This is to be used for all "INFORMATION HANDOUT" cover sheets. Edit as appropriate.

FOR CONTRACT NO.: 03-1A432**4**

INFORMATION HANDOUT

WATER QUALITY

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

PERMIT NO. WDID#5A51CR00047

PERMITS

STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME

NOTIFICATION NO. 1600-2009-0016-R2

UNITED STATES ARMY CORPS OF ENGINEERS

AGREEMENTS

NATIONAL MARINE FISHERIES SERVICES
(Biological and Conference Opinion)

NATIONAL MARINE FISHERIES SERVICES Enclosure 2
(Biological and Conference Opinion)

ENCROACHMENT PERMITS

CENTRAL VALLEY FLOOD PROTECTION BOARD ENCROACHMENT PERMIT

PERMIT NO. 18469 BD

MATERIALS INFORMATION

FOUNDATION REPORT
(New Feather River Bridge, Br. No. 18-0026R)

AMENDED FOUNDATION REPORT
(New Feather River Bridge, Br. No. 18-0026R)

FOUNDATION REPORT
(New Garden Highway UC, Br. No. 18-0025R)

FINAL SEISMIC DESIGN RECOMMENDATIONS, AND SOIL SPRINGS
(Feather River Bridge, Br. No. 18-0026R)

FINAL SEISMIC DESIGN RECOMMENDATIONS
(Garden Highway UC, Br. No. 18-0025R)

GEOTECHNICAL DESIGN REPORT

REVISED FINAL HYDRAULICS REPORT FOR FEATHER RIVER
(Br. No. 18-0026R, Dated 7/29/2008)

STRUCTURES REVISED FINAL HYDRAULIC REPORT FOR FEATHER RIVER
(Br. No. 18-0026R, Dated 6/4/2009)

DRIVEABILITY STUDY
(Feather River Bridge, Br. No. 18-0026R)

DRIVEABILITY STUDY FOR THE ANCHOR PILES AT PIER 12
(Feather River Bridge, Br. No. 18-0026R)

ROUTE: 03-SUT-99-10.9/14.7

State of California – The Resources Agency
DEPARTMENT OF FISH AND GAME
North Central Region
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670
(916) 358-2900

ARNOLD SCHWARZENEGGER, Governor

"NOTICE OF DETERMINATION"

The Department will file a Notice of Determination for your project. The Notice will be filed with the Office of Planning and Research, as required by CEQA. The Department's compliance with CEQA may be legally challenged for 35 days following the filing of the Notice of Determination.

This completes the Department's agreement process. You may proceed with your project according to the terms and provisions of your Streambed Alteration Agreement if you have obtained all other permits required from local, other State, and Federal agencies.

(12/01/03)

AGREEMENT REGARDING PROPOSED STREAM ALTERATION

THIS AGREEMENT, entered into between the State of California, Department of Fish and Game, hereinafter called DFG, and California Department of Transportation of Marysville, State of California, hereafter called Caltrans, is as follows:

WHEREAS, pursuant to California Fish and Game Code, Section 1602, Caltrans, on January 26, 2009, notified DFG that it intends to substantially divert or obstruct the natural flow of, or substantially change the bed, channel, or bank of, or use material from the streambed of, the following water: Feather River - Nelson Slough, in the County of Sutter, State of California, Section (nosections), Township 12N, Range 3E, USGS Map Nicolaus MDB&M.

WHEREAS, DFG, represented by Gary Hobgood, has determined that such operations may substantially adversely affect existing fish and wildlife resources including: giant garter snake (*Thamnophis couchi gigas*); Swainson's hawk (*Buteo swainsoni*); Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*); Central Valley spring-run Chinook salmon (*O. tshawytscha*); fall-/late fall-run Chinook salmon (*O. tshawytscha*); Central Valley steelhead (*O. mykiss*); green sturgeon (*Acipenser medirostris*), warm water fish species, amphibians, and other aquatic and terrestrial plant and wildlife species.

Project Description: State Route 99 Safety and Operational Improvement Project Segment 2 – Feather River Bridge Project.

Beginning the fall of 2009, Caltrans will begin construction of a new Feather River Bridge. The new bridge will be parallel to the existing bridge and will extend from levee to levee like the existing bridge. The new bridge will consist of 16 piers and 2 abutments. Each pier is made up of two seven and one-half foot diameter cast in steel shell piles (CISS piles). The piles will be driven with a large hammer like a D-100. The dirt will be removed from within the shell and the shell will then be filled with a steel structure and concrete. In addition to the piles for the bridge, the contractor will also be driving smaller piles (20"-24" or "H" piles) for the trestle and an additional four piles (approx 24") to support the temporary falsework. There will be 2 temporary bents in between each pier to support the bridge deck during construction.

Within the live channel of the Feather River there will be four piers (2 CISS piles each for a total of 8 CISS piles). The trestle is expected to require 52 (20"-24" or "H" piles) in order to span the Feather River. The temporary bents will result in an additional 72 (20"-24" piles) driven within the channel. All trestle and bent piles will be removed following construction.

Caltrans is proposing to drive the piles and build the bridge deck (outside of the active Feather River channel, piers 9-15) during the winter months (October 15 thru May 1). This area is technically floodplain because it is within the levees. The area was inundated during the 1997 flood event. During a typical year, this area is not inundated, as the Feather River does not exceed it's banks. Caltrans is proposing to have the contractor put together a "Flood Evacuation Plan". This plan would have to be approved by DFG and other interested parties (i.e. RWQCB) prior to any work outside of the standard window. This plan would have to be approved by Caltrans on an annual basis. The flood evacuation plan would detail who needs to be contacted (including but not limited DWR, DFG, RWQCB) when that needs to occur, what equipment and materials are expected to be in the floodplain and how the contractor will remove that equipment and material with short notice (24 hr.).

Stream Zone Defined: The stream zone is that portion of the stream channel that restricts lateral movement of water. For this project, the stream zone is delineated as the area on the water side of the water side hinge-point of the levee.

1. The notification, together with all supporting documents submitted with the notification, including the **Project Plans for Construction on State Highway in Sutter County near Nicolaus from Power Line Road from Power Line Road to 0.1 mile south of Laurel Avenue** dated December 19, 2008, **Feather River Bridge Project - Evaluation of Underwater Noise from Pile Driving Activities DRAFT** dated January 27, 2009, **State Route 99 Safety and Operational Improvement Project - Final Environmental Impact Report/Environmental Assessment And Section 4(F) Evaluation - State Route 99 in Sutter County, California** dated November 2003, **Biological Assessment - State Route 99 Safety and Operational Improvement Project** dated February 4, 2009 (including the **revision of Chapter 9 of the Biological Assessment - State Route 99 Safety and Operational Improvement Project** dated March 24, 2009), and the **Caltrans Revegetation - State Route 99 Safety and Operational Improvement Project** dated March 18, 2009 are hereby incorporated into this agreement to describe the location and features of the proposed project. Caltrans agrees that all work shall be done as described in the notification and supporting documents, incorporating all project modifications, wildlife resource protection features, mitigation measures, and provisions as described in this agreement. Where apparent conflicts exist between the notification and the provisions listed in this agreement, Caltrans shall comply with the provisions listed in this agreement. Caltrans further agrees to notify DFG of any modifications made to the project plans submitted to DFG. At the discretion of DFG, this agreement will be amended to accommodate modifications to the project plans submitted to DFG and/or new project activities. Please see the current fee schedule to determine the appropriate amendment fee.

2. Documents, plans, surveys, notifications, and requests pertaining to this project or required by this agreement may be sent via email to Gary Hobgood at ghobgood@dfg.ca.gov or delivered to DFG of Fish and Game at 1701 Nimbus Road, Suite A, Rancho Cordova, CA 95670. **Refer to Notification Number 1600-2009-0016-R2 when submitting documents to DFG.**

3. Unless otherwise specified in this agreement, the time period for completing the work within the stream zone of the Feather River & Nelson Slough shall be restricted to dry weather and shall be confined to the period of May 1 to October 1. Work periods for pile driving and tree removal are listed below. Construction activities shall be timed with awareness of precipitation forecasts and likely increases in stream flow. Construction activities within the stream zone shall cease until all reasonable erosion control measures, inside and outside of the stream zone, have been implemented prior to all storm events. Revegetation, restoration and erosion control work is not confined to this time period.

4. If Caltrans finds more time is needed to complete the authorized activity, Caltrans shall submit a written request for a work period time extension to DFG. The work period extension request shall provide the following information: 1) Describe the extent of work already completed; 2) Provide specific detail of the activities that remain to be completed within the stream zone; and 3) Detail the actual time required to complete each of the remaining activities within the stream zone. The work period extension request should consider the effects of increased stream conditions, rain delays, increased erosion control measures, limited access due to saturated soil conditions, and limited growth of erosion control grasses due to cool weather. Photographs of the work completed and the proposed work areas are helpful in assisting DFG

in its evaluation. Time extensions are issued at the discretion of DFG. DFG will review the written request to work beyond the established work period. DFG will have ten calendar days to approve the proposed work period extension. DFG reserves the right to require additional measures designed to protect natural resources.

5. Caltrans is responsible for obtaining all required permits and authorizations from local, state and federal agencies, include Incidental Take Permits and Consistency Determinations. Caltrans shall notify DFG where conflicts exist between the provisions of this agreement and those imposed by other regulatory agencies. Unless otherwise notified, Caltrans shall comply with the provision that offers the greatest protection to water quality, species of special concern and/or critical habitat.

6. The contractor shall sign Applicant's copy of this agreement prior to working within the stream zone. A copy of this agreement and a copy of the original notification, including the project description, as submitted to DFG, must be available upon request at the work site. The contractor or a designated crew supervisor shall be on site the entire time a work crew is working near the stream zone. The supervisor shall be completely familiar with the terms and conditions of this agreement and shall ensure compliance with all terms and conditions. DFG reserves the right to inspect the project site to ensure that there is compliance with the terms/conditions of this Agreement.

7. For each construction season, Caltrans shall notify DFG within two working days of beginning work within the stream zone of the Feather River and Nelson Slough. At the closes of each construction season, Caltrans shall provide DFG a summary to the work completed during the construction season that just ended and a summary of the work planned for the subsequent construction season. Upon completion of the project activities described in this agreement, the work area within the stream zone shall be digitally photographed. Photographs shall be submitted to DFG within two days of completion. Photographs and project commencement notification shall be submitted as instructed in item number 2 above.

8. Pile Driving Conditions:

   A. Prior to the start of construction, the contractor shall prepare a bridge construction plan. The plan would include a schedule of work and a methodology of implementation of all avoidance and minimization measures. The plan will also outline a Contingency Plan (Plan B) which is a work stoppage plan if the acoustical monitoring results demonstrate an exeedance of the 206 dB_{peak} for pile driving of piers 3,4,5,6,7 & 8. The primary measure of Plan B will be to identify primary contacts at DFG and NOAA fisheries and to determine a course of action to continue pile driving and minimize take of listed fish species. The bridge construction plan must be approved by the Caltrans RE, DFG and NOAA fisheries. The bridge construction plan shall be submitted as instructed in item number 2 above.

   B. Pile driving for the 7.5' diameter CISS piles that make up piers 3,4,5,6,7 & 8 will be limited to July 15 thru October 1.

   C. Caltrans will have in-water acoustical monitoring in place during the pile driving of the CISS piles that make up piers 3,4,5,6,7 & 8. If the construction activity results in an exceedance of the 206 dB_{peak}, the monitor will notify the RE and the contractor will stop driving piles at those piers and implement Plan B of the bridge construction plan.

D. An attenuation casing with a confined bubble curtain will be used for all in-water piles (piers 4,5,6 & 7).

E. An attenuation casing must be used for all in-water temporary (equal to or greater than 24" diameter) bent piles and trestle piles that are driven between June 15 and July 14. From July 15 to October 1 the temporary bent piles and trestle piles will not require an attenuation casing.

F. Pile driving will be limited to daylight hours to avoid crepuscular and nocturnal migration periods.

9. Other than work within the CISS piles, excavation within the flowing portion of the Feather River or Nelson Slough is not allowed without written authorization from DFG.

10. It is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird except as otherwise provided by the Fish and Game Code. No trees that contain active nests of birds shall be disturbed until all eggs have hatched and young birds have fledged without prior consultation and approval of a Department representative. It is recommended that the trees that are identified for removal, be removed during the non-nesting (between September 1 and February 15). If this is not possible and project construction is to begin during the nesting season (February 16 – August 30), all suitable nesting habitat within 500 ft of the limits of work shall be surveyed by a qualified biologist prior to initiating construction-related activities. Surveys will be conducted no more than 14 days prior to the start of work. If an active nest is discovered, a 300 foot buffer shall be established around the nest tree and delineated using orange construction fence or equivalent. The buffer shall be maintained in place until the end of the breeding season or until the young have fledged, as determined by a qualified biologist. In some instances, DFG may approve decreasing the specified buffers with implementation of other avoidance and minimization measures (e.g., having a qualified biologist on-site during construction activities during the nesting season to monitor nesting activity). If no nesting is discovered, construction can begin as planned. The survey results shall be provided to DFG prior to removing any trees. The survey shall be submitted to DFG as instructed in item number 2 above. Construction beginning during the non-nesting season and continuing into the nesting season shall not be subject to these measures.

11. Caltrans will minimize loss of riparian and other streamside vegetation through the use of Environmentally Sensitive Areas (ESA) which are demarcated on the plans and marked in the field with signs and/or fencing. Willows within 50 feet of the edge of the Feather River will be trimmed to ground level. Only those that are in the foot print of a bridge pile or temporary falsework pile will be removed.

12. Caltrans will prepare and have approved by NOAA fisheries and DFG a riparian restoration plan. This plan will include restoration of areas impacted by the proposed project, as well as areas that have been disturbed from previous activities or events. Areas restored from previous activities or events will be used as compensation for the permanent loss of riparian habitat due to the new bridge. The **Caltrans Revegetation - State Route 99 Safety and Operational Improvement Project** dated March 18, 2009 has been approved by DFG.

Modifications to the revegetation plan shall require review and approval from DFG.

13. Any riparian vegetation removal within 250 feet of the Feather River, that cannot be restored onsite, must be mitigated offsite at a ratio of 3:1. Caltrans is proposing the Beach Lake Mitigation bank for this compensation

14. Disturbance or removal of vegetation shall not exceed the minimum necessary to complete operations. Except for the trees specifically identified for removal in the notification, no native trees with a trunk diameter at breast height (DBH) in excess of four (4) inches shall be removed or damaged without prior consultation and approval of a Department representative. Using hand tools (clippers, chain saw, etc.), trees may be trimmed to the extent necessary to gain access to the work sites. All cleared material/vegetation shall be removed out of the riparian/stream zone.

15. Precautions to minimize turbidity/siltation shall be taken into account during project planning and implementation. This may require the placement of silt fencing, coir logs, coir rolls, straw bale dikes, or other siltation barriers so that silt and/or other deleterious materials are not allowed to pass to downstream reaches. Passage of sediment beyond the sediment barrier(s) is prohibited. If any sediment barrier fails to retain sediment, corrective measures shall be taken. The sediment barrier(s) shall be maintained in good operating condition throughout the construction period and the following rainy season. Maintenance includes, but is not limited to, removal of accumulated silt and/or replacement of damaged silt fencing, coir logs, coir rolls, and/or straw bale dikes. Caltrans is responsible for the removal of non-biodegradable silt barriers (such as plastic silt fencing) after the disturbed areas have been stabilized with erosion control vegetation (usually after the first growing season). Upon Department determination that turbidity/siltation levels resulting from project related activities constitute a threat to aquatic life, activities associated with the turbidity/siltation shall be halted until effective Department approved control devices are installed or abatement procedures are initiated.

16. During construction, all equipment refueling and maintenance shall occur more than 200 feet from the main channel, except for the pile driver(s) or other stationary equipment. Raw cement/concrete or washings thereof, asphalt, paint or other coating material, oil or other petroleum products, or any other substances which could be hazardous to aquatic life, resulting from project related activities, shall be prevented from contaminating the soil and/or entering the waters of the state. Any of these materials, placed within or where they may enter the stream by Caltrans or any party working under contract or with the permission of Caltrans, shall be removed immediately. DFG shall be notified immediately by Caltrans of any spills and shall be consulted regarding clean-up procedures.

17. During construction, the contractor shall not dump any litter or construction debris within the stream zone. All construction debris and associated materials shall be removed from the work site upon completion of this project.

18. This agreement is not valid and work may not begin until the agreement is signed by a representative of DFG of Fish & Game. Stream alteration work authorized by this agreement expires on December 31, 2013. This agreement shall remain in effect for that time necessary to satisfy all required mitigation and monitoring measures.

19. Requests for Extensions (agreement renewal), Minor Amendments, and Major Amendments must be submitted in writing prior to expiration of the agreement or commencement of work on modified project plans. Extensions and Amendments are issued at the discretion of DFG. Please see the current fee schedule to determine the appropriate fee.

20. DFG may take enforcement action and reserves the right to suspend and/or revoke this agreement if DFG determines that the circumstances warrant. The circumstances that could require these Department actions include, but are not limited to, the following: A) Failure to comply with the terms/conditions of this agreement. B) The information provided by Caltrans in support of the agreement/notification is determined by DFG to be incomplete, or inaccurate. C) When new information becomes available to DFG representative(s) that was not known when preparing the original terms/conditions of this agreement. D) The project as described in the notification, agreement, or amendment has changed, or conditions affecting fish and wildlife resources change.

21. If, in the opinion of DFG, conditions arise or change in such a manner as to be considered deleterious to aquatic life, operations shall cease until corrective measures are taken.

22. It is understood that DFG enters into this agreement for purposes of establishing protective features for fish and wildlife, in the event that a project is implemented. The decision to proceed with the project is the sole responsibility of Caltrans, and is not required by this agreement. It is agreed that all liability and/or incurred costs related to or arising out of Caltrans' project and the fish and wildlife protective conditions of this agreement, remain the sole responsibility of Caltrans. Caltrans agrees to hold harmless and defend the State of California and DFG of Fish and Game against any related claim made by any party or parties for personal injury or other damage.

SIGNATURE PAGE

Caltrans, as designated by the signature on this agreement, shall be responsible for the execution of all elements of this agreement. A copy of this agreement must be provided to contractor and subcontractors and must be in their possession at the work site.

Failure to comply with the provisions of this agreement and with other pertinent Code Sections, including but not limited to Fish and Game Code Sections 5650, 5652 and 5948, may result in prosecution.

Nothing in this agreement authorizes Caltrans to trespass on any land or property, nor does it relieve Caltrans of responsibility for compliance with applicable federal, state, or local laws or ordinances.

This agreement is not valid and work may not begin until the agreement is signed by a representative of DFG of Fish & Game.

Caltrans Representative: Darold Heikens
Please print and sign name

Date 4/02/09

Contractor: ______________________ Date ______________

Title: ______________________

Company: ______________________

Department Representative: ______________________ Date 4/2/09
Sandra Morey, Regional Manager

California Regional Water Quality Control Board
Central Valley Region
Karl E. Longley, ScD, P.E., Chair

Linda S. Adams
Secretary for Environmental Protection

11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

22 May 2009

Suzanne Melim
California Department of Transportation
PO Box 911
Marysville, CA 95901

CLEAN WATER ACT §401 TECHNICALLY CONDITIONED WATER QUALITY CERTIFICATION FOR DISCHARGE OF DREDGED AND/OR FILL MATERIALS FOR THE STATE ROUTE 99 SAFETY AND OPERATIONAL IMPROVEMENT PROJECT-SEGMENT 2 FEATHER RIVER BRIDGE, (WDID#5A51CR00047) SUTTER COUNTY

WATER QUALITY CERTIFICATION STANDARD CONDITIONS:

1. This certification action is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to §13330 of the California Water Code and §3867 of Title 23 of the California Code of Regulations (23 CCR).

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

3. The validity of any non-denial certification action shall be conditioned upon total payment of the full fee required under 23 CCR §3833, unless otherwise stated in writing by the certifying agency.

4. Certification is valid for the duration of the described project. Discharger shall notify the Central Valley Water Board in writing within 7 days of project completion.

ADDITIONAL TECHNICALLY CONDITIONED CERTIFICATION REQUIREMENTS:

In addition to the four standard conditions, the applicant shall satisfy the following:

1. Except for activities permitted by the U.S. Army Corps under §404 of the Clean Water Act, soil, silt, or other organic materials shall not be placed where such materials could pass into surface water or surface water drainage courses.

2. California Department of Transportation shall notify the Water Board in writing at least ten days prior to the start of any in-water construction or in-water construction related activities.

3. The discharge of petroleum products, hazardous materials, or other excavated materials to surface water is prohibited. Refueling of equipment within the floodplain or within 200 feet of a waterway is prohibited. Refueling areas shall be provided with secondary containment including drip pans and/or placement of absorbent material. No hazardous materials, pesticides, fuels, lubricants, oils, hydraulic fluids or other construction-related potentially hazardous substances should be stored within the floodplain or within 200 feet of a waterbody. California Department of Transportation needs to perform frequent inspections of construction equipment to insure leaks from the equipment are not occurring or are not a threat to water quality.

4. California Department of Transportation will schedule in-water work only during the low-flow period (June 15-October 15), which will reduce effects to listed fish species and water quality.

5. Wet concrete or grout shall not enter any surface water or surface water drainage course.

6. Activities shall not cause turbidity increases in surface water to exceed:

   a. where natural turbidity is between 0 and 5 Nephelometric Turbidity Units (NTUs), increases shall not exceed 1 NTU;
   b. where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20 percent;
   c. where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs;
   d. where natural turbidity is greater than 100 NTUs, increases shall not exceed 10 percent.

   Except that these limits will be eased during in-water working periods to allow a turbidity increase of 15 NTU over background turbidity as measured in surface waters 300 feet downstream from the working area. In determining compliance with the above limits, appropriate averaging periods may be applied provided that beneficial uses will be fully protected.

7. California Department of Transportation shall review and provide a copy of this 401 certification to their contractor and insure all construction staff are properly trained of the conditions of this 401 certification and take proper steps throughout the entire project to maintain and protect water quality. California Department of Transportation shall require their Contractor(s) to confirm, in writing, they have fully reviewed conditions this 401 certification and will submit any monitoring, required by this certification or the Central Valley Water Board.

8. Water shall not contain floating material in amounts that cause nuisance or adversely affect beneficial uses.

9. Waters in the work area or downstream shall not contain oils, greases, waxes, or other materials in concentrations that cause nuisance, result in a visible film or coating on the surface of water or on objects in the water, or otherwise adversely affect beneficial uses.

10. Activities shall not cause settleable matter to exceed 0.1 ml/l in surface waters as measured in surface waters 300 feet downstream from the project.

11. All areas disturbed by project activities shall be protected from washout or erosion.

12. Falsework shall not increase impacts to water or wetlands other than those identified in the application and approved by this permit.

13. California Department of Transportation shall notify the Water Board immediately if any criteria for turbidity, settleable matter, oil/grease, foam or construction-related fuels, lubricants, anti-freeze or similar vehicle-related substances are exceeded at any time throughout the project period.

14. California Department of Transportation shall notify the Water Board immediately of any spill of petroleum products or other organic or earthen materials.

15. From 15 October to 15 April, contractor will only have a minimal amount of equipment and construction material within the levees (only an amount that can be removed within 24-hours).

16. In the event that project activities result in the disturbance of bottom sediments, deposition of cement or soil materials, or discharge of other pollutants into surface waters, the following surveillance and monitoring shall be conducted immediately upstream and 300 feet downstream of the work site and the results reported to this office within two weeks of sampling:

Parameter	**Unit**	**Type of Sample**	**Frequency of Sample**
Turbidity	NTU	Grab	Every 4 hours during in water work
Settleable Material	ml/l	Grab	Same as above.
Visible Construction-related Pollutants		Visible Inspections	Continuous throughout construction period

17. California Department of Transportation shall comply with all Department of Fish and Game 1600 requirements for the project.

18. California Department of Transportation must obtain coverage under and comply with the NPDES General Permit for Storm Water Discharges Associated with Construction Activities issued by the State Water Resources Control Board.

19. California Department of Transportation must prepare and submit to the Water Board an approved flood emergency evacuation plan prior to the construction start date.

20. The Conditions in this water quality certification are based on the information in the attached "Project Information". If the information in the attached Project Information is modified or the project changes, this water quality certification is no longer valid until amended by the Regional Water Board.

21. Dewatering and Creation of Retention Ponds and/or Basins:
At the time of this 401 certification issuance, detailed information regarding dewatering frequency and methods as well as the location of and design, type, number, and size of possible retention ponds and/or basins was not available from California Department of Transportation. As a condition of this permit, prior to the start of any construction that will require these control measures, the California Department of Transportation must provide to the Central Valley Water Board a set of plans and specifications that outline where and how these measures will be implemented. This may include field visits by Central Valley Water Board staff prior to, during, and following the implementation of these measures. These control measures shall be protected from inundation during periods of high river flows.

ADDITIONAL STORM WATER QUALITY CONDITIONS:

The applicant shall also comply with the following storm water quality conditions:

1. During the construction phase, California Department of Transportation must employ strategies to minimize erosion, sedimentation, and the introduction of pollutants into waterways and storm water runoff. These strategies must include the following:

    a. the Storm Water Pollution Prevention Plan (SWPPP) must be implemented during the project planning and design phases and before construction begins.

    b. an effective combination of erosion and sediment control Best Management Practices (BMPs) must be implemented and adequately working prior to the rainy season and during all phases of construction.

2. California Department of Transportation must minimize the short and long-term impacts on receiving water quality from the State Route 99 Safety and Operational Improvement Project-Segment 2 Feather River Bridge, by implementing the following post-construction storm water management practices:

    a. minimize the amount of impervious surface;
    b. reduce peak runoff flows;
    c. provide treatment BMPs to reduce pollutants in runoff;
    d. ensure existing waters of the State (e.g. wetlands, vernal pools, or creeks) are not used as pollutant source controls and/or restore treatment controls;
    e. preserve and, where possible, create or restore areas that provide important water quality benefits, such as riparian corridors, wetlands, and buffer zones;
    f. limit disturbances of natural water bodies and natural drainage systems caused by development (including development of roads, highways, and bridges);
    g. use existing drainage master plans or studies to estimate increases in pollutant loads and flows resulting from projected future development and require

incorporation of structural and non-structural BMPs to mitigate the projected pollutant load increases in surface water runoff;

h. identify and avoid development in areas that are particularly susceptible to erosion and sediment loss, or establish development guidance that protects areas from erosion/sediment loss;

i. control post-development peak storm water run-off discharge rates and velocities to prevent or reduce downstream erosion, and to protect stream habitat.

3. California Department of Transportation must ensure that all development within the project provides verification of maintenance provisions for post-construction structural and treatment control BMPs. Verification shall include one or more of the following, as applicable:

   a. the developer's signed statement accepting responsibility for maintenance until the maintenance responsibility is legally transferred to another party; or
   b. written conditions in the sales or lease agreement that require the recipient to assume responsibility for maintenance; or
   c. written text in project conditions, covenants and restrictions for residential properties assigning maintenance responsibilities to a home owner's association, or other appropriate group, for maintenance of structural and treatment control BMPs; or
   d. any other legally enforceable agreement that assigns responsibility for storm water BMP maintenance.

REGIONAL WATER QUALITY CONTROL BOARD CONTACT PERSON:

Virginia S. Moran, Environmental Scientist
11020 Sun Center Drive #200
Rancho Cordova, California 95670-6114
(916) 464-4814
vmoran@waterboards.ca.gov

WATER QUALITY CERTIFICATION:

I hereby issue an order certifying that any discharge from California Department of Transportation, State Route 99 Safety and Operational Improvement Project-Segment 2 Feather River Bridge (WDID#5A51CR00047) will comply with the applicable provisions of §301 ("Effluent Limitations"), §302 ("Water Quality Related Effluent Limitations"), §303 ("Water Quality Standards and Implementation Plans"), §306 ("National Standards of Performance"), and §307 ("Toxic and Pretreatment Effluent Standards") of the Clean Water Act. This discharge is also regulated under State Water Resources Control Board Water Quality Order No. 2003-0017 DWQ "Statewide General Waste Discharge Requirements For Dredged Or Fill Discharges That Have Received State Water Quality Certification (General WDRs)".

Except insofar as may be modified by any preceding conditions, all certification actions are contingent on (a) the discharge being limited and all proposed mitigation being completed in strict compliance with the applicant's project description and the attached Project Information Sheet, and (b) compliance with all applicable requirements of the Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan).

for Pamela C. Creedon
Executive Officer

Enclosure: Project Information

cc: See Distribution list, page 11

PROJECT INFORMATION

Application Date: 30 January 2009

Applicant: Suzanne Melim, Associate Environmental Planner
California Department of Transportation
PO Box 911
Marysville, CA 95901

Project Name: State Route 99 Safety and Operational Improvement Project-Segment 2 Feather River Bridge

Application Number: WDID#5A51CR00047

U.S. Army Corps File Number: SPK 2008-01810

Type of Project: Transportation Upgrade Project

Project Location: Section N/A, Township 12 North, Range 3 East, MDB&M. Latitude: 38°54'00.07" and Longitude: 121°35'06.99".

County: Sutter County

Receiving Water(s) (hydrologic unit): Feather River and Nelson Slough, Sacramento Hydrologic Basin, Valley- American Hydrologic Unit #519.22, Pleasant Grove HSA

Water Body Type: Floodplain, River, Wetlands, Streambed

Designated Beneficial Uses: The Basin Plan for the Central Valley Regional Board has designated beneficial uses for surface and ground waters within the region. Beneficial uses that could be impacted by the project include: Municipal and Domestic Water Supply (MUN); Agricultural Supply (AGR); Industrial Supply (IND), Hydropower Generation (POW); Groundwater Recharge, Water Contact Recreation (REC-1); Non-Contact Water Recreation (REC-2); Warm Freshwater Habitat (WARM); Cold Freshwater Habitat (COLD); and Wildlife Habitat (WILD).

Project Description (purpose/goal): This project is part of an overall State Route 99 Safety and Operational Improvement Project designed to be implemented in three segments: Segments 1, 2, & 4. Segment 1 was completed in October 2007. (Segment 3 was completed between 1999 and 2000 and covered under a separate environmental process). Segment 4 was started on 20 April 2009 and is still under construction. This 401 certification is for Segment 2. Segment 2 will be completed in two tasks: Bridge Construction and Drainage Work.

BRIDGE CONSTRUCTION

Based on project information provided by the applicant, the Segment 2 component of the project begins north of Powerline Road extending north past Sacramento Avenue. Segment 2 will widen the existing road to the east. The project will include a new bridge across the Feather River and a new Garden Highway undercrossing.

The primary construction feature of the Segment 2 project is the placement of a new two-lane bridge across the Feather River that will convey the northbound traffic when completed. The existing two-lane bridge will be left in place and following construction of the new bridge, convey the southbound traffic. The new bridge will start at the existing southern levee and extend across the Feather River, its floodplain, and over Nelson Slough to the northern levee. The bridge will be approximately 3,000 ft long and will parallel the existing bridge. No work is proposed on the existing bridge.

The new bridge will have two abutments and 16 piers. The piers will be comprised of two 7.5-foot diameter cast steel shell piles. These hollow piles are driven or vibrated into the ground and steel framing is placed inside the shell followed by concrete and a pile cap. During excavation of the permanent piles, water may need to be pumped to detention/settling basins. Water may be pumped and taken off-site or retained within settling ponds or basins (see additional technically conditioned certification requirements). Following this construction, the bridge deck portion is then constructed on top of the piers. No cofferdams are proposed for this construction method.

The project will result in one pier (Pier 2) being built in a wetland area and four piers (4, 5, 6 &7) in the active channel of the Feather River. The remaining pier will be built within the confines of the levee but beyond the ordinary high water mark. The abutments are at the tops of the existing levees. The work within the levees is expected to take up to three seasons and California Department of Transportation intends to do this work throughout the entire season of each year.

This project will require in-water activity for construction. At the time of the 401 application, California Department of Transportation stated they could not identify how the near and/or in-water falsework for Segment 2 would be constructed, but most likely it will require the contractor to construct temporary floating "trestles" in order to perform construction from the water. A barge was considered but it was determined the water is too shallow. It is expected that the contractor will access Piers 2, 4, 5, 6, and 7 via these "trestles". Each trestle is expected to be built from a pair of 2-foot diameter steel shell piles placed every 30 feet with the decking built atop the piles. In addition to the trestle, the contractor will likely install temporary bent piles to support the bridge during construction. The temporary bents may be constructed from eight 2-foot diameter steel shell piles. Ninety-six piles may be driven for the temporary bents within Waters of the U.S. (backwater area south of the Feather River, the Feather River, and Nelson Slough). Following construction, the temporary piles and falsework will be removed.

DRAINAGE WORK

Nine drainage systems are included as part of this project. All drainage work will occur on the east side of the project. California Department of transportation intends to improve stormwater drainage with this phase of the work by performing the following projects: 1) extending culverts at five existing drainage locations; 2) relocating 2,900 feet of existing roadside ditch; and 3) adding 5,340 feet of new roadside stormwater ditches.

Surface water diversion may be necessary at cross canals and irrigation ditches where existing culverts will be extended. These diversions have to be designed and completed to maintain water quality/quantity in the canals and in order to meet giant garter snake avoidance and impact minimization measures. This could include a temporary check dam or similar measures. Base flow will have to be maintained down channel to provide water for agriculture needs. California Department of Transportation will develop and enact a plan that will address the issue of canal management to insure agricultural needs are met and giant garter snake habitat is protected. These measures may be implemented in compliance with and the cooperation of other regulatory agencies such as US Fish and Wildlife Service and California Department of Fish and Game.

Preliminary Water Quality Concerns: This project includes in-water construction activity as well as impacts to streambed and wetland. These activities may impact surface waters with increased turbidity and settleable matter as well as other project-related pollutants.

Proposed Mitigation to Address Concerns: Mitigation proposed by the applicant includes the following:

California Department of Transportation has selected a bridge type that does not require diversion or excavation of an active water-bearing channel.

California Department of Transportation has scheduled in-water work during the low-flow period (June 15-October 15), which will reduce effects to listed fish species and water quality.

California Department of Transportation has identified environmentally sensitive areas that will be avoided during construction and will greatly reduce potential impacts to wetlands and other sensitive habitats and resources.

California Department of Transportation will require the contractor to access piers in the Feather River with floating trestles, which will greatly reduce impacts to the channel.

Temporary piles will be left in place during the construction period. This will eliminate the need to re-drive piles for the temporary access trestle. Temporary bents left in place will reduce construction time. Both of these will greatly minimize construction impacts on listed fish species.

From October 15 to April 15, California Department of Transportation with require their contractor to have a minimal amount of equipment and construction material within the levees (only an amount that can be removed with 24-hour notice).

All falsework (temporary bent piles and trestle) will be installed in a manner that is expected to withstand a large flood event. This project duration is proposed for two to three years. Therefore, the selected contractor for California Department of Transportation will prepare an approved flood emergency evacuation plan prior to the start of construction within the flood plain.

California Department of Transportation has submitted a Final On-Site Mitigation Plan to the Central Valley Water Board (EA 03-1A4321-April 2009). Within areas undergoing temporary impacts, California Department of Transportation will replant native plant species within state right-of-ways and implement temporary and permanent erosion control measures including drill seeding, and permanent tree and shrub plantings.

California Department of Transportation will obtain coverage and comply with the NPDES General Permit for Storm Water Discharges Associated with Construction Activities issued by the State Water Resources Control Board. California Department of Transportation will implement Best Management Practices (BMPs) to control sedimentation and erosion. All temporary affected areas will be restored to pre-construction contours and conditions upon completion of construction activities. The contractor will be required to prepare and follow an approved Stormwater Pollution Prevention Plan (SWPPP) prior to construction.

California Department of Transportation will conduct turbidity and settleable matter testing during in water work, stopping work if Basin Plan criteria are exceeded or are observed.

Fill/Excavation Area: About 5,052 cubic yards of clean soil will be placed into 1.27 acres and 3,572 linear feet of jurisdictional wetland, 0.132 acre and 215 linear feet of riparian wetland, and 0.064 acre and 248 linear feet of un-vegetated streambed (for a total of 1.47 acres and 4,035 linear feet of fill).

Dredge Volume: None

U.S. Army Corps of Engineers Permit Number: SPK 2008-01810

Department of Fish and Game Streambed Alteration Agreement: 1600-2009-0016-R2

Possible Listed Species: Green Sturgeon, Central Valley steelhead including critical habitat, Central Valley spring-run Chinook salmon, Giant Garter Snake, Swainson's Hawk, Western yellow-billed cuckoo, and Bank Swallow.

Status of CEQA Compliance: A joint Final Environmental Impact Report / Environmental assessment between Caltrans and the U.S. Department of Transportation Federal Highway Administration was finalized as of 31 October 2003 and 04 November 2003 respectively. A Notice of Determination was filed as of 18 November 2003 (State Clearinghouse Number 2001092006).

Compensatory Mitigation: California Department of Transportation is proposing to create a combined 2.694 acres and 450 linear feet of jurisdictional wetland, riparian, and streambed; restore 0.568 acre and 590 linear feet of same, and enhance 0.62 acre and 5,340 linear feet of streambed. Mitigation for this project is at a 1:1 ratio. California Department of Transportation will be deducting 0.014 acre of credit for permanent impacts from the approved Beach Lake Mitigation Bank for credits that could not be mitigated onsite. The Army Corps of Engineers is accepting onsite restoration for the wetland riparian areas of roadside ditches that are being relocated/planted and monitored. Creation of additional ditches to offset temporary and permanent impacts from the culvert extensions has also been accepted as mitigation. There will be 2.087 acres of enhancement and restoration of wetlands, "other waters", and ditches onsite.

Application Fee Provided: Total fees of $24,448.00 have been submitted as required by 23 CCR §3833b(3)(A) and by 23 CCR §2200(e).

DISTRIBUTION LIST

U.S. Army Corp of Engineers
Sacramento District Office
Regulatory Section, Room 1480
1325 J Street
Sacramento, CA 95814-2922

Dave Smith
Wetlands Section Chief (W-3)
United States Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105

United States Fish & Wildlife Service
Sacramento Fish & Wildlife Office
2800 Cottage Way
Sacramento, CA 95825

Jeff Drongesen
Department of Fish and Game
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670

Bill Orme
State Water Resources Control Board
401 Certification and Wetlands Unit Chief
P.O. Box 100
Sacramento, CA 95814

Bill Jennings
CA Sportfishing Protection Alliance
3536 Rainier Avenue
Stockton, CA 95204

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO CA 95814-2922

REPLY TO
ATTENTION OF

June 24, 2009

Regulatory Division (SPK-2008-01810)

California Department of Transportation
Susan Bauer, Chief, Environmental Management
703 B Street/P.O. Box 911
Marysville, California 95901-0911

Dear Ms. Bauer:

This letter of permission authorizes your proposed discharge of dredged or fill material into approximately 2.179 acres of waters of the United States, including wetlands for your proposed State Route 99 Safety and Operational Improvement Project, Segment 2- Feather River Bridge. The project is located along State Route 99 between Post Mile (PM) 11.1 and PM 14.3 in Section 2, Township 12 North, Range 3 East, MDB&M, Latitude 38 54'00.07", Longitude -120 35'06.99", in Sutter County, California.

The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer. **Work in waters of the United States must be in accordance with the following conditions of authorization:**

General Conditions:

1. The time limit for completing the work authorized ends on Junc 16, 2014. If you find that you need more time to complete the authorized activity, submit a request for time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of these requirements if you abandon the permitted activity. This permit may be transferred upon request provided the work complies with the terms and conditions of this authorization. When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. Should you wish to cease to maintain the authorized activity or abandon it without a good faith transfer; you must obtain a permit modification from this office.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register.

4. You must insure that the work complies with the conditions of the Section 401 water quality certification (WDID#5A51CR00047), dated May 22, 2009, for this project.

5. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions:

1. You understand and agree, that, if future operations by the United States require the removal, relocation, or other alteration of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, you will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused hereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

2. Your use of the permitted activity must not interfere with the public's right to free navigation on all navigable waters of the United States.

3. You must install and maintain, at your expense, any safety lights and signals prescribed by the United States Coast Guard (USCG), through regulations or otherwise, on your authorized facilities.

4. To mitigate for the permanent loss of approximately 0.93-acre of perennial wetlands, you shall debit 0.93-acre of perennial wetland credits from Beach Lake Mitigation Bank. Evidence of this debit shall be provided to this office prior to proceeding with any activity otherwise authorized by this permit.

5. To compensate for the permanent loss of approximately 0.025-acre of waters of the United States, you shall re-create at least 0.025-acre of roadside ditches and other waterways adjacent to the modified roadway. Ditches and waterways shall be vegetated with native seed mix.

6. To insure on-site compensatory mitigation compliance, the document entitled *Final On-Site Mitigation Plan – SR99 Safety and Operational Improvement Project - Segment 2 (Feather River Bridge), EA 03-1A4321,* dated, April 2009, is incorporated by reference as a condition of this authorization except as modified by the following special conditions:

7. Any riparian vegetation removal within 250 feet of the Feather River, that cannot be restored onsite, must be mitigated offsite at a ratio of 3:1.

8. You shall construct the compensatory mitigation prescribed by this plan concurrently with, or in advance of, the start of construction of the authorized/permitted activity. Construction of compensatory mitigation shall be completed no later than February 2011 or the first (1^{st}) Fall following project construction completion.

9. To insure that mitigation is completed as required, you shall notify the District Engineer of the start date and the completion date of the mitigation construction, in writing and no later than ten (10) calendar days after each date.

10. This Corps permit does not authorize you to take an endangered species, in particular giant garter snake *(Thamnophis gigas)*, Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*), Central Valley steelhead DPS (*Oncorhynchus mykiss*), and Southern DPS of North American green sturgeon (*Acipenser medirostris*) or their designated critical habitat. In order to legally take a listed species, you must have separate authorization under the Endangered Species Act (e.g., an Endangered Species Act Section 10 permit, or a Biological Opinion under Endangered Species Act Section 7, with "incidental take" provisions with which you must comply). The Fish and Wildlife Service Biological Opinion, dated May 15, 2003 (Number 1-1-03-F-0089), amended September 27, 2006 (Number 1-1-06-F-0254), and National Marine Fisheries Service Biological Opinion, dated September 4, 2003 (SWR-02-SA-6441: FKF), amended June 9, 2009, contains mandatory terms and conditions to implement the reasonable and prudent measures that are associated with "incidental take" that is specified in the Biological Opinion. Your authorization under this Corps permit is conditional upon your compliance with all of the mandatory terms and conditions associated with "incidental take" of the referenced Biological Opinions, which terms and conditions are incorporated by reference in this permit. Failure to comply with the terms and conditions associated with incidental take of the Biological Opinions, where a take of the listed species occurs, would constitute an unauthorized take, and it would also constitute non-compliance with your Corps permit. The Fish and Wildlife Service and National Marine Fisheries Service are the appropriate authorities to determine compliance with the terms and conditions of their Biological Opinions, and with the Endangered Species Act. The permittee must comply with all conditions of these Biological Opinions, including those ascribed to the Corps.

11. You shall follow the specifications and standards described in the Storm Water Pollution Prevention Plan (SWPPP) and/or Water Pollution Control Plan (WPCP), to prevent erosion and sedimentation during and after construction. Construction work within wetlands and vernal pools will be conducted during periods of low flow (April 15-October 15), outside the rainy season work window.

12. You shall employ Best Management Practices (BMP's) to avoid and minimize environmental impacts. Temporary fills must be removed in their entirety and the affected areas returned to preconstruction elevations and conditions. The affected areas must be re-vegetated with a native seed mix.

13. All equipment staging, including Temporary Construction Areas (TCA's), shall take place within Caltrans approved areas within the project boundary. Prior to construction implementation, you shall ensure all equipment staging, TCA's, demolition and disposal, excavation, off pavement detours, and borrow and fill areas, have been evaluated under National Environmental Policy Act (NEPA),

Section 401 and 404 of the Clean Water Act, Section 7 of the Endangered Species Act and Section 106 of the National Historical Preservation Act and all required permits have been obtained.

14. To document pre- and post-project construction conditions, you shall submit numbered and dated photos of the permanent and temporary impact areas within the project site prior to project implementation and numbered and dated post-construction photos of the same areas within 30 days after project completion.

15. You must allow representatives from the Corps of Engineers to inspect the authorized activity and any mitigation, preservation, or avoidance areas at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

(X) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).

(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal projects.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (see 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5.

6. Extensions. General Condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

This letter of permission becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below. Attached to this verification is an approved jurisdictional determination (JD). If you are not in agreement with that approved JD, you can make an administrative appeal under 33 CFR 331. A notice of appeal options is enclosed.

We appreciate your feedback. At your earliest convenience, please tell us how we are doing by completing the customer survey on our website under *Customer Service Survey*.

Please refer to identification number SPK-2008-01810 in any correspondence concerning this project. If you have any questions, please contact Leah Fisher at, email *Leah.M.Fisher@usace.army.mil*, or telephone 916-557-6639. For more information regarding our program, please visit our website at *www.spk.usace.army.mil/regulatory.html*.

For and on the behalf of Colonel Thomas Chapman, District Engineer.

Sincerely,

Nancy A. Haley

Nancy A. Haley
Chief, California North Branch

Enclosure(s)

Copy furnished without enclosure(s)

Ms. Eva Begley, California Department of Transportation, 2800 Gateway Oaks Drive, Suite 100, MS#19, Sacramento, California 95833-4246
Mr. Paul Jones, U.S. Environmental Protection Agency, Region IX, Wetlands Regulatory Office (WTR-8), 75 Hawthorne Street, San Francisco, California, 94105-3901
Ms. Virginia Moran, Water Quality Certification Unit, Regional Water Quality Control Board, 11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Ms. Sandy Morey, California Department of Fish and Game, 1701 Nimbus Road, Rancho Cordova, California 95670-4504
Mr. Ken Sanchez, U.S. Fish and Wildlife Service, Forest-Foothill Branch, 2800 Cottage Way, W-2605, Sacramento, California, 95825
Ms. Maria Rea, National Marine Fisheries Service, 650 Capital Mall, Suite 8-300, Sacramento, California 95814-4706
Mr. Jay Punia, Central Valley Flood Protection Board, 3310 El Camino Avenue, Room LL40, Sacramento, California 95821

STATE OF CALIFORNIA
THE RESOURCES AGENCY

THE CENTRAL VALLEY FLOOD PROTECTION BOARD

PERMIT NO. 18469 BD

This Permit is issued to:

California Department of Transportation
2800 Gateway Oaks Drive
Sacramento, California 95833

To construct a second bridge, pre-cast concrete box girder, across the Feather River east of the existing Bridge (No. 18-0026) 41.84-feet-wide, 3,148-foot-long, supported by fifteen bents with two 48-inch-diameter steel pipe pilings each, and 2 abutments; and place rock riprap on both the right and left banks. The project is located in Nicolaus along Highway 99 (Section 12, T12N, R3E, MDB&M, Reclamation District 1001 and Maintenance Area 3, Feather River, Sutter County).

NOTE: Special Conditions have been incorporated herein which may place limitations on and/or require modification of your proposed project described above.

(SEAL)

Dated: JUN 26 2009

Jay S. Punia
General Manager

GENERAL CONDITIONS:

ONE: This permit is issued under the provisions of Sections 8700 – 8723 of the Water Code.

TWO: Only work described in the subject application is authorized hereby.

THREE: This permit does not grant a right to use or construct works on land owned by the Sacramento and San Joaquin Drainage District or on any other land.

FOUR: The approved work shall be accomplished under the direction and supervision of the State Department of Water Resources, and the permittee shall conform to all requirements of the Department and The Central Valley Flood Protection Board.

FIVE: Unless the work herein contemplated shall have been commenced within one year after issuance of this permit, the Board reserves the right to change any conditions in this permit as may be consistent with current flood control standards and policies of The Central Valley Flood Protection Board.

SIX: This permit shall remain in effect until revoked. In the event any conditions in this permit are not complied with, it may be revoked on 15 days' notice.

SEVEN: It is understood and agreed to by the permittee that the start of any work under this permit shall constitute an acceptance of the conditions in this permit and an agreement to perform work in accordance therewith.

EIGHT: This permit does not establish any precedent with respect to any other application received by The Central Valley Flood Protection Board.

NINE: The permittee shall, when required by law, secure the written order or consent from all other public agencies having jurisdiction.

TEN: The permittee is responsible for all personal liability and property damage which may arise out of failure on the permittee's part to perform the obligations under this permit. If any claim of liability is made against the State of California, or any departments thereof, the United States of America, a local district or other maintaining agencies and the officers, agents or employees thereof, the permittee shall defend and shall hold each of them harmless from each claim.

ELEVEN: The permittee shall exercise reasonable care to operate and maintain any work authorized herein to preclude injury to or damage to any works necessary to any plan of flood control adopted by the Board or the Legislature, or interfere with the successful execution, functioning or operation of any plan of flood control adopted by the Board or the Legislature.

TWELVE: Should any of the work not conform to the conditions of this permit, the permittee, upon order of The Central Valley Flood Protection Board, shall in the manner prescribed by the Board be responsible for the cost and expense to remove, alter, relocate, or reconstruct all or any part of the work herein approved.

SPECIAL CONDITIONS FOR PERMIT NO. 18469 BD

THIRTEEN: All work approved by this permit shall be in accordance with the submitted drawings and specifications except as modified by special permit conditions herein. No further work, other than that approved by this permit, shall be done in the area without prior approval of the Central Valley Flood Protection Board.

FOURTEEN: The permittee is responsible for all liability associated with construction, operation, and maintenance of the permitted facilities and shall defend and hold harmless the Central Valley Flood Protection Board and the State of California and/or any departments thereof from any liability or claims of liability associated therewith.

FIFTEEN: The Central Valley Flood Protection Board, the Department of Water Resources and Reclamation District No. 1001 and/or any departments thereof shall not be held liable for damages to the permitted encroachment(s) resulting from releases of water from reservoirs, flood fight, operation, maintenance, inspection, or emergency repair.

SIXTEEN: The permittee shall provide supervision and inspection services acceptable to the Central Valley Flood Protection Board. A professional engineer registered in the State of California shall certify that all work was inspected and performed in accordance with submitted drawings, specifications, and permit conditions.

SEVENTEEN: The permittee shall contact the Department of Water Resources by telephone, (916) 574-0609, and submit the enclosed postcard to schedule a preconstruction conference. Failure to do so at least 10 working days prior to start of work may result in delay of the project.

EIGHTEEN: No construction work of any kind shall be done during the flood season from November 1st to April 15th without prior written approval of the Central Valley Flood Protection Board.

NINETEEN: Prior to start of any demolition and/or construction activities within the Feather River flood control project works, CAL-TRANS shall provide the Central Valley Flood Protection Board with two (2) sets of layout plans for any/all temporary in channel cofferdams, gravel work pads, work trestles, scaffolding, piles and/or other appurtenances that are to remain within the floodway during the flood season from December 1st through April 15th.

TWENTY: Cleared trees and brush shall be completely burned or removed from the flood control project works, and downed trees or brush shall not remain in the project works during the flood season from November 1st to April 15th.

TWENTY-ONE: Fill material shall be placed only within the area indicated on the approved plans.

TWENTY-TWO: Backfill material for excavations within the levee section and within 10 feet of bridge supports within the floodway shall be placed in 4- to 6-inch layers and compacted to a minimum of 95 percent relative compaction per ASTM Method D698 at +/- 2 percent optimum moisture content or 90 percent relative compaction per ASTM Method D1557-91 at 0 to 4 percent above optimum moisture content.

TWENTY-THREE: Density tests by a certified materials laboratory will be required to verify compaction of backfill within the flood control project works.

TWENTY-FOUR: Stockpiled material and/or equipment being utilized on less than a weekly basis shall not remain in the flood control project works during the flood season from November 1st to April 15th.

TWENTY-FIVE: The soffit of the bridge shall be a minimum of 3 feet above the flood plane elevation of 56.0 feet, NGV Datum.

TWENTY-SIX: Vehicular access shall be provided from the bridge to all levee crown roadways.

TWENTY-SEVEN: The new piers and bents shall be constructed parallel to the direction of flow.

TWENTY-EIGHT: Drainage from the bridge shall not be discharged onto the levees.

TWENTY-NINE: In the event existing revetment on the channel banks or levee slopes is disturbed or displaced, it shall be restored to its original condition upon completion of the proposed installation.

THIRTY: The revetment shall not contain any reinforcing steel, floatable, or objectionable material. Asphalt or other petroleum-based products may not be used as fill or erosion protection on the levee section.

THIRTY-ONE: Revetment shall be uniformly placed and properly transitioned into the bank, levee slope, or adjacent revetment and in a manner which avoids segregation.

THIRTY-TWO: Quarry rock shall be used on slopes steeper than 3 horizontal to 1 vertical.

THIRTY-THREE: Revetment shall be quarry stone or cobbles and shall meet the following grading:

Quarry Stone

Stone Size	Percent Passing
15 inches;	100
8 inches;	80-95
6 inches;	45-80
4 inches;	15-45
2 inches;	0-15

THIRTY-FOUR: All fencing, gates and signs removed during construction of this project shall be replaced in kind and at the original locations. If it is necessary to relocate any fence, gate or sign, the permittee is required to obtain written approval from the Central Valley Flood Protection Board prior to installation at a new location if not shown on the submitted plans.

THIRTY-FIVE: All temporary fencing, gates and signs shall be removed upon completion of the project.

THIRTY-SIX: All construction debris generated by this project shall be disposed of outside of the Feather River flood control project works.

THIRTY-SEVEN: Trees, brush, sediment, and other debris shall be kept cleared from the bridge site and disposed of outside the flood control project works to maintain the design flow capacity and flowage area.

THIRTY-EIGHT: Debris that may accumulate on the herein permitted bridge piers shall be cleared off and disposed of outside the flood control project works after each period of high water.

THIRTY-NINE: The herein permitted bridge shall not interfere with operation and maintenance of the flood control project. If the permitted encroachment(s) are determined by any agency responsible for operation or maintenance of the flood control project to interfere, the permittee shall be required, at permittee's cost and expense, to modify or remove the permitted encroachment(s) under direction of the Central Valley Flood Protection Board or Department of Water Resources. If the permittee does not comply, the Central Valley Flood Protection Board may modify or remove the encroachment(s) at the permittee's expense.

FORTY: If the herein permitted structure(s) result(s) in an adverse hydraulic impact, the permittee shall provide appropriate mitigation measures, to be approved by the Central Valley Flood Protection Board, prior to implementation of said mitigation measures.

FORTY-ONE: If the bridge is damaged to the extent that it may impair the channel or floodway capacity, it shall be repaired or removed prior to the next flood season.

FORTY-TWO: The permittee may be required, at permittee's cost and expense, to remove, alter, relocate, or reconstruct all or any part of the permitted encroachment(s) if removal, alteration, relocation, or reconstruction is necessary as part of or in conjunction with any present or future flood control plan or project or if damaged by any cause. If the permittee does not comply, the Central Valley Flood Protection Board may remove the encroachment(s) at the permittee's expense.

FORTY-THREE: If the project, or any portion thereof, is to be abandoned in the future, the permittee or successor shall abandon the project under direction of the Central Valley Flood Protection Board and Department of Water Resources, at the permittee's or successor's cost and expense.

FORTY-FOUR: The permittee shall comply with all conditions set forth in the letter from Reclamation District No. 1001 dated 3-25-09, which is attached to this permit as Exhibit A and is incorporated by reference.

FORTY-FIVE: The permittee shall comply with all conditions set forth in the letter from the Department of the Army, dated June 18, 2009, which is attached to this permit as Exhibit B and is incorporated by reference.

Exhibit A

RECLAMATION DISTRICT 1001
1959 CORNELIUS AVENUE
RIO OSO, CA 95674
(530) 656-2318 FAX (530) 656-2165

CONDITION OF APPROVAL PERMIT # U4-3.28-08
Revised 3-25-09

APPROVAL OF PERMIT SUBMITTED BY STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION IS APPROVED SUBJECT TO THE FOLLOWING CONDITIONS:

Any work performed under this permit will constitute acceptance of the following CONDITIONS:

1. Approval of this permit by RECLAMATION DISTRICT 1001 (District) is conditional to the fact that the applicant shall, whenever the same is required by law, secure the written order or consent to any work hereunder from any other Federal, State, County and/or Public Agency.

2. RECLAMATION DISTRICT 1001 shall be notified ten (10) days in advance of start of work.

3. The Manager of RECLAMATION DISTRICT 1001 shall act on behalf of the District to inspect and approve all work performed under this permit.

4. Approval of this permit of RECLAMATION DISTRICT 1001 does not grant applicant permission to enter upon or construct any works upon any private and/or public lands without authorization.

5. The foregoing approval and consent are given upon the understanding that Applicant **State of CA Dept of Transportation** shall at **their** sole cost and expense remove, alter, relocate or reconstruct all or any part of the works herein approved immediately upon request of the undersigned District, should said works, or any portion thereof not conform to the application, or should they interfere with the proper operation or maintenance of flood control or reclamation works, or should it be required under any flood control plans hereafter adopted by said District, and in case Applicant should refuse or delay acting upon any request for such removal, alteration, relocation or reconstruction, said District may proceed to perform the required work and the cost thereof shall be paid by Applicant upon demand. **State of CA Dept of Transportation,** the Applicant herein named hereby accepts the authorization of RECLAMATION DISTRICT 1001 to proceed with the attached plans subject to the terms and conditions set forth, and agrees to abide by said terms and conditions, and on their own behalf and on behalf of their successors, agents and assigns, waives all claims arising directly or indirectly out of any act, consent or requirement of the Reclamation

District, and for their self, their successors, agents and assigns agrees to hold harmless the said Reclamation District from all claims or demands whatsoever arising out of the construction or operation of the facilities herein referred to.

6. The conditions of approval of this permit by ~~the Manager of~~ Reclamation District 1001 may be appealed to the Board of Trustees of Reclamation District 1001. Appeal shall be written and filed prior to start of work or within 30 days of approval by Manager.

7. Access to levees ~~from Highway 99~~ shall be provided at all times during construction by way of existing levee access ramps upstream in the town of Nicolaus and downstream off Garden Hwy.

8. No "stockpiling" or deposition of construction materials and/or debris on levee right of way shall be allowed at any time without written authorization of Reclamation District 1001's ~~Secretary~~/Manager.

9. Emergency access and an all weather crossing of center divide of highway shall be provided from Highway 99 onto levee crown roadway at the upstream and downstream junction of the Feather River south levee and Highway 99 roadway upon completion of construction of activities and shall be a minimum width of 20 feet.

10. Removable guardrail for access to Reclamation District No. 1001 (RD 1001). Levee patrol roads from Highway 99 shall be removed by Cal-Trans Maintenance Department personnel upon request by RD 1001's Manager when the water level of Feather River at the Nicolaus gauge, reaches elevation 43.0 feet USGS and/or when an emergency arises. Such request shall be made to Cal-Trans Maintenance Division in Marysville, CA or the office of the Regional Maintenance Manager in Sacramento, CA. Cal-Trans maintenance personnel will promptly reinstall the removable guardrail upon notification that the access is no longer needed by RD 1001's manager. Cal-Trans personnel shall remove said guardrails within eight (8) hours of notification.

11. During construction applicant shall provide approved type barriers to control the unauthorized use and/or access to levees.

12. Cal-Trans shall perpetuate continuous rock on all areas of water side slope of levee from a point-200 feet downstream to a point 200 feet upstream of bridge crossing. Any area damaged during construction will be repaired to its pre-existing condition. ~~with~~ Material must meet Army Corp of Engineers specifications for rock slope protection on rivers to elevation 43.0 feet USGS.

13. Any disturbed or excavated areas within the levee section or near bridge supports shall be backfilled in four (4) to six (6) inch layers with approved materials and shall be compacted to a relative compaction of not less than ninety (90) percent

(ASTM Standard D-1557). ~~Compaction tests shall be taken and the results of such tests furnished to this District. If testing is not performed, copies provided and/or District staff requires any additional testing, any such test(s) will be performed by any independent materials testing facility at the sole expense of Cal-Trans~~.

14. Cal-Trans shall ~~install~~ perpetuate an all weather low-water maintenance road on water side of levee under bridge crossing connecting existing levee patrol road. Should maintenance road be damaged during construction, Cal-Trans will repair to pre-existing condition.

15. All materials for the construction of any maintenance ramp shall be imported materials approved by District ~~staff~~ Manager and no materials not approved by District ~~staff~~ Manager shall be allowed.

16. A copy of this permit and its conditions of approval shall be on job site at all times.

17. Prior to start of construction, resident engineer for project shall meet with Reclamation District 1001 ~~staff~~ Manager for pre construction inspection and review of conditions.

18. ~~Project engineer~~ Cal-Trans Resident Engineer for project shall furnish Reclamation District 1001 ~~staff~~ Manager, site phone numbers and 24 hour emergency number for contact.

19. Cal-Trans shall be the responsible party for the removal of any and all debris that accumulates on and/or around bridge piers during construction.

Exhibit B

DEPARTMENT OF THE ARMY
U.S. Army Engineer District, Sacramento
Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

REPLY TO
ATTENTION OF

Flood Protection and Navigation Section (18469)

Mr. Jay Punia, Executive Officer
Central Valley Flood Protection Board
3310 El Camino Ave., Rm. LL40
Sacramento, California 95821

JUN 18 2009

Dear Mr. Punia:

We have reviewed a permit application by the California Department of Transportation (application number 18469). This project includes constructing a 41.84-feet wide and 3,148-feet long pre-cast concrete girder bridge across the channel and placing riprap on both the right and left bank levees of the Feather River. The proposed bridge includes fifteen bents, each with two 7.5-feet diameter cast in steel shell pilings, and two abutments and place rock riprap on the left and right banks. This project is located in Nicolaus, at 38.9016°N 121.5866°W NAD83, Sutter County, California.

The District Engineer has no objection to approval of this application by your Board from a flood control standpoint, subject to the following conditions:

a. That during flood season, November 1 to April 15, no work shall be performed in the levee sections and no stockpiles of material, temporary buildings or equipment shall remain in the floodway.

b. That in the event trees and brush are cleared, they shall be properly disposed of either by complete burning or complete removal outside the limits of the project right-of-way.

c. That the proposed bents for the bridge shall be parallel to the direction of flow and be in-line with the piles/bents of the existing Highway 99 bridge.

d. That drainage from the proposed bridge shall not direct water toward the levees without ensuring adequate erosion protection.

e. That the bottom of the bridge soffit shall be at least 3-feet above the design water surface profile, which is referenced as 53.0-feet COE datum in the Sacramento River Flood Control Project, Levee and Channel Profiles, file number 50-10-3334, sheet 3 of 4, dated March 15, 1957. The Sacramento District of the Corps of Engineers is currently working to determine the exact relationship between design profiles (which are referenced to a "Corps of Engineers Datum" or to a "U.S. engineering datum"), to NAVD88.

f. Engineered fill for levee embankment construction shall be performed using USACE requirements, specifically as outlined in CESPK-ED-GS Standard Operating Procedure SOP3, which was provided to Caltrans on June 5, 2009. Fill shall have a plasticity index of 8 to 40 and a liquid limit of less than 45. No particles shall be greater than 2-inches in maximum diameter. At least 20% of soils shall pass the #200 sieve. The moisture condition of the fill during placement shall be at -2% to +2% of optimum moisture content (OMC) at 95% maximum density (MD), ASTM D698 Standard Proctor, or 0% to +4% OMC at 90% MD ASTM D1557 Modified Proctor.

g. Before installing driven piles, Caltrans shall require the contractor to pre-drill oversize borings at least 6 inches larger in diameter than piles. Pre-drilling shall be performed to a depth in which stiff to hard clay material (ASTM D2488: CL, ML, CL-ML, MH, or CH) is no longer encountered, at least 25 feet below the levee foundation (approximate bottom of pre-drilled hole elevation, 40 feet for Abutment 1 and 20 feet for Abutment 17). Stiff to hard designation for clayey soils is defined for these purposes as normalized Standard Penetration Test Blow counts (N60) greater than 7. The annulus remaining after driving piles shall be grouted with cement-bentonite grout.

h. Existing levee material may be reused as engineered fill within the levee, provided that organics, high-plastic clays (CH), oversize material (i.e., greater than 2-inches), trash, and other deleterious material are removed.

i. Notify USACE Sacramento District geotechnical staff, Mr. Ed Ketchum, (916) 557-5383, at least 5 business days prior to initiation of pre-drilling, to coordinate an inspection of the levee conditions following the borings.

j. That the proposed bank protection work shall be placed uniformly and properly transitioned into the natural bank.

k. That in the event erosion occurs at the site, the applicant shall repair the eroded areas and place adequate bank protection on the natural bank.

l. That the proposed work shall not interfere with the integrity or hydraulic capacity (320,000 cfs) of the flood damage reduction project; easement access; or maintenance, inspection, and flood fighting procedures.

m. That access shall be established and/or maintained to allow continuous patrolling of the levee during periods of high water across the existing and proposed bridges.

n. Preliminary analysis by USACE Sacramento District, based on the Sacramento District's hydraulic model, indicates the new bridge may result in a decrease in freeboard (above the design profile) to the point where it could be less than the 3.0 feet required for the Federal Project. The Sacramento District recommends approving this permit contingent upon CALTRANS ensuring the levee will still have at least 3.0 feet of freeboard, based on the 1957 design profile and a flow of 320,000 cfs. This hydraulic analysis must be approved by the USACE Sacramento District and consistent with the Sacramento District's own hydraulic analysis. This must be complete prior to the start of construction. The Board should also be aware that this bridge design may result in less than 3.0 feet of clearance between the 100-year flow (329.814.90 cfs according to MBK Engineers, as described in the Final Hydraulic Report for the bridge by CALTRANS Structure Hydraulics group) which is out of compliance with Title 23.

It is noted that the soffit of the proposed bridge is less than 3-feet above the 200-year water surface elevation. The Board should consider requiring the applicant to construct the bridge soffit at least 3-feet above the 200-year elevation if there are plans to increase the level of protection in this area.

A copy of this letter is being furnished to Mr. Jeremy Arrich, Chief, Flood Project Integrity and Inspection Branch, 3310 El Camino Avenue, Suite LL30, Sacramento, CA, 95821.

Sincerely,

Kevin Knuuti

Kevin Knuuti, P.E.
Chief, Engineering Division

Memorandum

Flex your power!
Be energy efficient!

To: REID BUELL
Senior Engineering Geologist
Office of Geotechnical Design North

Attn: Abu Barrie

Date: May 23, 2008

File: 03-SUT-99-PM11.0
03-1A4321
Feather River Bridge
Bridge Number 18-0026R

From: **DEPARTMENT OF TRANSPORTATION**
Division of Engineering Services
Geotechnical Services - MS 5

Subject: Driveability Study for the Anchor Piles at Pier 12

Attached is a report summarizing the results of the driveability analysis perform by this Office for the anchor piles at Pier 12 of the above-referenced project.

If you have any questions or comments regarding this report, please contact Toua Vang at (916) 227-1060.

BRIAN LIEBICH, P.E.
Senior Transportation Engineer
Foundation Testing Branch

Attachment

TV:JT

FOUNDATION TESTING BRANCH

May 23, 2008

03-SUT-99-PM11.0

03-1A4321

Feather River Bridge

Bridge Number 18-0026R

Driveability Study for Anchor Piles at Pier 12

May 23, 2008

Project Information

03-SUT-99-11.0
03-1A4321
Feather River Bridge
Bridge Number 18-0026R

Subject

Driveability Study: Anchor Piles at Pier 12

Introduction

This Office has performed the pile driveability analysis for the proposed installation of the 48-inch diameter steel anchor pipe piles at Pier 12 of the above-referenced project. The analysis was based on the study requested by Mr. Abu Barrie of the Office of Geotechnical Design North on May 15, 2008, to support the foundation pile load test proposed at the location of Pier 12. Personnel from the Foundation Testing Branch (FTB) of the Office of Geotechnical Support performed the analysis utilizing the GRLWEAP™ computer program, Version 2005. This study provides the pile-driving systems to determine the appropriate hammer for achieving required tip elevations.

Description of Piling

The Feather River Bridge pile load test program includes the proposed installation of the 48-inch diameter steel anchor pipe piles at the control location of Pier 12. According to the Standard Specifications Section 49-5, "Steel Piles", steel pipe piles diameter that is greater than 14-inch shall conform to the requirements of ASTM Designation A252, Grade 3; therefore, this study will assume the steel minimum yield strength (Fy) of 45 ksi (Grade 3) for the analysis.

Subsurface Conditions and Soil Resistance Parameters

Based on the submitted Log of Test Borings (LOTB), Boring 07-B-11 was used in the analysis for the anchor piles at the control location of Pier 12. According to Boring 07-B-11, the foundation material at the site consists of loose to very dense sand, silty sand, sandy silt, fine sand with gravel and cobbles. Very soft cohesive soils (lean clay and silty clay) were encountered within the soil matrix at the upper strata and below the proposed tip elevation in the lower strata as shown in LOTB Boring 07-B-11. For complete description of the subsurface conditions, please refer to the Log of Test Boring. Table I presents the soil resistance parameters that were utilized to model the dynamic soil behavior.

Table I: Soil Resistance Parameters

PARAMETER	QUAKE	DAMPING
Skin (Shaft)	0.10 in	0.05 sec/ft
Toe	0.40 in	0.15 sec/ft

Pile Driving Resistance

When installing driven piles, the piles must overcome resistance to penetration developed by the soil. The driving resistance determines the size of the required impact hammer and the stress magnitude imparted to the steel pile by the driving system. An estimate of driving resistance is necessary to perform a driveability study when investigating the potential for pile damage due to steel overstressing during driving. Driving resistance can be related to static axial capacity using set-up and relaxation factors. These factors are applied to various soil layers penetrated while driving the steel pile. There are several methods available to estimate the pile static axial capacity and driving resistance. The methods will generally determine a range of axial capacities for a given pile penetration. To be conservative, pile tip elevations are generally based on lower estimates of static capacity, but higher capacity estimates are generally used for the driveability analysis.

The maximum driving resistance used in the analysis was based on information provided by Mr. Abu Barrie. According to the Geotechnical Designer, maximum driving resistance for the anchor piles is estimated to be 3,300 kips. This value was based on the anticipated driving resistance that consists of approximately 90% skin friction and 10% end bearing. Since layers of soft lean clay and silty clay (approximately 22 feet thick) were encountered within the embedded pile length, a set-up factor at this site is expected but given the length of pile and the depth location of the clay soils, set-up should be minimal.

Description of Pile Driving Systems

This study involved modeling the performance of three selected driving systems to reflect the range of rated energies possibly appropriate for the installation of the 48-inch diameter steel anchor pipe piles to the specified tip elevation at the control location of Pier 12.

The analyses were performed using GRLWEAP™ recommended, default parameters. For each hammer, the analysis was performed with the hammer operating at maximum stroke for determining driving-behavior stresses imparted to the steel pile. The analysis also includes the assumption that two (2) splices will be required at the approximate depth (pile length) of 50 feet and 100 feet. As a result, each hammer was utilized to demonstrate the predicted blow counts and corresponding maximum compressive stresses expected during pile driving. Standard configurations for the hammer driving systems and related components were based upon information published in GRLWEAP™ literature and database. The hammer characteristics are listed in Table II for the anchor piles at Pier 12.

Table II: Summary of Hammer Systems

Hammer Manufacturer	**APE**	**Delmag**	**Menck**
Hammer Model	**HI 400U**	**D 100-13**	**MHU 400**
Hammer Type	Hydraulic Impact	Open End Diesel	Hydraulic Impact
Rated Energy	400.0 ft-kips	265.67 ft-kips	289.55 ft-kips
Ram Weight	80.0 kips	22.1 kips	50.7 kips
Maximum Stroke	5.0 ft	13.5 ft	5.7 ft

Discussion of Results

Analysis printouts and charts depicting predicted relationships between ultimate capacity and driving stresses versus blow counts for each of the hammers are included in the appendix. The analyses results for the anchor piles at location of Pier 12 are summarized in Table III.

Table III: Summary of Results: Anchor Piles at Pier 12

Hammer Manufacturer / Model	Pile Thickness (inches)	Blow Counts (blows/ft)	Stroke (ft)	Allowable Compressive Stress at 95% F_y (ksi)	Compressive Stress at Maximum Stroke (ksi)
Delmag / D 100-13	0.75	568	8.3	42.75	29.46
Delmag / D 100-13	1.00	243	8.0	42.75	26.31
Delmag / D 100-13	1.25	169	8.0	42.75	24.19
Delmag / D 100-13	1.50	146	7.9	42.75	22.36
Menck / MHU 400	0.75	50	5.7	42.75	32.86
Menck / MHU 400	1.00	33	5.7	42.75	31.94
Menck / MHU 400	1.25	26	5.7	42.75	31.12
Menck / MHU 400	1.50	23	5.7	42.75	30.43
APE / HI 400U	0.75	39	5.0	42.75	30.12
APE / HI 400U	1.00	26	5.0	42.75	27.93
APE / HI 400U	1.25	23	5.0	42.75	27.57
APE / HI 400U	1.50	21	5.0	42.75	27.26

The GRLWEAP™ wave equation program is a one-dimensional analysis and does not consider buckling or bending of the pile due to non-uniform blows or localized stresses at the pile tip, which may occur during pile driving. Also, it has been observed in the field that significantly harder or softer driving could occur than the GRLWEAP™ predictions.

Anchor Piles at Pier 12

Analysis 1: Delmag D 100-13; 48-inch diameter steel anchor pipe piles at 0.75-inch, 1.00-inch, 1.25-inch, and 1.50- inch shell thickness

The analysis for the Delmag D 100-13 indicates that this hammer would be capable of driving the steel anchor pipe piles within the allowable compressive stress of 95% Fy at the estimated driving resistance of 3,300 kips with the maximum stroke condition but would exceed the maximum allowable blow count limit (blows/ft > 120).

Analysis 2: Menck MHU 400; 48-inch diameter steel anchor pipe piles at 0.75-inch, 1.00-inch, 1.25-inch, and 1.50- inch shell thickness

The analysis for the Menck MHU 400 indicates that this hammer would be capable of driving the steel anchor pipe piles within the allowable compressive stress of 95% Fy at the estimated driving resistance of 3,300 kips with the maximum stroke condition.

Analysis 3: APE HI 400U; 48-inch diameter steel anchor pipe piles at 0.75-inch, 1.00-inch, 1.25-inch, and 1.50- inch shell thickness

The analysis for the APE HI 400U indicates that this hammer would be capable of driving the steel anchor pipe piles within the allowable compressive stress of 95% Fy at the estimated driving resistance of 3,300 kips with the maximum stroke condition.

It should be noted that all driving output data generated by the GRLWEAP™ Program presumes uniform hammer blows, with leads and hammer perfectly aligned. The analyses do not consider the effects of eccentric blows, malfunctioning hammers, or Contractor-selected reduction in fuel setting for Diesel hammers. Some Diesel hammers may exhibit operating efficiencies significantly lower than the theoretical 80% used in the analyses, subject to condition and maintenance states. The analyses also do not consider higher stresses, which could be induced by bending, non-axial hammer alignment, or high local stress concentrations, and therefore should be considered as minimum values. Local pile damage can occur at the pile tip due to highly localized pile stresses caused by non-uniform resistance from sloping rock, boulders, cobbles, or obstructions, even if the calculated average axial stresses are within the allowable limits. These stresses cannot be predicted by wave equation analysis. The analysis results are only valid for the assumptions noted in the above sections and the soil profile input provided.

Conclusions and Recommendations

Based upon the results of the driveability analysis with reference to the submitted information from the Geotechnical Designer, the following have been concluded:

- Delmag hammer D 100-13 would be capable of driving the 48-inch diameter steel anchor pipe piles at 0.75-, 1.00-, 1.25-, and 1.5-inch shell thickness (Fy = 45 ksi) within the acceptable allowable compressive stress at the control location of Pier 12 but would exceed the maximum allowable blow counts limit (blows/ft > 120).

- Menck hammer MHU 400 would be capable of driving the 48-inch diameter steel anchor pipe piles at 0.75-, 1.00-, 1.25-, and 1.50-inch shell thickness (Fy = 45 ksi) within the acceptable allowable compressive stress at the control location of Pier 12.

- APE HI 400U would be capable of driving the 48-inch diameter steel anchor pipe piles at 0.75-, 1.00-, 1.25-, and 1.50-inch shell thickness (Fy = 45 ksi) within the acceptable allowable compressive stress at the control location of Pier 12.

- Piles shall be made using ASTM A 252, Grade 3 steel as per Section 49-5.01 of the Caltrans' Standard Specifications, or fabricated to specifications from steel of 50-ksi strength.

- A pile driving system submittal for this project is necessary upon hammer(s) selection. The driving system submittal must contain a driveability analysis showing that the proposed driving system will install all the piles to the specified tip elevations at acceptable rates of penetration without overstressing the piles.

- Hard driving conditions should be anticipated due to the very dense nature of the granular materials (gravel and cobbles). The possibility of boulders should also be anticipated and therefore a driving shoe may be necessary. Please refer to the Log of Test Borings for specific location and depths. The potential for center relief drilling should be addressed in the foundation recommendations.

- As only a limited number of large diameter (greater than 3.28 ft) steel pipe pile installation exist, the behavior of these piles during driving is not yet well documented and has often proved unpredictable. Therefore driving conditions during actual construction can differ significantly from those described in this report.

If you have any questions or comments pertaining to this report, please contact Toua Vang at (916) 227-1060.

REGISTERED PROFESSIONAL ENGINEER
JAMES TA
No. C053684
Exp. 06/2009
CIVIL
STATE OF CALIFORNIA

James Ta
05/27/08

TOUA VANG
Transportation Engineer, Civil
Foundation Testing Branch
Office of Geotechnical Support

JAMES L. TA, P.E.
Associate M & R Engineer
Foundation Testing Branch
Office of Geotechnical Support

APPENDIX

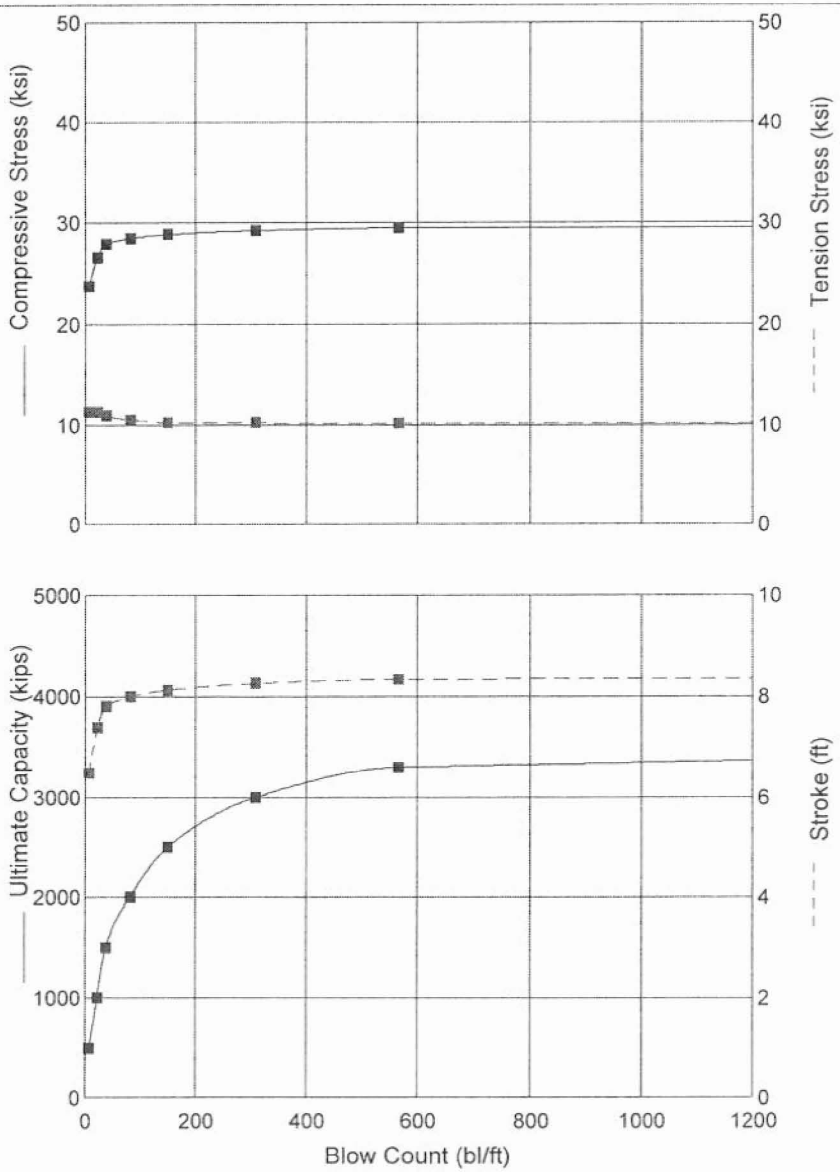
Driveability Analysis
Charts and Graphs

Feather River Bridge
Bridge Number 18-0026R

Anchor Piles at Pier 12

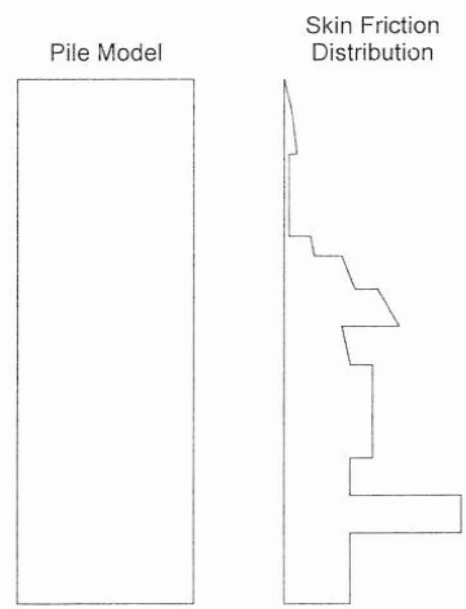
California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	111.33 in2

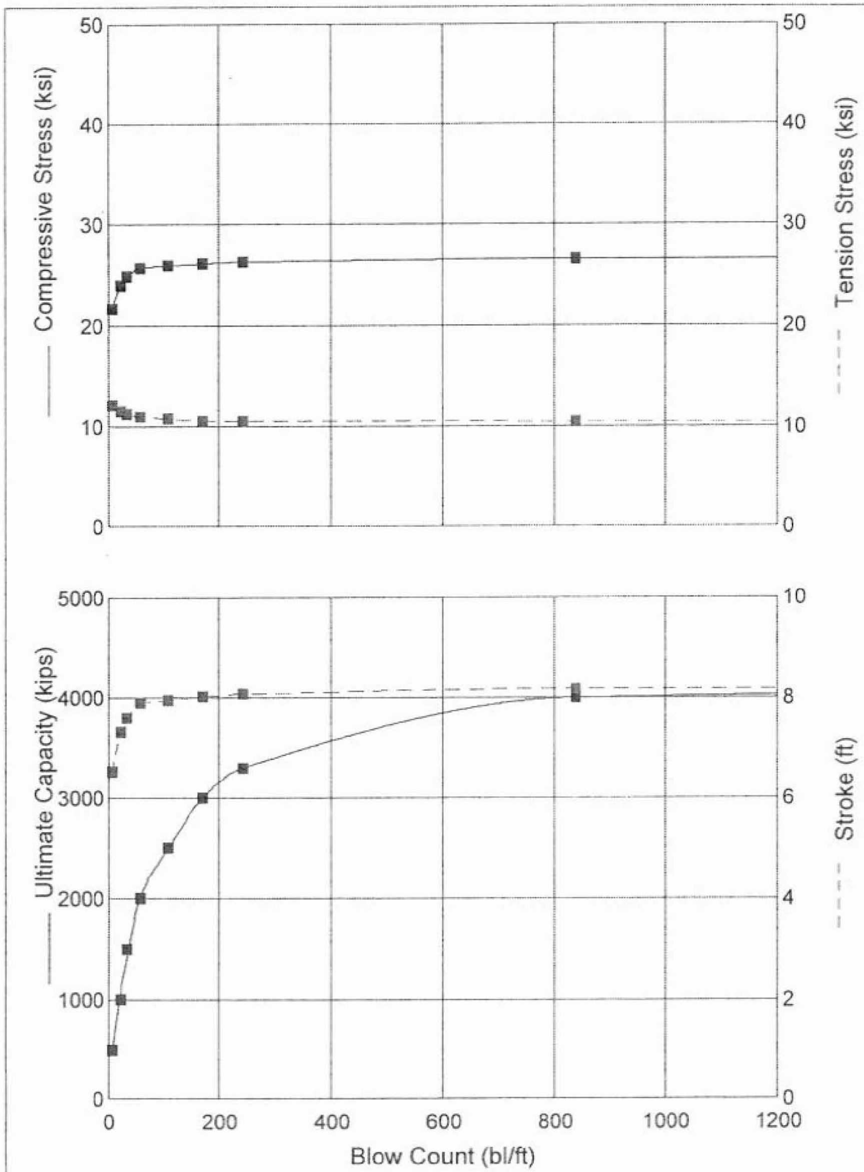


Res. Shaft = 90 %
(Proportional)

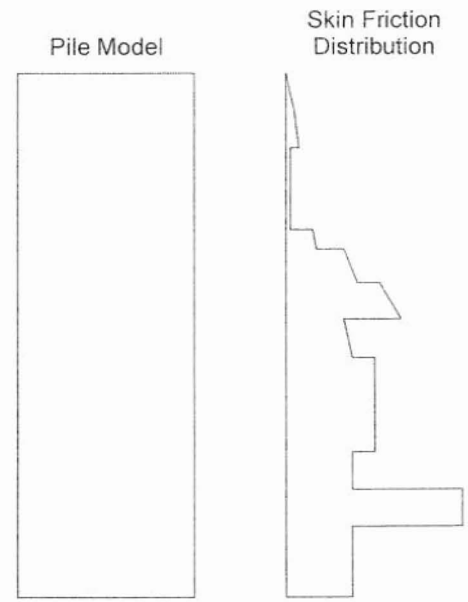
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	23.74	11.30	8.7	6.49	83.16
1000.0	26.60	11.31	22.5	7.38	77.59
1500.0	27.89	10.91	37.9	7.81	78.73
2000.0	28.46	10.53	81.4	8.00	80.92
2500.0	28.83	10.25	149.4	8.13	82.25
3000.0	29.21	10.20	310.2	8.26	83.73
3300.0	29.46	10.15	568.2	8.34	84.85
4000.0	30.00	9.87	9999.0	8.51	86.91

California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13		
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.400	in
Skin Damping	0.051	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	147.66	in2

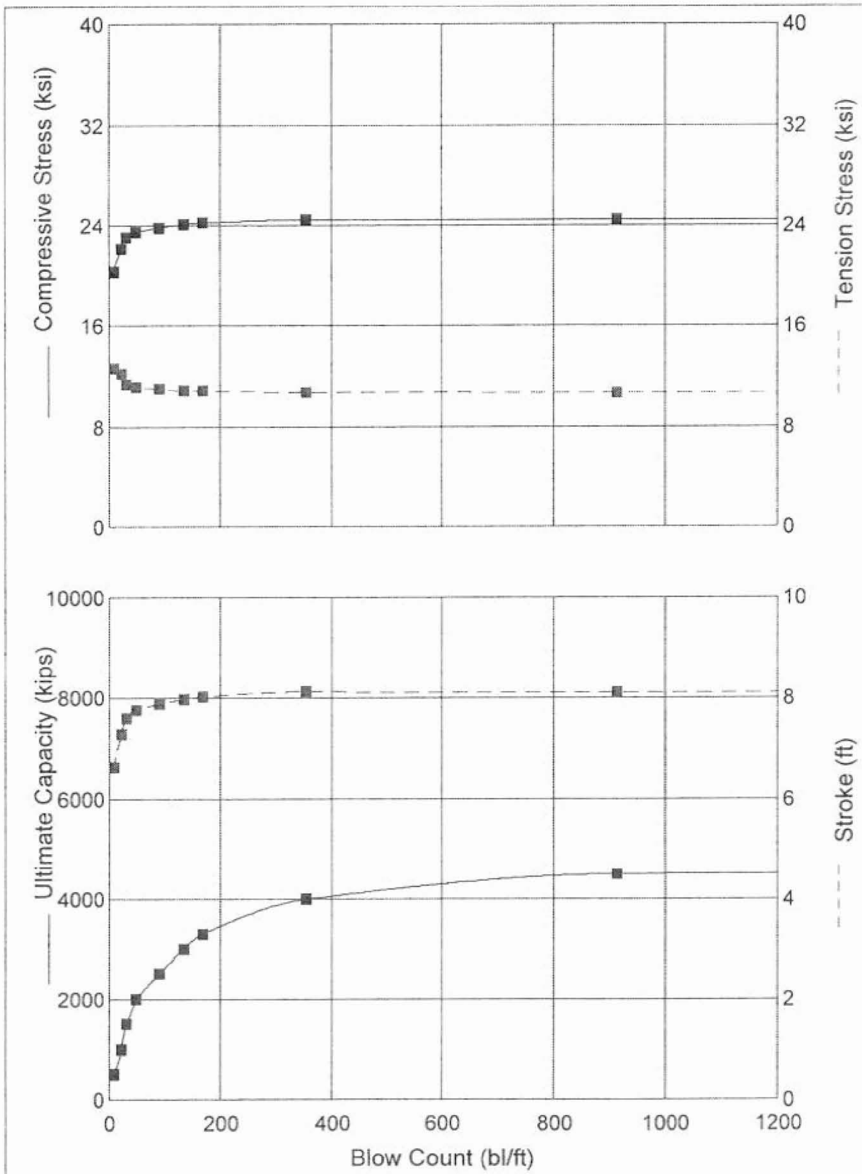


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	21.67	12.08	8.7	6.52	81.60
1000.0	24.05	11.49	22.4	7.31	77.96
1500.0	24.91	11.16	34.0	7.60	76.65
2000.0	25.73	10.97	56.9	7.89	80.41
2500.0	25.92	10.73	109.0	7.95	80.93
3000.0	26.13	10.53	171.8	8.02	81.77
3300.0	26.31	10.54	243.1	8.07	82.34
4000.0	26.61	10.45	841.2	8.18	83.64
4500.0	26.76	10.27	9999.0	8.23	84.20

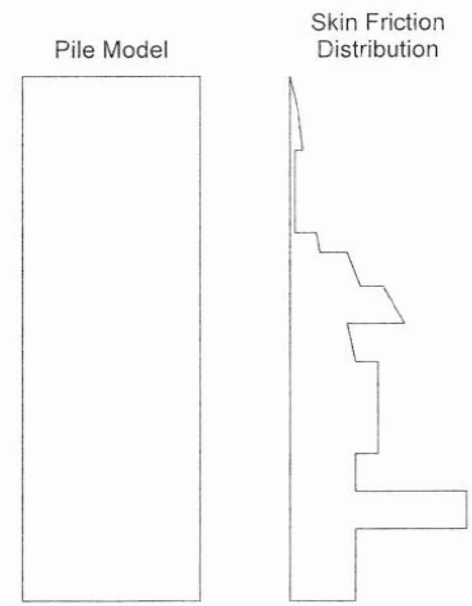
California D.O.T. Geotechnical Services
Feather River Pier 12

21-May-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	183.59 in2

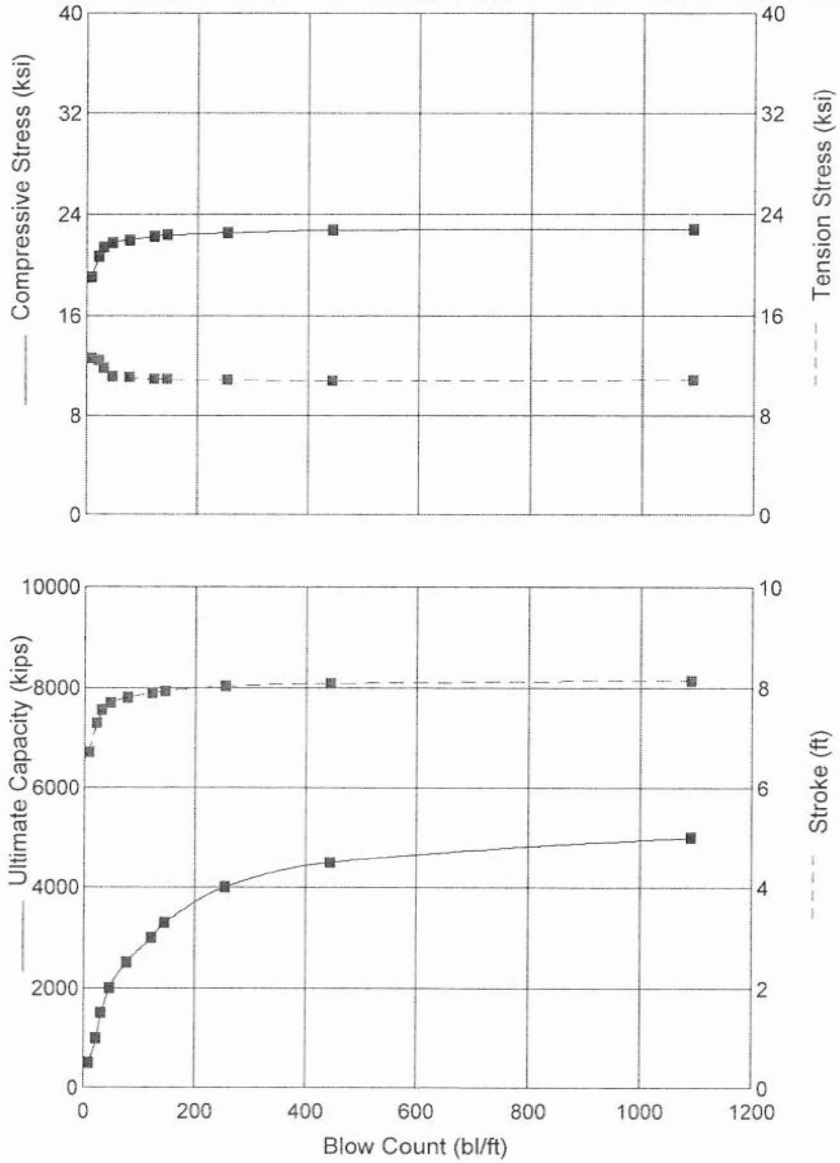


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	20.27	12.59	9.0	6.63	81.08
1000.0	22.14	12.22	23.2	7.28	77.95
1500.0	23.00	11.38	32.3	7.59	76.80
2000.0	23.48	11.15	50.2	7.75	78.80
2500.0	23.80	11.00	90.9	7.88	80.41
3000.0	24.07	10.85	133.7	7.97	81.54
3300.0	24.19	10.84	168.6	8.02	82.20
4000.0	24.44	10.72	354.3	8.12	83.38
4500.0	24.43	10.67	915.2	8.10	82.92
5000.0	24.58	10.49	9999.0	8.14	83.41

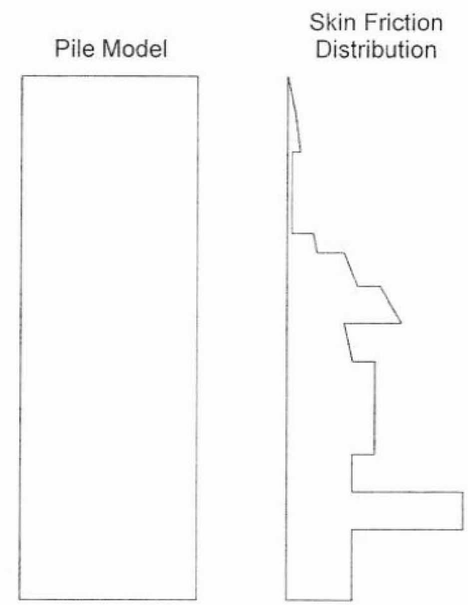
California D.O.T. Geotechnical Services
Feather River Pier 12

21-May-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	219.13 in2

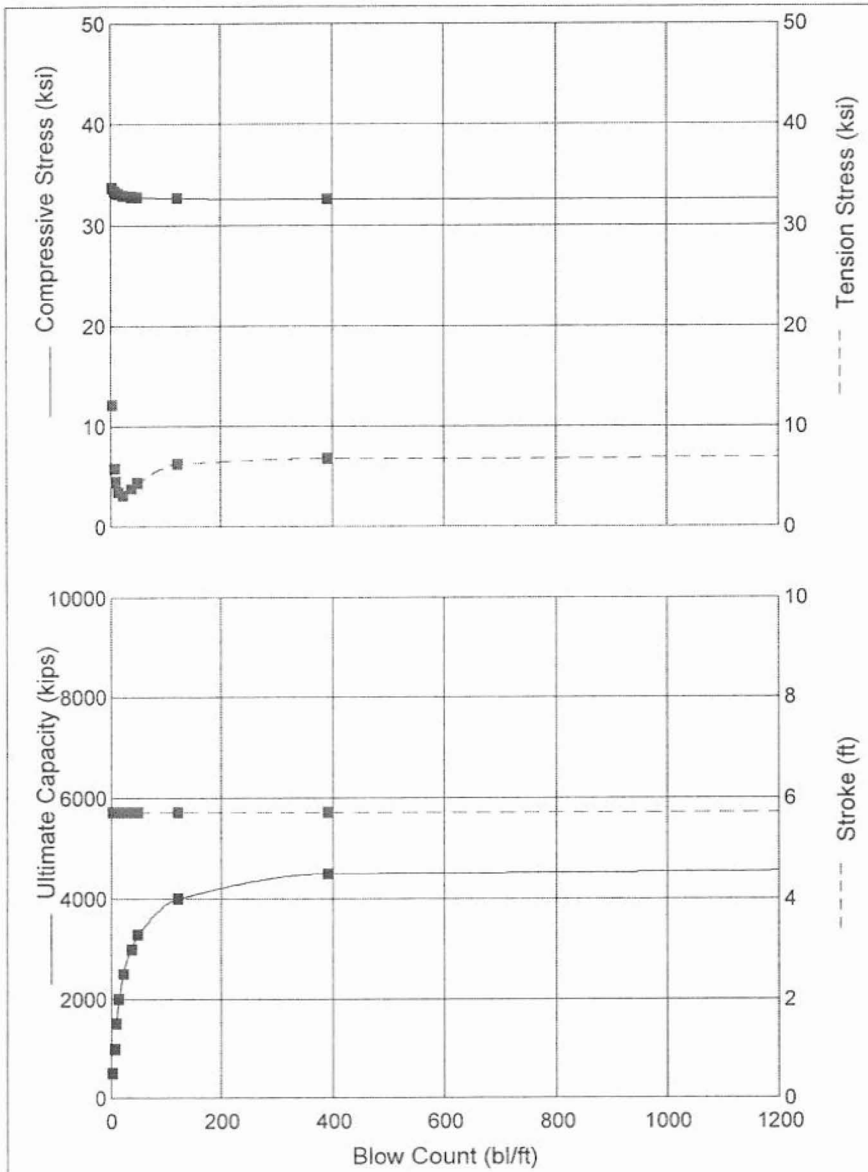


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	19.08	12.65	9.2	6.71	79.92
1000.0	20.68	12.48	24.0	7.29	77.66
1500.0	21.41	11.85	32.4	7.57	76.29
2000.0	21.77	11.14	47.1	7.70	78.03
2500.0	21.99	11.07	77.0	7.81	79.40
3000.0	22.25	10.93	121.2	7.90	80.54
3300.0	22.36	10.90	146.3	7.94	81.02
4000.0	22.52	10.85	253.8	8.03	82.04
4500.0	22.75	10.79	444.7	8.09	82.82
5000.0	22.85	10.84	1092.6	8.15	83.59

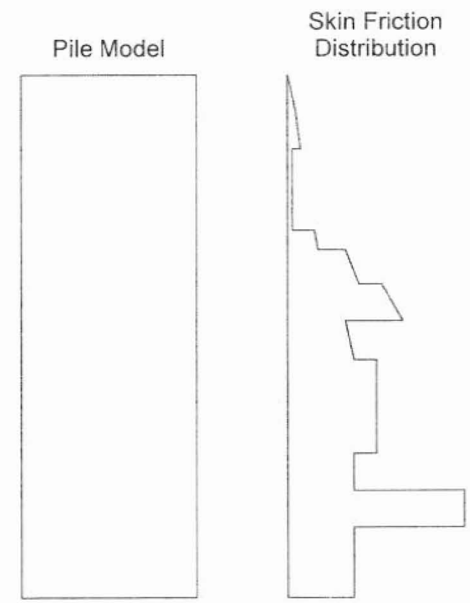
California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	111.33 in2



Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	33.77	12.04	3.4	5.71	272.24
1000.0	33.41	5.83	7.0	5.71	272.66
1500.0	33.24	4.49	10.5	5.71	270.23
2000.0	33.13	3.50	15.3	5.71	269.72
2500.0	33.03	3.11	23.3	5.71	269.34
3000.0	32.92	3.79	37.9	5.71	269.56
3300.0	32.86	4.44	50.0	5.71	269.53
4000.0	32.72	6.28	120.5	5.71	269.03
4500.0	32.62	6.81	392.7	5.71	268.40
5000.0	32.52	7.34	9999.0	5.71	267.58

California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
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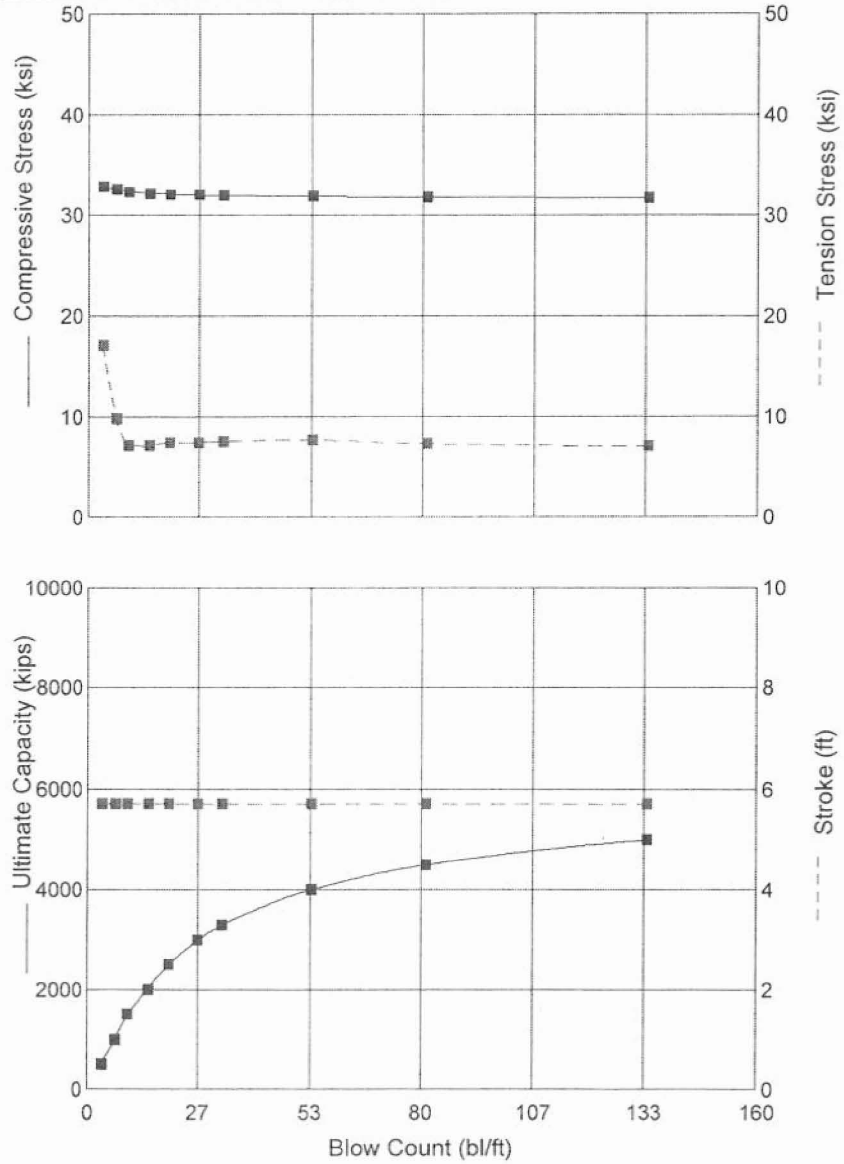
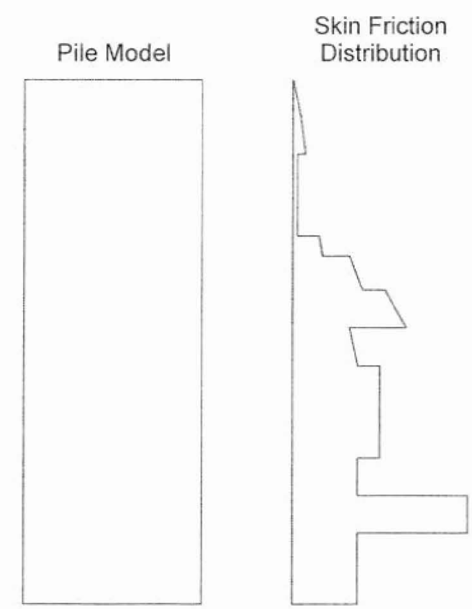


MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	147.66 in2



Res. Shaft = 90 %
(Proportional)

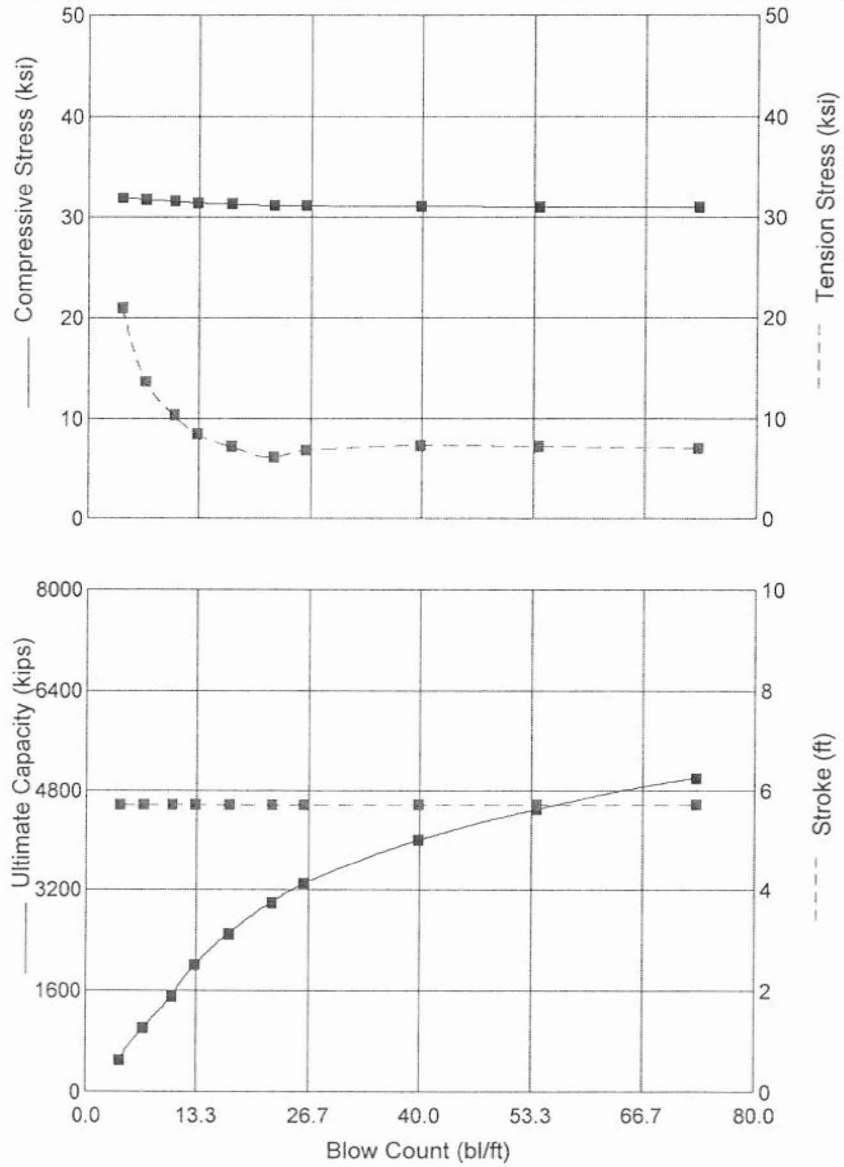
California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	32.82	17.11	3.7	5.71	272.56
1000.0	32.56	9.82	6.9	5.71	271.53
1500.0	32.34	7.18	9.9	5.71	271.48
2000.0	32.14	7.13	14.6	5.71	271.69
2500.0	32.06	7.45	19.8	5.71	271.53
3000.0	31.99	7.45	26.7	5.71	271.06
3300.0	31.94	7.54	32.5	5.71	270.65
4000.0	31.84	7.70	53.7	5.71	269.39
4500.0	31.76	7.30	81.1	5.71	268.31
5000.0	31.70	7.05	134.1	5.71	267.43

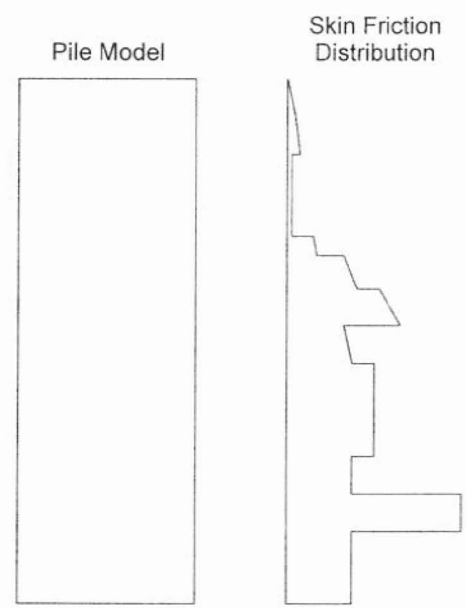
California D.O.T. Geotechnical Services
Feather River Pier 12

21-May-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	183.59 in2



Res. Shaft = 90 %
(Proportional)

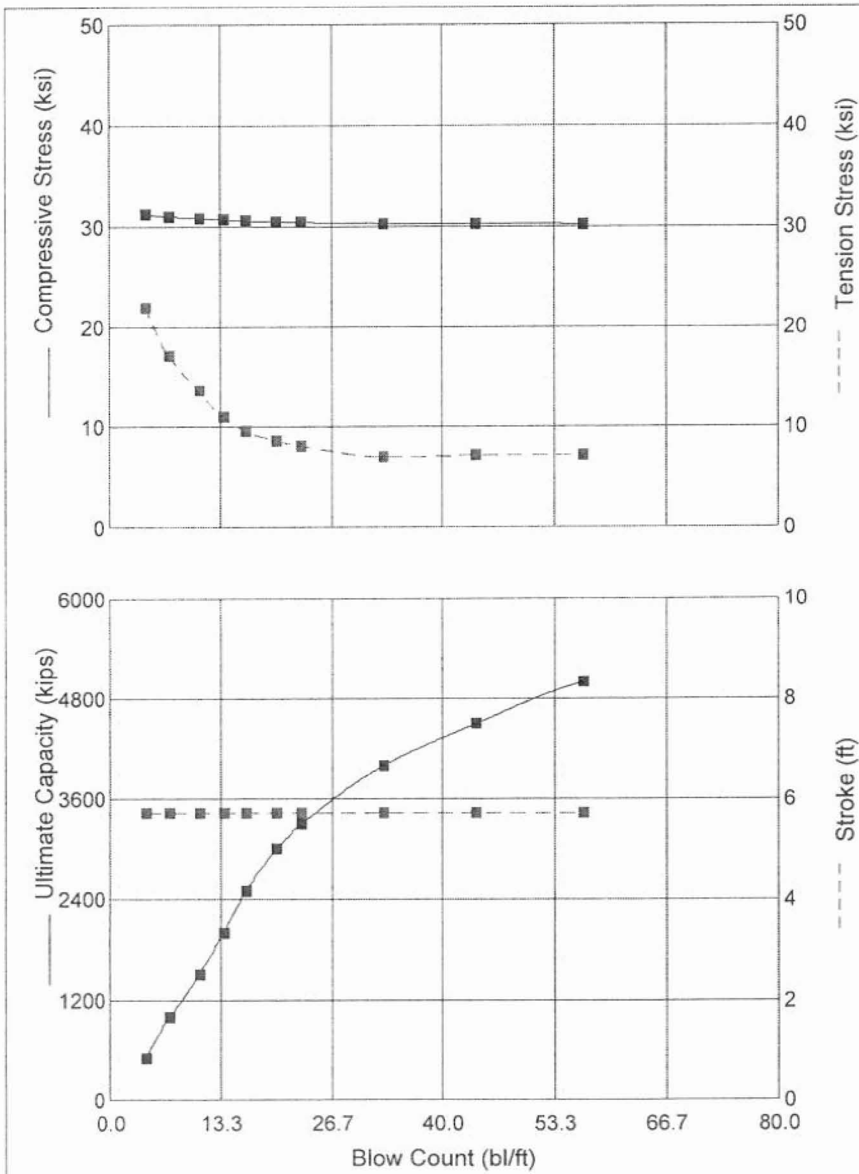
California D.O.T. Geotechnical Services
Feather River Pier 12

21-May-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	31.95	20.98	4.1	5.71	272.16
1000.0	31.75	13.67	6.9	5.71	272.08
1500.0	31.57	10.34	10.4	5.71	272.17
2000.0	31.41	8.45	13.2	5.71	271.94
2500.0	31.28	7.23	17.2	5.71	271.42
3000.0	31.16	6.19	22.3	5.71	270.65
3300.0	31.12	6.87	26.2	5.71	270.09
4000.0	31.05	7.33	39.8	5.71	269.01
4500.0	31.00	7.24	54.0	5.71	268.64
5000.0	30.95	7.11	73.1	5.71	268.26

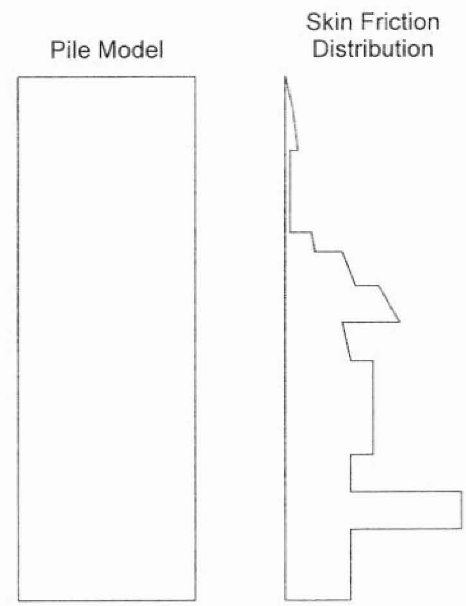
California D.O.T. Geotechnical Services
Feather River Pier 12

21-May-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71	ft
Efficiency	0.950	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.400	in
Skin Damping	0.051	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	219.13	in2

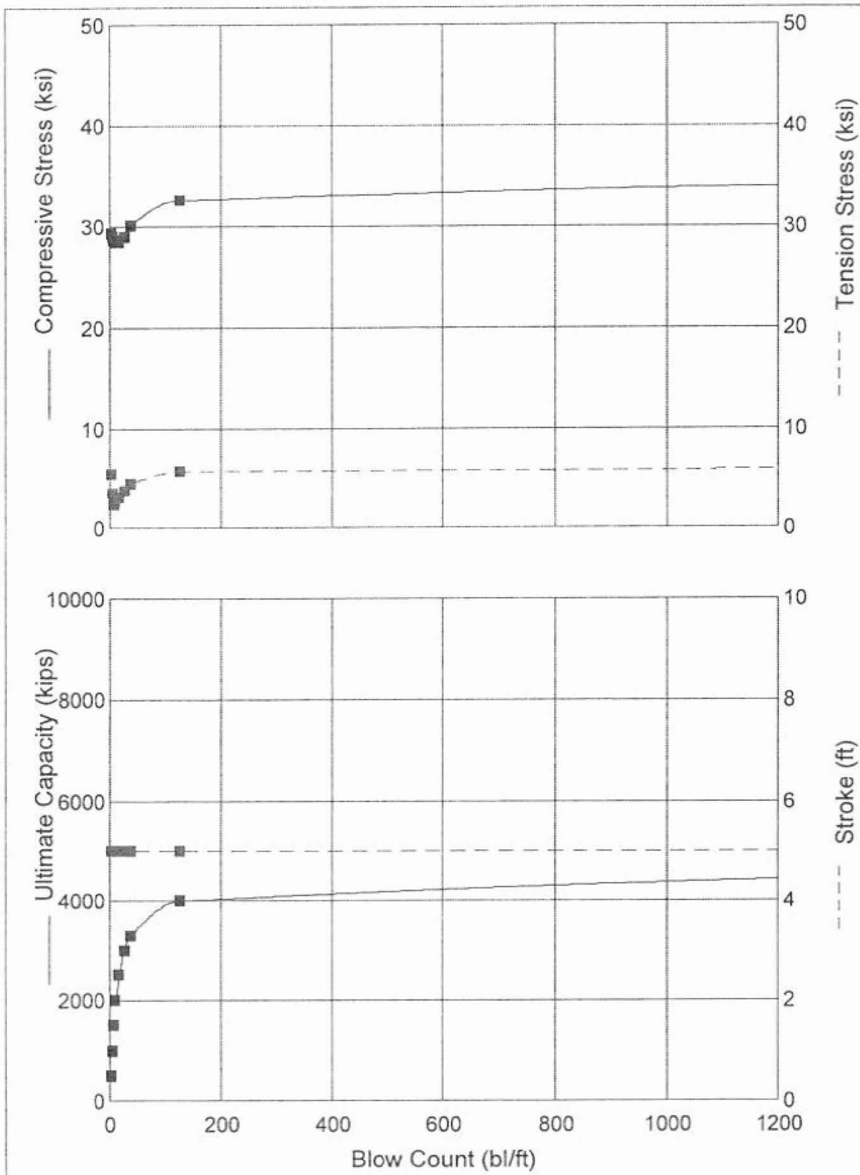


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	31.20	21.90	4.5	5.71	271.89
1000.0	30.98	17.05	7.2	5.71	271.99
1500.0	30.84	13.54	10.8	5.71	271.82
2000.0	30.70	10.92	13.7	5.71	271.39
2500.0	30.59	9.54	16.4	5.71	270.73
3000.0	30.49	8.57	20.1	5.71	269.90
3300.0	30.43	8.04	23.1	5.71	269.72
4000.0	30.31	6.96	33.0	5.71	269.24
4500.0	30.27	7.17	44.1	5.71	268.87
5000.0	30.22	7.19	56.9	5.71	268.49

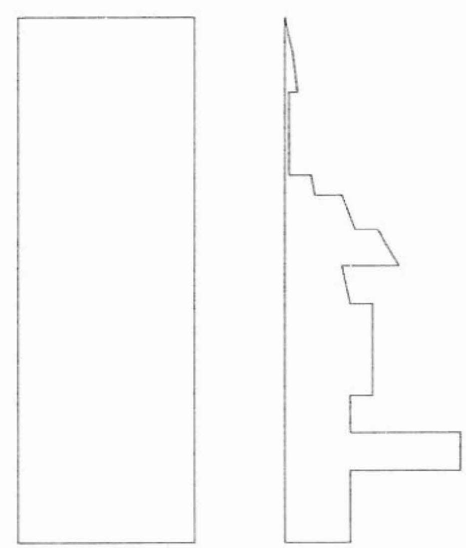
California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
GRLWEAP (TM) Version 2005



APE HI 400U

Stroke	5.00 ft
Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	111.33 in2

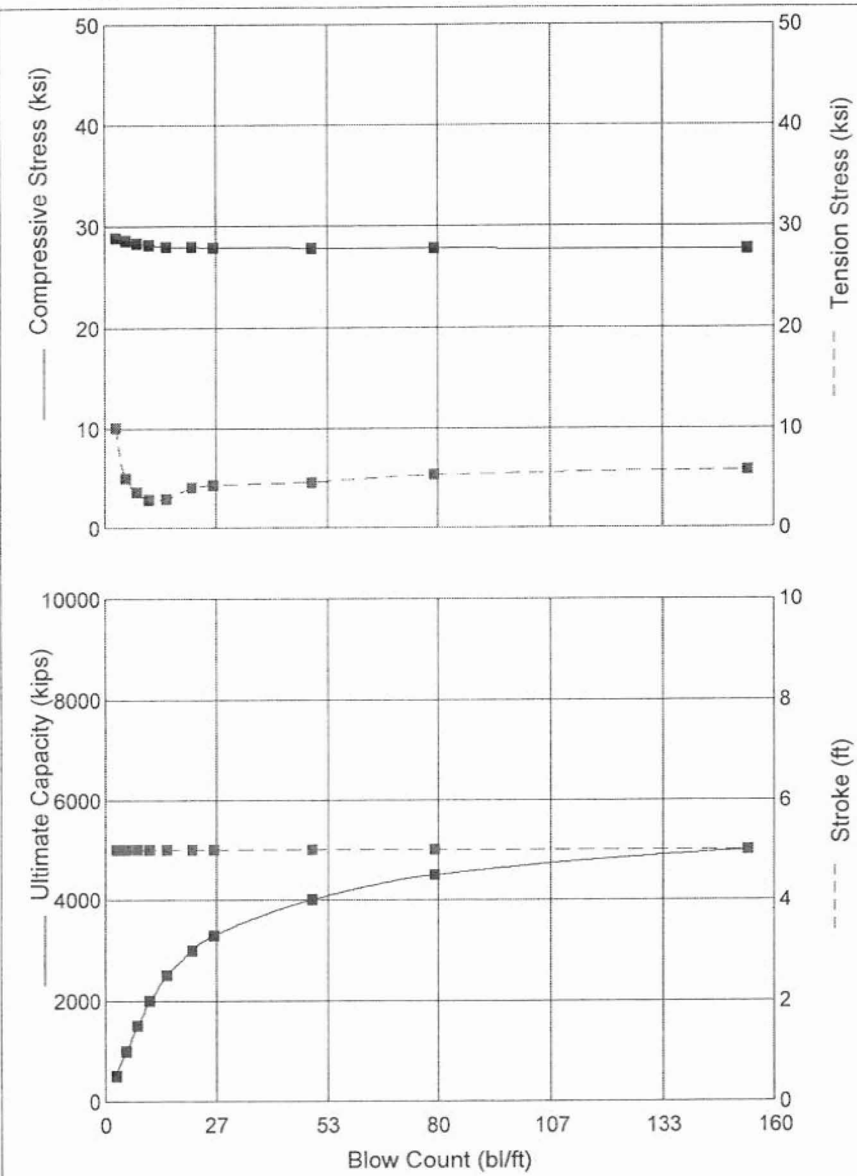


Res. Shaft = 90 %
(Proportional)

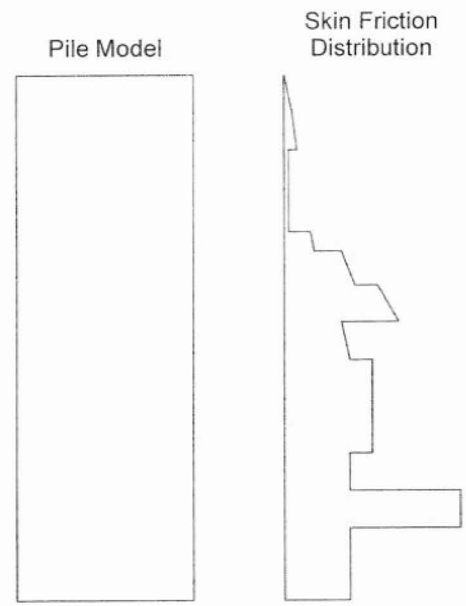
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	29.27	5.46	2.7	5.00	314.41
1000.0	28.92	3.54	5.1	5.00	336.05
1500.0	28.64	2.38	7.7	5.00	330.71
2000.0	28.47	2.62	10.8	5.00	329.47
2500.0	28.39	3.15	16.0	5.00	328.30
3000.0	28.95	3.78	26.7	5.00	324.79
3300.0	30.12	4.51	39.1	5.00	322.07
4000.0	32.63	5.73	124.7	5.00	319.95
4500.0	34.20	5.93	1609.4	5.00	319.39
5000.0	35.55	6.20	9999.0	5.00	318.81

California D.O.T. Geotechnical Services
Feather River Pier 12

23-May-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.400	in
Skin Damping	0.051	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	147.66	in2

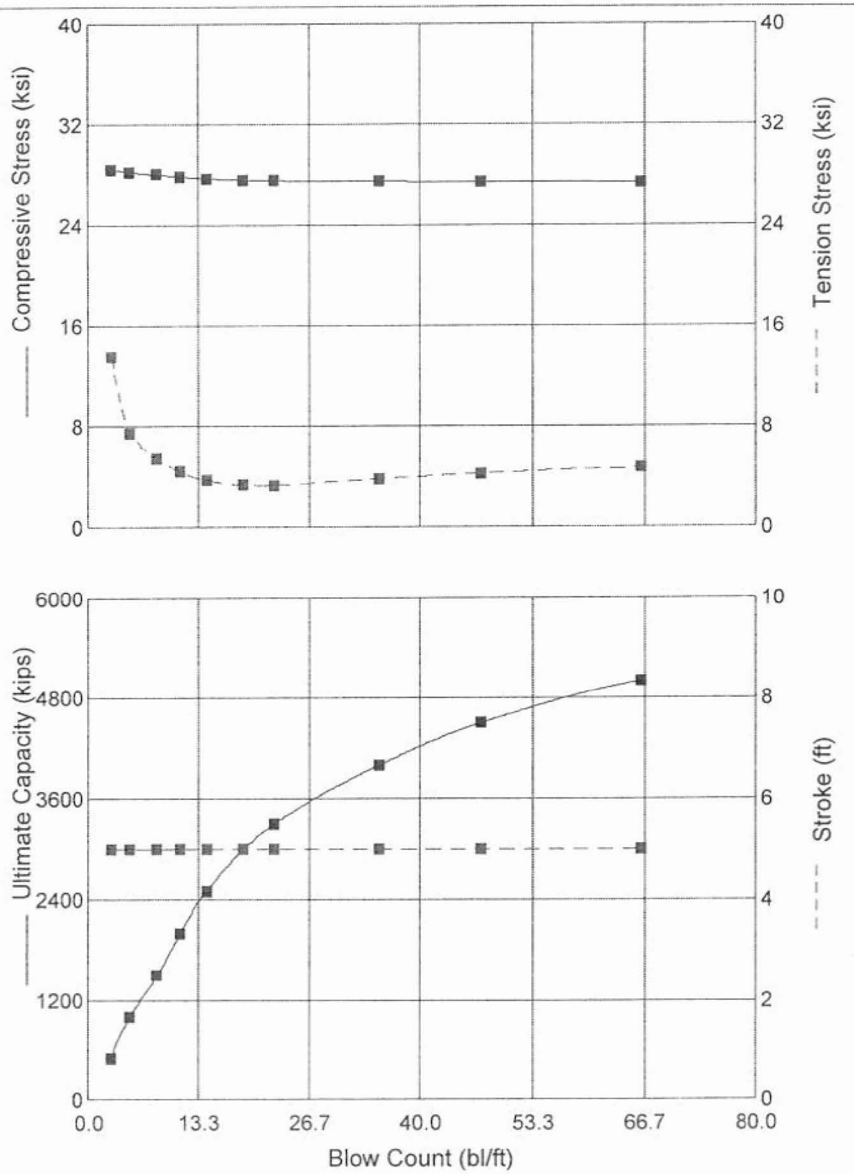


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	28.87	10.07	2.8	5.00	322.75
1000.0	28.61	5.05	5.1	5.00	327.03
1500.0	28.36	3.61	7.8	5.00	328.71
2000.0	28.18	2.88	10.7	5.00	327.65
2500.0	28.02	2.91	14.8	5.00	325.20
3000.0	27.96	4.05	20.8	5.00	321.89
3300.0	27.93	4.38	26.0	5.00	321.54
4000.0	27.84	4.65	49.6	5.00	320.67
4500.0	27.79	5.37	79.1	5.00	320.02
5000.0	27.73	5.85	153.6	5.00	319.24

California D.O.T. Geotechnical Services
Feather River Pier 12

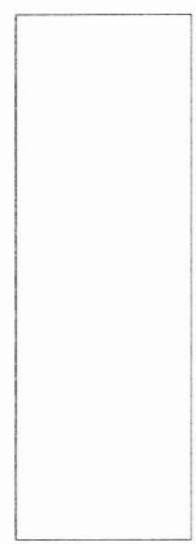
21-May-2008
GRLWEAP (TM) Version 2005



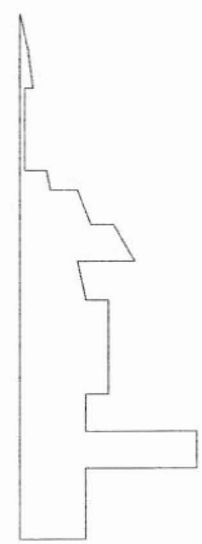
APE HI 400U

Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.400	in
Skin Damping	0.051	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	183.59	in2

Pile Model



Skin Friction
Distribution

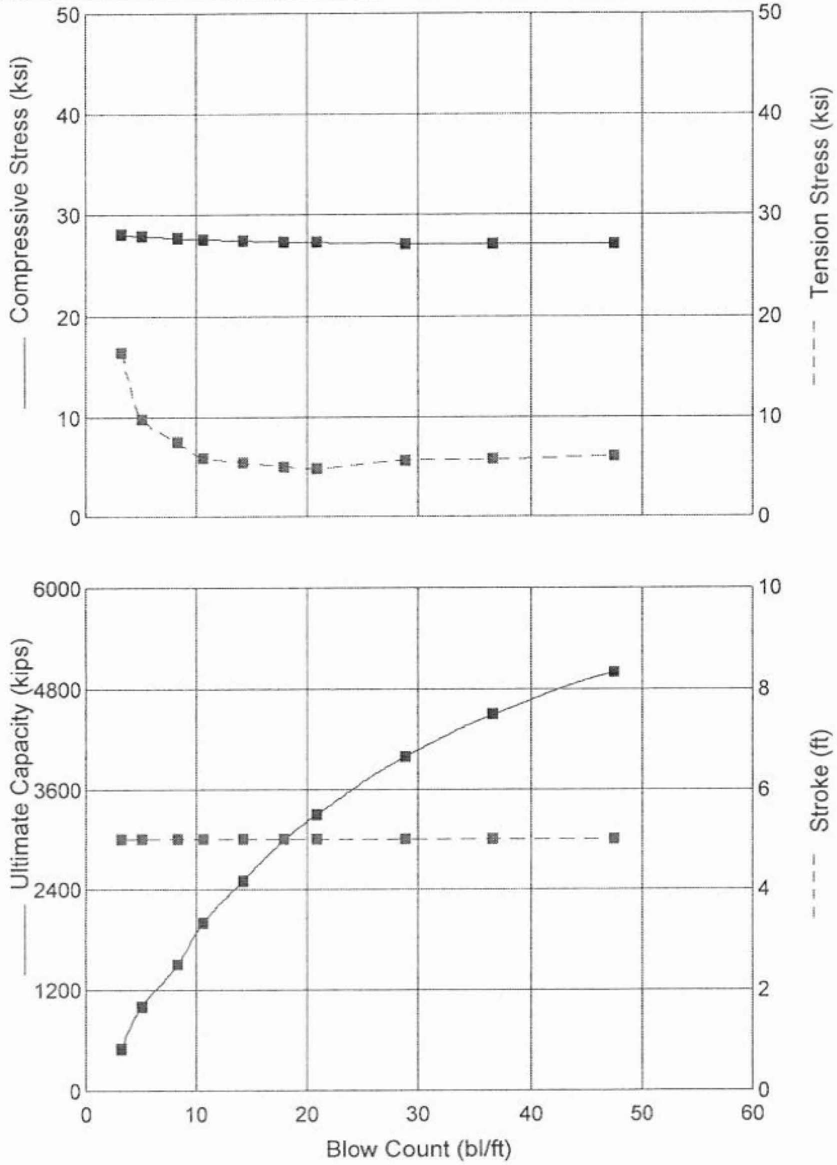


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	28.45	13.56	2.9	5.00	325.21
1000.0	28.25	7.44	5.1	5.00	326.92
1500.0	28.05	5.42	8.3	5.00	326.79
2000.0	27.89	4.45	11.2	5.00	325.01
2500.0	27.74	3.75	14.3	5.00	322.56
3000.0	27.61	3.40	18.7	5.00	321.96
3300.0	27.57	3.36	22.5	5.00	321.58
4000.0	27.50	3.86	35.2	5.00	321.69
4500.0	27.45	4.29	47.3	5.00	321.76
5000.0	27.41	4.74	66.2	5.00	321.61

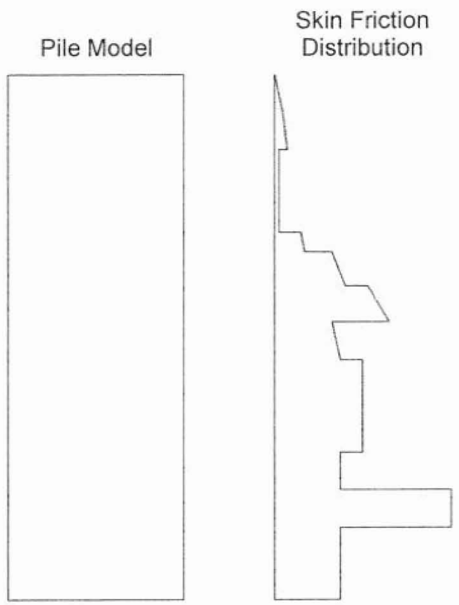
California D.O.T. Geotechnical Services
Feather River Pier 12

21-May-2008
GRLWEAP (TM) Version 2005



APE HI 400U

Stroke	5.00 ft
Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.400 in
Skin Damping	0.051 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	219.13 in2



Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	28.03	16.45	3.2	5.00	325.39
1000.0	27.86	9.84	5.1	5.00	325.98
1500.0	27.70	7.52	8.4	5.00	325.04
2000.0	27.57	5.97	10.7	5.00	322.80
2500.0	27.44	5.50	14.3	5.00	322.67
3000.0	27.32	5.08	18.0	5.00	322.99
3300.0	27.26	4.86	20.9	5.00	323.06
4000.0	27.15	5.71	28.9	5.00	322.94
4500.0	27.11	5.81	36.7	5.00	322.62
5000.0	27.07	6.11	47.5	5.00	322.11

Memorandum

Flex your power!
Be energy efficient!

To: REID BUELL
Senior Engineering Geologist
Office of Geotechnical Design North

Attn: Abu Barrie

Date: April 25, 2008

File: 03-SUT-99-PM11.0
03-1A4321
Feather River Bridge
Bridge Number 18-0026R

From: **DEPARTMENT OF TRANSPORTATION**
Division of Engineering Services
Geotechnical Services - MS 5

Subject: Driveability Study

Attached is a report summarizing the results of the driveability analysis perform by this Office for the subject piles of the above-referenced project.

If you have any questions or comments regarding this report, please contact Toua Vang at (916) 227-1060 or James Ta, P.E. at (916) 227-1050.

BRIAN LIEBICH, P.E.
Senior Transportation Engineer
Foundation Testing Branch

Attachment

JT/TV

FOUNDATION TESTING BRANCH

April 25, 2008

03-SUT-99-PM11.0

03-1A4321

Feather River Bridge

Bridge Number 18-0026R

Driveability Study

April 25, 2008

Project Information

03-SUT-99-PM11.0
03-1A4321
Feather River Bridge
Bridge Number 18-0026R

Subject

Driveability Study

Introduction

This Office has performed the pile driveability analyses for the proposed installation of the 90-inch diameter steel pipe piles at the abutment and pier locations of the above-referenced project. The analyses were based on the study requested by Mr. Abu Barrie of the Office of Geotechnical Design North on March 10, 2008, to support the foundation recommendations. Personnel from the Foundation Testing Branch (FTB) of the Office of Geotechnical Support performed the analysis utilizing the GRLWEAP™ computer program, Version 2005. This study provides the pile-driving systems to determine the appropriate hammer for achieving required tip elevations.

Description of Piling

The Feather River Bridge project includes the proposed installation of the 90-inch diameter steel pipe piles at the abutment and pier locations. According to the Standard Specifications Section 49-5, Steel Piles, "Steel pipe piles shall conform to the following requirements: 2) Steel pipe piles 360 mm (14-inch) and greater in diameter shall conform to the requirements in ASTM Designation: A252, Grade 3"; therefore, this study will assume the steel minimum yield strength of 45 ksi (Grade 3) for the analysis.

Subsurface Conditions and Soil Resistance Parameters

Based on the submitted Log of Test Borings (LOTB) performed at these control locations (North Bank, South Bank, and Channel), three test borings were analyzed for this study. Boring B-16 was drilled within the north bank abutment location, Boring B-1 was drilled within the south bank abutment location and Boring B-8 was drilled within the channel location of Pier 11. According to Borings B-1, B-8 and B-16, the foundation material at the site consists of loose to very dense sand, silty sand, sandy silt, fine sand with gravel and cobbles. Very stiff cohesive soils were encountered within the soil matrix in the lower strata of Boring B-8. Table I presents the soil resistance parameters that were utilized to model the dynamic soil behavior.

Table I: Soil Resistance Parameters

PARAMETER	QUAKE	DAMPING
Skin (Shaft)	0.10 in	0.05 sec/ft
Toe	0.75 in	0.15 sec/ft

Pile Driving Resistance

When installing driven piles, the piles must overcome resistance to penetration developed by the soil. The driving resistance determines the size of the required impact hammer and the stress magnitude imparted to the steel pile by the driving system. An estimate of driving resistance is necessary to perform a driveability study when investigating the potential for pile damage due to steel overstressing during driving. Driving resistance can be related to static axial capacity using set-up and relaxation factors. These factors are applied to various soil layers penetrated while driving the steel pile. There are several methods available to estimate the pile static axial capacity and driving resistance. The methods will generally determine a range of axial capacities for a given pile penetration. To be conservative, pile tip elevations are generally based on lower estimates of static capacity, but higher capacity estimates are generally used for the driveability analysis.

The maximum driving resistances used in the analyses were based on information provided by Mr. Abu Barrie. According to the Geotechnical Designer, the maximum driving resistance for the subject piles is estimated to be 6,000 kips. This value was based on the anticipated driving resistance that consist 60% to 90% from skin friction (Qs) and 40% to 10% from end bearing (Qp), at the abutment and pier locations. The set-up factor at this site is expected to be minimal and therefore negligible due to the presence of non-cohesive (granular) soils within the embedded length of the pile.

Description of Pile Driving Systems

This study involved modeling the performance of three selected driving systems to reflect the range of rated energies possibly appropriate for the installation of the 90-inch diameter steel pipe piles to the specified tip elevations at the abutment and pier locations.

The analyses were performed using GRLWEAP™ recommended, default parameters. For each hammer, the analysis was performed with the hammer operating at maximum stroke for determining driving-behavior stresses imparted to the steel pile. The analysis also includes the assumption that two (2) splices will be required at the approximate depth (pile length) of 50 feet and 100 feet. As a result, each hammer was utilized to demonstrate the predicted blow counts and corresponding maximum compressive stresses expected during pile driving. Standard configurations for the hammer driving systems and related components were based upon information published in GRLWEAP™ literature and database. The hammer characteristics are listed in Table II for the abutment and pier piles.

Table II: Summary of Hammer Systems

Hammer Manufacturer	APE	Delmag	Menck
Hammer Model	**HI 400U**	**D 100-13**	**MHU 400**
Hammer Type	Hydraulic Impact	Open End Diesel	Hydraulic Impact
Rated Energy	400.0 ft-kips	265.67 ft-kips	289.55 ft-kips
Ram Weight	80.0 kips	22.1 kips	50.7 kips
Maximum Stroke	5.0 ft	10.7 ft	5.7 ft

Discussion of Results

Analysis printouts and charts depicting predicted relationships between ultimate capacity and driving stresses versus blow counts for each of the hammers are included in Appendix A, B and C. The analyses results of the three control locations at the North Bank, South Bank and Channel are summarized below in Tables III, IV and V for the subject piles, respectively.

Table III: Summary of Results at the North Bank (B-16)

Hammer Manufacturer / Model	Pile Thickness (Inches)	Blow Counts (Blows/ft)	Stroke (ft)	Allowable Stress at 95% F_y (ksi)	Compressive Stress at Maximum Stroke (ksi)
Delmag / D 100-13	1.25	528	10.3	42.75	22.29
Delmag / D 100-13	1.50	447	10.3	42.75	20.38
Delmag / D 100-13	1.75	450	10.4	42.75	18.89
Delmag / D 100-13	2.00	465	10.5	42.75	17.53
Menck / MHU 400	1.25	120	5.7	42.75	28.31
Menck / MHU 400	1.50	106	5.7	42.75	27.20
Menck / MHU 400	1.75	97	5.7	42.75	26.17
Menck / MHU 400	2.00	96	5.7	42.75	25.21
APE / HI 400U	1.25	93	5	42.75	26.32
APE / HI 400U	1.50	76	5	42.75	25.62
APE / HI 400U	1.75	68	5	42.75	24.93
APE / HI 400U	2.00	65	5	42.75	24.32

Table IV: Summary of Results at the South Bank (B-1)

Hammer Manufacturer / Model	Pile Thickness (Inches)	Blow Counts (Blows/ft)	Stroke (ft)	Allowable Stress at 95% F_y (ksi)	Compressive Stress at Maximum Stroke (ksi)
Delmag / D 100-13	1.25	505	10.6	42.75	17.68
Delmag / D 100-13	1.50	522	10.3	42.75	20.34
Delmag / D 100-13	1.75	479	10.5	42.75	18.99
Delmag / D 100-13	2.00	505	10.6	42.75	17.68
Menck / MHU 400	1.25	94	5.7	42.75	27.55
Menck / MHU 400	1.50	83	5.7	42.75	26.48
Menck / MHU 400	1.75	80	5.7	42.75	25.48
Menck / MHU 400	2.00	81	5.7	42.75	24.61
APE / HI 400U	1.25	77	5	42.75	25.44
APE / HI 400U	1.50	64	5	42.75	24.84
APE / HI 400U	1.75	60	5	42.75	24.25
APE / HI 400U	2.00	59	5	42.75	23.69

Table V: Summary of Results at the Channel (B-8)

Hammer Manufacturer / Model	Pile Thickness (Inches)	Blow Counts (Blows/ft)	Stroke (ft)	Allowable Stress at 95% F_y (ksi)	Compressive Stress at Maximum Stroke (ksi)
Delmag / D 100-13	1.25	636	10.3	42.75	22.34
Delmag / D 100-13	1.50	506	10.3	42.75	20.43
Delmag / D 100-13	1.75	481	10.4	42.75	18.94

Table V (Continue): Summary of Results at the Channel (B-8)

Hammer Manufacturer / Model	Pile Thickness (Inches)	Blow Counts (Blows/ft)	Stroke (ft)	Allowable Stress at 95% F_y (ksi)	Compressive Stress at Maximum Stroke (ksi)
Delmag / D 100-13	2.00	511	10.5	42.75	17.72
Menck / MHU 400	1.25	93	5.7	42.75	27.84
Menck / MHU 400	1.50	82	5.7	42.75	26.71
Menck / MHU 400	1.75	79	5.7	42.75	25.68
Menck / MHU 400	2.00	80	5.7	42.75	24.79
APE / HI 400U	1.25	77	5	42.75	25.85
APE / HI 400U	1.50	64	5	42.75	25.19
APE / HI 400U	1.75	59	5	42.75	24.58
APE / HI 400U	2.00	58	5	42.75	23.98

The GRLWEAP™ wave equation program is a one-dimensional analysis and does not consider buckling or bending of the pile due to non-uniform blows or localized stresses at the pile tip, which may occur during pile driving. Also, it has been observed in the field that significantly harder or softer driving could occur than the GRLWEAP™ predictions.

North Bank and South Bank

Analysis 1: Delmag D 100-13; 90-inch diameter steel pipe piles at 1.25-inch, 1.50-inch, 1.75-inch, and 2.00- inch shell thickness

The analysis for the Delmag D 100-13 indicates that this hammer would be capable of driving the steel pipe piles within the allowable compressive stress of 95% Fy (0.95*45=42.75ksi) with the estimated 6,000 kips driving resistance at the maximum stroke condition but would exceed the maximum allowable blow counts limit (blow/ft > 120).

<u>Analysis 2:</u> Menck MHU 400; 90-inch diameter steel pipe piles at 1.25-inch, 1.50-inch, 1.75-inch, and 2.00-inch shell thickness

The analysis for the Menck MHU 400 indicates that this hammer would be capable of driving the steel pipe piles within the allowable compressive stress of 95% Fy (0.95*45=42.75ksi) with the estimated 6,000 kips driving resistance at the maximum stroke condition.

<u>Analysis 3:</u> APE HI 400U; 90-inch diameter steel pipe piles at 1.25-inch, 1.50-inch, 1.75-inch, and 2.00-inch shell thickness

The analysis for the APE HI 400U indicates that this hammer would be capable of driving the steel pipe piles within the allowable compressive stress of 95% Fy (0.95*45=42.75ksi) with the estimated driving resistance of 6,000 kips at the maximum stroke condition.

<u>Channel (Pier Location)</u>

<u>Analysis 4:</u> Delmag D 100-13; 90-inch diameter steel pipe piles at 1.25-inch, 1.50-inch, 1.75-inch, and 2.00-inch shell thickness

The analysis for the Delmag D 100-13 indicates that this hammer would be capable of driving the steel pipe piles within the allowable compressive stress of 95% Fy (0.95*45=42.75ksi) with the estimated 6,000 kips driving resistance at the maximum stroke condition but would exceed the maximum allowable blow counts limit (blows/ft > 120).

<u>Analysis 5:</u> Menck MHU 400; 90-inch diameter steel pipe piles at 1.25-inch, 1.50-inch, 1.75-inch, and 2.00-inch thickness

The analysis for the Menck MHU 400 indicates that this hammer would be capable of driving the steel pipe piles within the allowable compressive stress of 95% Fy (0.95*45=42.75ksi) with the estimated 6,000 kips driving resistance at the maximum stroke condition.

Analysis 6: APE HI 400U; 90-inch diameter steel pipe piles at 1.25-inch, 1.50-inch, 1.75-inch, and 2.00-inch shell thickness

The analysis for the APE HI 400U indicates that this hammer would be capable of driving the steel pipe piles within the allowable compressive stress of 95% Fy (0.95*45=42.75ksi) with the estimated driving resistance of 6,000 kips at the maximum stroke condition.

It should be noted that all driving output data generated by the GRLWEAP™ Program presumes uniform hammer blows, with leads and hammer perfectly aligned. The analyses do not consider the effects of eccentric blows, malfunctioning hammers, or Contractor-selected reduction in fuel setting for Diesel hammers. Some Diesel hammers may exhibit operating efficiencies significantly lower than the theoretical percentage used in the analyses, subject to condition and maintenance states. The analyses also do not consider higher stresses, which could be induced by bending, non-axial hammer alignment, or high local stress concentrations, and therefore should be considered as minimum values. Local pile damage can occur at the pile tip due to highly localized pile stresses caused by non-uniform resistance from sloping rock, boulders, cobbles, or obstructions, even if the calculated average axial stresses are within the allowable limits. These stresses cannot be predicted by wave equation analysis. The analysis results are only valid for the assumptions noted in the above sections and the soil profile input provided.

Conclusions and Recommendations

Based upon the results of the driveability analysis with reference to the submitted information from the Geotechnical Designer, the following have been concluded:

- Delmag hammer D 100-13 would be capable of driving the 90-inch diameter steel pipe piles at 1.25-, 1.50-, 1.75-, and 2.00-inch shell thickness (Fy=45ksi) within the acceptable allowable compressive stress at the north bank, south bank, and channel (pier) locations but would exceed the maximum allowable blow counts limit (blows/feet > 120).

- Menck hammer MHU 400 would be capable of driving the 90-inch diameter steel pipe piles at 1.25-, 1.50-, 1.75-, and 2.00-inch shell thickness (Fy=45ksi) within the acceptable allowable compressive stress at the north bank, south bank, and channel (pier) locations.

- APE HI 400U would be capable of driving the 90-inch diameter steel pipe piles at 1.25-, 1.5-, 1.75-, and 2.00-inch shell thickness within the acceptable allowable compressive stress at the north bank, south bank, and channel (pier) locations.

- Piles shall be made using ASTM A 252 Grade 3 steel as per section 49-5.01 of the Caltrans' Standard Specifications.

- A pile driving system submittal for this project is necessary upon hammer(s) selection. The driving system submittal must contain a driveability analysis showing that the proposed driving system will install all the piles to the specified tip elevations at acceptable rates of penetration without overstressing the piles.

- Hard driving conditions should be anticipated due to the very dense nature of the granular materials (gravel and cobbles). Please refer to the Log of Test Borings (LOTB) for specific location and depths. Center relief drilling may be necessary and this issue should be address in the foundation recommendations (if applicable).

- As only a limited number of large diameter (greater than 1 meter) and very few extremely large diameter (greater than 3 meters) pipe pile installations exist, the behavior of these piles during driving is not yet well documented. Therefore driving conditions during actual construction can differ significantly from those described in this report.

If you have any questions or comments pertaining to this report, please contact Toua Vang at (916) 227-1060.

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STATE OF CALIFORNIA

04/30/08

APPENDIX A

Driveability Analysis

Charts and Graphs

Feather River Bridge (North Bank)

Bridge Number 18-0026R

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	19.70	14.81	6.7	8.88	115.61
1500.0	20.97	14.39	28.7	9.52	110.11
2500.0	21.40	13.77	47.0	9.82	110.66
3500.0	21.86	13.74	103.4	10.01	113.24
4500.0	22.08	13.78	170.7	10.14	115.12
5500.0	22.12	13.70	321.1	10.23	116.09
6000.0	22.29	13.73	528.3	10.27	116.65
7500.0	22.53	13.71	9999.0	10.39	118.27

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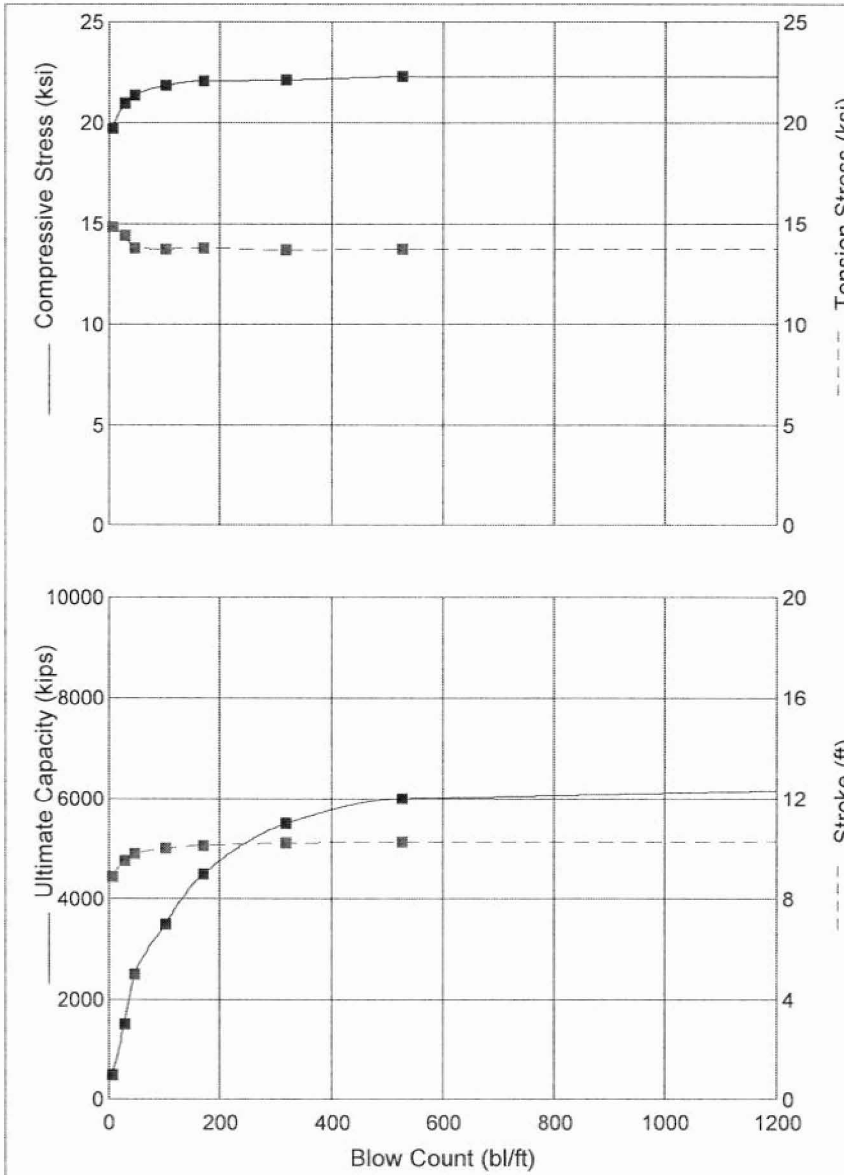
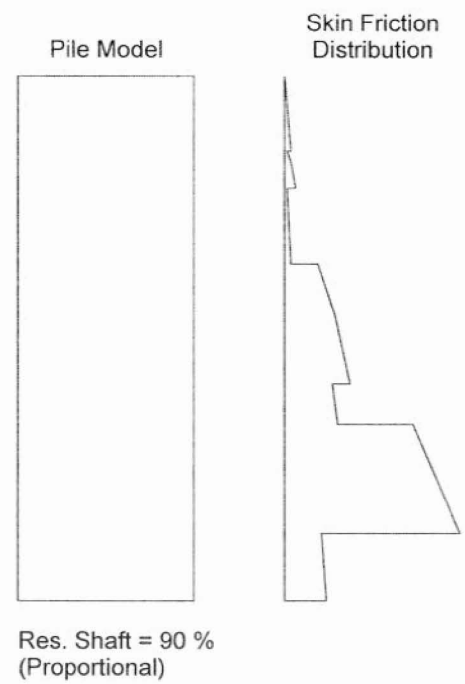
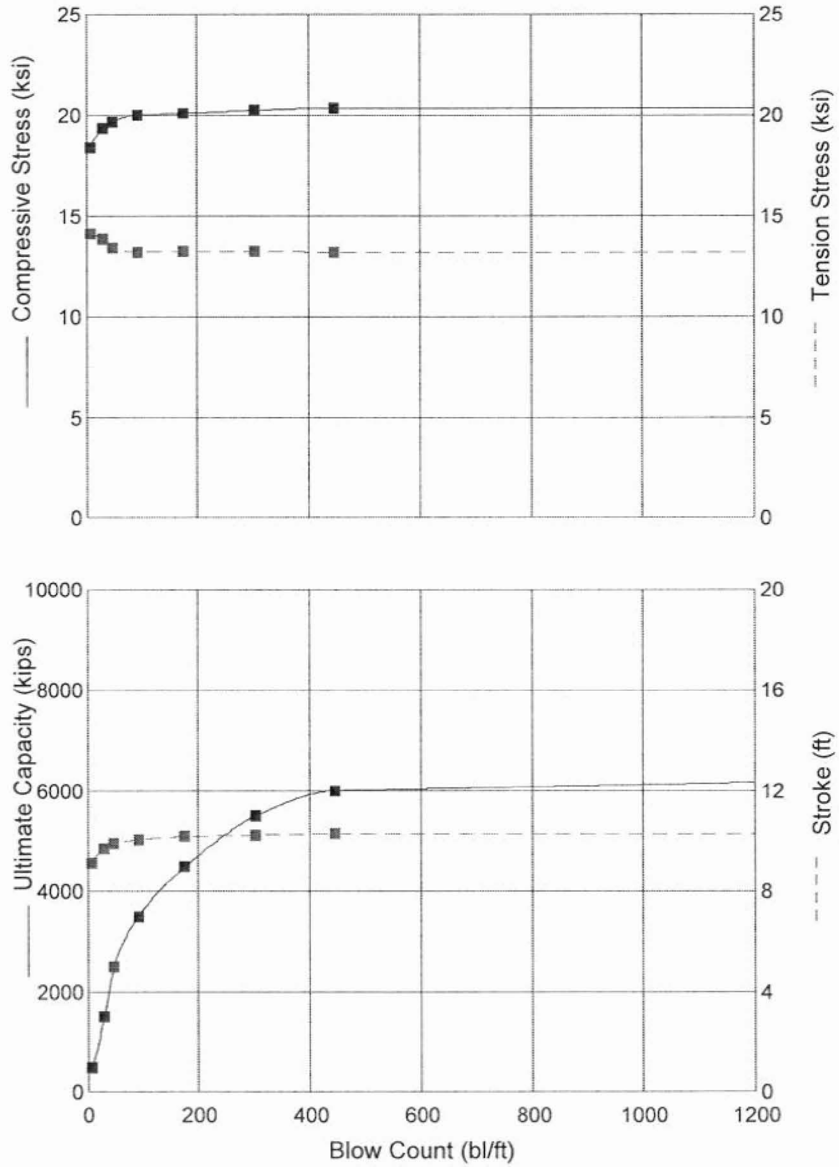


DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2

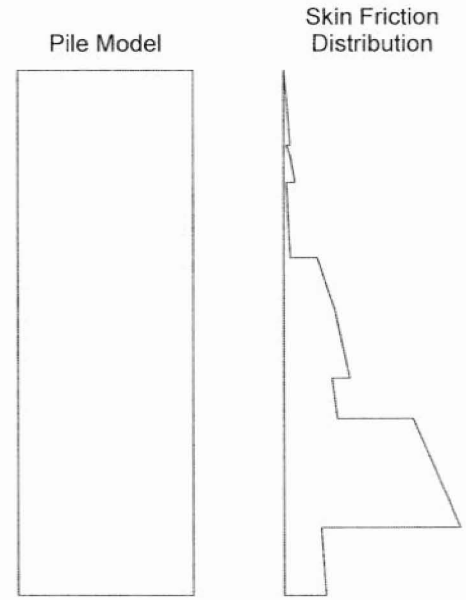


Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	18.40	14.11	6.6	9.14	114.70
1500.0	19.34	13.86	30.2	9.71	109.67
2500.0	19.66	13.41	47.0	9.92	109.82
3500.0	20.03	13.22	92.0	10.06	111.71
4500.0	20.12	13.24	176.6	10.19	113.47
5500.0	20.27	13.26	305.6	10.24	114.10
6000.0	20.38	13.22	446.7	10.29	114.62
7500.0	20.44	13.30	9999.0	10.41	116.09



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	417.05 in2



Res. Shaft = 90 %
(Proportional)

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	17.13	13.55	6.2	9.30	113.55
1500.0	18.05	13.28	31.7	9.88	109.02
2500.0	18.44	12.94	47.4	10.10	109.70
3500.0	18.45	12.67	87.2	10.17	110.20
4500.0	18.76	12.74	188.0	10.31	112.22
5500.0	18.80	12.72	316.2	10.34	112.44
6000.0	18.89	12.78	450.4	10.37	112.81
7500.0	18.95	12.90	9999.0	10.48	114.37

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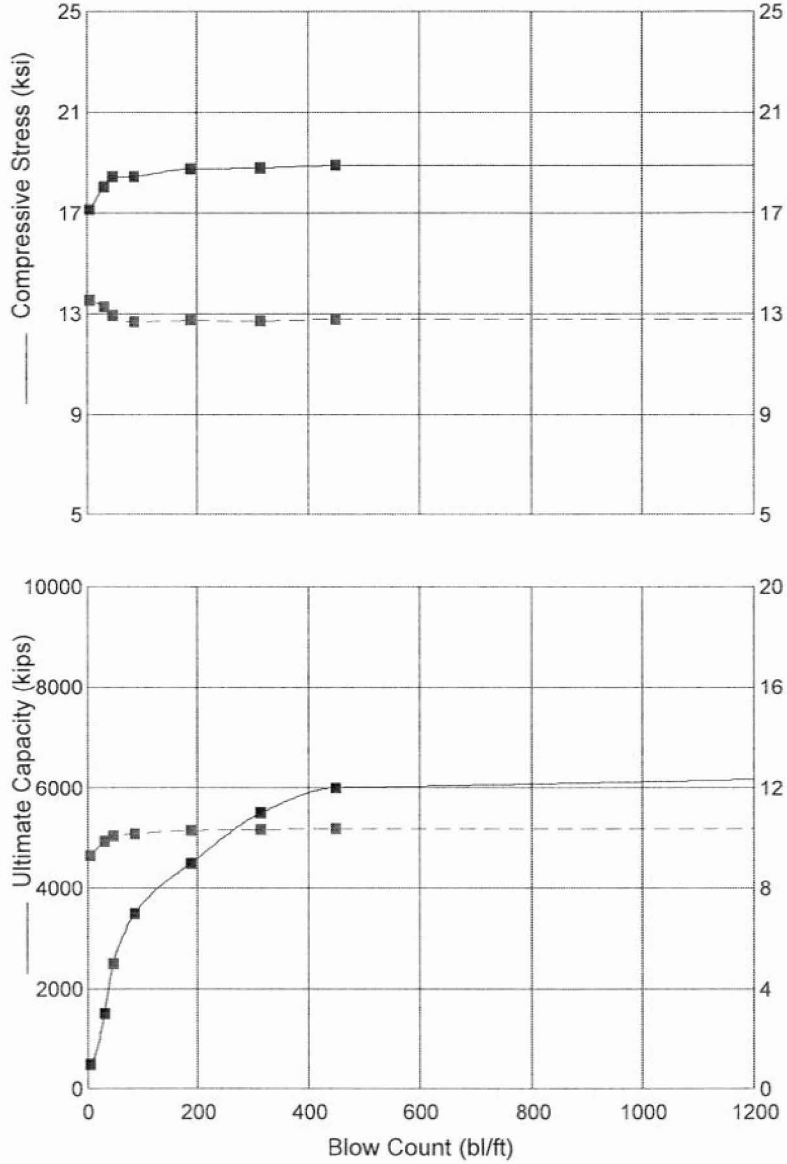
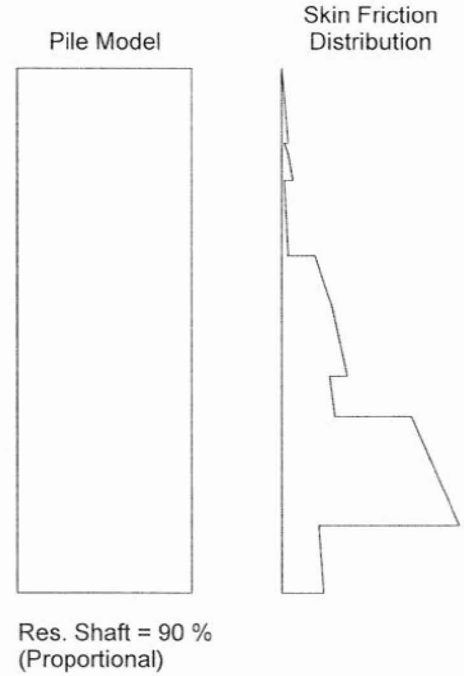


DELMAG D100-13

Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	485.18	in2



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	16.20	13.02	5.7	9.56	113.82
1500.0	16.92	12.56	33.3	9.99	107.12
2500.0	17.22	12.45	48.7	10.22	108.33
3500.0	17.39	12.27	84.5	10.30	108.92
4500.0	17.53	12.21	202.8	10.40	110.29
5500.0	17.54	12.27	334.8	10.47	111.26
6000.0	17.53	12.31	465.3	10.50	111.58
7500.0	17.74	12.41	9999.0	10.56	112.31

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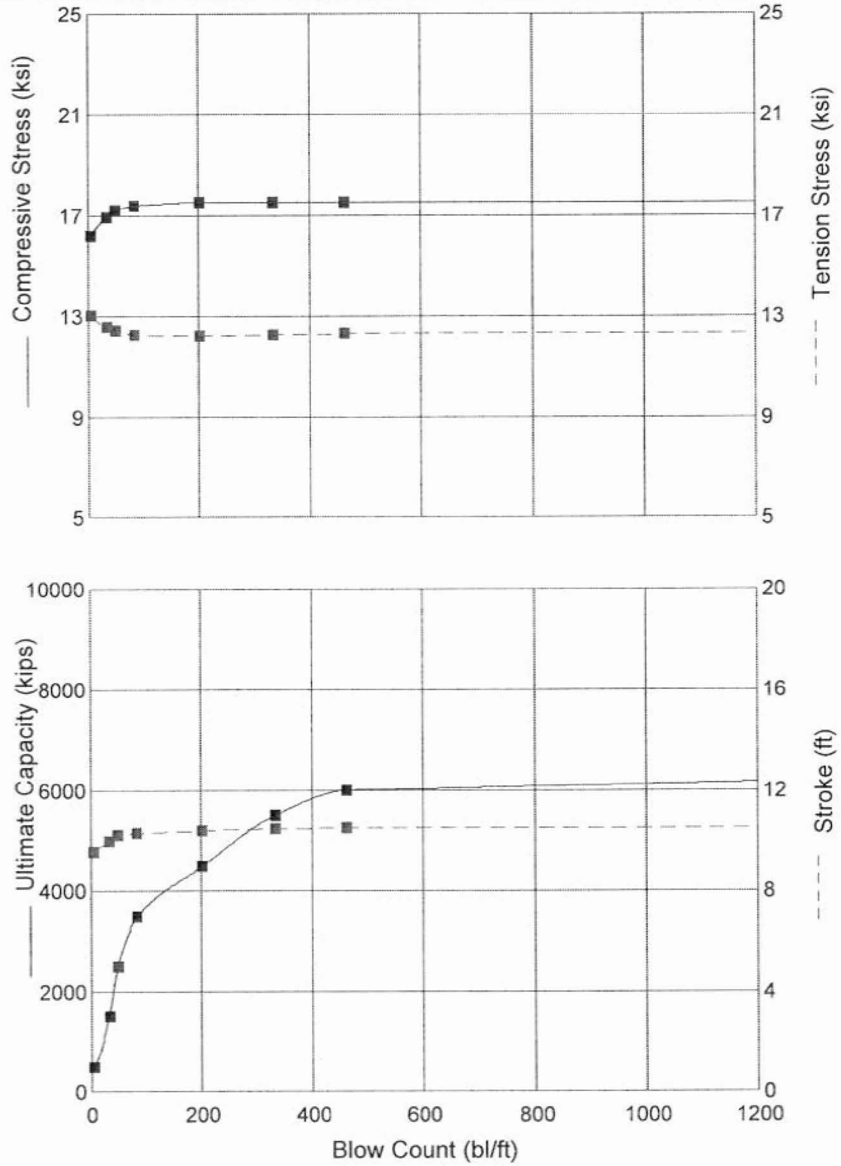
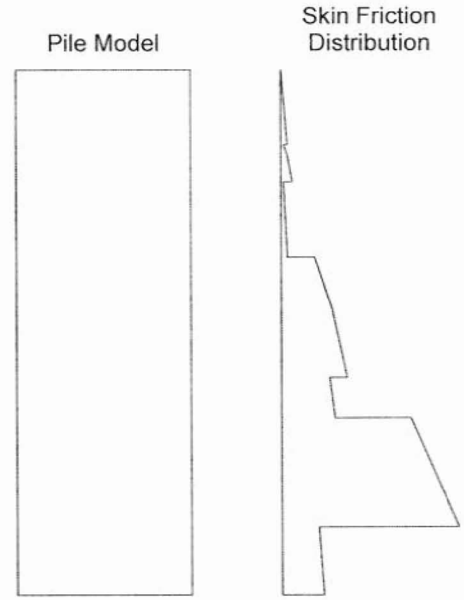


DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	552.92 in2



Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	28.86	23.61	6.5	5.71	270.31
1500.0	28.70	17.51	14.9	5.71	270.12
2500.0	28.59	14.90	22.6	5.71	269.83
3500.0	28.48	13.43	31.0	5.71	269.50
4500.0	28.41	12.20	45.9	5.71	269.28
5500.0	28.34	11.26	80.5	5.71	269.13
6000.0	28.31	10.85	120.1	5.71	269.08
7500.0	28.23	9.78	429.5	5.71	268.96
8500.0	28.19	9.22	9999.0	5.71	268.98

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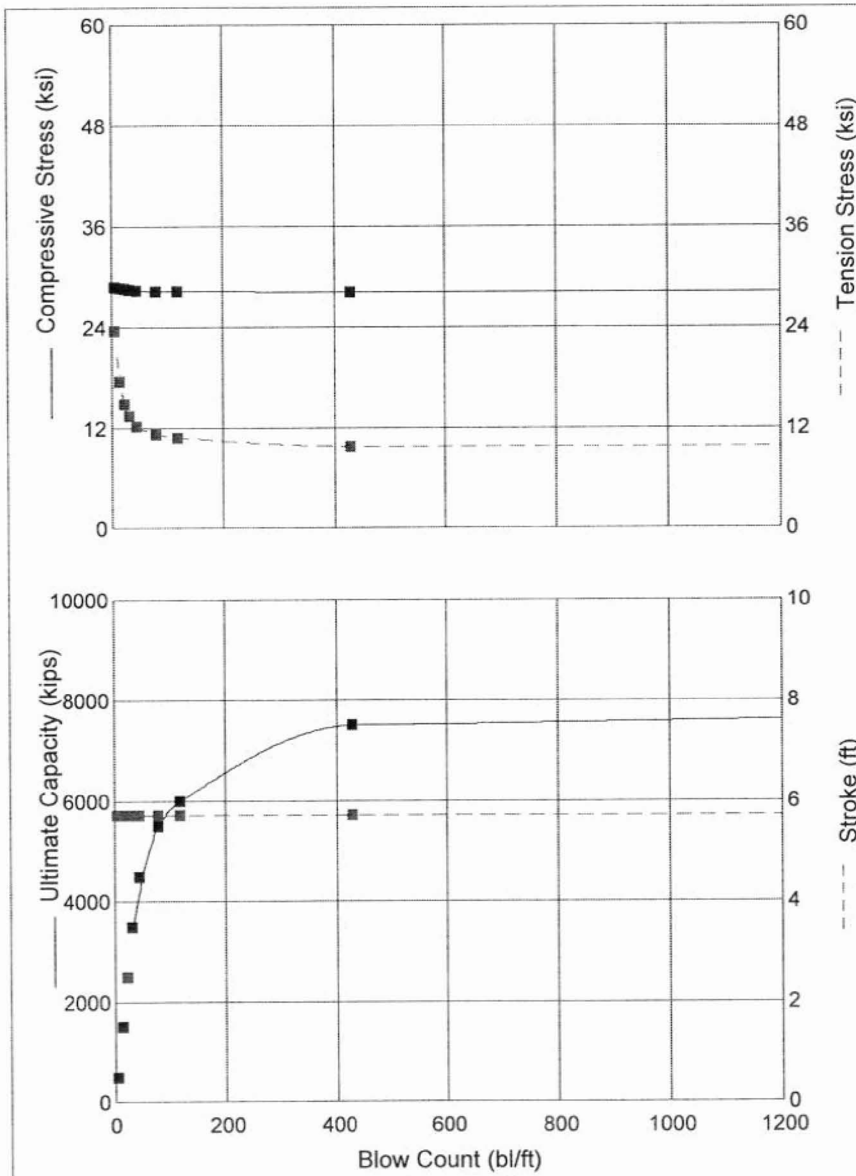
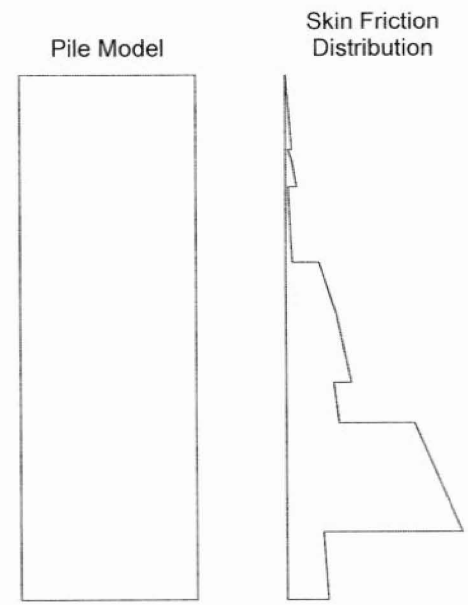


MENCK MHU 400	
Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2



Res. Shaft = 72 %
(Proportional)

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	27.64	22.57	7.0	5.71	269.35
1500.0	27.52	18.06	15.5	5.71	269.18
2500.0	27.43	16.39	24.9	5.71	269.17
3500.0	27.35	15.04	33.1	5.71	269.19
4500.0	27.29	13.95	46.9	5.71	269.20
5500.0	27.23	12.97	75.8	5.71	269.21
6000.0	27.20	12.57	105.9	5.71	269.22
7500.0	27.13	11.58	437.9	5.71	269.24
8500.0	27.09	11.01	9999.0	5.71	269.25

California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

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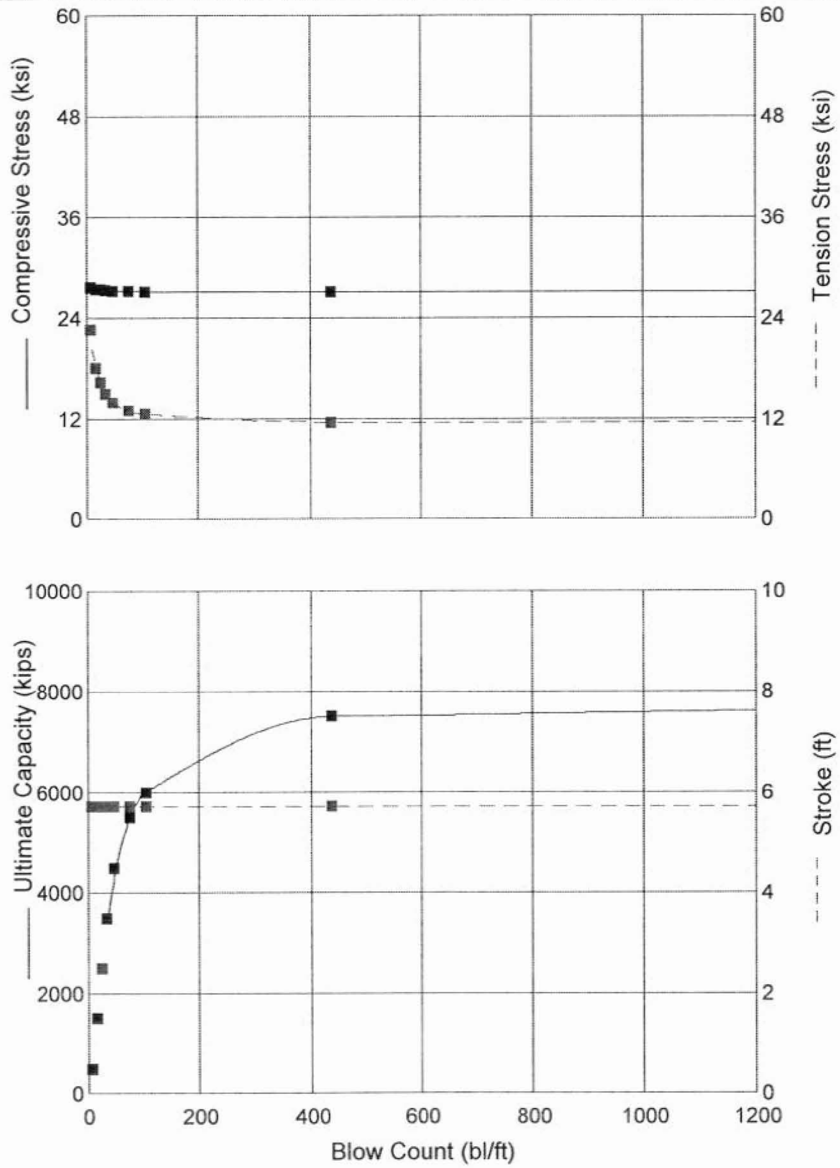
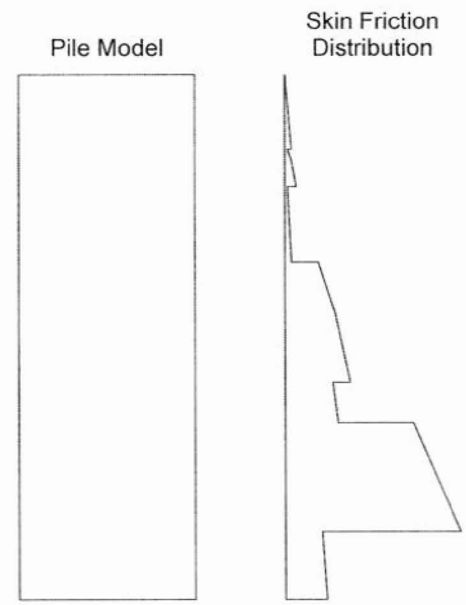


MENCK MHU 400	
Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	417.05 in2



Res. Shaft = 70 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	26.52	21.46	7.0	5.71	268.58
1500.0	26.43	18.67	16.1	5.71	268.58
2500.0	26.35	17.34	26.9	5.71	268.58
3500.0	26.29	16.16	35.1	5.71	268.69
4500.0	26.25	15.17	48.2	5.71	268.69
5500.0	26.20	14.34	73.2	5.71	268.69
6000.0	26.17	13.95	97.1	5.71	268.69
7500.0	26.10	12.96	436.4	5.71	268.69
8500.0	26.07	12.45	9999.0	5.71	268.69

California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

14-Apr-2008
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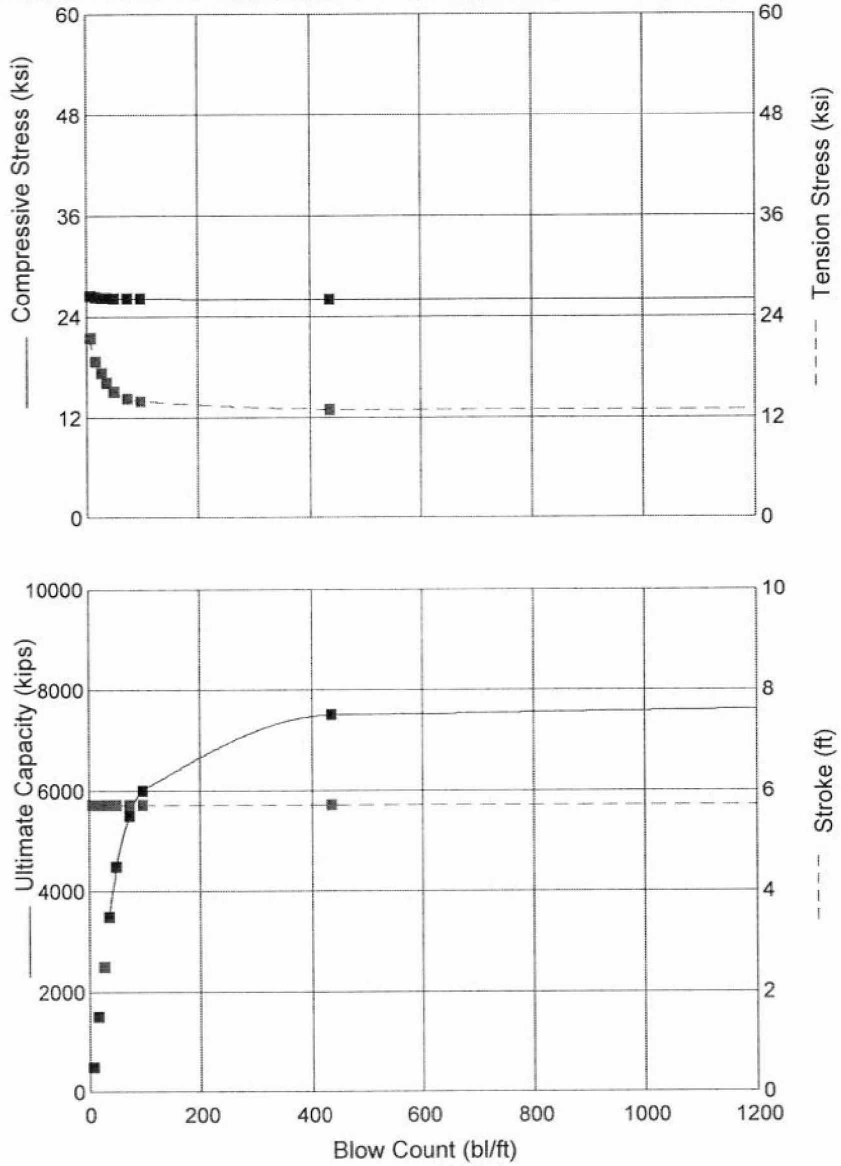
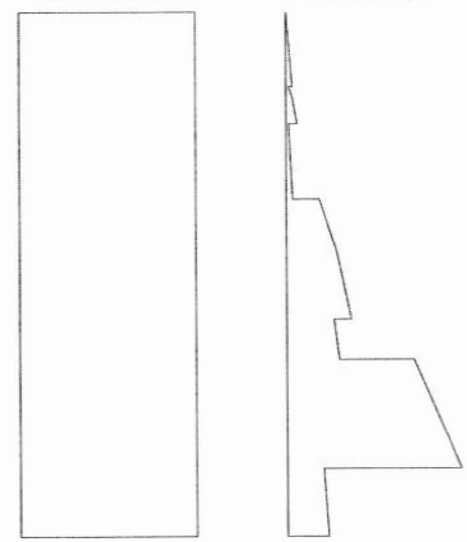


MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	485.18 in2

Pile Model

Skin Friction
Distribution



Res. Shaft = 70 %
(Proportional)

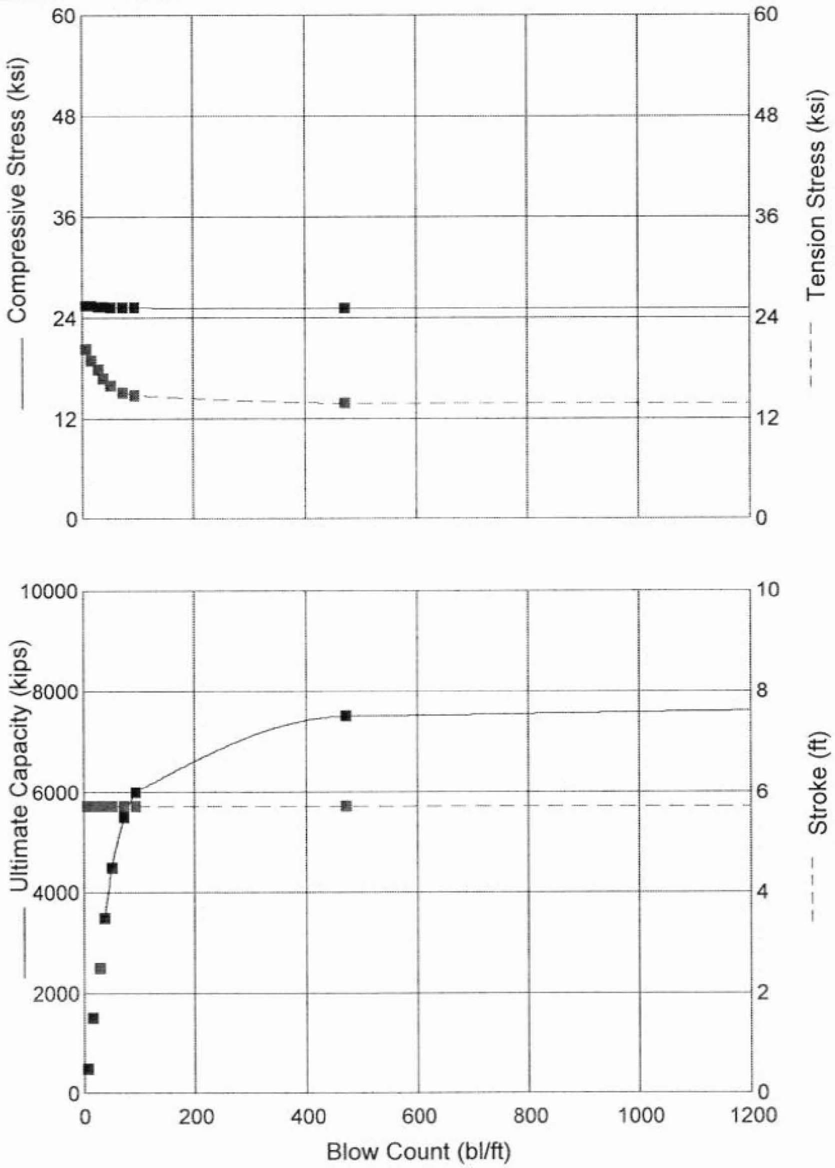
California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

14-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	25.49	20.33	7.0	5.71	267.76
1500.0	25.42	18.97	17.0	5.71	267.75
2500.0	25.36	17.86	29.2	5.71	267.74
3500.0	25.31	16.85	37.6	5.71	267.74
4500.0	25.27	15.95	50.6	5.71	267.73
5500.0	25.23	15.18	74.3	5.71	267.73
6000.0	25.21	14.84	95.6	5.71	267.72
7500.0	25.15	13.90	472.4	5.71	267.71
8500.0	25.12	13.43	9999.0	5.71	267.71

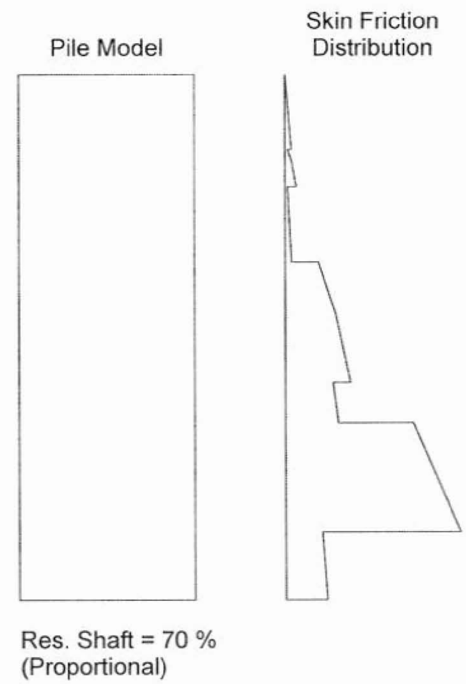
California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

14-Apr-2008
GRLWEAP (TM) Version 2005

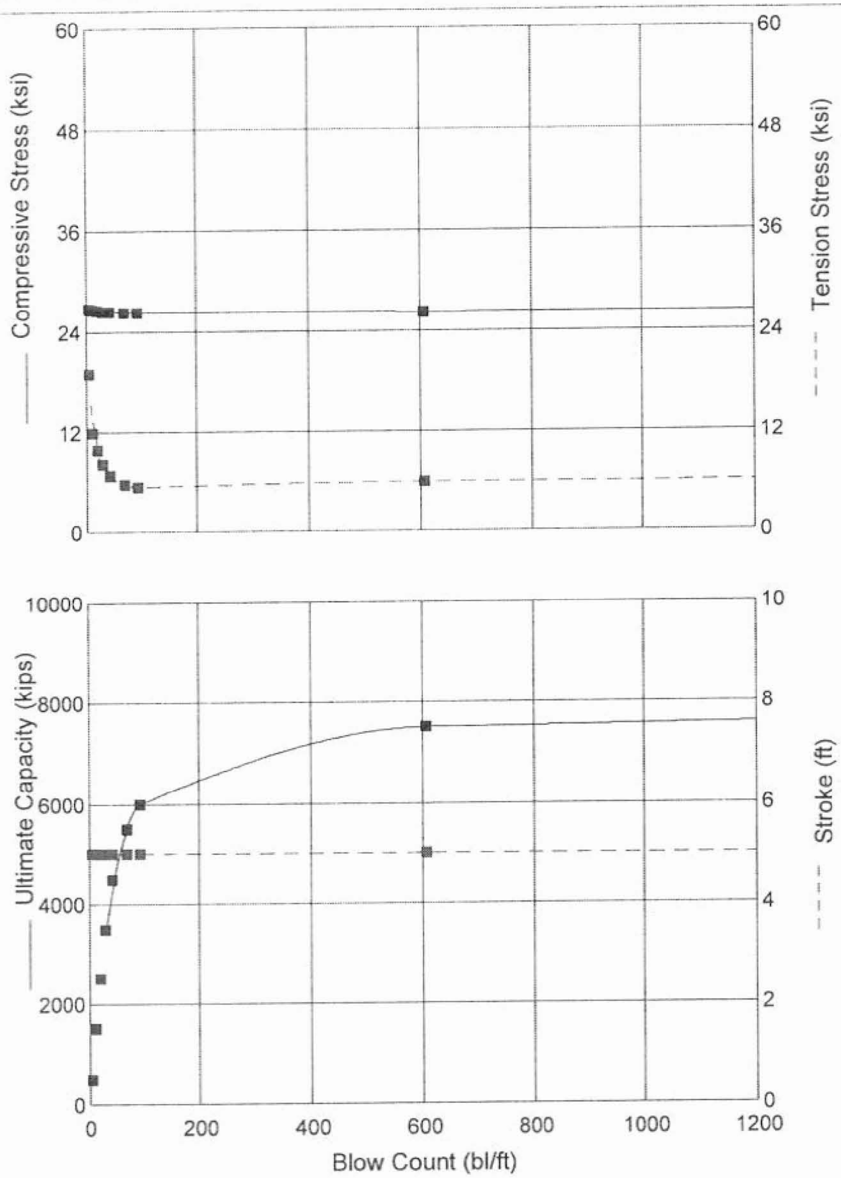


MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	552.92 in2

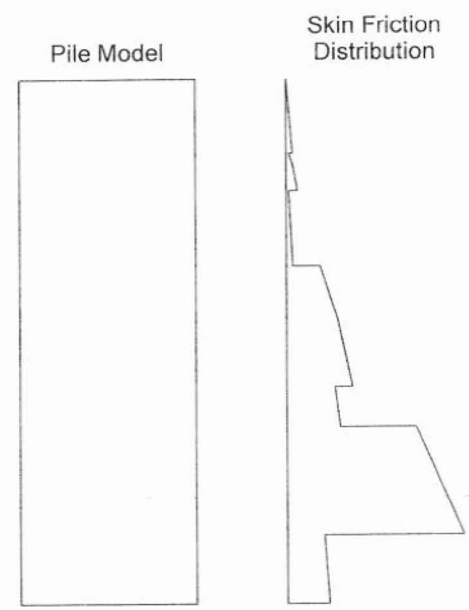


Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	26.78	18.93	4.7	5.00	322.77
1500.0	26.61	11.85	11.5	5.00	322.45
2500.0	26.49	9.86	20.8	5.00	322.55
3500.0	26.44	8.20	29.4	5.00	322.59
4500.0	26.39	6.75	43.4	5.00	322.51
5500.0	26.35	5.74	69.4	5.00	322.32
6000.0	26.32	5.42	93.2	5.00	322.18
7500.0	26.26	5.95	607.5	5.00	321.63
8500.0	26.31	6.74	9999.0	5.00	321.13



APE HI 400U

Stroke	5.00 ft
Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2



Res. Shaft = 60 %
(Proportional)

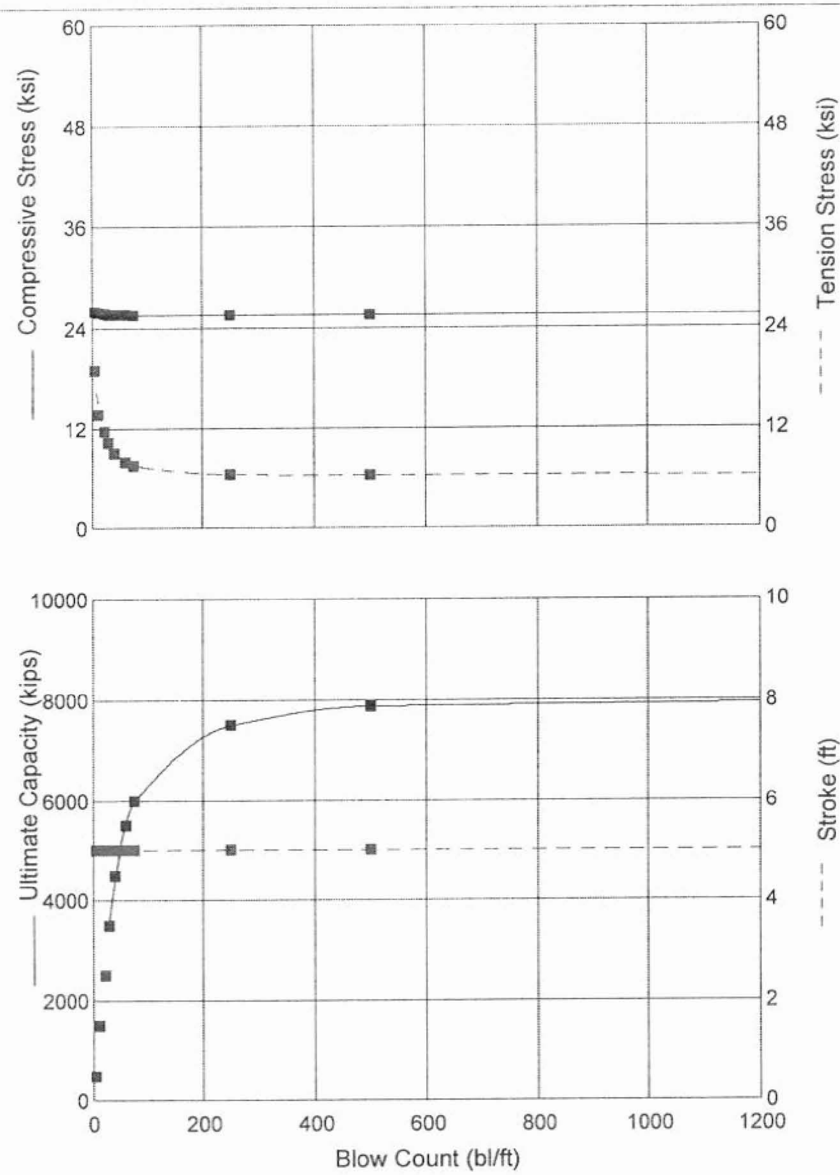
California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

26-Mar-2008
GRLWEAP (TM) Version 2005

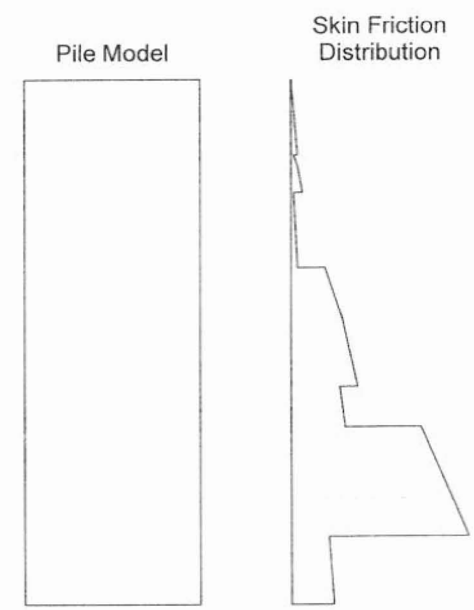
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	26.02	19.09	5.3	5.00	321.49
1500.0	25.89	13.69	11.6	5.00	321.49
2500.0	25.79	11.70	21.9	5.00	321.47
3500.0	25.71	10.30	29.0	5.00	321.37
4500.0	25.68	9.04	40.0	5.00	321.18
5500.0	25.64	7.94	59.7	5.00	320.91
6000.0	25.62	7.49	76.0	5.00	320.74
7500.0	25.56	6.49	250.4	5.00	320.13
7880.7	25.55	6.34	501.1	5.00	319.95
8500.0	25.54	6.15	9999.0	5.00	319.63

California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

26-Mar-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	417.05	in2



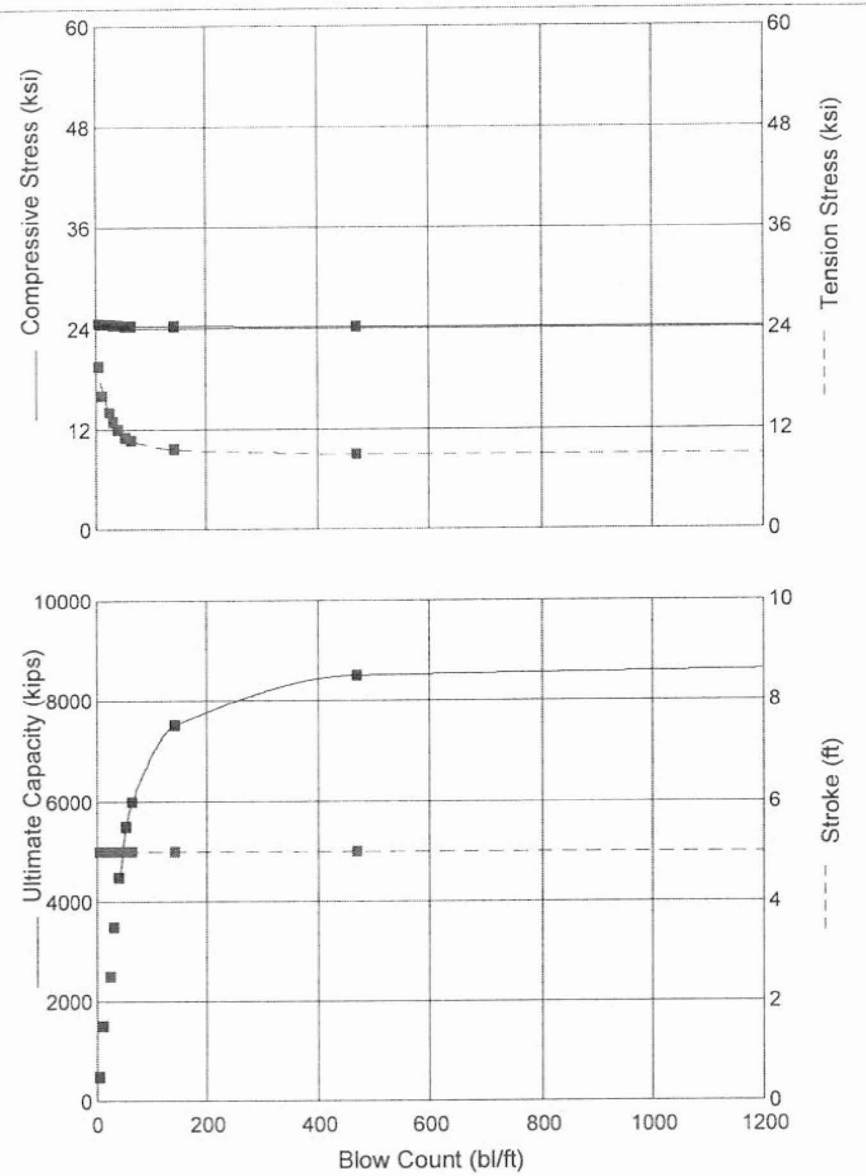
Res. Shaft = 60 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	25.31	19.66	5.8	5.00	320.45
1500.0	25.20	15.49	12.1	5.00	320.39
2500.0	25.13	13.06	23.2	5.00	320.29
3500.0	25.06	11.80	29.7	5.00	320.13
4500.0	25.00	10.72	39.2	5.00	319.91
5500.0	24.95	9.73	55.3	5.00	319.62
6000.0	24.93	9.27	68.2	5.00	319.45
7500.0	24.89	8.17	173.2	5.00	318.87
8500.0	24.87	7.61	1289.1	5.00	318.41
9500.0	24.85	7.23	9999.0	5.00	318.15

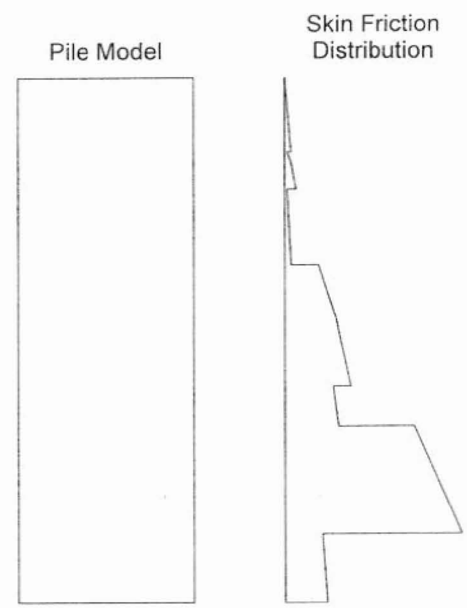
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	24.63	19.54	6.4	5.00	319.43
1500.0	24.55	16.11	12.5	5.00	319.34
2500.0	24.49	14.05	24.5	5.00	319.21
3500.0	24.43	12.88	30.9	5.00	319.04
4500.0	24.39	11.94	39.8	5.00	318.82
5500.0	24.34	11.06	54.0	5.00	318.55
6000.0	24.32	10.66	65.0	5.00	318.41
7500.0	24.27	9.62	143.7	5.00	317.89
8500.0	24.24	9.03	471.1	5.00	317.56
9500.0	24.22	8.55	9999.0	5.00	317.42

California D.O.T. Geotechnical Services
Drive Study (North Bank P-27 B-16)

26-Mar-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	552.92	in2



Res. Shaft = 60 %
(Proportional)

APPENDIX B

Driveability Analysis

Charts and Graphs

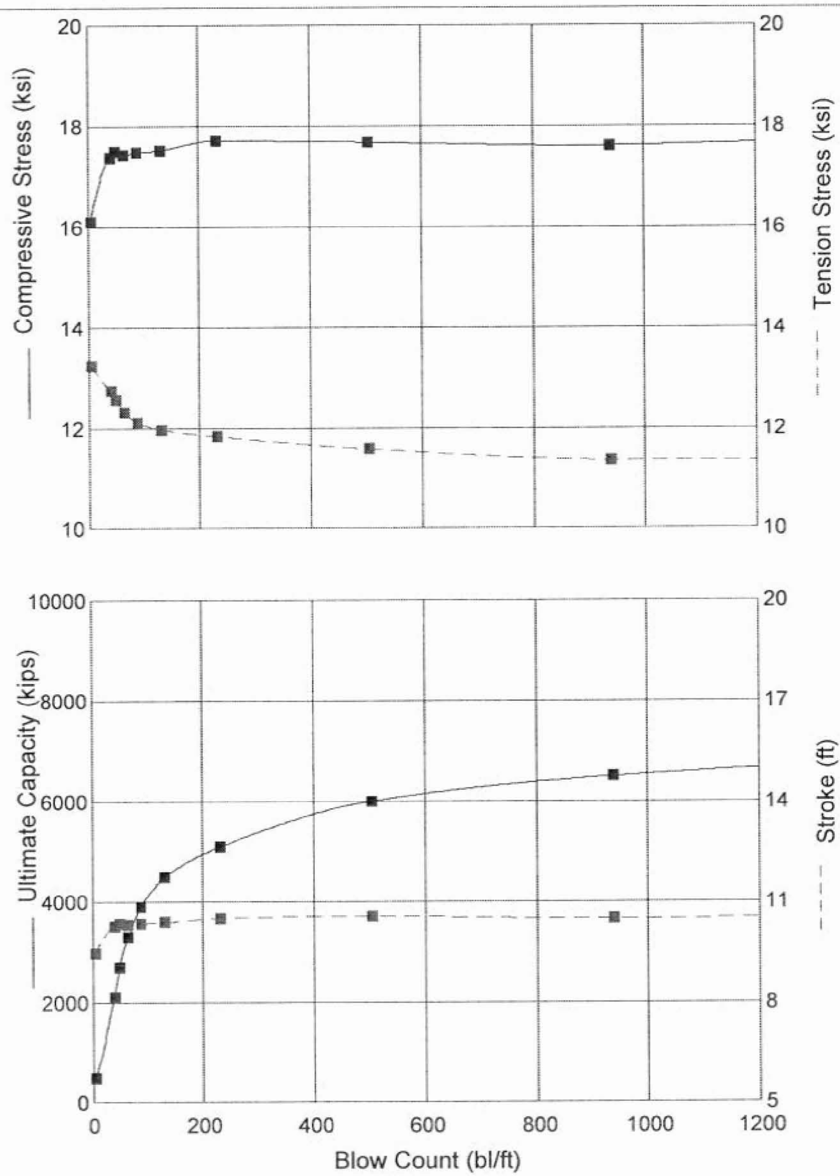
Feather River Bridge (South Bank)

Bridge Number 18-0026R

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	16.10	13.24	5.7	9.47	111.86
2100.0	17.37	12.75	39.7	10.27	107.76
2700.0	17.49	12.58	49.4	10.35	108.37
3300.0	17.42	12.32	64.4	10.31	107.41
3900.0	17.48	12.12	88.1	10.35	107.54
4500.0	17.52	11.97	132.4	10.39	107.75
5100.0	17.72	11.84	233.3	10.51	108.99
6000.0	17.68	11.58	505.2	10.57	109.31
6500.0	17.61	11.37	938.8	10.50	108.19
7000.0	17.93	11.36	1989.6	10.66	110.27

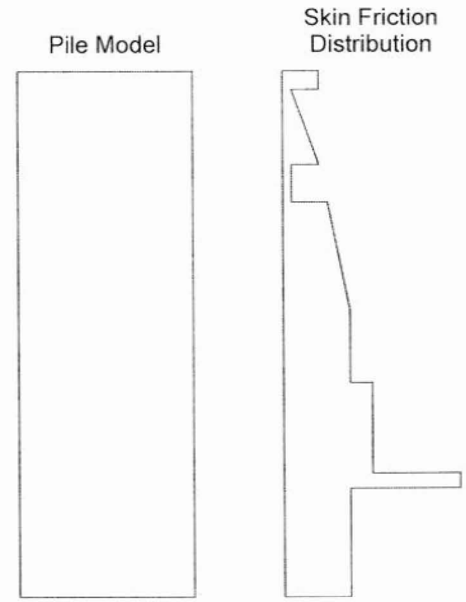
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	552.92 in2

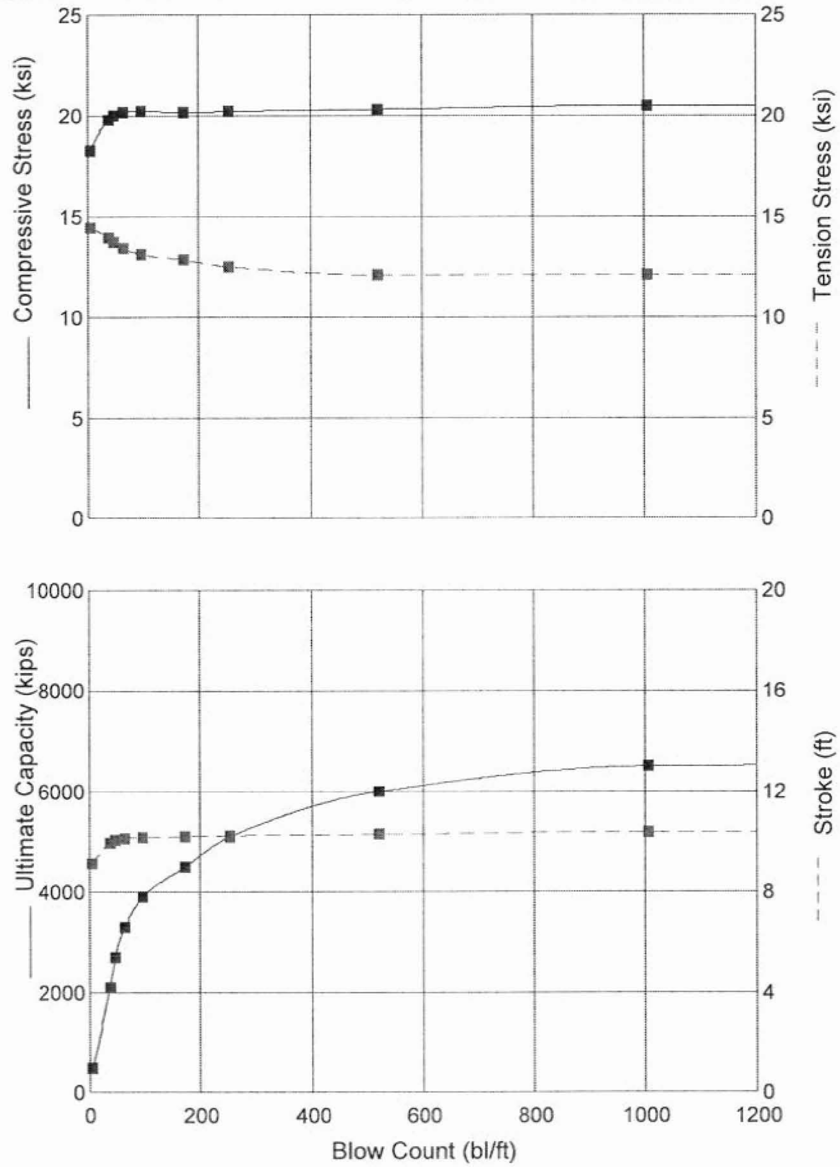


Res. Shaft = 90 %
(Proportional)

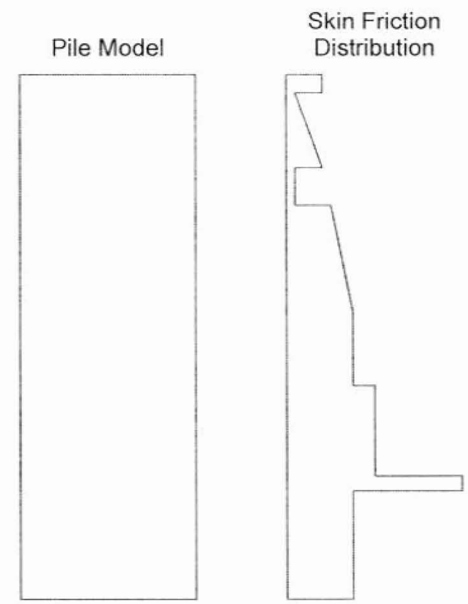
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	18.26	14.43	6.3	9.12	113.85
2100.0	19.77	13.96	37.2	9.94	108.53
2700.0	20.04	13.72	47.7	10.05	109.70
3300.0	20.19	13.43	64.4	10.14	110.51
3900.0	20.25	13.12	96.5	10.17	110.51
4500.0	20.18	12.84	173.5	10.21	110.56
5100.0	20.23	12.51	255.1	10.24	110.67
6000.0	20.34	12.10	522.3	10.29	110.74
6500.0	20.50	12.10	1006.0	10.38	111.82
7000.0	20.47	12.02	9999.0	10.37	111.39

California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13	
Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	417.05 in2



Res. Shaft = 90 %
(Proportional)

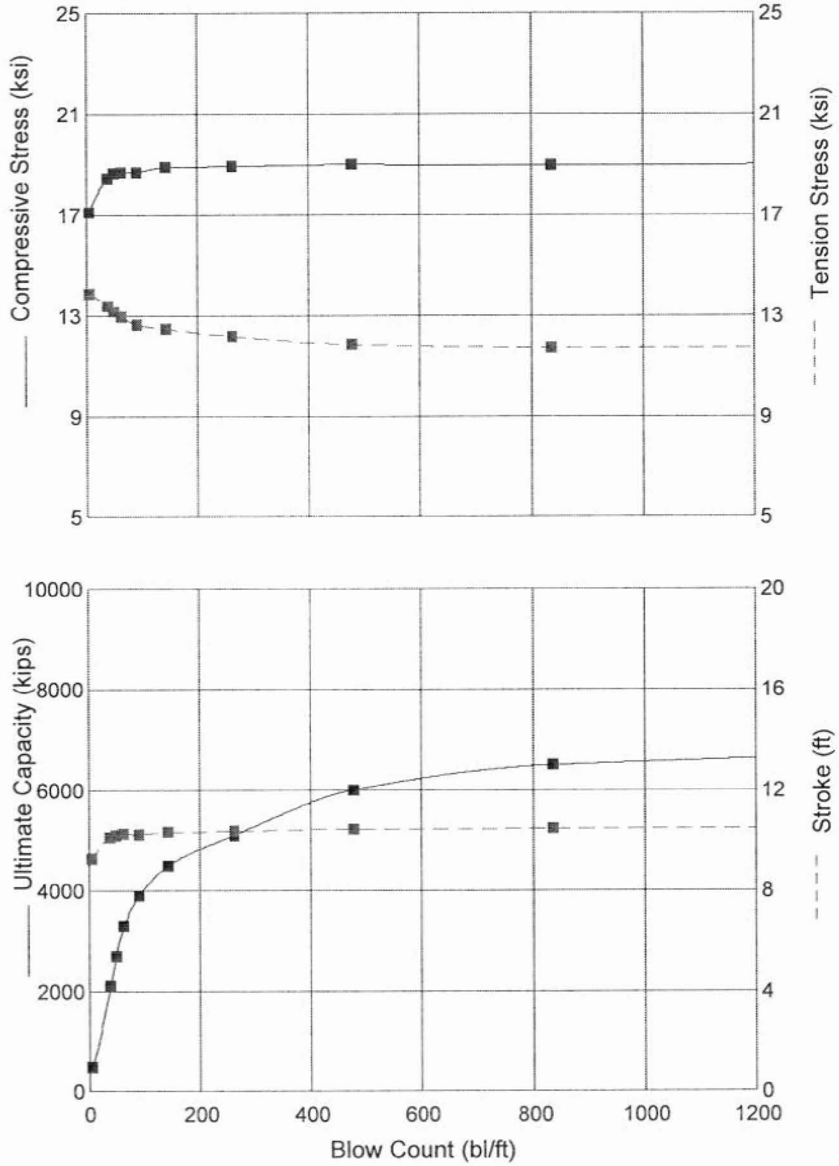
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

25-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	17.12	13.87	6.0	9.29	112.56
2100.0	18.46	13.39	38.4	10.12	108.53
2700.0	18.65	13.16	48.4	10.19	109.16
3300.0	18.71	12.96	63.1	10.28	110.06
3900.0	18.70	12.65	90.8	10.23	108.80
4500.0	18.89	12.46	143.0	10.34	109.89
5100.0	18.93	12.18	263.8	10.36	109.85
6000.0	18.99	11.86	479.3	10.45	110.57
6500.0	18.98	11.73	836.9	10.46	110.56
7000.0	19.06	11.68	2678.1	10.50	110.82

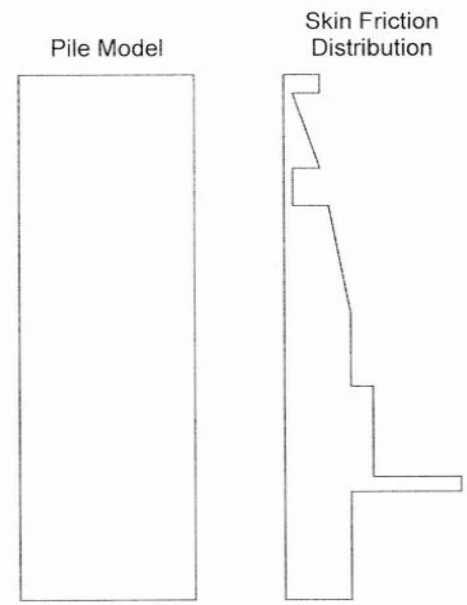
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	485.18 in2

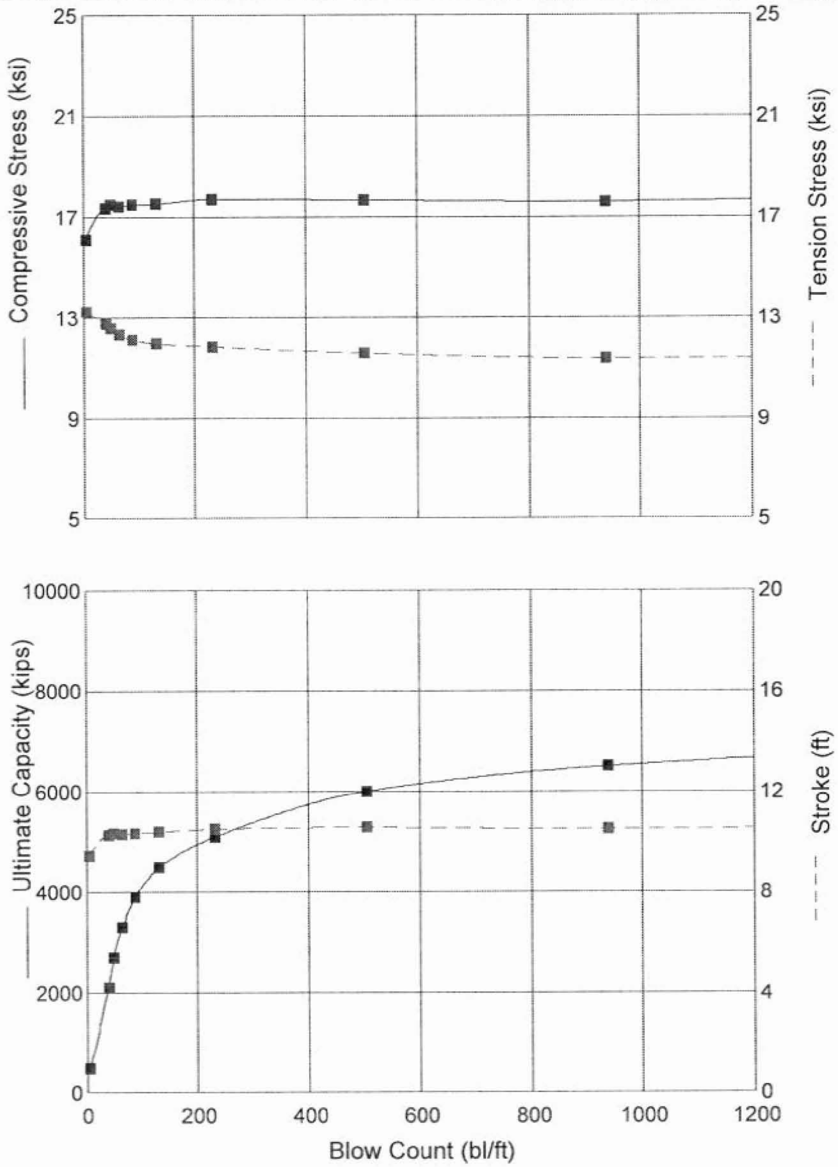


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	16.10	13.24	5.7	9.47	111.86
2100.0	17.37	12.75	39.7	10.27	107.76
2700.0	17.49	12.58	49.4	10.35	108.37
3300.0	17.42	12.32	64.4	10.31	107.41
3900.0	17.48	12.12	88.1	10.35	107.54
4500.0	17.52	11.97	132.4	10.39	107.75
5100.0	17.72	11.84	233.3	10.51	108.99
6000.0	17.68	11.58	505.2	10.57	109.31
6500.0	17.61	11.37	938.8	10.50	108.19
7000.0	17.93	11.36	1989.6	10.66	110.27

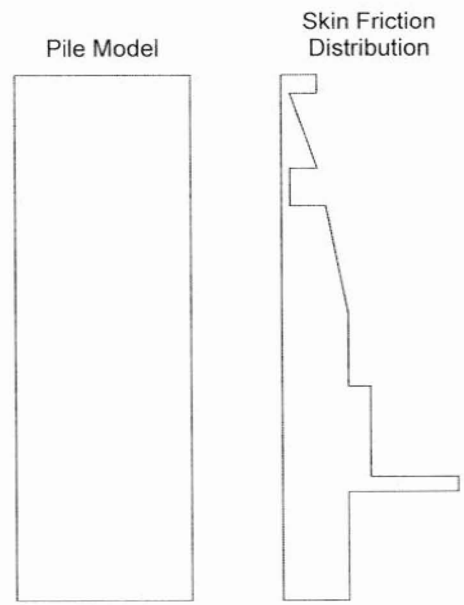
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	552.92	in2



Res. Shaft = 90 %
(Proportional)

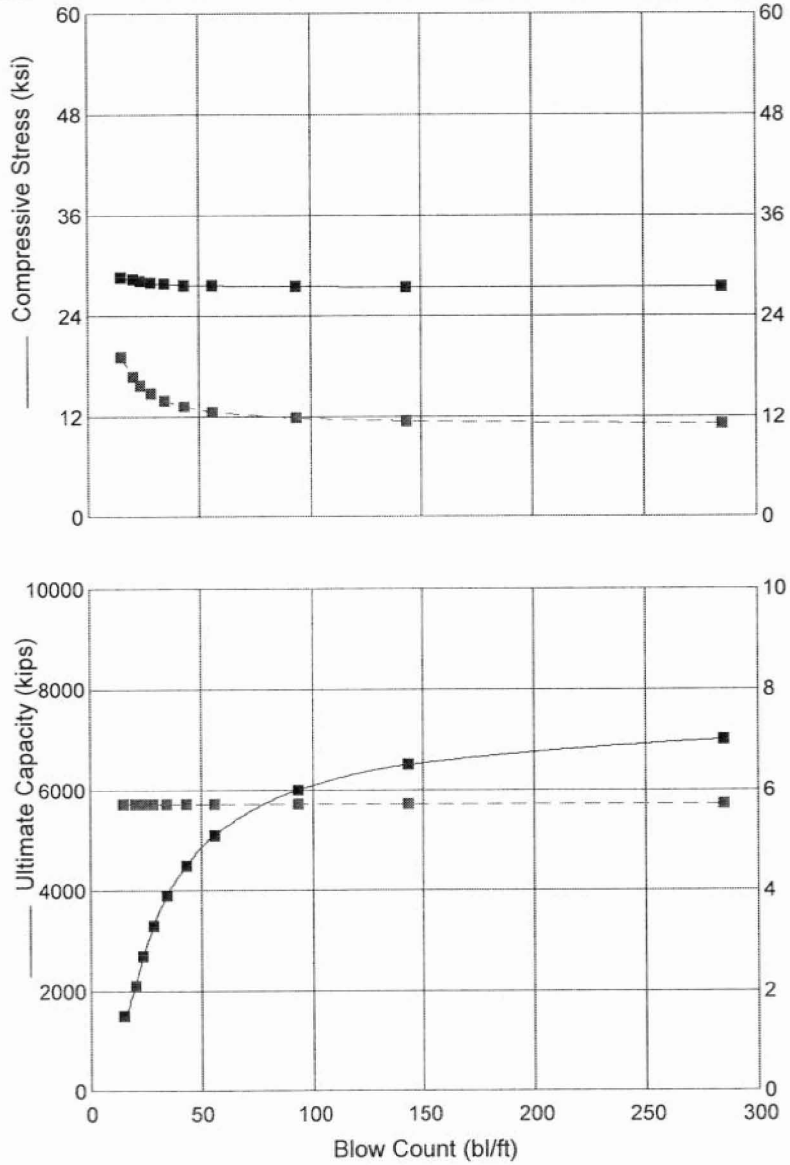
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

14-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	28.60	19.16	15.1	5.71	268.89
2100.0	28.38	16.81	20.3	5.71	268.42
2700.0	28.19	15.73	24.0	5.71	268.03
3300.0	28.02	14.82	28.6	5.71	267.84
3900.0	27.85	14.02	34.7	5.71	267.78
4500.0	27.71	13.28	43.2	5.71	267.73
5100.0	27.65	12.62	55.9	5.71	267.66
6000.0	27.55	11.85	93.9	5.71	267.56
6500.0	27.50	11.47	143.7	5.71	267.49
7000.0	27.44	11.11	285.1	5.71	267.42

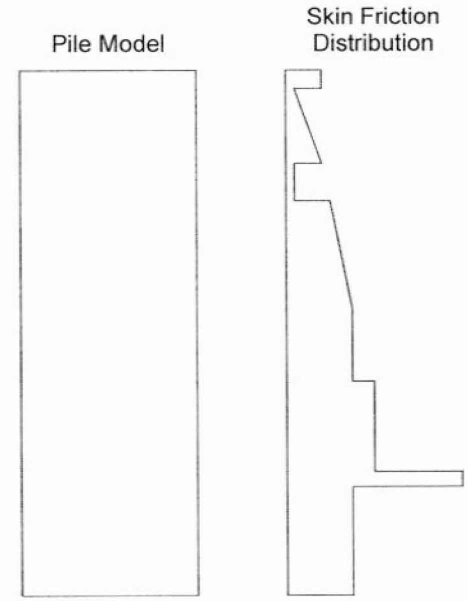
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2

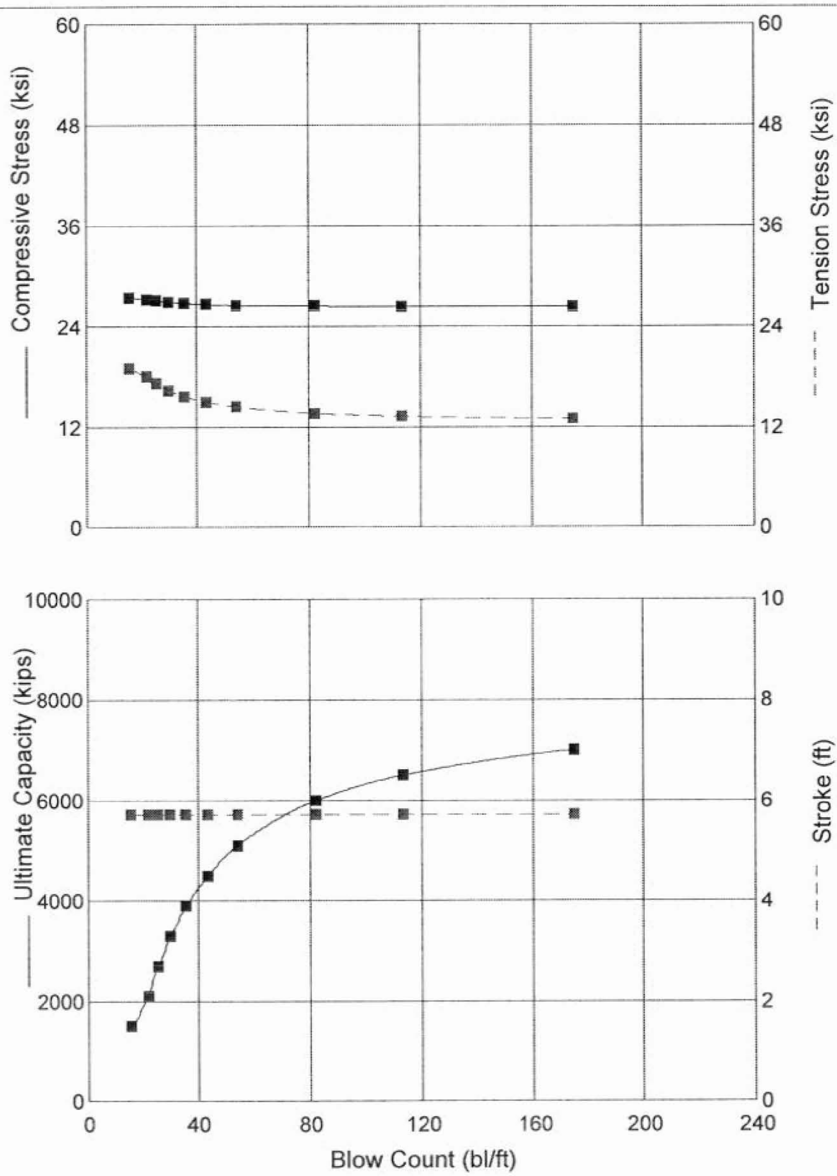


Res. Shaft = 70 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	27.47	19.04	15.6	5.71	268.11
2100.0	27.30	18.08	22.0	5.71	268.00
2700.0	27.14	17.19	25.7	5.71	267.89
3300.0	26.97	16.37	30.1	5.71	267.78
3900.0	26.83	15.68	35.8	5.71	267.67
4500.0	26.69	15.06	43.5	5.71	267.55
5100.0	26.56	14.49	54.3	5.71	267.43
6000.0	26.48	13.70	82.6	5.71	267.25
6500.0	26.43	13.34	113.3	5.71	267.15
7000.0	26.39	13.01	175.0	5.71	267.04

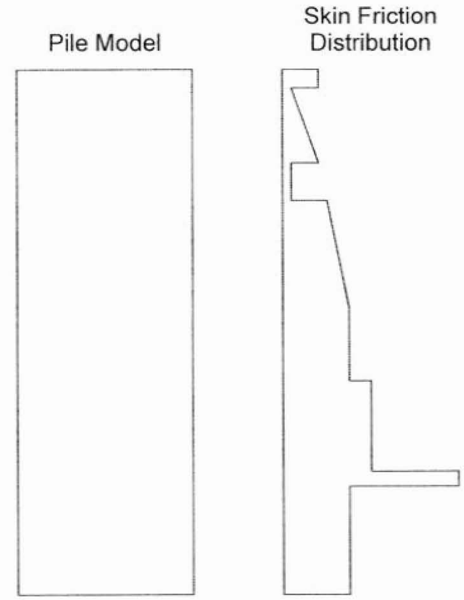
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	417.05 in2

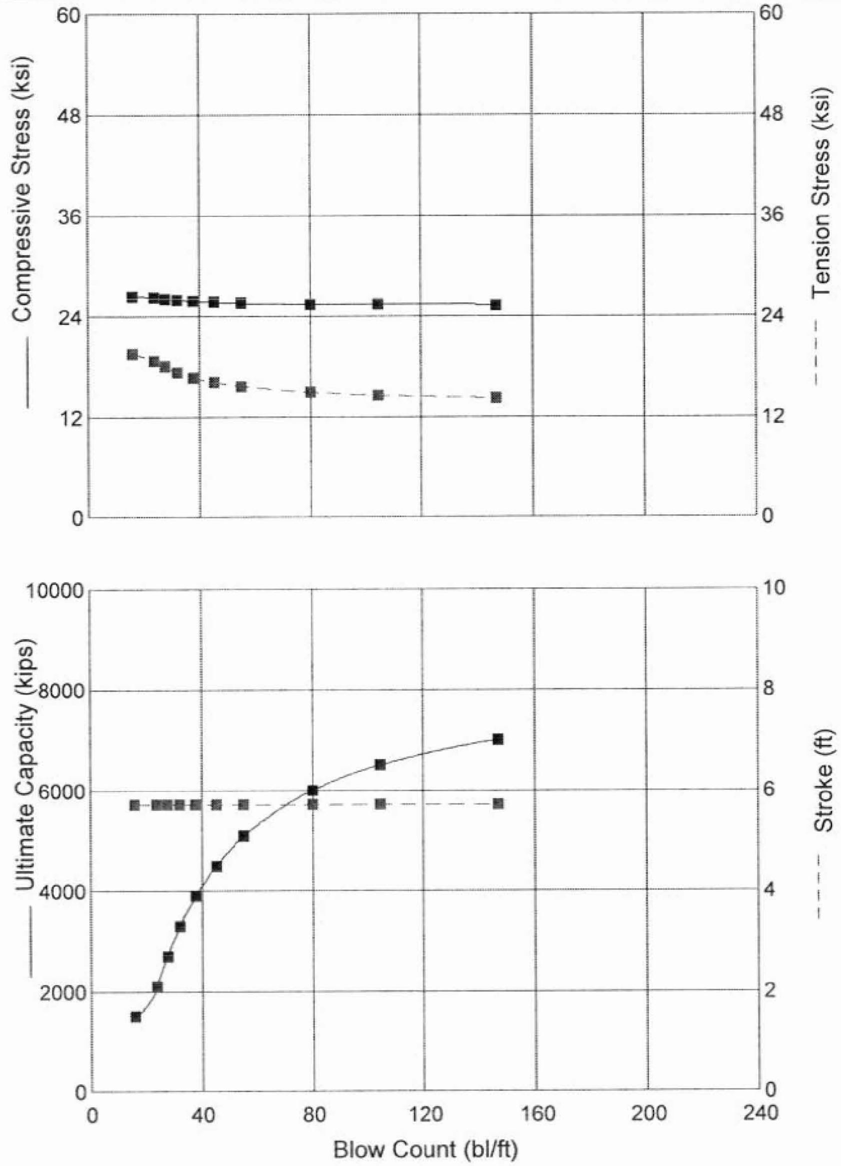


Res. Shaft = 70 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	26.43	19.56	16.1	5.71	267.25
2100.0	26.29	18.77	24.0	5.71	267.12
2700.0	26.15	18.03	27.7	5.71	266.98
3300.0	26.02	17.34	32.2	5.71	266.85
3900.0	25.88	16.72	37.9	5.71	266.71
4500.0	25.75	16.20	45.3	5.71	266.57
5100.0	25.63	15.70	55.4	5.71	266.43
6000.0	25.48	15.01	80.2	5.71	266.22
6500.0	25.45	14.65	104.6	5.71	266.09
7000.0	25.41	14.31	147.1	5.71	265.97

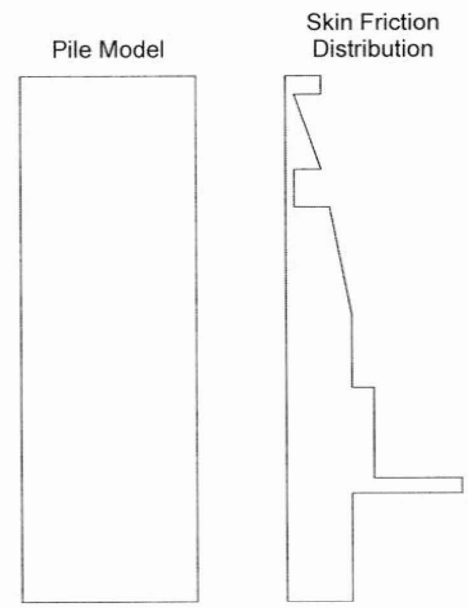
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71	ft
Efficiency	0.950	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	485.18	in2



Res. Shaft = 70 %
(Proportional)

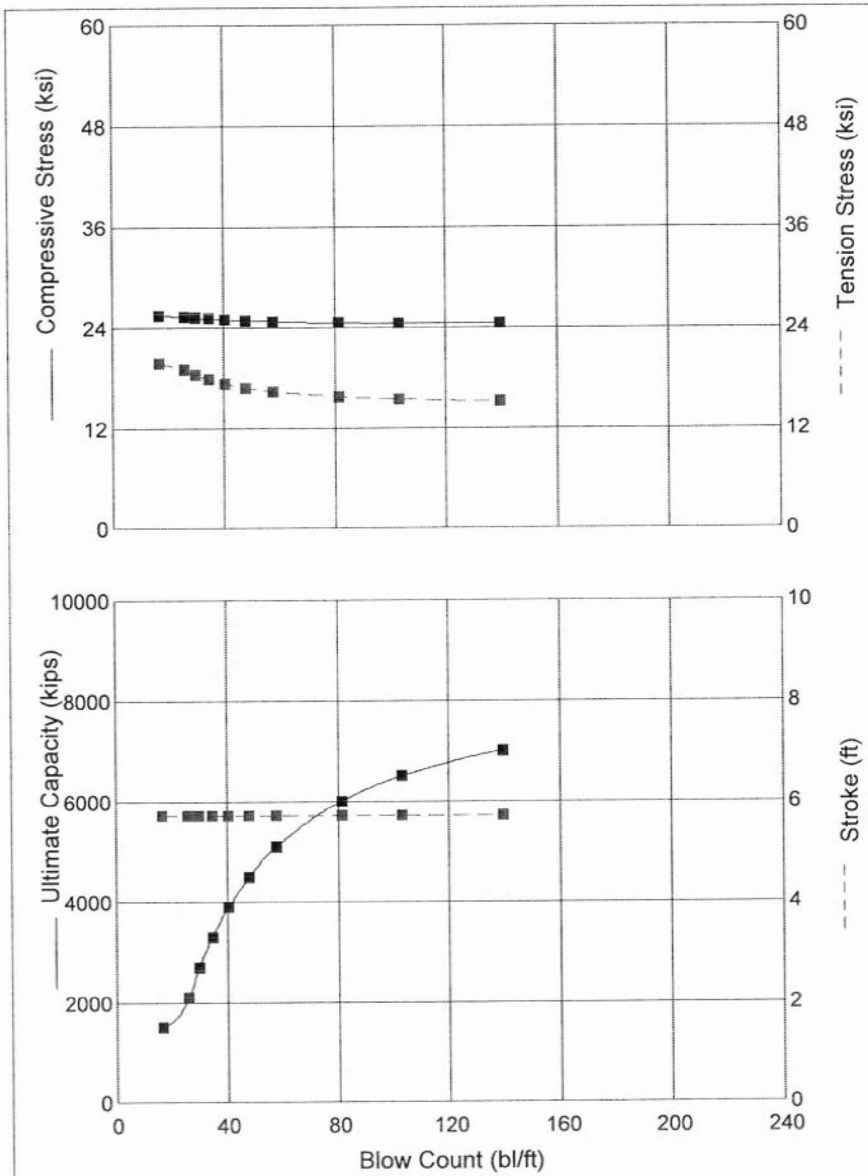
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

14-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	25.46	19.73	16.9	5.71	266.09
2100.0	25.34	19.06	26.2	5.71	265.95
2700.0	25.22	18.45	30.0	5.71	265.80
3300.0	25.11	17.86	34.7	5.71	265.66
3900.0	24.99	17.31	40.5	5.71	265.52
4500.0	24.88	16.85	47.9	5.71	265.37
5100.0	24.77	16.42	57.8	5.71	265.23
6000.0	24.61	15.81	81.4	5.71	265.01
6500.0	24.53	15.50	103.4	5.71	264.88
7000.0	24.50	15.19	139.5	5.71	264.76

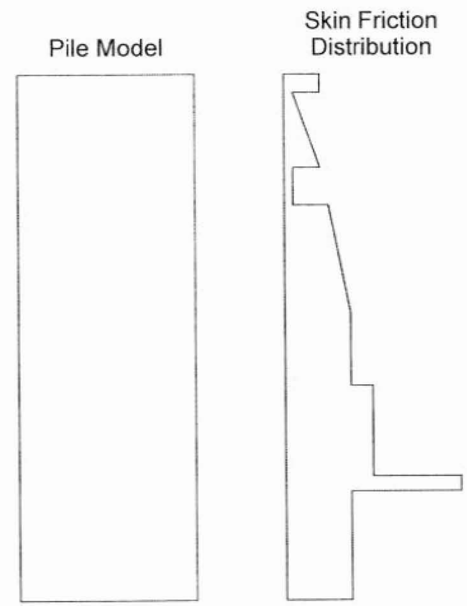
California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	552.92 in2

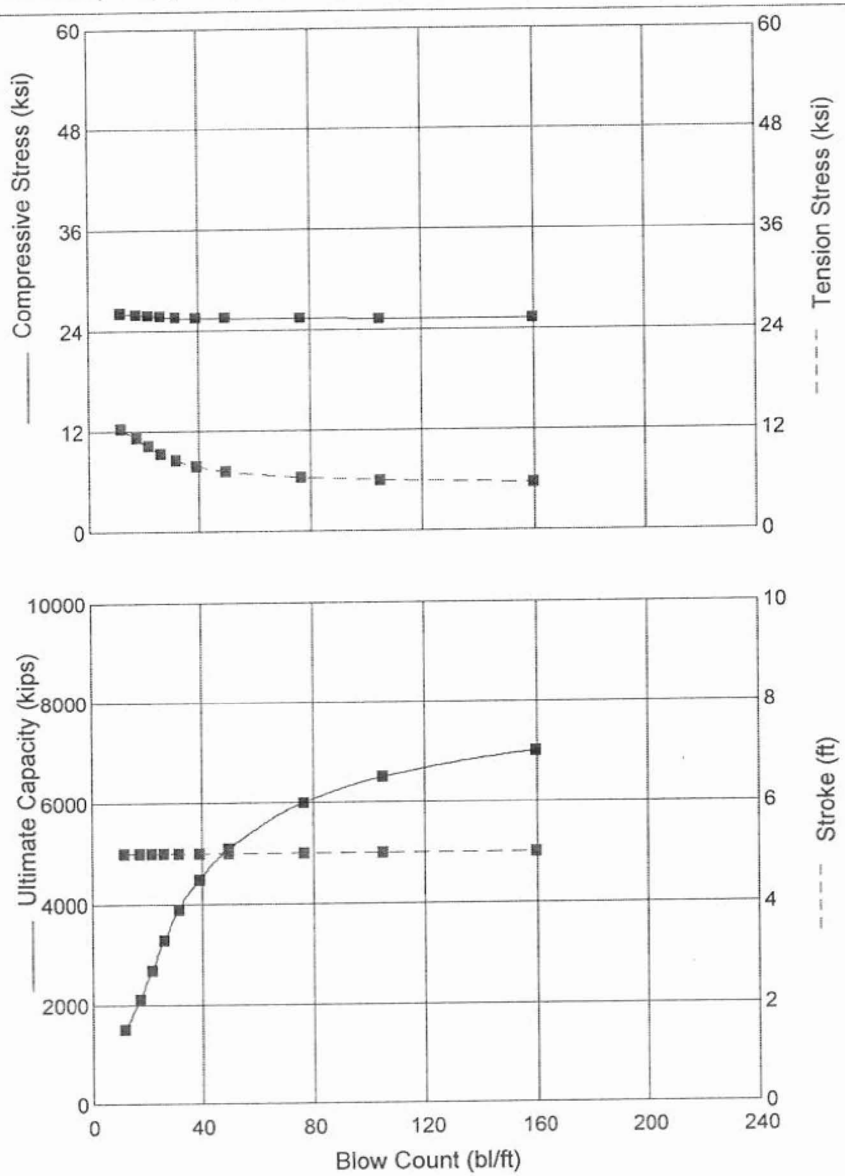


Res. Shaft = 70 %
(Proportional)

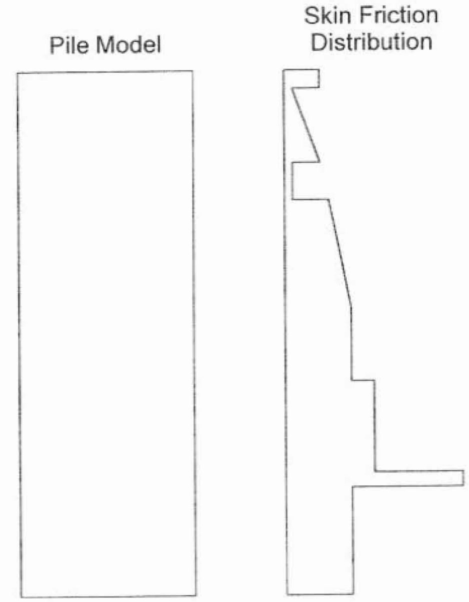
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	26.20	12.32	11.4	5.00	321.30
2100.0	26.04	11.19	17.2	5.00	321.13
2700.0	25.89	10.23	21.8	5.00	320.83
3300.0	25.75	9.38	26.1	5.00	320.41
3900.0	25.63	8.59	31.6	5.00	319.85
4500.0	25.58	7.88	39.2	5.00	319.18
5100.0	25.52	7.24	49.8	5.00	318.39
6000.0	25.44	6.46	76.9	5.00	317.02
6500.0	25.40	6.09	105.2	5.00	316.61
7000.0	25.37	5.75	159.7	5.00	316.23

California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

03-Apr-2008
GRLWEAP (TM) Version 2005



APE HI 400U	
Stroke	5.00 ft
Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2

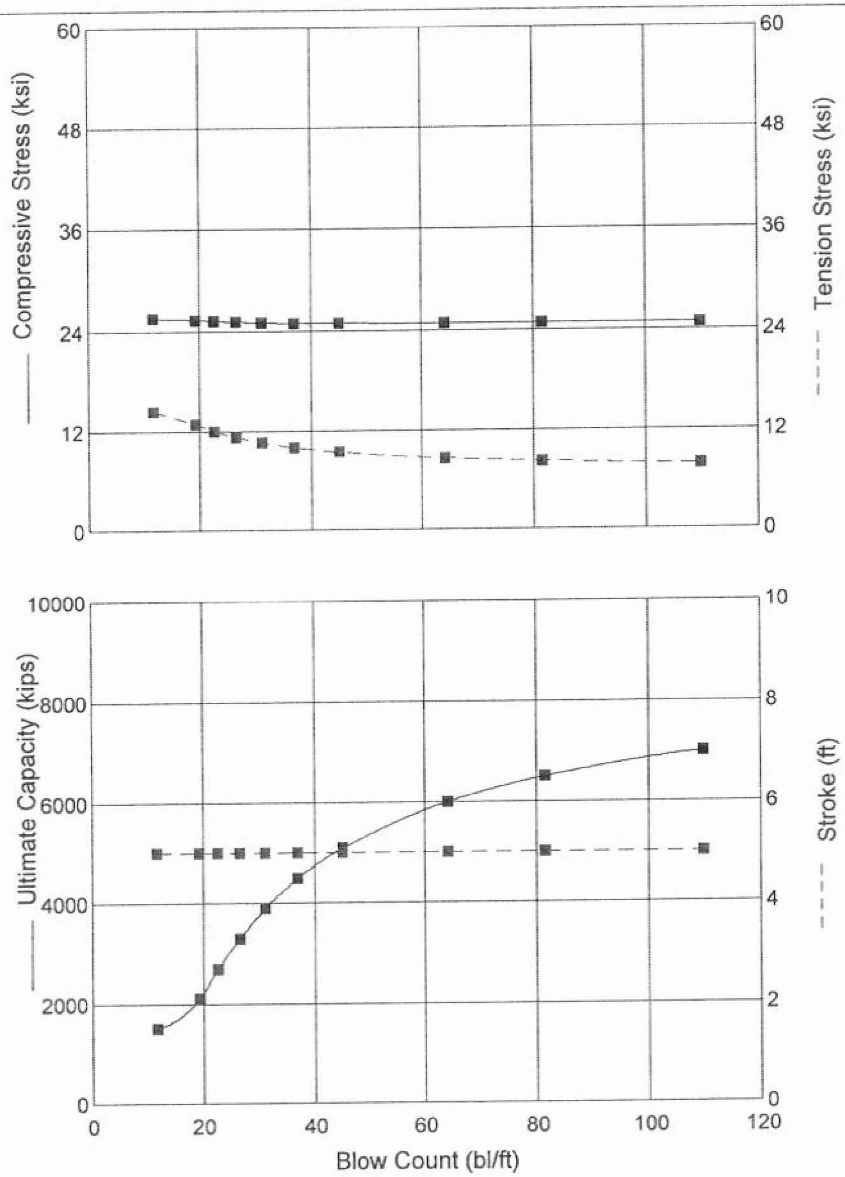


Res. Shaft = 60 %
(Proportional)

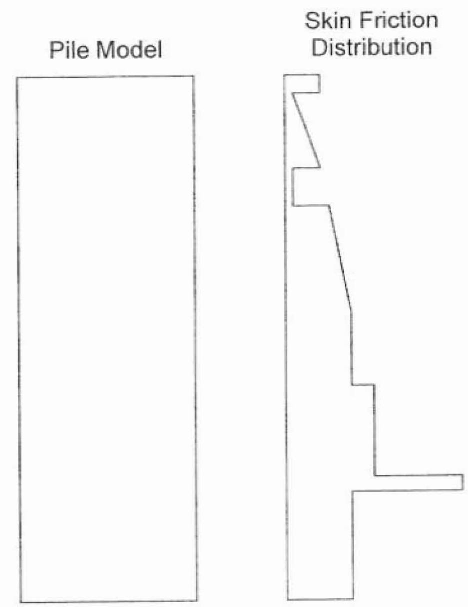
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	25.55	14.35	11.7	5.00	320.02
2100.0	25.38	12.86	19.3	5.00	319.70
2700.0	25.26	12.01	22.7	5.00	319.29
3300.0	25.15	11.28	26.5	5.00	318.79
3900.0	25.04	10.60	31.2	5.00	318.20
4500.0	24.95	9.97	37.1	5.00	317.51
5100.0	24.91	9.39	45.2	5.00	316.81
6000.0	24.84	8.61	64.2	5.00	316.20
6500.0	24.81	8.20	81.7	5.00	315.88
7000.0	24.79	7.86	109.8	5.00	315.57

California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

03-Apr-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	417.05	in2



Res. Shaft = 60 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	24.90	15.61	12.1	5.00	318.62
2100.0	24.76	14.07	19.5	5.00	318.25
2700.0	24.63	13.30	23.9	5.00	317.82
3300.0	24.54	12.62	27.6	5.00	317.31
3900.0	24.44	12.04	31.9	5.00	316.74
4500.0	24.35	11.49	37.3	5.00	316.17
5100.0	24.30	10.99	44.2	5.00	315.82
6000.0	24.25	10.28	59.6	5.00	315.31
6500.0	24.23	9.91	72.7	5.00	315.04
7000.0	24.22	9.57	92.1	5.00	314.77

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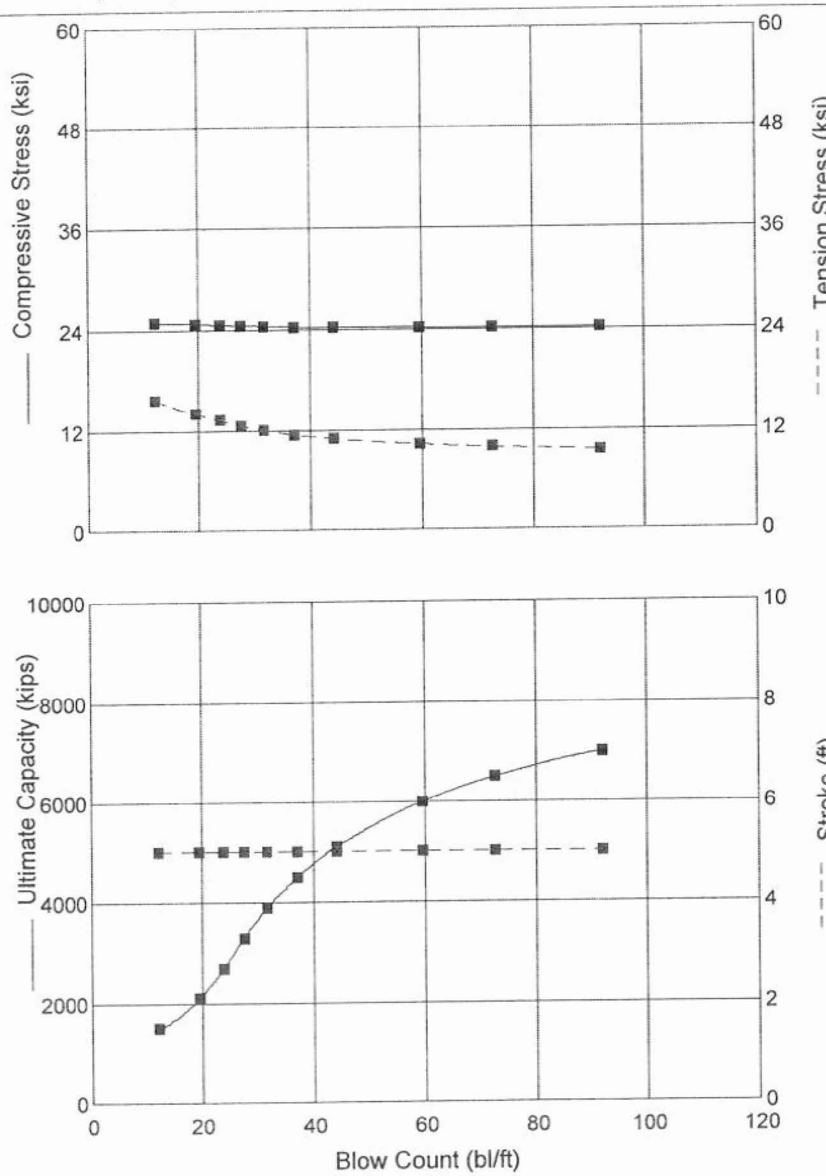
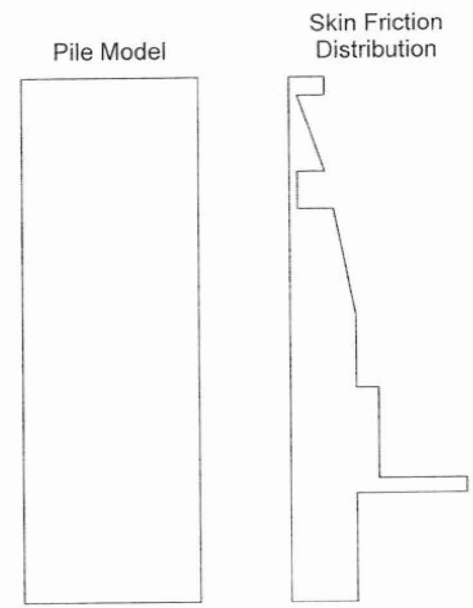
Driveability Study South Bank (P-5 B-1)

03-Apr-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	485.18	in2

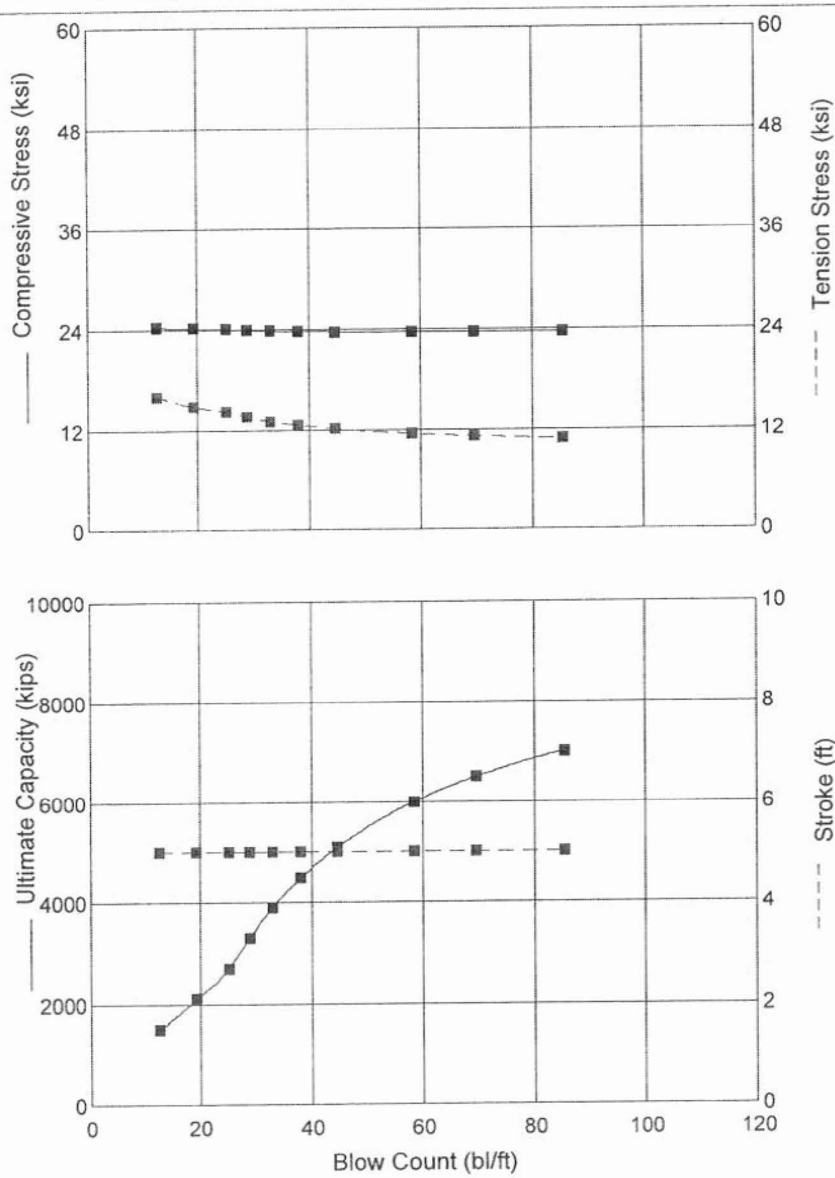


Res. Shaft = 60 %
(Proportional)

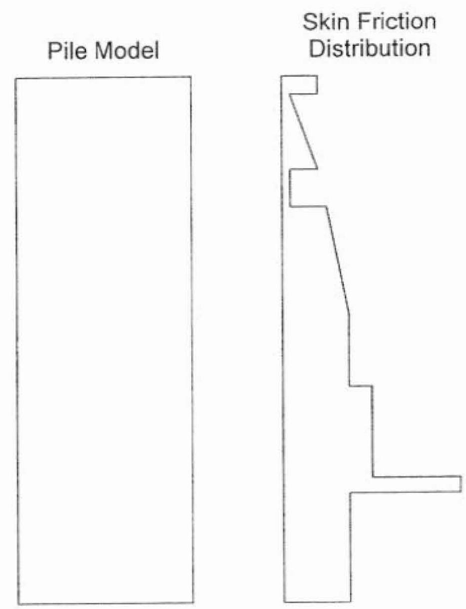
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1500.0	24.28	16.13	12.6	5.00	317.29
2100.0	24.16	14.90	19.4	5.00	316.93
2700.0	24.04	14.24	25.3	5.00	316.52
3300.0	23.94	13.63	28.9	5.00	316.06
3900.0	23.85	13.07	33.1	5.00	315.56
4500.0	23.77	12.59	38.2	5.00	315.13
5100.0	23.72	12.14	44.7	5.00	314.87
6000.0	23.69	11.51	58.5	5.00	314.82
6500.0	23.68	11.19	69.7	5.00	314.79
7000.0	23.66	10.88	85.5	5.00	314.76

California D.O.T. Geotechnical Services
Driveability Study South Bank (P-5 B-1)

03-Apr-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	552.92	in2



Res. Shaft = 60 %
(Proportional)

APPENDIX C

Driveability Analysis

Charts and Graphs

Feather River Bridge (Channel P-11)

Bridge Number 18-0026R

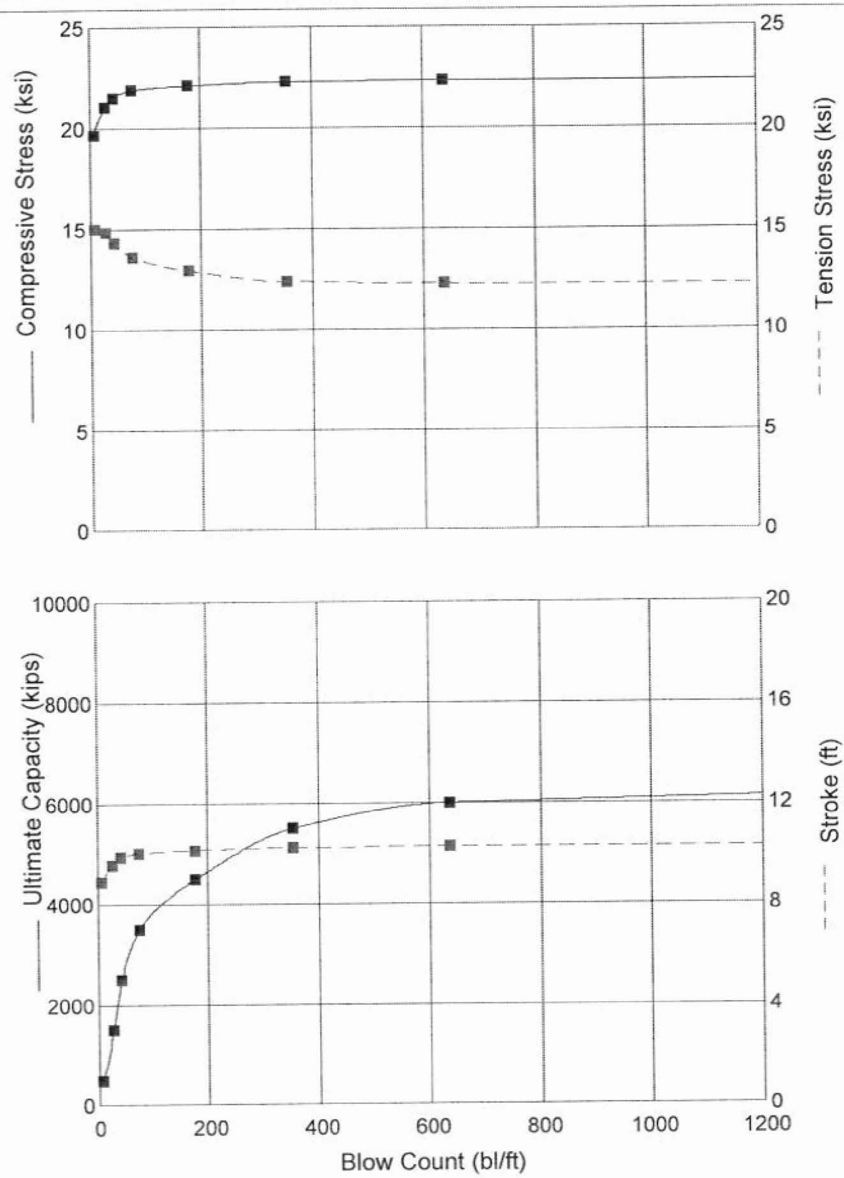
California D.O.T. Geotechnical Services
driveability study

25-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	19.65	15.00	6.8	8.88	115.12
1500.0	21.05	14.82	28.2	9.56	108.37
2500.0	21.52	14.29	42.1	9.89	111.14
3500.0	21.89	13.60	75.2	10.03	112.84
4500.0	22.11	12.92	178.5	10.14	114.12
5500.0	22.28	12.37	356.1	10.23	115.15
6000.0	22.34	12.26	636.4	10.26	115.29
7500.0	22.53	11.97	9999.0	10.36	116.34

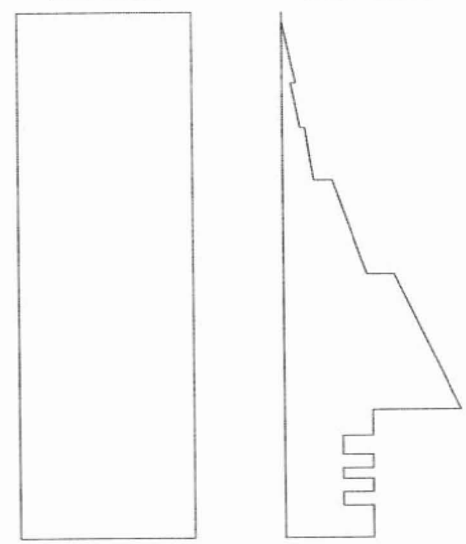
California D.O.T. Geotechnical Services
driveability study

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2



Res. Shaft = 90 %
(Proportional)

California D.O.T. Geotechnical Services
driveability study

25-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	18.39	14.48	6.6	9.13	112.84
1500.0	19.45	14.12	29.6	9.74	108.46
2500.0	19.99	13.80	42.7	10.04	110.96
3500.0	20.12	13.25	70.2	10.11	111.86
4500.0	20.11	12.71	158.3	10.19	112.72
5500.0	20.29	12.19	321.8	10.30	113.91
6000.0	20.43	11.94	506.0	10.31	113.88
7500.0	20.38	11.73	9999.0	10.36	114.24

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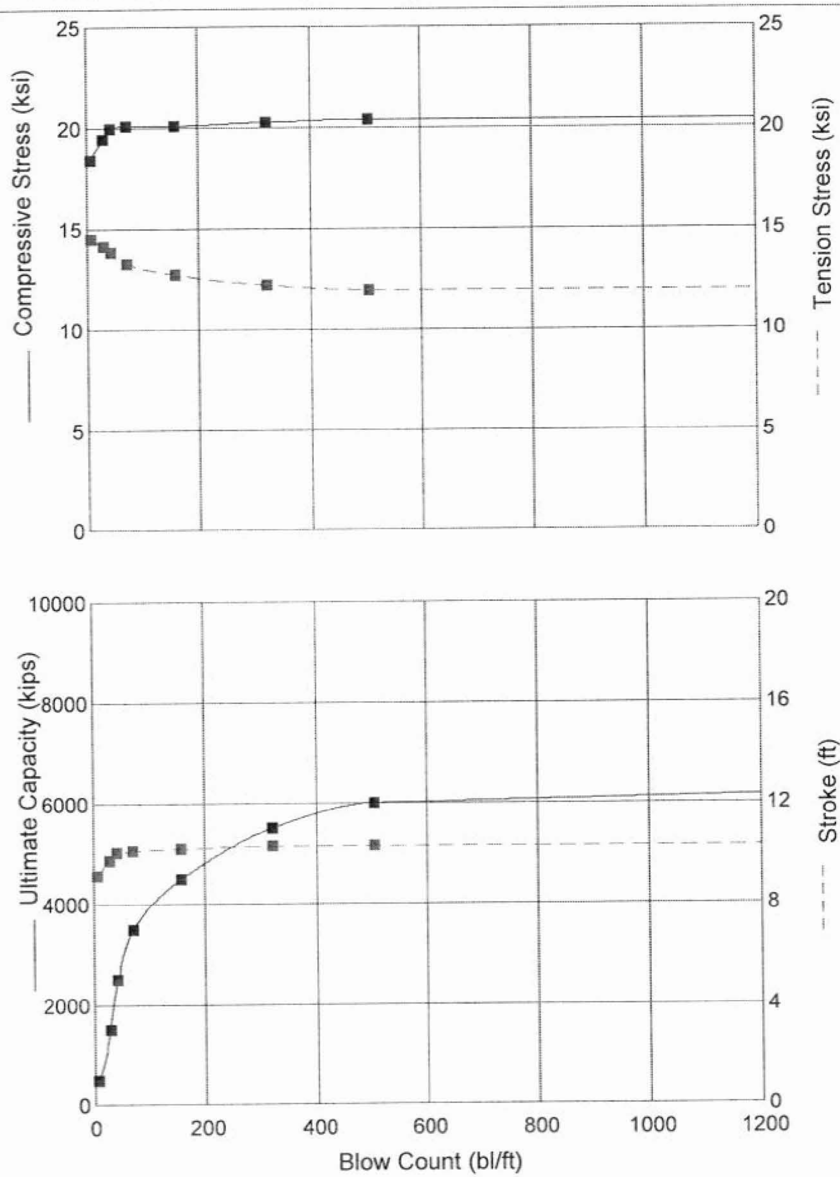
25-Apr-2008
GRLWEAP (TM) Version 2005

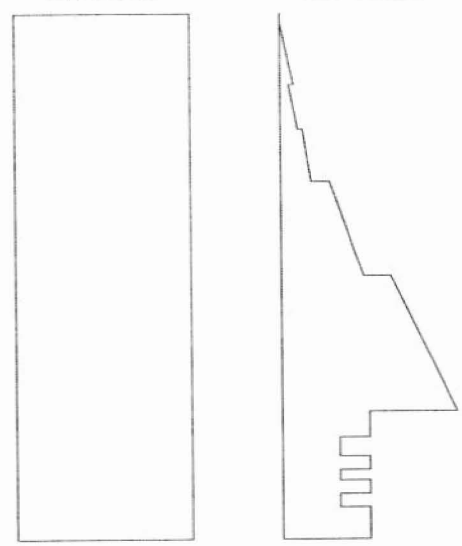


DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	417.05 in2

Pile Model

Skin Friction Distribution



Res. Shaft = 90 %
(Proportional)

California D.O.T. Geotechnical Services
driveability study

25-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	17.14	13.89	6.0	9.29	113.04
1500.0	18.08	13.40	31.2	9.86	107.22
2500.0	18.52	13.18	44.1	10.13	109.37
3500.0	18.55	12.78	68.5	10.23	110.72
4500.0	18.67	12.35	135.5	10.28	111.18
5500.0	18.92	11.96	329.2	10.39	112.50
6000.0	18.94	11.73	481.2	10.40	112.57
7500.0	19.06	11.46	9999.0	10.47	113.11

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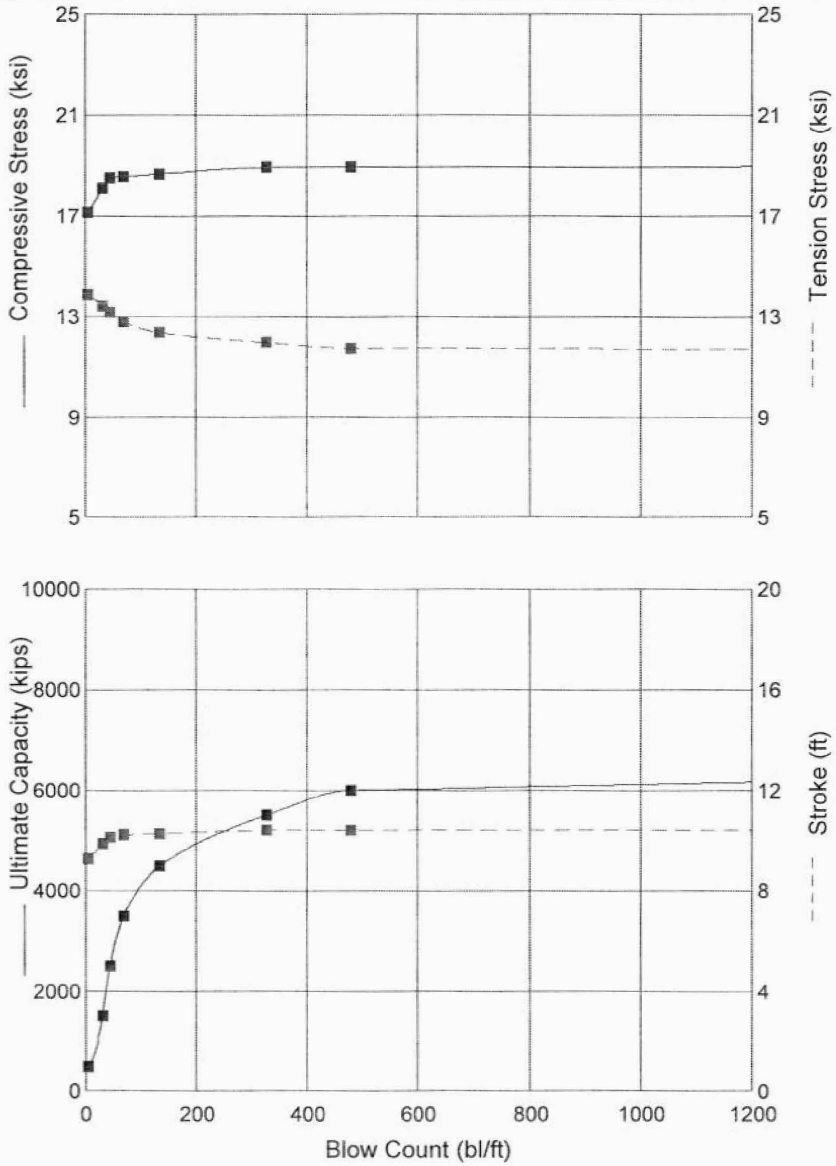
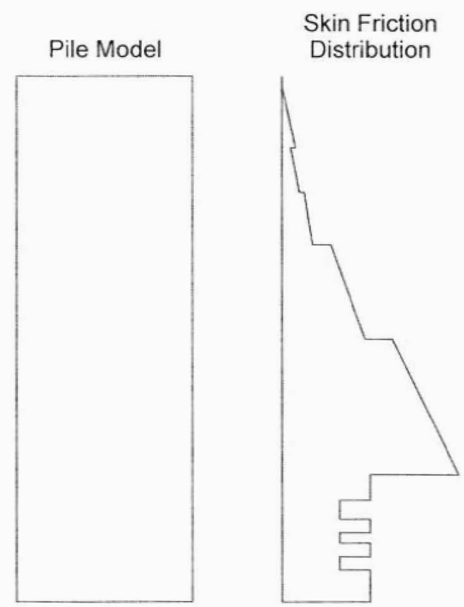
driveability study

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	485.18 in2

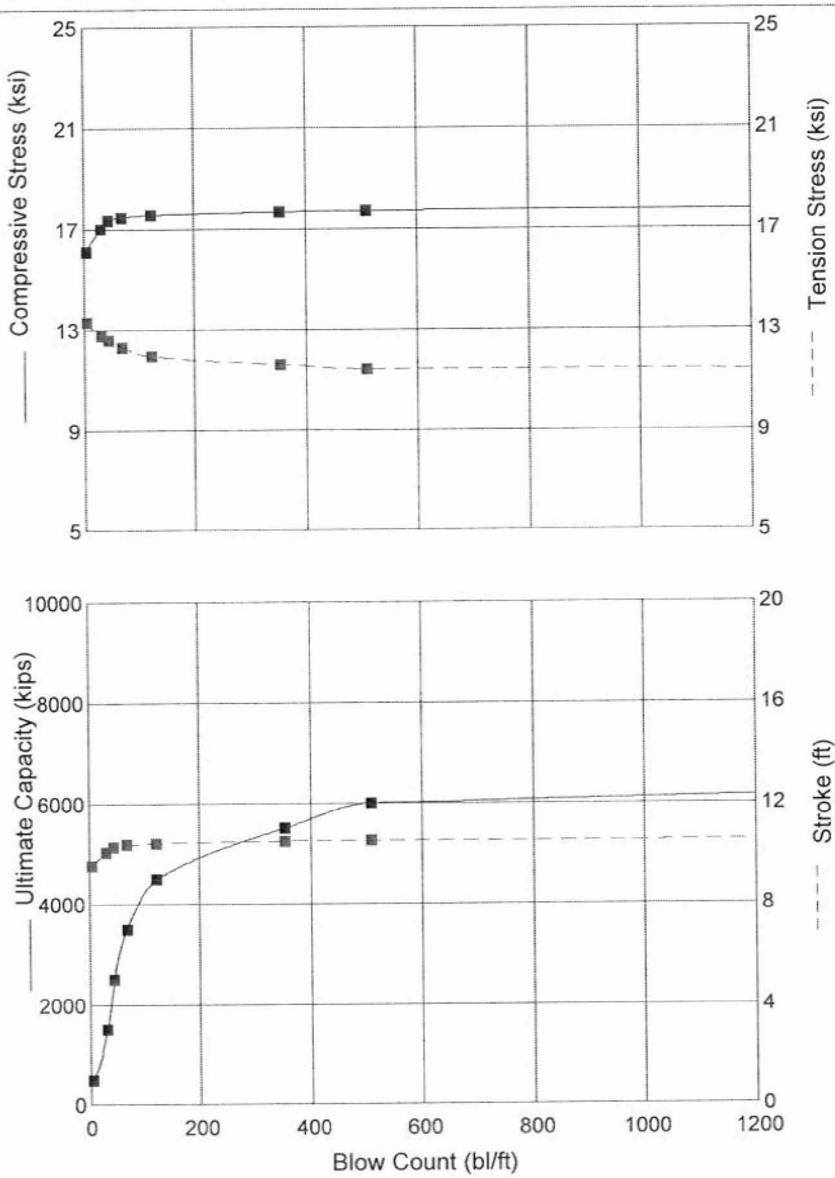


Res. Shaft = 90 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
500.0	16.09	13.30	5.8	9.53	113.02
1500.0	17.00	12.75	32.6	10.04	107.34
2500.0	17.34	12.58	45.4	10.27	108.40
3500.0	17.48	12.29	68.2	10.36	109.53
4500.0	17.57	11.94	123.2	10.41	110.00
5500.0	17.68	11.60	354.3	10.49	110.85
6000.0	17.72	11.42	510.6	10.52	111.13
7500.0	17.79	11.16	9999.0	10.62	112.35

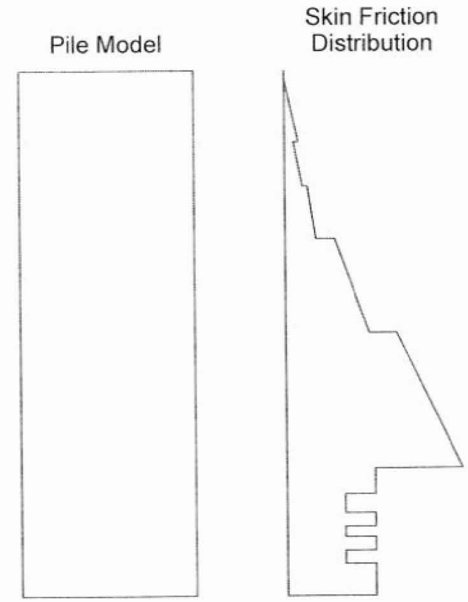
California D.O.T. Geotechnical Services
driveability study

25-Apr-2008
GRLWEAP (TM) Version 2005



DELMAG D100-13

Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	552.92 in2



Res. Shaft = 90 %
(Proportional)

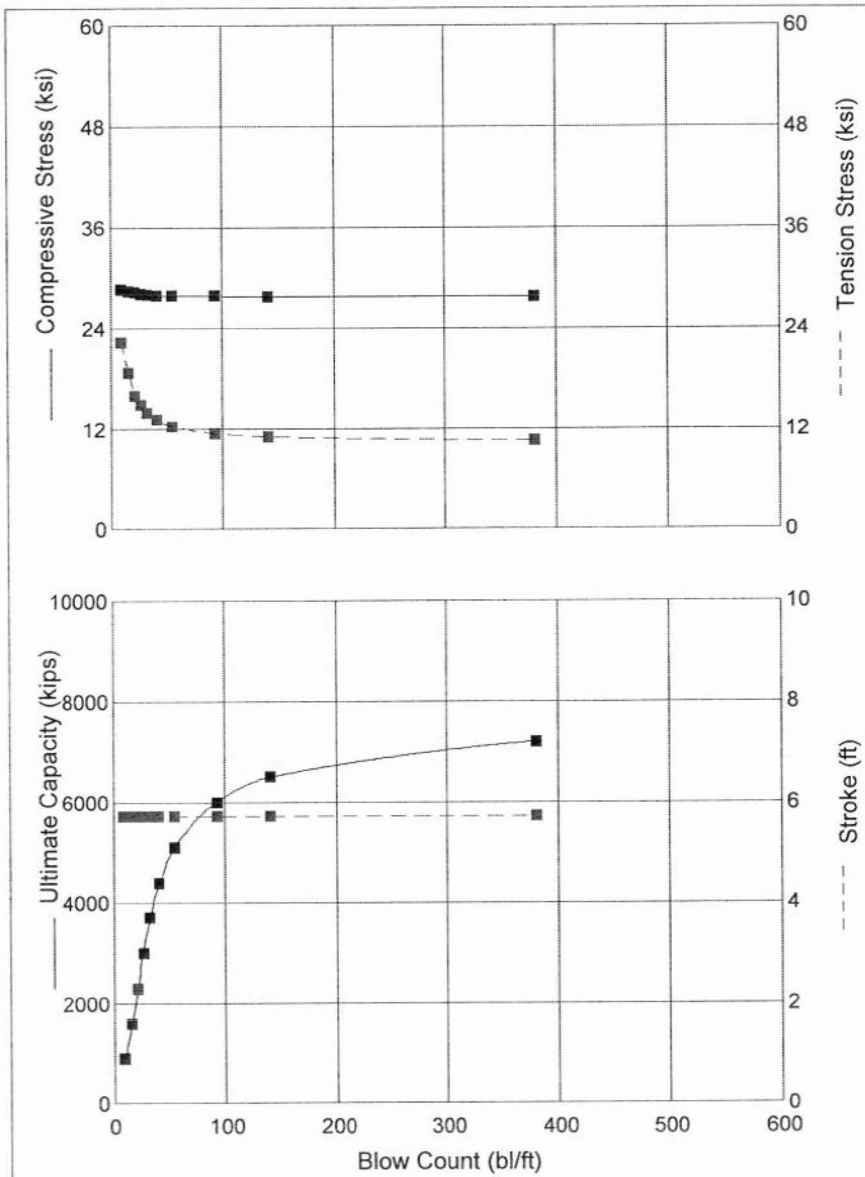
California D.O.T. Geotechnical Services
driveability study

14-Apr-2008
GRLWEAP (TM) Version 2005

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	28.65	22.27	9.2	5.71	270.18
1600.0	28.47	18.75	16.3	5.71	269.89
2300.0	28.31	15.97	21.5	5.71	269.57
3000.0	28.15	14.91	26.3	5.71	269.36
3700.0	28.01	13.96	32.5	5.71	269.23
4400.0	27.91	13.10	41.5	5.71	269.15
5100.0	27.88	12.33	55.7	5.71	269.07
6000.0	27.84	11.48	92.9	5.71	269.15
6500.0	27.82	11.05	141.2	5.71	269.19
7200.0	27.80	10.55	380.8	5.71	269.24

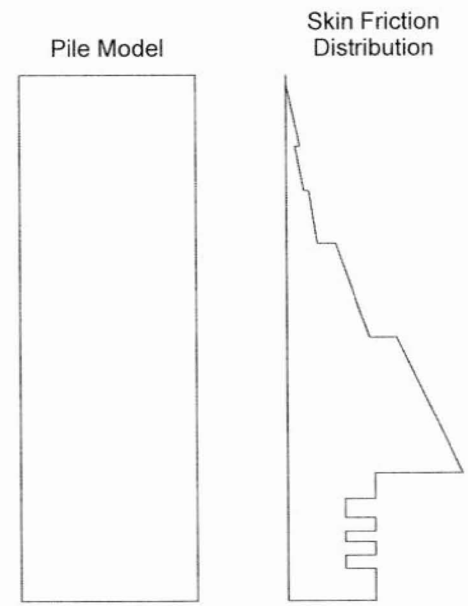
California D.O.T. Geotechnical Services
driveability study

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	348.52 in2

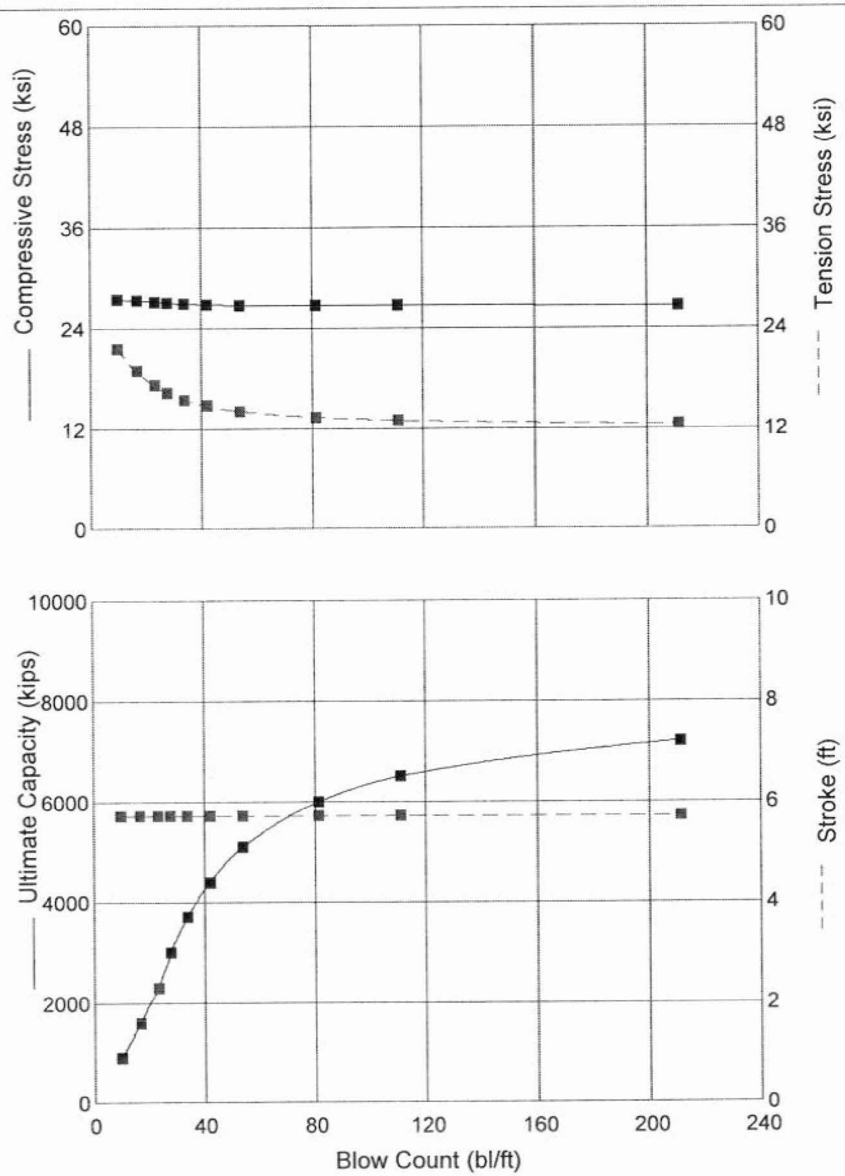


Res. Shaft = 70 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	27.47	21.57	9.9	5.71	269.22
1600.0	27.32	18.93	16.8	5.71	269.19
2300.0	27.19	17.28	23.3	5.71	269.21
3000.0	27.07	16.31	27.9	5.71	269.23
3700.0	26.95	15.48	33.8	5.71	269.25
4400.0	26.85	14.77	42.0	5.71	269.27
5100.0	26.75	14.12	54.1	5.71	269.29
6000.0	26.71	13.36	81.7	5.71	269.32
6500.0	26.69	12.97	111.1	5.71	269.33
7200.0	26.67	12.48	211.3	5.71	269.35

California D.O.T. Geotechnical Services
driveability study

14-Apr-2008
GRLWEAP (TM) Version 2005



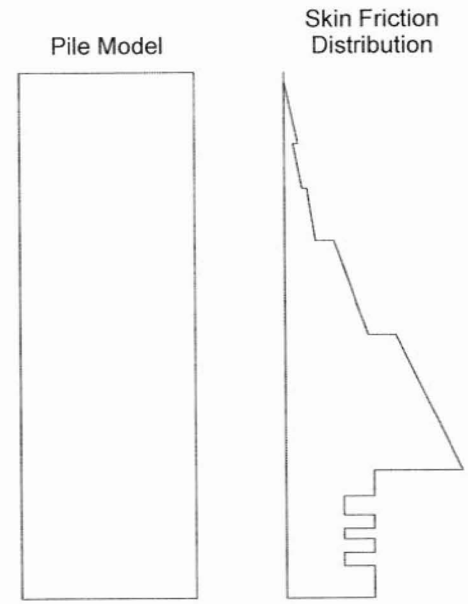
MENCK MHU 400

Stroke 5.71 ft
Efficiency 0.950

Helmet 0.00 kips

Skin Quake 0.100 in
Toe Quake 0.750 in
Skin Damping 0.050 sec/ft
Toe Damping 0.150 sec/ft

Pile Length 140.00 ft
Pile Penetration 140.00 ft
Pile Top Area 417.05 in2

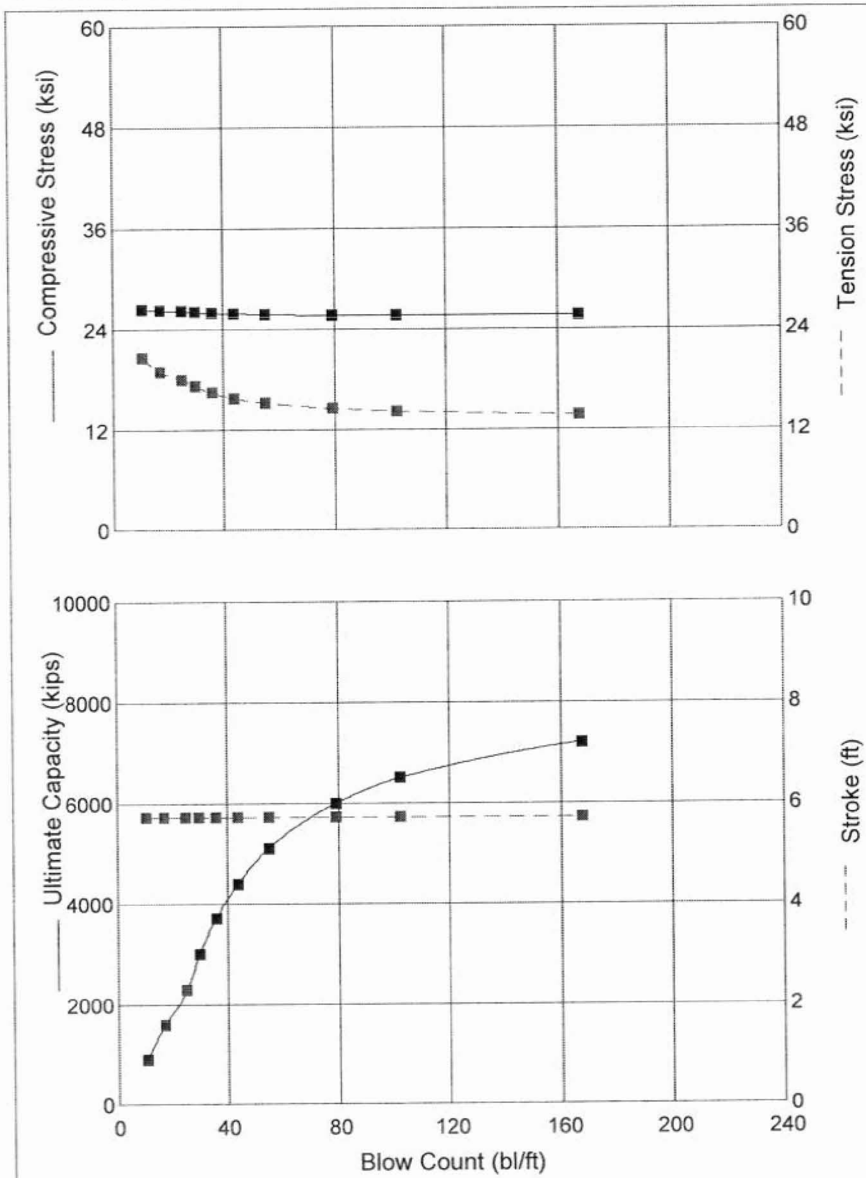


Res. Shaft = 70 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	26.37	20.59	10.6	5.71	268.58
1600.0	26.26	18.90	17.3	5.71	268.59
2300.0	26.15	18.01	25.3	5.71	268.59
3000.0	26.05	17.21	29.9	5.71	268.60
3700.0	25.97	16.46	35.9	5.71	268.71
4400.0	25.88	15.81	43.9	5.71	268.71
5100.0	25.79	15.25	55.2	5.71	268.71
6000.0	25.68	14.58	79.3	5.71	268.71
6500.0	25.66	14.23	102.6	5.71	268.71
7200.0	25.64	13.79	167.7	5.71	268.71

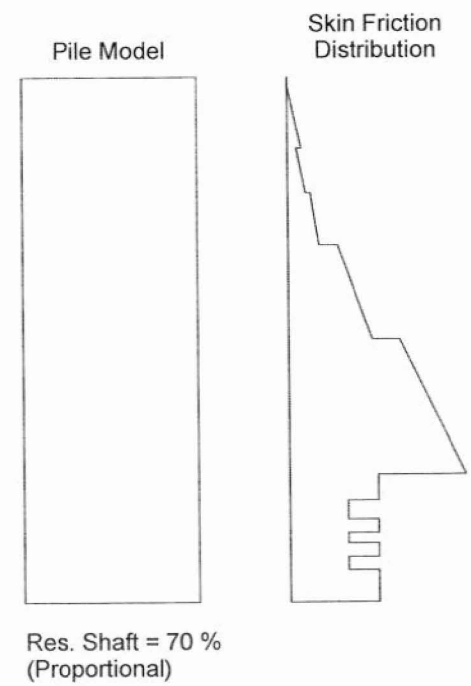
California D.O.T. Geotechnical Services
driveability study

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400

Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	485.18 in2



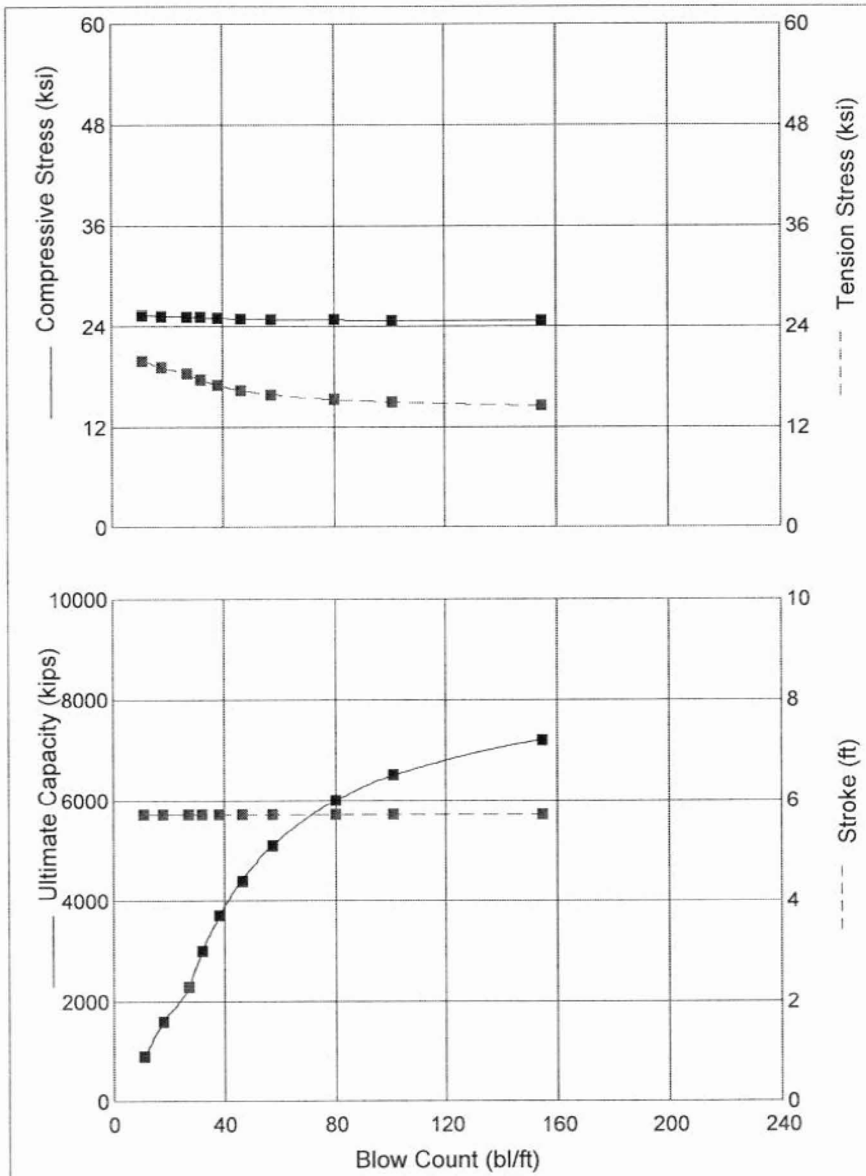
California D.O.T. Geotechnical Services
driveability study

14-Apr-2008
GRLWEAP (TM) Version 2005

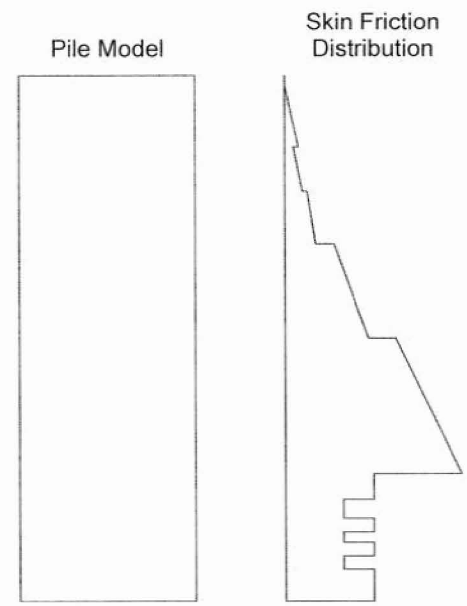
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	25.38	19.93	11.3	5.71	267.75
1600.0	25.28	19.11	18.2	5.71	267.75
2300.0	25.19	18.37	27.5	5.71	267.74
3000.0	25.10	17.68	32.3	5.71	267.74
3700.0	25.03	17.04	38.4	5.71	267.73
4400.0	24.96	16.44	46.4	5.71	267.73
5100.0	24.88	15.91	57.5	5.71	267.72
6000.0	24.79	15.31	80.4	5.71	267.71
6500.0	24.74	15.01	101.3	5.71	267.70
7200.0	24.69	14.61	154.8	5.71	267.70

California D.O.T. Geotechnical Services
driveability study

14-Apr-2008
GRLWEAP (TM) Version 2005



MENCK MHU 400	
Stroke	5.71 ft
Efficiency	0.950
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	552.92 in2

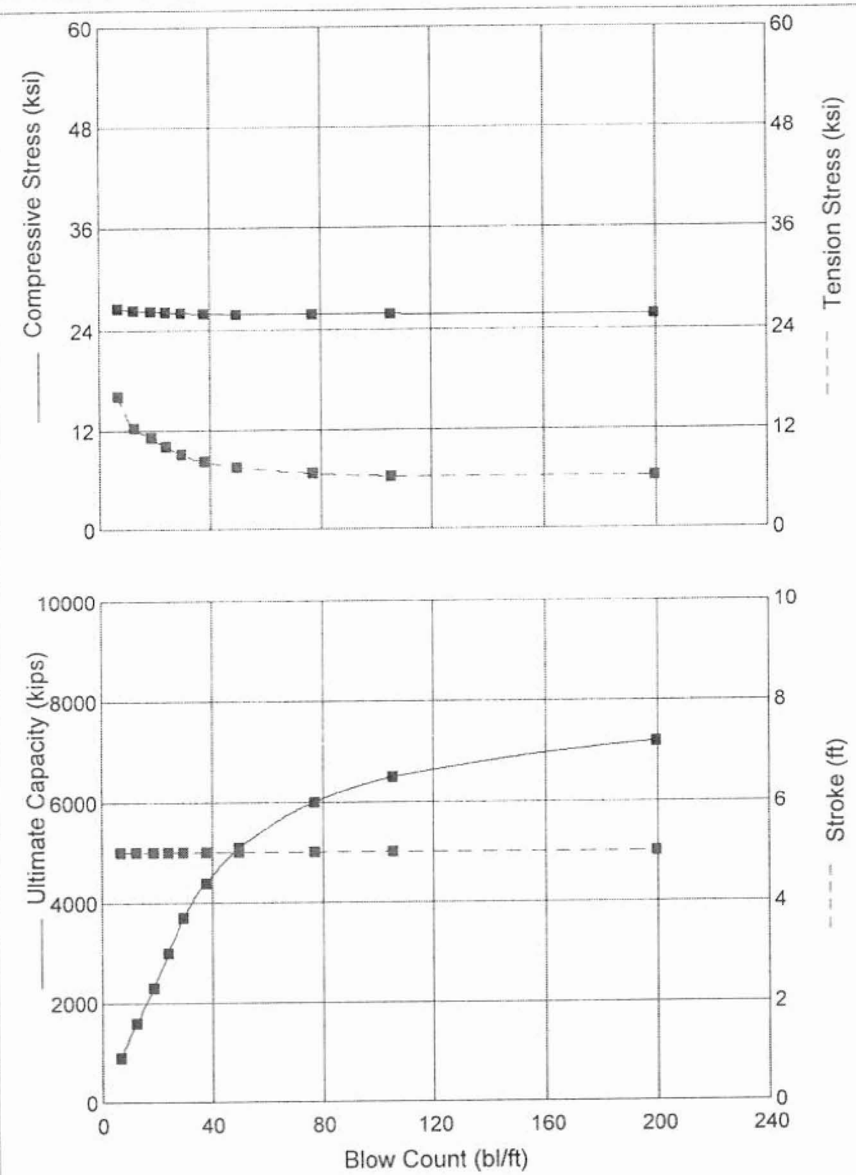


Res. Shaft = 70 %
(Proportional)

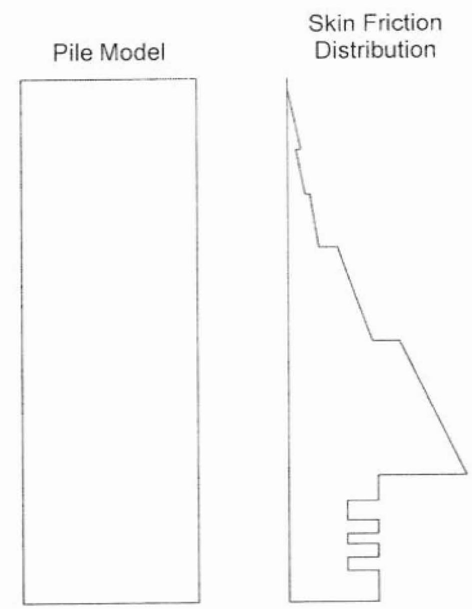
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	26.59	16.24	6.6	5.00	322.78
1600.0	26.41	12.30	12.5	5.00	322.54
2300.0	26.27	11.11	18.5	5.00	322.60
3000.0	26.18	10.05	23.8	5.00	322.52
3700.0	26.09	9.09	29.6	5.00	322.29
4400.0	26.00	8.24	37.7	5.00	321.93
5100.0	25.91	7.55	49.8	5.00	321.44
6000.0	25.85	6.80	77.1	5.00	320.65
6500.0	25.84	6.42	105.6	5.00	320.14
7200.0	25.82	6.41	199.4	5.00	319.35

California D.O.T. Geotechnical Services
driveability study

27-Mar-2008
GRLWEAP (TM) Version 2005

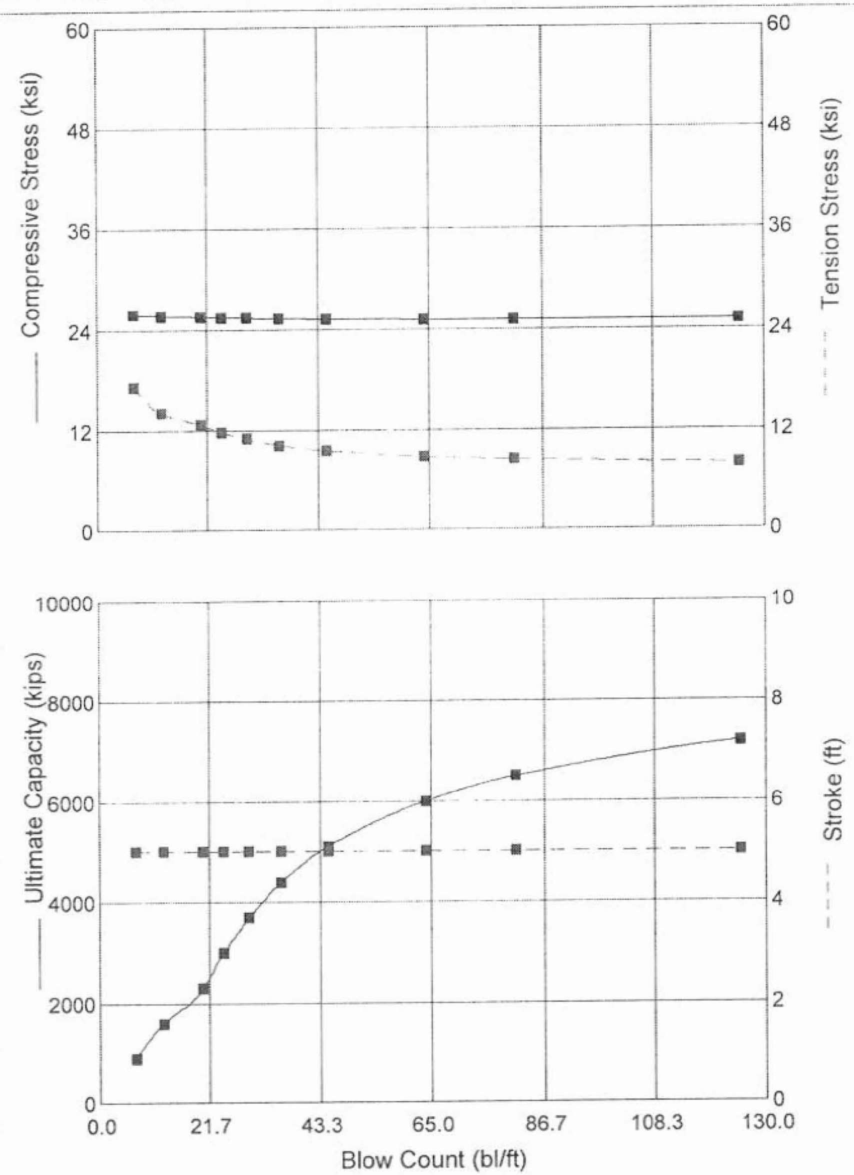


APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	348.52	in2

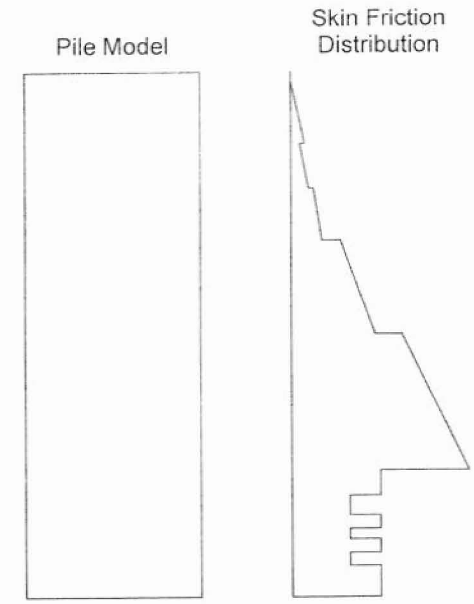


Res. Shaft = 60 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	25.86	17.22	7.3	5.00	321.48
1600.0	25.72	14.06	12.6	5.00	321.47
2300.0	25.59	12.68	20.5	5.00	321.36
3000.0	25.50	11.79	24.5	5.00	321.15
3700.0	25.43	10.97	29.5	5.00	320.84
4400.0	25.36	10.22	35.9	5.00	320.42
5100.0	25.28	9.55	45.0	5.00	319.91
6000.0	25.19	8.79	64.0	5.00	319.12
6500.0	25.16	8.44	81.3	5.00	318.97
7200.0	25.15	7.99	125.1	5.00	318.76



APE HI 400U	
Stroke	5.00 ft
Efficiency	0.800
Helmet	0.00 kips
Skin Quake	0.100 in
Toe Quake	0.750 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	140.00 ft
Pile Penetration	140.00 ft
Pile Top Area	417.05 in2



Res. Shaft = 60 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	25.18	18.15	7.9	5.00	320.41
1600.0	25.06	15.39	13.0	5.00	320.30
2300.0	24.96	13.86	21.8	5.00	320.12
3000.0	24.86	13.01	25.6	5.00	319.87
3700.0	24.78	12.32	30.3	5.00	319.54
4400.0	24.72	11.68	36.2	5.00	319.13
5100.0	24.65	11.10	44.0	5.00	318.65
6000.0	24.58	10.41	59.2	5.00	318.35
6500.0	24.54	10.06	72.1	5.00	318.22
7200.0	24.51	9.60	101.4	5.00	318.06

California D.O.T. Geotechnical Services
driveability study

27-Mar-2008
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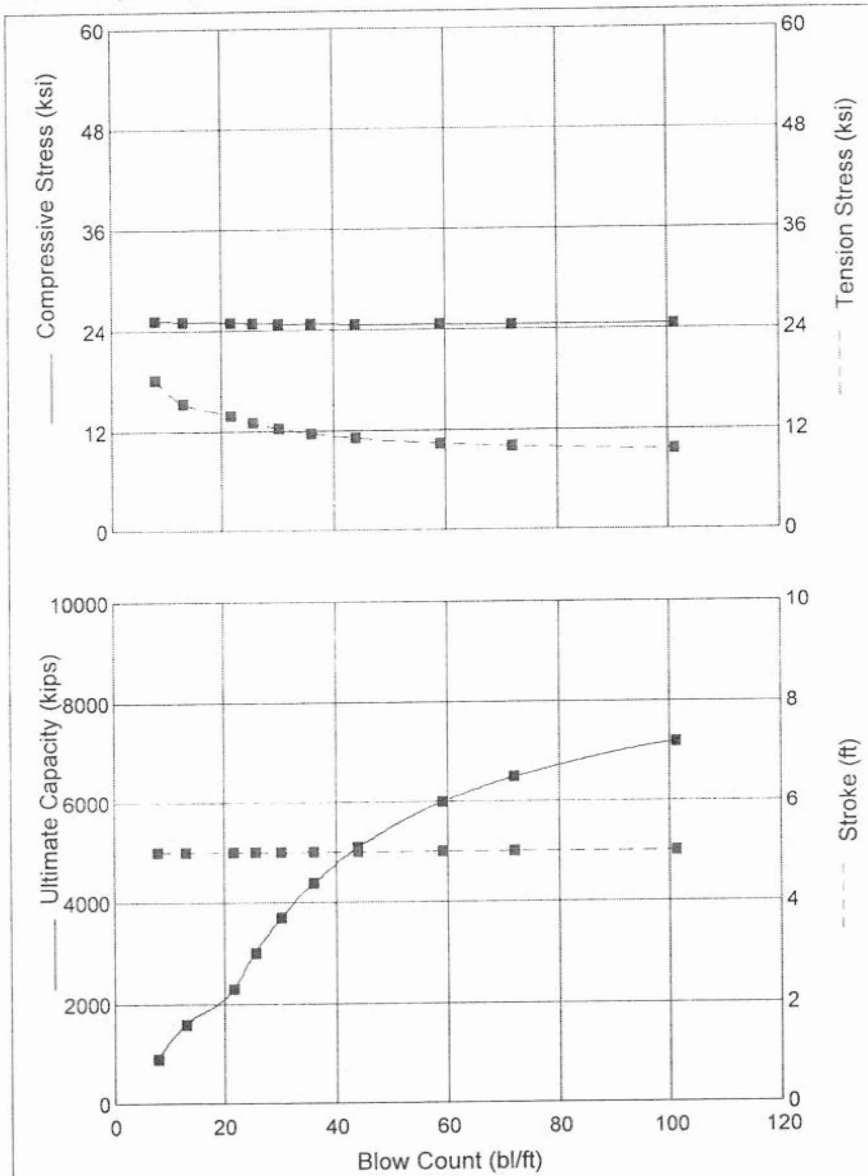
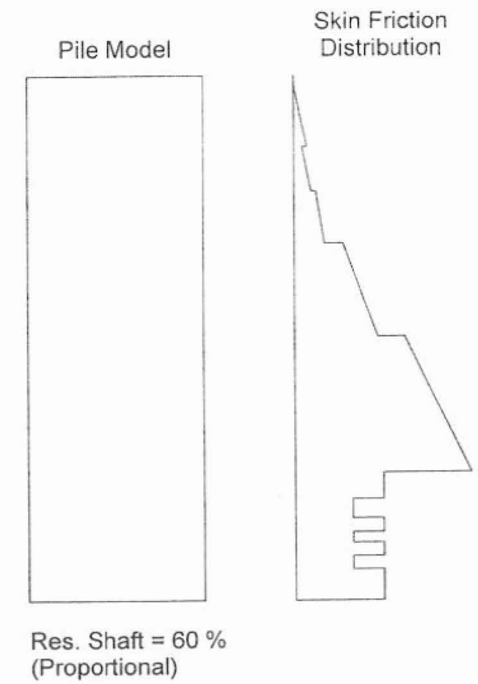


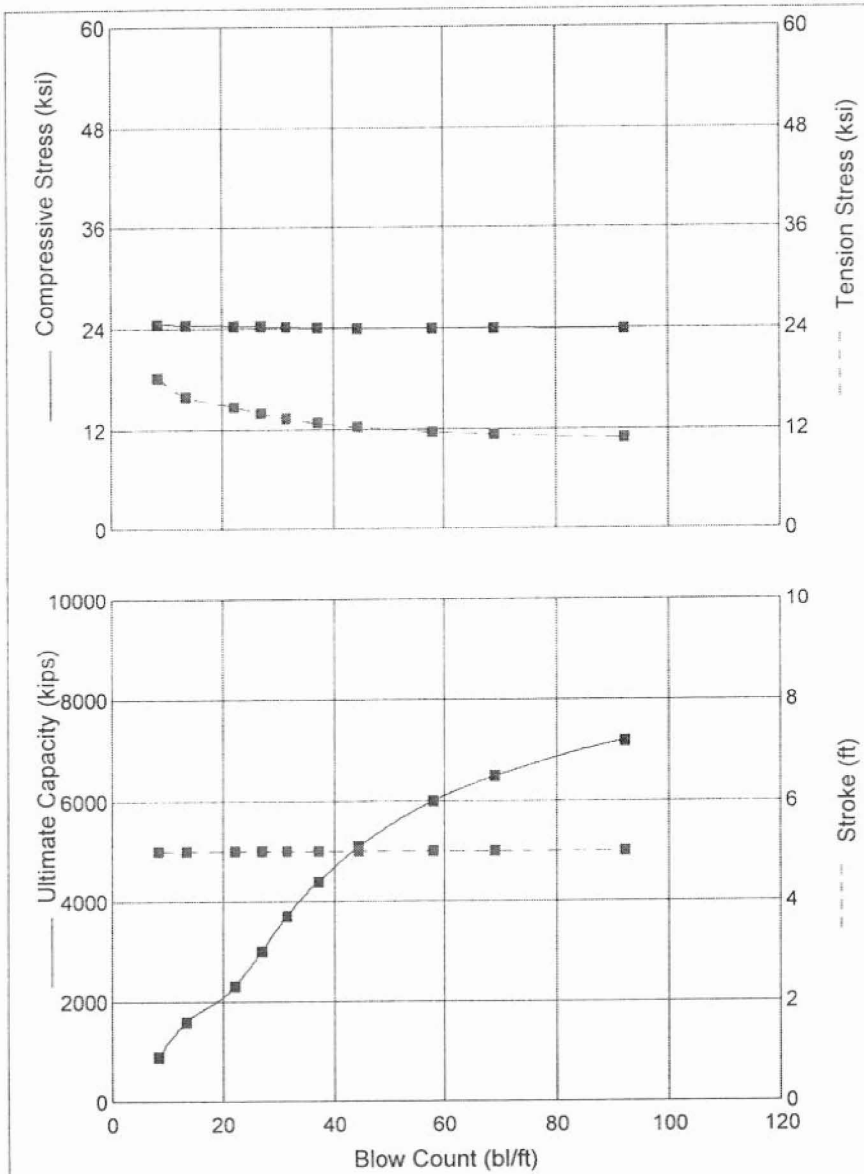
APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	485.18	in2



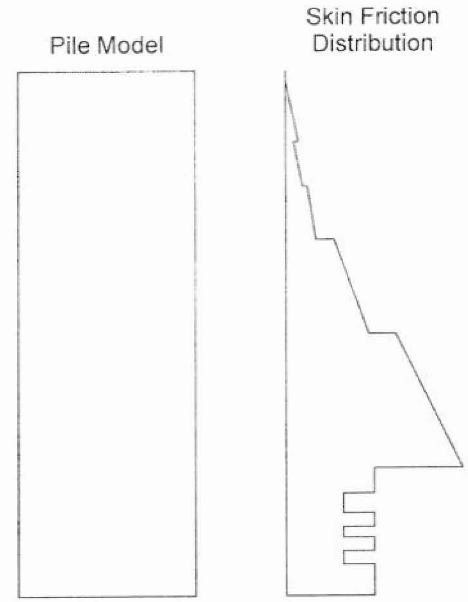
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
900.0	24.52	18.24	8.5	5.00	319.36
1600.0	24.43	16.01	13.5	5.00	319.22
2300.0	24.34	14.74	22.2	5.00	319.03
3000.0	24.26	14.01	27.0	5.00	318.78
3700.0	24.18	13.32	31.5	5.00	318.48
4400.0	24.11	12.76	37.2	5.00	318.12
5100.0	24.04	12.24	44.5	5.00	317.76
6000.0	23.98	11.63	58.1	5.00	317.58
6500.0	23.95	11.31	69.1	5.00	317.48
7200.0	23.92	10.89	92.3	5.00	317.35

California D.O.T. Geotechnical Services
driveability study

27-Mar-2008
GRLWEAP (TM) Version 2005



APE	HI 400U	
Stroke	5.00	ft
Efficiency	0.800	
Helmet	0.00	kips
Skin Quake	0.100	in
Toe Quake	0.750	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	140.00	ft
Pile Penetration	140.00	ft
Pile Top Area	552.92	in2



Res. Shaft = 60 %
(Proportional)

State of California
Department of Transportation

Structure Hydraulics

STRUCTURES
REVISED
FINAL HYDRAULIC REPORT

Feather River

Located on Route 99 in Sutter County

JOB:	FEATHER RIVER BRIDGE (Br. No. 18-0026 R)
LOCATION:	03-SUT-99- P.M. 12.03

This report has been prepared under my direction as the professional engineer in responsible charge of the work, in accordance with the provisions of the Professional Engineers Act of the State of California.

John Pham

REGISTERED CIVIL ENGINEER

REGISTRATION NUMBER C 51102

DATE: June 4, 200[illegible]

REGISTERED PROFESSIONAL ENGINEER
JOHN PHAM
No. 51102
Exp. 9/30/09
CIVIL
STATE OF CALIFORNIA

Feather River
Bridge No. 18-0026 R
03-SUT-99- P.M. 12.03
EA 03- 1A4321

Revised Hydrology & Hydraulics Report

General

This is the Revised Final Hydraulic Report for the proposed Feather River Bridge (Br. No. 18-0026), located at PM 12.03 on State Route 99 near Nicolaus in Sutter County. The project proposes to improve the existing State Route 99, starting from PM 10.9 and ending at PM 14.7 in Sutter County. The existing highway will be converted from two lanes to four lanes with a continuous median and left turn lanes. A new Feather River Bridge (Br. No. 18-0026R) will be constructed parallel to the existing Feather River Bridge.

All reference data and calculations of this hydraulic report are obtained from the following sources:

- Hydraulic and Hydrologic Documentation for FEMA Certification of Three River's Levee Improvement Authority Project prepared by MBK Engineers, dated December 2006.
- Floodplain Information- Feather River, Nicolas-CA prepared by Corps of Engineer, U.S. Army dated November 1968.
- Floodplain Study prepared by District 3 dated April 24, 1992.
- Preliminary Hydraulic Report prepared by Structures Hydraulics Office dated October 3, 2000.
- A field inspection was conducted by Structure Hydraulics on May 1, 2007
- Caltrans Bridge Maintenance Records (BIR'S)
- HEC-RAS Ver. 3.1.3, a hydraulic modeling computer program
- As-Built Plans for the Feather River Bridge dated 10/1956
- General Plans provided by Structure Design North, Branch 1,dated May 30, 2008
- Temporary construction configuration plans provided by Structure Design North, Branch 1,dated June 08, 2008
- 2007 Channel cross-sections provided by Preliminary Investigations North dated May 2007

Note:

All calculated elevations in this report are based upon the General Plan for the Feather River Bridge dated 05/30/2008, and the NGVD29 reference datum. Please verify datum references to the Final Design Plans and make elevation adjustments as required.

Existing Structure

The existing Feather River Bridge (Br. No.18-0026) was built in 1958 by Caltrans. It has 31 PC/PS girder spans. Both abutments and Pier 2 are founded on Raymond step taper piles and all other piers are founded on PC/PS concrete piles. The bridge has a total length of 3186 ft with an original width of 32.2 ft. The bridge was widened at the south side in 1999 to make a new total width of 43.6 ft. The Bridge Inspection Report dated January 20, 2005 from the Office of Special Investigation, Hydraulics Branch has determined that the bridge remains scour critical. The Item 113 code is 7, "Countermeasures have been installed to mitigate an existing problem with scour and to reduce the risk of bridge failure during a flood event. Instructions contained in a Plan of Action have been implemented to reduce the risk to users from a bridge failure during or immediately after a flood event". Sheet pile encasements were installed around Piers 13 and 14 to address scour due to channel migration. No additional work is needed for the existing structure, but the existing structure should be monitored for changes in the channel conditions.

Proposed Structures

The new Feather River Bridge (Br. No. 18-0026 R) is a 16 span Precast Spliced, Modified Bulb Tee Girder Bridge on two 7.5' diameter CISS Piles, and seat type abutments. Span configuration: 152'-6" and 115'-6" end spans and 13 spans @ 210' plus one span @ 150'. It has a total length of 3148 ft and 41.8 ft in width.

Basin

The watershed is approximately 5,372 square miles above its mouth at the town of Verona and with an additional 550 square miles from the Bear River system; a principal tributary located to the east of the Feather River. Between Marysville and Verona, the stream travels southerly about 28 miles along confined levees through flat terrain. The floodway width varies from 2,600 to 7,000 feet. Snowmelt and rain from Bear River would affect the water surface elevation of the Feather River as well as the flow from the upper part of the Sutter Bypass. The Sutter Bypass is a natural flood overflow channel that carries excess flow from the Sacramento River. Flows are moderated by the multiple reservoirs and dams; the Oroville, Marysville and New Bullards Bar reservoirs were built to control the flow during the extreme flood season. Feather River starts in the snowfields of the northern Sierra Nevada, ranging in elevation from 8000 feet to the flat valley land at 35 feet. The mean annual rainfall at is about 20 inches near the bridge site and 90 inches along the ridges near the West Branch headwaters of the North Fork Feather River. The maximum precipitation record was 165 inches, which occurred at LaPorte in the 1910 to 1911 wet season. The watershed is covered by farmland in the valley areas and thick forest in the mountain areas. The climate is distinguished by hot and dry summers and cool wet winters. The average temperature in the basin ranges from 96°F in summer to 27°F in winter. Rainstorms normally occur between November to April and have caused flooding many times in the past before the dam/reservoir system was in place.

Discharge

The discharge at the bridge or the released water regulated by reservoirs is about 320,000 cfs, obtained from a study prepared by Corps of Engineers, U.S. Army in 1968 for the California Reclamation Board, Sutter and Yuba Counties under title "Flood Plain Information of Feather River near Nicolaus, California". Recently, MBK Engineers completed a study "Hydraulic and Hydrologic Documentation for FEMA Certification of Three River's Levee Improvement Authority Project" in December 2006, and in the report, the discharge at the existing Feather River Bridge was increased to 329,814.90 cfs. The Corps of Engineers, U.S. Army requires using the approved discharge of 320,000 ft^3/s for calculations.

Stage

HEC-RAS Version 3.1.3 - streambed analysis computer programs were used for the water modeling and bridge scour calculations. The Manning's roughness coefficient (0.027 to 0.055) was taken from 2000 and 2007 field inspection reports. Preliminary Investigations North provided channel cross-sections. The General Plans from Structure Design North, Branch 1,dated May 30, 2008, was used for the bridge model. Channel migration, minor channel degradation and moderate debris condition were considered for the scour calculation. The estimated high water elevation at the upstream face of the structure based on is shown in TABLE 1.

TABLE 1

	Design Flood / 100-year storm 320,000 ft^3/s	
WS. Elevations. (Upstream side)	**Available Freeboard** (Base on lowest calculated soffit)	
Pre- condition	49.37 ft	7.43ft (At the existing bridge)
Post- condition	49.38 ft	3.62 ft (At the proposed bridge)

This hydraulic study shows that there will not be any significant increase on the base floodwater surface elevation in the area of the proposed project within the existing floodplain condition.

Streambed

The streambed of the Feather River consists of mostly loose sand with very little cohesive material. The stream channel slope at the site is relatively flat at both upstream and downstream segments of the proposed site. Channel migration has occurred in the past. The riverbank had migrated northward as the result of many large floods in earlier years, probably during 1955 to 1965. The thalweg had moved northward about 320 feet in the period of 31 years from 1956 to 1987, but it has stabilized, slowing its migration in the last 20 years. Minor channel migration still occurs although the channel seems laterally stable. For more information on the channel bed composition and its depths, please refer to the Log of Test Borings provided by the Foundation Investigation Branch, Division of Geotechnical Services for this project.

Velocity

Under the estimated channel discharge, the maximum velocity is 7.6 ft/s, and the average velocity is 5.0 ft/s.

Waterway

The proposed structure will be sufficient to pass the 100-year discharge plus adequate freeboard. The minimum waterway area is 65,000 ft^2.

Drift

Bridge maintenance records are available for the existing Feather River Bridge (Br. No. 18-0026). According to these records, moderate to large drift have been found around various piers and debris removal has been recommended several times. During the field investigation in May 1, 2007, trees up to 1.5 ft in diameter or larger were observed in front of Piers 13 to 15, at the upstream side of the bridge. One foot of debris width will be added at each side of the pier for pier scour calculations.

Minimum Soffit Elevation

The Feather River is in the State Reclamation Board's adopted designated floodways of the Central Valley. The Board requires that the soffit of the proposed bridge at the major waterway should be at least 3.0 feet above the water surface elevation for the 100-year discharge (see California Code of Regulation by Reclamation Board, Title 23, Division 1, Vol. 32, Section 128). The calculated 100-year water stage elevation is 49.38 ft, and the minimum allowable soffit elevation at the upstream side of the proposed structure is 52.38 ft.

Bridge Skew and Hydraulics Skew

There is zero bridge skew for both proposed and existing structures. Five degrees of hydraulic skew was used to calculate potential scour for pier design.

Scour and Channel Degradation

Based on available records from 1956 to 2007, the channel is considered laterally and vertically unstable. Channel degradation was observed and recorded from 1956 to the present time. Between 1956 to 1987, the thalweg has dropped 10 ft in elevation and moved 320 ft northward. Channel degradation and migration rates were slowed after 1987 at a rate about 0.1 foot per year. Future degradation for the estimated 75-year design lifespan of the proposed structure was calculated at approximately 5.0 ft. This value was used in estimating the total scour in this report. Maintenance records showed the existing structure has significant local scour history at Piers 13 and 14 due to the high water velocity during the big storms in the past years. The maximum local scour is anticipated at Piers 4 to 7 of the new structure. The total local pier scour depth is about 12.50 ft for the 7.5 ft diameter columns. The potential total pier scour depth (total local pier scour plus assumed future degradation) is 17.50 ft. Potential debris loading is considered in the scour calculation by adding the columns diameter two feet. The upstream cross sections were provided by the Preliminary Investigations North survey dated May 2007. The final supported elevation for all pier and abutment foundations should be consulted with the Geotechnical Branch. The anticipated scour depths are shown on TABLE 2.

TABLE 2

Thalweg Elevation (2007)	**Scour Elevation (Max)**
11.80 ft	-0.70 ft
Projected 75-yr Thalweg Elevation (2082)	**Scour Elevation (2082)**
6.80 ft	-5.70 ft

Bank Protection

Channel migration is influenced by flow velocity and bed materials. Loose sands cannot resist the high water velocities during a big storm discharges. It is difficult to predict outcomes due to the channel recharge process. Structure Hydraulics recommends placing the RSP at the abutment slopes. The rock size is provided in TABLE 3. District will determine whether bank protection is required at the roadway approaches.

TABLE 3

Recommendation for RSP rock size	**Ton**	***Thickness***
Outside layer	¼ Ton	3.3 ft
Inner layers RSP -Class	None	
Backing Class No.	1 or 2	1.25 ft or 1.80 ft
RSP Fabric	A	
Method of Placement	B	
Total minimum thickness	4.55 ft	

Note: *The minimum recommended rock weight is ¼ ton at easy access areas to prevent illegal removal of the material out of the site.*

Flood Plain Encroachment

The proposed project is in the flood hazard areas inundated by the 100-year flood. The zoning is "ZONE A"; no base flood elevation determined as shown on Sutter County, California Flood Insurance Rate Map (FIRM), Community-Panel Number 060394-0200 B, dated April 5, 1988. The entire proposed bridge lies within the State Reclamation Board designated floodway and will require a permit.

Hydrology study for Interim construction stage

The Department of Water Resources/US Army Corps of Engineers (DWR/COE) has made an additional request for design information regarding flow elevations during the construction phase of this waterway. Structure Design North, Branch 1 provided temporary construction configuration plans for a four-season construction project. The hydraulics models for the most likely conditions during construction were studied for two different scenarios; Two- Phase and Single phase. In Two- Phase, Stage 1 starts from Abutment 1 to Pier 9 and Stage 2 runs from Pier 9 to Abutment 17. The bridge with the temporary falsework configuration has more restraints than the finished structure because the increased number of temporary support girders (assumed 8 ft in width) in the channel will reduce the waterway. To ensure the backwater does not affect the existing structure downstream and significantly change the expected water level, the models with add-on temporary false work supports were studied using five different scenarios: 2-year storm, 5-year storm, 10-year storm, 50-year storm, and a 100-year storm. The results are listed on TABLE 4. For comparisons the difference between the Pre-condition and Interim construction methods, please refer TABLE 5.

TABLE 4

Existing Feather River Bridge (Br. No. 18-0026)

(Up stream side)

Events	**Discharge (ft^3/s)**	**Average Velocity. (ft/s)**	**WS Elev. (ft)**
2-year storm	82,000	5.01	32.35
5-year storm	122,000	5.06	36.64
10-year storm	152,000	4.75	39.43
50-year storm	272,000	4.91	47.39
100-year storm	320,000	5.21	49.37

New Feather River Bridge (Br. No. 18-0026R) – Two phases

Stage 1 (Up stream side)

Events	**Discharge (ft^3/s)**	**Average Velocity. (ft/s)**	**WS Elev. (ft)**
2-year storm	82,000	5.08	32.41
5-year storm	122,000	5.10	36.70
10-year storm	152,000	4.83	39.48
50-year storm	272,000	5.08	47.40
100-year storm	320,000	5.42	49.39

New Feather River Bridge (Br. No. 18-0026R) – Two phases

Stage 2 (Up stream side)

Events	**Discharge (ft^3/s)**	**Average Velocity. (ft/s)**	**WS Elev. (ft)**
2-year storm	82,000	4.69	32.37
5-year storm	122,000	4.78	36.66
10-year storm	152,000	4.60	39.46
50-year storm	272,000	4.93	47.42
100-year storm	320,000	5.27	49.42

New Feather River Bridge (Br. No. 18-0026R) – Single phase
(Assumed 2 ft wide &2 ft high debris at theUp stream side)

Events	Discharge (ft^3/s)	Average Velocity. (ft/s)	WS Elev. (ft)
2-year storm	82,000	4.93	32.77
5-year storm	122,000	4.92	37.15
10-year storm	152,000	4.71	40.00
50-year storm	272,000	5.24	47.36
100-year storm	320,000	5.58	49.37

Note: *Discharges (2-year to 50-year) were calculated with USGS FLOOD FREQUENCY EQUATION and compared the results with the GAGE METHOD (USGS Gage # 11425000) using whichever is greater.*

TABLE 5
New Feather River Bridge (Br. No. 18-0026R) – Interim phase
(Up stream side)

Events	Discharge (ft^3/s)	Average Velocity. (ft/s)	WS Elev. (ft)
Pre Condition	320,000	5.21	49.37
2 - Phases- Stage 1	320,000	5.42	49.39
2 - Phases- Stage2	320,000	5.27	49.42
Single phase	320,000	5.58	49.37

From the results of the study, the difference of the water surface elevations and velocities between the existing and proposed structures is minor and the resulting backwater is considered not significant during the Interim construction period.

Summary Information for the Bridge Designer

Below is a summary of key design parameters based on the hydrology and hydraulic analysis performed for this structure:

Minimum Soffit Elevation*		53.00 ft	
Potential Scour Elevation at Abutments/piers*		-6.0 ft (Assumes channel can migrate bank to bank)	
Required Waterway		65,000 ft^2	
Average Velocity		5.00 ft/s	
HYDROLOGIC SUMMARY			
Drainage Area: Natural stream 5,922 square miles			
	Design Flood	**Base Flood**	**Overtopping Flood**
Frequency (yrs)	100-Year	100-Year	N/A
Discharge (ft^3/s)	320,000	320,000	>1,500,000
Water Surface Elevation at Bridge (ft)*	49.38	49.38	63.00 @ Abutments
Flood plain data are based upon information available when the plans were prepared and are shown to meet federal requirements. The accuracy of said information is not warranted by the State and interested or affected parties should make their own investigation.			

- *All calculated elevations in this report are based on the General Plans from Structure Design North, Branch 1, and dated 05/30/2008.*
- *Potential Scour Elevation=Local Scour Elevation-5 ft for future degradation.*

Memorandum

Flex your power!
Be energy efficient!

To: MR. JEFF SIMS
Senior Bridge Engineer
Structure Design North, Branch 1

Attention: Greg Jones

Date: June 5, 2009

File: 03-SUT-99-PM 12.03
03-1A4321
Hwy 99 Widen, Seg 2
New Feather River Bridge
Br. No. 18-0026R

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5

Subject: Amended Foundation Report (FR)

Foundation Recommendations

This amends portions of the Foundation Report dated August 7, 2008 for Feather River Bridge (18-0026R) due to comments by the United States Army Corps of Engineers (USACE). The USACE has requested pre-drilling of Abutments 1 and 17 for depths of approximately five feet and 20 feet, respectively. The memo revises portions of the FR date August 7, 2008 to reflect this change. The proposed new Feather River Bridge structure, as indicated on the Feather River Bridge General Plan dated November 29, 2007, may be supported on Class 140 pipe piles at Abutments 1 and 17 according to the table below.

Table 1

Abutment Foundations Design Recommendations (Feather River Br-18-0026R)

Support	Pile	Cut-off Elevation (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip Elevations (ft)	Specified Tip Elevation (ft)	Nominal Driving Resistance Required (kips)
			Total	Permanent					
Abut 1	Class 140 Alt. W	47.75	4200	3150	140	280	-10.0(a), 15.0(c)	-10.0	280
Abut 17	Class 140 Alt. W	47.75	4200	3150	140	280	-20.0(a), -11.0(c)	-20.0	280

Notes:
1) Design tip elevations are controlled by: (a) Compression, (c) Settlement, respectively. The specified tip elevation shall not be raised above the design tip elevations for tolerable settlement.

Construction Considerations

All piles at Abutments 1 and 17 of the proposed new bridge shall be driven in oversized pre-drilled holes according to the provisions of Section 49-1.06 of the Caltrans Standard Specifications (May 2006) **except** for the following:

After driving the pile, the space around the pile shall be filled (sealed) to ground surface by cement-bentonite slurry. The cement-bentonite slurry shall be placed by the tremie method.

Table 2: Elevations of Pre-drilled holes

Support Location	Pre-drilled elevation (feet)
Abutment 1	40.0
Abutment 17	20.0

If you have any questions or require additional information on this subject, please contact Abu Barrie at 916-227 1043, or Reid Buell at 916-227 1012.

Report by

ABUBAKARR BARRIE
Engineering Geologist
Office of Geotechnical Design-North

REID BUELL, C.E.G NO. 1481
Senior Engineering Geologist
Office of Geotechnical Design-North

REGISTERED GEOLOGIST
REID L. BUELL
No. 1481
Exp. 4/30/11
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

c: R.E Pending
Structure OE (E-copy)
PCE (E-copy)
DME (E-copy)
GDN File
GS File

Memorandum

Flex your power!
Be energy efficient!

To: MR. JEFF SIMS
ENGINEERING SERVICES
DIVISION OF STRUCTURE DESIGN-MS 9 4/11G
OFFICE OF BRIDGE DESIGN-NORTH
BRANCH 1

Attention: Mr. Greg Jones

Date: April 28, 2008

File: 03-Sut-99-PM 12.03
03-1A4321
Feather River Bridge
Br. No. 18-0026R

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES - MS 5
OFFICE OF GEOTECHNICAL DESIGN - NORTH

Subject: Final Seismic Design Recommendations, and Soil Springs

This report presents the final seismic design recommendations, and soil springs for the Feather River Bridge located on State Highway 99 in Sutter County. Please note the soil spring data were e-mailed to you on April 16 and 18. 2008.

Geology

Based on a recent foundation investigation conducted by our office in July through September 2007, the foundation materials generally consists of loose to very dense granular silt, sand, and gravel interbedded with soft to hard clay.

Seismic Study

Based on Caltrans California Seismic Hazard Map 1996, the controlling fault for the site is Dunnigan Hills (style of faulting: reverse, including thrust) with a maximum credible earthquake moment magnitude of M_w=6.5, and is located about 30 km southwest of the site. The peak horizontal bedrock acceleration based on the above map is estimated to be 0.2g. There is no known active fault crossing the bridge site, therefore, the potential for surface rupture at the site is considered insignificant.

Based on the LOTB, a Caltrans Seismic Design Criteria Acceleration Response Spectrum corresponding to soil profile Type D is recommended for design (see Figure 1 in Appendix A).

Liquefaction Study

A detailed liquefaction analyses were performed for all support locations based on the recommendations outlined in the report entitled "Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils."

The completed analyses indicate the underlying loose granular materials have potential to liquefy during a strong ground shaking. Table shows the extent of the liquefiable layer(s).

	Estimated Elevation (feet)	
Support Location	Original Ground	Liquefiable Layers
Abutment 1	55	None
Pier 2	18	18 to 2
Pier 3	26	None
Pier 4	14	14 to 7
Pier 5	12	12 to -8
Pier 6	19	19 to 4 and -17 to -12
Pier 7	17	17 to 7 and -3 to -13
Pier 8	37	24 to 14
Pier 9	37	24 to 4
Pier 10	37	17 to -8
Pier 11	36	17 to -8
Pier 12	36	36 to 31
Pier 13	35	35 to 28 and 13 to -4
Pier 14	34	34 to 29 and 14 to -6
Pier 15	33	28 to18
Pier 16	27	22 to 7
Abutment 17	55	None

Soil Springs

The soil spring analyses were performed for two loading conditions. The first condition was based on when no channel degradation has taken place. The second case was analyzed when channel degradation has occurred to an elevation of 7 feet as provided by

Mr. Steve Ng of Hydrology/Hydraulics Office in a report entitled "Final Hydraulics Report for Feather River" dated July 11, 2007.

Therefore the lateral resistance (p-y curve) for the proposed 7.5' CISS pile were estimated for the two loading conditions. The p-y curves were generated using soil models included in the documentation for the computer program LPILE (Ensoft Inc., May 1997). The relevant soil parameters were estimated from correlations with Standard Penetration Testing (SPT) blow counts, and from soil descriptions contained in the field logs.

Please note that group reduction factor (GRF) for p-y curves has not been imposed. GRF should be applied after the pile layout is finalized. A GRF of 0.4 should be applied for the pile center-to center spacing of 2D, where D is the pile diameter. A GRF of one should be used for the pile spacing of 5D or greater. Use linear interpolation for pile spacing between 2D and 5D.

The axial and tip resistances, (t-z and q-z curves) for the proposed pile foundation of 7.5' CISS were also performed for the two loading conditions using the procedures outlined in the American Petroleum Institute Recommended Practice.

Please note the p-values through the liquefiable soils have been reduced to a residual strength of 20%; whereas the axial and tip resistances (t and z values) have been completely ignored through the same liquefiable layers. The plots and tabulated data for all p-y, t-z and q-z are attached in Appendices B, C and D.

If there are any questions regarding the design recommendations, please contact Reza Mahallati at (916) 227-7189.

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Attachments
1- Appendix A – ARS Curve
2- Appendix B – p-y Curves
2- Appendix C – t-z Curves
3- Appendix D – q-z Curves

c: Abu Barrie - (OGD-N), OGDN File

Appendix A

Recommended ARS Curve

Feather River Bridge
Br. No. 18-0026R
03-1A4321

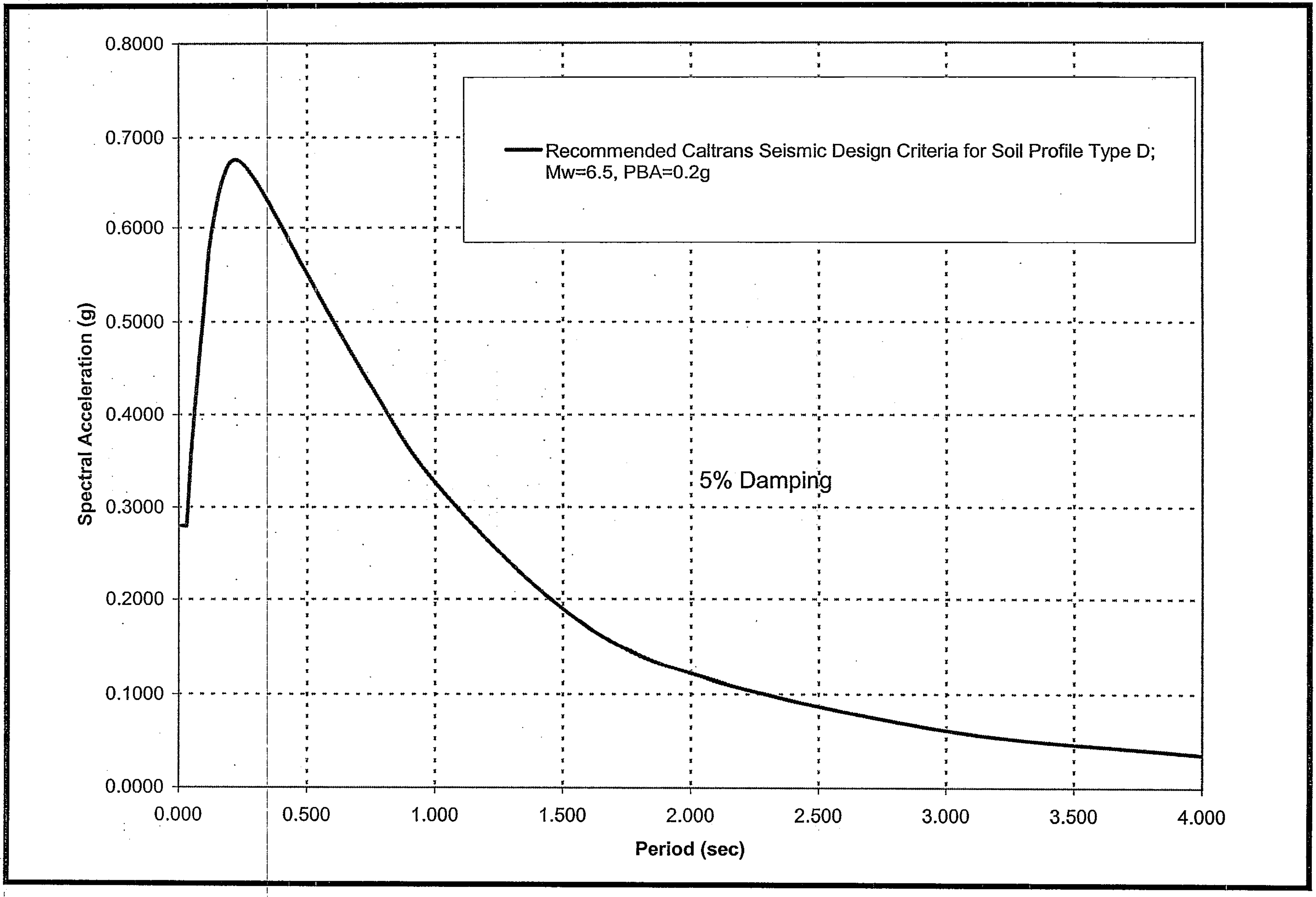


Figure 1. Acceleration Response Spectrum Recommended for Design

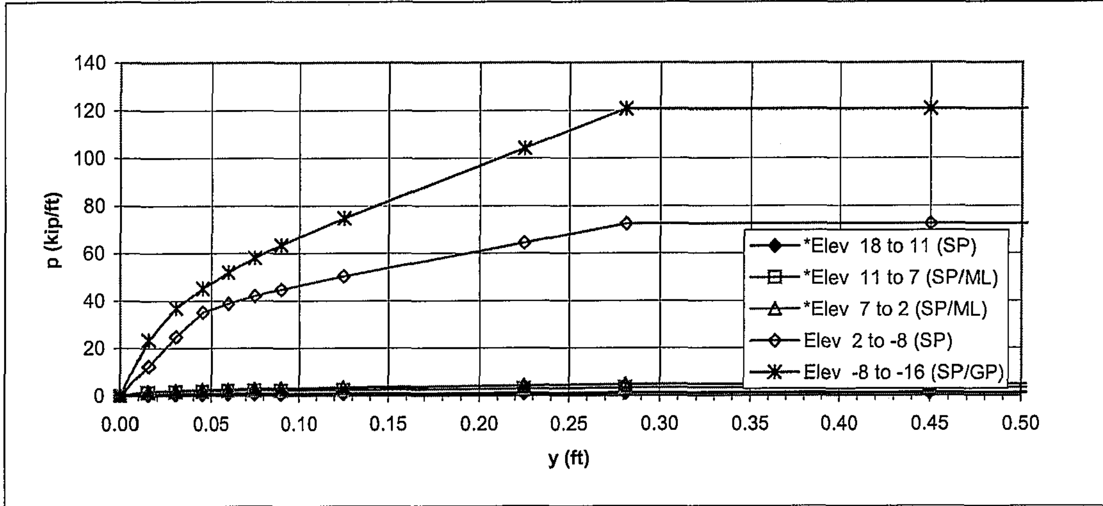
Appendix B

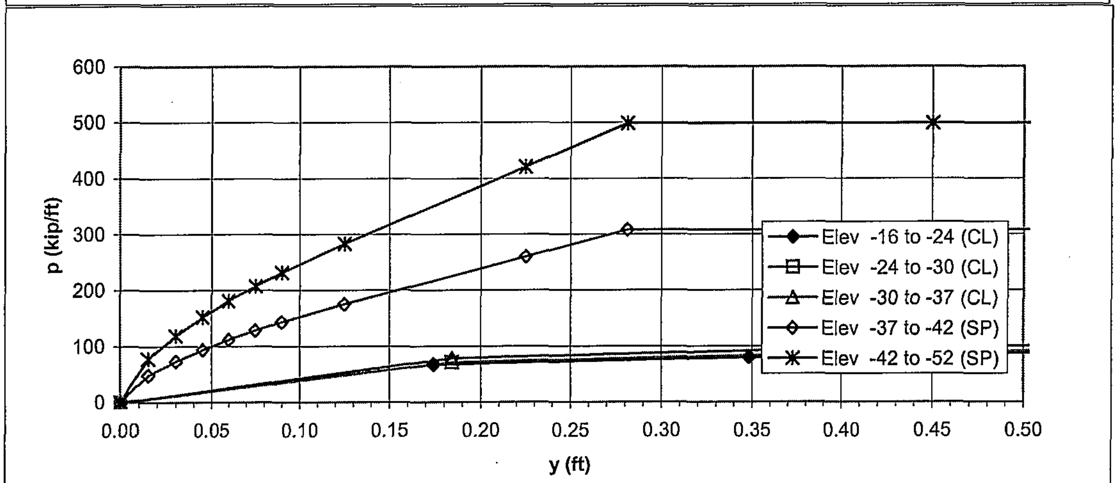
Lateral Resistance, p-y Curves

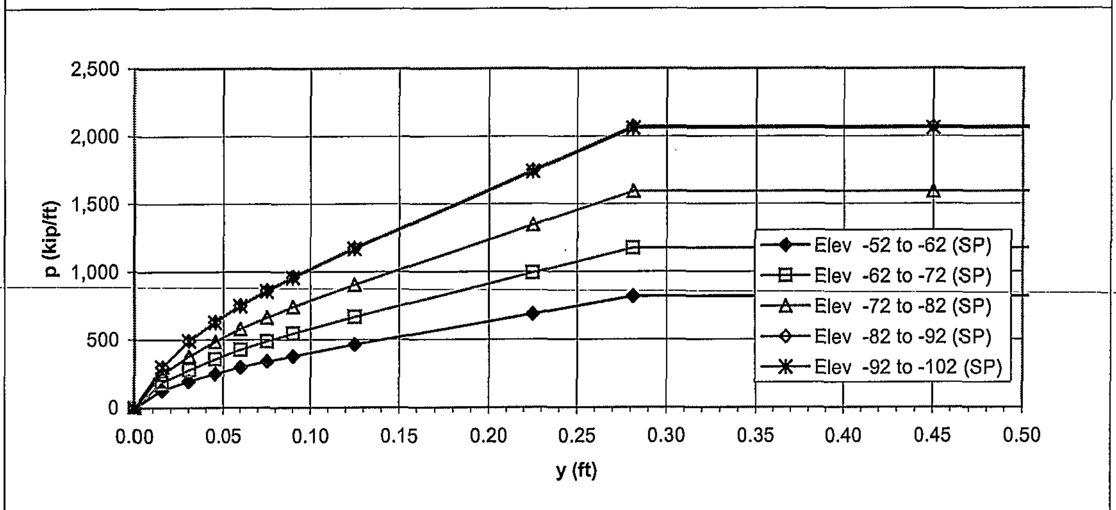
Loading Condition:
With and Without Channel Degradation

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 2 - No Degradation		**O.G.**	18.0	**Pile**	7.5' CISS
Sta.		**Cut-off**	18.0	**GWS**	50.0







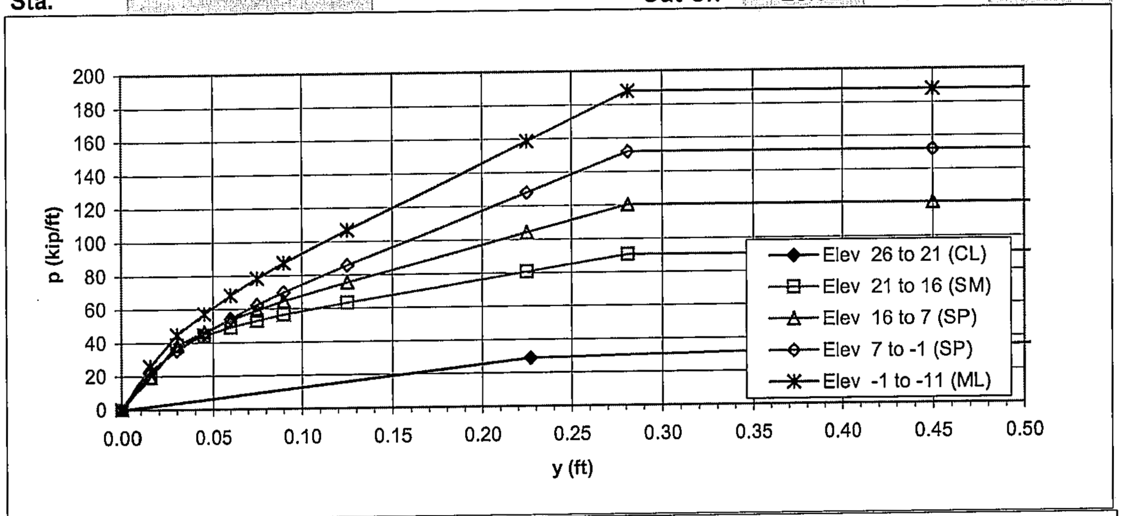
Post-Liquefaction

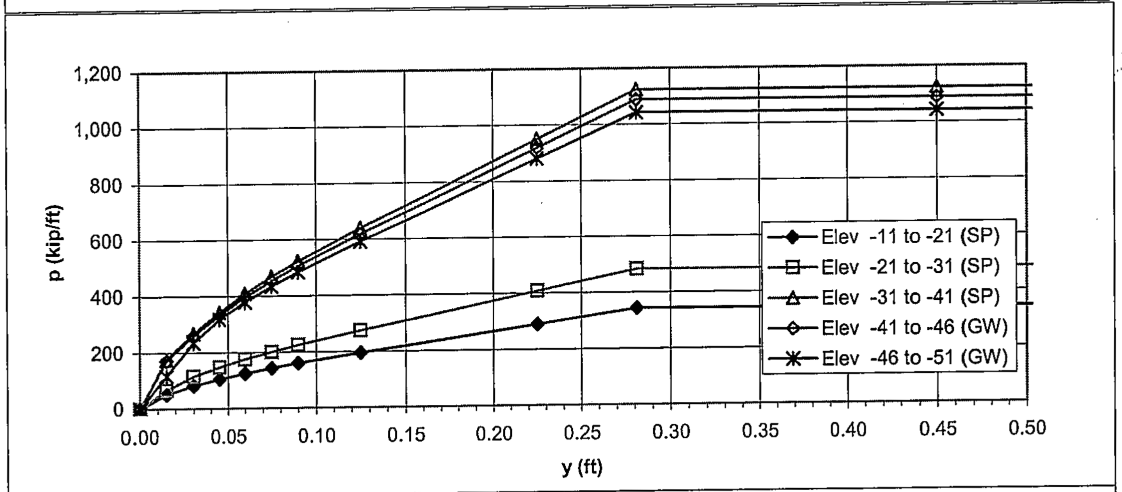
* - Liquefiable Layer

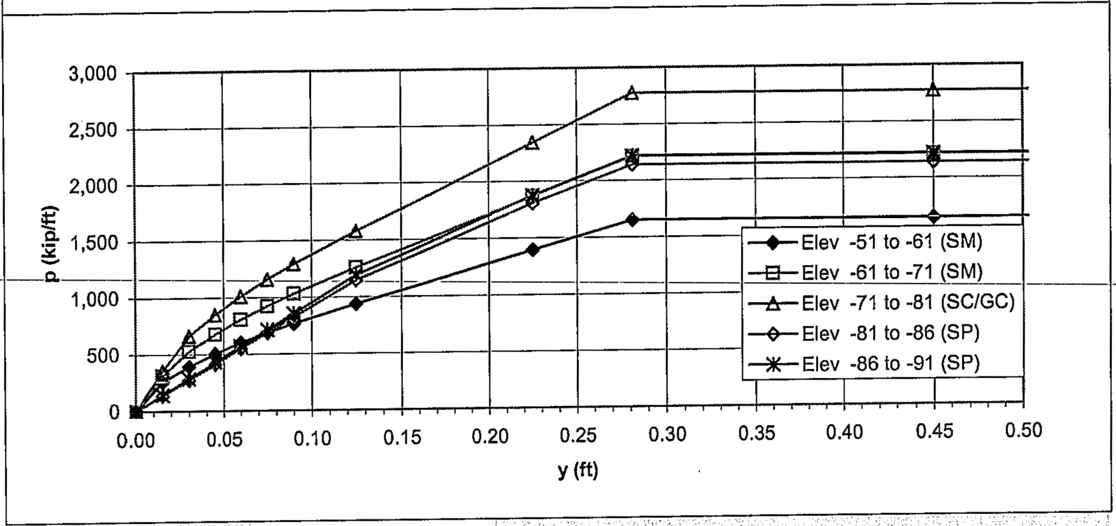
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 3 - No Degradation

Sta.		O.G.	26.0	Pile	7.5' CISS
		Cut-off	26.0	GWS	50.0



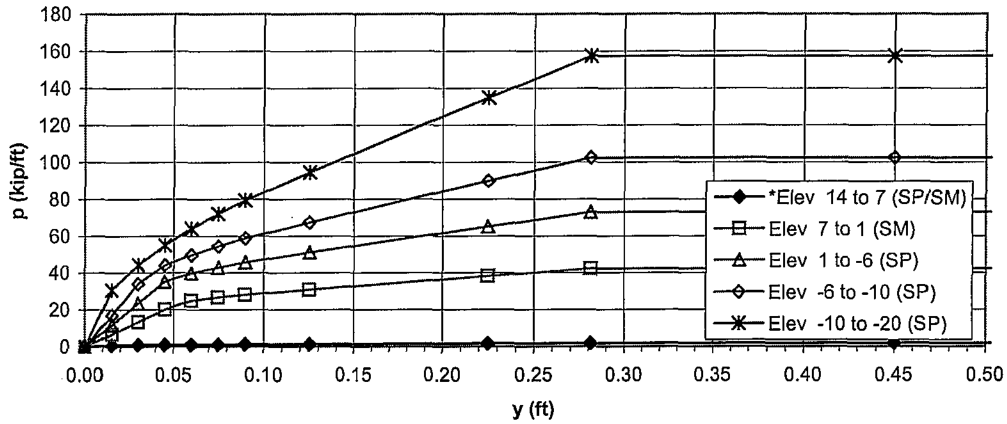


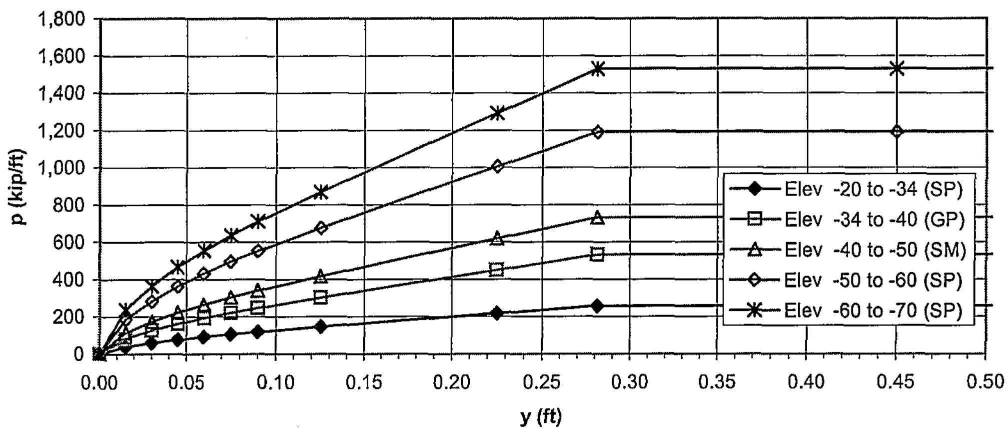


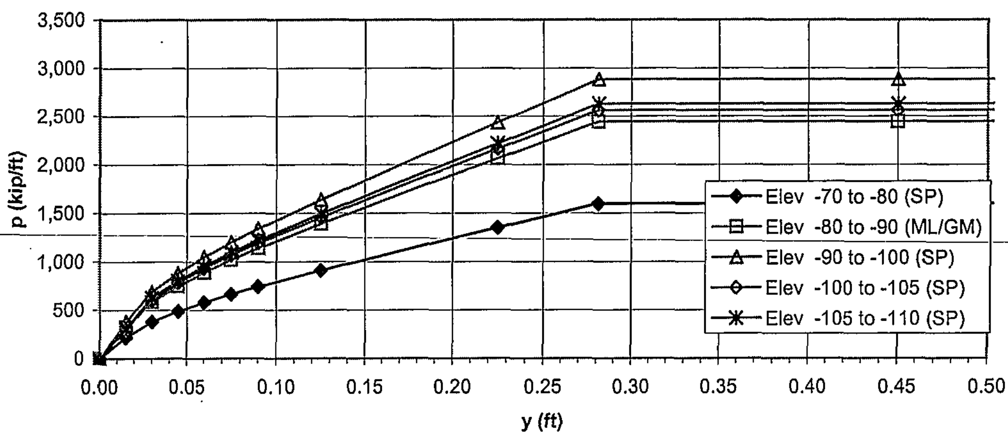
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - No Degradation

Sta.		O.G.	14.0	Pile	7.5' CISS
		Cut-off	14.0	GWS	50.0





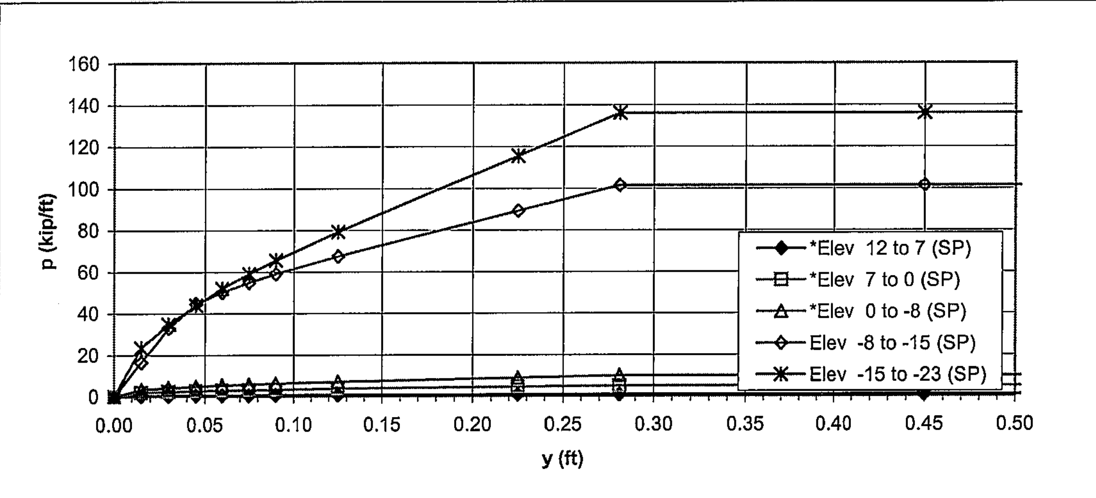


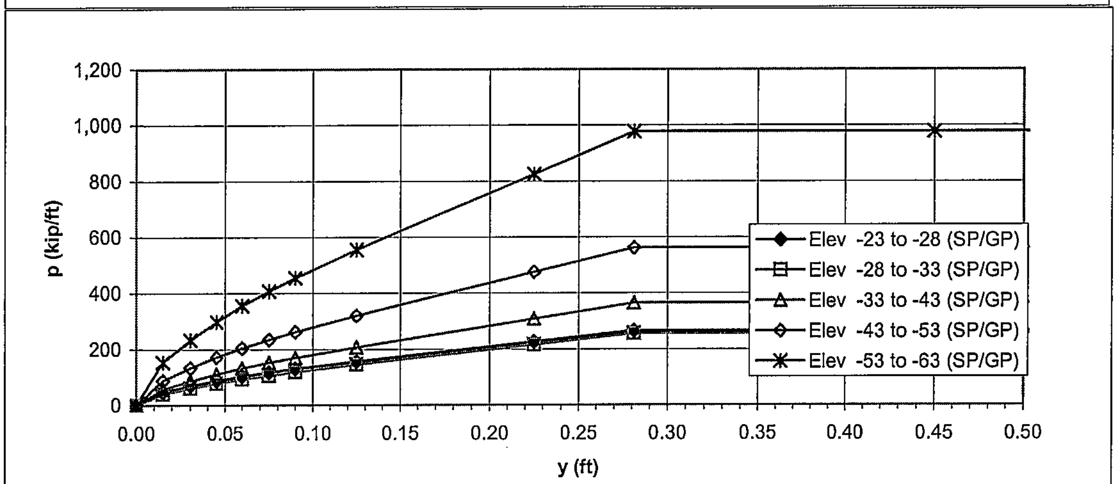
Post-Liquefaction

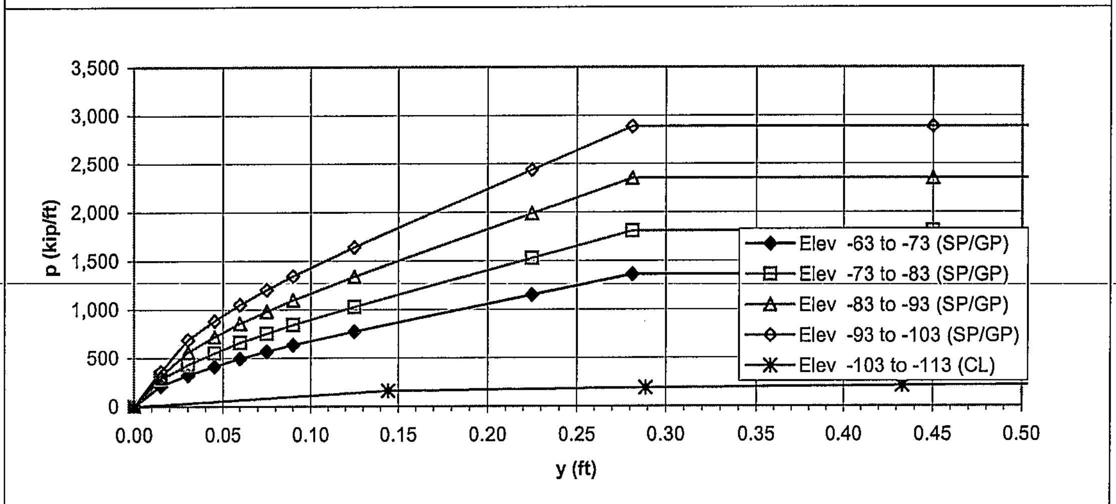
* - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 5 - No Degradation		**O.G.**	12.0	**Pile**	7.5' CISS
Sta.		**Cut-off**	12.0	**GWS**	50.0





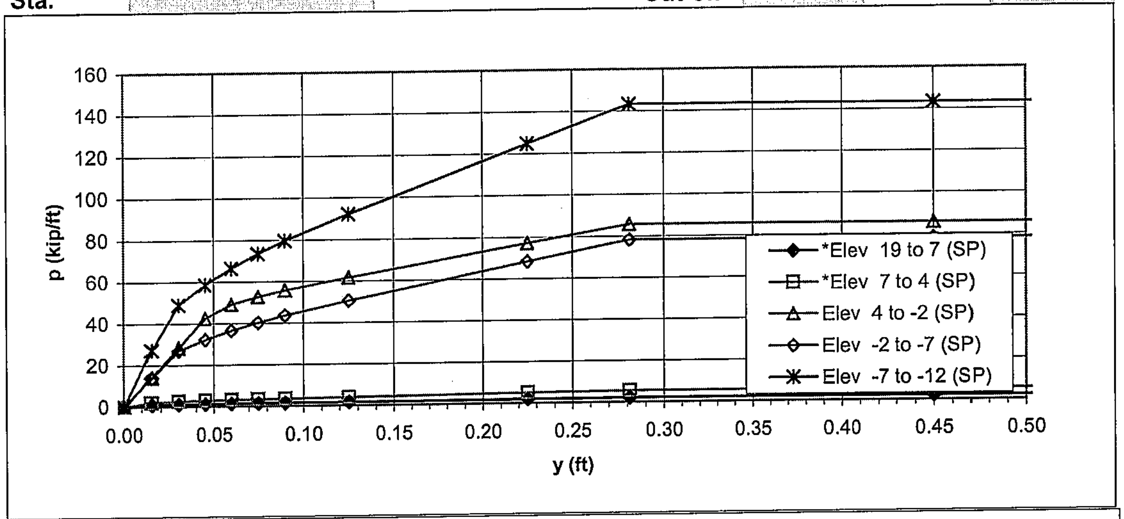


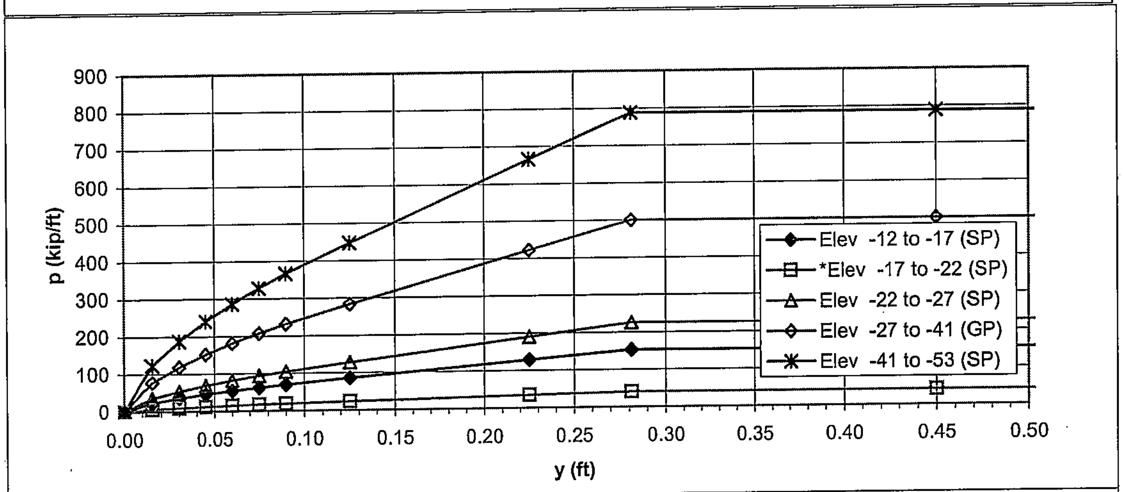
Post-Liquefaction | *** - Liquefiable Layer**

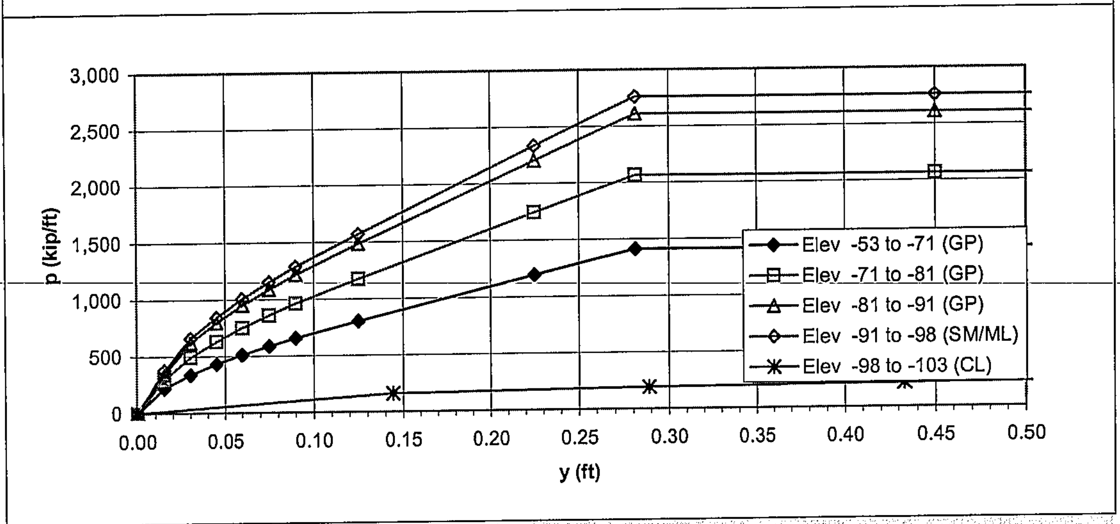
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - No Degradation

Sta.		O.G.	19.0	Pile	7.5' CISS
		Cut-off	19.0	GWS	50.0







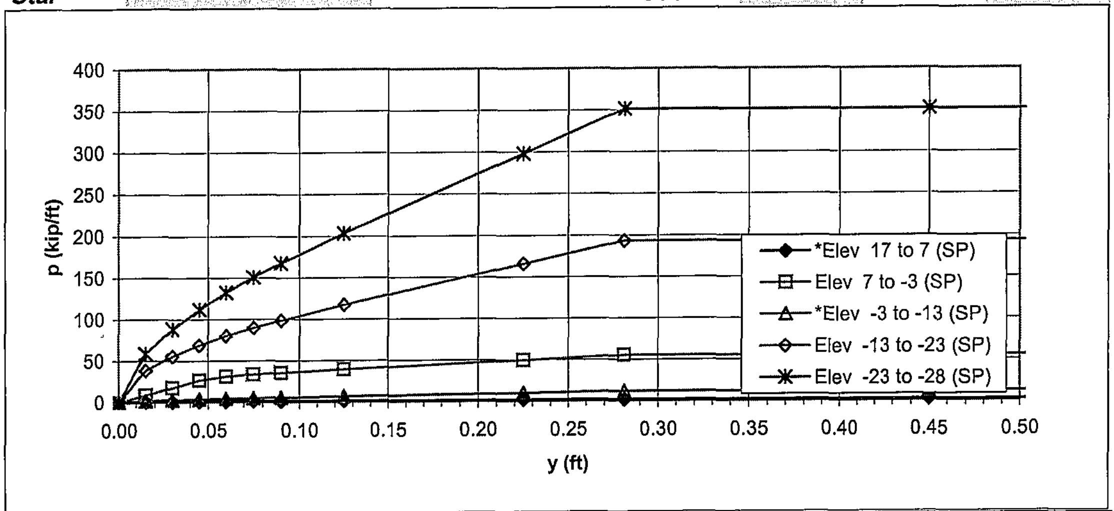
Post-Liquefaction

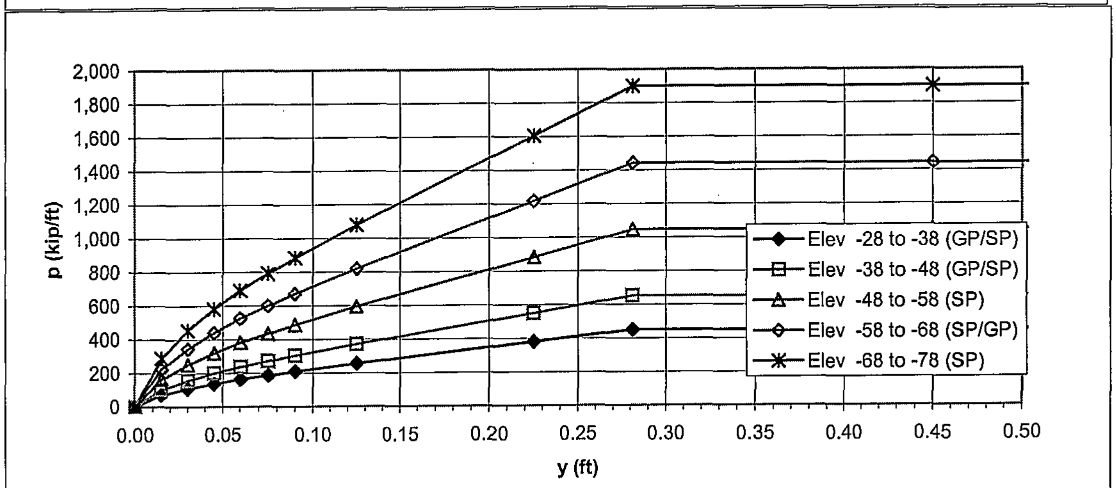
* - Liquefiable Layer

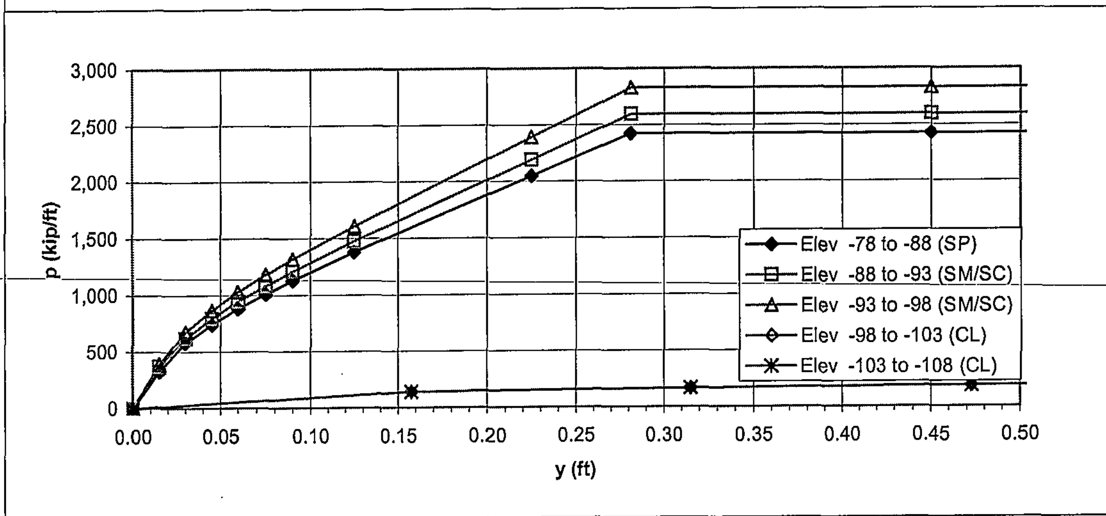
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 7 - No Degradation

Sta. | O.G. 17.0 | Pile 7.5' CISS
Cut-off 17.0 | GWS 50.0





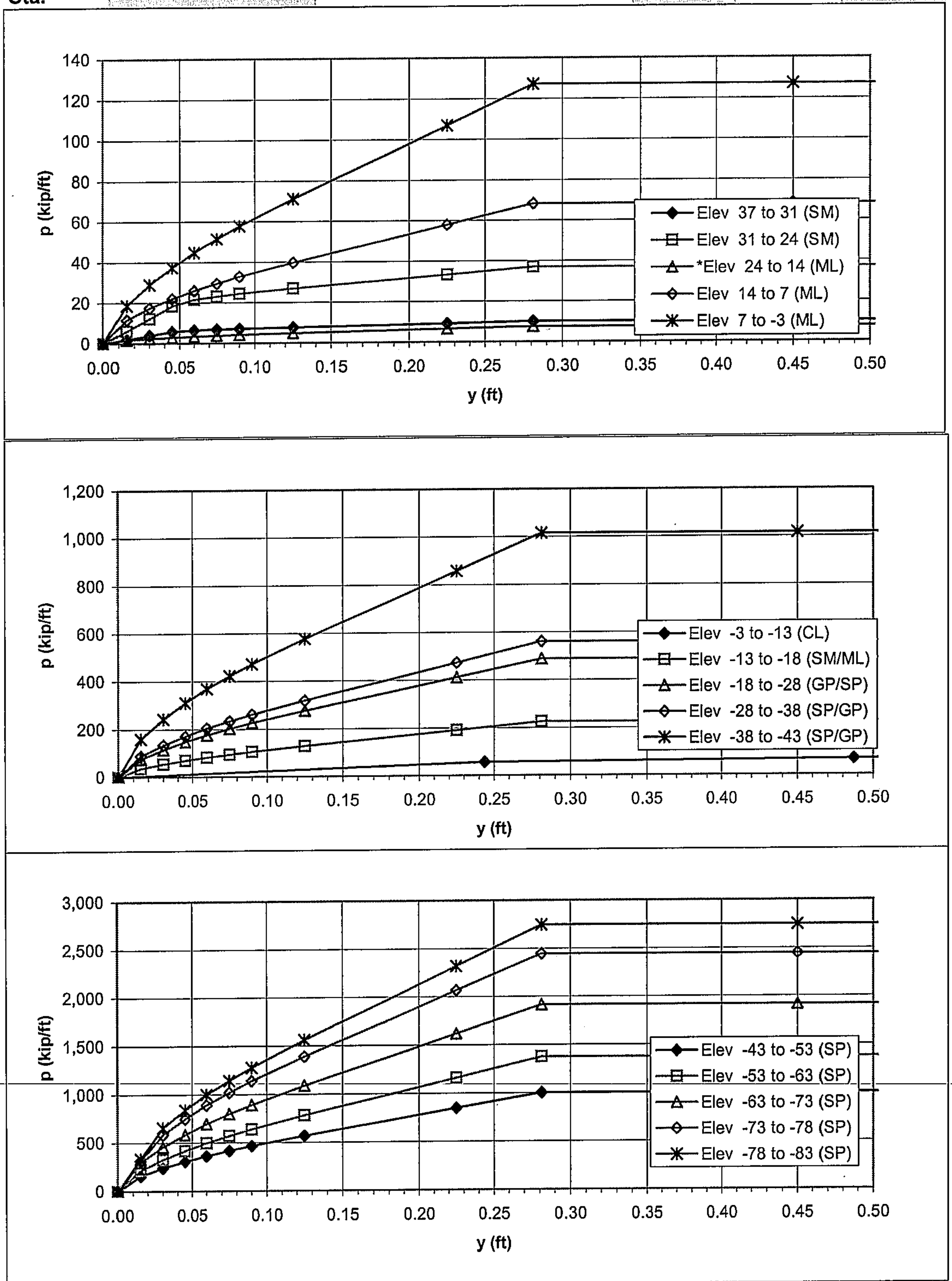


Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - No Degradation		O.G.	37.0	Pile	7.5' CISS
Sta.		Cut-off	37.0	GWS	50.0

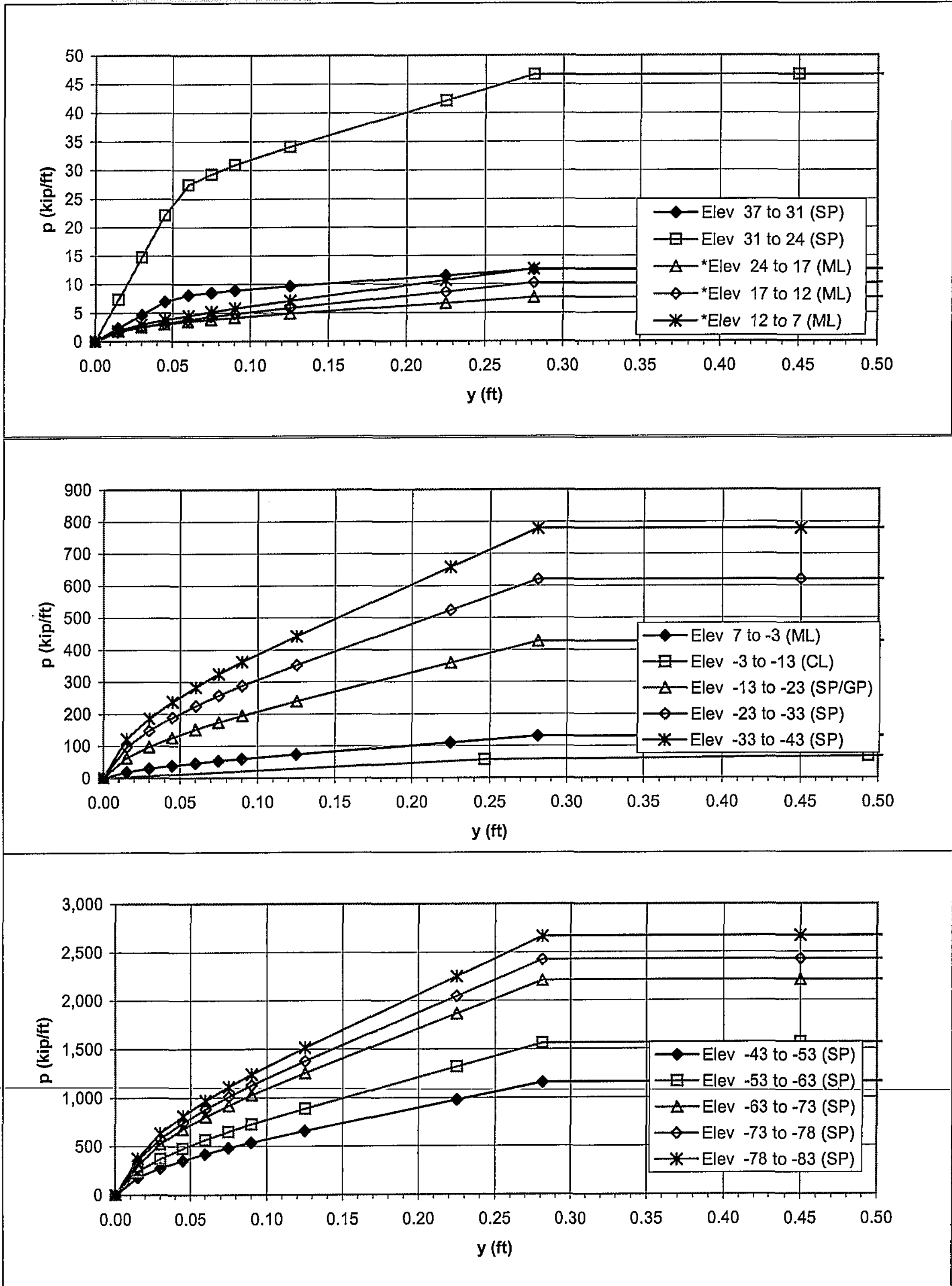


Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - No degradation		O.G.	37.0	Pile	7.5' CISS
Sta.		Cut-off	37.0	GWS	50.0



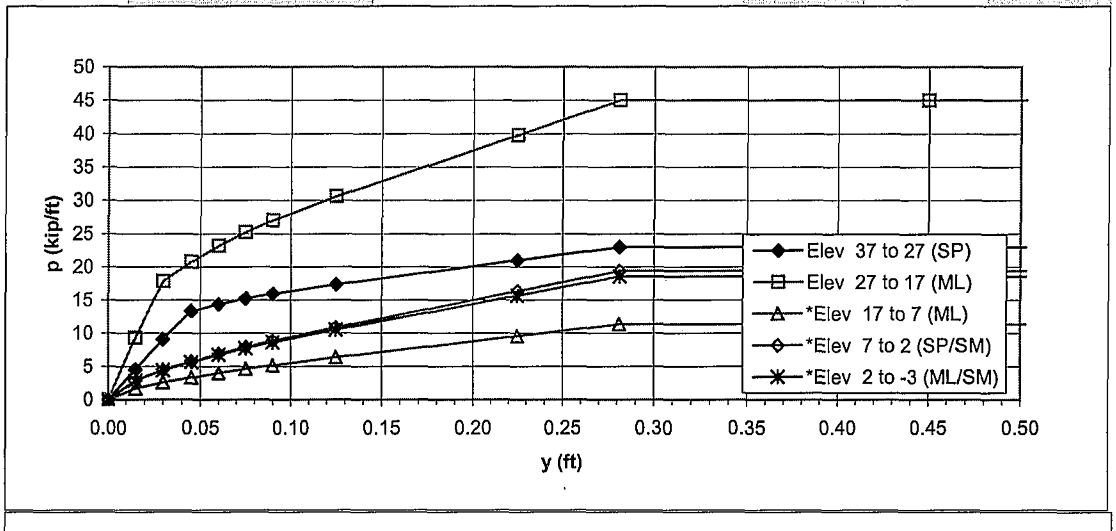
Post-Liquefaction

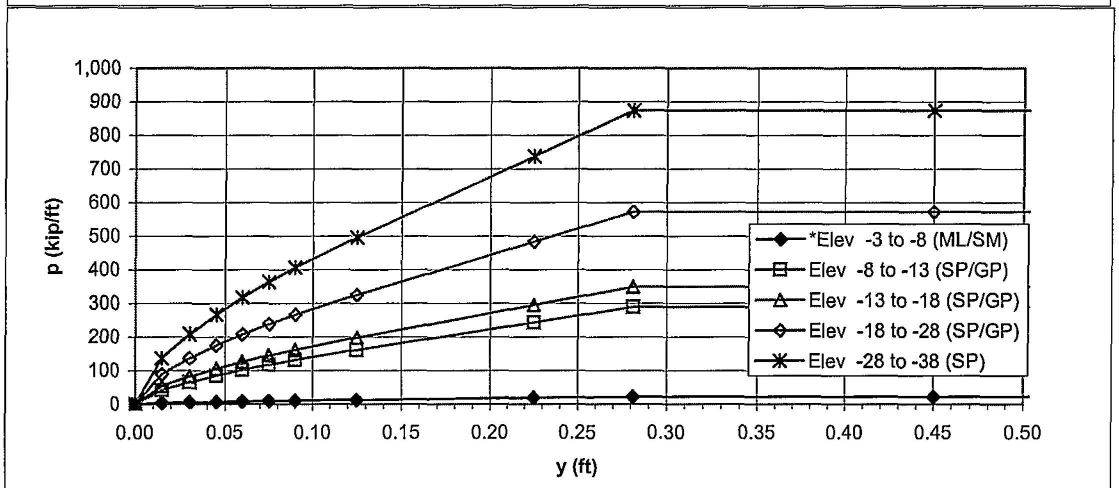
* - Liquefiable Layer

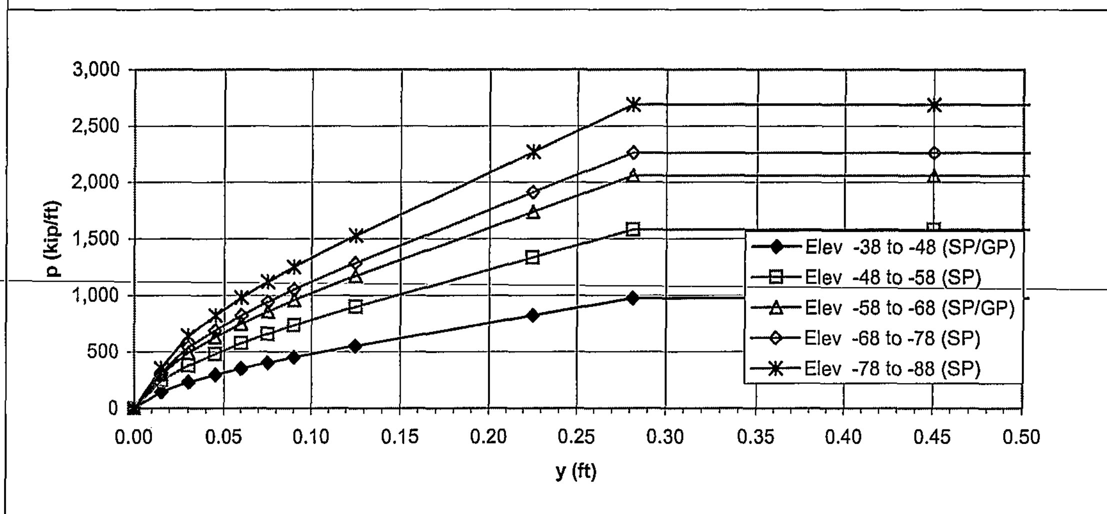
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Piers 10 and 11 - No Degradation

Sta.		O.G.	37.0	Pile	7.5' CISS
		Cut-off	37.0	GWS	50.0







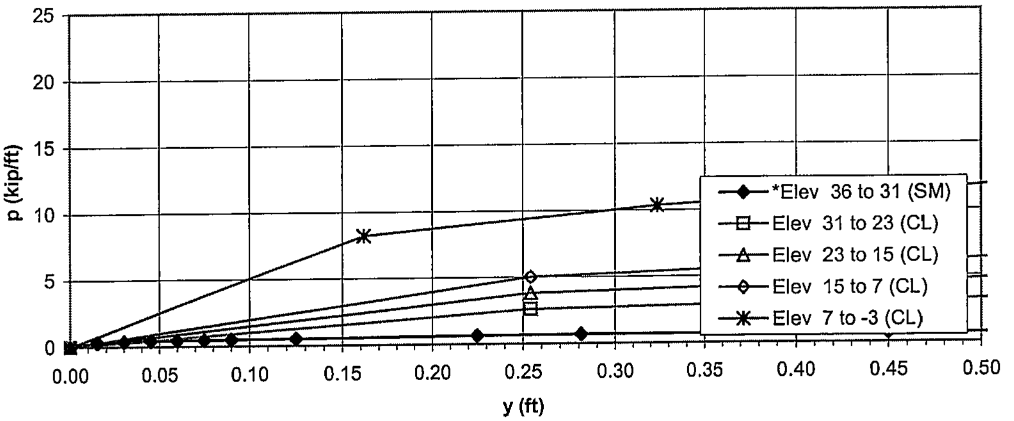
Post-Liquefaction

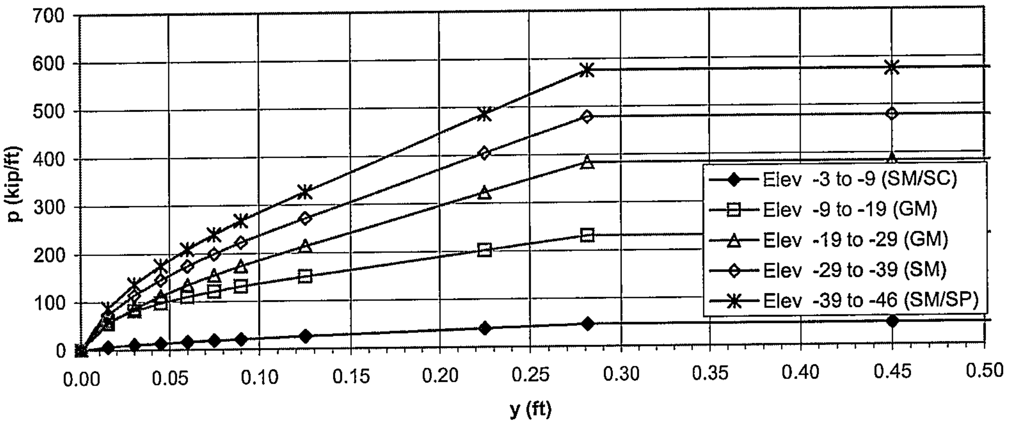
* - Liquefiable Layer

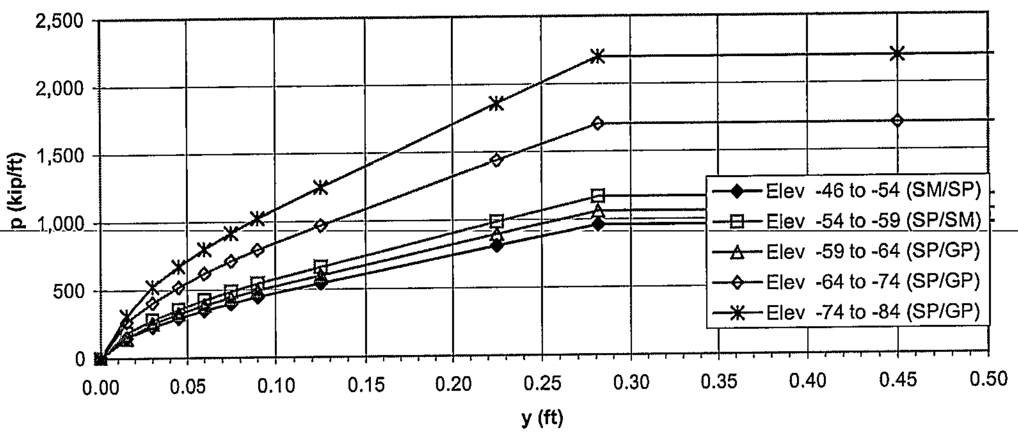
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - No Degradation

Sta.		O.G.	36.0	Pile	7.5' CISS
		Cut-off	36.0	GWS	50.0





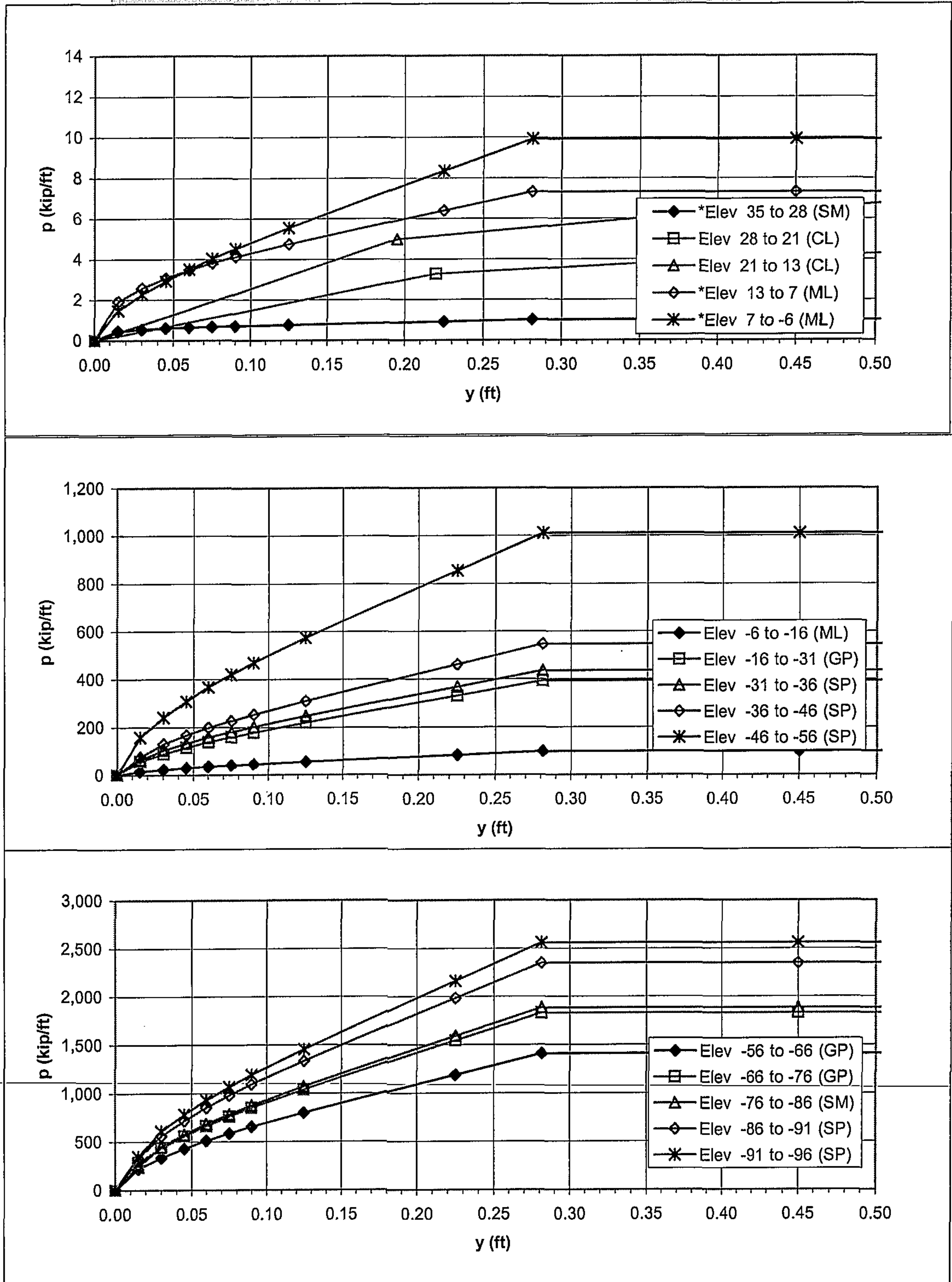


Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - No Degradation	**O.G.**	35.0	**Pile**	7.5' CISS
Sta.	**Cut-off**	35.0	**GWS**	50.0

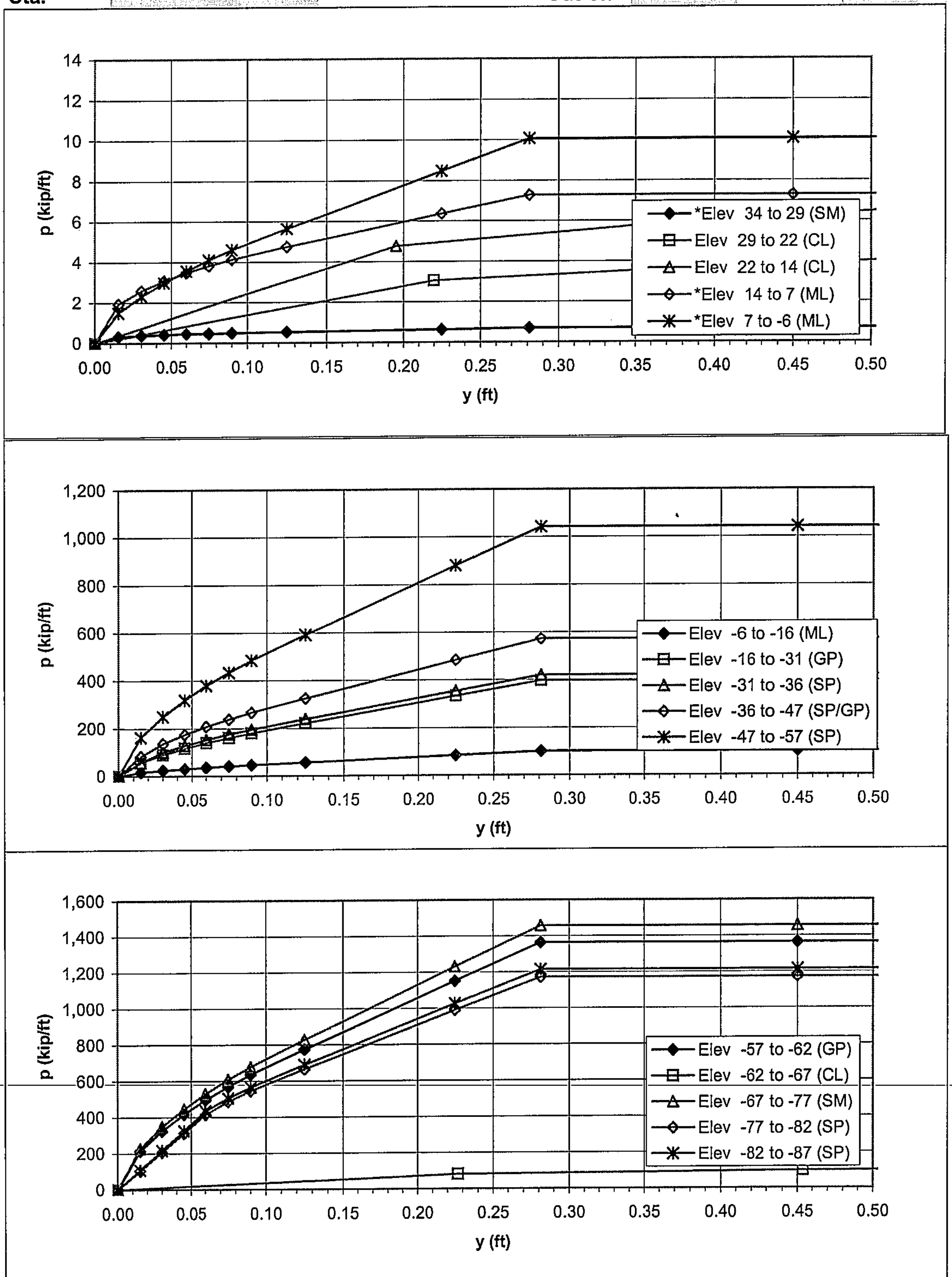


Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - No Degradation		O.G.	34.0	Pile	7.5' CISS
Sta.		Cut-off	34.0	GWS	50.0



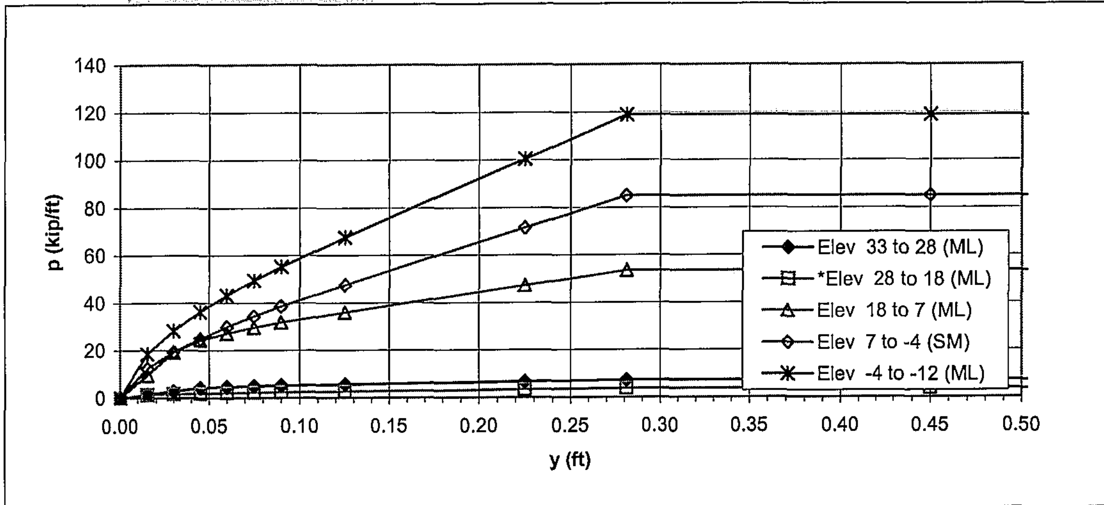
Post-Liquefaction

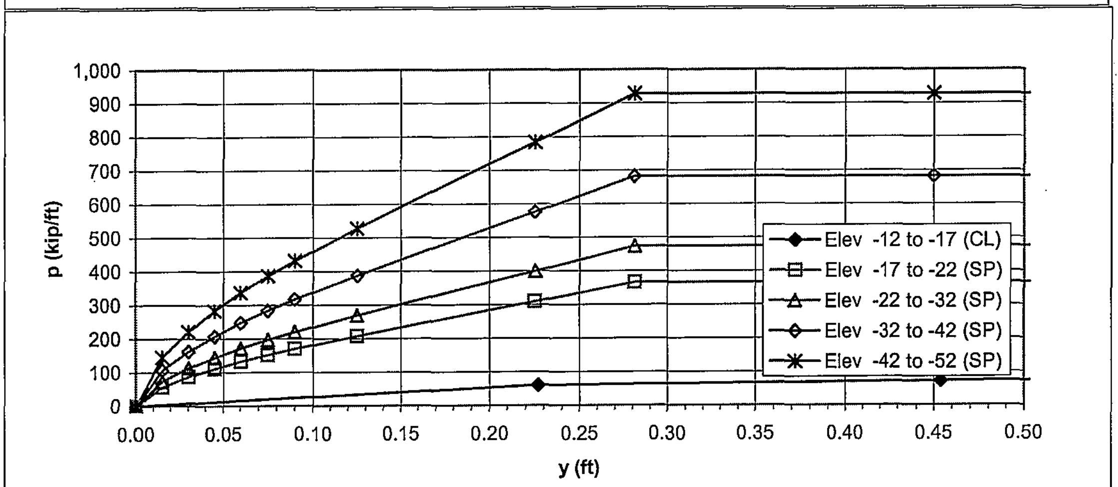
* - Liquefiable Layer

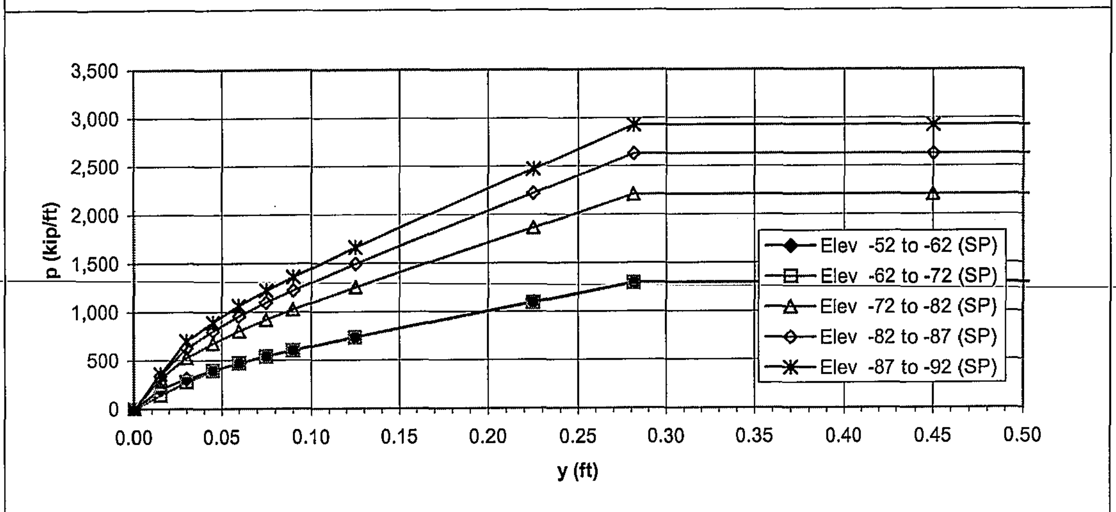
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - No Degradation

Sta.		O.G. 33.0	Pile	7.5' CISS
		Cut-off 33.0	GWS	50.0





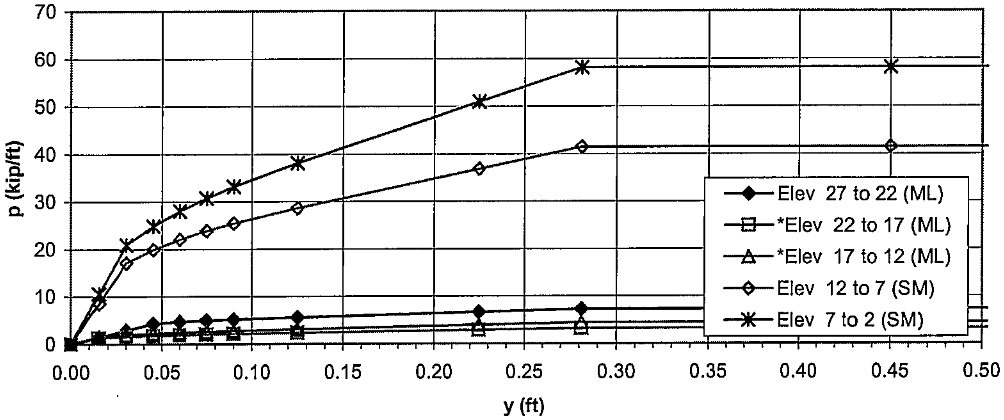


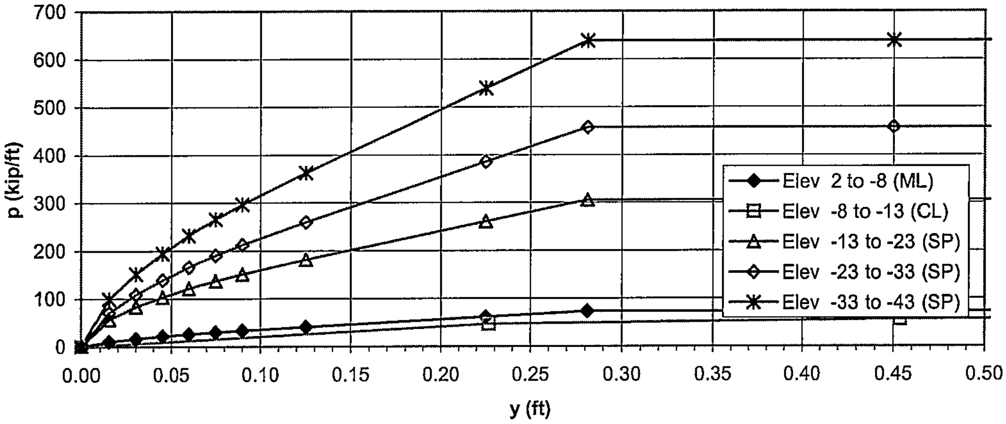
Post-Liquefaction

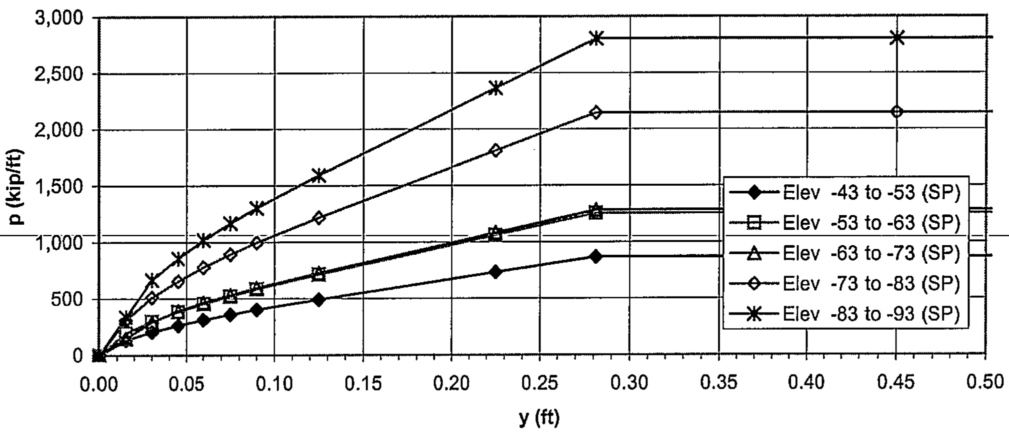
* - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - No Degradation		**O.G.**	27.0	**Pile**	7.5' CISS
Sta.		**Cut-off**	27.0	**GWS**	50.0







Post-Liquefaction

*** - Liquefiable Layer**

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 2 - No Degradation

Sta.

O.G.	18	Pile	7.5' CISS
Cut-off	18	GWS	50.0

y (ft)	*Elev 18 to 11 (SP)	y (ft)	*Elev 11 to 7 (SP/ML)	y (ft)	*Elev 7 to 2 (SP/ML)	y (ft)	Elev 2 to -8 (SP)	y (ft)	Elev -8 to -16 (SP/GP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.5	0.015	1	0.015	2	0.015	12	0.015	24
0.03	0.6	0.030	2	0.030	2	0.030	25	0.030	37
0.05	0.7	0.045	2	0.045	3	0.045	35	0.045	45
0.06	0.8	0.060	2	0.060	3	0.060	39	0.060	52
0.08	0.8	0.075	2	0.075	3	0.075	42	0.075	58
0.09	0.8	0.090	2	0.090	3	0.090	45	0.090	64
0.13	0.9	0.125	2	0.125	3	0.125	50	0.125	75
0.23	1.1	0.225	3	0.225	4	0.225	65	0.225	104
0.28	1.2	0.281	3	0.281	5	0.281	73	0.281	121
0.45	1.2	0.450	3	0.450	5	0.450	73	0.450	121
0.75	1.2	0.750	3	0.750	5	0.750	73	0.750	121

y (ft)	Elev -16 to -24 (CL)	y (ft)	Elev -24 to -30 (CL)	y (ft)	Elev -30 to -37 (CL)	y (ft)	Elev -37 to -42 (SP)	y (ft)	Elev -42 to -52 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.174	67	0.184	71	0.184	79	0.015	48	0.015	78
0.348	80	0.369	85	0.369	93	0.030	74	0.030	119
0.523	89	0.553	94	0.553	103	0.045	94	0.045	152
0.697	95	0.737	101	0.737	111	0.060	112	0.060	181
0.871	101	0.922	107	0.922	118	0.075	128	0.075	208
1.045	105	1.106	112	1.106	123	0.090	143	0.090	232
1.393	113	1.475	120	1.475	132	0.125	175	0.125	283
1.742	113	1.843	120	1.843	132	0.225	260	0.225	421
2.090	113	2.212	120	2.212	132	0.281	308	0.281	498
2.439	113	2.581	120	2.581	132	0.450	308	0.450	498
2.787	113	2.949	120	2.949	132	0.750	308	0.750	498

y (ft)	Elev -52 to -62 (SP)	y (ft)	Elev -62 to -72 (SP)	y (ft)	Elev -72 to -82 (SP)	y (ft)	Elev -82 to -92 (SP)	y (ft)	Elev -92 to -102 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	128	0.015	184	0.015	249	0.015	302	0.015	300
0.030	195	0.030	280	0.030	380	0.030	494	0.030	491
0.045	249	0.045	359	0.045	486	0.045	632	0.045	628
0.060	297	0.060	427	0.060	579	0.060	753	0.060	748
0.075	340	0.075	489	0.075	663	0.075	863	0.075	857
0.090	380	0.090	547	0.090	741	0.090	964	0.090	958
0.125	464	0.125	667	0.125	905	0.125	1,177	0.125	1,169
0.225	690	0.225	992	0.225	1,345	0.225	1,749	0.225	1,738
0.281	817	0.281	1,175	0.281	1,592	0.281	2,071	0.281	2,058
0.450	817	0.450	1,175	0.450	1,592	0.450	2,071	0.450	2,058
0.750	817	0.750	1,175	0.750	1,592	0.750	2,071	0.750	2,058

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
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Pier 3 - No Degradation

Sta.

O.G. 26 | Pile 7.5' CISS
Cut-off 26 | GWS 50.0

y (ft)	Elev 26 to 21 (CL)	y (ft)	Elev 21 to 16 (SM)	y (ft)	Elev 16 to 7 (SP)	y (ft)	Elev 7 to -1 (SP)	y (ft)	Elev -1 to -11 (ML)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.23	28.9	0.015	19	0.015	19	0.015	23	0.015	26
0.45	34.4	0.030	39	0.030	38	0.030	36	0.030	45
0.68	38.1	0.045	45	0.045	47	0.045	46	0.045	57
0.91	40.9	0.060	49	0.060	53	0.060	54	0.060	68
1.13	43.2	0.075	53	0.075	59	0.075	63	0.075	78
1.36	45.3	0.090	57	0.090	65	0.090	70	0.090	87
1.81	48.6	0.125	63	0.125	76	0.125	86	0.125	107
2.27	48.6	0.225	81	0.225	104	0.225	128	0.225	159
2.72	48.6	0.281	91	0.281	120	0.281	152	0.281	188
3.18	48.6	0.450	91	0.450	120	0.450	152	0.450	188
3.63	48.6	0.750	91	0.750	120	0.750	152	0.750	188

y (ft)	Elev -11 to -21 (SP)	y (ft)	Elev -21 to -31 (SP)	y (ft)	Elev -31 to -41 (SP)	y (ft)	Elev -41 to -46 (GW)	y (ft)	Elev -46 to -51 (GW)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	51	0.015	66	0.015	175	0.015	170	0.015	117
0.030	82	0.030	115	0.030	268	0.030	260	0.030	234
0.045	105	0.045	148	0.045	343	0.045	332	0.045	318
0.060	125	0.060	176	0.060	409	0.060	396	0.060	379
0.075	143	0.075	201	0.075	468	0.075	453	0.075	434
0.090	160	0.090	225	0.090	523	0.090	506	0.090	485
0.125	195	0.125	275	0.125	639	0.125	618	0.125	592
0.225	290	0.225	408	0.225	949	0.225	919	0.225	880
0.281	344	0.281	483	0.281	1,124	0.281	1,088	0.281	1,042
0.450	344	0.450	483	0.450	1,124	0.450	1,088	0.450	1,042
0.750	344	0.750	483	0.750	1,124	0.750	1,088	0.750	1,042

y (ft)	Elev -51 to -61 (SM)	y (ft)	Elev -61 to -71 (SM)	y (ft)	Elev -71 to -81 (SC/GC	y (ft)	Elev -81 to -86 (SP)	y (ft)	Elev -86 to -91 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	258	0.015	312	0.015	351	0.015	138	0.015	143
0.030	393	0.030	528	0.030	662	0.030	275	0.030	286
0.045	504	0.045	676	0.045	847	0.045	413	0.045	428
0.060	600	0.060	805	0.060	1,009	0.060	550	0.060	571
0.075	687	0.075	922	0.075	1,155	0.075	688	0.075	714
0.090	767	0.090	1,030	0.090	1,291	0.090	825	0.090	857
0.125	937	0.125	1,258	0.125	1,576	0.125	1,146	0.125	1,190
0.225	1,393	0.225	1,869	0.225	2,343	0.225	1,805	0.225	1,874
0.281	1,649	0.281	2,213	0.281	2,774	0.281	2,138	0.281	2,219
0.450	1,649	0.450	2,213	0.450	2,774	0.450	2,138	0.450	2,219
0.750	1,649	0.750	2,213	0.750	2,774	0.750	2,138	0.750	2,219

Note: p (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - No Degradation

Sta.

O.G. 14 | Pile 7.5' CISS
Cut-off 14 | GWS 50.0

y (ft)	*Elev 14 to 7 (SP/SM)	y (ft)	Elev 7 to 1 (SM)	y (ft)	Elev 1 to -6 (SP)	y (ft)	Elev -6 to -10 (SP)	y (ft)	Elev -10 to -20 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.9	0.015	7	0.015	12	0.015	17	0.015	31
0.03	1.0	0.030	13	0.030	24	0.030	34	0.030	44
0.05	1.1	0.045	20	0.045	35	0.045	44	0.045	55
0.06	1.2	0.060	25	0.060	40	0.060	50	0.060	64
0.08	1.3	0.075	27	0.075	43	0.075	55	0.075	72
0.09	1.3	0.090	28	0.090	46	0.090	59	0.090	80
0.13	1.4	0.125	31	0.125	51	0.125	68	0.125	95
0.23	1.7	0.225	38	0.225	65	0.225	90	0.225	135
0.28	1.9	0.281	42	0.281	73	0.281	102	0.281	157
0.45	1.9	0.450	42	0.450	73	0.450	102	0.450	157
0.75	1.9	0.750	42	0.750	73	0.750	102	0.750	157

y (ft)	Elev -20 to -34 (SP)	y (ft)	Elev -34 to -40 (GP)	y (ft)	Elev -40 to -50 (SM)	y (ft)	Elev -50 to -60 (SP)	y (ft)	Elev -60 to -70 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	40	0.015	83	0.015	115	0.015	187	0.015	239
0.030	61	0.030	127	0.030	175	0.030	284	0.030	365
0.045	79	0.045	163	0.045	224	0.045	364	0.045	467
0.060	94	0.060	194	0.060	267	0.060	433	0.060	556
0.075	107	0.075	222	0.075	305	0.075	496	0.075	637
0.090	120	0.090	248	0.090	341	0.090	554	0.090	712
0.125	146	0.125	303	0.125	416	0.125	677	0.125	869
0.225	217	0.225	450	0.225	619	0.225	1,006	0.225	1,292
0.281	257	0.281	533	0.281	733	0.281	1,191	0.281	1,530
0.450	257	0.450	533	0.450	733	0.450	1,191	0.450	1,530
0.750	257	0.750	533	0.750	733	0.750	1,191	0.750	1,530

y (ft)	Elev -70 to -80 (SP)	y (ft)	Elev -80 to -90 (ML/GM	y (ft)	Elev -90 to -100 (SP)	y (ft)	Elev -100 to -105 (SP)	y (ft)	Elev -105 to -110 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	217	0.015	326	0.015	382	0.015	301	0.015	314
0.030	381	0.030	583	0.030	688	0.030	601	0.030	627
0.045	487	0.045	747	0.045	880	0.045	782	0.045	802
0.060	580	0.060	889	0.060	1,048	0.060	931	0.060	955
0.075	665	0.075	1,018	0.075	1,200	0.075	1,067	0.075	1,094
0.090	743	0.090	1,138	0.090	1,341	0.090	1,192	0.090	1,223
0.125	907	0.125	1,389	0.125	1,637	0.125	1,455	0.125	1,493
0.225	1,348	0.225	2,065	0.225	2,434	0.225	2,163	0.225	2,219
0.281	1,596	0.281	2,445	0.281	2,882	0.281	2,561	0.281	2,627
0.450	1,596	0.450	2,445	0.450	2,882	0.450	2,561	0.450	2,627
0.750	1,596	0.750	2,445	0.750	2,882	0.750	2,561	0.750	2,627

Note: p (kip/ft) | **Post-Liquefaction** | * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 5 - No Degradation
Sta.

O.G.	12	Pile	7.5' CISS
Cut-off	12	GWS	50.0

y (ft)	*Elev 12 to 7 (SP)	y (ft)	*Elev 7 to 0 (SP)	y (ft)	*Elev 0 to -8 (SP)	y (ft)	Elev -8 to -15 (SP)	y (ft)	Elev -15 to -23 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.5	0.015	2	0.015	3	0.015	17	0.015	23
0.03	0.5	0.030	3	0.030	4	0.030	33	0.030	35
0.05	0.6	0.045	3	0.045	5	0.045	45	0.045	44
0.06	0.6	0.060	3	0.060	5	0.060	50	0.060	52
0.08	0.7	0.075	3	0.075	6	0.075	55	0.075	59
0.09	0.7	0.090	3	0.090	6	0.090	59	0.090	66
0.13	0.8	0.125	4	0.125	7	0.125	67	0.125	79
0.23	0.9	0.225	5	0.225	9	0.225	89	0.225	116
0.28	1.0	0.281	5	0.281	10	0.281	101	0.281	136
0.45	1.0	0.450	5	0.450	10	0.450	101	0.450	136
0.75	1.0	0.750	5	0.750	10	0.750	101	0.750	136

y (ft)	Elev -23 to -28 (SP/GP)	y (ft)	Elev -28 to -33 (SP/GP)	y (ft)	Elev -33 to -43 (SP/GP)	y (ft)	Elev -43 to -53 (SP/GP)	y (ft)	Elev -53 to -63 (SP/GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	48	0.015	40	0.015	57	0.015	88	0.015	153
0.030	70	0.030	61	0.030	87	0.030	134	0.030	233
0.045	88	0.045	78	0.045	111	0.045	172	0.045	298
0.060	103	0.060	93	0.060	133	0.060	204	0.060	355
0.075	117	0.075	107	0.075	152	0.075	234	0.075	407
0.090	130	0.090	119	0.090	170	0.090	262	0.090	455
0.125	156	0.125	145	0.125	207	0.125	319	0.125	555
0.225	226	0.225	216	0.225	308	0.225	475	0.225	825
0.281	266	0.281	256	0.281	365	0.281	562	0.281	977
0.450	266	0.450	256	0.450	365	0.450	562	0.450	977
0.750	266	0.750	256	0.750	365	0.750	562	0.750	977

y (ft)	Elev -63 to -73 (SP/GP)	y (ft)	Elev -73 to -83 (SP/GP)	y (ft)	Elev -83 to -93 (SP/GP)	y (ft)	Elev -93 to -103 (SP/GP)	y (ft)	Elev -103 to -113 (CL)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	213	0.015	281	0.015	316	0.015	360	0.144	161
0.030	325	0.030	431	0.030	561	0.030	689	0.289	191
0.045	415	0.045	552	0.045	718	0.045	881	0.433	211
0.060	495	0.060	657	0.060	855	0.060	1,049	0.578	227
0.075	567	0.075	753	0.075	980	0.075	1,202	0.722	240
0.090	633	0.090	841	0.090	1,095	0.090	1,343	0.866	251
0.125	773	0.125	1,027	0.125	1,336	0.125	1,640	1.155	270
0.225	1,149	0.225	1,526	0.225	1,987	0.225	2,437	1.444	270
0.281	1,360	0.281	1,807	0.281	2,352	0.281	2,886	1.733	270
0.450	1,360	0.450	1,807	0.450	2,352	0.450	2,886	2.022	270
0.750	1,360	0.750	1,807	0.750	2,352	0.750	2,886	2.311	270

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
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03-1A4321

Pier 6 - No Degradation

Sta.

O.G.	19	Pile	7.5' CISS
Cut-off	19	GWS	50.0

y (ft)	*Elev 19 to 7 (SP)	y (ft)	*Elev 7 to 4 (SP)	y (ft)	Elev 4 to -2 (SP)	y (ft)	Elev -2 to -7 (SP)	y (ft)	Elev -7 to -12 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.9	0.015	2	0.015	14	0.015	14	0.015	27
0.03	1.1	0.030	3	0.030	28	0.030	27	0.030	49
0.05	1.2	0.045	3	0.045	42	0.045	32	0.045	59
0.06	1.3	0.060	3	0.060	49	0.060	37	0.060	67
0.08	1.4	0.075	3	0.075	53	0.075	40	0.075	73
0.09	1.5	0.090	4	0.090	56	0.090	44	0.090	80
0.13	1.6	0.125	4	0.125	62	0.125	50	0.125	92
0.23	2.0	0.225	5	0.225	77	0.225	68	0.225	125
0.28	2.2	0.281	6	0.281	86	0.281	78	0.281	143
0.45	2.2	0.450	6	0.450	86	0.450	78	0.450	143
0.75	2.2	0.750	6	0.750	86	0.750	78	0.750	143

y (ft)	Elev -12 to -17 (SP)	y (ft)	*Elev -17 to -22 (SP)	y (ft)	Elev -22 to -27 (SP)	y (ft)	Elev -27 to -41 (GP)	y (ft)	Elev -41 to -53 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	23	0.015	6	0.015	35	0.015	78	0.015	123
0.030	36	0.030	10	0.030	54	0.030	119	0.030	188
0.045	46	0.045	12	0.045	69	0.045	152	0.045	240
0.060	55	0.060	15	0.060	82	0.060	181	0.060	286
0.075	63	0.075	17	0.075	94	0.075	208	0.075	328
0.090	70	0.090	19	0.090	105	0.090	232	0.090	367
0.125	86	0.125	23	0.125	128	0.125	284	0.125	448
0.225	129	0.225	34	0.225	191	0.225	422	0.225	665
0.281	153	0.281	41	0.281	226	0.281	500	0.281	788
0.450	153	0.450	41	0.450	226	0.450	500	0.450	788
0.750	153	0.750	41	0.750	226	0.750	500	0.750	788

y (ft)	Elev -53 to -71 (GP)	y (ft)	Elev -71 to -81 (GP)	y (ft)	Elev -81 to -91 (GP)	y (ft)	Elev -91 to -98 (SM/ML)	y (ft)	Elev -98 to -103 (CL)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	221	0.015	301	0.015	340	0.015	377	0.144	161
0.030	337	0.030	493	0.030	622	0.030	659	0.289	191
0.045	431	0.045	631	0.045	796	0.045	843	0.433	211
0.060	513	0.060	751	0.060	948	0.060	1,004	0.578	227
0.075	588	0.075	860	0.075	1,086	0.075	1,150	0.722	240
0.090	657	0.090	961	0.090	1,214	0.090	1,285	0.866	251
0.125	802	0.125	1,173	0.125	1,482	0.125	1,569	1.155	270
0.225	1,192	0.225	1,744	0.225	2,203	0.225	2,332	1.444	270
0.281	1,411	0.281	2,065	0.281	2,608	0.281	2,761	1.733	270
0.450	1,411	0.450	2,065	0.450	2,608	0.450	2,761	2.022	270
0.750	1,411	0.750	2,065	0.750	2,608	0.750	2,761	2.311	270

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
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Pier 7 - No Degradation

Sta. | O.G. 17 | Pile 7.5' CISS
Cut-off 17 | GWS 50.0

y (ft)	*Elev 17 to 7 (SP)	y (ft)	Elev 7 to -3 (SP)	y (ft)	*Elev -3 to -13 (SP)	y (ft)	Elev -13 to -23 (SP)	y (ft)	Elev -23 to -28 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.9	0.015	9	0.015	2	0.015	39	0.015	59
0.03	1.1	0.030	18	0.030	3	0.030	56	0.030	88
0.05	1.2	0.045	27	0.045	4	0.045	69	0.045	112
0.06	1.3	0.060	31	0.060	4	0.060	80	0.060	132
0.08	1.4	0.075	34	0.075	5	0.075	90	0.075	151
0.09	1.5	0.090	36	0.090	6	0.090	99	0.090	168
0.13	1.6	0.125	40	0.125	7	0.125	117	0.125	203
0.23	1.9	0.225	50	0.225	10	0.225	166	0.225	298
0.28	2.1	0.281	55	0.281	12	0.281	193	0.281	352
0.45	2.1	0.450	55	0.450	12	0.450	193	0.450	352
0.75	2.1	0.750	55	0.750	12	0.750	193	0.750	352

y (ft)	Elev -28 to -38 (GP/SP	y (ft)	Elev -38 to -48 (GP/SP)	y (ft)	Elev -48 to -58 (SP)	y (ft)	Elev -58 to -68 (SP/GP)	y (ft)	Elev -68 to -78 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	70	0.015	102	0.015	164	0.015	226	0.015	288
0.030	107	0.030	156	0.030	250	0.030	344	0.030	453
0.045	137	0.045	199	0.045	319	0.045	440	0.045	580
0.060	164	0.060	237	0.060	380	0.060	524	0.060	691
0.075	187	0.075	272	0.075	436	0.075	600	0.075	791
0.090	209	0.090	303	0.090	487	0.090	671	0.090	884
0.125	256	0.125	370	0.125	594	0.125	819	0.125	1,080
0.225	380	0.225	551	0.225	883	0.225	1,217	0.225	1,605
0.281	450	0.281	652	0.281	1,046	0.281	1,441	0.281	1,900
0.450	450	0.450	652	0.450	1,046	0.450	1,441	0.450	1,900
0.750	450	0.750	652	0.750	1,046	0.750	1,441	0.750	1,900

y (ft)	Elev -78 to -88 (SP)	y (ft)	Elev -88 to -93 (SM/SC)	y (ft)	Elev -93 to -98 (SM/SC)	y (ft)	Elev -98 to -103 (CL)	y (ft)	Elev -103 to -108 (CL)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	327	0.015	372	0.015	393	0.158	140	0.158	140
0.030	578	0.030	619	0.030	675	0.315	167	0.315	167
0.045	740	0.045	792	0.045	864	0.473	185	0.473	185
0.060	881	0.060	943	0.060	1,029	0.630	199	0.630	199
0.075	1,009	0.075	1,080	0.075	1,178	0.788	210	0.788	210
0.090	1,127	0.090	1,207	0.090	1,316	0.945	220	0.945	220
0.125	1,376	0.125	1,474	0.125	1,607	1.260	236	1.260	236
0.225	2,046	0.225	2,191	0.225	2,389	1.575	236	1.575	236
0.281	2,422	0.281	2,594	0.281	2,829	1.890	236	1.890	236
0.450	2,422	0.450	2,594	0.450	2,829	2.206	236	2.206	236
0.750	2,422	0.750	2,594	0.750	2,829	2.521	236	2.521	236

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - No Degradation

Sta.

O.G.	37	Pile	7.5' CISS
Cut-off	37	GWS	50.0

y (ft)	Elev 37 to 31 (SM)	y (ft)	Elev 31 to 24 (SM)	y (ft)	*Elev 24 to 14 (ML)	y (ft)	Elev 14 to 7 (ML)	y (ft)	Elev 7 to -3 (ML)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	1.9	0.015	6	0.015	2	0.015	12	0.015	19
0.03	3.9	0.030	12	0.030	2	0.030	17	0.030	29
0.05	5.8	0.045	18	0.045	3	0.045	22	0.045	37
0.06	6.5	0.060	22	0.060	3	0.060	26	0.060	45
0.08	6.9	0.075	23	0.075	4	0.075	30	0.075	52
0.09	7.2	0.090	24	0.090	4	0.090	33	0.090	58
0.13	7.8	0.125	27	0.125	5	0.125	40	0.125	71
0.23	9.3	0.225	33	0.225	7	0.225	58	0.225	107
0.28	10.1	0.281	37	0.281	8	0.281	68	0.281	127
0.45	10.1	0.450	37	0.450	8	0.450	68	0.450	127
0.75	10.1	0.750	37	0.750	8	0.750	68	0.750	127

y (ft)	Elev -3 to -13 (CL)	y (ft)	Elev -13 to -18 (SM/ML	y (ft)	Elev -18 to -28 (GP/SP	y (ft)	Elev -28 to -38 (SP/GP	y (ft)	Elev -38 to -43 (SP/GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.244	56	0.015	35	0.015	75	0.015	88	0.015	159
0.487	67	0.030	54	0.030	115	0.030	134	0.030	242
0.731	74	0.045	69	0.045	147	0.045	171	0.045	310
0.975	80	0.060	82	0.060	176	0.060	204	0.060	369
1.219	84	0.075	94	0.075	202	0.075	234	0.075	423
1.462	88	0.090	105	0.090	226	0.090	261	0.090	472
1.950	95	0.125	128	0.125	276	0.125	319	0.125	577
2.437	95	0.225	190	0.225	412	0.225	474	0.225	857
2.925	95	0.281	225	0.281	488	0.281	561	0.281	1,015
3.412	95	0.450	225	0.450	488	0.450	561	0.450	1,015
3.899	95	0.750	225	0.750	488	0.750	561	0.750	1,015

y (ft)	Elev -43 to -53 (SP)	y (ft)	Elev -53 to -63 (SP)	y (ft)	Elev -63 to -73 (SP)	y (ft)	Elev -73 to -78 (SP)	y (ft)	Elev -78 to -83 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	157	0.015	215	0.015	300	0.015	314	0.015	334
0.030	239	0.030	328	0.030	457	0.030	584	0.030	655
0.045	306	0.045	419	0.045	585	0.045	747	0.045	838
0.060	365	0.060	499	0.060	696	0.060	889	0.060	998
0.075	418	0.075	572	0.075	797	0.075	1,019	0.075	1,143
0.090	467	0.090	639	0.090	891	0.090	1,138	0.090	1,278
0.125	570	0.125	780	0.125	1,088	0.125	1,390	0.125	1,560
0.225	847	0.225	1,160	0.225	1,617	0.225	2,066	0.225	2,319
0.281	1,003	0.281	1,373	0.281	1,915	0.281	2,446	0.281	2,746
0.450	1,003	0.450	1,373	0.450	1,915	0.450	2,446	0.450	2,746
0.750	1,003	0.750	1,373	0.750	1,915	0.750	2,446	0.750	2,746

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - No degradation

Sta.

O.G.	37	**Pile**	7.5' CISS
Cut-off	37	**GWS**	50.0

y (ft)	Elev 37 to 31 (SP)	y (ft)	Elev 31 to 24 (SP)	y (ft)	*Elev 24 to 17 (ML)	y (ft)	*Elev 17 to 12 (ML)	y (ft)	*Elev 12 to 7 (ML)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	2.3	0.015	7	0.015	2	0.015	2	0.015	2
0.03	4.7	0.030	15	0.030	3	0.030	3	0.030	3
0.05	7.0	0.045	22	0.045	3	0.045	3	0.045	4
0.06	8.1	0.060	27	0.060	3	0.060	4	0.060	5
0.08	8.6	0.075	29	0.075	4	0.075	4	0.075	5
0.09	8.9	0.090	31	0.090	4	0.090	5	0.090	6
0.13	9.7	0.125	34	0.125	5	0.125	6	0.125	7
0.23	11.5	0.225	42	0.225	7	0.225	9	0.225	11
0.28	12.6	0.281	47	0.281	8	0.281	10	0.281	13
0.45	12.6	0.450	47	0.450	8	0.450	10	0.450	13
0.75	12.6	0.750	47	0.750	8	0.750	10	0.750	13

y (ft)	Elev 7 to -3 (ML)	y (ft)	Elev -3 to -13 (CL)	y (ft)	Elev -13 to -23 (SP/GP	y (ft)	Elev -23 to -33 (SP)	y (ft)	Elev -33 to -43 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	19	0.247	57	0.015	64	0.015	97	0.015	122
0.030	30	0.494	68	0.030	98	0.030	148	0.030	186
0.045	39	0.741	75	0.045	126	0.045	189	0.045	238
0.060	46	0.988	80	0.060	151	0.060	225	0.060	283
0.075	53	1.234	85	0.075	174	0.075	258	0.075	324
0.090	60	1.481	89	0.090	195	0.090	288	0.090	362
0.125	73	1.975	96	0.125	239	0.125	352	0.125	442
0.225	110	2.469	96	0.225	359	0.225	523	0.225	658
0.281	131	2.963	96	0.281	427	0.281	620	0.281	779
0.450	131	3.456	96	0.450	427	0.450	620	0.450	779
0.750	131	3.950	96	0.750	427	0.750	620	0.750	779

y (ft)	Elev -43 to -53 (SP)	y (ft)	Elev -53 to -63 (SP)	y (ft)	Elev -63 to -73 (SP)	y (ft)	Elev -73 to -78 (SP)	y (ft)	Elev -78 to -83 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	181	0.015	244	0.015	298	0.015	354	0.015	376
0.030	276	0.030	373	0.030	527	0.030	578	0.030	636
0.045	354	0.045	477	0.045	674	0.045	740	0.045	814
0.060	421	0.060	568	0.060	803	0.060	882	0.060	969
0.075	483	0.075	650	0.075	920	0.075	1,010	0.075	1,110
0.090	539	0.090	727	0.090	1,028	0.090	1,128	0.090	1,240
0.125	658	0.125	887	0.125	1,255	0.125	1,377	0.125	1,515
0.225	979	0.225	1,319	0.225	1,865	0.225	2,047	0.225	2,251
0.281	1,159	0.281	1,562	0.281	2,209	0.281	2,424	0.281	2,666
0.450	1,159	0.450	1,562	0.450	2,209	0.450	2,424	0.450	2,666
0.750	1,159	0.750	1,562	0.750	2,209	0.750	2,424	0.750	2,666

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Piers 10 and 11 - No Degradation

Sta.

O.G. 37 | Cut-off 37 | Pile 7.5' CISS | GWS 50.0

y (ft)	Elev 37 to 27 (SP)	y (ft)	Elev 27 to 17 (ML)	y (ft)	*Elev 17 to 7 (ML)	y (ft)	*Elev 7 to 2 (SP/SM)	y (ft)	*Elev 2 to -3 (ML/SM)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	4.5	0.015	9	0.015	2	0.015	3	0.015	3
0.03	9.1	0.030	18	0.030	3	0.030	4	0.030	4
0.05	13.4	0.045	21	0.045	3	0.045	6	0.045	6
0.06	14.4	0.060	23	0.060	4	0.060	7	0.060	7
0.08	15.2	0.075	25	0.075	5	0.075	8	0.075	8
0.09	16.0	0.090	27	0.090	5	0.090	9	0.090	9
0.13	17.4	0.125	31	0.125	6	0.125	11	0.125	11
0.23	21.0	0.225	40	0.225	10	0.225	16	0.225	16
0.28	23.0	0.281	45	0.281	11	0.281	19	0.281	19
0.45	23.0	0.450	45	0.450	11	0.450	19	0.450	19
0.75	23.0	0.750	45	0.750	11	0.750	19	0.750	19

y (ft)	*Elev -3 to -8 (ML/SM)	y (ft)	Elev -8 to -13 (SP/GP)	y (ft)	Elev -13 to -18 (SP/GP)	y (ft)	Elev -18 to -28 (SP/GP)	y (ft)	Elev -28 to -38 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	3	0.015	42	0.015	54	0.015	90	0.015	137
0.030	5	0.030	66	0.030	83	0.030	137	0.030	208
0.045	7	0.045	85	0.045	106	0.045	175	0.045	267
0.060	8	0.060	102	0.060	126	0.060	208	0.060	318
0.075	9	0.075	117	0.075	145	0.075	238	0.075	364
0.090	10	0.090	131	0.090	162	0.090	266	0.090	407
0.125	13	0.125	162	0.125	198	0.125	325	0.125	496
0.225	19	0.225	243	0.225	295	0.225	483	0.225	738
0.281	22	0.281	289	0.281	349	0.281	572	0.281	874
0.450	22	0.450	289	0.450	349	0.450	572	0.450	874
0.750	22	0.750	289	0.750	349	0.750	572	0.750	874

y (ft)	Elev -38 to -48 (SP/GP)	y (ft)	Elev -48 to -58 (SP)	y (ft)	Elev -58 to -68 (SP/GP)	y (ft)	Elev -68 to -78 (SP)	y (ft)	Elev -78 to -88 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	146	0.015	247	0.015	300	0.015	319	0.015	355
0.030	232	0.030	377	0.030	491	0.030	540	0.030	641
0.045	297	0.045	482	0.045	628	0.045	691	0.045	821
0.060	354	0.060	574	0.060	749	0.060	823	0.060	978
0.075	405	0.075	658	0.075	857	0.075	942	0.075	1,120
0.090	452	0.090	735	0.090	958	0.090	1,053	0.090	1,251
0.125	552	0.125	897	0.125	1,169	0.125	1,286	0.125	1,528
0.225	821	0.225	1,334	0.225	1,738	0.225	1,911	0.225	2,271
0.281	972	0.281	1,580	0.281	2,058	0.281	2,263	0.281	2,689
0.450	972	0.450	1,580	0.450	2,058	0.450	2,263	0.450	2,689
0.750	972	0.750	1,580	0.750	2,058	0.750	2,263	0.750	2,689

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - No Degradation
Sta.

O.G. 36 | Pile 7.5' CISS
Cut-off 36 | GWS 50.0

y (ft)	*Elev 36 to 31 (SM)	y (ft)	Elev 31 to 23 (CL)	y (ft)	Elev 23 to 15 (CL)	y (ft)	Elev 15 to 7 (CL)	y (ft)	Elev 7 to -3 (CL)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.3	0.254	3	0.254	4	0.254	5	0.162	8
0.03	0.4	0.508	3	0.508	5	0.508	6	0.324	10
0.05	0.4	1.017	4	1.017	6	1.017	8	0.647	13
0.06	0.5	1.525	5	1.525	7	1.525	9	0.971	15
0.08	0.5	2.034	5	2.034	8	2.034	10	1.295	16
0.09	0.5	2.542	6	2.542	8	2.542	11	1.618	18
0.13	0.5	3.050	6	3.050	9	3.050	12	1.942	19
0.23	0.6	3.559	6	3.559	9	3.559	12	2.266	20
0.28	0.7	4.067	7	4.067	10	4.067	13	2.589	21
0.45	0.7	7.626	7	7.626	10	7.626	13	4.855	21
0.75	0.7	12.710	7	12.710	10	12.710	13	8.091	21

y (ft)	Elev -3 to -9 (SM/SC)	y (ft)	Elev -9 to -19 (GM)	y (ft)	Elev -19 to -29 (GM)	y (ft)	Elev -29 to -39 (SM)	y (ft)	Elev -39 to -46 (SM/SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	7	0.015	61	0.015	56	0.015	75	0.015	87
0.030	11	0.030	82	0.030	87	0.030	114	0.030	137
0.045	14	0.045	98	0.045	112	0.045	146	0.045	176
0.060	16	0.060	110	0.060	135	0.060	174	0.060	209
0.075	19	0.075	121	0.075	155	0.075	199	0.075	240
0.090	21	0.090	131	0.090	174	0.090	223	0.090	268
0.125	26	0.125	151	0.125	214	0.125	272	0.125	327
0.225	39	0.225	202	0.225	323	0.225	404	0.225	486
0.281	46	0.281	231	0.281	384	0.281	479	0.281	575
0.450	46	0.450	231	0.450	384	0.450	479	0.450	575
0.750	46	0.750	231	0.750	384	0.750	479	0.750	575

y (ft)	Elev -46 to -54 (SM/SP)	y (ft)	Elev -54 to -59 (SP/SM)	y (ft)	Elev -59 to -64 (SP/GP)	y (ft)	Elev -64 to -74 (SP/GP)	y (ft)	Elev -74 to -84 (SP/GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	150	0.015	183	0.015	142	0.015	267	0.015	311
0.030	229	0.030	279	0.030	253	0.030	407	0.030	525
0.045	293	0.045	356	0.045	324	0.045	520	0.045	672
0.060	349	0.060	425	0.060	385	0.060	620	0.060	800
0.075	399	0.075	486	0.075	441	0.075	710	0.075	916
0.090	446	0.090	543	0.090	493	0.090	793	0.090	1,024
0.125	545	0.125	663	0.125	602	0.125	968	0.125	1,250
0.225	810	0.225	986	0.225	895	0.225	1,439	0.225	1,858
0.281	959	0.281	1,167	0.281	1,060	0.281	1,704	0.281	2,200
0.450	959	0.450	1,167	0.450	1,060	0.450	1,704	0.450	2,200
0.750	959	0.750	1,167	0.750	1,060	0.750	1,704	0.750	2,200

Note: p (kip/ft) **Post-Liquefaction** *- Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - No Degradation

Sta.

O.G. 35 | Cut-off 35 | Pile 7.5' CISS | GWS 50.0

y (ft)	*Elev 35 to 28 (SM)	y (ft)	Elev 28 to 21 (CL)	y (ft)	Elev 21 to 13 (CL)	y (ft)	*Elev 13 to 7 (ML)	y (ft)	*Elev 7 to -6 (ML)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.5	0.220	3	0.195	5	0.015	2	0.015	1
0.03	0.5	0.440	4	0.390	6	0.030	3	0.030	2
0.05	0.6	0.879	5	0.781	8	0.045	3	0.045	3
0.06	0.6	1.319	6	1.171	9	0.060	3	0.060	4
0.08	0.7	1.758	7	1.561	10	0.075	4	0.075	4
0.09	0.7	2.198	7	1.952	11	0.090	4	0.090	5
0.13	0.8	2.638	8	2.342	11	0.125	5	0.125	6
0.23	0.9	3.077	8	2.733	12	0.225	6	0.225	8
0.28	1.0	3.517	8	3.123	13	0.281	7	0.281	10
0.45	1.0	6.594	8	5.856	13	0.450	7	0.450	10
0.75	1.0	10.990	8	9.759	13	0.750	7	0.750	10

y (ft)	Elev -6 to -16 (ML)	y (ft)	Elev -16 to -31 (GP)	y (ft)	Elev -31 to -36 (SP)	y (ft)	Elev -36 to -46 (SP)	y (ft)	Elev -46 to -56 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	15	0.015	58	0.015	65	0.015	75	0.015	158
0.030	24	0.030	89	0.030	104	0.030	130	0.030	241
0.045	30	0.045	115	0.045	133	0.045	167	0.045	309
0.060	36	0.060	138	0.060	159	0.060	199	0.060	368
0.075	41	0.075	159	0.075	182	0.075	228	0.075	421
0.090	46	0.090	179	0.090	203	0.090	254	0.090	470
0.125	56	0.125	220	0.125	248	0.125	311	0.125	574
0.225	83	0.225	331	0.225	368	0.225	462	0.225	854
0.281	99	0.281	394	0.281	436	0.281	547	0.281	1,011
0.450	99	0.450	394	0.450	436	0.450	547	0.450	1,011
0.750	99	0.750	394	0.750	436	0.750	547	0.750	1,011

y (ft)	Elev -56 to -66 (GP)	y (ft)	Elev -66 to -76 (GP)	y (ft)	Elev -76 to -86 (SM)	y (ft)	Elev -86 to -91 (SP)	y (ft)	Elev -91 to -96 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	220	0.015	286	0.015	241	0.015	329	0.015	347
0.030	336	0.030	436	0.030	449	0.030	560	0.030	611
0.045	430	0.045	559	0.045	575	0.045	717	0.045	782
0.060	512	0.060	665	0.060	685	0.060	854	0.060	931
0.075	586	0.075	762	0.075	785	0.075	978	0.075	1,066
0.090	655	0.090	851	0.090	877	0.090	1,093	0.090	1,191
0.125	800	0.125	1,039	0.125	1,070	0.125	1,334	0.125	1,454
0.225	1,189	0.225	1,545	0.225	1,591	0.225	1,983	0.225	2,162
0.281	1,408	0.281	1,829	0.281	1,884	0.281	2,348	0.281	2,560
0.450	1,408	0.450	1,829	0.450	1,884	0.450	2,348	0.450	2,560
0.750	1,408	0.750	1,829	0.750	1,884	0.750	2,348	0.750	2,560

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - No Degradation

Sta.

O.G. 34 | Cut-off 34 | Pile 7.5' CISS | GWS 50.0

y (ft)	*Elev 34 to 29 (SM)	y (ft)	Elev 29 to 22 (CL)	y (ft)	Elev 22 to 14 (CL)	y (ft)	*Elev 14 to 7 (ML)	y (ft)	*Elev 7 to -6 (ML)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.3	0.220	3	0.195	5	0.015	2	0.015	2
0.03	0.4	0.440	4	0.390	6	0.030	3	0.030	2
0.05	0.4	0.879	5	0.781	8	0.045	3	0.045	3
0.06	0.5	1.319	6	1.171	9	0.060	3	0.060	4
0.08	0.5	1.758	6	1.561	10	0.075	4	0.075	4
0.09	0.5	2.198	7	1.952	10	0.090	4	0.090	5
0.13	0.5	2.638	7	2.342	11	0.125	5	0.125	6
0.23	0.6	3.077	7	2.733	12	0.225	6	0.225	8
0.28	0.7	3.517	8	3.123	12	0.281	7	0.281	10
0.45	0.7	6.594	8	5.856	12	0.450	7	0.450	10
0.75	0.7	10.990	8	9.759	12	0.750	7	0.750	10

y (ft)	Elev -6 to -16 (ML)	y (ft)	Elev -16 to -31 (GP)	y (ft)	Elev -31 to -36 (SP)	y (ft)	Elev -36 to -47 (SP/GP	y (ft)	Elev -47 to -57 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	16	0.015	58	0.015	56	0.015	83	0.015	163
0.030	24	0.030	90	0.030	100	0.030	136	0.030	249
0.045	30	0.045	116	0.045	128	0.045	175	0.045	318
0.060	36	0.060	140	0.060	153	0.060	208	0.060	379
0.075	42	0.075	161	0.075	175	0.075	238	0.075	434
0.090	46	0.090	180	0.090	195	0.090	266	0.090	485
0.125	57	0.125	222	0.125	239	0.125	325	0.125	592
0.225	84	0.225	334	0.225	355	0.225	483	0.225	880
0.281	100	0.281	397	0.281	420	0.281	572	0.281	1,042
0.450	100	0.450	397	0.450	420	0.450	572	0.450	1,042
0.750	100	0.750	397	0.750	420	0.750	572	0.750	1,042

y (ft)	Elev -57 to -62 (GP)	y (ft)	Elev -62 to -67 (CL)	y (ft)	Elev -67 to -77 (SM)	y (ft)	Elev -77 to -82 (SP)	y (ft)	Elev -82 to -87 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	213	0.227	80	0.015	228	0.015	104	0.015	109
0.030	325	0.454	95	0.030	348	0.030	208	0.030	217
0.045	416	0.681	106	0.045	445	0.045	311	0.045	326
0.060	496	0.907	114	0.060	530	0.060	415	0.060	435
0.075	568	1.134	120	0.075	607	0.075	488	0.075	506
0.090	634	1.361	126	0.090	678	0.090	545	0.090	565
0.125	775	1.815	135	0.125	828	0.125	665	0.125	690
0.225	1,152	2.268	135	0.225	1,231	0.225	989	0.225	1,025
0.281	1,364	2.722	135	0.281	1,457	0.281	1,171	0.281	1,214
0.450	1,364	3.176	135	0.450	1,457	0.450	1,171	0.450	1,214
0.750	1,364	3.630	135	0.750	1,457	0.750	1,171	0.750	1,214

Note: p (kip/ft) | Post-Liquefaction | * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - No Degradation

Sta.		O.G.	33	Pile	7.5' CISS
		Cut-off	33	GWS	50.0

y (ft)	Elev 33 to 28 (ML)	y (ft)	*Elev 28 to 18 (ML)	y (ft)	Elev 18 to 7 (ML)	y (ft)	Elev 7 to -4 (SM)	y (ft)	Elev -4 to -12 (ML)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	1.5	0.015	1	0.015	10	0.015	13	0.015	19
0.03	2.9	0.030	2	0.030	19	0.030	19	0.030	28
0.05	4.4	0.045	2	0.045	24	0.045	25	0.045	36
0.06	4.7	0.060	2	0.060	27	0.060	30	0.060	43
0.08	5.0	0.075	2	0.075	30	0.075	34	0.075	50
0.09	5.2	0.090	2	0.090	32	0.090	39	0.090	55
0.13	5.6	0.125	3	0.125	36	0.125	48	0.125	68
0.23	6.7	0.225	3	0.225	47	0.225	72	0.225	100
0.28	7.3	0.281	4	0.281	54	0.281	85	0.281	119
0.45	7.3	0.450	4	0.450	54	0.450	85	0.450	119
0.75	7.3	0.750	4	0.750	54	0.750	85	0.750	119

y (ft)	Elev -12 to -17 (CL)	y (ft)	Elev -17 to -22 (SP)	y (ft)	Elev -22 to -32 (SP)	y (ft)	Elev -32 to -42 (SP)	y (ft)	Elev -42 to -52 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.227	61	0.015	57	0.015	74	0.015	107	0.015	145
0.454	72	0.030	87	0.030	113	0.030	163	0.030	222
0.681	80	0.045	111	0.045	145	0.045	208	0.045	283
0.907	86	0.060	133	0.060	172	0.060	248	0.060	338
1.134	91	0.075	152	0.075	197	0.075	284	0.075	387
1.361	95	0.090	170	0.090	220	0.090	317	0.090	432
1.815	102	0.125	208	0.125	269	0.125	387	0.125	527
2.268	102	0.225	309	0.225	400	0.225	576	0.225	784
2.722	102	0.281	366	0.281	474	0.281	682	0.281	928
3.176	102	0.450	366	0.450	474	0.450	682	0.450	928
3.630	102	0.750	366	0.750	474	0.750	682	0.750	928

y (ft)	Elev -52 to -62 (SP)	y (ft)	Elev -62 to -72 (SP)	y (ft)	Elev -72 to -82 (SP)	y (ft)	Elev -82 to -87 (SP)	y (ft)	Elev -87 to -92 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	203	0.015	139	0.015	313	0.015	341	0.015	361
0.030	310	0.030	278	0.030	527	0.030	627	0.030	698
0.045	396	0.045	394	0.045	674	0.045	802	0.045	893
0.060	472	0.060	469	0.060	803	0.060	956	0.060	1,064
0.075	540	0.075	538	0.075	919	0.075	1,095	0.075	1,218
0.090	604	0.090	601	0.090	1,027	0.090	1,223	0.090	1,361
0.125	737	0.125	733	0.125	1,254	0.125	1,493	0.125	1,662
0.225	1,096	0.225	1,090	0.225	1,864	0.225	2,220	0.225	2,470
0.281	1,297	0.281	1,291	0.281	2,207	0.281	2,628	0.281	2,925
0.450	1,297	0.450	1,291	0.450	2,207	0.450	2,628	0.450	2,925
0.750	1,297	0.750	1,291	0.750	2,207	0.750	2,628	0.750	2,925

Note: p (kip/ft) **Post-Liquefaction** *** - Liquefiable Layer**

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - No Degradation

Sta.		O.G.	27	Pile	7.5' CISS
		Cut-off	27	GWS	50.0

y (ft)	Elev 27 to 22 (ML)	y (ft)	*Elev 22 to 17 (ML)	y (ft)	*Elev 17 to 12 (ML)	y (ft)	Elev 12 to 7 (SM)	y (ft)	Elev 7 to 2 (SM)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	1.5	0.015	1	0.015	2	0.015	9	0.015	11
0.03	2.9	0.030	2	0.030	2	0.030	17	0.030	21
0.05	4.4	0.045	2	0.045	2	0.045	20	0.045	25
0.06	4.7	0.060	2	0.060	2	0.060	22	0.060	28
0.08	5.0	0.075	2	0.075	3	0.075	24	0.075	31
0.09	5.2	0.090	2	0.090	3	0.090	25	0.090	33
0.13	5.6	0.125	2	0.125	3	0.125	29	0.125	38
0.23	6.7	0.225	3	0.225	4	0.225	37	0.225	51
0.28	7.3	0.281	3	0.281	4	0.281	41	0.281	58
0.45	7.3	0.450	3	0.450	4	0.450	41	0.450	58
0.75	7.3	0.750	3	0.750	4	0.750	41	0.750	58

y (ft)	Elev 2 to -8 (ML)	y (ft)	Elev -8 to -13 (CL)	y (ft)	Elev -13 to -23 (SP)	y (ft)	Elev -23 to -33 (SP)	y (ft)	Elev -33 to -43 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	11	0.227	47	0.015	57	0.015	72	0.015	100
0.030	17	0.454	56	0.030	83	0.030	109	0.030	152
0.045	22	0.681	62	0.045	104	0.045	140	0.045	195
0.060	26	0.907	67	0.060	122	0.060	166	0.060	232
0.075	30	1.134	71	0.075	137	0.075	190	0.075	266
0.090	34	1.361	74	0.090	152	0.090	213	0.090	297
0.125	41	1.815	80	0.125	182	0.125	260	0.125	363
0.225	62	2.268	80	0.225	261	0.225	386	0.225	539
0.281	73	2.722	80	0.281	305	0.281	457	0.281	638
0.450	73	3.176	80	0.450	305	0.450	457	0.450	638
0.750	73	3.630	80	0.750	305	0.750	457	0.750	638

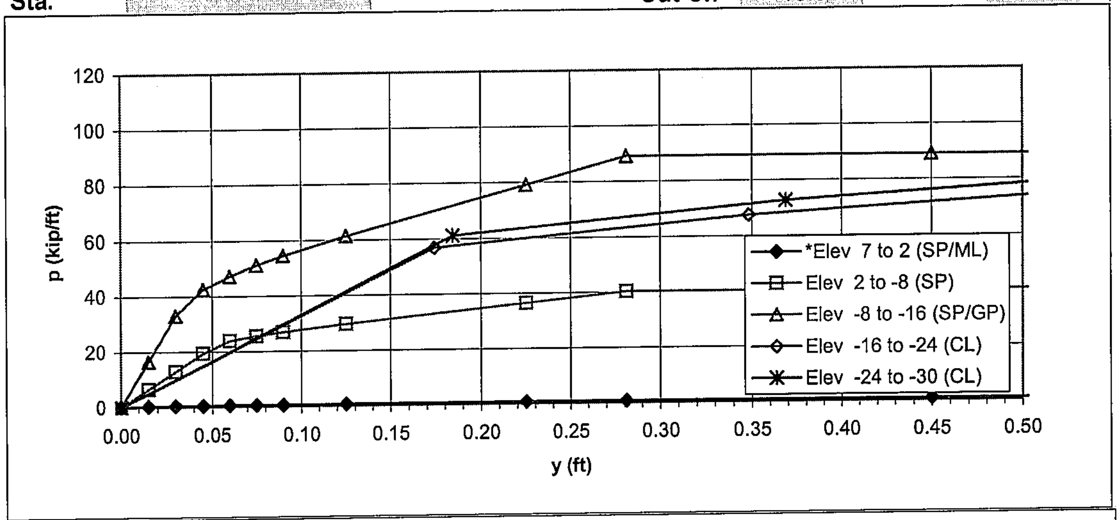
y (ft)	Elev -43 to -53 (SP)	y (ft)	Elev -53 to -63 (SP)	y (ft)	Elev -63 to -73 (SP)	y (ft)	Elev -73 to -83 (SP)	y (ft)	Elev -83 to -93 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	136	0.015	196	0.015	148	0.015	310	0.015	337
0.030	207	0.030	299	0.030	296	0.030	511	0.030	668
0.045	265	0.045	382	0.045	391	0.045	654	0.045	855
0.060	315	0.060	456	0.060	466	0.060	779	0.060	1,019
0.075	361	0.075	522	0.075	534	0.075	893	0.075	1,167
0.090	403	0.090	583	0.090	596	0.090	997	0.090	1,303
0.125	493	0.125	712	0.125	728	0.125	1,218	0.125	1,592
0.225	732	0.225	1,058	0.225	1,082	0.225	1,810	0.225	2,366
0.281	867	0.281	1,253	0.281	1,281	0.281	2,143	0.281	2,801
0.450	867	0.450	1,253	0.450	1,281	0.450	2,143	0.450	2,801
0.750	867	0.750	1,253	0.750	1,281	0.750	2,143	0.750	2,801

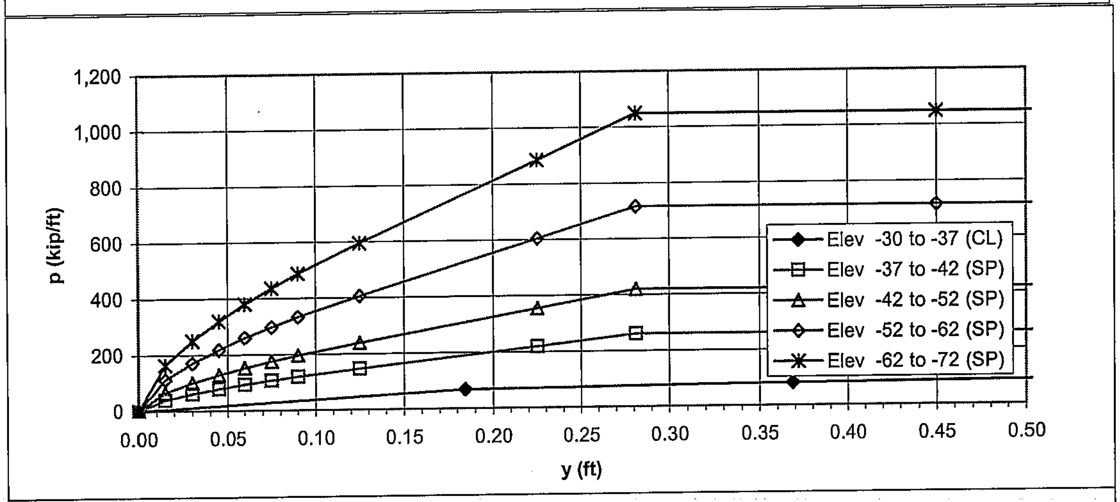
Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

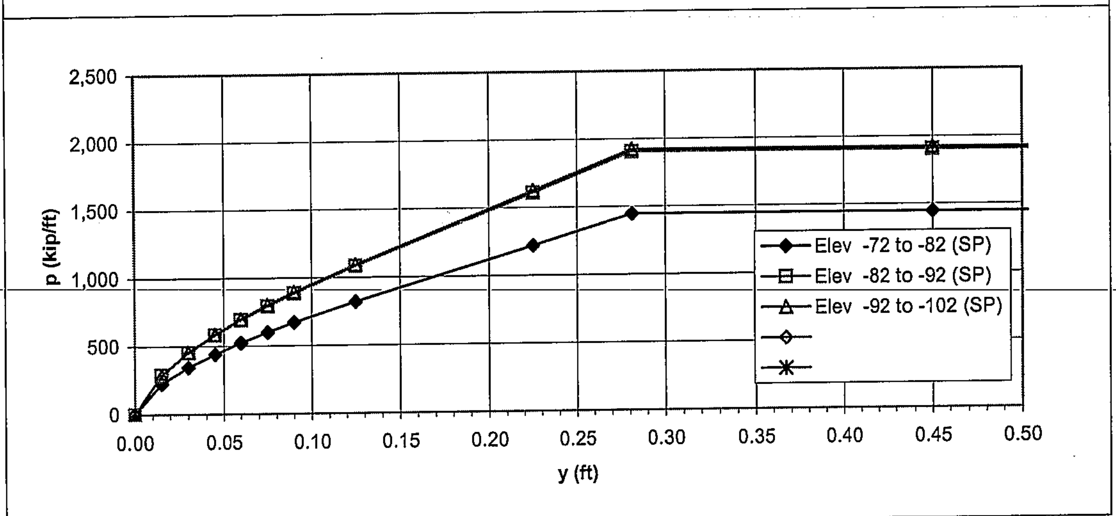
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 2 - with Degradation

Sta.		O.G.	7.0	Pile	7.5' CISS
		Cut-off	18.0	GWS	50.0







Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
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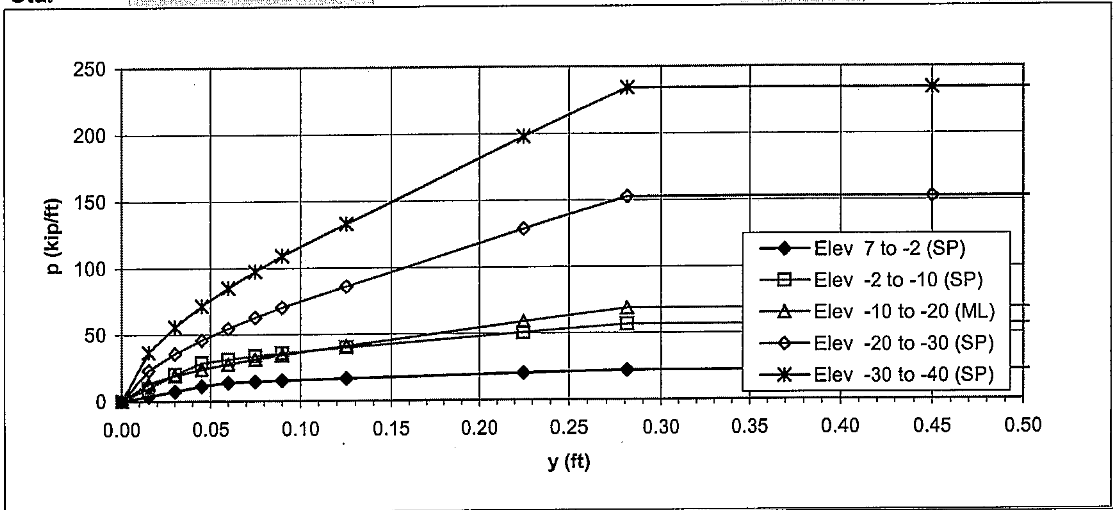
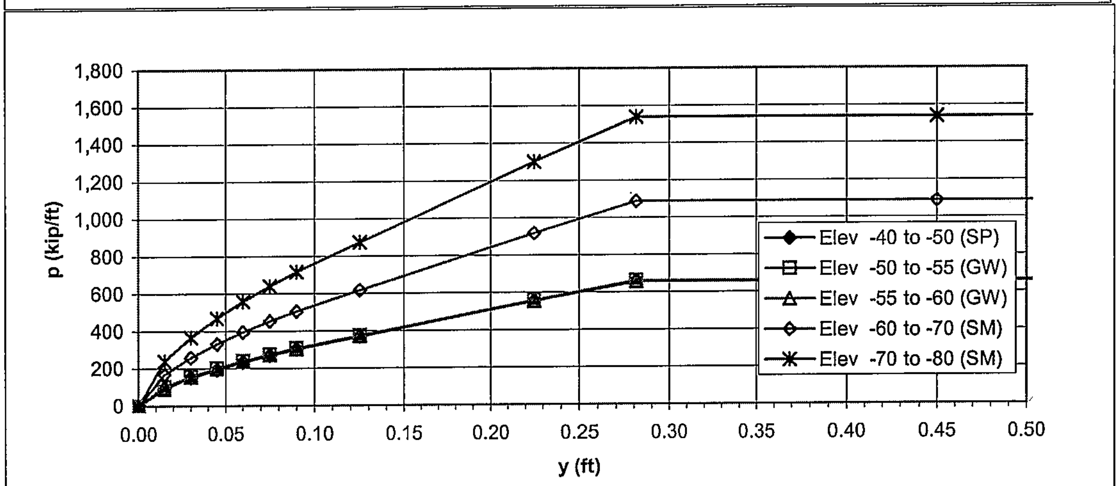
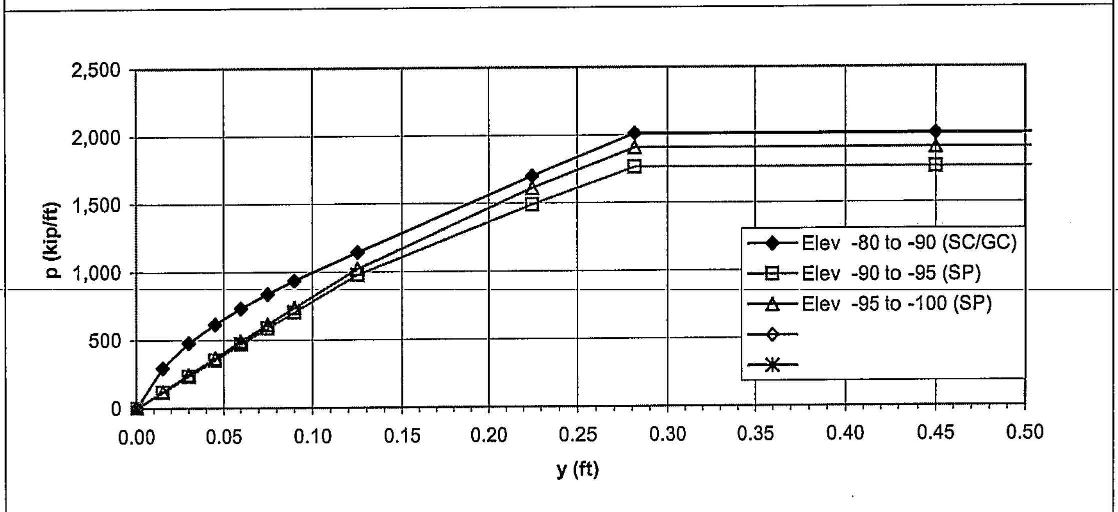
03-1A4321

Pier 3 - with Degradation

Sta.		O.G.	7.0	Pile	7.5' CISS
		Cut-off	26.0	GWS	50.0







Feather River Bridge
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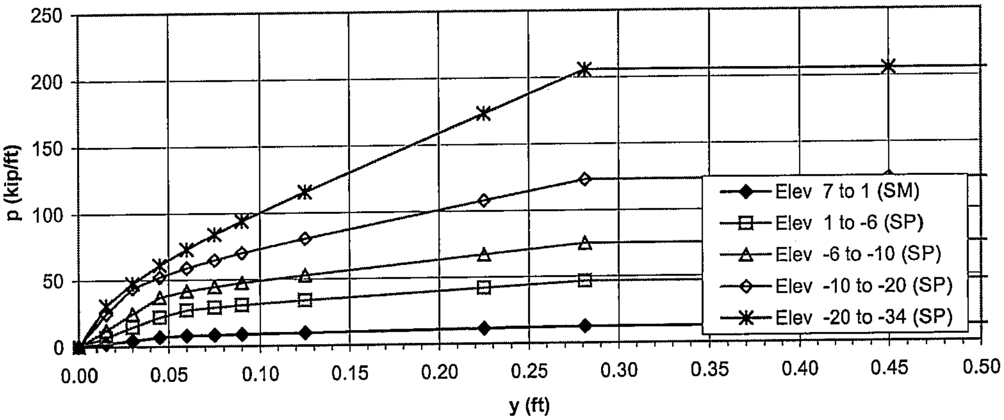
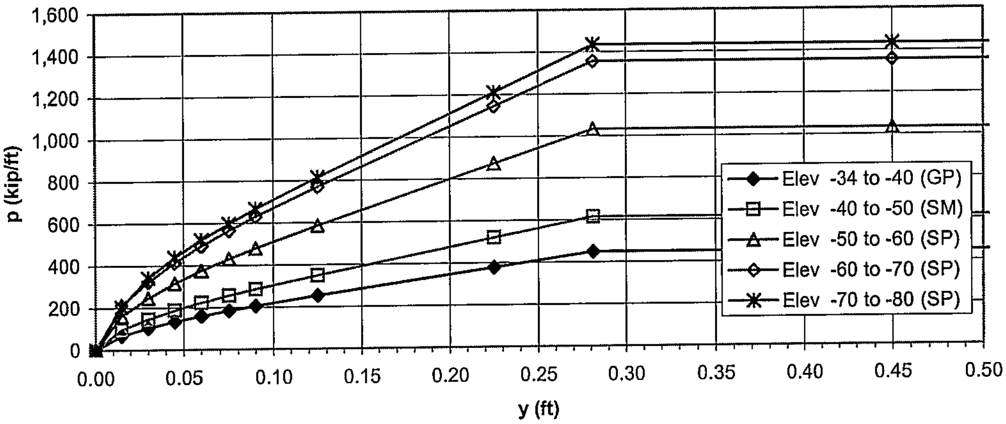
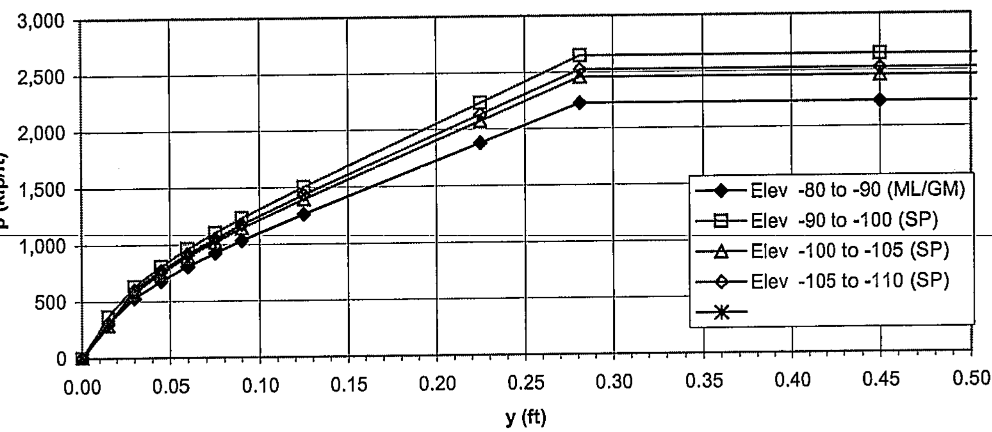
03-1A4321

Pier 4 - with Degradation	O.G.	7.0	Pile	7.5' CISS
Sta.	Cut-off	14.0	GWS	50.0







Feather River Bridge
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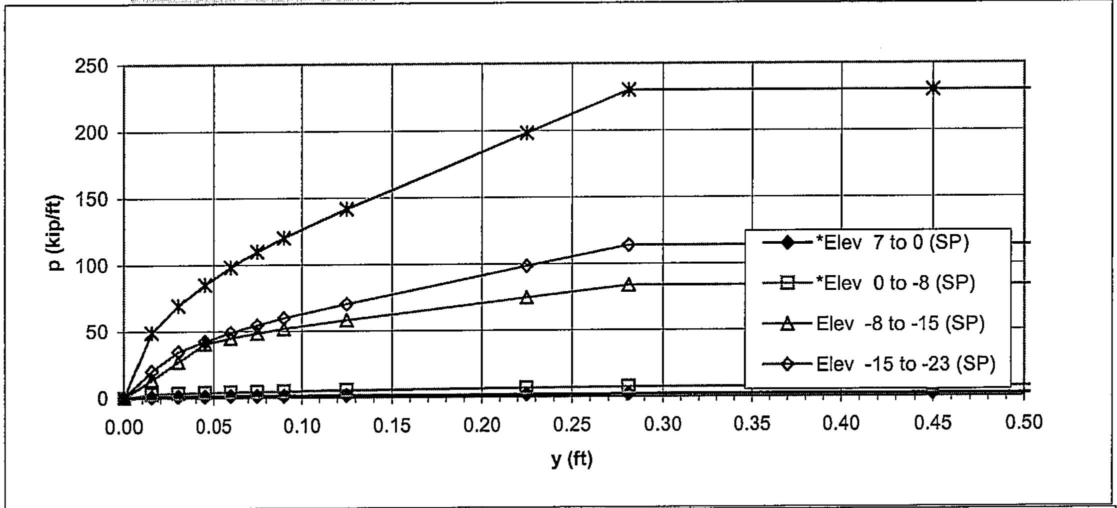
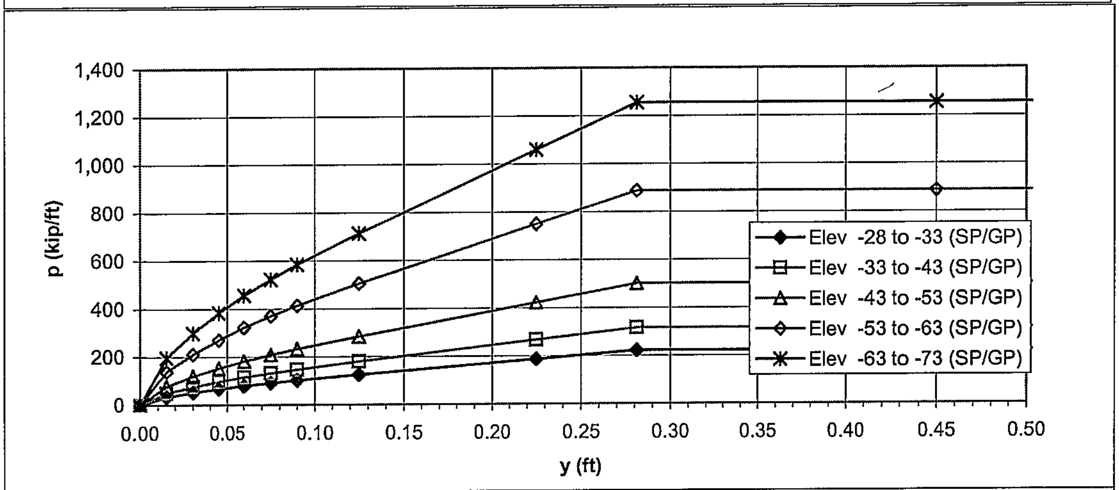
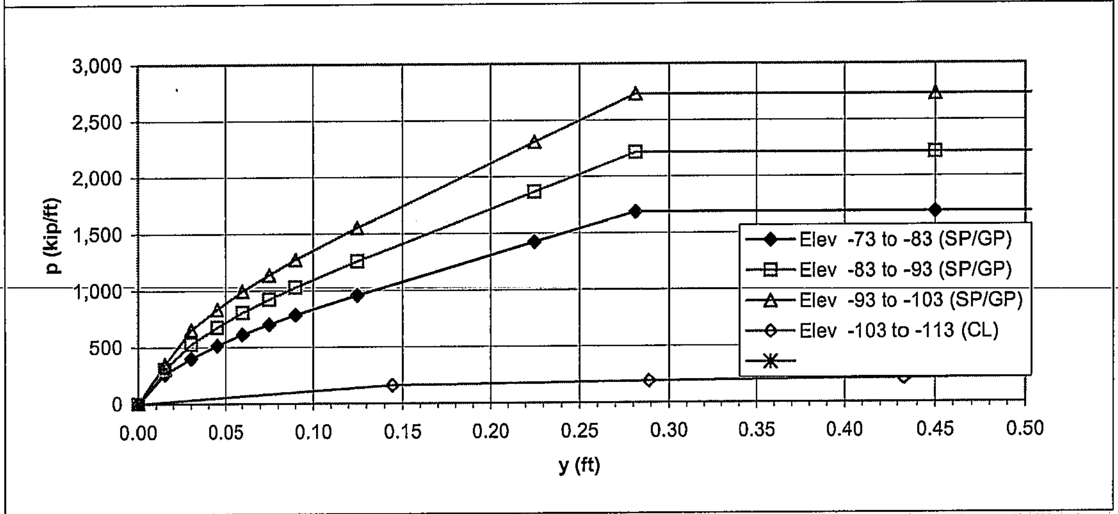
Pier 5 - with Degradation

Sta.		O.G.	7.0	Pile	7.5' CISS
		Cut-off	12.0	GWS	50.0







Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
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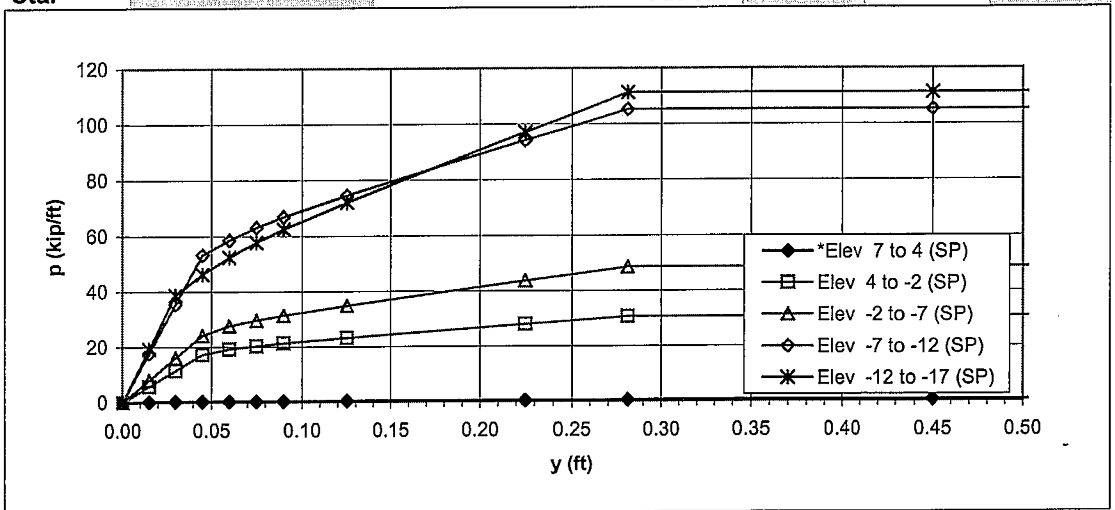
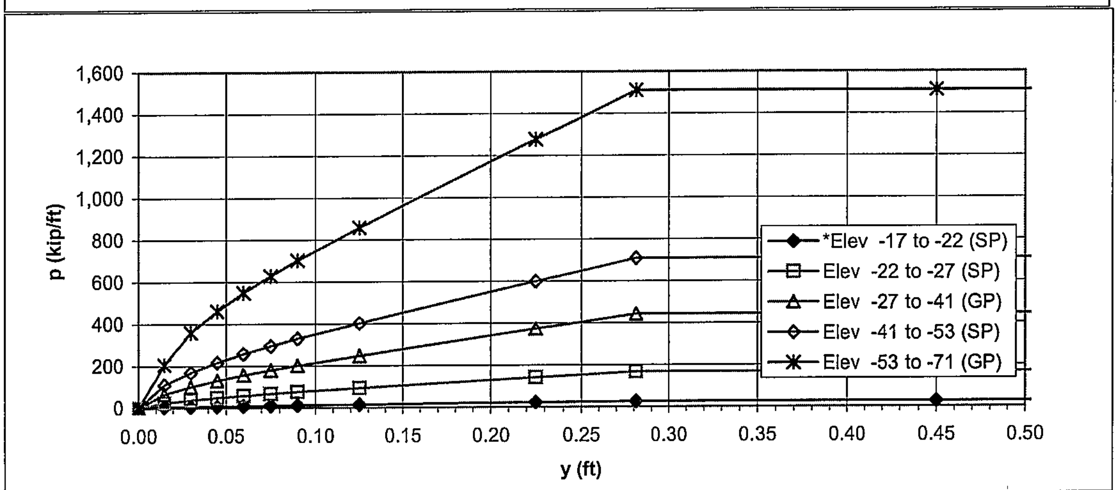
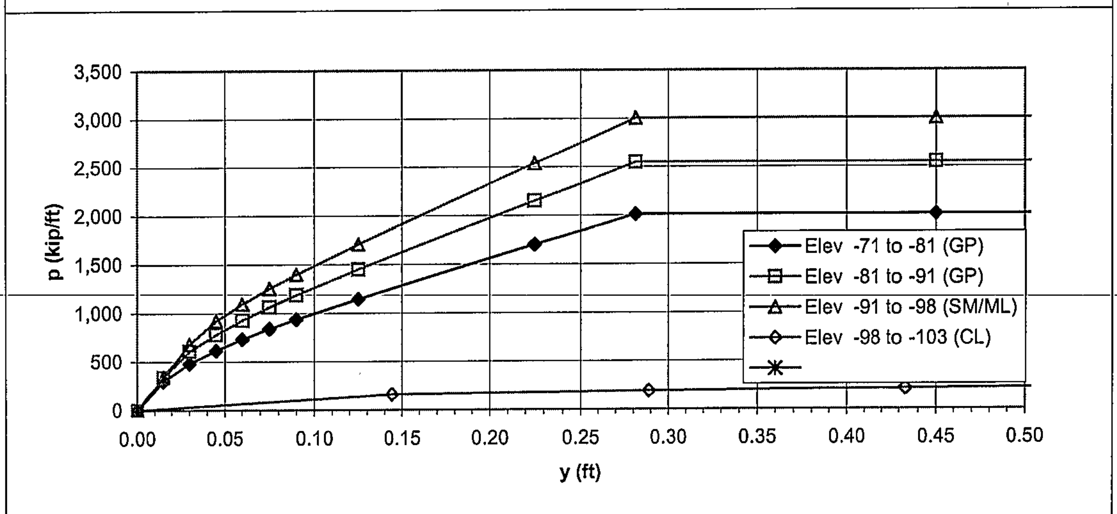
03-1A4321

Pier 6 - with Degradation

Sta.	O.G.	7.0	Pile	7.5' CISS
	Cut-off	19.0	GWS	50.0





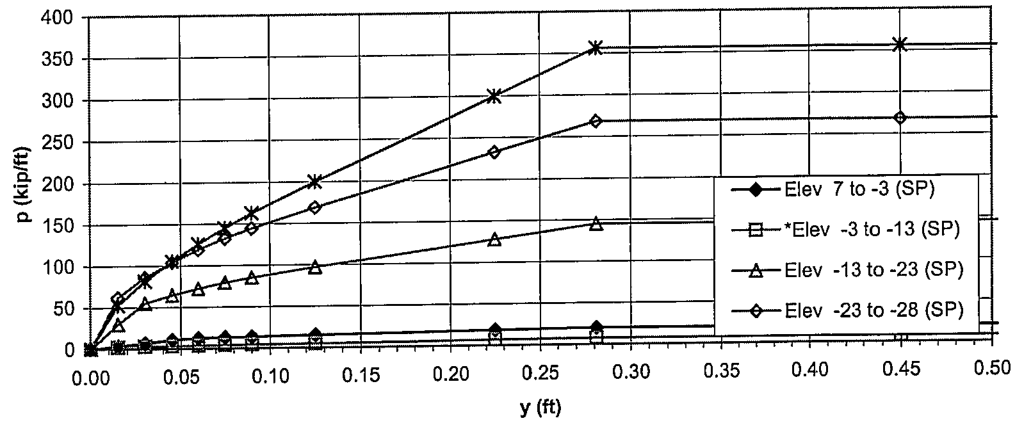


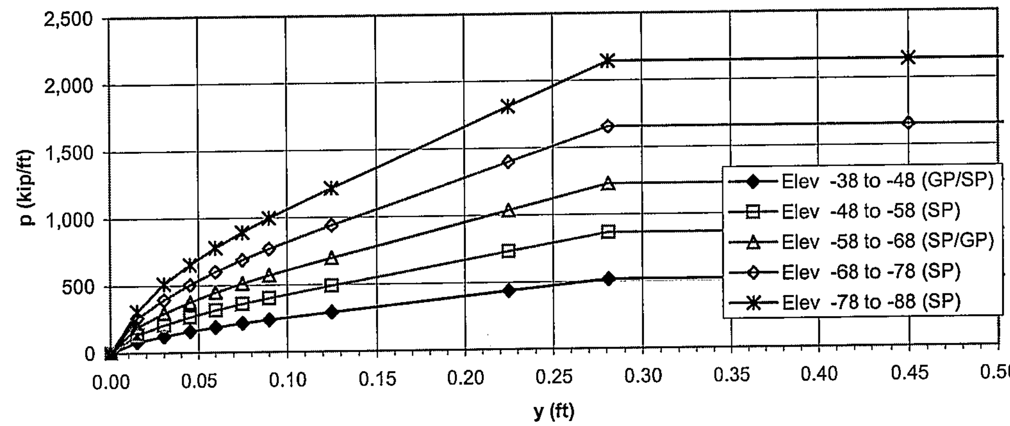
Post-Liquefaction

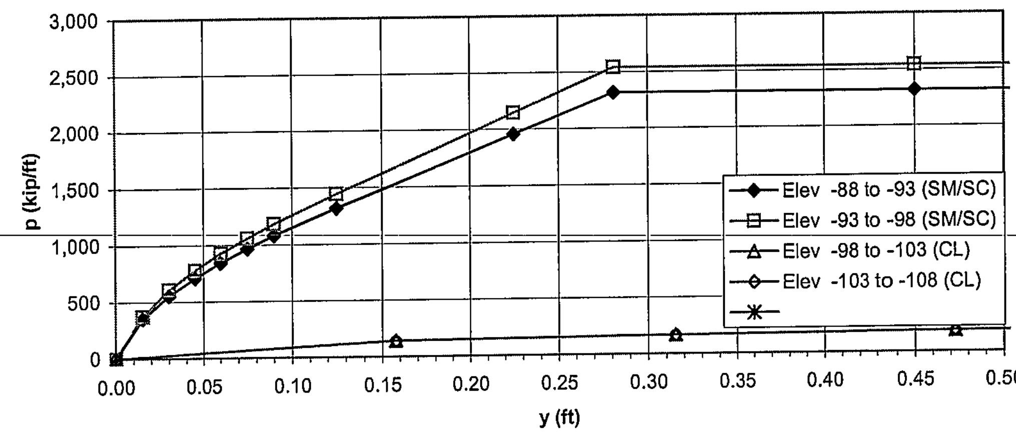
* - Liquefiable Layer

Pier 7 - with Degradation

Sta.		O.G. 7.0	Pile	7.5' CISS
		Cut-off 17.0	GWS	50.0







Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
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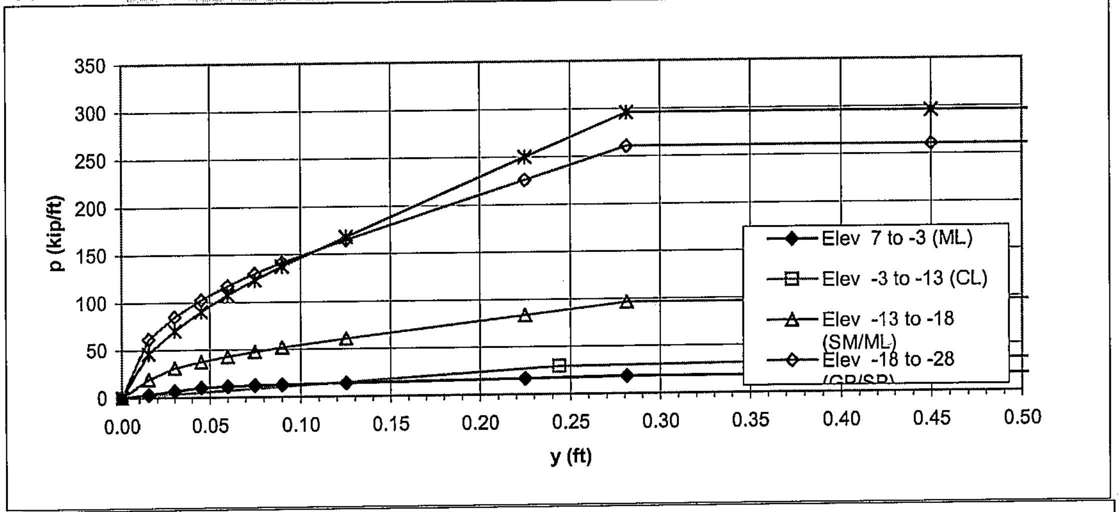
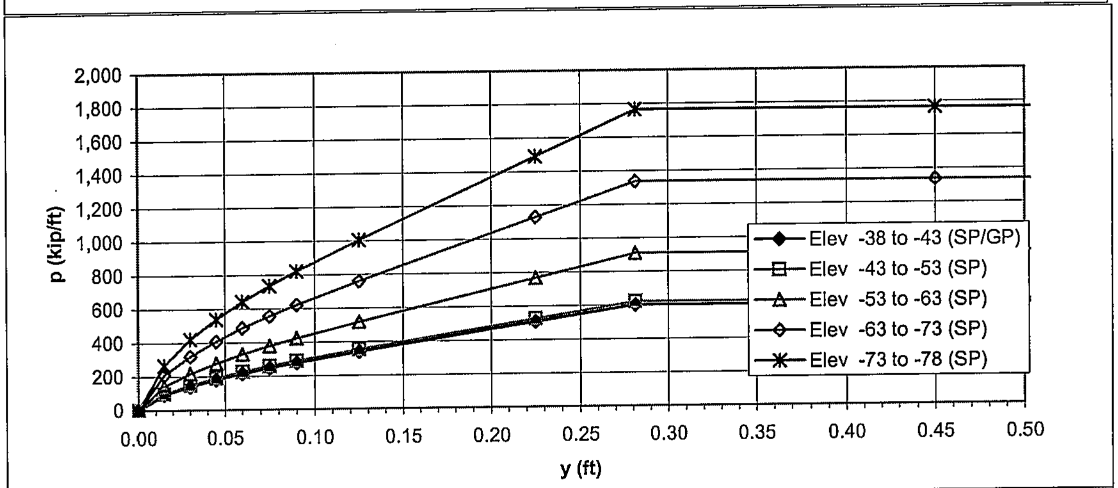
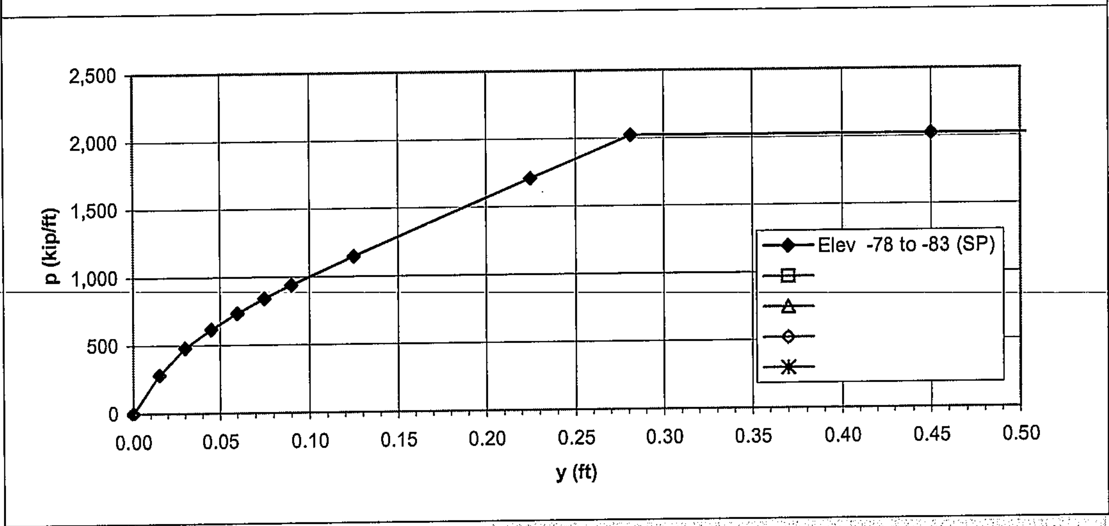
Pier 8 - with Degradation

Sta.	**O.G.** 7.0	**Pile** 7.5' CISS
	Cut-off 37.0	**GWS** 50.0







Feather River Bridge
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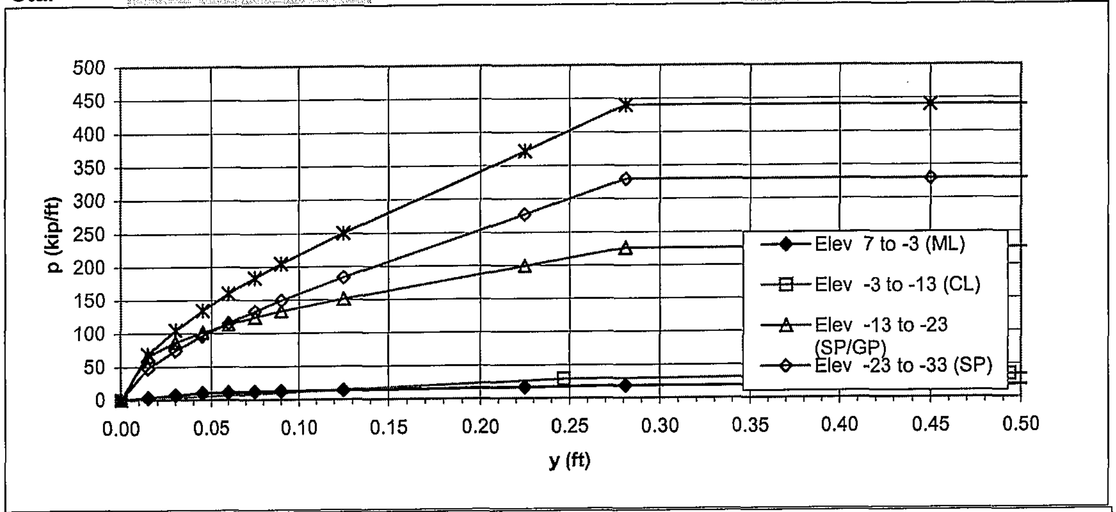
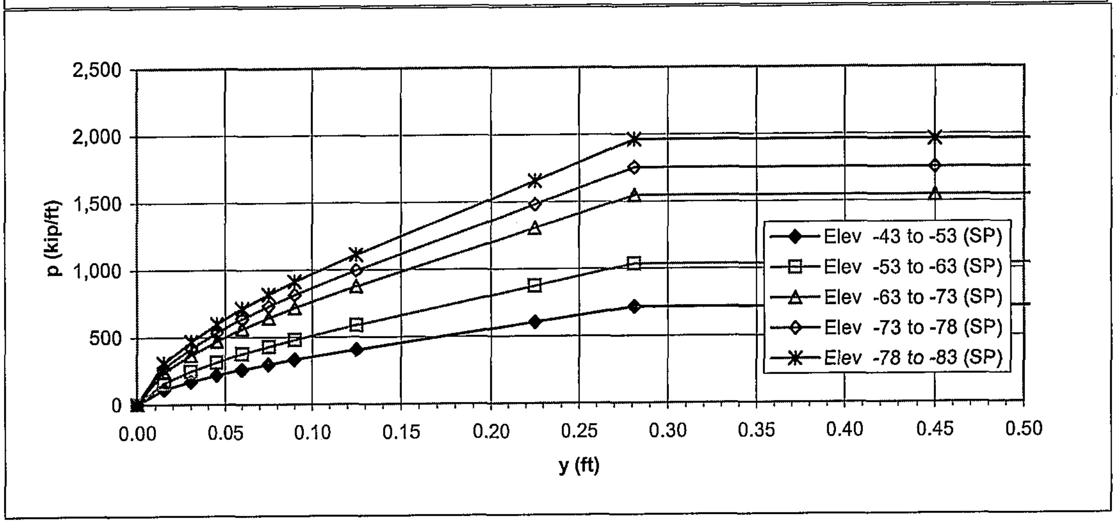
Pier 9 - with degradation

Sta. | O.G. 7.0 | Pile 7.5' CISS
Cut-off 37.0 | GWS 50.0





Feather River Bridge
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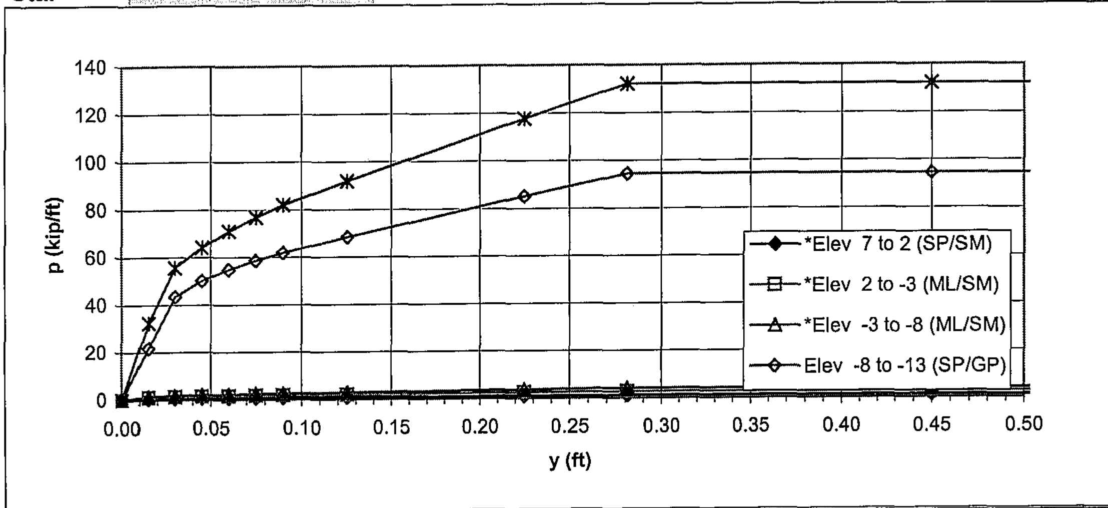
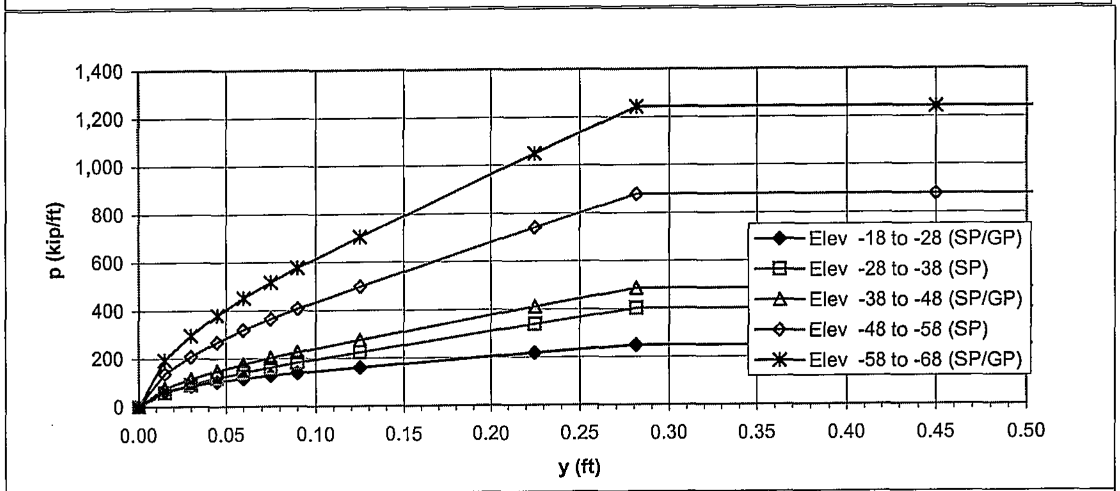
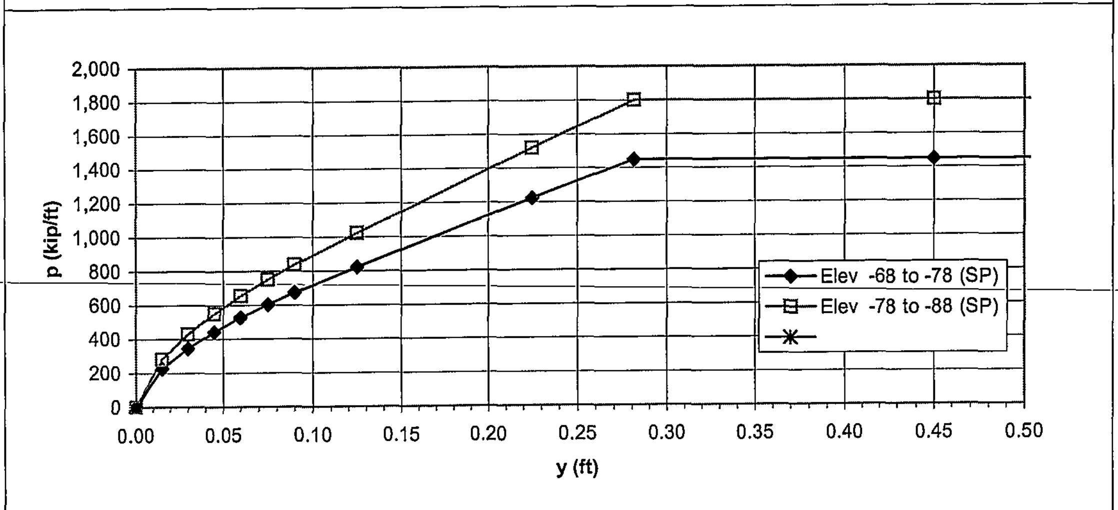
Piers 10 and 11 - with Degradation

Sta.		O.G.	7.0	Pile	7.5' CISS
		Cut-off	37.0	GWS	50.0







Post-Liquefaction

* - Liquefiable Layer

Feather River Bridge
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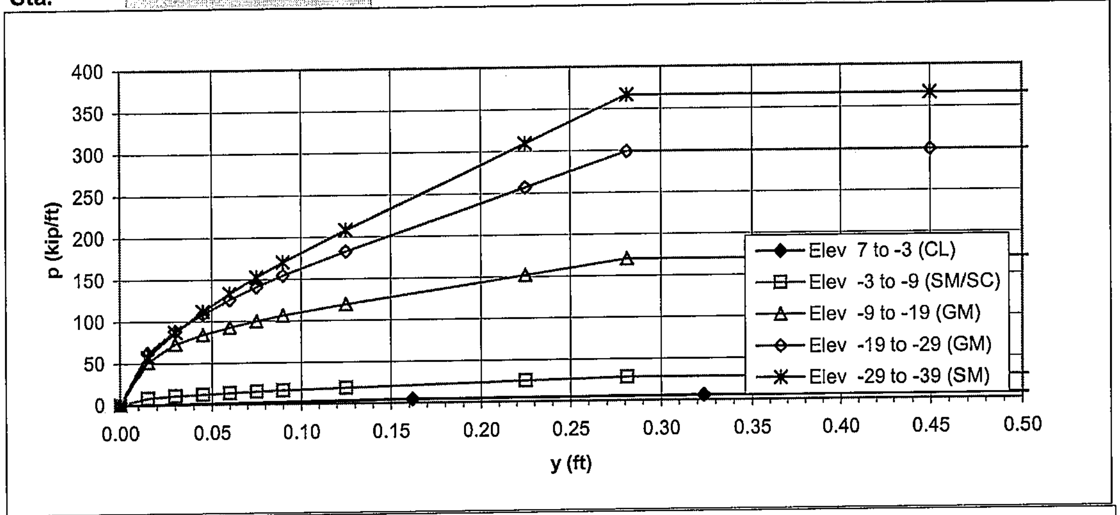
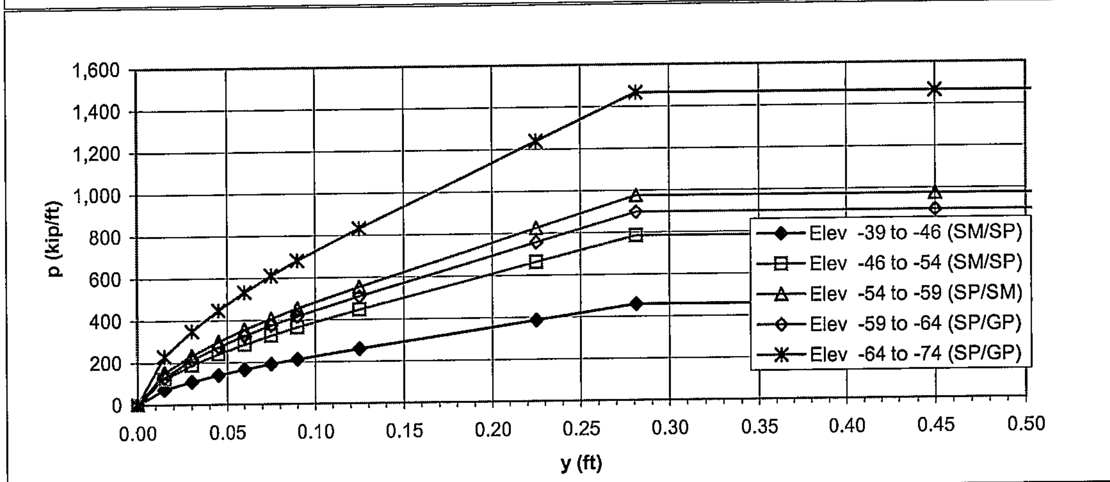
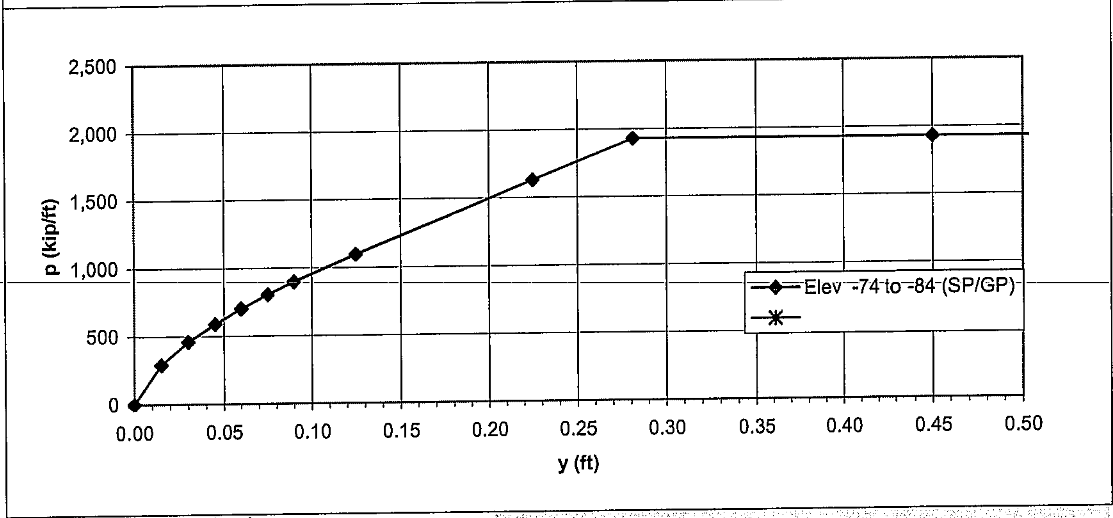
Pier 12 - with Degradation

Sta.		O.G.	7.0	Pile	7.5' CISS
		Cut-off	36.0	GWS	50.0







Feather River Bridge
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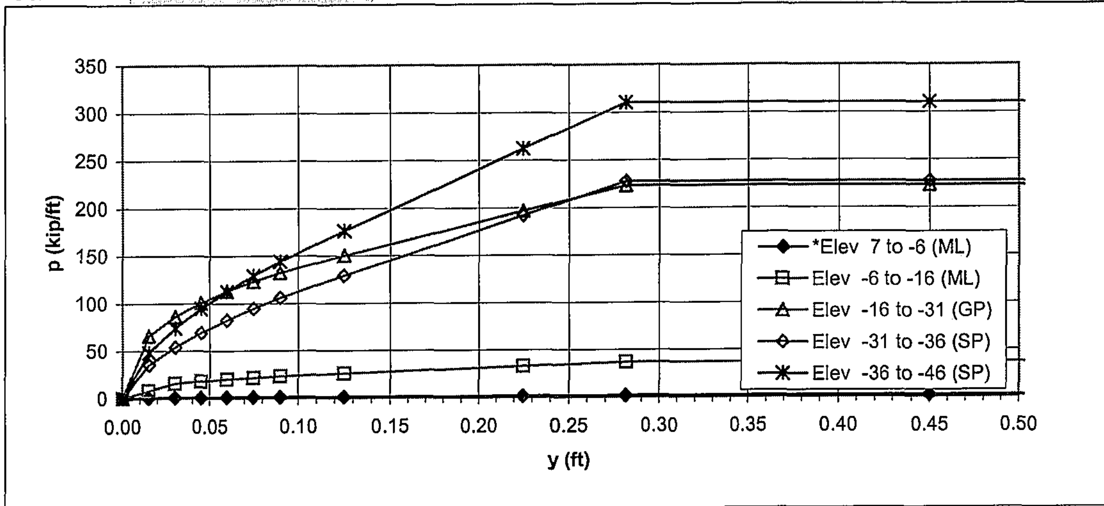
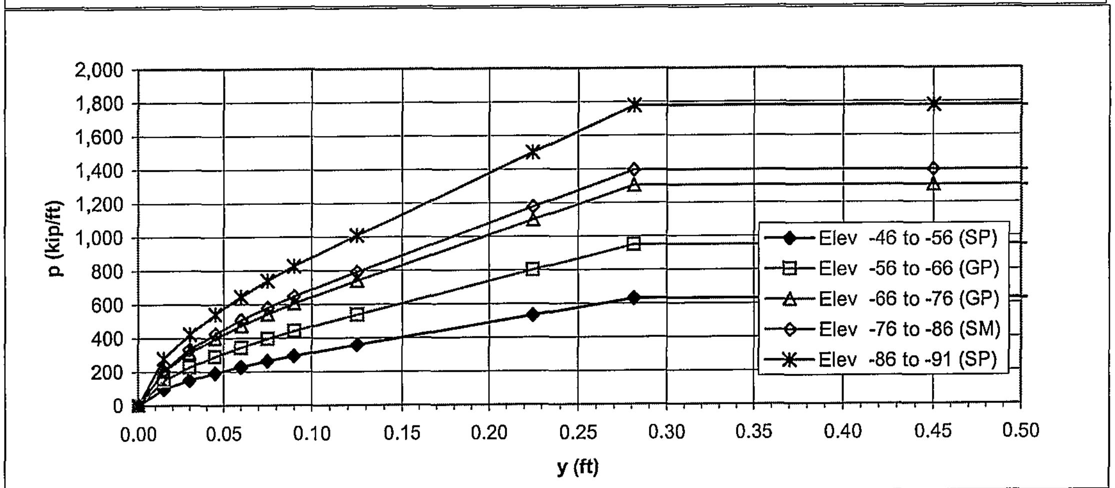
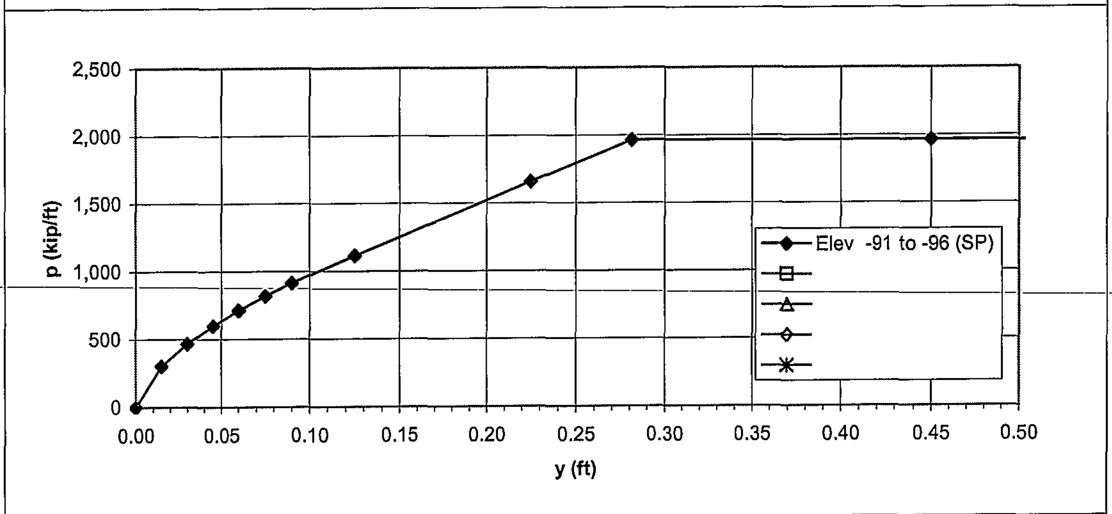
Pier 13 - with Degradation

Sta.		O.G.	7.0	Pile	7.5' CISS
		Cut-off	35.0	GWS	50.0







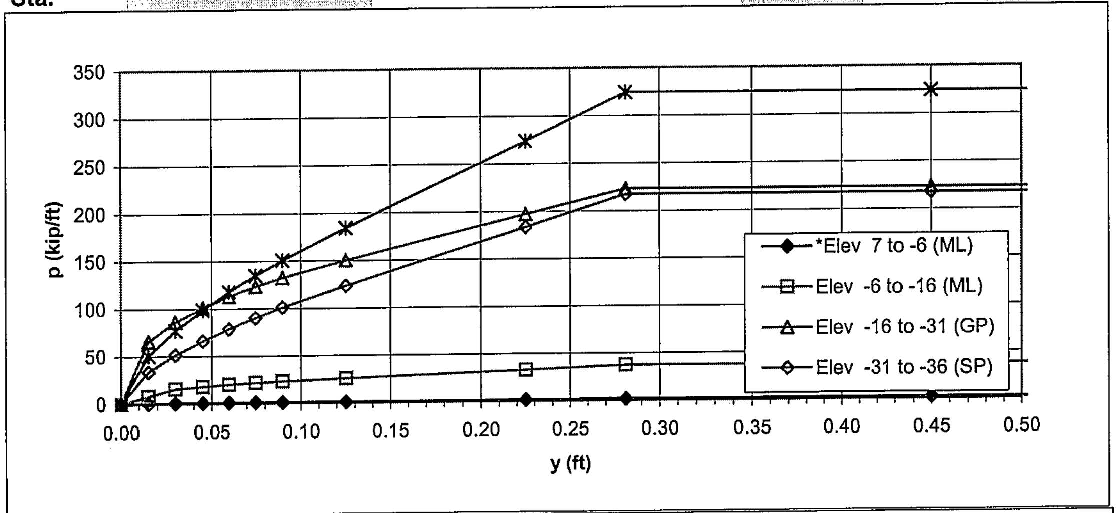
Post-Liquefaction

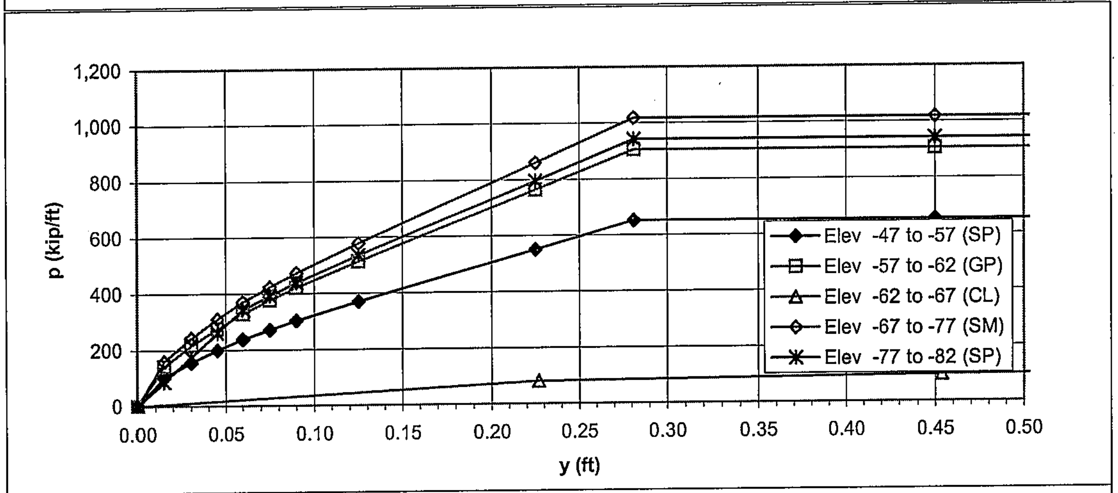
* - Liquefiable Layer

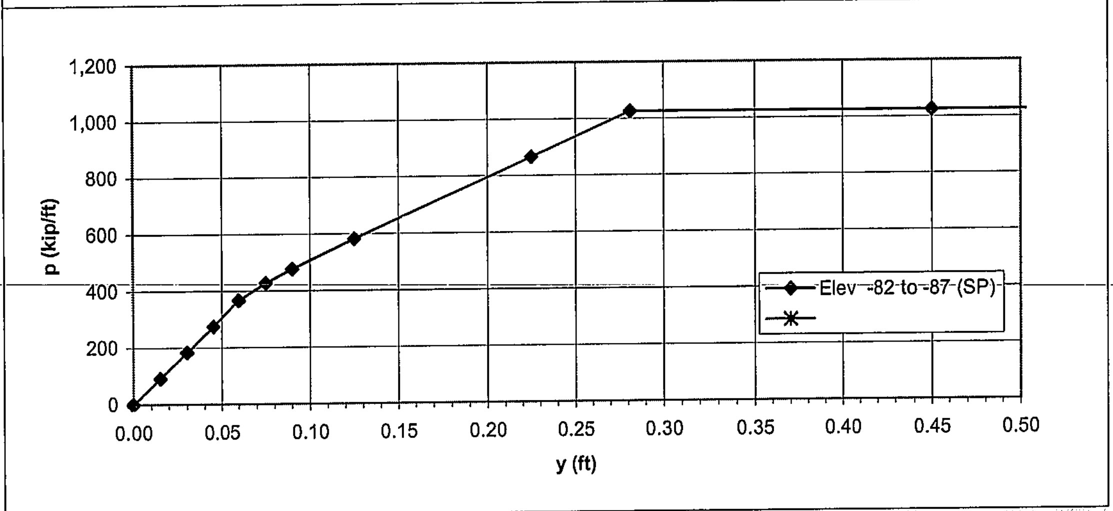
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - with Degradation

Sta.		**O.G.**	7.0	**Pile**	7.5' CISS
		Cut-off	34.0	**GWS**	50.0







Post-Liquefaction

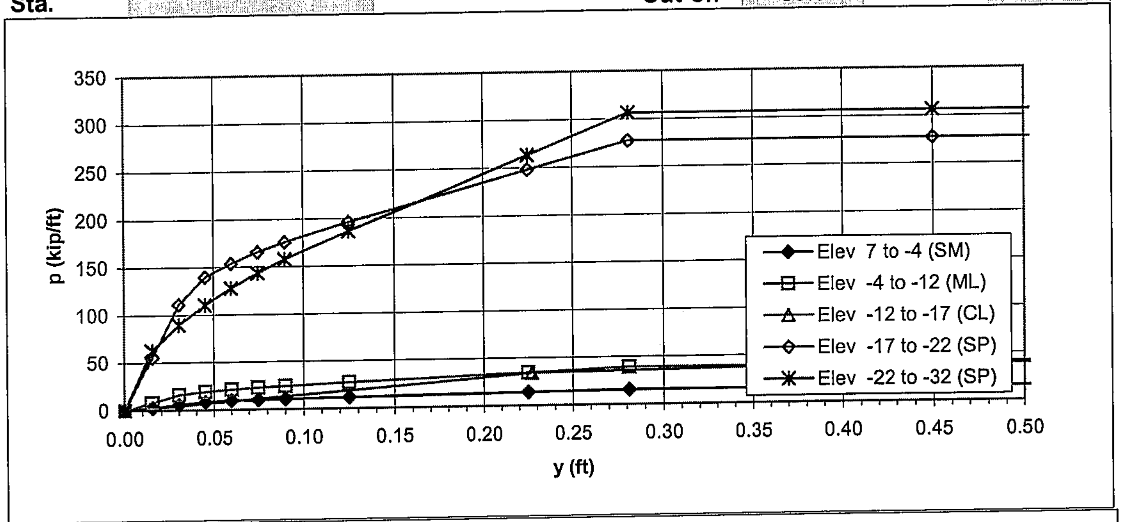
*** - Liquefiable Layer**

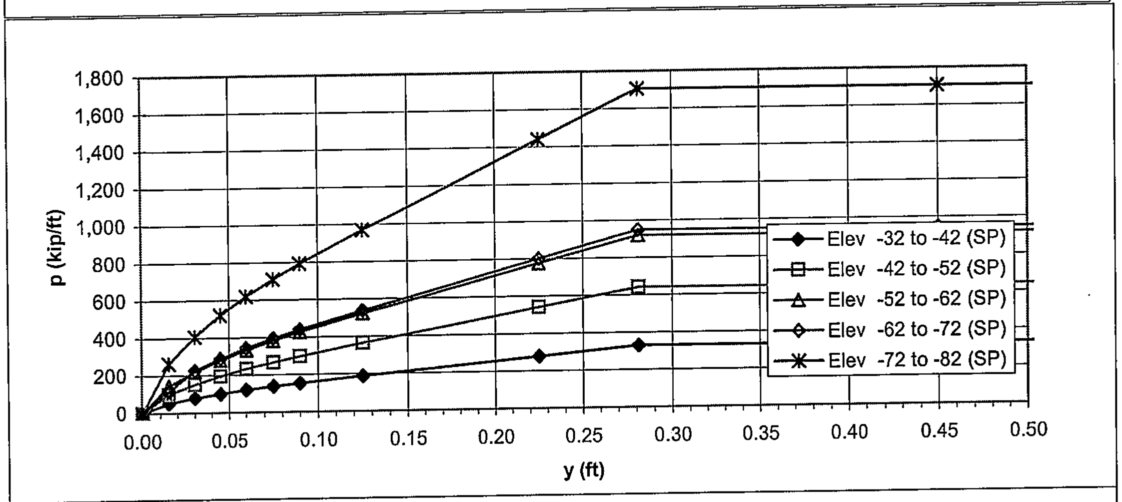
Feather River Bridge
Br. No. 18-0026R
03-1A4321

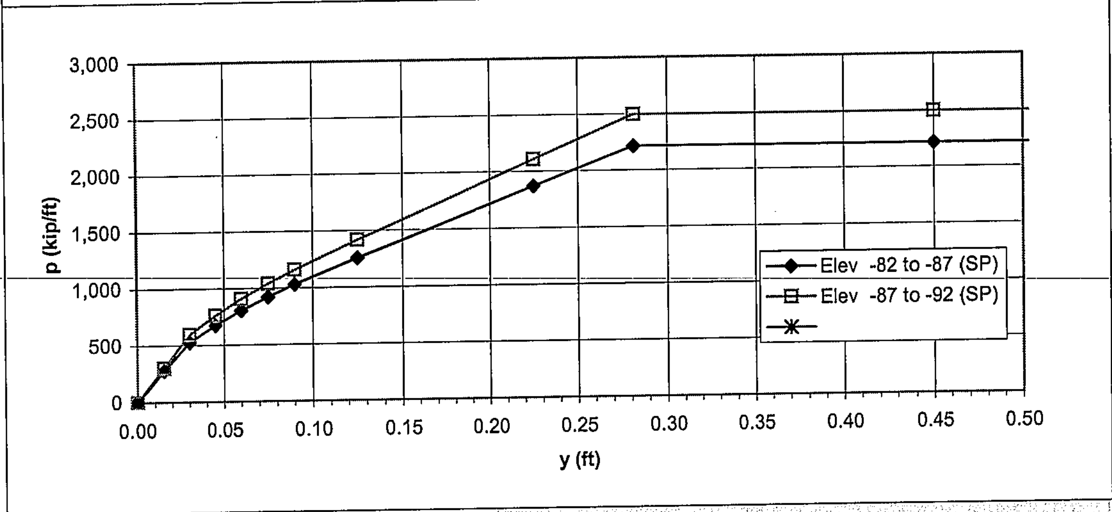
Pier 15 - with Degradation

Sta.

O.G.	7.0	Pile	7.5' CISS
Cut-off	33.0	GWS	50.0







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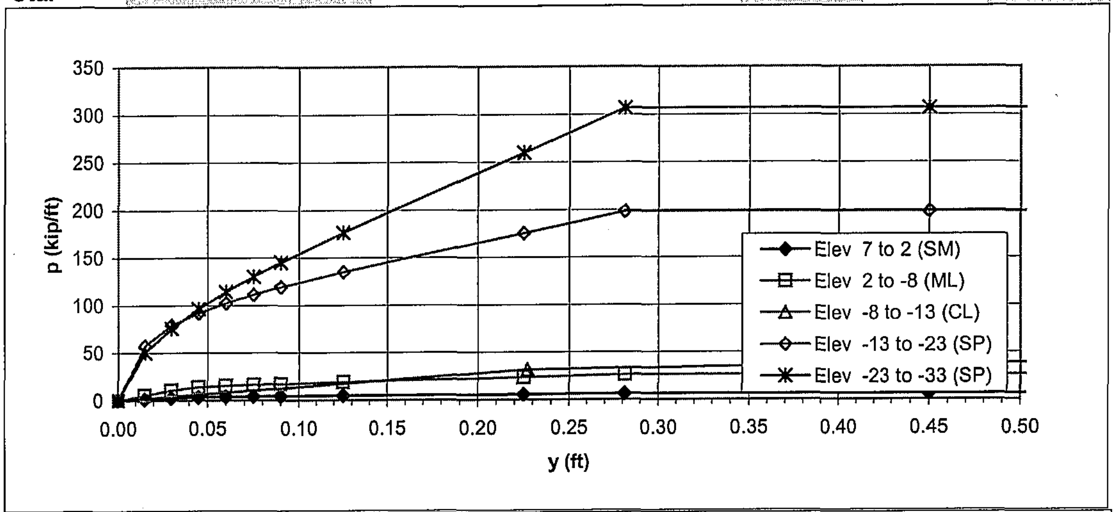
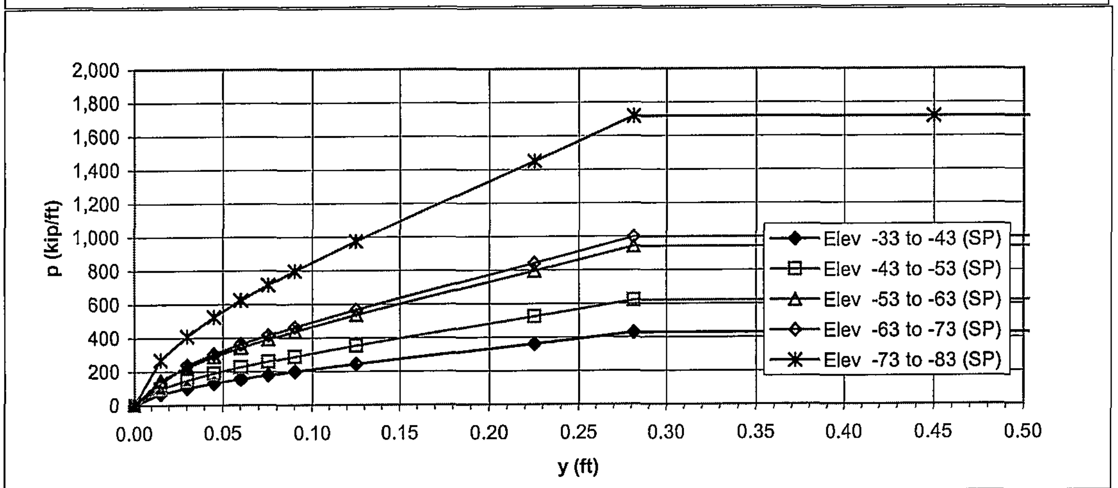
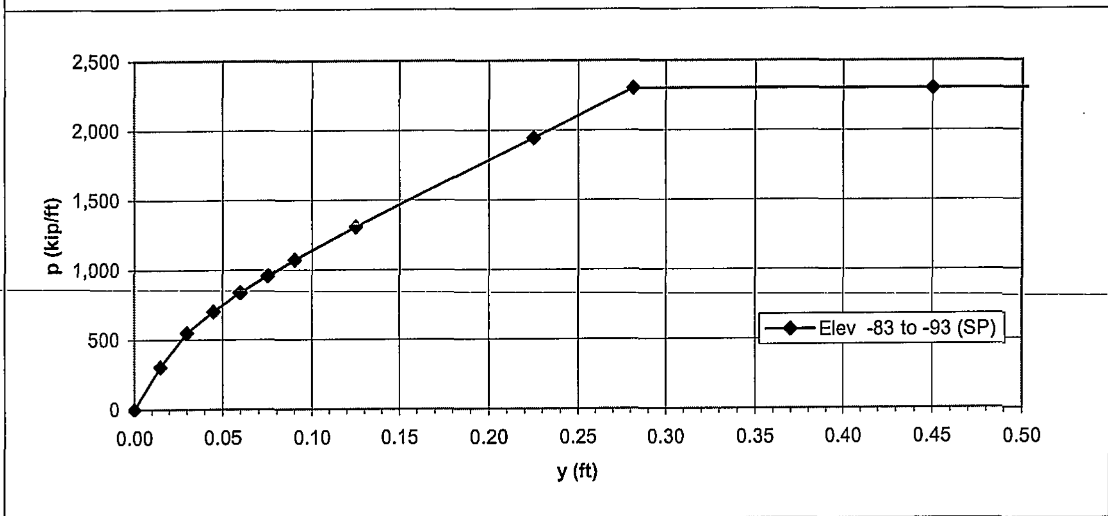
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - with Degradation	**O.G.**	7.0	**Pile**	**7.5' CISS**
Sta.	**Cut-off**	27.0	**GWS**	50.0







Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 2 - with Degradation

Sta.

O.G. 7 | Cut-off 18 | Pile 7.5' CISS | GWS 50.0

y (ft)	*Elev 7 to 2 (SP/ML)	y (ft)	Elev 2 to -8 (SP)	y (ft)	Elev -8 to -16 (SP/GP)	y (ft)	Elev -16 to -24 (CL)	y (ft)	Elev -24 to -30 (CL)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.4	0.015	6	0.015	16	0.174	57	0.184	61
0.03	0.5	0.030	13	0.030	33	0.348	67	0.369	73
0.05	0.5	0.045	19	0.045	42	0.523	75	0.553	80
0.06	0.5	0.060	24	0.060	47	0.697	80	0.737	86
0.08	0.6	0.075	26	0.075	51	0.871	85	0.922	91
0.09	0.6	0.090	27	0.090	55	1.045	89	1.106	96
0.13	0.6	0.125	30	0.125	61	1.393	95	1.475	103
0.23	0.8	0.225	36	0.225	79	1.742	95	1.843	103
0.28	0.8	0.281	40	0.281	89	2.090	95	2.212	103
0.45	0.8	0.450	40	0.450	89	2.439	95	2.581	103
0.75	0.8	0.750	40	0.750	89	2.787	95	2.949	103

y (ft)	Elev -30 to -37 (CL)	y (ft)	Elev -37 to -42 (SP)	y (ft)	Elev -42 to -52 (SP)	y (ft)	Elev -52 to -62 (SP)	y (ft)	Elev -62 to -72 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.184	68	0.015	39	0.015	66	0.015	112	0.015	164
0.369	81	0.030	61	0.030	100	0.030	171	0.030	250
0.553	90	0.045	78	0.045	128	0.045	218	0.045	320
0.737	97	0.060	93	0.060	153	0.060	260	0.060	381
0.922	102	0.075	107	0.075	175	0.075	298	0.075	437
1.106	107	0.090	120	0.090	196	0.090	333	0.090	488
1.475	115	0.125	147	0.125	239	0.125	407	0.125	596
1.843	115	0.225	219	0.225	355	0.225	604	0.225	886
2.212	115	0.281	260	0.281	421	0.281	716	0.281	1,049
2.581	115	0.450	260	0.450	421	0.450	716	0.450	1,049
2.949	115	0.750	260	0.750	421	0.750	716	0.750	1,049

y (ft)	Elev -72 to -82 (SP)	y (ft)	Elev -82 to -92 (SP)	y (ft)	Elev -92 to -102 (SP)				
0.000	0	0.000	0	0.000	0				
0.015	226	0.015	288	0.015	286				
0.030	345	0.030	454	0.030	459				
0.045	441	0.045	581	0.045	587				
0.060	525	0.060	692	0.060	699				
0.075	602	0.075	793	0.075	801				
0.090	672	0.090	886	0.090	895				
0.125	821	0.125	1,082	0.125	1,093				
0.225	1,220	0.225	1,608	0.225	1,624				
0.281	1,445	0.281	1,904	0.281	1,923				
0.450	1,445	0.450	1,904	0.450	1,923				
0.750	1,445	0.750	1,904	0.750	1,923				

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
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Pier 3 - with Degradation

Sta.

O.G. 7 | Pile 7.5' CISS
Cut-off 26 | GWS 50.0

y (ft)	Elev 7 to -2 (SP)	y (ft)	Elev -2 to -10 (SP)	y (ft)	Elev -10 to -20 (ML)	y (ft)	Elev -20 to -30 (SP)	y (ft)	Elev -30 to -40 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	3.8	0.015	10	0.015	13	0.015	23	0.015	37
0.03	7.6	0.030	20	0.030	19	0.030	36	0.030	56
0.05	11.4	0.045	29	0.045	24	0.045	46	0.045	72
0.06	14.0	0.060	32	0.060	28	0.060	55	0.060	85
0.08	14.8	0.075	34	0.075	31	0.075	63	0.075	98
0.09	15.5	0.090	36	0.090	35	0.090	70	0.090	109
0.13	16.9	0.125	40	0.125	41	0.125	86	0.125	133
0.23	20.3	0.225	51	0.225	59	0.225	129	0.225	198
0.28	22.2	0.281	57	0.281	69	0.281	153	0.281	234
0.45	22.2	0.450	57	0.450	69	0.450	153	0.450	234
0.75	22.2	0.750	57	0.750	69	0.750	153	0.750	234

y (ft)	Elev -40 to -50 (SP)	y (ft)	Elev -50 to -55 (GW)	y (ft)	Elev -55 to -60 (GW)	y (ft)	Elev -60 to -70 (SM)	y (ft)	Elev -70 to -80 (SM)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	99	0.015	104	0.015	92	0.015	170	0.015	241
0.030	152	0.030	158	0.030	156	0.030	259	0.030	367
0.045	196	0.045	202	0.045	200	0.045	332	0.045	470
0.060	235	0.060	241	0.060	238	0.060	395	0.060	560
0.075	270	0.075	276	0.075	273	0.075	453	0.075	641
0.090	302	0.090	308	0.090	305	0.090	506	0.090	716
0.125	371	0.125	376	0.125	373	0.125	618	0.125	874
0.225	556	0.225	559	0.225	554	0.225	918	0.225	1,300
0.281	660	0.281	662	0.281	656	0.281	1,087	0.281	1,539
0.450	660	0.450	662	0.450	656	0.450	1,087	0.450	1,539
0.750	660	0.750	662	0.750	656	0.750	1,087	0.750	1,539

y (ft)	Elev -80 to -90 (SC/GC)	y (ft)	Elev -90 to -95 (SP)	y (ft)	Elev -95 to -100 (SP)				
0.000	0	0.000	0	0.000	0				
0.015	297	0.015	117	0.015	123				
0.030	480	0.030	235	0.030	245				
0.045	614	0.045	352	0.045	368				
0.060	732	0.060	470	0.060	491				
0.075	838	0.075	587	0.075	613				
0.090	936	0.090	704	0.090	736				
0.125	1,143	0.125	978	0.125	1,022				
0.225	1,699	0.225	1,489	0.225	1,609				
0.281	2,012	0.281	1,763	0.281	1,906				
0.450	2,012	0.450	1,763	0.450	1,906				
0.750	2,012	0.750	1,763	0.750	1,906				

Note: p (kip/ft)

Feather River Bridge
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Pier 4 - with Degradation

Sta.

O.G.	7	Pile	7.5' CISS
Cut-off	14	GWS	50.0

y (ft)	Elev 7 to 1 (SM)	y (ft)	Elev 1 to -6 (SP)	y (ft)	Elev -6 to -10 (SP)	y (ft)	Elev -10 to -20 (SP)	y (ft)	Elev -20 to -34 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	2.3	0.015	7	0.015	12	0.015	25	0.015	31
0.03	4.7	0.030	15	0.030	25	0.030	44	0.030	48
0.05	7.0	0.045	22	0.045	37	0.045	52	0.045	61
0.06	8.1	0.060	27	0.060	42	0.060	59	0.060	73
0.08	8.6	0.075	29	0.075	45	0.075	65	0.075	84
0.09	8.9	0.090	31	0.090	48	0.090	70	0.090	94
0.13	9.7	0.125	34	0.125	53	0.125	81	0.125	116
0.23	11.5	0.225	42	0.225	67	0.225	108	0.225	173
0.28	12.6	0.281	47	0.281	75	0.281	123	0.281	206
0.45	12.6	0.450	47	0.450	75	0.450	123	0.450	206
0.75	12.6	0.750	47	0.750	75	0.750	123	0.750	206

y (ft)	Elev -34 to -40 (GP)	y (ft)	Elev -40 to -50 (SM)	y (ft)	Elev -50 to -60 (SP)	y (ft)	Elev -60 to -70 (SP)	y (ft)	Elev -70 to -80 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	68	0.015	96	0.015	162	0.015	212	0.015	205
0.030	104	0.030	147	0.030	246	0.030	323	0.030	342
0.045	134	0.045	188	0.045	315	0.045	414	0.045	438
0.060	160	0.060	224	0.060	375	0.060	493	0.060	522
0.075	184	0.075	256	0.075	430	0.075	564	0.075	597
0.090	206	0.090	286	0.090	480	0.090	631	0.090	667
0.125	253	0.125	350	0.125	587	0.125	770	0.125	815
0.225	379	0.225	520	0.225	872	0.225	1,145	0.225	1,211
0.281	450	0.281	615	0.281	1,032	0.281	1,355	0.281	1,434
0.450	450	0.450	615	0.450	1,032	0.450	1,355	0.450	1,434
0.750	450	0.750	615	0.750	1,032	0.750	1,355	0.750	1,434

y (ft)	Elev -80 to -90 (ML/GM	y (ft)	Elev -90 to -100 (SP)	y (ft)	Elev -100 to -105 (SP)	y (ft)	Elev -105 to -110 (SP)		
0.000	0	0.000	0	0.000	0	0.000	0		
0.015	311	0.015	365	0.015	288	0.015	301		
0.030	530	0.030	631	0.030	576	0.030	602		
0.045	679	0.045	808	0.045	750	0.045	770		
0.060	808	0.060	962	0.060	893	0.060	917		
0.075	926	0.075	1,102	0.075	1,023	0.075	1,050		
0.090	1,034	0.090	1,231	0.090	1,142	0.090	1,173		
0.125	1,263	0.125	1,503	0.125	1,395	0.125	1,433		
0.225	1,877	0.225	2,234	0.225	2,074	0.225	2,130		
0.281	2,223	0.281	2,645	0.281	2,455	0.281	2,522		
0.450	2,223	0.450	2,645	0.450	2,455	0.450	2,522		
0.750	2,223	0.750	2,645	0.750	2,455	0.750	2,522		

Note: p (kip/ft)

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Pier 5 - with Degradation

Sta.

O.G.	7	Pile	7.5' CISS
Cut-off	12	GWS	50.0

y (ft)	*Elev 7 to 0 (SP)	y (ft)	*Elev 0 to -8 (SP)	y (ft)	Elev -8 to -15 (SP)	y (ft)	Elev -15 to -23 (SP)	y (ft)	Elev -23 to -28 (SP/GP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	1.0	0.015	3	0.015	14	0.015	20	0.015	49
0.03	1.2	0.030	4	0.030	27	0.030	35	0.030	69
0.05	1.3	0.045	4	0.045	41	0.045	43	0.045	85
0.06	1.4	0.060	4	0.060	45	0.060	49	0.060	98
0.08	1.4	0.075	5	0.075	49	0.075	55	0.075	110
0.09	1.5	0.090	5	0.090	52	0.090	60	0.090	120
0.13	1.6	0.125	5	0.125	58	0.125	71	0.125	142
0.23	2.0	0.225	7	0.225	75	0.225	98	0.225	198
0.28	2.1	0.281	8	0.281	84	0.281	114	0.281	230
0.45	2.1	0.450	8	0.450	84	0.450	114	0.450	230
0.75	2.1	0.750	8	0.750	84	0.750	114	0.750	230

y (ft)	Elev -28 to -33 (SP/GP)	y (ft)	Elev -33 to -43 (SP/GP)	y (ft)	Elev -43 to -53 (SP/GP)	y (ft)	Elev -53 to -63 (SP/GP)	y (ft)	Elev -63 to -73 (SP/GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	34	0.015	50	0.015	78	0.015	139	0.015	196
0.030	52	0.030	76	0.030	120	0.030	212	0.030	299
0.045	67	0.045	97	0.045	153	0.045	271	0.045	383
0.060	80	0.060	115	0.060	182	0.060	323	0.060	456
0.075	92	0.075	132	0.075	209	0.075	370	0.075	523
0.090	102	0.090	147	0.090	233	0.090	413	0.090	584
0.125	126	0.125	180	0.125	285	0.125	504	0.125	713
0.225	188	0.225	267	0.225	423	0.225	750	0.225	1,060
0.281	222	0.281	317	0.281	501	0.281	888	0.281	1,255
0.450	222	0.450	317	0.450	501	0.450	888	0.450	1,255
0.750	222	0.750	317	0.750	501	0.750	888	0.750	1,255

y (ft)	Elev -73 to -83 (SP/GP)	y (ft)	Elev -83 to -93 (SP/GP)	y (ft)	Elev -93 to -103 (SP/GP)	y (ft)	Elev -103 to -113 (CL)		
0.000	0	0.000	0	0.000	0	0.000	0		
0.015	264	0.015	306	0.015	350	0.144	161		
0.030	402	0.030	528	0.030	652	0.289	191		
0.045	514	0.045	675	0.045	834	0.433	211		
0.060	613	0.060	804	0.060	993	0.578	227		
0.075	702	0.075	921	0.075	1,138	0.722	240		
0.090	784	0.090	1,029	0.090	1,271	0.866	251		
0.125	957	0.125	1,257	0.125	1,552	1.155	270		
0.225	1,423	0.225	1,868	0.225	2,307	1.444	270		
0.281	1,685	0.281	2,212	0.281	2,731	1.733	270		
0.450	1,685	0.450	2,212	0.450	2,731	2.022	270		
0.750	1,685	0.750	2,212	0.750	2,731	2.311	270		

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - with Degradation

Sta.

O.G.	7	Pile	7.5' CISS
Cut-off	19	GWS	50.0

y (ft)	*Elev 7 to 4 (SP)	y (ft)	Elev 4 to -2 (SP)	y (ft)	Elev -2 to -7 (SP)	y (ft)	Elev -7 to -12 (SP)	y (ft)	Elev -12 to -17 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.3	0.015	6	0.015	8	0.015	18	0.015	19
0.03	0.3	0.030	12	0.030	16	0.030	35	0.030	39
0.05	0.3	0.045	17	0.045	24	0.045	53	0.045	46
0.06	0.4	0.060	19	0.060	28	0.060	59	0.060	52
0.08	0.4	0.075	20	0.075	30	0.075	63	0.075	58
0.09	0.4	0.090	21	0.090	31	0.090	67	0.090	62
0.13	0.4	0.125	23	0.125	35	0.125	75	0.125	72
0.23	0.5	0.225	28	0.225	44	0.225	94	0.225	97
0.28	0.6	0.281	31	0.281	49	0.281	105	0.281	111
0.45	0.6	0.450	31	0.450	49	0.450	105	0.450	111
0.75	0.6	0.750	31	0.750	49	0.750	105	0.750	111

y (ft)	*Elev -17 to -22 (SP)	y (ft)	Elev -22 to -27 (SP)	y (ft)	Elev -27 to -41 (GP)	y (ft)	Elev -41 to -53 (SP)	y (ft)	Elev -53 to -71 (GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	4	0.015	25	0.015	65	0.015	111	0.015	206
0.030	6	0.030	38	0.030	101	0.030	169	0.030	361
0.045	8	0.045	49	0.045	131	0.045	217	0.045	461
0.060	10	0.060	59	0.060	157	0.060	258	0.060	549
0.075	11	0.075	68	0.075	180	0.075	296	0.075	629
0.090	12	0.090	76	0.090	202	0.090	330	0.090	703
0.125	15	0.125	94	0.125	248	0.125	403	0.125	859
0.225	23	0.225	141	0.225	373	0.225	599	0.225	1,276
0.281	27	0.281	167	0.281	443	0.281	710	0.281	1,511
0.450	27	0.450	167	0.450	443	0.450	710	0.450	1,511
0.750	27	0.750	167	0.750	443	0.750	710	0.750	1,511

y (ft)	Elev -71 to -81 (GP)	y (ft)	Elev -81 to -91 (GP)	y (ft)	Elev -91 to -98 (SM/ML)	y (ft)	Elev -98 to -103 (CL)		
0.000	0	0.000	0	0.000	0	0.000	0		
0.015	297	0.015	336	0.015	339	0.144	161		
0.030	480	0.030	608	0.030	679	0.289	191		
0.045	614	0.045	778	0.045	917	0.433	211		
0.060	732	0.060	927	0.060	1,092	0.578	227		
0.075	838	0.075	1,061	0.075	1,251	0.722	240		
0.090	936	0.090	1,186	0.090	1,398	0.866	251		
0.125	1,143	0.125	1,448	0.125	1,707	1.155	270		
0.225	1,699	0.225	2,152	0.225	2,537	1.444	270		
0.281	2,012	0.281	2,548	0.281	3,004	1.733	270		
0.450	2,012	0.450	2,548	0.450	3,004	2.022	270		
0.750	2,012	0.750	2,548	0.750	3,004	2.311	270		

Note: p (kip/ft) **Post-Liquefaction** *** - Liquefiable Layer**

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 7 - with Degradation

Sta.

O.G. 7 | Cut-off 17 | Pile 7.5' CISS | GWS 50.0

y (ft)	Elev 7 to -3 (SP)	y (ft)	*Elev -3 to -13 (SP)	y (ft)	Elev -13 to -23 (SP)	y (ft)	Elev -23 to -28 (SP)	y (ft)	Elev -28 to -38 (GP/SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	3.6	0.015	2	0.015	30	0.015	62	0.015	53
0.03	7.1	0.030	3	0.030	55	0.030	86	0.030	82
0.05	10.7	0.045	4	0.045	65	0.045	104	0.045	105
0.06	12.7	0.060	4	0.060	73	0.060	119	0.060	126
0.08	13.4	0.075	4	0.075	79	0.075	133	0.075	145
0.09	14.1	0.090	5	0.090	85	0.090	145	0.090	162
0.13	15.3	0.125	5	0.125	97	0.125	169	0.125	200
0.23	18.5	0.225	7	0.225	128	0.225	233	0.225	300
0.28	20.2	0.281	8	0.281	145	0.281	268	0.281	356
0.45	20.2	0.450	8	0.450	145	0.450	268	0.450	356
0.75	20.2	0.750	8	0.750	145	0.750	268	0.750	356

y (ft)	Elev -38 to -48 (GP/SP	y (ft)	Elev -48 to -58 (SP)	y (ft)	Elev -58 to -68 (SP/GP)	y (ft)	Elev -68 to -78 (SP)	y (ft)	Elev -78 to -88 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	81	0.015	135	0.015	192	0.015	259	0.015	307
0.030	124	0.030	206	0.030	293	0.030	394	0.030	511
0.045	158	0.045	264	0.045	375	0.045	505	0.045	654
0.060	188	0.060	314	0.060	446	0.060	601	0.060	779
0.075	216	0.075	360	0.075	511	0.075	689	0.075	892
0.090	241	0.090	402	0.090	571	0.090	769	0.090	997
0.125	294	0.125	491	0.125	697	0.125	939	0.125	1,217
0.225	437	0.225	730	0.225	1,036	0.225	1,396	0.225	1,809
0.281	518	0.281	864	0.281	1,227	0.281	1,653	0.281	2,142
0.450	518	0.450	864	0.450	1,227	0.450	1,653	0.450	2,142
0.750	518	0.750	864	0.750	1,227	0.750	1,653	0.750	2,142

y (ft)	Elev -88 to -93 (SM/SC	y (ft)	Elev -93 to -98 (SM/SC)	y (ft)	Elev -98 to -103 (CL)	y (ft)	Elev -103 to -108 (CL)		
0.000	0	0.000	0	0.000	0	0.000	0		
0.015	351	0.015	372	0.158	140	0.158	140		
0.030	553	0.030	606	0.315	167	0.315	167		
0.045	707	0.045	775	0.473	185	0.473	185		
0.060	842	0.060	924	0.630	199	0.630	199		
0.075	965	0.075	1,058	0.788	210	0.788	210		
0.090	1,078	0.090	1,182	0.945	220	0.945	220		
0.125	1,316	0.125	1,443	1.260	236	1.260	236		
0.225	1,956	0.225	2,145	1.575	236	1.575	236		
0.281	2,316	0.281	2,540	1.890	236	1.890	236		
0.450	2,316	0.450	2,540	2.206	236	2.206	236		
0.750	2,316	0.750	2,540	2.521	236	2.521	236		

Note: p (kip/ft) **Post-Liquefaction** *- Liquefiable Layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - with Degradation

Sta.

O.G. 7 | Cut-off 37 | Pile 7.5' CISS | GWS 50.0

y (ft)	Elev 7 to -3 (ML)	y (ft)	Elev -3 to -13 (CL)	y (ft)	Elev -13 to -18 (SM/ML)	y (ft)	Elev -18 to -28 (GP/SP)	y (ft)	Elev -28 to -38 (SP/GP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	3.6	0.244	29	0.015	19	0.015	62	0.015	46
0.03	7.1	0.487	35	0.030	31	0.030	85	0.030	71
0.05	10.7	0.731	39	0.045	38	0.045	103	0.045	90
0.06	11.7	0.975	42	0.060	43	0.060	117	0.060	108
0.08	12.4	1.219	44	0.075	48	0.075	130	0.075	123
0.09	13.0	1.462	46	0.090	52	0.090	142	0.090	138
0.13	14.1	1.950	50	0.125	61	0.125	165	0.125	168
0.23	17.0	2.437	50	0.225	84	0.225	226	0.225	250
0.28	18.7	2.925	50	0.281	97	0.281	261	0.281	296
0.45	18.7	3.412	50	0.450	97	0.450	261	0.450	296
0.75	18.7	3.899	50	0.750	97	0.750	261	0.750	296

y (ft)	Elev -38 to -43 (SP/GP	y (ft)	Elev -43 to -53 (SP)	y (ft)	Elev -53 to -63 (SP)	y (ft)	Elev -63 to -73 (SP)	y (ft)	Elev -73 to -78 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	92	0.015	97	0.015	142	0.015	209	0.015	265
0.030	141	0.030	148	0.030	217	0.030	319	0.030	421
0.045	181	0.045	190	0.045	278	0.045	408	0.045	539
0.060	216	0.060	226	0.060	331	0.060	486	0.060	642
0.075	248	0.075	259	0.075	379	0.075	557	0.075	735
0.090	277	0.090	289	0.090	423	0.090	622	0.090	821
0.125	340	0.125	353	0.125	516	0.125	759	0.125	1,003
0.225	507	0.225	525	0.225	768	0.225	1,129	0.225	1,491
0.281	601	0.281	622	0.281	909	0.281	1,336	0.281	1,765
0.450	601	0.450	622	0.450	909	0.450	1,336	0.450	1,765
0.750	601	0.750	622	0.750	909	0.750	1,336	0.750	1,765

y (ft)	Elev -78 to -83 (SP)
0.000	0
0.015	284
0.030	482
0.045	617
0.060	735
0.075	842
0.090	940
0.125	1,148
0.225	1,707
0.281	2,021
0.450	2,021
0.750	2,021

Note: p (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - with degradation

Sta.

O.G. 7 | Cut-off 37 | Pile 7.5' CISS | GWS 50.0

y (ft)	Elev 7 to -3 (ML)	y (ft)	Elev -3 to -13 (CL)	y (ft)	Elev -13 to -23 (SP/GP)	y (ft)	Elev -23 to -33 (SP)	y (ft)	Elev -33 to -43 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	3.6	0.247	29	0.015	66	0.015	48	0.015	69
0.03	7.1	0.494	34	0.030	87	0.030	75	0.030	105
0.05	10.7	0.741	38	0.045	102	0.045	96	0.045	134
0.06	11.7	0.988	41	0.060	114	0.060	116	0.060	160
0.08	12.4	1.234	43	0.075	124	0.075	133	0.075	183
0.09	13.0	1.481	45	0.090	133	0.090	149	0.090	205
0.13	14.2	1.975	49	0.125	152	0.125	184	0.125	250
0.23	17.1	2.469	49	0.225	199	0.225	277	0.225	372
0.28	18.7	2.963	49	0.281	226	0.281	329	0.281	440
0.45	18.7	3.456	49	0.450	226	0.450	329	0.450	440
0.75	18.7	3.950	49	0.750	226	0.750	329	0.750	440

y (ft)	Elev -43 to -53 (SP)	y (ft)	Elev -53 to -63 (SP)	y (ft)	Elev -63 to -73 (SP)	y (ft)	Elev -73 to -78 (SP)	y (ft)	Elev -78 to -83 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	112	0.015	162	0.015	242	0.015	274	0.015	307
0.030	171	0.030	247	0.030	369	0.030	418	0.030	468
0.045	219	0.045	316	0.045	472	0.045	535	0.045	599
0.060	261	0.060	376	0.060	562	0.060	637	0.060	713
0.075	299	0.075	431	0.075	644	0.075	730	0.075	817
0.090	334	0.090	482	0.090	719	0.090	815	0.090	912
0.125	407	0.125	588	0.125	878	0.125	996	0.125	1,114
0.225	606	0.225	874	0.225	1,305	0.225	1,480	0.225	1,656
0.281	717	0.281	1,035	0.281	1,545	0.281	1,752	0.281	1,961
0.450	717	0.450	1,035	0.450	1,545	0.450	1,752	0.450	1,961
0.750	717	0.750	1,035	0.750	1,545	0.750	1,752	0.750	1,961

Note: p (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Piers 10 and 11 - with Degradation

Sta.

O.G. 7 | Cut-off 37 | Pile 7.5' CISS | GWS 50.0

y (ft)	*Elev 7 to 2 (SP/SM)	y (ft)	*Elev 2 to -3 (ML/SM)	y (ft)	*Elev -3 to -8 (ML/SM)	y (ft)	Elev -8 to -13 (SP/GP)	y (ft)	Elev -13 to -18 (SP/GP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.6	0.015	1	0.015	1	0.015	22	0.015	32
0.03	0.7	0.030	1	0.030	2	0.030	44	0.030	56
0.05	0.8	0.045	2	0.045	2	0.045	50	0.045	64
0.06	0.8	0.060	2	0.060	2	0.060	55	0.060	71
0.08	0.8	0.075	2	0.075	3	0.075	59	0.075	77
0.09	0.9	0.090	2	0.090	3	0.090	62	0.090	82
0.13	1.0	0.125	2	0.125	3	0.125	68	0.125	92
0.23	1.1	0.225	3	0.225	4	0.225	85	0.225	118
0.28	1.2	0.281	3	0.281	4	0.281	94	0.281	132
0.45	1.2	0.450	3	0.450	4	0.450	94	0.450	132
0.75	1.2	0.750	3	0.750	4	0.750	94	0.750	132

y (ft)	Elev -18 to -28 (SP/GP)	y (ft)	Elev -28 to -38 (SP)	y (ft)	Elev -38 to -48 (SP/GP)	y (ft)	Elev -48 to -58 (SP)	y (ft)	Elev -58 to -68 (SP/GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	64	0.015	59	0.015	76	0.015	137	0.015	194
0.030	87	0.030	92	0.030	116	0.030	209	0.030	296
0.045	104	0.045	118	0.045	149	0.045	268	0.045	379
0.060	118	0.060	142	0.060	177	0.060	319	0.060	452
0.075	129	0.075	163	0.075	203	0.075	365	0.075	517
0.090	140	0.090	183	0.090	226	0.090	408	0.090	578
0.125	162	0.125	225	0.125	276	0.125	498	0.125	706
0.225	218	0.225	338	0.225	411	0.225	741	0.225	1,049
0.281	249	0.281	402	0.281	487	0.281	877	0.281	1,242
0.450	249	0.450	402	0.450	487	0.450	877	0.450	1,242
0.750	249	0.750	402	0.750	487	0.750	877	0.750	1,242

y (ft)	Elev -68 to -78 (SP)	y (ft)	Elev -78 to -88 (SP)
0.000	0	0.000	0
0.015	227	0.015	282
0.030	346	0.030	429
0.045	442	0.045	549
0.060	527	0.060	654
0.075	603	0.075	749
0.090	674	0.090	837
0.125	823	0.125	1,022
0.225	1,224	0.225	1,519
0.281	1,449	0.281	1,799
0.450	1,449	0.450	1,799
0.750	1,449	0.750	1,799

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
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Pier 12 - with Degradation

Sta.

O.G. 7 | Cut-off 36 | Pile 7.5' CISS | GWS 50.0

y (ft)	Elev 7 to -3 (CL)	y (ft)	Elev -3 to -9 (SM/SC)	y (ft)	Elev -9 to -19 (GM)	y (ft)	Elev -19 to -29 (GM)	y (ft)	Elev -29 to -39 (SM)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.16	4.6	0.015	8	0.015	51	0.015	62	0.015	57
0.32	5.8	0.030	11	0.030	73	0.030	88	0.030	87
0.65	7.3	0.045	13	0.045	84	0.045	109	0.045	112
0.97	8.4	0.060	14	0.060	93	0.060	126	0.060	133
1.29	9.2	0.075	15	0.075	100	0.075	141	0.075	153
1.62	9.9	0.090	17	0.090	107	0.090	155	0.090	170
1.94	10.5	0.125	19	0.125	119	0.125	183	0.125	208
2.27	11.1	0.225	25	0.225	152	0.225	257	0.225	309
2.59	11.6	0.281	28	0.281	170	0.281	299	0.281	366
4.85	11.6	0.450	28	0.450	170	0.450	299	0.450	366
8.09	11.6	0.750	28	0.750	170	0.750	299	0.750	366

y (ft)	Elev -39 to -46 (SM/SP)	y (ft)	Elev -46 to -54 (SM/SP)	y (ft)	Elev -54 to -59 (SP/SM	y (ft)	Elev -59 to -64 (SP/GP)	y (ft)	Elev -64 to -74 (SP/GP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	72	0.015	123	0.015	153	0.015	130	0.015	229
0.030	109	0.030	187	0.030	233	0.030	214	0.030	350
0.045	140	0.045	239	0.045	298	0.045	274	0.045	447
0.060	166	0.060	285	0.060	355	0.060	326	0.060	533
0.075	191	0.075	327	0.075	406	0.075	373	0.075	610
0.090	213	0.090	365	0.090	454	0.090	417	0.090	682
0.125	260	0.125	446	0.125	554	0.125	510	0.125	833
0.225	387	0.225	662	0.225	824	0.225	757	0.225	1,238
0.281	458	0.281	784	0.281	976	0.281	897	0.281	1,466
0.450	458	0.450	784	0.450	976	0.450	897	0.450	1,466
0.750	458	0.750	784	0.750	976	0.750	897	0.750	1,466

y (ft)	Elev -74 to -84 (SP/GP)								
0.000	0								
0.015	290								
0.030	460								
0.045	589								
0.060	701								
0.075	803								
0.090	897								
0.125	1,095								
0.225	1,628								
0.281	1,928								
0.450	1,928								
0.750	1,928								

Note: p (kip/ft)

Feather River Bridge
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Pier 13 - with Degradation

Sta.		O.G.	7	Pile	7.5' CISS
		Cut-off	35	GWS	50.0

y (ft)	*Elev 7 to -6 (ML)	y (ft)	Elev -6 to -16 (ML)	y (ft)	Elev -16 to -31 (GP)	y (ft)	Elev -31 to -36 (SP)	y (ft)	Elev -36 to -46 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.8	0.015	8	0.015	66	0.015	36	0.015	49
0.03	1.0	0.030	16	0.030	86	0.030	54	0.030	74
0.05	1.1	0.045	18	0.045	101	0.045	69	0.045	95
0.06	1.2	0.060	20	0.060	113	0.060	83	0.060	113
0.08	1.3	0.075	22	0.075	123	0.075	95	0.075	129
0.09	1.4	0.090	23	0.090	132	0.090	106	0.090	144
0.13	1.5	0.125	26	0.125	150	0.125	129	0.125	176
0.23	1.8	0.225	33	0.225	197	0.225	192	0.225	262
0.28	2.0	0.281	37	0.281	223	0.281	228	0.281	310
0.45	2.0	0.450	37	0.450	223	0.450	228	0.450	310
0.75	2.0	0.750	37	0.750	223	0.750	228	0.750	310

y (ft)	Elev -46 to -56 (SP)	y (ft)	Elev -56 to -66 (GP)	y (ft)	Elev -66 to -76 (GP)	y (ft)	Elev -76 to -86 (SM)	y (ft)	Elev -86 to -91 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	99	0.015	149	0.015	204	0.015	206	0.015	278
0.030	151	0.030	226	0.030	311	0.030	333	0.030	424
0.045	193	0.045	290	0.045	398	0.045	426	0.045	542
0.060	230	0.060	345	0.060	474	0.060	507	0.060	646
0.075	263	0.075	395	0.075	543	0.075	581	0.075	740
0.090	294	0.090	442	0.090	606	0.090	649	0.090	826
0.125	359	0.125	539	0.125	740	0.125	792	0.125	1,009
0.225	533	0.225	802	0.225	1,100	0.225	1,177	0.225	1,500
0.281	631	0.281	949	0.281	1,303	0.281	1,394	0.281	1,776
0.450	631	0.450	949	0.450	1,303	0.450	1,394	0.450	1,776
0.750	631	0.750	949	0.750	1,303	0.750	1,394	0.750	1,776

y (ft)	Elev -91 to -96 (SP)								
0.000	0								
0.015	302								
0.030	468								
0.045	599								
0.060	714								
0.075	817								
0.090	913								
0.125	1,115								
0.225	1,657								
0.281	1,962								
0.450	1,962								
0.750	1,962								

Note: p (kip/ft)   **Post-Liquefaction**   * - Liquefiable Layer

Feather River Bridge
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Pier 14 - with Degradation

Sta.

O.G.	7	**Pile**	7.5' CISS
Cut-off	34	**GWS**	50.0

y (ft)	*Elev 7 to -6 (ML)	y (ft)	Elev -6 to -16 (ML)	y (ft)	Elev -16 to -31 (GP)	y (ft)	Elev -31 to -36 (SP)	y (ft)	Elev -36 to -47 (SP/GP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	0.8	0.015	8	0.015	66	0.015	34	0.015	51
0.03	1.0	0.030	16	0.030	86	0.030	52	0.030	77
0.05	1.1	0.045	18	0.045	101	0.045	66	0.045	99
0.06	1.2	0.060	20	0.060	113	0.060	79	0.060	118
0.08	1.3	0.075	22	0.075	123	0.075	91	0.075	135
0.09	1.4	0.090	23	0.090	132	0.090	101	0.090	151
0.13	1.5	0.125	26	0.125	150	0.125	124	0.125	184
0.23	1.8	0.225	33	0.225	197	0.225	184	0.225	274
0.28	2.0	0.281	37	0.281	223	0.281	217	0.281	324
0.45	2.0	0.450	37	0.450	223	0.450	217	0.450	324
0.75	2.0	0.750	37	0.750	223	0.750	217	0.750	324

y (ft)	Elev -47 to -57 (SP)	y (ft)	Elev -57 to -62 (GP)	y (ft)	Elev -62 to -67 (CL)	y (ft)	Elev -67 to -77 (SM)	y (ft)	Elev -77 to -82 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	102	0.015	142	0.227	80	0.015	159	0.015	87
0.030	156	0.030	216	0.454	95	0.030	243	0.030	174
0.045	199	0.045	276	0.681	106	0.045	311	0.045	261
0.060	237	0.060	329	0.907	114	0.060	370	0.060	342
0.075	272	0.075	377	1.134	120	0.075	424	0.075	392
0.090	304	0.090	421	1.361	126	0.090	474	0.090	438
0.125	371	0.125	514	1.815	135	0.125	578	0.125	535
0.225	551	0.225	764	2.268	135	0.225	859	0.225	795
0.281	652	0.281	905	2.722	135	0.281	1,018	0.281	942
0.450	652	0.450	905	3.176	135	0.450	1,018	0.450	942
0.750	652	0.750	905	3.630	135	0.750	1,018	0.750	942

y (ft)	Elev -82 to -87 (SP)								
0.000	0								
0.015	92								
0.030	183								
0.045	275								
0.060	367								
0.075	427								
0.090	477								
0.125	582								
0.225	865								
0.281	1,024								
0.450	1,024								
0.750	1,024								

Note: p (kip/ft) **Post-Liquefaction** * - Liquefiable Layer

Feather River Bridge
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Pier 15 - with Degradation

Sta.

O.G.	7	Pile	7.5' CISS
Cut-off	33	GWS	50.0

y (ft)	Elev 7 to -4 (SM)	y (ft)	Elev -4 to -12 (ML)	y (ft)	Elev -12 to -17 (CL)	y (ft)	Elev -17 to -22 (SP)	y (ft)	Elev -22 to -32 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	2.9	0.015	8	0.227	34	0.015	56	0.015	63
0.03	5.7	0.030	16	0.454	41	0.030	111	0.030	90
0.05	8.6	0.045	19	0.681	45	0.045	140	0.045	111
0.06	9.7	0.060	21	0.907	48	0.060	154	0.060	128
0.08	10.3	0.075	23	1.134	51	0.075	166	0.075	144
0.09	10.8	0.090	24	1.361	53	0.090	176	0.090	158
0.13	11.7	0.125	27	1.815	57	0.125	196	0.125	187
0.23	14.2	0.225	35	2.268	57	0.225	248	0.225	263
0.28	15.6	0.281	39	2.722	57	0.281	277	0.281	306
0.45	15.6	0.450	39	3.176	57	0.450	277	0.450	306
0.75	15.6	0.750	39	3.630	57	0.750	277	0.750	306

y (ft)	Elev -32 to -42 (SP)	y (ft)	Elev -42 to -52 (SP)	y (ft)	Elev -52 to -62 (SP)	y (ft)	Elev -62 to -72 (SP)	y (ft)	Elev -72 to -82 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	52	0.015	100	0.015	144	0.015	116	0.015	264
0.030	79	0.030	153	0.030	219	0.030	226	0.030	407
0.045	101	0.045	196	0.045	281	0.045	289	0.045	521
0.060	120	0.060	233	0.060	335	0.060	345	0.060	620
0.075	138	0.075	267	0.075	383	0.075	395	0.075	710
0.090	154	0.090	298	0.090	428	0.090	441	0.090	793
0.125	188	0.125	364	0.125	523	0.125	539	0.125	969
0.225	280	0.225	542	0.225	777	0.225	801	0.225	1,440
0.281	331	0.281	641	0.281	920	0.281	948	0.281	1,705
0.450	331	0.450	641	0.450	920	0.450	948	0.450	1,705
0.750	331	0.750	641	0.750	920	0.750	948	0.750	1,705

y (ft)	Elev -82 to -87 (SP)	y (ft)	Elev -87 to -92 (SP)						
0.000	0	0.000	0						
0.015	278	0.015	300						
0.030	528	0.030	595						
0.045	675	0.045	761						
0.060	804	0.060	907						
0.075	921	0.075	1,038						
0.090	1,029	0.090	1,160						
0.125	1,257	0.125	1,417						
0.225	1,868	0.225	2,106						
0.281	2,212	0.281	2,493						
0.450	2,212	0.450	2,493						
0.750	2,212	0.750	2,493						

Note: p (kip/ft)

Feather River Bridge
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Pier 16 - with Degradation

Sta.

O.G. 7 | Pile 7.5' CISS
Cut-off 27 | GWS 50.0

y (ft)	Elev 7 to 2 (SM)	y (ft)	Elev 2 to -8 (ML)	y (ft)	Elev -8 to -13 (CL)	y (ft)	Elev -13 to -23 (SP)	y (ft)	Elev -23 to -33 (SP)
0.00	0.0	0.000	0	0.000	0	0.000	0	0.000	0
0.02	1.3	0.015	5	0.227	32	0.015	58	0.015	50
0.03	2.6	0.030	11	0.454	38	0.030	79	0.030	76
0.05	3.9	0.045	14	0.681	42	0.045	92	0.045	97
0.06	4.2	0.060	15	0.907	45	0.060	103	0.060	114
0.08	4.4	0.075	16	1.134	48	0.075	112	0.075	131
0.09	4.6	0.090	17	1.361	50	0.090	119	0.090	145
0.13	5.0	0.125	19	1.815	53	0.125	135	0.125	176
0.23	5.9	0.225	24	2.268	53	0.225	175	0.225	260
0.28	6.5	0.281	26	2.722	53	0.281	198	0.281	307
0.45	6.5	0.450	26	3.176	53	0.450	198	0.450	307
0.75	6.5	0.750	26	3.630	53	0.750	198	0.750	307

y (ft)	Elev -33 to -43 (SP)	y (ft)	Elev -43 to -53 (SP)	y (ft)	Elev -53 to -63 (SP)	y (ft)	Elev -63 to -73 (SP)	y (ft)	Elev -73 to -83 (SP)
0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
0.015	67	0.015	97	0.015	148	0.015	130	0.015	269
0.030	102	0.030	148	0.030	225	0.030	238	0.030	410
0.045	131	0.045	190	0.045	288	0.045	305	0.045	524
0.060	156	0.060	226	0.060	343	0.060	363	0.060	624
0.075	178	0.075	259	0.075	393	0.075	416	0.075	715
0.090	199	0.090	289	0.090	439	0.090	464	0.090	799
0.125	243	0.125	353	0.125	536	0.125	567	0.125	975
0.225	362	0.225	525	0.225	797	0.225	843	0.225	1,450
0.281	428	0.281	622	0.281	943	0.281	998	0.281	1,717
0.450	428	0.450	622	0.450	943	0.450	998	0.450	1,717
0.750	428	0.750	622	0.750	943	0.750	998	0.750	1,717

y (ft)	Elev -83 to -93 (SP)								
0.000	0								
0.015	304								
0.030	549								
0.045	703								
0.060	837								
0.075	959								
0.090	1,071								
0.125	1,308								
0.225	1,944								
0.281	2,302								
0.450	2,302								
0.750	2,302								

Note: p (kip/ft)

Appendix C

Axial Resistance, t-z Curves

Loading Condition:

With and Without Channel Degradation

Feather River Bridge
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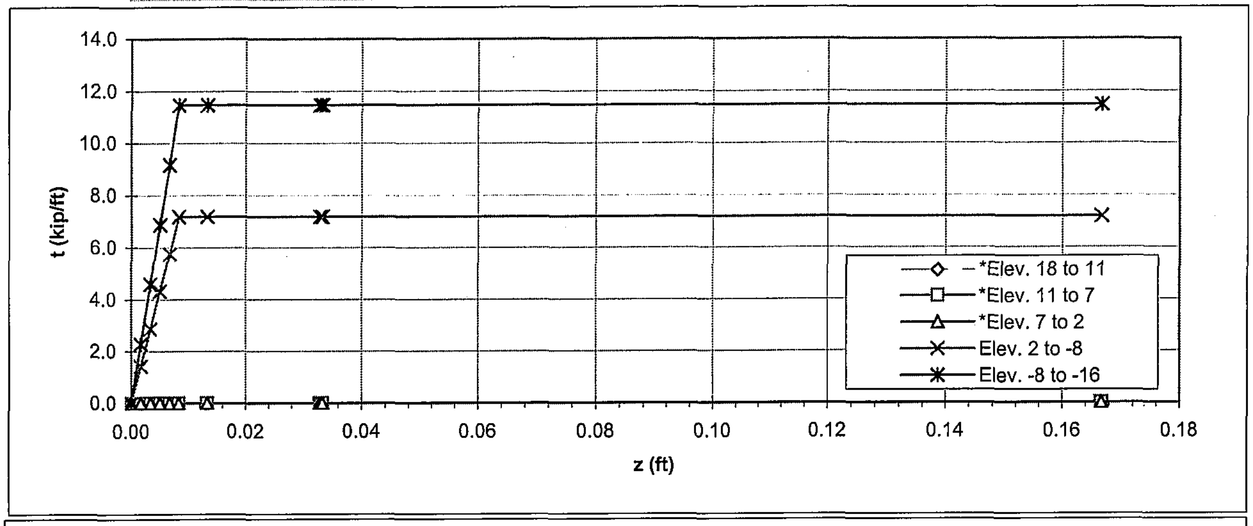
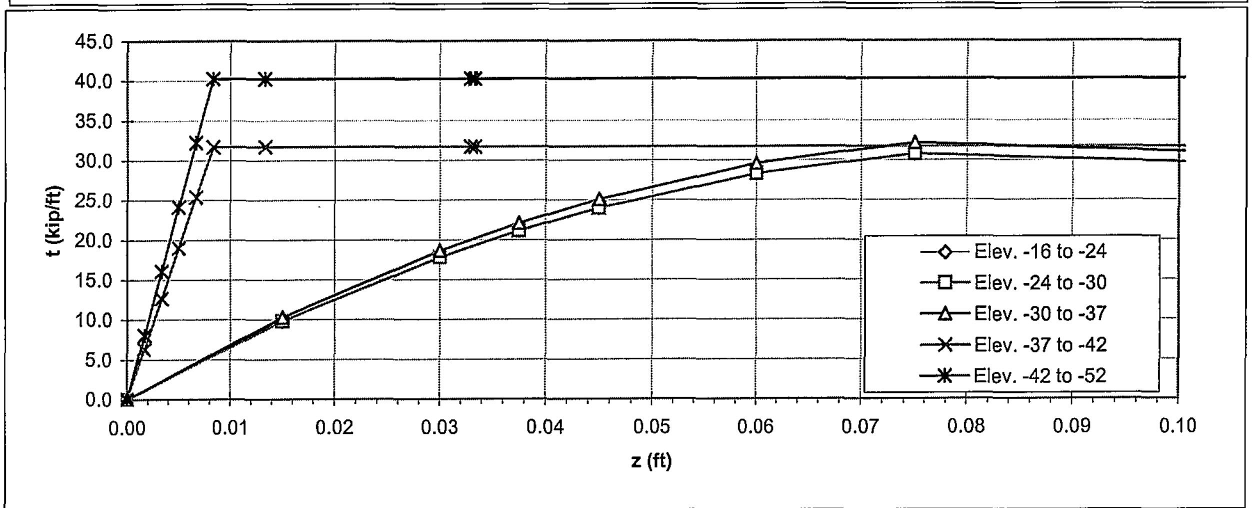
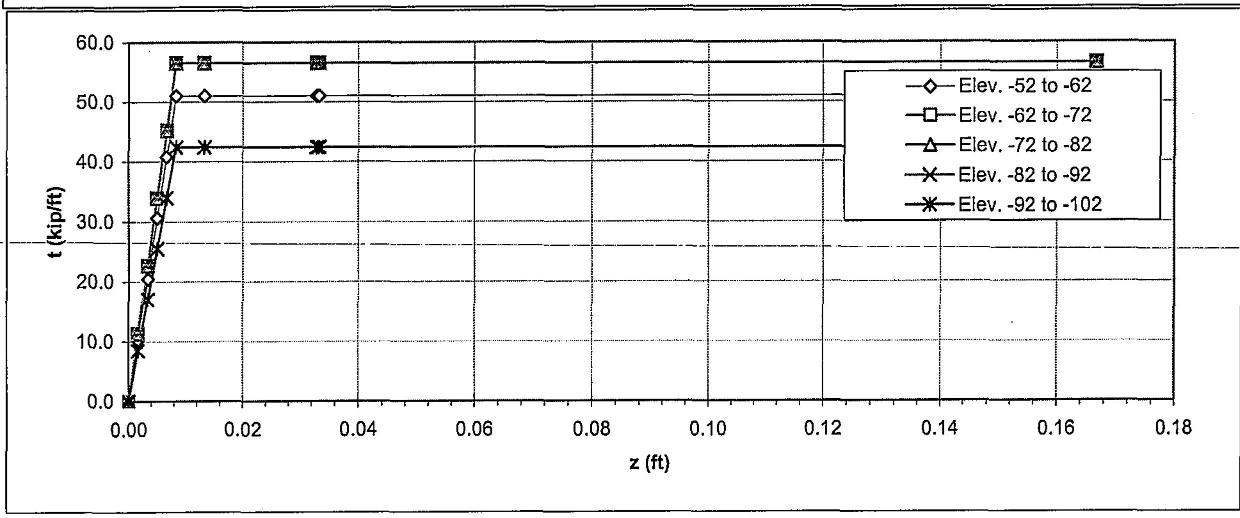
Pier 2 - No Degrdation

Sta.

O. G. Elev. 18.0 **Pile** 7.5' CISS
Cut off Elev. 18.0 **GWS** 50.0







*-Liquefiable layer

Feather River Bridge
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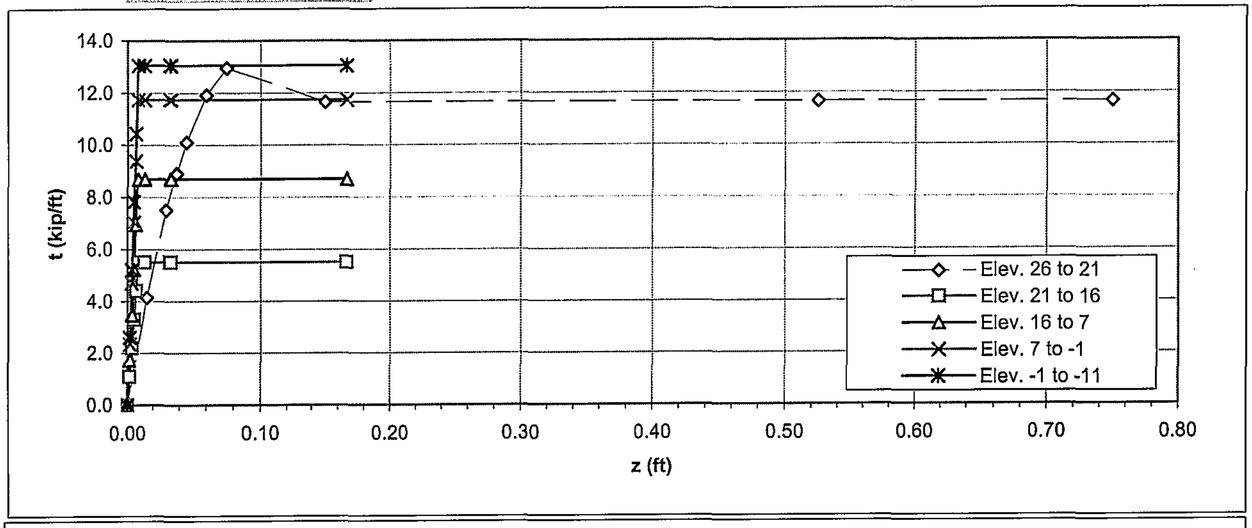
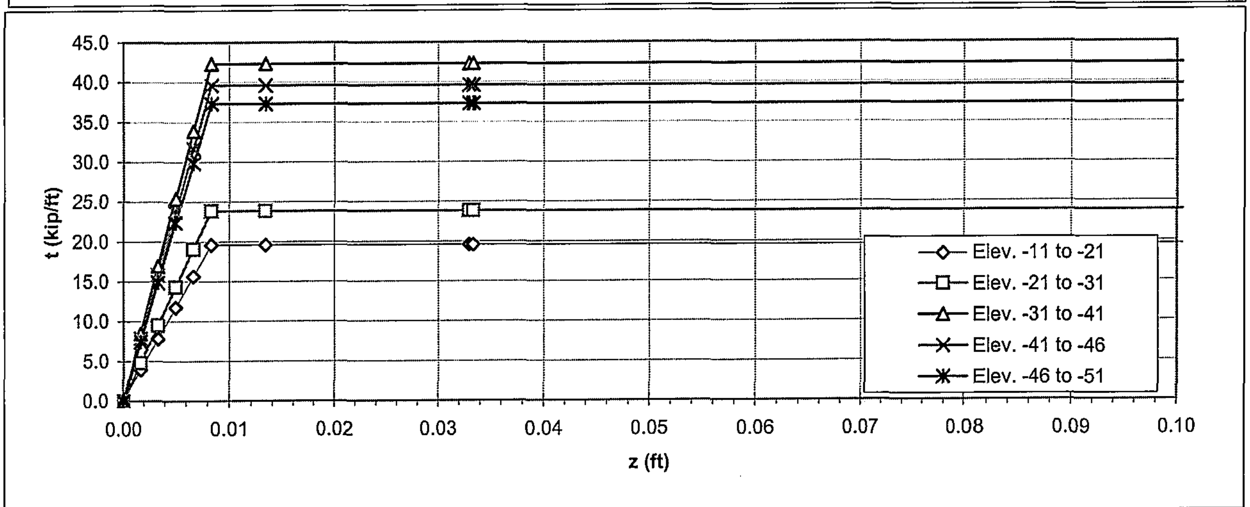
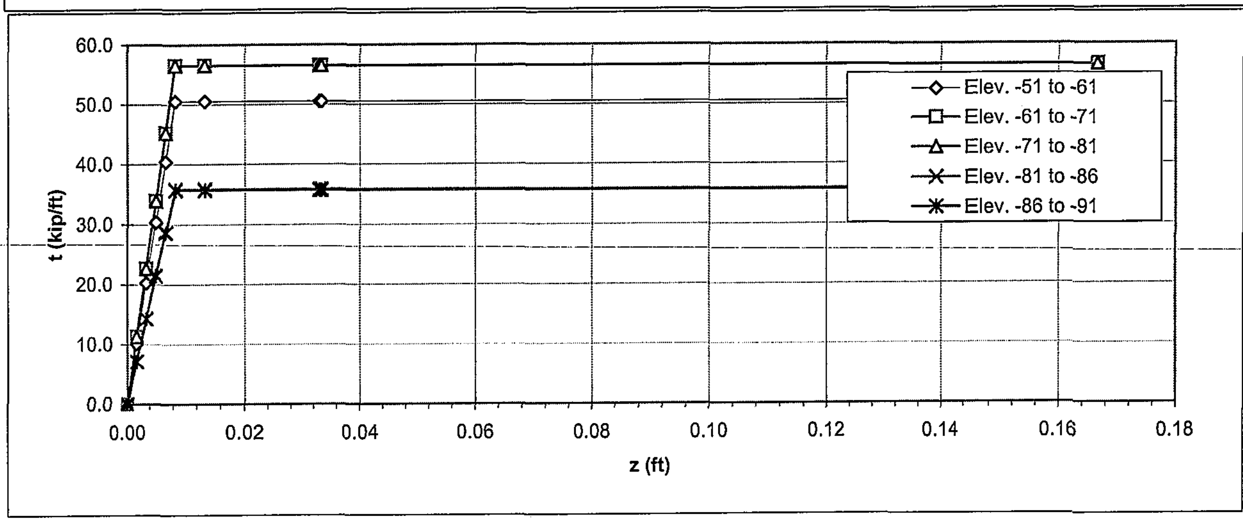
Pier 3 - No Degrdation

Sta.		**O. G. Elev.**	26.0	**Pile**	7.5' CISS
		Cut off Elev.	26.0	**GWS**	50.0







Feather River Bridge
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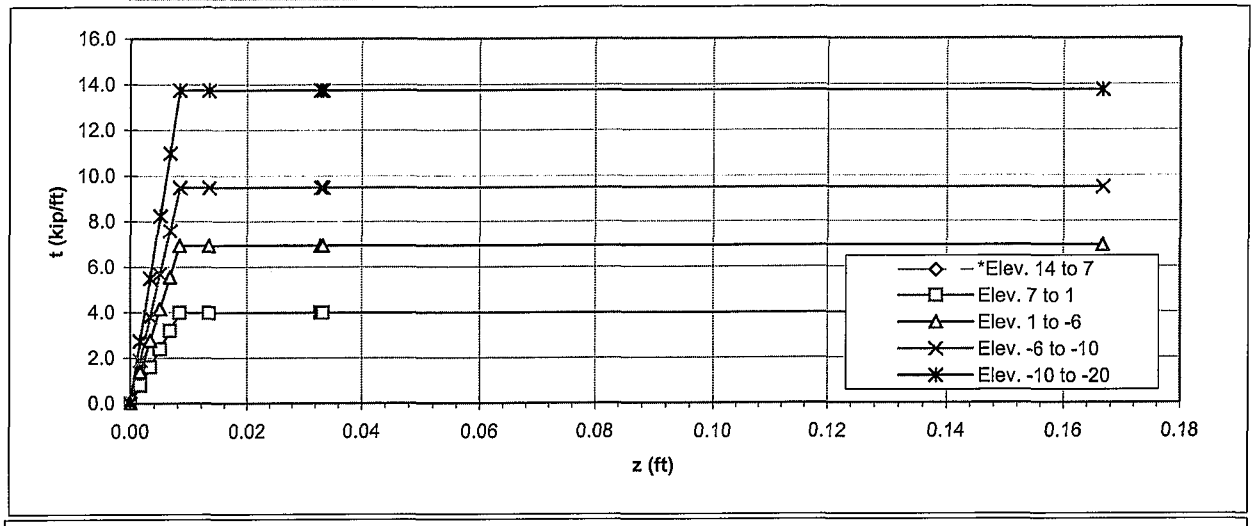
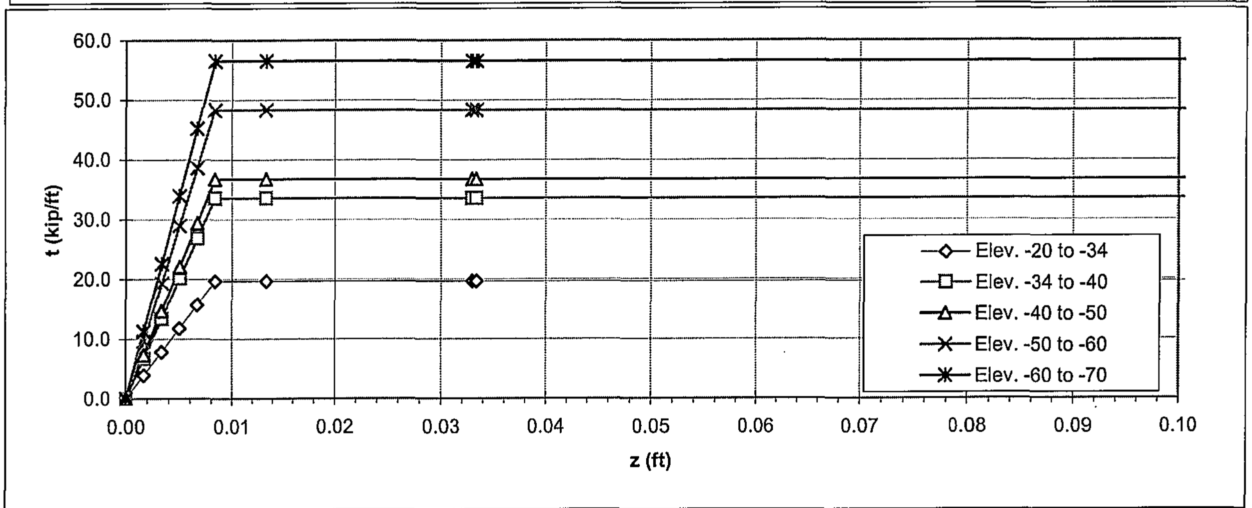
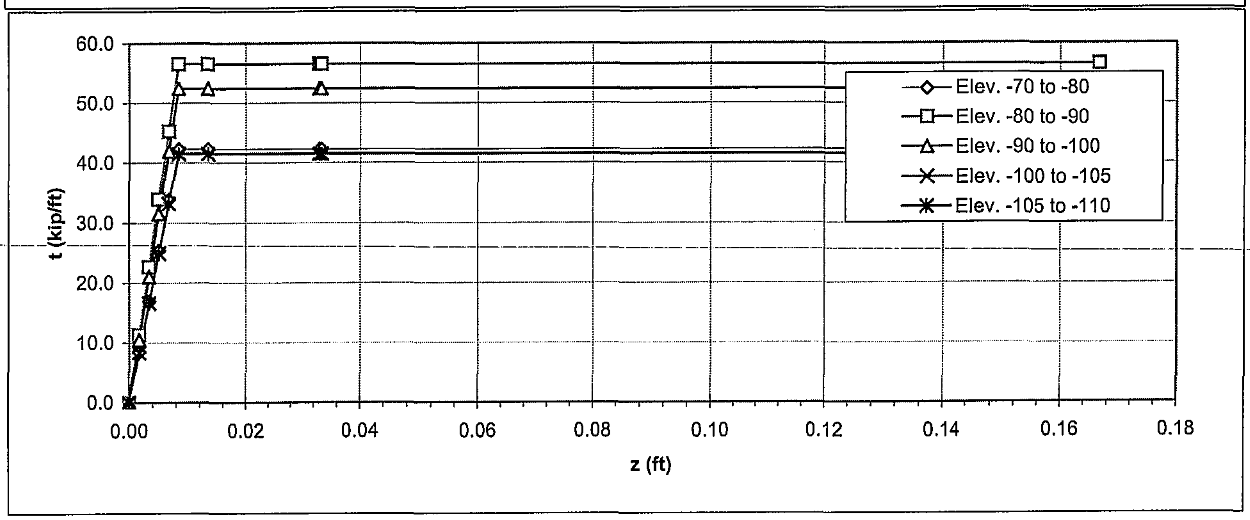
Pier 4 - No Degrdation

Sta.		**O. G. Elev.**	14.0	**Pile**	7.5' CISS
		Cut off Elev.	14.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
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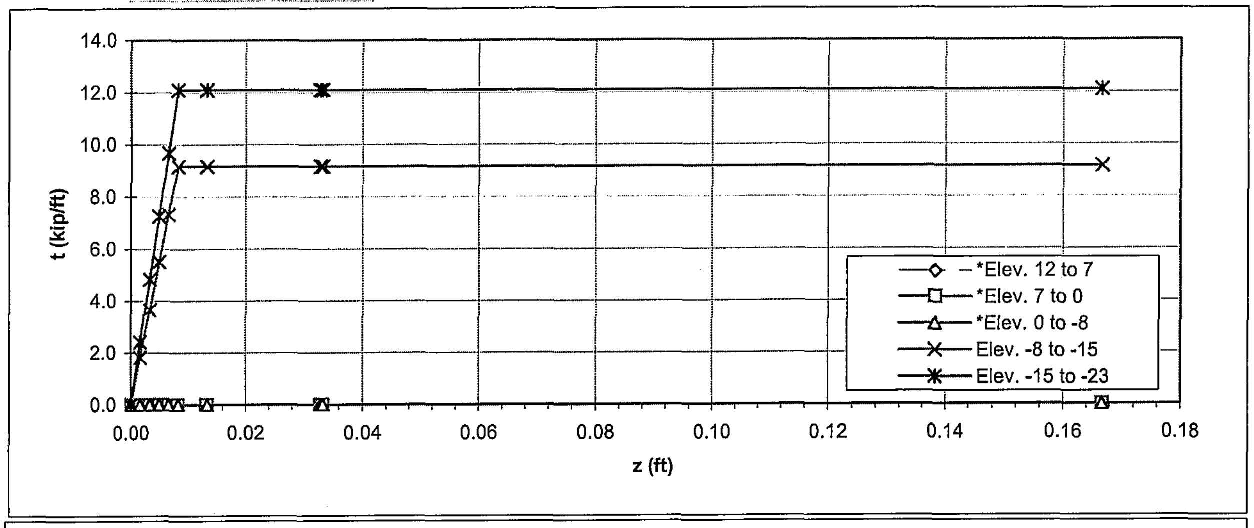
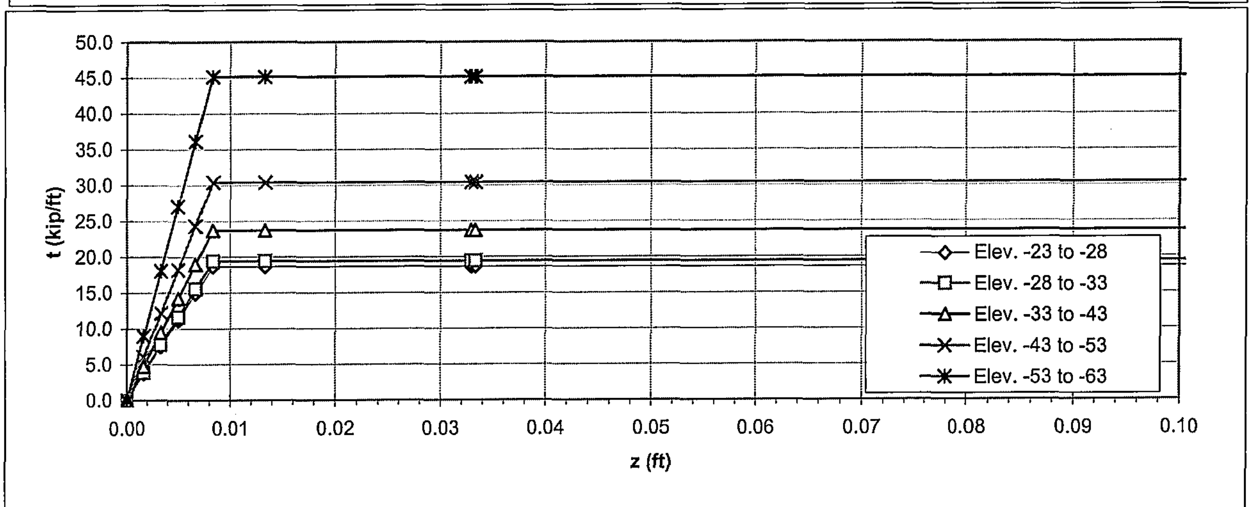
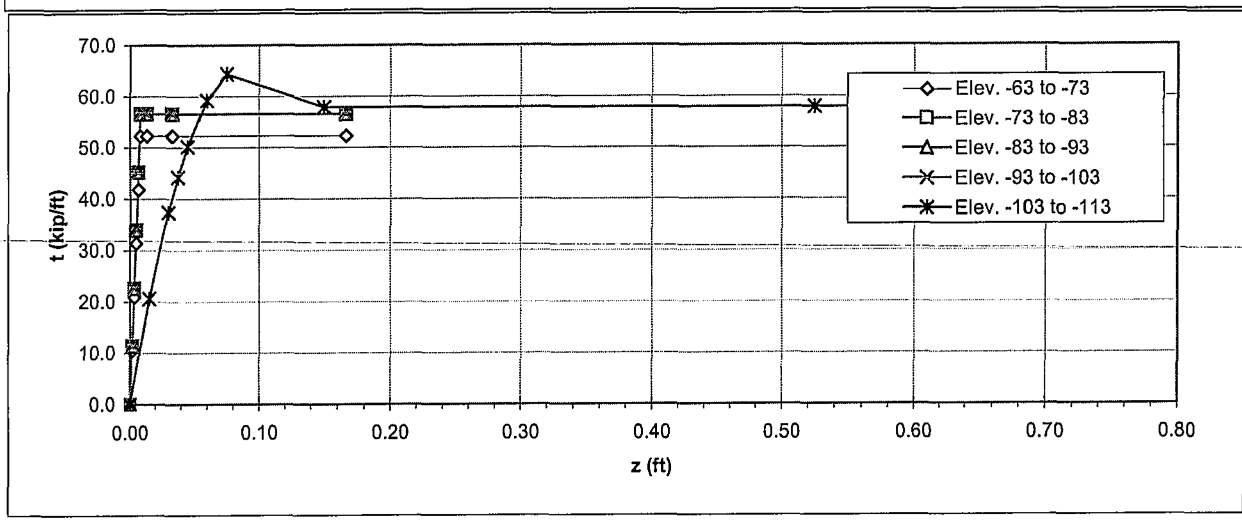
Pier 5 - No Degradation

Sta.		O. G. Elev.	12.0	Pile	7.5' CISS
		Cut off Elev.	12.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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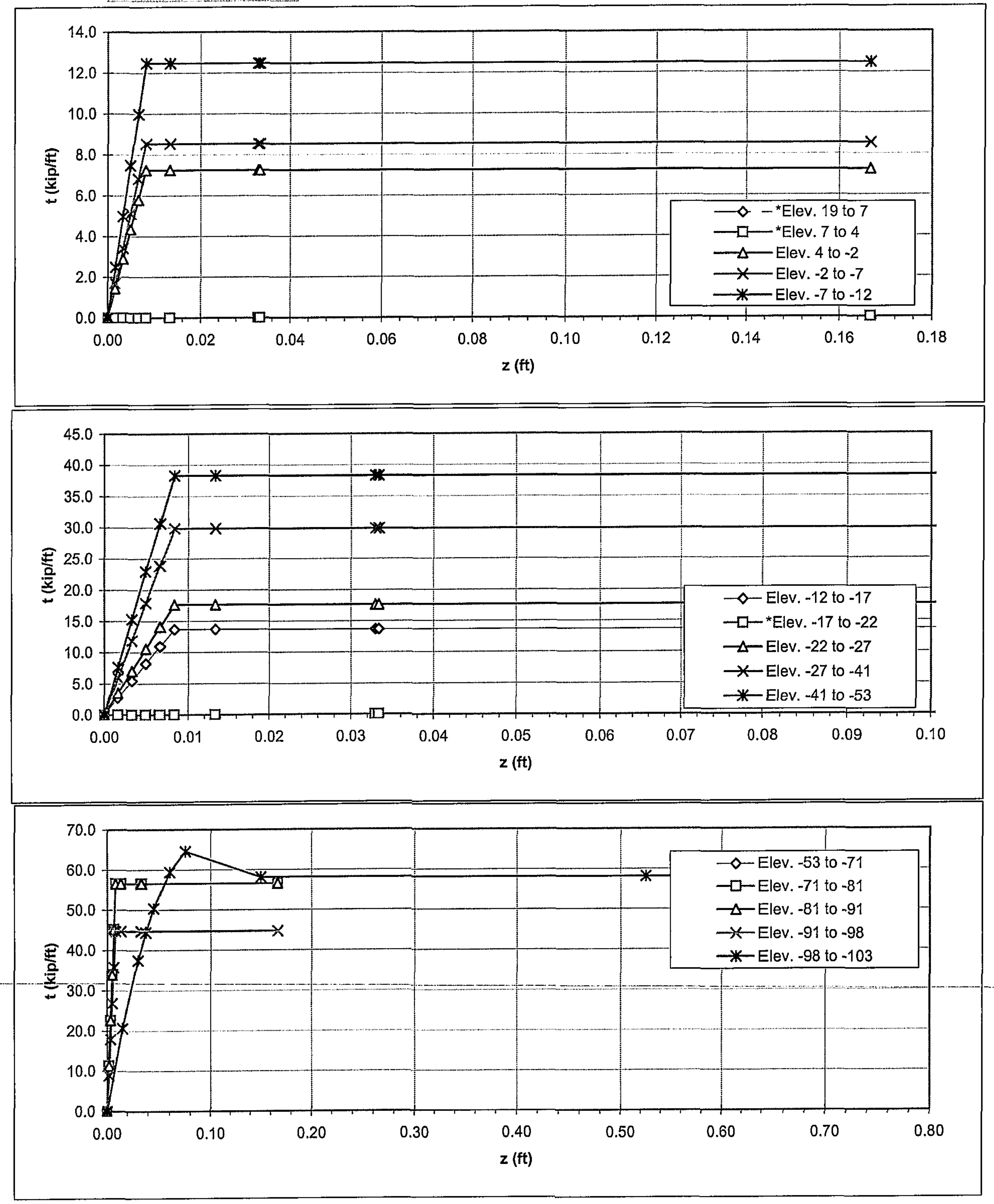
Pier 6 - No Degradation

Sta.			
O. G. Elev.	19.0	**Pile**	7.5' CISS
Cut off Elev.	19.0	**GWS**	50.0



*-Liquefiable layer

Feather River Bridge
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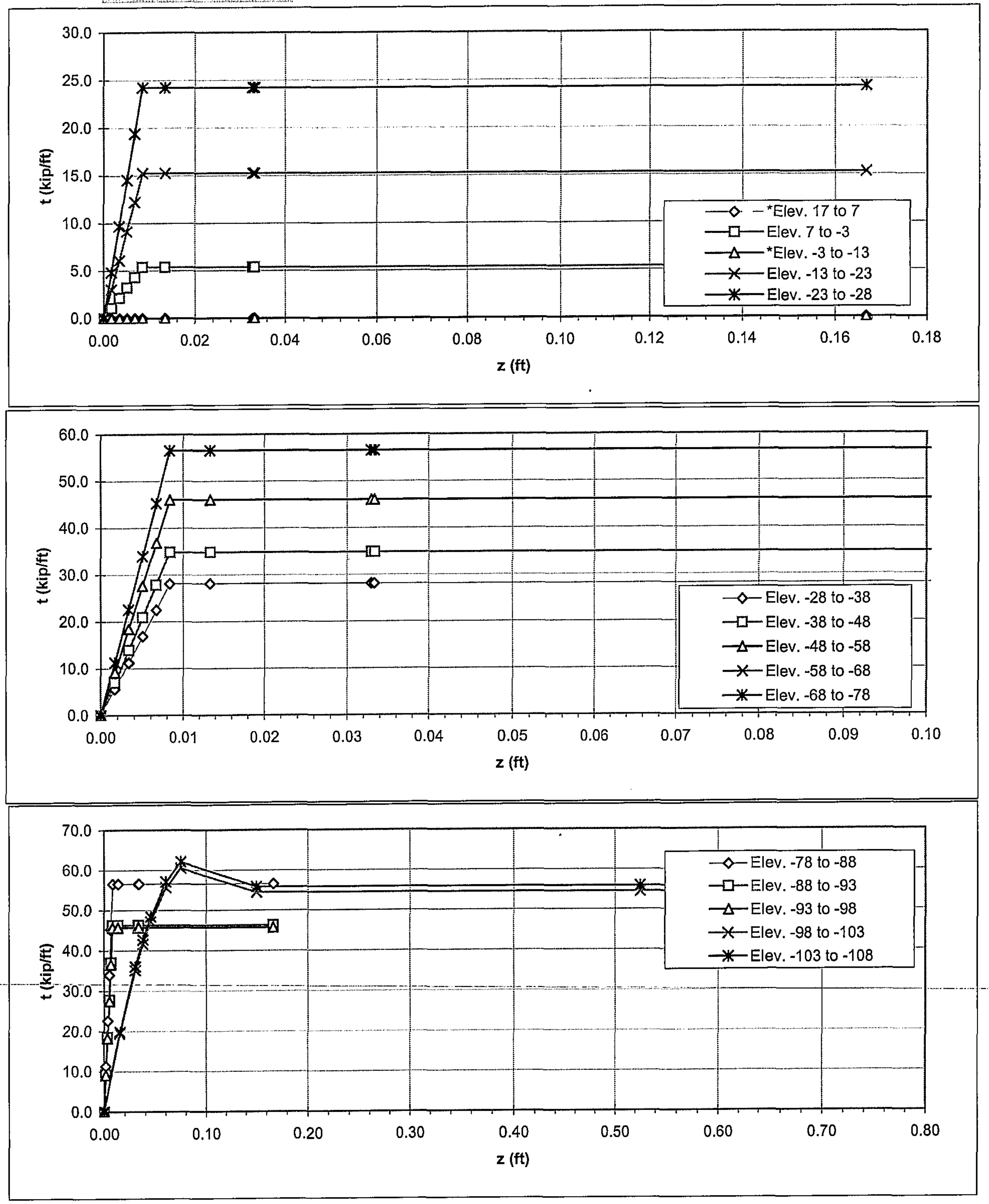
Pier 7 - No Degradation

Sta.		O. G. Elev.	17.0	Pile	7.5' CISS
		Cut off Elev.	17.0	GWS	50.0



*-Liquefiable layer

Feather River Bridge
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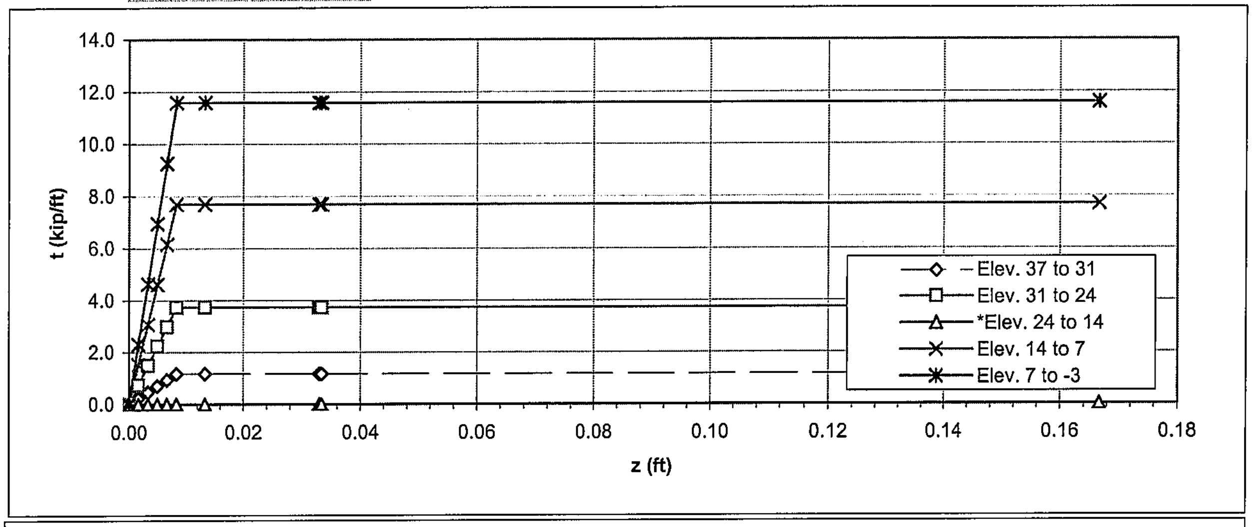
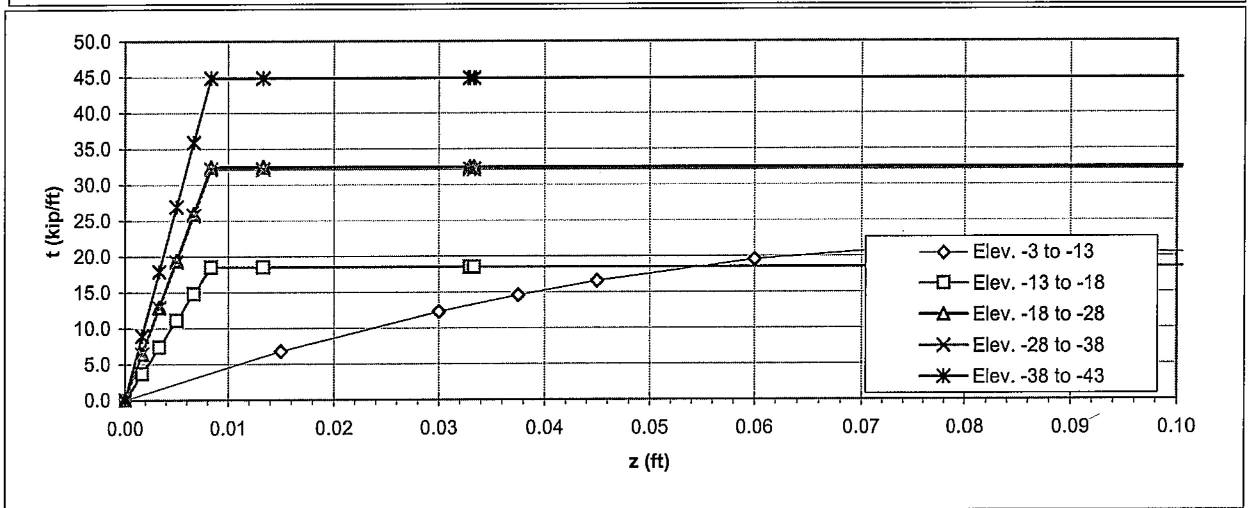
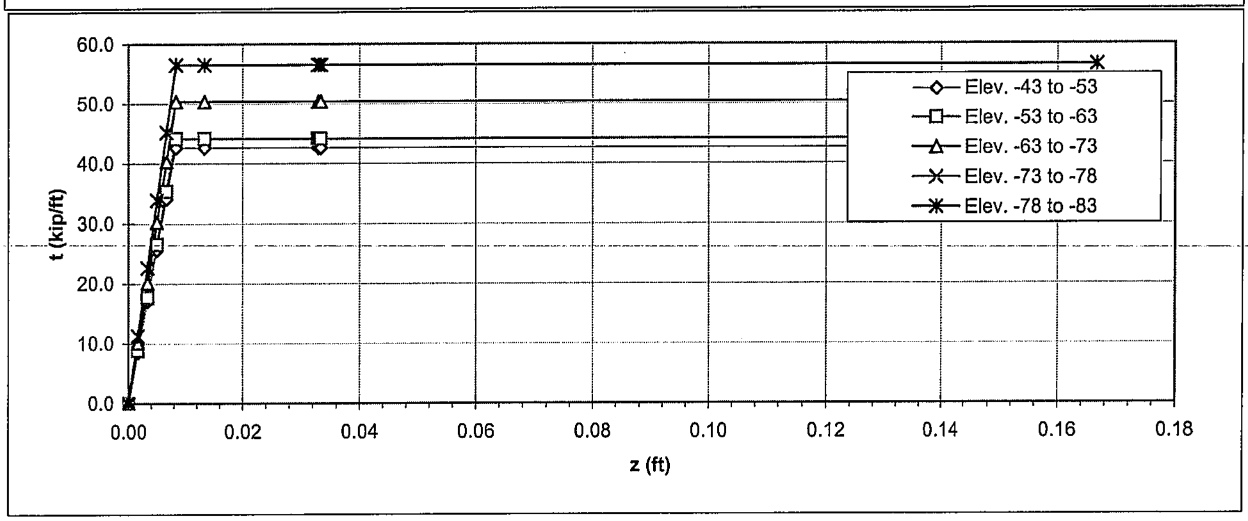
Pier 8 - No Degradation

Sta.

O. G. Elev.	37.0	Pile	7.5' CISS
Cut off Elev.	37.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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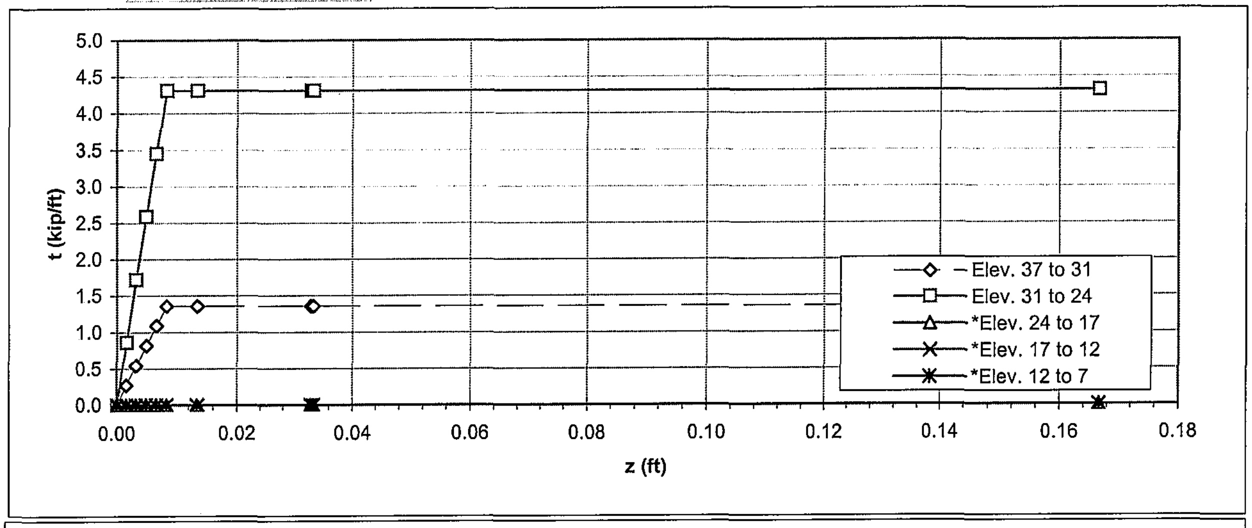
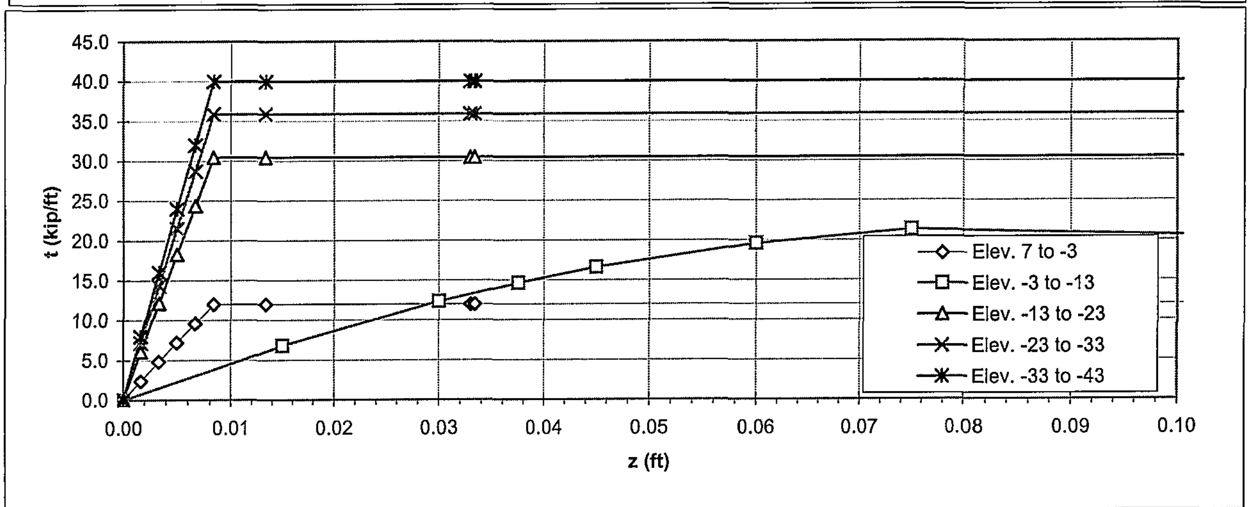
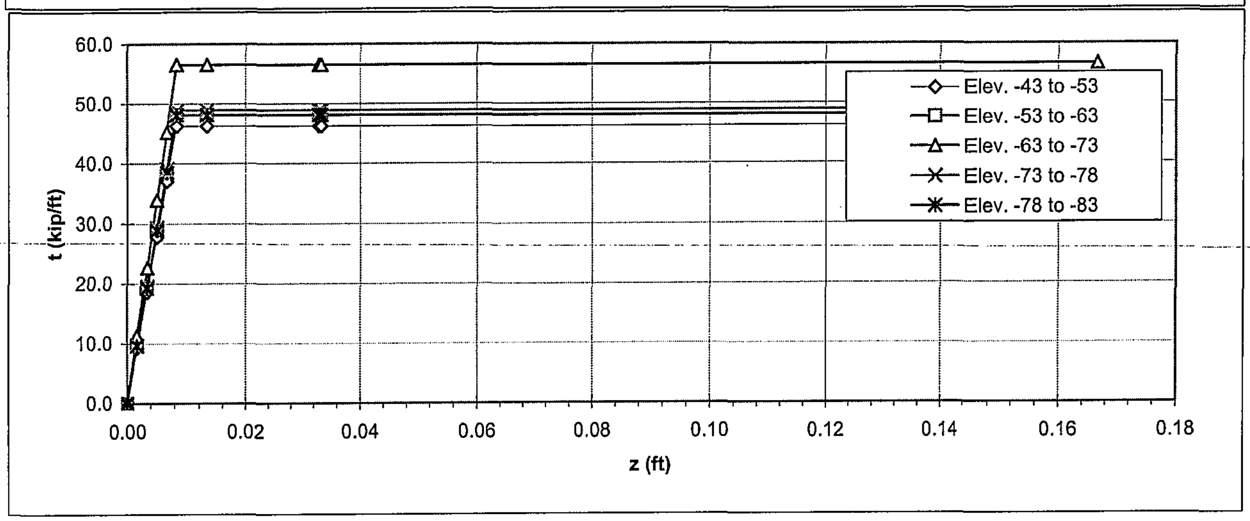
Pier 9 - No Degradation

Sta.		**O. G. Elev.**	37.0	**Pile**	7.5' CISS
		Cut off Elev.	37.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
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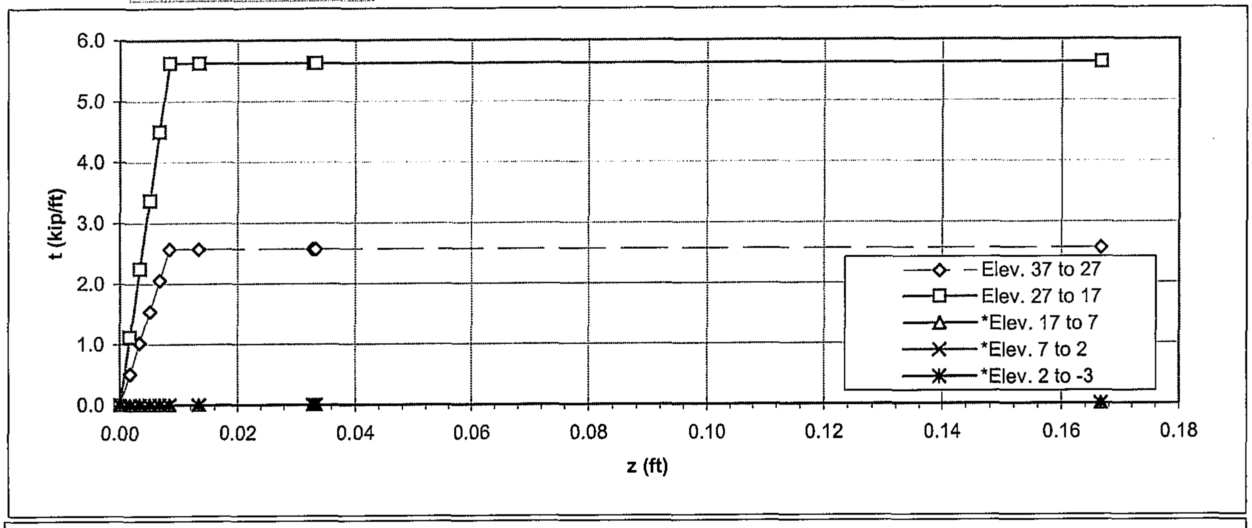
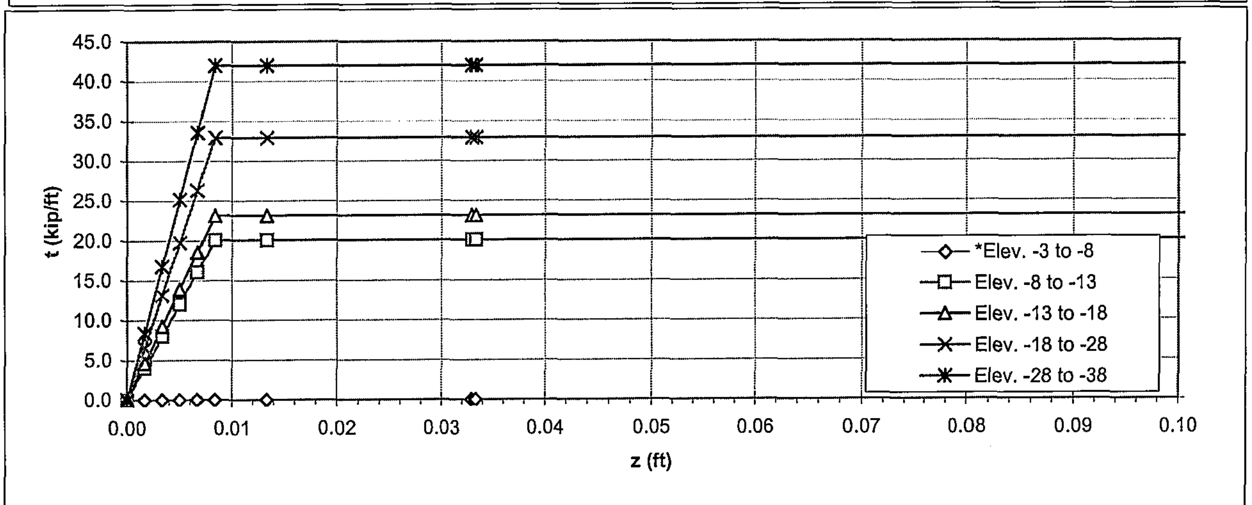
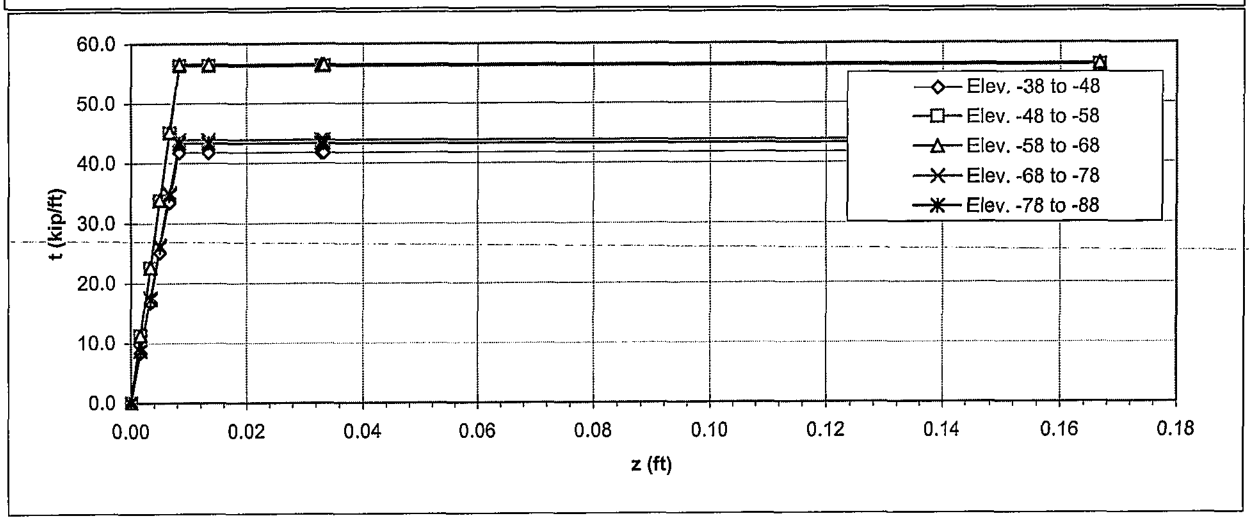
Pier 10 and 11 - No Degradation

Sta.		O. G. Elev.	37.0	Pile	7.5' CISS
		Cut off Elev.	37.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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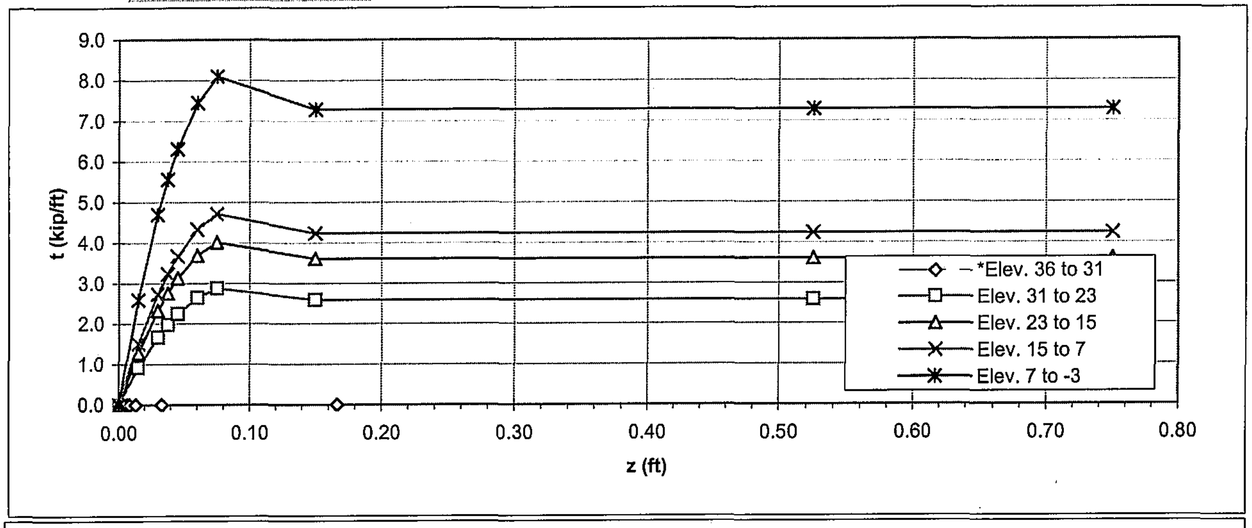
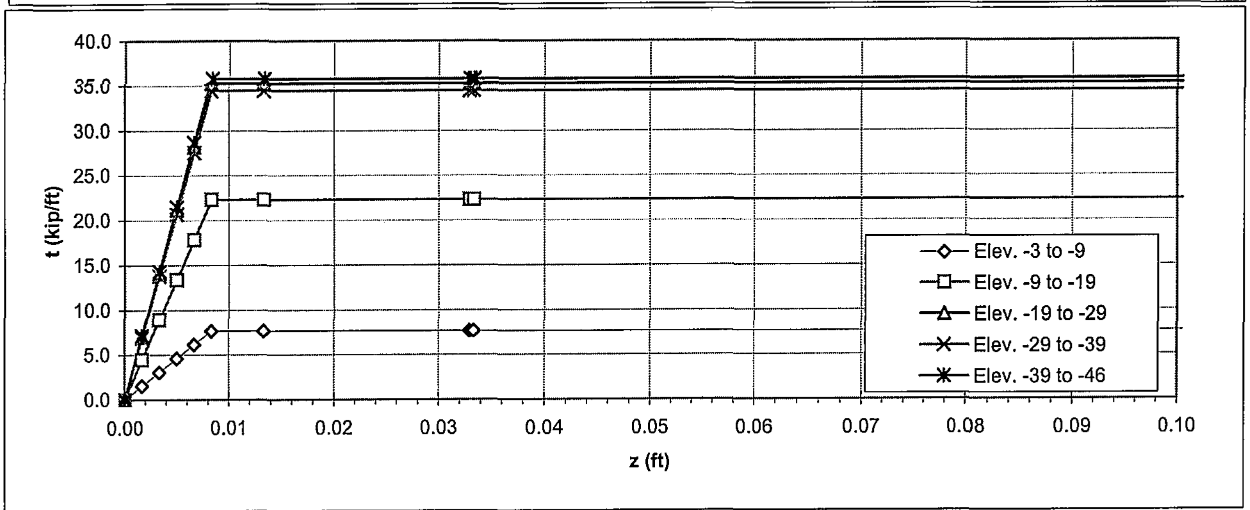
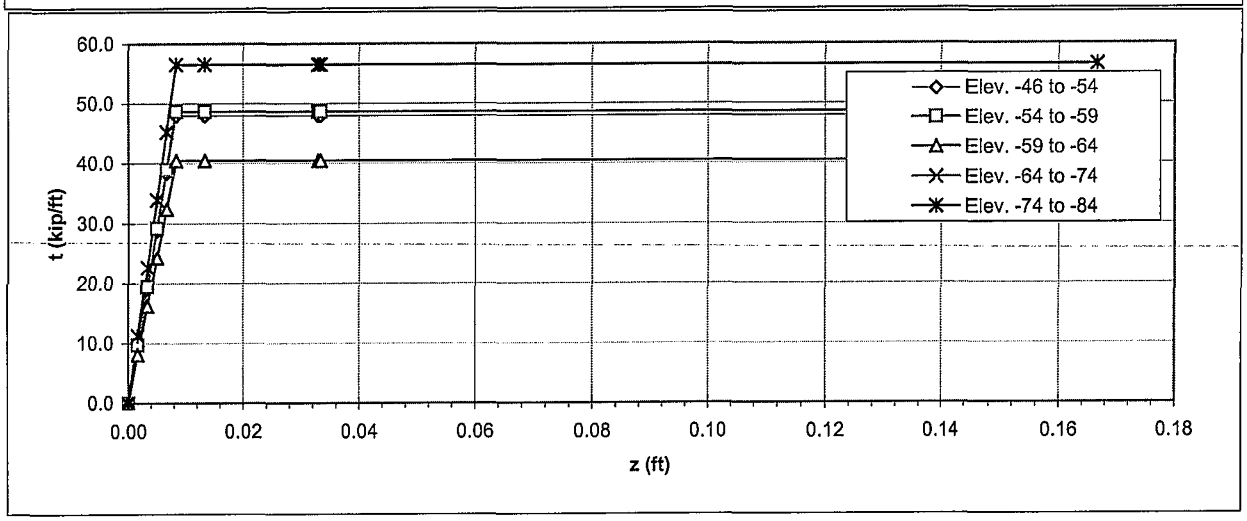
Pier 12 - No Degradation

Sta.		O. G. Elev.	36.0	Pile	7.5' CISS
		Cut off Elev.	36.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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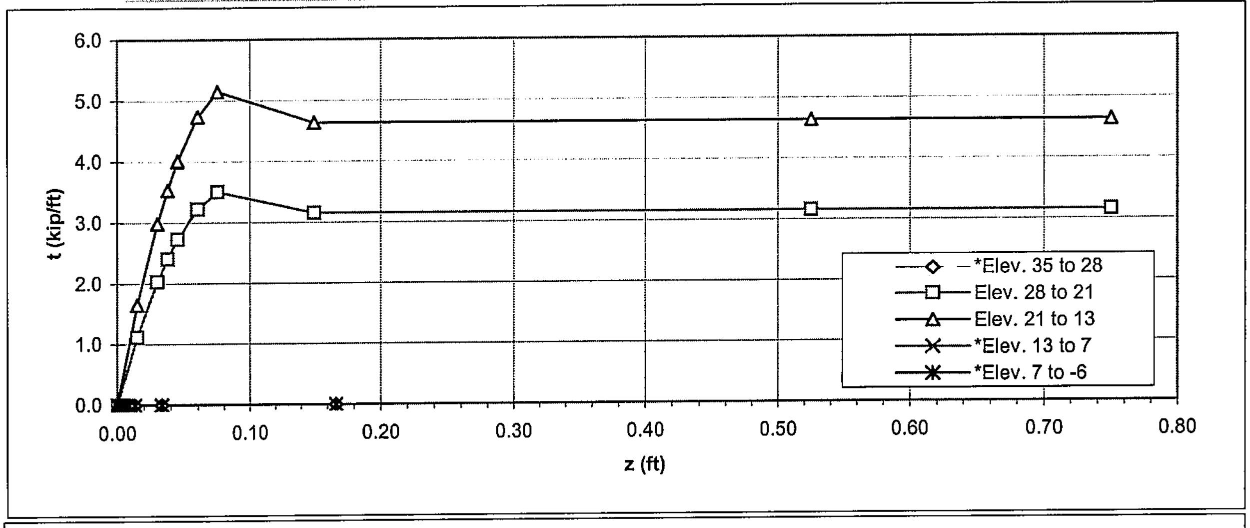
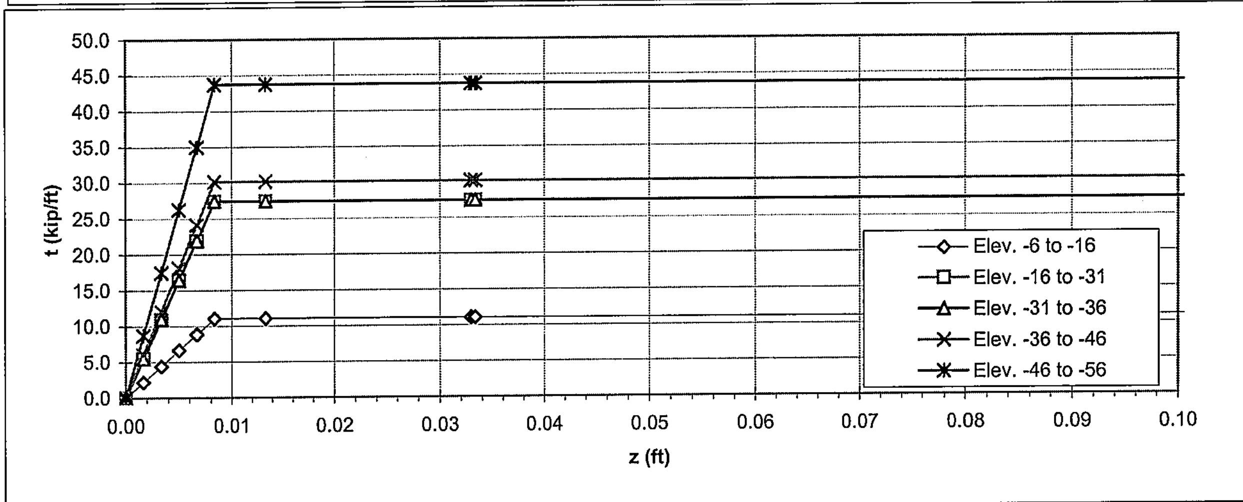
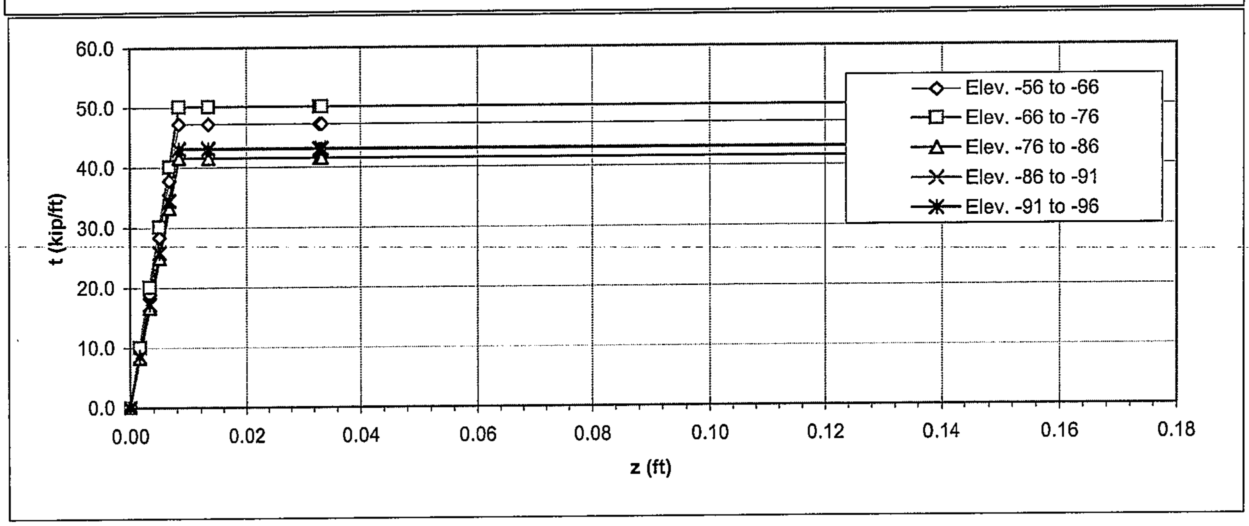
Pier 13 - No Degradation

Sta.

O. G. Elev.	35.0	Pile	7.5' CISS
Cut off Elev.	35.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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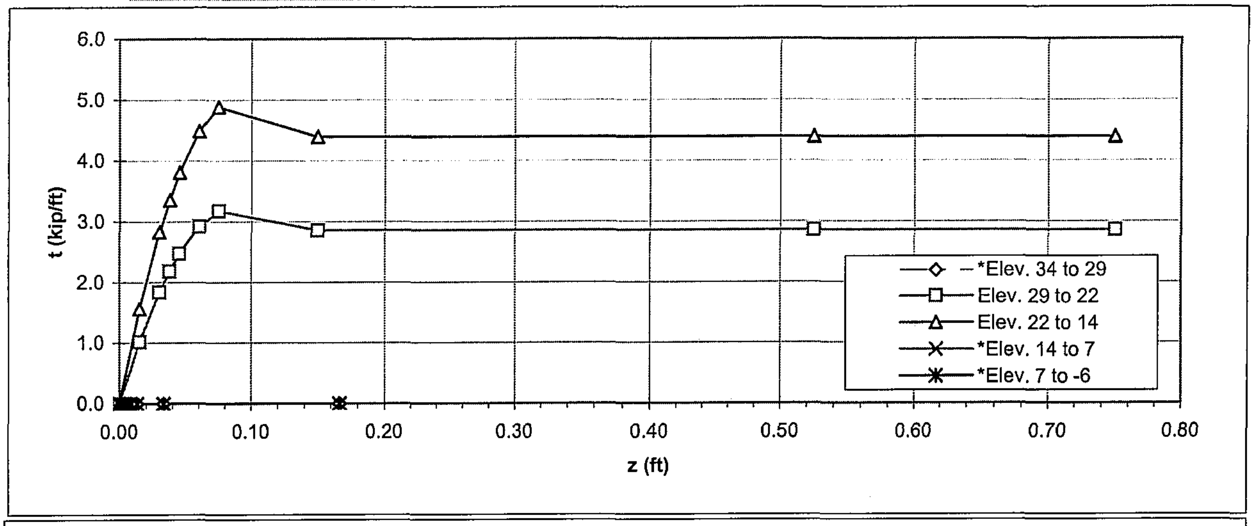
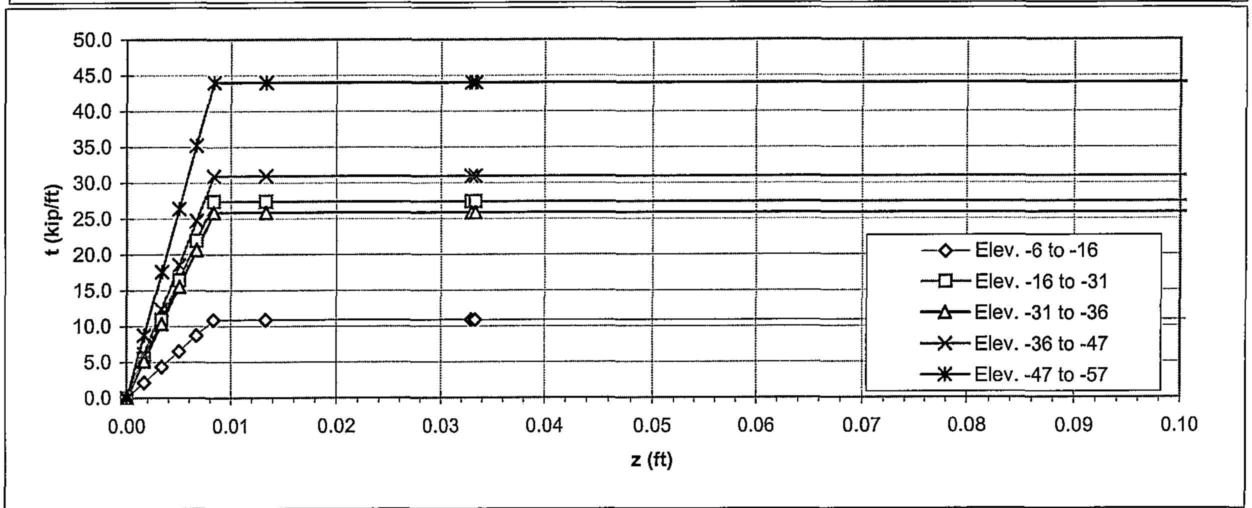
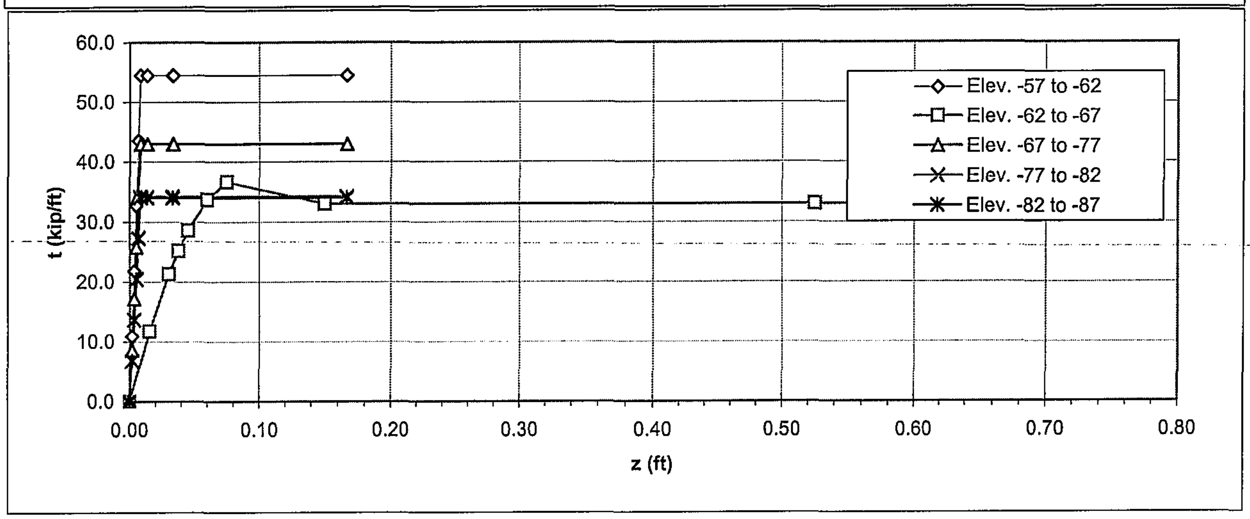
Pier 14 - No Degradation

Sta.		O. G. Elev.	34.0	Pile	7.5' CISS
		Cut off Elev.	34.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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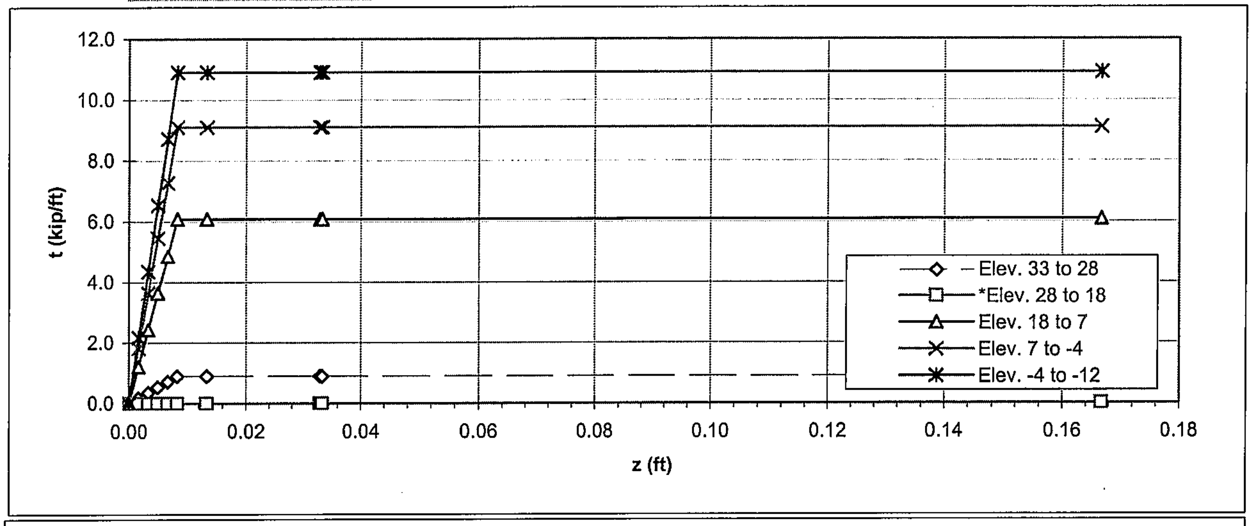
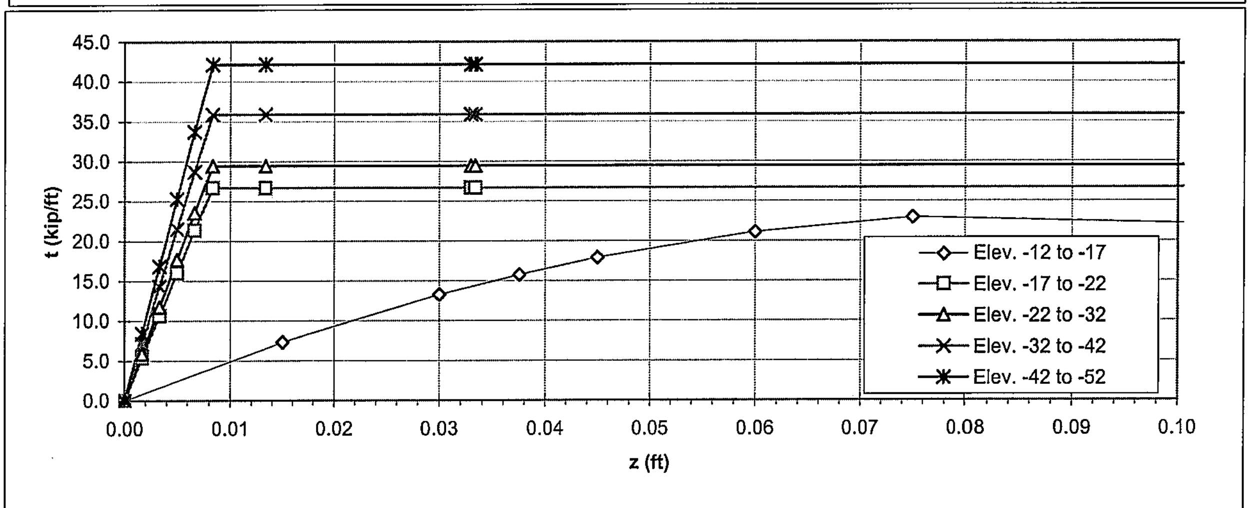
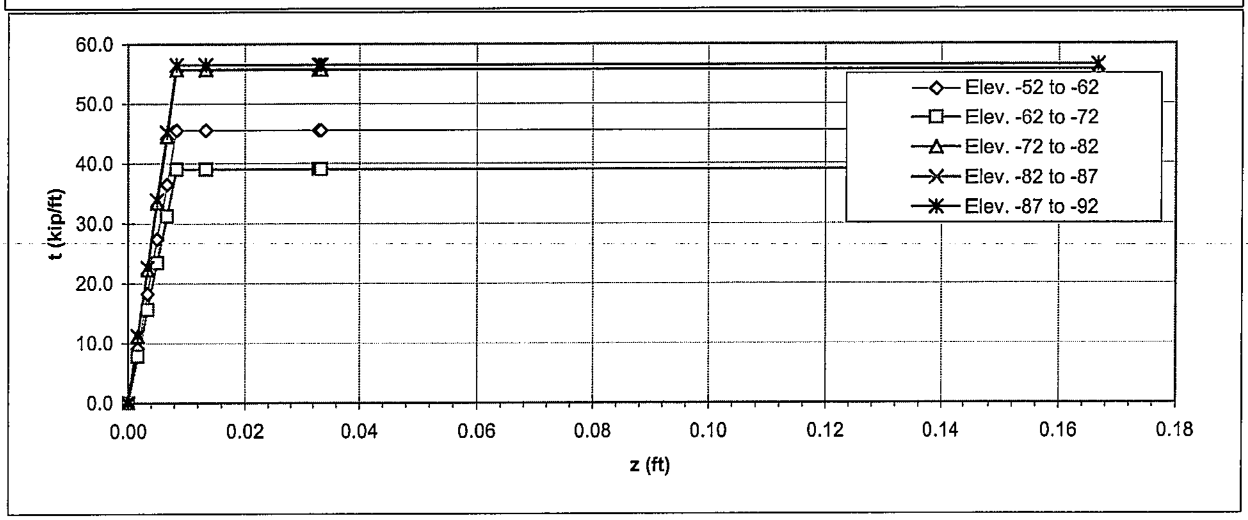
Pier 15 - No Degradation

Sta.

O. G. Elev.	33.0	**Pile**	7.5' CISS
Cut off Elev.	22.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
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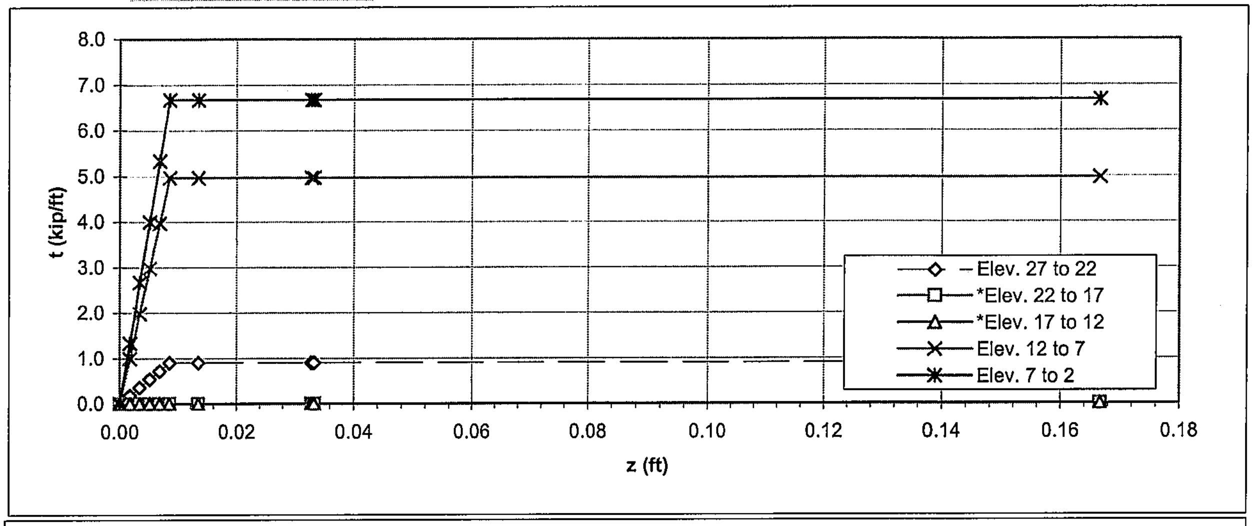
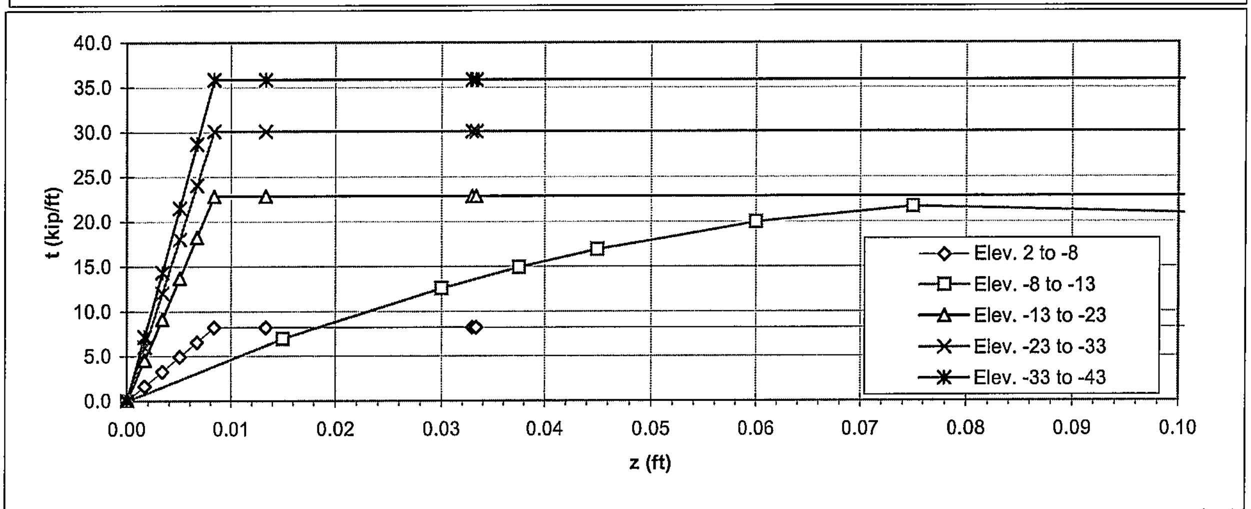
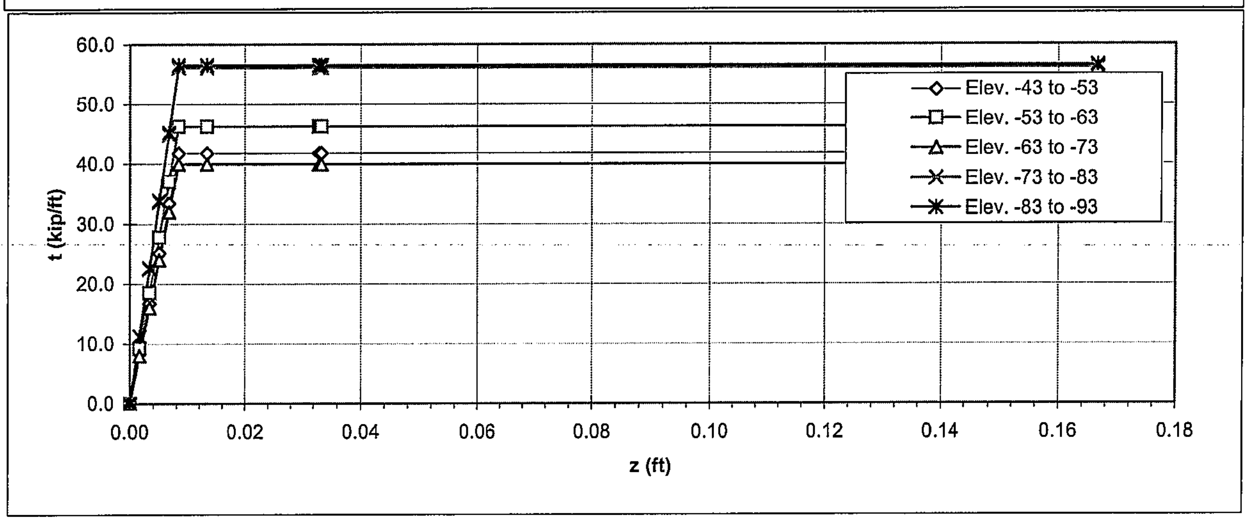
Pier 16 - No Degradation

Sta.

O. G. Elev.	27.0	Pile	7.5' CISS
Cut off Elev.	27.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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Pier 2 - No Degrdation

Sta.

O. G. Elev. 18.0 | Cut off Elev. 18.0 | Pile 7.5' CISS | GWS 50.0

z (ft)	*Elev. 18 to 11	z (ft)	*Elev. 11 to 7	z (ft)	*Elev. 7 to 2	z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -16
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.0	0.00	0.0	0.00	1.4	0.00	2.3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	2.9	0.00	4.6
0.01	0.0	0.01	0.0	0.01	0.0	0.01	4.3	0.01	6.9
0.01	0.0	0.01	0.0	0.01	0.0	0.01	5.8	0.01	9.2
0.01	0.0	0.01	0.0	0.01	0.0	0.01	7.2	0.01	11.5
0.01	0.0	0.01	0.0	0.01	0.0	0.01	7.2	0.01	11.5
0.03	0.0	0.03	0.0	0.03	0.0	0.03	7.2	0.03	11.5
0.03	0.0	0.03	0.0	0.03	0.0	0.03	7.2	0.03	11.5
0.17	0.0	0.17	0.0	0.17	0.0	0.17	7.2	0.17	11.5

z (ft)	Elev. -16 to -24	z (ft)	Elev. -24 to -30	z (ft)	Elev. -30 to -37	z (ft)	Elev. -37 to -42	z (ft)	Elev. -42 to -52
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.02	9.8	0.02	9.8	0.02	10.3	0.00	6.3	0.00	8.1
0.03	17.8	0.03	17.8	0.03	18.7	0.00	12.7	0.00	16.1
0.04	21.1	0.04	21.2	0.04	22.1	0.01	19.0	0.01	24.2
0.05	24.0	0.05	24.0	0.05	25.1	0.01	25.4	0.01	32.2
0.06	28.3	0.06	28.3	0.06	29.6	0.01	31.7	0.01	40.3
0.08	30.8	0.08	30.8	0.08	32.2	0.01	31.7	0.01	40.3
0.15	27.7	0.15	27.7	0.15	29.0	0.03	31.7	0.03	40.3
0.53	27.7	0.53	27.7	0.53	29.0	0.03	31.7	0.03	40.3
0.75	27.7	0.75	27.7	0.75	29.0	0.17	31.7	0.17	40.3

z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72	z (ft)	Elev. -72 to -82	z (ft)	Elev. -82 to -92	z (ft)	Elev. -92 to -102
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	10.2	0.00	11.3	0.00	11.3	0.00	11.3	0.00	8.5
0.00	20.4	0.00	22.6	0.00	22.6	0.00	22.6	0.00	17.0
0.01	30.6	0.01	33.9	0.01	33.9	0.01	33.9	0.01	25.5
0.01	40.8	0.01	45.2	0.01	45.2	0.01	45.2	0.01	34.0
0.01	51.0	0.01	56.5	0.01	56.5	0.01	56.5	0.01	42.5
0.01	51.0	0.01	56.5	0.01	56.5	0.01	56.5	0.01	42.5
0.03	51.0	0.03	56.5	0.03	56.5	0.03	56.5	0.03	42.5
0.03	51.0	0.03	56.5	0.03	56.5	0.03	56.5	0.03	42.5
0.17	51.0	0.17	56.5	0.17	56.5	0.17	56.5	0.17	42.5

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 3 - No Degrdation

Sta.

O. G. Elev. 26.0
Cut off Elev. 26.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 26 to 21	z (ft)	Elev. 21 to 16	z (ft)	Elev. 16 to 7	z (ft)	Elev. 7 to -1	z (ft)	Elev. -1 to -11
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.02	4.1	0.00	1.1	0.00	1.7	0.00	2.3	0.00	2.6
0.03	7.5	0.00	2.2	0.00	3.5	0.00	4.7	0.00	5.2
0.04	8.9	0.01	3.3	0.01	5.2	0.01	7.0	0.01	7.8
0.05	10.1	0.01	4.4	0.01	7.0	0.01	9.4	0.01	10.4
0.06	11.9	0.01	5.5	0.01	8.7	0.01	11.7	0.01	13.1
0.08	12.9	0.01	5.5	0.01	8.7	0.01	11.7	0.01	13.1
0.15	11.7	0.03	5.5	0.03	8.7	0.03	11.7	0.03	13.1
0.53	11.7	0.03	5.5	0.03	8.7	0.03	11.7	0.03	13.1
0.75	11.7	0.17	5.5	0.17	8.7	0.17	11.7	0.17	13.1

z (ft)	Elev. -11 to -21	z (ft)	Elev. -21 to -31	z (ft)	Elev. -31 to -41	z (ft)	Elev. -41 to -46	z (ft)	Elev. -46 to -51
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	3.9	0.00	4.8	0.00	8.5	0.00	7.9	0.00	7.5
0.00	7.8	0.00	9.5	0.00	16.9	0.00	15.8	0.00	14.9
0.01	11.7	0.01	14.3	0.01	25.4	0.01	23.8	0.01	22.4
0.01	15.7	0.01	19.1	0.01	33.9	0.01	31.7	0.01	29.8
0.01	19.6	0.01	23.8	0.01	42.3	0.01	39.6	0.01	37.3
0.01	19.6	0.01	23.8	0.01	42.3	0.01	39.6	0.01	37.3
0.03	19.6	0.03	23.8	0.03	42.3	0.03	39.6	0.03	37.3
0.03	19.6	0.03	23.8	0.03	42.3	0.03	39.6	0.03	37.3
0.17	19.6	0.17	23.8	0.17	42.3	0.17	39.6	0.17	37.3

z (ft)	Elev. -51 to -61	z (ft)	Elev. -61 to -71	z (ft)	Elev. -71 to -81	z (ft)	Elev. -81 to -86	z (ft)	Elev. -86 to -91
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	10.1	0.00	11.3	0.00	11.3	0.00	7.2	0.00	7.1
0.00	20.2	0.00	22.6	0.00	22.6	0.00	14.4	0.00	14.3
0.01	30.3	0.01	33.9	0.01	33.9	0.01	21.5	0.01	21.4
0.01	40.5	0.01	45.2	0.01	45.2	0.01	28.7	0.01	28.6
0.01	50.6	0.01	56.5	0.01	56.5	0.01	35.9	0.01	35.7
0.01	50.6	0.01	56.5	0.01	56.5	0.01	35.9	0.01	35.7
0.03	50.6	0.03	56.5	0.03	56.5	0.03	35.9	0.03	35.7
0.03	50.6	0.03	56.5	0.03	56.5	0.03	35.9	0.03	35.7
0.17	50.6	0.17	56.5	0.17	56.5	0.17	35.9	0.17	35.7

Note - t (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - No Degrdation

Sta.

O. G. Elev.	14.0	Pile	7.5' CISS
Cut off Elev.	14.0	GWS	50.0

z (ft)	*Elev. 14 to 7	z (ft)	Elev. 7 to 1	z (ft)	Elev. 1 to -6	z (ft)	Elev. -6 to -10	z (ft)	Elev. -10 to -20
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.8	0.00	1.4	0.00	1.9	0.00	2.7
0.00	0.0	0.00	1.6	0.00	2.8	0.00	3.8	0.00	5.5
0.00	0.0	0.01	2.4	0.01	4.2	0.01	5.7	0.01	8.2
0.00	0.0	0.01	3.2	0.01	5.5	0.01	7.6	0.01	11.0
0.00	0.0	0.01	4.0	0.01	6.9	0.01	9.5	0.01	13.7
0.00	0.0	0.01	4.0	0.01	6.9	0.01	9.5	0.01	13.7
0.00	0.0	0.03	4.0	0.03	6.9	0.03	9.5	0.03	13.7
0.00	0.0	0.03	4.0	0.03	6.9	0.03	9.5	0.03	13.7
0.00	0.0	0.17	4.0	0.17	6.9	0.17	9.5	0.17	13.7

z (ft)	Elev. -20 to -34	z (ft)	Elev. -34 to -40	z (ft)	Elev. -40 to -50	z (ft)	Elev. -50 to -60	z (ft)	Elev. -60 to -70
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	3.9	0.00	6.7	0.00	7.3	0.00	9.7	0.00	11.3
0.00	7.9	0.00	13.4	0.00	14.7	0.00	19.3	0.00	22.6
0.01	11.8	0.01	20.1	0.01	22.0	0.01	29.0	0.01	33.9
0.01	15.7	0.01	26.9	0.01	29.4	0.01	38.6	0.01	45.2
0.01	19.7	0.01	33.6	0.01	36.7	0.01	48.3	0.01	56.5
0.01	19.7	0.01	33.6	0.01	36.7	0.01	48.3	0.01	56.5
0.03	19.7	0.03	33.6	0.03	36.7	0.03	48.3	0.03	56.5
0.03	19.7	0.03	33.6	0.03	36.7	0.03	48.3	0.03	56.5
0.17	19.7	0.17	33.6	0.17	36.7	0.17	48.3	0.17	56.5

z (ft)	Elev. -70 to -80	z (ft)	Elev. -80 to -90	z (ft)	Elev. -90 to -100	z (ft)	Elev. -100 to -105	z (ft)	Elev. -105 to -110
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	8.5	0.00	11.3	0.00	10.5	0.00	8.3	0.00	8.3
0.00	16.9	0.00	22.6	0.00	21.0	0.00	16.6	0.00	16.6
0.01	25.4	0.01	33.9	0.01	31.5	0.01	25.0	0.01	24.9
0.01	33.8	0.01	45.2	0.01	42.0	0.01	33.3	0.01	33.2
0.01	42.3	0.01	56.5	0.01	52.5	0.01	41.6	0.01	41.5
0.01	42.3	0.01	56.5	0.01	52.5	0.01	41.6	0.01	41.5
0.03	42.3	0.03	56.5	0.03	52.5	0.03	41.6	0.03	41.5
0.03	42.3	0.03	56.5	0.03	52.5	0.03	41.6	0.03	41.5
0.17	42.3	0.17	56.5	0.17	52.5	0.17	41.6	0.17	41.5

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 5 - No Degradation

Sta.

O. G. Elev. 12.0
Cut off Elev. 12.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 12 to 7	z (ft)	*Elev. 7 to 0	z (ft)	*Elev. 0 to -8	z (ft)	Elev. -8 to -15	z (ft)	Elev. -15 to -23
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.0	0.00	0.0	0.00	1.8	0.00	2.4
0.00	0.0	0.00	0.0	0.00	0.0	0.00	3.7	0.00	4.8
0.01	0.0	0.01	0.0	0.01	0.0	0.01	5.5	0.01	7.3
0.01	0.0	0.01	0.0	0.01	0.0	0.01	7.3	0.01	9.7
0.01	0.0	0.01	0.0	0.01	0.0	0.01	9.2	0.01	12.1
0.01	0.0	0.01	0.0	0.01	0.0	0.01	9.2	0.01	12.1
0.03	0.0	0.03	0.0	0.03	0.0	0.03	9.2	0.03	12.1
0.03	0.0	0.03	0.0	0.03	0.0	0.03	9.2	0.03	12.1
0.17	0.0	0.17	0.0	0.17	0.0	0.17	9.2	0.17	12.1

z (ft)	Elev. -23 to -28	z (ft)	Elev. -28 to -33	z (ft)	Elev. -33 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	3.7	0.00	3.9	0.00	4.7	0.00	6.1	0.00	9.0
0.00	7.5	0.00	7.8	0.00	9.5	0.00	12.2	0.00	18.1
0.01	11.2	0.01	11.6	0.01	14.2	0.01	18.2	0.01	27.1
0.01	14.9	0.01	15.5	0.01	19.0	0.01	24.3	0.01	36.1
0.01	18.6	0.01	19.4	0.01	23.7	0.01	30.4	0.01	45.1
0.01	18.6	0.01	19.4	0.01	23.7	0.01	30.4	0.01	45.1
0.03	18.6	0.03	19.4	0.03	23.7	0.03	30.4	0.03	45.1
0.03	18.6	0.03	19.4	0.03	23.7	0.03	30.4	0.03	45.1
0.17	18.6	0.17	19.4	0.17	23.7	0.17	30.4	0.17	45.1

z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -83	z (ft)	Elev. -83 to -93	z (ft)	Elev. -93 to -103	z (ft)	Elev. -103 to -113
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	10.5	0.00	11.3	0.00	11.3	0.00	11.3	0.02	20.6
0.00	20.9	0.00	22.6	0.00	22.6	0.00	22.6	0.03	37.3
0.01	31.4	0.01	33.9	0.01	33.9	0.01	33.9	0.04	44.3
0.01	41.8	0.01	45.2	0.01	45.2	0.01	45.2	0.05	50.2
0.01	52.3	0.01	56.5	0.01	56.5	0.01	56.5	0.06	59.2
0.01	52.3	0.01	56.5	0.01	56.5	0.01	56.5	0.08	64.4
0.03	52.3	0.03	56.5	0.03	56.5	0.03	56.5	0.15	57.9
0.03	52.3	0.03	56.5	0.03	56.5	0.03	56.5	0.53	57.9
0.17	52.3	0.17	56.5	0.17	56.5	0.17	56.5	0.75	57.9

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - No Degradation

Sta.

O. G. Elev. 19.0
Cut off Elev. 19.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 19 to 7	z (ft)	*Elev. 7 to 4	z (ft)	Elev. 4 to -2	z (ft)	Elev. -2 to -7	z (ft)	Elev. -7 to -12
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.0	0.00	1.4	0.00	1.7	0.00	2.5
0.00	0.0	0.00	0.0	0.00	2.9	0.00	3.4	0.00	5.0
0.01	0.0	0.01	0.0	0.01	4.3	0.01	5.1	0.01	7.5
0.01	0.0	0.01	0.0	0.01	5.8	0.01	6.8	0.01	10.0
0.01	0.0	0.01	0.0	0.01	7.2	0.01	8.5	0.01	12.5
0.01	0.0	0.01	0.0	0.01	7.2	0.01	8.5	0.01	12.5
0.03	0.0	0.03	0.0	0.03	7.2	0.03	8.5	0.03	12.5
0.03	0.0	0.03	0.0	0.03	7.2	0.03	8.5	0.03	12.5
0.17	0.0	0.17	0.0	0.17	7.2	0.17	8.5	0.17	12.5

z (ft)	Elev. -12 to -17	z (ft)	*Elev. -17 to -22	z (ft)	Elev. -22 to -27	z (ft)	Elev. -27 to -41	z (ft)	Elev. -41 to -53
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	2.7	0.00	0.0	0.00	3.5	0.00	6.0	0.00	7.7
0.00	5.5	0.00	0.0	0.00	7.1	0.00	11.9	0.00	15.3
0.01	8.2	0.01	0.0	0.01	10.6	0.01	17.9	0.01	23.0
0.01	11.0	0.01	0.0	0.01	14.1	0.01	23.9	0.01	30.6
0.01	13.7	0.01	0.0	0.01	17.6	0.01	29.8	0.01	38.3
0.01	13.7	0.01	0.0	0.01	17.6	0.01	29.8	0.01	38.3
0.03	13.7	0.03	0.0	0.03	17.6	0.03	29.8	0.03	38.3
0.03	13.7	0.03	0.0	0.03	17.6	0.03	29.8	0.03	38.3
0.17	13.7	0.17	0.0	0.17	17.6	0.17	29.8	0.17	38.3

z (ft)	Elev. -53 to -71	z (ft)	Elev. -71 to -81	z (ft)	Elev. -81 to -91	z (ft)	Elev. -91 to -98	z (ft)	Elev. -98 to -103
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	11.3	0.00	11.3	0.00	11.3	0.00	8.9	0.02	20.7
0.00	22.6	0.00	22.6	0.00	22.6	0.00	17.9	0.03	37.5
0.01	33.9	0.01	33.9	0.01	33.9	0.01	26.8	0.04	44.4
0.01	45.2	0.01	45.2	0.01	45.2	0.01	35.8	0.05	50.4
0.01	56.5	0.01	56.5	0.01	56.5	0.01	44.7	0.06	59.4
0.01	56.5	0.01	56.5	0.01	56.5	0.01	44.7	0.08	64.6
0.03	56.5	0.03	56.5	0.03	56.5	0.03	44.7	0.15	58.1
0.03	56.5	0.03	56.5	0.03	56.5	0.03	44.7	0.53	58.1
0.17	56.5	0.17	56.5	0.17	56.5	0.17	44.7	0.75	58.1

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 7 - No Degradation

Sta.

O. G. Elev. 17.0
Cut off Elev. 17.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 17 to 7	z (ft)	Elev. 7 to -3	z (ft)	*Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -28
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	1.1	0.00	0.0	0.00	3.1	0.00	4.8
0.00	0.0	0.00	2.2	0.00	0.0	0.00	6.1	0.00	9.7
0.01	0.0	0.01	3.2	0.01	0.0	0.01	9.2	0.01	14.5
0.01	0.0	0.01	4.3	0.01	0.0	0.01	12.2	0.01	19.4
0.01	0.0	0.01	5.4	0.01	0.0	0.01	15.3	0.01	24.2
0.01	0.0	0.01	5.4	0.01	0.0	0.01	15.3	0.01	24.2
0.03	0.0	0.03	5.4	0.03	0.0	0.03	15.3	0.03	24.2
0.03	0.0	0.03	5.4	0.03	0.0	0.03	15.3	0.03	24.2
0.17	0.0	0.17	5.4	0.17	0.0	0.17	15.3	0.17	24.2

z (ft)	Elev. -28 to -38	z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68	z (ft)	Elev. -68 to -78
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	5.6	0.00	7.0	0.00	9.2	0.00	11.3	0.00	11.3
0.00	11.2	0.00	13.9	0.00	18.4	0.00	22.6	0.00	22.6
0.01	16.9	0.01	20.9	0.01	27.6	0.01	33.9	0.01	33.9
0.01	22.5	0.01	27.9	0.01	36.8	0.01	45.2	0.01	45.2
0.01	28.1	0.01	34.8	0.01	46.0	0.01	56.5	0.01	56.5
0.01	28.1	0.01	34.8	0.01	46.0	0.01	56.5	0.01	56.5
0.03	28.1	0.03	34.8	0.03	46.0	0.03	56.5	0.03	56.5
0.03	28.1	0.03	34.8	0.03	46.0	0.03	56.5	0.03	56.5
0.17	28.1	0.17	34.8	0.17	46.0	0.17	56.5	0.17	56.5

z (ft)	Elev. -78 to -88	z (ft)	Elev. -88 to -93	z (ft)	Elev. -93 to -98	z (ft)	Elev. -98 to -103	z (ft)	Elev. -103 to -108
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	11.3	0.00	9.3	0.00	9.1	0.02	19.4	0.02	19.9
0.00	22.6	0.00	18.5	0.00	18.3	0.03	35.1	0.03	36.0
0.01	33.9	0.01	27.8	0.01	27.4	0.04	41.6	0.04	42.7
0.01	45.2	0.01	37.0	0.01	36.6	0.05	47.2	0.05	48.4
0.01	56.5	0.01	46.3	0.01	45.7	0.06	55.7	0.06	57.1
0.01	56.5	0.01	46.3	0.01	45.7	0.08	60.6	0.08	62.1
0.03	56.5	0.03	46.3	0.03	45.7	0.15	54.5	0.15	55.9
0.03	56.5	0.03	46.3	0.03	45.7	0.53	54.5	0.53	55.9
0.17	56.5	0.17	46.3	0.17	45.7	0.75	54.5	0.75	55.9

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - No Degradation

Sta.

O. G. Elev. 37.0
Cut off Elev. 37.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 37 to 31	z (ft)	Elev. 31 to 24	z (ft)	*Elev. 24 to 14	z (ft)	Elev. 14 to 7	z (ft)	Elev. 7 to -3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.2	0.00	0.7	0.00	0.0	0.00	1.5	0.00	2.3
0.00	0.5	0.00	1.5	0.00	0.0	0.00	3.1	0.00	4.6
0.01	0.7	0.01	2.2	0.01	0.0	0.01	4.6	0.01	7.0
0.01	0.9	0.01	3.0	0.01	0.0	0.01	6.2	0.01	9.3
0.01	1.2	0.01	3.7	0.01	0.0	0.01	7.7	0.01	11.6
0.01	1.2	0.01	3.7	0.01	0.0	0.01	7.7	0.01	11.6
0.03	1.2	0.03	3.7	0.03	0.0	0.03	7.7	0.03	11.6
0.03	1.2	0.03	3.7	0.03	0.0	0.03	7.7	0.03	11.6
0.17	1.2	0.17	3.7	0.17	0.0	0.17	7.7	0.17	11.6

z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -18	z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38	z (ft)	Elev. -38 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.02	6.8	0.00	3.7	0.00	6.5	0.00	6.4	0.00	9.0
0.03	12.3	0.00	7.4	0.00	13.0	0.00	12.9	0.00	17.9
0.04	14.6	0.01	11.1	0.01	19.5	0.01	19.3	0.01	26.9
0.05	16.6	0.01	14.8	0.01	26.0	0.01	25.7	0.01	35.9
0.06	19.5	0.01	18.5	0.01	32.5	0.01	32.2	0.01	44.9
0.08	21.2	0.01	18.5	0.01	32.5	0.01	32.2	0.01	44.9
0.15	19.1	0.03	18.5	0.03	32.5	0.03	32.2	0.03	44.9
0.53	19.1	0.03	18.5	0.03	32.5	0.03	32.2	0.03	44.9
0.75	19.1	0.17	18.5	0.17	32.5	0.17	32.2	0.17	44.9

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78	z (ft)	Elev. -78 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	8.5	0.00	8.8	0.00	10.1	0.00	11.3	0.00	11.3
0.00	17.1	0.00	17.7	0.00	20.2	0.00	22.6	0.00	22.6
0.01	25.6	0.01	26.5	0.01	30.2	0.01	33.9	0.01	33.9
0.01	34.1	0.01	35.4	0.01	40.3	0.01	45.2	0.01	45.2
0.01	42.7	0.01	44.2	0.01	50.4	0.01	56.5	0.01	56.5
0.01	42.7	0.01	44.2	0.01	50.4	0.01	56.5	0.01	56.5
0.03	42.7	0.03	44.2	0.03	50.4	0.03	56.5	0.03	56.5
0.03	42.7	0.03	44.2	0.03	50.4	0.03	56.5	0.03	56.5
0.17	42.7	0.17	44.2	0.17	50.4	0.17	56.5	0.17	56.5

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - No Degradation

Sta.

O. G. Elev.	37.0
Cut off Elev.	37.0
Pile	7.5' CISS
GWS	50.0

z (ft)	Elev. 37 to 31	z (ft)	Elev. 31 to 24	z (ft)	*Elev. 24 to 17	z (ft)	*Elev. 17 to 12	z (ft)	*Elev. 12 to 7
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.3	0.00	0.9	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.5	0.00	1.7	0.00	0.0	0.00	0.0	0.00	0.0
0.01	0.8	0.01	2.6	0.01	0.0	0.01	0.0	0.01	0.0
0.01	1.1	0.01	3.4	0.01	0.0	0.01	0.0	0.01	0.0
0.01	1.4	0.01	4.3	0.01	0.0	0.01	0.0	0.01	0.0
0.01	1.4	0.01	4.3	0.01	0.0	0.01	0.0	0.01	0.0
0.03	1.4	0.03	4.3	0.03	0.0	0.03	0.0	0.03	0.0
0.03	1.4	0.03	4.3	0.03	0.0	0.03	0.0	0.03	0.0
0.17	1.4	0.17	4.3	0.17	0.0	0.17	0.0	0.17	0.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33	z (ft)	Elev. -33 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	2.4	0.02	6.8	0.00	6.1	0.00	7.2	0.00	8.0
0.00	4.8	0.03	12.4	0.00	12.2	0.00	14.4	0.00	16.0
0.01	7.2	0.04	14.6	0.01	18.3	0.01	21.5	0.01	24.0
0.01	9.6	0.05	16.6	0.01	24.4	0.01	28.7	0.01	32.0
0.01	12.0	0.06	19.6	0.01	30.5	0.01	35.9	0.01	40.0
0.01	12.0	0.08	21.3	0.01	30.5	0.01	35.9	0.01	40.0
0.03	12.0	0.15	19.2	0.03	30.5	0.03	35.9	0.03	40.0
0.03	12.0	0.53	19.2	0.03	30.5	0.03	35.9	0.03	40.0
0.17	12.0	0.75	19.2	0.17	30.5	0.17	35.9	0.17	40.0

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78	z (ft)	Elev. -78 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	9.3	0.00	9.6	0.00	11.3	0.00	9.8	0.00	9.6
0.00	18.5	0.00	19.3	0.00	22.6	0.00	19.6	0.00	19.2
0.01	27.8	0.01	28.9	0.01	33.9	0.01	29.4	0.01	28.9
0.01	37.0	0.01	38.5	0.01	45.2	0.01	39.1	0.01	38.5
0.01	46.3	0.01	48.2	0.01	56.5	0.01	48.9	0.01	48.1
0.01	46.3	0.01	48.2	0.01	56.5	0.01	48.9	0.01	48.1
0.03	46.3	0.03	48.2	0.03	56.5	0.03	48.9	0.03	48.1
0.03	46.3	0.03	48.2	0.03	56.5	0.03	48.9	0.03	48.1
0.17	46.3	0.17	48.2	0.17	56.5	0.17	48.9	0.17	48.1

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 10 and 11 - No Degradation

Sta.

O. G. Elev.	37.0	Pile	7.5' CISS
Cut off Elev.	37.0	GWS	50.0

z (ft)	Elev. 37 to 27	z (ft)	Elev. 27 to 17	z (ft)	*Elev. 17 to 7	z (ft)	*Elev. 7 to 2	z (ft)	*Elev. 2 to -3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.5	0.00	1.1	0.00	0.0	0.00	0.0	0.00	0.0
0.00	1.0	0.00	2.2	0.00	0.0	0.00	0.0	0.00	0.0
0.01	1.5	0.01	3.4	0.01	0.0	0.01	0.0	0.01	0.0
0.01	2.1	0.01	4.5	0.01	0.0	0.01	0.0	0.01	0.0
0.01	2.6	0.01	5.6	0.01	0.0	0.01	0.0	0.01	0.0
0.01	2.6	0.01	5.6	0.01	0.0	0.01	0.0	0.01	0.0
0.03	2.6	0.03	5.6	0.03	0.0	0.03	0.0	0.03	0.0
0.03	2.6	0.03	5.6	0.03	0.0	0.03	0.0	0.03	0.0
0.17	2.6	0.17	5.6	0.17	0.0	0.17	0.0	0.17	0.0

z (ft)	*Elev. -3 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -18	z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	4.0	0.00	4.6	0.00	6.6	0.00	8.4
0.00	0.0	0.00	8.0	0.00	9.3	0.00	13.2	0.00	16.8
0.01	0.0	0.01	12.0	0.01	13.9	0.01	19.7	0.01	25.2
0.01	0.0	0.01	16.1	0.01	18.5	0.01	26.3	0.01	33.6
0.01	0.0	0.01	20.1	0.01	23.2	0.01	32.9	0.01	42.0
0.01	0.0	0.01	20.1	0.01	23.2	0.01	32.9	0.01	42.0
0.03	0.0	0.03	20.1	0.03	23.2	0.03	32.9	0.03	42.0
0.03	0.0	0.03	20.1	0.03	23.2	0.03	32.9	0.03	42.0
0.17	0.0	0.17	20.1	0.17	23.2	0.17	32.9	0.17	42.0

z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68	z (ft)	Elev. -68 to -78	z (ft)	Elev. -78 to -88
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	8.4	0.00	11.3	0.00	11.3	0.00	8.8	0.00	8.7
0.00	16.7	0.00	22.5	0.00	22.6	0.00	17.6	0.00	17.4
0.01	25.1	0.01	33.8	0.01	33.9	0.01	26.3	0.01	26.0
0.01	33.5	0.01	45.0	0.01	45.2	0.01	35.1	0.01	34.7
0.01	41.8	0.01	56.3	0.01	56.5	0.01	43.9	0.01	43.4
0.01	41.8	0.01	56.3	0.01	56.5	0.01	43.9	0.01	43.4
0.03	41.8	0.03	56.3	0.03	56.5	0.03	43.9	0.03	43.4
0.03	41.8	0.03	56.3	0.03	56.5	0.03	43.9	0.03	43.4
0.17	41.8	0.17	56.3	0.17	56.5	0.17	43.9	0.17	43.4

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - No Degradation

Sta.

O. G. Elev. 36.0
Cut off Elev. 36.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 36 to 31	z (ft)	Elev. 31 to 23	z (ft)	Elev. 23 to 15	z (ft)	Elev. 15 to 7	z (ft)	Elev. 7 to -3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.02	0.9	0.02	1.3	0.02	1.5	0.02	2.6
0.00	0.0	0.03	1.7	0.03	2.3	0.03	2.7	0.03	4.7
0.01	0.0	0.04	2.0	0.04	2.8	0.04	3.2	0.04	5.6
0.01	0.0	0.05	2.2	0.05	3.1	0.05	3.7	0.05	6.3
0.01	0.0	0.06	2.7	0.06	3.7	0.06	4.3	0.06	7.4
0.01	0.0	0.08	2.9	0.08	4.0	0.08	4.7	0.08	8.1
0.03	0.0	0.15	2.6	0.15	3.6	0.15	4.2	0.15	7.3
0.03	0.0	0.53	2.6	0.53	3.6	0.53	4.2	0.53	7.3
0.17	0.0	0.75	2.6	0.75	3.6	0.75	4.2	0.75	7.3

z (ft)	Elev. -3 to -9	z (ft)	Elev. -9 to -19	z (ft)	Elev. -19 to -29	z (ft)	Elev. -29 to -39	z (ft)	Elev. -39 to -46
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	1.5	0.00	4.5	0.00	7.0	0.00	6.9	0.00	7.2
0.00	3.1	0.00	8.9	0.00	14.1	0.00	13.8	0.00	14.3
0.01	4.6	0.01	13.4	0.01	21.1	0.01	20.7	0.00	21.5
0.01	6.1	0.01	17.8	0.01	28.2	0.01	27.6	0.01	28.6
0.01	7.7	0.01	22.3	0.01	35.2	0.01	34.5	0.01	35.8
0.01	7.7	0.01	22.3	0.01	35.2	0.01	34.5	0.01	35.8
0.03	7.7	0.03	22.3	0.03	35.2	0.03	34.5	0.03	35.8
0.03	7.7	0.03	22.3	0.03	35.2	0.03	34.5	0.03	35.8
0.17	7.7	0.17	22.3	0.17	35.2	0.17	34.5	0.17	35.8

z (ft)	Elev. -46 to -54	z (ft)	Elev. -54 to -59	z (ft)	Elev. -59 to -64	z (ft)	Elev. -64 to -74	z (ft)	Elev. -74 to -84
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	9.6	0.00	9.7	0.00	8.1	0.00	11.3	0.00	11.3
0.00	19.2	0.00	19.5	0.00	16.2	0.00	22.6	0.00	22.6
0.01	28.8	0.01	29.2	0.01	24.3	0.01	33.9	0.01	33.9
0.01	38.3	0.01	38.9	0.01	32.4	0.01	45.2	0.01	45.2
0.01	47.9	0.01	48.6	0.01	40.4	0.01	56.5	0.01	56.5
0.01	47.9	0.01	48.6	0.01	40.4	0.01	56.5	0.01	56.5
0.03	47.9	0.03	48.6	0.03	40.4	0.03	56.5	0.03	56.5
0.03	47.9	0.03	48.6	0.03	40.4	0.03	56.5	0.03	56.5
0.17	47.9	0.17	48.6	0.17	40.4	0.17	56.5	0.17	56.5

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - No Degradation

Sta.

O. G. Elev. 35.0
Cut off Elev. 35.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 35 to 28	z (ft)	Elev. 28 to 21	z (ft)	Elev. 21 to 13	z (ft)	*Elev. 13 to 7	z (ft)	*Elev. 7 to -6
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.02	1.1	0.02	1.6	0.00	0.0	0.00	0.0
0.00	0.0	0.03	2.0	0.03	3.0	0.00	0.0	0.00	0.0
0.01	0.0	0.04	2.4	0.04	3.5	0.01	0.0	0.01	0.0
0.01	0.0	0.05	2.7	0.05	4.0	0.01	0.0	0.01	0.0
0.01	0.0	0.06	3.2	0.06	4.7	0.01	0.0	0.01	0.0
0.01	0.0	0.08	3.5	0.08	5.1	0.01	0.0	0.01	0.0
0.03	0.0	0.15	3.2	0.15	4.6	0.03	0.0	0.03	0.0
0.03	0.0	0.53	3.2	0.53	4.6	0.03	0.0	0.03	0.0
0.17	0.0	0.75	3.2	0.75	4.6	0.17	0.0	0.17	0.0

z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -46	z (ft)	Elev. -46 to -56
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	2.2	0.00	5.5	0.00	5.5	0.00	6.0	0.00	8.7
0.00	4.4	0.00	11.0	0.00	11.0	0.00	12.1	0.00	17.5
0.01	6.7	0.01	16.4	0.01	16.5	0.01	18.1	0.01	26.2
0.01	8.9	0.01	21.9	0.01	21.9	0.01	24.2	0.01	35.0
0.01	11.1	0.01	27.4	0.01	27.4	0.01	30.2	0.01	43.7
0.01	11.1	0.01	27.4	0.01	27.4	0.01	30.2	0.01	43.7
0.03	11.1	0.03	27.4	0.03	27.4	0.03	30.2	0.03	43.7
0.03	11.1	0.03	27.4	0.03	27.4	0.03	30.2	0.03	43.7
0.17	11.1	0.17	27.4	0.17	27.4	0.17	30.2	0.17	43.7

z (ft)	Elev. -56 to -66	z (ft)	Elev. -66 to -76	z (ft)	Elev. -76 to -86	z (ft)	Elev. -86 to -91	z (ft)	Elev. -91 to -96
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	9.4	0.00	10.0	0.00	8.3	0.00	8.6	0.00	8.6
0.00	18.9	0.00	20.1	0.00	16.6	0.00	17.3	0.00	17.2
0.01	28.3	0.01	30.1	0.01	25.0	0.01	25.9	0.01	25.8
0.01	37.8	0.01	40.2	0.01	33.3	0.01	34.6	0.01	34.4
0.01	47.2	0.01	50.2	0.01	41.6	0.01	43.2	0.01	43.1
0.01	47.2	0.01	50.2	0.01	41.6	0.01	43.2	0.01	43.1
0.03	47.2	0.03	50.2	0.03	41.6	0.03	43.2	0.03	43.1
0.03	47.2	0.03	50.2	0.03	41.6	0.03	43.2	0.03	43.1
0.17	47.2	0.17	50.2	0.17	41.6	0.17	43.2	0.17	43.1

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - No Degradation

Sta.

O. G. Elev. 34.0
Cut off Elev. 34.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 34 to 29	z (ft)	Elev. 29 to 22	z (ft)	Elev. 22 to 14	z (ft)	*Elev. 14 to 7	z (ft)	*Elev. 7 to -6
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.02	1.0	0.02	1.6	0.00	0.0	0.00	0.0
0.00	0.0	0.03	1.8	0.03	2.8	0.00	0.0	0.00	0.0
0.01	0.0	0.04	2.2	0.04	3.4	0.01	0.0	0.01	0.0
0.01	0.0	0.05	2.5	0.05	3.8	0.01	0.0	0.01	0.0
0.01	0.0	0.06	2.9	0.06	4.5	0.01	0.0	0.01	0.0
0.01	0.0	0.08	3.2	0.08	4.9	0.01	0.0	0.01	0.0
0.03	0.0	0.15	2.9	0.15	4.4	0.03	0.0	0.03	0.0
0.03	0.0	0.53	2.9	0.53	4.4	0.03	0.0	0.03	0.0
0.17	0.0	0.75	2.9	0.75	4.4	0.17	0.0	0.17	0.0

z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -47	z (ft)	Elev. -47 to -57
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	2.2	0.00	5.5	0.00	5.2	0.00	6.2	0.00	8.8
0.00	4.4	0.00	11.0	0.00	10.3	0.00	12.4	0.00	17.6
0.01	6.5	0.01	16.4	0.01	15.5	0.01	18.6	0.01	26.4
0.01	8.7	0.01	21.9	0.01	20.7	0.01	24.7	0.01	35.2
0.01	10.9	0.01	27.4	0.01	25.9	0.01	30.9	0.01	44.0
0.01	10.9	0.01	27.4	0.01	25.9	0.01	30.9	0.01	44.0
0.03	10.9	0.03	27.4	0.03	25.9	0.03	30.9	0.03	44.0
0.03	10.9	0.03	27.4	0.03	25.9	0.03	30.9	0.03	44.0
0.17	10.9	0.17	27.4	0.17	25.9	0.17	30.9	0.17	44.0

z (ft)	Elev. -57 to -62	z (ft)	Elev. -62 to -67	z (ft)	Elev. -67 to -77	z (ft)	Elev. -77 to -82	z (ft)	Elev. -82 to -87
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	10.9	0.02	11.7	0.00	8.6	0.00	6.8	0.00	6.8
0.00	21.8	0.03	21.3	0.00	17.2	0.00	13.7	0.00	13.6
0.01	32.7	0.04	25.2	0.01	25.8	0.01	20.5	0.01	20.4
0.01	43.6	0.05	28.6	0.01	34.4	0.01	27.4	0.01	27.2
0.01	54.5	0.06	33.7	0.01	43.0	0.01	34.2	0.01	34.0
0.01	54.5	0.08	36.6	0.01	43.0	0.01	34.2	0.01	34.0
0.03	54.5	0.15	33.0	0.03	43.0	0.03	34.2	0.03	34.0
0.03	54.5	0.53	33.0	0.03	43.0	0.03	34.2	0.03	34.0
0.17	54.5	0.75	33.0	0.17	43.0	0.17	34.2	0.17	34.0

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - No Degradation

Sta.

O. G. Elev. 33.0
Cut off Elev. 22.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 33 to 28	z (ft)	*Elev. 28 to 18	z (ft)	Elev. 18 to 7	z (ft)	Elev. 7 to -4	z (ft)	Elev. -4 to -12
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.2	0.00	0.0	0.00	1.2	0.00	1.8	0.00	2.2
0.00	0.4	0.00	0.0	0.00	2.4	0.00	3.6	0.00	4.4
0.01	0.5	0.01	0.0	0.01	3.6	0.01	5.5	0.01	6.5
0.01	0.7	0.01	0.0	0.01	4.9	0.01	7.3	0.01	8.7
0.01	0.9	0.01	0.0	0.01	6.1	0.01	9.1	0.01	10.9
0.01	0.9	0.01	0.0	0.01	6.1	0.01	9.1	0.01	10.9
0.03	0.9	0.03	0.0	0.03	6.1	0.03	9.1	0.03	10.9
0.03	0.9	0.03	0.0	0.03	6.1	0.03	9.1	0.03	10.9
0.17	0.9	0.17	0.0	0.17	6.1	0.17	9.1	0.17	10.9

z (ft)	Elev. -12 to -17	z (ft)	Elev. -17 to -22	z (ft)	Elev. -22 to -32	z (ft)	Elev. -32 to -42	z (ft)	Elev. -42 to -52
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.02	7.3	0.00	5.3	0.00	5.9	0.00	7.2	0.00	8.4
0.03	13.3	0.00	10.7	0.00	11.8	0.00	14.4	0.00	16.9
0.04	15.8	0.01	16.0	0.01	17.7	0.01	21.5	0.01	25.3
0.05	17.9	0.01	21.4	0.01	23.5	0.01	28.7	0.01	33.7
0.06	21.1	0.01	26.7	0.01	29.4	0.01	35.9	0.01	42.2
0.08	23.0	0.01	26.7	0.01	29.4	0.01	35.9	0.01	42.2
0.15	20.7	0.03	26.7	0.03	29.4	0.03	35.9	0.03	42.2
0.53	20.7	0.03	26.7	0.03	29.4	0.03	35.9	0.03	42.2
0.75	20.7	0.17	26.7	0.17	29.4	0.17	35.9	0.17	42.2

z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72	z (ft)	Elev. -72 to -82	z (ft)	Elev. -82 to -87	z (ft)	Elev. -87 to -92
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	9.1	0.00	7.8	0.00	11.1	0.00	11.3	0.00	11.3
0.00	18.2	0.00	15.6	0.00	22.3	0.00	22.6	0.00	22.6
0.01	27.4	0.01	23.4	0.01	33.4	0.00	33.9	0.00	33.9
0.01	36.5	0.01	31.2	0.01	44.6	0.01	45.2	0.01	45.2
0.01	45.6	0.01	39.0	0.01	55.7	0.01	56.5	0.01	56.5
0.01	45.6	0.01	39.0	0.01	55.7	0.01	56.5	0.01	56.5
0.03	45.6	0.03	39.0	0.03	55.7	0.03	56.5	0.03	56.5
0.03	45.6	0.03	39.0	0.03	55.7	0.03	56.5	0.03	56.5
0.17	45.6	0.17	39.0	0.17	55.7	0.17	56.5	0.17	56.5

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - No Degradation

Sta.

O. G. Elev. 27.0
Cut off Elev. 27.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 27 to 22	z (ft)	*Elev. 22 to 17	z (ft)	*Elev. 17 to 12	z (ft)	Elev. 12 to 7	z (ft)	Elev. 7 to 2
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.2	0.00	0.0	0.00	0.0	0.00	1.0	0.00	1.3
0.00	0.4	0.00	0.0	0.00	0.0	0.00	2.0	0.00	2.7
0.01	0.5	0.01	0.0	0.01	0.0	0.01	3.0	0.01	4.0
0.01	0.7	0.01	0.0	0.01	0.0	0.01	4.0	0.01	5.3
0.01	0.9	0.01	0.0	0.01	0.0	0.01	5.0	0.01	6.7
0.01	0.9	0.01	0.0	0.01	0.0	0.01	5.0	0.01	6.7
0.03	0.9	0.03	0.0	0.03	0.0	0.03	5.0	0.03	6.7
0.03	0.9	0.03	0.0	0.03	0.0	0.03	5.0	0.03	6.7
0.17	0.9	0.17	0.0	0.17	0.0	0.17	5.0	0.17	6.7

z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33	z (ft)	Elev. -33 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	1.6	0.02	6.9	0.00	4.6	0.00	6.0	0.00	7.2
0.00	3.3	0.03	12.6	0.00	9.1	0.00	12.0	0.00	14.3
0.01	4.9	0.04	14.9	0.01	13.7	0.01	18.1	0.01	21.5
0.01	6.6	0.05	16.9	0.01	18.3	0.01	24.1	0.01	28.7
0.01	8.2	0.06	19.9	0.01	22.8	0.01	30.1	0.01	35.9
0.01	8.2	0.08	21.7	0.01	22.8	0.01	30.1	0.01	35.9
0.03	8.2	0.15	19.5	0.03	22.8	0.03	30.1	0.03	35.9
0.03	8.2	0.53	19.5	0.03	22.8	0.03	30.1	0.03	35.9
0.17	8.2	0.75	19.5	0.17	22.8	0.17	30.1	0.17	35.9

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -83	z (ft)	Elev. -83 to -93
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	8.4	0.00	9.3	0.00	8.0	0.00	11.2	0.00	11.3
0.00	16.7	0.00	18.5	0.00	16.0	0.00	22.4	0.00	22.6
0.01	25.1	0.01	27.8	0.01	24.0	0.01	33.7	0.01	33.9
0.01	33.5	0.01	37.0	0.01	32.0	0.01	44.9	0.01	45.2
0.01	41.8	0.01	46.3	0.01	39.9	0.01	56.1	0.01	56.5
0.01	41.8	0.01	46.3	0.01	39.9	0.01	56.1	0.01	56.5
0.03	41.8	0.03	46.3	0.03	39.9	0.03	56.1	0.03	56.5
0.03	41.8	0.03	46.3	0.03	39.9	0.03	56.1	0.03	56.5
0.17	41.8	0.17	46.3	0.17	39.9	0.17	56.1	0.17	56.5

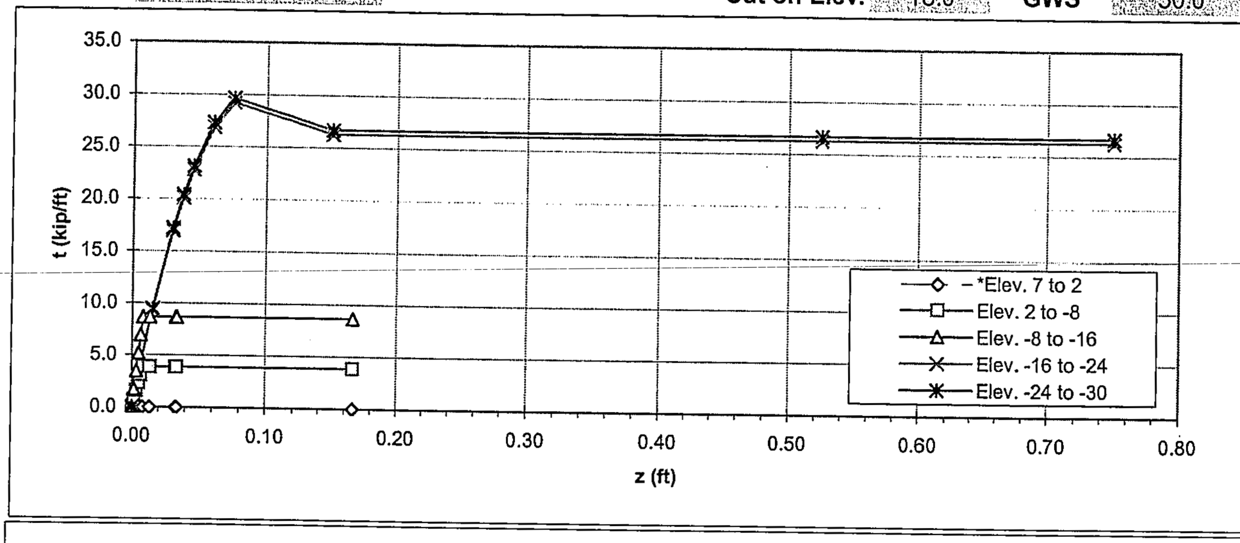
Note - t (kip/ft)
*-Liquefiable layer

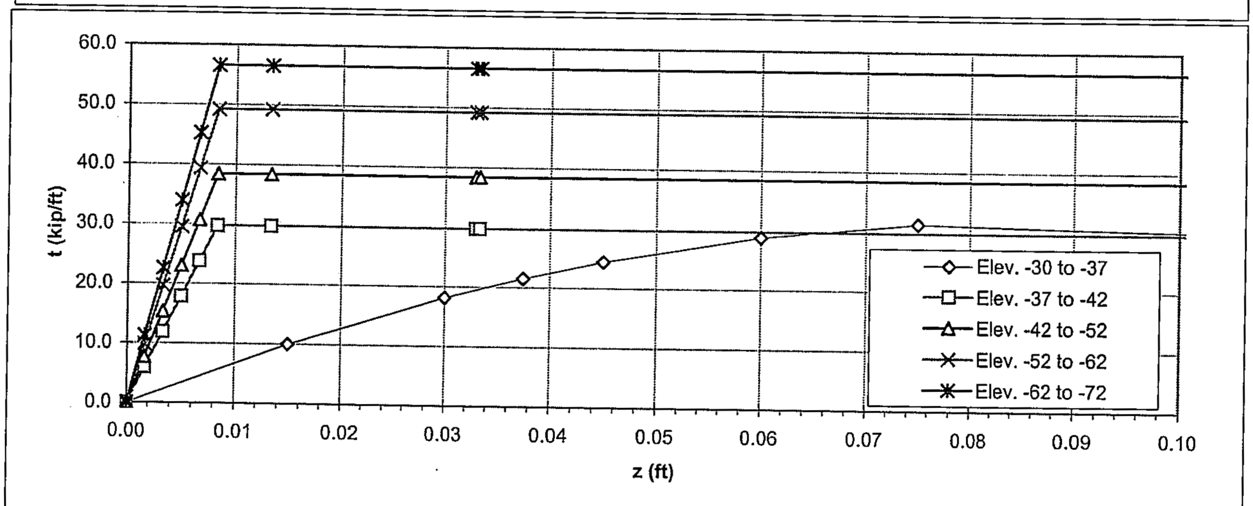
Feather River Bridge
Br. No. 18-0026R
03-1A4321

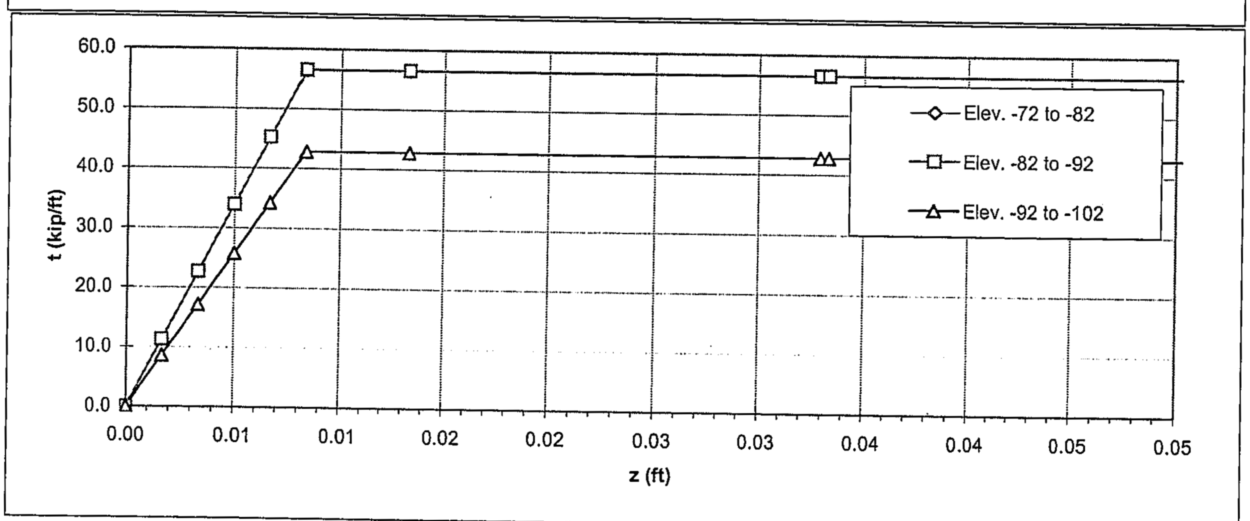
Pier 2 - with Degrdation

Sta.

O. G. Elev.	7.0	Pile	7.5' CISS
Cut off Elev.	18.0	GWS	50.0







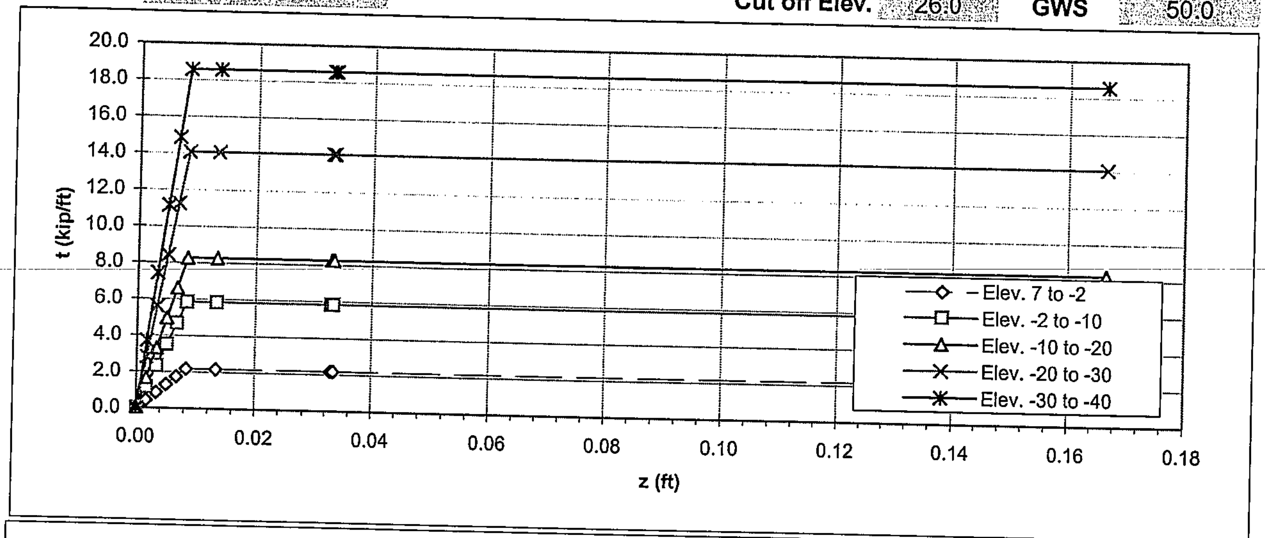
*-Liquefiable layer

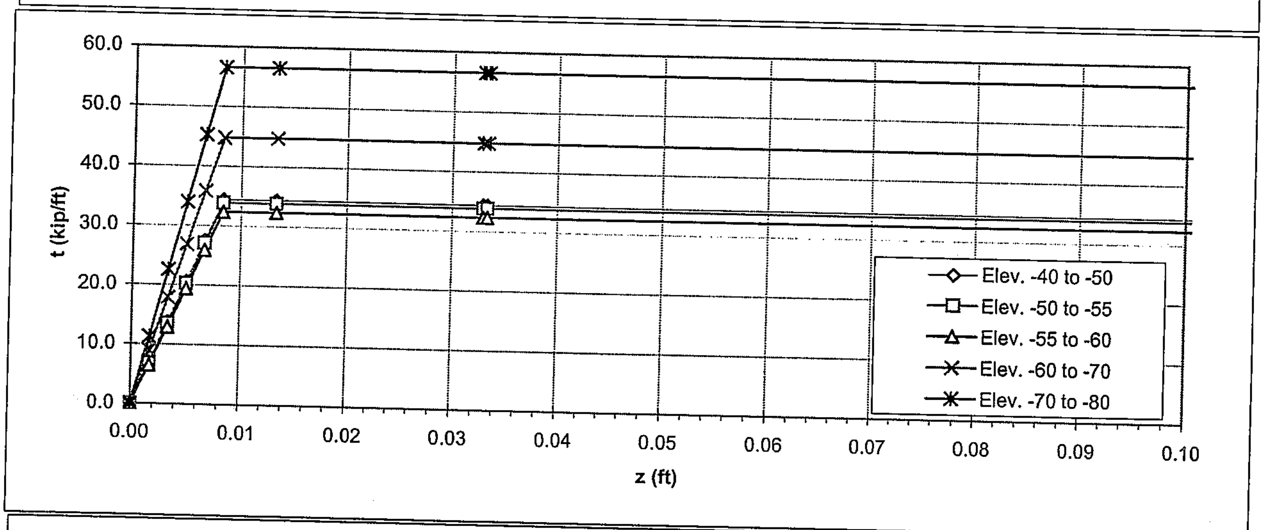
Feather River Bridge
Br. No. 18-0026R
03-1A4321

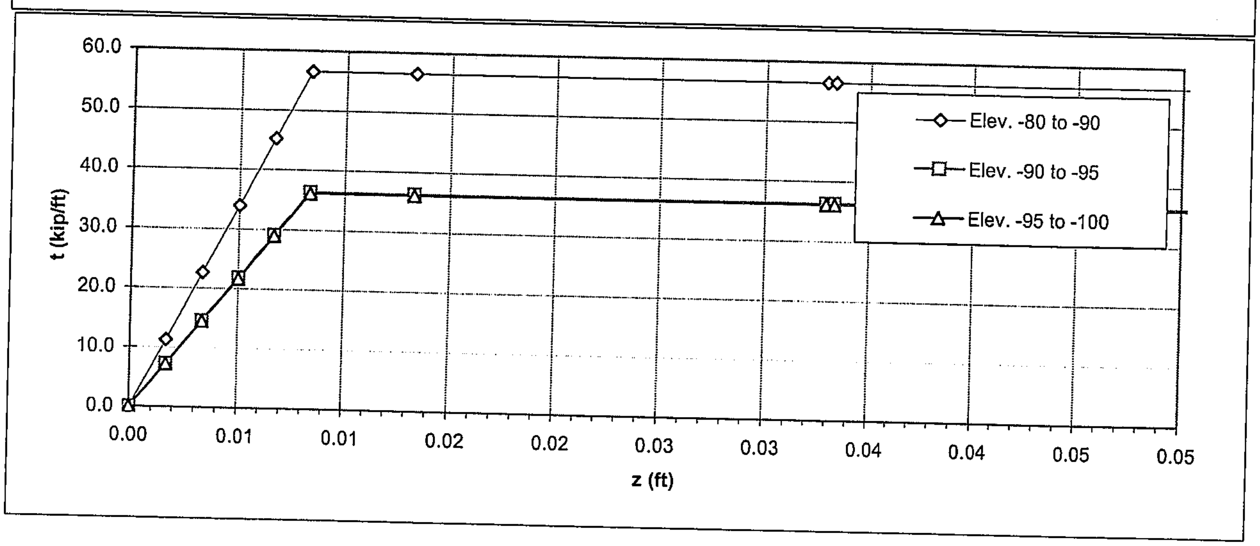
Pier 3 - with Degrdation

Sta.

O. G. Elev. 7.0 **Pile** 7.5' CISS
Cut off Elev. 26.0 **GWS** 50.0



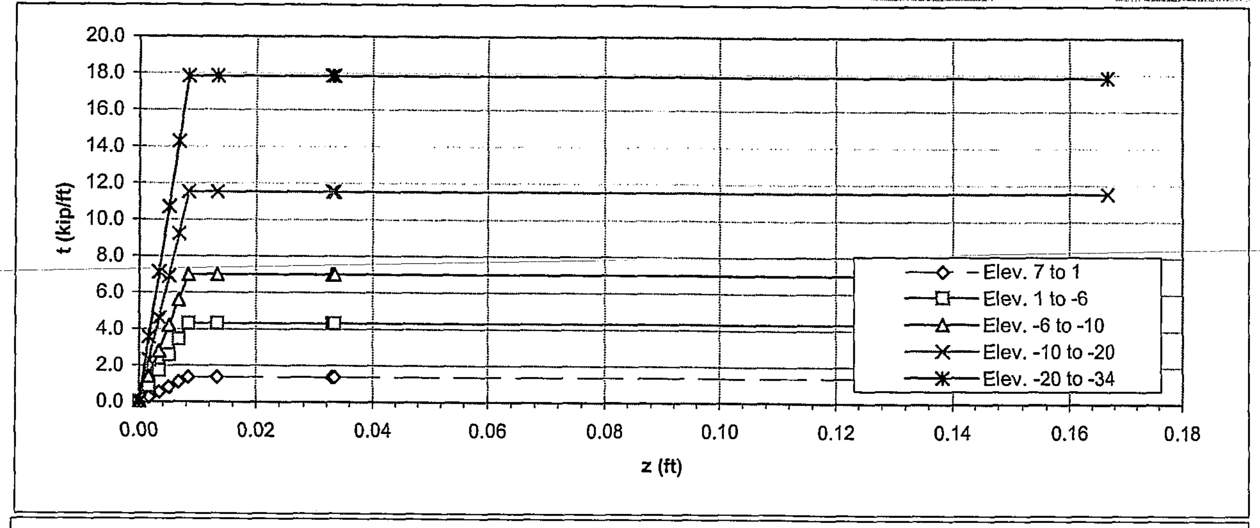


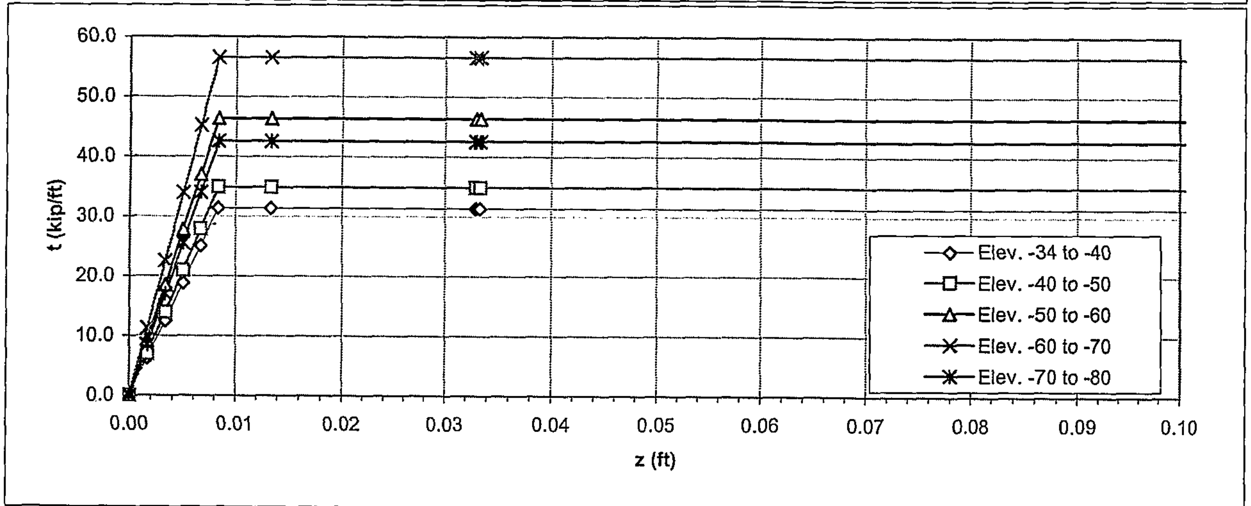


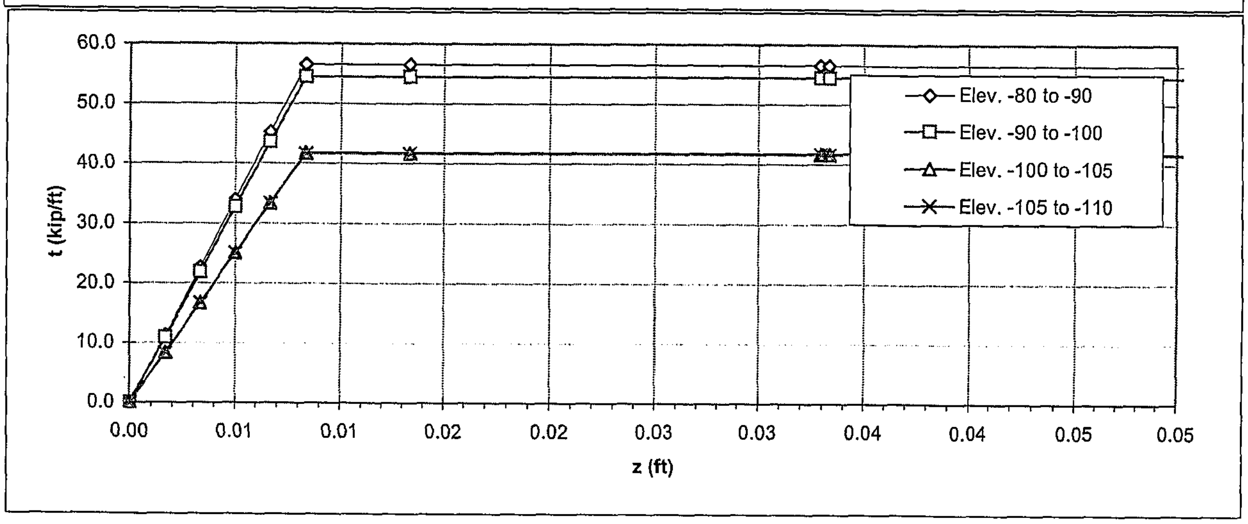
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - with Degrdation

Sta. O. G. Elev. 7.0 Pile 7.5' CISS
Cut off Elev. 14.0 GWS 50.0

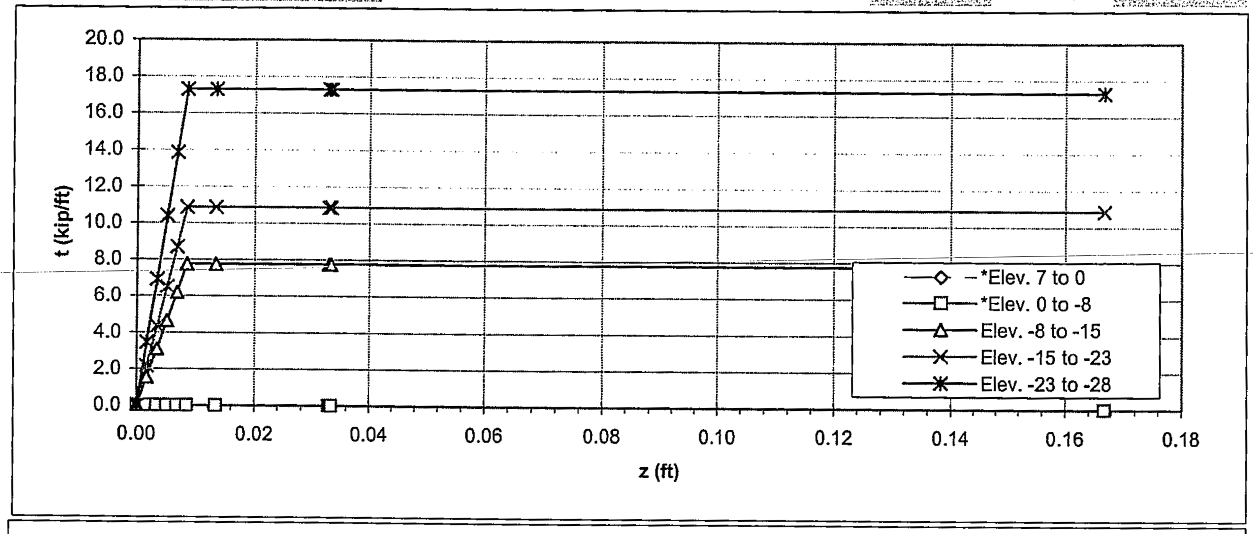


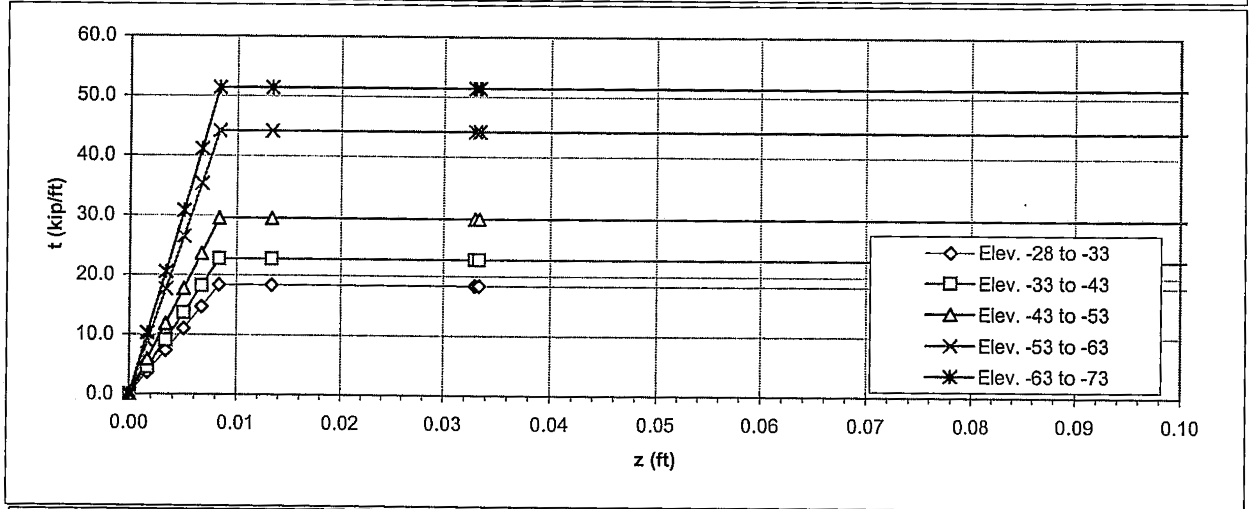


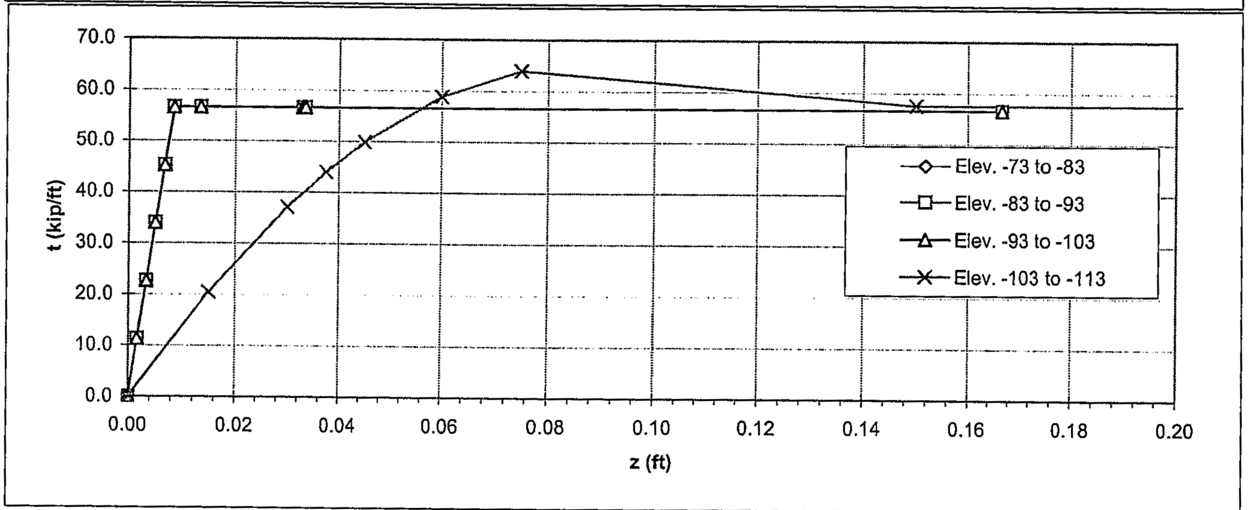


Pier 5 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	12.0	GWS	50.0





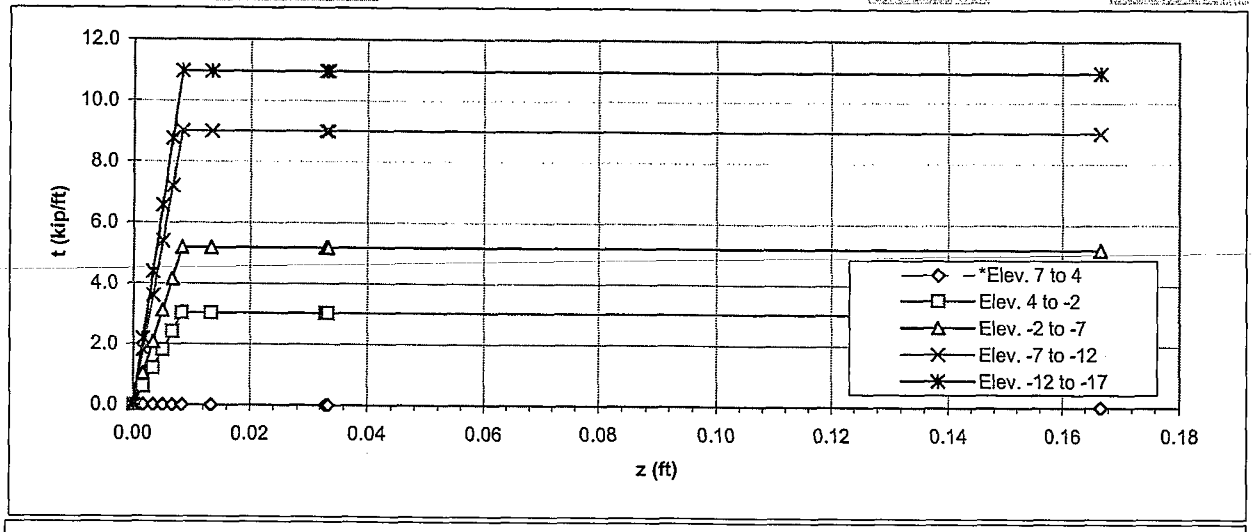


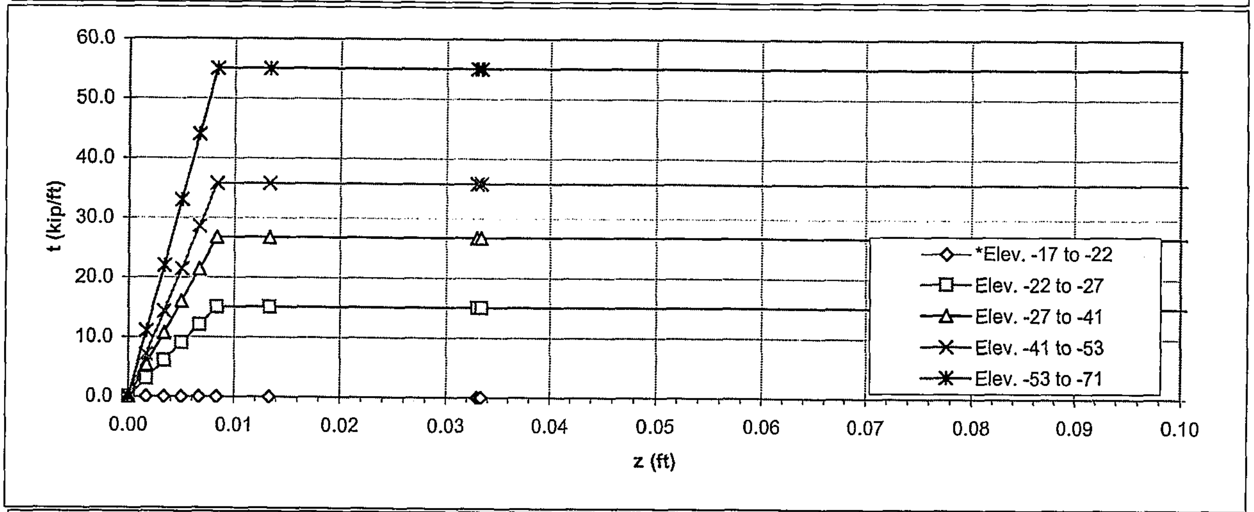
*-Liquefiable layer

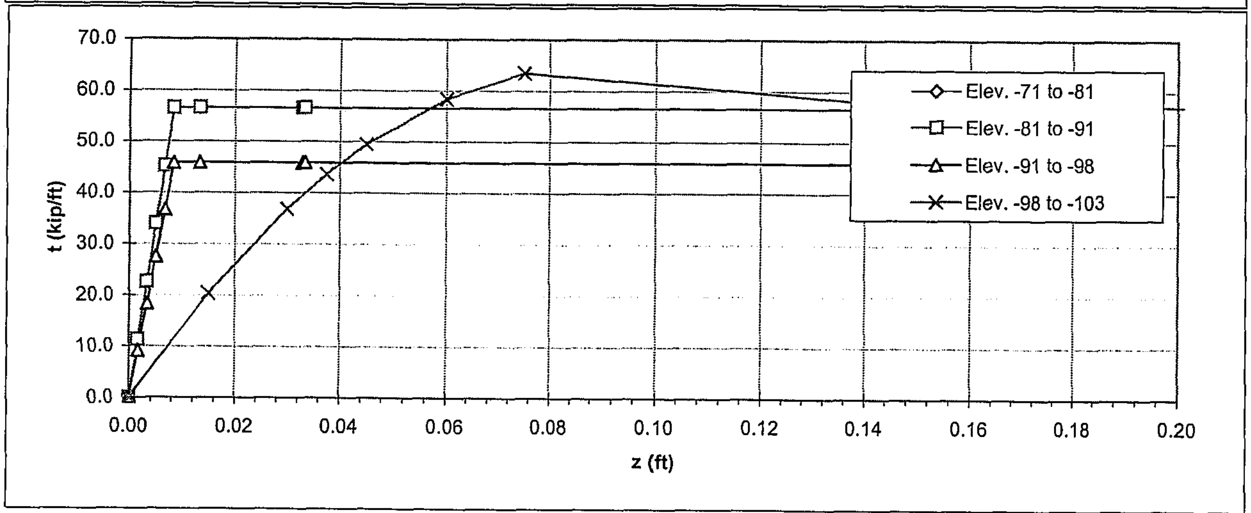
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	19.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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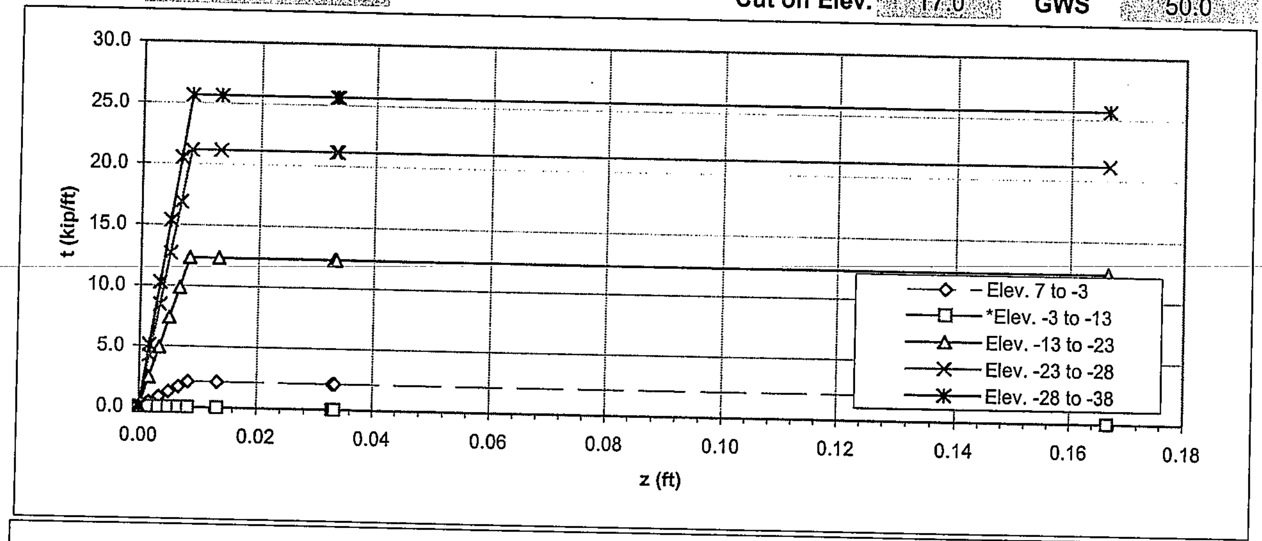
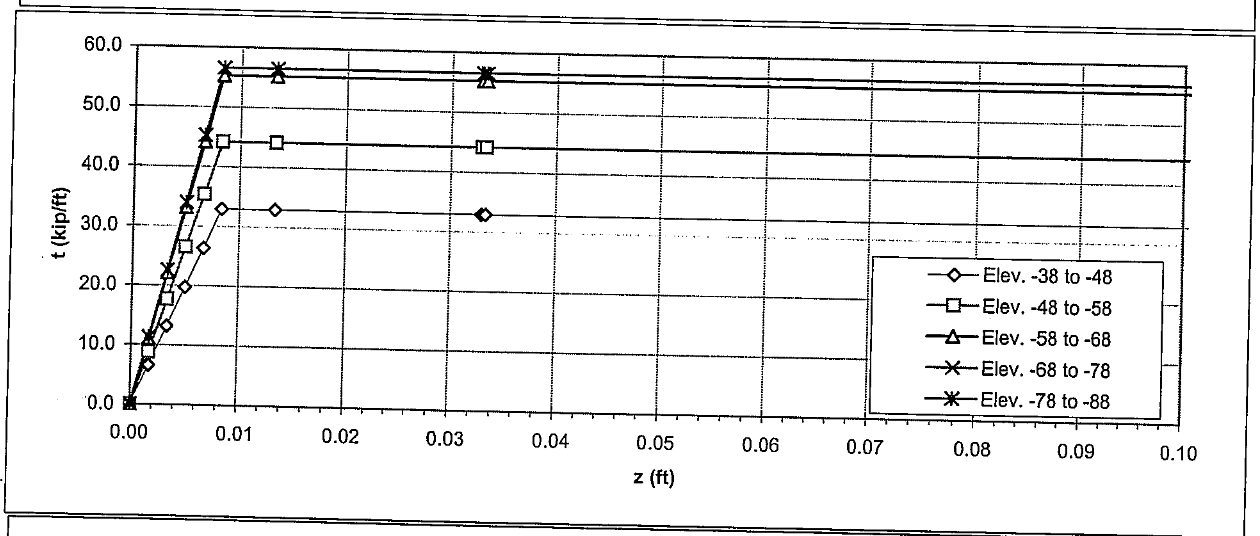
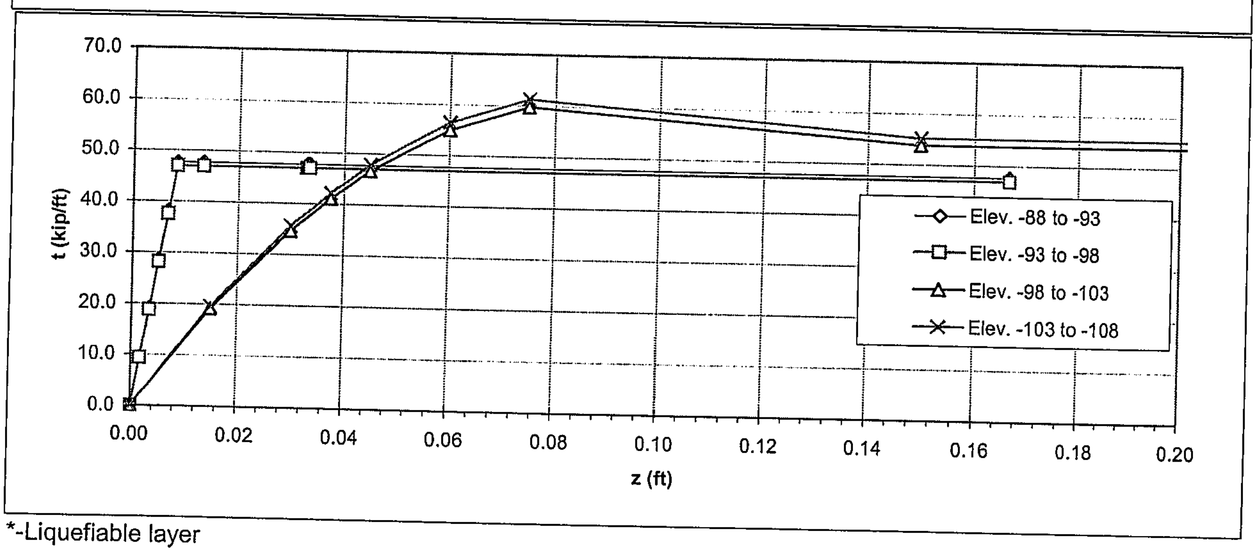
Pier 7 - with Degradation

Sta.

O. G. Elev.	7.0	Pile	7.5' CISS
Cut off Elev.	17.0	GWS	50.0







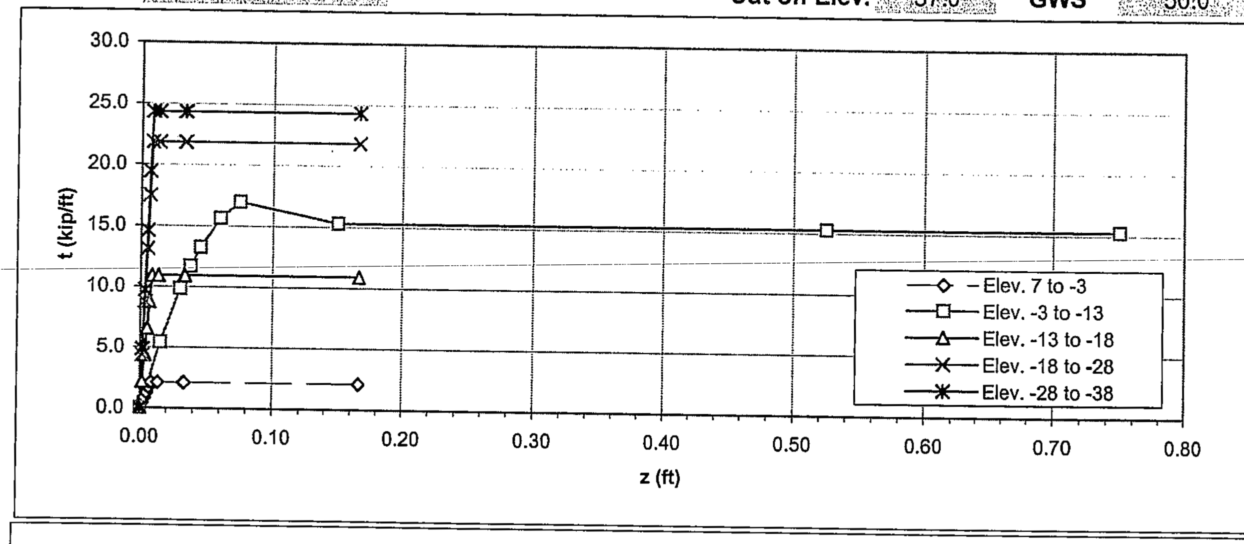
*-Liquefiable layer

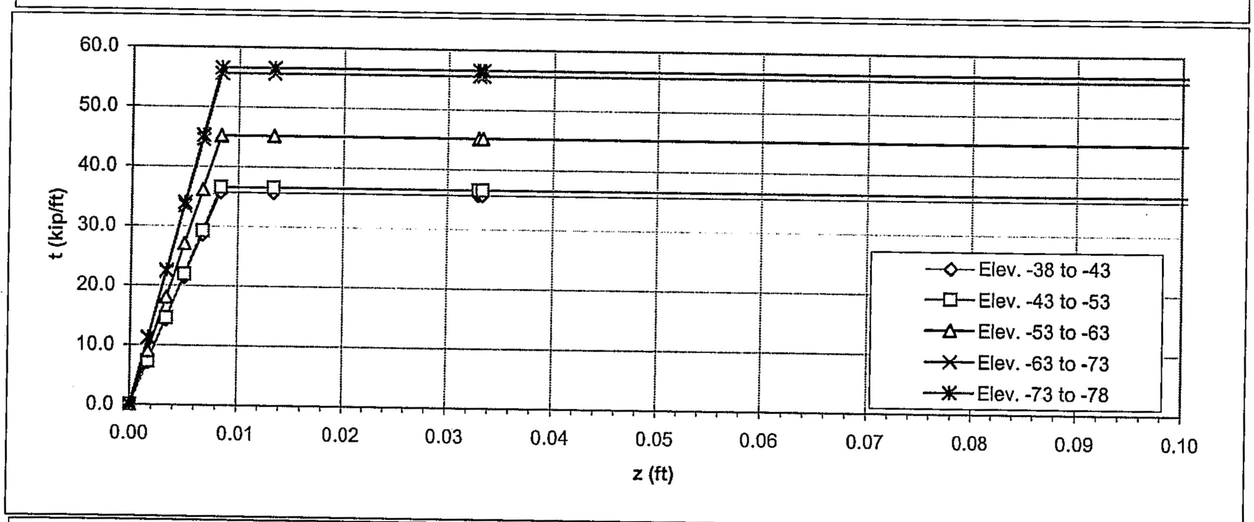
Feather River Bridge
Br. No. 18-0026R
03-1A4321

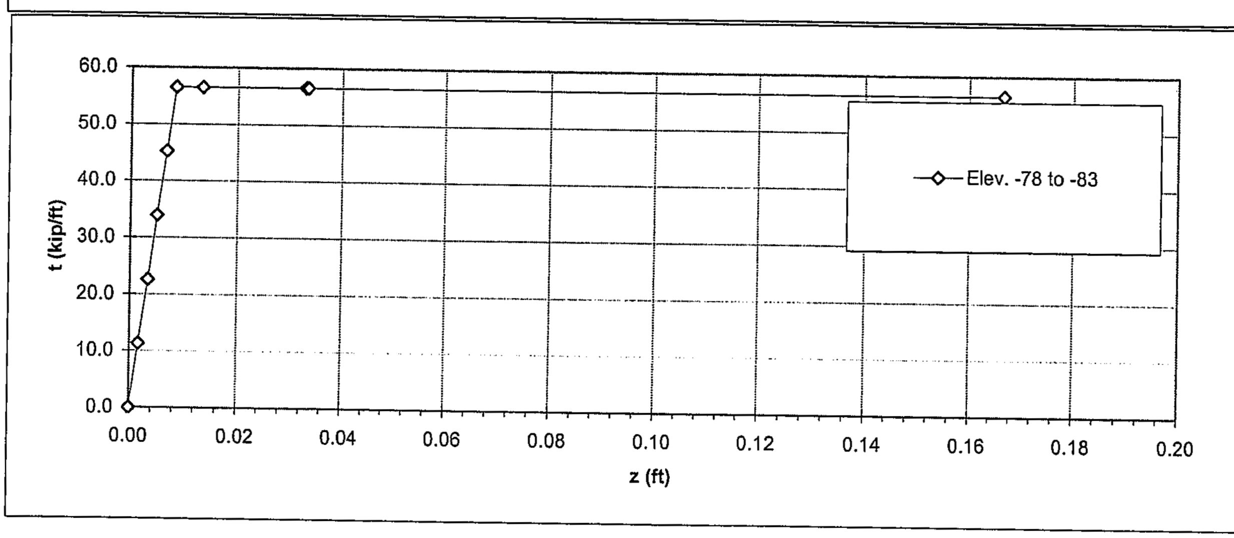
Pier 8 - with Degradation

Sta.

O. G. Elev. 7.0 Pile 7.5' CISS
Cut off Elev. 37.0 GWS 50.0

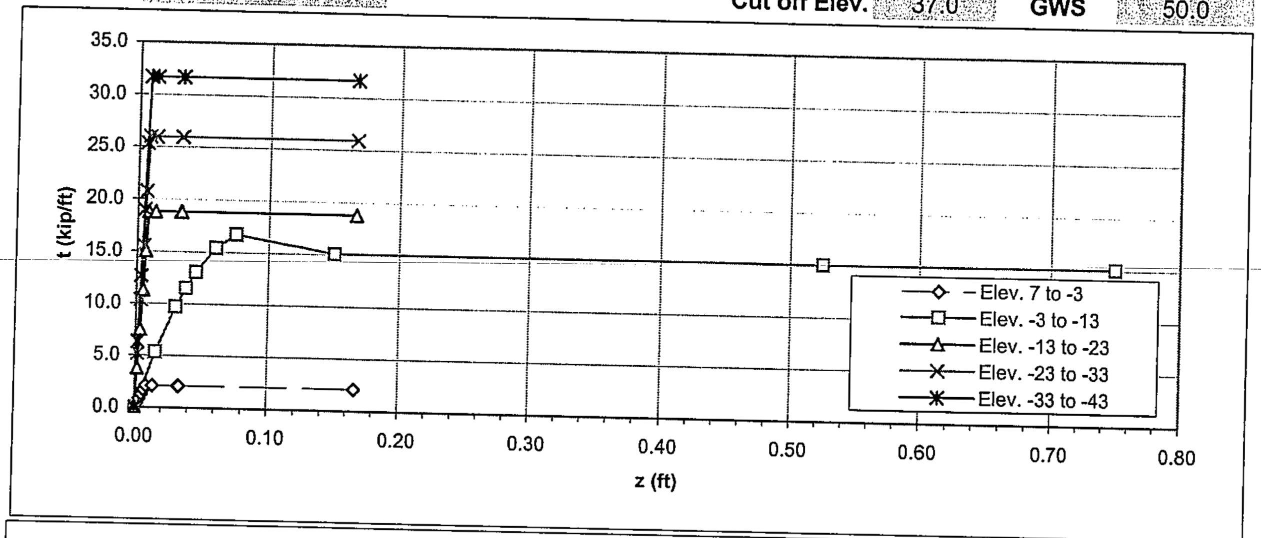


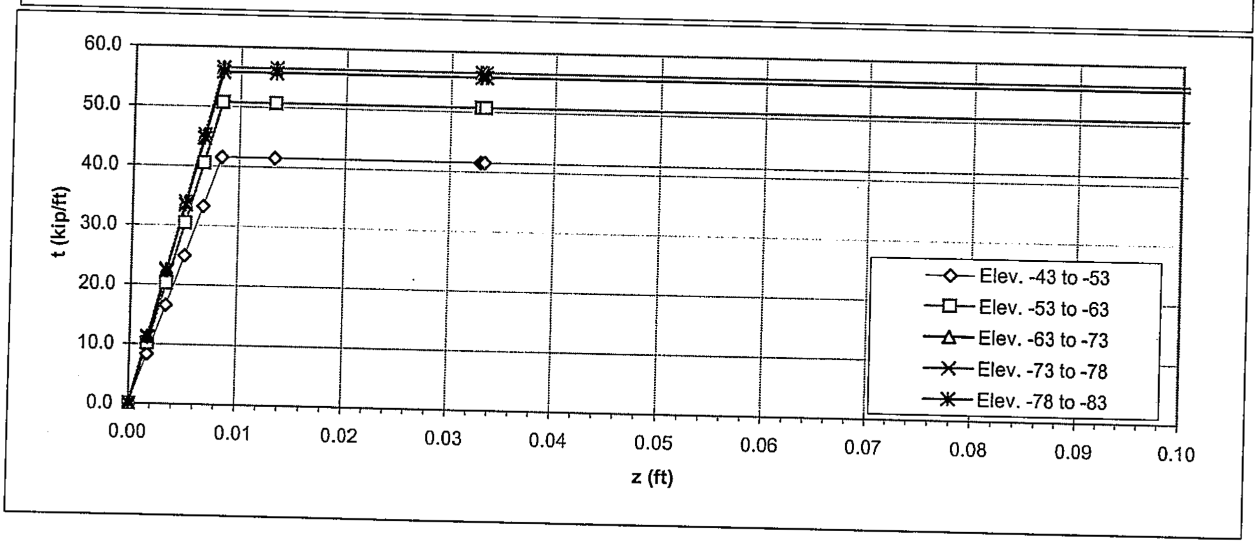




Pier 9 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	37.0	GWS	50.0





Feather River Bridge
Br. No. 18-0026R
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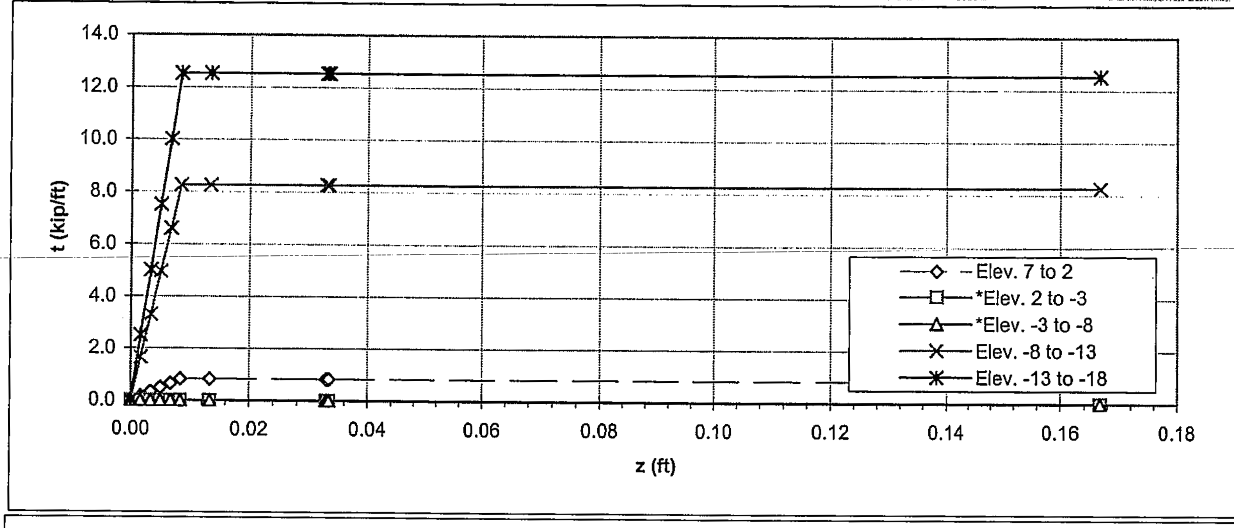
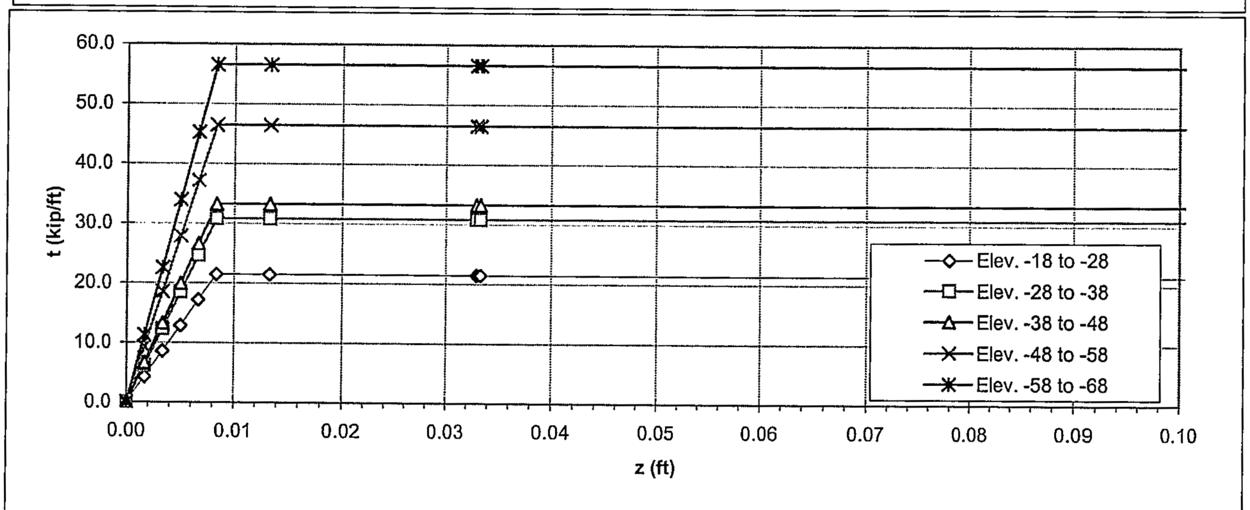
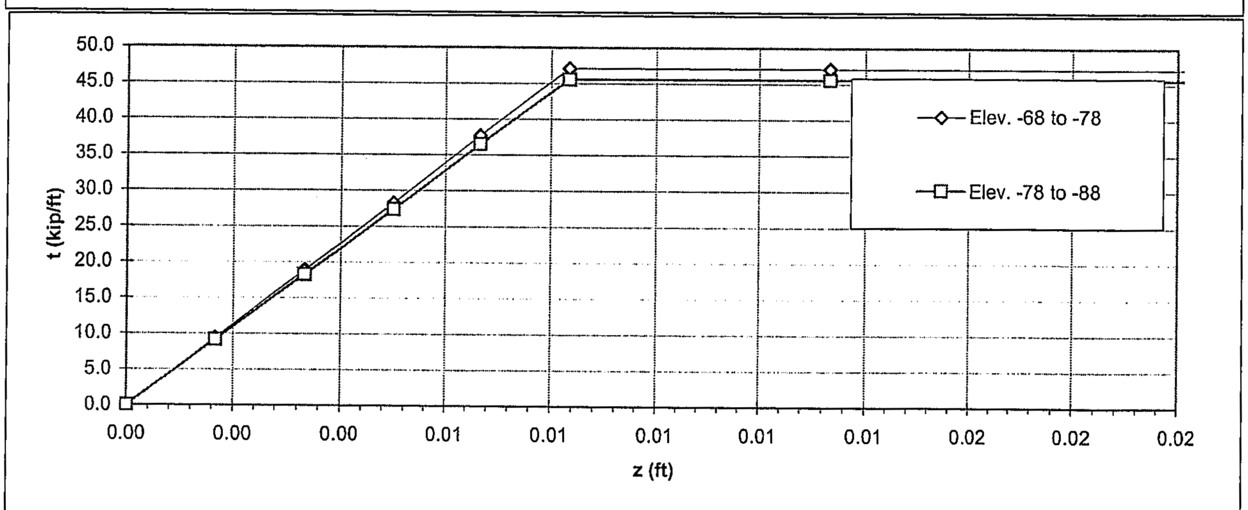
Pier 10 and 11 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	37.0	GWS	50.0





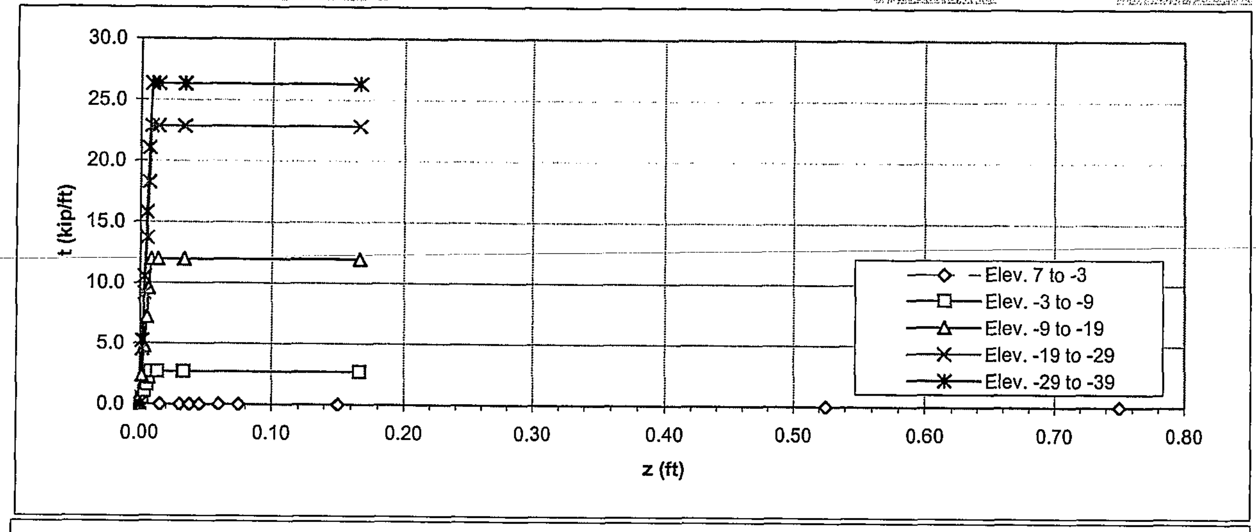


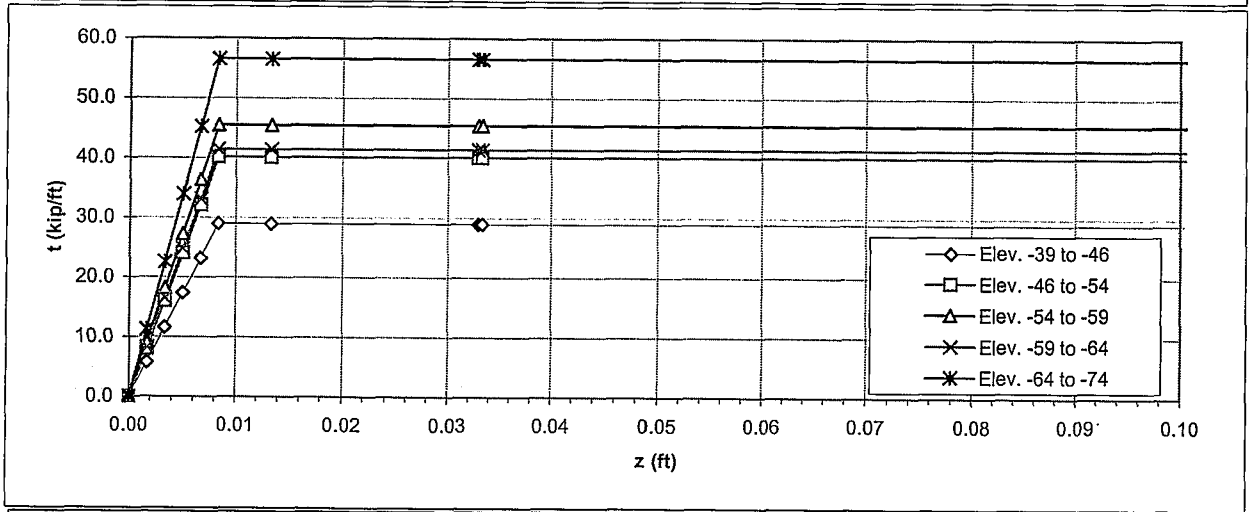
*-Liquefiable layer

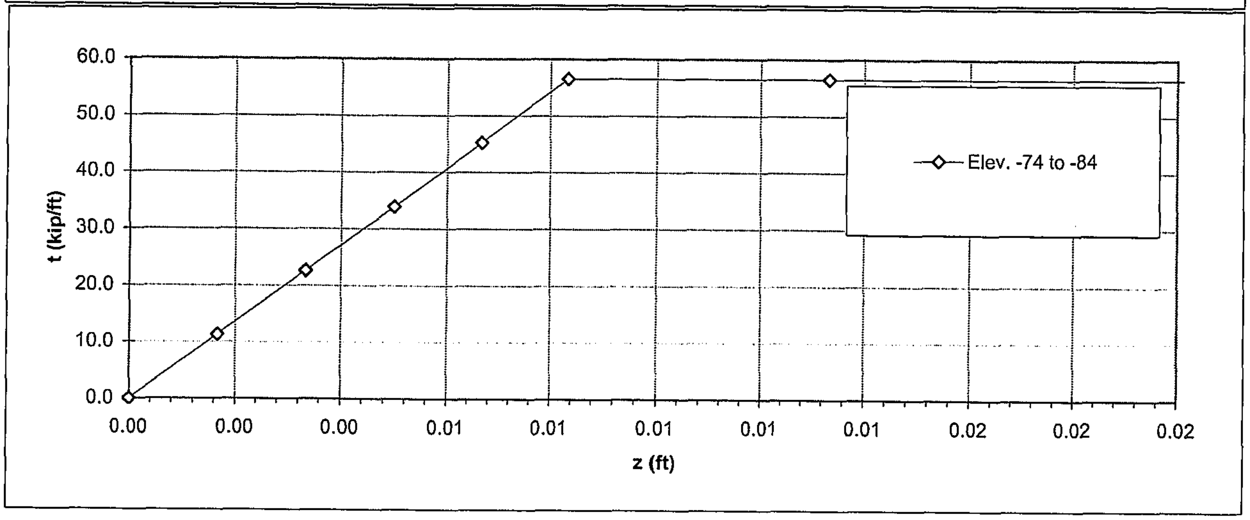
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	36.0	GWS	50.0



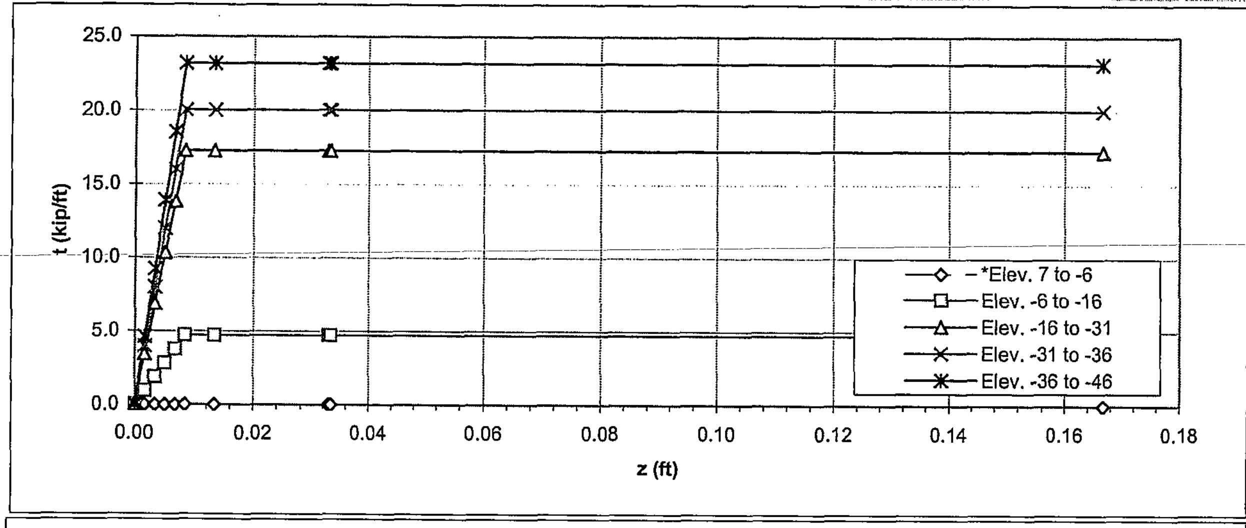


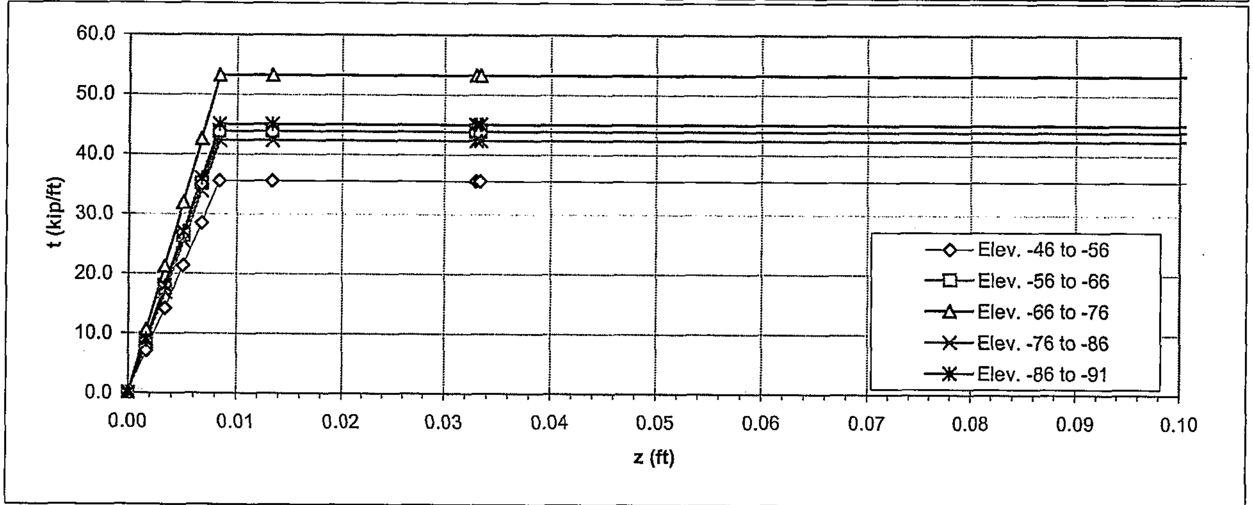


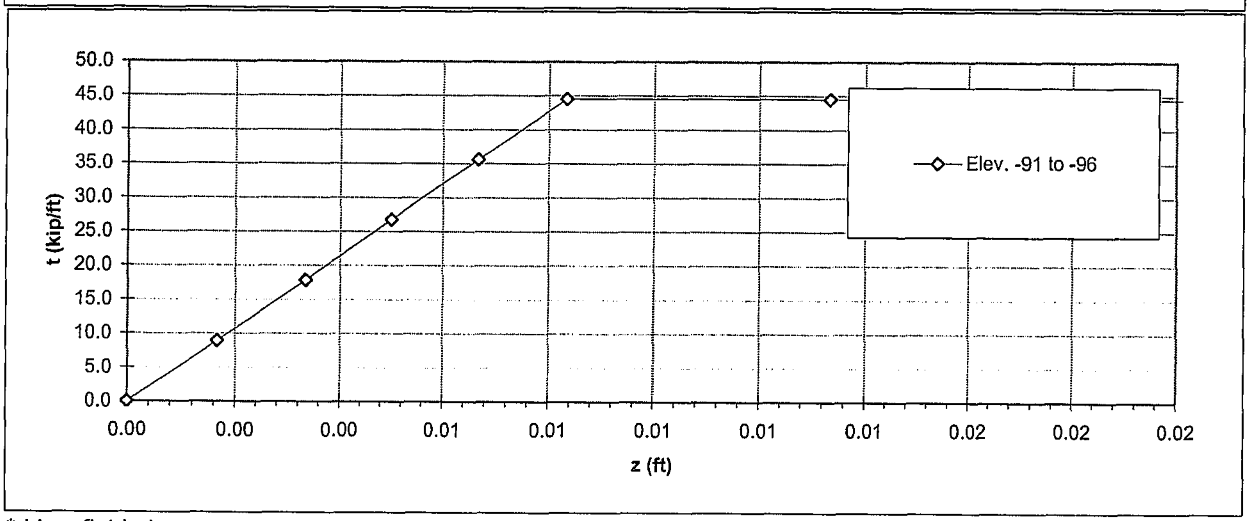
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - with Degradation

Sta.		**O. G. Elev.**	7.0	**Pile**	7.5' CISS
		Cut off Elev.	35.0	**GWS**	50.0





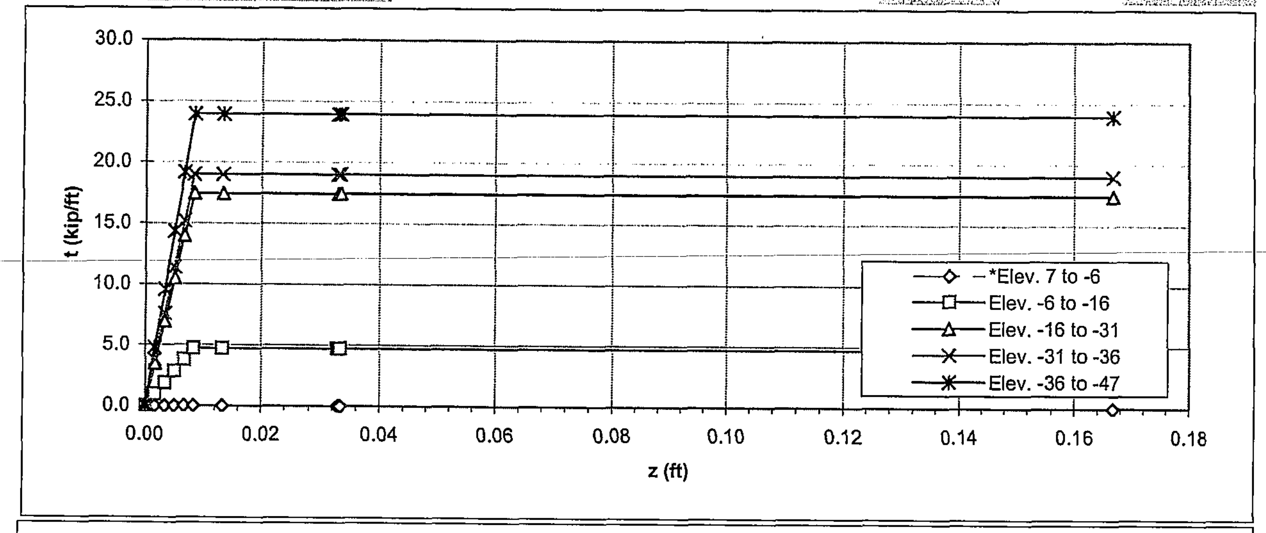


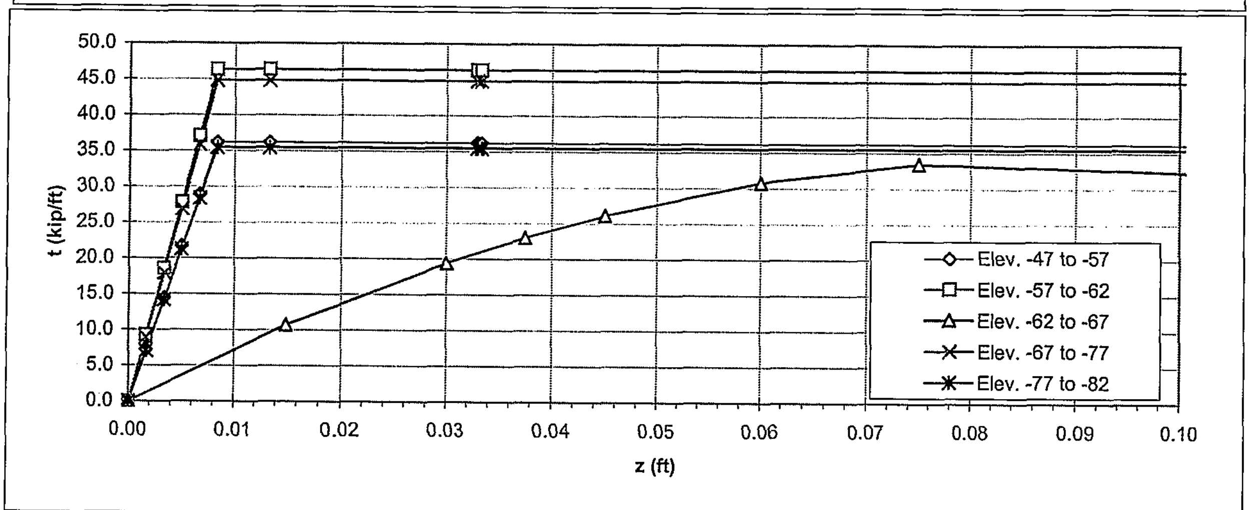
*-Liquefiable layer

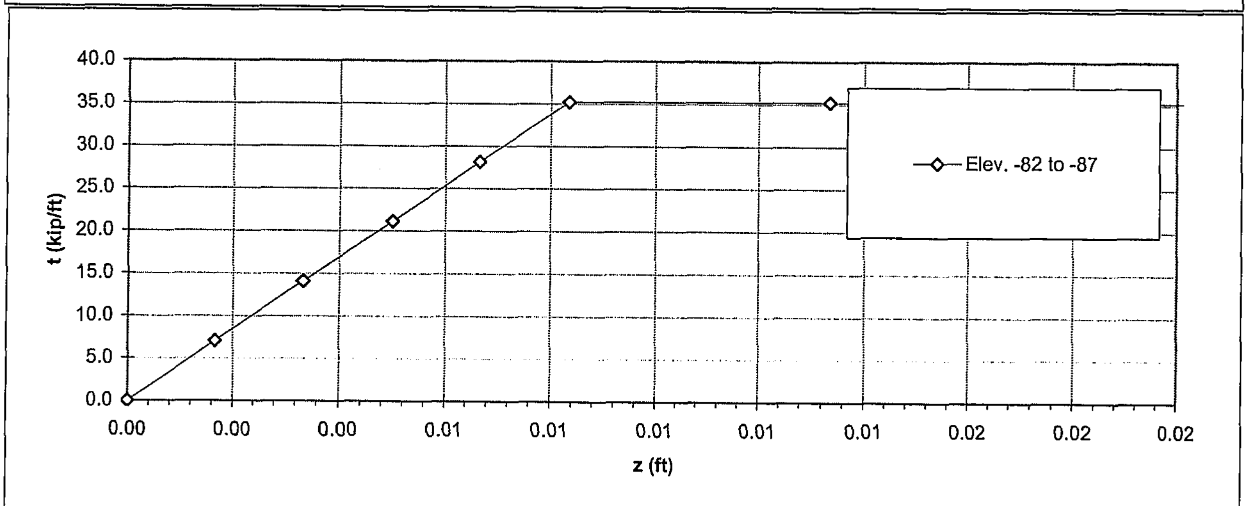
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	34.0	GWS	10.5





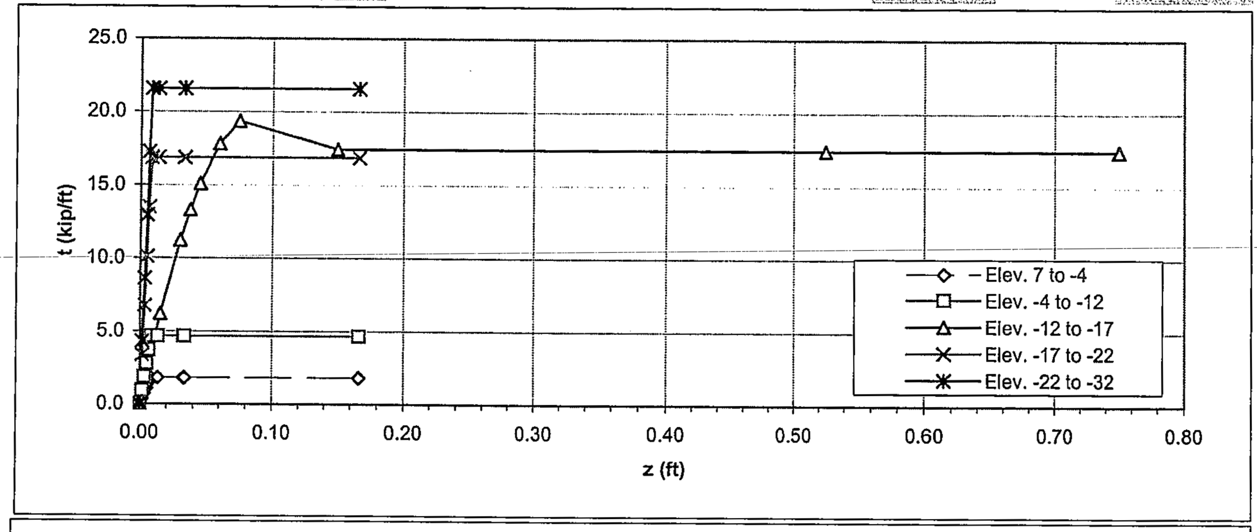


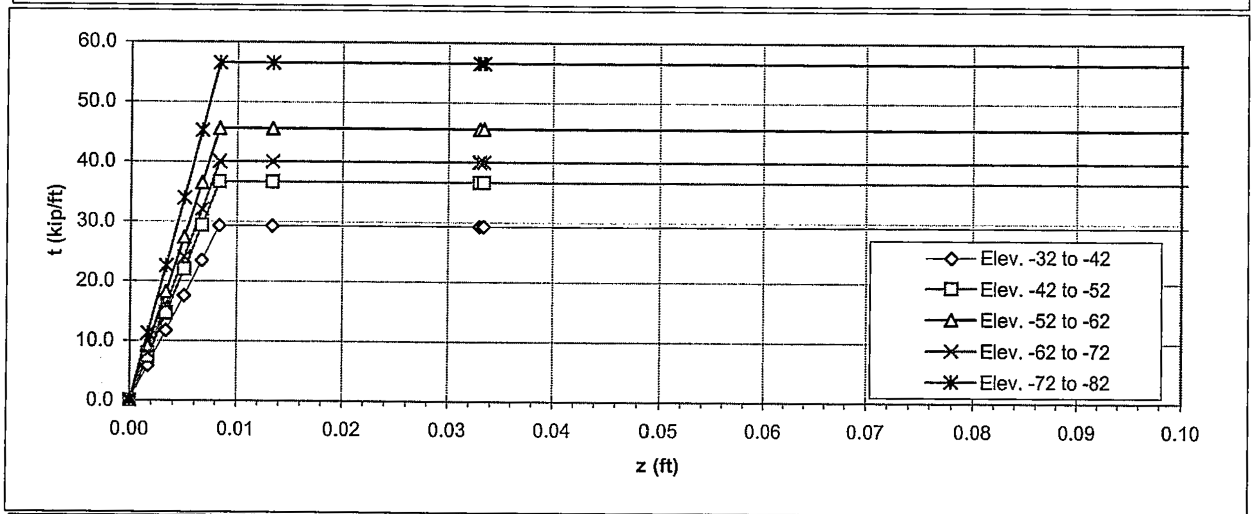
*-Liquefiable layer

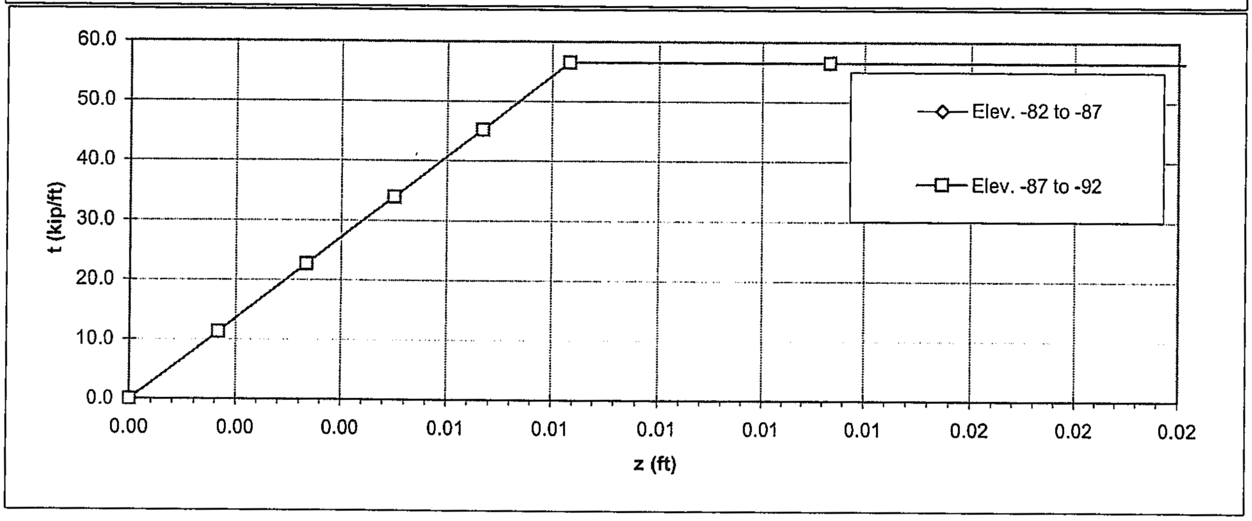
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - with Degradation

Sta.		**O. G. Elev.**	7.0	**Pile**	7.5' CISS
		Cut off Elev.	22.0	**GWS**	50.0







Feather River Bridge
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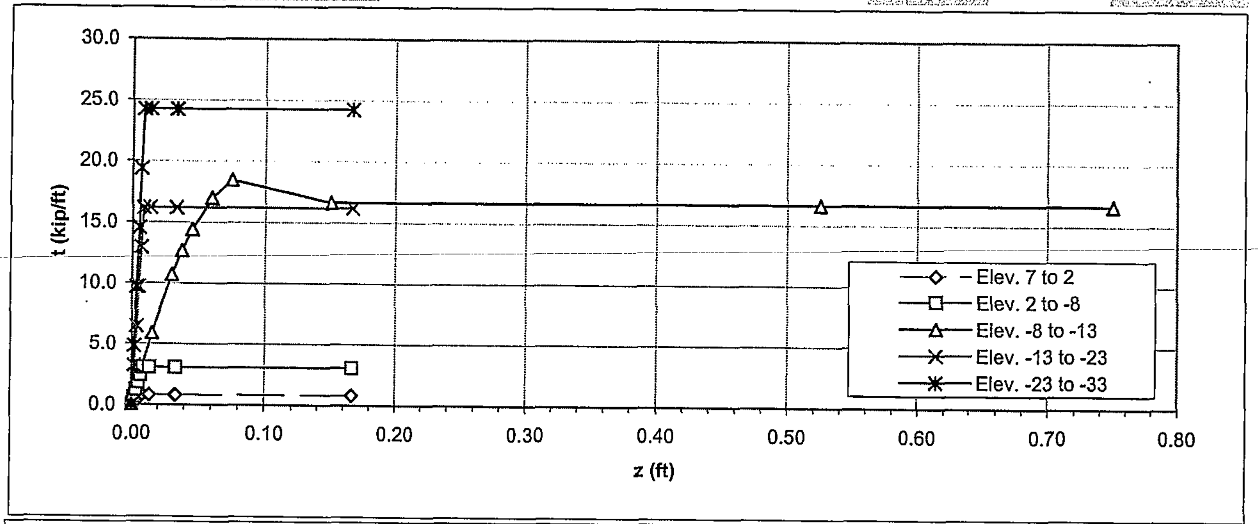
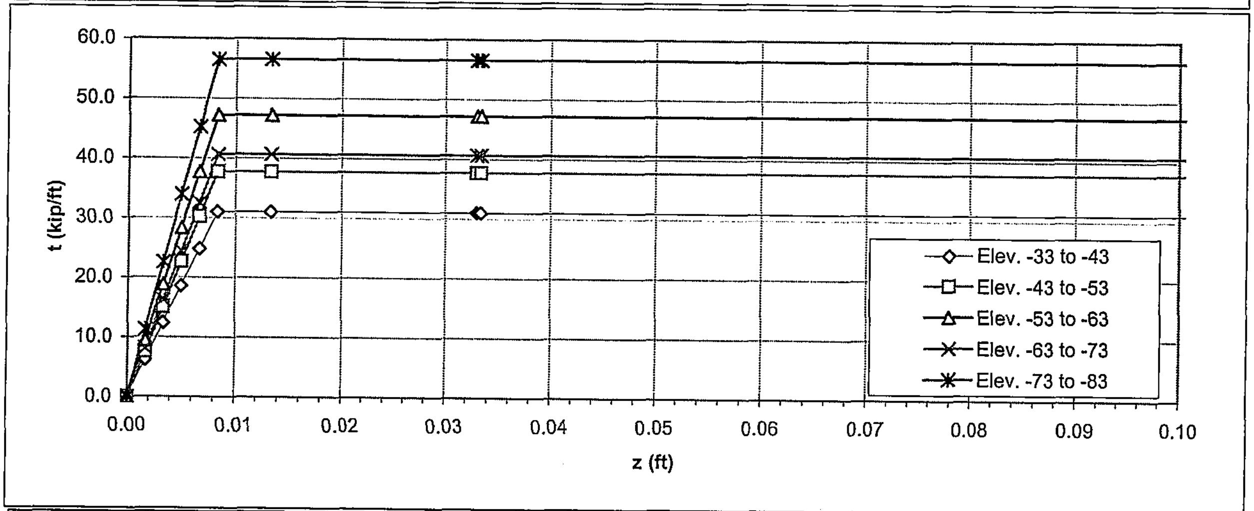
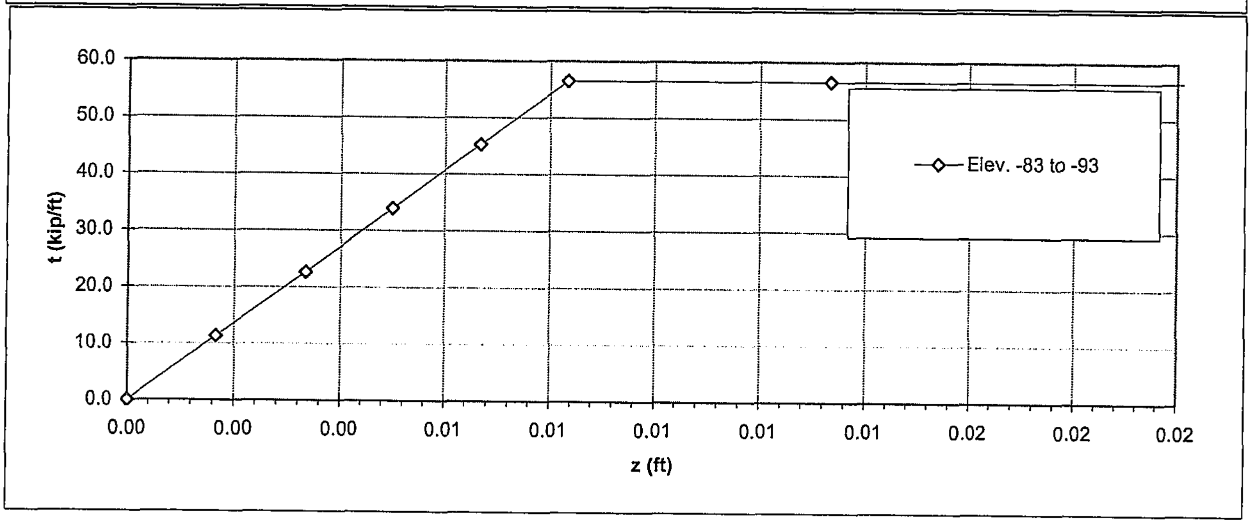
Pier 16 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	27.0	GWS	50.0







Feather River Bridge
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Pier 2 - with Degrdation

Sta.

O. G. Elev. 7.0
Cut off Elev. 18.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to 2	z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -16	z (ft)	Elev. -16 to -24	z (ft)	Elev. -24 to -30
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.8	0.00	1.7	0.02	9.3	0.02	9.5
0.00	0.0	0.00	1.5	0.00	3.5	0.03	16.9	0.03	17.2
0.01	0.0	0.01	2.3	0.01	5.2	0.04	20.1	0.04	20.4
0.01	0.0	0.01	3.1	0.01	6.9	0.05	22.8	0.05	23.1
0.01	0.0	0.01	3.9	0.01	8.7	0.06	26.9	0.06	27.3
0.01	0.0	0.01	3.9	0.01	8.7	0.08	29.2	0.08	29.7
0.03	0.0	0.03	3.9	0.03	8.7	0.15	26.3	0.15	26.7
0.03	0.0	0.03	3.9	0.03	8.7	0.53	26.3	0.53	26.7
0.17	0.0	0.17	3.9	0.17	8.7	0.75	26.3	0.75	26.7

z (ft)	Elev. -30 to -37	z (ft)	Elev. -37 to -42	z (ft)	Elev. -42 to -52	z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.02	10.0	0.00	5.9	0.00	7.7	0.00	9.8	0.00	11.3
0.03	18.2	0.00	11.9	0.00	15.3	0.00	19.7	0.00	22.6
0.04	21.5	0.01	17.8	0.01	23.0	0.01	29.5	0.01	33.9
0.05	24.4	0.01	23.8	0.01	30.7	0.01	39.4	0.01	45.2
0.06	28.8	0.01	29.7	0.01	38.4	0.01	49.2	0.01	56.5
0.08	31.3	0.01	29.7	0.01	38.4	0.01	49.2	0.01	56.5
0.15	28.2	0.03	29.7	0.03	38.4	0.03	49.2	0.03	56.5
0.53	28.2	0.03	29.7	0.03	38.4	0.03	49.2	0.03	56.5
0.75	28.2	0.17	29.7	0.17	38.4	0.17	49.2	0.17	56.5

z (ft)	Elev. -72 to -82	z (ft)	Elev. -82 to -92	z (ft)	Elev. -92 to -102				
0.00	0.0	0.00	0.0	0.00	0.0				
0.00	11.3	0.00	11.3	0.00	8.6				
0.00	22.6	0.00	22.6	0.00	17.1				
0.01	33.9	0.01	33.9	0.01	25.7				
0.01	45.2	0.01	45.2	0.01	34.3				
0.01	56.5	0.01	56.5	0.01	42.8				
0.01	56.5	0.01	56.5	0.01	42.8				
0.03	56.5	0.03	56.5	0.03	42.8				
0.03	56.5	0.03	56.5	0.03	42.8				
0.17	56.5	0.17	56.5	0.17	42.8				

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 3 - with Degrdation

Sta.

O. G. Elev. 7.0 **Pile** 7.5' CISS
Cut off Elev. 26.0 **GWS** 50.0

z (ft)	Elev. 7 to -2	z (ft)	Elev. -2 to -10	z (ft)	Elev. -10 to -20	z (ft)	Elev. -20 to -30	z (ft)	Elev. -30 to -40
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.4	0.00	1.2	0.00	1.7	0.00	2.8	0.00	3.7
0.00	0.9	0.00	2.3	0.00	3.3	0.00	5.6	0.00	7.4
0.01	1.3	0.01	3.5	0.01	5.0	0.01	8.4	0.01	11.1
0.01	1.7	0.01	4.7	0.01	6.6	0.01	11.2	0.01	14.9
0.01	2.2	0.01	5.8	0.01	8.3	0.01	14.1	0.01	18.6
0.01	2.2	0.01	5.8	0.01	8.3	0.01	14.1	0.01	18.6
0.03	2.2	0.03	5.8	0.03	8.3	0.03	14.1	0.03	18.6
0.03	2.2	0.03	5.8	0.03	8.3	0.03	14.1	0.03	18.6
0.17	2.2	0.17	5.8	0.17	8.3	0.17	14.1	0.17	18.6

z (ft)	Elev. -40 to -50	z (ft)	Elev. -50 to -55	z (ft)	Elev. -55 to -60	z (ft)	Elev. -60 to -70	z (ft)	Elev. -70 to -80
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	6.9	0.00	6.8	0.00	6.5	0.00	9.0	0.00	11.3
0.00	13.7	0.00	13.5	0.00	12.9	0.00	17.9	0.00	22.6
0.01	20.6	0.01	20.3	0.01	19.4	0.01	26.9	0.01	33.9
0.01	27.5	0.01	27.1	0.01	25.9	0.01	35.8	0.01	45.2
0.01	34.4	0.01	33.8	0.01	32.3	0.01	44.8	0.01	56.5
0.01	34.4	0.01	33.8	0.01	32.3	0.01	44.8	0.01	56.5
0.03	34.4	0.03	33.8	0.03	32.3	0.03	44.8	0.03	56.5
0.03	34.4	0.03	33.8	0.03	32.3	0.03	44.8	0.03	56.5
0.17	34.4	0.17	33.8	0.17	32.3	0.17	44.8	0.17	56.5

z (ft)	Elev. -80 to -90	z (ft)	Elev. -90 to -95	z (ft)	Elev. -95 to -100				
0.00	0.0	0.00	0.0	0.00	0.0				
0.00	11.3	0.00	7.3	0.00	7.2				
0.00	22.6	0.00	14.5	0.00	14.4				
0.01	33.9	0.01	21.8	0.01	21.7				
0.01	45.2	0.01	29.1	0.01	28.9				
0.01	56.5	0.01	36.3	0.01	36.1				
0.01	56.5	0.01	36.3	0.01	36.1				
0.03	56.5	0.03	36.3	0.03	36.1				
0.03	56.5	0.03	36.3	0.03	36.1				
0.17	56.5	0.17	36.3	0.17	36.1				

Note - t (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - with Degrdation

Sta.

O. G. Elev. 7.0
Cut off Elev. 14.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to 1	z (ft)	Elev. 1 to -6	z (ft)	Elev. -6 to -10	z (ft)	Elev. -10 to -20	z (ft)	Elev. -20 to -34
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.3	0.00	0.9	0.00	1.4	0.00	2.3	0.00	3.6
0.00	0.5	0.00	1.7	0.00	2.8	0.00	4.6	0.00	7.1
0.01	0.8	0.01	2.6	0.01	4.2	0.01	6.9	0.01	10.7
0.01	1.1	0.01	3.4	0.01	5.6	0.01	9.2	0.01	14.3
0.01	1.4	0.01	4.3	0.01	7.0	0.01	11.5	0.01	17.8
0.01	1.4	0.01	4.3	0.01	7.0	0.01	11.5	0.01	17.8
0.03	1.4	0.03	4.3	0.03	7.0	0.03	11.5	0.03	17.8
0.03	1.4	0.03	4.3	0.03	7.0	0.03	11.5	0.03	17.8
0.17	1.4	0.17	4.3	0.17	7.0	0.17	11.5	0.17	17.8

z (ft)	Elev. -34 to -40	z (ft)	Elev. -40 to -50	z (ft)	Elev. -50 to -60	z (ft)	Elev. -60 to -70	z (ft)	Elev. -70 to -80
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	6.3	0.00	7.0	0.00	9.3	0.00	11.3	0.00	8.5
0.00	12.6	0.00	13.9	0.00	18.5	0.00	22.6	0.00	17.0
0.01	18.8	0.01	20.9	0.01	27.8	0.01	33.9	0.01	25.5
0.01	25.1	0.01	27.9	0.01	37.0	0.01	45.2	0.01	34.1
0.01	31.4	0.01	34.8	0.01	46.3	0.01	56.5	0.01	42.6
0.01	31.4	0.01	34.8	0.01	46.3	0.01	56.5	0.01	42.6
0.03	31.4	0.03	34.8	0.03	46.3	0.03	56.5	0.03	42.6
0.03	31.4	0.03	34.8	0.03	46.3	0.03	56.5	0.03	42.6
0.17	31.4	0.17	34.8	0.17	46.3	0.17	56.5	0.17	42.6

z (ft)	Elev. -80 to -90	z (ft)	Elev. -90 to -100	z (ft)	Elev. -100 to -105	z (ft)	Elev. -105 to -110		
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.00	11.3	0.00	10.9	0.00	8.4	0.00	8.3		
0.00	22.6	0.00	21.8	0.00	16.7	0.00	16.7		
0.01	33.9	0.01	32.7	0.01	25.1	0.01	25.0		
0.01	45.2	0.01	43.6	0.01	33.4	0.01	33.3		
0.01	56.5	0.01	54.5	0.01	41.8	0.01	41.6		
0.01	56.5	0.01	54.5	0.01	41.8	0.01	41.6		
0.03	56.5	0.03	54.5	0.03	41.8	0.03	41.6		
0.03	56.5	0.03	54.5	0.03	41.8	0.03	41.6		
0.17	56.5	0.17	54.5	0.17	41.8	0.17	41.6		

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 5 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 12.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to 0	z (ft)	*Elev. 0 to -8	z (ft)	Elev. -8 to -15	z (ft)	Elev. -15 to -23	z (ft)	Elev. -23 to -28
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.0	0.00	1.5	0.00	2.2	0.00	3.5
0.00	0.0	0.00	0.0	0.00	3.1	0.00	4.3	0.00	6.9
0.01	0.0	0.01	0.0	0.01	4.6	0.01	6.5	0.01	10.4
0.01	0.0	0.01	0.0	0.01	6.2	0.01	8.7	0.01	13.8
0.01	0.0	0.01	0.0	0.01	7.7	0.01	10.9	0.01	17.3
0.01	0.0	0.01	0.0	0.01	7.7	0.01	10.9	0.01	17.3
0.03	0.0	0.03	0.0	0.03	7.7	0.03	10.9	0.03	17.3
0.03	0.0	0.03	0.0	0.03	7.7	0.03	10.9	0.03	17.3
0.17	0.0	0.17	0.0	0.17	7.7	0.17	10.9	0.17	17.3

z (ft)	Elev. -28 to -33	z (ft)	Elev. -33 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	3.7	0.00	4.6	0.00	5.9	0.00	8.8	0.00	10.3
0.00	7.3	0.00	9.1	0.00	11.8	0.00	17.7	0.00	20.6
0.01	11.0	0.01	13.7	0.01	17.7	0.00	26.5	0.01	30.8
0.01	14.7	0.01	18.2	0.01	23.6	0.01	35.3	0.01	41.1
0.01	18.4	0.01	22.8	0.01	29.5	0.01	44.2	0.01	51.4
0.01	18.4	0.01	22.8	0.01	29.5	0.01	44.2	0.01	51.4
0.03	18.4	0.03	22.8	0.03	29.5	0.03	44.2	0.03	51.4
0.03	18.4	0.03	22.8	0.03	29.5	0.03	44.2	0.03	51.4
0.17	18.4	0.17	22.8	0.17	29.5	0.17	44.2	0.17	51.4

z (ft)	Elev. -73 to -83	z (ft)	Elev. -83 to -93	z (ft)	Elev. -93 to -103	z (ft)	Elev. -103 to -113		
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.00	11.3	0.00	11.3	0.00	11.3	0.02	20.5		
0.00	22.6	0.00	22.6	0.00	22.6	0.03	37.1		
0.01	33.9	0.01	33.9	0.01	33.9	0.04	44.0		
0.01	45.2	0.01	45.2	0.01	45.2	0.05	49.9		
0.01	56.5	0.01	56.5	0.01	56.5	0.06	58.8		
0.01	56.5	0.01	56.5	0.01	56.5	0.08	63.9		
0.03	56.5	0.03	56.5	0.03	56.5	0.15	57.5		
0.03	56.5	0.03	56.5	0.03	56.5	0.53	57.5		
0.17	56.5	0.17	56.5	0.17	56.5	0.75	57.5		

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 19.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to 4	z (ft)	Elev. 4 to -2	z (ft)	Elev. -2 to -7	z (ft)	Elev. -7 to -12	z (ft)	Elev. -12 to -17
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.6	0.00	1.0	0.00	1.8	0.00	2.2
0.00	0.0	0.00	1.2	0.00	2.1	0.00	3.6	0.00	4.4
0.01	0.0	0.01	1.8	0.01	3.1	0.01	5.4	0.01	6.6
0.01	0.0	0.01	2.4	0.01	4.2	0.01	7.2	0.01	8.8
0.01	0.0	0.01	3.0	0.01	5.2	0.01	9.0	0.01	11.0
0.01	0.0	0.01	3.0	0.01	5.2	0.01	9.0	0.01	11.0
0.03	0.0	0.03	3.0	0.03	5.2	0.03	9.0	0.03	11.0
0.03	0.0	0.03	3.0	0.03	5.2	0.03	9.0	0.03	11.0
0.17	0.0	0.17	3.0	0.17	5.2	0.17	9.0	0.17	11.0

z (ft)	*Elev. -17 to -22	z (ft)	Elev. -22 to -27	z (ft)	Elev. -27 to -41	z (ft)	Elev. -41 to -53	z (ft)	Elev. -53 to -71
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	3.0	0.00	5.4	0.00	7.2	0.00	11.0
0.00	0.0	0.00	6.0	0.00	10.7	0.00	14.3	0.00	22.0
0.01	0.0	0.01	9.1	0.01	16.1	0.01	21.5	0.01	33.0
0.01	0.0	0.01	12.1	0.01	21.4	0.01	28.6	0.01	44.0
0.01	0.0	0.01	15.1	0.01	26.8	0.01	35.8	0.01	55.0
0.01	0.0	0.01	15.1	0.01	26.8	0.01	35.8	0.01	55.0
0.03	0.0	0.03	15.1	0.03	26.8	0.03	35.8	0.03	55.0
0.03	0.0	0.03	15.1	0.03	26.8	0.03	35.8	0.03	55.0
0.17	0.0	0.17	15.1	0.17	26.8	0.17	35.8	0.17	55.0

z (ft)	Elev. -71 to -81	z (ft)	Elev. -81 to -91	z (ft)	Elev. -91 to -98	z (ft)	Elev. -98 to -103		
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.00	11.3	0.00	11.3	0.00	9.2	0.02	20.3		
0.00	22.6	0.00	22.6	0.00	18.4	0.03	36.8		
0.01	33.9	0.01	33.9	0.01	27.5	0.04	43.7		
0.01	45.2	0.01	45.2	0.01	36.7	0.05	49.5		
0.01	56.5	0.01	56.5	0.01	45.9	0.06	58.4		
0.01	56.5	0.01	56.5	0.01	45.9	0.08	63.5		
0.03	56.5	0.03	56.5	0.03	45.9	0.15	57.2		
0.03	56.5	0.03	56.5	0.03	45.9	0.53	57.2		
0.17	56.5	0.17	56.5	0.17	45.9	0.75	57.2		

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 7 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 17.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	*Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -28	z (ft)	Elev. -28 to -38
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.4	0.00	0.0	0.00	2.5	0.00	4.2	0.00	5.1
0.00	0.8	0.00	0.0	0.00	4.9	0.00	8.5	0.00	10.3
0.01	1.3	0.01	0.0	0.01	7.4	0.01	12.7	0.01	15.4
0.01	1.7	0.01	0.0	0.01	9.9	0.01	16.9	0.01	20.5
0.01	2.1	0.01	0.0	0.01	12.3	0.01	21.1	0.01	25.6
0.01	2.1	0.01	0.0	0.01	12.3	0.01	21.1	0.01	25.6
0.03	2.1	0.03	0.0	0.03	12.3	0.03	21.1	0.03	25.6
0.03	2.1	0.03	0.0	0.03	12.3	0.03	21.1	0.03	25.6
0.17	2.1	0.17	0.0	0.17	12.3	0.17	21.1	0.17	25.6

z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68	z (ft)	Elev. -68 to -78	z (ft)	Elev. -78 to -88
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	6.6	0.00	8.8	0.00	11.0	0.00	11.3	0.00	11.3
0.00	13.2	0.00	17.7	0.00	22.1	0.00	22.6	0.00	22.6
0.01	19.7	0.01	26.5	0.01	33.1	0.01	33.9	0.01	33.9
0.01	26.3	0.01	35.3	0.01	44.2	0.01	45.2	0.01	45.2
0.01	32.9	0.01	44.2	0.01	55.2	0.01	56.5	0.01	56.5
0.01	32.9	0.01	44.2	0.01	55.2	0.01	56.5	0.01	56.5
0.03	32.9	0.03	44.2	0.03	55.2	0.03	56.5	0.03	56.5
0.03	32.9	0.03	44.2	0.03	55.2	0.03	56.5	0.03	56.5
0.17	32.9	0.17	44.2	0.17	55.2	0.17	56.5	0.17	56.5

z (ft)	Elev. -88 to -93	z (ft)	Elev. -93 to -98	z (ft)	Elev. -98 to -103	z (ft)	Elev. -103 to -108	z (ft)	Elev.
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.00	9.5	0.00	9.4	0.02	19.1	0.02	19.6		
0.00	19.1	0.00	18.8	0.03	34.7	0.03	35.6		
0.01	28.6	0.01	28.2	0.04	41.1	0.04	42.2		
0.01	38.2	0.01	37.5	0.05	46.6	0.05	47.8		
0.01	47.7	0.01	46.9	0.06	55.0	0.06	56.4		
0.01	47.7	0.01	46.9	0.08	59.8	0.08	61.3		
0.03	47.7	0.03	46.9	0.15	53.8	0.15	55.2		
0.03	47.7	0.03	46.9	0.53	53.8	0.53	55.2		
0.17	47.7	0.17	46.9	0.75	53.8	0.75	55.2		

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - with Degradation

Sta.

O. G. Elev. 7.0 **Pile** 7.5' CISS
Cut off Elev. 37.0 **GWS** 50.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -18	z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.4	0.02	5.4	0.00	2.2	0.00	4.4	0.00	4.9
0.00	0.8	0.03	9.9	0.00	4.4	0.00	8.7	0.00	9.7
0.01	1.3	0.04	11.7	0.01	6.6	0.01	13.1	0.01	14.6
0.01	1.7	0.05	13.3	0.01	8.7	0.01	17.5	0.01	19.5
0.01	2.1	0.06	15.6	0.01	10.9	0.01	21.8	0.01	24.3
0.01	2.1	0.08	17.0	0.01	10.9	0.01	21.8	0.01	24.3
0.03	2.1	0.15	15.3	0.03	10.9	0.03	21.8	0.03	24.3
0.03	2.1	0.53	15.3	0.03	10.9	0.03	21.8	0.03	24.3
0.17	2.1	0.75	15.3	0.17	10.9	0.17	21.8	0.17	24.3

z (ft)	Elev. -38 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	7.1	0.00	7.3	0.00	9.0	0.00	11.1	0.00	11.3
0.00	14.3	0.00	14.6	0.00	18.1	0.00	22.3	0.00	22.6
0.01	21.4	0.01	21.9	0.01	27.1	0.01	33.4	0.01	33.9
0.01	28.5	0.01	29.2	0.01	36.1	0.01	44.5	0.01	45.2
0.01	35.7	0.01	36.6	0.01	45.2	0.01	55.6	0.01	56.5
0.01	35.7	0.01	36.6	0.01	45.2	0.01	55.6	0.01	56.5
0.03	35.7	0.03	36.6	0.03	45.2	0.03	55.6	0.03	56.5
0.03	35.7	0.03	36.6	0.03	45.2	0.03	55.6	0.03	56.5
0.17	35.7	0.17	36.6	0.17	45.2	0.17	55.6	0.17	56.5

z (ft)	Elev. -78 to -83	z (ft)	Elev.	z (ft)	Elev.	z (ft)	Elev.	z (ft)	Elev.
0.00	0.0								
0.00	11.3								
0.00	22.6								
0.01	33.9								
0.01	45.2								
0.01	56.5								
0.01	56.5								
0.03	56.5								
0.03	56.5								
0.17	56.5								

Note - t (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 37.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33	z (ft)	Elev. -33 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.4	0.02	5.4	0.00	3.8	0.00	5.2	0.00	6.3
0.00	0.8	0.03	9.7	0.00	7.5	0.00	10.4	0.00	12.7
0.01	1.3	0.04	11.5	0.01	11.3	0.01	15.6	0.01	19.0
0.01	1.7	0.05	13.1	0.01	15.0	0.01	20.7	0.01	25.3
0.01	2.1	0.06	15.4	0.01	18.8	0.01	25.9	0.01	31.6
0.01	2.1	0.08	16.7	0.01	18.8	0.01	25.9	0.01	31.6
0.03	2.1	0.15	15.1	0.03	18.8	0.03	25.9	0.03	31.6
0.03	2.1	0.53	15.1	0.03	18.8	0.03	25.9	0.03	31.6
0.17	2.1	0.75	15.1	0.17	18.8	0.17	25.9	0.17	31.6

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78	z (ft)	Elev. -78 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	8.3	0.00	10.1	0.00	11.3	0.00	11.3	0.00	11.2
0.00	16.6	0.00	20.3	0.00	22.6	0.00	22.6	0.00	22.3
0.01	24.9	0.01	30.4	0.01	33.9	0.01	33.9	0.01	33.5
0.01	33.2	0.01	40.6	0.01	45.2	0.01	45.2	0.01	44.6
0.01	41.5	0.01	50.7	0.01	56.5	0.01	56.5	0.01	55.8
0.01	41.5	0.01	50.7	0.01	56.5	0.01	56.5	0.01	55.8
0.03	41.5	0.03	50.7	0.03	56.5	0.03	56.5	0.03	55.8
0.03	41.5	0.03	50.7	0.03	56.5	0.03	56.5	0.03	55.8
0.17	41.5	0.17	50.7	0.17	56.5	0.17	56.5	0.17	55.8

Note - t (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 10 and 11 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 37.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to 2	z (ft)	*Elev. 2 to -3	z (ft)	*Elev. -3 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -18
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.2	0.00	0.0	0.00	0.0	0.00	1.7	0.00	2.5
0.00	0.3	0.00	0.0	0.00	0.0	0.00	3.3	0.00	5.0
0.01	0.5	0.01	0.0	0.01	0.0	0.01	5.0	0.01	7.5
0.01	0.7	0.01	0.0	0.01	0.0	0.01	6.6	0.01	10.0
0.01	0.8	0.01	0.0	0.01	0.0	0.01	8.3	0.01	12.5
0.01	0.8	0.01	0.0	0.01	0.0	0.01	8.3	0.01	12.5
0.03	0.8	0.03	0.0	0.03	0.0	0.03	8.3	0.03	12.5
0.03	0.8	0.03	0.0	0.03	0.0	0.03	8.3	0.03	12.5
0.17	0.8	0.17	0.0	0.17	0.0	0.17	8.3	0.17	12.5

z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38	z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	4.3	0.00	6.2	0.00	6.7	0.00	9.3	0.00	11.3
0.00	8.6	0.00	12.3	0.00	13.3	0.00	18.6	0.00	22.6
0.01	12.9	0.01	18.5	0.01	20.0	0.01	27.9	0.01	33.9
0.01	17.2	0.01	24.7	0.01	26.6	0.01	37.2	0.01	45.2
0.01	21.5	0.01	30.8	0.01	33.3	0.01	46.5	0.01	56.5
0.01	21.5	0.01	30.8	0.01	33.3	0.01	46.5	0.01	56.5
0.03	21.5	0.03	30.8	0.03	33.3	0.03	46.5	0.03	56.5
0.03	21.5	0.03	30.8	0.03	33.3	0.03	46.5	0.03	56.5
0.17	21.5	0.17	30.8	0.17	33.3	0.17	46.5	0.17	56.5

z (ft)	Elev. -68 to -78	z (ft)	Elev. -78 to -88						
0.00	0.0	0.00	0.0						
0.00	9.4	0.00	9.1						
0.00	18.8	0.00	18.2						
0.01	28.3	0.01	27.4						
0.01	37.7	0.01	36.5						
0.01	47.1	0.01	45.6						
0.01	47.1	0.01	45.6						
0.03	47.1	0.03	45.6						
0.03	47.1	0.03	45.6						
0.17	47.1	0.17	45.6						

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 36.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -9	z (ft)	Elev. -9 to -19	z (ft)	Elev. -19 to -29	z (ft)	Elev. -29 to -39
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.02	0.0	0.00	0.5	0.00	2.4	0.00	4.6	0.00	5.3
0.03	0.0	0.00	1.1	0.00	4.8	0.00	9.1	0.00	10.5
0.04	0.0	0.01	1.6	0.01	7.2	0.01	13.7	0.01	15.8
0.05	0.0	0.01	2.2	0.01	9.6	0.01	18.3	0.01	21.1
0.06	0.0	0.01	2.7	0.01	12.0	0.01	22.8	0.01	26.3
0.08	0.0	0.01	2.7	0.01	12.0	0.01	22.8	0.01	26.3
0.15	0.0	0.03	2.7	0.03	12.0	0.03	22.8	0.03	26.3
0.53	0.0	0.03	2.7	0.03	12.0	0.03	22.8	0.03	26.3
0.75	0.0	0.17	2.7	0.17	12.0	0.17	22.8	0.17	26.3

z (ft)	Elev. -39 to -46	z (ft)	Elev. -46 to -54	z (ft)	Elev. -54 to -59	z (ft)	Elev. -59 to -64	z (ft)	Elev. -64 to -74
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	5.8	0.00	8.0	0.00	9.1	0.00	8.3	0.00	11.3
0.00	11.6	0.00	16.0	0.00	18.2	0.00	16.6	0.00	22.6
0.01	17.4	0.01	24.1	0.01	27.3	0.01	24.8	0.01	33.9
0.01	23.2	0.01	32.1	0.01	36.4	0.01	33.1	0.01	45.2
0.01	29.0	0.01	40.1	0.01	45.5	0.01	41.4	0.01	56.5
0.01	29.0	0.01	40.1	0.01	45.5	0.01	41.4	0.01	56.5
0.03	29.0	0.03	40.1	0.03	45.5	0.03	41.4	0.03	56.5
0.03	29.0	0.03	40.1	0.03	45.5	0.03	41.4	0.03	56.5
0.17	29.0	0.17	40.1	0.17	45.5	0.17	41.4	0.17	56.5

z (ft)	Elev. -74 to -84								
0.00	0.0								
0.00	11.3								
0.00	22.6								
0.01	33.9								
0.01	45.2								
0.01	56.5								
0.01	56.5								
0.03	56.5								
0.03	56.5								
0.17	56.5								

Note - t (kip/ft)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. -35.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to -6	z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -46
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.9	0.00	3.5	0.00	4.0	0.00	4.6
0.00	0.0	0.00	1.9	0.00	6.9	0.00	8.0	0.00	9.3
0.01	0.0	0.01	2.8	0.01	10.4	0.01	12.0	0.01	13.9
0.01	0.0	0.01	3.8	0.01	13.8	0.01	16.0	0.01	18.5
0.01	0.0	0.01	4.7	0.01	17.3	0.01	20.0	0.01	23.2
0.01	0.0	0.01	4.7	0.01	17.3	0.01	20.0	0.01	23.2
0.03	0.0	0.03	4.7	0.03	17.3	0.03	20.0	0.03	23.2
0.03	0.0	0.03	4.7	0.03	17.3	0.03	20.0	0.03	23.2
0.17	0.0	0.17	4.7	0.17	17.3	0.17	20.0	0.17	23.2

z (ft)	Elev. -46 to -56	z (ft)	Elev. -56 to -66	z (ft)	Elev. -66 to -76	z (ft)	Elev. -76 to -86	z (ft)	Elev. -86 to -91
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	7.1	0.00	8.8	0.00	10.7	0.00	8.5	0.00	9.0
0.00	14.2	0.00	17.5	0.00	21.3	0.00	16.9	0.00	18.0
0.01	21.4	0.01	26.3	0.01	32.0	0.01	25.4	0.01	27.0
0.01	28.5	0.01	35.1	0.01	42.6	0.01	33.9	0.01	36.0
0.01	35.6	0.01	43.8	0.01	53.3	0.01	42.3	0.01	45.0
0.01	35.6	0.01	43.8	0.01	53.3	0.01	42.3	0.01	45.0
0.03	35.6	0.03	43.8	0.03	53.3	0.03	42.3	0.03	45.0
0.03	35.6	0.03	43.8	0.03	53.3	0.03	42.3	0.03	45.0
0.17	35.6	0.17	43.8	0.17	53.3	0.17	42.3	0.17	45.0

z (ft)	Elev. -91 to -96								
0.00	0.0								
0.00	8.9								
0.00	17.8								
0.01	26.7								
0.01	35.6								
0.01	44.6								
0.01	44.6								
0.03	44.6								
0.03	44.6								
0.17	44.6								

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 34.0
Pile 7.5' CISS
GWS 10.5

z (ft)	*Elev. 7 to -6	z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -47
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.0	0.00	0.9	0.00	3.5	0.00	3.8	0.00	4.8
0.00	0.0	0.00	1.9	0.00	7.0	0.00	7.6	0.00	9.6
0.01	0.0	0.01	2.8	0.01	10.5	0.01	11.4	0.01	14.4
0.01	0.0	0.01	3.8	0.01	14.0	0.01	15.2	0.01	19.1
0.01	0.0	0.01	4.7	0.01	17.4	0.01	19.0	0.01	23.9
0.01	0.0	0.01	4.7	0.01	17.4	0.01	19.0	0.01	23.9
0.03	0.0	0.03	4.7	0.03	17.4	0.03	19.0	0.03	23.9
0.03	0.0	0.03	4.7	0.03	17.4	0.03	19.0	0.03	23.9
0.17	0.0	0.17	4.7	0.17	17.4	0.17	19.0	0.17	23.9

z (ft)	Elev. -47 to -57	z (ft)	Elev. -57 to -62	z (ft)	Elev. -62 to -67	z (ft)	Elev. -67 to -77	z (ft)	Elev. -77 to -82
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	7.2	0.00	9.3	0.02	10.7	0.00	9.0	0.00	7.1
0.00	14.5	0.00	18.5	0.03	19.4	0.00	17.9	0.00	14.2
0.01	21.7	0.01	27.8	0.04	23.0	0.01	26.9	0.01	21.3
0.01	28.9	0.01	37.1	0.05	26.1	0.01	35.8	0.01	28.4
0.01	36.2	0.01	46.3	0.06	30.8	0.01	44.8	0.01	35.5
0.01	36.2	0.01	46.3	0.08	33.5	0.01	44.8	0.01	35.5
0.03	36.2	0.03	46.3	0.15	30.1	0.03	44.8	0.03	35.5
0.03	36.2	0.03	46.3	0.53	30.1	0.03	44.8	0.03	35.5
0.17	36.2	0.17	46.3	0.75	30.1	0.17	44.8	0.17	35.5

z (ft)	Elev. -82 to -87								
0.00	0.0								
0.00	7.0								
0.00	14.1								
0.01	21.1								
0.01	28.2								
0.01	35.2								
0.01	35.2								
0.03	35.2								
0.03	35.2								
0.17	35.2								

Note - t (kip/ft)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 22.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -4	z (ft)	Elev. -4 to -12	z (ft)	Elev. -12 to -17	z (ft)	Elev. -17 to -22	z (ft)	Elev. -22 to -32
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.4	0.00	0.9	0.02	6.2	0.00	3.4	0.00	4.3
0.00	0.7	0.00	1.9	0.03	11.2	0.00	6.7	0.00	8.6
0.01	1.1	0.01	2.8	0.04	13.3	0.01	10.1	0.01	12.9
0.01	1.5	0.01	3.7	0.05	15.1	0.01	13.5	0.01	17.3
0.01	1.8	0.01	4.7	0.06	17.8	0.01	16.9	0.01	21.6
0.01	1.8	0.01	4.7	0.08	19.4	0.01	16.9	0.01	21.6
0.03	1.8	0.03	4.7	0.15	17.4	0.03	16.9	0.03	21.6
0.03	1.8	0.03	4.7	0.53	17.4	0.03	16.9	0.03	21.6
0.17	1.8	0.17	4.7	0.75	17.4	0.17	16.9	0.17	21.6

z (ft)	Elev. -32 to -42	z (ft)	Elev. -42 to -52	z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72	z (ft)	Elev. -72 to -82
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	5.9	0.00	7.3	0.00	9.1	0.00	8.0	0.00	11.3
0.00	11.7	0.00	14.7	0.00	18.2	0.00	16.0	0.00	22.6
0.01	17.6	0.01	22.0	0.01	27.4	0.01	24.0	0.01	33.9
0.01	23.5	0.01	29.3	0.01	36.5	0.01	32.1	0.01	45.2
0.01	29.3	0.01	36.7	0.01	45.6	0.01	40.1	0.01	56.5
0.01	29.3	0.01	36.7	0.01	45.6	0.01	40.1	0.01	56.5
0.03	29.3	0.03	36.7	0.03	45.6	0.03	40.1	0.03	56.5
0.03	29.3	0.03	36.7	0.03	45.6	0.03	40.1	0.03	56.5
0.17	29.3	0.17	36.7	0.17	45.6	0.17	40.1	0.17	56.5

z (ft)	Elev. -82 to -87	z (ft)	Elev. -87 to -92						
0.00	0.0	0.00	0.0						
0.00	11.3	0.00	11.3						
0.00	22.6	0.00	22.6						
0.01	33.9	0.01	33.9						
0.01	45.2	0.01	45.2						
0.01	56.5	0.01	56.5						
0.01	56.5	0.01	56.5						
0.03	56.5	0.03	56.5						
0.03	56.5	0.03	56.5						
0.17	56.5	0.17	56.5						

Note - t (kip/ft)

Feather River Bridge
Br. No. 18-0026R
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Pier 16 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 27.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to 2	z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	0.2	0.00	0.6	0.02	5.9	0.00	3.2	0.00	4.8
0.00	0.3	0.00	1.2	0.03	10.7	0.00	6.5	0.00	9.7
0.01	0.5	0.01	1.8	0.04	12.7	0.01	9.7	0.01	14.5
0.01	0.7	0.01	2.4	0.05	14.4	0.01	13.0	0.01	19.4
0.01	0.8	0.01	3.1	0.06	17.0	0.01	16.2	0.01	24.2
0.01	0.8	0.01	3.1	0.08	18.5	0.01	16.2	0.01	24.2
0.03	0.8	0.03	3.1	0.15	16.6	0.03	16.2	0.03	24.2
0.03	0.8	0.03	3.1	0.53	16.6	0.03	16.2	0.03	24.2
0.17	0.8	0.17	3.1	0.75	16.6	0.17	16.2	0.17	24.2

z (ft)	Elev. -33 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.00	6.2	0.00	7.5	0.00	9.4	0.00	8.1	0.00	11.3
0.00	12.4	0.00	15.1	0.00	18.9	0.00	16.3	0.00	22.6
0.01	18.6	0.01	22.6	0.01	28.3	0.01	24.4	0.01	33.9
0.01	24.8	0.01	30.2	0.01	37.7	0.01	32.5	0.01	45.2
0.01	31.0	0.01	37.7	0.01	47.2	0.01	40.7	0.01	56.5
0.01	31.0	0.01	37.7	0.01	47.2	0.01	40.7	0.01	56.5
0.03	31.0	0.03	37.7	0.03	47.2	0.03	40.7	0.03	56.5
0.03	31.0	0.03	37.7	0.03	47.2	0.03	40.7	0.03	56.5
0.17	31.0	0.17	37.7	0.17	47.2	0.17	40.7	0.17	56.5

z (ft)	Elev. -83 to -93								
0.00	0.0								
0.00	11.3								
0.00	22.6								
0.01	33.9								
0.01	45.2								
0.01	56.5								
0.01	56.5								
0.03	56.5								
0.03	56.5								
0.17	56.5								

Note - t (kip/ft)

Appendix D

Tip Resistance, q-z Curves

Loading Condition:

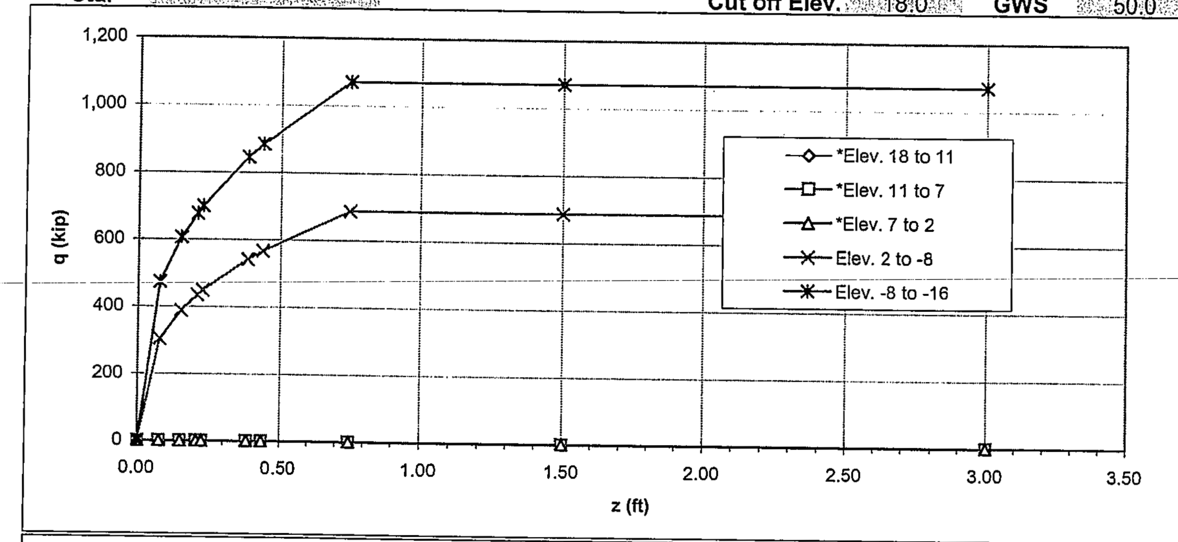
With and Without Channel Degradation

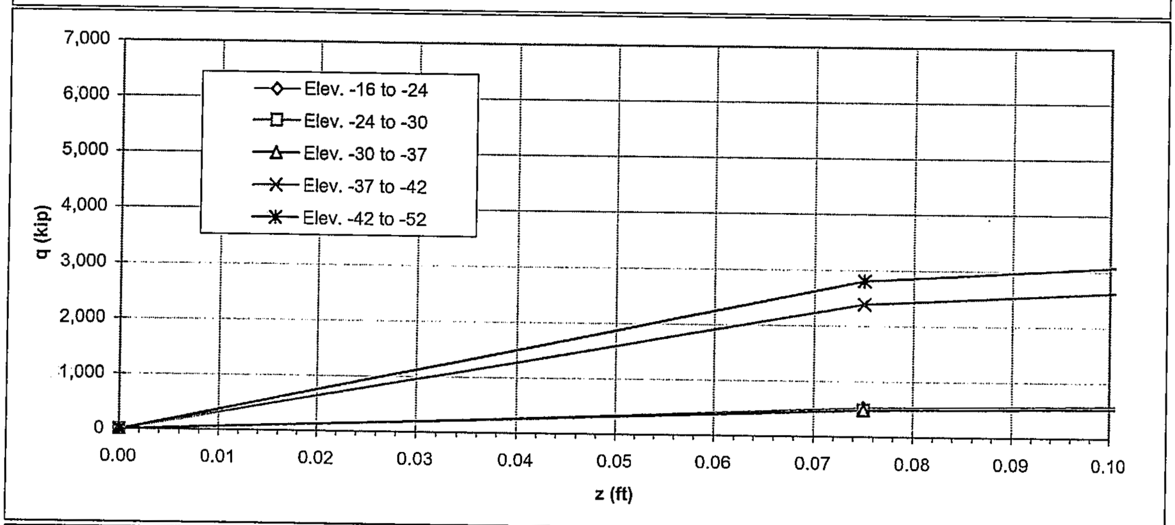
Feather River Bridge
Br. No. 18-0026R
03-1A4321

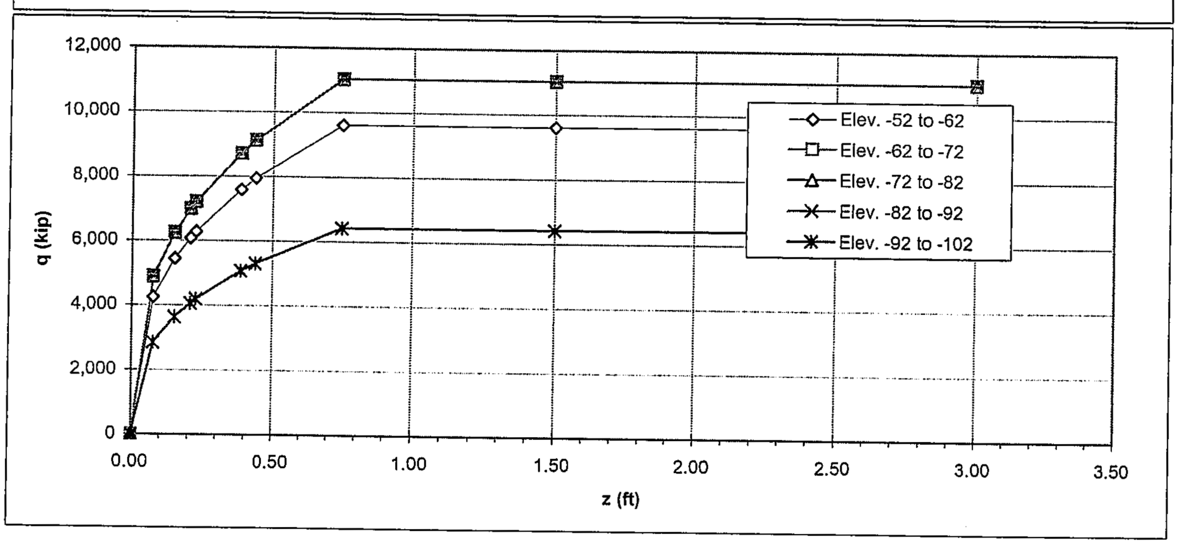
Pier 2 - No Degrdation

Sta.

O. G. Elev.	18.0	**Pile**	7.5' CISS
Cut off Elev.	18.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
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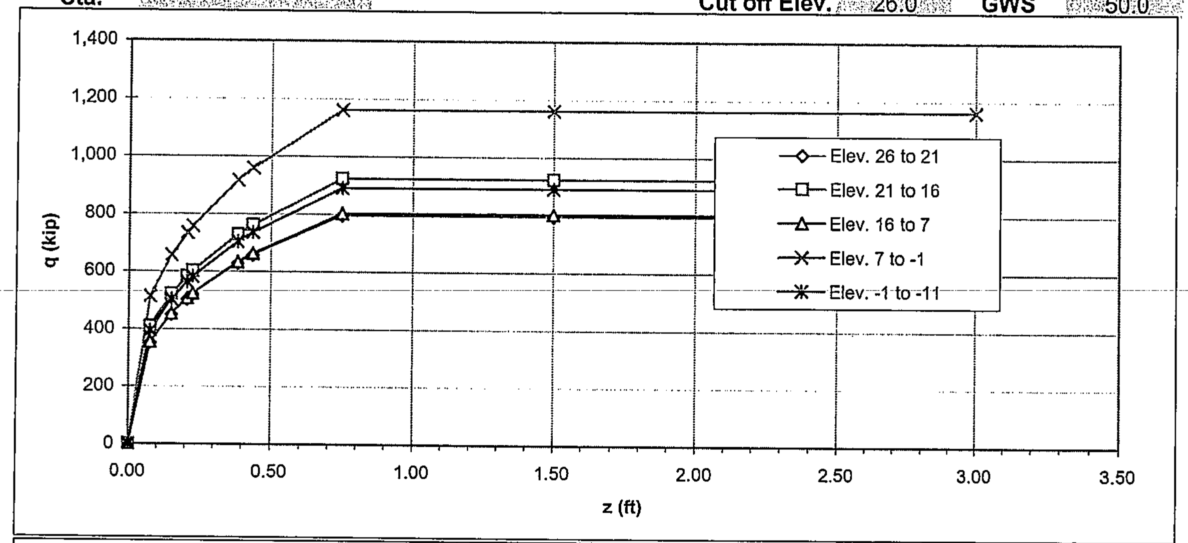
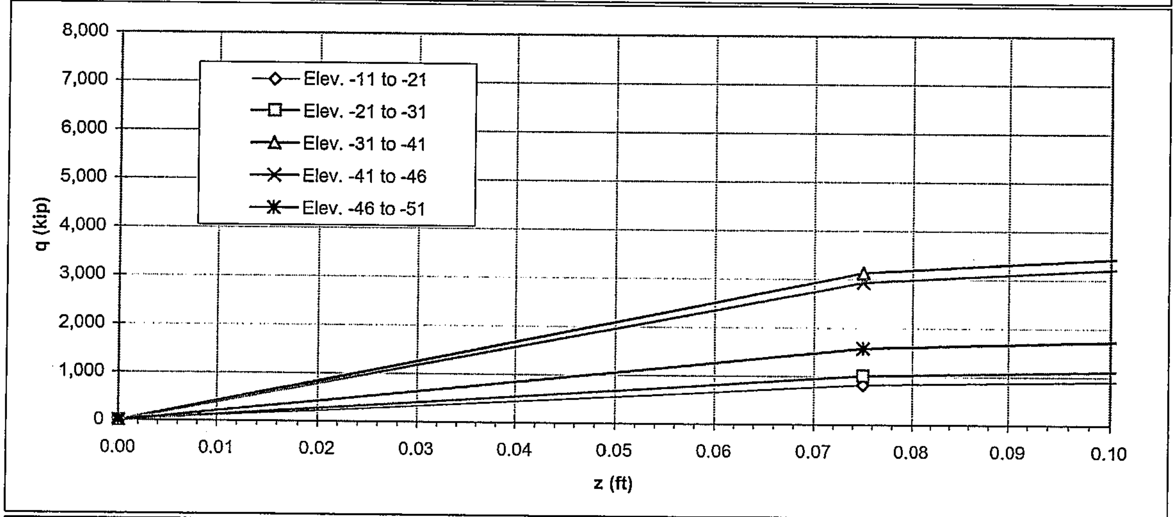
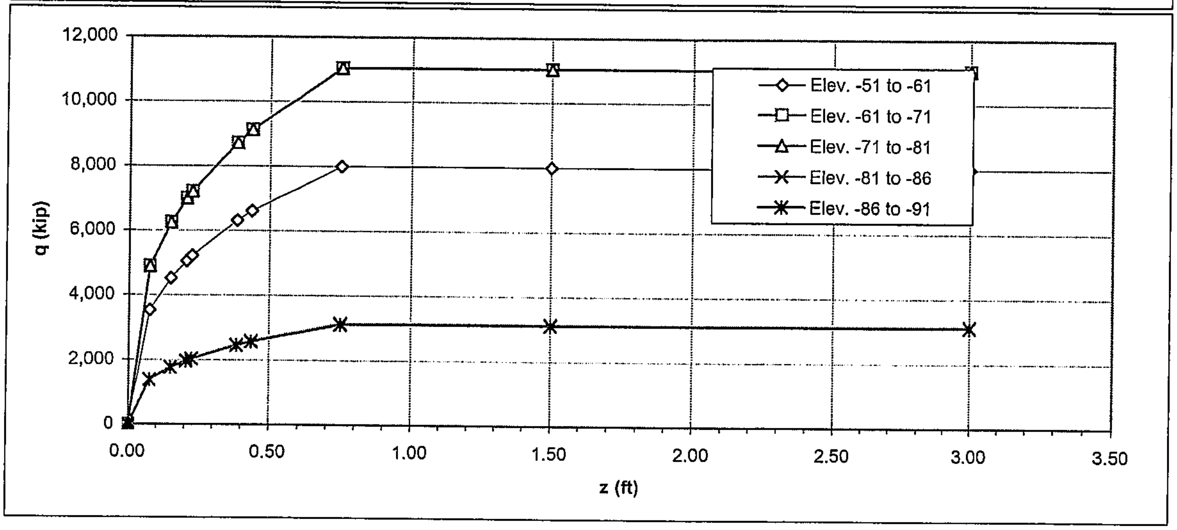
Pier 3 - No Degrdation

Sta.		O. G. Elev.	26.0	Pile	7.5' CISS
		Cut off Elev.	26.0	GWS	50.0







Feather River Bridge
Br. No. 18-0026R
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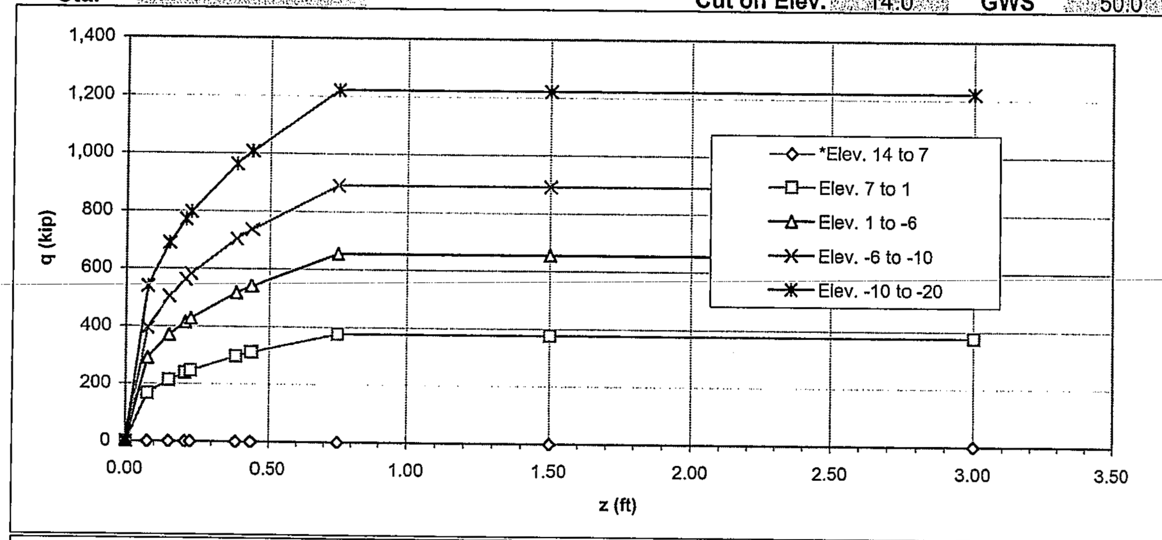
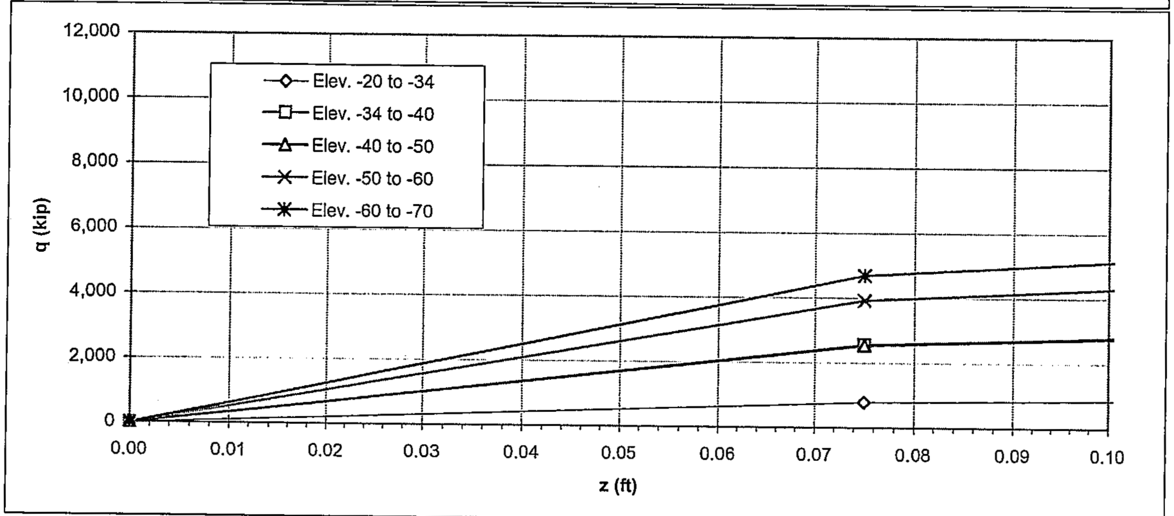
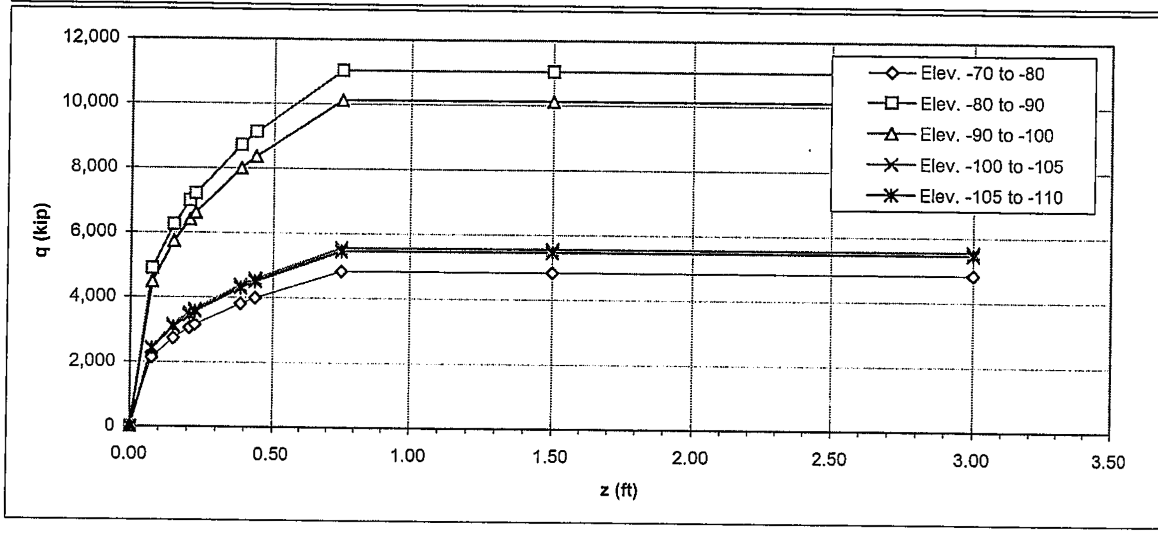
Pier 4 - No Degrdation

Sta.		**O. G. Elev.**	14.0	**Pile**	7.5' CISS
		Cut off Elev.	14.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
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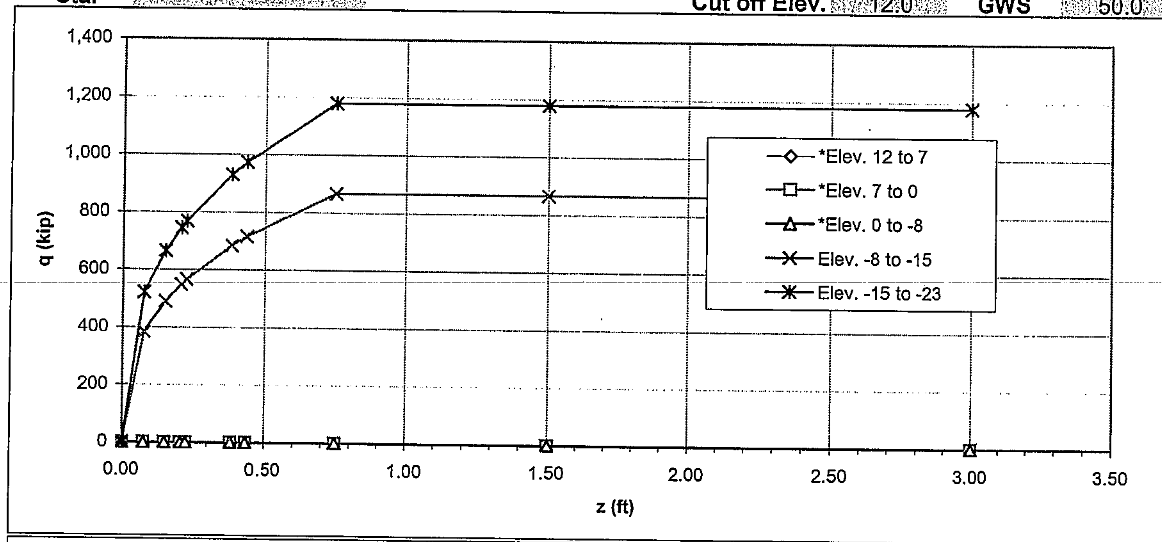
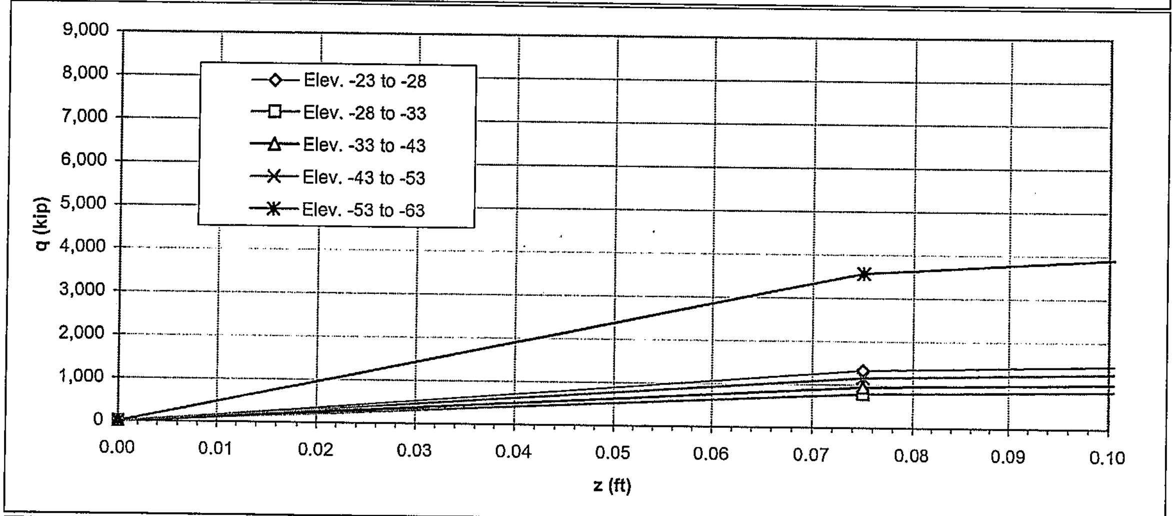
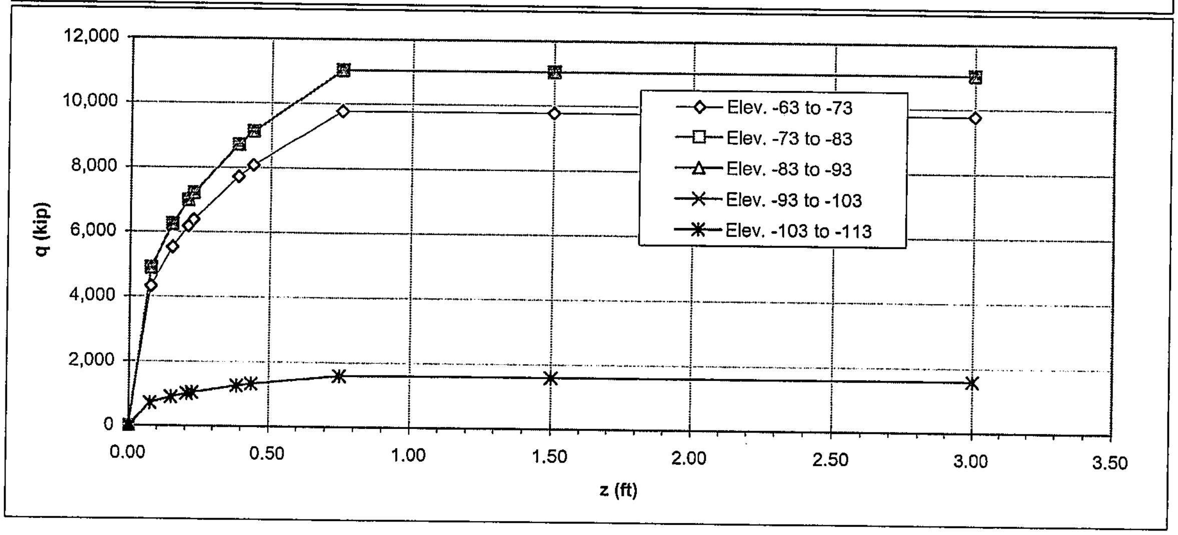
Pier 5 - No Degradation

Sta.		O. G. Elev.	12.0	Pile	7.5' CISS
		Cut off Elev.	12.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
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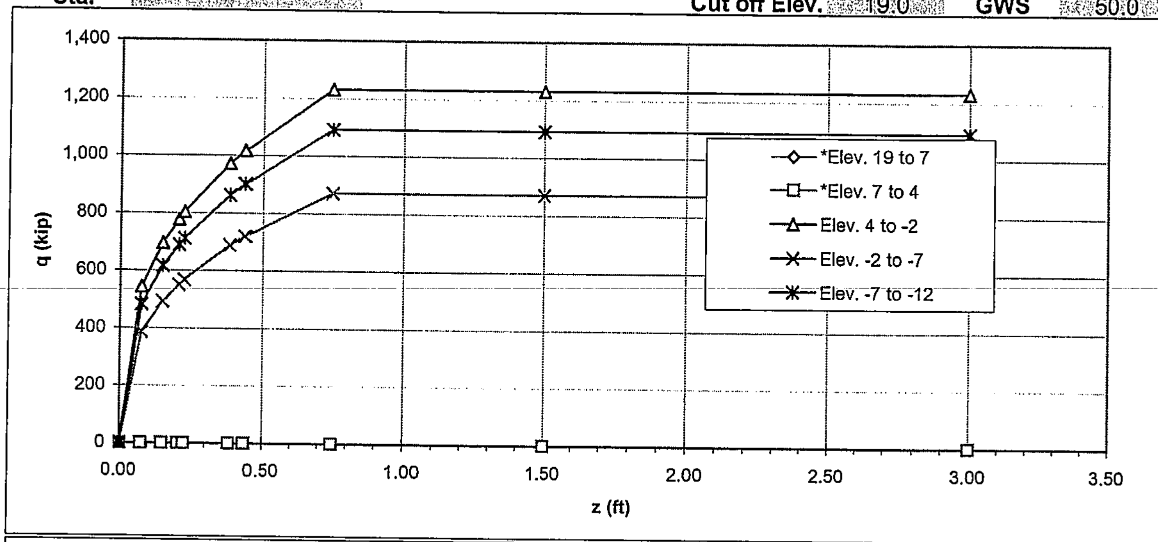
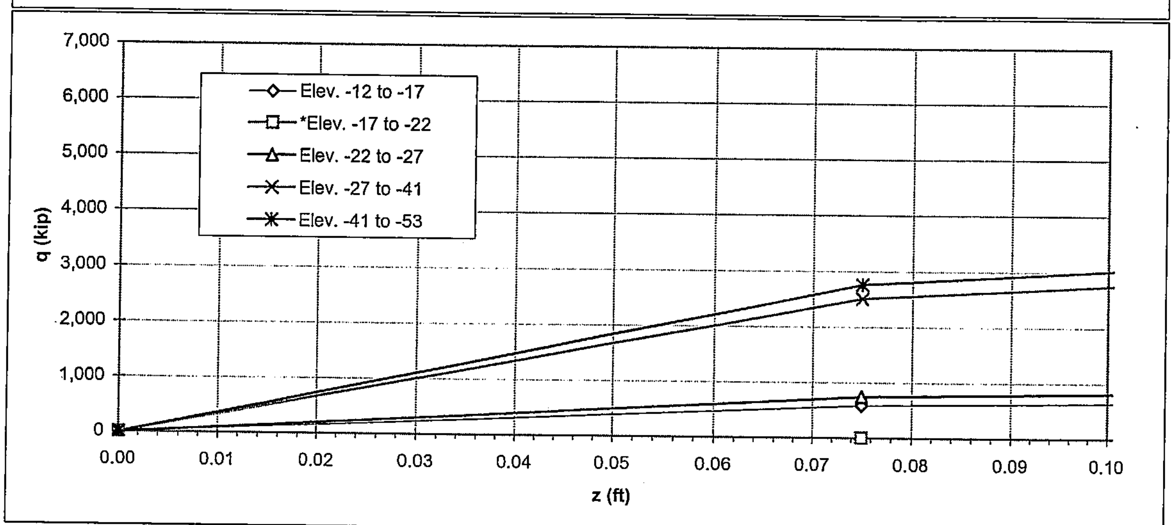
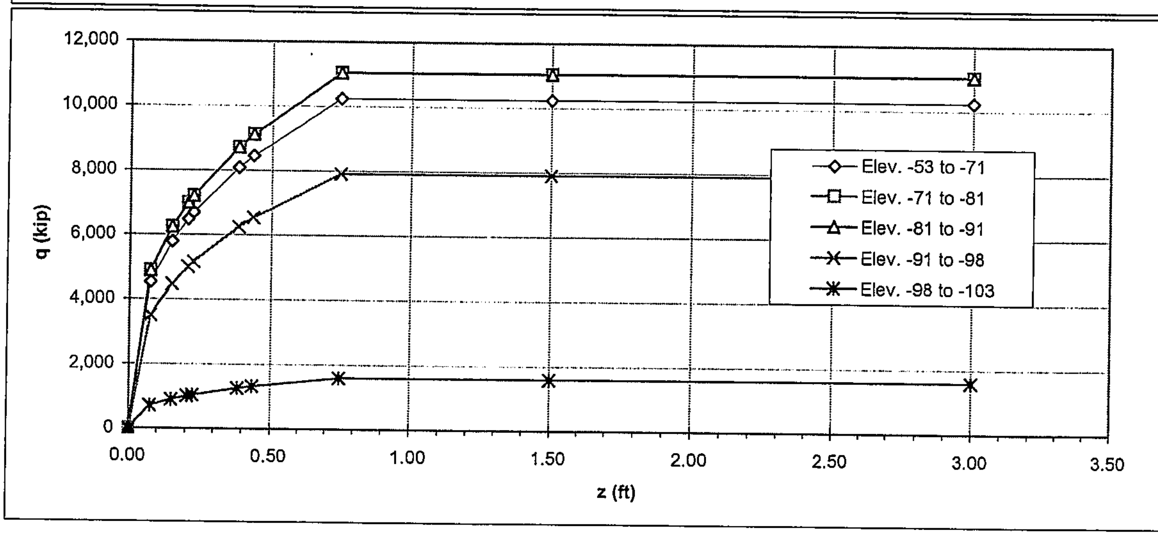
Pier 6 - No Degradation

Sta.		**O. G. Elev.**	19.0	**Pile**	7.5' CISS
		Cut off Elev.	19.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
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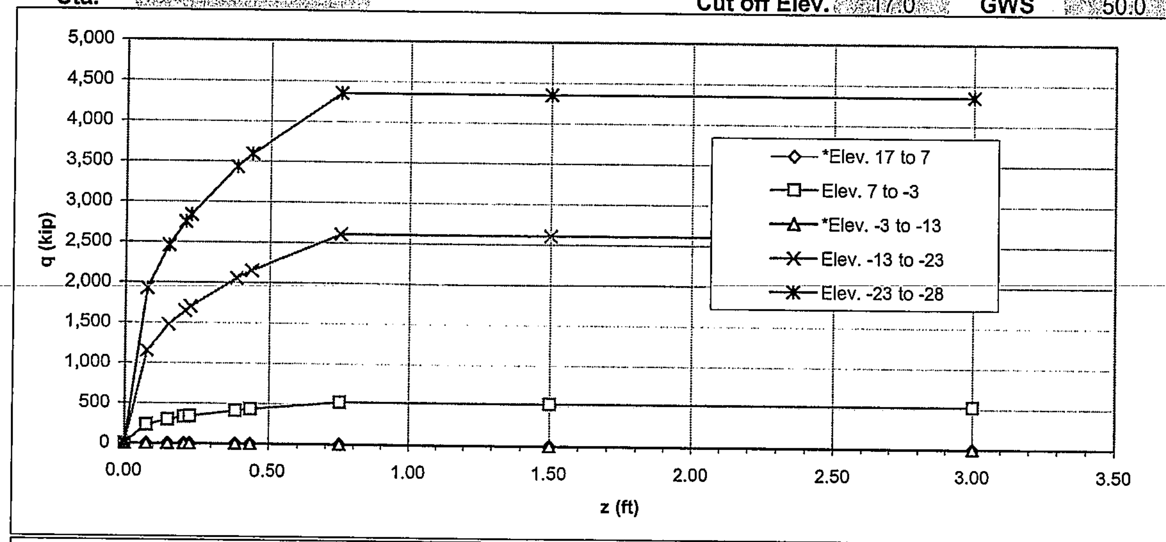
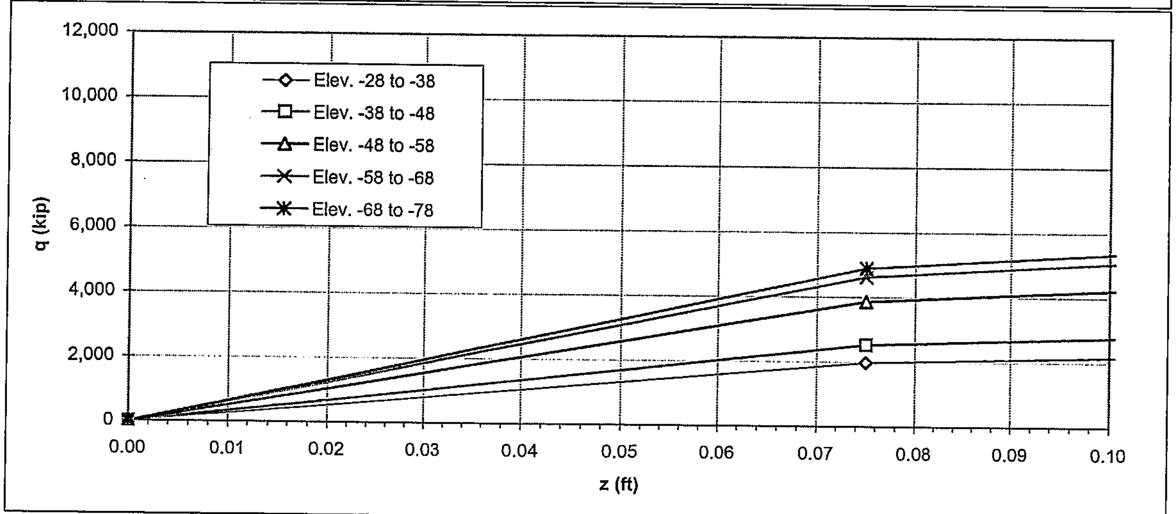
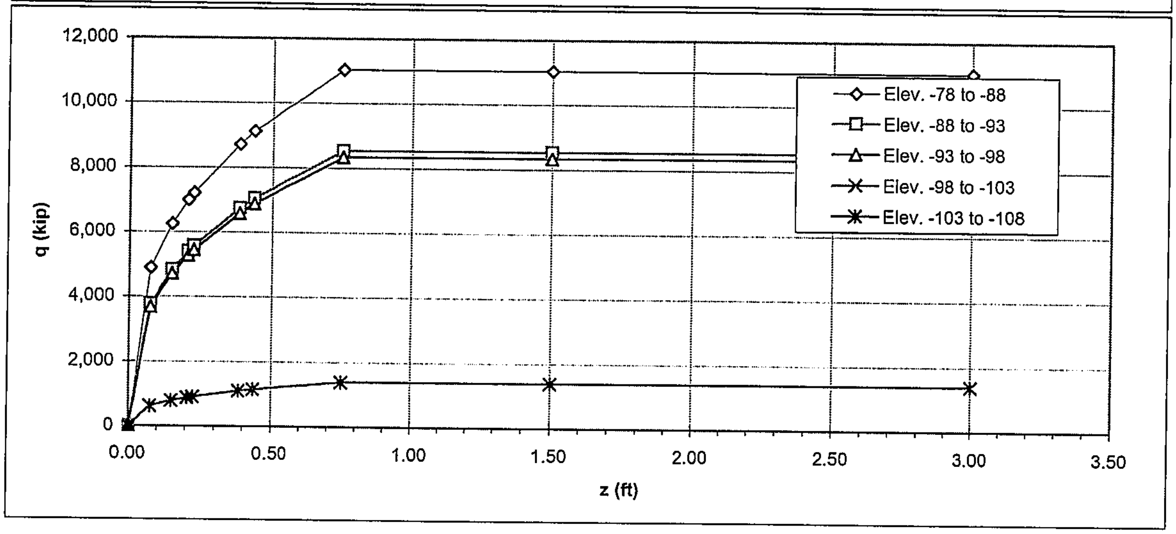
Pier 7 - No Degradation

Sta.

O. G. Elev. 17.0 Pile 7.5' CISS
Cut off Elev. 17.0 GWS 50.0







*-Liquefiable layer

Feather River Bridge
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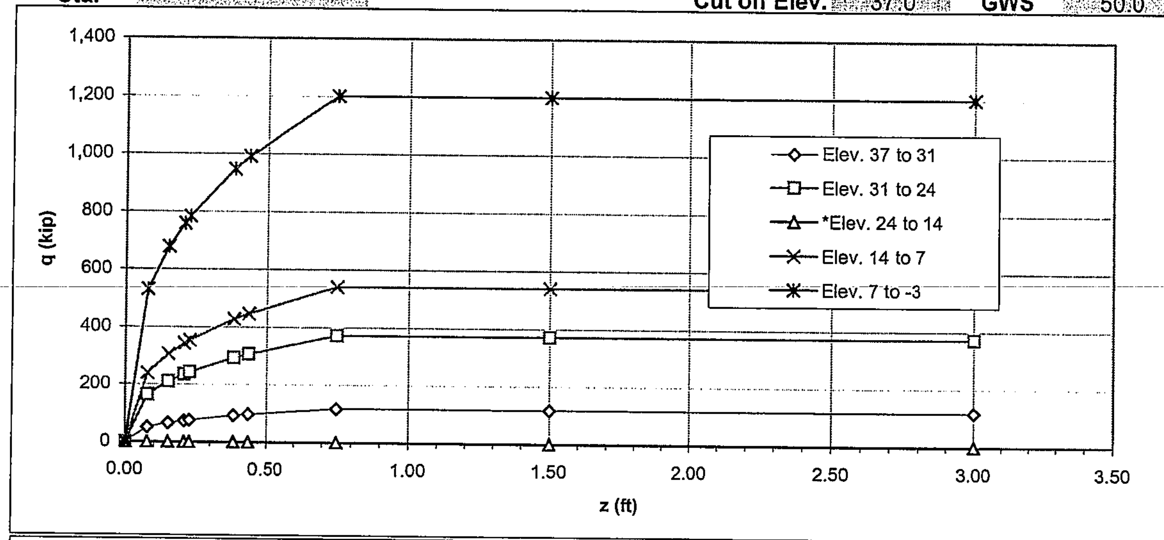
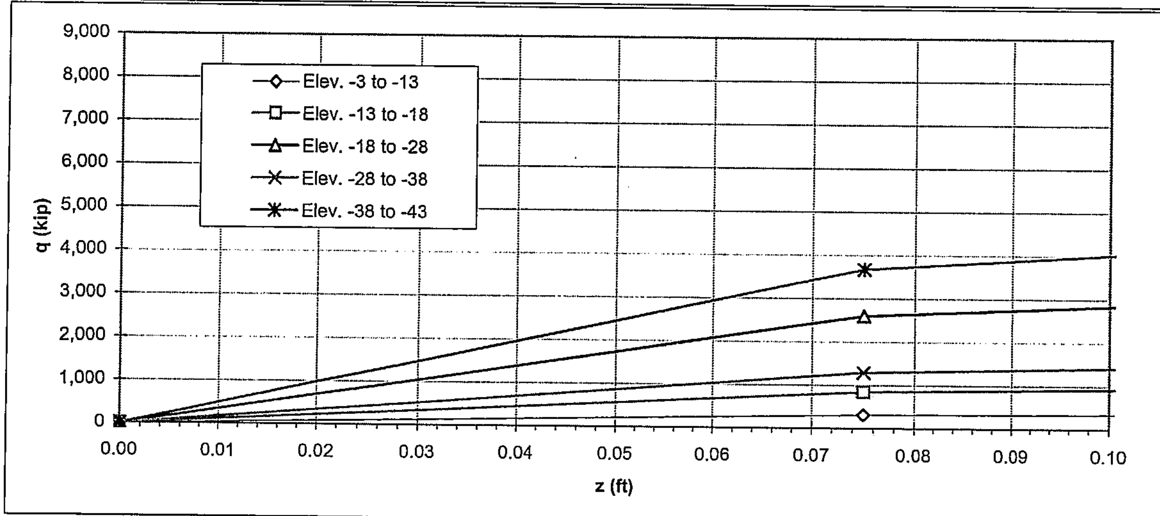
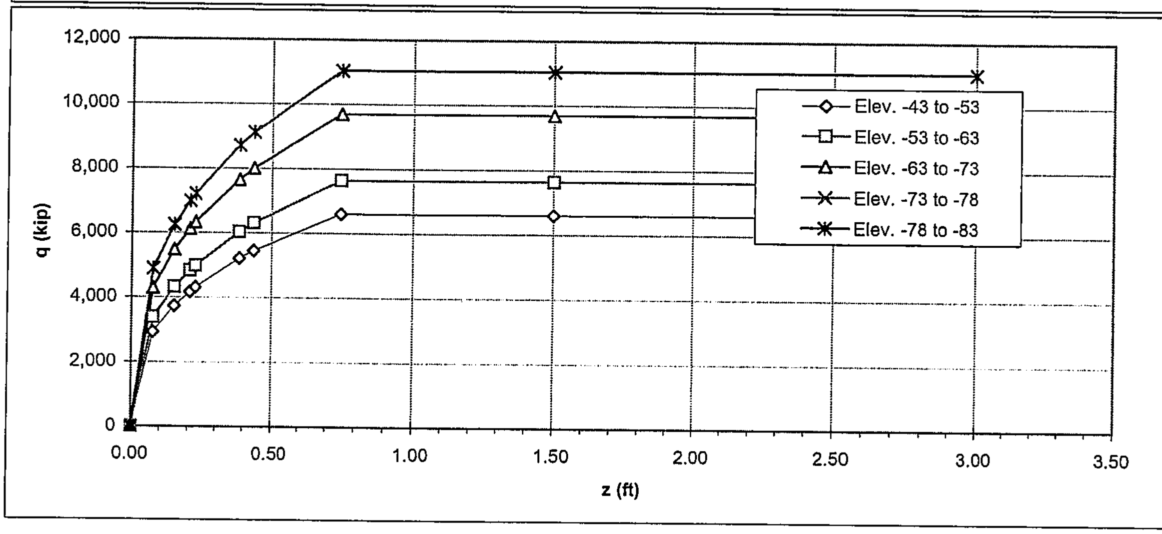
Pier 8 - No Degradation

Sta.

O. G. Elev.	37.0	Pile	7.5' CISS
Cut off Elev.	37.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
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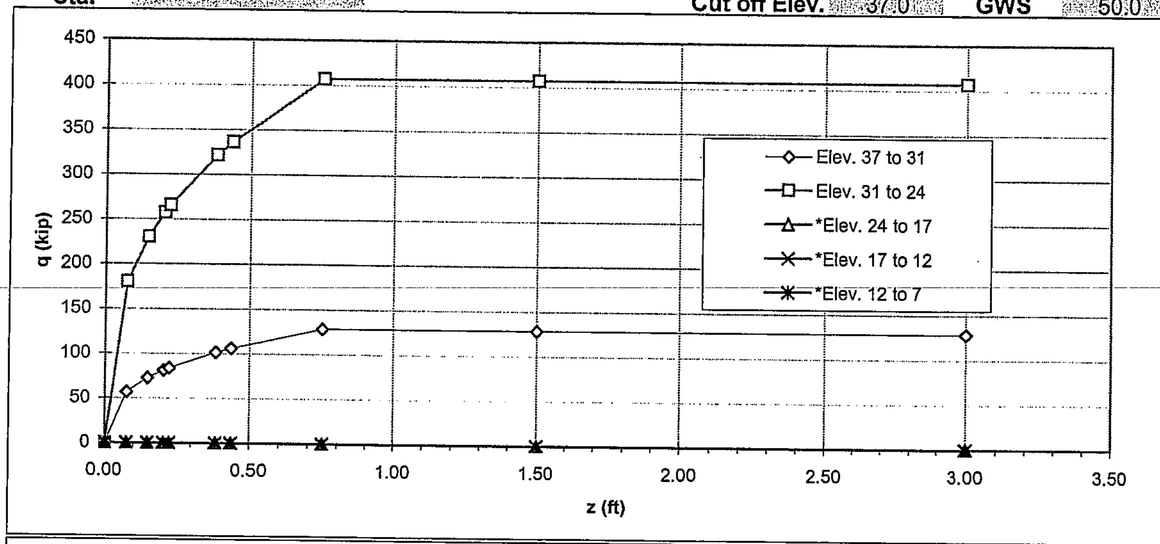
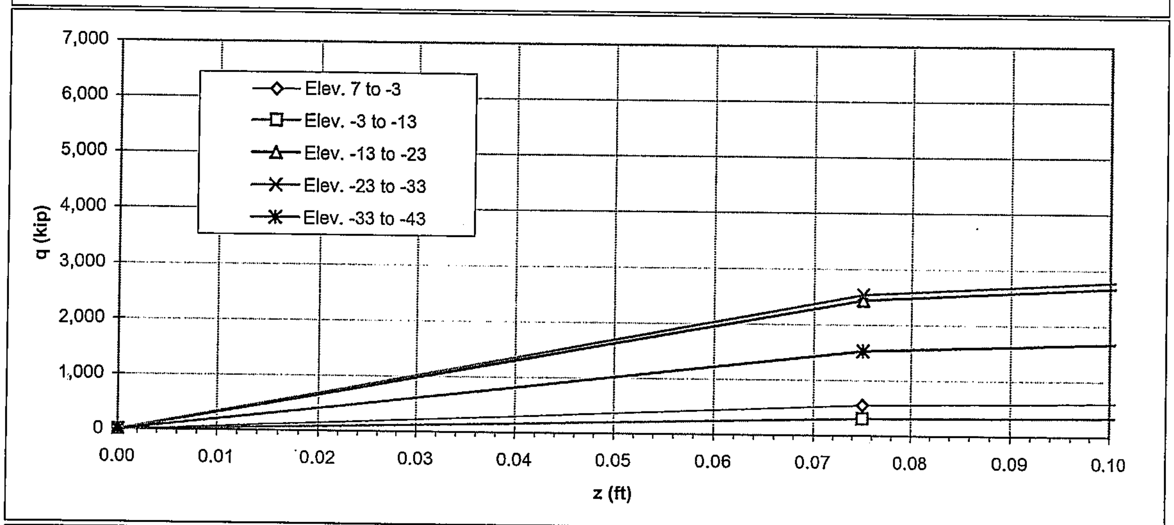
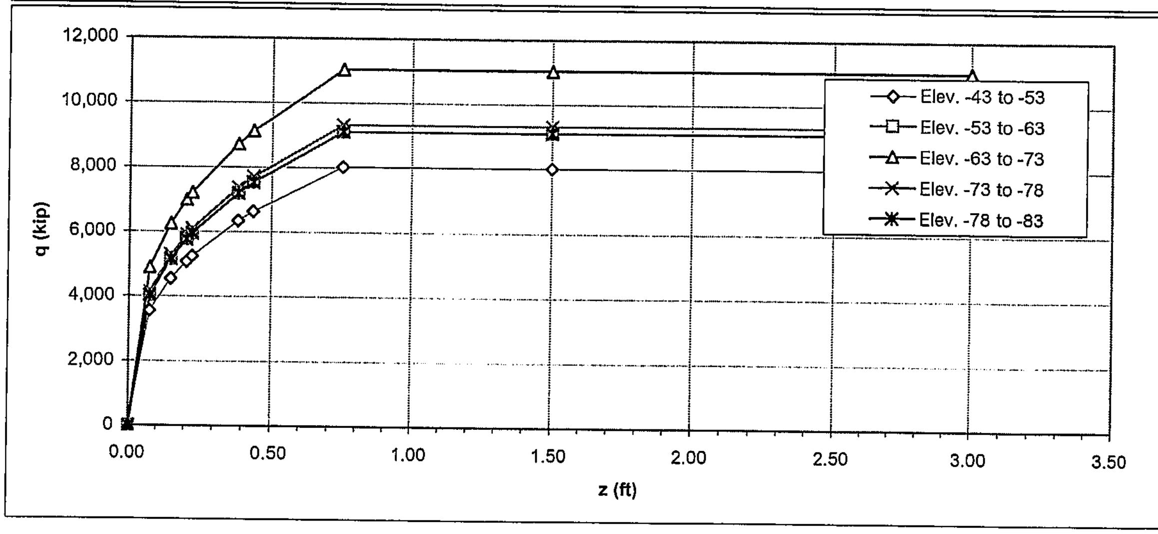
Pier 9 - No Degradation

Sta.

O. G. Elev. 37.0 **Pile** 7.5' CISS
Cut off Elev. 37.0 **GWS** 50.0







*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
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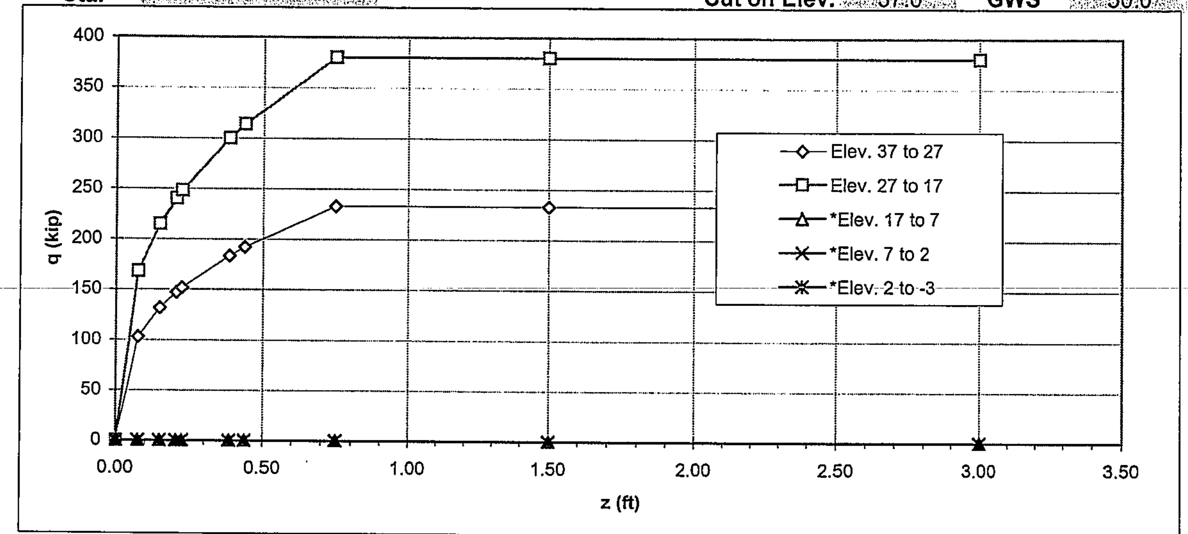
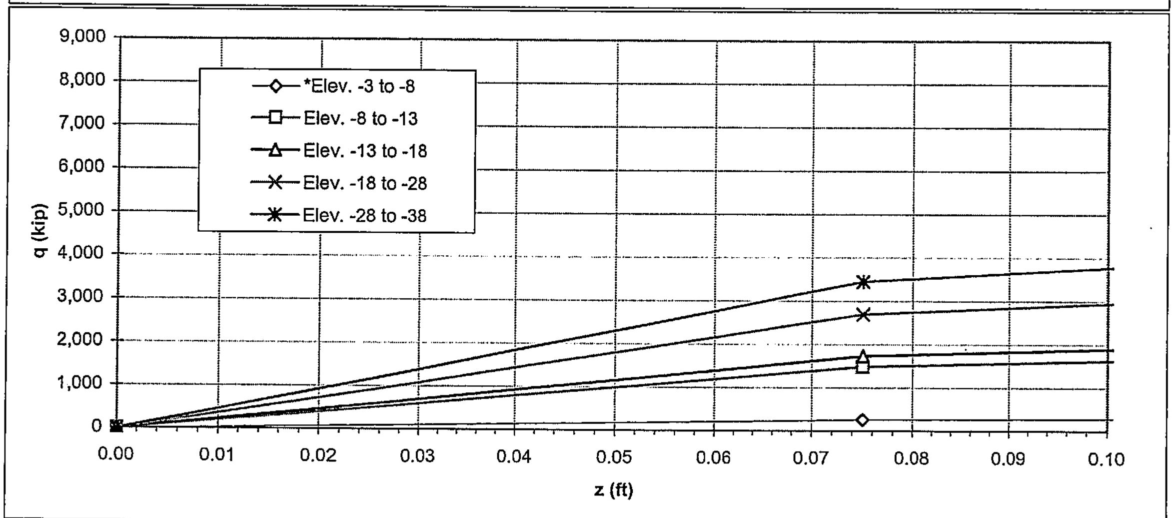
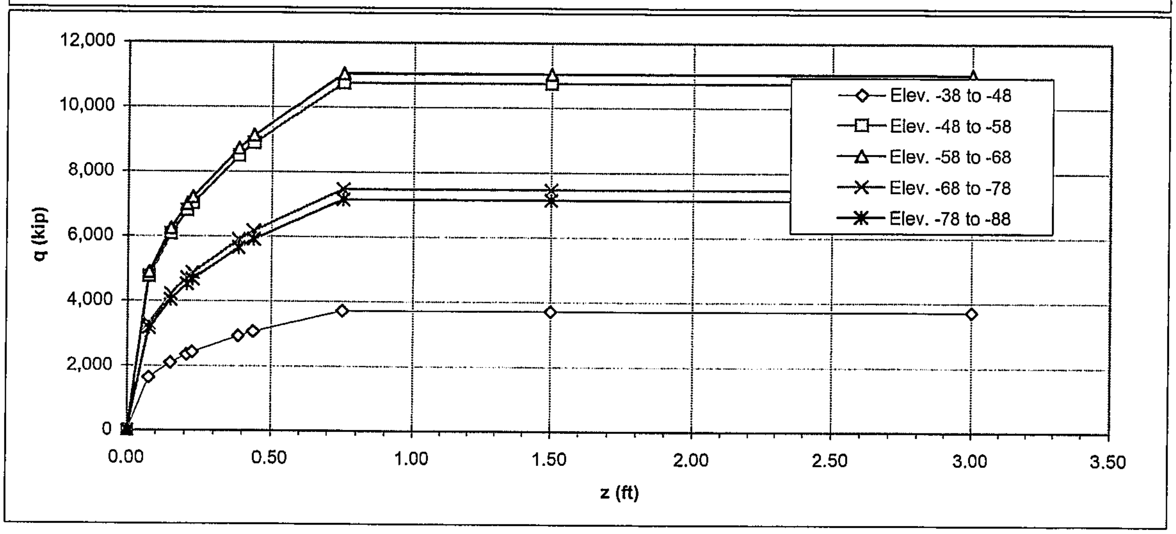
Pier 10 and 11 - No Degradation

Sta.

O. G. Elev.	37.0	Pile	7.5' CISS
Cut off Elev.	37.0	GWS	50.0







*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
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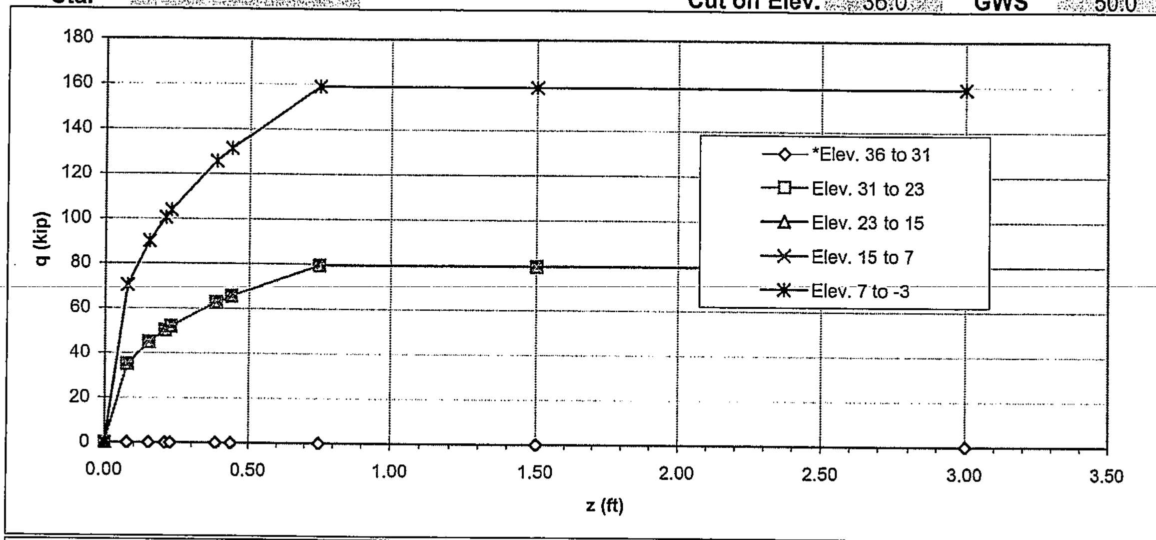
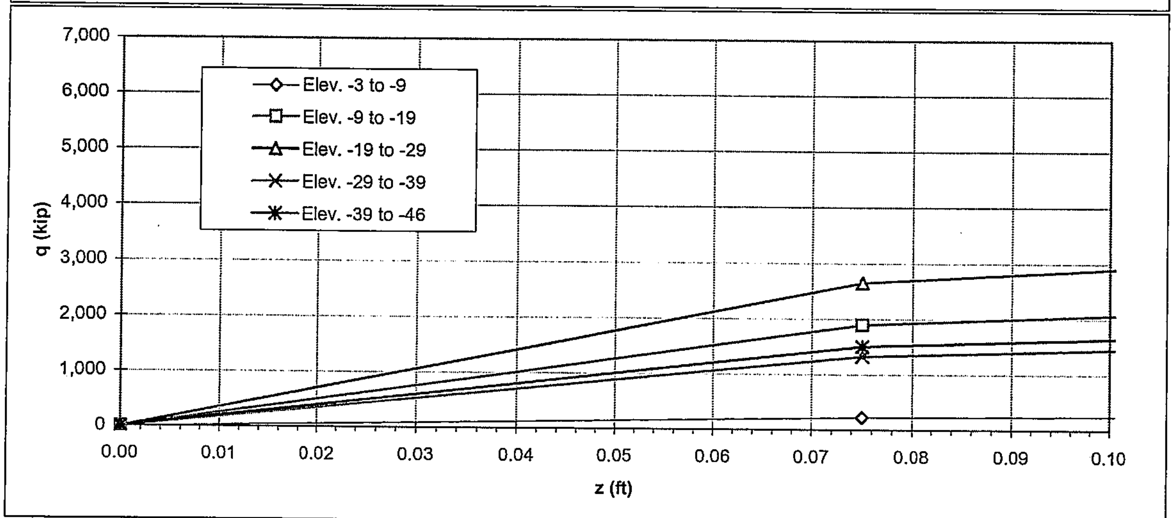
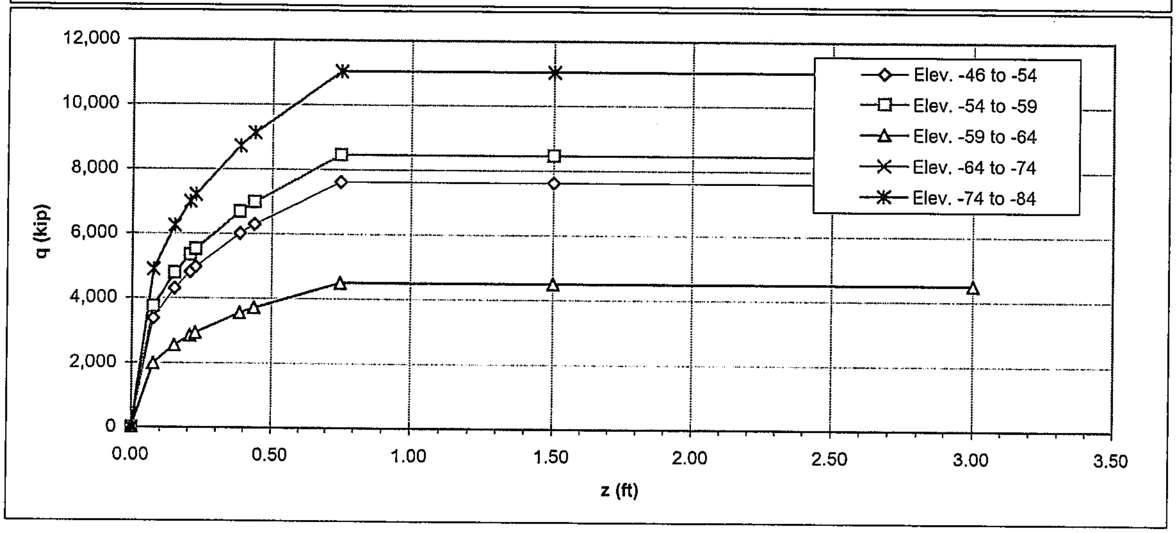
Pier 12 - No Degradation

Sta.		**O. G. Elev.**	36.0	**Pile**	7.5' CISS
		Cut off Elev.	36.0	**GWS**	50.0





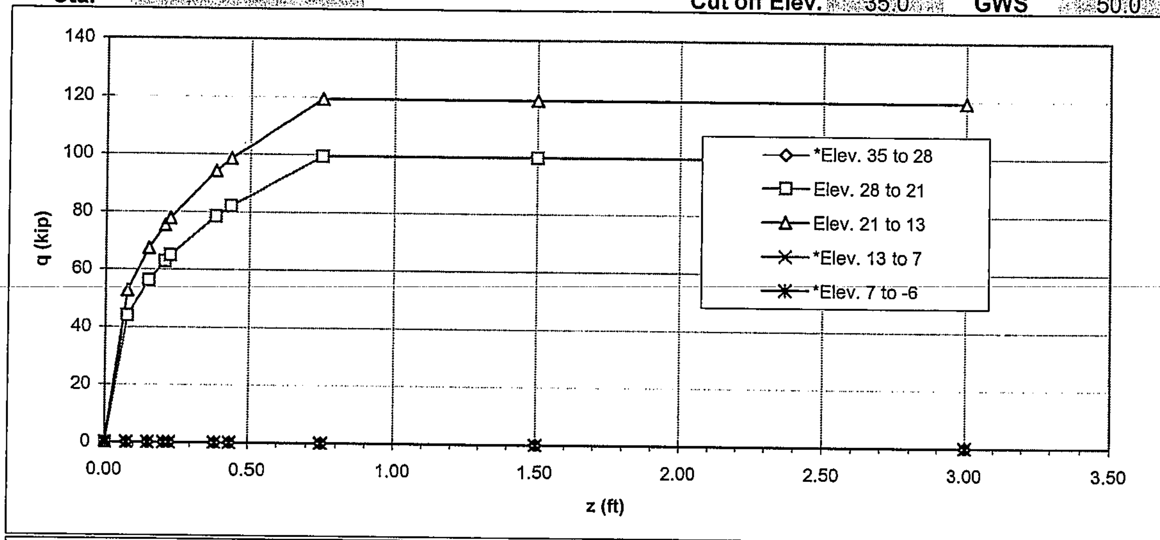


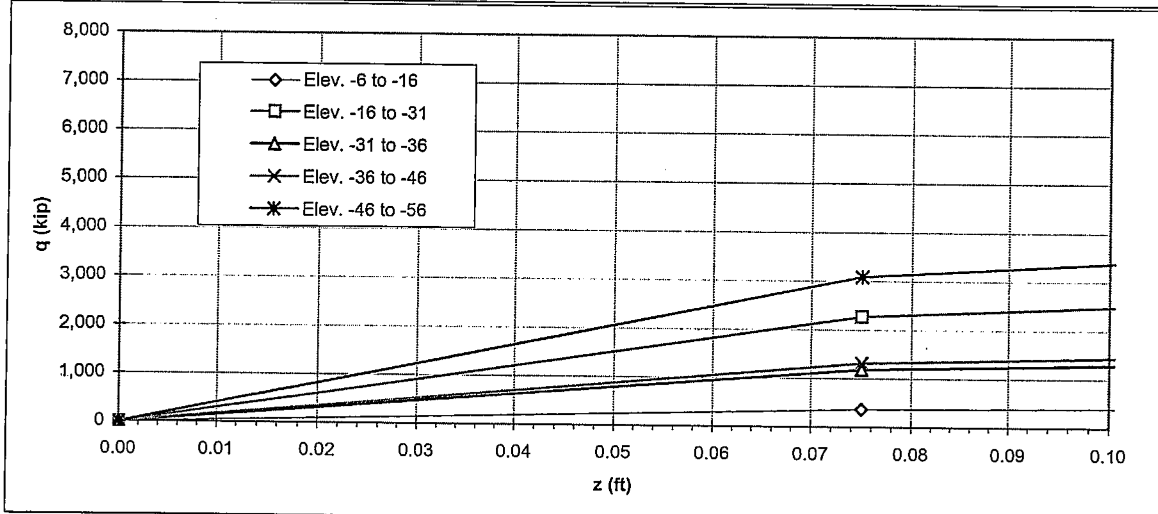
*-Liquefiable layer

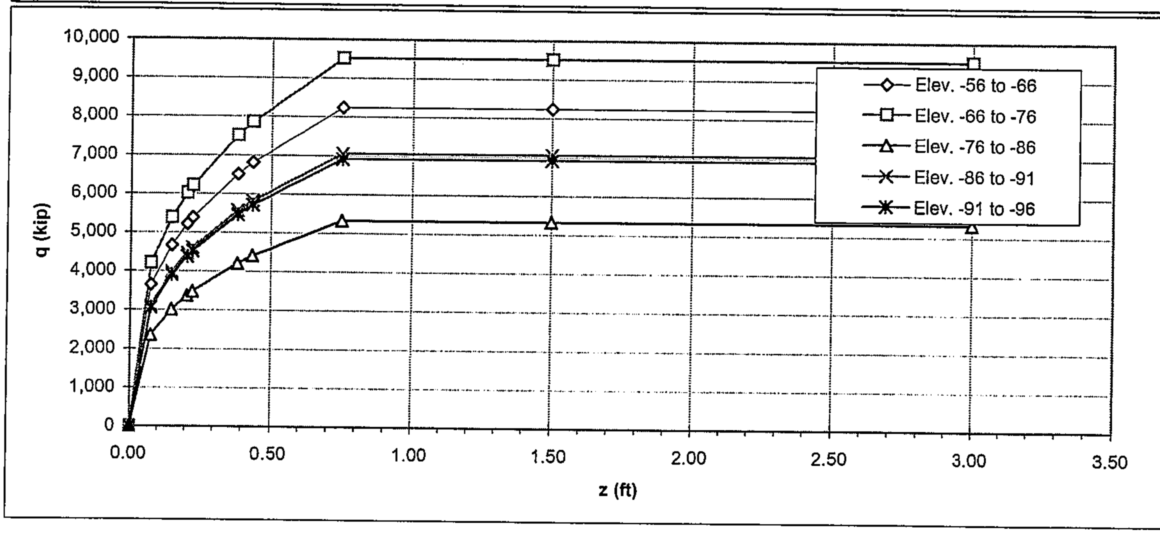
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - No Degradation

Sta.		O. G. Elev.	35.0	Pile	7.5' CISS
		Cut off Elev.	35.0	GWS	50.0







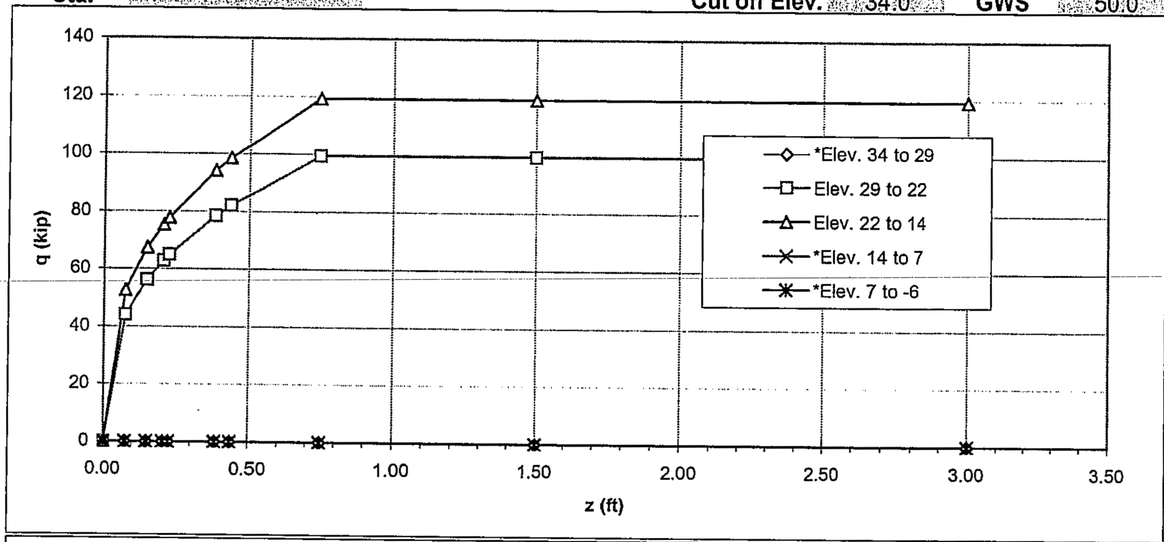
*-Liquefiable layer

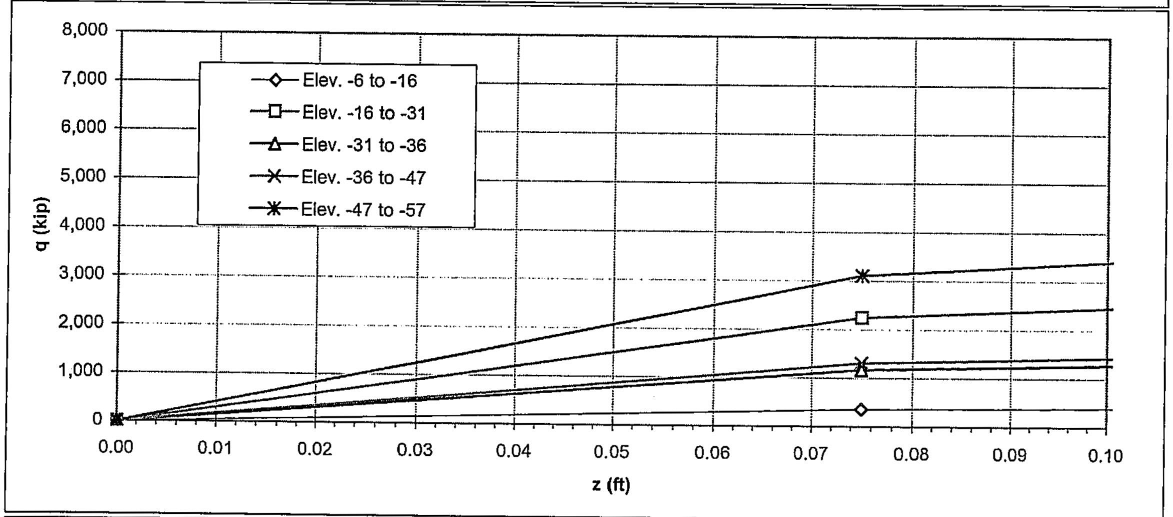
Feather River Bridge
Br. No. 18-0026R
03-1A4321

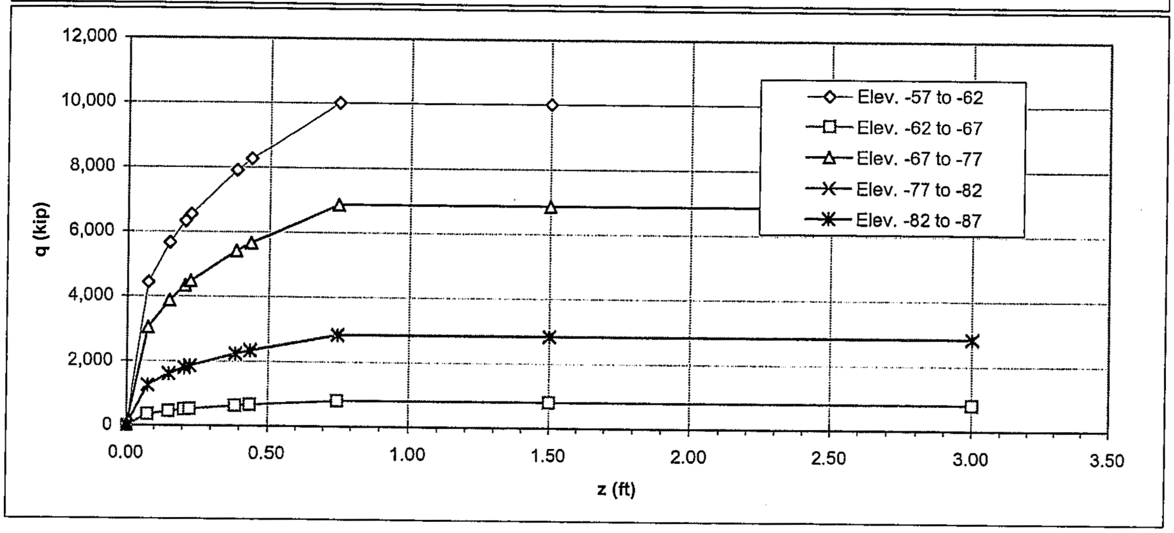
Pier 14 - No Degradation

Sta.

O. G. Elev. 34.0 **Pile** 7.5' CISS
Cut off Elev. 34.0 **GWS** 50.0







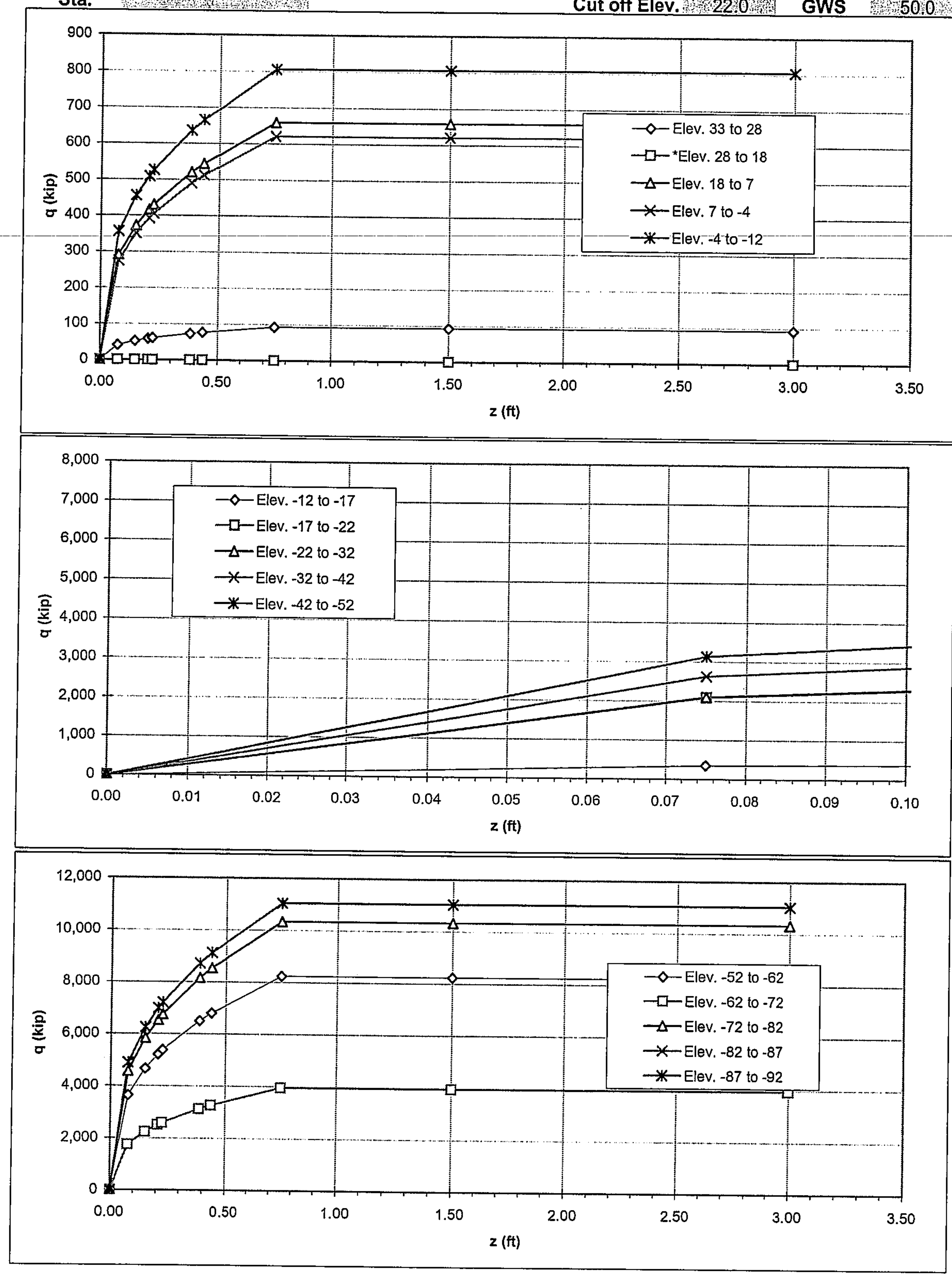
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - No Degradation

Sta.

O. G. Elev. 33.0 **Pile** 7.5' CISS
Cut off Elev. 22.0 **GWS** 50.0

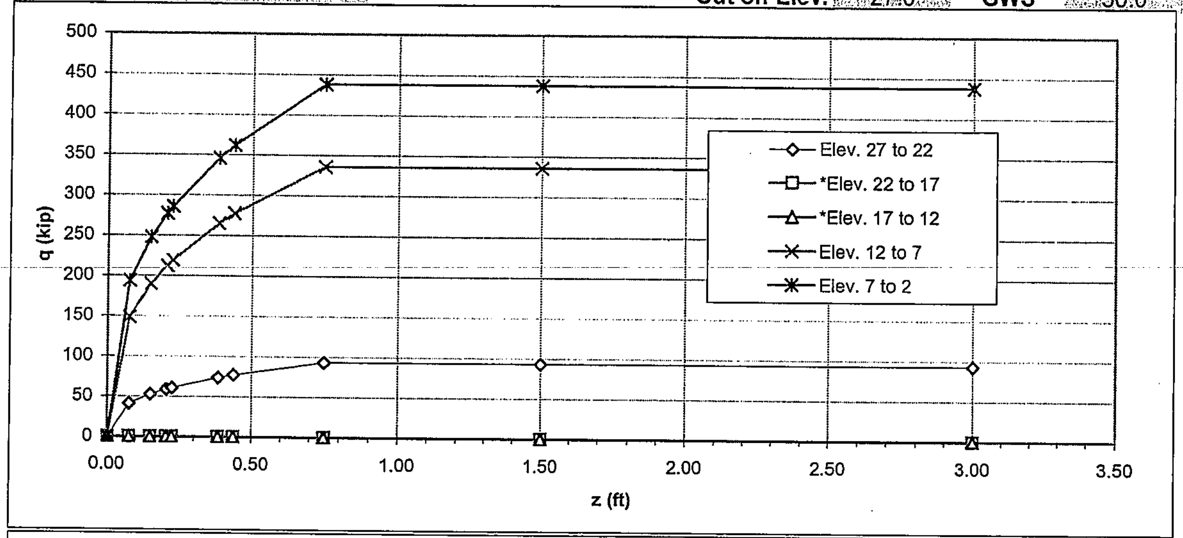


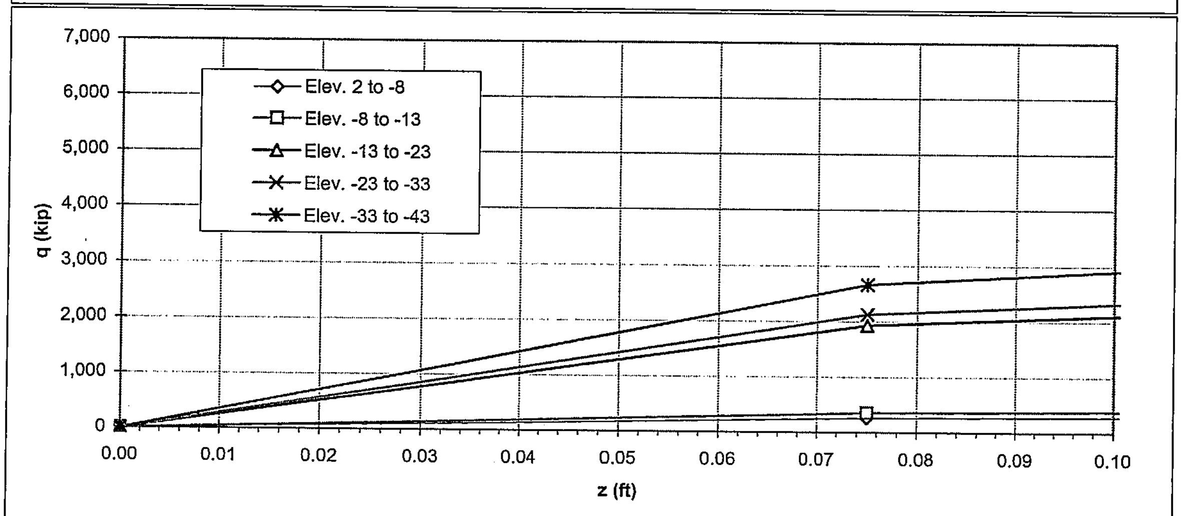
*-Liquefiable layer

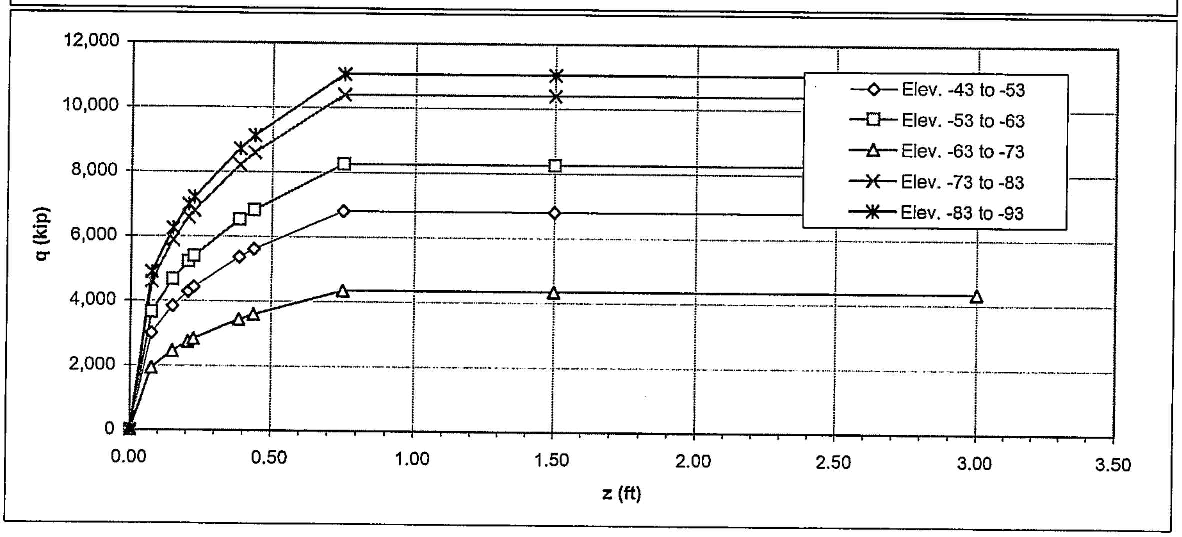
Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - No Degradation

Sta. | **O. G. Elev.** 27.0 | **Pile** 7.5' CISS
Cut off Elev. 27.0 | **GWS** 50.0







*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 2 - No Degrdation

Sta.

O. G. Elev. 18.0
Cut off Elev. 18.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 18 to 11	z (ft)	*Elev. 11 to 7	z (ft)	*Elev. 7 to 2	z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -16
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	0.0	0.08	0.0	0.08	304.2	0.08	474.3
0.15	0.0	0.15	0.0	0.15	0.0	0.15	388.8	0.15	606.2
0.21	0.0	0.21	0.0	0.21	0.0	0.21	434.6	0.21	677.7
0.23	0.0	0.23	0.0	0.23	0.0	0.23	448.8	0.23	699.8
0.38	0.0	0.38	0.0	0.38	0.0	0.38	542.7	0.38	846.2
0.44	0.0	0.44	0.0	0.44	0.0	0.44	567.8	0.44	885.4
0.75	0.0	0.75	0.0	0.75	0.0	0.75	687.3	0.75	1,071.7
1.50	0.0	1.50	0.0	1.50	0.0	1.50	687.3	1.50	1,071.7
3.00	0.0	3.00	0.0	3.00	0.0	3.00	687.3	3.00	1,071.7

z (ft)	Elev. -16 to -24	z (ft)	Elev. -24 to -30	z (ft)	Elev. -30 to -37	z (ft)	Elev. -37 to -42	z (ft)	Elev. -42 to -52
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	527.9	0.08	483.9	0.08	483.9	0.08	2,389.6	0.08	2,804.5
0.15	674.7	0.15	618.5	0.15	618.5	0.15	3,054.1	0.15	3,584.4
0.21	754.3	0.21	691.4	0.21	691.4	0.21	3,414.1	0.21	4,007.0
0.23	778.9	0.23	714.0	0.23	714.0	0.23	3,525.5	0.23	4,137.7
0.38	941.8	0.38	863.3	0.38	863.3	0.38	4,262.8	0.38	5,003.1
0.44	985.4	0.44	903.3	0.44	903.3	0.44	4,460.3	0.44	5,234.8
0.75	1,192.8	0.75	1,093.4	0.75	1,093.4	0.75	5,399.1	0.75	6,336.6
1.50	1,192.8	1.50	1,093.4	1.50	1,093.4	1.50	5,399.1	1.50	6,336.6
3.00	1,192.8	3.00	1,093.4	3.00	1,093.4	3.00	5,399.1	3.00	6,336.6

z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72	z (ft)	Elev. -72 to -82	z (ft)	Elev. -82 to -92	z (ft)	Elev. -92 to -102
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	4,255.2	0.08	4,888.2	0.08	4,888.2	0.08	4,888.2	0.08	2,841.4
0.15	5,438.6	0.15	6,247.7	0.15	6,247.7	0.15	6,247.7	0.15	3,631.6
0.21	6,079.8	0.21	6,984.2	0.21	6,984.2	0.21	6,984.2	0.21	4,059.8
0.23	6,278.1	0.23	7,212.0	0.23	7,212.0	0.23	7,212.0	0.23	4,192.2
0.38	7,591.1	0.38	8,720.4	0.38	8,720.4	0.38	8,720.4	0.38	5,069.0
0.44	7,942.7	0.44	9,124.3	0.44	9,124.3	0.44	9,124.3	0.44	5,303.8
0.75	9,614.4	0.75	11,044.7	0.75	11,044.7	0.75	11,044.7	0.75	6,420.0
1.50	9,614.4	1.50	11,044.7	1.50	11,044.7	1.50	11,044.7	1.50	6,420.0
3.00	9,614.4	3.00	11,044.7	3.00	11,044.7	3.00	11,044.7	3.00	6,420.0

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 3 - No Degrdation

Sta.

O. G. Elev.	26.0	Pile	7.5' CISS
Cut off Elev.	26.0	GWS	50.0

z (ft)	Elev. 26 to 21	z (ft)	Elev. 21 to 16	z (ft)	Elev. 16 to 7	z (ft)	Elev. 7 to -1	z (ft)	Elev. -1 to -11
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	352.0	0.08	408.7	0.08	355.2	0.08	514.2	0.08	394.7
0.15	449.8	0.15	522.4	0.15	454.0	0.15	657.2	0.15	504.4
0.21	502.9	0.21	584.0	0.21	507.5	0.21	734.7	0.21	563.9
0.23	519.3	0.23	603.0	0.23	524.0	0.23	758.7	0.23	582.3
0.38	627.9	0.38	729.2	0.38	633.7	0.38	917.3	0.38	704.0
0.44	656.9	0.44	762.9	0.44	663.0	0.44	959.8	0.44	736.7
0.75	795.2	0.75	923.5	0.75	802.5	0.75	1,161.9	0.75	891.7
1.50	795.2	1.50	923.5	1.50	802.5	1.50	1,161.9	1.50	891.7
3.00	795.2	3.00	923.5	3.00	802.5	3.00	1,161.9	3.00	891.7

z (ft)	Elev. -11 to -21	z (ft)	Elev. -21 to -31	z (ft)	Elev. -31 to -41	z (ft)	Elev. -41 to -46	z (ft)	Elev. -46 to -51
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	824.8	0.08	1,010.6	0.08	3,136.6	0.08	2,936.6	0.08	1,576.6
0.15	1,054.2	0.15	1,291.6	0.15	4,008.9	0.15	3,753.3	0.15	2,015.1
0.21	1,178.4	0.21	1,443.9	0.21	4,481.5	0.21	4,195.8	0.21	2,252.7
0.23	1,216.9	0.23	1,491.0	0.23	4,627.7	0.23	4,332.6	0.23	2,326.1
0.38	1,471.4	0.38	1,802.8	0.38	5,595.6	0.38	5,238.8	0.38	2,812.7
0.44	1,539.5	0.44	1,886.4	0.44	5,854.8	0.44	5,481.4	0.44	2,942.9
0.75	1,863.6	0.75	2,283.4	0.75	7,087.0	0.75	6,635.1	0.75	3,562.3
1.50	1,863.6	1.50	2,283.4	1.50	7,087.0	1.50	6,635.1	1.50	3,562.3
3.00	1,863.6	3.00	2,283.4	3.00	7,087.0	3.00	6,635.1	3.00	3,562.3

z (ft)	Elev. -51 to -61	z (ft)	Elev. -61 to -71	z (ft)	Elev. -71 to -81	z (ft)	Elev. -81 to -86	z (ft)	Elev. -86 to -91
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,538.2	0.08	4,888.2	0.08	4,888.2	0.08	1,389.7	0.08	1,372.7
0.15	4,522.2	0.15	6,247.7	0.15	6,247.7	0.15	1,776.2	0.15	1,754.5
0.21	5,055.3	0.21	6,984.2	0.21	6,984.2	0.21	1,985.5	0.21	1,961.3
0.23	5,220.2	0.23	7,212.0	0.23	7,212.0	0.23	2,050.3	0.23	2,025.3
0.38	6,312.0	0.38	8,720.4	0.38	8,720.4	0.38	2,479.1	0.38	2,448.9
0.44	6,604.4	0.44	9,124.3	0.44	9,124.3	0.44	2,594.0	0.44	2,562.3
0.75	7,994.4	0.75	11,044.7	0.75	11,044.7	0.75	3,139.9	0.75	3,101.6
1.50	7,994.4	1.50	11,044.7	1.50	11,044.7	1.50	3,139.9	1.50	3,101.6
3.00	7,994.4	3.00	11,044.7	3.00	11,044.7	3.00	3,139.9	3.00	3,101.6

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - No Degrdation

Sta.

O. G. Elev. 14.0
Cut off Elev. 14.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 14 to 7	z (ft)	Elev. 7 to 1	z (ft)	Elev. 1 to -6	z (ft)	Elev. -6 to -10	z (ft)	Elev. -10 to -20
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	166.7	0.08	290.0	0.08	394.6	0.08	540.2
0.15	0.0	0.15	213.0	0.15	370.6	0.15	504.4	0.15	690.4
0.21	0.0	0.21	238.1	0.21	414.3	0.21	563.8	0.21	771.8
0.23	0.0	0.23	245.9	0.23	427.8	0.23	582.2	0.23	797.0
0.38	0.0	0.38	297.3	0.38	517.3	0.38	704.0	0.38	963.7
0.44	0.0	0.44	311.1	0.44	541.2	0.44	736.6	0.44	1,008.3
0.75	0.0	0.75	376.6	0.75	655.1	0.75	891.6	0.75	1,220.5
1.50	0.0	1.50	376.6	1.50	655.1	1.50	891.6	1.50	1,220.5
3.00	0.0	3.00	376.6	3.00	655.1	3.00	891.6	3.00	1,220.5

z (ft)	Elev. -20 to -34	z (ft)	Elev. -34 to -40	z (ft)	Elev. -40 to -50	z (ft)	Elev. -50 to -60	z (ft)	Elev. -60 to -70
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	790.6	0.08	2,561.9	0.08	2,535.0	0.08	3,927.4	0.08	4,686.1
0.15	1,010.5	0.15	3,274.3	0.15	3,240.0	0.15	5,019.7	0.15	5,989.3
0.21	1,129.6	0.21	3,660.3	0.21	3,622.0	0.21	5,611.4	0.21	6,695.4
0.23	1,166.4	0.23	3,779.7	0.23	3,740.1	0.23	5,794.4	0.23	6,913.7
0.38	1,410.4	0.38	4,570.2	0.38	4,522.3	0.38	7,006.3	0.38	8,359.7
0.44	1,475.7	0.44	4,781.9	0.44	4,731.8	0.44	7,330.9	0.44	8,747.0
0.75	1,786.3	0.75	5,788.4	0.75	5,727.7	0.75	8,873.8	0.75	10,587.9
1.50	1,786.3	1.50	5,788.4	1.50	5,727.7	1.50	8,873.8	1.50	10,587.9
3.00	1,786.3	3.00	5,788.4	3.00	5,727.7	3.00	8,873.8	3.00	10,587.9

z (ft)	Elev. -70 to -80	z (ft)	Elev. -80 to -90	z (ft)	Elev. -90 to -100	z (ft)	Elev. -100 to -105	z (ft)	Elev. -105 to -110
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,140.5	0.08	4,888.2	0.08	4,482.4	0.08	2,457.3	0.08	2,413.0
0.15	2,735.7	0.15	6,247.7	0.15	5,728.9	0.15	3,140.7	0.15	3,084.0
0.21	3,058.2	0.21	6,984.2	0.21	6,404.3	0.21	3,510.9	0.21	3,447.6
0.23	3,158.0	0.23	7,212.0	0.23	6,613.2	0.23	3,625.4	0.23	3,560.0
0.38	3,818.5	0.38	8,720.4	0.38	7,996.3	0.38	4,383.7	0.38	4,304.6
0.44	3,995.4	0.44	9,124.3	0.44	8,366.7	0.44	4,586.7	0.44	4,504.0
0.75	4,836.3	0.75	11,044.7	0.75	10,127.7	0.75	5,552.1	0.75	5,452.0
1.50	4,836.3	1.50	11,044.7	1.50	10,127.7	1.50	5,552.1	1.50	5,452.0
3.00	4,836.3	3.00	11,044.7	3.00	10,127.7	3.00	5,552.1	3.00	5,452.0

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 5 - No Degradation

Sta.

O. G. Elev. 12.0
Cut off Elev. 12.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 12 to 7	z (ft)	*Elev. 7 to 0	z (ft)	*Elev. 0 to -8	z (ft)	Elev. -8 to -15	z (ft)	Elev. -15 to -23
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	0.0	0.08	0.0	0.08	383.9	0.08	521.8
0.15	0.0	0.15	0.0	0.15	0.0	0.15	490.6	0.15	666.9
0.21	0.0	0.21	0.0	0.21	0.0	0.21	548.5	0.21	745.5
0.23	0.0	0.23	0.0	0.23	0.0	0.23	566.4	0.23	769.9
0.38	0.0	0.38	0.0	0.38	0.0	0.38	684.8	0.38	930.9
0.44	0.0	0.44	0.0	0.44	0.0	0.44	716.5	0.44	974.0
0.75	0.0	0.75	0.0	0.75	0.0	0.75	867.3	0.75	1,179.0
1.50	0.0	1.50	0.0	1.50	0.0	1.50	867.3	1.50	1,179.0
3.00	0.0	3.00	0.0	3.00	0.0	3.00	867.3	3.00	1,179.0

z (ft)	Elev. -23 to -28	z (ft)	Elev. -28 to -33	z (ft)	Elev. -33 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	1,326.2	0.08	783.3	0.08	939.6	0.08	1,160.3	0.08	3,567.9
0.15	1,695.0	0.15	1,001.2	0.15	1,200.9	0.15	1,483.0	0.15	4,560.2
0.21	1,894.9	0.21	1,119.2	0.21	1,342.5	0.21	1,657.8	0.21	5,097.8
0.23	1,956.7	0.23	1,155.7	0.23	1,386.2	0.23	1,711.9	0.23	5,264.0
0.38	2,365.9	0.38	1,397.4	0.38	1,676.2	0.38	2,069.9	0.38	6,365.0
0.44	2,475.5	0.44	1,462.1	0.44	1,753.8	0.44	2,165.8	0.44	6,659.8
0.75	2,996.5	0.75	1,769.9	0.75	2,122.9	0.75	2,621.6	0.75	8,061.5
1.50	2,996.5	1.50	1,769.9	1.50	2,122.9	1.50	2,621.6	1.50	8,061.5
3.00	2,996.5	3.00	1,769.9	3.00	2,122.9	3.00	2,621.6	3.00	8,061.5

z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -83	z (ft)	Elev. -83 to -93	z (ft)	Elev. -93 to -103	z (ft)	Elev. -103 to -113
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	4,326.6	0.08	4,888.2	0.08	4,888.2	0.08	4,888.2	0.08	703.9
0.15	5,529.8	0.15	6,247.7	0.15	6,247.7	0.15	6,247.7	0.15	899.7
0.21	6,181.7	0.21	6,984.2	0.21	6,984.2	0.21	6,984.2	0.21	1,005.7
0.23	6,383.3	0.23	7,212.0	0.23	7,212.0	0.23	7,212.0	0.23	1,038.5
0.38	7,718.4	0.38	8,720.4	0.38	8,720.4	0.38	8,720.4	0.38	1,255.7
0.44	8,075.9	0.44	9,124.3	0.44	9,124.3	0.44	9,124.3	0.44	1,313.9
0.75	9,775.6	0.75	11,044.7	0.75	11,044.7	0.75	11,044.7	0.75	1,590.4
1.50	9,775.6	1.50	11,044.7	1.50	11,044.7	1.50	11,044.7	1.50	1,590.4
3.00	9,775.6	3.00	11,044.7	3.00	11,044.7	3.00	11,044.7	3.00	1,590.4

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - No Degradation

Sta.

O. G. Elev. 19.0
Cut off Elev. 19.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 19 to 7	z (ft)	*Elev. 7 to 4	z (ft)	Elev. 4 to -2	z (ft)	Elev. -2 to -7	z (ft)	Elev. -7 to -12
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	0.0	0.08	544.8	0.08	385.8	0.08	483.1
0.15	0.0	0.15	0.0	0.15	696.3	0.15	493.1	0.15	617.5
0.21	0.0	0.21	0.0	0.21	778.4	0.21	551.3	0.21	690.3
0.23	0.0	0.23	0.0	0.23	803.8	0.23	569.3	0.23	712.8
0.38	0.0	0.38	0.0	0.38	971.9	0.38	688.3	0.38	861.9
0.44	0.0	0.44	0.0	0.44	1,017.0	0.44	720.2	0.44	901.8
0.75	0.0	0.75	0.0	0.75	1,231.0	0.75	871.8	0.75	1,091.6
1.50	0.0	1.50	0.0	1.50	1,231.0	1.50	871.8	1.50	1,091.6
3.00	0.0	3.00	0.0	3.00	1,231.0	3.00	871.8	3.00	1,091.6

z (ft)	Elev. -12 to -17	z (ft)	*Elev. -17 to -22	z (ft)	Elev. -22 to -27	z (ft)	Elev. -27 to -41	z (ft)	Elev. -41 to -53
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	584.4	0.08	0.0	0.08	746.0	0.08	2,512.1	0.08	2,756.9
0.15	747.0	0.15	0.0	0.15	953.4	0.15	3,210.7	0.15	3,523.6
0.21	835.0	0.21	0.0	0.21	1,065.9	0.21	3,589.2	0.21	3,939.0
0.23	862.3	0.23	0.0	0.23	1,100.6	0.23	3,706.3	0.23	4,067.4
0.38	1,042.6	0.38	0.0	0.38	1,330.8	0.38	4,481.4	0.38	4,918.1
0.44	1,090.9	0.44	0.0	0.44	1,392.4	0.44	4,689.0	0.44	5,146.0
0.75	1,320.5	0.75	0.0	0.75	1,685.5	0.75	5,675.9	0.75	6,229.0
1.50	1,320.5	1.50	0.0	1.50	1,685.5	1.50	5,675.9	1.50	6,229.0
3.00	1,320.5	3.00	0.0	3.00	1,685.5	3.00	5,675.9	3.00	6,229.0

z (ft)	Elev. -53 to -71	z (ft)	Elev. -71 to -81	z (ft)	Elev. -81 to -91	z (ft)	Elev. -91 to -98	z (ft)	Elev. -98 to -103
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	4,531.9	0.08	4,888.2	0.08	4,888.2	0.08	3,501.5	0.08	703.9
0.15	5,792.2	0.15	6,247.7	0.15	6,247.7	0.15	4,475.2	0.15	899.7
0.21	6,475.0	0.21	6,984.2	0.21	6,984.2	0.21	5,002.8	0.21	1,005.7
0.23	6,686.2	0.23	7,212.0	0.23	7,212.0	0.23	5,165.9	0.23	1,038.5
0.38	8,084.6	0.38	8,720.4	0.38	8,720.4	0.38	6,246.4	0.38	1,255.7
0.44	8,459.1	0.44	9,124.3	0.44	9,124.3	0.44	6,535.7	0.44	1,313.9
0.75	10,239.5	0.75	11,044.7	0.75	11,044.7	0.75	7,911.3	0.75	1,590.4
1.50	10,239.5	1.50	11,044.7	1.50	11,044.7	1.50	7,911.3	1.50	1,590.4
3.00	10,239.5	3.00	11,044.7	3.00	11,044.7	3.00	7,911.3	3.00	1,590.4

Note - q (kip)
*-Liquefiable layer

Pier 7 - No Degradation

Sta.

O. G. Elev. 17.0 | Pile 7.5' CISS
Cut off Elev. 17.0 | GWS 50.0

z (ft)	*Elev. 17 to 7	z (ft)	Elev. 7 to -3	z (ft)	*Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -28
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	231.1	0.08	0.0	0.08	1,153.5	0.08	1,926.2
0.15	0.0	0.15	295.4	0.15	0.0	0.15	1,474.3	0.15	2,461.9
0.21	0.0	0.21	330.2	0.21	0.0	0.21	1,648.1	0.21	2,752.1
0.23	0.0	0.23	341.0	0.23	0.0	0.23	1,701.8	0.23	2,841.9
0.38	0.0	0.38	412.3	0.38	0.0	0.38	2,057.8	0.38	3,436.2
0.44	0.0	0.44	431.4	0.44	0.0	0.44	2,153.1	0.44	3,595.4
0.75	0.0	0.75	522.2	0.75	0.0	0.75	2,606.3	0.75	4,352.1
1.50	0.0	1.50	522.2	1.50	0.0	1.50	2,606.3	1.50	4,352.1
3.00	0.0	3.00	522.2	3.00	0.0	3.00	2,606.3	3.00	4,352.1

z (ft)	Elev. -28 to -38	z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68	z (ft)	Elev. -68 to -78
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	1,979.1	0.08	2,527.8	0.08	3,867.1	0.08	4,625.7	0.08	4,888.2
0.15	2,529.5	0.15	3,230.8	0.15	4,942.5	0.15	5,912.1	0.15	6,247.7
0.21	2,827.7	0.21	3,611.7	0.21	5,525.2	0.21	6,609.1	0.21	6,984.2
0.23	2,919.9	0.23	3,729.5	0.23	5,705.4	0.23	6,824.7	0.23	7,212.0
0.38	3,530.6	0.38	4,509.5	0.38	6,898.6	0.38	8,252.0	0.38	8,720.4
0.44	3,694.1	0.44	4,718.4	0.44	7,218.2	0.44	8,634.3	0.44	9,124.3
0.75	4,471.6	0.75	5,711.5	0.75	8,737.4	0.75	10,451.5	0.75	11,044.7
1.50	4,471.6	1.50	5,711.5	1.50	8,737.4	1.50	10,451.5	1.50	11,044.7
3.00	4,471.6	3.00	5,711.5	3.00	8,737.4	3.00	10,451.5	3.00	11,044.7

z (ft)	Elev. -78 to -88	z (ft)	Elev. -88 to -93	z (ft)	Elev. -93 to -98	z (ft)	Elev. -98 to -103	z (ft)	Elev. -103 to -108
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	4,888.2	0.08	3,777.2	0.08	3,687.7	0.08	615.9	0.08	615.9
0.15	6,247.7	0.15	4,827.6	0.15	4,713.3	0.15	787.2	0.15	787.2
0.21	6,984.2	0.21	5,396.8	0.21	5,268.9	0.21	880.0	0.21	880.0
0.23	7,212.0	0.23	5,572.8	0.23	5,440.8	0.23	908.7	0.23	908.7
0.38	8,720.4	0.38	6,738.3	0.38	6,578.7	0.38	1,098.8	0.38	1,098.8
0.44	9,124.3	0.44	7,050.4	0.44	6,883.5	0.44	1,149.7	0.44	1,149.7
0.75	11,044.7	0.75	8,534.3	0.75	8,332.2	0.75	1,391.6	0.75	1,391.6
1.50	11,044.7	1.50	8,534.3	1.50	8,332.2	1.50	1,391.6	1.50	1,391.6
3.00	11,044.7	3.00	8,534.3	3.00	8,332.2	3.00	1,391.6	3.00	1,391.6

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - No Degradation

Sta.

O. G. Elev. 37.0
Cut off Elev. 37.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 37 to 31	z (ft)	Elev. 31 to 24	z (ft)	*Elev. 24 to 14	z (ft)	Elev. 14 to 7	z (ft)	Elev. 7 to -3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	52.0	0.08	164.6	0.08	0.0	0.08	239.6	0.08	531.4
0.15	66.4	0.15	210.3	0.15	0.0	0.15	306.2	0.15	679.2
0.21	74.3	0.21	235.1	0.21	0.0	0.21	342.3	0.21	759.2
0.23	76.7	0.23	242.8	0.23	0.0	0.23	353.5	0.23	784.0
0.38	92.7	0.38	293.6	0.38	0.0	0.38	427.4	0.38	947.9
0.44	97.0	0.44	307.2	0.44	0.0	0.44	447.2	0.44	991.9
0.75	117.4	0.75	371.9	0.75	0.0	0.75	541.4	0.75	1,200.6
1.50	117.4	1.50	371.9	1.50	0.0	1.50	541.4	1.50	1,200.6
3.00	117.4	3.00	371.9	3.00	0.0	3.00	541.4	3.00	1,200.6

z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -18	z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38	z (ft)	Elev. -38 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	315.2	0.08	845.4	0.08	2,595.8	0.08	1,292.5	0.08	3,676.8
0.15	402.8	0.15	1,080.5	0.15	3,317.7	0.15	1,651.9	0.15	4,699.4
0.21	450.3	0.21	1,207.9	0.21	3,708.8	0.21	1,846.6	0.21	5,253.4
0.23	465.0	0.23	1,247.3	0.23	3,829.7	0.23	1,906.9	0.23	5,424.7
0.38	562.3	0.38	1,508.1	0.38	4,630.7	0.38	2,305.7	0.38	6,559.3
0.44	588.3	0.44	1,578.0	0.44	4,845.2	0.44	2,412.5	0.44	6,863.1
0.75	712.1	0.75	1,910.1	0.75	5,865.0	0.75	2,920.2	0.75	8,307.6
1.50	712.1	1.50	1,910.1	1.50	5,865.0	1.50	2,920.2	1.50	8,307.6
3.00	712.1	3.00	1,910.1	3.00	5,865.0	3.00	2,920.2	3.00	8,307.6

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78	z (ft)	Elev. -78 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,922.5	0.08	3,379.7	0.08	4,288.5	0.08	4,888.2	0.08	4,888.2
0.15	3,735.2	0.15	4,319.6	0.15	5,481.2	0.15	6,247.7	0.15	6,247.7
0.21	4,175.6	0.21	4,828.9	0.21	6,127.4	0.21	6,984.2	0.21	6,984.2
0.23	4,311.8	0.23	4,986.4	0.23	6,327.2	0.23	7,212.0	0.23	7,212.0
0.38	5,213.6	0.38	6,029.3	0.38	7,650.5	0.38	8,720.4	0.38	8,720.4
0.44	5,455.1	0.44	6,308.6	0.44	8,004.9	0.44	9,124.3	0.44	9,124.3
0.75	6,603.2	0.75	7,636.3	0.75	9,689.7	0.75	11,044.7	0.75	11,044.7
1.50	6,603.2	1.50	7,636.3	1.50	9,689.7	1.50	11,044.7	1.50	11,044.7
3.00	6,603.2	3.00	7,636.3	3.00	9,689.7	3.00	11,044.7	3.00	11,044.7

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - No Degradation

Sta.

O. G. Elev. 37.0 Pile 7.5' CISS
Cut off Elev. 37.0 GWS 50.0

z (ft)	Elev. 37 to 31	z (ft)	Elev. 31 to 24	z (ft)	*Elev. 24 to 17	z (ft)	*Elev. 17 to 12	z (ft)	*Elev. 12 to 7
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	56.9	0.08	180.2	0.08	0.0	0.08	0.0	0.08	0.0
0.15	72.7	0.15	230.3	0.15	0.0	0.15	0.0	0.15	0.0
0.21	81.3	0.21	257.4	0.21	0.0	0.21	0.0	0.21	0.0
0.23	83.9	0.23	265.8	0.23	0.0	0.23	0.0	0.23	0.0
0.38	101.5	0.38	321.4	0.38	0.0	0.38	0.0	0.38	0.0
0.44	106.2	0.44	336.3	0.44	0.0	0.44	0.0	0.44	0.0
0.75	128.6	0.75	407.1	0.75	0.0	0.75	0.0	0.75	0.0
1.50	128.6	1.50	407.1	1.50	0.0	1.50	0.0	1.50	0.0
3.00	128.6	3.00	407.1	3.00	0.0	3.00	0.0	3.00	0.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33	z (ft)	Elev. -33 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	551.0	0.08	309.0	0.08	2,438.8	0.08	2,537.5	0.08	1,525.5
0.15	704.2	0.15	395.0	0.15	3,117.1	0.15	3,243.2	0.15	1,949.8
0.21	787.2	0.21	441.5	0.21	3,484.5	0.21	3,625.6	0.21	2,179.6
0.23	812.9	0.23	455.9	0.23	3,598.2	0.23	3,743.8	0.23	2,250.7
0.38	982.9	0.38	551.3	0.38	4,350.7	0.38	4,526.8	0.38	2,721.5
0.44	1,028.4	0.44	576.8	0.44	4,552.3	0.44	4,736.5	0.44	2,847.5
0.75	1,244.9	0.75	698.2	0.75	5,510.4	0.75	5,733.4	0.75	3,446.8
1.50	1,244.9	1.50	698.2	1.50	5,510.4	1.50	5,733.4	1.50	3,446.8
3.00	1,244.9	3.00	698.2	3.00	5,510.4	3.00	5,733.4	3.00	3,446.8

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78	z (ft)	Elev. -78 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,551.3	0.08	4,036.0	0.08	4,888.2	0.08	4,128.7	0.08	4,032.0
0.15	4,538.9	0.15	5,158.4	0.15	6,247.7	0.15	5,276.8	0.15	5,153.3
0.21	5,074.0	0.21	5,766.6	0.21	6,984.2	0.21	5,898.9	0.21	5,760.8
0.23	5,239.4	0.23	5,954.6	0.23	7,212.0	0.23	6,091.3	0.23	5,948.7
0.38	6,335.3	0.38	7,200.0	0.38	8,720.4	0.38	7,365.3	0.38	7,192.8
0.44	6,628.7	0.44	7,533.5	0.44	9,124.3	0.44	7,706.5	0.44	7,526.0
0.75	8,023.9	0.75	9,119.1	0.75	11,044.7	0.75	9,328.4	0.75	9,110.0
1.50	8,023.9	1.50	9,119.1	1.50	11,044.7	1.50	9,328.4	1.50	9,110.0
3.00	8,023.9	3.00	9,119.1	3.00	11,044.7	3.00	9,328.4	3.00	9,110.0

Note - q (kip)
*-Liquefiable layer

Pier 10 and 11 - No Degradation

Sta.

O. G. Elev. 37.0
Cut off Elev. 37.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 37 to 27	z (ft)	Elev. 27 to 17	z (ft)	*Elev. 17 to 7	z (ft)	*Elev. 7 to 2	z (ft)	*Elev. 2 to -3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	103.0	0.08	168.2	0.08	0.0	0.08	0.0	0.08	0.0
0.15	131.7	0.15	215.0	0.15	0.0	0.15	0.0	0.15	0.0
0.21	147.2	0.21	240.4	0.21	0.0	0.21	0.0	0.21	0.0
0.23	152.0	0.23	248.2	0.23	0.0	0.23	0.0	0.23	0.0
0.38	183.8	0.38	300.1	0.38	0.0	0.38	0.0	0.38	0.0
0.44	192.3	0.44	314.0	0.44	0.0	0.44	0.0	0.44	0.0
0.75	232.8	0.75	380.1	0.75	0.0	0.75	0.0	0.75	0.0
1.50	232.8	1.50	380.1	1.50	0.0	1.50	0.0	1.50	0.0
3.00	232.8	3.00	380.1	3.00	0.0	3.00	0.0	3.00	0.0

z (ft)	*Elev. -3 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -18	z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	259.7	0.08	1,483.7	0.08	1,730.1	0.08	2,693.9	0.08	3,452.5
0.15	331.9	0.15	1,896.3	0.15	2,211.2	0.15	3,443.0	0.15	4,412.7
0.21	371.0	0.21	2,119.9	0.21	2,471.9	0.21	3,848.9	0.21	4,932.9
0.23	383.1	0.23	2,189.0	0.23	2,552.5	0.23	3,974.4	0.23	5,093.7
0.38	463.2	0.38	2,646.9	0.38	3,086.4	0.38	4,805.7	0.38	6,159.1
0.44	484.7	0.44	2,769.5	0.44	3,229.3	0.44	5,028.3	0.44	6,444.4
0.75	586.7	0.75	3,352.4	0.75	3,909.0	0.75	6,086.6	0.75	7,800.7
1.50	586.7	1.50	3,352.4	1.50	3,909.0	1.50	6,086.6	1.50	7,800.7
3.00	586.7	3.00	3,352.4	3.00	3,909.0	3.00	6,086.6	3.00	7,800.7

z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68	z (ft)	Elev. -68 to -78	z (ft)	Elev. -78 to -88
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	1,642.2	0.08	4,758.5	0.08	4,888.2	0.08	3,305.5	0.08	3,165.5
0.15	2,098.9	0.15	6,081.8	0.15	6,247.7	0.15	4,224.8	0.15	4,045.8
0.21	2,346.3	0.21	6,798.8	0.21	6,984.2	0.21	4,722.8	0.21	4,522.7
0.23	2,422.8	0.23	7,020.5	0.23	7,212.0	0.23	4,876.9	0.23	4,670.2
0.38	2,929.6	0.38	8,488.8	0.38	8,720.4	0.38	5,896.9	0.38	5,647.0
0.44	3,065.3	0.44	8,882.0	0.44	9,124.3	0.44	6,170.0	0.44	5,908.6
0.75	3,710.4	0.75	10,751.4	0.75	11,044.7	0.75	7,468.6	0.75	7,152.2
1.50	3,710.4	1.50	10,751.4	1.50	11,044.7	1.50	7,468.6	1.50	7,152.2
3.00	3,710.4	3.00	10,751.4	3.00	11,044.7	3.00	7,468.6	3.00	7,152.2

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - No Degradation

Sta.

O. G. Elev. 36.0
Cut off Elev. 36.0

Pile 7.5" CISS
GWS 50.0

z (ft)	*Elev. 36 to 31	z (ft)	Elev. 31 to 23	z (ft)	Elev. 23 to 15	z (ft)	Elev. 15 to 7	z (ft)	Elev. 7 to -3
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	35.2	0.08	35.2	0.08	35.2	0.08	70.4
0.15	0.0	0.15	45.0	0.15	45.0	0.15	45.0	0.15	90.0
0.21	0.0	0.21	50.3	0.21	50.3	0.21	50.3	0.21	100.6
0.23	0.0	0.23	51.9	0.23	51.9	0.23	51.9	0.23	103.9
0.38	0.0	0.38	62.8	0.38	62.8	0.38	62.8	0.38	125.6
0.44	0.0	0.44	65.7	0.44	65.7	0.44	65.7	0.44	131.4
0.75	0.0	0.75	79.5	0.75	79.5	0.75	79.5	0.75	159.0
1.50	0.0	1.50	79.5	1.50	79.5	1.50	79.5	1.50	159.0
3.00	0.0	3.00	79.5	3.00	79.5	3.00	79.5	3.00	159.0

z (ft)	Elev. -3 to -9	z (ft)	Elev. -9 to -19	z (ft)	Elev. -19 to -29	z (ft)	Elev. -29 to -39	z (ft)	Elev. -39 to -46
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	227.6	0.08	1,892.7	0.08	2,651.4	0.08	1,325.3	0.08	1,504.1
0.15	290.9	0.15	2,419.1	0.15	3,388.7	0.15	1,693.9	0.15	1,922.3
0.21	325.2	0.21	2,704.3	0.21	3,788.2	0.21	1,893.6	0.21	2,149.0
0.23	335.8	0.23	2,792.5	0.23	3,911.8	0.23	1,955.3	0.23	2,219.1
0.38	406.0	0.38	3,376.5	0.38	4,729.9	0.38	2,364.3	0.38	2,683.2
0.44	424.8	0.44	3,532.9	0.44	4,949.0	0.44	2,473.8	0.44	2,807.5
0.75	514.2	0.75	4,276.5	0.75	5,990.6	0.75	2,994.4	0.75	3,398.3
1.50	514.2	1.50	4,276.5	1.50	5,990.6	1.50	2,994.4	1.50	3,398.3
3.00	514.2	3.00	4,276.5	3.00	5,990.6	3.00	2,994.4	3.00	3,398.3

z (ft)	Elev. -46 to -54	z (ft)	Elev. -54 to -59	z (ft)	Elev. -59 to -64	z (ft)	Elev. -64 to -74	z (ft)	Elev. -74 to -84
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,370.0	0.08	3,741.3	0.08	1,989.8	0.08	4,888.2	0.08	4,888.2
0.15	4,307.2	0.15	4,781.7	0.15	2,543.1	0.15	6,247.7	0.15	6,247.7
0.21	4,815.0	0.21	5,345.4	0.21	2,843.0	0.21	6,984.2	0.21	6,984.2
0.23	4,972.0	0.23	5,519.7	0.23	2,935.7	0.23	7,212.0	0.23	7,212.0
0.38	6,011.9	0.38	6,674.2	0.38	3,549.7	0.38	8,720.4	0.38	8,720.4
0.44	6,290.4	0.44	6,983.4	0.44	3,714.1	0.44	9,124.3	0.44	9,124.3
0.75	7,614.3	0.75	8,453.1	0.75	4,495.8	0.75	11,044.7	0.75	11,044.7
1.50	7,614.3	1.50	8,453.1	1.50	4,495.8	1.50	11,044.7	1.50	11,044.7
3.00	7,614.3	3.00	8,453.1	3.00	4,495.8	3.00	11,044.7	3.00	11,044.7

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - No Degradation

Sta.

O. G. Elev. 35.0
Cut off Elev. 35.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 35 to 28	z (ft)	Elev. 28 to 21	z (ft)	Elev. 21 to 13	z (ft)	*Elev. 13 to 7	z (ft)	*Elev. 7 to -6
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	44.0	0.08	52.8	0.08	0.0	0.08	0.0
0.15	0.0	0.15	56.2	0.15	67.5	0.15	0.0	0.15	0.0
0.21	0.0	0.21	62.9	0.21	75.4	0.21	0.0	0.21	0.0
0.23	0.0	0.23	64.9	0.23	77.9	0.23	0.0	0.23	0.0
0.38	0.0	0.38	78.5	0.38	94.2	0.38	0.0	0.38	0.0
0.44	0.0	0.44	82.1	0.44	98.5	0.44	0.0	0.44	0.0
0.75	0.0	0.75	99.4	0.75	119.3	0.75	0.0	0.75	0.0
1.50	0.0	1.50	99.4	1.50	119.3	1.50	0.0	1.50	0.0
3.00	0.0	3.00	99.4	3.00	119.3	3.00	0.0	3.00	0.0

z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -46	z (ft)	Elev. -46 to -56
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	367.3	0.08	2,270.4	0.08	1,180.8	0.08	1,314.2	0.08	3,089.3
0.15	469.5	0.15	2,901.8	0.15	1,509.1	0.15	1,679.7	0.15	3,948.5
0.21	524.8	0.21	3,243.9	0.21	1,687.0	0.21	1,877.7	0.21	4,414.0
0.23	541.9	0.23	3,349.6	0.23	1,742.1	0.23	1,938.9	0.23	4,557.9
0.38	655.3	0.38	4,050.2	0.38	2,106.4	0.38	2,344.4	0.38	5,511.2
0.44	685.6	0.44	4,237.8	0.44	2,204.0	0.44	2,453.0	0.44	5,766.5
0.75	830.0	0.75	5,129.8	0.75	2,667.9	0.75	2,969.3	0.75	6,980.1
1.50	830.0	1.50	5,129.8	1.50	2,667.9	1.50	2,969.3	1.50	6,980.1
3.00	830.0	3.00	5,129.8	3.00	2,667.9	3.00	2,969.3	3.00	6,980.1

z (ft)	Elev. -56 to -66	z (ft)	Elev. -66 to -76	z (ft)	Elev. -76 to -86	z (ft)	Elev. -86 to -91	z (ft)	Elev. -91 to -96
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,648.6	0.08	4,211.8	0.08	2,357.2	0.08	3,121.1	0.08	3,061.2
0.15	4,663.2	0.15	5,383.1	0.15	3,012.8	0.15	3,989.0	0.15	3,912.5
0.21	5,213.0	0.21	6,017.7	0.21	3,368.0	0.21	4,459.3	0.21	4,373.8
0.23	5,383.0	0.23	6,214.0	0.23	3,477.8	0.23	4,604.7	0.23	4,516.4
0.38	6,508.9	0.38	7,513.6	0.38	4,205.2	0.38	5,567.8	0.38	5,461.0
0.44	6,810.4	0.44	7,861.7	0.44	4,400.0	0.44	5,825.7	0.44	5,714.0
0.75	8,243.7	0.75	9,516.3	0.75	5,326.1	0.75	7,051.8	0.75	6,916.6
1.50	8,243.7	1.50	9,516.3	1.50	5,326.1	1.50	7,051.8	1.50	6,916.6
3.00	8,243.7	3.00	9,516.3	3.00	5,326.1	3.00	7,051.8	3.00	6,916.6

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - No Degradation

Sta.

O. G. Elev. 34.0
Cut off Elev. 34.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 34 to 29	z (ft)	Elev. 29 to 22	z (ft)	Elev. 22 to 14	z (ft)	*Elev. 14 to 7	z (ft)	*Elev. 7 to -6
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	44.0	0.08	52.8	0.08	0.0	0.08	0.0
0.15	0.0	0.15	56.2	0.15	67.5	0.15	0.0	0.15	0.0
0.21	0.0	0.21	62.9	0.21	75.4	0.21	0.0	0.21	0.0
0.23	0.0	0.23	64.9	0.23	77.9	0.23	0.0	0.23	0.0
0.38	0.0	0.38	78.5	0.38	94.2	0.38	0.0	0.38	0.0
0.44	0.0	0.44	82.1	0.44	98.5	0.44	0.0	0.44	0.0
0.75	0.0	0.75	99.4	0.75	119.3	0.75	0.0	0.75	0.0
1.50	0.0	1.50	99.4	1.50	119.3	1.50	0.0	1.50	0.0
3.00	0.0	3.00	99.4	3.00	119.3	3.00	0.0	3.00	0.0

z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -47	z (ft)	Elev. -47 to -57
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	360.6	0.08	2,242.5	0.08	1,166.5	0.08	1,310.3	0.08	3,108.3
0.15	460.9	0.15	2,866.2	0.15	1,490.9	0.15	1,674.6	0.15	3,972.8
0.21	515.2	0.21	3,204.1	0.21	1,666.7	0.21	1,872.1	0.21	4,441.1
0.23	532.0	0.23	3,308.6	0.23	1,721.0	0.23	1,933.1	0.23	4,586.0
0.38	643.2	0.38	4,000.6	0.38	2,081.0	0.38	2,337.4	0.38	5,545.1
0.44	673.0	0.44	4,185.9	0.44	2,177.4	0.44	2,445.7	0.44	5,802.0
0.75	814.7	0.75	5,066.9	0.75	2,635.6	0.75	2,960.4	0.75	7,023.1
1.50	814.7	1.50	5,066.9	1.50	2,635.6	1.50	2,960.4	1.50	7,023.1
3.00	814.7	3.00	5,066.9	3.00	2,635.6	3.00	2,960.4	3.00	7,023.1

z (ft)	Elev. -57 to -62	z (ft)	Elev. -62 to -67	z (ft)	Elev. -67 to -77	z (ft)	Elev. -77 to -82	z (ft)	Elev. -82 to -87
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	4,430.3	0.08	352.0	0.08	3,034.3	0.08	1,261.8	0.08	1,248.7
0.15	5,662.3	0.15	449.8	0.15	3,878.1	0.15	1,612.8	0.15	1,595.9
0.21	6,329.8	0.21	502.9	0.21	4,335.3	0.21	1,802.9	0.21	1,784.1
0.23	6,536.3	0.23	519.3	0.23	4,476.7	0.23	1,861.7	0.23	1,842.3
0.38	7,903.3	0.38	627.9	0.38	5,413.0	0.38	2,251.1	0.38	2,227.6
0.44	8,269.4	0.44	656.9	0.44	5,663.7	0.44	2,355.3	0.44	2,330.8
0.75	10,009.9	0.75	795.2	0.75	6,855.8	0.75	2,851.0	0.75	2,821.3
1.50	10,009.9	1.50	795.2	1.50	6,855.8	1.50	2,851.0	1.50	2,821.3
3.00	10,009.9	3.00	795.2	3.00	6,855.8	3.00	2,851.0	3.00	2,821.3

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - No Degradation

Sta.

O. G. Elev. 33.0
Cut off Elev. 22.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 33 to 28	z (ft)	*Elev. 28 to 18	z (ft)	Elev. 18 to 7	z (ft)	Elev. 7 to -4	z (ft)	Elev. -4 to -12
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	41.3	0.08	0.0	0.08	291.7	0.08	274.8	0.08	356.5
0.15	52.7	0.15	0.0	0.15	372.8	0.15	351.2	0.15	455.7
0.21	58.9	0.21	0.0	0.21	416.8	0.21	392.6	0.21	509.4
0.23	60.9	0.23	0.0	0.23	430.4	0.23	405.4	0.23	526.0
0.38	73.6	0.38	0.0	0.38	520.4	0.38	490.2	0.38	636.0
0.44	77.0	0.44	0.0	0.44	544.5	0.44	512.9	0.44	665.5
0.75	93.2	0.75	0.0	0.75	659.1	0.75	620.9	0.75	805.5
1.50	93.2	1.50	0.0	1.50	659.1	1.50	620.9	1.50	805.5
3.00	93.2	3.00	0.0	3.00	659.1	3.00	620.9	3.00	805.5

z (ft)	Elev. -12 to -17	z (ft)	Elev. -17 to -22	z (ft)	Elev. -22 to -32	z (ft)	Elev. -32 to -42	z (ft)	Elev. -42 to -52
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	352.0	0.08	2,088.3	0.08	2,098.5	0.08	2,630.3	0.08	3,132.7
0.15	449.8	0.15	2,669.0	0.15	2,682.0	0.15	3,361.8	0.15	4,003.9
0.21	502.9	0.21	2,983.7	0.21	2,998.2	0.21	3,758.1	0.21	4,475.9
0.23	519.3	0.23	3,081.0	0.23	3,096.0	0.23	3,880.7	0.23	4,621.9
0.38	627.9	0.38	3,725.4	0.38	3,743.5	0.38	4,692.3	0.38	5,588.6
0.44	656.9	0.44	3,897.9	0.44	3,916.9	0.44	4,909.7	0.44	5,847.4
0.75	795.2	0.75	4,718.3	0.75	4,741.3	0.75	5,943.0	0.75	7,078.1
1.50	795.2	1.50	4,718.3	1.50	4,741.3	1.50	5,943.0	1.50	7,078.1
3.00	795.2	3.00	4,718.3	3.00	4,741.3	3.00	5,943.0	3.00	7,078.1

z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72	z (ft)	Elev. -72 to -82	z (ft)	Elev. -82 to -87	z (ft)	Elev. -87 to -92
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,644.8	0.08	1,750.4	0.08	4,572.9	0.08	4,888.2	0.08	4,888.2
0.15	4,658.4	0.15	2,237.1	0.15	5,844.6	0.15	6,247.7	0.15	6,247.7
0.21	5,207.6	0.21	2,500.9	0.21	6,533.6	0.21	6,984.2	0.21	6,984.2
0.23	5,377.4	0.23	2,582.4	0.23	6,746.7	0.23	7,212.0	0.23	7,212.0
0.38	6,502.1	0.38	3,122.6	0.38	8,157.8	0.38	8,720.4	0.38	8,720.4
0.44	6,803.3	0.44	3,267.2	0.44	8,535.7	0.44	9,124.3	0.44	9,124.3
0.75	8,235.1	0.75	3,954.8	0.75	10,332.1	0.75	11,044.7	0.75	11,044.7
1.50	8,235.1	1.50	3,954.8	1.50	10,332.1	1.50	11,044.7	1.50	11,044.7
3.00	8,235.1	3.00	3,954.8	3.00	10,332.1	3.00	11,044.7	3.00	11,044.7

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - No Degradation

Sta.

O. G. Elev. 27.0 | Pile 7.5' CISS
Cut off Elev. 27.0 | GWS 50.0

z (ft)	Elev. 27 to 22	z (ft)	*Elev. 22 to 17	z (ft)	*Elev. 17 to 12	z (ft)	Elev. 12 to 7	z (ft)	Elev. 7 to 2
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	41.3	0.08	0.0	0.08	0.0	0.08	148.6	0.08	193.9
0.15	52.7	0.15	0.0	0.15	0.0	0.15	190.0	0.15	247.8
0.21	58.9	0.21	0.0	0.21	0.0	0.21	212.4	0.21	277.0
0.23	60.9	0.23	0.0	0.23	0.0	0.23	219.3	0.23	286.1
0.38	73.6	0.38	0.0	0.38	0.0	0.38	265.2	0.38	345.9
0.44	77.0	0.44	0.0	0.44	0.0	0.44	277.5	0.44	361.9
0.75	93.2	0.75	0.0	0.75	0.0	0.75	335.8	0.75	438.1
1.50	93.2	1.50	0.0	1.50	0.0	1.50	335.8	1.50	438.1
3.00	93.2	3.00	0.0	3.00	0.0	3.00	335.8	3.00	438.1

z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33	z (ft)	Elev. -33 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	259.4	0.08	352.0	0.08	1,926.9	0.08	2,128.2	0.08	2,659.3
0.15	331.5	0.15	449.8	0.15	2,462.8	0.15	2,720.1	0.15	3,398.8
0.21	370.6	0.21	502.9	0.21	2,753.1	0.21	3,040.8	0.21	3,799.5
0.23	382.7	0.23	519.3	0.23	2,842.9	0.23	3,139.9	0.23	3,923.4
0.38	462.7	0.38	627.9	0.38	3,437.5	0.38	3,796.7	0.38	4,744.0
0.44	484.2	0.44	656.9	0.44	3,596.7	0.44	3,972.5	0.44	4,963.7
0.75	586.1	0.75	795.2	0.75	4,353.7	0.75	4,808.6	0.75	6,008.5
1.50	586.1	1.50	795.2	1.50	4,353.7	1.50	4,808.6	1.50	6,008.5
3.00	586.1	3.00	795.2	3.00	4,353.7	3.00	4,808.6	3.00	6,008.5

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -83	z (ft)	Elev. -83 to -93
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,007.0	0.08	3,654.2	0.08	1,923.3	0.08	4,604.5	0.08	4,888.2
0.15	3,843.3	0.15	4,670.4	0.15	2,458.1	0.15	5,885.0	0.15	6,247.7
0.21	4,296.4	0.21	5,221.0	0.21	2,747.9	0.21	6,578.8	0.21	6,984.2
0.23	4,436.5	0.23	5,391.3	0.23	2,837.5	0.23	6,793.4	0.23	7,212.0
0.38	5,364.4	0.38	6,518.9	0.38	3,431.0	0.38	8,214.2	0.38	8,720.4
0.44	5,612.9	0.44	6,820.8	0.44	3,589.9	0.44	8,594.7	0.44	9,124.3
0.75	6,794.2	0.75	8,256.4	0.75	4,345.5	0.75	10,403.6	0.75	11,044.7
1.50	6,794.2	1.50	8,256.4	1.50	4,345.5	1.50	10,403.6	1.50	11,044.7
3.00	6,794.2	3.00	8,256.4	3.00	4,345.5	3.00	10,403.6	3.00	11,044.7

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
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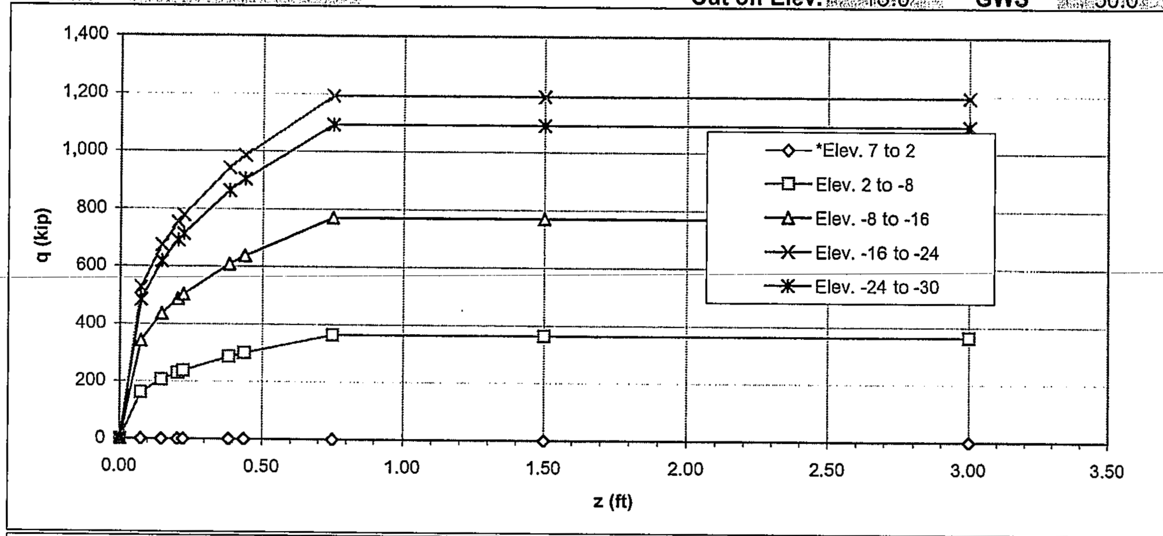
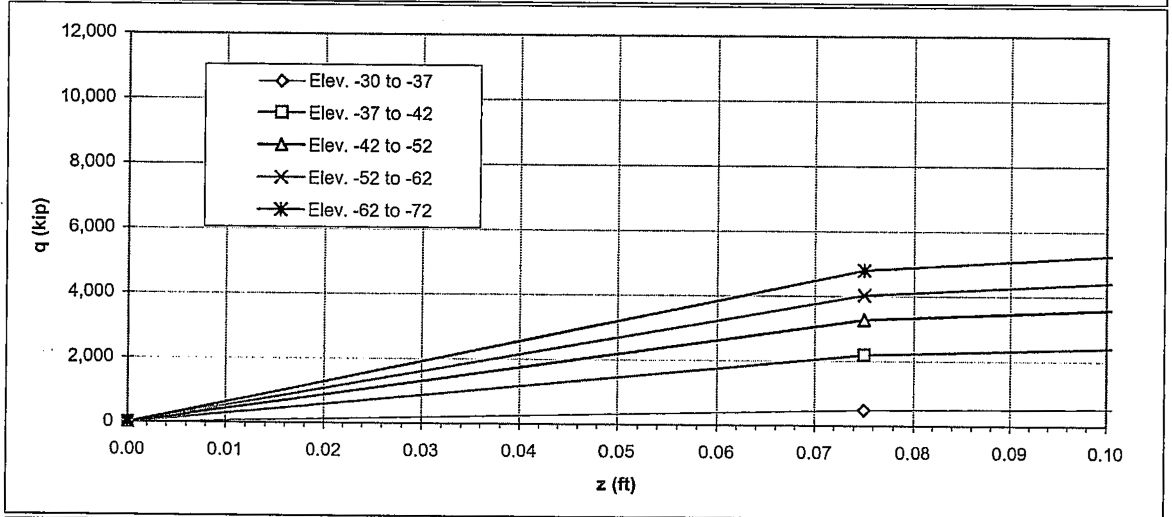
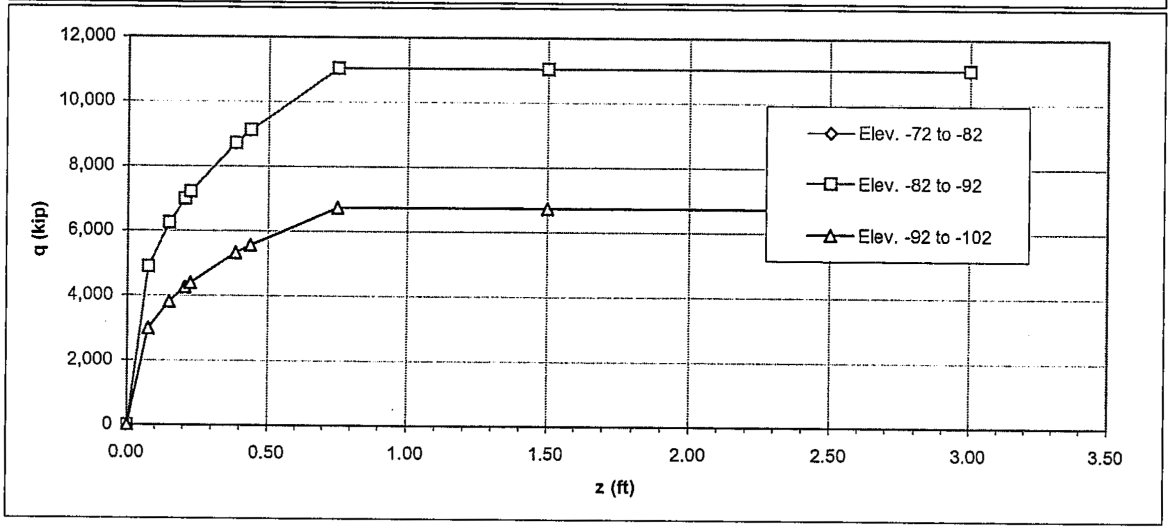
Pier 2 - with Degrdation

Sta.		**O. G. Elev.**	7.0	**Pile**	7.5' CISS
		Cut off Elev.	18.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
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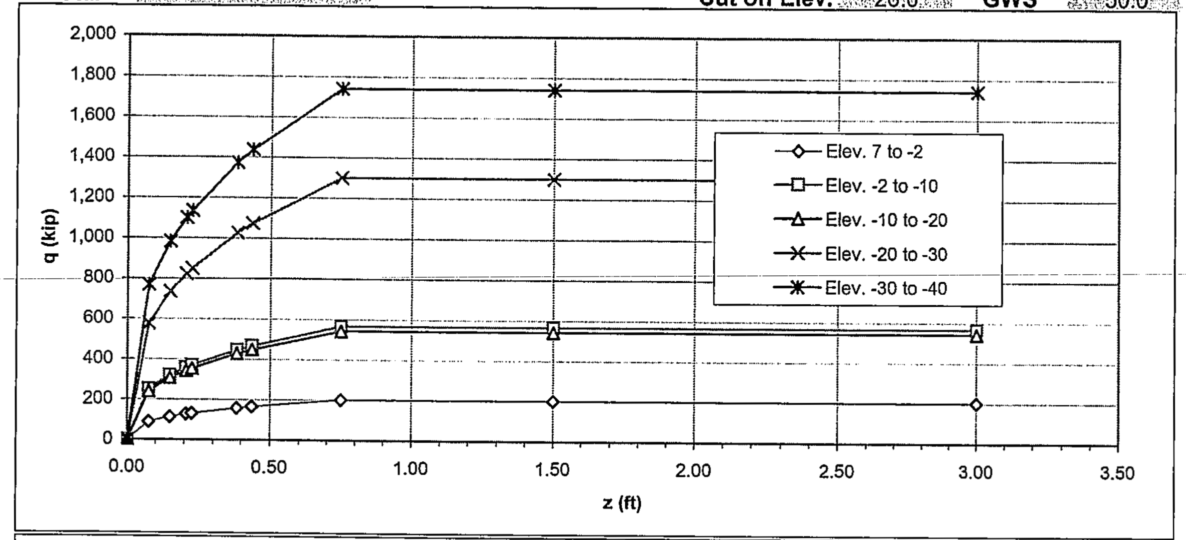
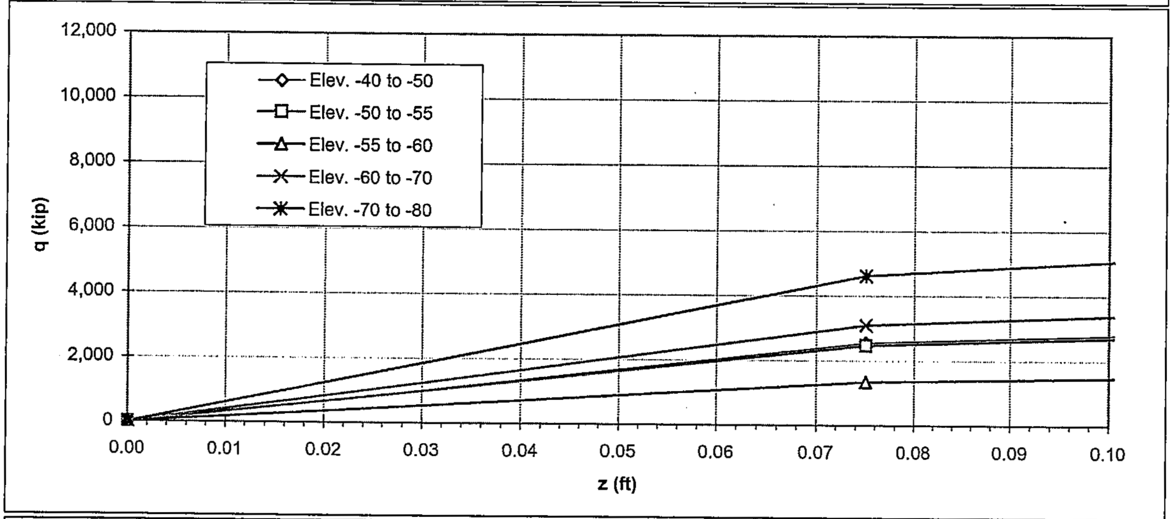
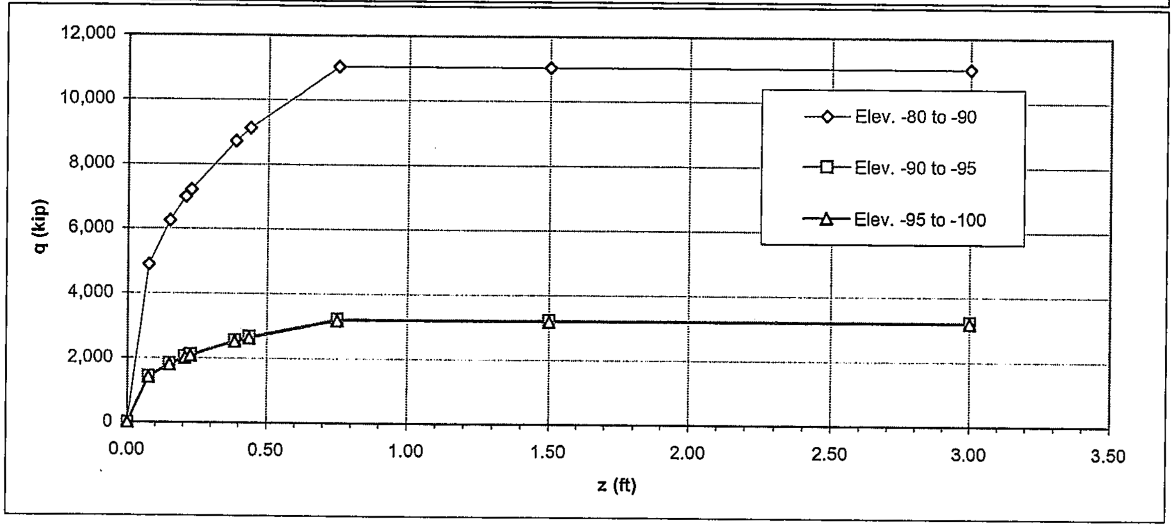
Pier 3 - with Degrdation

Sta.

O. G. Elev. 7.0 Pile 7.5' CISS
Cut off Elev. 26.0 GWS 50.0







Feather River Bridge
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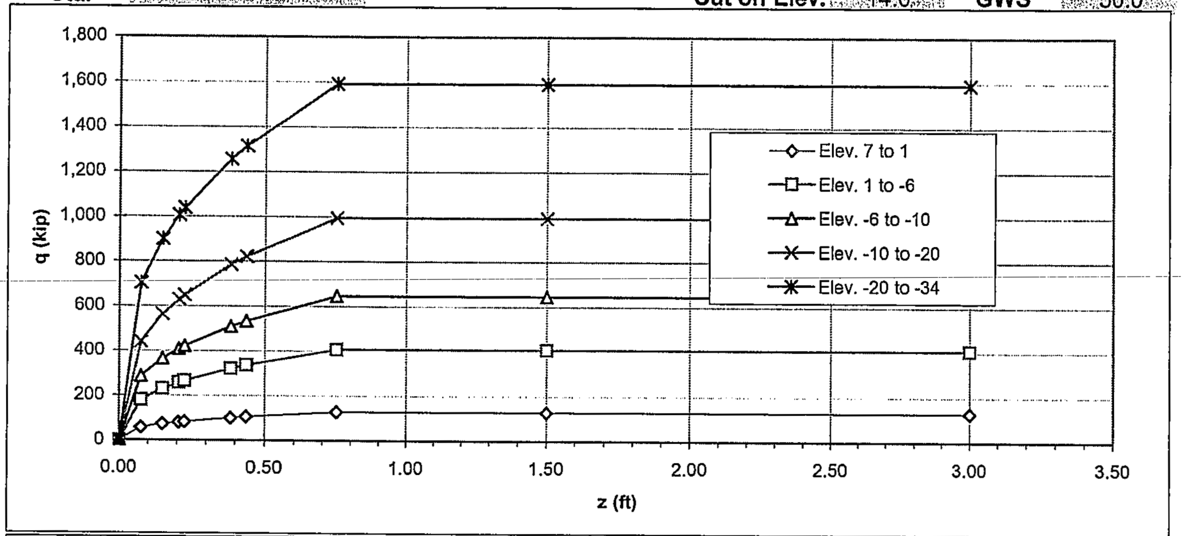
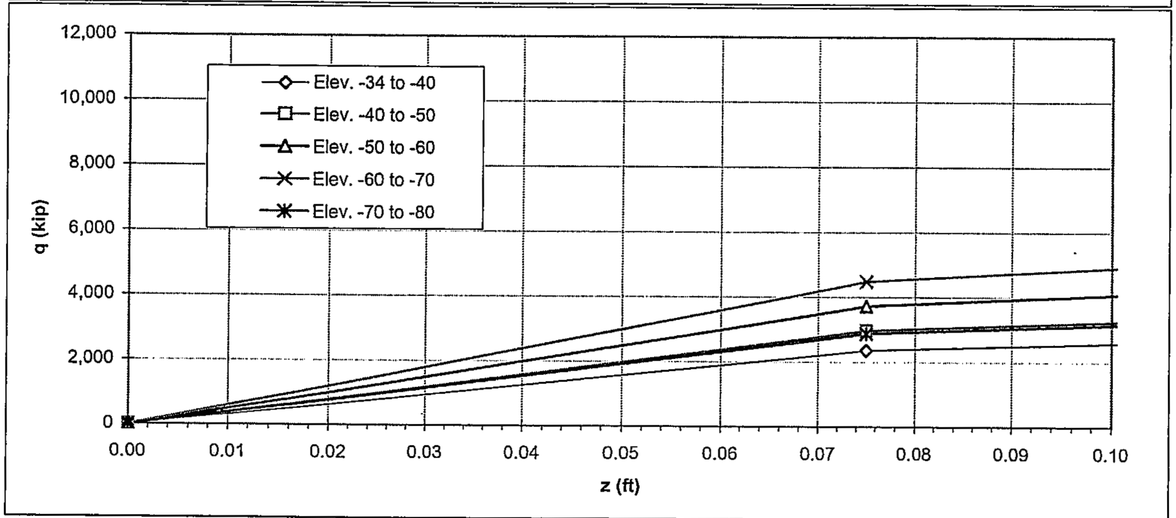
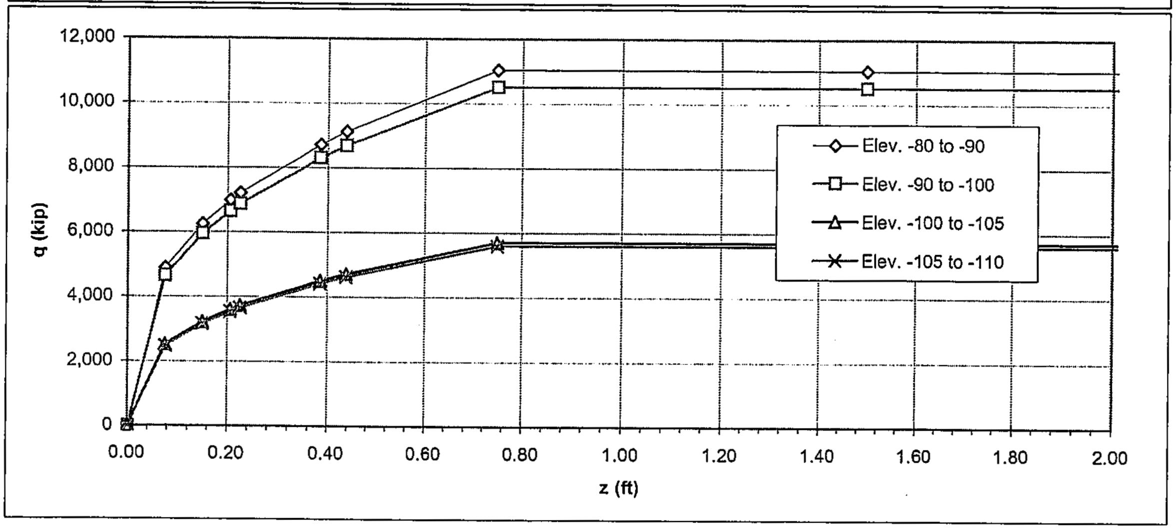
Pier 4 - with Degrdation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	14.0	GWS	50.0







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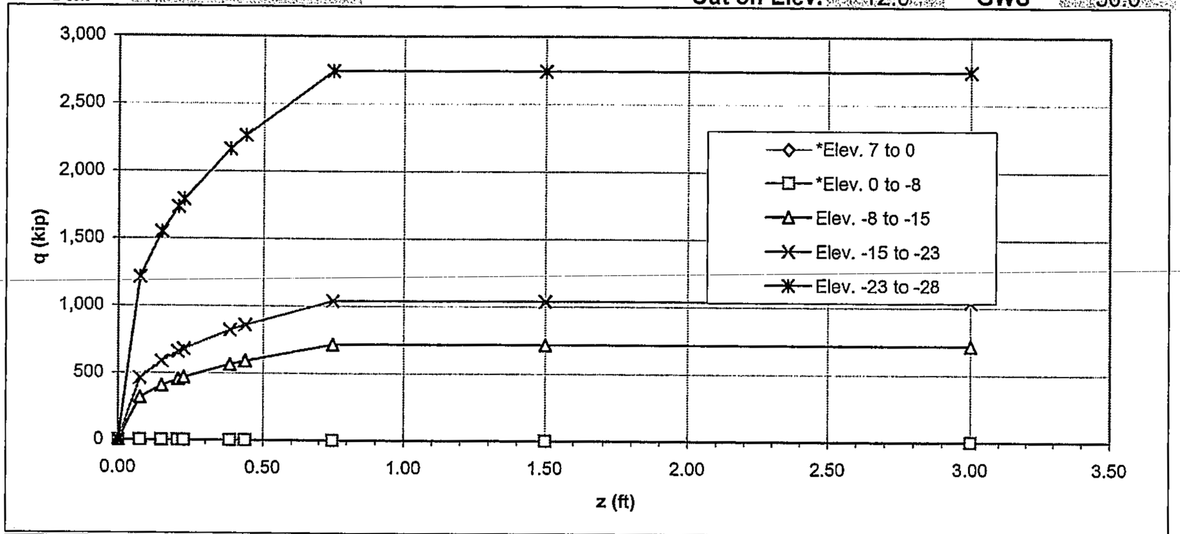
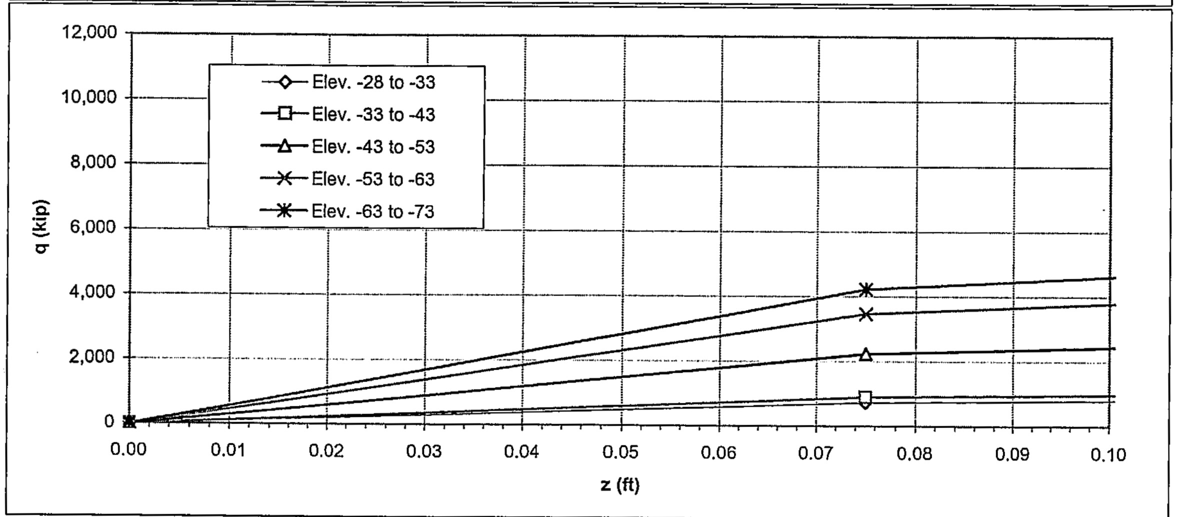
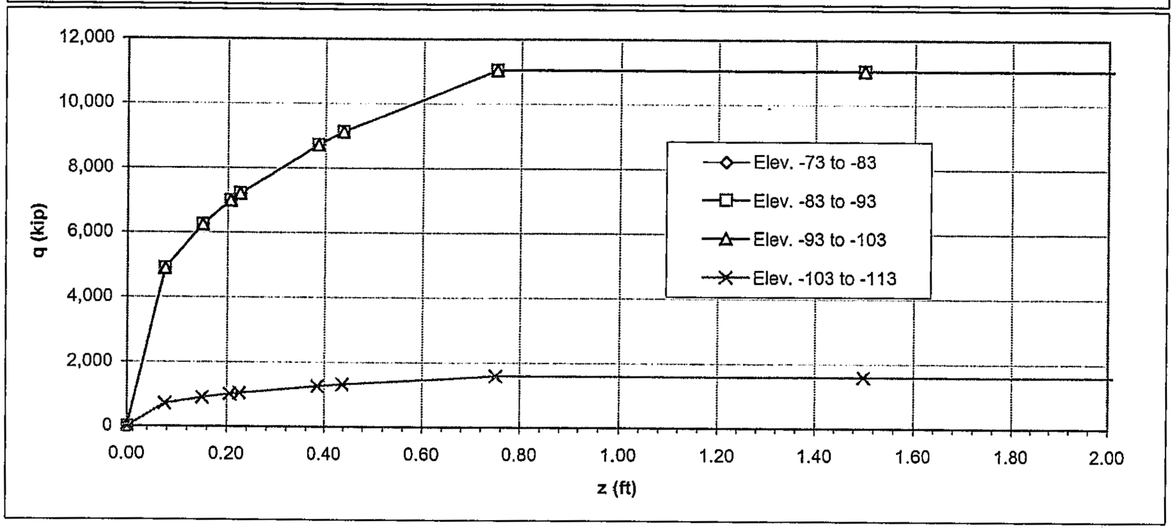
Pier 5 - with Degradation

Sta.

O. G. Elev.	7.0	**Pile**	7.5' CISS
Cut off Elev.	12.0	**GWS**	50.0







*-Liquefiable layer

Feather River Bridge
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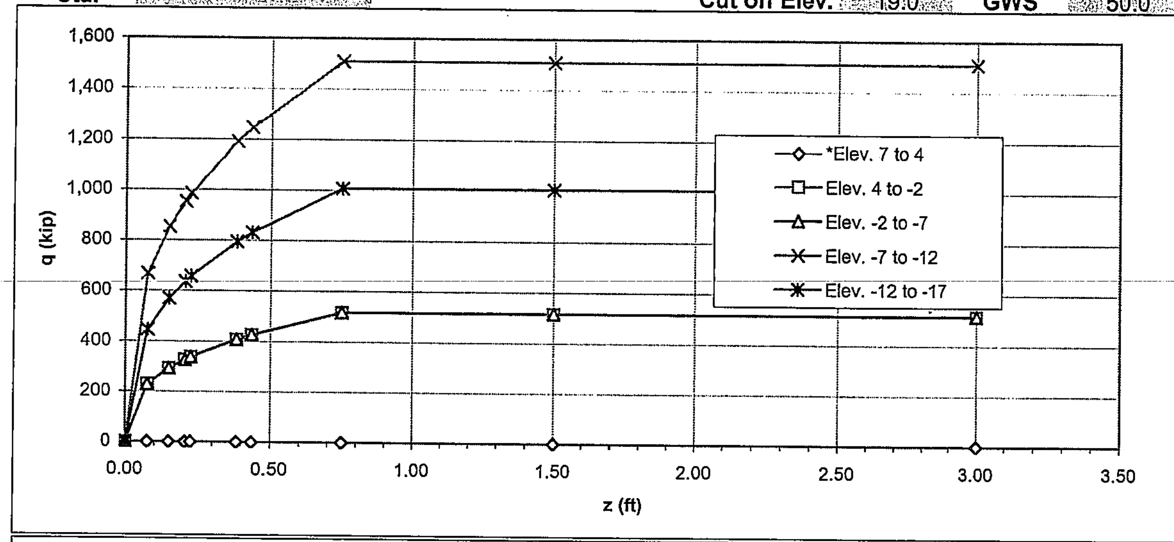
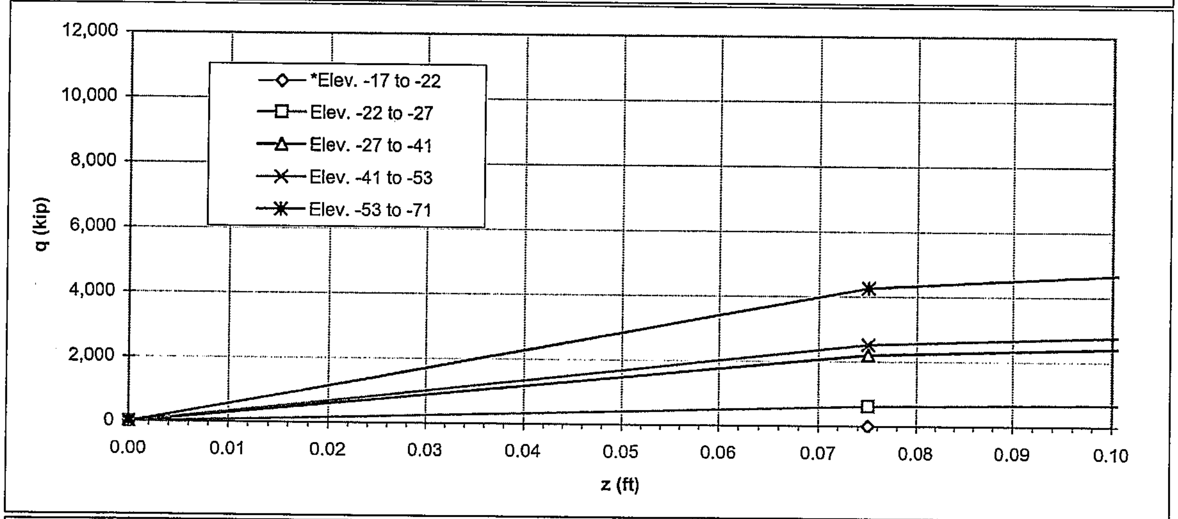
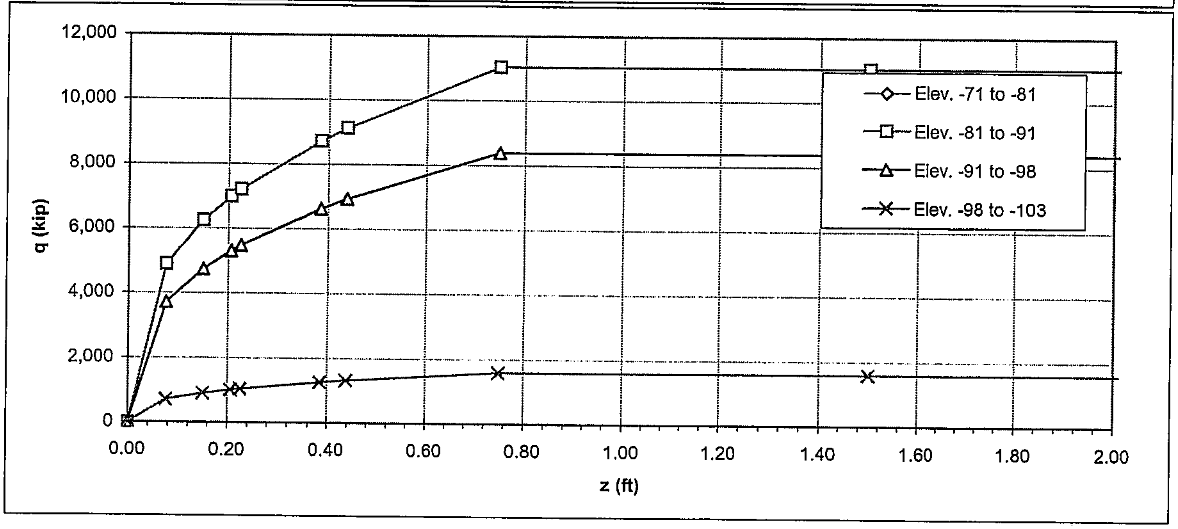
Pier 6 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	19.0	GWS	50.0







*-Liquefiable layer

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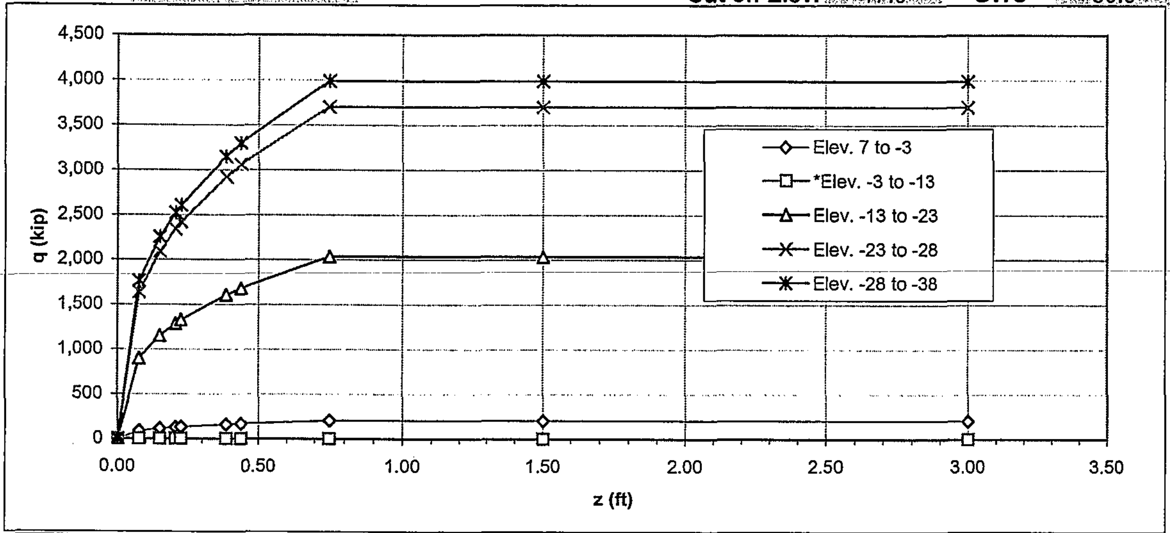
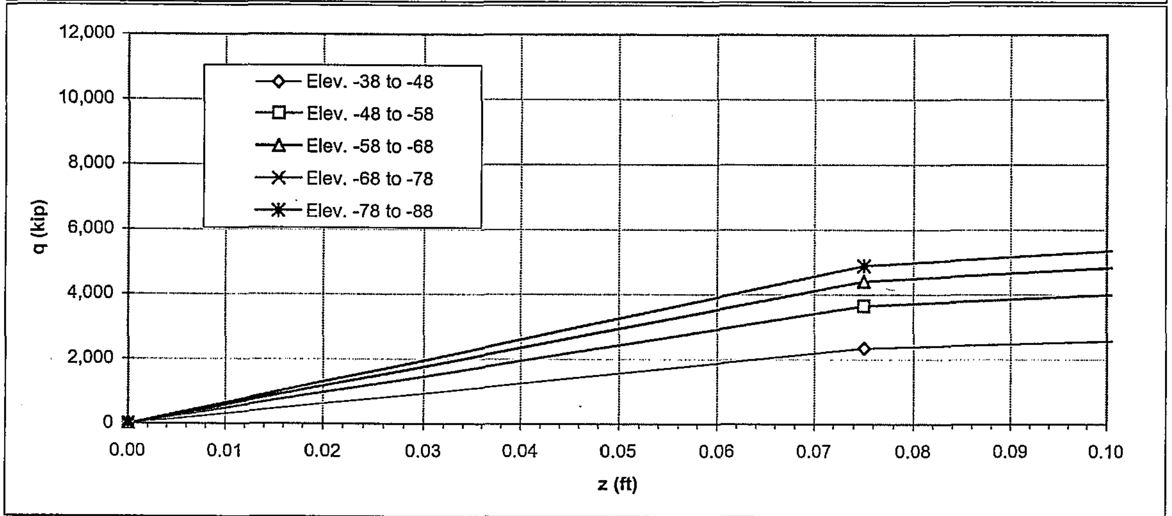
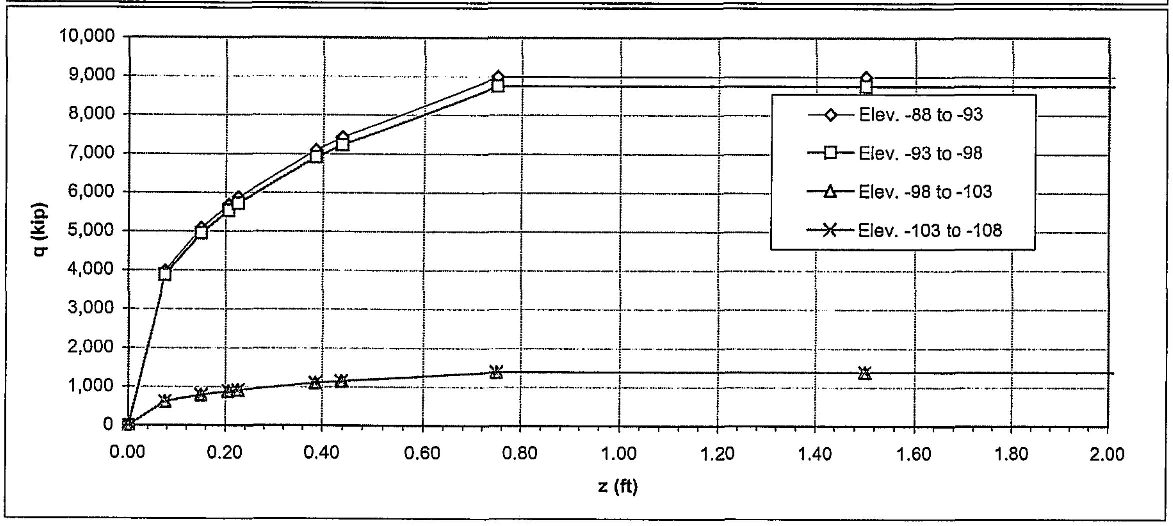
Pier 7 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	17.0	GWS	50.0







*-Liquefiable layer

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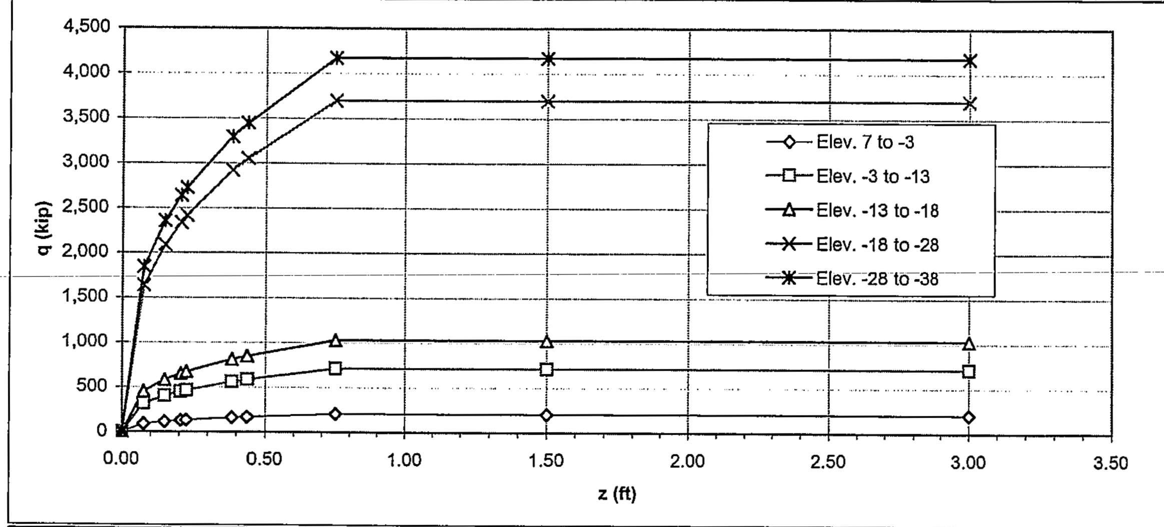
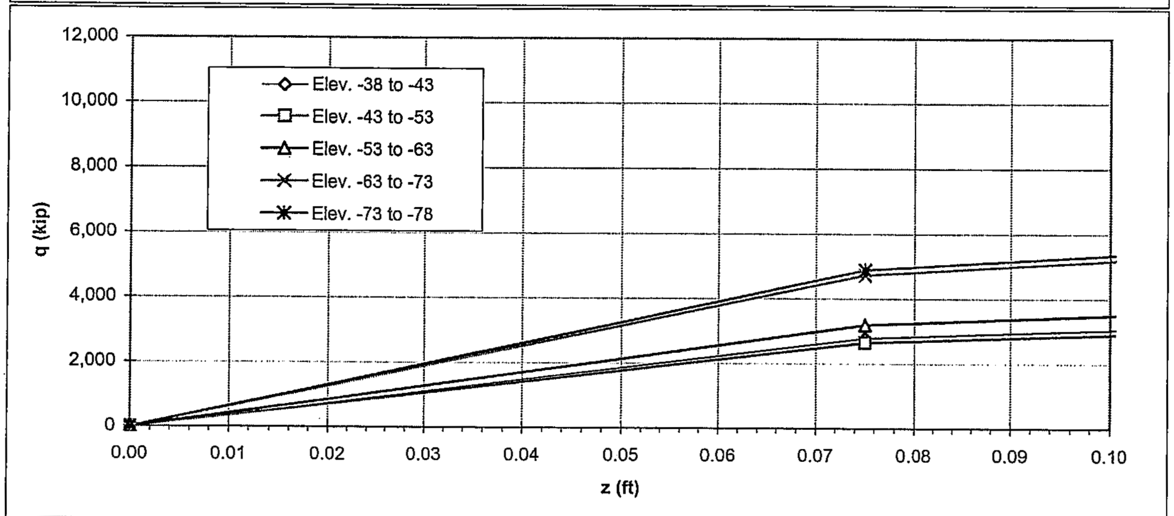
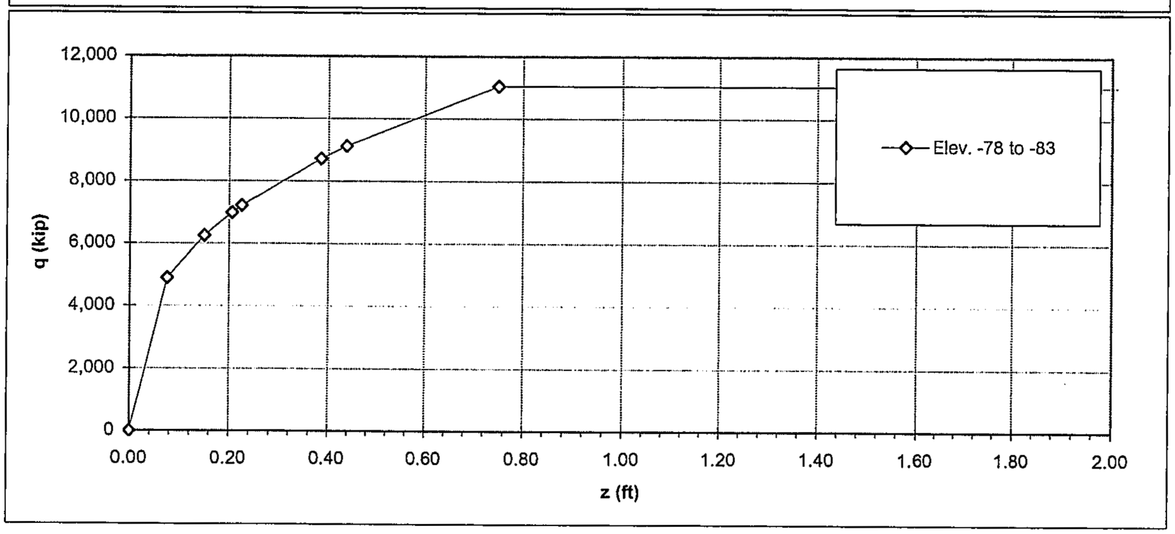
Pier 8 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	37.0	GWS	50.0







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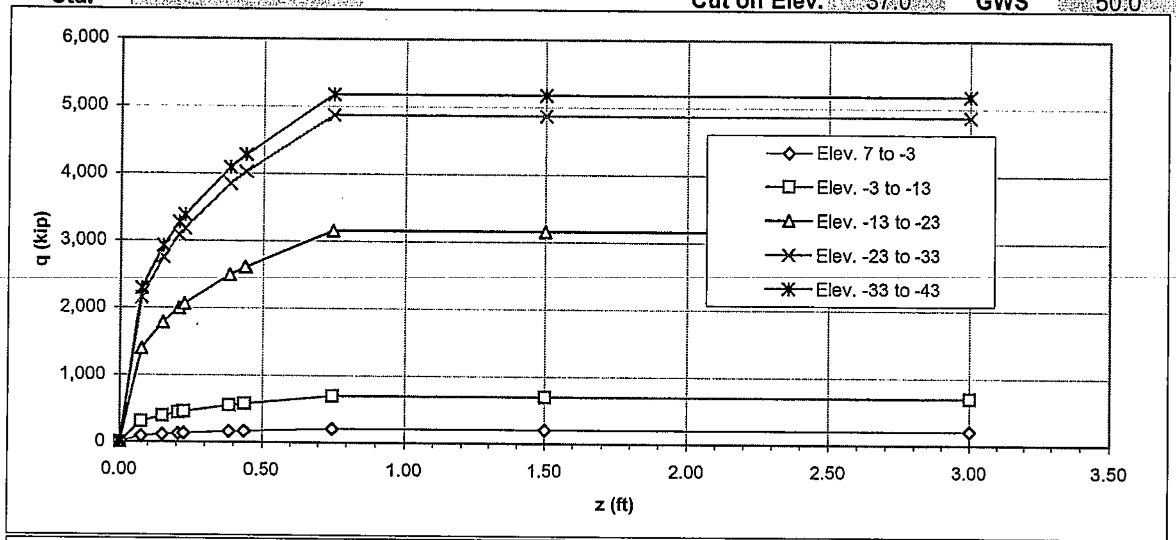
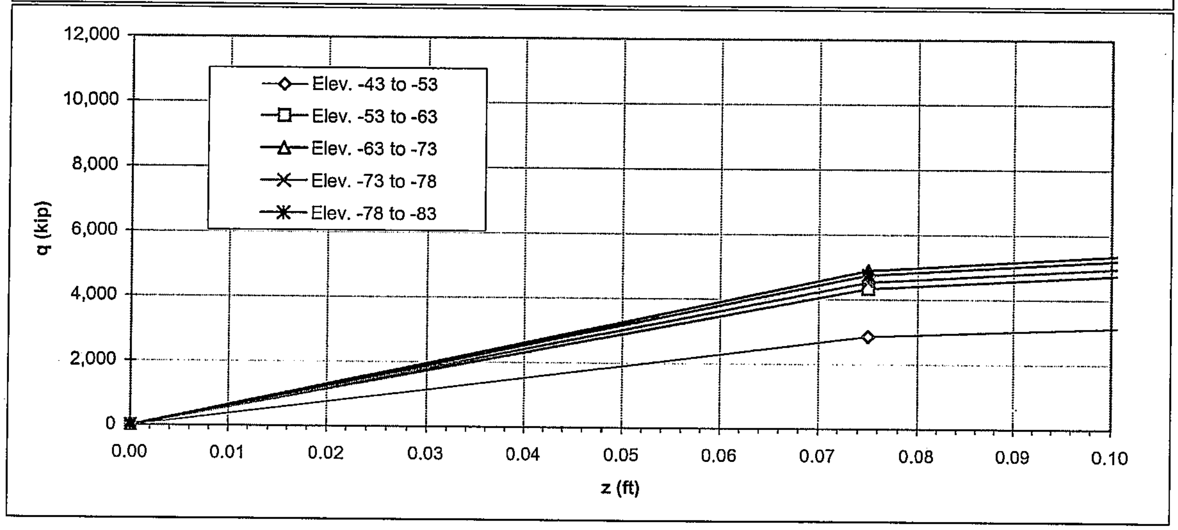
Pier 9 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	37.0	GWS	50.0





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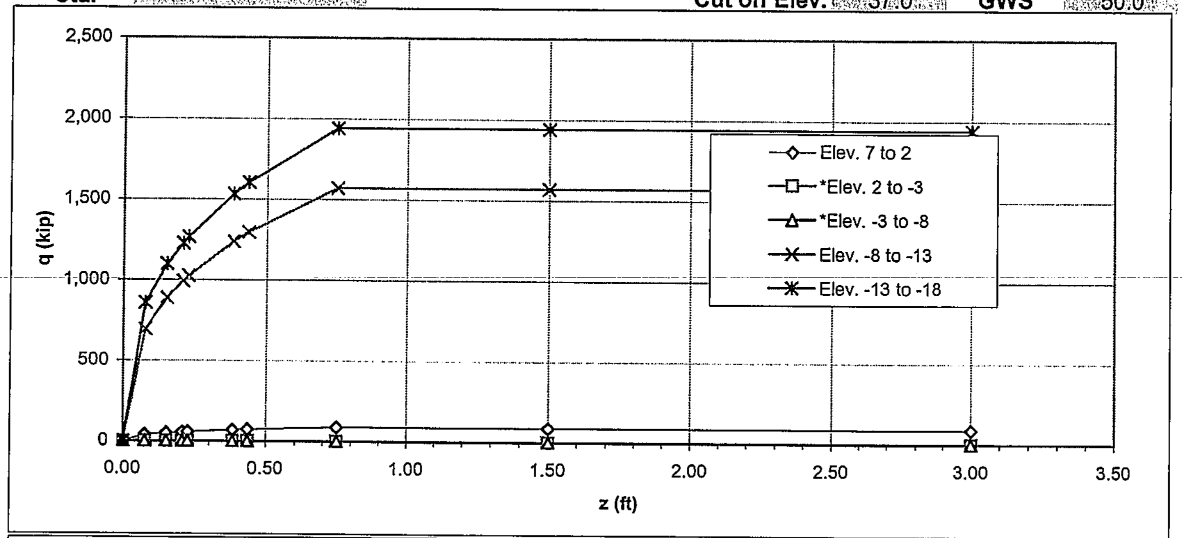
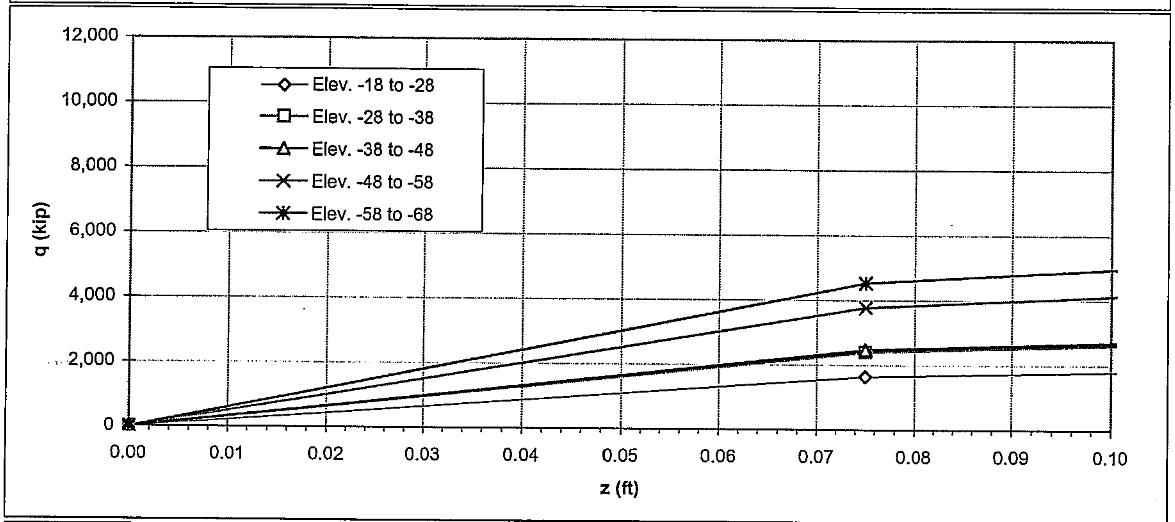
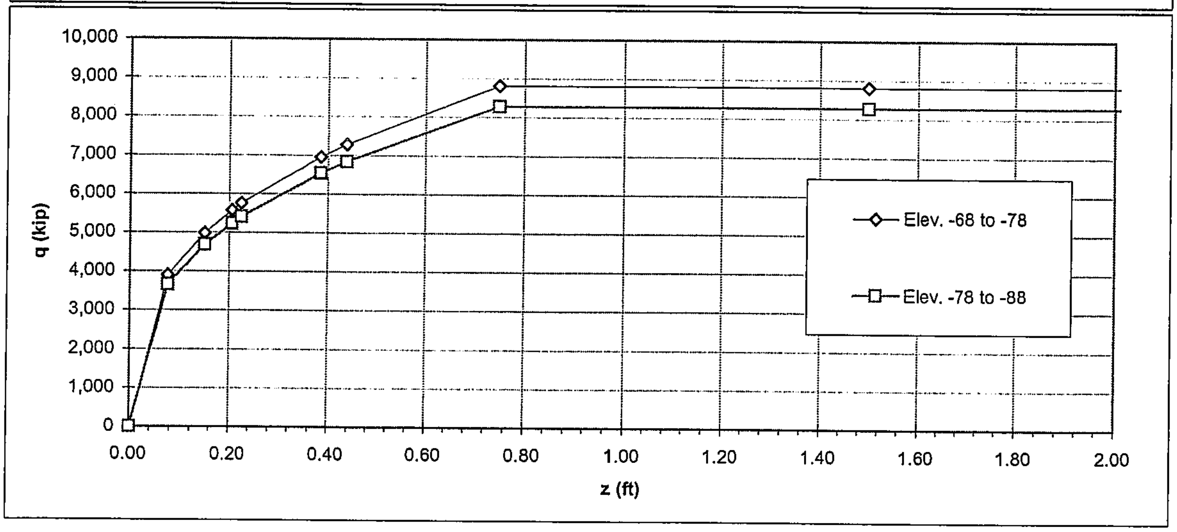
Pier 10 and 11 - with Degradation

Sta. | O. G. Elev. 7.0 | Cut off Elev. 37.0 | Pile 7.5' CISS | GWS 50.0







*-Liquefiable layer

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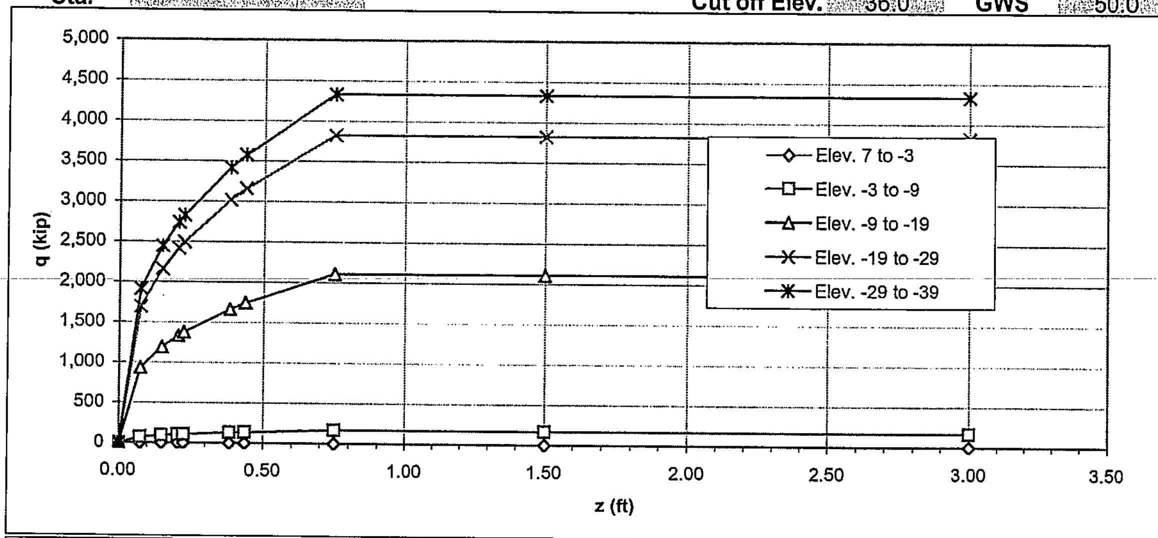
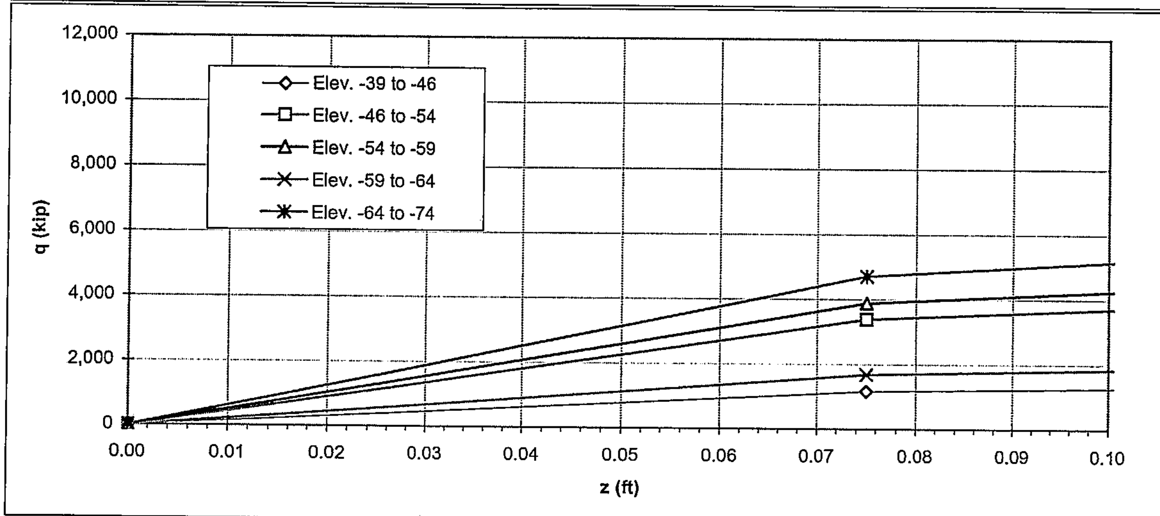
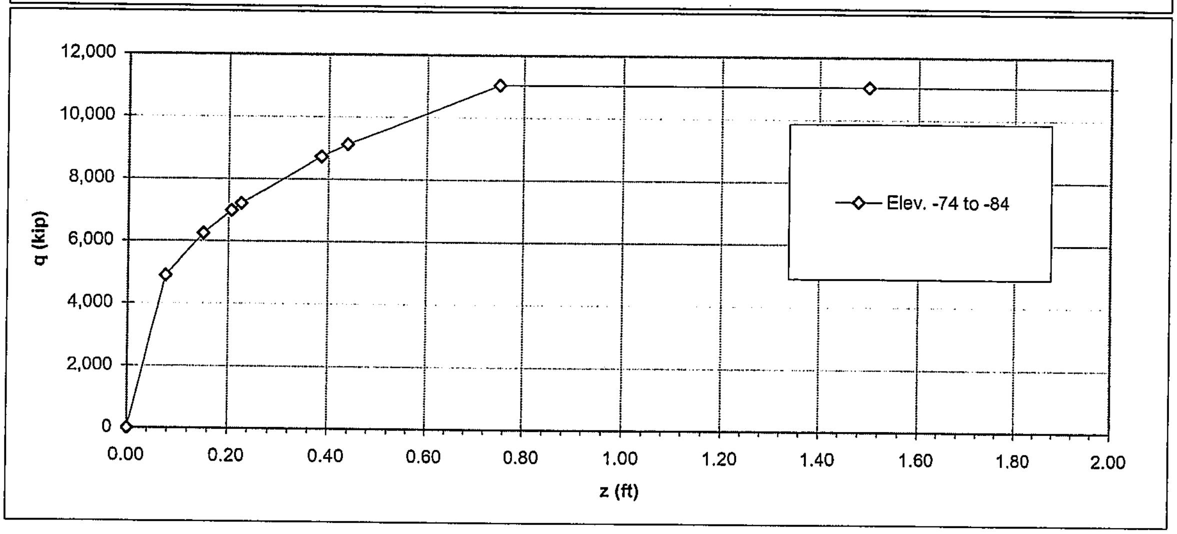
Pier 12 - with Degradation

Sta.		O. G. Elev.	7.0	Pile	7.5' CISS
		Cut off Elev.	36.0	GWS	50.0







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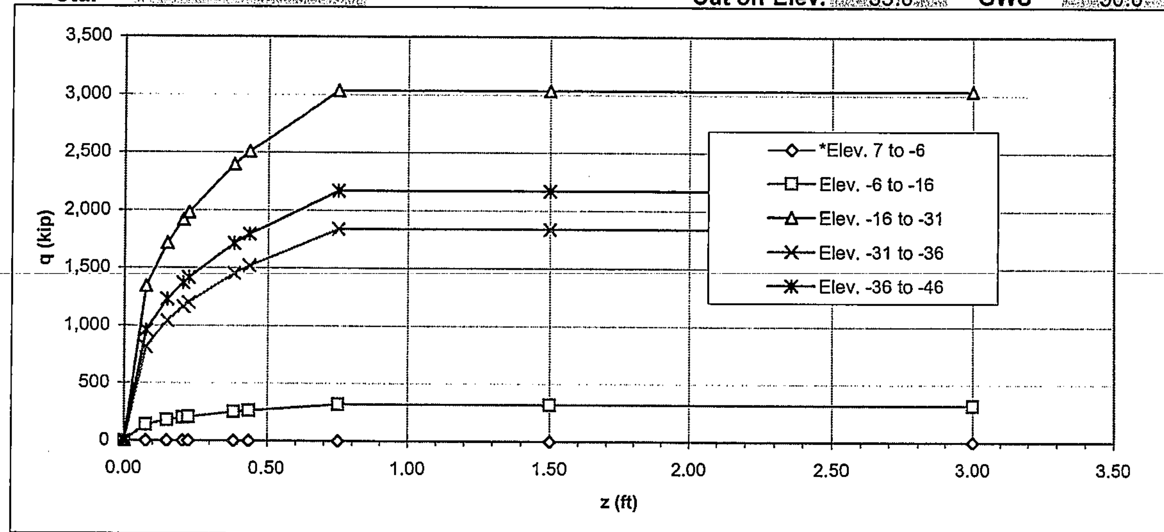
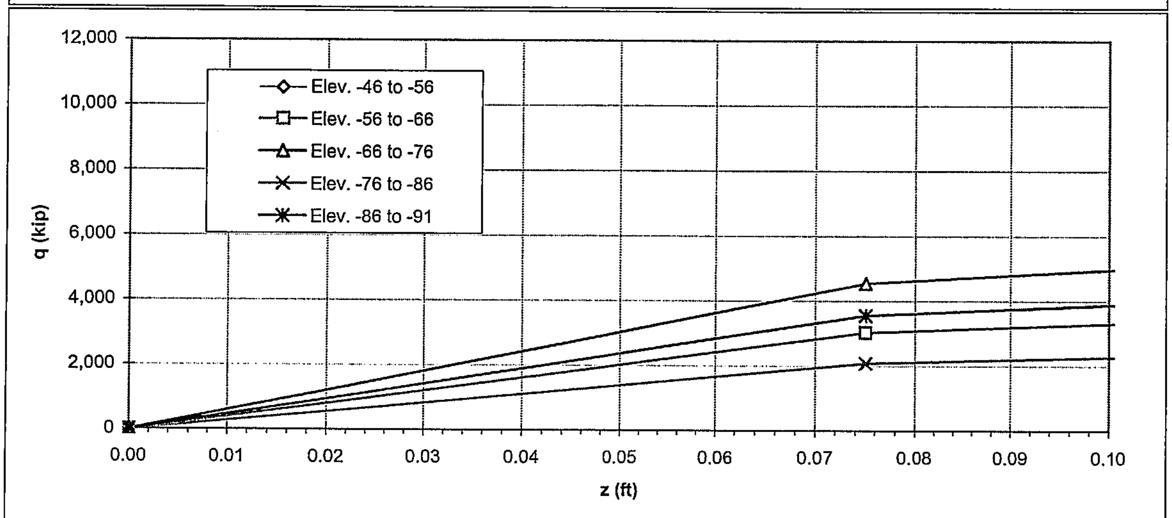
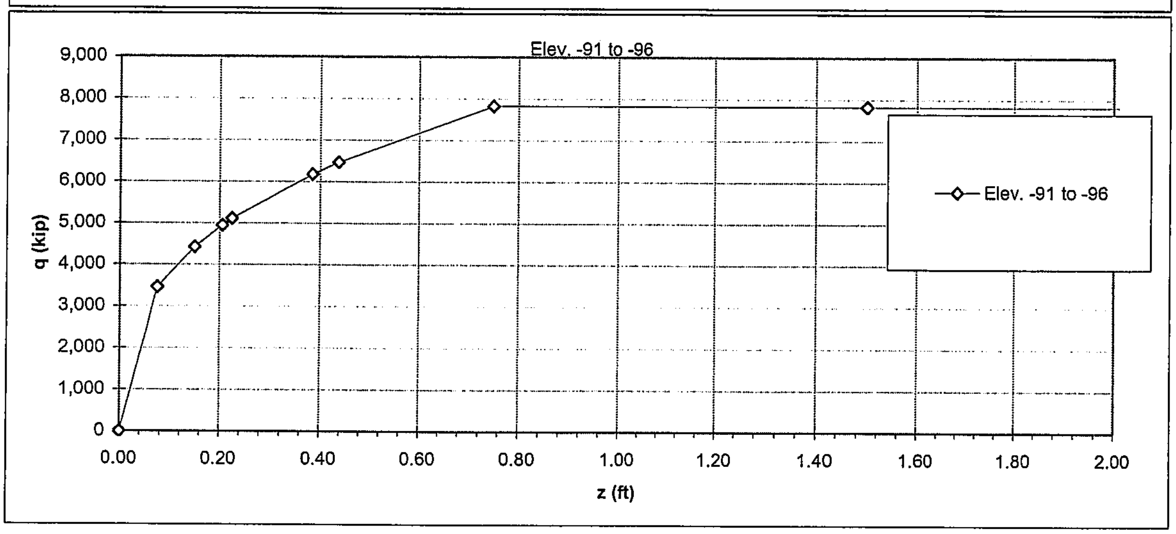
Pier 13 - with Degradation

Sta. **O. G. Elev.** 7.0 **Pile** 7.5' CISS
Cut off Elev. 35.0 **GWS** 50.0







*-Liquefiable layer

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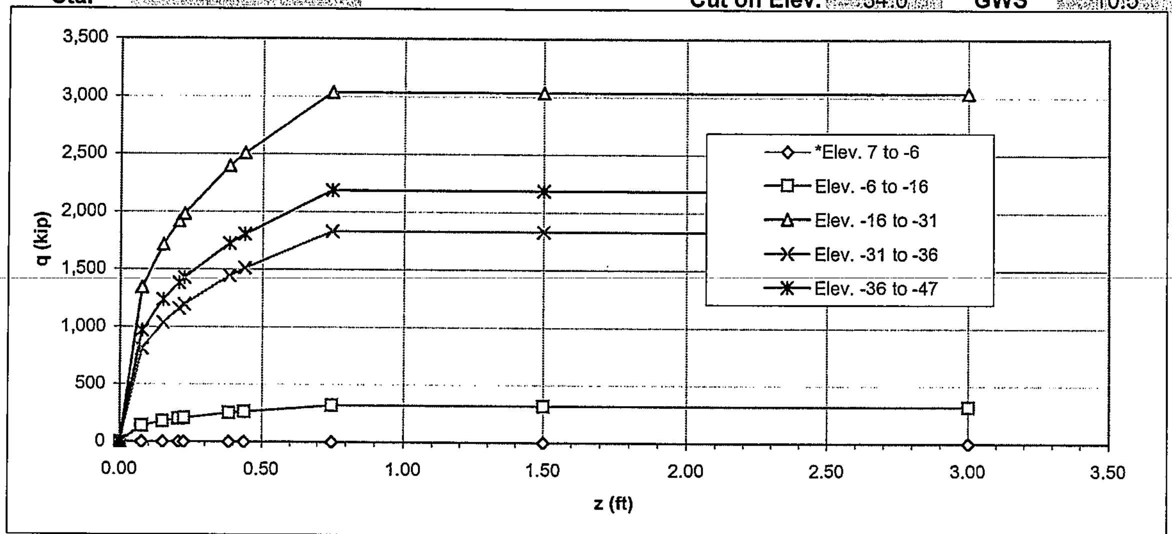
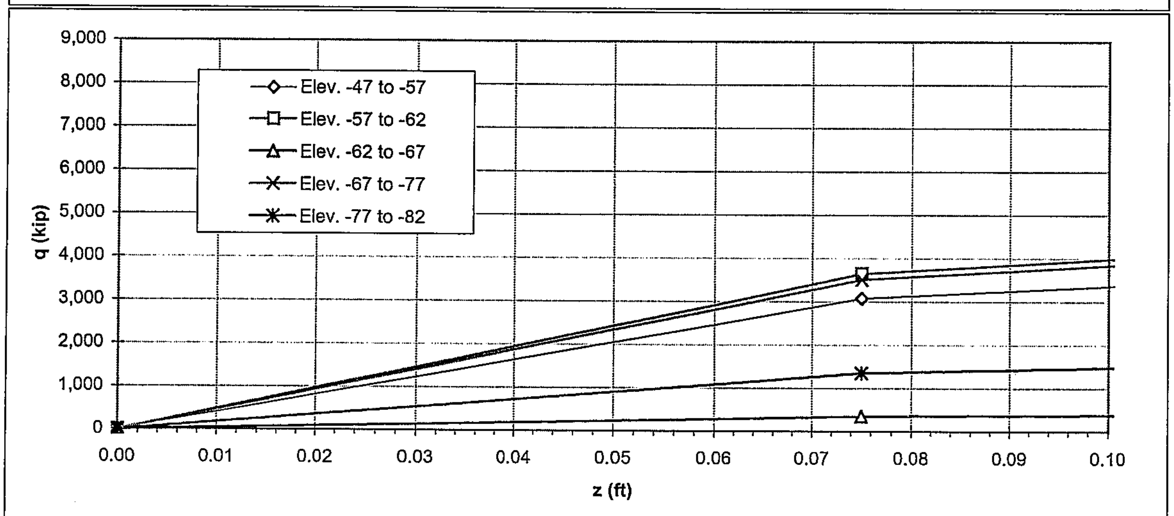
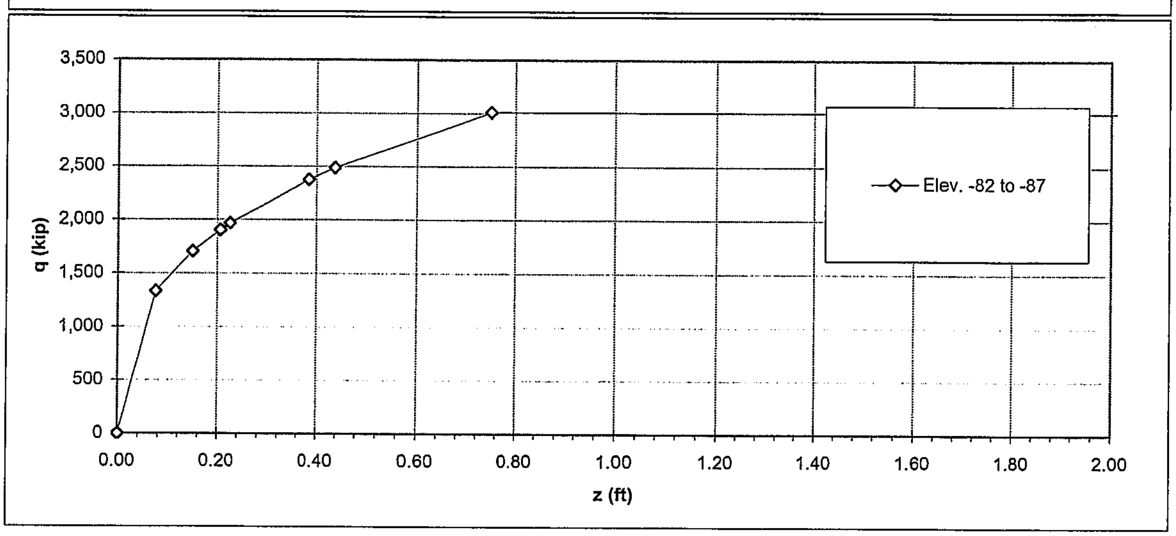
Pier 14 - with Degradation

Sta. | **O. G. Elev.** 7.0 | **Pile** 7.5' CISS
Cut off Elev. 34.0 | **GWS** 10.5







*-Liquefiable layer

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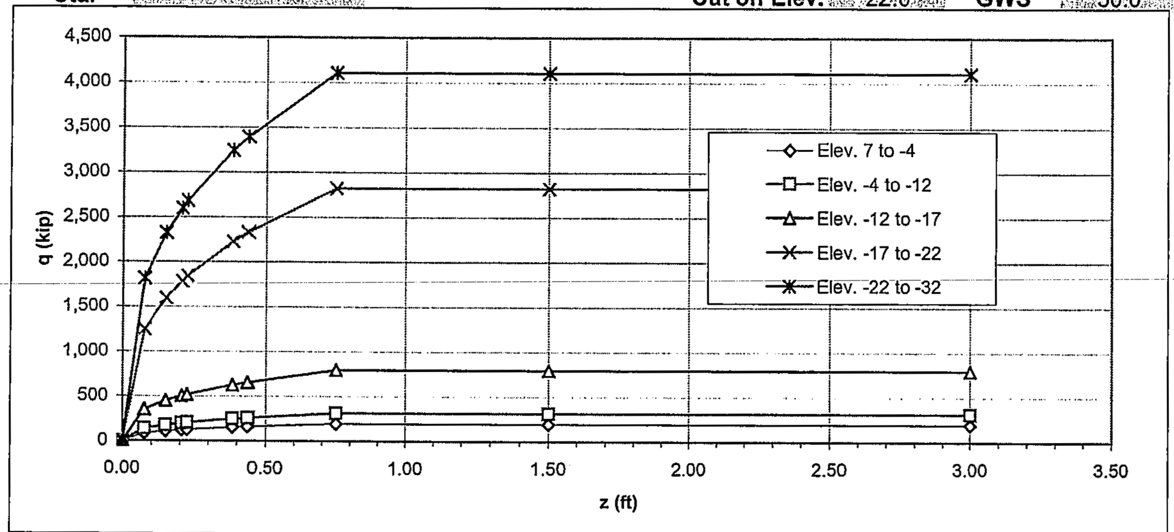
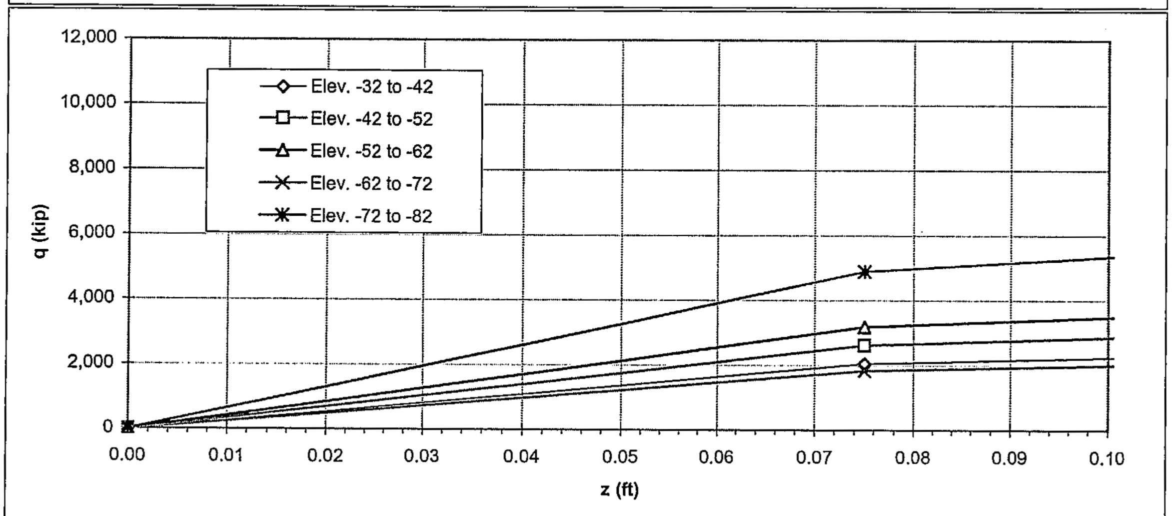
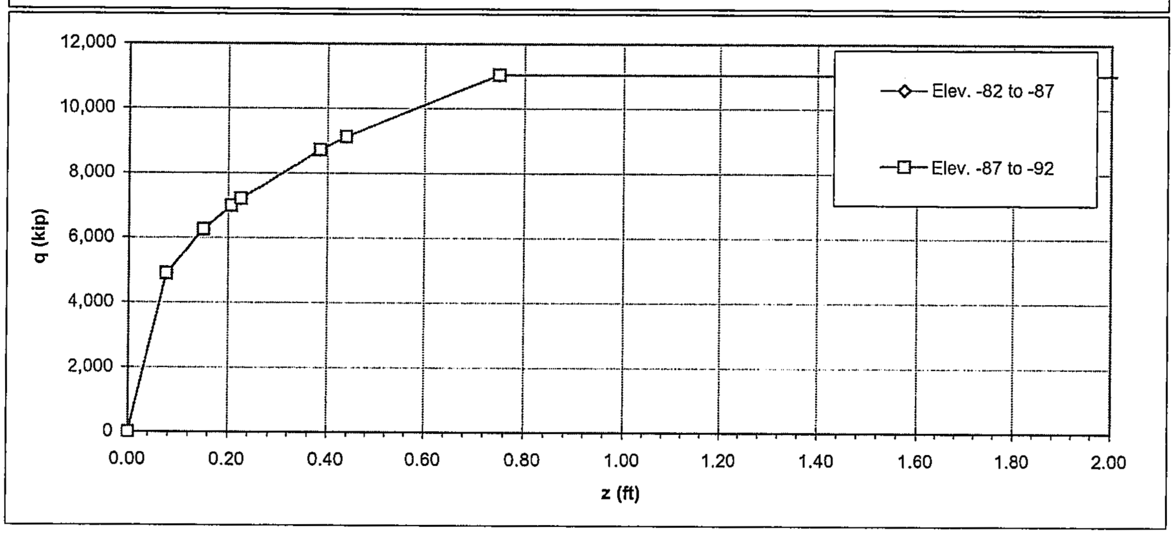
Pier 15 - with Degradation

Sta.		**O. G. Elev.**	7.0	**Pile**	7.5' CISS
		Cut off Elev.	22.0	**GWS**	50.0







0

Feather River Bridge
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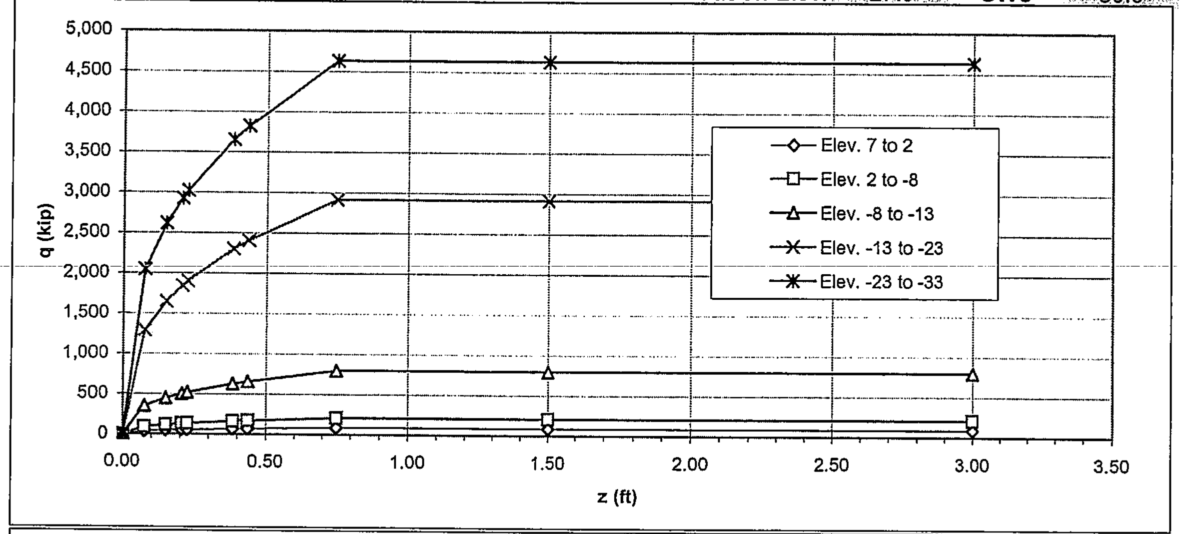
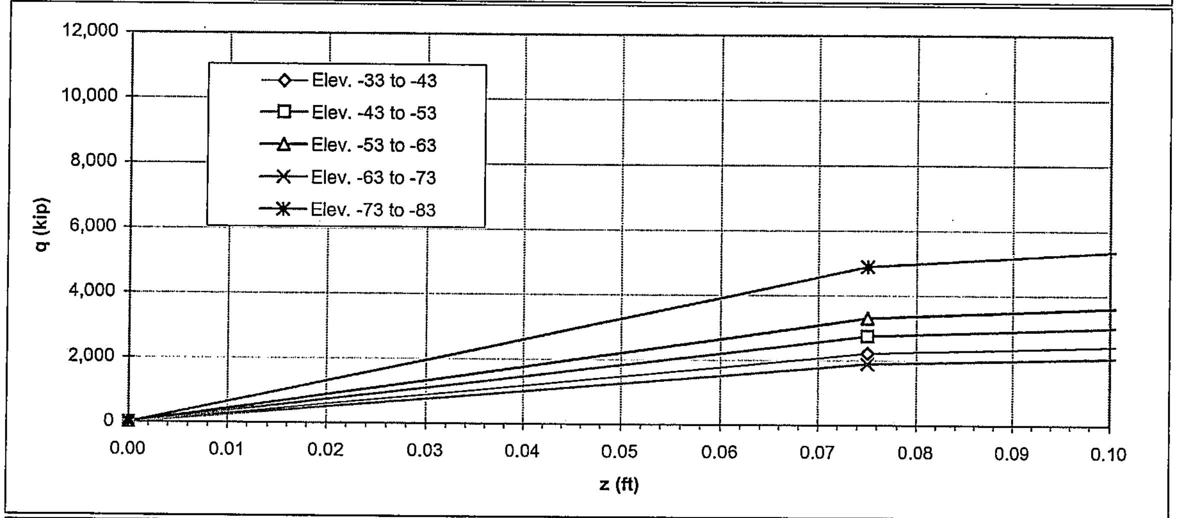
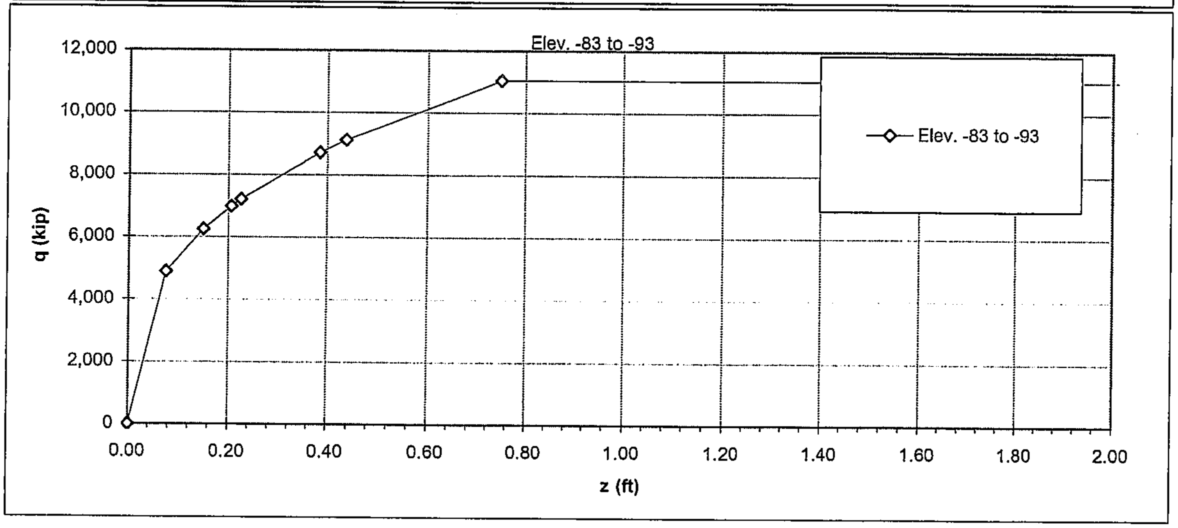
Pier 16 - with Degradation

Sta.

O. G. Elev.	7.0	**Pile**	7.5' CISS
Cut off Elev.	27.0	**GWS**	50.0







Feather River Bridge
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Pier 2 - with Degrdation

Sta.

O. G. Elev. 7.0
Cut off Elev. 18.0

Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to 2	z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -16	z (ft)	Elev. -16 to -24	z (ft)	Elev. -24 to -30
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	160.9	0.08	341.1	0.08	527.9	0.08	483.9
0.15	0.0	0.15	205.7	0.15	436.0	0.15	674.7	0.15	618.5
0.21	0.0	0.21	229.9	0.21	487.4	0.21	754.3	0.21	691.4
0.23	0.0	0.23	237.4	0.23	503.3	0.23	778.9	0.23	714.0
0.38	0.0	0.38	287.1	0.38	608.6	0.38	941.8	0.38	863.3
0.44	0.0	0.44	300.4	0.44	636.8	0.44	985.4	0.44	903.3
0.75	0.0	0.75	363.6	0.75	770.8	0.75	1,192.8	0.75	1,093.4
1.50	0.0	1.50	363.6	1.50	770.8	1.50	1,192.8	1.50	1,093.4
3.00	0.0	3.00	363.6	3.00	770.8	3.00	1,192.8	3.00	1,093.4

z (ft)	Elev. -30 to -37	z (ft)	Elev. -37 to -42	z (ft)	Elev. -42 to -52	z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	483.9	0.08	2,194.5	0.08	3,279.3	0.08	4,038.0	0.08	4,796.6
0.15	618.5	0.15	2,804.8	0.15	4,191.3	0.15	5,161.0	0.15	6,130.6
0.21	691.4	0.21	3,135.4	0.21	4,685.4	0.21	5,769.4	0.21	6,853.3
0.23	714.0	0.23	3,237.7	0.23	4,838.2	0.23	5,957.5	0.23	7,076.8
0.38	863.3	0.38	3,914.8	0.38	5,850.2	0.38	7,203.6	0.38	8,556.9
0.44	903.3	0.44	4,096.2	0.44	6,121.1	0.44	7,537.2	0.44	8,953.3
0.75	1,093.4	0.75	4,958.3	0.75	7,409.4	0.75	9,123.6	0.75	10,837.7
1.50	1,093.4	1.50	4,958.3	1.50	7,409.4	1.50	9,123.6	1.50	10,837.7
3.00	1,093.4	3.00	4,958.3	3.00	7,409.4	3.00	9,123.6	3.00	10,837.7

z (ft)	Elev. -72 to -82	z (ft)	Elev. -82 to -92	z (ft)	Elev. -92 to -102				
0.00	0.0	0.00	0.0	0.00	0.0				
0.08	4,888.2	0.08	4,888.2	0.08	2,980.3				
0.15	6,247.7	0.15	6,247.7	0.15	3,809.1				
0.21	6,984.2	0.21	6,984.2	0.21	4,258.1				
0.23	7,212.0	0.23	7,212.0	0.23	4,397.0				
0.38	8,720.4	0.38	8,720.4	0.38	5,316.6				
0.44	9,124.3	0.44	9,124.3	0.44	5,562.9				
0.75	11,044.7	0.75	11,044.7	0.75	6,733.7				
1.50	11,044.7	1.50	11,044.7	1.50	6,733.7				
3.00	11,044.7	3.00	11,044.7	3.00	6,733.7				

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 3 - with Degrdation

Sta.

O. G. Elev. 7.0
Cut off Elev. 26.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -2	z (ft)	Elev. -2 to -10	z (ft)	Elev. -10 to -20	z (ft)	Elev. -20 to -30	z (ft)	Elev. -30 to -40
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	89.0	0.08	250.7	0.08	240.0	0.08	575.5	0.08	770.3
0.15	113.8	0.15	320.4	0.15	306.8	0.15	735.5	0.15	984.6
0.21	127.2	0.21	358.1	0.21	342.9	0.21	822.2	0.21	1,100.7
0.23	131.4	0.23	369.8	0.23	354.1	0.23	849.1	0.23	1,136.6
0.38	158.8	0.38	447.2	0.38	428.2	0.38	1,026.6	0.38	1,374.3
0.44	166.2	0.44	467.9	0.44	448.0	0.44	1,074.2	0.44	1,437.9
0.75	201.2	0.75	566.4	0.75	542.3	0.75	1,300.3	0.75	1,740.6
1.50	201.2	1.50	566.4	1.50	542.3	1.50	1,300.3	1.50	1,740.6
3.00	201.2	3.00	566.4	3.00	542.3	3.00	1,300.3	3.00	1,740.6

z (ft)	Elev. -40 to -50	z (ft)	Elev. -50 to -55	z (ft)	Elev. -55 to -60	z (ft)	Elev. -60 to -70	z (ft)	Elev. -70 to -80
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,545.7	0.08	2,469.2	0.08	1,346.9	0.08	3,092.7	0.08	4,624.6
0.15	3,253.7	0.15	3,155.9	0.15	1,721.5	0.15	3,952.8	0.15	5,910.7
0.21	3,637.3	0.21	3,528.0	0.21	1,924.5	0.21	4,418.8	0.21	6,607.5
0.23	3,755.9	0.23	3,643.0	0.23	1,987.2	0.23	4,562.9	0.23	6,823.0
0.38	4,541.4	0.38	4,405.0	0.38	2,402.8	0.38	5,517.3	0.38	8,250.0
0.44	4,751.8	0.44	4,609.0	0.44	2,514.1	0.44	5,772.9	0.44	8,632.2
0.75	5,751.9	0.75	5,579.1	0.75	3,043.3	0.75	6,987.9	0.75	10,449.0
1.50	5,751.9	1.50	5,579.1	1.50	3,043.3	1.50	6,987.9	1.50	10,449.0
3.00	5,751.9	3.00	5,579.1	3.00	3,043.3	3.00	6,987.9	3.00	10,449.0

z (ft)	Elev. -80 to -90	z (ft)	Elev. -90 to -95	z (ft)	Elev. -95 to -100				
0.00	0.0	0.00	0.0	0.00	0.0				
0.08	4,888.2	0.08	1,427.6	0.08	1,407.9				
0.15	6,247.7	0.15	1,824.6	0.15	1,799.5				
0.21	6,984.2	0.21	2,039.7	0.21	2,011.6				
0.23	7,212.0	0.23	2,106.3	0.23	2,077.2				
0.38	8,720.4	0.38	2,546.8	0.38	2,511.7				
0.44	9,124.3	0.44	2,664.8	0.44	2,628.0				
0.75	11,044.7	0.75	3,225.6	0.75	3,181.1				
1.50	11,044.7	1.50	3,225.6	1.50	3,181.1				
3.00	11,044.7	3.00	3,225.6	3.00	3,181.1				

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 4 - with Degrdation

Sta.

O. G. Elev. 7.0
Cut off Elev. 14.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to 1	z (ft)	Elev. 1 to -6	z (ft)	Elev. -6 to -10	z (ft)	Elev. -10 to -20	z (ft)	Elev. -20 to -34
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	56.9	0.08	180.2	0.08	286.1	0.08	440.3	0.08	704.2
0.15	72.7	0.15	230.3	0.15	365.7	0.15	562.8	0.15	900.0
0.21	81.3	0.21	257.4	0.21	408.8	0.21	629.1	0.21	1,006.1
0.23	83.9	0.23	265.8	0.23	422.2	0.23	649.7	0.23	1,038.9
0.38	101.5	0.38	321.4	0.38	510.5	0.38	785.5	0.38	1,256.2
0.44	106.2	0.44	336.3	0.44	534.1	0.44	821.9	0.44	1,314.4
0.75	128.6	0.75	407.1	0.75	646.5	0.75	994.9	0.75	1,591.0
1.50	128.6	1.50	407.1	1.50	646.5	1.50	994.9	1.50	1,591.0
3.00	128.6	3.00	407.1	3.00	646.5	3.00	994.9	3.00	1,591.0

z (ft)	Elev. -34 to -40	z (ft)	Elev. -40 to -50	z (ft)	Elev. -50 to -60	z (ft)	Elev. -60 to -70	z (ft)	Elev. -70 to -80
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,361.0	0.08	2,967.9	0.08	3,726.5	0.08	4,485.2	0.08	2,881.7
0.15	3,017.5	0.15	3,793.2	0.15	4,762.9	0.15	5,732.5	0.15	3,683.1
0.21	3,373.3	0.21	4,240.4	0.21	5,324.4	0.21	6,408.3	0.21	4,117.3
0.23	3,483.3	0.23	4,378.7	0.23	5,498.0	0.23	6,617.3	0.23	4,251.6
0.38	4,211.8	0.38	5,294.5	0.38	6,647.9	0.38	8,001.3	0.38	5,140.8
0.44	4,406.9	0.44	5,539.8	0.44	6,955.9	0.44	8,372.0	0.44	5,379.0
0.75	5,334.4	0.75	6,705.7	0.75	8,419.9	0.75	10,134.0	0.75	6,511.1
1.50	5,334.4	1.50	6,705.7	1.50	8,419.9	1.50	10,134.0	1.50	6,511.1
3.00	5,334.4	3.00	6,705.7	3.00	8,419.9	3.00	10,134.0	3.00	6,511.1

z (ft)	Elev. -80 to -90	z (ft)	Elev. -90 to -100	z (ft)	Elev. -100 to -105	z (ft)	Elev. -105 to -110		
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.08	4,888.2	0.08	4,654.0	0.08	2,525.0	0.08	2,475.9		
0.15	6,247.7	0.15	5,948.3	0.15	3,227.2	0.15	3,164.5		
0.21	6,984.2	0.21	6,649.6	0.21	3,607.6	0.21	3,537.5		
0.23	7,212.0	0.23	6,866.4	0.23	3,725.3	0.23	3,652.9		
0.38	8,720.4	0.38	8,302.6	0.38	4,504.4	0.38	4,416.9		
0.44	9,124.3	0.44	8,687.1	0.44	4,713.1	0.44	4,621.5		
0.75	11,044.7	0.75	10,515.5	0.75	5,705.0	0.75	5,594.2		
1.50	11,044.7	1.50	10,515.5	1.50	5,705.0	1.50	5,594.2		
3.00	11,044.7	3.00	10,515.5	3.00	5,705.0	3.00	5,594.2		

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 5 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 12.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to 0	z (ft)	*Elev. 0 to -8	z (ft)	Elev. -8 to -15	z (ft)	Elev. -15 to -23	z (ft)	Elev. -23 to -28
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	0.0	0.08	316.8	0.08	460.2	0.08	1,213.7
0.15	0.0	0.15	0.0	0.15	404.9	0.15	588.2	0.15	1,551.2
0.21	0.0	0.21	0.0	0.21	452.6	0.21	657.5	0.21	1,734.1
0.23	0.0	0.23	0.0	0.23	467.4	0.23	679.0	0.23	1,790.7
0.38	0.0	0.38	0.0	0.38	565.1	0.38	821.0	0.38	2,165.2
0.44	0.0	0.44	0.0	0.44	591.3	0.44	859.0	0.44	2,265.5
0.75	0.0	0.75	0.0	0.75	715.8	0.75	1,039.8	0.75	2,742.3
1.50	0.0	1.50	0.0	1.50	715.8	1.50	1,039.8	1.50	2,742.3
3.00	0.0	3.00	0.0	3.00	715.8	3.00	1,039.8	3.00	2,742.3

z (ft)	Elev. -28 to -33	z (ft)	Elev. -33 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	731.5	0.08	891.7	0.08	2,235.1	0.08	3,467.5	0.08	4,226.1
0.15	934.9	0.15	1,139.7	0.15	2,856.7	0.15	4,431.8	0.15	5,401.4
0.21	1,045.1	0.21	1,274.1	0.21	3,193.5	0.21	4,954.2	0.21	6,038.2
0.23	1,079.2	0.23	1,315.6	0.23	3,297.6	0.23	5,115.8	0.23	6,235.1
0.38	1,304.9	0.38	1,590.8	0.38	3,987.3	0.38	6,185.8	0.38	7,539.2
0.44	1,365.4	0.44	1,664.5	0.44	4,172.0	0.44	6,472.3	0.44	7,888.4
0.75	1,652.7	0.75	2,014.8	0.75	5,050.1	0.75	7,834.5	0.75	9,548.6
1.50	1,652.7	1.50	2,014.8	1.50	5,050.1	1.50	7,834.5	1.50	9,548.6
3.00	1,652.7	3.00	2,014.8	3.00	5,050.1	3.00	7,834.5	3.00	9,548.6

z (ft)	Elev. -73 to -83	z (ft)	Elev. -83 to -93	z (ft)	Elev. -93 to -103	z (ft)	Elev. -103 to -113		
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.08	4,888.2	0.08	4,888.2	0.08	4,888.2	0.08	703.9		
0.15	6,247.7	0.15	6,247.7	0.15	6,247.7	0.15	899.7		
0.21	6,984.2	0.21	6,984.2	0.21	6,984.2	0.21	1,005.7		
0.23	7,212.0	0.23	7,212.0	0.23	7,212.0	0.23	1,038.5		
0.38	8,720.4	0.38	8,720.4	0.38	8,720.4	0.38	1,255.7		
0.44	9,124.3	0.44	9,124.3	0.44	9,124.3	0.44	1,313.9		
0.75	11,044.7	0.75	11,044.7	0.75	11,044.7	0.75	1,590.4		
1.50	11,044.7	1.50	11,044.7	1.50	11,044.7	1.50	1,590.4		
3.00	11,044.7	3.00	11,044.7	3.00	11,044.7	3.00	1,590.4		

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 6 - with Degradation

Sta.

O. G. Elev. 7.0 | Pile 7.5' CISS
Cut off Elev. 19.0 | GWS 50.0

z (ft)	*Elev. 7 to 4	z (ft)	Elev. 4 to -2	z (ft)	Elev. -2 to -7	z (ft)	Elev. -7 to -12	z (ft)	Elev. -12 to -17
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	227.6	0.08	228.8	0.08	667.8	0.08	445.7
0.15	0.0	0.15	290.9	0.15	292.4	0.15	853.5	0.15	569.6
0.21	0.0	0.21	325.2	0.21	326.9	0.21	954.1	0.21	636.7
0.23	0.0	0.23	335.8	0.23	337.5	0.23	985.2	0.23	657.5
0.38	0.0	0.38	406.0	0.38	408.1	0.38	1,191.3	0.38	795.0
0.44	0.0	0.44	424.8	0.44	427.1	0.44	1,246.5	0.44	831.9
0.75	0.0	0.75	514.2	0.75	516.9	0.75	1,508.8	0.75	1,006.9
1.50	0.0	1.50	514.2	1.50	516.9	1.50	1,508.8	1.50	1,006.9
3.00	0.0	3.00	514.2	3.00	516.9	3.00	1,508.8	3.00	1,006.9

z (ft)	*Elev. -17 to -22	z (ft)	Elev. -22 to -27	z (ft)	Elev. -27 to -41	z (ft)	Elev. -41 to -53	z (ft)	Elev. -53 to -71
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	616.8	0.08	2,196.8	0.08	2,524.0	0.08	4,265.0
0.15	0.0	0.15	788.3	0.15	2,807.7	0.15	3,225.9	0.15	5,451.0
0.21	0.0	0.21	881.3	0.21	3,138.7	0.21	3,606.2	0.21	6,093.7
0.23	0.0	0.23	910.0	0.23	3,241.1	0.23	3,723.8	0.23	6,292.4
0.38	0.0	0.38	1,100.3	0.38	3,918.9	0.38	4,502.7	0.38	7,608.5
0.44	0.0	0.44	1,151.3	0.44	4,100.5	0.44	4,711.2	0.44	7,960.9
0.75	0.0	0.75	1,393.6	0.75	4,963.5	0.75	5,702.8	0.75	9,636.4
1.50	0.0	1.50	1,393.6	1.50	4,963.5	1.50	5,702.8	1.50	9,636.4
3.00	0.0	3.00	1,393.6	3.00	4,963.5	3.00	5,702.8	3.00	9,636.4

z (ft)	Elev. -71 to -81	z (ft)	Elev. -81 to -91	z (ft)	Elev. -91 to -98	z (ft)	Elev. -98 to -103		
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.08	4,888.2	0.08	4,888.2	0.08	3,711.0	0.08	703.9		
0.15	6,247.7	0.15	6,247.7	0.15	4,743.0	0.15	899.7		
0.21	6,984.2	0.21	6,984.2	0.21	5,302.2	0.21	1,005.7		
0.23	7,212.0	0.23	7,212.0	0.23	5,475.1	0.23	1,038.5		
0.38	8,720.4	0.38	8,720.4	0.38	6,620.2	0.38	1,255.7		
0.44	9,124.3	0.44	9,124.3	0.44	6,926.9	0.44	1,313.9		
0.75	11,044.7	0.75	11,044.7	0.75	8,384.8	0.75	1,590.4		
1.50	11,044.7	1.50	11,044.7	1.50	8,384.8	1.50	1,590.4		
3.00	11,044.7	3.00	11,044.7	3.00	8,384.8	3.00	1,590.4		

Note - q (kip)
*-Liquefiable layer

Pier 7 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 17.0

Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	*Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -28	z (ft)	Elev. -28 to -38
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	90.7	0.08	0.0	0.08	901.4	0.08	1,638.5	0.08	1,766.0
0.15	116.0	0.15	0.0	0.15	1,152.1	0.15	2,094.2	0.15	2,257.1
0.21	129.6	0.21	0.0	0.21	1,287.9	0.21	2,341.1	0.21	2,523.2
0.23	133.9	0.23	0.0	0.23	1,329.9	0.23	2,417.4	0.23	2,605.5
0.38	161.8	0.38	0.0	0.38	1,608.0	0.38	2,923.1	0.38	3,150.5
0.44	169.3	0.44	0.0	0.44	1,682.5	0.44	3,058.5	0.44	3,296.4
0.75	205.0	0.75	0.0	0.75	2,036.6	0.75	3,702.2	0.75	3,990.2
1.50	205.0	1.50	0.0	1.50	2,036.6	1.50	3,702.2	1.50	3,990.2
3.00	205.0	3.00	0.0	3.00	2,036.6	3.00	3,702.2	3.00	3,990.2

z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68	z (ft)	Elev. -68 to -78	z (ft)	Elev. -78 to -88
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,345.8	0.08	3,657.1	0.08	4,415.7	0.08	4,888.2	0.08	4,888.2
0.15	2,998.2	0.15	4,674.1	0.15	5,643.7	0.15	6,247.7	0.15	6,247.7
0.21	3,351.7	0.21	5,225.1	0.21	6,309.1	0.21	6,984.2	0.21	6,984.2
0.23	3,461.0	0.23	5,395.5	0.23	6,514.8	0.23	7,212.0	0.23	7,212.0
0.38	4,184.8	0.38	6,524.0	0.38	7,877.4	0.38	8,720.4	0.38	8,720.4
0.44	4,378.7	0.44	6,826.2	0.44	8,242.3	0.44	9,124.3	0.44	9,124.3
0.75	5,300.3	0.75	8,262.9	0.75	9,977.0	0.75	11,044.7	0.75	11,044.7
1.50	5,300.3	1.50	8,262.9	1.50	9,977.0	1.50	11,044.7	1.50	11,044.7
3.00	5,300.3	3.00	8,262.9	3.00	9,977.0	3.00	11,044.7	3.00	11,044.7

z (ft)	Elev. -88 to -93	z (ft)	Elev. -93 to -98	z (ft)	Elev. -98 to -103	z (ft)	Elev. -103 to -108	z (ft)	Elev.
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0		
0.08	3,979.7	0.08	3,874.1	0.08	615.9	0.08	615.9		
0.15	5,086.4	0.15	4,951.5	0.15	787.2	0.15	787.2		
0.21	5,686.0	0.21	5,535.3	0.21	880.0	0.21	880.0		
0.23	5,871.5	0.23	5,715.8	0.23	908.7	0.23	908.7		
0.38	7,099.5	0.38	6,911.3	0.38	1,098.8	0.38	1,098.8		
0.44	7,428.4	0.44	7,231.4	0.44	1,149.7	0.44	1,149.7		
0.75	8,991.8	0.75	8,753.4	0.75	1,391.6	0.75	1,391.6		
1.50	8,991.8	1.50	8,753.4	1.50	1,391.6	1.50	1,391.6		
3.00	8,991.8	3.00	8,753.4	3.00	1,391.6	3.00	1,391.6		

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 8 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 37.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -18	z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	90.7	0.08	315.2	0.08	455.1	0.08	1,636.2	0.08	1,846.0
0.15	116.0	0.15	402.8	0.15	581.7	0.15	2,091.3	0.15	2,359.4
0.21	129.6	0.21	450.3	0.21	650.3	0.21	2,337.8	0.21	2,637.6
0.23	133.9	0.23	465.0	0.23	671.5	0.23	2,414.1	0.23	2,723.6
0.38	161.8	0.38	562.3	0.38	811.9	0.38	2,919.0	0.38	3,293.2
0.44	169.3	0.44	588.3	0.44	849.5	0.44	3,054.2	0.44	3,445.8
0.75	205.0	0.75	712.1	0.75	1,028.3	0.75	3,697.0	0.75	4,171.0
1.50	205.0	1.50	712.1	1.50	1,028.3	1.50	3,697.0	1.50	4,171.0
3.00	205.0	3.00	712.1	3.00	1,028.3	3.00	3,697.0	3.00	4,171.0

z (ft)	Elev. -38 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,789.2	0.08	2,647.2	0.08	3,194.3	0.08	4,726.0	0.08	4,888.2
0.15	3,564.9	0.15	3,383.4	0.15	4,082.6	0.15	6,040.3	0.15	6,247.7
0.21	3,985.1	0.21	3,782.2	0.21	4,563.9	0.21	6,752.4	0.21	6,984.2
0.23	4,115.1	0.23	3,905.6	0.23	4,712.8	0.23	6,972.6	0.23	7,212.0
0.38	4,975.8	0.38	4,722.4	0.38	5,698.5	0.38	8,430.9	0.38	8,720.4
0.44	5,206.3	0.44	4,941.2	0.44	5,962.4	0.44	8,821.4	0.44	9,124.3
0.75	6,302.0	0.75	5,981.2	0.75	7,217.3	0.75	10,678.1	0.75	11,044.7
1.50	6,302.0	1.50	5,981.2	1.50	7,217.3	1.50	10,678.1	1.50	11,044.7
3.00	6,302.0	3.00	5,981.2	3.00	7,217.3	3.00	10,678.1	3.00	11,044.7

z (ft)	Elev. -78 to -83	z (ft)	Elev.	z (ft)	Elev.	z (ft)	Elev.	z (ft)	Elev.
0.00	0.0								
0.08	4,888.2								
0.15	6,247.7								
0.21	6,984.2								
0.23	7,212.0								
0.38	8,720.4								
0.44	9,124.3								
0.75	11,044.7								
1.50	11,044.7								
3.00	11,044.7								

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 9 - with Degradation

Sta.

O. G. Elev. 7.0 | Pile 7.5' CISS
Cut off Elev. 37.0 | GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33	z (ft)	Elev. -33 to -43
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	90.7	0.08	309.0	0.08	1,398.0	0.08	2,156.7	0.08	2,292.7
0.15	116.0	0.15	395.0	0.15	1,786.8	0.15	2,756.5	0.15	2,930.3
0.21	129.6	0.21	441.5	0.21	1,997.5	0.21	3,081.4	0.21	3,275.7
0.23	133.9	0.23	455.9	0.23	2,062.6	0.23	3,181.9	0.23	3,382.6
0.38	161.8	0.38	551.3	0.38	2,494.0	0.38	3,847.4	0.38	4,090.0
0.44	169.3	0.44	576.8	0.44	2,609.5	0.44	4,025.6	0.44	4,279.5
0.75	205.0	0.75	698.2	0.75	3,158.8	0.75	4,872.9	0.75	5,180.2
1.50	205.0	1.50	698.2	1.50	3,158.8	1.50	4,872.9	1.50	5,180.2
3.00	205.0	3.00	698.2	3.00	3,158.8	3.00	4,872.9	3.00	5,180.2

z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -78	z (ft)	Elev. -78 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,860.0	0.08	4,333.7	0.08	4,888.2	0.08	4,529.1	0.08	4,753.0
0.15	3,655.4	0.15	5,538.9	0.15	6,247.7	0.15	5,788.6	0.15	6,074.8
0.21	4,086.3	0.21	6,191.9	0.21	6,984.2	0.21	6,471.0	0.21	6,790.9
0.23	4,219.6	0.23	6,393.8	0.23	7,212.0	0.23	6,682.1	0.23	7,012.4
0.38	5,102.2	0.38	7,731.1	0.38	8,720.4	0.38	8,079.6	0.38	8,479.0
0.44	5,338.5	0.44	8,089.2	0.44	9,124.3	0.44	8,453.9	0.44	8,871.8
0.75	6,462.1	0.75	9,791.7	0.75	11,044.7	0.75	10,233.2	0.75	10,739.0
1.50	6,462.1	1.50	9,791.7	1.50	11,044.7	1.50	10,233.2	1.50	10,739.0
3.00	6,462.1	3.00	9,791.7	3.00	11,044.7	3.00	10,233.2	3.00	10,739.0

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 10 and 11 - with Degradation

Sta. | O. G. Elev. 7.0 | Cut off Elev. 37.0 | Pile 7.5' CISS | GWS 50.0

z (ft)	Elev. 7 to 2	z (ft)	*Elev. 2 to -3	z (ft)	*Elev. -3 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -18
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	39.2	0.08	0.0	0.08	0.0	0.08	695.6	0.08	859.9
0.15	50.1	0.15	0.0	0.15	0.0	0.15	889.0	0.15	1,099.1
0.21	56.0	0.21	0.0	0.21	0.0	0.21	993.9	0.21	1,228.7
0.23	57.8	0.23	0.0	0.23	0.0	0.23	1,026.3	0.23	1,268.7
0.38	69.9	0.38	0.0	0.38	0.0	0.38	1,240.9	0.38	1,534.1
0.44	73.2	0.44	0.0	0.44	0.0	0.44	1,298.4	0.44	1,605.1
0.75	88.6	0.75	0.0	0.75	0.0	0.75	1,571.7	0.75	1,943.0
1.50	88.6	1.50	0.0	1.50	0.0	1.50	1,571.7	1.50	1,943.0
3.00	88.6	3.00	0.0	3.00	0.0	3.00	1,571.7	3.00	1,943.0

z (ft)	Elev. -18 to -28	z (ft)	Elev. -28 to -38	z (ft)	Elev. -38 to -48	z (ft)	Elev. -48 to -58	z (ft)	Elev. -58 to -68
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	1,643.9	0.08	2,402.6	0.08	2,471.8	0.08	3,776.8	0.08	4,535.5
0.15	2,101.1	0.15	3,070.7	0.15	3,159.2	0.15	4,827.2	0.15	5,796.8
0.21	2,348.8	0.21	3,432.7	0.21	3,531.6	0.21	5,396.2	0.21	6,480.2
0.23	2,425.4	0.23	3,544.7	0.23	3,646.8	0.23	5,572.2	0.23	6,691.5
0.38	2,932.7	0.38	4,286.1	0.38	4,409.5	0.38	6,737.7	0.38	8,091.1
0.44	3,068.5	0.44	4,484.6	0.44	4,613.7	0.44	7,049.8	0.44	8,465.8
0.75	3,714.3	0.75	5,428.5	0.75	5,584.8	0.75	8,533.5	0.75	10,247.6
1.50	3,714.3	1.50	5,428.5	1.50	5,584.8	1.50	8,533.5	1.50	10,247.6
3.00	3,714.3	3.00	5,428.5	3.00	5,584.8	3.00	8,533.5	3.00	10,247.6

z (ft)	Elev. -68 to -78	z (ft)	Elev. -78 to -88						
0.00	0.0	0.00	0.0						
0.08	3,899.7	0.08	3,663.8						
0.15	4,984.2	0.15	4,682.7						
0.21	5,571.8	0.21	5,234.7						
0.23	5,753.5	0.23	5,405.5						
0.38	6,956.8	0.38	6,536.0						
0.44	7,279.1	0.44	6,838.8						
0.75	8,811.1	0.75	8,278.1						
1.50	8,811.1	1.50	8,278.1						
3.00	8,811.1	3.00	8,278.1						

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 12 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 36.0
Pile 7.5' CISS
GWS 50.0

z (ft)	Elev. 7 to -3	z (ft)	Elev. -3 to -9	z (ft)	Elev. -9 to -19	z (ft)	Elev. -19 to -29	z (ft)	Elev. -29 to -39
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	73.8	0.08	933.3	0.08	1,691.9	0.08	1,916.8
0.15	0.0	0.15	94.3	0.15	1,192.8	0.15	2,162.4	0.15	2,449.9
0.21	0.0	0.21	105.4	0.21	1,333.4	0.21	2,417.4	0.21	2,738.7
0.23	0.0	0.23	108.8	0.23	1,376.9	0.23	2,496.2	0.23	2,828.1
0.38	0.0	0.38	131.6	0.38	1,664.9	0.38	3,018.3	0.38	3,419.6
0.44	0.0	0.44	137.7	0.44	1,742.0	0.44	3,158.1	0.44	3,578.0
0.75	0.0	0.75	166.6	0.75	2,108.6	0.75	3,822.8	0.75	4,331.0
1.50	0.0	1.50	166.6	1.50	2,108.6	1.50	3,822.8	1.50	4,331.0
3.00	0.0	3.00	166.6	3.00	2,108.6	3.00	3,822.8	3.00	4,331.0

z (ft)	Elev. -39 to -46	z (ft)	Elev. -46 to -54	z (ft)	Elev. -54 to -59	z (ft)	Elev. -59 to -64	z (ft)	Elev. -64 to -74
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	1,160.6	0.08	3,385.8	0.08	3,878.9	0.08	1,680.0	0.08	4,710.5
0.15	1,483.4	0.15	4,327.4	0.15	4,957.6	0.15	2,147.1	0.15	6,020.5
0.21	1,658.3	0.21	4,837.5	0.21	5,542.1	0.21	2,400.3	0.21	6,730.3
0.23	1,712.4	0.23	4,995.3	0.23	5,722.8	0.23	2,478.6	0.23	6,949.8
0.38	2,070.5	0.38	6,040.1	0.38	6,919.8	0.38	2,996.9	0.38	8,403.3
0.44	2,166.4	0.44	6,319.9	0.44	7,240.3	0.44	3,135.8	0.44	8,792.6
0.75	2,622.4	0.75	7,650.0	0.75	8,764.2	0.75	3,795.8	0.75	10,643.1
1.50	2,622.4	1.50	7,650.0	1.50	8,764.2	1.50	3,795.8	1.50	10,643.1
3.00	2,622.4	3.00	7,650.0	3.00	8,764.2	3.00	3,795.8	3.00	10,643.1

z (ft)	Elev. -74 to -84								
0.00	0.0								
0.08	4,888.2								
0.15	6,247.7								
0.21	6,984.2								
0.23	7,212.0								
0.38	8,720.4								
0.44	9,124.3								
0.75	11,044.7								
1.50	11,044.7								
3.00	11,044.7								

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 13 - with Degradation

Sta.

O. G. Elev. 7.0
Cut off Elev. 35.0
Pile 7.5' CISS
GWS 50.0

z (ft)	*Elev. 7 to -6	z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -46
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	141.3	0.08	1,343.4	0.08	814.8	0.08	960.9
0.15	0.0	0.15	180.6	0.15	1,717.0	0.15	1,041.4	0.15	1,228.2
0.21	0.0	0.21	201.8	0.21	1,919.4	0.21	1,164.2	0.21	1,373.0
0.23	0.0	0.23	208.4	0.23	1,982.0	0.23	1,202.1	0.23	1,417.7
0.38	0.0	0.38	252.0	0.38	2,396.5	0.38	1,453.6	0.38	1,714.3
0.44	0.0	0.44	263.7	0.44	2,507.5	0.44	1,520.9	0.44	1,793.7
0.75	0.0	0.75	319.2	0.75	3,035.3	0.75	1,841.0	0.75	2,171.2
1.50	0.0	1.50	319.2	1.50	3,035.3	1.50	1,841.0	1.50	2,171.2
3.00	0.0	3.00	319.2	3.00	3,035.3	3.00	1,841.0	3.00	2,171.2

z (ft)	Elev. -46 to -56	z (ft)	Elev. -56 to -66	z (ft)	Elev. -66 to -76	z (ft)	Elev. -76 to -86	z (ft)	Elev. -86 to -91
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,022.4	0.08	3,024.9	0.08	4,539.7	0.08	2,082.2	0.08	3,552.4
0.15	3,863.0	0.15	3,866.1	0.15	5,802.2	0.15	2,661.3	0.15	4,540.4
0.21	4,318.4	0.21	4,321.8	0.21	6,486.3	0.21	2,975.1	0.21	5,075.6
0.23	4,459.2	0.23	4,462.8	0.23	6,697.8	0.23	3,072.1	0.23	5,241.2
0.38	5,391.8	0.38	5,396.2	0.38	8,098.6	0.38	3,714.6	0.38	6,337.4
0.44	5,641.6	0.44	5,646.1	0.44	8,473.8	0.44	3,886.7	0.44	6,630.9
0.75	6,829.0	0.75	6,834.5	0.75	10,257.2	0.75	4,704.7	0.75	8,026.5
1.50	6,829.0	1.50	6,834.5	1.50	10,257.2	1.50	4,704.7	1.50	8,026.5
3.00	6,829.0	3.00	6,834.5	3.00	10,257.2	3.00	4,704.7	3.00	8,026.5

z (ft)	Elev. -91 to -96								
0.00	0.0								
0.08	3,460.4								
0.15	4,422.7								
0.21	4,944.1								
0.23	5,105.4								
0.38	6,173.2								
0.44	6,459.1								
0.75	7,818.5								
1.50	7,818.5								
3.00	7,818.5								

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 14 - with Degradation

Sta.

O. G. Elev. 7.0 | Pile 7.5' CISS
Cut off Elev. 34.0 | GWS 10.5

z (ft)	*Elev. 7 to -6	z (ft)	Elev. -6 to -16	z (ft)	Elev. -16 to -31	z (ft)	Elev. -31 to -36	z (ft)	Elev. -36 to -47
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	0.0	0.08	141.3	0.08	1,343.4	0.08	810.6	0.08	967.6
0.15	0.0	0.15	180.6	0.15	1,717.0	0.15	1,036.1	0.15	1,236.7
0.21	0.0	0.21	201.8	0.21	1,919.4	0.21	1,158.2	0.21	1,382.5
0.23	0.0	0.23	208.4	0.23	1,982.0	0.23	1,196.0	0.23	1,427.6
0.38	0.0	0.38	252.0	0.38	2,396.5	0.38	1,446.1	0.38	1,726.1
0.44	0.0	0.44	263.7	0.44	2,507.5	0.44	1,513.1	0.44	1,806.1
0.75	0.0	0.75	319.2	0.75	3,035.3	0.75	1,831.5	0.75	2,186.2
1.50	0.0	1.50	319.2	1.50	3,035.3	1.50	1,831.5	1.50	2,186.2
3.00	0.0	3.00	319.2	3.00	3,035.3	3.00	1,831.5	3.00	2,186.2

z (ft)	Elev. -47 to -57	z (ft)	Elev. -57 to -62	z (ft)	Elev. -62 to -67	z (ft)	Elev. -67 to -77	z (ft)	Elev. -77 to -82
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	3,076.6	0.08	3,645.6	0.08	352.0	0.08	3,510.6	0.08	1,352.9
0.15	3,932.2	0.15	4,659.4	0.15	449.8	0.15	4,486.9	0.15	1,729.2
0.21	4,395.8	0.21	5,208.7	0.21	502.9	0.21	5,015.8	0.21	1,933.0
0.23	4,539.1	0.23	5,378.6	0.23	519.3	0.23	5,179.4	0.23	1,996.1
0.38	5,488.5	0.38	6,503.5	0.38	627.9	0.38	6,262.7	0.38	2,413.6
0.44	5,742.7	0.44	6,804.8	0.44	656.9	0.44	6,552.8	0.44	2,525.4
0.75	6,951.4	0.75	8,237.0	0.75	795.2	0.75	7,931.9	0.75	3,056.9
1.50	6,951.4	1.50	8,237.0	1.50	795.2	1.50	7,931.9	1.50	3,056.9
3.00	6,951.4	3.00	8,237.0	3.00	795.2	3.00	7,931.9	3.00	3,056.9

z (ft)	Elev. -82 to -87								
0.00	0.0								
0.08	1,332.9								
0.15	1,703.5								
0.21	1,904.4								
0.23	1,966.5								
0.38	2,377.8								
0.44	2,487.9								
0.75	3,011.5								
1.50	3,011.5								
3.00	3,011.5								

Note - q (kip)
*-Liquefiable layer

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 15 - with Degradation

Sta.		**O. G. Elev.**	7.0	**Pile**	7.5' CISS
		Cut off Elev.	22.0	**GWS**	50.0

z (ft)	Elev. 7 to -4	z (ft)	Elev. -4 to -12	z (ft)	Elev. -12 to -17	z (ft)	Elev. -17 to -22	z (ft)	Elev. -22 to -32
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	86.2	0.08	139.2	0.08	352.0	0.08	1,249.7	0.08	1,818.7
0.15	110.2	0.15	177.9	0.15	449.8	0.15	1,597.2	0.15	2,324.4
0.21	123.2	0.21	198.8	0.21	502.9	0.21	1,785.5	0.21	2,598.5
0.23	127.2	0.23	205.3	0.23	519.3	0.23	1,843.7	0.23	2,683.2
0.38	153.9	0.38	248.3	0.38	627.9	0.38	2,229.3	0.38	3,244.4
0.44	161.0	0.44	259.8	0.44	656.9	0.44	2,332.6	0.44	3,394.7
0.75	194.9	0.75	314.4	0.75	795.2	0.75	2,823.6	0.75	4,109.1
1.50	194.9	1.50	314.4	1.50	795.2	1.50	2,823.6	1.50	4,109.1
3.00	194.9	3.00	314.4	3.00	795.2	3.00	2,823.6	3.00	4,109.1

z (ft)	Elev. -32 to -42	z (ft)	Elev. -42 to -52	z (ft)	Elev. -52 to -62	z (ft)	Elev. -62 to -72	z (ft)	Elev. -72 to -82
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,050.7	0.08	2,618.1	0.08	3,186.4	0.08	1,834.8	0.08	4,888.2
0.15	2,621.0	0.15	3,346.2	0.15	4,072.6	0.15	2,345.1	0.15	6,247.7
0.21	2,930.0	0.21	3,740.7	0.21	4,552.7	0.21	2,621.5	0.21	6,984.2
0.23	3,025.5	0.23	3,862.7	0.23	4,701.2	0.23	2,707.0	0.23	7,212.0
0.38	3,658.3	0.38	4,670.6	0.38	5,684.4	0.38	3,273.2	0.38	8,720.4
0.44	3,827.8	0.44	4,886.9	0.44	5,947.7	0.44	3,424.8	0.44	9,124.3
0.75	4,633.4	0.75	5,915.5	0.75	7,199.5	0.75	4,145.7	0.75	11,044.7
1.50	4,633.4	1.50	5,915.5	1.50	7,199.5	1.50	4,145.7	1.50	11,044.7
3.00	4,633.4	3.00	5,915.5	3.00	7,199.5	3.00	4,145.7	3.00	11,044.7

z (ft)	Elev. -82 to -87	z (ft)	Elev. -87 to -92						
0.00	0.0	0.00	0.0						
0.08	4,888.2	0.08	4,888.2						
0.15	6,247.7	0.15	6,247.7						
0.21	6,984.2	0.21	6,984.2						
0.23	7,212.0	0.23	7,212.0						
0.38	8,720.4	0.38	8,720.4						
0.44	9,124.3	0.44	9,124.3						
0.75	11,044.7	0.75	11,044.7						
1.50	11,044.7	1.50	11,044.7						
3.00	11,044.7	3.00	11,044.7						

Note - q (kip)

Feather River Bridge
Br. No. 18-0026R
03-1A4321

Pier 16 - with Degradation

Sta. | O. G. Elev. 7.0 | Cut off Elev. 27.0 | Pile 7.5' CISS | GWS 50.0

z (ft)	Elev. 7 to 2	z (ft)	Elev. 2 to -8	z (ft)	Elev. -8 to -13	z (ft)	Elev. -13 to -23	z (ft)	Elev. -23 to -33
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	39.2	0.08	91.6	0.08	352.0	0.08	1,291.0	0.08	2,049.6
0.15	50.1	0.15	117.1	0.15	449.8	0.15	1,650.0	0.15	2,619.6
0.21	56.0	0.21	130.9	0.21	502.9	0.21	1,844.5	0.21	2,928.5
0.23	57.8	0.23	135.2	0.23	519.3	0.23	1,904.7	0.23	3,024.0
0.38	69.9	0.38	163.5	0.38	627.9	0.38	2,303.0	0.38	3,656.4
0.44	73.2	0.44	171.0	0.44	656.9	0.44	2,409.7	0.44	3,825.8
0.75	88.6	0.75	207.0	0.75	795.2	0.75	2,916.9	0.75	4,631.0
1.50	88.6	1.50	207.0	1.50	795.2	1.50	2,916.9	1.50	4,631.0
3.00	88.6	3.00	207.0	3.00	795.2	3.00	2,916.9	3.00	4,631.0

z (ft)	Elev. -33 to -43	z (ft)	Elev. -43 to -53	z (ft)	Elev. -53 to -63	z (ft)	Elev. -63 to -73	z (ft)	Elev. -73 to -83
0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
0.08	2,217.6	0.08	2,751.4	0.08	3,302.5	0.08	1,896.0	0.08	4,888.2
0.15	2,834.4	0.15	3,516.6	0.15	4,221.0	0.15	2,423.3	0.15	6,247.7
0.21	3,168.5	0.21	3,931.1	0.21	4,718.6	0.21	2,709.0	0.21	6,984.2
0.23	3,271.8	0.23	4,059.3	0.23	4,872.5	0.23	2,797.4	0.23	7,212.0
0.38	3,956.1	0.38	4,908.4	0.38	5,891.5	0.38	3,382.4	0.38	8,720.4
0.44	4,139.4	0.44	5,135.7	0.44	6,164.5	0.44	3,539.1	0.44	9,124.3
0.75	5,010.6	0.75	6,216.6	0.75	7,461.9	0.75	4,284.0	0.75	11,044.7
1.50	5,010.6	1.50	6,216.6	1.50	7,461.9	1.50	4,284.0	1.50	11,044.7
3.00	5,010.6	3.00	6,216.6	3.00	7,461.9	3.00	4,284.0	3.00	11,044.7

z (ft)	Elev. -83 to -93								
0.00	0.0								
0.08	4,888.2								
0.15	6,247.7								
0.21	6,984.2								
0.23	7,212.0								
0.38	8,720.4								
0.44	9,124.3								
0.75	11,044.7								
1.50	11,044.7								
3.00	11,044.7								

Note - q (kip)

Memorandum

Flex your power!
Be energy efficient!

To: MR. JEFF SIMS
ENGINEERING SERVICES
DIVISION OF STRUCTURE DESIGN-MS 9 4/11G
OFFICE OF BRIDGE DESIGN-NORTH
BRANCH 1

Rec'd 5/12/08 CG

Attention: Mr. Greg Jones

Date: April 29, 2008

File: 03-Sut-99-PM 12.0
03-1A4321
Garden Highway UC
Br. No. 18-0025R

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES - MS 5
OFFICE OF GEOTECHNICAL DESIGN - NORTH

Subject: Final Seismic Design Recommendations

This report presents the final seismic design recommendations for the Garden Highway Undercrossing bridge located on State Highway 99 in Sutter County.

Geology

Based on a recent foundation investigation conducted by our office in July through September 2007, the foundation materials generally consists of loose to very dense granular silt, sand, and gravel interbedded with soft to hard clay. The groundwater table was encountered at an elevation of about 16 feet.

Seismic Study

Based on Caltrans California Seismic Hazard Map 1996, the controlling fault for the site is Dunnigan Hills (style of faulting: reverse, including thrust) with a maximum credible earthquake moment magnitude of M_w=6.5, and is located about 30 km southwest of the site. The peak horizontal bedrock acceleration based on the above map is estimated to be 0.2g. There is no known active fault crossing the bridge site, therefore, the potential for surface rupture at the site is considered insignificant.

Based on the LOTB, a Caltrans Seismic Design Criteria Acceleration Response Spectrum corresponding to soil profile Type D with a Peak Bed Rock Acceleration of 0.2g is recommended for design (see Figure 1 in Appendix A).

Liquefaction Study

A detailed liquefaction analyses were performed for the two support locations based on the recommendations outlined in the report entitled "Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils." Based on the ground water location and mechanical analyses of selected soil samples, the foundation materials is not susceptible to liquefaction during a strong ground shaking.

If there are any questions regarding the design recommendations, please contact Reza Mahallati at (916) 227-1033.

Reza Mahallati
Senior Materials and Research Engineer
Office of Geotechnical Design North

REGISTERED PROFESSIONAL ENGINEER
REZA MAHALLATI
No. 49374
Exp. 9/30/08
CIVIL
STATE OF CALIFORNIA

Attachment
1- Appendix A – ARS Curve

c: Abu Barrie - (OGD-N),
OGDN File

Appendix A

Recommended ARS Curve

Garden Highway Undercrossing
Br. No. 18-0025R
03-1A4321

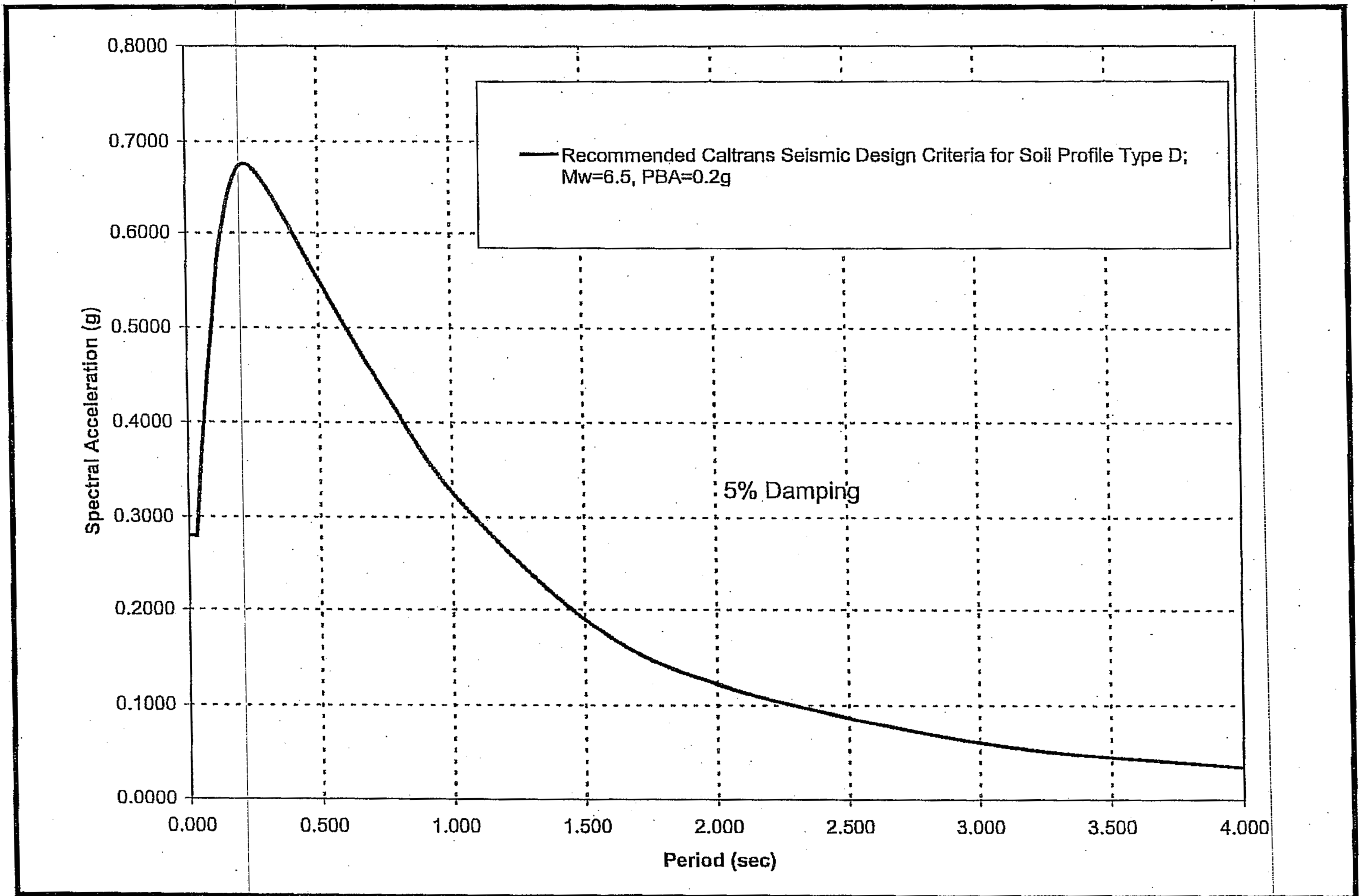

Figure 1. Acceleration Response Spectrum Recommended for Design

State of California
Department of Transportation

Business, Transportation and Housing Agency

Memorandum

Flex your power!
Be energy efficient!

To: MR. GERRY WONG
Branch Chief
District 3 – Design Branch S9

Date: May 1, 2008

File: 03-SUT-99
PM 12.3
EA 03-1A4321

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5

Subject: Geotechnical Design Report

Introduction

Per your request, we are providing a Geotechnical Design Report (GDR) for Highway 99 from PM 12.3 approximately 0.25 miles northwest of the town of Nicolaus in Sutter County, California. This project proposes to construct a new Feather River Bridge (Br. No. 18-0026R) and new Garden Highway Undercrossing (Br. No. 18-0025R) located to the east of the existing structures. This report addresses slope stability and settlement of the approach fills. Recommendations for the bridge structures will be provided in the Foundation Reports.

The purpose of this report is to analyses of anticipated site conditions as they pertain to the project described herein, and to recommend design and construction criteria. This report also establishes a geotechnical baseline to be used in assessing the merit and/or scope of potential changed site conditions and is intended for use by the project design engineer, construction personnel, bidders and contractors.

Pertinent Reports and Investigations

The following documents were reviewed to assist in the assessment of site conditions:

- Log-of-Test-Borings (LOTB), Garden Highway UC, Br. No. 18-0025.
- Log-of-Test-Borings (LOTB), Feather River Bridge, Br. No. 18-0026.
- Geologic Map of CA, Sacramento Quadrangle, CA Mines and Geology, 1987.
- Nicolaus, CA 7.5-minute quadrangle, United States Geological Survey, 1978.
- California Seismic Hazard Map 1996, Caltrans, Lalliana Mualchin, 1996.

Existing Facilities and Proposed Improvements

The new Feather River Bridge (Br. No. 18-0026R) and new Garden Highway Undercrossing (Br. No. 18-0025R) will be constructed to the east (up-stream) side of the existing structures on the same alignment. The project is located on Hwy 99 approximately 0.25 miles northwest of the town of Nicolaus in Sutter County, California. When completed, the existing structures will become the left of the structures and will convey southbound traffic while the proposed new structures will convey northbound traffic. The existing Feather River Bridge is a two-lane structure, which was constructed in 1958. The structure is 3,186 feet long, with a total of 31 spans and consists of six PC/PS girder- spans with one steel-welded six girder-span section. The existing Garden Highway Undercrossing is a two-lane structure, which was constructed in 1958. The structure is 111.9 feet long, with a total of 3 spans and consists of continuous concrete slab spans on piles and concrete open-end diaphragm abutments on piles.

Physical Setting

Climate

According to the Western Regional Climate Center for 1948-2005, the average annual precipitation in Marysville, located 27 km (17 miles) north of the project site is 548.4 mm (21.59 in). The majority of this precipitation falls between October and April. The average annual air temperature is approximately 17.1° C (62.7° F) with the highest average daily maximum of 35.8° C (96.4° F) in July and the lowest average daily minimum of 3.3° C (38.0° F) in January.

Topography and Drainage

The Nicolaus, CA 7.5-minute quadrangle shows that the terrain is relatively flat with elevations ranging from 7.6 to 10.7 meters (25 to 35 feet). The main drainage feature is the Feather River, which runs in a northeast / southwest direction through the project site.

Site Geology and Subsurface Conditions

According to the Geology of California (Norris and Webb 1990, 2nd Edition) the existing bridge site is located within the Great Valley geomorphic province of California. The

Geotechnical Recommendations

The following is a summary of our recommendations:

Slope Stability

The slopes at both the north and south ends of the proposed Feather River Bridge will be stable under the current conditions. In order to maintain slope stability under scour conditions, the abutment slope should be constructed with a horizontal distance of 15 feet from of the abutment wall to the edge of the slope on top of the levee and then a 1:1.5 (V:H) slope down to the river.

Settlement

The settlement of the fill embankment at the north approach is estimated to be 9-12 inches with a waiting period of 12-18 months. The settlement of the fill embankment at the south approach is estimated to be 2-3 inches with a waiting period of 2-3 months. The settlement of the fills should be monitored. The foundation construction should begin after the primary consolidation settlement is finished. Additionally, the impact of placement of additional fill on the existing Garden Hwy UC abutment piles was analyzed and the impact is negligible.

Project Information

Standard Special Provision S5-280, "Project Information", discloses to bidders and contractors a list of pertinent information available for their inspection prior to bid opening. The following is an excerpt from SSP S5-280 disclosing information originating from Geotechnical Services. Items listed to be included in the Information Handout will be provided in Acrobat (.pdf) format to the addressee(s) of this report via electronic mail.

Data and information attached with the project plans are:

A. None

Memorandum

Flex your power!
Be energy efficient!

To: MR. JEFF SIMS
Senior Bridge Engineer
Structure Design North, Branch 1

Attention: Greg Jones

Date: August 7, 2008

File: 03-SUT-99-PM 12.03
03-1A4321
Hwy 99 Widen, Seg 2
New Feather River Bridge
Br. No. 18-0026R

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5

Subject: Foundation Report

Scope of Work

This report presents Foundation Recommendations for the proposed new Feather River Bridge (Br. No. 18-0026R) located on Highway (Hwy) 99 in Sutter County. The Office of Geotechnical Design-North (OGD-N) has completed a foundation study for the new bridge. The study consisted of a review of 'As-Built' records of the existing bridge and a surface and subsurface field exploration program conducted at the site from July to September, 2007. The subsurface investigation included drilling and sampling the foundation soil at the site. Selected soil samples were analyzed and the results used to characterize and evaluate the subsurface soil and determine its suitability as foundation material for the new bridge. Fifteen mud rotary soil borings were drilled and sampled. The borings were from 120 to 250 ft deep. The Log of Test Borings (LOTBs) developed from this field investigation have been forwarded.

The recommendations presented in this report are based mainly on the data generated during this field exploration, and on a review of pertinent documents including the following:

1. The "As-Built" Log of Test Borings dated October 1, 1956.
2. Preliminary Geologic Recommendations and Resource Estimate for Advance Planning study, dated August 15, 2000.
3. Preliminary Seismic Design Recommendations, dated August 10, 2000.
4. The "As-Built" Log of Test Borings (Widen) dated December 20, 1994.
5. Foundation Investigation (Feather River Widen), dated September, 1995.
6. Preliminary Foundation Recommendations (Feather River Bridge) dated December 7, 2007.
7. Geology of California, R. M. Norris and R. W. Webb, (2nd Edition, 1990).
8. The Geology Map of the Sacramento Quadrangle; D. L. Wagner, C. W. Jennings, T. L. Bedrossian and E. J. Bortugno (Second printing 1987).

9. Revised Final Hydraulics Report for Feather River dated July 26, 2007.
10. Feather River Bridge Foundation Plans dated July 23, 2007.
11. Feather River Bridge General Plan dated November 29, 2007.

Project Description

This project is located approximately 25 miles north of Sacramento, on U.S. Hwy 99. It is approximately 0.25 mile northwest of the town of Nicolaus in Sutter County, California.

The new Feather River Bridge (Br. No. 18-0026R) will be constructed to the east (up-stream) side of the existing Feather River Bridge (Br. No. 18-0026) on a parallel alignment. When completed, the existing bridge (Br. No. 18-0026L) will convey southbound traffic while the proposed new bridge will convey northbound traffic. The existing bridge is a two-lane structure constructed in 1958 and widened in 1996. It is 3,186 feet long, with 31 spans that consist of six PC/PS girder- spans and one steel-welded six girder-span section.

The new bridge superstructure will be 3148 ft long and will be constructed parallel to, and separated from, the existing bridge by an approximately 9 ft wide median. It will consist of 16 spans comprised of pre-cast modified spliced bulb tee girders, supported at the piers by two column pile extensions. The pier foundation system will consist of two 7.5 ft diameter Cast-in-Steel-Shell (CISS) piles. The span lengths will be: spans 2 to 14: 210 ft. long; span 1: 152.6 ft.; span 15: 150 ft.; and span 16: 115.6 ft. long. The abutments will be seat type abutments supported by Class 140 pipe pile foundations.

The existing bridge crosses the Feather River, which consists of broad flood plains on the south and north banks of the active river channel. The flood plains are bounded north and south by levees, which stand at elevation approximately 59 feet. Based on the project Foundation Plan dated July 23, 2007, the original ground elevation at the south bank ranges approximately from 19 to 28 ft., while the river channel within the footprint of the new bridge ranges from 12 to 19 ft. in elevation. The north bank has a much broader flood plain that rises from approximately 27 to 36 ft. in elevation.

The south bank is more vegetated than the north bank. The vegetation on the south bank generally consists of trees and a thick undergrowth of low bushes, vines, shrubs and grass. The north bank is vegetated mainly by trees and scattered low bushes, shrubs and grass. On both the north and south banks, a shallow backwater occurs in a depression near the base of the levees. This body of water and its surrounding areas are considered as wetlands and are environmentally sensitive ecological areas.

The banks are easily accessible through existing gravel roads over the levees to the banks. Piers 2 and 3 of the new bridge will be located on the south bank. The new Piers 4 through 7 are located in the active river channel while Piers 8 through 16 will be constructed on the north bank.

The elevations used in this report are referenced to the NGVD29 Vertical Datum as provided on the project Foundation Plans dated July 23, 2007.

Site Geology and Subsurface Conditions

According to the Geology of California (Norris and Webb 1990, 2nd Edition), the existing bridge site is located within the Great Valley geomorphic province of California. The Geology Map of the Sacramento Quadrangle (Wagner, Jennings, Bedrossian and Bortugno, Second Printing, 1987) indicates that the site is underlain by Quaternary alluvium of Holocene age. The Holocene alluvium (Q) is comprised of an upper natural levee and channel deposits (Qa) and lower basin deposits (Qb). These Holocene materials consist of poorly sorted stream and basin deposits from clay to boulder size and overlie older alluvial formations at the site. The Log of Test Borings (LOTBs) for the existing bridge, dated October 1956 and February 1995, indicate that the site is underlain by loose to very dense fine sandy silt, silty fine sand, fine to medium to coarse micaceous sand, gravel, cobbles and minor amounts of organics. The granular material is generally interbedded with layers of very soft to very stiff to hard silty and sandy clays.

The subsurface investigation conducted from July to September 2007, explored to a maximum depth of 250 feet in seven of the borings. One boring each was drilled to approximately correspond to 14 of the support locations of the new bridge. Drilling was not performed for the locations of the new Piers 9, 11 and 13 but the subsurface conditions were inferred from adjacent borings and from previous borings for the existing bridge. Temporary stand pipe piezometers were installed in Borings 07-B1, 07-B12, 07-B15 and 07-B18 for ground water measurement.

The subsurface soil encountered during this foundation investigation consists mainly of granular materials of sand and gravel with interbeds of clay and silt. The granular soil consists of fine to coarse grained layers of loose to very dense silty sand, sand, gravels, and cobbles. The cohesive soils consist of soft to hard sandy clay, silty clay, sandy silt and silt. The soil layers are generally micaceous and contain organic materials in places.

The soil layers encountered can be generalized as follows:

1. A layer of very loose to loose silty sand and sand with gravel interbedded with seams of soft clay and silt and organics. This layer generally extends from the original ground surface to the maximum recorded elevation of -15 ft (Borings 07-B11 and 07-B15). Most of this layer has been determined to be scourable and susceptible to liquefaction.

2. The above layer either lies directly over gravel with cobbles or is separated from it by a 15 to 30 ft layer of medium dense silty sand and sand with a trace of cobbles. This gravel and cobble layer is recorded to extend from elevation -12 ft (Boring 07-17 at Abut. 17) to elevation -115 ft (Boring 07-B7) and consists of medium dense to

mostly very dense sub-angular to rounded clasts in a matrix of micaceous sand and/or silt.

3. Below the gravel layer is a repetitive layer of very dense or hard sandy silt with clay, or sandy clay with silt which is generally interbedded with medium dense to very dense silt, silty sand and sand. The sandy clay or silt is weakly to moderately cemented, and is usually brittle, fissured and blocky. This layer extends to the bottom of most of the deep borings.

The boring data will be provided on the LOTBs for this project.

Ground Water

As-built records for the existing bridge indicate that historically, the ground water levels encountered during the field investigations of 1956, 1994 and 1996 varied in the soil borings along the alignment of the existing structure. The highest ground water level was measured at the existing Pier 14 (Boring B-26) at elevation 34.3 feet in January 1995. The lowest ground water level was measured at elevation -16.8 feet at Abutment 32 in April 1994. This indicates that ground water level fluctuation should be anticipated with the seasonal rainfall and the water river level.

During the recent field exploration program conducted in July to September 2007, the ground water level was measured in November 2007 at elevation 17 ft in Borings 07-B1 on the south bank and 07-B12 on the north bank. These two borings are closest to the river channel. Ground water was also measured at elevation 19 ft in the same period in Borings 07-15 and 07-18 which are located farthest from the river channel.

The current project Hydraulics Report recommends a high water surface elevation of 50.4 feet for the design flood for a 100-year event.

Scour Evaluation

According to the As-Built Pile Data on General Plan No. 2, (revision date December 12, 1995) scour potential extends to elevation 0.0 ft for the existing Piers 3-6 located on the south bank, to elevation -5.0 ft at Piers 7 through 14 located in the active river channel, and from Piers 15 through 30 located on the north bank.

The Final Hydraulics Report for this project dated July 11, 2007 has noted that "the channel is considered laterally and vertically unstable." The thalweg has dropped 10 ft in elevation and moved 320 ft northward from 1956 to 1987, but the rate of degradation has slowed in recent years. Records indicate a history of significant local scour at the existing Piers 13 and 14 (in channel) due to high water velocity during big storms in past years. The project Hydraulics Report has projected that the maximum local scour will occur at Piers 4 to 8 of the new bridge.

The table below summarizes the projected scour regime at the site for the new bridge as provided in the above referenced Hydraulics Report.

Table 1: Scour summary for the new Feather River Bridge

Thalweg Elevation (2007)	Scour Elevation (Max)
11.8 ft	-6.00 ft
Projected 75-yr Thalweg Elevation (2082)	Scour Elevation (2082)
6.8 ft	-11.00 ft

For additional information on scour for this project, please refer to the Hydraulics Report referenced above.

The table below indicates the projected maximum total depth for scour and liquefaction at the piers based on the Hydraulics Report and the liquefaction analysis performed by OGD-N. These parameters are used in the design of the foundation for the new Feather River Bridge.

Table 2: Scour and liquefaction depths at the support location of the new bridge

Support Location	Depth of Scour	Depth of Liquefaction
Abutment 1	N/A	N/A
Pier 2	-11	2
Pier 3	-11	N/A
Pier 4	-11	7
Pier 5	-11	-8
Pier 6	-11	-22
Pier 7	-11	-13
Pier 8	-11	14
Pier 9	-11	7*
Pier 10	-11	-8
Pier 11	-11	-8*
Pier 12	-11	31
Pier 13	-11	-6*
Pier 14	-11	-6
Pier 15	-11	18
Pier 16	-11	7
Abutment 17	N/A	N/A

Note: * indicates extrapolation based on adjacent borings.

Based on the Hydraulics Report, the table below indicates the scour elevations for the different limit states that are used for the foundation design at all intermediate support locations of the new bridge.

Table 3: Scour elevations for the limit states

Limit State	Scour Elevation (feet)
Extreme Limit State	7
Strength Limit State	-2
Service Limit State	- 11.00

Corrosion Evaluation

Caltrans considers a site to be corrosive to foundation elements if one or more of the following conditions exist for the representative soil and/or water samples taken at the site:
Chloride concentration is 500 ppm or greater, sulfate concentration is 2000 ppm or greater, or the pH is 5.5 or less.

The Foundation Investigation report prepared for the widening of the existing bridge in 1995 concluded that this project site was a non-corrosive environment. Table 4 shows laboratory results for soil samples collected and analyzed during the recent foundation investigations conducted in 2007 for this project.

Table 4: Corrosion Test Summary Report-Feather River Bridge

SIC Number (TL101)	Boring Number (Location)	Sample Type	Sample Depth (ft)	Minimum Resistivity (ohm-cm)	pH	Chloride Content (ppm)	Sulfate Content (ppm)
C644038	07-B7 (channel)	Soil	135-140	984	8.01	20	76
C644039	07-B21 (N bank)	Soil	15-20	3820	7.06		
C644041	07-B21 (N bank)	Soil	105-110	1673	8.17		
C644046	07-B12 (N bank)	Soil	35-40	6504	7.81		
C644040	07-B21(channel)	Soil	30-35	4690	7.97		
C644042	07-B12 (N bank)	Soil	5-10	10875	7.27		
C644043	07-B12 (N bank)	Soil	15-20	6045	7.80		
C644045	07-B12 (N bank)	Soil	20-25	4600	7.61		
C644047	07-B10 (N bank)	Soil	5-10	5170	8.18		
C644048	07-B16 (N bank)	Soil	0-5	6227	7.55		
C644049	07-b16 (N bank)	Soil	20-25	5819	6.95		
C644050	07-B17 (N bank)	Soil	0-5	4449	7.50		
C644044	07-B17 (N bank)	Soil	50-55	3542	7.38		

Based on these corrosion results, the native soil beneath the new Feather River Bridge site is non-corrosive per Caltrans standards.

Seismic Study

Final Seismic Deign Recommendations for this project have been provided in a separate report dated April 28, 2008, by OGD-N. Please contact Mr. Reza Mahallati on 916-227-1033 if you need additional information this issue.

As-Built Foundation Data

The original structure constructed in 1958 is supported on Raymond step taper and concrete piles as shown in the table below.

Table 5: Pile Data Table for the existing bridge built in 1958

Support Location	Pile Type	Specified Tip Elevation (ft)
Abutment 1	Raymond step taper concrete piles	-17.0
Pier 2	Raymond step taper concrete piles	-20.0
Pier 3	PC/PS concrete piles	-30.0
Pier 4	PC/PS concrete piles	-35.0
Pier 5	PC/PS concrete piles	-30.0
Pier 6	PC/PS concrete piles	-35.0
Pier 7	PC/PS concrete piles	-45.0
Pier 8	PC/PS concrete piles	-50.0
Pier 9	PC/PS concrete piles	-54.0
Pier 10	PC/PS concrete piles	-59.0
Pier 11	PC/PS concrete piles	-54.0
Pier 12	PC/PS concrete piles	-36.0
Pier 13	PC/PS concrete piles	-33.0
Pier 14	PC/PS concrete piles	-33.0
Pier 15 thru Pier 18	PC/PS concrete piles	-36.0
Pier 19	PC/PS concrete piles	-32.0
Pier 20 thru Pier 29	PC/PS concrete piles	-27.0
Piers 30 & 31	PC/PS concrete piles	-25.0
Abutment 32	Raymond step taper concrete piles	-25.0

The original bridge was widened to the west (downstream) in 1996.
The widened portion is supported on Class 140 and Class 200 Alternative "W" Piles as shown in the table below.

Table 6: Pile Data Table for the existing bridge (widen) built in 1996

Support Location	Pile Type	Bottom of footing Elevation (ft)	Specified Tip Elevation (ft)
Abutment 1	Class 140 Alt. "W"	50.9	-20.0
Pier 2	Class 200 Alt "W"	32.9	-50.0
Pier 3	Class 200 Alt "W"	- 0.9	-50.0
Pier 4	Class 200 Alt "W"	- 0.8	-50.0
Pier 5	Class 200 Alt "W"	-1.1	-50.0
Pier 6	Class 200 Alt "W"	-2.7	-50.0
Pier 7	Class 200 Alt "W"	-2.9	-50.0
Pier 8	Class 200 Alt "W"	-3.9	-50.0
Pier 9	Class 200 Alt "W"	-2.9	-50.0
Pier 10	Class 200 Alt "W"	-1.6	-50.0
Pier 11	Class 200 Alt "W"	-1.1	-50.0
Pier 12	Class 200 Alt "W"	-3.3	-50.0
Pier 13	Class 200 Alt "W"	7.6	-40.0
Pier 14	Class 200 Alt "W"	7.8	-40.0
Pier 15	Class 200 Alt "W"	9.4	-50.0
Pier 16	Class 200 Alt "W"	9.8	-45.0
Pier 17	Class 200 Alt "W"	8.5	-45.0
Pier 18	Class 200 Alt "W"	9.4	-50.0
Pier 19	Class 200 Alt "W"	8.9	-50.0
Pier 20	Class 200 Alt "W"	8.7	-45.0
Pier 21	Class 200 Alt "W"	8.9	-40.0
Pier 22	Class 200 Alt "W"	9.1	-40.0
Pier 23	Class 200 Alt "W"	10.0	-40.0
Pier 24	Class 200 Alt "W"	10.2	-40.0
Pier 25	Class 200 Alt "W"	9.4	-40.0
Pier 26	Class 200 Alt "W"	9.4	-40.0
Pier 27	Class 200 Alt "W"	9.0	-50.0
Pier 28	Class 200 Alt "W"	8.9	-50.0
Pier 29	Class 200 Alt "W"	8.9	-50.0
Pier 30	Class 200 Alt "W"	8.9	-40.0
Pier 31	Class 200 Alt "W"	32.9	-40.0
Abutment 32	Class 140 Alt. "W"	50.9	-20.0

The design tip elevations were controlled by compression, tension and scour.
Scour elevations were 0.0 ft for Piers 3 to 6, and -5 ft for Piers 7 to 12 (channel) and Piers 15 to 30.

Foundation Recommendations

The proposed new Feather River Bridge structure, as indicated on the General Plan dated November 29, 2007, may be supported on Class 140 pipe piles at Abutments 1 and 17 according to the table below.

Table 7

Abutment Foundations Design Recommendations (Feather River Br-18-0026R)									
Support	Pile	Cut-off Elevation (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip Elevations (ft)	Specified Tip Elevation (ft)	Nominal Driving Resistance Required (kips)
			Total	Permanent					
Abut 1	Class 140 Alt. W	47.42	4200	3150	140	280	-6.0(a), 15.0(c)	-6.0	280
Abut 17	Class 140 Alt. W	46.92	4200	3150	140	280	-13.0(a), -11.0(c)	-13.0	280

Notes:

1) *Design tip elevations are controlled by: (a) Compression, (c) Settlement, respectively.*
2) *The specified tip elevation shall not be raised above the design tip elevations for tolerable settlement.*

The new Feather River Bridge as shown on the Feather River General Plan dated November 29, 2007, may be supported at all the pier locations on 7.5 ft diameter Cast-in-Steel-Shell (CISS) Pipe Piles according to the tables below.

The geotechnical capacity of the 7.5 ft pipe pile foundations recommended in this report were determined by utilizing the computer program APILE Plus, version 4.0 for Windows (Ensoft, Inc., 2004). This program is based on the procedures recommended by the American Petroleum Institute (API, 1987) for the determination of the axial capacity of large diameter pipe piles.

The geotechnical capacity of the CISS piles at the locations of Piers 2 through 16 of the new structure is based on a combination of skin friction and end bearing. In order to develop the end bearing, it is recommended that a minimum of 50 ft of undisturbed soil plug be maintained in all the CISS piles during clean out for the installation of the cage reinforcement. However, if the design for lateral loads and displacements requires less soil plug, please inform this Office for further recommendations.

Table 8

Pier Foundations Design Recommendations (Feather River Bridge-18-0026R)											
Support Location	Pile Type	Cut-off Elevation (ft)	Service-I Limit State Load per Support (kips)	Total Permissible Support Settlement (inches)	Required Factored Nominal Resistance (kips)				Design Tip Elevations (ft)	Specified Tip Elevation (ft)	Nominal Driving Resistance Required (kips)
					Strength Limit		Extreme Event				
					Comp. (φ=0.65)	Tension (φ=0.65)	Comp. (φ=1)	Tension (φ=1)			
Pier 2	CISS NPS 90 X 1.5	N/A	5005	1	3780	0	3130	0	-89.0 (a-I), -69.0 (a-II), -73.0(c)	-89.0	7900
Pier 3	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-110.0 (a-I), -74.0 (a-II), -65.0(c)	-110.0	8200
Pier 4	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-100.0 (a-I), -74.0 (a-II), -79.0(c)	-100.0	7600
Pier 5	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-120.0 (a-I), -66.0 (a-II), -73.0(c)	-120.0	7200
Pier 6	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-101.0 (a-I), -71.0 (a-II), -77.0(c)	-101.0	7400
Pier 7	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-108.0 (a-I), -66.0 (a-II), -72.0(c)	-108.0	7100
Pier 8	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-100.0 (a-I), -72.0 (a-II), -80.0(c)	-100.0	9800
Pier 9	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-98.0 (a-I), -68.0 (a-II), -76.0(c)	-98.0	9600
Pier 10	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-98.0 (a-I), -68.0 (a-II), -76.0(c)	-98.0	9600
Pier 11	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-98.0 (a-I), -68.0 (a-II), -76.0(c)	-98.0	9600
Pier 12	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-98.0 (a-I), -77.0 (a-II), -82.0(c)	-98.0	7800
Pier 13	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-106.0 (a-I), -76.0 (a-II), -82.0(c)	-106.0	8900
Pier 14	CISS NPS 90 X 1.5	N/A	5700	1	4190	0	3970	0	-106.0 (a-I), -76.0 (a-II), -82.0(c)	-106.0	8900
Pier 15	CISS NPS 90 X 1.5	N/A	4700	1	3580	0	3400	0	-93.0 (a-I), -77.0 (a-II), -76.0(c)	-93.0	8500
Pier 16	CISS NPS 90 X 1.5	N/A	4070	1	3160	0	3120	0	-86.0 (a-I), -73.0 (a-II), -72.0(c)	-86.0	7200

Notes:

1) *Design tip elevations are controlled by: (a-I) Compression (Strength Limit), (a-II) Compression (Extreme Event), (c) Settlement*
2) *The specified tip elevation shall not be raised above the design tip elevations for tolerable settlement.*
3) *The nominal driving resistance required is equal to the nominal resistance needed to support the factored load plus driving resistance from the unsuitable penetrated soil layers (liquefiable and scourable), which do not contribute to the design resistance. The extent of the unsuitable soil layers is provided in table 2.*

Table 9

PILE DATA TABLE (Feather River Bridge-18-0026R)

Location	Pile Type	Nominal Resistance (kips)		Design Tip Elevation (ft)	Specified Tip Elevation (ft)	Nominal Driving Resistance (kips)
		Compression	Tension			
Abut. 1	Class 140 Alt. W	280	0	-6.0(a), 15.0(c)	-6.0	280
Pier 2	CISS NPS 90 X 1.5	5800	0	-89.0 (a), -73.0(c)	-89.0	7900
Pier 3	CISS NPS 90 X 1.5	6500	0	-110.0 (a), -65.0(c)	-110.0	8200
Pier 4	CISS NPS 90 X 1.5	6500	0	-100.0 (a), -79.0(c)	-100.0	7600
Pier 5	CISS NPS 90 X 1.5	6500	0	-120.0(a), -73.0(c)	-120.0	7200
Pier 6	CISS NPS 90 X 1.5	6500	0	-101.0 (a), -77(c)	-101.0	7400
Pier 7	CISS NPS 90 X 1.5	6500	0	-108.0 (a), -72.0(c)	-108.0	7100
Pier 8	CISS NPS 90 X 1.5	6500	0	-100.0 (a), -80.0(c)	-100.0	9800
Pier 9	CISS NPS 90 X 1.5	6500	0	-98.0 (a), -76.0(c)	-98.0	9600
Pier 10	CISS NPS 90 X 1.5	6500	0	-98.0 (a), -76.0(c)	-98.0	9600
Pier 11	CISS NPS 90 X 1.5	6500	0	-98.0 (a), -76.0(c)	-98.0	9600
Pier 12	CISS NPS 90 X 1.5	6500	0	-98.0 (a), -77.0(c)	-98.0	7800
Pier 13	CISS NPS 90 X 1.5	6500	0	-106.0 (a), -84.0(c)	-106.0	8900
Pier 14	CISS NPS 90 X 1.5	6500	0	-106.0 (a), -84.0(c)	-106.0	8900
Pier 15	CISS NPS 90 X 1.5	5500	0	-93.0 (a), -76.0(c)	-93.0	8500
Pier 16	CISS NPS 90 X 1.5	4900	0	-86.0 (a), -72.0(c)	-86.0	7200
Abut. 17	Class 140 Alt. W	280	0	-13.0(a), -11.0(c)	-13.0	280

Notes:

1) *Design tip elevations for Abutments are controlled by: (a) Compression, (c) Settlement.*
2) *Design tip elevations for Piers are controlled by: (a) Compression, (c) Settlement.*

3) *The specified tip elevation shall not be raised above the design tip elevations for tolerable settlement.*
4) *Unsuitable soil layers (liquefiable and scourable) that do not contribute to the design nominal resistance exist at Piers 2 through 16. The extent of the unsuitable soil layers is provided in the following table.*

Table 10: Depth of Scourable and Liquefiable Soil Layers.

Support Location	Depth of Scourable Soil Layer	Depth of Liquefiable Soil Layer
Pier 2	-11	2
Pier 3	-11	N/A
Pier 4	-11	7
Pier 5	-11	-8
Pier 6	-11	-22
Pier 7	-11	-13
Pier 8	-11	14
Pier 9	-11	7
Pier 10	-11	-8
Pier 11	-11	-8
Pier 12	-11	31
Pier 13	-11	-6
Pier 14	-11	-6
Pier 15	-11	18
Pier 16	-11	7

Pile Load Test

We recommend that a compression pile load test be performed at Pier 12 of the new bridge. The pile load test at Pier 12 will control the specified tip elevation at Piers 2 through 16. The test pile and the first anchor pile to be installed shall be dynamically monitored while they are being driven. Based on the results obtained for the monitored anchor pile the remaining anchor piles may be dynamically monitored. An isolation casing with a minimum diameter of 9.5 ft shall be installed to elevation -2.0 ft and cleaned out prior to installing and driving the test pile. The load testing shall be performed to the nomial resistance of the test pile or the capacity of the test apparatus, but not less than a nominal load of 6500 kips. The test pile has a specified tip elevation of -98 feet.

The anchor piles shall be 4.0 foot diameter and 1.5 inches thick pipe piles and shall be driven to elevation –107 feet. Installation of the anchor piles may encounter hard driving through the dense to very dense granular soil layers containing cobbles. Pile toe protection (driving shoe) is required for driving the anchor piles to the specified tip at Pier 12. The toe protection shall consist of a welded pipe section with steel yield strength equal to the pile. The driving shoes shall be a minimum of 1.5 inches thick and 5 ft long for all the anchor piles for this project. If necessary, the end of the driving shoes may be beveled. The outer diameter of the driving shoes shall be identical to that of the pipe piles.

The load test shall be performed on the test pile after completion of the interior clean out and prior to placing concrete or reinforcement. Pile load testing is to be performed for compression only. A minimum period of 14 days is required for set-up after the initial driving of both the test and anchor piles. A re-tap should be performed on the test pile 7 days after the initial installation. The test pile shall be initially driven to within 1 ft of the specified tip elevation. The pile shall be driven to the specified tip elevation during the re-tap.

After the load testing is completed and the pile has been accepted, the test pile may be incorporated into the new bridge foundation system. The anchor piles and the isolation casing shall be removed in conformance with the provisions in Section 15-4.02, "Removal Methods," of the Standard Specifications, and the remaining holes shall be backfilled with a sand soil or other suitable material approved by the Engineer. The design configuration and specifications of the pile load test to be included with contract plans will be developed by the Foundation Testing Branch of the Office of Geotechnical Support. Please contact Brian Liebich at (916) 227-1000 for further information on this subject.

Pile acceptance criteria will be developed using a wave equation analysis after completion of the load testing and dynamic monitoring.

General Notes to Designer

1. The structure design engineer shall indicate the design pile tip elevation for lateral resistance in the pile data table.

2. If the design tip elevation for lateral resistance is lower than the design tip elevation for compression at Piers 2 through 16, contact the Office of Geotechnical Design - North for additional recommendations.

3. A pile driveability evaluation study has been conducted for both the load test anchor piles and production piles.

4. We request that all support locations be plotted in plan view on the Log of Test Borings tracings per "Memo to Designers" 4-2. This plotting should be done prior to requesting a final foundation review.

Construction Considerations

1. Ground water was encountered at this site during the geotechnical field investigation and should be considered at all phases of construction and pile installation. Ground water levels fluctuate seasonally and during construction may occur at elevations different from those indicated in this report.

2. The large diameter CISS piles at Piers 2 through 16 should be driven to the specified tip elevation without undue interruption in order to minimize increase in driving resistance due to soil "setup."

3. At Piers 2 through 16, the calculated geotechnical capacity of the CISS piles above the potential scour elevation of –2 feet for strength limit state (as recommended in the Hydraulics Report for this project), has been ignored for pile design purposes. However, the pile installation will have to account for the nominal driving resistance as indicated in the above pile data table. The Contractor's Driving System must be designed for the nominal driving resistances. A vibratory hammer may be used for the initial installation of the CISS piles but must not be used when the pile tip is below elevation –2 feet.

4. Depending on the type and size of hammer selected by the Contractor, "center relief" drilling through the CISS and anchor piles may be necessary to assist pile driving to the specified tip elevations. However, pre-drilling ahead of the pile is not allowed during pile driving. Center relief drilling shall not be allowed within 5 ft of the end of the pile during the installation of both the production and anchor piles for this project. No drilling to assist driving (center relief drilling) shall be allowed within the limits of undisturbed soil plug as recommended above. Equipment or methods used for cleaning out the shells shall not cause quick soil conditions.

5. Due to the anticipated pile installation in saturated soils, drilling through the CISS piles requires maintaining a pressure head inside the shells. During soil clean out inside the CISS piles, water/slurry pressure head must be maintained in the shell above the anticipated potentiometric level of ground water to prevent soil blowout/quick soil conditions from occurring. If required, a maximum of 10 feet of the recommended soil plug may be replaced by seal course.

6. After the lateral tip elevation has been achieved during pile driving, if a CISS pile refuses before reaching the specified tip elevation, this Office shall be notified for additional recommendations.

7. Newly placed embankment fill shall undergo a minimum settlement period and requires monitoring. For further information regarding waiting period, refer to the Geotechnical Design Report (GDR) for EA 03-1A4321, dated 5/1/2008. Pile driving shall commence after the waiting period recommended in the referenced GDR.

8. At Abutments 1 and 17 of the new the structure, we recommend that all the pipe piles be driven to the specified tip elevation provided in this report. However, if during pile driving a pile obtains two times the required nominal driving resistance as determined by Section 49-1.8 "Bearing Values and Penetration," of the Standard Specifications before achieving the specified tip elevation, please contact this Office for further evaluation.

9. The Office of Geotechnical Design - North should be invited to a pre-construction meeting.

10. Accumulated soil debris should be removed from the CISS pile prior to the placement of the steel reinforcement and structural concrete. This Office recommends that the Structure Representative/Resident Engineer fully inspect pile installation and clean-out processes of all the piles before placing the concrete and cage reinforcement.

The recommendations contained in this memorandum are based on specific project information regarding structure type, location and design loads that have been provided by Structure Design. If any conceptual changes to the structure are proposed during final project design, the Office of Geotechnical Design - North should review those changes to determine if the foundation recommendations contained herein are still applicable.

Project Information

Standard Special Provision S5-280, "Project Information", discloses to bidders and contractors a list of pertinent information available for their inspection prior to bid opening. The following is an excerpt from SSP S5-280 disclosing information originating from Geotechnical Services. Items listed to be included in the Information Handout will be provided in Acrobat (.pdf) format to the addressee (s) of this report via electronic mail.

Data and information attached with the project plans are:

1. <u>Log of Test Borings (New Feather River Bridge, Br No 18-0026R)</u>

Data and Information included in the Information Handout provided to the bidders and contractors are:

1. *<u>Foundation Report (New Feather River Bridge, Br No 18-0026R), dated 8/7/2008</u>*
2. *<u>Driveability Study, dated 4/25/2008</u>*
3. *<u>Geotechnical Design Report, for EA 03-1A4321, dated 5/1/2008</u>*

If you have any questions or need further information regarding this report, please contact Abu Barrie at (916) 227-7169, or Ron Richman at (805) 549-3385.

REGISTERED PROFESSIONAL ENGINEER
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c: R.E. Pending File
Structure OE (E-copy)
PCE (E-copy)
DME (E-copy)
GDN File
GS File

Memorandum

Flex your power!
Be energy efficient!

To: MR. JEFF SIMS
Senior Bridge Engineer
Structure Design North, Branch 1

Attention: Greg Jones

Date: August 7, 2008

File: 03-SUT-99-PM 12.03
03-1A4321
Hwy 99 Widen, Seg 2
New Garden Highway UC
Bridge Br. No. 18-0025R

**From: DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5**

Subject: Foundation Report

Scope of Work

The Office of Geotechnical Design-North (OGD-N) presents this Foundation Report for the proposed new Garden Highway Undercrossing (Br. No. 18-0025R) located on U.S. Highway (Hwy) 99 in Sutter County. The conclusions and recommendations provided in this report are based primarily on data generated from a subsurface exploration program conducted in August to September 2007, for the foundation of the new bridge. The study also included a review of 'As-Built' records of the existing bridge and other pertinent geologic records. The subsurface investigation included drilling and sampling the foundation soil at the site. Selected soil samples were analyzed and the results used to characterize and evaluate the subsurface soil and determine its suitability as foundation material for the new bridge. One mud rotary soil boring was drilled and sampled for each abutment location of the proposed new bridge. The borings were from 121 to 132 ft deep. The Log of Test Borings (LOTBs) developed from this field investigation will be forwarded when finalized.

Project Description

This project is part of Segment 2 of the Hwy 99 widening program. Garden Hwy UC Bridge is located south of, and adjacent to, Feather River Bridge, approximately 20 miles north of Sacramento, on U.S. Hwy 99. It is approximately 0.25 mile west of Nicolaus, in Sutter County, California.

The new Garden Hwy Bridge (Br. No. 18-0025R) will be constructed to the east side of the existing bridge (Br. No. 18-0025) on the same alignment. When completed, the existing bridge will convey southbound traffic while the proposed new bridge will carry northbound traffic on Hwy 99. The existing bridge is a two-lane structure constructed in 1958. It is a 112 ft long, 44 ft wide bridge consisting of three spans made of continuous Reinforced Concrete (RC) slabs supported by Class 90 RC piles at the bents. The abutments are comprised of RC open end diaphragms also supported by Class 90 RC piles. The existing bridge was widened in 1996 on the west side by an additional structure that matched the original bridge but is supported by driven pipe piles.

The new bridge will be about 104 ft long by about 46 ft wide and will be constructed to the east of the existing bridge on a similar alignment, separated by a median that is approximately 6 ft wide. It will consist of a simple span comprised of Cast-in-Place Pre-Stressed (CIP/ PS) box girder on seat type abutments, supported by Class 140 pipe pile foundations.

The existing bridge crosses over Garden Highway on the south bank of the Feather River west of Nicolaus. The project is located on farmland covered by nut trees. Based on the project Foundation Plan dated July 13, 2007, the original ground surface at the site is generally flat, ranging in elevation from approximately 34 to 35 ft. The finished grade of the new bridge and the approach roadway will be 51 and 53 ft at Abutments 1 and 2 respectively. The site is easily accessible from Hwy 99.

The elevations used in this report are referenced to the NGVD29 Vertical Datum as provided on the project Foundation Plans dated July 13, 2007.

Summary of Site Geology and Subsurface Conditions

According to the Geology of California (Norris and Webb 1990, 2nd Edition), the existing bridge site is located within the Great Valley geomorphic province of California. The Geology Map of the Sacramento Quadrangle (Wagner, Jennings, Bedrossian and Bortugno, Second Printing, 1987) indicates that the site is underlain by Quaternary alluvium of Holocene age. The Holocene alluvium (Q) is comprised of upper natural levee and channel deposits (Qa) and lower basin deposits (Qb). These Holocene materials consist of poorly sorted stream and basin deposits from clay to boulder size that overlie older alluvial formations at the site.

The subsurface investigation conducted from August to September 2007, explored to a maximum depth of 132 feet. One boring was drilled to approximately correspond to each abutment support location of the new bridge. A temporary piezometer was installed in Boring 07-B3 for ground water measurement.

The subsurface soil encountered during this foundation investigation consists mainly of granular materials of sand and gravel with interbeds of clay and silt. The granular soil consists of fine to coarse grained layers of loose to very dense silty sand, sand and gravel. The cohesive soils consist of stiff to hard sandy clay and silt with clay. The soil layers are generally micaceous and contain organic material and iron oxides in places.

The soil layers encountered can be generalized as follows:

1. An upper layer of stiff to very stiff silt and clay with loose to medium dense silty sand. This layer generally extends from original ground surface to approximately elevation 16 feet (Boring 07-B3).

2. Below the above layer is a layer of loose to medium dense sand and silty sand that extends approximately to elevation 0 feet (Borings 07-B3 and 07-B4).

3. Next is a layer of medium dense to very dense gravel with sand and silt which extends to approximately elevation -13 feet.

4. Below the above, is a layer of stiff to hard clay that extends to an elevation of about -37 feet (Boring 07-B3).

5. The next layers consist of alternating beds of medium dense to dense sand and very dense gravel that extend to the maximum depth explored, elevation -100 feet.

The boring data will be provided on the LOTBs for this project.

Ground Water

Ground water was encountered at elevation 16 feet in November 2007 at Boring number 07-B3.

Scour Evaluation

Surface water in the vicinity of the project will be limited to local storm water run-off, which must be controlled in shallow ditches or channels and directed away from foundation elements and embankment fills. There are no scour effects on the new bridge foundation because there is no water way under, or adjacent to the proposed new bridge.

Corrosion Evaluation

Caltrans considers a site to be corrosive to foundation elements if one or more of the following conditions exist for the representative soil and/or water samples taken at the site:
Chloride concentration is 500 ppm or greater, sulfate concentration is 2000 ppm or greater, or the pH is 5.5 or less.

Laboratory results for soil samples collected and analyzed during this foundation study are shown in the following table.

Table 1: Corrosion Test Summary Report-Garden Hwy UC

SIC Number (TL101)	Boring Number (Location)	Sample Type	Sample Depth (ft)	Minimum Resistivity (oh-cm)	pH	Chloride Content (ppm)	Sulfate Content (ppm)
C644027	07- B3 (Abut1)	Soil	0-1	9794	6.35		
C644026	07-B3 (Abut1)	Soil	26-31	7590	7.21		
C644028	07-B4 (Abut2)	Soil	5-7	3311	7.49		
C644029	07-B4 (Abut2)	Soil	10-15	6990	7.28		
C644030	07-B4 (Abut2)	Soil	45-50	3728	7.52		

Based on these results, the native soil beneath the project site is not corrosive to foundation elements per Caltrans standards.

Seismic Study

Final Seismic Deign Recommendations for this project have been provided in a separate report dated April 29, 2008. Please contact Mr. Reza Mahallati at 916-227-1033 for additional information this issue.

As-Built Foundation Data

The original structure constructed in 1958 is supported on Class 90 Reinforced Concrete (RC) piles as shown in the table below.

Table 2: Pile Data Table for the existing bridge built in 1958

Support Location	Pile Type	Specified Tip Elevation (ft)
Abutment 1	Class 90 RC piles	- 0.0
Bent 2	Class 90 RC Piles	- 0.0
Bent 3	Class 90 RC Piles	- 0.0
Abutment 4	Class 90 RC Piles	- 0.0

The original bridge was widened to the west in 1996. The widened portion is supported on Class 140 pipe piles.

Foundation Recommendations

The proposed new Garden Highway UC Bridge (Br. No. 18-0025), as indicated on the Garden Highway UC General Plan, March 20, 2008, may be supported on Class 140 pipe piles at Abutments 1 and 2 according to the table below.

Table 3

Abutment Foundations Design Recommendations (Garden Highway UC Bridge)									
Support	Pile	Cut-off Elevation (ft)	LRFD Service-I Limit State Load (kips) per Support		LRFD Service-I Limit State Total Load (kips) per Pile (Compression)	Nominal Resistance (kips)	Design Tip Elevations (ft)	Specified Tip Elevation (ft)	Nominal Driving Resistance Required (kips)
			Total	Permanent					
Abut 1	Class 140 Alt. W	47.14	1640	1352	130	260	-6.0(a)	-6.0	260
Abut 2	Class 140 Alt. W	48.65	1640	1352	130	260	-6.0(a), 7.5(c)	-6.0	260

Notes:

1) *Design tip elevations are controlled by: (a) Compression, (c) Settlement*
2) *Design tip elevation for settlement is not applicable to Abutment 1*
3) *The specified tip elevation shall not be raised above the design tip elevation for tolerable settlement*

Construction Considerations

1. All newly placed embankment fills shall undergo a minimum settlement period that requires monitoring. For details regarding waiting period, refer to the Geotechnical Design Report for EA 03-1A4321, dated 5/1/2008.

2. Piles shall be driven in predrilled holes through the existing and new fill, to elevation 34 ft at Abutments 1 and 2. Pre-drilling shall be performed in accordance of Section 49-1-06 of the Standard Specifications.

3. At Abutments 1 and 2 of the new structure, we recommend that all the pipe piles be driven to the specified tip elevation provided in this report. However, if during driving a pile achieves 2 times the required driving resistance within 5 ft of the specified tip elevation, as determined by Section 49-1.8 "Bearing Values and Penetration," of the Standard Specifications, it shall be considered adequate and may be cut off upon the approval of the Engineer.

4. The Office of Geotechnical Design-North should be invited to a pre-construction meeting.

The recommendations contained in this memorandum are based on specific project information regarding structure type, location and design loads that have been provided by Structure Design. If any conceptual changes to the structure are proposed during final project design, the Office of Geotechnical Design-North should review those changes to determine if the foundation recommendations contained herein are still applicable.

Project Information

Standard Special Provision S5-280, "Project Information", discloses to bidders and contractors a list of pertinent information available for their inspection prior to bid opening. The following is an excerpt from SSP S5-280 disclosing information originating from Geotechnical Services.

Items listed to be included in the Information Handout will be provided in Acrobat (.pdf) format to the addressee (s) of this report via electronic mail.

Data and information attached with the project plans are:

1. <u>Log of Test Boring (New Garden Hwy UC, Br. No. 18-025R)</u>

Data and Information included in the Information Handout provided to the bidders and contractors are:

1. *<u>Foundation Report (New Garden Highway UC, Br No 18-0025R), dated 8/7/2008</u>*
2. *<u>Geotechnical Design Report, for EA 03-1A4321, dated 5/1/2008</u>*

If you have any questions or need further information regarding this report, please contact Abu Barrie at (916) 227-7169, or Ron Richman at (805) 549-3385.

Report by:

ABUBAKARR BARRIE
Engineering Geologist
Office of Geotechnical Design-North

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RON RICHMAN, C039869
Senior Materials and Research Engineer
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Reviewed by

for

REID BUELL, C.E.G. No. 1481
Senior Engineering Geologist
Office of Geotechnical Design-North

c: R.E. Pending File
Structure OE (E-copy)
PCE (E-copy)
DME (E-copy)
GDN File
GS File

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

JUN 9 2009

In response refer to:
2009/00364

Susan D. Bauer
Chief, Environmental Management
Department of Transportation
703 B Street, P.O. Box 911
Marysville, California 95901-0911

Dear Ms. Bauer:

Enclosed is NOAA's National Marine Fisheries Service's (NMFS) biological and conference opinion (BO) (Enclosure 1) for the proposed Feather River Bridge project (Project) located in Sutter County, California, and its effects on Central Valley (CV) Spring-run Chinook salmon (*Oncorhynchus tshawytscha*), California CV Steelhead (*O. mykiss*), and Southern DPS of North American green sturgeon (*Acipenser medirostris*) in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your initial request for formal section 7 consultation on this project was received on February 5, 2009. On February 9, 2009, formal consultation was initiated by NMFS' Sacramento Area Office.

This BO is primarily based on the biological assessment (BA) provided on February 5, 2009. The BA incorporated recommendations and addressed NMFS comments as discussed in meetings, correspondence, and emails. As the project action area has been included as the proposed critical habitat for North American green sturgeon (published on September 8, 2008, 73 FR 52084), this BO is also a conference opinion addressing impacts to North American green sturgeon proposed critical habitat, which could be adopted as a biological opinion if and when the proposed project area is included in the final designation for North American green sturgeon proposed critical habitat.

Based on the best available scientific and commercial information, the BO concludes that the Project, as presented by the California Department of Transportation, is not likely to jeopardize the continued existence of the listed species or destroy or adversely modify designated or proposed critical habitat. NMFS anticipates that the proposed project will result in the incidental take of spring-run Chinook salmon, CV steelhead, and North American green sturgeon. An incidental take statement that includes reasonable and prudent measures and non-discretionary terms and conditions that are intended to minimize the impacts of the anticipated incidental take of CV spring-run Chinook salmon, CV steelhead, and Southern DPS of North American green sturgeon is included with the BO.

Also enclosed are NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha*) as required by the Magnuson-Stevens Fishery Conservation and Management Act as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the Project will adversely affect the EFH of Pacific salmon in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the BO as the EFH conservation recommendations.

Please contact Monica Gutierrez at (916) 930-3657, or via e-mail at Monica.Gutierrez@noaa.gov, if you have any questions regarding this response or require additional information.

Sincerely,

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file – ARN# 151422SWR2009SA00078
NMFS-PRD, Long Beach, CA
Bryan Chesney, Long Beach, CA

Enclosure 1

BIOLOGICAL and CONFERENCE OPINION

ACTION AGENCY: California Department of Transportation

ACTION: Feather River Bridge Project

CONSULTATION
CONDUCTED BY: Southwest Region, National Marine Fisheries Service

FILE TRACKING NUMBER: 151422SWR200900078

DATE ISSUED: June 9, 2009

I. CONSULTATION HISTORY

The California Department of Transportation (Caltrans) is proposing to construct Segment 2 of the State Route (SR) 99 Safety and Operational Improvement Project (SR 99 SOIP) (Project) in Sutter County, California. The Feather River Bridge project has a series of three segments and Segment 2 will widen the existing roadway to the east; adding two additional lanes, a center median/turn lane and eight foot shoulders.

On September 4, 2003, Federal Highway Administration (FHWA) and Caltrans were issued a biological opinion (BO) for Segment 1of the SR 99 SOIP. Since the time of the transmitted BO in 2003, green sturgeon has been listed as threatened, critical habitat has been designated for Chinook salmon and CV steelhead, and critical habitat has been proposed for North American green sturgeon. In addition, the agencies have agreed upon an interim criteria and methods for the evaluation of the effects of underwater noise from pile driving to fish.

On November 24, 2008, Caltrans, NMFS, Department of Fish and Game (CDFG), and two representatives from Jones and Stokes, attended a site visit at the Feather River Bridge project (Project) site to discuss construction effects to listed anadromous fish.

On February 5, 2009, NMFS received a letter from Caltrans (District 3) requesting initiation of formal section 7 consultation under ESA.

On February 9, 2009, formal consultation was initiated by NMFS' Sacramento Area Office.

On March 13, 2009, Suzy Melim (Caltrans), Monica Gutierrez (NMFS), Julie Cunningham (CDFG), Gary Hobgood (CDFG), and Duane Massa (CDFG) participated in a teleconference to discuss mitigation measures for the Project description.

II. DESCRIPTION OF THE PROPOSED ACTION

A. Construction Activities

Caltrans is proposing a highway improvement project on SR 99 in Sutter County, California. The proposed Project involves widening the SR 99, which will begin 0.2 miles north of Power Line Road and ends 0.6 miles north of Sacramento Avenue. The bridge widening will be along the east side of the existing alignment. Both the new Garden Highway under crossing (UC) and new Feather River Bridge will accommodate northbound traffic while the existing Garden Highway UC and the existing Feather River Bridge will accommodate southbound traffic. Caltrans also proposes to upgrade the existing drainage facility including extension of the three cross culverts and construction of two new cross culverts and three parallel culverts to connect roadside ditches and improve flow.

The new Feather River Bridge will be parallel to the existing bridge and will extend from levee to levee like the existing bridge. The new 1,300 foot long bridge will be built across the Feather River and through the floodplain. The bridge will be supported by two abutments (Abutment 1 and 17) and a total of 15 piers (Piers 2-16) (Figure 1). Each pier will consist of two 7.5-foot diameter cast in steel shell (CISS) piles. Pier 2 is on the edge of the backwater area on the south side of the river. Pier 3 and 8 will be located in an upland area, but near enough to the river to generate pile driving sound to the water. Piers 4-7 will be located within the ordinary high water mark (OHWM) of the Feather River. Piers 9-15 will be located on the upland area between the river and Nelson Slough. Pier 16 is located on the edge of Nelson Slough. The abutments will be located on the existing levees.

The construction of the CISS piles will involve pile driving with an impact hammer, remove the dirt from within the pile, and then placing a steel structure and concrete within the pile. In addition to the permanent bridge piles, the contractor will likely drive smaller piles (20-24 inch pipe piles) within the live channel and the backwater for the temporary trestle. There will be two temporary bents between each pier to support the bridge deck during construction, 9 or 10 of the temporary bents would be in-water (depending on the presence of water in the backwater channel at the time of installation). Each temporary in-water bent would consist of 8, 24-inch diameter piles, for a total of 72 to 80 piles.

Within the live channel of the Feather River there will be four piers (2 7.5-foot diameter CISS piles each for a total of 8 CISS piles). The trestle is expected to require 52 piles (20-24 in piles) in order to span the Feather River. The temporary bents will result in an additional 72 piles (approximately 24 inch piles) driven within the active stream channel. All trestle and bent piles will be removed following construction. These construction activities will result in the removal of 0.20 acres (ac) of non-wetland riparian adjacent to the Feather River.

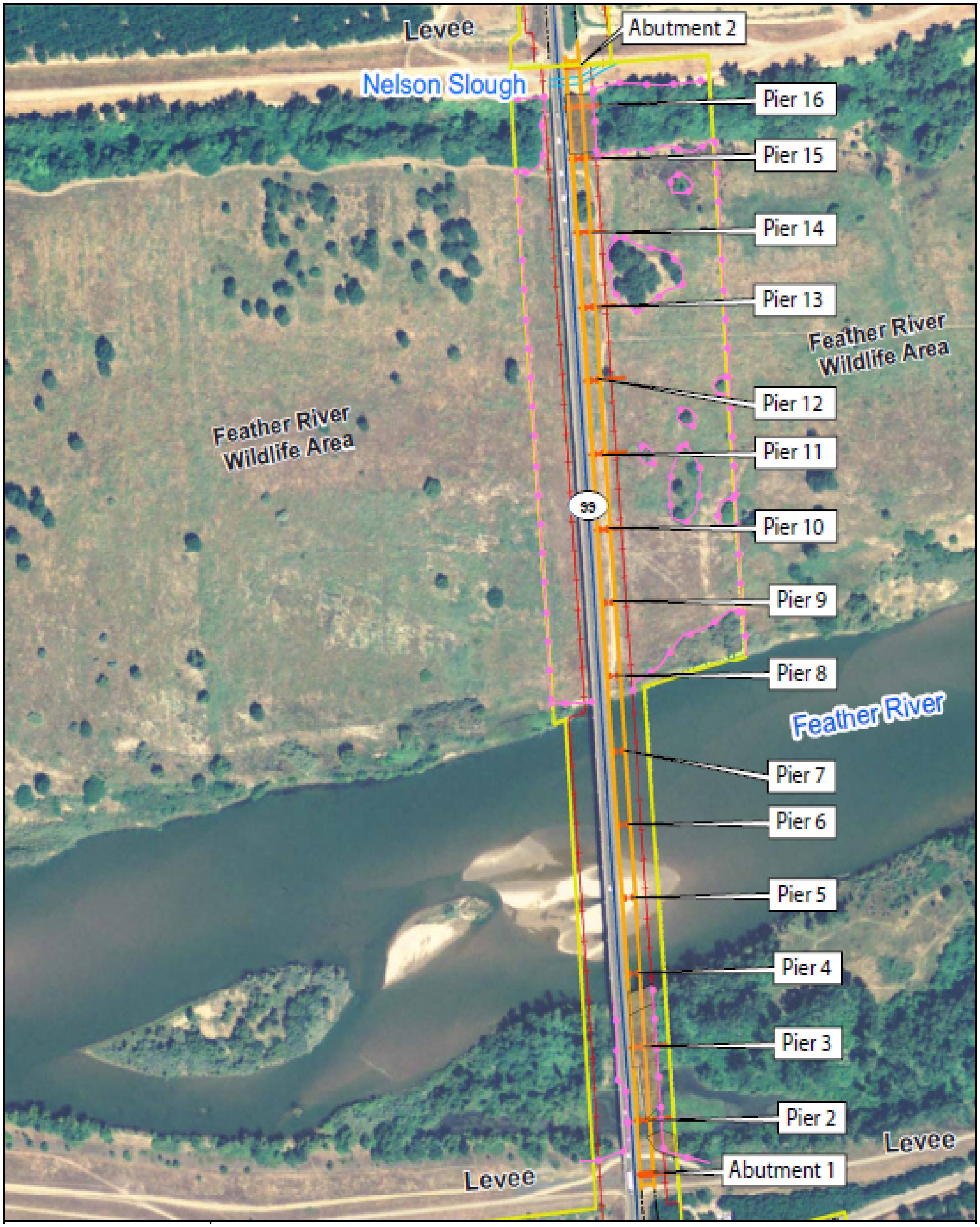

Figure 1. Location of piers and abutments across Feather River

It will take approximately two seasons of in-water work and an additional two seasons of construction for upland piers and bridge deck, for a total of four seasons of bridge work. The proposed Project is expected to begin in late summer of 2009 with the first season of in-stream work occurring in spring of 2010.

B. Action Area

Action area is defined as areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For purposes of this consultation, the action area consists of two components. The terrestrial component of the action area is defined by: 1) the project footprint, including all cleared areas, and staging areas; and 2) construction noise levels in excess of ambient conditions. The aquatic component of the action area is defined by: 1) the segment of the Feather River upstream and downstream of bridge construction sites where pile driving sound noise levels are expected to exceed ambient conditions; 2) construction-related water quality impacts in excess of ambient conditions; and 3) operational stormwater quality impacts in excess of ambient conditions. A plan view map of the project vicinity showing the action area boundary is presented in Figure 1.

The proposed Project is located on SR 99, post mile (PM) 11.1 (just south of Nicolaus Road) north to PM 14.3 (just north of Sacramento Avenue) in Sutter County, California (Figure 2). The Project site is approximately 3.2 miles long and covers 125 acres within the Environmental Study Limits (ESL). The proposed bridge will cross the Feather River near river mile (RM) 2.

The Project area has two distinct environmental settings. The first setting is where the new bridge will be located, which is within the confines of the Feather River levees. Within the levees is open space designated as part of the CDFG Feather River Wildlife Area, which is used for hunting and other recreational activities. Also within the levees are the Feather River, Nelson Slough (an overflow channel), and an adjacent backwater marsh area (located south of the river). The second environmental setting is outside the levees and consists of a variety of agricultural fields including orchards, row crops, alfalfa, and rice fields. Associated with the agricultural fields are cross drains and some ditches that convey agricultural water. There is one substantial cross ditch at Sacramento Avenue.

The topography in the project area is mainly flat, having been leveled for agriculture. Elevation ranges from 25 to 35 feet. Levees north and south of the Feather River significantly alter the natural terrain and confine both the river and Nelson Slough. The Mediterranean climate of the Central Valley is characterized by hot, dry summers, and cool, wet winters.

The landform at the project area is primarily basin floor and floodplain at a slope of 0 to 2 percent. Soils are a mixture of Columbia fine sand, Hollillipah loamy sand, Marcum clay loam, Nueva loam, and Shanghai salt loam, primarily sourced from old alluvium parent material. None of these soils are identified as hydric soils.

The action area lies in the southern-most portion of the Lower Feather River watershed. Water drains to the southwest. Natural hydrological features in the project study area consist of the

Feather River, an associated backwater marsh, and Nelson Slough (although this has been significantly altered). Manmade resources consist of irrigation canals and ditches, which originate from the various agricultural fields. Roadside ditches accumulate rainfall and highway runoff and are typically connected to the existing agricultural systems.

The action area for the Project includes the Feather River channel, extending 1500 feet upstream and 1500 feet downstream of the new bridge segment; and the Feather River floodplain (which includes the Feather River Wildlife Area and Nelson Slough), and the area immediately under the new bridge deck. This area is delineated because it represents the area within the Feather River which during high flow years; juvenile and rearing fish will use and thus could potentially be exposed to acoustic sounds of pile driving within the water column, floodplain, and slough. Nelson Slough is a densely vegetated riparian corridor at the base of the north levee and has isolated pools of standing water throughout the year. There is no standing water within the project area. However, in high flow years, juveniles are likely to rear in the Feather River Wildlife Area and Nelson Slough. Therefore, these habitats are considered designated critical habitats.

Figure 2. Project location map of Feather River Bridge project (Caltrans 2008)

C. Proposed Conservation Measures

The following conservation measures have been incorporated into the project design to avoid and/or minimize potential adverse effects of the proposed Project on special status fish species and their designated or proposed critical habitats.

1. Prior to the start of construction, the contractor shall prepare a bridge construction plan. The plan will include a schedule of work and a methodology of implementation of all avoidance and minimization measures. The plan will also outline a Plan B, which is a work stoppage plan if the acoustical monitoring results demonstrate an exceedance of the 206 decibels (dB)(peak) for pile driving of piers 3-8. The primary measure of Plan B will be to identify primary contacts at CDFG and NMFS to minimize take of listed anadromous fish species. The bridge construction plan must be approved by Caltrans, CDFG, and NMFS.

2. Pile driving for the 7.5 feet diameter CISS piles (for piers 3-8) will be limited to July 15 through October 1.

3. An attenuation casing with a confined bubble curtain will be used for all permanent in-water piles (piers 4, 5, 6, & 7).

4. An attenuation casing must be used for all in-water temporary bent piles and trestle piles (equal to or greater than 24-inch diameter) that are driven between June 15 and July 14. From July 15 to October 1, the temporary bent piles and trestle piles will not require an attenuation casing.

5. Caltrans will have in-water acoustical monitoring in place during the pile driving of the CISS piles that make up piers 3-8. If the construction activity results in an exceedance of the 206 dB(peak), the monitor will notify Caltrans and the contractor will stop driving piles at those piers and implement Plan B of the bridge construction plan.

6. Pile driving will be limited to daylight hours to avoid crepuscular and nocturnal migration periods.

7. Caltrans will minimize loss of riparian and other streamside vegetation through the use of Environmentally Sensitive Areas (ESAs) which are demarcated on the plans and marked in the field with signs and/or fencing. Willows within 50 feet of the edge of the Feather River will be trimmed to ground level. Only those that are in the foot print of a bridge pile or temporary falsework pile will be removed.

8. Prior to initiation of construction, Caltrans will prepare and have approved by NMFS and CDFG a riparian restoration plan onsite. This plan will include restoration of areas impacted by the proposed Project, as well as areas that have been disturbed from previous activities or events. Areas restored from previous activities or events will be used as compensation for the permanent loss of riparian habitat due to the new bridge.

9. River will be trimmed to ground level. Only those that are in the foot print of a bridge pile or temporary falsework pile will be removed.

10. Prior to initiation of construction, Caltrans will prepare and have approved by NMFS and CDFG a riparian restoration plan onsite. This plan will include restoration of areas impacted by the proposed Project, as well as areas that have been disturbed from previous activities or events. Areas restored from previous activities or events will be used as compensation for the permanent loss of riparian habitat due to the new bridge.

11. Any riparian vegetation removal within 250 feet of the Feather River, that cannot be restored onsite, must be mitigated offsite at a ratio of 3:1. Caltrans is proposing the Beach Lake Mitigation bank for this compensation.

12. The following are water quality measures that will be implemented during construction of the proposed project:

    - Caltrans will implement all applicable Best Management Practices (BMPs) to avoid sedimentation, spills, etc.
    - The contractor will be required to prepare a Stormwater Pollution Prevention Plan (SWPPP).
    - During construction, all equipment refueling and maintenance shall occur more than 200 feet from the main channel, except for the pile driver(s) or other stationary equipment. Any spill within the floodplain and active channel of the Feather River shall be reported to NMFS, CDFG and any other appropriate resource agencies within 48 hours.
    - The contractor shall have an absorbent boom available within 250 feet of the live channel during all in channel work and work on piers 3-8 to be readily prepared for quick containment of any unanticipated spills within or adjacent to the Feather River.
    - All measures from the 1602 Streambed Alteration Agreement, 404 and 401 water quality certifications/permits will be adhered to.
    - All vegetation will be removed outside of the migratory bird nesting period September 1 – February 15; however erosion control measures will be implemented to minimize runoff of sediment. If the vegetation cannot be removed outside of the nesting period then a pre-construction survey of the vegetation will be completed by a qualified biologist and a report sent to CDFG.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionary significant units (ESU) or distinct population segments (DPS) and designated or proposed critical habitat occur in the action area and may be affected by the proposed project:

Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
threatened (June 28, 2005, 70 FR 37160)
Central Valley spring-run Chinook salmon designated critical habitat
(September 2, 2005, 70 FR 52488)
Central Valley steelhead DPS (*Oncorhynchus mykiss*)
threatened (January 5, 2006, 71 FR 834)
Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)
Southern DPS of North American green sturgeon (*Acipenser medirostris*)
threatened (April 7, 2006, 71 FR 17757)
Southern DPS of North American green sturgeon proposed designated critical habitat (September 8, 2008, 73 FR 52084)

A. Species and Critical Habitat Listing Status

In 2005, NMFS completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (June 28, 2005, 70 FR 37160). On January 5, 2006, NMFS published a final listing determination for 10 steelhead DPSs, including Central Valley steelhead. The new listing concludes that CV steelhead will remain listed as threatened (71 FR 834).

1. <u>CV spring-run Chinook salmon</u>

NMFS listed the CV spring-run Chinook salmon ESU as threatened on September 16, 1999 (64 FR 50394). In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). This proposal was based on the recognition that although CV spring-run Chinook salmon productivity trends are positive, the ESU continues to face risks from having a limited number of remaining populations (*i.e.*, 3 existing independent populations from an estimated 17 historical populations), a limited geographic distribution, and potential hybridization with Feather River Hatchery (FRH) spring-run Chinook salmon, which until recently were not included in the ESU and are genetically divergent from other populations in Mill, Deer, and Butte Creeks. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV spring-run Chinook salmon as threatened (70 FR 37160). This decision also included the FRH spring-run Chinook salmon population as part of the CV spring-run Chinook salmon ESU. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488). Designated critical habitat includes approximately 8,935 net miles (mi) of riverine habitat and 470 mi^2 of estuarine habitat (primarily in San Francisco-San Pablo-Suisun Bays) in California

(70 FR 52488). The Feather River is designated critical habitat for CV spring-run Chinook salmon.

2. CV steelhead

CV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin river basins in California's Central Valley. In June 2004, after a complete status review of the 26 west coast salmon DPSs, NMFS proposed that CV steelhead remain listed as threatened (69 FR 33102), while the other Chinook salmon and steelhead were further reviewed. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV steelhead as threatened (70 FR 37160). This decision also included the Coleman National Fish Hatchery and FRH steelhead populations. These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the American, Feather, and Yuba Rivers, and Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta.

3. Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006, (70 FR 17386). The Southern DPS presently contains only a single spawning population in the Sacramento River, and adults and juveniles may occur within the action area. NMFS issued proposed critical habitat for the Southern DPS of North American green sturgeon on September 8, 2008 (73 FR 52084). The areas proposed as critical habitat include: coastal U.S. marine waters within 110 meters (m) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, and Yaquina Bay), and Washington (Willapa Bay and Grays Harbor).

B. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook salmon

a. General Life History

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. CV spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 to 56 degree Fahrenheit (°F) (Bell 1991; CDFG 1998). Boles *et al.* (1988) recommends water temperatures below 65 °F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 °F, and that fish can become stressed as temperatures approach 70 °F. Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 °F; although salmon can tolerate temperatures up to 65 °F before they experience an increased susceptibility to disease.

Information on the migration rates of adult Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter and Sandford 2003). Keefer and others (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter and Sanford (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while on their upstream migration (California Bay-Delta Authority (CALFED) 2001). Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins

(Stillwater Sciences 2004), particularly larger salmon such as Chinook salmon, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydro-acoustic monitoring showed peak upstream movement of adult CV spring-run Chinook salmon in lower Mill Creek, a tributary to the Sacramento River, occurring in the 4-hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. The upper preferred water temperature for spawning Chinook salmon is 55 to 57 °F (Chambers 1956; Smith 1973; Bjornn and Reiser 1991; Snider 2001).

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and other micro-crustaceans. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 mm to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others actively migrate, or are displaced downstream by the streams' current. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches along the way for a period of time ranging from weeks to a year (Healey 1991).

Rearing fry seek near shore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996a). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001).

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of maturation

(Kjelson *et al.* 1982; Brandes and McLain 2001).

Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. Martin *et al.* (2001) found that the daily migration of juveniles passing Red Bluff Diversion Dam (RBDD) is highest in the four hour period prior to sunrise. Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980; Levy and Northcote 1981).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997; Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960; Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982; Sommer *et al.* 2001; MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54 to 57 °F (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54 °F by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70 °F by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982; Levings 1982; Levings *et al.* 1986; Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to near shore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallons (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

b. CV spring-run Chinook salmon

Historically the spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 foot elevations) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874; Rutter 1904; Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers extirpated CV spring-run Chinook salmon from these watersheds. Naturally-spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Yoshiyama *et al*. 1998; Moyle 2002). Lindley *et al.* (2006) indicate adult CV spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al*. 1998). CV spring-run Chinook salmon spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult CV spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940; Fisher 1994).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and emigration timing is highly variable, as they may migrate downstream as young-of-the-year (YOY) or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al*. 2006). Studies in Butte Creek (Ward *et al*. 2002, 2003; McReynolds *et al*. 2005) found the majority of CV spring-run Chinook salmon migrants to be fry occurring primarily during December, January, and February, and that these movements appeared to be influenced by flow. Small numbers of CV spring-run Chinook salmon remained in Butte Creek to rear and migrate as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creeks juveniles typically exhibit a later YOY migration and an earlier yearling migration (Lindley *et al*. 2006).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing their yolk sac (Moyle 2002). Many will also disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper, faster water as they grow. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles are also observed between November and the end of May (Snider and Titus 2000). Based on the available information, the emigration timing of CV spring-run Chinook salmon appears highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998).

(1) Population Dynamics. The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The genetic integrity of Feather River spring-run Chinook salmon is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al*. 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 between 2002 and 2005. For the period of 2006 to 2008 the average abundance for the ESU fell to a low of 854 (CDFG 2009). Sacramento River tributary populations in Mill, Deer, and Butte creeks are probably the best trend indicators for the CV spring-run Chinook ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995 (until 2005). During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remains well below estimates of historic abundance. Additionally, in 2003 high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter Columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek. Most recently, returns on Butte , Mill, and Deer creeks have been the lowest since prior to 2000, with the 2008 estimate on Butte Creek at 3,935, 362 on Mill Creek and 140 on Deer Creek.

(2) Viable Salmonid Population Summary for Central Valley Spring-Run Chinook Salmon. The following summary has been compiled from the best available data and information on CV spring-run Chinook salmon to provide a general synopsis of the viability parameters for this ESU.

Abundance. The CV spring-run Chinook salmon ESU has experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). There has been more opportunistic utilization of migration-dependent streams overall. The FRH spring-run stock has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program.

Productivity. The 5-year geometric mean for the extant Butte, Deer, and Mill Creek spring-run populations ranges from 491 to 4,513 fish (Good *et al.* 2005), indicating increasing productivity over the short-term and projected as likely to continue (Good *et al.* 2005). The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run ESU currently is unknown.

Spatial Structure. Spring-run Chinook salmon presence has been reported more frequently in several upper Central Valley creeks, but the sustainability of these runs is unknown. Butte Creek spring-run cohorts have recently utilized all available habitat in the creek; the population cannot expand further and it is unknown if individuals have opportunistically migrated to other systems. The spatial structure of the spring-run ESU has been seriously compromised by the extirpation of all San Joaquin River basin spring-run populations.

Diversity. The CV spring-run ESU fails to meet the "representation and redundancy rule," since the Northern Sierra Nevada is the only diversity group in the spring-run ESU that contains demonstrably viable populations out of at least 3 diversity groups that historically contained them. Independent populations of spring-run only occur within the Northern Sierra Nevada diversity group. The Northwestern California diversity group contains a few ephemeral populations of spring-run that are likely dependent on the Northern Sierra Nevada populations for their continued existence. The spring-run populations that historically occurred in the Basalt and Porous Lava, and Southern Sierra Nevada, diversity groups have been extirpated. Over the long term, the three remaining independent populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run populations in the Deer, Mill and Butte Creek watersheds due to their close proximity to each other. Feather River spring-run have introgressed with the fall-run, and it appears that the Yuba River population may have been impacted by FRH fish straying into the Yuba River. Additionally, the diversity of the spring-run ESU has been further reduced with the loss of the San Joaquin River basin spring-run populations.

Butte Creek and Deer Creek spring-run are at low risk of extinction, satisfying both the population viability analysis (PVA) and other viability criteria. Mill Creek is at moderate extinction risk according to the PVA, but appear to satisfy the other viability criteria for low-risk status (Lindley *et al*. 2007). Spring-run fail the representation and redundancy rule for ESU viability, as their current distribution has been severely constricted. Therefore, spring-run are at moderate risk of extinction over an extended period of time.

2. CV steelhead

a. General Life History

Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter steelhead currently are found in California Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento River system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity river systems (McEwan and Jackson 1996).

CV steelhead generally leave the ocean from August through April (Busby *et al.* 1996) and enter freshwater from August to November and spawn from December to April in small streams and tributaries where cool, well oxygenated water is available year-round (Williams 2006; Hallock *et al.* 1961; McEwan and Jackson 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

Spawning occurs during winter and spring months. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51 °F. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating CV steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile CV steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle

2002). Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island.

(1) Population Dynamics. Historic CV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996; McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Recent estimates from trawling data in the Delta indicate that approximately 100,000 to 300,000 (mean 200,000) smolts emigrate to the ocean per year, representing approximately 3,600 female steelhead spawners in the Central Valley basin (Good *et al*. 2005). This can be compared with McEwan's (2001) estimate of one million to two million spawners before 1850, and 40,000 spawners in the 1960s.

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks and a few wild steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996). Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (Newton 2002). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, CV steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001). It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff has prepared juvenile migrant CV steelhead catch summaries on the San Joaquin River near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of CV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed.

Lindley *et al.* (2006) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

(2) Viable Salmonid Population Summary for CV Steelhead. The following summary has been compiled from the best available data and information on CV steelhead to provide a general synopsis of the viability parameters for this DPS

Abundance. All indications are that natural CV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005); the long-term trend remains negative. There has been little steelhead population monitoring despite 100 percent marking of hatchery steelhead since 1998. Hatchery production and returns are far greater than those of natural fish and include significant numbers of non-DPS-origin Eel River steelhead stock.

Productivity. An estimated 100,000 to 300,000 natural juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). Concurrently, one million in-DPS hatchery steelhead smolts and another half million out-of-DPS hatchery steelhead smolts are released annually in the Central Valley. The estimated ratio of non-clipped to clipped steelhead has decreased from 0.3 percent to less than 0.1 percent, with a net decrease to one-third of wild female spawners from 1998 to 2000 (Good *et al.* 2005).

Spatial Structure. Steelhead appear to be well-distributed where found throughout the Central Valley (Good *et al.* 2005). Until recently, there was very little documented evidence of steelhead due to the lack of monitoring efforts. Since2000, steelhead have been confirmed in the Stanislaus and Calaveras rivers.

Diversity. Analysis of natural and hatchery steelhead stocks in the Central Valley reveal genetic structure remaining in the DPS (Nielsen *et al.* 2003). There appears to be a great amount of gene flow among upper Sacramento River basin stocks, due to the post-dam, lower basin distribution of steelhead and management of stocks. Recent reductions in natural population sizes have created genetic bottlenecks in several CV steelhead stocks (Nielsen *et al.* 2003; Good *et al.* 2005). The out-of-basin steelhead stocks of the Nimbus and Mokelumne River hatcheries are not included in the CV steelhead DPS.

Lindley *et al*. (2007) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. The future of CV steelhead is uncertain due to limited data concerning their status. However, Lindley *et al.* (2007) concluded that there is sufficient evidence to suggest that the DPS is at moderate to high risk of extinction.

3. <u>Southern DPS of North American Green Sturgeon</u>

a. General Life History

North American green sturgeon are widely distributed along the Pacific Coast and have been documented offshore from Ensenada Mexico to the Bering Sea and found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002). In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath rivers in California and the Rogue River in southern Oregon.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicate differences at least between the Klamath River and San Pablo Bay samples (Adams *et al*. 2002). The Northern DPS includes all green sturgeon populations starting with the Eel River and extending northward. The southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The southern DPS of North American green sturgeon life cycle can be broken into three distinct phases based on developmental stage and habitat use: (1) year-round juveniles, (2) pre-and post-spawning adults, and (3) adult and sub-adult summer residents.

Southern DPS green sturgeon adults begin their upstream spawning migrations into the San Francisco Bay in March, reach Knights Landing during April, and spawn between March and July (Heublein *et al*. 2006). Peak spawning is believed to occur between April and June and thought to occur in deep turbulent pools (Adams *et al*. 2002). Substrate is likely large cobble but can range from clean sand to bedrock (USFWS 2002). Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. According to Heublein (2006), all adults leave the Sacramento River prior to September 1.

Adult green sturgeon in the San Francisco Estuary make significant long-distance movements with distinct directionality and are not related to salinity, current, or temperature, but resource availability (Kelley *et al*. 2007). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al*. 2002). Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al*. 2002). Holding in deep pools is a way to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the Glenn-Colusa Irrigation District (GCID) diversion (RM 205), the documented presence of adults in the Sacramento River during the spring and summer months, and the presence of larval green sturgeon in late summer in the lower Sacramento River indicating spawning ocurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Beamesderfer *et al.* 2004).

Based on the distribution of sturgeon eggs, larva, and juveniles in the Sacramento River, CDFG (2002) indicated that southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City possibly to Keswick Dam. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs each reproductive cycle, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992; Van Eenennaam *et al*. 2001).

After approximately 10 days larvae begin feeding, growing rapidly, and young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm fork length (CDFG 2002; USFWS 2002). The mean yearly total length of post-larval green sturgeon captured in rotary screw traps at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000 indicating they are approximately 2 weeks old. The mean yearly total length of post-larval green sturgeon captured in the GCID rotary screw trap, approximatley 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, unpublished data) indicating they are approximately 3 weeks old (Van Eenennaam *et al*. 2001).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other *Acipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions green sturgeon larvae cling to the bottom during the day and move into the water column at night (Van Eenennaam *et al*. 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.* (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. When ambient water temperatures reached 46 °F, downstream migrational behavior diminished and holding behavior increased. These data suggests that 9-to 10-month-old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm indicating they were from 2 to

3 years of age based on Klamath River age distribution work by Nakamoto *et al.* (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicate juvenile Southern DPS North American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al.* (2005).

(1) Population Dynamics. Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately there are many biases and errors associated with these data and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicate that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001); however, the portion of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay. Recent spawning population estimates using sibling based genetics by Israel (2006) indicate a maximum spawning population of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71). Based on the length and estimated age of post-larvae captured at RBDD (approximately two weeks of age) and GCID (downstream, approximately three weeks of age), it appears some Southern DPS North American green sturgeon are spawning above RBDD. Note, there are many assumptions with this interpretation (*i.e*., equal sampling efficiency and distribution of post-larvae across channels), and this information should be considered cautiously.

There are at least two records of confirmed adult sturgeon observation in the Feather River (Beamesderfer *et al*. 2004), however, there are no observations of juvenile or larval sturgeon even prior to the 1960s when Oroville Dam was built (NMFS 2005). There are also unconfirmed reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002).

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of CV spring-run Chinook salmon and CV steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries (Adams *et al.* 2002; Moyle 2002; Lindley *et al*. 2004).

(2) Population Viability Summary for the Southern DPS of North American Green Sturgeon. The Southern DPS of North American green sturgeon has not been analyzed to characterize the status and viability as has been done in recent efforts for Central Valley salmonid populations (Good *et al.* 2005; Lindley *et al*. 2006). However, the following summaries have been compiled from the best available data and information on North American green sturgeon to provide a general synopsis of the viability parameters for this DPS.

Abundance. Currently, there are no reliable data on population sizes, and data on population trends are also lacking. Fishery data collected at Federal and State pumping facilities in the Delta indicate a decreasing trend in abundance between 1968 and 2006 (70 FR 17386).

Productivity. There is insufficient information to evaluate the productivity of green sturgeon. However, as indicated above, there appears to be a declining trend in abundance, which indicate low to negative productivity.

Spatial Structure. Current data indicate that the Southern DPS of North American green sturgeon is comprised of a single population that spawns in the Sacramento River above and below RBDD. Although some individuals have been observed in the Feather and Yuba rivers, it is not yet known if these fish represent separate spawning populations. Therefore, the apparent presence of a single reproducing population puts the DPS at risk, due to extremely limited spatial structure.

Diversity. Green sturgeon genetic analyses shows strong differentiation between northern and southern populations, and therefore, the species was divided into Northern and Southern DPS's. However, the genetic diversity of the Southern DPS is not well understood.

The majority of the NMFS Biological Review Team (BRT) (NMFS 2005) felt that the blockage of green sturgeon spawning from what were certainly their historic spawning areas above Shasta Dam and the accompanying decrease in spawning habitat in the Feather River with the construction of Oroville Dam made the Southern green sturgeon DPS likely to become endangered in the foreseeable future throughout all of its range. Due to substantial habitat loss, and the decline in abundance observed at water pumping facilities, and the occurrence of only one breeding populations, the Southern DPS of North American green sturgeon remains at a moderate to high risk of extinction.

C. Factors Affecting the Species and Critical Habitat

Water development, water quality, over-harvesting, and disease and predation are some of the many issues affecting the decline of listed anadromous fish species in California. Hydropower, flood control, and water supply dams of the Federal Central Valley Project (CVP), State Water Project (SWP), and other municipal and private entities have permanently blocked or hindered salmonid and green sturgeon access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today.

As a result of migrational barriers, spring-run Chinook salmon, and steelhead populations have been confined to lower elevation mainstems that historically only were used for migration. Higher temperatures at these lower elevations during late-summer and fall are a major stressor to adult and juvenile salmonids. Thus, population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Green sturgeon populations were likely also affected by barriers and alterations to the natural hydrology. In particular, the RBDD blocked all access to the primary spawning habitat in the Sacramento River for many years under the old operational procedures, and continues to block a significant portion of the adult spawning run under current operationl procedures.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento and San Joaquin Rivers, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids and green sturgeon. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001).

Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects. Many of these levees use angular rock (riprap) to armor the bank from erosion. The effects of channelization, and rip-rapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of near-shore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000; Schmetterling *et al.* 2001; Garland *et al.* 2002). Simple slopes protected with rock revetment generally create near-shore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat condition typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is one of the primary causes of salmonid habitat degradation (NMFS 1996a). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and dissolved oxygen (DO) levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995). In addition, urban storm water and agricultural runoff may be contaminated with pesticides, oil, grease, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other organics and nutrients (CRWQCB 1998) that can potentially destroy aquatic life necessary for salmonid and green sturgeon survival (NMFS 1996a, b). Point source (PS) and non-point source (NPS) pollution occurs in almost every area where urbanization activity influences the watershed. Impervious surfaces (*i.e.*, concrete, asphalt, and buildings) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996a, b). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. In addition to the PS and NPS inputs from urban runoff, juvenile salmonids and green sturgeon are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

These human activities have led to increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids and green sturgeon. Most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in the sediment (Ingersoll 1995). Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids and green sturgeon. This may occur if a fish swims through a plume of the re-suspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (Environmental Protection Agency [EPA] 1994). However, the more likely route of exposure to salmonids and sturgeon is through the food chain, when fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids and green sturgeon depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids and green sturgeon to contaminated sediments is similar to water borne exposures.

Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the

Northern and Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement (adult spawner populations that have "escaped" the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

In-river recreational fisheries historically have taken CV spring-run Chinook salmon throughout the species' range. During the summer, holding adult CV spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of CV spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico Creeks and the Yuba River have been added to the existing CDFG regulations. The current regulations, including those developed for Sacramento River winter-run Chinook salmon provide some level of protection for spring-run fish (CDFG 1998).

There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally produced adult steelhead; however, the total number of CV steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al*. 2005).

Commercial harvest of white sturgeon results in the incidental bycatch of green sturgeon primarily along the Oregon and Washington coasts and within their coastal estuaries. Oregon, Washington and California have recently prohibited the retention of green sturgeon in their waters for commercial and recreational fisheries. Adams *et al.* (2002, 2007) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al.* (1991) indicated that averages of 4.7 to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appeared to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al.* (2002, 2007) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). However, recent changes to fishing regulations have made it illegal keep green sturgeon for harvest. Based on new research by Israel (2006 and past tagged fish returns reported by CDFG (2002)), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population.

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996a, 1996b, 1998). Specific diseases such as bacterial kidney disease, C*eratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996a, 1996b, 1998). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that wild fish tend to be less susceptible to pathogens than are hatchery-reared fish. Nevertheless, wild salmonids may contract diseases that are spread through the water column (*i.e.*, waterborne pathogens) as well as through interbreeding with infected hatchery fish. The stress of being released into the wild from a controlled hatchery environment frequently causes latent infections to convert into a more pathological state, and increases the potential of transmission from hatchery reared fish to wild stocks within the same waters.

Accelerated predation also may be a factor in the decline of listed salmonids and green sturgeon. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile fish and attract predators (Stevens 1961; Decato 1978; Vogel *et al.* 1988; Garcia 1989). On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion facility, areas where rock revetment has replaced natural river bank vegetation, and at South Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. The Sacramento pikeminnow is a species native to the Sacramento River basin and has co-evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g*. warm water, low-irregular flow, standing water, and water diversions) compared to its natural state and function decades ago in the pre-dam era, are more conducive to warm water species such as Sacramento pikeminnow and striped bass than to native salmonids.

For listed salmonids and green sturgeon, the construction of high dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent, or a minimum linear estimate of over 1,000 stream miles), and often resulted in precipitous declines in affected populations. For example, the completion of Friant Dam in 1947 has been linked with the extirpation of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River within just a few years. The reduced populations that remain below Central Valley dams are forced to spawn in lower elevation tailwater habitats of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is entirely dependent on managing reservoir releases to maintain cool water temperatures suitable for spawning, and/or rearing. This requirement has been difficult to achieve in all water year types and for all life stages of affected species. CV steelhead, in particular, seem to require the qualities of small tributary habitat similar to what they historically used for spawning; habitat that is largely unavailable to them under the current water management scenario. All salmonid species considered in this consultation have been adversely affected by the production of hatchery fish associated with the mitigation for the habitat lost to dam construction (*e.g.*, from genetic impacts, increased competition, exposure to novel diseases, *etc*.).

Similar to the listed salmonids, the Southern DPS of North American green sturgeon have been negatively impacted by hydroelectric and water storage operations in the Central Valley which ultimately affect the hydrology and accesibility of Central Valley rivers and streams to anadromous fish. Anthropogenic manipulations of the aquatic habitat, such as dredging, bank stabilization, and waste water discharges have also degraded the quality of the Central Valley's waterways for green sturgeon.

IV. ENVIRONMENTAL BASELINE

The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02).

A. Status of the Species and Critical Habitat within the Action Area

1. <u>Status of the Species within the Action Area</u>

The action area is located near RM 2 on the Feather River, near the confluence with the Sacramento River at RM 0. It functions primarily as a migratory corridor for adult and juvenile CV steelhead, CV spring-run Chinook salmon, and Southern DPS of North American green sturgeon. The action area also provides rearing habitat for juveniles of these species.

Following is a status summary of these species and their habitat within the Feather River and action area.

a. *CV spring-run Chinook Salmon*

The action area contains Feather River populations of CV spring-run Chinook salmon. Adults and juveniles migrate through the action area. Adults hold and spawn approximately 50 to 65 miles upstream, in the uppermost three miles of accessible habitat below the Feather River Fish Hatchery (DWR 2001). The number of naturally-spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from

2 fish in 1978 to 2,908 in 1964. Adult spring-run Chinook salmon that return to the Feather River Fish Hatchery have been counted each year since 1963, and their numbers have ranged from 146 in 1967 to 8,662 in 2003 (CDFG 2004). Coded-wire tag (CWT) information from FRH returns indicate substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon have spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock.

Based on run-time observations of spring-run Chinook salmon in the Feather River, adults are likely to be present in the action area during the upstream migration period between February and May, when they are migrating to upstream holding and spawning habitat. Results from Feather River Chinook salmon emigration studies indicate virtually all spring-run Chinook salmon juveniles in the Feather River exit as sub-yearlings (DWR 1999a, b, c). Emigration of young-of-year salmon begins immediately following emergence in late November, peaks in January or February, and continues through June (DWR 1999a, b, c). Rearing and migrating juveniles are likely to be present in the action area from January through June, with the greatest abundance of individuals in January and February.

b. *CV steelhead*

The action area is part of the designated critical habitat for CV steelhead. However, limited information exists regarding the abundance, location, and timing of steelhead spawning within the Feather River. The only available information on natural steelhead production in the action area comes from DWR redd surveys on the Feather River (DWR 2003). Based on these surveys, DWR estimated that a minimum of 163 steelhead spawned in the Feather River in 2003. Nearly half (*i.e.*, 48 percent) of all redds were located in the uppermost mile of existing anadromous habitat below the Feather River Fish Barrier Dam. The Feather River Fish Hatchery maintains records of the number of steelhead that have entered the hatchery annually since 1967. Feather River Fish Hatchery counts since 1969 ranged from a low of 78 in 1972 to a high of 2,587 in 1989, with an average of 904 adults per year (DWR 2001).

Steelhead adults migrate upstream in the Sacramento River during the period between September and March to spawn and are likely to enter into the Feather River during the same period. Chinook salmon emigration studies in the Feather River from 1995 through 1998 have incidentally captured steelhead young-of-year and yearlings. Young-of-year were captured from March through June, while yearlings were captured January through June. Steelhead were not captured during the early migration period, from October and December, but DWR researchers speculated that this may have occurred because the sampling gear may not be able to detect their presence during this time (DWR 1999a, b, c). Based on these results and steelhead emigration patterns in the Sacramento River, steelhead juveniles and smolts are expected to use the action area from December through June, with peak use from January through March.

c. *North American green sturgeon*

Proposed critical habitat for green sturgeon occurs within the proposed project's action area. Green sturgeon adults have been observed periodically in small numbers in the Feather River (Beamesderfer *et al.* 2004). There are at least two confirmed records of adult green sturgeon. There are no records of larval or juvenile sturgeon of either species, even prior to the 1960's when Oroville Dam was built. There are reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002), although no indication of spawning has been documented despite intensive sampling efforts (Niggemeyer and Duster 2003). Overall, it appears that green sturgeon use the Feather River almost exclusively in high flow years because of natural and man-made barriers, such as the bench at Shanghai Bend, that are harder to pass during drier years. Historical use of the Feather River (before construction of Oroville Dam) is unknown, but highly likely. CDFG suggests that Oroville Dam blocks access to potential spawning habitat and that Thermalito Afterbay warm water releases may increase temperatures to levels that are undesirable for spawning and incubation. Sturgeon (including some documented green sturgeon), still regularly occur in the Bear and Yuba rivers (CDFG 2002b; Beamesderfer *et al.* 2004) and therefore must migrate through the Feather River.

2. <u>Status of Critical Habitat within the Action Area</u>

The action area (*i.e*., lower Feather River) provides migration and rearing habitat for CV spring-run Chinook salmon, CV steelhead, and green sturgeon. The action area is designated critical habitat for CV spring-run Chinook salmon and CV steelhead, and proposed critical habitat for green sturgeon. Habitat requirements for these species are similar. The essential features of freshwater salmonid and green sturgeon habitat within the action include adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions.

Water temperatures in the action area generally are most favorable for anadromous fish during the winter and spring months and may be warmer than desired conditions from late spring through early fall. High temperatures primarily are caused by ambient air temperatures, but also are affected by the lack of riparian shading, and by thermal inputs from agricultural outfall water. Habitat within the action area primarily is used as juvenile rearing habitat and as a migration corridor by adults and juveniles. The condition and function of this habitat has been severely impaired through several factors discussed in the *Status of the Species and Habitat* section of this biological and conference opinion. The result has been the reduction in quantity and quality of several essential elements of rearing habitat required by juveniles to grow and survive. In spite of the degraded condition of this habitat, the conservation value of the action area is high because it is used by a large number of naturally-produced anadromous fish from the upper Feather River.

B. Factors Affecting the Species and Critical Habitat in the Action Area

The magnitude and duration of peak flows in the Feather River during the winter and spring are reduced by water impoundment in upstream reservoirs. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks. Consequently, flow in the Feather River often remains too low during the winter to provide quality rearing habitat.

High water temperatures limit habitat availability for listed salmonids in the lower Feather River (Boles *et al.* 1988). High summer water temperatures in the lower Feather River and Sutter Bypass can exceed 72 ° F. Such temperatures can create a thermal barrier to the migration of adult and juvenile salmonids (Kjelson *et al.* 1982; Rich 1997). Water diversions, for agricultural and municipal purposes are found throughout the action area and entrain and kill juvenile and salmon and steelhead during emigration periods during fall, winter, and spring months.

C. Likelihood of Species Persistence in the Action Area

Despite the impaired genetic status of the Feather River population, and the substantial reduction in habitat availability and suitability since the construction of the Oroville Facilities, the value of the lower Feather River basin as a migratory corridor for CV spring-run Chinook salmon, CV steelhead, and green sturgeon is high primarily because it contains habitat elements that support the rearing and growth of juveniles and the successful upstream migration of adults.

V. EFFECTS OF THE ACTION

Pursuant to Section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion assesses the effects of the Feather River Bridge project on CV spring-run Chinook salmon, CV steelhead, their designated critical habitats, the Southern DPS of North America green sturgeon, and their proposed critical habitats. The proposed Project is likely to adversely affect listed species and critical habitat through vibration of the piles for the permanent piles of the new bridge and temporary trestle. In the *Description of the Proposed Action* section of this Opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this biological and conference opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require NMFS to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the

Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of both surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA also requires NMFS to determine if Federal actions would appreciably diminish the value of critical habitat for the conservation of listed species (16 U.S.C. §1536). This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

A. Approach to the Assessment

NMFS generally approaches "jeopardy" analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed actions (these effects include direct impacts to a species habitat; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or disruptive noises). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' likelihood and extent of exposure to any adverse effects caused by the action (*i.e.* the extent of spatial and temporal overlap between the species and the effects of the action). Once NMFS has identified the level of exposure that a species will have to the effects of the action, the available evidence is evaluated to identify the species' probable response, including physical and behavioral reactions, to these effects. These responses then will be assessed to determine if they can reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

1. <u>Information Available for the Assessment</u>

To conduct the assessment, NMFS examined an extensive amount of evidence from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, previous biological opinions, documents evaluating the effects of underwater noise from pile driving, the biological assessment for this project, and project meeting notes. Additional information investigating the effects of the project's actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was obtained from the aforementioned resources. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

The potential adverse effects to listed species resulting from the proposed construction of the Feather River Bridge and the implementation of the mitigation features are primarily associated with elevated underwater sound pressure levels generated during pile driving. However, other potential impacts to listed salmonids and green sturgeon and designated or proposed critical habitat include turbidity resulting from ground disturbance for areas associated with bridge construction and mitigation.

The information used in this assessment includes *Status of the Species* and *Environmental Baseline* sections of this biological opinion, studies and accounts of the impacts of construction and pile driving activities on anadromous fish.

B. Assessment

The proposed Project includes actions that may adversely affect several life stages of listed fish species. Adverse effects to these species and their habitat may result from changes in water quality from construction activities, loss of riparian vegetation from construction activities, and physical injury and harassment of juveniles and adults from exposure to elevated levels of underwater sound produced during pile driving. The project includes integrated design features to avoid and minimize many of these potential impacts.

As described in the environmental baseline, adult CV steelhead enter freshwater to spawn between August to January with a peak migration period of September-October (Moyle 2002). The steelhead migration period overlaps the pile driving in-water work window (June 15-October 15). Adult green sturgeon upstream migration occurs from March through July (Moyle *et al.* 1995). However, their only known spawning habitat is in the Sacramento River, so adults are unlikely to migrate through the action area, and thus are unlikely to be exposed to the effects of the in-water work activities. There is still very little known about the downstream movements of North American green sturgeon after they have completed their spawning run, and there is a possibility that these fish may occur within the action area and be exposed to the effects of the in-water work activities. CV spring-run enter the Feather River from March through June and spawn the following autumn (Painter *et al*. 1977). Juvenile salmonids emigrate as fry, which suggests that rearing habitat in the action area is limiting or that conditions later in the season (such as the in-water work season) are less suitable (Sommer *et al*. 2001).

1. Pile Driving and Bridge Construction

The installation of steel piles with an impact hammer in the Feather River is expected to result in adverse effects to exposed fish due to high levels of underwater sound that will be produced. Adverse effects can range from physical injury to the exposed fish, sometimes resulting in death, to lesser impacts, such as behavioral modifications or increased susceptibility to predation, which do not necessarily result in death or long term adverse impacts by themselves. The degree to which an individual fish exposed to underwater sound will respond (from a startle response to immediate mortality) is dependent on a number of variables such as the species of fish, size of the fish, presence of a swimbladder, sound pressure intensity and frequency, shape of the sound wave (rise time), depth of the water around the pile and the bottom substrate composition and texture. Swimbladders, which are inflated with gas, can expand rapidly as the pressure waves pass through the fish and can press against, and strain, adjacent organs, such as the liver and kidney (Keevin and Hempen 1997). In addition, this pneumatic compression causes demonstrable injury, in the form of ruptured capillaries, internal bleeding, and maceration of highly vascular organs (Caltrans 2002). Hastings and Popper (2005) also noted that sound waves can cause different types of tissues to vibrate at different frequencies, and that this differential vibration can cause tearing of mesenteries and other sensitive connective tissues. Exposure to high noise levels can also lead to injury through "rectified diffusion," the formation and growth of bubbles in tissues. These bubbles can cause inflammation, cellular damage, and blockage or rupture of capillaries, arteries, and veins (Crum and Mao 1996; Stroetz *et al.* 2001; Vlahakis and Hubmayr 2000). Death from barotrauma and rectified diffusion injuries can be instantaneous, or delayed for minutes, hours or even days after exposure.

NMFS is uses a single strike peak sound pressure level (SPL) of 206 dB and an accumulated sound exposure level (SEL) of 187 dB to correlate underwater sound with potential injury to fish. These are the thresholds that indicate the onset of physical injury. The SPL is an expression of the sound pressure using the decibel scale and the standard reference pressures of micro-Pascal (1 μPa) for water and biological tissues. SEL is the exposure of fish to a total amount of energy (*i.e.*, dose) that can be used to determine a physical injury response. In other words, it is the time-integrated, sound-pressure-squared level. Because sound is a form of energy, the damage potential of a given sound environment will depend not only on its level, but also its duration. The root-mean-square (RMS) is 150 dB for a behavioral response in a fish. The level is determined by analyzing the waveform and computing the square root of the average of the squared pressures over the time period that comprises that portion of the waveform containing 90% of the sound (pressure squared) energy (Hastings and Popper 2005). This calculated RMS SPL is described as "RMS (impulse)" and is used to report an overall average SPL for a single pile driving pulse (Hastings and Popper 2005). Because all SEL measurements are normalized to a one second time interval, it may be used to compare the energy content of different exposures to sound. SEL is calculated by summing the cumulative pressure squared (*p*2) over time and is often used as an indication of the energy dose. The following table summarizes the criteria for injury to fish from underwater sound generated 10 meters (source level) from the pile driving (Table 1).

Interim Criteria for Injury	Interim Criteria in Decibels (dB)	Fish Response
Peak	206 dB	physical injury
Cumulative SEL	187 dB (for fish 2 grams or larger); 183 dB (for fish less than 2 grams)	physical injury
Root Mean Square (RMS)	150 dB	behavioral response

Table 1. Summary of interim criteria for injury to fish assuming a distance of 10 meters (source level from the driven pile).

The proposed project includes installation of up to 80 piles (all in the action area) including, 72, 20-24 inch diameter pipe piles for the temporary work trestle and 8, 7.5 foot diameter CISS piles for the permanent bridge. To reduce the likelihood of exposure to underwater noise levels, trestle and temporary bent pile installation will not begin until June 15, while installation of the CISS piles are limited from July 15 through October 1. An attenuation casing will be used for the in-water piles that will be driven from June 15 through July 14. This attenuation casing will reduce 5 dB from the source level. This timing window allows in-water work to occur when the numbers of listed fish in the action area are at their lowest, and the life stages of listed fish are less vulnerable *(i.e.* larger and able to avoid the action area) to the potential effects.

The noise assessment prepared by Caltrans in the BA, breaks down the impacts from driving the permanent and temporary impacts. Peak sound levels would not exceed the interim criteria of 206 dB, however the accumulated SEL criteria of 187 dB would be exceeded at various distances (depending the pile type) on 33 days during each in-water construction year. The highest peak sound levels estimated would be 205 db(peak), and would occur only when the fourth and fifth section of the in-water 7.5-foot diameter piles for piers 4, 5, 6, and 7 are driven (a total of 4 days per year). All other pile driving events would be 200 dB(peak) or less for the 7.5-foot diameter piles, or less than 193 db(peak) for the 2-foot diameter temporary trestle and bents piles. On 19 days each year that temporary piles (bent and trestle piles) are driven, the SEL would be exceeded out are relatively short distance of 197 feet up and downstream of the piles. On the 10 days when the larger, in-water pier pile sections are driven, it is estimated that the SEL would be exceeded out to 787 feet on 6 days and 1,640 feet on 4 days. For the 5 days of driving pile sections for piers 3 or 8 (the two piers close to shore), the SEL exceedance distance is intermediate, ranging from 164 feet to 722 feet.

The activities related to pile driving are temporary and will only last the duration of the in-water work activities. Sublethal and/or subinjurious effects to juvenile CV spring-run Chinook, CV steelhead, and green sturgeon, including altered behavior, auditory masking, and temporary hearing threshold shifts can affect vulnerability to predation, foraging success, and other factors that influence survival and fitness. Impact pile driving will take place during each in-water work window during the bridge construction period (*i.e.*, concurrently with pile driving during temporary trestle installation and during removal of the temporary piles as elements of bridge construction and demolition are completed). Because daily pile driving activities will be separated by overnight rest periods when migration can proceed uninhibited, upstream migration of listed fish are not expected to be significantly delayed. More extreme effects, including injury and mortality of migrating adults, could potentially occur during limited unattenuated pile driving. These effects will be limited to isolated, individual events at the beginning of project. Because the criteria to be exceeded within these relatively small areas, the actual potential for listed fish to be exposed to an accumulated 187 dB SEL is relatively low. The in-water construction window occurs after the downstream migration period for salmonids and very few juveniles would be expected to occupy this reach of the river due to warm water temperatures (60 to 75°F between June and October). The populations of these fish in the Feather River represent a small number of the entire population in the Central Valley, and the action is expected to have little impact upon the entire ESU and DPS. There is potential for adult CV spring-run Chinook, CV steelhead, and green sturgeon to be adversely effected from pile driving activities, however, it is expected to be relatively low due to their larger bodies. In addition, pile driving activities would only occur in the daytime which will avoid corpuscular and nocturnal periods when salmonid migrations are more common.

2. <u>Water Quality</u>

NMFS anticipates that some local increases in turbidity will result as a consequence of these actions. The increases in local turbidity levels are associated with the re-suspension of bottom sediments during the piling removal and installation phase of the construction process. The proposed in-water construction activities are not expected to lead to significant impacts to water quality in the action area. There are expected to be minor, short term increases in turbidity and sedimentation in localized areas due to the driving and removal of temporary piles. The expected increases in turbidity and suspended sediment may disrupt feeding and migratory behavior of listed fish over a small area for a short period of time. The turbidity associated with installation and removal of piles could result in localized displacement and likely behavioral modifications to individual salmonids and green sturgeon if they do not readily move away from the areas directly affected by the project. Turbidity and sedimentation events are not expected to affect feeding success of green sturgeon as they are not known to rely heavily on visual cues for feeding (Sillman *et al.* 2005). These temporary behavioral changes are not expected to result in injury or death of listed salmonids and green sturgeon. NMFS does not anticipate that turbidity levels associated with the pile driving will increase to deleterious levels. Furthermore, turbidity conditions are expected to return to ambient levels within hours to days of the termination of pile driving actions. Moreover, based on the timing of the pile driving actions, NMFS does not expect listed salmonids to be adversely effected by sedimentation and turbidity in the Feather

River. Green sturgeon, which can occupy waters containing variable levels of suspended sediment and thus turbidity, are not expected to be impacted by the slight increase in the turbidity levels anticipated from the pile driving action as explained above. In addition, green sturgeon presence in the Feather River is expected to be very low during the construction period, thus representing a very small fraction of the entire green sturgeon population in the Central Valley.

Unanticipated spills into the Feather River, such as toxic substances used at construction sites (gasoline and lubricants) can lead to adverse effects and mortality in juvenile and adult salmonids and green sturgeon. If these toxins seep into the water, these substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. However, NMFS expects that Caltrans will adhere to the standard BMP's and SWPPP during construction activities to prevent these kinds of effects on listed salmonids and green sturgeon. Therefore, NMFS does not expect the Project will result in water contamination that will injure or kill listed anadromous fish.

1. <u>Effects on Designated or Proposed Critical Habitat Primary Constituent Elements (PCEs)</u>

The basic premise to the conservation value of an overall critical habitat designation is the sum of the values of the components that comprise the habitat. For example, the conservation value of listed salmonid critical habitat is determined by the conservation value of the watersheds that make up the designated area. In turn, the conservation value of the components is the sum of the value of the PCEs that make up the area. PCEs are specific areas or functions, such as spawning or rearing habitat, that support different life history stages or requirements of the species. The conservation value of the PCE is the sum of the quantity, quality, and availability of the essential features of that PCE. Essential features are the specific processes, variables or elements that comprise a PCE. Thus, an example of a PCE would be spawning habitat and the essential features of that PCE are conditions such as clean spawning gravels, appropriate timing and duration of certain water temperatures, and water quality free of pollutants.

Therefore, reductions in the quantity, quality, or availability of one or more essential feature reduce the value of the PCE, which in turn reduces the function of the sub-area (*e.g.*, watersheds), which in turn reduces the function of the overall designation. In the strictest interpretation, reductions to any one essential feature or PCE would equate to a reduction in the value of the whole. However there are other considerations. We look to various factors to determine if the reduction in the value of an essential feature or PCE would affect higher levels of organization. For example:

- The timing, duration and magnitude of the reduction
- The permanent or temporary nature of the reduction
- Whether the essential feature or PCE is limiting (in the action area or across the

designation) to the recovery of the species or supports a critical life stage in the recovery needs of the species (for example, juvenile survival is a limiting factor in recovery of the species and the habitat element supports juvenile survival).

In our assessment, we combine information about the contribution of constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the conservation value of those areas of designated critical habitat that occur in the action area as our point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment of the consequences of the added effects of the proposed action on that conservation value.

a. Freshwater Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult salmonids and green sturgeon to migrate to and from spawning habitats, and for larval and juveniles to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. The addition of segment 2 of the Feather River Bridge will be a permanent structure, however, this segment of the bridge will not obstruct the migratory pathway for exposed fish. Fish that use the action area as a migratory corridor will be able to continue using the channel during and after construction of the proposed action.

b. Freshwater Riparian and Rearing Habitat

The southern bank of the Feather River is a densely vegetated habitat and dominated by floating primrose willow (*Ludwigia peploides*). The northern bank has a thin riparian zone of willows where Nelson Slough is located. These areas exist because the river is confined between two levees and is a perennial wetland because the flow of the river is managed by a water agency, thus, water levels often rise late in the summer. The dominant species are cottonwoods, valley oak, and box elder. The soils exhibit wetland characteristics and wetland hydrology.

Freshwater riparian habitats support juvenile growth and mobility. In addition, riparian vegetation support food communities for juveniles. Freshwater riparian habitat provide natural cover, such as shade, submerged and overhanging large wood, and aquatic vegetation to support refuge for juveniles from predators. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids. Freshwater rearing habitats have a high intrinsic value to salmonids, as the juvenile life stages are dependant on the function of this habitat for successful survival and recruitment. Green sturgeon on the other hand rely less on riparian habitat and more on the condition of the benthos which will not be affected.

Caltrans proposes to remove 0.20 acres of riparian vegetation adjacent to the Feather River. Impacts to the riparian habitat will be temporary due to, Caltrans minimization measures and implementation of a revegetation plan. The revegetation plan will restore and revegetate areas adjacent to the Feather River and Nelson Slough impacted by construction activities and to replace riparian trees removed by construction activities.

Though it may take 10 years to restore the full function of this component of salmonid and green sturgeon habitat where vegetation clearing will occur, the proposed restoration of riparian habitat following construction of the new bridge should, over time, be restored to its original state. During the period of riparian vegetation re-growth, rearing salmonid and green sturgeon juveniles will have less cover, thus, making migrating fish moving through the area be more susceptible to predation in high flow years. Caltrans has incorporated measures in the project description to keep the removal of riparian vegetation to a bare minimum.

The general planting strategy will be to use willow cuttings wherever appropriate soil and moisture conditions are present within impacted areas. This will be particularly focused on the banks of the Feather River. Cuttings will be taken from no more than 50% of the willow plants in an area and from no more than 30% of an individual plant. The palustrine riparian area between the backwater and the Feather River as well as the upland area within 100 feet of Nelson Slough will be planted with container material of valley oak, box elder, Oregon ash, and cottonwood. Under the bridge and interspersed within the large species will be medium sized shrubs. Mixed in the large and medium and spread out under the new bridge will be smaller plants. Following planting and revegetation, Caltrans will provide irrigation and monitoring.

c. Summary of PCEs in the Action Area

The PCEs of critical habitat that will be adversely affected include freshwater rearing sites for juveniles and freshwater migration corridors for both juveniles and adults. Up to 0.20 acres of riparian vegetation would be removed as a result of construction activities. The majority of these impacts are expected to be temporary due to the fact that all disturbed areas outside the actual footprint of the new bridge would be restored to their preconstruction conditions and any impacted riparian vegetation would be replaced with the planting of an appropriate assemblage of native riparian vegetation. These effects to the PCEs of critical habitat may result in a temporary redistribution of some individual fish, primarily rearing juvenile steelhead; however, due to the temporary nature of these effects. The freshwater migratory corridor will have little impact to the exposed fish. The temporary trestle piles will be removed upon completion of the proposed action and the permanent bridge piles will be aligned with the existing piers of the existing bridge. Therefore, NMFS expects that nearly all of the adverse effects to critical habitat from this project will be of a short-term nature and will not affect future generations of listed fish beyond the construction period of the project.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

The Project will construct a new bridge adjacent to the existing bridge. Land surrounding the Caltrans proposed project has two distinct settings. The first setting is where the new bridge will be located, which is within the confines of the Feather River levees. Within the levees is open space designated as part of the Department of Fish and Games Feather River Wildlife area, which is used for hunting and other recreational activities. Also within the levees are the Feather River, Nelson Slough (an overflow channel) and an adjacent backwater marsh area (located south of the river). The second environmental setting is outside of the levees and consists of a variety of agricultural fields including orchards, row crops, alfalfa, and rice fields. Associated with the agricultural fields are cross drains and some ditches that convey agricultural water.

Non-Federal actions that may affect the action area include ongoing agricultural activities and recreational activities. Agricultural practices in and upstream of the Feather River may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Feather River. Unscreened agricultural diversions throughout the channel entrain fish including juvenile salmonids and green sturgeon. Stormwater and irrigation discharges related to agricultural activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003). Recreational activities can potentially disturb the current riparian vegetation and/or listed fish in the active channel.

Global climate change is a broad-scale cumulative effect that is likely to affect the action area. The world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change (IPCC) 2001). Much of that increase will likely occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding and permanent inundation of low-lying natural ecosystems within the action area (*i.e.*, salt marsh, riverine, mud flats) affecting critical habitat primary constituent elements (PCEs).

Increased winter precipitation, decreased snow pack, and permafrost degradation could affect the flow and temperature of rivers and streams, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Pacific coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global climate change may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to over take native fish species and impact predator-prey relationships (Peterson and Kitchell 2001; Stachowicz *et al.* 2002).

An alarming prediction is that Sierra snow packs are expected to decrease with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains (CDWR 2006). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold-water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Shasta Lake and Lake Oroville, potentially could rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Central Valley steelhead) that must hold below the dam over the summer and fall periods.

Anticipated climate change may affect spatial and temporal precipitation patterns along with the intensity and duration of precipitation within the Feather River watershed. Ambient air temperatures in California are projected to increase several degrees centigrade (^{o}C) by the end of this century. As a result, it is possible that less precipitation will occur as snowfall and more will occur as rain in future years. The effect of climate change is anticipated to be more winter and less spring and summer run-off within the watershed. In addition, expected run-off is anticipated to be warmer, possibly affecting the ability to meet downstream water temperature objectives to protect salmon, steelhead and green sturgeon. A reduction in snowpack combined with increased ambient air temperatures is expected to result in earlier melting of snow and less run-off from the snowpack than that which occurs today. This combined with more precipitation as rain will affect future operations of all reservoirs within the Feather River Basin. A change in the run-off pattern within the Feather River watershed will likely affect reservoir storage and downstream river flows due to more frequent spillway releases. Currently, summer water temperatures often are close to the upper tolerance limits for salmon and steelhead and any increase in ambient air temperatures as a result of climate change is anticipated to make it more difficult at the very least, if not impossible, to meet established water temperature objectives on the lower Feather River. Reduced reservoir storage as a result of the anticipated change in run-off pattern may also affect the availability of a cold water supply necessary to maintain river temperatures downstream.

There are no specific plans for development within the action area of the proposed project. Therefore, further cumulative effects beyond those described above are not expected.

VII. INTEGRATION AND SYNTHESIS

This section integrates and adds the current conditions described in the status of the species and the environmental baseline for the action area with the effects of the proposed action and the cumulative effects of future actions. The purpose of this synthesis is to review the effects of the action in addition to the environmental baseline to understand how the action will affect the likelihood of the species' continued survival.

A. Summary of Status of the Species and Environmental Baseline

1. <u>CV spring-run Chinook salmon</u>

Historically, the majority of spring-run in the Central Valley were produced in the Southern Sierra Nevada Diversity Group, which contains the San Joaquin River and its tributaries. All spring-run populations in this diversity group have been extirpated (Lindley *et al*. 2007).

Lindley *et al*. (2007) determined that perhaps 15 of the 19 historical populations of spring-run are extinct, with their entire historical spawning habitats behind various impassable dams. Those authors only considered Butte, Deer, and Mill Creeks as watersheds with persistent populations of Chinook salmon known as spring-run, although they recognized that phenotypic Chinook salmon persist within the Feather River Hatchery population spawning in the Feather River below Oroville Dam and in the Yuba River below Englebright Dam. All of those population fall within the Northern Sierra Nevada diversity group. Butte and Deer creek spring-run populations are at low risk of extinction, and the Mill Creek population is at either a moderate or low risk (Lindley *et al*. 2007).

Viable CV spring-run Chinook salmon populations occur in only one of four diversity groups that historically contained them, and therefore fail the representation and redundancy rule for ESU viability (Lindley *et al.* 2007) Because the CV spring-run Chinook salmon ESU is spatially confined to relatively few remaining streams, continues to display broad fluctuations in abundance, and a large proportion of the population (*i.e.*, in Butte Creek) faces the risk of high mortality rates, the ESU remains at a moderate to high risk of extinction.

Past and present impacts within the Sacramento River basin have caused significant loss of habitat. Populations have declined drastically over the last century, and some subpopulations have been extirpated. The construction of dams has limited access to a large and significant portion of historical spawning and rearing. Dam operations have changed downstream flow patterns, effecting stream dynamics (*i.e.* geomorphology, habitat configuration, *etc*.), and affected available habitat through changes in water temperature characteristics, limiting gravel recruitment to available spawning reaches and limiting the introduction of LWM which contributes to habitat diversity.

Despite the impaired genetic status of the Feather River population, and the substantial reduction in habitat availability and suitability since the construction of the Oroville Facilities, the value of the lower Feather River basin as a migratory corridor, its location as the southern-most extant population of spring-run Chinook salmon, and its suitability as spawning and rearing habitat make it an important node of habitat for the survival and recovery of the species.

2. CV steelhead

CV steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). Lindley *et al*. (2006) estimated that historically there were at least 81 indpendant CV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin Rivers. This distribution has been greatly affected by dams (McEwan and Jackson 1996). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (Newton 2002). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Spatial structure for steelhead is fragmented and reduced by elimination or significant reduction of the major core populations (*i.e*. Sacramento River, Feather River, American River) that provided a source for the numerous smaller tributary and intermittent stream populations like Dry Creek, Auburn Ravine, Yuba River, Deer Creek, Mill Creek, and Antelope Creek. Tributary populations can likely never achieve the size and variability of the core populations in the long-term, generally due to the size and available resources of the tributaries.

Lindley *et al*. (2007) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. The future of CV steelhead is uncertain due to limited data concerning their status. However, Lindley *et al.* (2007) concluded that there is sufficient evidence to suggest that the DPS is at moderate to high risk of extinction.

Despite the substantial reduction in habitat availability and suitability since the construction of the Oroville Facilities, the value of the lower Feather River basin as a migratory corridor, and the presence of spawning and rearing habitat make it an important node of habitat for the survival and recovery of the species.

3. <u>Southern DPS of North American Green Sturgeon</u>

Currently, there are no reliable data on population size of the Southern DPS of green sturgeon, however, it is clear that the amount and quality of accessible habitat for this species has been greatly reduced and abundance of the Southern DPS of green sturgeon is declining. There is insufficient information to evaluate the productivity of green sturgeon. However, as indicated above, there appears to be a declining trend in abundance, which indicates low to negative productivity. Known historic and current spawning occurs in the Sacramento River, but the presence of adult fish in the Feather River suggests that an additional population may exist. Green sturgeon genetic analyses shows strong differentiation between northern and southern populations, and therefore, the species was divided into a Northern and Southern DPS. However, the genetic diversity of the Southern DPS is not well understood.

The principal threat to green sturgeon in the Southern DPS is the reduction of available spawning habitat due to the construction of barriers on Central Valley rivers. Other threats are insufficient flow rates, increased water temperatures, water diversion, non-native species, poaching, pesticide and heavy metal contamination, and harvest (NMFS 2005; 71 FR 17757).

The majority of the NMFS BRT (NMFS 2005) felt that the blockage of green sturgeon spawning from what were certainly their historic spawning areas above Shasta Dam and the accompanying decrease in spawning habitat in the Feather River with the construction of Oroville Dam made the Southern green sturgeon DPS likely to become endangered in the foreseeable future throughout all of its range. Due to substantial habitat loss, and the decline in abundance observed at water pumping facilities, and the occurrence of only one breeding populations, the Southern DPS of North American green sturgeon remains at a moderate to high risk of extinction.

Despite the overall effects of adult and juvenile green sturgeon in the Feather River over the period of two in-water work seasons due to pile driving activities is not expected to reduce the viability of the overall North American green sturgeon southern DPS. The value of the lower Feather River basin as a migratory corridor, and the presence of spawning and rearing habitat is high value because although few fish have been observed, the Feather River has the potential to support a second spawning population in the DPS, thus making it an important node of habitat for the survival and recovery of green sturgeon.

B. Summary of the Effects of the Proposed Action on Listed Species Likelihood of Survival and Recovery

Under the proposed Feather River Bridge project, adverse impacts to listed species stemming from increased sedimentation and acoustic impacts from pile driving are expected to occur. Even though these impacts may cause physiological stress to the extent that the normal behavior patterns (*e.g.*, feeding, sheltering and migration) of affected individuals may be disrupted, due to the timing of pile driving activities, the overall changes in turbidity and suspended sediment associated with this project are not expected to adversely affect listed species. These impacts are primarily low-level, short-term alteration of habitat conditions. The potential for the increase in suspended sediment to adversely affect adult green sturgeon is unclear. However, because sturgeon are demersal fish closely associated with the bottom substrate, feed by taste and feel with their barbels, and shovel up sediment with their snouts when searching for food, it is expected that they would be unaffected by the levels and duration of turbidity expected to be produced by the proposed project. In addition, green sturgeon presence in the Feather River is expected to be very low. Potential impacts are expected to be minimized by meeting California Central Valley Regional Water Quality Control Board (CVRWQCB) water quality objectives, Caltrans water pollution specifications, implementing BMPs for erosion control, staging equipment outside of the riparian corridor, limiting the amount of riparian vegetation removal, and restoring disturbed riparian habitat values at the project site.

Pile driving activities are scheduled to occur June 15-October 1. Elevated levels of underwater sound around the pile driving activities may cause temporary behavioral changes, loss or reduction of hearing in affected fish, and/or mortality to listed fish. These impacts will be substantially minimized by the pile driving work window restrictions (which correlates with the expected elevated water temperatures of 65-75 °F) and by using an attenuation casing for impact hammer-driven temporary piles 24-inches or greater in diameter during the period of June 15-July 14. Loss of hearing sensitivities in juvenile fish will expose them to higher risks of predation. Fish with impacted hearing capacities will have a lower ability to detect predators and may be unable to maintain position in the water column (inner ear equilibrium factors). NMFS believes that this limited exposure to underwater sound levels that would cause behavioral effects, injury, and/or mortality is unlikely to significantly affect growth or survival of exposed adult and juvenile salmonids and green sturgeon. Construction lapses, including daily breaks and nighttime non-working periods, as well as long periods when no pile driving is scheduled to occur, will allow fish to migrate through the action area and minimize the extent of impacts to survival and recovery of salmonid and green sturgeon populations. In addition, a low proportion of the population of fish in the Feather River will be exposed to the pile driving activities.

1. CV spring-run Chinook salmon

The new Feather River Bridge will be a permanent structure. However, this will not impede listed anadromous fish, such as spring-run to rear and/or migrate up and down the Feather River channel. The construction of the new Feather River Bridge is temporary and the pile driving effects on fish will only last as long as the duration of three summer seasons. In addition, summer temperatures will likely keep juveniles from entering the action area. Therefore, adverse effects to spring-run Chinook salmon are expected to occur only during the seasonal in-water work window. These adverse effects will affect a very small proportion of the standing population and would not appreciably reduce the likelihood of survival and recovery of the CV spring-run Chinook salmon. Injury to Chinook salmon will be at a peak sound level of 206 dB, 10 meters from the pile driving, between June15 and October 1. Mortality is expected if sound levels reach above cumulative SEL 187 dB during June 15 to October 1. However, fish presence in the action area is expected to be very low.

2. CV steelhead

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile CV steelhead to increased levels of turbidity and suspended sediment, as well as noise from pile driving activities. The exposure to noise in particular is expected to adversely affect a small number of individuals. During June 15 to October 1, noise from pile driving may delay or impede fish migration causing increased energy expenditure by affected individuals, but as sound pressure levels are not expected to exceed 206 dB, no direct mortality of juvenile or adult fish is expected at 10 meters from the piles. However, fish exposed to an accumulated SEL of 187 dB can be physically injured, and may lead to indirect mortality.

The elevated stress levels may degrade the fish’s health and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predator attacks. Even so, given the low level of exposure expected to result from adherence to the limited seasonal and diurnal in-water work windows, the limited adverse response expected from the few individuals of the Feather River population that are exposed to these adverse effects, and the relatively small contribution to juvenile production that the Feather River provides to the overall population numbers for the CV steelhead DPS, it is expected that the effects of the proposed project, when considered in the context of the current baseline and likely future cumulative effects, would not appreciably reduce the likelihood of survival and recovery of the CV steelhead DPS throughout its range.

3. Southern DPS of North American Green Sturgeon

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile North American green sturgeon to increased levels of turbidity and suspended sediment, as well as noise from pile driving activities. Given the previous analysis showing that green sturgeon are relatively tolerant of turbid/low light environments, the turbidity effects associated with the proposed project are not expected to result in measurable impacts to green sturgeon. The exposure to noise in particular is expected to adversely affect a small number of individuals. Noise may displace or impede fish that are rearing or holding in the action area causing disruptions in feeding and sheltering behavior of individuals. Prolonged exposure to high sound levels may also result in temporary impacts to the hearing ability of exposed fish, but sound pressure levels are not expected to exceed 206 dB, so no direct mortality of juvenile or adult fish is expected. However, fish exposed to an accumulated SEL of 187 dB can be physically injured and may lead to indirect mortality.

The elevated stress levels associated with sound exposure may degrade the fish's health and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predator attacks. However, the effects of the proposed action on the green sturgeon in the Feather River are difficult to determine given the paucity of empirical evidence. Based on the best available information, it is very likely that a green sturgeon population historically utilized the Feather River.

Due to the lack of general abundance information regarding the Southern DPS of North American green sturgeon in the Feather River, a variety of estimates must be utilized to determine the range of potential effects resulting from the take of a small number of green sturgeon due to the proposed action. Compared to the estimated population sizes suggested by the CDFG tagging efforts (CDFG 2002), juvenile and sub-adult captures passing Red Bluff Diversion Dam, and past Interagency Ecological Program (IEP) sampling efforts, the low level of take estimated from the proposed project would impact a very small proportion of the adult and sub-adult North American green sturgeon DPS. Ratios of tagged white to green sturgeon in San Pablo Bay have generated population estimates averaging 12,499 sub-adult and adult green sturgeon. Captures of juvenile green sturgeon passing Red Bluff Diversion Dam have exceeded 2,000 individuals in some years. Utilizing trap efficiency estimates generated for salmonids at this sampling site (Marten *et al* 2001) the total estimate of juvenile green sturgeon passing RBDD would be in excess of 20,000 fish during that sampling period. Given these juvenile population estimates, the low level of incidental take of North American green sturgeon that is expected to result from the proposed project represent a very small proportion of the standing population and is not expected to appreciably reduce the likelihood of survival and recovery of the Southern DPS of North American green sturgeon.

Very few individuals of the Feather River population are expected to be exposed to the affects of pile driving, therefore, will not appreciably reduce the continued survival and recovery of the green sturgeon Feather River population.

C. Summary of Effects of the Proposed Action on Critical Habitat

The effects of the proposed Feather River Bridge project is expected to have minimal adverse effects upon the functionality and conservation value of the freshwater rearing and migratory corridors designated or proposed as critical habitat in the Feather River. Impacts to the designated or proposed critical habitat within the action area that are related to the construction actions are temporary, lasting only as long as the pile driving and bridge construction activities. The construction actions should never impede or prevent migratory potential in the channel of the Feather River due to numerous factors, including: timing of work, location of the action (large open migratory habitat still accessible to fish), and protective measures implemented to minimize impacts to the river during construction (*i.e.*, BMPs and SWPPP). Temporary loss of foraging/rearing habitat is minimal, given the small footprint of the pile driving compared to the available habitat and replacement of riparian vegetation at onsite and offsite locations.

NMFS expects that nearly all of the adverse effects to critical habitat from this project will be of a short-term nature and will not affect future generations of listed fish beyond the construction period of the project.

VIII. CONCLUSION

After reviewing the best scientific and commercial data available, including the environmental baseline, the effects of the proposed project, and the cumulative effects, it is NMFS biological opinion that the Feather River Bridge project is not likely to jeopardize the continued existence of threatened CV Spring-run Chinook salmon, threatened CV steelhead, or threatened Southern DPS of North American green sturgeon, and is not likely to destroy or adversely modify designated or proposed critical habitat for these species.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The listing of the Southern DPS of North American green sturgeon became effective on July 7, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon, does not become effective until the issuance of a final 4(d) regulation, as appropriate.

The measures described below are non-discretionary, and must be undertaken by Caltrans, as appropriate, for the exemption in section 7(o)(2) to apply. Caltrans has a continuing duty to regulate the activity covered by this incidental take statement. If Caltrans (1) fails to assume and implement the terms and conditions or (2) fails to require any contractors to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to any contract, permit or grant documents, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Caltrans must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement [50 CFR §402.14(i)(3)].

A. Amount or Extent of Take

NMFS anticipates incidental take of CV spring-run Chinook salmon, CV steelhead, and North American green sturgeon from impacts directly related to pile driving activities and impairment of essential behavior patterns as a result of these activities. The incidental take is expected to be in the form of harm, harassment, or mortality of CV spring-run Chinook salmon, CV steelhead, and North America green sturgeon, resulting from the installation and removal of temporary and permanent piles. Incidental take is expected to occur for two in-water work window seasons, from June 15 through October 1 (over the course of two years), when individuals of CV spring-run Chinook salmon, CV steelhead, and green sturgeon could potentially be in the action area. Take is expected to be limited to migrating adults, and migrating, rearing and smolting juveniles.

NMFS cannot, using the best available information, quantify the anticipated incidental take of individual CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to describe the ecological surrogates that will lead to the take:

1. Take in the form of injury to juvenile CV spring-run Chinook salmon, CV steelhead, and North American green sturgeon for accumulated SEL of 187 dB that will be exceeded on 33 days during each of the 5 construction years. Specifically, injury is expected for SEL up to 205 dB for piers 4, 5, 6, and 7, for a total of 4 days per year; and peaks of up to 200 dB for 7.5-foot diameter piles; and 193 dB for 2-foot diameter trestle and bents piles between the months of June 15 and October 1.

If these ecological surrogates are not met and maintained, the proposed project will be considered to have exceeded anticipated take levels, thus requiring Caltrans to coordinate with NMFS within 24 hours on ways to reduce the amount of take down to anticipated levels. If remedial measures are not successful, re-initiation of the consultation will be required.

B. Effect of Take

NMFS has determined that the level of take resulting from the construction of the proposed project is not likely to jeopardize the continued existence of CV spring-run Chinook salmon, CV steelhead, or North American green sturgeon, and is not likely to destroy or adversely modify designated critical habitat for CV spring-run Chinook salmon, CV steelhead, or proposed critical habitat for North American green sturgeon.

C. Reasonable and Prudent Measures

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous fish.

1. Measures shall be taken to minimize the amount and duration of pile driving and its potential impacts on listed salmonids and green sturgeon, and to monitor the range and magnitude of compression shock waves generated by pile driving operations.

2. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

D. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, Caltrans must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary:

NMFS has determined that the level of take resulting from the construction of the proposed project is not likely to jeopardize the continued existence of CV spring-run Chinook salmon, CV steelhead, or North American green sturgeon, and is not likely to destroy or adversely modify designated critical habitat for CV spring-run Chinook salmon, CV steelhead, or proposed critical habitat for North American green sturgeon.

C. Reasonable and Prudent Measures

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous fish.

1. Measures shall be taken to minimize the amount and duration of pile driving and its potential impacts on listed salmonids, and to monitor the range and magnitude of compression shock waves generated by pile driving operations.

    - Caltrans shall monitor underwater sound during all impact hammer pile driving activities on land or in water whenever there is a possibility the activity may exceed the 206 dB peak sound level. If underwater sound produced during five or more strikes on a single day exceeds the maximum allowable level of 206 dB_{peak} at 14 meters from the pile being installed, then NMFS must be contacted within 24 hours.

    - Pile driving shall occur only during daylight hours from one hour after sunrise to one hour before sunset. This is to ensure that pile driving does not occur at dawn or dusk, during peak salmonid migration and feeding times.

2. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

    - Caltrans shall purchase riparian credits at a NMFS approved anadromous fish conservation bank at a 3:1 ratio for the aerial extent of riparian habitat affected by the action.

    - Caltrans shall monitor and maintain all onsite riparian plantings within the action area for three years, and provide irrigation, fertilization, and replacement plantings as necessary to insure full and rapid recovery of disturbed riparian habitat features beneficial to anadromous fish.

    - If a listed species is observed injured or killed by project activities, Caltrans shall contact NMFS within 48 hours at 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Notification shall include species identification, the number of fish, and a description of the action that resulted in take. If possible, dead individuals shall be collected, placed in an airtight bag, and refrigerated with the aforementioned information until further direction is received from NMFS.

- Annual updates and reports required by these terms and conditions shall be submitted by December 31 of each year during the construction period to:

Sacramento Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento CA 95814
FAX: (916) 930-3629
Phone: (916) 930-3600

XI. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Caltrans should support and promote aquatic and riparian habitat restoration within the Feather River Basin, and implement practices that avoid or minimize negative impacts to salmon, steelhead, and sturgeon on all of their project sites within critical habitat.

2. Caltrans should provide fiscal and staffing support to anadromous salmonid and sturgeon monitoring programs throughout the Sacramento-San Joaquin Delta to improve the understanding of migration and habitat utilization by salmonids and sturgeon in this region.

In order for NOAA Fisheries to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NOAA Fisheries requests notification of the implementation of any conservation recommendations.

XII. REINITIATION NOTICE

This concludes formal consultation on the Feather River Bridge project. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Enclosure 2

<u>Magnuson-Stevens Fishery Conservation and Management Act</u>

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.S.C. 180 *et seq.*), requires that Essential Fish Habitat (EFH) be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NOAA's National Marine Fisheries Service (NMFS) on any activity which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and, "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMPs.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the San Joaquin Delta (Delta) hydrologic unit (*i.e.*, number 18040003). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*), and CV fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the San Joaquin Delta hydrologic unit. The enclosed biological opinion (Enclosure 1) thoroughly addresses the species of Chinook salmon listed both under the Endangered Species Act (ESA) and the MSA which potentially will be affected by the proposed action. This includes the CV spring-run Chinook salmon. Therefore, this EFH consultation will concentrate primarily on the CV fall/late fall-run Chinook salmon which is covered under the MSA, although not listed under the ESA.

Factors limiting Chinook salmon populations in the Feather River include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, rip-rapping, *etc*. (Dettman *et al.* 1987; California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf *et al.* 1996a, 1996b).

A. Life History and Habitat Requirements

1. <u>Pacific Salmon</u>

General life history information for Central Valley fall-run Chinook salmon is summarized below. Further detailed information on the other Central Valley Chinook salmon Evolutionarily Significant Units (ESUs) are available in the enclosed biological opinion, the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESUs of Chinook salmon (63 FR 11482).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from July through December and spawn from October through December while adult Central Valley late fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from October to April and spawn from January to April (U.S. Fish and Wildlife Service [FWS] 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NMFS 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and into the San Francisco Bay and its estuarine waters (Kjelson *et al.* 1982). The remaining fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or larger juveniles, Central Valley Chinook salmon depend on passage through the Delta for access to the ocean.

II. PROPOSED ACTION

The proposed action is described in detail in section II (*Description of the Proposed Action*) of the enclosed biological opinion (Enclosure 1).

III. EFFECTS OF THE PROPOSED ACTION

The effects of the proposed action is described in detail on salmonid habitat (*i.e.*, Central Valley steelhead) are described at length in *Effects of the Action* of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH.

Effects to EFH stemming from construction activities that may contribute sediment and increase turbidity will be avoided or minimized by meeting Regional Water Quality Board objectives, Caltrans water pollution specifications, implementing applicable BMPs, staging equipment outside of the riparian corridor, limiting the amount of riparian vegetation removal, and replacing (if any) lost riparian vegetation at the project site.

EFH will be adversely affected by the disturbance of up to 0.20 acres of riparian vegetation as a result of construction activities as well as the occupation of the riverbed and water column by temporary work trestles and the columns of the new bridge's substructure. The majority of these impacts are expected to be temporary, as all disturbed areas outside the actual footprint of the new bridge would be restored to preconstruction conditions and any areas of disturbed vegetation would be replanted with native riparian vegetation. Additionally, implementation of the proposed project would result in a permanent net increase of riverine habitat since this project would result in fewer piers being located within the channel.

These effects to EFH may result in a temporary redistribution of some individuals, primarily migrating adult and rearing juvenile salmonids, but, due to the temporary nature of these disturbances, the adverse effects that are anticipated to result from the proposed project are not of the type, duration, or magnitude that would be expected to adversely modify EFH to the extent that it could lead to an appreciable reduction in the function and conservation role of the affected habitat. NMFS expects that nearly all of the adverse effects to EFH from this project will be of a short term nature and will not affect future generations of Pacific salmon beyond the construction period of the project.

IV. CONCLUSION

Based on the best available information, and upon review of the effects of the proposed Feather River Bridge project, NMFS believes that the construction and operation of the project features will have temporary adverse effects on EFH of Pacific salmon protected under MSA.

V. EFH CONSERVATION RECOMMENDATIONS

As the habitat requirements of Central Valley fall-run Chinook salmon within the action area are similar to those of the federally listed species addressed in the enclosed biological opinion, NMFS recommends that reasonable and prudent measures numbers 1 and 2 and their respective implementing terms and conditions listed in the incidental take statement prepared for Central Valley steelhead and the Southern DPS of North American green sturgeon in the associated biological opinion, be adopted as EFH conservation recommendations. Those terms and conditions which require the submittal of reports and status updates can be disregarded for the purposes of this EFH consultation as there is no need to duplicate those submittals.

VI. STATUTORY REQUIREMENTS

Section 305 (b) 4(B) of the MSA requires that the Federal lead agency provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR '600.920[j]). In the case of a response that is inconsistent with our recommendations, the lead agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

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State of California
Department of Transportation

Business, Transportation and Housing Agency

Memorandum

To: **Jeff Sims, Branch chief**
Structure Design North, Branch 1

Date: July 29, 2008

Attn: **Greg Jones**

File: Feather River Bridge
Bridge No. 18-0026
03-SUT-99- P.M. 12.03
EA 03- 1A4321

From: **Department of Transportation**
Division of Engineering Services
Office of Design and Technical Services
Structure Hydraulics and Hydrology, MS#9-HYD-1/2I

Subject: Revised Final Hydraulics Report for Feather River

The Revised Final Hydraulics Report for the above referenced project is attached for your records. If you have any questions, please call John Pham at 916-227-9859 (CALNET 498-9859) or me at 916-227-8018 (CALNET 498-8018).

STEVE NG, Branch Chief
Structure Hydraulics and Hydrology
Scour Mitigation

Attachment

c: Pete Whitfield – DM SM&I
Doug Brittsan – GS OGDN
Steve Jaques – DES P.I. North
Peggy Lim – DES Program Management
Darold Heikens – District 3 Project Management
Gerry Wong – District 3 Project Design

State of California
Department of Transportation

Structure Hydraulics

STRUCTURES
REVISED
FINAL HYDRAULIC REPORT

Feather River

Located on Route 99 in Sutter County

JOB:	FEATHER RIVER BRIDGE (Br. No. 18-0026 R)
LOCATION:	03-SUT-99- P.M. 12.03
DATE:	July 29, 2007

WRITTEN BY:
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REVIEWED BY:
Steve Ng

Revised Hydrology & Hydraulics Report

General

This is the Revised Final Hydraulic Report for the proposed Feather River Bridge (Br. No. 18-0026), located at PM 12.03 on State Route 99 near Nicolaus in Sutter County. The project proposes to improve the existing State Route 99, starting from PM 11.1 and ending at PM 14.3 in Sutter County. The existing highway will be converted from two lanes to four lanes with a continuous median and left turn lanes. A new Feather River Bridge (Br. No. 18-0026R) will be constructed parallel to the existing Feather River Bridge.

All reference data and calculations of this hydraulic report are obtained from the following sources:

- Hydraulic and Hydrologic Documentation for FEMA Certification of Three River's Levee Improvement Authority Project prepared by MBK Engineers, dated December 2006.
- Floodplain Information- Feather River, Nicolas-CA prepared by Corps of Engineer, U.S. Army dated November 1968.
- Floodplain Study prepared by District 3 dated April 24, 1992.
- Preliminary Hydraulic Report prepared by Structures Hydraulics Office dated October 3, 2000.
- A field inspection was conducted by Structure Hydraulics on May 1, 2007
- Caltrans Bridge Maintenance Records (BIR'S)
- HEC-RAS Ver. 3.1.3, a hydraulic modeling computer program
- As-Built Plans for the Feather River Bridge dated 10/1956
- General Plans provided by Structure Design North, Branch 1,dated May 30, 2008
- Temporary construction configuration plans provided by Structure Design North, Branch 1,dated June 08, 2008
- 2007 Channel cross-sections provided by Preliminary Investigations North dated May 2007

Note:

All calculated elevations in this report are based upon the General Plan for the Feather River Bridge dated 05/2007, and the NGVD29 reference datum. Please verify datum references to the Final Design Plans and make elevation adjustments as required.

Existing Structure

The existing Feather River Bridge (Br. No.18-0026) was built in 1958 by Caltrans. It has 31 PC/PS girder spans. Both abutments and Pier 2 are founded on Raymond step taper piles and all other piers are founded on PC/PS concrete piles. The bridge has a total length of 3186 ft with an original width of 32.2 ft. The bridge was widened at the south side in 1999 to make a new total width of 43.6 ft. The Bridge Inspection Report dated January 20, 2005 from the Office of Special Investigation, Hydraulics Branch has determined that the bridge remains scour critical. The Item 113 code is 7, "Countermeasures have been installed to mitigate an existing problem with scour and to reduce the risk of bridge failure during a flood event. Instructions contained in a Plan of Action have been implemented to reduce the risk to users from a bridge failure during or immediately after a flood event". Sheet pile encasements were installed around Piers 13 and 14 to address scour due to channel migration. No additional work is needed for the existing structure, but the existing structure should be monitored for changes in the channel conditions.

Proposed Structures

The new Feather River Bridge (Br. No. 18-0026 R) is a 16 span Precast Spliced, Modified Bulb Tee Girder Bridge on two 7.5' diameter CISS Piles, and seat type abutments. Span configuration: 152'6" and 115'6" end spans and 14 spans @ 210'. It has a total length of 3148 ft and 41.8 ft in width.

Basin

The watershed is approximately 5,372 square miles above its mouth at the town of Verona and with an additional 550 square miles from the Bear River system; a principal tributary located to the east of the Feather River. Between Marysville and Verona, the stream travels southerly about 28 miles along confined levees through flat terrain. The floodway width varies from 2,600 to 7,000 feet. Snowmelt and rain from Bear River would affect the water surface elevation of the Feather River as well as the flow from the upper part of the Sutter Bypass. The Sutter Bypass is a natural flood overflow channel that carries excess flow from the Sacramento River. Flows are moderated by the multiple reservoirs and dams; the Oroville, Marysville and New Bullards Bar reservoirs were built to control the flow during the extreme flood season. Feather River starts in the snowfields of the northern Sierra Nevada, ranging in elevation from 8000 feet to the flat valley land at 35 feet. The mean annual rainfall at is about 20 inches near the bridge site and

90 inches along the ridges near the West Branch headwaters of the North Fork Feather River. The maximum precipitation record was 165 inches, which occurred at LaPorte in the 1910 to 1911 wet season. The watershed is covered by farmland in the valley areas and thick forest in the mountain areas. The climate is distinguished by hot and dry summers and cool wet winters. The average temperature in the basin ranges from 96°F in summer to 27°F in winter. Rainstorms normally occur between November to April and have caused flooding many times in the past before the dam/reservoir system was in place.

Discharge

The discharge at the bridge or the released water regulated by reservoirs is about 320,000 cfs, obtained from a study prepared by Corps of Engineers, U.S. Army in 1968 for the California Reclamation Board, Sutter and Yuba Counties under title "Flood Plain Information of Feather River near Nicolaus, California". Recently, MBK Engineers completed a study "Hydraulic and Hydrologic Documentation for FEMA Certification of Three River's Levee Improvement Authority Project" in December 2006, and in the report, the discharge at the existing Feather River Bridge was increased to 329,814.90 cfs. Since the project is under California Reclamation Board jurisdiction, the Design Flood is the same as the 100-Year Flood and the discharge of 330,000 ft^3/s is used for calculations.

Stage

HEC-RAS Version 3.1.3 - streambed analysis computer programs were used for the water modeling and bridge scour calculations. The Manning's roughness coefficient (0.027 to 0.055) was taken from 2000 and 2007 field inspection reports. Preliminary Investigations North provided channel cross-sections. The General Plans from Structure Design North, Branch 1,dated May 30, 2008, was used for the bridge model. Channel migration, minor channel degradation and moderate debris condition were considered for the scour calculation. The estimated high water elevation at the upstream face of the structure based on is shown in TABLE 1.

TABLE 1

Design Flood / 100-year storm 330,000 ft^3/s	
WS. Elev.	**Available Freeboard** (Base on lowest calculated soffit)
50.4 ft	3.1 ft

This hydraulic study shows that there will not be any significant increase on the base floodwater surface elevation in the area of the proposed project within the existing floodplain condition.

Streambed

The streambed of the Feather River consists of mostly loose sand with very little cohesive material. The stream channel slope at the site is relatively flat at both upstream and downstream segments of the proposed site. Channel migration has occurred in the past. The riverbank had migrated northward as the result of many large floods in earlier years, probably during 1955 to 1965. The thalweg had moved northward about 320 feet in the period of 31 years from 1956 to 1987, but it has stabilized, slowing its migration in the last 20 years. Minor channel migration still occurs although the channel seems laterally stable. For more information on the channel bed composition and its depths, please refer to the Log of Test Borings provided by the Foundation Investigation Branch, Division of Geotechnical Services for this project.

Velocity

Under the estimated channel discharge, the maximum velocity is 7.6 ft/s, and the average velocity is 5.0 ft/s.

Waterway

The proposed structure will be sufficient to pass the 100-year discharge plus adequate freeboard. The minimum waterway area is 68,000 ft^2.

Drift

Bridge maintenance records are available for the existing Feather River Bridge (Br. No. 18-0026). According to these records, moderate to large drift have been found around various piers and debris removal has been recommended several times. During the field investigation in May 1, 2007, trees up to 1.5 ft in diameter or larger were observed in front of Piers 13 to 15, at the upstream side of the bridge. One foot of debris width will be added at each side of the pier for pier scour calculations.

Minimum Soffit Elevation

The Feather River is in the State Reclamation Board's adopted designated floodways of the Central Valley. The Board requires that the soffit of the proposed bridge at the major waterway should be at least 3.0 feet above the water surface elevation for the 100-year discharge (see California Code of Regulation by Reclamation Board, Title 23, Division 1, Vol. 32, Section 128). The calculated 100-year water stage elevation is 50.4 ft, and the minimum soffit elevation at the upstream side of the proposed structure is 53.4 ft.

Bridge Skew and Hydraulics Skew

There is no bridge skew for both proposed and existing structures. Five degrees of hydraulic skew was used to calculate potential scour for pier design.

Scour and Channel Degradation

Based on available records from 1956 to 2007, the channel is considered laterally and vertically unstable. Channel degradation was observed and recorded from 1956 to the present time. Between 1956 to 1987, the thalweg has dropped 10 ft in elevation and moved 320 ft northward. Channel degradation and migration rates were slowed after 1987 at a rate about 0.1 foot per year. Future degradation for the estimated 75-year design lifespan of the proposed structure was calculated at approximately 5.0 ft. This value was used in estimating the total scour in this report. Maintenance records showed the existing structure has significant local scour history at Piers 13 and 14 due to the high water velocity during the big storms in the past years. The maximum local scour is anticipated at Piers 4 to 8 of the new structure. The total local pier scour depth is about 16.50 ft for the 7.5 ft diameter columns. The potential total pier scour depth (total local pier scour plus assumed future degradation) is 21.50 ft. Potential debris loading is considered in the scour calculation by adding the columns diameter two feet. The upstream cross sections were provided by the Preliminary Investigations North survey dated May 2007. The final supported elevation for all pier and abutment foundations should be consulted with the Geotechnical Branch. The anticipated scour depths are shown on TABLE 2.

TABLE 2

Thalweg Elevation (2007)	**Scour Elevation (Max)**
11.80 ft	-5.00 ft
Projected 75-yr Thalweg Elevation (2082)	**Scour Elevation (2082)**
6.80 ft	-10.00 ft

Bank Protection

Channel migration is a characteristic of this particular river due to the high flow and non-cohesive bed materials. Loose sands cannot resist the high water velocity during a big storm discharge and it is difficult to predict the outcome because the channels recharge process. Structure Hydraulics recommends placing the RSP at the abutment slopes and the rock size is provided in TABLE 3. District will determine whether bank protection is required at the roadway approaches.

TABLE 3

Recommendation for RSP rock size	**Ton**	***Thickness***
Outside layer	¼ Ton	3.3 ft
Inner layers RSP -Class	None	
Backing Class No.	1 or 2	1.25 ft or 1.80 ft
RSP Fabric	A	
Method of Placement	B	
Total minimum thickness	4.55 ft	

Note: *The minimum recommended rock weight is ¼ ton at easy access areas to prevent illegal removal of the material out of the site.*

Flood Plain Encroachment

The proposed project is in the flood hazard areas inundated by the 100-year flood. The zoning is "ZONE A"; no base flood elevation determined as shown on Sutter County, California Flood Insurance Rate Map (FIRM), Community-Panel Number 060394-0200 B, dated April 5, 1988. The entire proposed bridge lies within the State Reclamation Board designated floodway and will require a permit.

Hydrology study for construction stage

Structure Design North, Branch 1 provided a temporary construction configuration plans for environmental permit acquisition. Based upon an assumed construction falsework, temporary girders will be used to support the structure during construction. The bridge configuration has more restraints than the finished structure because the increased number of temporary support girders will reduce the waterway. To ensure the backwater does not effect the exiting structure downstream, a model with add-on temporary girders was studied using five different scenarios: 2-year storm, 5-year storm, 10-year storm, 50-year storm, and 100-year storm. The results are listed in on TABLE 4.

TABLE 4

Existing Feather River Bridge (Br. No. 18-0026)

Events	Discharge (ft^3/s)	Average Velocity. (ft/s)	WS Elev. (ft)
2-year storm	82,000	4.28	33.72
5-year storm	122,000	4.02	38.39
10-year storm	152,000	4.00	41.09
50-year storm	272,000	4.73	47.86
100-year storm	330,000	5.10	50.38

Note: *Discharge was calculated with USGS FLOOD FREQUENCY EQUATION and compared the result with the GAGE METHOD (USGS Gage # 11425000) using whichever is greater.*

New Feather River Bridge (Br. No. 18-0026R)

(Temporary construction configuration)

Events	Discharge (ft^3/s)	Average Velocity. (ft/s)	WS Elev. (ft)
2-year storm	82,000	4.31	33.77
5-year storm	122,000	4.12	38.44
10-year storm	152,000	4.09	41.14
50-year storm	272,000	4.82	47.91
100-year storm	330,000	5.18	50.44

From the result of the study, the difference of the water surface elevation and velocities between the temporary proposed structure and the existing bridge are minor; therefore backwater is not a problem during the construction period.

Summary Information for the Bridge Designer

Below is a summary of key design parameters based on the hydrology and hydraulic analysis performed for this structure:

Minimum Soffit Elevation*	53.40 ft
Potential Scour Elevation at Abutments/piers*	-10.00 ft (Assumes channel can migrate bank to bank)
Required Waterway	68,300 ft^2
Average Velocity	5.00 ft/s

HYDROLOGIC SUMMARY			
Drainage Area: Natural stream 5,922 square miles			
	Design Flood	**Base Flood**	**Overtopping Flood**
Frequency (yrs)	100-Year	100-Year	N/A
Discharge (ft^3/s)	330,000	330,000	>1,500,000
Water Surface Elevation at Bridge (ft)*	50.40	50.40	63.00
Flood plain data are based upon information available when the plans were prepared and are shown to meet federal requirements. The accuracy of said information is not warranted by the State and interested or affected parties should make their own investigation.			

- *All calculated elevations in this report are based on the General Plans from Structure Design North, Branch 1, and dated 05/30/2008.*
- *Potential Scour Elevation=Local Scour Elevation-5 ft for future degradation.*

This report has been prepared under my direction as the professional engineer in responsible charge of the work, in accordance with the provisions of the Professional Engineers Act of the State of California.

John Pham

REGISTERED CIVIL ENGINEER

REGISTRATION NUMBER C 51102 DATE: JULY 29, 2008

REGISTERED PROFESSIONAL ENGINEER
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