State Route 4

Freeway Performance Initiative (FPI)
and
Corridor System Management Plan (CSMP)

TRANSPAC Board Meeting

February 11, 2010

Caltrans

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COMMISSION

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FPI Overview

What is the FPI?

- The MTC Freeway Performance Initiative (FPI) is a series of corridor-level studies that are the building blocks of a strategic freeway plan for the Bay Area. The FPI studies are also intended to inform the next update of the Long Range Transportation Plan.

What is the CSMP?

- The Corridor System Management Plans (CSMPs) undertaken by Caltrans are required for all corridors that receive CMIA funding to implement capital improvement projects. The intent of the CSMP is to ensure that there is a plan in place to preserve the mobility gains of CMIA-funded projects.

How are the FPI and CSMP related?

- The technical scope of work for the FPI and CSMP are essentially the same. Caltrans is currently working to incorporate the FPI results into the CSMP.

How will this analysis be used?

- Caltrans will submit the CSMP to the CTC to fulfill the Prop. 1B requirement. The FPI technical analysis will be used by MTC in the next RTP update, and is being provided to local stakeholders as a tool to supplement their own local planning processes.

SR 4 Corridor

FPI Study Process

Assessment of Existing Conditions

Analysis of Projected Future Conditions:

- Short-Term Evaluation (2009 - 2015)
- Long-Term Evaluation (2016 - 2030)

Congestion Mitigation Strategies:

- Demand Management
- Increased Capacity
- System Management
- Other

Prioritization of Congestion Mitigation Strategies:

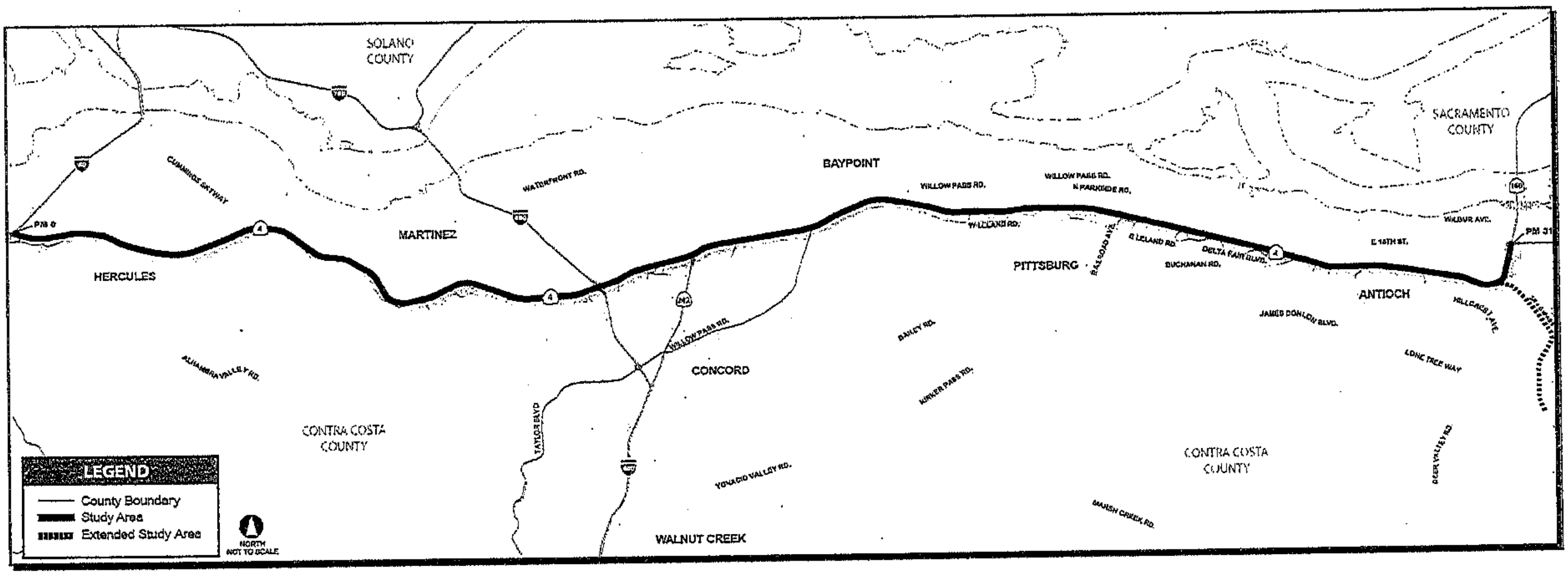
- Based on cost-effectiveness analysis

Stakeholder Outreach

A corridor TAC was formed and engaged at key milestones of the FPI including workshops to determine appropriate strategies for consideration in the SR 4 Corridor. Members included CCTA, local agency representatives, and BART.

SR 4 Corridor

Study Area



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SR 4 Corridor

Existing Conditions

- Highway Travel Characteristics
  - 40,000 to 160,000 vehicles per day; 4% to 7% are trucks.
  - Average peak hour vehicle occupancy is 1.3 persons per vehicle.
  - 20% of auto trips in the corridor are HOV 2+ eligible.
- Transit Service
  - 19% of peak hour person trips are made via BART.
  - BART parking lot at Pittsburg/Bay Point fills-up at 6:30 am; North Concord/Martinez remains below capacity throughout the day.
  - Other transit service accounts for approximately 10% of peak hour person trips.
- ITS Features
  - ITS coverage is approximately 10% of Caltrans' standards; concentration of coverage east of I-680.
  - Caltrans has recently made substantial progress in filling detection gaps.

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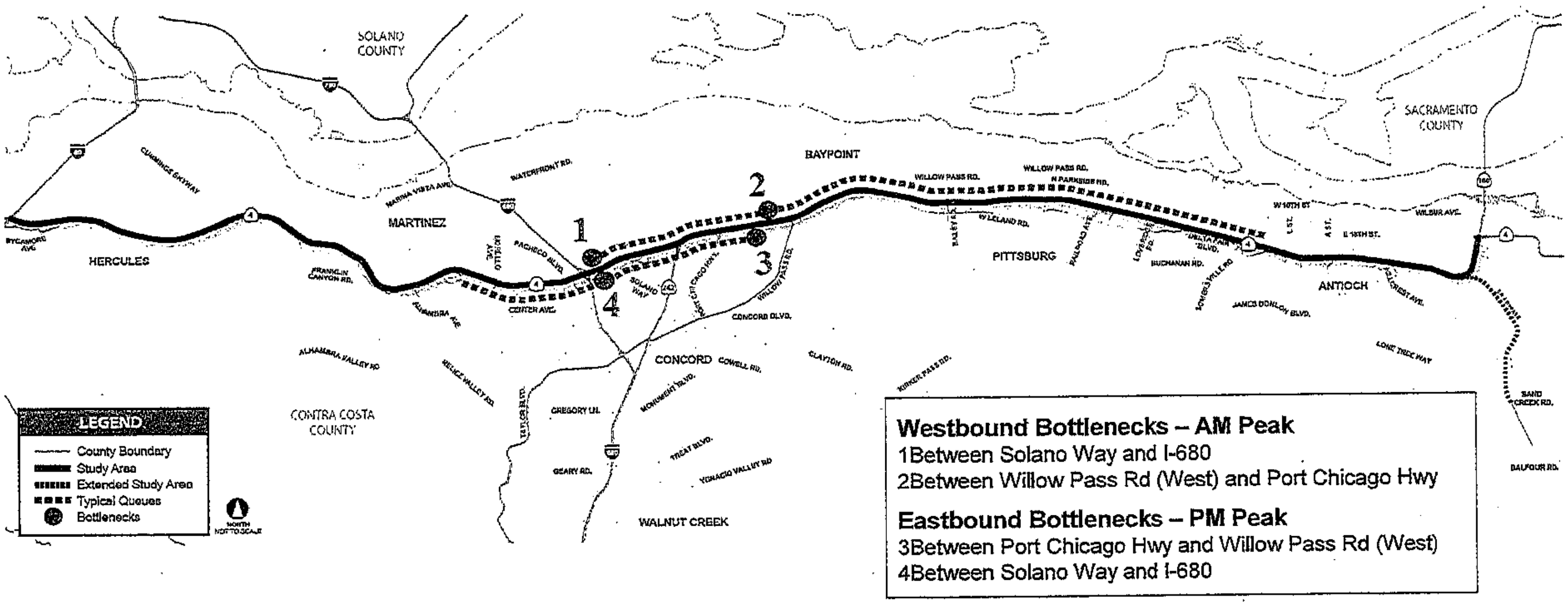
Congestion Mitigation Strategies – Short Term (2015)

Committed Improvements only

- Westbound AM Peak Hour travel time will increase from 1:07 to 1:20 for 33-mile corridor
- Eastbound PM Peak Hour travel time will increase from 0:49 to 1:06 for 33-mile corridor



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Congestion Mitigation Strategies – Short Term (2015)

Package A

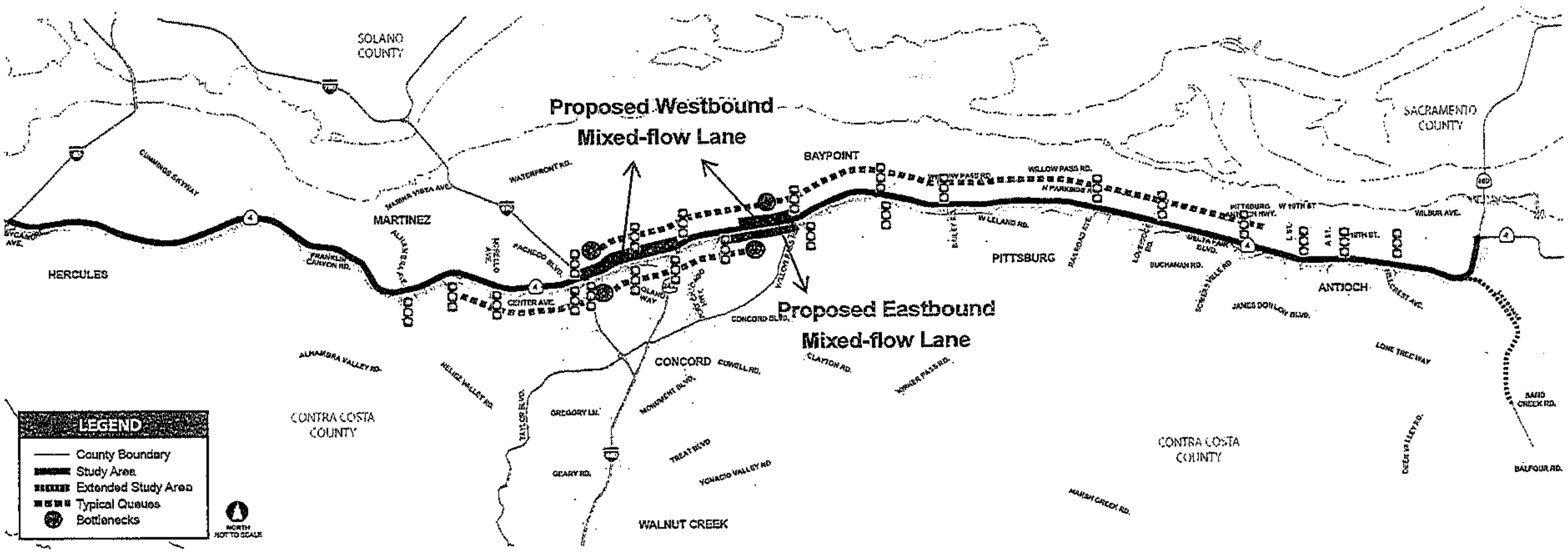
- Activate existing ITS.
- Fill gaps in ITS coverage as needed.

Package B

- WB ramp metering from SR 160 to I-680.
- WB mixed-flow lane from SR 242 to I-680.
- Extend WB mixed-flow lane from Willow Pass Rd (W) to Port Chicago Hwy.

Package C

- EB ramp metering from Alhambra Ave to Willow Pass Rd (E).
- Extend EB mixed-flow lane from Pt Chicago to Willow Pass Rd (W).



Reduction in Peak-Direction Delay	Vehicle Hours	12,900 hrs - 11,010 hrs = 1,890 hrs	85 % reduction
	Person Hours	14,800 hrs – 12,820 hrs = 1,980 hrs	87 % reduction

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Congestion Mitigation Strategies – Long Term (2030)

Package D

- Extend WB mixed-flow lane from 0.7 mi east of Willow Pass Rd (E) to Willow Pass Rd (W).

Package E

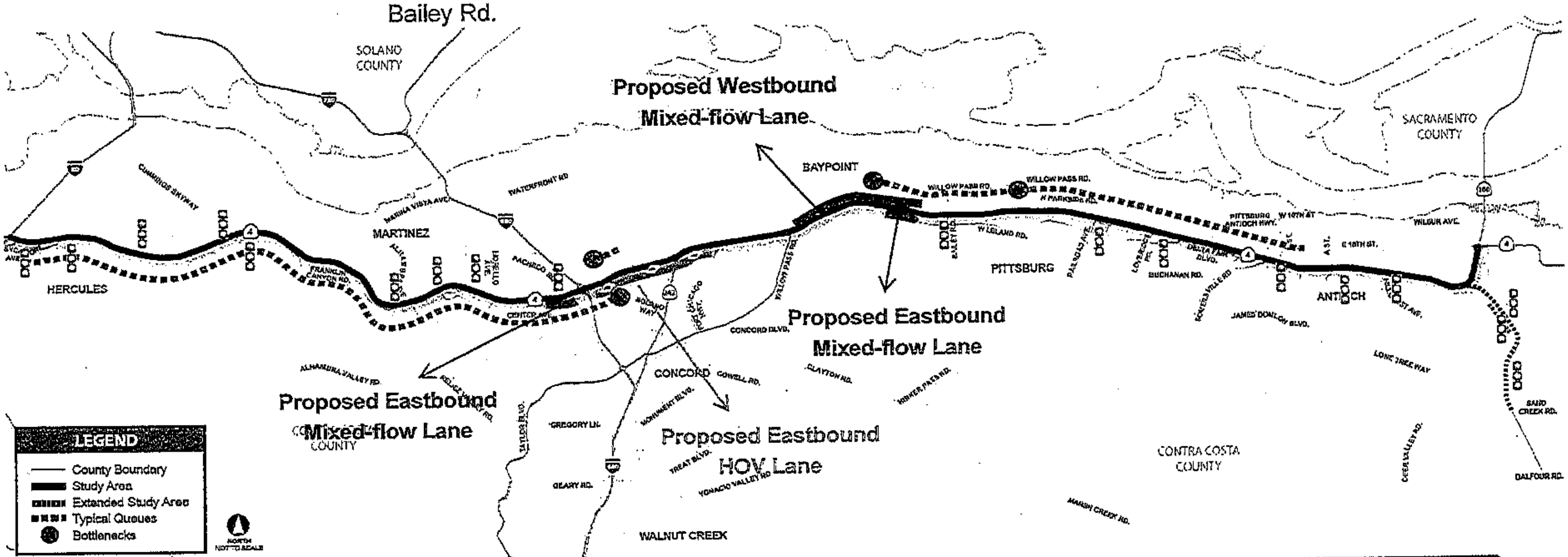
- Extend EB mixed-flow lane from 0.3 mi west of Pacheco Blvd to Pacheco Blvd.
- Extend EB HOV lane from I-680 to its start 0.1 mi east of the SR 4/SR 242 merge.
- Extend EB mixed-flow lane from Willow Pass Rd (E) to lane add 0.5 mi west of Bailey Rd.

Package F

- WB ramp metering on the SR 4 Bypass and from I-680 to I-80.

Package G

- EB ramp metering from I-80 to Alhambra Ave, from Willow Pass Rd (E) to SR 160 and on the SR 4 Bypass.



Reduction in Peak-Direction Delay	Vehicle Hours	24,900 hrs – 17,500 hrs = 7,400 hrs	70 % reduction
	Person Hours	28,600 hrs – 20,830 hrs = 7,770 hrs	73 % reduction

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Other Congestion Mitigation Strategies

Transit Enhancements

- Additional BART parking capacity.
- Increased bus transit access to the BART stations within the SR 4 Corridor.
- Improvements to existing park-and-ride stations and new park-and-ride stations at proposed eBART stations
- BART system-wide operational improvements.

BART Coordination

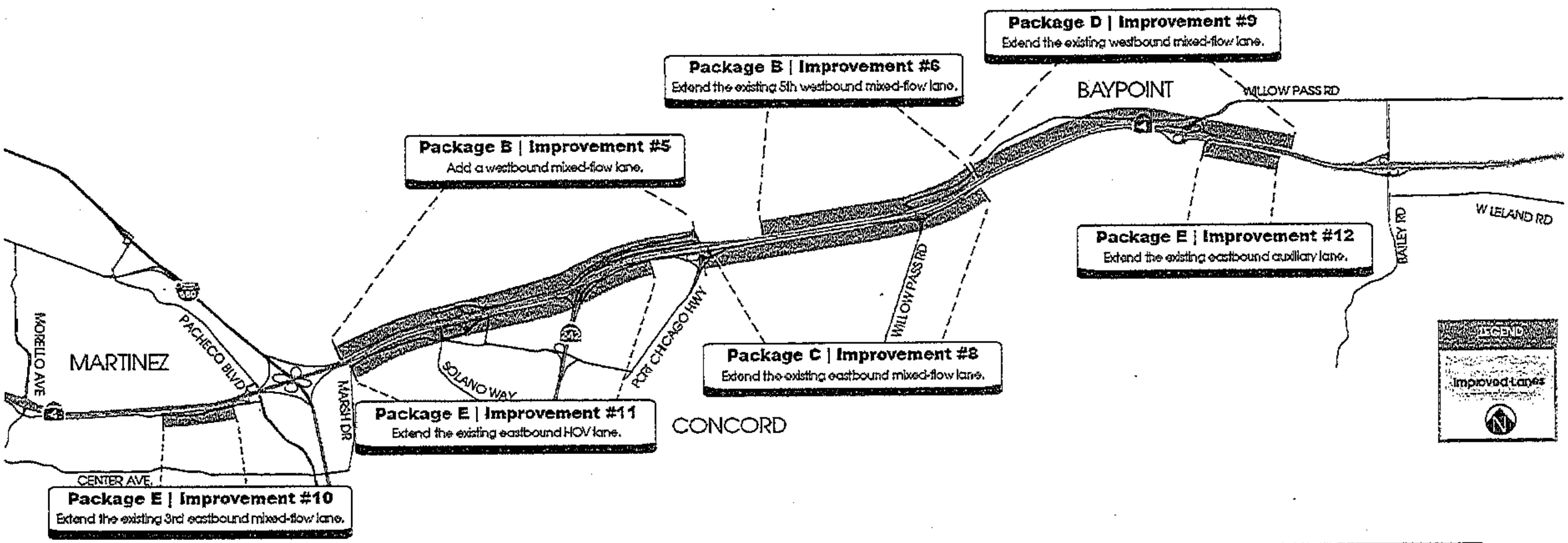
- Met in late March to discuss transit strategy development.
- Improvements are expected to accommodate ridership increases in the range of 10% to 20%.

Express Lanes

- The limits of the SR 4 Express Lanes proposed in MTC's Regional Express Lane Network would extend from I-680 to SR 160.
- Express Lanes on SR 4 would utilize the existing and programmed HOV lanes to utilize any available surplus capacity.

Summary/Key Findings

- INCREASED CAPACITY: Packages B and C ranked the highest, addressing westbound and eastbound congestion approaching the SR 242 and I-680 interchanges.
- ITS ENHANCEMENTS: Package A also ranked high providing the full coverage of ITS technology and system management needed to address non-recurrent delay and safety.
- With the exception of ramp metering, no additional congestion mitigation strategies are proposed for the eastern portion (i.e., east of Bailey Rd) or the western portion (i.e., west of the I-680 Interchange) of the SR 4 Corridor.
- Congestion in the vicinity of the I-680 Interchange will affect the western portion of the corridor between I-80 and I-680 if not mitigated.



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Summary/Key Findings

- ITS is a cost-effective strategy to address non-recurrent delay and manage system performance.
- Ramp metering can preserve mobility gains and improve freeway performance without negative consequences.
- Capacity improvements are focused on key bottlenecks between I-680 and Bailey Road.
- Transit strategies and Express Lanes should be evaluated in more detail.

SR 4 Corridor

Next Steps

- Receive local stakeholder comments on the proposed congestion mitigation strategies (RTPC TACs & Boards)
- Caltrans CSMP submittal to CTC
- FPI technical analysis used by MTC to inform the RTP
- FPI technical analysis provided to local stakeholders as a tool to inform their own planning processes

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SR 4 Corridor in Contra Costa County

Prioritized Congestion Mitigation Strategies Technical Memorandum

Prepared by: PBS&J
For: Metropolitan Transportation Commission
Final
November 9, 2009

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SR 4 Corridor in Contra Costa County

Prioritized Congestion Mitigation Strategies Technical Memorandum

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Introduction

This report presents the cost-effectiveness analysis and prioritization of congestion mitigation strategies for the State Route 4 (SR 4) Corridor in Contra Costa County based on the *Congestion Mitigation Strategies Technical Memorandum*, (PBS&J, November 9, 2009) completed for this corridor. The methods and performance measures used for the analysis and prioritization are based on those set forth in the *Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework* (MTC, October 2007). Consistent with the guidance provided by this document, the primary objectives of the *Prioritized Congestion Mitigation Strategies Technical Memorandum* are 1) to estimate and compare life-cycle benefits and life-cycle costs of the proposed corridor improvements and, 2) to provide a prioritized list of corridor improvements based on the cost-effectiveness. Corresponding to these objectives, the report is presented in nine sections:

- **Section 1: Key Findings.** An executive summary of the findings in this analysis.
- **Section 2: Proposed Congestion Mitigation Strategies.** A list of the proposed congestion mitigation strategies for the SR 4 Corridor.
- **Section 3: Methodology.** A description of the quantitative and qualitative performance measures, calculation of benefits value, methodology for determining capital costs, life-cycle benefit cost calculations and prioritization of proposed congestion mitigation strategies.
- **Section 4: Performance Measures.** Results of the performance measures used in the benefits analysis and a comparison of Baseline and Improved scenarios.
- **Section 5: Life-Cycle Benefits.** Results of the life-cycle benefits analysis for the quantitative benefits and discussion of qualitative benefits analysis.
- **Section 6: Capital Costs.** Results of the life-cycle cost analysis to include values for capital costs, and operation and maintenance (O&M) costs.
- **Section 7: Cost-Effectiveness Analysis.** Results of the comparison of life-cycle benefits and life-cycle costs.
- **Section 8: Prioritization.** Ranking of congestion mitigation strategies based solely on the results of the cost-effectiveness analysis conducted for each mitigation strategy package.
- **Section 9: Transit Mitigation Strategies.** A list of proposed transit mitigation strategies.
- **Section 10: Express Lane Mitigation Strategy.** Discussion of express lanes as a potential mitigation strategy.

Section 1: Key Findings

The cost-effectiveness analysis and the subsequent prioritization of congestion mitigation strategies along the SR 4 Corridor through Contra Costa County evaluated a total of 14 improvements grouped into seven packages. These seven packages represent approximately 228 million hours of life-cycle benefits and $212 million in life-cycle costs.

The packages are ranked below, as determined by the cost-effectiveness analysis:

Short-term Package Ranking

1. **Package B (Short-term, Westbound):**
   - Improvement #4: Implement ramp metering in the westbound direction on SR 4 between SR 160 and I-680.
   - Improvement #5: Add a westbound mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.
   - Improvement #6: Extend the existing westbound mixed-flow lane from the Willow Pass Road (West) off-ramp to the lane-add located 4,200 feet west of the Willow Pass Road (West) on-ramp.
2. **Package C (Short-term, Eastbound):**
   - Improvement #7: Implement ramp metering in the eastbound direction between Alhambra Avenue and Willow Pass Road (East).[1]
   - Improvement #8: Add an eastbound mixed-flow lane from the lane drop located 1,500 feet west of Port Chicago Highway on-ramp to the Willow Pass Road (West) on-ramp.
3. **Package A (Short-term, Eastbound & Westbound):**
   - Improvement #1: Activate existing ITS installations that currently are not fully operational.
   - Improvement #2: Assess gaps in the current and programmed ITS installations and supplement as needed.
   - Improvement #3: Extend ITS coverage to fill the gap between I-80 and I-680, and along the SR 4 Bypass.

Long-term Package Ranking

1. **Package G (Long-term, Eastbound):**
   - Improvement #14: Implement ramp metering in the eastbound direction between I-80 and Alhambra Avenue, between Willow Pass Road (East) and SR 160, and on the SR 4 Bypass.[2]
2. **Package E (Long-term, Eastbound):**
   - Improvement #10: Extend the existing eastbound mixed-flow lane from the lane drop located to 1,500 feet west of the Pacheco Boulevard off-ramp to the Pacheco Boulevard off-ramp.
   - Improvement #11: Extend the existing eastbound HOV lane from the I-680 NB off-ramp its start 3,000 feet west of the Port Chicago Highway on-ramp.
   - Improvement #12: Extend the existing eastbound mixed-flow lane from the Willow Pass Road (East) on-ramp to the lane add located 4,000 feet east of the Willow Pass Road (East) on-ramp.

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1 Caltrans' goal is for all ramp metering to be adaptive.

2 Although listed here as a long-term strategy, some benefit may be gained by accelerating the implementation of ramp metering in the eastbound direction between Willow Pass Road (East) and SR 160 in that it would address congestion that will not be alleviated until construction of the SR 4 East Widening Project is completed.

3. **Package D (Long-term, Westbound):**
   - Improvement #9: Extend the existing westbound mixed-flow lane from the lane drop located 3,500 feet east of the Willow Pass Road (East) off-ramp to the Willow Pass Road (West) off-ramp.

4. **Package F (Long-term, Westbound):**
   - Improvement #13: Implement ramp metering in the westbound direction on the SR 4 Bypass and on SR 4 between I-680 and I-80.

It should be noted that this prioritization is a result of the cost-effectiveness analysis of the quantitative benefits (mobility and reliability), and does not incorporate qualitative benefits (goods movement, HOV connectivity, and access management), or subjective matters such as funding or political influences. Information on the qualitative benefits of the proposed packages is included in this report to provide a comprehensive analysis for regional prioritizations.

In addition to the freeway mitigation strategies, a package of short-term and long-term transit mitigation strategies, Package H, is also included. These unranked transit mitigation improvements are listed below and discussed further in Section 9.

Package H (Short-term & Long-term, Eastbound & Westbound):

- Improvement #15: eBART.
- Improvement #16: Additional BART parking capacity.
- Improvement #17: Increased bus transit access to the BART stations.
- Improvement #18: Improvements to existing park-and-ride facilities in Martinez (Pacheco Boulevard), Antioch (Hillcrest Avenue), and Pittsburg (Bliss Avenue), as well as investment in new park-and-ride facilities at proposed/potential eBART stations.
- Improvement #19: BART system-wide operational improvements.

Section 2: Proposed Congestion Mitigation Strategies

Congestion mitigation strategies for the SR 4 Corridor incorporated for the analysis and prioritization were based on the short-term (2015) and long-term (2030) mitigation measures proposed in the *Congestion Mitigation Strategies Technical Memorandum* (MST), (PBS&J, November 9, 2009).

These congestion mitigation strategies were first screened for effectiveness. This screening process was performed with an analysis using the same macroscopic simulation model, FREQ12, as was used in the *Future Conditions Technical Memorandum* (PBS&J, October 9, 2009) to validate the effectiveness of the proposed mitigation improvements.

Based on the results of the FREQ12 testing of the performance of the mitigation strategies proposed in the MST, some strategies were modified, added, or deleted and were then combined to build logical packages of mitigation improvements; the proposed congestion mitigation improvements are listed below in Exhibit 2-1. Packages A through C are short-term improvement packages, and Packages D through G are long-term improvement packages. Those strategies that entail physical expansion of SR 4 to accommodate new HOV or mixed-flow facilities are illustrated in Appendix A.[3]

Exhibit 2-1: Proposed Mitigation Improvements on SR 4

Package	Year	Direction	ID	Mitigation Improvement
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.
			3	Extend ITS coverage to fill the gap between I-80 and I-680, and along the SR 4 Bypass.
B	2015	WB	4	Implement ramp metering in the westbound direction on SR 4 between SR 160 and I-680.
			5	Add a westbound mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.
			6	Extend the existing westbound mixed-flow lane from the Willow Pass Road (West) off-ramp to the lane-add located 4,200 feet west of the Willow Pass Road (West) on-ramp.
C	2015	EB	7	Implement ramp metering in the eastbound direction between Alhambra Avenue and Willow Pass Road (East).
			8	Add an eastbound mixed-flow lane from the lane drop located 1,500 feet west of Port Chicago Highway on-ramp to the Willow Pass Road (West) on-ramp.
D	2030	WB	9	Extend the existing westbound mixed-flow lane from the lane drop located 3,500 feet east of the Willow Pass Road (East) off-ramp to the Willow Pass Road (West) off-ramp.
E	2030	EB	10	Extend the existing eastbound mixed-flow lane from the lane drop located to 1,500 feet west of the Pacheco Boulevard off-ramp to the Pacheco Boulevard off-ramp.
			11	Extend the existing eastbound HOV lane from the I-680 NB off-ramp to its start 3,000 feet west of the Port Chicago Highway on-ramp.
			12	Extend the existing eastbound mixed-flow lane from the Willow Pass Road (East) on-ramp to the lane add located 4,000 feet east of the Willow Pass Road (East) on-ramp.
F	2030	WB	13	Implement ramp metering in the westbound direction on the SR 4 Bypass and on SR 4 between I-680 and I-80.
G	2030	EB	14	Implement ramp metering in the eastbound direction between I-80 and Alhambra Avenue, between Willow Pass Road (East) and SR 160, and on the SR 4 Bypass.
Abbreviations: ITS = Intelligent Transportation System; HOV = High Occupancy Vehicle; WB = westbound; EB = eastbound				

3 ITS and ramp metering congestion mitigation strategies were not illustrated in the map format because the text descriptions adequately describe the limits of those strategies.

Section 3: Methodology

This section provides an explanation of the methodology that was used to prepare the cost-effectiveness analysis and prioritization of congestion mitigation strategies for this report.

A cost-effectiveness analysis is a systematic evaluation of the economic advantages (benefits) and disadvantages (costs) of a set of investment alternatives. The primary objective of a cost-effectiveness analysis is to compare the proposed mitigation improvements based on their projected benefits and estimated costs. The cost- effectiveness analysis accounts for the fact that benefits generally accrue over a long period of time, while capital costs are incurred primarily in the initial years.[4]

The methods and performance measures used for the analysis and prioritization presented in this section were selected based on the guidance set forth in the FPI Framework, with the following two exceptions:[5]

(1) The quantitative performance measures were not monetized. This was agreed upon by this project's sponsoring agencies (MTC, Caltrans and CCTA) so that the performance measures would be presented in their fundamental units (e.g., person-hours of delay saved).

(2) Safety was not evaluated as part of this analysis. As noted under exception (1), the measure of person-hours of delay saved was selected to compare the quantitative performance measures, which is incompatible with the measures typically used to assess safety (i.e., number of fatality, injury and property damage collisions saved). Therefore, safety cannot be equitably evaluated side-by-side with the other performance measures according to the prioritization methodology.[6]

The following describes the data and calculations required for performing the cost-effectiveness analysis.

Benefits

The proposed mitigation improvements for the SR 4 Corridor in Contra Costa County were evaluated individually to assess the benefits of each improvement. These benefit performance measures include two quantitative performance measures and three qualitative performance measures. The quantitative performance measures are Mobility and Reliability; the qualitative performance measures are Goods Movement, HOV Connectivity, and Access Management. All values for the quantitative performance measures are represented in person-hours of delay saved.

Mobility

Mobility is a quantitative performance measure that describes how well the SR 4 Corridor moves people. Mobility can be measured in terms of recurrent vehicle delay, which is delay incurred on a typical travel day due to congested conditions in the corridor. Delay is measured as the amount of time lost for a vehicle traveling below 35 miles per hour (mph) within the corridor. By using a 35 mph standard, the recurrent delay calculated is the congested delay, not the total delay (which uses a 60 mph standard). The mobility performance measure is estimated for the implementation of each proposed mitigation improvement package.

Reliability

Reliability is a quantitative performance measure that captures the relative predictability of the public's travel time. This performance measure focuses on the extent to which mobility varies from day-to-day. Reliability can be measured in terms of

4 http://www.oim.dot.state.mn.us/EASS/
5 FPI Framework is the *Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework* (MTC, October 2007).
6 Exclusion of the safety performance measure did not affect the rankings presented in Sections 1 and 8.

non-recurrent delay, which is delay caused by irregular events, such as accidents, special events, maintenance, short-term construction, and weather. The reliability performance measure is estimated for the implementation of each proposed mitigation improvement package. It should be noted that based on Federal Highway Administration (FHWA) research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours).[7] This factor of three will be reflected in the prioritization of mitigation strategy packages shown in Section 8 and Appendix B of this technical memorandum.

Goods Movement

The goods movement performance measure is a qualitative measure that determines whether the corridor provides adequate freight mobility and reliability. As outlined in the FPI Framework, the goods movement measure will be assigned a "Yes" ranking if the improvement is located in one of the designated goods movements corridors.[8] A list of the goods movement corridors identified in MTC's submittal for Trade Corridor Improvement Funds (TCIF) under the 2006 Infrastructure Bond can be found in the FPI Framework. SR 4 is not designated as a goods movement corridor in the TCIF submittal and, therefore, will be given a "No" ranking for all improvements. It should be noted, however, that just because SR 4 is not designated as a goods movement corridor does not mean that the listed improvements have no impact on goods movement in the corridor. For the purposes of the FPI analysis, the goods movement performance measure is used specifically for comparing multiple corridors.

HOV System Connectivity

The HOV system connectivity performance measure is a qualitative measure that is used to evaluate if a corridor has an effective network of HOV lanes. This performance measure is significant because HOV lanes provide a travel-time savings incentive, increased reliability and air quality benefits. Proposed mitigation improvements that would increase HOV system connectivity can be ranked higher because of this qualitative benefit.

Access Management

The access management performance measure is a qualitative measure that evaluates the existing access management in the corridor, in terms of the number of access points such as ramps. The access management performance measure is an additional measure of safety and mobility that is not captured in those specific quantitative measures. Fewer access points along a corridor typically signifies improved mobility and safety. Mitigation measures that would improve access management by reducing the number of access points will be assigned a "Yes" ranking and can be placed higher in the prioritization.

Costs

Cost performance measures estimate the total costs associated with the proposed mitigation improvements to the corridor. The two cost performance measures are capital costs (also known as construction costs or upfront costs) and operation and maintenance (O&M) costs (also known as ongoing costs). These costs are described below and are all presented in dollars at their 2007 value. As with the benefit performance measures, a discount rate of 4% per year is used to convert future values to present values by accounting for inflation and interest rates as well as inclusion of a risk factor.

Capital Costs

Capital costs include the construction, right-of-way acquisition, vehicle procurement (transit), and mitigation costs. Construction costs include mainline, ramps, intersections, bridges, signalization, erosion control, drainage, maintenance-of-traffic and

7 This factor is from FHWA's ITS Deployment Analysis System (IDAS), which is based on the FHWA Highway Economic Requirements System (HERS).

8 *Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework* (MTC, October 2007).

mobilization. Unit prices of the construction items were obtained from Caltrans' Contract Cost Database and were applied to the quantity estimates.[9] Capital costs also include costs for engineering, administration, legal services, and a contingency add-in.

Operation and Maintenance (O&M) Costs

O&M costs are the annual costs estimated for operating and maintaining the proposed mitigation improvements. O&M costs include labor and materials for maintenance and repairs, utilities, financing, etc.

Scenarios

Benefits for the SR 4 Corridor were evaluated under two scenarios, Baseline Conditions and Improved Conditions (for a time period beginning after construction, referred to as Year 1, to the long-term future in 2030). A summary of all scenarios is listed below:

- Baseline Conditions, 2007
- Baseline Conditions, Year 1
- Baseline Conditions, 2015
- Baseline Conditions, 2030
- Improved Conditions, Year 1
- Improved Conditions, 2015
- Improved Conditions, 2030

Baseline Conditions

Benefits for Baseline Conditions were evaluated under 2007, 2015 and 2030 conditions and interpolated for all other years within the 2007 to 2030 timeline. Baseline 2007 Conditions were evaluated using 2007 data. Baseline 2015 Conditions incorporate existing 2007 conditions, projected growth in the area, and committed improvements in the SR 4 Corridor to be built between 2007 and 2015. Baseline 2030 Conditions also incorporate existing 2007 conditions, projected growth in the area, and committed projects.[10] A theoretical scenario of Baseline Year 1 is included in the interpolated values between Baseline 2007 Conditions and Baseline 2015 Conditions representing conditions after construction has been completed.

Improved Conditions

Benefits for Improved Conditions were evaluated under 2015 and 2030 conditions and interpolated for years in between. Data for a theoretical scenario of Improved Year 1 conditions were not modeled, but rather calculated based on available data from other scenarios.[11] Benefits are calculated from the end of construction, which varies by project, to 2030.

Analysis Approach for Prioritization

The benefit performance measures will be evaluated for all proposed mitigation improvements and for all scenarios described above. From these scenarios, the net increase in the quantitative benefits will be calculated from the end of construction (Year 1), to year 2030. This is known as the life-cycle benefits. Exhibit 3-4 illustrates the calculation of life-cycle benefits.

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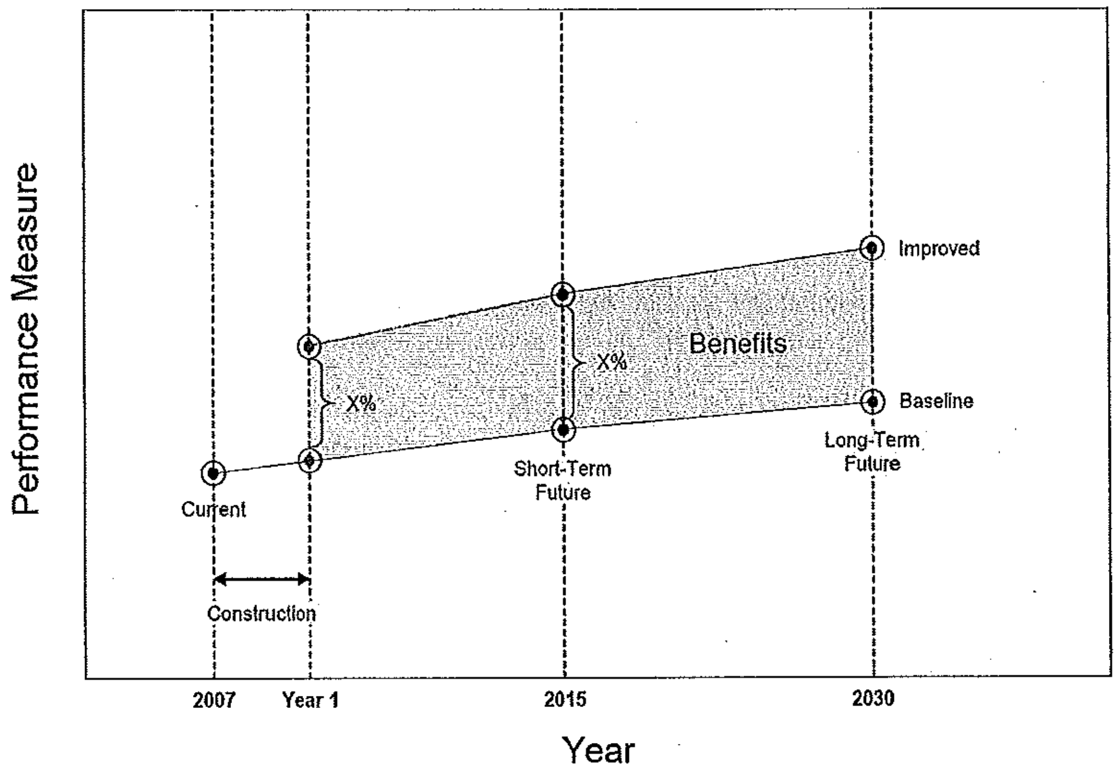
9 http://sv08data.dot.ca.gov/contractcost/

10 Committed projects are the (1) *SR 4 East Widening Project (Loveridge Road to SR160)*, and (2) Segments 1 and 2 of the SR 4 Bypass.

11 Benefit values for Baseline Year 1, Baseline 2015 and Improved 2015 are known; therefore, Improved Year 1 benefit values were estimated by assuming constant growth (see Exhibit 3-4).

Exhibit 3-4: Life-Cycle Benefits



Source: Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework (October 2007)

Detailed benefit cost estimates for each project would normally require inclusion of the duration of construction to determine when the improvement is completed and will begin accumulating benefits. However, for the purposes of this analysis, which compares a wide variety of improvements with varying construction schedules, all improvements were evaluated assuming the same length of construction such that Year 1 is the same year for all improvements.

The summation of the benefits from Year 1 to 2030 (the life-cycle benefits), will be compared to the cost performance measures of all the mitigation improvements.

Analysis Tools

A variety of analysis tools were used to evaluate the benefits of the proposed mitigation improvements. These tools include a combination of software calculations and manual calculations. The selection of the tools was mandated by the modeling capacity of the software programs and varies by the type of proposed mitigation improvement and the type of benefit. A summary of the tools used is presented in Exhibit 3-5.

Exhibit 3-5: Analysis Tools used for Developing Benefits

Type of Proposed Mitigation Improvement	Type of Benefit	
	Mobility	Reliability
Auxiliary Lane	FREQ	Manual Calculation (based on IDAS methodology)
Mixed-Flow Lane		
HOV Lane		
Ramp Metering		
ITS System Enhancements	N/A	Manual Calculation (based on IDAS methodology)

The formulas for the manual calculations are applied to the data (volumes, capacities, etc.) from FREQ, which ensures consistency between the differing analysis tools and benefits. The full methodologies and calculations of the above analysis tools used for developing mobility and reliability are available by request. Descriptions of the analysis tools follow below.

Software Calculations: FREQ

FREQ was used to evaluate recurrent congestion (mobility) for existing and future highway operating conditions. The version used was FREQ12 PE/PL, Version 3.01. The two models contained within FREQ12 are FREQ12PE, an entry control macroscopic model for analyzing ramp metering, and FREQ12PL, an on-freeway priority macroscopic model for analyzing HOV facilities. The analysis output from FREQ was used in the calculations of benefits and performance measures. The only mobility condition that FREQ was not used for was ITS System Enhancements. FREQ does not analyze ITS Improvements. Additionally, the ITS Improvements recommended target non-recurrent delay (reliability), and therefore show negligible mobility benefits.

Manual Calculations: IDAS and AASHTO

Two sources of formulas and methodology, IDAS and AASHTO, were utilized in the manual calculations.

The methodology from the ITS Deployment Analysis System (IDAS) software was used to perform manual calculations to evaluate all the ITS improvements for reliability benefits. These formulas and methodology are outlined in the IDAS User's Manual.

In addition to being used to evaluate ITS improvements, the IDAS methodology was also used to perform manual calculations to evaluate the reliability benefits of the other proposed mitigation improvements (auxiliary lanes, mixed-flow lanes, HOV lanes and ramp metering). This analysis relates the number of lanes and volume-over-capacity (V/C) ratios to travel time reliability rates.

Section 4: Performance Measures

Performance measures, such as vehicle demand, travel speed, travel time and vehicle delay, were calculated and used in the benefits analysis. Exhibits 4-1 through 4-4 present the performance measures for the following scenarios:

- Baseline Conditions, 2007 (no improvements)
- Baseline Conditions, 2015 (committed improvements)
- Baseline Conditions, 2030 (committed improvements)
- Improved Conditions, 2015 (committed improvements + short-term strategies)
- Improved Conditions, 2030 (committed improvements + short-term strategies + long-term strategies)

Additionally, exhibits 4-5 through 4-9 show the projected changes in bottleneck locations and their associated queues for the above scenarios.

Exhibit 4-1: Performance Measures on SR 4 – Westbound – AM Peak Hour

Measure (Full Analysis Area – 33 miles)	SR 4 Westbound - AM Peak Hour						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	3,700	5,300	7,800	2,400	-55%	3,400	-56%
Veh. Miles of Travel (VMT)	91,000	111,000	101,000	123,000	+11%	146,000	+45%
Average Speed (mph)	28 (HOV: 40)	25 (HOV: 49)	14 (HOV: 42)	52 (HOV: 58)	+108% (HOV: +18%)	43 (HOV: 56)	+207% (HOV: +33%)
Delay Index (free-flow speed of 60 mph / average speed)	2.1 (HOV: 1.5)	2.4 (HOV: 1.2)	4.3 (HOV: 1.4)	1.2 (HOV: 1.0)	---	1.4 (HOV: 1.1)	---
Average Corridor Travel Time (h:mm)	1:07 (HOV: 0:47)	1:20 (HOV: 0:41)	2:26 (HOV: 0:48)	0:39 (HOV: 0:34)	-51% (HOV: -17%)	0:46 (HOV: 0:36)	-68% (HOV: -25%)
Total Delay (VHT for speeds less than 60 mph)	2,180	3,440	6,190	430	-86%	1,060	-83%
Congestion Delay (VHT for speeds less than 35 mph)	1,690	2,730	5,450	190	-93%	570	-90%
Miles of Congested Segments (Speeds less than 35 mph)	8.0	12.0	17.0	2.0	-83%	5.0	-71%

Exhibit 4-2: Performance Measures on SR 4 – Eastbound – PM Peak Hour

Measure (Full Analysis Area – 33 miles)	SR 4 Eastbound - PM Peak Hour						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	3,000	3,900	6,800	2,800	-28%	4,900	-28%
Veh. Miles of Travel (VMT)	118,000	132,000	142,000	137,000	+4%	162,000	+14%
Average Speed (mph)	38 (HOV: 45)	31 (HOV: 32)	13 (HOV: 13)	46 (HOV: 46)	+48% (HOV: +44%)	28 (HOV: 29)	+115% (HOV: +123%)
Delay Index (free-flow speed of 60 mph / average speed)	1.6 (HOV: 1.3)	1.9 (HOV: 1.9)	4.6 (HOV: 4.6)	1.3 (HOV: 1.3)	---	2.1 (HOV: 2.1)	---
Average Corridor Travel Time (h:mm)	0:49 (HOV: 0:42)	1:06 (HOV: 1:04)	2:32 (HOV: 2:29)	0:44 (HOV: 0:44)	-33% (HOV: -31%)	1:13 (HOV: 1:09)	-52% (HOV: -54%)
Total Delay (VHT for speeds less than 60 mph)	1,040	1,780	4,550	630	-65%	2,310	-49%
Congestion Delay (VHT for speeds less than 35 mph)	690	1,400	4,030	430	-69%	1,770	-56%
Miles of Congested Segments (Speeds less than 35 mph)	3.5	6.5	16.0	2.5	-62%	10.5	-34%

Exhibit 4-3: Performance Measures on SR 4 – Westbound – AM Peak Period

Measure (Full Analysis Area – 33 miles)	SR 4 Westbound - AM Peak Period						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	11,000	16,500	22,700	8,700	-47%	11,700	-48%
Veh. Miles of Travel (VMT)	359,000	446,000	459,000	482,000	+8%	560,000	+22%
Average Speed (mph)	38 (HOV: 45)	34 (HOV: 53)	26 (HOV: 45)	54 (HOV: 58)	+59% (HOV: +9%)	48 (HOV: 57)	+85% (HOV: +27%)
Delay Index (free-flow speed of 60 mph / average speed)	1.6 (HOV: 1.3)	1.8 (HOV: 1.1)	2.3 (HOV: 1.3)	1.1 (HOV: 1.0)	---	1.3 (HOV: 1.1)	—
Average Corridor Travel Time (h:mm)	0:53 (HOV: 0:42)	1:05 (HOV: 0:38)	1:35 (HOV: 0:44)	0:37 (HOV: 0:34)	-43% (HOV: -11%)	0:42 (HOV: 0:35)	-56% (HOV: -20%)
Total Delay (VHT for speeds less than 60 mph)	5,170	9,270	15,140	1020	-89%	2,680	-82%
Congestion Delay (VHT for speeds less than 35 mph)	3,720	7,000	12,270	340	-95%	1,250	-90%
Miles of Congested Segments (Speeds less than 35 mph)	1.0 - 8.0 (Avg. 5.0)	3.0 - 12.0 (Avg. 8.5)	7.0 – 17.0 (Avg. 13.0)	0.0 - 2.0 (Avg. 1.0)	-88%	0.5 – 5.0 (Avg. 2.5)	-81%

Exhibit 4-4: Performance Measures on SR 4 – Eastbound – PM Peak Period

Measure (Full Analysis Area – 33 miles)	SR 4 Eastbound - PM Peak Period						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	10,200	12,100	19,400	9,900	-18%	15,100	-22%
Veh. Miles of Travel (VMT)	444,000	532,000	594,000	545,000	+2%	643,000	+8%
Average Speed (mph)	43 (HOV: 47)	44 (HOV: 45)	28 (HOV: 29)	53 (HOV: 53)	+20% (HOV: +18%)	41 (HOV: 43)	+46% (HOV: +48%)
Delay Index (free-flow speed of 60 mph / average speed)	1.4 (HOV: 1.3)	1.4 (HOV: 1.3)	2.1 (HOV: 2.1)	1.1 (HOV: 1.1)	---	1.5 (HOV: 1.4)	---
Average Corridor Travel Time (h:mm)	0:44 (HOV: 0:40)	0:49 (HOV: 0:47)	1:31 (HOV: 1:28)	0:38 (HOV: 0:38)	-22% (HOV: -19%)	0:54 (HOV: 0:51)	-41% (HOV: -42%)
Total Delay (VHT for speeds less than 60 mph)	2,980	3,580	9,780	1,210	-66%	4,700	-52%
Congestion Delay (VHT for speeds less than 35 mph)	1,900	2,430	8,070	590	-76%	3,330	-59%
Miles of Congested Segments (Speeds less than 35 mph)	1.5 – 3.5 (Avg. 2.0)	1.0 – 6.5 (Avg. 4.0)	4.0 – 16.0 (Avg. 10.0)	0.0 – 2.5 (Avg. 1.0)	-75%	0.5 – 10.5 (Avg. 5.0)	-50%

Exhibit 4-5: Locations of Bottlenecks and Recurrent Congestion on SR 4 - Baseline Conditions, 2007 (No Improvements)

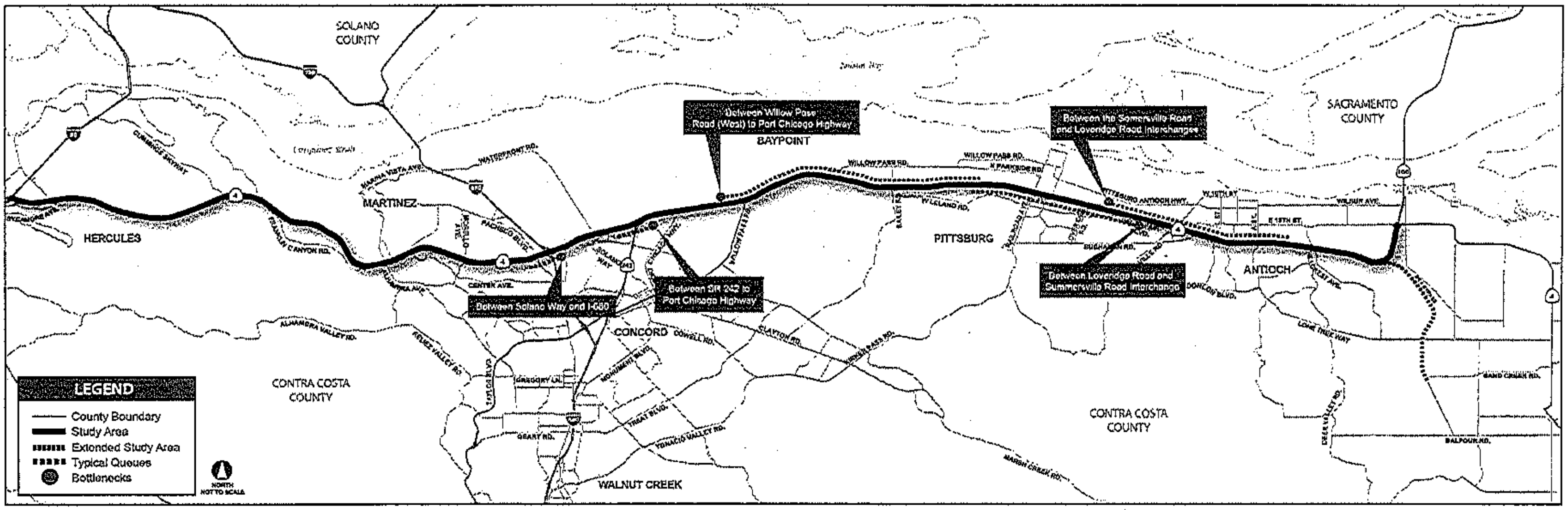


Exhibit 4-6: Locations of Bottlenecks and Recurrent Congestion on SR 4 - Baseline Conditions, 2015 (Committed Improvements)

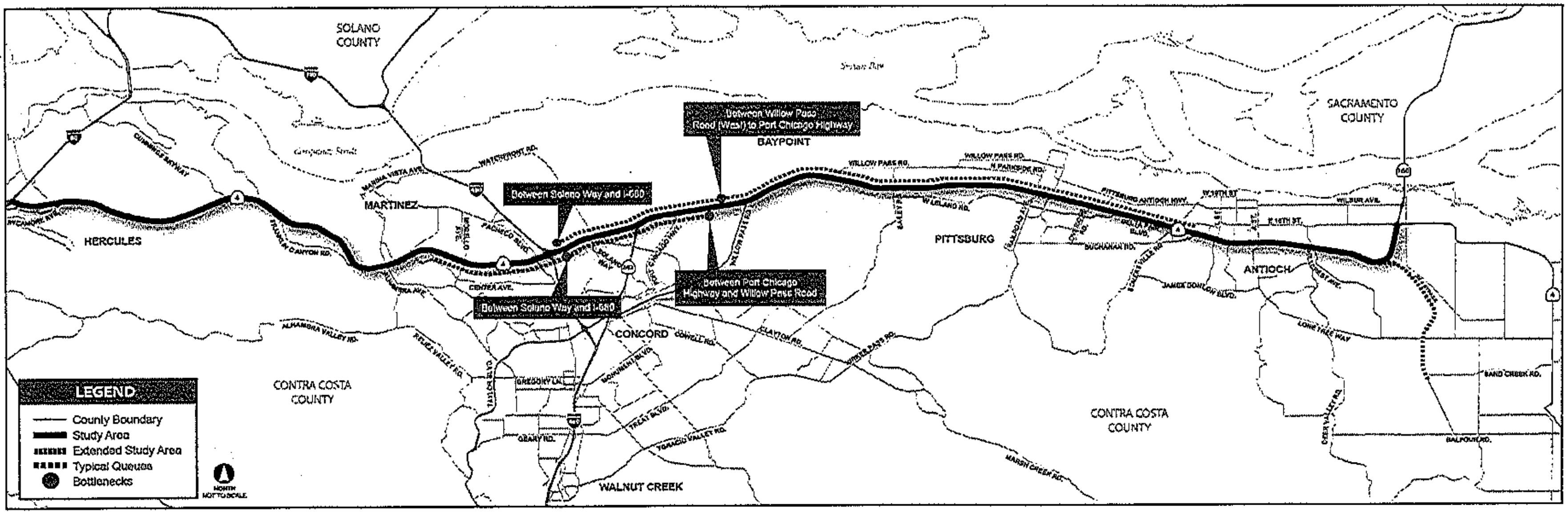


Exhibit 4-7: Locations of Bottlenecks and Recurrent Congestion on SR 4 - Improved Conditions, 2015 (Committed Improvements + Short-Term Strategies)

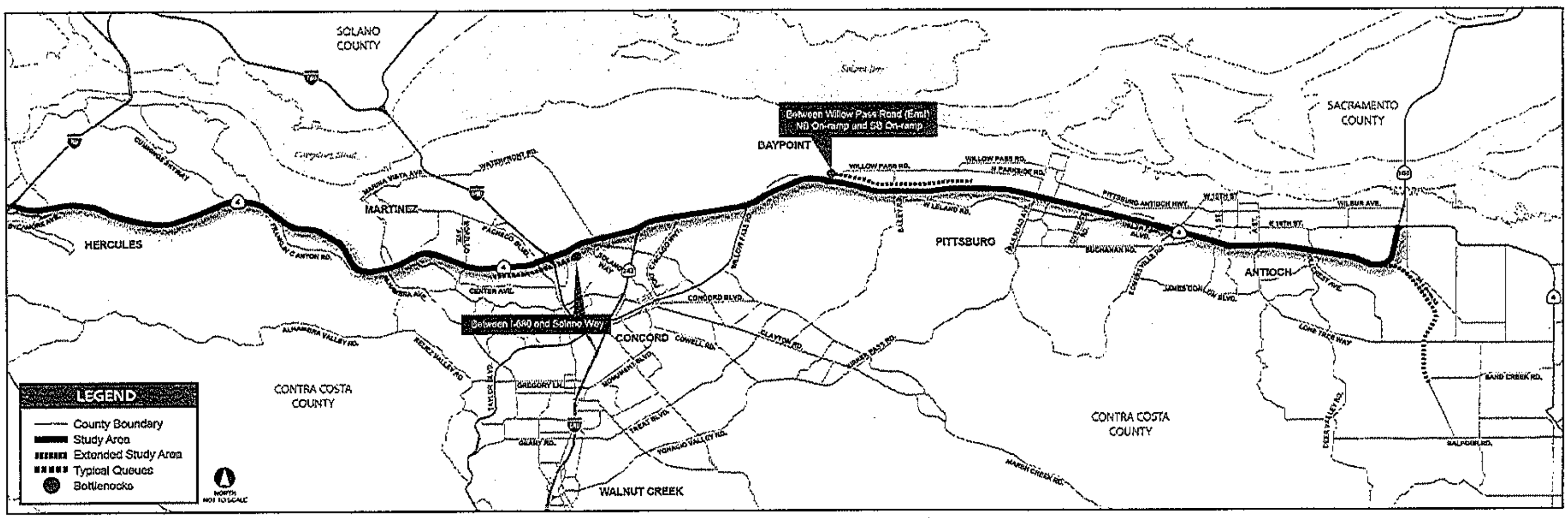


Exhibit 4-8: Locations of Bottlenecks and Recurrent Congestion on SR 4 - Baseline Conditions, 2030 (Committed Improvements)

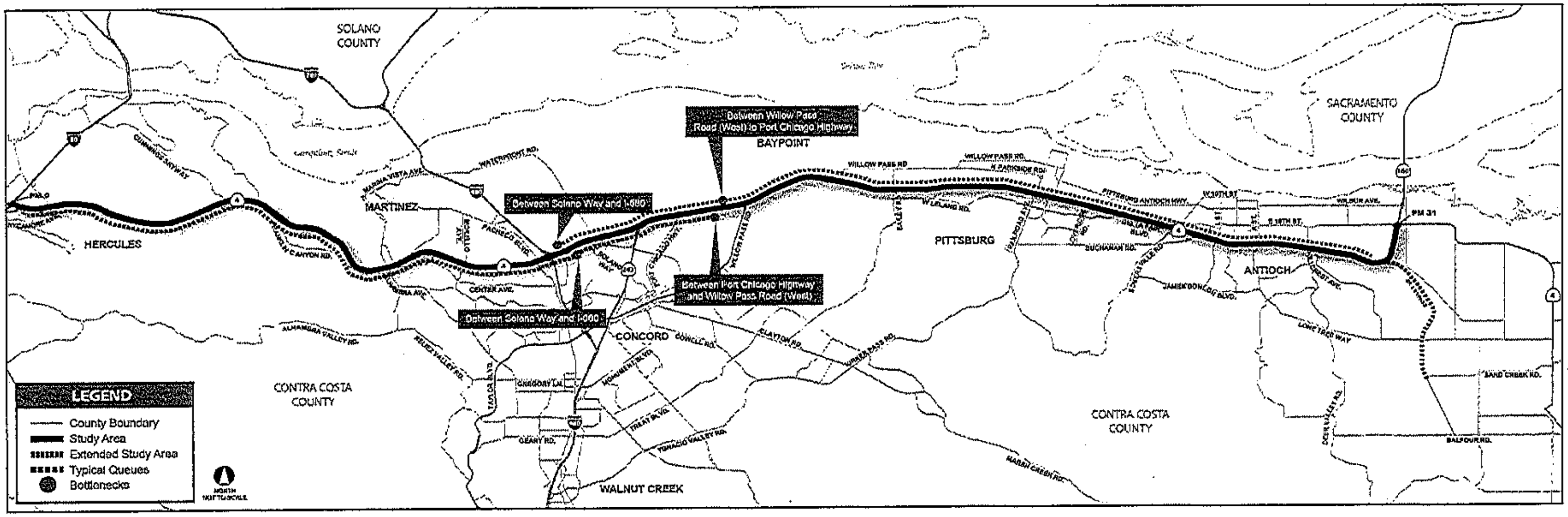
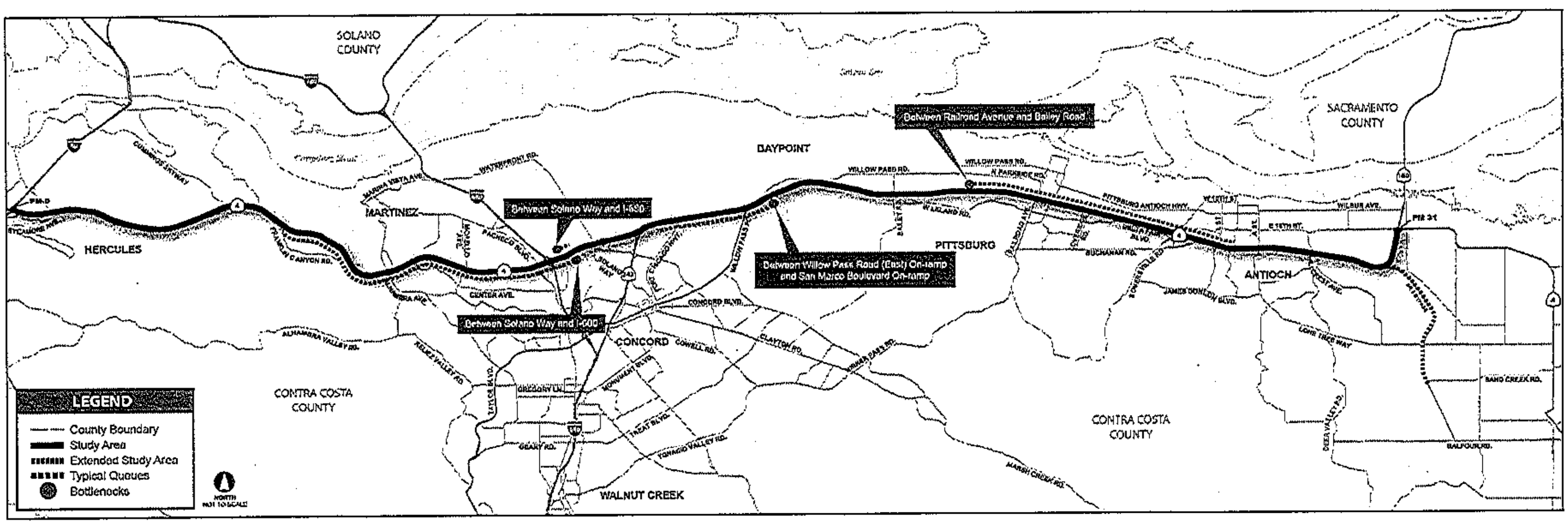


Exhibit 4-9: Locations of Bottlenecks and Recurrent Congestion on SR 4 - Improved Conditions, 2030 (Committed Improvements + Short-Term Strategies + Long-Term Strategies)



Section 5: Life-Cycle Benefits

The proposed mitigation improvements were evaluated to assess the quantitative and qualitative benefits of the improvements. The quantitative benefits, (mobility and reliability), were evaluated to estimate their life-cycle benefits. The qualitative benefits, (goods movement, HOV connectivity and access management), are also evaluated for subjective prioritization applications.

Quantitative Benefits

The quantitative benefits, mobility and reliability, were calculated for all proposed mitigation improvements as presented in Exhibit 5-1 using the analysis program (i.e., FREQ).

All calculations were performed on segment levels (e.g., Loveridge Road on-ramp to Somersville Road off-ramp) and then summed for the entire SR 4 Corridor. The mobility and reliability benefits shown in Exhibit 3-1 are the life-cycle values for 21 years, from 2009 (also known as Year 1) to 2030. These benefits include a 4% discount rate. Additional notes and assumptions of each of these benefits are provided in the following text.

Mobility

All mobility benefits were estimated using FREQ. Mobility was evaluated using actual volumes (as opposed to demand volumes) and measured in hours of recurrent delay. Specifically, congested delay was used as the type of recurrent delay used to calculate mobility.

In coordination with MTC and Caltrans staff, it was determined that mobility benefits would be quantified by evaluating recurrent delay by using congested delay, which is defined as delay resulting from vehicle speeds of less than 35 mph. Congested delay was used instead of total delay, which is defined as delays from vehicles speeds of less than 60 mph.

As a result of using congested delay instead of total delay, some improvements show no mobility benefits. This is not because the speeds remain unchanged with the addition of these improvements, but rather the absence of one of these improvements alone does not cause a decrease in speed below the 35 mph threshold. This is also due to the "All-In Differential" method.

The mobility benefit model is based on the following calculations:

1. Distances are divided by vehicle speeds to estimate travel times.
2. Calculated travel times are compared to 35 mph travel time standards of congested delay and their difference is the recurrent delay.
3. Factors are applied to convert the recurrent delay from peak period to daily and from daily to life-cycle.

Values of the life-cycle mobility benefits are presented in Exhibit 5-1.

Reliability

Reliability benefits were estimated either in IDAS or by manual computations using the travel time reliability rates provided in the IDAS User's Manual Table B 2.14. Reliability was evaluated using unconstrained volumes to calculate V/C ratios and Vehicle Miles Traveled (VMT). Unconstrained volumes were used instead of constrained volumes because the constrained volumes are lower in oversaturated conditions as a result of vehicles in queue.

The reliability benefit model is based on the following calculations:

1. Unconstrained volumes multiplied by distance results in unconstrained VMT.

2. Travel time reliability rates from IDAS are a function of number of lanes and V/C. The travel time reliability rate is the number of vehicle hours of non-recurrent delay per VMT.
3. Unconstrained VMT values multiplied by the travel time reliability rates yields the non-recurrent delay.
4. Factors are applied to convert the non-recurrent delay from peak period to daily and from daily to life-cycle.

Values of the life-cycle reliability benefits are presented in Exhibit 5-1.

Exhibit 5-1: Quantitative Measures of Life-Cycle Benefits

Pkg	Year	Dir.	ID	Mitigation Improvement	Life-Cycle Benefits		
					Mobility (per-hrs saved)	Reliability (per-hrs saved)	TOTAL (per-hrs saved)
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	0	11,480,000	34,440,000
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.			
			3	Extend ITS coverage to fill the gap between I-80 and I-680, and along the SR 4 Bypass.			
B	2015	WB	4	Implement ramp metering in the westbound direction on SR 4 between SR 160 and I-680.	77,809,000	7,243,000	99,538,000
			5	Add a westbound mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.			
			6	Extend the existing westbound mixed-flow lane from the Willow Pass Road (West) off-ramp to the lane-add located 4,200 feet west of the Willow Pass Road (West) on-ramp.			
C	2015	EB	7	Implement ramp metering in the eastbound direction between Alhambra Avenue and Willow Pass Road (East).	22,324,000	5,270,000	38,134,000
			8	Add an eastbound mixed-flow lane from the lane drop located 1,500 feet west of Port Chicago Highway on-ramp to the Willow Pass Road (West) on-ramp.			
D	2030	WB	9	Extend the existing westbound mixed-flow lane from the lane drop located 3,500 feet east of the Willow Pass Road (East) off-ramp to the Willow Pass Road (West) off-ramp.	2,926,000	5,011,000	17,959,000
E	2030	EB	10	Extend the existing eastbound mixed-flow lane from the lane drop located to 1,500 feet west of the Pacheco Boulevard off-ramp to the Pacheco Boulevard off-ramp.	8,595,000	6,058,000	26,769,000
			11	Extend the existing eastbound HOV lane from the I-680 NB off-ramp to its start 3,000 feet west of the Port Chicago Highway on-ramp.			
			12	Extend the existing eastbound mixed-flow lane from the Willow Pass Road (East) on-ramp to the lane add located 4,000 feet east of the Willow Pass Road (East) on-ramp.			
F	2030	WB	13	Implement ramp metering in the westbound direction on the SR 4 Bypass and on SR 4 between I-680 and I-80.	367,000	368,000	1,471,000
G	2030	EB	14	Implement ramp metering in the eastbound direction between I-80 and Alhambra Avenue, between Willow Pass Road (East) and SR 160, and on the SR 4 Bypass.	1,551,000	2,607,000	9,372,000

Abbreviations: ITS = Intelligent Transportation System; HOV = High Occupancy Vehicle

Note: Based on FHWA research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours). This factor is reflected in the "Total Life-Cycle Benefits" value.

Qualitative Benefits

The qualitative benefits were addressed for all proposed mitigation improvements as summarized below. These benefits were evaluated by determining if the proposed mitigation measure provided improvements in the SR 4 Corridor that cannot be easily quantified, but should be considered in the regional prioritization (i.e., comparing proposed mitigation improvements on SR 24 with proposed mitigation measures within other corridors in the region). These qualitative benefits, as outlined in the FPI Framework, are: goods movement, HOV connectivity, and access management. An improvement for these benefits is denoted by a "Yes." These qualitative benefits are not included in the ranking/prioritization of mitigation strategy packages because there is no specific dollar value associated with them. In accordance with the methodology described in Section 3 of this memorandum, the qualitative benefits are outlined below.

Goods Movement

For the goods movement performance measure, no mitigation improvements were given a "Yes" ranking. This is due to the fact that SR 4 is not designated as a goods movement corridor.

HOV System Connectivity

For the HOV system connectivity performance measure, the following mitigation improvement was given a "Yes" ranking:

- Improvement #11 of Package E: Extend the existing eastbound HOV lane from the I-680 NB off-ramp its start 3,000 feet west of the Port Chicago Highway on-ramp.

Access Management

For the access management performance measure, no mitigation improvements were given a "Yes" ranking. This is due to the fact that there are no proposed mitigation improvements that reduce the number of access points on the SR 4 Corridor.

As noted previously, the final prioritization does not incorporate the above qualitative performance measures. However, these qualitative "Yes" rankings are important in that they provide a more comprehensive analysis to inform the regional prioritization process.

Section 6: Life-Cycle Costs

Capital costs and O&M costs were calculated for all proposed mitigation improvements and are presented in Exhibit 6-1. Details on the methodology of the cost estimations are provided in Section 3. Capital costs were incurred during construction years and O&M costs were accrued annually after construction. Life-cycle costs were calculated for a life-cycle of 21 years, from 2009 to 2030 as with the life-cycle benefits. Life-cycle costs include a 4% discount rate.

Exhibit 6-1: Life-Cycle Costs

Pkg	Year	Dir.	ID	Mitigation Improvement	Capital Cost	O&M Cost (per year)	Life-Cycle Costs
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	$9,906,000	$297,200	$40,110,000
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.			
			3	Extend ITS coverage to fill the gap between I-80 and I-680, and along the SR 4 Bypass.	$18,074,000	$542,200	
B	2015	WB	4	Implement ramp metering in the westbound direction on SR 4 between SR 160 and I-680.	$12,976,000	$648,800	$68,220,000
			5	Add a westbound mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.	$23,851,000	$9,300	
			6	Extend the existing westbound mixed-flow lane from the Willow Pass Road (West) off-ramp to the lane-add located 4,200 feet west of the Willow Pass Road (West) on-ramp.	$21,577,000	$10,900	
C	2015	EB	7	Implement ramp metering in the eastbound direction between Alhambra Avenue and Willow Pass Road (East).	$2,978,000	$148,900	$33,070,000
			8	Add an eastbound mixed-flow lane from the lane drop located 1,500 feet west of Port Chicago Highway on-ramp to the Willow Pass Road (West) on-ramp.	$27,697,000	$9,000	
D	2030	WB	9	Extend the existing westbound mixed-flow lane from the lane drop located 3,500 feet east of the Wil ow Pass Road (East) off-ramp to the Willow Pass Road (West) off-ramp.	$22,172,000	$13,800	$22,400,000
E	2030	EB	10	Extend the existing eastbound mixed-flow lane from the lane drop located to 1,500 feet west of the Pacheco Boulevard off-ramp to the Pacheco Boulevard off-ramp.	$2,117,000	$1,800	$31,880,000
			11	Extend the existing eastbound HOV lane from the I-680 NB off-ramp to its start 3,000 feet west of the Port Chicago Highway on-ramp.	$25,687,000	$16,800	
			12	Extend the existing eastbound mixed-flow lane from the Willow Pass Road (East) on-ramp to the lane add located 4,000 feet east of the Willow Pass Road (East) on-ramp.	$3,757,000	$6,000	
F	2030	WB	13	Implement ramp metering in the westbound direction on the SR 4 Bypass and on SR 4 between I-680 and I-80.	$5,396,000	$7,600	$5,510,000
G	2030	EB	14	Implement ramp metering in the eastbound direction between I-80 and Alhambra Avenue, between Willow Pass Road (East) and SR 160, and on the SR 4 Bypass.	$10,448,000	$12,900	$10,640,000

Abbreviations: ITS = Intelligent Transportation System; HOV = High Occupancy Vehicle

Section 7: Life-Cycle Cost-Effectiveness Analysis

Life-cycle benefits and life-cycle costs were compared to estimate the life-cycle benefit cost for all proposed mitigation improvement packages, with the exception of the transit improvement package (Package H), and are presented in Exhibit 7-1. Details on the methodology used for the cost-effectiveness analysis are provided in Section 3. For each mitigation strategy package, life-cycle costs were divided by life-cycle benefits to estimate the life-cycle cost-effectiveness. The cost-effectiveness is presented as the cost for every hour of delay saved as estimated over a 21-year life-cycle, from 2009 to 2030.

Exhibit 7-1: Life-Cycle Cost-Effectiveness Analysis

Pkg	Year	Dir.	ID	Mitigation Improvement	Life-Cycle Benefits	Life-Cycle Costs	Cost-Effectiveness
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	34,440,000 person-hours of delay saved	$40,110,000	$1.16 / person-hour of delay saved
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.			
			3	Extend ITS coverage to fill the gap between I-80 and I-680, and along the SR 4 Bypass.			
B	2015	WB	4	Implement ramp metering in the westbound direction on SR 4 between SR 160 and I-680.	99,538,000 person-hours of delay saved	$68,220,000	$0.69 / person-hour of delay saved
			5	Add a westbound mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.			
			6	Extend the existing westbound mixed-flow lane from the Willow Pass Road (West) off-ramp to the lane-add located 4,200 feet west of the Willow Pass Road (West) on-ramp.			
C	2015	EB	7	Implement ramp metering in the eastbound direction between Alhambra Avenue and Willow Pass Road (East).	38,134,000 person-hours of delay saved	$33,070,000	$0.87 / person-hour of delay saved
			8	Add an eastbound mixed-flow lane from the lane drop located 1,500 feet west of Port Chicago Highway on-ramp to the Willow Pass Road (West) on-ramp.			
D	2030	WB	9	Extend the existing westbound mixed-flow lane from the lane drop located 3,500 feet east of the Wil ow Pass Road (East) off-ramp to the Willow Pass Road (West) off-ramp.	17,959,000 person-hours of delay saved	$22,400,000	$1.25 / person-hour of delay saved
E	2030	EB	10	Extend the existing eastbound mixed-flow lane from the lane drop located to 1,500 feet west of the Pacheco Boulevard off-ramp to the Pacheco Boulevard off-ramp.	26,769,000 person-hours of delay saved	$31,880,000	$1.19 / person-hour of delay saved
			11	Extend the existing eastbound HOV lane from the I-680 NB off-ramp to its start 3,000 feet west of the Port Chicago Highway on-ramp.			
			12	Extend the existing eastbound mixed-flow lane from the Willow Pass Road (East) on-ramp to the lane add located 4,000 feet east of the Willow Pass Road (East) on-ramp.			
F	2030	WB	13	Implement ramp metering in the westbound direction on the SR 4 Bypass and on SR 4 between I-680 and I-80.	1,471,000 person-hours of delay saved	$5,510,000	$3.75 / person-hour of delay saved
G	2030	EB	14	Implement ramp metering in the eastbound direction between I-80 and Alhambra Avenue, between Willow Pass Road (East) and SR 160, and on the SR 4 Bypass.	9,372,000 person-hours of delay saved	$10,640,000	$1.14 / person-hour of delay saved

Abbreviations: ITS = Intelligent Transportation Systems; HOV = High Occupancy Vehicle

Section 8: Prioritization

All proposed mitigation improvement packages were ranked/prioritized based solely on the calculated cost-effectiveness (described above in Sections 3 and 7) of their respective improvements. For the purposes of this prioritization exercise, qualitative benefits and political considerations were not included. Rankings are shown in ascending order with Rank 1 having the most cost-effectiveness (as determined in Section 7). Exhibit 8-1 shows the ranking for each mitigation improvement package.

Exhibit 8-1: Prioritization of Mitigation Improvements

					Package Rank	
Pkg	Year	Dir.	ID	Mitigation Improvement	Short-Term	Long-Term
B	2015	WB	4	Implement ramp metering in the westbound direction on SR 4 between SR 160 and I-680.	1	---
			5	Add a westbound mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.		
			6	Extend the existing westbound mixed-flow lane from the Willow Pass Road (West) off-ramp to the lane-add located 4,200 feet west of the Willow Pass Road (West) on-ramp.		
C	2015	EB	7	Implement ramp metering in the eastbound direction between Alhambra Avenue and Willow Pass Road (East).[12]	2	---
			8	Add an eastbound mixed-flow lane from the lane drop located 1,500 feet west of Port Chicago Highway on-ramp to the Willow Pass Road (West) on-ramp.		
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	3	---
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.		
			3	Extend ITS coverage to fill the gap between I-80 and I-680, and along the SR 4 Bypass.		
G	2030	EB	14	Implement ramp metering in the eastbound direction between I-80 and Alhambra Avenue, between Willow Pass Road (East) and SR 160, and on the SR 4 Bypass.	---	1
E	2030	EB	10	Extend the existing eastbound mixed-flow lane from the lane drop located to 1,500 feet west of the Pacheco Boulevard off-ramp to the Pacheco Boulevard off-ramp.[13]	---	2
			11	Extend the existing eastbound HOV lane from the I-680 NB off-ramp to its start 3,000 feet west of the Port Chicago Highway on-ramp.		
			12	Extend the existing eastbound mixed-flow lane from the Willow Pass Road (East) on-ramp to the lane add located 4,000 feet east of the Willow Pass Road (East) on-ramp.		
D	2030	WB	9	Extend the existing westbound mixed-flow lane from the lane drop located 3,500 feet east of the Willow Pass Road (East) off-ramp to the Willow Pass Road (West) off-ramp.	---	3
F	2030	WB	13	Implement ramp metering in the westbound direction on the SR 4 Bypass and on SR 4 between I-680 and I-80.	---	4

Abbreviations: ITS = Intelligent Transportation Systems; HOV = High Occupancy Vehicle

Package B and Package C ranked the highest of all the mitigation strategy packages, addressing westbound and eastbound congestion approaching the SR 242 and I-680 interchanges. The ITS package, Package A, also ranked high providing the full coverage of ITS technology and management needed to address nonrecurrent delay and safety on the SR 4 Corridor.

12 ITS Installations in Package A may be considered for implementation before the ramp metering mitigation (Improvement #7) in Package C, to so that the benefit of the ramp metering can be fully realized.

13 Notwithstanding the ranking of this mixed-flow lane extension (Improvement #10) in Package E, this project may be advanced in the regional planning and programming process to advance it in conjunction with the Pacheco Transit Center expansion.

Note that within the analysis period (2007 to 2030) no congestion mitigations exist in the eastern portion of the SR 4 Corridor because the committed SR 4 East Widening Project and SR 4 Bypass Project will mitigate future traffic demands.

Section 9: Transit Mitigation Strategies

While the FPI and CSMP processes focus on freeway mitigation strategies, improved transit service was raised by stakeholders along the SR 4 corridor. In the case of SR 4 these services include eBART and general strategies to increase transit access, including additional parking at BART stations in the corridor, enhanced bus feeder services, and operational enhancements to BART at a system-wide level that could accommodate ridership increases of 10 to 20 percent.[14]

eBART

The East Contra Costa BART Extension (eBART) project is included in the Regional Transportation Plan (RTP). The proposed project is a Diesel Multiple Vehicle (DMU) with expanded service from the Pittsburg/Bay Point BART station to a new station at Railroad Avenue and a terminus station east of Hillcrest Avenue in Antioch. The eBART project includes 300 parking spaces for the proposed station at Railroad Avenue and 2,600 parking spaces for the proposed station at Hillcrest Avenue. Life-cycle benefits and life-cycle costs were not estimated for eBART.

Additional Transit Strategies

As mentioned earlier, the short-term and long-term transit mitigation strategies in Package H include additional BART parking capacity, increased bus transit access to the BART stations, improvements to existing park-and-ride facilities in Martinez (Pacheco Boulevard), Antioch (Hillcrest Avenue), and Pittsburg (Bliss Avenue), as well as investment in new park-and-ride facilities at proposed/potential eBART stations, and BART system-wide operational improvements. A benefit cost ratio could not be estimated for this report, and thus these transit mitigation strategies cannot be ranked against other mitigation strategies for which life-cycle benefits and costs were available. For this reason, no prioritized recommendations are offered on this set of transit strategies and further analysis is recommended to determine the effectiveness of these improvements and their impacts on the corridor.

Exhibit 9-1: Transit Mitigation Improvements

Pkg	ID	Mitigation Improvement
H	15	eBART
	16	Additional BART parking capacity.
	17	Increased bus transit access to the BART stations.
	18	Improvements to existing park-and-ride facilities in Martinez (Pacheco Boulevard), Antioch (Hillcrest Avenue), and Pittsburg (Bliss Avenue), as well as investment in new park-and-ride facilities at proposed/potential eBART stations.
	19	BART system-wide operational improvements.

14 The feasibility of accommodating ridership increases in this range was discussed with BART as part of the stakeholder coordination process.

Section 10: Express Lanes

As described in the *Congestion Mitigation Strategies Technical Memorandum*, (PBS&J, November 9, 2009), in addition to the physical roadway mitigation improvements described in previous sections of this memorandum and the transit mitigation improvement measures described in Section 9, the option of converting the HOV lanes on SR 4 to Express Lanes (also referred to as High-Occupancy Toll Lanes, or HOT Lanes) is discussed here. Express Lanes allow HOV users to continue to use the carpool lane for free, but also allow single-occupant vehicles to access the carpool lane by paying a toll.

MTC's *Transportation 2035 Plan for the San Francisco Bay Area* (T-2035) proposes a Regional Express Lane Network for the Bay Area, which includes Express Lanes on SR 4 between I-680 and SR 160.[15] On July 16, 2009, the California Senate Transportation and Housing Committee passed Assembly Bill 744 (Torrico), which authorizes the creation of an 800-mile express lane network on Bay Area freeways. This bill must still be passed by the Senate Appropriations Committee before moving on to the Senate floor for authorization.

The conversion of HOV lanes to Express Lanes on SR 4 would increase the total number of vehicles using the HOV lanes, provided those lanes have available "vacant" capacity that can be "bought" by single-occupant drivers who are willing to pay a toll in exchange for a faster trip in the HOV lane. Toll-paying single-occupant vehicles are allowed to enter the HOV lane; however, as the volume of traffic in the lane begins to reach a pre-determined capacity level, the toll amount charged to single-occupant users increases dynamically in response to the demand. Real-time, variable pricing of the "vacant" capacity in the HOV lanes is used as a mechanism to limit the number of vehicles entering the lane. The Express Lane operator is required, through pricing and changeable message signs, to maintain free-flow conditions in the Express Lane at all times.

All existing Express Lanes in the United States are limited access facilities. In the Bay Area design, Express Lanes are separated from the adjacent mixed-flow lanes by a double-stripe line, similar to facilities in Seattle and Minneapolis. Lane markings, such as a single-dashed stripe or transition lane, designate ingress and egress zones. Non-carpools using the Express Lanes pay their tolls using electronic FasTrak® toll tags, which are already in use on the region's eight toll bridges; as a vehicle enters the Express Lane, an electronic reader detects the toll tag and deducts the toll from a prepaid account.

Documented benefits of Express Lanes in operation in the United States include: improved travel speeds in the mixed-flow lanes; increased corridor throughput; ability to provide a reliable travel option that can be used when most needed (most express lane travelers use the lanes no more than a few times a week); and, in some cases, revenue to support transit service. Further, there is no evidence that Express Lanes reduce carpool levels or transit ridership.

Should AB 744 or similar legislation be signed into law at some point in the future, significant further analysis and consultation with affected jurisdictions along the corridor will be required to determine the feasibility, cost-effectiveness and appropriateness of converting the HOV lanes to Express Lanes in the SR 4 Corridor. This process will inform whether and how (e.g., timing and phasing, design and operations policies) to pursue Express Lanes in the corridor.

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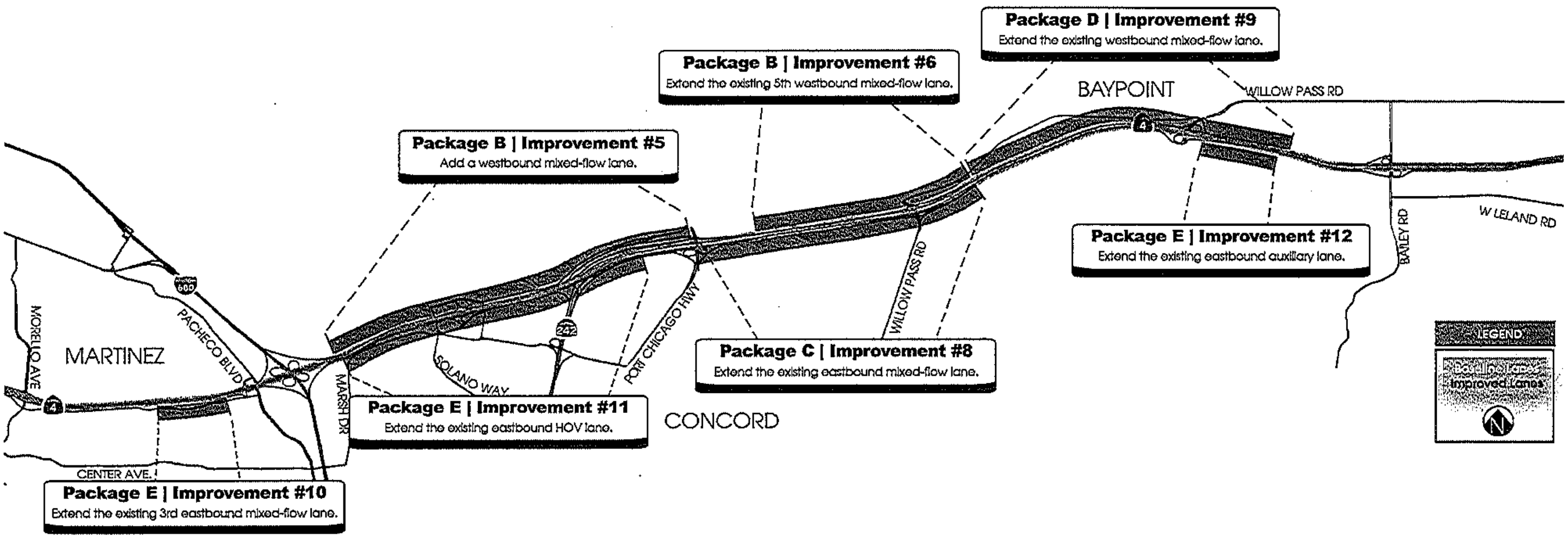
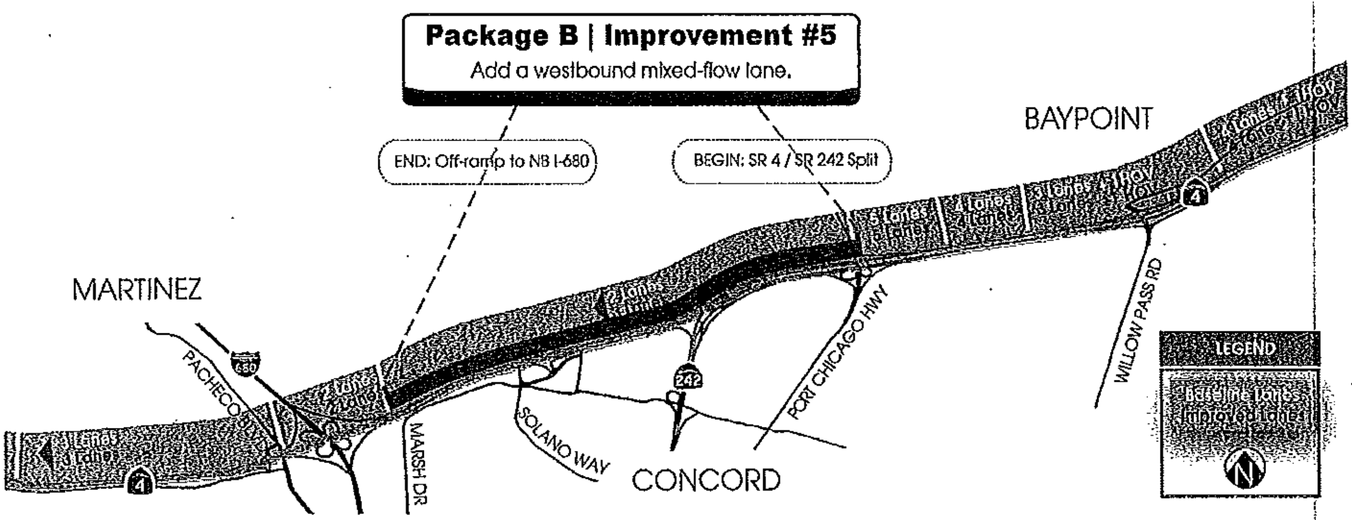
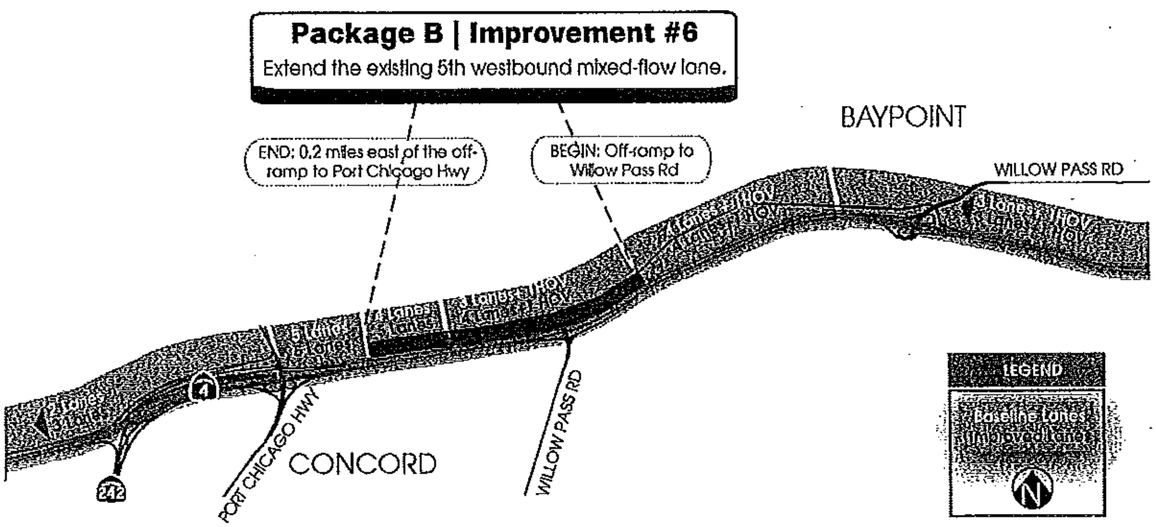
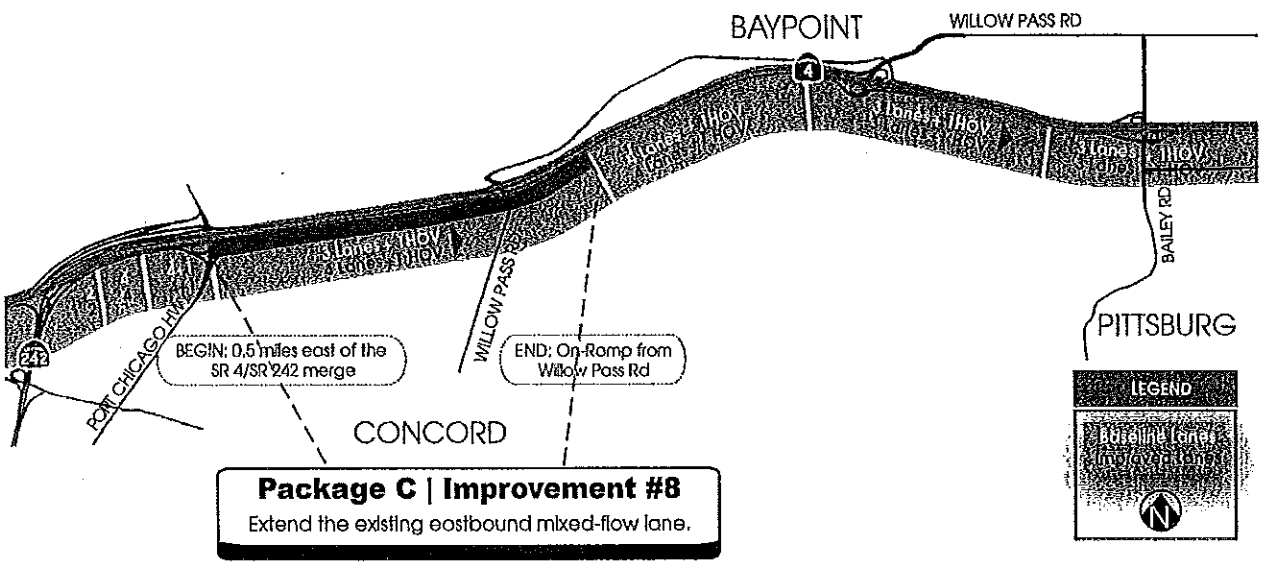
15 http://www.mtc.ca.gov/planning/hov/index.htm

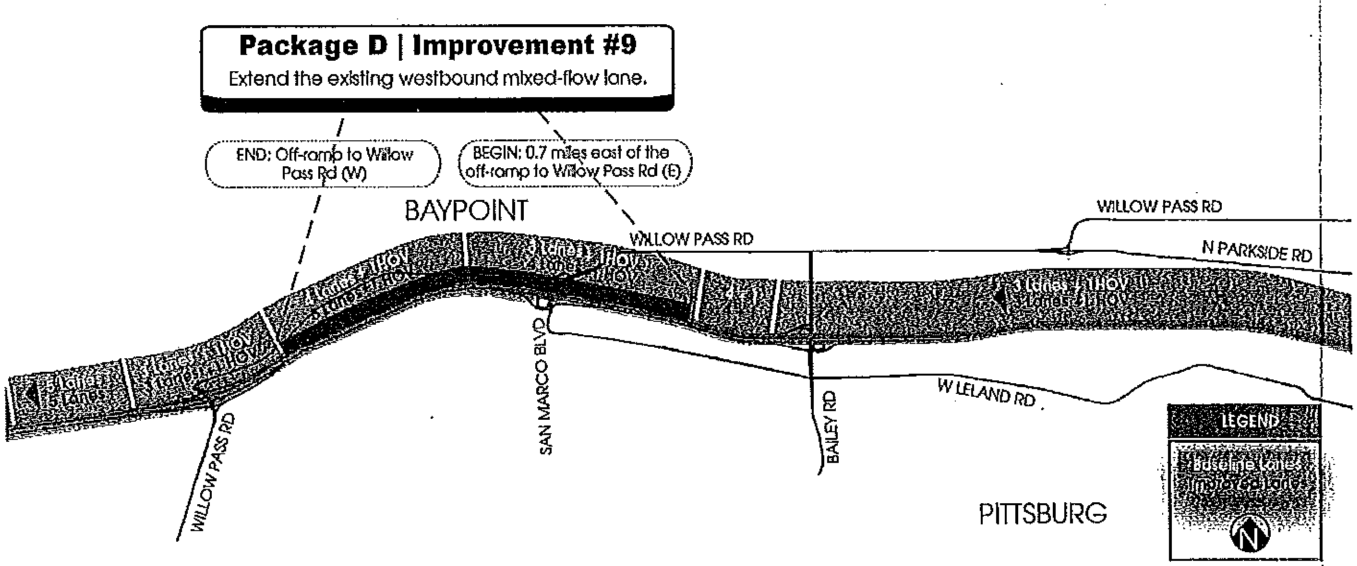
Appendix A: Illustration of Selected Mitigation Strategies

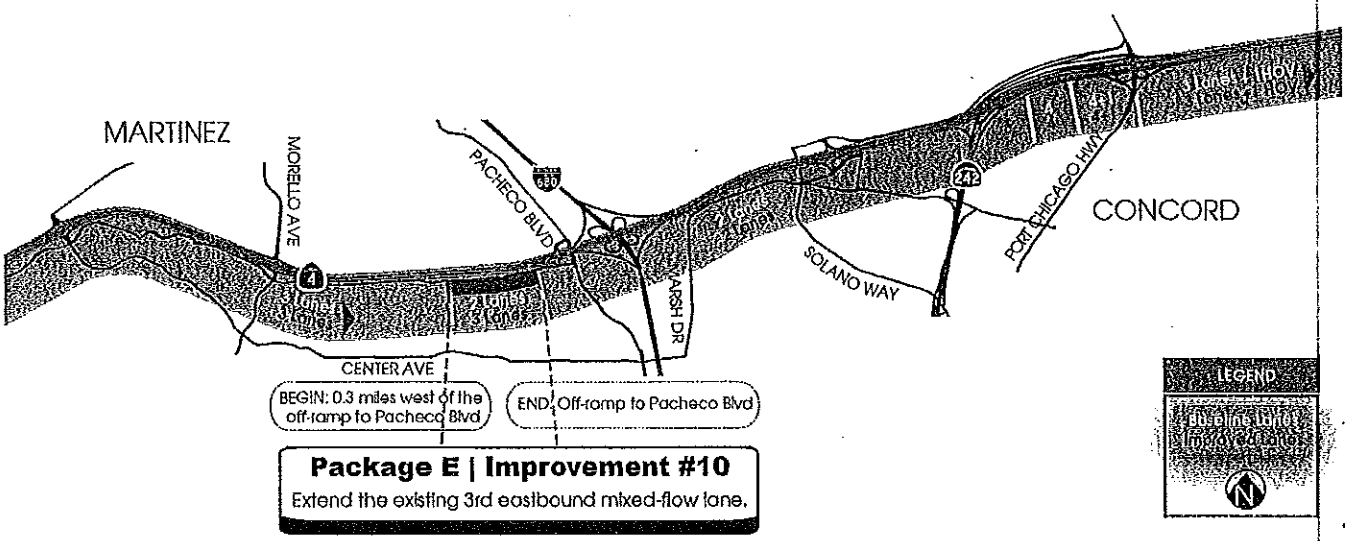

Package D | Improvement #9
Extend the existing westbound mixed-flow lane.
Package B | Improvement #6
Extend the existing 5th westbound mixed-flow lane.
Package B | Improvement #5
Add a westbound mixed-flow lane.
BAYPOINT
WILLOW PASS RD
W LELAND RD
BAILEY RD
Package E | Improvement #12
Extend the existing eastbound auxiliary lane.
MARTINEZ
MORELLO AVE
PACHECO BLVD
SOLANO WAY
PORT CHICAGO HWY
MARSH DR
Package C | Improvement #8
Extend the existing eastbound mixed-flow lane.
Package E | Improvement #11
Extend the existing eastbound HOV lane.
CONCORD
CENTER AVE.
Package E | Improvement #10
Extend the existing 3rd eastbound mixed-flow lane.
LEGEND
Improved Lanes

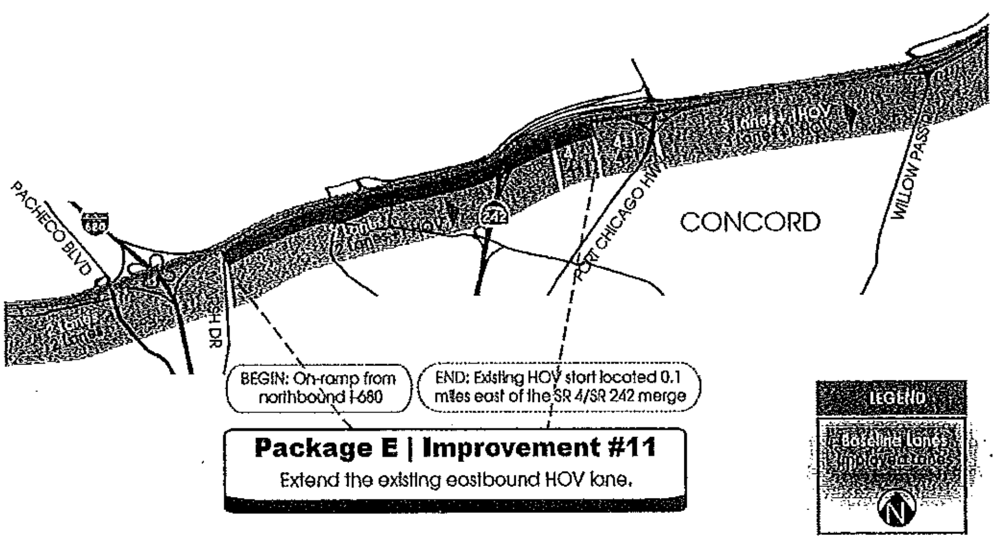

Package B | Improvement #5
Add a westbound mixed-flow lane.
END: Off-ramp to NB I-680
BEGIN: SR 4 / SR 242 Split
BAYPOINT
MARTINEZ
PACHECO
MARSH DR
SOLANO WAY
CONCORD
PORT CHICAGO HWY
WILLOW PASS RD
LEGEND
Baseline Lanes
Improved Lanes

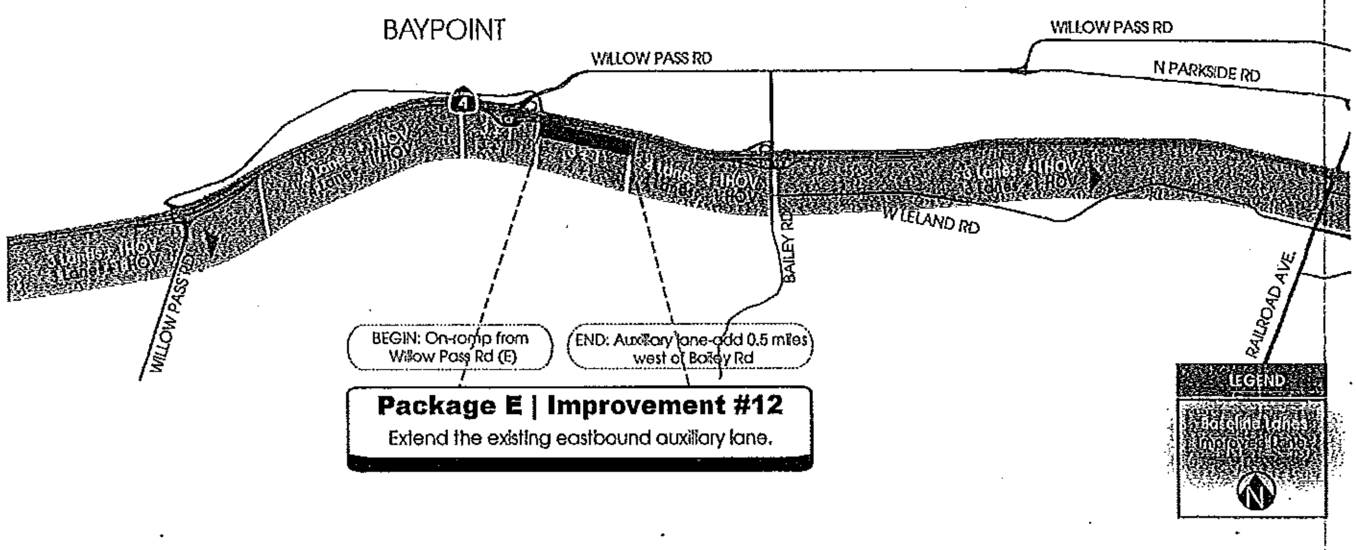

Package B | Improvement #6
Extend the existing 5th westbound mixed-flow lane.
END: 0.2 miles east of the off-ramp to Port Chicago Hwy
BEGIN: Off-ramp to Willow Pass Rd
BAYPOINT
WILLOW PASS RD
CONCORD
PORT CHICAGO HWY
LEGEND
Baseline Lanes
Improved Lanes


BAYPOINT
WILLOW PASS RD
BAILEY RD
PITTSBURG
WILLOW PASS RD
POINT CHICAGO HWY
BEGIN: 0.5 miles east of the SR 4/SR 242 merge
END: On-Ramp from Willow Pass Rd
CONCORD
Package C | Improvement #8
Extend the existing eastbound mixed-flow lane.
LEGEND


Package D | Improvement #9
Extend the existing westbound mixed-flow lane.
END: Off-ramp to Willow Pass Rd (W)
BEGIN: 0.7 miles east of the off-ramp to Willow Pass Rd (E)
BAYPOINT
WILLOW PASS RD
WILLOW PASS RD
N PARKSIDE RD
W LELAND RD
SAN MARCO BLVD
BAILEY RD
WILLOW PASS RD
PITTSBURG
LEGEND


MARTINEZ
MORELLO AVE
PACHECO BLVD
MARSH DR
SOLANO WAY
PORT CHICAGO HWY
CONCORD
CENTER AVE
BEGIN: 0.3 miles west of the off-ramp to Pacheco Blvd
END: Off-ramp to Pacheco Blvd
Package E | Improvement #10
Extend the existing 3rd eastbound mixed-flow lane.
LEGEND


PACHECO BLVD
PORT CHICAGO HWY
CONCORD
WILLOW PASS
BEGIN: On-ramp from northbound I-680
END: Existing HOV start located 0.1 miles east of the SR 4/SR 242 merge
Package E | Improvement #11
Extend the existing eastbound HOV lane.
LEGEND



BAYPOINT
WILLOW PASS RD
WILLOW PASS RD
N PARKSIDE RD
W LELAND RD
BAILEY RD
WILLOW PASS RD
RAILROAD AVE.
BEGIN: On-ramp from Willow Pass Rd (E)
END: Auxiliary lane-add 0.5 miles west of Bailey Rd
Package E | Improvement #12
Extend the existing eastbound auxiliary lane.
LEGEND

Appendix B: Life-Cycle Cost-Effectiveness Analysis and Prioritization

SR 4 Prioritized Congestion Mitigation Strategies: Cost-Effectiveness Analysis

Strategy	Life-Cycle Benefits: Mobility Benefits (per-hrs saved)	Life-Cycle Benefits: Reliability Benefits (per-hrs saved)	Life-Cycle Benefits: Total [1,2]	Life-Cycle Costs [3]	Life-Cycle Cost-Effectiveness: Cost to Person-Hour of Delay Saved	Package Rank [4]: Short Term	Package Rank [4]: Long Term
SHORT-TERM (2009-2015) MITIGATION STRATEGIES							
Short-term Strategies Package A							
1 Activate existing ITS installations that currently are not fully operational. 2 Assess gaps in the current and programmed ITS and supplement as needed. 3 Extend ITS coverage to fill the gap from I-80 to I-680, to on the SR 4 Bypass.	0	11,480,000	34,440,000	$40,110,000	$1.16 / per-hr of delay saved	3	—
Short-term Strategies Package B							
4 Implement WB ramp metering from SR 160 to I-680. 5 Add a WB mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp. 6 Extend the WB mixed-flow lane from the the Willow Pass Rd (W) off-ramp to the lane-add 0.8 mi west of the Willow Pass (W) on-ramp.	77,809,000	7,243,000	99,538,000	$68,220,000	$0.69 / per-hr of delay saved	1	—
Short-term Strategies Package C							
7 Implement EB ramp metering from Alhambra Ave to Willow Pass Rd (E). 8 Add an EB mixed-flow lane from the lane drop located 0.3 mi west of Port Chicago Hwy on-ramp to the Willow Pass Rd (W) on-ramp.	22,324,000	5,270,000	38,134,000	$33,070,000	$0.87 / per-hr of delay saved	2	—
LONG-TERM (2016-2030) MITIGATION STRATEGIES							
Long-term Strategies Package D							
9 Extend the WB mixed-flow lane from the lane drop 0.7 mi east of the Willow Pass Rd (E) off-ramp to the Willow Pass Rd (W) off-ramp.	2,926,000	5,011,000	17,959,000	$22,400,000	$1.25 / per-hr of delay saved	—	3
Long-term Strategies Package E							
10 Extend the EB mixed-flow lane from the lane drop 0.3 mi west of the Pacheco Blvd off-ramp to the Pacheco Blvd off-ramp. 11 Extend the EB HOV lane from the I-680 NB off-ramp to its start 0.6 mi west of the Port Chicago Hwy on-ramp. 12 Extend the EB mixed-flow lane from the Willow Pass Rd (E) on-ramp to the lane add 0.8 mi east of the Willow Pass Rd (E) on-ramp.	8,595,000	6,058,000	26,769,000	$31,880,000	$1.19 / per-hr of delay saved	—	2
Long-term Strategies Package F							
13 Implement ramp metering in the WB direction on the SR 4 Bypass and on SR 4 from I-680 to I-80.	367,000	368,000	1,471,000	$5,510,000	$3.75 / per-hr of delay saved	—	4
Long-term Strategies Package G							
14 Implement EB ramp metering from I-80 to Alhambra Ave, Willow Pass Rd (E) to SR 160, and on the SR 4 Bypass.	1,551,000	2,607,000	9,372,000	$10,640,000	$1.14 / per-hr of delay saved	—	1
ALL MITIGATION STRATEGIES							
	113,572,000	38,037,000	227,683,000	$211,830,000	$0.93 / per-hr of delay saved	—	—

Source: PBS&J, October 2008.

Notes:
1. Life-Cycle benefits only include mobility and reliability. (No safety or qualitative benefit measures.)
2. Based on FHWA research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours). This factor is incorporated into the "Total Life Cycle Benefits" value.
3. Life-Cycle costs include capital, and operating and maintenance.
4. Package rank based on cost effectiveness.

Section 10: Express Lanes

As described in the *Congestion Mitigation Strategies Technical Memorandum*, (PBS&J, November 9, 2009), in addition to the physical roadway mitigation improvements described in previous sections of this memorandum and the transit mitigation improvement measures described in Section 9, the option of converting the HOV lanes on SR 4 to Express Lanes (also referred to as High-Occupancy Toll Lanes, or HOT Lanes) is discussed here. Express Lanes allow HOV users to continue to use the carpool lane for free, but also allow single-occupant vehicles to access the carpool lane by paying a toll.

MTC's *Transportation 2035 Plan for the San Francisco Bay Area* (T-2035) proposes a Regional Express Lane Network for the Bay Area, which includes Express Lanes on SR 4 between I-680 and SR 160.[15] On July 16, 2009, the California Senate Transportation and Housing Committee passed Assembly Bill 744 (Torrico), which authorizes the creation of an 800-mile express lane network on Bay Area freeways. This bill must still be passed by the Senate Appropriations Committee before moving on to the Senate floor for authorization.

The conversion of HOV lanes to Express Lanes on SR 4 would increase the total number of vehicles using the HOV lanes, provided those lanes have available "vacant" capacity that can be "bought" by single-occupant drivers who are willing to pay a toll in exchange for a faster trip in the HOV lane. Toll-paying single-occupant vehicles are allowed to enter the HOV lane; however, as the volume of traffic in the lane begins to reach a pre-determined capacity level, the toll amount charged to single-occupant users increases dynamically in response to the demand. Real-time, variable pricing of the "vacant" capacity in the HOV lanes is used as a mechanism to limit the number of vehicles entering the lane. The Express Lane operator is required, through pricing and changeable message signs, to maintain free-flow conditions in the Express Lane at all times.

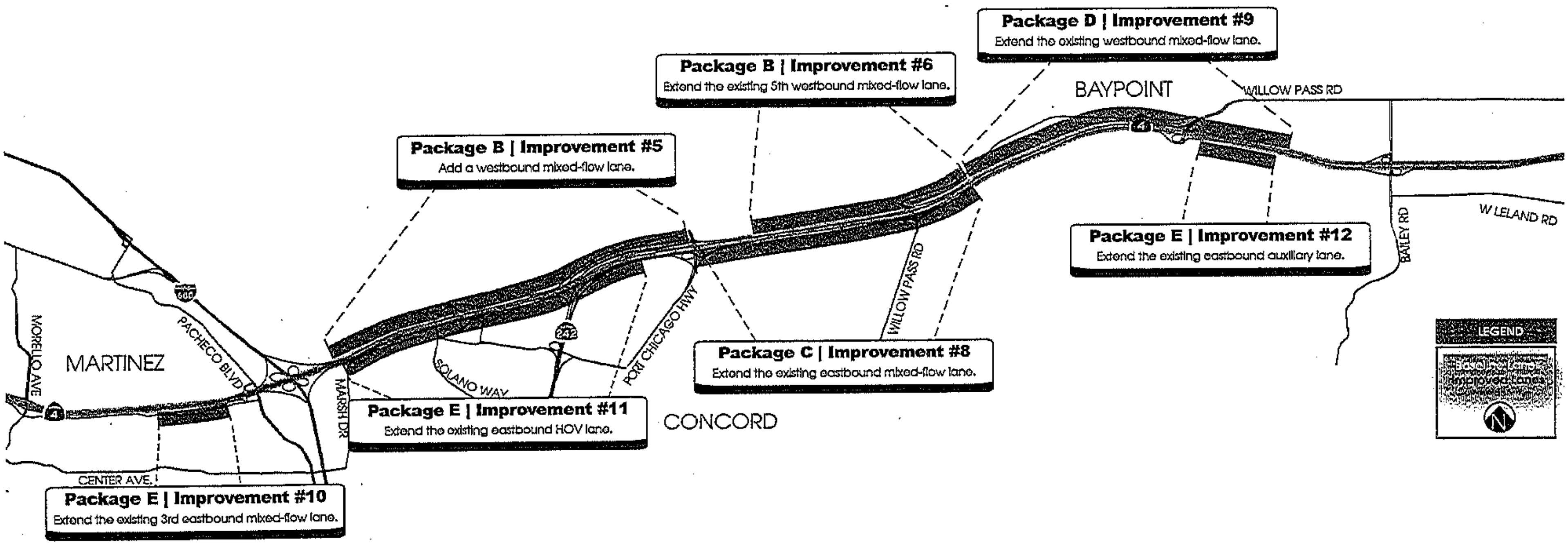
All existing Express Lanes in the United States are limited access facilities. In the Bay Area design, Express Lanes are separated from the adjacent mixed-flow lanes by a double-stripe line, similar to facilities in Seattle and Minneapolis. Lane markings, such as a single-dashed stripe or transition lane, designate ingress and egress zones. Non-carpools using the Express Lanes pay their tolls using electronic FasTrak® toll tags, which are already in use on the region's eight toll bridges; as a vehicle enters the Express Lane, an electronic reader detects the toll tag and deducts the toll from a prepaid account.

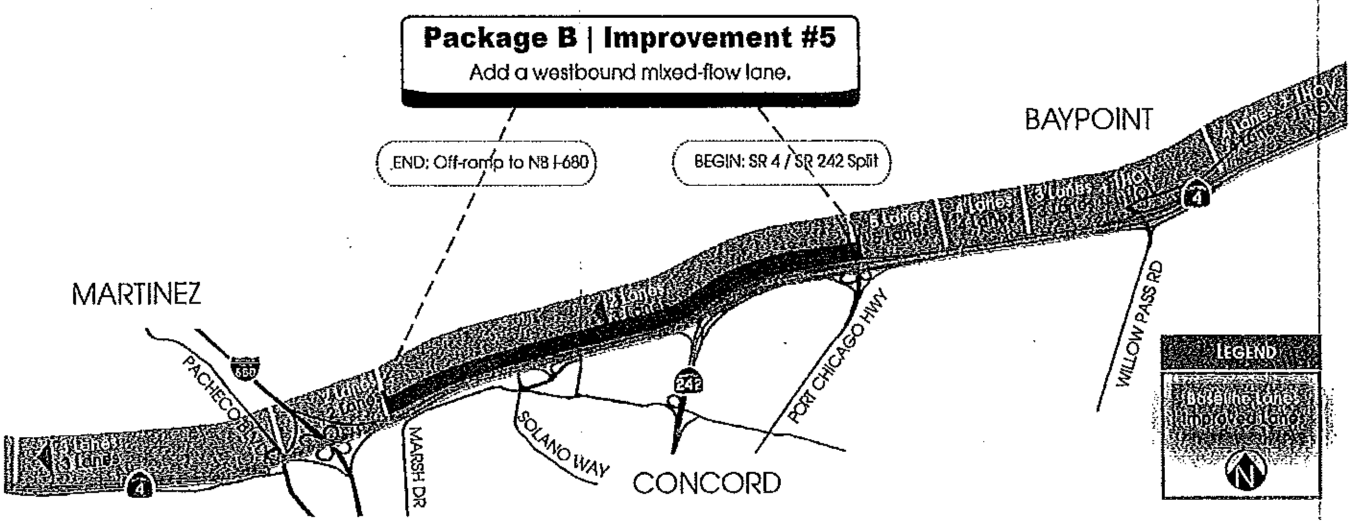
Documented benefits of Express Lanes in operation in the United States include: Improved travel speeds in the mixed-flow lanes; increased corridor throughput; ability to provide a reliable travel option that can be used when most needed (most express lane travelers use the lanes no more than a few times a week); and, in some cases, revenue to support transit service. Further, there is no evidence that Express Lanes reduce carpool levels or transit ridership.

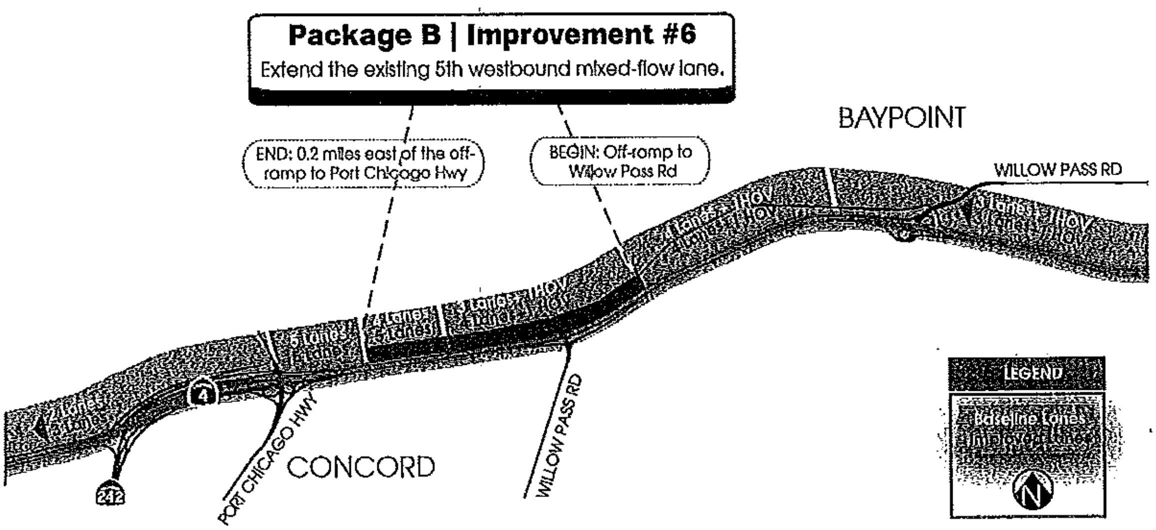
Should AB 744 or similar legislation be signed into law at some point in the future, significant further analysis and consultation with affected jurisdictions along the corridor will be required to determine the feasibility, cost-effectiveness and appropriateness of converting the HOV lanes to Express Lanes in the SR 4 Corridor. This process will inform whether and how (e.g., timing and phasing, design and operations policies) to pursue Express Lanes in the corridor.

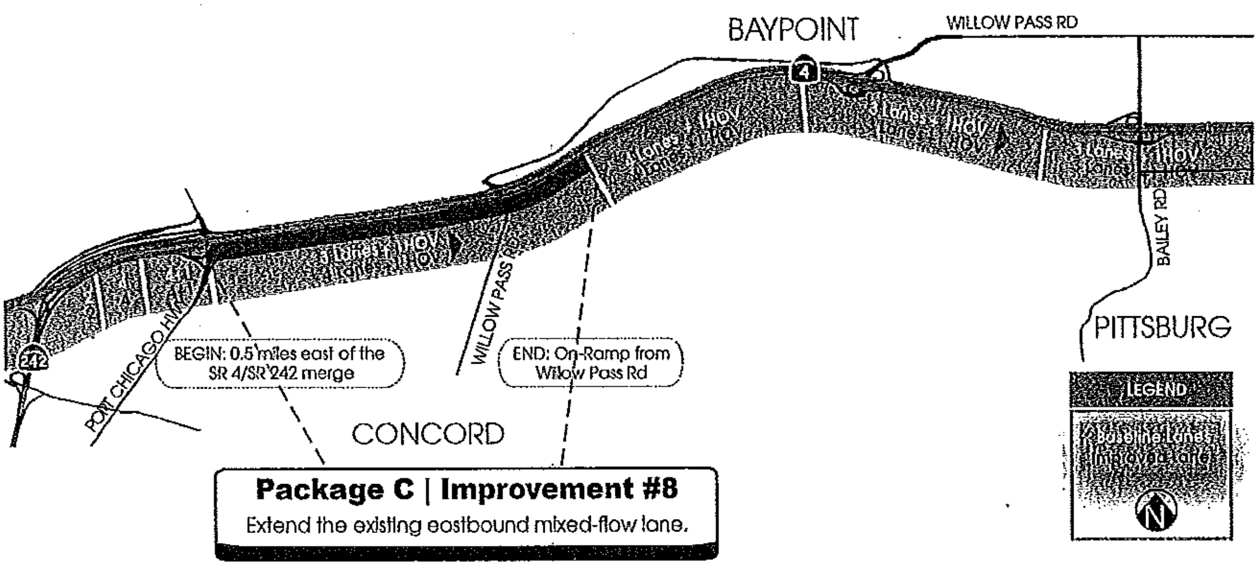
15 http://www.mtc.ca.gov/planning/hov/index.htm

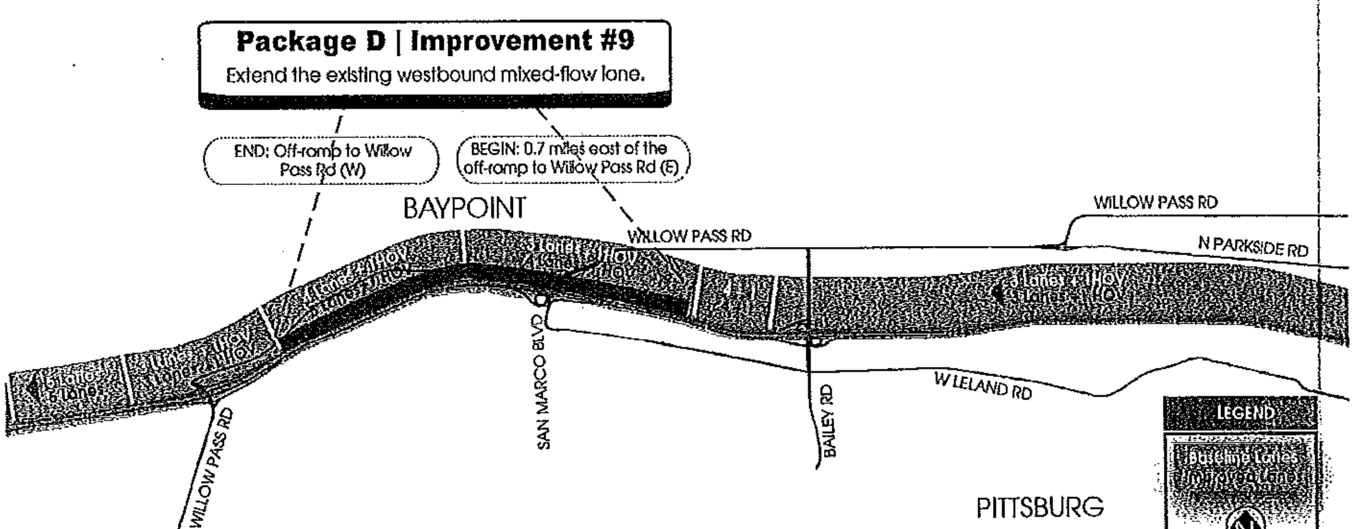
Appendix A: Illustration of Selected Mitigation Strategies

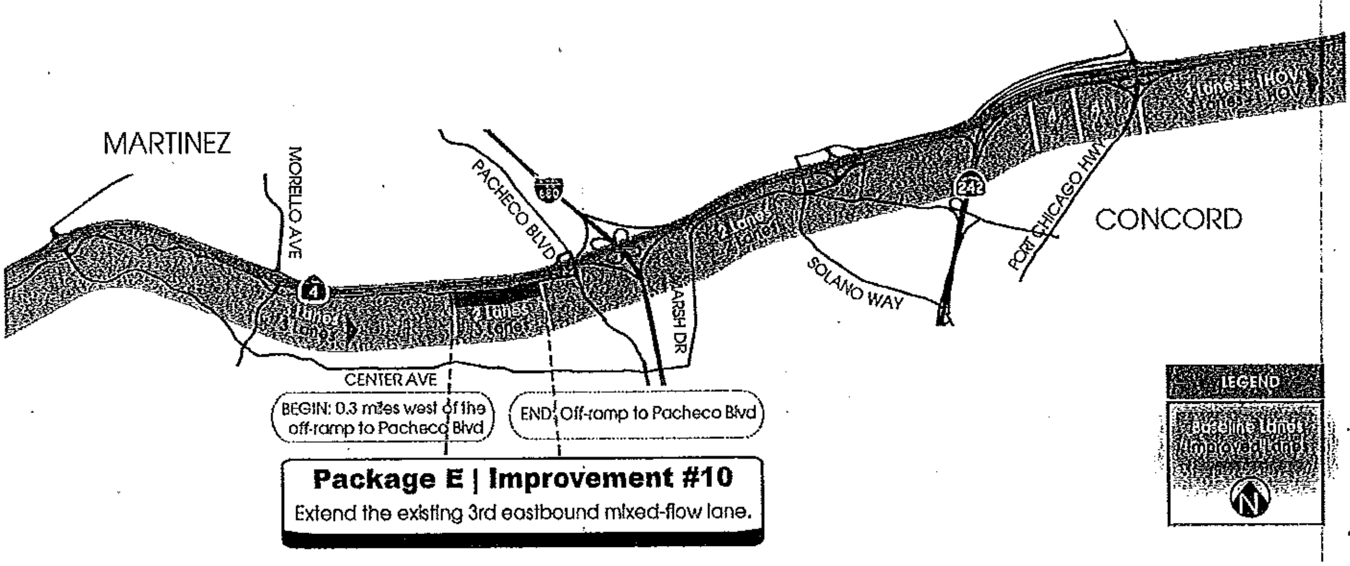

Package B | Improvement #5
Add a westbound mixed-flow lane.
Package B | Improvement #6
Extend the existing 5th westbound mixed-flow lane.
Package D | Improvement #9
Extend the existing westbound mixed-flow lane.
Package E | Improvement #12
Extend the existing eastbound auxiliary lane.
Package C | Improvement #8
Extend the existing eastbound mixed-flow lane.
Package E | Improvement #11
Extend the existing eastbound HOV lane.
Package E | Improvement #10
Extend the existing 3rd eastbound mixed-flow lane.
MARTINEZ
CONCORD
BAYPOINT
MORELLO AVE
PACHECO BLVD
CENTER AVE.
MARSH DR
SOLANO WAY
PORT CHICAGO HWY
WILLOW PASS RD
WILLOW PASS RD
BAILEY RD
W LELAND RD
4
4
680
242
LEGEND

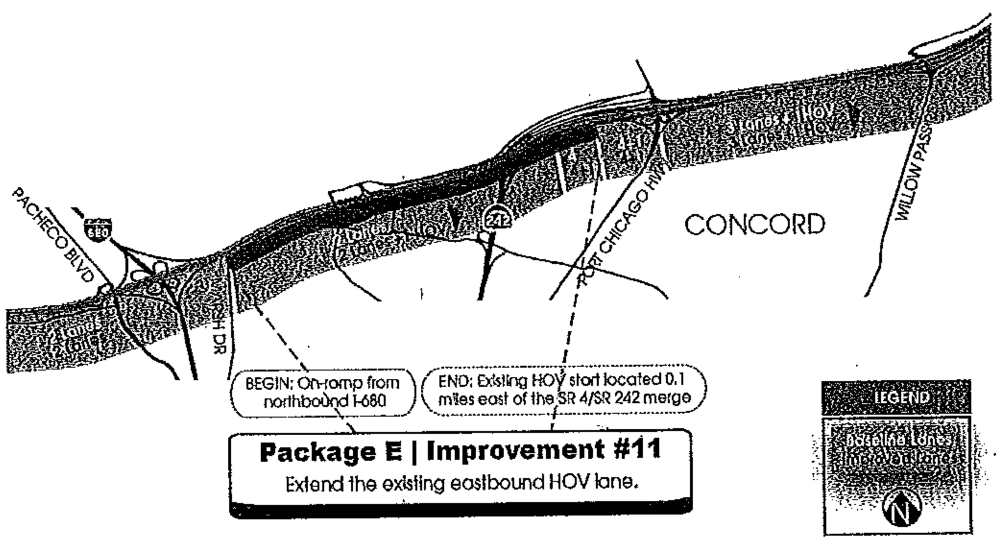

Package B | Improvement #5
Add a westbound mixed-flow lane.
END: Off-ramp to NB I-680
BEGIN: SR 4 / SR 242 Split
BAYPOINT
MARTINEZ
PACHECO BLVD
MARSH DR
SOLANO WAY
CONCORD
PORT CHICAGO HWY
WILLOW PASS RD
LEGEND

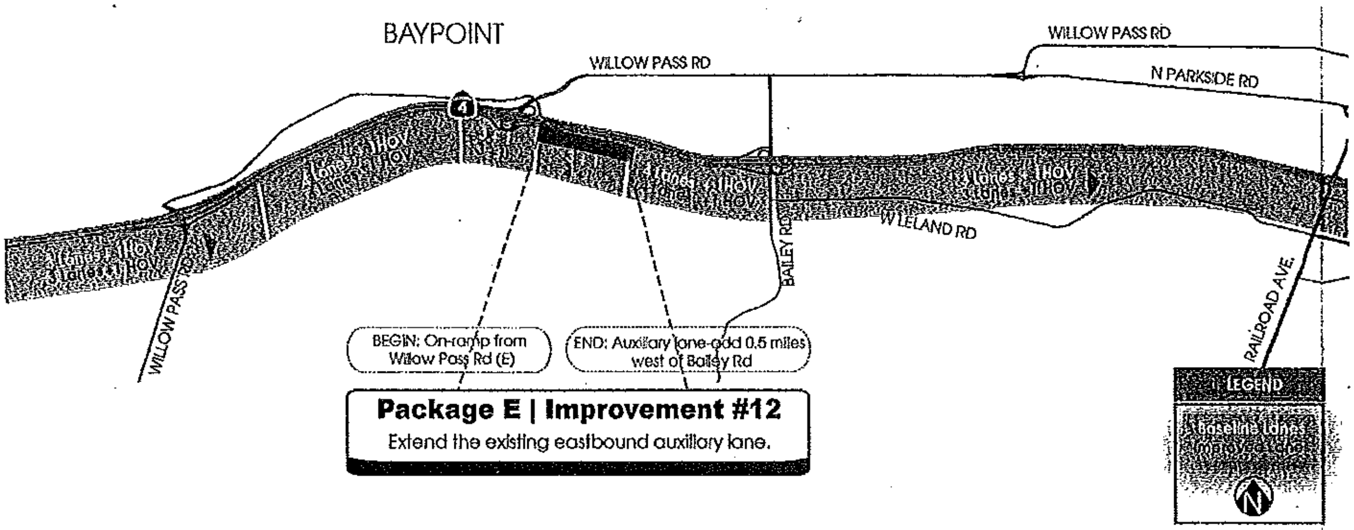

Package B | Improvement #6
Extend the existing 5th westbound mixed-flow lane.
END: 0.2 miles east of the off-ramp to Port Chicago Hwy
BEGIN: Off-ramp to Willow Pass Rd
BAYPOINT
WILLOW PASS RD
CONCORD
PORT CHICAGO HWY
LEGEND


BAYPOINT
WILLOW PASS RD
BAILEY RD
PITTSBURG
WILLOW PASS RD
PORT CHICAGO HWY
BEGIN: 0.5 miles east of the SR 4/SR 242 merge
END: On-Ramp from Willow Pass Rd
CONCORD
Package C | Improvement #8
Extend the existing eastbound mixed-flow lane.
LEGEND
Baseline Lanes
Improved Lane


Package D | Improvement #9
Extend the existing westbound mixed-flow lane.
END: Off-ramp to Willow Pass Rd (W)
BEGIN: 0.7 miles east of the off-ramp to Willow Pass Rd (E)
BAYPOINT
WILLOW PASS RD
WILLOW PASS RD
N PARKSIDE RD
SAN MARCO BLVD
W LELAND RD
BAILEY RD
WILLOW PASS RD
PITTSBURG
LEGEND
Baseline Lanes
Improved Lane


MARTINEZ
MORELLO AVE
PACHECO BLVD
CENTER AVE
ARSH DR
SOLANO WAY
PORT CHICAGO HWY
CONCORD
BEGIN: 0.3 miles west of the off-ramp to Pacheco Blvd
END: Off-ramp to Pacheco Blvd
Package E | Improvement #10
Extend the existing 3rd eastbound mixed-flow lane.
LEGEND


PACHECO BLVD
SH DR
PORT CHICAGO HWY
CONCORD
WILLOW PASS
BEGIN: On-ramp from northbound I-680
END: Existing HOV start located 0.1 miles east of the SR 4/SR 242 merge
Package E | Improvement #11
Extend the existing eastbound HOV lane.
LEGEND


BAYPOINT
WILLOW PASS RD
WILLOW PASS RD
N PARKSIDE RD
W LELAND RD
BAILEY RD
WILLOW PASS RD
RAILROAD AVE.
BEGIN: On-ramp from Willow Pass Rd (E)
END: Auxiliary lane-add 0.5 miles west of Bailey Rd
Package E | Improvement #12
Extend the existing eastbound auxiliary lane.
LEGEND

Appendix B: Life-Cycle Cost-Effectiveness Analysis and Prioritization

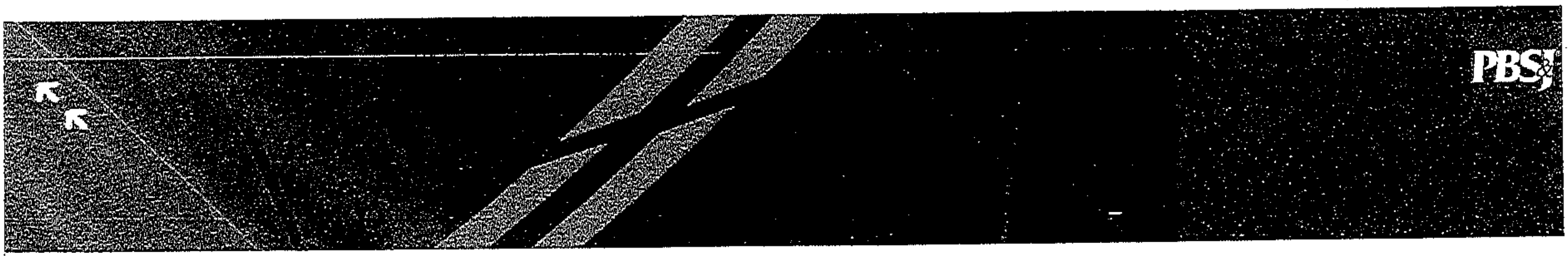
SR 4 Prioritized Congestion Mitigation Strategies: Cost-Effectiveness Analysis

	Life-Cycle Benefits			Life-Cycle Costs[3]	Life-Cycle Cost-Effectiveness	Package Rank[4]	
	Mobility Benefits (per-hrs saved)	Reliability Benefits (per-hrs saved)	Total[1,2]		Cost to Person-Hour of Delay Saved	Short Term	Long Term
SHORT-TERM (2009-2015) MITIGATION STRATEGIES							
Short-term Strategies Package A							
1 Activate existing ITS installations that currently are not fully operational.							
2 Assess gaps in the current and programmed ITS and supplement as needed.	0	11,480,000	34,440,000	$40,110,000	$1.16 / per-hr of delay saved	3	—
3 Extend ITS coverage to fill the gap from I-80 to I-680, to on the SR 4 Bypass.							
Short-term Strategies Package B							
4 Implement WB ramp metering from SR 160 to I-680.							
5 Add a WB mixed-flow lane from the SR 242 off-ramp to the I-680 NB off-ramp.	77,809,000	7,243,000	99,538,000	$68,220,000	$0.69 / per-hr of delay saved	1	—
6 Extend the WB mixed-flow lane from the the Willow Pass Rd (W) off-ramp to the lane-add 0.8 mi west of the Willow Pass (W) on-ramp.							
Short-term Strategies Package C							
7 Implement EB ramp metering from Alhambra Ave to Willow Pass Rd (E).	22,324,000	5,270,000	38,134,000	$33,070,000	$0.87 / per-hr of delay saved	2	—
8 Add an EB mixed-flow lane from the lane drop located 0.3 mi west of Port Chicago Hwy on-ramp to the Willow Pass Rd (W) on-ramp.							
LONG-TERM (2016-2030) MITIGATION STRATEGIES							
Long-term Strategies Package D							
9 Extend the WB mixed-flow lane from the lane drop 0.7 mi east of the Willow Pass Rd (E) off-ramp to the Willow Pass Rd (W) off-ramp.	2,926,000	5,011,000	17,959,000	$22,400,000	$1.25 / per-hr of delay saved	—	3
Long-term Strategies Package E							
10 Extend the EB mixed-flow lane from the lane drop 0.3 mi west of the Pacheco Blvd off-ramp to the Pacheco Blvd off-ramp.							
11 Extend the EB HOV lane from the I-680 NB off-ramp to its start 0.6 mi west of the Port Chicago Hwy on-ramp.	8,595,000	6,058,000	26,769,000	$31,880,000	$1.19 / per-hr of delay saved	—	2
12 Extend the EB mixed-flow lane from the Willow Pass Rd (E) on-ramp to the lane add 0.8 mi east of the Willow Pass Rd (E) on-ramp.							
Long-term Strategies Package F							
13 Implement ramp metering in the WB direction on the SR 4 Bypass and on SR 4 from I-680 to I-80.	367,000	368,000	1,471,000	$5,510,000	$3.75 / per-hr of delay saved	—	4
Long-term Strategies Package G							
14 Implement EB ramp metering from I-80 to Alhambra Ave, Willow Pass Rd (E) to SR 160, and on the SR 4 Bypass.	1,551,000	2,607,000	9,372,000	$10,640,000	$1.14 / per-hr of delay saved	—	1
ALL MITIGATION STRATEGIES							
	113,572,000	38,037,000	227,683,000	$211,830,000	$0.93 / per-hr of delay saved	—	—

Source: PBS&J, October 2009.

Notes:
1. Life-Cycle benefits only include mobility and reliability. (No safety or qualitative benefit measures.)
2. Based on FHWA research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours). This factor is incorporated into the "Total Life Cycle Benefits" value.
3. Life-Cycle costs include capital, and operating and maintenance.
4. Package rank based on cost effectiveness.

State Route 24



Freeway Performance Initiative (FPI)
and
Corridor System Management Plan (CSMP)

TRANSPAC Board Meeting

February 11, 2010

Caltrans

METROPOLITAN
TRANSPORTATION
COMMISSION

SR 24 Corridor

Introduction

PBSJ

SR 24 Corridor

FPI Overview

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Study Area

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FPI Overview

PBSJ

What is the FPI?

- The MTC Freeway Performance Initiative (FPI) is a series of corridor-level studies that are the building blocks of a strategic freeway plan for the Bay Area. The FPI studies are also intended to inform the next update of the Long Range Transportation Plan.

What is the CSMP?

- The Corridor System Management Plans (CSMPs) undertaken by Caltrans are required for all corridors that receive CMIA funding to implement capital improvement projects. The intent of the CSMP is to ensure that there is a plan in place to preserve the mobility gains of CMIA-funded projects.

How are the FPI and CSMP related?

- The technical scope of work for the FPI and CSMP are essentially the same. Caltrans is currently working to incorporate the FPI results into the CSMP.

How will this analysis be used?

- Caltrans will submit the CSMP to the CTC to fulfill the Prop. 1B requirement. The FPI technical analysis will be used by MTC in the next RTP update, and is being provided to local stakeholders as a tool to supplement their own local planning processes.

SR 24 Corridor

FPI Study Process

PBSJ

Assessment of Existing Conditions

Analysis of Projected Future Conditions:

- Short-Term Evaluation (2009 - 2015)
- Long-Term Evaluation (2016 - 2030)

Congestion Mitigation Strategies:

- Demand Management
- Increased Capacity
- System Management
- Other

Prioritization of Congestion Mitigation Strategies:

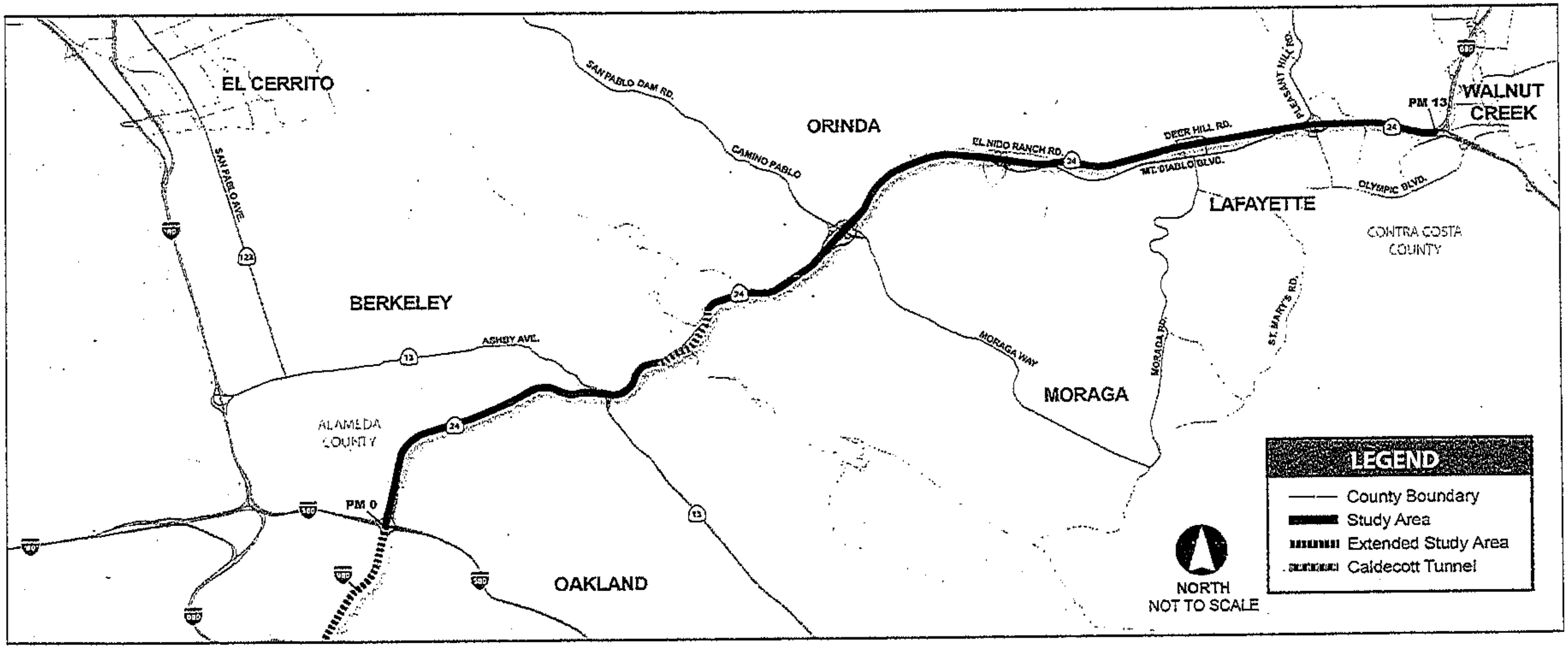
- Based on cost-effectiveness analysis

Stakeholder Outreach

A corridor TAC was formed and engaged at key milestones of the FPI including workshops to determine appropriate strategies for consideration in the SR 24 Corridor. Members included CCTA, local agency representatives, and BART.

SR 24 Corridor

Study Area



SR 24 Corridor

PBS&J

Existing Conditions

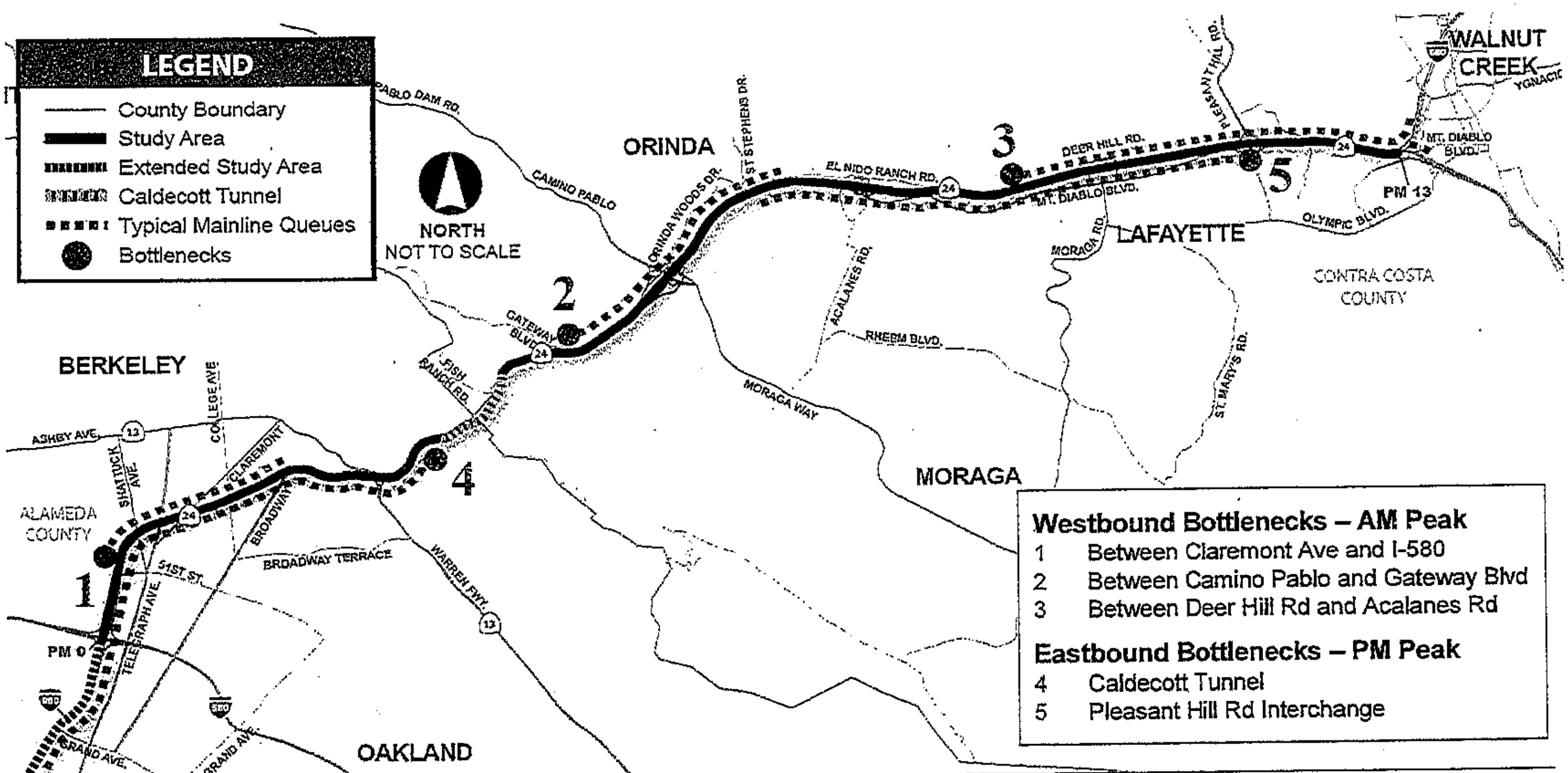
- Highway Travel Characteristics
  - 130,000 to 190,000 vehicles per day; 2% to 3% are trucks.
  - Over 60% of westbound AM peak period commuters through the Caldecott Tunnel travel by car, and a majority of them drive alone.
  - 12% of auto trips in the corridor are HOV 2+ eligible.
  - Average peak hour vehicle occupancy is 1.1 persons per vehicle.
- Transit Service
  - 34% to 41% of peak hour person trips are made via BART.
  - BART parking lots fill-up between 7:00 am and 7:30 am.
  - Other transit service accounts for approximately 3% of peak hour person trips.
- ITS Features
  - ITS coverage is approximately 30% of Caltrans' standards; concentration of coverage on the Contra Costa County side.
  - Caltrans has recently made substantial progress in filling detection gaps.

SR 24 Corridor

Congestion Mitigation Strategies – Short Term (2015)

Committed Improvements only

- Westbound AM Peak Hour travel time will increase from 0:20 to 0:31 for 15-mile corridor
- Eastbound PM Peak Hour travel time will increase from 0:42 to 0:54 for 15-mile corridor



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SR 24 Corridor

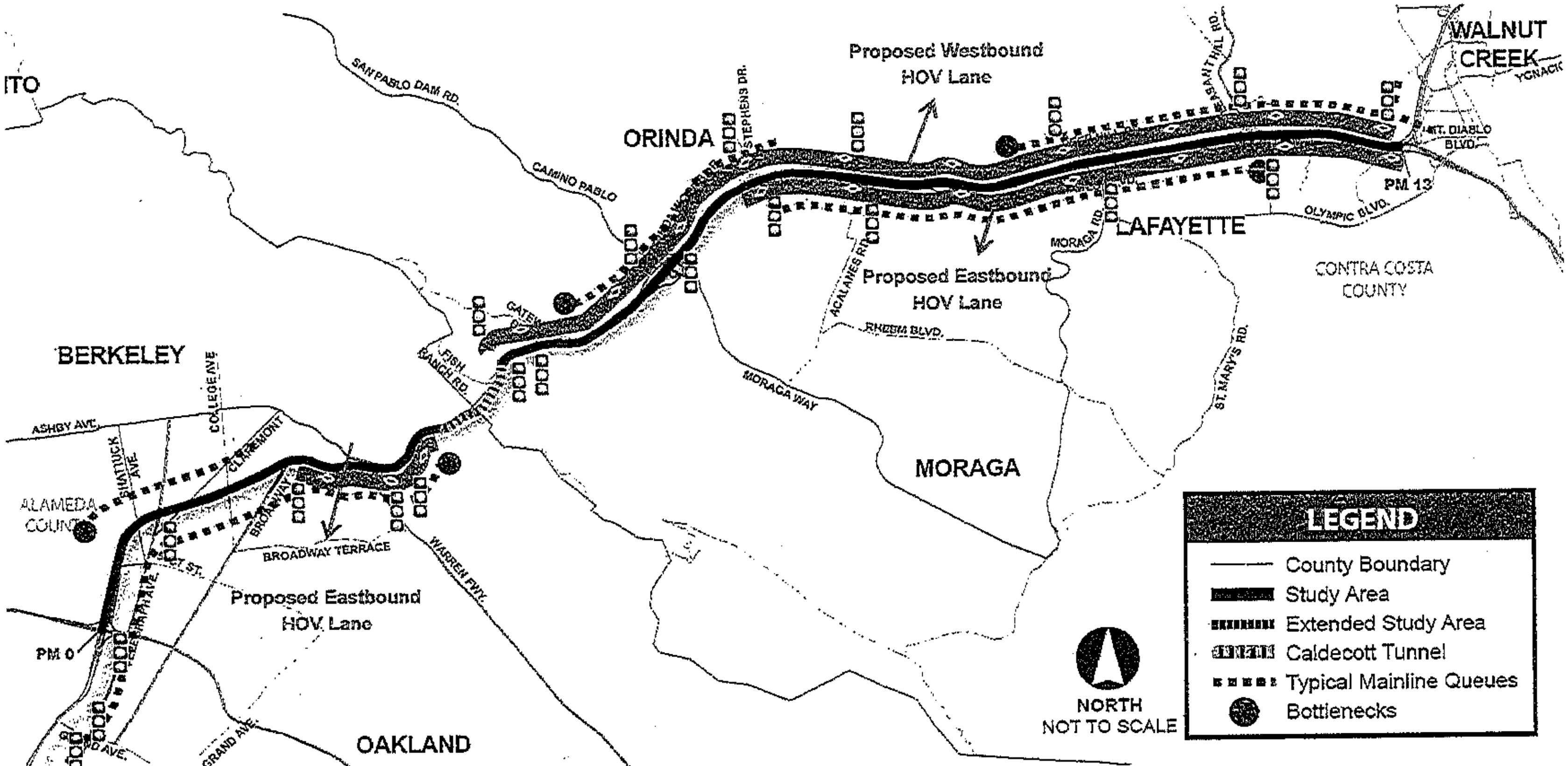
Congestion Mitigation Strategies – Short Term (2015)

Package A
- Activate existing ITS.
- Fill gaps in ITS coverage as needed.

Package B
- WB ramp metering from I-680 to the Tunnel.
- WB HOV-2 lane from I-680 to the Tunnel.

Package C
- EB ramp metering from I-580 to the Tunnel and on I-980.
- EB HOV-2 lane from Broadway to the Tunnel.

Package D
- EB ramp metering from the Tunnel to I-680.
- EB HOV-2 lane from St Stephens Rd to I-680.



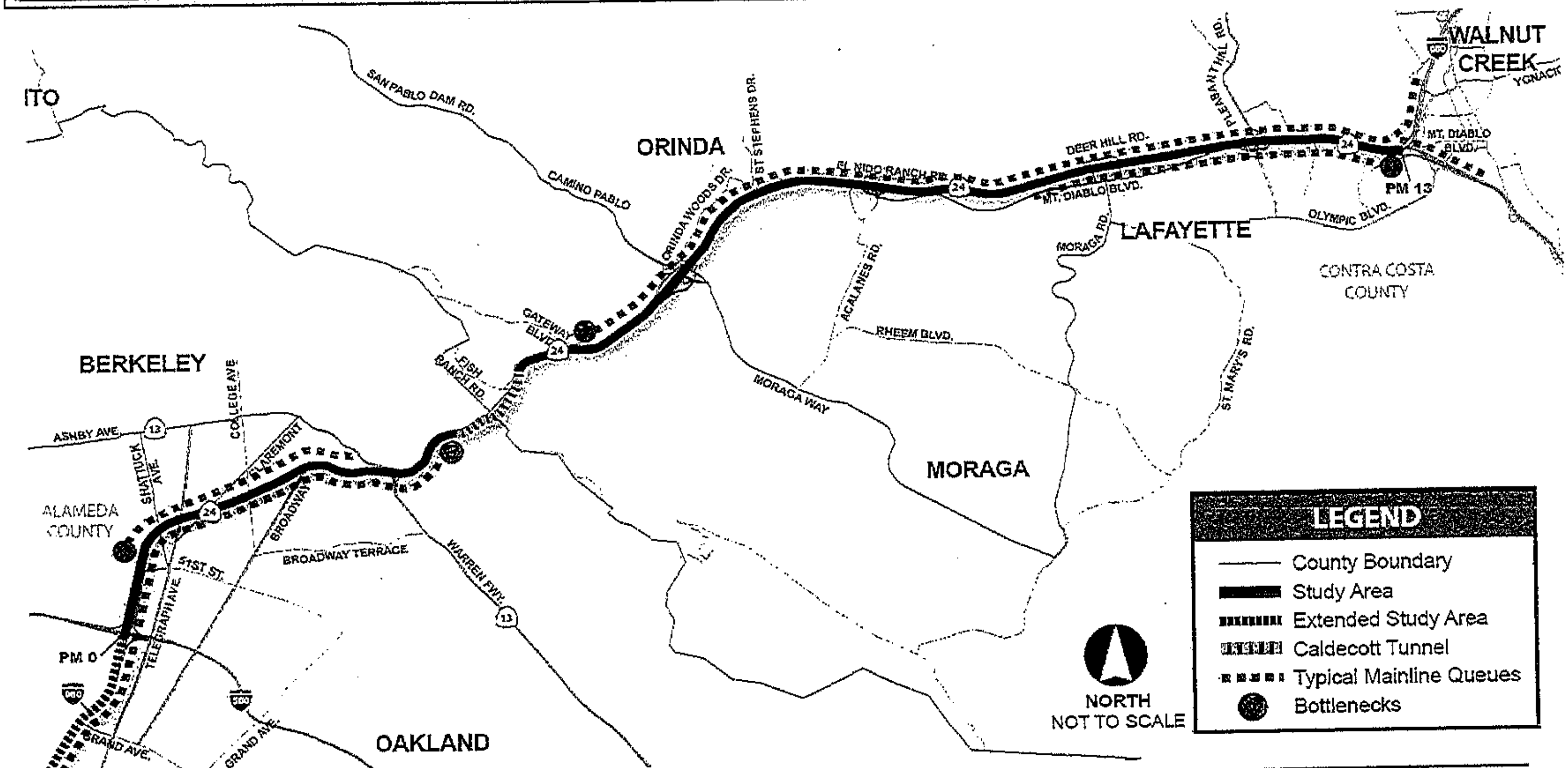
Reduction in Peak-Direction Delay	Vehicle Hours	16,200 hrs - 4,140 hrs = 12,060 hrs	26 % reduction
	Person Hours	17,700 hrs - 5,040 hrs = 12,660 hrs	28 % reduction

SR 24 Corridor

Congestion Mitigation Strategies – Long Term (2030)

Implementation of Short-Term Strategies

Reduction in Peak-Direction Delay	Vehicle Hours	32,200 hrs – 9,140 hrs = 23,060 hrs	28 % reduction
	Person Hours	34,100 hrs – 9,890 hrs = 24,210 hrs	29 % reduction



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SR 24 Corridor

Other Congestion Mitigation Strategies

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Transit Enhancements

- Additional BART parking capacity at upstream BART stations.
- Increased feeder-bus service to the BART stations within the SR 24 Corridor.
- BART system-wide operational improvements.

BART Coordination

- Met in late March to discuss transit strategy development.
- Improvements are expected to accommodate ridership increases in the range of 10% to 20%.

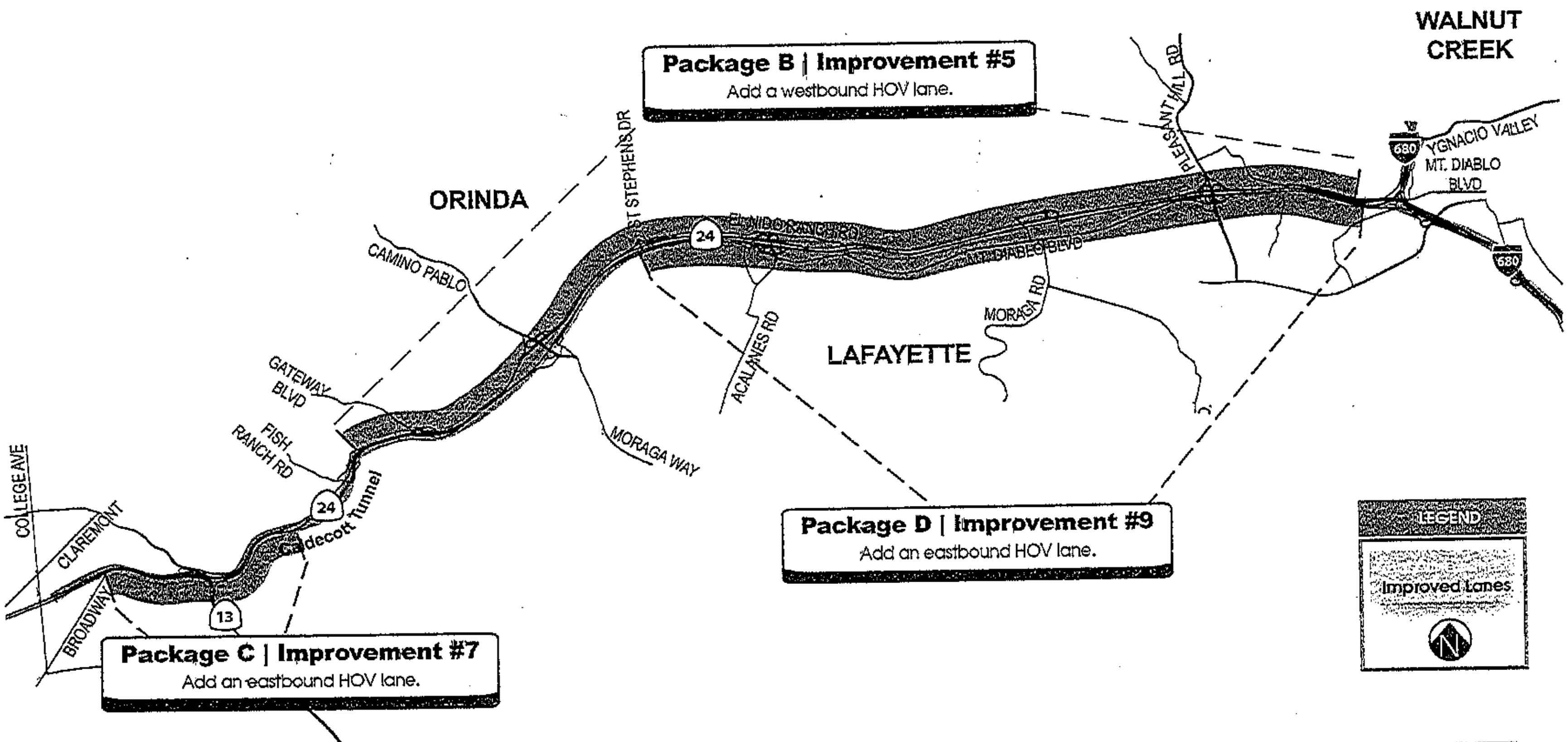
Congestion Pricing

- To be studied later.

SR 24 Corridor

Summary/Key Findings

- ITS ENHANCEMENTS: Package A ranked the highest providing the full coverage of ITS technology and management needed to address non-recurrent delay and safety.
- HOV LANES: HOV lanes proposed in Packages B, C and D provide a less congested, more reliable option for motorists willing to carpool.



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Summary/Key Findings

PBS&J

- No additional capacity during the peak period for single-occupant vehicles.
- Consistent with the findings of the *SR 24 Transit Capacity Study*, the HOV-lane strategies can provide increased mobility through the corridor for vehicles with two or more occupants.
- ITS is a cost-effective strategy to address non-recurrent delay and manage system performance.
- Transit strategies and roadway pricing should be evaluated in more detail.

SR 24 Corridor

Next Steps

- Receive local stakeholder comments on the proposed congestion mitigation strategies (RTPC TACs & Boards)
- Caltrans CSMP submittal to CTC
- FPI technical analysis used by MTC to inform the RTP
- FPI technical analysis provided to local stakeholders as a tool to inform their own planning processes

Metropolitan Transportation Commission

SR 24 Corridor in Alameda and Contra Costa Counties

Prioritized Congestion Mitigation Strategies Technical Memorandum

Prepared by: PBS&J
For: Metropolitan Transportation Commission
Final
November 9, 2009

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Metropolitan Transportation Commission

SR 24 Corridor in Alameda and Contra Costa Counties

Prioritized Congestion Mitigation Strategies Technical Memorandum

Prepared by: PBS&J
For: Metropolitan Transportation Commission
Final
November 9, 2009

Introduction

This report presents the cost-effectiveness analysis and prioritization of congestion mitigation strategies for the State Route 24 (SR 24) Corridor in Alameda and Contra Costa Counties based on the *Congestion Mitigation Strategies Technical Memorandum,* (PBS&J, November 9, 2009) completed for this corridor. The methods and performance measures used for the analysis and prioritization are based on those set forth in the *Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework* (MTC, October 2007). Consistent with the guidance provided by this document, the primary objectives of the *Prioritized Congestion Mitigation Strategies Technical Memorandum* are 1) to estimate and compare life-cycle benefits and life-cycle costs of the proposed corridor improvements and, 2) to provide a prioritized list of corridor improvements based on the cost-effectiveness. Corresponding to these objectives, the report is presented in nine sections:

- **Section 1: Key Findings.** An executive summary of the findings in this analysis.
- **Section 2: Proposed Congestion Mitigation Strategies.** A list of the proposed congestion mitigation strategies for the SR 24 Corridor.
- **Section 3: Methodology.** A description of the quantitative and qualitative performance measures, calculation of benefits value, methodology for determining capital costs, life-cycle benefit cost calculations and prioritization of proposed congestion mitigation strategies.
- **Section 4: Performance Measures.** Results of the performance measures used in the benefits analysis and a comparison of Baseline and Improved scenarios.
- **Section 5: Life-Cycle Benefits.** Results of the life-cycle benefits analysis for the quantitative benefits and discussion of qualitative benefits analysis.
- **Section 6: Capital Costs.** Results of the life-cycle cost analysis to include values for capital costs, and operation and maintenance (O&M) costs.
- **Section 7: Cost-Effectiveness Analysis.** Results of the comparison of life-cycle benefits and life-cycle costs.
- **Section 8: Prioritization.** Ranking of congestion mitigation strategies based solely on the results of the cost-effectiveness analysis conducted for each mitigation strategy package.
- **Section 9: Transit Mitigation Strategies.** A list of proposed transit mitigation strategies.

Section 1: Key Findings

The cost-effectiveness analysis and the subsequent prioritization of congestion mitigation strategies along the SR 24 Corridor through Alameda and Contra Costa Counties evaluated a total of ten improvements grouped into five packages. These five packages represent over 156 million hours of life-cycle benefits and about $247 million in life-cycle costs.

The packages are ranked below, as determined by the cost-effectiveness analysis:

Short-term Package Ranking

1. **Package A (Short-term, Eastbound & Westbound):**
   - Improvement #1: Activate existing ITS installations that currently are not fully operational.
   - Improvement #2: Assess gaps in the current and programmed ITS installations and supplement as needed.
   - Improvement #3: Extend ITS coverage to fill the gap between I-580 and the Caldecott Tunnel.
2. **Package D (Short-term, Eastbound):**
   - Improvement #8: Implement ramp metering in the eastbound direction between the Caldecott Tunnel and I-680.[1]
   - Improvement #9: Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange. (Left shoulder or widen on right.). During non peak hours, this lane would be open to all users (mixed-flow operations).
3. **Package B (Short-term, Westbound):**
   - Improvement #4: Implement ramp metering in the westbound direction between I-680 and the Caldecott Tunnel.
   - Improvement #5: Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel. During non peak hours, this lane would be open to all users (mixed-flow operations).
4. **Package C (Short-term, Eastbound):**
   - Improvement #6: Implement ramp metering in the eastbound direction between I-580 and the Caldecott Tunnel and on the SR 24 Extended Corridor (I-980) from I-880 to I-580.
   - Improvement #7: Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel. During non peak hours, this lane would be open to all users (mixed-flow operations).

Long-term Package Ranking

1. **Package E (Long-term, Westbound):**
   - Improvement #10: Implement ramp metering in the westbound direction between the Caldecott Tunnel and I-580 and on the SR 24 Extended Corridor (I-980) from I-580 to I-880.

It should be noted that this prioritization is a result of the cost-effectiveness analysis of the quantitative benefits (mobility and reliability), and does not incorporate qualitative benefits (goods movement, HOV connectivity, and access management), or subjective matters such as funding or political influences. Information on the qualitative benefits of the proposed packages is included in this report to provide a comprehensive analysis for regional prioritizations.

1 Caltrans goal is for all ramp metering to be adaptive.

A package of short-term and long-term transit mitigation strategies, Package F, is also included. This unranked package is listed below and discussed further in Section 9.

Package F (Short-term & Long-term, Eastbound & Westbound):

- Improvement #11: Additional BART parking capacity at upstream BART stations.
- Improvement #12: Increased bus transit access to the BART stations within the SR 24 Corridor.
- Improvement #13: BART system-wide operational improvements.[2]

2 Improvements include the Central County Crossover Project.

Section 2: Proposed Congestion Mitigation Strategies

Congestion mitigation strategies for the SR 24 Corridor incorporated for the analysis and prioritization were based on the short-term (2015) and long-term (2030) mitigation measures proposed in the *Congestion Mitigation Strategies Technical Memorandum* (MST), (PBS&J, November 9, 2009).

These congestion mitigation strategies were first screened for effectiveness. This screening process was performed with an analysis using the same macroscopic simulation model, FREQ12, as was used in the *Future Conditions Technical Memorandum* (PBS&J, October 9, 2009) to validate the effectiveness of the proposed mitigation improvements.

Based on the results of the FREQ12 testing of the performance of the mitigation strategies proposed in the MST, some strategies were modified, added, or deleted and were then combined to build logical packages of mitigation improvements; the proposed congestion mitigation improvements are listed below in Exhibit 2-1. Packages A through D are short-term improvement packages and Package E is a long-term improvement package. Those strategies that entail physical expansion of SR 24 to accommodate new HOV or mixed-flow facilities are illustrated in Appendix A.[3]

Exhibit 2-1: Proposed Mitigation Improvements on SR 24

Package	Year	Direction	ID	Mitigation Improvement
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.
			3	Extend ITS coverage to fill the gap between I-580 and the Caldecott Tunnel.
B	2015	WB	4	Implement ramp metering in the westbound direction between I-680 and the Caldecott Tunnel.
			5	Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel.
C	2015	EB	6	Implement ramp metering in the eastbound direction between I-580 and the Caldecott Tunnel and on the SR 24 Extended Corridor (I-980) from I-880 to I-580.
			7	Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel.
D	2015	EB	8	Implement ramp metering in the eastbound direction between the Caldecott Tunnel and I-680.
			9	Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange (left shoulder or widen on right).
E	2030	WB	10	Implement ramp metering in the westbound direction between the Caldecott Tunnel and I-580 and on the SR 24 Extended Corridor (I-980) from I-580 to I-880.
Abbreviations: ITS = Intelligent Transportation System; HOV = High Occupancy Vehicle; WB = westbound; EB = eastbound				

3 ITS and ramp metering congestion mitigation strategies were not illustrated in the map format because the text descriptions adequately describe the limits of those strategies.

Section 3: Methodology

This section provides an explanation of the methodology that was used to prepare the cost-effectiveness analysis and prioritization of congestion mitigation strategies for this report.

A cost-effectiveness analysis is a systematic evaluation of the economic advantages (benefits) and disadvantages (costs) of a set of investment alternatives. The primary objective of a cost-effectiveness analysis is to compare the proposed mitigation improvements based on their projected benefits and estimated costs. The cost- effectiveness analysis accounts for the fact that benefits generally accrue over a long period of time, while capital costs are incurred primarily in the initial years.[4]

The methods and performance measures used for the analysis and prioritization presented in this section were selected based on the guidance set forth in the FPI Framework, with the following two exceptions:[5]

(1) The quantitative performance measures were not monetized. This was agreed upon by this project's sponsoring agencies (MTC, Caltrans and CCTA) so that the performance measures would be presented in their fundamental units (e.g., person-hours of delay saved).

(2) Safety was not evaluated as part of this analysis. As noted under exception (1), the measure of person-hours of delay saved was selected to compare the quantitative performance measures, which is incompatible with the measures typically used to assess safety (i.e., number of fatality, injury and property damage collisions saved). Therefore, safety cannot be equitably evaluated side-by-side with the other performance measures according to the prioritization methodology.[6]

The following describes the data and calculations required for performing the cost-effectiveness analysis.

Benefits

The proposed mitigation improvements for the SR 24 Corridor in Alameda and Contra Costa Counties were evaluated individually to assess the benefits of each improvement. These benefit performance measures include two quantitative performance measures and three qualitative performance measures. The quantitative performance measures are Mobility and Reliability; the qualitative performance measures are Goods Movement, HOV Connectivity, and Access Management. All values for the quantitative performance measures are represented in person-hours of delay saved.

Mobility

Mobility is a quantitative performance measure that describes how well the SR 24 Corridor moves people. Mobility can be measured in terms of recurrent vehicle delay, which is delay incurred on a typical travel day due to congested conditions in the corridor. Delay is measured as the amount of time lost for a vehicle traveling below 35 miles per hour (mph) within the corridor. By using a 35 mph standard, the recurrent delay calculated is the congested delay, not the total delay (which uses a 60 mph standard). The mobility performance measure is estimated for the implementation of each proposed mitigation improvement package.

Reliability

Reliability is a quantitative performance measure that captures the relative predictability of the public's travel time. This performance measure focuses on the extent to which mobility varies from day-to-day. Reliability can be measured in terms of

4 http://www.oim.dot.state.mn.us/EASS/
5 FPI Framework is the *Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework* (MTC, October 2007).
6 Exclusion of the safety performance measure did not affect the rankings presented in Sections 1 and 8.

non-recurrent delay, which is delay caused by irregular events, such as accidents, special events, maintenance, short-term construction, and weather. The reliability performance measure is estimated for the implementation of each proposed mitigation improvement package. It should be noted that based on Federal Highway Administration (FHWA) research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours).[7] This factor of three will be reflected in the prioritization of mitigation strategy packages shown in Section 8 and Appendix B of this technical memorandum.

Goods Movement

The goods movement performance measure is a qualitative measure that determines whether the corridor provides adequate freight mobility and reliability. As outlined in the FPI Framework, the goods movement measure will be assigned a "Yes" ranking if the improvement is located in one of the designated goods movements corridors.[8] A list of the goods movement corridors identified in MTC's submittal for Trade Corridor Improvement Funds (TCIF) under the 2006 Infrastructure Bond can be found in the FPI Framework. SR 24 is not designated as a goods movement corridor in the TCIF submittal and, therefore, will be given a "No" ranking for all improvements. It should be noted, however, that just because SR 24 is not designated as a goods movement corridor does not mean that the listed improvements have no impact on goods movement in the corridor. For the purposes of the FPI analysis, the goods movement performance measure is used specifically for comparing multiple corridors.

HOV System Connectivity

The HOV system connectivity performance measure is a qualitative measure that is used to evaluate if a corridor has an effective network of HOV lanes. This performance measure is significant because HOV lanes provide a travel-time savings incentive, increased reliability and air quality benefits. Proposed mitigation improvements that would increase HOV system connectivity can be ranked higher because of this qualitative benefit.

Access Management

The access management performance measure is a qualitative measure that evaluates the existing access management in the corridor, in terms of the number of access points such as ramps. The access management performance measure is an additional measure of safety and mobility that is not captured in those specific quantitative measures. Fewer access points along a corridor typically signify improved mobility and safety. Mitigation measures that would improve access management by reducing the number of access points will be assigned a "Yes" ranking and can be placed higher in the prioritization.

Cost

Cost performance measures estimate the total costs associated with the proposed mitigation improvements to the corridor. The two cost performance measures are capital costs (also known as construction costs or upfront costs) and operation and maintenance (O&M) costs (also known as ongoing costs). These costs are described below and are all presented in dollars at their 2007 value. As with the benefit performance measures, a discount rate of 4% per year is used to convert future values to present values by accounting for inflation and interest rates as well as inclusion of a risk factor.

Capital Costs

Capital costs include the construction, right-of-way acquisition, vehicle procurement (transit), and mitigation costs. Construction costs include mainline, ramps, intersections, bridges, signalization, erosion control, drainage, maintenance-of-traffic and

[7] This factor is from FHWA's ITS Deployment Analysis System (IDAS), which is based on the FHWA Highway Economic Requirements System (HERS).
[8] *Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework* (MTC, October 2007)

mobilization. Unit prices of the construction items were obtained from Caltrans' Contract Cost Database and were applied to the quantity estimates.[9] Capital costs also include costs for engineering, administration, legal services, and a contingency add-in.

Operation and Maintenance (O&M) Costs

O&M costs are the annual costs estimated for operating and maintaining the proposed mitigation improvements. O&M costs include labor and materials for maintenance and repairs, utilities, financing, etc.

Scenarios

Benefits for the SR 24 Corridor were evaluated under two scenarios, Baseline Conditions and Improved Conditions (for a time period beginning after construction, referred to as Year 1, to the long-term future in 2030). A summary of all scenarios is listed below:

- Baseline Conditions, 2007
- Baseline Conditions, Year 1
- Baseline Conditions, 2015
- Baseline Conditions, 2030
- Improved Conditions, Year 1
- Improved Conditions, 2015
- Improved Conditions, 2030

Baseline Conditions

Benefits for Baseline Conditions were evaluated under 2007, 2015 and 2030 conditions and interpolated for all other years within the 2007 to 2030 timeline. Baseline 2007 Conditions were evaluated using 2007 data. Baseline 2015 Conditions incorporate existing 2007 conditions, projected growth in the area, and committed improvements in the SR 24 Corridor to be built between 2007 and 2015. Baseline 2030 Conditions also incorporate existing 2007 conditions, projected growth in the area, and committed projects.[10] A theoretical scenario of Baseline Year 1 is included in the interpolated values between Baseline 2007 Conditions and Baseline 2015 Conditions representing conditions after construction has been completed.

Improved Conditions

Benefits for Improved Conditions were evaluated under 2015 and 2030 conditions and interpolated for years in between. Data for a theoretical scenario of Improved Year 1 conditions were not modeled, but rather calculated based on available data from other scenarios.[11] Benefits are calculated from the end of construction, which varies by project, to 2030.

Analysis Approach for Prioritization

The benefit performance measures will be evaluated for all proposed mitigation improvements and for all scenarios described above. From these scenarios, the net increase in the quantitative benefits will be calculated from the end of construction (Year 1), to year 2030. This is known as the life-cycle benefits. Exhibit 3-4 illustrates the calculation of life-cycle benefits.

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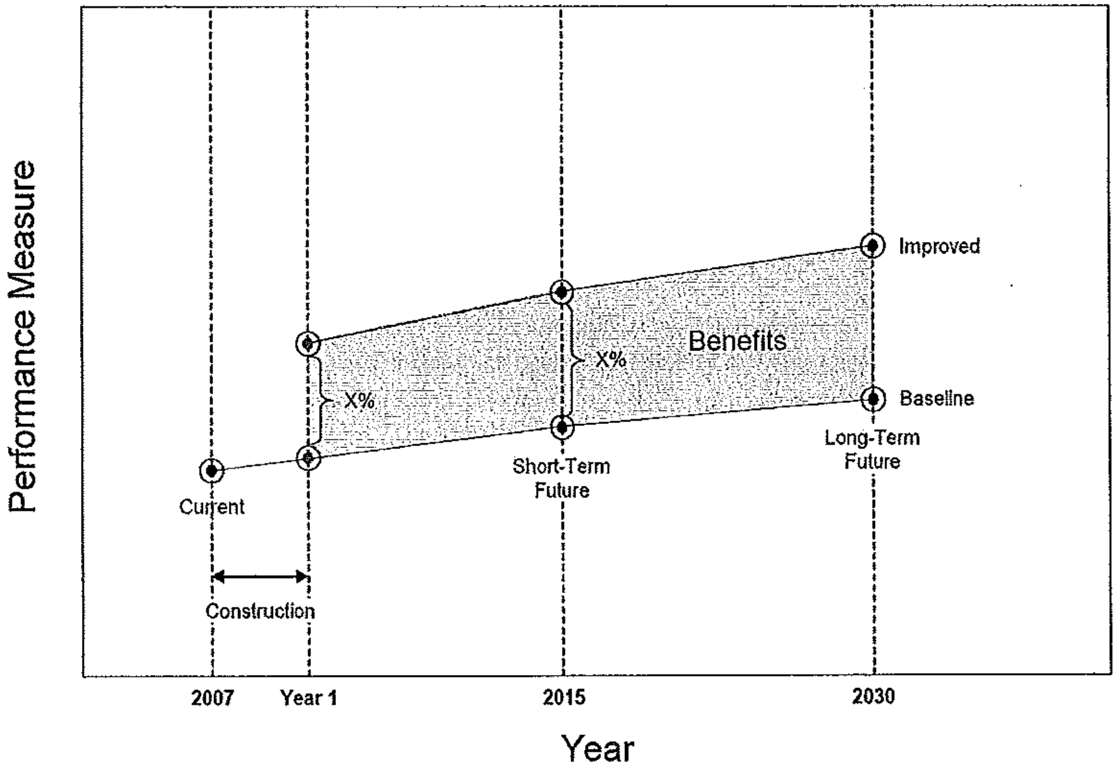
9 http://sv08data.dot.ca.gov/contractcost/

10 The one committed project is the *Caldecott Improvement Project* (4th Tunnel Bore).

11 Benefit values for Baseline Year 1, Baseline 2015 and Improved 2015 are known; therefore, Improved Year 1 benefit values were estimated by assuming constant growth (see Exhibit 3-4).

Exhibit 3-4: Life-Cycle Benefits



Source: Freeway Performance Initiative Traffic Analysis: Performance and Analysis Framework (October 2007)

Detailed benefit cost estimates for each project would normally require inclusion of the duration of construction to determine when the improvement is completed and will begin accumulating benefits. However, for the purposes of this analysis, which compares a wide variety of improvements with varying construction schedules, all improvements were evaluated assuming the same length of construction such that Year 1 is the same year for all improvements.

The summation of the benefits from Year 1 to 2030 (the life-cycle benefits), will be compared to the cost performance measures of all the mitigation improvements.

Analysis Tools

A variety of analysis tools were used to evaluate the benefits of the proposed mitigation improvements. These tools include a combination of software calculations and manual calculations. The selection of the tools was mandated by the modeling capacity of the software programs and varies by the type of proposed mitigation improvement and the type of benefit. A summary of the tools used is presented in Exhibit 3-5.

Exhibit 3-5: Analysis Tools used for Developing Benefits

Type of Proposed Mitigation Improvement	Type of Benefit	
	Mobility	Reliability
Auxiliary Lane	FREQ	Manual Calculation (based on IDAS methodology)
HOV Lane		
Ramp Metering		
ITS System Enhancements	N/A	Manual Calculation (based on IDAS methodology)

The formulas for the manual calculations are applied to the data (volumes, capacities, etc.) from FREQ, which ensures consistency between the differing analysis tools and benefits. The full methodologies and calculations of the above analysis tools used for developing mobility and reliability are available by request. Descriptions of the analysis tools follow below.

Software Calculations: FREQ

FREQ was used to evaluate recurrent congestion (mobility) for existing and future highway operating conditions. The version used was FREQ12 PE/PL, Version 3.01. The two models contained within FREQ12 are FREQ12PE, an entry control macroscopic model for analyzing ramp metering, and FREQ12PL, an on-freeway priority macroscopic model for analyzing HOV facilities. The analysis output from FREQ was used in the calculations of benefits and performance measures. The only mobility condition that FREQ was not used for was ITS System Enhancements. FREQ does not analyze ITS Improvements. Additionally, the ITS Improvements recommended target non-recurrent delay (reliability), and therefore show negligible mobility benefits.

Manual Calculations: IDAS and AASHTO

Two sources of formulas and methodology, IDAS and AASHTO, were utilized in the manual calculations.

The methodology from the ITS Deployment Analysis System (IDAS) software was used to perform manual calculations to evaluate all the ITS improvements for reliability benefits. These formulas and methodology are outlined in the IDAS User's Manual.

In addition to being used to evaluate ITS improvements, the IDAS methodology was also used to perform manual calculations to evaluate the reliability benefits of the other proposed mitigation improvements (auxiliary lanes, HOV lanes and ramp metering). This analysis relates the number of lanes and volume-over-capacity (V/C) ratios to travel time reliability rates.

Section 4: Performance Measures

Performance measures, such as vehicle demand, travel speed, travel time and vehicle delay, were calculated and used in the benefits analysis. Exhibits 4-1 through 4-4 present the performance measures for the following scenarios:

- Baseline Conditions, 2007 (no improvements)
- Baseline Conditions, 2015 (committed improvements)
- Baseline Conditions, 2030 (committed improvements)
- Improved Conditions, 2015 (committed improvements + short-term strategies)
- Improved Conditions, 2030 (committed improvements + short-term strategies + long-term strategies)

Additionally, exhibits 4-5 through 4-9 show the projected changes in bottleneck locations and their associated queues for the above scenarios.

Exhibit 4-1: Performance Measures on SR 24 – Westbound – AM Peak Hour

Measure (Full Analysis Area – 15 miles)	SR 24 Westbound - AM Peak Hour						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	4,300	6,100	11,300	5,400	-11%	9,500	-16%
Veh. Miles of Travel (VMT)	225,000	230,000	199,000	234,000	+2%	204,000	+3%
Average Speed (mph)	48	31	16	35 (HOV: 52)	+13% (HOV: +68%)	20 (HOV: 40)	+25% (HOV: +150%)
Delay Index (free-flow speed of 60 mph / average speed)	1.3	1.9	3.8	1.7 (HOV: 1.2)	—	3.0 (HOV: 1.5)	---
Average Corridor Travel Time (h:mm)	0:20	0:31	00:59	0:28 (HOV: 0:19)	-10% (HOV: -39%)	0:49 (HOV: 0:24)	-17% (HOV: -59%)
Total Delay (VHT for speeds less than 60 mph)	580	2,270	8,020	1,570	-31%	6,200	-23%
Congestion Delay (VHT for speeds less than 35 mph)	290	1,330	6,300	1,110	-17%	4,500	-29%
Miles of Congested Segments (Speeds less than 35 mph)	1.5	5.0	7.5	3.5	-30%	7.5	0%

Exhibit 4-2: Performance Measures on SR 24 – Eastbound – PM Peak Hour

Measure (Full Analysis Area – 15 miles)	SR 24 Eastbound - PM Peak Hour						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	4,700	5,800	8,000	5,300	-9%	5,600	-30%
Veh. Miles of Travel (VMT)	136,000	130,000	135,000	140,000	+8%	149,000	+10%
Average Speed (mph)	22	17	15	21 (HOV: 25)	+24% (HOV: +47%)	21 (HOV: 27)	+40% (HOV: +80%)
Delay Index (free-flow speed of 60 mph / average speed)	2.7	3.5	4.0	2.9 (HOV: 2.4)	---	2.9 (HOV: 2.2)	—
Average Corridor Travel Time (h:mm)	0:42	0:54	1:01	0:44 (HOV: 0:36)	-19% (HOV: -33%)	0:44 (HOV: 0:33)	-28% (HOV: -46%)
Total Delay (VHT for speeds less than 60 mph)	2,420	3,620	5,720	2,980	-18%	3,160	-45%
Congestion Delay (VHT for speeds less than 35 mph)	1,990	2,550	4,250	2,170	-15%	2,270	-47%
Miles of Congested Segments (Speeds less than 35 mph)	6.0	9.0	13.5	6.0	-33%	8.0	-41%

Exhibit 4-3: Performance Measures on SR 24 – Westbound – AM Peak Period

Measure (Full Analysis Area – 15 miles)	SR 24 Westbound - AM Peak Period						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	15,400	21,100	32,900	19,000	-10%	29,800	-9%
Veh. Miles of Travel (VMT)	866,000	913,000	837,000	922,000	+1%	871,000	+4%
Average Speed (mph)	54	39	26	44 (HOV: 54)	13% (HOV: +38%)	26 (HOV: 44)	0% (HOV: +69%)
Delay Index (free-flow speed of 60 mph / average speed)	1.1	1.5	2.3	1.4 (HOV: 1.1)	---	2.3 (HOV: 1.4)	---
Average Corridor Travel Time (h:mm)	0:18	0:26	0:42	0:23 (HOV: 0:18)	-12% (HOV: -31%)	0:42 (HOV: 0:22)	0% (HOV: -48%)
Total Delay (VHT for speeds less than 60 mph)	1,330	6,000	19,100	3,870	-36%	15,580	-18%
Congestion Delay (VHT for speeds less than 35 mph)	540	3,200	13,620	2,650	-17%	11,370	-17%
Miles of Congested Segments (Speeds less than 35 mph)	0 - 1.5 (Avg. 1.0)	2.0 - 5.0 (Avg. 4.0)	5.0 - 7.5 (Avg. 7.0)	0.0 - 3.5 (Avg. 2.0)	-50%	2.5 - 7.5 (Avg. 6.0)	-14%

Exhibit 4-4: Performance Measures on SR 24 – Eastbound – PM Peak Period

Measure (Full Analysis Area – 15 miles)	SR 24 Eastbound - PM Peak Period						
	Baseline			Improved			
	2007	2015	2030	2015	Change	2030	Change
Veh. Hours of Travel (VHT)	15,600	19,500	22,200	17,400	-11%	16,900	-24%
Veh. Miles of Travel (VMT)	548,000	560,000	551,000	565,000	+1%	575,000	+4%
Average Speed (mph)	31	26	25	28 (HOV: 34)	+8% (HOV: +31%)	33 (HOV: 38)	+32% (HOV: +52%)
Delay Index (free-flow speed of 60 mph / average speed)	1.9	2.3	2.4	2.1 (HOV: 1.8)	---	1.8 (HOV: 1.6)	---
Average Corridor Travel Time (h:mm)	0:33	0:39	0:43	0:37 (HOV: 0:30)	-5% (HOV: -23%)	0:33 (HOV: 0:27)	-23% (HOV: -37%)
Total Delay (VHT for speeds less than 60 mph)	6,500	10,200	13,100	8,190	-20%	7,440	-43%
Congestion Delay (VHT for speeds less than 35 mph)	5,160	6,800	8,800	6,200	-9%	5,260	-40%
Miles of Congested Segments (Speeds less than 35 mph)	2.0 - 6.0 (Avg. 4.5)	3.5 - 9.5 (Avg. 7.0)	4.5 - 13.5 (Avg. 10.5)	2.0 - 6.0 (Avg. 4.5)	-36%	1.0 - 8.0 (Avg. 5.0)	-52%

Exhibit 4-5: Location of Bottlenecks and Recurrent Congestion on SR 24 - Baseline Conditions, 2007 (No Improvements)

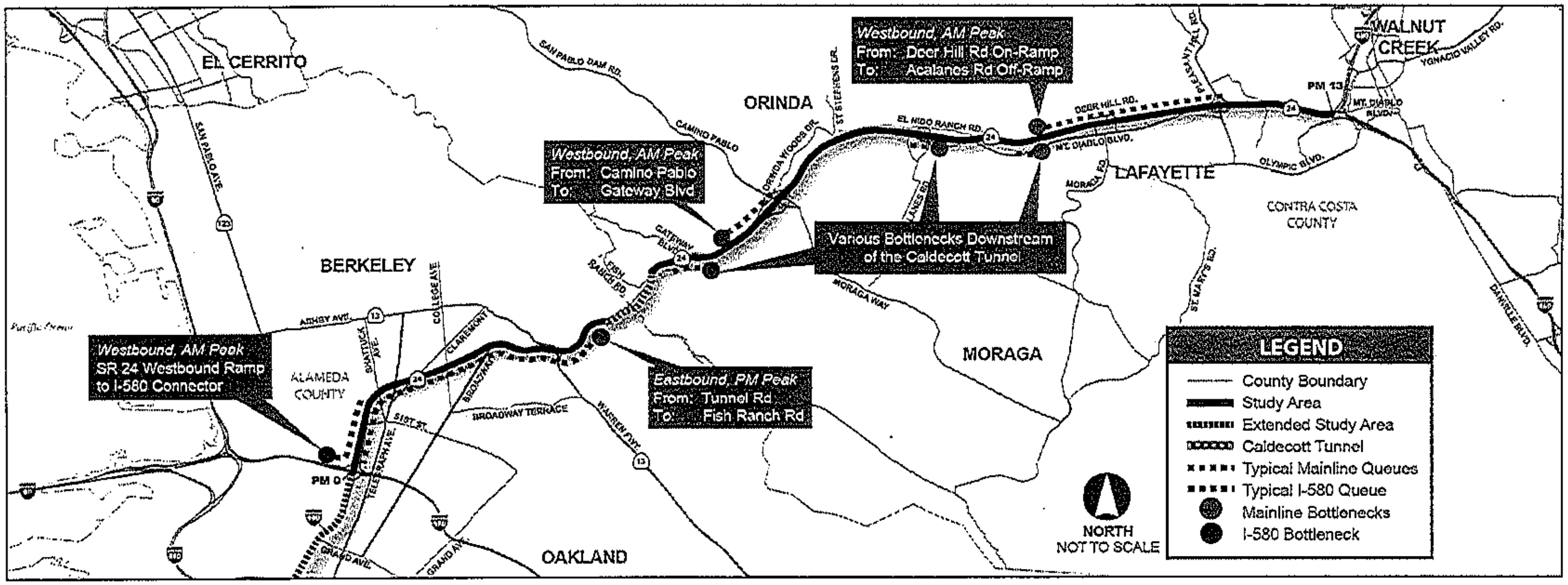


Exhibit 4-6: Location of Bottlenecks and Recurrent Congestion on SR 24 - Baseline Conditions, 2015 (Committed Improvements)

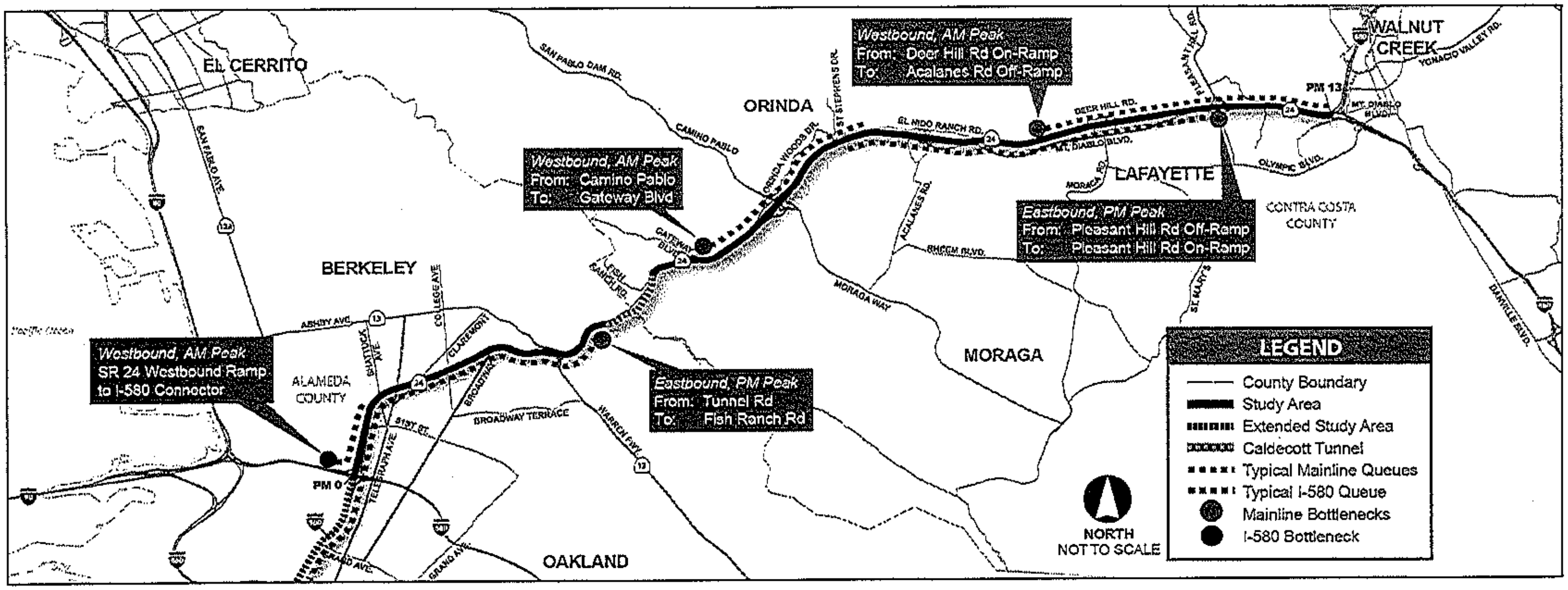


Exhibit 4-7: Location of Bottlenecks and Recurrent Congestion on SR 24 - Improved Conditions, 2015 (Committed Improvements + Short-Term Strategies)

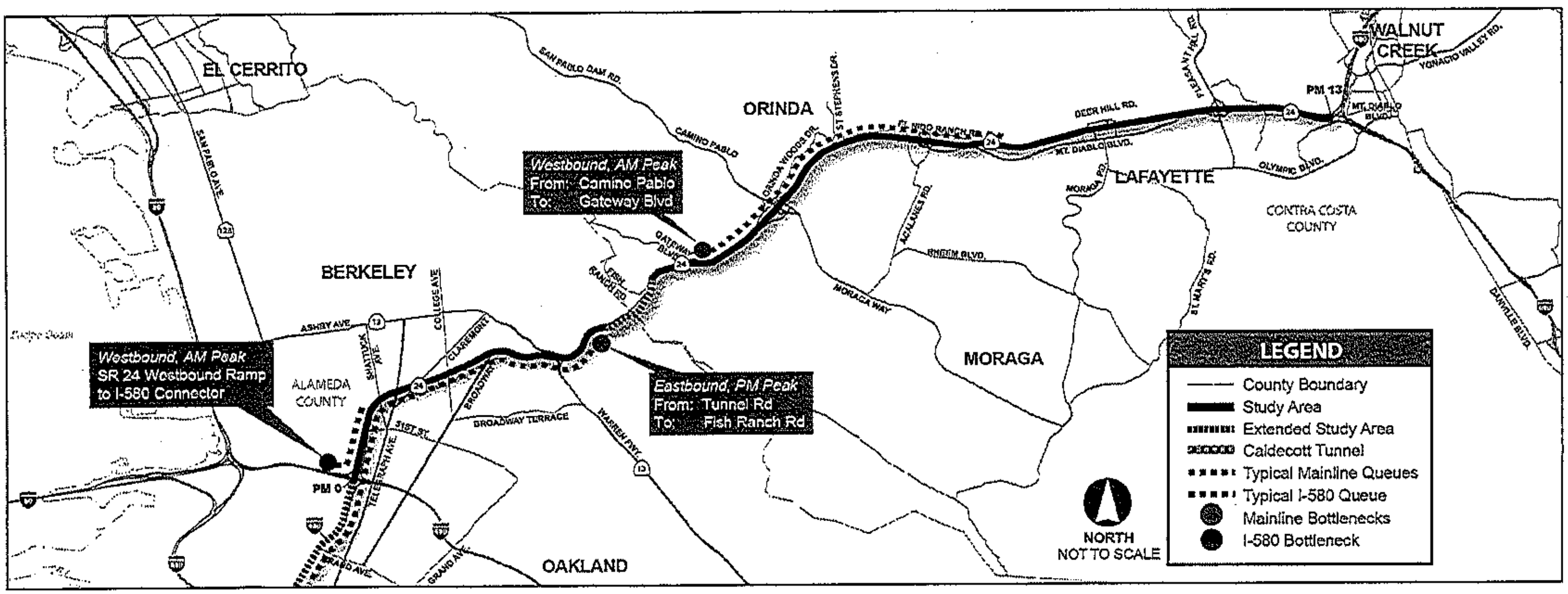


Exhibit 4-8: Location of Bottlenecks and Recurrent Congestion on SR 24 - Baseline Conditions, 2030 (Committed Improvements)

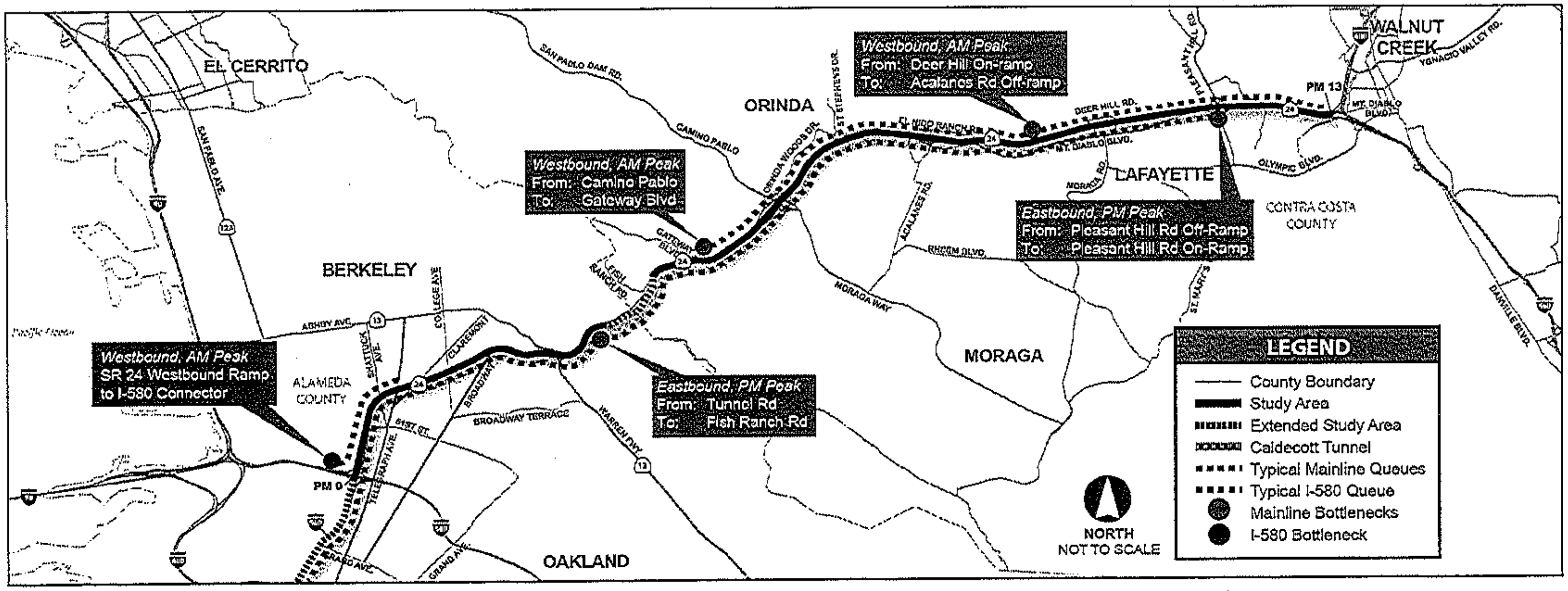
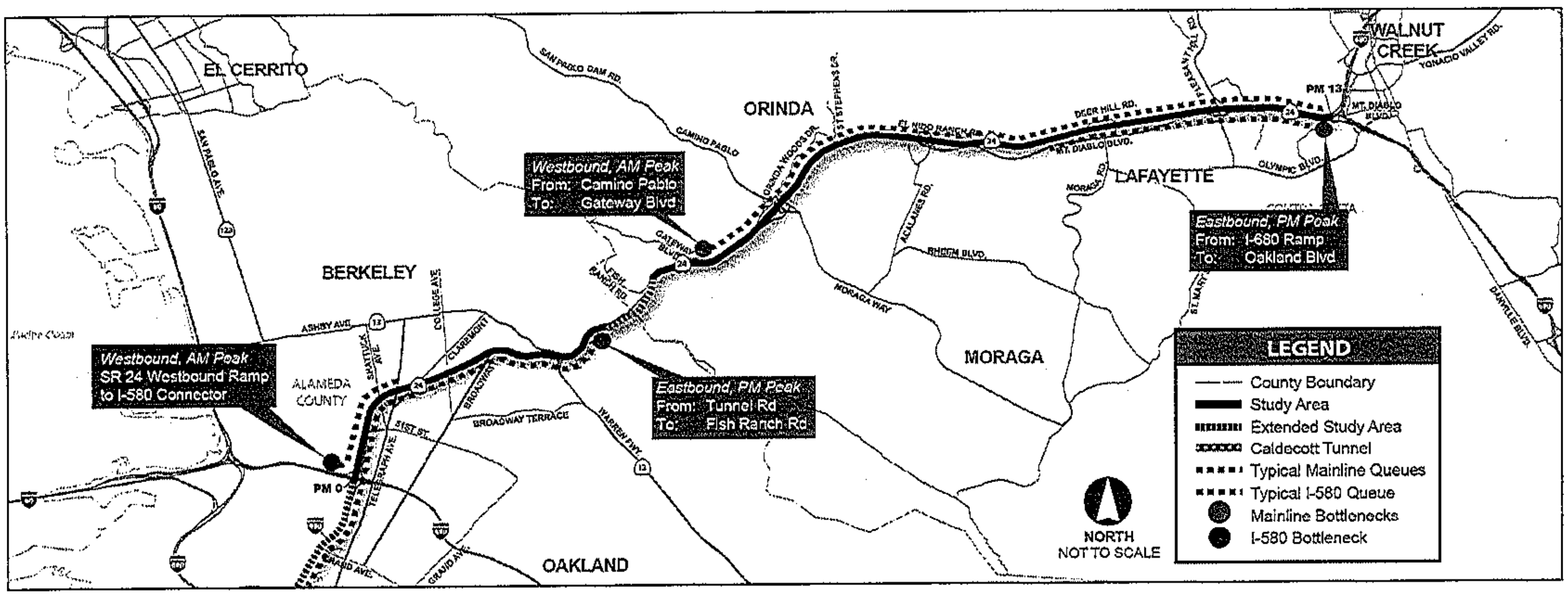


Exhibit 4-9: Location of Bottlenecks and Recurrent Congestion on SR 24 - Improved Conditions, 2030 (Committed Improvements + Short-Term Strategies + Long-Term Strategies)



Section 5: Life-Cycle Benefits

The proposed mitigation improvements were evaluated to assess the quantitative and qualitative benefits of the improvements. The quantitative benefits, (mobility and reliability), were evaluated to estimate their life-cycle benefits. The qualitative benefits, (goods movement, HOV connectivity and access management), are also evaluated for subjective prioritization applications.

Quantitative Benefits

The quantitative benefits, mobility and reliability were calculated for all proposed mitigation improvements as presented in Exhibit 5-1 using the analysis program (i.e., FREQ).

All calculations were performed on segment levels (e.g., Camino Pablo on-ramp to Gateway Boulevard [Wilder Road] off-ramp) and then summed for the entire SR 24 Corridor. The mobility and reliability benefits shown in Exhibit 3-1 are the life-cycle values for 21 years, from 2009 (also known as Year 1) to 2030. These benefits include a 4% discount rate. Additional notes and assumptions of each of these benefits are provided in the following text.

Mobility

All mobility benefits were estimated using FREQ. Mobility was evaluated using actual volumes (as opposed to demand volumes) and measured in hours of recurrent delay. Specifically, congested delay was used as the type of recurrent delay used to calculate mobility.

In coordination with MTC and Caltrans staff, it was determined that mobility benefits would be quantified by evaluating recurrent delay by using congested delay, which is defined as delay resulting from vehicle speeds of less than 35 mph. Congested delay was used instead of total delay, which is defined as delays from vehicles speeds of less than 60 mph.

As a result of using congested delay instead of total delay, some improvements show no mobility benefits. This is not because the speeds remain unchanged with the addition of these improvements, but rather the absence of one of these improvements alone does not cause a decrease in speed below the 35 mph threshold. This is also due to the "All-In Differential" method.

The mobility benefit model is based on the following calculations:

1. Distances are divided by vehicle speeds to estimate travel times.
2. Calculated travel times are compared to 35 mph travel time standards of congested delay and their difference is the recurrent delay.
3. Factors are applied to convert the recurrent delay from peak period to daily and from daily to life-cycle.

Values of the life-cycle mobility benefits are presented in Exhibit 5-1.

Reliability

Reliability benefits were estimated either in IDAS or by manual computations using the travel time reliability rates provided in the IDAS User's Manual Table B 2.14. Reliability was evaluated using unconstrained volumes to calculate V/C ratios and Vehicle Miles Traveled (VMT). Unconstrained volumes were used instead of constrained volumes because the constrained volumes are lower in oversaturated conditions as a result of vehicles in queue.

The reliability benefit model is based on the following calculations:

1. Unconstrained volumes multiplied by distance results in unconstrained VMT.
2. Travel time reliability rates from IDAS are a function of number of lanes and V/C. The travel time reliability rate is the number of vehicle hours of non-recurrent delay per VMT.

3. Unconstrained VMT values multiplied by the travel time reliability rates yields the non-recurrent delay.
4. Factors are applied to convert the non-recurrent delay from peak period to daily and from daily to life-cycle.

Values of the life-cycle reliability benefits are presented in Exhibit 5-1.

Exhibit 5-1: Quantitative Measures of Life-Cycle Benefits

Pkg	Year	Dir.	ID	Mitigation Improvement	Life-Cycle Benefits Mobility (per-hrs saved)	Life-Cycle Benefits Reliability (per-hrs saved)	Life-Cycle Benefits TOTAL (per-hrs saved)
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	0	9,946,000	29,838,000
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.			
			3	Extend ITS coverage to fill the gap between I-580 and the Caldecott Tunnel.			
B	2015	WB	4	Implement ramp metering in the westbound direction between I-680 and the Caldecott Tunnel.	17,858,000	14,355,000	60,923,000
			5	Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel.			
C	2015	EB	6	Implement ramp metering in the eastbound direction between I-580 and the Caldecott Tunnel and on the SR 24 Extended Corridor (I-980) from I-880 to I-580.	5,927,000	2,673,000	13,946,000
			7	Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel.			
D	2015	EB	8	Implement ramp metering in the eastbound direction between the Caldecott Tunnel and I-680.	16,668,000	10,605,000	48,483,000
			9	Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange (left shoulder or widen on right).			
E	2030	WB	10	Implement ramp metering in the westbound direction between the Caldecott Tunnel and I-580 and on the SR 24 Extended Corridor (I-980) from I-580 to I-880.	412,000	1,095,000	3,697,000

Abbreviations: ITS = Intelligent Transportation System; HOV = High Occupancy Vehicle

Note: Based on FHWA research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours). This factor is reflected in the "Total Life-Cycle Benefits" value.

Qualitative Benefits

The qualitative benefits were addressed for all proposed mitigation improvements as summarized below. These benefits were evaluated by determining if the proposed mitigation measure provided improvements in the SR 24 Corridor that cannot be easily quantified, but should be considered in the regional prioritization (i.e., comparing proposed mitigation improvements on SR 24 with proposed mitigation measures within other corridors in the region). These qualitative benefits, as outlined in the FPI Framework, are: goods movement, HOV connectivity, and access management. An improvement for these benefits is denoted by a "Yes." These qualitative benefits are not included in the ranking/prioritization of mitigation strategy packages because there is no specific dollar value associated with them. In accordance with the methodology described in Section 3 of this memorandum, the qualitative benefits are outlined below.

Goods Movement

For the goods movement performance measure, no mitigation improvements were given a "Yes" ranking. This is due to the fact that SR 24 is not designated as a goods movement corridor.

HOV System Connectivity

For the HOV system connectivity performance measure, the following mitigation improvements were given a "Yes" ranking:

- Improvement #5 of Package B: Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel.
- Improvement #7 of Package C: Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel.
- Improvement #9 of Package D: Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange. (Left shoulder or widen on right.).

Access Management

For the access management performance measure, no mitigation improvements were given a "Yes" ranking. This is due to the fact that there are no proposed mitigation improvements that reduce the number of access points on the SR 24 Corridor.

As noted previously, the final prioritization does not incorporate the above qualitative performance measures. However, these qualitative "Yes" rankings are important in that they provide a more comprehensive analysis to inform the regional prioritization process.

Section 6: Life-Cycle Costs

Capital costs and O&M costs were calculated for all proposed mitigation improvements, with the exception of those improvements that have to do with transit and tolling, and are presented in Exhibit 6-1. Details on the methodology for these cost estimations are provided in Section 3. Capital costs were incurred during construction years and O&M costs were accrued annually after construction. Life-cycle costs were calculated for a life-cycle of 21 years, from 2009 to 2030 as with the life-cycle benefits. Life-cycle costs include a 4% discount rate.

Exhibit 6-1: Life-Cycle Costs

Pkg	Year	Dir.	ID	Mitigation Improvement	Capital Cost	O&M Cost (per year)	Life-Cycle Costs
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	$ 5,151,000	$ 154,500	$ 17,580,000
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.			
			3	Extend ITS coverage to fill the gap between I-580 and the Caldecott Tunnel.	$ 7,113,000	$ 213,400	
B	2015	WB	4	Implement ramp metering in the westbound direction between I-680 and the Caldecott Tunnel.	$ 5,682,000	$ 284,100	$ 112,950,000
			5	Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel.	$ 102,425,000	$ 51,400	
C	2015	EB	6	Implement ramp metering in the eastbound direction between I-580 and the Caldecott Tunnel and on the SR 24 Extended Corridor (I-980) from I-880 to I-580.	$ 7,600,000	$ 380,000	$ 36,650,000
			7	Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel.	$ 23,403,000	$ 10,500	
D	2015	EB	8	Implement ramp metering in the eastbound direction between the Caldecott Tunnel and I-680.	$ 5,056,000	$ 252,800	$ 69,730,000
			9	Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange (left shoulder or widen on right).	$ 60,566,000	$ 31,800	
E	2030	WB	10	Implement ramp metering in the westbound direction between the Caldecott Tunnel and I-580 and on the SR 24 Extended Corridor (I-980) from I-580 to I-880.	$ 5,672,000	$ 283,600	$ 9,770,000

Abbreviations: ITS = Intelligent Transportation System; HOV = High Occupancy Vehicle

Section 7: Life-Cycle Cost-Effectiveness Analysis

Life-cycle benefits and life-cycle costs were compared to estimate the life-cycle cost-effectiveness for all proposed mitigation improvement packages, with the exception of the transit improvement package (Package F), and are presented in Exhibit 7-1. Details on the methodology used for the cost-effectiveness analysis are provided in Section 3. For each mitigation strategy package, life-cycle costs were divided by life-cycle benefits to estimate the life-cycle cost-effectiveness. The cost-effectiveness is presented as the cost for every hour of delay saved as estimated over a 21-year life-cycle, from 2009 to 2030.

Exhibit 7-1: Life-Cycle Cost-Effectiveness Analysis

Pkg	Year	Dir.	ID	Mitigation Improvement	Life-Cycle Benefits	Life-Cycle Costs	Cost-Effectiveness
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	29,838,000 person-hours of delay saved	$ 17,580,000	$0.59 / person-hour of delay saved
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.			
			3	Extend ITS coverage to fill the gap between I-580 and the Caldecott Tunnel.			
B	2015	WB	4	Implement ramp metering in the westbound direction between I-680 and the Caldecott Tunnel.	60,923,000 person-hours of delay saved	$ 112,950,000	$1.85 / person-hour of delay saved
			5	Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel.			
C	2015	EB	6	Implement ramp metering in the eastbound direction between I-580 and the Caldecott Tunnel and on the SR 24 Extended Corridor (I-980) from I-880 to I-580.	13,946,000 person-hours of delay saved	$ 36,650,000	$2.63 / person-hour of delay saved
			7	Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel.			
D	2015	EB	8	Implement ramp metering in the eastbound direction between the Caldecott Tunnel and I-680.	48,483,000 person-hours of delay saved	$ 69,730,000	$1.44 / person-hour of delay saved
			9	Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange (left shoulder or widen on right).			
E	2030	WB	10	Implement ramp metering in the westbound direction between the Caldecott Tunnel and I-580 and on the SR 24 Extended Corridor (I-980) from I-580 to I-880.	3,697,000 person-hours of delay saved	$ 9,770,000	$2.64 / person-hour of delay saved

Abbreviations: ITS = Intelligent Transportation Systems; HOV = High Occupancy Vehicle

Section 8: Prioritization

All proposed mitigation improvement packages were ranked/prioritized based solely on the calculated cost-effectiveness (described above in Sections 3 and 7) of their respective improvements. For the purposes of this prioritization exercise, qualitative benefits and political considerations were not included. Rankings are shown in ascending order with Rank 1 having the most cost-effectiveness (as determined in Section 7). Exhibit 8-1 shows the ranking for each mitigation improvement package.

Exhibit 8-1: Prioritization of Mitigation Improvements

Pkg	Year	Dir.	ID	Mitigation Improvement	Package Rank	
					Short-Term	Long-Term
A	2015	Both	1	Activate existing ITS installations that currently are not fully operational.	1	--
			2	Assess gaps in the current and programmed ITS installations and supplement as needed.		
			3	Extend ITS coverage to fill the gap between I-580 and the Caldecott Tunnel.		
D	2015	EB	8	Implement ramp metering in the eastbound direction between the Caldecott Tunnel and I-680.	2	--
			9	Add an eastbound HOV-2 Lane from the St Stephens Dr Interchange to the I-680 Interchange (left shoulder or widen on right).		
B	2015	WB	4	Implement ramp metering in the westbound direction between I-680 and the Caldecott Tunnel.	3	--
			5	Add a westbound left-shoulder HOV-2 Lane from I-680 to the Caldecott Tunnel.		
C	2015	EB	6	Implement ramp metering in the eastbound direction between I-580 and the Caldecott Tunnel and on the SR 24 Extended Corridor (I-980) from I-880 to I-580.	4	--
			7	Add an eastbound left-shoulder HOV-2 Lane from the Broadway on-ramp to the Caldecott Tunnel.		
E	2030	WB	10	Implement ramp metering in the westbound direction between the Caldecott Tunnel and I-580 and on the SR 24 Extended Corridor (I-980) from I-580 to I-880.	---	1
Abbreviations: ITS = Intelligent Transportation Systems; HOV = High Occupancy Vehicle						

The ITS package, Package A, ranked the highest providing the full coverage of ITS technology and management needed to address nonrecurrent delay and safety on the SR 24 Corridor. Package D also ranked high because the HOV lane in this package is does not merge back into the mixed-flow lanes lane like the HOV lanes in Packages B and C, which have to merge before the Caldecott Tunnel.

As documented previously in the *Congestion Mitigation Strategies Technical Memorandum*, (PBS&J, November 9, 2009), it should be noted that Improvement #5 (Package B), provides a westbound HOV Lane, bringing the cross section of SR 24 westbound, west of Pleasant Hill Road to five lanes (four mixed-flow, one HOV), which is one more lane than cited in Gateway Constraint Policy set forth in the Lamorinda Action Plan Update (July 2008). In recognition of the Gateway Constraint Policy, a variation on this strategy that would shorten the proposed HOV lane, eliminating the segment between Pleasant Hill Road and I-680, was also evaluated. The analysis of the shortened HOV lane indicated that the associated costs and benefits would decrease by only 19% and 8%, respectively as compared to the full-length HOV lane proposed as Improvement #5. This relatively nominal change would not affect the overall ranking of Package B, shown above in Exhibit 8-1.

Section 9: Transit Mitigation Strategies

While the FPI and CSMP processes focus on freeway mitigation strategies, improved transit service was raised by stakeholders along the SR 24 corridor. In the case of SR 24 these services include a general package of increased transit access strategies, including additional parking at BART stations upstream of the corridor, enhanced bus feeder services, and operational enhancements to BART at a system-wide level that could accommodate ridership increases of 10 to 20 percent.[12]

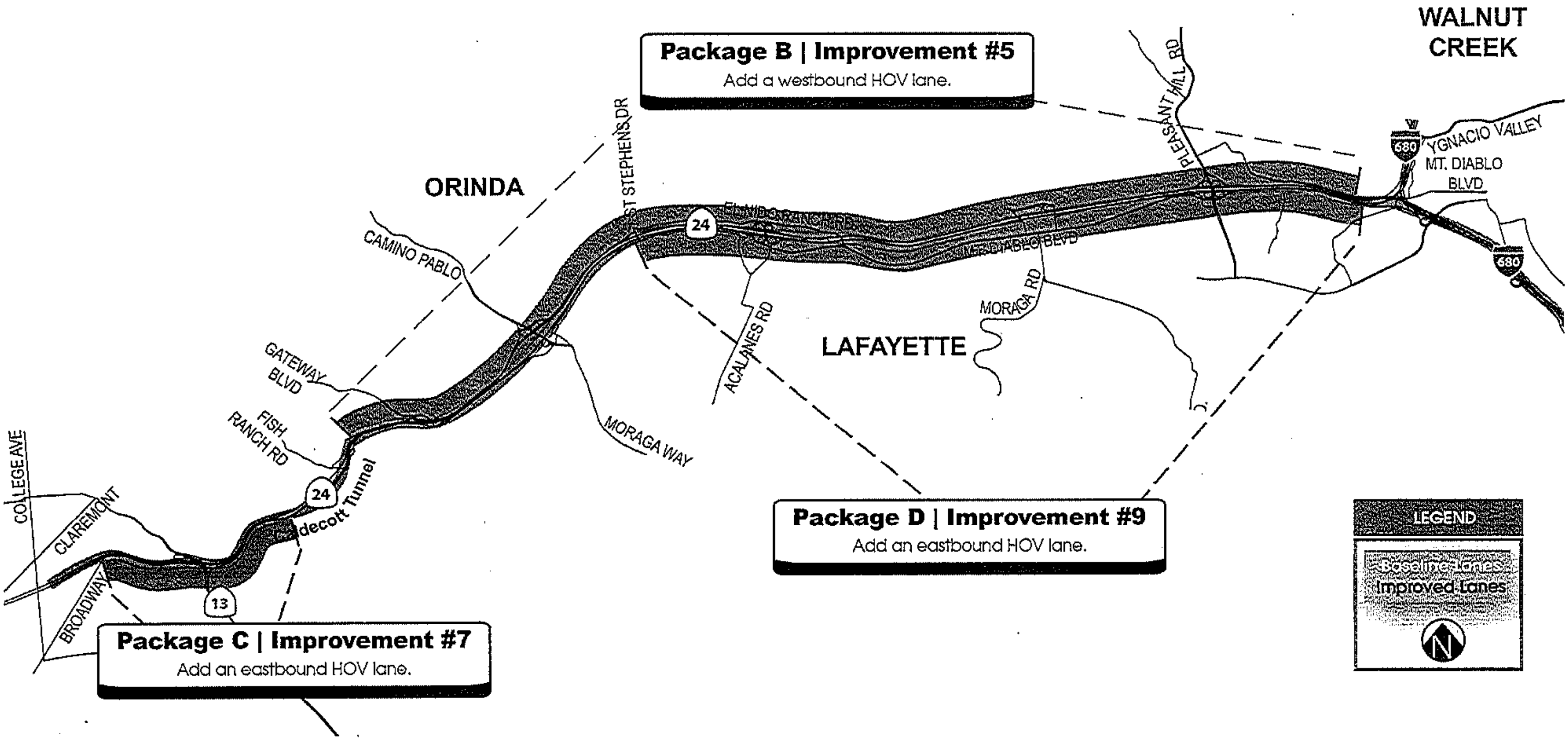
The transit mitigation strategies in Package F include both short-term and long-term strategies. A benefit cost ratio could not be estimated for this report, and thus these transit mitigation strategies cannot be ranked against other mitigation strategies for which life-cycle benefits and costs were available. For this reason, no prioritized recommendations are offered on this set of transit strategies and further analysis is recommended to determine the effectiveness of these improvements and their impacts on the corridor.

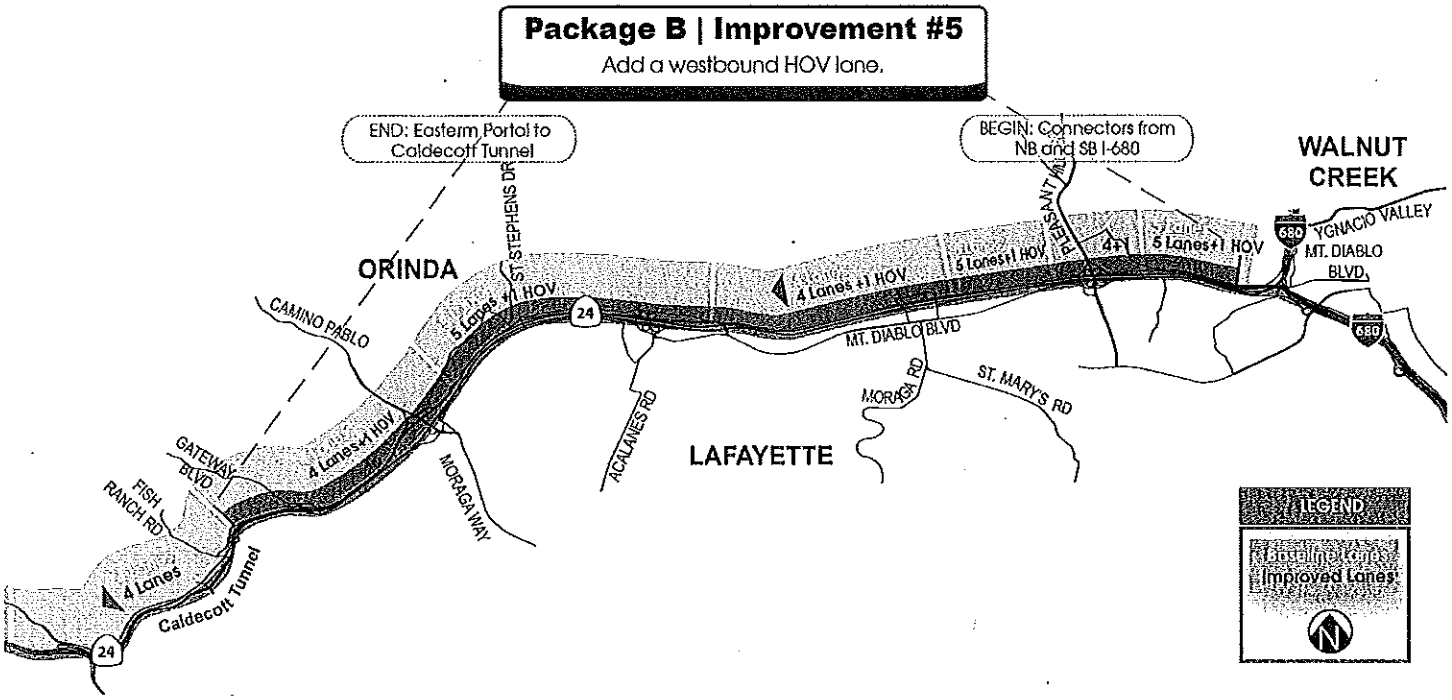
Exhibit 9-1: Transit Mitigation Improvements

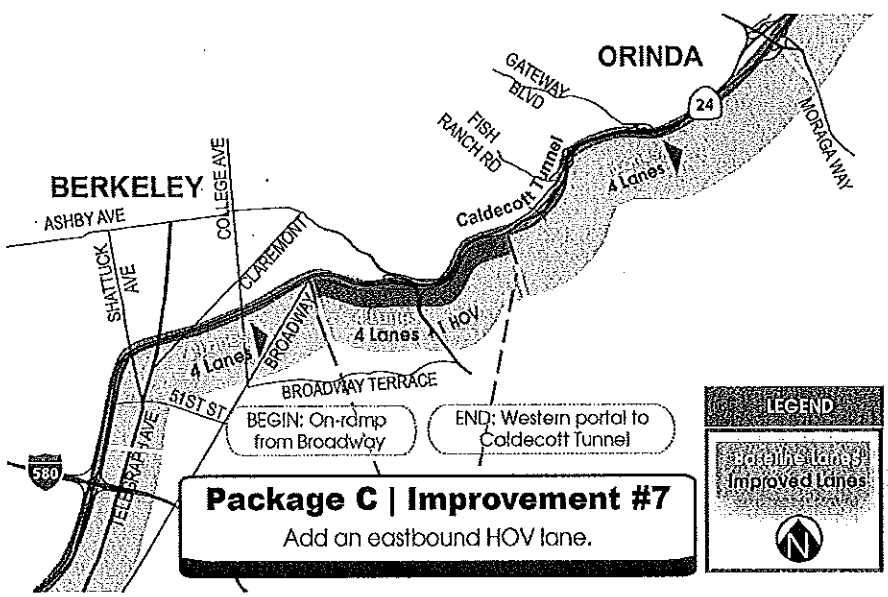
Pkg	ID	Mitigation Improvement
F	11	Additional BART parking capacity at upstream BART stations.
	12	Increased bus transit access to the BART stations within the SR 24 Corridor.
	13	BART system-wide operational improvements.

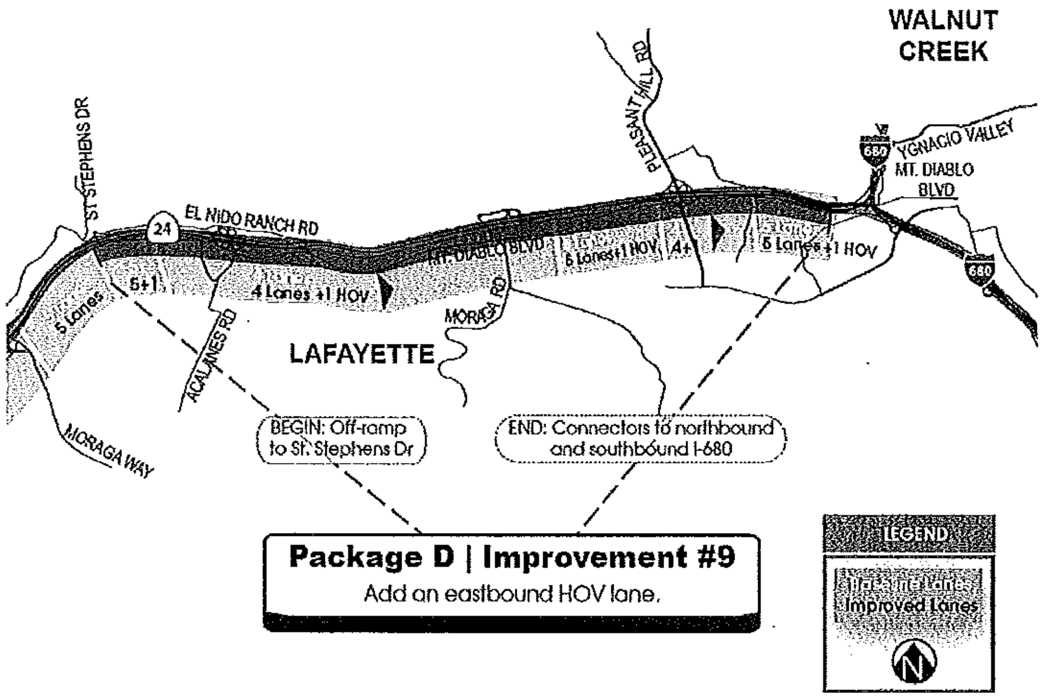
12 The feasibility of accommodating ridership increases in this range was discussed with BART as part of the stakeholder coordination process.

Appendix A: Illustration of Selected Mitigation Strategies


WALNUT
CREEK
YGNACIO VALLEY
MT. DIABLO
BLVD
680
Package B | Improvement #5
Add a westbound HOV lane.
PLEASANT HILL RD
ORINDA
ST STEPHENS DR
CAMINO PABLO
24
MT DIABLO BLVD
MORAGA RD
LAFAYETTE
ACALANES RD
MORAGA WAY
GATEWAY
BLVD
FISH
RANCH RD
Caldecott Tunnel
COLLEGE AVE
CLAREMONT
BROADWAY
13
Package C | Improvement #7
Add an eastbound HOV lane.
Package D | Improvement #9
Add an eastbound HOV lane.
LEGEND
Baseline Lanes
Improved Lanes
N


Package B | Improvement #5
Add a westbound HOV lane.
END: Eastern Portal to Caldecott Tunnel
BEGIN: Connectors from NB and SB I-680
WALNUT CREEK
ORINDA
LAFAYETTE
YGNACIO VALLEY
MT. DIABLO BLVD
680
24
ST. STEPHENS DR
PLEASANT HILL
CAMINO PABLO
5 Lanes +1 HOV
4 Lanes +1 HOV
5 Lanes+1 HOV
4+1
4 Lanes
MT. DIABLO BLVD
MORAGA RD
ST. MARY'S RD
ACALANES RD
MORAGA WAY
GATEWAY BLVD
FISH RANCH RD
Caldecott Tunnel
LEGEND
Baseline Lanes
Improved Lanes


ORINDA
BERKELEY
GATEWAY BLVD
FISH RANCH RD
24
MORAGA WAY
Caldecott Tunnel
4 Lanes
ASHBY AVE
COLLEGE AVE
SHATTUCK AVE
CLAREMONT
BROADWAY
4 Lanes
1 HOV
BROADWAY TERRACE
51ST ST
TELEGRAPH AVE
580
BEGIN: On-ramp from Broadway
END: Western portal to Caldecott Tunnel
Package C | Improvement #7
Add an eastbound HOV lane.
LEGEND
Baseline Lanes
Improved Lanes


WALNUT
CREEK
ST STEPHENS DR
24
EL NIDO RANCH RD
PLEASANT HILL RD
YGNACIO VALLEY
680
MT. DIABLO
BLVD
MT. DIABLO BLVD
5 Lanes
5+1
4 Lanes +1 HOV
6 Lanes+1 HOV
4+
5 Lanes +1 HOV
680
MORAGA RD
ACALANES RD
LAFAYETTE
MORAGA WAY
BEGIN: Off-ramp
to St. Stephens Dr
END: Connectors to northbound
and southbound I-680
Package D | Improvement #9
Add an eastbound HOV lane.
LEGEND
Improved Lanes
N

Appendix B: Life-Cycle Cost-Effectiveness Analysis and Prioritization

SR 24 Prioritized Congestion Mitigation Strategies: Cost-Effectiveness Analysis

	Life-Cycle Benefits			Life-Cycle Costs[3]	Life-Cycle Cost-Effectiveness	Package Rank[4]	
	Mobility Benefits (per-hrs saved)	Reliability Benefits (per-hrs saved)	Total[1 2]		Cost to Person-Hour of Delay Saved	Short Term	Long Term
SHORT-TERM (2009-2015) MITIGATION STRATEGIES							
Short-term Strategies Package A							
1 Activate existing ITS installations that currently are not fully operational. 2 Assess gaps in the current and programmed ITS and supplement as needed. 3 Extend ITS coverage to fill the gap from I-580 to the Tunnel.	0	9,946,000	29,838,000	$17,580,000	$0.59 / per-hr of delay saved	1	—
Short-term Strategies Package B							
4 Implement WB ramp metering from I-680 to the Tunnel. 5 Add a WB left-shoulder HOV-2 Lane from I-680 to the Tunnel.	17,858,000	14,355,000	60,923,000	$112,950,000	$1.85 / per-hr of delay saved	3	—
Short-term Strategies Package C							
6 Implement EB ramp metering from I-680 to the Tunnel. 7 Add an EB left-shoulder HOV-2 Lane from I-680 to the Tunnel.	5,927,000	2,673,000	13,946,000	$36,650,000	$2.63 / per-hr of delay saved	4	—
Short-term Strategies Package D							
8 Implement EB ramp metering from I-680 to the Tunnel. 9 Add an EB left-shoulder HOV-2 Lane from I-680 to the Tunnel.	16,668,000	10,605,000	48,483,000	$69,730,000	$1.44 / per-hr of delay saved	2	—
LONG-TERM (2016-2030) MITIGATION STRATEGIES							
Long-term Strategies Package E							
10 Implement WB ramp metering from the Tunnel to I-580 and on I-980.	412,000	1,095,000	3,697,000	$9,770,000	$2.64 / per-hr of delay saved	—	1
ALL MITIGATION STRATEGIES							
	40,865,000	38,674,000	156,887,000	$246,680,000	$1.57 / per-hr of delay saved	—	—

Source: PBS&J, October 2009.

Notes:
1. Life-Cycle benefits only include mobility and reliability. (No safety or qualitative benefit measures.)
2. Based on FHWA research, motorists consider non-recurrent delay (i.e., reliability hours) to be equivalent to three times that of recurrent delay (i.e., mobility hours). This factor is incorporated into the "Total Life Cycle Benefits" value.
3. Life-Cycle costs include capital, and operating and maintenance.
4. Package rank based on cost effectiveness.