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Caltrans

Corridor System Management Plan (CSMP)

Los Angeles County I-405 Corridor

Final Report

Executive Summary

September 2010

I approve this Corridor System Management Plan (CSMP) for I-405 in Caltrans District 7 as the overall Policy Statement and Strategic Plan that will guide transportation decisions and investment for the I-405 Corridor from I-110 to the I-5 junction in Los Angeles County.

Approval

3/8/11

MICHAEL MILES
District 7 Director

Date

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This document represents the Executive Summary for the Los Angeles Interstate 405 (I-405) Corridor System Management Plan (CSMP) developed on behalf of the Southern California Association of Governments (SCAG) and the California Department of Transportation (Caltrans) by System Metrics Group. A more detailed technical CSMP is available upon request.

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). CMIA money is partially funding the northbound I-405 High Occupancy Vehicle (HOV) lane from I-10 in Los Angeles to US-101 in Sherman Oaks. Approximately, $730 million in CMIA funds have been adopted by the CTC for this project.

To receive CMIA funds, California Transportation Commission (CTC) guidelines required that project nominations describe how mobility gains from funded corridor improvements would be maintained over time. A CSMP therefore aims to define how corridors will be managed over time, 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.

This Executive Summary and technical CSMP represent the results of a study that included several key steps, including:

- Stakeholder Involvement
- Corridor Performance Assessment
- Bottleneck Identification and Causality Analysis
- Scenario Development and Analysis
- Conclusions and Recommendations.

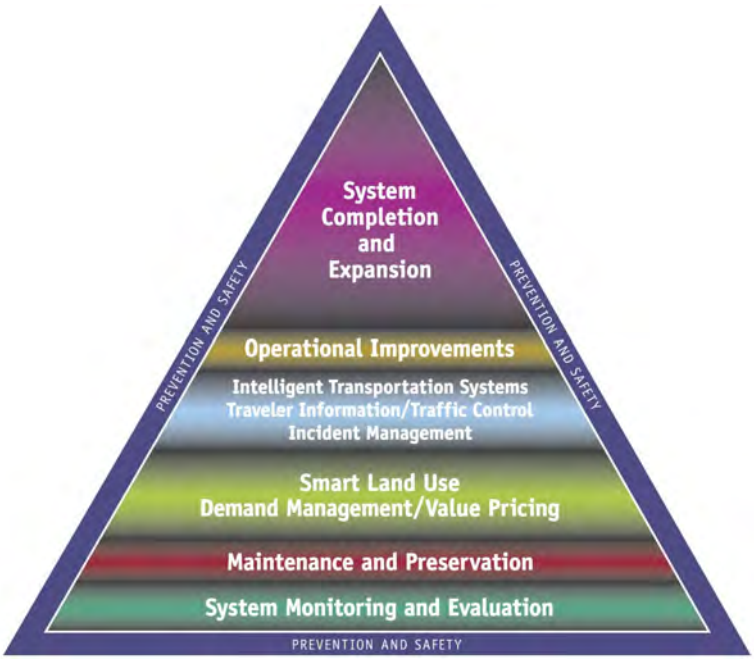
Highlights of each of these steps are included in later sections of this summary.

BACKGROUND

Los Angeles County's transportation system faces numerous challenges — the demand for transportation keeps rising, congestion is increasing, and infrastructure is aging. At the same time, traditional transportation finance mechanisms are not able to provide adequate funding to keep expanding the infrastructure to keep up with demand. Caltrans recognized that infrastructure expansion cannot keep pace with demand, and adopted a system management philosophy to address current and future transportation needs in a comprehensive manner. Exhibit ES-1 conceptually illustrates system management as a pyramid. The exhibit shows that the transportation decision makers

and practitioners at all jurisdictions must expand their "tool box" to include many complementary strategies with an increased focus on operational investments (shown in the middle part of the pyramid) to complement the traditional system expansion investments.

Exhibit ES-1: System Management Pyramid



This I-405 CSMP aims to define how Caltrans and its stakeholders will manage the corridor over time, focusing on operational strategies in addition to already funded expansion projects. The goal is to get the most out of the existing system and maintain and/or improve its performance. The CSMP fully respects previous decisions and complements them with additional promising investment suggestions where appropriate. The CSMP development effort relies on complex analytical tools, including micro simulation models, to isolate deficiencies and quantify improvements for even relatively small operational investments.

Caltrans develops integrated multimodal projects in balance with community goals, plans, and values. Caltrans seeks and tries 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 is more focused on reducing congestion and increasing mobility through capital and operational strategies. The future CSMP work will further address pedestrian, bicycle

and transit components and seek to manage and improve the whole network as an interactive system.

STAKEHOLDER INVOLVEMENT

The study involved corridor stakeholders throughout in two ways. First, a technical committee was formed and met on an almost monthly basis to discuss progress, technical challenges, data needs, and preliminary conclusions. This technical committee was comprised mainly of Caltrans, SCAG, and Metro professionals as well as the consulting team members.

Other corridor stakeholders, including representatives from the South Bay Cities Council of Governments and the Los Angeles Department of Transportation (LADOT) were debriefed at critical milestones. Feedback from these 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.

Caltrans would like to thank all of its partners for contributing to this CSMP development process. In addition, the 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.

CORRIDOR PERFORMANCE ASSESSMENT

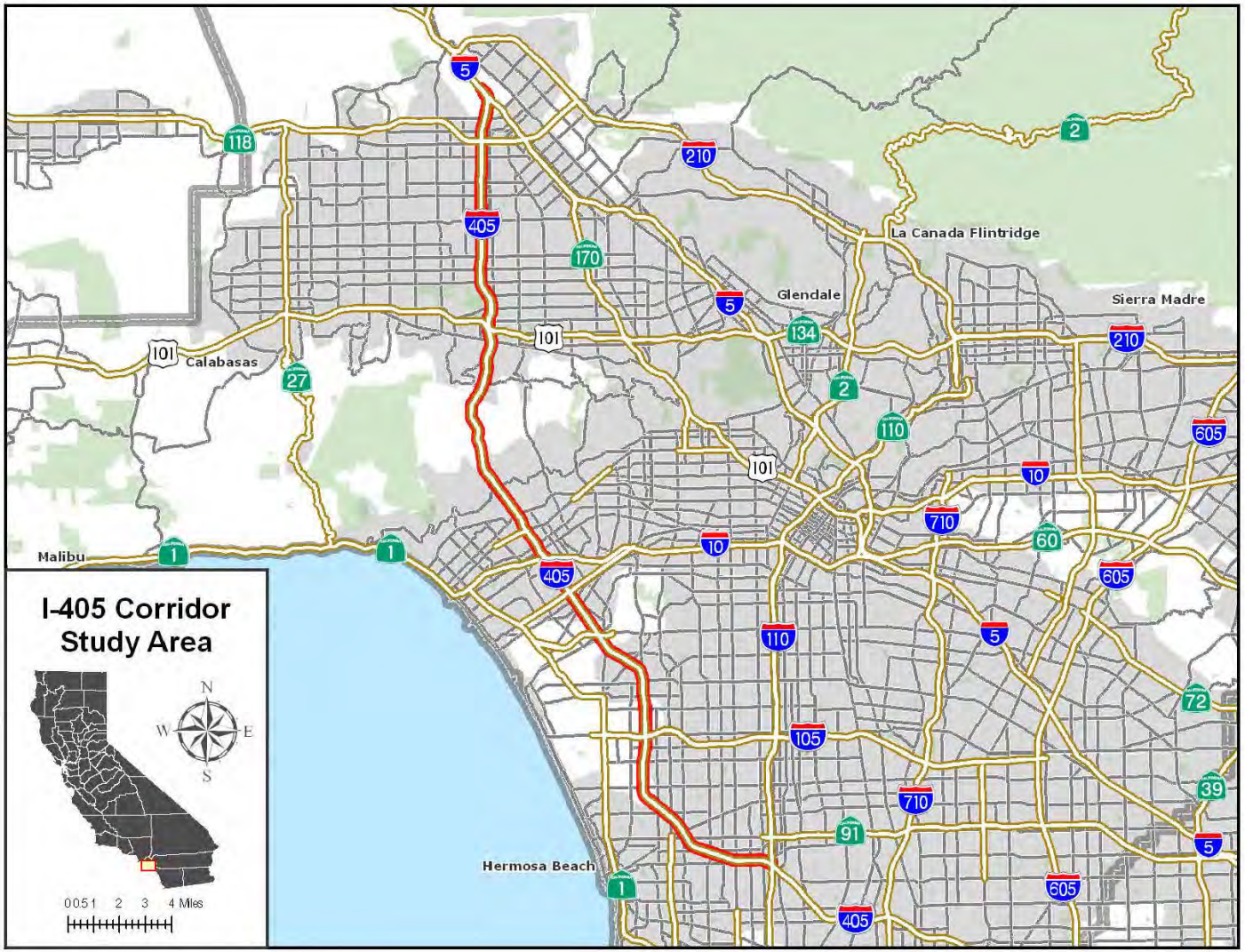
This section briefly describes the I-405 corridor and summarizes the results of the comprehensive corridor performance assessment conducted.

Corridor Description

Exhibit ES-2 shows the location of the Los Angeles County I-405 CSMP corridor. The corridor is approximately 36 miles long and runs from I-110 in San Pedro to the I-5 Interchange in the San Fernando Valley. It connects with six major freeways from north to south: I-110, I-105, SR-90, I-10, US-101, and SR-118.

I-405 is an eight to twelve-lane freeway with a concrete median barrier that separates northbound and southbound traffic for most of the corridor. There are auxiliary lanes along many sections of the corridor with some only available one one side of the freeway. There are also HOV lanes on both directions of the corridor, except for the

Exhibit ES-2: Los Angeles County I-405 CSMP Corridor Map



northbound segment from I-10 to US-101, which is currently under construction.

According to 2008 traffic volumes from Caltrans, I-405 carries between 137,000 and 310,000 annual average daily traffic (AADT). The highest AADT was reported south of the I-105 Interchange and north of the I-10 Interchange.

I-405 corridor is a Surface Transportation Assistance Act (STAA) state truck route. According to 2008 Caltrans truck traffic estimates, trucks make up about four percent of total daily traffic along the entire corridor, with the highest percentage (4.6 percent) at the I-110 Interchange.

Various transit lines operate near the I-405 corridor. In the northern portion of the corridor from US-101 to I-5, Metro operates Line 234, which runs south along Sepulveda Boulevard from the Sylmar/San Fernando Metrolink Station southbound. Lines 233 and 237 run parallel to the study corridor along Van Nuys Boulevard. In the southern portion of the study corridor, from the I-10 to the I-110, Metro operates Line 215, which runs along Inglewood Avenue parallel to the corridor. Metro Rapid Lines 740 and 940, local bus Line 40, and Express Line 442 run along Hawthorne Boulevard while Line 211 operates along Prairie Avenue. The Metro Rail Green Line crosses the freeway running along the I-105 freeway and terminates at the Redondo Beach Avenue Station. Other transit operators that provide services near the corridor include Metrolink commuter rail service; Antelope Valley Transit; Santa Clarita Transit; Culver City Transit; Los Angeles City Department of Transportation Commuter Express, and the Santa Monica's Big Blue Bus.

There are several bicycle facilities near I-405, mainly concentrated in the southern section of the corridor near the ocean. The longest bike path that is parallel to the corridor travels along the Pacific Coast Highway from Hermosa Beach to Malibu.

The South Bay and Westside are major employment centers and trip generator for the I-405 corridor. Located near the I-105 Interchange, the South Bay houses the Los Angeles International Airport, many shopping malls, and residential developments. The Westside communities of Santa Monica, Westwood, and the Century City are also large employment centers with numerous office buildings and dense residential developments.

There are several major universities and several community colleges near the corridor. The most significant given its size and proximity to I-405 is the University of California, Los Angeles (UCLA). The University of Los Angeles is located in Westwood, north of the I-10 Interchange. Loyola Marymount University (LMU) is located one mile west of the study corridor and south of the SR-90 Freeway. California State University Northridge (CSUN) is located approximately three miles west of the study corridor and near the SR-118 (Simi Valley) Freeway. It is a public university with an estimated enrollment of 35,000 students. California State University Dominguez Hills is located approximately one mile from the I-405 freeway and east of the I-110 freeway. It is a

four-year university offering undergraduate and graduate degrees. It has an estimated enrollment of 12,800 students.

One major commercial airport and four smaller general aviation airports lie near the corridor. The Los Angeles International Airport is located northwest of the I-105 and I-405 junction. The smaller airports near the study corridor include the Santa Monica, Van Nuys, Hawthorne Municipal, and Torrance Municipal Airports.

Corridor Performance Assessment

The I-405 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

Two primary measures quantify mobility in this report: delay and travel time. Each is estimated from field automatic detection data and forecasted using macro or micro models. The Performance Measurement System[1] (PeMS) provided access to the historical freeway detection data needed to estimate the two mobility measures. PeMS collects detector volume and occupancy data on the freeway that are used to estimate speed, delay and travel time.

Delay

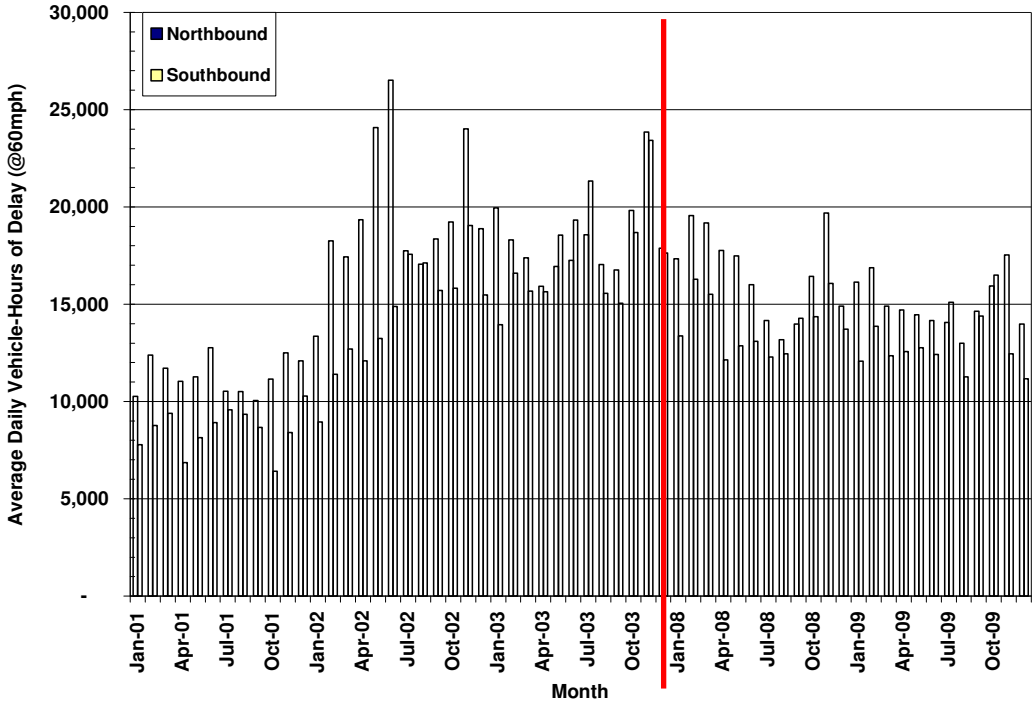
Delay is defined as the observed travel time less the travel time under non-congested conditions at 60 miles per hour (mph) and is reported as vehicle-hours of delay. The assessment is based on two time periods: one that reflects pre-construction conditions and another that reflects present conditions. The pre-construction period is the three years of 2001-2003 before the major construction of the HOV-lane began. The present conditions period refers to the years 2008 and 2009, where the HOV construction was being done on a different portion of the corridor. As of 2010, the HOV lane is being constructed on the northbound segment between I-10 and US-101.

Delays in this report were calculated as the difference in travel time between estimated speeds and free-flow conditions at 60 mph, applied to the observed volume. Exhibit ES-3 shows the average daily delay by direction for each month for the mainline facility, and ES-4 shows the HOV facility results. This exhibit reveals a few notable trends:

[1] Developed and maintained by Caltrans and accessible at PeMS@dot.ca.gov

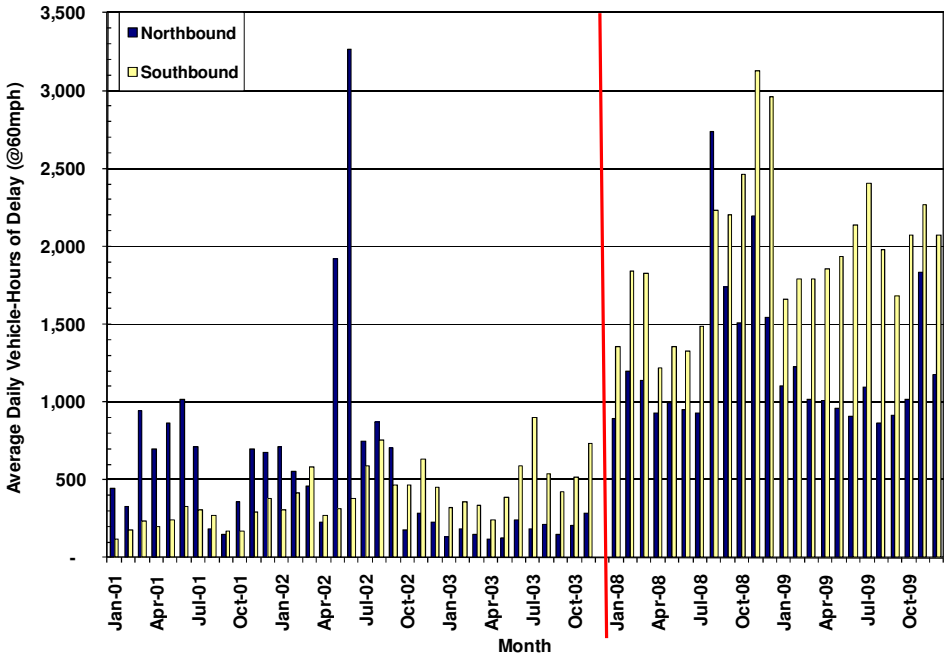
- Congestion on the mainline facility increased from 2001 to 2003, which may have been due to economic growth in the region. Delay declined in 2008 and 2009, most likely due to the global financial downturn and the associated recession.
- The northbound mainline facility experienced greater overall congestion than the southbound mainline facility.
- The HOV facility experienced an increase in delay from 2003 to 2008 partly because the facility was extended during this time.

Exhibit ES-3: I-405 Mainline Average Weekday Delay by Month (2001-2003 & 2008-2009)



Delay can be segmented into two components. *Severe delay* is delay that occurs when speeds are below 35 mph and *other delay* where speeds are between 35 and 60 mph. Severe delay represents breakdown conditions. "Other" delay represents conditions approaching or leaving the breakdown congestion, or areas that cause temporary slowdowns. However, it can also be a leading indicator of future severe delay.

Exhibit ES-4: I-405 HOV Lane Weekday Delay by Month (2001-2003 & 2008-2009)



Exhibits ES-5 (Mainline lanes) and ES-6 (HOV lanes) show average severe and other daily vehicle-hours of delay by day of the week. A few notes related to these exhibits:

- Severe delay makes up about 80 percent of all weekday delay on the corridor in both directions of the corridor and both mainline and HOV facilities.

- On the mainline facility, Thursdays in the northbound direction experienced the highest delays. In the southbound direction of the mainline, the level of congestion grew during the workweek and peaked on Fridays from 2001-2003. Fridays in 2003 experienced the highest "severe" delay, at about 20,000 vehicle-hours. However, in 2008 and 2009, Thursdays experienced the highest "severe" delay in the southbound direction at approximately 13,000 vehicle-hours.

- On the mainline facility, the downward trend is again clear from 2003 to 2008. Unlike the mainline facility, the HOV facility experienced a notable increase in delay in 2008 and 2009 compared to pre-construction levels.

- On the HOV facility, delay peaked on Fridays in both directions. Exhibit ES-6 clearly shows that delay in the southbound direction increased in 2008 and 2009 compared to 2003 levels.

Exhibit ES-5: I-405 Mainline Delay by Day of Week by Severity (2001-2003 & 2008-2009)

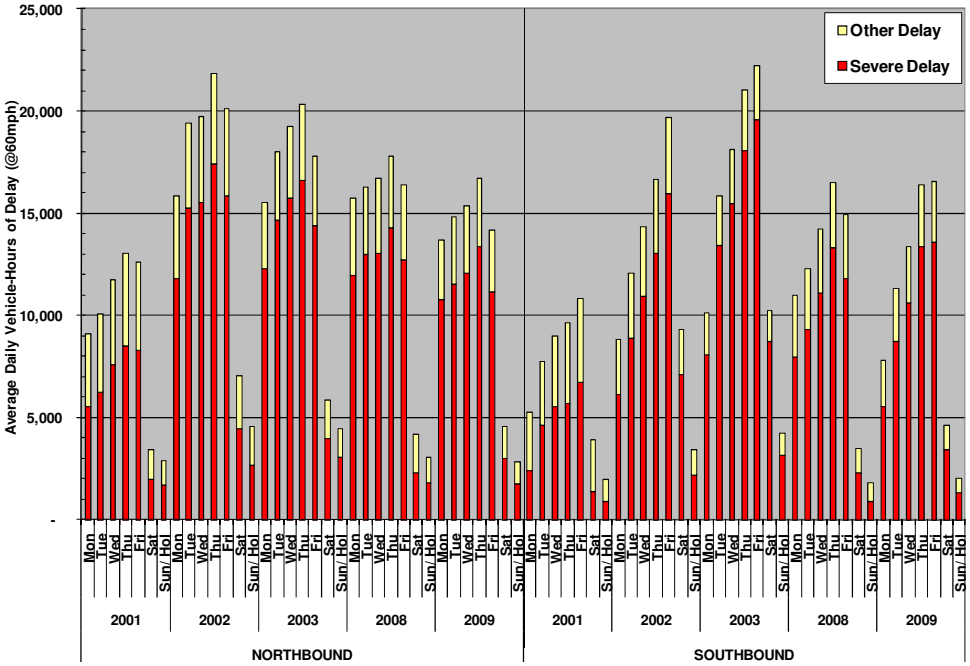
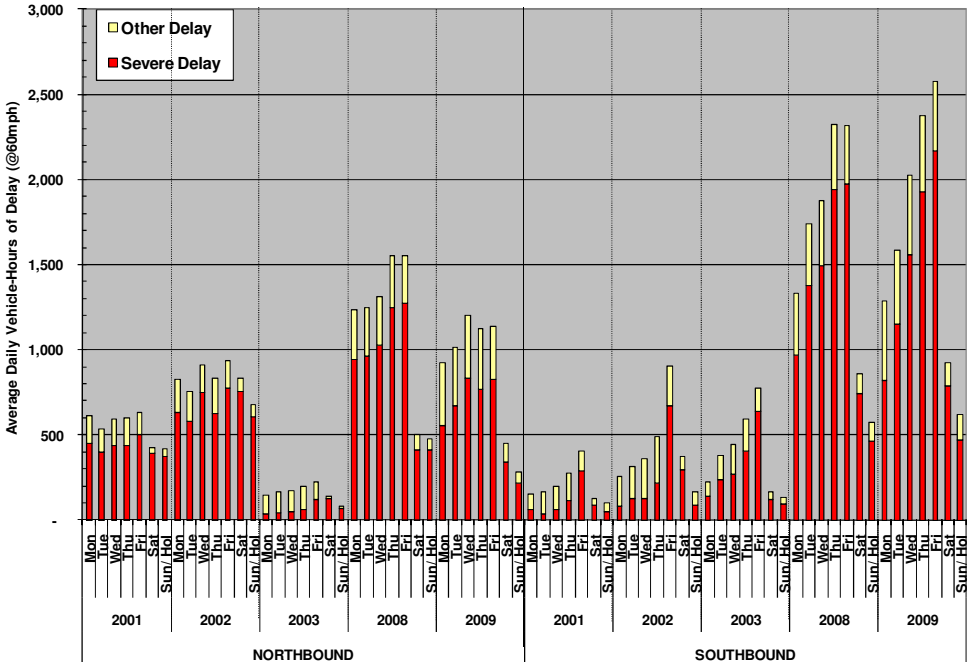


Exhibit ES-6: I-405 HOV Lane Delay by Day of Week by Severity (2001-2003 & 2008-2009)



Exhibits ES-7 and ES-8 summarize average annual weekday delay by hour of the day for the mainline facility. Exhibits ES-9 and ES-10 summarize delays for the HOV facility. This data allow planners and decision makers to understand the trend in peak period delay spiking and peak period spreading by comparing the duration of the peak period congestion. A few notes on these four exhibits:

- The AM peak period delay spike occurs between 7:00 and 8:00 AM, and the PM peak hour is at 5:00 PM. This is typical for an urban corridor serving a large number of work trips during the peak period.

- The duration of congestion on the mainline is much longer during the PM peak period, starting around 2:00 PM and lasting until 7:00 PM. In contrast, the AM peak period lasts about 3 hours, from approximately 6:30 AM until 9:30 AM.

- In 2009, the northbound mainline PM peak period congestion was about 20 percent less than the 2003 peak (from a high of over 2,800 hours in 2003 to around 2,200 hours in 2009).

- In the northbound direction of the HOV-lane, delay was fairly even between both peak periods in 2001-2003 at around 50 vehicle-hours of delay. However, in 2008 and 2009, delay increased significantly during the AM and PM peak periods by almost three times that of pre-construction levels.

Exhibit ES-7: Northbound I-405 Mainline Hourly Delay (2001-2003 & 2008-2009)

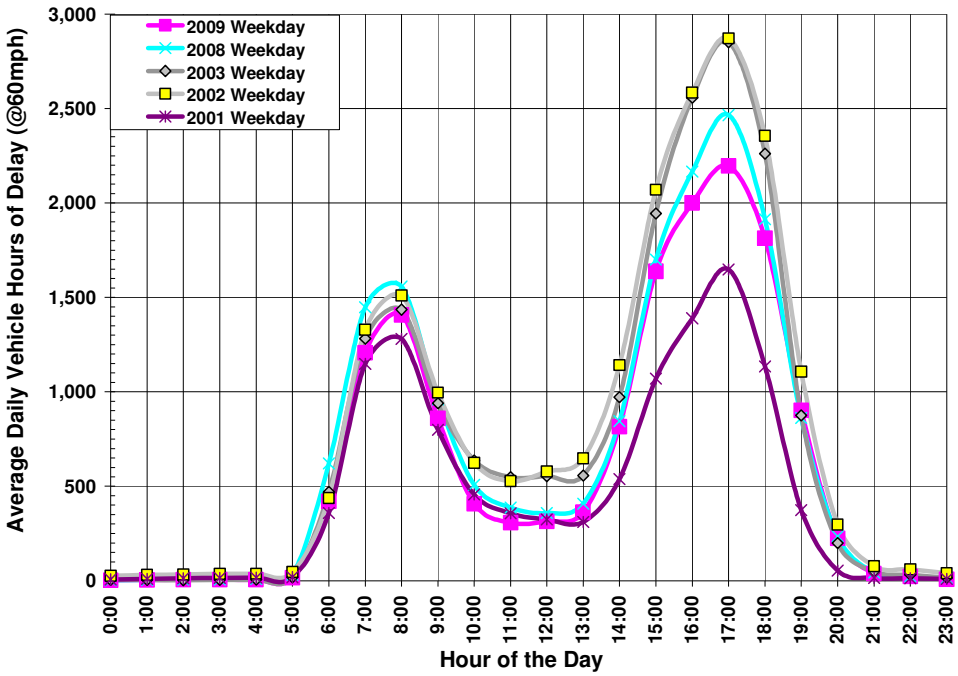


Exhibit ES-8: Southbound I-405 Mainline Hourly Delay (2001-2003, & 2008-2009)

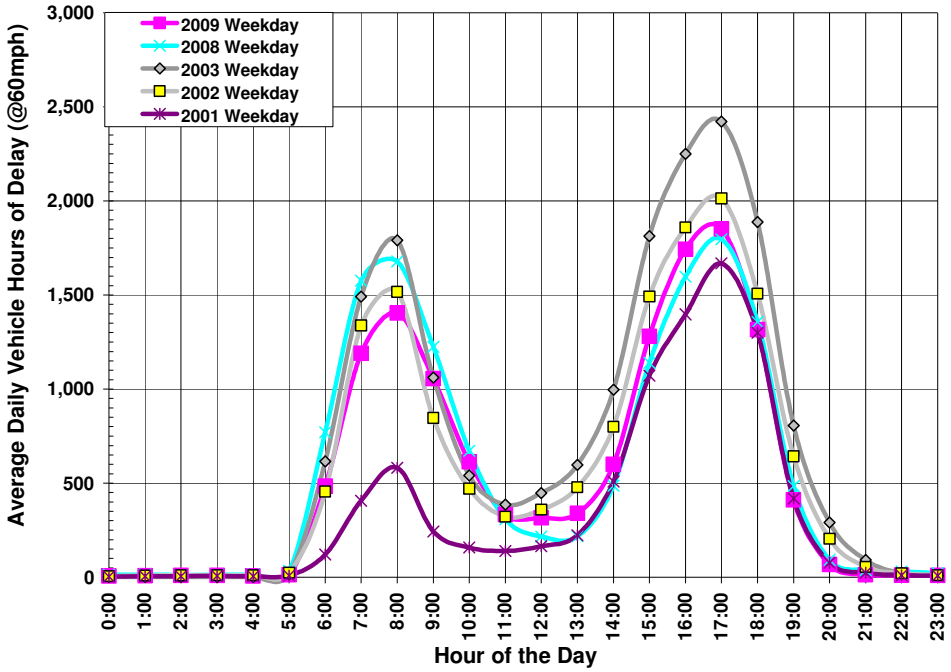


Exhibit ES-9: Northbound I-405 HOV Lane Hourly Delay (2001-2003, & 2008-2009)

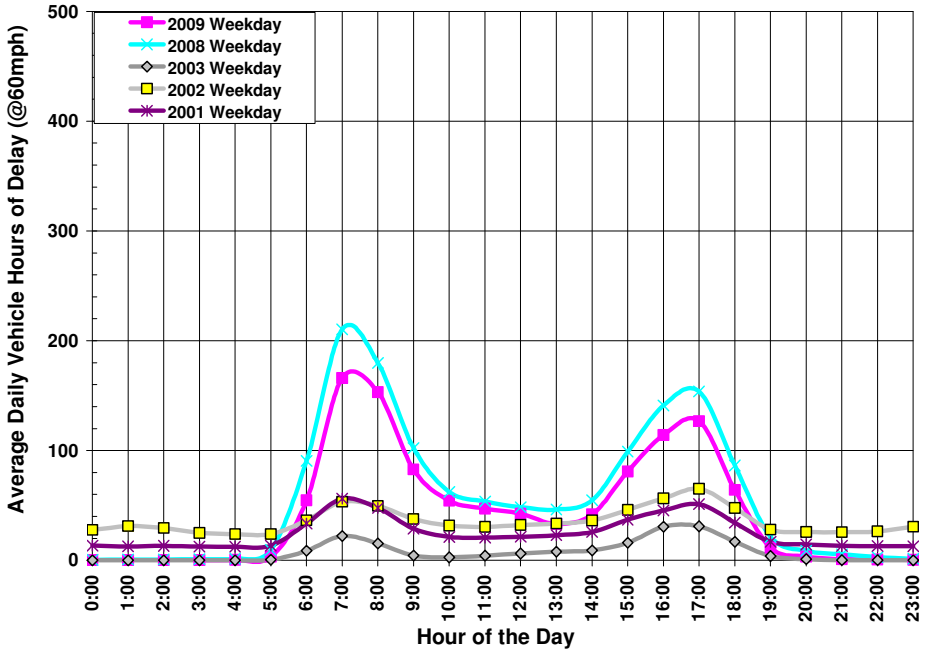
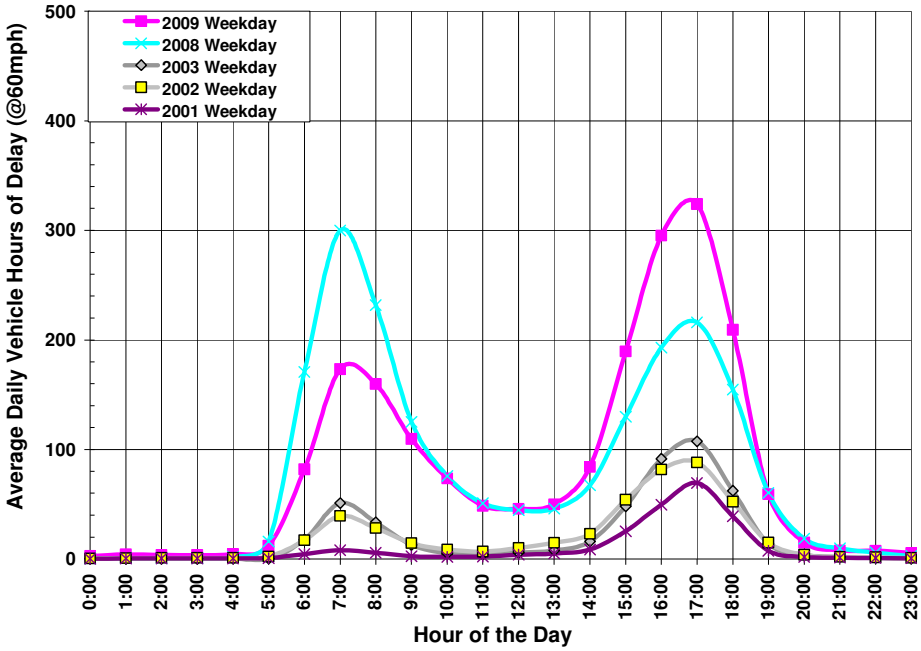


Exhibit ES-10: Southbound I-405 HOV Lane Hourly Delay (2001-2003, & 2008-2009)



Travel Time

The travel time performance measure represents the average time it takes for a vehicle to travel between the I-110 Interchange and the I-5 Interchange and vice versa (approximately 36 miles).

Exhibits ES-11 and ES-12 summarize average annual travel times estimated for the corridor by hour of day for the 2001-2003 (pre-construction) and 2008-2009 (present conditions) time periods. Unlike most other corridors that experience a directional pattern of congestion, the I-405 has the same pattern of congestion irrespective of direction with the highest travel time occurring in the PM peak. Similar to delay, travel times diminished in 2008 and 2009 compared to prior years. In the northbound direction of the mainline facility, PM peak period travel time decreased to 56 minutes in 2009 from 64 and 61 minutes in 2002 and 2003.

Since the HOV lane does not currently extend throughout the entire study corridor, it is inappropriate to compare travel times between the mainline and HOV facilities. In the northbound direction of the HOV facility, travel times were highest in 2008 when it reached 48 minutes at the 7:00 AM peak hour and 47 minutes at the 5:00 PM peak hour. Similarly, in the southbound direction, travel times were greater in 2008 than in prior years. This is primarily attributed to the extension of the HOV-lane since 2003.

Exhibit ES-11: Northbound I-405 Mainline Travel Time by Hour (2001-2003 & 2008-2009)

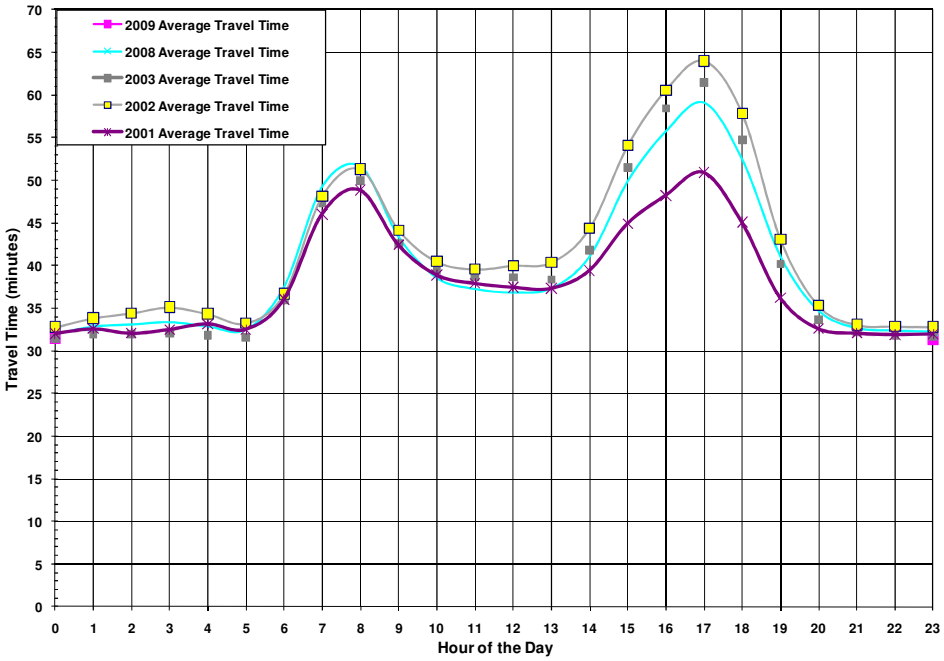


Exhibit ES-12: Southbound I-405 Mainline Travel Time by Hour (2001-2003 & 2008-2009)

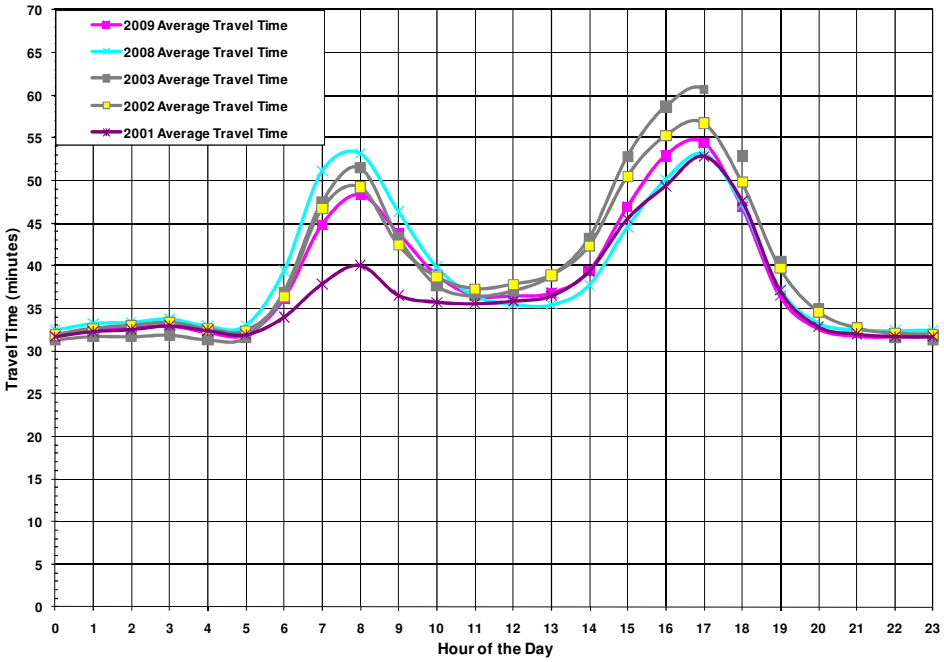


Exhibit ES-13: Northbound I-405 HOV Lane Travel Time by Hour (2001-2003 & 2008-2009)

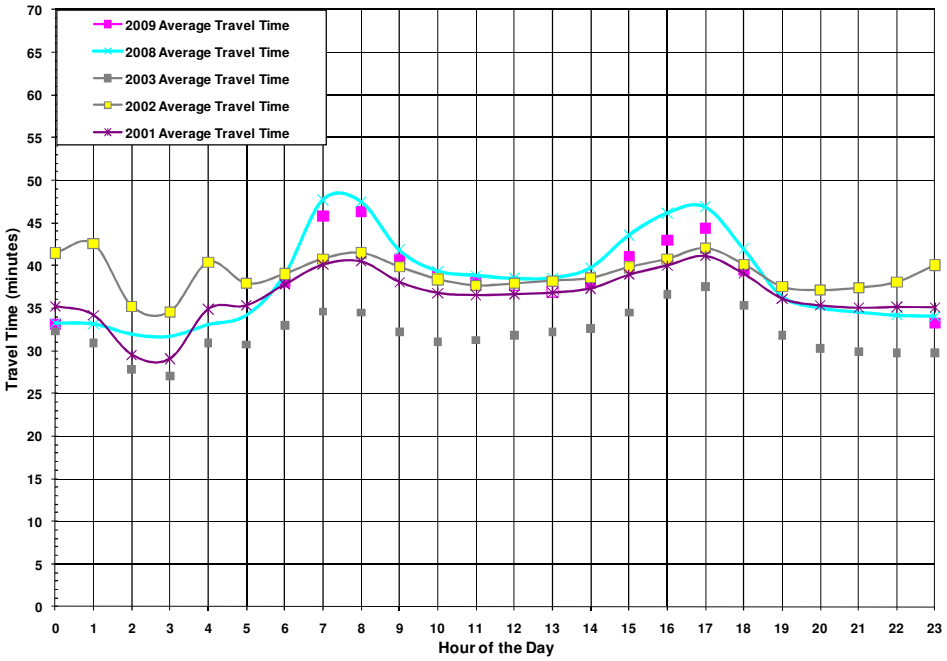
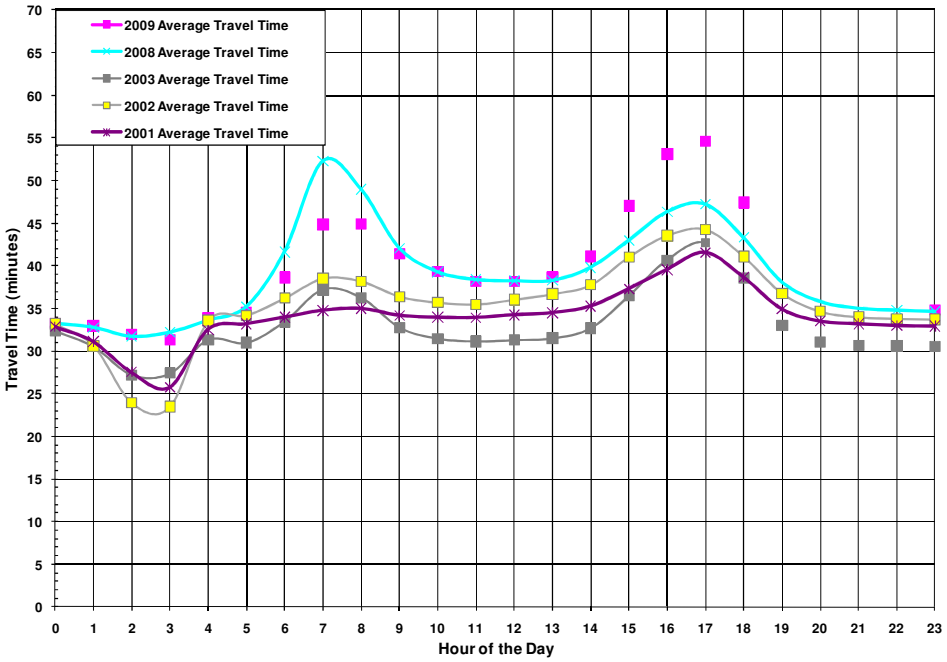


Exhibit ES-14: Southbound I-405 HOV Lane Travel Time by Hour (2001-2003 & 2008-2009)



Reliability

Reliability captures the degree of predictability in travel time. Reliability focuses on how travel time varies from day to day and - to an extent - 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 CSMP used the "buffer index", which 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.

The following exhibits illustrate travel time variability along I-405 on non-holiday weekdays for 2003. The main report shows the buffer index for the additional years (2001-2002 & 2008-2009) for the both mainline and HOV facilities, but this Executive Summary reports only the data for the 2003 mainline since that year was used as the base year for modeling.

The following observations on the reliability results are worth noting in respect to the mainline facility:

- In 2003 in the northbound direction of the mainline facility, 5:00 PM had the highest estimated average travel time at approximately 62 minutes and the highest estimated buffer index time of 19 minutes for a buffer index of 30 percent. In other words, to arrive on time 95 percent of the time, a commuter would need to leave for work 81 minutes before the start time to travel the entire length of the I-405 study corridor.
- In the southbound direction of the mainline facility, the 5:00 PM hour had the estimated average travel time of 62 minutes in 2003 with a buffer time of 32 minutes for a buffer index of 52 percent.

It is important to keep track of the reliability statistic, in part to evaluate incident management improvement strategies, and in part to gauge the effectiveness of safety projects delivered.

Exhibit ES-15: Northbound I-405 Mainline Travel Time Variability (2003)

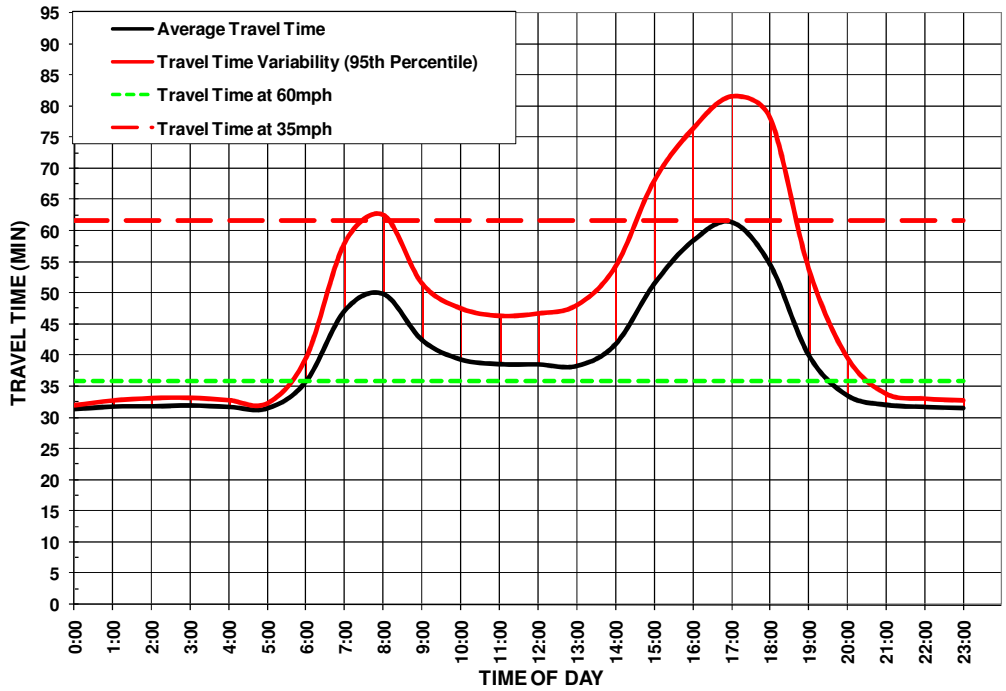
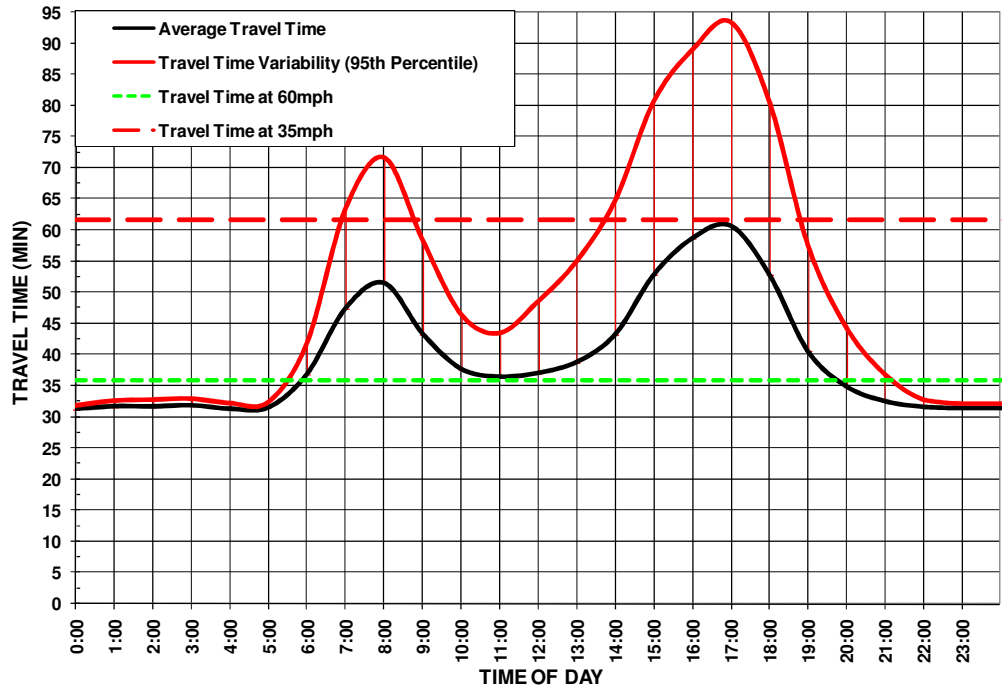


Exhibit ES-16: Southbound I-405 Mainline Travel Time Variability (2003)



Safety

The adopted performance measures to assess safety involve the number of accidents and the accident rates computed from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). TASAS is a traffic records system containing an accident database linked to a highway database. The highway database contains descriptive 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 intends 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 does not intend to supplant more detailed safety investigations routinely performed by Caltrans staff.

Exhibits ES-17 and ES-18 show the I-405 total number of northbound and southbound accidents by month, respectively. Accidents are reported for the study corridor and not separated by mainline and HOV facility. The exhibits summarize the latest available three-year data from January 1, 2006 through December 31, 2008.

From 2006 to 2008, northbound I-405 experienced up to 200 collisions per month, while the southbound direction had up to 210 monthly collisions. The total number of accidents for both the northbound and southbound directions decreased slightly in 2008. Many of the collisions were rear-end collisions, which can be indicative of congestion-related incidents.

Exhibit ES-17: Northbound I-405 Monthly Collisions (2006-2008)

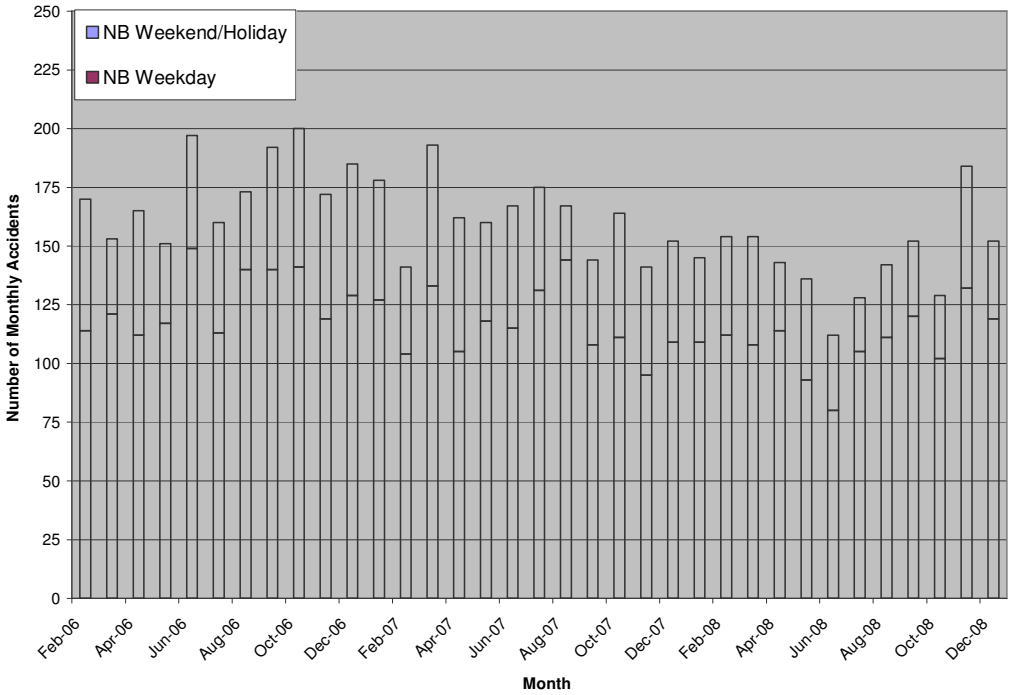
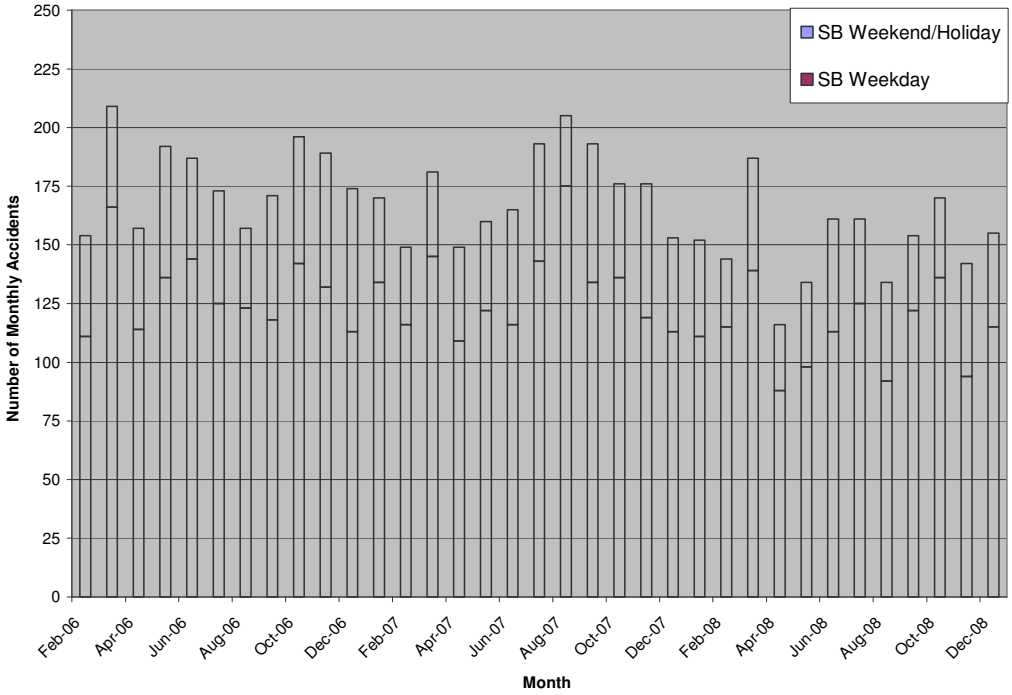


Exhibit ES-18: Southbound I-405 Monthly Collisions (2006-2008)



Productivity

Productivity is a system efficiency measure used to analyze the throughput of the corridor during congested conditions. Restoring lost productivity is one focus area of CSMPs.

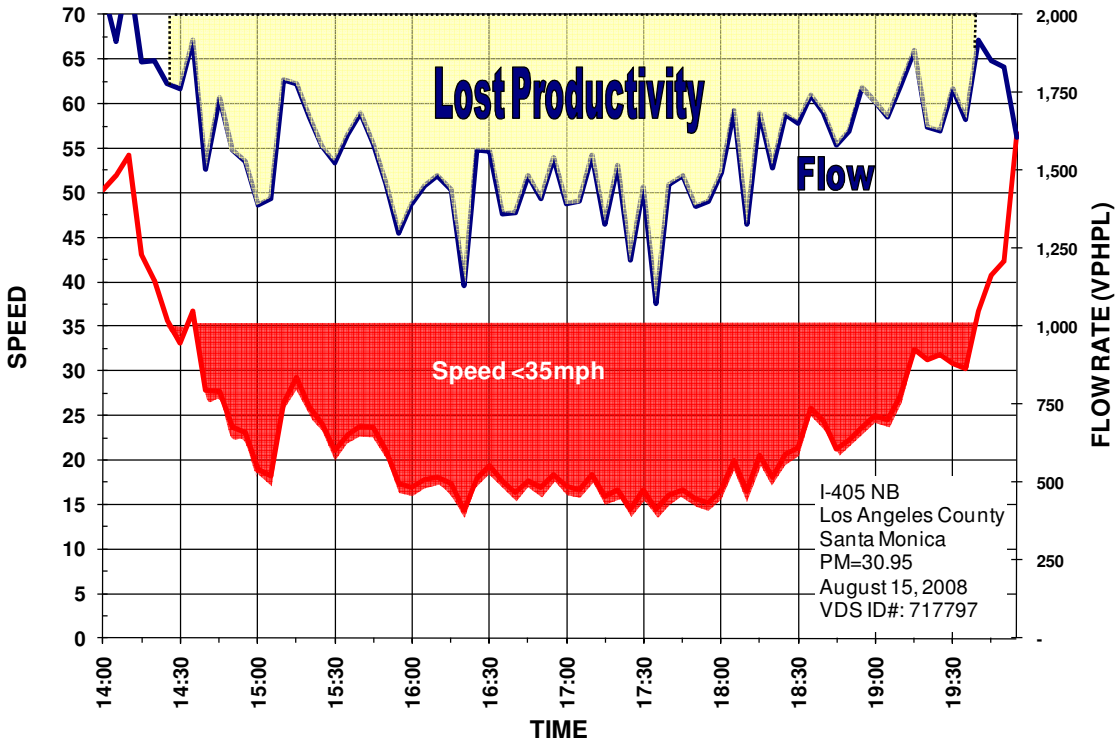
Exhibit ES-19 illustrates how congestion leads to lost productivity. The exhibit was created using observed I-405 data from a non-holiday weekday in August 2008 from the detection data in PeMS. It shows speeds (red line) and flow rates (blue line) on northbound I-405 at Santa Monica Boulevard, a highly congested location on the corridor.

Flow rates (measured as vehicle-per-hour-per-lane or vphpl) at Santa Monica Boulevard average around 1,800 vphpl between 2:00 PM and 3:00 PM, which is slightly less than a typical peak period maximum flow rate. However, flow rates higher than this effective maximum flow cannot be sustained for a significant time.

Once volumes approach this maximum rate, traffic becomes unstable. 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 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 ES-19, throughput drops by nearly 30 percent during the peak period (from over 1,800 to around 1,200 vphpl). This five-lane road therefore operates as if it were a three-and-a-half lane road just when demand is at its highest. Stated differently, 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”.

Exhibit ES-19: Productivity Loss During Severe Congestion



The estimated average non-holiday, weekday lost lane-miles by period and year on I-405 are shown Exhibits ES-20 (mainline) and ES-21 (HOV). A few notes on these two exhibits:

- On the mainline facility, the largest productivity losses occurred in the PM peak hours in both directions. From 2008-2009 an increase in productivity in the AM and PM peak was reported. The southbound direction of the mainline experienced an improvement in productivity from 2003 to 2008 in the PM peak period when lost-lane miles decreased from 12.5 to 10.8.
- The southbound HOV facility experienced the greatest losses in productivity during the PM peak. From 2003 to 2008, productivity on both directions of the HOV-lane declined as lost-lane miles significantly increased. From 2008 to 2009, productivity increased in northbound AM and PM peak periods.

Operational strategies are critical to recovering such productivity losses. These strategies include building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improving incident management.

Exhibit ES-20: I-405 Mainline Equivalent Lost Lane-Miles by Direction, Time Period, and Year

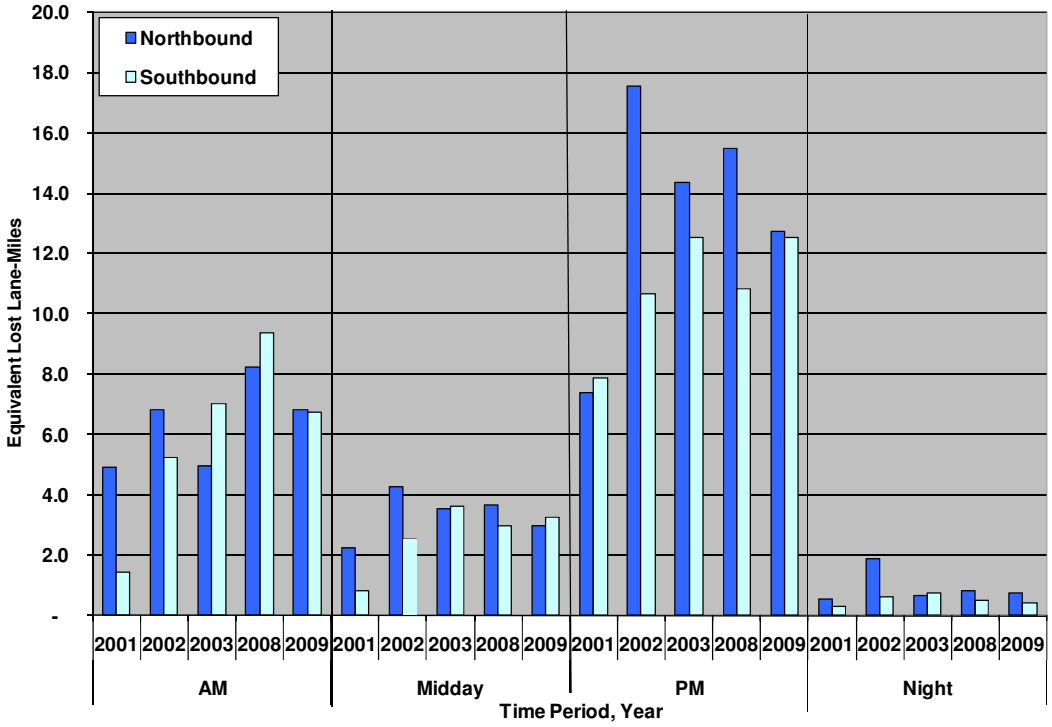
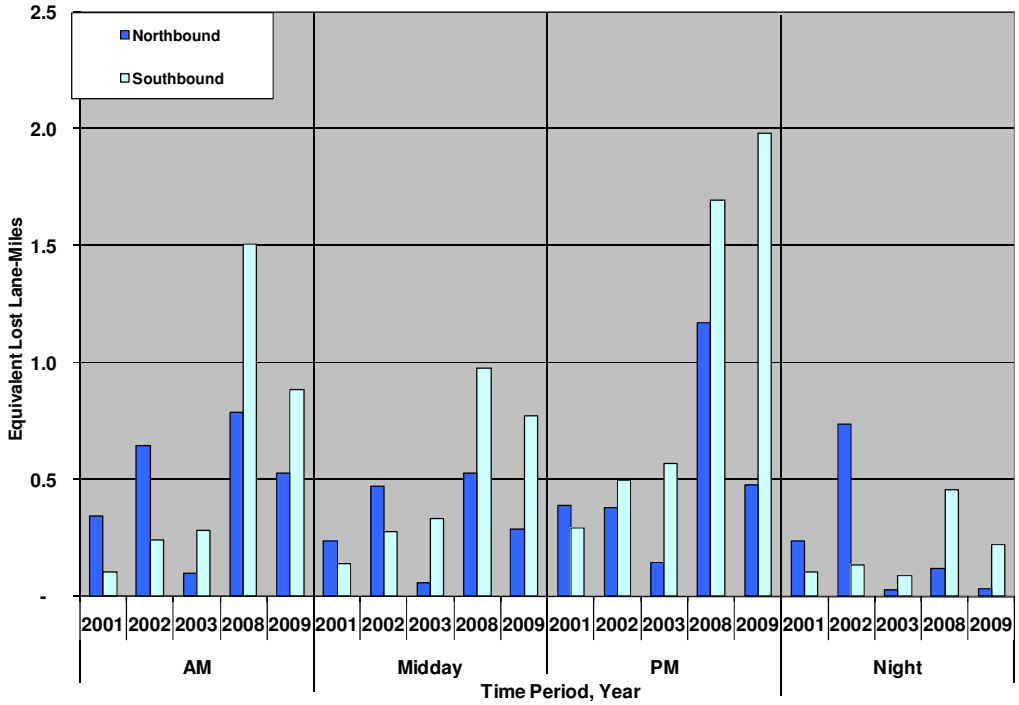


Exhibit ES-21: I-405 HOV Equivalent Lost Lane-Miles by Direction, Time Period, and Year



BOTTLENECK IDENTIFICATION AND CAUSALITY ANALYSIS

Exhibits ES-22 and ES-23 summarize the northbound and southbound bottleneck locations, the time period that it is active, and the causes of the bottlenecks. Exhibits ES-24 and ES-25 are maps of the corridor showing these bottleneck locations for the AM and PM peak periods, respectively.

Major bottlenecks are the primary cause of congestion and lost productivity. By definition, a bottleneck is a condition where traffic demand exceeds the effective carrying capacity of the roadway. In most cases, the cause of a bottleneck is related to a sudden reduction in capacity, such as a lane drop, heavy merging and weaving, driver distractions, or a surge in demand that the road cannot accommodate. In many cases, bottlenecks are caused by a combination of factors.

The specific location and causality of each major I-405 bottleneck was verified by multiple field observations on separate weekdays throughout 2007 and the beginning of 2008. Several bottleneck locations were videotaped to assist in micro-simulation model calibration. Furthermore, they were verified with local stakeholders, Caltrans, and SCAG.

The detailed final report explains in detail the process and results of the bottleneck identification and causality analysis.

Exhibit ES-22: Northbound I-405 Bottleneck Locations

Abs	CA	Bottleneck Location	Active Period		Causality Summary
			AM	PM	
37.4	13.7	Normandie Off	✓	✓	Heavy demand from I-110 & Vermont; lane drop
39.1	15.3	Crenshaw Off	✓	✓	Excessive queuing at NB off-ramp
41.2	17.5	Hawthorne On	✓		Platoon on-ramp traffic merging
42.2	18.4	Inglewood On	✓	✓	Roadway geometrics
49.2	25.4	Sepulveda Off	✓	✓	La Tijera on-ramp merging; roadway geometrics
51.2	27.4	Culver On	✓	✓	Heavy demand from SR-90; on-ramp merging
52.6	28.9	National Off	✓	✓	Weaving; lane drop
53.7	29.9	I-10 On	✓	✓	Heavy demand from I-10 and merging
55.4	31.6	Wilshire On		✓	Platoon merging from C/D on-ramp
58.5	34.7	Getty On		✓	Merging from Sunset/Sepulveda on-ramps; grade
60.4	36.7	Mulholland Drive		✓	Long steep uphill grade
62.7	38.9	US-101 Off		✓	Weaving and queuing from the connector off
65.2	41.5	Victory On		✓	Platoon merging from on-ramp traffic

Exhibit ES-23: Southbound I-405 Bottleneck Locations

Abs	CA	Bottleneck Location	Active Period		Causality Summary
			AM	PM	
70.1	46.2	Devonshire On	✓		Heavy demand from SR-118; merging from consecutive ramps
68.7	44.9	Nordhoff Street Off	✓		Lane drop at Nordhoff
65.1	41.3	Victory On	✓		Platoon merging
62.9	39.2	US-101 Off	✓		Heavy volumes; lane drop; merging
60.3	36.5	Mulholland	✓		Long steep uphill grade
56.7	32.9	Sunset	✓		On-ramp traffic merging
55.2	31.5	Wilshire	✓		Off-ramp traffic queues to mainline
52.9	29.1	I-10 On		✓	Heavy demand from I-10 On and merging
51.1	27.4	Culver On	✓	✓	On-ramp traffic merging
48.9	25.1	Howard Hughes Off	✓	✓	Heavy demand from SR-90; roadway geometry
44.1	20.3	El Segundo On	✓	✓	Demand from I-105 and El Segundo; lane drops
41.9	18.1	Inglewood	✓	✓	Roadway geometrics
36.0	12.5	I-110 Fwy	✓	✓	Heavy demand from I-110; weaving/merging; lane drop

Exhibit ES-24: I-405 AM Bottleneck Locations

Exhibit ES-25: I-405 PM Bottleneck Locations

SCENARIO DEVELOPMENT AND ANALYSIS

Fully understanding how a corridor performs and why it performs the way it does sets the foundation for evaluating potential solutions. Several steps were required to develop evaluate improvements, including:

- Developing traffic models for 2003 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

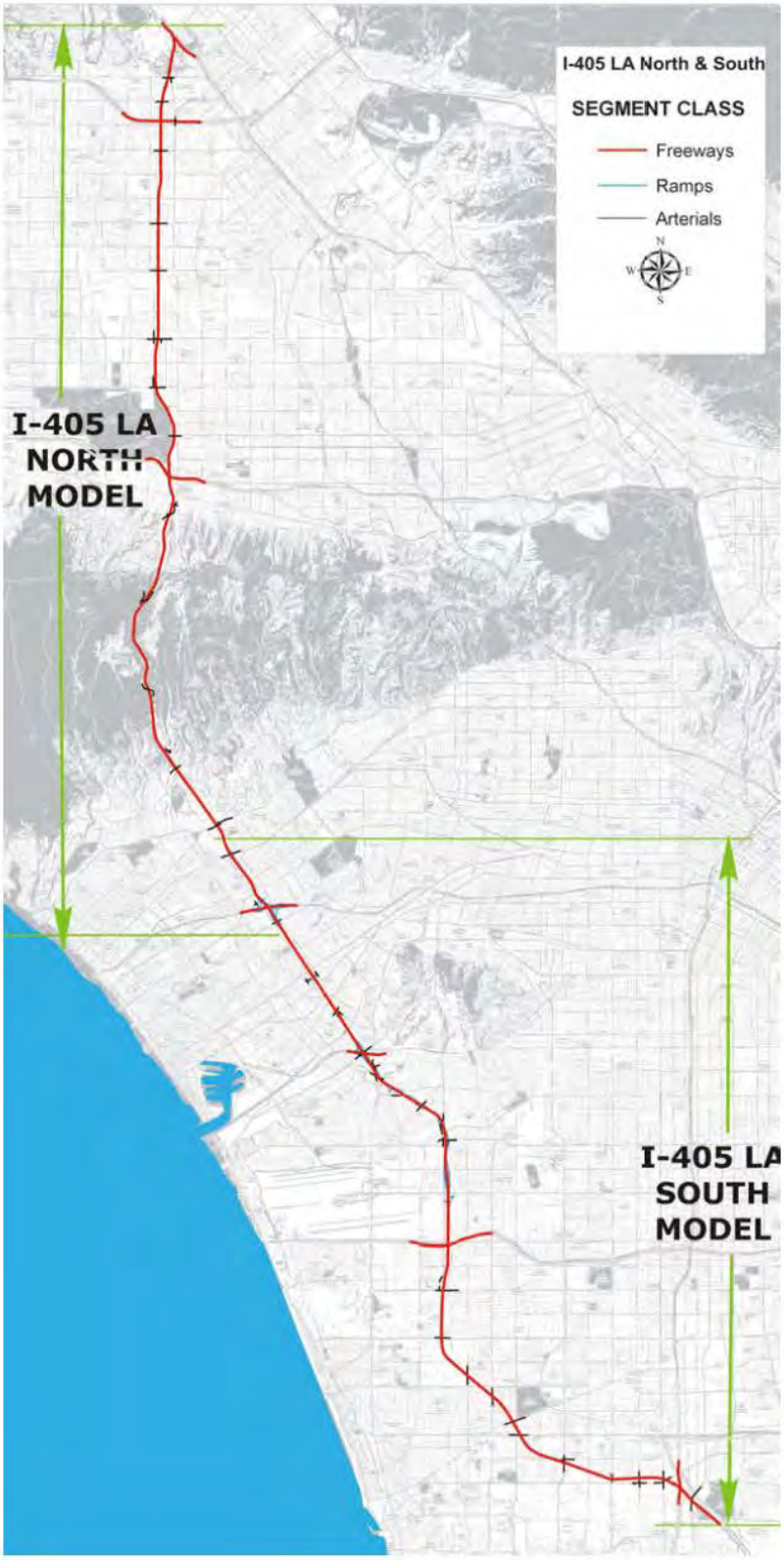
The study team developed a traffic model using the Paramics micro-simulation software. It is important to note that micro-simulation models are complex to develop and calibrate for a large urban corridor. However, it is one of the only tools capable of providing a reasonable approximation of bottleneck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

Due to the long length of the study corridor, the corridor was divided into two separate models. The North Corridor Model extends from I-10 to I-5 and the South Corridor Model extends from I-110 to I-10, with a short overlap section at the I-10 junction capture the congestion at this interchange. ES-26 shows the roadway network included in both models. All freeway interchanges, as well as on and off-ramps, with limited arterials were included. Adding more arterials would have challenged the calibration process and the overall project schedule.

The model was calibrated against 2003 conditions. As previously mentioned in the report, the base year was chosen due to the construction activities from 2003 to 2009 and the availability of detector data in 2003. Following 2003, the construction activities associated with the addition of the HOV lane prevented a large number of detectors from reporting data. Calibrating against 2003 conditions was a resource intensive effort, requiring multiple iterations until the model reasonably matched bottleneck locations and relative severity. Once the 2003 base year calibration was approved, a future 2020 baseline model was also developed based on SCAG's travel demand model projections.

These two models were then 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 ES-26: 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. However, this would have entailed thousands of model runs. Instead, the team combined projects based on a number of factors, including:

Instead, projects were combined into "scenarios" based on a number of factors, including:

- Projects that were fully constructed and open to traffic from 2003 base year to current year 2010 and tested with both the 2003 and 2020 models
- Projects that were fully programmed and funded were combined separately from projects that were not and tested with both the 2003 and 2020 models
- Short and medium range operational projects were grouped into scenarios and tested with the both the 2003 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 assumes that projects delivered before 2016 could reasonably be evaluated using the 2003 base year model. The 2020 forecast year for the I-405 study 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 Regional Transportation Plan (RTP), it may wish to update the micro-simulation model with revised demand projections.

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

Scenario testing performed for the performed for the I-405 CSMP differed from traditional "alternatives evaluations" done 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, so each alternative is evaluated separately and results among competing alternatives are compared resulting in a locally preferred alternative. In contrast, for the I-405 CSMP, scenarios build on each other in that a scenario contains the projects from the previous scenario plus one or more projects as long as the incremental scenario results showed an acceptable level of performance improvement. This incremental scenario evaluation approach is important since CSMPs are new and are often confused with alternatives studies.

Since I-405 was divided into two separate models, the North Corridor and the South Corridor, separate scenario lists were developed for each corridor. The results of the North Corridor will be presented first followed by the South Corridor.

North Corridor Model Results

The North Corridor Model covers the section of the corridor from I-10 to I-5, which is approximately 20 miles in distance. The travel pattern on this stretch of the corridor is directional with the southbound direction experiencing greater delay in the AM peak and the northbound direction experiencing greater delay in the PM peak.

Exhibit ES-27 summarizes the scenario-testing approach and scenarios tested. It also provides a general description of the projects included in the 2003 and 2020 micro-simulation runs.

Exhibits ES-28 and ES-29 show the delay results for all the 2003 scenarios evaluated for the AM and PM peak periods, respectively. Exhibits ES-30 and ES-31 show the delay results for all the 2020 scenarios evaluated for the AM and PM peak periods, respectively. For each scenario, the modeling team produced results by facility type (i.e., mainline, HOV, Arterials, and ramps) and vehicle type (SOV, HOV, 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.

Exhibit ES-27: Micro-Simulation Modeling Approach for the North Corridor

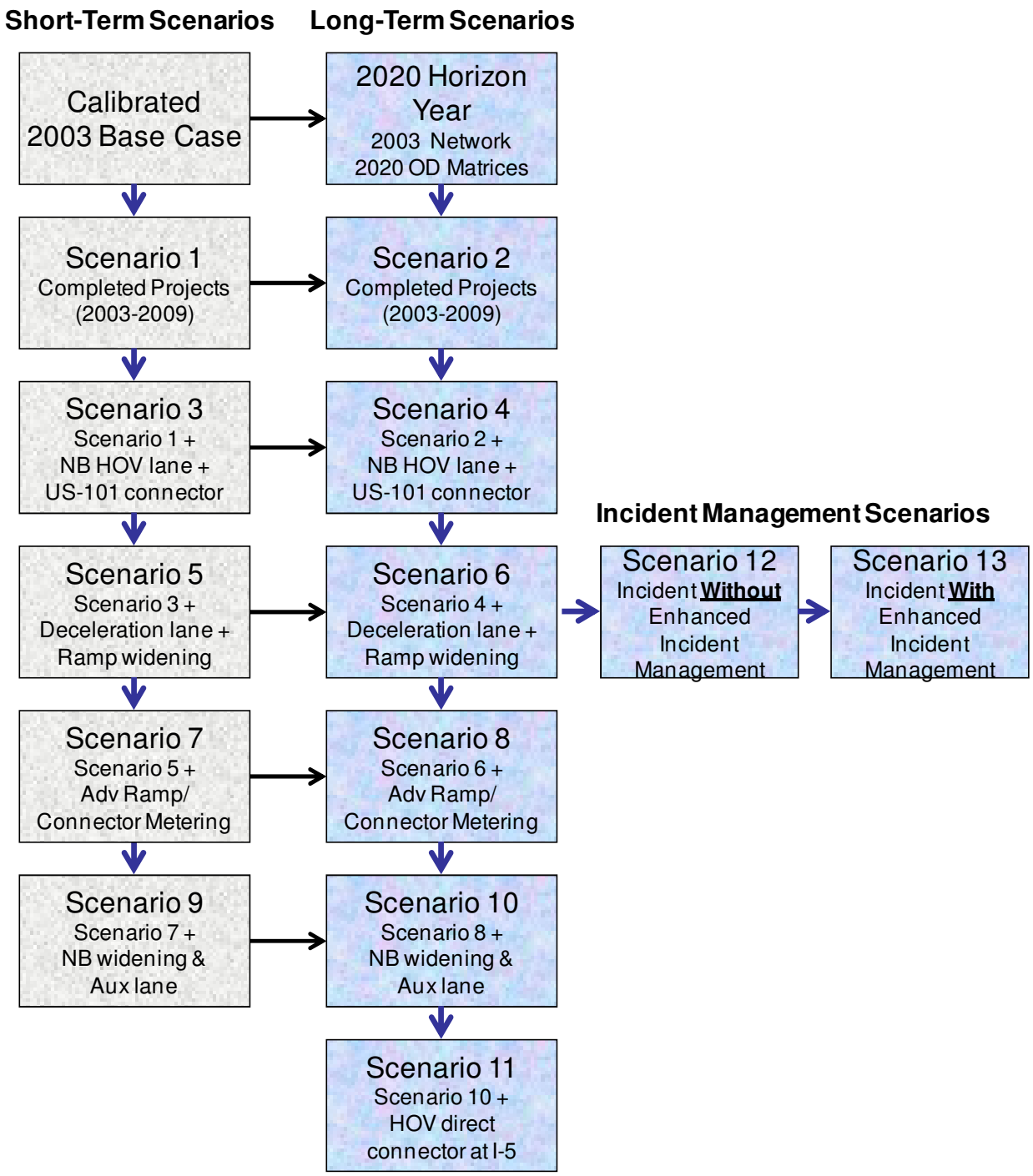


Exhibit ES-28: North Corridor – 2003 AM Peak Micro-Simulation Delay Results

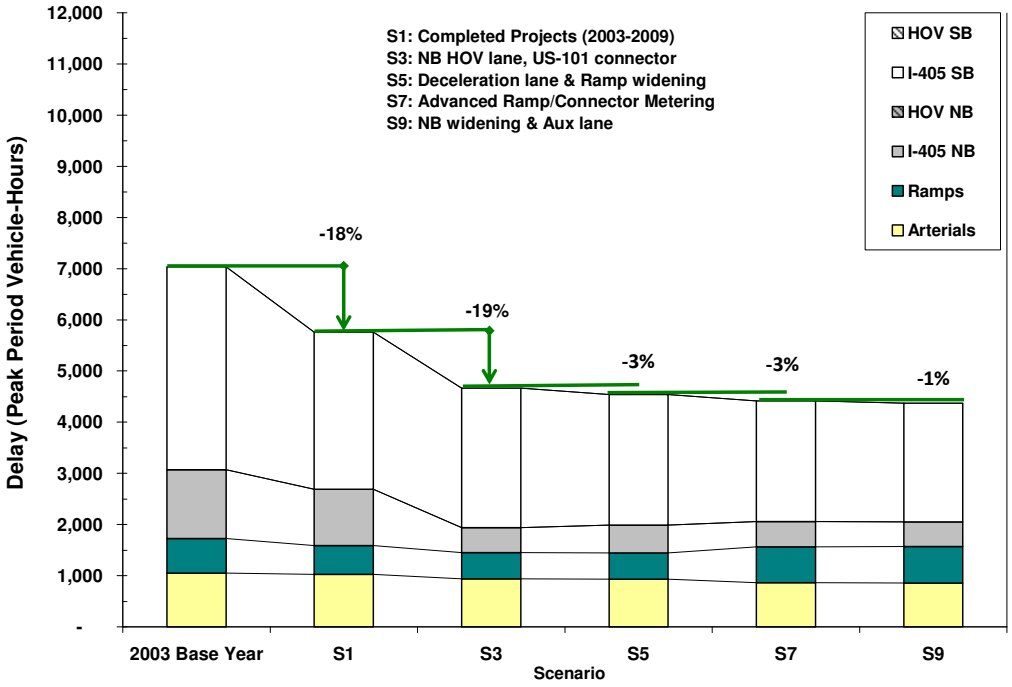


Exhibit ES-29: North Corridor – 2003 PM Peak Micro-Simulation Delay Results

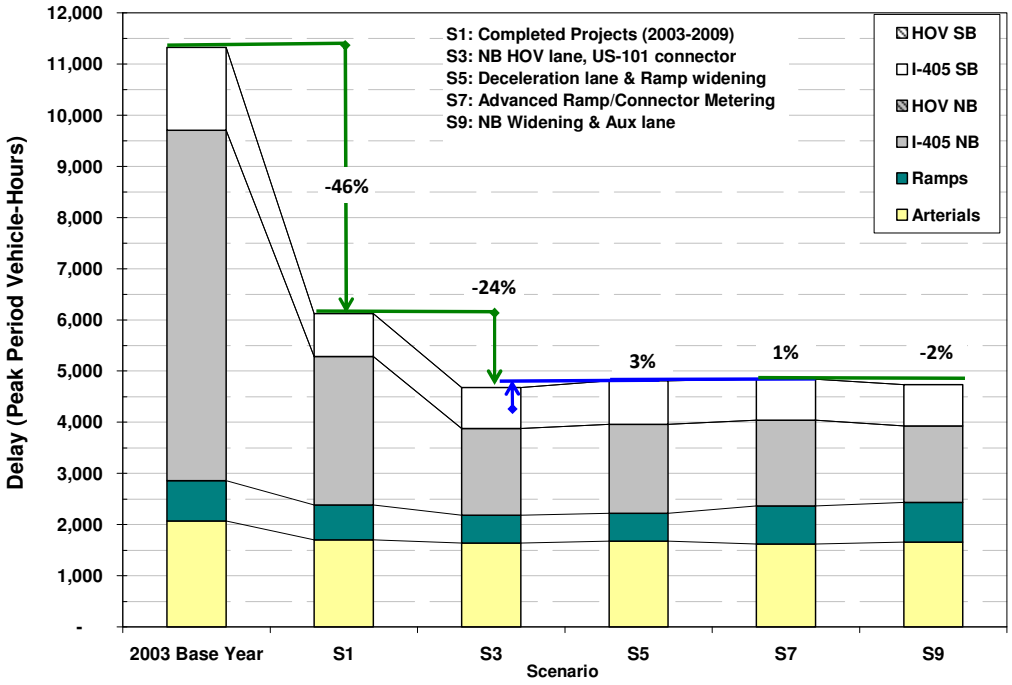


Exhibit ES-30: North Corridor – 2020 AM Peak Micro- Simulation Delay Results

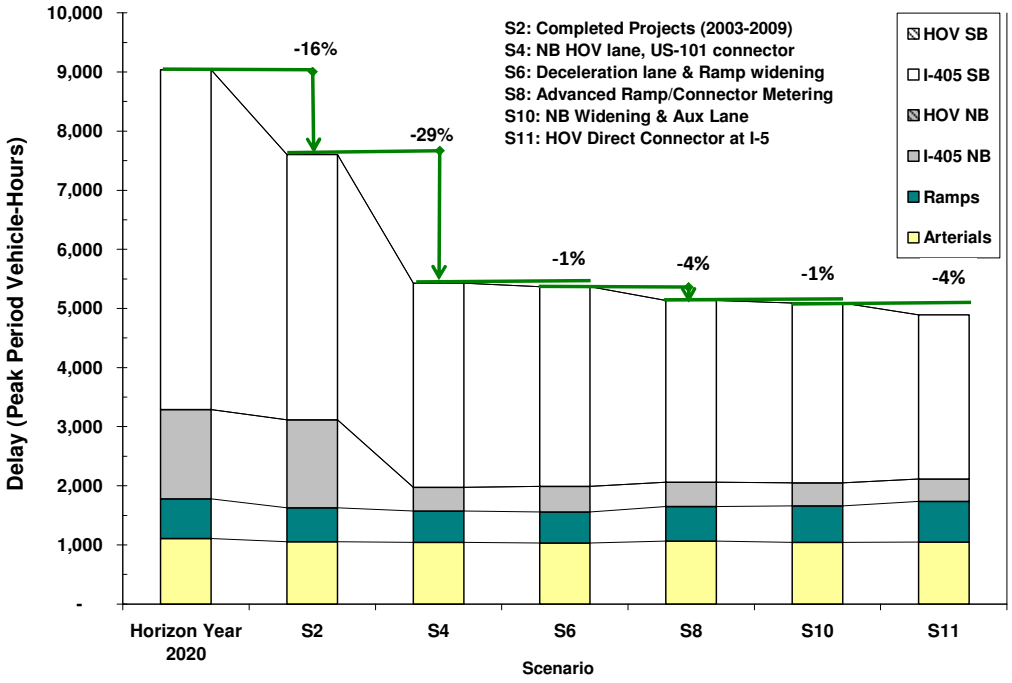
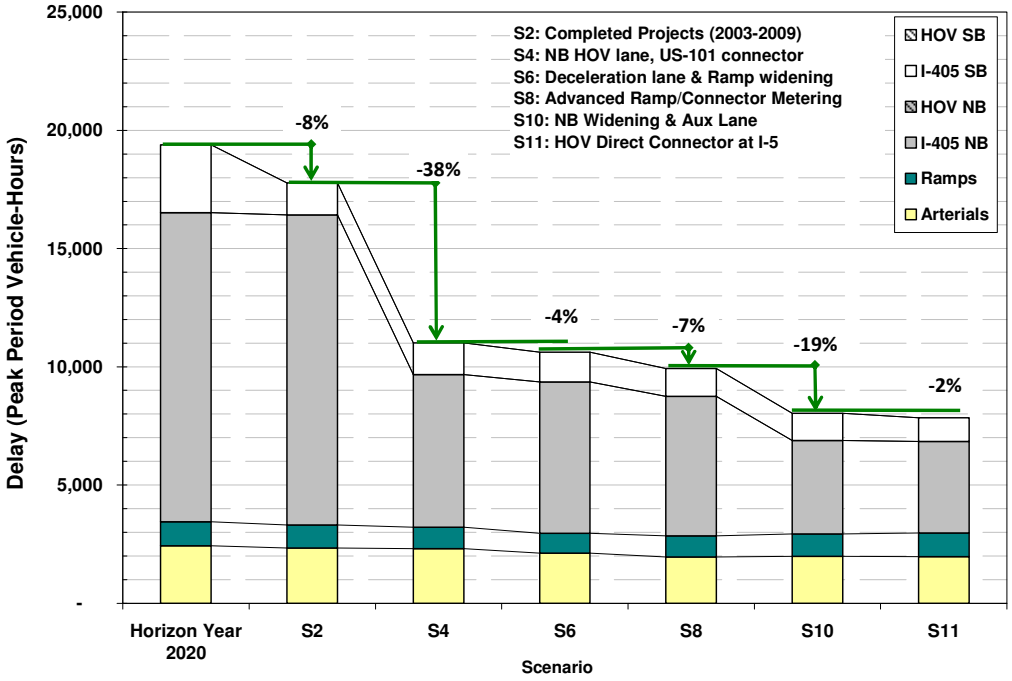


Exhibit ES-31: North Corridor – 2020 PM Peak Micro- Simulation Delay Results



North Corridor Model: 2003 Base Year and 2020 Do Minimum Horizon Year

Absent any physical improvements, the model estimates that total delay on the north corridor (mainline, HOV, ramps, and arterials) increases by over 55 percent by 2020 compared to 2003 (from a total of around 18,000 vehicle-hours to over than 28,000 vehicle-hours) in the AM and PM peak hours combined. As described below, the completed improvements and programmed projects lead to significant decreases and improved mobility on the corridor.

North Corridor Model: Scenarios 1 and 2 (Completed Projects 2003-2009)

Scenarios 1 and 2 include all mobility-related projects that were completed between 2003 and 2009. Results from this scenario were compared to the existing conditions of the corridor in 2009 to determine the reasonableness of the model. Scenario 1 and 2 projects included:

- Adding a northbound auxiliary lane from Mulholland to Ventura Boulevard
- Widening the northbound I-405 connector to southbound US-101 to add a lane
- Extending the northbound I-405 HOV lane from south of Ventura Boulevard to south of Burbank Boulevard where it joins the existing HOV lane
- Closing the gap at the I-405/US-101 connector
- Constructing the southbound auxiliary lane and HOV lane from Waterford Avenue to I-10.

The 2003 model estimates that Scenario 1 would reduce overall delay on the corridor by nearly 35 percent over the base model (from around 18,000 vehicle-hours to 12,000 vehicle-hours), most of which occurs in the PM peak period. The delay reduction in the PM peak (5,000 vehicle-hours) can be largely attributed to the improvements in the northbound direction at the US-101 Interchange, which experienced an 80 percent drop in delay, which is equivalent to a reduction of 2,800 vehicle-hours. At this location, a northbound auxiliary lane was constructed and the US-101 connector was widened and modified. The southbound direction in the PM also experienced a significant delay reduction of over 750 vehicle-hours, largely from the auxiliary lane construction.

The 2020 model estimates that Scenario 2 will reduce corridor delay by 16 percent in the AM and 8 percent in the PM. In total, this scenario will reduce daily delay by more than 3,000 vehicle-hours over the horizon year.

North Corridor Model: Scenarios 3 and 4 (NB HOV Lane, US-101 Connector)

Scenarios 3 and 4 include two fully funded projects that are expected to be delivered in 2016. One is the Sepulveda Pass Widening Project, which will extend the northbound HOV lane from I-10 to US-101 with several interchange modifications. The other is the construction of the freeway connector from southbound I-405 to northbound and southbound US-101.

The 2003 model shows that Scenario 3 will improve overall delay on the corridor by about 19 percent in the AM and 24 percent in the PM, which is equivalent to a total reduction of 2,500 vehicle-hours. In the northbound direction, the addition of the HOV lane resulted in a delay reduction of 600 vehicle-hours (or 55 percent) in the AM peak and 1,200 vehicle-hours (or 40 percent) in the PM peak. The northbound segment from I-10 to Wilshire experienced a notable improvement in delay during both peak periods with a reduction of over 1,000 vehicle-hours. In the southbound direction, the corridor experienced a moderate reduction of over 400 vehicle-hours of delay. However, the southbound segment from Victory to US-101 during the AM experienced a significant delay reduction of over 350 vehicle-hours, which can be attributed to the construction of the US-101 connector.

The 2020 model shows that Scenario 4 will decrease delay by 29 percent in the AM peak and 38 percent in the PM peak or almost 9,000 vehicle-hours of daily delay. The additional capacity from the HOV lane will provide greater delay reductions in 2020.

North Corridor Model: Scenarios 5 and 6 (Deceleration Lane, Ramp Widening)

Scenarios 5 and 6 include two operational projects that have been proposed by Caltrans and can be implemented within a short period of time. Both of these projects affect the southbound direction of the corridor: the construction of a southbound deceleration lane from Mulholland to Sunset, and the widening of the southbound Ventura Boulevard on-ramp.

The 2003 model estimates that Scenario 5 will reduce delay in the AM by three percent (or 130 vehicle-hours) and insignificantly increase delay by three percent in the PM peak. These results are expected since both projects in this scenario are minor operational improvements.

The 2020 model estimates a one percent improvement in delay in the AM peak and a four percent improvement in the PM peak, or a combined total reduction of 450 daily vehicle-hours.

North Corridor Model: Scenarios 7 and 8 (Advanced Ramp/Connector Metering)

Scenarios 7 and 8 build on Scenarios 5 and 6 by adding advanced ramp metering system such as dynamic or adaptive ramp metering system with connector metering

with queue control (to ensure that queuing does not exceed the capacity of the connector) at the following locations:

- Eastbound and westbound I-10 connectors to I-405
- Eastbound and westbound SR-118 connectors to I-405.

The 2003 model estimates that advanced ramp metering will improve delay slightly by three percent in the AM peak, or 120 vehicle-hours, and increase delay insignificantly in the PM peak. The 2020 model estimates greater gains with a four percent delay reduction in the AM and a seven percent delay reduction in the PM peak, or a combined total of 900 daily vehicle-hours. Although the mainline facility experienced an improvement in delay during both the AM and PM peak hours, the ramps experienced an overall delay increase, thereby resulting in only a small improvement for the overall corridor.

Note that there are various types of advanced ramp metering systems deployed around the world, including System-wide Adaptive Ramp Metering System or SWARM tested in Los Angeles I-210 freeway corridor. For the I-405 modeling purposes, the ALINEA system was tested as a proxy for any advanced ramp metering system, as its algorithm for the model was readily available (and SWARM is not). It is, however, not necessarily recommended that ALINEA be deployed but rather some type of advanced ramp metering system that would produce similar, if not better results.

North Corridor Model: Scenarios 9 and 10 (NB Widening and Auxiliary Lane)

Scenarios 9 and 10 build on Scenarios 7 and 8 by including two short range operational improvement projects proposed by the study team. Both of these projects affect the northbound direction of the corridor: the construction of an auxiliary lane from Victory Boulevard to Sherman Way, and widening to add new lane from SR-118 off-ramp to Devonshire on-ramp. Both of these improvements could be implemented within public right-of-way and with roadway modification.

The 2003 model estimates that Scenario 9 will reduce delay in the AM and PM peak period modestly by only one to two percent, or a combined total of around 150 vehicle-hours of delay. The 2020 model estimates a greater reduction in delay by nearly 1,900 vehicle-hours (or 19 percent) in the PM peak. This is expected since most of the congestion is in the northbound direction during the PM peak.

North Corridor Model: Scenario 11 (HOV Direct Connector at I-5)

Scenario 11 (long range planned improvement) is tested with only the 2020 model and builds on Scenarios 10 by adding the HOV direct connectors at the I-5 interchange. The estimated completion date for this project is 2029.

The 2020 model estimates that Scenario 11 will reduce delay by 200 vehicle-hours in both peak periods, for a combined total of 400 vehicle-hours on the corridor (4 percent reduction in the AM and 2 percent reduction in the PM). This improvement did not show a significant delay reduction, which is likely due to the congested conditions along the I-5 mainline corridor. Should the I-5 corridor from the I-405 to SR-14 be improved, this project could yield significantly better results.

North Corridor Model: Scenarios 12 and 13 (Enhanced Incident Management)

Two incident scenarios were tested on top of Scenario 6 to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. In the first scenario, Scenario 12, one collision incident with one outside lane closure was simulated in the southbound direction in the AM peak period model and in the northbound direction in the PM peak period model. The incident simulation location and duration was selected based on review of the 2010 actual incident data, at one of the high incident frequency locations. The following are the Scenario details:

- Southbound AM peak period starting at 7:00 AM, close outermost mainline lane for 35 minutes at absolute post mile 54.1 (at Olympic)
- Northbound PM peak period starting at 3:00 PM, close outermost mainline lane for 35 minutes at absolute post mile 69.7 (at Devonshire)

In the second scenario, Scenario 13, the same collision incident was simulated with a reduction in duration by 10 minutes in both the southbound and the northbound direction. It is estimated, based on recent actual incident management data analysis results provided by Caltrans, that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes. This scenario represents a typical moderate level incident at one location during the peak period direction.

An enhanced incident management system 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. 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 hours.

Without enhanced incident management, the first scenario produced a six percent increase in congestion in the AM and a 43 percent increase in the PM over Scenario 6 -

an increase of about 5,000 vehicle-hours delay. With enhanced incident management, the model results indicated a two percent reduction in delay in the AM and eight percent in the PM peak periods, which is a decrease in delay of over 1,200 vehicle-hours for both incidents.

South Corridor Model Results

The South Model covers the section of the corridor from I-110 to I-10, which is approximately 18 miles in distance. There is no clear directional pattern of travel on this section of the corridor.

Exhibit ES-32 summarizes the approach for scenario testing. It also provides a general description of the projects included in the 2003 and 2020 micro-simulation runs.

Exhibits ES-33 and ES-34 show the delay results by facility type and peak period for all the scenarios that were evaluated using the 2003 base year model. Exhibits ES-35 and ES-36 show the same results, but for the scenarios that were evaluated using the 2020 horizon year model.

Exhibit ES-32: I-405 Micro-Simulation Modeling Approach for the South Corridor

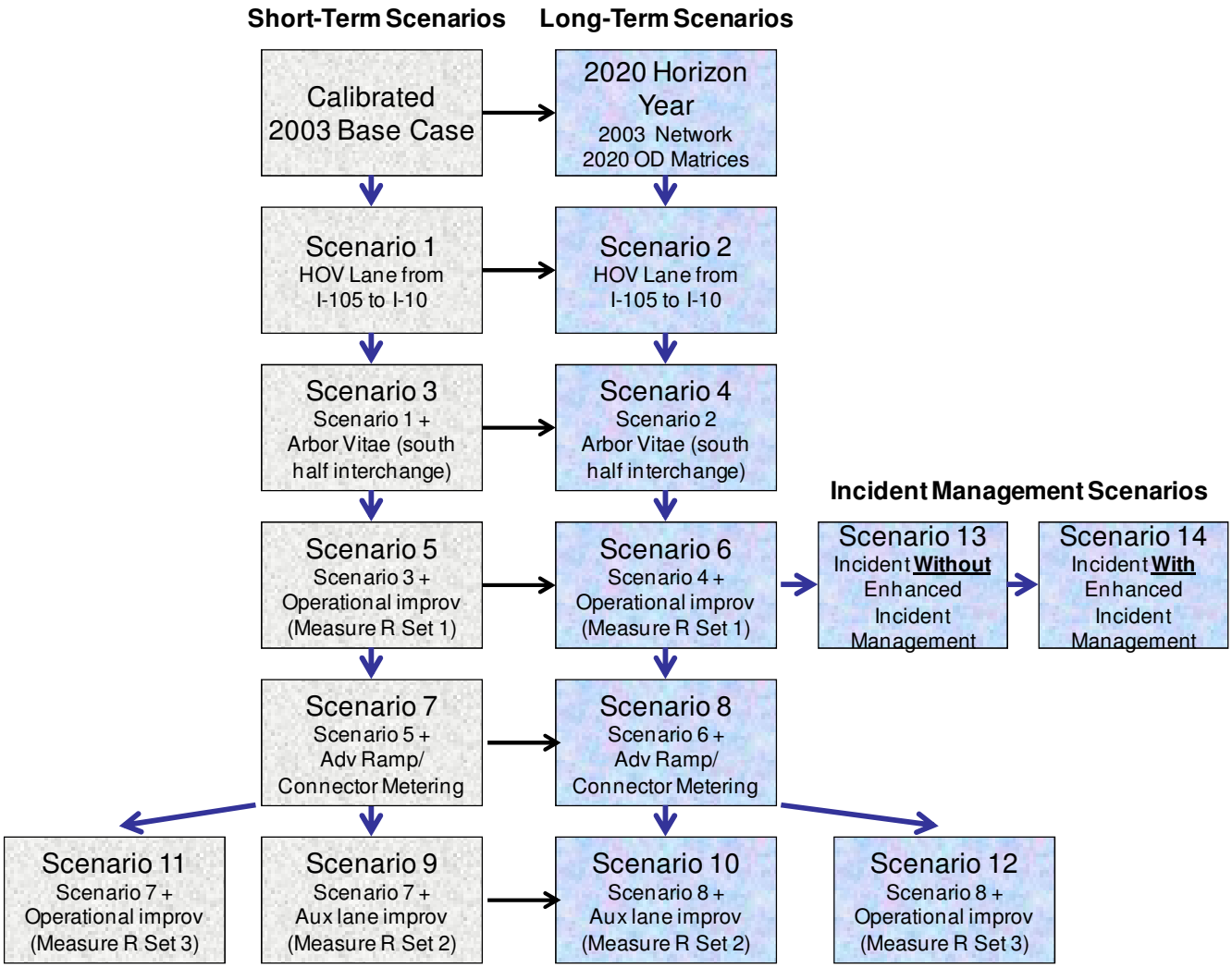


Exhibit ES-33: South Corridor – 2003 AM Peak Micro- Simulation Delay Results by Scenario

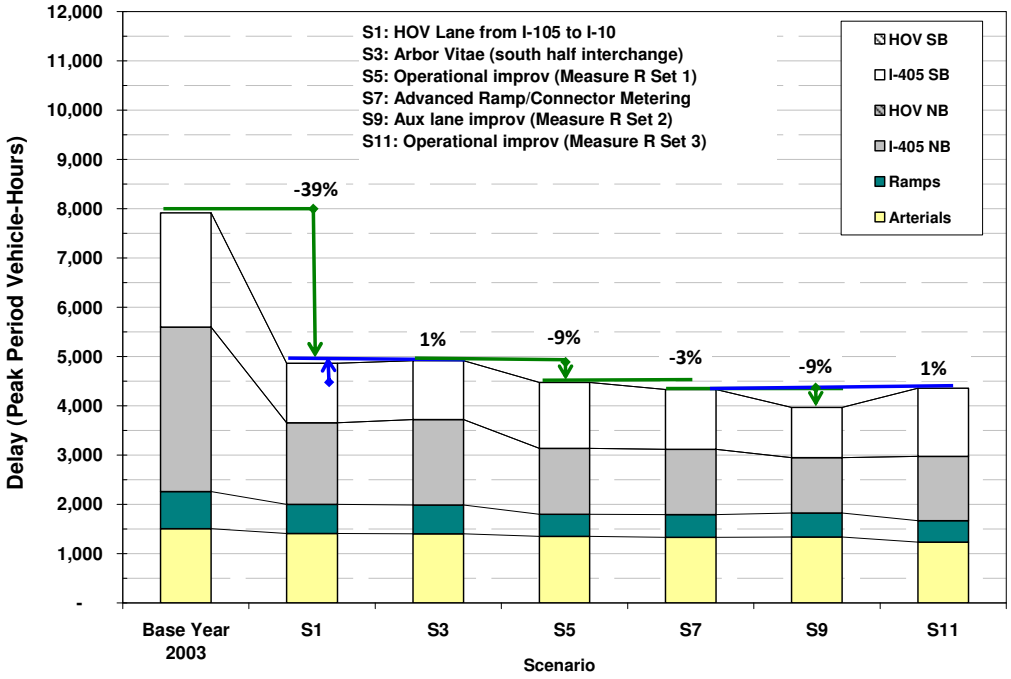


Exhibit ES-34: South Corridor – 2003 PM Peak Micro-Simulation Delay Results by Scenario

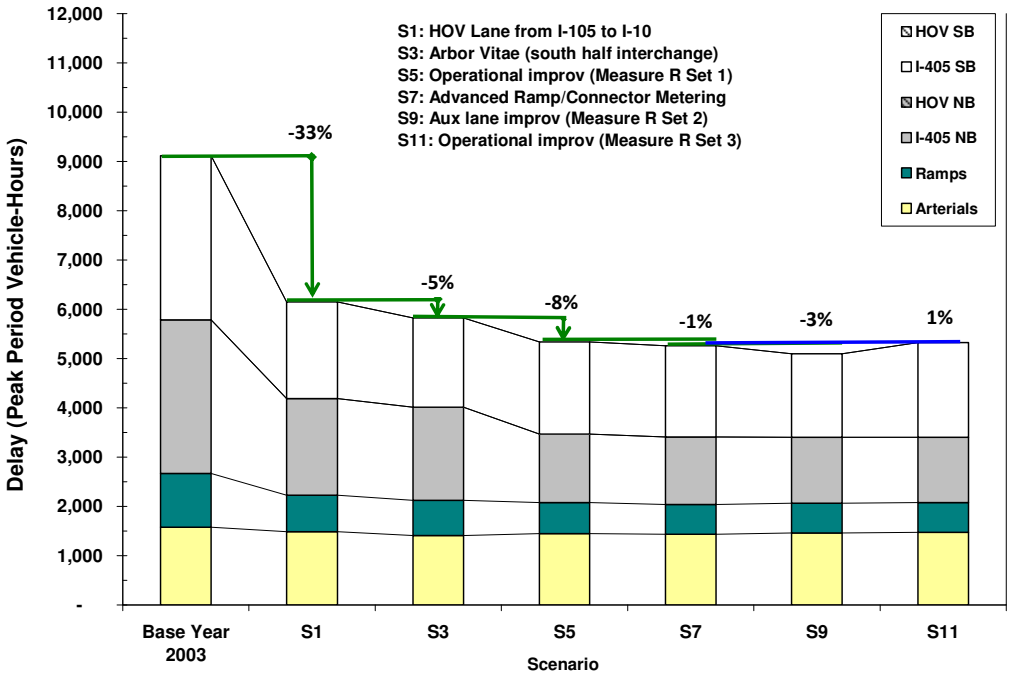


Exhibit ES-35: South Corridor – 2020 AM Peak Micro-Simulation Delay Results by Scenario

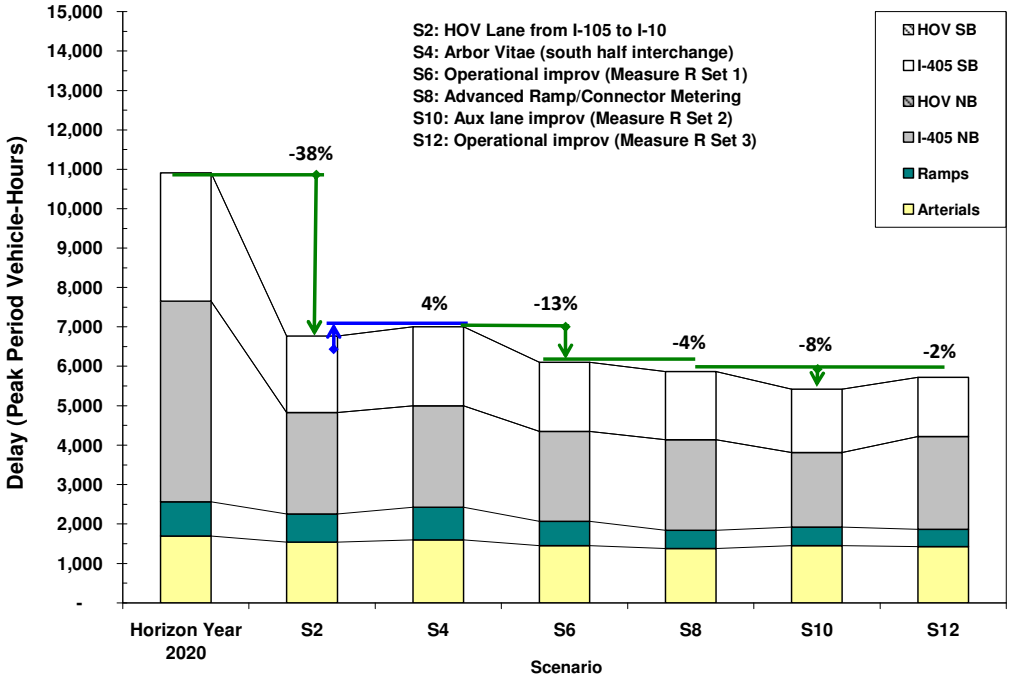
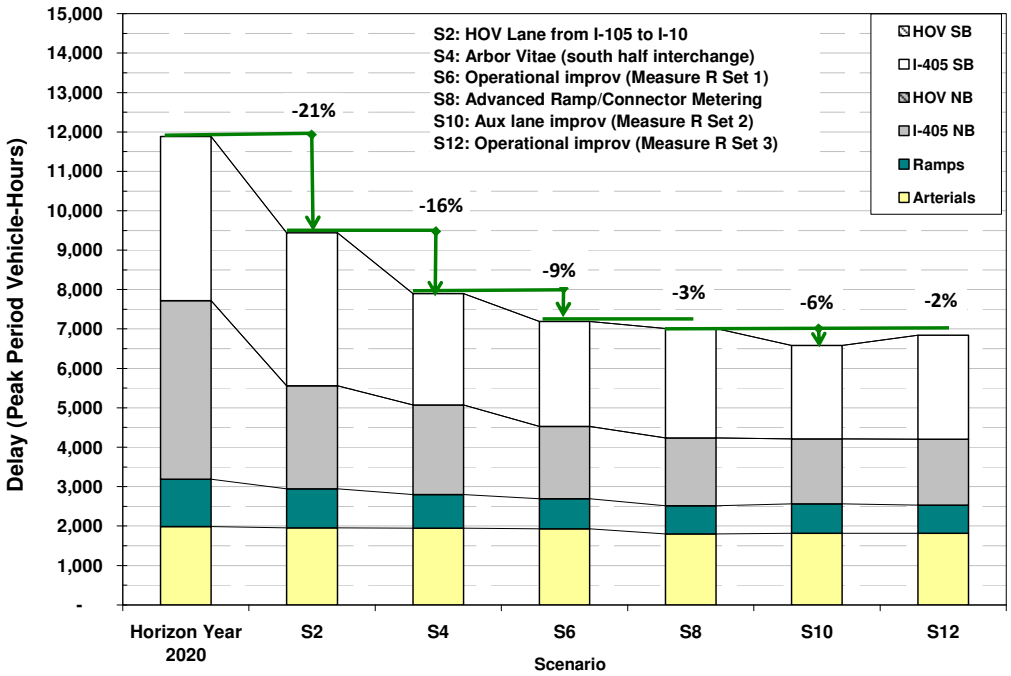


Exhibit ES-36: South Corridor – 2020 PM Peak Micro-Simulation Delay Results by Scenario



South Corridor Model: Base Year and Do Minimum Horizon Year

Absent any physical improvements, the model estimates that total delay on the south corridor (mainline, HOV, ramps, and arterials) increases about 35 percent from around 17,000 vehicle-hours in 2003 to nearly 23,000 by 2020, in the AM and PM peak hours combined. As described below, the completed HOV lanes and programmed projects lead to significant decreases and improved mobility on the corridor.

South Corridor Model: Scenarios 1 and 2 (HOV Lane from I-105 to I-10)

Scenarios 1 and 2 include all mobility-related, projects that were completed between 2003 and 2010. Results from this scenario were compared to the existing conditions of the corridor in 2010 to determine the reasonableness of the model. The project that was included in Scenarios 1 and 2 is the HOV lane addition in both directions from I-105 to SR-90 and from SR-90 to I-10. This HOV lane from I-105 to SR-90 opened in 2008 while the section from SR-90 to I-10 opened in late 2009.

The 2003 model estimates that Scenario 1 reduces delay on the corridor by about 39 percent in the AM peak and 33 percent in the PM peak, for a combined total reduction of 6,000 daily vehicle-hours of delay. Although the entire corridor experienced a decline in delay due to the HOV widening, one location stood out in particular. The northbound bottleneck at National experienced a 90 percent decrease during the AM peak compared to the base year from around 900 daily vehicle-hours of delay to 85.

The 2020 model estimates that Scenario 2 reduces delay on the corridor by about 4,100 vehicle-hours (38 percent) in the AM peak and 2,500 vehicle-hours (21 percent) in the PM peak. Similar to the 2003 model, the 2020 model shows a significant improvement at the northbound National bottleneck location during the PM peak from 1,375 vehicle-hours of delay to 100 vehicle-hours, an improvement of about 93 percent.

South Corridor Model: Scenarios 3 and 4 (Arbor Vitae – South Half Interchange)

Scenarios 3 and 4 build upon Scenarios 1 and 2 and test one project that is fully funded and is expected to be delivered in 2013. This project constructs the south half of an interchange at Arbor Vitae Avenue in Inglewood. This south half of the interchange comprises a new northbound off-ramp at Arbor Vitae and a southbound Arbor Vitae on-ramp.

The 2003 model shows that Scenario 3 slightly improves delay on the corridor by over 300 vehicle-hours (five percent) in the PM peak with minimal effect on the AM peak.

The 2020 model estimates greater gains with the Arbor Vitae Interchange during the PM peak with a delay reduction of over 1,500 vehicle-hours, or a 16 percent reduction. The

southbound segment from Howard Hughes to El Segundo improved about 25 percent from over 3,000 vehicle-hours of delay in Scenario 2 to 2,230 vehicle-hours in Scenario 4. This indicates that the model assumes distribution of the demand from other nearby interchanges and redirecting them to the new Arbor Vitae interchange.

South Corridor Model: Scenarios 5 and 6 (Operational Improvements – Measure R Set 1)

Scenarios 5 and 6 build upon Scenarios 3 and 4 and include operational projects that are either fully funded or expected to be funded with local funds in the near term. These projects include:

- Adding a northbound auxiliary lane from La Tijera to Jefferson
- At 182nd Street/Crenshaw – widening the northbound off-ramp to 182nd Street and modifying the single at the terminus
- At Hawthorne – constructing a new on-ramp for the southbound Hawthorne Boulevard onto northbound I-405 with upgraded signals at southbound and northbound ramps
- At Rosecrans/Hindry – widening the southbound I-405 off-ramp onto Hindry Avenue and install a signal
- Eliminating the lane drop on northbound I-405 at Normandie by adding an auxiliary lane to the Western Avenue off-ramp

The 2003 model estimates that Scenario 5 reduces overall delay on the corridor by over 400 vehicle-hours (9 percent) in the AM and by almost 500 vehicle-hours (8 percent) in the PM peak. The northbound segment from Normandie to Crenshaw experienced a combined decrease of 600 vehicle-hours of delay during both AM and PM peaks. This improvement can be attributed to the elimination of the lane drop at the northbound Normandie interchange.

The 2020 model shows a similar trend as the 2003 model. Scenario 6 reduces delay on the corridor by 13 percent in the AM peak (a reduction of 900 vehicle-hours) and 9 percent in the PM peak period (a reduction of 700 vehicle-hours). This scenario shows a reduction of 350 vehicle-hours (27 percent) of delay in the northbound direction from Inglewood to Sepulveda during the AM peak. This can be attributed to the addition of the northbound auxiliary lane at La Tijera, which improves merging.

South Corridor Model: Scenarios 7 and 8 (Advanced Ramp/Connector Metering)

Scenarios 7 and 8 build on Scenarios 5 and 6 by adding advanced ramp metering system such as dynamic or adaptive ramp metering system with connector metering with queue control (to ensure that queuing does not exceed the capacity of the connector) at the following locations:

- Eastbound and westbound I-10 connectors to I-405
- Eastbound and westbound SR-90 connectors to I-405.

The 2003 model estimates that advanced ramp metering will modestly reduce delay by one percent in the AM peak and four percent in the PM peak, for a combined reduction of 200 daily vehicle-hours of delay.

The 2020 model estimates a similar modest improvement with Scenario 8 – a four percent reduction in delay in the AM peak and three percent in the PM peak, for a combined reduction of 400 daily vehicle-hours of delay.

South Corridor Model: Scenarios 9 and 10 (Auxiliary Lane Improvements – Measure R Set 2)

Scenarios 9 and 10 build upon Scenarios 7 and 8 and include local planned operational projects with potential funding availability. These projects include:

- Adding a northbound auxiliary lane from Hawthorne Blvd to Inglewood Ave
- Adding a northbound auxiliary lane from Inglewood Ave to Rosecrans Ave
- Adding a northbound lane from south of El Segundo to I-105
- Adding a southbound auxiliary lane from Howard Hughes Pkwy to Century.

The third and fourth projects on the list above were modified by the study team from the original project description for increased viability.

The 2003 model estimates that the proposed improvements would reduce delay by nine percent in the AM peak (or 370 vehicle-hours) and three percent in the PM peak (or 160 vehicle-hours). The 2020 model estimates similar results with a reduction in delay of eight percent in the AM peak (440 vehicle-hours) and six percent in the PM peak (430 vehicle-hours). Since significant delay reductions were experienced as a result of the previous scenarios, these auxiliary lane projects produced only a moderate reduction in delay.

South Corridor Model: Scenarios 11 and 12 (Operational Improvements – Measure R Set 3)

Scenarios 11 and 12, represents an alternate to Scenarios 9 and 10, and build upon Scenarios 7 and 8. They also include local planned operational projects with potential funding availability. These projects include:

- At Crenshaw Boulevard, constructing a new southbound on-ramp from northbound Crenshaw Boulevard
- Adding a northbound auxiliary lane from Redondo Beach Boulevard to Hawthorne Boulevard
- Widening the northbound off-ramp at Rosecrans Avenue
- At Crenshaw Boulevard at 182nd Street – widening 182nd Street and the east side of Crenshaw Boulevard (3 northbound through) and modifying signal. Modifying the northbound on-ramp from 182nd Street to provide 2 lanes and modify signal.

The 2003 model estimates that the proposed improvements would have little or no impact in reducing delay in either the AM or PM peak period.

The 2020 model estimates nominal results with a reduction in delay of about two percent in the AM peak and two percent in the PM peak, for a combined total of less than 500 vehicle-hours delay reduction. By comparison, these improvements would be less effective than those of Scenarios 9 and 10, in part due to the increased congestion in the southbound direction approaching the I-110 interchange. Should there be improvements in the future at the I-110 interchange, these improvements could yield much better results.

South Corridor Model: Scenarios 13 and 14 (Enhanced Incident Management)

Two incident scenarios were tested on top of Scenario 6 to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. In the first scenario, Scenario 13, one collision incident with one outside lane closure was simulated in the northbound and one in the southbound direction in the PM peak period models. The incident simulation location and duration was selected based on review of the 2010 actual incident data, at one of the high incident frequency locations. The following are the Scenario details:

- Southbound PM peak period starting at 3:30 PM, close outermost mainline lane for 35 minutes at absolute post mile 41.6 (at Inglewood)

- Northbound PM peak period starting at 4:00 PM, close outermost mainline lane for 35 minutes at absolute post mile 42.0 (at Inglewood)

In the second scenario, Scenario 14, the same collision incident was simulated with a reduction in duration by 10 minutes for each of the incidents. It is estimated, based on actual incident management data analysis results provided by Caltrans, that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes. This scenario represents a typical moderate level incident at one location during the peak period direction.

An enhanced incident management system 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. 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 hours.

The 2020 model shows that without enhanced incident management, the first scenario (Scenario 13) produced a 17 percent increase in congestion in the PM peak period for both incidents combined, an increase of over 1,000 vehicle-hours delay. With enhanced incident management, there was a decrease in delay of about four percent combined or about 400 vehicle-hours for improving the incident detection, verification, response, and clearance time of two moderate level incidents in the PM peak period, one in each direction.

Benefit-Cost Analysis

Following an in-depth review of model results by the study team and the SCAG technical committee, the study team performed a benefit-cost analysis (BCA) for each scenario.

Using the California Benefit-Cost Model (Cal-B/C) developed on behalf of Caltrans by the study team; benefits in three key areas were estimated: travel time savings, vehicle operating cost savings, and emission reduction savings. The benefits generated from this exercise are based solely on congestion relief related benefits. However, these results are conservative since there are other benefits not captured by this analysis, including benefits from deploying bus rapid transit, which will achieve other accessibility benefits.

Project costs were developed from SCAG and Caltrans project planning and programming documents. A B/C greater than 1.0 means that a scenario's projects return greater benefits than it costs to construct or implement. It is important to consider the total benefits that a project brings. For example, a large capital expansion project, such as adding major lane additions, can have a high cost and a low B/C ratio, but it would bring much higher absolute benefits to I-405 users. Exhibits ES-37 and ES-38 shows the benefit to cost ranges classified from low (with a B/C of 1.0 to 2.0) to very high (with a B/C of over 10).

I-405 North Corridor Model Benefit-Cost Results

The benefit-cost results for the North Corridor scenarios are shown in Exhibit ES-37.

Exhibit ES-37: North Model – Scenario Benefit/Cost (B/C) Results

Scenario	Scenario Description	Benefit/Cost Ranges			
		Low	Medium	Medium-High	High
		<1	≤1 and <2	≤2 and <5	≤5 and <10
1/2	Completed Projects (2003-2009)			★★★	
3/4	NB HOV lane, US-101 Connector	★			
5/6	Deceleration Lane & Ramp Widening			★★★	
7/8	Advanced Ramp Metering				★★★★
9/10	NB Widening & Aux Lane				★★★★
11	HOV Direct Connector at I-5	★			

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

- Scenarios 1 and 2 (Completed Projects – 2003 to 2010) produce a benefit-cost ratio of over 2:1. This result is consistent with typical capacity enhancement projects with high costs – the cost of this improvement exceeds $130 million. The benefits are substantial at over $280 million.
- Scenarios 3 and 4 (NB HOV Lane, US-101 Connector) produce a benefit-cost ratio below one due to the high cost of construction at over $1.3 billion. The benefits are substantial, however, at over $730 million.
- Scenarios 5 and 6 (Deceleration Lane and Ramp Widening) produce a relatively high benefit-cost ratio of nearly 5 to 1. This is primarily due to the low cost of the construction at below $10 million.
- Scenarios 7 and 8 (Advanced Ramp Metering with Connector Metering) produce benefit-cost ratio of nearly 7:1, which is consistent with typical transportation management projects.

- Scenarios 9 and 10 (NB Widening and Auxiliary Lane) produce a benefit-cost ratio of 5.5 to 1, again consistent with typical operational improvement projects. Benefits of over $160 million could be realized.
- Scenario 11 (HOV Direct Connectors) produce a relatively low benefit-cost ratio of 0.1, which is unexpected. This is likely due to the over-saturated and congested conditions along the I-5 mainline corridor. Should the I-5 corridor from the I-405 to SR-14 be improved, this project could yield significantly better results.
- Implementation of enhanced incident management would result in over 1,200 vehicle-hours of delay savings for each incident. With approximately 1,800 collisions per year experienced on this corridor, that would translate to a delay savings of over one million vehicle-hours.
- The benefit-cost ratio of all scenarios combined is just under 1 to 1 due to the high cost of the HOV widening project at over $1.3 billion. However, the total combined benefits could well exceed $1 billion, substantially reducing congestion and delay, improving mobility, and improving air quality.
- The projects also reduce greenhouse gas (GHG) emissions by over 850 thousand tons over 20 years, averaging over 40,000-ton reduction per year.

I-405 South Corridor Benefit-Cost Results

Exhibit ES-38 summarizes the benefit-cost results for the South corridor scenarios.

Exhibit ES-38: South Model – Scenario Benefit/Cost (B/C) Results

Scenario	Scenario Description	Benefit/Cost Ranges			
		Low	Medium	Medium-High	High
		<1	≤1 and <2	≤2 and <5	≤5 and <10
1/2	HOV lane from I-105 to I-10			★★★	
3/4	Arbor Vitae (south half of IC)		★★		
5/6	Operational Improvs (Measure R Set 1)		★★		
7/8	Advanced Ramp Metering			★★★	
9/10	Aux Lane Improvs (Measure R Set 2)	★			
11/12	Operational Improvs (Measure R Set 3)	★			

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

- Scenarios 1 and 2 (Completed HOV Lane from I-105 to I-10) produce a relatively high benefit-cost ratio of over 2:1, considering the high cost at nearly $300 million. This result is consistent with typical capital expansion projects in the State but higher than typical of Southern California freeways with higher costs.

- Scenarios 3 and 4 (Arbor Vitae Interchange) produce a benefit-cost ratio of 1.6 to 1 with benefits of over $100 million, which is unexpected considering that it is only a half interchange improvement.
- Scenarios 5 and 6 (Operational Projects – Measure R Set 1) produce a relatively low benefit-cost ratio of 1.4 to 1, despite the over $130 million in benefits. This is much lower than the typical operational improvement projects, primarily due to the high cost of construction at nearly $100 million, common for Southern California.
- Scenarios 7 and 8 (Advanced Ramp Metering with Connector Metering) produce a benefit-cost ratio of nearly 3:1, which is relatively lower than the typical transportation management projects, unlike the North Corridor.
- Scenarios 9 and 10 (Auxiliary Lanes – Measure R Set 2) produce a relatively low benefit-cost ratio of less than one, again due to the high cost of construction and significant reduction in delay on the corridor by Scenario 7 and 8 with previous scenario improvements. Modest benefits of over $50 million could be realized at the cost of well over $100 million.
- Scenarios 11 and 12 (Operational Improvements – Measure R Set 3) that build upon Scenarios 7 and 8 and tested as an alternative to the Measure R Set 2, also produce a relatively low benefit-cost ratio of less than one for the same reasons, despite the comparatively lower construction cost at an estimated $67 million. By comparison, they yield significantly less benefits than those of Scenario 9 and 10.
- Implementation of enhanced incident management would result in about vehicle-hours of delay savings for each incident. With approximately 1,750 collisions per year experienced on this corridor, that would translate to a delay savings of up to 350,000 vehicle-hours.
- The benefit-cost ratio of all scenarios combined is over 1.5 to 1. If all projects were delivered at current costs, the public would get a dollar and a half of benefits for each dollar expended. In current dollars, costs add up to around $600 million whereas the benefits are estimated to be over $920 million.
- The projects also reduce greenhouse gas (GHG) emissions by about 560 thousand tons over 20 years. This reduction averages nearly 30,000 tons per year.

CONCLUSIONS AND RECOMMENDATIONS

This section presents the overall conclusions and recommendations based on the micro-simulation analyses presented in the previous section. After a thorough review, the calibrated base year and forecast year model, of each scenario developed and analyzed, the study team believes that both the scenario results are reasonable and allow for more informed decision-making. Caution is advised in making decisions based on modeling alone. There other technical factors to be considered using engineering and professional judgment and experience in order to make the most effective project decisions that affect millions if not billions of dollars of investments.

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

North Corridor Improvements

- The combination of all scenarios significantly reduces overall congestion on the corridor. Projected 2020 congestion after implementation of all scenarios is below 2003 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 less than 5,000 hours compared to the 2003 base year delay of 7,000 hours. This represents a reduction of almost 30 percent. In the PM peak period, the model projects total delay in 2020 after delivering all projects to be around 8,000 hours compared to the 2003 base year delay of almost 11,500 hours. This represents a reduction of over 30 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 2003.
- Completing the northbound HOV lane from I-10 to US-101 and closing the HOV lane system gap are expected to result in substantial improvements - a 50 percent reduction in delay and more than $1 billion in net benefits by future year 2020. The results of recently completed programmed projects (Scenarios 1 and 2) and the programmed CMIA project (Scenarios 3 and 4) were included in the model to make this determination. However, due to the high costs of these projects of the HOV project, the benefit cost of these projects (i.e., combining scenarios 1 through 4) is less than one. This is not atypical for major expansion projects on an urban corridor.
- Operational improvement projects associated with Scenarios 5, 6, 9, 10 that complement the HOV widening and CMIA projects could result in net mobility improvements of over $200 million in benefits over the 20-year planning period. With benefit to cost ratio of over 5 to 1, these improvements are strongly recommended for funding and implementation.
- Advanced ramp metering with connector metering (Scenarios 7 and 8) could be very cost effective with nearly 7 to 1 benefit-cost results. The district should

continue to research and evaluate the deployment of advanced ramp metering given the high potential for mobility improvement.

- Although the HOV direct connector at the I-5 interchange is not expected to produce any significant congestion relief and the investment yields a benefit to cost ratio of significantly less than one. The benefits may be more significant should the stretch of northbound I-5, north of I-405 be improved in the future. However, until further analysis is conducted to evaluate this extension, this project is not recommended for funding or implementation.
- Enhanced incident management system associated with Scenarios 12 and 13 to address non-recurrent congestion could be proven effective with daily delay reduction of over 1,200 vehicle-hours during the AM and PM peak hours over the non-incident management scenario. Over the course of a year, the delay savings would add up to more than one million vehicle-hours (given 1,800 collisions per year per TASAS).

South Corridor Improvements

- Similar to the North Corridor results, the combination of all scenarios significantly reduces overall congestion on the corridor. Projected 2020 congestion after implementation of all scenarios is below 2003 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 less than 6,000 hours compared to the 2003 base year delay of around 8,000 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 around 7,000 hours compared to the 2003 base year delay of almost 9,000 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 2003.
- The completed HOV widening improvements from 2003 to 2010 associated with Scenarios 1 and 2 are estimated to account for over $600 million in benefits, representing a benefit to cost ratio of over 2.
- Advanced ramp metering with connector metering are expected to produce modest results on this corridor with a 3 to 1 benefit-cost ratio. Despite the relatively lower benefit to cost ratio in comparison to other typical demand management projects, it may be a necessary project to moderate the high demand merge from the SR-90 interchange on-ramps.
- Operational improvement projects that complement the recently completed HOV widening project could result in net mobility improvements of well over $300 million in benefits over 20 year period. Despite the relatively low benefit to cost ratio of little over 1 to 1, these improvements increase corridor-wide productivity and efficiency.

- Similar to the North Corridor, enhanced incident management also shows promise for the South Corridor. Over the course of a year, the delay savings would add up to 350,000 vehicle-hours for the total number of collisions that typically occur on the south segment of I-405.