per tie.
c. Ballast shall be placed one (1) inch higher than the top of tie to provide a separate lining between asphalt and the tie.

10.0 CRUSHED WALKWAY ROCK

a. Walkway Rock shall be of the same quality material specified for ballast shall conform to the gradation requirements for size No. 5 Table 2-2 Section 2.4, of the AREMA manual.
b. Crushed Walkway Rock shall be placed two (2) inches in depth where required.
c. The percent passing each sieve shall be as follows:

Sieve Size	Percent Passing by Weight
1" – 1/2"	100
1"	90-100
3/4"	40-75
1/2"	15-35
3/8"	0-15
No. 4	0-5

11.0 PERMANENT TRACK CONSTRUCTION

Trackwork for projects will be typical ballasted track construction.

11.1 BALLASTED TRACK

a. Ballasted track shall be the primary type used for track work constructed at grade. It shall consist of subballast, ballast, cross-ties, rails, and rail fasteners.

b. The top of ballast elevation shall be one (1) inch below top of tie, except in the area six (6) inches on either side of the rail where the ballast shall be cribbed to maintain one (1) inch of clearance between the bottom of the rail and the top of ballast.

c. Ballast conforming to AREMA size No. 4A shall be used for all track areas.

d. At locations where subgrade material is unsuitable, a stabilizing course of compacted fill or asphalt shall be utilized.

11.2 TRACK GAUGE

a. The standard track gauge shall be four (4) feet eight and one half (8½) inches. Track gauge shall be measured between the gauge sides of the heads of rails at a distance of 5/8 inch below the top of rails. Wider gauges shall be used in some curves, depending upon the degree of curvature. Track gauges shall follow AREMA tables of practical gauges and flangeways for curved track, plan no. 791-59.

b. Gauge widening shall be distributed through the spiral curve for a spiral-circular-spiral type curve. For circular curves without spirals, the gauge widening distance shall be distributed by placing half the distance on the tangent and half on the circular curve. c. Gauges for special trackwork shall be as recommended in the AREMA portfolio of trackwork plans except as modified to reflect the physical and operational characteristics of the system.

11.3 TRACK CONSTRUCTION TOLERANCES

a. Track construction tolerances are determined by taking into consideration safety, speed of operation and type of service to be provided. All new track construction shall be constructed as class 5 in accordance with FRA Title 49, Part 213. Track shall be constructed to the tolerances shown in the following table:

	Vertical Track Alignment			Horizontal Track Alignment		
Type of Track	Gauge Variation	Cross Level Variation	Total Deviation	Middle Ordinate in 62' Chord	Total Deviation	Middle Ordinate In 62' Chord
Mainline Track	+/- 1/8"	+/- 1/8"	+/- 1/2"	+/- 1/8"	+/- 1/2"	+/- 1/4"
Yard Track	+1.4" -1/8"	+/- 1/4"	+/- 1/2"	+/- 1/4"	+/- 1/2"	+/- 1/4"

Notes:

(1) Variations of gauge and cross level shall not exceed 1/8" per 31' of track.

(2) Total deviation is measured between the theoretical and actual alignment at any point in the track.

b. Maintenance of existing track shall be Class 3 in accordance with FRA Title 49, part 213.

11.4 RAIL

a. The standard rail section shall be new 136 RE pound Continuous Welded Rail (CWR), meeting AREMA material requirements on mainline tracks, intermodal container stack train storage yard tracks, intermodal container stack train loading/unloading tracks, and yard tracks.
b. Jointed rail may be used only for temporary track construction or as approved by the Chief Harbor Engineer. Second hand (relay) rail may be used providing it meets the requirements of AREMA grading for Class 1 and passes ultrasonic testing for the entire length of the rail. Rails shall be either control-cooled carbon steel or special alloy rails as manufactured in accordance with the requirements of AREMA.
c. Rail Hardness – Brinell Hardness Number (BHN)
    1. For standard strength rail used in tangent track and curves of less than five (5) degrees the minimum BHN shall be three hundred (300).
    2. For high strength rail used in curves of greater than five (5) degrees and all turnouts the minimum BHN shall be three hundred sixty (360).

11.5 TURNOUTS

a. Turnout rail size shall be the same as the track size. See Design Criteria for turnout size.
b. All new turnouts shall be constructed of 136-RE rail.
c. Turnouts shall be continuously welded rail except at specific areas indicating a thirty six (36) inch whole joint bar bonded insulated which shall be a poly-insulated type.
d. Switch points, stock rails, closure rails, guard rails, and frog wing rails and all associated components shall be fabricated from new, high strength (Head Hardened) Rail.
e. All turnouts shall be equipped with floating heel blocks and adjustable rail braces. Rail braces shall be Bethlehem boltless adjustable braces with boltless adjustable clamps.
f. All turnouts shall be insulated and utilize resilient rail fasteners throughout.
g. All turnouts shall have electrical conduits and pull boxes for installation of automated power switching in the future.
h. All vertical switch rods and gauge plates shall be insulated.

11.6 FROGS

a. Frogs for open-track turnouts shall be AREMA Railbound Manganese (RBM) high integrity heavy wall three shot explosion hardened steel castings with mitered heel, extended heel and rail wings with frog base plate and gauge plates utilizing a resilient fastening system.
b. Frogs for tracks embedded in pavement shall be one-piece, solid cast manganese with frog base plate and gauge plates utilizing a resilient fastening system.
c. Frogs shall be radiographed tested in accordance with AREMA.
d. Frogs shall have extended legs for thermite welding.

11.7 SWITCH POINTS

a. Switch points shall be Samson undercut type with Manganese steel tips in accordance with AREMA Specifications.
    1. Manganese steel tips lengths shall be as follows:
    2. Two (2) feet eight (8) inches for No. 8 turnouts
    3. Three (3) foot six (6) inches for Nos. 9, 10, 15, and 20 turnouts.

b. Switch points shall have adjustable braces.
c. Switch points shall be straight points with a uniform riser bolted in Manganese steel switch point guard.
d. Switch points, rods, and gauge plates shall all be insulated.
e. Switch point lengths shall be as follows:
    1. Sixteen (16) feet six (6) inches for Nos. 8, 9 and 10 turnouts.
    2. Nineteen (19) feet six (6) inches for No. 11 turnouts.
    3. Twenty six (26) feet zero (0) inches for No. 15 turnout.
    4. Thirty-nine (39) feet zero (0) inches for No. 20 turnouts fabricated from rail fifty-six (56) feet long for field welding.
f. Switch point rollers shall be required for all turnouts.
g. Switch point throw shall be four and three quarters (4-¾) inch with a tolerance of plus or minus one quarter (¼) inch.

11.8 GUARD RAILS

a. Guard rails shall be raised one (1) inch above top of running rail for all turnouts.
    1. Guard rails shall be boltless and adjustable with a hardened ABC U69 type guard bar in accordance with AREMA specifications.
b. Guard rails shall be hook-flange or boltless-adjustable for Nos. 15 and 20 turnouts.
c. Guard rail lengths shall be as follows:
    1. Fifteen (15) feet for Nos. 8, 9, 10 and 11 turnouts.
    2. Twenty six (26) feet for Nos. 15 and 20 turnouts.
d. Guard rails shall be Bethlehem hook flange raised guard rail with plates or an engineer approved equal.
e. Switch point guard shall be adjustable Manganese steel type.

11.9 SWITCH STANDS

Switch stands shall be located on the diverging side of the turnout. For parallel tracks, the switch stand shall be located on the outside of the track. All switch stands shall have switch rods and connections that can be retrofitted to remote – controlled power operation.

For open ballasted track the following shall apply:

a. Switch stand shall be high-star, lockable, non-trailable on mainline tracks.
b. Adjustable switch stand shall be ABC Tri-Glide 22-E.
c. Target shall be low mast fastened sturdy and highly reflective with green and red colors.
d. Headblock ties shall be sixteen and a half (16.5) feet for switch stands located on outside of track and have a minimum clearance of eight and a half (8.5) feet from track centerline to switch stand.
e. Headblock ties shall be fourteen (14) feet for switch stands located between tracks and have a minimum clearance of six (6) feet from track centerline to switch stand.

For track embedded in pavement the following shall apply:

a. Switch stands shall be enclosed, parallel-throw in-pavement type such as Racor 336-EC flush with pavement.
b. Switch throw assemblies shall be supplied with all boxes and components for use in pavement. The lid shall open to a position that provides convenient access to the switch throw handle, and

that allows the open lid to rest in a position that it will not inadvertently slam shut while the train person is operating the switch throw lever.

c. Paved switch shall have a spring connecting rod.
d. Vertical switch rods shall be enclosed with steel box cover with ability to support H-25 loading (125.000 lb. Axle load) spread over five (5) square feet.
e. Steel box covers shall be flush with pavement and top of rail.

11.10 TURNOUT SUPPLEMENT FOR PAVED AREAS

a. All turnouts imbedded in pavement shall utilize special fabricated switch rod access boxes and fabricated switch point flangeway guards.
b. Pavements guards are required for switch points.
c. Switch points protectors shall be required and located on the inside running rail web area on the right side for a right hand turnout or the left side for a left hand turnout.
d. Turnouts in paved areas shall be welded with thirty six (36) inch six (6) hole joint bar for jointed areas.
e. Paved switches shall have a spring connecting rod.
f. Guard rails shall be flush with the running rail.
g. Switch and connecting rod boxes shall be flush with the pavement with ability to support H-25 loading (125,000 lb. Axle load) spread owner five (5) square feet

11.11 RAIL ANCHORING

a. In conventional ballasted track construction, where timber ties and track spikes are used, rail anchors shall be applied. Details shall be in accordance with AREMA standard plans.
b. Rail joints shall be used where rail welding is not practical or where required by signal track circuits.
c. Thirty-six (36) inch long, six (6) hole joint bars shall be used at rail joints. Drilling, punching, and track bolts shall be as specified by AREMA standard plans.

11.12 INSULATED JOINTS

Where required by the track signal circuits, insulated rail joints shall be installed. These shall be prefabricated bonded joints and shall meet the following track requirements:

a. Insulated joints shall be six (6) hole Allegheny-type, epoxy bonded, field fabricated.
b. For installation in CWR (I-bonds) shall be six (6) hole Allegheny-type, epoxy-bonded, pre-fabricated from new rail twenty (20) feet long for field welding in place.
c. For installation in jointed rail I-bonds shall be six (6) whole bolted Allegheny-types for field installation.

The following shall apply for electrical continuity testing of bonded insulated joints:

a. Perform separate tests between the running rails, and between the bar and the running rails.
b. Individual tests of the electrical resistance between each of the running rails and the bar shall be greater than ten thousand (10,000) ohms.
c. The electrical resistance between the running rails shall be greater than thirty thousand (30,000) ohms.

11.13 INSULATED RESILIENT FASTENERS (IRF) FOR CONCRETE TIES

The following shall apply for IRF for concrete ties:

a. Insulated resilient fasteners with rail seat abrasion pads and iron shoulders shall be used on all

trackage with concrete ties.

b. Pandrol E-2055 clips, Safelok or an Engineer approved equal shall be used as clips to concrete ties. POLB prefers the use of Safelock clips.
c. Two (2) clips shall be used on each base plate
d. When IRF are used with wood ties, the plates and hold-down screws shall be of a type approved for use with IRF by the IRF manufacturer.

11.14 ANCHORS ON TIMBER TIES

The following shall apply for anchors on timber ties:

a. Anchors shall be sixteen (16) per each thirty-nine (39) feet of rail.
b. Box anchor every other tie on CWR.
c. All anchors shall be in accordance with AREMA standards.

11.15 TIE PLATES

The following shall apply for tie plates:

a. Tie plates for timber ties with resilient fasteners shall be seven and three-quarters (7.75) inch by sixteen (16) inch for six (6) inch base rail with screw spikes for plate hold-downs and be of a type approved for use with resilient fasteners by the resilient fastener manufacturer.
b. Hole punching shall be six (6) with four (4) to be one (1) inch holes and two-eleven sixteenth (11/16) inch holes.
c. Tie plates shall be fastened evenly on wood ties within one eighth (1/8) inch alignment.

11.16 JOINT BARS

The following shall apply to joint bars:

a. Bars shall be thirty-six (36) inch bars with six (6) holes utilizing six (6) inch long one and one eighth (1-1/8) inch diameter bolts with four (4) inch thread length. Joint bars are to match the rail section. Joint bars are to be insulated.
b. Hole punching spacing shall be : Two and seven sixteenths (2-7/16) inches; six (6) inches; six (6) inches; six (6) inches, seven and one eighth (7-1/8) inches; six (6) inches; six (6) inches; and two and seven sixteenths (2-7/16) inches in accordance with Chapter 4 of AREMA.
c. Joint bars shall be six (6) hole bars appropriate for the rail size in accordance with AREMA.

11.17 SPIKES

The following shall apply for screw spikes:

a. Screw spikes shall be used for all newly constructed track with timber ties and turnouts.
b. Screw spikes shall be six (6) inches long and be able to fit one (1) inch diameter pandrol plates.

The following shall apply to cut spikes:

a. Cut spikes can be used for shoofly track, temporary track construction and maintenance as necessary.
b. Rail spikes shall be five –eighths (5/8) inch x six (6) inch.
c. Each tie plate in a turnout or horizontal curve shall have two (2) plate holding spikes and two (2) rail holding spikes.
d. Tangent track shall have a minimum of two (2) spikes per tie plate.
e. Cut spikes shall not be used on curves over six (6) degrees. For curves over six (6) degrees, a resilient fastening system shall be used.

12.0 TEMPORARY TRACK CONSTRUCTION (SHOOFLY TRACK)

a. Temporary track construction may be required in order to stage some of the site construction work while maintaining rail service. This temporary track work may be accomplished with timber ties and relay rail. Relay rail shall be Class 1 in accordance with AREMA standards.
b. If timber ties are to be used, the tie spacing shall be nineteen and one half (19.5) inches, center to center. Jointed rail sticks shall not be less than thirty-three (33) feet in length.
c. Tolerances shall be the same as permanent track construction.
d. It is the responsibility of the Contractor to remove this temporary work at the appropriate time and to dispose/salvage all materials.

13.0 CONTINUOUSLY WELDED RAIL (CWR)

The Work specified in this section consists of providing rails, fabricating rails into continuous welded rail (CWR) strings using the electric flash butt welding method, inspecting, testing, shipping and delivering the CWR strings to the project work site.

13.1 RAIL

a. Rail shall be 136 CWR per AREMA.
b. Procedures, material testing and other submittals listed in AREMA standards and herein are to be made to the Engineer and approved prior to iniation of the specific activity.
c. All new rail shall be 136 RE lb meeting the requirements of Chapter 4, Part 2 "Specifications for Steel Rails" of AREMA and Supplementary Requirements S2 "Manual Ultrasonic Testing".
d. Prior to the start of welding, a CWR schedule shall be submitted listing the lengths of CWR strings to be fabricated and the location of each string in the finished track. Also included in the submittal shall be a schedule of CWR lengths and the CWR string designation system.
e. Prior to the start of welding submit drawings and specifications of the proposed equipment, materials, methods and procedures to be used for the electric flash butt welding process for joining of the rail. Include layouts of the welding line showing locations of welding components.
f. Prior to transportation of the rail, submit procedures for transportation of the CWR to work site, proposed off-load locations and timing, stockpiling and handling procedures.
g. Perform flash butt welding and testing of the rail to the requirements of Chapter 4, Part 2 "Specifications for Fabrication on Continuous Welded Rail".
h. The fabrication of the CWR shall be done offsite.
i. Weld CWR strings to minimum delivered lengths at work site of. At grade crossings, strings equal to the width of the crossing plus forty (40) feet twenty (20) feet on each side of crossing measured along the center line of track) will be permitted. A minimum of twenty (20) feet is required between the end of the crossing panel and the first weld.
j. Cut out and reweld rejected welds with a minimum of nineteen (19) feet - 6 inch plugs. This work shall be at the Contractor's expense.
k. Bolt holes are not permitted except for insulated joints.

13.2 RAIL CUTTING AND PREPARATION OF ENDS

a. Saw cut or abrasive disc-cut rails used for electric flash butt welds square and clean by means of accepted equipment.
b. Torch cutting of rail is prohibited.
c. Prepare the head and base of rails prior to welding by removing mill scale down to bright metal for a length of approximately six (6) inches from the welding end.

d. Remove all burrs from the rail end area where the welding current carrying electrodes contact the head and base of the rail.
e. Holes are not permitted in the rail.
f. Torch cut rails at the end of CWR strings must be saw cut a minimum of six (6) inches from the torch cut end or three (3) feet from a shop weld prior to welding.

13.3 RAIL DESTRESSING PROCEDURE (BY MECHANICAL PULLING)

Rail Destressing shall be in accordance with AREMA and the following:

a. Upon track construction at the proposed alignment, place joint bars between each four hundred eighty (480) foot length of ribbon rail.
b. Place ballast material in and around track tie cribs and surface track to its alignment and grade.
c. Weld rail lengths to nine hundred sixty (960) feet each.
d. Calculate the elongation required to bring the rail into equilibrium using the thermal expansion equation:

$$\Delta L = a(T)L = (TD - TA)L$$

Coefficient of thermal expansion = 6.5x0.000001/F°
TD = design temperature (F°)
TA = actual temperature (F°)
L = rail length (ft.)

e. Unclip the rail on each side of the joint. The amount of rail to unclip is based on the amount of elongation required. For each inch of rail to pull a minimum of one hundred (100) feet of track shall be unclipped on each side of the joint.
f. The rail to be cut shall be equivalent to the calculated rail equilibrium distance plus one (1) inch required for the welding procedure.
g. Rail pullers will be used to pull the rail to the desired distance.
h. The rail shall be welded and the pullers will be released once the rail is cooled less than six hundred (600) F°.
i. The clips shall be replaced and the welds ground flush.

13.4 WELDING

The following method procedures, equipment and materials shall be used for welding CWR.

a. Thermite welding, materials and equipment shall be as manufactured by "Boutet", "Orgotherm", "Elektro-Thermite", or other Engineer approved equal for standard rail.
b. Thermite welding, methods and procedures shall comply with the AREMA Manual, Chapter 4, "Thermite Welding-Rail Joints-1980," and with the welding kit manufacturer's recommendations and as specified herein.
c. Rail ends for thermite welding shall be prepared in accordance with the recommendations of the welding kit manufacturer.
d. For thermite welding, the rail ends shall be preheated prior to welding to a sufficient temperature and for sufficient time to ensure full fusion of the weld metal to the rail ends without cracking of the rail or weld.
e. The completed weld shall be finished by mechanically controlled grinding to conform to the same requirements specified for shop welding.
f. Welds shall not be made within six (6) inches of bolt holes, or pin holes, or within three (3) feet of plant weld.
g. Manufacturers recommendations shall be used for compromise welds.
h. For welding heat treated or high strength rails, the recommendations of the rail manufacturer

shall be followed.

i. Welds must be in cribs between ties and located no closer than four (4) inches to nearest tie.
j. Torch cut rails at the end of CWR strings must be saw cut a minimum of six (6) inches from the saw cut end or within three (3) feet of a factory weld prior to welding.

13.5 FIELD WELDING RECORDS

a. Field welding records shall be continuously maintained and furnished bi-weekly to the Engineer. Records shall include the following details:
   - Date and time of weld(s)
   - Location by station, stating track and rail
   - Contractor's foreman
   - Weather, air and rail temperature
   - Track condition, anchorage and rail stress

b. Rail shall be painted in legible characters at least one and one half (1-1/2) inches high at each field weld with the following information:
   - Date of Weld (MO/DAY/YR)
   - Initials of welder performing weld
   - Air temperature at time of weld (AT XXX)
   - Rail temperature at time of weld (RT XXX)

Example: 5/5/93 ABC AT90 RT120

13.6 TOLERANCES OF FIELD WELDS

a. Using a straight edge thirty six (36) inches in length, and placing the straight against the welded joint area the following tolerances must not be exceeded:

Rail Head:

- Vertical Offset 0.020 inches
- Horizontal Offset 0.040 inches
- Vertical Crown 0.030 - 0.045 inches
- Horizontal Kink 0.020 inches

Rail Base

- Horizontal Offset 0.060 inches
- Offset Bending 0.010 per inch

13.7 FINISHING OF FIELD WELDS

The following shall apply to the finishing of welds:

a. Sharp edges and burrs are to be removed, including chimneys from all welds. All welds shall be ground smooth.
b. Weld joints shall be smooth on top and sides and straight in line. No over grinding is permitted.
c. Weld joints shall be smooth on sides and bottom. Offset blending permitted at rate of one hundredth (0.010) per inch.
d. Weld joints shall be smooth on both sides to within approximately one eighth (1/8) inch of original contour. Width of remaining upset will be between one half (½) inch and five eighths (5/8) inch.

13.8 FIELD WELD TESTING

The following shall apply to the field testing of welds:

a. Rail welds shall be tested through the use of a testing agency using the Ultrasonic Testing Method in accordance with ASTM E 164.
b. Each completed weld shall have full penetration and complete fusion and be entirely free of cracks. Total area of internal defects such as porosity and slag inclusions shall not exceed six hundredths (0.060) square inch and the largest single porosity or slag defect permitted shall not exceed one eighth (1/8) inch in diameter.
c. Other causes for rejection of welds shall be:
    - Cracks that show in the finished weld are cause to reject the weld.
    - Pit holes that show in the web and base of the weld after finish grinding are cause to reject the weld. Pit holes in head not exceeding one quarter (1/4) inch in depth may be repaired by gas welding or as approved by the Engineer.
    - Welded joints not meeting these technical provisions and tolerances will replaced at no additional cost. The defective weld shall be cut out, and a new section of rail not less than thirteen (13) feet long shall be inserted welded and retested at no additional cost.

13.9 CUTTING IN SHORT SECTION RAIL AND THERMITE WELDING THE ENDS

The following procedure shall be used in cutting in short section rail and the thermite welding of rail ends.

a. A short section of rail shall be cut in the CWR, as approved by the Engineer, for the following reasons:
    - To repair defective rail
    - To repair defective welds
b. Before cutting out rail in CWR, prevent remaining CWR from further movement by applying anchors. After cutting CWR, rail expander/puller or other means shall be used to prevent rail movement.
c. The ends of the short rail section and the CWR shall be sawed or abrasive cut.
d. Follow procedures specified for completing field welding by the thermite process.
e. Repair of rail due to damage by the Contractor shall be at Contractor's expense.
f. When repairing defective rail or welds, new rail shall be the same length as rail being replaced, or as required to achieve thermal adjustment.
g. If secondhand rail was originally installed, replacement is to be in kind.

13.10 TOLERANCES IN ELECTRIC FLASH BUTT WELDS

Tolerance in electric flash butt welds shall be in accordance with tolerances set forth in the AREMA Manual, Chapter 4, Part 2, Section "Specifications for Fabrication of Continuous Welded Rail - 1983."

13.11 ULTRASONIC TESTING OF PRODUCTION WELDS

The following shall apply for the Ultasonic Testing of Production Welds:

a. Test all welds ultrasonically at the welding plant for defects in accordance with ASTM E164 using an inspection team approved by POLB. The cost for testing is to be borne by the Vendor.
b. The POLB will perform weld testing on field welds through the use of an inspection agency conducting ultrasonic testing.

13.12 REPLACEMENT OF DEFECTIVE WELDS

Defective flash both production welds giving fault indications in Magnetic Particle or Ultrasonic Inspection during production shall be cut-out, rewelded and retested. These repairs shall be done in the

shop and not left for field repair.

14.0 **CONCRETE TIES** All track construction shall utilize concrete ties for regular track and timber ties for turnouts. The following criteria shall apply for concrete ties:

a. Concrete ties shall be spaced at a maximum of twenty four (24) inches and not less than twenty (20) inches, center to center. On curves of radius less than three hundred (300) feet concrete ties shall be used and spaced a maximum of twenty (20) inches and not less than eighteen inches (18), center to center.
b. For road crossings the tie spacing shall be in accordance with manufacturers' specifications for paving material, for both timber and concrete ties.
c. Concrete ties shall be of the type referred to as the "Union Pacific Scallop Style" with dimensions as follows:
    - Length: Eight (8) foot six (6) inches +/- one eighth (1/8) inch.
    - Height, at rail seat: Eight and three quarters (8 ¾) inches +/- three sixteenths (3/16) inches
    - Base width: Ten and one half (10-1/2) inches +/- one eighth (1/8) inch.
    - The rail seat shall provide for a cant of one (1) in forty (40) toward the centerline of the tie.
    - Weight: Maximum weight shall be seven hundred fifty (750) pounds.
    - Height, at center of tie: Six and one quarter (6-1/4) inches, +/- three sixteenths 3/16 inches.
    - Rail pad: Pandrol three (3) part assembly with six point five (6.5) mid polyurethane pad in double dimple studded configuration including a nine tenths (0.9) mm steel plate.
    - All concrete ties must be imprinted with the letters POLB on top of the tie.
d. Standard concrete ties shall be designed to the following bending moment capacities:
    - Rail positive seat bending: 300 in-kips
    - Center negative bending –200- in-kips
e. Concrete grade crossing ties shall be ten (10) foot long, flat top, prestressed, in accordance with AREMA standards.
f. Maximum weight for grade crossing ties shall be nine hundred (900) lbs.
g. Guard rail ties shall be eight (8) foot six (6) inches long
h. Concrete Tie Materials: Wire shall conform to ASTM A881. Strand shall conform to ASTM A886. Cement shall comply with ASTM C150 type III. Aggregate shall be non-reactive. Ductile castings shall comply with ASTM A53665-45-12. Concrete admixtures shall comply with ASTM C494 (no fly ash or silica fume may be used)
i. Concrete Material Qualification Testing: Aggregates shall be tested to ASTM C227 and C1260 prior to use. Cement shall be tested to ASTM C112 and C150. Total alkali level of cement shall not exceed four tenths (0.4) percent
j. Concrete Tie Qualification testing:" Six (6) ties shall be taken at random from the first (3) three casts and tested for RS+, RS-, C+, C-, and Bond development. Ties shall be tested for dimensional compliance. Two (2) ties shall be jointly picked by the supplier and the Port's representative to show acceptable surface finish, air voids, and spalling/breakage.
k. Concrete tie Production testing: Concrete ties shall be tested for compressive strength using four (4) x eight (8) or six (6) x twelve (12) cylinders. A minimum of two (2) concrete cylinders shall achieve forty five hundred (4500) psi prior to detensioning.. Concrete twenty eight (28) day compressive strength shall exceed seven thousand (7000) psi (average of three (3) cylinders) with no individual cylinder less than six thousand five hundred (6500) psi. For each

production day, at least one (1) tie shall be tested for dimensional conformance, RS+, and C-bending. All ties produced shall be inspected visually for defects and certified.

l. Concrete tie shall be prestressed, mono-block type.
m. Concrete tie fasteners shall be Safelok Clip 36800. Other components shall include Insulators (type 38249), Rail pads (type 38280) and Assembly (type 36192-A1). For curves over two (2) degrees shall include insulators type 36180. For curves over four (4) degrees include Rail, Pad Assembly type 38319.
n. Protrusion of Pretensioning Tendons - One eighth (1/8) inch maximum beyond the ends of the ties.
o. Markings - Mark on top of the ties with indented or raised letters to indicate the manufacturer, type of tie and year of manufacture and POLB.

15.0 TIMBER TIES

a. Timber ties shall have dimensions as follows:
    - Length: Nine (9) feet
    - Height: Seven (7) inches
    - Width: Nine (9) inches
b. Timber ties shall be in accordance with Chapter 3 of AREMA.
c. Timber tie spacing shall be a maximum of nineteen and one half (19.5) inches and a minimum of eighteen (18) inches, center to center.
d. All wood ties shall have steel end plates.
e. Timber tie fasteners shall be Pandrol E-2055 clips.
f. Timber tie wood treatment shall be in accordance with AREMA.
g. Switch ties shall have the dimensions for height and width as previously stated, but the length shall vary as required.

16.0 SPECIAL TRACKWORK MATERIALS

16.1 GENERAL

This section specifies the material requirements for complete special trackwork materials including, turnouts and crossovers with ties, derails, bolts, lock washers, bumping posts and wheel stops to be furnished in accordance with Plans and these technical provisions.

16.2 TURNOUTS AND CROSSOVERS

a. Turnouts and crossovers shall have switch points with uniform risers.
b. There shall be no "Laced Ties", use appropriate "Long Ties".
c. Electric switches shall be of Model M23A as manufactured by Union Switch, or approved equal.
d. Manual switches shall be of Model T-20 as manufactured by Union Switch, or approved equal.
e. Electric Locks shall be of Model SL-21 or SL-25 as manufactured by Union Switch, or approved equal.
f. Pandrol Type "E" fasteners or an Engineer approved equal, shall be used on all timber turnout ties.
g. Switch ties shall be timber,with Pandrol Type "E" Fasteners or Engineer approved equivalent.

17.0 DERAILS

a. The Engineer shall provide a positive method to protect individuals working on rail equipment located on other than mainline track. Consideration shall be given to locations of derails,

grades, on tracks and other derail installation requirements.

b. Derail type shall be Western-Cullen-Hayes model HBX double end sliding derail, size Nos. 8, with standard two (2) tie operated stand with connecting rods and reflectorized low target.

18.0 BUMPING POSTS

a. Bolt material and coatings shall be per AREMA Class B specification for rail fastening size.
b. All bolts shall be new.

19.0 WHEEL STOPS

Wheel stops shall be site specific. Wheel stops shall be Western Cullen Hayes type SH, hinged wheel stop.

20.0 CONCRETE GRADE CROSSINGS

20.1 GENERAL

No field welds shall be allowed through crossings or within twenty (20) feet of the end of the crossing.

20.2 MODULE CROSSINGS

Concrete grade crossing on POLB main roadways four (4) lanes or more with heavy truck traffic and loading shall be as follows:

a. Grade crossing shall be eleven (11) feet wide by five (5) feet long Star Track II HD module or eight (8) feet wide by five (5) feet long Star Track II module with grout holes or ten (10) feet wide by eight (8) feet long CXT PTS Prestressed Track Slab System or Engineer approved equal.
b. Module shall sit on twelve (12) inches of CAB on twenty-four (24) inches of granular fill compacted to ninety five (95) percent, Geogrid to be placed between layers. Geotextile to be placed below the granular fill.
c. The roadway approaches to the grade crossing systems shall include a ten (10) feet wide concrete reinforced approach slab. The track approaches shall include an eight (8) to one (1) approach.

Concrete grade crossing on POLB secondary roadway with minor truck traffic shall be as follows:

a. Grade crossings shall be Railroad Common Standard Type 10W manufactured by OMNI or CXT full depth concrete crossing panel or engineer approved equal. The crossing panels shall be prestressed, full depth with steel frame and pre-attached flangeway filler with precast end restraints.
b. Grade crossing panels shall sit flush evenly to one another with zero gap for tangent track. For curved track over four (4) degrees, the gap between panels shall not exceed one-quarter (1/4) inch maximum gap between panels.
c. Concrete panels to sit on ten (10) foot long wood ties, on eighteen (18) inch track centers with lag bolts.
d. The roadway approaches to the grade crossing system shall include a ten (10) feet wide concrete reinforced approach slab. The track approach shall include an eight (8) to one (1) approach.
e. Geotextile filter fabric shall be placed under all grade crossings between the subballast and the ballast.
f. Tamping of ballast shall not be performed until a minimum of eight (8) inches of ballast is below the base of cross ties and then precaution shall be taken in setting the tamping feet to

prevent driving the ballast through the geotextile. Probes of any type, including alignment probes, will not be used where geotextile is installed.

g. Construction of track through a grade crossing shall be completed to finish line and grade, surfaced, and ballast compacted and dressed before grade crossing panels are installed.
h. Concrete grade crossing panels shall be installed in accordance with manufacturer's instructions.
i. Grade subgrade to drain away from ballast section at completion of crossing work.
j. Flange way filler shall be as recommended by manufacturer. Asphalt paving filler shall be AR 8000 class B mix per SSPWC.
k. Wearing surface shall be diamond mark "POLB".
l. Each crossing shall have a four (4) feet minimum reinforced concrete approach. The concrete shall be type II Portland concrete cement 520-C-3250 minimum strength with four (4) inch slump per Section 201, "Concrete Mortar and Related Materials" and 203, "Bituminous Materials" of the SSPWC.
m. The manufacturers warranty for the grade crossing shall be for a minimum of five (5) years.

24.0 RAILROAD CROSSING SIGNAL SYSTEM

The following shall apply to railroad crossing systems used within the POLB system:

a. The design shall be in accordance with both FRA and PUC regulations.
b. Signal system bungalow shall be six (6) feet by six (6) feet aluminum with outside lights. The bungalow shall state "The Port of Long Beach","Pier #", and Milepost, CPUC #, and a PHL emergency phone number. The area outside the bungalow shall be paved.
c. Two (2) sets of backup batteries and rectifiers. The batteries shall be rated at four hundred (400) amp hours and the rectifier being twelve (12) volt forty (40) amps.

25.0 RAILROAD SAFETY WARNING SYSTEM

All railyard facilities shall have a positive method to warn employees of train movement, which shall include audio and visual signals in keeping with the Pacific Coast Marine Safety Code.

26.0 REQUIREMENTS WHEN WORKING WITHIN, ADJACENT OR ABOVE RAILROAD TRACKS

The following shall apply when working in the vicinity of railroad tracks:

a. The Contractor shall not enter any location, perform any work, or locate any piece of equipment within ten (10) feet of the nearest rail of any railroad track without prior authorization from the Engineer. All work shall be performed in accordance with the provisions of Title 49, Part 214 of the Code of Federal Regulations.
b. The Contractor shall submit a written Work Plan to the Engineer not less than ten (10) days prior to beginning work. The Work Plan shall include the location, starting and stopping times, a description of the work to be performed, the work crews involved, and the Contractor's recommendations regarding track outages and railroad safety protection (Flagmen). No work may be performed, nor any piece of equipment moved within ten (10) feet of the nearest rail of any railroad track until the Work Plan in approved by the Engineer. Flagmen, if required, will be provided by the City at no cost to the Contractor for days which the City deems necessary for the project. If the number of flagging days are exceeded due to the Contractor's actions the Contractor shall pay for the flagging services beyond the days paid by the Port. The flagging charges paid by the Contractor will be withheld from payment due. The flagging charges are five hundred fifty ($550) day for Pacific Harbor Line flagging services. The Contractor may

cancel scheduled Flagmen with written notice to the Engineer at least forty-eight (48) hours prior to the start of the work. However, if the Contractor fails to provide such notice of cancellation within the required time, any cost to the City for scheduled Flagmen will be withheld from payment due to the Contractor.

c. The Contractor shall provide qualified Watchmen when working within twenty (20) feet of the track centerline for the safety and protection of the Contractor's personnel and equipment during construction operations. Watchmen shall be properly trained and equipped in accordance with Title 49, Part 214 of the Code of Federal Regulations. The cost of Watchmen shall be included within the cost of related bid items for such work. The Pacific Harbor Line (PHL) will qualify the Watchmen for the project. The Contractor shall submit an approved list of PHL trained watchmen to the Engineer prior to working within twenty (20) feet of the track centerline.
d. Crossing of tracks by the Contractor's equipment other than at public or private road crossings is prohibited without specific authorization by the Engineer.
e. The Contractor shall report any accidents, injuries, track defects, or any unusual track conditions which may affect the safe and efficient operation of the railroad to the Engineer by the first available means of communication.
f. The Contractor shall be responsible for the prevention of damage to railroad facilities, equipment and operating trains due to his activities. In the event the Contractor damages railroad facilities or equipment, he shall immediately report the damage to the Engineer. Repair of damage caused by Contractor's operations shall be at the expense of the Contractor and accomplished to the satisfaction of the Engineer.
g. The Contractor shall be responsible for compliance with the requirements of the Roadway Worker Protection Act (the Act) issued by the FRA.

The Port of LONG BEACH / **The Port of Los Angeles**

Insurance Requirements for Joint Revocable Permit/Joint Temporary Entry & Use License

Requestor: C. Tsai

Name of Licensee/Permitee: Cal Trans

Division: Engineering

Division Reference Number: TBD

Description of Operations/Project: Heim Bridge Replacement

Based upon the information provided, the following types/limits of insurance are required of the entity listed above. Please refer to the applicable permit/license document for complete insurance wording requirements.

☒ **General Liability Insurance** with minimum limits of $10,000,000 and if written with an aggregate, the aggregate shall be double the per occurrence limit.

- ☒ ISO Form CG 0001 or CG 0002
- ☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured
- ☒ Include Products/Completed Operations
- ☒ Include Contractual Liability – Railroads
- ☒ Include Explosion, Collapse, Underground Hazards (XCU)

☒ **Automobile Liability Insurance** with minimum limits of $5,000,000 per accident

- ☒ ISO Form CA 0001
- ☒ Symbol 1 ☐ Symbol 2 ☐ Symbol 8 ☐ Symbol 9
- ☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☒ **Workers' Compensation Insurance (Statutory)**

- ☒ $1,000,000 Employer's Liability Insurance
- ☒ Statutory U.S.L. & H. Insurance ☒ Statutory Jones Act Insurance
- ☐ Statutory FELA Insurance
- ☒ Waiver of Subrogation in favor of the Port of Long Beach and the Port of Los Angeles (required for all coverage checked)

The Port of LONG BEACH / **The Port of Los Angeles**

Insurance Requirements for Joint Revocable Permit/Joint Temporary Entry & Use License

☒ **Watercraft Liability Insurance** including Protection & Indemnity and Water Pollution Liability with minimum limits of $5,000,000 per loss and $10,000,000 total all losses.

☒ Bodily Injury ☒ Death ☒ Mental Anguish
☒ Cleanup Costs ☒ Property Damage ☒ Defense Costs

☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Environmental Impairment Liability Insurance** with minimum limits of _____per loss and _____ total all losses.

☐ On-site Coverage ☐ Off-site Coverage ☐ Bodily Injury
☐ Death ☐ Mental Anguish ☐ Property Damage
☐ Defense Costs ☐ Clean-up Costs ☐ Sudden & Accidental

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☒ **Contractor's Pollution Liability Insurance** covering all of the contractor's operations minimum limits of $5,000,000 per loss and $10,000,000 total all losses.

☒ On-site coverage ☒ Off-site Coverage ☒ Bodily Injury
☒ Death ☒ Mental Anguish ☒ Property Damage
☒ Defense costs ☒ Clean-up Costs

☒ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Professional Liability Insurance** with minimum limits of _____.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Producers Professional Liability Insurance** with minimum limits of _____.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Aircraft Liability Insurance** with minimum limits of _____ per occurrence.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

The Port of LONG BEACH / **The Port of Los Angeles**

Insurance Requirements for Joint Revocable Permit/Joint Temporary Entry & Use License

☐ **Garagekeepers Liability Insurance** with minimum limits of _____ per loss.

☐ Endorsement naming the Port of Long Beach & the Port of Los Angeles as Additional Insured

☐ **Property Insurance** with no coinsurance clause.

☐ All Risk ☐ Full Replacement Cost

☐ **Builder's Risk Insurance** for property constructed on behalf of the City, maintained until full acceptance of the work.

☐ All Risk ☐ 100% of completed Contract costs
☐ Loss Payee (POLB) ☐ Collapse (including resulting from design error)

☒ **30-day notice of cancellation to both Ports for all insurance policies (10 days for non-payment of premium).**

☒ **Miscellaneous**: Insurance required to be provided by general contractor selected by Cal Trans to replace Heim Bridge.

Port of Long Beach Risk Management Division Contact Information

Name R. Baratta Phone # 562-901-1775 Date 8/6/10

Signature: _____

Port of Los Angeles Risk Management Division Contact Information

Name K. Merkovsky Phone # 310-732-3971 Date _____

Signature: _____