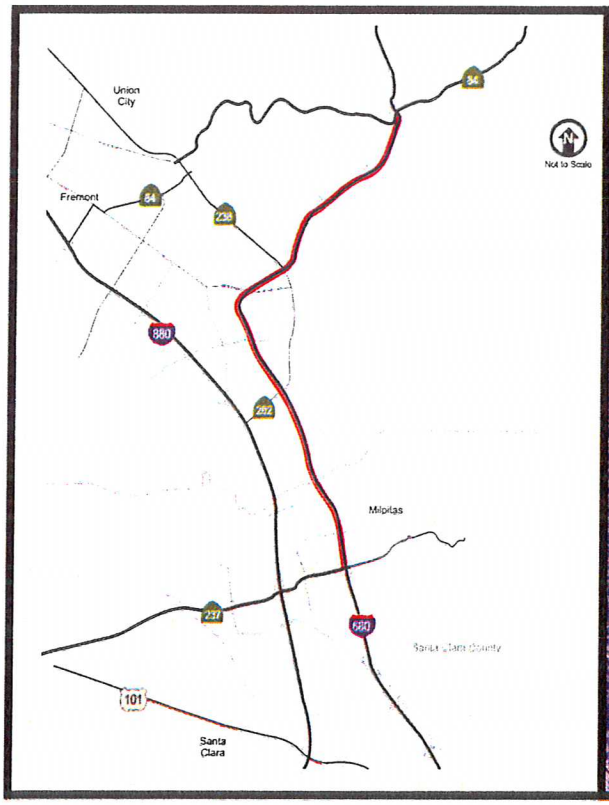
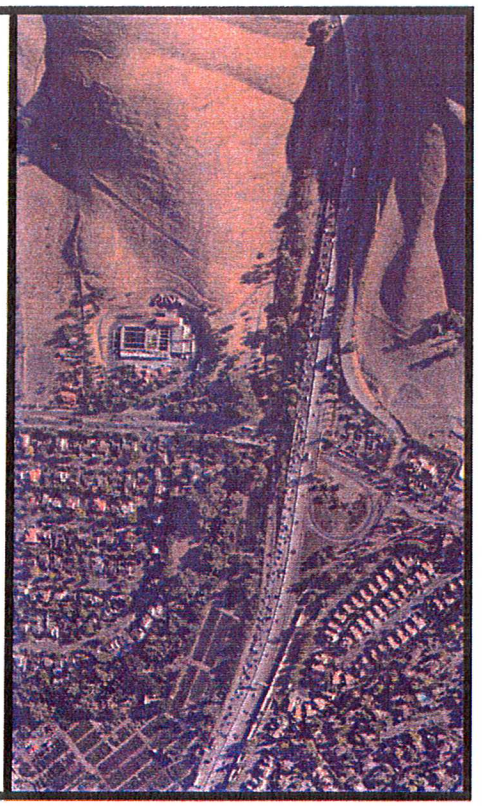
Alameda I-680 Express Carpool Lane Project

Before Study – Existing Conditions





Prepared for:
Alameda Congestion Management Agency

March 2, 2009

Submitted by:

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March 2, 2009

Ms. Beth Walukas

Manager of Planning

Alameda County Congestion Management Agency

1333 Broadway, Suite 220

Oakland, CA 94612

Subject: Alameda I-680 Express Carpool Lane Project P08-077

Before Study – Existing Conditions

Dear Ms. Walukas:

Dowling Associates Inc. is pleased to submit this Existing Conditions report for the Before Study of the I-680 Express Carpool Lane Project – Project Evaluation Framework for the segment of Interstate 680 located from the Route 84 interchange in Alameda County to the Route 237 interchange in Santa Clara County.

Please contact me at (510) 839-1742 ext. 119 or Allen Huang at ext. 123 if you have any questions.

Sincerely,

Dowling Associates, Inc.

Michael N. Aronson, P.E.

Principal

Allen Huang

Project Manager

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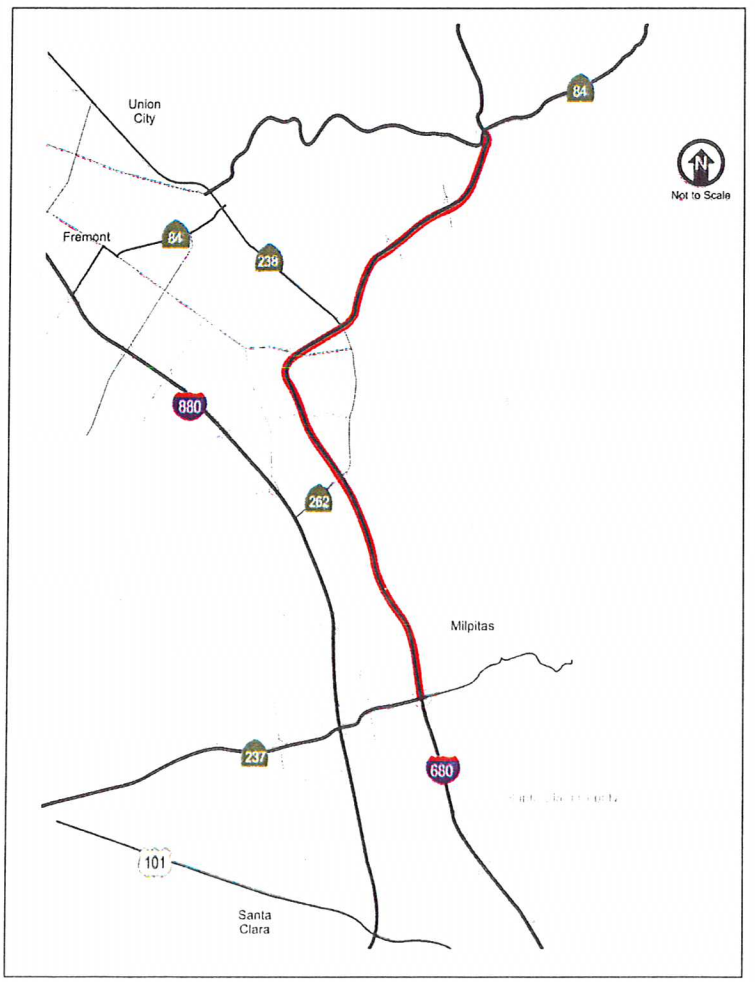
1. Introduction

This draft report presents the goals, objectives and evaluation results for the Existing Conditions: Before Study of the I-680 Express Carpool Lane Project – Project Evaluation. It also establishes procedures for an After Study to be completed after the Express Carpool Lane Project is implemented.

Project Description

The study corridor is southbound Interstate 680 from the Route 84 interchange in Alameda County to the Route 237 interchange in Santa Clara County. The I-680 Express Carpool Lane Project will implement a high-occupancy vehicle and toll (HOT) lane in the existing high-occupancy vehicle (HOV) lane. Construction of the project started in the fall of 2008.

Exhibit 1: Study Area of I-680 SB Express Carpool Lane Evaluation



Requirements for Project Evaluation

The evaluation of the Express Lane is required by Streets and Highways Code Section 149.5 (g) which states:

> *Not later than three years after the administering agency first collects revenues from the program authorized by this section, the administering agency shall submit a report to the Legislature on its findings, conclusions, and recommendations concerning the demonstration program authorized by this section. The report shall include an analysis of the effect of the HOT Lanes on the adjacent mixed flow lanes and any comments submitted by the Departments of Transportation and California Highway Patrol regarding operation of the lane.*

The requirements specifically pertain to evaluation of the Express Lanes after implementation. However, in order to compare conditions before and after implementation, it was necessary to collect data prior to project construction to set the baseline for a comparative evaluation. In addition, consistent procedures needed to be established for both the "before" and "after" studies.

Study Purpose

This Existing Conditions – Before Study has two purposes:

1. Establish methodologies for data collection and evaluation to be used in this Before study as well as a future After study.
2. Establish a benchmark for the existing I-580 freeway operations prior to the implementation of the HOV and Express Lanes.

The following sections include goals and objectives for project evaluation, methodologies for data collection and analysis, a summary of existing data collection, performance measures for the study corridor and a control corridor, and information on safety, transit and economic conditions.

2. Goals and Objectives

In April 2006, the Alameda County Congestion Management Agency (CMA) completed the *Southbound I-680 Smart Carpool Lane Concept of Operations*[1] . The Concept of Operations study found that the current HOV lane was underutilized during the morning peak-traffic period by both carpools and transit vehicles. These conditions could result in increased driver frustration and slower travel times in the corridor.

The excess High Occupancy Vehicle (HOV) lane capacity could be utilized in a more effective manner by allowing Single Occupancy Vehicles (SOVs) to use the HOV lane for a fee. The goal of the Southbound I-680 Smart Carpool Lane (Smart Lane) Project (now referred to as the Express Carpool Lane Project) is to improve travel efficiency in the corridor and provide more options to individual travelers.

The Before and After evaluations will provide feedback on the performance of the system, particularly in relation to the overall goals of the Express Carpool Lane Project, including the following:

1. Optimize the HOV lane usage to improve traffic throughput in the corridor;
2. Utilize this new revenue stream to help pay for transportation improvements and transit operations in the corridor;
3. Maintain LOS C or better for all Express Lane users;
4. Improve highway and transit in corridor with revenues generated; and
5. Employ new Intelligent Transportation System (ITS) technologies such as dynamic pricing and in-vehicle electronic enforcement

This Before Study has collected necessary data to facilitate the evaluation of the above goals, especially goals (1), (3) and (4), which can be quantified and explained via the freeway data. Exhibit 2 provides a summary of the data and evaluation pertaining to the goals and objectives. More detailed explanations of each measure of effectiveness are presented in the evaluation sections.

[1] ACCMA Southbound I-680 Smart Carpool Lane Concept of Operations, April 2006.

Exhibit 2: Overall Evaluation Approach

Goals	Required Data Collection	Performance Measures from Data collection	Evaluation Methods
Optimize the HOV lane usage to improve traffic throughput in the corridor	Traffic volume surveys on freeway and ramps, Vehicle occupancy surveys, Travel time surveys.	Vehicle and person throughput, Vehicle occupancy, Percentage of HOV vehicles	Student's t-test for statistical hypothesis testing of significance of differences in means.
Maintain LOS C or better for all Express Lane users	Traffic volumes, roadway geometry	Level of Service (LOS)	Level of service based on Highway Capacity Manual (HCM) using FREQ software
Improve highway and transit in corridor with revenues generated	Transit ridership in corridor	Travel times and travel time savings, Transit vehicles and passengers	Student's t-test for statistical hypothesis testing of significance of differences in means.

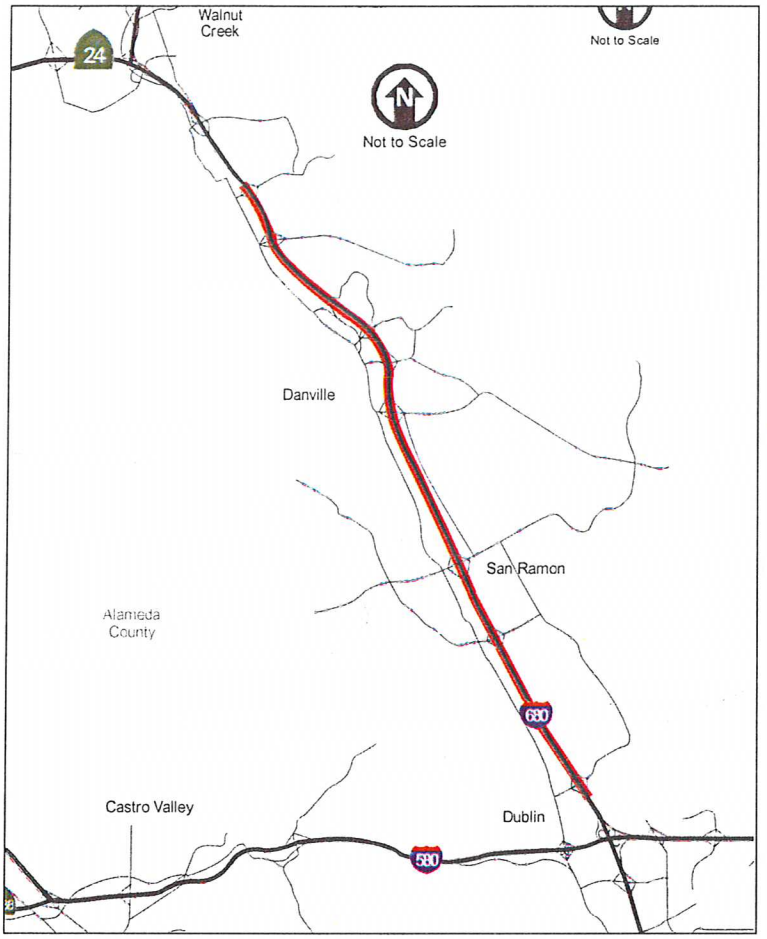
Selection of Control Corridor

A control corridor is defined in addition to the study corridor. The control corridor will help determine if any changes in travel behavior are due to the Express Lane project or other travel trends within the San Francisco Bay Area. The selected control corridor should have a similar configuration as the study corridor in the "Before" condition (freeway with HOV lane), but will not be changed between the "Before" and "After" studies.

The selection of the control corridor was finalized through discussions with the CMA. The selected control corridor is the I-680 northbound direction between Alcosta Boulevard in San Ramon and Livorna Road in Alamo. This segment was selected for the following reasons:

- Traffic demand and travel characteristics would be similar except that the direction of the peak commute is reversed between morning and afternoon hours.
- Length of HOV lane corridor is similar
- There are no planned major improvements along the corridor for the next three years
- This corridor serves similar suburban area traffic as the study corridor

Exhibit 3: I-680 Northbound Control Corridor



Hereafter, "Study Corridor" and "Control Corridor" will be used as common terms in this report:

- **Study Corridor**: I-680 Southbound Between SR 84 and SR 237
- **Control Corridor**: I-680 Northbound Between Alcosta Boulevard and Livorna Road

3. Study Methodologies

Characteristics of Corridor

The I-680 study corridor is primarily a commuter route serving the Tri-Valley area, and providing the major connection between east Contra Costa County, east Alameda County, and Santa Clara County. Through the study area, the study corridor generally has four lanes, consisting of three mixed-flow lanes and one carpool (HOV) lane that is in effect during the morning (5:00 AM to 9:00 AM) and afternoon peak commute periods (3:00 PM to 7:00 PM).

Performance Evaluation Methodologies

A majority of the performance measures are developed directly from the traffic data collected, including freeway speeds, vehicle occupancy surveys, travel time savings on the carpool lane, travel time reliability, transit ridership, accident data, etc. Traffic operations modeling was used to produce freeway level of service performance measures.

Level of Service
Traffic operations performance is evaluated in terms of "level of service" (LOS), which is a measure of driving conditions and vehicle delay. Levels of service range from A (best) to F (poorest). Levels of service A, B and C indicate conditions where traffic can move relatively freely. Level of service D describes conditions where delay is more noticeable. Level of service E describes conditions where traffic volumes are at or close to capacity, resulting in significant delays and unstable traffic flow. Level of service F characterizes conditions with unstable flow, where freeway operations break down, traffic demand exceeds available capacity, with very slow speeds (stop and go), long delays, and queuing at freeways.

Levels of service on the study and control corridors are reported using two methodologies:

- LOS based on floating car survey speed, consistent with the CMA LOS Monitoring studies
- LOS based on density, consistent with the 2000 Highway Capacity Manual (2000 HCM)

The floating car survey attempts to represent the average traffic conditions of the roadway. However, there are limited samples (limited probe vehicles) on the roadway at any given instance to represent the true average conditions of the road. Excessive merging and weaving activities may also distort the survey from representing true average travel conditions. The LOS obtained through this method represents the traffic conditions those specific probe vehicles experienced through the corridor.

An alternative method to represent the average traffic conditions of all vehicles along the corridor is through developing a traffic operations model. The selected software is FREQ, developed by the Institute for Transportation Studies at the University of California at Berkeley.

The FREQ model was calibrated to represent field conditions and can generate speeds, densities, levels of service (based on the Highway Capacity Manual criteria), bottleneck locations and queue lengths and delays for each segment.

CMA LOS Monitoring Methodologies

The Alameda County Congestion Management Agency establishes LOS primarily based on surveyed average travel speed through freeway sections, as shown in Exhibit 4. Segments of freeway generally span from one to three interchanges.

Exhibit 4: CMA Freeway Level of Service Criteria

Level of Service	Density (pc/mi/ln)[1]	Speed (mph)	V/C Ratio	Maximum Service Flow (pcphpl)[2]
A	≤12	≤60	0.35	700
B	≤20	≤55	0.58	1,000
C	≤30	≤49	0.75	1,500
D	≤42	≤41	0.90	1,800
E	≤67	≤30	1.00	2,000
F	>67	>30	--	--

Source: Level of Service Monitoring Report 2008, Alameda County Congestion Management Agency, September 25, 2008. Adapted from Table 4-1, Special Report 209, Highway Capacity Manual; 1985.
1. Passenger cars per mile per lane
2. Maximum service flow under ideal conditions, expressed as passenger cars per hour per lane.

Highway Capacity Manual and FREQ Analysis

Freeway segments are evaluated based on the methodology outlined in Chapters 13 and 23 of the HCM 2000. The LOS is determined based on density, which is related to flow rate and the average travel speed on the facility. Exhibit 5 shows the density thresholds based on the 2000 HCM. In the HCM, an estimate of density is calculated based on various inputs, such as flow rate, lane geometry, etc… For this analysis, LOS is computed through the FREQ (Version 12) software, which is a macroscopic model primarily used for corridor evaluations, and computes LOS consistent with HCM 2000. FREQ 12 is capable of calculating LOS separately for HOV and mixed-flow lanes, and can also identify bottleneck locations and queue lengths affecting freeway performance.

Exhibit 5: HCM 2000 Freeway Level of Service Criteria

Level of Service	Density (passenger cars/mile/lane)
A	<11.0
B	>11.0–18.0
C	>18.0–26.0
D	>26.0–35.0
E	>35.0–45.0
F	>45.0

Source: Transportation Research Board, *Highway Capacity Manual*, Washington, DC, 2000.

FREQ Model Calibration

Models using the FREQ software were built for the I-680 study and control corridors. The models were calibrated and validated based on the observed corridor-wide travel times, and data and observations indicating general bottleneck and queuing locations.

A FREQ model is set up to represent every single segment (or subsection) along the corridor. A subsection is defined when there is a change in geometry and volume, such as a lane drop, lane addition, on-ramp, or off-ramp junctions etc. Main factors that affect calibration and validation of the model results include freeway and ramp capacities, free-flow speed, as well as the "lower limb" speed curve, as defined by HCM 2000.

Freeway mainline capacities generally can vary between 1900 vehicle per hour (vph) to 2200 vph, depending on driver characteristics, traffic stream composition, and the level of weaving and merging activities, etc. This analysis assumed a 2000 vph per lane of capacity as a starting point for the mainline, and adjusted as necessary to replicate existing observed conditions. Freeway ramps were assumed at a capacity of 1500 vph per lane. Free flow speeds on the freeway were assumed at 65 MPH, and were only adjusted if field observations indicated otherwise. In FREQ, trucks are accounted for in the freeway performance computation based on adjusted capacity; therefore, the freeway capacity parameters were further adjusted to achieve calibration goals where the freeway corridors include high truck usage.

HOV lane capacities are generally lower than mixed flow lanes (but could potentially be as high as mixed-flow lanes under certain situations). The general assumption for HOV lane capacity for this study is 1500 vph, and was modified as necessary to match field observations and travel time surveys. In some locations, low-speed or stopped traffic flow was observed in the HOV lane even though the number of vehicles in the HOV lane was under the assumed capacity. This can occur when adjacent mixed-flow lanes are heavily congested, and vehicles entering and exiting the HOV lane can have a tremendous effect on the traffic flow in the HOV lane. This type of individual vehicle interaction could not be easily simulated in a macroscopic model such as FREQ. Therefore, HOV lane capacity was further adjusted to emulate this effect in travel speed, and to better match actual travel times through the corridor. These modified capacities of HOV lanes may not represent the true capacity of the lane but do more accurately reflect the dynamics of traffic interactions with the mixed-flow lanes.

4. Summary of Existing Data Collection

A majority of the field surveys and data collection were completed on September 9-10, 2008 along the study corridor, and on September 24-25, 2008 for the control corridor.

Vehicle Classification and Occupancy Survey

Vehicle occupancy and classification data were collected for both the study and control corridors. These data were collected through manual observation of each freeway lane, from 5:00 AM to 7:00 PM. One surveyor was assigned to one lane of travel to collect occupancy data.

For the study corridor, the occupancy surveys were conducted at four locations: Andrade Road interchange, Washington Boulevard interchange, Mission Boulevard interchange, and Calaveras Boulevard (SR 237) interchange. For the control corridor, the surveys were conducted at two locations: Alcosta Boulevard interchange and Livorna Road interchange. Observations were performed on the overpass bridge or near the freeway ramps.

Vehicle classification included separate counts of drive-alone vehicles, carpool with two passengers, carpool with three or more passengers, vanpool, buses, motorcycle and trucks. These survey results are also utilized as a source to determine the total vehicle traffic flows on the mainline for operational analysis. Since the data were collected on a lane-by-lane basis, the number of HOV lane violators could be calculated. The HOV lane violation data from September and October 2008 were also collected from the California Highway Patrol.

Floating Car Travel Time Survey

Floating car surveys for both the control and study corridors were collected on the same days as vehicle classification surveys. Floating car surveys were conducted by running "probe vehicles" along the corridors during the peak commute hours of 7:00 AM – 9:00 AM, and 3:00 – 6:00 PM. These probe vehicles typically traveled on the number three lane (second rightmost lane) to best represent the average travel conditions of the mixed-flow lanes. Instead of staying in the same lane throughout the corridor, the probe vehicles would attempt to pass the same number of vehicles as the number of vehicles that passed them. For the study corridor, four probe vehicles were utilized along the mixed-flow lanes, and two for the carpool lane. On the control corridor, both the mixed-flow lanes and carpool had two probe vehicles conducting the survey.

Transponder Travel Time Data

The Metropolitan Transportation Commission (MTC) compiles continuous travel time data on freeways based on transponders in vehicles through the 511.org program. For this study, MTC provided averaged travel time data for the study and control corridors for the entire months of September and October 2008.

Measurements were obtained by detecting FasTrak toll tag readers on the freeways. The transponder data was averaged for each minute. The 511 data was averaged for a total of 24

days, including every Tuesday, Wednesday and Thursday from September 8 to October 30, 2008 for this analysis. The mean of the 511 travel time data for each hour was computed based on the travel time observations for each minute (60 computations per hour) collected for 24 days. For each hour of the day, a total of 1,440 (=24×60) computations were used to perform the travel time statistics.

Travel times provided by this source represent the average travel times of all vehicles with FasTrak transponders across all lanes of travel. Therefore, both the mixed-flow lane data and carpool lane data are grouped together. For example, there were about 270 cars detected from 6:00 AM to 7:00 AM on a regular weekday driving southbound I-680 from south of I-580 interchange to south of SR-84 as seen in Exhibit 6.

Exhibit 6: A Sample of FasTrak Detections During Weekdays

Hour	Tue, 10/21/08	Wed, 10/22/08	Thur, 10/23/09
12:00 AM	4	1	4
1:00 AM	4	5	1
2:00 AM	4	3	7
3:00 AM	6	8	9
4:00 AM	49	42	51
5:00 AM	164	140	143
6:00 AM	278	266	289
7:00 AM	244	241	236
8:00 AM	224	175	232
9:00 AM	195	189	171
10:00 AM	113	106	85
11:00 AM	61	64	45
12:00 PM	33	43	39
1:00 PM	48	37	39
2:00 PM	33	34	34
3:00 PM	34	32	27
4:00 PM	37	52	45
5:00 PM	46	50	42
6:00 PM	60	62	60
7:00 PM	34	31	36
8:00 PM	21	21	36
9:00 PM	24	21	19
10:00 PM	11	14	16
11:00 PM	7	12	6
Total Detection	1734	1649	1672

Source: 511.org FasTrak Detection of I-680 southbound from South of I-580 interchange to South of SR-84

Aerial Photograph Survey

Aerial photography for the study corridor was obtained by flying a helicopter along the corridor between the peak commute hours of 7:00 AM – 9:00 AM and 3:00 – 6:00 PM. Snapshots were taken along the entire corridor. These photos provide an additional source to determine existing bottleneck locations, as well as lengths of queues associated with those bottleneck locations. The

aerial photography survey could not be conducted on the same day as the floating car surveys and vehicle classification counts, due to weather restrictions (fog overcast), and was conducted at a later date on September 23, 2008.

PeMS Database

The University of California at Berkeley maintains a Freeway Performance Measurement System (PeMS) database based on detectors on roads throughout the Bay Area. The PeMS data were utilized primarily to collect freeway mainline counts. Mainline counts at available detection stations were extracted for the same days as the other data collection (floating car, occupancy survey, etc.), and were used to check to consistency and continuity of counts along the corridors.

Ramp Counts

Twenty-four hour freeway ramp counts were collected at all freeway on- and off-ramps within each of the control and study corridors. The ramp counts were collected using standard automatic hose counter machines. These ramp counts were utilized to create a set of balanced existing demand counts for each individual segment along the corridor.

Transit Data

Transit operators and routes that run on the study and control freeway corridors were identified from transit operator websites. The on and off ramps used by the relevant bus routes were identified from route maps for all cases except the San Joaquin Regional Transit District (RTD); the RTD provided maps via email because the website did not include a route description. The peak-period and off-peak headways were identified from route schedules posted on the transit operator websites. In almost all cases, the bus routes that run on the freeway corridors are commuter routes that only operate during the peak periods.

Accident Data

The California Highway Patrol (CHP) keeps a database of accident reports for collisions that occur on California roadway facilities, called the Statewide Integrated Traffic Records System (SWITRS). An electronic database of SWITRS data for collisions that occurred on the I-680 study and control corridors during the years 2005, 2006, and 2007 was provided by the CHP Data Services Department.

5. Study Corridor Performance Measures

The following performance measures were used to describe the existing traffic operations conditions along the study corridor. The evaluation of freeway performance was focused primarily during the hours of the enforced periods for the HOV lanes, which is from 5:00-9:00 AM, and 3:00-7:00 PM.

Travel Speed and Travel Time Analyses

It is essential to check the quality of the speed and the travel time data prior to conducting the evaluation. Three data sources were consulted to perform the travel speed and the travel time analysis: floating car surveys, 511.org data and the PeMS data were used to perform the analyses described below.

Speed/Travel Time by Segment

Freeway LOS was evaluated based on probe vehicle speed surveys summarized in Exhibit 6 and Exhibit 7. Separate speed survey data are presented for the mixed-flow lanes versus the HOV lane. The results show the average performance for each hour within both the morning and afternoon commute periods. As shown in these exhibits, during the morning peak period, traffic congestion occurred on the mixed-flow lanes primarily between 8:00 to 9:00 AM, with freeway speeds significantly reduced between the Mission Boulevard (south) and Andrade Road interchanges. No congestion was observed during the afternoon commute period along this corridor. The HOV lane remained mostly in free-flow conditions throughout the morning and afternoon commute hours as well.

Exhibit 9 through Exhibit 12 present the surveyed travel speeds of the HOV facilities and the mixed flow lanes between each freeway interchange on the southbound study corridor (SR-84 to SR-237) and the northbound control corridor (Alcosta Blvd. to Livorna Blvd.).

On September 24th 2008, the HOV facility of the southbound I-680 was congested due to an incident: travel speed on HOV lane dropped from 60 mph to 15 mph shown in Exhibit 10.

Exhibit 7: Freeway LOS Based on Floating Car Survey Speeds – AM Peak Period

Segment Limits		Length	HOV Lane		Mixed-Flow Lanes	
From	To	(miles)	Speed	LOS	Speed	LOS
5:00 AM - 6:00 AM						
Avg. of 4 avaliable PeMS stations		- -	72	A	65	A
6:00 AM - 7:00 AM						
Avg. of 4 avaliable PeMS stations		- -	70	A	63	A
7:00 AM - 8:00 AM						
SR 84 (Vallecitos)	Calaveras Rd	0.3	55	B	42	D
Calaveras Rd	Andrade Rd	1.34	63	A	52	C
Andrade Rd	Sheridan	1.39	67	A	52	C
Sheridan	Vargas	0.82	71	A	60	A
Vargas	Mission Blvd	1.09	67	A	59	B
Mission Blvd	Washington Blvd	1.14	66	A	45	D
Washington Blvd	Durham Rd	1.3	67	A	43	D
Durham Rd	Mission Blvd	1.61	68	A	44	D
Mission Blvd	Scott Creek Rd	2.17	69	A	61	A
Scott Creek Rd	Jacklin Rd	1.47	72	A	65	A
Jacklin Rd	SR 237	0.8	65	A	58	B
8:00 AM - 9:00 AM						
SR 84 (Vallecitos)	Calaveras Rd	0.3	54	C	50	C
Calaveras Rd	Andrade Rd	1.34	64	A	50	C
Andrade Rd	Sheridan	1.39	55	C	38	E
Sheridan	Vargas	0.82	59	B	25	F
Vargas	Mission Blvd	1.09	55	B	33	E
Mission Blvd	Washington Blvd	1.14	56	B	32	E
Washington Blvd	Durham Rd	1.3	64	A	37	E
Durham Rd	Mission Blvd	1.61	68	A	36	E
Mission Blvd	Scott Creek Rd	2.17	69	A	61	A
Scott Creek Rd	Jacklin Rd	1.47	71	A	66	A
Jacklin Rd	SR 237	0.8	58	B	59	B

Note: LOS threshold based on CMA LOS Monitoring Report, 2008

Exhibit 8: Freeway LOS Based on Floating Car Survey Speeds – PM Peak Period

Segment Limits		Length	HOV Lane		Mixed-Flow Lanes	
From	To	(miles)	Speed	LOS	Speed	LOS
3:00 PM - 4:00 PM						
SR 84 (Vallecitos)	Calaveras Rd	0.3	55	B	45	D
Calaveras Rd	Andrade Rd	1.34	67	A	63	A
Andrade Rd	Sheridan	1.39	69	A	62	A
Sheridan	Vargas	0.82	73	A	68	A
Vargas	Mission Blvd	1.09	74	A	67	A
Mission Blvd	Washington Blvd	1.14	72	A	67	A
Washington Blvd	Durham Rd	1.3	72	A	66	A
Durham Rd	Mission Blvd	1.61	74	A	65	A
Mission Blvd	Scott Creek Rd	2.17	73	A	66	A
Scott Creek Rd	Jacklin Rd	1.47	72	A	64	A
Jacklin Rd	SR 237	0.8	65	A	59	B
4:00 PM - 5:00 PM						
SR 84 (Vallecitos)	Calaveras Rd	0.3	57	B	52	C
Calaveras Rd	Andrade Rd	1.34	66	A	65	A
Andrade Rd	Sheridan	1.39	69	A	62	A
Sheridan	Vargas	0.82	71	A	67	A
Vargas	Mission Blvd	1.09	71	A	67	A
Mission Blvd	Washington Blvd	1.14	70	A	68	A
Washington Blvd	Durham Rd	1.3	70	A	67	A
Durham Rd	Mission Blvd	1.61	72	A	67	A
Mission Blvd	Scott Creek Rd	2.17	72	A	66	A
Scott Creek Rd	Jacklin Rd	1.47	72	A	66	A
Jacklin Rd	SR 237	0.8	60	B	61	A
5:00 PM - 6:00 PM						
SR 84 (Vallecitos)	Calaveras Rd	0.3	62	A	48	D
Calaveras Rd	Andrade Rd	1.34	67	A	65	A
Andrade Rd	Sheridan	1.39	70	A	62	A
Sheridan	Vargas	0.82	72	A	67	A
Vargas	Mission Blvd	1.09	71	A	68	A
Mission Blvd	Washington Blvd	1.14	73	A	68	A
Washington Blvd	Durham Rd	1.3	71	A	67	A
Durham Rd	Mission Blvd	1.61	71	A	67	A
Mission Blvd	Scott Creek Rd	2.17	75	A	66	A
Scott Creek Rd	Jacklin Rd	1.47	74	A	66	A
Jacklin Rd	SR 237	0.8	67	A	61	A
6:00 PM - 7:00 PM						
Avg. of 4 avaliable PeMS stations		- -	69	A	64	A

Note: LOS threshold based on CMA LOS Monitoring Report, 2008

Exhibit 9: I-680 SB Surveyed AM Travel Speeds - HOV Lane

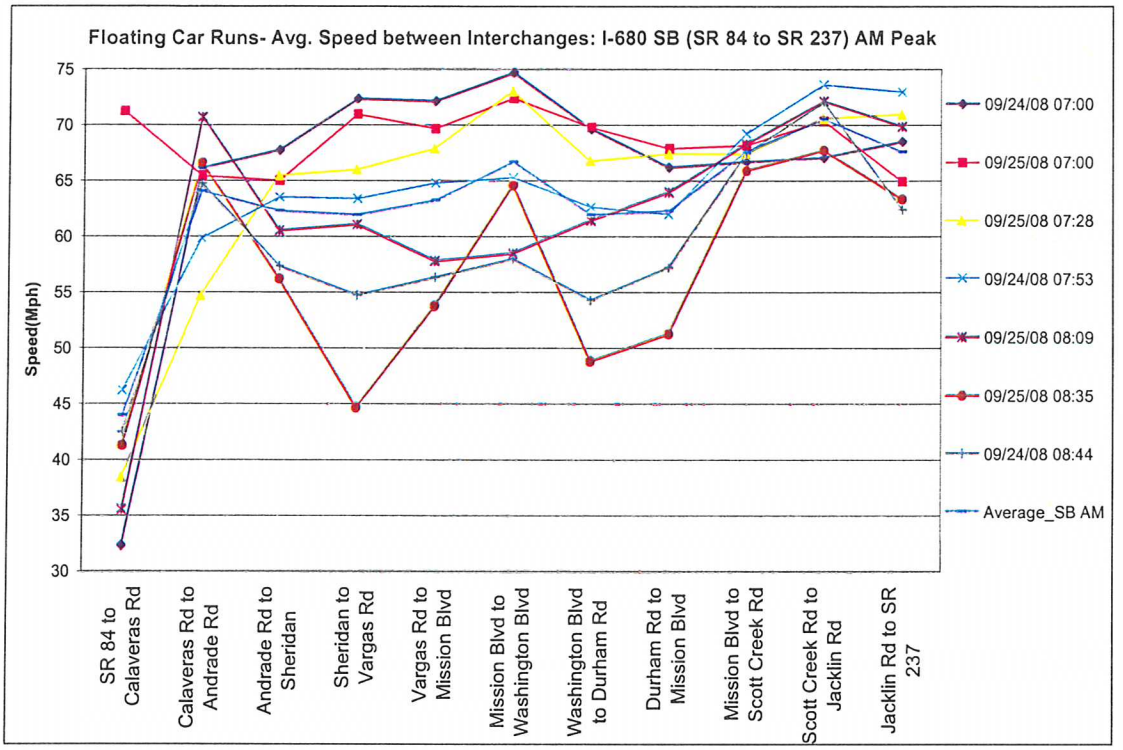
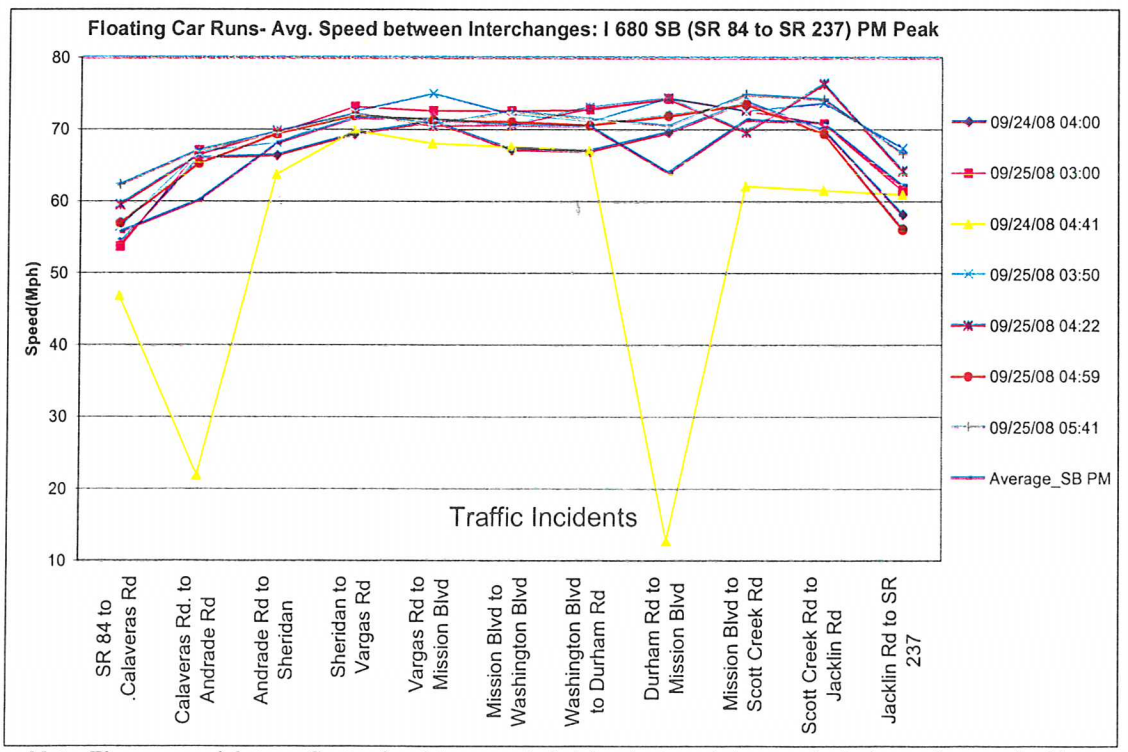


Exhibit 10: I-680 SB Surveyed PM Travel Speeds - HOV Lane



Note: The surveyed data on September 24 was excluded for the travel time analysis due to freeway incidents.

Exhibit 11: I-680 SB Surveyed AM Travel Speeds - Mixed Flow Lanes

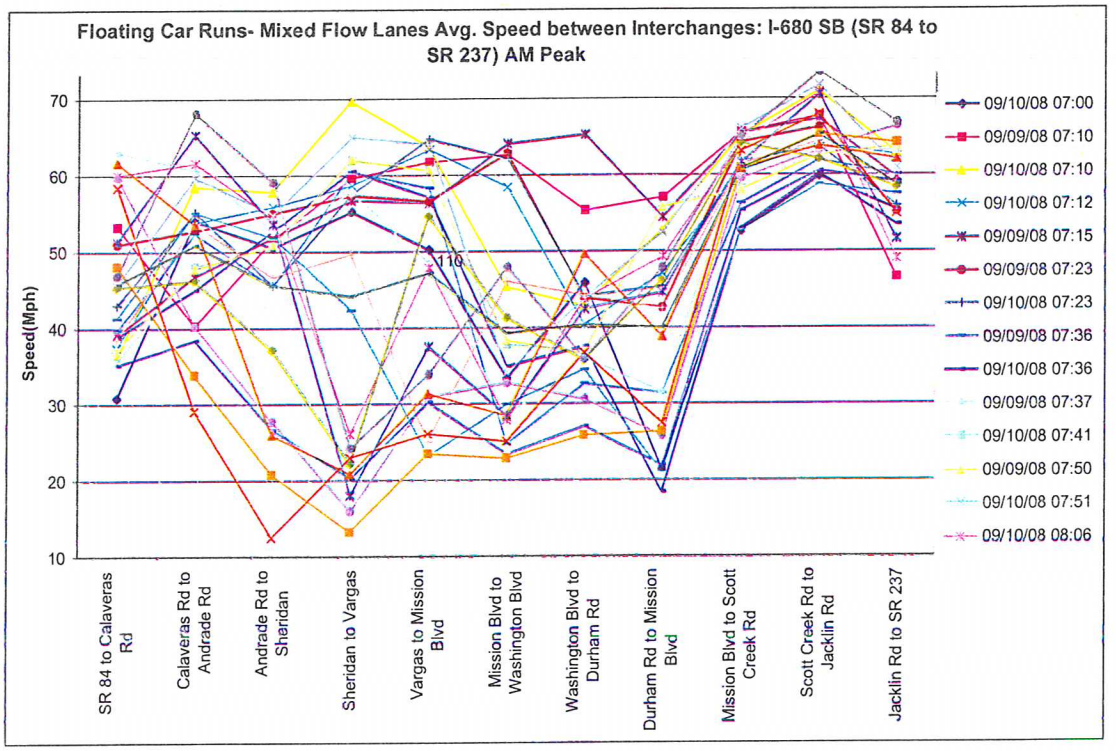
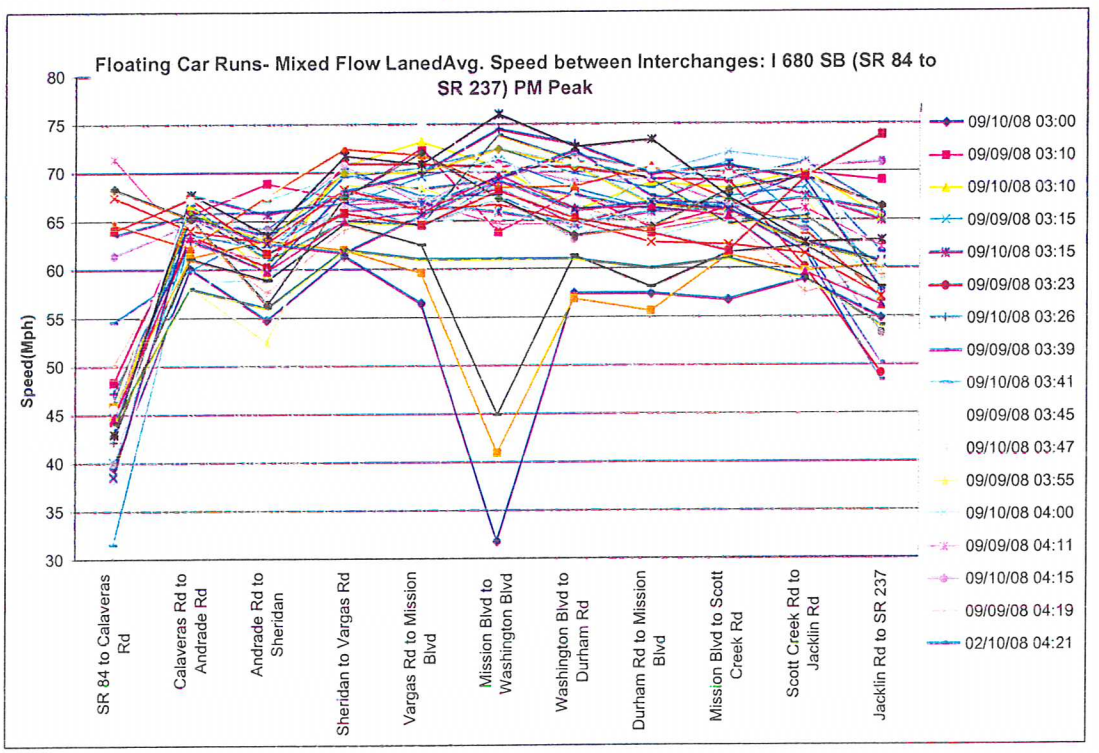


Exhibit 12: I-680 SB Surveyed PM Travel Speeds - Mixed Flow Lanes



Study Corridor Freeway Bottleneck and Queues

Freeway bottleneck locations and queue lengths were determined from examination of the aerial photography survey. Exhibit 13 and Exhibit 14 illustrate the major bottleneck and freeway queues during the morning commute peak hour. Exhibit 15 provides a schematic of the bottleneck locations along the corridor during the AM peak periods. There was no congestion observed during the PM peak periods.

Exhibit 13: Aerial Photo Survey of AM Peak Hour at Mission Boulevard (south)

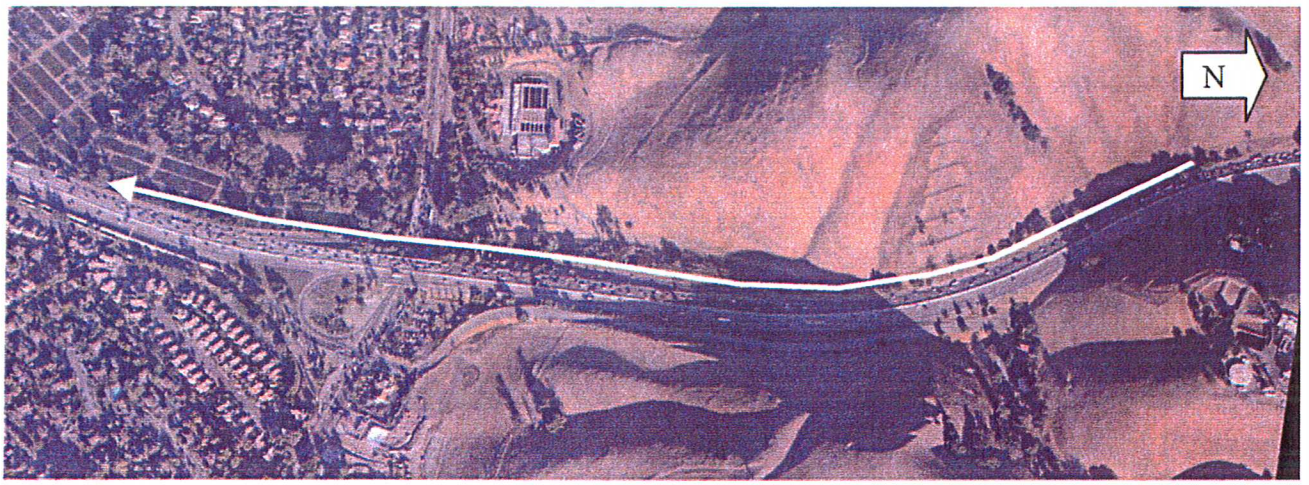
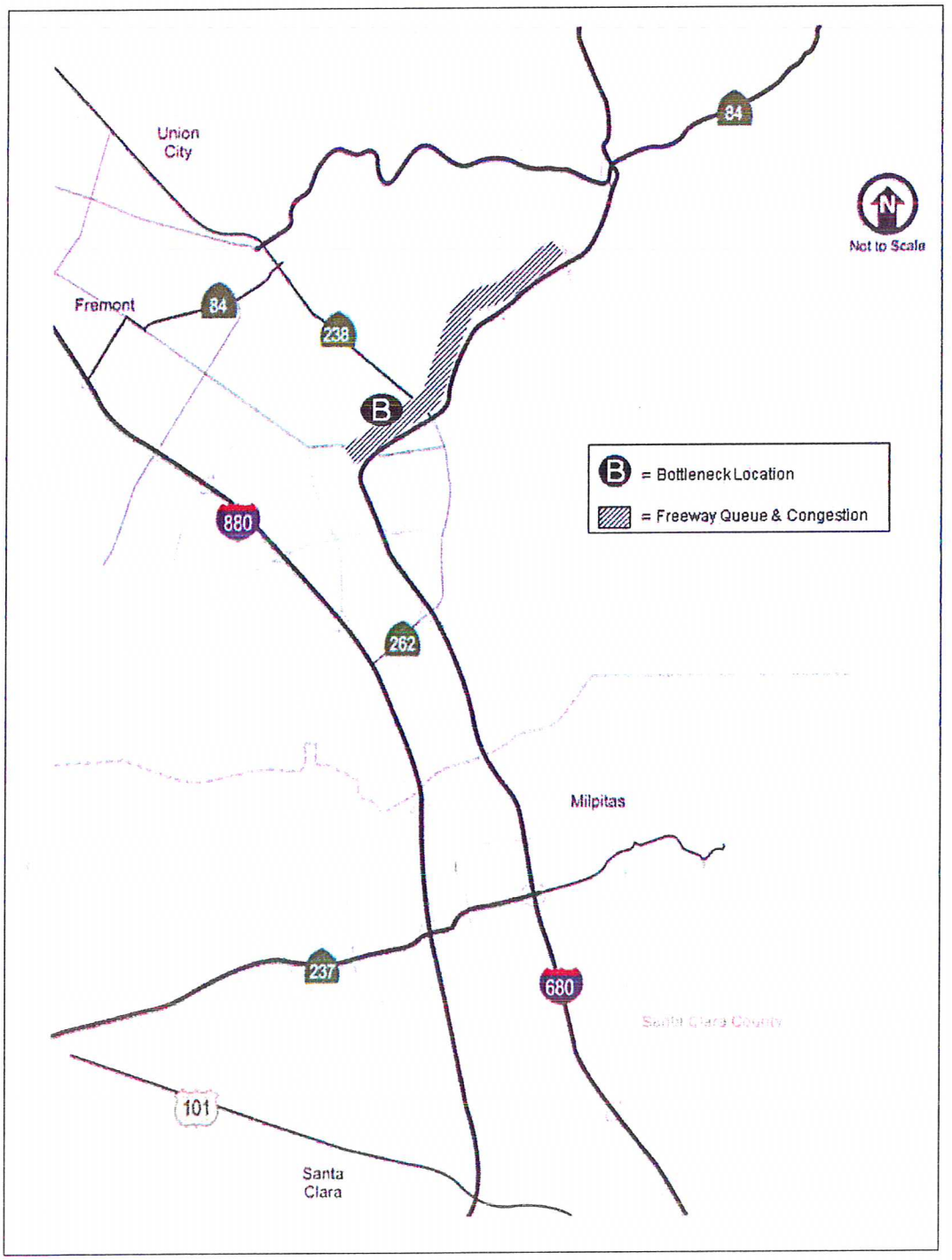


Exhibit 14: Aerial Photo Survey of AM Peak Hour at Vargas Road

Exhibit 15: Study Corridor General Bottleneck and Queues Based on Aerial Photo Observations – AM Peak Period (Mixed-Flow Lanes)



Travel Time Savings
Average travel times for both the mixed-flow lanes and HOV lane are summarized in Exhibit 16, for each hour of the study period. The maximum travel time savings for vehicles utilizing the HOV lane was over seven minutes during the AM peak period, and approximately one minute during the PM peak period.

Exhibit 16: HOV Travel Time Savings on I-680 Southbound Study Corridor

Time Slice	Actual (minutes)		HOV Travel Time Savings
	HOV	Mixed-Flow	(minutes)
5:00-6:00 AM[1]	11.2	12.4	1.2
6:00-7:00 AM[1]	11.4	12.7	1.3
7:00-8:00 AM	11.8	15.5	3.8
8:00-9:00 AM	12.9	20.4	7.5
3:00-4:00 PM	11.2	12.4	1.3
4:00-5:00 PM	11.3	12.1	0.8
5:00-6:00 PM	11.1	12.1	1
6:00-7:00 PM[1]	11.7	12.6	1

Note: [1] The travel speed (5:00-7:00 AM and 6:00-7:00 PM) was obtained via PeMS (average of 4 count stations). The total length of the study corridor is approximately 14 miles. The rest of the datasets were based on the floating car travel time surveys

Travel Time Reliability
Reliability of a freeway system is measured by the amount of variation of travel times. Travel time reliability is often as large or a larger concern than average travel time. Freight traffic, especially where just-in-time inventories are being served, is especially sensitive to travel time reliability. The following statistics for travel time were computed by time of day to measure travel time reliability on the study and control corridors:

- Mean Travel Time by time of day
- Standard Deviation of travel time by time of day
- Coefficient of Variation of travel time by time of day

The mean travel time can be used as a measure of central tendency for the data. The standard deviation provides the information of the variability of the travel time on the freeway study and control corridors. The Coefficient of Variation is the ratio of the Standard Deviation to the Mean. The coefficient of variation is useful because it puts the standard deviation of data in context of the mean of the data. The coefficient of variation is a dimensionless number. The coefficient of variation instead of the standard deviation can be used to compare the different mean travel times on the study and control corridors at different times of the day.

Exhibit 17 through Exhibit 19 provide the travel time plots and travel time variability on the study corridor, I-680 SB between SR 84 in Alameda County and SR 237 in Santa Clara County. Exhibit 17 shows the hourly mean travel time based on all 511.org FasTrak transponders. During

the hours starting at 8:00 AM and 9:00 AM, the I-680 southbound corridor had the longest travel time (roughly between 17 and 25 minutes) from SR-84 to SR-237. The afternoon travel time (roughly 13 minutes from 10:00 AM to 8:00 PM) is very consistent and stable.

Exhibit 18 shows that the standard deviations and coefficients of variation of the travel time increased abruptly during the AM peak hours, between 7:00 AM and 9:00 AM on the study corridor. This means that the travel time variability increases and travel time reliability decreases during the AM time period.

The standard deviations and coefficients of variation of the PM travel time stay stable, as shown in Exhibit 17 and Exhibit 18, which indicate the travel time during the PM time period is more reliable than the travel time during the AM time period.

Exhibit 17: 511.org I-680 SB Travel Times

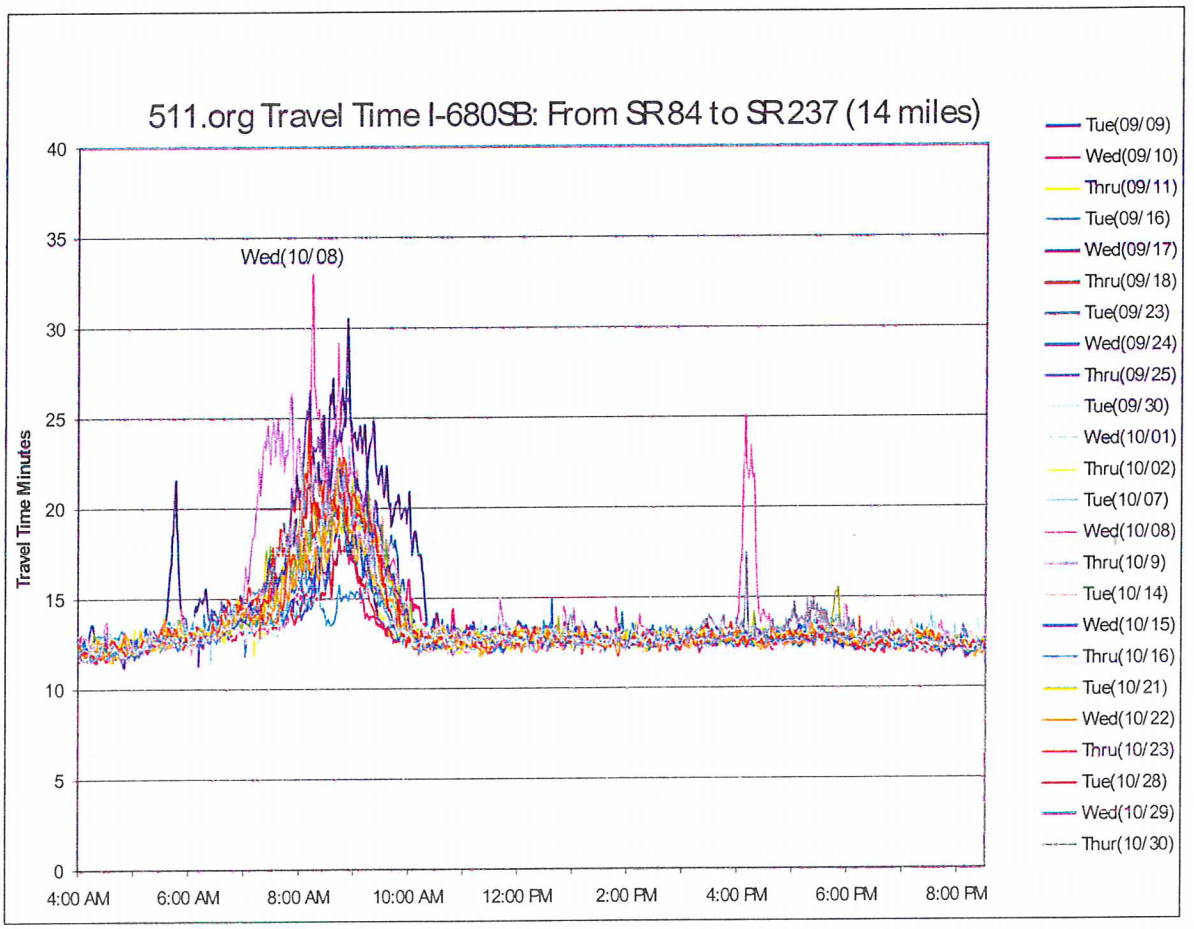


Exhibit 18: 511. org I-680 SB Travel Time Variability

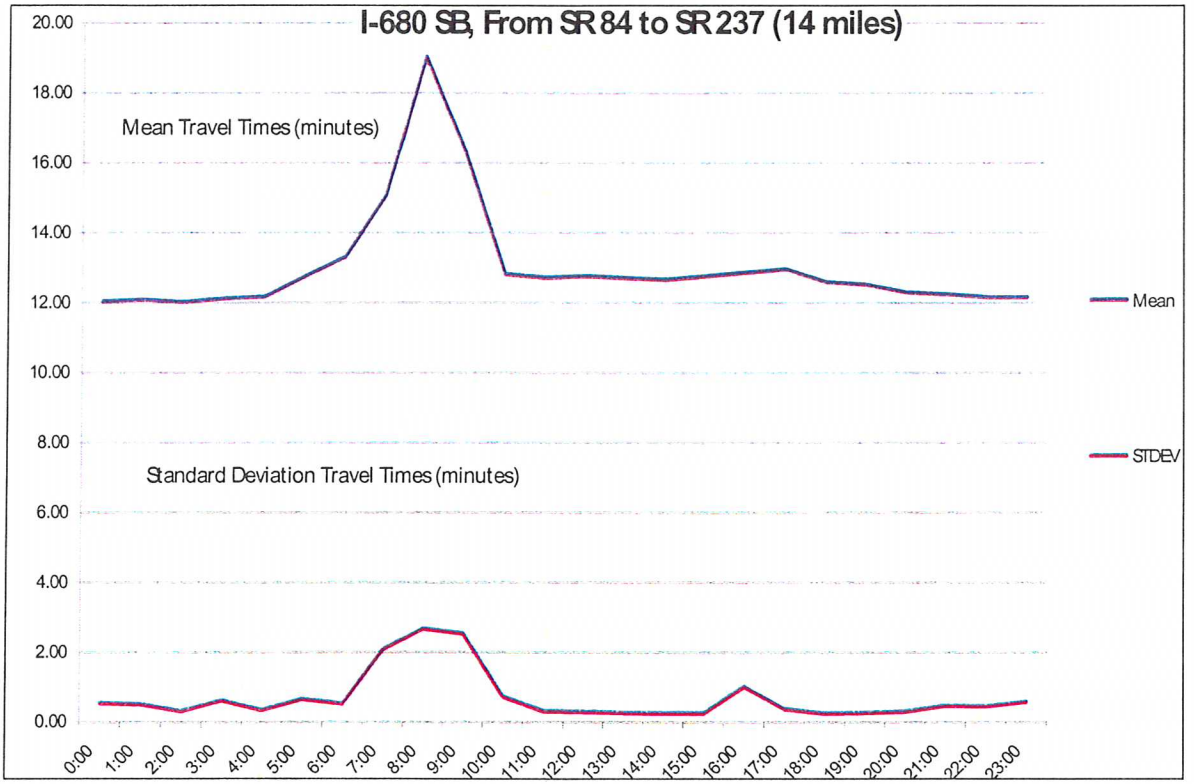


Exhibit 19: 511.org I-680 SB Travel Time Rate and Coefficient of Variation

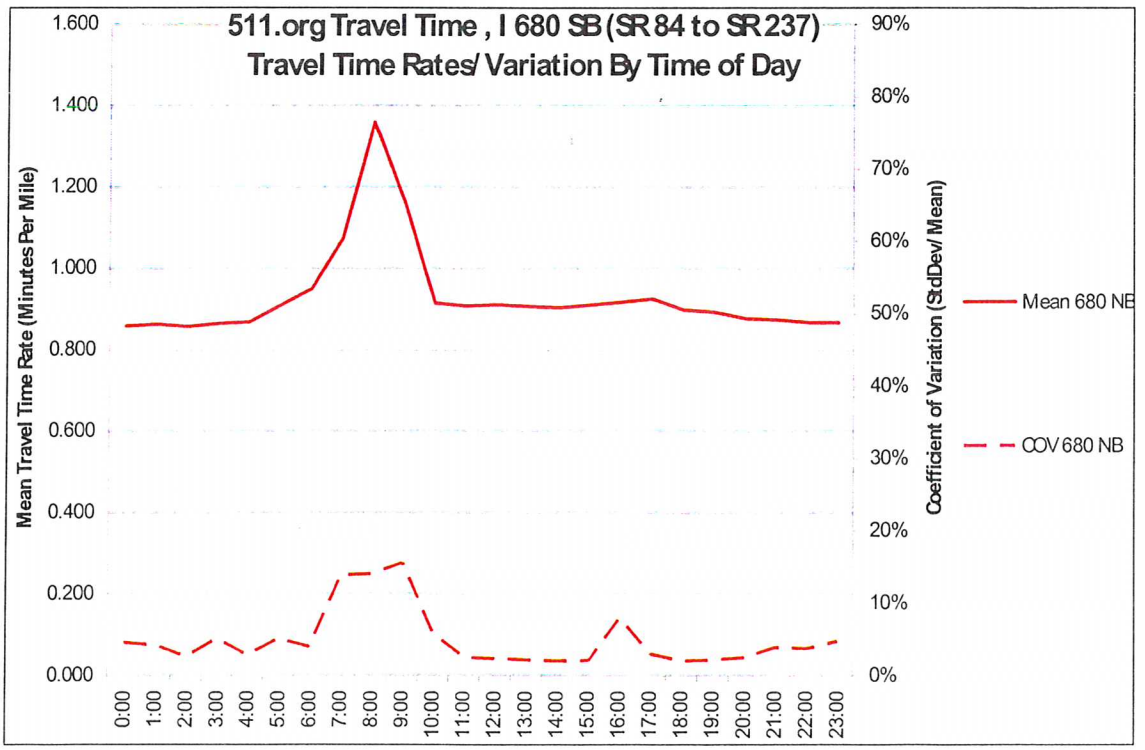


Exhibit 20 shows the mean travel time and the 90 percent confidence interval of the mean travel time for the study corridor. The 90 percent confidence interval of the mean implies that in the long run, 90 percent of the computed confidence intervals will contain the true value of the population mean. In other words, if a driver traveled on the southbound I-680, the travel time would be roughly 13 minutes. However, if a driver traveled between 7:00 AM to 9:00 AM, the possible travel time would be roughly 20 minutes from SR-84 to SR-237 shown in Exhibit 20.

Exhibit 20: I-680 SB Study Corridor Travel Time

Time	511.org Travel Time (Minutes)		
	Mean	90 % Confidence Interval	
		Lower Bound	Upper Bound
0:00	12.05	12.02	12.07
1:00	12.10	12.08	12.12
2:00	12.03	12.02	12.04
3:00	12.13	12.10	12.16
4:00	12.18	12.16	12.19
5:00	12.76	12.73	12.79
6:00	13.32	13.30	13.34
7:00	15.07	14.98	15.16
8:00	19.03	18.92	19.15
9:00	16.31	16.20	16.42
10:00	12.83	12.80	12.86
11:00	12.72	12.71	12.73
12:00	12.77	12.76	12.78
13:00	12.71	12.70	12.73
14:00	12.67	12.66	12.68
15:00	12.77	12.76	12.78
16:00	12.87	12.82	12.91
17:00	12.97	12.96	12.99
18:00	12.60	12.59	12.62
19:00	12.53	12.52	12.54
20:00	12.31	12.29	12.32
21:00	12.25	12.23	12.27
22:00	12.17	12.15	12.19
23:00	12.16	12.13	12.18

Vehicle Occupancy Analysis

Exhibit 21 through Exhibit 24 summarizes vehicle occupancy survey results along the study corridor. In general, carpool vehicles with two or more passengers consisted of approximately nine to fourteen percent of the total traffic composition. Trucks varied from four to six percent along the corridor. The surveyed 14-hour traffic volumes were checked with the available PeMS count stations. For example, at the PeMS # 400376 station near SR-262, the difference between the surveyed data and PeMS database was less than 1.5 percent.

Vehicle occupancy surveys were conducted from 5:00 AM to 7:00 PM. However, due to the low visibility before 7:00 AM the occupancy in each vehicle could not be verified. Thus, the vehicle occupancy data are presented for hours after 7:00 AM only.

Exhibit 21: Occupancy Survey Summary at Andrade Road

Time	SOV	HOV2	HOV3+	Bus	Vanpool	Motorcycle	Trucks
Counts							
5:00 AM - 7:00 AM	8,393						
7:00 AM - 9:00 AM	8,663	1,455	91	10	4	113	371
3:00 PM - 7:00 PM	9,117	1,951	347	23	7	76	457
7:00 AM - 7:00 PM	31,347	5,505	642	62	25	315	2,091
5:00 AM - 7:00 PM	48,379						
Percentage							
Morning: 7-9 AM	80.9%	13.6%	0.8%	0.1%	0.0%	1.1%	3.5%
Afternoon: 3-7 PM	76.1%	16.3%	2.9%	0.2%	0.1%	0.6%	3.8%
7:00 AM - 7:00 PM	78.4%	13.8%	1.6%	0.2%	0.1%	0.8%	5.2%

Note: Data for total number of vehicles only available between 5:00 AM to 7:00 AM and 6:30 PM to 7:00 PM because visibility was limited during these times.

Exhibit 22: Occupancy Survey Summary at Washington Boulevard

Time	SOV	HOV2	HOV3+	Bus	Vanpool	Motorcycle	Trucks
Counts							
5:00 AM - 7:00 AM	9,105						
7:00 AM - 9:00 AM	10,183	1,463	67	22	16	136	431
3:00 PM - 7:00 PM	10,784	2,881	124	18	14	108	559
7:00 AM - 7:00 PM	37,806	7,558	664	76	44	460	2,567
5:00 AM - 7:00 PM	58,277						
Percentage							
Morning: 7-9 AM	82.7%	11.9%	0.5%	0.2%	0.1%	1.1%	3.5%
Afternoon: 3-7 PM	74.4%	19.9%	0.9%	0.1%	0.1%	0.7%	3.9%
7:00 AM - 7:00 PM	76.9%	15.4%	1.3%	0.2%	0.1%	0.9%	5.2%

Note: Data for total number of vehicles only available between 5:00 AM to 7:00 AM and 6:30 PM to 7:00 PM because visibility was limited during these times.

Exhibit 23: Occupancy Survey Summary at Mission Boulevard (South)

Time	SOV	HOV2	HOV3+	Bus	Vanpool	Motorcycle	Trucks
Counts							
5:00 AM - 7:00 AM	6,319						
7:00 AM - 9:00 AM	9,401	764	78	17	10	46	371
3:00 PM - 7:00 PM	10,376	1,493	266	25	11	71	553
7:00 AM - 7:00 PM	32,823	4,262	582	74	35	204	2,371
5:00 AM - 7:00 PM	46,668						
Percentage							
Morning: 7-9 AM	88.0%	7.1%	0.7%	0.2%	0.1%	0.4%	3.5%
Afternoon: 3-7 PM	81.1%	11.7%	2.1%	0.2%	0.1%	0.6%	4.3%
7:00 AM - 7:00 PM	81.3%	10.6%	1.4%	0.2%	0.1%	0.5%	5.9%

Note: Data for total number of vehicles only available between 5:00 AM to 7:00 AM and 6:30 PM to 7:00 PM because visibility was limited during these times.

Exhibit 24: Occupancy Survey Summary at Calaveras Boulevard (SR 237)

Time	SOV	HOV2	HOV3+	Bus	Vanpool	Motorcycle	Trucks
Counts							
5:00 AM - 7:00 AM	3,778						
7:00 AM - 9:00 AM	5,976	589	84	27	60	26	240
3:00 PM - 7:00 PM	13,287	3,431	326	36	175	99	303
7:00 AM - 7:00 PM	32,488	6,513	588	126	486	191	1,460
5:00 AM - 7:00 PM	45,628						
Percentage							
Morning: 7-9 AM	85.4%	8.4%	1.2%	0.4%	0.9%	0.4%	3.4%
Afternoon: 3-7 PM	75.3%	19.4%	1.8%	0.2%	1.0%	0.6%	1.7%
7:00 AM - 7:00 PM	77.6%	15.6%	1.4%	0.3%	1.2%	0.5%	3.5%

Note: Data for total number of vehicles only available between 5:00 AM to 7:00 AM and 6:30 PM to 7:00 PM because visibility was limited during these times.

Vehicle/Passenger Throughput

Based on the vehicle occupancy survey, total passenger throughput at the various study corridor sections are estimated and presented in Exhibit 25. These estimates do not include transit riders, which will be presented later in the Transit section.

Exhibit 25: Freeway Passenger Throughput (Without Transit Passengers)

Time	Passenger Throughput (Non-Transit)			
	Andrade	Washington	Mission	Calaveras
5:00 AM - 7:00 AM	8,393	9,105	6,319	3,778
Morning: 7-9 AM	12,386	13,964	11,652	7,920
Afternoon: 3-7 PM	14,787	17,693	14,950	22,302
5:00 AM - 7:00 PM	55,490	67,527	52,399	54,700

Note: An average occupancy rate of 3.5 is assumed for carpools with 3 or more passengers. Passengers of transit buses are excluded, and will be presented under the Transit Vehicles and Passengers section. Between 5:00 to 7:00 AM, the occupancy is assumed to be 1 driver because the occupancy in each vehicle could not be observed due to low visibility.

Level of Service Based on Highway Capacity Manual

Level of service based on the *Highway Capacity Manual* was evaluated using the FREQ software. The FREQ software, developed by the Institute for Transportation Studies at the University of California at Berkeley can generate speeds, densities, levels of service (based on the Highway Capacity Manual criteria), bottleneck locations and queue lengths and delays for each segment.

Analysis Period and Existing Data

The analysis periods selected for the study corridor along I-680 southbound are from 5:00 AM to 9:00 AM, and from 3:00 PM to 7:00 PM. These time periods include the majority of the busiest weekday commute hours in the morning and afternoon. These time periods are also consistent with the HOV lane enforced hours.

Existing freeway mainline counts were collected from two sources: available PeMS count stations and manual mainline occupancy counts. Freeway ramp counts were collected using 24-hour tube count machines. A set of balanced freeway traffic counts were produced; the data were provided to the Alameda CMA on an external hard drive.

FREQ Model Validation

The following validation criteria were used to validate the FREQ model:

- Correctly identify the location the location of every bottleneck
- Correctly identify the starting and ending time of congestion at every bottleneck within plus or minus one time interval
- Correctly identify the maximum length and time of occurrence of every congested area within plus or minus ten percent of actual length and within plus or minus one time interval
- Correctly estimate the trip travel time in each time interval within plus or minus ten percent of the actual trip travel time
- Correctly estimate the approximate number of vehicles in the queue at every ramp in every time interval

Exhibit 26 provides a summary of the corridor-wide validation results for the I-680 southbound study corridor, between SR-84 and SR-237. As shown in the exhibit, travel time along the corridor was calibrated and validated to each time slice for both the AM and PM peak periods.

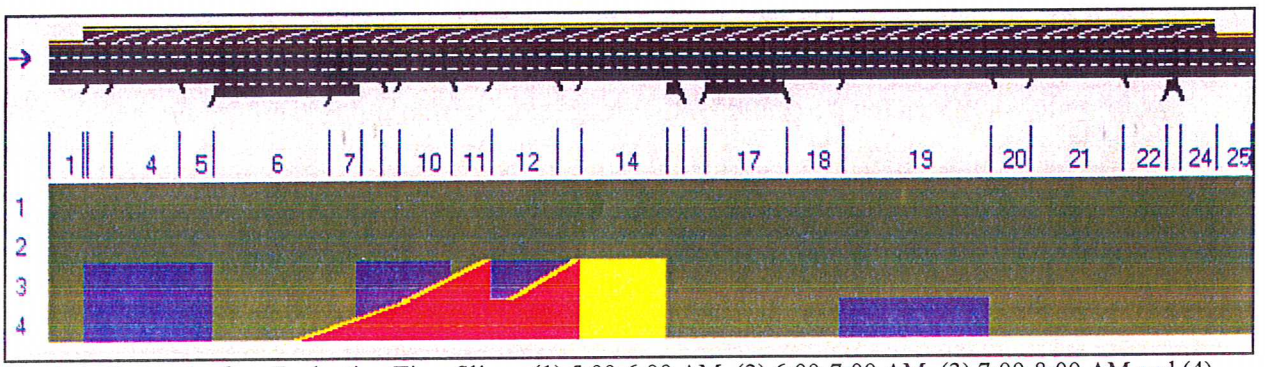
Exhibit 26: FREQ Model Travel Time Validation – I-680 SB Study Corridor

Time Slice	Observed (minutes)		FREQ (minutes)		FREQ/Observed	
	HOV	Mixed-Flow	HOV	Mixed-Flow	HOV	Mixed-Flow
5:00-6:00 AM[1]	11.8	12.7	11.71	13.19	-0.3%	4.0%
6:00-7:00 AM[1]	11.8	13.2	11.71	13.61	-0.3%	3.0%
7:00-8:00 AM	11.8	15.5	11.71	16.71	-0.3%	7.7%
8:00-9:00 AM	12.9	20.4	11.71	20.43	-9.2%	0.1%
3:00-4:00 PM	11.2	12.4	11.44	13.48	4.9%	6.2%
4:00-5:00 PM	11.3	12.1	12.46	16.44	3.3%	9.4%
5:00-6:00 PM	11.1	12.1	12.66	18.06	5.8%	9.8%
6:00-7:00 PM[1]	11.8	12.6	12.66	18.06	-0.3%	5.0%

Note: [1] The observed PeMS speed data on September 10, 2008 was applied. The traffic was free-flow conditions. 705 seconds was assumed to be the free-flow travel time on this corridor. The rest of the observed travel time data was based on the floating car surveys.

In addition to travel time, general freeway queuing and bottleneck locations were compared between field observations and the FREQ simulation results. Exhibit 27 illustrates freeway bottlenecks (yellow sections), and queues (red sections) of the FREQ simulated traffic conditions. The Y axis indicates the four Evaluation Time Slices: (1) 5:00-6:00 AM, (2) 6:00-7:00 AM, (3) 7:00-8:00 AM and (4) 8:00-9:00 AM. The X axis indicates specific freeway subsections, as listed in Exhibit 28. Subsection 14 represents the Washington Boulevard interchange; Subsection 11 is between Andrade Road and Sheridan Road. The FREQ simulated congestion locations match with field observed conditions (from aerial photos).

Exhibit 27: FREQ Model Simulated Bottleneck and Queues – AM Period



Y axis indicates the four Evaluation Time Slices: (1) 5:00-6:00 AM, (2) 6:00-7:00 AM, (3) 7:00-8:00 AM and (4) 8:00-9:00 AM. X axis indicates the freeway segments shown in Exhibit 28.

FREQ LOS Results

Exhibit 28 through Exhibit 31 summarize freeway performance measures computed by FREQ for each freeway segment. The levels of service for the AM and PM periods for both the carpool lane and mixed-flow lanes are presented. All FREQ output data were provided to the Alameda CMA on an external hard drive. The levels of service for the HOV lane were all LOS B or better during the existing AM and PM time periods. Before 7:00 AM, the levels of service of the mixed flow lanes were all LOS C or better and then dropped to D, E and F after 7:00 AM. The levels of service of the mixed flow lanes were all LOS C or better during the PM time periods.

Exhibit 28: FREQ Analysis LOS Summary – Existing AM HOV Lane

Seg #	From	To	5:00 - 6:00	6:00 - 7:00	7:00 - 8:00	8:00 - 9:00
1	North of SR 84 on-ramp	HOV Begin	--	--	--	--
2	HOV Begin	SR 84 On-ramp	A	A	A	A
3	SR 84 On-ramp	Paloma Rd on-ramp	A	A	B	B
4	Paloma Rd on-ramp	Andrade Rd off-ramp	A	A	B	B
5	Andrade Rd off-ramp	Andrade Rd on-ramp	A	A	B	B
6	Andrade Rd on-ramp	Sheridan Rd on-ramp	A	A	B	B
7	Sheridan Rd on-ramp	Lane Drop	A	A	B	B
8	Lane Drop	Vargas Rd off-ramp	A	A	B	B
9	Vargas Rd off-ramp	Vargas Rd on-ramp	A	A	B	B
10	Vargas Rd on-ramp	SR 238 off-ramp	A	A	B	B
11	SR 238 off-ramp	SR 238 on-ramp	A	A	A	A
12	SR 238 on-ramp	Washington Blvd off-ramp	A	A	B	B
13	Washington Blvd off-ramp	Washington Blvd on-ramp	A	A	B	B
14	Washington Blvd on-ramp	Lane Add	A	A	B	B
15	Lane Add	Automall Pkwy off-ramp	A	A	B	B
16	Automall Pkwy off-ramp	Automall Pkwy on-ramp	A	A	A	A
17	Automall Pkwy on-ramp	SR 262 off-ramp	A	A	B	B
18	SR 262 off-ramp	SR 262 on-ramp	A	A	A	A
19	SR 262 on-ramp	Scott Creek Rd off-ramp	A	A	A	B
20	Scott Creek Rd off-ramp	Scott Creek Rd on-ramp	A	A	A	A
21	Scott Creek Rd on-ramp	Jacklin Rd off-ramp	A	A	A	A
22	Jacklin Rd off-ramp	Jacklin Rd on-ramp	A	A	A	A
23	Jacklin Rd on-ramp	SR-237 off-ramp	A	A	A	A
24	SR-237 off-ramp	South of SR-237 off-ramp	A	A	A	A
25		Second Half of Split	--	--	--	--

Exhibit 29: FREQ Analysis LOS Summary – Existing AM Mixed-Flow Lanes

Seg #	From	To	5:00 - 6:00	6:00 - 7:00	7:00 - 8:00	8:00 - 9:00
1	North of SR 84 on-ramp	HOV Begin	B	C	D	D
2	HOV Begin	SR 84 on-ramp	B	C	C	C
3	SR 84 on-ramp	Paloma Rd on-ramp	B	C	D	D
4	Paloma Rd on-ramp	Andrade Rd off-ramp	B	C	D	D
5	Andrade Rd off-ramp	Andrade Rd on-ramp	B	C	D	D
6	Andrade Rd on-ramp	Sheridan Rd on-ramp	B	C	C	C
7	Sheridan Rd on-ramp	Lane Drop	B	C	C	F
8	Lane Drop	Vargas Rd off-ramp	B	C	D	F
9	Vargas Rd off-ramp	Vargas Rd on-ramp	B	C	D	F
10	Vargas Rd on-ramp	SR 238 off-ramp	B	C	F	F
11	SR 238 off-ramp	SR 238 on-ramp	B	C	F	F
12	SR 238 on-ramp	Washington Blvd off-ramp	B	D	F	F
13	Washington Blvd off-ramp	Washington Blvd on-ramp	B	C	F	F
14	Washington Blvd on-ramp	Lane Add	B	D	E	E
15	Lane Add	Automall Pkwy off-ramp	B	C	C	C
16	Automall Pkwy off-ramp	Automall Pkwy on-ramp	B	C	C	C
17	Automall Pkwy on-ramp	SR 262 off-ramp	A	B	C	C
18	SR 262 off-ramp	SR 262 on-ramp	A	B	C	C
19	SR 262 on-ramp	Scott Creek Rd off-ramp	A	B	D	D
20	Scott Creek Rd off-ramp	Scott Creek Rd on-ramp	A	B	C	C
21	Scott Creek Rd on-ramp	Jacklin Rd off-ramp	A	B	C	C
22	Jacklin Rd off-ramp	Jacklin Rd on-ramp	A	B	C	C
23	Jacklin Rd on-ramp	SR-237 off-ramp	A	B	B	C
24	SR-237 off-ramp	South of SR 237 off-ramp	A	B	C	C
25		Second Half of Split	A	B	C	C

Exhibit 30: FREQ Analysis LOS Summary – Existing PM HOV Lane

Seg #	From	To	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00	6:00 - 7:00
1	North of SR 84 on-ramp	HOV Begin	--	--	--	--
2	HOV Begin	SR 84 On-ramp	A	A	B	A
3	SR 84 On-ramp	Paloma Rd on-ramp	A	B	B	B
4	Paloma Rd on-ramp	Andrade Rd off-ramp	A	B	B	B
5	Andrade Rd off-ramp	Andrade Rd on-ramp	A	B	B	B
6	Andrade Rd on-ramp	Sheridan Rd on-ramp	A	B	B	B
7	Sheridan Rd on-ramp	Lane Drop	A	B	B	B
8	Lane Drop	Vargas Rd off-ramp	A	B	B	B
9	Vargas Rd off-ramp	Vargas Rd on-ramp	A	B	B	B
10	Vargas Rd on-ramp	SR 238 off-ramp	A	B	B	B
11	SR 238 off-ramp	SR 238 on-ramp	A	A	B	A
12	SR 238 on-ramp	Washington Blvd off-ramp	A	B	B	B
13	Washington Blvd off-ramp	Washington Blvd on-ramp	A	B	B	A
14	Washington Blvd on-ramp	Lane Add	A	B	B	B
15	Lane Add	Automall Pkwy off-ramp	A	B	B	B
16	Automall Pkwy off-ramp	Automall Pkwy on-ramp	A	A	B	A
17	Automall Pkwy on-ramp	SR 262 off-ramp	A	B	B	B
18	SR 262 off-ramp	SR 262 on-ramp	A	A	B	A
19	SR 262 on-ramp	Scott Creek Rd off-ramp	A	B	B	B
20	Scott Creek Rd off-ramp	Scott Creek Rd on-ramp	A	B	B	A
21	Scott Creek Rd on-ramp	Jacklin Rd off-ramp	A	B	B	B
22	Jacklin Rd off-ramp	Jacklin Rd on-ramp	A	B	B	A
23	Jacklin Rd on-ramp	SR-237 off-ramp	A	B	B	A
24	SR-237 off-ramp	South of SR-237 off-ramp	A	B	B	A
25		Second Half of Split	--	--	--	--

Exhibit 31: FREQ Analysis LOS Summary – Existing PM Mixed-Flow Lanes

Seg #	From	To	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00	6:00 - 7:00
1	North of SR 84 on-ramp	HOV Begin	B	C	C	C
2	HOV Begin	SR 84 on-ramp	B	B	C	B
3	SR 84 on-ramp	Paloma Rd on-ramp	B	B	C	B
4	Paloma Rd on-ramp	Andrade Rd off-ramp	B	B	C	B
5	Andrade Rd off-ramp	Andrade Rd on-ramp	B	B	C	B
6	Andrade Rd on-ramp	Sheridan Rd on-ramp	A	B	B	B
7	Sheridan Rd on-ramp	Lane Drop	A	B	B	B
8	Lane Drop	Vargas Rd off-ramp	B	B	C	B
9	Vargas Rd off-ramp	Vargas Rd on-ramp	B	B	C	B
10	Vargas Rd on-ramp	SR 238 off-ramp	B	B	C	B
11	SR 238 off-ramp	SR 238 on-ramp	B	B	B	B
12	SR 238 on-ramp	Washington Blvd off-ramp	B	B	C	B
13	Washington Blvd off-ramp	Washington Blvd on-ramp	B	B	B	B
14	Washington Blvd on-ramp	Lane Add	B	B	C	B
15	Lane Add	Automall Pkwy off-ramp	A	B	B	B
16	Automall Pkwy off-ramp	Automall Pkwy on-ramp	B	B	B	B
17	Automall Pkwy on-ramp	SR 262 off-ramp	B	B	B	B
18	SR 262 off-ramp	SR 262 on-ramp	A	B	B	B
19	SR 262 on-ramp	Scott Creek Rd off-ramp	B	B	C	B
20	Scott Creek Rd off-ramp	Scott Creek Rd on-ramp	B	B	C	B
21	Scott Creek Rd on-ramp	Jacklin Rd off-ramp	B	C	C	B
22	Jacklin Rd off-ramp	Jacklin Rd on-ramp	B	C	C	B
23	Jacklin Rd on-ramp	SR-237 off-ramp	B	B	B	B
24	SR-237 off-ramp	South of SR 237 off-ramp	B	C	C	B
25		Second Half of Split	B	C	C	C

6. Control Corridor Performance Measures

The following performance measurements describe the existing traffic operations conditions along the control corridor. The freeway performance evaluation was focused during the hours of the HOV lane enforced periods, from 6:00 to 9:00 AM and 3:00 to 6:00 PM. The purpose of the control corridor is to determine if any changes in travel behavior are due to the Express Lane project or other travel trends within the San Francisco Bay Area.

Travel Time Analysis

Speed/Travel Time by Segment

Freeway LOS based on probe vehicle speed surveys is summarized in Exhibit 32 and Exhibit 33. Separate speed survey data are presented for the mixed-flow lanes versus the HOV lane. The results show the average performance for each hour within both the morning and afternoon commute periods. As shown in these exhibits, this corridor experienced congestion in the mixed-flow lanes during both the morning and afternoon commute hours. Freeway speeds were typically affected by congestion from the Crow Canyon Road interchange to the Stone Valley and Livorna Road interchanges. The HOV lane operated mostly under free-flow conditions, except for the peak afternoon hour between 5:00 to 6:00 PM, where it was reduced to 20-40 MPH near the El Cerro Road and Livorna Road interchanges.

Exhibit 32: Freeway LOS Based on Floating Car Survey Speeds – AM Peak Period

Segment Limits		Length	HOV Lane		Mixed-Flow Lanes	
From	To	(miles)	Speed	LOS	Speed	LOS
6:00 AM - 7:00 AM						
Averaged of 24 PeMS count stations		- -	73	A	65	A
7:00 AM - 8:00 AM						
Alcosta Blvd	Bollinger Canyon Rd	2.83	61	A	59	B
Bollinger Canyon Rd	Crow Canyon Rd	1.28	72	A	65	A
Crow Canyon Rd	Sycamore Valley Rd	2.51	65	A	50	C
Sycamore Valley Rd	Diablo Rd	0.79	64	A	54	C
Diablo Rd	El Cerro Blvd	0.62	65	A	48	D
El Cerro Blvd	El Pintado Rd	0.57	62	A	43	D
El Pintado Rd	Stone Valley Rd	1.59	60	B	43	D
Stone Valley Rd	Livorna Rd	0.89	63	A	59	B
8:00 AM - 9:00 AM						
Alcosta Blvd	Bollinger Canyon Rd	2.83	60	A	62	A
Bollinger Canyon Rd	Crow Canyon Rd	1.28	60	B	17	F
Crow Canyon Rd	Sycamore Valley Rd	2.51	56	B	19	F
Sycamore Valley Rd	Diablo Rd	0.79	58	B	23	F
Diablo Rd	El Cerro Blvd	0.62	48	D	40	E
El Cerro Blvd	El Pintado Rd	0.57	53	C	28	F
El Pintado Rd	Stone Valley Rd	1.59	58	B	51	C
Stone Valley Rd	Livorna Rd	0.89	51	C	46	D

Note: LOS threshold based on CMA LOS Monitoring Report, 2008

Exhibit 33: Freeway LOS Based on Floating Car Survey Speeds – PM Peak Period

Segment Limits		Length	HOV Lane		Mixed-Flow Lanes	
From	To	(miles)	Speed	LOS	Speed	LOS
3:00 PM - 4:00 PM						
Alcosta Blvd	Bollinger Canyon Rd	2.83	65	A	60	A
Bollinger Canyon Rd	Crow Canyon Rd	1.28	72	A	64	A
Crow Canyon Rd	Sycamore Valley Rd	2.51	69	A	61	A
Sycamore Valley Rd	Diablo Rd	0.79	62	A	50	C
Diablo Rd	El Cerro Blvd	0.62	52	C	42	D
El Cerro Blvd	El Pintado Rd	0.57	49	C	39	E
El Pintado Rd	Stone Valley Rd	1.59	63	A	51	C
Stone Valley Rd	Livorna Rd	0.89	58	B	55	C
4:00 PM - 5:00 PM						
Alcosta Blvd	Bollinger Canyon Rd	2.83	63	A	62	A
Bollinger Canyon Rd	Crow Canyon Rd	1.28	72	A	65	A
Crow Canyon Rd	Sycamore Valley Rd	2.51	66	A	45	D
Sycamore Valley Rd	Diablo Rd	0.79	56	B	36	E
Diablo Rd	El Cerro Blvd	0.62	61	A	32	E
El Cerro Blvd	El Pintado Rd	0.57	54	C	26	F
El Pintado Rd	Stone Valley Rd	1.59	49	C	34	E
Stone Valley Rd	Livorna Rd	0.89	28	F	29	F
5:00 PM - 6:00 PM						
Alcosta Blvd	Bollinger Canyon Rd	2.83	64	A	60	B
Bollinger Canyon Rd	Crow Canyon Rd	1.28	59	B	54	C
Crow Canyon Rd	Sycamore Valley Rd	2.51	55	C	35	E
Sycamore Valley Rd	Diablo Rd	0.79	44	D	32	E
Diablo Rd	El Cerro Blvd	0.62	26	F	35	E
El Cerro Blvd	El Pintado Rd	0.57	37	E	33	E
El Pintado Rd	Stone Valley Rd	1.59	49	D	35	E
Stone Valley Rd	Livorna Rd	0.89	23	F	24	F

Note: LOS threshold based on CMA LOS Monitoring Report, 2008

Exhibit 34 and Exhibit 35 present the speeds between each freeway interchange for the HOV lane on northbound I-680 from Alcosta Blvd. to Livorna Rd. based on surveys conducted on September 24 and 25, 2008.

Exhibit 36 and Exhibit 37 present the surveyed speed between each freeway interchange for the mixed flow lanes.

Based on the surveyed speeds, the mixed flow lanes experienced a wider range of the travel speeds compared to the speeds on the HOV lane. More data on the speed variation is presented in the travel time reliability section.

Exhibit 34: Surveyed AM Travel Speed between Interchanges on I-680 NB HOV Lane

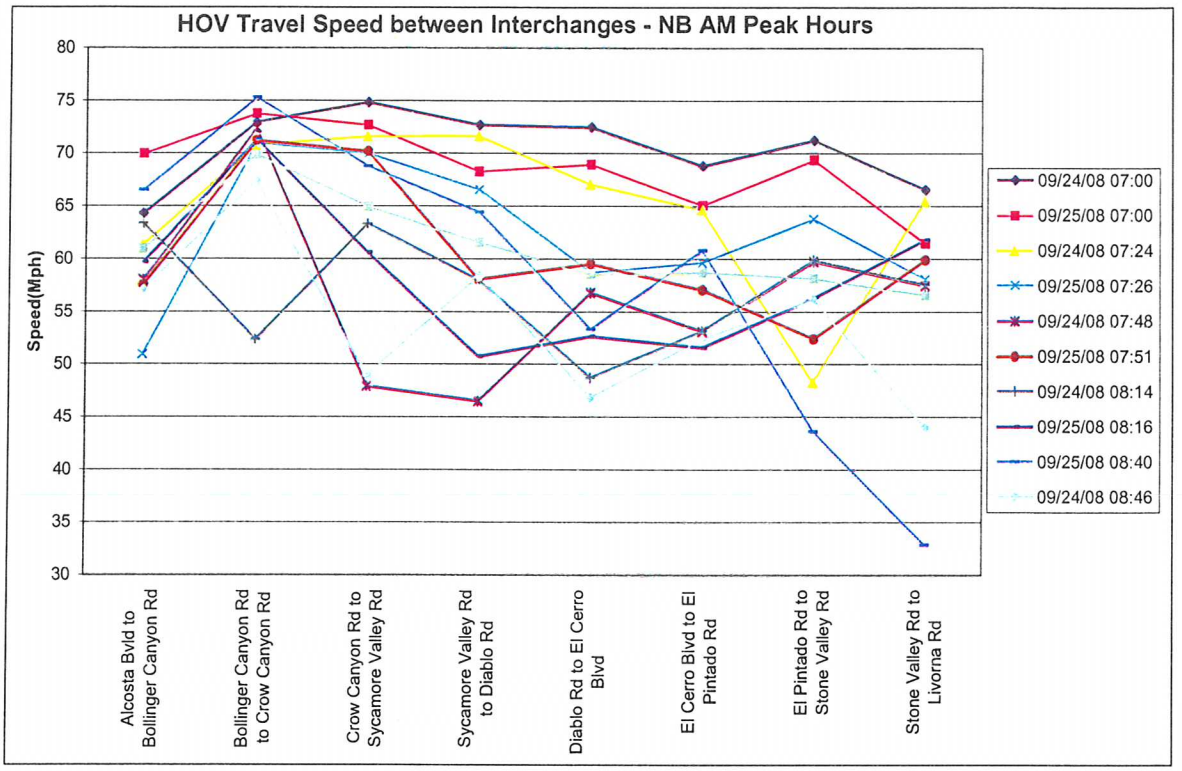


Exhibit 35: Surveyed PM Travel Speed between Interchanges on I-680 NB HOV Lane

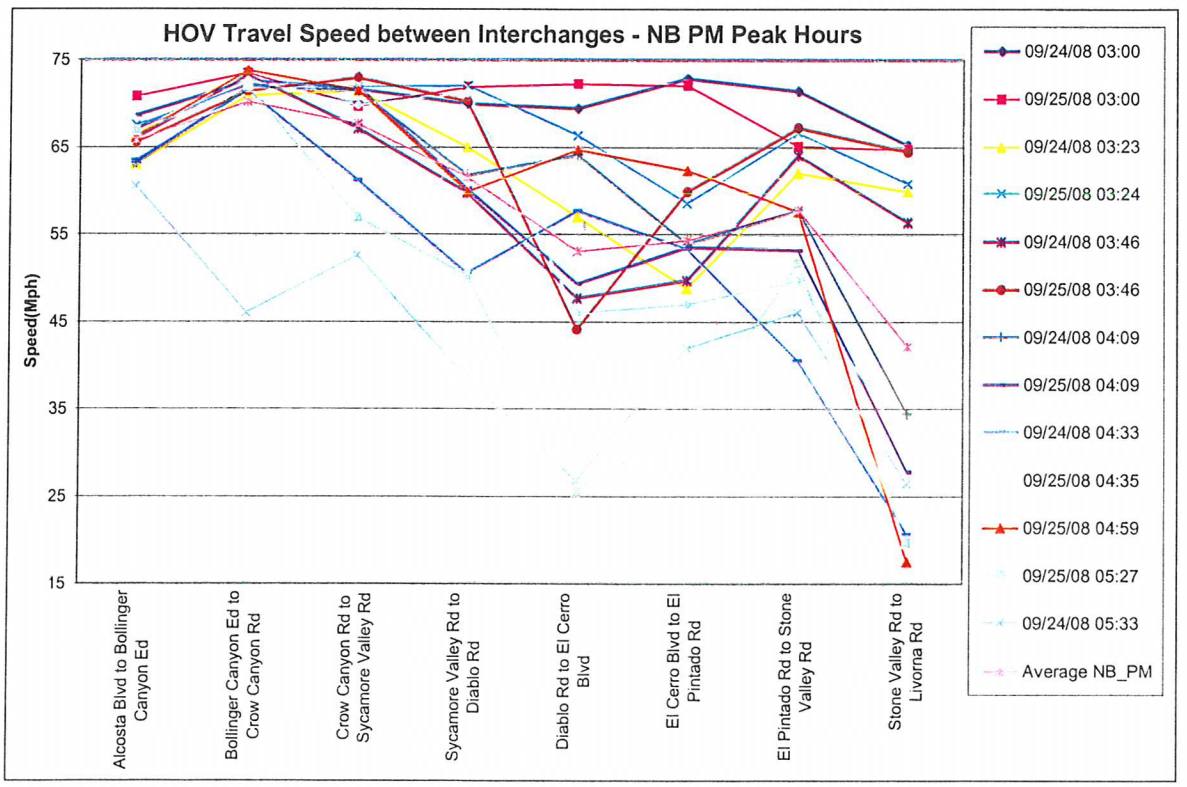


Exhibit 36: Surveyed AM Travel Speed between Interchanges on I-680 NB Mixed Flow Lanes

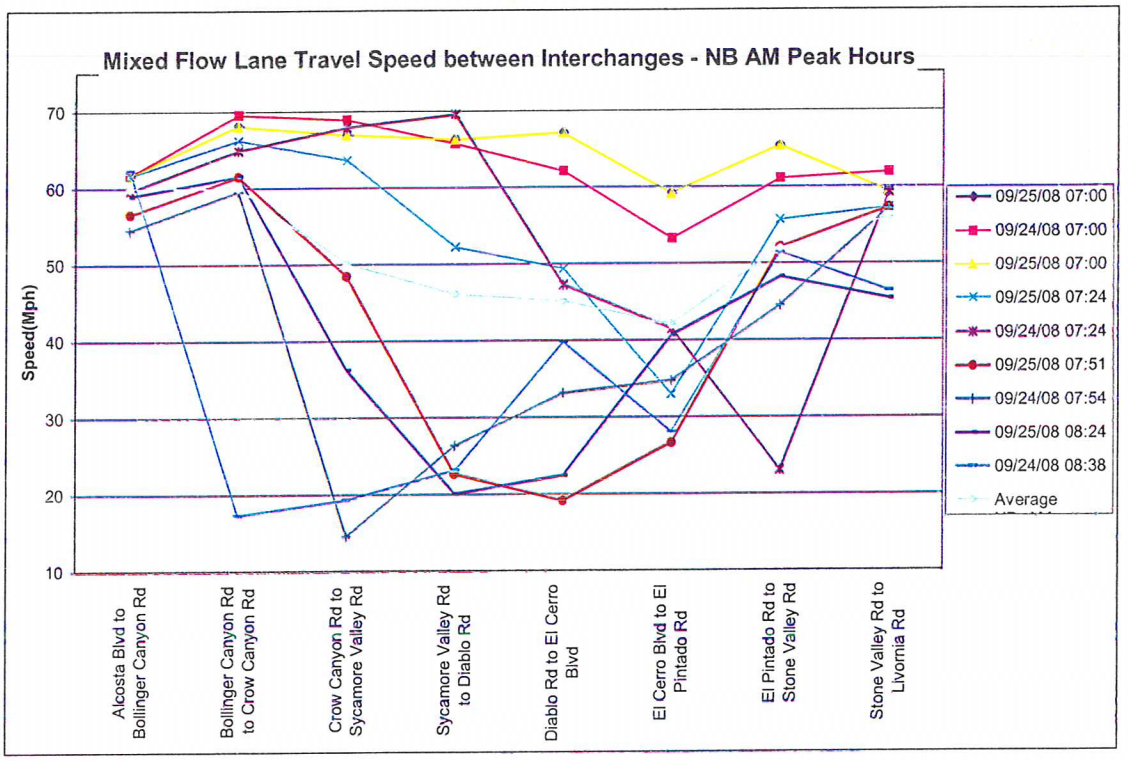
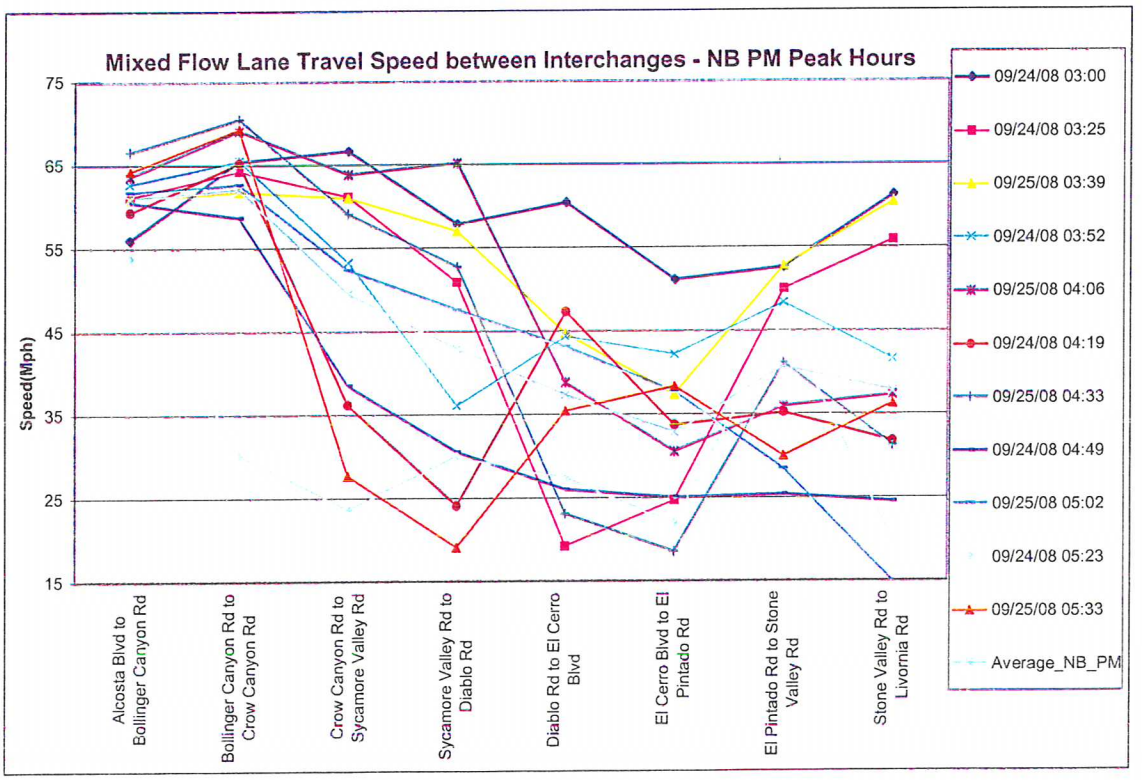


Exhibit 37: Surveyed PM Travel Speed between Interchanges on I-680 NB Mixed Flow Lanes



Control Corridor Freeway Bottleneck and Queues

No detailed aerial photography surveys were conducted on the control corridor; therefore, freeway queues were estimated based on field observations, as well as the floating car speed surveys. Exhibit 38 and Exhibit 39 provide schematics of the overall congestion along the corridor.

Exhibit 38: Control Corridor General Bottleneck and Queues AM Period (Mixed-Flow Lanes)

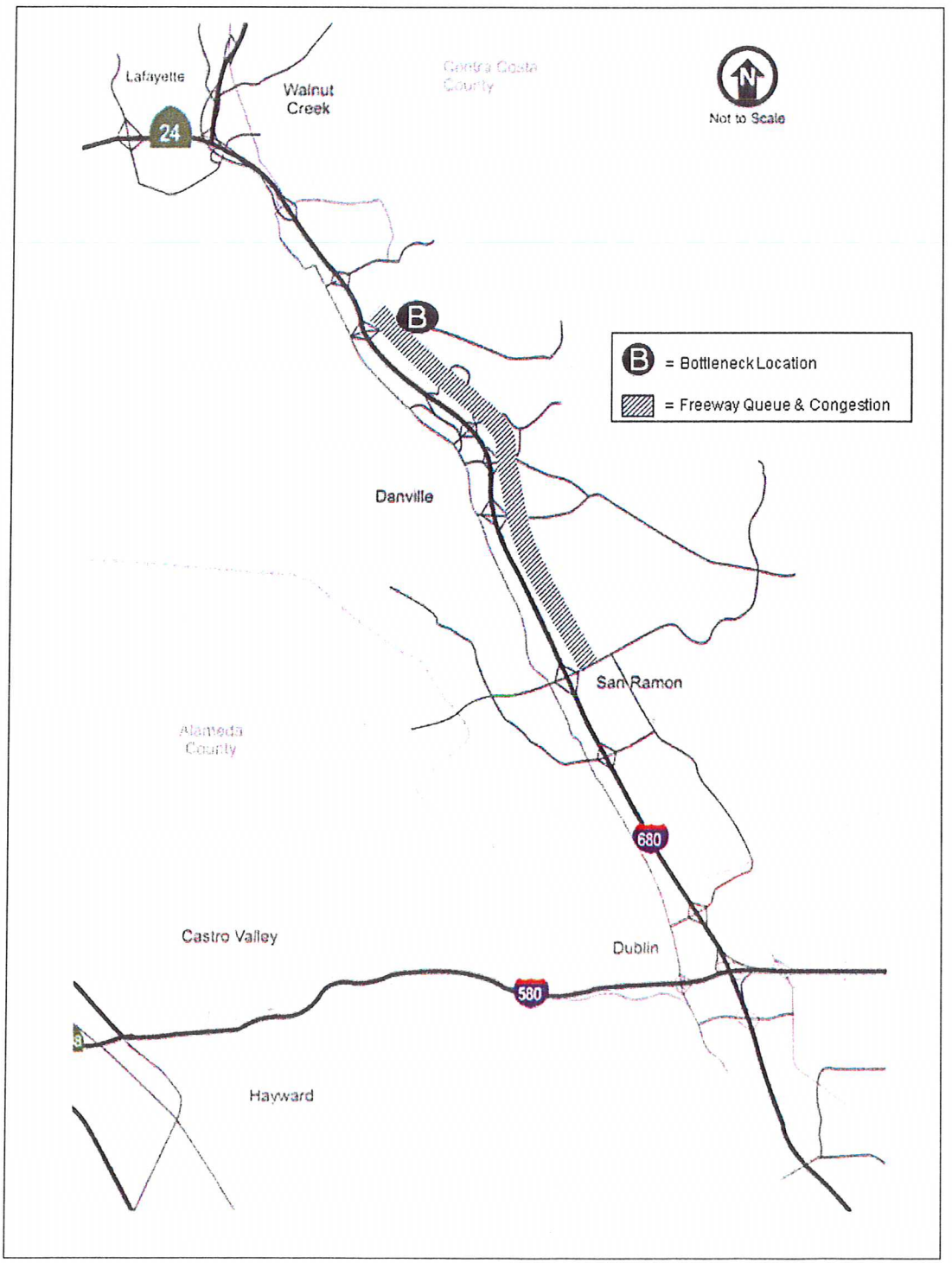
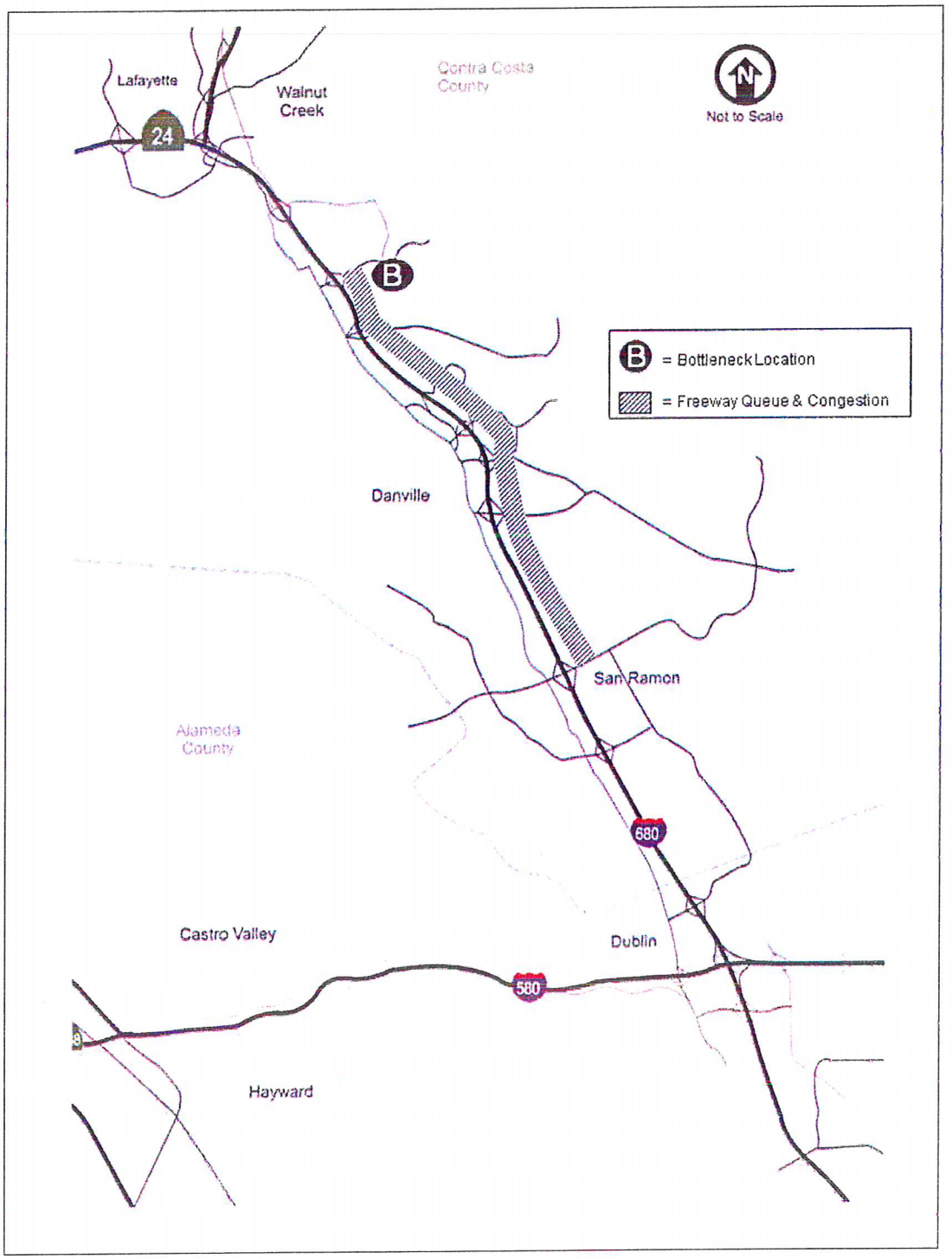


Exhibit 39: Control Corridor General Bottleneck and Queues
PM Period (Mixed-Flow Lanes)



Travel Time Savings

Average travel times for both the mixed-flow lanes and HOV lane are summarized in Exhibit 40, for each hour of the study period. Maximum travel time savings for vehicles utilizing HOV lane were over ten minutes during the AM peak hour, and approximately five minutes during the PM peak hour.

Exhibit 40: HOV Travel Time Savings on I-680 Northbound Control Corridor

Time	Floating Survey (minutes)		HOV Travel Time Savings
	HOV	Mixed-Flow	(minutes)
6:00-7:00 AM[1]	9.9	11.1	1.2
7:00-8:00 AM	10.7	15.3	4.6
8:00-9:00 AM	11.8	22.3	10.5
3:00-4:00 PM	10.5	12.6	2.1
4:00-5:00 PM	12.3	17.4	5.1
5:00-6:00 PM	13.6	18.7	5.1

Note: [1] The observed travel time was derived from the averaged speed of 24 PeMS count stations and then divided by the length of the corridor (approximately 12 miles). The rest of the datasets were based on the floating car travel time surveys.

Travel Time Reliability

The 511.org data were used for the analysis of the travel time reliability. The data were evaluated for a total of 24 days, including every Tuesday, Wednesday and Thursday from September 8 to October 30, 2008 for this analysis. The mean of the 511 travel time data for each hour was computed based on the travel time observations for each minute (60 computations per hour) collected for 24 days. For each hour of the day, a total of 1,440 (=24×60) computations were used to perform the travel time statistics.

Travel times provided by this source represent the average travel times of all vehicles with FasTrak transponders across all travel lanes on the corridor. Exhibit 41 through Exhibit 43 show the travel time plots and travel time variability on the control corridor, I-680 northbound between Alcosta Boulevard Alameda County and Livorna Road in Contra Costa County.

The AM peak period started at 7:00 AM and ended at 9:00 AM. The PM peak period started at 4:30 PM and ended at 6:00 PM, as shown in Exhibit 41. The travel time variation evaluations indicate that the morning peak period has more consistent travel times than the afternoon peak period (i.e., there is more variation in PM peak hours), as shown in Exhibit 42 and Exhibit 43.

Exhibit 41: I-680 NB Travel Times

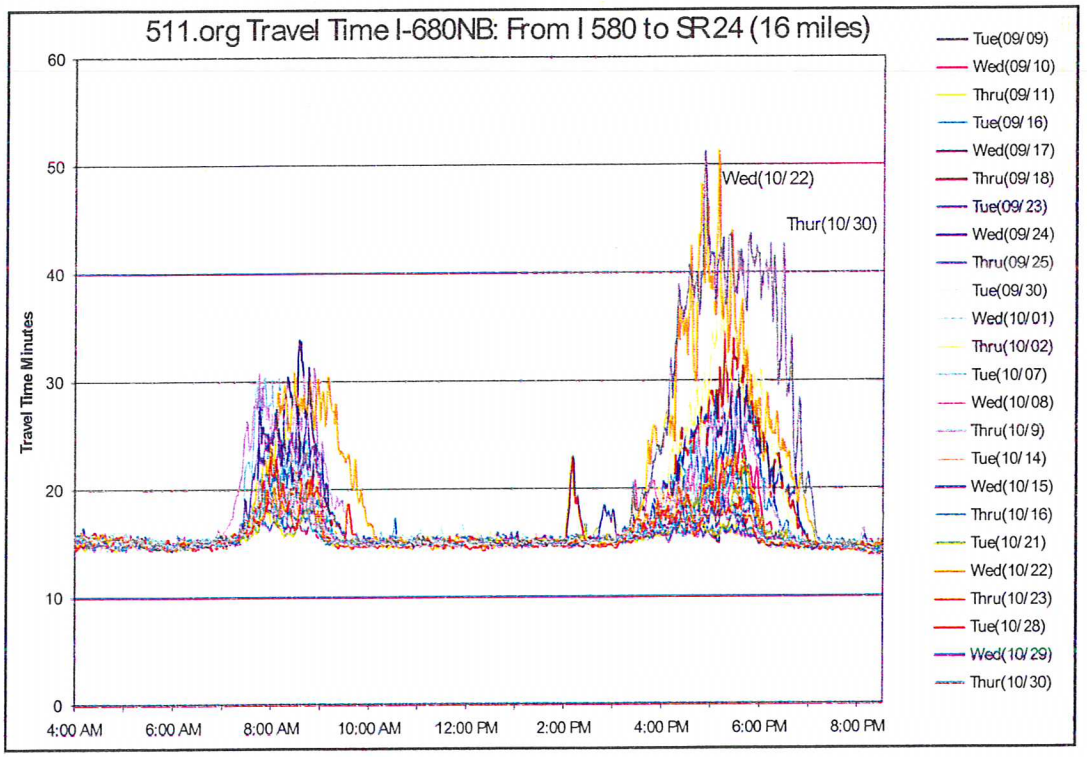


Exhibit 42: I-680 NB Travel Time Variability

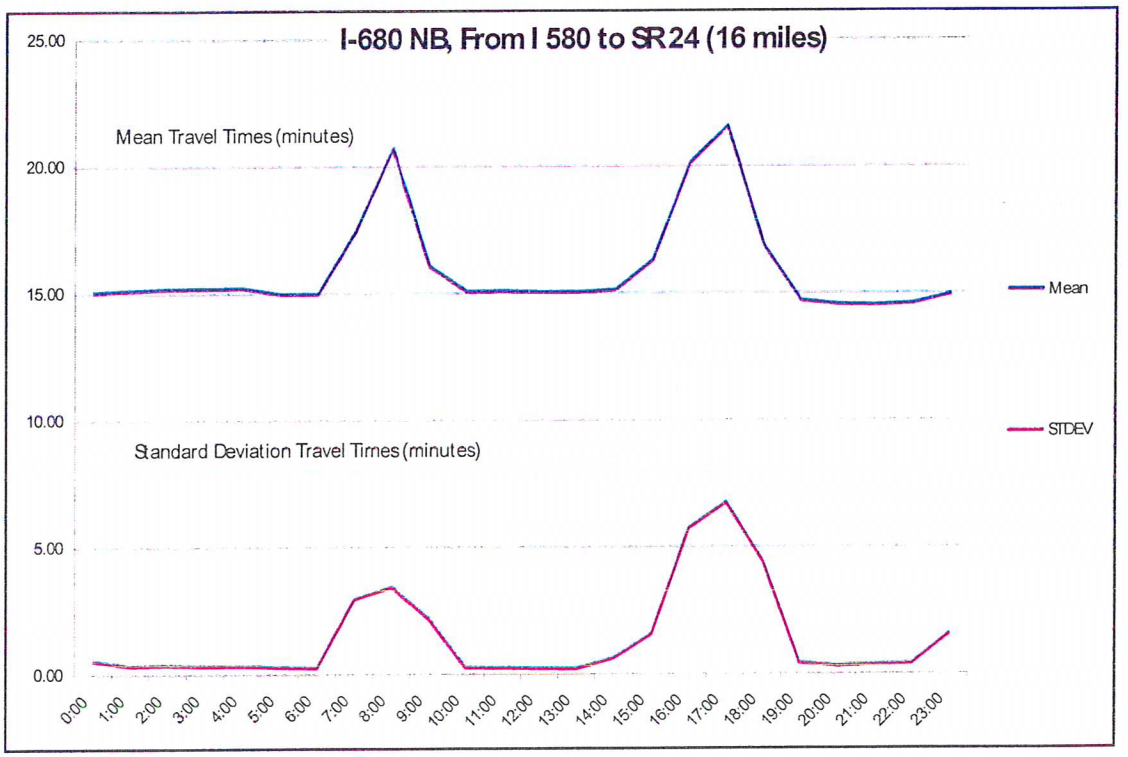


Exhibit 43: I-680 NB Travel Time Rate and Coefficient of Variation

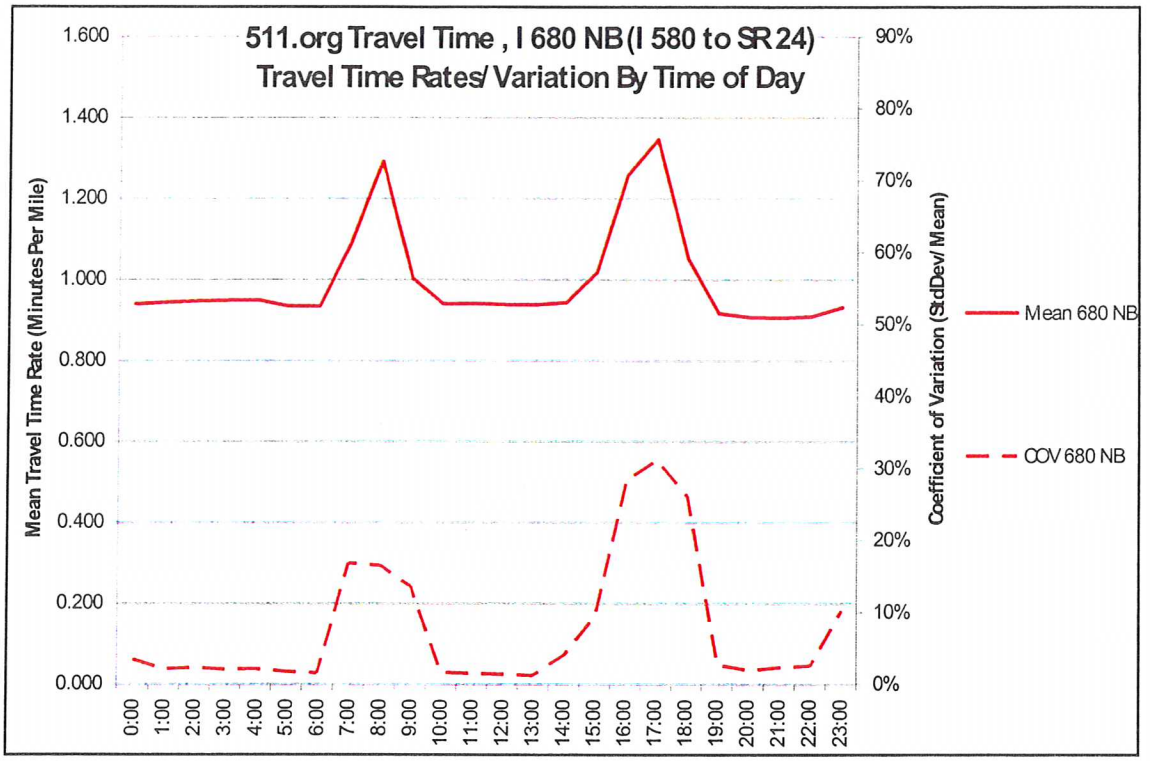


Exhibit 44 shows the mean travel time and the 90 percent confidence interval of the mean travel time for the control corridor. The 90 percent confidence interval of the mean implies that in the long run, 90 percent of the computed confidence intervals will contain the true value of the population mean.

The travel time during AM peak hours (7:00 – 9:00 AM) was between 17 minutes and 20 minutes and the travel time during PM peak hours (3:00 – 6:00 PM) was roughly between 16 and 22 minutes.

Exhibit 44: I-680 NB Control Corridor Travel Time

Time	511.org Travel Time (Minutes)		
	Mean	90 % Confidence Interval	
		Lower Bound	Upper Bound
0:00	15.06	15.04	15.08
1:00	15.13	15.11	15.14
2:00	15.19	15.17	15.20
3:00	15.21	15.19	15.22
4:00	15.21	15.20	15.23
5:00	14.98	14.96	14.99
6:00	14.97	14.96	14.99
7:00	17.42	17.29	17.55
8:00	20.68	20.53	20.83
9:00	16.07	15.97	16.16
10:00	15.06	15.05	15.08
11:00	15.09	15.08	15.10
12:00	15.05	15.04	15.06
13:00	15.04	15.03	15.04
14:00	15.13	15.10	15.16
15:00	16.31	16.24	16.38
16:00	20.15	19.90	20.39
17:00	21.57	21.27	21.86
18:00	16.86	16.67	17.05
19:00	14.70	14.68	14.72
20:00	14.55	14.54	14.57
21:00	14.53	14.51	14.55
22:00	14.58	14.56	14.60
23:00	14.93	14.87	15.00

Vehicle Occupancy Analysis

Exhibit 45 and Exhibit 46 summarize vehicle occupancy survey results along the control corridor. In general, carpool vehicles with two or more passengers consisted of approximately fifteen percent of the total traffic composition, while trucks accounted for approximately four percent.

Exhibit 45: Occupancy Survey Summary at Alcosta Boulevard Overpass

Time	SOV	HOV2	HOV3+	Bus	Vanpool	Motorcycle	Trucks
Counts							
5:00 AM - 7:00 AM	4,719						
7:00 AM - 9:00 AM	8,692	1,111	70	22	39	51	409
3:00 PM - 7:00 PM	16,793	3,614	334	38	111	146	432
7:00 AM - 7:00 PM	43,633	8,280	588	105	270	350	2,186
5:00 AM - 7:00 PM	60,131						
Percentage							
Morning: 7-9 AM	83.6%	10.7%	0.7%	0.2%	0.4%	0.5%	3.9%
Afternoon: 3-7 PM	78.2%	16.8%	1.6%	0.2%	0.5%	0.7%	2.0%
7:00 AM - 7:00 PM	78.7%	14.9%	1.1%	0.2%	0.5%	0.6%	3.9%

Note: Data for total number of vehicles only available between 5:00 AM to 7:00 AM

Exhibit 46: Occupancy Survey Summary at Livorna Road Overpass

Time	SOV	HOV2	HOV3+	Bus	Vanpool	Motorcycle	Trucks
Counts							
5:00 AM - 7:00 AM	5,839						
7:00 AM - 9:00 AM	11,346	1,306	52	43	54	85	409
3:00 PM - 7:00 PM	19,670	5,113	412	96	161	181	387
7:00 AM - 7:00 PM	54,770	10,132	630	219	347	459	2,384
5:00 AM - 7:00 PM	74,780						
Percentage							
Morning: 7-9 AM	85.3%	9.8%	0.4%	0.3%	0.4%	0.6%	3.1%
Afternoon: 3-7 PM	75.6%	19.7%	1.6%	0.4%	0.6%	0.7%	1.5%
7:00 AM - 7:00 PM	79.4%	14.7%	0.9%	0.3%	0.5%	0.7%	3.5%

Note: Data for total number of vehicles only available between 5:00 AM to 7:00 AM

Vehicle/Passenger Throughput

Based on the vehicle occupancy survey, total passenger throughput at the various study corridor sections was estimated and is presented in Exhibit 47. These estimates do not include transit riders, which are presented in the Transit section.

Exhibit 47: Control Corridor Freeway Passenger Throughput (Without Transit Passengers)

Time	Passenger Throughput (Non-Transit)	
	Alcosta	Livorna
5:00 AM - 7:00 AM	4,719	5,839
Morning: 7-9 AM	11,756	14,823
Afternoon: 3-7 PM	19,984	24,654
5:00 AM - 7:00 PM	70,451	87,136

Note: An average occupancy rate of 3.5 is assumed for carpools with 3 or more passengers. Passengers of transit buses are excluded, and will be presented under the Transit Vehicles and Passengers section. Between 5:00 to 7:00 AM, the occupancy is assumed to be 1 driver because the occupancy in each vehicle could not be observed due to low visibility.

Level of Service Analysis Based on Highway Capacity Manual

Analysis Period and Existing Data

The analysis period selected for the control corridor along I-680 northbound is from 6:00 AM to 9:00 AM and from 3:00 PM to 6:00 PM. These time periods include the majority of the busiest weekday commute hours in the morning and afternoon. These time periods are also consistent with the HOV lane enforced hours.

Existing freeway mainline counts were collected from two sources: available PeMS count stations and manual mainline occupancy counts. Freeway ramp counts were collected using 24-hour tube count machines. A set of balanced freeway traffic counts were produced; the data were provided to the Alameda CMA on an external hard drive.

FREQ Model Validation

The following validation criteria were used to validate the FREQ model:

- Correctly identify the location the location of every bottleneck
- Correctly identify the starting and ending time of congestion at every bottleneck within plus or minus one time interval
- Correctly identify the maximum length and time of occurrence of every congested area within plus or minus ten percent of actual length and within plus or minus one time interval
- Correctly estimate the trip travel time in each time interval within plus or minus ten percent of the actual trip travel time
- Correctly estimate the approximate number of vehicles in the queue at every ramp in every time interval

Exhibit 48 provides a summary of the corridor-wide validation results for the I-680 control corridor in the northbound direction, between the Alcosta Boulevard and Livorna Road interchanges. As shown in the exhibit, travel time along the corridor was calibrated and validated to each time hour for both the AM and PM peak periods.

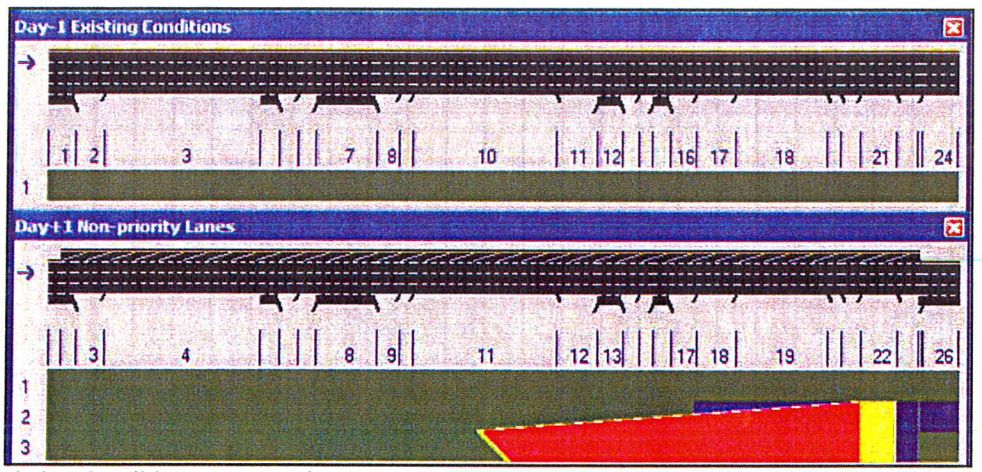
In addition to travel time, general freeway queuing and bottleneck locations were compared between field observations and the FREQ simulation results. Exhibit 48 and Exhibit 49 illustrate freeway bottlenecks (yellow sections), and queues (red sections) of the FREQ simulated traffic conditions. The Y axis indicates the three Evaluation Time Slices: (1) 6:00-7:00 AM, (2) 7:00-8:00 AM and (3) 8:00-9:00 AM. In general, the FREQ simulation freeway queues match fairly well with the field observations of congested freeway sections. The X axis indicates specific freeway subsections, as listed in Exhibit 50. Subsection 22 represents Stone Valley Road to Livorna Road, and subsection 11 represents Crow Canyon Road to Sycamore Valley Road.

Exhibit 48: FREQ Model Travel Time Validation – I-680 NB Control Corridor

Time Slice	Observed (minutes)		FREQ (minutes)		FREQ/Observed	
	HOV	Mixed-Flow	HOV	Mixed-Flow	HOV	Mixed-Flow
5:00-6:00 AM[1,2]	N/A	11.1	N/A	11.5	N/A	3.7%
6:00-7:00 AM[2]	9.9	11.1	10.9	11.5	9.8%	3.7%
7:00-8:00 AM	10.7	15.3	10.9	16.1	1.8%	5.6%
8:00-9:00 AM	11.8	22.3	10.9	22.7	-8.2%	1.9%
3:00-4:00 PM	10.5	12.6	11.4	13.5	9.0%	7.1%
4:00-5:00 PM	12.3	17.4	12.5	16.4	1.6%	-5.2%
5:00-6:00 PM	13.6	18.7	12.7	18.1	-6.8%	-3.3%
6:00-7:00 PM[1,2]	N/A	12.8	N/A	11.5	N/A	-9.7%

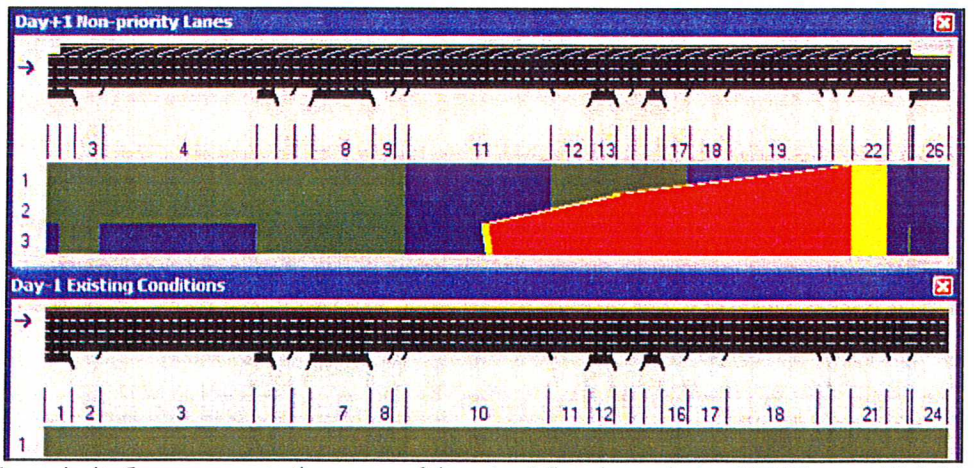
Note: 1. The northbound HOV lane does not operates during the time periods of 5:00-6:00AM or 6:00-7:00PM.
2. The observed travel speed was based on the average of 24 PeMS count stations.

Exhibit 49: FREQ Model Simulated Bottleneck and Queues – AM Period



The Day-1 Existing Conditions presents the queue of all lanes during non-HOV hour from 5:00-6:00 AM. The Day+1 Non-priority Lanes presents the queue of the mixed flow lanes during HOV hours: (1) 6:00-7:00 AM, (2) 7:00-8:00 AM and (3) 8:00-9:00 AM. X axis indicates the freeway segments shown in Exhibit 51.

Exhibit 50: FREQ Model Simulated Bottleneck and Queues – PM Period



The Day+1 Non-priority Lanes presents the queue of the mixed flow lanes during HOV hours: (1) 3:00-4:00 PM, (2) 4:00-5:00 PM and (3) 5:00-6:00 PM. The Day-1 Existing Conditions presents the queue of all lanes during non-HOV hour from 6:00-7:00 PM. X axis indicates the freeway segments shown in Exhibit 51.

FREQ LOS Results

Error! Not a valid bookmark self-reference. through Exhibit 54 summarize freeway performance measures computed by FREQ for each control corridor freeway segment. The level of service for the AM and PM periods for both the carpool lane and mixed-flow lanes are presented. All FREQ output data were provided to the Alameda CMA on an external hard drive.

Exhibit 51: Control Corridor FREQ Analysis LOS Summary – Existing AM Peak HOV Lane

Seg #	From	To	6:00 - 7:00	7:00 - 8:00	8:00 - 9:00
2	I-680 NB south of Alcosta	Alcosta Blvd off-ramp	A	A	A
3	Alcosta Blvd off-ramp	Alcosta Blvd on-ramp	A	A	A
4	Alcosta Blvd on-ramp	Bollinger Canyon off-ramp decel lane	A	B	B
5	Bollinger Canyon off-ramp decel lane	Bollinger Canyon Rd off-ramp	A	B	B
6	Bollinger Canyon Rd off-ramp	Bollinger Canyon Rd EB on-ramp	A	A	A
7	Bollinger Canyon Rd EB on-ramp	Bollinger Canyon Rd WB on-ramp	A	A	A
8	Bollinger Canyon Rd WB on-ramp	Crow Canyon Rd off-ramp	A	A	A
9	Crow Canyon Rd off-ramp	Crow Canyon Rd EB on-ramp	A	A	A
10	Crow Canyon Rd EB on-ramp	Crow Canyon Rd WB on-ramp	A	A	A
11	Crow Canyon Rd WB on-ramp	Sycamore Valley Rd off-ramp	A	B	A
12	Sycamore Valley Rd off-ramp	Sycamore Valley Rd on-ramp	A	A	A
13	Sycamore Valley Rd on-ramp	Diablo Rd off-ramp	A	B	A
14	Diablo Rd off-ramp	Diablo Rd EB on-ramp	A	B	A
15	Diablo Rd EB on-ramp	Diablo Rd WB on-ramp	A	B	A
16	Diablo Rd WB on-ramp	El Cerro Blvd off-ramp	A	B	B
17	El Cerro Blvd off-ramp	El Cerro Blvd on-ramp	A	B	A
18	El Cerro Blvd on-ramp	El Pintado Rd on-ramp	A	B	B
19	El Pintado Rd on-ramp	Stone Valley Rd EB off-ramp	A	B	B
20	Stone Valley Rd EB off-ramp	Stone Valley Rd WB off-ramp	A	B	B
21	Stone Valley Rd WB off-ramp	Stone Valley Rd on-ramp	A	B	B
22	Stone Valley Rd on-ramp	Livorna Rd off-ramp	A	B	B
23	Livorna Rd off-ramp	End of HOV lane	A	B	B
24	End of HOV lane	Livorna Rd on-ramp	A	B	B
25	Livorna Rd on-ramp	I-680 NB north of Livorna			

Note: The northbound HOV lane does not operates during the time periods of 5:00-6:00AM or 6:00-7:00PM.

Exhibit 52: Control Corridor FREQ Analysis LOS Summary – Existing AM Mixed-Flow Lanes

Seg #	From	To	5:00 - 6:00	6:00 - 7:00	7:00 - 8:00	8:00 - 9:00
2	I-680 NB south of Alcosta	Alcosta Blvd off-ramp	A	B	C	C
3	Alcosta Blvd off-ramp	Alcosta Blvd on-ramp	A	B	C	C
4	Alcosta Blvd on-ramp	Bollinger Canyon off-ramp decel lane	A	B	D	D
5	Bollinger Canyon off-ramp decel lane	Bollinger Canyon Rd off-ramp	A	B	C	C
6	Bollinger Canyon Rd off-ramp	Bollinger Canyon Rd EB on-ramp	A	B	C	C
7	Bollinger Canyon Rd EB on-ramp	Bollinger Canyon Rd WB on-ramp	A	B	C	C
8	Bollinger Canyon Rd WB on-ramp	Crow Canyon Rd off-ramp	A	A	C	B
9	Crow Canyon Rd off-ramp	Crow Canyon Rd EB on-ramp	A	B	C	B
10	Crow Canyon Rd EB on-ramp	Crow Canyon Rd WB on-ramp	A	B	C	C
11	Crow Canyon Rd WB on-ramp	Sycamore Valley Rd off-ramp	A	B	F	F
12	Sycamore Valley Rd off-ramp	Sycamore Valley Rd on-ramp	A	B	F	F
13	Sycamore Valley Rd on-ramp	Diablo Rd off-ramp	A	B	F	F
14	Diablo Rd off-ramp	Diablo Rd EB on-ramp	A	B	F	F
15	Diablo Rd EB on-ramp	Diablo Rd WB on-ramp	A	C	F	F
16	Diablo Rd WB on-ramp	El Cerro Blvd off-ramp	A	B	F	F
17	El Cerro Blvd off-ramp	El Cerro Blvd on-ramp	A	C	F	F
18	El Cerro Blvd on-ramp	El Pintado Rd on-ramp	A	C	F	F
19	El Pintado Rd on-ramp	Stone Valley Rd EB off-ramp	A	C	F	F
20	Stone Valley Rd EB off-ramp	Stone Valley Rd WB off-ramp	A	C	F	F
21	Stone Valley Rd WB off-ramp	Stone Valley Rd on-ramp	A	C	F	F
22	Stone Valley Rd on-ramp	Livorna Rd off-ramp	A	C	E	E
23	Livorna Rd off-ramp	End of HOV lane	A	C	E	E
24	End of HOV lane	Livorna Rd on-ramp	A	B	D	D
25	Livorna Rd on-ramp	I-680 NB north of Livorna	A	B	D	D

Exhibit 53: Control Corridor FREQ Analysis LOS Summary – Existing PM HOV Lane

Seg #	From	To	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00
2	I-680 NB south of Alcosta	Alcosta Blvd off-ramp	B	B	C
3	Alcosta Blvd off-ramp	Alcosta Blvd on-ramp	B	B	C
4	Alcosta Blvd on-ramp	Bollinger Canyon off-ramp decel lane	B	C	C
5	Bollinger Canyon off-ramp decel lane	Bollinger Canyon Rd off-ramp	B	C	C
6	Bollinger Canyon Rd off-ramp	Bollinger Canyon Rd EB on-ramp	B	B	B
7	Bollinger Canyon Rd EB on-ramp	Bollinger Canyon Rd WB on-ramp	B	B	B
8	Bollinger Canyon Rd WB on-ramp	Crow Canyon Rd off-ramp	B	C	C
9	Crow Canyon Rd off-ramp	Crow Canyon Rd EB on-ramp	B	B	B
10	Crow Canyon Rd EB on-ramp	Crow Canyon Rd WB on-ramp	B	C	B
11	Crow Canyon Rd WB on-ramp	Sycamore Valley Rd off-ramp	C	F	C
12	Sycamore Valley Rd off-ramp	Sycamore Valley Rd on-ramp	C	F	D
13	Sycamore Valley Rd on-ramp	Diablo Rd off-ramp	C	F	D
14	Diablo Rd off-ramp	Diablo Rd EB on-ramp	C	F	E
15	Diablo Rd EB on-ramp	Diablo Rd WB on-ramp	F	F	F
16	Diablo Rd WB on-ramp	El Cerro Blvd off-ramp	F	F	F
17	El Cerro Blvd off-ramp	El Cerro Blvd on-ramp	F	F	F
18	El Cerro Blvd on-ramp	El Pintado Rd on-ramp	F	F	F
19	El Pintado Rd on-ramp	Stone Valley Rd EB off-ramp	E	E	E
20	Stone Valley Rd EB off-ramp	Stone Valley Rd WB off-ramp	C	C	C
21	Stone Valley Rd WB off-ramp	Stone Valley Rd on-ramp	C	C	C
22	Stone Valley Rd on-ramp	Livorna Rd off-ramp	C	C	C
23	Livorna Rd off-ramp	End of HOV lane	C	C	C
24	End of HOV lane	Livorna Rd on-ramp	C	C	C
25	Livorna Rd on-ramp	I-680 NB north of Livorna			

Note: The northbound HOV lane does not operates during the time periods of 5:00-6:00AM or 6:00-7:00PM.

Exhibit 54: Control Corridor FREQ Analysis LOS Summary – Existing PM Peak Hour Mixed-Flow Lanes

Seg #	From	To	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00	6:00 - 7:00
2	I-680 NB south of Alcosta	Alcosta Blvd off-ramp	C	C	C	C
3	Alcosta Blvd off-ramp	Alcosta Blvd on-ramp	C	C	D	C
4	Alcosta Blvd on-ramp	Bollinger Canyon off-ramp decel lane	C	D	D	C
5	Bollinger Canyon off-ramp decel lane	Bollinger Canyon Rd off-ramp	C	C	C	B
6	Bollinger Canyon Rd off-ramp	Bollinger Canyon Rd EB on-ramp	C	C	C	B
7	Bollinger Canyon Rd EB on-ramp	Bollinger Canyon Rd WB on-ramp	C	C	C	B
8	Bollinger Canyon Rd WB on-ramp	Crow Canyon Rd off-ramp	C	C	C	B
9	Crow Canyon Rd off-ramp	Crow Canyon Rd EB on-ramp	C	C	C	B
10	Crow Canyon Rd EB on-ramp	Crow Canyon Rd WB on-ramp	C	C	C	C
11	Crow Canyon Rd WB on-ramp	Sycamore Valley Rd off-ramp	D	F	F	C
12	Sycamore Valley Rd off-ramp	Sycamore Valley Rd on-ramp	C	F	F	C
13	Sycamore Valley Rd on-ramp	Diablo Rd off-ramp	C	F	F	B
14	Diablo Rd off-ramp	Diablo Rd EB on-ramp	F	F	F	C
15	Diablo Rd EB on-ramp	Diablo Rd WB on-ramp	F	F	F	C
16	Diablo Rd WB on-ramp	El Cerro Blvd off-ramp	F	F	F	B
17	El Cerro Blvd off-ramp	El Cerro Blvd on-ramp	F	F	F	C
18	El Cerro Blvd on-ramp	El Pintado Rd on-ramp	F	F	F	C
19	El Pintado Rd on-ramp	Stone Valley Rd EB off-ramp	F	F	F	C
20	Stone Valley Rd EB off-ramp	Stone Valley Rd WB off-ramp	F	F	F	C
21	Stone Valley Rd WB off-ramp	Stone Valley Rd on-ramp	F	F	F	C
22	Stone Valley Rd on-ramp	Livorna Rd off-ramp	E	E	E	C
23	Livorna Rd off-ramp	End of HOV lane	D	D	D	C
24	End of HOV lane	Livorna Rd on-ramp	D	D	D	C
25	Livorna Rd on-ramp	I-680 NB north of Livorna	D	D	D	C

7. Transit Vehicles and Passengers

Transit operators and routes that run on the study and control freeway corridors were identified from transit operator websites. The on and off ramps used by the relevant bus routes were identified from route maps for all cases except the San Joaquin Regional Transit District (RTD); the RTD provided maps via email because the website did not include a route description. The peak-period and off-peak headways were identified from route schedules posted on the transit operator websites. In almost all cases, the bus routes that run on the freeway corridors are commuter routes that only operate during the peak periods.

The transit operators were contacted to get the most recent available ridership data. Average weekday ridership was identified as the common level of ridership data available from all providers. A September 2008 monthly ridership report was provided by the Central Contra Costa Transit Authority (CCCTA), Modesto Area Express (MAX), and San Joaquin RTD; if the average weekday ridership was not in the report, it was calculated from the total monthly ridership. The Livermore Amador Valley Transit Authority (WHEELS) and Santa Clara Valley Transportation Authority (VTA) both provided specific average daily ridership numbers for the month of September 2008 for requested routes. Finally, Tri-Delta Transit provided average daily ridership over the three-month period of July through September 2008 (the fiscal quarter), but noted that the data indicates little variance from month to month. Exhibit 55 through Exhibit 58 summarizes the ridership information from all transit providers in the I-680 study and control corridors. Ridership by segment, as described in Exhibit 57 and Exhibit 58, was compiled based on the on and off-ramps used by each route.

As can be seen in Exhibit 55 and Exhibit 57, transit ridership on the study corridor is highest to the south of N. Mission Boulevard. The high ridership numbers on this section of the corridor can be largely attributed to the VTA routes that connect the Fremont BART station to Milpitas and San Jose. On the control corridor, transit ridership is primarily driven by the Bishop Ranch employment center, noted as a destination for many of the routes listed in Exhibit 56. As can be seen in Exhibits 56 and 58, Bollinger Canyon Road is where many of the transit routes enter or exit the corridor.

Exhibit 55: I-680 Study Corridor Existing Transit Summary

Transit Provider and Route	Origin - Destination	Freeway Segment	Average weekday ridership	Peak Period Frequency (minutes) AM	Peak Period Frequency (minutes) PM	Off-Peak Frequency (minutes)
San Joaquin Regional Transit District (RTD)						
162	Tracy - Lockheed Martin (Sunnyvale)	SR 84 to East Calaveras Blvd/SR 237	32	1 time	1 time	--
164	Manteca - Lockheed Martin (Sunnyvale)	SR 84 to East Calaveras Blvd/SR 237	52	1 time	1 time	--
166	Stockton - Lockheed Martin (Sunnyvale)	SR 84 to East Calaveras Blvd/SR 237	47	1 time	1 time	--
170	Stockton - San Jose Metro Drive Light Rail Station	SR 84 to East Calaveras Blvd/SR 237	43	1 time	1 time	--
172	Stockton - Lockheed Martin (Sunnyvale)	SR 84 to East Calaveras Blvd/SR 237	37	1 time	1 time	--
173	Stockton - Northrop Grumman (Sunnyvale)	SR 84 to East Calaveras Blvd/SR 237	47	1 time	1 time	--
174	Stockton - Mountain View/Palo Alto	SR 84 to East Calaveras Blvd/SR 237	39	1 time	1 time	--
175	Stockton - Santa Clara	SR 84 to East Calaveras Blvd/SR 237	34	1 time	1 time	--
Santa Clara Valley Transportation Authority (VTA)						
180	Fremont BART - Milpitas Main Transit Center - San Jose Diridon Transit Center	North Mission Blvd/SR 238 to East Calaveras Blvd/SR 237	1,858	15	15	15-60
181	Fremont BART - San Jose Diridon Transit Center	North Mission Blvd/SR 238 to South Mission Blvd/SR 262	797	15	15	--

Source: Transit agency websites and representatives, 2008

Exhibit 56: I-680 NB Control Corridor Existing Transit Summary

Transit Provider and Route	Origin - Destination	Freeway Segment	Average weekday ridership	Peak Period Frequency (minutes) AM	Peak Period Frequency (minutes) PM	Off-Peak Frequency (minutes)
Central Contra Costa Transit Authority (CCCTA)						
920	Mitchel Dr. Park & Ride - San Ramon Transit Center	Alcosta Rd to Bollinger Canyon Rd / Crow Canyon Rd to Livorna Rd	273	60	60	--
960B	Mitchel Dr. Park & Ride - Bishop Ranch	Bollinger Canyon Rd to Livorna Rd	467	15-30	15-40	--
960C	Mitchel Dr. Park & Ride - Bishop Ranch	Bollinger Canyon Rd to Livorna Rd	261	30	30	--
970B	Bishop Ranch - Dublin BART	Alcosta Rd to Bollinger Canyon Rd	58	30-45	30-75	--
970C	Bishop Ranch - Dublin BART	Alcosta Rd to Bollinger Canyon Rd	59	30	30-60	--
Livermore Amador Valley Transit Authority (LAVTA WHEELS)						
70X	Dublin BART - Pleasant Hill BART	Alcosta Rd to Livorna Rd	281	30	30	--

Source: Transit agency websites and representatives, 2008

Exhibit 57: Average Daily Transit Ridership for the I-680 Study Corridor

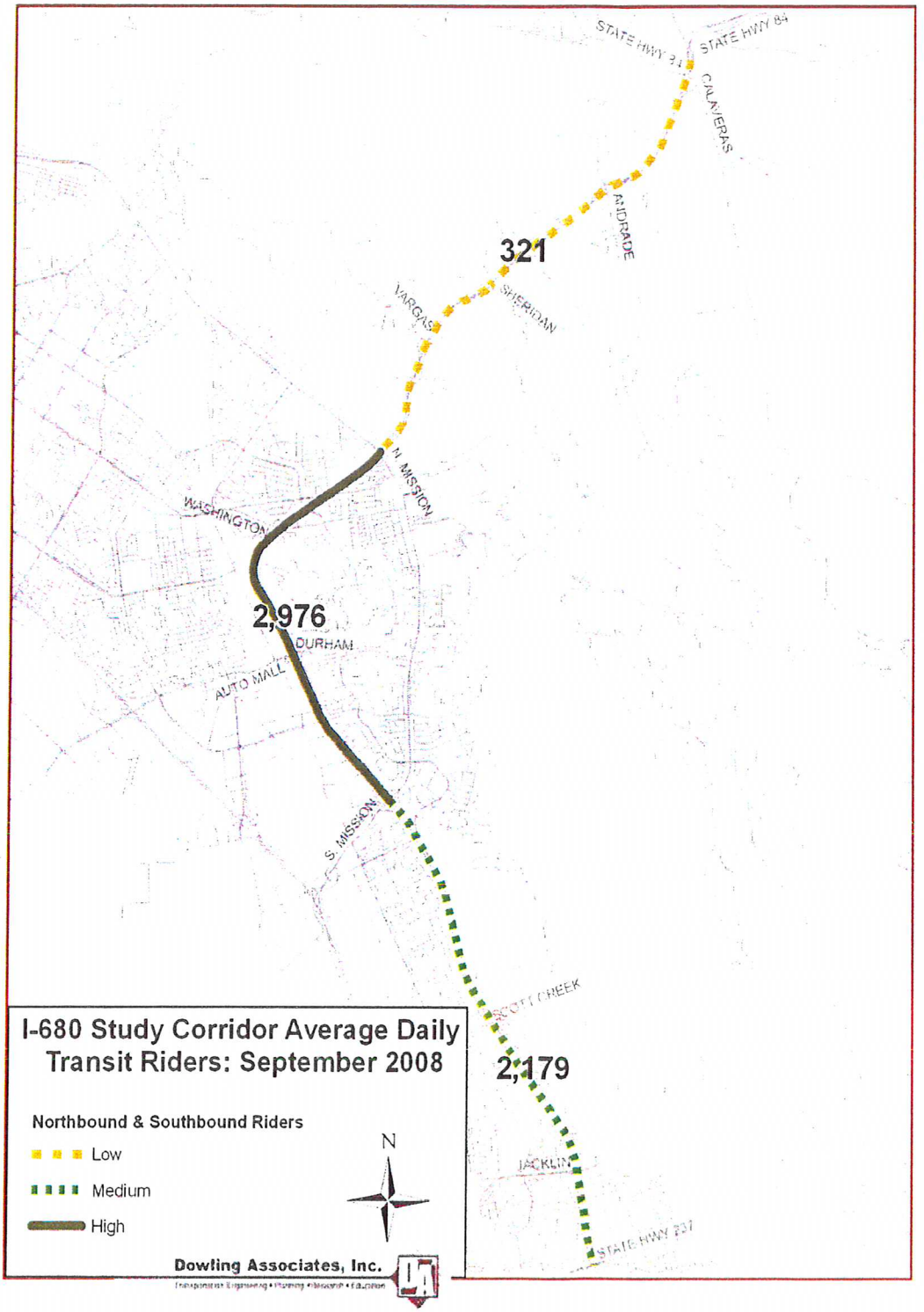
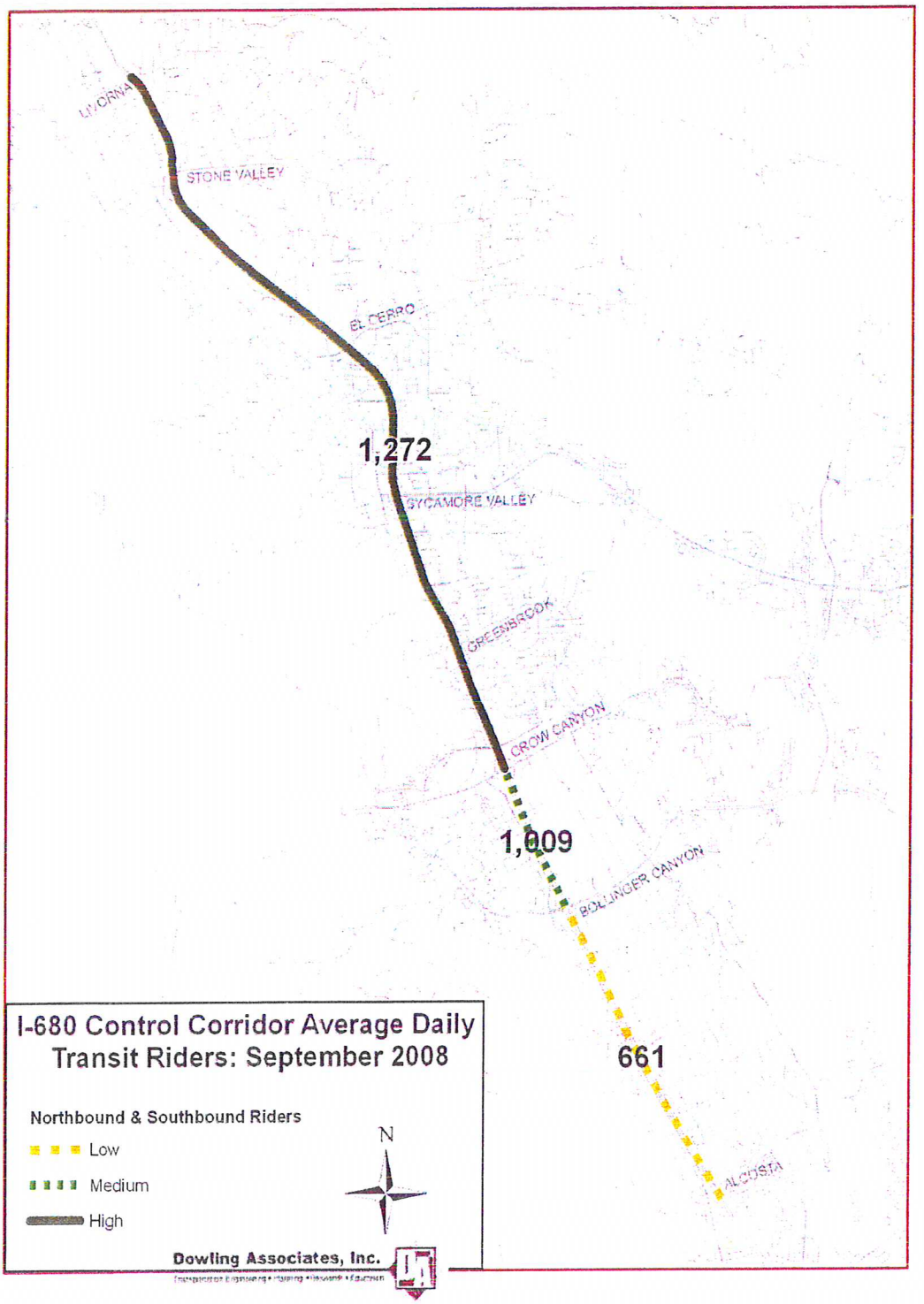


Exhibit 58: Average Daily Transit Ridership for the I-680 Control Corridor



8. Safety

The California Highway Patrol Information Service Unit was contacted to obtain Statewide Integrated Traffic Records System (SWITRS) accident data. Accident data for the most recent available three-year period (2005 through 2007) on the study corridor and control corridor were collected.

The SWITRS dataset includes information such as when and where each collision occurred, as well as details on the cause and severity of the accident. The SWITRS data were examined to identify trends on the study and control corridors. A spatial aspect was also added to the SWITRS dataset for the southbound I-680 study corridor and the northbound I-680 control corridor through the development of a geographic information systems (GIS) shapefile that represents each collision record with a point along the corridor. This GIS file enables further visual analysis and mapping opportunities.

The "Vehicle Miles Traveled" for two-way traffic on the study and control corridor segments and the corresponding collision rates per million vehicle miles traveled (MVM) were calculated in order to compare the study and control corridors to Caltrans District 4 and California statewide freeway facilities. The Average Annual Daily Traffic volumes for year 2006 (most recent available volumes) were used on the respective segments, as reported by Caltrans. The corridor collision rates for 2006 were then calculated per million vehicle miles traveled and compared to the district-wide and state-wide freeway facility rates reported in the Caltrans report *2006 Collision Data on California State Highways (road miles, travel, collisions, collision rates).*

The following exhibits summarize:

- The total number of collisions on the corridors
- The range of the severity of sustained injuries for all reported collisions on the corridors
- The primary factor causing the collision, as recorded by the reporting officer, for all reported collisions on the corridors
- The trends in time of day that collisions occurred on the corridors

Exhibit 59: Total Collisions on the I-680 Study and Control Corridors

	Study Corridor		Control Corridor	
Year	Southbound	Northbound	Northbound	Southbound
2005	262	177	277	160
2006	264	187	288	160
2007	211	192	258	136

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 60: Total Collisions Along I-680 SB Study Corridor, 2005-2007

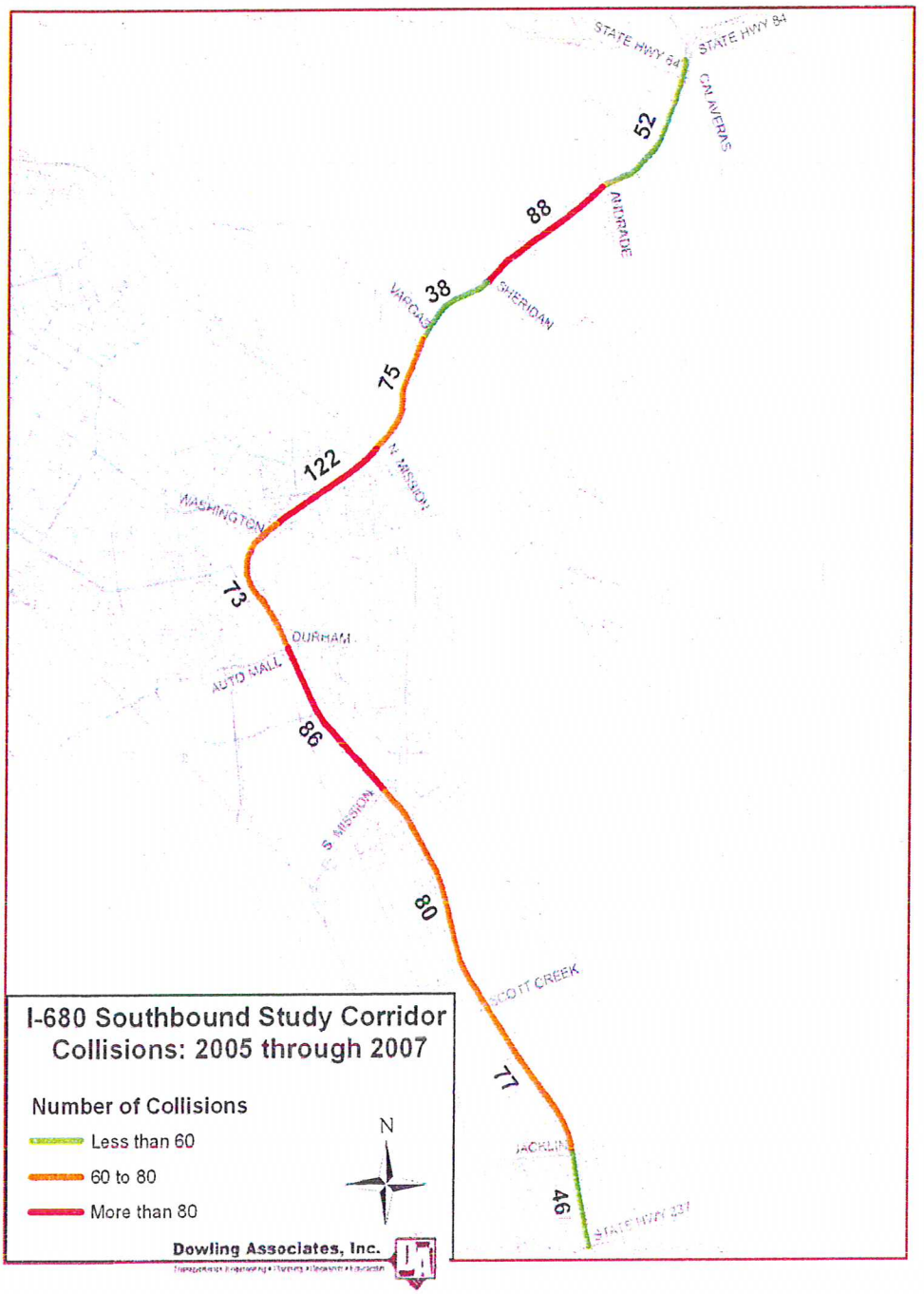


Exhibit 61: Total Collisions Along I-680 NB Control Corridor, 2005-2007

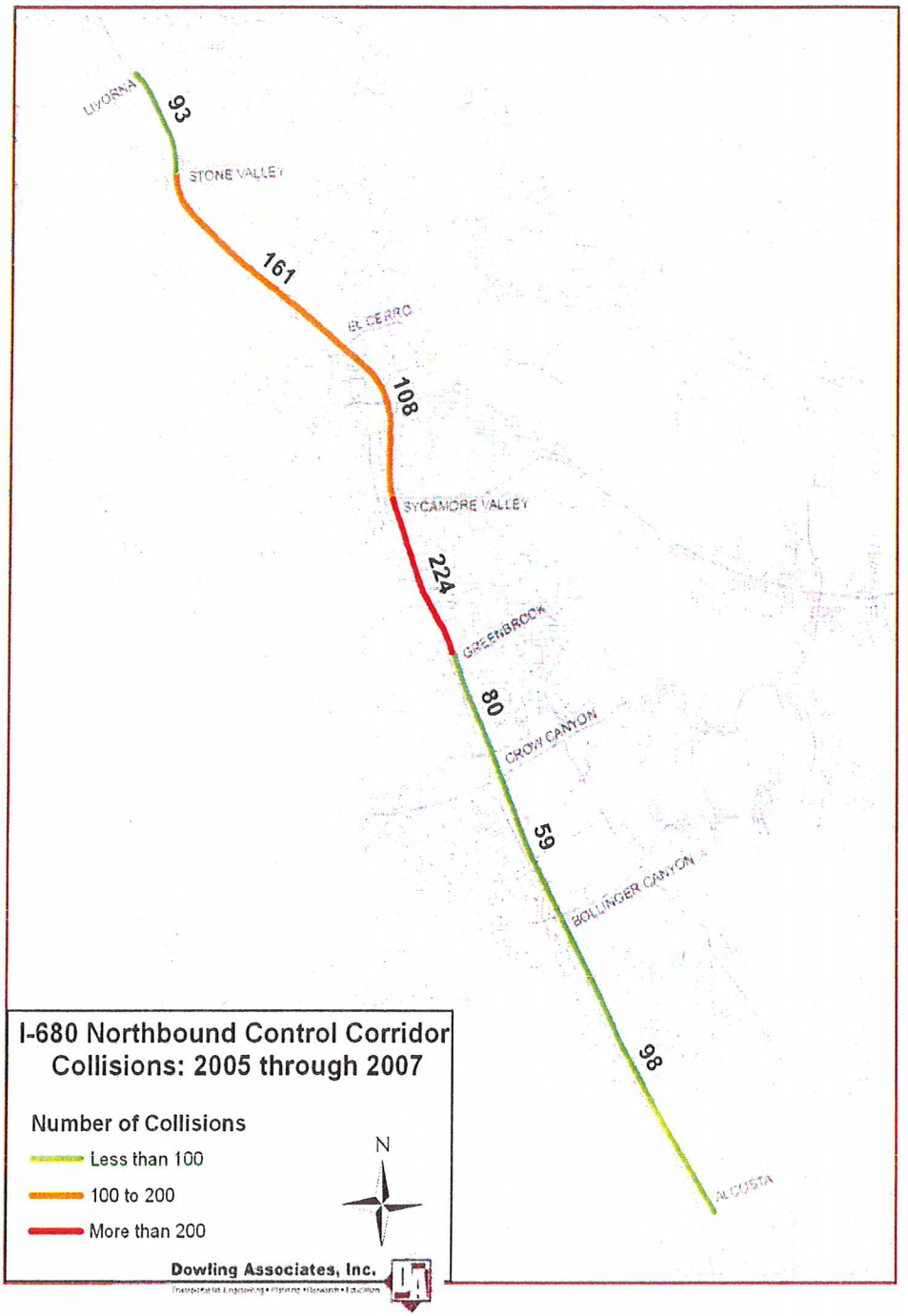


Exhibit 62: 2006 Collisions on the I-680 Study and Control Corridors Compared to Caltrans District 4 and Statewide Averages

Location	Road Miles	Mil. Veh. Miles Traveled (MVM)	Collisions	
			Total Number	Rate (MVM)
Study Corridor	13.69	733.8	451	0.61
Control Corridor	11.26	697.5	448	0.64
Caltrans District 4	127.9	29,773.3	26,911	0.90
Statewide	4,306.8	148,874.0	135,838	0.91

Exhibit 63: Severity of Sustained Injuries on the I-680 SB Study Corridor

Severity	2005	2006	2007	Total
No Injury	169	185	138	492
Complaint of Pain	57	47	49	153
Visible Injury	28	30	21	79
Severe Injury	7	1	3	11
Fatal	1	1	0	2
Total	262	264	211	737

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 64: Severity of Sustained Injuries on the I-680 NB Control Corridor

Severity	2005	2006	2007	Total
No Injury	197	220	175	592
Complaint of Pain	57	50	63	170
Visible Injury	18	14	19	51
Severe Injury	5	2	1	8
Fatal	0	2	0	2
Total	277	288	258	823

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 65: Collision Primary Factors on I-680 SB Study Corridor

Primary Factor Category	2005	2006	2007	Total
Unsafe Speed	130	151	108	389
Improper Turning	58	36	28	122
Unsafe Lane Change	43	43	33	119
Following too Closely	1	10	10	21
Driving Under the Influence	11	5	7	23
Other than Driver	8	6	15	29
Unsafe Starting or Backing	1	1	2	4
Other Hazardous Violation	3	4	6	13
Improper Passing	0	1	0	1
Other Equipment	3	2	0	5
Wrong Side of Road	0	1	0	1
Not Stated	4	4	2	10
Total	262	264	211	737

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 66: Collision Primary Factors on I-680 NB Control Corridor

Primary Factor Category	2005	2006	2007	Total
Unsafe Speed	193	202	149	544
Improper Turning	17	26	19	62
Unsafe Lane Change	27	24	32	83
Following too Closely	15	16	27	58
Driving Under the Influence	8	4	11	23
Other than Driver	11	9	5	25
Unsafe Starting or Backing	3	1	4	8
Other Hazardous Violation	0	2	4	6
Improper Passing	1	0	0	1
Impeding Traffic	0	0	1	1
Pedestrian Violation	0	0	1	1
Traffic Signals and Signs	0	0	1	1
Not Stated	2	4	4	10
Total	277	288	258	823

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 67: Collision Types on I-680 SB Study Corridor

Type	2005	2006	2007	Total
Head-On	0	1	0	1
Sideswipe	44	44	38	126
Rear End	121	146	111	378
Broadside	7	3	3	13
Hit Object	73	57	45	175
Overturned	13	11	10	34
Vehicle/Pedestrian	1	0	0	1
Other	2	1	4	7
Not Stated	1	1	0	2
Total	262	264	211	737

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 68: Collision Types on I-680 NB Control Corridor

Type	2005	2006	2007	Total
Head-On	0	1	2	3
Sideswipe	29	26	34	89
Rear End	205	214	178	597
Broadside	2	2	4	8
Hit Object	35	36	35	106
Overturned	3	2	4	9
Other	2	6	1	9
Not Stated	1	1	0	2
Total	277	288	258	823

Source: California Highway Patrol SWITRS data, 2005-2007

Exhibit 69: Collisions by Time of Day on the I-680 SB Study Corridor

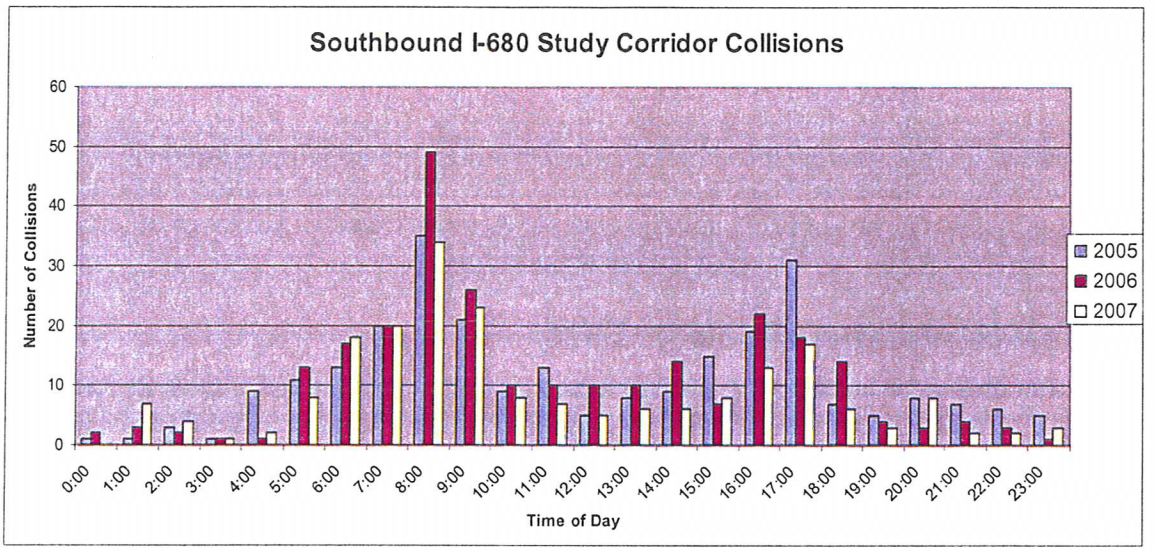
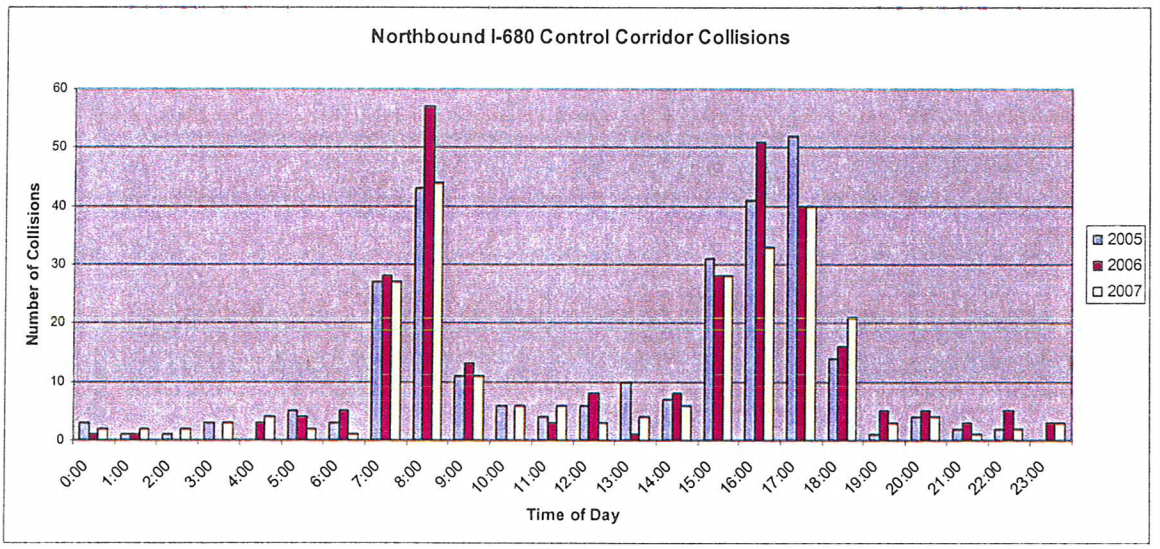


Exhibit 70: Collisions by Time of Day on the I-680 NB Control Corridor



9. HOV Lane Violation Enforcement

The violation rates on HOV lanes is an additional performance measure which will apply to the "Before" and the "After" studies for the I-680 corridors. The recommended procedure would provide a summary of observed HOV lane violators based on the violation data obtained from the California Highway Patrol (CHP) and the occupancy survey results. Hours of enforcement for the existing HOV lanes are also provided in this section.

I-680 CHP HOV Lane Violation Data

HOV violation data were provided by the California Highway Patrol (CHP), Data Services Department. Relevant freeway beats and the carpool violation codes were obtained from the Dublin and San Jose CHP offices, as well as a description of the beat boundaries. Each CHP beat includes both sides of the freeway within the beat boundaries.

Exhibit 71: CHP I-680 SB Study Corridor HOV Lane Violations

I-680 Carpool Violations	Sep-08	Oct-08
SR 84 to N. Mission Blvd	8	4
N. Mission Blvd to Alameda/Santa Clara County line	48	57
Alameda/Santa Clara County line to Hwy 101*	16	5

Source: California Highway Patrol, Data Services

Note: Data for the I-680 study corridor in Santa Clara County is not available for the isolated study area

Exhibit 72: CHP I-680 NB Control Corridor HOV Lane Violations

I-680 Carpool Violations	Sep-08	Oct-08
Stoneridge Dr to Bollinger Canyon Rd	12	4
Bollinger Canyon Rd to Diablo Rd	8	8
Diablo Rd to Olympic Blvd*	28	42

Source: California Highway Patrol, Data Services

Note: I-680 Control Corridor has multiple beat numbering systems for this specific segment; this data may not contain carpool violations issued under subsets of the primary beat number.

I-680 HOV Lane Violation Data from Manual Occupancy Survey

The manual vehicle occupancy survey was conducted from 5:00 AM to 7:00 PM. There are several limitations regarding these field observations:

1. Single occupancy electric vehicles and permitted hybrid vehicles are allowed to be in HOV lanes

   Field surveyors were not able to see the ACCESS OK permit stickers on hybrid/electric vehicles. Permitted vehicles would be identified as SOVs in HOV lanes.

2. Passengers in the back seats

   It was very challenging to determine if there were passengers in the back seat of larger vehicles and vehicles with tinted rear windows. In these situations, if a passenger could not be observed in the front seat, the vehicle was counted as SOV.

3. Low visibility in early morning and in late afternoon

   The surveys began at 5:00 AM and were completed at 7:00 PM. However, at the time of the surveys, sunrise was around 6:30 AM and sunset was around 6:00 PM., Before sunrise and after sunset vehicle occupancy could not be accurately identified.

Exhibit 73: Surveyed HOV Violation Rates

I-680 Southbound Study Corridor		Occupancy			Other Vehicle Types				Total	Violation %
Time	Loation	1	2	3+	BUS	VANPOOL	MOTORCYCLE	TRUCK		
AM 7:00 - 9:00	Andrade Rd	265	1,752	18	4	2	52	73	2,165	12%
PM 3:00 - 7:00		193	1,160	99	7	3	25	55	1,541	13%
AM 7:00 - 9:00	Washington Blvd	597	1,145	46	15	5	117	66	1,991	30%
PM 3:00 - 7:00		264	877	18	5	2	48	49	1,262	21%
AM 7:00 - 9:00	Mission Blvd 262	530	974	56	13	7	44	59	1,680	32%
PM 3:00 - 7:00		239	839	137	6	5	42	55	1,320	18%
AM 7:00 - 9:00	Calaveras Blvd 237	219	424	35	3	2	18	26	725	30%
PM 3:00 - 7:00		971	1,354	106	3	9	61	40	2,543	38%
I-680 Northbound Control Corridor		Occupancy			Other Vehicle Types				Total	Violation %
Time	Loation	1	2	3+	BUS	VANPOOL	MOTORCYCLE	TRUCK		
AM 7:00 - 9:00	Alcosta Blvd	184	2,120	21	7	12	3	214	2,559	7%
PM 3:00 - 6:00		514	4,159	62	5	41	8	133	4,920	10%
AM 7:00 - 9:00	Livorna Rd	730	1,808	25	19	21	69	1	2,672	27%
PM 3:00 - 6:00		1,391	2,612	211	26	76	117	1	4,433	31%

The HOV lane violation rates on several of the corridor segments were significantly higher than expected. In order to verify the survey results, Dowling staff performed three spot checks to ensure the quality of the surveyed violation rates. The observations were conducted for the I-680 southbound study corridor from the Paseo Padre Parkway overpass and for the I-680 northbound control corridor from the Bollinger Canyon Road overpass. The following observations were made, confirming the high violation rates recorded in the larger vehicle occupancy survey:

- 12/03/08: PM Peak (4:30 to 4:50 PM): HOV=88, SOV=13, Violation Rate = 13% (13/101)
- 12/04/08: AM Peak (8:45 to 9:00 AM); HOV=150, SOV=118, Violation Rate = 44% (118/268)
- 12/04/08: AM Peak (8:36 to 9:00 AM); HOV=95, SOV=75, Violation Rate = 44% (75/170)

During the 24-minute observation of I-680 northbound from Bollinger Canyon Road, at least four SOV drivers observed the surveyor on the bridge and abruptly merged from the HOV lane to the mixed-flow lanes.

Based on the observed violation rates presented here, the HOV lane violations in the study and control corridors could be enforced more strictly.

SOVs in HOV Lane During Non-HOV Operation Hours

Exhibit 74 shows the HOV lane occupancy during the midday period, when SOVs are legally allowed to use HOV lanes.

Exhibit 74: Summary of SOV on HOV Lane During Non Enforced Hours

I-680 Southbound Study Corridor SOV in HOV Legally		Occupancy			Other Vehicle Types				Total	%
Time	Location	1	2	3+	BUS	VANPOOL	MOTORCYCLE	TRUCK		
9:00 AM - 3:00 PM	Andrade Rd	2,394	515	31	6	5	45	236	3,230	74%
	Washington Blvd	3,295	833	31	5	1	75	303	4,542	73%
	Mission Blvd 263	2,578	695	71	7	4	39	288	3,680	70%
	Calaveras Blvd 238	1,619	503	32	3	3	22	126	2,307	70%
I-680 Northbound Control Corridor SOV in HOV Legally		Occupancy			Other Vehicle Types				Total	%
Time	Location	1	2	3+	BUS	VANPOOL	MOTORCYCLE	TRUCK		
9:00 AM - 3:00 PM	Alcosta Blvd	5,096	918	71	11	46	44	507	6,691	76%
	Livorna Rd	6,675	1,014	43	7	33	115	1	7,886	85%

10. Gas Prices and Economic Conditions

According to the Energy Information Administration[1], the average price for all grades of gasoline in California was $3.84 per gallon in September 2008 and $3.44 per gallon in October 2008. The gas prices in California through the months of January 2008 to October 2008 were at historic highs.

The California economy was in recession during the period of the study. The California unemployment rate was 7.7% in September 2008 according to the Bureau of Labor Statistics.[2]

The high gas prices and recessionary economic conditions during the period of data collection for the Before Study may have impacted the travel behavior on the study and control corridors. The After Study shall acknowledge the existing economic conditions at the time of the Before Study, so the measures of effectiveness of the Express Carpool Lanes in the After Study will be presented in the appropriate context.

[1] Official Energy Statistics from the U.S. Government
http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_nus_m.htm

[2] http://www.bls.gov/eag/eag.ca.htm