UPDATED FINAL

CORRIDOR SYSTEM MANAGEMENT PLAN (CSMP)
LOS ANGELES COUNTY I-210 CORRIDOR COMPREHENSIVE PERFORMANCE ASSESSMENT

August 3, 2009

System Metrics Group, Inc.

Table of Contents

Table of Contents i
List of Exhibits iii

1. INTRODUCTION 1
    Background 3
    Existing Data Sources 4
    Freeway Detection Status 5

2. CORRIDOR DESCRIPTION 15
    Corridor Roadway Facility 15
    Recent Roadway Improvements 20
    Transit 20
    Special Event Facilities and Trip Generators 24
    Demand Profiles 27

3. CORRIDOR-WIDE PERFORMANCE AND TRENDS 30
    MOBILITY 30
        Delay 30
        Travel Time 52
    RELIABILITY 56
    SAFETY 68
    PRODUCTIVITY 73
    PAVEMENT CONDITION 78
        Performance Measures 78
        Existing Pavement Condition 79

4. BOTTLENECK IDENTIFICATION AND ANALYSIS 87
    Eastbound Bottlenecks 87
    Westbound Bottlenecks 87
    ANALYSIS OF BOTTLENECK AREAS 89
    Mobility by Bottleneck Area 92
    Safety by Bottleneck Area 95
    Productivity by Bottleneck Area 101

5. CAUSALITY ANALYSIS 104
    Mainline Facility 105
        Eastbound Bottlenecks and Causes 105
        Westbound Bottlenecks and Causes 110
    High Occupancy Vehicle Facility 116
        Eastbound HOV Bottlenecks and Causes 116
        Westbound HOV Bottlenecks and Causes 118

APPENDIX 121
4A. BOTTLENECK ANALYSIS 122
ANALYSIS DETAILS 123
HICOMP 123
Probe Vehicle Runs 125
Freeway Performance Measurement System (PeMS) 128

List of Exhibits

Exhibit 1-1: Map of Study Area 1
Exhibit 1-2: System Management Pyramid 4
Exhibit 1-3: PeMS Sensor Data Quality (December 2008) 5
Exhibit 1-4: I-210 Eastbound Mainline Amount of Good Detection (2004-2008) 6
Exhibit 1-5: I-210 Westbound Mainline Amount of Good Detection (2004-2008) 7
Exhibit 1-6: I-210 Eastbound HOV Amount of Good Detection (2004-2008) 8
Exhibit 1-7: I-210 Westbound HOV Amount of Good Detection (2004-2008) 9
Exhibit 1-8: I-210 Eastbound ML Detection Added (2004-2008) 10
Exhibit 1-9: I-210 Westbound Detection Added (2004-2008) 11
Exhibit 1-10: I-210 Gaps In Mainline Detection (December 2008) 12
Exhibit 1-11: I-210 Gaps In HOV Detection (December 2008) 13
Exhibit 2-1: I-210 Corridor Lane Configuration 16
Exhibit 2-2: Major Interchanges and AADT along the I-210 Corridor 17
Exhibit 2-3: Los Angeles and Ventura County Truck Networks 18
Exhibit 2-4: Metro Area Transit Map Servicing Routes along I-210 Corridor 21
Exhibit 2-5: Metrolink Commuter Rail System Map 22
Exhibit 2-6: Major Special Event Facilities/Trip Generators 25
Exhibit 2-7: Aggregate Analysis Zones for Demand Profile Analysis 27
Exhibit 2-8: AM Peak Origin Destination by Aggregated Analysis Zone 28
Exhibit 2-9: PM Peak Origin Destination by Aggregated Analysis Zone 28
Exhibit 3-1: Average Daily Vehicle-Hours of Delay (2005-2007) 32
Exhibit 3-2: HICOMP Congested Segments (2005-2007) 33
Exhibit 3-3: 2007 AM Peak Period HICOMP Congested Segments Map 34
Exhibit 3-4: 2007 PM Peak Period HICOMP Congested Segments Map 35
Exhibit 3-5: PeMS Sensor Data Quality February 22, 2007 37
Exhibit 3-6: I-210 (SR-134 to SR-57) PeMS Sensor Data Quality 2004-2006 38
Exhibit 3-7: I-210 Eastbound Mainline Average Daily Delay by Time Period (2004-2008) 40
Exhibit 3-8: I-210 Westbound Mainline Average Daily Delay by Time Period (2004-2008) 41
Exhibit 3-9: I-210 Eastbound HOV Average Daily Delay by Time Period (2004-2008) 42
Exhibit 3-10: I-210 Westbound HOV Average Daily Delay by Time Period (2004-2008) 43
Exhibit 3-11: I-210 Mainline Average Weekday Delay by Month (2004-2008) 44
Exhibit 3-12: I-210 HOV Average Weekday Delay by Month (2004-2008) 45
Exhibit 3-13: I-210 Mainline Average Delay by Day of Week by Severity (2004-2008) 46
Exhibit 3-14: I-210 HOV Average Delay by Day of Week by Severity (2004-2008) 47
Exhibit 3-15: Eastbound Mainline Average Weekday Hourly Delay (2004-2008) 48
Exhibit 3-16: Westbound Mainline Average Weekday Hourly Delay (2004-2008) 48
Exhibit 3-17: Eastbound HOV Average Weekday Hourly Delay (2004-2008) 49
Exhibit 3-18: Westbound HOV Average Weekday Hourly Delay (2004-2008) 50
Exhibit 3-19: Eastbound Mainline Travel Time by Time of Day (2004-2008) 52
Exhibit 3-20: Westbound Mainline Travel Time by Time of Day (2004-2008) 53
Exhibit 3-21: Eastbound HOV Travel Time by Time of Day (2004-2008) 53
Exhibit 3-22: Westbound HOV Travel Time by Time of Day (2004-2008) 54
Exhibit 3-23: Eastbound Mainline Travel Time Variability (2004) 56
Exhibit 3-24: Westbound Mainline Travel Time Variability (2004) 57
Exhibit 3-25: Eastbound Mainline Travel Time Variability (2005) 57
Exhibit 3-26: Westbound Mainline Travel Time Variability (2005) 58
Exhibit 3-27: Eastbound Mainline Travel Time Variability (2006) 58

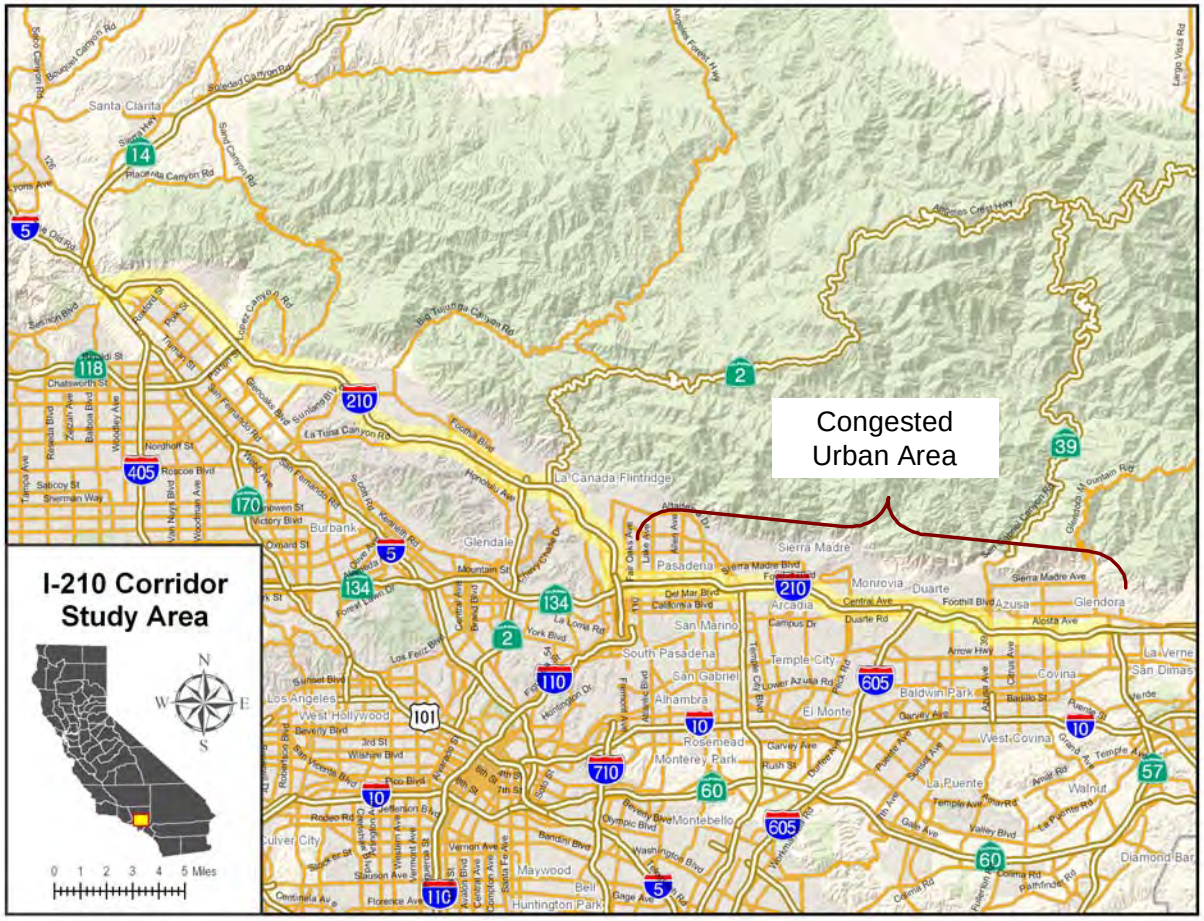
Exhibit 3-28: Westbound Mainline Travel Time Variability (2006) 59
Exhibit 3-29: Eastbound Mainline Travel Time Variability (2007) 59
Exhibit 3-30: Westbound Mainline Travel Time Variability (2007) 60
Exhibit 3-31: Eastbound Mainline Travel Time Variability (2008) 60
Exhibit 3-32: Westbound Mainline Travel Time Variability (2008) 61
Exhibit 3-33: Eastbound HOV Travel Time Variability (2004) 62
Exhibit 3-34: Westbound HOV Travel Time Variability (2004) 62
Exhibit 3-35: Eastbound HOV Travel Time Variability (2005) 63
Exhibit 3-36: Westbound HOV Travel Time Variability (2005) 63
Exhibit 3-37: Eastbound HOV Travel Time Variability (2006) 64
Exhibit 3-38: Westbound HOV Travel Time Variability (2006) 64
Exhibit 3-39: Eastbound HOV Travel Time Variability (2007) 65
Exhibit 3-40: Westbound HOV Travel Time Variability (2007) 65
Exhibit 3-41: Eastbound HOV Travel Time Variability (2008) 66
Exhibit 3-42: Westbound HOV Travel Time Variability (2008) 66
Exhibit 3-43: Eastbound Monthly Accidents, PM 0 to 22 (2004-2007) 69
Exhibit 3-44: Westbound Monthly Accidents, PM 0 to 22 (2004-2007) 69
Exhibit 3-45: Eastbound Monthly Accidents, PM 22 to 45 (2004-2007) 70
Exhibit 3-46: Westbound Monthly Accidents, PM 22 to 45 (2004-2007) 70
Exhibit 3-47: Total Number of Accidents by Type and Accident Rate (2004-2007) 71
Exhibit 3-48: Lost Productivity Illustrated 74
Exhibit 3-49: Average Lost Lane-Miles by Direction, Time Period, and Year (Mainline) 75
Exhibit 3-50: Average Lost Lane-Miles by Direction, Time Period, and Year (HOV) 76
Exhibit 3-51: Pavement Condition States Illustrated 79
Exhibit 3-52: Distressed Lane-Miles on I-210 Corridor (2006-2007) 81
Exhibit 3-53: I-210 Distressed Lane-Miles Trends 82
Exhibit 3-54: I-210 Distressed Lane-Miles by Type 82
Exhibit 3-55: I-210 Road Roughness (2006-2007) 83
Exhibit 3-56: Eastbound I-210 Road Roughness (2003-2007) 84
Exhibit 3-57: Westbound I-210 Road Roughness (2003-2007) 85
Exhibit 4-1: Dividing a Corridor into Bottleneck Areas 89
Exhibit 4-2: I-210 Bottleneck Locations and Bottleneck Areas 90
Exhibit 4-3: Eastbound I-210 Identified Bottleneck Areas 91
Exhibit 4-4: Westbound I-210 Identified Bottleneck Areas 91
Exhibit 4-5: Eastbound I-210 Annual Vehicle-Hours of Delay (2006) 92
Exhibit 4-6: Westbound I-210 Annual Vehicle-Hours of Delay (2006) 93
Exhibit 4-7: Eastbound I-210 Delay per Lane-Mile (2006) 94
Exhibit 4-8: Westbound I-210 Delay per Lane-Mile (2006) 94
Exhibit 4-9: Eastbound I-210 Collision Locations (2006) 95
Exhibit 4-10: Eastbound I-210 Location of Collisions by Bottleneck Area (2003-2007) 96
Exhibit 4-11: Westbound I-210 Collision Locations (2006) 97
Exhibit 4-12: Westbound I-210 Collision Locations (2003-2007) 98
Exhibit 4-13: Eastbound I-210 Total Accidents (2006-2007) 99
Exhibit 4-14: Westbound I-210 Total Accidents (2006-2007) 100
Exhibit 4-15: Eastbound I-210 Lost Lane-Miles (2006) 101
Exhibit 4-16: Westbound I-210 Lost Lane-Miles (2006) 102
Exhibit 5-1: Eastbound I-210 at SR-134/Lincoln Tunnel 105
Exhibit 5-2: Eastbound I-210 at Santa Anita/Huntington 107
Exhibit 5-3: Eastbound I-210 at I-605 Off 108

Exhibit 5-4: Eastbound I-210 at Irwindale 109
Exhibit 5-5: Westbound I-210 at Azusa 110
Exhibit 5-6: Westbound I-210 at Irwindale and I-605 111
Exhibit 5-7: Westbound I-210 at Santa Anita 112
Exhibit 5-8: Westbound I-210 at Rosemead 113
Exhibit 5-9: Westbound I-210 at Lake and SR-134 114
Exhibit 5-10: Westbound I-210 at SR-118 115
Exhibit 5-11: Eastbound I-210 ML & HOVL PeMS Speed Contour (June 2009) 117
Exhibit 5-12: Westbound I-210 ML & HOVL PeMS Speed Contour (June 2009) 119
Exhibit A4-1: Summary of Bottlenecks Identified and Verified 122
Exhibit A4-2: 2006 HICOMP AM Congestion Map with Potential Bottlenecks 124
Exhibit A4-3: 2006 HICOMP PM Congestion Map with Potential Bottlenecks 125
Exhibit A4-4: WB-210 Sample Probe Vehicle Runs 126
Exhibit A4-5: EB-210 Sample Probe Vehicle Runs 127
Exhibit A4-6: PeMS WB-210 Speed Contour Plots – April/November 2006 129
Exhibit A4-7: PeMS WB-210 Long (Speed) Contours – 2006 by Quarter 131
Exhibit A4-8: PeMS EB-210 Speed Contour Plots – April/November 2006 133
Exhibit A4-9: PeMS EB-210 Long (Speed) Contours – 2006 by Quarter 134

1. INTRODUCTION

The I-210 Corridor System Management Plan (CSMP) Comprehensive Performance Assessment provides a corridor-wide assessment of performance along the I-210 freeway in Los Angeles County. The complete I-210 Corridor extends from the I-5 junction to the SR-57 junction – a distance of approximately 45 miles. This Comprehensive Performance Assessment focuses on the congested urban section between the SR-134 junction and the SR-57 junction – a distance of approximately 20 miles – but aspects of the entire corridor are described. Exhibit 1-1 shows the location of the study corridor and the congested urban area.

Exhibit 1-1: Map of Study Area



The Comprehensive Performance Assessment details the performance of the corridor so that future investment decisions can build on its findings and conclusions. It also provides the basis for testing alternatives to ensure reasonable returns on investment for public funds. This assessment provides performance information for a number of

years, including 2006 which is the base year for microsimulation modeling and alternatives testing.

The Comprehensive Performance Assessment presents performance measurement findings, identifies bottlenecks that lead to less than optimal performance, and diagnoses the causes for these bottlenecks in detail. In future steps of the CSMP development process, alternative investment strategies will be modeled and evaluated to understand their relative benefits and eventually develop a recommended implementation plan for existing and potential future funding.

This report and the associated CSMP should be updated on a regular basis. 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.

Updates should every two to three years. To the extent possible, this document has been organized to facilitate updates with simple insertion of new and updated sections without re-writing the entire document.

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

2. *Corridor Description*
   This section describes the corridor, including the roadway facility, major interchanges and relative demands at these interchanges, rail and transit services along the freeway facility, and special event facilities or trip generators. This section has been expanded since the prior (May 2008) comprehensive performance assessment to include a subsection that profiles travel demand along the corridor.

3. *Corridor-Wide Performance and Trends*
   The section presents multiple years of performance data for the defined CSMP freeway facility of the corridor, including mobility, reliability, safety, and productivity performance measures. The section has been augmented since the May 2008 report to include the performance of the HOV facility and the pavement condition of the freeway. When available, the performance data has been updated to reflect conditions through December 2008.

4. *Bottleneck Identification*
   The section identifies the locations of bottlenecks or choke points on the freeway facility. These bottlenecks are generally the major cause for mobility and productivity performance degradations and are often related to safety degradations as well. This section has been rewritten since the last comprehensive performance assessment to include performance results for

delay, productivity, and safety by major "bottleneck area". This addition allows for the relative prioritization of bottlenecks in regards to their contribution to corridor performance degradation. The original bottleneck analysis section has been moved to the appendix for comparison.

5. *Causality Analysis*
   This section diagnoses the bottlenecks identified in Section 4 and identifies the causes of each bottleneck through additional data analysis and significant field observations. Videos were taken for many of the major bottlenecks (to the extent possible) to verify conclusions. Sections 4 and 5 provide valuable input in selecting projects to address the critical bottlenecks. They also provide the baseline against which the micro-simulation models will be validated.

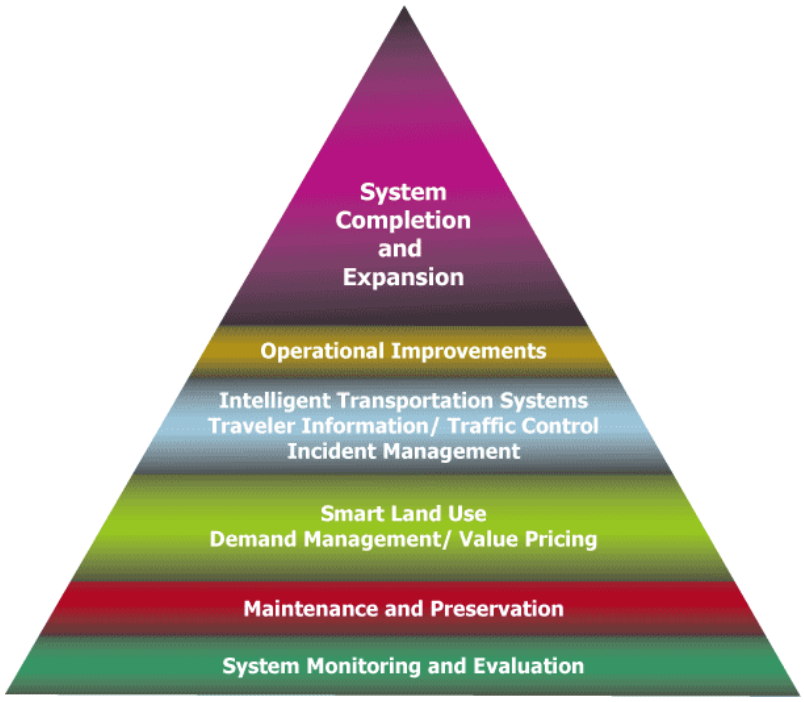
The remainder of this introduction provides a brief background on the system management framework that led to the CSMP requirement. It also includes a discussion on data sources and the state of detection on the I-210 freeway facility.

Background

Over the last few years, the Southern California Association of Governments (SCAG) and Caltrans have been developing a framework called "System Management," which is depicted in Exhibit 1-2. This framework aims to get the most from transportation infrastructure through a variety of strategies, not just through the traditional and increasingly expensive expansion projects. The last SCAG Regional Transportation Plan (RTP) highlighted system management concepts. The framework has been embraced by the current California Administration as part of its Strategic Growth Plan.

One major aspect of system management is an increased focus on operational strategies and investments. Operational solutions are generally less expensive and often can be implemented much faster. They can also produce results that, when compared to traditional expansion projects, provide higher returns on the scarce transportation funding available. Partly because of the focus on operational strategies, system management relies on much more detailed data.

Exhibit 1-2: System Management Pyramid



The base of the system management "pyramid" shown in Exhibit 1-2 is titled "System Monitoring and Evaluation." It is the foundation of all other decisions, and it includes identifying problems, evaluating solutions (and combinations of solutions), and eventually funding the most promising strategies. This document represents the first round of developing the system monitoring foundation for the I-210 Corridor.

Existing Data Sources

The data available for the assessing existing conditions along the corridor include the following sources:

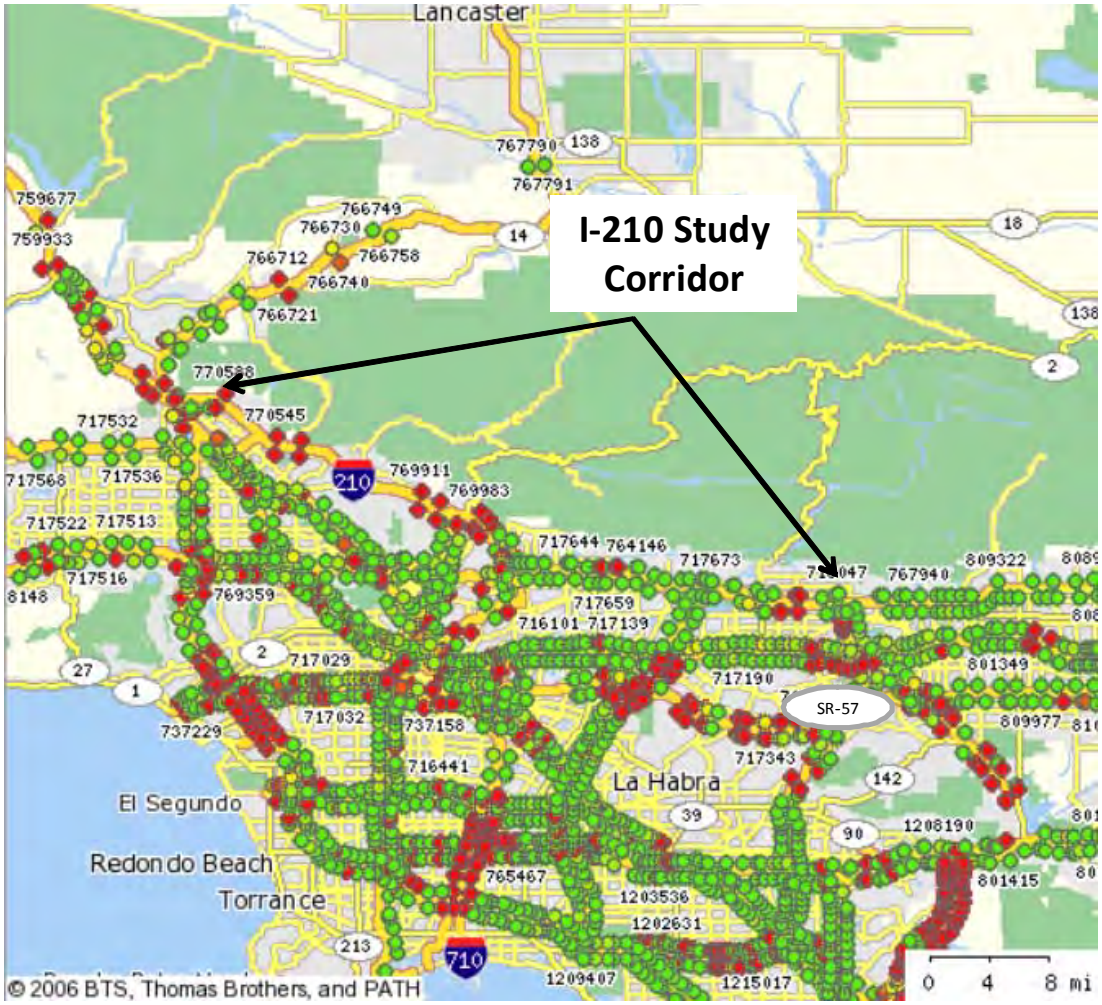
- Caltrans HICOMP report and data files (2004 to 2007)
- Caltrans Freeway Performance Measurement System (PeMS)
- Caltrans District 7 probe vehicle runs (electronic tachometer data)
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS)
- Traffic study reports (various)
- Aerial photographs (Google Earth) and Caltrans photologs
- Internet (i.e. Metro website, Metrolink website, Foothill Transit website, etc.).

Details for each data source are provided in applicable sections of 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 1-3 depicts the corridor freeway facility with the detectors in place as of December 30, 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 and the majority functioning well (based on the green color) in the eastern portion of the corridor. These are the 20 miles in the congested urban area between the SR-134 junction and the SR-57 junction. The western portion of the corridor has large gaps in detection and the data was not available on the illustrated date.

Exhibit 1-3: PeMS Sensor Data Quality (December 2008)

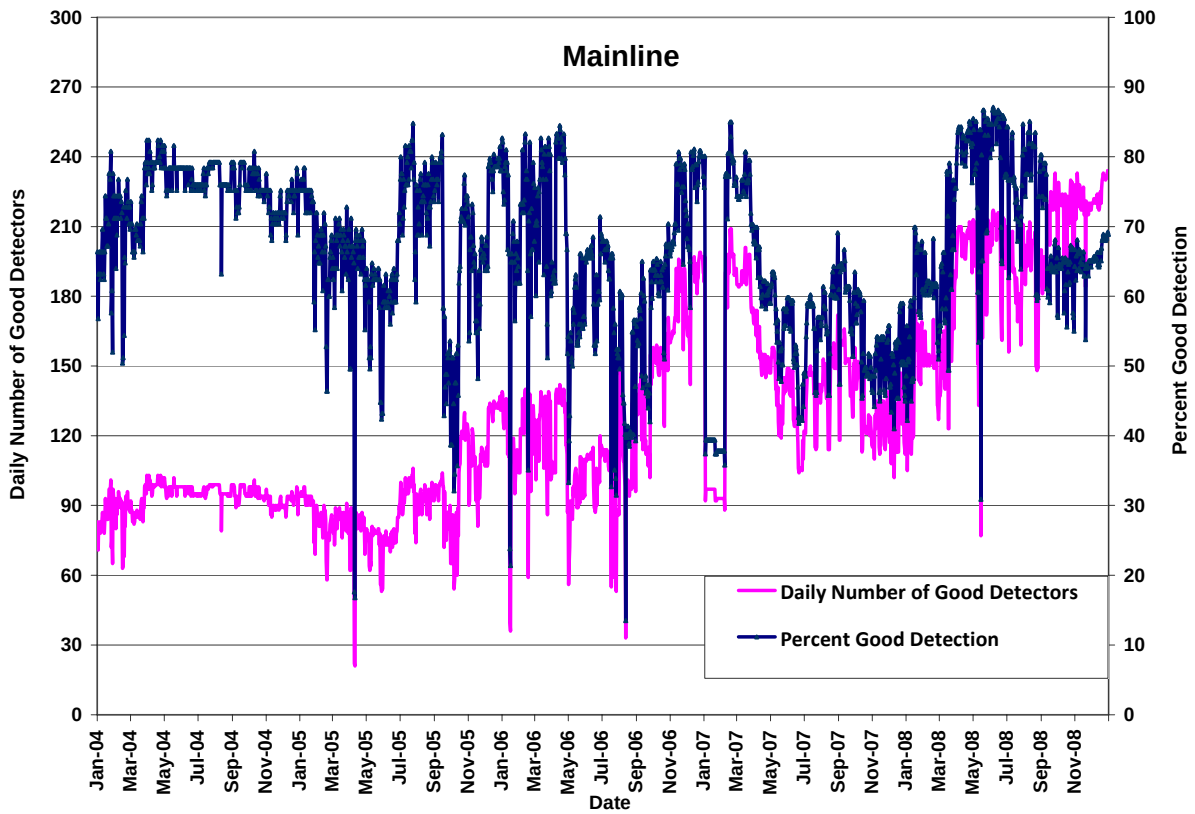


The following exhibits provide a better picture of how the detectors on the corridor performed over a longer period of time from January 2004 to December 2008. Exhibits 1-4 and 1-5 report the number and percentage of daily "good" detectors on the mainline (ML) facility (including ramps) of the study corridor. Exhibits 1-6 and 1-7 report the same information for the HOV facility. 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.

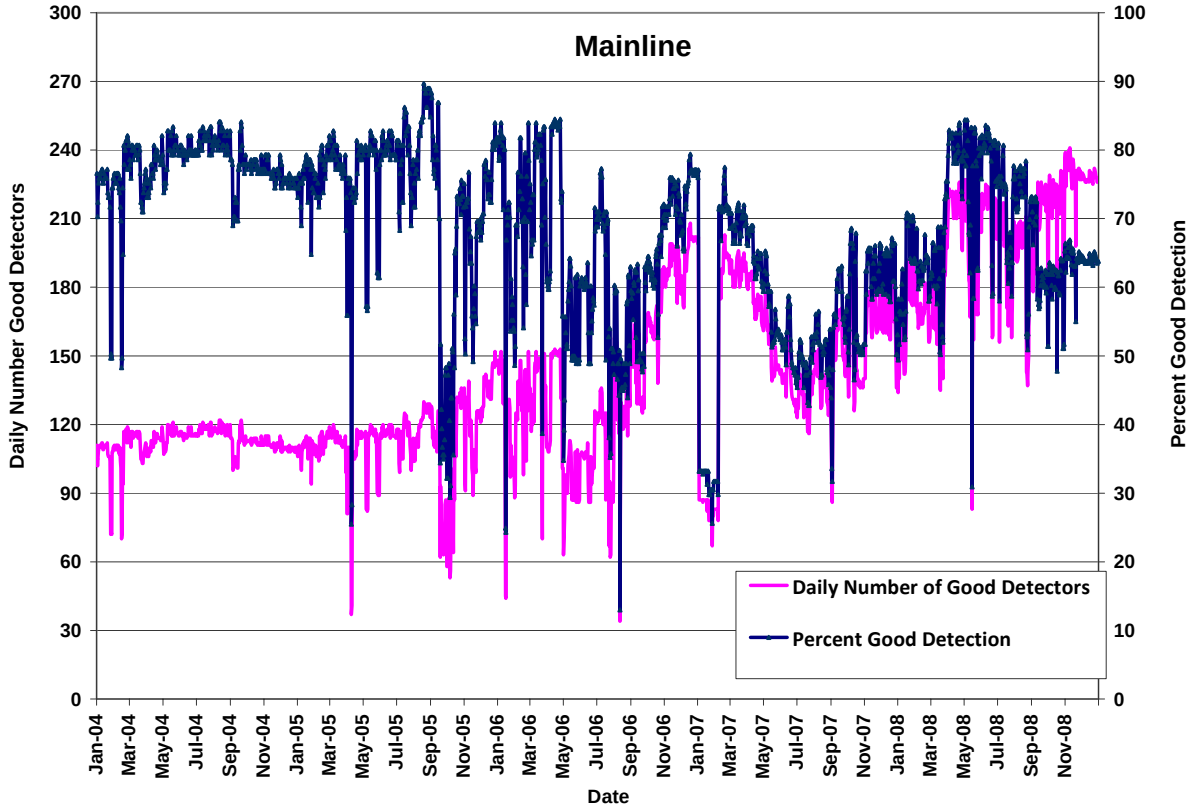
The first two exhibits (Exhibits 1-4 and 1-5) suggest that the available detection coverage is roughly the same in the two directions. The number of good detectors increased from 2004 through 2006, particularly during the last half of 2006. In percentage terms, the available detection generally ranged from 60 to 80 percent during this period. In 2007, the available detection dropped in both percent and number of detectors. In 2008, the number of good detectors has increased to about 230 detectors in each direction. In percentage terms, the amount of good direction has decreased from highs of over 80 percent, but good detection still represents 65 to 70 percent of total detection in both directions.

Exhibit 1-4: I-210 Eastbound Mainline Amount of Good Detection (2004-2008)



Source: System Metrics Group (using PeMS data)

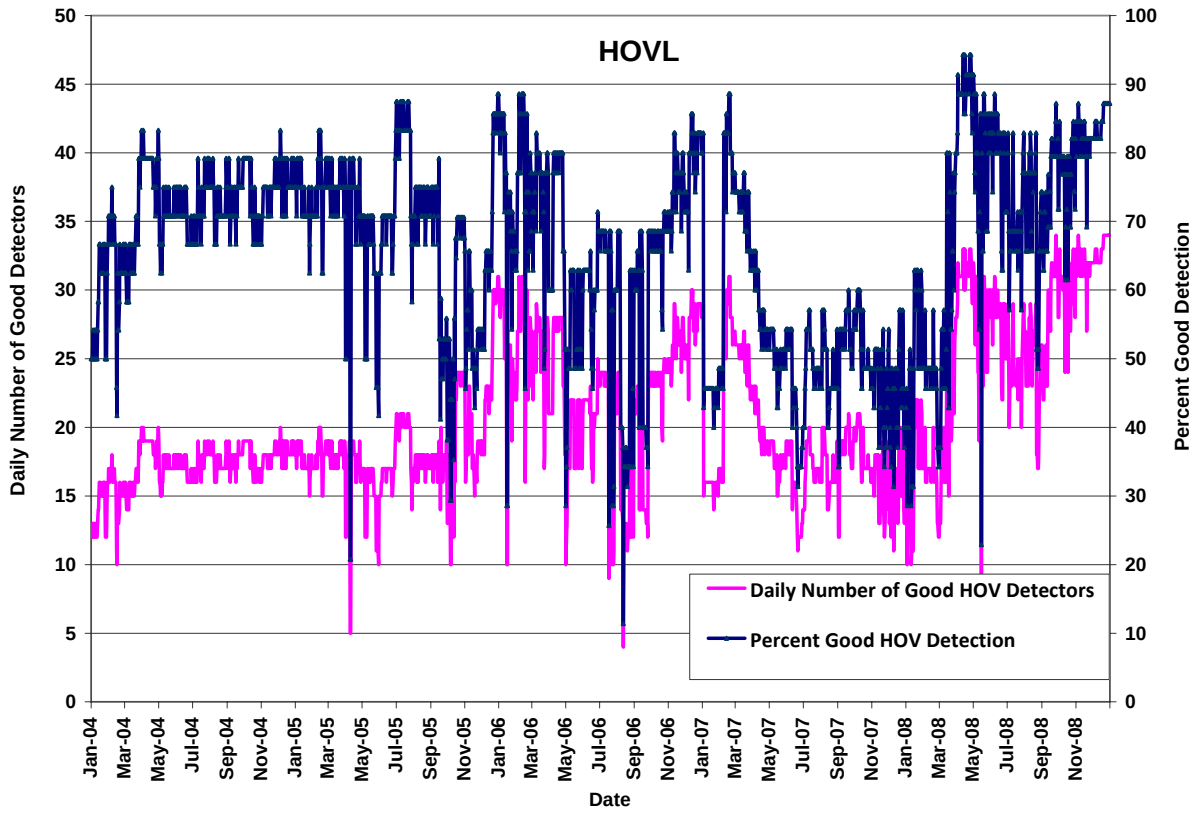
Exhibit 1-5: I-210 Westbound Mainline Amount of Good Detection (2004-2008)



Source: System Metrics Group (using PeMS data)

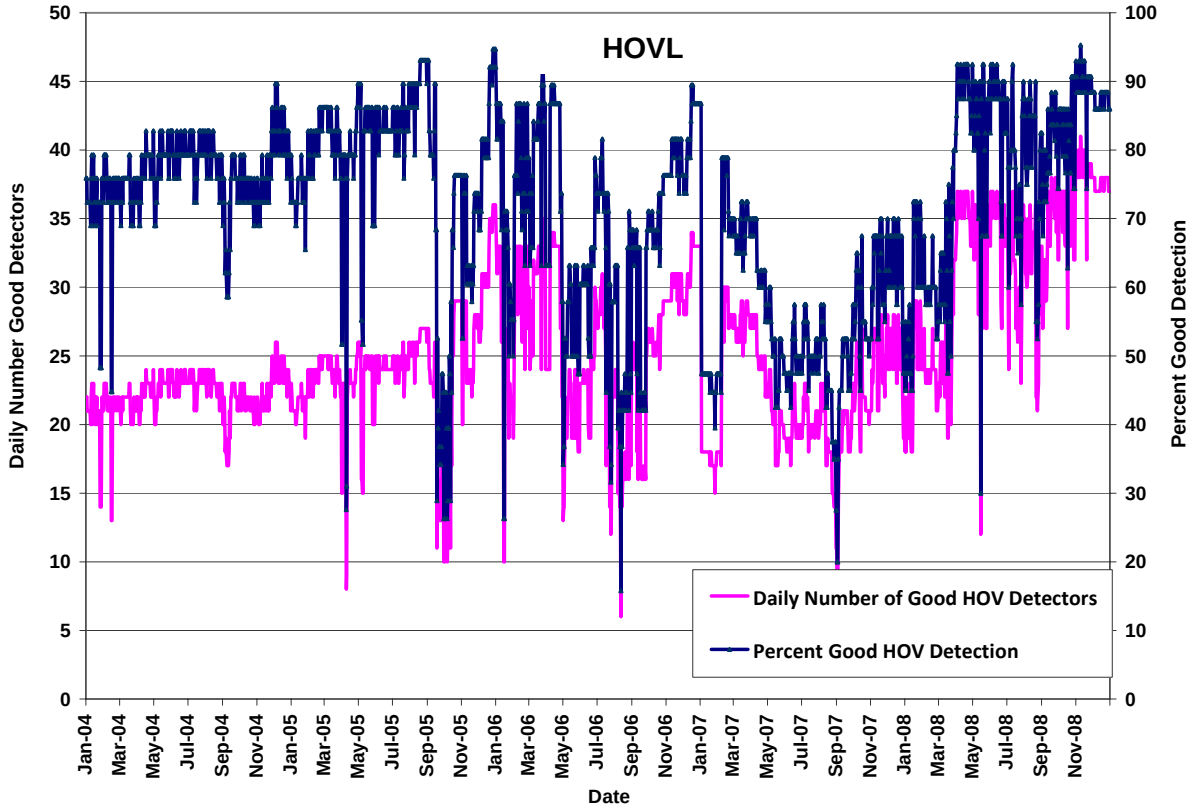
As Exhibits 1-6 and 1-7 show, detection quality on the HOV-lanes (HOVL) roughly mirrored that on the mainline. Like the mainline, HOV detection quality dropped in 2007, but has since recovered. By the end of 2008, good detection as a percent of total detection stood at roughly 85 percent in both directions. A comparison of Exhibits 1-6 and 1-7 shows that detection quality is fairly even between the two directions.

Exhibit 1-6: I-210 Eastbound HOV Amount of Good Detection (2004-2008)



Source: System Metrics Group (using PeMS data)

Exhibit 1-7: I-210 Westbound HOV Amount of Good Detection (2004-2008)



Source: System Metrics Group (using PeMS data)

Part of the 2008 increase in detection quality may be attributed to improved maintenance of the existing detection. However, further deployment has also played a part. Exhibits 1-8 and 1-9 show the detection added to the corridor between June 2, 2004 and December 3, 2008. Detection was added in two large batches in 2005 and 2008. During this period, 36 detectors were added in the eastbound direction and 34 detectors were added in the westbound direction. This trend is very encouraging and should allow for detailed data analysis now and in the future.

Exhibit 1-10 shows an analysis of gaps in mainline detection coverage. While there are several segments extending over 0.75 miles without detection in either direction, the larger gaps are in the western part of the corridor (indicated by smaller postmiles). For example, there is a 4.0 to 4.5 mile gap in detection from Bledsoe Street to Pierce Street or Terra Bella. This gap in detectors is complimented by a number of non-working detectors in the western portion of the corridor (see Exhibit 1-3 for an example). Much of the analysis in this comprehensive performance assessment focuses on the eastern congested urban area as a result of the detection gap.

Exhibit I-11 shows that the gaps in HOV detection coverage mirror those for mainline detection.

Exhibit 1-8: I-210 Eastbound ML Detection Added (2004-2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
EASTBOUND					
769703	HIGHLAND	HOV	R35.8	36.089	9/11/2008
769773	NB 605 TO EB 210 CON	HOV	R36.6	36.889	9/11/2008
770407	AZUSA 1	HOV	R39.64	39.929	9/11/2008
768945	CITRUS 1	HOV	R40.56	40.849	11/1/2005
769759	NB 57 TO EB 210 CON	HOV	R44.6	44.889	9/11/2008
770599	W/B 210 TO N/B 5	Mainline	R.32	0.32	9/11/2008
768297	YARNELL ST	Mainline	R1	1	9/16/2005
768283	ROXFORD ST	Mainline	R2.1	2.1	9/16/2005
770587	BLEDSOE ST.	Mainline	R2.75	2.75	9/11/2008
770544	TERRA BELLA	Mainline	R7.19	7.19	9/16/2005
770556	ORCAS AVE	Mainline	R8.6	8.6	9/11/2008
771202	BIG TUNGA WASH	Mainline	R10.2	10.2	9/11/2008
770464	N OF LA TUNA CYN #3	Mainline	R11.85	11.83	9/11/2008
770475	N OF LA TUNA CYN #2	Mainline	R12.5	12.48	9/11/2008
770487	N OF LA TUNA CANYON	Mainline	R13.4	13.38	9/11/2008
770499	S OF LA TUNA CYN RD	Mainline	R14.6	14.58	9/11/2008
769880	PENNSYLVANIA	Mainline	R17	16.98	9/11/2008
769847	OCEAN VIEW	Mainline	R18.2	18.18	9/11/2008
769984	GOULD	Mainline	R20.42	20.4	9/11/2008
769806	FOOTHILL	Mainline	R21	20.98	9/11/2008
769788	BERKSHIRE	Mainline	R21.6	21.58	9/11/2008
770567	HAMMOND ST.	Mainline	R23.81	23.79	9/11/2008
770578	WINONA WAY	Mainline	R24.462	24.442	9/11/2008
769701	HIGHLAND	Mainline	R35.8	36.089	9/11/2008
769772	NB 605 TO EB 210 CON	Mainline	R36.6	36.889	9/11/2008
769758	NB 57 TO EB 210 CON	Mainline	R44.6	44.889	9/11/2008
767883	FOOTHILL BL	Mainline	R47	47.289	9/16/2005
767896	BIXBY DR	Mainline	R47.5	47.789	9/16/2005
767925	FRUIT ST	Mainline	R48.2	48.489	9/16/2005
767942	LIVE OAK CANYON	Mainline	R48.8	49.089	9/16/2005
767970	TOWNE AV	Mainline	R49.68	49.969	9/16/2005
767984	MOUNTAIN AV	Mainline	R50	50.289	9/16/2005
767998	INDIAN HILL BL	Mainline	R50.46	50.749	9/16/2005
768012	MILLS AV	Mainline	R51	51.289	9/16/2005
768026	E/O MILLS AV	Mainline	R51.5	51.789	9/16/2005
768041	BASELINE RD	Mainline	R51.85	52.139	9/16/2005

Source: System Metrics Group (using PeMS data)

Exhibit 1-9: I-210 Westbound Detection Added (2004-2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
WESTBOUND					
769704	HIGHLAND	HOV	R35.8	36.089	9/11/2008
769723	NB 605 TO WB 210 CON	HOV	R36	36.289	9/11/2008
769745	NB 57 TO WB 210 CONN	HOV	R43.9	44.189	9/11/2008
770598	W/B 210 TO N/B 5	Mainline	R.32	0.32	9/11/2008
770588	BLEDSOE ST.	Mainline	R2.75	2.75	9/11/2008
770519	N. OF PIERCE ST.	Mainline	R6.7	6.7	9/11/2008
770545	TERRA BELLA	Mainline	R7.19	7.19	9/11/2008
770555	ORCAS AVE	Mainline	R8.6	8.6	9/11/2008
770530	BIG TUNGA WASH	Mainline	R10.2	10.2	9/11/2008
770463	N OF LA TUNA CYN #3	Mainline	R11.85	11.83	9/11/2008
770474	N OF LA TUNA CYN #2	Mainline	R12.5	12.48	9/11/2008
770486	N OF LA TUNA CANYON	Mainline	R13.4	13.38	9/11/2008
770498	S OF LA TUNA CYN RD	Mainline	R14.6	14.58	9/11/2008
769911	PENNSYLVANIA	Mainline	R16.6	16.58	9/11/2008
769926	OCEAN VIEW	Mainline	R17.9	17.88	9/11/2008
769983	GOULD	Mainline	R20.42	20.4	9/11/2008
769807	FOOTHILL	Mainline	R21	20.98	9/11/2008
770000	BERKSHIRE	Mainline	R21.41	21.39	9/11/2008
770568	HAMMOND ST.	Mainline	R23.81	23.79	9/11/2008
770579	WINONA WAY	Mainline	R24.462	24.442	9/11/2008
769702	HIGHLAND	Mainline	R35.8	36.089	9/11/2008
769722	NB 605 TO WB 210 CON	Mainline	R36	36.289	9/11/2008
769744	NB 57 TO WB 210 CONN	Mainline	R43.9	44.189	9/11/2008
769136	FOOTHILL BLVD SB	Mainline	R46.46	46.749	2/21/2007
769150	FOOTHILL BLVD NB	Mainline	R46.65	46.939	2/21/2007
767898	BIXBY DR	Mainline	R47.5	47.789	9/16/2005
767910	FRUIT ST	Mainline	R47.9	48.189	9/16/2005
767940	LIVE OAK CANYON	Mainline	R48.8	49.089	9/16/2005
767955	TOWNE AV	Mainline	R49.6	49.889	9/16/2005
767986	MOUNTAIN AV	Mainline	R50	50.289	9/16/2005
768000	INDIAN HILL BL	Mainline	R50.46	50.749	9/16/2005
768014	MILLS AV	Mainline	R51	51.289	9/16/2005
768028	E/O MILLS AV	Mainline	R51.5	51.789	9/16/2005
768055	BASELINE RD	Mainline	R51.94	52.229	9/16/2005

Source: System Metrics Group (using PeMS data)

Exhibit 1-10: I-210 Gaps In Mainline Detection (December 2008)

Location		Abs PM		Length
From	To	From	To	(Miles)
EASTBOUND				
YARNELL ST	ROXFORD ST	1.00	2.10	**1.10**
BLEDSOE ST.	TERRA BELLA	2.75	7.19	**4.44**
TERRA BELLA	ORCAS AVE	7.19	8.60	**1.41**
ORCAS AVE	BIG TUNGA WASH	8.60	10.20	**1.60**
BIG TUNGA WASH	N OF LA TUNA CYN #3	10.20	11.83	**1.63**
N OF LA TUNA CYN #2	N OF LA TUNA CANYON	12.48	13.38	**0.90**
N OF LA TUNA CANYON	S OF LA TUNA CYN RD	13.38	14.58	**1.20**
S OF LA TUNA CYN RD	WALNUT	14.58	16.98	**2.40**
PENNSYLVANIA	OCEAN VIEW	16.98	18.18	**1.20**
OCEAN VIEW	GOULD	18.18	20.40	**2.22**
BERKSHIRE	ARROYO	21.58	22.60	**1.02**
ALLEN	SAN GABRIEL	27.63	28.68	**1.05**
SAN GABRIEL	SIERRA MADRE V2	28.68	29.44	**0.76**
MICHILLINDA	BALDWIN	30.30	31.24	**0.94**
BALDWIN	SANTA ANITA 2	31.24	32.35	**1.11**
SANTA ANITA 2	HUNTINGTON 1	32.35	33.15	**0.80**
HUNTINGTON 2	MYRTLE AV	33.38	34.44	**1.06**
MYRTLE AV	MOUNTAIN	34.44	35.41	**0.97**
NB 605 TO EB 210 CON	IRWINDALE	36.89	38.30	**1.41**
IRWINDALE	VERNON	38.30	39.34	**1.04**
AZUSA 2	CITRUS 1	40.00	40.85	**0.85**
CITRUS 2	GRAND AV	40.99	41.98	**0.99**
GRAND AV	SUNFLOWER AV	41.979	43.589	**1.61**
SUNFLOWER AV	LONE HILL AV	43.589	44.489	**0.90**
WESTBOUND				
W/B 210 TO N/B 5	BLEDSOE ST.	0.32	2.75	**2.43**
BLEDSOE ST.	N. OF PIERCE ST.	2.75	6.70	**3.95**
TERRA BELLA	ORCAS AVE	7.19	8.60	**1.41**
ORCAS AVE	BIG TUNGA WASH	8.60	10.20	**1.60**
BIG TUNGA WASH	N OF LA TUNA CYN #3	10.20	11.83	**1.63**
N OF LA TUNA CYN #2	N OF LA TUNA CANYON	12.48	13.38	**0.90**
N OF LA TUNA CANYON	S OF LA TUNA CYN RD	13.38	14.58	**1.20**
S OF LA TUNA CYN RD	PENNSYLVANIA	14.58	16.58	**2.00**
PENNSYLVANIA	OCEAN VIEW	16.58	17.88	**1.30**
OCEAN VIEW	GOULD	17.88	20.40	**2.52**
BERKSHIRE	ARROYO 1	21.39	22.30	**0.91**
LINCOLN 1	HAMMOND ST.	23.00	23.79	**0.79**
HILL	ALTADENA	26.80	28.03	**1.23**
SAN GABRIEL	SIERRA MADRE V1	28.27	29.17	**0.90**
BALDWIN 2	SANTA ANITA 1	31.00	32.02	**1.02**
SANTA ANITA 2	HUNTINGTON 1	32.20	33.05	**0.85**
HUNTINGTON 1	MYRTLE AV	33.05	34.05	**1.00**
MYRTLE AV	MOUNTAIN AV	34.05	34.90	**0.85**
MOUNT OLIVE DR / 605	IRWINDALE 1	36.59	38.07	**1.48**
IRWINDALE 2	VERNON	38.21	39.16	**0.95**
CITRUS	GRAND 1	40.55	41.79	**1.24**
GRAND 2	SUNFLOWER AV	41.97	43.39	**1.42**
SUNFLOWER AV	NB 57 TO WB 210 CONN	43.39	44.19	**0.80**

Source: System Metrics Group (using PeMS data)

Exhibit 1-11: I-210 Gaps In HOV Detection (December 2008)

Location		Abs PM		Length
From	To	From	To	(Miles)
EASTBOUND				
ALLEN	SAN GABRIEL	27.63	28.68	**1.05**
SAN GABRIEL	SIERRA MADRE V2	28.68	29.44	**0.76**
MICHILLINDA	BALDWIN	30.30	31.24	**0.94**
BALDWIN	SANTA ANITA 2	31.24	32.35	**1.11**
SANTA ANITA 2	HUNTINGTON 1	32.35	33.15	**0.80**
HUNTINGTON 2	MYRTLE AV	33.38	34.44	**1.06**
MYRTLE AV	MOUNTAIN	34.44	35.41	**0.97**
NB 605 TO EB 210 CON	IRWINDALE	36.89	38.30	**1.41**
AZUSA 2	CITRUS 1	40.00	40.85	**0.85**
CITRUS 2	GRAND AV	40.99	41.98	**0.99**
GRAND AV	SUNFLOWER AV	41.98	43.59	**1.61**
SUNFLOWER AV	LONE HILL AV	43.59	44.49	**0.90**
WESTBOUND				
HILL	ALTADENA	26.80	28.03	**1.23**
SAN GABRIEL	SIERRA MADRE V1	28.27	29.17	**0.90**
BALDWIN 2	SANTA ANITA 1	31.00	32.02	**1.02**
SANTA ANITA 2	HUNTINGTON 1	32.20	33.05	**0.85**
HUNTINGTON 1	MYRTLE AV	33.05	34.05	**1.00**
MYRTLE AV	MOUNTAIN AV	34.05	34.90	**0.85**
MOUNT OLIVE DR / 605	IRWINDALE 1	36.59	38.07	**1.48**
IRWINDALE 2	VERNON	38.21	39.16	**0.95**
CITRUS	GRAND 1	40.55	41.79	**1.24**
GRAND 2	SUNFLOWER AV	41.97	43.39	**1.42**
SUNFLOWER AV	NB 57 TO WB 210 CONN	43.39	44.19	**0.80**

Source: System Metrics Group (using PeMS data)

NOTE: The next page is intentionally left blank so that Caltrans can insert updates to the detection analysis results presented in Exhibits 1-4 through 1-11 and discuss the ramifications of its findings (e.g., have the gaps been filled, is detector reliability improving or diminishing, etc.). Similar place holder pages have been inserted throughout the document for future updates.

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2. CORRIDOR DESCRIPTION

The Los Angeles County I-210 Corridor extends approximately 45 miles from the I-5 (Golden State Freeway) interchange in San Fernando and to the SR-57 (Orange Freeway) interchange. It traverses through the cities of San Fernando, La Canada Flintridge, Pasadena, Arcadia, Monrovia, Duarte, Azusa, and San Dimas. Since detection data is missing for a large portion of this corridor, the bottleneck identification, causality analysis, and many of the performance trends report focusing on the 20-mile congested urban section between SR-134 and SR-57.

Corridor Roadway Facility

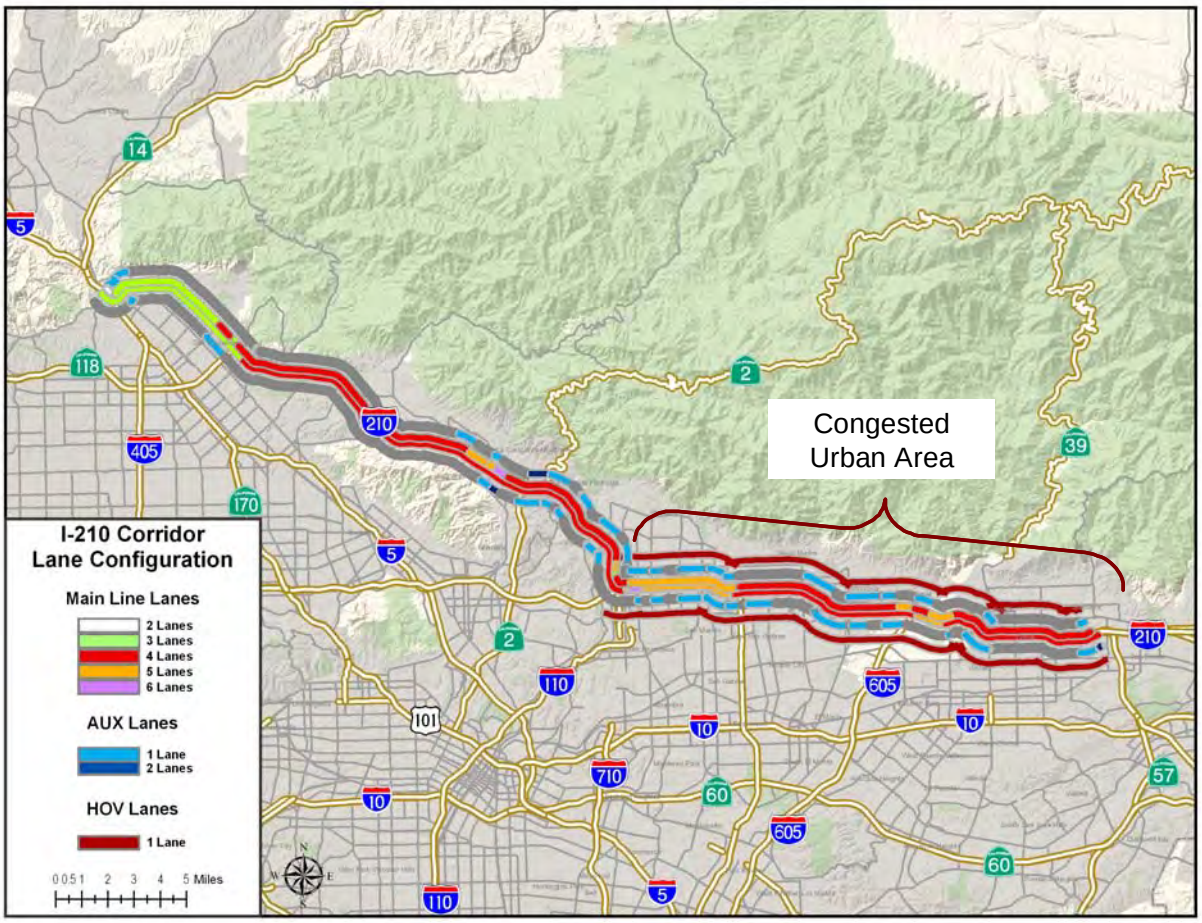
The study corridor traverses a large portion of the northern section of Los Angeles County and connects several of the major communities. The corridor includes 45 miles of I-210 from its beginning at the I-5 junction (postmile R0) in Sylmar through Sunland, Glendale, La Crescenta, La Canada Flintridge, Pasadena, and San Gabriel Valley to SR-57 junction (postmile R45). The LA-210 corridor intersects many of the key north-south corridors in Los Angeles County. The major interchanges in the I-210 Corridor include the following:

- I-5, which provides a north-south connection throughout the State as well as Los Angeles County
- SR-118, which provides an east-west connection from the I-210 freeway/San Fernando to Ventura County
- SR-2 (Glendale Freeway), which provides north-south access from Foothill Boulevard to the downtown Los Angeles area
- SR-2 (Angeles Crest Highway), which provides access through the Angeles National Forest
- SR-134 (Ventura), which make connection to the west with the US-101 freeway and to the south with Long Beach
- Lake Avenue, which is a major north-south arterial traversing through the cities of Altadena, Pasadena, and South Pasadena
- SR-19 (Rosemead Boulevard), which provides access to the San Gabriel Valley and south Los Angeles areas
- Santa Anita Avenue, which is a major north-south arterial traversing through the cities of Arcadia, Temple City, and El Monte
- I-605 (San Gabriel River Freeway), which provides north-south access from Historic Route 66 to Orange County connecting to the I-405 freeway
- SR-57, which provides a north-south connection to Glendora, San Dimas, Pomona, Diamond Bar, and Orange County.

The I-210 Corridor is a divided eight to ten-lane freeway with a concrete median and an additional outside auxiliary lane at various sections throughout most of the corridor. A

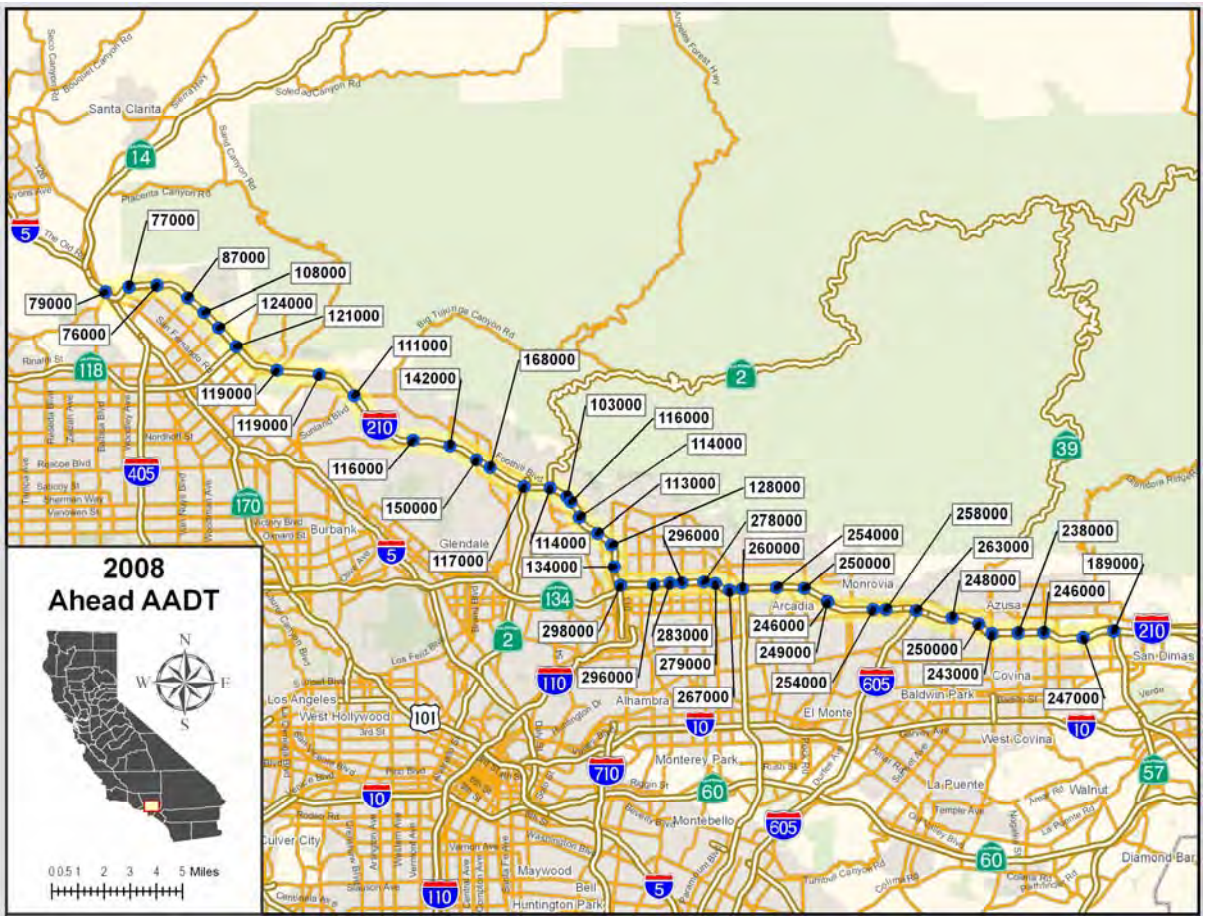
single High Occupancy Vehicle (HOV) lane is provided in each direction through the congestion urban area, which is the focus of the study corridor (from the SR-134 interchange to the SR-57 interchange). Exhibit 2-1 illustrates the lane configurations along the I-210 Corridor and highlights the congested urban area.

Exhibit 2-1: I-210 Corridor Lane Configuration



The 2008 Caltrans Traffic and Volume Data Systems indicate that the annual average daily traffic (AADT) ranges from 76,000 to 298,000 vehicles per day, as depicted in Exhibit 2-2.

Exhibit 2-2: Major Interchanges and AADT along the I-210 Corridor

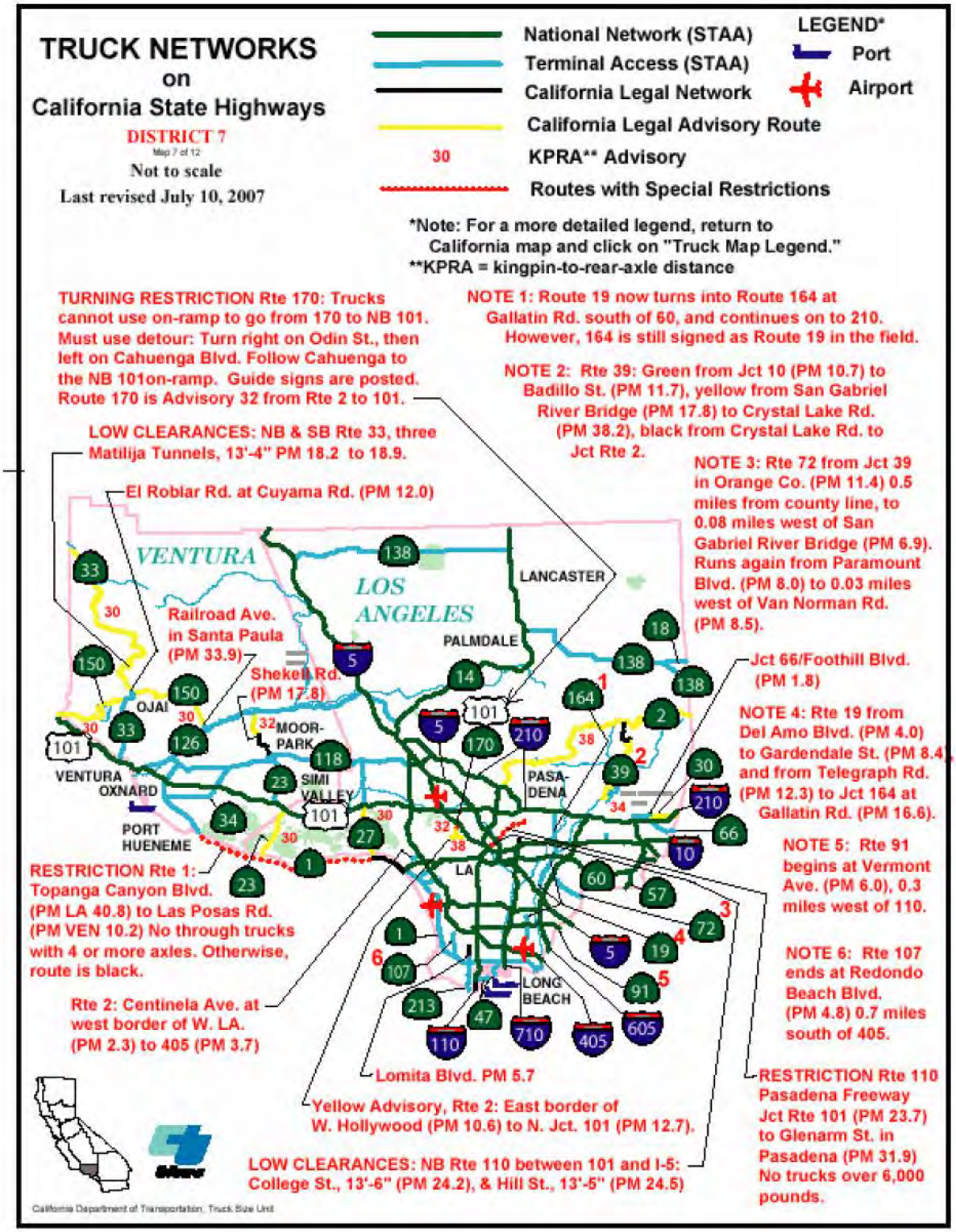


Source: AADT is from the Caltrans Traffic and Vehicle Data Systems Unit[1]

As illustrated in Exhibit 2-3, the I-210 Corridor is a part of the Surface Transportation Assistance Act (STAA) National Truck Network. According to the 2007 Annual Average Daily Truck Traffic on the California State Highway System published by Caltrans in September 2008, this corridor's daily truck traffic ranges from 4.2 percent to 9.9 percent of the total daily traffic.

[1] http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

Exhibit 2-3: Los Angeles and Ventura County Truck Networks



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Recent Roadway Improvements

Several roadway improvements have recently been completed and are currently under construction along the corridor. In preparation of System-Wide Adaptive Ramp Metering (SWARM) implementation, various on-ramps between SR-134 and SR-57 have been modified either to remove or implement metering with traffic signals on the HOV bypass lanes. Also, freeway connector on-ramps from I-605 and SR-57 have been modified to implement connector metering with traffic signals. Closed-circuit television (CCTV) cameras and fiber optic communications are being added along the corridor.

Transit

Major transit operators within the I-210 Corridor include Los Angeles County Metropolitan Transportation Authority (Metro), Metrolink commuter rail service, Foothill Transit, Los Angeles City Department of Transportation Commuter Express, and Pasadena Area Rapid Transit System (ARTS).

Metro services 1,433 square miles in Los Angeles County with over 190 bus lines and an average weekday passenger boarding of 1,200,000. It operates bus, bus rapid, and rail service along the I-210 Corridor. Within the corridor, Metro operates Line 236 which runs from the I-5 interchange to a parallel route along Glenoaks Boulevard and Hubbard Street to the San Fernando Metrolink Station. Line 224 operates from the Los Angeles County Olive View-UCLA Medical Center just north of I-210 and runs parallel to the corridor along San Fernando Road. Lines 90 and 91 provide parallel service along the I-210 Corridor from Sunland to downtown Los Angeles. Line 292 services the Glenoaks Boulevard corridor parallel to the I-210 Corridor. Line 290 runs along the corridor and Foothill Boulevard in Sunland. Line 267 operates from La Canada Flintridge to Pasadena along Lincoln Avenue and Del Mar Boulevard and Line 394 operates along San Fernando Road, which is parallel to the I-210 Corridor. Within the study corridor, Lines 177 and 181 also operate on parallel local routes in the Cities of Pasadena and Arcadia. In addition to these bus lines, Metro operates Metro Rapid 780 along Colorado Boulevard terminating at the Hill Street station. Metro Rail Gold Line provides light-rail service from downtown Los Angeles Union Station to the Sierra Madre Villa station. This service runs along the center median of the I-210 freeway and terminates at the Sierra Madre Villa station.

Foothill Transit provides many bus lines servicing 327 square miles of the San Gabriel and Pomona Valley area. It has a weekday ridership of more than 48,000 with an annual ridership of approximately 15 million. Along the I-210 Corridor, some of the major Foothill Transit lines include: Line 690 runs on the I-210 Corridor from Pasadena to pass the SR-57 interchange; Line 187 provides parallel service along Colorado Boulevard; Line 184 runs along both northerly and southerly of the corridor and provides

service from the City of Arcadia to the City of Duarte; Line 492 provides parallel service along Live Oak Avenue and Arrow Highway, south of the I-210 Corridor.

The City of Los Angeles Department of Transportation also operates two Commuter Service lines that service the San Gabriel Valley. Line 549 runs on the SR-134 (Ventura Freeway) from the Encino and North Hollywood area to the Pasadena area, and Line 409 connects downtown Los Angeles to the Glendale/Montrose area within the vicinity of the study corridor.

Other transit agencies, such as the Pasadena Rapid Transit System and the Glendale Bee, operate local bus service that provides transportation between residential neighborhoods and business centers.

Exhibit 2-4 provides a Metro map of the transit lines servicing the various routes along the I-210 Corridor.

Exhibit 2-4: Metro Area Transit Map Servicing Routes along I-210 Corridor

The Metrolink Antelope Valley Line provides commuter rail service from the Antelope Valley along the I-5 and San Fernando Road to downtown Los Angeles. It runs parallel to the I-210 Corridor from the I-5 and continues in a southwesterly direction to downtown Los Angeles. Exhibit 2-5 provides the system-wide Metrolink map for the Southern California region.

Exhibit 2-5: Metrolink Commuter Rail System Map

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Special Event Facilities and Trip Generators

Exhibit 2-6 maps some of the major institutions, centers, and facilities that may generate large number of trips along the I-210 Corridor. Most of these facilities are concentrated in the congested urban area.

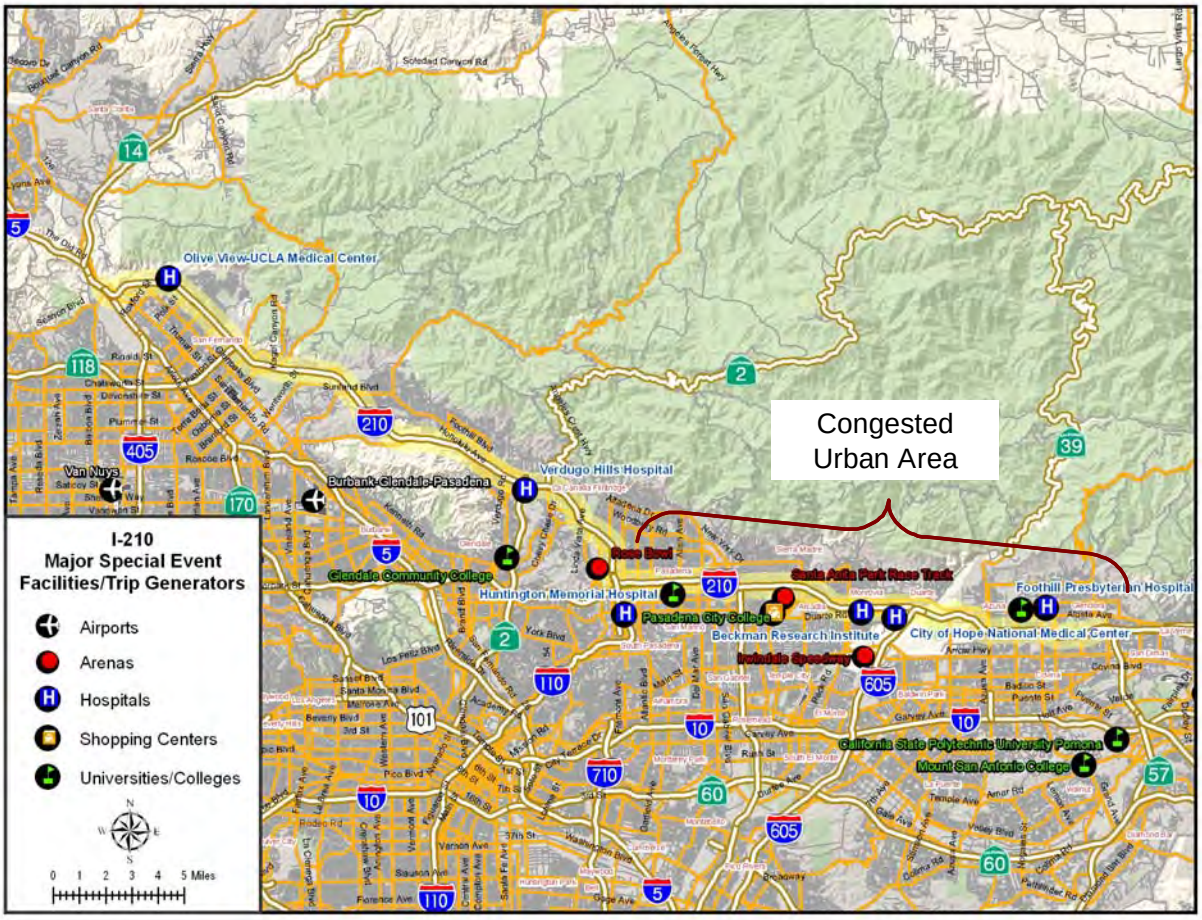
There are fourteen colleges/universities near the I-210 Corridor. The smaller colleges have student enrollments of less than 2,000. The California State Polytechnic University Pomona is located south of the I-210 and is a public university with an estimated enrollment of 25,500 students. Mount San Antonio College is approximately five miles south of the I-210 in the City of Walnut. It is the largest public two-year community college in the nation with an estimated enrollment of 42,000 students. Citrus College is located one mile north of the I-210 and is a public 2-year college with estimated enrollment of 12,000 students. Azusa Pacific University is located one mile south of the I-210 and is a private four-year college with an estimated enrollment of 8,200 students offering Bachelors, Masters, and Doctorate Degrees. Pasadena City College, one mile south of the I-210, is a public two-year college with an estimated enrollment of 29,000 students. Glendale Community College is approximately five miles near the SR-2 freeway. It is a two-year college with an estimated enrollment of 21,000 students. In addition to these educational facilities, many school districts are located along the I-210 Corridor with traffic that could affect corridors in mornings and afternoons.

There are five major medical facilities within proximity of the corridor. Foothill Presbyterian Hospital is located one mile north of I-210 in the city of Glendora, west of the SR-57. It provides general acute care services, 24-hour emergency room services and medical/surgical services with 106 hospital beds. City of Hope National Medical Center is a non-profit organization and is a designated cancer center. City of Hope comprises an ambulatory and in-patient cancer treatment center as well as a biomedical research facility known as the Beckman Research Institute. It has 158 licensed hospital beds, 84 of which are devoted to bone marrow transplantation patients. Verdugo Hills Hospital, located south of the I-210 freeway near the junction of the Glendale Freeway, provides acute care facility with an emergency room and contains 158 beds. Olive View-UCLA Medical Center is located north of I-210 and three miles east of the I-5 Freeway. It is a teaching hospital affiliated with UCLA School of Medicine with 377 beds. St. Luke Medical Center is north of the I-210 in the city of Pasadena with an emergency room with 165 beds.

Another major special event facility is the Rose Bowl Stadium, which is located northwest of the I-210/SR-134 interchange. The stadium is the home of the Tournament of Roses Football Game, UCLA Bruin Football, Fourth of July celebrations, concerts, religious services, filming, and the World's Largest Flea Market. It has a seating capacity of over 90,000 and its parking lots are available for a wide variety of rental uses.

Other major special event facilities include the Santa Anita Park Horse Track, Irwindale Speedway, and various large shopping malls. The Bob Hope Airport in Burbank is also a major traffic generator.

Exhibit 2-6: Major Special Event Facilities/Trip Generators



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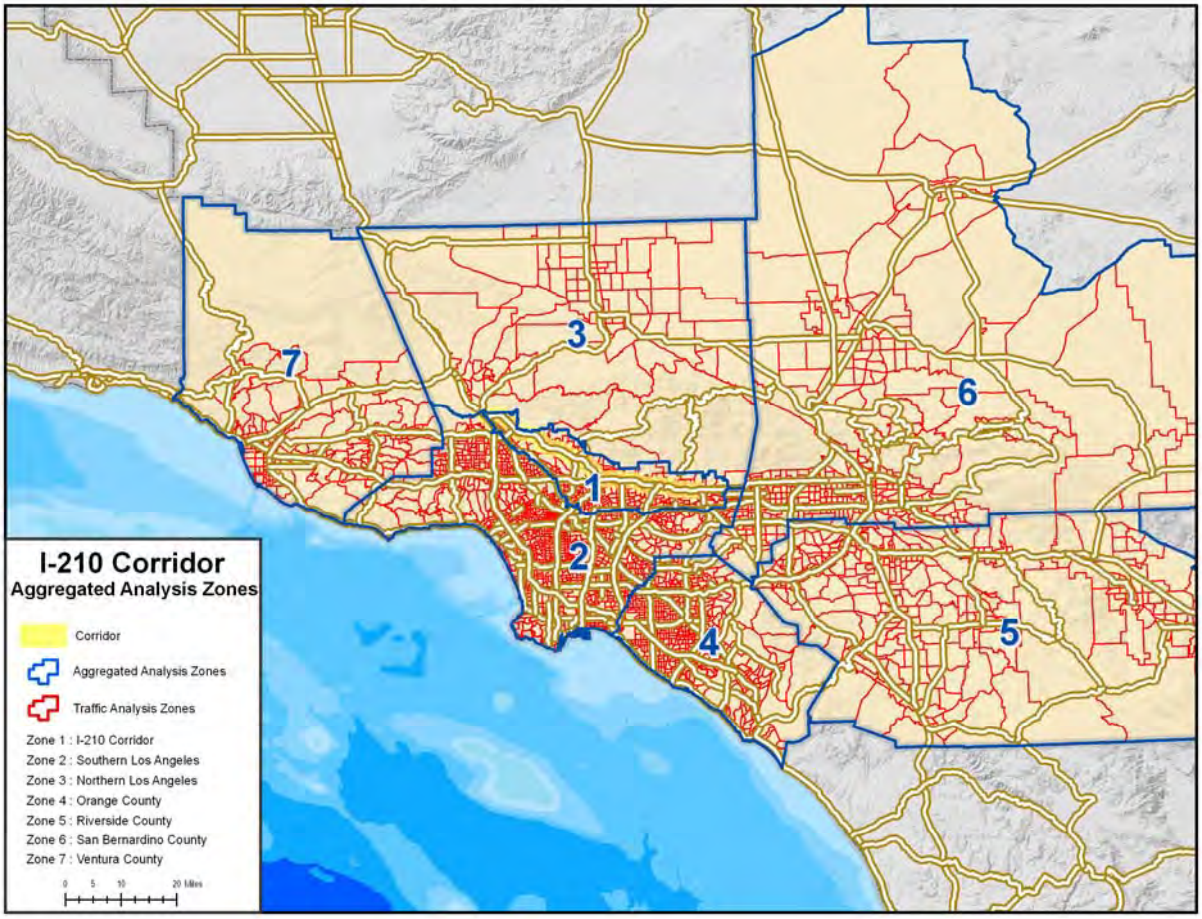
Demand Profiles

Caltrans' version of the SCAG travel demand model was used to characterize the travel pattern of trips made on the I-210 Corridor. A "select link analysis" helped to isolate the corridor and identify the origins and destinations of trips along I-210. The origins and destinations were identified by Traffic Analysis Zone (TAZ), which were grouped into the seven aggregate analysis zones mapped in Exhibit 2-7.

Exhibit 2-7: Aggregate Analysis Zones for Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zone as depicted in Exhibits 2-8 and 2-9 for the AM and PM peak periods. This analysis shows that the vast majority (about 86 percent) of travelers along the I-210 study corridor are traveling within Los Angeles County. About 38 percent of the travel is for trips along the corridor and another 41 percent is for travel to and from Zone 2 (Southern Los Angeles County), which includes Downtown Los Angeles and the urban core of the region.

During the AM peak period, 87 percent of all trips originate and terminate in Los Angeles County. Of this percentage, 39 percent represents travel along the corridor, while 41 percent represents travel to and from Southern Los Angeles County and the other 7 percent traveling to other parts of Los Angeles County. As depicted in Exhibit 2-8, the remaining trips originate outside Los Angeles County and terminate in Los Angeles County (8 percent), originate in Los Angeles County and terminate in other counties (5 percent), or originate and terminate outside Los Angeles County (less than 1 percent). This data suggests that a large percentage of traffic in the AM peak period uses I-210 to connect to other freeways headed south to Southern Los Angeles County.

Exhibit 2-8: AM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE							
	AM Trips	**I-210 Corridor**	**Southern LA**	**Northern LA**	**Orange County**	**Riverside**	**San Bernardino**	**Ventura**	**Outside Zones**
FROM ZONE	**I-210 Corridor**	83,477	49,842	3,872	3,230	622	3,431	884	483
	Southern LA	37,275	1,703	504	31	129	518	22	225
	Northern LA	7,780	1,766	76	61	29	95	150	14
	Orange County	2,852	45	12	0	0	0	0	74
	Riverside	1,678	286	9	0	0	0	6	113
	San Bernardino	7,932	1,652	71	0	0	0	29	99
	Ventura	2,006	103	50	10	45	109	0	33
	Outside Zones	280	180	9	21	85	90	10	336

86.9%	Trips starting and ending in Los Angeles County
4.6%	Trips starting in LA County and ending outside of LA County
8.0%	Trips staring outside of LA County and ending in LA County
0.5%	Trips starting outside of LA County and ending outside of LA County

The same patterns occur during the PM peak period, which experiences roughly 52 percent more demand than the AM. As shown in Exhibit 2-9, roughly 85 percent of all trips originate and terminate in Los Angeles County. Of this percentage, 38 percent represents travel along the corridor, while 41 percent represents travel to and from Southern Los Angeles County with much smaller percentages traveling to other parts of Los Angeles County. The remaining trips originate outside Los Angeles County and terminate in Los Angeles County (8 percent), originate in Los Angeles County and terminate in other counties (6 percent), or originate and terminate outside Los Angeles County (about 1 percent).

Exhibit 2-9: PM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE							
	PM Trips	**I-210 Corridor**	**Southern LA**	**Northern LA**	**Orange County**	**Riverside**	**San Bernardino**	**Ventura**	**Outside Zones**
FROM ZONE	**I-210 Corridor**	122,552	58,306	10,380	4,747	2,271	11,035	2,886	597
	Southern LA	74,797	2,809	1,617	122	409	2,048	154	363
	Northern LA	7,297	1,092	133	53	43	155	76	16
	Orange County	5,735	55	96	0	0	1	13	111
	Riverside	1,306	248	27	0	0	0	23	135
	San Bernardino	7,103	1,275	167	3	0	0	105	125
	Ventura	2,056	103	55	14	46	134	0	46
	Outside Zones	1,062	546	23	284	341	278	15	1,164

85.4%	Trips starting and ending in LA County
7.6%	Trips starting in LA County and ending outside of LA County
6.1%	Trips staring outside of LA County and ending in LA County
0.9%	Trips starting outside of LA County and ending outside of LA County

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3. CORRIDOR-WIDE PERFORMANCE AND TRENDS

This section summarizes the analysis results of the performance measures used to evaluate the existing conditions of the I-210 Corridor. The primary objectives of the measures are to provide a sound technical basis for describing traffic performance on the corridor. Data from the mainline (ML) and high-occupancy vehicle (HOV) facilities are analyzed separately under each performance measure. Information is presented for several years. The base year for the analysis and subsequent simulation modeling to test CSMP scenarios is 2006.

The performance measures used in this section capture four key areas:

- **Mobility** describes how well people and freight move along the corridor
- **Reliability** captures the relative predictability of travel along the corridor
- **Safety** provides an overview of collisions along the corridor
- **Productivity** describes the productivity loss due to traffic inefficiencies.
- **Pavement Condition** describes the structural adequacy and ride quality of the pavement.

MOBILITY

The mobility performance measures are both measurable and straightforward for documenting current conditions. They can also be forecasted, which makes them useful for future comparisons. Two primary measures are typically used to quantify mobility: delay and travel time.

Delay

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

$$(\text{Vehicles Affected per Hour}) \times (\text{SegmentLength}) \times (\text{Duration}) \times \left[\frac{1}{(\text{Congested Speed})} - \frac{1}{(\text{Threshold Speed})} \right]$$

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 2000 vehicles per hour per lane), while others use a measured or estimated flow rate. The segment length is the distance under which the congested speed prevails. The duration is how long the congested period lasts (measured in hours), with the congested period being the amount of time spent below the threshold speed. The threshold speed is the speed under which congestion is considered to occur. Any speed can be used, but two commonly used threshold speeds are 35 mph and 60 mph.

Caltrans defines the threshold speed as 35 mph and assumes a fixed 2,000 vehicles per hour per lane are experiencing the delay to estimate severe delay for reporting congestion for the statewide Highway Congestion Monitoring Report (HICOMP).

In calculating total delay, PeMS uses the 60 mph threshold speed and the observed number of vehicles reported by detection systems. The congestion results of HICOMP and PeMS are difficult to compare due to these methodological differences, so they are discussed separately in this assessment.

Caltrans Highway Congestion Monitoring Program (HICOMP)

The HICOMP report has been published by Caltrans annually since 1987.[2] Delay is presented as average daily vehicle-hours of delay (DVHD). In HICOMP, Caltrans attempts to capture recurrent congestion during "typical" incident-free weekday peak periods. Recurrent delay is defined in HICOMP as a condition where speeds drop below 35 mph for a period of 15-minutes or longer during weekday AM or PM commute periods.

For the HICOMP report, probe vehicle runs are performed at most only two to four days during the entire year. Ideally, two days of data collection in the spring and two in the fall of the year, 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 PeMS data, congestion levels vary from day to day and depend on any number of factors including accidents, weather, and special events.

Exhibits 3-1 shows yearly delay trends from 2005 to 2007 for the AM and PM peak travel period for both directions along the I-210 Corridor. As indicated, the westbound direction had the most significant congestion during the AM peak period while the eastbound direction experienced the most congestion during the PM peak period. There was a small amount of congestion in the eastbound direction during the AM peak period in 2006 and 2007. However, westbound congestion was insignificant during the PM peak period.

[2] Located at <www.dot.ca.gov/hq/traffops/sysmgtpl/HICOMP/index.htm>

Exhibit 3-1: Average Daily Vehicle-Hours of Delay (2005-2007)

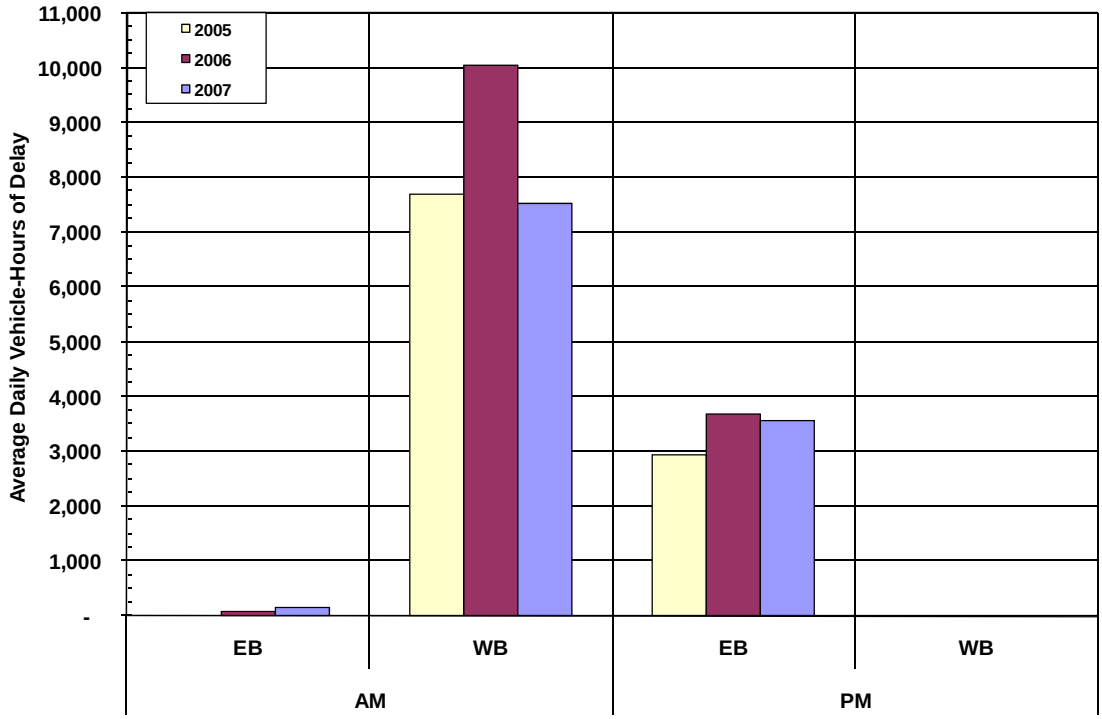


Exhibit 3-2 shows the complete list of congested segments reported in the HICOMP report for the I-210 Corridor. A congested segment may vary in distance or size from one year to the next as well as from day to day.

The most congested segment on the I-210 Corridor in 2007 was in the westbound direction in the AM peak period between Fifth Avenue and Vernon Avenue, where delay experienced in this segment totaled over 2,200 vehicle-hours.

Exhibits 3-3 and 3-4 provide maps illustrating the 2007 congested segments during the AM and PM peak commute periods for the I-210. The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown.

Exhibit 3-2: HICOMP Congested Segments (2005-2007)

Period	Dir	Generalized Congested Area	Generalized Area Congested Hours of Delay 2005	2006	2007
AM	EB	Lincoln Bl to Fair Oaks Ave		78	
		SR134/I210 to Arroyo Blvd			149
	WB	Fruit St to Lone Hill Ave	177		
		Lone Hill Ave to Azusa Ave	2,155	3,143	
		Irwindale Ave to Mountain Ave	3,951	2,007	
		Mountain Ave (Monrovia) to Rosemead Bl		2,015	
		Mountain Ave (Monrovia) to Lake Ave	1,395		
		Mountain Ave (Monrovia) to Rosemead Bl		2,015	
		Foothill Bl to west of Lake Ave		866	
		Hill Ave to Fifth Ave			1,342
		Fifth Ave to Vernon Ave			2,253
		Vernon Ave to Galanto Ave			1,327
		Galanto Ave to Sunflower Ave			1,051
		Sunflower Ave to Walnut Cr			1,547
AM PEAK PERIOD SUMMARY			7,678	10,124	7,669
PM	EB	SR-134 to Baldwin Ave	743		
		JCT SR-164 to El Molino Av			287
		East Banch Arcadia to JCT SR-164			414
		West of Lake Ave to Sierra Madre Bl		431	
		Magnolia Ave to East Branch Arcadia			1,129
		Citrus Ave to Magnolia			1,734
		Sierra Madre Bl to Mountain Ave (Monrovia)		2,771	
		Baldwin Ave to I-605	1,849		
		Irwindale Ave to Citrus Ave	328	469	
PM PEAK PERIOD SUMMARY			2,920	3,671	3,564
		TOTAL CORRIDOR CONGESTION	**10,598**	**13,795**	**11,233**

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

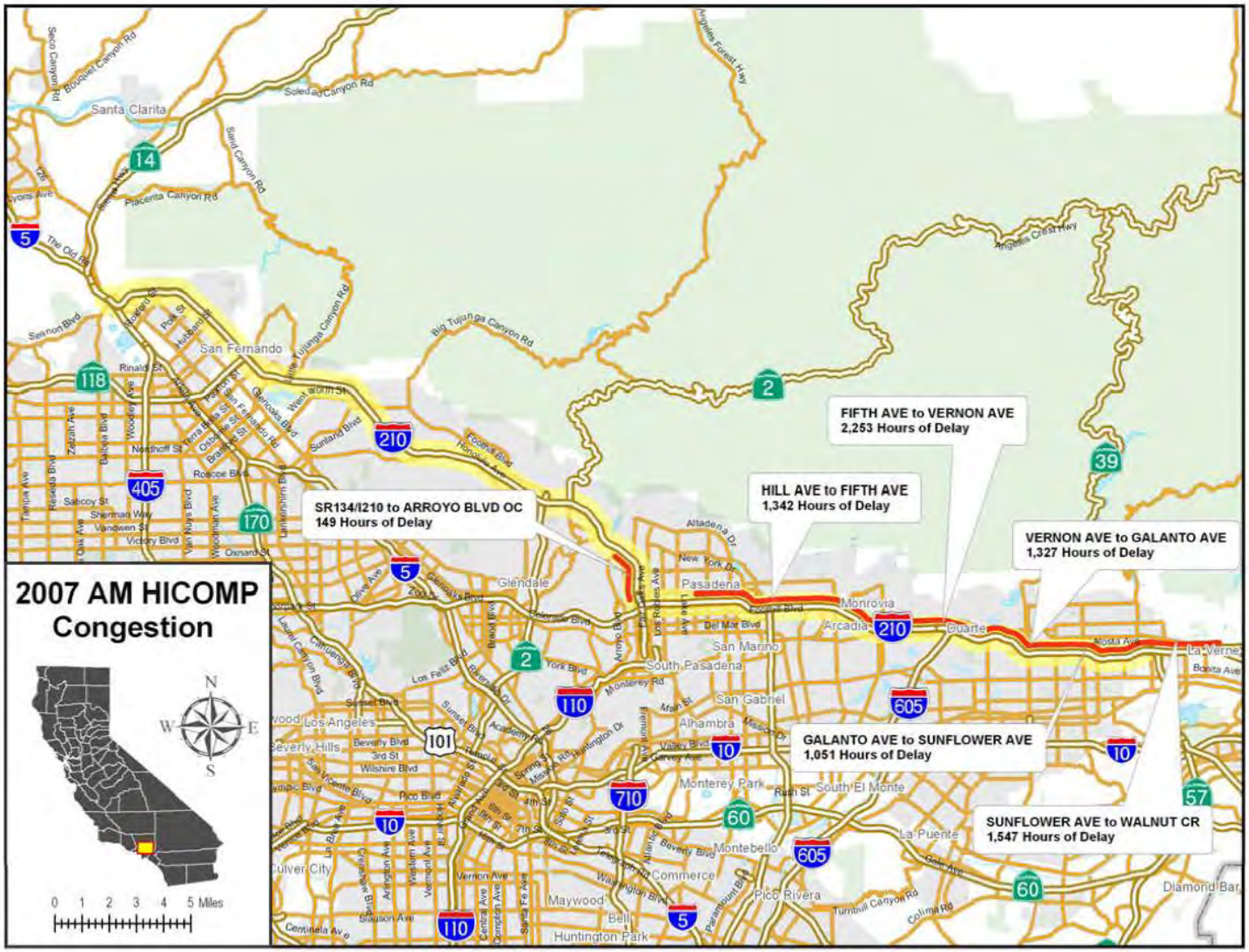
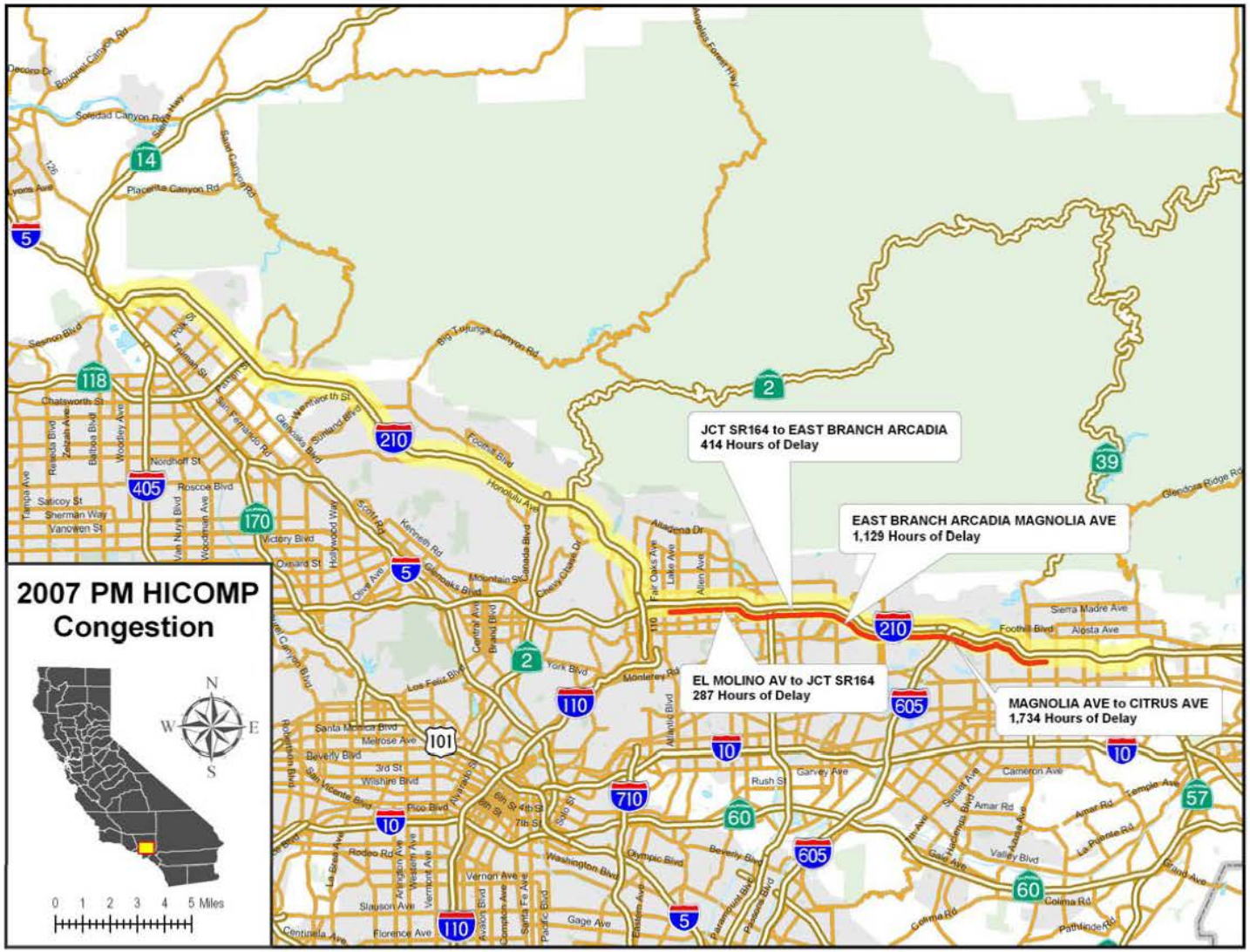


Exhibit 3-4: 2007 PM Peak Period HICOMP Congested Segments Map



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Freeway Performance Measurement System (PeMS)

Exhibit 3-5 is a graphic from PeMS showing the I-210 Corridor vehicle detection stations (VDS) and the "good" (green) and "bad" (red) VDS data available for February 22, 2007. As illustrated in the exhibit, the detection for the I-210 Corridor is mostly good in the congested urban area. The exhibit also shows that no VDS existed west of SR-2 in February 2007. As described in the earlier Freeway Detection Status section, some detection has been added since 2007 in the western portion of the corridor, but there are large gaps and the data quality is bad (see Exhibit 1-3). The existing data does not allow performance to be summarized for the western portion of the corridor, but there is currently and historically little to no congestion along this section of the corridor. Accordingly, the focus of the performance assessment is the congested urban area between the SR-134 (postmile R22) and SR-57 (postmile R45) interchanges.

Exhibit 3-6 shows that data quality for working sensors varies by month throughout the study corridor. The westbound detection is generally better than for the eastbound detection. Detection reaches approximately 80 percent for the westbound direction and approximately 75 percent for the eastbound direction. While not perfect, the data quality is sufficient for the analysis to produce reasonably accurate results.

Exhibit 3-5: PeMS Sensor Data Quality February 22, 2007

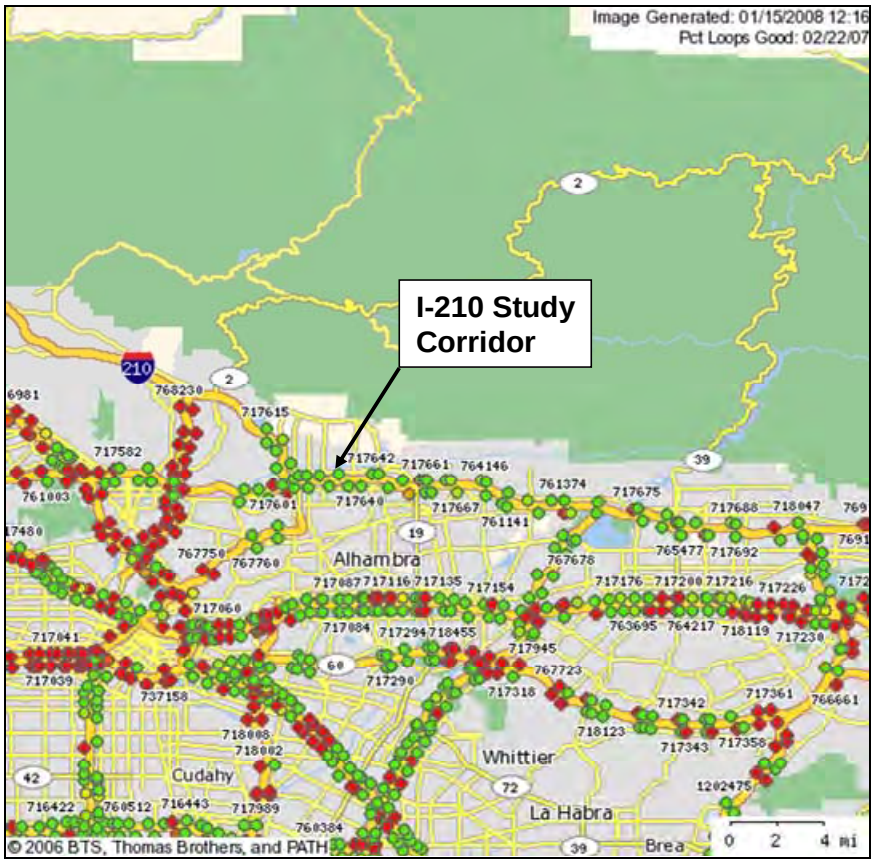
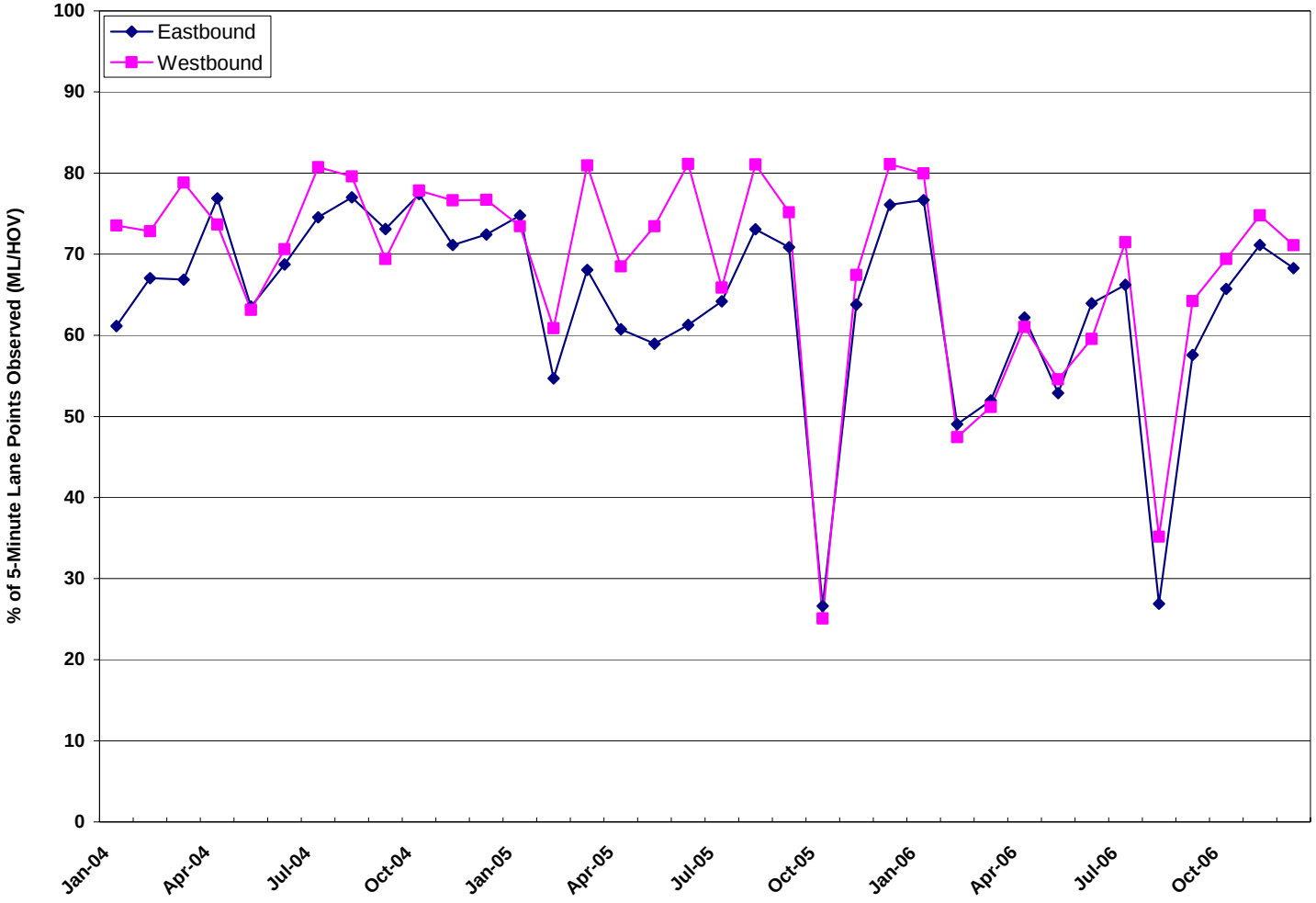


Exhibit 3-6: I-210 (SR-134 to SR-57) PeMS Sensor Data Quality 2004-2006



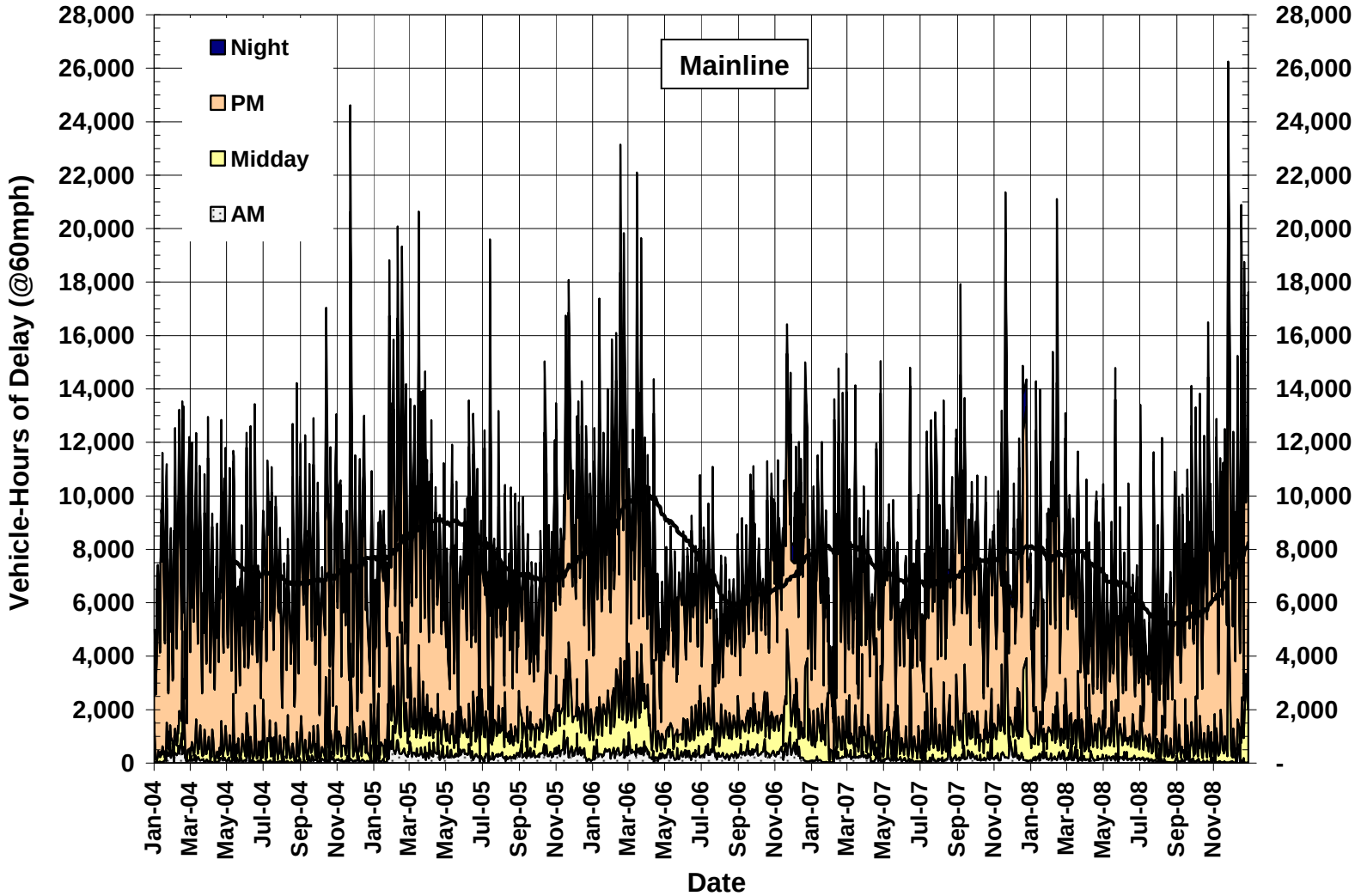
The study compiled five years of PeMS data from 2004 to 2008. Unlike the HICOMP report, in which delay is calculated only for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2000 vehicles per hour, delays presented in this section represent the difference in travel 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. The total delay by time period for the corridor for each direction is shown in Exhibits 3-7 and 3-8.

Total delay along the I-210 Corridor was computed for four time periods: AM peak (6:00 AM to 9:00 AM), Midday (9:00 AM to 3:00 PM), PM peak (3:00 PM to 7:00 PM), and evening/early AM (7:00 PM to 6:00 AM). Delay is computed as the difference in estimated travel time and a hypothetical travel time at a threshold speed of 60 miles per hour. This is different from the Comprehensive System Monitoring and HICOMP reporting methodology, which uses a “severe” threshold speed of 35 mph.

Weekday delay for the mainline facility is presented in Exhibits 3-7 and 3-8 during the five-year period from 2004 to 2008. There is also a 90-day moving average to “smooth” out the day-to-day variations and illustrate better the seasonal and annual changes in congestion over time. I-210 eastbound experiences the highest levels of congestion during PM peak period, while I-210 westbound experiences the highest levels of congestion during the AM peak period. Eastbound PM peak delay averages approximately 5,700 vehicle-hours while westbound AM peak delay averages approximately 4,100 vehicle-hours.

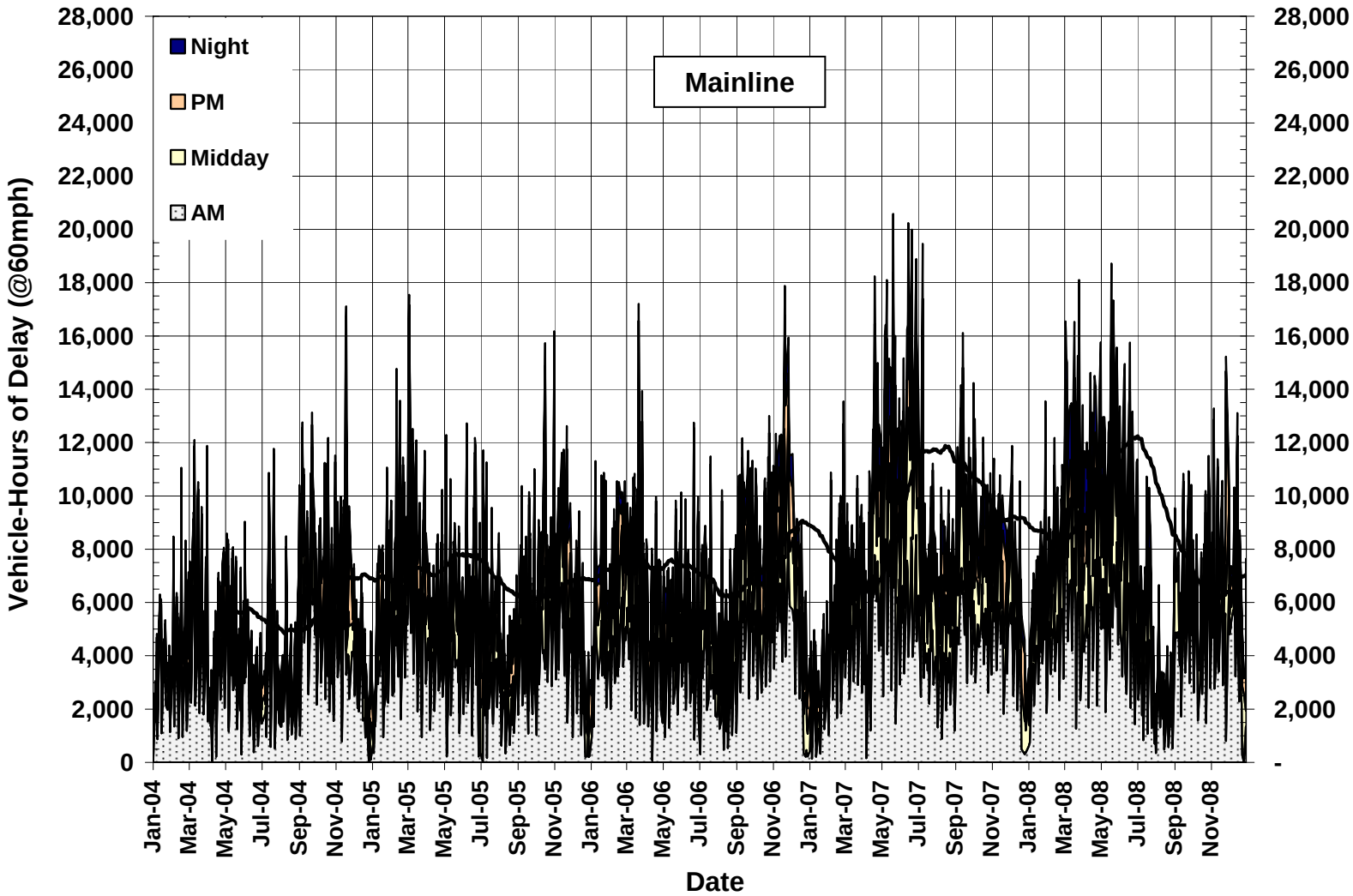
Exhibits 3-9 and 3-10 show that delay on the HOV facility followed the same pattern as the mainline facility with more congestion occurring in the PM peak for the eastbound direction and in the AM peak for the westbound direction. During the 2004-2008 period, the average daily delay on the eastbound HOV lanes was around 1,600 hours with the highest delay occurring in November 2008. Similar to the mainline trend, the westbound HOV facility experienced less delay than did the eastbound facility with an average delay around 1,200 hours during the same five-year period.

Exhibit 3-7: I-210 Eastbound Mainline Average Daily Delay by Time Period (2004-2008)



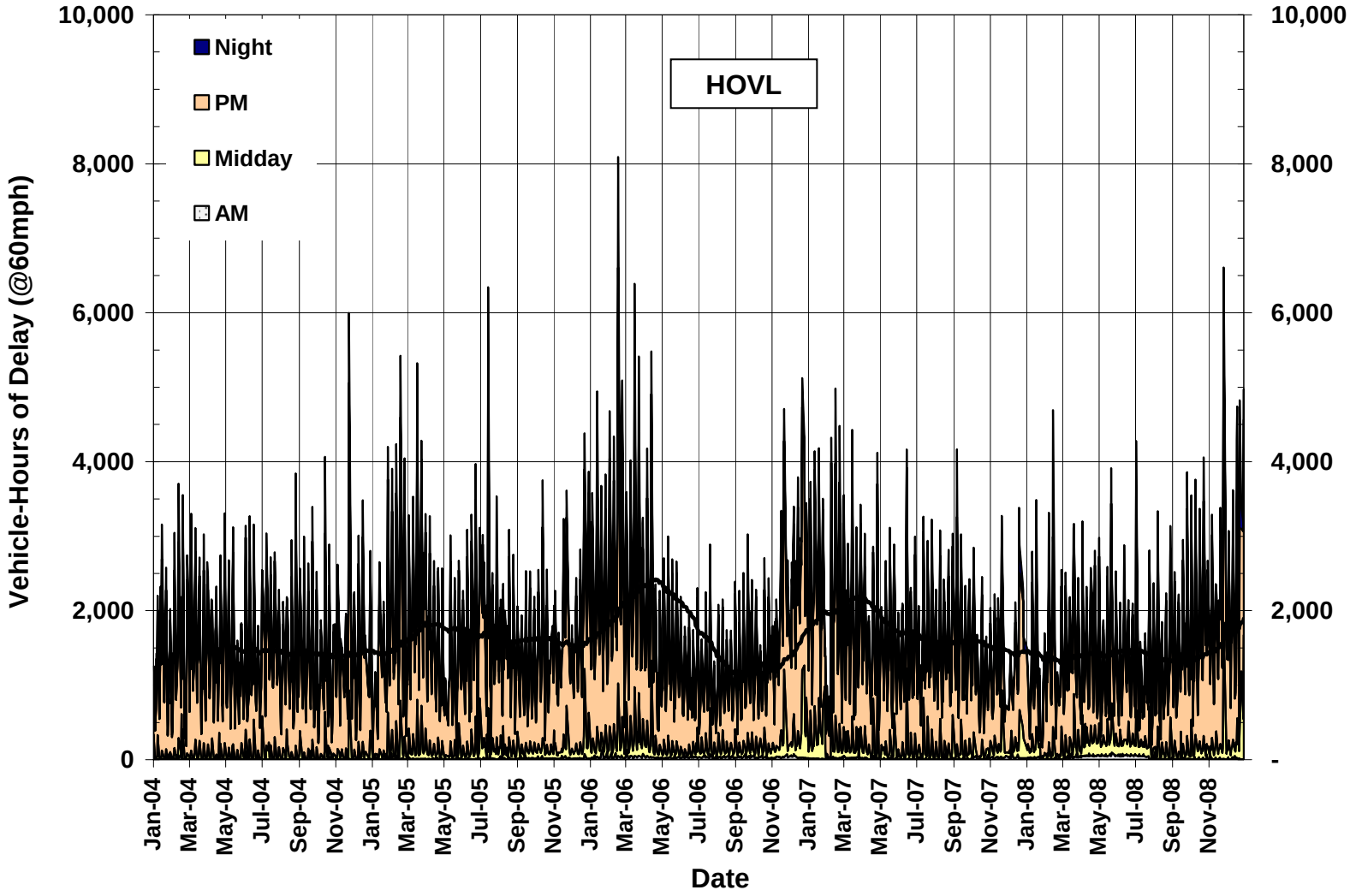
Source: SMG Analysis of PeMS data

Exhibit 3-8: I-210 Westbound Mainline Average Daily Delay by Time Period (2004-2008)



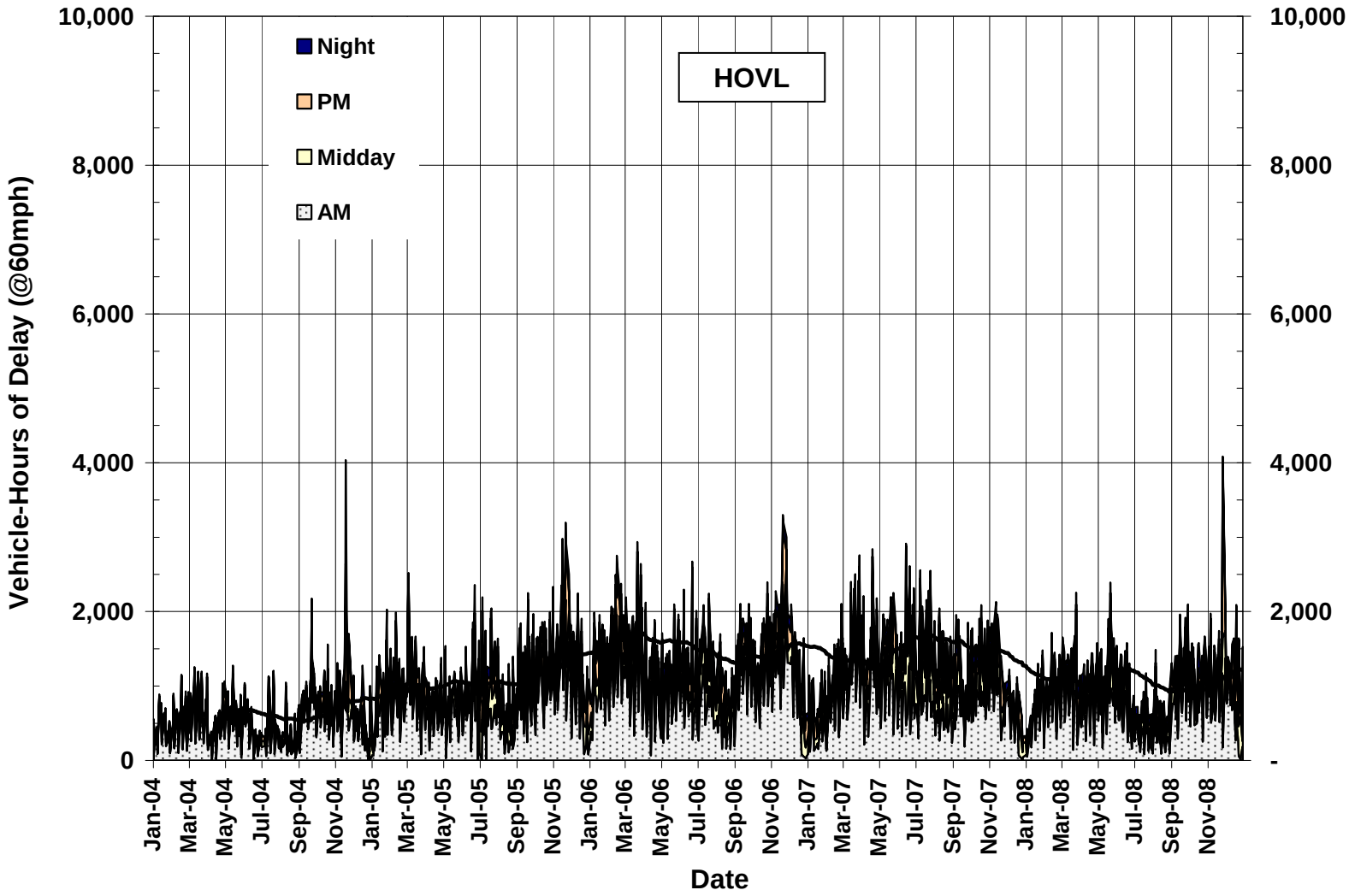
Source: SMG Analysis of PeMS data

Exhibit 3-9: I-210 Eastbound HOV Average Daily Delay by Time Period (2004-2008)



Source: SMG Analysis of PeMS data

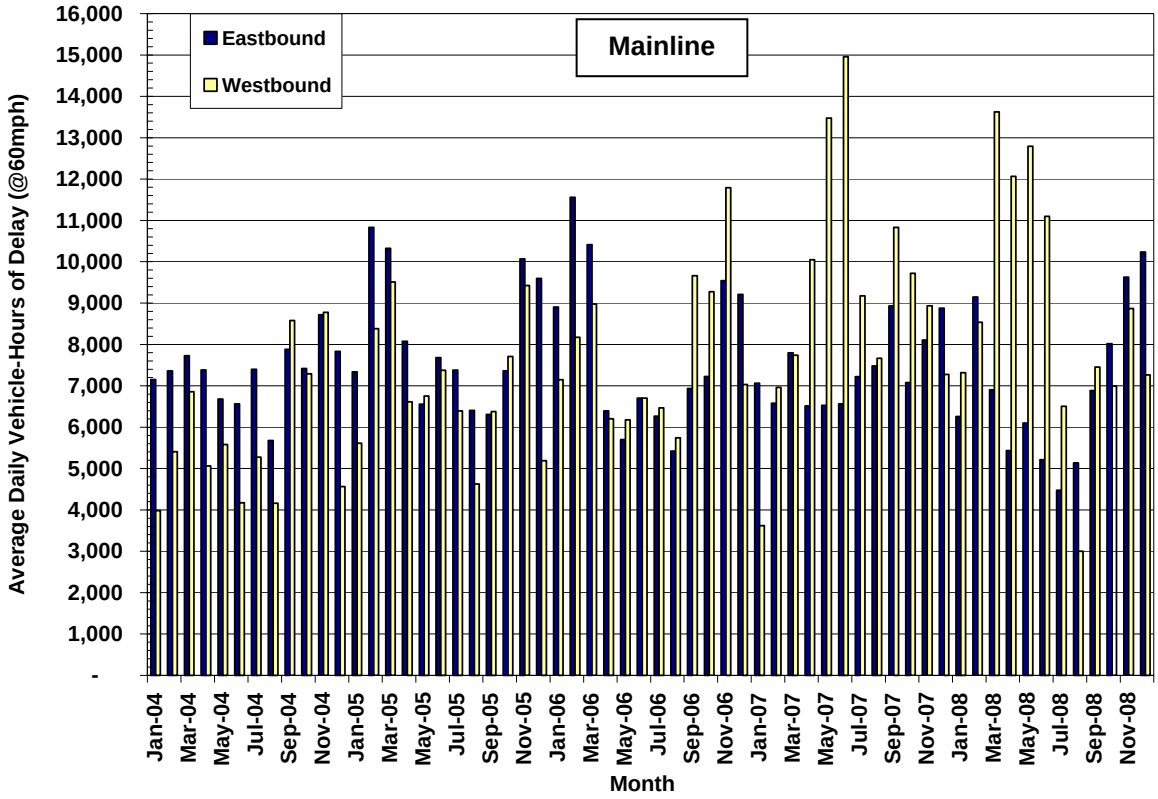
Exhibit 3-10: I-210 Westbound HOV Average Daily Delay by Time Period (2004-2008)



Source: SMG Analysis of PeMS data

Exhibits 3-11 and 3-12 depict the average daily weekday delay by month for the mainline and HOV facilities. As indicated in Exhibit 3-11, the average weekday delay on the mainline facility varies from month to month. Average weekday delays range from approximately 4,500 vehicle-hours to 11,600 vehicle-hours in the eastbound direction and from approximately 3,000 vehicle-hours to 15,000 vehicle-hours in the westbound direction.

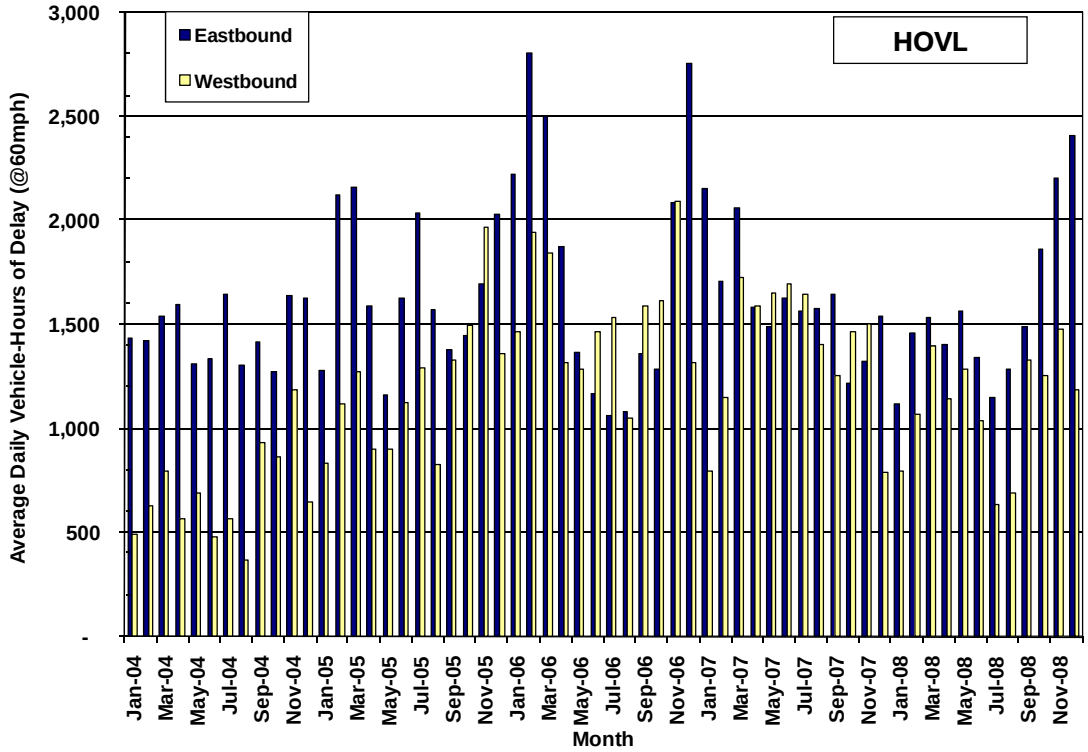
Exhibit 3-11: I-210 Mainline Average Weekday Delay by Month (2004-2008)



Source: SMG Analysis of PeMS data

Exhibit 3-12 shows that the HOV lanes exhibit similar variations. The delays on the eastbound HOV lanes range from 1,060 daily vehicle-hours to 2,800. Like the mainline facility, the westbound HOV lanes exhibit greater variation in delay, ranging from 400 daily vehicle-hours to 2,100 daily vehicle-hours.

Exhibit 3-12: I-210 HOV Average Weekday Delay by Month (2004-2008)



Source: SMG Analysis of PeMS data

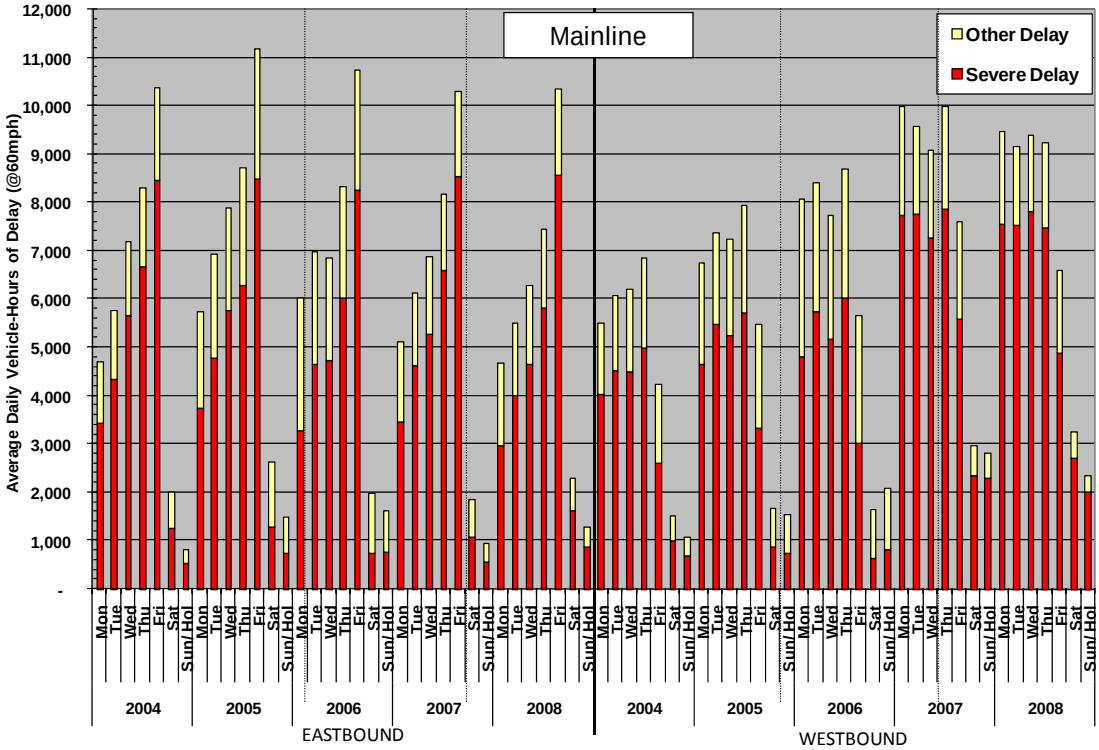
Delays presented to this point represent the difference in travel time between "actual" conditions and free-flow conditions at 60 miles per hour. This delay can be segmented into two components as shown in Exhibits 3-13 and 3-14:

- 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 represents breakdown conditions and is generally the focus of 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. Although combating congestion requires the focus on severe congestion, it is important to review "other" congestion and understand its trends. This could allow for pro-active intervention before the "other" congestion turns into severe congestion.

As indicated in Exhibit 3-13, the eastbound direction experienced the highest "severe" delays on Fridays, peaking at more than 11,000 vehicle-hours in 2005. In the westbound direction, "severe" delays do not vary as drastically among the weekdays. These delays have been increasing since 2004, although 2007 and 2008 delays are of roughly similar magnitude.

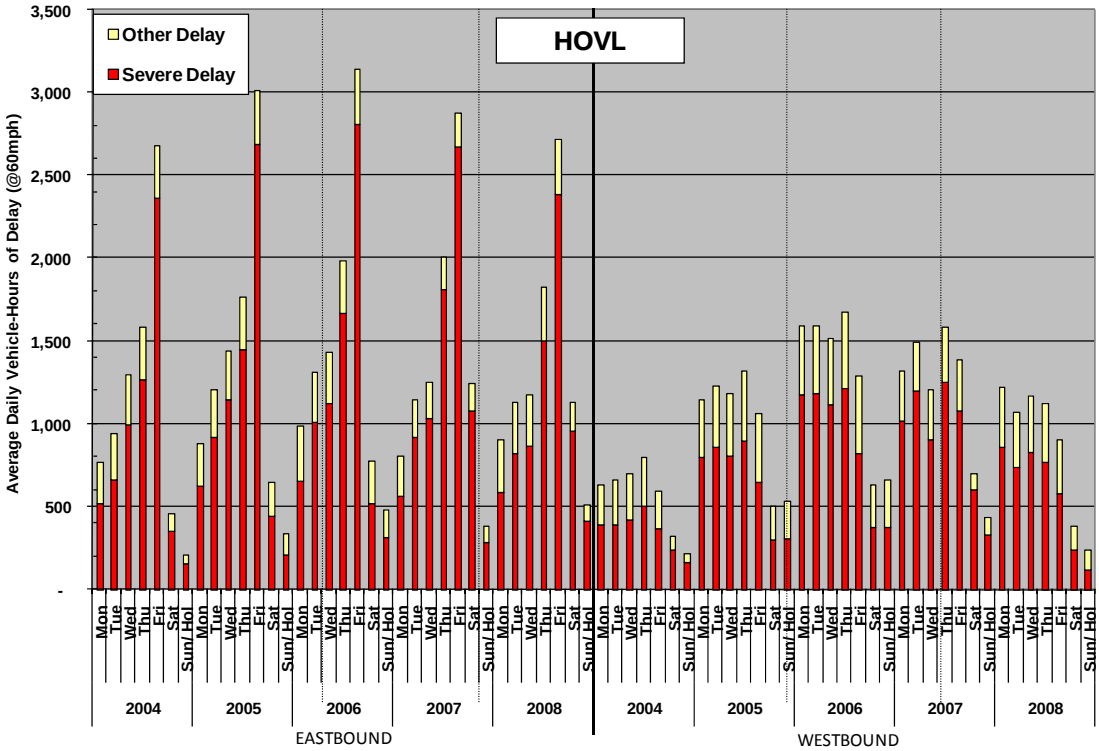
Exhibit 3-13: I-210 Mainline Average Delay by Day of Week by Severity (2004-2008)



Source: SMG Analysis of PeMS data

Exhibit 3-14 shows comparable data for the HOV facility. In the eastbound direction, the variation by day of the week appears to be more pronounced for the HOV facility than for the mainline. Much larger delays occur on Fridays than any other day by a large margin (50 to 70 percent greater delays than on Thursdays). Like the mainline facilities, the HOV lanes exhibit fewer daily vehicle-hours of delay in the westbound direction than in the eastbound direction. The variation among days of the week is also less in the westbound direction, where the highest delays tend to occur on Thursdays.

Exhibit 3-14: I-210 HOV Average Delay by Day of Week by Severity (2004-2008)

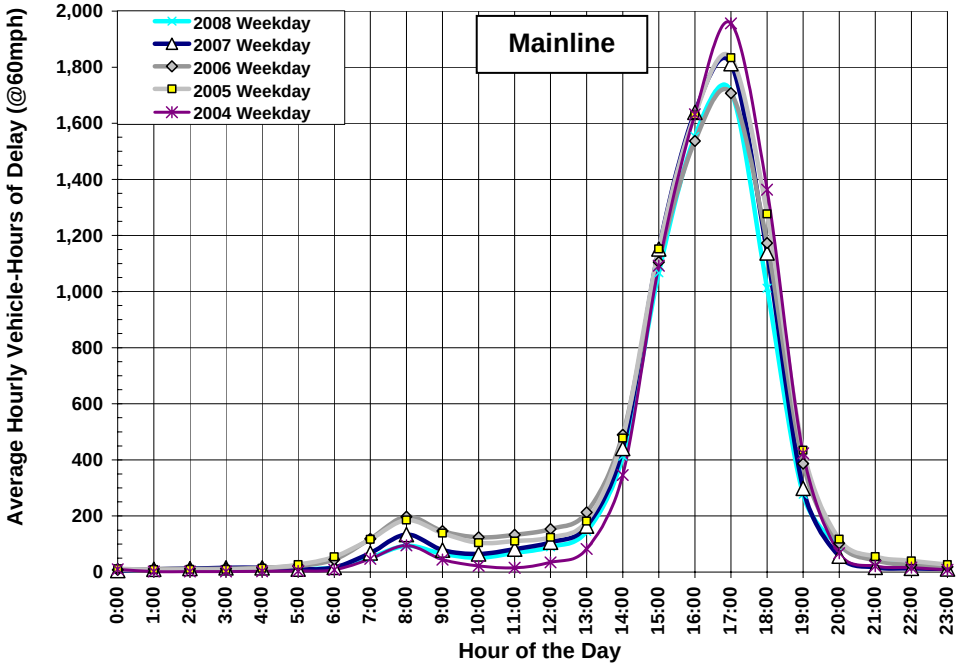


Source: SMG Analysis of PeMS data

Another way to understand the characteristics of congestion and related delays is shown in Exhibits 3-15 through 3-18, which summarize average weekday delay by hour for the five years analyzed (2004 to 2008) for both the mainline and the HOV lanes. These exhibits show the peaking characteristics of congestion and how the peak period is changing over time.

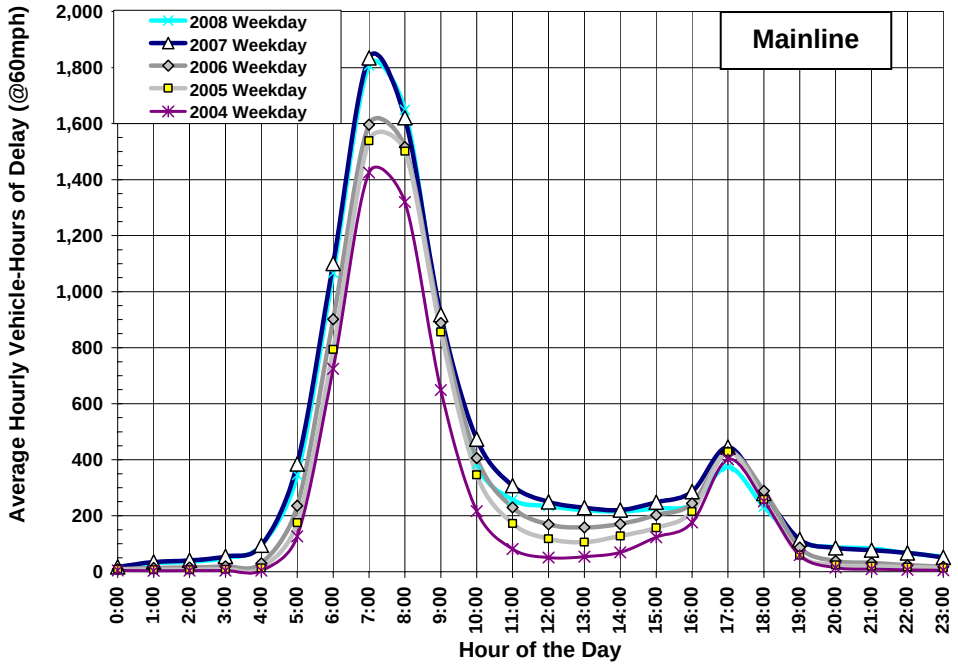
Exhibit 3-15 summarizes the average weekday hourly delay for the mainline in the eastbound direction. Peak hourly delay ranges from 1,700 to 2,400 vehicle-hours with the congested occurring from approximately 2:00 PM to 7:00 PM. Exhibit 3-16 shows the average weekday hourly delay for the mainline in the westbound direction. Peak hourly delay ranges from 1,400 to 1,900 vehicle-hours with the congested period occurring from approximately 5:00 AM to 10:00 AM.

Exhibit 3-15: Eastbound Mainline Average Weekday Hourly Delay (2004-2008)



Source: SMG Analysis of PeMS data

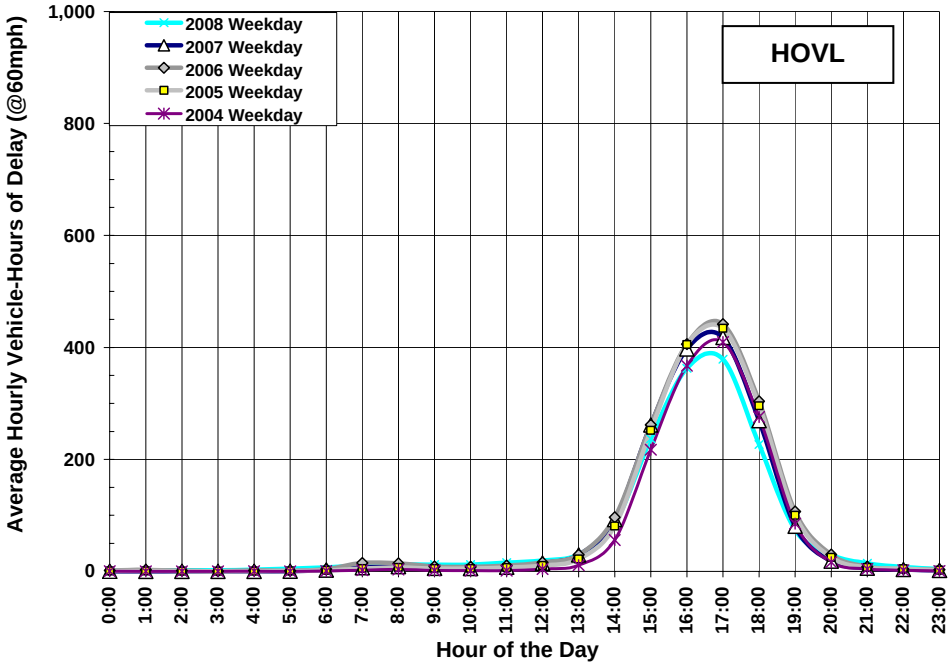
Exhibit 3-16: Westbound Mainline Average Weekday Hourly Delay (2004-2008)



Source: SMG Analysis of PeMS data

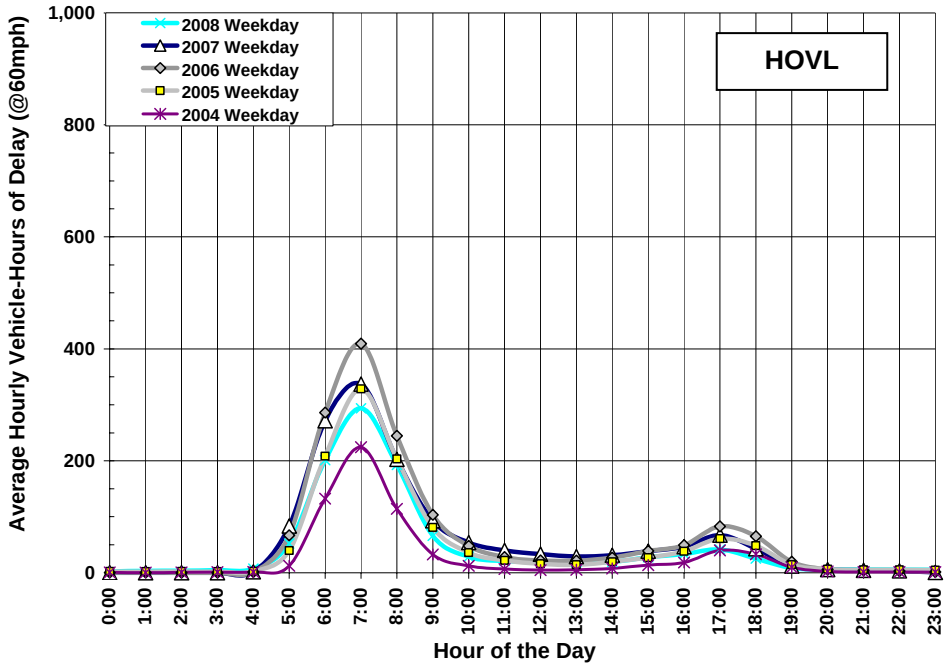
As shown in Exhibits 3-17 and 3-18 delays on the HOV lanes roughly mirror those on the mainline facilities. The HOV westbound direction (Exhibit 3-18) shows two humps with the larger delays in the morning just like the mainline (Exhibit 3-16). In the eastbound direction, the HOV lanes have the largest delays at 4:00 PM and 5:00 PM (Exhibit 3-17). Unlike the mainline facilities (Exhibit 3-17), the HOV facilities do not show much (if any) delay in the eastbound direction during the morning.

Exhibit 3-17: Eastbound HOV Average Weekday Hourly Delay (2004-2008)



Source: SMG Analysis of PeMS data

Exhibit 3-18: Westbound HOV Average Weekday Hourly Delay (2004-2008)



Source: SMG Analysis of PeMS data

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Travel Time

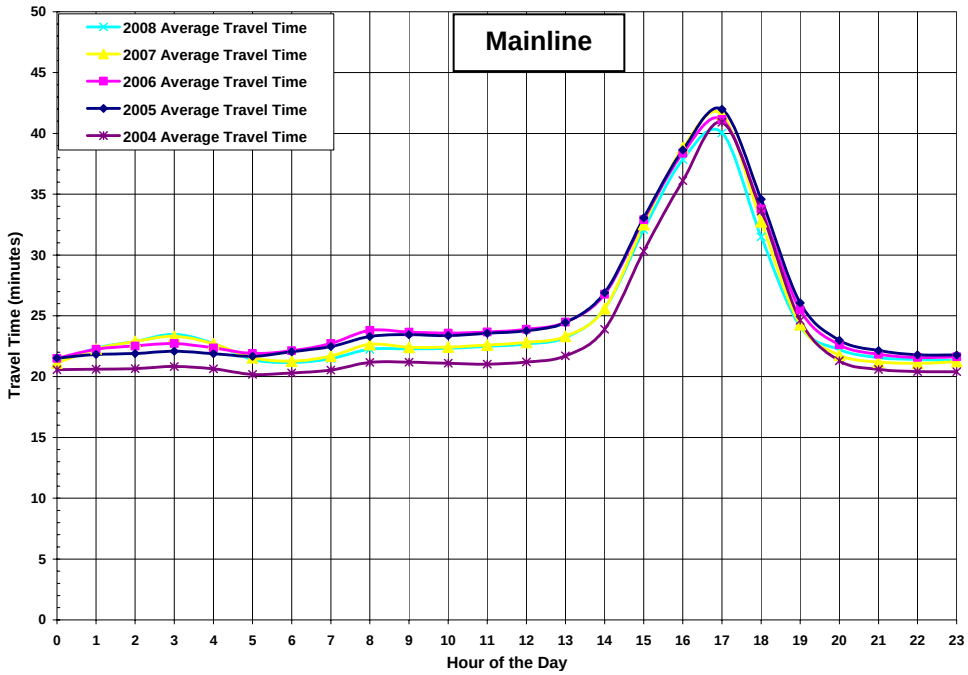
Travel time is reported as the amount of time for a vehicle to traverse the distance between two points on a corridor. In this section, travel time is estimated using data from PeMS for the 23-mile urban area of the I-210 Corridor from west of SR-134 to east of SR-57. Travel time on parallel arterials was not included for this analysis.

Exhibits 3-19 through 3-22 summarize the travel times estimated for the mainline and HOV facilities using PeMS data. As shown in Exhibits 3-19 and 3-20, travel along the mainline takes about 21 to 22 minutes during the off-peak periods. This corresponds to a speed of about 65 mph. As shown in Exhibits 3-21 and 3-22, travel times are comparable, although slightly less, on the HOV lanes.

In the eastbound direction, the mainline had typical travel times of approximately 41 minutes during the PM peak hour (5 to 6 PM). By comparison, the HOV lanes experienced travel times ranging from 41 to 48 minutes during the same peak hour.

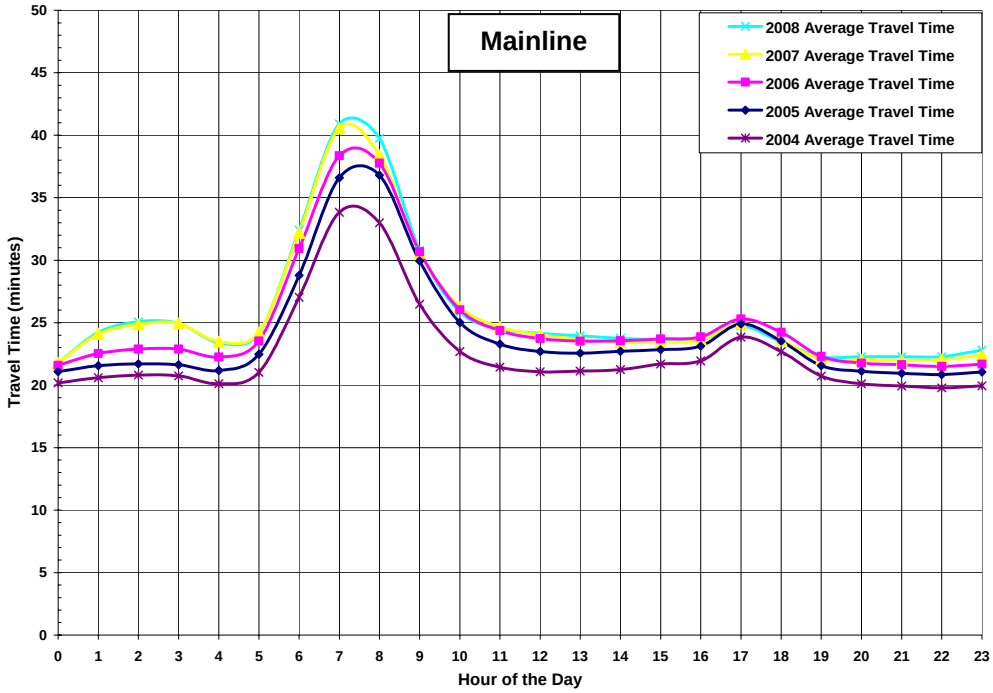
In the westbound direction, the mainline had travel times ranging from 34 to 41 minutes during the AM peak hour (7 to 8 AM). The PM peak hour occurs from 5 PM to 6 PM in the westbound direction. Travel times are about 24 to 25 minutes and only slightly above those found in the off-peak period. The HOV lanes experienced similar travel times in both peak periods.

Exhibit 3-19: Eastbound Mainline Travel Time by Time of Day (2004-2008)



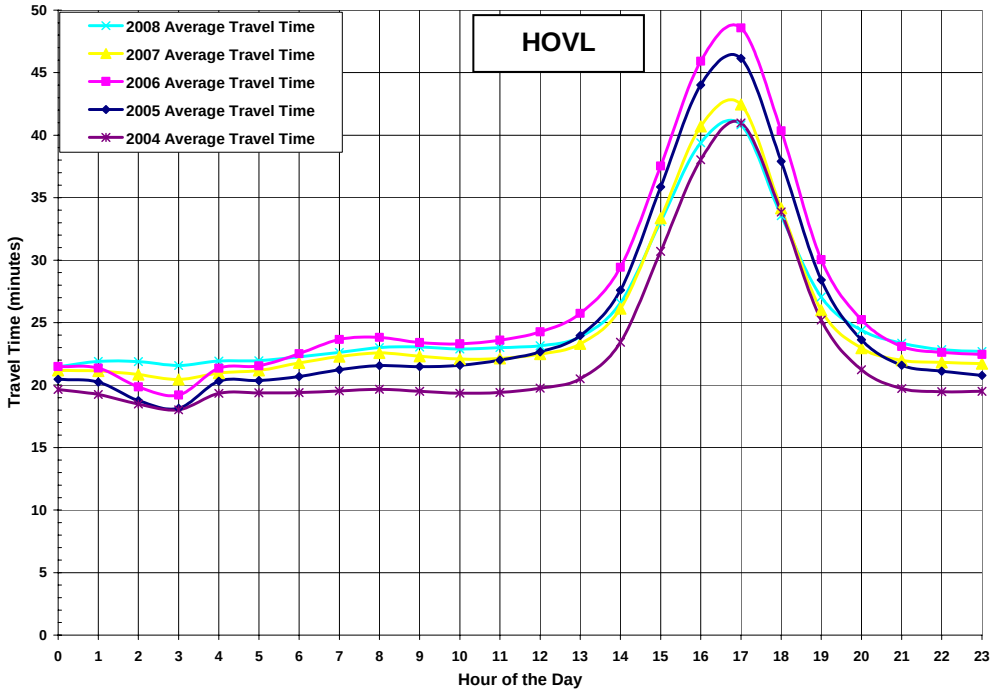
Source: SMG Analysis of PeMS data

Exhibit 3-20: Westbound Mainline Travel Time by Time of Day (2004-2008)



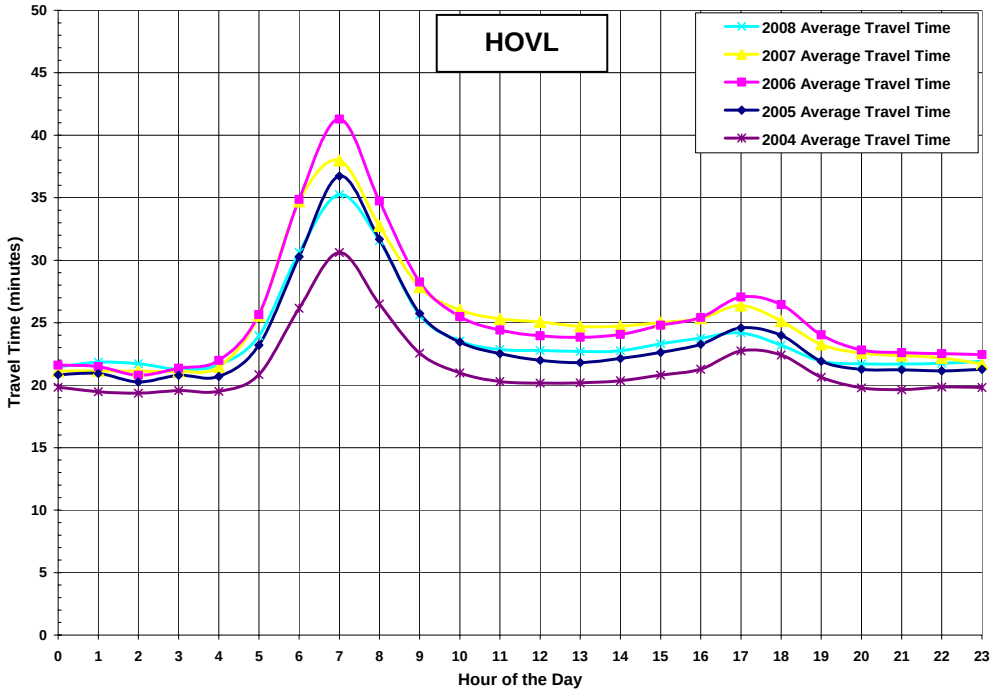
Source: SMG Analysis of PeMS data

Exhibit 3-21: Eastbound HOV Travel Time by Time of Day (2004-2008)



Source: SMG Analysis of PeMS data

Exhibit 3-22: Westbound HOV Travel Time by Time of Day (2004-2008)



Source: SMG Analysis of PeMS data

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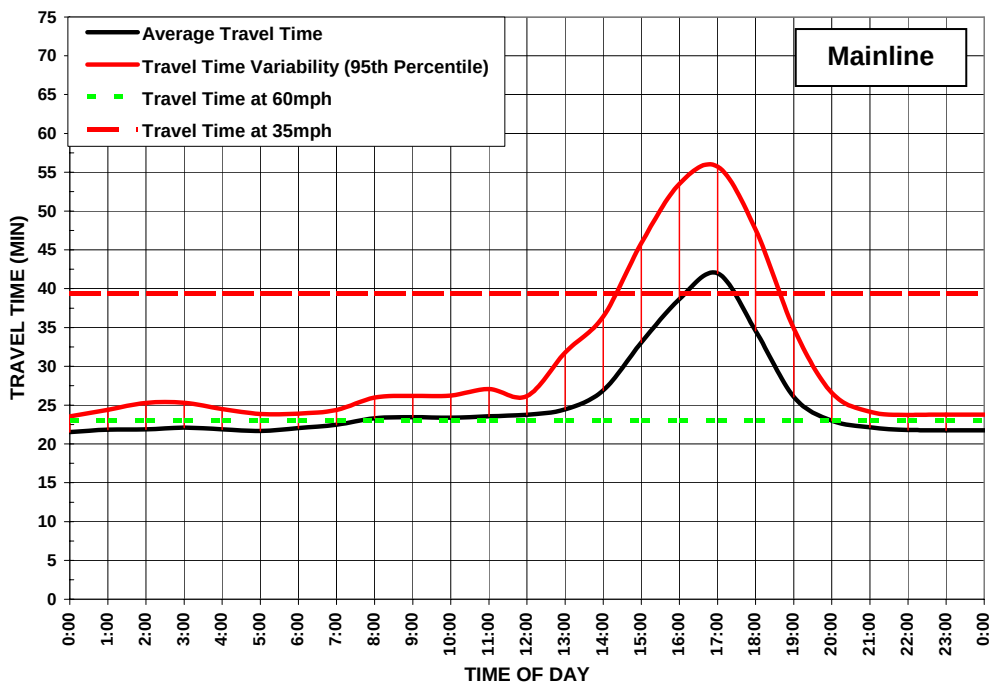
RELIABILITY

Reliability captures the degree of predictability in the public's travel time. Unlike mobility, which measures the rate of travel, the reliability measure focuses on how travel time varies from day to day. To measure reliability, the study team used statistical measures of variability on the travel times estimated from the PeMS data. The 95th percentile was chosen to represent the maximum travel time that most people would experienced on the corridor. Severe events, such as fatal collisions, could cause longer travel times, but the 95th percentile was chosen as a balance between extreme events and a "typical" travel day.

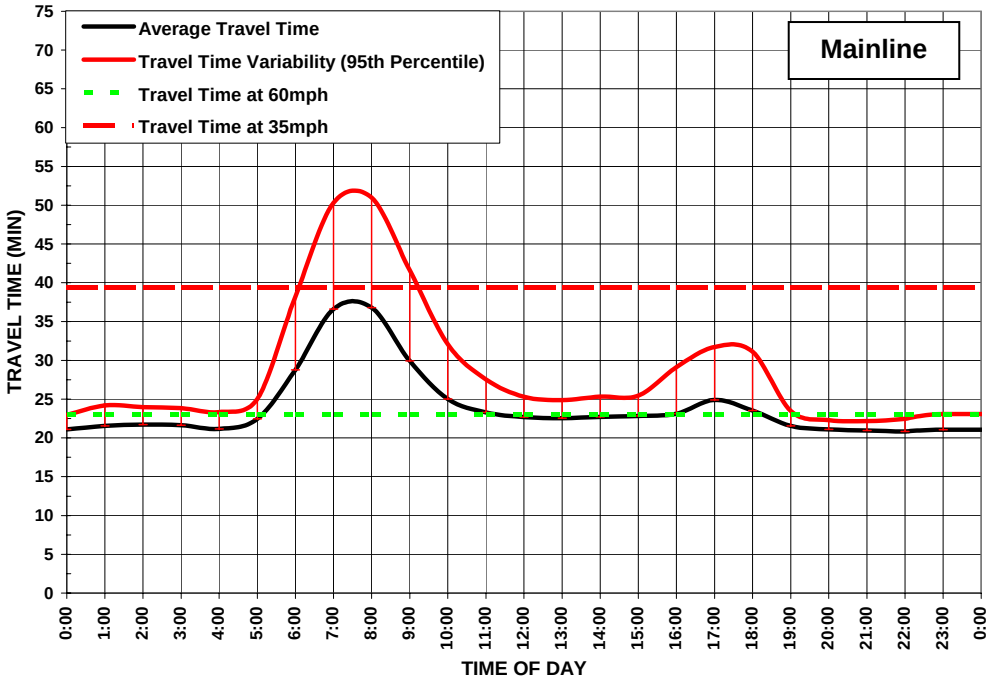
Exhibits 3-23 to 3-32 illustrate the variability of travel time along I-210 from SR-134 to SR-57 for weekdays averaged throughout the indicated year. As evident in the exhibits, travel times can range considerably more than the mean travel time during the peak hours. Daily reliability will vary within this range (mean to maximum) depending on the number and extent of incidents occurring during travel. Travel times of less than the mean are infrequent, typically occurring during the day preceding or following a holiday weekend. The exhibits demonstrate that travel time reliability has been fairly constant over the five years. The greatest reliability occurs during the peak periods – often with travel times reflecting congested conditions (travel at speeds under 35 mph).

Exhibit 3-23: Eastbound Mainline Travel Time Variability (2004)



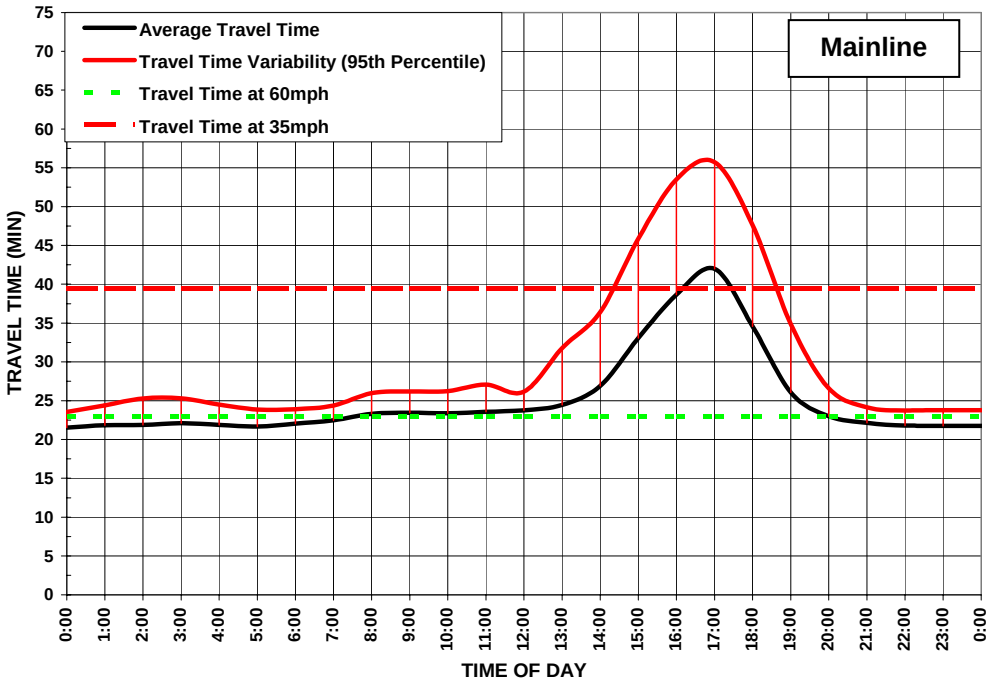
Source: SMG Analysis of PeMS data

Exhibit 3-24: Westbound Mainline Travel Time Variability (2004)



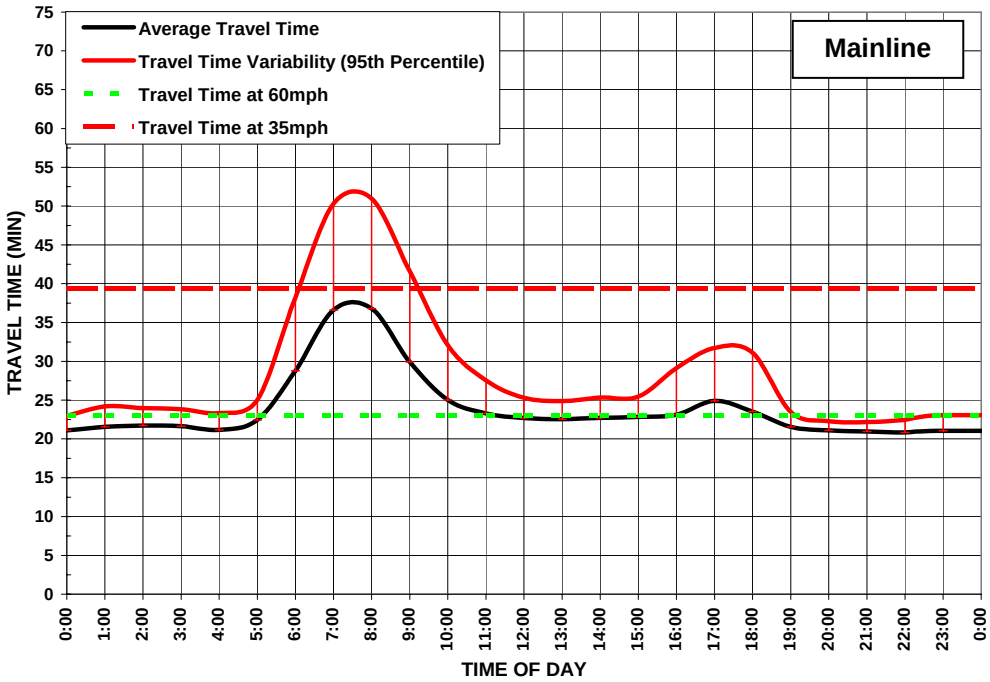
Source: SMG Analysis of PeMS data

Exhibit 3-25: Eastbound Mainline Travel Time Variability (2005)



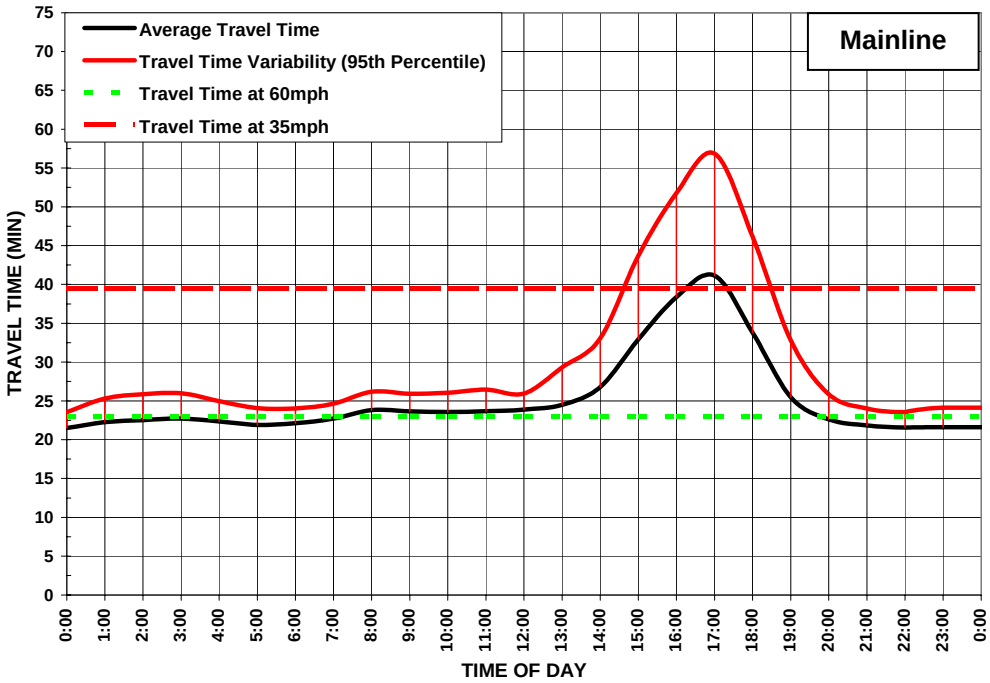
Source: SMG Analysis of PeMS data

Exhibit 3-26: Westbound Mainline Travel Time Variability (2005)



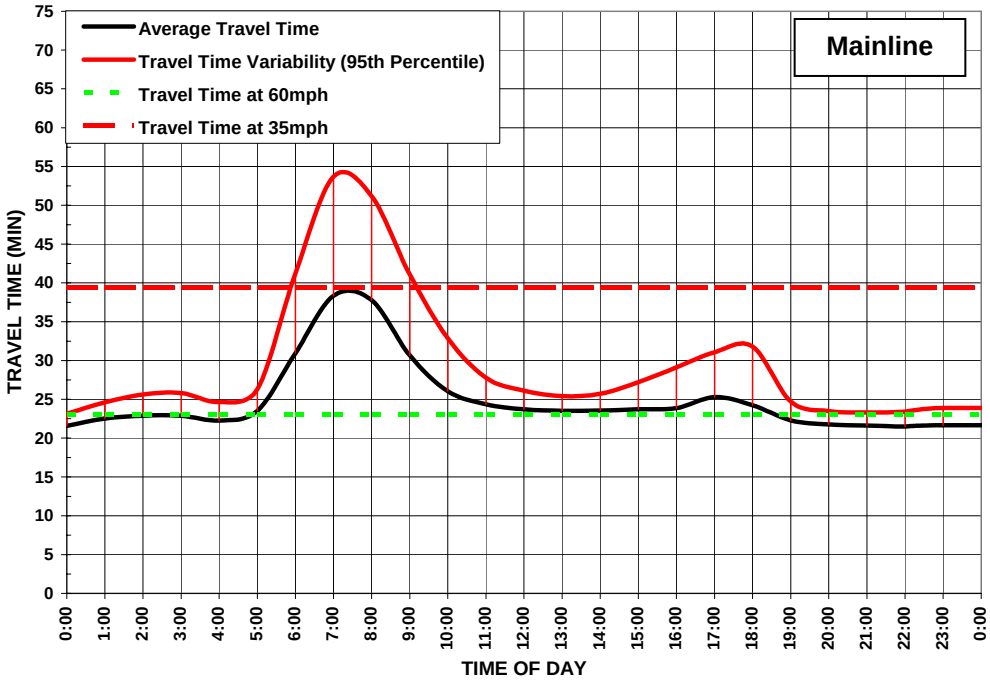
Source: SMG Analysis of PeMS data

Exhibit 3-27: Eastbound Mainline Travel Time Variability (2006)



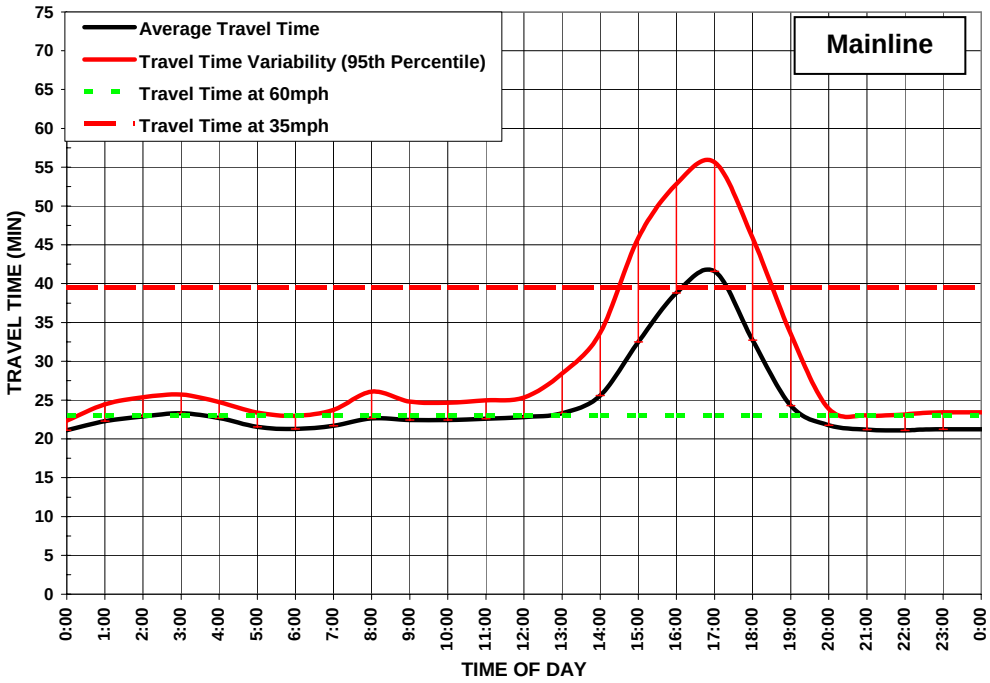
Source: SMG Analysis of PeMS data

Exhibit 3-28: Westbound Mainline Travel Time Variability (2006)



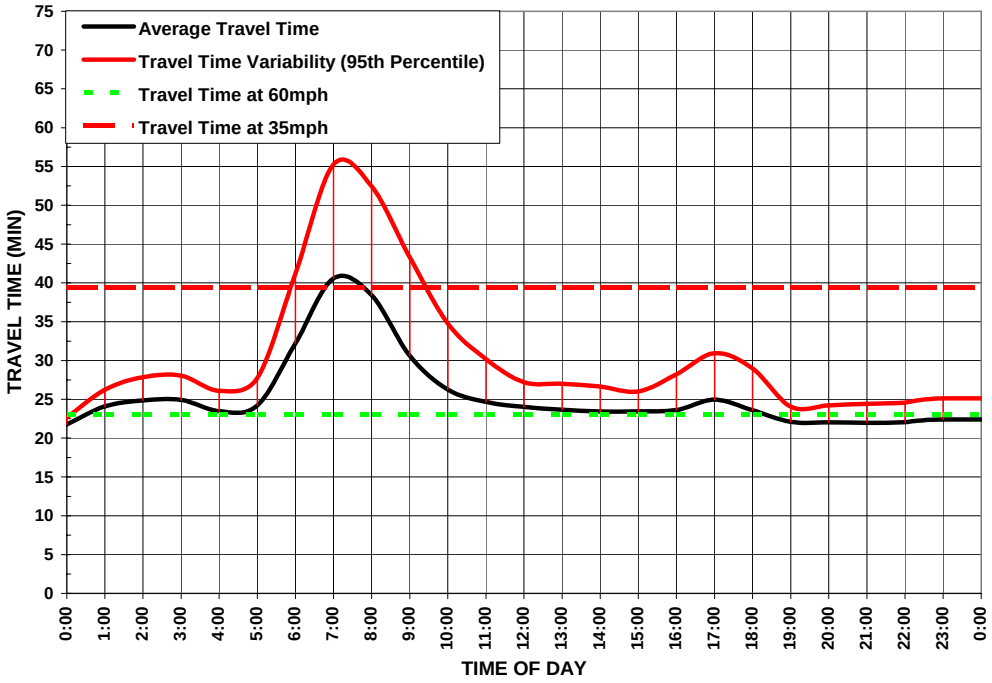
Source: SMG Analysis of PeMS data

Exhibit 3-29: Eastbound Mainline Travel Time Variability (2007)



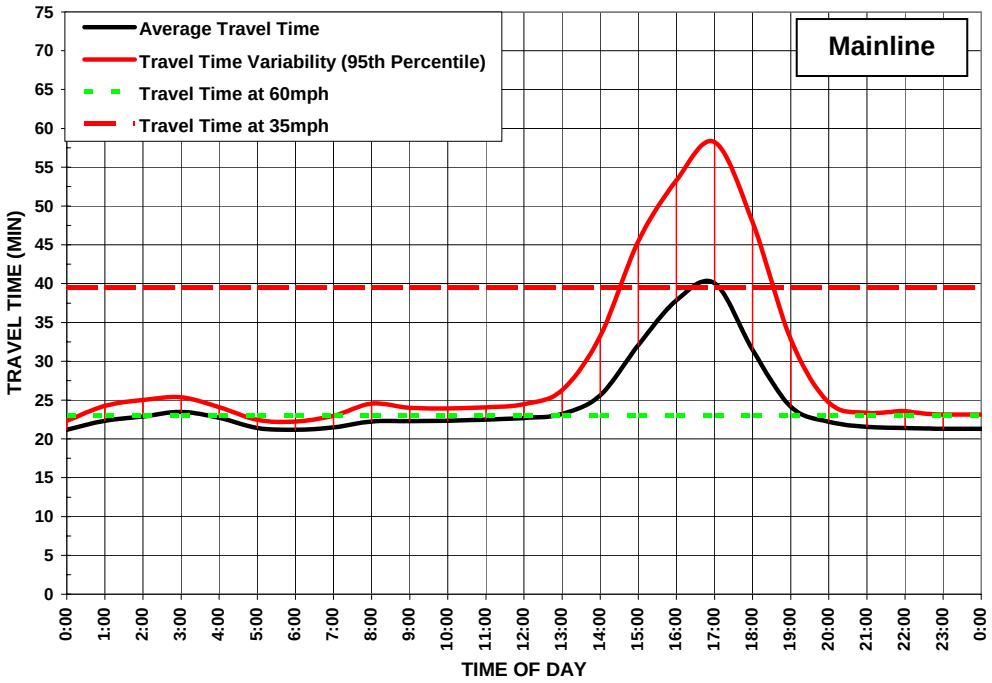
Source: SMG Analysis of PeMS data

Exhibit 3-30: Westbound Mainline Travel Time Variability (2007)



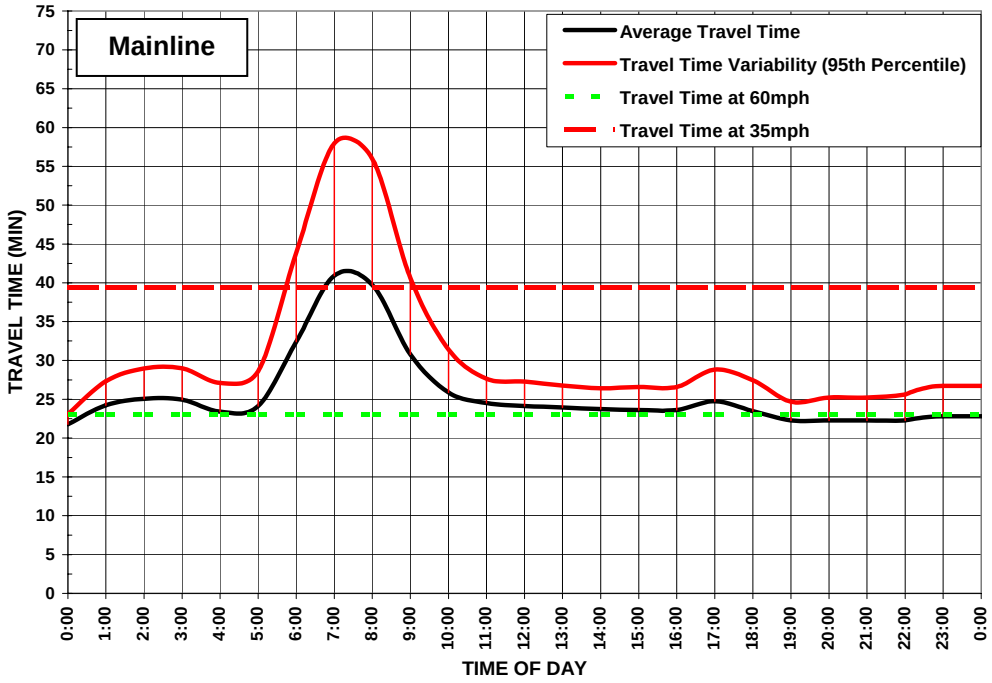
Source: SMG Analysis of PeMS data

Exhibit 3-31: Eastbound Mainline Travel Time Variability (2008)



Source: SMG Analysis of PeMS data

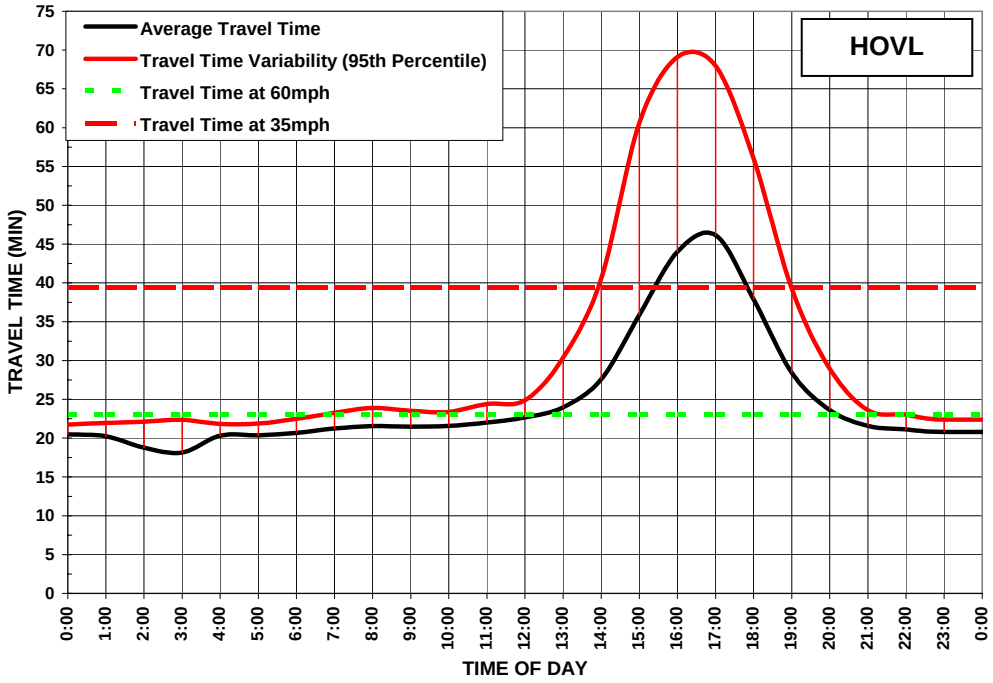
Exhibit 3-32: Westbound Mainline Travel Time Variability (2008)



Source: SMG Analysis of PeMS data

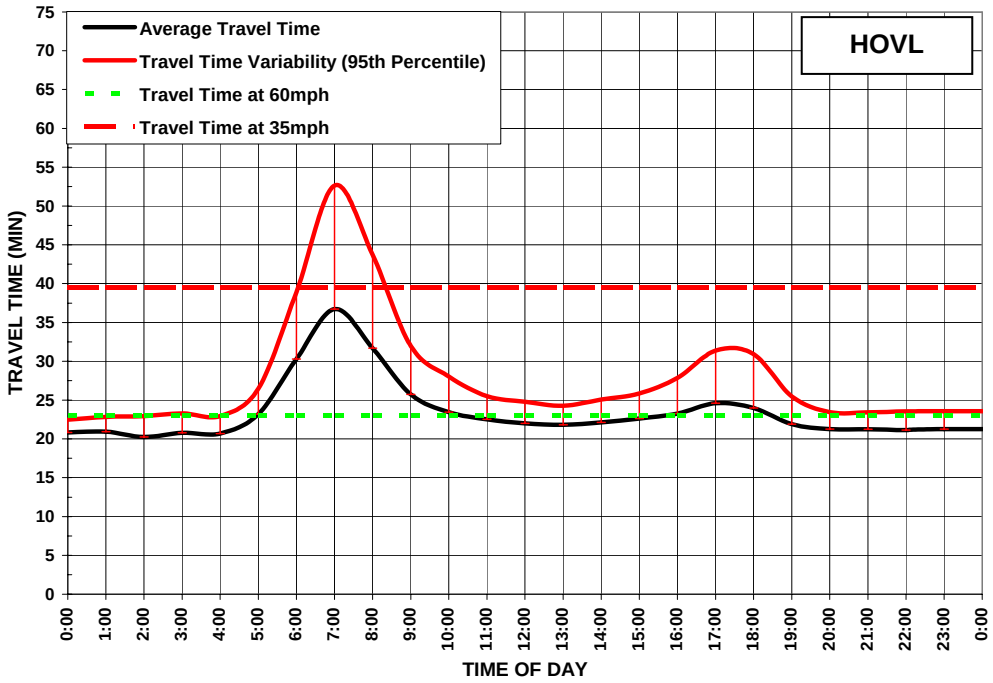
Similarly, Exhibits 3-33 through 3-42 show travel time variability on the HOV facility for both the eastbound and westbound direction from 2004 to 2008. Unlike the mainline facility, the HOV lanes appear to have had improved reliability over the last two years (2007 and 2008).

Exhibit 3-33: Eastbound HOV Travel Time Variability (2004)



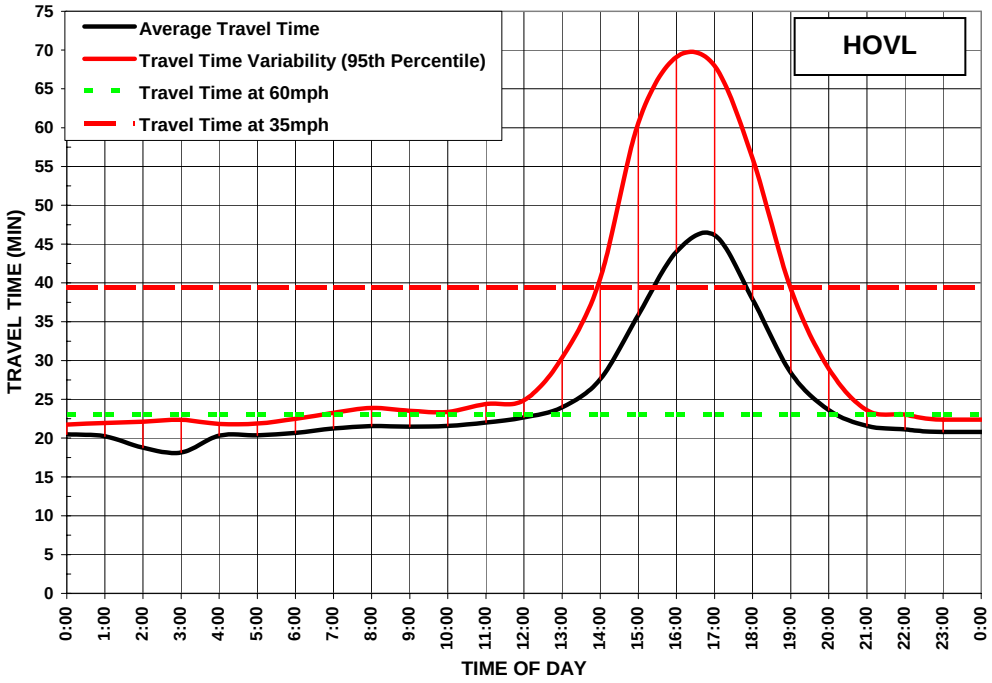
Source: SMG Analysis of PeMS data

Exhibit 3-34: Westbound HOV Travel Time Variability (2004)



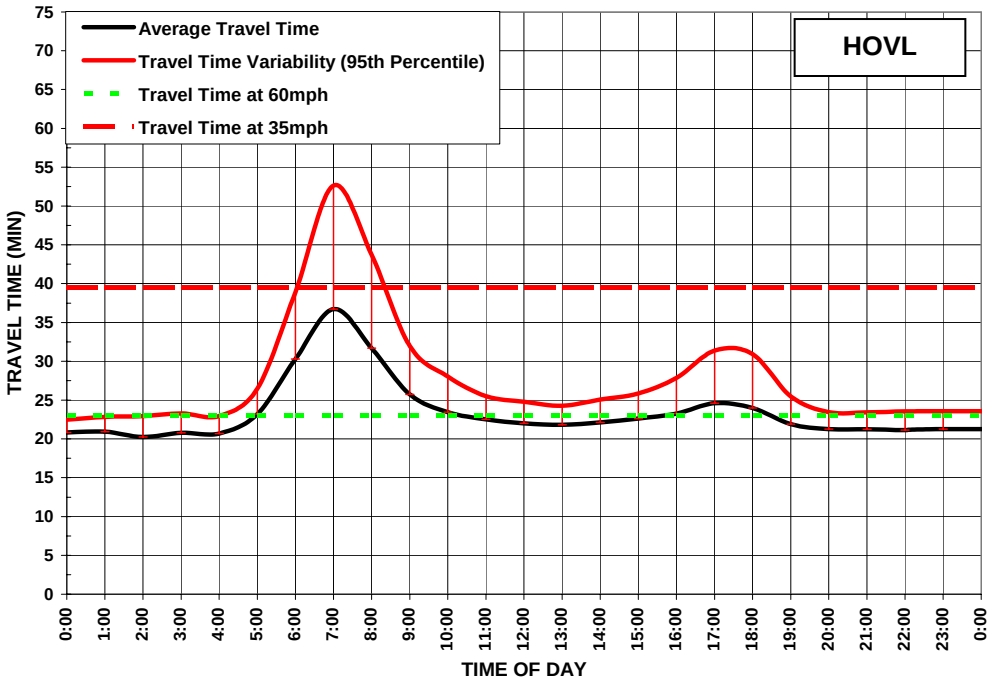
Source: SMG Analysis of PeMS data

Exhibit 3-35: Eastbound HOV Travel Time Variability (2005)



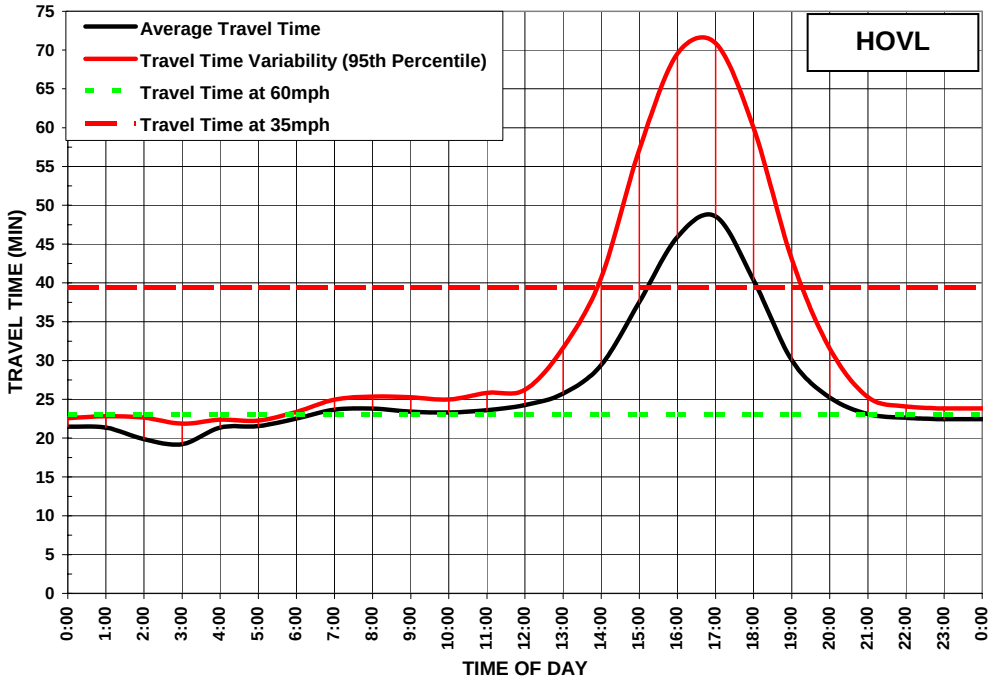
Source: SMG Analysis of PeMS data

Exhibit 3-36: Westbound HOV Travel Time Variability (2005)



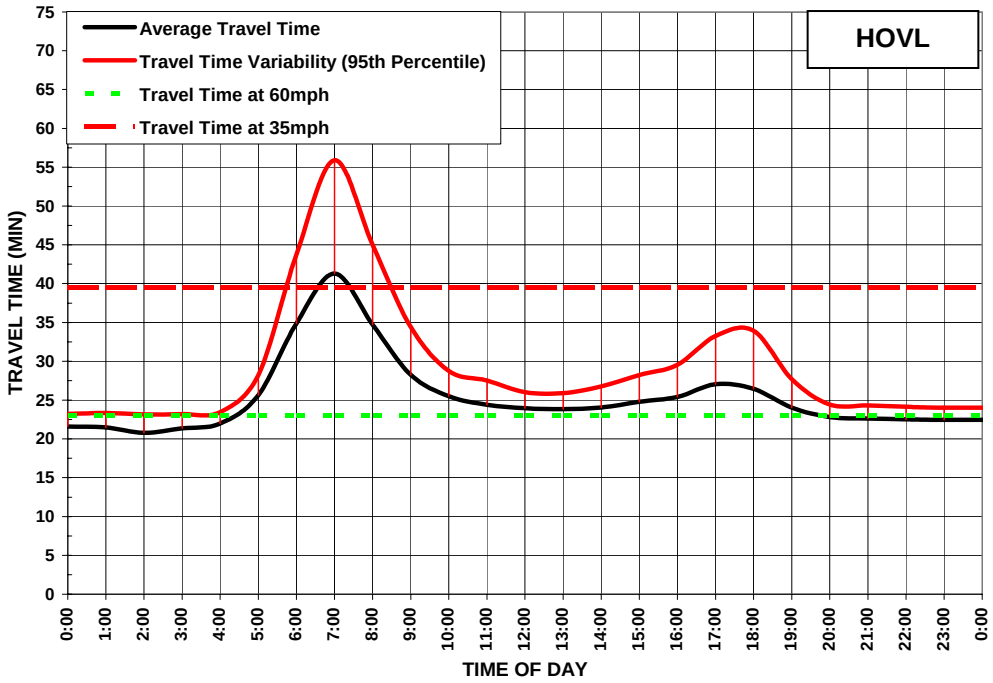
Source: SMG Analysis of PeMS data

Exhibit 3-37: Eastbound HOV Travel Time Variability (2006)



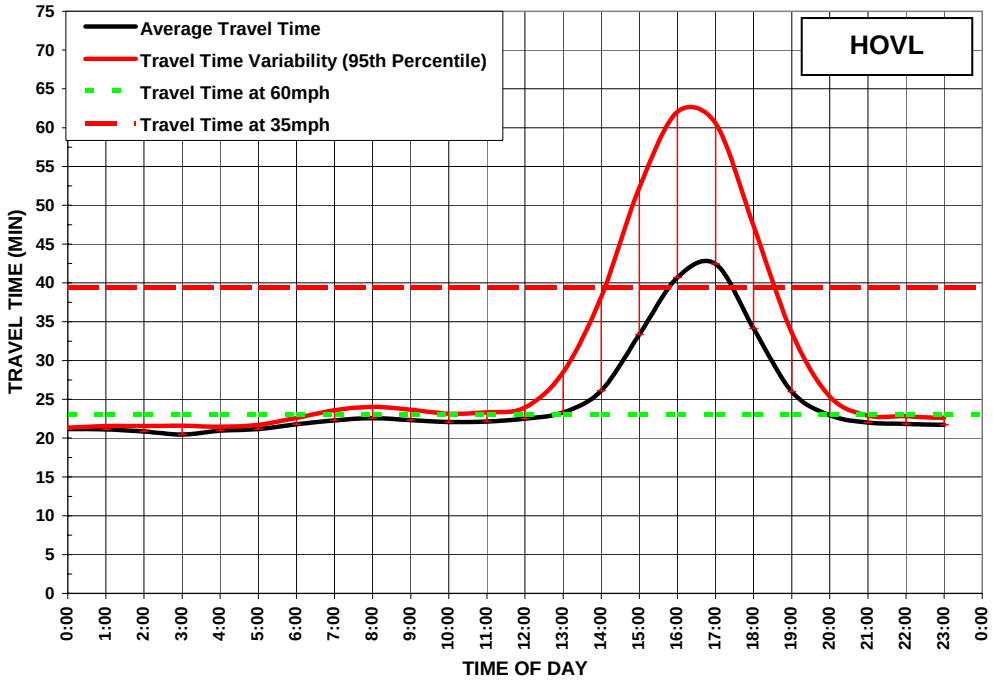
Source: SMG Analysis of PeMS data

Exhibit 3-38: Westbound HOV Travel Time Variability (2006)



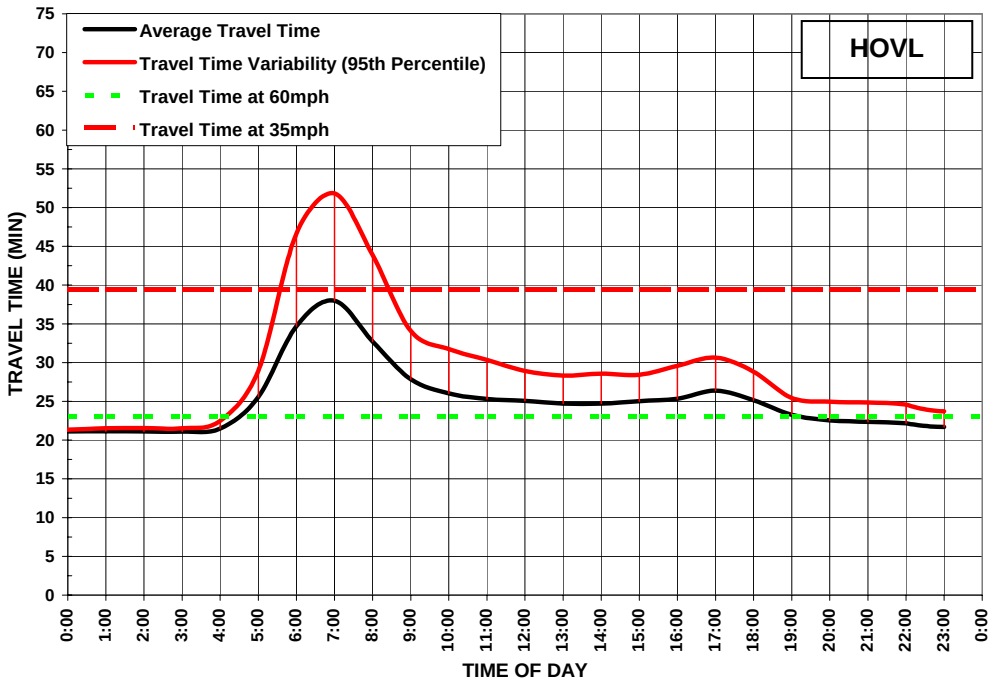
Source: SMG Analysis of PeMS data

Exhibit 3-39: Eastbound HOV Travel Time Variability (2007)



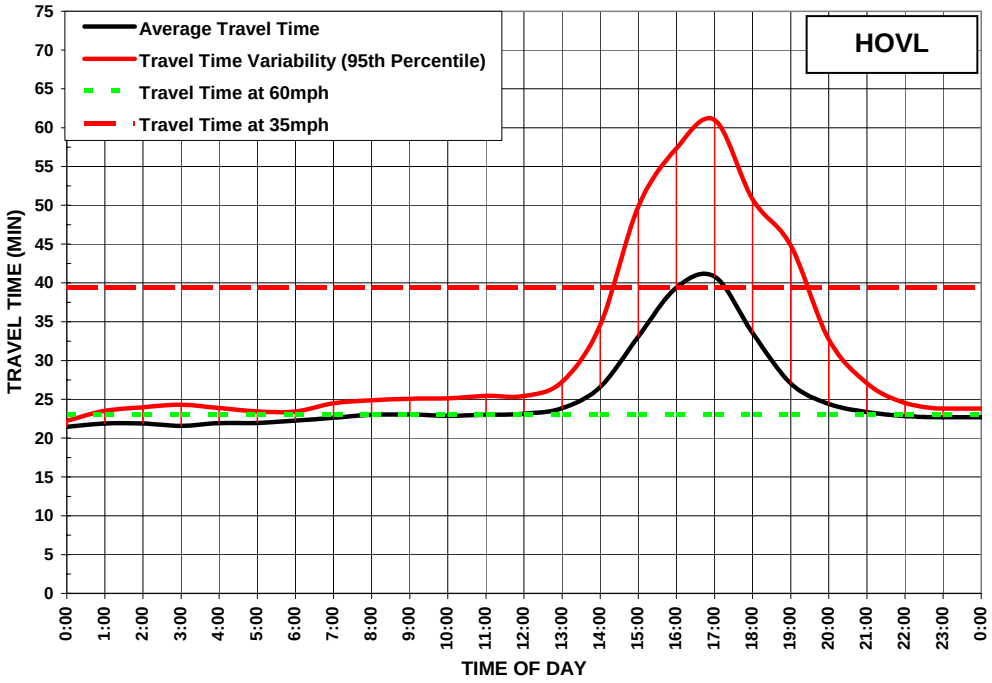
Source: SMG Analysis of PeMS data

Exhibit 3-40: Westbound HOV Travel Time Variability (2007)



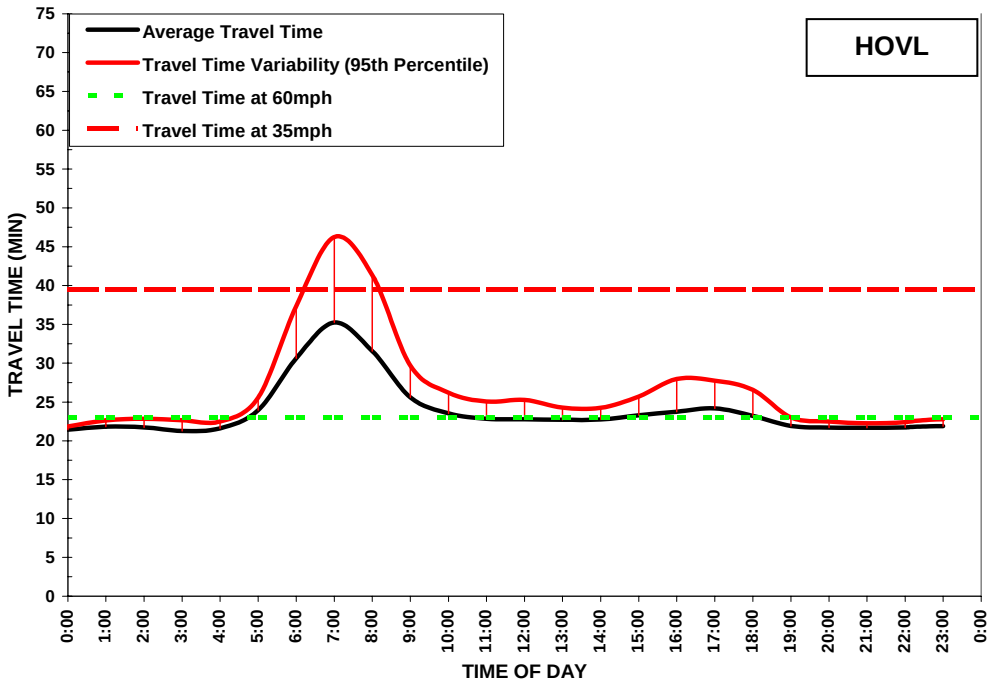
Source: SMG Analysis of PeMS data

Exhibit 3-41: Eastbound HOV Travel Time Variability (2008)



Source: SMG Analysis of PeMS data

Exhibit 3-42: Westbound HOV Travel Time Variability (2008)



Source: SMG Analysis of PeMS data

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SAFETY

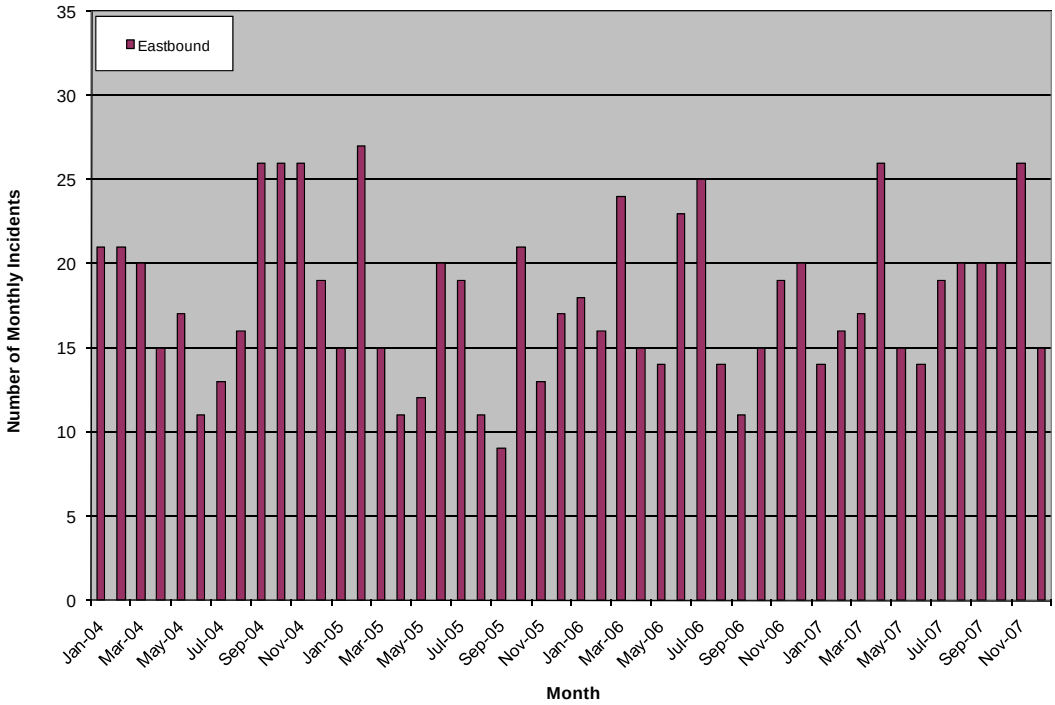
The adopted performance measures to assess safety are: the number of accidents and accident rates computed from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). This is a traffic records system containing an accident database linked to a highway database. The highway database contains 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 excluded (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 3-43 and 3-44 illustrate the I-210 eastbound and westbound accidents by month for the western half of the corridor from I-5 junction (postmile 0) to SR-134 (postmile 22). This is the less urbanized section, not included in the other performance statistics. Exhibits 3-45 and 3-46 illustrate the I-210 eastbound and westbound accidents by month for the eastern half of the corridor from SR-134 (postmile R22) to SR-57 (postmile R45). This is the congested urban area assessed in the other performance statistics. Caltrans typically analyzes safety data for the latest three years. The latest available TASAS data from PeMS is to June 30, 2006. Therefore, monthly data from July 1, 2003 through June 30, 2006 were analyzed and results presented.

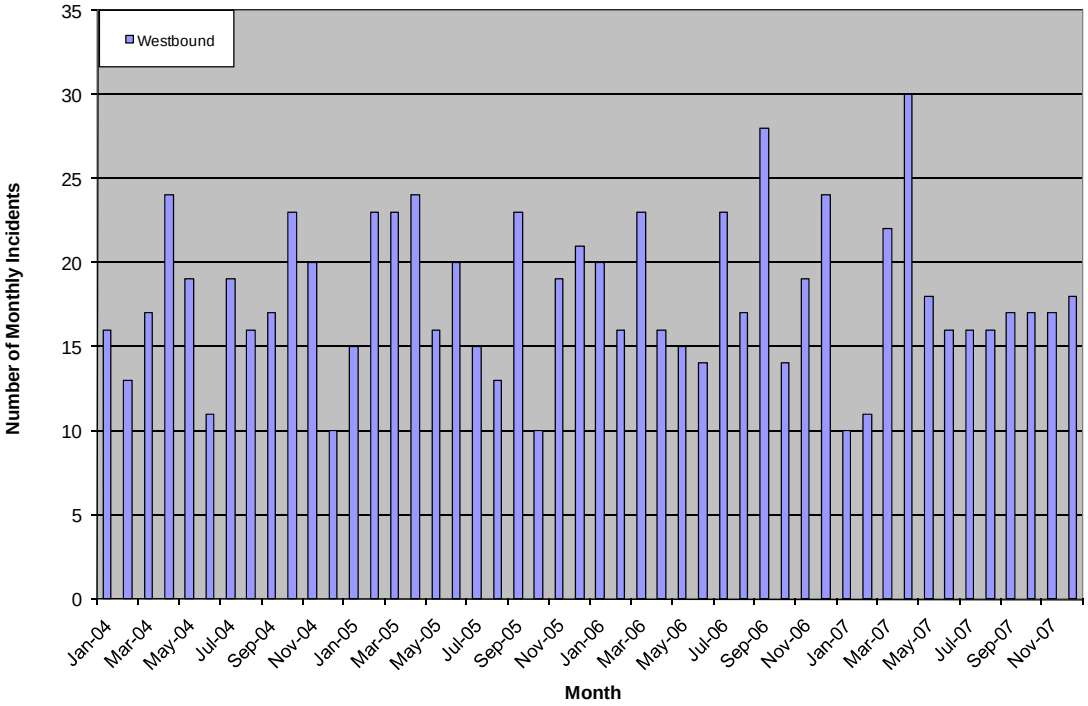
As indicated, the eastbound and westbound had approximately equal number of accidents. However, the western half of the corridor, from I-5 to SR-134 (Exhibits Exhibit 3-43 and 3-44), experienced as many as 25 accidents per month per direction while the eastern half of the corridor (Exhibits 3-45 and 3-46), from SR-134 to SR-57, experienced as many as 80 accidents per month per direction. The higher number of accidents in the eastern section is attributable to the higher traffic volume in the urban area. The AADT for selected segments of the corridor can be found in Exhibit 2-2.

Exhibit 3-43: Eastbound Monthly Accidents, PM 0 to 22 (2004-2007)



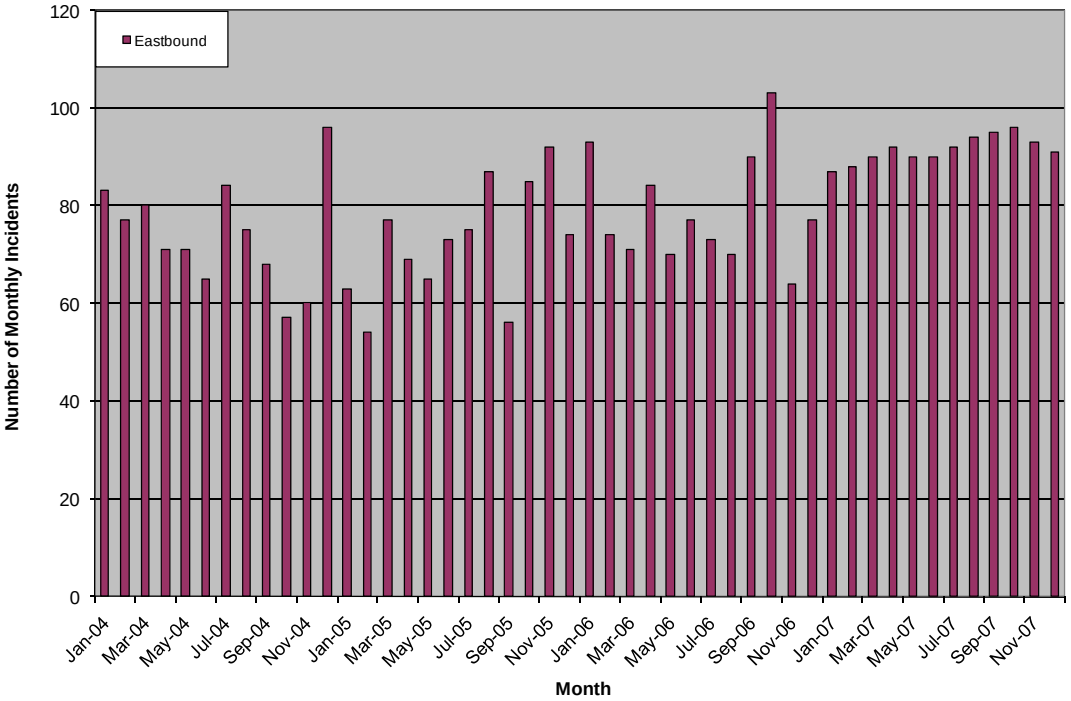
Source: SMG Analysis of PeMS data

Exhibit 3-44: Westbound Monthly Accidents, PM 0 to 22 (2004-2007)



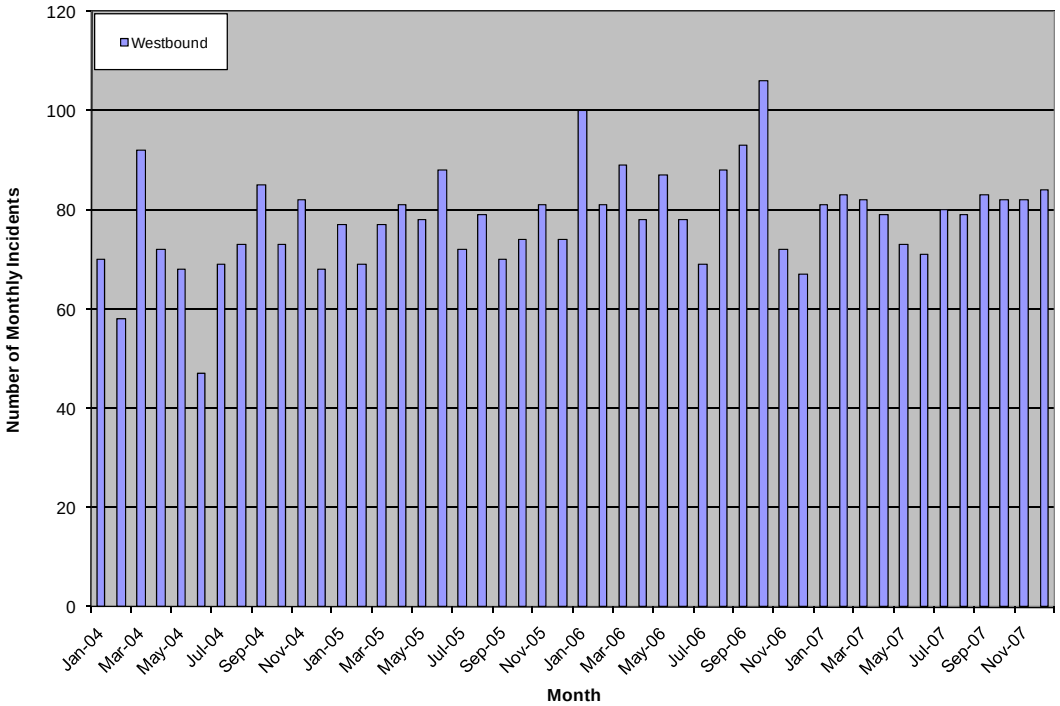
Source: SMG Analysis of PeMS data

Exhibit 3-45: Eastbound Monthly Accidents, PM 22 to 45 (2004-2007)



Source: SMG Analysis of PeMS data

Exhibit 3-46: Westbound Monthly Accidents, PM 22 to 45 (2004-2007)



Source: SMG Analysis of PeMS data

Exhibit 3-47 presents the latest TASAS three-year accident data for period from April 1, 2004 through March 31, 2007 for the I-210 Corridor from I-5 to the Los Angeles/San Bernardino County Line, as provided by Caltrans. Total number of accidents by type (fatality, injury, and property damage only (PDO), vehicle miles of travel, and the accident rate by type are provided. As indicated in the exhibit, the I-210 Corridor experienced lower accident rates in both fatalities and injuries as compared to the average rates experienced by similar roadway facilities.

Exhibit 3-47: Total Number of Accidents by Type and Accident Rate (2004-2007)

		Number of Accidents					Accident Rates					
							Actual			Average		
From	***To***	***Fat***	***Inj***	***PDO***	***Total***	***MVM***	***Fat***	***F+I***	***Total***	***Fat***	***F+I***	***Total***
Eastbound												
I-5 (Golden State Freeway)	San Bernardino County Line	22	955	2110	3087	5086.64	0.004	0.19	0.61	0.005	0.29	0.93
Westbound												
San Bernardino County Line	I-5 (Golden State Freeway)	19	1065	2257	3341	5086.64	0.004	0.21	0.66	0.005	0.29	0.93

Note: Accident rates expressed as # of accidents/Million Vehicle Miles (MVM)

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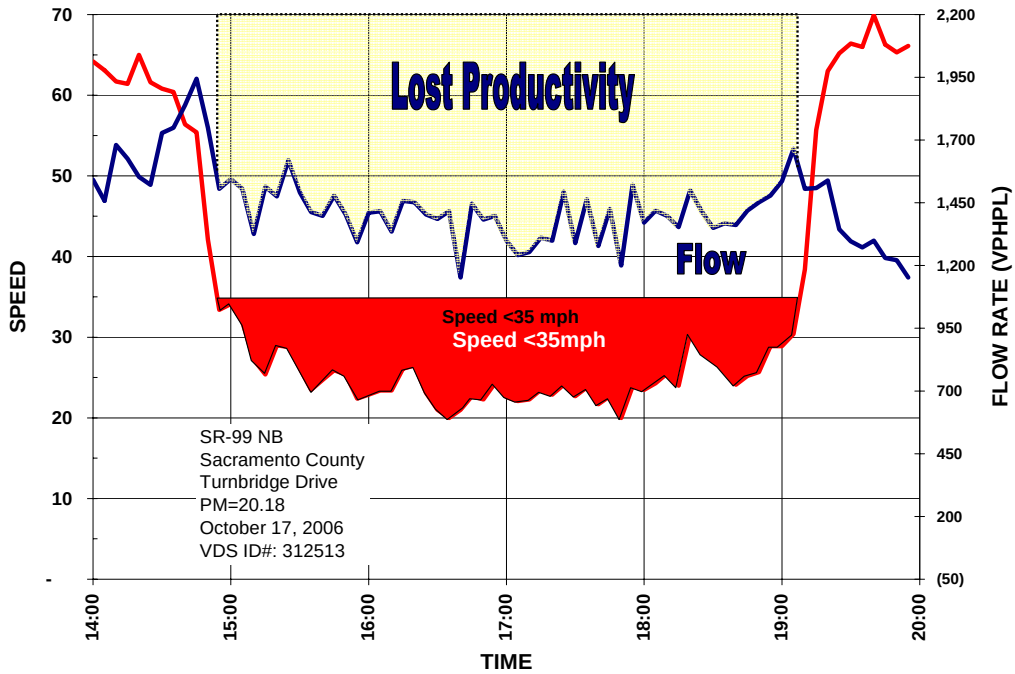
PRODUCTIVITY

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 estimate 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 occurs often when capacity is needed the most.

This loss in productivity example is illustrated in Exhibit 3-48. As traffic flow increases to the capacity limits of a roadway, speeds decline rapidly and throughput drops dramatically. This loss in throughput is the lost productivity of the system. There are a few ways to estimate productivity losses. Regardless of the approach, productivity calculations require good detection or significant field data collection at congested locations. One approach is to convert this lost productivity into "equivalent lost lane-miles." These lost lane-miles represent a theoretical level of capacity that would need to be added in order to achieve maximum productivity. For example, losing six lane-miles implies that congestion has caused a loss in capacity roughly equivalent to lane along a six-mile section of freeway.

Exhibit 3-48: Lost Productivity Illustrated



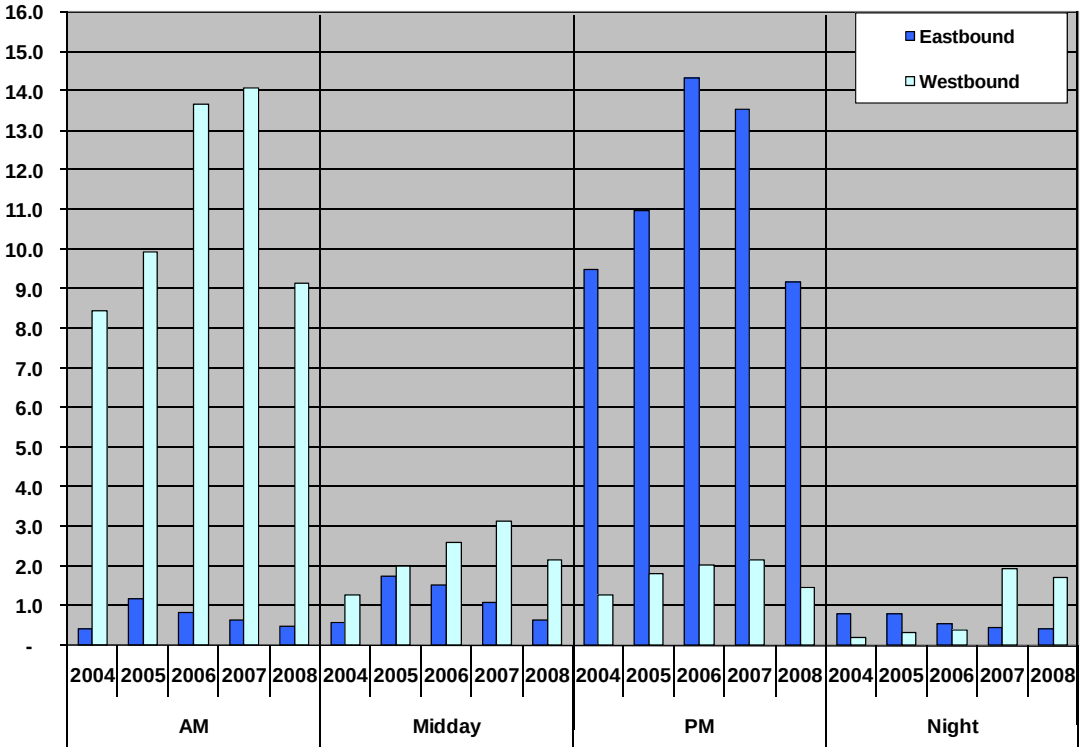
Equivalent lost lane-miles is computed as follows (for congested locations only):

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

Exhibits 3-49 and 3-50 summarize the productivity losses on the I-210 Corridor mainline and HOV facilities during the 2004-2008 period. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the eastbound direction during the PM peak hours, which is the direction and time period that experienced the most congestion. On the mainline facility, the westbound direction experienced nearly as high productivity loses during the AM peak period. On the HOV lanes, a greater productivity loss in the eastbound peak period is more evident.

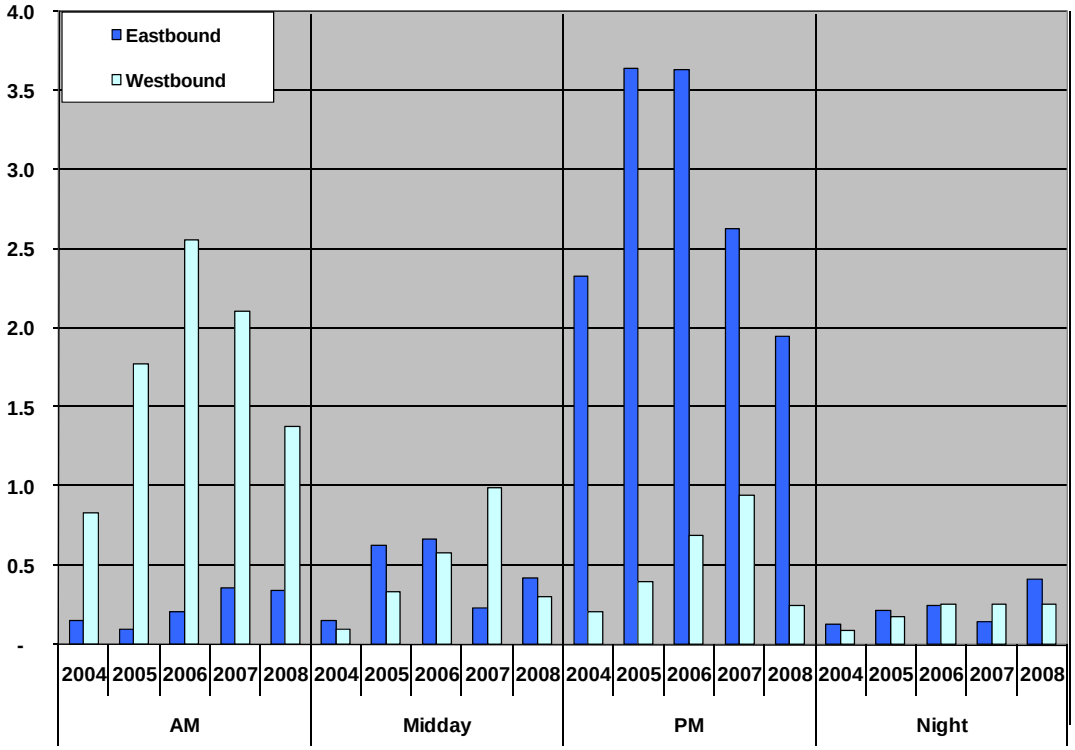
Strategies to combat such productivity losses are primarily related to operations. These strategies include: building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improving incident clearance times.

Exhibit 3-49: Average Lost Lane-Miles by Direction, Time Period, and Year (Mainline)



Source: SMG Analysis of PeMS data

Exhibit 3-50: Average Lost Lane-Miles by Direction, Time Period, and Year (HOV)



Source: SMG Analysis of PeMS data

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PAVEMENT CONDITION

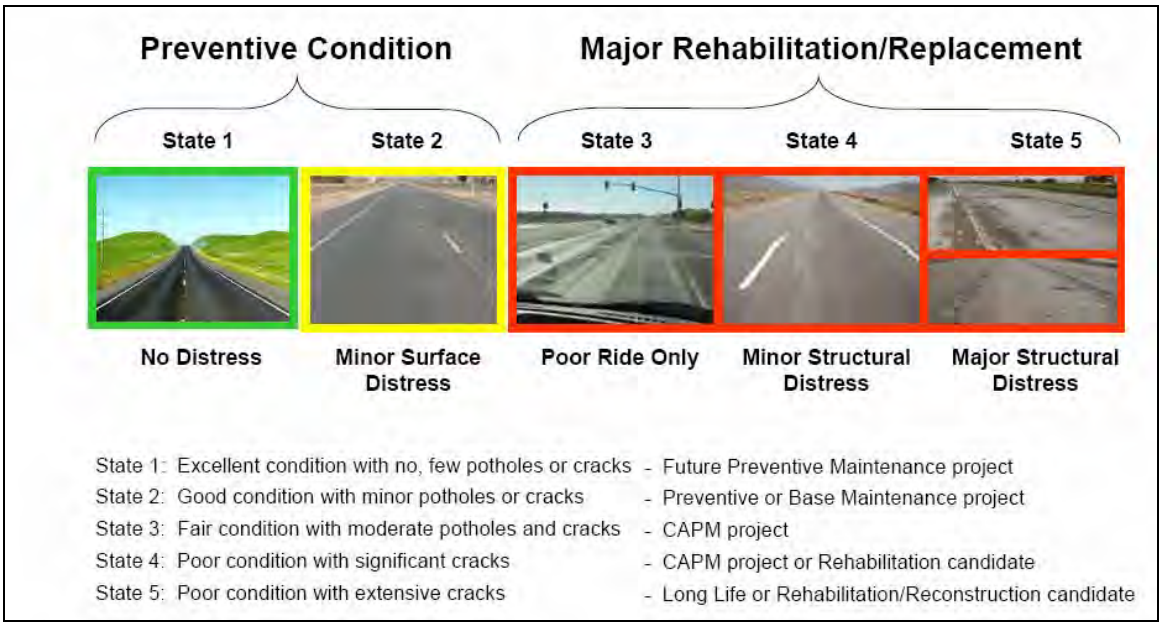
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation 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.

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 3-51 provides an illustration of this distinction. The first two pavement conditions include roadway that provides adequate ride quality and is structurally adequate. The remaining three conditions are included in the calculation of distressed lane-miles.

Exhibit 3-51: 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.

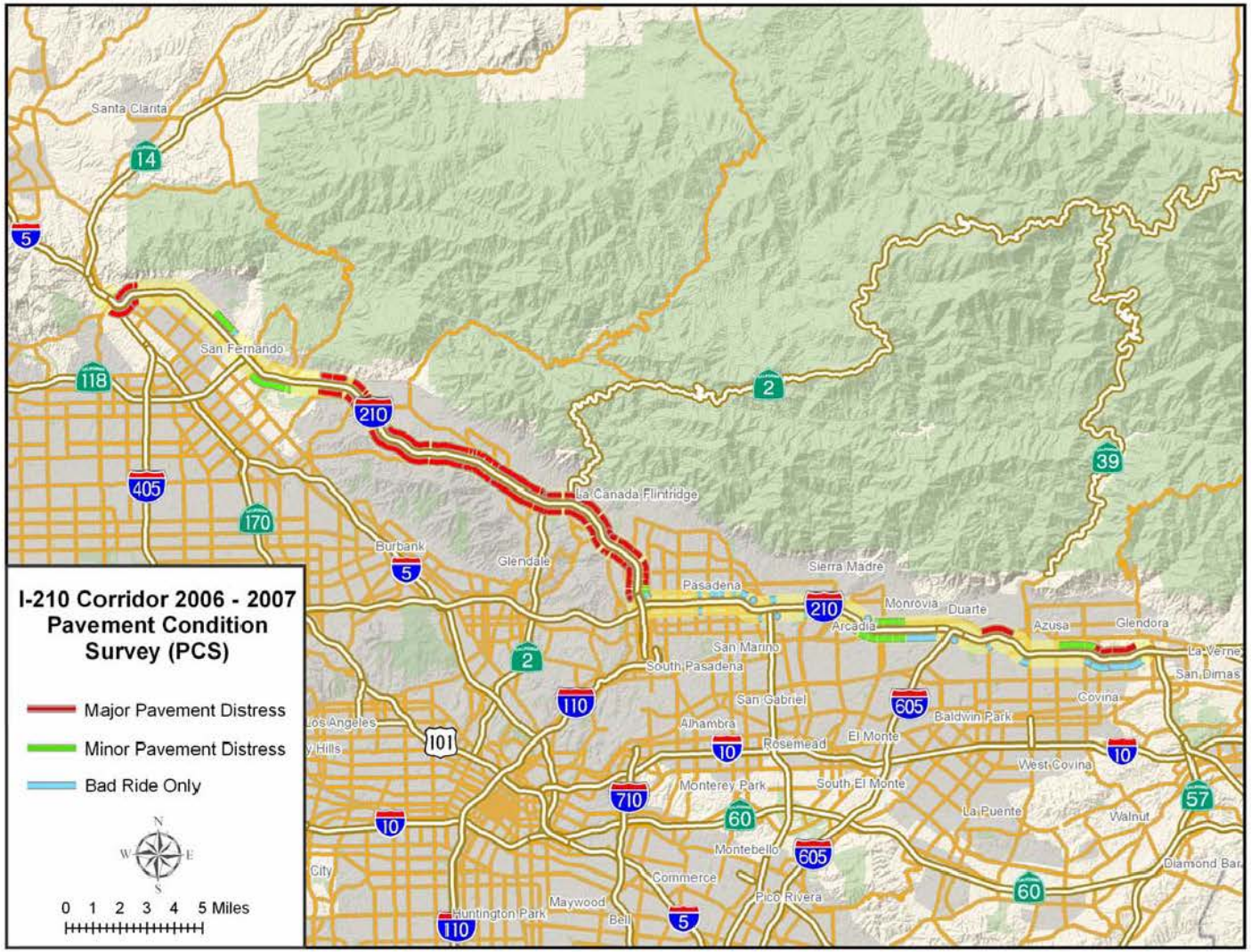
Exhibit 3-52 shows the pavement distress recorded along the I-210 Corridor for the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3-51.

In general, pavement on the I-210 Corridor is in better condition than the pavement in District 7 as a whole. Most major pavement distress occurs along a 16-mile section between Wentworth Street in Sunland (just south of San Fernando) and SR-134. Other sections generally show no distress, minor pavement distress, or bad ride quality only.

Exhibit 3-53 shows results from prior pavement condition surveys for the I-210 Corridor. After increasing by about 20 distressed lane-miles per year between 2003 and 2005, the total number of distressed lane-miles was cut in half from about 140 to about 70 lane-miles by the 2006-07 period. Most of the improvement was due to the rehabilitation of minor pavement distress. Ride quality only issues have increased slightly, while the amount of major distress has declined slightly from about 70 to about 50 lane-miles.

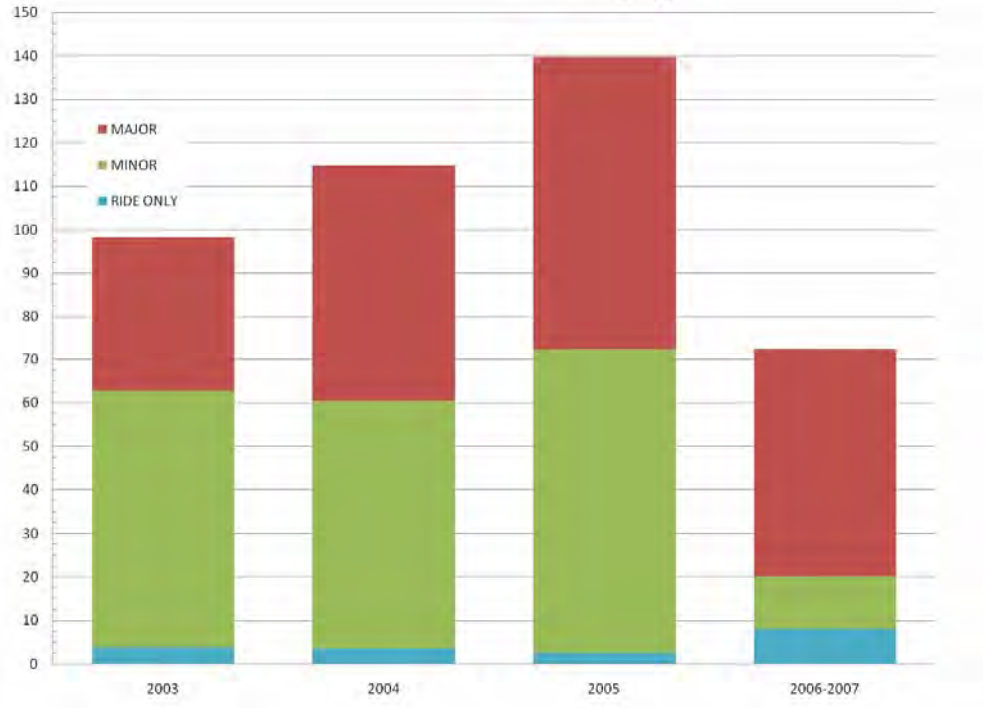
Exhibit 3-54 shows how the mix in the types of distressed lane-miles has changed over the last few years. As the minor and ride quality issues have been addressed, major rehabilitation needs have increased as a share of total needs. However, as shown in Exhibit 3-53, the total number of distressed lane-miles has decreased and most of the major distress is concentrated in one section.

Exhibit 3-52: Distressed Lane-Miles on I-210 Corridor (2006-2007)



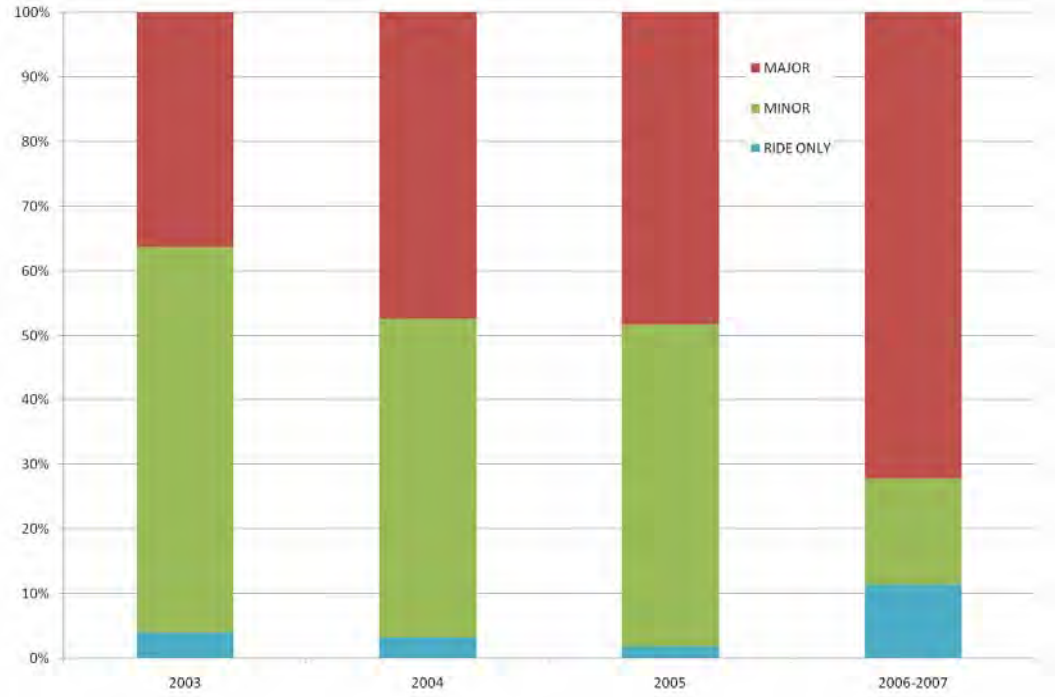
Source: SMG mapping of 2007 Pavement Condition Survey data

Exhibit 3-53: I-210 Distressed Lane-Miles Trends



Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-54: I-210 Distressed Lane-Miles by Type



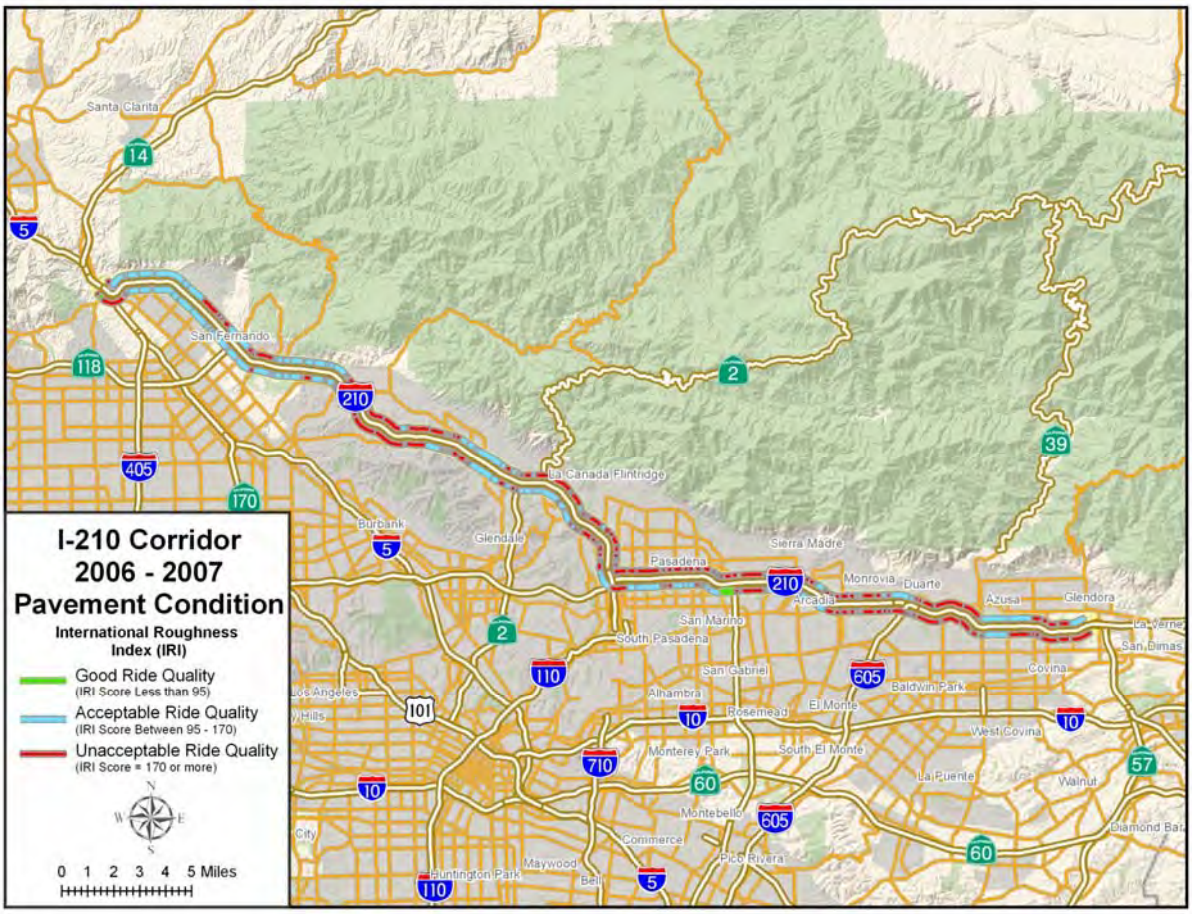
Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-55 shows IRI along the study corridor for the lane with the poorest pavement condition along each freeway segment. The worst pavement quality is shown since pavement investment decisions are made on this basis. Although the exhibit suggests there are many sections with unacceptable ride quality, there are many lanes with good ride quality within these sections. The study corridor comprises roughly 426 lane-miles, of which:

- 19 lane-miles, or 4 percent, are considered to have good ride quality (IRI ≤ 95)
- 303 lane-miles, or 71 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- 104 lane miles, or 24 percent, are considered to have unacceptable ride quality (IRI > 170)

Note that these percentages do not total to 100 percent due to rounding. The majority of the 104 lane-mile with unacceptable ride quality occur in sections with pavement distress, so few lane-miles exhibit only ride issues (as shown in Exhibits 3-52 and 3-53).

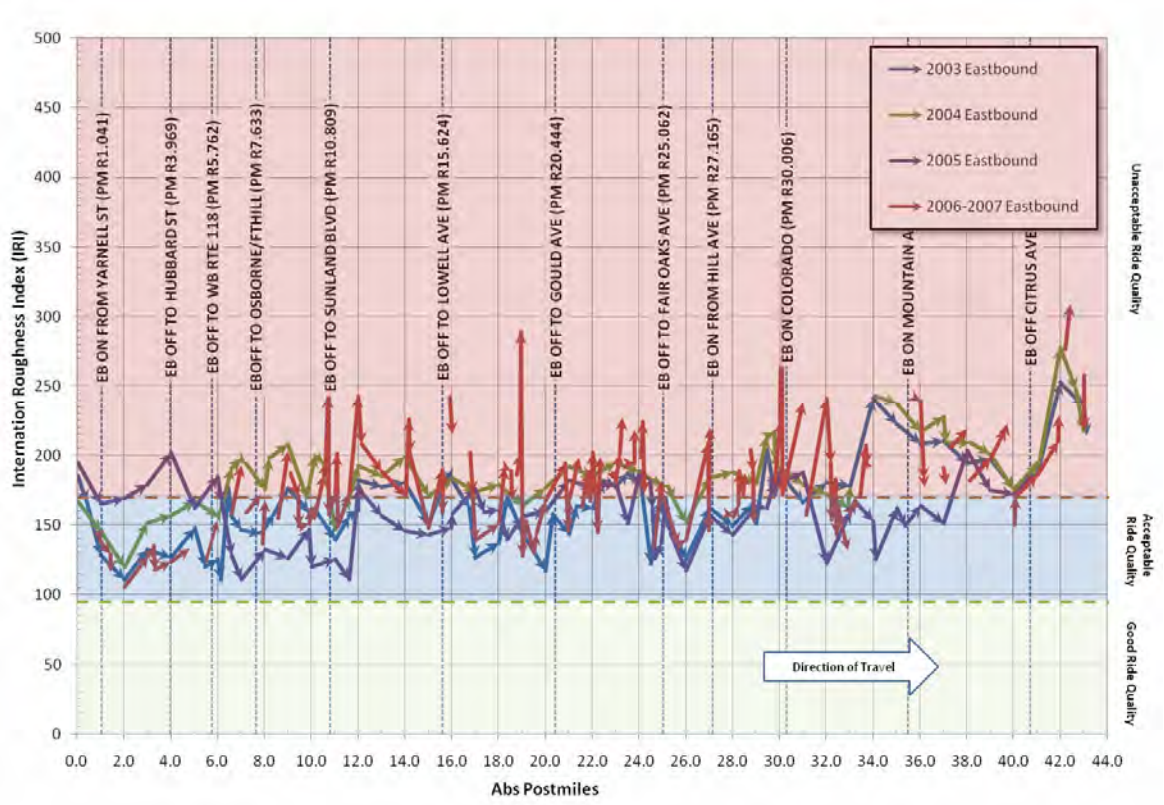
Exhibit 3-55: I-210 Road Roughness (2006-2007)



Source: SMG mapping of 2007 Pavement Condition Survey data

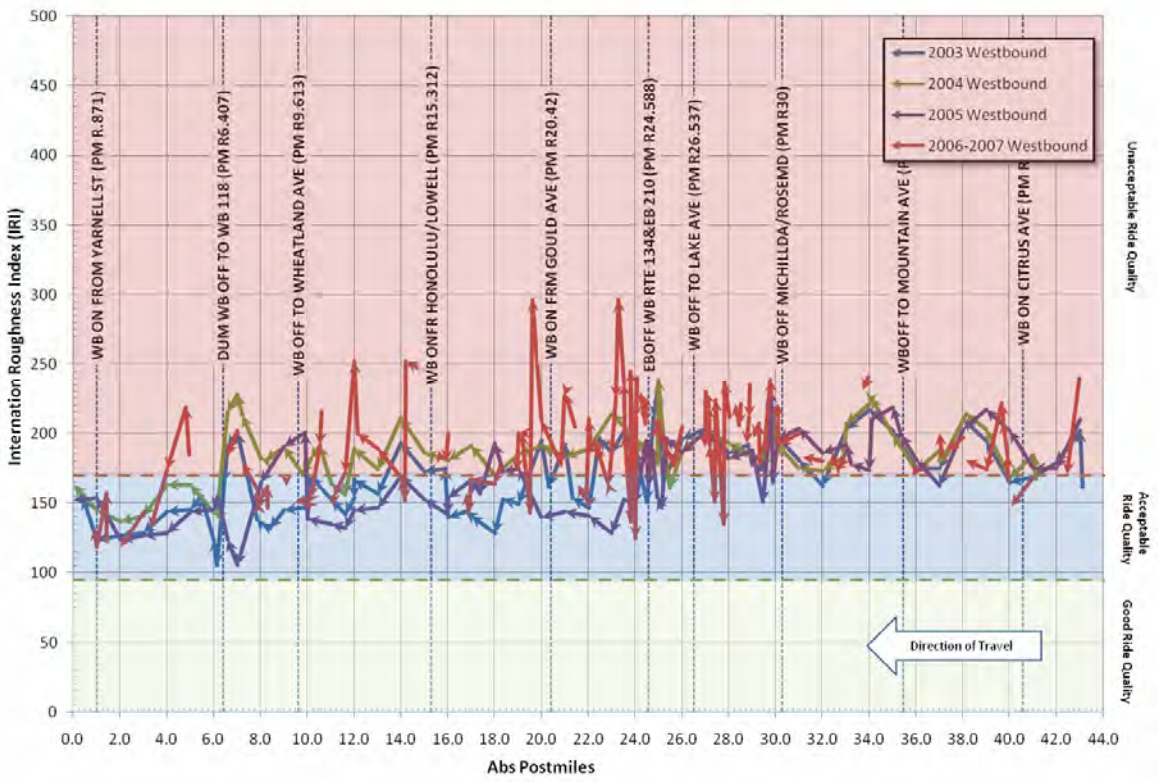
Exhibits 3-56 and 3-57 present ride conditions for the worst lane in each section on the I-210 Corridor using IRI from the last four pavement surveys. The information is presented by postmile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). Ride quality has worsened slightly over the last few surveys, but it has improved on some roadway sections, such as the portion in San Fernando between I-5 and Sunland Boulevard. The exhibits exclude sections that were not measured or had calibration problems (i.e., IRI = 0) in the 2006-07 period.

Exhibit 3-56: Eastbound I-210 Road Roughness (2003-2007)



Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-57: Westbound I-210 Road Roughness (2003-2007)



Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

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4. BOTTLENECK IDENTIFICATION AND ANALYSIS

Bottlenecks were identified in the Comprehensive Performance Assessment dated May 2008. They were identified based on a variety of data sources, including HICOMP, probe vehicle runs, and PeMS. Significant field visits were also conducted in November and December 2007 as well as February and May 2008 to confirm these bottleneck locations. As a result of the field work and additional data analysis, the reoccurring bottlenecks were identified for both directions. This section contains a more detailed analysis of the bottleneck areas than in the May 2008 Comprehensive Performance Assessment. The initial analysis from the May 2008 report is found in the Appendix.

Eastbound Bottlenecks

Starting at the SR-134 junction and moving eastbound, the following bottlenecks were identified:

- Mountain On-Ramp to Fair Oaks: The bottleneck at this location is caused by inadequate capacity on the SR-134 connector.
- Lake On-Ramp to Hill Off-Ramp: Heavy on-ramp traffic causes the bottleneck at this location.
- San Gabriel On-Ramp to Madre Off-Ramp: The primary cause of this bottleneck is reduced capacity due to road curvature.
- Rosemead On-Ramp to Baldwin Off-Ramp: Two consecutive on-ramps create this bottleneck.
- Santa Anita On-Ramp to Huntington Off-Ramp: The mainline facility has reduced capacity at this location due to multiple curves and the ramp traffic.
- Mountain On-Ramp to I-605 Off-Ramp: Two consecutive on-ramps and a freeway connector create heavy weaving and a bottleneck at this location.
- Irwindale On-Ramp to Vernon Off-Ramp: The combination of heavy on-ramp traffic and multiple curves in the roadway create this bottleneck.
- Azusa On-Ramp to Citrus Off-Ramp: Added demand from the ramp exceeds the available capacity of the mainline facility.
- Citrus On-Ramp to Grand Off-Ramp: The mainline facility is near capacity and cannot accommodate additional traffic from the ramp.
- SR-57 On-Ramp to San Dimas Off-Ramp: The mainline facility cannot accommodate additional traffic from the ramp.

Westbound Bottlenecks

Starting from SR-57 and moving westbound, the following bottlenecks were identified:

- Azusa On-Ramp to Vernon Off-Ramp: This bottleneck is caused by heavy traffic from two consecutive on-ramps at the crest of a curve.

- Irwindale On-Ramp to I-605 Off-Ramp: This bottleneck results from road curvature and weaving due to closely spaced on-ramps and a freeway connector.
- Santa Anita On-Ramp to Baldwin Off-Ramp: Road curvature and heavy on-ramp traffic causes this bottleneck.
- Baldwin On-Ramp to Michillinda Off-Ramp: Heavy traffic at two consecutive on-ramps causes this bottleneck.
- Rosemead On-Ramp to Sierra Madre Villa Off-Ramp: Combined traffic from three on-ramps creates this bottleneck.
- Lake On-ramp to SR-134 Off-ramp: The primary cause of this bottleneck is the weaving of heavy traffic from the Lake on-ramp and from vehicles exiting to westbound I-210.
- SR-118 On-Ramp to Maclay Street Off-Ramp: This bottleneck is caused primarily by the heavy on-ramp traffic.

ANALYSIS OF BOTTLENECK AREAS

Once the bottlenecks are 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 these bottleneck areas, the 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) and limited to the mainline facility due to the limited detection available on the HOV facility. Based on this approach, the study corridor comprises several bottleneck areas, which differ by direction. Exhibit 4-1 illustrates the general concept of bottleneck areas in one direction. The red lines in the exhibit represent the bottleneck locations and the arrows represent the bottleneck areas.

Exhibit 4-1: Dividing a Corridor into Bottleneck Areas

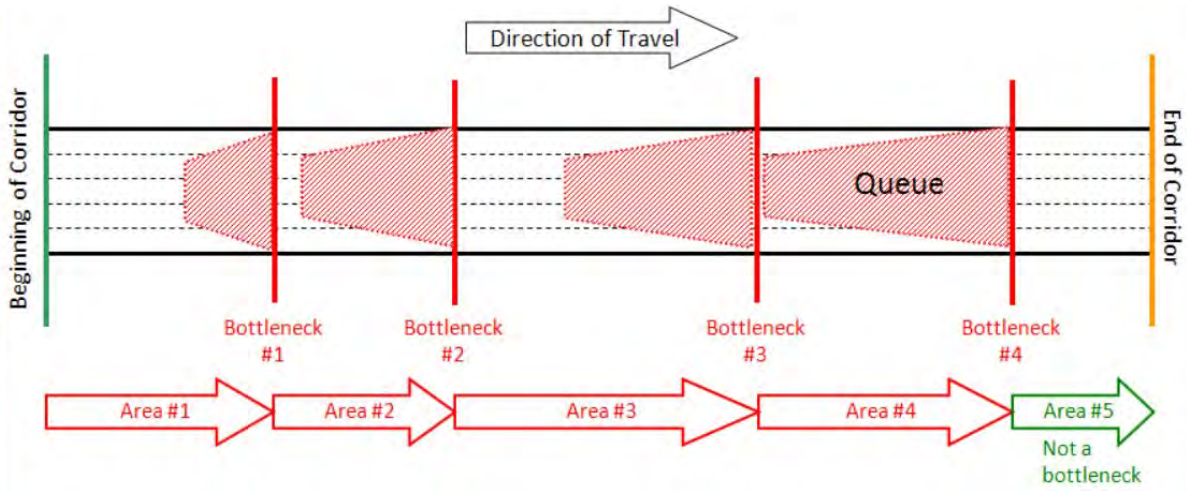
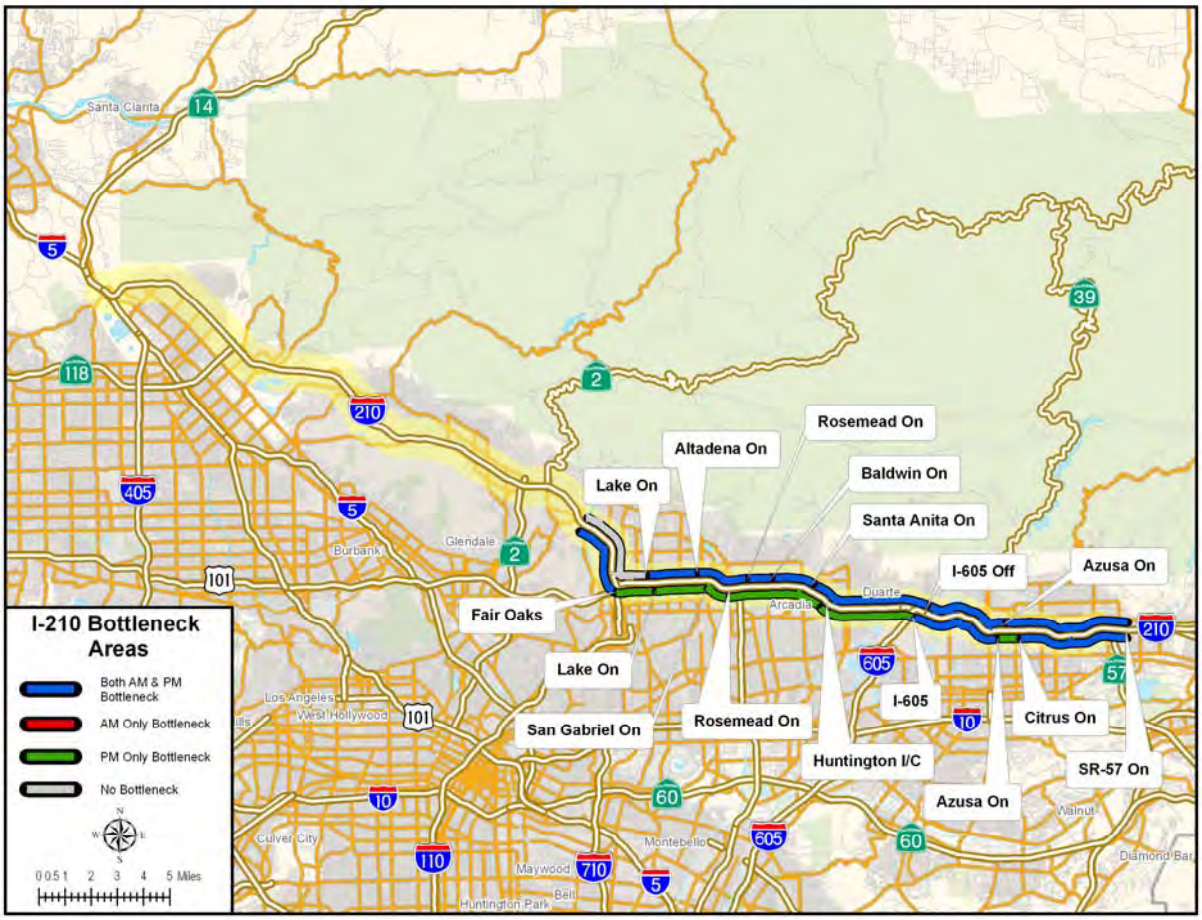


Exhibit 4-2 graphically illustrates the location of each of the bottleneck locations and areas for the I-210 Corridor.

Exhibit 4-2: I-210 Bottleneck Locations and Bottleneck Areas



Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. This section will use the previously discussed performance measures of mobility, safety, and productivity to evaluate each bottleneck area. The results from this bottleneck analysis will reveal which segments of the corridor should be prioritized for improvements.

Exhibits 4-3 and 4-4 summarize the location of the bottlenecks identified in the eastbound and westbound directions of I-210. As the exhibits show, some of the bottlenecks in the eastbound direction occur only during the PM peak period.

Exhibit 4-3: Eastbound I-210 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Fair Oaks	SR-134 to Fair Oaks	▯	▯	22.0	R22.0	25.0	R25.0	3.0
Lake On	Fair Oaks to Lake On		▯	25.0	R25.0	26.5	R26.5	1.5
San Gabriel On	Lake On to San Gabriel On		▯	26.5	R26.5	28.6	R28.7	2.1
Rosemead On	San Gabriel On to Rosemead On		▯	28.6	R28.7	29.4	R29.4	0.8
Huntington I/C	Rosemead On to Huntington I/C		▯	29.4	R29.4	33.0	R32.7	3.6
I-605	Huntington I/C to I-605		▯	33.0	R32.7	36.6	R36.3	3.6
Azusa On	I-605 to Azusa On	▯	▯	36.6	R36.3	40.0	R39.7	3.4
Citrus On	Azusa On to Citrus On		▯	40.0	R39.7	40.8	R40.6	0.8
SR-57 On	Citrus On to SR-57 On	▯	▯	40.8	R40.6	45.0	R45.0	4.2

Exhibit 4-4: Westbound I-210 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Azusa On	SR-57 to Azusa On	▯	▯	45.0	R45.0	40.1	R39.8	4.9
I-605 Off	Azusa On to I-605 Off	▯	▯	40.1	R39.8	36.8	R36.5	3.3
Santa Anita On	I-605 Off to Santa Anita On	▯	▯	36.8	R36.5	32.2	R31.9	4.6
Baldwin On	Santa Anita On to Baldwin On	▯	▯	32.2	R31.9	30.7	R30.4	1.5
Rosemead On	Baldwin On to Rosemead On	▯	▯	30.7	R30.4	29.7	L29.7	1.0
Altadena On	Rosemead On to Altadena On	▯	▯	29.7	L29.7	28.0	R28.1	1.7
Lake On	Altadena On to Lake On	▯	▯	28.0	R28.1	26.1	R26.1	1.9
None	Lake On to SR-134	N/A		26.1	R26.1	22.0	R22.0	4.1

Mobility by Bottleneck Area

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

Exhibits 4-5 and 4-6 show the vehicle-hours of delay experienced by bottleneck area and reflect the directional pattern of travel on I-210. As depicted in Exhibit 4-5, delay in the eastbound direction is concentrated in the PM peak. The bottleneck area between Rosemead On-Ramp and the Huntington Interchange, which is the location of the bottleneck, experienced the greatest delay in the eastbound direction. This bottleneck accounted for roughly 408,000 annual vehicle-hours of delay or 30 percent of the corridor delay during the PM peak.

Exhibit 4-6 shows that delay in the westbound direction exhibits the reverse pattern. The delays in the AM peak period are much larger than those in the PM peak period. During the AM peak period, the largest delays occur between SR-57 and Azusa On-Ramp with 321,000 vehicle-hours of delay (33 percent) followed by the bottleneck area at I-605 Off-Ramp to the Santa Anita On-Ramp with nearly 300,000 vehicle-hours of delay (30 percent).

Exhibit 4-5: Eastbound I-210 Annual Vehicle-Hours of Delay (2006)

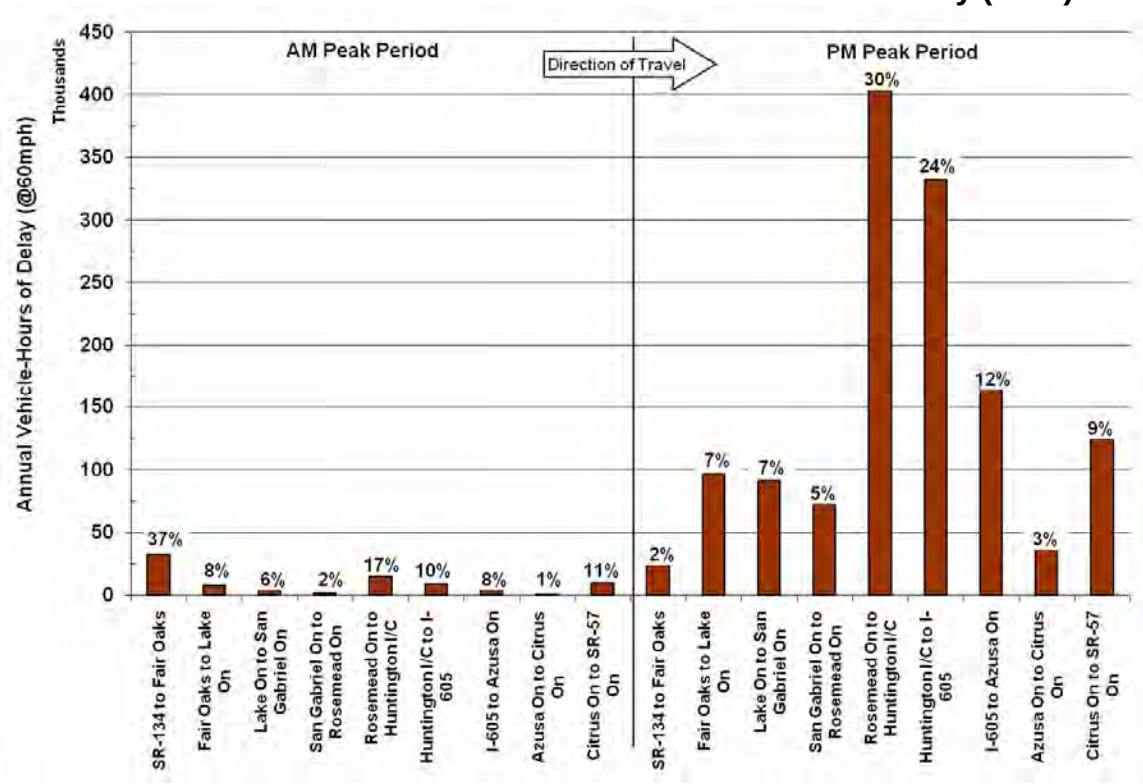
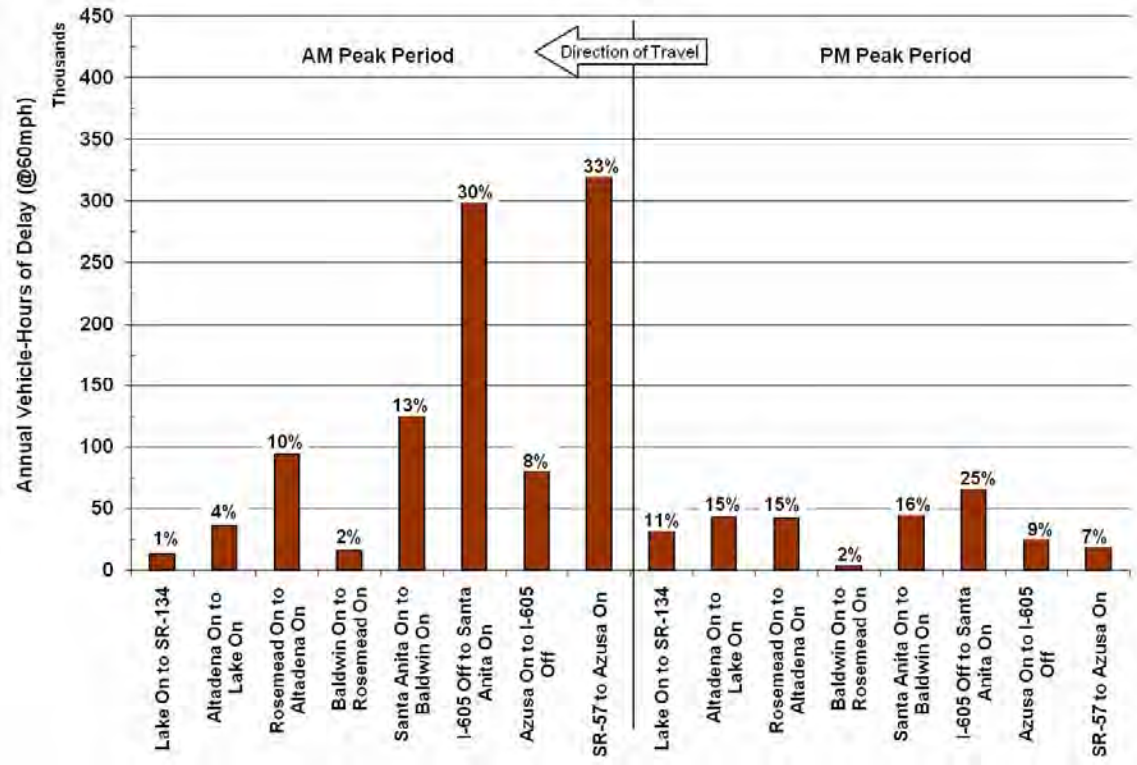


Exhibit 4-6: Westbound I-210 Annual Vehicle-Hours of Delay (2006)



Exhibits 4-7 and 4-8 are normalized to reflect the concentration of delays in the physical area of the corridor. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. The results of these exhibits reveal slightly different delay patterns than those shown in Exhibits 4-5 and 4-6. In the eastbound direction, the areas with the largest delay in the PM peak period are similar to those shown in the non-normalized graph (compare Exhibit 4-7 with Exhibit 4-5). The area between Rosemead On-Ramp and the Huntington Interchange remains the location with the largest delays. However, the patterns in the eastbound direction are different. The section between Santa Anita On-Ramp and Baldwin On-Ramp has the largest concentration of delay. This bottleneck area is followed by the two areas previously identified in Exhibit 4-6.

Exhibit 4-7: Eastbound I-210 Delay per Lane-Mile (2006)

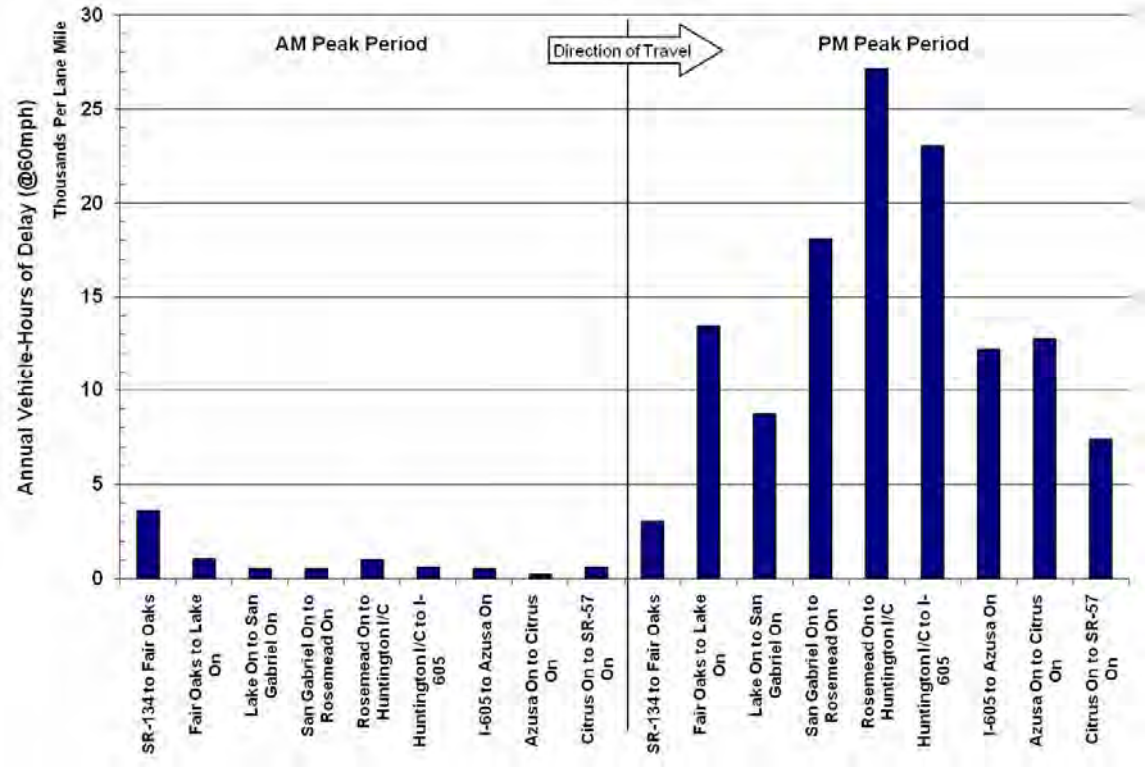
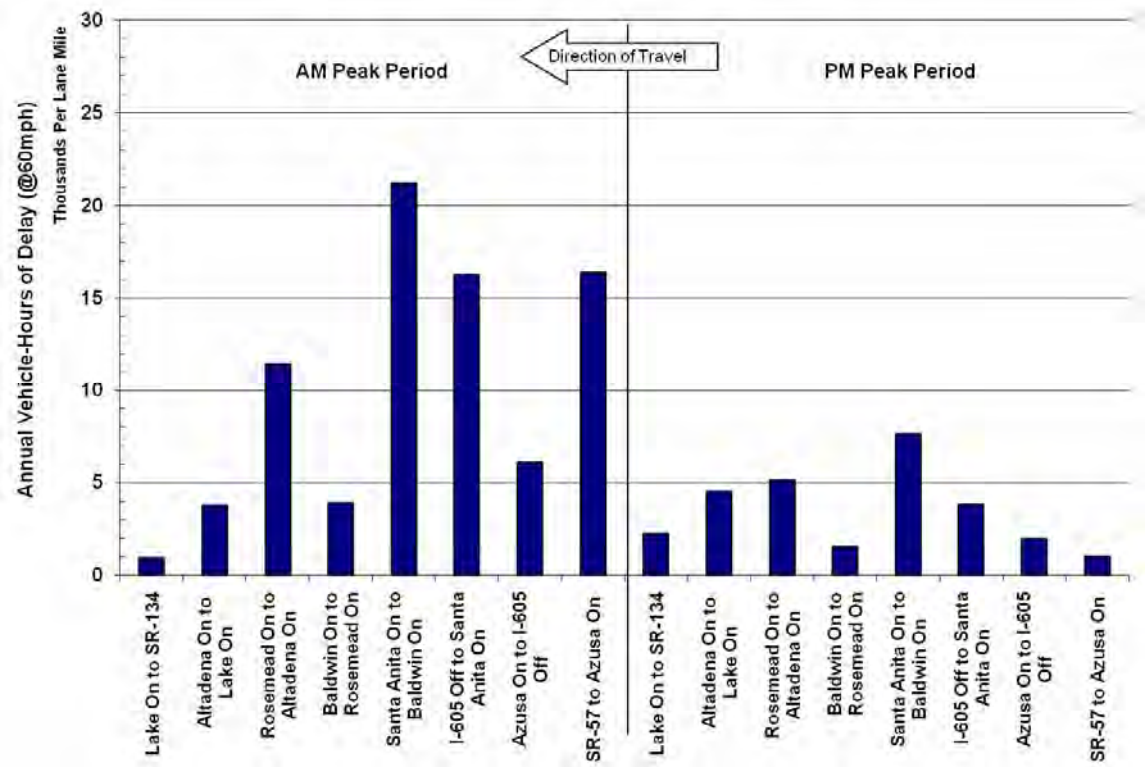


Exhibit 4-8: Westbound I-210 Delay per Lane-Mile (2006)



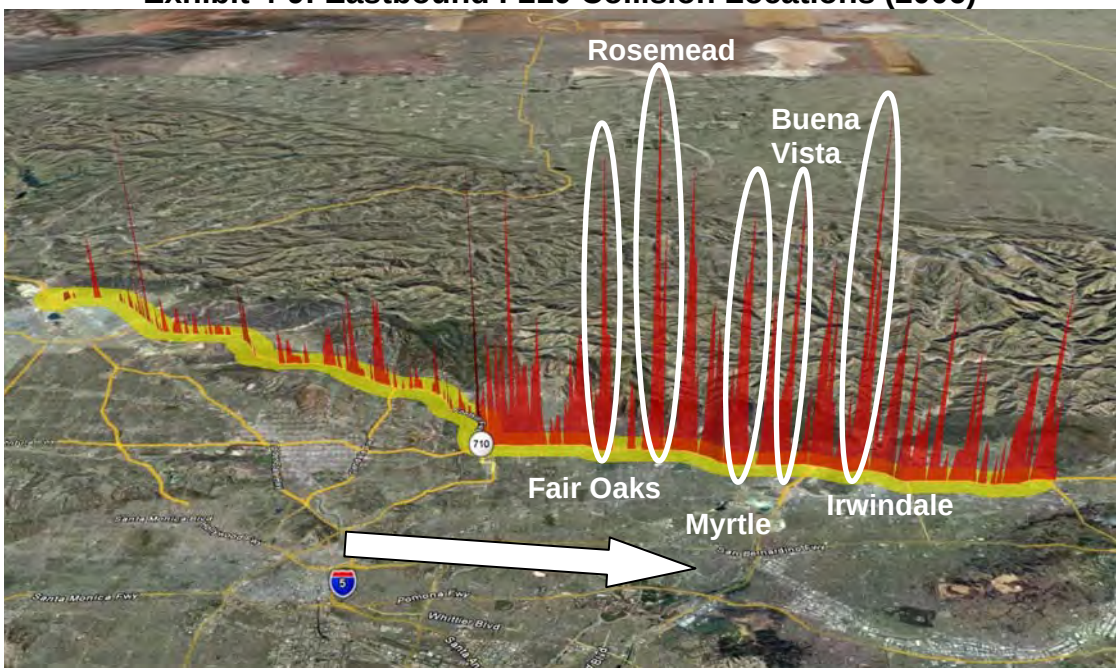
Safety by Bottleneck Area

As indicated previously in Section 3, the safety assessment in this report characterizes the overall accident history and trends along the corridor. It also highlights notable accident concentration locations or readily apparent patterns. The following discussion examines the patterns by bottleneck area.

Exhibit 4-9 shows the location of all collisions plotted along the I-210 Corridor in the eastbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) that occurred within 0.1 mile segments in 2006. The highest spike corresponds to roughly 20 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.

The magnitude of these spikes is less interesting than the concentration. Previous sections reported performance results for the congested urban area between the SR-134 and the SR-57. This is due mostly to the lack of detection in the western section. However, as Exhibit 4-9 shows, this focus also makes sense from a performance standpoint. The number of collisions is much greater in the congested urban area. As explained earlier, this is probably due to higher traffic volumes.

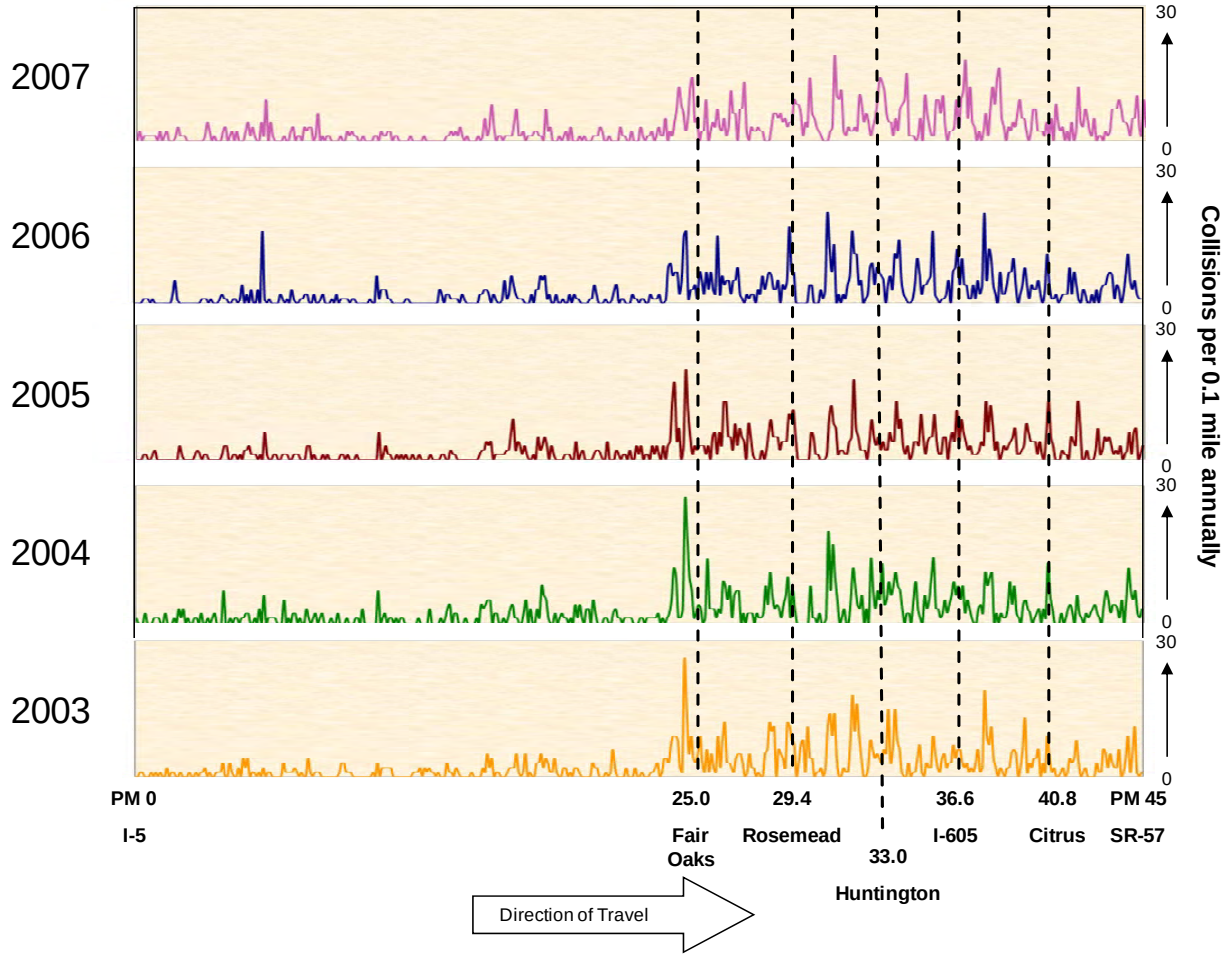
Exhibit 4-9: Eastbound I-210 Collision Locations (2006)



Source: SMG analysis of TASAS data

Exhibit 4-10 illustrates the same data for the five-year period between 2003 and 2007. Each graph within the exhibit represents one year, with the spikes indicating the number of collisions which occurred at a specific post mile location. The collisions range anywhere between zero (the minimum) and 30 (the maximum) as reflected on the y-axis. The vertical lines in the exhibit separate the corridor by bottleneck area. Exhibit 4-10 suggests that the high accident locations identified in 2006 (Exhibit 4-9) were similar in the preceding years. Moving eastbound, spikes indicating high accident locations were most notable near Fair Oaks at (PM 25.0), followed by Rosemead (PM 29.4), Myrtle Avenue (PM 34.1), Buena Vista (PM 35.6), and Irwindale Avenue (37.9). Between 2003 and 2005, there is a tall spike near Fair Oaks (PM 25.0), which is also a bottleneck location. The exhibit shows that the pattern of collisions has remained fairly consistent over the years.

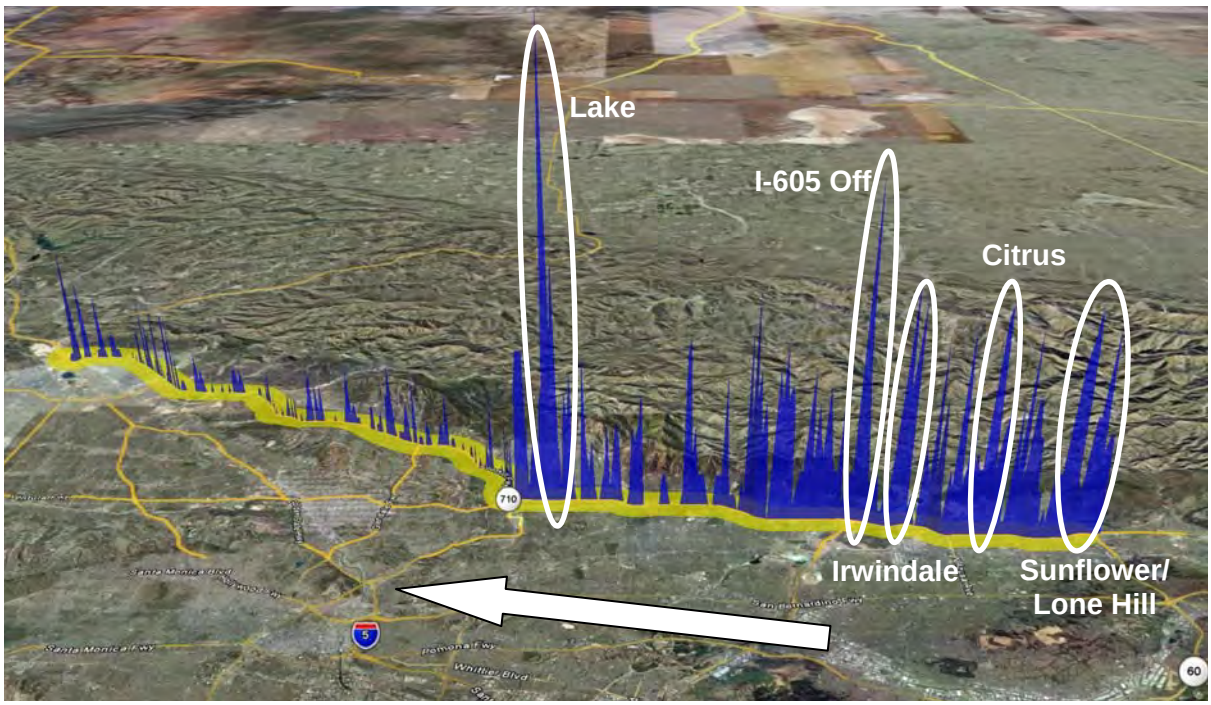
Exhibit 4-10: Eastbound I-210 Location of Collisions by Bottleneck Area (2003-2007)



Source: SMG analysis of TASAS data

Exhibit 4-11 shows the same 2006 collision data for I-210 in the westbound direction. The largest spike in this exhibit corresponds roughly to 26 collisions per 0.1 miles. The westbound direction experienced slightly more accidents than the eastbound direction did in 2006. Like the eastbound direction, there are noticeably higher numbers of collisions in the eastern urban section of the corridor (east of SR-134). As shown in Exhibit 4-11, the highest spike (of 26 collisions per 0.1 miles) occurs near SR-134 at the Lake interchange.

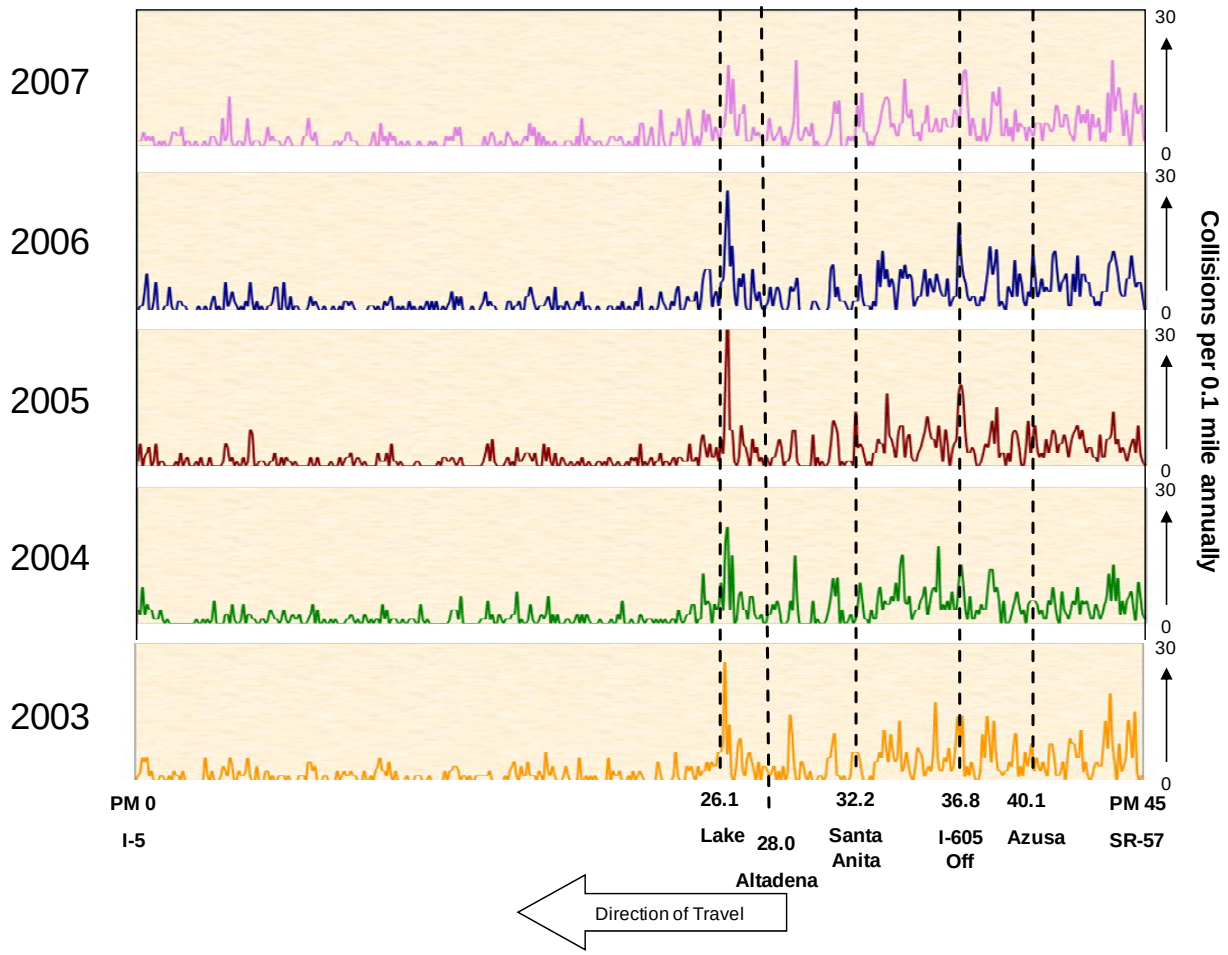
Exhibit 4-11: Westbound I-210 Collision Locations (2006)



Source: SMG analysis of TASAS data

Exhibit 4-12 shows the trend of collisions for the westbound direction from 2003 to 2007 period. The pattern of collisions has been fairly steady from one year to the next. The highest number of accidents has occurred consistently at Lake Avenue (PM 26.1). Other high accidents locations are depicted in Exhibit 4-11. Moving westbound, these are near Lone Hill and Sunflower (PM 43.5), Citrus Avenue (PM 40.9), Irwindale Avenue (PM 38.0), and the I-605 Off Ramp (PM 36.8). The high-collision location at the I-605 Off-ramp and Lake Avenue are also bottleneck locations, as identified in Exhibit 4-12.

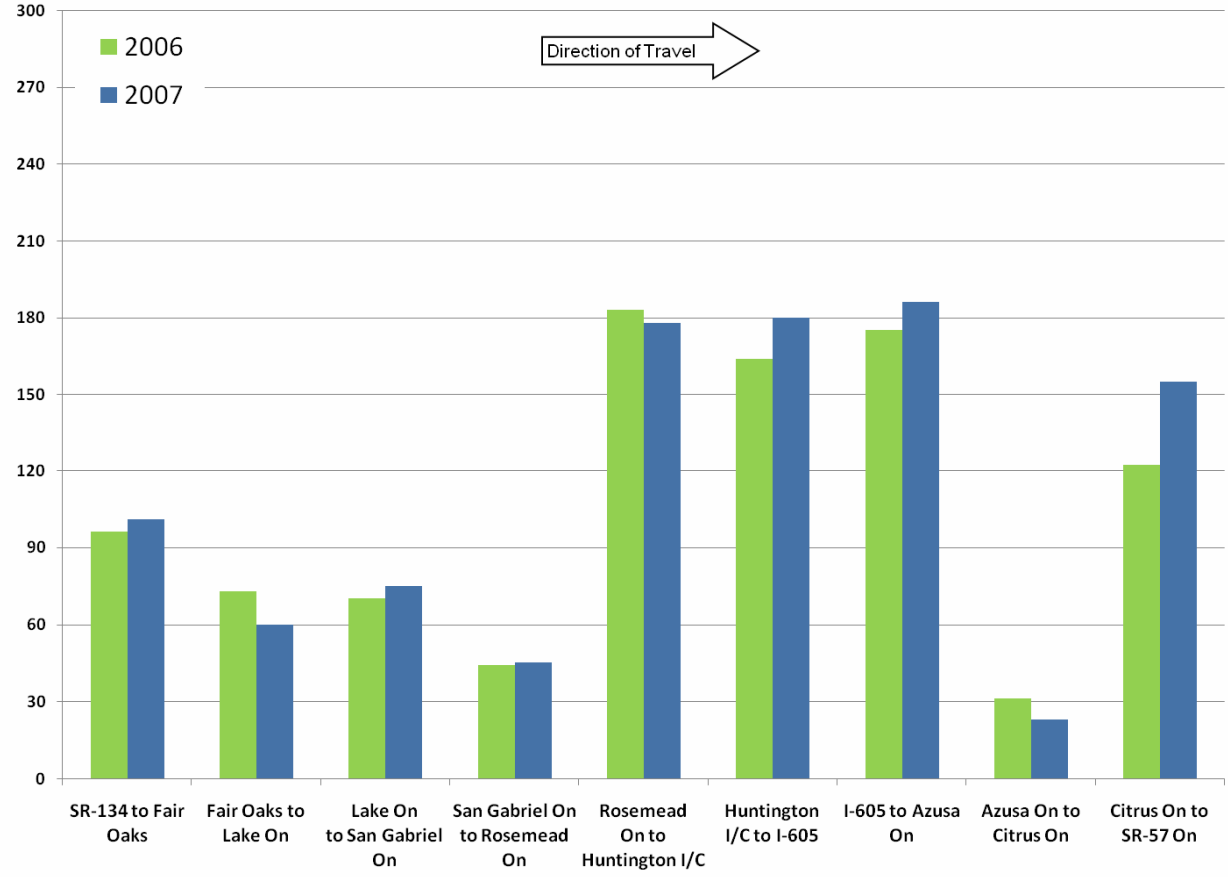
Exhibit 4-12: Westbound I-210 Collision Locations (2003-2007)



Source: SMG analysis of TASAS data

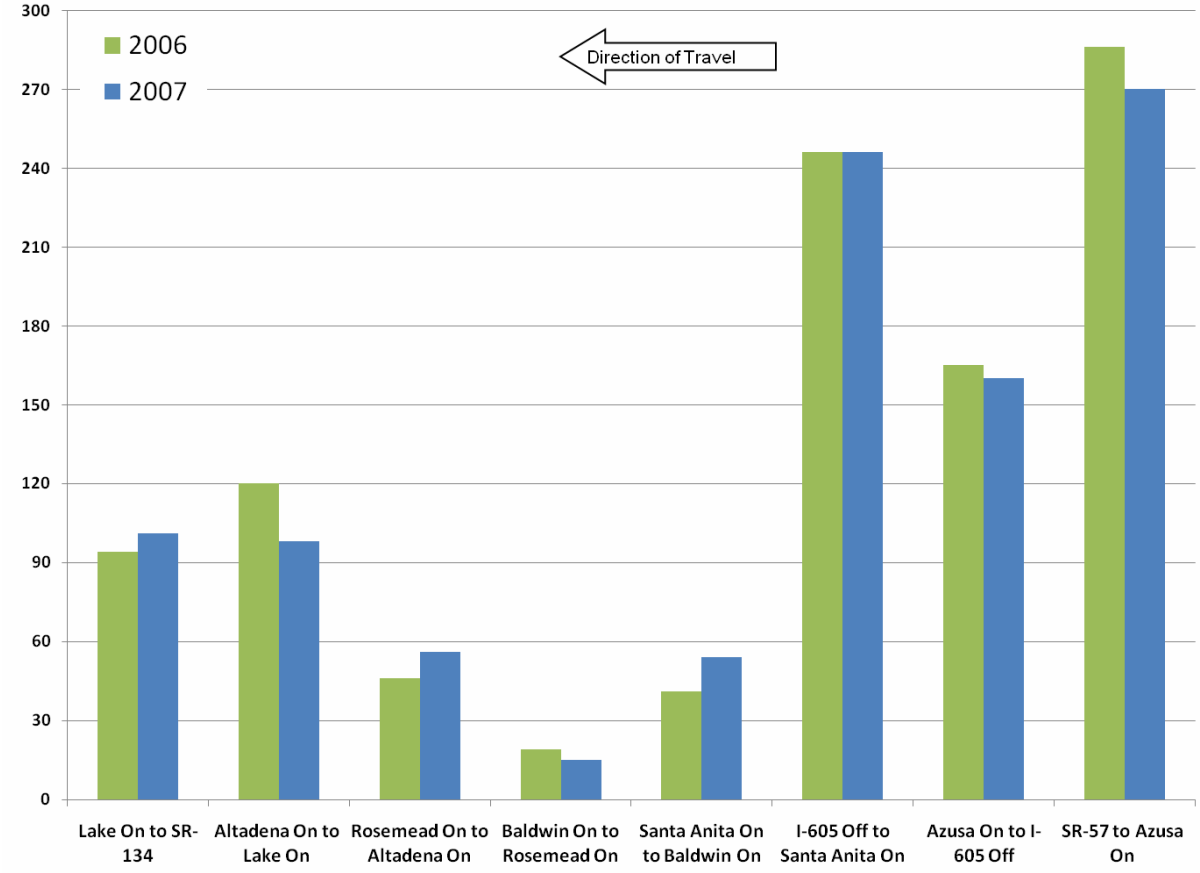
Exhibits 4-13 and 4-14 summarize the total number of accidents reported in TASAS by bottleneck area. The bars show the total of accidents that occurred in 2006 and 2007, the latest two years available in TASAS. The two years experienced roughly the same number of accidents. The number of accidents is also consistent between the two directions, although the location of accidents clusters differently. In the eastbound direction, the greatest number of accidents occurs in the three bottleneck areas in the central part of the corridor between Rosemead and Azusa. In the westbound direction, most accidents are somewhat further east and cluster in the three bottleneck areas from Santa Anita to SR-57.

Exhibit 4-13: Eastbound I-210 Total Accidents (2006 & 2007)



Source: SMG analysis of TASAS data

Exhibit 4-14: Westbound I-210 Total Accidents (2006 & 2007)



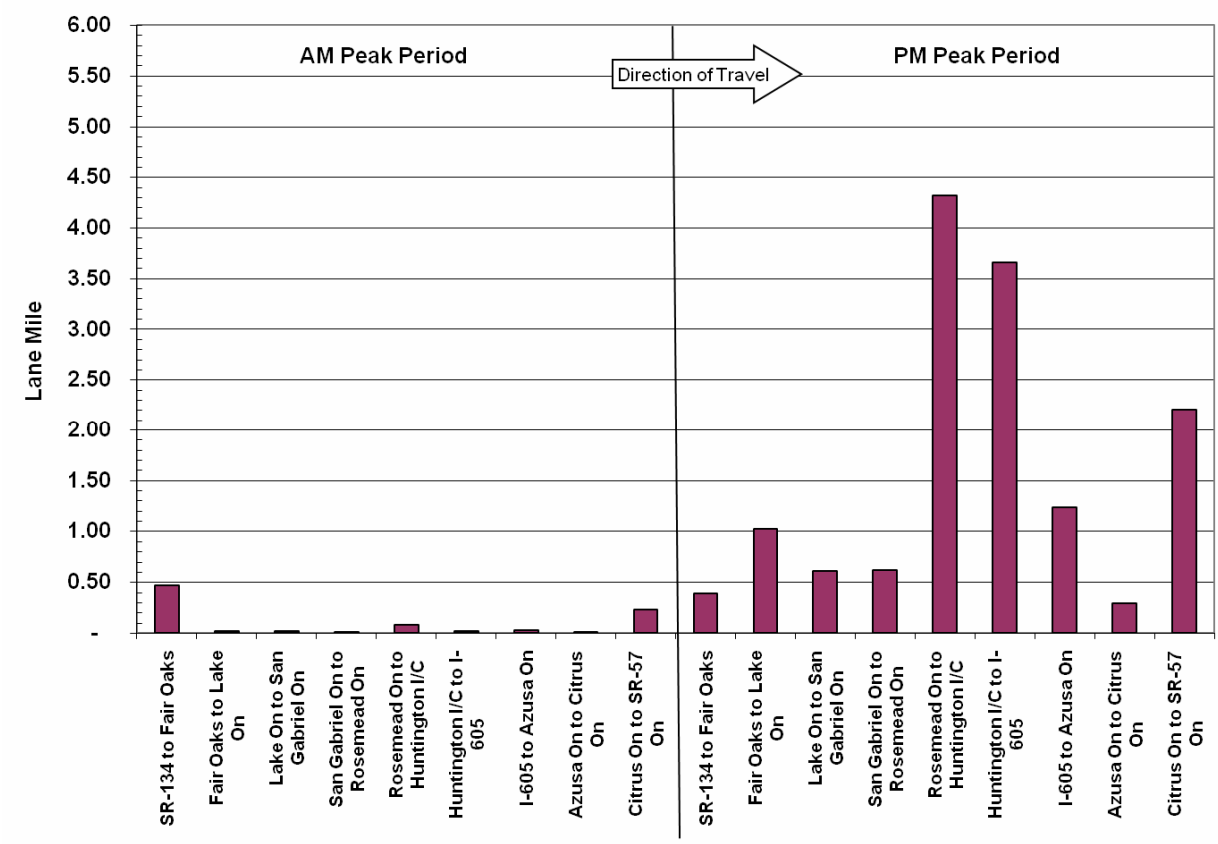
Source: SMG analysis of TASAS data

Productivity by Bottleneck Area

As discussed in Section 3, the productivity of a corridor is defined as the degree of utilization 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 capacity that would need to be added to achieve maximum productivity. Actually adding this number of lane-miles would not necessarily achieve the desired throughput due to operational issues.

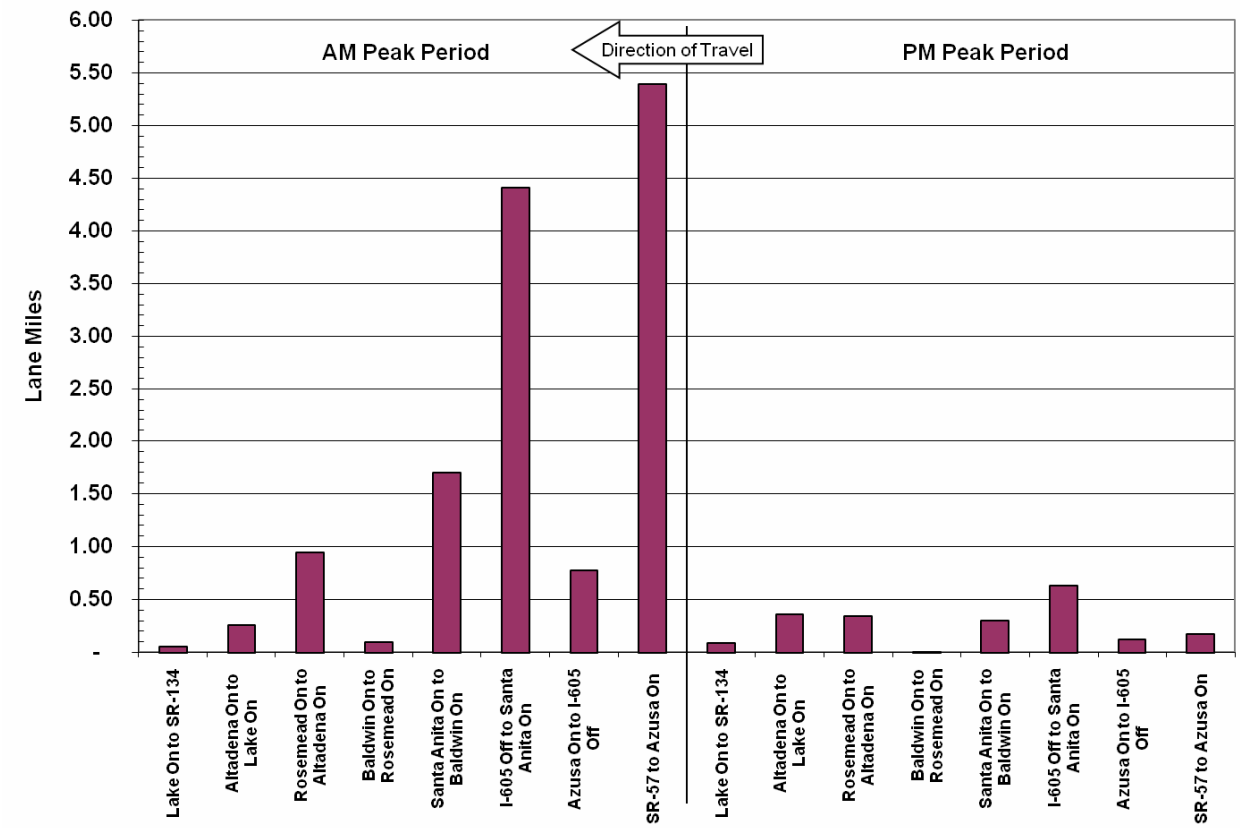
Exhibits 4-15 and 4-16 show the productivity losses for the corridor. In the eastbound direction (Exhibit 4-15), the two bottleneck areas between the Rosemead On-Ramp and the I-605 experienced the worst productivity losses in the PM peak. Together, these two bottleneck areas lose about 8 lane-miles. Since this section is just over 7 miles long, the productivity loss is the equivalent of losing more than a lane of I-210. This section of lost productivity is in a similar area (although a bit smaller) to the section with high accidents (Exhibit 4-13). It is also very consistent with the location of the highest delays along the corridor (Exhibits 4-5 and 4-7).

Exhibit 4-15: Eastbound I-210 Lost Lane-Miles (2006)



In the westbound direction (Exhibit 4-16), the largest productivity loss occurs in the bottleneck area between SR-57 and Azusa On-Ramp (nearly 5.50 lost lane-miles). The next largest productivity loss occurs in the bottleneck area from I-605 Off-Ramp to Santa Anita On-Ramp (almost 4.5 lost lane-miles). As in the eastbound direction, these locations are consistent with the highest number of accidents (Exhibit 4-14) and the largest delays (Exhibits 4-6 and 4-8).

Exhibit 4-16: Westbound I-210 Lost Lane-Miles (2006)



Page Intentionally Left Blank for Future Updates on Bottleneck Identification, Bottleneck Area Definition, and Performance Measures by Bottleneck Area

5. CAUSALITY ANALYSIS

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-210 Corridor, field observations were conducted by the project team on multiple days (midweek) in November and December 2007 as well as February and May 2008 during the AM and PM peak hours.

By definition, a bottleneck is a condition where traffic demand exceeds the capacity of the roadway facility. In most cases, the cause of bottlenecks is related to a sudden reduction in capacity, such as roadway geometry, heavy merging and weaving, and driver distractions; or a surge in demand that the facility cannot accommodate. Due to the limited vehicle detector stations along this corridor, traffic volume data was not readily available for consideration. Nevertheless, major bottleneck conditions were verified and their causes identified. Below is a summary of the causes of the bottleneck locations.

Mainline Facility

Eastbound Bottlenecks and Causes

The eastbound bottlenecks and congestion were mostly in the PM peak hours, although evidence of some of the same bottlenecks to a lesser degree was found in the AM peak hours. The causes of these bottleneck locations are summarized below.

Mountain On-Ramp to Fair Oaks

Exhibit 5-1 is an aerial photograph of the eastbound I-210 mainline approaching the SR-134 interchange and the Lincoln tunnel. Most of the traffic is headed either on the eastbound I-210 freeway or the westbound SR-134. The two-lane connector capacity is often inadequate to accommodate the demand. As a result, significant congestion and queuing occurs from this location, mostly in the AM peak hours but sometimes even in the PM peak hours. Congestion and queuing is accentuated on days preceding major holiday weekends.

Exhibit 5-1: Eastbound I-210 at SR-134/Lincoln Tunnel

Lake On-Ramp to Hill Off-Ramp

The primary cause of this bottleneck is the heavy traffic from Lake on-ramp that the mainline facility cannot accommodate the surge in demand. The Lake on-ramp often exceeds 900 vehicles per hour during PM peak hours, even with ramp metering.

San Gabriel On-Ramp to Madre Off-Ramp

The primary cause of this bottleneck is that the mainline capacity at this location cannot accommodate the increase in demand from the San Gabriel on-ramp, although the demand is modest at less than 600 vehicles per hour with ramp metering. There is a large reversing horizontal curve, to the right at San Gabriel and then left at Madre; however, an auxiliary lane is provided between the two interchanges with sufficient distance to allow for easier merging and weaving.

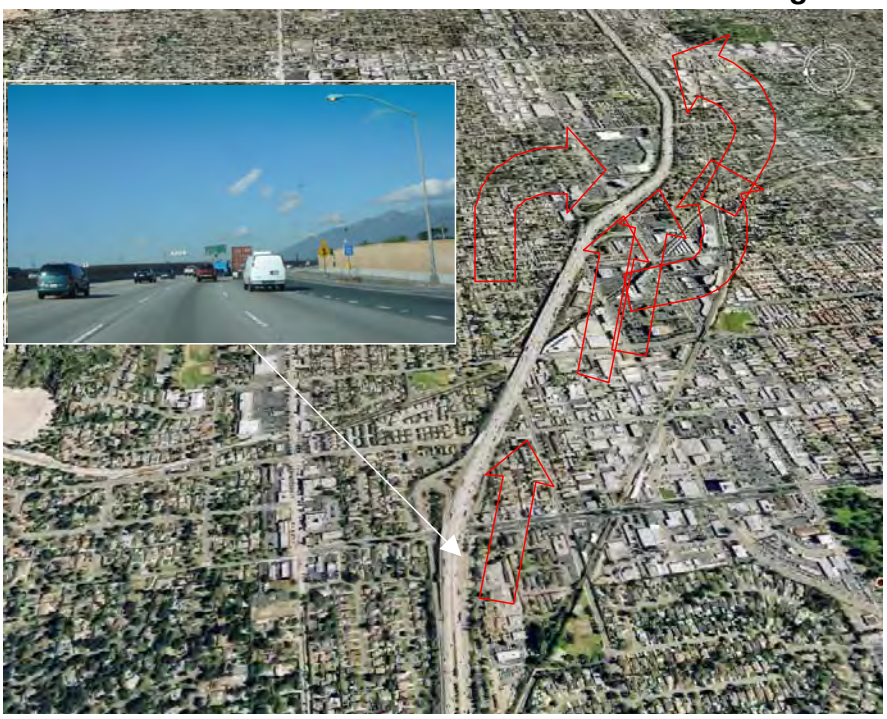
Rosemead On-Ramp to Baldwin Off-Ramp

The primary cause of this bottleneck is the heavy traffic from two consecutive on-ramps from Rosemead and Michillinda merging into the freeway traffic. Although the ramp volumes are very modest at less than 400 vehicles per hour combined, the mainline facility cannot accommodate the additional demand since the mainline traffic is near or at the threshold levels

Santa Anita On-Ramp to Huntington Off-Ramp

Exhibit 5-2 is an aerial photograph of the eastbound I-210 mainline between Santa Anita and Huntington. As shown, the roadway here has multiple large horizontal curves with narrowing effect through this segment. Given the geometric conditions, the mainline cannot accommodate the additional demand from the Santa Anita and Huntington ramps.

Exhibit 5-2: Eastbound I-210 at Santa Anita/Huntington



Mountain On-Ramp to I-605 Off-Ramp

Exhibit 5-3 is an aerial photograph of the eastbound I-210 mainline approaching the I-605 interchange. The primary cause of this bottleneck is the heavy traffic from two consecutive on-ramps from Mountain and Buena Vista merging into the freeway traffic, compounded by mainline traffic weaving to get into the outside lanes in order to exit at I-605 connector. Combined, the two ramps exceed 1,200 vehicles per hour during PM peak hours, even with ramp metering. The photo illustrates the heavy traffic and difficulty in weaving.

Exhibit 5-3: Eastbound I-210 at I-605 Off

Irwindale On-Ramp to Vernon Off-Ramp

Exhibit 5-4 is an aerial photograph of the eastbound I-210 mainline between Irwindale and Azusa. As shown, the roadway here has multiple large horizontal curves. The primary cause of this bottleneck is the heavy traffic from the Irwindale on-ramp combined with the curvature of the roadway. Irwindale on-ramp exceeds 700 vehicles per hour during AM peak hours, even with ramp metering. The mainline traffic must negotiate the long turn and accommodate the merging traffic from ramp.

Exhibit 5-4: Eastbound I-210 at Irwindale

Azusa On-Ramp to Citrus Off-Ramp, Citrus On-Ramp to Grand Off-Ramp, and SR-57 On-Ramp to San Dimas Off-Ramp

The primary cause of these bottlenecks is the added demand from the ramps exceeding the available capacity of the mainline facility. The mainline traffic is at or near the threshold levels during the PM peak hours and cannot accommodate the additional demand.

Westbound Bottlenecks and Causes

Westbound bottlenecks and congestion were mostly in the AM peak hours, although evidence of the same bottlenecks to a lesser degree was found in the PM peak hours. The following is a summary of the eastbound bottlenecks and the identified causes.

Azusa On-Ramp to Vernon Off-Ramp

Exhibit 5-5 is an aerial photograph of the westbound I-210 mainline approaching Azusa on-ramp. As shown, the roadway has a large horizontal curve to the right. The primary cause of this bottleneck is the heavy traffic from two consecutive on-ramps from Azusa merging into the freeway traffic at the crest of the curve. Combined, the two ramps exceed 1,000 vehicles per hour during AM peak hours, even with ramp metering. The mainline traffic must negotiate the long turn and accommodate the merging traffic from consecutive ramps.

Exhibit 5-5: Westbound I-210 at Azusa

Irwindale On-Ramp to I-605 Off-Ramp

Exhibit 5-6 is an aerial photograph of the westbound I-210 mainline between Irwindale and I-605. As shown, the roadway here also has a large horizontal curve to the right. The primary cause of this bottleneck is the heavy traffic from two consecutive on-ramps from Irwindale merging into the freeway traffic, compounded by mainline traffic weaving to get into the outside lanes in order to exit at I-605 connector. Combined, the two ramps exceed 800 vehicles per hour during AM peak hours, even with ramp metering.

Exhibit 5-6: Westbound I-210 at Irwindale and I-605

Santa Anita On-Ramp to Baldwin Off-Ramp

Exhibit 5-7 is an aerial photograph of the westbound I-210 mainline between Huntington and Santa Anita. As shown, the roadway here has multiple large horizontal curves. The primary cause of this bottleneck is the heavy traffic from two consecutive on-ramps from Santa Anita merging into the freeway traffic at the crest of the curve. Combined, the two ramps exceed 900 vehicles per hour during AM peak hours, even with ramp metering. The mainline traffic must negotiate the long turn and accommodate the merging traffic from consecutive ramps. The lower photo shows the backup traffic in all lanes at Huntington. The upper photo shows the right two lanes congested while the inner lanes begin to move faster and separate. This indicates that the ramp traffic merging is affecting the mainline traffic flow.

Exhibit 5-7: Westbound I-210 at Santa Anita

Baldwin On-Ramp to Michillinda Off-Ramp

Like most of the other locations, the primary cause of this bottleneck is the heavy traffic from two consecutive on-ramps from Baldwin (North and South Baldwin) merging into the freeway traffic. Combined, the two ramps exceed 900 vehicles per hour during AM peak hours, even with ramp metering.

Rosemead On-Ramp to Sierra Madre Villa Off-Ramp

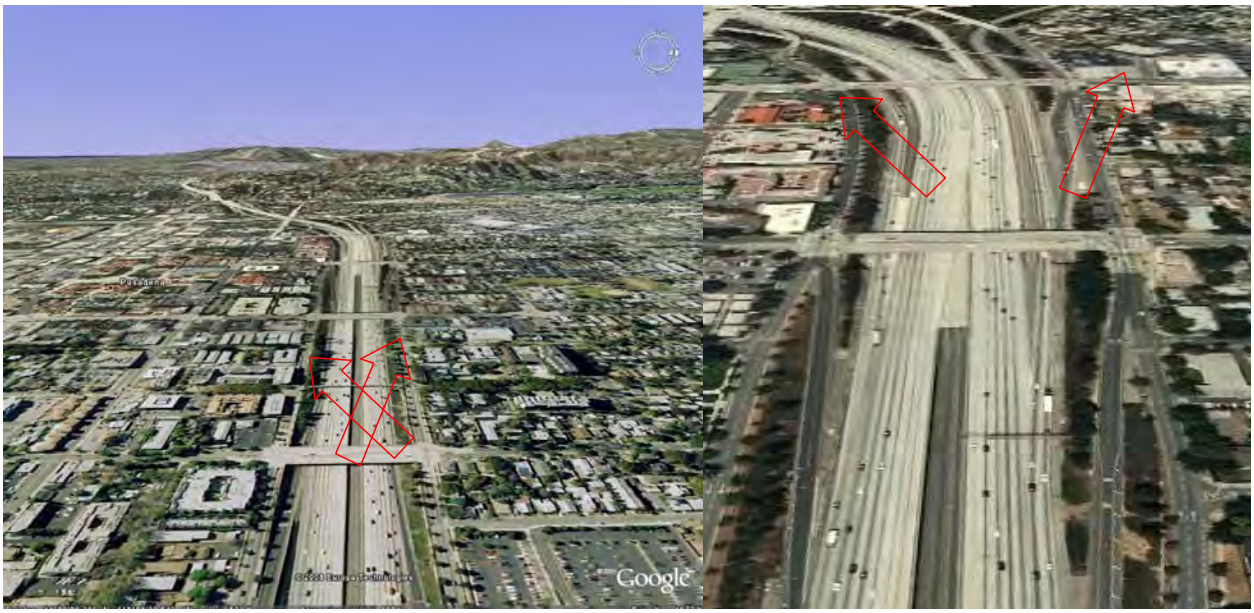
The primary cause of this bottleneck is the heavy traffic from three consecutive on-ramps from Michillinda, Foothill, and Rosemead merging into the freeway traffic, compounded by the weaving from traffic exiting at Sierra Madre Villa. Combined the three ramps exceed 1,700 vehicles per hour during AM peak hours, even with ramp metering. Exhibit 5-8 illustrates this location.

Exhibit 5-8: Westbound I-210 at Rosemead

Lake On-Ramp to SR-134 Off-Ramp

The primary cause of this bottleneck is the weaving between the heavy traffic from the Lake on-ramp and exiting traffic to I-210 west. Lake on-ramp exceeds 700 vehicles per hour during AM peak hours, even with ramp metering. Exhibit 5-9 illustrates this location.

Exhibit 5-9: Westbound I-210 at Lake and SR-134



SR-118 On-Ramp to Maclay Street Off-Ramp

The primary cause of this bottleneck is the heavy SR-118 freeway on-ramp traffic merging with the I-210 mainline traffic during the PM peak hours. The eastbound SR-118 freeway terminates at this I-210 junction. Two connector lanes to westbound I-210 merge into one and enter the freeway. The I-210 mainline facility cannot handle the heavy demand and platoon of vehicles from this connector. Exhibit 5-10 illustrates this location. The bottom photograph illustrates the light volume on the westbound I-210 mainline approaching the SR-118 interchange. The middle photograph illustrates the congestion and queuing resulting from the SR-118 connector on-ramp merging. To make matters worse, the fourth lane (provided from the connector on) is dropped after the Maclay Street off-ramp, as shown on the top photograph. It also shows the clearing of the congestion past the Maclay Street interchange.

Exhibit 5-10: Westbound I-210 at SR-118

High Occupancy Vehicle Facility

A bottleneck and causality analyses was also conducted for the HOV facility of the SR-210 Corridor. The HOV-lane stretches about 20-miles in each direction between SR-134 and SR-57. They operate on a full-time basis separated by a buffer with varying widths. It has a vehicle occupancy requirement of two plus (2+) in both directions. PeMS was primarily used to conduct the HOV analysis.

Eastbound HOV Bottlenecks and Causes

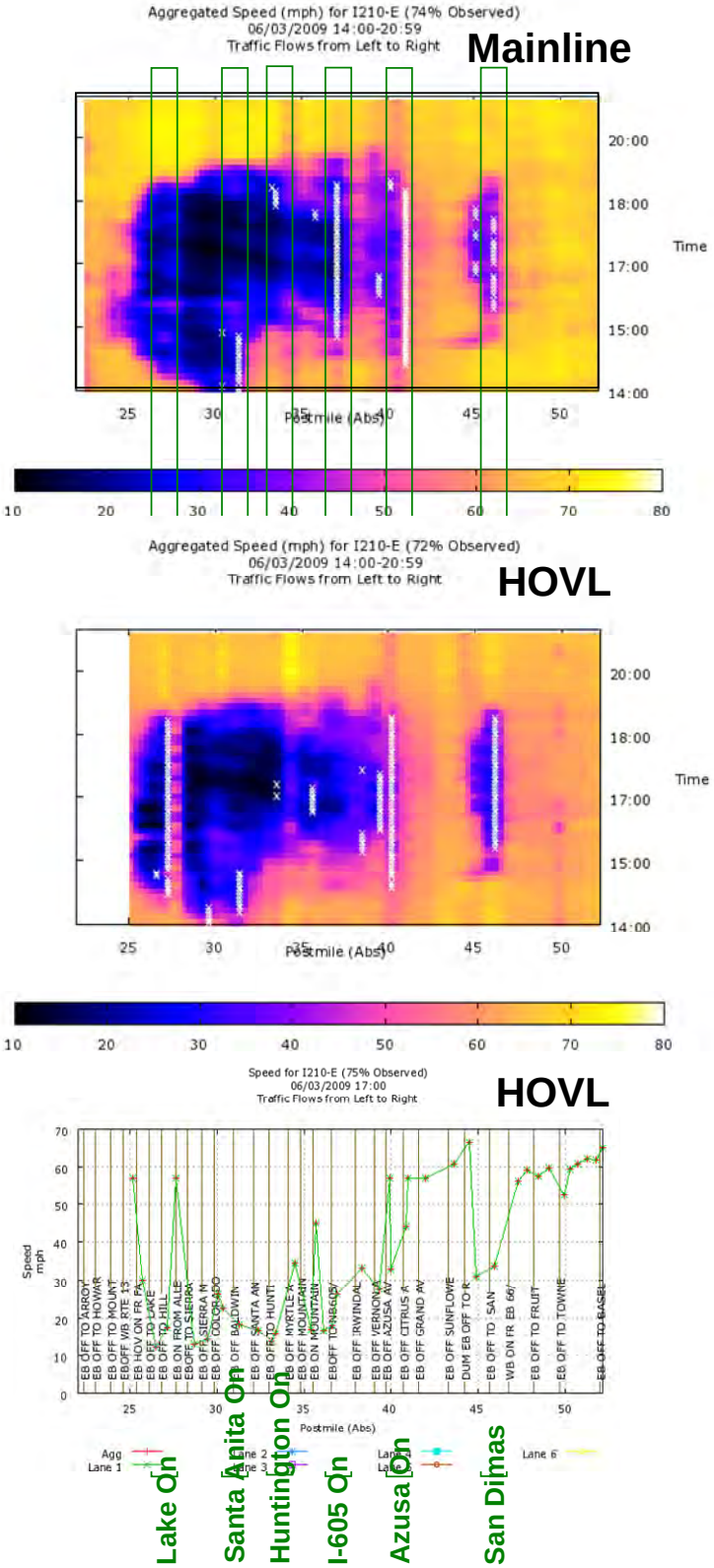
In the eastbound direction, six major bottlenecks were identified based on data analysis, at the following locations:

- Lake Avenue On
- Santa Anita Avenue On
- Huntington Drive On
- I-605 On
- Azusa Avenue On
- San Dimas

Exhibit 5-11 presents the PeMS speed contour diagram of the eastbound I-210 mainline and HOV lanes for a recent weekday in June 2009. These diagrams indicate locations of congestion and bottlenecks. A review of multiple sample days and monthly averages throughout 2007 and 2008 revealed the appearance of the same bottleneck locations.

As indicated in Exhibit 5-11, the HOV-lane bottleneck locations coincide exactly with the mainline bottleneck locations. This is primarily due to the close proximity of the HOV-lane to the mainline lane. For most of the facility, the existing HOV-lane is separated from the mainline by a double yellow and white stripe separation (about 2 feet in width). The HOV-lane has little to no inside shoulder. When the mainline is congested and speeds are at stop and go, the HOV traffic will also slow down (out of caution), breaking down the flow particularly near the HOV-lane ingress/egress locations and at roadway curves.

Exhibit 5-11: Eastbound I-210 ML & HOVL PeMS Speed Contour (June 2009)



Westbound HOV Bottlenecks and Causes

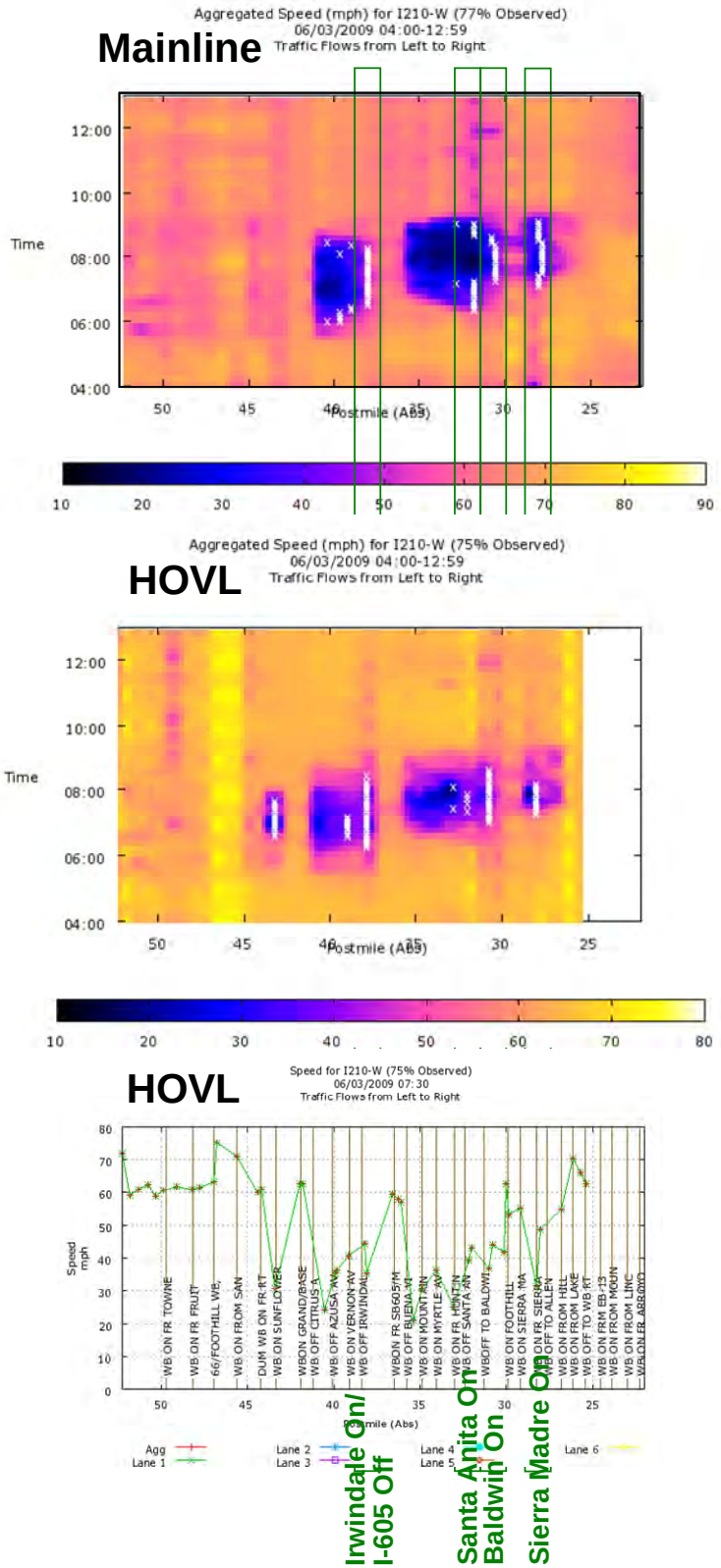
In the westbound direction, four major bottlenecks were identified based on data analysis, at the following locations:

- Irwindale Avenue On/I-605 Off
- Santa Anita Avenue On
- Baldwin Avenue On
- Sierra Madre On

Exhibit 5-12 presents the PeMS speed contour diagram of the westbound I-210 mainline and HOV lanes for a recent weekday in June 2009. These diagrams indicate locations of congestion and bottlenecks. A review of multiple sample days and monthly averages throughout 2007 and 2008 revealed the appearance of the same bottleneck locations.

Like the eastbound direction, the westbound HOV-lane bottleneck locations also coincide with the mainline bottleneck locations, as indicated in Exhibit 5-12. Again, this is primarily due to the close proximity of the HOV-lane to the mainline lane. For most of the facility, the westbound HOV-lane is separated from the mainline by a double yellow and white stripe separation (about 2 feet in width). The HOV-lane has little to no inside shoulder. When the mainline is congested and speeds are at stop and go, the HOV traffic will also slow down (out of caution), breaking down the flow particularly near the HOV-lane ingress/egress locations and at roadway curves.

Exhibit 5-12: Westbound I-210 ML & HOVL PeMS Speed Contour (June 2009)



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APPENDIX

This appendix is an exact copy of Section 4 of the Comprehensive Performance Assessment document developed and submitted to Caltrans in May 2008. It is included for reference purposes and to allow future updates. This analysis identified bottlenecks based on a number of data sources and field observations. It represents the foundation for the conclusions in Section 4 of this Comprehensive Performance Assessment report, which built on the original findings and confirmed these conclusions with additional data analysis.

4A. BOTTLENECK ANALYSIS

In this section of the report, the results of the bottleneck analysis are presented. The bottleneck analysis was conducted to identify potential bottleneck locations. Potential freeway bottleneck locations that create mobility constraints are identified and documented, and their relative contribution to corridor-wide congestion is reported.

A variety of sources were used to identify bottlenecks. They include the following:

- Caltrans Highway Congestion Monitoring Program (HICOMP) 2006 report;
- Probe vehicle runs (electronic tach runs)
  - *Caltrans District 7 tach runs*
- Freeway Performance Measurement System (PeMS)
  - *Speed contour plots*
  - *Flow data; and*
- Aerial photos (Google Earth) and Caltrans photologs
- Field observations

Exhibit 4-1 provides a summary of the bottlenecks identified from the analysis of the various sources. Each bottleneck was verified in separate field observations made on a normal weekday in November and December 2007, and February and May 2008.

Exhibit A4-1: Summary of Bottlenecks Identified and Verified

BOTTLENECK LOCATION	Bottleneck Area Post Mile Range		HICOMP [a] Report		Caltrans [b] Probe Veh. Runs		PeMS [c] Speed Contours		Field [d] Observations	
	ABS	CT	AM	PM	AM	PM	AM	PM	AM	PM
WESTBOUND										
Azusa on to Vernon off	40.1/39.4	R39.8/39.1	✓	-	✓	-	✓	✓	✓	✓
Irwindale on to I-605 off	38.3/36.8	R38.0/36.5	-	-	✓	-	✓	✓	✓	✓
Santa Anita on to Baldwin off	32.0/31.3	R31.7/31.0	-	-	✓	-	✓	✓	✓	✓
Baldwin on to Michillinda off	31.0/30.3	R30.7/30.0	-	-	-	-	✓	✓	✓	✓
Rosemead on to Sierra Madre off	29.7/29.4	L29.7/R29.4	✓	-	✓	-	✓	✓	✓	✓
Altadena on to Allen off	28.0/27.6	R28.1/27.7	-	-	-	-	✓	✓	✓	✓
Lake on to SR-134 off	26.1/25.5	R26.1/25.5	✓	-	✓	-	✓	✓	✓	✓
SR-134 to SR-118 off	25.5/6.4	R25.5/6.4	-	-	-	-	na	na	-	-
SR-118 on to Maclay off	5.9/5.0	R5.9/5.0	-	-	-	-	na	na	-	✓
Maclay on to I-5	4.8/0.0	R4.8/0.0	-	-	-	-	na	na	-	-
EASTBOUND										
I-5 to Mountain	0.0/24.2	R0.0/24.2	-	-	-	-	na	na	-	-
Mountain on to Fair Oaks	24.2/25.0	R24.2/25.0	✓	-	-	-	✓	✓	-	-
Lake on to Hill off	26.5/26.8	R26.5/26.8	-	-	-	-	-	✓	-	✓
Sierra Madre on to Madre off	28.7/29.1	R28.7/29.1	-	✓	-	-	-	-	-	✓
Rosemead on to Baldwin off	29.4/31.0	R29.4/30.7	-	-	-	✓	-	-	-	✓
Santa Anita on to Huntington off	32.4/33.0	R32.1/32.7	-	-	-	✓	-	✓	-	✓
Mountain on to I-605 off	35.5/36.6	R35.2/36.3	-	✓	-	✓	-	✓	-	✓
Irwindale on to Vernon off	38.3/39.0	R38.0/38.7	-	-	-	✓	-	-	-	-
Azusa on to Citrus off	40.1/40.7	R39.8/40.4	-	-	-	-	✓	✓	✓	✓
Citrus on to Grand off	40.5/41.6	R40.2/41.3	-	✓	-	✓	-	✓	-	✓
SR-57 on to San Dimas off	44.6/45.6	R44.3/45.3	-	-	-	✓	✓	✓	✓	✓

NOTES:
[a] Based on 2006 HICOMP report.
[b] Based on Caltrans District 7 sample probe vehicle runs, taken in March/May 2002.
[c] Based on Performance Measurement System (PeMS) sample daily speed contours taken from April & November 2006, and 2006 quarterly weekday averages.
[d] Based on field observations made on typical non-holiday weekdays in November and December 2007, and in February and May 2008.
na Data not available
\- No indication of bottleneck from this source.

ANALYSIS DETAILS

HICOMP

In review of the Caltrans Highway Congestion Monitoring Program (HICOMP) 2006 report, potential problem areas are initially identified. As illustrated in Exhibit 4-2 and 4-3, the downstream end of congested segments could potentially be bottleneck areas in the westbound direction, as outlined in blue circles, and in the eastbound direction, as outlined in red circles.

- As indicated, in the AM peak there are potentially three major bottlenecks in the westbound direction and one major bottleneck in the eastbound direction:
    - SR-39/Azusa (WB)
    - Foothill Boulevard (WB)
    - Lake Avenue (WB)
    - SR-134 (EB)
- In the PM peak, there are potentially three major bottlenecks in the eastbound direction and none in the westbound direction:
    - Sierra Madre Boulevard (EB)
    - Mountain Ave/I-605 (EB)
    - Citrus Avenue (EB)

Further analysis would be needed, however, to determine their actual locations and possibly any other bottlenecks along the corridor not identified in the HICOMP. The review of the HICOMP provides a good starting point to keep in mind of the congested areas and possible bottleneck locations as more detailed analysis is conducted.

Exhibit A4-2: 2006 HICOMP AM Congestion Map with Potential Bottlenecks

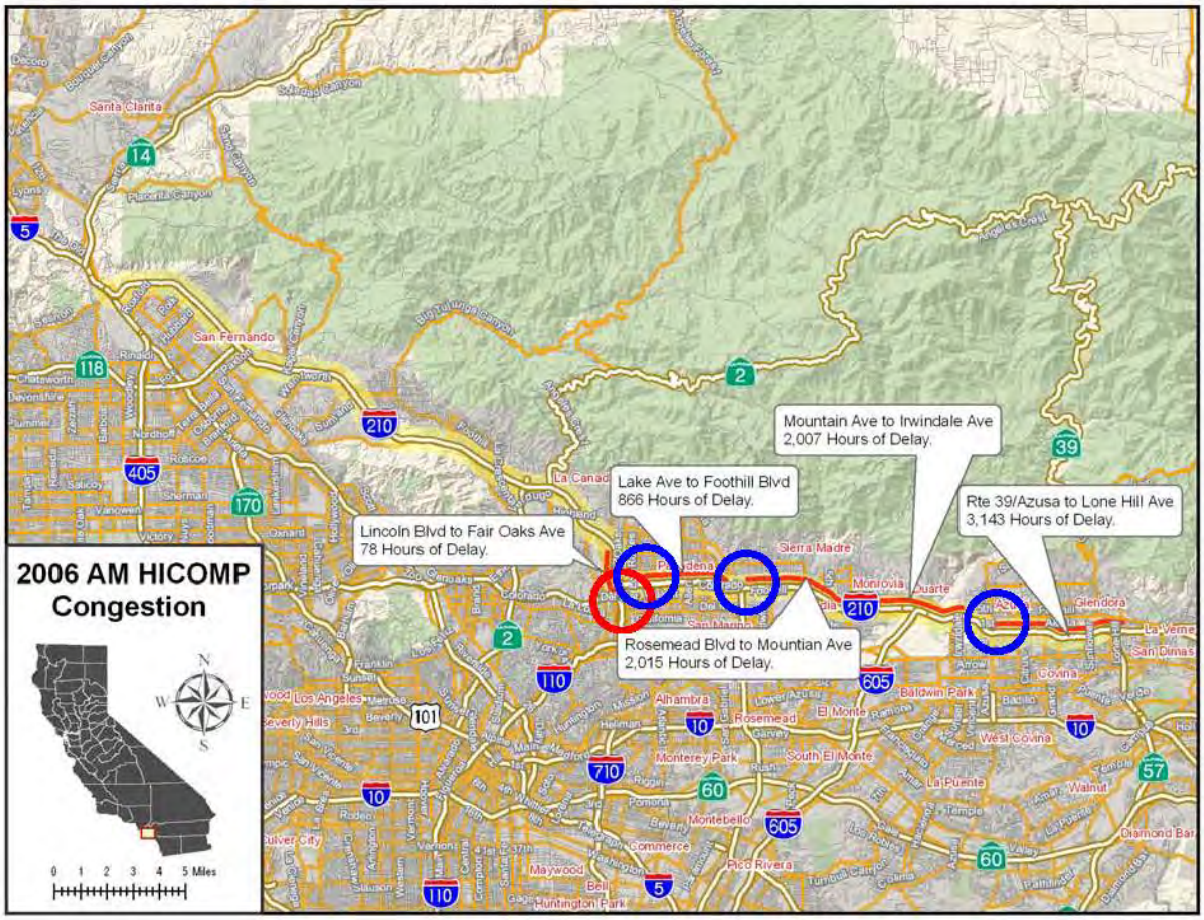
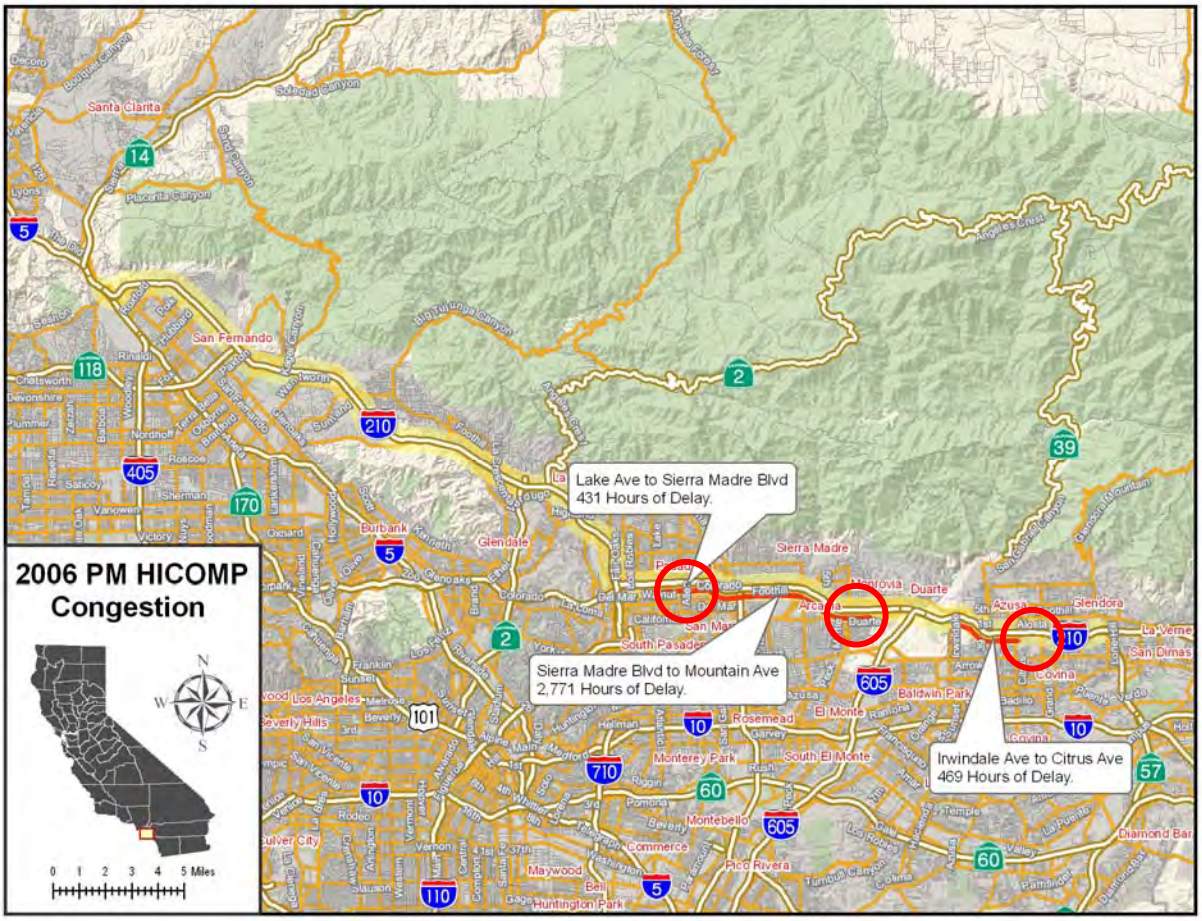


Exhibit A4-3: 2006 HICOMP PM Congestion Map with Potential Bottlenecks



Probe Vehicle Runs

The probe vehicle runs (electronic tach runs) provide speed plots across the corridor at various departure times. A vehicle equipped with an electronic (GPS or tachograph) 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 length. Bottlenecks can be found at the end of a slow congested speed location where speeds pick up to 30 miles per hour to 50 miles per hour.

Caltrans District 7 collected probe vehicle run data in March and May of 2002, their most recent data available, for the I-210 from Calgrove Boulevard (north of I-5) to Foothill Boulevard (east of SR-57). Exhibit 4-4 illustrates the westbound probe vehicle runs at 7AM, 7:30AM, and 8AM. Exhibit 4-5 illustrates the I-210 eastbound probe vehicle runs, from Foothill to I-5, at 4PM, 5PM, and 6PM conducted on March/May 2006. No speeds below 35 miles per hour were reported in the westbound direction during the PM peak hours or in the eastbound direction during the AM peak hours.

Exhibit A4-4: WB-210 Sample Probe Vehicle Runs

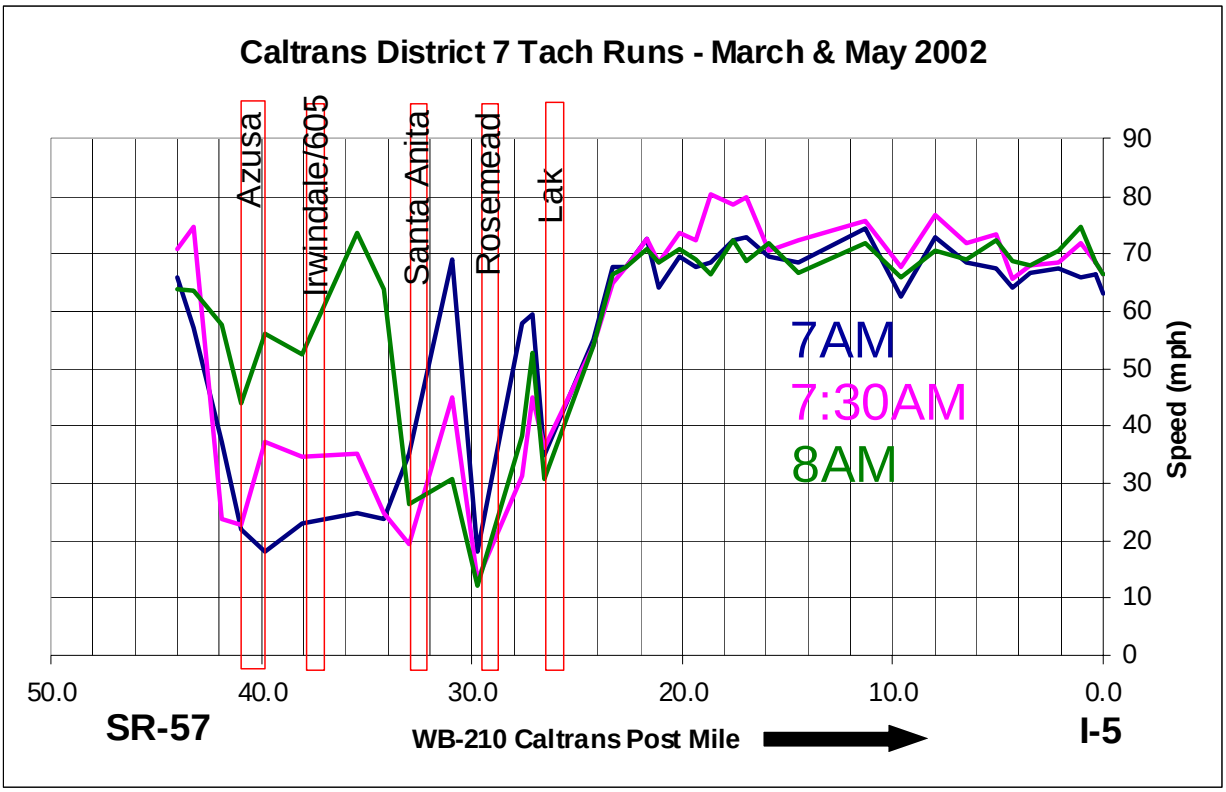
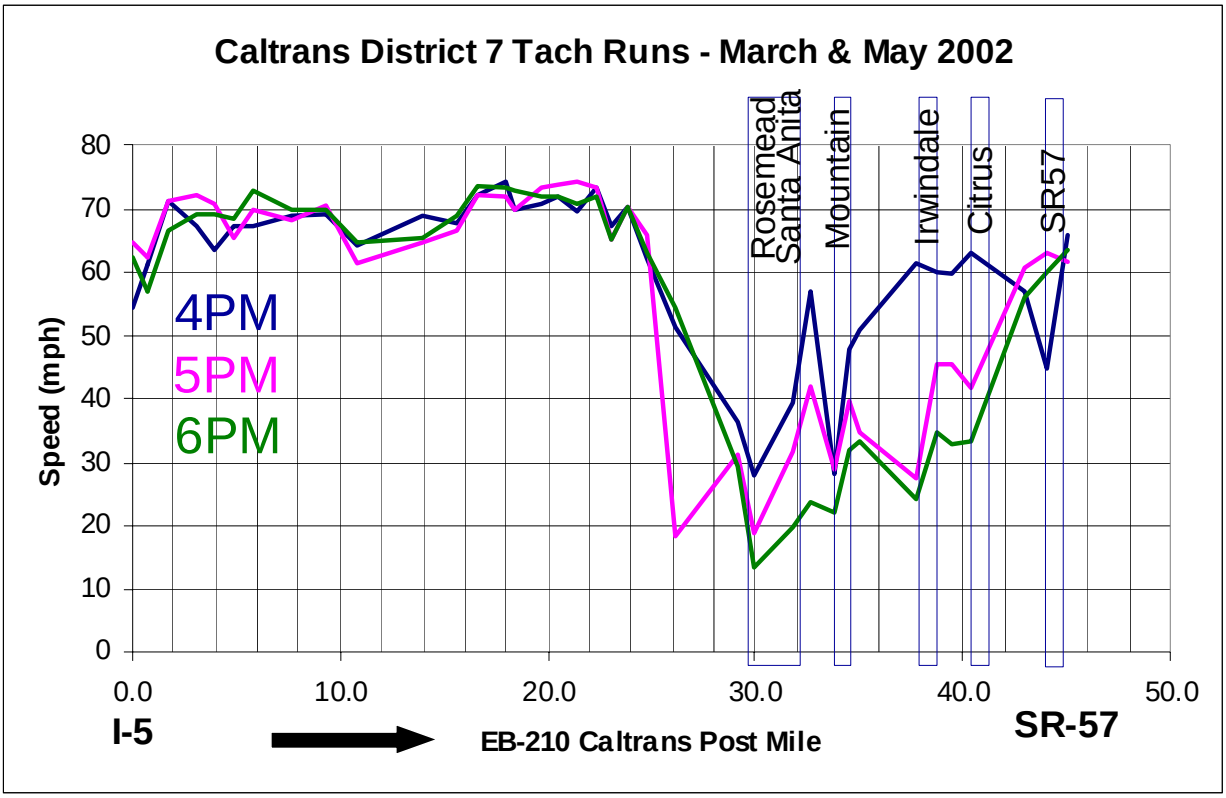


Exhibit A4-5: EB-210 Sample Probe Vehicle Runs



- As indicated, major <u>westbound</u> bottlenecks from the probe vehicle runs were identified at:
    - Azusa on
    - Irwindale/I-605
    - Santa Anita on
    - Rosemead on
    - Lake on

- As indicated, major <u>eastbound</u> bottlenecks from the probe vehicle runs were identified at:
    - Rosemead on
    - Santa Anita on
    - Mountain/I-605
    - Irwindale on
    - Citrus on
    - SR-57 on

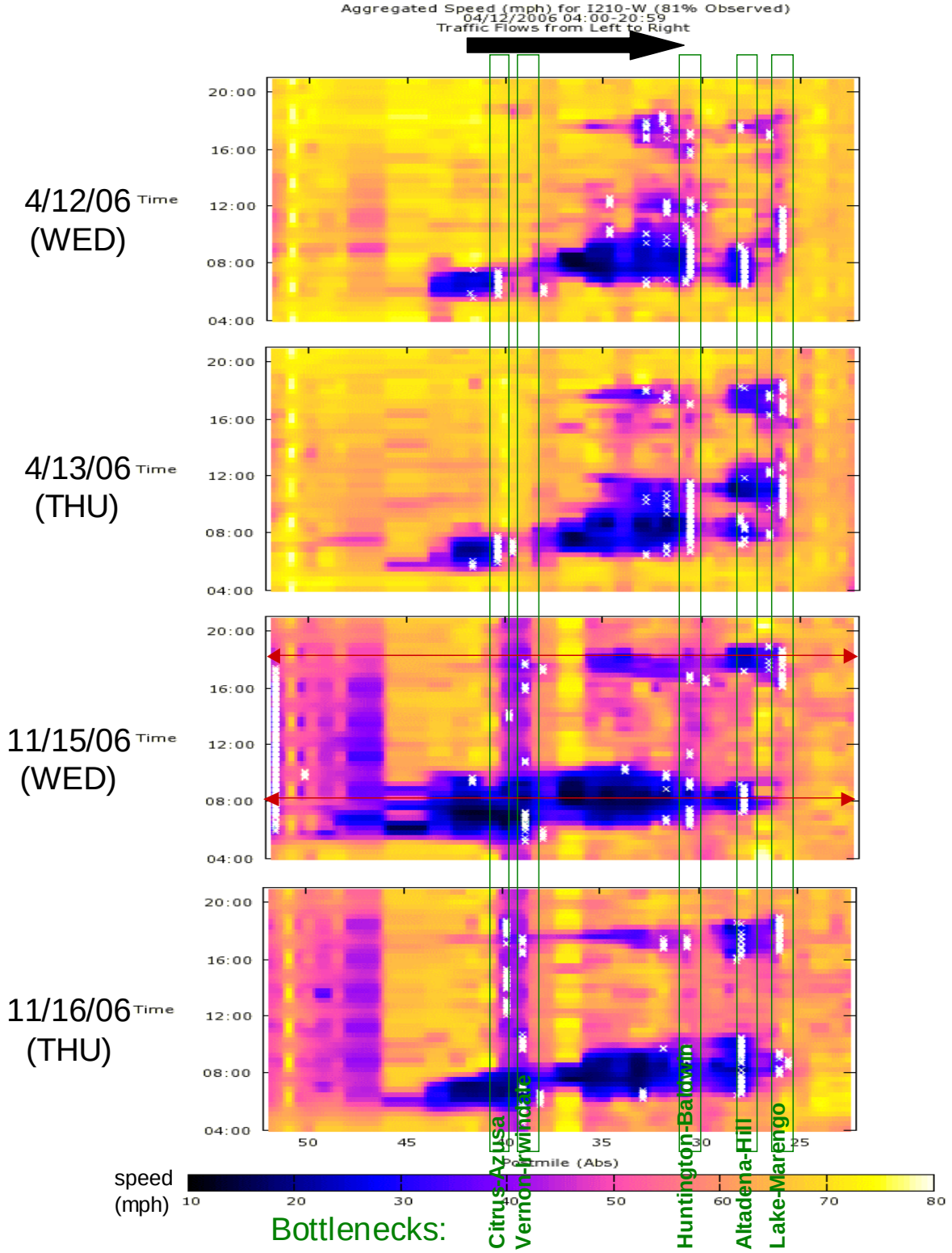
Freeway Performance Measurement System (PeMS)

In PeMS, speed plots are also used to identify potential bottleneck locations. Speed plots are very similar to probe vehicle run graphs. Unlike the probe vehicle runs, however, each speed plot has universally the same time across the corridor. For example, an 8AM plot includes the speed at one end of the corridor at 8AM and the speed at the other end of the corridor also at 8AM. 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, they both identify the same problem areas. These speed plots are then compiled at every five minutes and presented in speed contour plots.

WESTBOUND

Exhibit 4-6 illustrates the speed contour plots on Wednesday, April 12, 2006 and November 15, 2006, and Thursday, April 13, 2006 and November 16, 2006. These speed contour plots represent typical weekday samples to illustrate repetitive pattern in the bottleneck locations and congestion formed from them. The four sample days had observed or “good” detection data that ranged from 73% (November 16, 2006) to 87% (April 13, 2006), providing reasonably accurate results.

Exhibit A4-6: PeMS WB-210 Speed Contour Plots – April/November 2006



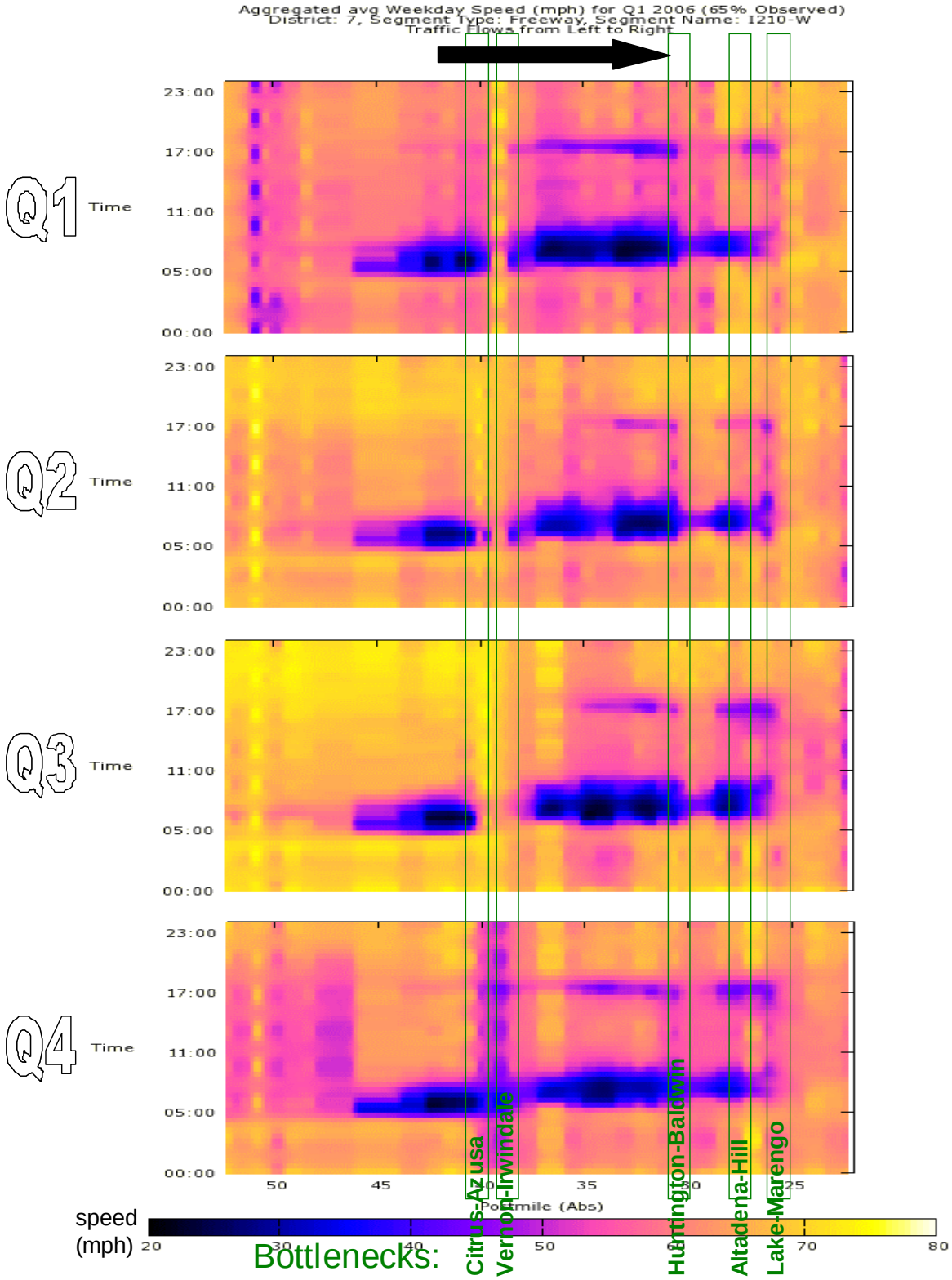
These speed contour plots illustrate the typical speed contour diagram for the I-210 freeway in the westbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4AM to 8PM. Along the horizontal axis is the corridor segment from east of SR-57 to west of SR-134. The various colors represent the average speeds corresponding to the color speed chart shown below the diagram. As shown, the dark blue blotches represent congested areas where speeds are reduced. The ends of each dark blotches represent bottleneck areas, 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, queue lengths. The vertical length is the congested time period.

- Based on these contour plots of typical weekday samples in April and November 2006, the following bottlenecks were identified in the <u>westbound</u> direction:

    - Azusa on
    - Irwindale/I-605
    - Santa Anita on
    - Baldwin on
    - Rosemead on
    - Altadena on
    - Lake on

In addition to multiple days, larger averages were also analyzed. Exhibits 4-7 illustrate weekday averages by each quarter of 2006. The same bottleneck locations are identified. From the long contours, the same bottlenecks are evident.

Exhibit A4-7: PeMS WB-210 Long (Speed) Contours – 2006 by Quarter



EASTBOUND

Similarly, speed contour plots for the same sample days and 2006 quarterly weekday average long contours were analyzed for the eastbound direction. Exhibit 4-8 and Exhibit 4-9 illustrate the speed contour plots for the I-210 freeway corridor in the eastbound direction (traffic moving left to right on the plot) on four typical weekdays in April and November 2006 and 2006 quarterly weekday average long contours. Along the vertical axis is the time period from 4AM to 8PM. Along the horizontal axis is the corridor segment from west of SR-134 to east of SR-57. The four sample days had observed or "good" detection data that ranged from 65% (November 16, 2006) to 86% (April 13, 2006), providing reasonably accurate results.

- Based on these contour plots of typical weekday samples in April and November 2006, the following bottlenecks were identified in the eastbound direction:
    - SR-134
    - Lake on
    - Huntington Off
    - I-605 off
    - Azusa on
    - SR-57 on

Exhibit A4-8: PeMS EB-210 Speed Contour Plots – April/November 2006

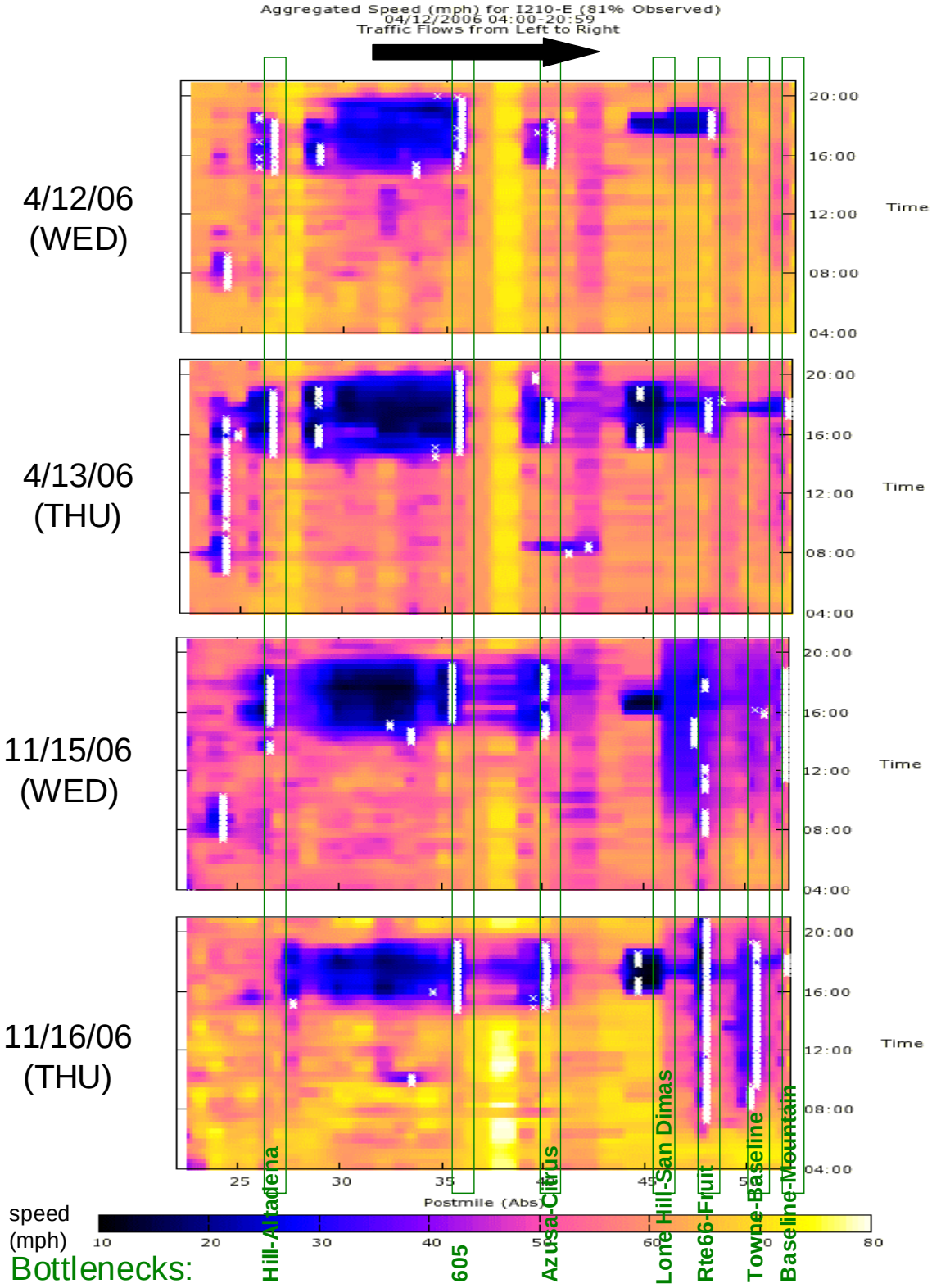
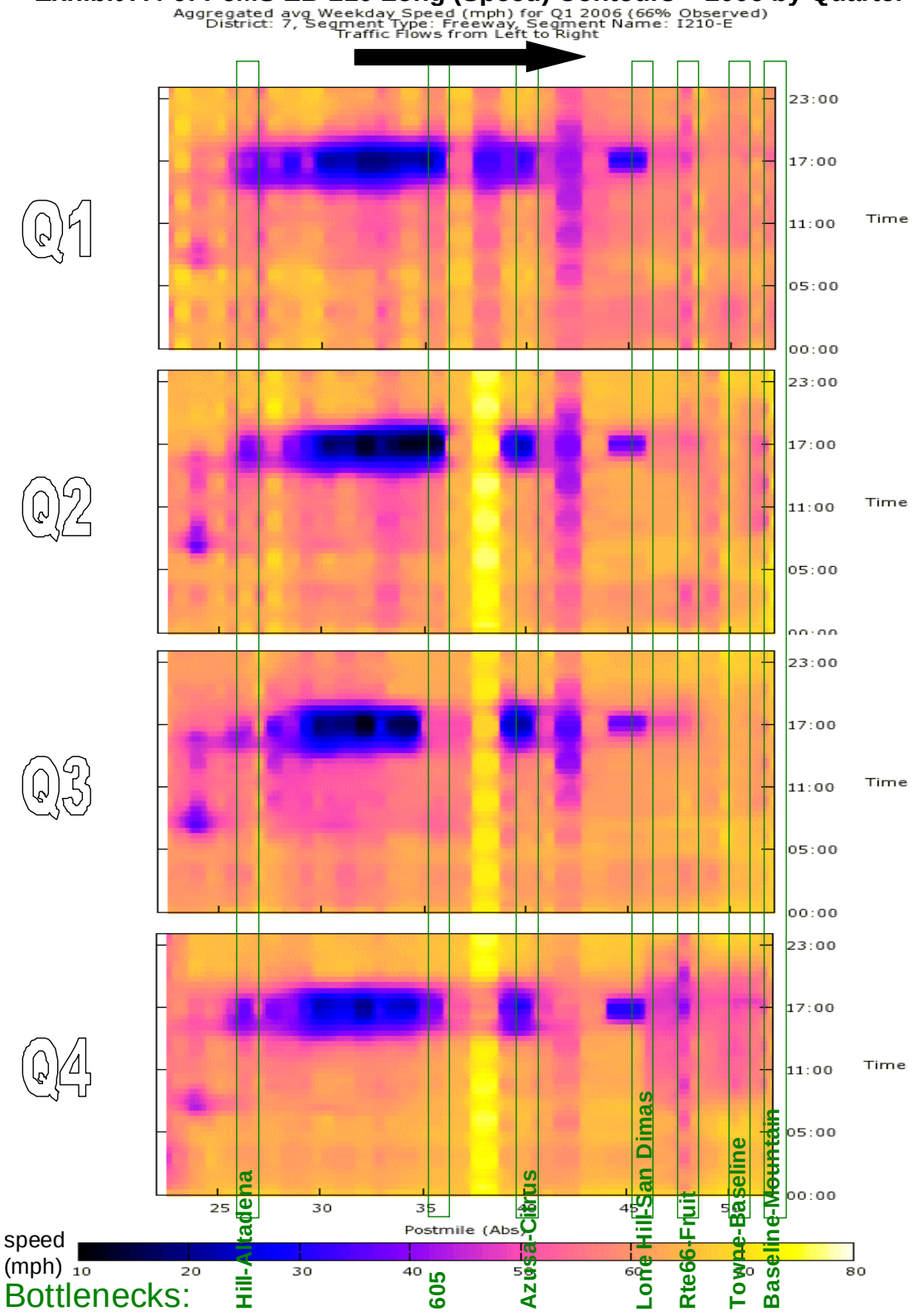



Exhibit A4-9: PeMS EB-210 Long (Speed) Contours – 2006 by Quarter