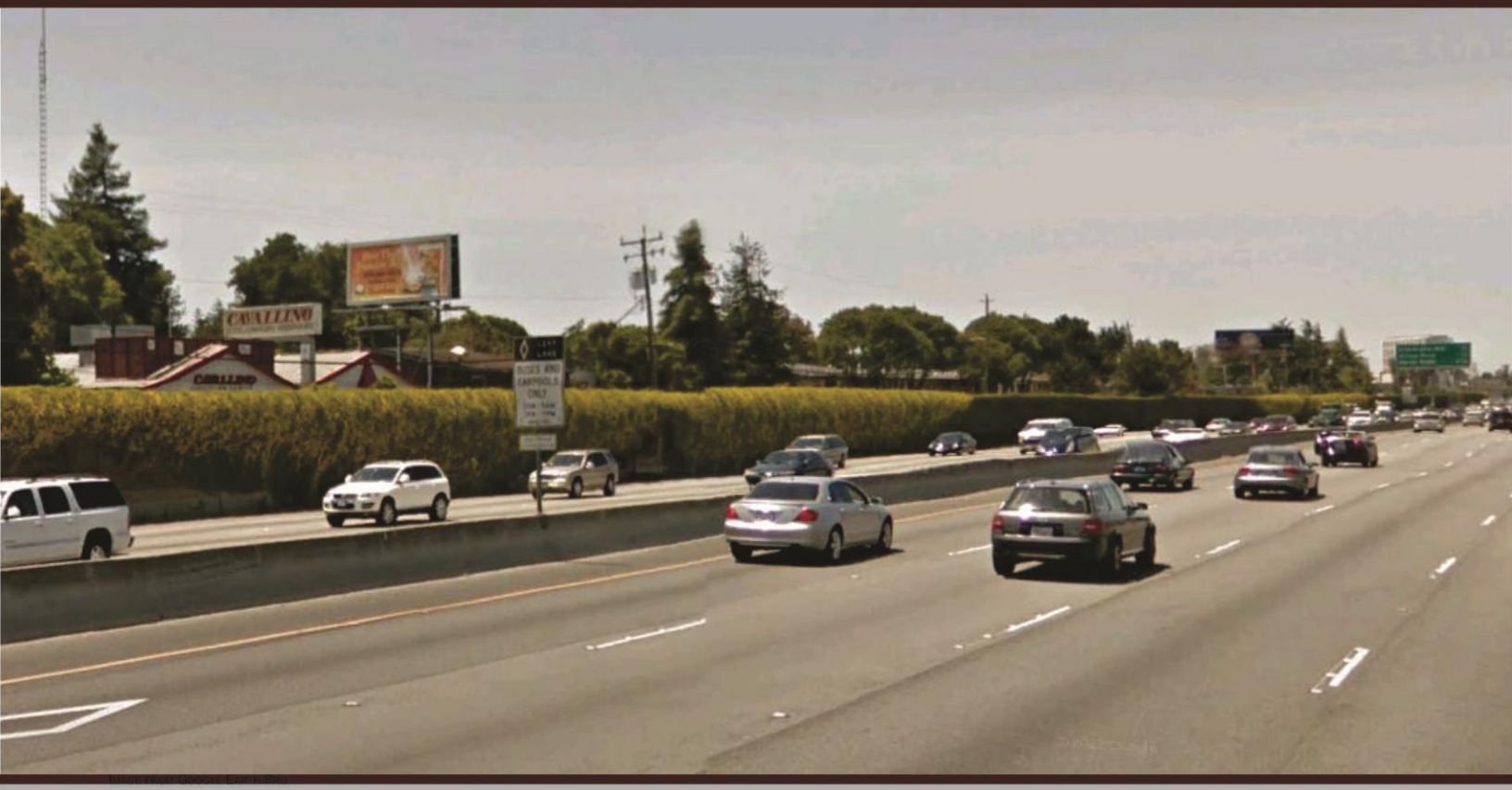
SAN MATEO 101
HYBRID HOV LANE ANALYSIS
FINAL MAINLINE REPORT



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Prepared For:

Metropolitan Transportation Commission

March 2012

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March 8, 2012

Mr. Albert Yee
Director, Highway and Arterial Operations
Metropolitan Transportation Commission
101 Eighth Street
Oakland, CA

Subject: San Mateo 101 Hybrid HOV Lane Analysis
Deliverable 7 - Final Mainline Report

Project #: DA-101-SM-#9
(P09039.010, KAI 170670)

Dear Mr. Yee:

Kittelson & Associates/Dowling is pleased to present this final mainline report in support of your San Mateo 101 Hybrid HOV Lane Study. This is deliverable 7 of Task Order 9.

I would like to thank the SM 101 team and the corridor stakeholders for their many contributions and suggestions. I would like to give credit to Danielle Stanislaus, Winnie Chung and Mike Kerns from MTC, for providing advice and review throughout the study.

Our subconsultant: Brad Leveen and Karsten Adams of Mark Thomas & Company developed the design concepts and cost estimates.

I would like to give credit to several engineers and planners at Dowling Associates who contributed greatly to this effort: Kevin Chen was project engineer on this project. Damian Stefanakis and Aaron Elias provided demand forecasting and technical analysis support. Ruth Holtmann created the graphics.

Please give me a call at 510-839-1742 extension 120 if you have any questions.

Sincerely,
KITTELSON & ASSOCIATES, INC./Dowling

Richard G. Dowling, Ph.D., P.E.
Senior Principal Engineer

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1. Executive Summary

The purpose of this study has been to work with MTC, Caltrans, C/CAG, and SMCTA to investigate the feasibility of extending HOV lanes on US 101 from their current terminus at Whipple Avenue to the San Francisco/San Mateo County line (approximately 19 miles), without requiring a great deal of new right of way or reducing the number of existing mixed-flow through lanes. Previously, an HOV Lane Feasibility Analysis (Dowling Associates, 2011) was completed that evaluated two options to extend the HOV lane within the county. One option was to add a new HOV lane in each direction, while the other option was to convert the existing number one lane (left-most lane) to HOV lane in each direction. The add lane option would require significant right-of-way acquisition adversely impacting adjacent land uses, while the convert a lane option would adversely impact travel time in the mixed-flow lanes. This current study evaluates the traffic operations effects, design concepts, and cost estimates of a hybrid HOV lane option that combines the best features of the "add lane" and the "convert lane" options, and evaluates whether this hybrid HOV lane option is operationally feasible.

Study Approach

The general approach used to develop the "hybrid" HOV Lane option was to:

1. First identify the few segments of US 101 where there was sufficient spare right of way available to add an HOV lane. If so, then use the spare right of way to add an HOV lane.
2. For the majority of segments where there is insufficient spare right of way, check to see if an auxiliary lane is present.
    a. If an auxiliary lane is present, then check if the current maximum utilization of the auxiliary lane is less than the estimated usage of an HOV lane.
        i. If the auxiliary lane would be less utilized than an HOV lane, then punch the auxiliary lane through the downstream interchange (thereby making it a new through lane), and convert the left hand mixed-flow lane to HOV operation.
        ii. If the auxiliary lane would be more heavily used than an HOV lane, then acquire the necessary right of way to widen US 101 by one lane in each direction, preserving the auxiliary lanes.

The result of this process was a cost effective method to widen US 101 from 8 continuous through lanes to 10 continuous through lanes, with the two new inside lanes converted to HOV operation.

Existing traffic data and the future baseline forecast were obtained from the US 101 Corridor System Management Plan (CSMP)[1]. A FREQ model of the freeway was used to evaluate the mobility impacts of the Hybrid HOV Option. The C/CAG countywide travel demand model was used to develop forecasts for 2015 and 2030 as part of the HOV Lane Feasibility Analysis[2]. Induced demand effects of added capacity on the US 101 freeway were taken into account by using C/CAG model forecasts that had been developed for an added HOV lane each direction on US 101. Those forecast results were then extrapolated to year 2040 forecast volumes for the hybrid HOV lane analysis. This will be 20 years beyond the estimated opening year between 2015 and 2020. The C/CAG model was also used to assess countywide effects of the proposed hybrid HOV lane option.

Results

Based on preliminary analysis, the cost of extending HOV lanes on US 101 the full length of San Mateo County is estimated to range between $285 million and $325 million, if implemented using the hybrid HOV lane option described in this study.

[1] Technical Report for the US 101 Corridor System Management Plan, prepared by Dowling Associates, September 2010.
[2] Technical Report for the US 101 HOV Lane Feasibility Analysis, prepared by Dowling Associates, 2011.

In terms of freeway operations in the mixed-flow lanes, the hybrid HOV lane option would remove auxiliary lanes between freeway interchanges with right-of-way constraints but are not expected to cause significant operational effects. The hybrid option would also result in minor shifts to bottleneck locations throughout the corridor with a few new bottlenecks forming due to the loss of the auxiliary lane. However, these effects would not significantly affect mainline operations.

The corridor wide mobility performance results for Year 2040 are summarized in Exhibit 1. With the hybrid HOV lane option on the SM 101 freeway corridor:

- Carpool mode share would be increased by 2 to 3 percentage points. That is an increase from the existing 16% HOV's in the traffic stream to about 18% to 19%;
- Vehicle miles of travel would be increased by 7%, which would improve productivity of the freeway;
- Both vehicle hours of travel and vehicle hours of delay would be reduced by 3%, and 9%, respectively, which translate to lower gasoline consumption and greenhouse gas emissions
- Person hours of delay would be reduced by 8%, which translates into direct cost savings to freeway users;
- Average peak period speeds would be increased for both vehicle-trips and person-trips.

Exhibit 1: 2040 Freeway System Performance Changes from Baseline

Performance Measures	2040 Baseline	2040 Hybrid HOV	Difference
VMT – vehicle miles of travel	4,925,100	5,264,400	7%
VHT – vehicle hours of travel	196,000	190,500	-3%
VHD – vehicle hours of delay	120,400	109,400	-9%
PHD – person hours of delay	120,600	110,900	-8%
Average vehicle speed (MPH)	25.1	27.6	10%
Average person speed (MPH)	25.9	29.9	15%

Source: FREQ Analysis, both HOV and mixed-flow lanes.

In terms of countywide effects, the C/CAG travel demand model showed that the hybrid HOV lane option would serve more vehicles through the US 101 corridor, therefore, would generally reduce vehicle traffic on the parallel arterial system within the county. Evaluating all roadways within the county, the C/CAG model showed that VMT would increase by about 1% with the proposed HOV lane option, when comparing to the baseline conditions. Additionally, vehicle hours of delay would decrease by 7% and person-hours of delay (PHD) would be reduced by 8%. The hybrid HOV lanes would reduce VMT on local streets by 1% to 2%, while reducing vehicle hours of delay by a similar percentage. Congested lane miles would be reduced by 2% to 7%.

Carpool vehicles and express transit buses would experience much improved travel time savings and reliability with the HOV lane. The analysis found that average peak period travel times for HOV's would be improved on the order of 11 to 32 minutes. For mixed-flow lane users, average travel times would be significantly improved, on the order of 30 minutes of travel time savings compared to baseline conditions for PM peak period travel in the northbound direction. SOV's using US 101 during the AM peak period and in the southbound direction during the PM peak period, however, would experience minor increases of between 2 and 8 minutes when compared to baseline conditions (see Exhibit 2). (All of these travel time savings or increases are for travel the full length of the corridor.)

Maximum peak hour travel times (as opposed to the averages for the full peak period described above) would be affected to a much greater extent. HOV lane users would experience savings of 20 to 68 minutes (30% to 65% reduction in maximum peak hour travel times for travel the full length of the corridor). Mixed-flow lane users would experience significant maximum peak hour travel time savings for northbound travel in the PM peak period (65 minutes, 26% savings on travel time the full length of the corridor). However, mixed-flow lane users would experience increased maximum travel times during the peak periods of 8 to 16 more minutes (7%

to 10% of travel time full length of corridor) in the southbound direction (PM Peak) and during the AM peak (both directions).

Exhibit 2: Travel Time Comparisons Along the Study Corridor

Average Peak Period Travel Time												
Dir/Peak	Baseline			Hybrid HOV Lane			Hybrid HOV Versus Baseline					
	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow Diff		HOV Diff		HOV TT Savings	
	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(%)	(mins.)	(%)	(mins.)	(%)
Northbound AM	108.6	54.5	54.1	117.1	43.7	73.4	8.5	8%	-10.8	-20%	19.3	36%
Northbound PM	169	61.4	107.6	139.4	45.6	93.8	-29.6	-18%	-15.8	-26%	-13.8	-13%
Southbound AM	70.5	69.6	0.9	72.8	37.5	35.3	2.3	3%	-32.1	-46%	34.4	>100%
Southbound PM	95.6	61.6	34	99.8	43.4	56.4	4.2	4%	-18.2	-30%	22.4	66%
Maximum Peak Period Travel Time												
Dir/Peak	Baseline			Hybrid HOV Lane			Hybrid HOV Versus Baseline					
	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow Diff		HOV Diff		HOV TT Savings	
	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(%)	(mins.)	(%)	(mins.)	(%)
Northbound AM	161.8	63.3	98.5	177.8	43.4	134.4	16	10%	-19.9	-31%	35.9	36%
Northbound PM	249.7	75.5	174.2	184.5	47.1	137.4	-65.2	-26%	-28.4	-38%	-36.8	-21%
Southbound AM	105.9	105.9	0	113.8	37.5	76.3	7.9	7%	-68.4	-65%	76.3	>100%
Southbound PM	139.8	88.4	51.4	153.8	50.7	103.1	14	10%	-37.7	-43%	51.7	101%

Note: In the northbound direction, carpool vehicles on the HOV lane is assumed to be in free-flow conditions upstream of the study area, or south of SR 85, based on evaluation of HOV demand volumes.
In the southbound direction, there is no HOV lane upstream of the study area at Harney Way interchange, therefore carpool vehicles are assumed to experience the same amount of travel as the mixed-flow traffic upstream of the study area.

Source: Peak period average travel times from FREQ analysis, including congestion beyond study limits south of SR 85 interchange (13 miles), and north of San Francisco county line (9 miles). Total distance is approximately 43 miles for the northbound direction, and 39 miles for the southbound direction.

2. Introduction and Approach

The purpose of this study is to work with MTC, Caltrans, C/CAG, and SMCTA to investigate the feasibility of extending HOV lanes on US 101 from their current terminus at Whipple Avenue north to the San Francisco/San Mateo County line (approximately 19 miles), without requiring a great deal of new right of way or reducing the number of existing mixed-flow through lanes (The Hybrid Option). Previously, an HOV Lane Feasibility Analysis (Dowling Associates, 2011) was completed that evaluated two options to extend the HOV lane within the county. One option was to add a new HOV lane in each direction, while the other option was to convert the existing number one lane (left-most lane) to HOV lane in each direction. The add lane option would require significant right-of-way acquisition adversely impacting adjacent land uses, while the convert a lane option would adversely impact travel time in the mixed-flow lanes. This current study evaluates the traffic operations effects, design concepts, and cost estimates of a hybrid HOV lane option that combines the best features of the "add lane" and the "convert lane" options, and evaluates whether this hybrid HOV lane option is operationally feasible.

This study builds on two previous studies conducted for the San Mateo US 101 corridor: the Corridor System Management Plan (CSMP, Dowling Associates, 2010), and the HOV Lane Feasibility Analysis. The CSMP provided a comprehensive collection of existing traffic data for the corridor, along with future trends in traffic demands and traffic operations.

2.1. Study Corridor

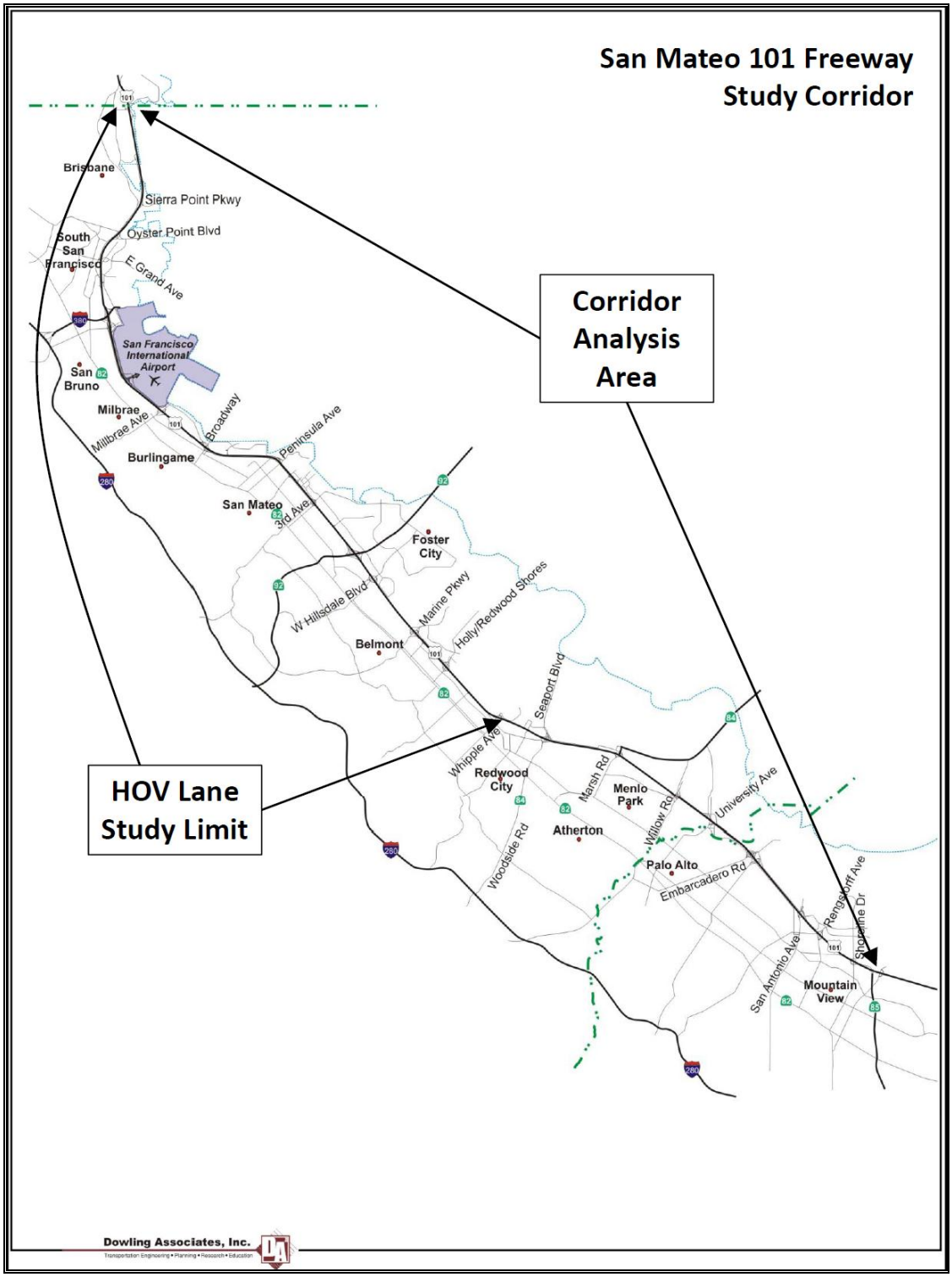
The US-101 Peninsula HOV Lane study corridor covers a total of 30 miles of the US 101 freeway from the San Francisco/San Mateo County line to the SR 85 interchange in Santa Clara County (see Exhibit 3). In addition, the study corridor was extended for about nine miles into San Francisco County, and thirteen miles south of SR 85 to capture all congestion impacts caused by or affecting operations within the study corridor.

HOV lanes currently extend south of Whipple Avenue along Route 101 into Santa Clara County. Baseline conditions include future-year improvements described in the San Mateo US 101 Corridor System Management Plan (CSMP) Technical Report, 2010. In general, there are auxiliary lane(s) in both directions between all interchanges (on-ramp to off-ramp) from Whipple Avenue to Harney Way except for the following:

- Northbound between Sierra Point Parkway to Harney
- Southbound between Harney Way and Oyster Point Boulevard

The Santa Clara 101 Express Lanes were not assumed to be in place for the baseline improvements. The operations analysis did not look at the operations impacts of necking down from two express lanes in Santa Clara County to a single HOV lane in San Mateo County. This effect was outside the focus of the current study, which was the extension of the existing single HOV lanes north of Whipple Avenue.

Exhibit 3: Study Corridor Map



2.2. Study Approach

The general approach of the "hybrid" HOV Lane study is to cost effectively extend HOV lanes north on US 101 from Whipple Avenue to the San Francisco County line by converting auxiliary lanes to through lanes (or adding lanes in some segments) and extending these lanes through the interchanges to create a 10-lane freeway. The inside lanes would then be restriped as HOV lanes and 8 continuous mixed-flow lanes would be maintained along the entire corridor. Auxiliary lanes would be eliminated in many segments except where traffic analysis shows they would be beneficial to maintaining freeway operations.

The corridor is divided into five sections based on their general characteristics, and then further divided into sixteen (16) contiguous segments for analysis purposes. Each segment generally extends from one local road interchange to the next local road interchange (center of overcrossing to center of overcrossing). Partial interchanges (i.e. hook on/off ramps on one direction only) were not used to divide segments but are included in the longer segment between full interchanges.

The initial design approach used to create the fifth lane in each direction and extend the HOV lanes was generally based on the strategy outlined below:

Section A - Whipple Ave to Millbrae Ave (Segments 1 – 8):
(This section is characterized by existing auxiliary lanes and narrow inside shoulders.)
- Convert existing auxiliary lanes to thru lanes and extend through interchanges by reducing inside/outside shoulders at overcrossing structures
- Convert inside lane to HOV (1 HOV + 4 mixed-flow)
- Add new auxiliary lane where still required by traffic analysis
- Assume no outside widening except where new auxiliary lanes are required

Section B - Millbrae Ave to I-380 (Segments 9 – 11):
(This section is characterized by multiple existing auxiliary lanes and extra wide inside shoulders.)
- Add new HOV lane to inside of existing lanes using extra wide inside shoulder space (1 HOV + 4 mixed-flow) and reduce inside shoulders to non-standard
- Assume minimal outside widening and retention of existing auxiliary lanes in this section

Section C - I-380 to South San Francisco (SSF) Overhead (OH) (Segment 12):
(This section is characterized by multiple existing auxiliary lanes and varying width inside shoulders.)
- Realign freeway median and narrow shoulder where necessary to accommodate adding HOV lane or converting auxiliary lane to through lane (1 HOV + 4 mixed-flow)
- Add new auxiliary lane where still required by traffic analysis

Section D – SSF OH to Sierra Point Overhead (Segments 13 – 15):
(This section is characterized by auxiliary lanes, narrow inside shoulders, and elevated freeway railroad undercrossing structures.)
- Convert inside lane to HOV where existing auxiliary lanes are present and convert existing auxiliary lanes to thru lanes (1 HOV + 4 mixed-flow)
- Reduce lane and shoulder widths in order to accommodate a 5-lane section in each direction on South San Francisco OH, widen to accommodate 5-lane section on Sierra Point OH

Section E - Sierra Point Overhead to SF County Line (Segment 16):
(This section is characterized by lack of auxiliary lanes and extra wide inside shoulders.)
- Add new HOV lane to inside of existing lanes using extra wide inside shoulder space (1 HOV + 4 mixed-flow) and reduce inside shoulders to non-standard
- Assume minimal outside widening

This study primarily focuses on freeway operations analysis for Year 2040 conditions, which will be 20 years beyond the estimated opening year of 2020 or earlier.

3. Travel Demand Forecast

This chapter presents the travel demand forecasting process and results.

3.1. The Demand Model

The HOV demand forecasts were developed using the C/CAG travel demand model (ABAG Projection 2005 version), as well as existing traffic volumes and occupancy survey results. Two-person HOV's currently account for 15% to 17% of the peak period vehicle stream on US 101 while three-person HOV's and buses account for only 1% to 2% of the peak period vehicle stream. This study assumed the HOV occupancy requirement would remain at two persons per vehicle.

The C/CAG model is a traditional 4-step model covering the entire 9 county MTC region, focused on San Mateo County (finer zone and network detail). This was the latest and most current version of the C/CAG model available at the initiation of the study, and represents and contains socio-economic data sets for 2005, 2015, and 2030.

3.2. 2040 Forecast Extrapolation Procedures

While the project implementation schedule is uncertain at this time, it was assumed for the purposes of this analysis that the project would be open for operation between 2015 and 2020. Therefore, to conduct traffic analysis of the proposed HOV lane project for 20-years beyond opening year, traffic forecasts were developed to reflect Year 2040, by conservatively assuming an opening year of 2020.

The previous San Mateo/Santa Clara 101 HOV Lane Feasibility Analysis study had developed two sets of traffic forecasts, for 2015 and 2030 conditions. These forecasts were obtained from the C/CAG travel demand model. Raw model forecast volumes were adjusted based on taking the incremental difference between base year and future year, and adding to existing traffic volumes. To develop Year 2040 traffic forecasts, volumes were extrapolated from readily available forecast results from 2015 and 2030 forecasts, as illustrated below in Exhibit 4. Two sets of traffic forecasts were developed for 2040: one for the hybrid HOV lane option, and the other for baseline No Project conditions. Furthermore, 2040 volumes were checked and capped to no less than existing volume or 2030 adjusted forecasted volumes.

Exhibit 4. 2040 Forecast Volume Extrapolation Equation

$$2040V = 2030V + (2030V - 2015V) \times \frac{(2040-2030)}{(2030-2015)}$$

For example, if 2015 ramp volume is 1,000 vph, and 2030 ramp volume is 1,200 vph, then 2040 forecast volume would be 1,333 vph as shown below:

$$2040V = 1{,}200 + (1200-1000) \times \frac{10 \text{ years}}{15 \text{ years}} = 1{,}333 \text{ vph}$$

Changes in mode shift were determined based on C/CAG model forecasts. On average throughout the corridor, the new HOV lane would encourage higher shared-ride mode split, from about 16.4% to about 19%, or an increase of about 2.6%. The 2040 extrapolated forecast volumes for the hybrid HOV lane option were developed using the previous 2015 and 2030 "Add an HOV Lane Scenario". In reality, the hybrid HOV lane would result in less induced demands compared to the "Add an HOV Lane Scenario" by providing less overall capacity; therefore, this assumption would produce more conservative results on the freeway. Exhibit 5 provides a comparison of 2040 forecast results at key mainline locations, between baseline conditions and hybrid HOV lane condition. As shown in the comparison, induced demands accounted for approximately 5% to 7% on average along the corridor.

Exhibit 5. 2040 Forecast Volume Comparison Between Baseline and Hybrid HOV

Location	AM 4-HOUR						
	2040 Baseline			2040 Hybrid HOV Lane			Total % Diff
	Mixed-Flow	HOV	Total	Mixed-Flow	HOV	Total	
Northbound							
South of SR 85	29,074	4,504	33,578	29,813	4,388	34,201	2%
South of SR 92			35,551	31,738	6,427	38,165	7%
South of I-380	N/A		35,366	31,754	6,272	38,026	8%
San Francisco county line			31,719	28,333	5,512	33,845	7%
Average			34,054			36,059	6%
Southbound							
South of SR 85	23,155	1,572	24,727	22,879	1,730	24,609	0%
South of SR 92			33,446	32,584	4,203	36,787	10%
South of I-380	N/A		27,007	25,708	4,245	29,953	11%
San Francisco county line			26,469	23,859	3,935	27,794	5%
Average			27,912			29,786	7%
Location	**PM 5-HOUR**						
	2040 Baseline			**2040 Hybrid HOV Lane**			**Total % Diff**
	Mixed-Flow	**HOV**	**Total**	**Mixed-Flow**	**HOV**	**Total**	
Northbound							
South of SR 85	35,654	4,902	40,556	35,094	5,500	40,594	0%
South of SR 92			43,519	38,367	8,349	46,716	7%
South of I-380	N/A		48,835	43,972	8,193	52,165	7%
San Francisco county line			39,804	34,539	7,408	41,947	5%
Average			43,179			45,356	5%
Southbound							
South of SR 85	29,222	2,583	31,805	30,830	3,100	33,930	7%
South of SR 92			37,506	32,157	6,727	38,884	4%
South of I-380	N/A		34,788	28,607	7,585	36,192	4%
San Francisco county line			37,151	32,094	6,899	38,993	5%
Average			35,313			37,000	5%

Exhibit 6 provides a summary of forecasted hourly demand volumes on the hybrid HOV lane. Details of extrapolated volumes for 2040 are included in Appendix A.

Exhibit 6. Hybrid HOV Lane 2040 Forecast Hourly Demand Volumes

AM Peak Period					
	6 - 7 AM	**7 - 8 AM**	**8 - 9 AM**	**9 - 10 AM**	**AM Total**
Northbound					
South of SR 85	1,068	1,217	969	1,084	4,338
South of SR 92	1,307	1,800	1,744	1,576	6,427
South of I-380	1,284	1,785	1,736	1,471	6,276
San Francisco county line	1,172	1,588	1,495	1,257	5,512
Southbound					
South of SR 85	492	611	386	241	1,730
South of SR 92	904	1,267	1,023	1,009	4,203
South of I-380	782	1,288	1,191	984	4,245
San Francisco county line	804	1,177	1,103	851	3,935

PM Peak Period						
	2:30-3:30 PM	**3:30-4:30 PM**	**4:30-5:30 PM**	**5:30-6:30 PM**	**6:30-7:30 PM**	**PM Total**
Northbound						
South of SR 85	1,071	1,122	1,119	1,065	1,123	5,500
South of SR 92	1,611	1,735	1,917	1,712	1,374	8,349
South of I-380	1,535	1,690	1,884	1,735	1,349	8,193
San Francisco county line	1,399	1,472	1,711	1,598	1,228	7,408
Southbound						
South of SR 85	765	693	684	480	478	3,100
South of SR 92	1,183	1,208	1,435	1,541	1,360	6,727
South of I-380	1,498	1,509	1,569	1,636	1,373	7,585
San Francisco county line	1,174	1,282	1,502	1,587	1,354	6,899

3.3. Verification of Extrapolated 2040 Forecasts

The "new" C/CAG travel demand model, prepared by the Valley Transportation Authority, became available in early October 2011. This model reflects ABAG projection "pre-P11" socio-economic data set, for sustainable community strategies (SCS). Exhibit 7 provides a comparison of the 2030 forecast results, as well as 2040 extrapolated forecast results developed using the "old" C/CAG demand model, and the "new" C/CAG model's 2035 raw model volumes for AM and PM peak periods. Both the 2030 and extrapolated 2040 forecasts developed from the old model are generally higher compared to those forecasted from the new model. The extrapolated 2040 forecasts based on the old model are between 15% and 24% higher than the 2035 forecasts based on the new model, except for the southbound PM peak period, which the new model showed being 5% to 6% higher. The higher forecast volumes based on the old model suggest that the current operational analysis using these forecast volumes, is rather conservative. In particular, in the vicinity of SR 92 interchange, 2040 forecasts from the old model are 24% to 30% higher than those forecasted from the new model, except for southbound PM peak, where the new model is higher by 10%.

Based on the volume comparisons above, the conclusions from this study should be conservative in identifying potential operational hot spots.

Exhibit 7. Forecast Comparison Between the Old and New C/CAG Models

Location	AM 4-Hour					PM 4-Hour				
	Old C/CAG - Forecasted 2030	Old C/CAG - Extrapolated 2040	New C/CAG 2035	2030 Old C/CAG vs 2035 New C/CAG (% Diff)	2040 Old C/CAG vs 2035 New C/CAG (% Diff)	Old C/CAG - Forecasted 2030	Old C/CAG - Extrapolated 2040	New C/CAG 2035	2030 Old C/CAG vs 2035 New C/CAG (% Diff)	2040 Old C/CAG vs 2035 New C/CAG (% Diff)
Northbound										
South of SR 85	32,204	34,201	21,225	52%	61%	30,624	32,921	23,034	33%	43%
South of SR 92	38,016	38,165	30,282	26%	26%	37,895	38,859	31,428	21%	24%
South of I-380	37,628	38,026	32,743	15%	16%	41,513	43,467	34,545	20%	26%
San Francisco county line	32,759	33,845	31,692	3%	7%	33,045	34,407	33,842	-2%	2%
Average	35,152	36,059	28,986	21%	24%	35,769	37,414	30,712	16%	22%
Southbound										
South of SR 85	23,589	24,609	22,541	5%	9%	26,529	28,231	25,926	2%	9%
South of SR 92	36,189	36,787	28,362	28%	30%	33,590	32,478	36,116	-7%	-10%
South of I-380	29,968	29,953	23,527	27%	27%	29,176	29,077	30,331	-4%	-4%
San Francisco county line	26,729	27,794	28,804	-7%	-4%	31,604	32,283	35,617	-11%	-9%
Average	29,119	29,786	25,809	13%	15%	30,225	30,517	31,998	-6%	-5%

Note: Positive differences indicate that the forecasts based on the older model are higher than those based on the new model. Readers should allow for the 5 years of growth (nominally around 5%) that may be ordinarily expected to occur between 2030 (old model) and 2035 (new model) and between 2035 (new model) and 2040 (extrapolated old model).

4. Traffic Operations Analysis

This chapter describes the effect on traffic operations of extending the hybrid alternative HOV lanes throughout the SM-101 corridor in San Mateo County. These effects are identified in terms of the following performance measures:

- The impacts on SM-101 freeway operations, including changes in bottleneck locations, areas of congestion, peak period speeds in the managed and mixed-flow lanes, mixed-flow lane vehicle delays, and time-savings for HOV lane-eligible vehicles.
- The corridor-wide benefits (e.g., in changes in corridor-wide person hours of delay on SM-101 corridor).

4.1. Analysis Methodology

The FREQ modeling software was used to simulate peak period freeway operations on the US-101 study corridor in San Mateo County. FREQ is a macroscopic freeway facility operations simulation model that can generate speeds, densities, volume/capacity ratios, levels of service (based on the *Highway Capacity Manual 2000* criteria), bottleneck locations, queue lengths, and delays by each hour and study section.

FREQ inputs include on-ramp and off-ramp demands for a single direction by hour within each peak period. FREQ estimates an origin-destination table from the ramp volumes for each hour. It then propagates the vehicles down the length of the freeway, queuing the vehicles when demand exceeds capacity and reducing the volumes reaching downstream off-ramps when traffic is trapped at a bottleneck. Excess demand is stored on the freeway at the end of each hour and then released in the following hour, if capacity permits. FREQ predicts speeds and densities of traffic based on the volume/capacity ratios and the classical speed-flow and flow-density curves.

The FREQ model covers 30.4 miles of the US 101 freeway from the San Francisco/San Mateo County line to the SR 85 interchange in Santa Clara County. Freeway operations were evaluated for the SM-101 study corridor from 6:00 AM to 10:00 AM and from 2:30 PM to 7:30 PM. These time periods include the majority of the busiest weekday commute hours in the morning and afternoon, as well as the HOV lane hours.

In addition, the southbound entry link (in San Francisco County) was initially extended for about nine miles so as to be able to store the queues resulting under the future scenarios. Similarly, the northbound entry link (in Santa Clara County) was initially extended thirteen miles. These entry links with unusually long link lengths resulted in erroneous computation results within FREQ. Therefore, these unusually long links were removed from the FREQ files, and supplemental computations were performed externally to evaluate queues and delays associated with the entry links.

The FREQ model was calibrated to the local conditions for each direction and each peak period by running it for existing conditions and comparing the model-predicted bottleneck locations and queues with those observed in the field at the time the traffic counts were collected. The input data and assumptions used in the validation and application of the SM-101 FREQ models are described below:

- Existing freeway mainline counts were collected from two sources: available PeMS count stations and manual mainline occupancy counts. Freeway ramp counts were collected from tube machines conducted January 28-29, 2009. A set of freeway balanced traffic counts were produced using this data for input into the FREQ models. The FREQ freeway models were validated based on this count data and field observations from floating car surveys conducted on January 28, 2009.
- The free flow speed on the mainline freeway was assumed to be 65 mph.

- The capacity of each freeway section was established based on its geometry and known or assumed bottleneck flow rates within the corridor. The capacity for the mainline freeway, and that of the HOV lane, was generally assumed to be 1900 vehicles per hour per lane (vphpl). The capacity of the auxiliary lanes was assumed to be the minimum of (a) the maximum hourly on-ramp volume, (b) the maximum hourly off-ramp volume, or (c) the hourly capacity per lane for through lanes.
- Vehicle occupancy was estimated based on counts taken at three locations along the study corridor; one location each north of I-380, between I-380 and SR 92, and between SR 92 and Whipple Avenue. The vehicle occupancy data south of Whipple Avenue was obtained through Caltrans.
- Traffic demand was then estimated for each section and adjusted until congestion locations, congestion onset times, congestion clearance times, queue lengths, delay, and travel times matched those observed in the field.
- HOV occupancy requirement would remain at 2+ persons per vehicle.
- All US 101 CSMP baseline corridor improvements were assumed to be in place (see San Mateo 101 Corridor System Management Plan Technical Report, 2010, for listing of improvements).
- Ramp metering was assumed to be in effect for full length of corridor, except for freeway-to-freeway connectors. This included widening of all on-ramps where feasible to provide HOV queue bypass lanes. No bypass lanes were assumed for freeway-to-freeway ramps.
- The FREQ model was allowed to vary metering rates between a minimum metering rate of 240 vph and a maximum metering rate of 900 vph for single-lane on-ramps and 1700 vph for dual lane on-ramps. FREQ selected the optimal metering rate for each ramp within the defined range that would maximize person-miles of freeway travel.

For the FREQ model runs of future SM-101 scenarios, the C/CAG travel demand model was used to generate forecasts of demand and estimates of mode shifts, route shifts, and destination shifts at a region-wide level during the 4-hour AM peak period and the 5-hour PM peak period. Growth factors and changes in occupancy factors were calculated based on these forecasts and applied to the existing demand volumes.

The proportions of HOVs in the traffic stream at each on-ramp were further adjusted manually to balance freeway volumes such that congestion on the priority lane did not exceed the congestion in the mixed-flow lanes.

4.2. 2040 Baseline Traffic Operations

As described earlier in Chapter 2, baseline conditions include future-year improvements described in the San Mateo US 101 Corridor System Management Plan (CSMP) Technical Report, 2010. Detailed FREQ subsection input data are provided in the Appendix B.

4.2.1. Freeway Bottleneck Analysis for 2040 Baseline Conditions

Peak period mixed-flow lane bottleneck locations, as well as the locations and extent of congestion approaching controlling bottlenecks during the height of the peak, are described below for Year 2040 conditions. Mixed-flow lane bottlenecks and maximum queue lengths for Baseline conditions are shown in Exhibit 8.

Substantial traffic growth is expected to occur on U.S.101 between now and 2040. This growth will result in new bottlenecks developing by year 2040 and longer queues approaching existing bottlenecks.

Northbound AM Peak – During the AM peak period, five (5) bottlenecks would develop in the following freeway segments:

- Rengstorff Avenue loop off-ramp to on-ramp
- Willow Road loop off-ramp to loop on-ramp
- Marine Parkway loop on-ramp to diagonal on-ramp
- 3rd Avenue off-ramp to on-ramp
- Bayshore Boulevard off ramp to Sierra Point Parkway off-ramp

By the height of the peak (when delay or travel time through the corridor is the longest), it would take approximately 162 minutes for mixed-flow lane vehicles to travel through the entire corridor (including the 13-mile section south of SR 85), of which about 121 minutes are associated with delay due to bottleneck and queuing effects. Two of the bottlenecks, Rengstorff Avenue and Marine Parkway, will have become hidden by queues from the downstream bottlenecks. The Rengstorff Avenue bottleneck will be hidden by queues extending south approximately 9 miles beyond the SR-85 study limit from the Willow Road bottleneck, resulting in a total queue length of 15.4 miles. Similarly, the Marine Parkway bottleneck will be hidden by queues extending south of the Woodside interchange from the 3rd Avenue bottleneck, with a total queue length of about 10 miles. The bottleneck at Bayshore Boulevard/Sierra Point Parkway will also develop during the AM peak period, with a queue extending approximately 2.1 miles to south of the North Access Road interchange.

The HOV lane would generally operate at or near free flow speeds throughout the peak period, except between the Rengstorff interchange and San Antonio interchange, where HOV lane would operate at reduced speeds between about 30 to 50 MPH.

Northbound PM Peak – During the PM peak period, five (5) bottlenecks would develop in the following freeway segments:

- Rengstorff Avenue loop off-ramp to on-ramp
- Marsh loop on–ramp to diagonal on-ramp
- 3rd Avenue off-ramp to on-ramp
- Peninsula Avenue off-ramp to on-ramp
- Sierra Point Parkway on-ramp to Harney Way off-ramp

By the height of the peak, it would take approximately 250 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 209 minutes are associated with delay due to bottleneck and queuing effects. Two of these the bottlenecks, Marsh Road and Rengstorff Avenue, will have become hidden by queues from the downstream bottlenecks, with severe congestion approaching Marsh Road and 3rd Avenue

bottlenecks. The combination of these bottlenecks would result in maximum queues extending a total of 29.7 miles, or approximately 13.2 miles south of the SR-85 interchange. Minor congestion would occur approaching the Peninsula Avenue bottleneck, and queues from the bottleneck at Sierra Point Parkway/Harney Way would extend as far south as the Grand Avenue interchange, or approximately 2.1 miles.

The HOV lane would operate at or near free flow speeds throughout the peak period.

Southbound AM Peak – During the AM peak period, five (5) bottlenecks would develop in the following freeway segments:

- Beatty Road on-ramp to Sierra Point Parkway off-ramp
- Millbrae Avenue loop on-ramp to diagonal on-ramp
- Hillsdale Boulevard loop on-ramp to diagonal on-ramp
- Willow Road loop off-ramp to diagonal on-ramp
- University Avenue off-ramp to on-ramp

By the height of the peak, it would take approximately 106 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 68 minutes are associated with delay due to bottleneck and queuing effects. The Millbrae bottleneck will have become hidden by queues from the downstream bottleneck at Hillsdale, and would result an overall queue length of over 12 miles. Minor congestion would occur approaching the Beatty Road, Willow Road and University Avenue bottlenecks. The bottlenecks at Willow Road and University Avenue would not appear during the height of the peak.

The HOV lane would operate at or near free flow speeds throughout the peak period.

Southbound PM Peak – During the PM peak period, two (2) bottlenecks would develop in the following freeway segments:

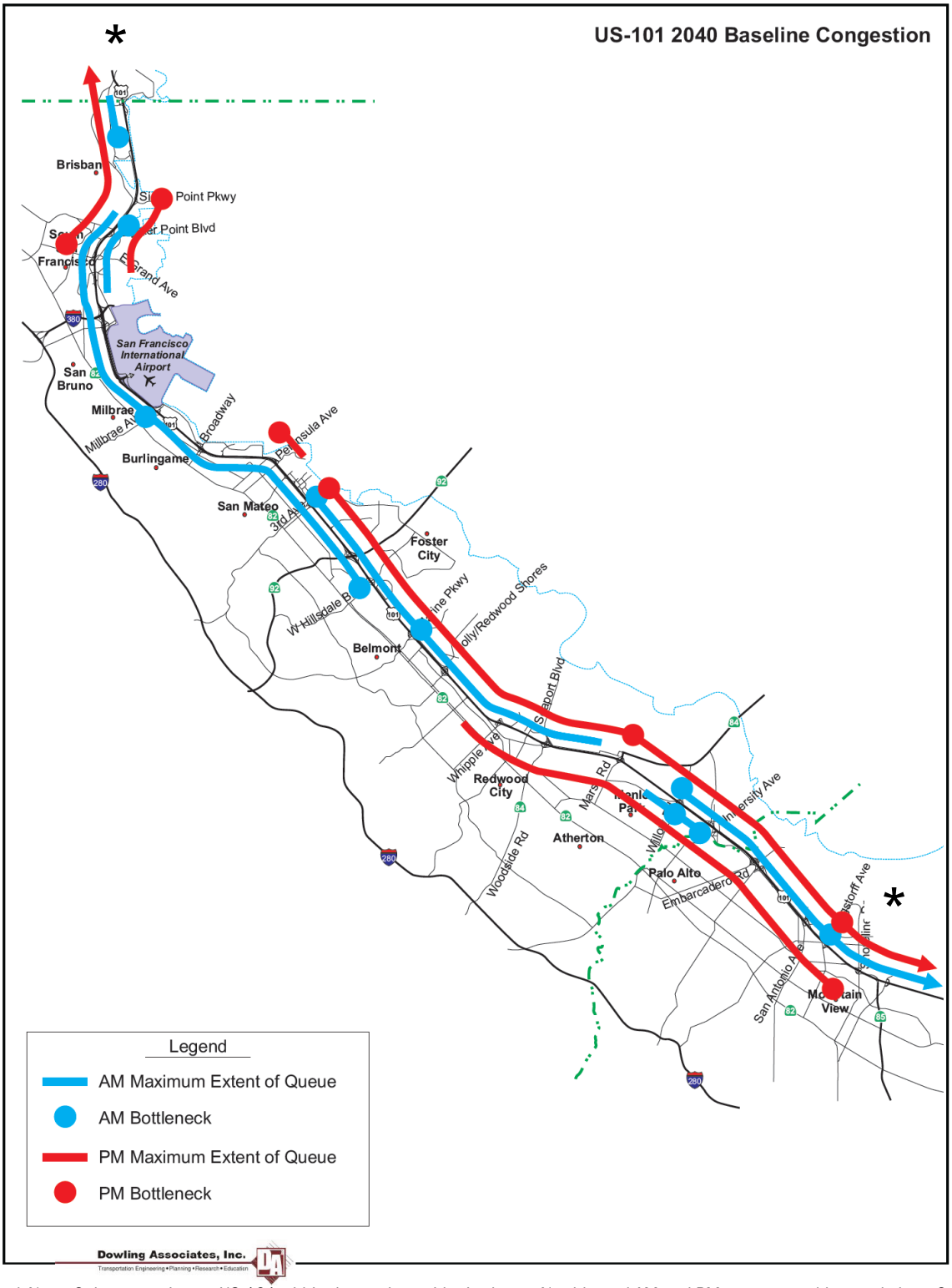
- Oyster Point Boulevard on-ramp to Miller Avenue off-ramp
- Rengstorff Avenue on-ramp to Old Middlefield Way on-ramp

By the height of the peak, it would take approximately 140 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 102 minutes are associated with delay due to bottleneck and queuing effects. Queues resulting from the Rengstorff Avenue bottleneck would extend beyond the Whipple Avenue off-ramp, or approximately 9 miles. As for the bottleneck at Oyster Point Boulevard, queues would extend approximately 9.2 miles beyond the study limit into the San Francisco County, resulting in a total queue length of 12.6 miles.

The HOV lane would operate at or near free flow speeds throughout the peak period.

Detailed FREQ subsection output data, as well as graphical outputs are included in the Appendix C and Appendix D.

Exhibit 8: Freeway Bottlenecks and Queues in 2040 Baseline



* Note: Only congestion on US 101 within the study corridor is shown. Northbound AM and PM queues would extend about 9 miles, and 13 miles south of SR 85, respectively, while southbound PM peak would extend about 9 miles into San Francisco.

4.2.2. Freeway On-Ramp Queues

Ramp metering was assumed for all on-ramps on the SM-101 corridor, excluding freeway-to-freeway ramps. FREQ selected the optimal metering rate for each ramp that would maximize person-miles of freeway travel. Ramp queuing analysis indicates the following ramps would have significant queue overflows. (A queue overflow is defined as the predicted 50 percentile queue of vehicles at the meter exceeding the available storage capacity on the ramp, sometime during either the AM or PM peak periods.)

Northbound

- SR 85 on-ramp during AM peak period
- Shoreline Boulevard northbound on-ramp during both AM and PM peak periods
- San Antonio Road northbound on-ramp during AM peak period
- Oregon Expressway on-ramp during PM peak period
- Marsh Road SB on-ramp during AM peak period
- Holly Street on-ramp during PM peak period
- Millbrae Avenue on-ramp during PM peak period
- E Grand Avenue on-ramp during AM peak period
- Oyster Point Boulevard on-ramp during AM peak period

Southbound

- Sierra Parkway on-ramp during PM peak period
- Airport Boulevard on-ramp during PM peak period
- San Bruno Avenue on-ramp during AM peak period
- Broadway on-ramp during PM peak period
- 3rd Avenue on-ramp during PM peak period
- Fashion Island Boulevard on-ramp during AM peak period
- Hillsdale Boulevard loop on-ramp during AM peak period
- Hillsdale Boulevard diagonal on-ramp during PM peak period
- Ralston Avenue on-ramp during both AM and PM peak periods
- Brittan Avenue on-ramp during PM peak period
- Woodside on-ramp during PM peak period
- University Avenue on-ramp during AM peak period
- Charleston Rd on-ramp during both AM and PM peak periods
- Rengstorff Avenue on-ramp during PM peak period
- Shoreline Boulevard on-ramp during AM peak period

Details of on-ramp queues are included in the Appendix E.

4.3. 2040 With Hybrid HOV Lane Traffic Operations

This section discusses the traffic operation impacts of adding a hybrid HOV lane each direction from the existing HOV lane terminus at the Whipple Avenue interchange to the San Francisco/San Mateo county line. Impacts are compared to the 2040 baseline condition.

4.3.1. Hybrid HOV Lane Configuration and Auxiliary Lane Assumptions

As mentioned previously, the general approach of the "hybrid" HOV Lane study is to cost effectively extend HOV lanes north on US 101 from Whipple Avenue to the San Francisco County line by converting auxiliary lanes to through lanes (or adding lanes in some segments) and extending these lanes through the interchanges to create a 10-lane freeway. The inside lanes would then be restriped as HOV lanes and 8 continuous mixed-flow lanes would be maintained along the entire corridor.

Auxiliary lanes would be eliminated except where traffic analysis shows they would be beneficial to maintaining freeway operations or where there is sufficient right of way to add a HOV lane. Initially, HOV volumes were compared to potential auxiliary lane volumes (on-ramp or off-ramp volumes) in each freeway segment, if HOV volumes are higher than the highest auxiliary lane ramp volume, then the lane conversion would likely yield operational improvements for non-HOV traffic, and therefore the auxiliary lane could be eliminated (actually the auxiliary lane would be extended through the downstream interchange to become a new through lane, and the existing left hand through lane would be converted to HOV lane operation, in effect, adding an HOV lane and eliminating the auxiliary lane). Conversely, if HOV volumes are lower, then it would likely be required to retain the auxiliary lane in order to maintain mixed-flow traffic service levels, in which case, the freeway would then need to be widened to accommodate the lane addition. Subsequently, more detailed FREQ simulations were conducted to refine auxiliary lane requirements throughout the corridor.

Based on this approach, the following auxiliary lanes would be retained:

Northbound Direction

- Whipple Avenue loop on-ramp to diagonal on-ramp
- Marine Parkway/Ralston Avenue diagonal on-ramp to Hillsdale off-ramp
- Hillsdale Boulevard diagonal on-ramp to SR 92 off-ramp
- SR 92 WB diagonal on-ramp to lane drop just south of Kehoe Ave
- Millbrae Avenue on-ramp to I-380 off-ramp
- I-380 on-ramp and South Airport Boulevard off-ramp

In addition, at the northern HOV lane terminus at the Harney Way interchange, the HOV lane is assumed to transition into a mixed-flow lane, which the mainline would continue as five mixed-flow lanes into San Francisco County to connect with the existing five-lane section immediately downstream of the Third Street off-ramp.

Southbound Direction

- Airport Blvd/Produce Ave on-ramp to I-380 WB off-ramp (2 aux lanes)
- I-380 WB off-ramp to N Access Road/SF Airport off-ramp
- I-380 on-ramp to San Bruno Avenue on-ramp
- Last SF Airport on-ramp to Millbrae Avenue off-ramp
- 3rd Avenue on-ramp to SR 92 off-ramp
- SR 92 EB on-ramp to Hillsdale off-ramp
- Hillsdale Boulevard on-ramp to Marine Parkway/Ralston Avenue off-ramp

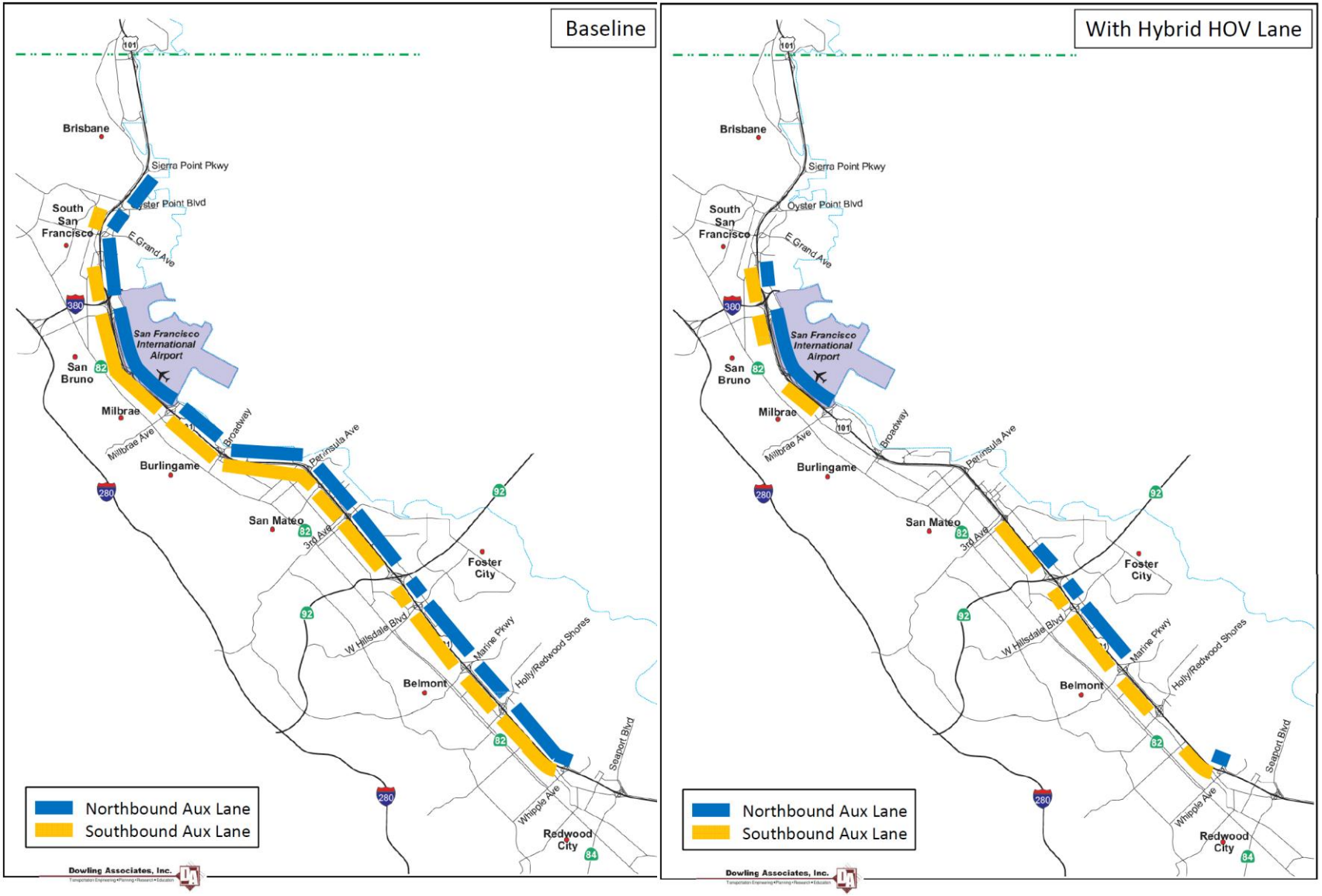
- Marine Parkway/Ralston Avenue on-ramp to Holly Street off-ramp
- Brittan Avenue on-ramp to Whipple Avenue off-ramp

At three (3) northbound locations, partial auxiliary lanes (deceleration lanes) in advance of the exit are proposed in order to maintain 2-lane off-ramps:

- Northbound off-ramp at Marine Parkway
- Northbound off-ramp at SFO
- Northbound off-ramp at Harney Way

Similarly for the southbound direction approaching the SR 92 off-ramp, a deceleration lane would be maintained approaching the off-ramp, in order to keep the off-ramp at 3-lanes. Exhibit 9 provides a map comparing auxiliary lanes in place for the baseline and hybrid HOV lane options. Additional details of FREQ subsection input data are included in the Appendix B. Also, detailed hybrid HOV lane option lane configuration is included in Appendix G.

Exhibit 9: Auxiliary Lane Locations – Between Whipple Avenue and Harney Road



4.3.2. Freeway Bottleneck Analysis with Hybrid HOV Lane

Peak period mixed-flow lane bottleneck locations, as well as the locations and extent of congestion approaching controlling bottlenecks during the height of the peak, are described below for Year 2040 conditions with the hybrid HOV lane option. Mixed-flow lane bottlenecks and maximum queue lengths are shown in Exhibit 10.

Substantial traffic growth is expected to occur on U.S.101 between now and 2040. This growth will result in new bottlenecks developing by year 2040 and longer queues approaching existing bottlenecks.

Northbound AM Peak – During the AM peak period, six (6) bottlenecks would develop in the following freeway segments:

- Rengstorff Avenue loop off-ramp to on-ramp
- Willow Road loop off-ramp to loop on-ramp
- Woodside Road off–ramp to on-ramp
- Kehoe on-ramp to 3rd off-ramp
- 3rd on-ramp to Dore off-ramp
- Broadway on-ramp to Millbrae off-ramp

By the height of the peak (when delay or travel time through the corridor is the longest), it would take approximately 178 minutes to travel through the entire corridor (including the 13 miles section south of SR 85), of which about 137 minutes are associated with delay due to bottleneck and queuing effects. Two of these the bottlenecks, Rengstorff Avenue and Kehoe, will have become hidden by queues from the downstream bottlenecks. The Rengstorff Avenue bottleneck will be hidden by queues extending south approximately 10.6 miles beyond the SR-85 study limit from the Willow Road bottleneck, resulting in a total queue length of 17 miles. Similarly, the Kehoe bottleneck will be embedded in a 6-mile queue extending beyond the Holly Street interchange from the 3rd Avenue bottleneck. The Woodside bottleneck would result in queues extending to south of the Marsh interchange, or approximately 3 miles. The bottleneck at Broadway would develop earlier in the peak period, and disappear during the height of the peak.

The HOV lane would generally operate at or near free flow speeds throughout the peak period, except between the SR 92 interchange and 3rd Avenue interchange, where it would operate with reduced speeds between about 30 and 50 MPH.

Northbound PM Peak – During the PM peak period, five (5) bottlenecks would develop in the following freeway segments:

- Rengstorff Avenue loop off-ramp to on-ramp
- Marsh loop on–ramp to diagonal on-ramp
- 3rd Avenue on-ramp to Dore off-ramp
- Anza on-ramp to Broadway off-ramp
- Broadway on-ramp to Millbrae off-ramp

By the height of the peak, it would take approximately 185 minutes to travel through the entire corridor, of which about 144 minutes are associated with delay due to bottleneck and queuing effects. Three of these bottlenecks, 3rd Avenue, Anza Road, and Rengstorff Avenue, will have become hidden by queues from the downstream bottlenecks. The Rengstorff Avenue bottleneck will be hidden by queues extending south approximately 13 miles beyond the SR-85 study limit from the Marsh bottleneck, resulting in a total queue length of 21 miles. Similarly, the 3rd Avenue and Anza bottlenecks will be hidden by queues extending to south of the Woodside Road interchange from the Broadway bottleneck, or approximately 12 miles.

The HOV lane would generally operate at or near free flow speeds throughout the peak period, except between the Holly interchange and SR 92 interchange, where it would operate with reduced speeds between about 20

and 40 MPH, and between the Peninsula interchange and the Broadway interchange, where speeds would be reduced to about 40 and 50 MPH.

Southbound AM Peak – During the AM peak period, four (4) bottlenecks would develop in the following freeway segments:

- SFO Airport on-ramp from international terminal to on-ramp from domestic terminal
- Hillsdale Boulevard loop on-ramp to diagonal on-ramp.
- Willow Road loop off-ramp to diagonal on-ramp
- University Avenue off-ramp to on-ramp

The HOV lane would operate at or near free flow speeds throughout the peak period.

By the height of the peak, it would take approximately 114 minutes to travel through the entire corridor, of which about 76 minutes are associated with delay due to bottleneck and queuing effects. The SFO Airport bottleneck will have become hidden by queues from the downstream bottleneck, resulting in queues extending to north of the Sierra Point on-ramp from the Marsh bottleneck, or approximately 14 miles. Both the Willow Road and University Avenue bottlenecks would not occur during the height of the peak.

Southbound PM Peak – During the PM peak period, two (2) bottlenecks would develop in the following freeway segments:

- Oyster Point Boulevard on-ramp to Miller Avenue off-ramp
- Rengstorff Avenue on-ramp to Old Middlefield Way on-ramp

By the height of the peak, it would take approximately 154 minutes to travel through the entire corridor, of which about 116 minutes are associated with delay due to bottleneck and queuing effects. Queues resulting from the Rengstorff Avenue bottleneck would extend beyond the Hillsdale Boulevard interchange, or approximately 14 miles. As for the Oyster Point Boulevard interchange, queues would extend approximately 4.7miles beyond the study limit into the San Francisco County, resulting in a total queue length of 8.7 miles.

The HOV lane would operate at or near free flow speeds throughout the peak period.

As described previously in the traffic forecast section, the 2040 extrapolated traffic volumes are rather conservative (on the high side), particularly in the vicinity of the SR 92 interchange. Therefore, traffic congestion and hot spots identified above represent a fairly conservative evaluation of 2040 freeway conditions with the hybrid HOV lane option.

Detailed FREQ subsection output data, as well as graphical outputs are included in the Appendix C and Appendix D.

4.3.3. Freeway On-Ramp Queues

Ramp metering was assumed for all on-ramps on the SM-101 corridor, excluding freeway-to-freeway ramps. FREQ selected the optimal metering rate for each ramp that would maximize person-miles of freeway travel. Ramp queuing analysis indicates the following ramps would have significant queue overflows. During subsequent phases of the study, detailed analysis may be required to fully assess the impacts of these queues.

Northbound

- SR 85 on-ramp during AM peak period
- Shoreline Boulevard northbound on-ramp during both AM and PM peak periods
- San Antonio Road northbound on-ramp during AM peak period

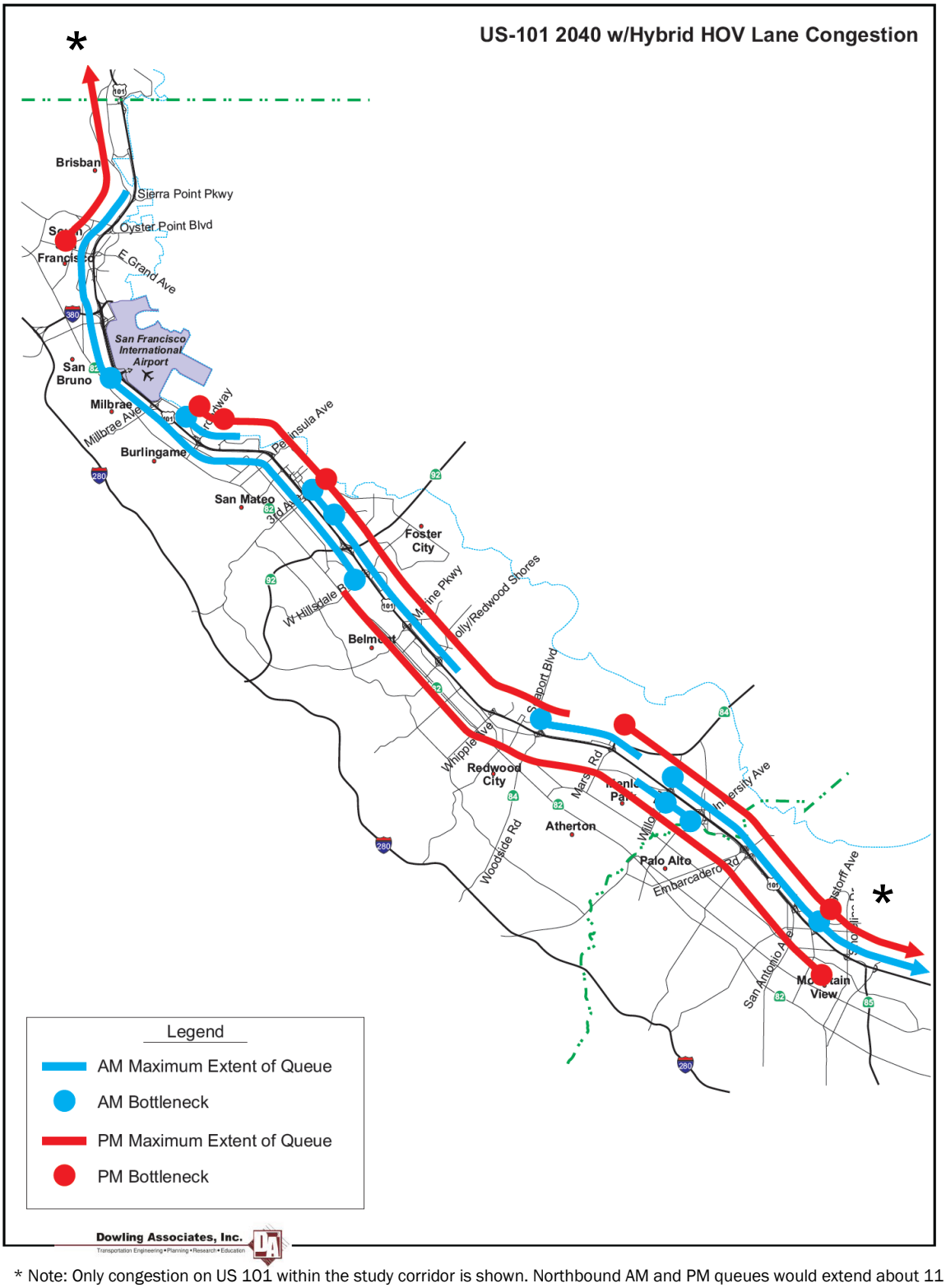
- Oregon Expressway on-ramp during PM peak period
- Whipple Avenue NB on-ramp during both AM and PM peak periods
- Holly Street on-ramp during PM peak period
- Marine Parkway loop on-ramp during PM peak period
- E Grand Avenue on-ramp during AM peak period

Southbound

- Sierra Parkway on-ramp during PM peak period
- Airport Boulevard on-ramp during PM peak period
- Broadway on-ramp during PM peak period
- 3rd Avenue on-ramp during PM peak period
- Hillsdale Boulevard diagonal on-ramp during PM peak period
- Ralston Avenue on-ramp during both AM and PM peak periods
- Brittan Avenue on-ramp during PM peak period
- Woodside on-ramp during PM peak period
- University Avenue on-ramp during AM peak period
- Oregon Expressway on-ramp during AM peak period
- Charleston Rd on-ramp during both AM and PM peak periods
- Rengstorff Avenue on-ramp during PM peak period
- Shoreline Boulevard on-ramp during AM peak period

Details of on-ramp queues are included in the Appendix E.

Exhibit 10: Freeway Bottlenecks and Queues in 2040 with Hybrid HOV Lane



* Note: Only congestion on US 101 within the study corridor is shown. Northbound AM and PM queues would extend about 11 miles, and 13 miles south of SR 85, respectively, while southbound PM peak would extend about 5 miles into San Francisco.

4.4. Travel Time Comparisons

Freeway corridor travel times are presented below in Exhibit 11 and Exhibit 12.

Exhibit 11 compares average peak period freeway travel times for the entire study corridor from SR 85 in Mountain View, to Harney Way in San Francisco. The travel times also account for the congestions that would occur beyond the study limits. As shown below, with the hybrid HOV lane, northbound PM traffic would experience a significant travel time savings of about 30 minutes, or 18% reduction in the mixed-flow lanes. This is primarily due to the new hybrid HOV lane that would provide relief to the severe bottleneck at 3rd Avenue. While in other cases including northbound AM, southbound AM and PM, the hybrid option would incur slightly higher travel times of no more than 9 minutes, or an increase of 8% compared to baseline conditions in the mixed-flow lanes. As noted on the exhibit, the travel times shown represents distance traveled beyond the study limits, to include congested travel times beyond the study limits: i.e. 13 miles south of SR 85 interchange, and 9 miles north of San Francisco county line. In terms of HOV carpool users, with the hybrid HOV lane option, these users would experience significantly improved travel times through the corridor, compared to mixed-flow lane users. The improvements would range from 19 to 34 minutes, with southbound AM peak period that would experience the most benefit.

Exhibit 11: Average Peak Period Travel Time Comparison Along the Study Corridor

Average Peak Period Travel Time												
Dir/Peak	Baseline			Hybrid HOV Lane			Hybrid HOV Versus Baseline					
	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow Diff		HOV Diff		HOV TT Savings	
	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(%)	(mins.)	(%)	(mins.)	(%)
Northbound AM	108.6	54.5	54.1	117.1	43.7	73.4	8.5	8%	-10.8	-20%	19.3	36%
Northbound PM	169	61.4	107.6	139.4	45.6	93.8	-29.6	-18%	-15.8	-26%	-13.8	-13%
Southbound AM	70.5	69.6	0.9	72.8	37.5	35.3	2.3	3%	-32.1	-46%	34.4	>100%
Southbound PM	95.6	61.6	34	99.8	43.4	56.4	4.2	4%	-18.2	-30%	22.4	66%

Source: Peak period average travel times from FREQ analysis, including congestions beyond study limits south of SR 85 interchange (13 miles), and north of San Francisco county line (9 miles). Total distance is approximately 43 miles for northbound, and 39 miles for southbound.

Exhibit 12 provides a similar comparison of the maximum corridor travel time between the baseline and hybrid HOV lane option, during each peak period. Similar trends are shown in the exhibit in terms of the improved travel times both the carpool lane and mixed-flow lane users would experience, at a greater magnitude. Northbound mixed-flow lane users would benefit the greatest amount of travel time savings with the hybrid HOV lane option, with 65 minutes in reduction during the PM peak period.

Exhibit 12: Peak Hour Maximum Travel Time Comparison Along the Study Corridor

Maximum Peak Period Travel Time												
Dir/Peak	Baseline			Hybrid HOV Lane			Hybrid HOV Versus Baseline					
	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow	HOV	HOV TT Savings	Mixed-Flow Diff		HOV Diff		HOV TT Savings	
	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(mins.)	(%)	(mins.)	(%)	(mins.)	(%)
Northbound AM	161.8	63.3	98.5	177.8	43.4	134.4	16	10%	-19.9	-31%	35.9	36%
Northbound PM	249.7	75.5	174.2	184.5	47.1	137.4	-65.2	-26%	-28.4	-38%	-36.8	-21%
Southbound AM	105.9	105.9	0	113.8	37.5	76.3	7.9	7%	-68.4	-65%	76.3	>100%
Southbound PM	139.8	88.4	51.4	153.8	50.7	103.1	14	10%	-37.7	-43%	51.7	101%

Source: Peak period average travel times from FREQ analysis, including congestions beyond study limits south of SR 85 interchange (13 miles), and north of San Francisco county line (9 miles). Total distance is approximately 43 miles for northbound, and 39 miles for southbound.

Freeway corridor travel speed comparisons are presented below in Exhibit 13 through Exhibit 16.

Exhibit 13 provides a comparison of average speeds in the northbound direction during the AM peak period. HOV lane speeds are generally similar between baseline and hybrid HOV lane options, except for a short section near the San Antonio interchange, where the baseline would experience a minor slow down. This is a result of shifting some HOV traffic demand to avoid an unrealistic situation where the lane is congested while the mixed-flow lanes are free-flow.

On the mixed-flow lanes, travel speeds are generally similar, except between the Whipple interchange to the Holly interchange, and from the Airport interchange to the Bayshore interchange, where the hybrid option would operate at higher speeds. Conversely, from the Peninsula interchange to the Millbrae interchange, baseline conditions would operate at higher speeds.

Exhibit 13: Freeway Travel Speed Comparison – Northbound AM Peak Period Average

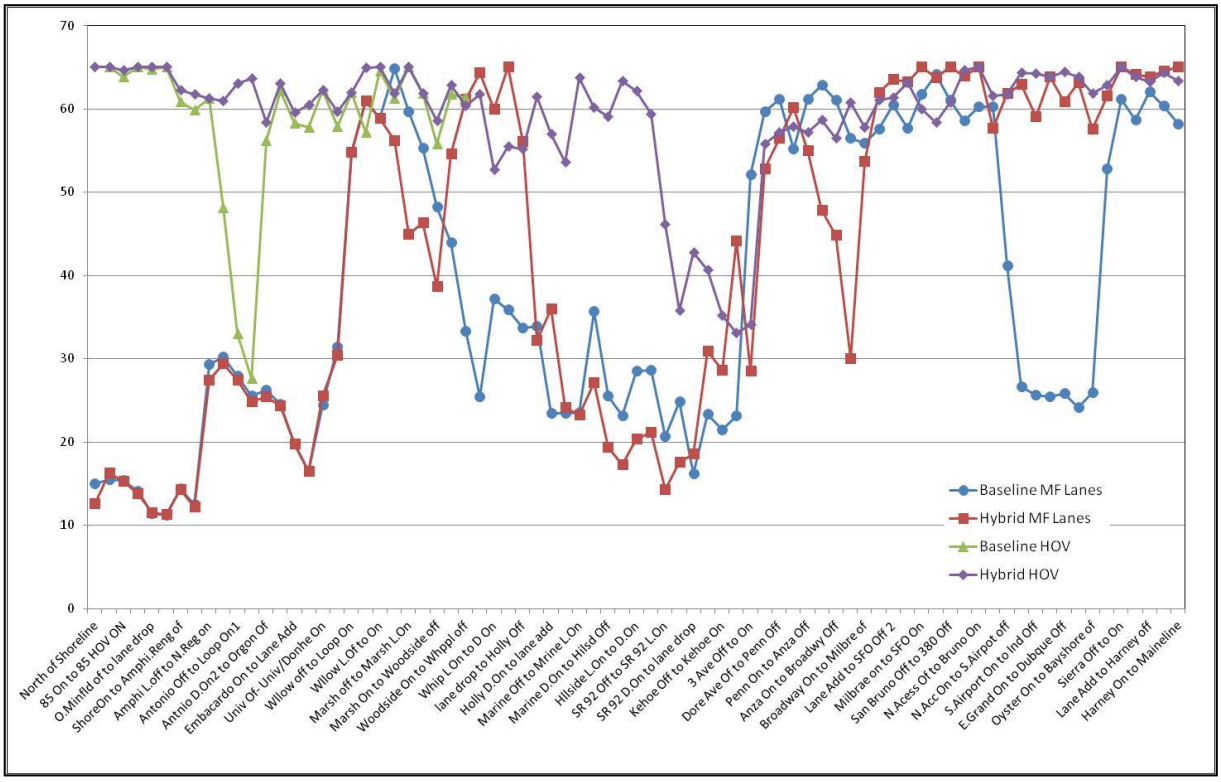


Exhibit 14 provides a comparison of average speeds in the northbound direction during the PM peak period. HOV lane speeds are generally similar between baseline and hybrid HOV lane options. On the mixed-flow lanes, travel speeds are generally similar, except between 3rd and Millbrae interchanges, where the baseline conditions would operate at higher speeds. Conversely, from the Grand Avenue interchange to San Francisco, the hybrid HOV lane option would operate at higher speeds.

Exhibit 15 provides a comparison of average speeds in the southbound direction during the AM peak period. HOV lane speeds are generally similar between baseline and hybrid HOV lane options. On the mixed-flow lanes, travel speeds are generally similar, except from San Francisco to the Sierra Point interchange, where the hybrid HOV lane option would operate at higher speeds. Conversely, the from Sierra Point interchange to Airport, the hybrid HOV lane option would operate at lower speeds compared to baseline.

Exhibit 16 provides a comparison of average speeds in the southbound direction during the PM peak period. Both the HOV lane and mixed-flow lane speeds are generally similar between baseline and hybrid HOV lane options, except between Hillsdale interchange and Woodside interchange, where the hybrid HOV lane option would experience slower speeds on mixed-flow lanes compared to baseline.

Exhibit 14: Freeway Travel Speed Comparison – Northbound PM Peak Period Average

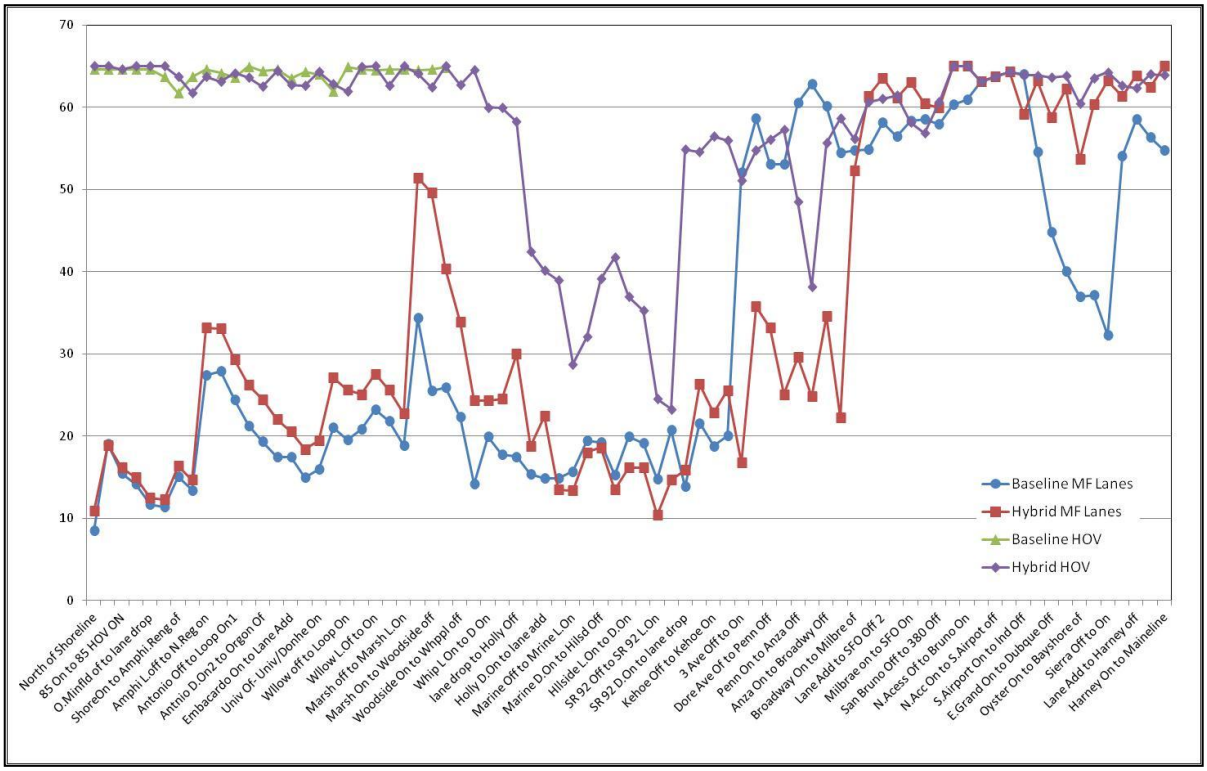


Exhibit 15: Freeway Travel Speed Comparison – Southbound AM Peak Period Average

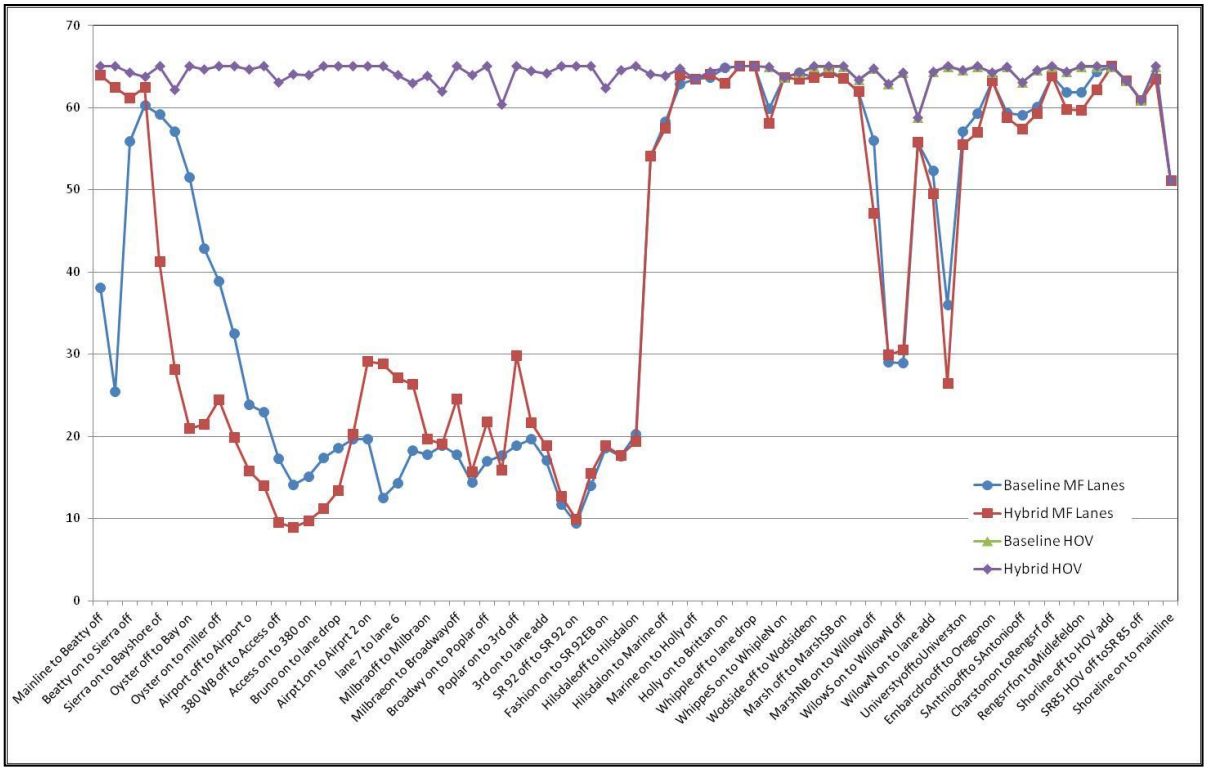
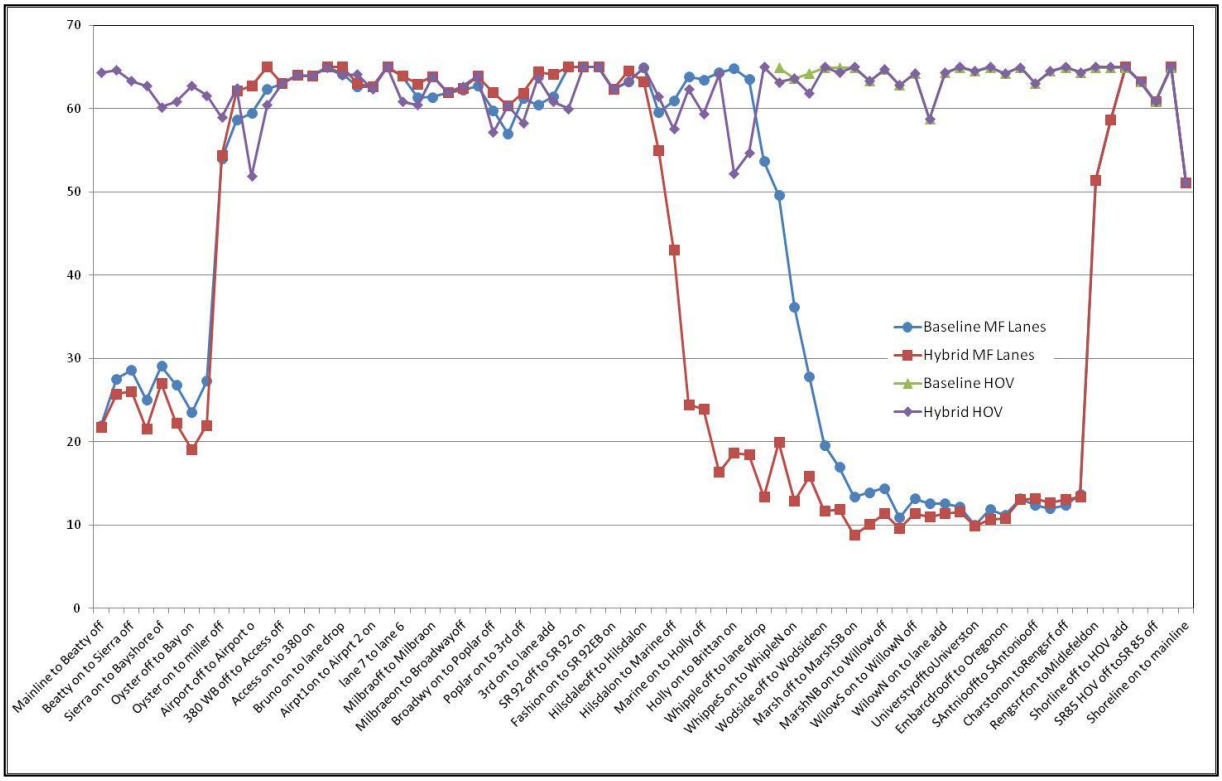


Exhibit 16: Freeway Travel Speed Comparison – Southbound PM Peak Period Average



4.5. Congestion Duration Comparison

Congestion duration would be similar between the baseline conditions and the hybrid HOV lane option. In the southbound direction, congestion would begin at about 7 AM at the worst bottleneck location at Hillsdale interchange for both scenarios. Congestion would dissipate by 11:25 PM under baseline conditions, and dissipate by 10:15 PM under the hybrid HOV lane scenario. In the northbound direction, congestion would begin at about 6 AM at the Rengstorff interchange, and at 7 AM at the Willow interchange, congestion would overlap between these two worst bottleneck locations. Congestion would dissipate by 11:20 PM under the baseline scenario, and by 12:05 AM (next day) under the hybrid HOV lane scenario. The duration of congestion is increased in the hybrid alternative primarily due to induced traffic demands at the southern end of the corridor, where no improvements are proposed for this hybrid HOV lane option at that location. The congestion duration is estimated based on existing mainline hourly volume profiles from PEMS, at selected locations.

4.6. Mainline Throughput Comparison

Exhibit 17 provides a comparison of simulated mainline throughput between 2040 baseline conditions and the hybrid HOV lane option. Total peak period throughputs at key locations through the corridor are compared. As shown in the exhibit, there would be higher throughputs with the hybrid HOV lane option, throughout the corridor. AM peak period's largest difference is 3,547 vehicles in the southbound direction south of SR 92, while PM peak period's largest difference is 3,980 vehicles in the northbound direction, also south of SR 92.

Exhibit 17: Mainline Throughput Comparison

Location	Baseline		Hybrid HOV		Difference	
	AM 4-Hour	PM 5-Hour	AM 4-Hour	PM 5-Hour	AM 4-Hour	PM 5-Hour
Northbound						
South of SR 85	22,067	27,608	22,199	29,002	132	1,394
South of SR 92	29,223	35,053	31,363	39,033	2,140	3,980
South of I-380	31,492	43,771	34,007	46,323	2,515	2,552
San Francisco county line	27,753	36,831	29,422	39,376	1,669	2,545
Southbound						
South of SR 85	22,691	27,610	22,705	28,562	14	952
South of SR 92	27,804	35,937	31,351	37,006	3,547	1,069
South of I-380	23,955	32,891	25,387	35,039	1,432	2,148
San Francisco county line	26,327	33,382	27,790	37,813	1,463	4,431

4.7. Corridor-wide Performance Effects

The corridor wide mobility performance results for Year 2040 are summarized in Exhibit 18, with more detailed results tabulated in Exhibit 19. These exhibits represent the results for total of mixed-flow lanes and the HOV lane.

Exhibit 18: 2040 Freeway System Performance Changes from Baseline

Performance Measures	2040 Baseline	2040 Hybrid HOV	Difference
VMT – vehicle miles of travel	4,925,100	5,264,400	7%
VHT – vehicle hours of travel	196,000	190,500	-3%
VHD – vehicle hours of delay	120,400	109,400	-9%
PHD – person hours of delay	120,600	110,900	-8%
Average vehicle speed (MPH)	25.1	27.6	10%
Average person speed (MPH)	25.9	29.9	15%

Source: FREQ Analysis, both HOV and mixed-flow lanes.

In summary, compared to 2040 baseline conditions, the hybrid HOV lane option results in the following changes:

- Overall vehicle-miles traveled during the AM and PM peak periods combined increases 7%. The southbound direction would incur a slightly higher increase than the northbound direction.
- Overall vehicle-hours traveled during the AM and PM peak periods combined decreases 3%. The northbound direction would incur a reduction, while the southbound would be increased with the hybrid option.
- Overall vehicle-hours of delay during the AM and PM peak periods combined decreases 9%. The northbound direction would experience a greater reduction than the southbound direction.
- Overall average vehicle speed increases by 10%, with significantly higher speed increase in the northbound than the southbound direction, when compared to baseline conditions.

Person performance measures would show a similar trend as for the vehicle performance measures:

- Overall person-miles traveled during the AM and PM peak periods combined increases 19%. The southbound direction would incur a slightly higher increase than the northbound direction.
- Overall person-hours traveled during the AM and PM peak periods combined increases by 3%. The northbound direction would incur a slight reduction, while the southbound would be increased with the hybrid option.
- Overall person-hours of delay during the AM and PM peak periods combined decreases 8%. The northbound direction would experience a greater reduction than the southbound direction.
- Overall average person speed increases by 16%, with significantly higher speed increase in the northbound than the southbound direction, when compared to baseline conditions.

Exhibit 19: Freeway System Performance Comparison

Performance	Northbound		Southbound		NB & SB Combined	
	2040 Base	2040 HOV Add	2040 Base	2040 HOV Add	2040 Base	2040 HOV Add
VMT (AM)	1,189,400	1,238,800	997,900	1,075,200	2,187,300	2,314,000
VMT (PM)	1,455,200	1,561,600	1,282,600	1,388,800	2,737,800	2,950,400
Total VMT	2,644,600	2,800,400	2,280,500	2,464,000	4,925,100	5,264,400
Change from Base		6%		8%		7%
VHT (AM)	44,700	47,300	27,500	28,300	72,200	75,600
VHT (PM)	79,400	69,800	44,400	45,100	123,800	114,900
Total VHT	124,100	117,100	71,900	73,400	196,000	190,500
Change from Base		-6%		2%		-3%
VHD (AM)	26,400	28,200	12,200	11,800	38,600	40,000
VHD (PM)	57,100	45,800	24,700	23,600	81,800	69,400
Total VHD	83,500	74,000	36,900	35,400	120,400	109,400
Change from Base		-11%		-4%		-9%
MPH (AM)	27	26	36	38	30.3	30.6
MPH (PM)	18	22	29	31	22.1	25.7
Avg Veh MPH	21	24	32	34	25.1	27.6
Change from Base		12%		6%		10%
PMT (AM)	1,271,200	1,460,100	1,035,400	1,217,700	2,306,600	2,677,800
PMT (PM)	1,538,900	1,838,500	1,352,200	1,641,200	2,891,100	3,479,700
Total PMT	2,810,100	3,298,600	2,387,600	2,858,900	5,197,700	6,157,500
Change from Base		17%		20%		19%
PHT (AM)	46,100	51,100	28,100	30,500	74,200	81,600
PHT (PM)	80,700	74,900	45,500	49,100	126,200	124,000
Total PHT	126,800	126,000	73,600	79,600	200,400	205,600
Change from Base		-1%		8%		3%
PHD (AM)	26,600	28,700	12,200	11,800	38,800	40,500
PHD (PM)	57,100	46,600	24,700	23,800	81,800	70,400
Total PHD	83,700	75,300	36,900	35,600	120,600	110,900
Change from Base		-10%		-4%		-8%
MPH (AM)	28	29	37	40	31.1	32.8
MPH (PM)	19	25	30	33	22.9	28.1
Avg Person MPH	22	26	32	36	25.9	29.9
Change from Base		18%		11%		16%

Source: FREQ Analysis.

4.8. Effects of Taking Away Auxiliary Lanes

Throughout a majority of the corridor between Whipple Avenue and Harney Way, auxiliary lanes between interchanges would be taken away for conversion to the hybrid HOV lane. New northbound bottlenecks would develop at:

- Kehoe on-ramp to 3rd off-ramp (AM)
- 3rd on-ramp to Dore off-ramp (AM & PM)
- Anza on-ramp to Broadway off-ramp (PM)
- Broadway on-ramp to Millbrae off-ramp (AM & PM)

In the southbound direction, a new bottleneck would develop at:

- SFO Airport on-ramp from international terminal to on-ramp from domestic terminal (AM)

However, these new bottlenecks would not create significant operational impacts for US 101 traffic, as shown in prior section results, as they would generally be hidden by queues from other downstream bottlenecks, or only minor queues would develop approaching them.

Although taking away auxiliary lanes would result in new bottlenecks at locations listed above, the hybrid HOV lane would provide additional freeway throughput across the freeway system.

Section 4.4 also provided travel time comparisons for mixed-flow lanes between the baseline and hybrid HOV lane option, which demonstrated that mixed-flow lane users would experience similar or lower average peak period travel times along the corridor.

5. Impacts to Countywide Roadways and Other Freeways

The C/CAG countywide model was applied to determine how adding a hybrid HOV lane would change the peak period demand for surface streets and other major routes in the corridor in addition to US 101 (e.g., I-280, SR-84, SR-92, SR-82, I-380). Since the demand model is only available for up to 2030 forecast, it is reasonably assumed that a similar trend would result under 2040 conditions.

Exhibit 20 shows the changes in the entire county in terms vehicle and person trip performance measures after adding the hybrid HOV lane option in each direction of US 101. Compared to baseline conditions, VMT(vehicle miles traveled) would increase by about 1%. Vehicle hours of delay would decrease by 7%, person-hours of delay (PHD) countywide would be reduced by 8%.

Exhibit 20: Countywide Performance Comparison

MOE	2030 Baseline	2030 Hybrid HOV Lane	Difference
Vehicle Miles of Travel (VMT)	13,629,473	13,730,820	1%
Vehicle Hours of Travel (VHT)	435,786	428,609	-2%
Vehicle Hours of Delay (VHD)	115,558	106,985	-7%
Mean Vehicle Speed (mph)	31.3	32.0	2%
Person Miles of Travel (PMT)	16,654,099	16,846,069	1%
Person Hours of Travel (PHT)	536,932	529,007	-1%
Person Hours of Delay (PHD)	141,693	129,775	-8%
Mean Person Speed (mph)	31.0	31.8	3%

Source: C/CAG model, AM & PM combined.

Detailed peak period performance comparisons for all roadways in the county, freeways, and surface streets are shown in Exhibit 21, Exhibit 22, and Exhibit 23, respectively. Freeways within the county include US 101, I-280, I-380, SR-84 and SR 92.

The hybrid HOV lane would have the following impacts compared to the Baseline scenarios:

- All Freeways within San Mateo County – Exhibit 22 shows the changes to vehicle and person trip performance measures on freeways. The hybrid HOV lanes would increase VMT by 2%, indicating that the hybrid HOV lane option would attract more induced demands onto the freeway system. However, the overall increased demands on the freeway would be served more efficiently with the hybrid HOV lane option as indicated by the reduction in vehicle hours of delay, on the order of 11% to 13%, and mean vehicle speeds would be improved by 4% to 5%. The hybrid HOV lane option would also result in a reduction in person hours of delay in the range of 13% to 15%. In addition, Person miles of travel would incur a higher percent increase than vehicle miles of travel, which shows that the hybrid HOV lane option would encourage more mode shift to carpool users than the drive alone share.

- Surface/Arterial streets within San Mateo County –Exhibit 23 shows the changes to vehicle and person trip performance measures on surface streets. The hybrid HOV lanes would reduce VMT on local streets by 1% to 2%, while reducing vehicle hours of delay by a similar percentage. Congested lane miles would be reduced by 2% to 7%. Mean vehicle speeds would remain approximately unchanged.

Exhibit 21: Countywide Performance Comparison – AM and PM Peak Periods

	2030 Baseline	2030 Hybrid HOV Lane	Difference
AM 4 Hour Peak Period			
Vehicle Miles of Travel (VMT)	5,984,256	6,025,040	1%
Vehicle Hours of Travel (VHT)	202,232	198,441	-2%
Vehicle Hours of Delay (VHD)	63,402	58,742	-7%
Mean Vehicle Speed (mph)	29.6	30.4	3%
Congested Lane-Miles	776.5	751.9	-3%
Person Miles of Travel (PMT)	7,403,513	7,500,061	1%
Person Hours of Travel (PHT)	253,319	249,363	-2%
Person Hours of Delay (PHD)	78,363	71,925	-8%
Mean Person Speed (mph)	29.2	30.1	3%
PM 5 Hour Peak Period			
Vehicle Miles of Travel (VMT)	7,645,216	7,705,779	1%
Vehicle Hours of Travel (VHT)	233,554	230,168	-1%
Vehicle Hours of Delay (VHD)	52,155	48,243	-8%
Mean Vehicle Speed (mph)	32.7	33.5	2%
Congested Lane-Miles	666.8	627.0	-6%
Person Miles of Travel (PMT)	9,250,586	9,346,007	1%
Person Hours of Travel (PHT)	283,614	279,644	-1%
Person Hours of Delay (PHD)	63,330	57,850	-9%
Mean Person Speed (mph)	32.6	33.4	2%

Source: C/CAG Model.

Exhibit 22: Freeway Performance Comparison – AM and PM Peak Periods

	2030 Baseline	2030 Hybrid HOV Lane	Difference
AM 4 Hour Peak Period			
Vehicle Miles of Travel (VMT)	3,598,874	3,678,326	2%
Vehicle Hours of Travel (VHT)	94,965	92,838	-2%
Vehicle Hours of Delay (VHD)	36,795	32,631	-11%
Mean Vehicle Speed (mph)	37.9	39.6	5%
Congested Lane-Miles	375.8	378.5	1%
Person Miles of Travel (PMT)	4,428,961	4,582,328	3%
Person Hours of Travel (PHT)	117,111	115,557	-1%
Person Hours of Delay (PHD)	44,267	38,546	-13%
Mean Person Speed (mph)	37.8	39.7	5%
PM 5 Hour Peak Period			
Vehicle Miles of Travel (VMT)	4,665,770	4,768,524	2%
Vehicle Hours of Travel (VHT)	104,156	102,274	-2%
Vehicle Hours of Delay (VHD)	29,669	25,950	-13%
Mean Vehicle Speed (mph)	44.8	46.6	4%
Congested Lane-Miles	334.6	303.1	-9%
Person Miles of Travel (PMT)	5,648,383	5,804,757	3%
Person Hours of Travel (PHT)	126,299	124,433	-1%
Person Hours of Delay (PHD)	35,511	30,278	-15%
Mean Person Speed (mph)	44.7	46.6	4%

Source: C/CAG Model.

Exhibit 23: Surface Street Performance Comparison – AM and PM Peak Periods

	2030 Baseline	2030 Hybrid HOV Lane	Difference
AM 4 Hour Peak Period			
Vehicle Miles of Travel (VMT)	2,385,383	2,346,714	-2%
Vehicle Hours of Travel (VHT)	107,266	105,603	-2%
Vehicle Hours of Delay (VHD)	26,607	26,111	-2%
Mean Vehicle Speed (mph)	22.2	22.2	0%
Congested Lane-Miles	400.7	373.5	-7%
Person Miles of Travel (PMT)	2,974,551	2,917,733	-2%
Person Hours of Travel (PHT)	136,207	133,806	-2%
Person Hours of Delay (PHD)	34,096	33,379	-2%
Mean Person Speed (mph)	21.8	21.8	0%
PM 5 Hour Peak Period			
Vehicle Miles of Travel (VMT)	2,979,446	2,937,255	-1%
Vehicle Hours of Travel (VHT)	129,398	127,894	-1%
Vehicle Hours of Delay (VHD)	22,486	22,293	-1%
Mean Vehicle Speed (mph)	23.0	23.0	0%
Congested Lane-Miles	332.2	324.0	-2%
Person Miles of Travel (PMT)	3,602,203	3,541,251	-2%
Person Hours of Travel (PHT)	157,315	155,211	-1%
Person Hours of Delay (PHD)	27,820	27,572	-1%
Mean Person Speed (mph)	22.9	22.8	0%

Source: C/CAG Model.

6. Greenhouse Gas Emissions Effects

The effects of countywide greenhouse gas emissions from vehicles for the baseline and hybrid HOV lane option are described in this chapter.

6.1. Development of Greenhouse Gas Emission Rates

On-road mobile sources consist of three compounds including Carbon Dioxide (CO2), Methane (CH4), and Nitrous Oxide (N2O). The greenhouse gas emission rates are computed in units of carbon dioxide equivalent (CO2-eq) which weights and combines contributions for each greenhouse gas emitted. Each compound differs in warming influence due to differing radiative properties and atmospheric half-lives. The carbon dioxide equivalent emissions metric is based on each gas' potential to cause global warming, relative to that of CO.

Emissions are a function of the mix of vehicle classes; vehicle ages; vehicle maintenances; ambient conditions; and how aggressively the vehicle is operated. Emission rates used in this study reflect the vehicle population from California's major urban centers in the Bay Area, Central Valley, and Southern California. Temperature and humidity of 70 degree Fahrenheit and 30% relative humidity are assumed, and rates are provided in 5mph increments up to 65 mph. The rates were computed for 2010 (existing condition), 2020 (AB 32 and SB 375 milestone), and 2035 (cumulative condition, and a SB 375 milestone).

From the above described in-house work by Dowling Associates, emission rates were developed for three sub-classes of operating vehicles;

- Light duty autos (LDA), light duty trucks (LDT), medium duty trucks (MDT), and motorcycles (MCY) (generally vehicles up to 8,500 lbs gross weight rating)
- Heavy trucks (HDT) (vehicle with a gross vehicle weight rating of 8,501 lbs. or grater)
- Buses (UBUS)

These CO2 equivalent emission rates by vehicle speed were then applied to the C/CAG model output (VMT by speed bin) to obtain total greenhouse gas emissions.

The C/CAG model was used to tally VMT on each link direction by speed bin. A speed bin is a 5 mph (or so) range of speeds. If the link speed in one direction fell within the range of one speed bin, then all the VMT on that direction of the link would be put in that speed bin. The emission rate for that speed bin was then multiplied by the VMT in the speed bin and the results summed across all speed bins to obtain the emissions.

6.2. Greenhouse Gas Emissions of Hybrid HOV Lane Option

Exhibit 24 provides a comparison of the greenhouse gas emissions for the baseline conditions and hybrid HOV lane option. The hybrid HOV lane option would result in higher VMT in the county, although average travel speeds are generally higher, the major emissions, CO2 and CO, is approximately 0.5%, and 0.3% higher than baseline conditions, respectively.

Exhibit 24: Summary of Countywide Greenhouse Gas Emission for Peak Period (AM and PM)

GHG	Baseline	Hybrid	Diff
CO2 (1000)	2.02	2.03	0.5%
TOG	2.59	2.59	0.0%
CO	8.73	8.76	0.3%
NOx	1.05	1.05	0.0%
PM10	0.19	0.19	0.0%

Source: C/CAG Model and California EMFAC Model, Emissions measured in tons, except CO2, which is measured in 1000 tons.

Key:
CO2 (1000) = Carbon Dioxide in thousands of tons
TOG = Total organic gases
CO = Carbon Monoxide
NOx = Nitrous oxides
PM10 = particulate matter under 10 microns in size
Diff = difference between hybrid HOV lane option and baseline

7. Design Concept and Design Exceptions

This chapter identifies the methodology used to establish a continuous fifth through lane in each direction for HOV; discusses the corridor characteristics and constraints; and identifies the Caltrans design exceptions that would be necessary to make this hybrid HOV lane option feasible.

7.1. Design Strategy

As described in Chapter 2, the corridor is divided into five sections based on their general characteristics, and then further divided into sixteen (16) contiguous segments for analysis purposes. Each segment generally extends from one local road interchange to the next local road interchange (center of overcrossing to center of overcrossing). Partial interchanges (i.e. hook on/off ramps on one direction only) were not used to divide segments but are included in the longer segment between full interchanges. A detailed discussion of each of the 16 segments is included later in this chapter.

The corridor was analyzed for potential locations for median CHP enforcement areas. Only 2 locations have sufficient room for cost effectively adding median CHP enforcement – a segment between Ralston Avenue and Hillsdale Boulevard and a segment between the SFO Airport ramps and San Bruno Avenue. These have been identified and drawn on the layout sheets in Appendix H.

Detailed analysis of the realignment and reconstruction of interchange ramps to accommodate the fifth through lane is not included with this initial conceptual study. However, the approximate realignment to meet the new outside edge of travel way is drawn in and the potential non-standard alignment features at the ramp conforms are identified.

Design Concept Exhibits
Exhibits, plans, and sections at critical "pinch points" have been prepared to accompany this report.

The *Proposed Design Summary Table* (Appendix F) is a one-page 11x17 sheet that summarizes the proposed freeway lane and shoulder widths for each segment and overcrossing from Whipple Avenue to the SF/SM County line after the fifth through lane has been created. Minimum vertical clearance over existing pavement is indicated for overcrossing structures. Non-standard lane and shoulder widths are shown in blue and red.

A large, schematic exhibit titled "*Proposed Hybrid HOV Lane Configurations*" (Appendix G) shows the entire 19-mile corridor graphically with schematic diagrams identifying (a) existing lane/shoulder configurations; (b) proposed lane/shoulder configurations; and (c) an overview bar diagram of the number and type of proposed lanes. The location of the "initial strategy" Sections A thru E discussed in Chapter 2 are also identified on this schematic exhibit.

A set of conceptual design *layout sheets* (Appendix H) show the proposed lane configurations and revised ramp connections at 1"=200' scale superimposed on an aerial background. There are 18 layout sheets.

A set of *cross section sheets* (Appendix I) show the existing and proposed lane/shoulder widths at each critical constraint point. These include a section for each local road overcrossing structure and additional sections for critical constraint points between interchanges.

7.2. Detailed Discussions by Segment

The following sections discuss the general characteristics, design constraints, and Caltrans design exceptions that would be needed to cost effectively add an HOV lane in addition to the existing through lanes. The discussion is organized by freeway segment from interchange to interchange. See the exhibit, "Proposed HOV

Hybrid Lane Configurations," in Appendix G for schematic diagrams showing the existing and proposed lane and shoulder widths.

1. Whipple Avenue to Holly Street

Characteristics and Constraints

This segment extends approximately 1.8 miles through the cities of Redwood City and San Carlos, includes a partial interchange on the west side (southbound hook off/on ramps) at Brittan Avenue, and is characterized by two distinct sub-segments. From Whipple Avenue to approximately Brittan Avenue (1.0 miles) the freeway is bordered on the east by the San Francisco Bay and on the west by commercial/industrial buildings in Redwood City and San Carlos. There are no frontage roads. A Class 1 bike path runs parallel and immediately adjacent to the freeway along the east side, separated from the freeway by a Type 60 concrete barrier and from the Bay wetlands by a 4-foot high chain link fence. A 24-inch Redwood City reclaimed water line runs the entire distance under the bike path. Cordilleras Creek passes under the freeway through a box culvert north of Whipple.

From Brittan Avenue to Holly Street (0.8 miles) the freeway passes through San Carlos and is bordered on the east side by the Skyway Road frontage road with adjacent commercial/industrial/office buildings and on the west side by commercial/industrial buildings directly abutting the State right of way. The San Carlos Airport lies just east of the freeway between Skyway Road and San Francisco Bay. Pulgas Creek passes under the freeway through a box culvert just north of Brittan.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under Whipple (4 mixed); 5 lanes Whipple to Holly (4 mixed + Aux).
- Proposed – 5 lanes under Whipple (HOV + 4 mixed); short 6 lane segment from Whipple loop on-ramp to Whipple diagonal on-ramp (HOV + 4 mixed + Aux); 5 lanes Whipple to Holly (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under Holly to C-D on-ramp (4 mixed); 5 lanes C-D on-ramp to Whipple (4 mixed + Aux); Brittan hook on-ramp merges into Aux lane.
- Proposed – 5 lanes under Holly to C-D on-ramp (HOV + 4 mixed); 6 lanes C-D on-ramp to Whipple (HOV + 4 mixed + Aux); Brittan hook on-ramp merges into Aux lane.

Required Design Exceptions

- Whipple NB off-ramp - 330' deceleration length (Std 470')
- Holly NB off-ramp - 160' deceleration length (Std 270')
- Non-standard inside shoulder width
- Non-standard outside shoulder width (NB only)
- Some lane widths 11'

Reasons for Exceptions

East Side

a) SF Bay wetlands
b) Class 1 bike path (BCDC "Bay Trail")

West Side

a) Businesses and commercial/industrial buildings at right of way
b) Brittan Ave hook off/on ramps
c) SB Holly to Brittan Collector-Distributor Road

2. Holly Street to Ralston Avenue

Characteristics and Constraints

This segment extends 1.1 miles through the cities of San Carlos and Belmont and includes a partial interchange on the west side (southbound hook off/on ramps) at Harbor Boulevard. The freeway is primarily bordered by office buildings, research & development (R&D) buildings, and commercial/industrial buildings on the east side. The Shoreway Drive frontage road runs parallel to the freeway along the east side between Holly and Ralston. The north half of Shoreway Drive is immediately adjacent to the freeway, separated by a Type 60 concrete barrier. The southern half is separated from the freeway by a vegetated roadside drainage ditch. The west side of the freeway is bordered by commercial/industrial buildings south of Harbor and by a residential trailer park and sound wall north of Harbor. A southbound collector-distributor road runs between the trailer park/sound wall and the freeway from Ralston down to Harbor. A large drainage channel passes under the freeway through 4 large pipe culverts just north of Holly and drains into Phelps Slough. Belmont Creek passes under the freeway through a box culvert just south of Harbor.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under Holly (4 mixed); 5 lanes Holly to Ralston (4 mixed + Aux).
- Proposed – 5 lanes under Holly (HOV + 4 mixed); 5 lanes Holly to Ralston (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under Ralston to C-D on-ramp past Harbor (4 mixed); 5 lanes Harbor/C-D on-ramp to Holly (4 mixed + Aux).
- Proposed – 5 lanes under Ralston to C-D on-ramp past Harbor (HOV + 4 mixed); 6 lanes Harbor/C-D on-ramp to Holly (HOV + 4 mixed + Aux).

Required Design Exceptions

- Holly SB off-ramp - 210' deceleration length measured at CD curve (Std 270') or 410' deceleration length measured at Ramp curve (Std 420')
- Ralston NB off-ramp - 310' deceleration length (Std 420')
- Ralston NB off-ramp – 300' auxiliary lane before two-lane exit (Std 1,300')
- Non-standard inside shoulder widths
- Some lane widths 11'

Reasons for Exceptions

East Side

a) Shoreway Drive frontage road and businesses
b) Phelps slough wetlands

West Side

a) Businesses and commercial/industrial buildings
b) Residential trailer park
c) Existing sound wall and C-D road

3. Ralston Avenue to Hillsdale Boulevard

Characteristics and Constraints

This segment extends 1.6 miles through the cities of Belmont and San Mateo. The Ralston pedestrian overcrossing (POC) is currently being constructed over the freeway through the northern portion of the Ralston Ave interchange. The southern half of the segment is bordered on the east side by O'Neill Slough and SF Bay wetlands, and on the west side by a sound wall and single family residential homes. The northern half is bordered on the east side by a sound wall, the La Selva Street frontage road, and townhomes/multi-family apartment buildings; and on the west side by a sound wall and single family residential homes abutting the sound wall. Laurel Creek passes under the freeway through a box culvert at approximately the midpoint of this

segment. The existing sound wall on the east side is constructed on a retaining wall at the edge of existing shoulder for approximately 600 feet where it crosses over the box culvert. There is a gap in the existing sound wall along the freeway on the west side of the drainage channel since there is a private sound wall set further back between the residential homes and the drainage channel.

Existing/Proposed Cross Section
Northbound

- Existing – 4 lanes under Ralston (4 mixed); 5 lanes Ralston to Hillsdale (4 mixed + Aux).
- Proposed – 5 lanes under Ralston (HOV + 4 mixed); 6 lanes Ralston to Hillsdale (HOV + 4 mixed + Aux).

Southbound

- Existing – 4 lanes under Hillsdale (4 mixed); 5 lanes Hillsdale to Ralston (4 mixed + Aux).
- Proposed – 5 lanes under Hillsdale (HOV + 4 mixed); 6 lanes Hillsdale to Ralston (HOV + 4 mixed + Aux).

Required Design Exceptions

- Ralston SB off-ramp - 120' deceleration length measured at CD curve (Std 270') or 330' deceleration length measured at Ramp curve (Std 420')
- Hillsdale NB off-ramp - 400' deceleration length (Std 470')
- Non-standard inside shoulder widths
- Some lane widths 11'

Reasons for Exceptions
East Side

a) O'Neill Slough wetlands
b) Existing sound wall at edge of shoulder over large drainage channel

West Side

a) Wetland ditch
b) Existing sound wall

4. Hillsdale Boulevard to Route 92

Characteristics and Constraints
This segment extends 0.8 miles through the city of San Mateo and is bordered on both sides by sound walls constructed along the right of way. Immediately behind the sound wall on the east side are single family homes in a residential neighborhood; and immediately behind the sound wall on the west side are multi-story condominiums along the south half of the segment, and single family homes along the north half of the segment. There are no frontage roads adjacent to the freeway in this segment. A drainage channel passes under the freeway just south of SR 92 through a box culvert.

Existing/Proposed Cross Section
Northbound

- Existing – 4 lanes under Hillsdale (4 mixed); 5 lanes Hillsdale to SR 92 (4 mixed + Aux).
- Proposed – 5 lanes under Hillsdale (HOV + 4 mixed); 6 lanes Hillsdale to SR 92 (HOV + 4 mixed + Aux).

Southbound

- Existing – 4 lanes under SR 92 & Fashion Island Blvd (4 mixed); 5 lanes SR 92 to Hillsdale (4 mixed + Aux).
- Proposed – 5 lanes under SR 92 & Fashion Island Blvd (HOV + 4 mixed); 6 lanes SR 92 to Hillsdale (HOV + 4 mixed + Aux).

Required Design Exceptions

- SR 92 SB on-ramps – Distance between successive on-ramps less than 1,000'
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions

East Side

a) Sound wall and residential homes at right of way

West Side

a) Sound wall, businesses and residential condos at right of way

5. Route 92 to 3rd Avenue

Characteristics and Constraints

This segment extends 1.6 miles through the city of San Mateo and includes a partial interchange on the east side (northbound hook off/on ramps) at Kehoe Avenue. Fashion Island Boulevard passes over the freeway on its own overcrossing structure through the middle of the SR 92 interchange. On the east side, the freeway is bordered the entire length by a sound wall and single family residential homes. Beacon Avenue runs parallel to the freeway as a frontage road immediately behind the sound wall for approximately 1,200 feet just south of the 3rd Ave interchange. There are no other frontage roads on the east side. On the west side, the freeway is also bordered by a sound wall for the entire length. South Amphlett Boulevard extends the entire distance from SR 92 to 3rd as a frontage road immediately behind the sound wall. The first half block fronting on South Amphlett Blvd consists primarily of small commercial businesses, a few apartment buildings, and a large Marriott Hotel complex for most of the distance between interchanges. Behind the half block row of businesses are single family residential homes. A large drainage channel passes under the freeway through a box culvert between SR 92 and Kehoe Ave and drains into Seal Slough. San Mateo Creek passes under the freeway and the south half of the 3rd Ave interchange through several low bridge structures and runs directly out to San Francisco Bay.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under SR 92 & Fashion Island (4 mixed); 6 lanes merging to 5 lanes SR 92 to Kehoe (6 to 5 mixed); 5 lanes Kehoe to 3rd (4 mixed + Aux).
- Proposed – 5 lanes under SR 92 & Fashion Island (HOV + 4 mixed); 7 lanes merging to 5 lanes SR 92 to Kehoe (HOV + 6 to 4 mixed); 5 lanes Kehoe to 3rd (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under 3rd (4 mixed); 5 lanes 3rd to SR 92 (4 mixed + Aux).
- Proposed – 5 lanes under 3rd (HOV + 4 mixed); 6 lanes 3rd Ave to lane add (HOV + 4 mixed + Aux); 7 lanes from lane add to SR 92 off-ramp (HOV + 4 mixed + 2 Aux).

Required Design Exceptions

- Kehoe NB off-ramp - 220' deceleration length (Std 270')
- Third NB off-ramp - 110' deceleration length (Std 270')/ non-std ramp geometry
- Third SB on-ramp – non-standard ramp geometry/less than 50 mph design speed
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions

East Side

a) Sound wall and single family homes at right of way
b) Kehoe Ave hook off/on ramps
c) S Bayshore Blvd frontage road

West Side
a) Sound wall
b) South Amphlett Blvd frontage road
c) Commercial businesses

6. 3rd Avenue to Peninsula Avenue

Characteristics and Constraints

This segment extends 1.2 miles through the city of San Mateo and includes a partial interchange on the east side (northbound hook off/on ramps) at Dore Avenue, and a partial interchange on the west side (southbound hook off/on ramps) at Poplar Avenue. The Monte Diablo pedestrian overcrossing (POC) passes over the freeway at approximately the midpoint of this segment. On the east side, the freeway is bordered most of the way by a sound wall from 3rd to north of Dore Ave. North of the sound wall the freeway is bordered by the Poplar Creek Golf Course. Bayshore Boulevard runs the entire distance parallel to the freeway as a frontage road immediately behind the sound wall and then between the freeway and the golf course. Bayshore Blvd frontage road is bordered by small commercial businesses and a few hotels/motels. Beyond the businesses along the frontage road are single family residential homes. On the west side, the freeway is bordered the entire length by a low sound wall. Immediately behind the sound wall, North Amphlett Boulevard runs the entire distance as a frontage road. The first half block fronting on the North Amphlett Blvd frontage road consists primarily of small commercial businesses. Behind the half block row of businesses are single family residential homes.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under 3rd (4 mixed); 5 lanes 3rd to Peninsula (4 mixed + Aux).
- Proposed – 5 lanes under 3rd (HOV + 4 mixed); 5 lanes 3rd to Peninsula (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under Peninsula (4 mixed); 5 lanes Peninsula to 3rd (4 mixed + Aux).
- Proposed – 5 lanes under Peninsula (HOV + 4 mixed); 5 lanes Peninsula to 3rd (HOV + 4 mixed).

Required Design Exceptions

- Third NB on-ramp – non-standard ramp merge
- Third SB off-ramp - 110' deceleration length (Std 270')/ non-std ramp geometry
- Dore NB off-ramp - 240' deceleration length (Std 570')/ non-std ramp geometry
- Poplar SB off-ramp - 90' deceleration length (Std 570')
- Poplar SB on-ramp – non-standard ramp merge
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions

East Side
a) Existing sound wall
b) Bayshore Blvd frontage road
c) Commercial businesses

West Side
a) Existing sound wall
b) North Amphlett Blvd frontage road
c) Commercial businesses

7. Peninsula Avenue to Broadway

Characteristics and Constraints

This segment extends 1.9 miles through the town of Burlingame and includes a partial interchange on the east side (northbound hook off/on ramps) at Anza Boulevard. The Broadway pedestrian overcrossing (POC) passes over the freeway through the southern half of the Broadway interchange. On the east side, the freeway is bordered most of the way by the Anza Lagoon. Lang Road runs for a short distance parallel to the freeway as a frontage road between Peninsula Ave and the Anza Lagoon. Lang Road is bordered by light industrial businesses and warehouses. Anza Boulevard crosses over the lagoon from the hook off/on ramps on a bridge structure to serve businesses and office buildings along a narrow strip of land between the lagoon and SF Bay. On the west side, the freeway is bordered the entire length by a sound wall at the edge of shoulder and the Rollins Road frontage road (name changes to North Amphlett Blvd at the south end just before reaching Peninsula. Rollins Road is bordered primarily by apartment buildings backed by a large neighborhood of single family residential homes. The very north end of Rollins Rd is bordered by commercial business, a car dealership, and some restaurants. North Amphlett at the south end is bordered by commercial businesses.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under Peninsula (4 mixed); 5 lanes Peninsula to Broadway (4 mixed + Aux).
- Proposed – 5 lanes under Peninsula (HOV + 4 mixed); 5 lanes Peninsula to Broadway (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under Broadway (4 mixed); 5 lanes Broadway to Peninsula (4 mixed + Aux).
- Proposed – 5 lanes under Broadway (HOV + 4 mixed); 5 lanes Broadway to Peninsula (HOV + 4 mixed).

Required Design Exceptions

- Peninsula NB off-ramp - 410' deceleration length (Std 470')
- Broadway SB on-ramp – non-standard ramp merge
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions

East Side

a) Anza Lagoon and associated wetlands
b) Lang Road frontage road
c) Anza hook off/on ramps

West Side

a) Existing sound wall
b) Rollins Road/North Amphlett frontage road
c) Apartment buildings and residential homes

8. Broadway to Millbrae Avenue

Characteristics and Constraints

This segment extends 1.4 miles through the town of Burlingame and the city of Millbrae. The freeway is bordered on both sides be commercial business/light industrial uses. There are no sound walls along this segment. On the east side, Gilbreth Road runs parallel to the freeway as a frontage road along the middle third of the segment. On the west side, Adrian Road runs parallel to the freeway along the north two-thirds of the segment as a frontage road. There is no frontage road along the west side in the south third of the segment. Two separate drainage channels pass under the freeway through box culverts in the south third of the

segment. Another two drainage channels pass under the freeway in separate box culverts just south of the Millbrae Ave interchange.

Existing/Proposed Cross Section
Northbound

- Existing – 4 lanes under Broadway (4 mixed); 5 lanes Broadway to Millbrae (4 mixed + Aux).
- Proposed – 5 lanes under Broadway (HOV + 4 mixed); 5 lanes Broadway to Millbrae (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under Millbrae (4 mixed); 5 lanes Millbrae to Broadway (4 mixed + Aux).
- Proposed – 5 lanes under Millbrae (HOV + 4 mixed); 5 lanes Millbrae to Broadway (HOV + 4 mixed).

Proposed Broadway Interchange Replacement
A new Broadway interchange is currently under design and is in the final PA/ED stage, sponsored by the City of Burlingame and SMCTA. The current structure design in the proposed preferred alternative will allow for five lanes to pass under the bridges in each direction.

Required Design Exceptions

- Broadway SB off-ramp - 270' deceleration length (Std 470')
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions
East Side

a) Businesses and commercial/industrial buildings at right of way
b) Gilbreth frontage road

West Side

a) Businesses and commercial/industrial buildings at right of way
b) Adrian frontage road

9. Millbrae Avenue to SFO Connector Ramps

Characteristics and Constraints
This segment extends 1.2 miles through the city of Millbrae and adjacent to the San Francisco International airport (SFO). There are no sound walls along this segment. On the east side the freeway is bordered by SFO, the South McDonnell Road frontage road, and a long, complex, braided ramps system serving the northbound access to SFO and the Millbrae Ave on-ramps. The Millbrae Sewer Treatment Plant is located immediately adjacent to the freeway, just north of the Millbrae Ave overcrossing within the northeast quadrant of the Millbrae Ave interchange. On the west side, the freeway is bordered by an extended stretch of wetlands and special status species habitat. A large drainage channel passes under the freeway on a bridge structure just north of the Millbrae Ave interchange.

Existing/Proposed Cross Section
Northbound

- Existing – 4 lanes under Millbrae (4 mixed); 5 lanes approaching SFO braided off-ramp (4 mixed + Aux); 4 lanes SFO off-ramp to Millbrae braided on-ramp (4 mixed); 5 lanes Millbrae on-ramp northbound continuing under SFO connector ramps (5 mixed).
- Proposed – 5 lanes under Millbrae (HOV + 4 mixed); 6 lanes approaching SFO braided off-ramp (HOV + 4 mixed + Aux); 5 lanes SFO off-ramp to Millbrae braided on-ramp (HOV + 4 mixed); 6 lanes Millbrae on-ramp northbound continuing under SFO connector ramps (HOV + 5 mixed).

Southbound

- Existing – 5 lanes under SFO connector ramps (5 mixed); 6 lanes south of SFO on-ramps (4 mixed + 2 Aux); 5 lanes SFO Aux lane drop to Millbrae (4 mixed + Aux).

- Proposed – 6 lanes under SFO connector ramps (HOV + 5 mixed); 5 lanes from lane drop to SFO on-ramps (HOV + 4 mixed); 6 lanes south of SFO on-ramps (HOV + 4 mixed + 1 Aux).

Required Design Exceptions
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions
East Side
a) Complex, multi-lane braided ramps
b) McDonnell frontage road
c) San Francisco Airport

West Side
a) Wetlands and special status species habitat

10. SFO Connector Ramps to San Bruno Avenue

Characteristics and Constraints
This segment extends 1.2 miles through the city of San Bruno and adjacent to the San Francisco International airport (SFO). The BART-SFO access rail line crosses over the freeway on a high overcrossing structure just north of the SFO connector ramp overcrossings. There are no sound walls along this segment. On the east side the freeway is bordered by SFO, the North McDonnell Road frontage road, and the 2-lane elevated SFO-380 northbound connector structure. On the west side, the freeway is bordered by an extended stretch of wetlands and special status species habitat and the 3-lane at-grade 380-SFO southbound collector-distributor road.

Existing/Proposed Cross Section
Northbound
- Existing – 5 lanes under SFO connector ramps (5 mixed); 6 lanes SFO NB on-ramp to San Bruno Ave (4 mixed + 2 Aux) (1 Aux exits to San Bruno Ave and 1 Aux exits to WB 380).
- Proposed – 6 lanes under SFO connector ramps (HOV + 5 mixed); 6 lanes SFO NB on-ramp to San Bruno Ave (HOV + 4 mixed + Aux).

Southbound
- Existing – 4 lanes under San Bruno Ave (4 mixed); 5 lanes from I-380 slip on-ramp southbound continuing under SFO connector ramps (5 mixed).
- Proposed – 5 lanes under San Bruno Ave (HOV + 4 mixed); 6 lanes from I-380 slip on-ramp southbound continuing to lane drop under SFO connector ramps (HOV + 5 mixed).

Required Design Exceptions
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions
East Side
a) SFO Infrastructure and facilities
b) I-380 elevated connector structure
c) North McDonnell frontage road

West Side
a) Wetlands and special status species habitat
b) I-380/SFO C-D road

11. San Bruno Avenue to I-380

Characteristics and Constraints

This segment extends 0.3 miles through the city of San Bruno and adjacent to the San Francisco International airport (SFO). There are no sound walls along this segment. This segment of freeway is sandwiched between multiple sections of freeway ramps and connectors. On the east side are the 101 to EB 380/North Access Rd connector ramp structure and the northbound San Bruno Ave/SFO on-ramp C-D road. On the west side are the WB 380/North Access Rd to 101 connector ramp and the SFO/San Bruno Ave/North Access Rd C-D road. San Bruno Creek passes under this segment of the freeway through a long box culvert and empties into the San Bruno Channel on the east side of the 101/380 interchange complex.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under San Bruno Ave and continuing under I-380 OC and Connector Ramps (4 mixed).
- Proposed – 5 lanes under San Bruno Ave and continuing under I-380 OC and Connector Ramps (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under I-380 OC and Connector Ramps and continuing under San Bruno Ave (4 mixed).
- Proposed – 5 lanes under I-380 OC and Connector Ramps and continuing under San Bruno Ave (HOV + 4 mixed).

Required Design Exceptions

- N Access Rd NB off-ramp - 200' deceleration length (Std 270')
- Non-standard inside shoulder width
- Some lane widths 11'

Reasons for Exceptions

East Side

a) I-380 Connector structure columns and approaches

West Side

a) I-380 Connector structure columns and approaches

12. I-380 to SSF OH

Characteristics and Constraints

This segment extends 1.2 miles through the city of South San Francisco. The east side is primarily bordered by industrial and commercial buildings with a section of wetlands at the south end near the 101/380 interchange where the San Bruno Channel passes through. The east side is primarily bordered by parking lots for the San Francisco Airport, as well as industrial and storage buildings.

In the middle of this segment in the NB direction, there is a partial hook ramp interchange to South Airport Boulevard, which roughly runs parallel to but offset from Route 101 on the east side. In the NB direction, there is also an isolated diagonal off-ramp to Executive Drive/East Grand Boulevard. In the SB direction, there is a partial interchange to Produce Avenue/South Airport Blvd, with a hook off-ramp and diagonal on-ramp. This diagonal on-ramp also serves as a two-way frontage road for Terminal Court, which is a cul-de-sac that intersects the on-ramp right before it merges onto Route 101.

Toward the south end of this segment, a large canal crosses underneath Route 101 in box culverts, which feed into Colma Creek. Toward the north end of this segment, Colma Creek passes underneath the Colma Creek Bridge, South Airport Boulevard passes underneath the Colma Road UC, and a RR track spur passes underneath the South San Francisco Belt Railway OH.

Existing/Proposed Cross Section
Northbound

- Existing – 4 lanes from I-380 OC to 380 on-ramp (4 mixed); 6 lanes from 380 on-ramp to South Airport Boulevard off-ramp (4 mixed + 2 Aux); 5 lanes from South Airport Boulevard off-ramp to East Grand Boulevard off-ramp (4 mixed + Aux); 4 lanes from East Grand Boulevard off-ramp to SSF OH (4 mixed).
- Proposed – 5 lanes from 380 OC to 380 on-ramp (HOV + 4 mixed); 6 lanes from 380 on-ramp to South Airport Boulevard off-ramp (HOV + 4 mixed + Aux); 5 lanes from South Airport Boulevard off-ramp to SSF OH (HOV + 4 mixed).

Southbound

- Existing – 4 lanes from SSF OH to Produce Avenue on-ramp (4 mixed); 6 lanes from Produce Avenue on-ramp to WB 380 off-ramp (4 mixed + 2 Aux); 5 lanes from WB 380 off-ramp to SFO/San Bruno Avenue/North Access Rd off-ramp (4 mixed + Aux); 4 lanes from SFO/San Bruno/North Access off-ramp to I-380 (4 mixed).
- Proposed – 5 lanes from SSF OH to Produce Avenue on-ramp (HOV + 4 mixed); 7 lanes from Produce Avenue on-ramp to WB 380 off-ramp (HOV + 4 mixed + 2 Aux); 6 lanes from WB 380 off-ramp to SFO/San Bruno Avenue/North Access Rd off-ramp (HOV + 4 mixed + Aux); 5 lanes from SFO/San Bruno/North Access off-ramp to I-380 (HOV + 4 mixed).

Required Design Exceptions

- Non-standard outside shoulder width (NB at Colma Creek Bridge)
- Non-standard connector merge at 380 NB on-ramp
- Non-standard inside shoulder widths
- Some lane widths 11'

Reasons for Exceptions
East & West Sides

a) To avoid reconstructing the 380 Separation structures and widening bridge and OH/UC structures (inside shoulder widths). The freeway median barrier is proposed to be realigned to provide balanced lane/shoulder configurations in both directions.

East Side

a) Some NB lanes are required to be narrowed to 11' between 380 and South Airport Boulevard to avoid widening canal bridge structure and to avoid making deceleration length to tight South Airport Boulevard hook off-ramp nonstandard.
b) Spot location of minimum 8' outside shoulder at Colma Creek Bridge to avoid widening structure.

13. SSF OH to Oyster Point Boulevard

Characteristics and Constraints
This segment extends 0.9 miles through the city of South San Francisco. The east side is bordered by Dubuque Avenue frontage road immediately adjacent to the freeway, separated by a Type 60 concrete barrier. Behind Dubuque Avenue are primarily industrial and commercial buildings. The west side is bordered by Airport Boulevard frontage road separated by a retaining wall and/or a row of trees and vegetation. Behind Airport Blvd are primarily commercial or industrial buildings bordering downtown South San Francisco. The southern portion of this segment is the South San Francisco Overhead structure which is approximately 800 feet long and crosses over 6 RR tracks (Caltrain and UPRR), East Grand Avenue, and the NB diagonal on-ramp.

Existing/Proposed Cross Section
Northbound

- Existing – 4 lanes at SSF OH (4 mixed); 5 lanes East Grand to Oyster Point (4 mixed + Aux).
- Proposed – 5 lanes at SSF OH (HOV + 4 mixed); 5 lanes East Grand to Oyster Point (HOV + 4 mixed).

Southbound

- Existing – 5 lanes Oyster Point to East Grand (4 mixed + Aux); 4 lanes at SSF OH (4 mixed).
- Proposed – 5 lanes Oyster Point to East Grand (HOV + 4 mixed); 5 lanes at SSF OH (HOV + 4 mixed).

SSF Overhead Modifications

To fit a fifth through lane each direction across the SSF OH the structure would be widened slightly by infill structure widening between the two existing side-by-side structures. Ten lanes would be provided by converting existing auxiliary lanes (north and south of the SSF OH), narrowing shoulders and all lanes, and realigning the freeway median barrier.

Required Design Exceptions

- Grand Ave SB off-ramp - 110' deceleration length (Std 270')
- Grand Ave NB on-ramp – non-standard merge length
- Oyster Point Blvd SB on-ramp – non-standard merge length
- Non-standard inside shoulder widths
- Non-standard outside shoulder widths (at SSF OH)
- All lane widths 11' (at SSF OH)

Reasons for Exceptions

East & West Sides

a) SSF OH structure cannot be widened to the east side because it would create nonstandard vertical clearance to the RR tracks that pass beneath it (lane and shoulder widths)
b) Adjacent frontage roads, retaining wall and barriers (inside shoulder widths)

14. Oyster Point Boulevard to Sierra Point Off-ramp Separation

Characteristics and Constraints

This segment extends 0.6 miles through the cities of South San Francisco and Brisbane. The east side is bordered by a canal that drains beneath the RR tracks to SF Bay, and on the west side by the Bay Shore Boulevard/ Airport Boulevard frontage road. In the middle of this segment in the SB direction only, there is a partial hook ramp interchange to the Bay Shore Boulevard/ Airport Boulevard frontage road.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes under Oyster Point Boulevard (4 mixed); 5 lanes Oyster Point to Sierra Point Off-ramp (4 mixed + Aux).
- Proposed – 5 lanes under Oyster Point Boulevard (HOV + 4 mixed); 5 lanes Oyster Point to Sierra Point Off-ramp (HOV + 4 mixed).

Southbound

- Existing – 4 lanes under Sierra Point Off-ramp Separation to Oyster Point Blvd (4 mixed).
- Proposed – 5 lanes under Sierra Point Off-ramp Separation to Oyster Point Blvd (HOV + 4 mixed).

Required Design Exceptions

- Bayshore Blvd SB on-ramp – non-standard merge length
- Oyster Pt East SB off-ramp - 180' deceleration length (Std 270')
- Non-standard outside shoulder width (SB at Oyster Point Blvd)
- Non-standard inside shoulder widths
- Some lane widths 11' (SB direction and at Oyster Point Blvd)

Reasons for Exceptions

East & West Sides

a) To avoid reconstructing the Oyster Point OC and Separation structures (lane and shoulder widths)

West Side

a) Bay Shore Blvd and Oyster Point Blvd Ramps.

15. Sierra Point Off-ramp Separation to Sierra Point OH

Characteristics and Constraints

This segment extends 0.3 miles through the city of Brisbane. The southern half of the segment is bordered on the east side by the Sierra Point Parkway off-ramp and RR tracks, and on the west side by the Bay Shore Boulevard frontage road. The northern half consists of the approximately 700' long Sierra Point Overhead structure which crosses over 2 RR tracks (Caltrain & UPRR) and Sierra Point Parkway.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes Sierra Point Off-ramp Separation through Sierra Point OH (4 mixed).
- Proposed – 5 lanes Sierra Point Off-ramp Separation through Sierra Point OH (HOV + 4 mixed).

Southbound

- Existing – 4 lanes across Sierra Point OH to Sierra Point Off-ramp Separation (4 mixed).
- Proposed – 5 lanes across Sierra Point OH to Sierra Point Off-ramp Separation (HOV + 4 mixed).

Sierra Point Overhead Modifications

To fit a fifth through lane each direction across the Sierra Point OH, the structure could be widened on the outsides to accommodate 10 lanes.

Required Design Exceptions

- Non-standard inside shoulder widths

Reasons for Exceptions

East & West Sides

a) Bay Shore Blvd and Oyster Point Blvd Ramps and to maintain consistency of inside shoulder widths for the proposed freeway segments immediately north and south of this segment.

16. Sierra Point OH to SF County Line

Characteristics and Constraints

This segment extends 2.4 miles through the city of Brisbane and includes a partial interchange on the west side at Sierra Point Parkway (SB off/on hook ramps). The southern half of the segment is bordered on the east side by SF Bay, and on the west side by the Sierra Point Parkway frontage road and adjacent Brisbane Lagoon. The northern half is bordered on the east side by SF Bay and Harney Way, and on the west side by a large undeveloped swath of land owned by Universal Paragon Corporation which is planned for development with the Brisbane Baylands project. A large drainage channel passes under the freeway through a box culvert between Brisbane Lagoon and SF Bay.

Existing/Proposed Cross Section

Northbound

- Existing – 4 lanes Sierra Point OH to SF County Line (4 mixed) with a 2,400' Aux lane added before the Harney Way off-ramp.
- Proposed – 5 lanes Sierra Point OH to Harney Way off-ramp lane add (HOV + 4 mixed); 6 lanes for 2,400' before Harney Way off-ramp (HOV + 4 mixed + Aux); 5 lanes Harney Way off-ramp to lane add just north of Third Street in SF County (5 mixed).

Southbound

- Existing – 4 lanes SF County Line to Sierra point OH (4 mixed).
- Proposed – 5 lanes SF County Line to Sierra Point OH (HOV + 4 mixed).

Required Design Exception

- Third St (SF) NB off-ramp – 230' deceleration length (Std 270')
- Non-standard inside shoulder widths
- Some lane widths 11' (SB direction)

Reasons for Exception

East & West Sides

a) Utilize existing wide inside shoulder without widening/realigning entire freeway or impacting SF Bay shore line and Brisbane Lagoon.

7.3. Future Conversion of HOV Lanes to Express Lanes

The geometric feasibility and effects of possible ultimate conversion of the HOV lanes to Express Lanes was evaluated for the corridor. Caltrans' "Traffic Operations Policy Directive No. 11-02" (PD 11-02), dated April 7, 2011, provides the current guidance on Express Lane planning and design. The "2003 HOV Guidelines" provide supporting design guidance unless superseded by the PD 11-02. The standards for Express Lane layout, striping, and toll collection methods are continually evolving as this is a relatively new feature for State highways in California.

Due to the dense, urban nature of this corridor, the many existing constraints, and the typically short distance between on and off ramps, it is assumed that an ultimate Express Lane, if implemented, would have to be a continuous access type lane rather than a limited-access type lane. The 2003 HOV Guidelines and guidance provided by PD 11-02 indicate that the Express Lane would not likely have a buffer separation since there is not sufficient room between on and off ramps to provide the necessary distances between ingress/egress sections of the buffer and the ramp entrance/exit points. At most, the lane divider stripe would likely be restriped with a wider white dash than is used for the HOV lane to indicate that the lane has a special purpose and the HOV diamond symbols would be removed.

Thus the primary impact of converting HOV lanes to Express Lanes would likely be the need for installation of equipment for reading FasTrak Electronic Toll Collection devices. These would likely be median barrier mounted poles with ETC card readers and associated wiring and communication infrastructure. Additional signage would need to be installed to clarify usage of the Express Lanes.

There may also be a need for additional or enhanced CHP enforcement areas beyond those that may be approved for an HOV only facility. If additional median CHP enforcement areas are needed, high costs may be incurred to widen the freeway in constrained areas to provide room for these.

8. Cost Estimates

This chapter presents the preliminary cost estimate for the hybrid HOV lane concept including project development, right of way, and construction costs, and discusses the methodology used to develop the estimate.

8.1. Cost Estimate Summary

Based on preliminary analysis, the cost is estimated to range between $285 million and $325 million.

A standardized 1-page conceptual design cost estimate format was developed for each of the 16 study location segments (defined previously in Chapter 2) to provide a uniform method of totaling costs for the hybrid HOV lane concept. Each segment goes from center of overcrossing to center of overcrossing and includes both northbound and southbound work in that segment. The 1-page format is loosely based on the Caltrans Project Study Report (PSR) cost estimate format, but is simplified and streamlined to fit the conceptual design analysis of this study. The individual segment cost estimates are included in Appendix J.

Exhibit 25 summarizes the cost estimates for each of the 16 segments broken down into the primary categories: (1) Roadway Items, (2) Structure Items, (3) Right of Way Items, and (4) Soft Costs.

The current phase of analysis does not include detailed study of the interchanges themselves but primarily focuses on the work required to extend the new, fifth freeway lane each direction through the bridge structures at each interchange. Since the Route 101 corridor in San Mateo County is so heavily constrained by existing development, these cost estimates assumed that the design exceptions outlined in Chapter 7 would be approved, and that the interchange off-ramps would just be shortened by the amount needed to extend the fifth lane past the off-ramp. This typically shortens the off-ramp deceleration length to less than the current Caltrans standard and would require a design exception from Caltrans as noted previously. To provide a standard deceleration length, the off-ramp would typically have to be relocated laterally outward requiring additional right of way and impacting frontage roads, businesses, residences, and environmentally sensitive areas outside the State right of way.

The individual segment cost estimates only include a small amount of additional pavement reconstruction at each off-ramp to account for vertical adjustments to the ramp/freeway connection after widening. A cost range was added at the end of this cost summary table to capture potential additional project costs for improving off-ramp deceleration lengths. The amount of this additional cost would vary depending on the extent to which Caltrans is able to grant design exceptions for non-standard deceleration lengths. Until further detailed study is completed at each interchange location and this information is discussed with Caltrans the cost can only be estimated as a possible range between $10 million and $40 million.

Exhibit 25: Route 101 Hybrid HOV Lane Cost Estimate Summary Table

Location Name	Roadway Subtotal	Structure Subtotal	Right of Way Subtotal	Soft Costs Subtotal	Total Costs
1. Whipple Avenue to Holly Street	$13,720,000	$230,000	$1,910,000	$5,360,000	$21,200,000
2. Holly Street to Ralston Avenue	$8,330,000	$80,000	$1,160,000	$3,230,000	$12,800,000
3. Ralston Avenue to Hillsdale Blvd.	$19,040,000	$550,000	$2,370,000	$7,490,000	$29,500,000
4. Hillsdale Boulevard to Route 92	$9,590,000	$0	$100,000	$3,560,000	$13,300,000
5. Route 92 to 3rd Avenue	$12,570,000	$230,000	$4,700,000	$5,210,000	$22,700,000
6. 3rd Avenue to Peninsula Avenue	$4,060,000	$0	$1,270,000	$1,640,000	$7,000,000
7. Peninsula Avenue to Broadway	$9,780,000	$0	$660,000	$3,690,000	$14,100,000
8. Broadway to Millbrae Avenue	$6,280,000	$150,000	$230,000	$2,410,000	$9,100,000
9. Millbrae Avenue to SFO Conn.	$12,110,000	$0	$400,000	$4,530,000	$17,000,000
10. SFO Conn. to San Bruno Avenue	$12,700,000	$0	$300,000	$4,730,000	$17,700,000
11. San Bruno Avenue to I-380	$4,740,000	$0	$100,000	$1,770,000	$6,600,000
12. I-380 to SSF OH	$15,080,000	$330,000	$500,000	$5,760,000	$21,700,000
13. SSF OH to Oyster Point Blvd.	$6,570,000	$6,950,000	$300,000	$5,040,000	$18,900,000
14. Oyster Point Blvd to S.P. Off Sep.	$8,130,000	$3,640,000	$300,000	$4,390,000	$16,500,000
15. S.P. Off Sep. to Sierra Point OH	$7,680,000	$10,040,000	$300,000	$6,590,000	$24,600,000
16. Sierra Point OH to SF County Line	$22,960,000	$210,000	$400,000	$8,620,000	$32,200,000
Category Totals	$173,300,000	$22,400,000	$15,000,000	$74,000,000	
	GRAND TOTAL (with shortened off-ramps)				$285,000,000
Potential Additional Cost for improving deceleration lengths at off-ramps				$10,000,000 to	$40,000,000
	POTENTIAL GRAND TOTAL (with relocated/lengthened off-ramps)			$295,000,000 to	$325,000,000

8.2. Cost Estimation Methodology

The 1-page cost estimate format consists of a heading section that identifies the location and length of the segment. Beneath the heading is the cost estimate for four primary categories: (1) Roadway Items, (2) Structure Items, (3) Right of Way Items, and (4) Soft Costs.

(1) Roadway items include the cost of actual infrastructure improvements on the ground and the associated work to construct them, such as pavement, barriers, walls, traffic control/staging, and drainage.

The primary driver for developing the roadway item cost estimates for each segment was the amount of widening (new pavement) and retaining walls/barriers required for each segment. A unit cost for new pavement was developed based on historic trends and recent construction costs and includes all the items necessary to construct a typical freeway or ramp structural section down to the subgrade, including excavation and ADL material treatment. A similar unit cost for retaining wall, sound wall, and concrete barrier was developed which includes foundations, excavation, and backfill. A few other easily identified items were also quantified such as area of clearing and demo, amount of overlay, ramp metering relocations, and overhead sign relocations. An initial lump sum cost was then established for less easily quantified items such as traffic control, storm drainage, and water pollution control/treatment as a percentage of the primary work based on other major freeway project average costs for these items. The lump sum items were finally adjusted up or

down from the standard percentage for each segment based on unique aspects or complexities and type/magnitude of work in that segment.

Minor and miscellaneous items capture the cost of smaller items such as fences, signing and striping, sidewalks, etc. Roadway additions cover work that cannot be predicted or calculated beforehand because of its uncertain nature or amount, such as removal of unsuitable material, increases in asphalt content, etc. Mobilization is the cost for the contractor to get started on the work and mobilize equipment for each stage of construction. Contingency cost is included to account for the preliminary, conceptual level of the estimates, and is separate from roadway additions. Contingency costs are lowered as the design of a project progresses and becomes more detailed.

(2) Structure items include the cost of widening or rebuilding concrete and steel overcrossing, overhead and bridge structures. The structure widening unit cost was developed from established preliminary engineering unit cost data for standard freeway bridge work and then adjusted upward for bridges with especially complex or complicating features.

(3) Right of way items include the cost of acquiring private property, relocating utilities, and providing environmental mitigation for project impacts to environmentally sensitive areas including anticipated wetlands.

(4) Soft Costs are the support costs required to get the project environmentally cleared, designed, and built, including environmental and engineering studies & reports; plans, specifications and estimates; construction support and administration; surveying; and right of way engineering and acquisition services.

Since it has not been determined yet exactly how the project segments might be phased and constructed over time, the soft costs were calculated based on a percentage of construction cost for each individual segment. If multiple segments were to be combined into one project, however, there should be some economy of scale realized in the soft costs and they would be expected to be lower as a percentage of the total construction cost (i.e. the combined soft cost for a group of segments done together as one project should be lower than the total of the estimates for each segment individually that are shown in these estimates).

Additional Cost Estimate Assumptions

A cost to overlay the freeway with a new layer of asphalt concrete pavement (0.1' thick) was assumed wherever the existing traveled lanes are proposed to be shifted in order to provide a clean finished surface free of striping grind marks. Where lanes are proposed to be shifted onto existing shoulders with thin pavement sections, the existing shoulders are assumed to be replaced with new traffic rated pavement sections.

At all on-ramps within project limits, new ramp metering equipment was assumed in the cost estimate if the ramp was realigned. An HOV preferential lane was also assumed at most of the on-ramps if adding the extra lane did not involve a large right of way acquisition or environmental impact. Cost for barriers and retaining walls were assumed if embankment from widening the roadway would impact adjacent private right of way or environmentally sensitive areas such as creeks, canals/ditches and the bay.

Water pollution control and water treatment costs are difficult to estimate at this stage because of the conceptual level of the layout plans and because of evolving standards for more stringent storm water runoff treatment. Based on evaluation of the study segments, a range of 15% to 30% of the pavement costs were assumed for water pollution control and water treatment costs depending on the amount of widening and availability of adjacent pervious surfaces to provide biofiltration swales. Costs for underground utility relocations are also difficult to estimate without further information on what is currently in place. Research of existing as-built plans and observation of above ground utilities guided cost estimation for this item.

Unit costs and percentages for all of the items were developed from a combination of analyzing similar types of freeway projects already constructed, historical cost data available from Caltrans, and previous experience with these types of estimates.

The cost estimate is based on the geometry and design exceptions identified in Chapter 7. Depending on Caltrans' acceptance of non-standard ramp geometry, costs could increase for on-ramps by making them more standard with added HOV preferential lanes and longer merge tapers.

For the segment from 3rd Ave to Route 92, cost estimates were prepared for two separate southbound alternatives. The alternative that is included in the overall 101 hybrid HOV lane project cost is the one that assumes a full auxiliary lane from 3rd Ave on-ramp to Route 92 off-ramp, which widens the freeway out into the parallel frontage road (Amphlett Blvd). This requires reconstruction of the adjacent soundwall and either eliminating on-street parking along this section of Amphlett Blvd, or converting it to a one-way street which would allow room for parking. The alternative that assumes no auxiliary lane between 3rd Ave on-ramp and Route 92 off-ramp would not impact the adjacent soundwall and frontage road, and would therefore cost $10M less (including soft costs) than the alternative with full auxiliary lane.

8.3. Primary Work effecting cost in each Segment

This section lists the primary work driving the cost in each segment.

1. Whipple Avenue to Holly Street

- Outside widening on southbound (SB) side with retaining walls, barriers and C-D road realignment
- SB side widening requires widening of Cordilleras Creek and Pulgas Creek bridge structures
- SB side widening requires strip right of way acquisition from adjacent business parking lots
- SB side widening impacts adjacent roadside ditch wetlands
- Freeway median barrier realigned north of Whipple to avoid impact to northbound (NB) side wetlands

2. Holly Street to Ralston Avenue

- Outside widening on SB side with barriers and C-D road realignment
- SB side widening requires widening of Belmont Creek bridge structure

3. Ralston Avenue to Hillsdale Boulevard

- Outside widening on both NB & SB sides with new median barrier for CHP enforcement
- Widening on NB side requires barrier, retaining walls and sound walls and impact to adjacent slough/wetlands
- Widening on both NB & SB sides of Laurel Creek bridge structure

4. Hillsdale Boulevard to Route 92

- Outside widening on both NB & SB sides

5. Route 92 to 3rd Avenue

- Outside widening on both NB & SB sides
- Widening on SB side requires sound wall reconstruction, frontage road reconfiguration, underground gas line relocation and right of way take
- Freeway median barrier realigned to the east to reduce impacts on SB side
- Widen creek bridges for 3rd Ave ramp realignments

6. 3rd Avenue to Peninsula Avenue

- Realign 3rd Ave ramps
- Realign SB Poplar Ave ramps

7. Peninsula Avenue to Broadway

- Realign NB Peninsula Ave ramp with retaining wall, barrier, frontage road reconfiguration and right of way take

8. Broadway to Millbrae Avenue

- Realign NB Broadway ramp with barrier and drainage canal bridge widening
- Outside widening south of Millbrae Ave
- Inside freeway pavement and median barrier replacement south of Millbrae Ave

9. Millbrae Avenue to SFO Connector Ramps

- Replace inside shoulders with traffic-rated pavement structural section
- Replace and realign median barrier

10. SFO Connector Ramps to San Bruno Avenue

- Replace inside shoulders with traffic-rated pavement structural section
- Replace and realign median barrier

11. San Bruno Avenue to I-380

- Outside widening on NB side with some retaining wall
- Replace inside shoulders with traffic-rated pavement structural section
- Replace median barrier

12. I-380 to SSF OH

- Outside widening on both NB & SB sides
- Replace inside shoulders with traffic-rated pavement structural section
- Replace and realign median barrier
- Widen bridges over Colma Creek channels

13. SSF OH to Oyster Point Boulevard

- Outside widening south of Oyster Point Blvd
- Widen South San Francisco Overhead freeway bridge structure in median
- New retaining walls

14. Oyster Point Boulevard to Sierra Point Off-ramp Separation

- Outside widening on both NB & SB sides
- Replace Sierra Point Off-ramp Separation structure
- New retaining walls

15. Sierra Point Off-ramp Separation to Sierra Point OH

- Outside widening on both NB & SB sides
- Widen Sierra Point Overhead freeway bridge structure on both sides
- New retaining walls

16. Sierra Point OH to SF County Line

- Outside widening on both NB & SB sides north of Sierra Point Overhead
- Outside widening on NB side north of Harney Way to 3rd Avenue
- Widen Blanken Avenue undercrossing structure on NB side
- Replace inside shoulders with traffic-rated pavement structural section
- Replace median barrier
- New retaining walls

9. Conclusions

This study has investigated the traffic operation effects, road geometry and costs of the hybrid HOV lane option to extend the existing HOV lane from Whipple Avenue in Redwood City, to Harney Way in San Francisco County, in both directions. This would provide a continuous carpool lane facility connecting San Francisco, through San Mateo, and Santa Clara counties. The continuous HOV lane would encourage more users to carpool, in the order of 2% to 3%, in addition to the existing 16% carpool travelers.

In terms of freeway operations in the mixed-flow lanes, the hybrid HOV lane option would take away auxiliary lanes between freeway interchanges where there are right-of-way constraints and no significant operational effects are anticipated. With the proposed option, there would be some minor shifts in bottleneck locations throughout the corridor, and a few new bottlenecks would result from taking away auxiliary lane. However, these effects would not significantly affect mainline operations.

Carpool vehicles and express transit buses would experience much improved travel time savings and reliabilities through the HOV lane. The analysis found that average peak period travel times for HOV's would be improved on the order of 11 to 32 minutes, through the entire length of the corridor.

The hybrid HOV lane option would increase freeway VMT by 7% compared to the baseline conditions. Freeway vehicle hours of travel and delay would be decreased in the order of 3% and 9%, respectively, and system-wide person hours of delay would be reduced by 8%.

The hybrid HOV lane option on US 101 would enable the US 101 freeway to move more vehicles through the US 101 corridor, therefore, reducing vehicle traffic on the parallel arterial system within the county, including major routes such as the El Camino Real, and Interstate 280.

9.1. Staging Option

This study evaluated the hybrid HOV lane option for the entire length between Whipple Road and San Francisco county line. As the results have shown, it would be most beneficial to have that lane implemented the full length of the County in both directions. However, should funding and other constraints require a staged implementation, then a logical staging end point of the hybrid HOV lane could be the I-380 interchange. Therefore, the first stage of the hybrid HOV lane option could extend from Whipple Road to the I-380 interchange. The I-380 interchange is identified as a potential staging limit because HOV volumes are generally lower (on the order of 10% to 17% lower) north of I-380. In addition, there would be relatively minor traffic congestion north of I-380, except for southbound PM peak conditions, where both the baseline and hybrid HOV lane option would result in significant queues backing up into San Francisco County.

9.2. Next Steps

If the stakeholders wish to proceed with implementation of the hybrid HOV lanes on US 101, the next step would be to conduct the traffic, design, and other analyses appropriate for the next stage of the project development process. During the next phase, traffic forecast volumes may need to be updated using the new C/CAG model that recently became available in October, 2011 (with a more recent socio-economic dataset of ABAG projections). Freeway mainline analysis may need to be updated as well in light of changes in the forecast results using the new model and land use forecasts. In addition, more detailed ramp capacity analysis, and ramp intersection analysis would be required to further evaluate ramp queuing effects on arterial streets and freeways along the corridor.

10. Appendices

A. Detail 2040 Extrapolated Forecast Results

B. Detail FREQ Subsection Input Data

C. Detail FREQ Output Graphics for Bottleneck Locations and Queues

D. Detail FREQ input and output files

E. Detail FREQ simulated on-ramp queues

F. Proposed Design Summary Table

G. Schematic Exhibit of Route 101 Corridor

H. Layout Sheets

I. Cross Sections at Critical Constraint Points

J. Cost Estimates

11. Response to Comments

Comments provided by stakeholders are based on individual Deliverables 4B, 4C, 4D, and 5. Those individual memorandums were combined into this Final Mainline Report. In responding to comments, if revisions or additions were made, references are provided in this final document.

Comments provided by: Lance Hall, Office of Highway Operations, Caltrans, January 11, 2012.

Response prepared by: Kevin Chen, Kittelson & Associates/ Dowling
Brad Leveen, Karsten Adam, Mark Thomas Co.
January 31, 2012

Deliverable 4D:

1. Comment: Executive Summary, last paragraph, page 4: The memorandum states *the hybrid option would also result in minor shifts to bottleneck locations throughout the corridor with a few new bottlenecks forming due to the loss of the auxiliary lane.* If these auxiliary lanes where maintained would this relieve these bottlenecks?

   Response: Auxiliary lanes were proposed to be removed from those locations due to right of way constraints. Based on traffic forecast, the hybrid HOV lane would provide higher throughput in those segments than an auxiliary lane and providing an overall benefit to the system. If auxiliary lanes were to be retained, delays associated with those bottleneck locations identified could potentially be reduced or eliminated, but additional new bottleneck could form downstream from releasing additional traffic from these bottlenecks, and would also increase delays at expected downstream bottleneck locations. Other design alternatives could be explored should the study progress to the next phase.

   Follow-up Comment: How was it determined which auxiliary lanes were retained and which were removed?

   Follow-up Response: The following description has been added to the report regarding determination of auxiliary retention:

   Initially, HOV volumes were compared to potential auxiliary lane volumes (on-ramp or off-ramp volumes) in each freeway segment, if HOV volumes are higher than the highest auxiliary lane ramp volume, then the lane conversion would likely yield operational improvements for non-HOV traffic, and therefore the auxiliary lane could be eliminated (actually the auxiliary lane would be extended through the adjacent intersections to become a new through lane, and the existing left hand through lane would be converted to HOV lane operation, in effect, adding an HOV lane and eliminating the auxiliary lane). Conversely, if HOV volumes are lower, then it would likely be required to retain the auxiliary lane in order to maintain mixed-flow traffic service levels, in which case, the freeway would then need to be widened to accommodate the lane addition. Subsequently, more detailed FREQ simulations were conducted to refine auxiliary lane requirements throughout the corridor. Finally, geometric evaluation is conducted to determine the feasibility in retaining those auxiliary lanes – page 17.

2. Comment: Executive Summary, page 5: When referring to the countywide effects throughout the report it should be indicated that these results were determined with the C/CAG travel demand forecast model and that an operational analysis was not performed as it was on the analysis for US 101.

Response: Language is revised to clarify the tool used – see page 2.

3. Comment: Executive Summary, Exhibit 2: From this table there doesn't appear to be a benefit of this proposed Hybrid HOV Lane in the northbound direction AM peak period. Both the mixed-flow lanes and HOV lane travel time is increasing compared to the Baseline.

   Response: The exhibit is revised for the northbound direction – see page 3. HOV carpool travel time comparison is also added. Travel times for HOV carpoolers upstream of the study area (i.e. south of SR 85) are assumed to be in free-flow conditions, based on evaluation of the demand volumes.

4. Comment: Introduction and Existing Conditions, pages 7-8: There seems to be a gap between Sections C and D. Section C ends at the Grand Ave. Overhead and Section D begins at the South San Francisco Overhead.

   Response: There is no gap in the sections. The SSF Overhead was misnamed the Grand Ave Overhead but they are actually the same. Text is revised – see pages 6.

5. Comment: Travel Demand Forecast, Exhibit 5, page 11: Why has the mixed-flow and total demand volume decreased for the 2040 Hybrid HOV Lane alternative on southbound US 101 south of SR 85 in the AM peak period compared to the Baseline alternative?

   Response: The decrease is relatively minor as a percentage of the total volume. As a result of mode shift for the hybrid HOV lane option, more carpoolers and fewer drive-alones were forecasted on US 101 corridor. Carpoolers have higher occupancy than drive alone. Although the total vehicle volume is decreased, total passenger volume is actually increased.

6. Comment: Traffic Operations Analysis, 3rd bullet, page 13: How were the impacts on other state highways determined? If it was based on the C/CAG travel demand forecast model analysis then this should not be under the traffic operations analysis section.

   Response: A new chapter is created to describe impacts on countywide roadways and other state highways", as it was based on the C/CAG model – see new Chapter 5, page 33.

7. Comment: Traffic Operations Analysis, 2nd bullet, page 14: The capacity of an HOV lane should be 1650 vph. The capacity used of 1900 vph is too high. Using a capacity of 1650 vph in the HOV will maintain the requirements set by FHWA in operating HOV lanes.

   Response: Response: We understand that 1,650 vph is a desirable operational capacity that Caltrans would like to achieve and maintain, to ensure free flow conditions on the HOV lane (i.e. LOS C). For the actual traffic operations analysis, we have assumed the physical capacity of the facility before operations break down (i.e. LOS E), which is 1,900 vph. Note also that 1,900 vph per lane was used as the capacity for mixed-flow lanes as well.

   Follow-up Comment: Nowhere have we seen HOV volumes as high as 1900 vphpl, using this capacity will over estimate the operation of the HOV lane.

   Follow-up Response: For the purpose of this planning level study, the HOV lane capacity is assumed to be the same as adjacent mixed-flow lanes. This would maintain consistency with the recently completed San Mateo US 101 CSMP Study, as well as the San Mateo US 101 Add/Convert HOV Lane Study. Modifications to the HOV lane capacity could be explored should the study progress to the next phase.

8. Comment: Traffic Operations Analysis, 4th bullet, page 14: Does the modeled delay also match the existing delay?

   Response: The FREQ model was calibrated and validated to existing conditions (bottlenecks, queues, travel/delay times) during San Mateo 101 CSMP study.

9. Comment: 2040 Baseline Traffic Operations, Southbound AM peak, 4th bullet, page 16: The proposed Willow Rd./US 101 interchange modification project would remove the Willow Rd. loop off-ramp. The Baseline alternative and Hybrid HOV Lane alternative should include this proposed interchange project.

   Response: Baseline project assumptions were obtained from the San Mateo 101 CSMP study. Willow Road interchange modification was requested not to be included as part of the assumptions at that time. Regarding the ramp configuration changes, removal of the loop off-ramp would not eliminate the bottleneck at this location, as the demand volume would still be greater than the 3-lane capacity at this section. Refinement of the analysis could be performed should the study progress to the next phase.

10. Comment: Freeway On-ramp Queues, Northbound, last bullet, page 18: The memorandum indicates that the Oyster Point Blvd. on-ramp during the AM peak period would have a significant queue overflow on this ramp. Normally Oyster Point Blvd. traffic flow is from US 101 to Oyster Point Blvd. in the AM peak and from Oyster Point Blvd. to US 101 in the PM peak. The peak volume of traffic to NB US 101 from Oyster Point Blvd. is in the PM peak period. Check to see if the ramp queue overflow should be PM peak instead of AM peak.

    Response: Based on traffic forecast, AM peak hour volume would be higher than PM peak hour volume in the future year.

    Follow-up Comment: The Forecast model should be re-evaluated as this does not appear to be accurate, existing PM peak hour volumes at this ramp are approximately double the AM peak hour volume.

    Follow-up Response: While existing volumes showed PM peak hour volumes to be higher than AM, the San Mateo C/CAG travel model (which is the approved model for this study) forecasted higher growth in the AM peak than PM peak at this particular on-ramp, due to redistribution of trips associated with development growth assumptions.

11. Comment: 2040 With Hybrid HOV Lane Traffic Operations, 2nd paragraph, page 19: The memorandum states *the Santa Clara 101 Express Lanes were not assumed to be in place for the baseline improvements but they were assumed to be in place as dual lanes each direction from the San Mateo County line south to SR 85, as part of the HOV lane options.* The SCL County US 101 Express Lanes should also be included in the Baseline alternative as these lanes are proposed to be in place by 2040. Not including them in the Baseline alternative and including them in the Hybrid HOV Lane alternative would skew the results of the Hybrid HOV Lane alternative by including the benefits of the US 101 Express Lane project. This wouldn't show the independent utility of the Hybrid HOV Lane project when comparing to the Baseline alternative.

    Response: The study did not include the dual HOV/express lanes from San Mateo County line south to SR 85 in either the baseline or with hybrid HOV lane option. This line has been removed from the description. The sentence is revised and is moved to Chapter 2, to read: "*The Santa Clara 101 Express Lanes were not assumed to be in place for the baseline improvements"* – see page 4.

    Follow-up Comment: The dual HOV lanes should be considered in the next phase of this project.

    Follow-up Response: Comment is noted.

12. Comment: 2040 With Hybrid HOV Lane Traffic Operations, 2nd paragraph, page 19: The memorandum states *the operations analysis did not look at the operations impacts of necking down from two express lanes in Santa Clara County to a single HOV lane in San Mateo County.* Why not, if this geometric constraint is within the study limits? This could potentially reduce the travel time within the HOV lane in the study limits. The memorandum also states *this effect was outside the focus of the current study, which was the extension of the existing single HOV lanes north of Whipple Avenue*. Was the HOV lane travel times taken only within the project limits or within the study limits? If HOV lane travel times along with the mixed-flow lane travel times include travel times beyond the project limits then this effect was not outside the focus of the current study.

    Response: Base on the 2040 analysis, the HOV lane would generally operate under capacity in the southern section (i.e. south of the San Mateo county line). The only bottleneck that would occur is under baseline AM northbound direction, where a minor bottleneck at the San Antonio interchange would result in a minimal delay of approximately 1 minute on the HOV lane. Therefore, necking down from dual express lanes to a single would not result in substantial travel time increased to the HOV lane.

    Follow-up Comment: The dual HOV lanes should be considered in the next phase of this project.

    Follow-up Response: Comment is noted.

13. Comment: Hybrid HOV Lane Configuration and Auxiliary Lane Assumptions, Northbound Direction, 1st bullet, page 19: Explain why this auxiliary lane from the Whipple Ave. loop on-ramp to the diagonal on-ramp would be critical to maintaining freeway operations? This would basically be an acceleration lane for the loop on-ramp.

    Response: The auxiliary lane extension would provide additional freeway capacity and helps to accommodate high loop on-ramp volumes (1494 vph). In terms of design geometry, this acceleration lane can be accommodated fairly easily without right of way concerns.

    Follow-up Comment: This acceleration lane would allow more on-ramp traffic on to the freeway at the expense of the freeway traffic, this would not be recommended.

    Follow-up Response: The intention of this study is to retain as much auxiliary lane as possible. For this case, since existing loop ramp feeds into a full auxiliary lane, and with the hybrid HOV lane, this section of the auxiliary lane can be accommodated geometrically, therefore is retained. Other design alternatives could be explored should the study progress to the next phase.

14. Comment: Hybrid HOV Lane Configuration and Auxiliary Lane Assumptions, Northbound Direction, 4th bullet, page 19: Explain why the auxiliary lane would be dropped prior to the Kehoe Ave. off-ramp or for that matter prior to the 3rd Ave. off-ramp as it is today. Dropping this auxiliary lane at this point would create two lane drops in a very short distance and would basically force all of the westbound SR 92 and Fashion Island Blvd. on-ramp traffic into one lane.

    Response: There are severe right of way constraints at this location. In order to maintain WB 92 on-ramp as a 2-lane ramp, both lanes would need to be dropped prior to Kehoe to avoid costly right of way acquisitions. Other design alternatives could be explored should the study progress to the next phase.

    Follow-up Comment: How was it determined which auxiliary lanes were retained and which were removed? Not retaining this auxiliary lane there would probably be an impact to SR 92.

    Follow-up Response: See response #1 regarding the process to retain auxiliary lane. We acknowledge that not retaining this auxiliary lane could potentially be an impact to SR 92. However, based on geometric evaluation, there are severe right of way constraints in this segment to accommodate a full auxiliary lane.

The trade-offs associated with implementing this project would be evaluated should the study progress to the next phase.

15. Comment: Hybrid HOV Lane Configuration and Auxiliary Lane Assumptions, Southbound Direction, 3rd and 4th bullet, page 19: Explain why the auxiliary lane would not be continued between the San Bruno Ave. on-ramp and the last SF Airport on-ramp? Removing this auxiliary lane could potential cause a bottleneck at this section.

    Response: There are right of way constraints in this area. Removing this auxiliary lane would not result a new bottleneck during the PM peak period. During AM peak period, although a bottleneck would be formed at the SFO on-ramp, however, queues from a downstream bottleneck at Hillsdale would extend through this area for the most part of the peak period, and would negate any benefits that the auxiliary lane provides. Other design alternatives could be explored should the study progress to the next phase.

    Follow-up Comment: How was it determined which auxiliary lanes were retained and which were removed? Not retaining this auxiliary lane there would be an impact to EB I-380.

    Follow-up Response: See response #1 regarding the process to retain auxiliary lane. We acknowledge that not retaining this auxiliary lane could potentially be an impact to EB I-380. However, based on geometric evaluation, there are severe right of way constraints in this segment to accommodate a full auxiliary lane. The trade-offs associated with implementing this project would be evaluated should the study progress to the next phase.

16. Comment: Freeway Bottleneck Analysis with Hybrid HOV Lane, Northbound AM Peak, 4th, 5th and 6th bullets, page 22: If the auxiliary lanes were retained between Kehoe Ave. and Millbrae Ave. would this eliminate these bottlenecks or reduce the delay and queuing from these bottlenecks?

    Response: Auxiliary lanes were proposed to be removed from those locations due to right of way constraints. Based on traffic forecast, the hybrid HOV lane would provide higher throughput in those segments than an auxiliary lane and providing an overall benefit to the system. If auxiliary lanes were to be retained, delays associated with those bottleneck locations identified could potentially be reduced or eliminated, but additional new bottleneck could form downstream from releasing additional traffic from these bottlenecks, and would also increase delays at expected downstream bottleneck locations. Other design alternatives could be explored should the study progress to the next phase.

17. Comment: Freeway Bottleneck Analysis with Hybrid HOV Lane, Northbound PM Peak, 3rd, 4th and 5th bullets, page 22: If the auxiliary lanes were retained between 3rd Ave. and Millbrae Ave. would this eliminate these bottlenecks or reduce the delay and queuing from these bottlenecks?

    Response: see response #16.

18. Comment: Freeway Bottleneck Analysis with Hybrid HOV Lane, Southbound AM Peak, 1st bullet, page 23: If the auxiliary lane was retained between SFO Airport on-ramp from international terminal to on-ramp from domestic terminal would this eliminate this bottleneck or reduce the delay and queuing from this bottleneck?

    Response: see response #16.

19. Comment: Freeway Bottleneck Analysis with Hybrid HOV Lane, Southbound AM Peak, 3rd bullet, page 23: With the proposed Willow Rd. interchange modification project the loop off-ramp would no longer exist.

    Response: See comment/response #9.

20. Comment: Freeway Bottleneck Analysis with Hybrid HOV Lane, Southbound PM Peak, 1st bullet, page 23: If the auxiliary lane was retained between Oyster Point Blvd. on-ramp and Miller Ave. off-ramp would this eliminate this bottleneck or reduce the delay and queuing from this bottleneck?

    Response: see response #16.

21. Comment: Freeway On-Ramp Queue, page 24: Three on-ramps are developing queues in the Hybrid HOV Lane Alternative that are not developing in the No Build Alternative, NB US 101 from Whipple Ave. NB on-ramp AM and PM peak , NB US 101 from Marine Parkway loop on-ramp PM peak and SB US 101 from Oregon Exp. on-ramp AM peak. Why are these queues developing in the Hybrid HOV Lane Alt. and not in the No Build Alt.?

    Response: Two sets of forecast were generated as part of this study: one for baseline conditions, and another for with hybrid HOV lane condition. In an effort to be conservative, the traffic forecast used for the hybrid HOV lane alternative assumed that with the proposed HOV lane in each direction, there would be induced demands to the corridor. Therefore, ramp volumes are different between the two alternatives.

22. Comment: Travel Time Comparisons, last paragraph, page 26: Should indicate that the 65 minutes in reduction is in the PM peak period.

    Response: text is revised as suggested – page 24.

23. Comment: Exhibit 12, page 28: Why is there a speed reduction near San Antonio Rd. in the Baseline HOV lane and not in the Hybrid HOV lane? There is no difference in the Hybrid HOV lane and the Baseline HOV lane at this location.

    Response: The FREQ analysis tool has a limitation that it does not dynamically shift demand volumes to balance traffic congestions between the HOV lane and the mixed-flow lanes. Therefore, to avoid unrealistic situations where HOV lane are congested while mixed-flow lanes are in free-flow conditions, vehicle occupancy (HOV%) inputs at upstream origins were adjusted. For this situation, to avoid unreasonable HOV lane congestion near the Whipple Road interchange under the hybrid HOV lane scenario, upstream HOV percentages were reduced.

    Follow-up Comment: By fixing one problem in the FREQ model you have created another one. Need to create the speed reduction in the Hybrid model similar to the Baseline model near San Antonio Rd.

    Follow-up Response: Further refinement to the HOV lane operations could be addressed should the study progress to the next phase. It should be noted that the overall delay to the hybrid HOV lane would not be significantly different – i.e. if there's a slow down at San Antonio interchange, which would reduce the throughput to the downstream bottleneck, and would reduce the delays associated with the downstream bottlenecks at SR 92 and 3Rd Avenue interchanges.

24. Comment: Exhibit 17, page 32: How can the total MPH for Northbound and Southbound 2040 Base and 2040 HOV be greater than the AM and PM MPH? In addition, should indicate the difference between the MPH for vehicles and MPH for persons or label differently.

    Response #24: "Total MPH" is revised to read "Average MPH". Text is also revised to add Vehicle and Person MPH, respectively. In addition, the Average Vehicle and Passenger MPH has been corrected on the revised report (going from left to right on the report: 21, 24, 32, 34 for Avg Veh MPH, and 22, 26, 32, 36 for Avg Pass. MPH) – page 31.

25. Comment: Exhibit 17, page 32: Why isn't there any change in PHD compared to VHD for Northbound 2040 Base Alt. PM, Southbound 2040 Base Alt. AM , PM and Total and for Southbound 2040 HOV AM?

Response: The differences between PHD and VHD were small. Values were rounded to the nearest 100 for general public presentation. HOV lane delays are not significant compared to mixed-flow lane delays for those scenarios.

Follow-up Comment: How was the PHD calculated? Was the VHD multiplied by average vehicle occupancy (AVO)? What AVO was used?

Follow-up Response: Average vehicle occupancy information is based on data from the San Mateo US 101 CSMP study. For the HOV lane, an average occupancy of 2.15 is used, and 1.0 is used for mixed-flow lanes.

26. Comment: Impacts on Countywide Roadways, page 34: The memorandum should indicate that this section is based on a travel demand forecast model analysis and not based on traffic operational analysis model as the rest of the study is.

    Response: The layout of the report is revised to move this section into a separate chapter, as it was based on the C/CAG model – see new Chapter 5, page 33.

Deliverables 4A and 4B:

27. Comment: Design Strategy, page 2: There seems to be a gap between Sections C and D. Section C ends at the Grand Ave. Overhead and Section D begins at the South San Francisco Overhead.

    Response: There is no gap in the sections. The SSF Overhead was misnamed the Grand Ave Overhead but they are actually the same. Text is revised – see Chapter 2 – page 6.

28. Comment: Holly Street to Ralston Avenue, Existing/Proposed Cross Section, Northbound, page 5: The proposed alternative should have 5 lanes Holly to lane add (HOV + 4 mixed) and 6 lanes lane add to Ralston (HOV + 4 mixed+ deceleration lane).

    Since the "lane add" on NB 101 right before the Ralston off-ramp is just a short 300' segment of auxiliary lane provided for a 2-lane off-ramp (one lane must be dropped for a 2-lane exit), the current description has been maintained to avoid confusion.

29. Comment: Route 92 to 3rd Avenue, Existing/Proposed Cross Section, Northbound, page 8: Under the proposed alternative there are 6 lanes between the SR 92 on-ramp and just South of Kehoe Ave. off-ramp.

    The NB 101 section between Route 92 and Kehoe Ave off-ramp is mostly a transition section from the Route 92 connector ramp merging with 101, so the number of lanes on this section of 101 actually varies from 7 to 5 lanes. The proposed section description is modified to state 7 lanes merging to 5 lanes between 92 and Kehoe – page 42.

30. Comment: Appendix C, Northbound US 101, Sheet 5: Will the one lane on-ramp be able to handle the traffic volume from EB and WB I-380?

    Response: The analysis and design assumed this to be maintained as a 2-lane on-ramp to handle the traffic volume. The difference is that currently, the 2-lane on-ramp continues on the mainline as 2 auxiliary lanes along the freeway, whereas with the hybrid option, we are proposing to maintain a 2-lane on-ramp up to the freeway connection, after which the outside ramp lane would merge with the inside ramp lane and continue as 1 auxiliary lane. The northbound on-ramp volume is actually fairly low, with highest peak hour volume at about 818 vph, which would not require the on-ramp to be 2-lane.

31. Comment: Appendix C, Southbound US 101, Sheet 6: Will the one lane on-ramp be able to handle the traffic volume from EB I-380?

    Response: The analysis and design assumed this to be maintained as a 2-lane on-ramp to handle the traffic volume. Currently the inside lane of the 2-lane ramp merges with the outside freeway lane (a nonstandard "inside merge") while the outside ramp lane continues as 1 auxiliary lane. We are proposing to maintain a 2-lane on-ramp up to the freeway connection, after which the outside lane of the 2-lane ramp would merge with the inside ramp lane (a standard outside merge) and continue as 1 auxiliary lane. The display has been modified to show the 2 ramp lanes extending further before merging – Appendix H. The southbound on-ramp volume is fairly high, with highest peak hour volume at about 2,385 vph, which would require the on-ramp to provide 2-lane capacity.

    Follow-up Comment: The proposed one-lane on-ramp will not be able to handle a volume of 2,385 vph.

    Follow-up Response: Two-lane on-ramps are maintained as existing configuration. The drawing has been corrected. See revised layout sheet #6.

32. Comment: Appendix C, Northbound US 101, Sheet 12: The shoulder strip goes through the Kehoe Ave. on-ramp, this should be removed.

    Response: This has been corrected on the display – Appendix H.

Comments provided by: MTC, November, 2011.

Response prepared by: ***Kevin Chen, Kittelson & Associates/ Dowling***
January 31, 2012

Deliverable 4D:

1. Comment: Provide a comparison of congestion duration between baseline and hybrid HOV lane scenario?

   Response: In the southbound direction, congestion would begin at about 7 AM at the worst bottleneck location at Hillsdale interchange. Congestion would dissipate by 11:25 PM under baseline conditions, and dissipate by 10:15 PM under the hybrid HOV lane scenario.
   In the northbound direction, congestion would begin at about 6 AM at the Rengstorff interchange, and at 7 AM at the Willow interchange, congestion would overlap between these two worst bottleneck locations. Congestion would dissipate by 11:20 PM under the baseline scenario, and by 12:05 AM (next day) under the hybrid HOV lane scenario. The duration of congestion is increased in the hybrid alternative primarily due to induced traffic demands at the southern end of the corridor, where no improvements are proposed for this hybrid HOV lane option at that location.
   The congestion duration is estimated based on existing mainline hourly volume profiles from PEMS, at selected locations - See new section 4.5 on page 28.

2. Comment: Provide a summary table of HOV lane hourly demand volumes?

   Response: New table is provided in the report, see page 9 Exhibit 6.

3. Comment: Provide a comparison of mainline throughput comparison between baseline and hybrid HOV lane scenario.

   Response: New table is provided in the report - see pages 28-29.

4. Comment: Provide a comparison of GHG emissions between baseline and hybrid HOV lane scenario.

   Response: New chapter is provided – page 36 - 37, Chapter 6. Notice that overall there are less emissions in 2030 compared to 2015, due to higher percentage of cleaner vehicles are assumed in by year 2030 in the EMFAC analysis.

Comments provided by: Sandy Wong, C/CAG, January 9, 2012.

Response prepared by: ***Kevin Chen, Kittelson & Associates/ Dowling***
January 31, 2012

Deliverable 4D:

1. Comment: Based on C/CAG travel time monitoring, from county line to county line, travel time on US 101 is approximately 30 to 40 minutes for 2011. This memo describes the 2040 Baseline Average Travel Time will grow to between 70 and 169 minutes. I understand the study corridor extends into SCL county and SF county, but I just want to ask if that's a reasonable output. Also, what might be the reason for travel time to increase for the mixed-flow in the Hybrid scenario as compared to the Baseline scenario?

   Response: The study corridor does extend into SCL and SF counties. Furthermore, in order to fully capture the congestion effects, the limits of the corridor were further extended 13 miles south of SR 85 interchange, and 9 miles north of San Francisco county line. Total distance is approximately 43 miles for the northbound direction, and 39 miles for the southbound direction. In addition, the travel times reported represent 2040 conditions, which accounted for approximately 30 years of traffic growth compared to current conditions reported in the C/CAG travel time monitoring report.

2. Comment: Based Section 4.3.1 lists the locations where Aux lanes will remain in the Hybrid scenario. But the memo does not describe the process as to how those locations were determined.

   Response: The methodology was previously described per Deliverable 2C (Initial Traffic Volume Assessment Memo). We have added the methodology into the revised report – see page 17.

Comments provided by: Richard Napier, C/CAG, January 11, 2012.

Response prepared by: ***Kevin Chen, Kittelson & Associates/Dowling***
Brad Leveen, Karsten Adam, Mark Thomas Co.
January 31, 2012

Deliverable 5

1. Comment: The cost is likely higher if the current favorable climate cost numbers were used as a basis. I would be interest in the amount it would increase if you made less favorable cost assumptions

   Response: We used fairly conservative unit prices averaging out highs and lows over past 10 years. It's more likely the bigger overall driver in potential cost increases would stem from how willing Caltrans is to accept the proposed design exceptions (narrow lanes & shoulders, structure clearances, shortened ramps), and the amount of "extras" they would like included with the project, including some ramp access changes that Mike Thomas talked about at the last large group meeting, barrier, soundwall and overhead sign upgrades, underground stormwater storage areas, overlaying the entire freeway with new pavement (not just in areas of shifted lanes where we already assumed overlay), safety and maintenance enhancements, etc.
   Another consideration on unit prices would be the size of the projects this overall project would be broken down into. For example, breaking it into 2 or 3 large stretches would likely decrease unit cost for materials from economy of scale, but would only draw bids from large contractors able to handle the work. Likewise, breaking it into 10 smaller projects could increase unit costs, but the bids might be more competitive with more contractors being able to handle the scope of work.
   The cost estimates should be viewed as a "minimum reasonable expected cost" to develop the improvements given a best case scenario where all identified design exceptions are approved by Caltrans and there are a minimal amount of "touch it you fix it" add-ons and extras.
   The other weakness in cost estimates is that we don't have a good handle on required on/off ramp revisions. These were to be analyzed more thoroughly in a "second phase" of analysis where we studied each interchange in more detail, but this next phase has not been authorized or completed yet. The typical effect on existing ramps of adding the fifth freeway lane is a reduction in ramp accel/decel lengths. Generally, to provide standard lengths a significant impact to adjacent frontage roads and right of way would be required. We assumed (and stated) design exceptions for most of these shortened ramps but we did not get any real feedback from Caltrans Design on the proposed ramp exceptions so we can't be as confident of their acceptance.
   Given all these variables, it is hard to predict any specific amount of increase until more detailed studies are completed and Caltrans weighs in more thoroughly on the design and proposed design exceptions.

Deliverable 4D:

2. Comment: Page 6 Exhibit 2 – The Northbound PM travel time of 249 min seems high. Why.

   Response: The study corridor does extend into SCL and SF counties. Furthermore, in order to fully capture the congestion effects, the limits of the corridor were further extended 13 miles south of SR 85 interchange, and 9 miles north of San Francisco county line. Total distance is approximately 43 miles for the northbound direction, and 39 miles for the southbound direction. In addition, the travel times reported represent 2040 conditions, which accounted for approximately 30 years of traffic growth compared to current conditions reported in the C/CAG travel time monitoring report.

3. Comment: Why is this direction (northbound PM) the only one with a benefit? The other three Direction-Time all shows an increase.

   Response: Due to lane configuration changes with the hybrid HOV lane option, the mixed-flow users could experience longer travel times when compared to baseline conditions. However, HOV users would experience significant reductions to travel times with the hybrid HOV option as shown in the report.

4. Comment: Page 22 - Travel time of 178-185 minutes through the corridor seems high?

   Response: See response #2 above.

5. Comment: Page 26 - HOV lane savings of 65 minutes seems high?

   Response: It appears that the comment intended to say 56 minutes instead of 65 minutes, as shown on the table. Based on the freeway analysis results for 2040 conditions, mixed-flow lanes would experience significant delays during SB PM peak period, from freeway bottlenecks at Oyster Point Blvd and at Rengstorff. Maximum queue length associated these two bottlenecks would be 8.7 miles and 14 miles, respectively. The maximum travel time for the 39 miles of freeway would be as long as 154 minutes. The HOV lane would operate mostly under free flow conditions. Therefore, the resulting travel time savings for HOV users would average to be about 56 minutes for the peak period.

6. Comment: Page 27 Exhibit 11 – The Northbound PM travel time of 249 min seems high. Why?

   Response: See response #2 above.

7. Comment: Why is this direction the only one with a benefit? The other three Direction-Time all shows an increase.

   Response: See response #3 above