Caltrans

Corridor System Management Plan (CSMP)

Los Angeles I-5 South Corridor

From Orange County Line to I-710

Final Report

September 2010

I approve this Corridor System Management Plan (CSMP) for the I-5 South Corridor in Caltrans District 7 as the overall Policy Statement and Strategic Plan that will guide transportation decisions and investment for the I-5 Corridor from the Orange County Line to I-710 in Los Angeles County.

Approval

for MICHAEL MILES 5/4/11
District 7 Director Date

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1. INTRODUCTION

This document represents the draft Final Report of the Los Angeles Interstate 5 (I-5) South Corridor System Management Plan (CSMP) developed by the California Department of Transportation (Caltrans). The I-5 South study corridor begins at the Orange County/Los Angeles County border at Post Mile 0.0 and runs northwest to the I-710 (Long Beach Freeway) interchange at Post Mile 13.8.

This final report contains the results of a two-year study that included several key steps, including:

- Stakeholder Involvement (discussed below in this Section 1)
- Corridor Description and Performance Assessment (Sections 2 and 3)
- Bottleneck Identification and Causality Analysis (Section 4)
- Scenario Development and Analysis (Section 5)
- Conclusions and Recommendations (Section 6).

This CSMP is the direct result of the November 2006 voter-approved Proposition 1B (The Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006). This ballot measure included a funding program deposited into a Corridor Mobility Improvement Account (CMIA). The CMIA will partially fund the construction of High Occupancy Vehicle (HOV) lanes from the Los Angeles/Orange County line to the I-605, a distance of about seven miles. Approximately $387 million in CMIA funds have been adopted by the CTC for this project.

To receive CMIA funds, the California Transportation Commission (CTC) guidelines required that project sponsors describe in a CSMP how mobility gains from CMIA funded corridor improvements would be maintained over time. Therefore, a CSMP aims to define how corridors will be managed in the long term, focusing on operational strategies in addition to the already funded expansion projects. The goal is to get the most out of the existing system and maintain or improve corridor performance.

The I-5 CSMP involved corridor stakeholders in the study to discuss progress, technical challenges, data needs, and preliminary conclusions. Representatives from cities bordering I-5 were briefed at critical milestones. Feedback from stakeholders helped solidify the findings of the performance assessment, bottleneck identification, and causality analysis given their intimate knowledge of local conditions. Moreover, various stakeholders have provided support and insight, and shared valuable field and project data without which this study would not have been possible.

This report presents performance measurement findings, identifies bottlenecks that lead to less than optimal performance, and diagnoses the causes for these bottlenecks in detail. Alternative investment strategies were modeled using the year 2007 as the Base Year and 2020 as the Horizon Year.

This CSMP should be updated by Caltrans on a regular basis since corridor performance can vary dramatically over time due to changes in demand patterns, economic conditions, and delivery of projects and strategies among others. Such changes could influence the conclusions of the CSMP and the relative priorities in investments. Therefore, it is recommended that updates occur no less than every two to three years. To the extent possible, this document has been organized to facilitate such updates.

The following discussion provides background to the system management approach in general and CSMPs in particular.

What is a Corridor System Management Plan (CSMP)?

In November 2006, voters approved Proposition 1B. This ballot measure included a funding program that to be deposited into the CMIA. For a project to be nominated by a Caltrans district or regional agency, CTC guidelines for the CMIA require that the project nomination describe how mobility gains of urban corridor capacity improvements would be maintained over time.

The guidelines also stipulate that the CTC will give priority to project nominations that include a CSMP. A CSMP is a comprehensive plan for maintaining the congestion reduction and productivity improvements achieved on a CMIA corridor. CSMPs incorporate all travel modes - including state highways and freeways, parallel and connecting Roadways, public transit (bus, bus rapid transit, light rail, intercity rail), carpool/vanpool programs, and bikeways. CSMPs also include intelligent transportation technologies such as ramp metering, coordinated traffic signals, changeable message signs for traveler information, and improved incident management.

This CSMP is the first attempt to integrate the overall concept of system management into Caltrans' planning and decision making processes for the corridor. The traditional planning approach identified localized freeway problem areas and then developed solutions to fix those problems often by building expensive capital improvement projects. The I-5 CSMP focuses on the system management approach with a greater emphasis on using on-going performance assessments to identify operational strategies that yield higher congestion reduction and productivity benefits relative to the amount of money spent.

Caltrans develops integrated multimodal projects in balance with community goals, plans, and values. Caltrans seeks to address the safety and mobility needs of bicyclists, pedestrians, and transit users in all projects, regardless of funding. Bicycle, pedestrian, and transit travel is facilitated by creating "complete streets" beginning early in system planning and continuing through project delivery, maintenance, and operations. Developing a network of complete streets requires collaboration among all Caltrans functional units and stakeholders. As the first-generation CSMP, this report focuses more on reducing congestion and increasing mobility through capital and operational strategies. Future CSMP work will further address pedestrian, bicycle and transit components and seek to manage and improve the whole network as an interactive system.

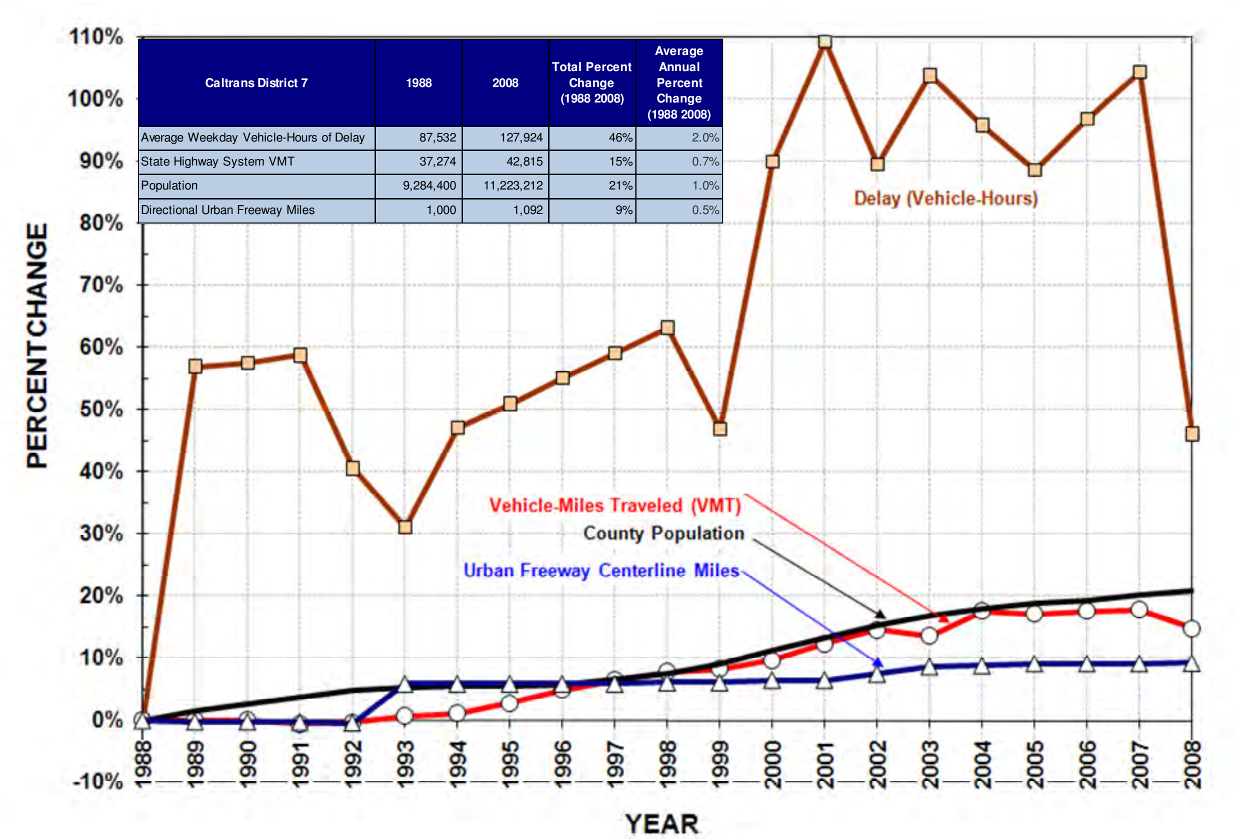
What is System Management?

With the rising cost and complexity of construction and right of way acquisition, the era of large-scale freeway construction is coming to an end. Compared to the growth of vehicle-miles traveled (VMT) and population, congestion is growing at a much higher rate.

Exhibit 1-1 shows Los Angeles congestion (measured by average weekday recurring vehicle-hours of delay), VMT, and population between 1988 and 2008. Over that 20-year period, congestion increased 50 percent from the 1988 congestion level (just under two percent per year). Over the same period, VMT and population rose by about 20 percent (one percent per year). However, urban freeway miles barely grew at less than one-half a percentage point per year.

Clearly, infrastructure expansion has not kept pace with demographic and travel trends and is not likely to keep pace in the future. Therefore, if conditions are to improve, or at least not deteriorate as fast, a new approach to transportation decision making and investment is needed.

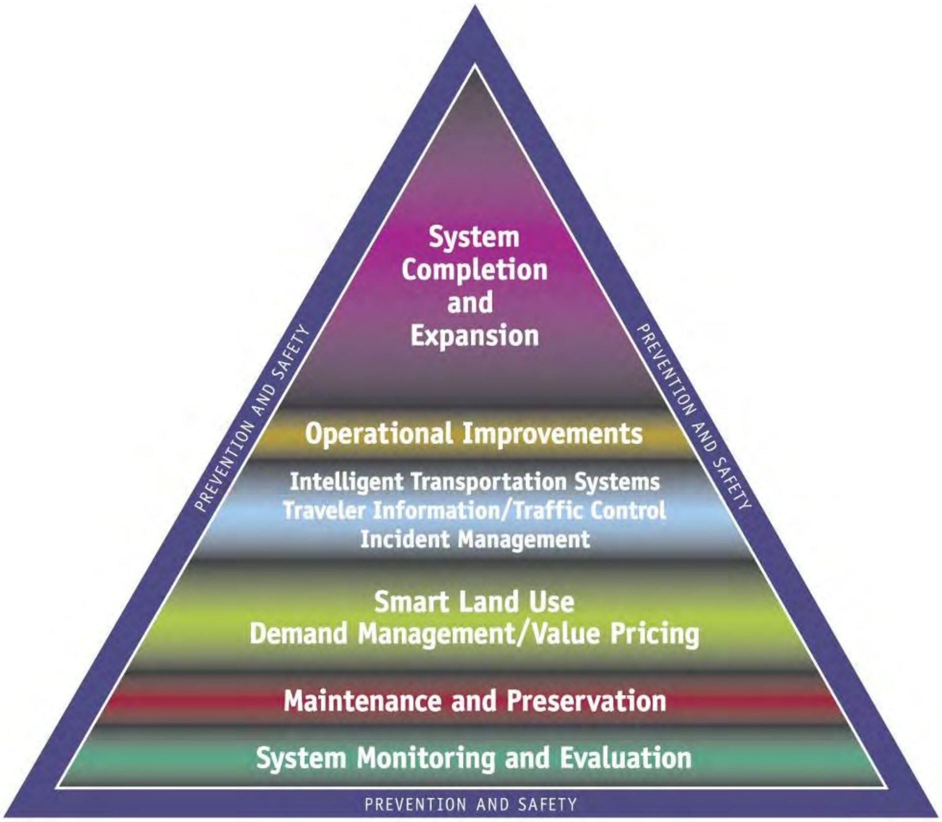
Exhibit 1-1: District 7 Growth Trends (1988-2008)



Caltrans District 7	1988	2008	Total Percent Change (1988 2008)	Average Annual Percent Change (1988 2008)
Average Weekday Vehicle-Hours of Delay	87,532	127,924	46%	2.0%
State Highway System VMT	37,274	42,815	15%	0.7%
Population	9,284,400	11,223,212	21%	1.0%
Directional Urban Freeway Miles	1,000	1,092	9%	0.5%

Caltrans recognizes this dilemma and has adopted a mission statement that embraces the concept of system management. This mission and its goals are supported by the system management approach illustrated in the System Management pyramid shown in Exhibit 1-2.

Exhibit 1-2: System Management Pyramid



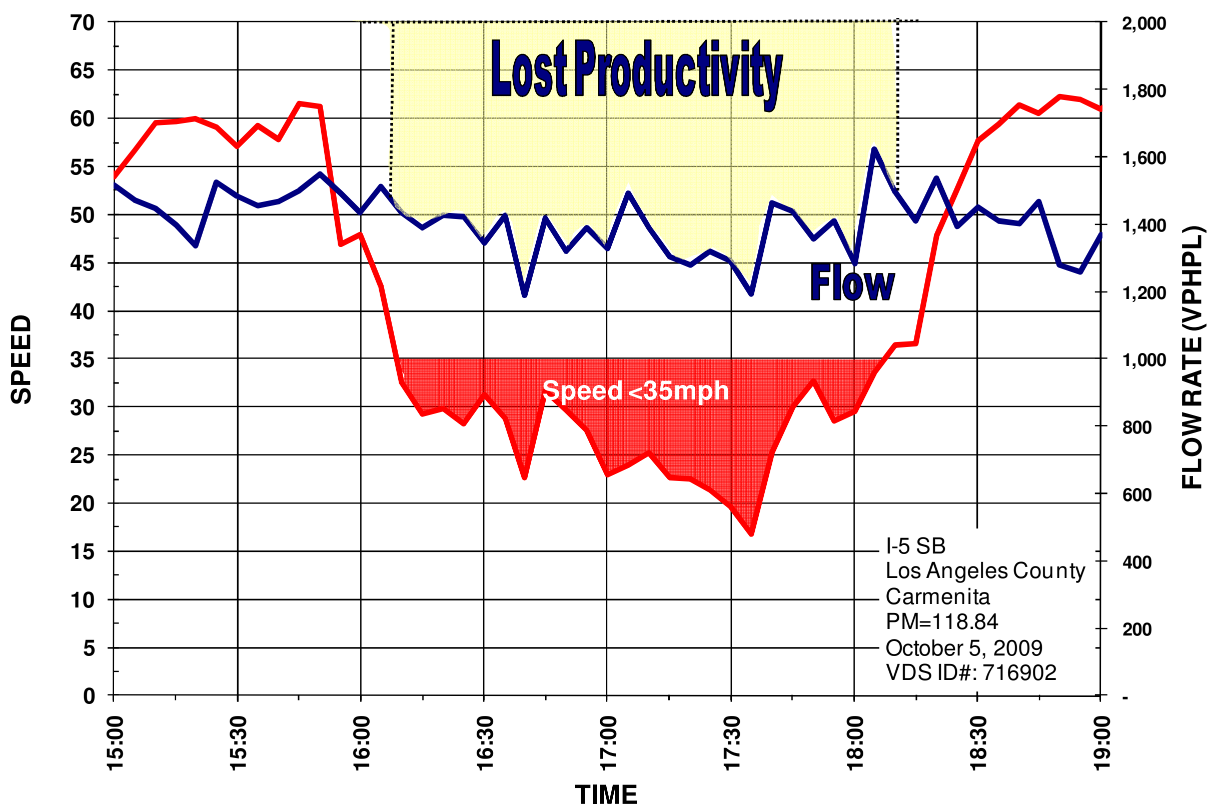
System Management is being touted at the federal, state, regional and local levels. It addresses both transportation demand and supply to get the best system performance possible. Ideally, Caltrans would develop a regional system management plan that addresses all components of the pyramid for an entire region comprehensively. However, because the system management approach is relatively new, it is prudent to apply it at the corridor level first.

The foundation of system management is monitoring and evaluation (shown as the base of the pyramid). This monitoring is done by comprehensive performance assessment and evaluation. Understanding how a corridor performs and why it performs the way it does is critical to crafting appropriate strategies. Section 3 is dedicated to performance assessment. It would be desirable for Caltrans to update this performance assessment every two or three years to ensure that future corridor issues can be identified and addressed before breakdown occurs on the corridor.

A critical goal of system management is to "get the most out" of the existing system, or maximize system productivity. One would think that a given freeway is most productive during peak commute times. Yet, this is not true for heavy commute corridors. In fact, for Los Angeles' urban freeways that have been experiencing growing congestion, the opposite is true. When demand is the highest, the flow breaks down and productivity declines.

Exhibit 1-3 illustrates how congestion leads to lost productivity. The exhibit uses observed data from I-5 sensors for a typical autumn 2009 afternoon peak period (October 5, 2009). It shows speeds (in red) and flow rates (in blue) on southbound I-5 at Carmenita Avenue, one of the most congested locations on the corridor.

Exhibit 1-3: Productivity Loss During Congestion



Flow rates (measured as vehicle-per-hour-per-lane or "vphpl") at Carmenita Avenue was nearly 1,600 vphpl between 3:00 PM and 4:00 PM, which is slightly less than a typical peak period maximum flow rate.

Once volumes exceed this maximum flow rate, traffic becomes unstable. Any additional merging or weaving, traffic breaks down and speeds rapidly plummet to below 35-mph. In essence, every incremental merge takes up two spots on the freeway for a short time. However, since the volume is close to the capacity, these merges lead to queues. Moreover, rather than accommodating the same number of vehicles, flow rates also drop and vehicles back up creating bottlenecks and associated congestion.

At the location shown in Exhibit 1-3, throughput drops by 20 percent on average during the peak period (from over 1,600 to around 1,200 vphpl). This three-lane road therefore operates with 20 percent less capacity when demand is at its highest. Just when the corridor needed the most capacity, it performed in the least productive manner and effectively lost lanes. This loss in throughput can be aggregated and presented as "Equivalent Lost-Lane-Miles".

This is lost productivity. Where there is sufficient automatic detection, this loss in throughput can be quantified and presented as "Equivalent Lost Lane-Miles". Discussed in more detail later in this report, the productivity losses on southbound I-5 were over 7.0 daily lane-miles during the PM peak period in 2009. Caltrans works hard to recover this lost productivity by investing in improvements that utilize public funds in the most effective manner. By largely implementing operational strategies, Caltrans can leverage past investments and restore productivity.

Although still an important strategy, infrastructure expansion (at the top of the pyramid in Exhibit 1-2) cannot be the only strategy for addressing the mobility needs in Los Angeles County. System management must be an important consideration as Caltrans and its partners evaluate the need for facility expansion investments. The system management philosophy begins by defining how the system is performing, understanding why it is performing that way, and then evaluating different strategies, including operations centric strategies, to address deficiencies. Various tools can be used to estimate potential benefits to determine if these benefits are worthy of the costs to implement the strategy.

Stakeholder Involvement

The I-5 South Corridor CSMP involved corridor stakeholders including representatives from cities bordering I-5, the Southern California Association of Governments (SCAG), and the Los Angeles County Metropolitan Transportation Authority (Metro). Caltrans briefed stakeholders at critical milestones. Feedback from the stakeholders helped solidify the findings of the performance assessment, bottleneck identification, and causality analysis given their intimate knowledge of local conditions. Moreover, various stakeholders have provided support and insight, and shared valuable field and project data without which this study would not have been possible.

The stakeholders included representatives from the following organizations:

- ♦ Southern California Association of Governments (SCAG)
- ♦ Los Angeles County Metropolitan Transportation Authority (Metro)
- ♦ I-5 Consortium Cities Joint Powers Authority (JPA)
- ♦ Gateway Cities Council of Governments
- ♦ City of Norwalk

- City of Downey
- City of La Mirada
- City of Santa Fe Springs.

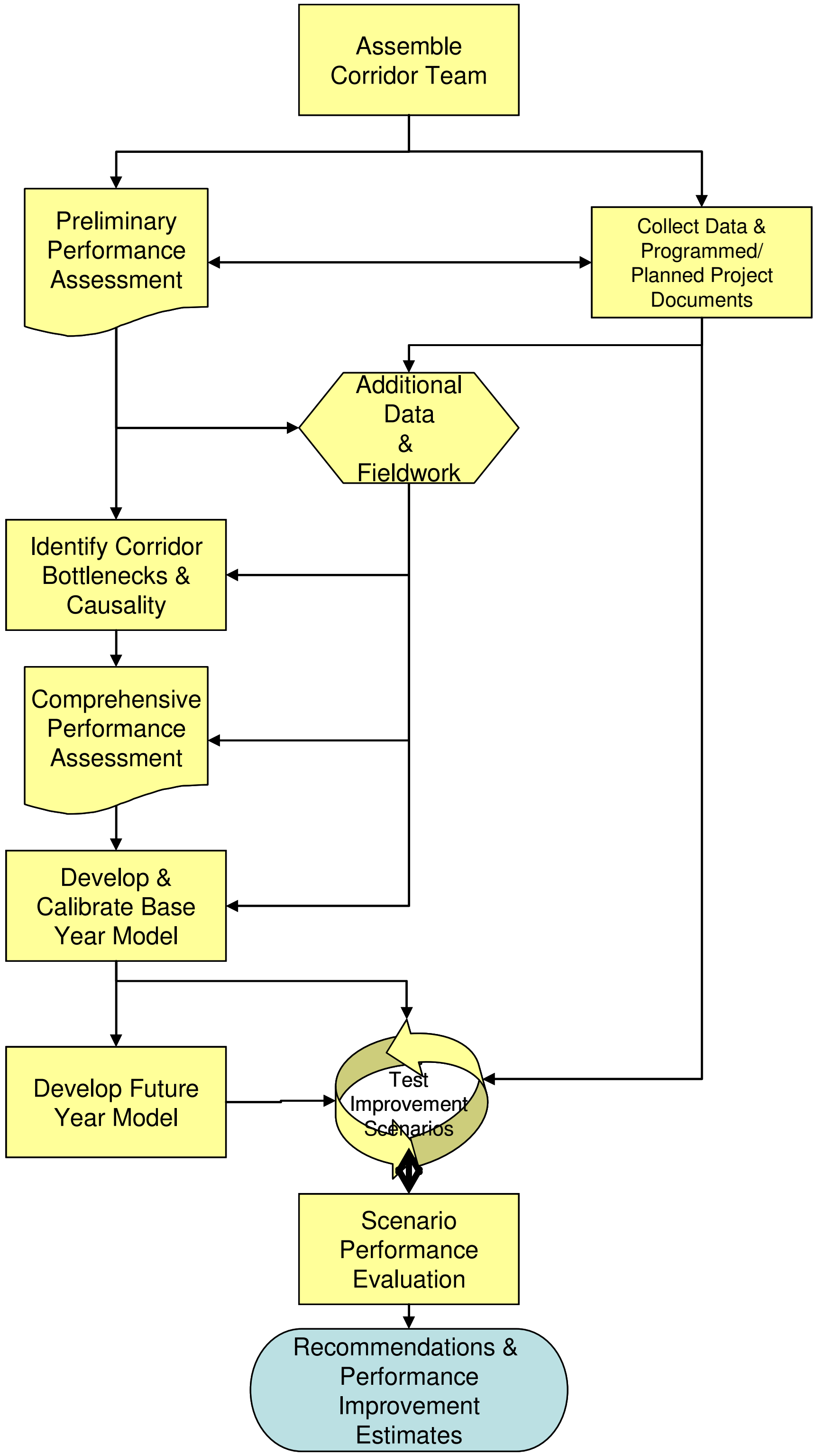
Caltrans would like to thank all of its partners for contributing to this CSMP development process. In addition, CSMP development provided a venue for closer coordination between Caltrans planning and operations professionals, which is critical to the success of the system management approach.

Study Approach

The I-5 CSMP study approach follows system management principles by placing an emphasis on performance monitoring and evaluation (the base of the pyramid in Exhibit 1-2), and on using lower cost operational improvements to maintain system productivity.

Exhibit 1-4 is a flow chart that illustrates this approach. Each step of the approach is described following the chart.

Exhibit 1-4: Study Approach



Assemble Corridor Team

The first task in this effort was undertaken by Caltrans with the creation of an I-5 CSMP team. The team met periodically to review project progress and to provide feedback to the study team.

In addition to the CSMP team, Caltrans also identified cities and other major stakeholders along the I-5 corridor whose input was solicited during the bottleneck identification and scenario development processes. The stakeholders group convened several times during the study period to receive local feedback on relevant issues and "buy off" at critical junctures.

Preliminary Performance Assessment

The Preliminary Performance Assessment Report presented a brief description of the corridor and existing projects along or adjacent to I-5. It included a corridor-wide performance assessment for four key performance areas: mobility, reliability, safety, and productivity. The assessment also included a preliminary bottleneck location assessment based on readily available existing data and limited field observations.

The results of the Preliminary Performance Assessment were updated and included in the Comprehensive Performance Assessment described below. The results of these two assessments are presented in the Corridor Description and Corridor Performance sections - Sections 2 and 3 of this final report.

For future I-5 CSMP reporting, the Preliminary Performance Assessment should not be necessary since its main purpose is to identify data gaps – particularly detection gaps. It is anticipated that these gaps will be addressed with improved automatic detection. Future updates to CSMPs can be made to this final report.

Collect Data and Programmed/Planned Project Information

In conjunction with the Preliminary Performance Assessment, SMG reviewed existing studies, plans and other programming documents to assess additional data collection needs for modeling and scenario development. One of the key elements of this study was to identify projects that would be implemented in the short- and long-term time frames to be included in the Vissim micro-simulation model developed by the modeling team.

Details of the projects included in the scenario analysis are discussed in Section 5: Scenario Development and Evaluation.

Additional Data Collection and Fieldwork

The study team determined locations where additional manual traffic counts would be needed to calibrate the 2007 Base Year model and coordinated the collection of the traffic count data. Traffic data counts collected included peak period turning movement counts and 24-hour average daily traffic (ADT) counts. In addition, signal timing data were obtained from Caltrans and various cities for use in the model calibration.

The study team conducted several field visits in September, October, and November 2008 to observe field conditions during peak periods and videotape potential bottleneck locations. This fieldwork will be discussed in Section 4: Bottleneck Identification and Causality Analysis.

Identify Corridor Bottlenecks and Causality

Building on the Preliminary Performance Assessment and the fieldwork, the study team identified major AM and PM peak period bottlenecks along the corridor. These bottlenecks will be discussed in detail in Section 4 of this report.

Comprehensive Performance Assessment

Once the bottlenecks were identified and the causality of the bottlenecks determined, SMG prepared a Comprehensive Performance Assessment, which was delivered to Caltrans in May 2009. This report builds on the Preliminary Performance Assessment with a discussion of bottleneck causality findings – including performance results for each individual bottleneck area. It also included corridor-wide performance results updated to reflect 2008 conditions.

Develop and Calibrate Base Year Model

Using the bottleneck areas as the basis for calibration, the modeling team developed a calibrated 2007 Base Year model for the corridor. This model was calibrated against California and Federal Highway Administration (FHWA) guidelines for model calibration. In addition, the model was evaluated to ensure that each bottleneck area was represented in the model and that travel times and speeds were consistent with observed data. This process required several review iterations and an independent model peer reviewer.

Discussion of the calibrated 2007 Base Year model can be found in Section 5: Scenario Development and Evaluation.

Develop Future Year Model

Following the approval of the 2007 Base Year model, the modeling team developed a 2020 Horizon Year model to be used to test the impacts of short-term programmed projects as well as future operational improvements including the impacts of improved incident management on the corridor.

Discussion of the 2020 Horizon Year model can be found in Section 5: Scenario Development and Evaluation.

Test Improvement Scenarios

The study team developed 11 scenarios that were evaluated using the micro-simulation model. Short-term scenarios included programmed projects that would likely be completed typically within the next five years along with other operational improvements such as improved ramp metering.

In addition to the short-term evaluations, short-term projects were also tested using the 2020 Horizon Year model to assess their long-term impacts. In addition, the study team developed and tested other scenarios using only the 2020 model. These scenarios included programmed and planned projects that would not be completed within five years of 2007 and that would likely only experience benefits in the long-term.

Scenario testing results are presented in Section 5: Scenario Development and Evaluation.

Scenario Performance Evaluations

Once scenarios were developed and fully tested, simulation results for each scenario were subjected to a benefit-cost evaluation to determine how much “bang for the buck” each scenario would deliver. The study team performed a detailed benefit-cost assessment using the California Benefit-Cost model (Cal-B/C).

The results of the benefit-cost analysis are presented in Section 5: Scenario Development and Evaluation.

Recommendations and Performance Improvement Estimates

The study team developed final recommendations for future operational improvements that could be reasonably expected to maintain the mobility gains achieved by existing programmed and planned projects. Section 6 summarizes these findings.

The remainder of this report is organized into six sections (Section 1 is this introduction):

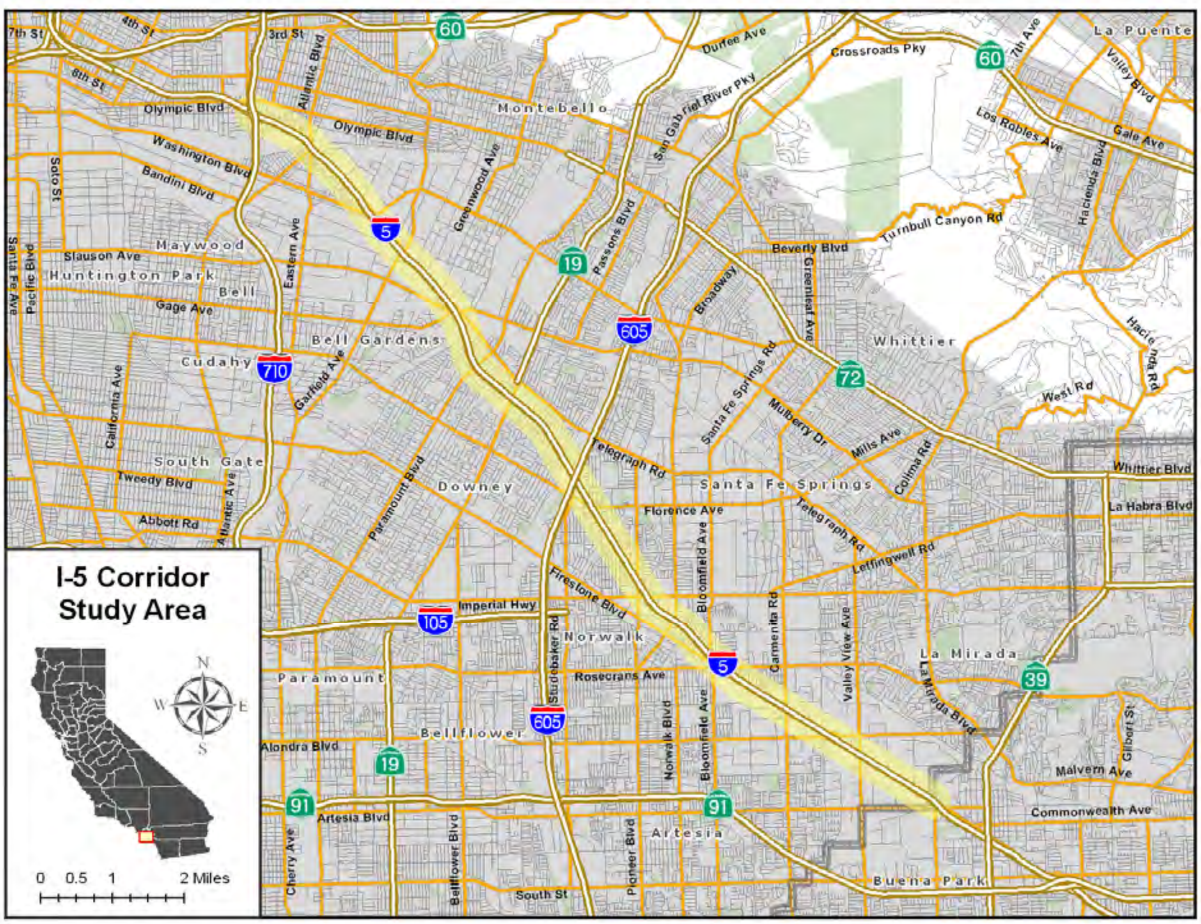
2. *Corridor Description* describes the corridor, including the roadway facility, major interchanges and relative demands at these interchanges, relevant transit services serving freeway travelers, special event facilities/trip generators, and an I-5 origin-destination demand profile from the SCAG regional model.
3. *Corridor Performance Assessment* presents multiple years (2005 to 2009) of performance data for the freeway portion of the I-5 corridor. Statistics are included for the mobility, reliability, safety, and productivity performance measures.
4. *Bottleneck Identification and Causality Analysis* identifies bottlenecks, or choke points, on the I-5. It also diagnoses the bottlenecks and identifies the causes of each location through additional data analysis and field observations. This section has performance results for delay, productivity, and safety by major "bottleneck area", which allows for the relative prioritization of bottlenecks in terms of their contribution to corridor performance degradation. It also provides input to selecting projects to address the critical bottlenecks, and provides the baseline against which the micro-simulation models were validated.
5. *Scenario Development and Analysis* discusses the scenario development approach and summarizes the expected future performance based on the Vissim micro simulation model developed by the modeling team for the corridor.
6. *Conclusions and Recommendations* describes the projects and scenarios that were evaluated and recommends a phased implementation of the most promising set of strategies.

The appendices provide project lists for the micro-simulation scenarios and detailed benefit-cost results.

2. CORRIDOR DESCRIPTION

As shown in Exhibit 2-1, the Golden State Freeway (I-5) South CSMP Corridor begins at the Orange County/Los Angeles County border and runs in a northwesterly direction to the I-710 (Long Beach Freeway) interchange. The freeway corridor, as defined by Caltrans District 7, extends approximately 14 miles from the Orange County (OC)/Los Angeles (LA) County Line at Post Mile (PM) 0.000 to the I-710 interchange at PM 13.784. It traverses the cities of La Mirada, Norwalk, Santa Fe Springs, Downey, Pico Rivera, Bell Gardens, and Commerce.

Exhibit 2-1: Los Angeles I-5 South CSMP Corridor Map



Corridor Roadway Facility

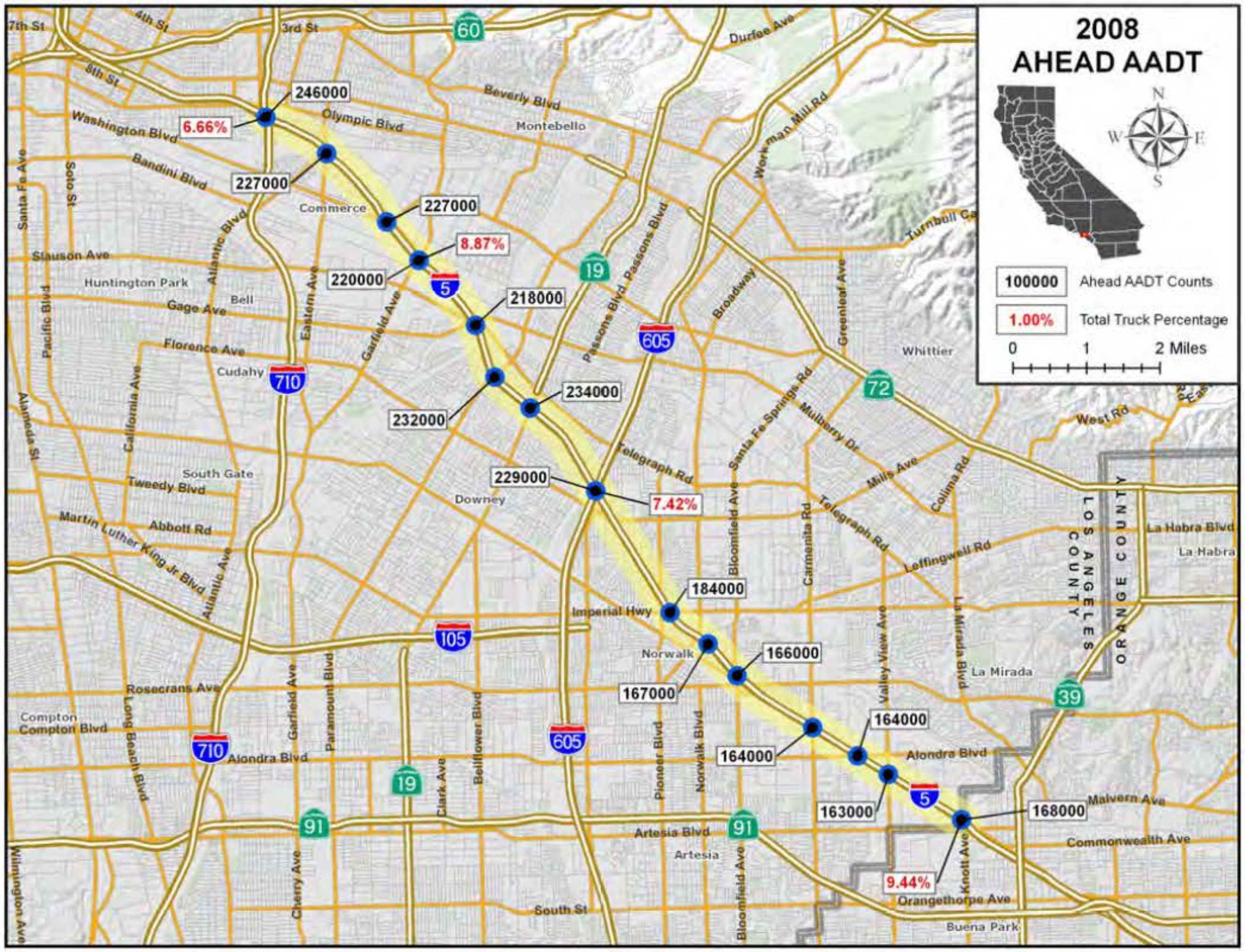
The study corridor crosses through Los Angeles County and includes the following major freeway-to-freeway and arterial interchanges:

- Artesia Boulevard runs east-to-west connecting Orange County at Beach Boulevard (SR-39) to the South Bay and the coastal cities of Hermosa Beach and Manhattan Beach.
- Valley View Avenue runs north-to-south connecting Imperial Highway to the Garden Grove Freeway (SR-22) in Orange County.
- Rosecrans Avenue runs east-to-west connecting the city of Fullerton in Orange County to the South Bay and the coastal cities of Manhattan Beach and El Segundo.
- Imperial Highway runs east-to-west and connects the Riverside Freeway (SR-91) in the city of Anaheim to the Los Angeles World Airports.
- The San Gabriel River Freeway (I-605) runs north-to-south and provides access to the cities of Norwalk, Downey, Pico Rivera, and Santa Fe Springs. It also provides access to Orange County and the I-105 freeway connecting to the Los Angeles World Airports.
- Lakewood Boulevard/Rosemead Boulevard (SR-19) runs north-to-south paralleling the I-605, connecting the I-210 and San Gabriel Valley to the Long Beach Airport and the I-405 Freeway.
- Long Beach Freeway (I-710) runs north-to-south and connects the San Gabriel Valley to the Port of Long Beach. It provides access to the cities of East Los Angeles and Commerce.

According to 2008 traffic volumes from Caltrans (Exhibit 2-2), I-5 South Corridor carries between 163,000 and 246,000 annual average daily traffic (AADT) depending on the location. The highest AADT occurs at the I-710 Interchange, while the lowest occurs just north of Artesia Boulevard.

As illustrated in Exhibit 2-3, the I-5 South CSMP Corridor is a Surface Transportation Assistance Act (STAA) route, which permits large trucks to operate on it. According to the 2008 Caltrans Annual Average Daily Truck Traffic data, verified truck counts comprise between 7 and 10 percent of the total daily traffic along the corridor with the highest percentage (9.5 percent) occurring at the Orange/Los Angeles County Line. These percentages are high and indicate that the corridor is heavily used by trucks. Some of these trucks may be destined for Hobart Railyard, which is the largest intermodal railyard in the country and located at the north end of the study corridor near the I-5/I-710 Interchange on Washington Boulevard in the City of Commerce. The railyard includes intermodal facilities and handles the distribution of international containers to out-of-state places, such as Chicago and Memphis.

Exhibit 2-2: AADT and Truck Percentages on the I-5 South CSMP Corridor



Source: AADT is from the Caltrans Traffic and Vehicle Data Systems Unit

Exhibit 2-3: Los Angeles County Truck Network on California State Highways

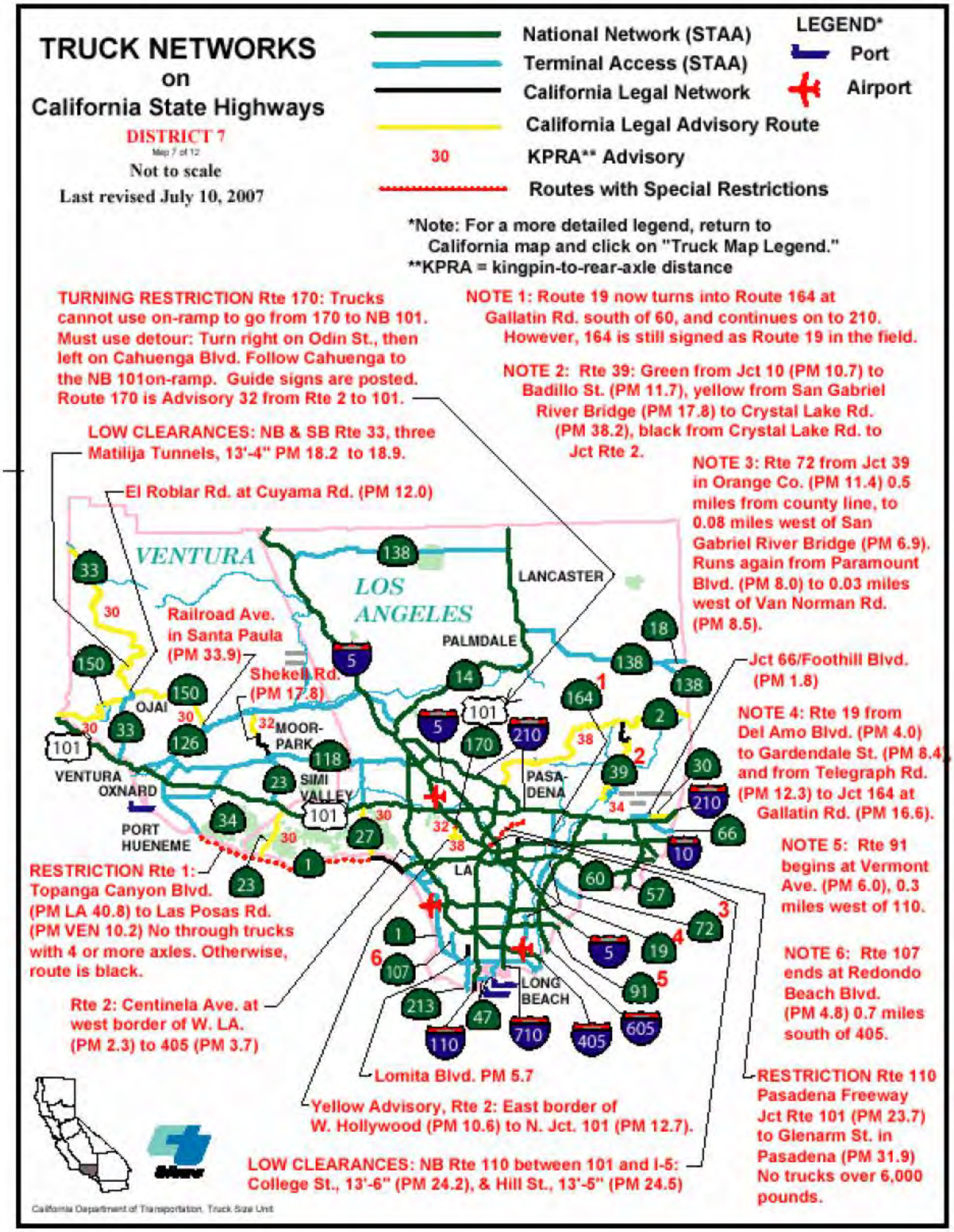
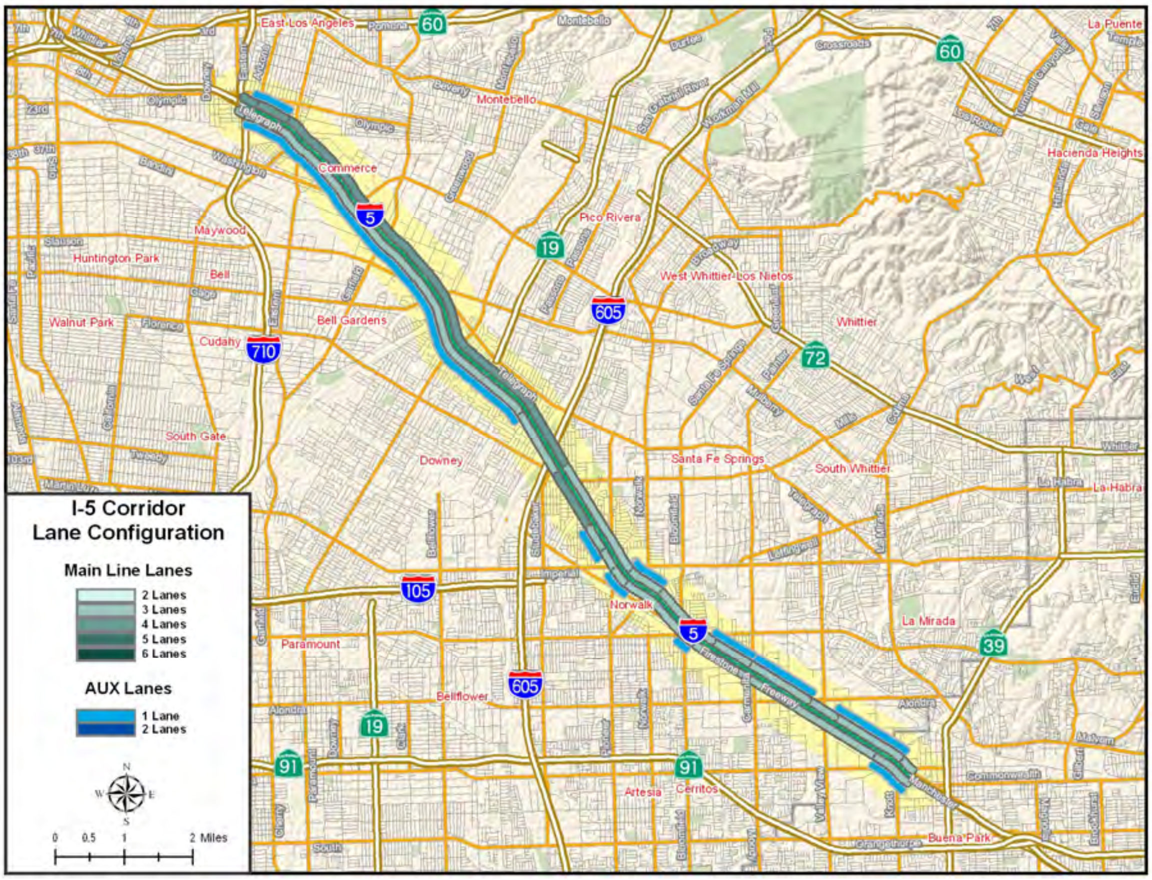


Exhibit 2-4 shows the lane configurations on the corridor according to the latest available aerial photos and field visit visits conducted. The current Transportation System Network (TSN) records and latest available aerial photos and photologs indicate that the I-5 generally has three to five lanes in each direction of travel. A concrete median barrier separates northbound and southbound traffic for most of the corridor. There are auxiliary lanes along many sections of the corridor with some only available on only one side of the freeway. High occupancy vehicle (HOV) lanes are currently not part of the corridor, but are planned for construction.

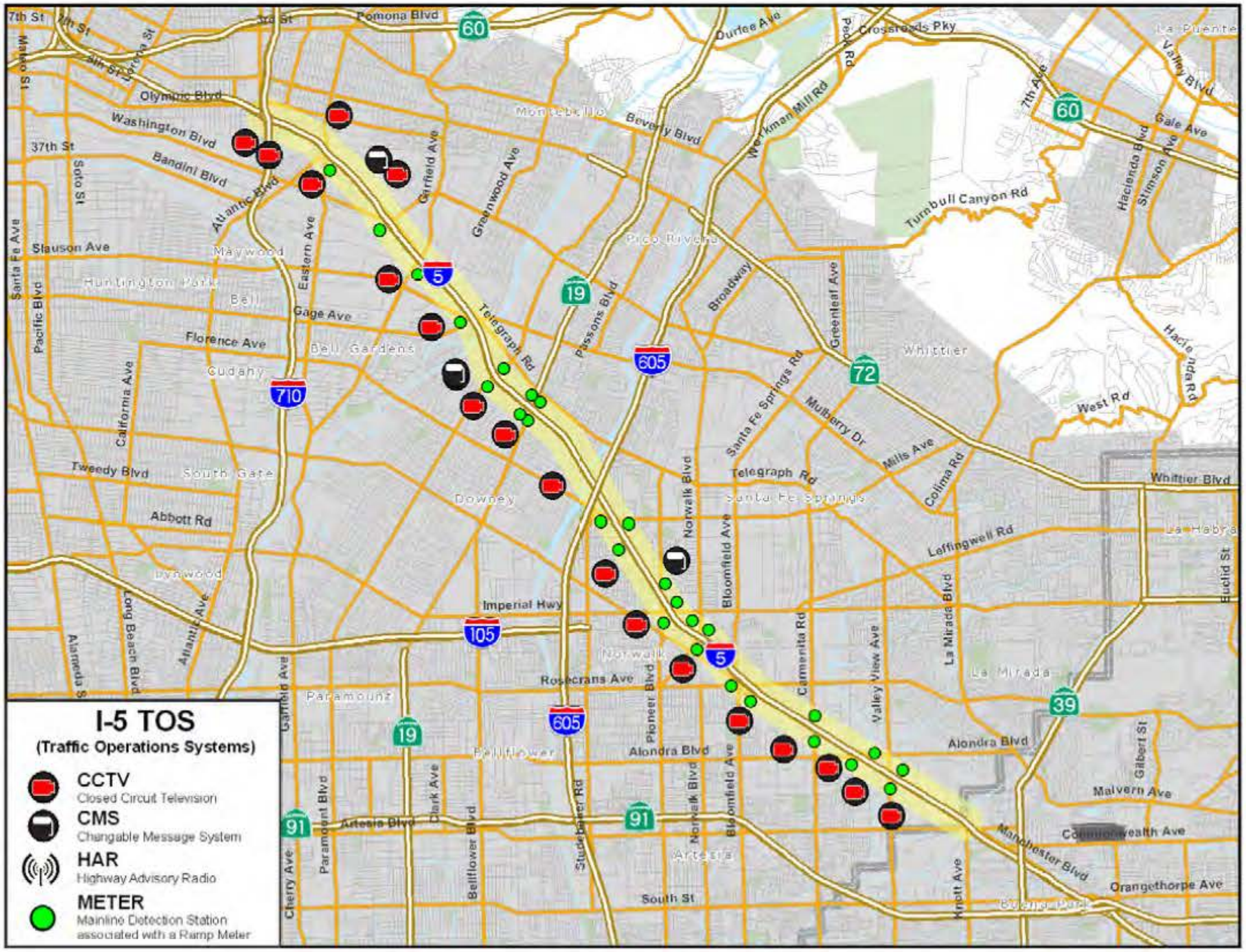
Exhibit 2-4: Lane Configurations on the I-5 South CSMP Corridor



Source: SMG mapping of field-verified lane configurations (April 2009)

The corridor also includes traffic operations and management systems, as shown in Exhibit 2-5. These include closed-circuit television (CCTV) cameras and fiber optic communications, changeable message signs (CMS), and vehicle detection stations.

Exhibit 2-5: Transportation Management Systems on the I-5 South CSMP Corridor



Corridor Transit Services

The following major public transportation operators provide service near the I-5 CSMP corridor:

- Southern California Regional Rail Authority (SCCRA) - Metrolink
- Amtrak
- Los Angeles County Metropolitan Transportation Authority (Metro).

Both the Metrolink Orange County Line and 91 Line offer rail service from downtown Los Angeles to Orange County. The Orange County Line terminates in Oceanside in San Diego County with an average weekday ridership of 2,315, while the 91 Line terminates in downtown Riverside with an average weekday ridership of 7,841. Exhibit 2-6 shows the Metrolink system map for Southern California.

Amtrak offers the Coast Starlight and Pacific Surfliner rail services that operate parallel to the I-5 South Corridor. The Coast Starlight offers daily service from Los Angeles to Oakland and Seattle. The Pacific Surfliner provides high-frequency service from San Diego to San Luis Obispo, via Los Angeles. The Pacific Surfliner is the second busiest corridor in the country with 2,898,859 riders in Fiscal Year (FY) 2008. According to the FY 2008 Amtrak Fact Sheet on the State of California, California has the highest Amtrak usage of any state in the country.

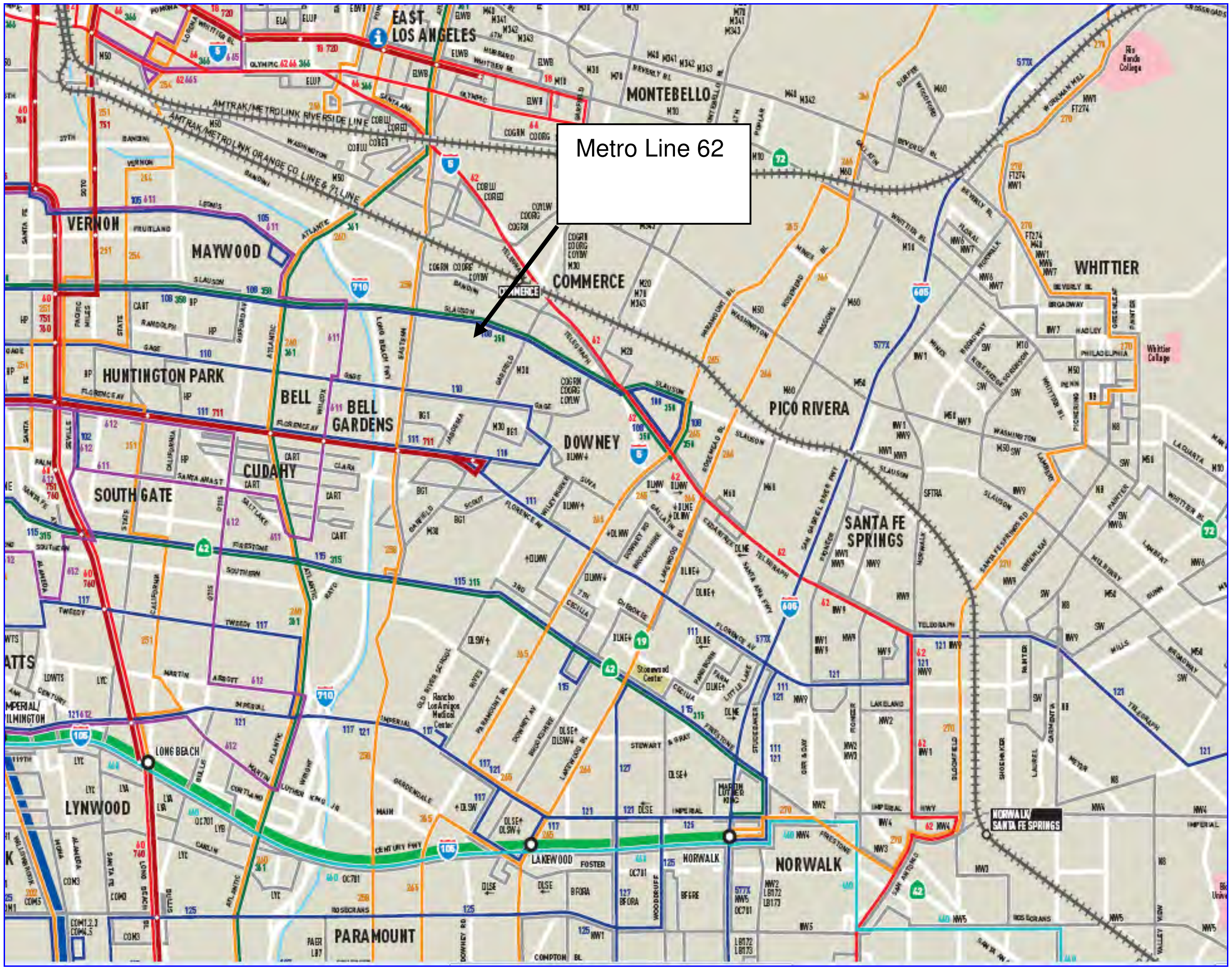
Metro services 1,433 square miles in Los Angeles County with over 190 bus lines and an average weekday passenger boarding of 1.2 million. Metro Line 62 runs along Telegraph Road paralleling the entire segment of the I-5 Corridor. Exhibit 2-7 shows Metro service in the vicinity of the I-5 South Corridor.

There are several park and ride facilities near the study corridor, as illustrated in Exhibit 2-8. The parking lots which are closest to the corridor are at Lakewood and Fullerton. There are three others that are in close proximity to the I-105 corridor.

Exhibit 2-6: Metrolink System Map

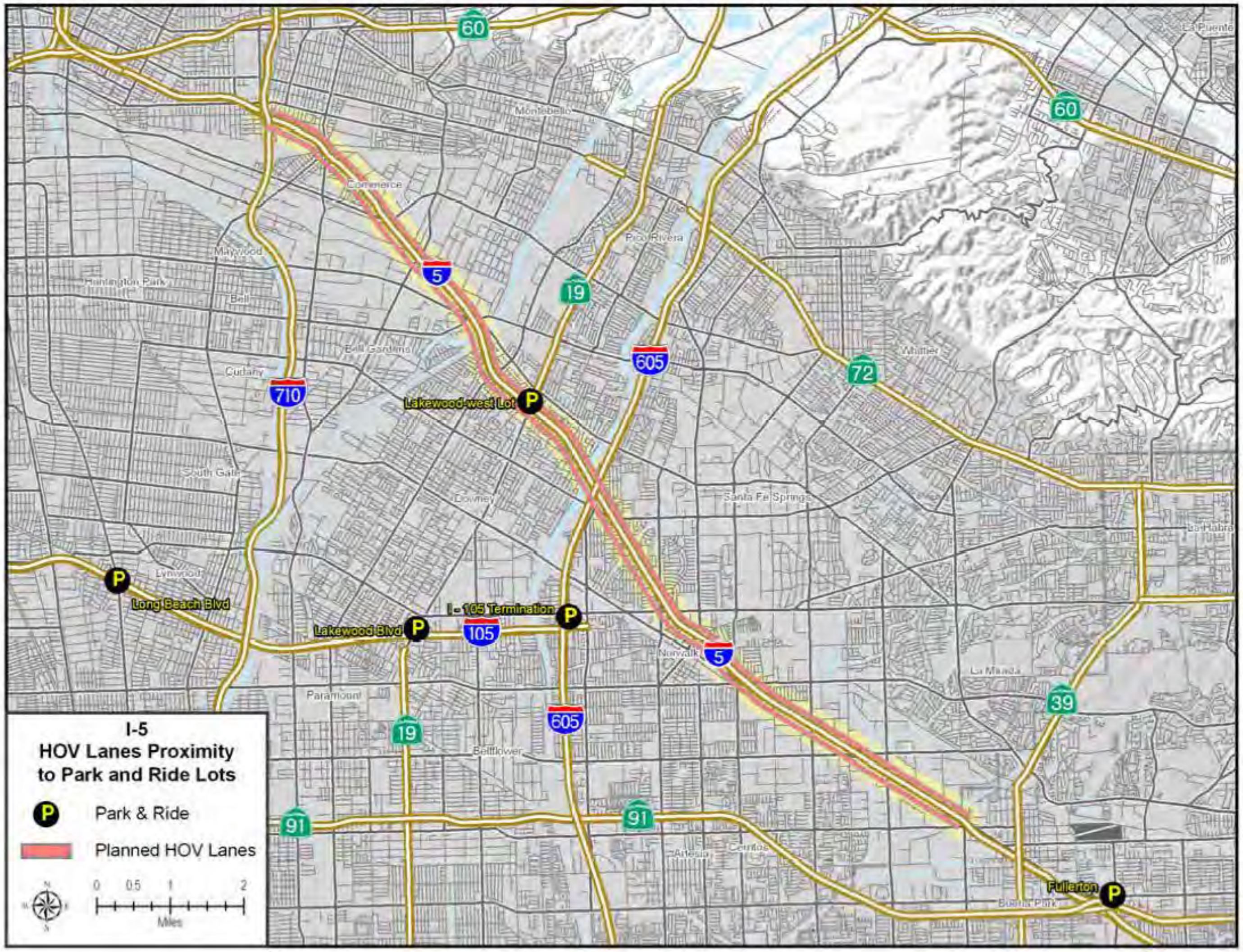
Source: Metrolink

Exhibit 2-7: Metro Services Near the I-5 South CSMP Corridor



Source: Metro

Exhibit 2-8: Park and Ride Facilities Near the I-5 South CSMP Corridor

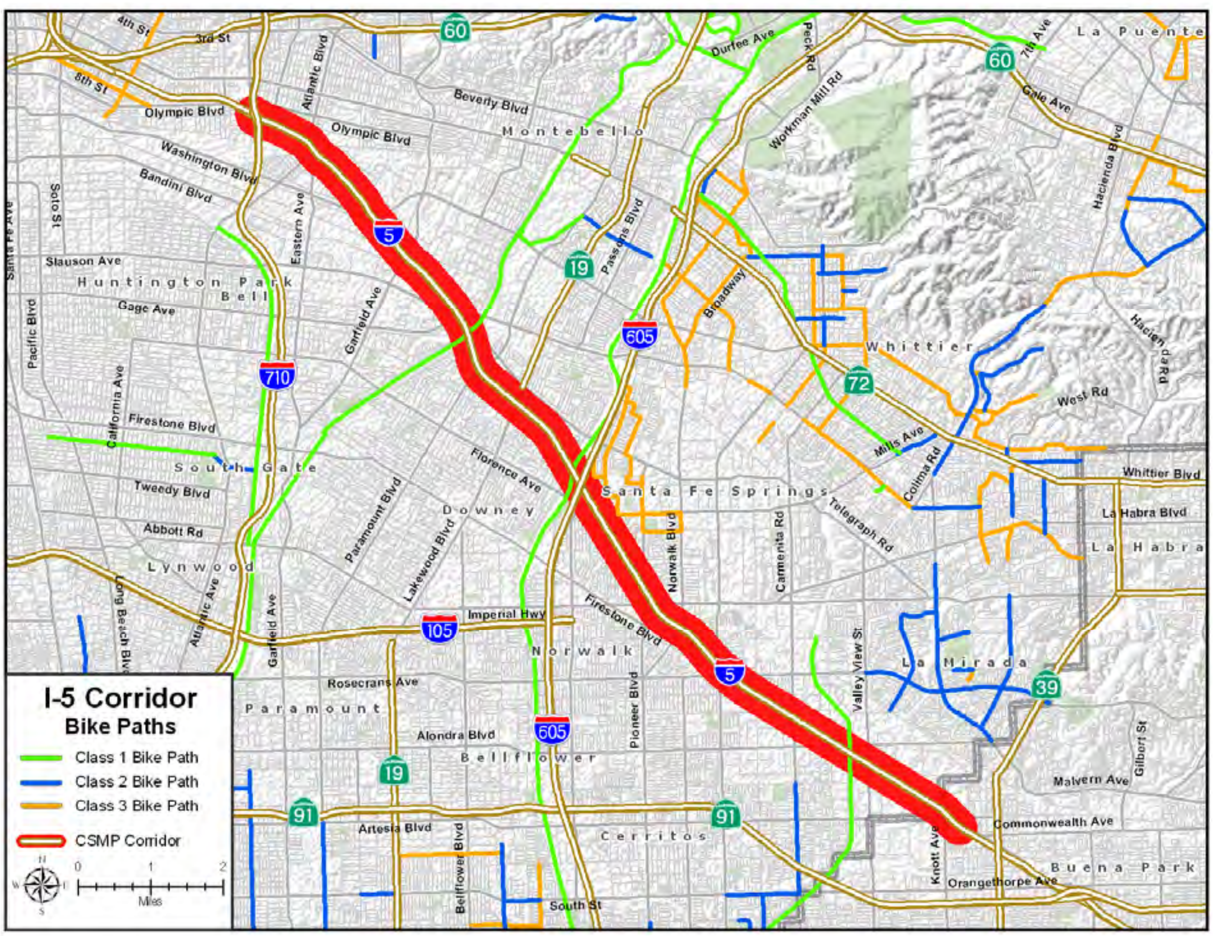


Bicycle Facilities

Few bicycle facilities are available near the study corridor. Class I bike paths run parallel to Valley View Street, I-605, and I-710, which intersect I-5. There are also various Class III bike paths in the City of Santa Fe Springs, just south of I-605. However, no bike path runs parallel to the study corridor. Exhibit 2-9 identifies the bike paths near the corridor and specifies the class of each path. There are three classes of bicycle facilities:

- Class I bike paths consist of a paved path within an exclusive right of way
- Class II bike lanes consist of signed and striped lanes within a street right of way,
- Class III bike routes are preferred routes on existing streets identified by signs only.

Exhibit 2-9: Bicycle Facilities Near the I-5 South CSMP Corridor



Special Event Facilities/Trip Generators

There are various facilities and institutions located along I-5 that may generate significant trips along the corridor. Downtown Los Angeles, other employment centers, and industrial warehouses are found along the corridor, as are the ports of Los Angeles and Long Beach further south. Exhibit 2-10 shows the location of the most significant traffic generators.

Dodger Stadium is the home of the Los Angeles Dodgers Major League Baseball team. The stadium has a seating capacity of approximately 56,000 and is adjacent to downtown Los Angeles, northwest of the I-5/SR-110 Interchange.

The Staples Center is a multi-purpose sports arena in Downtown Los Angeles. It is home to several professional sports franchises - the NBA's Los Angeles Lakers and Los Angeles Clippers, the NHL's Los Angeles Kings and the WNBA's Los Angeles Sparks. The arena is host to 250 events and nearly 4,000,000 visitors a year. It can seat up to 20,000 patrons for concerts and roughly 18,000 for sporting events. Staples Center is located approximately six miles northwest of the I-5/I-710 Interchange.

Biola University is a private Christian university offering Bachelors, Masters, and Doctorate degrees. It is located in the City of La Mirada, 1.5 miles east of I-5.
Cerritos College is a two-year community college located in the City of Norwalk, approximately three miles west of the I-5 and within the southern portion of the corridor. Many elementary, middle, and high schools near the I-5 Corridor may also influence morning and afternoon traffic.

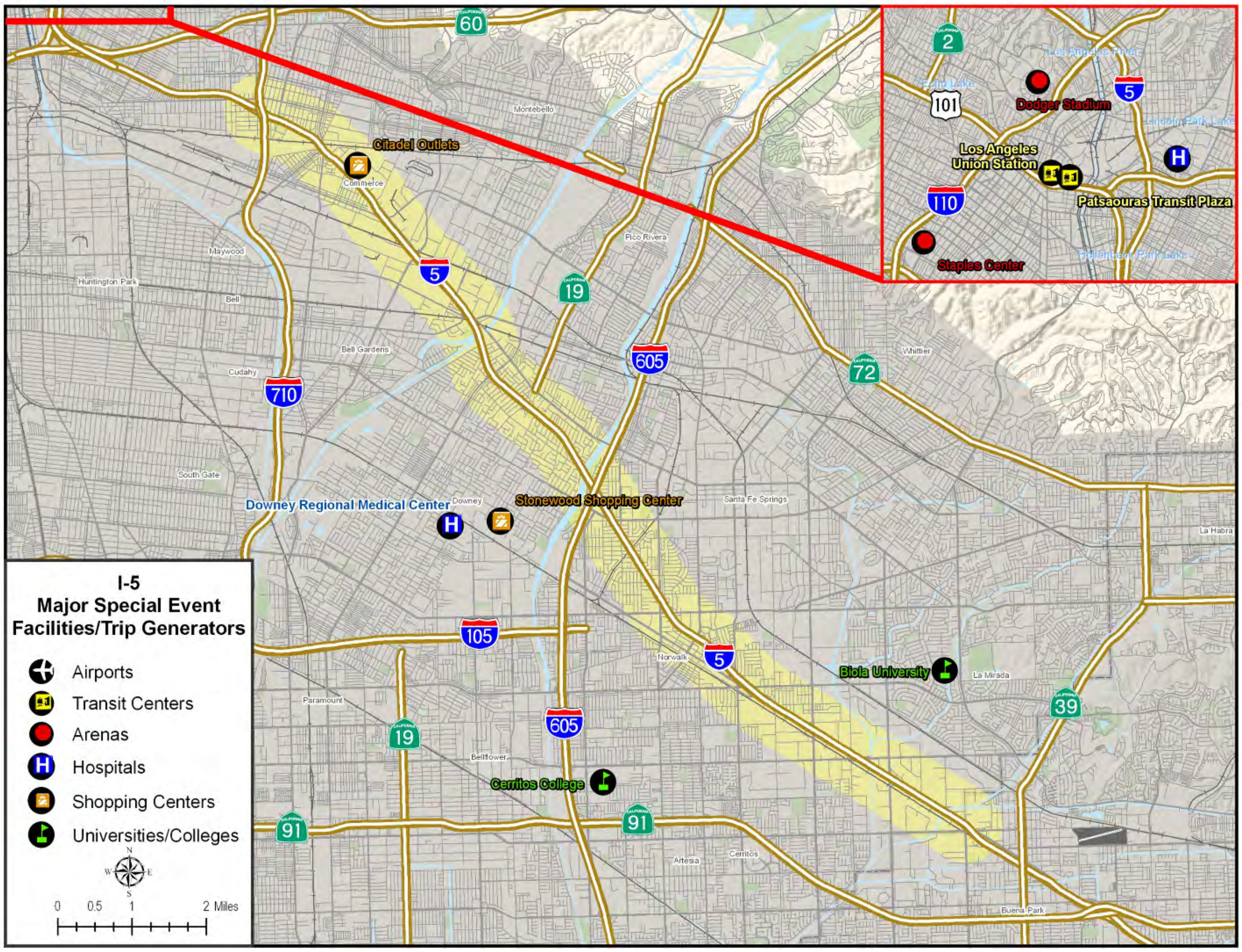
The Citadel Outlets, Los Angeles' only outlet center opened in November 1990 as a mixed-use project which includes a retail outlet center, a food court, five office buildings, and a 201-room Double Tree Hotel. It is located immediately west of I-5 in the City of Commerce. Stonewood Shopping Center is located in the City of Downey on Firestone Boulevard, west of I-5. It is comprises more than 170 shops, eateries, and department stores.

The Downey Regional Medical Center is a medical facility within close proximity to I-5. It is a 199-bed facility located approximately 1.5 miles west of the I-5 in Downey.

In addition to the facilities listed above, Los Angeles Union Station, located in downtown Los Angeles approximately one mile west of the I-5, is the terminus for four long-distance Amtrak trains. Union Station serves as the hub for Metrolink's passenger trains and provides connections to the Metro Red, Purple, and Gold light-rail lines. The Patsaouras Transit Plaza is attached to Union Station. It provides many bus services including regular Metro and Metro Rapid bus lines, downtown DASH shuttles, FlyAway express service to Los Angeles World Airports, and several other municipal bus lines.

A major generator for truck traffic is the Union Pacific and Burlington Northern Santa Fe Railway (BNSF) railroad yard near the I-710 and I-5 junction. Much of the freight traffic destined for the rail yard originates at the Ports of Long Beach and Los Angeles.

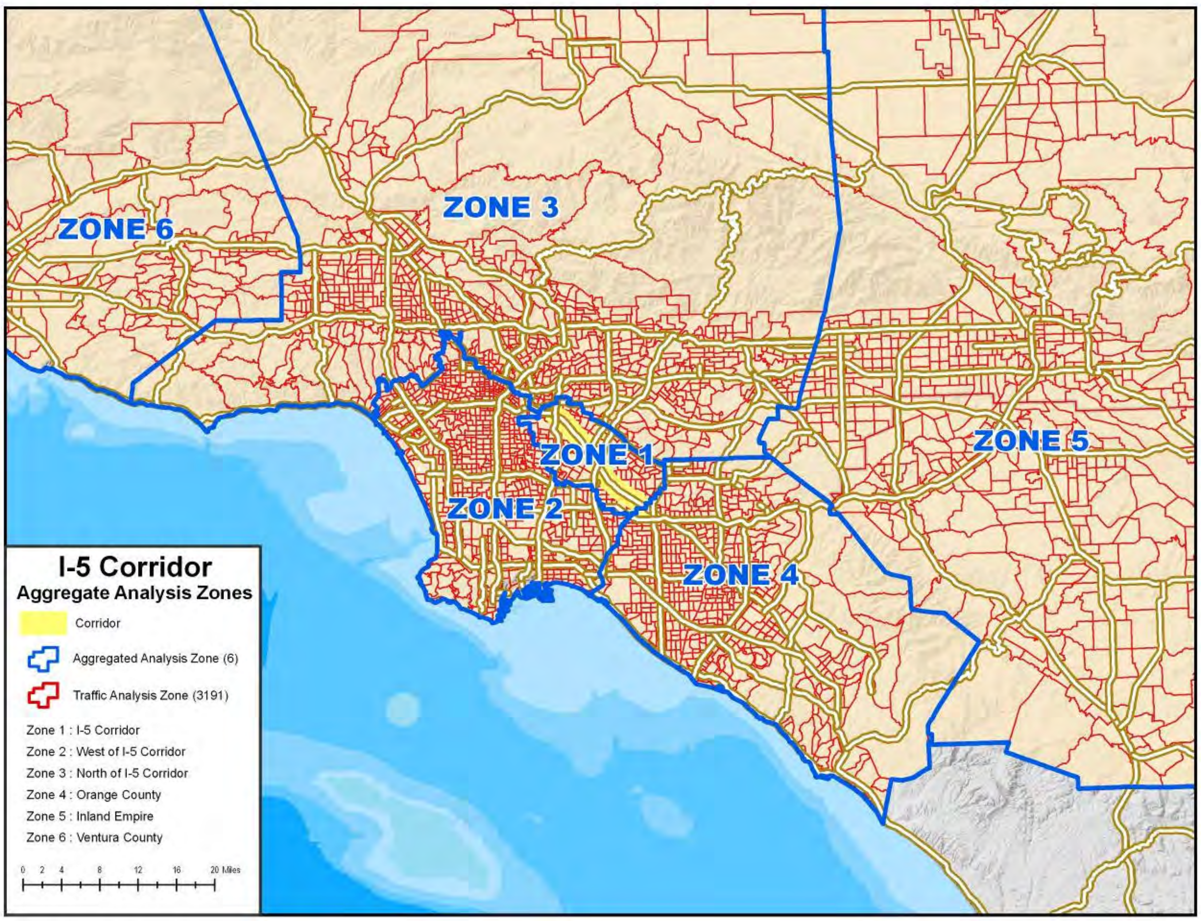
Exhibit 2-10: Major Special Event Facilities/Trip Generators



Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the I-5 South Corridor. Based on SCAG's 2000 travel demand model, this "select link analysis" isolated the I-5 South Corridor and identified the origins and destinations of trips made on the corridor. The origins and destinations were identified by Traffic Analysis Zone (TAZ), which were grouped into six aggregate analysis zones as shown in Exhibit 2-11. These zones were determined by county line and proximity to the corridor.

Exhibit 2-11: Aggregate Analysis Zones for I-5 South CSMP Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zone as shown on Exhibits 2-12 and 2-13 for the AM and PM peak periods. This analysis shows that a significant percentage of trips using the I-5 corridor represent inter-county trips. Approximately 60 percent of the trips either started or ended outside Los Angeles County.

During the AM peak period from 6:00 AM to 9:00 AM, about 40 percent of all trips originate and terminate in Los Angeles County (Zones 1, 2, or 3). The remaining trips originate in Los Angeles County and terminate in another county (23 percent), originate outside Los Angeles County and terminate in Los Angeles County (24 percent), or originate and terminate outside Los Angeles County (13 percent).

Exhibit 2-12: AM Peak Origin Destination by Aggregated Analysis Zone

		To Zone						
	AM Trips	I-5 Corridor (South)	West of I-5 Corridor	North of I-5 Corridor	Orange County	Inland Empire	Ventura County	Outsize Zones
From Zone	I-5 Corridor (South)	57	1,414	718	552	677	18	28
	West of I-5 Corridor	987	14,804	10,427	4,137	8,429	914	901
	North of I-5 Corridor	573	10,449	7,089	4,180	6,245	529	408
	Orange County	411	5,891	4,289	178	3,361	391	564
	Inland Empire	451	8,352	6,348	2,361	4,823	591	464
	Ventura County	6	943	582	398	591	0	61
	Outsize Zones	11	401	194	175	190	30	840

~ 40%	Trips starting and ending in Los Angeles County
~ 23%	Trips starting in Los Angeles County and ending outside of Los Angeles County
~ 24%	Trips starting outside of Los Angeles County and ending in Los Angeles County
~ 13%	Trips starting and ending outside of Los Angeles County

During the PM peak period from 3:00 to 7:00 PM (which experiences about 32 percent more demand than the AM peak period), the picture is similar. Roughly 39 percent of trips originate and terminate in Los Angeles County. The remaining trips originate in Los Angeles County and terminate in another county (24 percent), originate outside Los Angeles County and terminate in Los Angeles County (24 percent), or originate and terminate outside Los Angeles County (14 percent).

Exhibit 2-13: PM Peak Origin Destination by Aggregated Analysis Zone

		To Zone						
	PM Trips	I-5 Corridor (South)	West of I-5 Corridor	North of I-5 Corridor	Orange County	Inland Empire	Ventura County	Outsize Zones
From Zone	I-5 Corridor (South)	101	1,535	835	663	730	21	29
	West of I-5 Corridor	1,819	21,173	15,096	7,897	12,137	1,411	947
	North of I-5 Corridor	1,061	14,587	10,206	6,805	9,029	880	463
	Orange County	716	7,179	6,251	432	4,116	651	501
	Inland Empire	913	12,006	8,917	4,969	7,146	945	501
	Ventura County	26	1,416	849	699	850	0	78
	Outsize Zones	34	1,587	550	1,104	775	55	1,265

~ 39%	Trips starting and ending in Los Angeles County
~ 24%	Trips starting in Los Angeles County and ending outside of Los Angeles County
~ 24%	Trips starting outside of Los Angeles County and ending in Los Angeles County
~ 14%	Trips starting and ending outside of Los Angeles County

3. CORRIDOR PERFORMANCE ASSESSMENT

This section summarizes the performance measures used to evaluate the existing conditions of the I-5 Corridor. The measures provide a technical basis to describe traffic performance on I-5 and were used to calibrate the micro-simulation model.

Before discussing the performance measures, this section describes the quality of the data used in the analysis. This was done to ensure that the automatic sensor data used for the analysis was sufficiently reliable.

Following the data quality discussion, four key performance areas are discussed in detail: mobility, reliability, safety, and productivity. The section also has information on the structural adequacy and ride quality of the pavement along the corridor.

A. Data Sources and Detection

The existing available data analyzed for the I-5 Corridor included the following sources:

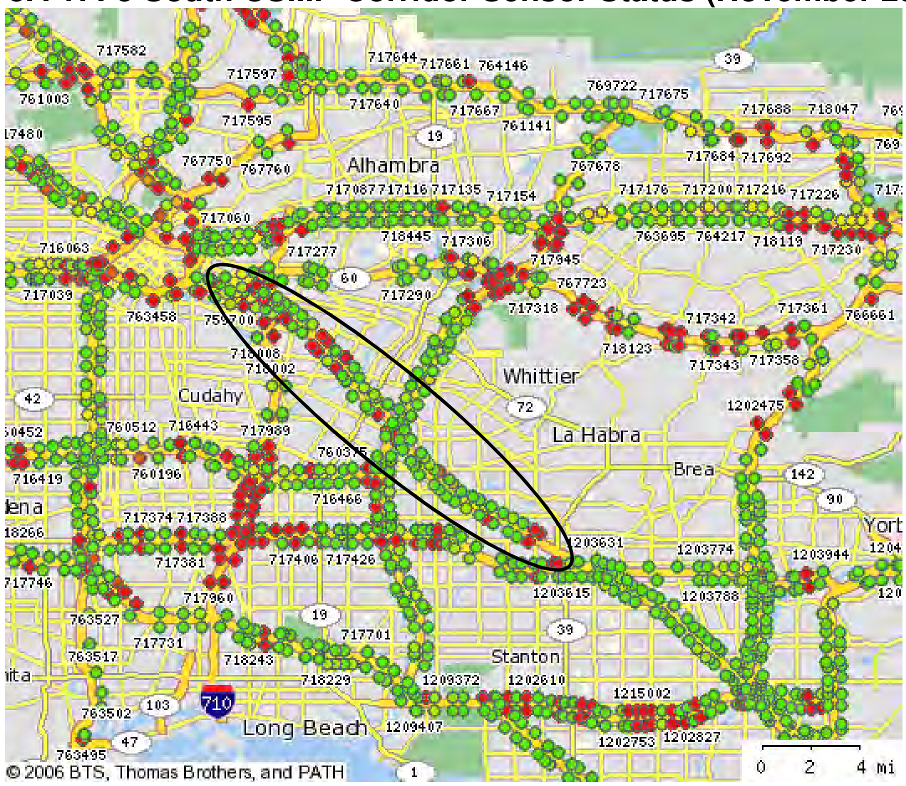
- Caltrans Highway Congestion Monitoring Program (HICOMP) report and data files (2004 - 2007)
- Caltrans Freeway detector data
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS) from PeMS
- Traffic study reports (various)
- Aerial photographs (Microsoft Virtual Earth and Google Earth) and Caltrans photologs
- Internet (i.e. Metro website, Metrolink website, etc.).

Numerous documents describe these data sources, so they are not discussed in detail in this report. However, given the need for comprehensive and continuous monitoring and evaluation, detection coverage and quality are discussed in more detail below.

Freeway Detection Status

Exhibit 3A-1 depicts the corridor freeway facility with the detectors in place as of November 25, 2008. This date was chosen randomly to provide a snapshot of the detection status. The exhibit shows that there are many detectors on the mainline, almost all functioning well (based on the green color). Furthermore, it illustrates some seemingly small gaps between detectors at some locations.

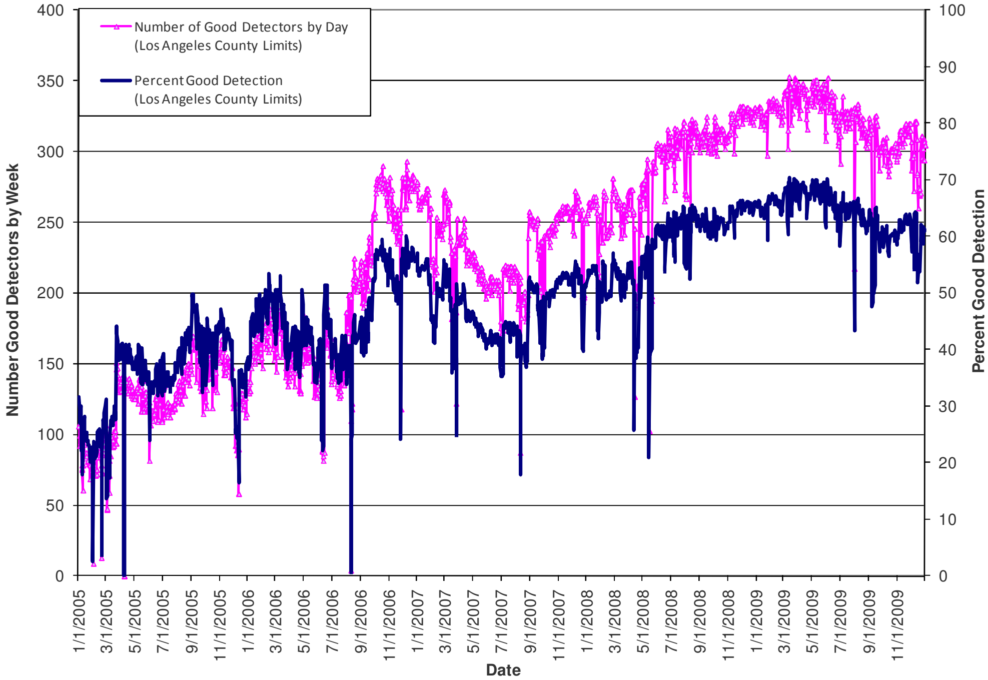
Exhibit 3A-1: I-5 South CSMP Corridor Sensor Status (November 25, 2008)



Source: Caltrans detector data

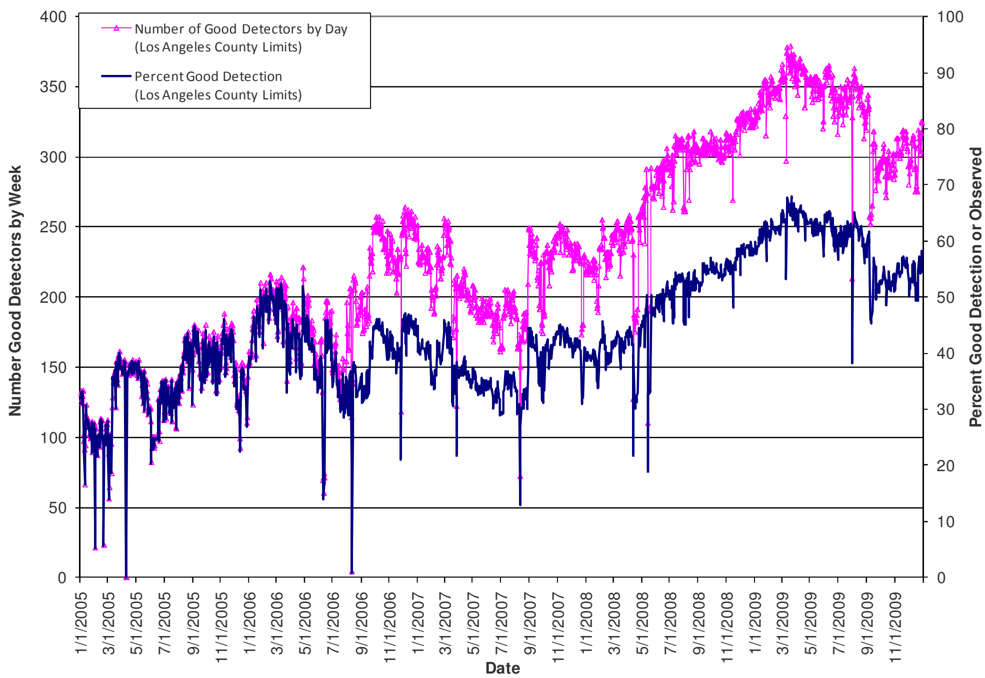
The following exhibits provide a better picture of how the detectors on the corridor performed over a longer period of time. Exhibits 3A-2 and 3A-3 report the number and percentage of "good" detectors by week for all of I-5 in Los Angeles County from 2005 to 2009. The left y-axis shows the scale used for the number of detectors, while the right y-axis shows the scale used for the percent good detectors. These exhibits suggest that detection in the northbound direction (Exhibit 3A-2) was slightly better than the southbound direction (Exhibit 3A-3), particularly in 2007 and 2008 when the percentage of good detectors in the northbound direction reported around 50 percent compared to 40 percent in the southbound direction. However, 2009 shows a significant increase in percentage of good detections for both directions, where the northbound direction slightly exceeds the southbound direction with 64 percent compared to 60 percent for the northbound direction.

Exhibit 3A-2: Amount of Good Detection on Northbound I-5 (All Los Angeles County)



Source: Caltrans detector data

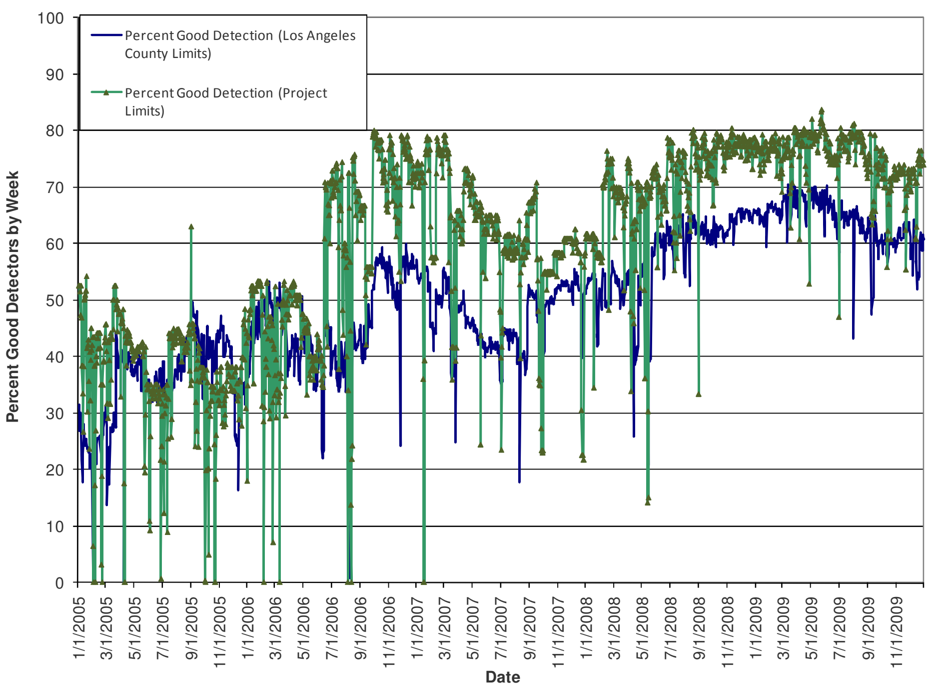
Exhibit 3A-3: Amount of Good Detection on Southbound I-5 (All Los Angeles County)



Source: Caltrans detector data

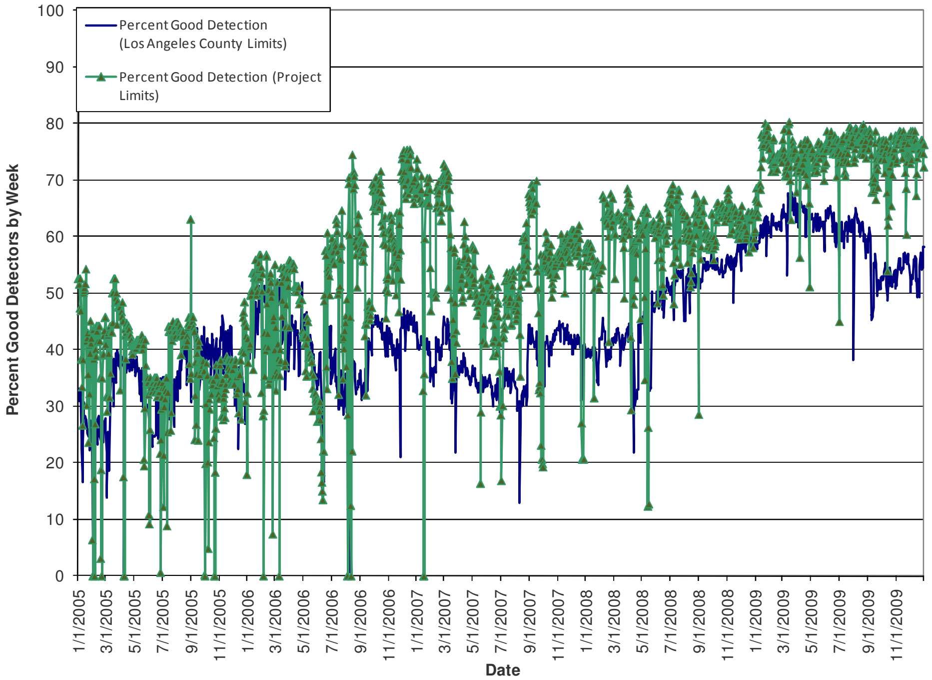
Exhibits 3A-4 and 3A-5 isolate the I-5 South CSMP Corridor (in green) and reports the percentage of good detectors within the I-5 corridor limits compared to all of LA County (in blue). As the exhibits illustrate, the I-5 South CSMP Corridor has better detection in both directions relative to the freeway as a whole (in LA County). As for the countywide statistics reported in the previous exhibits, the northbound direction (Exhibit 3A-4) of the study corridor exhibited greater detection compared to the southbound direction (Exhibit 3A-5). The detection on the study corridor generally improved between 2005 and 2009, reaching 84 percent in the northbound direction and 80 percent in the southbound direction.

Exhibit 3A-4: Amount of Good Detection on Northbound I-5 (I-5 South CSMP Corridor)



Source: Caltrans detector data

Exhibit 3A-5: Amount of Good Detection on Southbound I-5 (I-5 South CSMP Corridor)



Source: Caltrans detector data

An analysis of gaps without detection is shown in Exhibit 3A-6. Note that there is one segment in each direction extending over 0.75 miles without detection. These should be considered for deployment of additional detection when funding becomes available.

Exhibit 3A-6: I-5 Gaps In Detection (September 2010)

Location	Abs PM		Length (Miles)
	From	To	
NORTHBOUND			
SB 605 to NB 5 to Garnish (ML)	123.63	124.43	0.80
SOUTHBOUND			
SB 605 to NB 5 to Garnish	123.60	124.37	0.77

Source: Caltrans detector data

B. Corridor Performance Assessment

The I-5 South CSMP focuses on four categories of performance measures:

- *Mobility* describes how quickly people and freight move along the corridor.
- *Reliability* captures the relative predictability of travel time along the corridor.
- *Safety* provides an overview of collisions along the corridor.
- *Productivity* quantifies the degree to which traffic inefficiencies at bottlenecks or hot spots reduce flow rates along the corridor

MOBILITY

Mobility describes how well the corridor moves people and freight. The mobility performance measures are both readily measurable and straightforward for documenting current conditions and are readily forecasted making them useful for future comparisons. Two primary measures are typically used to quantify mobility: delay and travel time.

Delay

Delay is defined as the total observed travel time less the travel time under non-congested conditions, and is reported as vehicle-hours of delay. Delay can be computed for severe congested conditions using the following formula:

$$(\text{Vehicles Affected per Hour})\times(Dis\tan ce)\times(Duration)\times\left[\frac{1}{(\text{Congested Speed})}-\frac{1}{\text{35mph}}\right]$$

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 2,000 vehicles per hour per lane), while others use a measured or estimated flow rate. The distance is the length under which the congested speed prevails and the duration is the hours of congestion experience below the threshold speed.

The threshold speed can also vary. In general, the threshold speed represents free-flow or some other pre-defined speed. In this CSMP analysis, 60 mph is considered free-flow speed for the corridor, and will be used to calculate delay.

Different reports and studies use other threshold speeds, typically 35 mph (e.g., HICOMP), which is defined here as the “severe congestion” speed threshold, and 45 mph (Federal Highway Administration threshold to define HOV degradation).

The HICOMP annual report discussed in the following section uses the 35 mph threshold speed and assumes 2,000 vehicles per hour per lane as the throughput threshold. HICOMP therefore reports on severe delay, while the automatic detector data uses 60 mph and the reported number of vehicles reported by the detectors. Each of these two sources is discussed separately since their results are extremely difficult to compare because of methodological and data collection differences.

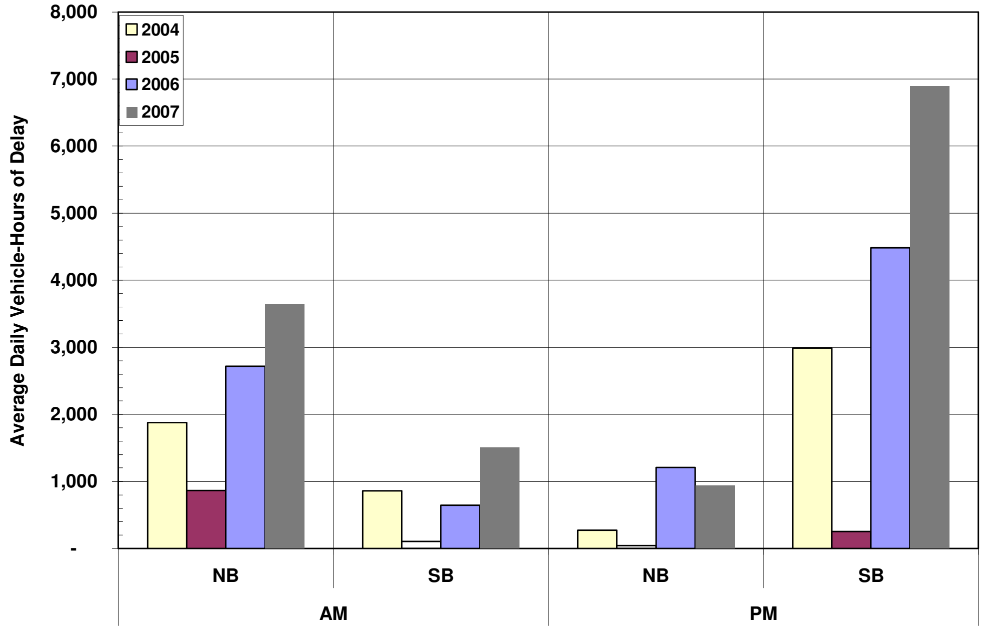
Caltrans HICOMP

The Caltrans Highway Congestion Monitoring Program (HICOMP) report has been published annually by Caltrans since 1987. Delay is presented as average daily vehicle-hours of delay (DVHD). The HICOMP defines delay as travel time in excess of free flow travel time when speeds dip below 35 mph for 15 minutes or longer.

For the HICOMP report, probe vehicle runs are performed only one to four days during the entire year for the mainline facility only. Ideally, two days of data collection in the spring and two in the fall of the year are desired, but resource constraints may affect the number of runs performed during a given year. As will be discussed later in this section when discussing the automatic detector data, congestion levels vary from day to day and depend on any number of factors including accidents, weather, and special events, the price of gasoline, and construction activities.

Exhibit 3B-1 shows yearly delay trends from 2004 through 2007 for the AM and PM peak travel period along the I-5 Corridor in both directions. As shown in Exhibit 3B-1, northbound traffic experienced the most significant congestion during the AM peak period, while southbound traffic experienced the most congestion during the PM peak period. Delay during these peak periods increased sizably from 2006 to 2007. The significant drop in delay shown for 2005 may reflect limited data available due to poor detection, rather than an actual decrease in congestion.

Exhibit 3B-1: HICOMP Average Daily Vehicle-Hours of Delay (2004-2007)



Source: 2004-2007 HICOMP Reports

Exhibit 3B-2 lists all of the congested segments shown in the last four HICOMP reports for the I-5 South Corridor. As the exhibit illustrates, the length of the congested segments vary from one year to the next.

Exhibit 3B-2: HICOMP Congested Segments (2004-2007)

Period	Dir	CA PM From/To	Generalized Congested Area	Generalized Area Congested Average Vehicle Hours of Delay 2004	2005	2006	2007
AM	NB	0.0/1.5	LA/Orange County Line to Alondra Bl		80	86	
		0.4/2.4	n/o Artesia Blvd to Carmentia Blvd				112
		2.4/5.4	Carmentia Rd to Pioneer Blvd				1,533
		2.4/5.9	Carmenita Rd to Orr and Day Rd			1,827	
		3.5/10.5	Rosecrans Ave to Telegraph/Garfield		787		
		3.5/11.5	Rosecrans Ave to Washington Bl	1,877			
		5.4/10.4	Pioneer Blvd to s/o Slauson Ave				1,208
		5.9/10.4	Orr and Day Rd to Greenwood			803	
		12.4/15.4	s/o Lorena St to s/o Atlantic Blvd				793
	SB	10.0/2.5	Slauson Av/Gage Av Ave to Carmenita Rd	859			
		6.9/4.4	I-605 to Norwalk Blvd				346
		6.4/0.0	Florence Ave to Los Angeles/Orange County Line			645	
		6.0/2.0	Florence Ave to Carmenita Dr		105		
		4.4/0.4	Norwalk Blvd to Artesia Blvd				1,161
AM PEAK PERIOD SUMMARY				2,736	972	3,360	5,153
PM	NB	0.0/1.5	LA/Orange County Line to Alondra Bl		40	149	
		0/2.4	Commonwealth Ave to Carmenita Rd				300
		2.4/5.4	Carmenita Rd to Pioneer Blvd				638
		2.4/5.9	Carmenita Rd to Orr and Day Rd			1,057	
		3.5/9.5	Rosecrans Ave to Rio Hondo River	103			
		9.5/18.5	Rio Hondo River to north of State St	167			
	SB	18.0/9.5	Brooklyn Ave to Rio Hondo River	2,553			
		17.9/10.9	Cesar E Chavez Ave to Garfield Ave				3,375
		17.9/9.4	Brooklyn Ave to Rio Hondo River			2,591	
		10.4/7.4	s/o Garfield Ave to n/o I-605				357
		9.5/2.5	Rio Hondo River to Carmenita Dr	436			
		9.4/7.4	Rio Hondo to Lemoran Ave			132	
		6.9/2.4	I-605 to Carmenita Rd			1,130	
		6.9/0	I-605 to Commonwealth Ave				3,159
		5.5/1.5	Pioneer Bl to Alondra Bl		254		
		2.4/0.4	Carmenita Rd to Artesia Ave			631	
PM PEAK PERIOD SUMMARY				3,261	294	5,689	7,829
TOTAL CORRIDOR CONGESTION				**5,996**	**1,266**	**9,048**	**12,982**

According to Exhibit 3B-2, the most congested segment during the AM peak period was from Rosecrans Avenue to Washington Boulevard. While delay on this segment decreased in 2005, it increased slightly to above 2004 levels in 2006 (when both portions are considered). Congestion is slightly lower in 2007. During the PM peak period, the most congested segment was from Brooklyn Avenue to the Rio Hondo River. Delay dropped significantly in 2005, while in 2006 it was similar to the delay experienced in 2004. In 2007, the delay was even greater, while the congested area was a mile shorter. The decrease in delay in 2005 may have been due to a lack of good detector data in 2005 as well as decreases in the number of accidents.

Exhibits 3B-3 and 3B-4 present the congestion information in map form for the AM and PM peak commute periods in 2007. The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown. More "generalized" congested segments were created so that segment comparisons can be made from one year to the next.

Exhibit 3B-3: HICOMP Congested Segments Map - AM Peak Period (2007)

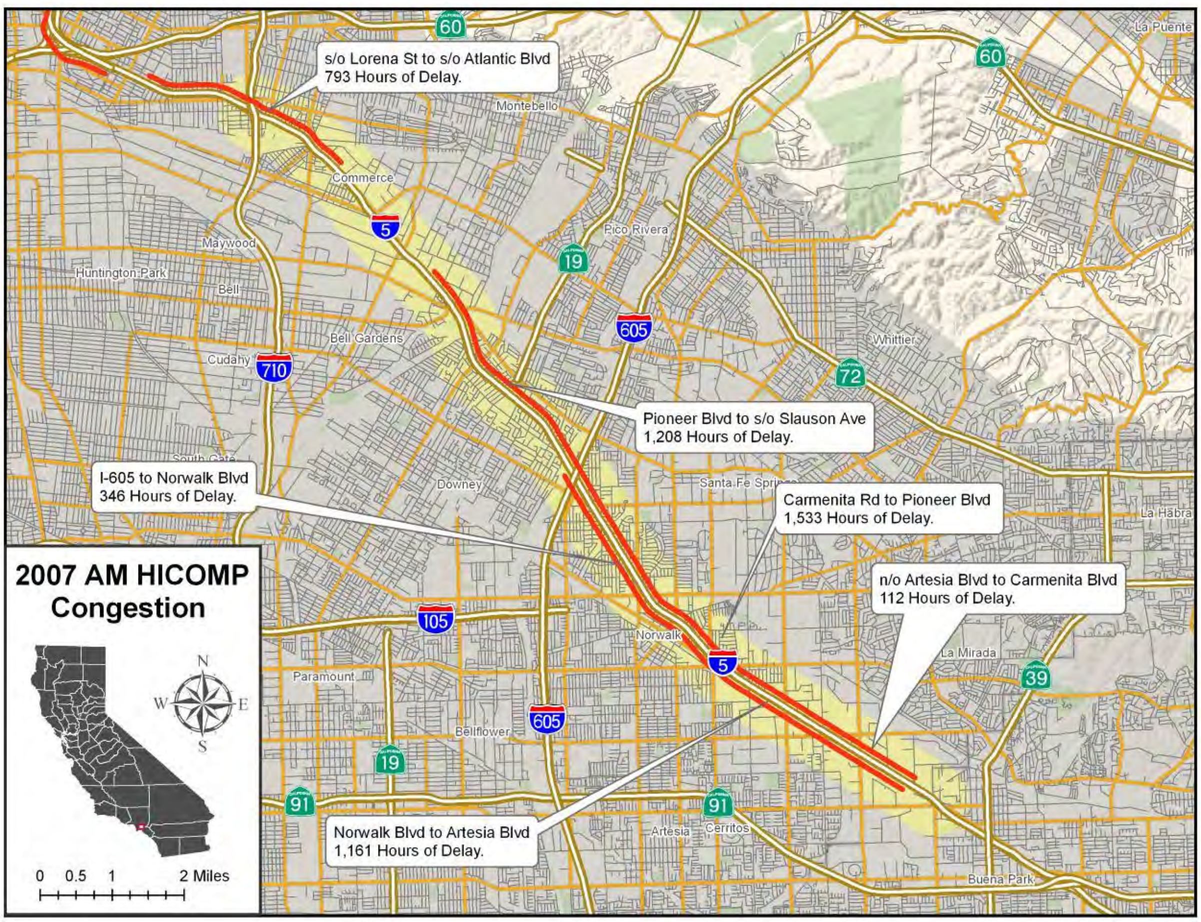
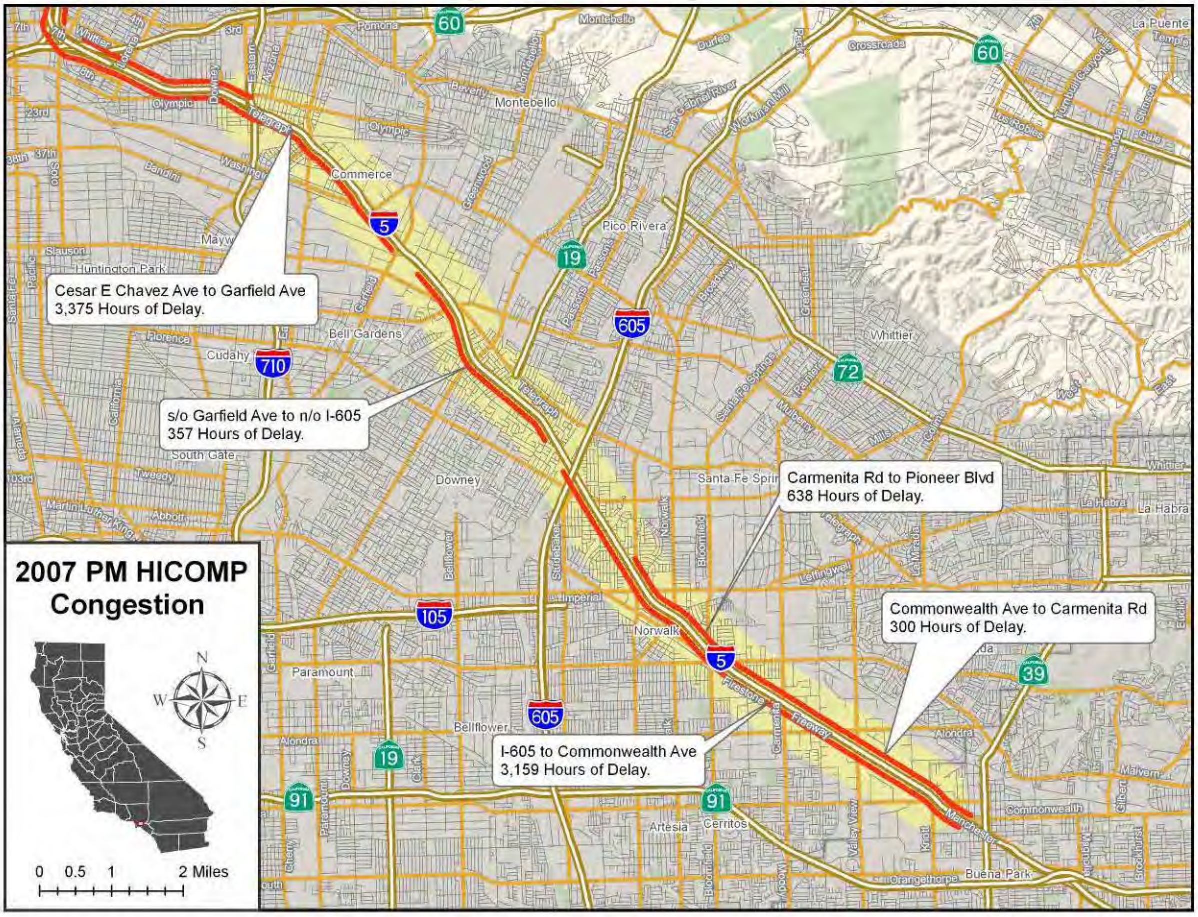


Exhibit 3B-4: HICOMP Congested Segments Map - PM Peak Period (2007)



Automatic Detector Data

Using freeways detector data, delay is computed for every day and summarized in different ways, which is not possible when using probe vehicle data.

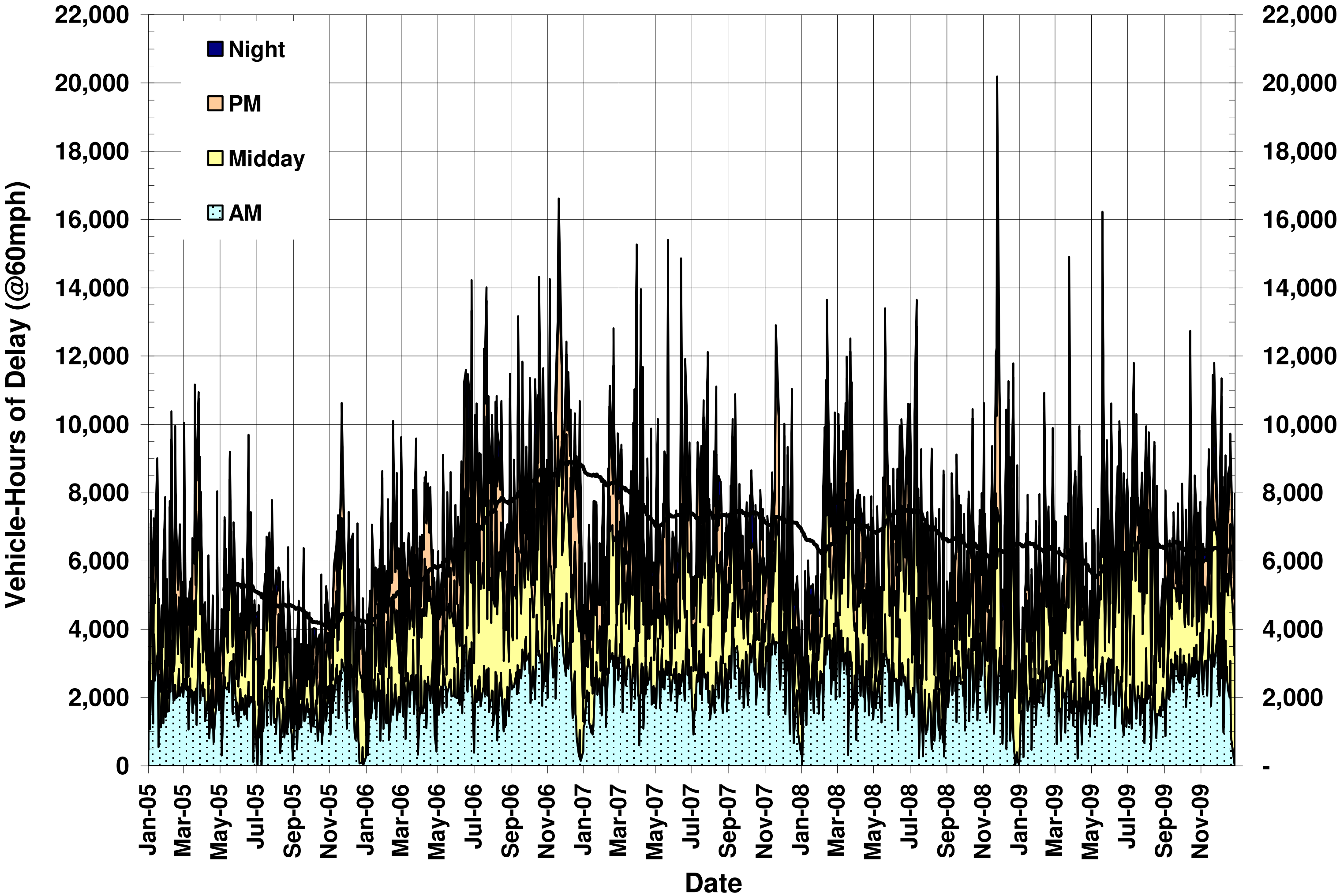
Performance assessments were initially conducted for the three-year period between 2005 and 2007. These assessments were recently updated through December 2009. The performance assessment includes five years of automatic detector data. Unlike HICOMP where delay is only considered and captured for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delay presented in this section represent the difference in travel time between actual conditions and free-flow conditions at 60 miles per hour, applied to the actual output flow volume collected from a vehicle detector station.

Exhibits 3B-5 and 3B-6 show the five-year trend in weekday (i.e., excluding weekends and holidays) delay for the entire corridor in the northbound and southbound directions respectively. The exhibits also show a 90-day moving average that reduces the day-to-day variations and more easily illustrates the seasonal and annual changes in congestion over time.

As illustrated in Exhibit 3B-5, delay in the northbound direction was concentrated in the AM peak period, followed by the Midday period. The exhibit shows a trend consistent with the HICOMP report table - delay levels increased in 2006. As described earlier, the drop in 2005 could be due to less detection data available. In 2007 to 2009, total delay remained steady between 6,000 and 8,000 vehicle-hours.

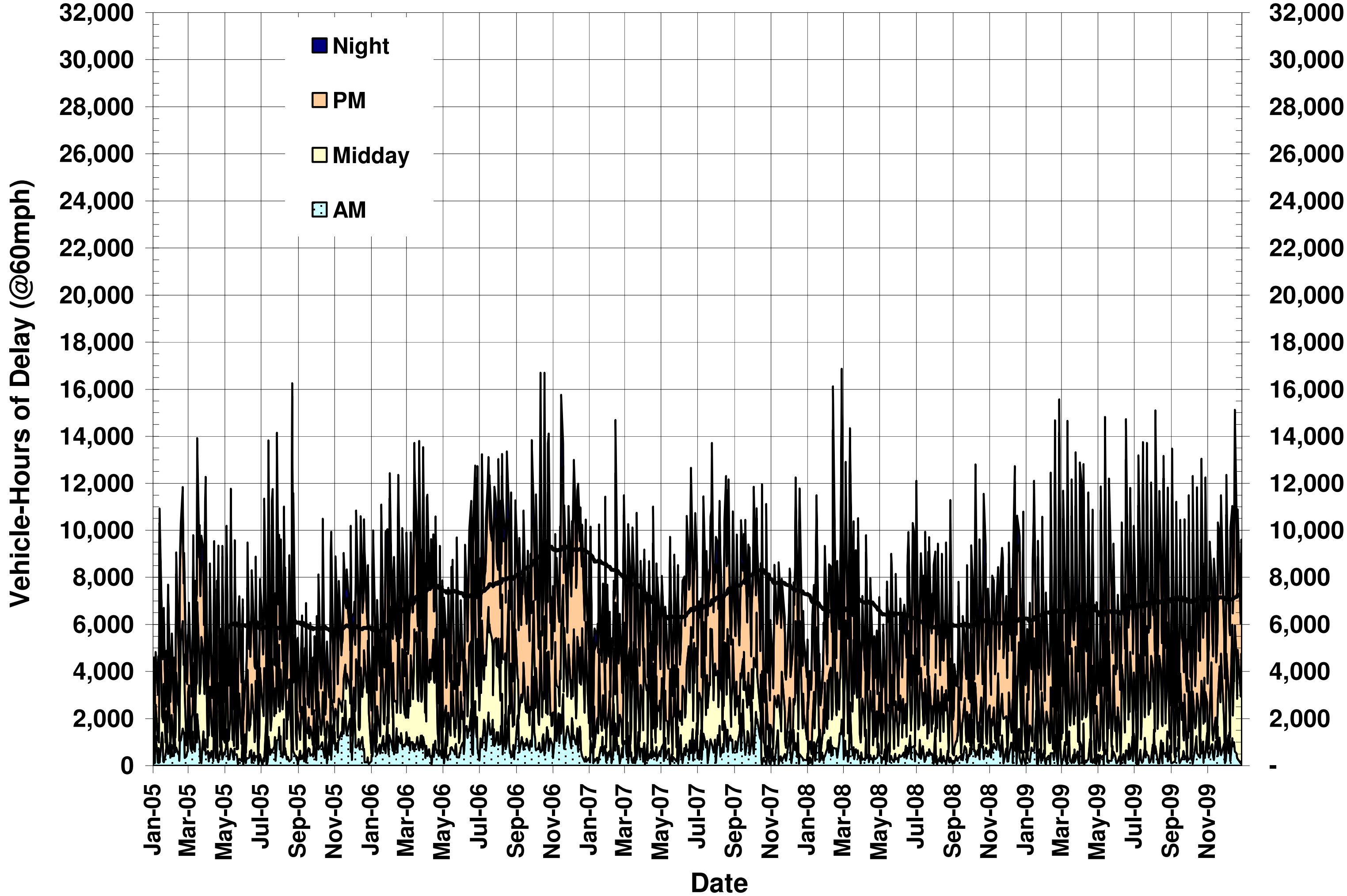
Delay in the southbound direction revealed an opposite trend from the northbound direction with delay concentrated in the PM peak instead of the AM peak. This suggests a directional commute patterns towards downtown Los Angeles. As shown in Exhibit 3B-6, the majority of delay in the southbound direction occurred during the PM peak. Delay in the southbound direction followed the same pattern as the northbound direction with an increase in delay in 2006, followed by a decline in early 2007, a steady flattening in 2008, and a slight increase in 2009. In 2008 and 2009, total delay in the southbound direction hovered between 6,000 and 8,000 vehicle-hours.

Exhibit 3B-5: Northbound I-5 Average Daily Delay by Time Period (2005-2009)



Source: Caltrans detector data

Exhibit 3B-6: Southbound I-5 Average Daily Delay by Time Period (2005-2009)

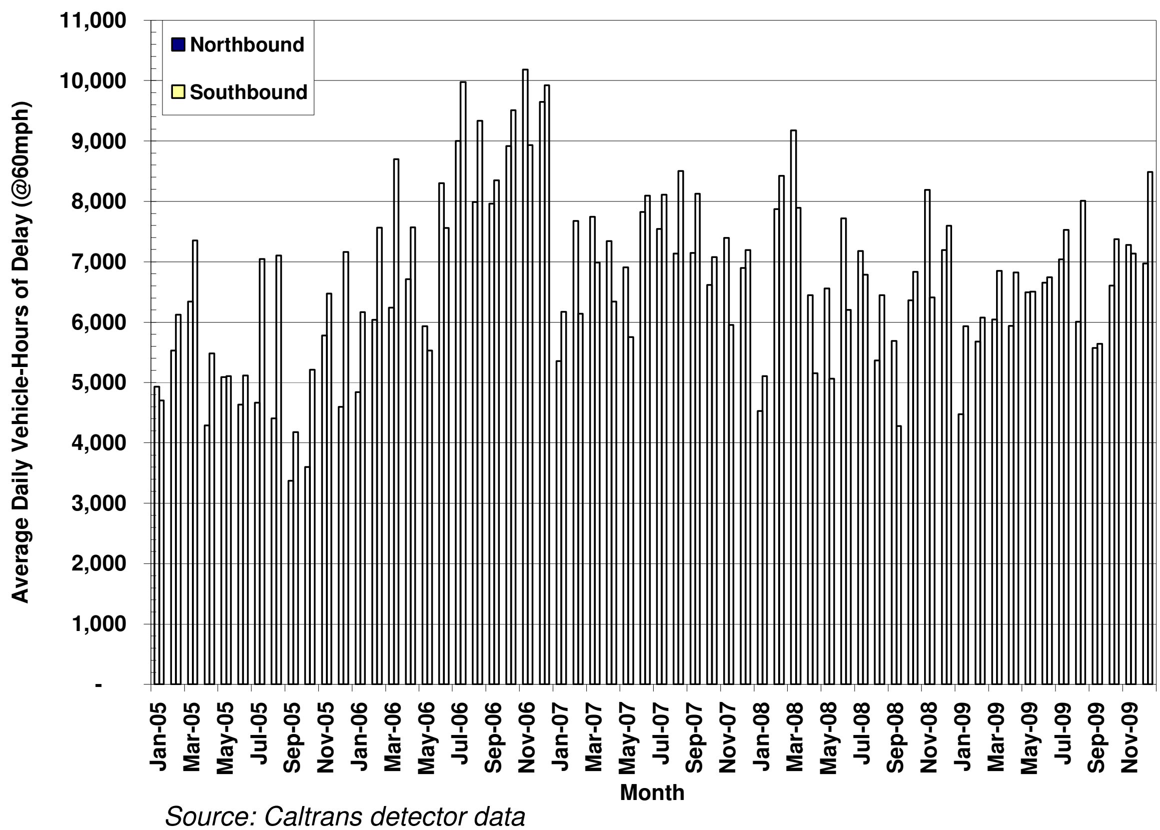


Source: Caltrans detector data

Exhibit 3B-7 shows the average weekday daily vehicle-hours of delay for each month between 2005 and 2009 for the I-5 South Corridor. These figures exclude weekends and holidays. This exhibit reveals the following delay trends:

- Congestion on the corridor increased from 2005 to 2006, which was probably due to economic growth in the region and the country. In 2007, however, delay decreased and leveled off, most likely due to the global financial meltdown and the associated recession. By the end of 2009, congestion levels still had not reached 2006 levels.
- Delay was lower during the winter months and was highest in 2006.
- In 2005 and 2006, southbound delay was worse than northbound delay almost every month. However, starting in 2007, northbound delay reached the southbound levels.

Exhibit 3B-7: I-5 Average Weekday Delay by Month (2005-2009)



Source: Caltrans detector data

Delay presented to this point represents the difference in travel time between "actual" conditions and free-flow conditions at 60 miles per hour. This delay can be separated into two components as shown in Exhibit 3B-8:

- Severe delay – delay occurring when speeds are below 35 miles per hour
- Other delay – delay occurring when speeds are between 35 and 60 miles per hour.

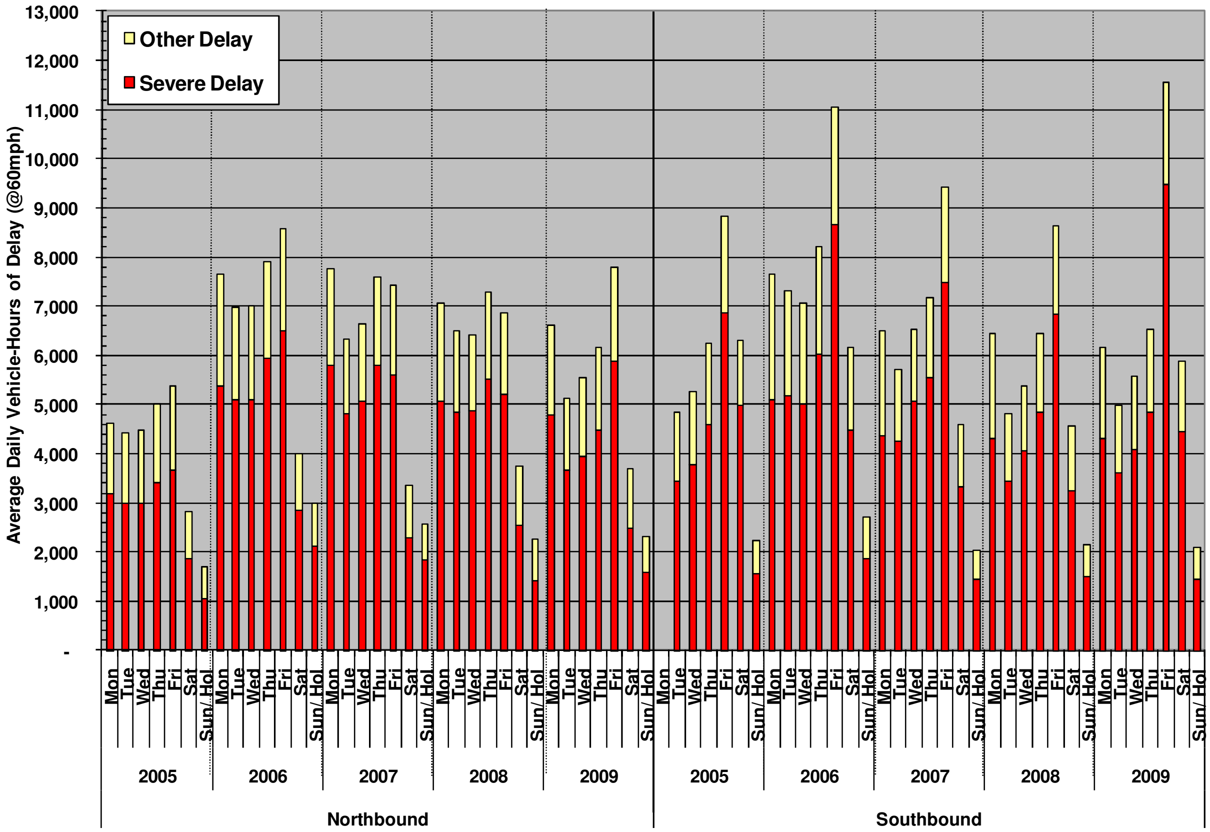
Severe delay in Exhibit 3B-8 represents breakdown conditions and is the focus of most congestion mitigation strategies. "Other" delay represents conditions approaching the breakdown congestion, leaving the breakdown conditions, or areas that cause temporary slowdowns rather than widespread breakdowns.

Exhibit 3B-8 shows average severe and other daily vehicle-hours of delay by day of the week. As depicted in the exhibit:

- Severe delay makes up about 70 percent of all weekday delay on the corridor in either the northbound or the southbound directions.
- Fridays in the southbound direction generally experience the highest delays, probably due to weekend travel. The second highest delays generally occur on Thursdays.
- Delay was highest in 2006 when southbound delay tended to be greater in magnitude than northbound delay.

Although combating congestion requires the focus on severe congestion, it is important to review "other" congestion and understand its trends. This could allow for proactive intervention before the "other" congestion turns into severe congestion.

Exhibit 3B-8: I-5 Average Delay by Day of Week by Severity (2005-2009)



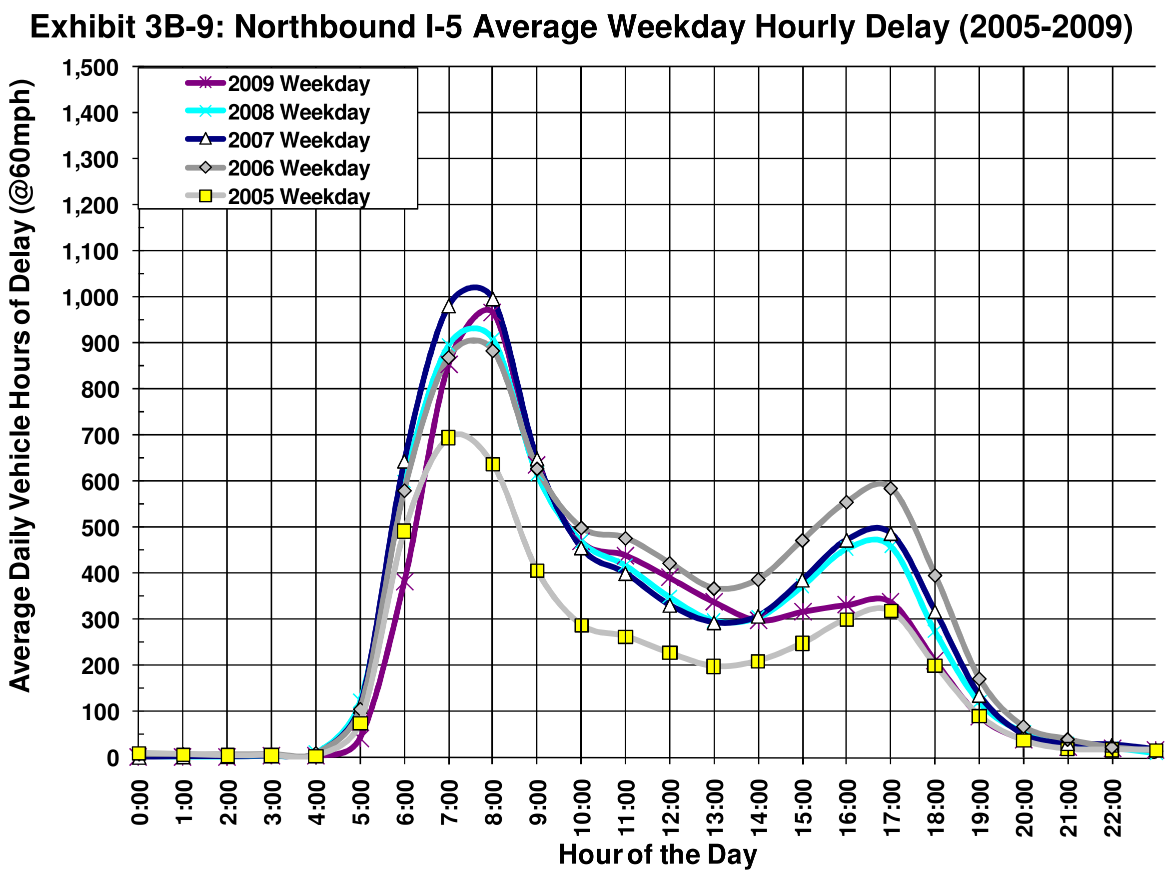
Source: Caltrans detector data

Another way to understand the characteristics of congestion and related delays is to examine average weekday delays by hour. Exhibits 3B-9 and 3B-10 summarize average weekday hourly delay for each year over a five-year period from 2005 to 2009. Each point represents the total delay for the hour. For example, the 7:00 AM point is the sum of delay from 7:00 AM to 8:00 AM. The exhibits show the peaking characteristics of congestion and how the peak period changes over time.

The corridor is highly directional with the northbound freeway experiencing significant delay during the AM peak and the southbound freeway experiencing significant delay during the PM peak. The delay spike for the AM peak period occurs between 7:00 AM and 9:00 AM, while the delay spike for the PM peak period occurs between 5:00 PM and 6:00 PM. This type of directionality is typical for an urban corridor serving many work trips during the peak period.

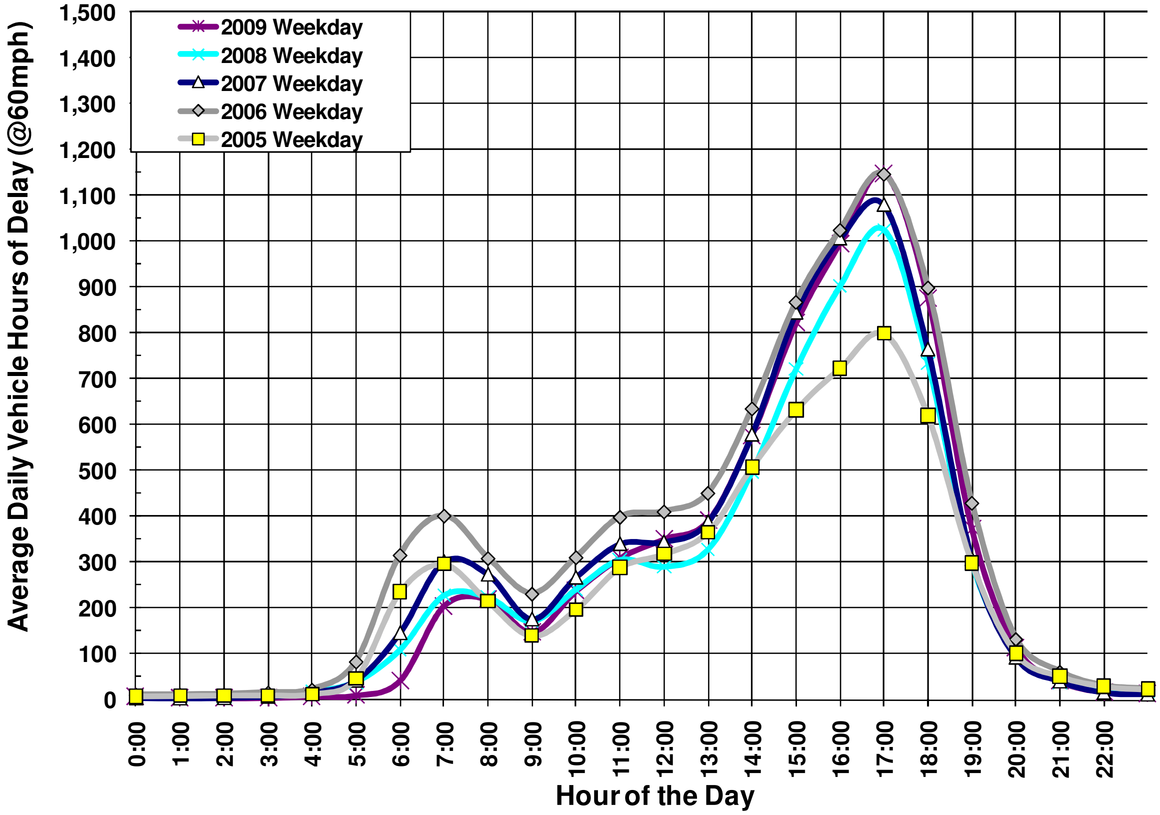
During the 7:00 AM peak hour in the northbound direction, Exhibit 3B-9 reveals that 2007 experienced the greatest delay with over 1,000 vehicle-hours, followed by 2008 with slightly above 900 vehicle-hours. During the 5:00 PM peak hour in the Southbound direction, Exhibit 3B-10 reveals that 2006 and 2007 experienced the highest average daily vehicle-hours of delay with roughly 1,100. This number declined slightly in 2008 and increased again in 2009.

In 2009, northbound PM peak period congestion was over 45 percent less than it was in 2006 (from an estimated high of over 600 vehicle-hours in 2006 to around 320 vehicle-hours in 2009). The same trend occurred during the southbound AM with 2006 delay levels at about twice 2009 levels (from 400 vehicle-hours in 2006 to 200 vehicle-hours in 2009. Midday congestion is present on both directions of the corridor and ranges from about 200 to 400 vehicle-hours.



Source: Caltrans detector data

Exhibit 3B-10: Southbound I-5 Average Weekday Hourly Delay (2005-2009)



Source: Caltrans detector data

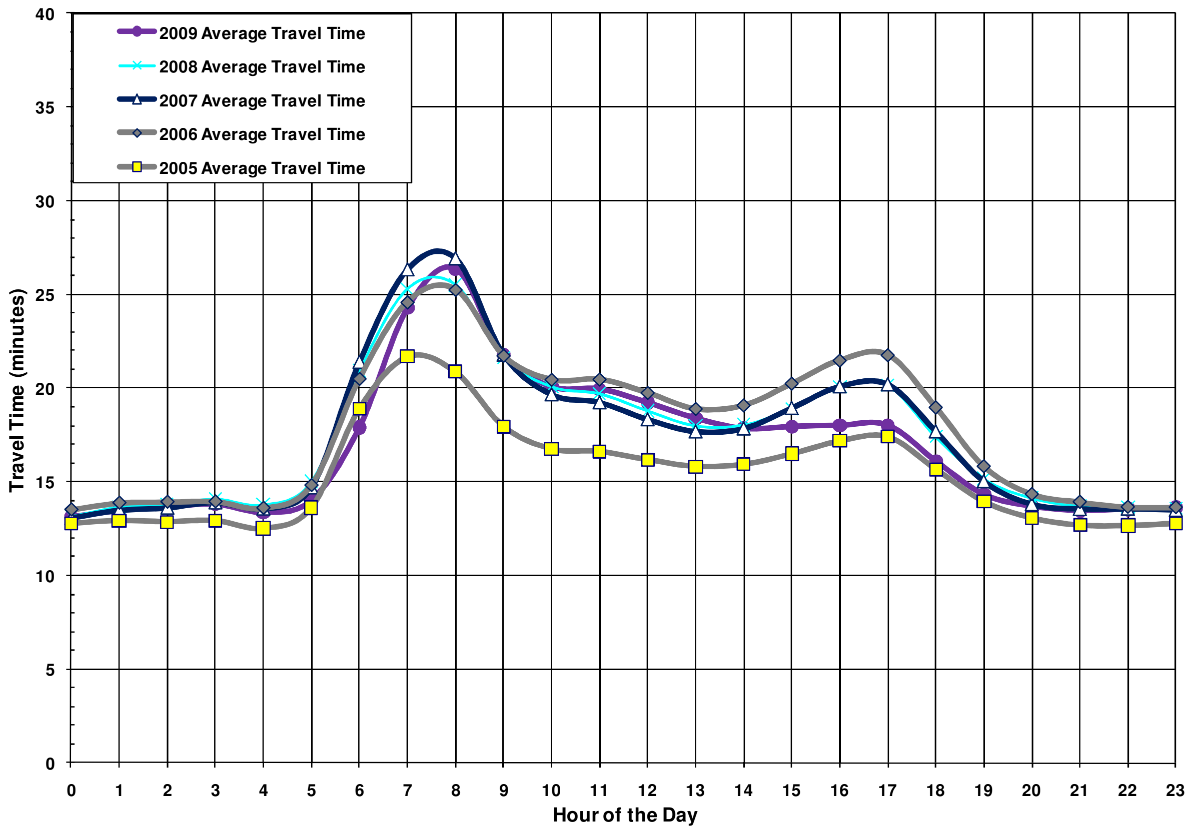
Travel Time

Travel time is reported as the amount of time it takes a vehicle to travel between two points on a corridor, as estimated using automatic detector data in this analysis. In the case of the I-5 South Corridor, the time it takes to travel 14 miles of the corridor from the Orange/LA County line to the I-710 Interchange is 14 minutes traveling at 60 mph. Travel time on parallel arterials is not included in the analysis.

Exhibits 3B-11 and 3B-12 summarize average annual travel times estimated for the I-5 South Corridor by hour of day for the years 2005 through 2009. Similar to delay, 2006 travel times were highest in the northbound direction during the AM peak and in the southbound direction during the PM peak.

As shown in Exhibit 3B-11, the northbound direction had typical travel times of approximately 22 to 27 minutes during the peak congested periods and about 16 to 20 minutes during the middle of the day. At the 7:00 AM hour, travel times were highest in 2007 at 27 minutes, followed by 2008 at 25 minutes. During the 8:00 AM hour, travel times were also highest in 2007 at 27 minutes followed by 2009 at 26 minutes. During the PM and off-peak hours, 2006 experienced the highest travel times.

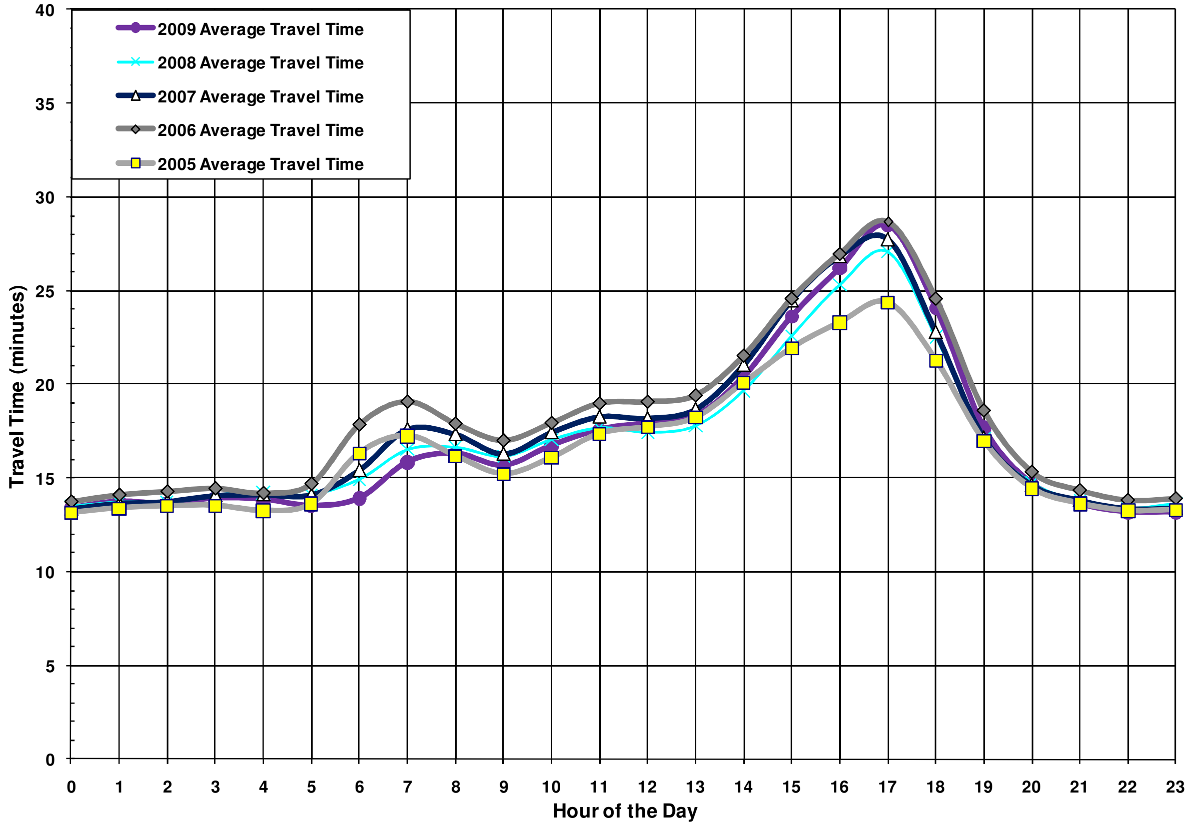
Exhibit 3B-11: Northbound I-5 Travel Time by Hour (2005-2009)



Source: Caltrans detector data

In the southbound direction (see Exhibit 3B-12), typical travel times range from approximately 24 to 29 minutes during the PM peak hour and from about 16 to 18 minutes during the midday. During both peak and non-peak hours, 2006 experienced the highest travel times at 29 minutes, followed by nearly identical travel times in 2009 and 2008. Travel time variability throughout this four-year period is consistent with the delay trends observed for this corridor. As delay improves, travel time also improves.

Exhibit 3B-12: Southbound I-5 Travel Time by Hour (2005-2009)



Source: Caltrans detector data

RELIABILITY

Reliability captures the degree of predictability in travel time. Reliability focuses on how travel time varies from day to day and reflects the impacts of accidents, incidents, weather, and special events. Improving reliability is an important goal for transportation agencies and efforts to accomplish this include incident management, traveler information, and special event planning.

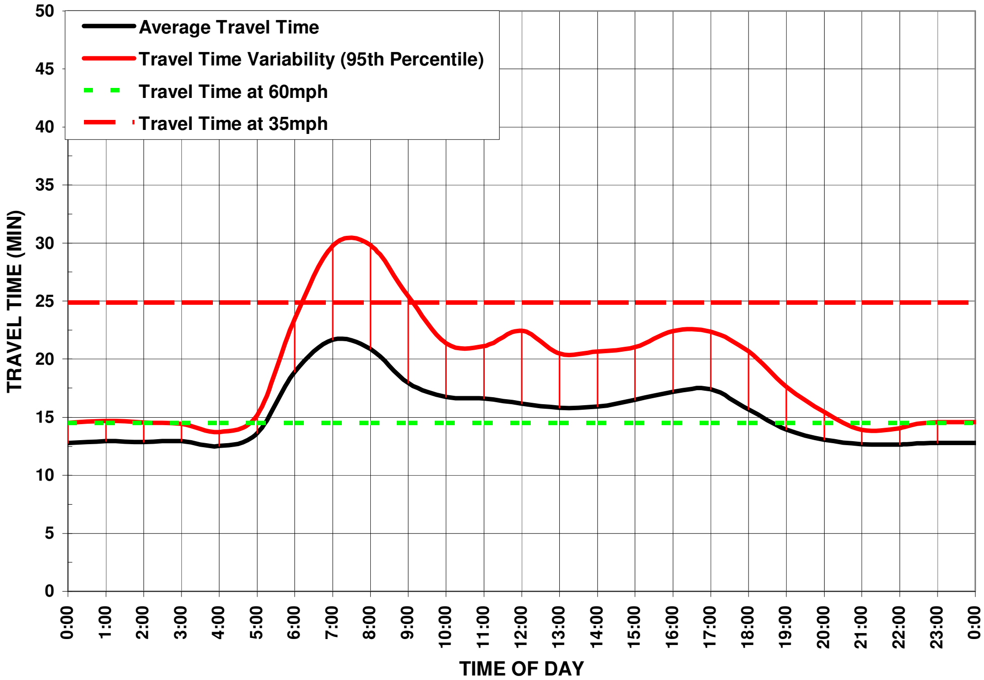
To measure reliability, the study team used automatic detector data to estimate the "buffer index." The buffer index reflects the additional time required (over and beyond the average) to ensure an on-time arrival 95 percent of the time. In other words, if a person must be on time 95 days out of 100 (or 19 out of 20 workdays per month), then that person must add additional time to their average expected travel time to ensure an on-time arrival. That additional time is the buffer time. Severe events, such as collisions, could cause longer travel times, but the 95th percentile represents a balance between days with extreme events (e.g., major accidents) and other, more "typical" travel days.

Exhibits 3B-13 through 3B-20 on the following pages illustrate the variability of travel time along the I-5 Corridor on weekdays for the years 2005, 2006, 2007, 2008, and 2009. Exhibits 3B-13 through 3B-16 present travel time variability for the northbound direction, and Exhibits 3B-17 through 3B-20 present travel time variability for the southbound direction.

In the northbound direction, the 8:00 AM peak hour was the most unreliable in addition to being the slowest hour. In 2005 (shown in Exhibit 3B-13), motorists driving the entire length of the corridor had to add 9 minutes to an average travel time of 21 minutes (for a total travel time of 30 minutes) to ensure that they arrived on time 95 percent of the time. This is 15 minutes longer than the 15-minute travel time at 60 mph. In the following four years (Exhibits 3B-14 through 3B-17), the time needed to arrive on time 95 percent increased by 7 minutes to 37 minutes.

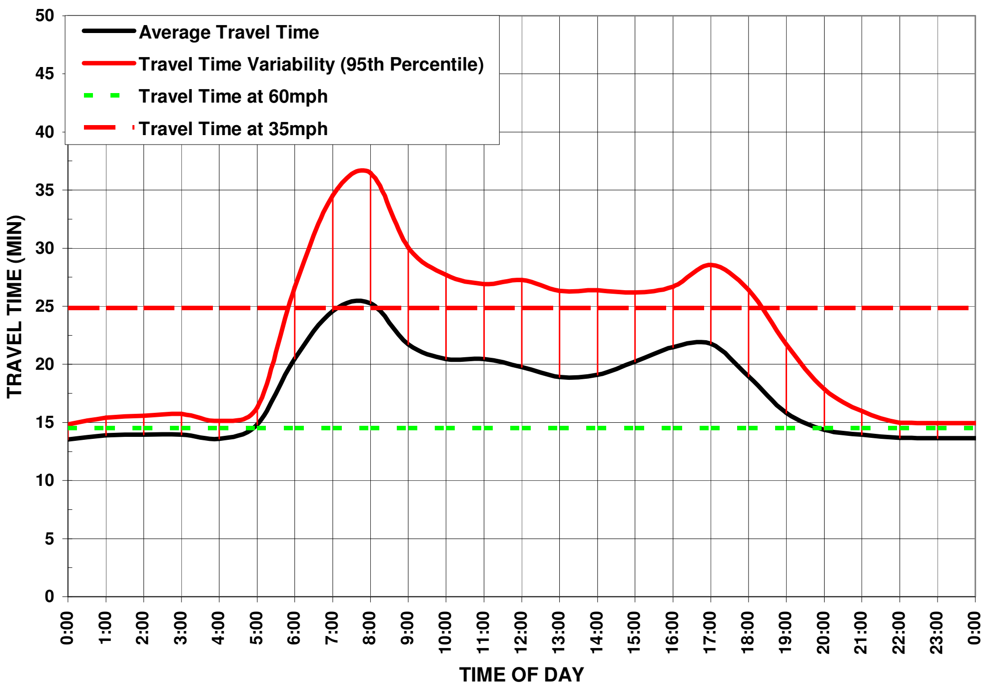
In the southbound direction, the most unreliable hour was 5:00 PM. Unlike the northbound direction which experienced the highest travel times during the AM peak period, the southbound direction experienced higher travel times during the PM peak period. In 2005 (Exhibit 3B-18), the time needed to arrive on time 95 percent of the time was 31 minutes during the 5:00 PM peak hour. In 2006 (Exhibit 3B-19), travel time variability increased slightly to 37 minutes, decreased in 2007 (Exhibit 3B-20) and 2008 to 34 minutes (Exhibit 3B-21), and increased again in 2009 (Exhibit 3B-22) to 36 minutes.

Exhibit 3B-13: Northbound I-5 Travel Time Variation (2005)



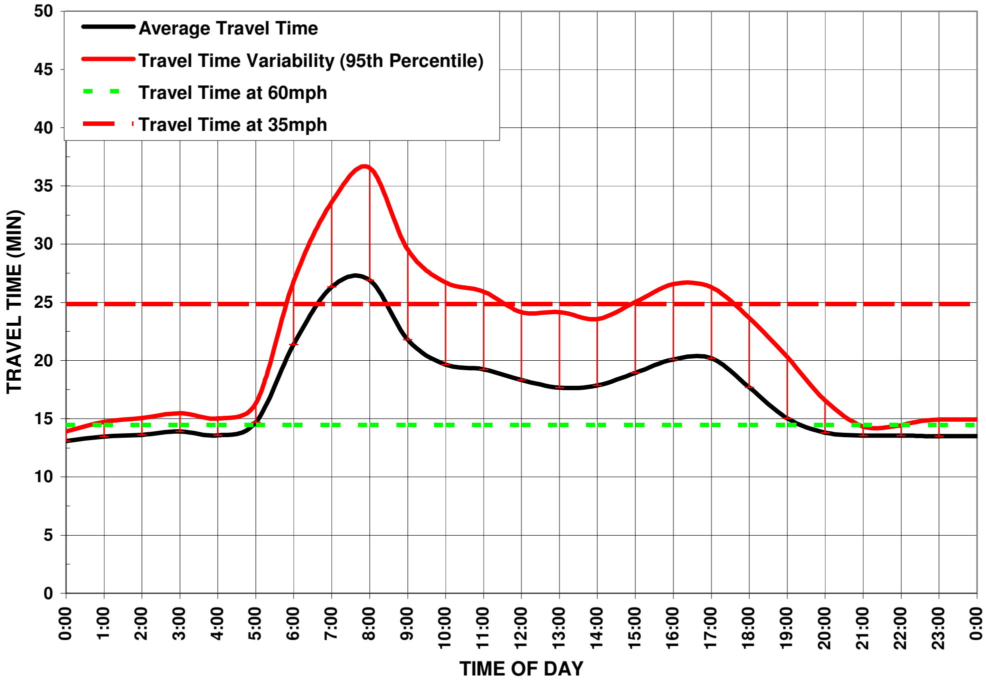
Source: Caltrans detector data

Exhibit 3B-14: Northbound I-5 Travel Time Variation (2006)



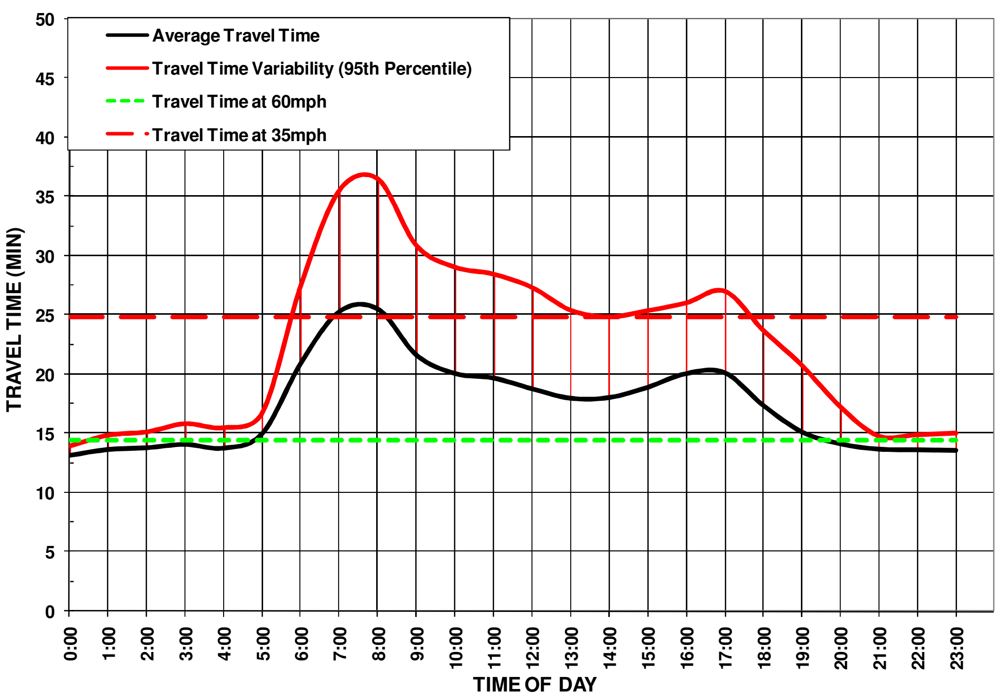
Source: Caltrans detector data

Exhibit 3B-15: Northbound I-5 Travel Time Variation (2007)



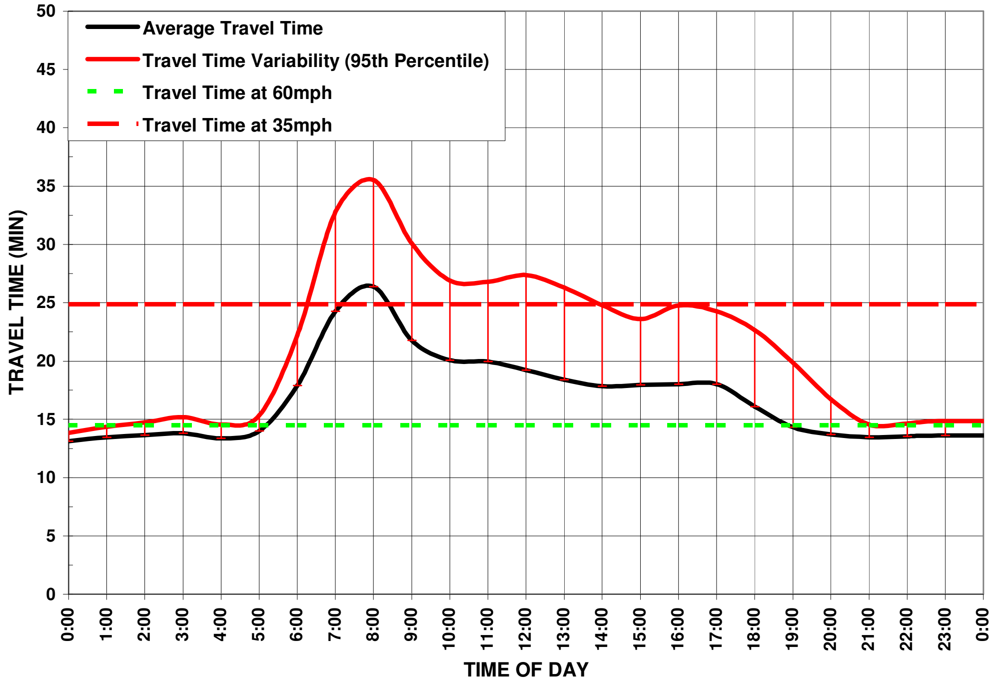
Source: Caltrans detector data

Exhibit 3B-16: Northbound I-5 Travel Time Variation (2008)



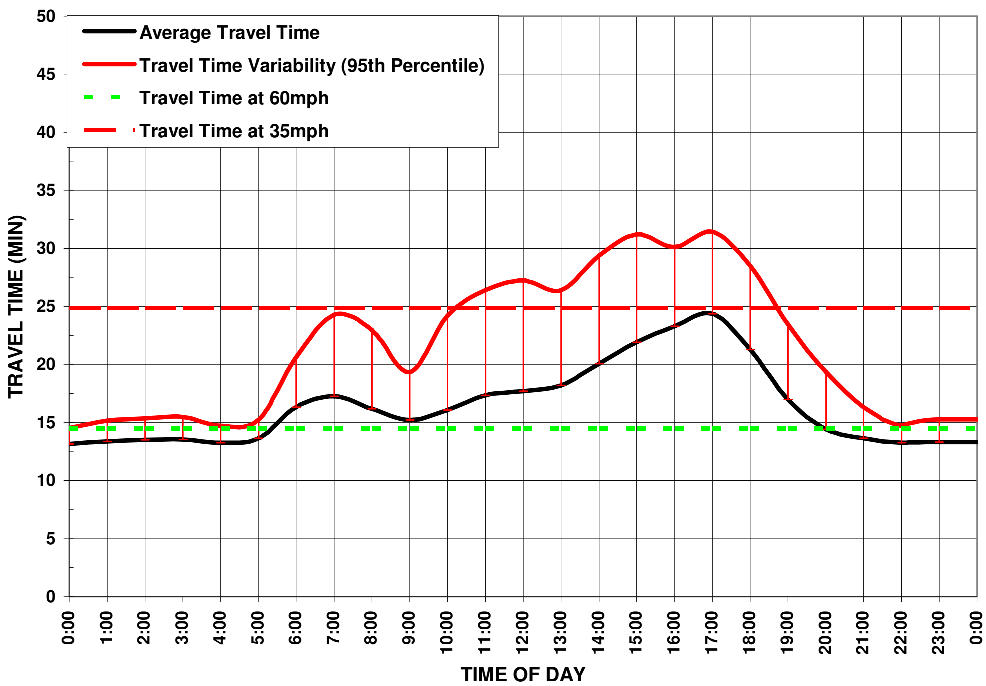
Source: Caltrans detector data

Exhibit 3B-17: Northbound I-5 Travel Time Variation (2009)



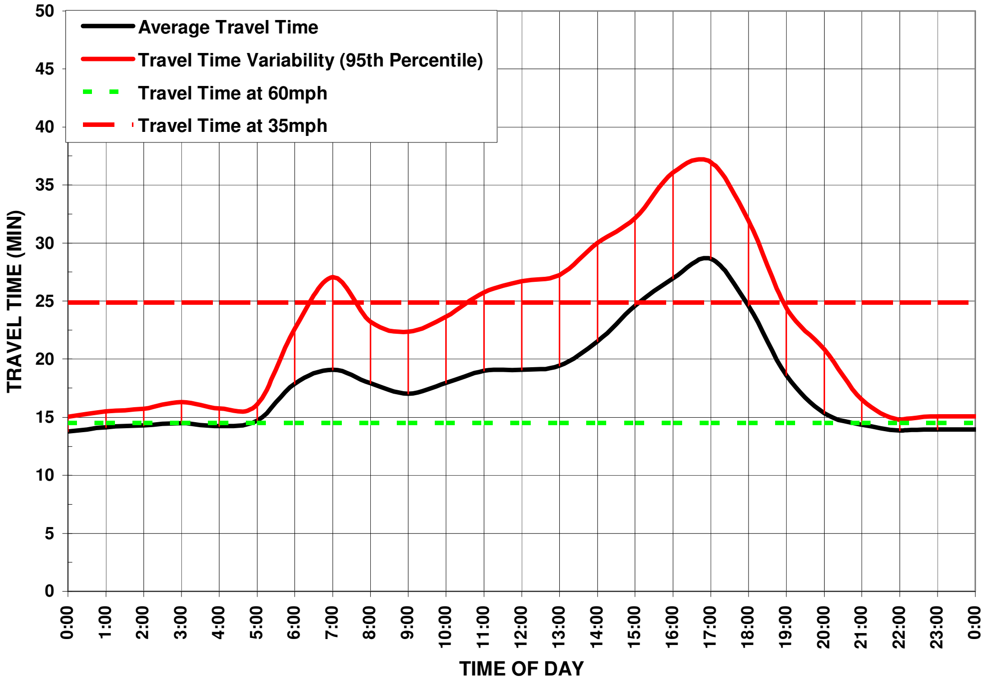
Source: Caltrans detector data

Exhibit 3B-18: Southbound I-5 Travel Time Variation (2005)



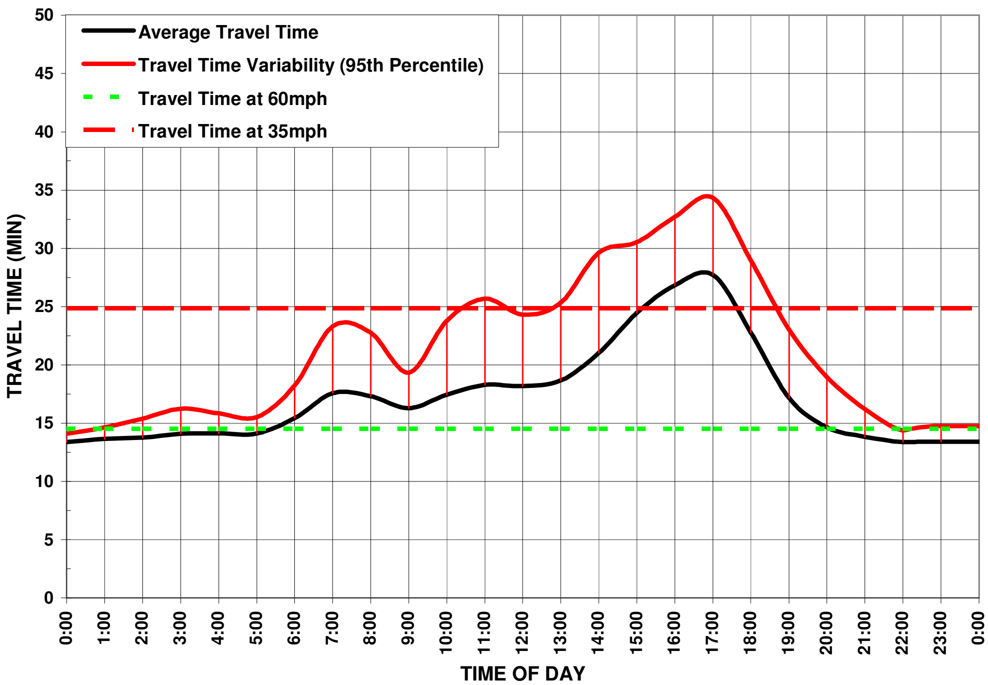
Source: Caltrans detector data

Exhibit 3B-19: Southbound I-5 Travel Time Variation (2006)



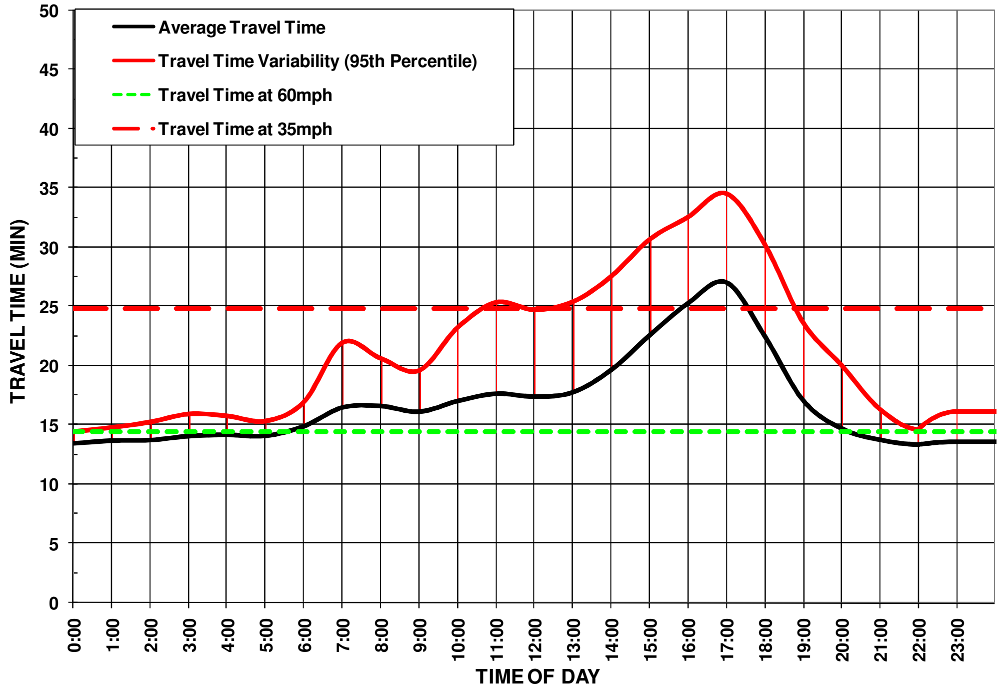
Source: Caltrans detector data

Exhibit 3B-20: Southbound I-5 Travel Time Variation (2007)



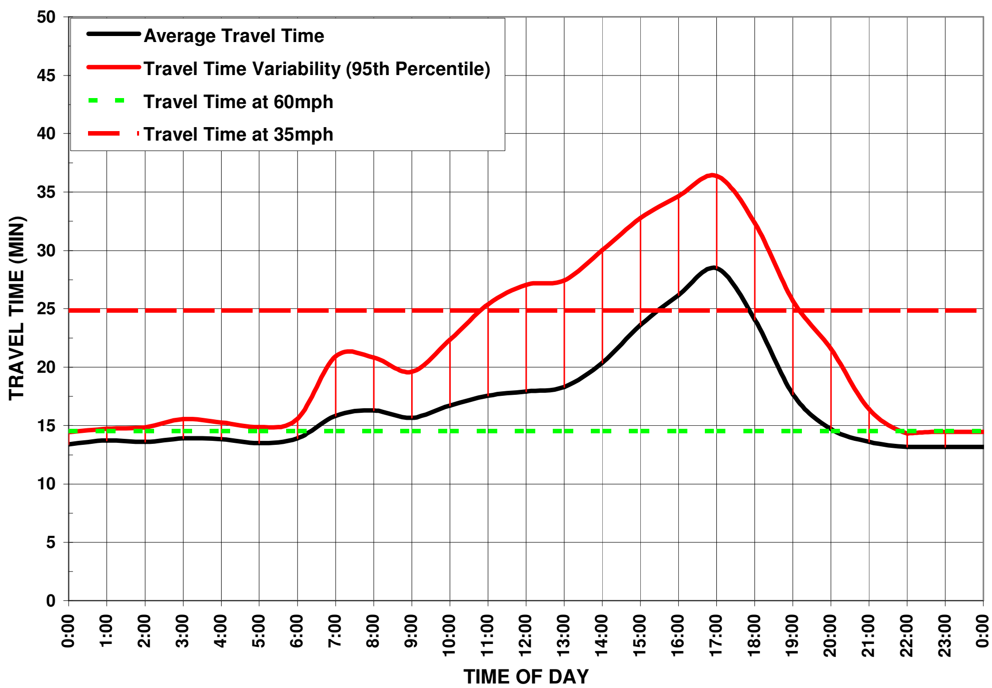
Source: Caltrans detector data

Exhibit 3B-21: Southbound I-5 Travel Time Variation (2008)



Source: Caltrans detector data

Exhibit 3B-22: Southbound I-5 Travel Time Variation (2009)



Source: Caltrans detector data

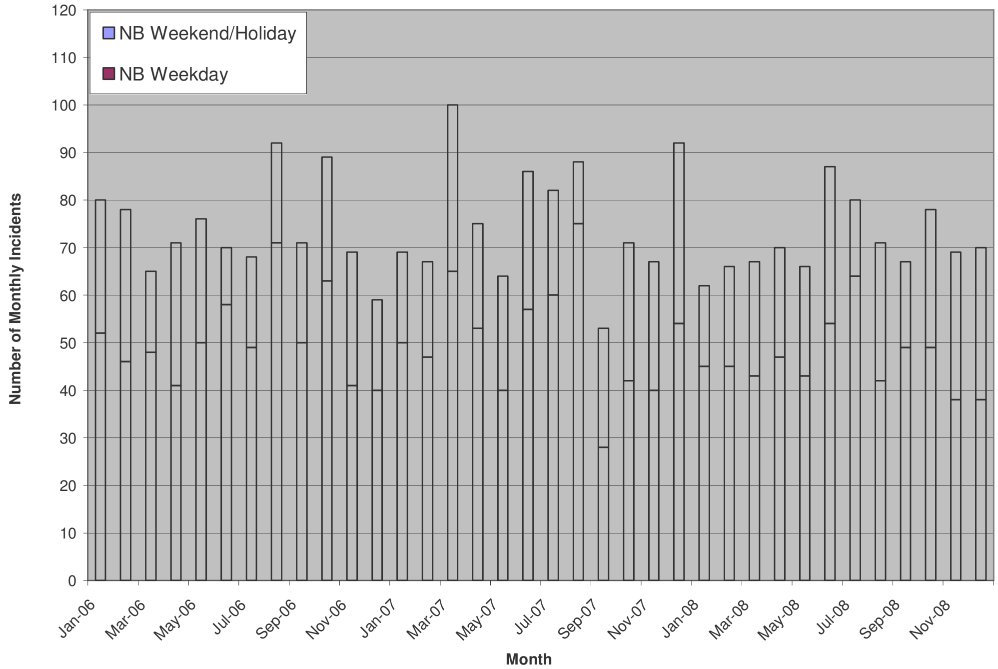
SAFETY

Collision data in terms of the number of accidents and accident rates from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS) were used for the safety measure. TASAS is a traffic records system containing an accident database linked to a highway database. The highway database contains description elements of highway segments, intersections and ramps, access control, traffic volumes and other data. TASAS contains specific data for accidents on state highways. Accidents on non-state highways are not included (e.g., local streets and roads).

The safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. This report is not intended to supplant more detailed safety investigations routinely performed by Caltrans staff.

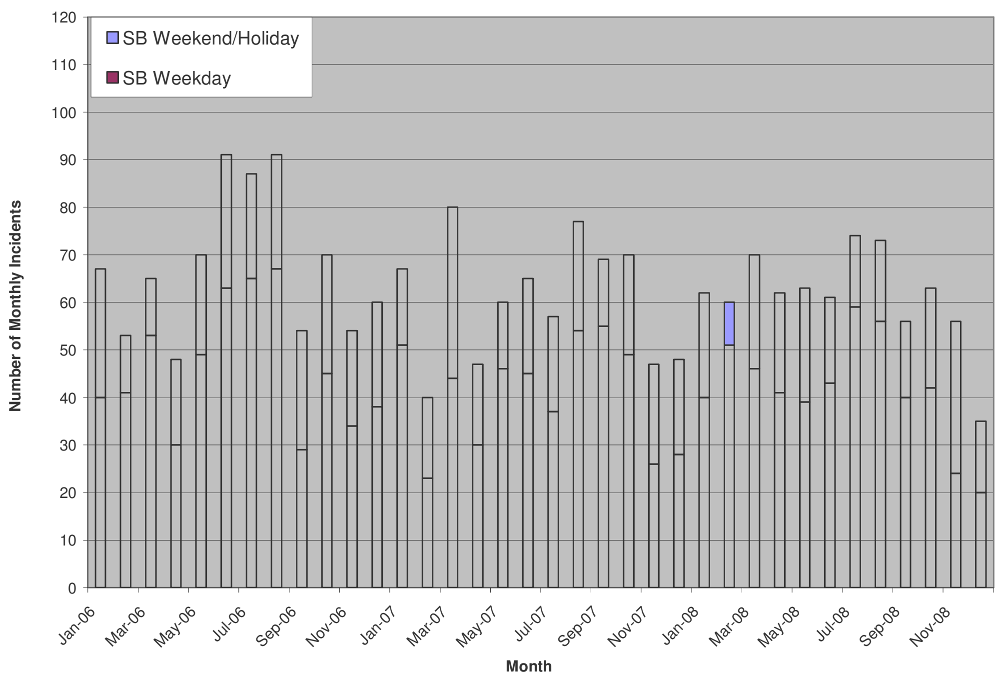
Exhibits 3B-23 and 3B-24 show the number of accidents experienced on I-5 for both directions of travel by month. The monthly accidents are broken down by weekdays and weekends. The exhibits summarize the latest available, three-year data from January 1, 2006 through December 31, 2008. Weekday accidents comprised typically over 60 percent of total accidents. Total monthly accidents in the northbound direction increased from 890 in 2006 to 910 in 2007 and decreased to 850 in 2008. In the southbound direction, total monthly accidents decreased annually from 2006 to 2008. The average monthly number of collisions during the three-year period was greater in the northbound direction (75 collisions) than the southbound direction (65 collisions).

Exhibit 3B-23: Northbound I-5 Monthly Accidents (2006-2008)



Source: SMG analysis of TASAS data

Exhibit 3B-24: Southbound I-5 Monthly Accidents (2006-2008)



Source: SMG analysis of TASAS data

PRODUCTIVITY

Productivity is a system efficiency measure used to analyze the capacity of the corridor, and is defined as the ratio of output (or service) per unit of input. In the case of transportation, productivity is the number of people served divided by the level of service provided. For highways, it is the number of vehicles compared to the capacity of the roadways.

For the corridor analysis, productivity is defined as the percent utilization of a facility or mode under peak conditions. The highway productivity performance measure is calculated as actual volume divided by the capacity of the highway. Travel demand models generally do not project capacity loss for highways, but detailed micro-simulation tools can forecast productivity. For highways, productivity is particularly important because the lowest “production” from the transportation system often occurs when capacity is needed the most.

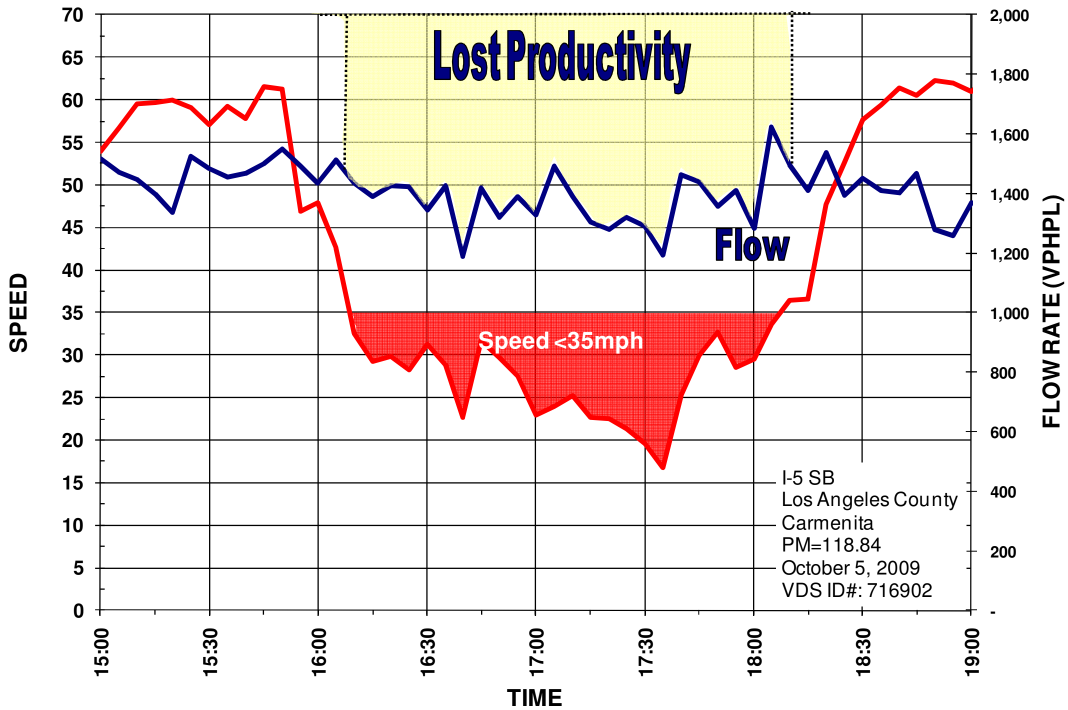
Exhibit 3B-25 illustrates how congestion leads to lost productivity. As traffic flows increase to the capacity limits of a roadway, speeds decline rapidly and throughput drops dramatically. The exhibit uses observed data from I-5 sensors for a typical autumn 2009 afternoon peak period (October 5, 2009). It shows speeds (in red) and flow rates (in blue) on southbound I-5 at Carmenita Avenue, one of the most congested locations on the corridor.

Flow rates (measured as vehicle-per-hour-per-lane or “vphpl”) at Carmenita Avenue averaged slightly over 1,600 vphpl between 2:30 PM and 3:00 PM, which is slightly less than a typical peak period maximum flow rate. Generally, freeway flow rates over 2,000 vehicles per hour per lane cannot be sustained over a long period.

Once volumes approach this maximum rate, traffic becomes unstable. With any additional merging or weaving, traffic breaks down and speeds can rapidly plummet to below 35 mph. In essence, every incremental merge takes up two spots on the freeway for a short time. However, since the volume is close to capacity, these merges lead to queues. Rather than accommodating the same number of vehicles, flow rates also drop and vehicles back up, creating bottlenecks and associated congestion.

There are a few ways to estimate productivity losses. One approach is to convert this lost productivity into "equivalent lost lane-miles." At the location shown in Exhibit 3B-25, throughput drops by nearly 20 percent on average during the peak period (from over 1,600 to around 1,200 vphpl). This three-lane road therefore operates with 20 percent less capacity when demand is at its highest. Just when the corridor needed the most capacity, it performed in the least productive manner and effectively lost lanes. This loss in throughput can be aggregated and presented as “equivalent lost-lane-miles”. Regardless of the approach, productivity calculations require good detection or significant field data collection at congested locations.

Exhibit 3B-25: Lost Productivity Illustrated on I-5 South Corridor



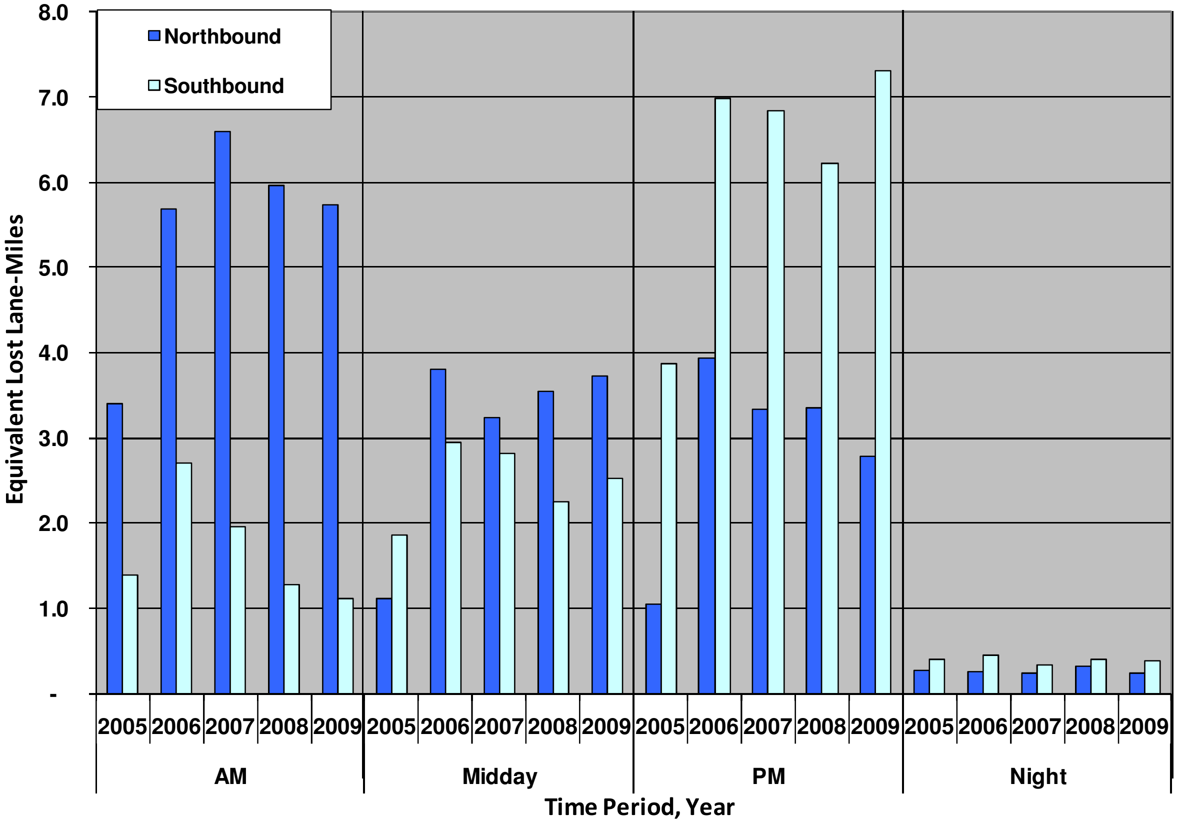
Equivalent lost lane-miles is computed as follows (for congested locations only):

$$LostLaneMiles = \left(1 - \frac{ObservedLaneThroughput}{2000vphpl}\right) \times Lanes \times CongestedDistance$$

Strategies to combat such productivity losses are primarily related to operations. These strategies include: building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improving incident clearance times.

Exhibit 3B-26 summarizes the productivity losses on the I-5 Corridor for the 2005 to 2009 period. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the PM peak hours in the southbound direction. Productivity during the PM peak in both directions improved from 2006 to 2008, but declined in 2009 with lost lane-miles peaking at over 7.0. Productivity during the AM improved annually in the northbound direction from 2007 to 2009 as lost lane-miles declined from 6.7 in 2007 to 6.0 in 2008 and 5.8 in 2009.

Exhibit 3B-26: I-5 Daily Equivalent Lost Lane-Miles by Direction and Period (2005-2009)



Source: Caltrans detector data

C. Pavement Condition

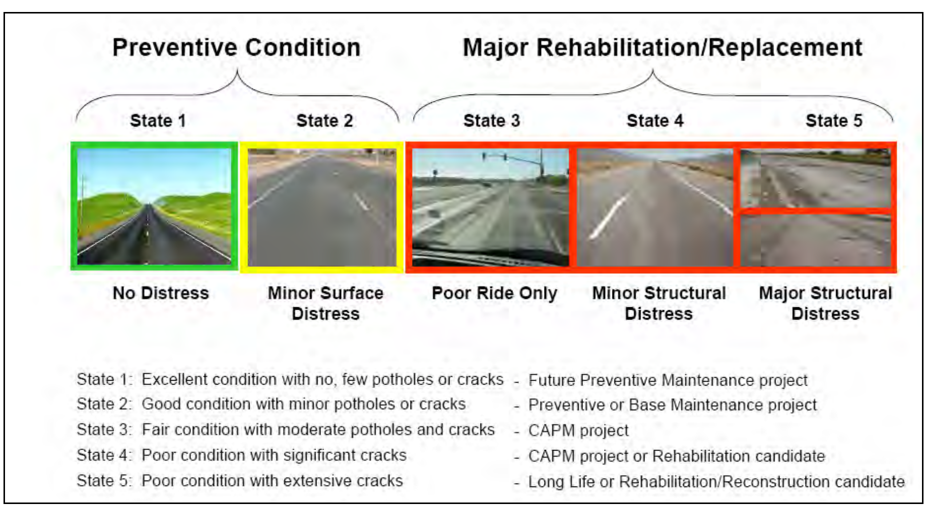
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation refers to maintaining the structural adequacy and ride quality of the pavement. It is possible for a roadway section to have structural distress without affecting ride quality. Likewise, a roadway section may exhibit poor ride quality, while the pavement remains structurally adequate.

PAVEMENT PERFORMANCE MEASURES

Caltrans conducts an annual Pavement Condition Survey (PCS) that can be used to compute two performance measures commonly estimated by Caltrans: distressed lane-miles and International Roughness Index (IRI). Although Caltrans generally uses distressed lane-miles for external reporting, this report uses the Caltrans data to present results for both measures.

Using distressed lane-miles allows us to distinguish among pavement segments that require only preventive maintenance at relatively low costs and segments that require major rehabilitation or replacement at significantly higher costs. All segments that require major rehabilitation or replacement are considered to be distressed. Segments with poor ride quality are also considered to be distressed. Exhibit 3C-1 provides an illustration of this distinction. The first two pavement conditions include roadways that provide adequate ride quality and are structurally adequate. The remaining three conditions are included in the calculation of distressed lane-miles.

Exhibit 3C-1: Pavement Condition States Illustrated



Source: Caltrans Division of Maintenance, 2007 State of the Pavement Report

IRI distinguishes between smooth-riding and rough-riding pavement. The distinction is based on measuring the up and down movement of a vehicle over pavement. When such movement is measured at 95 inches per mile or less, the pavement is considered good or smooth-riding. When movements are between 95 and 170 inches per mile, the pavement is considered acceptable. Measurements above 170 inches per mile reflect unacceptable or rough-riding conditions.

EXISTING PAVEMENT CONDITION

The most recent pavement condition survey, completed in November 2007, recorded 12,998 distressed lane-miles statewide. Unlike prior surveys, the 2007 PCS included pavement field studies for a period longer than a year, due to an update in the data collection methodology. The survey includes data for 23 months from January 2006 to November 2007.

The field work consists of two parts. In the first part, pavement raters visually inspect the pavement surface to assess structural adequacy. In the second part, field staff uses vans with automated profilers to measure ride quality. The 2007 PCS revealed that the majority of distressed pavement was on freeways and expressways (Class 1 roads). This is the result of approximately 56 percent of the State Highway System falling into this road class. As a percentage of total lane-miles for each class, collectors and local roads (Class 3 roads) had the highest amount of distress.

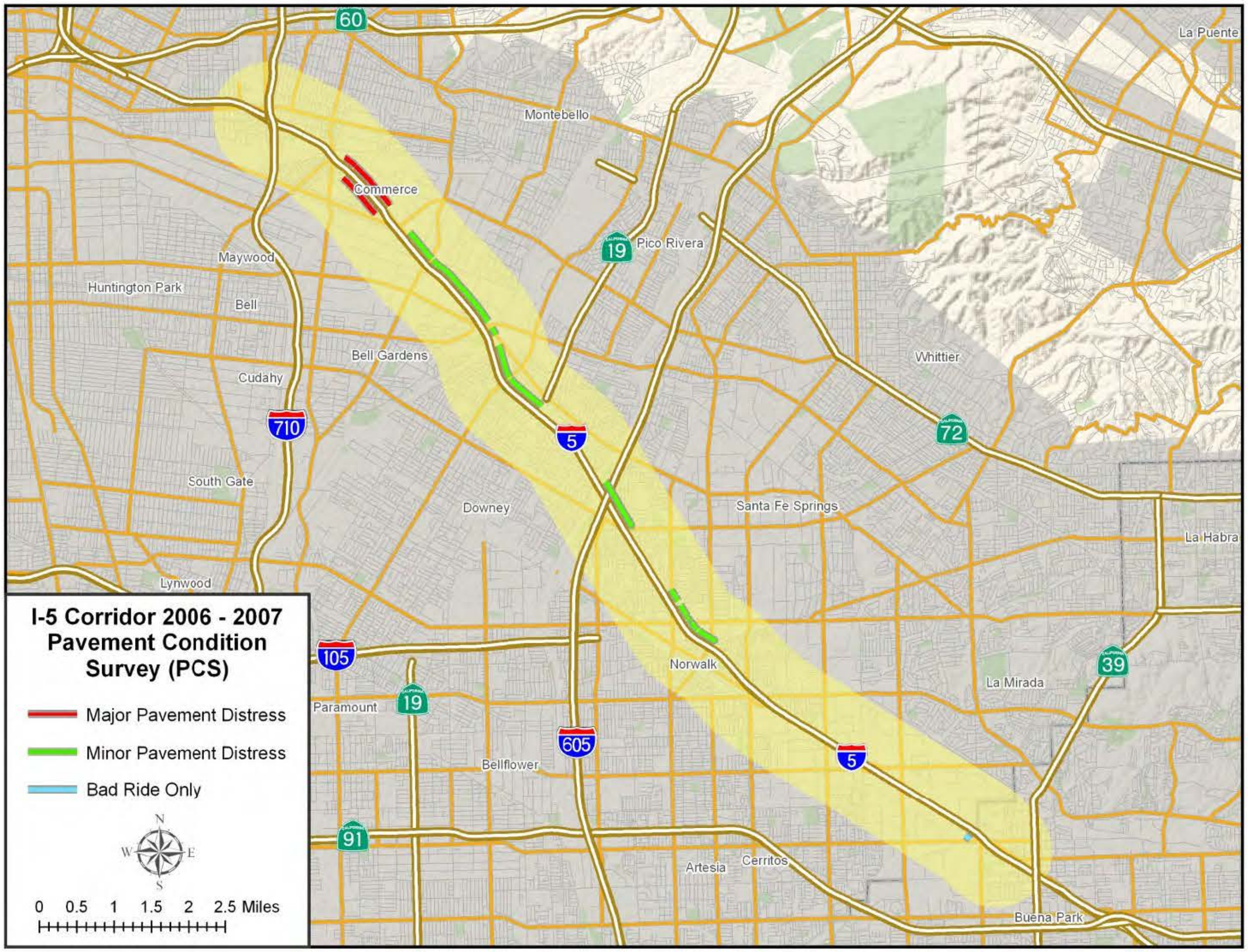
Exhibit 3C-2 shows pavement distress along the I-5 Corridor according to the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3C-1.

The I-5 Corridor has considerably less pavement distress than does a typical freeway in District 7. As seen in Exhibit 3C-2, some portions of northbound I-5 have minor pavement distress, but comparable distress is not found in the southbound direction. There is also a small section (less than a mile) with major pavement distress in the City of Commerce. A very minor section in the southern portion of the corridor has ride only issues.

Exhibit 3C-3 shows results from prior pavement condition surveys along the I-5 Corridor. Pavement quality along the corridor has improved steadily since 2004. Most of the major distress has been eliminated.

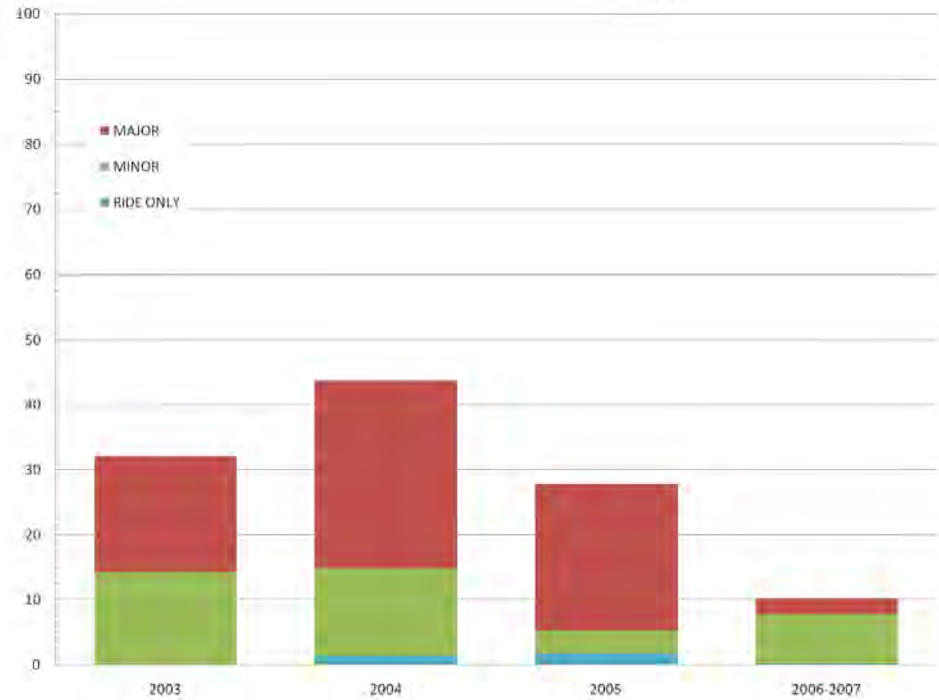
The change in the percent mix of distressed lane-miles is shown more clearly in Exhibit 3C-4. Minor pavement distress makes up roughly 75 percent of the issues along the corridor.

Exhibit 3C-2: Distressed Lane-Miles on I-5 South Corridor (2006-2007)



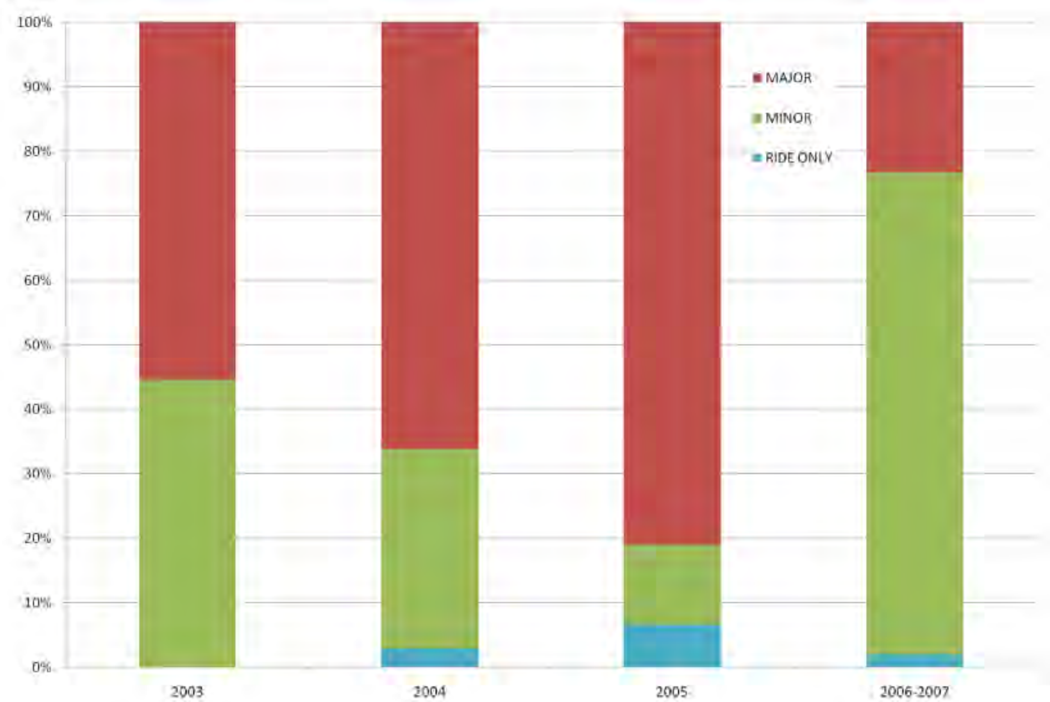
Source: Pavement Condition Survey data

Exhibit 3C-3: I-5 South Distressed Lane-Miles Trends (2003-2007)



Source: Pavement Condition Survey data

Exhibit 3C-4: I-5 South Distressed Lane-Miles by Type (2003-2007)



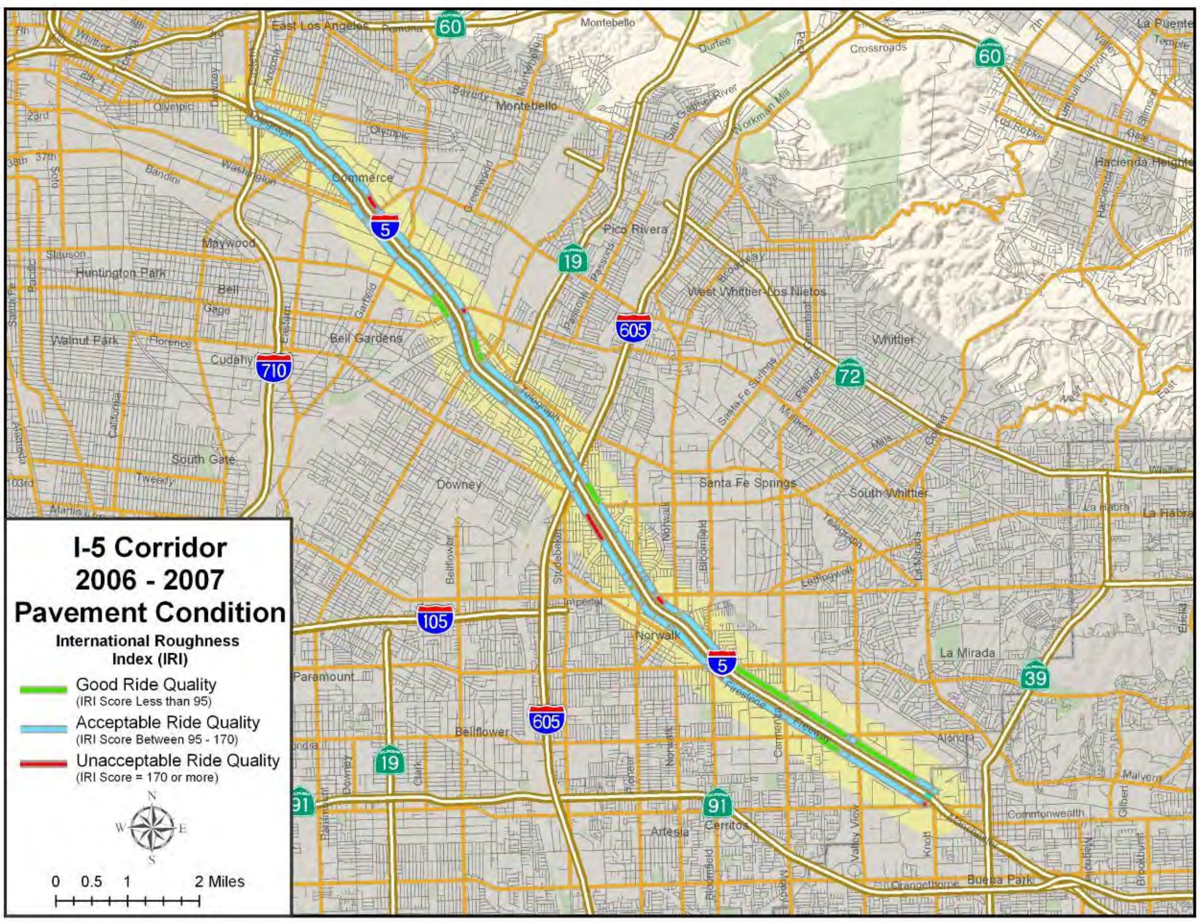
Source: Pavement Condition Survey data

Exhibit 3C-5 shows IRI along the study corridor for the lane with the poorest pavement condition in each freeway segment. The poorest pavement conditions are shown in the exhibit because pavement investment decisions are made on this basis. As the exhibit shows, very little of the corridor has ride quality in the unacceptable range. However, much of the corridor exhibits only acceptable ride quality, which means that ride quality could drop to the unacceptable range in future years.

When the conditions on all lanes are considered, the study corridor comprises roughly 97 lane-miles, of which:

- 48 lane-miles, or 50 percent, are considered to have good ride quality (IRI ≤ 95)
- 48 lane-miles, or 49 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- Just over 1 lane-mile, or about 1 percent, is considered to have unacceptable ride quality (IRI > 170)

Exhibit 3C-5: I-5 South Road Roughness (2006-2007)

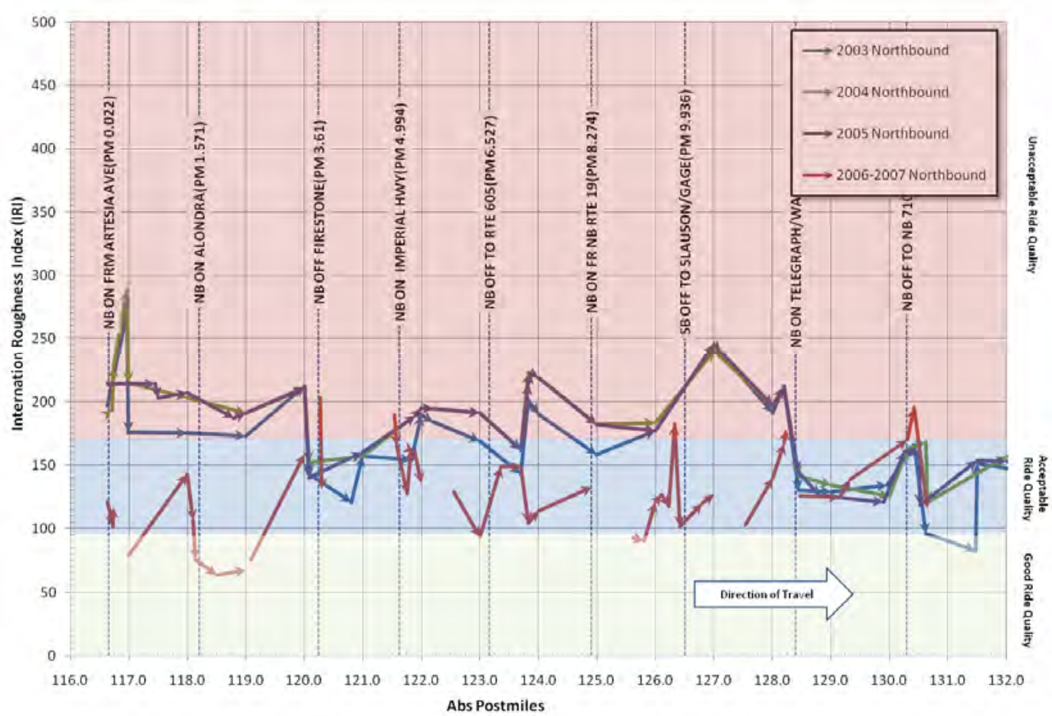


Source: Pavement Condition Survey data

Exhibits 3C-6 and 3C-7 present ride conditions for the I-5 South CSMP Corridor using IRI from the last four pavement surveys. The information is presented by Post Mile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). The IRI conditions reported in the latest PCS are considerably better than those in prior years and reflect an eleven-mile pavement rehabilitation and improvement project from Buena Park to the City of Commerce completed in 2005.

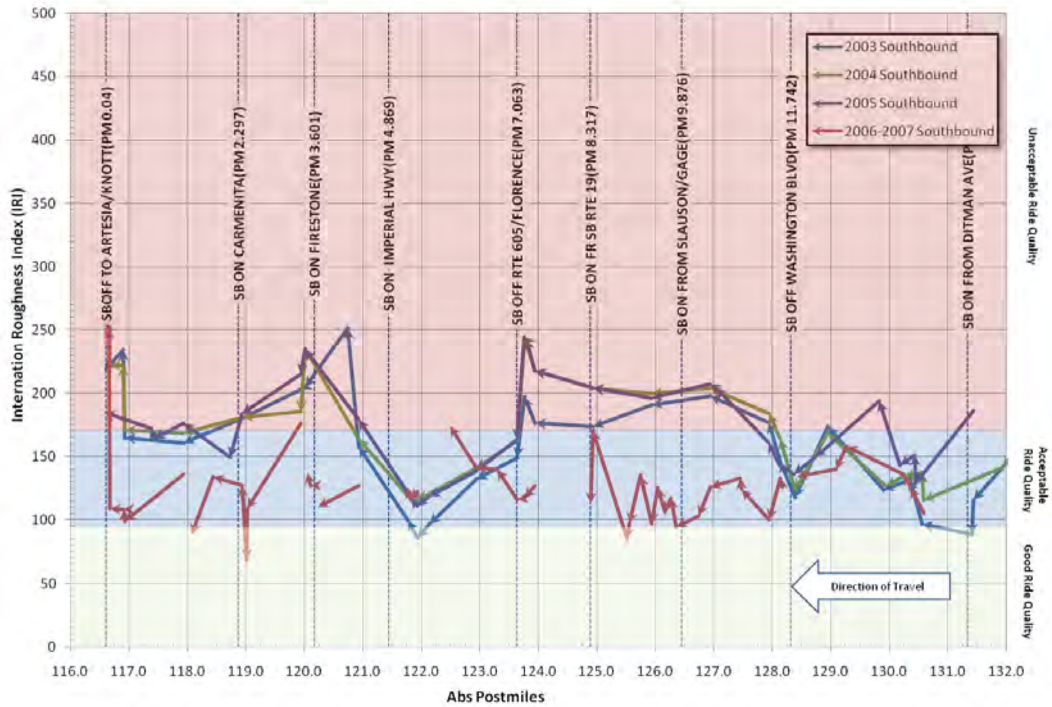
The exhibits exclude a number of sections that were not measured or had calibration issues (i.e., IRI = 0) in the 2006-07 period.

Exhibit 3C-6: Northbound I-5 South Road Roughness (2003-2007)



Source: Pavement Condition Survey data

Exhibit 3C-7: Southbound I-5 South Road Roughness (2003-2007)



Source: Pavement Condition Survey data

4. BOTTLENECK IDENTIFICATION & CAUSALITY ANALYSIS

A. Bottleneck Identification

Major bottlenecks are the primary cause of congestion and lost productivity. A bottleneck is a location where traffic demand exceeds the effective carrying capacity of the roadway. In most cases, the cause of a bottleneck relates to a sudden reduction in capacity, such as a lane drop, merging and weaving, driver distractions, a surge in demand, or a combination of factors.

Los Angeles I-5 South Corridor bottlenecks were identified and verified during 2007 and 2008 based on a variety of data sources, including State Highway Congestion Monitoring Program (HICOMP) data, Caltrans District 7 probe vehicle runs, automatic detector data, and extensive consultant team field observations and video-taping.

Potential bottleneck locations were initially identified in the Preliminary Performance Assessment report delivered in 2008. The Comprehensive Performance Assessment delivered in 2009 presented the results of additional analysis and extensive field observations.

The study team conducted the field observations, videotaping major bottlenecks to document the locations and potential causes of the bottlenecks. These efforts resulted in confirming consistent sets of bottlenecks for both directions of the freeway. Exhibit 4A-1 summarizes the bottleneck locations identified in this analysis and the time period that these bottlenecks are active. Exhibits 4A-2 and 4A-3 are maps showing verified bottleneck locations for the AM and PM peak periods, respectively.

Exhibit 4A-1: I-5 South Corridor Bottlenecks

Dir	Abs	CA	Bottleneck Location	Active Period	
				AM	PM
Northbound	119.1	2.5	Carmenita IC	✓	✓
	121.9	5.2	Pioneer On	✓	✓
	123.6	7.0	I-605 On	✓	
	125.5	8.8	Paramount On	✓	
	126.5	9.8	Telegraph Off	✓	
	130.5	13.7	I-710 On	✓	✓
Dir	Abs	CA	Bottleneck Location	Active Period	
				AM	PM
Southbound	128.0	11.5	Washington On		✓
	125.5	8.9	Paramount On		✓
	123.6	7.0	I-605 Off	✓	✓
	118.8	2.3	Carmenita IC	✓	✓
	117.6	1.0	Valley View IC		✓
	116.0	0.0	OC/LA County Line	✓	✓

Exhibit 4A-2: Map of Major AM Bottlenecks on I-5 South Corridor

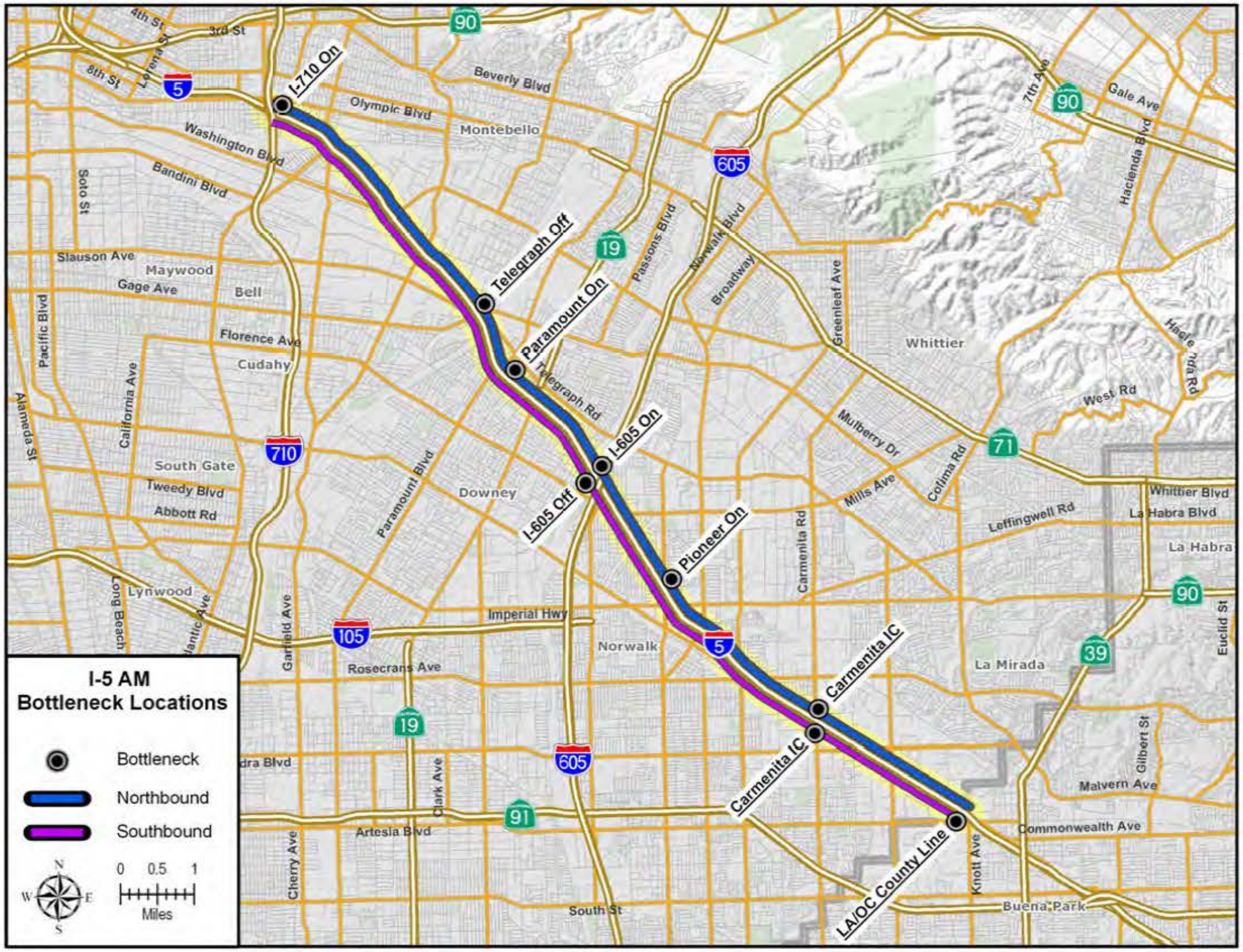
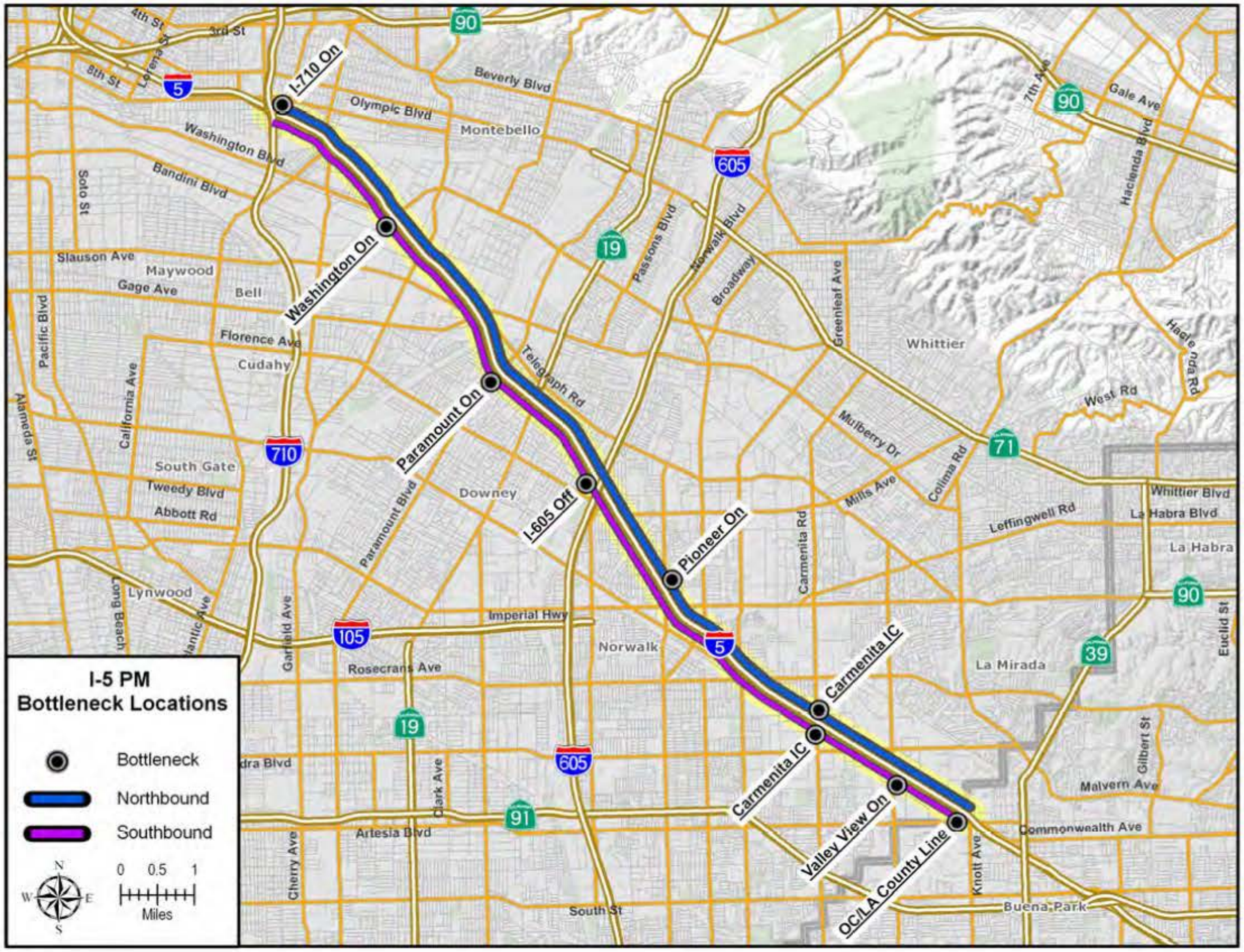


Exhibit 4A-3: Map of Major PM Bottlenecks on I-5 South Corridor



The rest of this section presents the initial bottleneck identification analysis performed as part of the Preliminary Performance Assessment.

A variety of sources were initially used to identify bottlenecks:

- State Highway Congestion Monitoring Program (HICOMP) 2006 report
- Caltrans Freeway detector data
- Aerial photos (Google Earth) and Caltrans photologs.

Highway Congestion Monitoring Program

The State Highway Congestion Monitoring Program (HICOMP) annual report was the first tool used by the study team to identify problem areas. Published annually since 1987, HICOMP attempts to measure "typical" peak period, weekday, and recurring traffic congestion on urban area freeways. HICOMP does not include congestion on other state highways or local surface streets. Non-recurrent congestion such as holiday, maintenance, construction or special-event generated traffic congestion is also not included. HICOMP data is useful for finding general trends and making regional comparisons of freeway performance, but some estimates presented in the report are based on a limited number of observations. Furthermore, HICOMP does not attempt to capture bottleneck locations, but simply report on locations of likely recurrent congestion.

Using the 2006 HICOMP data, potential problem areas were initially identified. As illustrated in Exhibit 4A-4 and 4A-5, the downstream end of congested segments were initially considered bottleneck areas in the northbound direction (shown with blue circles) and in the southbound direction (shown with red circles).

Exhibit 4A-4: HICOMP AM Congestion Map with Potential Bottlenecks (2006)

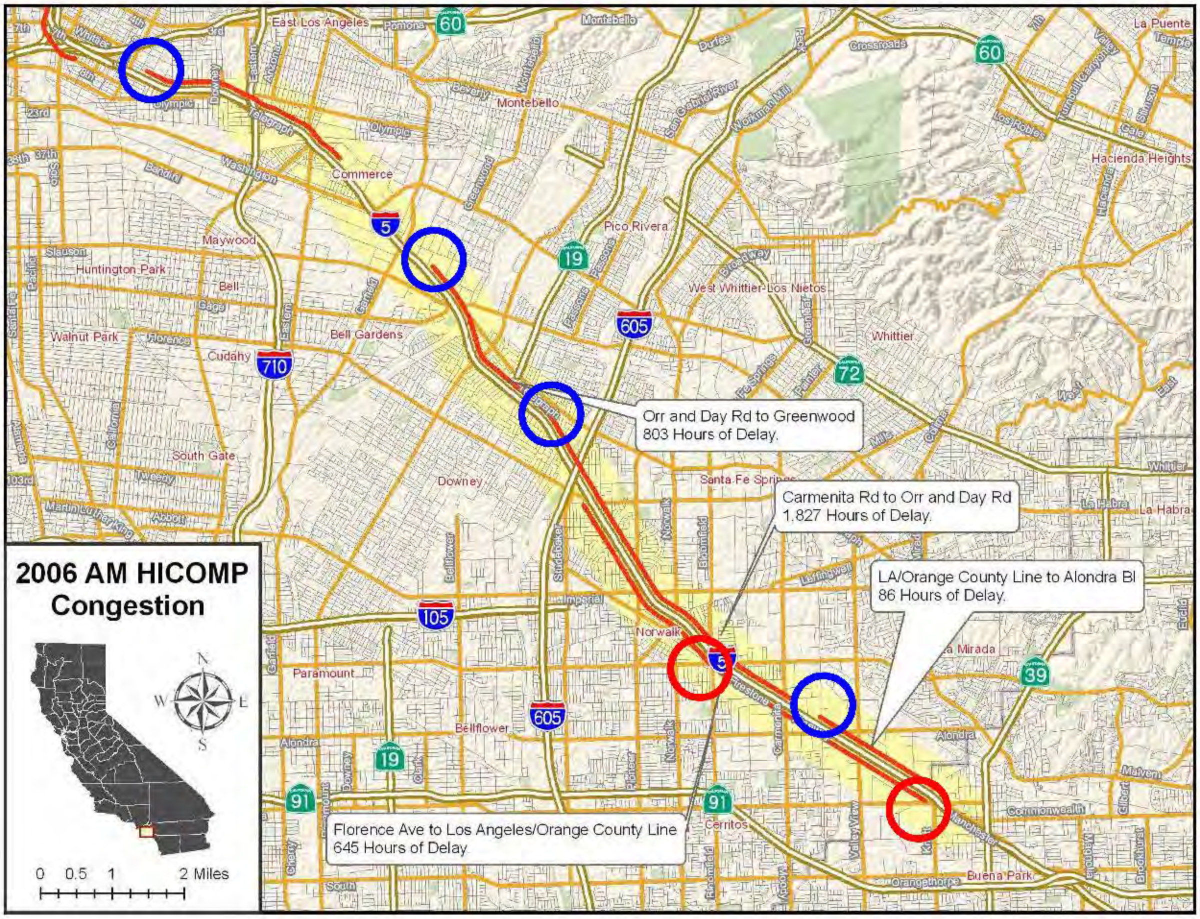
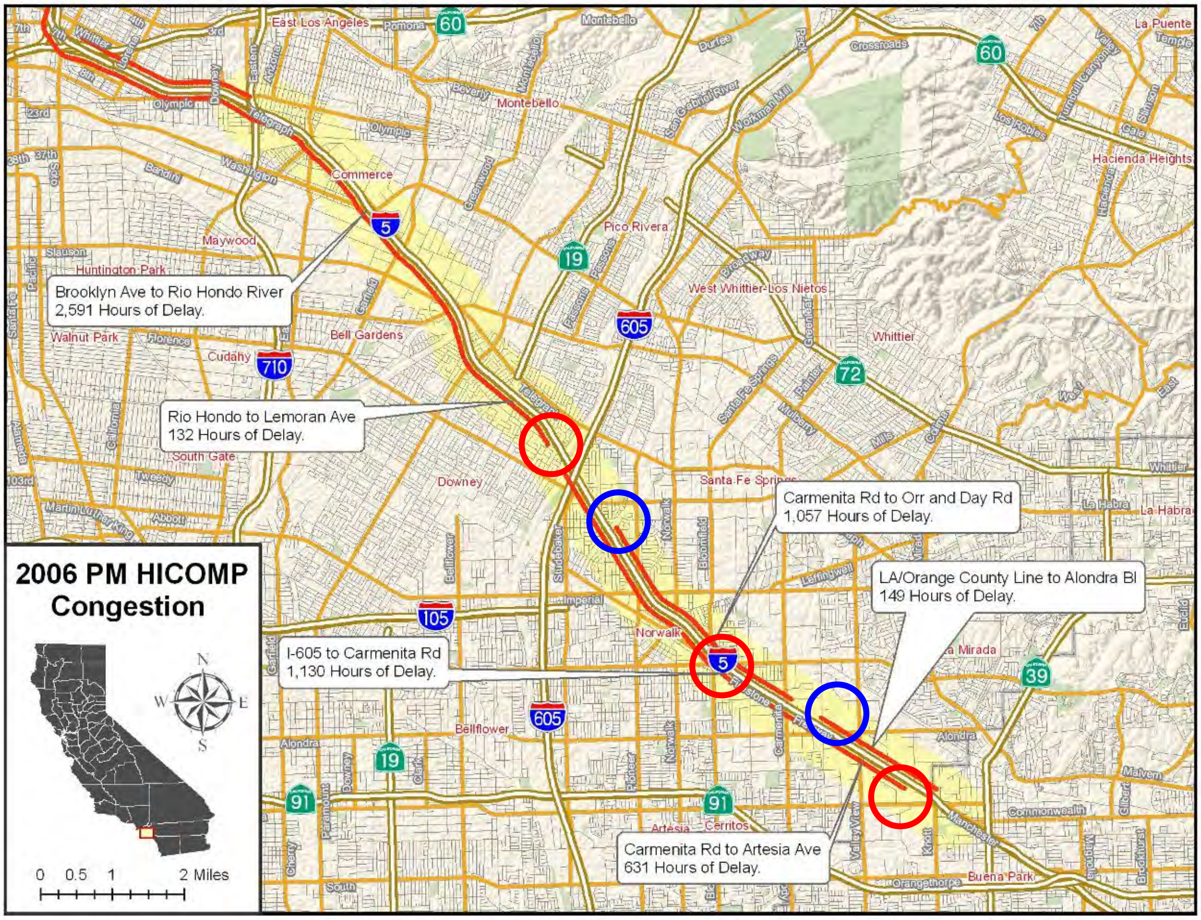


Exhibit 4A-5: HICOMP PM Congestion Map with Potential Bottlenecks (2006)



Probe Vehicle Runs

The probe vehicle runs (electronic tachometer runs) provide speed plots across the corridor at various departure times. A vehicle equipped with an electronic (GPS or tachometer) device is driven along the corridor at various departure times, typically in a middle lane, during the peak period, at regular, 20 to 30 minute intervals. Actual speeds are recorded as the vehicle traverses the corridor. Bottlenecks can be found at the end of congested segment, where speeds generally increase from about 30 miles per hour to 50 miles per hour.

Caltrans District 7 collected probe vehicle run data in May 2000 for the I-5 freeway from the Orange County Line to the Calzona Street interchange. The freeway corridor runs were broken into two separate segments from the Orange County Line (Artesia Avenue) to Rosemead Boulevard and Rosemead Boulevard to the Calzona Street interchange. For each segment, the runs were conducted from 5:30 AM to 11:00 AM and from 2:30 PM to 7:30 PM. Exhibit 4A-6 illustrates the I-5 northbound probe vehicle runs conducted on separate days in May 2000 at specific time intervals: 7:00 AM, 8:00 AM, 9:00 AM, 4:00 PM, and 5:00 PM. However, these probe vehicle runs could be capturing entirely different condition than automatic detector data, since they were collected several years earlier.

Exhibit 4A-6: Northbound I-5 Sample Probe Vehicle Runs (May 2000)

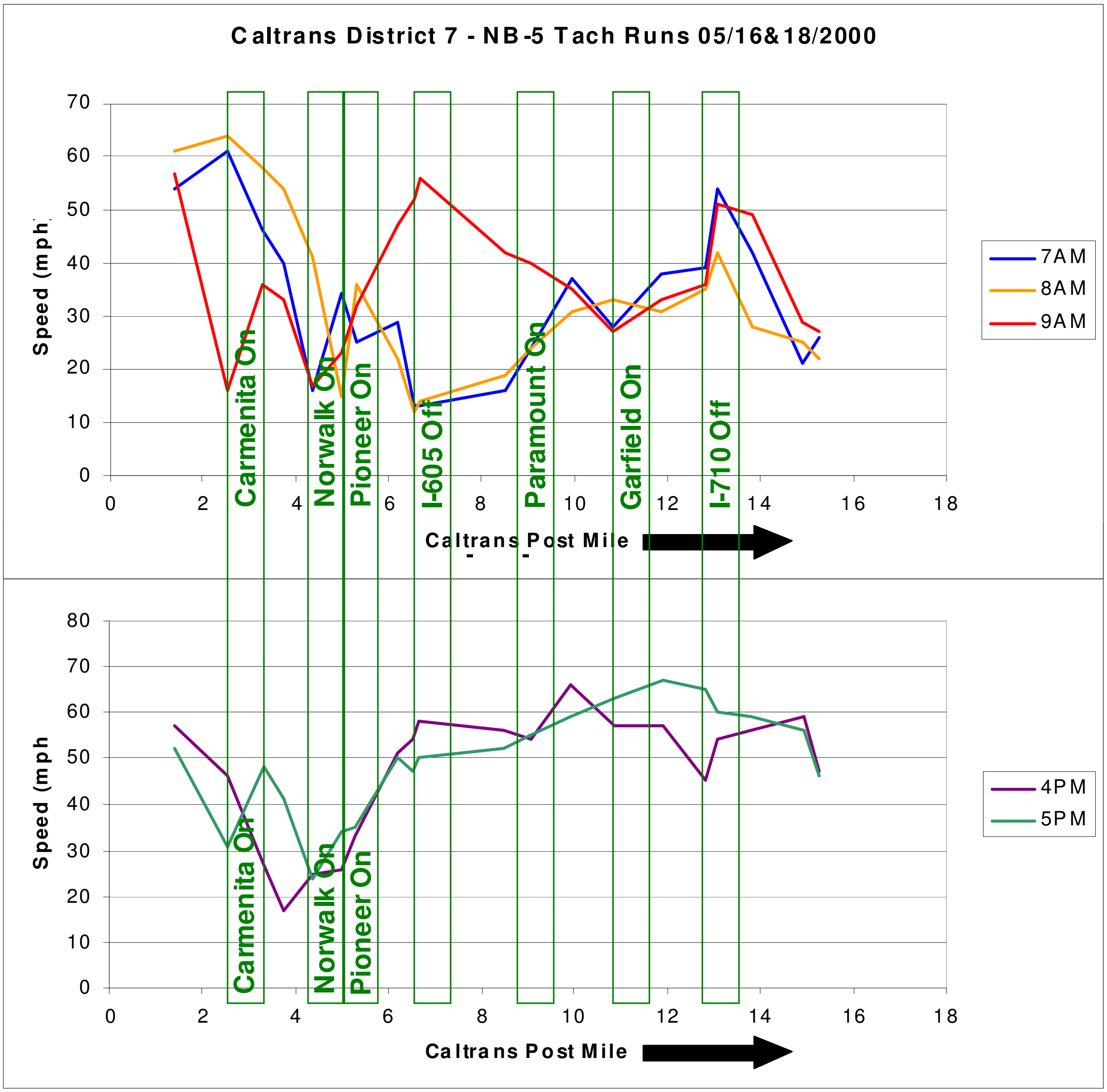
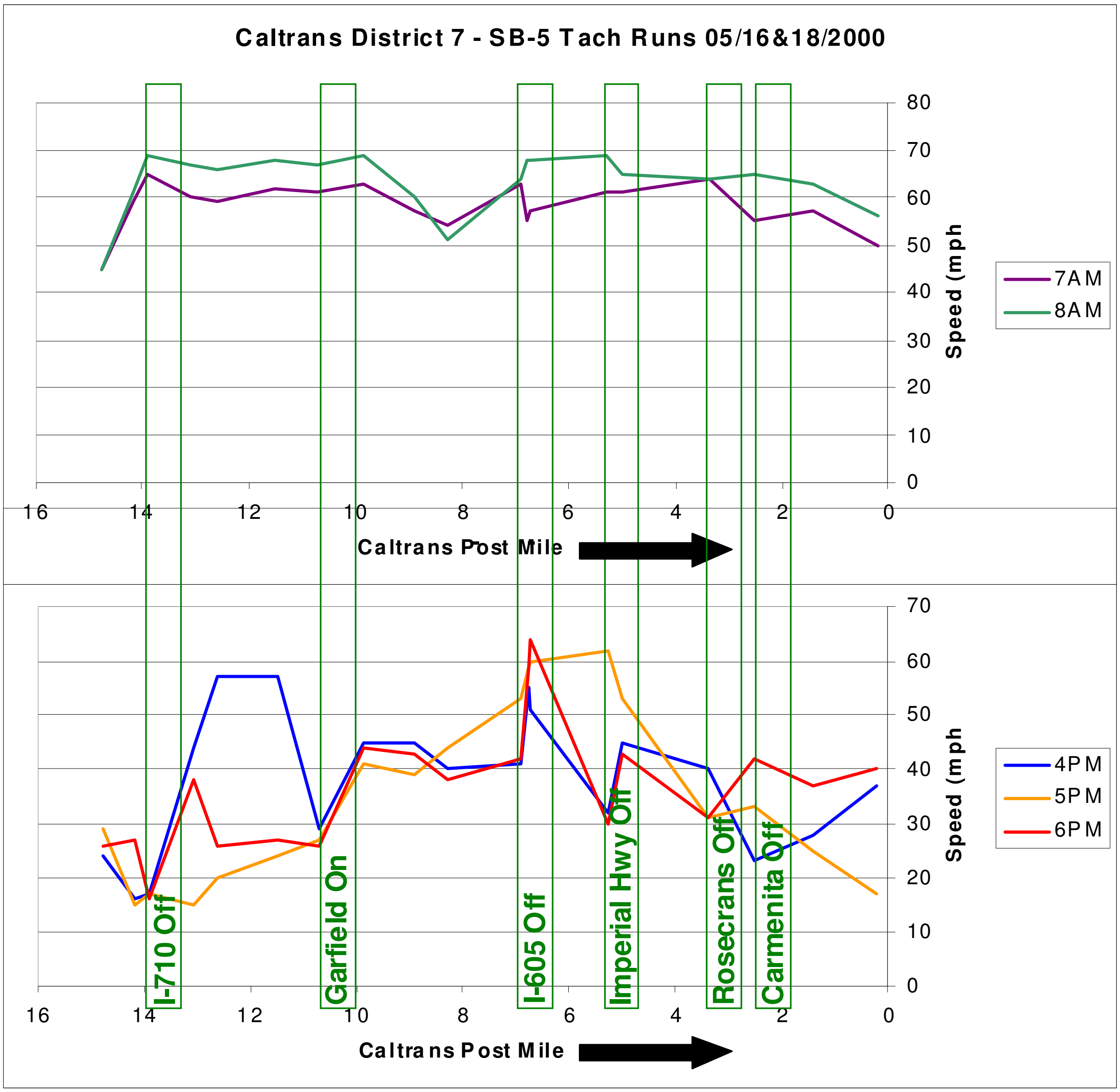


Exhibit 4A-7 shows the I-5 southbound probe vehicle runs, which were conducted on separated days in May 2000, for five specific times: 7:00 AM, 8:00 AM, 4:00 PM, 5:00 PM, and 6:00 PM. There are slow speeds (congestion) and bottleneck evident only in the PM peak hours in the southbound direction.

Exhibit 4A-7: Southbound I-5 Sample Probe Vehicle Runs (May 2000)



Automatic Detector Data

The third source used to identify potential bottlenecks prior to the in-depth field visits was to review speed contour and speed profile plots from automatic detectors. The study team downloaded detector data from the Caltrans Performance Measurement System (PeMS) to conduct this analysis.

Speed contour plots show speeds for every detector location for every five-minute period throughout the day. The resulting plot shows the location, extent, and duration of congestion.

Speed profile plots are very similar to probe vehicle graphs. Unlike the probe vehicle runs, each speed plot has the same time across the corridor. For example, an 8:00 AM plot includes the speed at one end of the corridor at 8:00 AM and the speed at the other end of the corridor also at 8:00 AM. With probe vehicle runs, the end time, or time at the end of the corridor is the departure time plus the actual travel time. Despite this difference, the two sets of graphs identify similar problem areas. These speed plots are then compiled at five minute intervals and presented in speed contour plots.

<u>Northbound I-5 Detector Analysis</u>

Exhibit 4A-8 shows the speed contour plots for Wednesday, February 28, 2007 and Thursday, March 1, 2007. The speed contour plots represent a typical weekday sample to illustrate the bottleneck locations and the resulting congestion. The sample days had observed or "good" detection data of 74 and 80 percent, providing reasonably accurate results.

The speed contour plots are typical speed contour diagrams for the I-5 freeway in the northbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4:00 AM to 8:00 PM. Along the horizontal axis is the corridor segment from the Orange County Line to the I-710 interchange. The various colors indicate the average speeds corresponding to the color speed chart shown below the diagram. The dark blue blotches represent congested areas where speeds are reduced. The end of each dark blotch represents a bottleneck area, where speeds pickup after congestion, typically to 30 to 50 miles per hour in a relatively short distance. The horizontal length of each plot is the congested segment or queue lengths. The vertical length is the congested time period.

Exhibit 4A-9 shows the speed profile plots for Thursday, March 1, 2007. The speed profile plots represent a typical weekday sample to illustrate the bottleneck locations and congestion formed at a particular time in the day, in this case 8:00 AM and 5:00 PM. The speed profile plots illustrate the typical speed profile diagram for the I-5 freeway in the northbound direction (traffic moving left to right on the plot).

Exhibit 4A-8: Northbound I-5 Speed Contour Plots (February/March 2007)

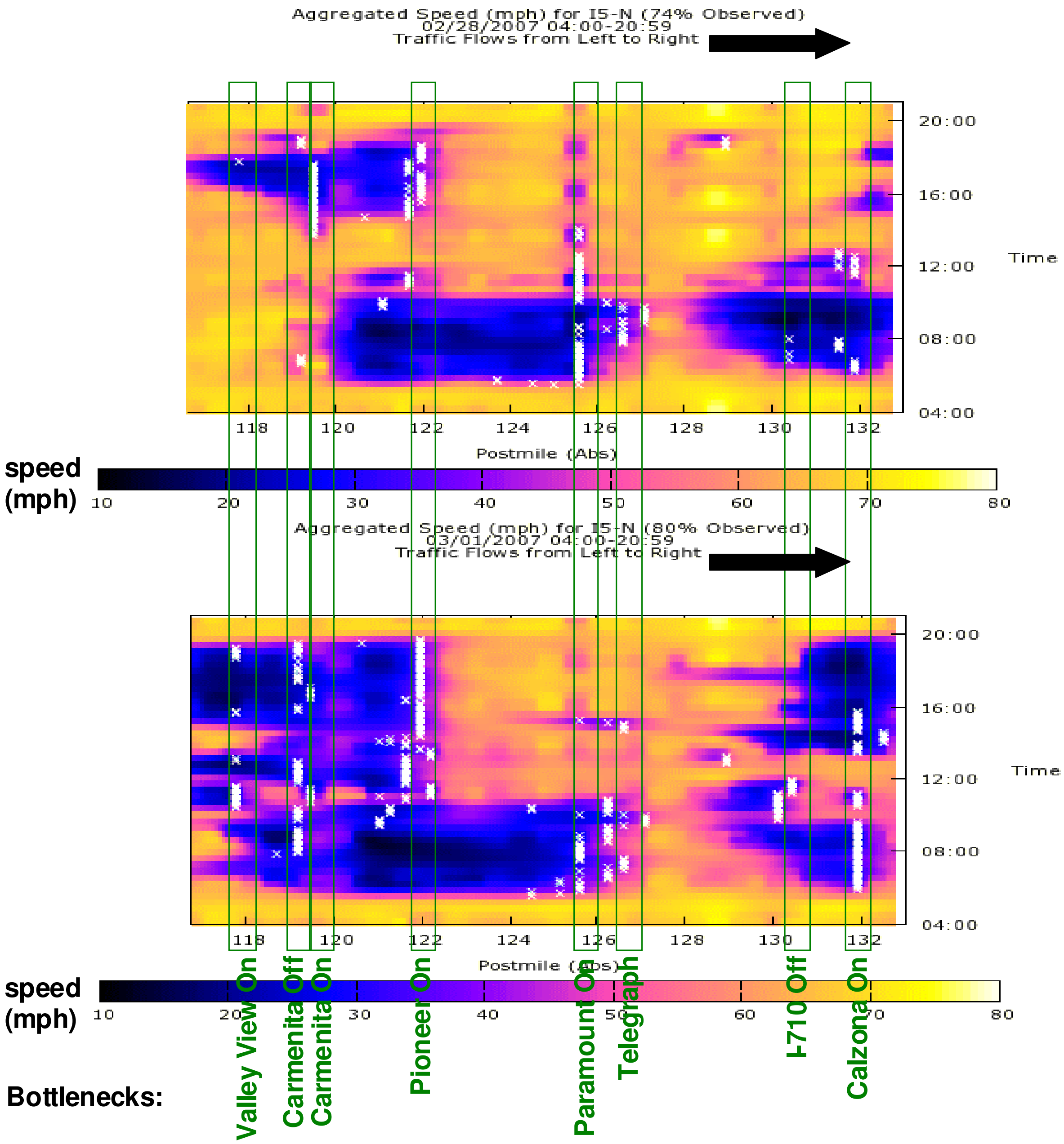
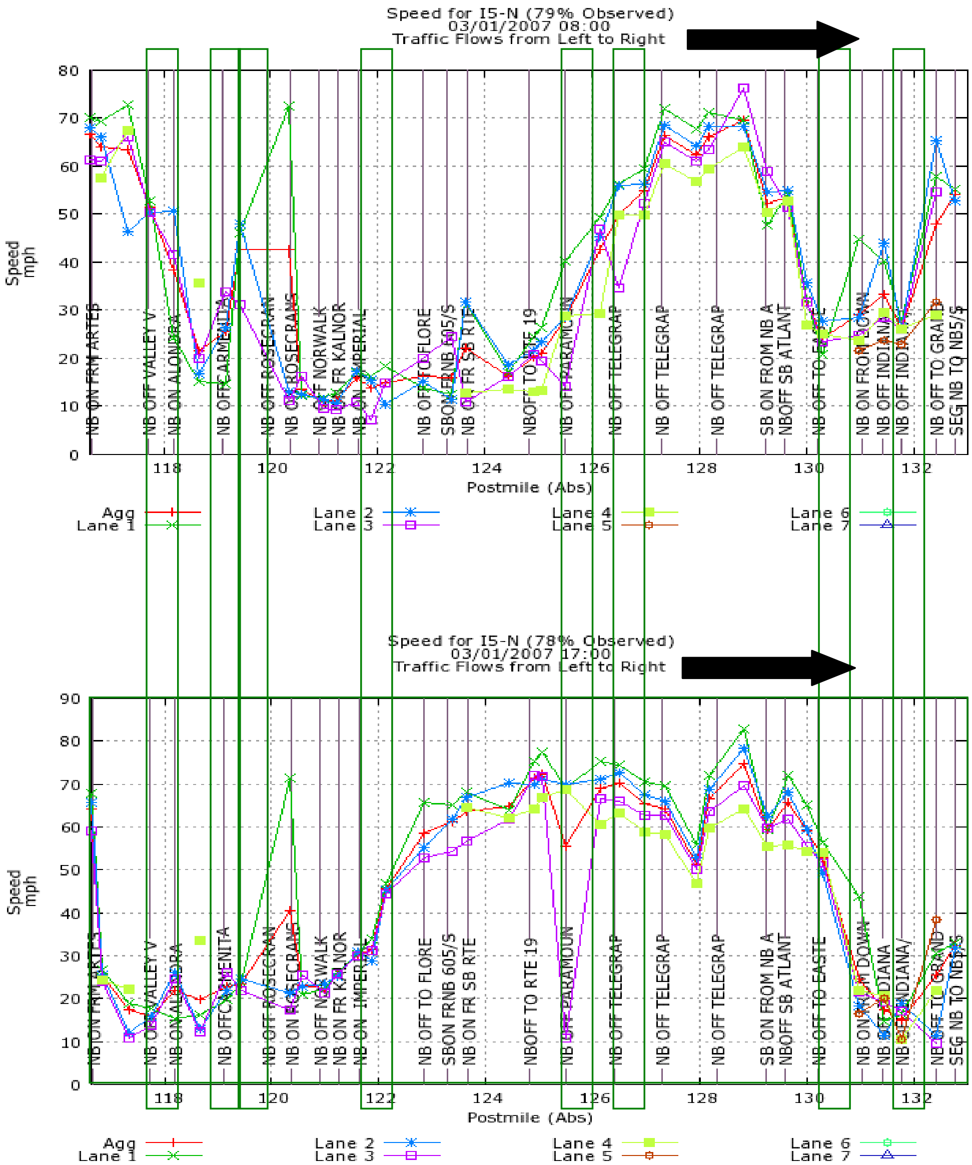
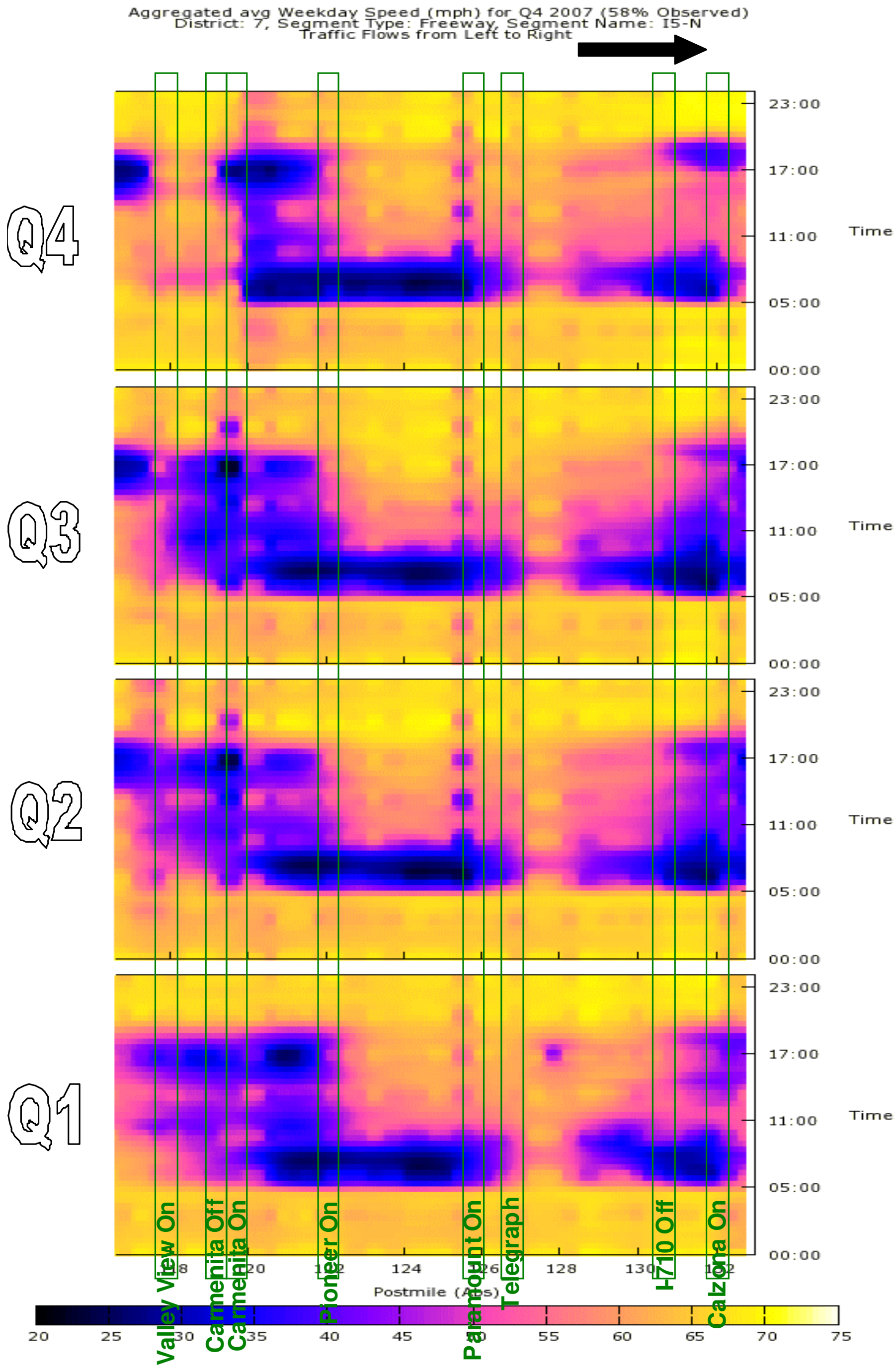


Exhibit 4A-9: Northbound I-5 Speed Profile Plots (March 2007)



In addition to multiple days, averages over longer periods were also considered. Exhibit 4A-10 shows weekday averages by each quarter of 2007. Again, the same bottleneck locations are identified. From the long contours, the same bottlenecks are evident, further validating the reoccurring pattern of the bottleneck locations.

Exhibit 4A-10: Northbound I-5 Speed Long Contours (2007 Quarterly Averages)



Southbound I-5 Detector Analysis

Similarly, the study team analyzed speed contour and profile plots in the southbound direction for probe vehicle sample days in February and March 2007. The results were validated by examining additional days in October 2006 and quarterly averages for 2007. Exhibits 4A-11 to Exhibit 4A-14 illustrate the speed contour and profile plots for the I-5 freeway corridor in the southbound direction (traffic moving left to right on the plot) for sample weekdays in February and March 2007, additional typical weekdays in October 2006, and 2007 quarterly weekday average long contours. Along the vertical axis is the time period from 4:00 AM to 8:00 PM. Along the horizontal axis is the corridor segment from the Orange County Line to the I-710 interchange. Similar to the northbound speed contour analysis results, the southbound speed contour analysis results indicated reoccurring bottleneck locations across multiple weekdays and quarterly averages.

Exhibit 4A-11: Southbound I-5 Speed Contour Plots (February/March 2007)

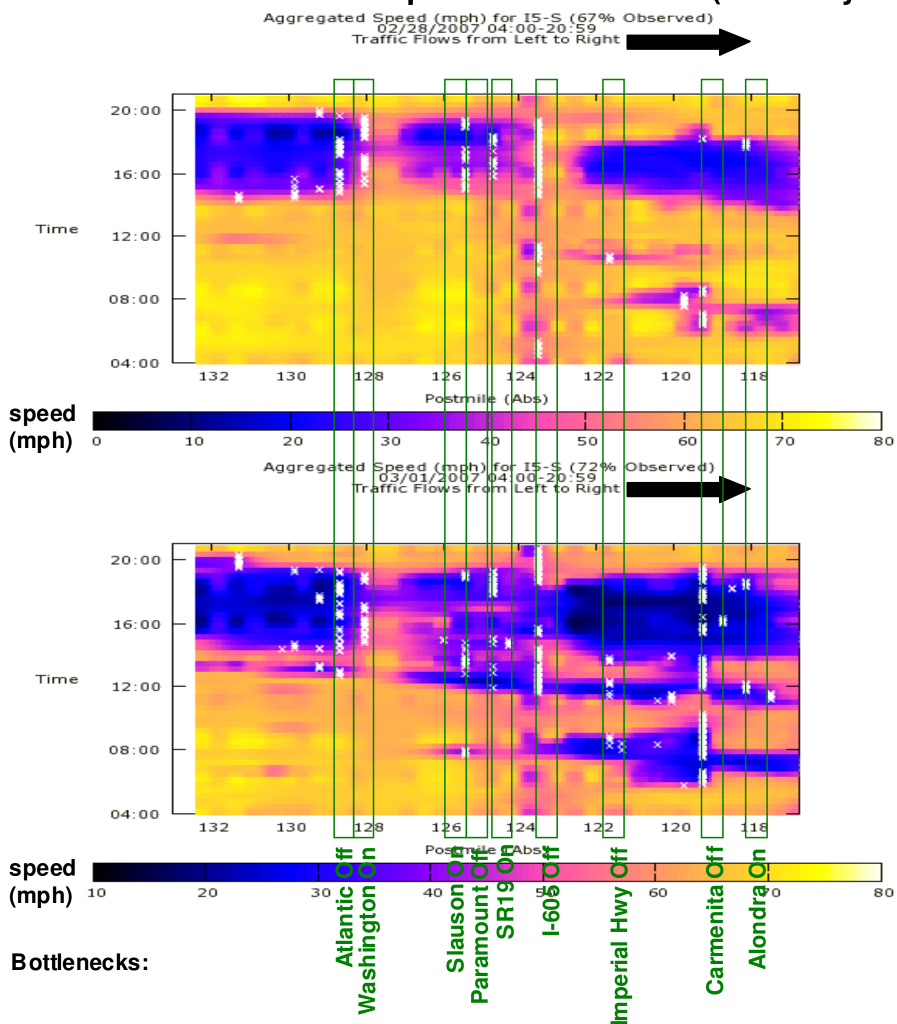


Exhibit A4-12: Southbound I-5 Speed Profile Plots (March 2007)

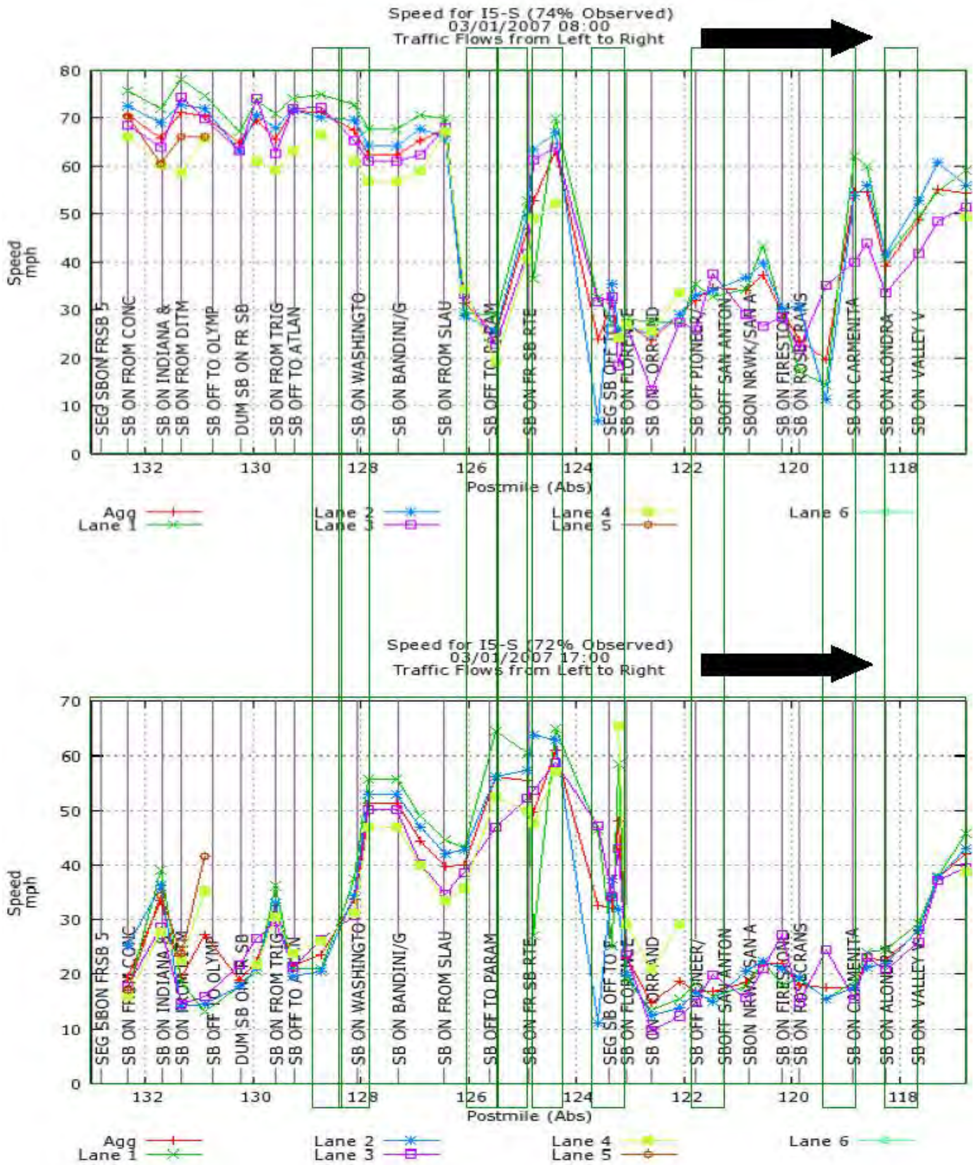


Exhibit A4-13: Southbound I-5 Speed Contour Plots (October 2006)

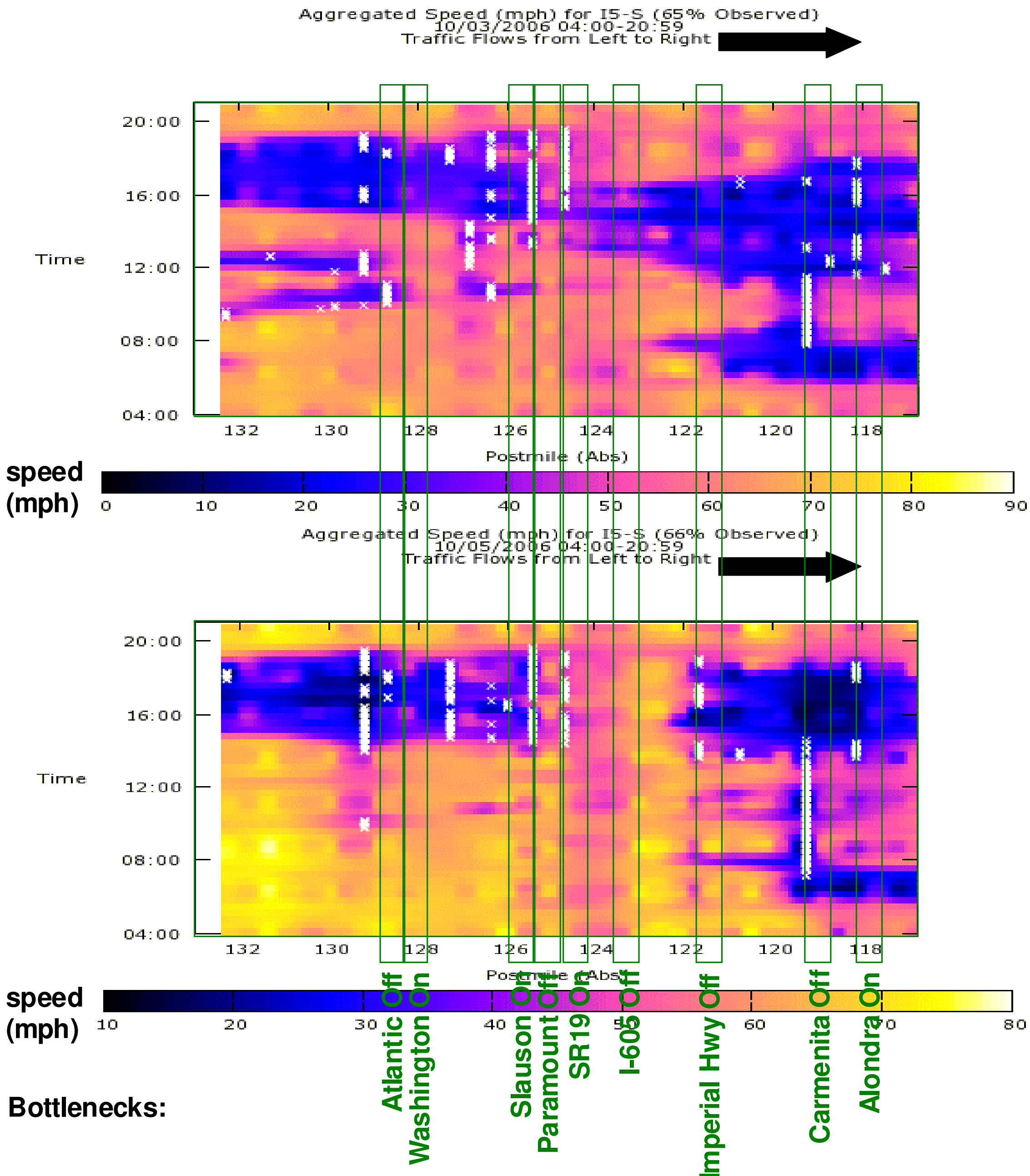
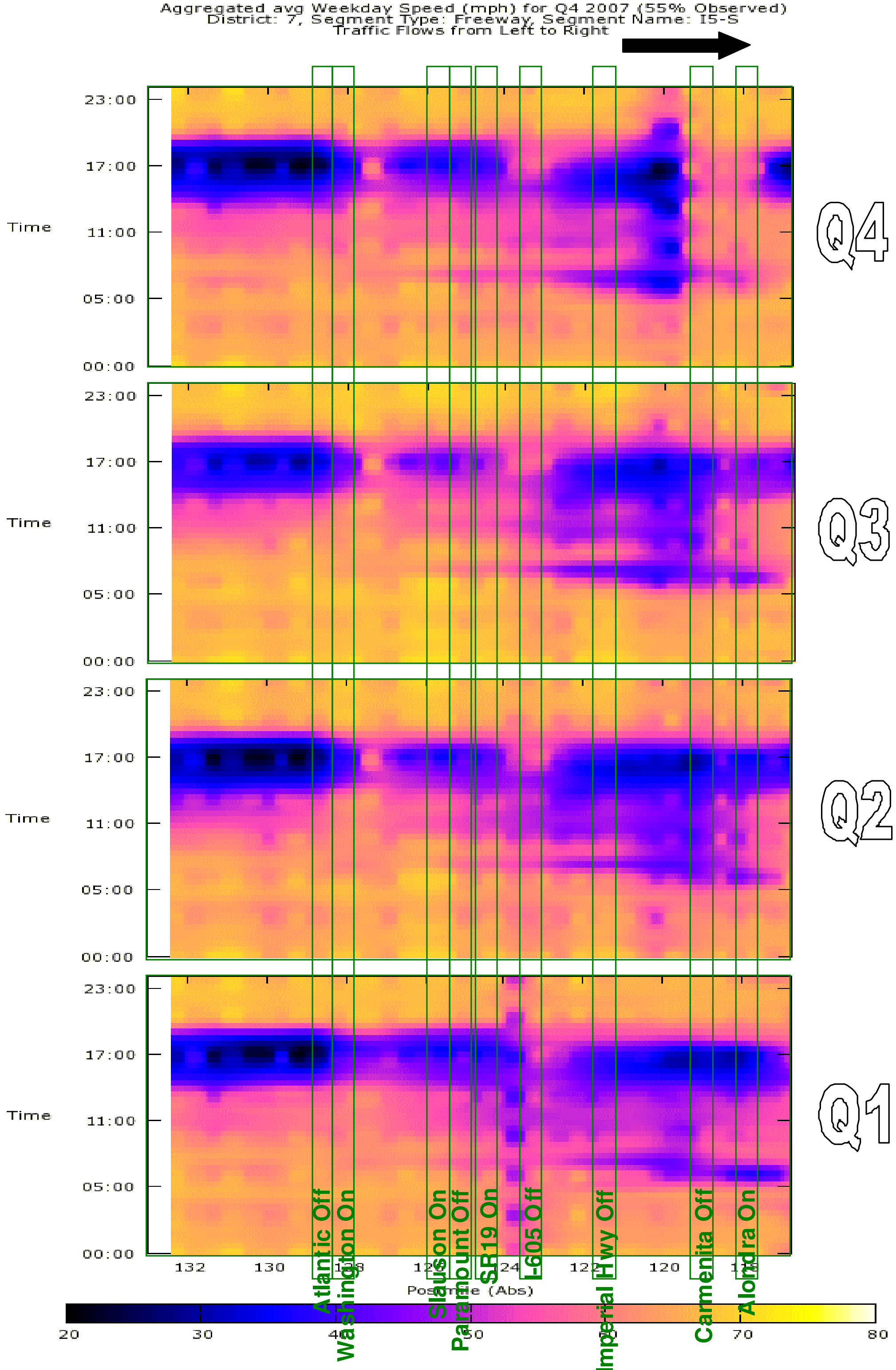


Exhibit A4-14: Southbound I-5 Speed Long Contours (2007 Quarterly Averages)



B. Bottleneck Causality Analysis

The causes of each bottleneck location identified in the previous section are discussed in this part of the report.

Major bottlenecks are the location of corridor performance degradation and resulting congestion and lost productivity. It is important to verify the specific location and cause of each major bottleneck to determine appropriate solutions to traffic operational problems.

The location of each major bottleneck should be verified by multiple field observations on separate days. The cause of each major bottleneck can also identified by field observations and additional traffic data analysis. For the I-5 Corridor, field observations were conducted by the project consultant team on multiple days (midweek) in September, October, and November 2008 during the AM and PM peak hours. The most recent field reviews were conducted from November 18 to 20, 2008.

By definition, a bottleneck is a condition where traffic demand exceeds the capacity of the roadway facility. The cause of a bottleneck is typically related to a sudden reduction in capacity, such as a physical loss when a lane drop occurs or when heavy merging and weaving take place at major on and off-ramps. Other variables that can cause reductions in capacity include weather or driver distractions. On the demand side, surges in demand can be larger than a roadway can accommodate. In many cases, it is a combination of increased demand and capacity reductions.

NORTHBOUND BOTTLENECKS CAUSALITY

Major northbound bottlenecks and congestion often occurs during both AM and PM peak hours. The following is a summary of the northbound bottlenecks and the identified causes.

The following northbound bottlenecks were identified in the previous section:

- Carmenita Interchange
- Pioneer On-Ramp
- I-605 On-Ramp
- Paramount On-Ramp
- Telegraph Off-Ramp
- I-710 On-Ramp.

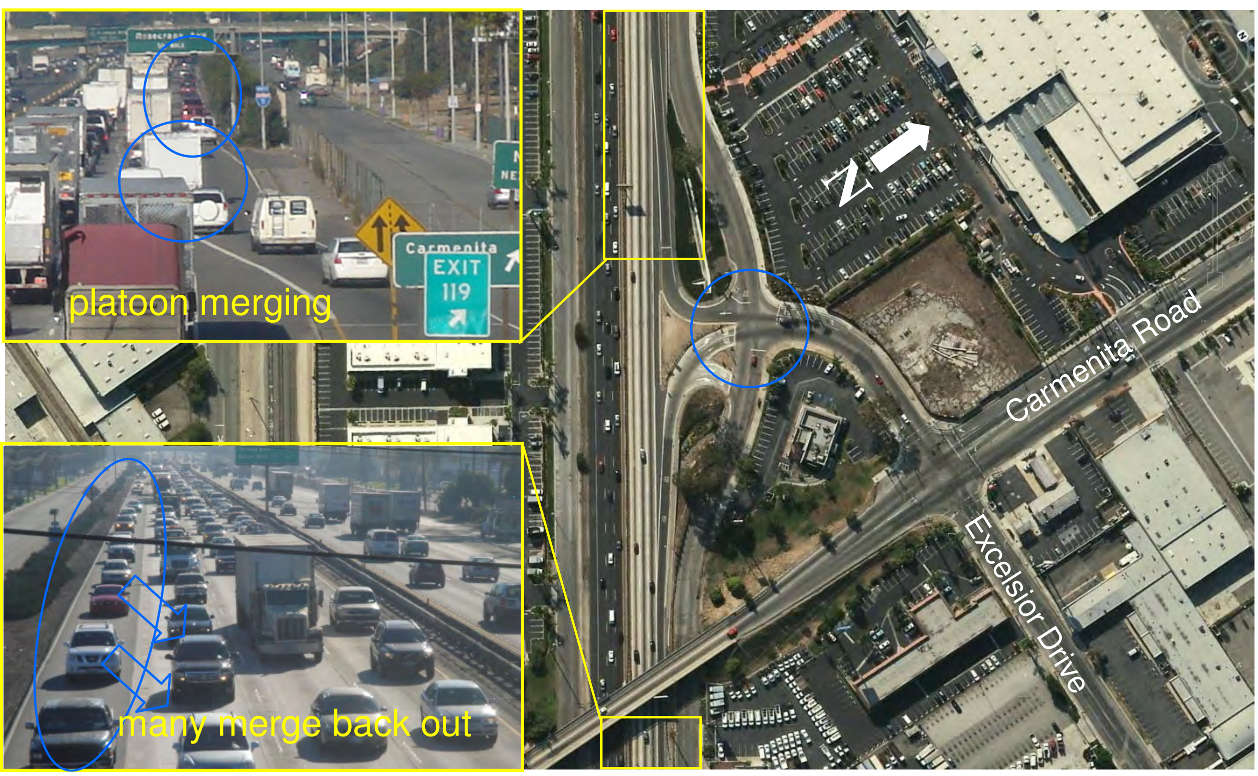
<u>Carmenita Road Interchange</u>

Exhibit 4B-1 is an aerial photograph of the northbound I-5 mainline at the Carmenita Road Interchange. As shown, the on- and off-ramps are slip ramps that no longer meet the current demand. The poor geometric configuration of this interchange results in inefficient traffic operations. The primary cause of this bottleneck is the traffic merging from both the off-ramp and the on-ramp.

As the lower inset digital photograph indicates, much of the heavy traffic in the auxiliary lane merges back into the mainline, rather than exiting at the off-ramp. The mainline at capacity cannot absorb the additional demand, resulting in a bottleneck. Also, as the upper inset photograph indicates, the traffic from the on-ramp merges onto the mainline as the auxiliary lane ends at Rosecrans Avenue, also resulting in a bottleneck condition. The ramp metering at the on-ramp is ineffective due to the lack of storage capacity on the ramp.

Additionally, the intersection at the base of the ramps is a stop-controlled intersection. During heavy peak periods, the off-ramp traffic queues onto the mainline from the intersection.

Exhibit 4B-1: Northbound I-5 at Carmenita Road IC



Imperial Highway On/Pioneer Boulevard On-Ramp

Exhibit 4B-2 is an aerial photograph of the northbound I-5 mainline between Imperial Highway and Pioneer Boulevard. As shown, there are two on-ramps in close proximity, one from Imperial Highway and another from Pioneer Boulevard.

As indicated from the inset photographs, the configuration of both ramps includes a very short taper. This makes for a difficult merge transition, particularly with heavy truck traffic present on the mainline. In addition, there is a short but noticeable vertical grade as the freeway crosses over the two interchanges, slowing vehicles down, especially heavy trucks. This is also evident in the photographs.

Although the ramp volumes are not heavy (even during peak hours), it is enough to disrupt the mainline flow and create the bottleneck condition. Just past the Pioneer Boulevard on-ramp, traffic flow returns to free-flow speeds.

Exhibit 4B-2: Northbound I-5 at Imperial Highway and Pioneer Blvd. Interchanges

Florence Avenue/I-605 On-Ramp

Exhibit 4B-3 is an aerial photograph of the northbound I-5 mainline at the I-605 Interchange. As indicated in the top blue oval, the two connector on-ramps from the I-605 merge together into a new (fourth) lane. Just upstream of the connector on-ramp to the I-5 is the Florence Avenue on-ramp merge, as indicated in the bottom blue oval.

Although this location does not always form a bottleneck, it does occur, whenever the ramp or mainline traffic volumes are heavy. With traffic growth, it is likely to be a major bottleneck in the future.

Exhibit 4B-3: Northbound I-5 at Florence Avenue and I-605 On-Ramp

Paramount Boulevard On-Ramp

Exhibit 4B-4 is an aerial photograph of the northbound I-5 at Paramount Boulevard. The bottleneck condition at this location is caused by the platoon of vehicles merging onto the freeway mainline as the mainline traffic makes the turn (see the inset photograph). The photograph illustrates the mainline queuing behind the merge point and the free-flow conditions just past it.

The platoon is due to the ramp metering location too far back the ramp as indicated by the blue circle, releasing two vehicles at a time. By the time they reach the merge point, a platoon of four to six vehicles already are formed as they merge onto the freeway. The congestion and queuing extends for many miles behind this bottleneck during the AM peak hours. Some congestion also forms behind this bottleneck during the PM peak hours.

Exhibit 4B-4: Northbound I-5 at Paramount Boulevard On-Ramp

Telegraph Road/Slauson Avenue Off-Ramp

Exhibit 4B-5 is an aerial photograph of the northbound I-5 approaching the Telegraph Road/Slauson Avenue off-ramp. The bottleneck condition at this location is caused by the combination of uphill grade, roadway curvature, and slow speeds coming out of the Paramount Boulevard bottleneck, as evident in the inset photograph. As the traffic travels over the hill and around the curve, speeds increase to free-flow speeds and the queue begins to dissipate.

Exhibit 4B-5: Northbound I-5 Approaching Telegraph Road/Slauson Avenue Off

<u>I-710 On-Ramp</u>

The last bottleneck in the northbound direction is at the I-710 connector on-ramp. Exhibit 4B-6 is an aerial photograph of the northbound I-5 at the I-710 on-ramp merge point. About a mile and a half further downstream, the freeway separates into the US-101 in the left lanes, the I-5 in the middle lanes, and the I-10 in the right lanes. Traffic from the I-710 merges from the left. As a result, there is a significant amount of cross-weaving at this junction as some of the I-5 vehicles are shifting to the left to use US-101 and some of the I-710 vehicles are shifting to the right to use I-10.

Exhibit 4B-6: Northbound I-5 at I-710 On-Ramp

SOUTHBOUND BOTTLENECKS CAUSALITY

The southbound bottlenecks occur mostly in the PM peak hours although the same bottlenecks occur to a lesser degree in the AM peak hours. The southbound bottlenecks were identified at:

- Washington On-Ramp
- Paramount On-Ramp
- I-605 Off-Ramp
- Carmenita Interchange
- Valley View Interchange
- Orange/Los Angeles County Line.

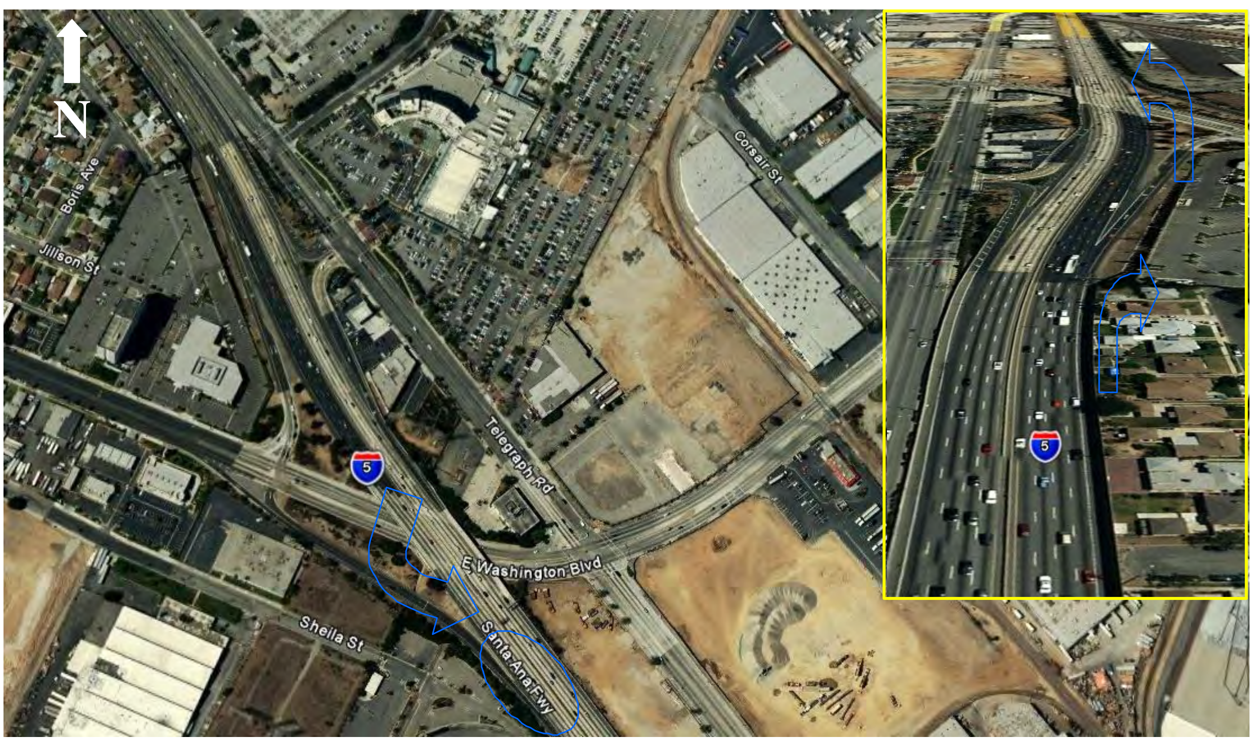
The following is a summary of the southbound bottlenecks and identified causes.

<u>Washington Boulevard Interchange</u>

Exhibit 4B-7 is an aerial photograph of the southbound I-5 mainline at the Washington Boulevard Interchange. Although substantial congestion was not observed in any of the field visits at this location, vehicles did slow down to below 35 miles per hour on many occasions during the PM peak hours. It is likely that the primary cause of the bottleneck at this location is the presence of an on-ramp merge beyond the crest of a vertical grade.

Although this location appears to be the primary bottleneck location, sometimes the bottleneck occurs at Atlantic Boulevard interchange further upstream or at Bandini Boulevard/Slauson Avenue interchange further downstream. Similar to the Washington Boulevard interchange, geometric configurations at both locations appear to affect traffic flow and reduce travel speed during the PM peak hours.

Exhibit 4B-7: Southbound I-5 at Washington Blvd. Interchange



<u>Paramount Boulevard On/Lakewood Boulevard On</u>

Exhibit 4B-8 is an aerial photograph of the southbound I-5 at the Paramount Boulevard and Lakewood Boulevard interchanges. The primary location of the bottleneck is at the Paramount Boulevard on-ramp merge. However, bottlenecks also form on frequent occasions at the Lakewood Boulevard on-ramps as well.

The primary cause of the bottleneck at Paramount Boulevard on-ramp is its location affecting the merge. As the inset photograph illustrates, queues often extends to the Slauson Avenue interchange. It also illustrates the geometric configuration of the vertical grade over the crest and dropping down (past Paramount Boulevard, while moving in a turn to the left). The on-ramp merge point is at the peak of the roadway curve to the left and descent, causing vehicles to slow down suddenly to allow for the slow moving on-ramp traffic to merge.

The cause of the bottleneck at the Lakewood Boulevard on-ramp is due to the consecutive on-ramps merging, not allowing the mainline traffic to recover from the merging. When ramp traffic is heavy during the peak hours, the mainline cannot accommodate the additional demand and merging effects.

Exhibit 4B-8: Southbound I-5 at Paramount and Lakewood Blvd. Interchanges

I-605 Off-Ramp

Exhibit 4B-9 is an aerial photograph of the southbound I-5 at the I-605 connector off-ramp. As shown, the mainline roadway loses one lane to the I-605 off, going from four lanes to three. Based on the field reviews, it does not appear to be the lane drop that causes the bottleneck at this location but rather the queuing of the I-605 off-ramp traffic backing up onto the I-5 mainline. As a result, the third lane is sometimes blocked as well since the third lane is an option lane for I-5 and I-605 exit. This bottleneck condition only occurs when the exiting traffic at the I-605 off-ramp is heavy during the peak hours.

Exhibit 4B-9: Southbound I-5 at I-605 Off-Ramp

Carmenita Road Interchange

Exhibit 4B-10 is an aerial photograph of the southbound I-5 mainline at Carmenita Road Interchange. As shown, like the northbound, the on and off-ramps are slip ramps that no longer meet the current demand, but unlike the northbound, these ramps do not connect to an auxiliary lane. The poor geometric configuration of this interchange results in inefficient traffic operations.

The upper inset photograph shows the significant congestion and queues approaching the interchange. The next photograph below shows the congestion loosening up at the off-ramp location. Passing the on-ramp, the speeds return to free-flow conditions.
From the field observations it was noticed that the ramp traffic itself does not seem to directly cause the bottleneck condition, unlike the northbound direction. The bottleneck is likely due to the poor geometric configuration of the interchange causing the slow down at this junction. The on-ramp traffic is just below 500 vehicles per hour during the peak hours.

Exhibit 4B-10: Southbound I-5 at Carmenita Road IC

Valley View Avenue Interchange/Artesia Boulevard Construction

Exhibit 4B-11 is an aerial photograph of the southbound I-5 mainline at Valley View Avenue Interchange. The traffic effects are very similar to Carmenita Road as the interchange is also very similar in configuration. Just past this interchange is the beginning of the mainline construction approaching Artesia Boulevard. The construction elements with alignment shift, changing pavement conditions, concrete rails on both sides, little or no shoulder width, and construction activities causes the traffic to breakdown since the reduced capacity associated with construction cannot accommodate the constant demand.

Exhibit 4B-11: Southbound I-5 at Valley View Ave. and Artesia Blvd.

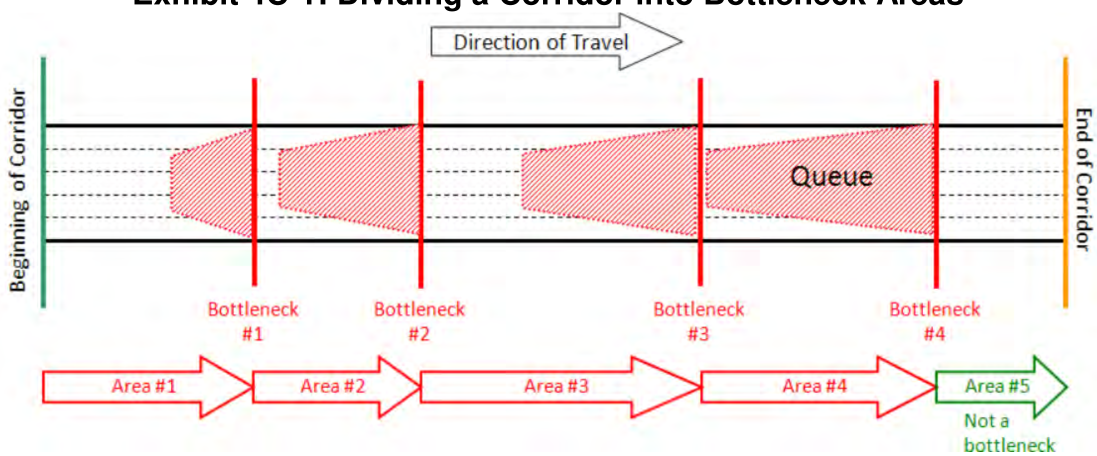
C. Bottleneck Area Analysis

Once the bottlenecks were identified, the corridor is divided into "bottleneck areas." Bottleneck areas represent segments that are defined by one major bottleneck (or a number of smaller ones). By segmenting the corridors into such bottleneck areas, some performance statistics that were presented earlier for the entire corridor can be segmented by bottleneck area. This way, the relative contribution of each bottleneck area to the degradation of the corridor performance can be gauged. The performance statistics that lend themselves to such segmentation include:

- Delay
- Productivity
- Safety.

The analysis of bottleneck areas is based on 2007 data (when available), the base year of the model. Based on this segmentation approach, the study corridor comprises several bottleneck areas, which differ by direction. Exhibit 4C-1 illustrates the general concept of bottleneck areas. The red lines in the exhibit represent the bottleneck locations and the arrows represent the bottleneck areas.

Exhibit 4C-1: Dividing a Corridor into Bottleneck Areas



Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. Based on the above, the bottlenecks previously identified in Exhibit 4A-1 are shown again in Exhibits 4C-2 and 4C-3 with the associated bottleneck areas.

Exhibit 4C-2: Northbound I-5 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Carmenita IC	OC/LA County line to Carmenita IC	✓	✓	116.0	0.0	119.1	2.5	3.1
Pioneer On	Carmenita IC to Pioneer On	✓	✓	119.1	2.5	121.9	5.2	2.8
I-605 On	Pioneer On to I-605 On	✓		121.9	5.2	123.6	7.0	1.7
Paramount On	I-605 On to Paramount On	✓		123.6	7.0	125.5	8.8	1.9
Telegraph Off	Paramount On to Telegraph Off/Slauson	✓		125.5	8.8	126.5	9.8	1.0
I-710 On	Telegraph Off/Slauson to I-710 On	✓	✓	126.5	9.8	130.5	13.7	4.0

Exhibit 4C-3: Southbound I-5 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Washington On	I-710 to Washington On		✓	130.5	13.7	128.0	11.5	2.5
Paramount On	Washington On to Paramount On		✓	128.0	11.5	125.5	8.9	2.5
I-605 Off	Paramount On to I-605 Off	✓	✓	125.5	8.9	123.6	7.0	1.9
Carmenita IC	I-605 Off to Carmenita IC	✓	✓	123.6	7.0	118.8	2.3	4.8
Valley View IC	Carmenita IC to Valley View On		✓	118.8	2.3	117.6	1.0	1.2
OC/LA County Line	Valley View On to OC/LA County line	✓	✓	117.6	1.0	116.0	0.0	1.6

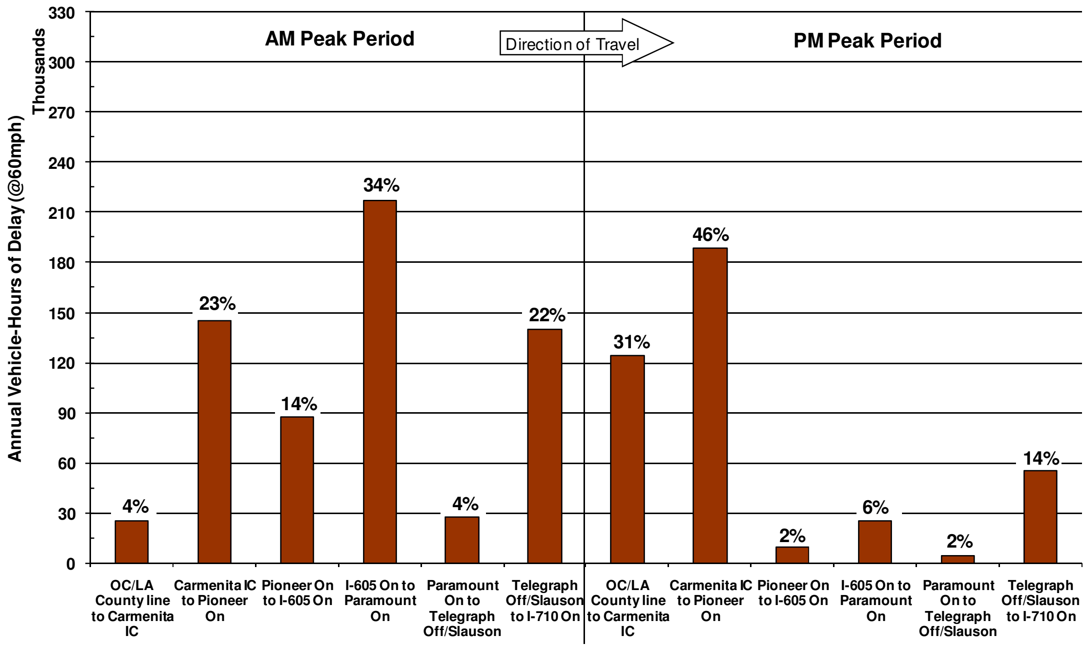
MOBILITY BY BOTTLENECK AREA

Mobility describes how efficiently the corridor moves vehicles. To evaluate how well (or poorly) each bottleneck area moves vehicles, vehicle-hours of delay were calculated for each segment. The results reveal the areas of the corridor that experience the worst mobility.

Exhibits 4C-4 and 4C-6 illustrate the vehicle-hours of delay experienced by each bottleneck area. As depicted in Exhibit 4C-4, delay in the northbound direction is slightly higher in the AM peak compared to the PM peak. The segment between I-605 to Paramount experienced the greatest delay during the AM peak with 34 percent of the corridor's delay, or over 210,000 annual vehicle-hours of delay. During the PM peak, the segment between Carmenita and Pioneer experienced the greatest delay.

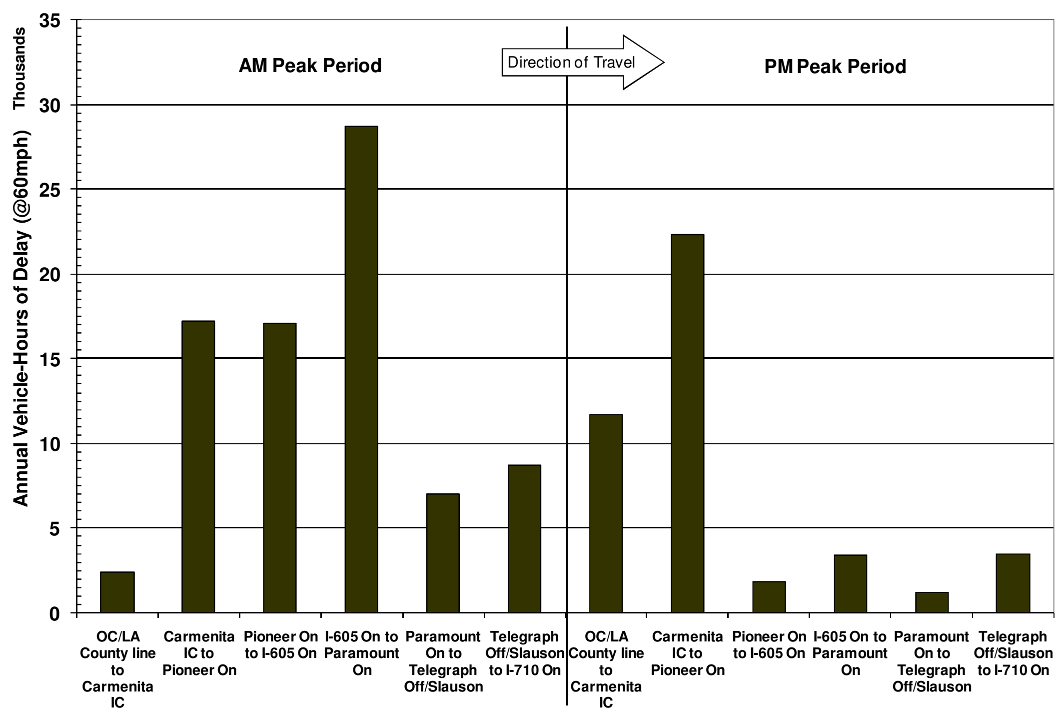
Delay in the southbound direction varied significantly between AM and PM peak periods. Exhibit 4C-6 shows that during the PM peak, the two combined segments of I-710 to Washington and I-605 to Carmenita experienced over 60 percent of the delay on the corridor, or about 270,000 annual vehicle-hours of delay each. In the AM peak, the segment between I-605 and Carmenita experienced the most delay with 61 percent of the delay on the corridor, or nearly 110,000 annual vehicle-hours of delay.

Exhibit 4C-4: Northbound I-5 Annual Vehicle-Hours of Delay (2007)



Source: Caltrans detector data

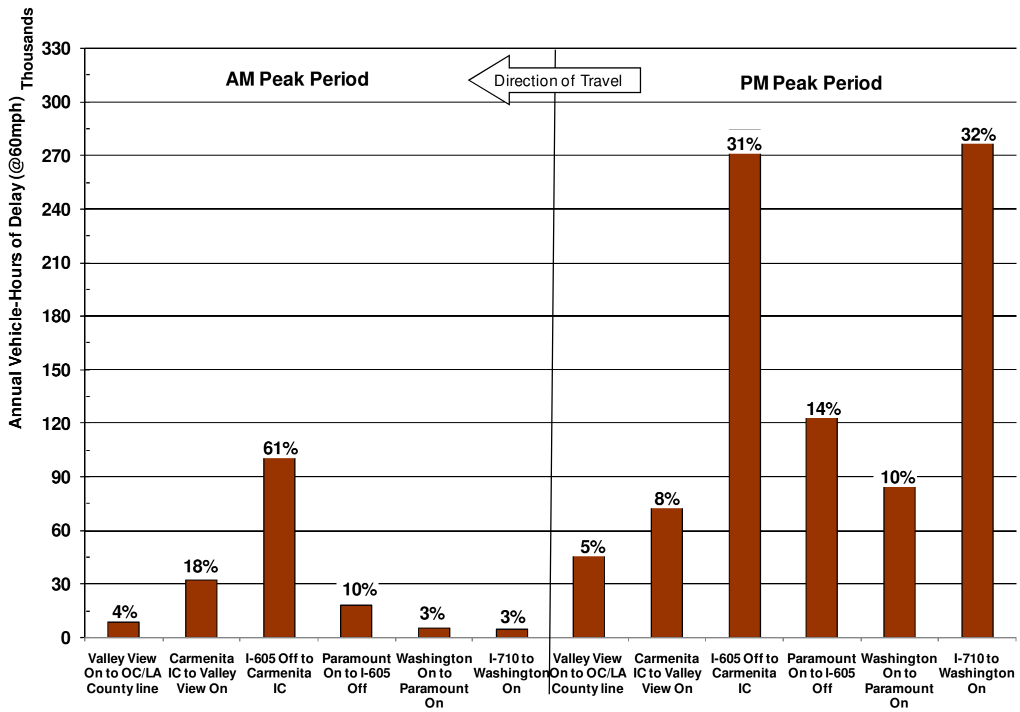
Exhibit 4C-5: Northbound I-5 Delay per Lane-Mile (2007)



Source: Caltrans detector data

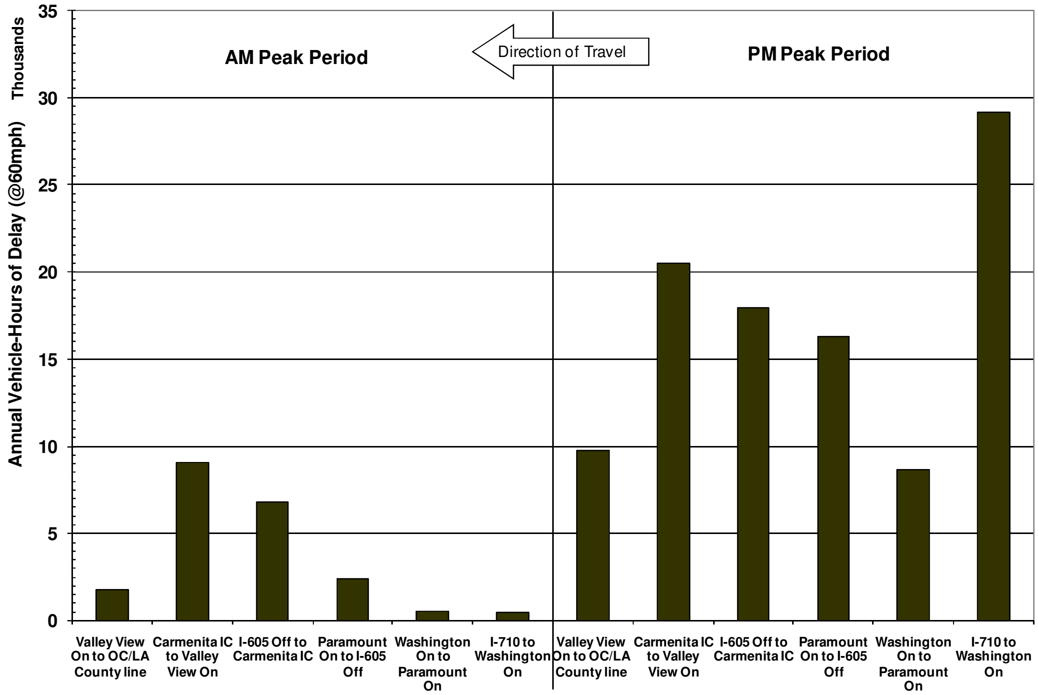
Exhibits 4C-5 and 4C-7 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. In both directions, the results were similar to the delay shown in Exhibits 4C-4 and 4C-6. However, in the southbound direction (Exhibit 4C-7), normalizing lane-miles resulted in more evenly distributed delay among the bottleneck areas during the PM peak period.

Exhibit 4C-6: Southbound I-5 Annual Vehicle-Hours of Delay (2007)



Source: Caltrans detector data

Exhibit 4C-7: Southbound I-5 Delay per Lane-Mile (2007)



Source: Caltrans detector data

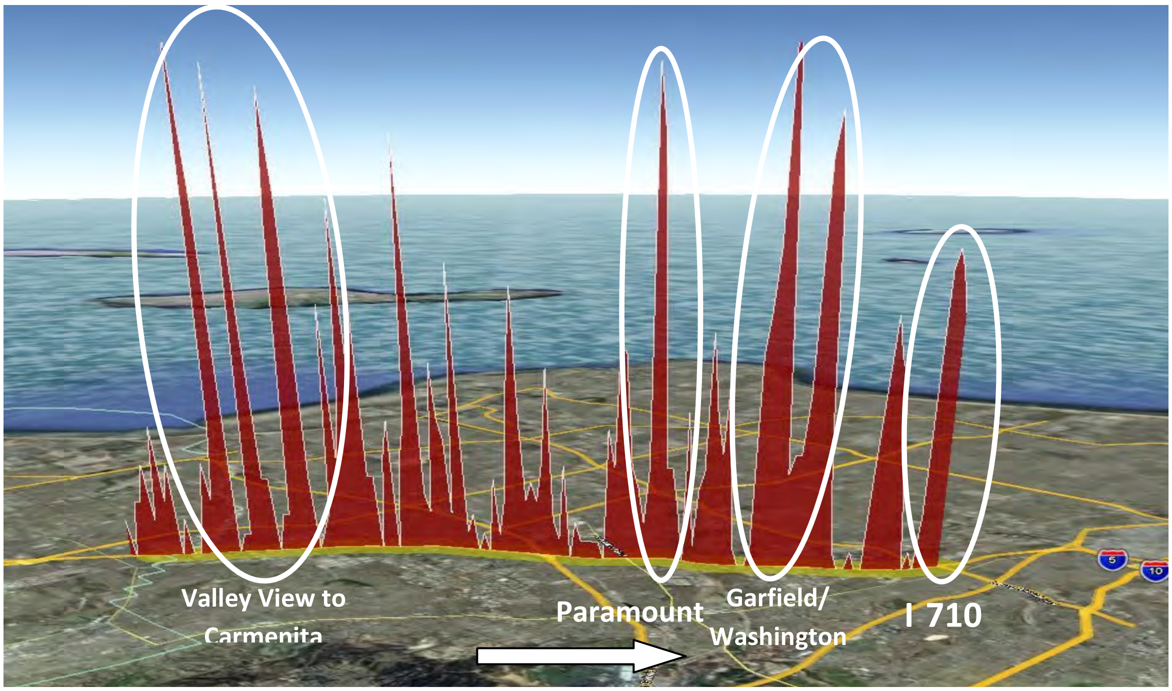
SAFETY BY BOTTLENECK AREA

As previously indicated in Section 3, the safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. The following discussion examines the pattern of collisions by bottleneck areas.

Exhibit 4C-8 shows the location of all collisions plotted along the I-5 Corridor in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) occurring within 0.1 mile segments during 2007. The highest spike corresponds to roughly 28 collisions in a single 0.1 mile location. The size of the spikes is a function of how collisions are grouped. If the data were grouped in 0.2 mile segments, the spikes would be higher.

As evident in Exhibit 4C-8, the study corridor has a high concentration of collisions at many locations. Therefore, it is relevant to identify the locations that have disproportionately high collision rates. Starting from the Orange/Los Angeles County Line and moving northbound, a large number of collisions occurred around Valley View and Carmenita, near Paramount, between Garfield and Washington, and at the I-710 Interchange. In many cases, a spike in the number of collisions occurs in the same location as a bottleneck. For example, a spike occurred at Carmenita and Paramount, which are also bottleneck locations.

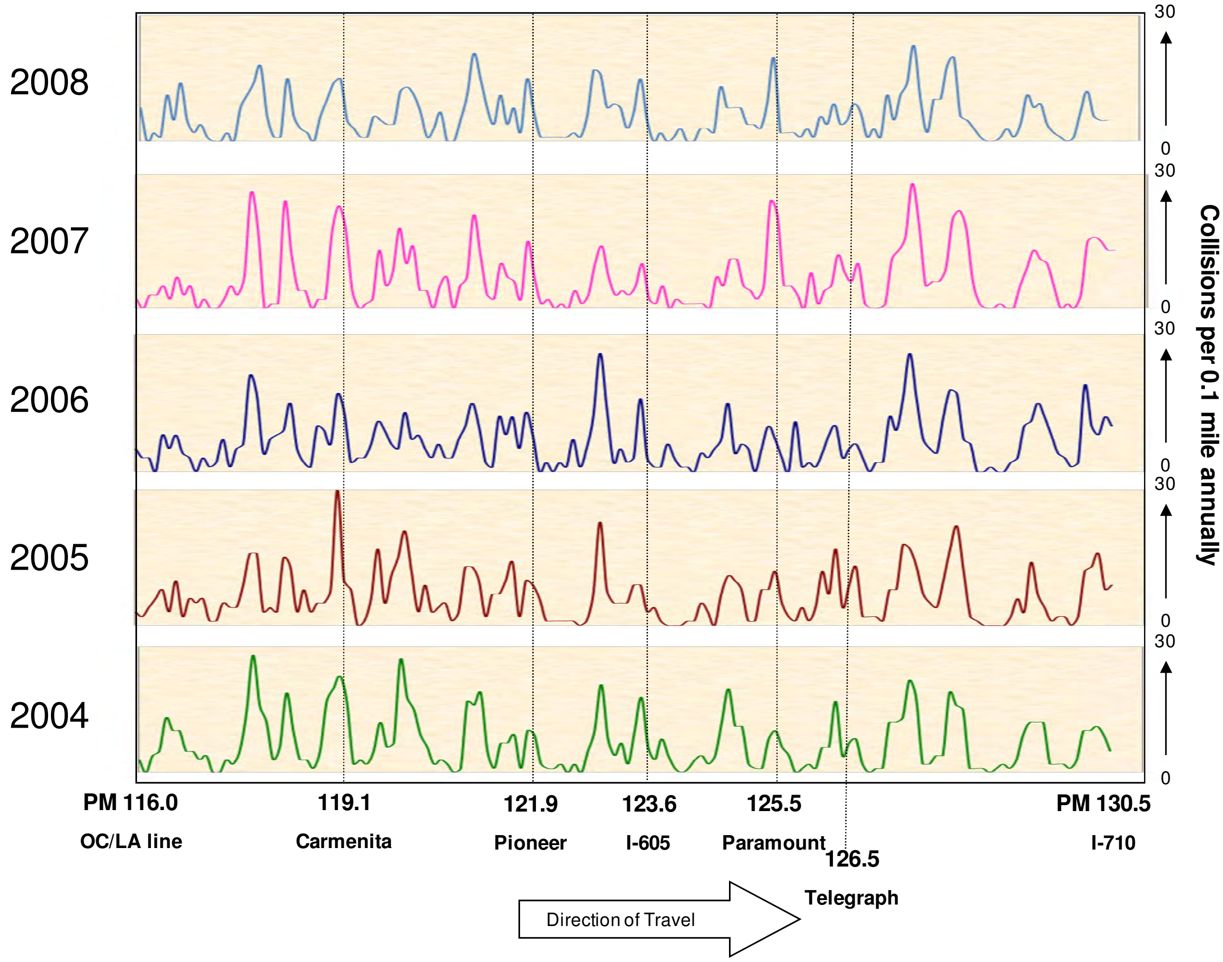
Exhibit 4C-8: Northbound I-5 Collision Locations (2007)



Source: TASAS

Exhibit 4C-9 illustrates the same data for the five-year period from 2004 to 2008. The vertical lines in the exhibit separate the corridor by bottleneck area. This exhibit is an extension of Exhibit 4C-8 as it includes collision data from the years preceding 2007. As indicated in Exhibit 4C-8 and as shown in Exhibit 4C-9, a high number of collisions occurred at Carmenita (PM 119.1) and at Paramount (PM 125.5). Exhibit 4C-9 shows that the pattern of collisions has stayed fairly consistent from one year to the next. However, the group of collisions near Paramount has increased overall since 2004.

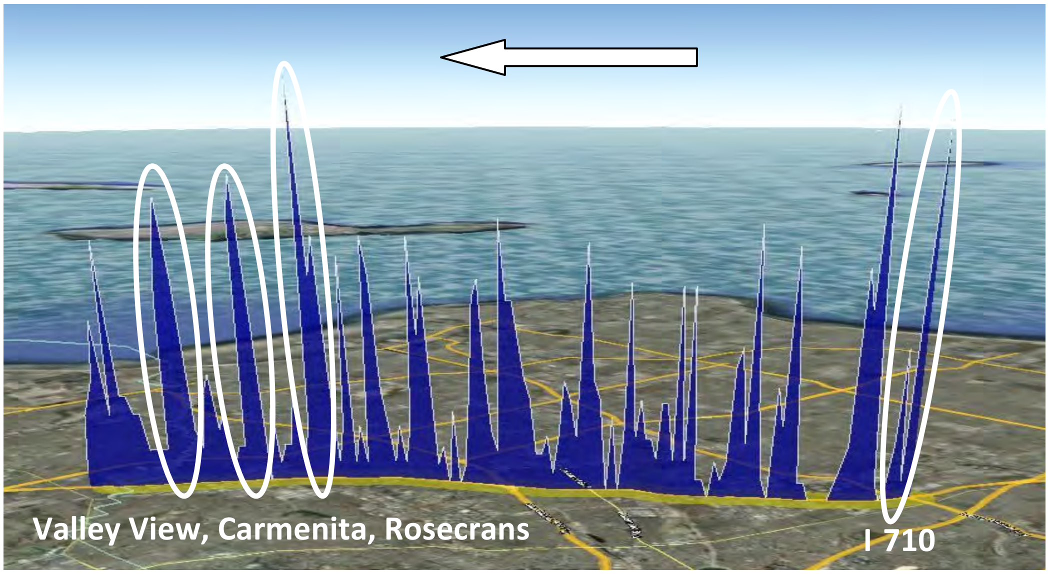
Exhibit 4C-9: Northbound I-5 Collision Locations (2004-2008)



Source: TASAS

Exhibit 4C-10 shows the same 2007 collision data for the I-5 in the southbound direction. The largest spike in this exhibit corresponds roughly to 20 collisions per 0.1 miles. The pattern in the southbound direction is similar to that in the northbound direction but with greater variance in spike lengths. Moving in the southbound direction from I-710, spikes are most notable at the I-710 Interchange, and near Rosecrans, Carmenita, and Valley View. The locations at Carmenita and Valley View are also bottleneck locations.

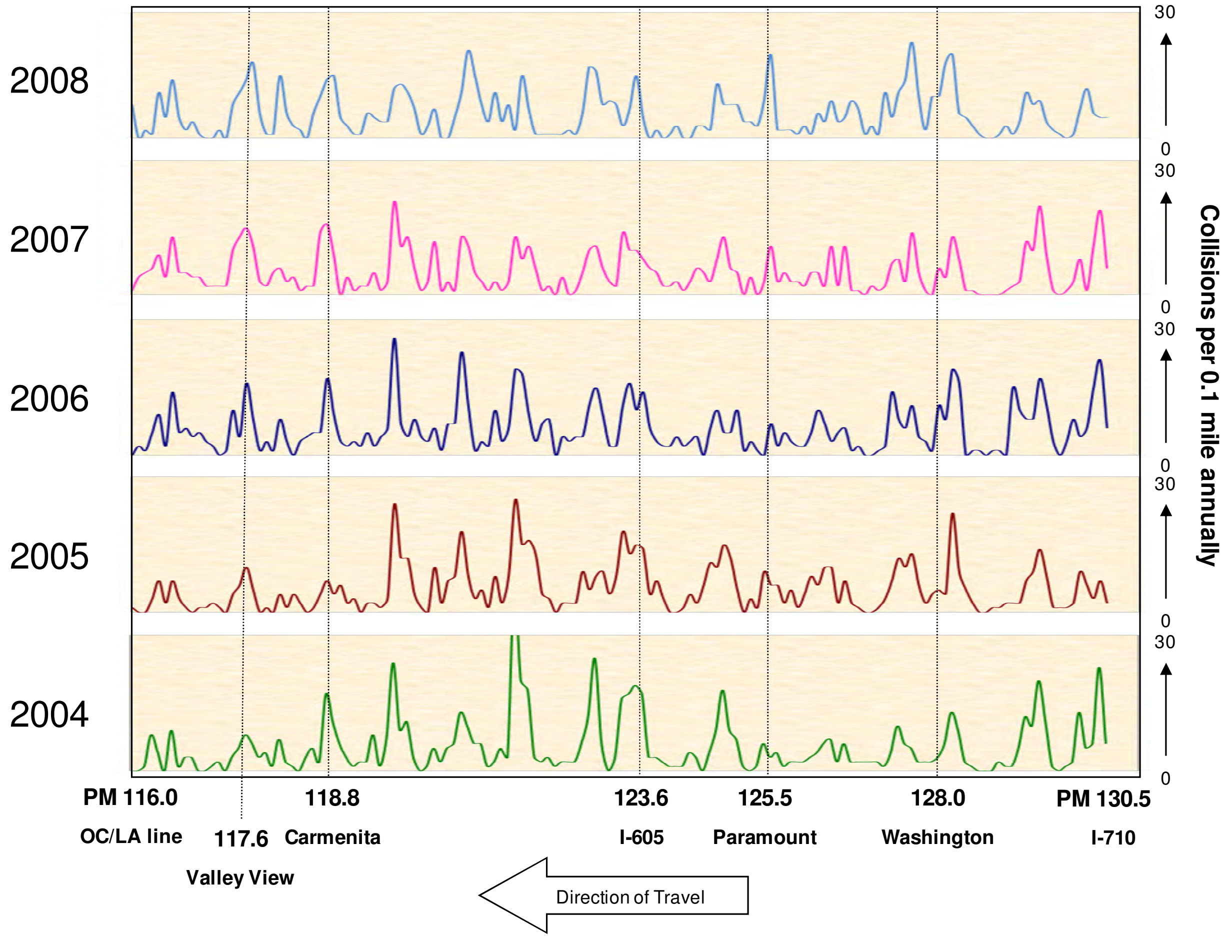
Exhibit 4C-10: Southbound I-5 Collision Locations (2007)



Source: TASAS

Exhibit 4C-11 shows the trend of collisions for the southbound direction during the 2004-2008 period by bottleneck area. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next. The bottleneck area with the highest spikes or largest number of collisions is located between the I-605 Interchange (PM 123.6) and Carmenita (PM 118.8). Collisions which occurred in this bottleneck area have decreased since 2004.

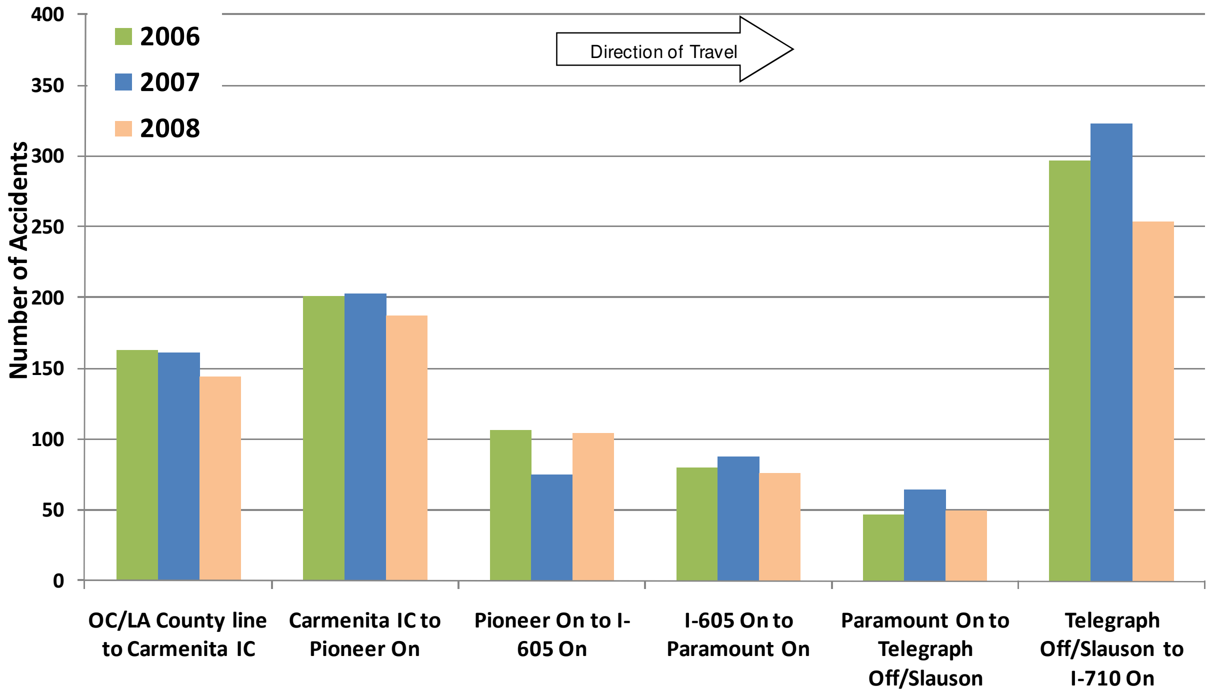
Exhibit 4C-11: Southbound I-5 Collision Locations (2004-2008)



Source: TASAS data

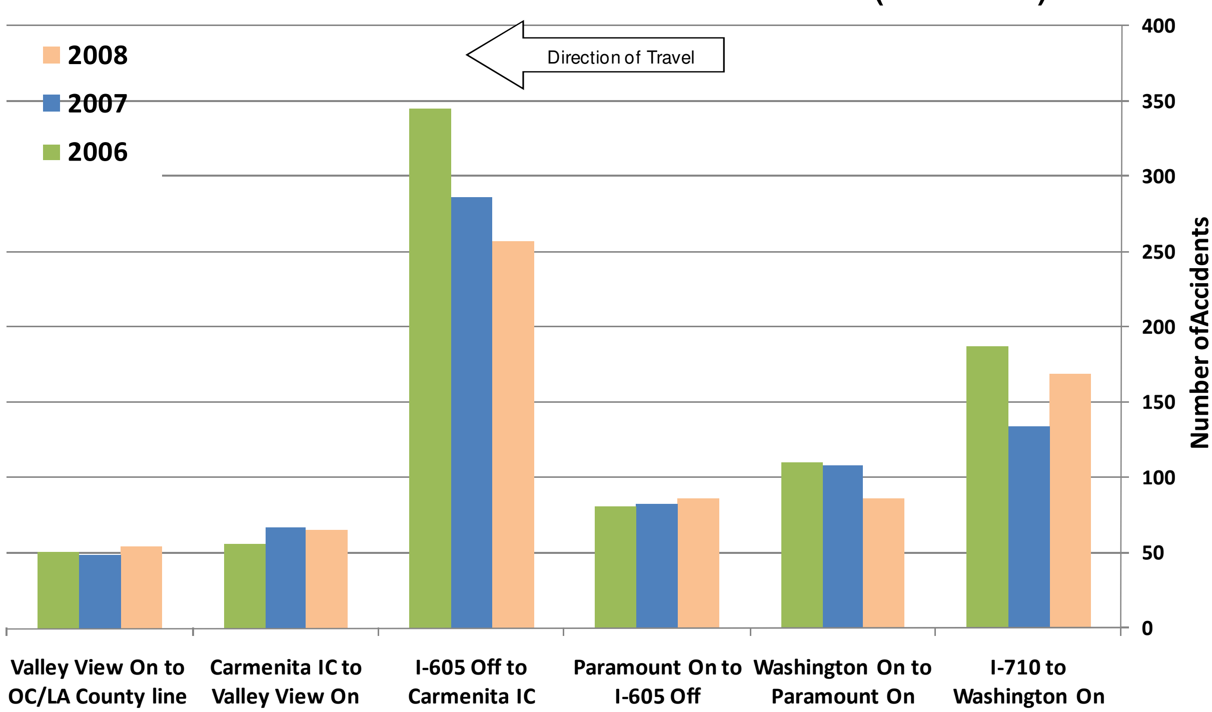
Exhibits 4C-12 and 4-13 present the total number of accidents reported in TASAS by bottleneck area. The bars show the total of accidents that occurred annually in 2006, 2007, and 2008, the latest three years available in TASAS. In the northbound direction, the segment from Telegraph/Slauson to I-710 experienced the highest number of accidents compared to the other segments with over 250 annual accidents during each year. In the southbound direction, the segment between I-605 and Carmenita exceeded every other segment in accidents with nearly 300 in 2007 and over 250 in 2008. This bottleneck area is also the longest segment in distance at nearly five miles.

Exhibit 4C-12: Northbound I-5 Total Accidents (2006-2008)



Source: TASAS data

Exhibit 4C-13: Southbound I-5 Total Accidents (2006-2008)



Source: TASAS data

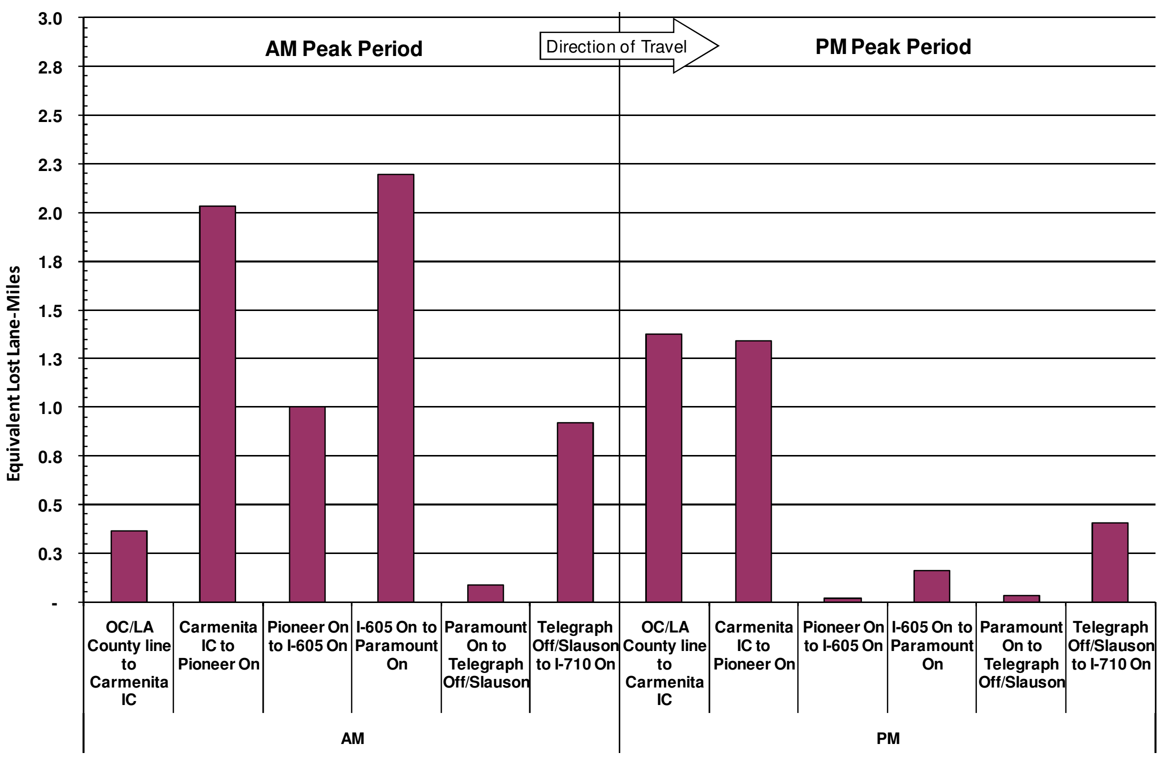
PRODUCTIVITY BY BOTTLENECK AREA

As previously discussed in Section 3, the productivity of a corridor is defined as the percent utilization of a facility or mode under peak conditions. Productivity is measured by calculating the lost productivity of the corridor and converting it into "lost lane-miles." These lost lane-miles represent a theoretical level of capacity that would have to be added in order to achieve maximum productivity.

Exhibits 4C-14 and 4C-15 show the productivity losses for both directions of the corridor.

In the northbound direction, the segment from I-605 to Paramount had the worst productivity of any other segment with just under 2.2 daily equivalent lost lane-miles in the AM peak. The section from Carmenita to Pioneer had similar productivity losses of about 2.0 daily lane-miles. During the PM peak, the segments from the County line to Carmenita, and from Carmenita to Pioneer had productivity losses of approximately 1.4 equivalent lost lane-miles each.

Exhibit 4C-14: Northbound I-5 Equivalent Lost Lane-Miles (2007)

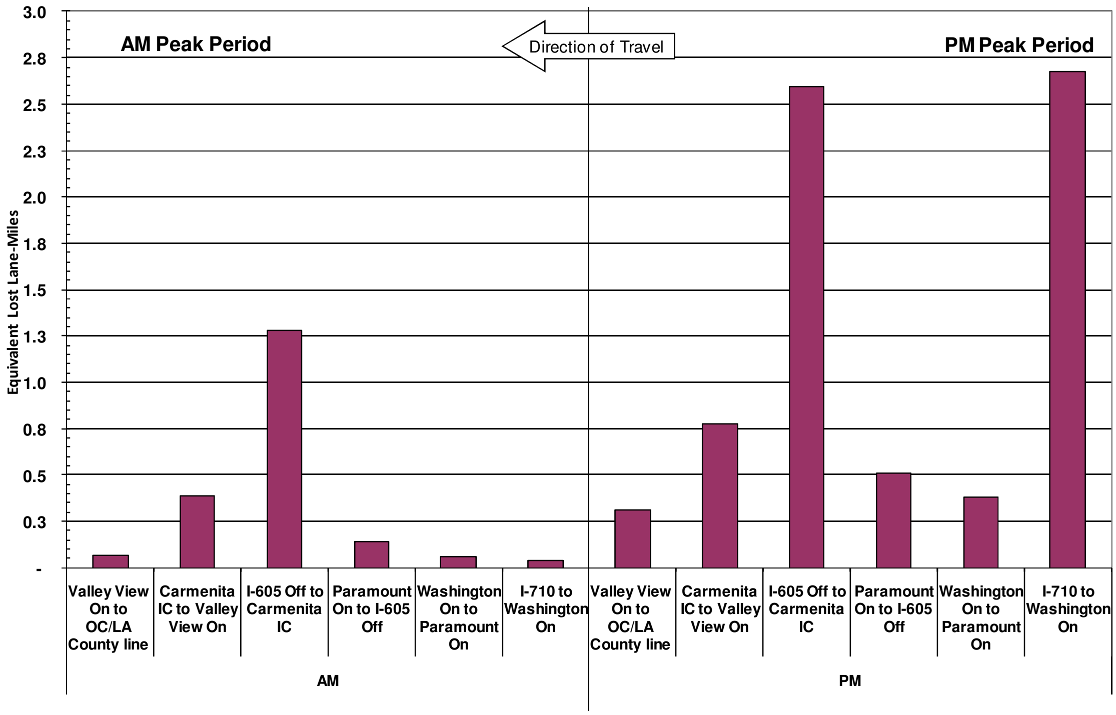


Source: Caltrans detector data

In the southbound direction, the segment from the I-710 to Washington had the worst productivity of any segment on the study corridor with 2.7 daily equivalent lost lane-miles in the PM peak. The segment from the I-605 to Carmenita was just as unproductive with over 2.5 daily equivalent lost lane-miles during the PM peak. During the AM peak, the segment from the I-605 to Carmenita suffered the worst productivity at about 1.3 lane-miles, while the rest of the segments experienced relatively high levels of productivity with under 0.5 lost lane-miles.

The segments of the corridor with the highest productivity losses coincide with the segments that experience the greatest annual vehicle-hours of delay.

Exhibit 4C-15: Southbound I-5 Equivalent Lost Lane-Miles (2007)



Source: Caltrans detector data

5. SCENARIO DEVELOPMENT AND ANALYSIS

The previous sections presented the diagnostic part of the CSMP effort. They describe the corridor, examine its performance trends, and pinpoint its bottlenecks and related causes. This section describes the improvement evaluation component of the CSMP effort. It describes the logic behind developing the scenarios to be evaluated and presents the mobility results estimated by using the Vissim micro-simulation model. It also summarizes the overall benefit cost analysis results conducted to compare costs to benefits. The following steps are discussed in more detail below:

- Developing traffic models for 2007 base year and 2020 long-term demand
- Combining projects in a logical manner for modeling and testing
- Evaluating model outputs and summarizing results
- Conducting a benefit cost assessment of scenarios.

Traffic Model Development

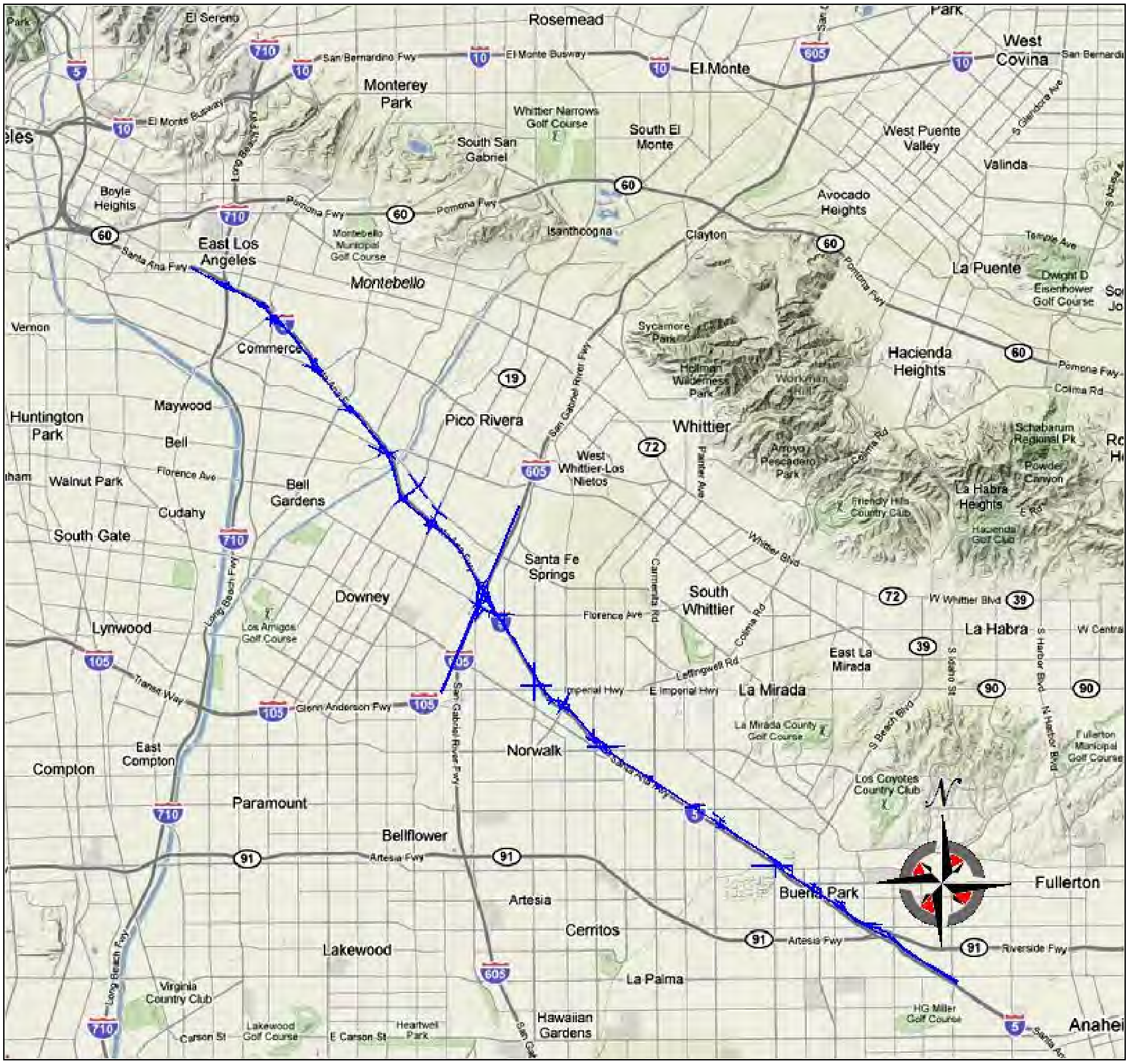
The study team developed a traffic model using the VISSIM micro-simulation software. It is important to note that micro-simulation models are complex to develop and calibrate for a large urban corridor. However, it is one of the only tools capable of providing a reasonable approximation of bottleneck formation and queue development. Therefore, such tools help quantify the impacts of operational strategies, which traditional travel demand models cannot.

The model was calibrated against 2007 conditions. This was a resource-intensive effort, requiring several submittal and review cycles until the model reasonably matched bottleneck locations and relative severity. Once calibration was approved, a 2020 model was also developed based on SCAG's travel demand model demand projections.

These two models were used to evaluate different scenarios (combinations of projects) to quantify the associated congestion relief benefits and to compare total project costs against their benefits.

Exhibit 5-1 depicts the network included in the model. There are no parallel arterials in the model with the exception of arterials at interchanges. All freeway interchanges were included as well as on-ramps and off-ramps.

Exhibit 5-1: I-5 South Micro-Simulation Model Network



Scenario Development Framework

The study team developed a framework for combining projects into scenarios. It would be desirable to evaluate every possible combination of projects, but this would have entailed thousands of model runs. Instead, the team combined projects based on a number of factors, including:

- Projects fully programmed and funded were combined separately from projects that were not and tested with both the 2007 and 2020 models.
- Short and medium range operational projects were grouped into scenarios and tested with the both the 2007 and 2020 models.
- Longer range projects to be delivered by 2020 and beyond were used to develop scenarios to be tested with the 2020 model only.

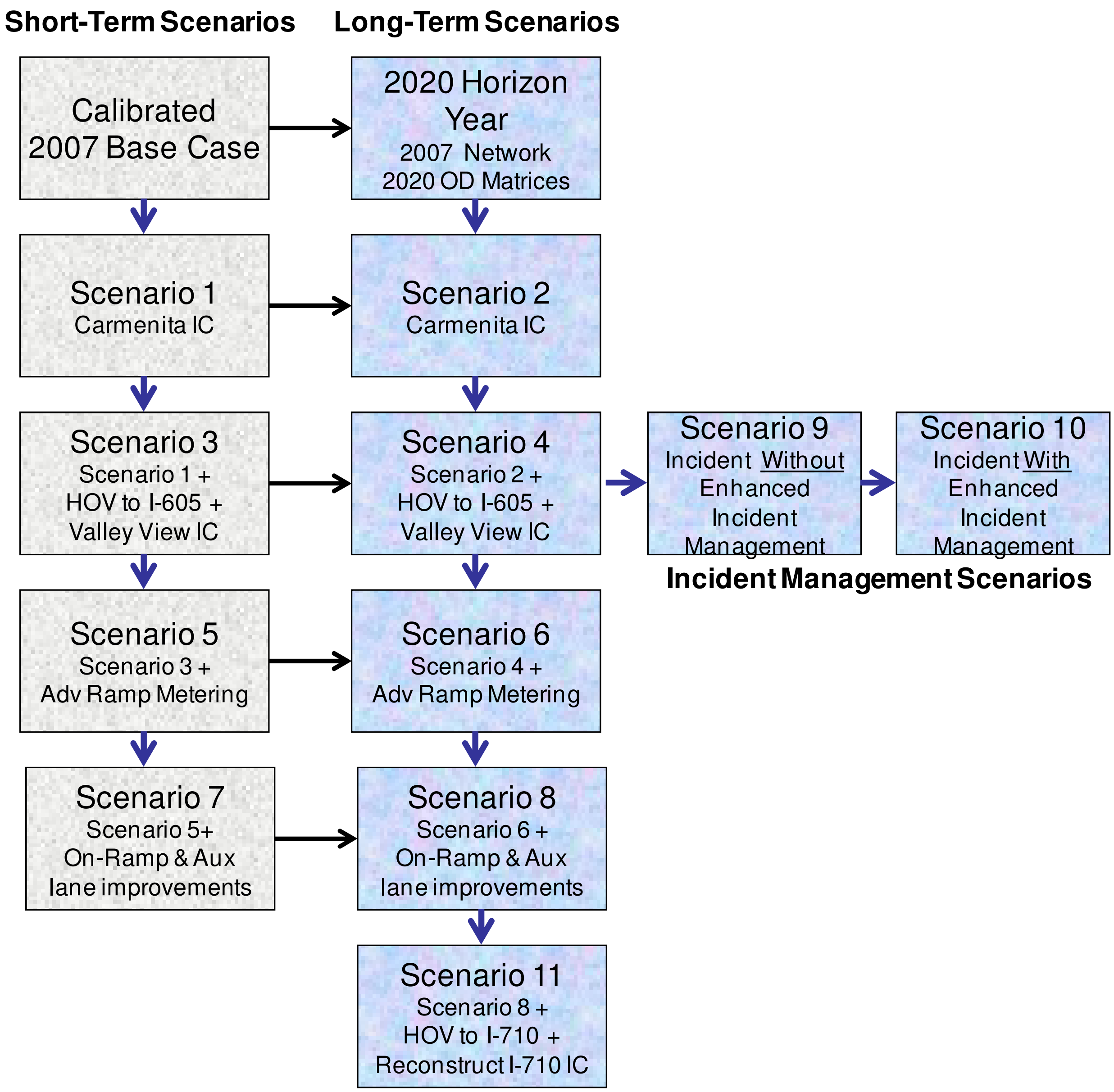
The study team assumed that projects delivered before 2016 could reasonably be evaluated using the 2007 base year model. The 2020 forecast year for the I-5 South Corridor was consistent with the SCAG 2020 regional travel demand model origin-destination matrices used to develop the 2008 Regional Transportation Plan (RTP). When SCAG updates its travel demand model and the RTP, it may wish to update the micro-simulation model with revised demand projections.

Project lists used to develop scenarios were from the Regional Transportation Improvement Program (RTIP), the RTP, and other sources (e.g., special studies). The study team eliminated projects that do not directly affect mobility. For instance, sound wall, landscaping, or minor arterial improvement projects were eliminated since micro-simulation models cannot evaluate them.

Scenario testing for the I-5 South Corridor CSMP differs from the traditional “alternatives evaluations” for Major Investment Studies (MIS) or Environmental Impact Reports (EIRs). An MIS or EIR focuses on identifying alternative solutions to address current or projected corridor problems. Each alternative is evaluated separately and results among competing alternatives are compared resulting in a locally preferred alternative. In contrast, for the I-5 South Corridor CSMP, scenarios build on each other. Each scenario contains the projects from the previous scenario plus additional projects as long as the incremental scenario results showed an acceptable level of performance improvement. This incremental scenario evaluation approach is important to understand since CSMPs are new and often compared with alternatives studies.

Exhibit 5-2 summarizes the approach used and scenarios tested. It also provides a general description of the projects included in the 2007 and 2020 micro-simulation runs. As can be seen in the exhibit, most projects were tested in both the short-term and long-term and built upon prior scenarios. Enhanced incident management was tested in Scenarios 9 and 10 by comparing congestion with and without enhanced incident management. These scenarios assume that the prior scenario projects were built in the horizon year model and are expected for the longer term and were not tested using the short-term model. Appendix A provides the detailed project list included in each scenario.

Exhibit 5-2: Micro-Simulation Modeling Approach



Scenario Evaluation Results

Exhibits 5-3 and 5-4 show the delay results for all the 2007 scenarios evaluated for the AM and PM peak periods, respectively. Exhibits 5-5 and 5-6 show the delay results for all the 2020 scenarios evaluated for the AM and PM peak periods, respectively. The percentages shown in the exhibits indicate the difference in delay between the current scenario and the previous scenario (e.g., Percent Change = (Current Scenario/Previous Scenario)/Previous Scenario). Impacts of strategies differ based on a number of factors such as traffic flow conditions, ramp storage, bottleneck locations, and levels of congestion.

For each scenario, the modeling team produced results by facility type (i.e., mainline, HOV, arterials, and ramps) and vehicle type (SOV, HOV, and trucks) as well as speed contour diagrams (discussed in more detail in the full technical CSMP). The study team scrutinized the results to ensure that they were consistent with general traffic engineering principles. The following sections summarize findings for each scenario tested and reviewed by the study team.

A traffic report with all the model output details is available under separate cover.

Exhibit 5-3: AM Peak Micro-Simulation Delay Results by Scenario (2007)

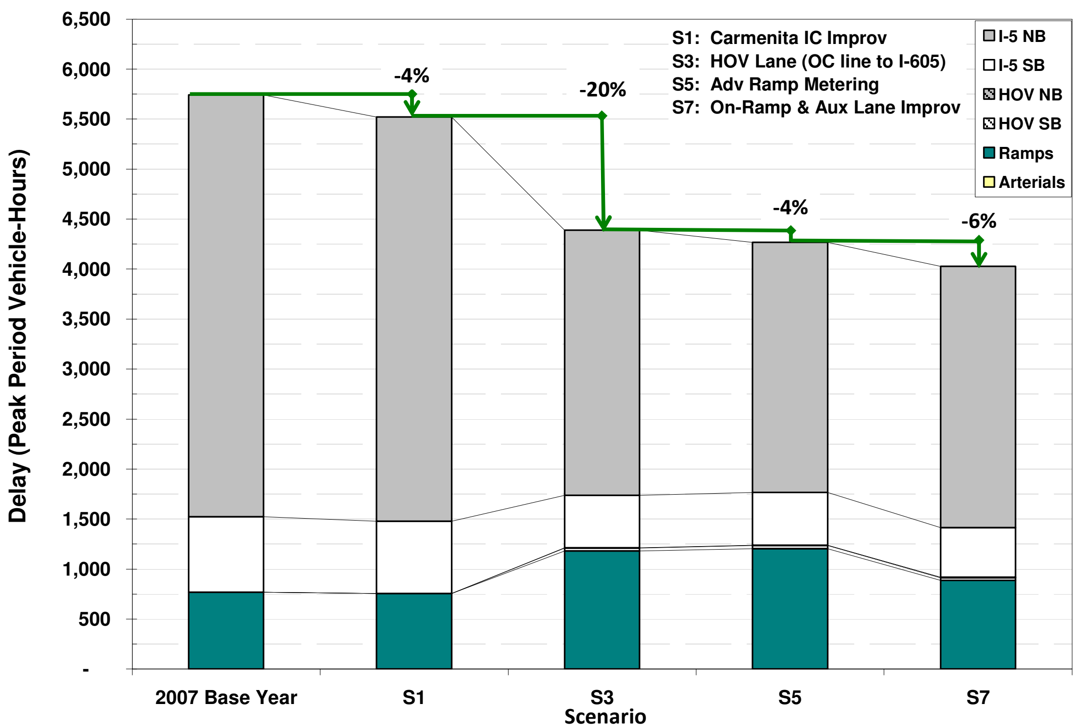


Exhibit 5-4: PM Peak Micro-Simulation Delay Results by Scenario (2007)

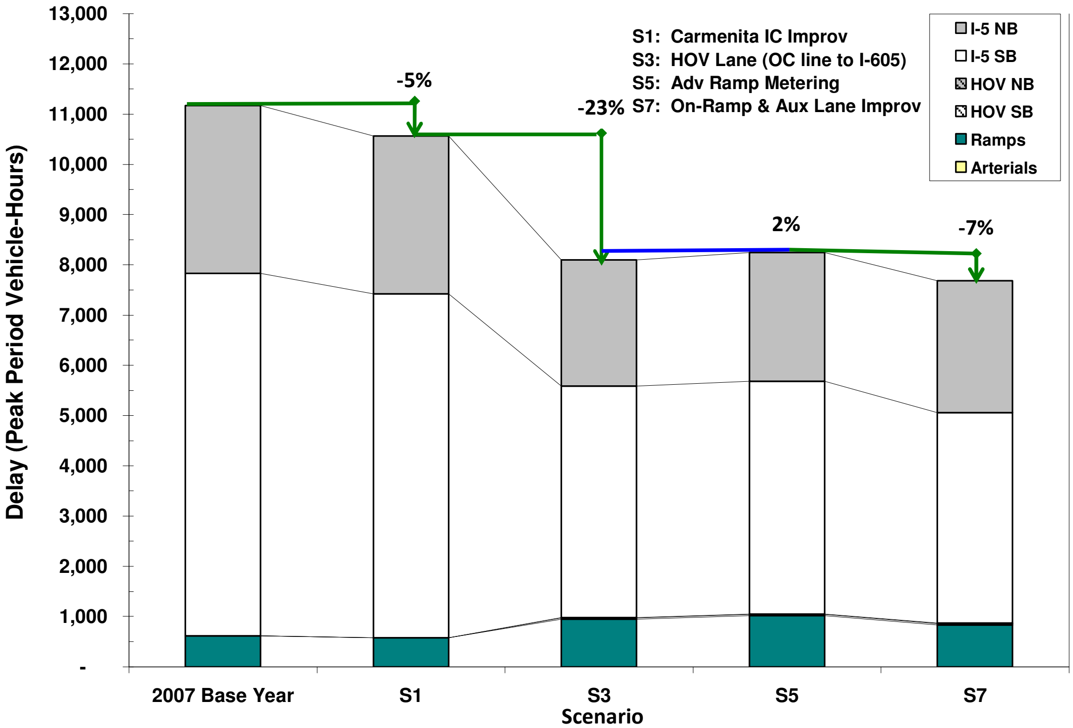


Exhibit 5-5: AM Peak Micro-Simulation Delay by Scenario (2020)

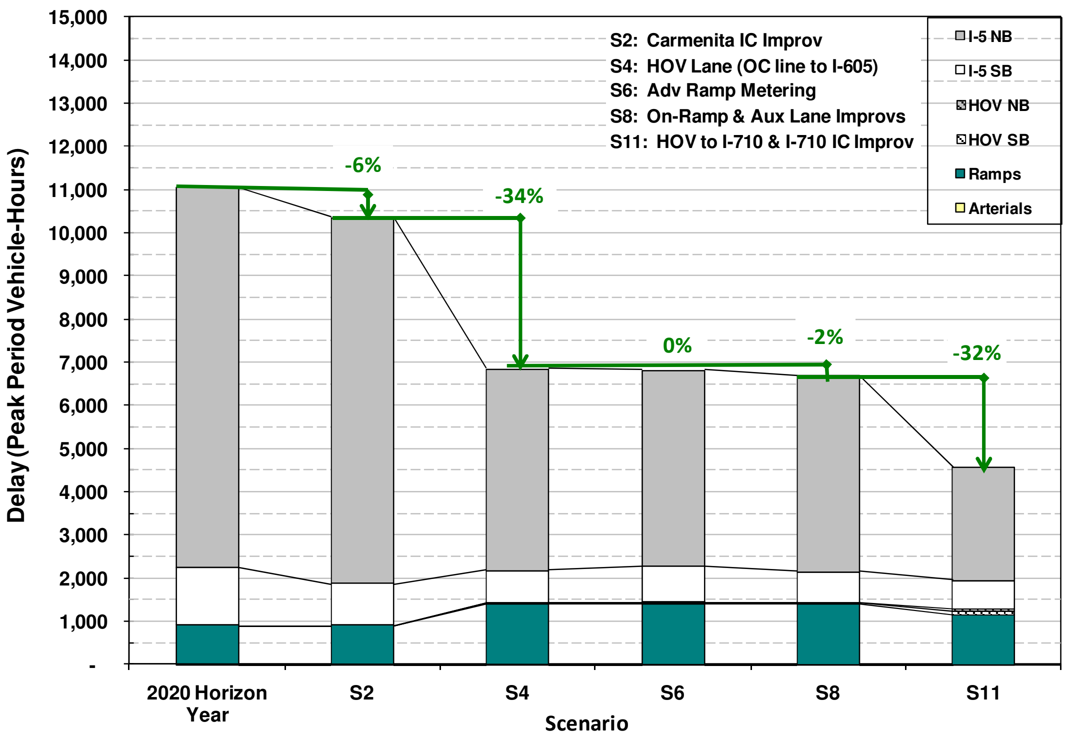
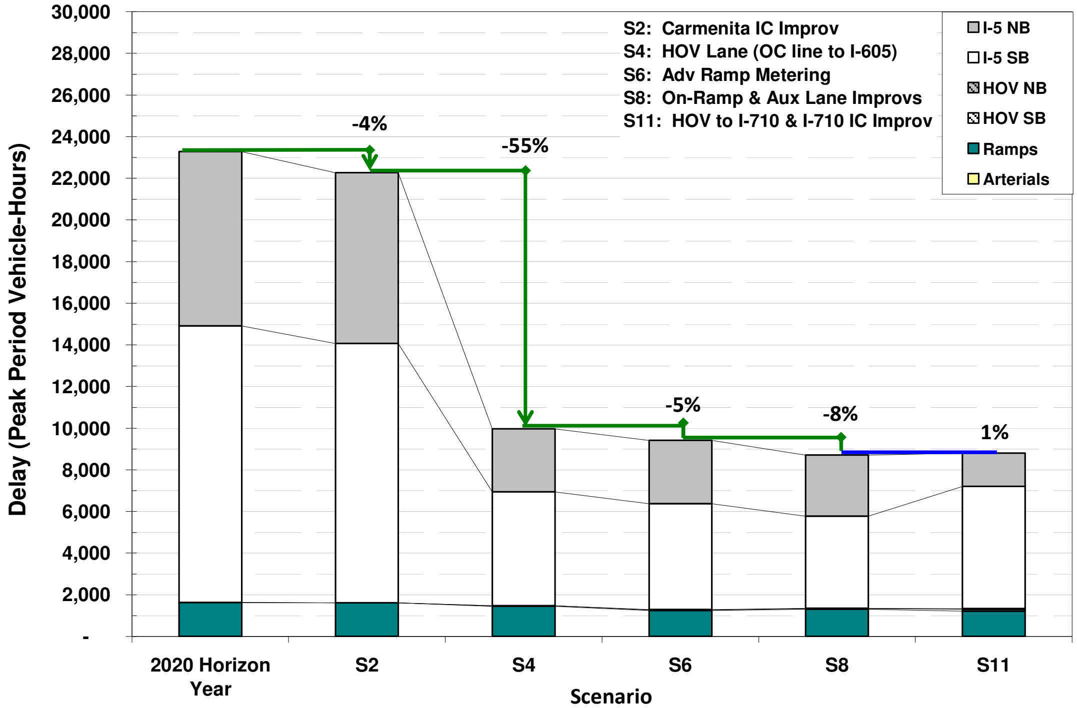


Exhibit 5-6: PM Peak Micro-Simulation Delay by Scenario (2020)



Exhibits 5-7 through 5-10 summarize the delay results of the 2007 base year model by bottleneck area for the northbound and southbound directions and for each peak period. Exhibits 5-11 through 5-14 report the delay results of the 2020 horizon year model.

Exhibit 5-7: Northbound AM Delay by Scenario and Bottleneck Area (2007)

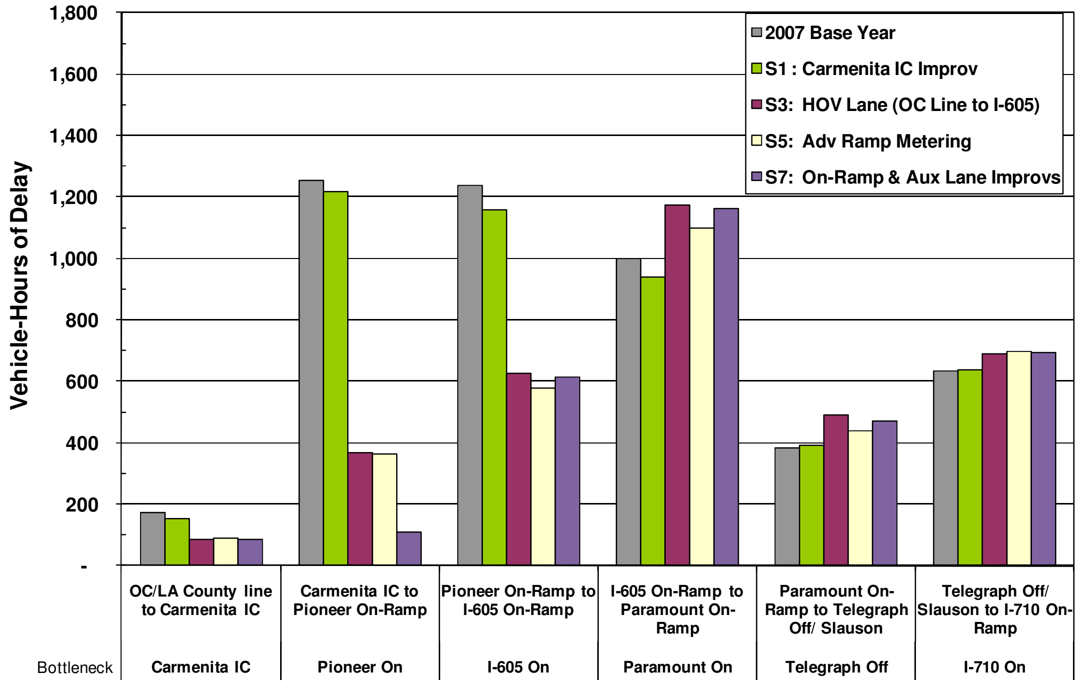


Exhibit 5-8: Northbound PM Delay by Scenario and Bottleneck Area (2007)

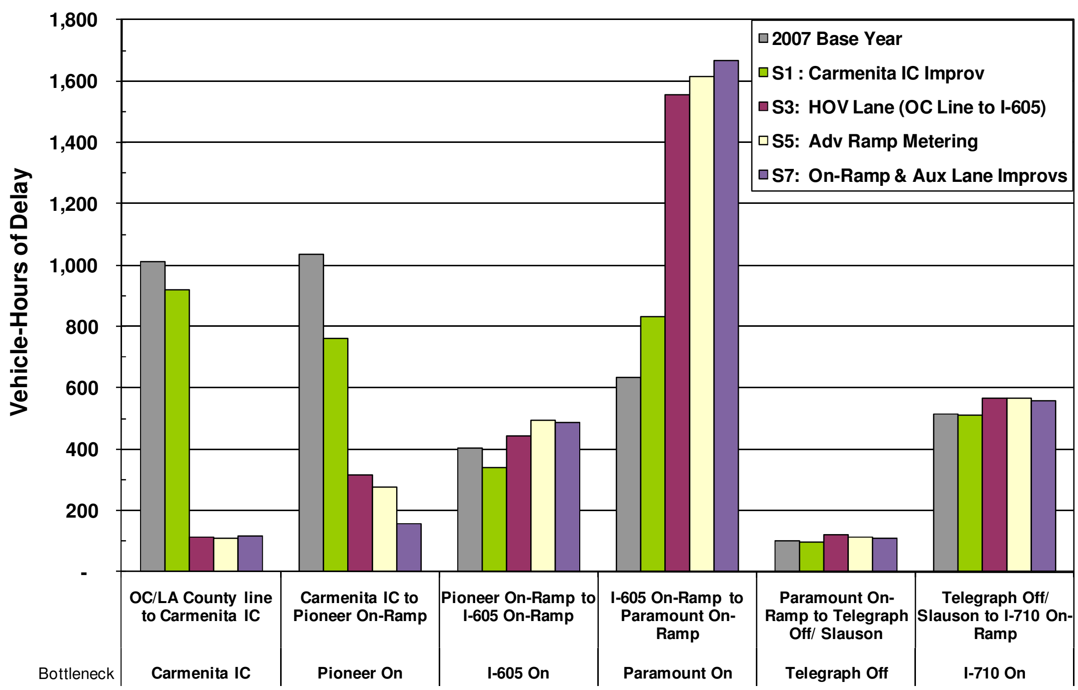


Exhibit 5-9: Southbound AM Delay by Scenario and Bottleneck Area (2007)

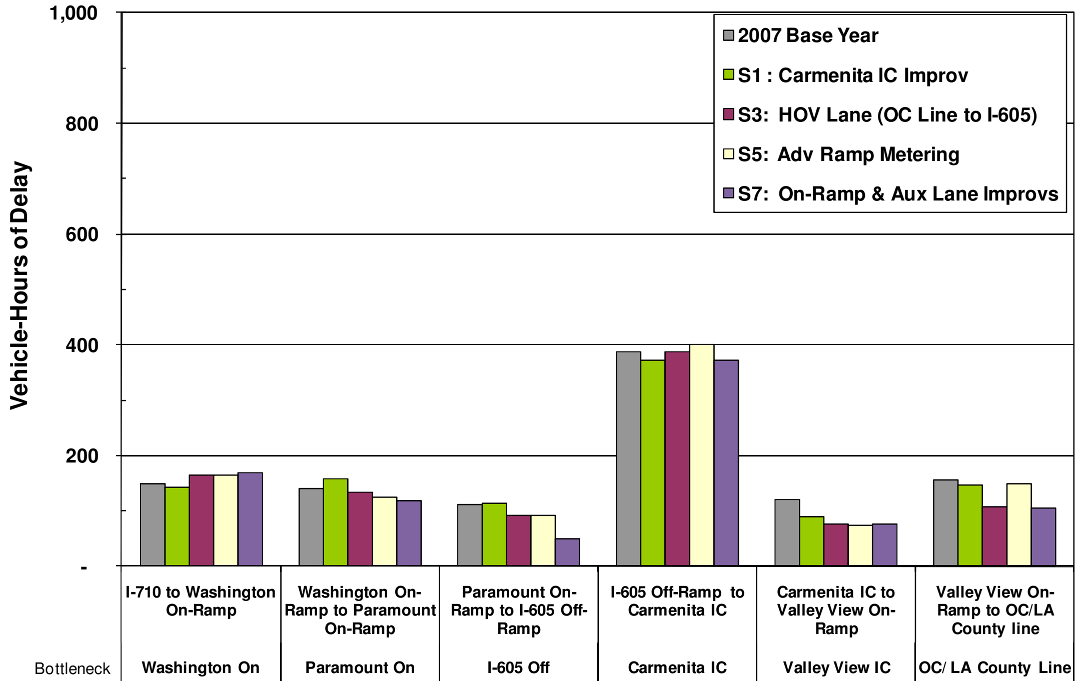


Exhibit 5-10: Southbound PM Delay by Scenario and Bottleneck Area (2007)

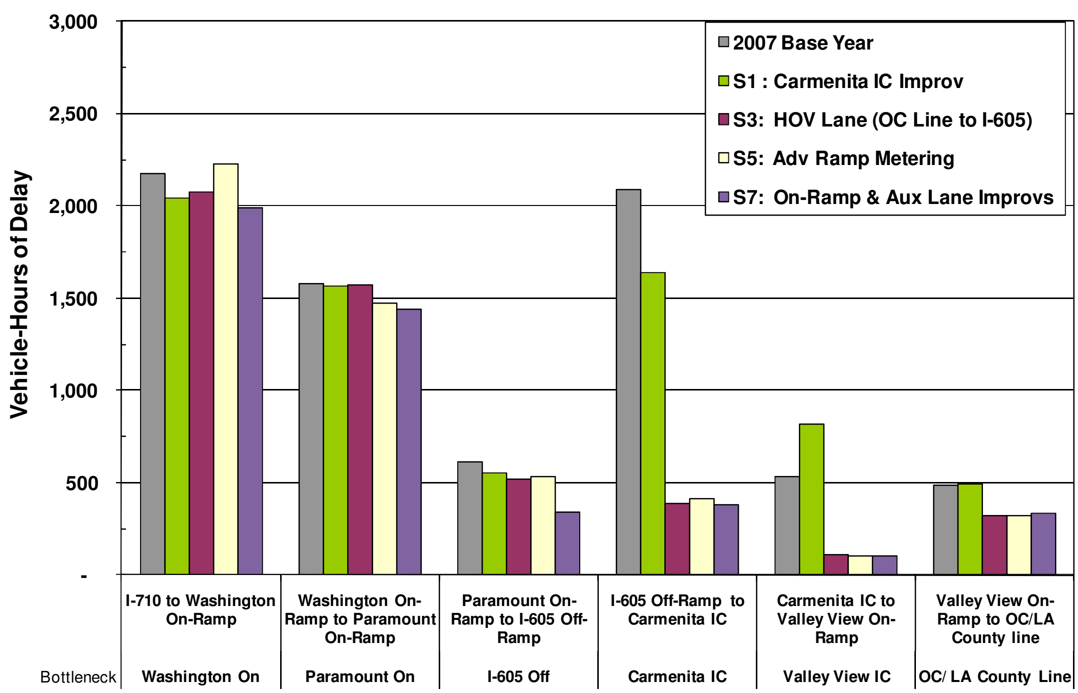


Exhibit 5-11: Northbound AM Delay by Scenario and Bottleneck Area (2020)

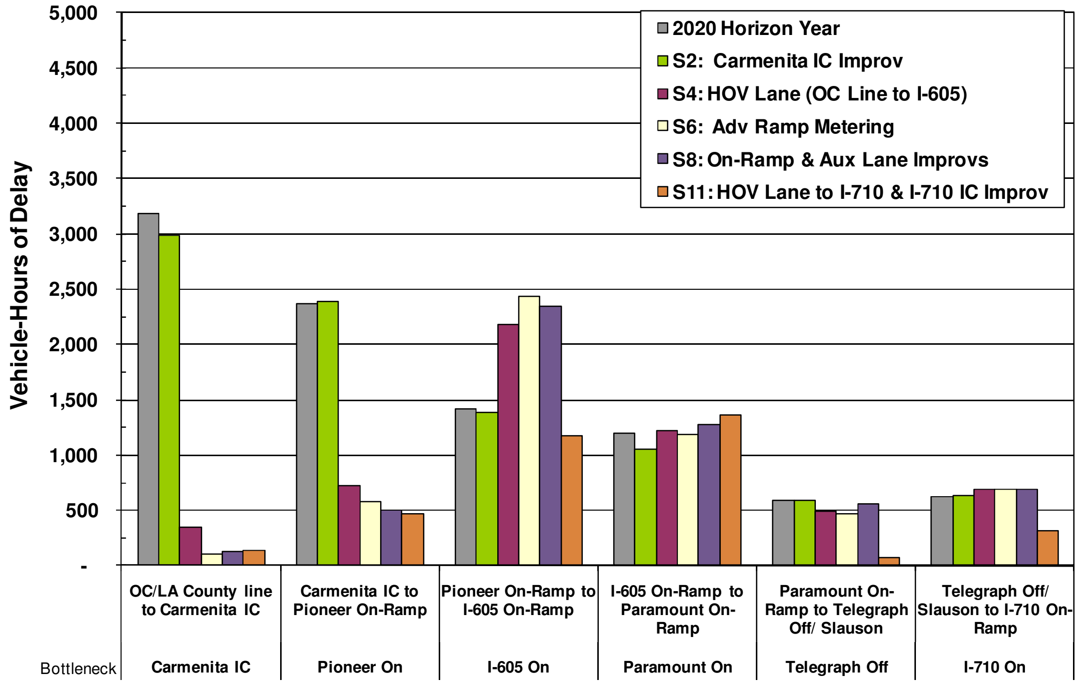


Exhibit 5-12: Northbound PM Delay by Scenario and Bottleneck Area (2020)

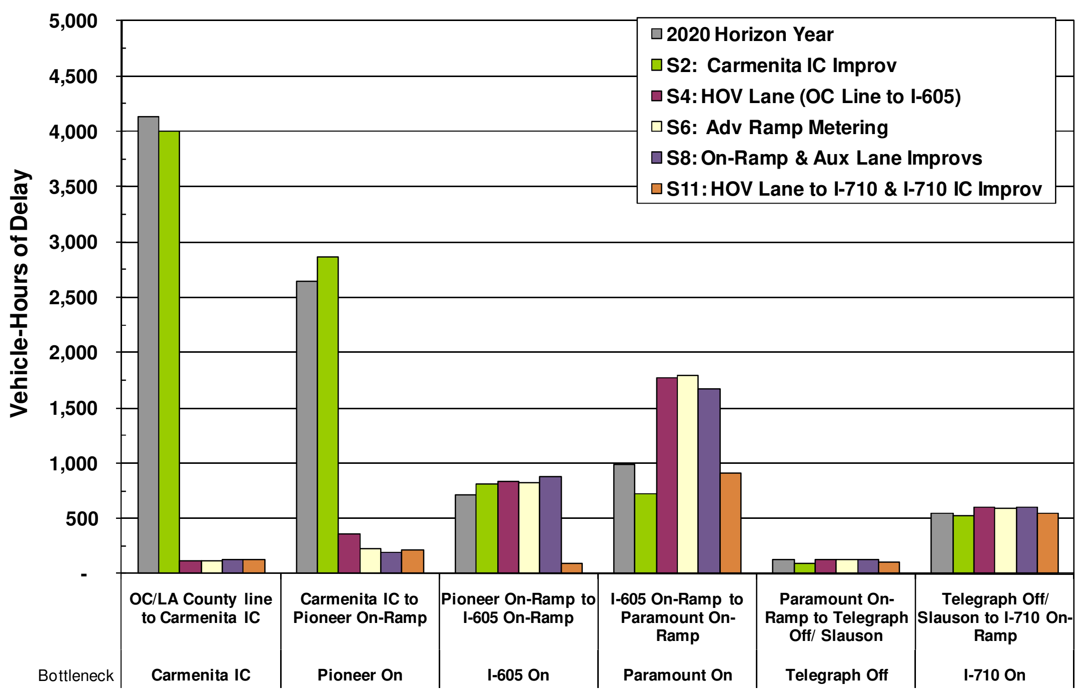


Exhibit 5-13: Southbound AM Delay by Scenario and Bottleneck Area (2020)

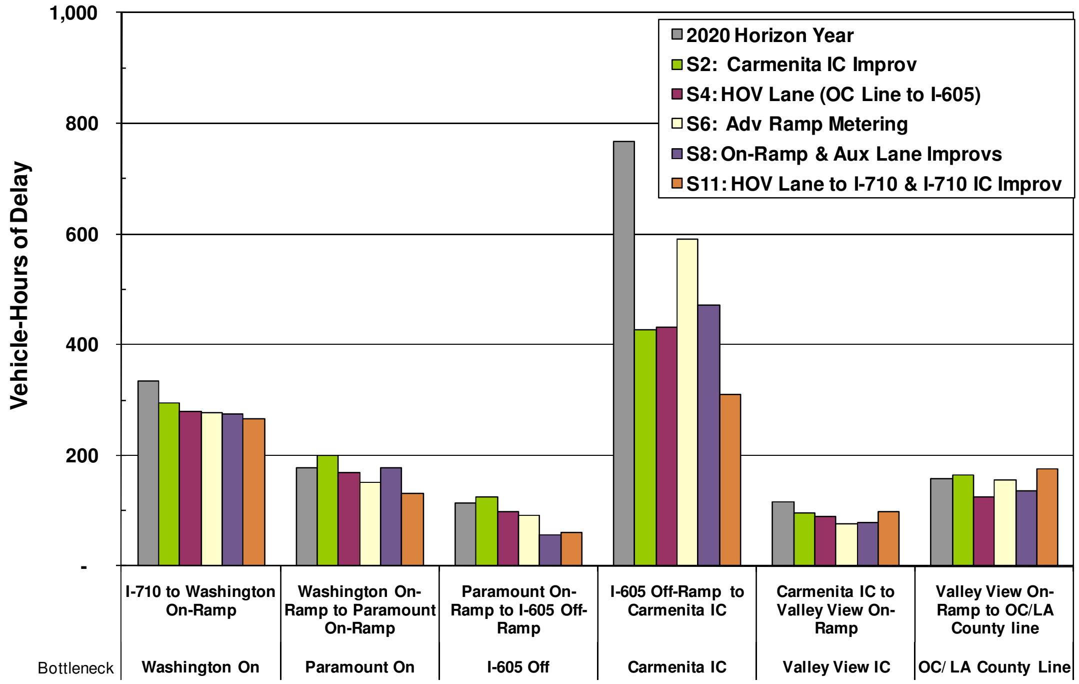
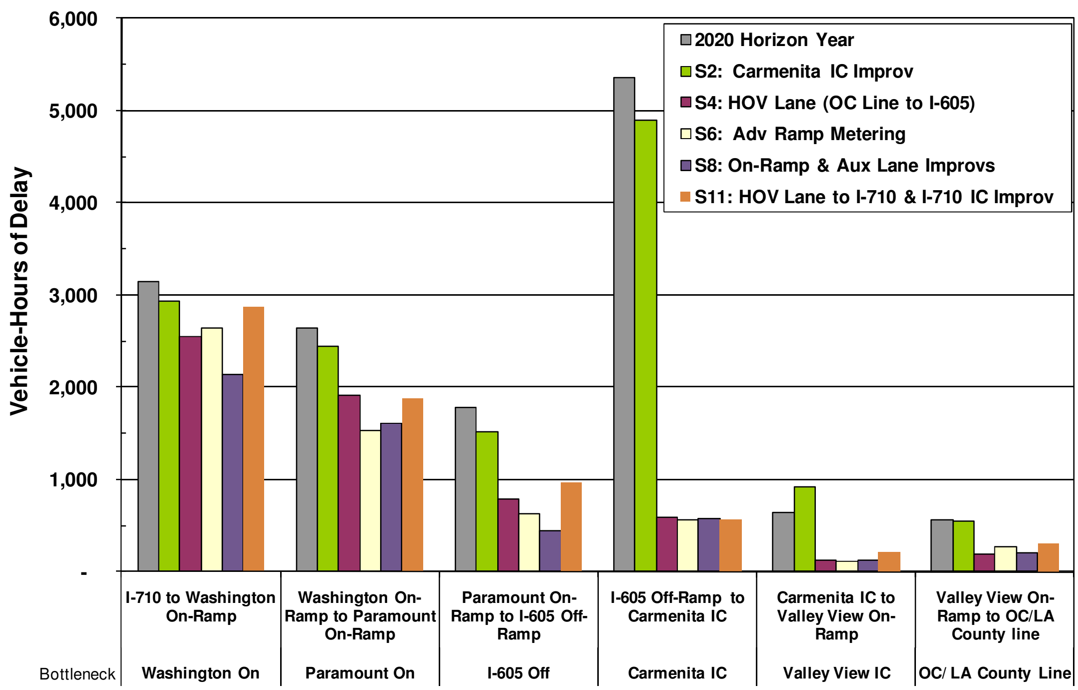


Exhibit 5-14: Southbound PM Delay by Scenario and Bottleneck Area (2020)



The following sections summarize findings for each scenario tested and reviewed by the study team.

2007 Base Year and 2020 Do Minimum Horizon Year

Absent any physical improvements, the modeling team estimates that by 2020, total delay (on mainline, HOV, ramps, and arterials) will double compared to 2007 (from a total of around 17,000 vehicle-hours daily to just fewer than 35,000 vehicle-hours) in the combined AM and PM peak periods.

Scenarios 1 and 2 (Carmenita Interchange)

Scenarios 1 and 2 test one of the two projects fully funded on the corridor. The Carmenita Interchange Improvement removes an existing two-lane steel structure and replaces it with a new eight-lane concrete structure with tight diamond ramps. It also elevates the interchange and arterial above an existing at-grade railroad crossing. The existing crossing causes traffic at the southbound off-ramp to back onto the corridor during the morning and afternoon peak hours. This project is expected to be completed in 2013.

The 2007 model estimates that Scenario 1 would reduce overall delay on the corridor by about 4 to 5 percent (800 vehicle-hours) over the base model during the AM and PM peak periods. Likewise, the 2020 model estimates that Scenario 2 would reduce overall delay on the corridor by about 4 percent (over 1,500 vehicle-hours) compared to the Do Minimum Horizon Year base during the AM and PM peak periods.

Scenarios 3 and 4 (HOV and General Purpose Widening)

Scenarios 3 and 4 build on Scenarios 1 and 2, and test an HOV widening project funded partially by the CMIA. The project involves constructing one HOV lane and one general- purpose (GP) lane in each direction between the Orange/Los Angeles County Line and I-605. The project also reconstructs the Valley View Interchange and upgrades the 6.7-mile segment to conform to current highway design. The expected completion of this project is 2016.

The 2007 model estimates that Scenario 3 will reduce delay by 20 percent in the AM peak and 23 percent in the PM peak, for a total delay reduction of 3,600 daily vehicle-hours compared to Scenario 1. The 2020 model estimates that Scenario 4 will reduce overall delay on the corridor by about 34 to 55 percent over the Scenario 2 results during both the AM and PM peak periods. This reduction is substantial at over 15,000 vehicle-hours and improves mobility from the Orange County line to the I-605 interchange, particularly in the southbound direction. These improvements are expected to allow more northbound traffic to flow downstream of I-605 and increase congestion in this section.

Scenarios 5 and 6 (Advanced Ramp Metering)

Scenarios 5 and 6 build on Scenarios 3 and 4 by adding an advanced ramp metering system, such as dynamic or adaptive ramp metering. Although connector metering at the I-605 and I-710 interchanges would significantly add to advanced ramp metering operations along this corridor, the existing configurations do not support effective implementation without substantial and costly interchange modifications.

The 2007 model estimates that advanced ramp metering reduces delay by 3 percent in the AM peak (or 120 daily vehicle-hours) and slightly increases delay in the PM peak. The 2020 model estimates greater gains with a total delay reduction of almost 600 daily vehicle-hours.

There are various types of advanced ramp metering systems deployed around the world, including the System-wide Adaptive Ramp Metering System (SWARM) tested on Los Angeles I-210 freeway corridor. For modeling on the I-5 South Corridor, the ALINEA system was tested as proxy for any advanced ramp metering system, since its algorithm for the model was readily available (and the algorithm for SWARM was not). However, the study team is not necessarily recommending ALINEA be deployed on I-5, but rather some type of advanced ramp metering system that would produce similar or better results.

Scenarios 7 and 8 (Operational Improvements)

Scenarios 7 and 8 add low-cost operational improvements (that could be implemented by 2016) to the improvements tested in the previous scenarios:

- Adding a northbound auxiliary lane from Rosecrans to San Antonio
- Adding a northbound auxiliary lane from Imperial Highway to the Pioneer on-ramp
- Moving the Florence on-ramp metering downstream and closer to the I-5 merge, while reducing the metering rate.
- Restriping the southbound I-710 on-ramp to a solid white line 1,000 feet past the merge
- Adding an auxiliary lane from Paramount to the Lakewood on-ramp, converging the Lakewood on-ramps into a single auxiliary lane, and moving the Lakewood on-ramp merge further downstream
- Adding a third storage lane on the I-605 connector off-ramp and widening the bridge
- Widening the Rosecrans on-ramp for more storage and reducing the metering rate.

The 2007 model estimates that Scenario 7 reduces delay by six percent in the AM peak and seven percent in the PM peak, for a total delay reduction of about 800 daily vehicle-hours. The 2020 model estimates that Scenario 8 reduces delay by two percent in the AM peak and eight percent in the PM peak, or a total delay reduction of just over 800 vehicle-hours.

Scenarios 9 and 10 (Enhanced Incident Management)

The study team tested two incident scenarios built upon the Scenario 4 network to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. The proposed enhanced incident management strategies would entail upgrading or enhancing the current Caltrans incident management system that includes deployment of intelligent transportation system (ITS) field devices, central control/communications software, communications medium (i.e. fiber optic lines), advanced traveler information system, and/or freeway service patrol (FSP) program to reduce incident detection, verification, response, and clearance times.

In the first scenario (Scenario 9), a collision incident with one outside lane closure was simulated in the northbound direction in the AM peak period model and in the southbound direction in the PM peak period model. The incident simulation location and duration were selected based on review of the 2010 actual incident data at one of the high-frequency incident locations. The following are the scenario details:

- Northbound AM peak period starting at 7:00 AM, close outermost mainline lane for 35 minutes at absolute post mile 126.3 (south of Slauson)
- Southbound PM peak period starting at 4:00 PM, close outermost mainline lane for 35 minutes at absolute post mile 123.1 (south of I-605).

In the second scenario (Scenario 10), the same collision incident was simulated with a 10-minute reduction in duration in both the northbound and southbound directions. Based on actual Caltrans incident management data, it is estimated that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes.

These scenarios represent a typical moderate incident at one location during the peak period direction. Data suggest that incidents vary significantly in terms of impact and duration. Some incidents last hundreds of minutes, some close multiple lanes, and some occur at multiple locations simultaneously. There are also numerous minor incidents without lane closures that last only a few minutes that also result in congestion. There are also many incidents that occur during off-peak periods.

As indicated in Exhibits 5-15 and 5-16, without enhanced incident management, Scenario 9 produces a 46 percent increase in congestion in the AM peak and a 35 percent increase in the PM over Scenario 4, an increase of over 6,000 hours of vehicle delay. With enhanced incident management, Scenario 10 evaluation resulted in delay decrease by 19 percent in the AM peak and 11 percent in the PM peak against Scenario 9 results, a reduction of over 3,200 vehicle-hours for improving the incident detection, verification, response, and clearance time of one moderate level incident for both of the peak periods.

These results reflect benefits realized during the peak direction period. Additional benefits would be realized during off-peak hours and in the off-peak direction.

Exhibit 5-15: AM Delay Results for Enhanced Incident Management (2020)

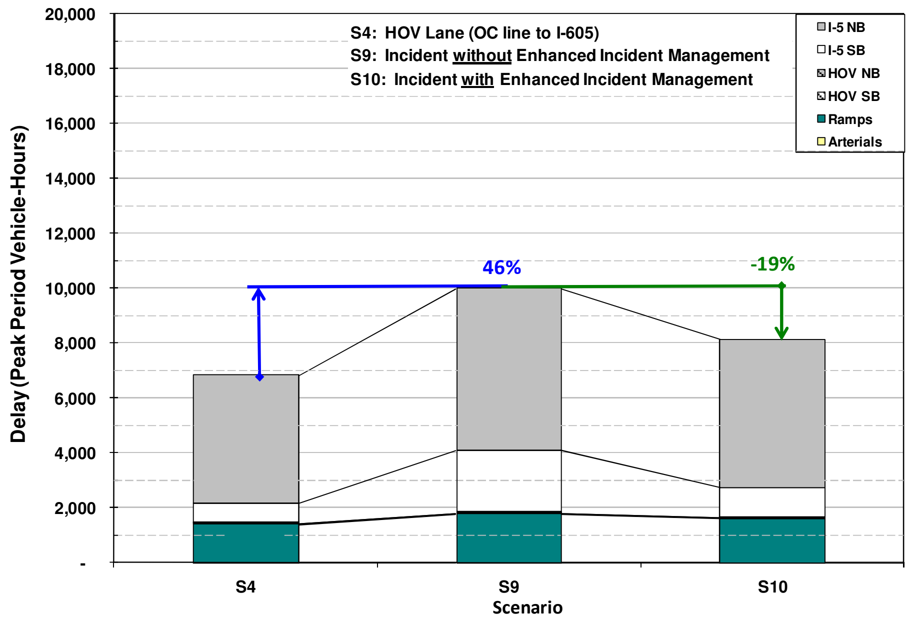
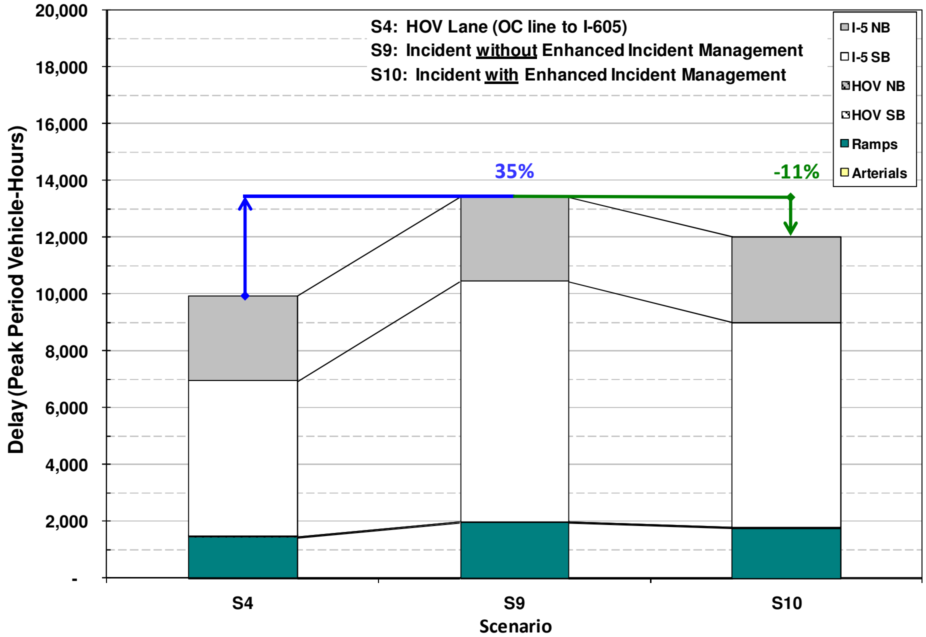


Exhibit 5-16: PM Delay Results for Enhanced Incident Management (2020)



Scenario 11 (HOV Widening to I-710 and I-710 IC Improvement)

Scenario 11 tests two capital expansion projects using the 2020 horizon year model. The scenario builds on Scenario 8 and includes the following improvements:

- Adding an HOV lane in each direction from the Florence Avenue Overcrossing to south of Eastern Avenue (length of 6.6 miles)
- Reconstructing the I-710/I-5 Interchange to support widening the I-5 freeway and new freeway-to-freeway connections.

Since the designs for these projects are very preliminary, the final configurations could differ significantly from what was modeled in Scenario 11. As a result the conceptual design elements included in Scenario 11 may not capture the full mobility improvements once the designs are finalized. However, the model results provide some insight into the potential benefits of the projects.

The 2020 model estimates that Scenario 11 will reduce delay as much as a 32 percent in the AM peak period (or over 2,100 daily vehicle-hours), mostly on the northbound mainline facility (which experienced a reduction of 1,900 vehicle-hours). However, the PM peak experienced a slight increase in congestion with gains achieved in the northbound direction being offset by increases in delay in the southbound direction. The study team suggests that design changes in the southbound direction may be necessary to improve operational performance.

Benefit-Cost Analysis

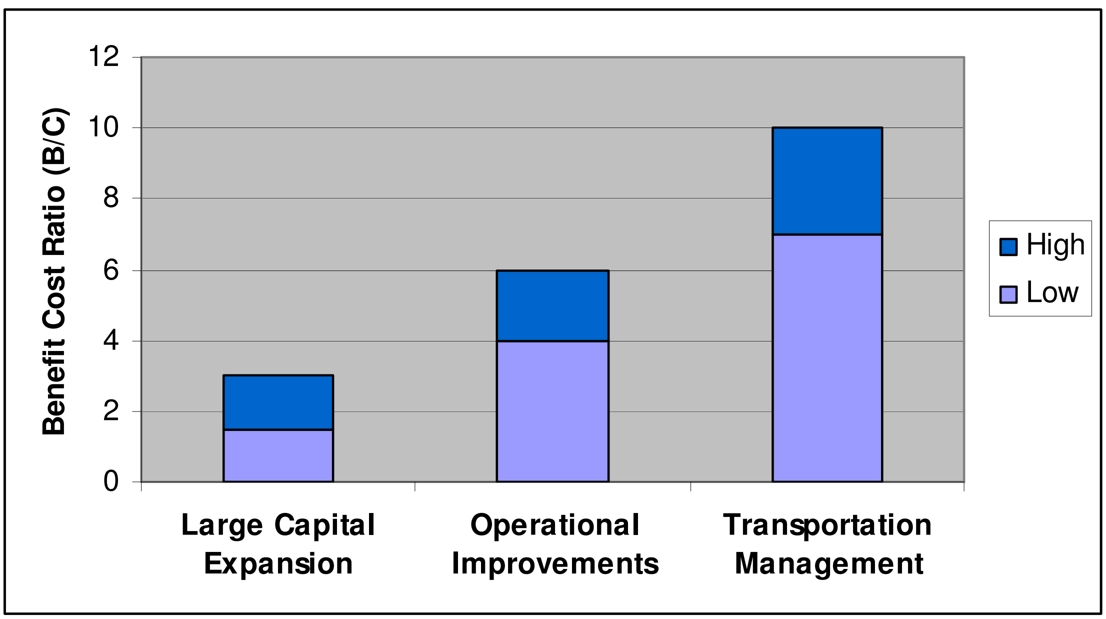
Following an in-depth review of the model results, the study team developed a benefit-cost (B/C) analysis for each scenario. The benefit-cost results represent the incremental benefits over the incremental costs of a given scenario.

The study team used the California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) developed by Caltrans to estimate benefits in three key areas: travel time savings, vehicle operating cost savings, and emission reduction savings. The results are conservative since this analysis does not capture other benefits, such as reductions in congestion from deploying bus rapid transit.

Project costs were developed from SCAG and Caltrans project planning and programming documents. These costs include construction and support costs in current dollars. The study team estimated costs for projects that did not have cost estimates by reviewing similar completed projects. A B/C ratio greater than one means that a scenario's projects return greater benefits than they cost to construct or implement.

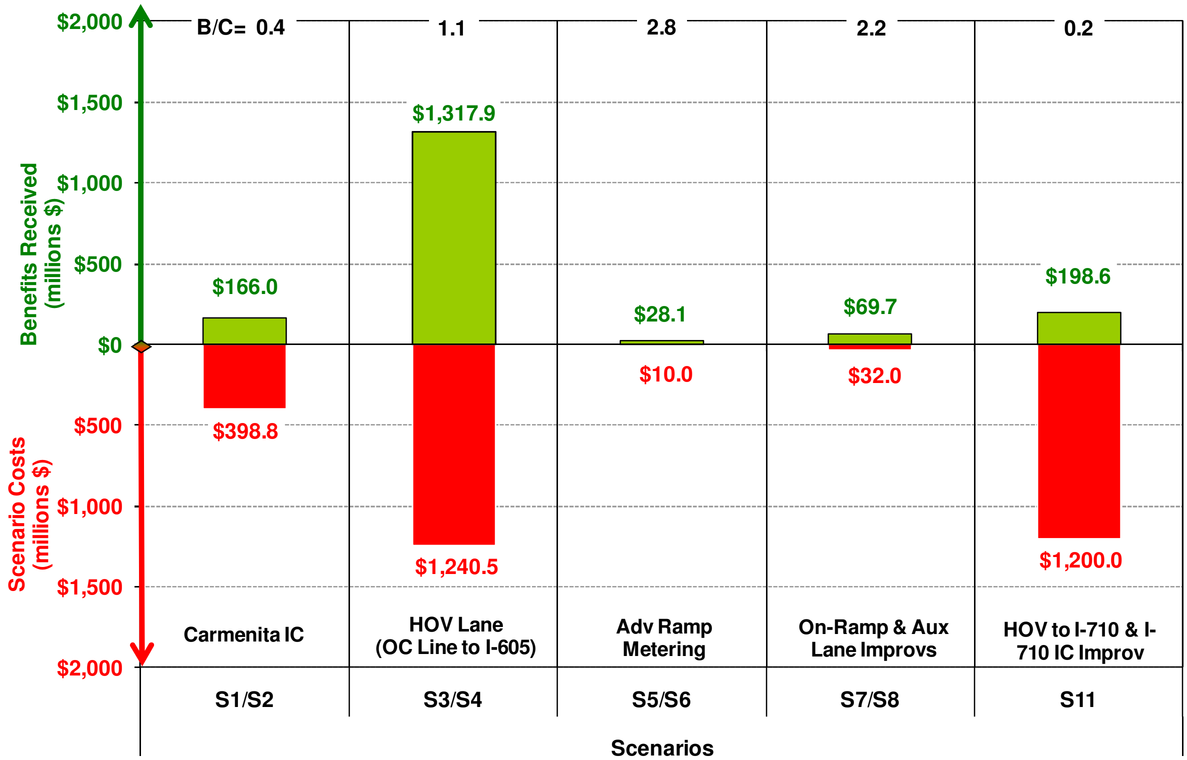
It is important to consider the total benefits that a project brings. For example, a large capital expansion project can cost a great deal and have a low B/C ratio, but brings much higher absolute benefits to I-5 users. Exhibit 5-17 illustrates typical benefit-cost ratios for different project types.

Exhibit 5-17: Benefit-Cost Ratios for Typical Projects



The benefit-cost analysis for the I-5 South corridor is summarized in Exhibit 5-18.

Exhibit 5-18: Scenario Benefit/Cost (B/C) Results



The benefit-cost findings for each scenario are as follows:

- Scenarios 1 and 2 (Carmenita Interchange) produce a benefit-cost ratio of less than one. This is low compared to a typical interchange improvement and is due to a high project cost of nearly $400 million. The elimination of an at-grade rail crossing contributes to this high cost. Typical interchange modifications cost under $30 million, even with right-of-way acquisitions. However, the benefits are large at over $160 million. If the Carmenita Interchange had a more typical cost (about $30 million), the benefit-cost ratio would be greater than five, which is consistent with similar projects.
- The Carmenita Interchange addresses several operational deficiencies that cannot be captured in the micro-simulation model, which captures only the benefits of the freeway components. The model captures neither the benefits in arterial circulation nor the elimination of the railroad crossing. Total benefits (including the grade separation, arterial circulation and off-peak hours) are likely to be significantly higher, so the true benefit-cost ratio may exceed one.

- Scenarios 3 and 4 (HOV Lane Widening from Orange County Line to I-605) produce a benefit-cost ratio of just over one. Although this is less than a typical capital expansion project, the benefits are large at over $1.3 billion. The high density of the surrounding communities, the diagonal alignment of the corridor, and the age of the freeway are likely what cause high roadway improvement costs (particularly right-of-way) of over $1.2 billion along this corridor.
- Scenarios 5 and 6 (Advanced Ramp Metering) produce a benefit-cost ratio of about three. While high compared to other scenarios, this benefit-cost ratio is low compared to some transportation management strategies. This is likely due to the limited effect of the advanced ramp metering strategy, which does not include connector metering. The benefit-cost ratio would likely be higher if connector metering were included at the I-605 and I-710 interchanges.
- Scenarios 7 and 8 (Operational Improvements) produce a benefit-cost ratio of a little over two. As with the other scenarios, this result is low relative to typical projects (benefit-cost ratios of about four to six are expected for operational improvements).
- Scenario 11 (HOV Lane Widening from I-605 to I-710 and I-710 IC Modification) produces a relatively low benefit-cost ratio of below one, but the analysis assumes a very high cost at $1.2 billion. The designs are very preliminary and there is no official cost estimate for the project. As such, the estimated benefit-cost ratio should be taken as a rough approximation of the concept.
- The benefit-cost ratio of all scenarios combined is less than one. Several of the tested projects have extremely high costs such as the programmed HOV widening on I-605 (over $1.2 billion) and the Carmenita Interchange improvement (almost $400 million) as well as the conservatively high estimate ($1.2 billion) for the Scenario 11 HOV lane widening. In addition, the simulation modeling does not capture all benefits (i.e., arterial and grade crossing benefits) at Carmenita. In current dollars, total costs are around $2.9 billion whereas the benefits are estimated at just under $1.8 billion.
- The projects alleviate greenhouse gas (GHG) emissions by about 1.3 million tons over 20 years, averaging a reduction of over 64,000 tons per year.

Detailed benefit-cost results can be found in Appendix B.

6. CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions and recommendations based on the analysis in the previous section. Many of these conclusions are based primarily on the micro-simulation model results. The model was developed based on the best data available at the time. The study team believes that the calibrated base year model, the forecast year model, and the scenario results are reasonable. However, caution should always be used when making decisions based on modeling alone, especially complex models such as this one.

Based on the results, the study team offers the following conclusions and recommendations:

- The combination of all scenarios significantly reduces overall congestion on the corridor. Projected 2020 congestion after implementation of all scenarios is below 2007 levels in both the AM and PM peak period. In the AM peak period, the model projects total delay in 2020 after delivering all projects to be around 4,500 vehicle-hours compared to the 2007 base year delay of over 5,700 vehicle-hours. This represents a reduction of 25 percent. In the PM peak period, the model projects total delay in 2020 after delivering all projects to be just under 9,000 vehicle-hours compared to the 2007 base year delay of 11,000 hours. This represents a reduction of over 20 percent. Clearly, the scenarios deliver significant mobility benefits to the corridor. Despite the growth in demand, future 2020 congestion will be less than experienced in 2007.
- The programmed Carmenita Interchange modification and the CMIA project, which constructs the HOV lanes from the Orange County Line to I-605, are expected to produce substantial mobility benefits of nearly $1.5 billion that could potentially reduce delay by as much as 20,000 vehicle-hours each day. This could improve mobility by well over 50 percent over current and projected conditions.
- Advanced ramp metering results in only modest mobility improvements on this corridor, likely due to lack of controlled connector metering at a major freeway-to-freeway interchange.
- Operational improvements, such as auxiliary lanes and ramp improvements, combined with advanced ramp metering could leverage on the programmed capital expansion projects by making the corridor more efficient and productive and result in additional mobility benefits of nearly $100 million.
- Model analysis of the very preliminary design elements of planned I-710 interchange modifications and HOV lane extension from I-605 to I-710 indicated only modest results with gains in the northbound direction that are offset by worsening conditions in the southbound direction. The study team suggests

possible design changes, particularly in the southbound direction to optimize the beneficial results.

- An enhanced incident management system associated with Scenarios 9 and 10 to address non-recurrent congestion proved to be effective with a delay reduction of over 1,600 vehicle-hours for one modest level incident with a typical duration of 35 minutes reduced to 25 minutes. With the I-5 South corridor experiencing up to 1,500 collisions per year, this translates to total annual delay savings of over 2,400,000 vehicle-hours for the study corridor.

Speed Contour Maps

Exhibits 6-1 through 6-4 show the speed contour maps for the 2020 horizon year baseline (do minimum). For the northbound direction, the peak is greater in the AM, although both AM and PM have significant congestion. For the southbound direction, the peak is mainly in the PM. Exhibits 6-5 and 6-6 illustrate the speed contour maps produced by the northbound model at the conclusion of Scenario 11, the final scenario tested. The exhibits show the last remaining residual congestion approaching Paramount Boulevard in the AM and PM peak in the northbound direction. Exhibit 6-7 illustrates the speed contour map produced by the southbound model in the PM peak at the conclusion of Scenario 11, final scenario tested. As indicated, there is still noticeable congestion by year 2020 approaching the Paramount and Lakewood in the PM peak.

Exhibit 6-1: Northbound AM Peak Model Speed Contours at Baseline (2020)

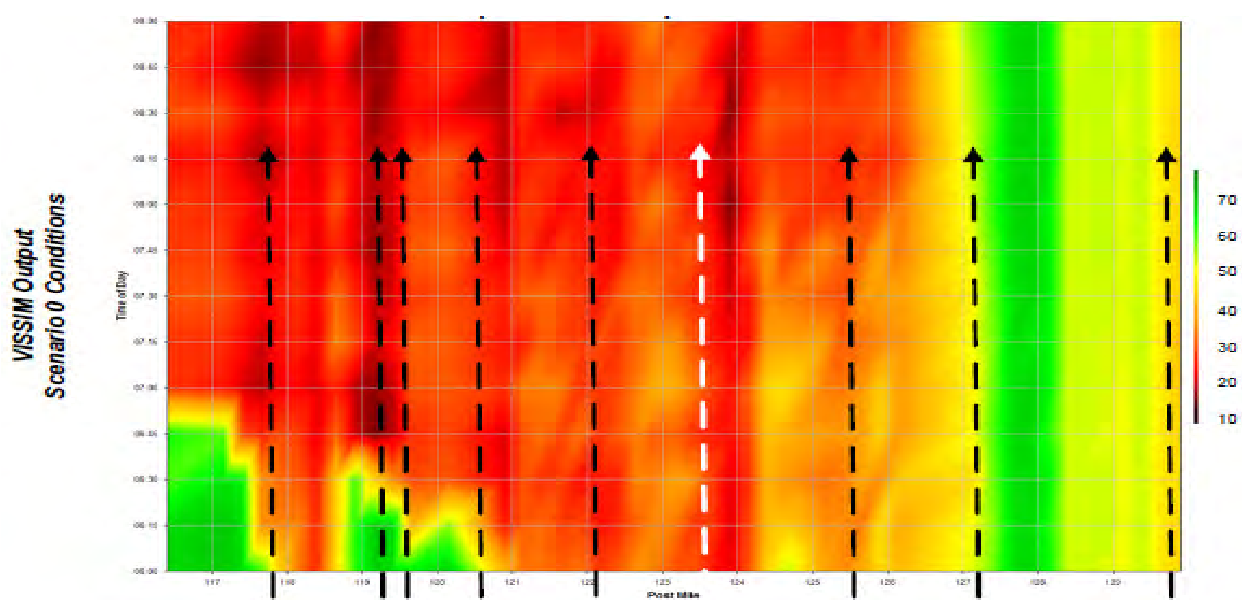


Exhibit 6-2: Northbound PM Peak Model Speed Contours at Baseline (2020)

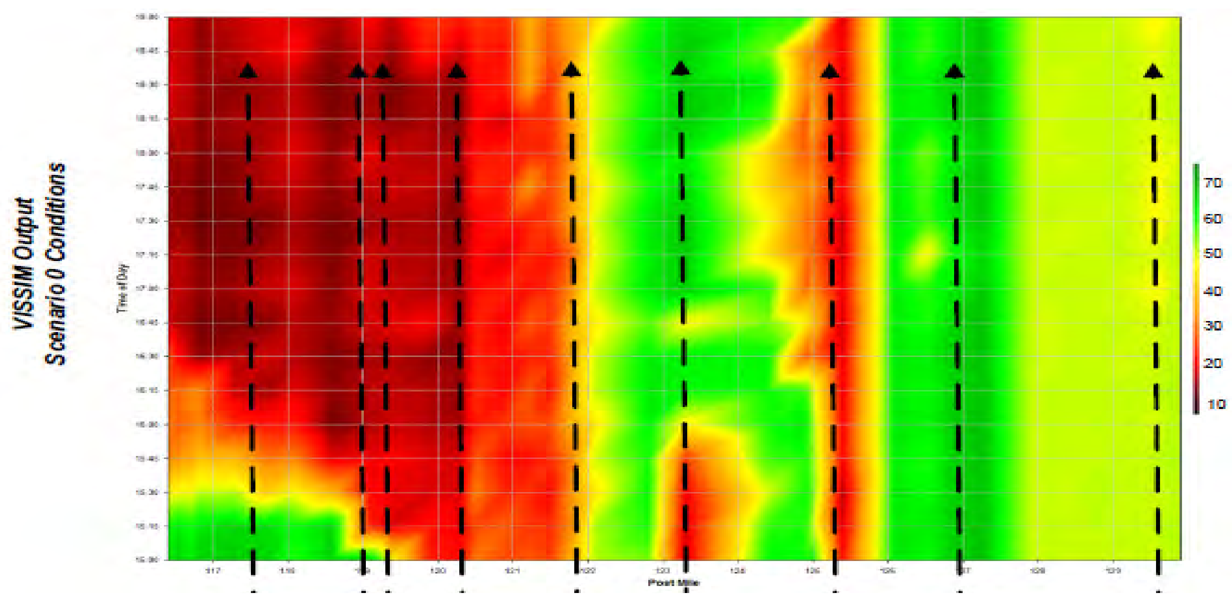


Exhibit 6-3: Southbound AM Peak Model Speed Contours at Baseline (2020)

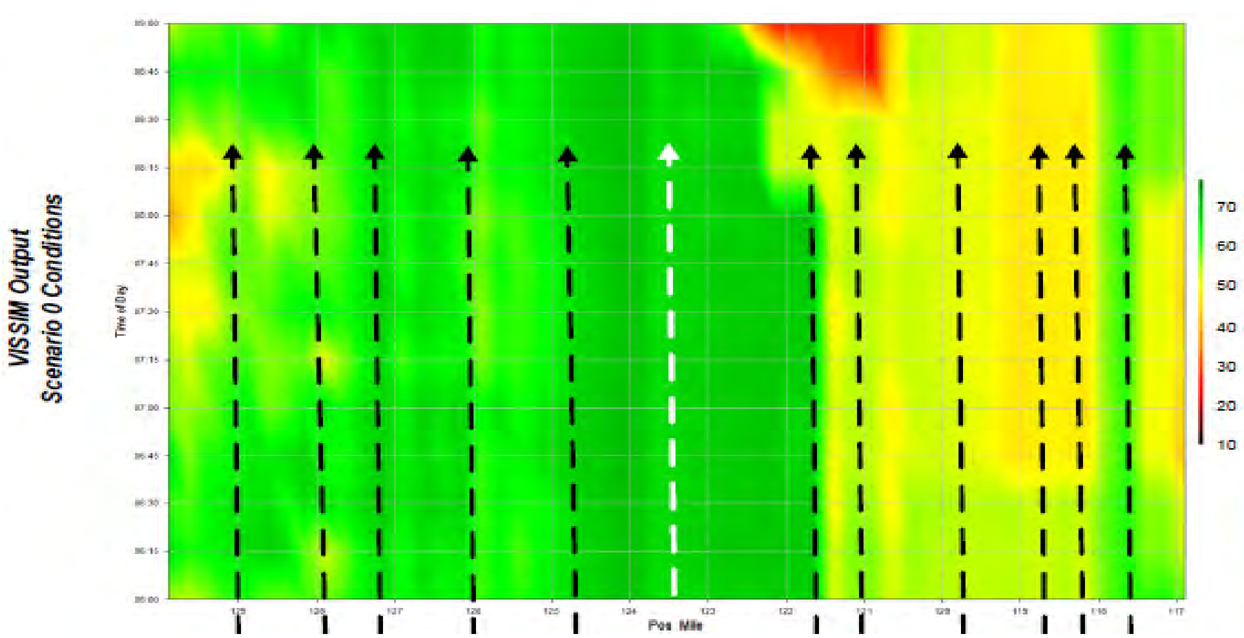


Exhibit 6-4: Southbound PM Peak Model Speed Contours at Baseline (2020)

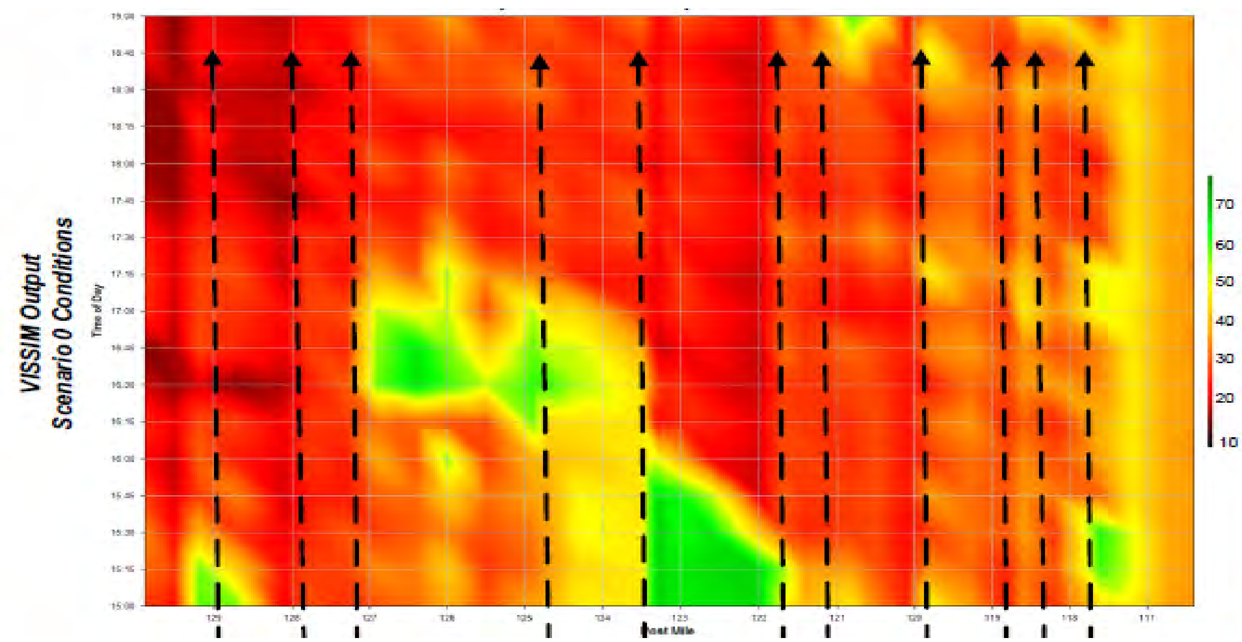


Exhibit 6-5: Northbound AM Peak Model Speed Contours After Scenario 11 (2020)

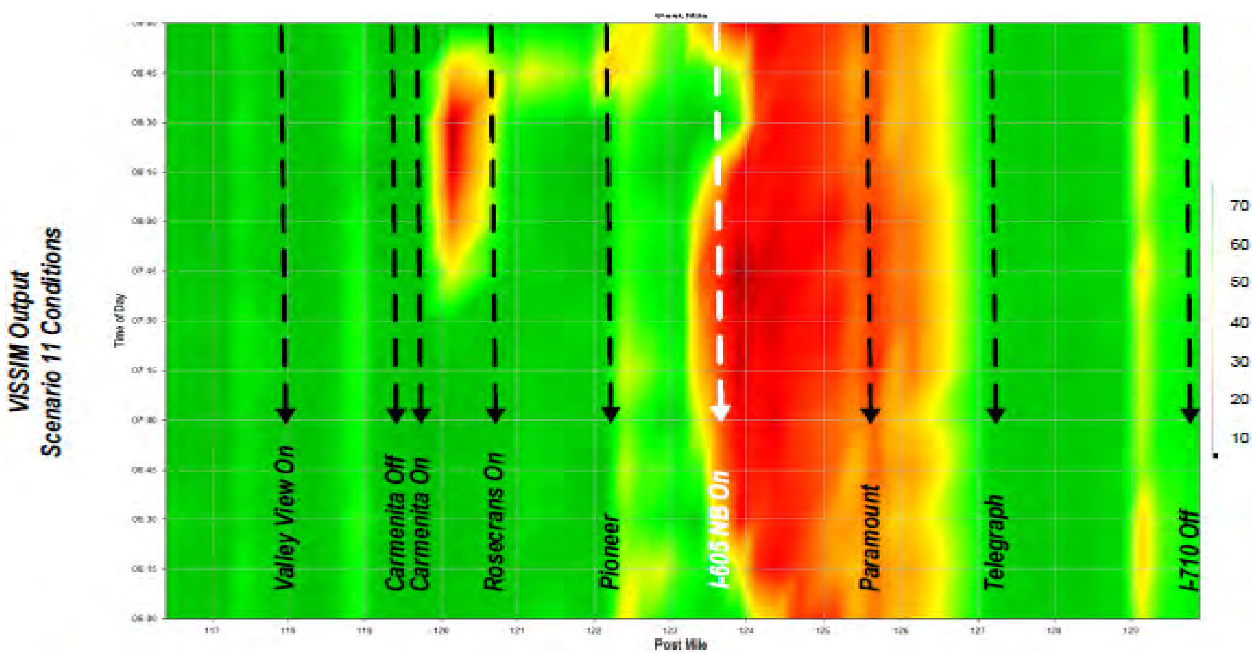


Exhibit 6-6: Northbound PM Peak Model Speed Contours After Scenario 11 (2020)

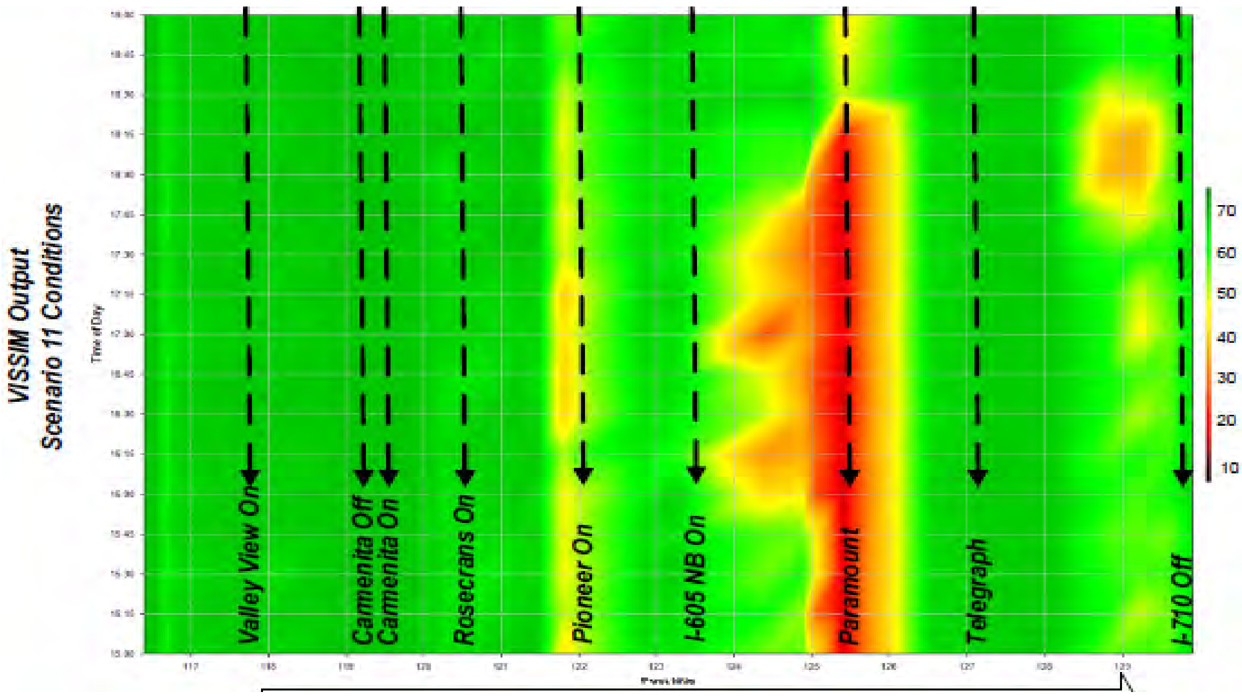
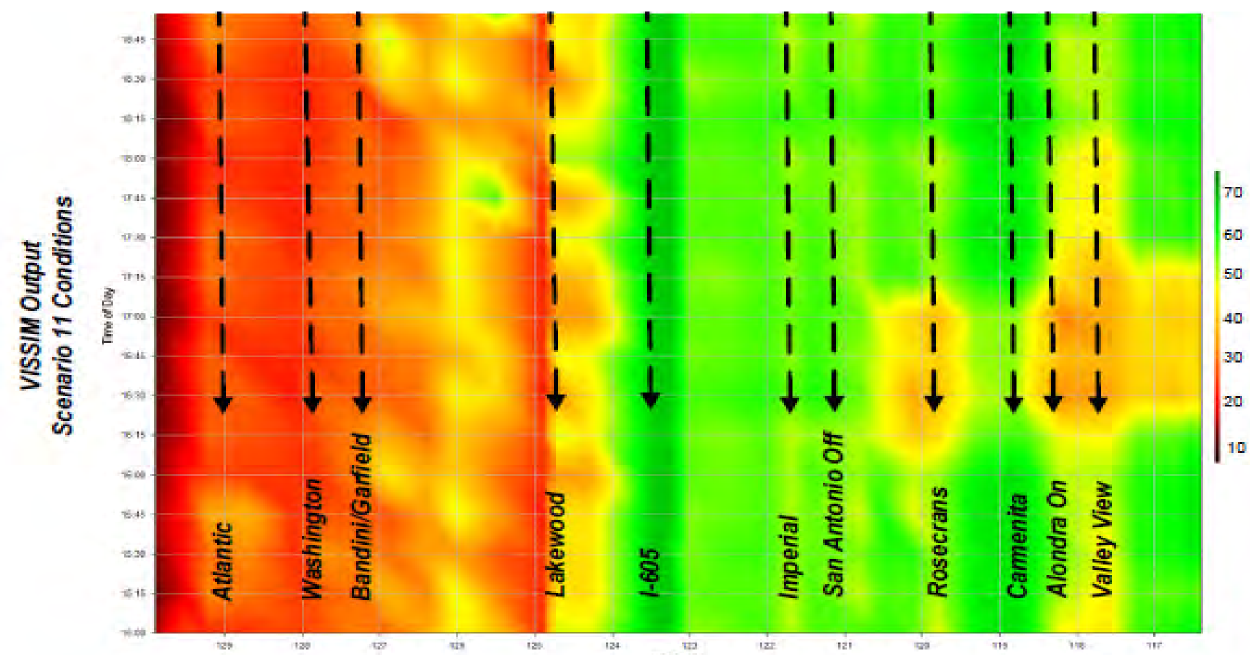


Exhibit 6-7: Southbound PM Peak Model Speed Contours After Scenario 11 (2020)



This is the first-generation CSMP for the I-5 South Corridor. It is important to emphasize that CSMPs should be updated, on a regular basis, if possible. This is particularly important since traffic conditions and patterns can differ from current projections. After projects are delivered, it is also useful to compare actual results with estimated ones in this document so that models can be further improved as appropriate.

CSMPs, or some variation, should become the normal course of business that includes detailed performance assessments, an in-depth understanding of the reasons for performance deterioration, and an analytical framework that allows for evaluating complementary operational strategies that maximize system productivity.

Appendix A: I-5 South Detailed Scenario Descriptions

Scenario	Proj ID	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)*
1 (2007-1) 2 (2020-1)	LA0D73B EA 2159C	Carmenita IC improvement	CALTRANS	2013	06 & 08 TIP	$398,790
3 (2007-2) 4 (2020-2)	LA0D73 EA 2159A	Widen for HOV & mixed flow lanes (OC Line to I-605) and reconstruct Valley View Interchange	CALTRANS	2016	06 & 08 TIP/ CMIA	$1,240,523
5 (2007-3) 6 (2020-3)	Proposed (SMG)	Advanced Ramp Metering on entire corridor with queue control				$10,000
7 (2007-4) 8 (2020-4)	Proposed (SMG)	Add NB auxiliary lane from Rosecrans to San Antonio				$1,000
		Add NB auxiliary lane from Imperial Hwy to Pioneer On				$10,000
		Move Florence on ramp metering downstream, closer to I-5 merge (and reduce meter rate)				$500
		SB-710 On-ramp: Restripe to solid white 1000 feet past merge				$100
		Add aux lane from Paramount to Lakewood on-ramp, converge Lakewood on-ramps into aux lane, and move Lakewood on-ramp merge further downstream				$5,000
		Add third storage lane on I-605 connector Off (widen bridge)				$15,000
		Widen Rosecrans on-ramp for more storage (reduce meter rate)				$400
9 (2020-5) 10 (2020-6) -Builds on Sc 4	Proposed (SMG)	Enhanced Incident Management System				
11 (2020-7) -Builds on Sc 8	LAE2577 EA 2159F	Widening with HOV & mixed flow lanes from I-605 to I-710	CALTRANS	2023	06 & 08 TIP (PAED only)	$1,200,000
	2159E	Reconstruction Reconstruction of I-710/I-5 IC, providing I-5 freeway widening & new freeway to freeway connections		2018	Planned	

**Total Cost includes construction and support costs in current dollars*

Appendix B: Benefit-Cost Analysis Results

This appendix provides more detailed Benefit-Cost Analysis (BCA) results than found in Section 5 of the I-5 South Corridor System Management Plan (CSMP) Final Report. The BCA results for this CSMP were estimated by using the *California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) Version 4.0* developed for Caltrans by System Metrics Group, Inc. (SMG).

Caltrans uses Cal-B/C to conduct investment analyses of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP), and other ad hoc analyses requiring BCA. Cal-B/C is a spreadsheet-based tool that can prepare analyses of highway, transit, and passenger rail projects. Users input data defining the type, scope, and cost of projects. The model calculates life-cycle costs, net present values, benefit-cost ratios, internal rates of return, payback periods, annual benefits, and life-cycle benefits. Cal-B/C can be used to evaluate capacity expansion projects, transportation management systems (TMS), and operational improvements.

Cal-B/C measures, in constant dollars, four categories of benefits:

- Travel time savings (reduced travel time and new trips)
- Vehicle operating cost savings (fuel and non-fuel operating cost reductions)
- Accident cost savings (safety benefits)
- Emission reductions (air quality and greenhouse gas benefits).

Each of these benefits was estimated for the peak period for the following categories:

- **Life-Cycle Costs** - present values of all net project costs, including initial and subsequent costs in real current dollars.
- **Life-Cycle Benefits** - sum of the present value benefits for the project.
- **Net Present Value** - life-cycle benefits minus the life-cycle costs. The value of benefits exceeds the value of costs for a project with a positive net present value.
- **Benefit/Cost Ratio** - benefits relative to the costs of a project. A project with a benefit-cost ratio greater than one has a positive economic value.
- **Rate of Return on Investment** - discount rate at which benefits and costs are equal. For a project with a rate of return greater than the discount rate, the benefits are greater than costs and the project has a positive economic value. The user can use rate of return to compare projects with different costs and different benefit flows over different time periods. This is particularly useful for project staging.

- **Payback Period** - number of years it takes for the net benefits (life-cycle benefits minus life-cycle costs) to equal the initial construction costs. For a project with a payback period longer than the life-cycle of the project, initial construction costs are not recovered. The payback period varies inversely with the benefit-cost ratio. A shorter payback period yields a higher benefit-cost ratio.

The model calculates these results over a standard 20-year project life-cycle, itemizes each user benefit, and displays the annualized and life-cycle user benefits. Below the itemized project benefits, Cal-B/C displays three additional benefit measures:

- **Person-Hours of Time Saved** - reduction in person-hours of travel time due to the project. A positive value indicates a net benefit.
- **Additional CO_2 Emissions (tons)** -additional CO_2 emissions that occur because of the project. The emissions are estimated using average speed categories using data from the California Air Resources Board (CARB) EMFAC model. This is a gross calculation because the emissions factors do not take into account changes in speed cycling or driver behavior. A negative value indicates a project benefit. Projects in areas with severe congestion will generally lower CO_2 emissions.
- **Additional CO_2 Emissions (in millions of dollars)** - valued CO_2 emissions using a recent economic valuing methodology.

A copy of Cal-B/C v4.0, the User's Guide, and detailed technical documentation can be found at the Caltrans' Division of Transportation Planning, Office of Transportation Economics website at http://www.dot.ca.gov/hq/tpp/offices/ote/benefit.html.

The exhibits in this appendix are listed as follows:

- Exhibit B-1: BCA Results - S1/S2 Carmenita Interchange
- Exhibit B-2: BCA Results - S3/S4 HOV and General Purpose Widening
- Exhibit B-3: BCA Results - S5/S6 Advanced Ramp Metering
- Exhibit B-4: BCA Results - S7/S8 Operational Improvements
- Exhibit B-5: BCA Results - S11 HOV Lane to I-710 and I-710 IC Improvement (Incremental)
- Exhibit B-6: Cumulative BCA Results.

Exhibit B-1: BCA Results - S1/S2 Carmenita Interchange

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$398.8
Life-Cycle Benefits (mil. $)	$166.0
Net Present Value (mil. $)	-$232.8
Benefit / Cost Ratio:	0.4
Rate of Return on Investment:	-3.4%
Payback Period:	20+ years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$6.8	$135.9
Veh. Op. Cost Savings	$1.1	$21.4
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$0.4	$8.7
TOTAL BENEFITS	$8.3	$166.0
Person-Hours of Time Saved	855,799	17,115,987
Additional CO_2 Emissions (tons)	-5,164	-103,273
Additional CO_2 Emissions (mil. $)	-$0.2	-$3.1

Incremental Costs (mil. $)	$398.8
Incremental Benefits (mil. $)	$166.0
Incremental Benefit / Cost Ratio	0.4

Exhibit B-2: BCA Results - S3/S4 HOV and General Purpose Widening

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,639.3
Life-Cycle Benefits (mil. $)	$1,483.9
Net Present Value (mil. $)	-$155.4
Benefit / Cost Ratio:	0.9
Rate of Return on Investment:	3.1%
Payback Period:	16 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$59.0	$1,180.2
Veh. Op. Cost Savings	$11.0	$221.0
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$4.1	$82.8
TOTAL BENEFITS	$74.2	$1,483.9
Person-Hours of Time Saved	7,511,403	150,228,056
Additional CO_2 Emissions (tons)	-55,581	-1,111,627
Additional CO_2 Emissions (mil. $)	-$1.6	-$32.4

Incremental Costs (mil. $)	$1,240.5
Incremental Benefits (mil. $)	$1,317.9
Incremental Benefit / Cost Ratio	1.1

Exhibit B-3: BCA Results - S5/S6 Advanced Ramp Metering

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,649.3
Life-Cycle Benefits (mil. $)	$1,512.0
Net Present Value (mil. $)	-$137.3
Benefit / Cost Ratio:	0.9
Rate of Return on Investment:	3.2%
Payback Period:	16 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$60.3	$1,206.1
Veh. Op. Cost Savings	$11.2	$223.1
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$4.1	$82.8
TOTAL BENEFITS	$75.6	$1,512.0
Person-Hours of Time Saved	7,683,742	153,674,840
Additional CO_2 Emissions (tons)	-56,299	-1,125,983
Additional CO_2 Emissions (mil. $	-$1.6	-$32.7

Incremental Costs (mil. $)	$10.0
Incremental Benefits (mil. $)	$28.1
Incremental Benefit / Cost Ratio	2.8

Exhibit B-4: BCA Results - S7/S8 Operational Improvements

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,681.3
Life-Cycle Benefits (mil. $)	$1,581.8
Net Present Value (mil. $)	-$99.6
Benefit / Cost Ratio:	0.9
Rate of Return on Investment:	3.4%
Payback Period:	16 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$63.4	$1,268.2
Veh. Op. Cost Savings	$11.4	$228.6
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$4.2	$85.0
TOTAL BENEFITS	$79.1	$1,581.8
Person-Hours of Time Saved	8,055,385	161,107,708
Additional CO_2 Emissions (tons)	-57,732	-1,154,645
Additional CO_2 Emissions (mil. $	-$1.7	-$33.6

Incremental Costs (mil. $)	$32.0
Incremental Benefits (mil. $)	$69.7
Incremental Benefit / Cost Ratio	2.2

Exhibit B-5: BCA Results - S11 HOV Lane to I-710 and I-710 IC Improvement (Incremental)

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,200.0
Life-Cycle Benefits (mil. $)	$198.6
Net Present Value (mil. $)	-$1,001.4
Benefit / Cost Ratio:	0.2
Rate of Return on Investment:	#DIV/0!
Payback Period:	20+ years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$7.6	$151.0
Veh. Op. Cost Savings	$1.5	$29.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$0.9	$18.3
TOTAL BENEFITS	$9.9	$198.6
Person-Hours of Time Saved	836,052	16,721,032
Additional CO_2 Emissions (tons)	-6,518	-130,369
Additional CO_2 Emissions (mil. $	-$0.2	-$4.0

Exhibit B-6: Cumulative BCA Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$2,881.3
Life-Cycle Benefits (mil. $)	$1,780.4
Net Present Value (mil. $)	-$1,100.9
Benefit / Cost Ratio:	0.6
Rate of Return on Investment:	n/a
Payback Period:	n/a

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$71.0	$1,419.3
Veh. Op. Cost Savings	$12.9	$257.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$5.2	$103.2
TOTAL BENEFITS	$89.0	$1,780.4
Person-Hours of Time Saved	8,891,437	177,828,741
Additional CO_2 Emissions (tons)	-64,251	-1,285,014
Additional CO_2 Emissions (mil. $	-$1.9	-$37.5