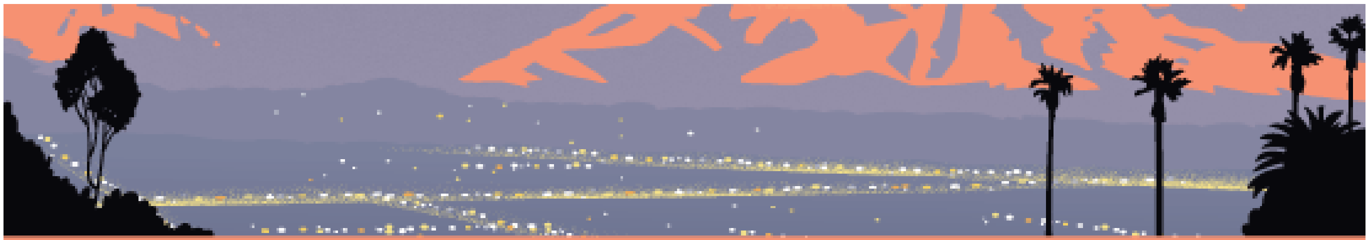

SR-710 Study

Alternatives Analysis Report

Appendix F

Conceptual Engineering Report

Metro

Alternatives Analysis Phase

State Route 710 Study
Conceptual Engineering Report

Prepared for

Metro

Los Angeles County
Metropolitan Transportation Authority

December 2012

CH2MHILL®

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Acronyms and Abbreviations

AA	Alternatives Analysis
AASHTO	American Association of State Highway and Transportation Officials
ac	alternating current
ADA	Americans with Disabilities Act
ADM	Add Drop Multiplexer
ADT	average daily traffic
APEFZ	Alquist-Priolo Earthquake Fault Zone
ATEL	administrative telephone
ATM	Active Traffic Management
AWG	American Wire Gauge
bgs	below ground surface
BMP	best management practice
BRT	Bus Rapid Transit
Cal OSHA	State of California OSHA
Cal State LA	California State University, Los Angeles Caltech California Institute of Technology
Caltrans	California Department of Transportation
CCTV	closed-caption television
C/D	collector/distributor
CD/m^2	Candela per square meter
cfm	cubic feet per minute
cfs	cubic feet per second
CH	hydrocarbon
CIE	International Commission on Illumination
CGS	California Geological Survey
CMS	changeable message signs
CO/SO	carbon monoxide and smoke obscuration [measurement system]
CPU	central processing unit
CRT	cathode ray tube
CTS	cable transmission system
db/km	decibels per kilometer
dc	direct current
DLL	disturbed limit line
DVR	digital video recorder
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELAC	East Los Angeles College
EMI	electromagnetic interference
EMP	[The F&EM shall provide for storage, processing, and transmission of the alarm to EMP for annunciation.]
E/O	electrical-to-optical
EPABX	Electronic Private Automatic Branch Exchange
EPB	earth pressure balance [type of boring machine]
EPDM	ethylene propylene diene monomer
EPFT	Elysian Park Fold and Thrust Belt
ESOP	Emergency Seismic Operation Procedures
ETEL	emergency telephone

ETS	Emergency Trip Station
FACP	fire alarm control panel
FACU	fire alarm and control unit
F&EM	Facilities and Emergency Management
FHWA	Federal Highway Administration
FLS	fire-life-safety
FOCT	fiber optics cable transmission
fpm	feet per minute
FRP	forced reduced performance
FSS	fire suppression system
ft^2	square feet
ft/s	feet per second
FTA	Federal Transit Administration
FTIP	Federal Transportation Improvement Program
FXO	Foreign Exchange Office
FXS	Foreign Exchange Subscriber
GHz	gigahertz
GIS	geographic information system
GP	general purpose
gpm	gallons per minute
GSRD	gross solids removal devices
HAS	hydrologic sub area
HDM	Highway Design Manual [Caltrans]
HOV	high-occupancy vehicle
hp	horsepower
HRR	heat release rate
HSG	Hydrologic Soil Group
HVAC	heating, ventilation, and air conditioning
Hz	hertz
IDF	intensity-duration-frequency
IDS	Intrusion and Detection System
IEN	Information Exchange Network
IESNA	Illuminating Engineering Society of America
I/O	input/output
ISP	Inside Plant
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
JPL	Jet Propulsion Laboratory
ksf	kips per square foot
kV	kilovolt
LACDPW	Los Angeles County Department of Public Works
LAN	local area network
LASD	Los Angeles County Sheriff Department
lbs	pounds
LED	light-emitting diode
lm	lumens
LOS	level of service
LRT	Light Rail Transit

LRV	light rail vehicle
LTEL	elevator telephone
µm	micrometer
Mbps	megabits per second
MDF	Main Distribution Frame
MHz	megahertz
mm/yr	millimeters per year
mph	miles per hour
MS4	Municipal Separate Storm Sewer System
MTA	Metropolitan Transportation Authority
MTEL	maintenance telephone
MUTCD	Manual on Uniform Traffic Control Devices
MW	megawatt(s)
MXO	Multiple Exchange Office
MXS	Multiple Exchange Subscriber
NASA	National Aeronautics and Space Administration
NB	northbound
NEIS	Northeast Interceptor Sewer [Program]
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association]
NGVD	National Geodetic Vertical Datum
nm	nanometer
NPDES	National Pollutant Discharge Elimination System
OC	overcrossing
OCS	overhead contact system
O/E	optical-to-electrical
OG	original ground
O&M	operations and maintenance
OMC	operation-maintenance-control
OSHA	Occupational Safety and Health Administration
OSP	Outside Plant
OWS	operator work station
PA	public announcement
PCC	Pasadena City College
PIARC	World Road Association
PLC	programmable logic controller
PM	particulate matter
PM_{10}	particulate matter with a diameter less than 10 µm
PPDG	Program Planning and Design Guide [Caltrans]
psi	pounds per square inch
PTEL	passenger assistance telephone
PTZ	pan-tilt-zoom
RAM	random access memory
RAP	remote annunciator panel
RCB	reinforced concrete box
RCC	reinforced concrete channel
RCP	reinforced concrete pipe
RCTC	Regional Connector Transportation Corridor
REMP	remote emergency management panel

RIITS	Regional Integration of Intelligent Transportation System
ROC	Rail Operation Center
RTP	*Regional Transportation Plan* [SCAG]
RTU	remote terminal unit
RUS	Rural Utilities Service
RWQCB	Regional Water Quality Control Board
SAV	Stand-alone Fare Validator
SB	southbound
SCADA	supervisory control and data acquisition
SCAG	Southern California Association of Governments
SCC	Standardized Cost Categories
SCRRA	Southern California Regional Rail Authority
SEM	sequential excavation method
SNO_x	nitrogen oxides
SR	State Route
SSD	stopping sight distance
SSSD	safe stopping sight distance
STI	System Transmission Intelligibility
SUSM	Standard Urban Storm Water Mitigation Plan
TBM	tunnel boring machine
T_c	time of concentration
TC&C	Train Control and Communication
TCP	Transmission Control Protocol
TDC	targeted design constituent
TDH	total dynamic head
TDM	Travel Demand Management
TE	tractive effort
TES	Traction Electrification System
TIA	Telecommunications Industry Association
TMDL	total maximum daily load
TOS	Transit Operations Supervisor
TPSS	traction power substation
TRU	transformer-rectifier unit
TSM	Transportation System Management
TSP	Transit Signal Priority
TSSP	Traffic Signal Synchronization Program
TVA	Threat and Vulnerability Analysis
TVM	Ticket Vending Machine
TWC	train-to-wayside communication
U-Link	University-Link Rail Project [Seattle]
UPRR	Union Pacific Railroad
UPS	uninterruptible power supply
UCS	University of Southern California
UFS	Universal Fare System
USEPA	United States Environmental Protection Agency
VDC	volts direct current
VDS	Video Detection System
VFD	variable frequency drive
VLAN	virtual local area network

VMS	variable message signs
VT	Virtual Tributary
WB	westbound
WQV	water quality volume

SECTION 1

Introduction

This Conceptual Engineering Report has been prepared to accompany the conceptual drawings and cost estimate for the State Route (SR) 710 Study project. The report provides discussions on the alignments and profiles, station configurations, existing utilities, geologic conditions, and tunneling methods to be considered for all alternatives.

1.1 Purpose of Project

The purpose of the proposed project is to effectively and efficiently accommodate regional and local north-south travel demands in the study area of the western San Gabriel Valley and east/northeast Los Angeles, including the following considerations:

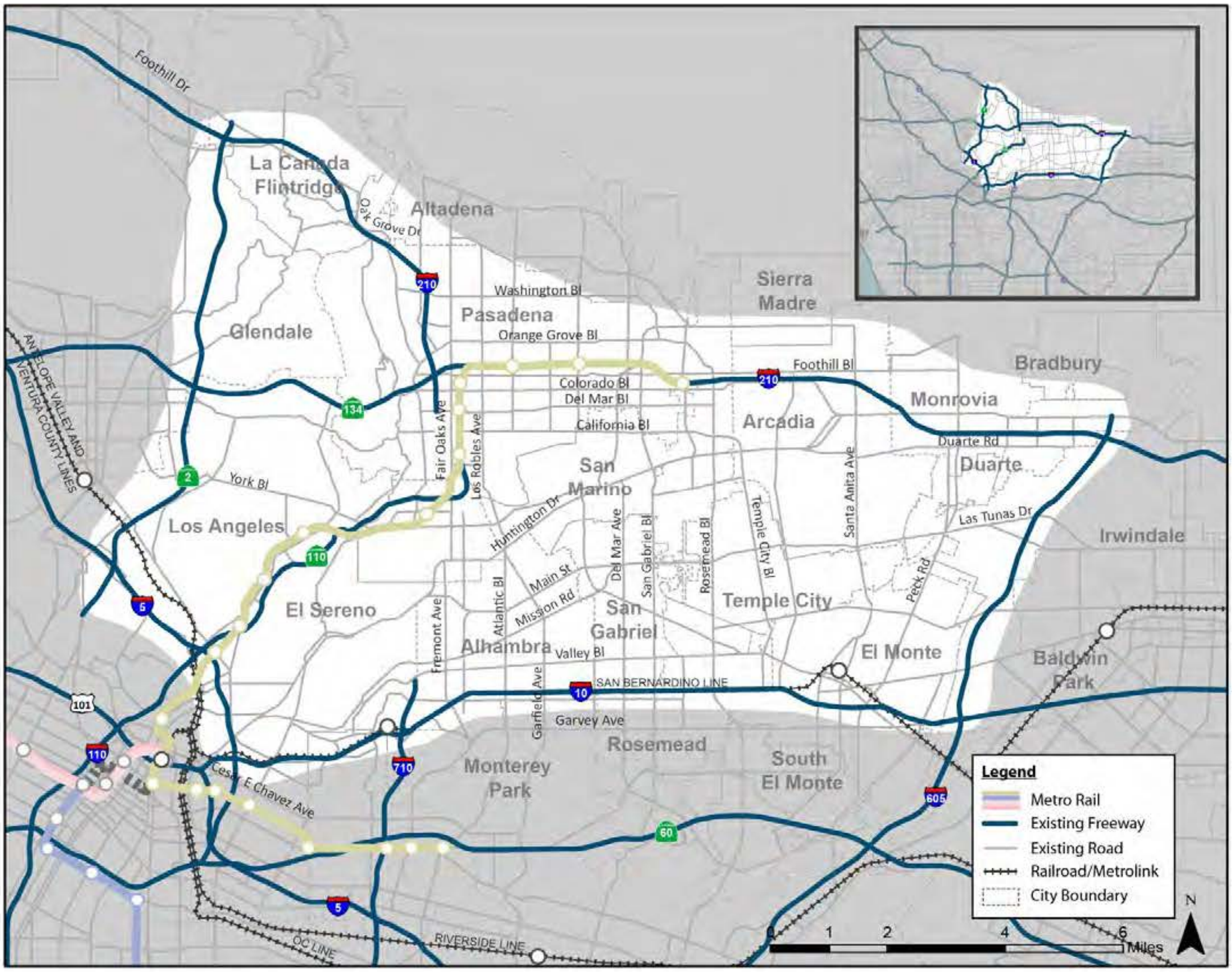
- Improve efficiency of the existing regional freeway and transit networks
- Reduce congestion on local arterials adversely affected as a result of the lack of a north-south route to accommodate regional traffic volumes
- Minimize environmental impacts
- A detailed description of the project’s purpose and need is located in the Alternative Analysis Report.

1.2 Study Area

The study area is approximately 100 square miles and is generally bounded by the I-210 freeway on the north, the I-605 freeway on the east, the I-10 freeway on the south, and the I-5 and SR 2 freeways on the west. The study area includes all or portions of the cities of Alhambra, Arcadia, Duarte, El Monte, Glendale, La Cañada Flintridge, Los Angeles, Monrovia, Monterey Park, Pasadena, Rosemead, San Gabriel, San Marino, Sierra Madre, South Pasadena, and Temple City. It also includes several distinct neighborhoods, including El Sereno and Highland Park, within the City of Los Angeles; and parts of several unincorporated communities, such as La Crescenta-Montrose and Altadena, in the western San Gabriel Valley and foothills.

The study area is illustrated in Figure 1-1. According to data from the Southern California Association of Governments (SCAG), the study area had a population of 1.18 million people in 2008, with 450,000 jobs located in the study area. By 2035, the study area is forecast to have a population of 1.33 million people and an employment base of 507,000 jobs.

FIGURE 1-1
Study Area



SECTION 2

Conceptual Alternatives

A wide range of possible transportation alternatives were identified during past studies and comments received during the "SR 710 Conversations" from elected officials, stakeholders, city and agency staff, and the community. The resulting alternatives were evaluated and refined through a three-step screening process to identify the alternatives that best meet the Need and Purpose of the study. The details of the screening process, selection criteria, and the alternatives selected for further conceptual engineering and initial environmental analysis evaluation are presented in the Alternative Analysis Report (CH2M HILL, 2012).

Using the screening process a total of 12 alternatives were selected for conceptual engineering and initial environmental evaluation. This set of 12 alternatives considered were screened from the preliminary set of alternatives that was developed and represents a wide range of modes and alignments. The screening process is described in detail in the Alternative Analysis Report. The set of alternatives considered for conceptual engineering includes a No Build alternative, a Transportation System Management (TSM)/Travel Demand Management (TDM) alternative, two Bus Rapid Transit (BRT) alternatives (with one additional design variation that was developed during the evaluation process), two Light Rail Transit (LRT) alternatives (with two additional design variations that were developed during the evaluation process), four freeway alternatives, and two highway/arterial alternatives. These alternatives are described in detail below.

2.1 No Build Alternative

The No Build alternative includes all of the projects that are identified in the financially constrained project list of the SCAG's *2008 Regional Transportation Plan (RTP): Making the Connections*. The No Build alternative also includes currently planned projects in Los Angeles County that are identified in Measure R, such as the extension of the Metro Gold Line to Azusa, as well as those in the "Constrained Plan" of Metro's 2009 Long Range Transportation Plan (through the year 2035). The No Build alternative does not include any of the alternatives identified in this SR 710 study.

2.2 Transportation System Management/Travel Demand Management (TSM/TDM) Alternative

The TSM/TDM alternative consists of strategies and improvements to improve operational efficiency and capacity for all modes in the transportation system with lower-cost capital investments and/or lower potential impacts. TSM elements aim to improve the operational efficiency of the existing transportation network, and the TDM elements are oriented toward reducing traffic demand during peak periods. The TSM/TDM alternative includes Intelligent Transportation Systems (ITS) elements, increased bus service, active transportation (bicycle) facilities, congested intersection spot improvements, selected local street capacity enhancement improvements, adaptive traffic signal systems, and freeway access improvements. The individual elements of the TSM/TDM alternative are described below. A summary is included in Table 2-1.

2.2.1 Transportation System Management (TSM) Elements

The TSM portion of the TSM/TDM alternative includes ITS elements, intersection spot improvements, and selected local street improvements.

ITS Improvements. The ITS improvements in the TSM/TDM alternative are intended to integrate with the ITS structure for the San Gabriel Valley developed by the San Gabriel Valley Traffic Forum, led by Los Angeles County and consisting of representatives of all San Gabriel Valley (Valley) cities. Figure 2-1 shows the proposed ITS improvements as part of the TSM/TDM alternative. Many corridors in the Valley have already benefited from Metro's Traffic Signal Synchronization Program (TSSP), funded through various Metro Call-for-Projects since its inception in 1995. The only remaining major north-south corridor in the Valley in which TSSP has not been implemented is Garfield Avenue; therefore, TSSP along this corridor is included in the TSM/TDM alternative. In addition, many of the initial corridors that were upgraded could benefit from an update to their signal timing because of changes in traffic volumes and patterns since implementation. Therefore, the TSM/TDM alternative includes signal optimization on corridors along Del Mar Avenue, Rosemead Boulevard, Temple City Boulevard, Santa Anita Avenue, and Peck Road. Beyond TSSP, implementation of Transit Signal Priority (TSP) is included on Rosemead Boulevard to support the proposed expanded Metro Rapid Bus service in the TSM alternative.

Active Traffic Management (ATM) technology and strategies are also included in the TSM/TDM alternative. The major elements of ATM are arterial speed data collection and arterial changeable message signs (CMS). Data on arterial speeds would be collected and distributed through Los Angeles County’s Information Exchange Network (IEN). Many technologies are available for speed data collection, or the data could be purchased from a third-party provider. Travel time data collected through this effort could be provided to navigation systems providers for distribution to the traveling public. In addition, arterial CMS or “trailblazer” message signs would be installed at key locations to make travel time and other traffic data available to the public.

Intersection Hot Spot Improvements. Because the TSM/TDM alternative is intended to be a low cost, low impact alternative, intersection improvements generally consist of adding critical lanes to increase capacity while avoiding right-of-way (ROW) acquisition as much as possible. To ROW needs, lane additions were accommodated via removal of on-street parking, median islands, and left turn lanes where possible. If this approach was not possible, then limited ROW acquisition has been identified to improve capacity at critical locations.

Local Street Improvements. A procedure similar to identifying hot spot improvement locations was used to identify roadway segment improvement locations for inclusion in the TSM/TDM alternative. Congested street segments were identified along major north-south arterials based on 2035 average daily traffic (ADT) volumes in the study area compared to the number of available lanes. Segments were ranked based on ADT volumes per lane, and the ranking resulted in seven local street segments being identified as having the greatest need for capacity improvements. The segments included in the TSM/TDM alternative are shown in Figure 2-2.

To the extent possible, the roadway improvements included in the TSM/TSM alternative rely on using the available width of existing parking lanes, median islands, left turn lanes, or surplus width built into the existing cross-section, without widening the street. In some locations, widening of the street and ROW is required.

TABLE 2-1
TSM/TDM Alternative Elements

Category	Description	Location
TSM Elements		
ITS Improvements		
ITS-1	Transit Signal Priority	Rosemead Blvd (Foothill Blvd, Del Amo Blvd)
ITS-2	Install VDS on SR 110	SR 110 north of US-101
ITS-3	Install VDS at intersections	At key locations in study area
ITS-4	Arterial speed data collection	On key north/south arterials
ITS-5	Install arterial CMS	At key locations in study area
ITS-6	New TSSP on Garfield Ave	Huntington Dr to I-10
ITS-7	Signal optimization on Del Mar Ave	Huntington Dr to I-10
ITS-8	Signal optimization on Rosemead Blvd	Foothill Blvd to I-10
ITS-9	Signal optimization on Temple City Blvd	Duarte Rd to I-10
ITS-10	Signal optimization on Santa Anita Ave	Foothill Blvd to I-10
ITS-11	Signal optimization on Peck Rd	Live Oak Blvd to I-10

TABLE 2-1
TSM/TDM Alternative Elements

Category	Description	Location
Intersection Hot Spot Improvements		
I-1	Intersection Operational Improvements	Broadway/Colorado Blvd
I-2	Intersection Operational Improvements	Eagle Rock Blvd/York Blvd
I-3	Intersection Operational Improvements	Eastern Ave/Huntington Dr
I-4	Intersection Operational Improvements	SR 710 Southbound On-Ramp/Valley Blvd
I-5	Intersection Operational Improvements	SR 710 Northbound Off-Ramp/Valley Blvd
I-6	Intersection Operational Improvements	Fremont St/Columbia St/Pasadena Ave
I-7	Intersection Operational Improvements	Fair Oaks Ave/Mission St
I-8	Intersection Operational Improvements	Fair Oaks Ave/Monterey Rd
I-9	Intersection Operational Improvements	Fremont St/Monterey Rd
I-10	Intersection Operational Improvements	Huntington Dr/Fair Oaks Ave
I-11	Intersection Operational Improvements	Fremont St/Huntington Dr
I-12	Intersection Operational Improvements	Fremont St/Valley Blvd
I-13	Intersection Operational Improvements	Garfield Ave/Huntington Dr
I-14	Intersection Operational Improvements	Atlantic Blvd/Huntington Dr
I-15	Intersection Operational Improvements	Atlantic Blvd/Garfield Ave
I-16	Intersection Operational Improvements	Garfield Ave/Mission Rd
I-17	Intersection Operational Improvements	Garfield Ave/Valley Blvd
I-18	Intersection Operational Improvements	San Gabriel Blvd/Huntington Dr
I-19	Intersection Operational Improvements	San Gabriel Blvd/Mission Rd
I-20	Intersection Operational Improvements	Rosemead Blvd/Mission Rd
Local Street Hot Spot Improvements		
L-1	Figueroa St	From SR 134 to Colorado Blvd
L-2a	Fremont Ave	From Huntington Dr to Alhambra Rd
L-2b	Fremont Ave	From Poplar Blvd to Commonwealth Ave
L-2c	Fremont Ave	From Mission Rd to Valley Blvd
L-3	Atlantic Blvd	From Glendon Wy to I-10
L-4	Garfield Ave	From Valley Blvd to Glendon Wy
L-5	Rosemead Blvd	From Lower Azusa Rd to Marshall St
TDM Elements		
Bus Service Improvements		
Bus-1	Additional bus service	See Figure 2-9
Bus-2	Bus stop enhancements	Along TSM routes

TABLE 2-1
TSM/TDM Alternative Elements

Category	Description	Location
Bicycle Facility Improvements		
Bike-1	Rosemead Blvd bike lanes (Class II/III)	Colorado Blvd to Valley Blvd (through County, Temple City, Rosemead)
Bike-2	Del Mar Ave bike lanes (Class II/III)	Huntington Dr to Valley Blvd (through San Marino, San Gabriel)
Bike-3	Huntington Dr bike lanes (Class II/III)	Mission Rd to Santa Anita Ave (through LA, South Pasadena, San Marino, Alhambra, County, Arcadia)
Bike-4	Foothill Blvd bike lanes (Class II/III)	In La Canada Flintridge
Bike-5	Orange Grove bike route (Class III)	Walnut St to Columbia St (in Pasadena)
Bike-6	California Blvd bike route (Class III)	Grand Ave to Marengo Ave (in Pasadena)
Bike-7	Add bike parking at transit stations	Gold Line stations
Bike-8	Improve bicycle detection at existing intersections	Along bike routes in study area

Notes: TSSP=Traffic Signal Synchronization Program; VDS= Video Detection System; CMS=Changeable Message Signs

2.2.2 Travel Demand Management (TDM) Elements

Most TDM programs are implemented at the municipal level through the project development review and approval process. Metro does not have the authority to impose limits on project trip generation or alter municipality parking policies; therefore, the TDM portion of the TSM/TDM alternative includes expanded bus service and bicycle improvements. Metro would also continue to support rideshare matching services, the guaranteed ride home program, and other TDM efforts.

Expanded Bus Service. The transit service improvements included in the TSM/TDM alternative are illustrated in Figure 2-3. These transit improvements are also included in the BRT and LRT alternatives, but are not included in the freeway and highway/arterial alternatives. The bus service improvements included in the TSM/TDM alternative were developed using the Metro travel demand model to identify service improvements that could be implemented at reasonable productivity (passenger loads per vehicle). Some bus enhancements double existing bus service. In addition, one new Metro Rapid service on Rosemead Boulevard is proposed.

No increase to existing LRT service is included in the TSM/TDM alternative. The study area is currently served by the Metro Gold Line LRT. Other Metro projects are studying alternatives for extending the Gold Line, and Metro ultimately plans to increase service to 5-minute frequency during peak hours. These improvements are included in the No Build alternative. When combined with other Metro rail services, these improvements will result in LRT frequencies of 2.5 minutes during peak hours in the downtown Regional Connector, which is the capacity of that facility. Therefore, it is not feasible to increase Gold Line service beyond the improvements included in the No Build alternative.

FIGURE 2-1
TSM/TDM Alternative – ITS Improvements

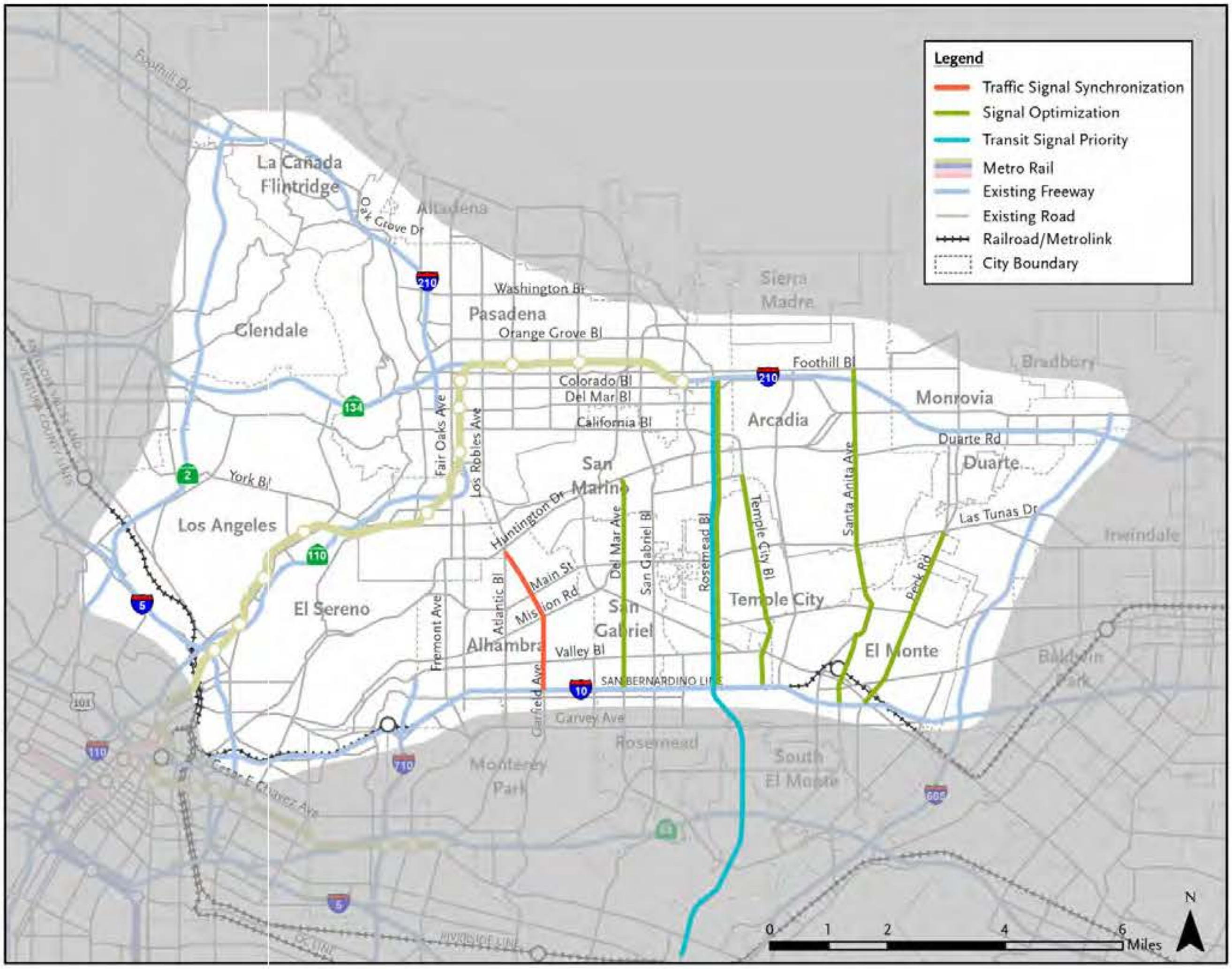


FIGURE 2-2

TSM/TDM Alternative – Intersection and Local Street Improvements

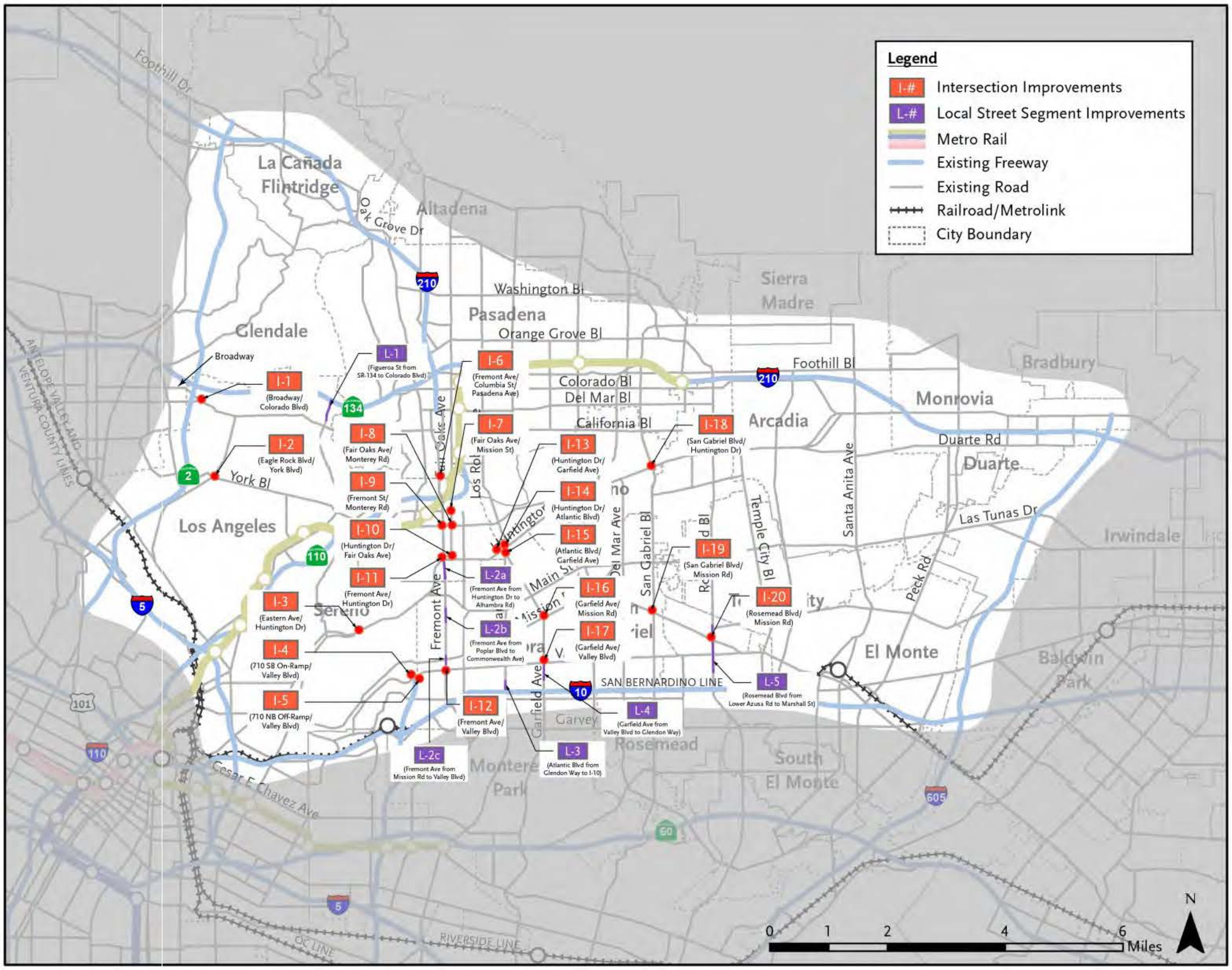
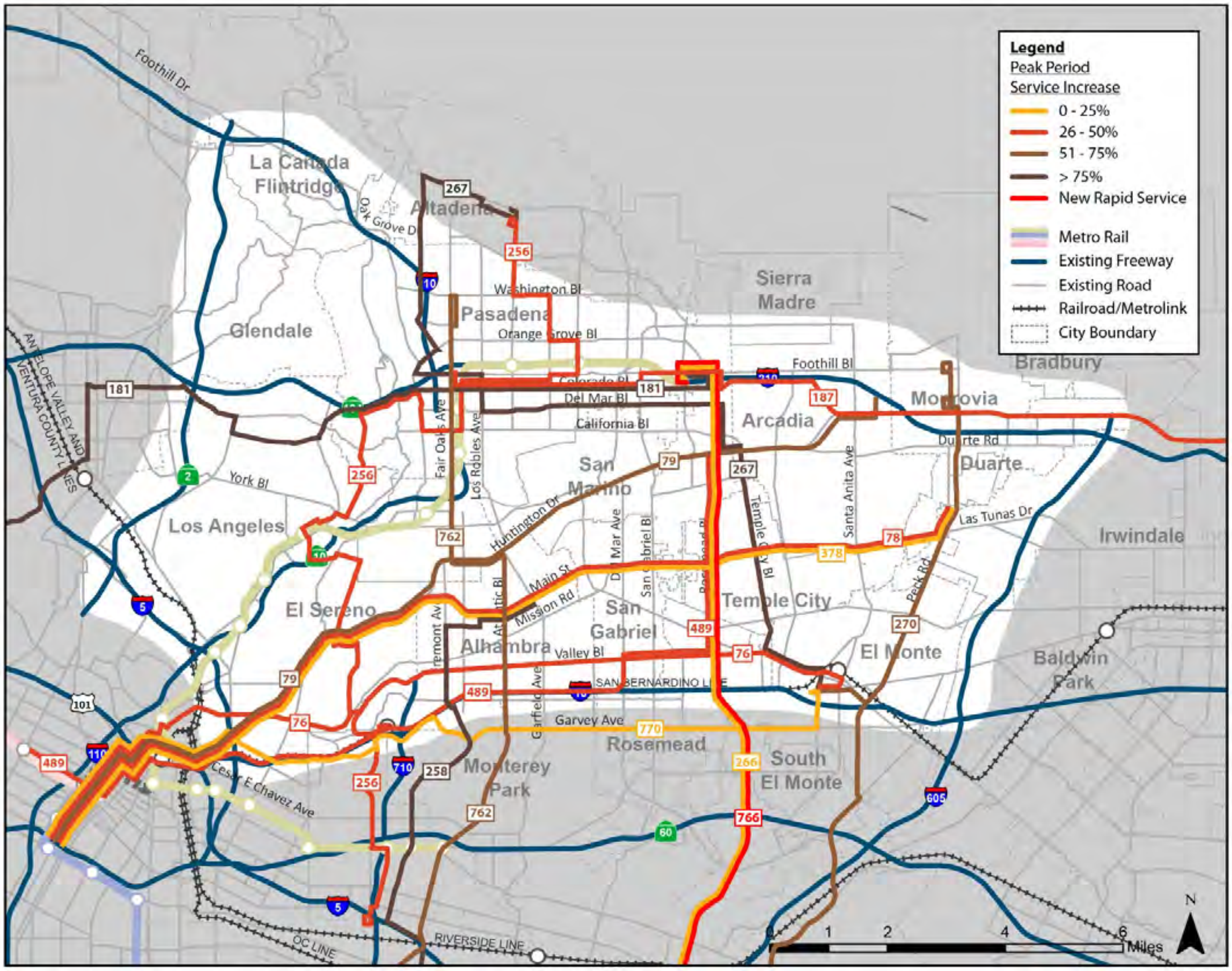


FIGURE 2-3
TSM/TDM Alternative – Expanded Bus Service



Bicycle Improvements. Bicycle improvements included in the TSM/TDM alternative were developed by reviewing bicycle plans for Los Angeles County and for cities in the study area to determine bicycle facility improvements already identified by the jurisdictions of the study area, whether funded or not. The review focused on facilities that were at least in part Class I (off-street facility) or Class II (striped bicycle lanes). Consistent with the Need and Purpose of the project, proposed bicycle facilities included in the TSM/TDM alternative were sought that serve north-south travel between employment and commercial areas, not exclusively recreational travel. Proposed facilities that improve access to transit stations were also identified. Installing bicycle detection at traffic signals at 20 selected intersections in the study area is also included in the TSM/TDM alternative. Figure 2-4 shows the locations for selected bicycle lane improvements in the study area.

2.3 Bus Rapid Transit (BRT) Alternatives

The BRT alternatives would provide higher-speed, higher frequency bus service operating in a combination of new, dedicated bus lanes and existing, mixed-flow traffic lanes. Bus priority methods such as synchronized traffic signal timing and preferential treatment of bus arrivals at signalized intersections would also be incorporated into the BRT system. The BRT alternatives also include all of the additional transit service provided in the TSM/TDM alternative, except where those services overlap with the BRT service itself. Where feasible, BRT vehicles would operate in exclusive lanes, generally in existing ROW through restriping the roadway; prohibiting on-street parking; and narrowing or eliminating existing medians, planted parkways, and narrowing sidewalks. During peak hours, buses would operate every 10 minutes. During off-peak hours, buses would operate every 20 minutes.

2.3.1 Alternative BRT-1

Alternative BRT-1 would provide BRT service between Patsaouras Transit Plaza at Los Angeles Union Station and the Jet Propulsion Laboratory (JPL) in La Cañada Flintridge, a routing not currently served by Metro. BRT vehicles would travel along Mission Road and Huntington Drive to Fair Oaks Avenue in South Pasadena. They would then travel on Fair Oaks Avenue through South Pasadena and Pasadena, turning onto Woodbury Road and following Woodbury Road and Oak Grove Drive to the JPL. The length of the improvements for Alternative BRT-1 would be 13.9 miles. Figure 2-5 illustrates the alignment of Alternative BRT-1.

Portions of the Alternative BRT-1 route operate in exclusive bus lanes and mixed-flow lanes, as illustrated in Figure 2-5. The Alternative BRT-1 vehicles would operate in exclusive lanes, generally adjacent to the curb, in the following general areas:

- Mission Road from Cesar Chavez Boulevard to Huntington Drive
- Huntington Drive from Mission Road to Fair Oaks Avenue
- Fair Oaks Avenue from Huntington Drive to Columbia Street
- Fair Oaks Avenue from Columbia Street to Del Mar Boulevard (northbound only)
- Woodbury Road from Fair Oaks Avenue to Windsor Avenue

Other Metro routes that share part of the alignment would also be able to use these lanes.

FIGURE 2-4
TSM/TDM Alternative – Bicycle Improvements

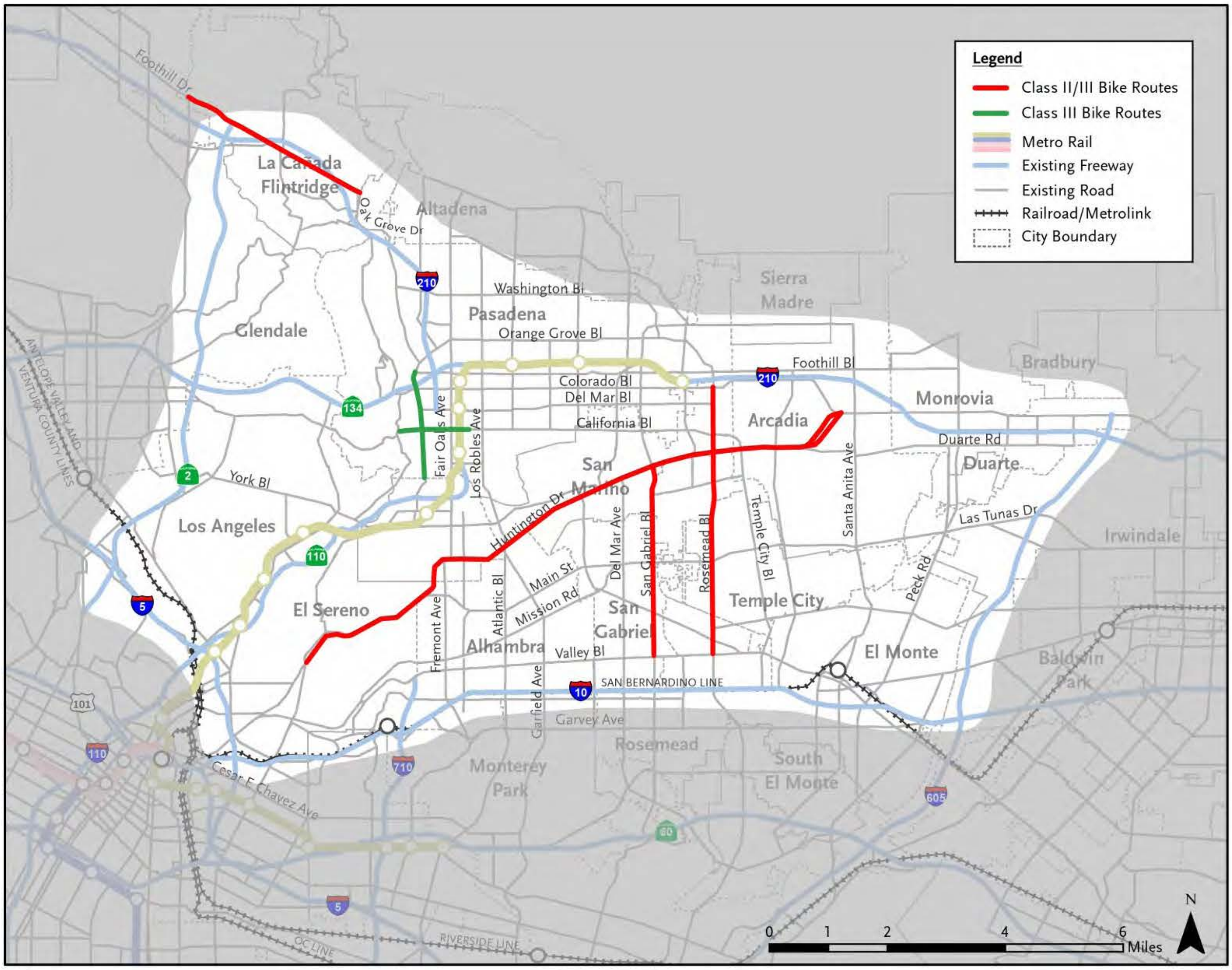
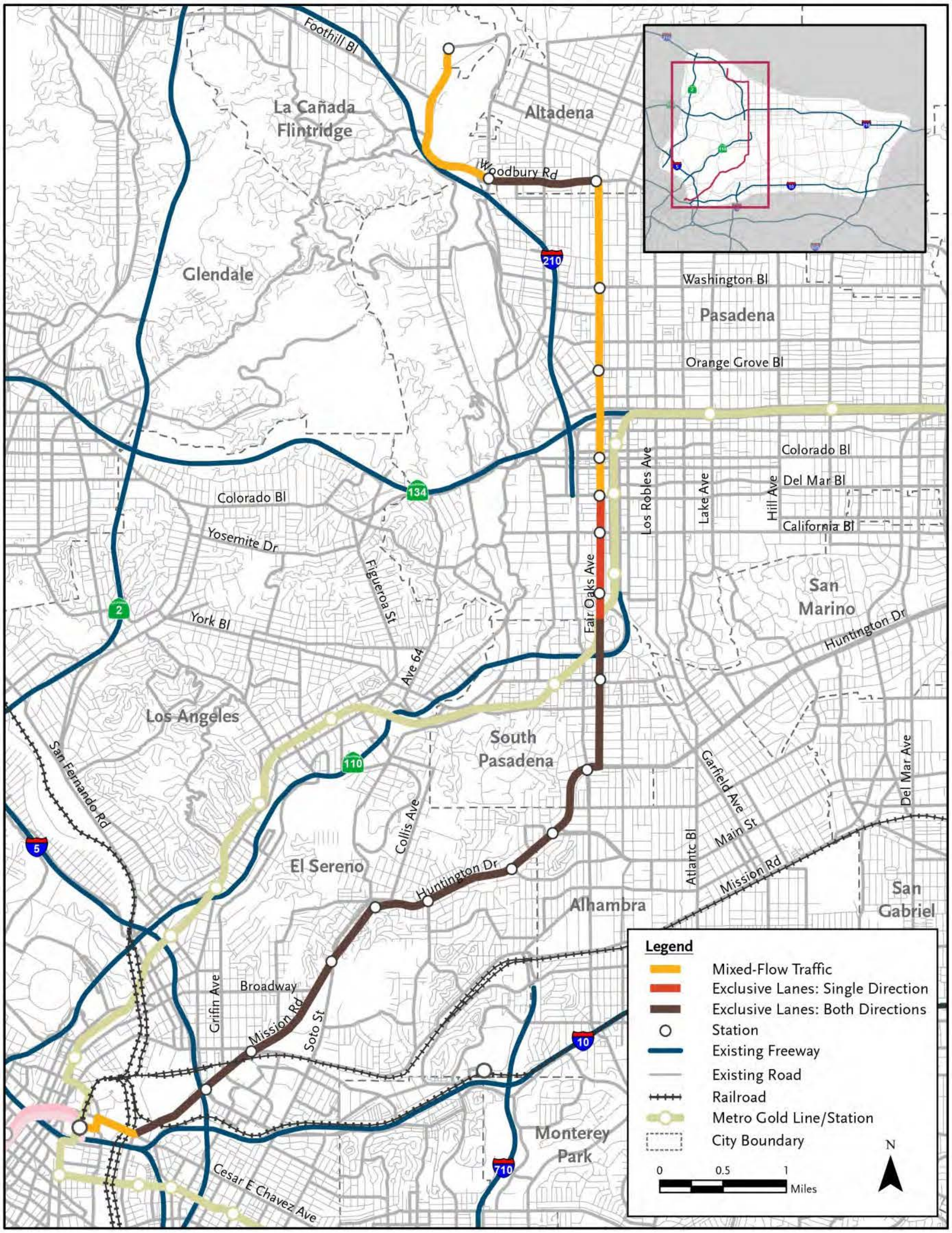


FIGURE 2-5
Alternative BRT-1 Alignment



The exclusive lanes would be created generally in existing ROW through a variety of methods, including restriping the roadway, prohibiting on-street parking, and narrowing or eliminating medians, planted parkways, and narrowing sidewalks. Property acquisition for ROW would be required in a limited number of locations. In other areas, exclusive lanes could not be provided without substantial ROW acquisition. In these areas, the buses would share existing lanes with other traffic. Figure 2-6 illustrates the proposed roadway cross-sections at three typical locations for the BRT alternatives.

Alternative BRT-1 includes all of the additional transit service provided in the TSM/TDM alternative, with the following exceptions:

- Route 378 would be truncated on the west at Huntington Drive/Main Street to avoid duplicating the service provided by BRT-1.
- Headways of Routes 78 would not be increased over the No Build alternative.

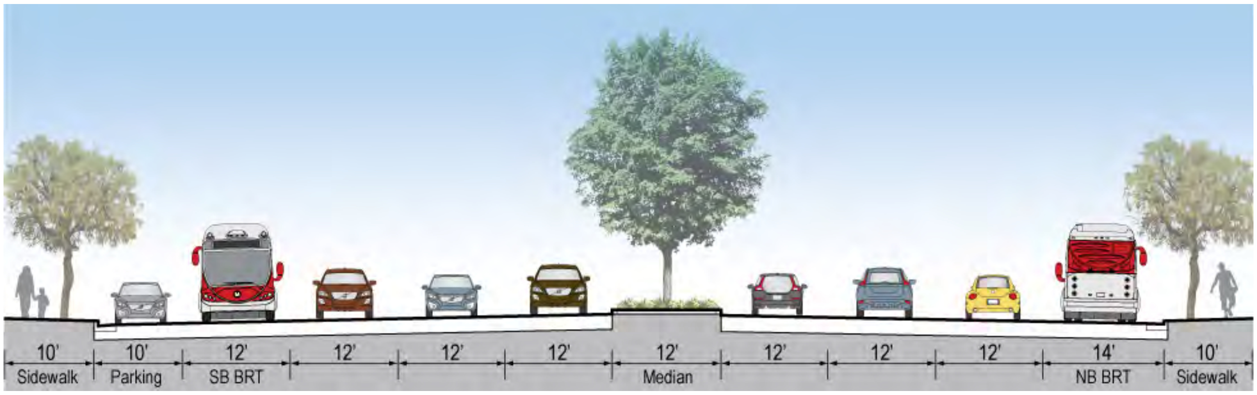
Alternative BRT-1 bus stops would be placed at approximately ½-mile intervals, at major activity centers and cross streets, as shown in Table 2-2 and Figure 2-5.

TABLE 2-2
Alternative BRT-1 Stop Locations

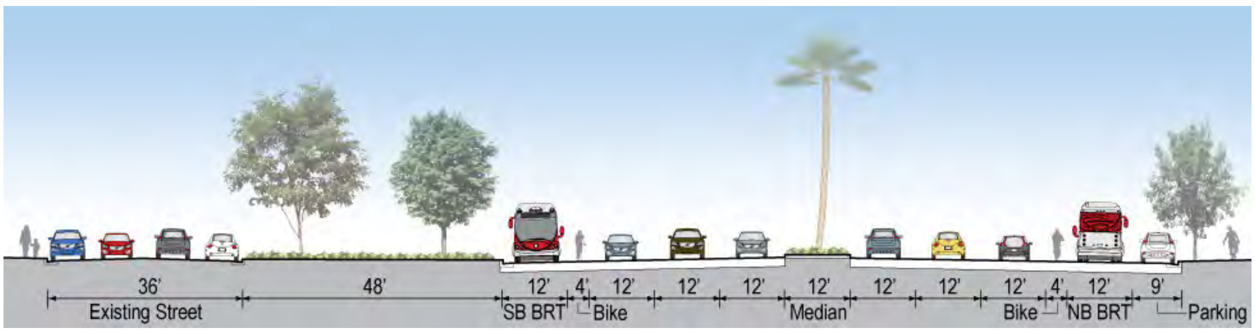
Union Station
Mission Rd at Marengo St/Daly St
Mission Rd at Valley Blvd/Main St
Huntington Dr at Soto St
Huntington Dr at Monterey Rd
Huntington Dr at Eastern Ave
Huntington Dr at Poplar Blvd
Huntington Dr at Main St
Huntington Dr at Fremont Ave
Fair Oaks Ave at Mission St
Fair Oaks Ave at Glenarm St
Fair Oaks Ave at California Blvd
Fair Oaks Ave at Del Mar Blvd
Fair Oaks Ave at Colorado Blvd
Fair Oaks Ave at Orange Grove Blvd
Fair Oaks Ave at Washington Blvd
Fair Oaks Ave at Woodbury Rd
Woodbury Rd at Lincoln Ave
NASA JPL

FIGURE 2-6

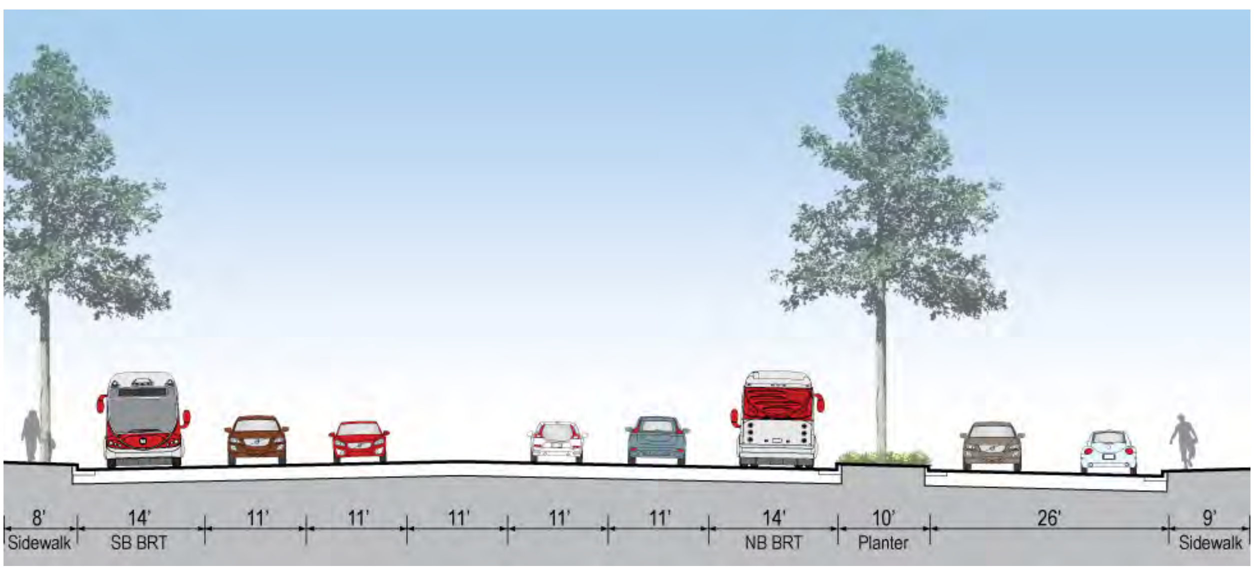
BRT Alternatives Typical Cross-Sections (Fair Oaks near Lyndon Street)



Alternative BRT-1/6/6A: Fair Oakes Avenue near Lyndon Street



Alternative BRT-1: Huntington Drive near Poplar Street



Alternative BRT-6: Atlantic Boulevard near Brightwood Street

2.3.2 Alternative BRT-6

Alternative BRT-6 would provide BRT service between Atlantic Boulevard at Whittier Boulevard and Pasadena City College (PCC) and the California Institute of Technology (Caltech) in Pasadena. BRT vehicles would travel along Atlantic Boulevard to Huntington Drive, then travel briefly west along Huntington Drive to Fair Oaks Avenue before traveling north along Fair Oaks Avenue into Pasadena. In Pasadena, the BRT vehicles would travel along California Boulevard, making a loop to PCC and Caltech via Hill Avenue, California Boulevard, and Lake Avenue. The total length of the route would be 13.8 miles. Figure 2-7 illustrates the alignment of Alternative BRT-6.

Portions of the Alternative BRT-6 route operate in exclusive bus lanes and mixed-flow lanes. The Alternative BRT-6 vehicles would operate in exclusive lanes, generally adjacent to the curb, in the following general areas:

- Atlantic Boulevard from Whittier Boulevard to Beverly Boulevard (northbound only)
- Atlantic Boulevard from Floral Avenue to Harding Avenue
- Atlantic Boulevard from Harding Avenue to Valley Boulevard (southbound only)
- Huntington Drive from Atlantic Boulevard to Fair Oaks Avenue
- Fair Oaks Avenue from Huntington Drive to Columbia Street
- Fair Oaks Avenue from Columbia Street to Del Mar Boulevard (northbound only)
- Colorado Boulevard from Fair Oaks Avenue to Hill Avenue
- Hill Avenue from Del Mar Boulevard to California Boulevard
- California Boulevard from Hill Avenue to Lake Avenue
- Lake Avenue from California Boulevard to Colorado Boulevard

The exclusive lanes would be created generally in existing ROW through a variety of methods, including restriping the roadway; prohibiting on-street parking; and narrowing or eliminating medians, planted parkways, and narrowing sidewalks. No property acquisition would be required for Alternative BRT-6. In some areas, exclusive lanes could not be provided without substantial ROW acquisition. In these areas, the buses would share existing lanes with other traffic.

Bus stops would be placed at approximately ½-mile intervals, at major activity centers and cross streets, as shown in Table 2-3.

TABLE 2-3
Alternative BRT-6 Stop Locations

Alternative BRT-6 Stop Locations
Atlantic Blvd at Whittier Blvd
Atlantic Blvd between Pomona Blvd and Beverly Blvd
Atlantic Blvd at Riggin St
Atlantic Blvd at Cadiz St
Atlantic Blvd at Garvey Ave
Atlantic Blvd at Valley Blvd
Atlantic Blvd at Main St
Atlantic Blvd at Alhambra Rd
Huntington Drive at Garfield Rd
Huntington Drive at Marengo Ave
Fair Oaks Ave at Mission St
Fair Oaks Ave at Glenarm St
Fair Oaks Ave at California Blvd
Fair Oaks Ave at Del Mar Blvd
Fair Oaks Ave at Colorado Blvd
Colorado Blvd at Los Robles Ave

TABLE 2-3
Alternative BRT-6 Stop Locations

Colorado Blvd at Lake Ave
California Blvd at Lake Ave
California Blvd at Hill Ave
Colorado Blvd at Hill Ave

Alternative BRT-6 includes all of the additional transit service provided in the TSM/TDM alternative, with the following exceptions:

- Route 762 would operate as Alternative BRT-6 in the areas where the two routes overlap.
- Route 260 would operate with headways of 10 minutes during peak periods and 20 minutes during off-peak periods.

2.3.3 Alternative BRT-6A

Alternative BRT-6A is a design variation of Alternative BRT-6. Alternative BRT-6A provides exclusive bus lanes for a longer part of the route than does BRT-6. Instead of traveling both eastbound and westbound on Colorado Boulevard, Alternative BRT-6A would travel only eastbound on Colorado Boulevard and then return westbound on California Boulevard after stopping at PCC and Caltech. Alternative BRT-6A was developed to address ROW constraints on Fair Oaks Avenue north of Glenarm Street in Pasadena. There is sufficient room in this section for an exclusive bus lane in one direction only. By operating in only one direction on Fair Oaks Avenue in this section (and the other on Raymond Avenue), BRT-6A can provide exclusive bus lanes for a longer part of the route than does BRT-6. The total length of the route would be 14.2 miles. Figure 2-8 illustrates the alignment of Alternative BRT-6A.

2.3.4 Other BRT Options Considered

Two additional options of Alternative BRT-6 were considered but not ultimately included in the alternative. The first variation would have included an aerial station above the El Monte Busway in the median of I-10 at Atlantic Boulevard. The station would include ramps from the El Monte Busway, allowing it to be served by Alternative BRT-6 vehicles as well as buses operating on the Busway, so that passengers could transfer from a north-south bus to an east-west bus. Construction of the transfer station and the ramps to serve it would have required widening I-10 for a substantial distance on either side of the station. This widening would require the acquisition and demolition of several dozen residential properties. Therefore, the aerial transfer station was not incorporated in Alternative BRT-6.

A second option was considered that consisted of an aerial flyover for Alternative BRT-6 at I-10. At-grade exclusive lanes cannot be provided on Atlantic Boulevard at this location because of the limited width of the roadway as it passes underneath the freeway. However, the vertical clearance requirement for the potential flyover above the Metrolink tracks in the median of I-10 would have required that the flyover extend north of Glendon Way and south of Hellman Avenue, resulting in a structure nearly half a mile long. Because Alternative BRT-6 does not include a northbound lane in this area and the southbound lane terminates just north of the area at Valley Boulevard, this option was not included due to the additional cost and impact of an aerial flyover did not justify the small potential benefit.

FIGURE 2-7
Alternative BRT-6 Alignment

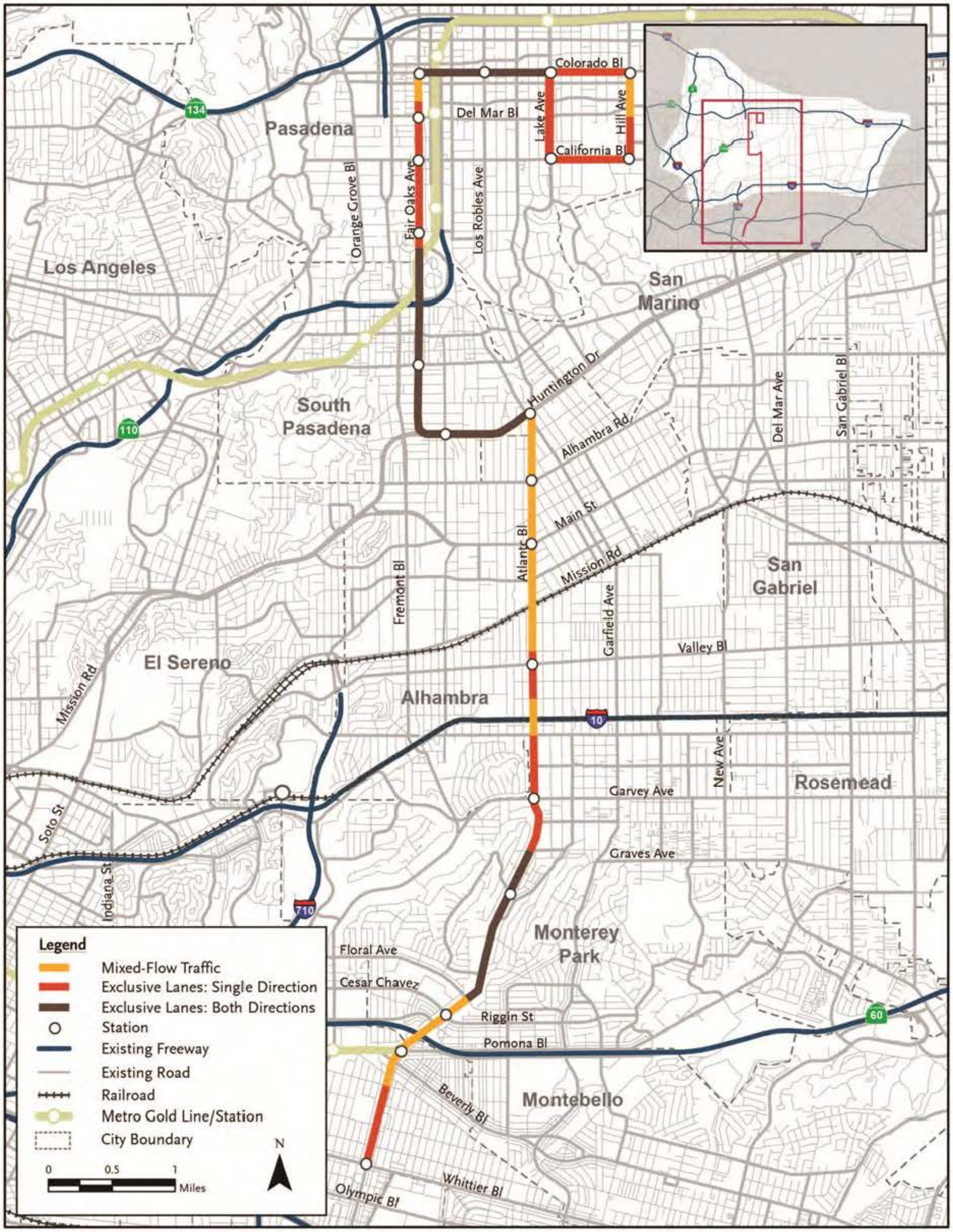
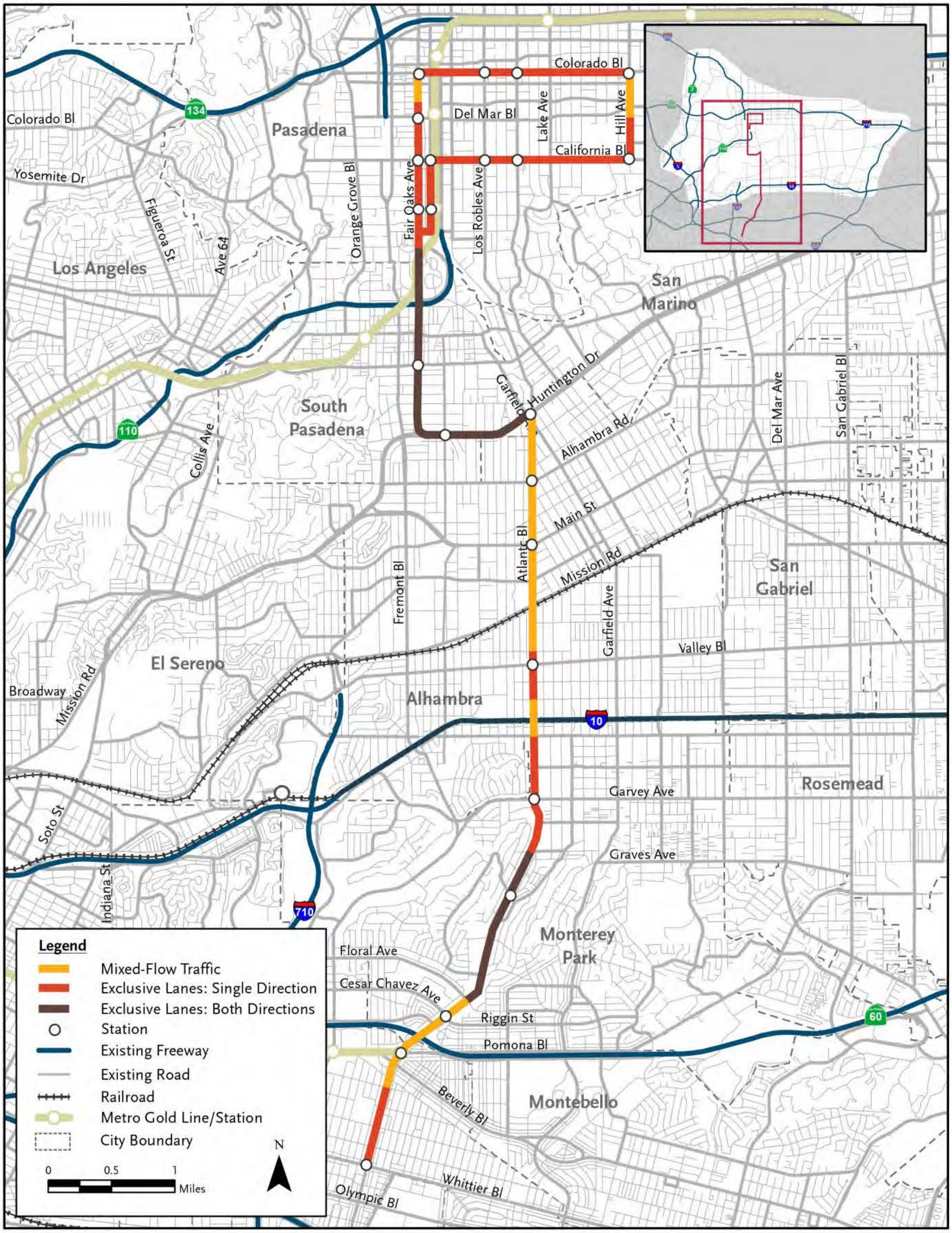


FIGURE 2-8
Alternative BRT-6A Alignment



2.4 Light Rail Transit (LRT) Alternatives

The LRT alternatives would be similar to the Metro Gold Line and Metro Blue Line currently operated by Metro in Los Angeles County. LRT systems typically operate along dedicated rights-of-way at-grade, but can be built in aerial or underground configurations where necessary. They are electrically powered through an overhead contact system (OCS) powered by traction power substations at approximately 1.5-mile spacing. In the dedicated ROW, Metro LRT vehicles can operate at speeds of up to 55 miles per hour (mph). The LRT alternatives include all of the additional transit service provided in the TSM/TDM alternative, except where those services overlap with the LRT service itself. Trains would operate every 5 minutes during peak hours and every 10 minutes during off-peak hours. Figure 2-9 illustrates typical roadway cross-sections for each of the LRT alternatives.

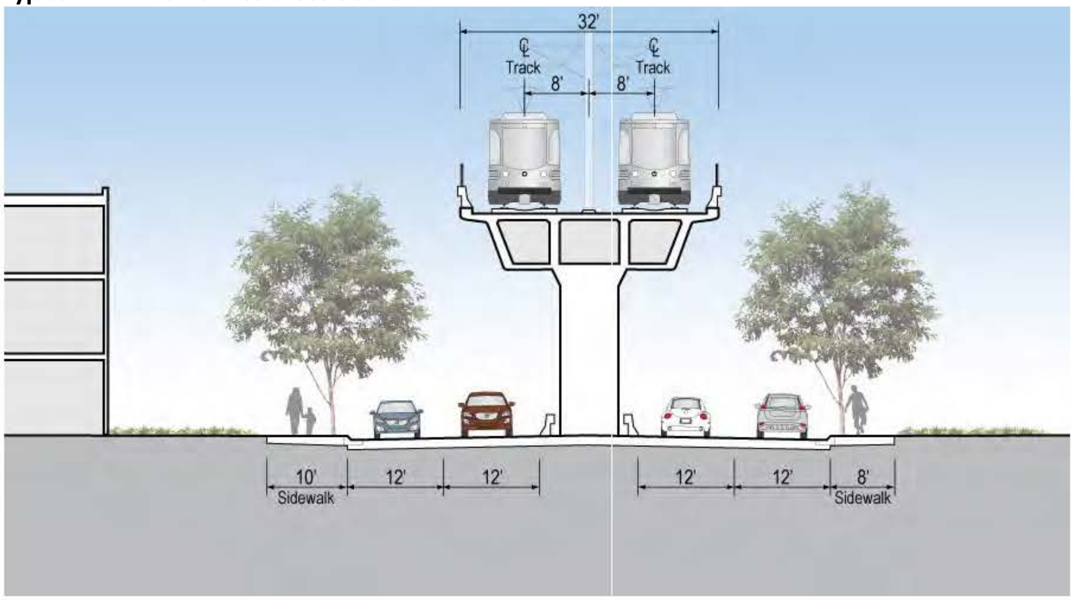
2.4.1 Alternative LRT-4A

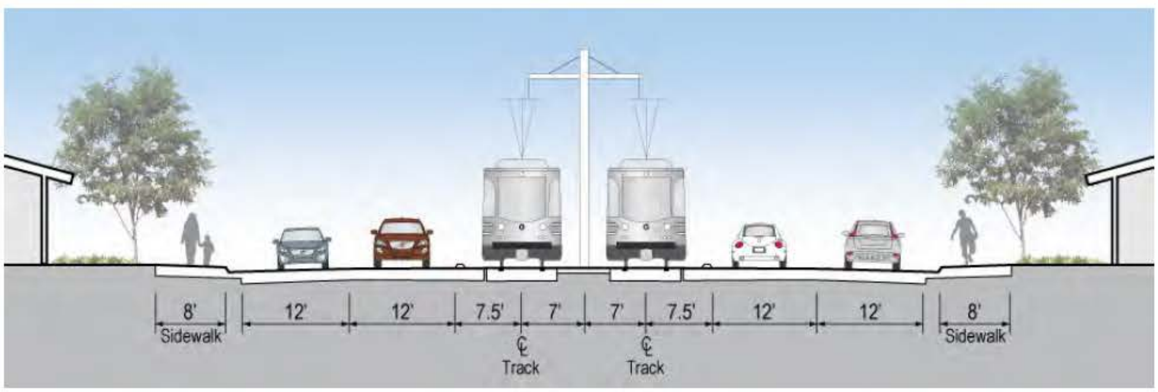
Alternative LRT-4A would begin at an aerial station on Mednik Avenue adjacent to the existing East LA Civic Center Station on the Metro Gold Line. From there, the line would run north on Mednik Avenue on an elevated structure, then turn west on Floral Drive, then turn north across Corporate Center Drive and enter the I-710 ROW. After entering the I-710 ROW, the alignment would travel north, with a station at Cal State LA, providing a transfer location for El Monte Busway and Metrolink service. Continuing north of Cal State LA, the LRT-4A alignment would enter a bored tunnel between Valley Boulevard and Mission Road. The bored tunnel alignment would travel northeast to Fremont Avenue, with a station near the Los Angeles County office building in Alhambra. The alignment would then run north under Fremont Avenue, shifting slightly east to Fair Oaks Avenue, remaining in a tunnel. Stations would be placed under Fair Oaks Avenue near Huntington Drive and Mission Street. The alignment would continue in a tunnel under SR 110, and continue north to a terminus station near the existing Fillmore Station on the Metro Gold Line. Figure 2-10 illustrates the alignment and station location of Alternative LRT-4A; Table 2-4 lists the station locations as well. The length of Alternative LRT-4A would be approximately 7.6 miles. Park-and-ride facilities would be provided at all stations except for Cal State LA and Fillmore. Figure 2-11 represents the 2035 Metro Rail network with Measure R projects, plus LRT-4A.

TABLE 2-4
Alternative LRT-4A – Station Locations

Mednik Ave
Floral Dr
Cal State LA
Alhambra (Fremont Ave)
Huntington Dr
South Pasadena (Mission St)
Fillmore Station

FIGURE 2-9
Typical LRT Alternatives Cross-Sections





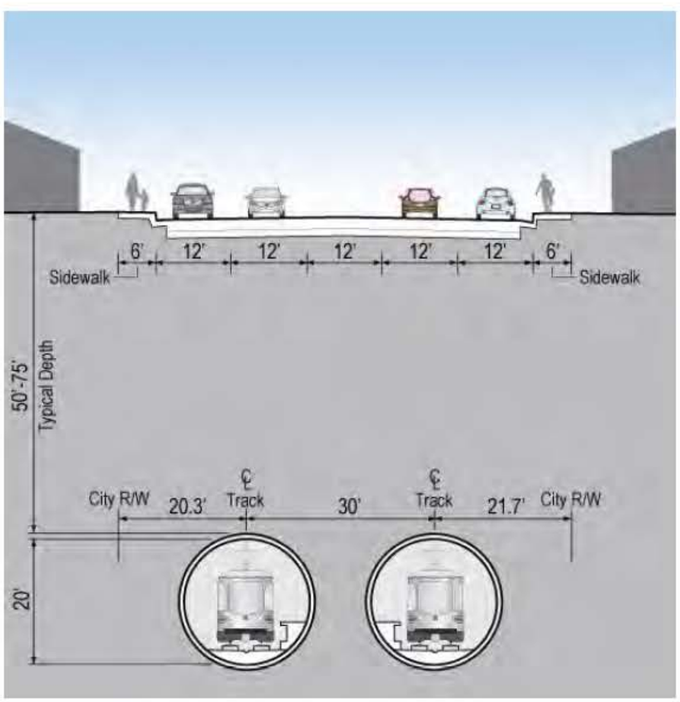


FIGURE 2-10
Alternative LRT-4A Alignment

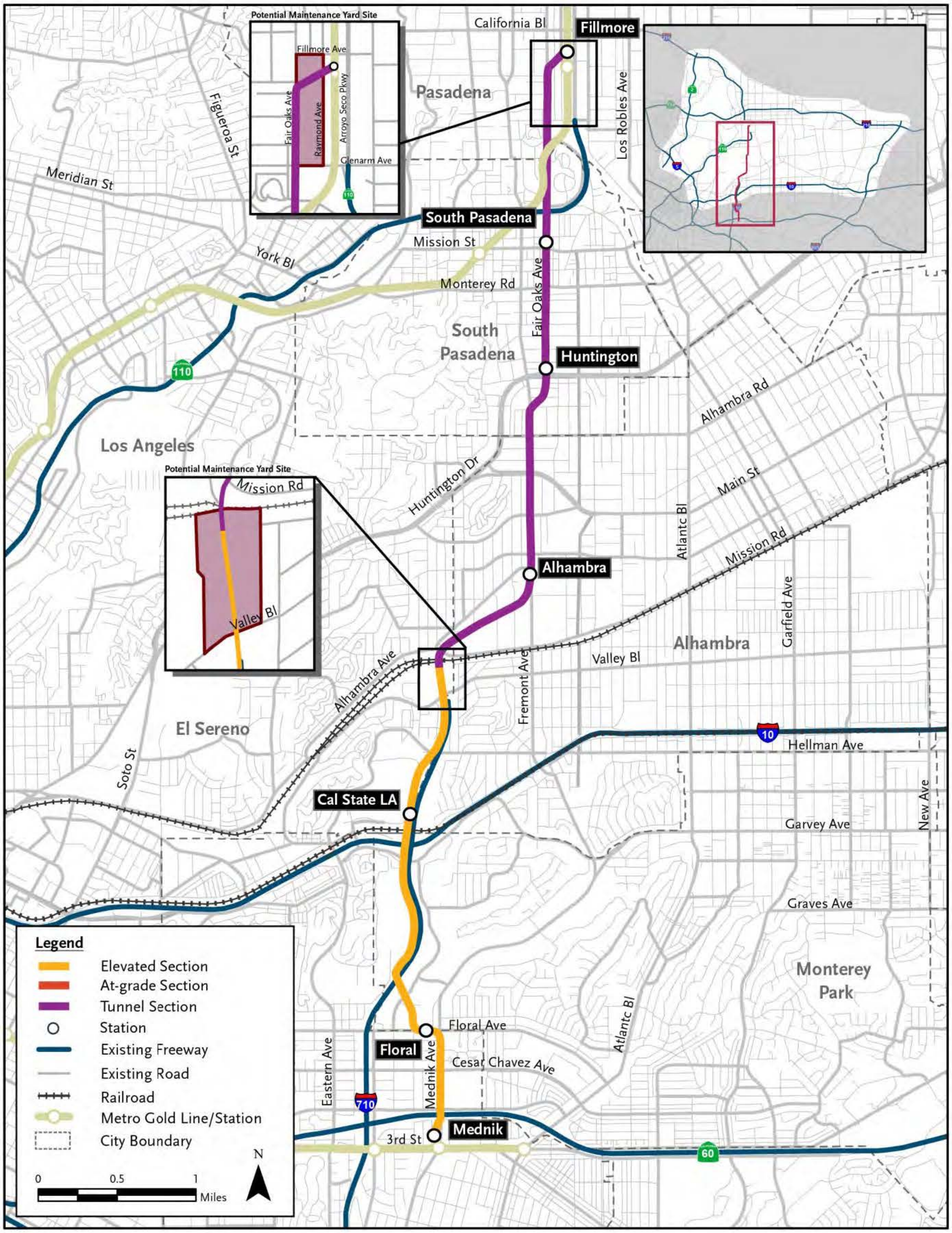


FIGURE 2-11
2035 Metro Rail Network with Measure R Projects and LRT-4A

2.4.2 Alternative LRT-4B

Alternative LRT-4B was developed as an option to Alternative LRT-4A to reduce the length of tunneling required. Alternative LRT-4B would also begin at an aerial station on Mednik Avenue adjacent to the existing East LA Civic Center Station on the Metro Gold Line, and follow the same path as LRT-4A to the Cal State LA Station. Alternative LRT-4B would deviate from Alternative LRT-4A north of the Cal State LA station. Instead of immediately entering a tunnel, Alternative LRT-4B would continue on an elevated structure above Mission Road, turning north on Palm Avenue. The alignment would descend to grade on Palm Avenue, with an at-grade station near the intersection of Palm Avenue and Orange Street to serve the area around the Los Angeles County Public Works building. Alternative LRT-4B would then enter a bored tunnel before Main Street and continue along an alignment similar to that of Alternative LRT-4A. The length of Alternative LRT-4B would be approximately 8.3 miles. Figure 2-12 illustrates the alignment and station locations of Alternative LRT-4B. The station locations for Alternative LRT-4B are the same as for Alternative LRT-4A and are listed in Table 2-5. Stations would be approximately 1 ¼ miles apart on average.

TABLE 2-5
Alternative LRT-4B – Station Locations

Mednik Ave
Floral Dr
Cal State LA
Alhambra (Palm Ave)
Huntington Dr
South Pasadena (Mission St)
Fillmore Station

2.4.3 Alternative LRT-4D

Alternative LRT-4D was developed as another option of Alternative LRT-4A to eliminate the bored tunnel section and use only cut-and-cover tunnel techniques. Alternative LRT-4D would originate at an underground station beneath Beverly Boulevard, near the existing Atlantic Station on the Metro Gold Line. It would continue north underground, transitioning to an elevated structure in First Street. The elevated alignment would then turn north onto Mednik Avenue and follow the same alignment as Alternative LRT-4B to Palm Avenue. North of the Palm Avenue Station, Alternative LRT-4D would enter a cut-and-cover tunnel under the Southern California Edison ROW adjacent to Raymond Avenue, following that ROW to Huntington Drive. Alternative LRT-4D would continue underground beneath Huntington Drive to Fair Oaks Avenue, then follow generally the same alignment as Alternative LRT-4A and Alternative LRT-4B to the Fillmore Station. Park-and-ride facilities would be provided at all stations except Cal State LA and Fillmore. The length of Alternative LRT-4D would be approximately 8.7 miles. Figure 2-13 illustrates the alignment of Alternative LRT-4D. The stations for Alternative LRT-4D are listed in Table 2-6. Stations would be approximately 1 ¼ miles apart on average.

TABLE 2-6
Alternative LRT-4D – Station Locations

Beverly Blvd
Floral Dr
Cal State LA
Alhambra (Palm Ave)
Huntington Dr
South Pasadena (Mission St)
Fillmore Station

FIGURE 2-12
Alternative LRT-4B Alignment

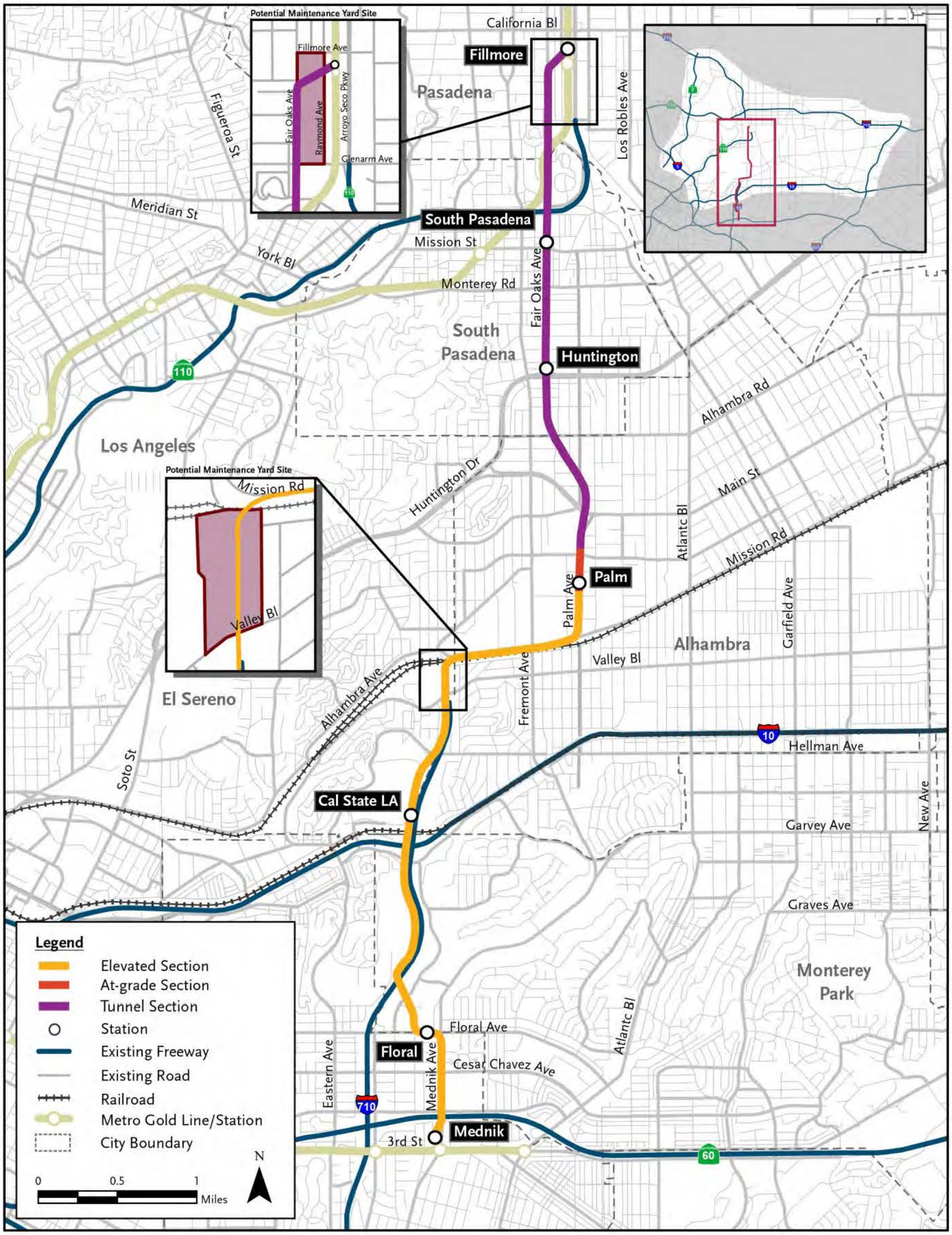
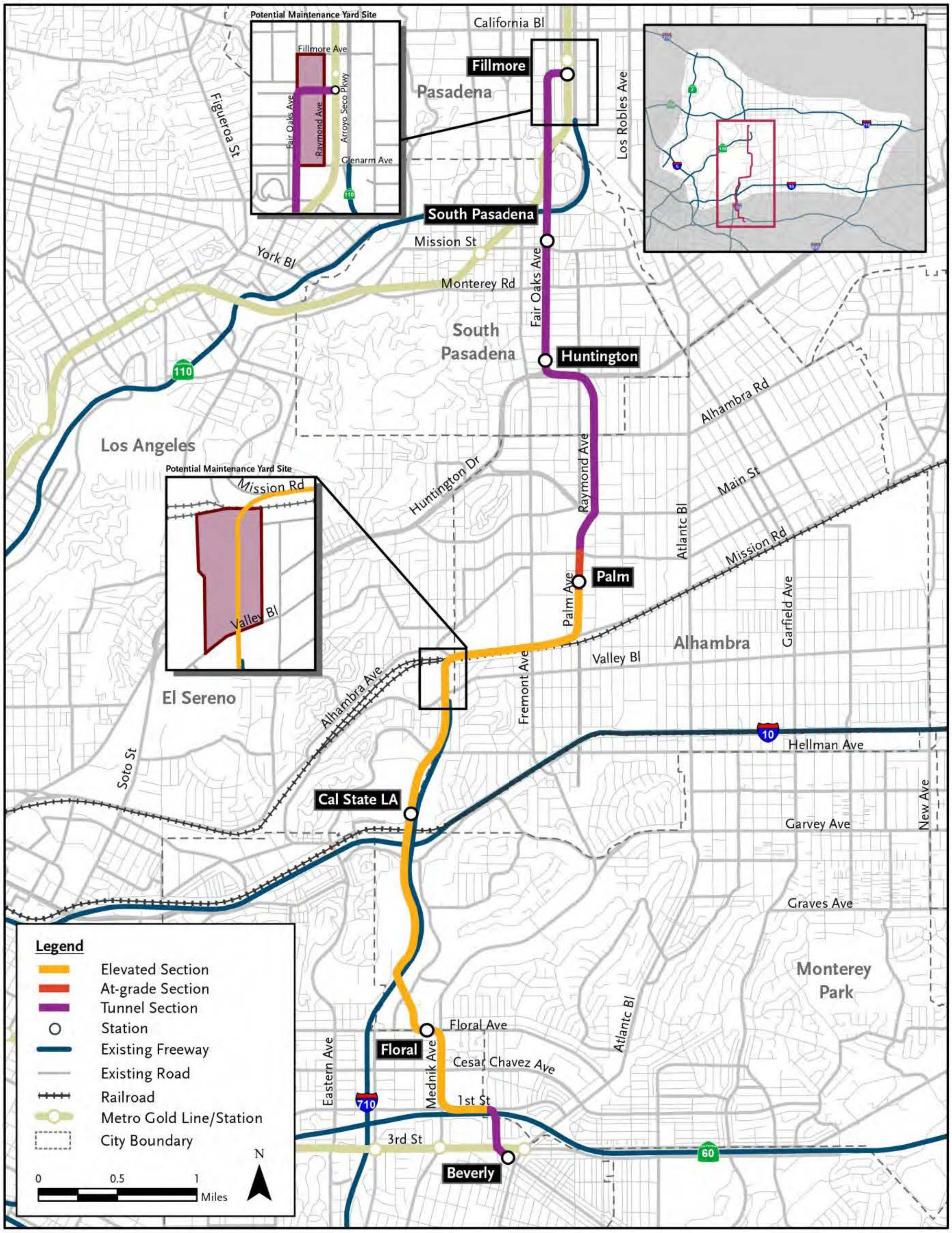


FIGURE 2-13
Alternative LRT-4D Alignment



2.4.4 Alternative LRT-6

Alternative LRT-6 would connect the existing Atlantic and Fillmore stations on the Metro Gold Line. Alternative LRT-6 would begin as an aerial station on Atlantic Boulevard near Pomona Boulevard to avoid impacting the SR 60/Atlantic Boulevard interchange. The alignment would run north on Atlantic Boulevard on an elevated structure across SR 60, with another elevated station at Atlantic Square, near East LA College. It would then descend to grade and continue north on Atlantic Boulevard, with stations at Monterey Park Hospital and Garvey Avenue. It would then return to an aerial configuration to cross above I-10, returning to grade prior to reaching stations at Valley Boulevard, Main Street, and Pine Street (Huntington Drive). It would turn west on Huntington Drive and then north along Fair Oaks Avenue, remaining at-grade with a station near Mission Street. After crossing SR 110, Alternative LRT-6 would again become elevated, turning eastbound onto Fillmore Street, with a new, elevated station above the existing Fillmore Station on the Metro Gold Line. The length of Alternative LRT-6 would be approximately 8.3 miles. Figure 2-14 illustrates the alignment and stations of Alternative LRT-6. Alternative LRT-6 station locations are listed in Table 2-7. Park-and-ride facilities would be provided at all stations except Pomona Boulevard and Fillmore Street for Alternative LRT-6.

TABLE 2-7
Alternative LRT-6 – Station Locations

Alternative LRT-6 – Station Locations
Pomona Blvd
Atlantic Square/East LA College
Monterey Park Hospital
Garvey Ave
Valley Blvd
Main St
Pine St (Huntington Blvd)
Mission St
Fillmore St

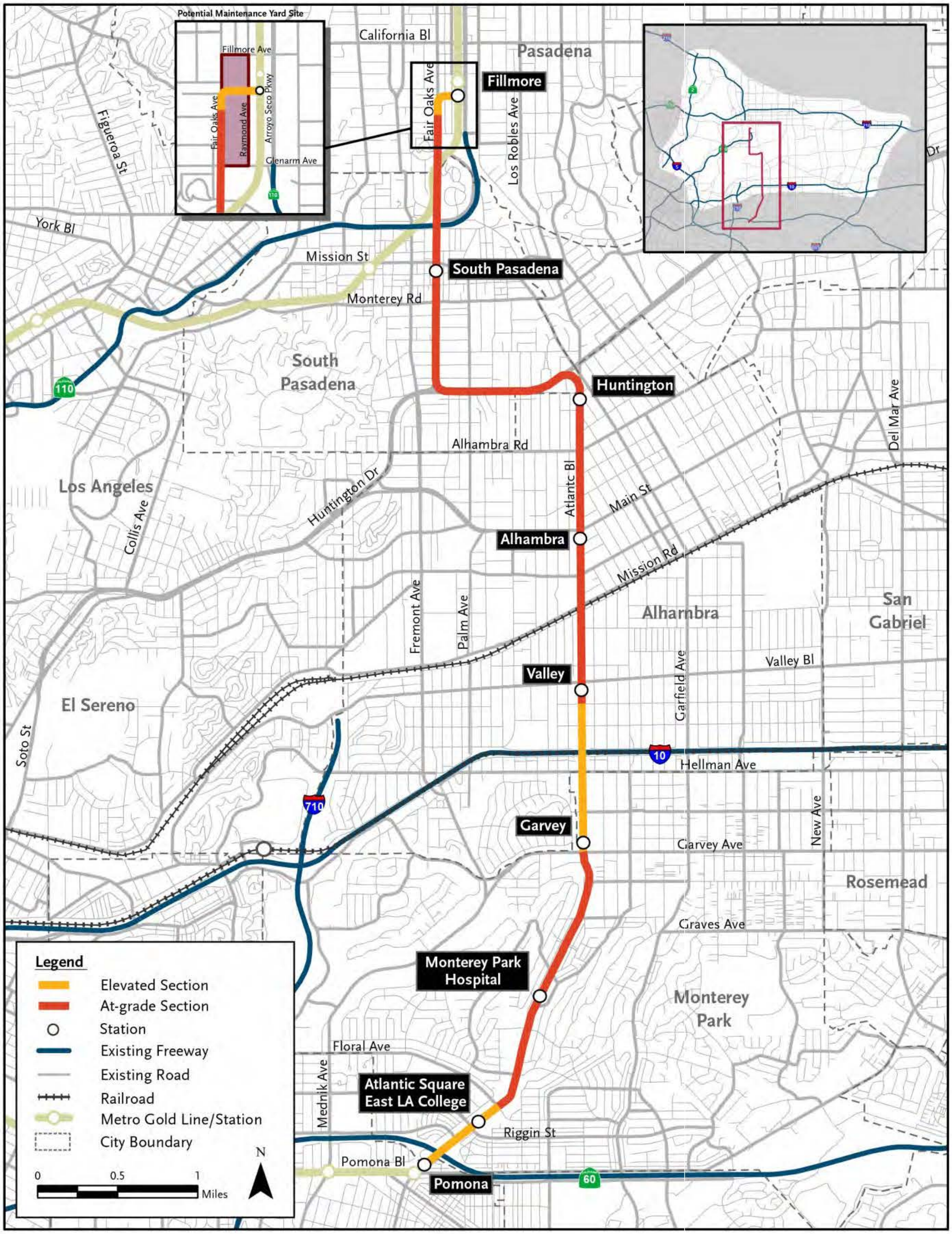
2.4.5 LRT Maintenance Yards

The LRT alternatives would each require a maintenance yard where light-rail vehicles (LRVs) would be cleaned, maintained, and stored. The maintenance yards would include a car wash, paint shop, and other maintenance facilities. It would also have enough storage tracks to accommodate all of the LRVs required to operate the light-rail line. Two potential sites have been identified to accommodate a maintenance yard, only one of which would be required:

- Valley Boulevard Site — This site is approximately 13 acres, located at the end of SR 710 primarily between Valley Boulevard and the Union Pacific Railroad's Alhambra Subdivision rail line, in the City of Los Angeles. Additional LRV storage would be located south of Valley Boulevard, within the California Department of Transportation (Caltrans) ROW. This site could be used for alternatives LRT-4A, LRT-4B, or LRT-4D, but not for Alternative LRT-6.
- Glenarm Street Site — This site is approximately 18 acres, located between Glenarm Street and Fillmore Street on the south and north and between Fair Oaks Avenue and Raymond Avenue on the west and east, in the City of Pasadena. This site could be used for any of the LRT alternatives.

The locations of each maintenance yard is illustrated on Figures 2-10, and 2-12 through 2-14.

FIGURE 2-14
Alternative LRT-6 Alignment



2.5 Freeway Alternatives

The four freeway alternatives would extend SR 710 as an access-controlled freeway with a total of four travel lanes in each direction. Three of the freeway alternatives (F-2, F-5, and F-7) would be constructed in tunnels, using primarily bored tunnels with short segments of cut-and-cover tunnels to access the bored tunnel. The fourth freeway alternative (F-6) consists primarily of a combination of surface and depressed segments, with one short cut-and-cover tunnel segment. Figures 2-15A, 2-15B, and 2-15C illustrate typical cross-sections for the freeway alternatives.

2.5.1 Alternative F-2

Alternative F-2 would originate at the existing SR 710 southerly stub, at the I-10 freeway in Alhambra, and connect to the SR 2 freeway in the vicinity of the existing Verdugo Road and York Boulevard interchanges, as shown in Figures 2-16 and 2-17. The alternative would be an eight-lane freeway primarily constructed in two bored tunnels. Each tunnel would be dedicated to either northbound or southbound travel, with two lanes on each of the two levels in each tunnel (the upper level and the lower level). Cut-and-cover tunnels would be used for the tunnel entry and exit points (portals) at the southerly and northerly termini with I-10 and SR 2, respectively. At the southerly terminus, Alternative F-2 would proceed under Valley Boulevard and the railroad tracks, while maintaining access to Valley Boulevard to and from the south. For the northbound tunnel, both the upper and lower levels would connect to northbound SR 2. The upper and lower levels of the southbound tunnel would provide different access opportunities. For the southbound tunnel, the upper level would connect to all directions at the SR 710/I-10 interchange, but the lower level would connect only to southbound SR 710. The length of improvements for F-2 would be approximately 6.9 miles, including 4.3 miles of bored tunnel and 0.7-miles of cut-and-cover tunnel, and 1.9 miles of surface/depresses/elevated alignment. Figure-18 illustrates Alternative F-2 alignment.

2.5.2 Alternative F-5

Alternative F-5 would also originate at the existing SR 710 southerly stub near I-10, and continue northward connecting to SR 134 near the Colorado Boulevard interchange, as shown in Figure 2-19. The southerly tunnel portal for Alternative F-5 would be the same as the Alternative F-2 as shown in -15. The connection to the SR 134 freeway is illustrated in Figure 2-20.This alternative would also be an eight-lane freeway with two bored tunnels for directional travel similar to Alternative F-2. The SR 134/SR 710 interchange would provide ramps to and from SR 134 for both eastbound and westbound travel. Colorado Boulevard would be realigned in the vicinity of the new interchange. At the southerly terminus, Alternative F-5 would proceed under Valley Boulevard and the railroad tracks, while maintaining access to Valley Boulevard to and from the south. Similar to Alternative F-2, the upper and lower levels of the northbound and southbound tunnels would provide different access opportunities. For the northbound tunnel, the upper level would connect to the eastbound and westbound SR 134, but the lower level would connect only to eastbound SR 134. For the southbound tunnel, the upper level would connect to all directions at the SR 710/I-10 interchange, but the lower level would connect only to southbound SR 710. The length of improvements for Alternative F-5 would be approximately 5.8 miles, including 3.8 miles of bored tunnel and 0.6-miles of cut-and-cover tunnel, and 1.4 miles of surface/depressed/elevated alignment.

FIGURE 2-15A

Freeway Alternative F-6 Depressed Cross-Section

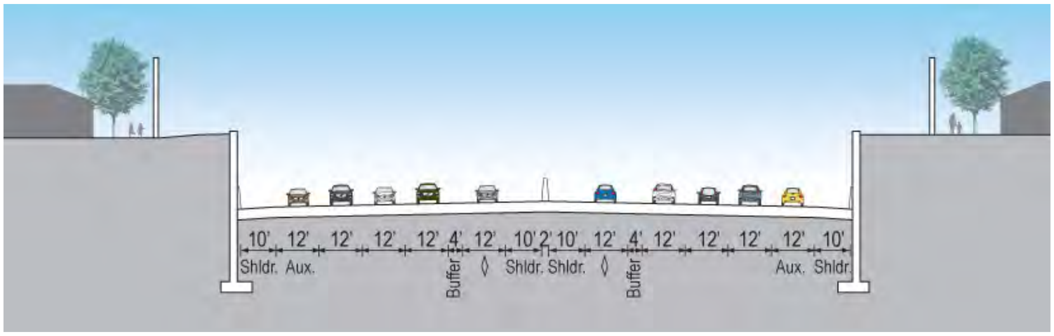


FIGURE 2-15B

Freeway Alternatives F-2, F-5 and F-7 Cut-&-Cover Cross-Section

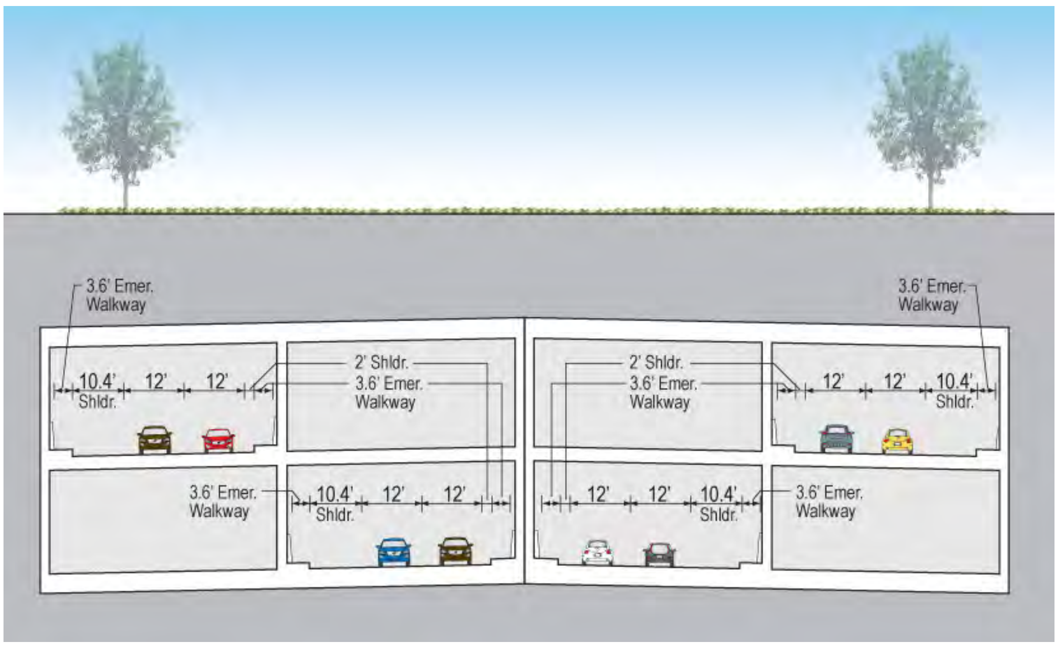


FIGURE 2-15C
Freeway Alternatives F-2, F-5, and F-7 Bored Tunnel Cross-Section

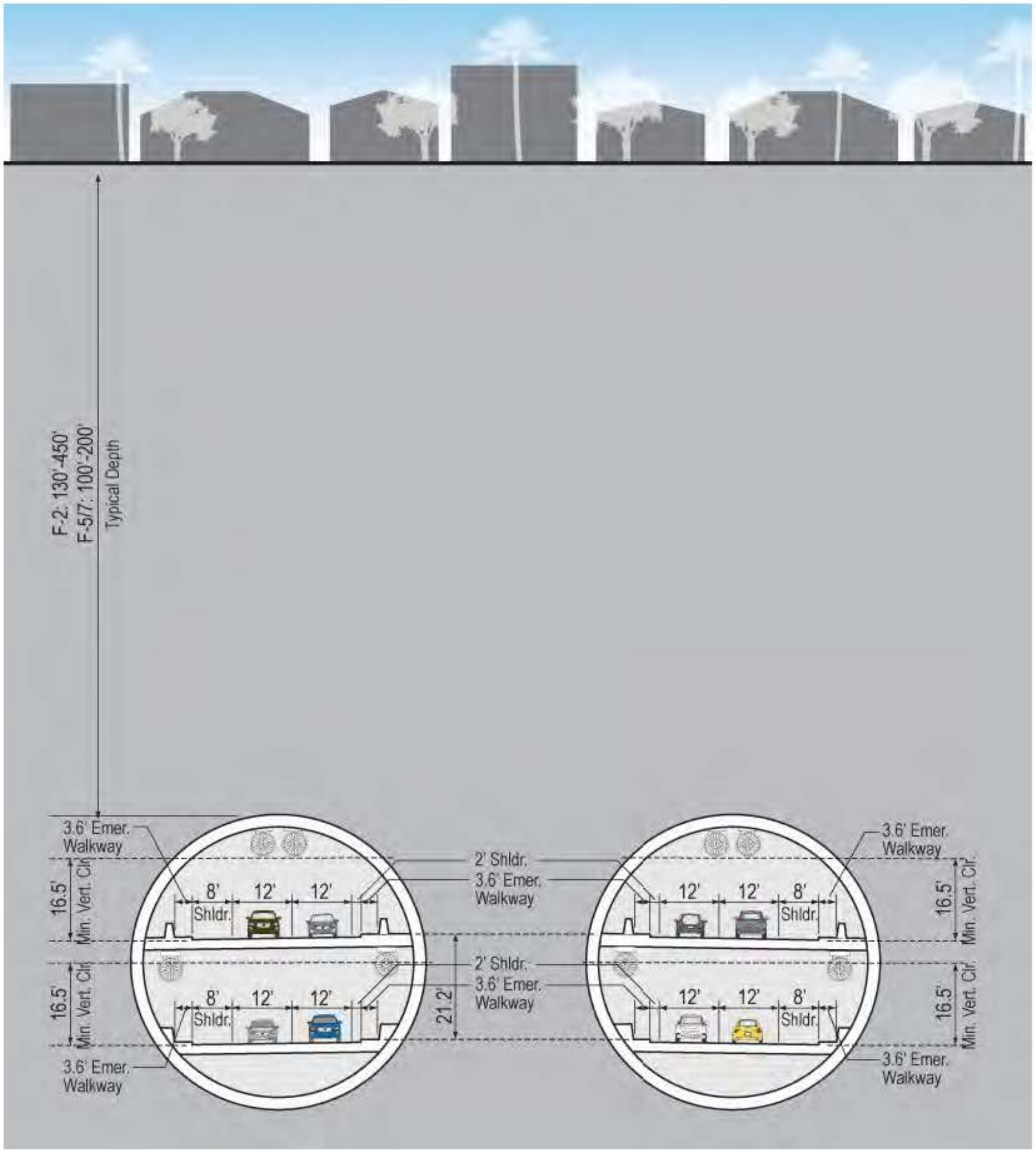


FIGURE 2-16

Alternative F-2, F-5 and F-7: Engineering Exhibit: Existing SR 710 Stub North Connection to I-10 & ramps to/from Valley Blvd

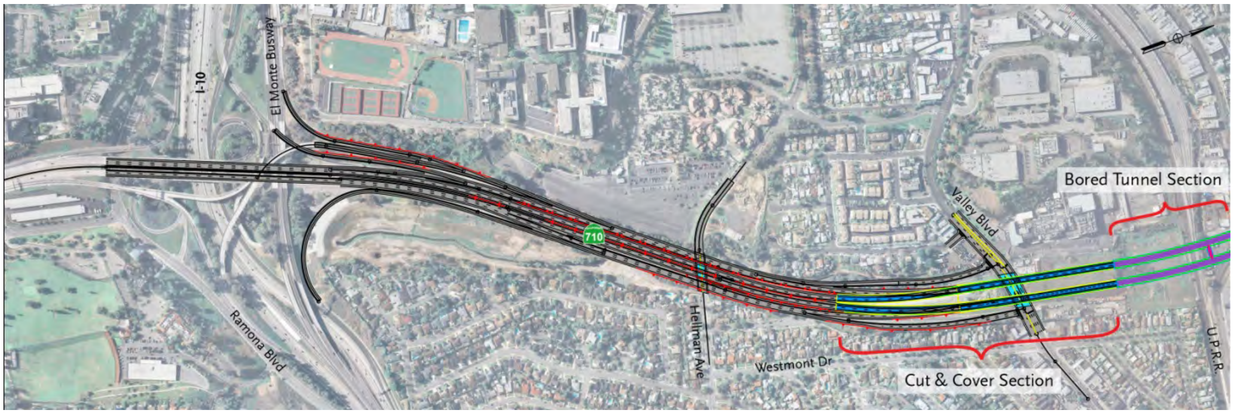


FIGURE 2-17

Alternative F-2: Engineering Exhibit: SR 2 Connection

FIGURE 2-18
Alternative F-2 Alignment

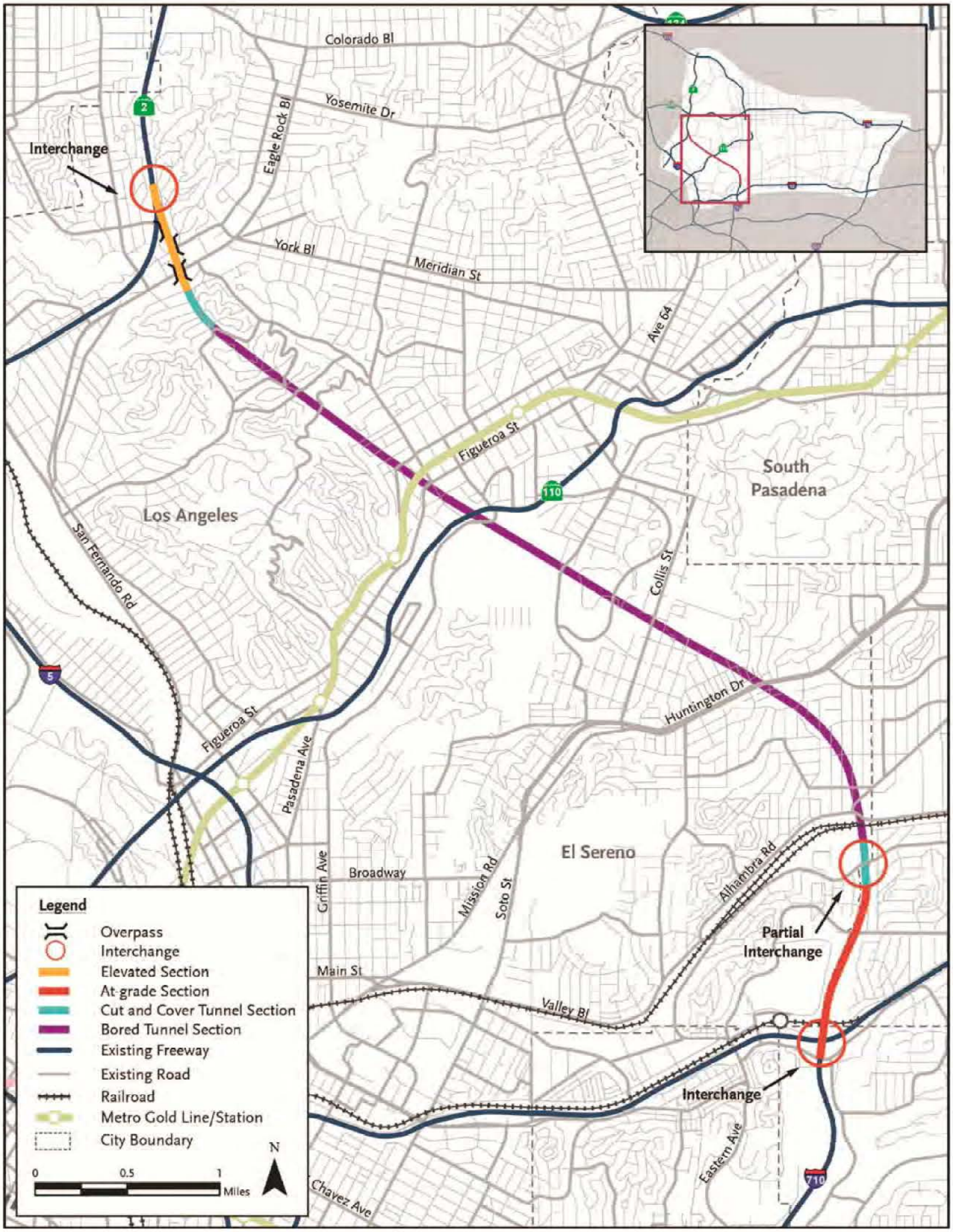


FIGURE 2-19
Alternative F-5 Alignment

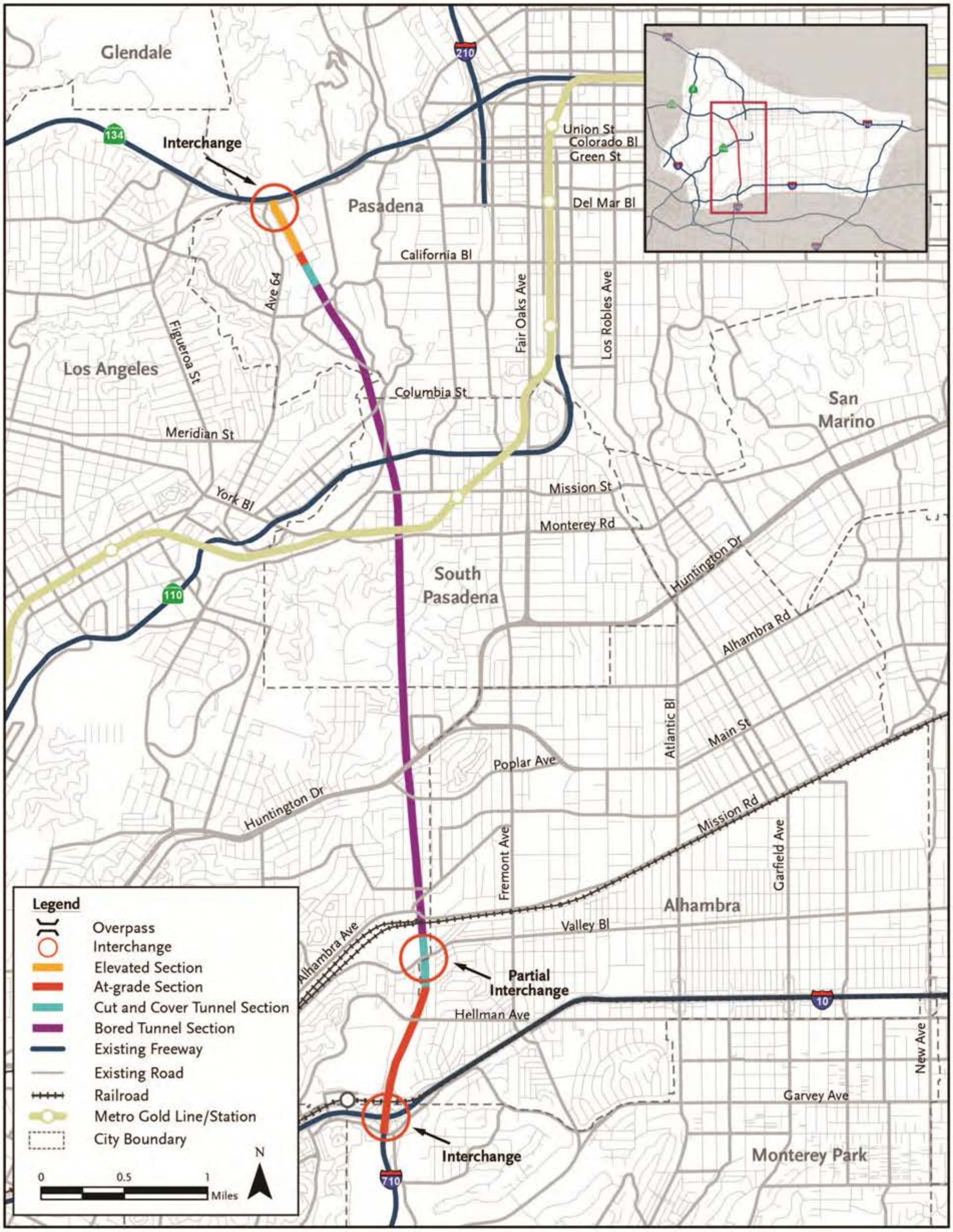


FIGURE 2-20
Alternative F-5: Engineering Exhibit: Connection to SR 134

2.5.3 Alternative F-6

Alternative F-6 would also originate at the existing SR 710 southerly stub near I-10, and would consist of a combination of surface, depressed, cut-and-cover, and elevated freeway segments, ultimately connecting to the existing SR 710 northerly stub just south of the I-210/SR 134 interchange. Generally, Alternative F-6 would follow a very similar alignment to the “Depressed Meridian Variation” approved in the Record of Decision in 1992. From the existing SR 710 southerly stub the freeway travels over Valley Boulevard, the Union Pacific Railroad (UPRR) tracks, and Mission Road/Alhambra Avenue. Figure 2-21 illustrates the alignment of Alternative F-6. Alternative F-6 would be an eight-lane freeway providing three general purpose lanes and one high-occupancy vehicle (HOV) lane in each direction. A typical cross-section for a depressed portion can be seen in Figure 2-15a. Ramps provide full access to the freeway from Valley Boulevard and Mission Road/Alhambra Avenue. The freeway then transitions from an aerial alignment to a depressed alignment along Sheffield Avenue, and then passes under Huntington Drive. A full interchange is provided at Huntington Drive, as shown in Figure 2-22. North of Huntington Drive, the freeway turns slightly to the east and continues north just west of Meridian Avenue until the vicinity of Columbia Street, passing under the Metro Gold Line and SR 110. Turning to the east again, the freeway travels under Pasadena Avenue in a short cut-and-cover section approximately 0.4-mile long, shown in Figure 2-23, and then enters the existing Caltrans ROW between St. John Avenue and Pasadena Avenue, connecting to the existing SR 710 northerly stub just south of the I-210/SR 134 interchange, shown in Figure 2--24. Alternative F-6 would be grade separated at major arterials. Minor streets that currently cross the alignment would become discontinuous with the use of cul-de-sacs. The length of improvements for F-6 is approximately 5.8 miles, including 0.4-miles of cut-and-cover tunnel, and 5.4 miles of surface/depresses/elevated alignment.

FIGURE 2-21
Alternative F-6 Alignment

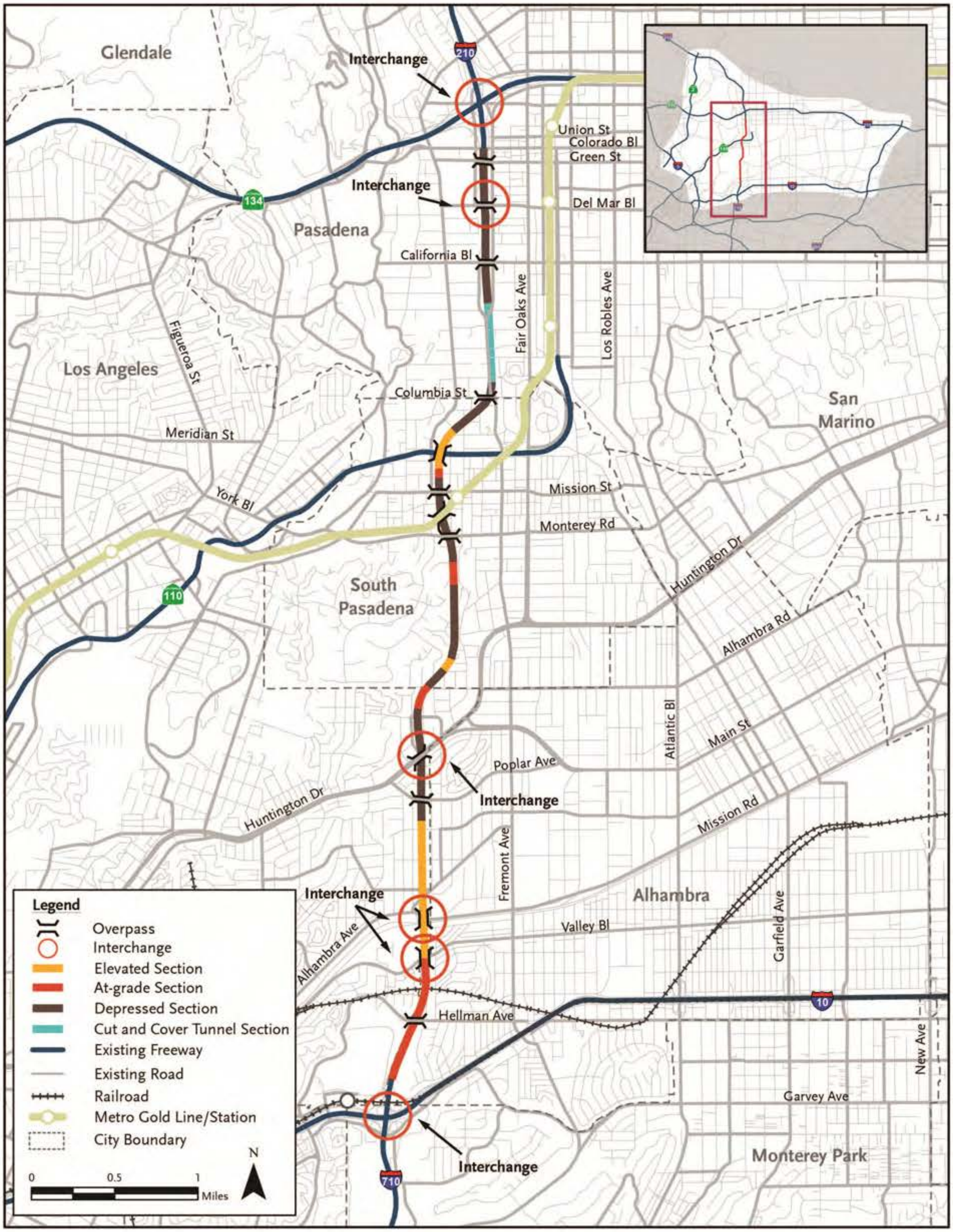


FIGURE 2-22

Alternative F-6: Engineering Exhibit: Huntington Interchange

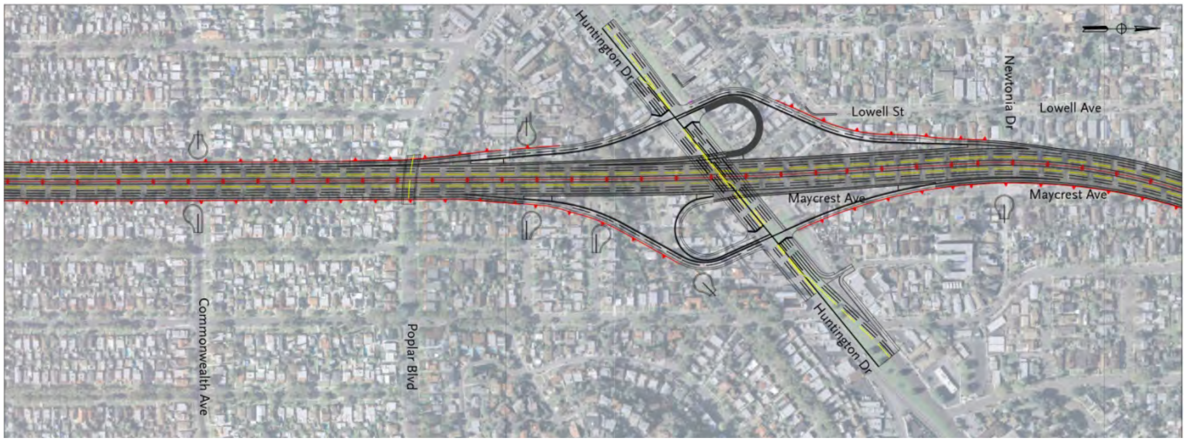


FIGURE 2-23

Alternative F-6: Engineering Exhibit: Cut-and-cover Section Under Pasadena Avenue

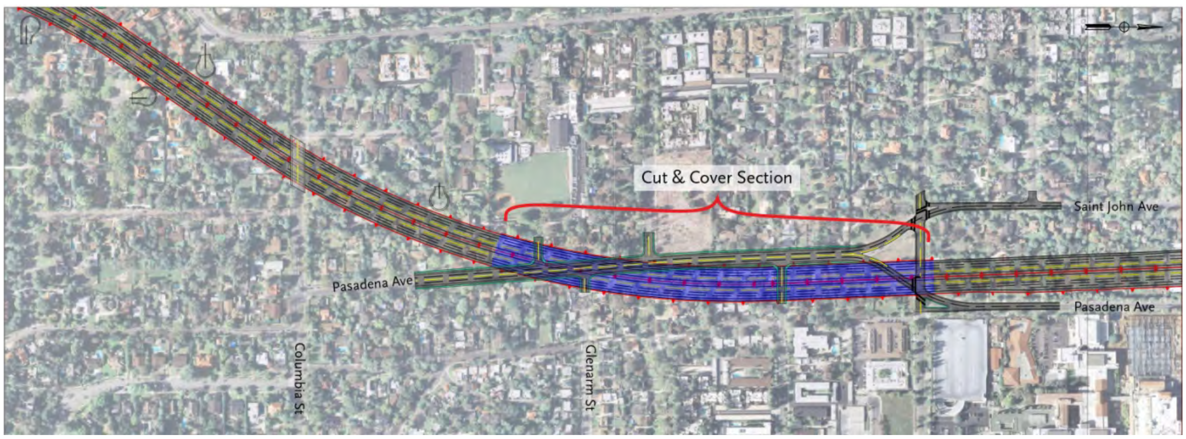
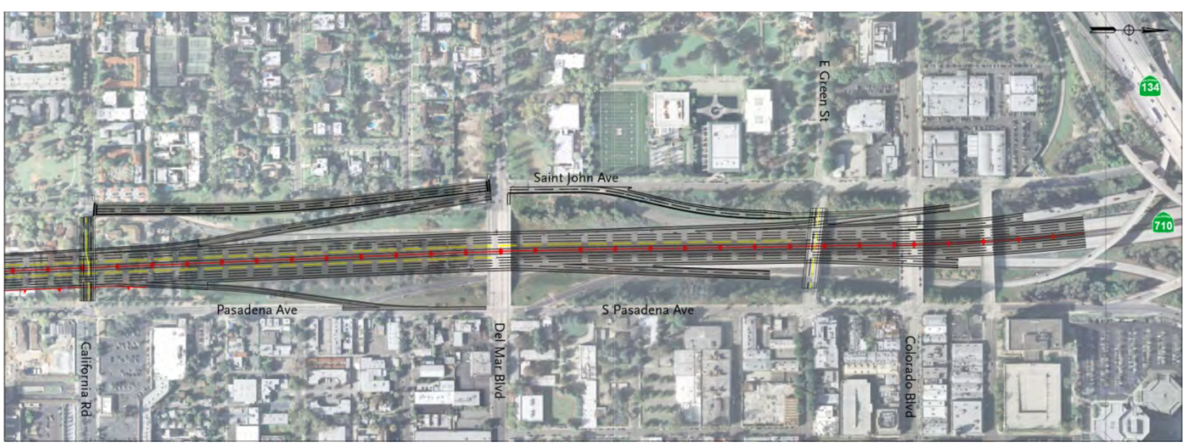


FIGURE 2-24

Alternative F-6: Engineering Exhibit: Existing SR 710 Stub South of I-210/SR 134 Interchanges Connection



2.5.4 Alternative F-7

Alternative F-7 would also originate at the existing southerly SR 710 stub just north of I-10. It would connect via a bored tunnel to the existing northerly SR 710 stub just south of the I-210/SR 134 interchange in Pasadena as shown in Figure 2-25. The tunnel portal for Alternative F-7 would be the same as the Alternative F-2 and F-5 portal shown previously in Figure 2-16. This alternative would also be an eight-lane freeway with two bored tunnels for directional travel similar to Alternatives F-2 and F-5, and each tunnel would have two travel lanes on two levels. At the southerly terminus, Alternative F-7 would proceed under Valley Boulevard and the railroad tracks, while maintaining access to Valley Boulevard to and from the south. Similar to Alternative F-5, the upper and lower levels of the northbound and southbound tunnels would provide different access opportunities. For the northbound tunnel, the upper level would connect to all directions at the I-210/SR 134 interchange, but the lower level would connect only to westbound I-210. For the southbound tunnel, the upper level would connect to all directions at the SR 710/I-10 interchange, but the lower level would connect only to southbound SR 710. The length of improvements for Alternative F-7 would be approximately 6.3 miles, including 4.2 miles of bored tunnel, 0.7-mile of cut-and-cover tunnel, and 1.4 miles of surface/depresses/elevated alignment.

This alternative also includes the extension of St. John Avenue from its current terminus at Del Mar Boulevard to California Boulevard, because the existing access to the St John Avenue/California Boulevard intersection would be eliminated. The Del Mar Boulevard crossing over the freeway would be over the cut and cover tunnel, therefore Del Mar Boulevard would be reconstructed at-grade rather than on a bridge structure.

FIGURE 2-25
Alternative F-7: Engineering Exhibit: Existing SR 710 Stub South of I-210/SR 134 Interchanges Connection

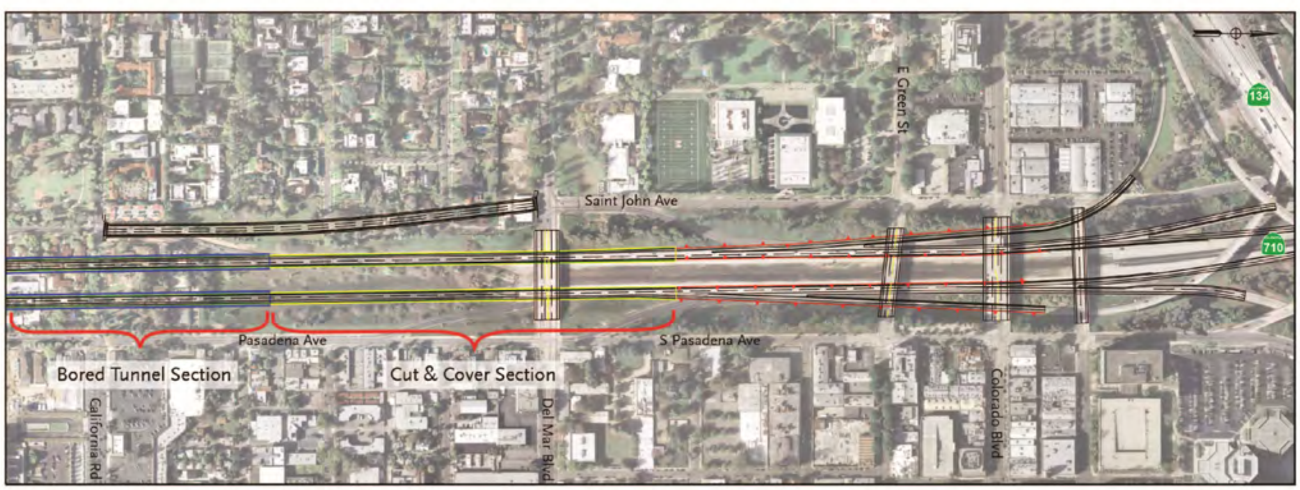
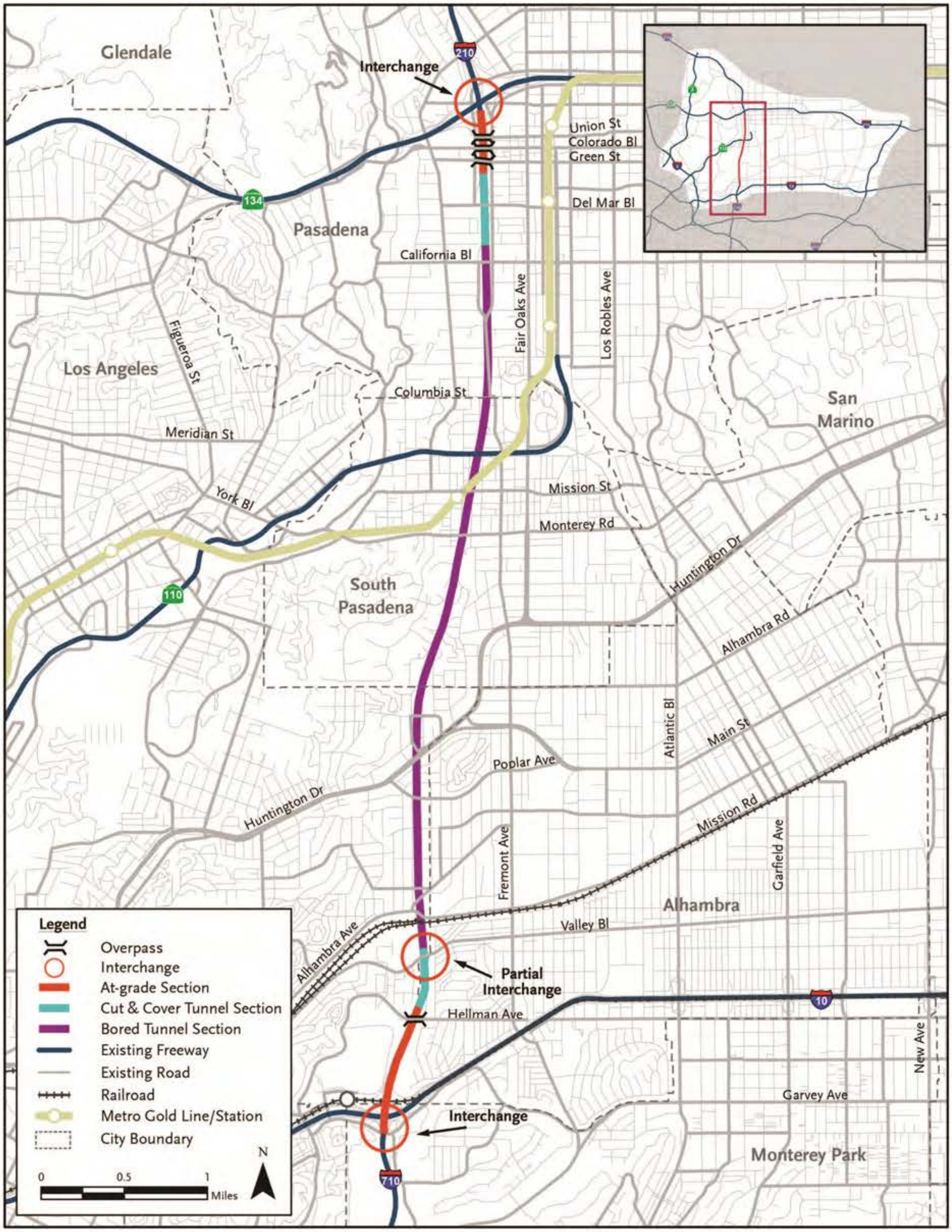


FIGURE 2-26
Alternative F-7 Alignment



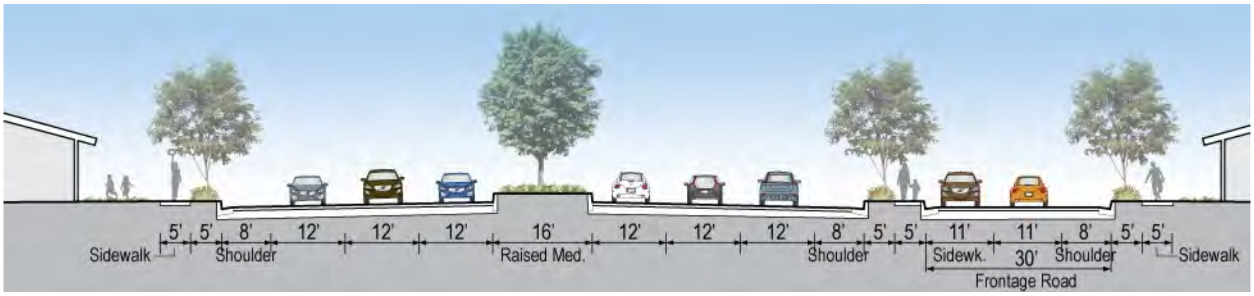
2.6 Highway/Arterial Alternatives

The highway/arterial alternatives would provide major widening of the existing streets along the alignments. Each of these alternatives would provide three lanes in each direction and a 16-foot-wide raised median along the length of the alignments. Where possible, the roadway widening associated with each alternative is limited to one side of the existing street to reduce the number of required property acquisitions. Sensitive properties such as retail centers, businesses, churches, schools, and historic properties were considered when selecting which side of the street to widen. Properties would be maintained on the other side of the street and in many areas have a frontage road to limit access points along the highway/arterial. The frontage roads would provide a separate access to properties and also reduce the number of driveways and access points along the highway/arterial to improve highway safety and performance. The number of intersections with the new highway/arterial would be reduced to provide for more throughput capacity. In addition, smaller local side streets with existing access to the street to be widened would be converted to a cul-de-sac design in many locations. Figure 2-27 illustrates typical cross-sections for the highway alternatives.

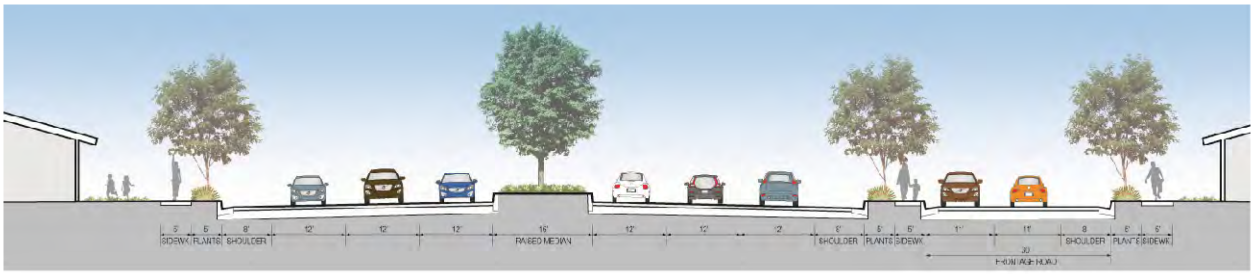
2.6.1 Alternative H-2

Alternative H-2 would begin at the existing SR 710 southerly stub just north of I-10 and connect the SR 710 freeway directly to Concord Avenue. The SR 710 freeway would come to an end at Valley Boulevard and transition to a highway/arterial at Concord Avenue that would travel over Valley Boulevard, the UPRR tracks, and Mission Road/Alhambra Avenue to Concord Avenue. The alignment would then continue along Concord Avenue to Fremont Avenue, to Monterey Road, to York Avenue, to Avenue 64, and to Colorado Boulevard, ending near the intersection of San Rafael Avenue and Linda Vista Avenue. A connector between Mission Road and the main alignment is provided. The addition of a frontage road is not always feasible because of the hilly terrain, particularly near the mid-segment of Avenue 64. Access to the local streets is provided by connector roads to the local streets and by intersections with access to the local streets. Minor alignment modifications are proposed along the mid-segment of Avenue 64 to increase the existing curve radii to improve safety. The profile of this alignment takes advantage of existing fill already in place for SR 710 to pass over Valley Boulevard, and allows for protection of utilities along Valley Boulevard and Mission Road. The at-grade railroad crossing at Pasadena Avenue/Monterey Road is maintained because an underpass or overpass would necessitate significant property impacts adjacent to the alignment. Furthermore, access to local streets would be limited, and additional earthwork, retaining walls, and utility relocations would be required. The length of improvements for Alternative H-2 would be approximately 7.4 miles. Figure 2-28 illustrates Alternative H-2 connecting the SR 710 freeway directly to Concord Avenue. Figure 2-29 illustrates Alternative H-2 ending near the intersection of San Rafael Avenue and Linda Vista Avenue, connecting to Colorado Boulevard. Figure 2-30 illustrates the alignment of Alternative H-2.

FIGURE 2-27
Typical Highway/Arterial Alternatives Cross- Sections (Alternatives H-2 and H-6)



Alternative H-2: Fremont Avenue near Main Street

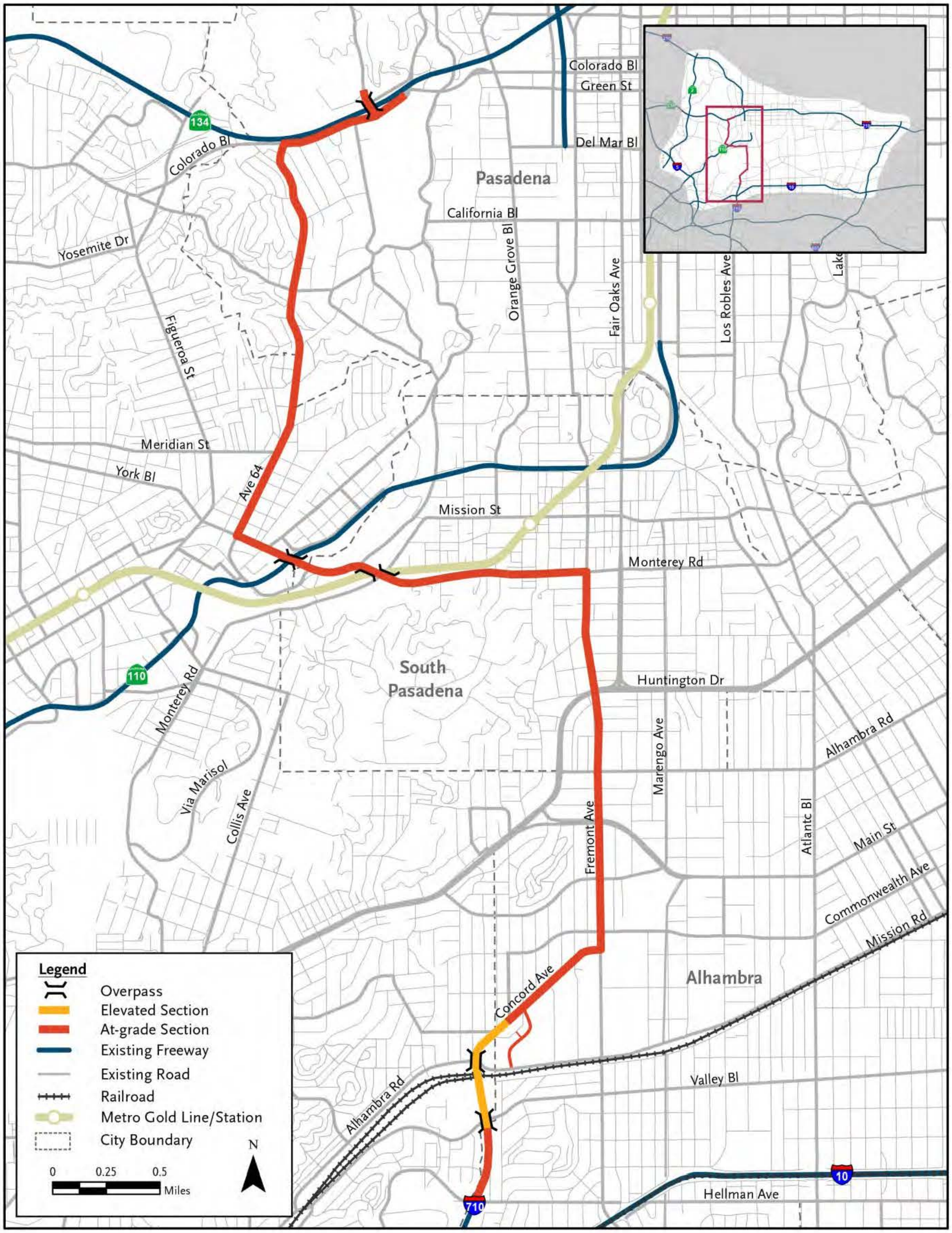


Alternative H-6: Sheffield Avenue near Norwich Avenue

FIGURE 2-28
Alternative H-2: SR 710 Southerly Stub Tie-In North of I-10 with Connection to Valley Blvd & Mission Rd

FIGURE 2-29
Alternative H-2: Connection to Colorado Blvd and SR 134 via San Rafael Interchange

FIGURE 2-30
Alternative H-2 Alignment



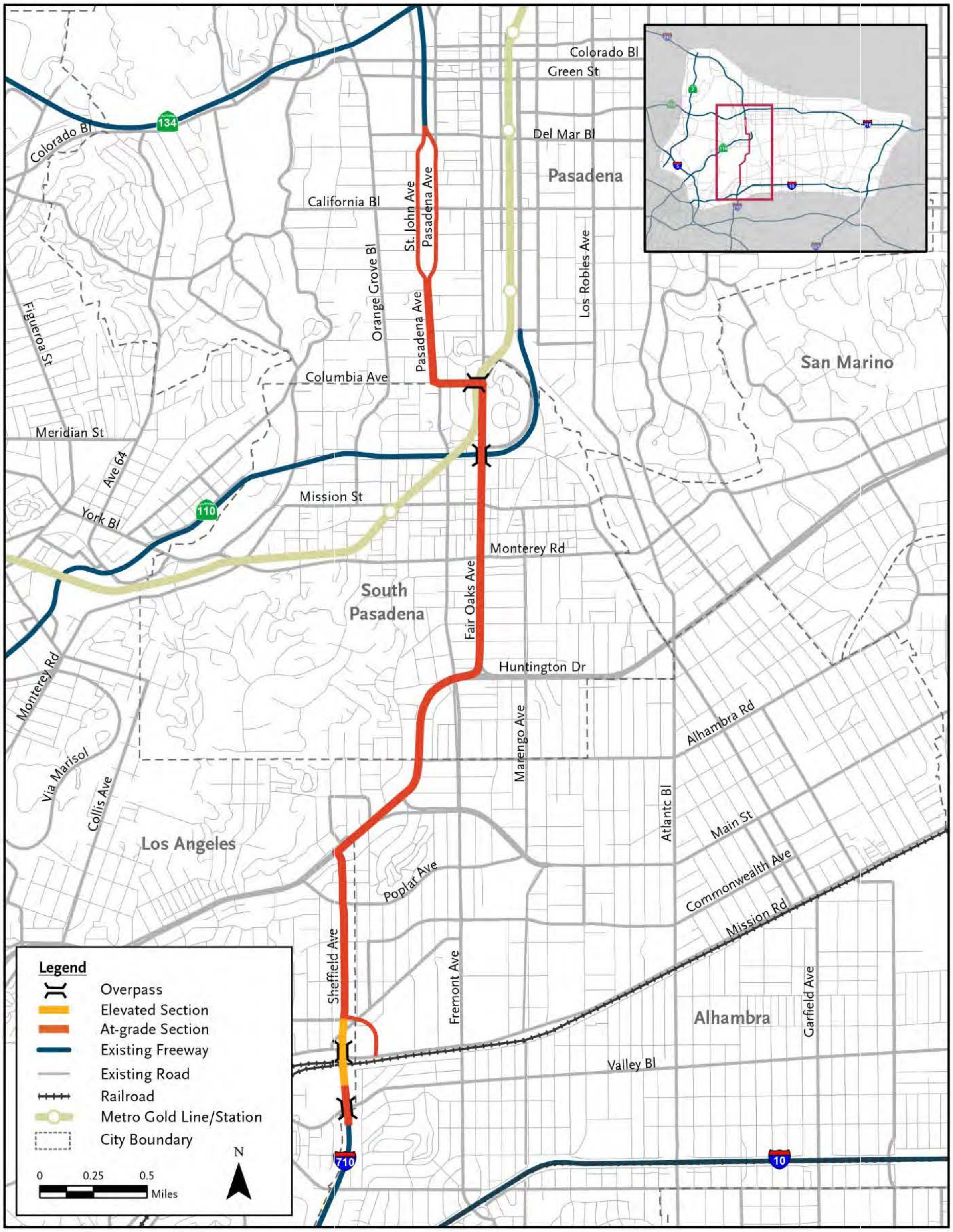
2.6.2 Alternative H-6

Alternative H-6 would also begin at the existing SR 710 southerly stub just north of I-10 and connect the SR 710 freeway directly to Sheffield Avenue. The SR 710 freeway would come to an end at Valley Boulevard and transition to a highway/arterial that would travel over Valley Boulevard, the UPRR tracks, and Mission Road/Alhambra Avenue to Sheffield Avenue. The alignment would then continue along Sheffield Avenue to Huntington Drive, to Fair Oaks Avenue, to Columbia Street, to Pasadena Avenue. Just north of the intersection of Pasadena Avenue and Bellefontaine Street, the roadway would split between St. John Avenue and Pasadena Avenue with ramp connections on existing alignments. A connector between Mission Road and the main alignment is provided. The addition of a frontage road is not always feasible because of ROW constraints, specifically along Fair Oaks Avenue. The profile of this alignment takes advantage of existing fill already in place for SR 710 to pass over Valley Blvd and allows for protection of utilities along Valley Blvd and Mission Boulevard. Figure 2-31 illustrates Alternative H-6 connecting the SR 710 freeway directly to Valley Blvd. Figure 2-32 illustrates Alternative H-6 ending near Pasadena Avenue and St. John Avenue. The improvements in both directions would end near Del Mar Boulevard. The length of improvements for Arterial Alternative H-6 would be approximately 6.3 miles. Figure 2-33 illustrates the alignment of Alternative H-6.

FIGURE 2-31
Alternative H-6: SR 710 stub north of I-10 Connection to Valley Blvd

FIGURE 2-32
Alternative H-6: Connection to St John/Pasadena Ave

FIGURE 2-33
Alternative H-6 Alignment



Design

Design considerations for each of the selected 12 alternatives is detailed in the following sections. The design approach was performed at a conceptual level and therefore this section's descriptions are based on this level of detail which had limited survey and utility information. As such, the assumptions and design decisions described are conceptual. The design will be enhanced/modified as more technical information becomes available during subsequent phases of the project.

3.1 Alternative TSM/TDM Engineering Considerations

The TSM/TDM alternative consists of providing strategic improvements to improve the operational efficiency and capacity of the existing transportation network within the SR 710 study area. Such improvements include restriping, and widening of local street segments and congested intersections at critical locations where high levels of congestion exist.

Local Street Improvements

North-south local streets in the study area were evaluated based on projected volumes and existing lane configurations to determine segments with highest congestion requiring additional lanes. Projected 2035 ADT volumes were obtained from SCAG's regional model, assigned to respective local street segments, and divided by the number of lanes of each segment to yield the volume per lane of each segment. This volume was compared to a selected threshold of 13,000 vehicles per day per lane to determine if additional lanes were needed on each local street segment.

Local street segments that were determined to need additional lanes (this occurred on segments nearest freeway facilities) relied on lower-impact measures such as converting on-street parking and raised or painted median island areas to through lanes. In some cases, this could require the elimination of turn lanes (for example, left turn lanes) at key intersections that would conflict with through lanes added.

Local street widening was proposed when lower-impact measures were determined to be infeasible.

Table 3-1 outlines the proposed local street improvements, which are illustrated in Figure 2-2.

TABLE 3-1
Local Street Improvements

Number	Local Street	Limits		Add'l Lanes	Proposed Improvements
L-1	Figueroa Street	SR-134	Colorado Blvd	1	Additional studies needed to determine needed improvements
L-2a	Fremont Avenue	Huntington Dr	Alhambra Rd	1	Restriping
L-2b		Poplar Blvd	Commonwealth Ave	1	Remove on street parking Widen east side Restriping
L-2c		Mission Rd	Valley Blvd	2	Remove raised median Street widening on west side Restriping
L-3	Atlantic Blvd	Glendon Wy	I-10	1	Remove portion of raised median Remove left turn lanes Restriping

TABLE 3-1
Local Street Improvements

L-4	Garfield Avenue	Valley Blvd	Norwood Pl	1	Remove left turn lanes Restriping
		Norwood Pl	Glendon Way	1	Remove on street parking Remove left turn pockets Restriping
L-5	Rosemead Blvd	Lower Azusa Rd	Mission Dr	1	Stripe an additional lane in each direction to provide for 6 lanes of traffic
		Mission Dr	Valley Blvd	1	
		Valley Blvd	Marshall St	1	

Congested "Hot Spot" Intersection Improvements

A total of 20 "hot spot" intersections in the study area were identified for improvement based on taking the average projected 2035 volumes and dividing by the existing lane configurations. Those intersections with highest volumes and least number of lanes ranked higher and resulted in the 20 most critical locations to be considered for improvement.

The 20 intersections were evaluated for capacity enhancements based on the following improvements in the order shown:

Operational Enhancements – this includes adaptive signal systems and/or traffic signal synchronization.

Capacity Enhancements – this includes restriping to add more lanes and widening to accommodate through and turn lanes.

Mobility Improvements – this includes significant realignment improvements such as arterial realignment and/or intersection elimination to improve regional and local operational and capacity needs.

Operational Enhancements

Some hot spot intersections do not appear to require widening or additional lanes but rather require traffic signal coordination enhancements because of visible congestion and proximity of several intersections, particularly in downtown areas. For example, Fair Oaks Avenue in downtown South Pasadena has visible congestion during peak periods, with queues from one intersection backing up to another intersection.

Capacity Enhancements

Several hot spot intersections require separate turn and through lanes because of excessive queuing. Such congestion was exacerbated at locations where weaving patterns by regional traffic seeking access to freeways is common. In such cases, restriping and intersection widening was proposed to increase capacity needs. In other cases, left turn lanes were eliminated and “pork chop” raised median islands were added on residential street approaches to over-capacity intersections to improve street capacity through restriping without widening, where possible.

Mobility Improvements

In some cases, hot spot intersections with highest congestion levels were determined to be congested because of their proximity to other hot spot intersections. As a result, these intersections required the development of multiple alternatives including realigning streets in various configurations to provide greater separation for enhanced queuing capacity.

Some options, such as the realignment of Atlantic Boulevard and Garfield Avenue were developed and evaluated. Table 3-2 outlines the 20 hot spot intersections and the proposed improvements at each location. These are illustrated in Figure 2-2.

TABLE 3-2
Hot Spot Intersections and Proposed Improvements

Number	Intersection	Proposed Improvements
I-1	Broadway and Colorado Boulevard	Remove left turn movement from Colorado to Lockhaven Ave
I-2	Eagle Rock Boulevard and York Boulevard	Add a left turn lane west of Eagle Rock Remove parking on the north side of the intersection and along both sides of Eagle Rock Blvd and Ellenwood Dr/York Hill Place Expand York to two lanes in each direction Add a north to east right turn lane, requiring an additional lane on York Blvd and Eagle Rock Blvd Widen York Boulevard east approach to the intersection
I-3	Eastern Avenue and Huntington Drive	Add a dedicated northbound right turn lane on Eastern Ave Potential dual left turn lanes on northbound Eastern Ave
I-4 & I-5	SR 710 and Valley Boulevard	Add dedicated right turn lane eastbound Valley to southbound on-ramp Add eastbound travel lane to Westmont Add eastbound to southbound right turn lane at Westmont Add southbound lane for on-ramp Add northbound right turn lane for off ramp
I-6	Fremont Avenue/Columbia Ave/South Pasadena Avenue	Widen South Pasadena Avenue to a minimum of four traffic lanes Realign Fremont on a curved alignment to connect to the South Pasadena and Columbia Street intersection
I-7	Fair Oaks Avenue and Mission Street	Optimize signal timing and implement adaptive traffic signal control
I-8	Fair Oaks Avenue and Monterey Road	Add southbound to westbound right turn lane, sidewalk, plus right-of-way Add westbound to northbound right turn lane with signal and parkway modifications. Restripe to fit improvement
I-9	Fremont Avenue at Monterey Road Intersection	Add westbound to northbound right turn lane, sidewalk, plus right-of-way
I-10	Fair Oaks Avenue and Huntington Drive	Remove median portion to add third southbound left turn lane on Fair Oaks Avenue at Huntington Drive
I-11	Fremont Avenue and Huntington Drive	Convert northbound and southbound right turn lanes to through right lanes Widen southbound departure lane at southwest quadrant Restripe to add westbound left turn lane
I-12	Fremont Avenue and Valley Boulevard	Add second southbound through lane Add third northbound through lane Extend green time for eastbound left turn lane
I-13	Alternative 3 (Garfield Avenue Realignment)	Close Garfield Avenue between Atlantic Boulevard and Huntington Drive
I-14	Garfield Avenue	Realign Garfield Avenue westerly to intersect Atlantic Boulevard south of the current intersection
I-15	Atlantic Boulevard	Provide one northbound through lane, one northbound through-right lane, two westbound right turn lanes, one southbound left turn lane and two southbound through lanes on Atlantic Boulevard at realigned

TABLE 3-2
Hot Spot Intersections and Proposed Improvements

Number	Intersection	Proposed Improvements
		Garfield Avenue
	Huntington Drive	Prevent southbound lanes from Garfield Avenue across Huntington Drive by adding raised median island
		Convert southbound lanes to right turn lanes on Garfield Avenue at Huntington Drive
		Add second eastbound left turn lane on Huntington Drive at Los Robles Avenue
		Widen to add southbound right turn lane on Los Robles Avenue at Huntington Drive
		Add eastbound right lane with pork chop island on Huntington Drive at Atlantic Boulevard
I-16	Garfield Avenue and Mission Road	Widen to provide one southbound through-right lane
		Widen to provide one northbound right turn lane
		Extend westbound left turn lane storage by 100 feet
I-17	Garfield Avenue and Valley Boulevard	Widen to add one southbound through-right lane
		Extend eastbound right turn lane storage
I-18	San Gabriel Boulevard and Huntington Drive	Remove median portion and add second eastbound left turn lane on Huntington Drive
		Stripe eastbound right turn lane on Huntington Drive
I-19	San Gabriel Boulevard at Mission Road	Widen at the intersection to allow for a right turn lane
I-20	Rosemead Boulevard at Mission Drive	Stripe an additional lane in each direction to provide for 6 lanes of traffic
		Add eastbound to southbound right turn lane, sidewalk, signal, plus right-of-way
		Add westbound to northbound right turn lane with sidewalk, signal plus right-of-way
		Restripe to fit improvement

3.1.1 Design of Horizontal Alignments

Horizontal alignments for local street and hot spot intersection improvements will mostly maintain current centerline alignments. However, local street realignments and intersection elimination will change existing horizontal alignments significantly. For example, a proposed roundabout alternative at Garfield Avenue and Huntington Drive will involve the realignment of several approaches with an entirely new alignment for the roundabout, and currently proposes a 200-foot radius to accommodate the projected vehicular volumes. Although this alternative was determined to not be feasible based on right of way impacts, other alternatives, such as the realignment of Atlantic Boulevard to meet Garfield Boulevard and the realignment of Garfield Boulevard to meet Atlantic Boulevard south of their current intersection were developed.

3.1.2 Design of Vertical Alignment

Vertical alignments for local street and hot spot intersection improvements are not expected to change significantly from current conditions.

3.1.3 Design Exceptions

Local streets and intersections were mostly designed to meet local agency design criteria. At locations near freeway interchanges, improvements do not encroach or deviate from Caltrans design standards.

The only deviations to local agency standards occur with local street improvements where parking or median areas were eliminated to add more lanes. Such improvements do not deviate from standard lane widths but do deviate from local agency roadway classification standards, which include median and on-street parking.

3.2 BRT Alternatives

3.2.1 BRT Operating Plan

Bus Rapid Transit, BRT, will provide a modal alternative to address the transportation deficiencies within the city of Pasadena and surrounding areas. Initially, six (6) BRT alternatives were developed based on ridership on existing Metro bus routes, the location of major trip generators in the area, creating connections that would address issues concerning the SR 710 gap, and operating on major corridors that may support BRT infrastructure. Out of the 6 initial alternatives, three alternatives have been selected for further consideration.

- BRT - 1: Operates between Los Angeles Union Station and the NASA Jet Propulsion Laboratory (JPL) in Pasadena via Mission Road, Huntington Drive, Fair Oaks Avenue, Woodbury Road and Oak Grove Drive.
- BRT - 6: Operates between East Los Angeles and the NASA Jet Propulsion Laboratory in Pasadena via Atlantic Boulevard, Huntington Drive, Fair Oaks Avenue, Woodbury Road and Oak Grove Drive.
- BRT - 6A: Operates between East Los Angeles and downtown Pasadena via Atlantic Boulevard, Huntington Drive, Fair Oaks Avenue and Colorado Boulevard.

Operating plans were created and conceptual engineering plans were developed for each of the three alternatives using guidelines from AASTHO, Caltrans Highway Design Manual and the City of LA Bike Plan.

3.2.2 Alternative BRT–1 Engineering Considerations

3.2.2.1 Design of Horizontal Alignment

The design of the BRT-1 alignment proposes to add a BRT route to provide a continuous public transportation route from LA’s Union Station to the JPL property in Pasadena. This alternative proposes to use mostly existing ROW to add a new BRT lane. Throughout the length of BRT-1, the new lane would alternate between providing an exclusive BRT lane or shared BRT lane with through traffic and right turn movements to avoid impacting existing intersection traffic. Class II bike lanes would be included along this BRT route per the new City of LA Bike Plan. Lane width requirements throughout the alignment are as follows: 12-ft minimum exclusive BRT lane, 11-ft minimum traffic lane, 10-ft minimum median, 2-ft minimum gutter, and 6-ft minimum sidewalks. Bike lanes are 4-ft minimum when in between a BRT lane and traffic lane and 5-ft minimum (including the 2-ft gutter) when adjacent to the curb/sidewalk. These were the main BRT design criteria used throughout the BRT-1 alignment, along with keeping the improvements within the existing ROW limits.

The proposed BRT lane would begin at the first bus stop location at Patsaouras Transit Plaza at LA’s Union Station on N. Vignes St. The BRT-exclusive lane would travel up N. Vignes St, then would make a right turn at East Cesar Chavez Ave. The bike lanes would not begin until Cesar Chavez Ave and then continue along the length of the BRT route within the city limits of Los Angeles. The alignment runs along East Cesar Chavez Ave. For the entire length of East Cesar Chavez Ave, the BRT will share the center lanes with other traffic. Bike lanes will be provided on East Cesar Chavez. Since the BRT will be travelling in the center lane through its 1/3-mile stretch on East Cesar Chavez Ave, the bike lanes will be placed adjacent to the curb/sidewalk. In all other locations, the BRT lane will be placed in the outer lanes with bike lanes in between the BRT lane and mixed flow lanes.

The route would then make a left turn to head north on Mission Road. Just past this turn, both southbound and northbound routes would transition to dedicated BRT lanes with portions of shared use at intersections with local streets for right turn movements. Some ROW acquisition will be required on both the west and east sides along

Mission Road, affecting parking, sidewalks, and some park space. Without the acquisition of ROW, there would only be enough space for one exclusive BRT lane between Barbee St and Parkside Ave approximately 40 feet of motel structure will be affected by the ROW acquisition. There will be two bus stop locations within this stretch at the intersections of Mission Rd and Marengo St and Mission Rd and Main St.

At the intersection of Mission Rd, Soto Rd, Huntington Dr, and Huntington Dr South, there will be planned improvements for the Soto Street bridge reconstruction, which the BRT will pass under. The Soto Street bridge reconstruction is listed in the Federal Transportation Improvement Program (FTIP), under PPNO 3093 3380 and is not included in this project. At this intersection, the BRT route would turn onto Huntington Dr South in the existing ROW. This segment of the route will allow for exclusive BRT lanes with shared access near intersections to facilitate right turn movements for other traffic. There will be no bike lanes along the entire stretch of Huntington Dr South. These bike lanes continue onto Huntington Dr North at the major intersection of Mission Rd, Soto Rd, Huntington Dr North and South. Bus stop locations will be at the intersection of Huntington Dr S. and Huntington Dr N. and another at Huntington Dr S. and Monterey Rd.

As Huntington Dr S. merges onto Huntington Dr, bike lanes would be continued and ultimately end at the Los Angeles City limits at the intersection of Huntington Dr and Kendall Ave. The improvements complement a planned FTIP capacity improvement project for Huntington Drive within the City of Los Angeles.

Throughout the remainder of Huntington Dr before the turn on Fair Oaks Ave, there would be exclusive BRT lanes in both directions. Existing parking would remain from El Sereno Ave up to Portola Ave due to available ROW width. After this stretch, existing parking would be impacted by the BRT lanes. The four bus stop locations will be at the intersections of Huntington Dr and El Sereno Ave, Poplar Ave, Main St, and Fremont Ave.

After travelling up Huntington Dr, the BRT lanes would make a left turn onto Fair Oaks Ave. The BRT lanes would continue on Fair Oaks Ave in the existing ROW past the SR 110 freeway overcrossing. At State St the exclusive southbound (SB) BRT only lane would end, transitioning into a shared lane. The exclusive northbound (NB) BRT only lane would end just before intersecting Colorado Blvd and would then continue as shared lane. Parking would not be affected in the SB direction of Fair Oaks from Spruce St to Monterrey Dr. There would be eight bus stop locations at the intersections of Fair Oaks and Mission St, Glenarm St, California Blvd, Del Mar Blvd, Colorado Blvd, Orange Grove Blvd, Washington Blvd, and Woodbury Rd.

The route would then make a left turn queue jump onto Woodbury Rd with both NB and SB converting back into BRT-only lanes in the existing ROW. The BRT lanes would continue onto Oak Grove Dr, transitioning into shared lanes at this point. The route would then end on Oak Grove Dr at Foothill Blvd. There would be a bus stop location at the intersections of Woodbury Rd and Lincoln Ave and another at the intersection at Oak Grove Dr and Foothill Blvd.

3.2.2.2 Design of Vertical Alignment

Vertical alignment for Alternative BRT-1 would follow existing conditions.

3.2.3 Alternative BRT–6 Engineering Considerations

3.2.3.1 Design of Horizontal Alignment

The design of the BRT-6 alignment proposes to add a BRT route to provide a continuous public transportation route from East Los Angeles near Garfield High School to downtown Pasadena. This BRT route would overlap with the existing Metro 762 bus line from East Los Angeles to Pasadena. This alternative proposes to add a new BRT lane within the existing ROW. Throughout the length of the BRT-6 alignment, the new lane would alternate between an exclusive BRT lane and a shared BRT lane with through traffic and right turn movements to avoid impacting existing intersection traffic. Lane width requirements throughout the alignment are as follows: 12-ft minimum exclusive BRT lane, 11-ft minimum traffic lane, 10-ft minimum median, 2-ft minimum gutter and 6-ft minimum sidewalks. These were the main design criteria used throughout the alignment along with meeting ROW limits.

The proposed BRT lane would begin with a station at the intersection of Atlantic Blvd and Whittier Blvd. The NB BRT lane would be exclusive while the SB BRT lane would be shared.

At the intersection with 4th St, the NB lane would transition into a shared lane until Atlantic Blvd meets Floral Ave, where both NB and SB would have exclusive BRT lanes with portions of shared use to facilitate right turn movements for other traffic. In this segment of the route, there would be stations for both directions at the intersections of Atlantic Ave and Pomona Blvd, Atlantic Ave and Riggin St, Atlantic Ave and Cadiz St, and Atlantic Ave and Garvey Ave.

At the intersection of Harding Ave, the NB exclusive BRT lane would end and continue on Atlantic Blvd as a shared lane. The SB exclusive BRT lane would not transition to shared use until the intersection with Valley Blvd. Along this piece of the route, there would be bus stations for both directions at the intersections of Atlantic Ave and Valley Blvd, Atlantic Blvd and Alhambra Rd, and Atlantic Blvd and Garfield Ave before turning onto Huntington Dr with both NB and SB converting into exclusive BRT lanes.

The route would continue on Huntington Dr with stations for both the NB and SB route at the intersection of Huntington Dr and Marengo Ave before making a turn at Fair Oaks Ave. At the intersection with State St the exclusive SB BRT lane would end, transitioning to a shared lane. Along Fair Oaks Blvd, there would be bus stations at the intersection of Fair Oaks Blvd and Mission St, Fair Oaks Ave and Glenarm St, Fair Oaks Ave and California Blvd, Fair Oaks Ave and Del Mar Blvd, and Fair Oaks Ave and Colorado Blvd. The BRT lanes would then turn at Colorado Blvd with both NB and SB continuing as exclusive BRT lanes. In order to avoid ROW impacts, on-street parking would be removed to allow for the exclusive BRT lanes. Local properties are currently being evaluated as proposed parking structure sites to supplement the loss of on-street parking.

There would be bus stations at the intersections of Colorado Blvd and Los Robles Ave and Colorado Blvd and Lake Ave. At the intersection of Colorado Blvd and Lake Ave, the BRT route would begin a loop around the downtown Pasadena area. The NB BRT lane would continue east on Colorado Blvd with a bus station at the intersection of Colorado Blvd and Hill Ave before turning right at the intersection with Hill Ave, transitioning into a shared lane. At the intersection with Del Mar Blvd the exclusive BRT lane would resume and the route would then make a right turn onto California Blvd. There would be two bus stations at the intersections of California and Hill and California and Lake.

At Lake Ave the route would make a right turn to head north and end the loop at the intersection of Lake Ave and Colorado Blvd, with the SB lane turning left onto Colorado Blvd.

3.2.3.2 Design of Vertical Alignment

Vertical alignments for Alternative BRT-6 would follow existing conditions.

3.2.4 Alternative BRT-6A Engineering Considerations

3.2.4.1 Design of Horizontal Alignment

The design of the BRT-6A alignment proposes to add a BRT route to provide a continuous public transportation route from East Los Angeles near Garfield High School to downtown Pasadena. This BRT route would overlap with the existing Metro 762 bus line from East Los Angeles to Pasadena. This alternative proposes to use existing ROW to add a new BRT lane. Throughout the length of the alignment, the new lane would alternate between an exclusive BRT lane and a shared BRT lane with through traffic and right turn movements to avoid impacting existing intersection traffic. Lane width requirements throughout the alignment are as follows: 12-ft minimum exclusive BRT lane, 11-ft minimum traffic lane, 10-ft minimum median, 2-ft minimum gutter and 6-ft minimum sidewalks. These were the main design criteria used throughout the alignment along with meeting ROW limits.

The proposed BRT lane would begin with a station at the intersection of Atlantic Blvd and Whittier Blvd. The NB BRT lane would be exclusive while the SB lane would be shared.

At the intersection with 4th St, the NB lane would transition into a shared lane until Atlantic Blvd meets Floral Ave, where both NB and SB would have exclusive BRT lanes with portions of shared use to facilitate right turn movements for other traffic. In this segment of the route, there would be stations for both directions at the intersections of Atlantic Ave and Pomona Blvd, Atlantic Ave and Riggin St, Atlantic Ave and Cadiz St, and Atlantic Ave and Garvey Ave.

At the intersection of Harding Ave, the NB exclusive BRT lane would end and continue on Atlantic Blvd as a shared lane. The SB exclusive BRT lane would not transition to shared use until the intersection with Valley Blvd. Along this piece of the route, there would be bus stations for both directions at the intersections of Atlantic Ave and Valley Blvd, Atlantic Blvd and Alhambra Rd, and Atlantic Blvd and Garfield Ave before turning onto Huntington Dr, with both NB and SB converting into exclusive BRT lanes.

The route would continue on Huntington Dr with stations for both the NB and SB route at the intersection of Huntington Dr and Marengo Ave before making a turn at Fair Oaks Ave. At the intersection with State St the exclusive SB BRT lane would end, transitioning to a shared lane. Along Fair Oaks Blvd, there would be bus stations at the intersection of Fair Oaks Blvd and Mission St, Fair Oaks Ave and Glenarm St, Fair Oaks Ave and California Blvd, Fair Oaks Ave and Del Mar Blvd, and Fair Oaks Ave and Colorado Blvd. The BRT lanes would then turn at Colorado Blvd with both NB and SB continuing as exclusive BRT lanes. In order to avoid ROW impacts, on-street parking would be removed to allow for the exclusive BRT lanes. Local properties are currently being evaluated as proposed parking structure sites to supplement the loss of on-street parking.

There would be bus stations at the intersections of Colorado Blvd and Los Robles Ave and Colorado Blvd and Lake Ave. At the intersection of Colorado Blvd and Lake Ave the BRT route would begin a loop around the downtown Pasadena area. The NB BRT lane would continue east on Colorado Blvd with a bus station at the intersection of Colorado Blvd and Hill Ave before turning right at the intersection with Hill Ave, transitioning into a shared lane. At the intersection with Del Mar Blvd the exclusive BRT lane would resume and the route would then make a right turn onto California Blvd. There would be two bus stations, at the intersections of California and Hill and California and Lake.

At Raymond Ave the route would make a left turn, continuing as an exclusive BRT lane. The BRT route would then make a right turn onto Glenarm St and end the loop by turning left to head south on Fair Oaks Ave.

Instead of continuing the loop up Lake Ave and making a left turn on Colorado, as was the case in BRT-6, BRT-6A continues west on California Blvd and makes a left turn onto Raymond Ave continuing as an exclusive BRT lane. Raymond Ave runs parallel to Fair Oaks Ave two blocks west. The major difference between this alternative and BRT-6 is that BRT-6A would not have to loop around the congested downtown Pasadena area. This BRT-6A route would minimize parking impacts on both Lake Blvd and Colorado Blvd, impacting parking on Raymond Ave only. The BRT route would then make a right turn onto Glenarm St and end the loop by turning left to head south on Fair Oaks Ave.

3.2.4.2 Design of Vertical Alignment

Vertical alignments for Alternative BRT-6A would follow existing conditions.

3.3 LRT Alternatives

The design of LRT alternatives primarily considered station placement, right-of-way constraints, placement of aerial and tunnel sections along the various alignments, and minimization of impacts to surrounding neighborhoods, businesses and existing structures, such as buildings and bridges.

The design of LRT alternatives primarily considered station placement, right-of-way constraints, placement of aerial and tunnel sections along alignment, and minimization of impacts to surrounding neighborhoods, businesses and existing structures, such as bridges.

3.3.1 LRT Operating Plan

The LRT conceptual operating assumptions and plans, including span of service, frequency of service, station dwell times, end-of-line layovers, average intersection delay, and operating costs are detailed in the technical memorandum dated September 24, 2012, and titled “SR 710 Study – Draft LRT Preliminary Operating Plans.”

3.3.2 Design Criteria

Every effort was made to comply with Metro's 2010 Design Criteria without exception. Table 3-3 summarizes the criteria that were followed when developing the LRT alternatives.

TABLE 3-3
Summary of Design Criteria

Criteria	Dimension	Reference
Guideway		
• Track Centers (Tangent Track)	14 feet	• Section 4.1.3.3 H.5
• Track Center (Center Platform)	25 feet	• Section 4 Figure.4.22
• Center Platform	16 feet	• Section 4 Figure 4.22
• Clearance to outer curb face of adjacent traffic	6 feet	• Section 4.1.3.3 H.1
Stations		
• Platform Length	270 feet	• Section 6.1.6.E.4 - Architectural
• Platform Height	39 inches	• Section 6.16.4 – Architectural
• Minimum horizontal tangent length beyond end of platform	50 feet	• Section 4.1.6.2 B
• Minimum vertical tangent length beyond end of platform	50 feet	• Section 4.1.6.4 B
• Maximum track grade at platform	1%	• Section 4.1.6.4 B
Track Horizontal and Vertical Geometry		
• Horizontal Alignment – Curves		
o Minimum Radius	100 feet/1000 feet (tunnel)	• Section 4.1.6.3 – 2/4.1.6.3 (A-3)
o Minimum Length	100 feet	• Section 4.1.6.3 - 5
o Preferred Length	L=3V (L=Length, V=Speed)	• Section 4.1.6.3 - 4
• Vertical Alignment		
o Vertical Clearance	15 feet	• Section 4.1.3.4 A
o Height of OC wire above top of rail	14.0ft-22.5ft	• Section 4.1.3.4 B
Pedestrian Ramp		
• Slope	5% preferred	• Section 6.14.5.A – Architectural
• Width	48 inches minimum	• Section 6.16.5 – Architectural

3.3.3 Alternative LRT–4A Engineering Considerations

The LRT 4A alternative consists of a nearly 7.6-mile LRT corridor designed to provide transit services to various communities within the SR 710 study area. The LRT 4A alignment, which is mostly grade-separated, connects to the Metro Gold Line LRT extensions to Pasadena and East Los Angeles at the north and south ends, respectively.

3.3.3.1 Design of Horizontal and Vertical Alignment

Starting at the southerly limits of LRT-4A, the Mednik station needs to be aerial because of the requirement for stations to be on straight track, and Mednik curves as it approaches Third Street. If the station were placed at-grade north of the curve, it would block Civic Center Way, and there is not enough room between Civic Center Way and SR 60 for a station. An at-grade station cannot be south of Third Street at-grade, because the alignment cannot cross the Gold Line alignment at-grade. An aerial station over Mednik Avenue north of Third Street would require straddle bents over the street, permanent property acquisition for access, and temporary construction easements. Since acquisition/easements were required in any case, it was determined that the best location for the station would be on the commercial property on the west side of Mednik Avenue. This eliminates the need for straddle bents over the street and allows for potential integration of the station into a reuse of the property.

The alignment transitions to the median of Mednik Avenue after crossing SR 60. This allows the existing bridge over SR 60 to remain intact. Use of the median of Mednik Avenue avoids property acquisition on either side. The alignment cannot return to grade because it needs to be aerial by Floral Drive again in order to make the grade over the hill into the I-710 right-of-way without impacting access to the corporate park on the north side of Floral Drive.

Along Floral Drive, the alignment is on the north side of the street. This allows a larger turning radius for the curve from Mednik Avenue to Floral Drive, keeps the alignment farther away from homes, maintains access to local businesses, and eliminates traffic impacts on Flora Drive by making use of the sloped setback on the north side of the street.

The alignment then crosses the parking lot of the corporate park on the north side of Floral Drive near Corporate Center Drive. It remains aerial so that vehicles can still use the parking lot, and the only impacts will be the loss of a few parking spaces for the placement of columns. It then skirts the edge of the large drainage basin between I-710 and Corporate Center Drive, to transition into the I-710 right-of-way.

The alignment immediately transitions to the west side of I-710 because the hillside below City Terrace provides greater width than the hillside on the east side, and it provides a direct alignment to reach the Cal State LA Station.

The Cal State LA Station is located vertically below the level of the Cal State LA campus. It cannot be at the same level because this would make the columns as it crosses I-10 too tall. Being below the grade of the university is acceptable because vertical circulation (e.g., elevators) will be required anyway to move passengers across the tracks from the station to the university. An alternative that placed the station farther west, under the university's tennis courts was investigated but determined not to be feasible horizontally, as well as adding considerable cost and disruption to the university.

North of Cal State LA, the alignment remains aerial to cross Hellman Avenue, the southbound on-ramp from Valley Boulevard to SR 710 south, and then Valley Boulevard. It cannot descend to grade before crossing these roadways. If it is determined that it is essential to descend to grade (and into a tunnel) south of Valley Boulevard, this may be possible if the southbound on-ramp were relocated, but this has not been investigated in detail.

The alignment enters a bored tunnel portal as soon as possible (on an approximate 5% grade) after crossing Valley Boulevard. The alignment of the first bored tunnel section is constrained by the 1000' turning radius requirement of the tunnel boring machine (TBM) and by the need to locate a station near the Los Angeles County Department of Public Works building in Alhambra. These two constraints make it impossible to remain under public right-of-way.

After the Alhambra station, the alignment remains under Fremont Avenue as long as possible to reduce the need for easements under residential property. It eventually transitions under residential property to align with Fair Oaks Avenue, constrained again by the 1000' turning radius requirement of the TBM. The Huntington Station is placed north of Huntington Drive as soon as the track straightens out, providing a station on a tangent alignment per Metro standards, under Fair Oaks Avenue.

The South Pasadena station has been located south of the center of downtown South Pasadena to avoid building a station on the Raymond fault. Once the location of the fault is better known, the location of this station can be refined in future phases of the project.

The alignment remains under Fair Oaks Avenue until it turns to reach an underground station near the existing Fillmore Station on the Gold Line. The angle and location of the turn are determined by the turning radius of the TBM.

3.3.4 Alternative LRT–4B Engineering Considerations

The LRT 4B alternative consists of a nearly 7.6-mile LRT corridor designed to provide transit services to various communities within the SR 710 study area. Like Alternative 4A, the LRT 4B alignment is mostly grade- separated and connects to the Metro Gold Line LRT extensions to Pasadena and East Los Angeles at the north and south ends, respectively.

3.3.4.1 Design of Horizontal and Vertical Alignment

The goal of LRT-4B is to reduce the length of the tunnel, since tunneling is generally the most expensive type of construction. The design is the same as LRT-4A to Cal State LA. North of Cal State LA, the alignment differs from LRT-4A and remains aerial over Valley Boulevard and the UPRR's Alhambra Subdivision. It then turns east to avoid right-of-way impacts and runs along the south side of Mission Road, adjacent to the existing railroad trench. Since there are very few cross streets intersecting Mission Road from the south because of the railroad trench, staying on the south side of Mission Road avoids placing columns in the roadway median that might make left turns into and out of abutting properties on the north more difficult. The alignment turns to the north on Palm Avenue. Palm Avenue was selected because it has the widest right-of-way of any north-south street in the vicinity, even though it has only a single lane of roadway traffic in each direction. Palm Avenue has ROW excess width because the median of Palm Avenue is actually an old Southern Pacific RR right-of-way.

The alignment returns to existing grade on Palm Avenue immediately south of Orange Street, which is the earliest opportunity after crossing Mission Road while maintaining design standards for vertical grades. A center platform station is located on Palm Avenue immediately north of Orange Street. The alignment remains at grade across Commonwealth Avenue. When Palm Avenue turns to the east, the alignment enters a tunnel in the Target Store parking lot, which would be used as the TBM launch site. The alignment then continues north in a bored tunnel, veering to the west to align with Fair Oaks Avenue. This transition is constrained by the turning radius of the TBM. The alignment then continues north under Fairs Oaks Avenue, where the design issues are once again the same as those of LRT-4A to the northern terminus.

3.3.5 Alternative LRT–4D Engineering Considerations

The LRT 4D alternative consists of a nearly 7.6-mile LRT corridor designed to provide transit services to various communities within the SR 710 study area. Like Alternatives 4A and 4B, the Alternative 4D alignment, which is mostly grade-separated, connects to the Metro Gold Line LRT extensions to Pasadena and East Los Angeles at the north and south ends, respectively.

3.3.5.1 Design of Horizontal and Vertical Alignment

The goal of LRT-4D is to reduce the length of the tunnel even more than LRT-4B and to replace the bored tunnel with a cut-and-cover tunnel, since cut-and-cover tunneling can be less expensive than using a TBM. LRT-4D also includes an alternative station location at the south terminus near the Atlantic Station to explore other options for connecting to the Metro Gold Line.

Near the Atlantic Station, SR 60 is elevated, whereas near the Mednik Station is depressed. It is also abutted by residential land uses. Therefore, the alignment of LRT-4D is underground in this area, since crossing above SR 60 would require a high structure through a residential area. Thus, LRT-4D begins with an underground station beneath Beverly Boulevard, near the existing Atlantic Station. From there, it continues in a cut-and-cover tunnel underneath Woods Avenue. It then turns west under First Street and transitions to an aerial structure. As with LRT-4A, the alignment needs to be aerial by Floral Drive in order to transition to the SR 710 right-of-way, and it is not feasible to have an intermediate at-grade segment between the tunnel segment and the aerial segment because transitions at any other location would block major cross streets. The aerial structure turns north on Mednik Avenue, over the southwest corner of Belvedere Park, and from that point the design is the same as LRT-4B to the Palm Avenue station.

When Palm Avenue turns to the east, north of Commonwealth Avenue, the alignment turns with it and enters a cut-and-cover tunnel. A short distance later, it turns north under the Southern California Edison right-of-way on the east side of Raymond Avenue. North of Raymond Avenue, the SCE ROW is no longer adjacent to the street, running between the backyards of houses, and the alignment remains in the ROW. It leaves the ROW at Huntington Drive. The alignment of LRT-4A cannot remain in the ROW north of Huntington because a building has been constructed in the ROW. The alignment runs under Huntington Drive and then Fair Oaks Avenue. It then travels under SR 110, and continues as a cut-and-cover tunnel to an underground station beneath Fillmore Street, near the existing Fillmore Station.

3.3.6 Alternative LRT-6 Engineering Considerations

The LRT 6 alternative consists of a nearly 8.3-mile LRT corridor designed to provide a higher ridership alternative consisting mostly of an at-grade alignment through various communities within the SR 710 study area. The LRT 6 alignment, which includes at-grade street running as well as aerial structure segments over major I-10 and SR 60, connects to the Metro Gold Line LRT extensions to Pasadena and East Los Angeles at the north and south ends, respectively.

3.3.6.1 Design of Horizontal and Vertical Alignment

LRT-6 is generally an at-grade alignment along Atlantic Boulevard, Huntington Drive, and Fair Oaks Avenue. It begins on Atlantic Boulevard just north of Pomona Boulevard with an elevated station. This station cannot be at-grade because it would block the SR 60 eastbound off-ramp. In addition, if it were at-grade, it would require the removal of one lane in each direction through the SR 60 interchange or reconstruction of the bridges that carry SR 60 over Atlantic Boulevard. Therefore, an elevated station was selected, with the alignment remaining elevated over SR 60 and then returning to grade south of Brightwood Street. The alignment remains at grade until crossing Garvey Avenue, when it begins to climb again to cross I-10 and the Metrolink San Bernardino Line. The Atlantic Boulevard undercrossing of I-10 is very narrow, with two lanes in each direction, so the alignment cannot remain at street level without either reducing Atlantic Boulevard to one lane in each direction, or reconstructing the bridges carrying the I-10 mainline, the adjacent ramps, and the Metrolink track (in the freeway median) over the roadway. The alignment returns to grade before Valley Boulevard.

The alignment continues at grade along Atlantic Boulevard until making a sweeping left turn through the Ralph's Supermarket parking lot north of Pine Street, onto Huntington Drive, requiring the acquisition of that property. A turn onto Pine Street was investigated as an alternative, but because of the narrow width of Pine Street, this option would impact the residences along that street. The alignment then turns north on Fair Oaks Avenue, remaining at grade until north of Glenarm Street. It then transitions to an aerial configuration and turns to the right onto Fillmore Street, terminating at an aerial station above the existing Fillmore Station of the Gold Line. The alignment cannot remain at grade for this final segment because there is insufficient space on Fillmore Street to accommodate a station and the required tail tracks between Fair Oaks Avenue and the existing Gold Line tracks.

3.4 Freeway Alternatives

3.4.1 Freeway Design Criteria

Design of the four freeway alternatives and two highway/arterial alternatives was based on the Caltrans Highway Design Manual [HDM] 6th Edition updated May 2012.

A summary of Highway Design Manual standard design criteria and proposed criteria for freeways is shown in Table 3-4. A summary of design exceptions is provided for each freeway alignment in the following sections.

TABLE 3-4
Freeway Design Standards Summary

Design Feature	Standard	Proposed in Tunnel Locations	Proposed outside Tunnel Locations	HDM Section
Design Speed	55-80 MPH	70 MPH	70 MPH	101.2
Maximum Profile Grade	4%	4%	4%	204.3
Minimum Lane Width	12'	12'	12'	301.1
Standard Cross Slope	2%	2%	2%	301.2(2)

TABLE 3-4
Freeway Design Standards Summary

Minimum Inside Shoulder Width	5’/10'	2'	5'/10’	302.1
Minimum Outside Shoulder Width	10'	8'	10'	302.1
Curb Type	Not Used	A1-6	Not Used	303.2
Minimum Median Width	36’	N/A	22’	305.1
Minimum Vertical Clearance Above Lanes	16.5'	16.5'	16.5'	309.2(1)(a)
Minimum Vertical Clearance Above Shoulders	16.5'	16.5'	16.5'	309.2(1)(a)

3.4.2 Freeway Alternatives

Four freeway alternatives were selected to be studied for conceptual engineering: F-2, F-5, F-6 and F-7. With the exception of Alternative F-6, all of the freeway alternatives have tunnel sections. Alternatives F-2, F-5, and F-7 share the same south portal design, connecting existing SR 710 to the proposed tunnel alignments. Similar to Alternative F-7, F-6 connects the northern and southern stubs of SR 710, as does F-7; however, the F-6 alternative is in a depressed section throughout much of its alignment. The F-2 alternative connects the southern stub of SR 710 to SR 2 north of Eagle Rock Blvd. Alternative F-5 connects the southern stub of SR 710 to SR 134 west of San Rafael Ave and east of Figueroa St. The general alignments of each alternative are:

- Alternative F-2: Connects the southern stub of SR 710 to SR 2 north of Eagle Rock Blvd in the vicinity of the existing Verdugo Road and York Boulevard interchanges, primarily in bored tunnel.
- Alternative F-5: Connects the southern stub of SR 710 to SR 134 west of San Rafael Ave and east of Figueroa St, primarily in a bored tunnel.
- Alternative F-6 Connects the northern and southern stubs of SR 710, primarily in a depressed alignment
- Alternative F-7: Connects the northern and southern stubs of SR 710, primarily in a bored tunnel.

Although every effort was made to comply with the Caltrans design standards, some existing and potential conditions may require deviations from the standard design. All conditions which may deviate from the standard design will be appropriately addressed prior to Project Approval.

3.4.3 South Portal Design Considerations (F-2, F-5, F-7)

The south portal is located near the I-10/SR 710 interchange, which includes the I-10 and SR 710 system ramps, the El Monte Busway, the Metrolink San Bernardino line, and Cal State University LA CSULA bus and Metrolink station. The design of the south portal avoids reconstructing this interchange.

Special attention was paid to minimizing impacts to the surrounding communities where feasible. Tunnel impacts to the surrounding community were minimized by locating the south portal south of Valley Boulevard within the Caltrans ROW. In addition, the half diamond interchange at Valley Blvd will remain in its current configuration, because providing for a complete diamond interchange would force the portal north of Valley Blvd. The beginning of tunnel bore is located south of the UPRR line to avoid any conflicts with the railroad.

Traffic within the tunnels was designed to have one direction of travel per tunnel bore, with the top level servicing all connecting routes and the bottom level servicing only north-south travel.

The south portal geometry requires curve radii less than 3,000 feet in order to avoid ROW takes. Wide shoulders were provided to allow for a minimum of 65 mph stopping sight distance (SSD), because providing for 70 mph SSD would have required additional ROW takes.

As proposed, the south portal configuration results in some impacts to the surrounding areas. For example, impacting the Dorchester Storm Channel just west of the SB Valley Blvd on-ramp is unavoidable. This forced the

SR 710 profile to remain high so that all improvements would cross over the storm drain. It is proposed that the storm drain be reconstructed in a box culvert. Additionally, the proposed design does not provide adequate vertical clearance under the existing Hellman Ave overcrossing; therefore, this overcrossing would be reconstructed and raised in order to provide the minimum vertical clearance.

The existing SB exit to the westbound (WB) El Monte Busway is currently signed for buses only. It is anticipated car access will eventually be allowed. Special attention to channelization and metering will need to be considered in the bus stop area to make this possible.

3.4.4 Alternative F-2 Engineering Considerations

3.4.4.1 Alignment and North Portal Design Considerations

Alternative F-2 would originate at the existing SR 710 southerly stub, at the I-10 freeway in Alhambra, and connect to the SR 2 freeway in the vicinity of the existing Verdugo Road and York Boulevard interchanges. A majority of Alternative F-2's alignment is within a dual bored tunnel section. Because of the high cost of tunneling, the alignment length was minimized as much as possible.

Geometrically, the horizontal and vertical alignments beyond the south portal are flexible for future refinements as the project is developed. The separation between the bored tunnels is a minimum 60 feet, which is consistent with geotechnical recommendations.

Traffic within the tunnel was configured to have one direction of travel per tunnel bore. Both levels of the NB SR 710 connect to the NB SR 2 only. In addition, the southbound SR 710 connection will only be able to be reached from the southbound SR 2 freeway. Reconstruction of the SR 2/SR 134 interchange would be avoided because of the complexity of the interchange, and cost considerations.

Although minimizing impacts to the surrounding communities was a design focus, some unavoidable impacts are necessary with the current design. The north portal would eliminate access through Oban Drive, Division Street, Barry Knoll Drive, College Crest Drive, Ackerman Drive, Verdugo View Drive, Scandia Way, and 42nd Street. The York Blvd interchange would be eliminated to accommodate the new connection for the SR 710/SR 2 interchange. It should also be noted that the system interchange spacing of SR 2/SR 134 would be decreased with the addition of the SR 2/SR 710 system interchange.

3.4.5 Alternative F-5 Engineering Considerations

3.4.5.1 Alignment and North Portal Design Considerations

Alternative F-5 is one of the freeway-tunnel alternatives that carries traffic from/to the existing SR 710 and SR 134 freeways with the new SR 710/SR 134 connection between San Rafael Avenue and Figueroa Street. From the existing SR 710 terminus, the length of tunnel section is maximized to reduce the ROW impacts. At the south portal area, south of Valley Blvd, the separation between the southbound and northbound tunnels is a minimum of 60 feet, separating further as the tunnels approach the north portal to SR 134. The alignments then turn and spread horizontally to allow the connection to SR 134.

To minimize complicated traffic movements, traffic within the tunnel was configured to have one direction of travel per tunnel bore. Based on traffic volume distribution of each movement, the lower tunnel from northbound SR 710 connects only to eastbound SR 134. In the opposite direction, and the lower tunnel to southbound SR 710 is accessed from westbound SR 134. The upper tunnels are split and connect to both directions of SR 134.

The short distances between the Figueroa and San Rafael interchanges require a system of collector/distributor(C/D) roads and braided ramps that were developed to eliminate weaving issues along SR 134. Colorado Boulevard was realigned to the south to accommodate the new ramps and C/D road.

All the alignment lengths were minimized to reduce cost without compromising required standards. Furthermore, 20,000-foot and larger radius curves were used to keep the roadway cross-slope constant throughout the tunnel section.

The challenge of the design of the proposed profiles is the existing undulating terrain at the north end of Alternative F-5. In order to meet the existing grade, which rises toward SR 134 at an average of 5 percent slope, the proposed profile was designed with an 8 percent slope, which is a deviation from Caltrans Standards and unlikely to be approved.

3.4.6 Alternative F-6 Engineering Considerations

3.4.6.1 Alignment and North Portal Design Considerations

The F-6 alternative was based on the "Depressed Meridian" alignment designed by Caltrans in 1994. The conceptual design attempted to maintain and minimize the "Depressed Meridian" footprint; therefore, the intent was to follow the horizontal and vertical alignments previously developed as closely as possible while minimizing design exceptions. This includes maintaining the originally proposed typical cross-section of one HOV lane and three general purpose (GP) lanes in each direction.

There are some design variations between the original "Depressed Meridian" alignment and the current conceptual design. Even though a depressed section would minimize visual and audible impacts, it was impractical to keep the vertical alignment in a depressed section throughout the entire length of the alternative. In order to avoid building very tall retaining walls (50'+) or constructing multiple tunnels, the alignment is elevated in some sections.

The proposed horizontal alignment deviates from the "Depressed Meridian" alignment at Pasadena Avenue, where the Caltrans alignment used sharp reversing curves to align the freeway under Pasadena Avenue, the F-6 alternative alignment is straightened and runs just to the east of Pasadena Avenue. A tunnel section is proposed in this location to account for the high skew angle crossing of Pasadena Avenue.

An additional deviation from original design occurs at the split diamond interchange at Hellman Avenue. This interchange was eliminated because the configuration prevented the connection from SB SR 710 to WB I-10, and also impacted multiple residences along Highbury Avenue.

The design attempted to maintain current traffic flow where the proposed SR 710 alignment crossed a local street. This was provided for by designing overcrossings for local streets over the proposed SR 710 depressed alignment when feasible. Cul-de-sacs and reconfiguring local streets were proposed at the local street crossing if spanning over the freeway was not feasible.

The complicated braided ramp interchanges at Pasadena Ave, St John Ave, and SR 134/SR 210 in the "Depressed Meridian" alternative were removed in favor of a simpler half diamond interchange. This allows the existing over-crossing structures to remain. This is also a more achievable design, and is similar to the Alternative F-7 interchange design in this area.

3.4.7 Alternative F-7 Engineering Considerations

3.4.7.1 Alignment and North Portal Design Considerations

Alternative F-7's alignment connects the southern SR 710 stub terminating at Valley Boulevard in Alhambra to the SR 710 north stub just south of I-210 in Pasadena. The alignment length is minimized as much as possible to reduce project cost. The bored tunnel length is maximized to reduce the amount of right-of-way impacts.

Geometrically, 20,000'+ radii curves were used so that the roadway plane in the tunnel could remain at a constant slope throughout the bored tunnel. To minimize complicated traffic movements approaching and leaving the bored tunnel, traffic within the tunnel was configured to have one direction of travel per tunnel bore. The separation between the bored tunnels is a minimum 60 feet, which is consistent with geotechnical recommendations. The bores further separate near the north portal so that the top levels align horizontally with the existing freeway stub. The horizontal and vertical alignments of the tunnel are flexible as the project is further developed and additional information is obtained to assist in optimizing the geometrics. Special attention was paid to minimizing impacts to the surrounding communities. This is evident because the majority of the proposed design fits within Caltran's right-of-way.

At the northern stub in Pasadena, the bridge at Del Mar Boulevard is proposed to be replaced with fill in the final condition, since it will be over the cut-and-cover tunnel. In addition, the existing bridges at Green St, Colorado Blvd, and Union St will need to be replaced to accommodate the lowered profile of SR 710 and the lane transitions. The existing on- and off-ramps at Pasadena Ave and St John Ave are incompatible with the proposed design. Nearby existing on- and off-ramps at Walnut St, Orange Grove Blvd, St John Ave, and Marengo Ave will provide all the movements provided by the removed ramps. Improvements to the local intersections in this area will be studied in the next phase of the project to determine if any additional improvements are needed to accommodate the diverted traffic.

It should be noted that reconfiguring the I-210/SR 134/I 710 interchange would be avoided with the proposed alignment. Also, the complexity of the interchange makes a new design extremely challenging and costly. Therefore, the existing connector ramp bridges will remain, and the ramp configuration will remain.

3.5 Highway Alternatives

After an initial screening of highway alternatives, two remaining alternatives were selected for conceptual engineering. The design considerations of these alternatives (H-2 and H-6) are described in the following sections.

3.5.1 Highway Alternatives Design Standards

A summary of Highway Design Manual standard design criteria and proposed criteria for highways is shown in Table 3-5. A summary of design exceptions is provided for each freeway alignment in the following sections. Although every effort was made to comply with the Caltrans design standards, some existing and potential conditions may require deviations from the standard design. All conditions which may deviate from the standard design will be appropriately addressed prior to Project Approval.

TABLE 3-5
Highway Design Standards Summary

Design Feature	Standard	Proposed	HDM Section
Design Speed	40-60 MPH	55	101.2
Maximum Profile Grade	7%	7%	204.3
Minimum Lane Width	12'	12'	301.1
Standard Cross Slope	2%	2%	301.2(2)
Minimum Outside Shoulder Width	8'	8'	302.1
Curb Type	B-6	B-6	303.2
Minimum Vertical Clearance Lanes	16.5'	16.5'	309.2(1)(a)
Outer Separation	26’	18’	310.2

3.5.2 Alternative H-2 Engineering Considerations

3.5.2.1 Design of Horizontal Alignment

The design of the H-2 alternative alignment proposes to improve the existing local streets to provide a continuous flow of traffic between SR 710 and SR 134. This alternative proposes to build three lanes in each direction throughout entire length of the alternative per the traffic analysis recommendation, also included is a 16-foot raised median.

Along Concord Avenue the properties on the northwest side would be kept and the widening would take place on the opposite side. By doing that, as many driveway accesses to the highway as possible are eliminated to improve the flow of through traffic. Another reason is that the properties on the side of the widening are perpendicular to the existing road and are large enough to provide room for the proposed improvements. A frontage road would run along part of the existing Concord Avenue to serve the remaining driveways and to connect the local streets.

Along Fremont Avenue the widening shifts from the west side to the east side at certain locations to avoid impacting sensitive properties such as homes, retail centers, businesses, schools, and churches. The number of intersections with direct access to frontage roads is limited because of the short distance between the main alignment and the parallel frontage road (Caltrans requires a separation of at least 30 feet and only 10 feet is available). Direct access was provided only where it was believed to be critical for emergency vehicle accessibility.

Along Monterey Rd the widening takes place on the north side, while the south side of the existing street is maintained at most locations. This helps to minimize the impacts on sensitive properties such as homes, churches, and historic properties. Although most of the frontage roads are proposed on the south side, small segments of road were needed to connect the local streets on the north side.

Along Avenue 64 most of the widening takes place on the west side of the existing street, except when approaching Colorado Blvd, where the widening shifts to the east side. This helps to minimize the impacts on sensitive properties such as homes, churches, schools, and historic properties. Also, the properties on the west side are perpendicular to the existing street and are large enough to provide room for the proposed improvements. Adding a frontage road was not always feasible because of the hilly terrain (especially around the mid-segment of Avenue 64), and access to the local streets would be provided by proposing segments of connector roads between the local streets and by providing new intersections along the main alignment for access to the local streets. Some alignment improvements are proposed along Avenue 64 by the hilly area to increase the existing curve radii in order to meet the 55 mph design speed.

In the last segment of the proposed alternative at the tie into Colorado Blvd, we could only widen to the south side because the SR 134 freeway is located next to Colorado Blvd on the north side. Some new connections are proposed between local streets to provide access between them and to allow faster response for emergency vehicles.

3.5.2.2 Design of Vertical Alignment

The H-2 profile matches the existing sag vertical curve south of Valley Blvd, goes over Valley Blvd, UPRR tracks, and Mission Rd, and then comes down to match the original ground (OG). The profile goes over these facilities because there are fills already in place for the highway to go over at Valley Blvd. This overpass configuration also eliminates the need for a pump station, which is usually required at underpasses, while preserving the existing utilities along Valley Blvd and Mission Rd.

The grades are maintained as flat as possible to follow the OG, and up to a maximum of 5 percent to meet Americans with Disabilities Act (ADA) accessibility requirements. By following the OG, the amount of earthwork is kept to a minimum. The length of vertical curves meet the sight distance (500’) required for the 55 mph design speed.

The at-grade railroad crossing at Pasadena Avenue/Monterrey Rd is maintained because both an underpass or an overpass would cause a high level of impacts, with ROW takes on the properties adjacent to the main alignment, and because it would be difficult to provide access to the local streets and private properties. Also, additional earthwork, retaining walls, and utility relocations would be required.

Along Avenue 64 and within the hilly area, the profile was set in such a way as to try to balance cut-and- fill volumes. This was also done for the profile along Colorado Blvd with the same intent, and to meet the sight distance at vertical curves for the design speed, except at the tie-in location, where the existing conditions do not allow for higher design speeds.

3.5.3 Alternative H-6 Engineering Considerations

3.5.3.1 Design of Horizontal Alignment

The design of the H-6 alternative alignment proposes to improve the existing local streets to provide greater through traffic flow for the area between the north and south stubs of SR 710. This alternative proposes to build three lanes in each direction throughout entire length of the project per traffic analysis recommendation, with a 16-foot raised median.

Along Sheffield Avenue the properties on the easterly side would be kept and the widening would take place on the opposite side. This alignment shift allows the elimination of as many driveway access points to the highway as possible to improve the flow of traffic. Another reason is that the properties on the side of the widening are perpendicular to the existing street and are large enough to provide room for the proposed improvements. A frontage road would run along part of the existing Sheffield Avenue to serve the remaining driveways and to connect the local streets.

Along Huntington Dr the widening would maintain the existing alignment of Huntington to minimize impacting sensitive properties such as retail centers, businesses, schools, and churches. The number of intersections with direct access to the realignment would be limited to increase through traffic operations while decreasing the amount of signal-controlled intersections. Various streets that had existing local access to Huntington would end in a cul-de-sac to improve segment level of service (LOS).

At the intersection of Huntington Drive and Fair Oaks Ave the alignment makes a left turn to continue northerly. Existing free right turn lanes from Fair Oaks Ave would be maintained. Local streets north of the intersection would have cul-de-sacs constructed to improve traffic operations and minimize problems associated with closely spaced intersections. Access to the highway would be directed to other signalized locations.

Along Fair Oaks Ave the alignment shifts easterly to avoid impacts to several properties that include homes, commercial and hospital sites. The alignment will maintain connection with SR 110, with minor improvements done at the intersections to maintain all traffic movements. Widening of the WB off-ramp will require retaining walls to maintain capacity.

Fair Oaks Ave will continue northerly until Columbia St, where it turns westerly. The existing intersection will be widened on the east side to minimize impacts to the railroad ROW and bridge on the west side. The alignment will continue along Columbia St until it turns northerly to connect to Pasadena Ave. The south leg of the intersection will be realigned to intersect with Fremont Ave to provide local access. Along Pasadena Ave the alignment is designed to minimize impacts to the west resulting from the re-alignment to meet Fremont Ave. A frontage road will be provided to provide access to the properties on the west side of Pasadena Ave. At Bellefontaine St, the NB and SB directions split, meeting the existing alignments of the one-way couplet of Pasadena Ave and St John Ave. The frontage road servicing the hospital will end in a cul-de-sac. Direct emergency access to the hospital would be provided to the hospital on the NB leg of the alignment.

3.5.3.2 Design of Vertical Alignment

For the H-6 alternative, the profile matches the existing sag vertical curve south of Valley Blvd, goes over Valley Blvd, UPRR, and Mission Rd, and then comes down to match the OG. The profile goes over these facilities because there are some fills already in place for the highway to go over at Valley Blvd. This overpass alternative also eliminates the need for a pump station, which is usually required at underpasses, and this alignment preserves any existing utilities along Valley Blvd and Mission Rd .

The grades are maintained as flat as possible to follow the OG, and up to a maximum of 5 percent to meet ADA accessibility requirements. By following the OG, the amount of earthwork is kept to a minimum. The length of vertical curves meets the sight distance (500’) required for the 55 mph design speed.

Along Pasadena Ave the alignment is maintained as flat as possible to minimize impacts to existing properties and maintain access at signalized intersections. North of Pasadena Ave the alignment maintains existing until it connects to SR 710 north of California Blvd.

3.6 Mapping and Utility Methodology

The mapping of utilities focused on key areas for the conceptual phase rather than the entire project area. Engineers working on the design of the alternatives identified particular areas of concern that became the focus of the utility mapping study.

For key areas along alignments identified by designers, as-built utility plans and facility maps were collected from various public and private agencies. Topographic survey and high resolution aerial photographic images were made available by Caltrans. The topographic survey provided curb lines and vault locations as references. Where topographic information was missing, the aerial photographs were used to approximate curb lines.

There are several significant utilities in proximity to the project's alternative alignments, including, but not limited to, large storm drains and high-pressure gas lines. Findings are conceptual and a complete utility composite plan will be performed in the next phase of the project, when updated topographic base mapping is completed.

3.7 Drainage Considerations

This section will document the conceptual offsite drainage, pump stations, and stormwater treatment strategies and assumptions. For this conceptual study, onsite drainage systems, such as inlets and small diameter pipes, were not investigated in detail. Therefore, this report does not discuss onsite drainage. Onsite drainage items will be considered in the next phase of the SR 710 Study. A detailed discussion of offsite drainage, pump stations and stormwater treatment can be found in the SR 710 Drainage and Stormwater Treatment Technical Memorandum presented in Appendix C.

3.7.1 Offsite Drainage

Potential project conflicts with regional (offsite) drainage systems were identified using the Los Angeles County Department of Public Works (LACDPW) design-construction plan online map. The existing offsite systems and alignment of alternatives are presented in Appendix C. Each potential conflict site was investigated by comparing the layouts and profiles of the drainage systems with the alternative alignments. If a conflict was identified, a conceptual plan and associated cost were developed to mitigate the impact. Because the as-builts were based on the National Geodetic Vertical Datum of 1929 (NGVD 29), a 2.5 ft adjustment was applied when comparing elevations between proposed alignments and as-builts.

The conceptual study concluded that there are some conflicts to the regional systems in the freeway (F-2, F-5, F-6, and F-7), highway (H-2 and H-6), and LRT (LRT-4A, LRT-4B, and LRT-4D) alternatives. There are discussed in more detail in the Drainage Technical Memorandum presented in Appendix C. The alignments of Alternatives LRT-6, BRT (BRT-1, BRT-6, and BRT-6A), and TSM/TDM are at grade, so there is no conflict with the existing drainage systems.

3.7.2 Pump Stations

Pump stations at the low point are required in the freeway (F-2, F-5, F-7), and LRT (LRT-4A, LRT-4B, LRT-4D) alternatives. Additional pump stations at tunnel portals are needed to collect and treat stormwater entering the tunnel in Alternatives F-2, F-5, and F-7. Alternative F-6 is an open-trench and 3 pump stations are proposed at local low points in the profile. Alternatives LRT-6, highways (H-2 and H-6), BRT (BRT-1, BRT-6, BRT-6A), and TSM/TDM have no tunnel or trench and no pump stations are needed. A detailed discussion of pump stations is provided in the Drainage Technical Memorandum presented in Appendix C.

3.7.3 Stormwater Treatment

The freeway and highway alternatives will be within Caltrans right-of-way, and will need to comply with the Caltrans Project Planning and Design Guide (PPDG). The LRT and BRT alternatives are subject to Standard Urban Storm Water Mitigation Plan (SUSMP) requirements of the Los Angeles County Department of Public Works.

For all alternatives, treatment BMPs will be implemented to the maximum extent practicable. Given the draft status of the new Los Angeles County MS4 permit, and also for consistency in the analysis, all alternatives were analyzed following the Caltrans PPDG. The TDC (Targeted Design Constituent) approach set forth in the Caltrans PPDG was used to determine the treatment strategy for the potential treatment BMPs. According to the PPDG, a project must consider treatment to target a TDC when an affected water body within the project limits is on the 303(d) list for one or more of these constituents.

Based on the water body impairments identified for the project, the priority pollutants designated as TDCs are: phosphorus, nitrogen, total copper, dissolved copper, lead, zinc, and dissolved zinc. The BMP selection will be dependent on infiltration capacity and site-specific determination of feasibility. Although infiltration devices are the preferred treatment BMPs, they are likely not appropriate for the project due to the soil conditions.

Based on a conceptual analysis of site feasibility, the combination of Treatment BMPs for the project may include media filters, biofiltration strips, biofiltration swales, detention basins, and GSRDs. Final selection of BMPs will be made during final design, based on a site-specific determination of feasibility. BMPs along the LRT and BRT alternatives may also include other BMPs approved for use by the Los Angeles County MS4 permit.

SECTION 4

Geologic and Geotechnical Conditions

4.1 Regional Geology

4.1.1 Physiography

The SR 710 Alternative Study area primarily consists of the western San Gabriel Valley, the southern San Rafael Hills, the eastern portion of the Elysian Hills, and the Repetto Hills areas of Los Angeles-Pasadena. These areas are within the transition zone between the northwest-southeast-trending Peninsular Ranges physiographic/geologic province on the south, and the east-west-trending Transverse Ranges province on the north. The San Gabriel Valley floor gently descends southerly from elevations of 700 to 1,000 feet along the northern margin to approximately 300 to 400 feet in the south. The gradual descent is interrupted locally by a 10- to 150-foot escarpment trending from east-west to northeast-southwest and extending from the Monrovia area to the South Pasadena area and westerly into the hills of Glendale and Los Angeles. Associated with this escarpment are closed depressions, springs, reverse-tilted fan surfaces, and small ridges. All of these features are a result of fault displacement by the Raymond fault.

4.1.2 Subsurface Conditions

Regional geologic maps indicate that geologic deposits within the SR 710 Alternative Study area are marine and nonmarine Quaternary-age (approximately less than 2 million years old) sediments, deposited atop marine sedimentary rocks of Tertiary-age (approximately 2 to 16 million years old), which overlie a crystalline basement complex of Cretaceous and Pre-Cretaceous (120 to 160+ million years old) igneous and metamorphic rocks.

Young and Old, Quaternary-age alluvial materials are encountered within the area of the alternatives. The alluvial materials consist of interbedded lenses and/or discontinuous layers of fine-grained soil (clay and silt) and coarse-grained materials (sand and gravel) that generally increase in strength with depth. Local portions of these alluvial materials are susceptible to liquefaction along some of the proposed alternatives, as detailed in geotechnical memorandum prepared for the SR 710 Alternative Analysis (CH2M HILL, 2012).

Pliocene and Miocene-age bedrock formations are mapped within the area of the alternatives. These formations include the Fernando, Puente and Topanga Formations. These formations consist primarily of marine claystone and siltstone; sandstone, shale, and siltstone; and siltstone, sandstone and conglomerate/breccia respectively.

The northern area of the alternatives is mapped as being underlain by Cretaceous-age basement complex rocks. These rocks are designated as Wilson diorite or quartz diorite; however, these rocks comprise a wide suite of lithologies, including diorite, monzonite, quartz diorite, quartz monzonite, and gneissic diorite.

Alternative specific geologic conditions and hazards are presented in the geotechnical memorandum prepared for the SR 710 Alternative Analysis (CH2M HILL, 2012).

4.1.3 Geologic Structure

The convergence of the Peninsular Ranges and the Transverse Ranges has resulted in a very complex geologic structure. As the northwest vergent blocks of the Peninsula Ranges interact with the south vergent Transverse Ranges, a series of new structures has formed to accommodate the collision, including east-west compressional folding and thrusting and east-west trending left lateral faulting to shunt structural blocks off to the west.
The San Gabriel Basin is a large down-warp created by regional north-northeast to south-southwest directed compressional geological forces that have uplifted the San Gabriel Mountains and folded the rocks in adjacent hills. Although they are called blind, these contractional thrust faults do express themselves at the surface by the uplift of the hills and valleys within the alternatives' area. The Elysian, Repetto, and San Rafael Hills exist primarily a result of late-Quaternary-age folding and uplift (less than about 500,000 years old). The faults and folds in the hills largely trend southeasterly from the Santa Monica Mountains to the Puente Hills and are commonly referred

to as the Elysian Park Fold and Thrust Belt (EPFT). Known active surface faults in the area of the alternatives are the Raymond and Alhambra Wash faults. The Eagle Rock and San Rafael faults are generally considered to be potentially active as there is inadequate evidence as to their recency of activity.

4.2 Regional Faulting

The surface faults of greatest significance to the alignments are described in detail below. They include the Raymond, Alhambra Wash, Eagle Rock and San Rafael faults. The Raymond fault is the major active fault in the area of the alternatives. It is a left-lateral, reverse-oblique fault that dips steeply (approximately 80 degrees) to the north. It extends southwesterly from the Sierra Madre fault zone at the base of the San Gabriel Mountains to the Raymond Hill area of South Pasadena, where the Raymond fault continues to the west, for a length of 12 to 15.5 miles. The most recent major surface rupture on the Raymond fault occurred sometime about 1,000 to 2,000 years ago and the recurrence interval for surface rupturing events may be about 3,300 years. There is little consensus on the rate of slip, with estimates varying from 0.1 to 0.4 millimeters per year (mm/yr) up to 1.5 mm/yr. Earthquake magnitude estimates are M_W 6.0 to 7.0, with 6.7 preferred, an event that would generate 3 to 5 feet of displacement. The State of California (California Geological Survey [CGS]) has established an Alquist-Priolo Earthquake Fault Zone (APEFZ) along the Raymond fault from the San Gabriel Mountains in the east to near the intersection of Avenue 50 and York Boulevard on the west.

The Alhambra Wash fault is a short northwest-southeast-trending fault in the southern part of the San Gabriel Valley that steps the Whittier fault northward. The surficial expression of the fault segment is approximately 1.5 miles long extending from State Route 60 on the southeast to San Gabriel Boulevard on the northwest. The fault is designated as an APEFZ and, therefore, is considered to be active. The potential for surface displacement on the Alhambra Wash fault is poorly known but unpublished work has confirmed multiple late Pleistocene to Holocene ruptures. The maximum magnitude of an event on the Alhambra Wash fault could be about 6.25 if it ruptures separately, but it likely ruptures in larger events with the Whittier fault.

The San Rafael fault trends along the southerly side of the San Rafael Hills across the Arroyo Seco then along the north sides of Grace and Raymond Hills in southwestern Pasadena (Lamar, 1970). To the northwest, the fault apparently dies out north of the Eagle Rock fault as a series of disjointed strands in the basement complex of the San Rafael Hills. It has been observed to dip northeast at 80 degrees with basement rock to the north against Tertiary-age sediments to the south. The kinematics and recency of activity for this fault are unknown.

The Eagle Rock fault, mapped as an eastward continuation of the Verdugo fault, lies between the San Rafael and Raymond faults (Lamar, 1970). Southeast of the San Rafael Hills, the fault may be expressed by irregular terrain in a nearly flat surface of overlying terrace deposits. The fault is well exposed where it separates granitic rocks from conglomerate-breccia of the Topanga Formation west of Arroyo Seco. A combined rupture of the Verdugo and Eagle Rock faults is the most likely scenario for the maximum earthquake magnitude on the Eagle Rock fault.

4.3 Groundwater Conditions

Groundwater levels vary considerably across the alternatives' area and occur as deep alluvial aquifers as well as shallow perched zones. The underlying bedrock formations contain groundwater but are not considered aquifers. Significant amounts of groundwater might be encountered locally within faulted and/or fractured bedrock zones. There will be groundwater inflows into potential tunnel excavations unless control measures are implemented.

Significant, deep, groundwater aquifers are present within the large alluvial fans which are transected by portions of each alternative alignment. These deep aquifers are overlain by local perched groundwater bodies. In addition, groundwater is under unconfined conditions within the unconsolidated alluvial materials at approximate depths of 10 to 25 feet bgs within Arroyo Seco.

Several of the faults within the study area act as groundwater barriers with different groundwater levels on either side of the fault. Very shallow historically highest groundwater levels (on the order of 10 to 20 feet bgs) have been reported within the alluvial deposits on the north side of the Raymond fault.

SECTION 5
Structure Considerations

5.1 Freeway Overcrossings/ Bridge Replacement

The overcrossing structure type is selected based on the existing structure type, bridge span length, available clearance and other constraints. Most of the time, a cast-in-place, prestressed concrete box-girder bridge is likely the most cost-effective solution and is thus recommended for bridge replacement. When possible, a pier/bent is used in the middle of the proposed SR 710 alignment to reduce the span length of the replacement bridge. This minimizes the superstructure depth relative to that required for a single-span bridge.

The bent foundation consists of pier shafts in accordance with conceptual geotechnical judgment. This will enable the foundation to be constructed prior to excavating down the proposed SR 710 profile grade. The pile tip elevations will be based on developing the required pile capacity at or below the final grade.

In case of tall retaining walls (that is, approximately 35 feet or higher) along the east and west sides of proposed SR 710, secant pile walls are recommended at this location based on conceptual geotechnical judgment. Rather than terminating the walls at the original grade and lengthening the bridge behind the walls to the slope catch point, for a cost-effective approach the secant pile walls are extended up to the soffit of the superstructure, backfilled, and used as the abutment foundation for the bridge.

In case of short retaining walls along the east and west sides of proposed SR 710, short-seat abutments on pile foundations are used. It may be noted that the abutment pile foundations are based on conceptual geotechnical judgment and the final grade should be able to accommodate the proposed abutment locations and wall heights.

Typically, a pedestrian fence on both sides of the replacement structure, similar to that provided for the existing bridge, will be necessary.

Alternative F2 is comprised of only two overcrossings. There is Valley Blvd OC which is a single span structure that is 220 ft in length. Hellman Ave OC is 4 span for a length of 260 ft.

Alternative F5 includes 9 bridge structures with a majority of those being freeway ramps. There are 6 ramps consisting of ETS Ramp, WTS Ramp, WBS Ramp, NTE Ramp, NTW Ramp and NBE Ramp. These range in length from 550 ft up to 1775 ft with four span up to eleven span structures. The three overcrossings are Patrician Way OC, Valley Blvd OC and Hellman Ave OC with lengths from 220 ft up to 440 ft.

For Alternative F6, a total of 12 bridges will be replaced. There are 8 overcrossings (OC) going over the SR 710 including Hellman Ave OC, Poplar Blvd OC, Huntington Dr OC, Monterey Road OC, Railroad OH, Mission St OC, Columbia St OC, Green St OC and California OC. These structures range in length from 200 to 400 ft and typically consist of 2 spans with columns in the SR 710 median. Also, there are 4 undercrossings (UC) that are part of the SR 710 freeway. These are roughly 140 ft wide and range in length from 200 ft to 1650 ft. There is a single span UC and up to seven span UC.

Alternative F7 consists of 6 structures which are all overcrossings including Valley Blvd OC, Hellman Ave OC, Del Mar Blvd OC, West Green St OC, West Colorado Blvd OC and West Union St OC. Bridge lengths vary from 220 ft up to 460 ft with single span thru four-span structures.

5.1.1 Order of Work Constraints

In the majority of the overcrossing bridges, the assumed order of work consists of first constructing the secant pile walls while removing the existing bridge and building the new structure in stages, and then excavating the SR 710 roadway to the proposed profile grade. It is important to emphasize that, if the replacement structure is constructed after the roadway excavation, a significantly taller falsework system will be required for casting the bridge superstructure. Temporary shoring may be required below the existing structure to permit access for drilling operations if the secant pile wall is constructed prior to removing the existing bridge above the wall.

5.1.2 Stage Construction Considerations

It is presumed at this time that most of the overcrossings will use the same alignment and width as the existing bridges. Construction staging during demolition and construction of the new overcrossing structures must therefore be considered if detours are not available and traffic cannot be totally stopped on the existing bridges. All Freeway Alternatives and Highway Alternatives include overcrossings on the SR 710 alignment.

5.2 Ramps

The ramp structure type is selected based on the location, bridge span length, available clearance and other constraints. Most of the time, a cast-in-place, prestressed concrete box-girder bridge is likely the most cost-effective solution and thus is recommended for ramp structures. Locating bents through roadway/freeway alignment is critical for reasonable span lengths. This will control the superstructure depth of the ramp structure. The bent foundation consists of pier shafts in accordance with conceptual geotechnical judgment. It will also minimize the foundation footprint.

Alternative F5 includes 6 ramps that range in length from 550 ft up to 1775 ft with four span up to eleven span structures. Ramp width varies from 30 ft to 60 ft. Structure depth is kept at a constant 8 ft for all ramps.

5.3 Freeway Cut-and-cover Tunnel

The cut-and-cover tunnel will be used as the transition of the roadway from the surface level to the tunnel level. These structures are a reinforced concrete box-type structure. The number of concrete boxes varies from one to five based on the locations in the proposed SR 710 alignment. At each tunnel intersection, two concrete boxes will be placed one over another to match the profile of the roadway inside the bored tunnel. Each concrete box will be designed to accommodate the necessary utility system. At this time, it is the geotechnical judgment that the existing soil-bearing capacity will be able to accommodate the cut-and-cover tunnel system.

Alternative F-2 south cut-and-cover tunnel is 1750 feet long, while the north is 2150 feet long. Alternative F-5 cut-and-cover tunnels are broken into two parts: south, and north. The south cut-and-cover tunnel is roughly 1750 feet in length and the north tunnel is 1200 feet long. Alternative F-6 has one main cut-and-cover tunnel system, referred to as Glenarm and Bellfontaine. Total length is approximately 2000 feet. Alternative F-7 south cut-and-cover tunnel is 1750 feet in length, while the north tunnel is 1600 feet long. Finally, Alternative LRT-4D has three separate cut-and-cover tunnel systems with lengths of 2800 feet, 7800 feet ,and 8800 feet, respectively. These are all single concrete box cut-and-cover tunnel structures.

5.4 LRT Structures

The structural design for the LRT alternatives meets all applicable portions of the Metro Rail Design Criteria, state of California general laws, regulations, codes, and manuals pertaining to structural design. This includes criteria for: Bridges, aerial guideways, cut-and-cover subway structures, tunnel's passenger stations, earth-retaining structures, and surface buildings.

For design of aerial guideways, superstructures will consist of cast-in-place prestressed concrete box girders, either single cell or multi cell, depending on the overall width of the track way. The superstructure will span from 80 feet to about 150 on single or multi column bents. The sizes of the piers will range from 5 feet to 7 feet and will be supported on reinforced concrete footings with pile foundations. The structure approaches will have MSE walls on both sides at start and end of the structures. Duct bank will be either supported at the edge or in the median of the box structures.

Each structural component shall be designed for the appropriate load combination limit states and load factors as specified in Section 5 of the Metro Rail Design Criteria. Additionally, for precast segmentally constructed bridges, consider load combination in Caltrans BDS implemented AASHTO LRFD equation 3.4.1-2 for service limit state(Service VI in table 5-2 Metro Rail Design Criteria).

Underground guideways and structures are enclosed facilities, requiring special structural and geotechnical design considerations that may include: lighting, ventilation, fire protection systems and access and emergency egress capacity based on Metro’s determination.

The structural shells for tunnels consist of plate elements, such as: walls, base slabs and roofs. These items form the resisting box along the longitudinal axis of these structures and shall be contiguous moment resisting structural elements. These elements are intended to give resistance to all static, dynamic and seismic forces and distortions in accordance with design criteria through structural continuity, redundancy, and ductility for the service life specified.

SECTION 6

Bored Tunnel Considerations and Construction Methods

6.1 Tunnel Configurations

6.1.1 Freeway Tunnel Configuration

The freeway tunnel configuration is governed by regulatory agency requirements as well as the space needed for ventilation, traffic operations, and equipment. The tunnel configuration is largely determined by required horizontal and vertical freeway clearances and other uses of tunnel space, such as for emergency egress, ventilation ducts, drainage, communications, and utilities.

Current regulations, guidelines, and criteria established by Caltrans and other regulating agencies, outlined below, were reviewed when developing the designs and configurations in this evaluation. Two tunnels that were considered as a basis for some of the space allowances were the Caldecott 4th Bore Tunnel and Devil's Slide Tunnel, both in northern California; these are Caltrans' most recent highway tunnels. Additionally, engineering standards and applicable regulations that do pertain to tunnels of this size change with time; therefore, it will be important to revisit the criteria as the project proceeds through the planning, design, and environmental review phases.

Chapter 300 of the Caltrans HDM, "Geometric Cross Section," provides guidance on dimensions for roadway width, shoulders, and other horizontal and vertical clearances (Caltrans, 2012). Requirements from the ADA and NFPA were also consulted, in addition to precedents from previous large-diameter tunnel projects.

6.1.2 Roadway Width

In accordance with Index 301.1 of the Caltrans HDM, the standard lane width should be 12 feet per lane. This has been adopted as the width of the travel lanes for this project.

6.1.3 Shoulders

Shoulder requirements were based on Index 309.3, "Tunnel Clearances," of the Caltrans HDM, which specifies requirements for tunnel shoulders and surface road freeway shoulders. Index 309.3 states the following for tunnels:

> *Tunnel construction is so infrequent and costly that the horizontal width should be considered on an individual basis. For minimum width standards for freeway tunnels see Index 309.1.*

Index 309.1(3)(a) of the Caltrans HDM, which provides mandatory standards on minimum clearances, directs the reader to Table 302.1, Mandatory Standards for Paved Shoulder Width. Table 6-1 provides mandatory shoulder widths according to HDM Table 302.1.

TABLE 6-1
Mandatory Shoulder Widths

Total Number of Lanes in Both Directions	*2 Lanes	*4 Lanes
Left Paved Shoulder Width	Not specified	5 feet
Right Paved Shoulder Width	8 feet	10 feet

Notes:
*Total number of lanes in both directions

Shoulder widths of 2 and 8 feet on the left and right sides of the freeway, respectively, are recommended for this project at this time. The left shoulder is a clearance allowance between the travelled way and the pedestrian walkway, because it is not wide enough to accommodate a vehicle. These widths are similar to those used in the Devil's Slide Tunnel, which was recently constructed for Caltrans. At Caltrans' request during the review of the conceptual engineering study, a 10-foot-wide right shoulder will be evaluated and used in future phases of this project in order to comply with HDM Section 300 that requires freeways to have a 10-foot right shoulder.

6.1.4 Pedestrian Walkways

No specific guidelines are available from Caltrans on tunnel walkway widths. However, the Devil's Slide Tunnel and Caldecott 4th Bore Tunnel provide recent Caltrans examples. Walkway width is approximately 4 feet in the Devil's Slide Tunnel and slightly over 3.3 feet in the Caldecott 4th Bore Tunnel. Because of the lack of specific guidelines in the Caltrans HDM, requirements from the ADA and NFPA were consulted for determining walkway widths. Two 3.6 feet walkways are proposed. At Caltrans' request during the review of the conceptual engineering study, a 4-foot-wide walkway will be provided on the side of the cross passages in future phases of this project. This will provide room for a 10-foot right shoulder and provide a greater emergency walkway width on the remaining walkway.

6.1.5 Americans with Disabilities Act

The ADA does not specifically address freeway tunnel requirements. Interpretation of applicable ADA provisions for other transportation facilities suggests a minimum walkway width of 3 feet be provided to accommodate wheelchairs. ADA guidelines specify wheelchair ramp slopes that range from 1:12 to 1:20 (vertical: horizontal), depending on the maximum horizontal distance between landings. Also, the cross- slopes on wheelchair ramps are not to exceed 1:50 (vertical: horizontal). Future consideration is being given to not providing a curb along the walkways to more easily accommodate ADA requirements.

6.1.6 National Fire Protection Association

NFPA 502 (2011), as shown on Table 6-2, requires a minimum emergency walkway width of 3.6 feet on the side of the tunnel adjacent to cross passageways for the full tunnel length of the tunnel. It is also stated that the walkway must be protected from oncoming traffic by either a curb, change in elevation, or barrier. A minimum walkway width of 3.6 feet, which meets the NFPA requirement, is recommended for the walkways on both sides of the freeway tunnel alternatives. Having the walkways on both sides of the tunnel is conservative; depending on the operating approach, it may be possible to eliminate one in the future, provided adequate public safety can be provided. A vertical grade separation of 6 inches between the shoulder/roadway and the walkway is currently shown in the design, which may be eliminated in future phases of this project to more easily accommodate ADA requirements.

6.1.7 Vertical Clearance

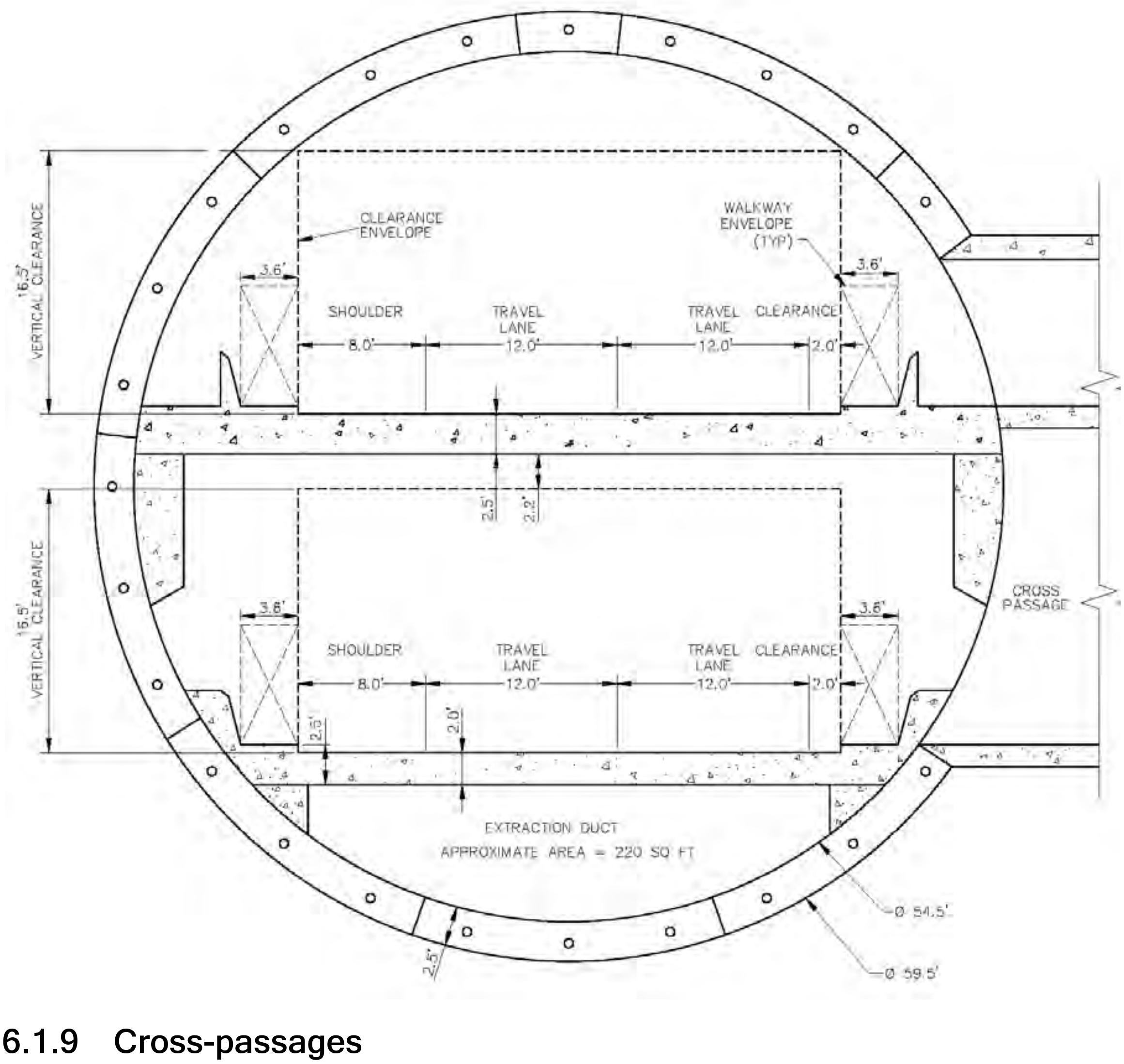
The vertical clearance is determined by the clear height required above the highway grade for traffic. Caltrans HDM Table 309.2A, "Minimum Vertical Clearances," indicates that a freeway (new construction) is required to have a minimum vertical clearance above the travel lanes and shoulders of 16.5 feet. Additionally, the vertical clearance to signs and minor structures is 18.5 feet for a normal at-grade freeway. For the purposes of developing the tunnel cross-sections for this study, a vertical clearance of 16.5 feet was used for the vertical clearance to minor structures and signs for the tunnel; this is similar to the 16.7 feet of vertical clearance in the Caldecott 4th Bore. If a maximum posted vehicle height of 15 feet could be used for the tunnels, this would provide a clearance of about 1.5 feet between the top of a vehicle and the lowest of any appurtenances installed in the tunnel based on the configuration proposed.

ADA standards require a minimum vertical clearance of 80 inches above walkways. Chapter 300 of the Caltrans HDM does not provide clear guidance on the minimum vertical clearance required above walkways. The vertical clearance used for the walkways in this evaluation is 7.5 feet, which is similar to the current design of the Caldecott 4th Bore Tunnel.

6.1.8 Conceptual Design Cross-section

The proposed freeway tunnels will be two bored tunnels, each carrying four lanes of traffic in a stacked configuration, with all four lanes of traffic in each tunnel moving in the same direction, which is consistent with the SR 710 [Environmental Impact Report/Environmental Impact Statement] EIR/EIS Results and Future System Performance Report (CH2M HILL, 2012b). The inside diameter for each of the four-lane tunnels is proposed to be 54.5 feet. The outside diameter of the tunnel is 59.5 feet (accommodating a tunnel lining thickness of 2.5 feet). The inside diameter of the tunnel was dimensioned based on the smallest-diameter circle that could fit around the components of the tunnels, as described in the preceding sections. Figure 6-1 shows the tunnels' internal configuration and dimensions.

FIGURE 6-1
Southbound Freeway Tunnel Configuration



6.1.9 Cross-passages

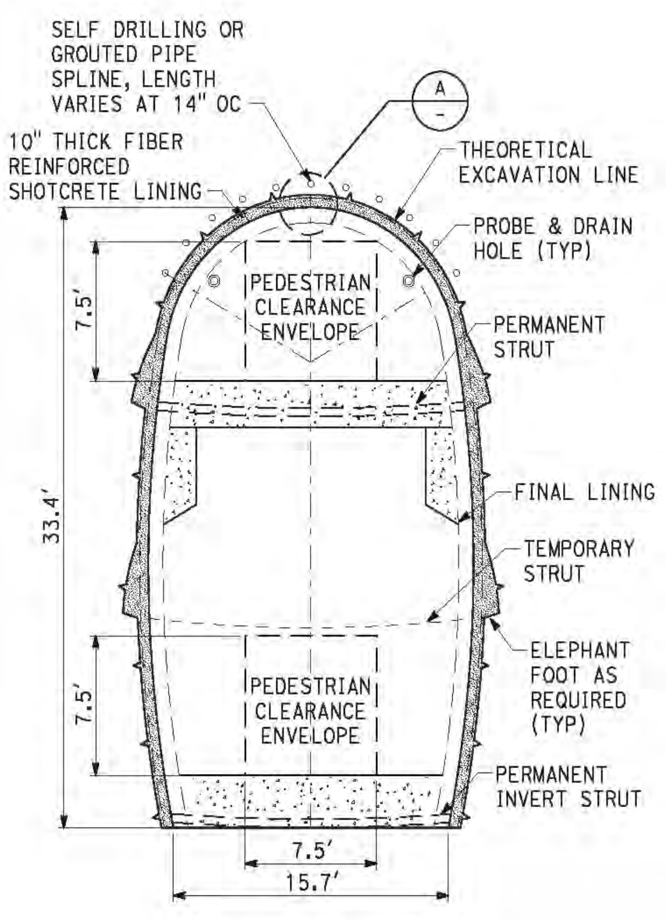
From a safety perspective, providing a safe means of egress in the event of an emergency is a critical design consideration for the tunnels. The freeway tunnel configuration has twin bores, and therefore can accommodate cross-passages that connect each tunnel bore to the adjacent bore, thereby providing a means of egress from one bore to another. Cross-passages (sometimes referred to as tunnel cross-passageways) can be used instead of tunnel emergency exits to the surface. These cross-passages proposed for the SR 710 project were dimensioned following the minimum clearance requirements specified in the relevant NFPA sections. Two typical cross-passages are proposed for the freeway alternatives: one is to provide means of egress for people, and the other is for emergency vehicles.

6.1.9.1 Pedestrian Cross-passages

The shape and dimensions of the typical cross-passage for pedestrians were developed based on the stacked configuration of the freeway tunnels, the minimal clearances for walkways, and the assumed tunneling method to be used. The clearance envelope for the pedestrian walkway is approximately 7.5 feet wide by 7.5 feet high on each level of the tunnel. The section was designed so that the pedestrian cross-passages are on the same level as the walkways in the vehicle tunnels so that no steps or ramps would be required. The final configuration and clearances meet the NFPA 502 requirements for road tunnels as mentioned in Table 6-2. The cross-passages will be spaced approximately every 650 feet in accordance with NFPA 502 (2011).

In maintaining the clearance envelope developed for the specified freeway tunnels, the total external height of the pedestrian cross-passage is proposed to be approximately 34 feet. A modified horseshoe shape is proposed to minimize cross-sectional area while accounting for the required clearances; details regarding the excavation and support of these cross-passages follow in Section 6.3.4. Figure 6-2 shows the dimensions of the typical cross-section of the pedestrian cross-passages.

FIGURE 6-2
Pedestrian Cross-passage Cross-section (Freeway)



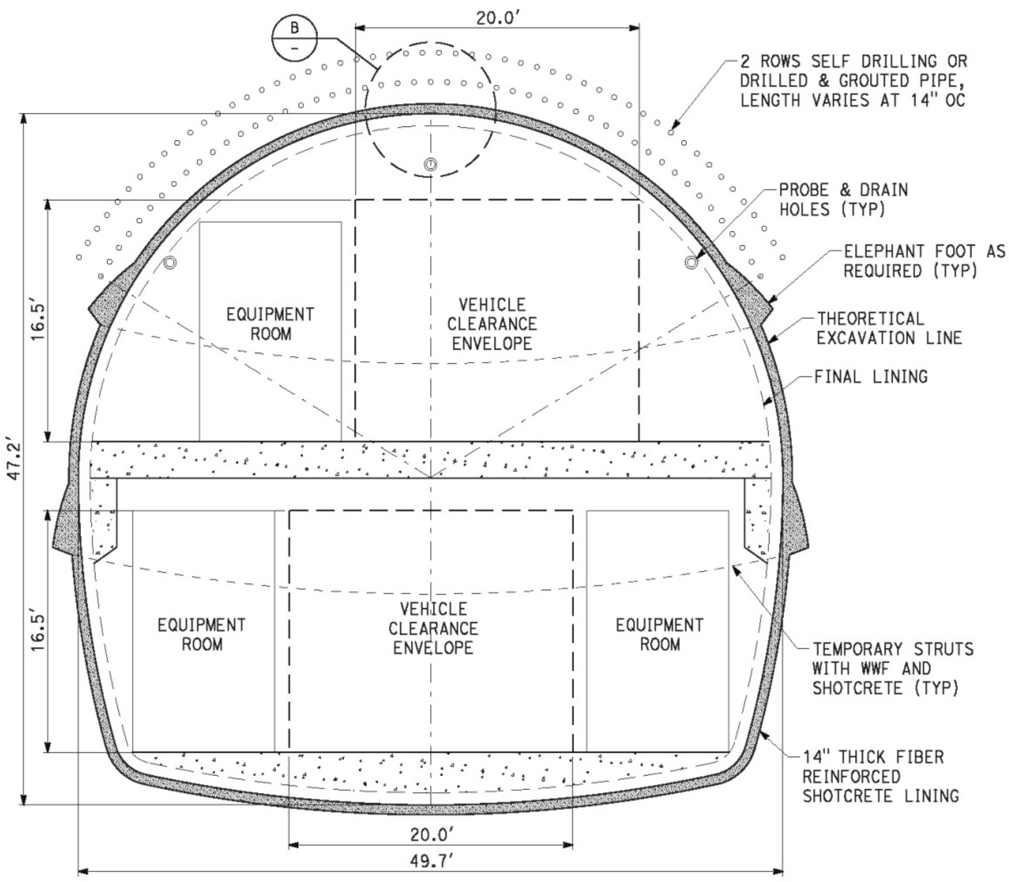
6.1.9.2 Emergency Vehicle Cross--Passage

There are no regulations in the HDM or set by NFPA requiring cross-passages for emergency vehicles; however, available information was reviewed regarding emergency vehicle cross-passages provided for recent twin bore freeway tunnels throughout Europe and the US. This review included road tunnel projects such as the Port of

Dublin Tunnel, M-30 Tunnel (Spain), Devil's Slide Tunnel (California), and Sparvo Tunnel (Italy). It was found that these tunnels have larger cross-passages—occurring less frequently than the pedestrian cross-passages—for emergency response vehicles to cross between the tunnel bores in an emergency. These passages can also be used to transfer passenger vehicles between bores in an emergency. Based on this review, it is suggested that every fourth cross-passage be an emergency vehicle cross-passage, which equates to a spacing of approximately 2,600 feet between emergency vehicle cross-passages.

For the typical emergency cross-passage, a minimum clearance envelope of 20 feet wide by 16.5 feet high is provided for the emergency vehicles. Additional width at the entrances/exits to the freeway bores may need to be further reviewed to accommodate the turning radius of the emergency vehicles. An optimized shape was developed for the typical cross-section because of the sequential excavation method (SEM) that is expected to be employed for the cross-passage construction. This shape fits around the required components and clearances and maintains the stacked configuration of the freeway tunnels. Based on the required clearances for the emergency vehicles and space for tunnel operations equipment, the total excavation dimensions for the emergency vehicle cross-passages are approximately 50 feet wide by 48 feet high. Figure 6-3 shows the dimensions of the typical cross-section of the emergency vehicle cross-passages; details regarding the excavation and support of these cross- passages follow in Section 6.3.4.

FIGURE 6-3
Emergency Vehicle Cross-passage Cross-section



6.1.10 Tunnel Refinements

Several other items will need to be further designed in order to confirm the conceptual design dimensions. These items, such as the segmental lining thickness, roadway/slab thickness, and the areas needed for ventilation, equipment, and signage, are discussed in other sections of this report.

6.2 LRT Alternatives Configuration

In contrast to freeway tunnels, Metro has published design criteria (Metro Rail Design Criteria) for LRT circular bored tunnels (Metro, 2010). Information from previous and current LRT projects for Metro was also reviewed. The Regional Connector Transportation Corridor (RCTC) LRT project is currently in design for Metro in downtown Los Angeles; the cross-sections from the RCTC were referenced to determine the conceptual configuration for this project. It is assumed that the LRT tunnels will be constructed as twin-bored tunnels, each bore with one LRT track, similar to those of the RCTC project.

6.2.1 Vertical and Horizontal Clearances

The vertical clearance provided in this cross-section is approximately 14 feet from the top of rail, which is consistent with what was used in the design of the RCTC. The horizontal clearance envelope is approximately 12.25 feet wide, centered over the centerline of the tracks, which exceeds what was used on the RCTC project. This horizontal clearance will accommodate LRT operations on a horizontal curve. Additionally, approximately 4 inches of air clearance remain between the clearance envelope and the segmental lining. Sufficient space remains above the LRT clearance envelope for the overhead contact system (OCS).

6.2.2 Pedestrian Walkway

A walkway running the entire longitudinal length of the tunnel is necessary to provide pedestrians access to egress locations in the event of an emergency. NFPA 130 (2010) requirements, as referenced in Table 6-2, state that the minimum unobstructed walkway should be at least 2.5 feet wide and 6.7 feet high. ADA requires a minimum of 3 feet of width to accommodate wheelchairs. The proposed clearance envelope for the LRT walkway meets these requirements.

6.2.3 Conceptual Design Cross-section

The inside diameter for each of the LRT tunnels is shown as approximately 20 feet, which exceeds the minimum diameter requirements outlined in the Metro Rail Design Criteria (2010). The outside diameter of the tunnel would be 22 feet, with a maximum assumed tunnel lining thickness of 12 inches. Further modifications of this cross-section will be made in future phases of this project. Figure 6-4 shows a generalized concept of the tunnels' internal configuration; it does not include details of the vehicle dynamic envelope, pantograph, or overhead contact system.

6.2.4 Cross-passages

The proposed LRT pedestrian cross-passage configuration was based on a configuration referenced in previous and current LRT Metro projects. The cross-passages designed for Metro's RCTC tunnels meet the NFPA 130 requirements (Table 6-2) and provide a minimum clearance envelope of 3.7 feet in width and 7 feet in height. The internal cross-passages are approximately 14.5 feet high (invert to crown), and 9.5 feet wide at springline. The "egg-shaped" configuration is derived by the optimal cross-section selected for SEM tunneling expected to be employed for the cross-passage construction; details regarding the excavation and support of these cross passages follow in Section 6.3.4. Figure 6-5 shows the dimensions of the typical cross-section of the LRT cross-passages. The cross-passages will be spaced approximately every 800 feet, in accordance with NFPA 130 (Table 6-2).

FIGURE 6-4
LRT Tunnel Conceptual Configuration

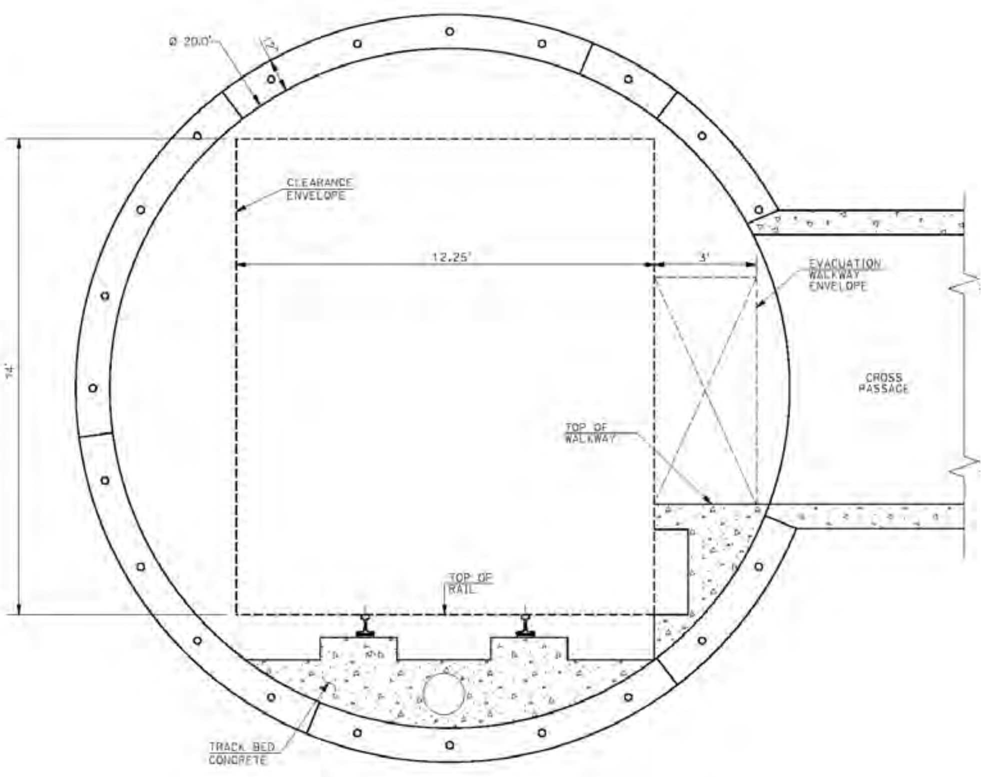
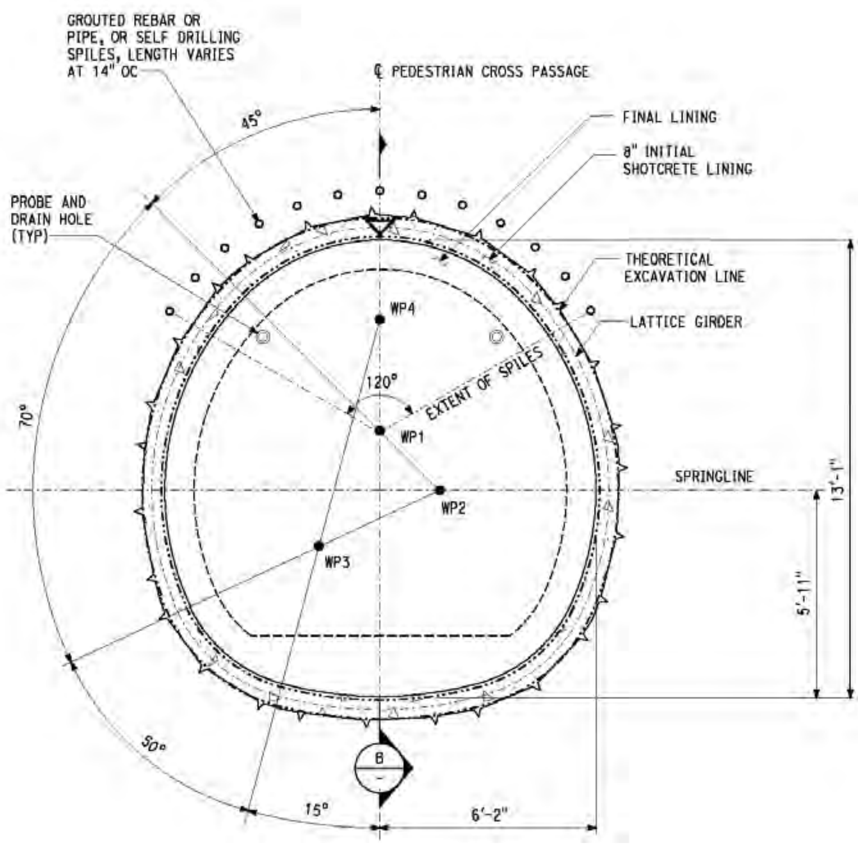


FIGURE 6-5
Pedestrian Cross-passage Cross-section (LRT)



6.2.5 Tunnel Design for Fault Offset

Tunnels and underground structures generally perform well in earthquakes, except where ground displacement could occur where the tunnel crosses active faults or where other seismically induced ground failure such as slope failure or liquefaction could occur. It is a challenge to design a practical structure that can accommodate large fault offsets; however, crossing the Raymond fault cannot be avoided for several alternatives of the current study. Significant lining damage can be expected as a result of fault offset where the tunnel structure crosses this fault zone, and the objective would be to design the structure to avoid collapse in an earthquake and at the same time have a system that could be repaired without major reconstruction to restore functionality after an event.

To accommodate the expected fault offset, a larger tunnel vault reach for each tunnel bore is proposed. The following important aspects of the Raymond fault crossing were considered in the conceptual design based on the information from CH2M HILL's Final Geotechnical Summary Report (2010):

- The dip of the fault appears to be about 80 degrees to the north.
- The anticipated amount of lateral offset per event is estimated at 0.8 to 3.4 feet with a vertical component approximately 8 percent of the lateral offset (CH2M HILL, 2010).
- The fault can be considered "a left-lateral reverse oblique fault, but primarily a strike-slip feature" (CH2M HILL, 2010).
- The width of the fault zone and distribution of slip planes have not been accurately established and will be determined during the future phases of this project. The length of the vault cavern has been conservatively chosen to address this uncertainty in fault zone width and position, and the fault slip is assumed to occur at one plane.

The proposed vault reach will be 300 feet long so as to extend it well beyond the anticipated boundaries of the fault width, and will consist of an enlarged tunnel cross-section to accommodate the fault offset. The vault cross-section will be sized to allow for a 4-foot fault offset, and will be designed as a series of ring elements with shear fuses to allow the offset to occur without collapse of the tunnel lining. The design will include widened corbel supports and an articulated roadway deck structure to allow for the lateral movement in the freeway tunnel. Figures 6-6 and 6-7 show the vault in cross-section for both the freeway and LRT alternatives, respectively. Additional concepts, such as a concept where the roadways move as a separate structure independently from the tunnel lining, will be studied in the next phase of this project.

FIGURE 6-6
Special Seismic Section—Freeway

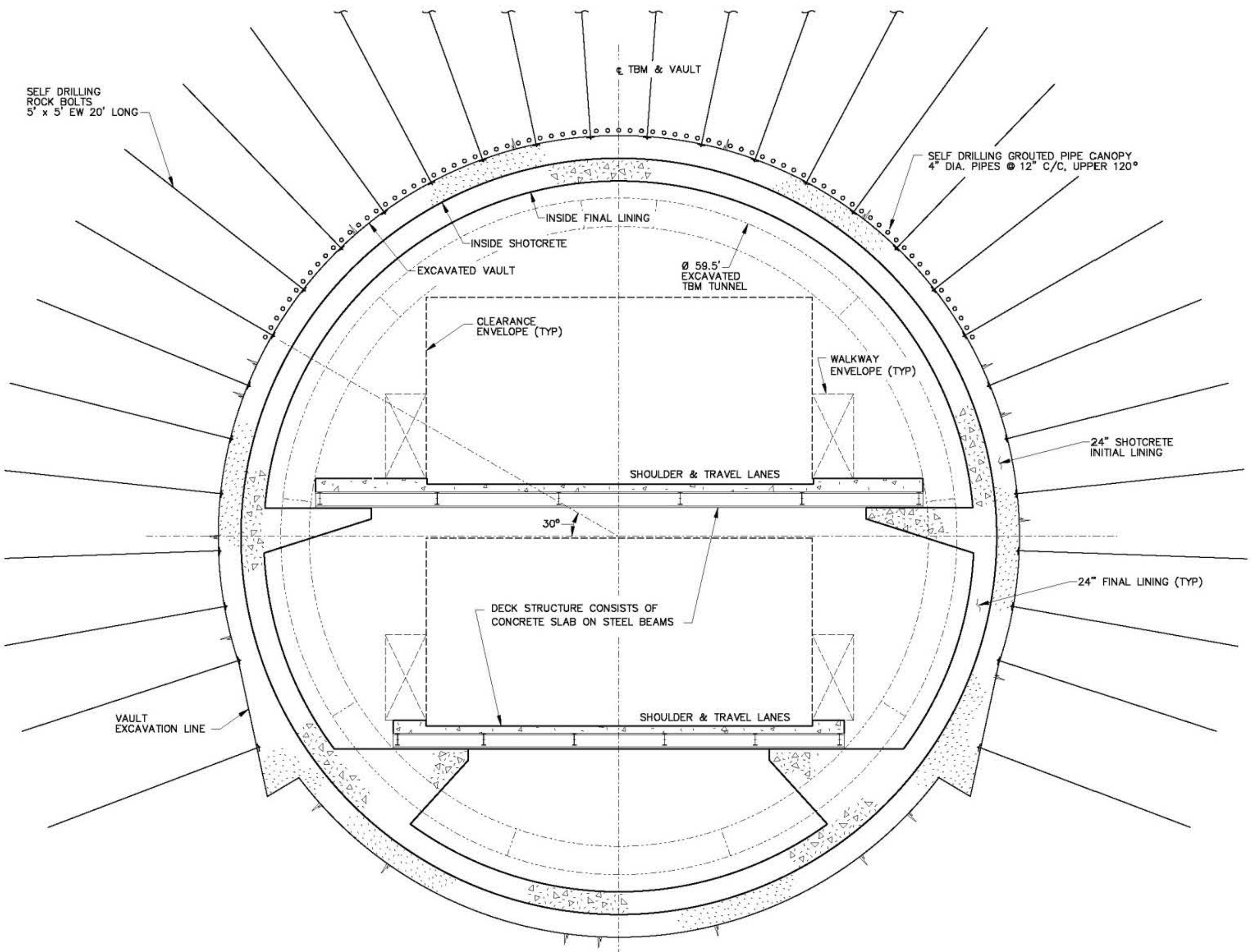
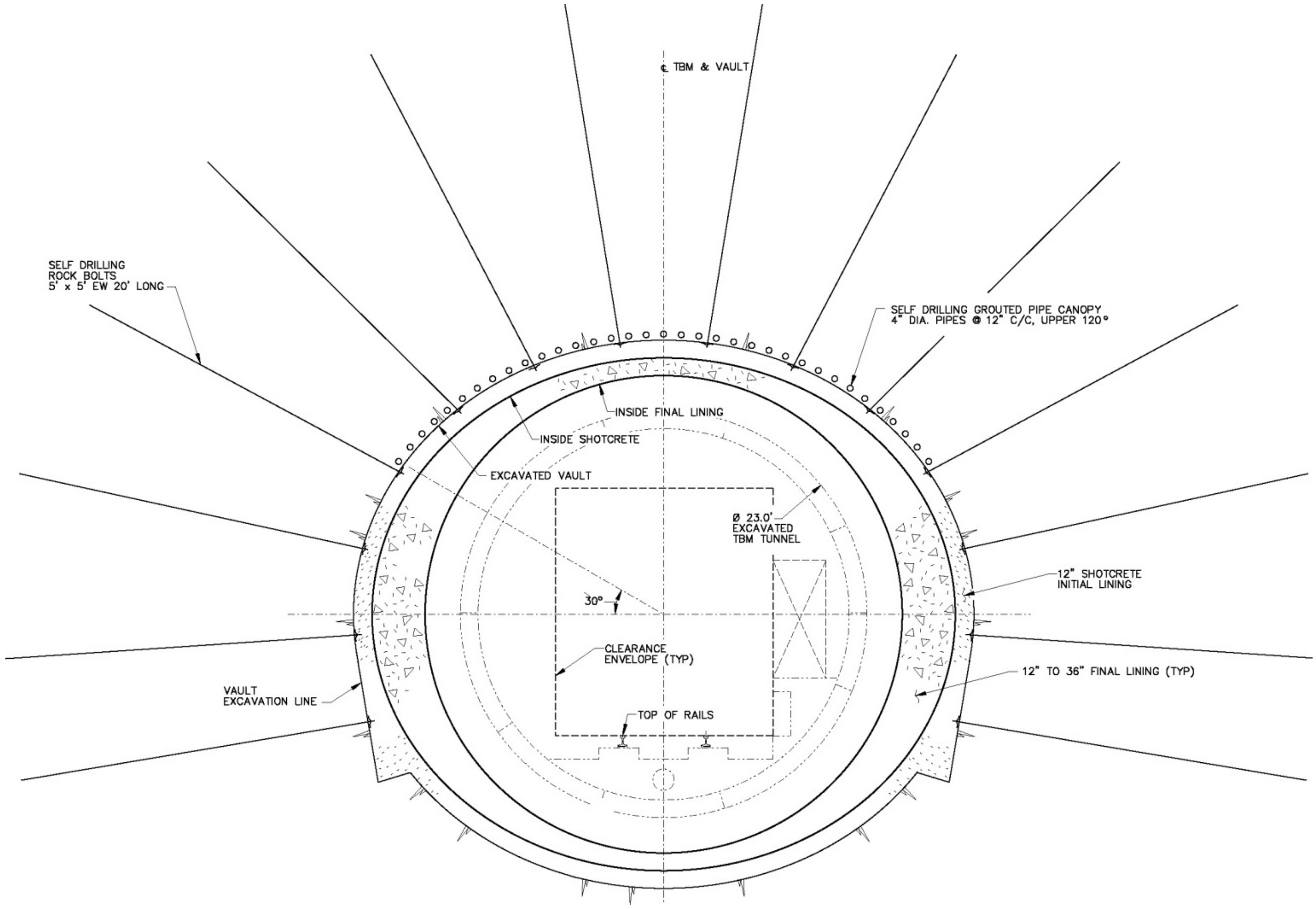


FIGURE 6-7
Special Seismic Section—LRT



6.3 Assumed Tunnel Excavation Methods

The method of excavation for tunnels and other tunnel components, such as cross-passages and utility chambers, is largely governed by the ground and groundwater conditions. Typically in long tunnels, using a tunnel boring machine (TBM) and a precast concrete liner system is desirable because of cost and schedule. However, in most tunneling projects, tunnel components (cross-passages, utility chambers, etc.) can be constructed more effectively using conventional hand-mining methods, which are commonly referred to in the tunneling industry as SEM.

6.3.1 Freeway and LRT Tunnel Alternatives

Where ground conditions are appropriate, TBM excavation methods are generally more cost-effective for long tunnels because the additional equipment expense is offset by higher advance rates, as compared to the SEM. Because of the length and size of the proposed freeway and LRT tunnels, it is assumed that the tunnels would be excavated by a TBM. Various TBM types could be considered for the excavation of the tunnels; the feasibility of each TBM method should be evaluated considering the following factors:

- Soil/rock type
- Strength and abrasivity of ground
- Permeability of ground
- Maximum groundwater pressures
- Grain size characteristics
- Uniformity of ground conditions

- Expected ground behavior (for example, standup time and heading stability)
- Potential for hazardous gasses

Considering the range of ground and groundwater conditions along the tunnel alignments, the use of a pressurized-face TBM seems the most viable approach for this project. Pressurized-face TBMs that include earth pressure balance tunnel boring machines (EPB TBMs) or slurry pressure balance tunnel boring machines (slurry TBMs) are likely most suitable for the anticipated ground conditions found in the five alternatives and for meeting other project requirements.

These specialized TBMs could be adaptable to the expected range of anticipated geologic conditions or by using a flexible approach that allows excavation methods to be changed to suit the geology or perform well in mixed-face conditions. Because of the variability in geology along the proposed alternatives, the TBM could have a cutterhead with tools that could be changed to excavate either soil or rock. Pressurized-face excavation methods would likely need to be used for face stability in the alluvium or in fractured or crushed rock zones. Using these pressurized-face methods can reduce the potential for ground loss into the face of the tunnel during excavation and, in turn, ground surface settlement.

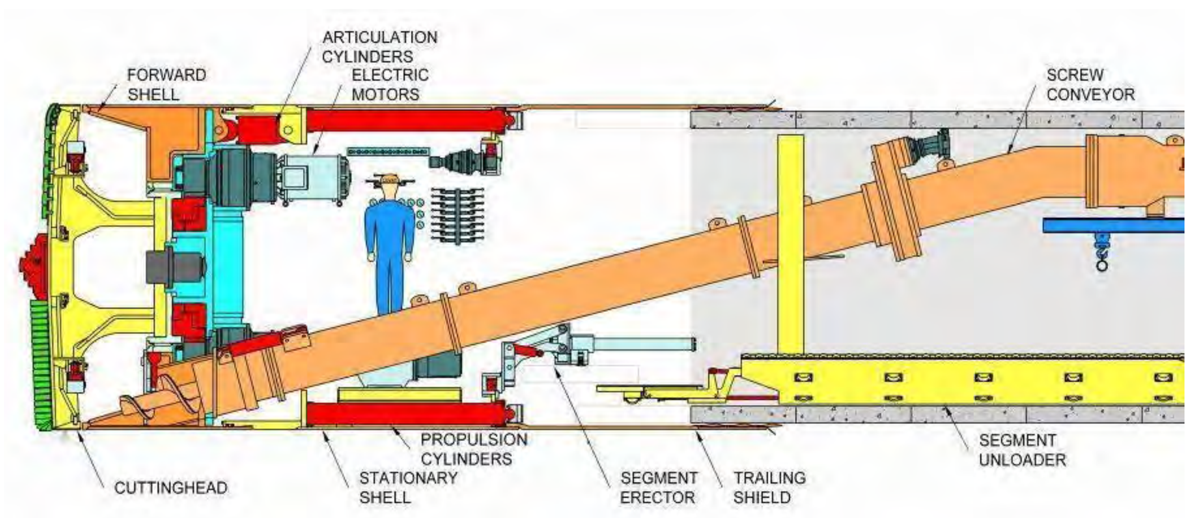
The main characteristics of these pressurized-face TBM methods are discussed in detail in the following sections. Excavation methods for cross-passages will involve other approaches that can control groundwater inflows and stabilize the ground to prevent unacceptable ground movements from occurring.

6.3.2 Earth Pressure Balance Tunnel Boring Machines

In the EPB TBM method, earth pressures at the face are a result of hydrostatic and active earth pressures. A screw conveyor is connected to the plenum and by synchronizing the TBM advance rate and the screw conveyor extraction rate, pressure is maintained constantly to counterbalance the face pressure.

A schematic diagram of an EPB TBM is shown in Figure 6-8. Excavated spoils are discharged onto a conveyor belt through a slide gate at the rear of the screw auger and then into muck cars. Slide gates may be positioned along the screw conveyor to remove obstructions such as rock clasts or cobbles.

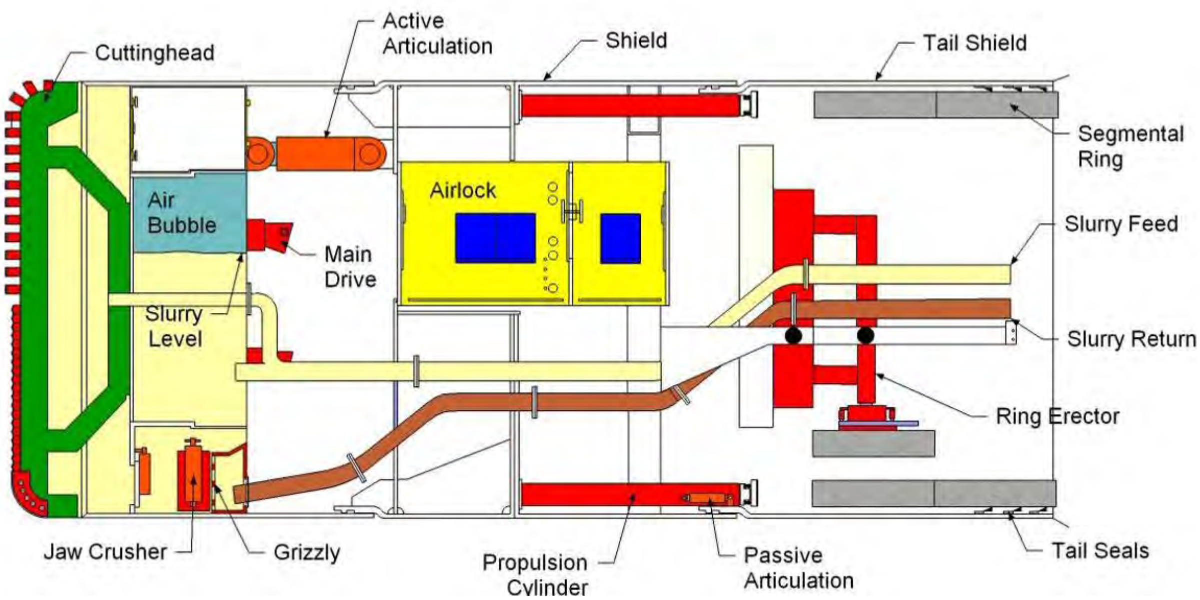
FIGURE 6-8
EPB TBM Schematic



6.3.3 Slurry Tunnel Boring Machines

Slurry TBMs rely on bentonite slurry to apply a positive pressure to the tunnel face, which counterbalances the external earth and hydrostatic pressures. This is achieved by a filter cake, or “impermeable” membrane, that forms on the tunnel face as excavation proceeds. In slurry tunneling, the use of bentonite can be minimized or omitted if the ground contains adequate clay-sized particles. The excavated material is suspended in the slurry and pumped through a closed piping system to a slurry separation plant at the ground surface, where the suspended material is removed from the slurry. The muck removed at the separation plant is disposed of off-site, while the slurry is reconditioned and pumped back to the tunnel face. In addition to counterbalancing the external pressures at the tunnel face, the slurry also helps lubricate the cutterhead, reduces cutting tool abrasion, and makes spoils inert for ease of solid removal. A longitudinal section of a slurry TBM is shown in Figure 6-9.

FIGURE 6-9
Slurry TBM Schematic



6.3.4 Cross-passages

Based on the expected ground conditions and cross-passage lengths, it is assumed that the excavation and support of the cross-passages for both the freeway and LRT tunnels would be performed using SEM. This method offers flexibility in geometry such that it can accommodate almost any size of opening. The method is employed in hard rock using drill-and-blast excavation techniques, medium hard and soft rock using roadheaders, and soft ground using backhoe excavation. The typical tunnel cross-sections for SEM include egg-shaped or modified horseshoe-shaped configurations to promote smooth stress redistribution in the ground around the newly created opening.

During the SEM excavation, the construction sequence is routinely adjusted to account for the changes in ground conditions and required support. In SEM, tunnel excavation and support are performed in a series of drifts that are sequenced to create successively larger openings until the design profile is achieved. An example of an SEM excavation in progress is shown in Figure 6-10.

FIGURE 6-10
Beacon Hill Station—SEM Execution

The execution of tunnel excavation and ground support using this method typically includes the following main guidelines:

- Ground and excavation and support classification based on a thorough ground investigation.
- Predefinition and implementation of ground support classes based on actual ground conditions observed in a routine manner.
- Continuous monitoring of ground settlements and conditions using geotechnical instrumentation.
- Prior to tunneling excavation, installation of pre-excavation support elements and ground improvement, including grouting, spiling, dewatering, ground freezing, and other measures.
- During excavation, placement of ground support elements—including shotcrete, lattice girders, steel sets, and other elements—to provide a rapid and fast-setting support to the exposed ground. Shotcrete is typically reinforced by steel fibers or welded wire fabric; occasionally, plastic fibers are also used for reinforcement.
- Employment of a dual-lining support consisting of an initial shotcrete lining and a final, cast-in-place concrete or shotcrete lining.

In SEM tunneling, initial support is provided early on. In soft ground and weak rock it is required directly following the excavation of a specified length and is installed prior to the excavation of the next round in sequence. The intent is to provide structural support to the newly created opening and maintain safe tunneling conditions. Initial support layout is dictated by engineering principles, economic considerations, and risk management needs. With higher support demands of the ground and with shotcrete thicknesses of generally 6 inches or more, lattice girders may be embedded within the shotcrete. Occasionally and if needed by special support requirements, rolled steel sets are used instead of, or in combination with, lattice girders. Figure 6-11 shows shotcrete installation in a SEM excavation.

As shown in the proposed typical cross-passage designs for the freeway and LRT tunnels, the openings are designed to meet the required clearance envelopes. Egg-shaped or modified horseshoe-shaped configurations are used to reduce the cross-section areas and to increase stability during excavation. Fiber-reinforced shotcrete lining coupled with lattice girders and pre-support spiling (if needed) would be incorporated in the initial ground support design. The minimum thickness of the initial ground support shotcrete varies by the cross-section's span and the resulting ground support required. Invert closures are incorporated either by reinforced concrete/shotcrete, or permanent invert struts. This type of closure has a better distribution of stresses around the opening perimeter.

FIGURE 6-11
SEM—Initial Support Shotcrete Placed by a Robotic Arm

6.3.5 Seismic Vault

Construction of the tunnel vault reach at the Raymond fault zone poses a challenge not only in terms of constructability, but also because of its impact on the construction schedule. Three feasible concepts for constructing the vault reach have been considered and will be evaluated further after more detailed geotechnical information about ground conditions becomes available:

1. *Mine the vault reach cavern from within the TBM-driven tunnel*. At a safe distance behind the TBM and its trailing gear, install rock dowels and remove one ring of segments while installing the shotcrete lining as excavation support. Install a first round of grouted pipe spiles, remove the next ring of segments, excavate and install the shotcrete lining, and repeat this sequence for the length of the vault reach cavern. After excavation is complete, install a cast-in-place concrete final lining and the roadway deck structure. This operation would have an impact on the TBM trailing gear and mucking operations and the installation of the roadway deck or rail, and would require specialized equipment to disassemble the segmental lining.
2. *Mine the vault reach cavern from a drift driven around the TBM*. Depending on the trailing gear, a temporary adit could be driven from behind the TBM or its trailing gear. After construction of the vault reach cavern with SEM methods, the TBM is then walked through the vault reach cavern. The advantage of this approach is a more controlled vault reach cavern excavation, but results in an extended period of TBM down time while the vault reach cavern is excavated.
3. *Mine the vault reach cavern from a shaft ahead of the TBM drive*. The construction shaft would be about 200 feet deep and ideally should be situated near the tunnel alignment, which is in a congested, built-up area. The availability of suitable land will thus have to be investigated. After construction of the vault reach cavern with SEM methods, the TBM is then walked through the vault cavern. This approach allows construction of the shaft and vault reach cavern to begin while the TBM is being mobilized, and allows for a more controlled SEM approach to the vault reach cavern work.

The conceptual cost estimate is based on excavating the vault reach cavern using the approach described for the first option above, but this approach should be re-evaluated and refined in greater detail in future phases.

6.4 Tunnel Lining Concepts

A one-pass bolted and gasketed precast concrete segmental lining has been chosen as the initial and final tunnel lining over the entire tunneled alignment. The only exception is the vault section in the Raymond fault zone where a separate concept has been developed for the tunnel support, as discussed in Section 4. The lining will be designed to withstand temporary and permanent ground and groundwater loads, as well as other temporary loads such as construction and TBM jacking loads, seismic loads, and fire loads. Gaskets used in this lining render the lining essentially gas and watertight and prevent any substantial entry of groundwater into the tunnel. Geology and groundwater conditions along the SR 710 alignment will require a high-quality initial lining, and it is therefore economical to design this lining for the permanent loading as well. Such linings, in which the initial or primary support also functions as the permanent or final liner, have been employed reliably on many projects in the past, such as the large-diameters tunnels on the M-30 Project in Madrid.

6.4.1 Lining Analysis and Design

During this conceptual engineering phase of this project, the analysis and design of the lining is for static external ground and groundwater loads, because these will largely determine the lining thickness, concrete strength, and reinforcing percentages. The structural design of the lining, including the determination of load factors and resistance factors, is per the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications (2007). Assumptions regarding ground behavior, the methods used to determine the ground and groundwater loads on the lining, and lining analysis and design details are discussed in the following sections.

6.5 Geology and Groundwater Assumptions

The SR 710 tunnels will be excavated mostly in the soft interbedded siltstones, claystones, mudstones, and sandstones of the Puente, Topanga, and Fernando formations. The siltstones and claystones are more similar to very hard clays than rock; the sandstones are typically weak, friable, and sand-like, rather than rock-like. Occasionally in the Puente and Fernando formations, the layers are strongly cemented and more rock-like; however, these layers are typically only a few feet thick and not extensive. The Topanga Formation also includes a very strong conglomerate in the weak sandstone matrix, and a small portion of the alignment will be excavated in a weak Diorite basement rock. Based on this geology, the properties assumed in this analysis were for weak to very weak siltstones, claystones, and mudstones, assuming these are more soil-like than rock-like, because these are expected to produce the largest lining loads.

Groundwater along the tunnel alignment is variable; perched water will be present in the alluvium, and fault zones may act as water barriers and produce large groundwater differentials on either side. High groundwater levels have been conservatively assumed for this analysis. Additional investigations are required to better define the water table along the alignments.

6.5.1 Conceptual Ground and Groundwater Loads

The TBM used for this project is expected to have a large annular gap, on the order of 8 to 12 inches, between the excavated diameter and the segmental lining outer diameter. In order to prevent excessive ground convergence into this annular gap, shield bentonite injection and tail void grouting are typically used. Despite these measures, some ground convergence is expected to occur, resulting in ground relaxation around the tunnel. As the ground relaxes, the ground load on the lining reduces to some fraction of the full overburden. At this stage, however, because of the limited geotechnical data that are available, no ground relaxation is assumed. Full overburden load has been assumed to act on the segmental lining. Additionally, groundwater pressures have been assumed on the lining based on conservative interpretations of the groundwater level indicated in the borings. During future phases of this project, as additional geotechnical data become available, detailed estimates of ground relaxation will be performed. Details regarding the values of overburden height and groundwater levels used for the freeway and LRT linings are as follows.

6.5.1.1 Freeway Lining Loads

The ground cover over most of the alignments for the SR 710 freeway tunnels is in the range of 100 to 200 feet over the tunnel crown, except at the portals, where the cover is shallower. In terms of the tunnel diameter, this cover is equal to 1.7 to 3.3 diameters. The vertical ground load assumed for the analysis corresponds to 200 feet of overburden. Groundwater has been assumed to be 25 feet below grade, which is the shallowest groundwater indicated in the borings that are in proximity to the freeway alignments. Lateral load on the lining has been based on at-rest lateral pressures, as discussed in the following sections.

6.5.1.2 LRT Lining Loads

The ground cover over most of the alignment for the SR 710 LRT tunnels is approximately 60 feet, or three diameters, over the tunnel crown. Groundwater has been assumed to be 10 feet above the tunnel crown, which is the shallowest groundwater indicated in the borings that are in proximity to the LRT alignments. Lateral load on the lining has been based on at-rest lateral pressures, as discussed in the following sections.

6.5.2 Geotechnical Parameters for Analysis

The geotechnical parameters were obtained primarily from the Final Geotechnical Summary Report by CH2M HILL (2010). A range of K_0 values (0.5, 1.0, and 1.5) was assumed, based on values used for the nearby RCTC project and the Northeast Interceptor Sewer (NEIS) projects. Ground modulus values were obtained from the pressuremeter testing contained in the CH2M HILL (2010) report, generally ranging between 2,000 and 4,000 kips per square foot (ksf) in general, with a few values outside this range. For this analysis, the 2,000 ksf modulus value was used as a reasonably conservative modulus.

For the numerical analysis, two sets of parameters for ground strength were used, based on test data from the Topanga and Puente formations. The first set consists of ground modulus values and ground strength in terms of undrained shear strength from pressuremeter tests. In the second set, Mohr-Coulomb envelope parameters (cohesion and friction angle) were used. The undrained shear strength is used in numerical analysis to determine short-term (undrained) lining loads; the cohesion and friction angle are required to assess long-term lining (drained) loads as a result of pore pressure equilibration. As additional geotechnical testing is performed, the modulus values should be revised.

6.5.3 Analysis Methods

To determine forces on the segmental lining from the ground and groundwater loads, closed-form analysis methods were performed for both the freeway and LRT alternatives using the Ranken method (Ranken, 1978). Additionally, a numerical analysis was performed for the freeway alternatives using PLAXIS version 2D2010.01 (PLAXIS BV, 2010), a finite-element based numerical code.

The Ranken method calculates the moment, thrust, and shear for no-slip and full-slip conditions between the ground and the liner, providing bounding values for the forces on the liner.

The numerical method also calculates the moment, thrust, and shear in the lining and can model interaction between the tunnels. Because the materials modeled are “soil-like,” an elastic-perfectly plastic model was used for the analysis. The analyses were first run undrained to obtain the short-term loads on the lining, and then a fluid-mechanical coupled analysis was performed to dissipate the pore pressures around the tunnel and obtain the long-term loads on the lining. This analysis is valid for the cohesive layers of the Puente and Topanga formations under a high water table. When additional data are available for noncohesive strata, further analyses will be performed.

6.5.4 Load and Resistance Factors

Although full overburden and water pressure loads have been used in the analysis as mentioned above, load factors have still been used in the design. The load factor for soil load is 1.35 per AASHTO Bridge Design Specifications (2007), and the load factor for water pressure is taken to be 1.1, because water pressure is known with better certainty than the soil loads. For the Ranken analysis, these individual load factors were used, but for the numerical analyses an average load factor of 1.2 was assumed, because in this analysis it is not possible to separate the forces resulting from soil and water pressure loads. Resistance factors per AASHTO (2007) have been used for both Ranken and numerical analyses.

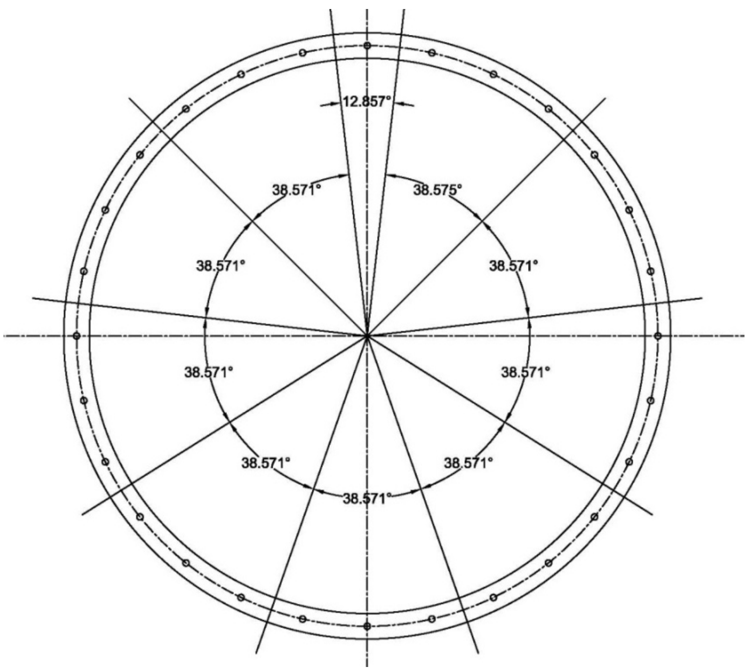
6.6 Freeway Alternatives

6.6.1 Freeway Segmental Lining Configuration

The segmental lining configuration chosen for analysis is shown in Figure 6-12. The liner is composed of nine segments plus a key, resulting in ten total joints. As described in Section 4.1, the tunnel has an inner diameter of 54.5 feet and an outer diameter of 59.5 feet, assuming a 30-inch segment thickness.

The axial and bending stiffness of the lining were reduced to account for joints and plywood packers between the segments. These calculations indicate that the axial stiffness reduction resulting from the presence of packers is approximately 25 percent, and the bending stiffness reduction resulting from the presence of joints is approximately 75 percent. For modeling purposes, an average reduction of stiffness of 50 percent has been assumed; this reduction is applied to the Modulus of Elasticity (E) of the concrete of the segments. The segment E has thus been modeled as 50 percent of the intact E.

FIGURE 6-12
Freeway Segmental Lining Configuration



6.6.2 Freeway Tunnel Analysis Results

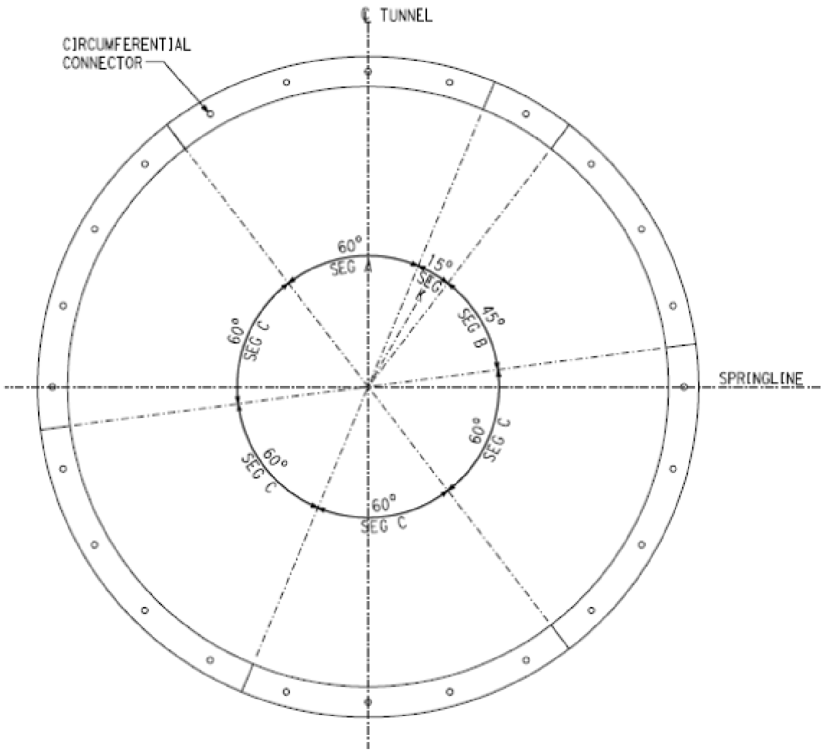
The Ranken and the numerical analyses both indicate that a 30-inch-thick lining with 1 percent reinforcing and 8,000 pounds per square inch (psi) concrete will be required, based on the worst-case ground conditions indicated by the geotechnical data currently available. As additional explorations are performed, the lining design can be refined to possibly accommodate lower concrete strengths and reinforcing percentages in better ground conditions. It is also likely that the overall lining thickness can be reduced during subsequent phases of the project; however, 30 inches is recommended at this time pending additional geotechnical and seismic investigations and more detailed design, including joint design, design for TBM thrust loads, and seismic design.

6.7 LRT Alternatives

6.7.1 LRT Segmental Liner Configuration

The liner is composed of six segments plus a key, resulting in seven total joints. The configuration, shown in Figure 6-13, shows three longitudinal bolts per regular segment and one bolt in the key. As described in Section 4.2, the current tunnel configuration has an inner diameter of 20 feet and an outer diameter of approximately 22 feet.

FIGURE 6-13
LRT Segmental Lining Configuration



The axial and bending stiffnesses of the lining were reduced to account for joints and plywood packers. The calculations indicate that the axial stiffness reduction, resulting from the presence of packers, is approximately 35 percent, and the bending stiffness reduction, resulting from the presence of joints, is approximately 65 percent. For modeling purposes, an average reduction of stiffness of 50 percent has been assumed; this reduction is applied to the Modulus of Elasticity (E) of the concrete of the segments.

6.7.2 LRT Tunnel Analysis Results

The Ranken analysis indicates that a 10-inch-thick lining with 1 percent reinforcing and 6,000 psi concrete will be required, based on the worst-case ground conditions indicated by the geotechnical data currently available. Although a numerical analysis was not performed, it is not expected that such analyses will significantly change the required lining thickness. This assumption is based on experience from projects such as RCTC in Los Angeles, and the University-Link Rail Project (U-Link) in Seattle, Washington. These light rail projects feature twin bore tunnels with similar diameter and spacing, overburden heights, and ground properties.

6.8 Tunnel Lining Fire Resistance

Resistance of the segmental lining for both the freeway and the LRT alternatives is a critical lining design criterion. At this conceptual engineering phase, the design fire event has not been fully defined and thus no analysis has been performed on the linings for a fire load. During future design phases, studies will be required to determine the effectiveness of the ventilation system in limiting the increase in the wall temperature of the final lining during the design fire to comply with NFPA criteria. The following measures can be considered to improve the performance of the final lining exposed to a fire, and increase its fire resistance:

- Increase the concrete cover over the reinforcing steel to 3 inches to restrict the temperature rise in the reinforcing steel to 300 degrees C
- Use polypropylene fibers in the concrete mix, which has been shown to prevent spalling of concrete during a fire

- Specify fire-resistant tunnel cladding, such as aluminum silicate insulation boards or vermiculite cement, over the exposed lining within the interior of the tunnel
- Specify the use of aggregate that is thermally stable, such as limestone and dolomite

The gaskets are also subject to fire safety considerations. Because gaskets are located within specially designed joints near the outer edge of the lining system, they are not directly exposed to an open flame resulting from a fire within the tunnel. The concrete lining is sufficient to act as a radiant heat barrier and prevent ignition of the ethylene propylene diene monomer (EPDM) gaskets during a tunnel fire (Schurch, 2006). The project-specific fire safety aspects of the gaskets would need to be addressed in future design phases.

6.9 Tunnel Systems

The purpose of this section is to explain the different fire-life-safety (FLS) systems for the freeway and LRT tunnels as per the relevant guidelines and standards. The following sections are divided by alternative type and describe the different FLS system requirements separately.

The guidelines and standards listed in Table 6-2 are the basis for the design of the FLS systems in both the freeway and LRT tunnel options. Table 6-3 lists the references used from guidance provided by relevant agencies. Table 6-4 lists additional NFPA references that were used.

TABLE 6-2
FLS Guidelines and Standards

NFPA	502 Standard for Roads Tunnels, Bridges and Other Limited Access Highway (2011) 130 Standard for Fixed Guideway Transit and Passenger Rail Systems (2010)
AASHTO	Roadway Lighting Design Guide Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals Roadway Design Guide
ANSI/IEEE	80 Guide for Safety in AC Substation Grounding 81 Guide for Measuring Earth Resistivity
Caltrans	Highway Design Manual Signal, Lighting and Electrical Systems Design Guide Manual on Uniform Traffic Control Devices
Metro	Rail Design Criteria Fire Life Safety Criteria

Notes:
NFPA = National Fire Prevention Association
AASHTO = American Association of State Highway and Transportation Officials
ANSI = American National Standards Institute
IEEE = Institute of Electrical and Electronics Engineers
Caltrans = California Department of Transportation
Metro = Los Angeles County Metropolitan Transportation Authority

TABLE 6-3
FLS References Used

CIE	88 Guide for the Lighting of Road Tunnels and Underpasses
EIA	Electronic Industries Alliance Standards and Technical Problems
FHWA	Traffic Control Systems Handbook
IEEE	Standard 730 Software Quality Assurance Plan
IEEE	Standard 830 Recommended Practice for Software Requirements
IEEE	Standard 1012 Software Verification and Validation
IEEE	Standard 1016 Recommended Practice for software Design Descriptions
IESNA	RP-8 Roadway Lighting
ANSI / IESNA	RP-22-2011 Tunnel Lighting
IESNA	LM-50-99 Photometric Measurement of Roadway Lighting Installations
IESNA	LM-71-96 Photometric Measurement of Tunnel Lighting Installation
IESNA	Lighting Handbook
IESNA	RP-19 Roadway Sign Lighting
ITE	Traffic Engineering Handbook
ANSI	C2 National Electrical Safety Code
NIST	SP 800-82 Guide to Industrial Control Systems (ICS) Security
TIA/EIA	FOTP 455-171A Attenuation by Substitution Measurements for Short-Length Multimode Graded-Index and Single Mode Optical fiber Cable Assemblies
TIA/EIA	FOTP 455-61A Measurement of Fiber or Cable Attenuation Using an Optical Time-domain Reflectometer (OTDR)
UL	1971 Signaling Devices for the hearing Impaired

Notes:
CIE = International Commission on Illumination
EIA = Electronic Industries Alliance
FHWA = Federal Highway Administration
IEEE = Institute of Electrical and Electronics Engineers
IESNA = Illuminating Engineering Society of America
ITE = Institute of Transportation Engineers
ANSI = American National Standards Institute
NIST = National Institute of Standards and Technology
TIA = Telecommunications Industry Association
UL = Underwriters Laboratories, Inc.

TABLE 6-4
Additional References to NFPA

NFPA	10 Standard for Portable Fire Extinguishers
NFPA	13 Installation of Sprinkler Systems
NFPA	14 Installation of Standpipe and Hose Systems
NFPA	17 Standard for Dry Chemical Extinguishing Systems
NFPA	20 Installation of Stationary Pumps for Fire Protection

TABLE 6-4
Additional References to NFPA

NFPA	24 Installation of Private Fire Service Mains and Their Appurtenances
NFPA	25 Inspection, Testing and Maintenance of Water-Based Fire Protection System
NFPA	30 Flammable and Combustible Liquid Code
NFPA	70 National Electric Code
NFPA	72 National Fire Alarm and Signaling Code
NFPA	90A Installation of Air Conditioning and Ventilating Systems
NFPA	101 Life Safety Code
NFPA	110 Emergency and Standby Power Systems
NFPA	220 Types of Building Construction
NFPA	241 Safeguarding Construction, Alteration and Demolition Operations
NFPA	251 Standard Methods of Tests of Fire Endurance of Building Construction and Materials
NFPA	1600 Standard on Disaster/Emergency Management and Business Continuity Programs
NFPA	1963 Standard for Fire Hose Connections
NFPA	2001 Standard on Clean Agent Fire Extinguishing Systems

Notes:
NFPA = National Fire Prevention Association

6.10 Operation and Safety Equipment

The following sections describe the necessary operation and safety equipment for the freeway alternatives. The recommended operation and safety equipment for these alternatives consists of closed-circuit television (CCTV), telephone, traffic signs, exit identification, portable fire extinguishers, and variable message signs (VMS).

6.10.1 CCTV

CCTV cameras will be mounted along the tunnel. Cameras with a pan-tilt-zoom (PTZ) function will be located at the emergency exits (cross-passages) to supervise these areas. Fixed-position cameras (without the PTZ function) will be installed inside the tunnels at intervals of approximately 400 feet so the entire length of the tunnel has camera coverage. These cameras are used to supervise the traffic flow and are also used to identify smoke, obstacles on the road, and other hazards.

6.10.2 Telephone and Loudspeaker

Call boxes inside the tunnel enable motorists to communicate with emergency personnel in case of an emergency. The spacing between the call boxes will be determined in future phases of the project.

A tunnel loudspeaker system will be installed so that in an emergency situation instructions can be given to motorists, allowing them to evacuate a potentially dangerous area through the safest escape routes. The spacing between the loudspeakers will be determined in future phases of the project.

6.10.3 Traffic Stop

A traffic stop system is necessary to stop any traffic from entering the approach roadways to the tunnels if there is an emergency in the tunnel. The traffic stop system will consist of traffic signals in the tunnels, as well as on all of the approach roadways.

6.10.4 Emergency Exit

According to NFPA 502, it is recommended that cross-passages be placed at 650-foot intervals throughout the tunnels. Exit signs that guide motorists to the cross-passages will be mounted on the tunnel walls. The exit doors at the cross-passages will be marked by illuminated or reflective exit signs to increase visibility.

6.10.5 Tenable Environment

A tenable environment will be provided by means of several measurements like ventilation, fire detection system, among other systems to allow for ready evacuation through the space.

6.10.6 Signs

VMS units will be placed in the tunnels, at the tunnel portals, and on the approach roadways to control traffic within the tunnel, to clear traffic downstream of a fire site following the activation of a fire alarm within the tunnel, and to inform motorists about accidents or provide any other necessary information. In addition, the speed limit signs shall be located at the same locations as the VMS and traffic signals, following the recommendations of NFPA 502 to provide maximum visibility to motorists. Signs will be provided to stop traffic from reaching the approach roads to the tunnels and also to stop traffic at the tunnel portals.

All traffic signs shall be installed according to the California Manual on Uniform Traffic Control Devices (MUTCD) and shall be placed in accordance with the requirements of NFPA 502. In order to avoid entry of a vehicle loaded with explosives or flammable materials, a “No Explosives or Flammable Materials” sign will be located before the tunnel entrance, where motorists can still change their route and avoid the tunnel if necessary.

In addition to these safety signs, informal signs (for example, “Turn On Headlights” and “Tunnel”) will be placed in advance of the tunnel portal.

Emergency exit signs will guide motorists inside the tunnel to the cross-passages in the event of an emergency. These exit signs would be illuminated. These exit signs and all safety signs would be connected to the emergency power supply system.

6.11 Freeway Fire Detection System

The fire alarm and detection system includes an addressable analog system with manual and automatic alarm initiation, automatic heat and smoke detectors, and signal transmission through signal line circuits dedicated to fire alarm services only.

Smoke and heat detectors, manual fire alarm boxes, and horn/strobe alarms will be installed in the control buildings. The electrical niches will also have heat detectors and manual fire alarm boxes.

Manual fire alarm boxes will be installed in the tunnels in front of each cross passage, in the same locations as the emergency telephones. Linear heat detectors will be installed on the ceilings of the tunnels. This system uses a heat-sensitive cable as an alarm element. The automatic fire detection system will be capable of identifying the location of the fire to within 50 feet or less.

Fire alarm and control units (FACUs) will be installed in the control buildings and in the electrical niches to monitor all alarms of the tunnel and protected premises, including the linear detector system alarms. The FACU will monitor the fire suppression system, including the building sprinklers and tunnel standpipe system. The FACUs are connected to each other in a network via fiber optic cables.

An annunciator panel will be installed in the control rooms at the control buildings. In the event of an alarm, the system status will be reported to the local fire department.

There are no specific guidelines in NFPA 130 for the fire detection system for the LRT tunnel alternatives. Details of fire detection will be defined during the next phase of this project.

6.12 Fire Fighting System

The following sections provide information in the fire fighting systems for the freeway and LRT tunnel alternatives.

6.12.1 Freeway Tunnel

The fire fighting system would be designed as a Class 1 system (described in detail in NFPA 17 Section 3.3.15.1) according to NFPA requirements. The system consists of two individual standpipe cycles and must be able to deliver fire water for up to one hour.

The standby system would be designed as a wet pipe. Because of the warm weather conditions throughout the year, no special requirements are needed to prevent the fire water from freezing in the water line. The standpipe system has to be connected to a municipal or privately owned waterworks system. To guarantee that there is enough fire water available in the event of fire, a water basin shall be located at the upper tunnel portal (that is, the portal located at a higher elevation).

The water basin supplies two individual standpipe headers. The first header comprises fire pumps that produce the required pressure for the hose connections inside the tunnel. This standpipe header is required to supply the first part of the tunnels with fire water. This first fire water header supplies the fire water for both tunnels, upper and lower decks.

The second fire water header pipe, which is connected to the water basin, makes use of the difference in height between the upper and the lower tunnel portals. Therefore, no fire water pumps are necessary to produce the required pressure and flow at the hose connections. The header pipe shall supply the upper and lower decks of both tunnels with fire water. In the lower section of the tunnels, throttle valves are required to reduce the flow rate to the required values as per NFPA standard.

6.12.1.1 Fire Department Connection

As per NPFA requirements, at least two fire department connections are required for each water line. Therefore, there will be one fire department connection at each tunnel portal (for the upper and lower decks). The size of the connections would be at least 4 inches, but this will be discussed and coordinated with the local fire authority.

6.12.1.2 Fire Hose Connection

The standpipe system is provided with fire hose connections. The hose connections will be located in tunnel niches, and the interval between the hose connections would not exceed 275 feet as per NFPA requirements. The size of the pipes would be 2.5 inches according to NFPA requirements.

6.12.1.3 Deluge System

The freeway tunnel is designed with a fixed fire fighting system as per the requirements of the NFPA, which says that this system must be installed when vehicles downstream of an incident site cannot be evacuated under all traffic conditions. Since a steady stream of traffic is expected in the tunnel, it is not possible to clear the traffic downstream of the fire site under all conditions; therefore, we propose to install a deluge system. This system would be designed to be sufficient to handle the expected fire loads.

6.12.1.4 Fire Pumps

All necessary fire pumps for the standpipe system would be driven electrically and will fulfill the requirements of NFPA 20. The pumps will operate in a duty/standby configuration, which means that one pump shall always be available if one of the other pumps fails.

6.12.1.5 Fire Extinguishers

Portable fire extinguishers with a rating of 2-A:20-B:C and a total maximum weight of 20 pounds are planned to be located along the entire length of the tunnel.

6.12.2 Light Rail Transit Tunnel

The fire fighting system for the LRT tunnel shall be a wet standpipe system. The system must be able to cover the fire water demand for one hour. The line shall be designed as a Class 1 standpipe system according to NFPA 14 specifications.

Because of year-round warm weather conditions, no special requirements are needed to prevent the fire water from freezing in the water line. The system has to be connected to a municipal or privately owned waterworks system that can provide adequate pressure and flow rate in case of fire.

The fire fighting system for the entire railway tunnel is divided into two sections of standby pipes. One standpipe will be supplied from the pumping station at the Fillmore Station, and the second standpipe will be supplied from the Huntington Station. This system is necessary to fulfill the specifications regarding the maximum system pressures per the NFPA 14 standard. In both stations, fire pumps are required to deliver the necessary system pressure. For each fire pump, an additional standby pump shall be installed that will activate in case of a failure of the duty pump.

Additionally, a sprinkler system is required in every railway station. The sprinkler systems shall be supplied by pumps located in each of the rail stations. To adequately suppress a fire, each system is divided into zones. If a fire starts in one of the zones, the respective valves will automatically open and that zone will be flooded.

6.12.2.1 Fire Hose Connection

The standpipe system must be provided with 2.5-inch fire hose connections. These hose connections will be located according to the specifications in the NFPA 130 standard.

6.12.2.2 Fire Pumps

All fire pumps necessary for the standpipe system are electrically driven and fulfill the requirements in NFPA 20. The pumps will operate in a duty/standby configuration, which means that one pump shall always be available if one of the other pumps fails.

6.12.2.3 Fire Extinguishers

Portable fire extinguishers will be located approximately every 220 feet in the tunnels. The removal of a fire extinguisher will be detected by a removal switch and will activate a fire alarm. Type and location of the fire extinguishers will be defined by the fire authority.

6.12.2.4 Sprinkler System

An automatic sprinkler system is required for stations, storage areas, trash rooms, and in steel truss areas of escalators.

6.13 Electrical System

The following describes the requirements and proposed electrical system for the freeway and LRT alternatives.

6.13.1 Freeway Tunnel

6.13.1.1 Power System

The electrical system is designed as a Category D system according to NFPA requirements. The system will support life safety operations, fire emergency operations, and normal operations, and is designed as a redundant electrical system. The electrical system will also allow routine maintenance without disruption of the traffic in each tube.

Technical rooms will be located at every vehicle cross-passage (approximately every 2,600 feet) at the upper and lower decks. These technical rooms consist of transformer rooms, medium-voltage rooms, low-voltage rooms, and battery rooms.

The medium-voltage distribution will be fed by 34.5 kilovolt (kV) cable lines. Dry-type transformers convert the medium voltage to low voltage (480V/277V). This voltage level is used for the power supply of the lighting system, ventilation system, pumps, etc. Other distribution transformers supply the measure and control systems, the regular room installations, etc., with a voltage of 208V/120V.

An operation building and an electrical substation will be situated near tunnel portal. Distribution transformers are placed at each building for medium- and low-voltage distributions. Each electrical substation will be provided with utility feeders for the tunnel power supply.

6.13.1.2 Emergency Power System

An online uninterruptable power supply (UPS) will provide power to critical loads for which a momentary power outage or interruption is not acceptable (for example, emergency lighting, tunnel closure and traffic control, exit signs, emergency communication, tunnel drainage, fire alarm and detection, CCTV, fire fighting system). The emergency circuits will remain functional for a period of not less than one hour.

6.13.1.3 Lighting System

The tunnel lighting is divided into three different zones: the threshold zone, the transition zone, and the interior zone.

The threshold zone helps the eye to adapt to the darkness inside of the tunnel. The length of this zone depends on the traffic speed limit and the estimated safe stopping sight distance (SSSD). The luminance in the threshold zone can be adjusted with respect to changes in the exterior luminance. The threshold zone is divided into two zones. The second zone has a lower luminance and lasts 2 seconds.

The transition zone helps the eye to adapt to the low luminance in the interior zone. The luminance at the beginning of the transition zone is equal to that at the end of the threshold zone. The luminance is gradually reduced to the level of the interior zone toward the end of the transition zone. Depending on the travel speed, there are additional zones in the transition zone. The length of each step should be increased by 1 second, starting with 3 seconds for the first transitional step. There will up to three steps in the transition zone.

The interior zone has the lowest luminance in the tunnel and is divided into several sections. Each section is supplied by the low-voltage network at the nearest electrical niche. At night, the luminance can be reduced to 2.5 cd/m^2. According to American National Standards Institute (ANSI) Illuminating Engineering Society of America (IESNA) RP-22, the uniformity ratio of the interior lighting shall be 2 to 1, average-to-minimum, and 3.5 to 1, maximum-to-minimum.

6.13.1.4 Emergency Lighting System

The emergency lighting shall be designed as a Category D system according to NFPA 502 requirements.

Emergency lighting is supplied via a fire-resistant cable or an embedded cable with protection lasting 2 hours. The emergency lighting is installed in each lighting zone of the tunnel. To maintain the function of the emergency lighting in case of power failure, the system will be connected to the emergency power supply from the emergency distribution boards at the nearest electrical niche and shall be wired in separate cable ducts.

6.13.2 Light Rail Transit Tunnel

6.13.2.1 Power System

The tunnel includes four enclosed stations: Alhambra Station, Huntington Station, South Pasadena Station, and Fillmore Station. Each station is equipped with several transformers and a medium-voltage and low-voltage distribution network.

The medium-voltage distribution is connected to two local utility companies (as a redundant power connection to the utility grid) and supplies the two traction power transformers. These transformers supply rectifiers that produce 750V direct current (dc) for the traction power supply and are designed as a redundant transformer system. The medium-voltage network and the traction power supply are situated in the traction power room.

Two auxiliary rooms are located at both ends of each station where two transformers are installed. Each room will be connected to the medium-voltage distribution network from the traction power room. The transformers are linked to the low-voltage network via a bus coupler and are designed as a redundant transformer unit.

6.13.2.2 Emergency Power System

An online UPS provides power to critical loads—for example, emergency lighting, protective signaling systems, emergency ventilation, emergency communication, fire command center—and will therefore guarantee emergency operation. The emergency lighting shall be powered by the emergency power supply from the emergency distribution panels.

6.13.2.3 Lighting System

The lighting system is separated into the standard and the emergency tunnel lighting.

The tunnel walkway shall be illuminated during normal operation, and emergency light operation. The cross-passages would also be illuminated.

6.13.2.4 Emergency Lighting System

The emergency lighting system will be connected to the critical load circuit described in the emergency power system above.

6.14 Radio and Control Systems

The following describes the requirements and proposed radio and control systems for the freeway and LRT alternatives.

6.14.1 Freeway Tunnel

6.14.1.1 Radio System

The terminal for the radio system will be located in the operation building. The terminal will receive the radio signal from an antenna and pass it on to the amplifiers via fiber optic cables. There will be three antennas; the 800 megahertz (MHz antenna will be used for the public safety service, the others for AM and FM signals. Electrical-to-optical (E/O) converters will be located in the operation building to convert the electric signal to an optical signal. The signals will be transmitted to the technical rooms via fiber optics. Optical-to-electrical (O/E) converters in the low-voltage distribution rooms will convert the optical signals to electrical signals. Two AM radiator cables and one FM leaky coax cable will be connected to the amplifiers to supply each tunnel sector with the radio signal. The two AM radiators and the FM leaky coax cables will be installed on the ceiling. The tunnel will be divided into sections to reduce the maximum failure length.

In accordance with the NFPA 502 requirements, a two-way radio system is designed so fire department personnel can communicate with the fire department communication center.

6.14.1.2 Control System

At the operation building and the electrical substation, there will be servers connected to switches. These switches will be connected to switches in every low-voltage distribution room at the vehicle cross-passages via fiber optics. The control system is installed for supervising systems and control systems.

6.14.2 Light Rail Transit Tunnel

6.14.2.1 Radio System

The terminal for the radio system will be located at the Fillmore Station and will receive signals from the Rail Operation Center (ROC), passing them on via fiber optic cable to the amplifiers. According to NFPA 130, a two-way communication radio network forms the basis of the design. An E/O converter at the Fillmore Station will convert the electrical signal to an optical signal, which will be transmitted via fiber optics to each station. At these stations O/E converters will reconvert the optical signals into electrical signals.

In each tube are two leaky coax cables, which are connected to the amplifiers in the stations. There will be a separate cable for the transmitting and the receiving signal. The FM leaky coax cable will be used for the public safety services and communication between the ROC and train.

6.14.2.2 Communication System

Different types of telephones will be provided inside the tunnel (emergency and maintenance telephones). The emergency telephones (ETELs) will be located at each blue light station (described in detail in NFPA 130 Sections 6.2.7 and 10.4.1) and the tunnel entrances. The blue light stations will be at each cross-passage and at the ends of station platforms. Maintenance telephones will be located at the cross-passages.

6.15 Summary

Given the requirements outlined in the previous sections, Figures 6-14 and 6-15 show a conceptual cross- section of both the freeway and LRT tunnels, respectively, including the necessary tunnel systems equipment. These conceptual cross-sections will be refined in future phases of this project.

FIGURE 6-14

Freeway Cross-section Showing Conceptual Equipment Layout

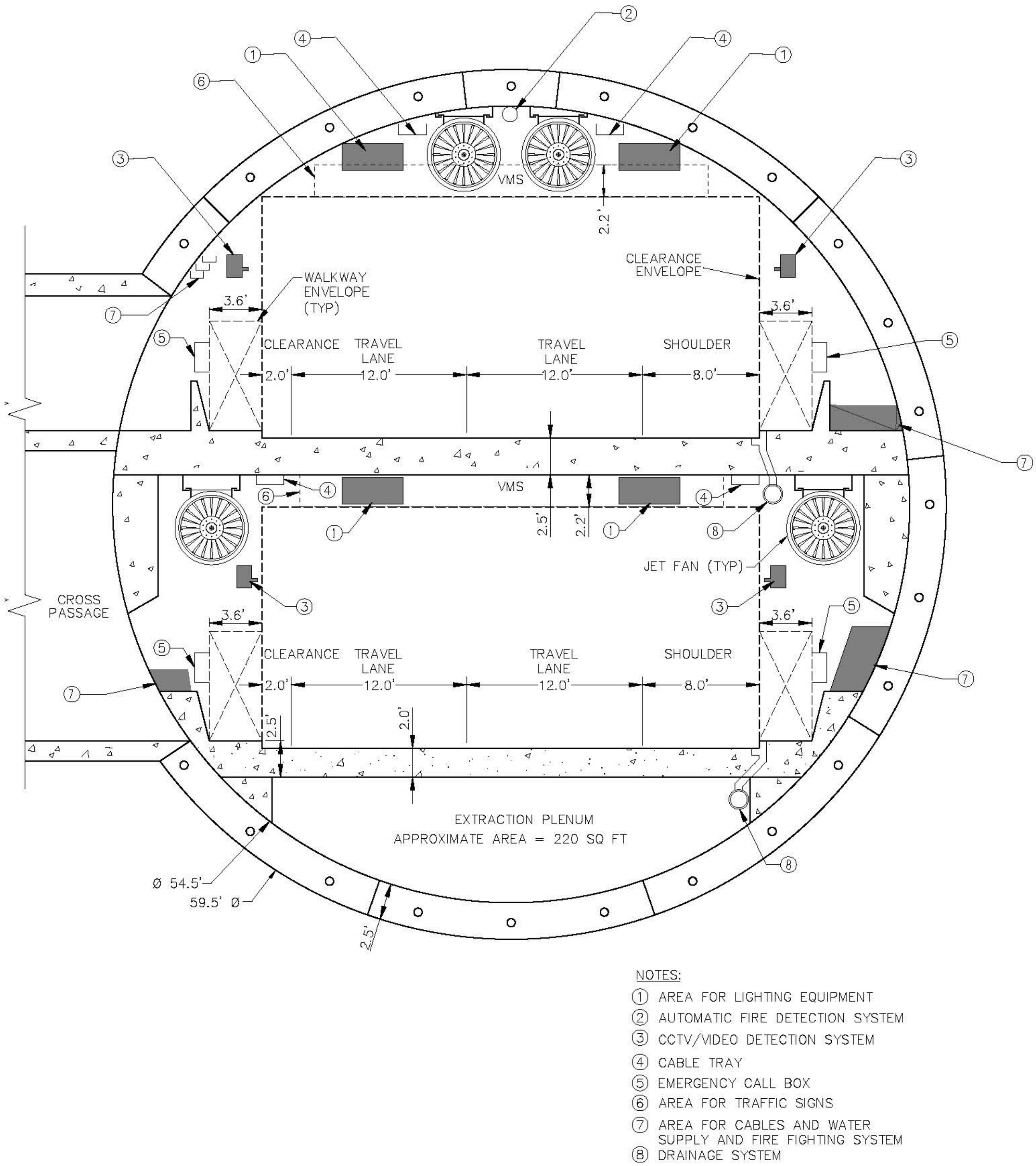
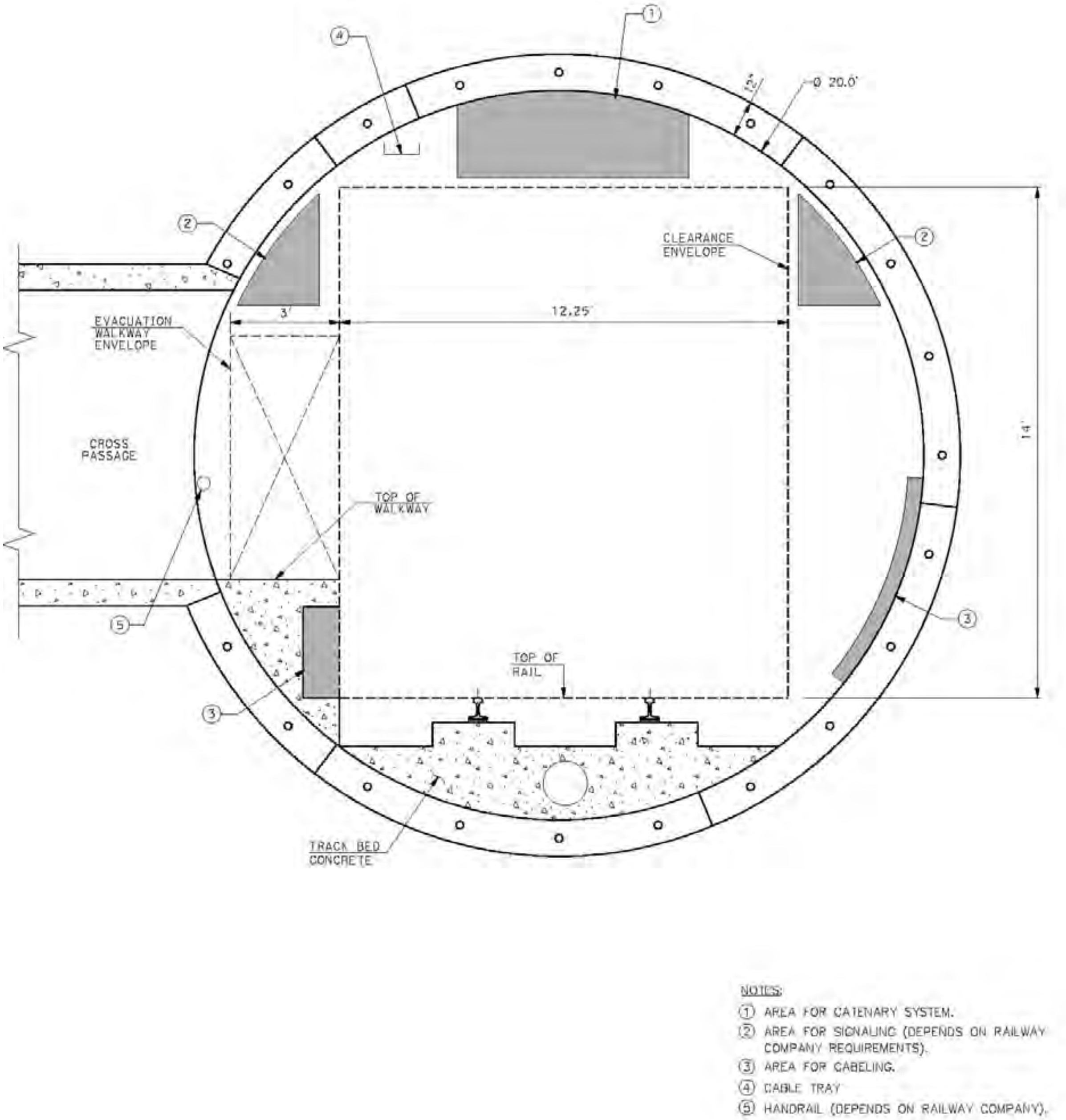


FIGURE 6-15
LRT Cross-section Showing Conceptual Equipment Layout



6.16 Tunnel Ventilation Concepts

6.16.1 Fundamentals

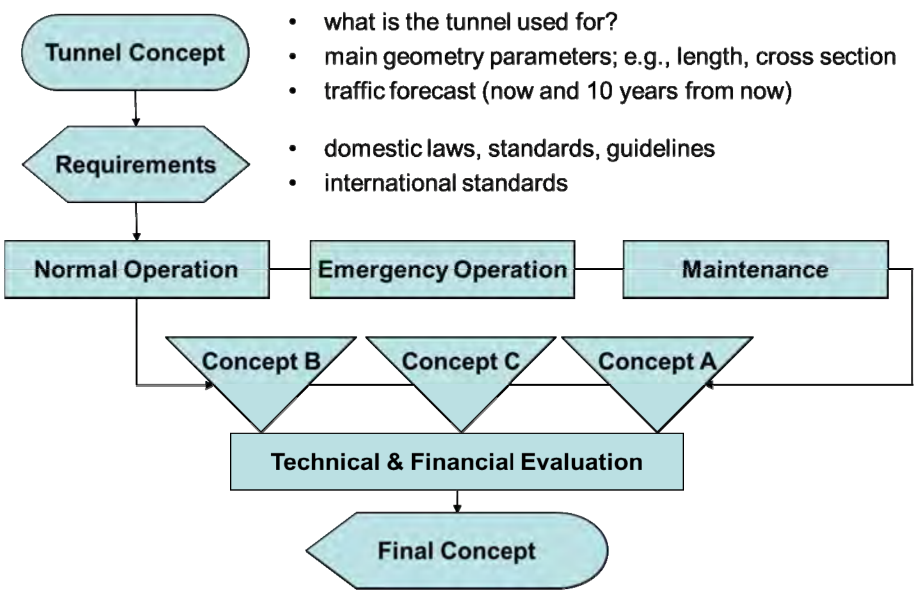
Because of the central role of ventilation in any tunnel safety concept, and its interface with many other project components, the exploration of possible ventilation schemes is crucial in the early stages of the project. Tunnel ventilation may have an impact on the choice of the tunnel concept and the required tunnel geometry.

As seemingly small changes in the fundamental assumptions for ventilation may alter the preference of one concept over another, or even whether a certain concept is feasible, it is important to identify the ventilation requirements at an early stage of the project and to look at the ventilation concept in conjunction with the other systems involved.

In this section, the fundamental assumptions for the ventilation design of the tunnel options in the SR 710 project are summarized and the resulting ventilation concepts are outlined. At this stage, the report serves mainly as a basis for the choice of the ventilation concept and the requirements for the mechanical installations.

Figure 6-16 shows a schematic representation of the process followed to work out suitable ventilation concepts for a given tunnel. Starting from the tunnel geometry, fundamental parameters, and requirements, ventilation concepts considering the three operational modes (normal operation, emergency ventilation, and maintenance) can be elaborated. Typically, the number of concepts is narrowed down to not more than three in an early project phase. As a result of an in-depth discussion with other project partners representing related project components such as civil engineering, power supply, and tunnel systems, as well as a rough cost estimate, a final ventilation concept can be defined.

FIGURE 6-16
Developing a Tunnel Ventilation Concept



6.16.2 Guidelines and Standards

For ventilation planning in the US, the central standard is NFPA 502, issued by the National Fire Protection Association. Additionally, California standards have been consulted. Reference may also be made to the state of the art as defined by comparable technical solutions or internationally applied standards.

The main guidelines and standards used in this project are:

- State of California. Vehicle Code. Section 35550-35558.
- California Building Code (CBC)
- Los Angeles City Fire Code (LA Fire Code)
- Los Angeles County Building Code
- Los Angeles County Fire Code (LACo Fire Code)
- NFPA 502: Standard for Road Tunnels, Bridges, and other Limited Access Freeways. National Fire Protection Association. Current Edition: 2011.
- NFPA 101, Life Safety Code
- PIARC (World Road Association) guidelines where applicable

6.16.3 Geometry

Currently, alternatives for a freeway and LRT system are being considered. Ventilation schemes were developed based on the cross-sections as shown in Figure 6-14 and Figure 6-15 of this report.

6.16.4 Traffic

Ventilation calculations and schemes were based on the current understanding of the expected traffic volumes in the tunnels when completed. The relevant year for the ventilation requirements is 2035.

The total average daily traffic volume for option F7 in the year 2035 is 88830 (north bound) and 95530 (south bound (CH2M HILL, 2012a). There are 9.9 percent trucks in both traffic directions. In this traffic data, the change of the traffic flow in the project area resulting from the construction of the new structure is considered. The maximum truck load is 80,000 pounds (California Department of Motor Vehicles, 2012).

6.16.5 Atmospheric Conditions

Currently, empirical data on atmospheric conditions are being collected. Until these data are available, the following assumptions have been made for use in developing the ventilation concepts based on previous project experience with tunnels of similar length:

- Height corrected barometric pressure difference: 100 Pascals (Pa)
- 95-percentile temperature (summer): 86°F
- 5-percentile temperature (winter): 59°F
- Temperature in tunnel (summer): 77°F
- Temperature in tunnel (winter): 68°F

6.16.6 Ventilation Criteria

Ventilation criteria have been developed for both the normal and emergency operational modes of the tunnel. During normal operation, the main ventilation aims are to:

- Maintain air quality at acceptable values to provide for safe driving and to avoid health risks to tunnel occupants
- Avoid concentration of noxious gases outside the tunnel at the portal areas

With reference to PIARC recommendations, these general aims are translated into threshold values, which are summarized in Table 6-5.

TABLE 6-5
Normal Operation: Threshold Values for Ventilation System

Carbon monoxide concentration	70 parts per million (ppm)
Visibility, extinction coefficient	5/kilometers (60% transmission for a light beam with 100 meters)
Nitrogen oxides	n/a

NOTES:
n/a = not applicable

In the case of emergency operation, the main ventilation aims are to:

- Remove and control smoke and heated gases
- Maintain a smoke-free environment along the escape path

Refer to NPFA 502, which contains the specific ventilation criteria that were used to develop the ventilation schemes presented in the following sections. Table 6-6 summarizes the emergency operation ventilation criteria.

TABLE 6-6
Emergency Operation: Threshold Values for Ventilation System

Longitudinal flow velocity from entrance portal to incident location	Critical velocity
For systems with smoke extraction:	
Longitudinal flow velocity from exit portal to incident location	> 0
Exhaust air flow rate	According to design HRR and longitudinal flow velocities on both sides of the incident location

6.16.7 Design Fire Scenario

Determining a design fire scenario is necessary to begin the ventilation design. The design fire scenario represents a particular combination of events. Some factors considered when determining the design fire scenario include:

- Type, size, and location of ignition source
- Type of fuel
- Fuel load density and fuel arrangement
- Type of fire
- Fire growth rate
- Fire peak heat release rate
- Tunnel ventilation system
- External environmental conditions
- Fire suppression
- Human intervention(s)

The designer is obligated to make a number of assumptions to make sure that the design will be optimized to save lives and retain the structural integrity of the tunnel under the foreseeable fire scenarios. A tenable environment is well-defined by NFPA 502 and other standards. To develop a time-of-tenability curve, the project team must develop:

- A fire heat release curve as a function of time
- A design evacuation (egress) curve as a function of time
- A design systems response curve as a function of time

These considerations are currently being performed by the project team with the aim of developing the relevant fire scenario for the SR 710 tunnels.

Considering that tanker trucks are banned from using the tunnel, that only one truck can be involved in an incident and that sprinklers are used, the design peak heat release rate has been found to be 100 MW.

For further information on the heat release rate, refer to ILF's memorandum (ILF, 2012).

6.17 Normal Operation

In order to reach the ventilation aims for normal operation, a mechanical ventilation system in the tunnel and exhaust air filters in the portal buildings will be required. In this section, the requirements for normal operation of the freeway and LRT tunnels are discussed.

6.17.1 Fresh Air Calculation

The calculation of the fresh air requirement for the freeway option is based on the current World Road Association (PIARC) values for the base emissions in the USA (2012).

Figures 6-17 and 6-18 display the flow rate in the tunnel required to dilute the air in the freeway tunnel so that the ventilation criteria are met. The calculation considers the influence of the bulk driving speed on the traffic density, slope, and emission values.

For bulk speeds of 30–40 mph, the required fresh air flow rate reaches its peak with about 650,000 cubic feet per minute (cfm). If ventilated longitudinally, the resulting flow velocity is about 526 feet per minute (fpm).

For the LRT option, no exhaust gases are expected, but ventilation may be necessary during normal operation in order to reduce the temperature. However, the required flow rates will not determine the size of the ventilation equipment; this case is therefore not evaluated here.

FIGURE 6-17
Fresh Air Requirement for a Two-Lane Driving Deck (+1.8% Slope)

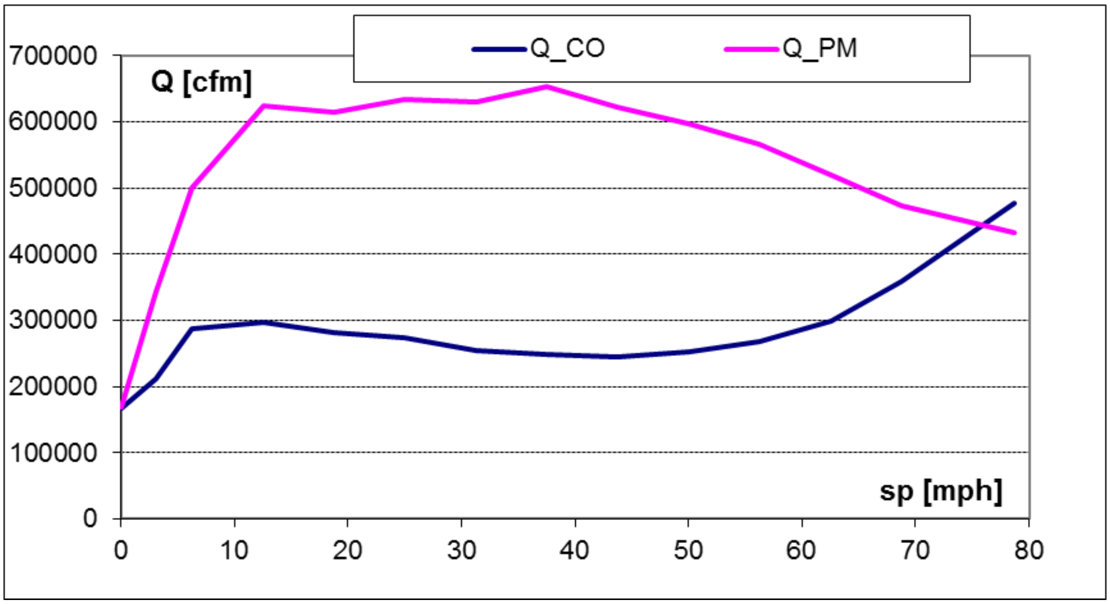
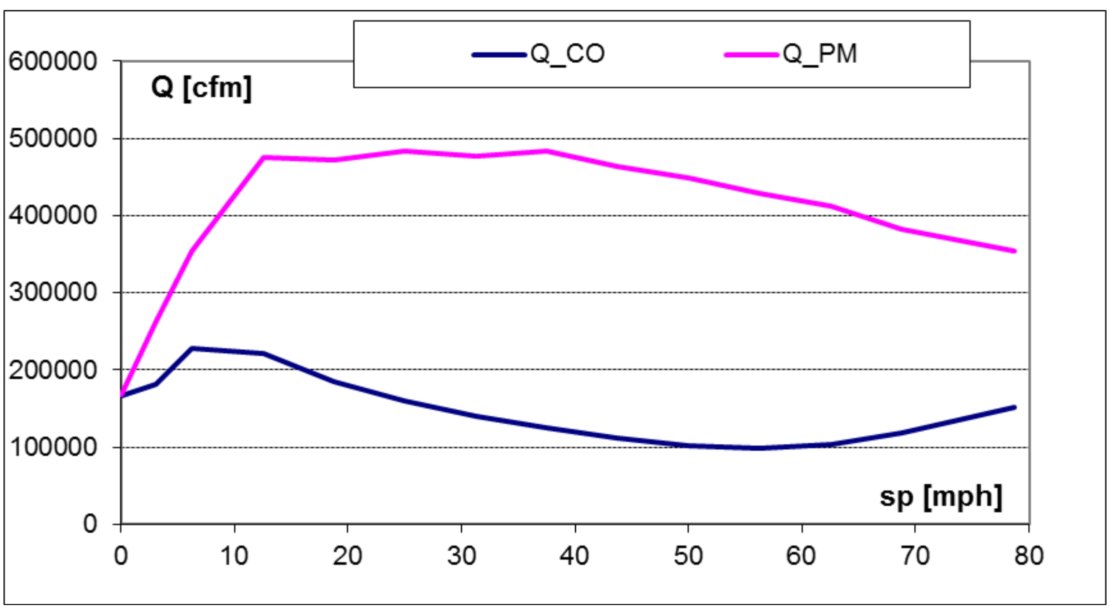


FIGURE 6-18
Fresh Air Requirement for a Two-Lane Driving Deck (-1.8% Slope)



The threshold values in Table 8-1 are currently in discussion considering the exposure of tunnel users over an extended period of time when they are in slowly moving traffic. The use of OSHA threshold values may be required and will lead to higher required volumetric flow rates of fresh air. This may lead to the requirement of intermediate air scrubbing stations, which is why at this stage these stations are integral part of the ventilation design.

6.17.2 Freeway Ventilation Concepts

The following ventilation concepts are considered for the freeway tunnel alternatives:

- Concept 1: Distributed smoke extraction with exhaust duct in invert
- Concept 2: Distributed smoke extraction with third bore as exhaust duct
- Concept 3: Midpoint smoke extraction
- Concept 4: Longitudinal ventilation

In case self-ventilation resulting from the piston effect of the vehicles does not result in a sufficiently large air exchange, jet fans will be used to support the natural flow. This will typically be the case only for very slow-moving traffic.

All the concepts mentioned above are technically feasible under the assumptions made in Section 6.16 for normal operation of the freeway tunnels.

In all freeway ventilation concepts, air filtering devices with a flow bypass for emergency operation will be installed in the portal buildings of the exit portals. They are designed to minimize the emission of vehicular pollutants from the tunnel in the portal areas.

Figures 6-19 through 6-22 are schematic drawings of the four freeway ventilation schemes. These drawings show the two bores with two driving decks in each direction. In all concepts, the longitudinal flow is controlled with jet fans, which are suspended in the tunnel vault (upper deck) or mounted laterally (lower deck).

In Concepts 1 and 2, the smoke exhaust system consists of exhaust points with evenly spaced controllable dampers, a smoke exhaust channel in the invert, exhaust cross-vents between both inverts, lateral exhaust niches to connect the exhaust openings of both decks to the exhaust channel, and emergency exhaust fans for each tunnel in both portal buildings. The longitudinal spacing of the dampers is about 300 feet. There are cross-connections between the exhaust inverts with a spacing of approximately 1,500 feet.

Concept 3 is similar to Concept 1; however, there is only one exhaust point, which is located in the center of the tunnel. Concept 4 uses longitudinal ventilation only, with no exhaust extraction system.

FIGURE 6-19
Concept 1, Normal Operation

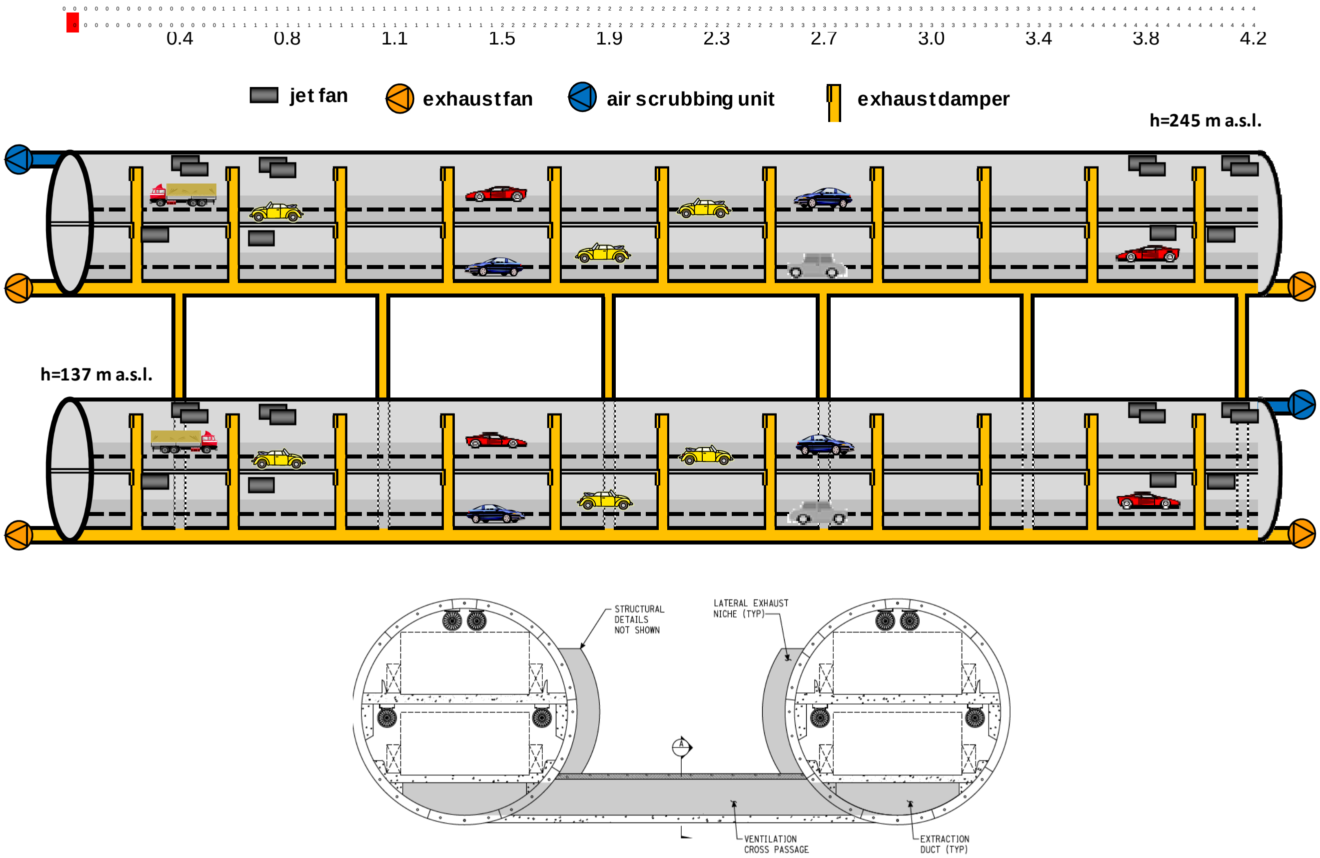
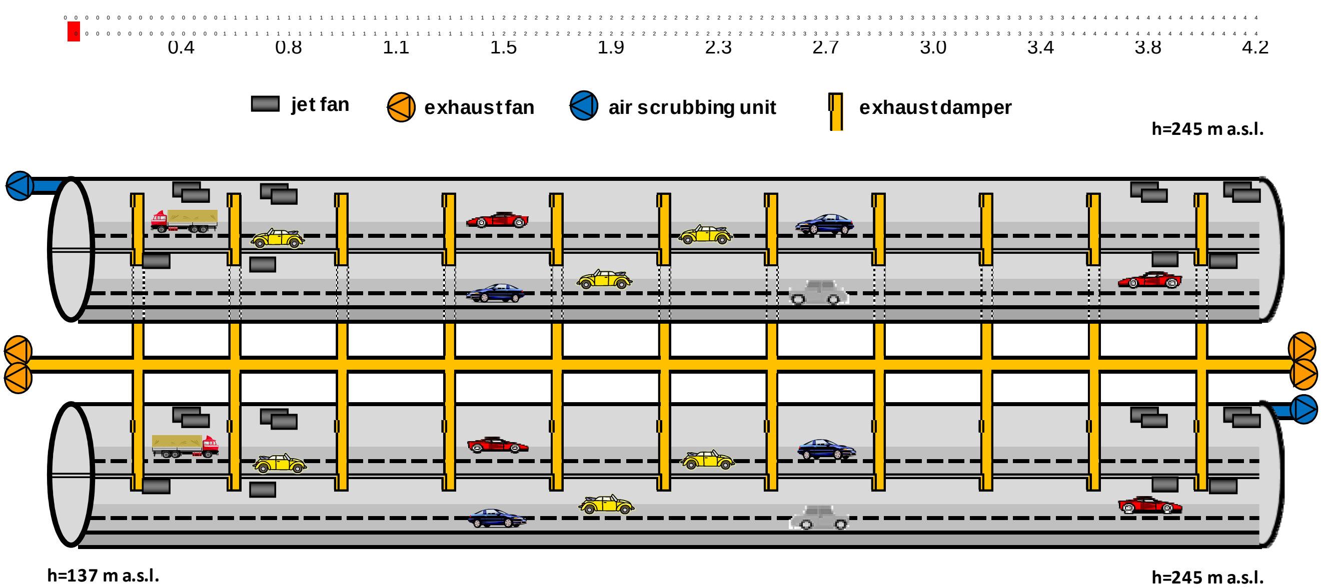


FIGURE 6-20
Concept 2, Normal Operation



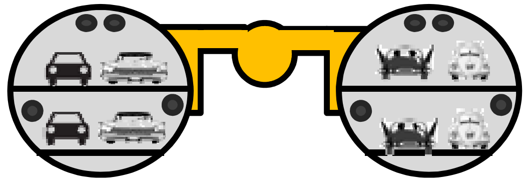
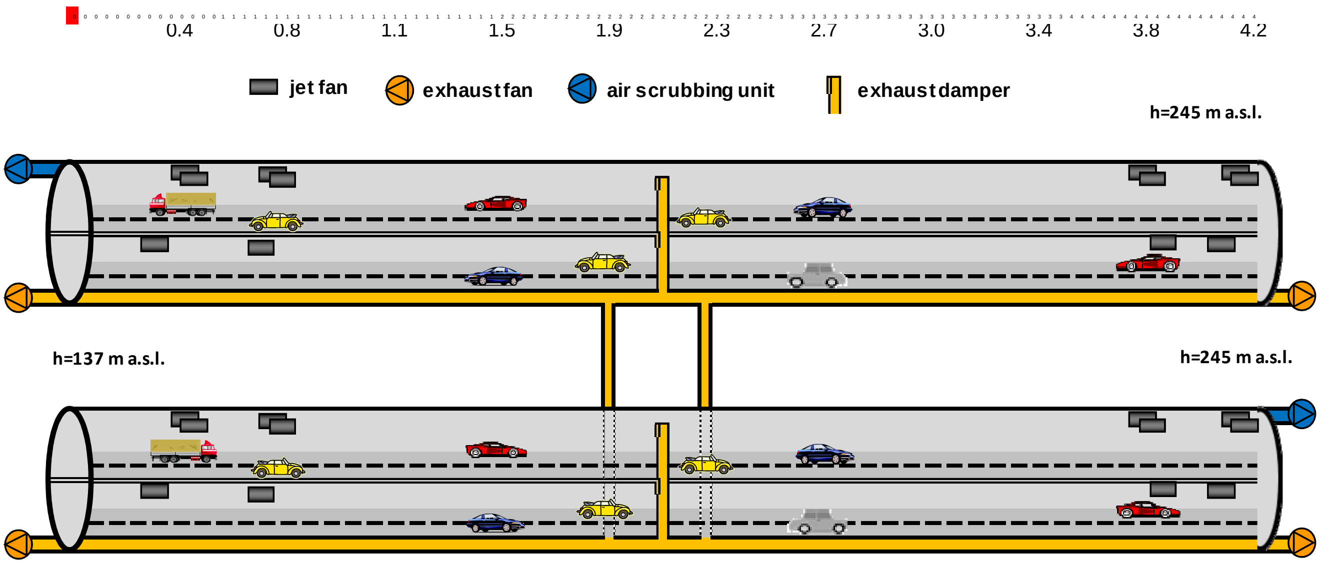


FIGURE 6-21
Concept 3, Normal Operation



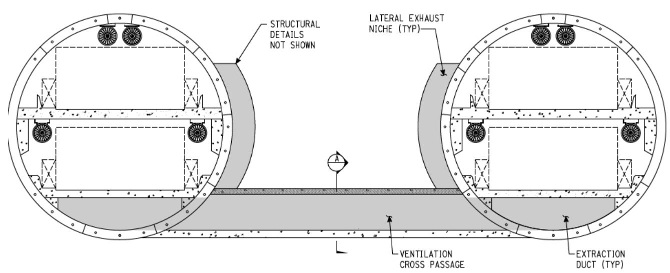
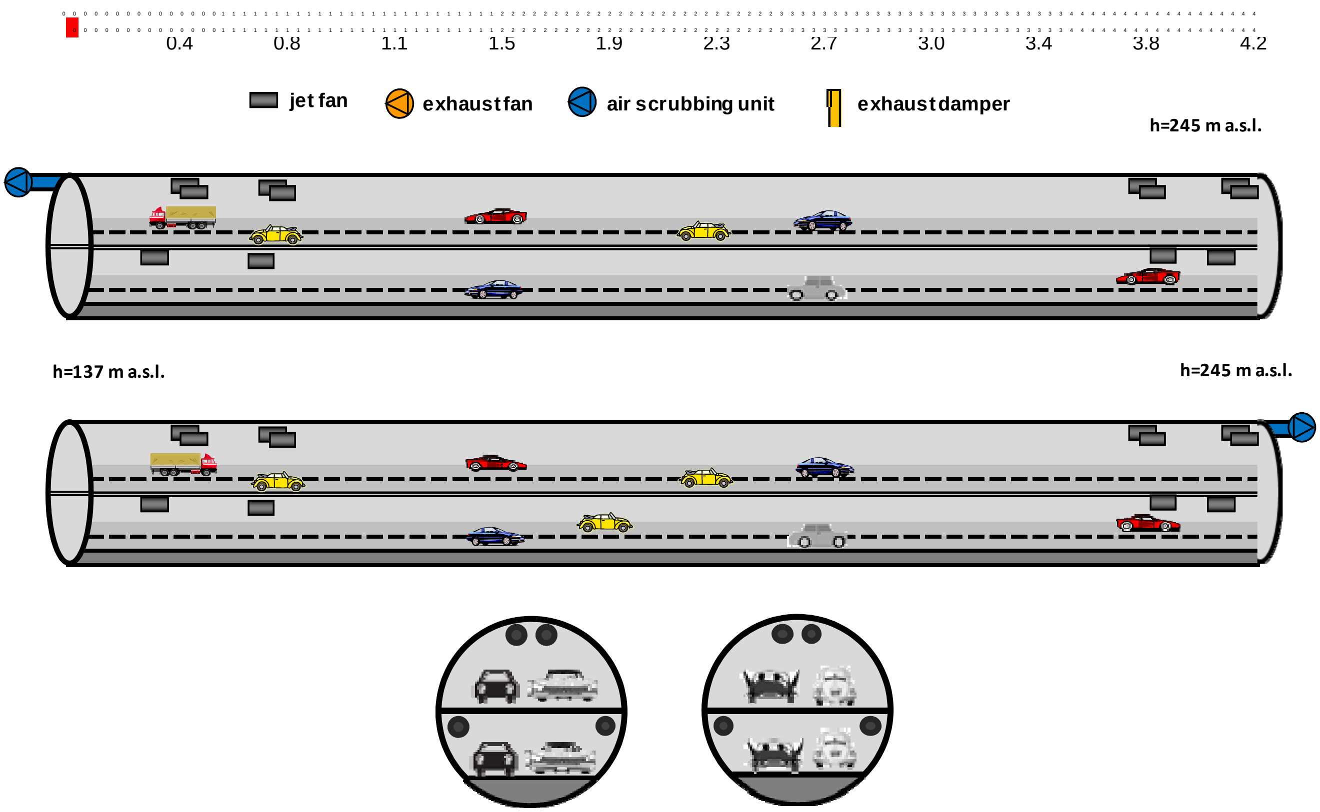


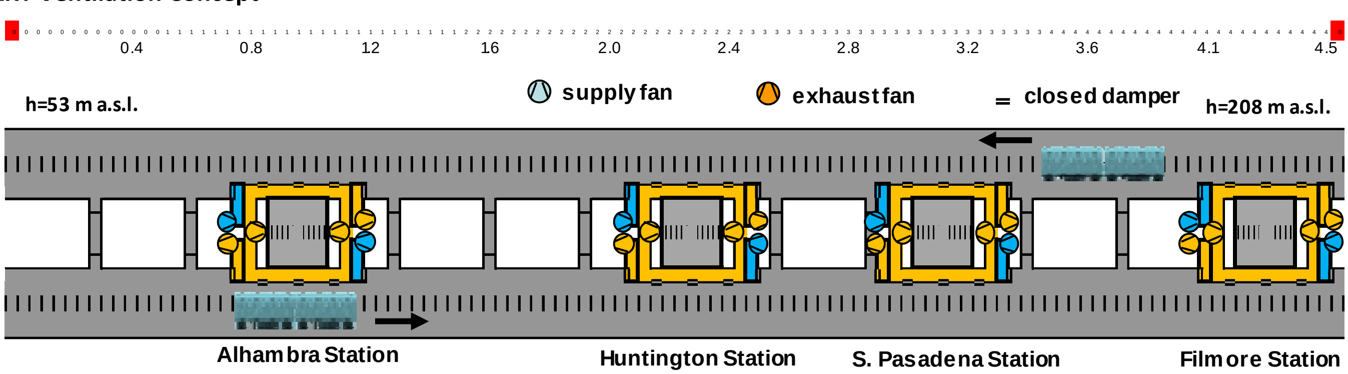
FIGURE 6-22
Concept 4, Normal Operation



6.17.3 LRT Ventilation Concept

The ventilation concept for the LRT option consists of smoke extraction with controllable dampers along the platforms, and a push-pull system for ventilation between the stations. All fans are located in the stations, which allows for the purging of the tunnel system during normal operation in order to keep temperatures down. Figure 6-23 is a ventilation schematic.

FIGURE 6-23
LRT Ventilation Concept



6.17.4 Control

During normal operation, the mechanical ventilation system is triggered by air quality sensors that will be installed along the driving tunnel. For the freeway option this refers to the CO and opacity sensors. In the LRT system the trigger will be the temperature inside the tunnels and station platforms.

6.18 Emergency Operation

For all ventilation concepts, the control of smoke and the creation of a safe evacuation route for the tunnel users are the main ventilation aims.

6.18.1 Freeway Emergency Ventilation

Based on the design heat release rate of 100 MW, the critical velocity for the maximum slope of 3.5 percent is 10.5 feet per second (ft/s) (630 fpm) in the freeway tunnels. In all concepts with smoke extraction, the ventilation aim is to reach critical velocity upstream of the incident location toward the incident location. Downstream of the incident location, a flow with a low velocity from the exit portal to the incident location shall be reached. For the freeway, this results in a required exhaust flow rate at the incident location of about 20,305 cfs at a temperature of 566°F.

It is required that at least two dampers be opened to extract the smoke and to operate both exhaust fans attached to one tunnel. Therefore, smoke will be expelled at both portal ventilation buildings. Depending on the final dimensions of dampers and exhaust channels, it may be necessary to pass the smoke across the exhaust vents to the exhaust channel of the nonincident tunnel and to also use its exhaust fans.

Although all displayed concepts are technically feasible and fulfill the requirements of the governing codes, the ventilation concepts differ, particularly in the length of the smoke zone. A preference for a particular concept will be based on an assessment of the safety requirements for the SR 710 tunnels.

In ventilation Concepts 1 and 2, a smoke extraction with dampers every 300 feet is designed so that smoke will not spread over a length of more than 600 feet in the tunnel (Figures 6-24 and 6-25).

In ventilation Concept 3, the smoke zone extends to half the length of the tunnel (Figure 6-26). For incidents in the first half of the tunnel (in the driving direction), smoke is extracted at the midpoint and exhausted to the portal stations. For incidents in the second half of the tunnel (in the driving direction), smoke will be expelled by the exit portal using longitudinal ventilation via jet fans.

In Concept 4, smoke is expelled by the exit portal using the jet fans, regardless of the incident locations. Hence, smoke will fill the entire tunnel downstream (in the driving direction) of the incident location (Figure 6-27).

The longitudinal flow velocity is controlled with jet fans that are installed in the tunnel. In Concepts 1, 2, and 3, there is a smoke extraction system with emergency exhaust stations at both portals. The air scrubbing device at the exit portal is bypassed during emergency extraction.

All of the presented concepts are technically feasible and comply with the governing regulations, in particular NFPA 502. Considering that a fire could occur when vehicles are located at both sides of the fire, only concepts 1 and 2 provide a situation where smoke is not spread through much of the tunnel and the associated vehicles. Even if traffic on both sides of the fire could be avoided, a smoke extraction creating a smoke zone limited to about 600 ft is a requirement in most industrial countries and must therefore be considered as state-of-the-art for this project as well. It is therefore recommended to pursue concepts 1 and 2 for the SR 710 tunnel freeway alternatives.

FIGURE 6-24

Concept 1, Emergency Operation

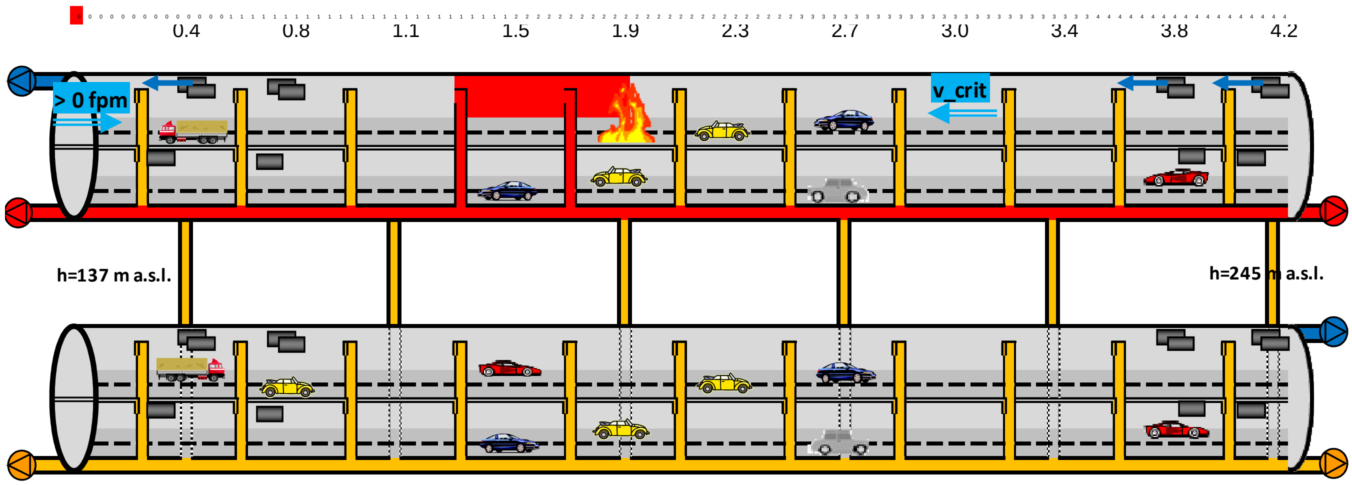


FIGURE 6-25

Concept 2, Emergency Operation

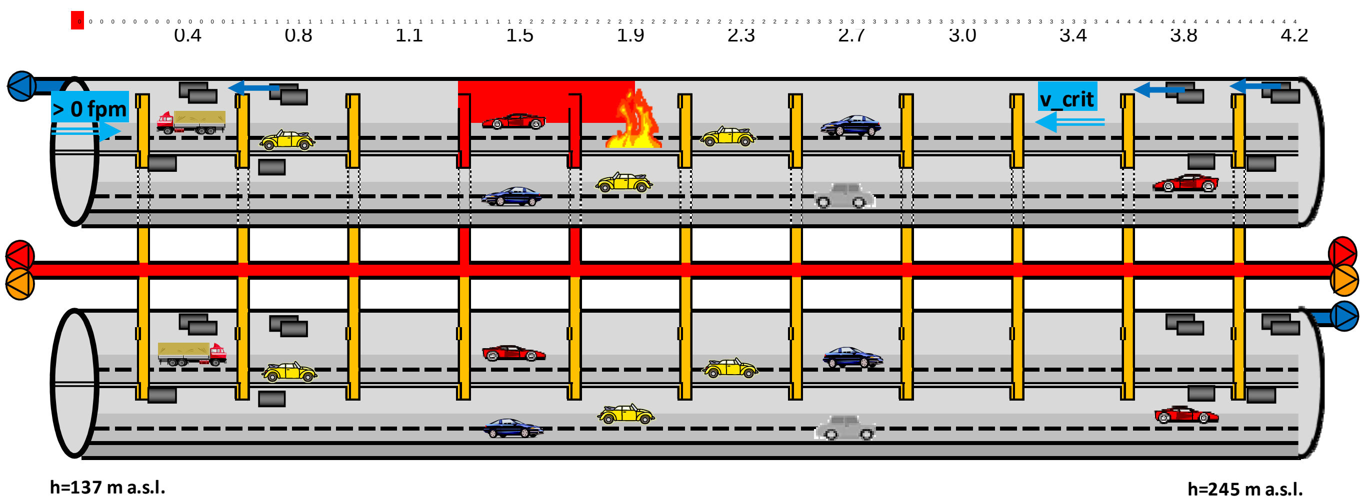


FIGURE 6-26
Concept 3, Emergency Operation

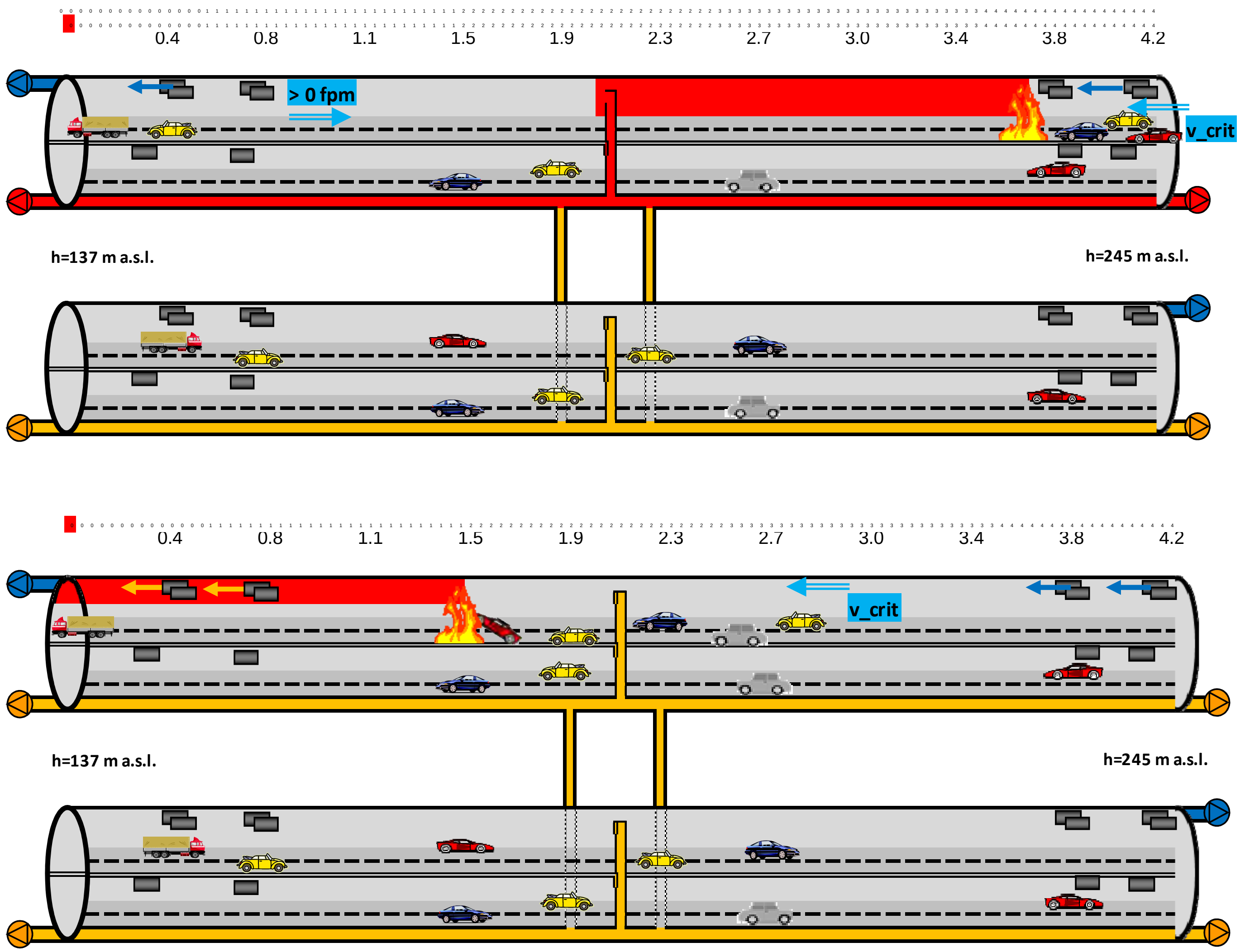
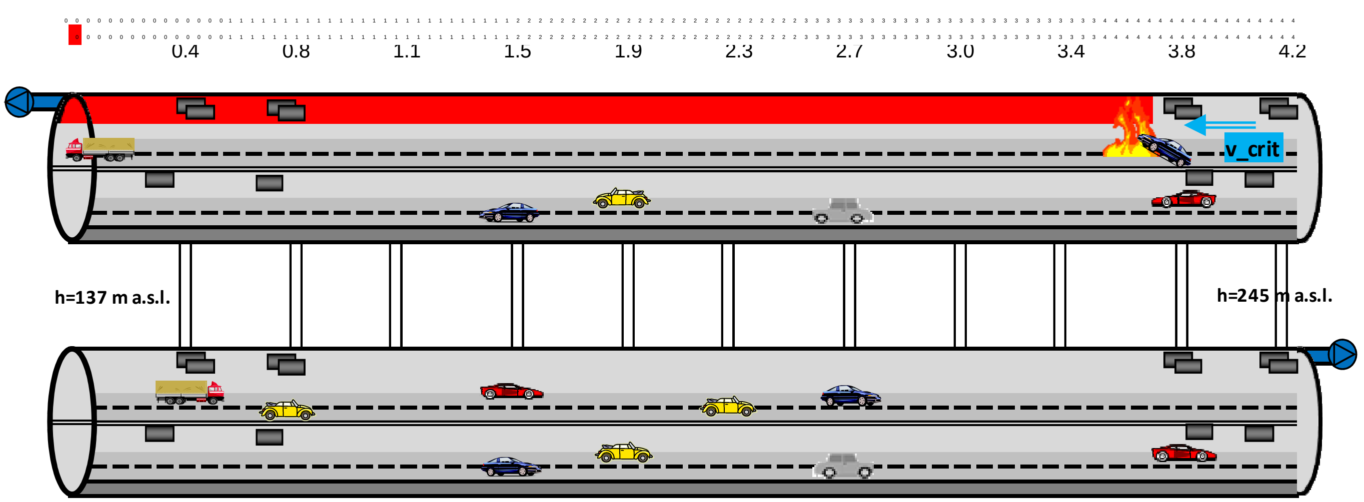


FIGURE 6-27
Concept 4, Emergency Operation



6.18.2 LRT Emergency Ventilation

In the case of the LRT tunnel alternatives, two emergency cases must be considered:

- Case 1: Incident between two stations (Figure 6-28)
- Case 2: Incident in a station (Figure 6-29)

For Case 1, a typical push-pull system is in place. It is designed to create critical velocity upstream (in the driving direction) of the fire so that the flow induced for the emergency situation is limited to the reach between two stations. The schematic drawing shows six fans in each station and depicts the different functions these fans have. The ones at the outer sides of each station are for the push-pull system, while the inner ones serve as exhaust fans for the platform exhaust duct.

For Case 2, a platform exhaust system with dampers approximately every 60 feet is in place. It is designed so that all the smoke produced is extracted near the train and allows safe evacuation by way of the station platforms.

During detailed design, it can be decided if these different functions can be provided by a smaller number of fans; that is, by using reversible fans.

FIGURE 6-28
Schematic of Case 1, Incident between Stations

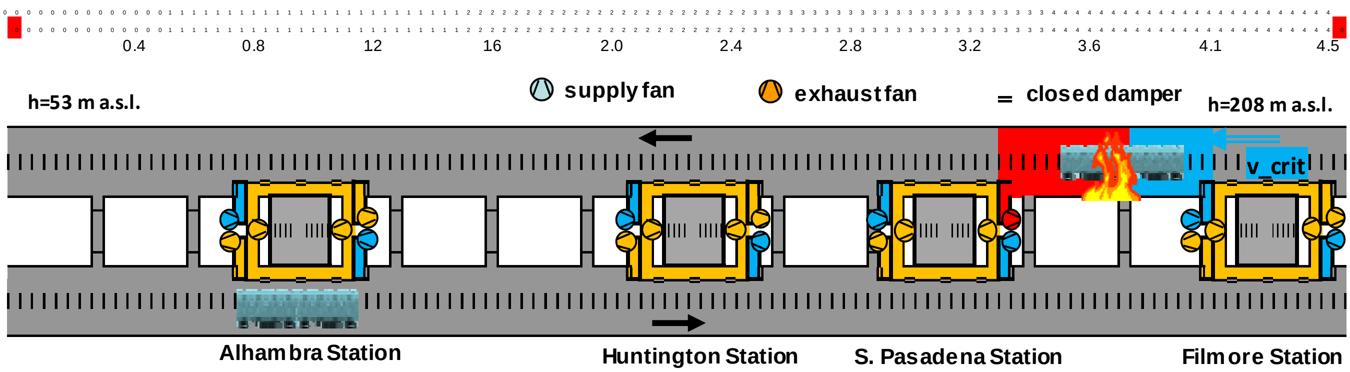
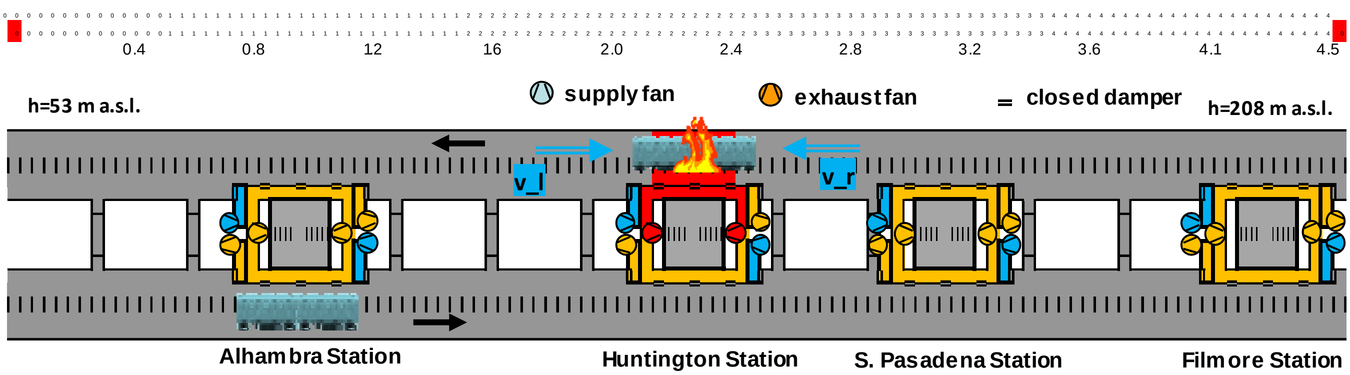


FIGURE 6-29
Schematic of Case 2, Incident at a Station



6.19 Air Filtering

Conceptual dispersion models (which are not within the scope of this report) have shown that the concentration of pollutants will not exceed permissible values at the portal areas. However, as a precautionary measure to address concerns of increased concentrations of pollutants in the portal areas, all freeway options have an air scrubbing system at the exit portal of each tunnel. This will remove particulate matter (PM) emissions, and will also address the noxious gases.

This section gives a general overview of air filtering technologies. Different pollutants require different techniques for their removal. Table 6-7 lists pollutants and cleaning methods relevant in a tunnel environment.

TABLE 6-7
Pollutants and Cleaning Methods Relevant in a Tunnel Environment

Pollutant	Scrubbing Method
Particulate Matter (PM)	electrostatic
Nitrogen Oxides	absorption, catalytic
Carbon Monoxide	catalytic, combustion
CH	absorption, catalytic, combustion
Sulfur Dioxide	absorption, catalytic

6.19.1 Electrostatic Filters

Electrostatic filters are used to clean tunnel air of PM. PM can be dispersed over a wide area near the tunnel portals. Of particular attention are the PM_{10} particles, which include a weighted sum of all particles with a diameter of less than 10 micrometers (µm).

In road traffic, PM stems from incomplete combustion, particularly in diesel engines, and if not filtered, from tire abrasion and from dust transported with the vehicles and deposited in the tunnel. The first measure to reduce PM emissions from tunnel portals is therefore to make sure that the tunnel is regularly cleaned with high-pressure water. The second measure is the installation and use of electrostatic air filters at the tunnel portals, which can clean the exhaust air at the corresponding portal continuously. Several companies offer technical systems particularly suited for the tunnel environment.

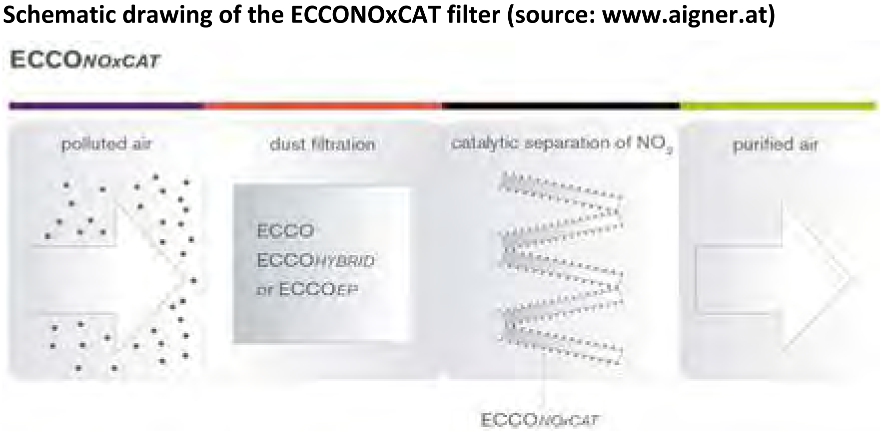
6.19.1.1 Function

Electrostatic filters remove particulate matter, typically in a three-step approach (Figure 6-30):

1. Protective grid for large particles.
2. Ionization of exhaust air and subsequent segregation in electrically charged collectors.
3. Electrostatically charged filter medium.

Depending on the requirements, these steps can be repeated within the filter device in order to improve their efficiency. The ionizer and the electrostatic filter cell are automatically wet cleaned with connected water treatment. The dry dust from the filter media is automatically collected into dust bins and must be disposed of regularly.

FIGURE 6-30
Schematic drawing of the ECCONOxCAT filter (source: www.aigner.at)



6.19.2 Catalytic Filters/Adsorption

Products of incomplete combustion (that is, carbon monoxide, CH, nitrogen oxides, SNO_x), can be reduced catalytically or by adsorption.

Catalyst materials include ceramics with platinum or palladium coating. This method requires frequent regeneration, which is why it can also be considered adsorption.

Adsorbents include potassium (K^+) or calcium (Ca^+) in combination with the hydroxide radical (OH^-) and active charcoal. The costs for (regenerative) catalytic methods and for adsorbing filters are generally comparably high, because the active material needs replacement and disposal.

6.19.3 Biological Filters

Biological filters can be used to reduce the portal emissions of carbon monoxide, sulfur dioxide, and products of incomplete combustion (carbon hydrates). They consist of bacteria that need fertilizer and oxygen to live. Biological filters with noteworthy capacities are fairly expensive, which is partially because of the need to remove the biological waste.

6.19.4 Combustion

As an alternative to catalytic or adsorptive removal of pollutants, products of incomplete combustion can also be reduced by burning them; for example, in a gas turbine or an internal combustion engine. The functional principle is fairly simple, but the costs are high because the device must be continuously fueled.

6.20 Tunnel Operations Concepts

6.20.1 Fundamentals

The operation-maintenance-control (OMC) building will be part of the ventilation/control building near the south portal of the tunnel. It is anticipated that the required rooms for the OMC building will be separated into two levels (1st floor and 2nd floor) along with a ventilation building).

6.20.2 Guidelines and Standards

The guidelines and standards used to complete this section include the following:

- NFPA 502:2011: Standard Road tunnels, Bridges and Other Limited Access Highways and its Referenced Standard and Codes
- NFPA 90A:2012: Installation of Air Conditioning and Ventilating Systems
- NFPA 70:2011: National Electric Code
- NFPA 72:2010: National Fire Alarm and Signaling Code

See also the Guidelines and Standards listed in Section 6-1.

6.21 Functional Zones of the OMC Building

It is anticipated that there will be six functional zones within the OMC building:

1. Operational zone: Station control room, offices, meeting rooms, event/meeting room
2. Crew workshops: Workshops for electrical, mechanical crew
3. General rooms: Restrooms, washrooms, break room
4. Equipment rooms: Switchgear rooms, control equipment rooms, generator rooms, HVAC room, etc.
5. Storage rooms: Archive rooms, mechanical/electrical spare part rooms, etc.
6. Garage: Garage for approximately three maintenance vehicles

The OMC building will be further developed during the next phase of the project.

6.21.1 Offices

It is anticipated that office rooms for the operation and maintenance staff would be needed. The installed equipment in each office room depends on the staff that will be using the room, and will be coordinated with the requirements of the overall operation and control tasks of this OMC building.

6.21.2 Maintenance Areas

Several areas for performing maintenance and repair work are being considered. Additionally, a garage room for maintenance vehicles would be located in the OMC building.

6.22 Operation Requirements

The following describes the operation requirements for the tunnel alternatives.

6.22.1 Operation and Control Room

The operation and control room will only be used for the operation of the freeway tunnel alternatives. It is anticipated that the operation and control room will be located on the 2nd floor of the OMC building

6.22.2 Connection to Overall Traffic Control System

The connection to the overall traffic control system will be considered via a direct connection to the control system of the tunnel. In this case, the control system of the tunnel will get first priority in case of any emergency, and will forward necessary information on a second priority level to the overall traffic control system.

6.23 Tunnel Portal and LRT Station Excavation Support Concepts

Portals will be located at the ends of the tunnel sections and will serve as permanent access to the tunnels. A portal aids in the transition of the at-grade portion of the roadway or track to the tunneled portion. The freeway alternatives have portals at both the north and south ends of each alternative, and the LRT alternatives only have portals at the south end because the alternatives both terminate at an underground station at their north end.

During construction of the bored tunnels, a construction portal will be excavated at the location where the bored tunnels begin. The construction portals will be temporary and will be used to launch the TBMs used to excavate the bored portions of the tunnels. After the excavation of the bored tunnels is complete, the construction portal will become the cut-and-cover portion of the tunnels and the permanent portal will be constructed where the cut-and-cover tunnels transition to at-grade or aerial roadways. This section of the report discusses the support of excavation for the construction portals. Additionally, underground stations will be located along each LRT alternative, and will be excavated and supported in a manner similar to a portal.

6.24 Design Approach

6.24.1 Freeway Portals

Slurry wall support is anticipated for all the freeway portals. This is primarily because of the significant depth of these excavations and the expected loads on the portals. The walls would be designed based on triangular lateral earth pressure diagrams that are an average of the at-rest and active conditions. This is recognizing that the slurry wall will be very stiff, although some movement will take place and therefore the pressures will likely be somewhere in between the active and at-rest conditions. As the design progresses, and additional geotechnical data are available, other pressure diagrams such as braced pressure diagrams may be used if additional analysis indicates that such pressures will materialize.

All portal excavations were assumed to be drained (that is, some means of hydrostatic pressure relief will be provided at the freeway portals). However, it may be determined that a cost-effective means of hydrostatic pressure relief will not be feasible at certain portals, in which case the effect of water pressure will have to be considered in wall design. The methods of providing the pressure relief or alternate wall designs considering the water pressure will be explored further as the design progresses.

6.24.2 LRT Portals and Stations

It is anticipated that soldier pile and lagging wall support has been shown for all the LRT portals and station excavations. This is because of the relatively shallow (compared to the freeway portals) depth of these excavations. Given the flexible nature of the excavation support wall, it is expected that vertical soil arching will result, leading to braced pressure diagram type lateral pressures on these walls; therefore, braced pressure diagrams were used in the design of these portals and excavations. All excavations were assumed to be drained (that is, some means of hydrostatic pressure relief will be provided at the portals and excavations). The methods of providing the pressure relief will be explored further as the design progresses. As with the freeway portals, surcharge loads were assumed where appropriate to account for any construction equipment that could be located near the excavation. Soil parameters required for the calculation of active, passive, and at-rest pressures were obtained from the currently available geotechnical data contained in the 2010 CH2M HILL report.

6.24.3 Freeway Portal Concepts

The construction portals in the north and south area for the freeway alternatives are all in the range of 120 to 170 feet deep near the portal's head wall. These areas would be at least 240 feet wide at the head wall (where the TBMs will be launched) in order to accommodate the two 60-foot bores spaced one diameter apart, with half-diameter clearance from each bore to the side walls. The geology and the depth to groundwater vary among all the portal excavations; however, given the considerable depth and width of these portals, slurry walls with tiebacks were chosen as the temporary portal excavation support method for all of the portals.

Cuts that are in the 120- to 140-foot range have a single vertical face. Cuts greater than 140 feet are shown to be benched, with the lower wall approximately 100 feet in height and the upper wall the remaining height. The walls are separated by a bench that has a width equal to the height of the lower wall (that is, 100 feet). This bench width renders the two walls separate; no interaction occurs between the upper and lower walls.

Figures 6-31 and 6-32 show a possible conceptual support of excavation method for the common freeway south portal in both plan and section, respectively. This conceptual method includes a 4-foot-thick slurry wall with steel reinforcement and tiebacks. Additionally, because tiebacks cannot be used along the entirety of the head wall (because of the TBMs being launched), a gravity wall (created with ground improvement) has been assumed behind the head wall to reduce the lateral loads on that wall. This concept will require structural improvement of the ground using jet grout or large-diameter secant piles.

Other methods—such as benched soldier piles and lagging with tiebacks or soil nailing, both with dewatering—are also possible for the freeway portals and may be evaluated during future phases of this project.

FIGURE 6-31
Plan of South Portal Support of Excavation

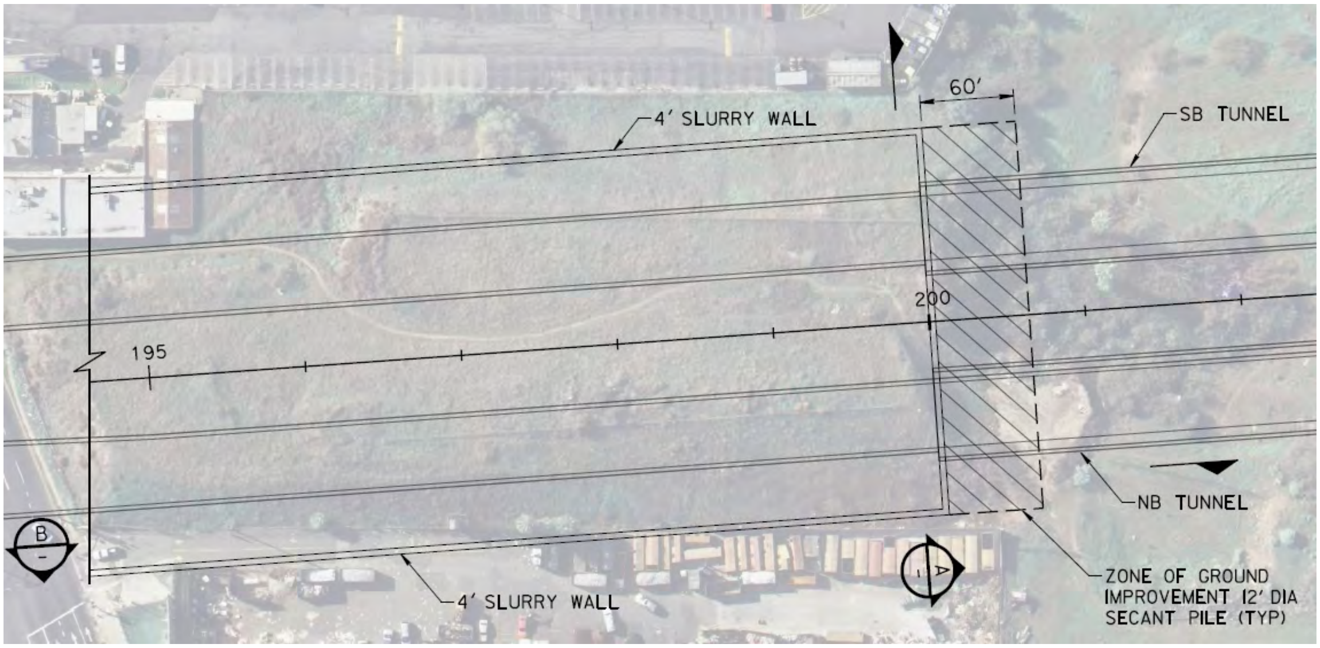
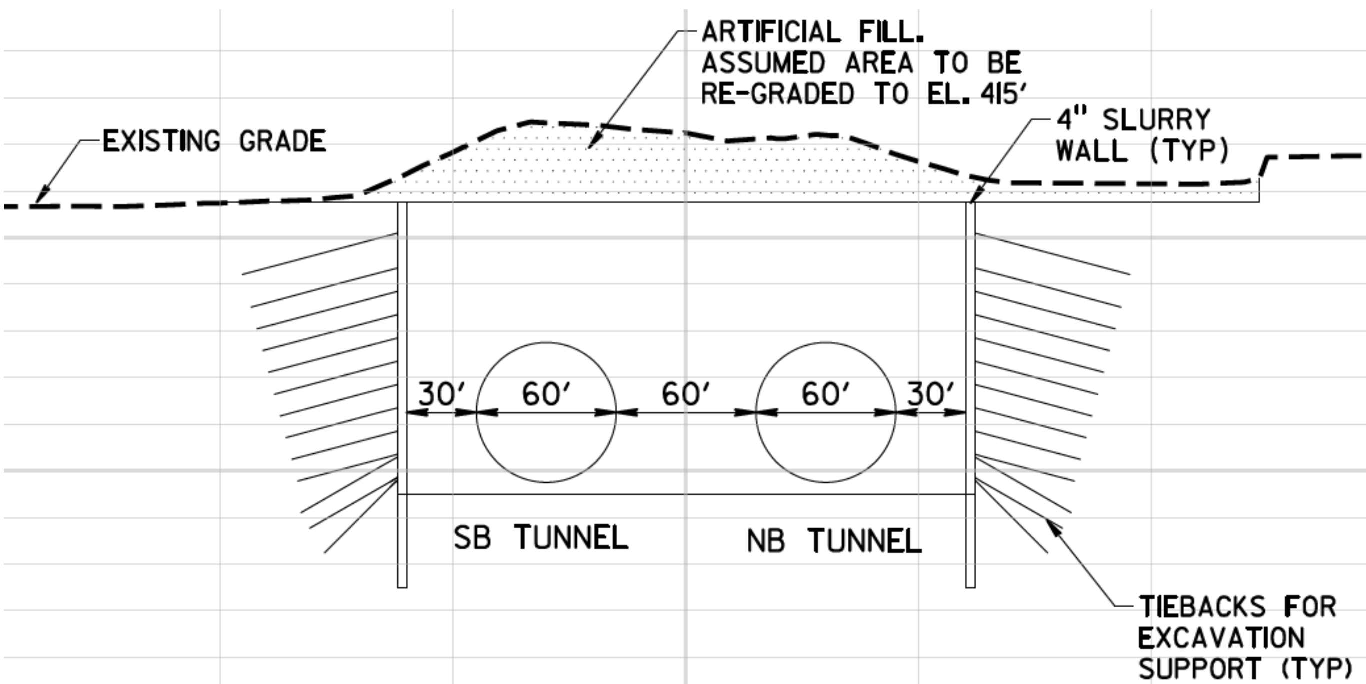


FIGURE 6-32
Section of South Portal Support of Excavation at Head Wall



6.24.4 LRT Portal and Station Concepts

LRT portal excavations are on the order of 30 to 50 feet in depth, and station excavations are on the order of 100 to 120 feet in depth. The width of the portals and the stations are in the 60- to 80-foot range. The portal excavations and the station excavations for the LRT alignment are all shown to be supported by braced/tied-back soldier pile and lagging walls.

For the portals, the head wall can be supported using a gravity wall similar to the concept discussed above for the freeway portals. This concept will require structural improvement of the ground using jet grout or large-diameter secant piles. Alternatively, nonstructural methods of ground improvement, such as chemical grouting, can be considered because the span of the portal face over the tunnel bores is only approximately 20 feet. Such nonstructural methods of ground improvement can reduce the loads on the portal head walls to a level that can be managed by soldier piles and lagging, with one level of bracing/tiebacks above the LRT tunnel bores.

For the stations, structural or nonstructural ground improvement methods can be used in order to manage lateral loads at the head wall over the span of the tunnel bores. Nonstructural methods will require lateral support of the head wall with multiple levels of bracing/tiebacks above the tunnel bores. Figures 6-33 and 6-34 show the typical support of excavation concept for an LRT station in both plan and section, respectively.

FIGURE 6-33
Plan of Typical LRT Station Support of Excavation

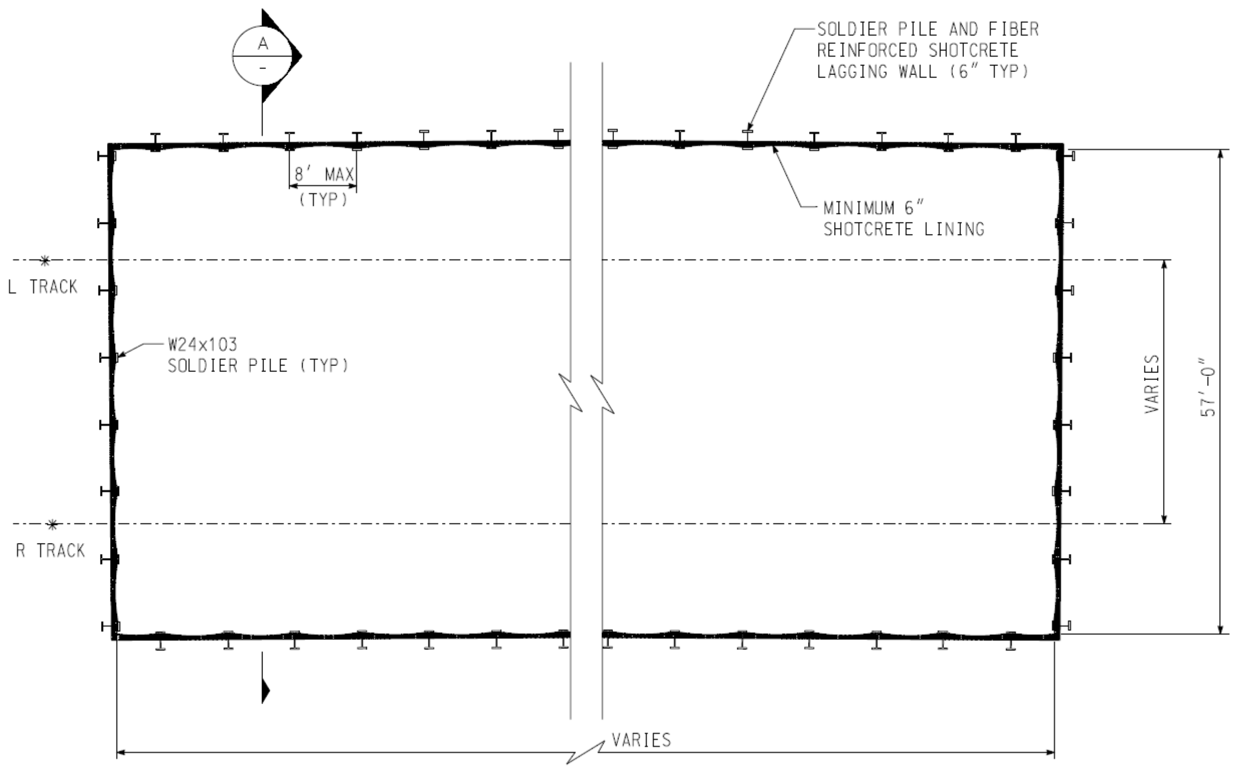
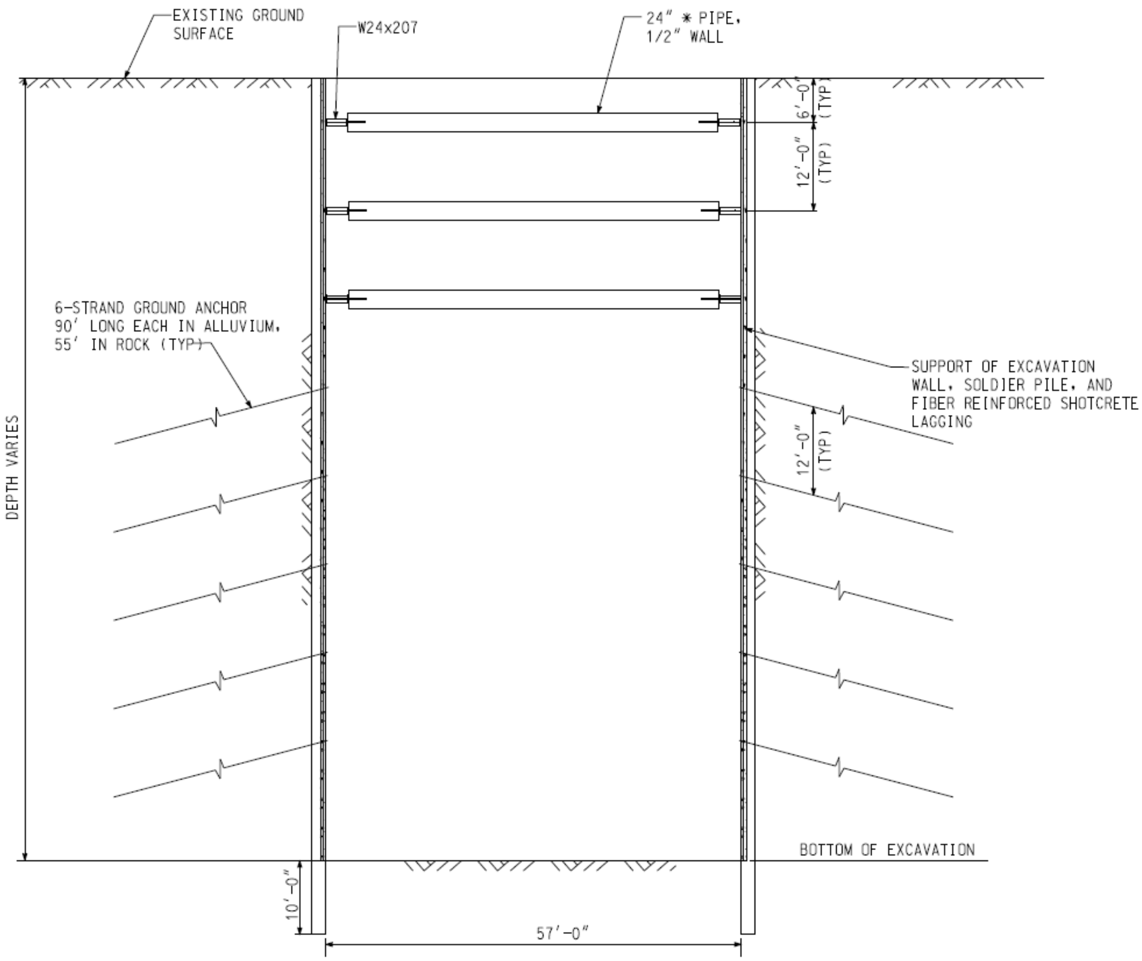


FIGURE 6-34
Section of Typical LRT Station Support of Excavation



6.25 Settlement Control

6.26 Ground Movements

Ground movements considered during this phase of the project are resulting from the bored tunnel excavation and from the portal and LRT station excavations. There may also be minimal settlement resulting from cross-passage excavation. More detailed analysis of settlement would be completed in future phases of this project.

6.26.1 Bored Tunnel Excavation

The ground loss that occurs in soft ground formations is a function of several factors, including expected ground conditions, presence of groundwater, construction means and methods, and overall workmanship. Ground loss during excavation is typically caused by a combination of three general sources: face loss, shield loss, and tail loss.

Face loss is ground loss at the heading of the tunnel, often caused by unstable ground behavior at the face (raveling, running, squeezing, or flowing ground conditions). Overexcavation of material, because of the presence of boulders or hard inclusions, can also lead to face loss. Shield loss is often caused by intrusion of surrounding material into the overcut annulus of the TBM shield. Steering overcuts, either from excavating curves or to make steering corrections, can enlarge the volume of this annular space and increase the resulting shield loss. Tail void loss occurs as the shield passes, and is often caused by intrusion of surrounding material into the annulus between the outside skin of the shield and the outside surface of the primary support. Deflection of the primary support under load can also lead to additional tail void loss. Settlement can also continue after excavation is complete because of lining deflection and redistribution of ground and water pressures, and is usually significant for soft, cohesive deposits. The sum total of the face, shield, and tail void losses is typically referred to as volume loss and is usually expressed as a percentage of the excavated area.

Of particular concern for the SR 710 project is the large annular gap, on the order of 8 to 12 inches, that will result between the diameter excavated by the TBM and the segmental lining extrados. This gap is primarily a result of the large tail shield thickness of large-diameter TBMs, although overcut, tail shield taper, and the gap between the shield and the segments also contribute to the annular gap. Because this gap can lead to large shield and tail void losses, controlling the deformation of the ground into this gap is critical for settlement control for large-diameter TBMs.

6.26.1.1 Case Histories

A number of case histories were reviewed for settlements resulting from large-diameter TBM excavation with large annular gaps. The TBM diameters in these case histories were all larger than 40 feet, and the annular gaps were between 4 and 11 inches. All of the tunnels were in soft ground, with some in soft clays, silts, and sands with a high groundwater table and only 0.5 to 1.0 tunnel diameter of cover. These case histories demonstrate that a high level of settlement control is achievable, even with large-diameter TBMs with a large annular gap. In almost all cases, the largest settlements were recorded in the portal areas, where the cover is typically shallow and the TBM crew is on a learning curve. With higher cover over the tunnel, recorded settlements were low. As an example, the M-30 North and South Bypass Tunnels in Madrid, with an excavated diameter of 49.86 feet and an 11-inch annular gap, experienced settlements on the order of 0.2- to 0.4-inch over most of the alignment, and 1 to 1.5 inches in the portal zones (Tunnels and Tunneling International, 2006). The ground consisted of alluvium over a hard clay, with gypsum layers and a high groundwater table. Ground improvement was performed in the portal zones around critical structures to mitigate settlement impacts.

A volume loss was estimated from these case histories using the empirical tunnel settlement procedures pioneered by Peck (1969). Trough width parameters were assumed based on geological conditions described in the case histories. The range in the estimated volume losses was between 0.25 percent and 0.5 percent, with the higher losses almost always occurring for the largest recorded settlements near the portals. Based on these projects, for the SR 710 tunnels a maximum volume loss of 0.5 percent was assigned to the portal zones, which consisted of zones of alluvium, mixed face, and low rock cover. A minimum volume loss of 0.25 percent was assigned to zones of at least one diameter of rock cover over the tunnel crown. When the SR 710 tunnels are below more than four diameters of rock cover, settlement is assumed to be negligible.

6.26.1.2 Screening Method

Simplified screening criteria were used at this phase to identify buildings and other structures that are susceptible to damage from bored tunnel settlement. Commonly, maximum total settlement and maximum angular distortion (slope of settlement trough) are considered at this level of screening. Because angular distortion is assumed to be negligible at this time, only vertical settlement is considered in the screening.

To identify susceptible structures, zones experiencing more than 0.25-inch of settlement are identified for each alignment. These limits are determined by calculating the predicted settlement at intervals along the alignment and locating the distance from the centerline of the two tunnels at which settlement is equal to 0.25-inch. For each region in alluvium or rock, a single conservative value is used as the disturbed limit line (DLL). All structures fully or partially located within these limits are identified and flagged as potentially affected by settlement.

6.26.2 Freeway Portal and LRT Station Excavation

The freeway portals are supported by slurry walls with ground anchors. The LRT stations and portals are supported using soldier piles and lagging, and with ground anchors. Data from Clough and O'Rourke (1990), U-Link, and the Los Angeles Metro Red Line Segment 2 Hollywood/Vine and Hollywood/Western Stations (Smirnoff, et al., 1997) were used to estimate the settlement trough.

The procedure to determine the extent of open-cut excavations is as follows:

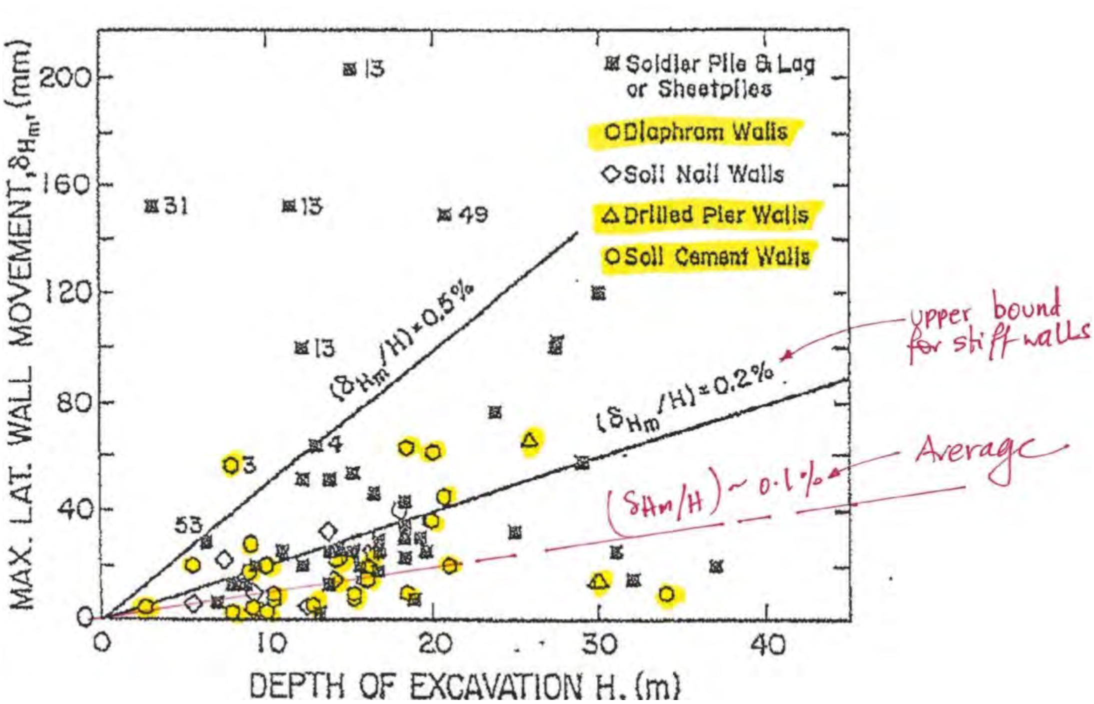
- Estimate the ratio of maximum lateral movement to wall height.

- Assume that the maximum vertical settlement is equal to the maximum lateral movement.
- Use the triangular bound charts in Clough and O'Rourke (1990) to estimate the limit of the settlement trough, based on the ratio of the vertical settlement to wall height (same as the lateral movement to wall height ratio).
- Assume the end of the settlement trough to be the DLL, which is more conservative than the 0.25-inch settlement limit.

6.26.2.1 Screening Method

The Clough and O'Rourke data for stiff clays, sands, and residual soils were used, because they are competent soils similar to the dense Old Alluvium and the very weak siltstones and claystones and weak friable sandstones of the SR 710 Puente/Topanga formations. The Clough and O'Rourke data provide an estimate of maximum lateral wall movement for a given wall height (Figure 6-35). The data suggest that the maximum lateral movement to wall height ratio is 0.2 percent for stiff walls (for example, slurry walls, drilled pile walls, soil cement walls) as an upper bound. Most of the data, however, fall at or below the 0.1 percent limit.

FIGURE 6-35
Observed Lateral Movements for In Situ Walls in Stiff Clays, Residual Soils and Sands (Clough and O'Rourke, 1990)



Recent data from the soldier pile and lagging walls in the U-Link project and the Hollywood/Vine and Hollywood/Western station excavations, and slurry wall excavations in the U-Link project also suggest that the maximum lateral wall movement to depth of excavation is between 0.05 percent and 0.1 percent. Based on these projects, the maximum lateral movement to wall height ratio is assumed to be 0.1 percent.

With 0.1 percent as the maximum lateral movement to wall height ratio, as well as the maximum vertical settlement to wall height ratio, the triangular bound line for sands and hard clays from Clough and O'Rourke can be projected to estimate the settlement trough limit. This limit is 0.6 wall height for sands and 1.0 wall height for hard clays (Figures 6-36 and 6-37). The limit for the 0.25-inch settlement limit will be somewhat smaller; however, a ratio of 1H:1V was used as a conservative DLL for all cut-and-cover excavations.

FIGURE 6-36
Settlement Envelope Adjacent to Excavations in Sands (Clough and O'Rourke, 1990)

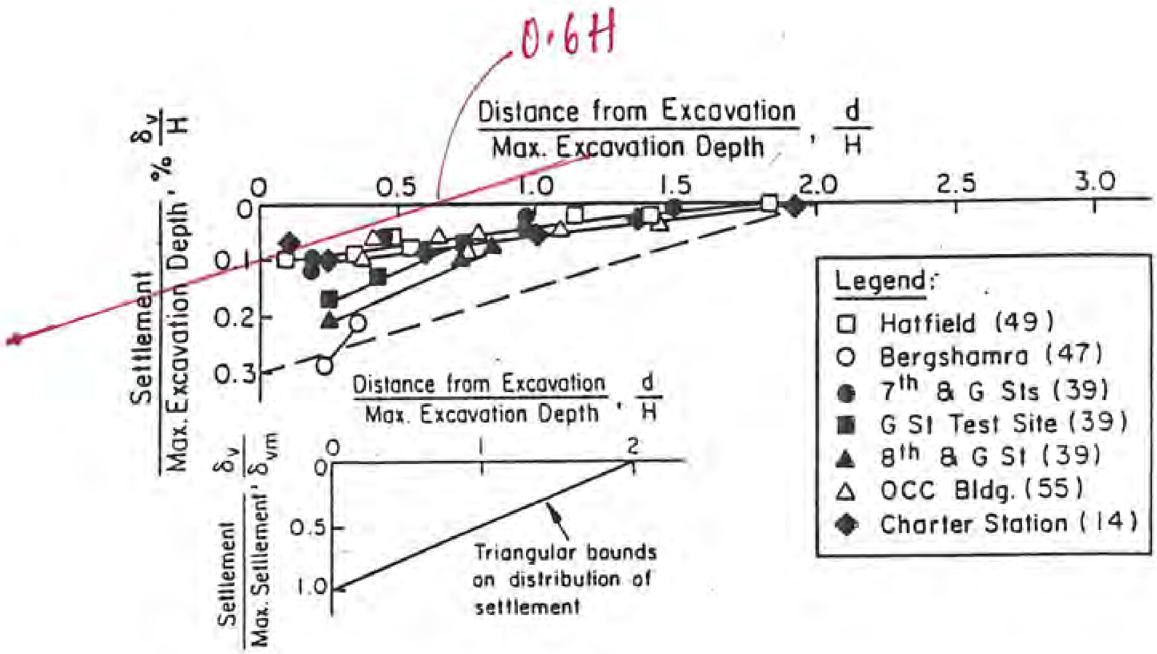
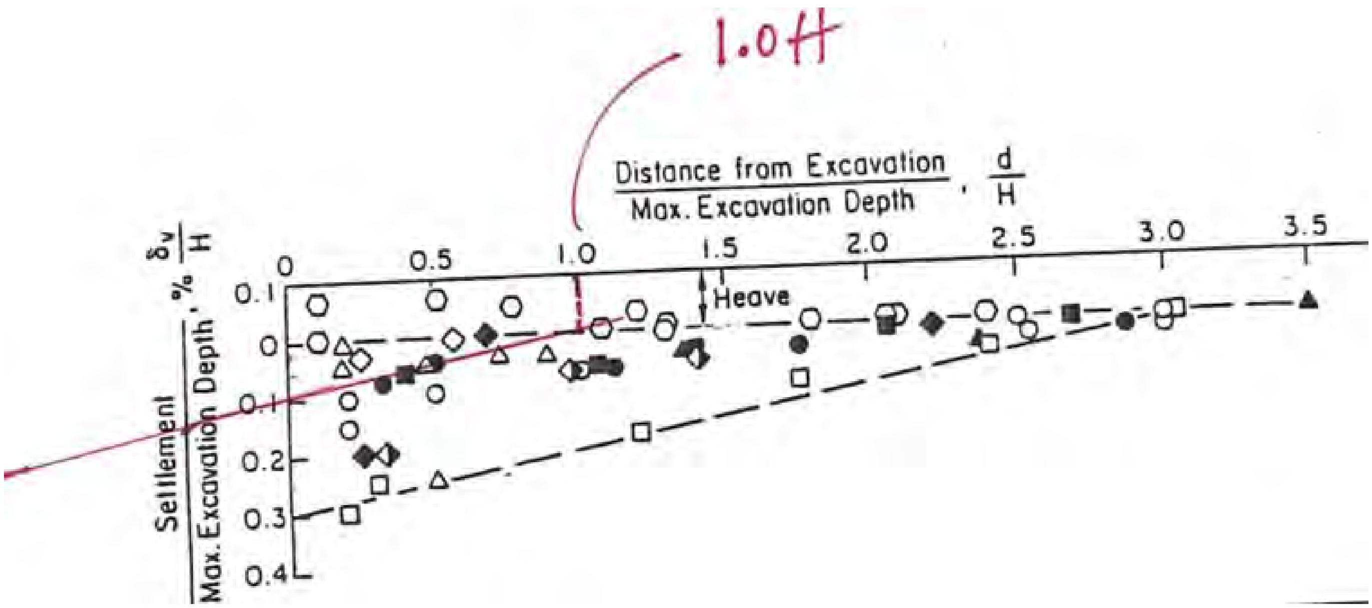


FIGURE 6-37
Settlement Envelope Adjacent to Excavations in Stiff Clays (Clough and O'Rourke, 1990)



6.27 Results and Mitigation Measures

Existing structures/buildings will be identified that could be affected by settlement issues for each bored tunnel alignment. These existing structures/buildings may require mitigation efforts to prevent structural damage resulting from settlement. For cost estimation purposes, compensation grouting was considered as the most likely mitigation method to offset settlement resulting from bored tunnel excavation.

The methodology of compensation grouting involves carefully controlled injection of grout between underground excavations and structures requiring protection from settlement. For tunnel applications, the grouting pipes are installed above the intended tunnel position in advance of tunneling. A key component in controlling compensation grouting is careful monitoring of both structure and ground movements to allow the timing and quantity of grout injected to be optimized. Grout can be injected repeatedly via sleeve port pipes (also known as tube à manchettes), with the injected volumes from each port being controlled to limit the lateral spread of the grout. Grout injection can take place before, during, and after tunneling activity by reusing the sleeve port pipes. Often a "preconditioning" phase of grouting is carried out before tunneling, to stiffen the ground and produce a slight heave in structures above.

A significant advantage of compensation grouting is the wide range of soil conditions in which it can be applied, from hard clays and very dense sands to very soft clays and very loose sands. However, compensation grouting must be used carefully, particularly when implemented close to existing foundations and tunnel linings. Damage to buildings resulting from heave, and collapse of tunnel linings is a potential risk.

6.28 Construction Considerations

6.29 Staging Areas

At least one of the tunnel portals would be used as the mining portal for the excavation of the twin bored tunnels. For the freeway alternatives, which each have a south and north portal, mining could be performed simultaneously at both portals depending on the project schedule. The LRT alternatives would be mined from their south portals because these alternatives only have one portal (there is no site available for a mining portal at the north end of the LRT alternatives).

Sufficient area would be needed adjacent to the portal(s) for the excavation activities and other construction-related items. Some of these activities and items include, but are not limited to, the following:

- TBM delivery, preparation, and assembly
- Tunnel excavation, muck stockpiling, loading, and hauling
- Treatment of contaminated water and disposal
- Stormwater management and other environmental mitigation measures, including construction of sound walls
- Ancillary tunnel equipment (slurry separation plant; muck handling, storage, and loading facilities; ventilation fans; groundwater pumping and treatment facilities; backfill grout plant; electrical equipment; transformers; etc.)
- Construction material storage (precast concrete segments, cement silos, rail, ventilation ducts, etc.)
- Construction offices
- Casting yards for concrete segments if segments will be cast on-site
- Parking for tunnel crews and Metro and Caltrans' construction management personnel

Based on previous and current tunneling projects, it is anticipated that a clear staging area at each portal would be necessary for the freeway tunnel excavation. The LRT tunnel alternatives would require a smaller area.

6.30 Muck Handling and Disposal

Muck generated from portal and tunnel excavation will be temporarily stockpiled on site at the portal(s) and then transported and disposed of off-site. The freeway or LRT tunnel would likely be excavated using an EPB TBM or slurry TBM. Muck generated from either type of machine is generally wet (because of the use of conditioners and additives and also possibly because of the presence of groundwater) and often requires dewatering or temporary storage for drying before being transported off site for disposal. Storage capacity needed for excavated muck at the surface can be estimated from the expected daily advance rates of tunnel excavation in conjunction with any local restrictions imposed on trucking hours and routes, and operation hours of disposal sites.

Muck generated from portal and tunnel excavation could potentially be contaminated by naturally occurring substances such as petroleum, or by man-made substances remaining from previous use of the sites. The exploration program during future phases of the project will provide sufficient information to better identify the characteristics of muck to be encountered. The type of muck disposal site will depend on the environmental characteristics of the muck; at this phase of the project it has been assumed that the muck disposal sites will be located within a 1-hour driving distance from the portals for estimating purposes. Potential muck disposal sites will be identified in future phases of this project.

6.31 Power Needs and Supply Options

Power will be required at portal locations (as well as station locations for the LRT alternatives) to serve construction activities. The TBM and its auxiliary equipment used for construction of the proposed twin-bore tunnels will consume the majority of power required for the entire project. Therefore, power required for the tunneling operations' mining portals will be the main focus. Different types of TBMs will have different power requirements. For example, a slurry TBM will require booster pumps at specific intervals to pump the slurry, and a slurry separation plant on the ground surface, whereas an EPB TBM will not. Auxiliary equipment required during tunnel excavation would consist of tunnel and shaft lighting and ventilation, sump pumps, muck hoists, man hoists, shop support, yard lighting, grout plant, a slurry plant (if using a slurry TBM), and office facilities. Equipment will vary, depending on the selected contractor's preferred means and methods of construction. Power supplied by utilities must be delivered to the site via power drops. Costs associated with installation of these power drops can be significant and depend on proximity of the site to the existing power supply.

As an example of TBM power requirements, the EPB TBM proposed to be used on the Alaskan Way Tunnel in Seattle—which is similar in size to the proposed freeway alternatives for this project—has a peak power requirement of greater than 20,000 kW. This power requirement is for one TBM and includes its trailing gear/backup equipment but does not include other ancillary tunnel construction equipment such as ventilation fans, conveyors or slurry pumps, and equipment in the portal. Power requirements will vary based on machine type and size, and are expected to be less than that for a TBM to excavate an LRT alternative. Power requirements for each of the alternatives will be evaluated in future phases of this project.

SECTION 7

LRT Systems

7.1 General Requirements

The systems requirements under consideration are fare collection, signals and train control, rail transit vehicles, communications, traction power and distribution, central control, security systems, and other system elements required for the project. Metro's Operation & Maintenance, Engineering, and Planning groups will participate in the determination of basis of design for each system element. Design coordination meetings will also be arranged between the design team, Metro staff, and outside agencies as appropriate to produce an integrated system design.

Technical specifications will be performance-based, but some equipment may need to be specified in detail to meet the interface requirements of the Metro rail vehicles, wayside equipment design, and the existing Control Center. Design documents shall be in accordance with the California Public Contracts Code, Section 3400 and all other local applicable codes. Sole source specifications must be avoided unless a detailed justification of requirements that limit the sources of supply is provided and accepted by Metro. Specifications will also require addressing interface issues and meeting safety and security requirements of subsystems to meet overall system safety and security goals.

7.2 Fare Collection

The fare collection system would be designed to be compatible with Metro station design standards. The design must make sure that the layouts of the ticket vending machines and fare gates are compatible with Metro's Universal Fare System (UFS) system-wide vending machine procurement contract. Further, the placement of machines must comply with Metro security requirements for monitoring (CCTV and intrusion alarms). Infrastructure at the stations must satisfy UFS requirements for power and communications services, and protection of equipment from the elements.

CCTV surveillance of the UFS machine arrays and supervisory control and data acquisition (SCADA) intrusion alarm points would be accommodated in the station fare vending machine area designs. Fare collection system design shall be deferred until selection of a preferred alternative.

7.3 Train Control

The design of the Train Control System (including related on-board equipment) shall provide a design that is fully integrated into the civil, facilities, and other subsystem designs in accordance with Metro Rail Design Criteria Section 9/Systems, and the overall operation plan adopted for the project. Train control system design shall be deferred until selection of a preferred alternative.

7.4 Rail Vehicles

The rail vehicle chosen for the project will be the P2550 LRV, which is consistent with existing MTA rail lines. The P2550 is a 90-fot-long articulated car, with a tare weight of 108,390 pounds (lbs). The traction power study was performed with uniform AW2 train loading, which is 134,570 lbs/car and represents 175 people (at 150 lbs/person) per car.

The initial acceleration rate of the AW2 loaded train, at nominal 750 volts direct current (VDC) voltage and flat tangent track, is 3 mph/sec. The in-service braking rate is about 3.2 mph/sec.

The P2550 features regenerative braking with a maximum voltage in regenerative braking mode of 900 VDC.

Auxiliary power of 60 kW/car, used for air-conditioning and ventilation, lighting, and other auxiliary loads, was assumed for the purposes of the study.

The nominal tractive effort (TE) characteristic of the P2550 has three zones:

- Constant TW zone, where a TE of up to 19,670 lbs and as needed to achieve the 3 mph/sec initial acceleration rate is maintained up to 20 mph
- Constant power zone from 20 mph to 50 mph
- Falling power characteristic at speeds above 50 mph

The P2550 also features limited forced reduced performance (FRP) capability, where the propulsion current is progressively reduced if the line voltage falls below 650 VDC. Based on available data (where the car's output power is given at lower voltage levels), the propulsion current reduction rate below 650 VDC was determined as 1.5 A/V. These FRP parameters were incorporated in the vehicle model used in the study.

The design of the wayside train-to-wayside communication (TWC) equipment would be compatible with the vehicle on-board TWC equipment.

7.5 Communications

The communications systems shall consist of private voice and data circuits connecting the ROC with stations and other areas within the Metro system. The communications system would be designed to be compatible with and based on the existing communications system used on the Metro rail system. It shall also support the operational requirements of the Metro Transit System specified in Metro's LRT Design Criteria.

The following subsystems and/or functions are considered part of the communications system:

- Cable Transmission System
- CCTV
- Telephone System
- Public Address/Variable Message Sign
- SCADA
- Intrusion Detection and Access Control
- Radio and Tunnel Antenna System
- Control and Display Consoles at the ROC
- Tunnel Surveillance
- Ticket Vending
- Seismic Detection
- Facilities Emergency Management System
- Fire Alarms System
- Communications Power System

7.5.1 Cable Transmission System (CTS)

The cable transmission system (CTS) shall incorporate both the backbone fiber optics high-speed data transport system and the metallic cable distribution system within the yard, passenger stations, maintenance shops, and administration buildings. The CTS consists of the following elements:

1. A fiber optics cable transmission (FOCT) network shall consist of SONET OC-48 folded ring architecture for the sub-rings connecting back to the main station nodes, which provide connectivity to the OC-192 SONET main backbone ring. The dual feed unidirectional path switch paths of each sub-ring would be GR-1400 CORE-compliant and consist of two, 24-strand, single mode fiber optic cables contained within physically separated conduits.

   The FOCT shall include fiber optic spurs to connect outlying substations and signal houses back to the Train Control and Communication (TC&C) Room at the station, with a minimum of 12 strands of single mode fiber for each SCADA spur and 4 strands of single mode fiber in each CCTV spur.

Fiber cables shall comply with ITU-T G.651 D and Rural Utilities Service (RUS) PE-90. Fiber transmission loss shall not exceed 0.35 decibels per kilometer (dB/km) at 1310 nanometers (nm).

2. Outside Plant (OSP) Copper Cable. The OSP cable system shall connect station TC&C rooms and be installed in conduits between the traction power substations (TPSS)/ Signaling Bungalows with a minimum of 25 pair.

   Copper OSP cables would be gel-filled, multi-pair 22 American Wire Gauge (AWG) with an overall shield and sheath, compliant to RUS PE-39.

3. Inside Plant (ISP) Copper Cable. ISP copper cable shall use Cat 3 wire and terminations unless otherwise specified. Serial connector interfaces in the ISP would be RS-232/RS-485. All ISP cables would be plenum rated.

4. For long distance runs in high EMI areas ISP/OSP may be replaced by the appropriately rated single-mode fiber optic cable. Interfaces to connecting equipment shall in that case support optical interface input/output (I/O) modules.

5. SONET Add Drop Multiplexers (ADMs) and Channel Bank: SONET ADMs and channel banks would be supplied at each station TC&C Room to interface with the existing SONET/Virtual Tributary (VT) data transport network.

6. Main Distribution Frames (MDFs) would be used to terminate all fiber optic cables as well as Cat 3, Cat 6, and other copper cable.

7. Cable Terminating Blocks: Would be used to terminate all ISP OSP copper plants.

8. The CTS shall have protector blocks, patch panels, and ancillary installation, fastening, and grounding hardware.

7.5.2 Closed-circuit Television

A CCTV system would be employed to enable visual monitoring at all stations, with remote monitoring at the ROC. Newly installed CCTV equipment shall interface with all existing equipment previously installed in the system.

The CCTV system shall include cameras to monitor selected station areas. The camera video signals at each station would be carried via coaxial cables to the local TC&C Room, recorded on a local digital video recorder (DVR) and transmitted using the CTS fiber optic system to the ROC as MPEG4 digital video. Equipment provided at the TC&C Room shall include a port to enable a laptop computer to be connected for local viewing and control of any selected station camera.

Six cameras would be required at a typical station.

7.5.2.1 ROC CCTV System

Video signals from each station DVR would be transmitted to the ROC via the CTS using dedicated CCTV fiber optic spur cables of the backbone cable system. Video Signal Picture to Noise Ratio measured at the input to the video matrix switch (after modulation, multiplexing, transmission, de-multiplexing, and demodulation processes) would be a minimum of 44 dB. CCTV would be interfaced with public area emergency telephone/passenger assistance telephone (ETEL/PTEL) such that patron activation of an ETEL/PTEL unit shall cause the activation of the closest CCTV, and the camera image shall remain fixed on that particular phone until reset.

7.5.2.2 Digital Video Recorders

Rack-mounted DVRs would be provided at each TC&C Room to enable the recording and playback of images from all cameras associated with a particular station. DVRs would be controllable locally through a laptop port and remotely from the ROC using the existing Eastman ETZ Control System. DVRs shall provide a minimum of 1.5 terabytes of internal video storage. Individual camera IDs would be generated in the DVR.

7.5.3 Telephone System

The telephone communications services would interconnect with the systems in use for the existing Metro rail lines. Telephones would be connected to the existing EPABX using foreign Exchange Office/Foreign Exchange Subscriber (FXO/FXS) and Multiple Exchange Office/Multiple Exchange Subscriber (MXO/MXS) channel units via the FOCT system and/or copper inside/outside plant wire pairs.

7.5.3.1 EPABX

The EPABX would be of a distributed type with the main node located at the central control. The distributed nodes would be located as required to serve the additional passenger stations.

Equipment failure alarms from each telephone subsystem at each station would be provided to the SCADA subsystem at each station. The EPABX shall provide line status monitoring and alarms. SCADA and EPABX trunk circuits shall have dual redundant paths within the multiplexed system. Ant loss on circuits 6.312 Mbps and higher at the receiving end shall cause an automatic switchover to the redundant path.

Included in the telephone system are the following:

- Administrative telephone (ATEL)
- ETEL
- PTEL
- Maintenance telephone (MTEL)
- Public Telephone Service
- Elevator Telephone (LTEL)

The ATEL group shall provide the day-to-day administrative and operational telephone communications within the rail system. As a minimum, ATELs would be located in any location where personnel are based, including platforms at terminal stations both at-grade and aerial.

The ETEL group shall provide priority point-to-point telephone communications for emergency reporting and coordination. Telephones in this group shall have preprogrammed calling destinations determined by the EPABX. Telephone instruments in the ETEL group would be one of three types, to be determined by the instrument location and function as follows:

- Type “A” – Emergency only, with handset and single-button activation, used at nonpublic locations where only access to the emergency reporting position is required.

- Type “B” – Hands-free with single-button activation, used at public locations such as in elevators and at fire hose cabinets, and requiring no further user action after initial activation. See Provisions for Individuals with Disabilities, for ADA requirements.

- Type “C” – Combination ATEL/ETEL with handset, tone dialing key pad, and single button activation for emergency use. This instrument shall provide the user the option of dial access to any telephone in the system, or priority access to the emergency reporting position. The instrument would be used only at nonpublic locations. When initiating a call, each ETEL location would be automatically identified to the emergency reporting position.

ETEL service would be provided at each passenger station, both at-grade and aerial, and along the trainway. Emergency phones would be located at the Emergency Management Panel, at the Emergency Trip Station (ETS), in elevators, and at the fire hose cabinets.

As part of the ETEL service group functions, the EPABX shall provide simplified emergency reporting. This provision shall allow any telephone serviced by the communications system EPABX and its satellites to have rapid access to the Central Control emergency reporting position by dialing the Universal Emergency Calling Code “911.”

The PTEL group shall provide priority point-to-point telephone service from designated station fare collection areas and any other designated public location to a preprogrammed destination at the Central Control Facility. Instruments in this group would be identical electrically and physically to the Type B ETEL, except for distinctive activation buttons to differentiate them from ETEL instruments. PTELs shall provide provisions for individuals with disabilities for ADA requirements.

The MTEL group shall provide access to the dial telephone system for maintenance personnel working in the Metro rail system. MTEL access would be provided at designated locations where occasional, infrequent telephone service is required (for example, sump pumps, mechanical equipment rooms, etc.), and does not warrant permanent installation of telephone instruments. MTEL service would be made available by installing modular telephone jacks, allowing maintenance personnel to use telephone installer-type handsets for placing and receiving calls.

Public Telephone Service: Facilities for implementing public telephone service at or adjacent to station platforms would be coordinated with the local telephone company. Such facilities may also be provided in free areas. In any case, the location shall not interfere with pedestrian flow.

LTEL: Would be a fully supervised and alarmed line with an automatic ring-down feature to connect directly to the ROC. LTELs would be ADA-compliant.

7.5.4 PA and Variable Message Signs

A fully supervised public announcement (PA) subsystem would be provided at each passenger station both at-grade and aerial.

The PA VMS system shall permit operators to originate both live and prerecorded announcements to patrons and staff within stations. The ability to automatically activate dynamic train arrival destinations and other selected messages would be provided. The system’s prerecorded voice announcements would be coordinated with stored, preset text messages displayed on the VMS signboards. Prerecorded audio messages and their corresponding text messages would be played simultaneously in accordance with ADA requirements. The PA portion of the systems would be supervised in accordance with provisions of NFPA 72. The PA system performance would be designed and tested to provide a level of intelligibility equal or better than STI 0.75

The PA/VMS system shall consist of public address message and signed announcement devices at each of the passenger station stops, with associated local controls at the station’s remote controls, and system status and alarm reporting at the ROC.

The station PA equipment shall consist of preamplifiers, signal conditioning equipment, equalizers, power amplifiers, ambient noise sensing and level adjustment, cabling, loudspeakers and enclosures, local control panels, and all other required interfaces for operation and status monitoring of the equipment.

Speakers at passenger stations would be installed and designed to provide uniformly distributed sound pressure levels within designated coverage areas. All speakers would be located where they are readily accessible for safety testing and maintenance replacement.

PA/VMS displays would be installed in each station’s train boarding platforms, one for each direction. The double-sided display unit shall consist of two light-emitting diode (LED) message signboards housed in a weatherproof enclosure that would be both tamper-proof and vandal-resistant.

Station PA amplifiers, associated signal conditioning equipment, and the VMS display controller would be installed in equipment racks within the station TC&C rooms. The equipment racks cabinet shall include a local microphone position to be used for performing operation and test functions, and keypads to initiate VMS messages.

ROC equipment shall include control and selection panels for originating and logging PA/VMS system announcements. There would be a master PA/VMA system with redundant controllers. Control and selection panels would be provided in the Dispatchers and CCTV Observers consoles at the ROC Control Center.

7.5.5 Supervisory Control and Data Acquisition

The SCADA system consists of remote terminal units (RTUs) located within the Train Control and Communications rooms to provide system monitoring, alarm, and control from the ROC.

RTUs and other remote I/Os would be provided at each of the at-grade passenger stations, TPSS, and TC&C rooms as well as any additional RTUs necessary to implement all of the stated interface requirements defined in the contract documents.

Serial communication links would be provided for each RTU for the following systems:

- Train Control
- UPS

The SCADA protocol at the ROC would be Modbus Transmission Control Protocol (TCP). Other communications protocols would be determined by the requirements of the field I/O equipment interfaced with the SCADA RTU. Interface to the CTS for data transmission between each TC&C location and the ROC would be on a LAN via an Ethernet Gateway switch.

SCADA interface to the fire alarm control panels (FACPs) would be by discrete dedicated inputs/outputs to the various I/O devices. RTU contact input interface would be capable of accepting isolated Form C contact inputs using 24 VDC sensing voltage from a field battery source.

Redundant interconnecting links to the CTS at each RTU site would be provided so the SCADA system would be able to communicate with the RTUs simultaneously on both links.

RTUs would be capable of running full diagnostics self-test procedures. RTUs shall have a watchdog timeout function that sends an alarm to the ROX whenever the RTU detects a total loss of communication with the main SCADA server. At such times, the RTU would be able to operate in fallback local automatic mode.

7.5.6 Intrusion Detection and Access Control

The Intrusion and Detection System (IDS) shall provide controlled access through designated doors, roll-up grills, and hatches to detect unauthorized entries. All detected entries, alarms, and troubles would be transmitted to the ROC for reporting and recording using the SONET CTS.

Intrusion detection would be provided for the following locations:

- Train control and communications rooms
- Auxiliary power rams
- Sprinkler valve rooms
- Electrical rooms
- Cable rooms
- Station entrance to roll-up grills
- Train control shelters
- TPSSs
- Emergency exits
- At-grade station access hatches
- Ancillary area doors

The major components of the IDS system are as follows:

- Existing Video Display Terminals and Printers
- Existing Central Processing Unit (CPU)
- Intrusion detection rack with modems
- Access Card Readers
- Card Reader Controllers
- Intrusion detection magnetic door contacts

- Intrusion detection limit switches
- The electric door strikes
- Exit request devices
- Audible alarm devices
- Bypass switches
- Local station intrusion detection monitors and control processing equipment and rack

Upon detection of an intrusion alarm the following sequence shall occur:

- Intrusion detection systems shall produce an alarm at the local station processing equipment
- Local station processing equipment shall store, process, and transmit the alarm to the Facilities and Emergency Management (F&EM) systems.
- All alarms would be transmitted to the main intrusion detection CPU at the ROC and outputted to the printer.

The F&EM shall provide for storage, processing, and transmission of the alarm to EMP for annunciation. The system shall maintain a record of the access/intrusion event on the main CPU at the ROC. The record shall include door openings, alarms, input of cards with voided security classification numbers, attempted use of invalid identification cards, identification of valid cards used, and all operator commands.

Time from initiation of IDS equipment to the annunciation at the ROC and the EMP shall not exceed 2 seconds. All IDS records would be retrievable via both cathode ray tube (CRT) screen, and printed document form.

7.5.7 Radio Subsystem

The radio communications subsystem shall provide two-way voice communication services in areas where cable or optical fiber cannot practically reach or where mobility is either desirable or necessary. This system shall serve selected rail line passenger vehicles and maintenance vehicles as well as hand-held portables. Separate radio channels would be provided that currently link into and extend communications for the following talk groups: operations, maintenance, security, and fire/police/medical emergency services.

Radio coverage shall extend from existing Metro lines to include all future operating locations. The radio subsystem shall include the ROC, any newly built-out wayside, and would be integrated with all existing field radio equipment.

The uplink (talk-in) and downlink (talk-out) radio coverage paths would be equalized between all portable and rail vehicles. Worst-case talkback paths would be considered when doing typical link budget analysis. The radio transmission system shall build upon existing two-way channels mapped to the following frequencies and service groups:

The radio system would be designed to conform to future governmental interoperability plans, and migration to narrow band and future data radio operations.

Signal quality would be CM-4 with a 95 percent coverage probability at 95 percent of the required locations. At-grade and aerial coverage shall include the area extending 2,000 feet from each side of the track ROW, as well as the main and satellite yards and Central Control Facility external areas such as parking lots, etc.

Expansion of trunked or pooled radio channels would be capable of expansion of up to 250 user group ROC links to the radio subsystem: Voting- equipment would be located at the ROC and have the capability to accommodate all radio receiver equipment associated with the new build-out section to include those locations in the signal strength polling voting process.

All radio equipment would be linked to the ROC for the remote control (from the ROC) and supervision of transmit and receive functions for the field repeaters.

7.5.7.1 Multi-site 900 MHZ Trunk Radio System

The current light rail radio communications system consists of several elements: a multisite 900 MHz trunk radio system and backbone, the radio control equipment to be located in dispatch consoles, mobile radios, portable radios, and control systems (Table 7-1). The current voice radio system consists of a 5-channel, expandable to 10 channel, 900 MHz trunk radio system that shall involve radio transmit and receive equipment at remote sites. Additional sites would be provided to extend radio transmissions to new stations and underground as required.

TABLE 7-1
Radio Transmission Systems

Band	Group	Deployment
R1: 160 MHz Rail Band	Mainline Rail operations	Talk around/repeater at ROC 160.425 MHz (talk-out) and 160.635 MHz (talk-in)
R2: Emergency Operations	All users	160.695 MHz (talk-out) and 160.755 MHz (talk-in) with telephone patch-in interface at ROC
R3: Simplex 161.505 MHz	Yard operations	Provides link within Yard Controller
R4: Duplex 161.265, 160.935 MHz Metro Subway Data	Data transfer to and from revenue service vehicles	Train Identification and Control Unit and Central Data Unit communications
R5: 161.1450 MHz and 160.7250 MHz	Rail Maintenance	
Two duplex channels T1: 453.4750	Transit Police	All areas Metro Transit Operations
Six duplex channels UHF Police Band	Los Angeles Police Department	Repeater operation. Centrally administered.
Eight duplex channels in 800-860 MHz Band	Required City and County of LA Fire Dept. Coordination	Underground radiating cable in subway and tunnel
900 MHz	Transit operations supervisor (TOS) and ROC supervisor	900 MHz trunk radio system and backbone

Radio dispatch control equipment would be provided for light rail transit operations supervisor (TOS), communication controller and ROC supervisor console positions. The equipment would be capable of monitoring and accessing all of the talk groups in the system.

7.5.8 Ticket Vending Subsystem

The Ticket Vending Machine (TVM) system includes ticket vending and Stand-alone Fare Validator (SAV) equipment located at the station platforms. At each station these machines would be connected to a network server device. The network server is to be interconnected to the CTS’s virtual local area network (VLAN) circuits and leased telephone lines to the Central Fare Collection Processor at the ROC.

Leased telephone lines to connect to the network server back to the ROC would interface at the telephone backboard connecting block of each TC&C Room. Power to each fare vending machine would be provided from each passenger station’s normal electrical service power panel. Power for the network server device would be provided from each passenger station’s UPS panel.

7.5.9 Fire Alarm Subsystem

The fire alarm system shall include, but not be limited to, FACP, EMP, alarm devices, transmitters, signal initiating devices, power supplies, battery charger, standby batteries, printers, condor, fittings, wiring, and all accessories required to form a complete coordinated system ready for operation.

The fire detection system shall comply with the California building code and with the requirements set forth by the California State Fire Marshal, NFPA 72, and NFPA 130.

The alarms and troubles from the stations, train control shelters, and traction power substations would be collected and formatted as individual zones. The FACP shall provide the logic in interface functions necessary for the communication of data to the EMP and SCADA RTU, and for automatic monitoring and control of the interconnected facility equipment.

The FACP would be an intelligent device with network communications capability. It would be of a modular design for the use of future system expansion. The FACP shall incorporate microprocessor-based CPU, which shall communicate and control the following types of equipment: addressable detectors, addressable modules, at-grade station remote annunciator panel, EMP, remote emergency management panel (REMP), F&EM, printers, and system controlled devices.

The fire alarm system shall also include displays that shall provide all the controls and indicators required for system operation. These displays would be used to program system parameters. The display assembly shall contain and display as required custom alphanumeric labels for all intelligent detectors, addressable modules, and software zones. The system display shall include the following operator control switches: signal silence, lamp test, reset, system test, and acknowledge.

Each EMP shall have an associated REMP. One remote annunciator panel (RAP) would be installed at each station. The RAP shall provide annunciation and remote control for the FACP. The RAP shall mimic the display and control portion of the FACP to provide the event and programmed messages as displayed on the main FACP. At each station, the RAP would be located outside the TC&C Room door. The RAP shall provide communication with the FACP over a remote data port interface.

The EMP may be used by Fire Department personnel as command centers during emergency situations.

7.5.10 Facilities and Emergency Management Subsystem

The F&EM system provides the programmable logic controller (PLC) necessary to provide logic processing, real-time data storage, and communication transmission interface with the EMP, ROC, and operator work station (OWS) systems for remote system monitoring and control. This PLC shall pass on data from the following subsystems:

- Ventilation control
- Fire alarm
- Intrusion detection
- Gas detection
- Seismic detection
- Other facilities-related equipment

7.5.10.1 F&EM Programmable Logic Controller

The PLC would be the main element in the F&EM system that shall monitor and issue control commands to the station equipment under supervisory control actions. The F&EM PLC system shall perform all necessary functions to enable operating personnel at the ROC or user interfaces at the EMP to carry a remote/local monitoring and supervisory control functions on station equipment.

Under normal operating conditions, control would be from the ROC. However, station control of the F&EM system device would be available during any manual operation of the EMP.

All real-time data from switches, relays, transducers, and all other equipment would be collected by the PLC from remote I/O equipment and sensors. The PLC would be capable of responding to polls and updates at the rate of two (2) per second.

The PLC shall accept and respond to periodic on-demand requests for its specific data from the SCADA or the EMP subsystems. The PLC shall transfer and communicate the current values of the requested points, and only this specific information requested by the SCADA or the EMP would be transmitted on demand by the F&EM PLC.

The PLC system shall perform supervisory control action on station equipment as requested by the ROC or the EMP. The PLC shall accept messages and control data from the SCADA subsystem and from the EMP subsystems to store in its database and be made available for applications processing inside the PLC as necessitated by software application requirements.

The PLC shall pass the control requests received from the ROC to station equipment via the dedicated wired I/O communications network terminating outward at the PLC. This shall constitute a hardwired and supervised set of field-routed signal cables or its functional equivalent. The PLC would be responsible for monitoring the I/O ports and equipment for the correct response.

The PLC shall respond to SCADA or the EMP after determining if the control action was successful or unsuccessful. Regardless of whether controllers work from the EMP or from the SCADA system indications of current status, an alarm would be transmitted to both locations from the PLC. However, only one location, would be in control at any given time.

7.5.10.2 System Reliability

The PLC would be configured in a redundant mode with primary and standby hardware. Any failure in the primary PLC shall cause automatic failover to the standby PLC. A failure from primarily to standby shall also cause the primary PLC's failover capability to be disabled until reset from the EMP. This is to prevent ping-ponging of the units when a failure condition exists in both.

The PLC system would be designed such that no failure within the TLC system shall permit the equipment to be operated in an unsafe manner. The contractor shall submit for review and approval a complete list of potential failure and abnormal conditions, the means of detection and reporting of each condition, and suggestions for automatic control action(s), if any, to be taken to maintain safe, stable operation.

Operator Work Station (OWS)

The OWS would provide the programming terminal located in the TC&C Room that shall allow the PLC to be programmed onsite. Once the PLC is programmed, failure of the OWS shall not adversely affect systems operation. The OWS would be a PC-compatible type computer, with Windows XP/Vista O/S and 4 gigahertz (GHz) microprocessor, with random access memory (RAM) and hard drive storage to meet the database and applications needs plus a minimum of 50 percent headroom for growth.

Software and Database

All application software provided to the OWS to support supervisory control and EMP annunciation would be capable of easy expansion to accommodate the anticipated growth of the system. Application programs would be able to obtain the size and configuration of the system from easily modified parameters contained in the database. Reassembly or recompiling of the software, or parts of the software, shall not be necessary to accommodate growth within the established size of the system database tables.

The F&EM system shall have a real-time database that would be expandable through well-documented generating and editing procedures so that future functions added by the user can readily be included with a minimum of down time or system disruption.

F&EM Programmable Logic Controller

Software would be provided to continuously monitor hardware and communications network performance in real-time with a minimum of interference with the normal F&EM system functions. The data sampling period over which statistics are gathered would be adjustable by the user. The accumulated statistical results would be available for output to both computer terminal displays and to loggers after each period, and would be capable of being provided in an on demand fashion anytime during the period. All statistical information would be archived and reset at the start of each sampling period.

7.5.11 Seismic Detection System

The seismic event detection equipment would be capable of detecting seismic waves that cause local ground accelerations and would record and transmit minor and major alarms of seismic events to the SCADA via the CTS and to the F&EM system. Seismic equipment shall function independently at each location. Emergency Seismic Operation Procedures (ESOPs) in accordance with pre-programmed emergency scenarios would be activated whenever a major seismic event is detected.

The seismic detection equipment would be comprised of the following major components:

- Minor Alarm Seismic Switch
- Major Alarm Seismic Switch
- Event Recording System

Seismic detection equipment would be furnished in sets. Each set shall include two seismic switches (one minor alarm and one major alarm) and one event recorder. Equipment would be user adjustable and separated to optimize both vertical and horizontal detection. Seismic detection equipment would be located in the TC&C rooms of designated passenger stations and would be bolted to a concrete floor or pad.

Seismic Switches

Seismic switches would be tri-axial acceleration types. Ground motion equal to or above the given set point of the equipment shall actuate the equipment. Once actuated, ground motion signals shall remain actuated for a minimum of 6 seconds after the ground motion has fallen below the set point. After 6 seconds the seismic switch shall reset automatically. Set points would be user adjustable. Seismic switches shall contain both major and minor alarm set points and two units of each would be supplied for redundancy purposes. Seismic switches would be designed to provide a separate signal to the seismic recorder to confirm that the recorder has been activated.

Seismic Recorders

Seismic recorders shall provide a record of seismic event data, including pre-event data. Pre-event memory would be set for 10 seconds. Set points would be user adjustable. Recorders would be actuated by either the external or internal seismic switches. Data recorded shall include event time, event duration, peak acceleration, and three channels of information: longitudinal, vertical, and transverse. Recording range would be at least 1.0 acceleration (g) to -1.0 g.

Recording time shall not be less than 10 minutes. Correct time would be traceable to an accurate time source and, at a minimum, verified and corrected once per day.

Recorded events may be retrieved either automatically via the communications system, or manually by onsite computer. Physical interface would be a nine-pin RS232C type serial port. The recorder would be compatible with Q-Tronics or approved equivalent.

Each seismic detector set shall receive 120 volts alternating current (AC) single phase power from the UPS. The terminal block for power would be separate from the terminal block for signals. Seismic detection enclosures shall have a National Electrical Manufacturers Association (NEMA) Type 3R rating and a latchable cover. These enclosures shall protect the equipment if a ceiling-mounted fire sprinkler is activated.

Electrical Interfaces

Interface with F&EM PLCs would be through a parallel discrete-bit interface via a voltage-free, normally closed contact. The signals would provide 0.1 g, 0.2 g event detection as well as a loss of power signal to indicate the loss of output from internal power converters or transformers. Inside the equipment enclosure a terminal block would be provided for terminating field-routed signal cable to the F&EM system.

7.5.12 Control and Display Consoles at the Rail Operations Center

Apparatus at central control includes console equipment to support various manned positions, recorders, printer, displays, and special processing components. These include but may not be limited to the following:

- ROC Consoles: The ROC consoles provide the displays, CRT workstations, and controls for the train operations, communications, traction power, as well as the monitoring and control of the fixed facilities and emergency equipment.
- CCTV Area Console: Provides camera selection and control capability to allow the console operator to display the video from any camera on a large-screen monitor. Each operations console shall provide access to the intercom, to the Systems Communications console in the operations control room, to an ATEL line, and access to passenger PA equipment.
- Train Dispatcher and Systems Communications Consoles: These consoles perform all functions for processing control situations at each work station.
- System Status Display Console: The system status display subsystem shall provide a dynamic representation of the condition of the train control system and the attraction power contact rail/conductor wire to monitor the operation of trains. The display shall contain indications for track occupancy within and between stations, track occupancy within interlocking, route alignment, traffic direction, contact rail/overhead contact system segment status, and other vital and non-vital alarms and indications.

7.5.13 Uninterruptable Power Supply Subsystem

The UPS units would be connected to the station's vital power panels and shall rectify incoming 120V, 60 Hz AC power to DC, charge and maintain charge on the connected batteries banks, invert the DC to 120V 60 HZ AC, which would be connected to an associated AC power panel for distribution to all connected subsystems requiring inverted power.

Rectifiers, battery banks, and inverters shall provide sufficient capacity to support their connected loads plus 50 percent to account for future loads. They are to have sufficient capacity for a power outage of not less than 4 hours, while retaining 20 percent of full rated charge.

The battery systems would be sealed, non-outgassing, gel types designed such that the battery would be automatically disconnected from its associated load should its capacity fall below 20 percent of full rated charge.

The Rectifier and Float Charge System would be capable of powering their connected loads while simultaneously bringing depleted charge batteries from 20 percent charge to 100 percent charge within a 16-hour period. UPS supplies would be configured for automatic switch-over to the bypass mode in the event of a UPS battery system and or inverter failure. Manual bypass shall also be provided for maintenance and testing purposes. The UPS system would be connected to the SCADA system to implement the following alarms and controls:

- Loss of incoming AC power
- Battery load shed
- Inverter failure
- Low battery reserve
- Automatic switch to bypass mode
- Manual set to bypass mode
- Control switch to bypass
- Control switch to online

Battery Cabinets

The gel-cell batteries provided would be mounted in an enclosed battery cabinet configured to permit forced exhaust convection air to enter the cabinets near their base.

Each cabinet shall also contain spill containment pans and acid absorptive mats in accordance with applicable building codes and practices. The absorptive mat would be capable of neutralizing a spill from the largest battery within the cabinet to a pH of between 7.0 and 9.0.

7.6 Fire Detection and Suppression Monitoring

The fire detection and suppression system for the project would comply with the California Building Code and would meet the requirements set forth by the California State Fire Marshal.

The subsystem would include, but not be limited to, FACP, EMP, printers, power supplies, battery chargers, standby batteries, transmitters, signal initiating devices, alarm devices, conduits, fittings, wiring, and all associated accessories as required.

The FACP would transmit alarm/trouble zones to the F&EM system's PLC for processing. The PLC would then provide the logic and interface functions necessary for pass-on of data to the EMP, SCADA via RTU, and for automatic operation and control of the interconnected facility equipment.

7.6.1 Fire Detection

The fire detection system would be capable of providing multiple zone detection, cross-zone detection in conjunction with fire suppression systems, and automatic ventilation controls.

Fire control panels would be lockable with alarm reset function, on/off controls, and alarm disable control, all accessible by key only.

Each smoke detector would be equipped with an indicator that illuminates upon detector actuation.

Each heat detector shall provide a combination of fixed temperature and rate-of-rise heat detection.

7.6.2 Suppression Monitoring

The fire suppression monitoring system alarms and status indications would be annunciated at central control and, where provided, at the local EMP.

The system shall monitor water flow switches and valve tamper switches for automatic sprinklers (including pre-action systems), wet standpipes, water curtains, and other suppression systems throughout the Metro system.

7.7 Central Control

It is envisioned that the project be incorporated into the existing ROC and be integrated with the existing Metro's LRT operations. It is important to assess its impact on Metro's operation because this would allow Metro to interconnect multiple LRT lines to operate through-service; in particular, the impact on the existing ROC.

7.7.1 Existing Central Control Facility

Metro rail operations are managed from the ROC located at Imperial Highway and Wilmington Avenue, which includes management, controller training, and supporting service personnel.

In addition to operations, the Los Angeles County Sheriff Department (LASD) operates out of the ROC, covering both dispatch and security.

ROC currently serves as the main control center for all Metro lines operated by Metro, which include operations on Metro Blue Line, Metro Green Line, Metro Red Line, and Metro Gold line. It is also planned to serve the future Metro Expo Line and Regional Connector. In addition, the ROC is heavily taxed in accommodating training, conference services, and staff office space necessary for the current transit and supporting operations.

The current ROC configuration has evolved over the years as new rail lines have been added and expanded. The operating theater is organized into two main areas for line service management and observation of CCTV images. In view of the fact that the existing lines are isolated from each other, line control and service delivery are provided on a line per line basis. This is reflected in the ROC by having dedicated overview display panels and operator consoles for each line. The same operating philosophy would be applied to the project.

The ROC currently includes a number of train control, communication, and security systems that enable control center personnel to perform their duties and responsibilities. Table 7-2 identifies the various systems installed at the ROC with respective locations.

TABLE 7-2
Existing ROC Systems

System	Rail Line	Location
Overview Displays and Projectors	All	Operating Theater
Controller and Observer Consoles All Operating Theater	All	Operating Theater
Automatic Train Control	Green	Computer Equipment Room
Telephone System	All	Computer Equipment Room
Transit Automatic Controls	Red/Purple	Computer Equipment Room
Train Control System	Blue/Gold	Computer Equipment Room
Radio System	All	Communications/ Signaling Equipment Room
Advanced Information Management System - Light Rail SCADA	Blue/Green/Gold	Communications/ Signaling Equipment Room
RIITS Database	Blue/Green/Gold	Communications/ Signaling Equipment Room
Digital Voice Logger System All Communications/ Signaling	All	Communications/ Signaling Equipment Room
SCADA Network	All	Communications/ Signaling Equipment Room
IDS	Red/Purple	Communications/ Signaling Equipment Room
VMS	Blue/Green	Communications/ Signaling Equipment Room
Wayside Intrusion Detection System	Green	Communications/ Signaling Equipment Room
SCADA Information Web Server	All	Communications/ Signaling Equipment Room
PA/VMS System	All	Communications/ Signaling Equipment Room

Notes:
SCADA = supervisory control and data acquisition
RIITS = Regional Integration of Intelligent Transportation System
IDS = Intrusion and Detection System
VMS = variable message signs
PA = public announcement

7.7.2 Revised ROC Operating Theater

The ROC Operating Theater is divided into two main areas: the Service Control Area, and CCTV Monitoring Area. The Service Control Area is dedicated to train operation, interlocking control, and service delivery, whereas the CCTV Monitoring Area is dedicated to observing CCTV operations, alarms, and answering telephone calls from passengers and Metro staff.

The existing Service Control Area includes four sections for the control of the various lines. Each section includes an overview display and associated work stations. The four sections are organized as follows:

- Metro Gold Line with three work stations
- Metro Red Line with three work stations

- Metro Blue Line and Expo Phase I with three work stations
- Metro Green Line with three work stations

TABLE 7-3
Existing CCTV Monitoring Area Equipment

Rail Line	# CCTV Monitors	# Consoles
Metro Green Line	4	2
Metro Red Line	6	2
Metro Pasadena Gold Line and Metro Eastside Gold Line Extension	8	2
Metro Blue Line and Expo Line Phase 1	12	2
Supervision	n/a	2
Totals	30	10

7.7.3 Revised ROC Computer Equipment Room

The existing Computer Equipment Room houses train control processing units for the Metro Red Line, Metro Blue Line, Metro Green Line, and Metro Pasadena Gold Line. In addition to this, it also contains the PBX equipment for the ROC, and battery racks. It contains three workstations and two workbenches.

Based on a visual inspection, it appears that the Computer Equipment Room has sufficient space to accommodate equipment related to the project. However, no conceptual layout has been drafted as of yet because of the unavailability of current layout drawings of the room. These are needed in order to make a thorough assessment of the current space availability and to determine the modifications needed, including HVAC modifications, if necessary. This would be validated in the subsequent phase of the project.

7.7.4 Revised ROC Communication/Signaling Equipment Room

The existing Communication/Signaling Equipment Room contains five rows of open frame racks with various types of equipment mounted on them. The equipment types range from termination equipment to communication equipment to fiber optic equipment to train control equipment, power supply equipment, etc.

7.8 Traction Power and Distribution

The design of the traction power supply and distribution system must meet the performance requirements and be fully integrated with all related vehicle, subsystem, civil and facilities design. The design shall adhere to the requirements listed in Metro Rail Design Criteria Section 7/Electrical.

The development of the design of the traction power supply and distribution system will take into account the substations and vehicle characteristics. The design will contain all engineering data required to produce the plans, specifications, and estimates required. The design will integrate all traction power supply and distribution system design elements, with related system elements from other disciplines. The traction power supply and distribution system design will require coordination with design elements (signaling, communications, structures, civil, etc.), as well as with third parties (utilities, local cities, etc.). Conceptual engineering efforts on the traction power supply and distribution system are limited to identifying the location for the TPSS based on a qualitative analysis. All analysis of the traction power and OCS will be deferred until after selection of a preferred alternative.

The traction electrification system (TES) is comprised of the following major subsystems:

- TPSS

- DC power distribution system, which includes the positive DC feeders and OCS, and the negative DC return feeders and running rails

7.8.1 Traction Power Substations

Primary power would be three-phase AC provided by the LACDWP at 34.5 kV. The TPSS would convert the 34.5 kV AC to DC power at nominal 750V DC system voltage for distribution to trains via the OCS. Rectification would be achieved by either a diode-based or thyristor controlled 12-pulse power rectifier with one transformer-rectifier unit (TRU) per substation. The incoming utility feeders to the TPSSs must be independent; that is, supplied from different step-down utility transformers.

The SR 710 Study Conceptual design has four LRT alternatives: LRT 4A, 4B, 4D, and LRT 6 in the CE stage of this project. As there are differences in the speed limits, gradients and feasible TPSS sites from a real estate point of view between the four alternatives, they were evaluated by Traction simulation study. These studies determined the number, ratings and locations of the TPSSs required for each alternative, and establish if the standard OCS has adequate capacity electrically, or needs reinforcement.

The number, locations, and ratings of the TPSSs are typically determined using TES performance criteria with regard to the minimum acceptable train voltage and maximum permissible thermal load on the OCS. The analysis is performed for normal and contingency operating conditions. The contingency scenarios considered by the study are one TPSS out of service, with electrical continuity at the TPSS sectionalizing gap maintained by closing normally open bypass switches.

7.8.2 DC Power Distribution System

The DC power distribution system is divided into positive and negative sides. The positive side would comprise an OCS, parallel feeders, and positive DC feeders connecting the OCS to the TPSS. The negative side would be comprised of 115 RE running rails, track impedance bonds (if necessary), cross-bonds, and negative return feeders connecting the running rails to the TPSS.

7.8.3 Overhead Contact System

The OCS would consist of a set of two copper wires – a contact wire and a messenger wire – supported by steel poles mounted on reinforced concrete foundations. OCS poles would be spaced along the LRT alternatives, between or adjacent to the tracks, at a typical spacing of 150 feet.

The OCS would be designed to match OCS configuration per the traction power simulation study and with the consideration of minimizing visual impact. The design of the OCS would be based on technical, economical, operational, and maintenance requirements, as well as on the local climatic conditions. The OCS design would be coordinated with the car dynamic performance characteristics to be sure that current collection is maintained. The OCS shall also accommodate the physical characteristics of the car and the performance requirements of the propulsion system associated with the car; that is, clearance envelopes, propulsion power supply voltage, etc. Further, the OCS would be designed to provide adequate pantograph envelope, pantograph security, structure capacity for poles and foundations, and wire and components safety factors.

All analysis of the OCS will be deferred until after selection of a preferred alternative.

7.9 Safety/Security

7.9.1 Safety

Safety is a primary consideration, from conceptual engineering through revenue operations. To achieve safety goals, all applicable codes and regulations, augmented by modern safety engineering technology and industry standards, are to be used to achieve a level of safety that equals or exceeds that of the rail transit industry.

Safety can be achieved by eliminating, minimizing, or controlling hazards through analysis, review, and design selection. The objectives of the safety program are the elimination or control of Category I and II hazards as defined in the Metro Guidelines for Preparation of Safety and Systems Assurance Analyses, 5-001A, and the assurance that no single point failure or no undetected failure (latent) in combination with an additional failure would result in a Category I or II hazard.

To achieve these objectives and provide a level of safety that equals or exceeds that of other rail transit systems requires a comprehensive and complete safety program. That program is described in detail in the Metro System Safety Program Plan.

The safety program would establish safety requirements and verify safety of design through analyses. It would also help assure that the Metro rail system provides for health and safety provisions affecting maintenance and operations personnel that equal or exceed the requirements of the Occupational Safety and Health Administration, State of California (CAL/OSHA), the Occupational Safety and Health Administration (OSHA), the U.S. Department of Labor, and ADA.

A Functional Hazard Analysis would be prepared that analyzes the loss or malfunction of each operational function and categorizes its affect on the equipment, personnel, patrons, and general public to determine the associated hazard level (Category I, II, III, IV) as defined in the MTA Guidelines for Preparation of Systems Safety Assurance Analyses 5-001A.

7.9.2 Security

Security refers to the prevention of acts defined as unlawful, criminal, or intended to bring harm to another person or damage property. The project alternatives, including proposed station areas, proposed park-and-ride facilities, proposed maintenance yards, operational parameters, and surrounding neighborhoods were evaluated to determine crime risks.

The primary objective of a security program is to make sure that the design includes features that enhance both the actual and perceived security of the using public. Of nearly equal importance is the need to protect system employees from crime and harassment, and property from loss, damage, or vandalism.

The design shall provide for a high level of security for patrons and operating personnel. Facility design and operating procedures shall promote a sense of well-being by patrons and personnel, discouraging acts of crime, violence, and abuse. Security provisions shall also discourage acts of vandalism, theft, and fraud.

The design shall include features that enhance patron and personnel security. These shall include maximum visibility from surrounding areas, with no hidden corners or alcoves; locks on doors to any rooms; landscaping; and lighting levels that support the intended means of surveillance.

A Threat and Vulnerability Analysis (TVA) will be conducted after the selection of a preferred alternative. The TVA will follow Federal Transit Administration (FTA) (FTA C 5800.1 and FTA Project Management Guidelines, Chapter 2) and Metro protocols. The TVA process will provide a more refined and detailed analysis of the security environment by identifying domestic and international security threats, potential vulnerabilities/shortcomings in the transit system, and then making recommendations to reduce those vulnerabilities to acceptable levels.

7.10 Mechanical

7.10.1 Elevators

Elevators will be installed in aerial stations and will be located so as to keep the travel distance to the platform at a minimum. In stations with parking garages, parking for the handicapped will be located near the elevators. Elevator cabs will be sized for accommodating a gurney for Fire Department use. The elevator will be glazed or will have transparent panels to allow an unobstructed view both into and out of the car. Elevator finish materials are brushed stainless steel on glazed wall surfaces, doors, frames, sill, and trim, as indicated on the Metro Rail Design Criteria/Section 6 Architectural Standards. The hoistway doors will be safety glazed and of standard design. Elevators shall be hydraulic type with separate or combined equipment rooms.

7.10.2 Escalators

Each entrance to aerial stations will include at least two escalators (ingress/egress) and two stairs. Escalators will be paired with stairs to provide required exiting capacity. If it is not possible to provide four devices at the station, stair/escalators can be split into single pairs.

All escalators will be 48 inches nominal width, dual direction, with 90 fpm in both directions in accordance with Metro's Design Criteria. Escalators are specified as capable of operating 24 hours non-stop. Escalators are systemwide, standard elements, as indicated in Metro's Architectural Standard and Directive Drawings. All escalators shall have stainless steel cladding. Electrical

7.11 Electrical

7.11.1 Power Sources

Primary power would be three-phase AC provided by the LACDWP.

Because all the stations would be located above ground, either at-grade or in an aerial configuration, a direct 480V power supply from the power utility company would be provided if available. The primary power supply would be at 34.5 kV for all stations. Transfer switches would use a main-tie-main circuit breaker concept.

7.11.2 Power Supply Reliability

The stations will be powered from two independent power sources. In the case of an emergency or electrical outage, this will allow for the emergency generators to activate lighting and ventilation equipment as a back-up power supply.

7.11.3 Power Distribution System

The power distribution system would provide power to all mechanical equipment, such as lighting, elevators, escalators, sump pumps, sewage discharge systems, and irrigation systems through a series of motor control centers, local control stations, and power distribution panel boards. Power would also be provided for all of the systems-related equipment and would incorporate a power distribution design with comprehensive protective device coordination and short circuit analysis.

7.11.4 Grounding

Grounding systems would include an electrical station grounding system with a buried ground grid system to be sure that all exposed electrical equipment is bonded to prevent any electrical hazards. A direct grounding system or single point ground would also be provided for the communications system, and a reference grounding system would be provided in the TC&C Room.

7.11.5 Supply Voltage and Voltage Drop

AC station power for the general facilities would be 480V, 3-phase, 3 wire or 4 wire at 60 hertz (Hz). Station and tunnel lighting would be at 277V single-phase, motors at 480 3-phase or 120V single-phase and power outlets at either 480V or 120. Voltage drop from the auxiliary transformers to the farthest device or equipment would be no greater than 5 percent per code, and 3 percent for lighting and feeder circuits.

7.11.6 Lighting

Normal and emergency lighting systems would be kept independent of each other. Station lighting would consist of decorative high-intensity discharge and/or fluorescent lighting for platform edge lighting and other types of lighting fixtures per Metro's lighting standards. Lighting shall use the latest energy saving lighting and lighting control technology.

SECTION 8

Right-of-Way Considerations

ROW impacts were determined by overlaying the design footprint of each alternative on top of the Los Angeles County Assessor's parcel boundary layer in the geographic information system (GIS). The system identified properties that were impacted by the designs and each impacted property's underlying ownership information and physical characteristics were subsequently exported to a database for later use in ROW cost estimation. At this phase of the analysis, the impact assessment will be completed without site visits that would be required to verify the correctness of property ownership information. As such, the conclusions of the analysis are conceptual.

Several design alternatives evaluated in this analysis contain sections of bored tunnel that will not impact the properties on the surface that require acquisition of the property in fee. Similarly, some alternatives contain sections of overhead aerial structure that will not directly impact the underlying properties. The acquisition of subterranean and aerial easements are considered impacts for this analysis and also will be considered in the ROW cost estimation process.

A number of transportation and infrastructure properties were identified by the analysis as being impacted. It was, however, agreed that the necessary relocation or reconfiguration of these properties would be handled by the agencies overseeing the design and construction of the project and would therefore not be considered impacts.

8.1 Summary of Potential Effects to Resources by Alternative

Table 8-1 summarizes the number of potentially impacted properties for each alternative. If one alternative has multiple options, the number of properties for each option are separated by a slash.

TABLE 8-1
Potential Impacts to Resources by Alternative

Properties (Acquisition Type)	TSM/ TDM	BRT-1	BRT-6/6A	LRT-4A/B/D	LRT-6	F-2	F-5	F-6	F-7	H-2	H-6
Commercial (Full)	30	19	0/0	40/47/61	151	9	37	36	2	59	72
Residential (Full)	23	0	0/0	10/8/1942	63	304	218	440	3	573	112
Commercial (Part/Easement)	10	0	0/0	90/65/17	91	30	24	0	31	10	5
Residential (Part/Easement)	11	0	0/0	80/79/2	182	580	428	0	401	1	0

A more detailed description of resources potentially impacted by each alternative is detailed in the ROW Technical Memorandum located in the Alternative Analysis Report.

SECTION 9
Project Cost

9.1 Construction Cost

The methodology used in developing the conceptual cost estimates has been created in conformance with Caltrans guidelines for estimating capital costs for all highway alternatives. All transit alternatives used the FTA's Standardized Cost Categories (SCC) to develop costs typically associated with transit projects. These cost categories were incorporated into the Caltrans template. Cost estimates for each alternative are provided in Appendix B.

Cost data and quantity take-offs for each alternative have been developed as a design team collaborative effort. Unit costs have been developed using the Caltrans Cost Database and most recent Metro transit project costs. These reflect the current bidding climate and bids, and our recent experience on similar projects. Ancillary costs were estimated as a percentage of the major items of work using engineering judgment and Caltrans standard guidelines. Because of the high-level conceptual approach of the Alternatives Analysis (AA) cost estimate, summary costs were rounded.

9.1.1 General Approach

Each alternative's conceptual layout plan serves as the basis for the quantity take-offs and has been used to identify the various infrastructure elements used in estimating cost. Cost items not shown on the plans or items estimated by a percentage, such as tunnel systems, have been identified and estimated using historical data.

9.1.2 Cost Estimating Assumptions

The basic assumptions and criteria used to develop the cost data were as follows:

- Estimates have been prepared using 2012 dollars
- Contingency is set at 35 percent for all items except for ROW, which is set at 25 percent
- ROW acquisition costs are inclusive of full and partial acquisitions. ROW costs such as temporary construction easements, railroad easements, relocation assistance, clearance and demolition of residential and commercial properties, and fees associated with title, escrow, and appraisals are also included.

9.1.3 Adequacy of Cost Estimates

At the AA stage, the cost estimates are rounded, which is considered reasonable based on the conceptual level engineering of the project design. Cost estimates will be updated as the project moves forward.

Future phases of work will require a more comprehensive estimating approach, along with a complete development and re-assessment of project risks.

Any risk involved in estimating is accounted for in the contingency of cost items.

A summary of the construction and right-of-way costs is provided below in Table 9-1: Total Construction and Right-of-way Costs by Alternative.

TABLE 9-1
Total Construction and Right-of-Way Costs by Alternative

Alternative	Construction Cost (millions $)	ROW Cost (millions $)	Total Cost (millions $)
No Build	0	0	0
TSM/TDM	30	90	120
BRT-1	50	30	80
BRT-6	50	0	50
BRT-6A	50	0	50
LRT-4A	2,400	200	2,600
LRT-4B	2,200	225	2,425
LRT-4D	2,100	300	2,400
LRT-6	1,125	700	1,825
F-2	6,100	325	6,425
F-5	5,750	525	6,275
F-6	1,450	675	2,125
F-7	5,350	75	5,425
H-2	500	850	1,350
H-6	325	425	750

9.2 Operations and Maintenance Costs

Detailed operations and maintenance (O &M) costs have not been quantified at the conceptual design level because the level of detail needed to determine these costs is not yet defined. A summary of costs typically associated with O&M for the Freeway and Transit alternatives are described below.

9.2.1 Operations and Maintenance Costs for Freeway Tunnel Alternatives

In general, operating costs primarily include electric power, lighting, ventilation, and staff costs. Staff includes administration, incident response workers, maintenance, and operations staff. These costs may also include contractors and inspectors, support equipment and vehicles, consumables, and supplies and utilities.

Maintenance costs would include items necessary to provide efficient operation of the tunnel system, such as maintenance of the ventilation scrubbers, control building, and equipment; the cleaning/replacement of lights and tiles; general cleaning; and sweeping the tunnel. Also, the O&M costs will have to include the equipment and material costs.

9.2.2 Operations and Maintenance Costs for BRT Alternatives

The BRT conceptual operating assumptions and plans, including span of service, frequency of service, vehicle requirements, service amenities, and operating costs are detailed in the technical memorandum dated September 24, 2012, and titled “SR 710 Study – Draft BRT Conceptual Operating Plans.”

9.2.3 Operations and Maintenance Costs for LRT Alternatives

The LRT conceptual operating assumptions and plans, including span of service, frequency of service, station dwell times, end-of-line layovers, average intersection delay, and operating costs are detailed in the technical memorandum dated September 24, 2012, and titled “SR 710 Study – Draft LRT Conceptual Operating Plans.”

SECTION 10

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Appendix A
Conceptual Engineering Strip Maps

Appendix A: Conceptual Engineering 3'x5' Strip Maps* - Contents

Alternative	Sheet Title	Sheet Count	Total Sheets by Alternative
F-2	Plans, Profiles and Typical Sections	4	6
	Profiles	2	
F-5	Plans, Profiles and Typical Sections	4	8
	Profiles	4	
F-6	Plans, Profiles and Typical Sections	4	6
	Profiles	2	
F-7	Plans, Profiles and Typical Sections	4	6
	Profiles	2	
H-2	Plans, Profiles and Typical Sections	5	5
H-6	Plans, Profiles and Typical Sections	4	4
LRT-4A	Plans, Profiles and Typical Sections	4	5
	LRT-4A Proposed Maintenance Yard Facility	1	
LRT-4B	Plans, Profiles and Typical Sections	2	2
LRT-4D	Plans, Profiles and Typical Sections	3	4
	LRT- 4B/4D Proposed Maintenance Yard Facility	1	
LRT-6	Plans, Profiles and Typical Sections	5	6
	LRT-6 Proposed Maintenance Yard Facility	1	
BRT-1	Plans and Typical Sections	9	9
BRT-6/6A	Plans and Typical Sections	10	10
TSM-TDM	Plans and Typical Sections	19	19
	Total	90	90

*The strip maps are attached to the Conceptual Engineering Report (CER) and not included herein. The CER PDF will include all strip maps.

Click on the alternative to see engineering strip maps.

Appendix B
Conceptual Engineering Cost Estimates

CONCEPTUAL COST ESTIMATES SUMMARY

PROJECT DESCRIPTION
STATE ROUTE 710 STUDY

Proposed Improvement:	BRT-1 Cost in 2012 $	BRT-6 Cost in 2012 $	BRT-6A Cost in 2012 $	F-2 Cost in 2012 $	F-5 Cost in 2012 $	F-6 Cost in 2012 $	F-7 Cost in 2012 $	H-2 Cost in 2012 $	H-6 Cost in 2012 $	LRT-4A Cost in 2012 $	LRT-4B Cost in 2012 $	LRT-4D Cost in 2012 $	LRT-6 Cost in 2012 $	TSM/TDM Cost in 2012 $
ROADWAY ITEMS	$44,000,000	$47,000,000	$49,000,000	$277,000,000	$449,000,000	$898,000,000	$332,000,000	$398,000,000	$259,000,000	$19,000,000	$27,000,000	$25,000,000	$4,000,000	$26,000,000
STRUCTURE ITEMS	$0	$0	$0	$986,000,000	$653,000,000	$469,000,000	$574,000,000	$82,000,000	$45,000,000	$0	$0	$0	$0	$1,000,000
FREEWAY TUNNEL & VENT. ITEMS	$0	$0	$0	$4,828,000,000	$4,603,000,000	$40,000,000	$4,441,000,000	$0	$0	$0	$0	$0	$0	$0
LRT ITEMS	$0	$0	$0	$0	$0	$0	$0	$0	$0	$859,000,000	$985,000,000	$860,000,000	$1,097,000,000	$0
LRT TUNNEL & VENT. ITEMS	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,471,000,000	$1,140,000,000	$1,184,000,000	$0	$0
SUBTOTAL CONSTRUCTION	$44,000,000	$47,000,000	$49,000,000	$6,091,000,000	$5,705,000,000	$1,407,000,000	$5,347,000,000	$480,000,000	$304,000,000	$2,349,000,000	$2,152,000,000	$2,069,000,000	$1,101,000,000	$27,000,000
RIGHT OF WAY	$30,000,000	$0	$0	$308,000,000	$514,000,000	$655,000,000	$65,000,000	$834,000,000	$410,000,000	$191,000,000	$213,000,000	$285,000,000	$681,000,000	$90,000,000
TOTAL COST	$74,000,000	$47,000,000	$49,000,000	$6,399,000,000	$6,219,000,000	$2,062,000,000	$5,412,000,000	$1,314,000,000	$714,000,000	$2,540,000,000	$2,365,000,000	$2,354,000,000	$1,782,000,000	$117,000,000
CONSTRUCTION COST (SAY)	$50,000,000	$50,000,000	$50,000,000	$6,100,000,000	$5,750,000,000	$1,450,000,000	$5,350,000,000	$500,000,000	$325,000,000	$2,400,000,000	$2,200,000,000	$2,100,000,000	$1,125,000,000	$30,000,000
RIGHT OF WAY COST (SAY)	$30,000,000	$0	$0	$325,000,000	$525,000,000	$675,000,000	$75,000,000	$850,000,000	$425,000,000	$200,000,000	$225,000,000	$300,000,000	$700,000,000	$90,000,000
TOTAL COST (SAY)	$80,000,000	$50,000,000	$50,000,000	$6,425,000,000	$6,275,000,000	$2,125,000,000	$5,425,000,000	$1,350,000,000	$750,000,000	$2,600,000,000	$2,425,000,000	$2,400,000,000	$1,825,000,000	$120,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

Contract PS4710-2755
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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE BRT-1

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		**$44,000,000**
STRUCTURE ITEMS		**$0**
FREEWAY TUNNEL & VENTILATION ITEMS		**$0**
LRT ITEMS		**$0**
LRT TUNNEL & VENTILATION ITEMS		**$0**
SUBTOTAL CONSTRUCTION		**$44,000,000**
	SAY	**$50,000,000**
RIGHT OF WAY		**$30,000,000**
	SAY	**$30,000,000**
	TOTAL COST	**$80,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

I. Roadway Items

Section 1 - Earthwork	**Quantity**		**Unit**		**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	17		Acre		$20,000	$340,000	
Roadway Excavation	51,000		CY		$15	$765,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	51,000	x	0%	x	$20	$0	
Hazardous Waste Material/ADL	51,000	x	10%	x	$100	$510,000	
						Total Earthwork	**$3,615,000**

Section 2 - Structural Section	**Quantity**		**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	205,000		SF	$8.00	$1,640,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	79,200		LF	$20.00	$1,584,000	
Sidewalks	540,200		SF	$5.00	$2,701,000	
			%		**Cost**	
Misc Pvmt Items & Removals (15% of Pvmt)	$1,640,000	x	15%		$246,000	
					Total Structural Section	**$6,171,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

I. Roadway Items (CONT.)

Section 3 - Drainage	**Rdwy Pvmt**		**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	$1,640,000	x	20%		$328,000	
Utilites (15% of Pvmt)	$1,640,000	x	15%		$246,000	
	Quantity		**Unit**	**Unit Cost**	**Cost**	
Offsite/Regional Drainage						
1. No conflict with Existing Drainage System	0		LF	$3,540	$0	
BMP						
1. BMPs (concrete-vault Austin Filters)	11,000		CF	$82	$902,000	
					Total Drainage Items	**$1,476,000**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Proposed bus lanes are almost entirely over exisitng roadway. Therefore, the area considered for treatment is only new impervious area. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	8	Acre	$97,500	$780,000	
Modify Irrigation System*	8	Acre	$63,000	$504,000	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$1,284,000**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	14	MI	$650,000	$9,100,000	
Signalized Intersections	4	EA	$270,000	$1,080,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP	$1,640,000 x	20%		$328,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$1,640,000 x	7%		$114,800	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$1,640,000 x	20%		$328,000	
Construction Staging (40% Rdwy Pvmt)	$1,640,000 x	40%		$656,000	
				Total Traffic Items	**$11,606,800**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$24,152,800**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$24,152,800	x 15%	$3,622,920	
			Total Minor Items	**$3,622,920**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$24,152,800			
Minor Items - Section 6	$3,622,920			
Subtotal Sections 1-6	$27,775,720	x 10% Mobilization (includes 10% of Mob Cost)	$3,086,192	
			Total Roadway Mobilization	**$3,086,192**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$24,152,800			
Minor Items - Section 6	$3,622,920			
Subtotal Sections 1-6	$27,775,720	x 10%	$2,777,572	
Contingencies				
Subtotal Sections 1-5	$24,152,800			
Minor Items - Section 6	$3,622,920			
Subtotal Sections 1-6	$27,775,720	x 35%	$9,721,502	
			Total Roadway Additions	**$12,499,074**
			Subtotal for Sections 6, 7 & 8	**$19,208,186**
			Subtotal for Sections 1-5	**$24,152,800**
			TOTAL ROADWAY ITEMS SECTIONS 1-8	**$44,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Bridge 1	0	SF	$300	$0	
Bridge 2	0	SF	$300	$0	
Bridge 3	0	SF	$300	$0	
Bridge 4	0	SF	$300	$0	
Bridge 5	0	SF	$300	$0	
Bridge 6	0	SF	$300	$0	
Bridge 7	0	SF	$300	$0	
Bridge 8	0	SF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items			Cost	Section Cost	
Subtotal Section 9	$0	x 10%	$0		
				Total Minor Items	**$0**

Section 11 - Mobilization

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Subtotal Sections 9 & 10	$0	x 10% Mobilization (includes 10% of Mob Cost)	$0		
				Total Structure Mobilization	**$0**
				Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 10%	$0		
Contingencies					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 35%	$0		
				Total Structure Additions	**$0**
				Subtotal for Sections 10, 11 & 12	**$0**
				Subtotal for Sections 1-5	**$24,152,800**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

IV. LRT Items

Section 17 - LRT Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			**Cost**		**Section Cost**
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0	
				Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	10%	$0	

Contingencies

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	35%	$0	
				Total LRT Additions	**$0**
				Sub Total for Sections 19 & 20	**$0**
				Sub Total for Sections 17 & 18	**$0**
				TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$12,600	$0	
Control Building	0	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
				Subtotal for Section 21	**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-1

VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	0	LS	$0	$0
R/W Acquisition (Commercial)	1	LS	$13,908,830	$13,908,830
Permanent R/W Easement (Tunnel)	0	SF	$0	$0
Relocation Assistance	1	LS	$8,350,000	$8,350,000
Clearance/Demolition (Residential)	0	SF	$5	$0
Clearance/Demolition (Commercial)	140,392	SF	$7	$982,744
Title, Escrow, and Appraisal Fees (per parcel)	19	EA	$20,000	$380,000
			Total for Section 25	**$23,621,574**

Section 26 - Additions

Contingencies

Subtotal Section 25	$23,621,574				
Sum	$23,621,574	x	25%	$5,905,394	
				Total for Section 26	**$5,905,394**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$30,000,000**

Assumptions:

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

Contract PS4710-2755
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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE BRT-6A

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$49,000,000
STRUCTURE ITEMS		$0
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$49,000,000
	SAY	$50,000,000
RIGHT OF WAY		$0
	SAY	$0
	TOTAL COST	$50,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

I. Roadway Items

Section 1 - Earthwork	Quantity		Unit		Unit Cost	Cost	Section Cost
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	13		Acre		$20,000	$280,000	
Roadway Excavation	51,771		CY		$15	$780,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	51,771	x	0%	x	$20	$0	
Hazardous Waste Material/ADL	51,771	x	10%	x	$100	$517,710	
						Total Earthwork	**$3,577,710**

Section 2 - Structural Section	Quantity		Unit	Unit Cost	Cost	Section Cost
Mainline Pvmt & Shldrs	24,141		SF	$8.00	$200,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	99,600		LF	$20.00	$1,992,000	
Sidewalks	956,601		SF	$5.00	$4,783,500	
			%		**Cost**	
Misc Pvmt Items & Removals (15% of Pvmt)	$200,000	x	15%		$30,000	
					Total Structural Section	**$7,005,500**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

I. Roadway Items (CONT.)

Section 3 - Drainage	**Rdwy Pvmt**		**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	200,000	x	20%		$40,000	
Utilites (15% of Pvmt)	$200,000	x	15%		$30,000	
	Quantity		**Unit**	**Unit Cost**	**Cost**	
Offsite/Regional Drainage						
1. No conflict with Existing Drainage System	0		LF	NA	$0	
BMP						
1. BMPs (concrete-vault Austin Filters)	8,000		CF	$82	$656,000	
					Total Drainage Items	**$726,000**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Proposed bus lanes are almost entirely over exisitng roadway. Therefore, the area considered for treatment is only new impervious area. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

I. Roadway Items (CONT.)

Section 4 - Specialty Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	3	Acre	$97,500	$292,500	
Modify Irrigation System*	3	Acre	$63,000	$189,000	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$481,500**

Section 5 - Traffic Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Fiber Optic & Twisted Pair Cable system	14.2	MI	$650,000	$9,750,000	
Signalized Intersections	19.0	EA	$270,000	$5,130,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$200,000 x	20%		$40,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$200,000 x	7%		$14,000	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$200,000 x	20%		$40,000	
Construction Staging (40% Rdwy Pvmt)	$200,000 x	40%		$80,000	
				Total Traffic Items	**$15,054,000**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$26,844,710**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$26,844,710	x 15%	$4,026,707	
			Total Minor Items	**$4,026,707**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$26,844,710			
Minor Items - Section 6	$4,026,707			
Subtotal Sections 1-6	$30,871,417	x 10% Mobilization (includes 10% of Mob Cost)	$3,430,158	
			Total Roadway Mobilization	**$3,430,158**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$26,844,710			
Minor Items - Section 6	$4,026,707			
Subtotal Sections 1-6	$30,871,417	x 10%	$3,087,142	
Contingencies				
Subtotal Sections 1-5	$26,844,710			
Minor Items - Section 6	$4,026,707			
Subtotal Sections 1-6	$30,871,417	x 35%	$10,804,996	
			Total Roadway Additions	**$13,892,138**
			Subtotal for Sections 6, 7 & 8	**$21,349,003**
			Subtotal for Sections 1-5	**$26,844,710**
			TOTAL ROADWAY ITEMS SECTIONS 1-8	**$49,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

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II. Structure Items

Section 9 - Structure Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Bridge 1	0	SF	$300	$0	
Bridge 2	0	SF	$300	$0	
Bridge 3	0	SF	$300	$0	
Bridge 4	0	SF	$300	$0	
Bridge 5	0	SF	$300	$0	
Bridge 6	0	SF	$300	$0	
Bridge 7	0	SF	$300	$0	
Bridge 8	0	SF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items			**Cost**	**Section Cost**	
Subtotal Section 9	$0	x 10%	$0		
				Total Minor Items	**$0**

Section 11 - Mobilization

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Subtotal Sections 9 & 10	$0	x 10% Mobilization (includes 10% of Mob Cost)	$0		
				Total Structure Mobilization	**$0**
				Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 10%	$0		
Contingencies					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 35%	$0		
				Total Structure Additions	**$0**
				Subtotal for Sections 10, 11 & 12	**$0**
				Subtotal for Sections 1-5	**$26,844,710**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

III. Freeway Tunnel & Ventilation Items

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Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

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IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0
			Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	10%	$0

Contingencies

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	35%	$0

Total LRT Additions	**$0**
Sub Total for Sections 19 & 20	**$0**
Sub Total for Sections 17 & 18	**$0**
TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

V. LRT Tunnel & Ventilation Items

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Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
				Total LRT Tunnel Mobilization	**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total LRT Tunnel Additions	**$0**
				Subtotal for Sections 22, 23 & 24	**$0**
				Subtotal for Section 21	**$0**
				TOTAL LRT TUNNEL ITEMS SECTIONS 21-24	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6A

VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	0	LS	$0	$0
R/W Acquisition (Commercial)	0	LS	$0	$0
Permanent R/W Easement (Tunnel)	0	SF	$0	$0
Relocation Assistance	0	LS	$0	$0
Clearance/Demolition (Residential)	0	SF	$5	$0
Clearance/Demolition (Commercial)	0	SF	$7	$0
Title, Escrow, and Appraisal Fees (per parcel)	0	EA	$20,000	$0
			Total for Section 25	**$0**

Section 26 - Additions

Contingencies

Subtotal Section 25	$0				
Sum	$0	x	25%	$0	
				Total for Section 26	**$0**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$0**

Assumptions:

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

Contract PS4710-2755
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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE BRT-6

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$47,000,000
STRUCTURE ITEMS		$0
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$47,000,000
	SAY	$50,000,000
RIGHT OF WAY		$0
	SAY	$0
	TOTAL COST	$50,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

I. Roadway Items

Section 1 - Earthwork	Quantity		Unit		Unit Cost	Cost	Section Cost
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	15		Acre		$20,000	$320,000	
Roadway Excavation	58,847		CY		$15	$885,000	
			%		Unit Cost	Cost	
Imported Borrow Due to Unsuitable On-Site Soil	58,847	x	0%	x	$20	$0	
Hazardous Waste Material/ADL	58,847	x	10%	x	$100	$588,470	
						Total Earthwork	**$3,793,471**

Section 2 - Structural Section	Quantity		Unit	Unit Cost	Cost	Section Cost
Mainline Pvmt & Shldrs	24,948		SF	$8.00	$200,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	115,400		LF	$20.00	$2,308,000	
Sidewalks	904,200		SF	$5.00	$4,521,000	
			%		Cost	
Misc Pvmt Items & Removals (5% of Pvmt)	$200,000	x	15%		$30,000	
					Total Structural Section	**$7,059,000**

I. Roadway Items (CONT.)

Section 3 - Drainage	**Rdwy Pvmt**		**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	200,000	x	20%		$40,000	
Utilites (15% of Pvmt)	$200,000	x	15%		$30,000	
	Quantity		**Unit**	**Unit Cost**	**Cost**	
Offsite/Regional Drainage						
No conflict with Existing Drainage System	0		LF	NA	$0	
BMP						
1. BMPs (concrete-vault Austin Filters)	8,000		CF	$82	$656,000	
					Total Drainage Items	**$726,000**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Proposed bus lanes are almost entirely over exisitng roadway. Therefore, the area considered for treatment is only new impervious area. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

I. Roadway Items (CONT.)

Section 4 - Specialty Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	3	Acre	$97,500	$292,500	
Modify Irrigation System*	3	Acre	$63,000	$189,000	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$481,500**

Section 5 - Traffic Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Fiber Optic & Twisted Pair Cable system	13.8	MI	$650,000	$9,100,000	
Signalized Intersections	17.0	EA	$270,000	$4,590,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$200,000 x	20%		$40,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$200,000 x	7%		$14,000	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$200,000 x	20%		$40,000	
Construction Staging (40% Rdwy Pvmt)	$200,000 x	40%		$80,000	
				Total Traffic Items	**$13,864,000**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$25,923,971**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$25,923,971	x 15%	$3,888,596	
		Total Minor Items		**$3,888,596**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$25,923,971			
Minor Items - Section 6	$3,888,596			
Subtotal Sections 1-6	$29,812,567	x 10% Mobilization (includes 10% of Mob Cost)	$3,312,508	
		Total Roadway Mobilization		**$3,312,508**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$25,923,971			
Minor Items - Section 6	$3,888,596			
Subtotal Sections 1-6	$29,812,567	x 10%	$2,981,257	
Contingencies				
Subtotal Sections 1-5	$25,923,971			
Minor Items - Section 6	$3,888,596			
Subtotal Sections 1-6	$29,812,567	x 35%	$10,434,399	
		Total Roadway Additions		**$13,415,656**
		Subtotal for Sections 6, 7 & 8		**$20,616,760**
		Subtotal for Sections 1-5		**$25,923,971**
		TOTAL ROADWAY ITEMS SECTIONS 1-8		**$47,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

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II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Bridge 1	0	SF	$300	$0	
Bridge 2	0	SF	$300	$0	
Bridge 3	0	SF	$300	$0	
Bridge 4	0	SF	$300	$0	
Bridge 5	0	SF	$300	$0	
Bridge 6	0	SF	$300	$0	
Bridge 7	0	SF	$300	$0	
Bridge 8	0	SF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items			Cost	Section Cost	
Subtotal Section 9	$0	x 10%	$0		
				Total Minor Items	**$0**

Section 11 - Mobilization

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Subtotal Sections 9 & 10	$0	x 10% Mobilization (includes 10% of Mob Cost)	$0		
				Total Structure Mobilization	**$0**
				Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 10%	$0		
Contingencies					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 35%	$0		
				Total Structure Additions	**$0**
				Subtotal for Sections 10, 11 & 12	**$0**
				Subtotal for Sections 1-5	**$25,923,971**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

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III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	$0
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	$0
				Section Total	$0

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	$0

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	$0
				Total Sections 13-15	$0

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	$0
				Subtotal for Sections 14, 15 & 16	$0
				Subtotal for Section 13	$0
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	$0

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

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IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

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IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0

Total LRT Mobilization $0

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	10%	$0

Contingencies

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	35%	$0

Total LRT Additions $0

Sub Total for Sections 19 & 20 $0

Sub Total for Sections 17 & 18 $0

TOTAL LRT ITEMS SECTIONS 17-20 $0

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

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V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$12,600	$0	
Control Building	0	LS	$0	$0	
				Subtotal LRT Tunnel Systems	**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
				Total LRT Tunnel Mobilization	**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total LRT Tunnel Additions	**$0**
				Subtotal for Sections 22, 23 & 24	**$0**
				Subtotal for Section 21	**$0**
				TOTAL LRT TUNNEL ITEMS SECTIONS 21-24	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE BRT-6

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	0	LS	$0	$0
R/W Acquisition (Commercial)	0	LS	$0	$0
Permanent R/W Easement (Tunnel)	0	SF	$0	$0
Utility Relocation	0	LS	$0	$0
Utility Protection (included elsewhere)	0	LS	$0	$0
Relocation Assistance	0	LS	$0	$0
Clearance/Demolition (Residential)	0	SF	$5	$0
Clearance/Demolition (Commercial)	0	SF	$7	$0
Title, Escrow, and Appraisal Fees (per parcel)	0	EA	$20,000	$0
			Total for Section 25	**$0**

Section 26 - Additions

Contingencies

Subtotal Section 25	$0			
Sum	$0	x 25%	$0	
			Total for Section 26	**$0**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$0**

Assumptions:

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE F-2

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$277,000,000
STRUCTURE ITEMS		$986,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$4,828,000,000
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$6,091,000,000
	SAY	$6,100,000,000
RIGHT OF WAY		$308,000,000
	SAY	$325,000,000
	TOTAL COST	$6,425,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

I. Roadway Items

Section 1 - Earthwork	**Quantity**		**Unit**		**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	74		Acre		$20,000	$1,480,000	
Roadway Excavation	241,187		CY		$15	$3,630,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	241,187	x	75%	x	$20	$3,617,805	
Hazardous Waste Material/ADL	241,187	x	10%	x	$100	$2,411,870	
						Total Earthwork	**$13,139,675**

Section 2 - Structural Section	**Quantity**		**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	2,182,985		SF	$12.00	$26,196,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	3,845		LF	$20.00	$78,000	
Sidewalks	14,385		SF	$5.00	$72,000	
			%		**Cost**	
Misc Pvmt Items & Removals (25% of Pvmt)	$26,196,000	x	25%		$6,549,000	
					Total Structural Section	**$32,895,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

I. Roadway Items (CONT.)

Section 3 - Drainage & Utilities

			%		Cost	Section Cost
Onsite Drainage (45% of Pvmt)	$26,196,000	x	45%		$11,788,200	
Utilites (25% of Pvmt)	$26,196,000	x	25%		$6,549,000	

Offsite/Regional Drainage	Quantity	Unit	Unit Cost	Cost	
1. Dbl. 10'x14' RCB, Sta 160+00-170+00, Replacing Dorchester Ave. Storm Drain 20'x14' RCC	760	LF	$4,040	$3,070,400	
2. Stormwater pump station at station 162+00, Q50 = 22.7 cfs 2+1 main pumps: 5100 gpm at 30 ft TDH, 75 hp each, 2 small submersible sump pumps, 10 hp each; backup power generator, with controls and communications	1	LS	$2,000,000	$2,000,000	
3. Tunnel water drain pump station at LP Sta 232 + 50. Main water source is FSS. Per NFPA 13, assume 2 zones be on at the same time, 5000 sq ft max zone, 0.3 gpm/sq ft, plus one hydrant, total flow is 4000 gpm. 2+1 main pump configuration, plus two small sump pumps. Main pump: 2500 gpm at 220 ft TDH, 200 hp; sump pump: 600 gpm, 50 hp; one backup generator, controls and communications.	1	LS	$2,500,000	$2,500,000	
BMP					
1. BMPs (concrete-vault Austin Filters)	135,000	CF	$82	$11,070,000	
				Total Drainage Items	**$36,977,600**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

I. Roadway Items (CONT.)

Section 4 - Specialty Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	114	Acre	$97,500	$11,115,000	
Modify Irrigation System*	114	Acre	$63,000	$7,182,000	
Retaining Wall (H=0-10 FT)	5,770	LF	$1,000	$5,800,000	
Retaining Wall (H=10-15 FT)	1,260	LF	$1,700	$2,210,000	
Retaining Wall (H=15-20 FT)	1,875	LF	$2,850	$5,415,000	
Retaining Wall (H=20-30 FT)	1,910	LF	$3,850	$7,700,000	
Retaining Wall (H=30-40 FT)	250	LF	$5,000	$1,500,000	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	17,200	LF	$500	$9,000,000	
Temporary Shoring	162,000	SF	$10	$1,620,000	
Wall Aesthetic Treatment	180,000	SF	$10	$1,800,000	
Concrete Barrier (Type 60D)	11,065	LF	$70	$774,550	
				Total Specialty Items	**$54,116,550**

Section 5 - Traffic Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Fiber Optic & Twisted Pair Cable system	6.9	MI	$650,000	$4,550,000	
Signalized Intersections	2.0	EA	$270,000	$540,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (25% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$26,196,000 x	25%		$6,549,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$26,196,000 x	7%		$1,833,720	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$26,196,000 x	20%		$5,239,200	
Construction Staging (40% Rdwy Pvmt)	$26,196,000 x	40%		$10,478,400	
				Total Traffic Items	**$24,100,320**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$161,230,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$161,230,000	x 10.00%	$16,123,000	
		Total Minor Items		**$16,123,000**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$161,230,000			
Minor Items - Section 6	$16,123,000			
Subtotal Sections 1-6	$177,353,000	x 10% Mobilization (includes 10% of Mob Cost)	$19,705,889	
		Total Roadway Mobilization		**$19,705,889**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$161,230,000			
Minor Items - Section 6	$16,123,000			
Subtotal Sections 1-6	$177,353,000	x 10.00%	$17,735,300	
Contingencies				
Subtotal Sections 1-5	$161,230,000			
Minor Items - Section 6	$16,123,000			
Subtotal Sections 1-6	$177,353,000	x 35.00%	$62,073,550	
		Total Roadway Additions		**$79,808,850**
		Subtotal for Sections 6, 7 & 8		**$115,637,739**
		Subtotal for Sections 1-5		**$161,230,000**
		TOTAL ROADWAY ITEMS SECTIONS 1-8		**$277,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Valley Blvd OC	22,000	SF	$250	$5,500,000	
Hellman Ave OC	16,640	SF	$250	$4,175,000	
Northbound Connector "NBTP1" LINE	128,000	SF	$250	$32,000,000	
Northbound Connector "NBBT1" LINE	186,240	SF	$250	$46,575,000	
Southbound Connector "SBTP1" LINE	230,400	SF	$250	$57,600,000	
Southbound Connector "SBBT1" LINE	236,800	SF	$250	$59,200,000	
South Cut & Cover Cross Passages	2	EA	$367,500	$735,000	
South Cut & Cover Tunnel	1,750	LF	$60,000	$105,000,000	
North Cut & Cover Cross Passages	4	EA	$367,500	$1,470,000	
North Cut & Cover Tunnel	2,150	LF	$110,000	$236,500,000	
				Total Structure Items	**$548,755,000**

Section 10 - Minor Items			Cost	Section Cost	
Subtotal Section 9	$548,755,000	x 15.00%	$82,313,250		
				Total Minor Items	**$82,313,250**

Section 11 - Mobilization

Subtotal Section 9	$548,755,000				
Minor Items - Section 10	$82,313,250				
Subtotal Sections 9 & 10	$631,068,250 x	10% Mobilization (includes 10% of Mob Cost)	$70,118,695		
				Total Structure Mobilization	**$70,118,695**
				Total Sections 9-11	**$701,186,945**

Section 12 - Additions

Supplemental					
Subtotal Section 9	$548,755,000				
Minor Items - Section 10	$82,313,250				
Sum	$631,068,250	x 10.00%	$63,106,825		
Contingencies					
Subtotal Section 9	$548,755,000				
Minor Items - Section 10	$82,313,250				
Sum	$631,068,250	x 35.00%	$220,873,888		
				Total Structure Additions	**$283,981,000**
				Subtotal for Sections 10, 11 & 12	**$436,412,945**
				Subtotal for Section 9	**$548,755,000**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$986,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$50,476,000	$50,476,000	
Electrical	1	LS	$126,352,257	$126,352,257	
System and Instrumentation	1	LS	$28,228,000	$28,228,000	
Tunnel Drainage System	4.33	MI	$659,479	$2,852,746	
Control Building	1	LS	$15,000,000	$15,000,000	
				Subtotal Tunnel Systems	**$222,910,000**
Freeway Tunnel Items					
South Portal Development	1	LS	$209,399,975	$209,399,975	
North Portal Development	1	LS	$303,689,754	$303,689,754	
Northbound Tunnel Excavation	22,840	LF	$36,313	$829,388,920	
Southbound Tunnel Excavation	22,840	LF	$36,313	$829,388,920	
Pedestrian Cross Passages - Excav, Supp, Conc.	26	EA	$3,163,735	$82,257,116	
Instrumentation & Building Protection	1	LS	$8,616,978	$8,616,978	
Vehicle Cross Passages - Excav, Supp, Conc.	8	EA	$6,180,068	$49,440,546	
Vent Tube Cross Passages - Excav, Supp, Conc.	25	EA	$3,348,648	$83,716,208	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	91,360	EA	$2,500	$228,400,000	
				Subtotal Tunnel	**$2,624,299,000**
				Section Total	**$2,847,209,000**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Section 13	$2,847,209,000	x 5%	$142,361,000		
				Total Minor Items	**$142,361,000**

Section 15 - Mobilization					
Equipment Mobilization			$454,125,000		
General Mobilization / De-mobilization			$40,845,696		
Tunnel System Subtotal	$222,910,000				
Minor Items - Section 14	$142,361,000				
Subtotal	$365,271,000	x 10%	$40,585,700		
			Total Freeway Tunnel Mobilization		**$535,557,000**
				Total Sections 13-15	**$3,525,127,000**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$222,910,000				
Minor Items - Section 14	$142,361,000				
Sum	$365,271,000	x 5%	$18,264,000		
Contingencies					
Subtotal Section 13-15	$3,525,127,000				
Minor Items - Section 14	$142,361,000				
Sum	$3,667,488,000	x 35%	$1,283,621,000		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total Freeway Tunnel Additions		**$1,301,885,000**
			Subtotal for Sections 14, 15 & 16		**$1,979,803,000**
				Subtotal for Section 13	**$2,847,209,000**
		TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16			**$4,828,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

IV. LRT Items

Section 17 - LRT Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			**Cost**		**Section Cost**
Subtotal Section 17	$0	x 10.00%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0	
				Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental					
Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	10%	$0	
Contingencies					
Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	35%	$0	
				Total LRT Additions	**$0**
				Sub Total for Sections 19 & 20	**$0**
				Sub Total for Sections 17 & 18	**$0**
				TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$126,000	$0	
Control Building	0	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
			Subtotal for Section 21		**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-2

VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$155,419,710	$155,419,710
R/W Acquisition (Commercial)	1	LS	$19,729,425	$19,729,425
Temporary Construction Easements (Residential)	0	SF		$0
Temporary Construction Easements (Commercial)	0	SF		$0
Permanent R/W Easement (Tunnel)	4,533,172	SF	$8	$37,053,976
Permanent Aerial Easement from UPRR	0	SF		$0
Relocation Assistance	1	LS		$21,025,000
Clearance/Demolition (Residential)	1,050,311	SF	$5	$5,252,000
Clearance/Demolition (Commercial)	166,139	SF	$7	$1,163,400
Title, Escrow, and Appraisal Fees	313	EA	$20,000	$6,260,000
			Total for Section 25	**$245,904,000**

Section 26 - Additions

Contingencies

Subtotal Section 25	$245,904,000			
Sum	$245,904,000	x	25.00%	$61,476,000
			Total for Section 26	**$61,476,000**
			TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26	**$308,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

Contract PS4710-2755
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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE F-5

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$449,000,000
STRUCTURE ITEMS		$653,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$4,603,000,000
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$5,705,000,000
	SAY	$5,750,000,000
RIGHT OF WAY		$514,000,000
	SAY	$525,000,000
	TOTAL COST	$6,275,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

I. Roadway Items

Section 1 - Earthwork	**Quantity**		**Unit**		**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	51		Acre		$20,000	$1,020,000	
Roadway Excavation	946,676		CY		$15	$14,205,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	946,676	x	75%	x	$20	$14,200,140	
Hazardous Waste Material/ADL	946,676	x	10%	x	$100	$9,466,760	
						Total Earthwork	**$40,891,900**

Section 2 - Structural Section	**Quantity**		**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	2,446,416		SF	$12.00	$29,364,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	17,046		LF	$20.00	$342,000	
Sidewalks	118,995		SF	$5.00	$595,000	
			%		**Cost**	
Misc Pvmt Items & Removals (35% of Pvmt)	$29,364,000	x	35%		$10,277,400	
					Total Structural Section	**$40,578,400**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

I. Roadway Items (CONT.)

Section 3 - Drainage & Utilities			%		Cost	Section Cost
Onsite Drainage (45% of Pvmt)	$29,364,000	x	45%		$13,213,800	
Utilites (25% of Pvmt)	$29,364,000	x	25%		$7,341,000	

Offsite/Regional Drainage	Quantity	Unit	Unit Cost	Cost	
1. Dbl. 10'x14' RCB, Sta 160+00-170+00, Replacing Dorchester Ave. Storm Drain 20'x14' RCC	760	LF	$4,040	$3,070,400	
2. Stormwater pump station at Sta 168+85; Q50 = 34.3 cfs 2+1 main pumps: 8000 gpm at 90 ft TDH, 250 hp each, 2 small submersible sump pumps, 25 hp each; backup power generator, with controls and communications	1	LS	$3,000,000	$3,000,000	
3. Stormwater pump station at Sta 211+00; Q50 = 8.4 cfs 1+1 main pumps: 4000 gpm at 90 ft TDH, 150 hp each, 2 small submersible sump pumps, 25 hp each; backup power generator, with controls and communications	1	LS	$1,700,000	$1,700,000	
4. Tunnel water drain pump station near LP Sta 214+00. Main water source is FSS. Per NFPA 13, assume 2 zones be on at the same time, 5000 sq ft max zone, 0.3 gpm/sq ft, plus one hydrant, total flow is 4000 gpm. 2+1 main pump configuration, plus two small sump pumps. Main pump: 2500 gpm at 220 ft TDH, 200 hp; sump pump: 600 gpm, 50 hp; one backup generator, controls and communications.	1	LS	$2,300,000	$2,300,000	
BMP					
1. BMPs (concrete-vault Austin Filters)	79,000	CF	$82	$6,478,000	
				Total Drainage Items	**$37,103,200**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

I. Roadway Items (CONT.)

Section 4 - Specialty Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	42	Acre	$97,500	$4,095,000	
Modify Irrigation System*	42	Acre	$63,000	$2,646,000	
Retaining Wall (H=0-10 FT)	15,600	LF	$1,000	$15,600,000	
Retaining Wall (H=10-15 FT)	2,900	LF	$1,700	$4,930,000	
Retaining Wall (H=15-20 FT)	2,200	LF	$2,850	$6,270,000	
Retaining Wall (H=20-30 FT)	5,700	LF	$3,850	$21,945,000	
Retaining Wall (H=30-40 FT)	2,550	LF	$5,000	$13,000,000	
Retaining Wall (H=40+ FT)	4,900	LF	$6,000	$29,400,000	
Soundwalls	16,000	LF	$500	$8,000,000	
Temporary Shoring	335,885	SF	$10	$3,360,000	
Wall Aesthetic Treatment	373,205	SF	$10	$3,740,000	
Concrete Barrier (Type 60D)	33,850	LF	$70	$2,369,500	
				Total Specialty Items	**$115,355,500**

Section 5 - Traffic Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Fiber Optic & Twisted Pair Cable system	10.0	MI	$650,000	$6,500,000	
Signalized Intersections	9.0	EA	$270,000	$2,430,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (25% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$29,364,000 x	25%		$7,341,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$29,364,000 x	7%		$2,055,480	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$29,364,000 x	20%		$5,872,800	
Construction Staging (40% Rdwy Pvmt)	$29,364,000 x	40%		$11,745,600	
				Total Traffic Items	**$27,014,880**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$260,943,880**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$260,943,880	x 10%	$26,094,388	
			Total Minor Items	**$26,094,388**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$260,943,880			
Minor Items - Section 6	$26,094,388			
Subtotal Sections 1-6	$287,038,268	x 10% Mobilization (includes 10% of Mob Cost)	$31,893,141	
			Total Roadway Mobilization	**$31,893,141**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$260,943,880			
Minor Items - Section 6	$26,094,388			
Subtotal Sections 1-6	$287,038,268	x 10%	$28,703,827	
Contingencies				
Subtotal Sections 1-5	$260,943,880			
Minor Items - Section 6	$26,094,388			
Subtotal Sections 1-6	$287,038,268	x 35%	$100,463,394	
			Total Roadway Additions	**$129,167,221**

Subtotal for Sections 6, 7 & 8	**$187,154,750**
Subtotal for Sections 1-5	**$260,943,880**
TOTAL ROADWAY ITEMS SECTIONS 1-8	**$449,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

II. Structure Items

Contract PS4710-2755
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Section 9 - Structure Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Valley Blvd OC	22,000	SF	$250	$5,500,000	
Hellman Ave OC	16,640	SF	$250	$4,175,000	
ETS Ramp	27,444	SF	$250	$6,861,000	
WTS Ramp - 2 lane portion	74,248	SF	$250	$18,562,000	
1 lane portion	16,496	SF	$250	$4,124,000	
WBS Ramp - 2 lane portion	55,216	SF	$250	$13,804,000	
transition from 3 to 2 lanes	40,913	SF	$250	$10,228,250	
NTE Ramp	59,660	SF	$250	$14,915,000	
NTW Ramp - 1 lane portion	55,573	SF	$250	$13,893,250	
2 lane portion	39,488	SF	$250	$9,872,000	
NBE Ramp	62,745	SF	$250	$15,686,250	
Patrician Way OC	25,752	SF	$250	$6,438,000	
South Cut & Cover Cross Passages	3	EA	$367,500	$1,102,500	
South Cut & Cover Tunnel	1,760	LF	$60,000	$105,600,000	
North Cut & Cover Cross Passages	2	EA	$367,500	$735,000	
North Cut & Cover Tunnel	1,200	LF	$110,000	$132,000,000	
				Total Structure Items	**$363,496,250**

Section 10 - Minor Items			**Cost**	**Section Cost**	
Subtotal Section 9	$363,496,250	x 15%	$54,524,438		
				Total Minor Items	**$54,524,438**

Section 11 - Mobilization

Subtotal Section 9	$363,496,250				
Minor Items - Section 10	$54,524,438				
Subtotal Sections 9 & 10	$418,020,688	x 10% Mobilization (includes 10% of Mob Cost)	$46,446,744		
				Total Structure Mobilization	**$46,446,744**
				Total Sections 9-11	**$464,467,432**

Section 12 - Additions

Supplemental

Subtotal Section 9	$363,496,250				
Minor Items - Section 10	$54,524,438				
Sum	$418,020,688	x 10%	$41,802,069		

Contingencies

Subtotal Section 9	$363,496,250				
Minor Items - Section 10	$54,524,438				
Sum	$418,020,688	x 35%	$146,307,241		
				Total Structure Additions	**$188,109,310**
				Subtotal for Sections 10, 11 & 12	**$289,080,492**
				Subtotal for Section 9	**$363,496,250**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$653,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$42,739,000	$42,739,000	
Electrical	1	LS	$123,556,106	$123,556,106	
System and Instrumentation	1	LS	$23,901,000	$23,901,000	
Tunnel Drainage System	3.77	MI	$659,479	$2,485,536	
Control Building	1.00	LS	$15,000,000	$15,000,000	
				Subtotal Tunnel Systems	**$207,682,000**
Freeway Tunnel Items					
South Portal Development	1	LS	$210,596,546	$210,596,546	
North Portal Development	1	LS	$226,001,677	$226,001,677	
Northbound Tunnel Excavation	19,900	LF	$37,501	$746,269,900	
Southbound Tunnel Excavation	19,900	LF	$37,501	$746,269,900	
Pedestrian Cross Passages - Excav, Supp, Conc.	23	EA	$3,120,658	$71,775,126	
Instrumentation & Building Protection	1	LS	$78,779,332	$78,779,332	
Vehicle Cross Passages - Excav, Supp, Conc.	7	EA	$6,574,298	$46,020,086	
Vent Tube Cross Passages - Excav, Supp, Conc.	22	EA	$3,305,191	$72,714,208	
Special Seismic Section/Vault	2	EA	$31,218,893	$62,437,786	
Roadway Deck/Slab	79,600	EA	$2,500	$199,000,000	
				Subtotal Tunnel	**$2,459,865,000**
				Section Total	**$2,667,547,000**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Section 13	$2,667,547,000	x 5%	$133,378,000		
				Total Minor Items	**$133,378,000**

Section 15 - Mobilization					
Equipment Mobilization			$454,125,000		
General Mobilization / De-mobilization			$39,374,515		
Tunnel System Subtotal	$207,682,000				
Minor Items - Section 14	$133,378,000				
Subtotal	$341,060,000	x 10%	$37,895,600		
				Total Freeway Tunnel Mobilization	**$531,396,000**
				Total Sections 13-15	**$3,332,321,000**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$207,682,000				
Minor Items - Section 14	$133,378,000				
Sum	$341,060,000	x 5%	$17,053,000		
Contingencies					
Subtotal Section 13-15	$3,332,321,000				
Minor Items - Section 14	$133,378,000				
Sum	$3,465,699,000	x 35%	$1,212,995,000		
Contingency for Special Seismic Section	$62,437,786	x 65%	$40,585,000		
				Total Freeway Tunnel Additions	**$1,270,633,000**
				Subtotal for Sections 14, 15 & 16	**$1,935,407,000**
				Subtotal for Section 13	**$2,667,547,000**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$4,603,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0
			Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	10%	$0

Contingencies

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	35%	$0

Total LRT Additions	**$0**
Sub Total for Sections 19 & 20	**$0**
Sub Total for Sections 17 & 18	**$0**
TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

V. LRT Tunnel & Ventilation Items

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Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$12,600	$0	
Control Building	0	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
			Subtotal for Section 21		**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-5

VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$252,016,280	$252,016,280
R/W Acquisition (Commercial)	1	LS	$85,407,292	$85,407,292
Temporary Construction Easements (Residential)	0	SF		$0
Temporary Construction Easements (Commercial)	0	SF		$0
Permanent R/W Easement (Tunnel)	3,718,886	SF	$9	$32,831,020
Permanent Aerial Easement from UPRR	0	SF		$0
Relocation Assistance	1	LS		$21,102,000
Clearance/Demolition (Residential)	1,232,781	SF	$5	$6,164,000
Clearance/Demolition (Commercial)	1,139,596	SF	$7	$7,977,200
Title, Escrow, and Appraisal Fees (per parcel)	255	EA	$20,000	$5,100,000
			Total for Section 25	**$410,597,792**

Section 26 - Additions

Contingencies

Subtotal Section 25	$410,597,792			
Sum	$410,597,792	x	25%	$102,649,448
			Total for Section 26	**$102,649,448**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$514,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE F-6

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$898,000,000
STRUCTURE ITEMS		$469,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$40,000,000
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$1,407,000,000
	SAY	$1,450,000,000
RIGHT OF WAY		$655,000,000
	SAY	$675,000,000
	TOTAL COST	$2,125,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

I. Roadway Items

Section 1 - Earthwork	**Quantity**		**Unit**		**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	64		Acre		$20,000	$1,280,000	
Roadway Excavation	4,500,000		CY		$15	$67,500,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	4,500,000	x	0%	x	$20	$0	
Hazardous Waste Material/ADL	4,500,000	x	10%	x	$100	$45,000,000	
						Total Earthwork	**$115,780,000**

Section 2 - Structural Section	**Quantity**		**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	5,709,035		SF	$12.00	$68,520,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	297,672		LF	$20.00	$5,954,000	
Sidewalks	194,858		SF	$5.00	$974,500	
			%		**Cost**	
Misc Pvmt Items & Removals (10% of Pvmt)	$68,520,000	x	10%		$6,852,000	
					Total Structural Section	**$82,300,500**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

I. Roadway Items (CONT.)

Section 3 - Drainage & Utilities			%		Cost	Section Cost
Onsite Drainage (20% of Pvmt)	$68,520,000	x	20%		$13,704,000	
Utilites (15% of Pvmt)	$68,520,000	x	15%		$10,278,000	

	Quantity	Unit	Unit Cost	Cost	Section Cost
Offsite/Regional Drainage					
1. Remove Exist Pumping Station near Del Mar Bridge	1	EA	$250,000	$250,000	
2. 36" RCP, near Monterey Rd, Replacing MTD689 36" RCP	210	LF	$800	$168,000	
3. 24" RCP, near Monterey Rd, Replacing MTD689 24" RCP	60	LF	$295	$17,700	
4. 18" RCP, near Monterey Rd, Replacing MTD689 18" RCP	60	LF	$245	$14,700	
5. 33" RCP, near Columbia St, Replacing South Pasadana Drain 33" RCP	460	LF	$590	$271,400	
6. 51" RCP, near Columbia St, Replacing South Pasadana Drain 51" RCP	300	LF	$1,800	$540,000	
7. Stormwater pump station at Sta 204+20; Q50 = 137.1 cfs 5+1 main pumps: 12500 gpm at 90 ft TDH, 450 hp each, 2 small submersible sump pumps, 30 hp each; backup power generator, with controls and communications	1	LS	$7,500,000	$7,500,000	
8. Stormwater pump station at station 300+00; Q50 = 124.4 cfs; 1+1 main pumps: 12000 gpm at 60 ft TDH, 250 hp each, 2 small submersible sump pumps, 15 hp each; backup power generator, with controls and communications	1	LS	$6,800,000	$6,800,000	
9. Stormwater pump station at Sta 344+00; Q50 = 50 cfs 2+1 main pumps: 12000 gpm at 45 ft TDH, 200 hp each, 2 small submersible sump pumps, 15 hp each; backup power generator, with controls and communications	1	LS	$3,200,000	$3,200,000	
BMP					
1. BMPs (concrete-vault Austin Filters)	512,000	CF	$82	$41,984,000	
				Total Drainage Items	**$84,727,800**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

I. Roadway Items (CONT.)

Section 4 - Specialty Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	27	Acre	$97,500	$2,632,500	
Modify Irrigation System*	27	Acre	$63,000	$1,701,000	
Retaining Wall (H=0-10 FT)	4,700	LF	$1,000	$4,700,000	
Retaining Wall (H=10-15 FT)	2,000	LF	$1,700	$3,400,000	
Retaining Wall (H=15-20 FT)	2,700	LF	$2,850	$7,695,000	
Retaining Wall (H=20-30 FT)	5,900	LF	$3,850	$22,715,000	
Retaining Wall (H=30-40 FT)	9,000	LF	$5,000	$45,000,000	
Retaining Wall (H=40+ FT)	7,600	LF	$6,000	$45,600,000	
Soundwalls	8,000	LF	$500	$4,000,000	
Temporary Shoring	855,000	SF	$10	$8,550,000	
Wall Aesthetic Treatment	950,000	SF	$10	$9,500,000	
Concrete Barrier (Type 60D)	31,900	LF	$70	$2,233,000	
				Total Specialty Items	**$157,726,500**

Section 5 - Traffic Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Fiber Optic & Twisted Pair Cable system	11.3	MI	$650,000	$7,800,000	
Signalized Intersections	6.0	EA	$270,000	$1,620,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$68,520,000 x	20%		$13,704,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$68,520,000 x	7%		$4,796,400	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$68,520,000 x	20%		$13,704,000	
Construction Staging (40% Rdwy Pvmt)	$68,520,000 x	40%		$27,408,000	
				Total Traffic Items	**$59,612,400**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$500,148,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$500,148,000	x 15%	$75,022,200	
		Total Minor Items		**$75,022,200**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$500,148,000			
Minor Items - Section 6	$75,022,200			
Subtotal Sections 1-6	$575,170,200	x 10% Mobilization (includes 10% of Mob Cost)	$63,907,800	
		Total Roadway Mobilization		**$63,907,800**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$500,148,000			
Minor Items - Section 6	$75,022,200			
Subtotal Sections 1-6	$575,170,200	x 10%	$57,517,020	
Contingencies				
Subtotal Sections 1-5	$500,148,000			
Minor Items - Section 6	$75,022,200			
Subtotal Sections 1-6	$575,170,200	x 35%	$201,309,570	
		Total Roadway Additions		**$258,826,590**
		Subtotal for Sections 6, 7 & 8		**$397,756,590**
		Subtotal for Sections 1-5		**$500,148,000**
		TOTAL ROADWAY ITEMS SECTIONS 1-8		**$898,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

II. Structure Items

Section 9 - Structure Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Hellman Ave OC	15,360	SF	$250	$4,000,000	
710 UC #1 (Valley Blvd UC)	29,200	SF	$250	$7,300,000	
710 UC #2 (UPRR, Mission & Concord)	240,900	SF	$250	$60,225,000	
Poplar Blvd OC	22,800	SF	$250	$5,700,000	
Huntington Dr OC	39,530	SF	$250	$9,900,000	
Monterey Road OC	18,800	SF	$250	$4,700,000	
Railroad OH	11,375	SF	$250	$2,843,750	
Mission St OC	14,820	SF	$250	$3,705,000	
Arroyo Seco Parkway UC	32,400	SF	$250	$8,100,000	
Columbia St OC	13,760	SF	$250	$3,440,000	
Green St OC	25,080	SF	$250	$6,270,000	
California OC	18,425	SF	$250	$4,606,250	
Cut & Cover Tunnel (Glenarm & Bellefontaine)	2,000	LF	$76,000	$152,000,000	
				Total Structure Items	**$272,790,000**

Section 10 - Minor Items			**Cost**	**Section Cost**	
Subtotal Section 9	$272,790,000	x 10%	$27,279,000		
				Total Minor Items	**$27,279,000**

Section 11 - Mobilization					
Subtotal Section 9	$272,790,000				
Minor Items - Section 10	$27,279,000				
Subtotal Sections 9 & 10	$300,069,000	x 10% Mobilization (includes 10% of Mob Cost)	$33,341,000		
				Total Structure Mobilization	**$33,341,000**
				Total Sections 9-11	**$333,410,000**

Section 12 - Additions					
Supplemental					
Subtotal Section 9	$272,790,000				
Minor Items - Section 10	$27,279,000				
Sum	$300,069,000	x 10%	$30,006,900		
Contingencies					
Subtotal Section 9	$272,790,000				
Minor Items - Section 10	$27,279,000				
Sum	$300,069,000	x 35%	$105,024,150		
				Total Structure Additions	**$135,031,050**
				Subtotal for Sections 10, 11 & 12	**$195,651,050**
				Subtotal for Section 9	**$272,790,000**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$469,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

III. Freeway Tunnel & Ventilation Items

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Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$4,303,000	$4,303,000	
Electrical	1	LS	$13,829,600	$13,829,600	
System and Instrumentation	1	LS	$2,406,400	$2,406,400	
Tunnel Drainage System	0.4	MI	$504,000	$201,600	
Control Building	0	LS	$0	$0	
				Subtotal Tunnel Systems	**$20,741,000**
Freeway Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$20,741,000**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Section 13	$20,741,000	x 15%	$3,112,000		
				Total Minor Items	**$3,112,000**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$20,741,000				
Minor Items - Section 14	$3,112,000				
Subtotal	$23,853,000	x 10%	$2,650,300		
				Total Freeway Tunnel Mobilization	**$2,651,000**
				Total Sections 13-15	**$26,504,000**

Section 16 - Additions					
Supplemental					
Subtotal Section 13	$20,741,000				
Minor Items - Section 14	$3,112,000				
Sum	$23,853,000	x 10%	$2,386,000		
Contingencies					
Subtotal Section 13-15	$26,504,000				
Minor Items - Section 14	$3,112,000				
Sum	$29,616,000	x 35%	$10,366,000		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$12,752,000**
				Subtotal for Sections 14, 15 & 16	**$18,515,000**
				Subtotal for Section 13	**$20,741,000**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$40,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0					
Minor Items - Section 18	$0					
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0		
					Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental						
Subtotal Section 17	$0					
Minor Items - Section 18	$0					
Sum	$0	x	10%	$0		
Contingencies						
Subtotal Section 17	$0					
Minor Items - Section 18	$0					
Sum	$0	x	35%	$0		
					Total LRT Additions	**$0**
					Sub Total for Sections 19 & 20	**$0**
					Sub Total for Sections 17 & 18	**$0**
					TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

V. LRT Tunnel & Ventilation Items

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Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$126,000	$0	
Control Building	0	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
			Subtotal for Section 21		**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-6

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$399,470,055	$399,470,055
R/W Acquisition (Commercial)	1	LS	$61,123,420	$61,123,420
Permanent R/W Easement (Tunnel)	0	SF		$0
Relocation Assistance	1	LS		$38,835,000
Clearance/Demolition (Residential)	2,023,132	SF	$5	$10,116,000
Clearance/Demolition (Commercial)	617,771	SF	$7	$4,324,600
Title, Escrow, and Appraisal Fees (per parcel)	484	EA	$20,000	$9,680,000
			Total for Section 25	**$523,549,075**

Section 26 - Additions

Contingencies

Subtotal Section 25	$523,549,075			
Sum	$523,549,075	x 25%	$130,887,269	
			Total for Section 26	**$130,887,269**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$655,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

Contract PS4710-2755
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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE F-7

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$332,000,000
STRUCTURE ITEMS		$574,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$4,441,000,000
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$5,347,000,000
	SAY	$5,350,000,000
RIGHT OF WAY		$65,000,000
	SAY	$75,000,000
	TOTAL COST	$5,425,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

Contract PS4710-2755
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I. Roadway Items

Section 1 - Earthwork	**Quantity**		**Unit**		**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	78.4		Acre		$20,000	$1,580,000	
Roadway Excavation	731,500		CY		$15	$10,980,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	731,500	x	75%	x	$20	$10,972,500	
Hazardous Waste Material/ADL	731,500	x	10%	x	$100	$7,315,000	
						Total Earthwork	**$32,847,500**

Section 2 - Structural Section	**Quantity**		**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	1,599,165		SF	$12.00	$19,200,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	11,156		LF	$20.00	$224,000	
Sidewalks	32,998		SF	$5.00	$165,000	
Mainline Re-Striping	10,560		LF	$3.00	$31,800	
			%		**Cost**	
Misc Pvmt Items & Removals (45% of Pvmt)	$19,200,000	x	45%		$8,640,000	
					Total Structural Section	**$28,260,800**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

I. Roadway Items (CONT.)

Section 3 - Drainage & Utilities

			%		Cost	Section Cost
Onsite Drainage (45% of Pvmt)	$19,200,000	x	45%		$8,640,000	
Utilites (25% of Pvmt)	$19,200,000	x	25%		$4,800,000	

Offsite/Regional Drainage	Quantity	Unit	Unit Cost	Cost
1. Dbl. 10'x14' RCB, Sta 160+00-170+00, Replacing Dorchester Ave. Storm Drain 20'x14' RCC	760	LF	$4,040	$3,070,400
2. Remove Exist Pumping Station near Del Mar Bridge	1	EA	$250,000	$250,000
3. Stormwater pump station at Sta 162+00; Q50 = 29.5 cfs 2+1 main pumps: 7000 gpm at 45 ft TDH, 125 hp each, 2 small submersible sump pumps, 25 hp each; backup power generator, with controls and communications	1	LS	$3,500,000	$3,500,000
4. Stormwater pump station at Sta 510+00; Q50 = 40 cfs 2+1 main pumps: 9200 gpm at 80 ft TDH, 250 hp each, 2 small submersible sump pumps, 25 hp each; backup power generator, with controls and communications	1	LS	$3,200,000	$3,200,000
5. Tunnel water drain pump station at LP Sta 218+00. Main water source is FSS. Per NFPA 13, assume 2 zones be on at the same time, 5000 sq ft max zone, 0.3 gpm/sq ft, plus one hydrant, total flow is 4000 gpm. 2+1 main pump configuration, plus two small sump pumps. main pump: 2500 gpm at 220 ft TDH, 200 hp; sump pump: 600 gpm, 50 hp; one backup generator, controls and communications	1	LS	$2,300,000	$2,300,000
BMP				
1. BMPs (concrete-vault Austin Filters)	113,000	CF	$82	$9,266,000

Total Drainage Items **$35,026,400**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	49	Acre	$97,500	$4,777,500	
Modify Irrigation System*	49	Acre	$63,000	$3,087,000	
Retaining Wall (H=0-10 FT)	6,000	LF	$1,000	$6,000,000	
Retaining Wall (H=10-15 FT)	2,600	LF	$1,700	$4,420,000	
Retaining Wall (H=15-20 FT)	2,450	LF	$2,850	$7,125,000	
Retaining Wall (H=20-30 FT)	4,250	LF	$3,850	$16,555,000	
Retaining Wall (H=30-40 FT)	1,300	LF	$5,000	$6,500,000	
Retaining Wall (H=40+ FT)	150	LF	$6,000	$900,000	
Soundwalls	32,000	LF	$500	$16,000,000	
Temporary Shoring	207,900	SF	$10	$2,080,000	
Wall Aesthetic Treatment	231,000	SF	$10	$2,310,000	
Concrete Barrier (Type 60D)	16,750	LF	$70	$1,172,500	
				Total Specialty Items	**$70,927,000**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	4.8	MI	$650,000	$3,250,000	
Signalized Intersections	2.0	EA	$270,000	$540,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (25% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$19,200,000 x	25%		$4,800,000	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$19,200,000 x	7%		$1,344,000	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$19,200,000 x	20%		$3,840,000	
Construction Staging (40% Rdwy Pvmt)	$19,200,000 x	40%		$7,680,000	
				Total Traffic Items	**$17,664,000**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$184,726,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$184,726,000	x 15%	$27,708,900	
		Total Minor Items		**$27,708,900**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$184,726,000			
Minor Items - Section 6	$27,708,900			
Subtotal Sections 1-6	$212,434,900	x 10% Mobilization (includes 10% of Mob Cost)	$23,603,878	
		Total Roadway Mobilization		**$23,603,878**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$184,726,000			
Minor Items - Section 6	$27,708,900			
Subtotal Sections 1-6	$212,434,900	x 10%	$21,243,490	
Contingencies				
Subtotal Sections 1-5	$184,726,000			
Minor Items - Section 6	$27,708,900			
Subtotal Sections 1-6	$212,434,900	x 35%	$74,352,215	
		Total Roadway Additions		**$95,595,705**
		Subtotal for Sections 6, 7 & 8		**$146,908,483**
		Subtotal for Sections 1-5		**$184,726,000**
		TOTAL ROADWAY ITEMS SECTIONS 1-8		**$332,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Valley Blvd OC	22,000	SF	$250	$5,500,000	
Hellman Ave OC	16,640	SF	$250	$4,175,000	
Del Mar Blvd OC	25,500	SF	$250	$6,375,000	
West Green Street OC	19,272	SF	$250	$4,825,000	
West Colorado Blvd OC	43,600	SF	$250	$10,900,000	
West Union Street OC	21,160	SF	$250	$5,300,000	
South Cut & Cover Cross Passages	3	EA	$367,500	$1,102,500	
South Cut & Cover Tunnel	1,750	LF	$87,134	$152,484,500	
North Cut & Cover Cross Passages	3	EA	$367,500	$1,102,500	
North Cut & Cover Tunnel	1,600	LF	$79,840	$127,744,000	
				Total Structure Items	**$319,508,500**
	$282,433,500				

Section 10 - Minor Items			Cost	Section Cost	
Subtotal Section 9	$319,508,500	x 15%	$47,926,275		
				Total Minor Items	**$47,926,275**

Section 11 - Mobilization

Subtotal Section 9	$319,508,500				
Minor Items - Section 10	$47,926,275				
Subtotal Sections 9 & 10	$367,434,775	x 10% Mobilization (includes 10% of Mob Cost)	$40,826,087		
				Total Structure Mobilization	**$40,826,087**
				Total Sections 9-11	**$408,260,862**

Section 12 - Additions

Supplemental

Subtotal Section 9	$319,508,500				
Minor Items - Section 10	$47,926,275				
Sum	$367,434,775	x 10%	$36,743,478		

Contingencies

Subtotal Section 9	$319,508,500				
Minor Items - Section 10	$47,926,275				
Sum	$367,434,775	x 35%	$128,602,172		

Total Structure Additions	**$165,346,000**
Subtotal for Sections 10, 11 & 12	**$254,098,362**
Subtotal for Section 9	**$319,508,500**
TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$574,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

III. Freeway Tunnel & Ventilation Items

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Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$50,883,000	$50,883,000	
Electrical	1	LS	$136,812,000	$136,812,000	
System and Instrumentation	1	LS	$28,454,000	$28,454,000	
Tunnel Drainage System	4.17	MI	$659,479	$2,752,201	
Control Building	1	LS	$15,000,000	$15,000,000	
				Subtotal Tunnel Systems	**$233,902,000**
Freeway Tunnel Items					
South Portal Development	1	LS	$132,061,385	$132,061,385	
North Portal Development	1	LS	$117,262,202	$117,262,202	
Northbound Tunnel Excavation	22,035	LF	$36,162	$796,829,670	
Southbound Tunnel Excavation	22,035	LF	$36,162	$796,829,670	
Pedestrian Cross Passages - Excav, Supp, Conc.	25	EA	$2,651,068	$66,276,700	
Instrumentation & Building Protection	1	LS	$7,750,653	$7,750,653	
Vehicle Cross Passages - Excav, Supp, Conc.	7	EA	$5,585,078	$39,095,546	
Vent Tube Cross Passages - Excav, Supp, Conc.	24	EA	$3,302,406	$79,257,744	
Special Seismic Section/Vault	2	EA	$31,210,513	$62,421,026	
Roadway Deck/Slab	88,140	EA	$2,500	$220,350,000	
				Subtotal Tunnel	**$2,318,134,596**
				Section Total	**$2,552,036,596**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Section 13	$2,552,036,596	x 5%	$127,602,000		
				Total Minor Items	**$127,602,000**

Section 15 - Mobilization					
Equipment Mobilization			$454,125,000		
General Mobilization / De-mobilization			$38,626,242		
Tunnel System Subtotal	$233,902,000				
Minor Items - Section 14	$127,602,000				
Subtotal	$361,504,000	x 10%	$40,167,100		
				Total Freeway Tunnel Mobilization	**$532,918,342**
				Total Sections 13-15	**$3,212,556,938**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$233,902,000				
Minor Items - Section 14	$127,602,000				
Sum	$361,504,000	x 5%	$18,076,000		
Contingencies					
Subtotal Section 13-15	$3,212,556,938				
Minor Items - Section 14	$127,602,000				
Sum	$3,340,158,938	x 35%	$1,169,056,000		
Contingency for Special Seismic Section	$62,421,026	x 65%	$40,574,000		
				Total Freeway Tunnel Additions	**$1,227,706,000**
				Subtotal for Sections 14, 15 & 16	**$1,888,226,342**
				Subtotal for Section 13	**$2,552,036,596**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$4,441,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$0	x 10.00%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

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IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0	
				Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	10%	$0	

Contingencies

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	35%	$0	
				Total LRT Additions	**$0**
				Sub Total for Sections 19 & 20	**$0**
				Sub Total for Sections 17 & 18	**$0**
				TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

V. LRT Tunnel & Ventilation Items

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Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$126,000	$0	
Control Building	0	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
			Subtotal for Section 21		**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$810,000	$810,000
R/W Acquisition (Commercial)	1	LS	$16,897,303	$16,897,303
Permanent R/W Easement (Tunnel)	2,668,029	SF	$10	$25,758,556
Relocation Assistance	1	LS		$4,005,000
Clearance/Demolition (Residential)	3,996	SF	$5	$20,000
Clearance/Demolition (Commercial)	483,910	SF	$7	$3,388,000
Title, Escrow, and Appraisal Fees (per parcel)	18	EA	$20,000	$360,000
			Total for Section 25	**$51,238,859**

Section 26 - Additions

Contingencies

Subtotal Section 25	$51,238,859				
Sum	$51,238,859	x	25%	$12,809,715	
				Total for Section 26	**$12,809,715**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26	**$65,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE H-2

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$398,000,000
STRUCTURE ITEMS		$82,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$480,000,000
	SAY	$500,000,000
RIGHT OF WAY		$834,000,000
	SAY	$850,000,000
	TOTAL COST	$1,350,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

I. Roadway Items

Section 1 - Earthwork	Quantity		Unit		Unit Cost	Cost	Section Cost
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
ALTERNATIVE H-2	110		Acre		$20,000	$2,200,000	
Roadway Excavation	486,000		CY		$15	$7,290,000	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	486,000	x	0%	x	$20	$0	
Hazardous Waste Material/ADL	486,000	x	10%	x	$100	$4,860,000	
						Total Earthwork	**$16,350,000**

Section 2 - Structural Section	Quantity		Unit	Unit Cost	Cost	Section Cost
Mainline Pvmt & Shldrs	4,967,000		SF	$8.00	$39,736,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	195,000		LF	$20.00	$3,900,000	
Sidewalks	467,000		SF	$5.00	$2,335,000	
			%		**Cost**	
Misc Pvmt Items & Removals (15% of Pvmt)	$39,736,000	x	15%		$5,960,400	
					Total Structural Section	**$51,931,400**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

I. Roadway Items (CONT.)

Section 3 - Drainage & Utilities			**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	$39,736,000	x	20%		$7,947,200	
Utilites (15% of Pvmt)	$39,736,000	x	15%		$5,960,400	

	Quantity	**Unit**	**Unit Cost**	**Cost**	
Offsite/Regional Drainage					
1. 18" RCP, Sta 215+83 - 219+35, replacing MTD689 18" RCP	300	LS	$165	$49,500	
BMP					
1. BMPs (concrete-vault Austin Filters)	418,000	CF	$82	$34,276,000	
				Total Drainage Items	**$48,233,100**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	26	Acre	$97,500	$2,632,500	
Modify Irrigation System*	26	Acre	$63,000	$1,701,000	
Retaining Wall (H=0-10 FT)	3,414	LF	$1,000	$3,500,000	
Retaining Wall (H=10-15 FT)	2,053	LF	$1,700	$3,570,000	
Retaining Wall (H=15-20 FT)	9,038	LF	$2,850	$25,935,000	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	39,000	LF	$400	$15,600,000	
Temporary Shoring	393,300	SF	$10	$3,940,000	
Wall Aesthetic Treatment	437,000	SF	$6	$2,622,000	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$59,500,500**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	7.4	MI	$650,000	$5,200,000	
Signalized Intersections	21	EA	$270,000	$5,670,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$39,736,000 x	20%		$7,947,200	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$39,736,000 x	7%		$2,781,520	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$39,736,000 x	20%		$7,947,200	
Construction Staging (40% Rdwy Pvmt)	$39,736,000 x	40%		$15,894,400	
				Total Traffic Items	**$45,440,320**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$221,456,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$221,456,000	x 15%	$33,218,400	
		Total Minor Items		**$33,218,400**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$221,456,000			
Minor Items - Section 6	$33,218,400			
Subtotal Sections 1-6	$254,674,400	x 10% Mobilization (includes 10% of Mob Cost)	$28,297,156	
		Total Roadway Mobilization		**$28,297,156**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$221,456,000			
Minor Items - Section 6	$33,218,400			
Subtotal Sections 1-6	$254,674,400	x 10%	$25,467,440	
Contingencies				
Subtotal Sections 1-5	$221,456,000			
Minor Items - Section 6	$33,218,400			
Subtotal Sections 1-6	$254,674,400	x 35%	$89,136,040	
		Total Roadway Additions		**$114,603,480**
		Subtotal for Sections 6, 7 & 8		**$176,119,036**
		Subtotal for Sections 1-5		**$221,456,000**
		TOTAL ROADWAY ITEMS SECTIONS 1-8		**$398,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

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II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Valley Blvd Overcrossing (Bridge)	29,400	SF	$250	$7,500,000	
Mission Rd Overcrossing (Bridge)	51,700	SF	$250	$12,925,000	
SR-110 Overcrossing (Bridge)	100,900	SF	$250	$25,225,000	
				Total Structure Items	**$45,650,000**

Section 10 - Minor Items			Cost	Section Cost	
Subtotal Section 9	$45,650,000	x 15%	$6,847,500		
				Total Minor Items	**$6,847,500**

Section 11 - Mobilization

Subtotal Section 9	$45,650,000				
Minor Items - Section 10	$6,847,500				
Subtotal Sections 9 & 10	$52,497,500	x 10% Mobilization (includes 10% of Mob Cost)	$5,833,056		
				Total Structure Mobilization	**$5,833,056**
				Total Sections 9-11	**$58,330,556**

Section 12 - Additions

Supplemental

Subtotal Section 9	$45,650,000				
Minor Items - Section 10	$6,847,500				
Sum	$52,497,500	x 10%	$5,249,750		

Contingencies

Subtotal Section 9	$45,650,000				
Minor Items - Section 10	$6,847,500				
Sum	$52,497,500	x 35%	$18,374,125		
				Total Structure Additions	**$23,624,000**
				Subtotal for Sections 10, 11 & 12	**$36,304,556**
				Subtotal for Section 9	**$45,650,000**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$82,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE F-7

III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

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IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
ALTERNATIVE H-2	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0

Total LRT Mobilization **$0**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	10%	$0

Contingencies

Subtotal Section 17	$0			
Minor Items - Section 18	$0			
Sum	$0	x	35%	$0

Total LRT Additions **$0**

Sub Total for Sections 19 & 20 **$0**

Sub Total for Sections 17 & 18 **$0**

TOTAL LRT ITEMS SECTIONS 17-20 **$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
				Subtotal for Section 21	**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-2

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$443,850,600	$443,850,600
R/W Acquisition (Commercial)	1	LS	$109,779,070	$109,779,070
Permanent R/W Easement (Tunnel)	0	SF	$8	$0
Relocation Assistance	1	LS	$78,875,000	$78,875,000
Clearance/Demolition (Residential)	2,223,412	SF	$5	$11,117,060
Clearance/Demolition (Commercial)	1,481,218	SF	$7	$10,368,533
Title, Escrow, and Appraisal Fees (per parcel)	632	EA	$20,000	$12,640,000
			Total for Section 25	**$666,630,263**

Section 26 - Additions

Contingencies

Subtotal Section 25	$666,630,263			
Sum	$666,630,263	x 25%	$166,657,566	
			Total for Section 26	**$166,657,566**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$834,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE H-6

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$259,000,000
STRUCTURE ITEMS		$45,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$304,000,000
	SAY	$325,000,000
RIGHT OF WAY		$410,000,000
	SAY	$425,000,000
	TOTAL COST	$750,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

I. Roadway Items

Section 1 - Earthwork	Quantity		Unit		Unit Cost	Cost	Section Cost
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
ALTERNATIVE H-6	181		Acre		$20,000	$3,620,000	
Roadway Excavation	132,294		CY		$15	$1,995,000	
			%		Unit Cost	Cost	
Imported Borrow Due to Unsuitable On-Site Soil	132,294	x	0%	x	$20	$0	
Hazardous Waste Material/ADL	132,294	x	10%	x	$100	$1,322,940	
						Total Earthwork	**$8,937,940**

Section 2 - Structural Section	Quantity		Unit	Unit Cost	Cost	Section Cost
Mainline Pvmt & Shldrs	4,130,025		SF	$8.00	$33,048,000	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	103,180		LF	$20.00	$2,064,000	
Sidewalks	269,025		SF	$5.00	$1,345,500	
			%		Cost	
Misc Pvmt Items & Removals (15% of Pvmt)	$33,048,000	x	15%		$4,957,200	
					Total Structural Section	**$41,414,700**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

I. Roadway Items (CONT.)

Section 3 - Drainage & Utilities						
			%		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	$33,048,000	x	20%		$6,609,600	
Utilites (15% of Pvmt)	$33,048,000	x	15%		$4,957,200	
	Quantity		**Unit**	**Unit Cost**	**Cost**	
Offsite/Regional Drainage						
No conflict with existing drainage system	0		LS	NA	$0	
BMP						
1. BMPs (concrete-vault Austin Filters)	261,000		CF	$82	$21,402,000	
					Total Drainage Items	**$32,968,800**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	11	Acre	$97,500	$1,072,500	
ALTERNATIVE H-6	11	Acre	$63,000	$693,000	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	1,000	LF	$2,850	$2,850,000	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	36,000	LF	$500	$18,000,000	
Temporary Shoring	18,000	SF	$10	$180,000	
Wall Aesthetic Treatment	20,000	SF	$10	$200,000	
Concrete Barrier (Type 60D)	1,000	LF	$70	$70,000	
				Total Specialty Items	**$23,065,500**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	5.7	MI	$650,000	$3,900,000	
Signalized Intersections	16	EA	$270,000	$4,320,000	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$33,048,000 x	20%		$6,609,600	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$33,048,000 x	7%		$2,313,360	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$33,048,000 x	20%		$6,609,600	
Construction Staging (40% Rdwy Pvmt)	$33,048,000 x	40%		$13,219,200	
				Total Traffic Items	**$36,971,760**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$144,000,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$144,000,000	x 15%	$21,600,000	
			Total Minor Items	**$21,600,000**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$144,000,000			
Minor Items - Section 6	$21,600,000			
Subtotal Sections 1-6	$165,600,000	x 10% Mobilization (includes 10% of Mob Cost)	$18,400,000	
			Total Roadway Mobilization	**$18,400,000**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$144,000,000			
Minor Items - Section 6	$21,600,000			
Subtotal Sections 1-6	$165,600,000	x 10%	$16,560,000	
Contingencies				
Subtotal Sections 1-5	$144,000,000			
Minor Items - Section 6	$21,600,000			
Subtotal Sections 1-6	$165,600,000	x 35%	$57,960,000	
			Total Roadway Additions	**$74,520,000**

Subtotal for Sections 6, 7 & 8	**$114,520,000**
Subtotal for Sections 1-5	**$144,000,000**
TOTAL ROADWAY ITEMS SECTIONS 1-8	**$259,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

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II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Valley Blvd Overcrossing (Bridge)	29,400	SF	$250	$7,500,000	
Mission Rd Overcrossing (Bridge)	44,900	SF	$250	$11,225,000	
SR-110 Overcrossing (Bridge)	12,100	SF	$250	$3,025,000	
UPRR Columbia	12,500	SF	$250	$3,125,000	
				Total Structure Items	**$24,875,000**

Section 10 - Minor Items			Cost	Section Cost
Subtotal Section 9	$24,875,000	x 15%	$3,731,250	
			Total Minor Items	**$3,731,250**

Section 11 - Mobilization

Subtotal Section 9	$24,875,000			
Minor Items - Section 10	$3,731,250			
Subtotal Sections 9 & 10	$28,606,250	x 10% Mobilization (includes 10% of Mob Cost)	$3,178,473	
			Total Structure Mobilization	**$3,178,473**
			Total Sections 9-11	**$31,784,723**

Section 12 - Additions

Supplemental

Subtotal Section 9	$24,875,000			
Minor Items - Section 10	$3,731,250			
Sum	$28,606,250	x 10%	$2,860,625	

Contingencies

Subtotal Section 9	$24,875,000			
Minor Items - Section 10	$3,731,250			
Sum	$28,606,250	x 35%	$10,012,188	

Total Structure Additions	**$12,873,000**
Subtotal for Sections 10, 11 & 12	**$19,782,723**
Subtotal for Section 9	**$24,875,000**
TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$45,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

III. Freeway Tunnel & Ventilation Items

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Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

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IV. LRT Items

Section 17 - LRT Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
ALTERNATIVE H-6	0	Route FT	$8,000	$0	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	0	Route FT	$2,600	$0	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	0	Route FT	$720	$0	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	0	EA	$980,000	$0	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.012 Below grade station	0	EA		$0	
20.021 LRT Station Elevated Center Platform	0	EA	$15,000,000	$0	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	0	EA	$250,000	$0	
30.03 Support Facility Heavy Maintenance	0	LS	$75,000,000	$0	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	0	Route FT	$210	$0	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	0	Route FT	$450	$0	
50.012 Train Controls: Ductbank & Pullboxes	0	Route FT	$130	$0	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	0	Route FT	$430	$0	
50.032 Traction Power: Building Installation	0	Route FT	$52	$0	
50.041 Traction power distribution: Catenary OCS Pole	0	Route FT	$220	$0	
50.042 Traction power distribution: Ductbank Pullboxes	0	Route FT	$130	$0	
50.043 Traction power distribution: OCS Poles Foundations	0	Route FT	$62	$0	
5.051 Communications: Communications Equipment Installation	0	Route FT	$440	$0	
5.052 Communications: Ductbank & Pullboxes	0	Route FT	$130	$0	
5.071 Fare Collection: Ticket Vending Machines	0	EA	$860,000	$0	
5.072 Central Control	0	EA	$2,400,000	$0	
70.01 LRT Vehicles	0	EA	$3,500,000	$0	
				Total LRT Section	**$0**

Section 18 - LRT Minor Items			**Cost**		**Section Cost**
Subtotal Section 17	$0	x 10%	$0		
				Total Minor Items	**$0**
				Total for Sections 17 & 18	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

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IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Subtotal Sections 17 & 18	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0	
				Total LRT Mobilization	**$0**

Section 20 - LRT Additions

Supplemental					
Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	10%	$0	
Contingencies					
Subtotal Section 17	$0				
Minor Items - Section 18	$0				
Sum	$0	x	35%	$0	
				Total LRT Additions	**$0**
				Sub Total for Sections 19 & 20	**$0**
				Sub Total for Sections 17 & 18	**$0**
				TOTAL LRT ITEMS SECTIONS 17-20	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$126,000	$0	
Control Building	0	LS	$0	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
			Total LRT Tunnel Mobilization		**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
			Total LRT Tunnel Additions		**$0**
			Subtotal for Sections 22, 23 & 24		**$0**
			Subtotal for Section 21		**$0**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE H-6

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$139,279,425	$139,279,425
R/W Acquisition (Commercial)	1	LS	$138,221,140	$138,221,140
Permanent R/W Easement (Tunnel)	0	SF	$8	$0
Relocation Assistance	1	LS	$40,575,000	$40,575,000
Clearance/Demolition (Residential)	194,978	SF	$5	$974,890
Clearance/Demolition (Commercial)	674,599	SF	$7	$4,722,200
Title, Escrow, and Appraisal Fees (per parcel)	184	EA	$20,000	$3,680,000
			Total for Section 25	**$327,452,655**

Section 26 - Additions

Contingencies

Subtotal Section 25	$327,452,655			
Sum	$327,452,655	x 25%	$81,863,164	
			Total for Section 26	**$81,863,164**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$410,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE LRT-4A

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$19,000,000
STRUCTURE ITEMS		$0
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$859,000,000
LRT TUNNEL & VENTILATION ITEMS		$1,471,000,000
SUBTOTAL CONSTRUCTION		$2,349,000,000
	SAY	$2,400,000,000
RIGHT OF WAY		$191,000,000
	SAY	$200,000,000
	TOTAL COST	$2,600,000,000
	SAY	$2,600,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

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I. Roadway Items

Section 1 - Earthwork	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1	LS	$2,000,000	$2,000,000	
Clearing and Grubbing	0	Acre	$20,000	$0	
Roadway Excavation	0	CY	$15	$0	
		%	**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	0 x	40% x	$20	$0	
Hazardous Waste Material/ADL	0 x	10% x	$50	$0	
				Total Earthwork	**$2,000,000**

Section 2 - Structural Section	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	0	SF	$20.00	$0	
Mainline AC Overlay	0	SF	$1.00	$0	
Curb and Gutter	0	LF	$20.00	$0	
Sidewalks	0	SF	$5.00	$0	
Mainline Re-Striping	0	LF	$0.50	$0	
		%		**Cost**	
Misc Pvmt Items & Removals (5% of Pvmt)	$0 x	5%		$0	
				Total Structural Section	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

I. Roadway Items (CONT.)

Section 3 - Drainage

	Rdwy Pvmt		%		Cost	Section Cost
Onsite Drainage (20% of Pvmt)	0	x	20%		$0	
Utilities (15% of Pvmt)	0	x	15%		$0	

	Quantity	Unit	Unit Cost	Cost	Section Cost
Offsite/Regional Drainage					
1. 22'X11' concrete channel, Sta 75+00-96+00, replacing 22'x11' Caltrans concrete channel	330	LF	$1,100	$363,000	
2. Tunnel water drain pump station at LP Sta 191+89 Main water source is FSS. Per NFPA 13, assume 2 zones be on at the same time, 5000 sq ft max zone, 0.15 gpm/sq ft for, plus one hydrant, total flow small sump 1+1 main pump configuration, plus two small sump pumps. main pump: 2500 gpm at 125 ft TDH, 125 hp; sump pump: 100 gpm, 7.5 hp; one backup generator, controls and communications	1	LS	$2,000,000	$2,000,000	
BMP					
1. BMPs (concrete-vault Austin Filters)	71,000	CF	$82	$5,822,000	
				Total Drainage Items	**$8,185,000**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.
4. Stormwater in the elevated segment is assumed draining off before the tunnel section.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0	Acre	$97,500	$0	
Modify Irrigation System*	0	Acre	$63,000	$0	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$0**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	0.0	MI	$650,000	$0	
Signalized Intersections	0.0	EA	$270,000	$0	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$0 x	20%		$0	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$0 x	7%		$0	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$0 x	20%		$0	
Construction Staging (40% Rdwy Pvmt)	$0 x	40%		$0	
				Total Traffic Items	**$0**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$10,185,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

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I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$10,185,000	x 15%	$1,527,750	
			Total Minor Items	**$1,527,750**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$10,185,000			
Minor Items - Section 6	$1,527,750			
Subtotal Sections 1-6	$11,712,750	x 10% Mobilization (includes 10% of Mob Cost)	$1,301,417	
			Total Roadway Mobilization	**$1,301,417**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$10,185,000			
Minor Items - Section 6	$1,527,750			
Subtotal Sections 1-6	$11,712,750	x 10%	$1,171,275	
Contingencies				
Subtotal Sections 1-5	$10,185,000			
Minor Items - Section 6	$1,527,750			
Subtotal Sections 1-6	$11,712,750	x 35%	$4,099,463	
			Total Roadway Additions	**$5,270,738**
			Subtotal for Sections 6, 7 & 8	**$8,099,905**
			TOTAL ROADWAY ITEMS SECTIONS 1-8	**$19,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

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II. Structure Items

Section 9 - Structure Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	LF	$300	$0	
	0	LF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items			**Cost**	**Section Cost**	
Subtotal Section 9	$0	x 10%	$0		
				Total Minor Items	**$0**

Section 11 - Mobilization

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Subtotal Sections 9 & 10	$0	x 10% Mobilization (includes 10% of Mob Cost)	$0		
				Total Structure Mobilization	**$0**
				Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 10%	$0		
Contingencies					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 35%	$0		
				Total Structure Additions	**$0**
				Subtotal for Sections 10, 11 & 12	**$0**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

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III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$0	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

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IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	16589	Route FT	$8,000	$132,712,000	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	800	Route FT	$2,600	$2,080,000	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	41000	Route FT	$720	$29,520,000	
10.10 Track: Embedded	0	Route FT	$920	$0	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	4	EA	$980,000	$3,920,000	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	0	EA	$3,800,000	$0	
20.021 LRT Station Elevated Center Platform	3	EA	$15,000,000	$45,000,000	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	36	EA	$250,000	$9,000,000	
30.03 Support Facility Heavy Maintenance	1	LS	$75,000,000	$75,000,000	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	41000	Route FT	$210	$8,610,000	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	41000	Route FT	$70	$2,870,000	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	41000	Route FT	$450	$18,450,000	
50.012 Train Controls: Ductbank & Pullboxes	41000	Route FT	$130	$5,330,000	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	41000	Route FT	$430	$17,630,000	
50.032 Traction Power: Building Installation	41000	Route FT	$52	$2,132,000	
50.041 Traction power distribution: Catenary OCS Pole	41000	Route FT	$220	$9,020,000	
50.042 Traction power distribution: Ductbank Pullboxes	41000	Route FT	$130	$5,330,000	
50.043 Traction power distribution: OCS Poles Foundations	41000	Route FT	$62	$2,542,000	
5.051 Communications: Communications Equipment Installation	41000	Route FT	$440	$18,040,000	
5.052 Communications: Ductbank & Pullboxes	41000	Route FT	$130	$5,330,000	
5.071 Fare Collection: Ticket Vending Machines	12	EA	$860,000	$10,320,000	
5.072 Central Control	1	EA	$2,400,000	$2,400,000	
70.01 LRT Vehicles	27	EA	$3,500,000	$94,500,000	
				Total LRT Section	**$499,736,000**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$499,736,000	x 10%	$49,973,600		
				Total Minor Items	**$49,973,600**
				Total for Sections 17 & 18	**$549,709,600**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$499,736,000			
Minor Items - Section 18	$49,973,600			
Subtotal Sections 17 & 18	$549,709,600	x	10% Mobilization (includes 10% of Mob Cost)	$61,078,900

Total LRT Mobilization **$61,078,900**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$499,736,000			
Minor Items - Section 18	$49,973,600			
Sum	$549,709,600	x	10%	$54,970,960

Contingencies

Subtotal Section 17	$499,736,000			
Minor Items - Section 18	$49,973,600			
Sum	$549,709,600	x	35%	$192,398,360

Total LRT Additions **$247,369,320**

Sub Total for Sections 19 & 20 **$308,448,220**

TOTAL LRT ITEMS SECTIONS 17-20 **$859,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$16,132,572	$16,132,572	
Electrical	1	LS	$144,957,555	$144,957,555	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	4.47	MI	$126,000	$563,220	
Control Building	1	LS	$10,000,000	$10,000,000	
			Subtotal LRT Tunnel Systems		**$171,653,347**
LRT Tunnel Items					
South Portal Development	1	LS	$11,408,000	$11,408,000	
Station 1 - Excavation, Support, Lining. Finishes	1	LS	$100,000,000	$100,000,000	
Station 2/Crossover - Excavation, Support, Lining, Finishes	1	LS	$110,000,000	$110,000,000	
Station 3 - Excavation, support, Lining, Finishes	1	LS	$100,000,000	$100,000,000	
Station 4/Crossover - Excavation, Support, Finishes	1	LS	$110,000,000	$110,000,000	
Northbound Tunnel Excavation	20,760	LF	$6,552	$136,019,520	
Southbound Tunnel Excavation	20,760	LF	$6,552	$136,019,520	
Instrumentation & Building Protection	1	LS	$42,207,000	$42,207,000	
Tunnel Cross Passages - Excavation, Support, Lining	23	EA	$1,993,260	$45,844,980	
Special Seismic Section	2	EA	$19,284,000	$38,568,000	
				Subtotal Tunnel	**$830,067,020**
				Section Total	**$1,001,720,367**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$171,653,347	x 5%	$8,582,668		
				Total Minor Items	**$8,582,668**

Section 23 - Mobilization					
Equipment Mobilization			$21,193,000		
General Mobilization / De-mobilization			$9,906,000		
Tunnel System Subtotal	$171,653,347				
Minor Items - Section 22	$8,582,668				
Subtotal	$180,236,015	x 10%	$20,026,224		
			Total LRT Tunnel Mobilization		**$51,125,224**
				Total Sections 21-23	**$1,061,428,259**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$171,653,347				
Minor Items - Section 22	$8,582,668				
Sum	$180,236,015	x 5%	$9,012,000		
Contingencies					
Subtotal Section 21-23	$1,061,428,259				
Minor Items - Section 22	$8,582,668				
Sum	$1,070,010,927	x 35%	$374,504,000		
Contingency for Special Seismic Section	$38,568,000	x 65%	$25,070,000		
			Total LRT Tunnel Additions		**$408,586,000**
			Subtotal for Sections 22, 23 & 24		**$468,293,892**
			Subtotal for Section 21		**$1,001,720,367**
			TOTAL LRT TUNNEL ITEMS SECTIONS 21-24		**$1,471,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4A

VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$12,007,275	$12,007,275
R/W Acquisition (Commercial)	1	LS	$108,740,350	$108,740,350
Permanent R/W Easement (Tunnel)	1	LS	$4,013,622	$4,013,622
Permanent Aerial Easement	1	LS	$10,817,081	$10,817,081
Relocation Assistance	1	LS	$10,355,000	$10,355,000
Clearance/Demolition (Residential)	43,906	SF	$5	$219,530
Clearance/Demolition (Commercial)	736,352	SF	$7	$5,154,464
Title, Escrow, and Appraisal Fees	50	EA	$20,000	$1,000,000
			Total for Section 25	**$152,307,322**

Section 26 - Additions

Contingencies

Subtotal Section 25	$152,307,322			
Sum	$152,307,322	x 25%	$38,076,831	
			Total for Section 26	**$38,076,831**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$191,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE LRT-4B

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$27,000,000
STRUCTURE ITEMS		$0
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$985,000,000
LRT TUNNEL & VENTILATION ITEMS		$1,140,000,000
SUBTOTAL CONSTRUCTION		$2,152,000,000
	SAY	$2,200,000,000
RIGHT OF WAY		$213,000,000
	SAY	$225,000,000
	TOTAL COST	$2,425,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

I. Roadway Items

Section 1 - Earthwork	Quantity		Unit		Unit Cost	Cost	Section Cost
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	0.0		Acre		$20,000	$0	
Roadway Excavation	0		CY		$15	$0	
			%		Unit Cost	Cost	
Imported Borrow Due to Unsuitable On-Site Soil	0	x	40%	x	$20	$0	
Hazardous Waste Material/ADL	0	x	10%	x	$50	$0	
						Total Earthwork	**$2,000,000**

Section 2 - Structural Section	Quantity		Unit	Unit Cost	Cost	Section Cost
Mainline Pvmt & Shldrs	0		SF	$20.00	$0	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	0		LF	$20.00	$0	
Sidewalks	0		SF	$5.00	$0	
Mainline Re-Striping	0		LF	$0.50	$0	
			%		Cost	
Misc Pvmt Items & Removals (5% of Pvmt)	$0	x	5.00%		$0	
					Total Structural Section	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

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I. Roadway Items (CONT.)

Section 3 - Drainage	**Rdwy Pvmt**		**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	0	x	20%		$0	
Utilities (15% of Pvmt)	0	x	15%		$0	

Offsite/Regional Drainage	**Quantity**	**Unit**	**Unit Cost**	**Cost**	
1. 22'x11' concrete channel, Sta. 75+00-96+00, replacing 22'x11' Caltrans concrete channel	330	LF	$1,100	$363,000	
2. 24" RCP, Sta. 263+90-264+50, Replacing Alhambra 24" RCP	100	LF	$ 160	$ 16,000	
3. Tunnel water drain pump station at LP Sta 286+00 main water source is FSS. Per NFPA 13, assume 2 zones be on at the same time, 5000 sq ft max zone, 0.15 gpm/sq ft, plus one hydrant, total flow is 2500 gpm. 1+1 main pump configuration, plus two small sump pumps. main pump: 2500 gpm at 125 ft TDH, 125 hp; sump pump: 100 gpm, 7.5 hp; one backup generator, controls and communications	1	LS	$ 2,000,000	$ 2,000,000	
BMP					
1. BMPs (concrete-vault Austin Filters)	126,000	CF	$82	$10,332,000	
				Total Drainage Items	**$12,711,000**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, including exisitng pavement. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.
4. Stormwater in the elevated segment is assumed draining off before the tunnel section.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

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I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0	Acre	$97,500	$0	
Modify Irrigation System*	0	Acre	$63,000	$0	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$0**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	0.0	MI	$650,000	$0	
Signalized Intersections	0.0	EA	$270,000	$0	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$0 x	20%		$0	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$0 x	7%		$0	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$0 x	20%		$0	
Construction Staging (40% Rdwy Pvmt)	$0 x	40%		$0	
				Total Traffic Items	**$0**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$14,711,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$14,711,000	x 15%	$2,206,650	
		Total Minor Items		**$2,207,000**

Section 7 - Mobilization

			Cost	**Section Cost**
Subtotal Sections 1-5	$14,711,000			
Minor Items - Section 6	$2,207,000			
Subtotal Sections 1-6	$16,918,000	x 10% Mobilization (includes 10% of Mob Cost)	$1,879,778	
		Total Roadway Mobilization		**$1,880,000**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$14,711,000			
Minor Items - Section 6	$2,206,650			
Subtotal Sections 1-6	$16,917,650	x 10%	$1,691,765	
Contingencies				
Subtotal Sections 1-5	$14,711,000			
Minor Items - Section 6	$2,207,000			
Subtotal Sections 1-6	$16,918,000	x 35%	$5,921,300	
		Total Roadway Additions		**$7,614,000**
		Subtotal for Sections 6, 7 & 8		**$11,701,000**
		TOTAL ROADWAY ITEMS SECTIONS 1-8		**$27,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

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II. Structure Items

Section 9 - Structure Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	LF	$300	$0	
	0	LF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items			**Cost**	**Section Cost**	
Subtotal Section 9	$0	x 10%	$0		
				Total Minor Items	**$0**

Section 11 - Mobilization					
Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Subtotal Sections 9 & 10	$0	x 10% Mobilization (includes 10% of Mob Cost)	$0		
				Total Structure Mobilization	**$0**
				Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental			
Subtotal Section 9	$0		
Minor Items - Section 10	$0		
Sum	$0	x 10%	$0
Contingencies			
Subtotal Section 9	$0		
Minor Items - Section 10	$0		
Sum	$0	x 35%	$0

Total Structure Additions	**$0**
Subtotal for Sections 10, 11 & 12	**$0**
TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

III. Freeway Tunnel & Ventilation Items

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Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$0	$0	
Electrical	0	LS	$0	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$0	$0	
Control Building	0	LS	$0	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$0	$0	
North Portal Development	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$0	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$0	$0	
Special Seismic Section/Vault	0	EA	$0	$0	
Roadway Deck/Slab	0	EA	$0	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

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IV. LRT Items

Section 17 - LRT Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
10.01 Guideway: At-grade exclusive right-of-way	0	Route FT	$480	$0	
10.03 Guideway: At-grade in mixed traffic	1425	Route FT	$560	$798,000	
10.041 Guideway: Aerial Typical Span	22925	Route FT	$8,000	$183,400,000	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	800	Route FT	$2,600	$2,080,000	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	40131	Route FT	$720	$28,894,320	
10.10 Track: Embedded	1425	Route FT	$920	$1,311,000	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	5	EA	$980,000	$4,900,000	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	1	EA	$3,800,000	$3,800,000	
20.021 LRT Station Elevated Center Platform	3	EA	$15,000,000	$45,000,000	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	42	EA	$250,000	$10,500,000	
30.03 Support Facility Heavy Maintenance	1	LS	$75,000,000	$75,000,000	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	40131	Route FT	$210	$8,427,510	
40.022 Site Utilities: At-Grade Guideway within Street	0	Route FT	$580	$0	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	42356	Route FT	$70	$2,964,920	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	42356	Route FT	$450	$19,060,200	
50.012 Train Controls: Ductbank & Pullboxes	42356	Route FT	$130	$5,506,280	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	42356	Route FT	$430	$18,213,080	
50.032 Traction Power: Building Installation	42356	Route FT	$52	$2,202,512	
50.041 Traction power distribution: Catenary OCS Pole	42356	Route FT	$220	$9,318,320	
50.042 Traction power distribution: Ductbank Pullboxes	42356	Route FT	$130	$5,506,280	
50.043 Traction power distribution: OCS Poles Foundations	42356	Route FT	$62	$2,626,072	
5.051 Communications: Communications Equipment Installation	42356	Route FT	$440	$18,636,640	
5.052 Communications: Ductbank & Pullboxes	42356	Route FT	$130	$5,506,280	
5.071 Fare Collection: Ticket Vending Machines	14	EA	$860,000	$12,040,000	
5.072 Central Control	1	EA	$2,400,000	$2,400,000	
70.01 LRT Vehicles	30	EA	$3,500,000	$105,000,000	
				Total LRT Section	**$573,091,414**

Section 18 - LRT Minor Items			**Cost**		**Section Cost**
Subtotal Section 17	$573,091,414	x 10.00%	$57,309,142		
				Total Minor Items	**$57,309,142**
				Total for Sections 17 & 18	**$630,400,556**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$573,091,414			
Minor Items - Section 18	$57,309,142			
Subtotal Sections 17 & 18	$630,400,556	x	10% Mobilization (includes 10% of Mob Cost)	$70,044,507

Total LRT Mobilization **$70,045,000**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$573,091,414			
Minor Items - Section 18	$57,309,142			
Sum	$630,400,556	x	10%	$63,040,056

Contingencies

Subtotal Section 17	$573,091,414			
Minor Items - Section 18	$57,309,142			
Sum	$630,400,556	x	35%	$220,640,195

Total LRT Additions	**$283,680,251**
Sub Total for Sections 19 & 20	**$353,725,251**
Sub Total for Sections 17 & 18	**$630,400,556**
TOTAL LRT ITEMS SECTIONS 17-20	**$985,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

V. LRT Tunnel & Ventilation Items

Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$11,082,315	$11,082,315	
Electrical	1	LS	$101,646,705	$101,646,705	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	2.76	MI	$126,000	$348,242	
Control Building	1	LS	$10,000,000	$10,000,000	
				Subtotal Tunnel Systems	**$123,077,263**
LRT Tunnel Items					
South Portal Development	1	LS	$12,511,841	$12,511,841	
Station 1/Crossover - Excavation, Support, Lining, Finishe:	1	LS	$110,000,000	$110,000,000	
Station 2 - Excavation, Support, Lining, Finishes	1	LS	$100,000,000	$100,000,000	
Station 3/Crossover - Excavation, Support, Finishes	1	LS	$110,000,000	$110,000,000	
Northbound Tunnel Excavation	14,593	LF	$6,905	$100,764,665	
Southbound Tunnel Excavation	14,593	LF	$6,905	$100,764,665	
Instrumentation & Building Protection	1	LS	$41,397,755	$41,397,755	
Tunnel Cross Passages - Excavation, Support, Lining	16	EA	$1,991,115	$31,857,840	
Special Seismic Section	2	EA	$19,080,633	$38,161,266	
				Subtotal Tunnel	**$645,458,032**
				Section Total	**$768,535,295**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$123,077,263	x 5%	$6,153,864		
				Total Minor Items	**$6,153,864**

Section 23 - Mobilization					
Equipment Mobilization			$21,193,000		
General Mobilization / De-mobilization			$9,082,268		
Tunnel System Subtotal	$123,077,263				
Minor Items - Section 22	$6,153,864				
Subtotal	$129,231,127	x 10%	$14,359,014		
				Total LRT Tunnel Mobilization	**$44,634,282**
				Total Sections 21-23	**$819,323,441**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$123,077,263				
Minor Items - Section 22	$6,153,864				
Sum	$129,231,127	x 5%	$6,462,000		
Contingencies					
Subtotal Section 21-23	$819,323,441				
Minor Items - Section 22	$6,153,864				
Sum	$825,477,305	x 35%	$288,918,000		
Contingency for Special Seismic Section	$38,161,266	x 65%	$24,805,000		
				Total LRT Tunnel Additions	**$320,185,000**
				Subtotal for Sections 22, 23 & 24	**$370,973,146**
				Subtotal for Section 21	**$768,535,295**
				TOTAL LRT TUNNEL ITEMS SECTIONS 21-24	**$1,140,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4B

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$1,937,500	$1,937,500
R/W Acquisition (Commercial)	1	LS	$94,302,720	$94,302,720
Permanent R/W Easement (Tunnel)	1	LS	3235211	$3,235,211
Permanent Aerial Easement	1	LS	$14,802,194	$14,802,194
Relocation Assistance	1	LS	$48,130,000	$48,130,000
Clearance/Demolition (Residential)	16,289	LS	$5	$85,000
Clearance/Demolition (Commercial)	889,784	SF	$7	$6,230,000
Title, Escrow, and Appraisal Fees (per parcel)	56	EA	$20,000	$1,120,000
			Total for Section 25	**$169,843,000**

Section 26 - Additions

Contingencies

Subtotal Section 25	$169,843,000			
Sum	$169,843,000	x	25%	$42,460,750
			Total for Section 26	**$42,460,750**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$213,000,000**

Assumptions:

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE LRT-4D

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$25,000,000
STRUCTURE ITEMS		$0
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$860,000,000
LRT TUNNEL & VENTILATION ITEMS		$1,184,000,000
SUBTOTAL CONSTRUCTION		$2,069,000,000
	SAY	$2,100,000,000
RIGHT OF WAY		$285,000,000
	SAY	$300,000,000
	TOTAL COST	$2,400,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

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I. Roadway Items

Section 1 - Earthwork	Quantity		Unit		Unit Cost	Cost	Section Cost
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	0.0		Acre		$20,000	$0	
Roadway Excavation	0		CY		$15	$0	
			%		Unit Cost	Cost	
Imported Borrow Due to Unsuitable On-Site Soil	0	x	40%	x	$20	$0	
Hazardous Waste Material/ADL	0	x	10%	x	$50	$0	
						Total Earthwork	**$2,000,000**

Section 2 - Structural Section	Quantity		Unit	Unit Cost	Cost	Section Cost
Mainline Pvmt & Shldrs	0		SF	$20.00	$0	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	0		LF	$20.00	$0	
Sidewalks	0		SF	$5.00	$0	
Mainline Re-Striping	0		LF	$0.50	$0	
			%		Cost	
Misc Pvmt Items & Removals (5% of Pvmt)	$0	x	5%		$0	
					Total Structural Section	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

I. Roadway Items (CONT.)

Section 3 - Drainage	**Rdwy Pvmt**		**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	0	x	20%		$0	
Utilites (15% of Pvmt)	0	x	15%		$0	

Offsite/Regional Drainage	**Quantity**	**Unit**	**Unit Cost**	**Cost**	
1. 1. 22'x11' concrete channel, Sta. 99+00-120+00, replacing 22'x11' Caltrans concrete channel	330	LF	$1,100	$363,000	
2. Tunnel water drain pump station at LP Sta 290 + 38 Main water source is FSS. Per NFPA 13, assume 2 zones be on at the same time, 5000 sq ft max zone, 0.15 gpm/sq ft, plus one hydrant, total flow is 2500 gpm. 1+1 main pump configuration, plus two small sump pumps. main pump: 2500 gpm at 75 ft TDH, 75 hp; sump pump: 100 gpm, 5 hp; one backup generator, controls and communications	1	LS	$1,900,000	$1,900,000	
BMP					
1. BMPs (concrete-vault Austin Filters)	112,000	CF	$82	$9,184,000	
				Total Drainage Items	**$11,447,000**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Tributary area for BMPs counts all impervious area outside tunnel, even if some areas are above existing roadway. Site-specific determination of feasibility will be made during final design.
3. The BMP cost was derived from the Caltrans BMP Retrofit Program. The costs in that report represent 1999 dollars, so the unit costs were doubled to account for increased construction costs and represent 2012 dollars. Final BMP selection may consist of other BMPs.
4. Stormwater in the elevated segment is assumed draining off before the tunnel section.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0	Acre	$97,500	$0	
Modify Irrigation System*	0	Acre	$63,000	$0	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$0**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	0.0	MI	$650,000	$0	
Signalized Intersections	0.0	EA	$270,000	$0	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$0 x	20%		$0	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$0 x	7%		$0	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$0 x	20%		$0	
Construction Staging (40% Rdwy Pvmt)	$0 x	40%		$0	
				Total Traffic Items	**$0**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$13,447,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

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I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$13,447,000	x 15%	$2,017,050	
			Total Minor Items	**$2,018,000**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$13,447,000			
Minor Items - Section 6	$2,018,000			
Subtotal Sections 1-6	$15,465,000	x 10% Mobilization (includes 10% of Mob Cost)	$1,718,334	
			Total Roadway Mobilization	**$1,719,000**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$13,447,000			
Minor Items - Section 6	$2,018,000			
Subtotal Sections 1-6	$15,465,000	x 10%	$1,546,500	
Contingencies				
Subtotal Sections 1-5	$13,447,000			
Minor Items - Section 6	$2,018,000			
Subtotal Sections 1-6	$15,465,000	x 35%	$5,412,750	
			Total Roadway Additions	**$6,960,000**

Subtotal for Sections 6, 7 & 8	**$10,697,000**
Subtotal for Sections 1-5	**$13,447,000**
TOTAL ROADWAY ITEMS SECTIONS 1-8	**$25,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

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II. Structure Items

Section 9 - Structure Items	Quantity	Unit	Unit Cost	Cost	Section Cost
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items			Cost	Section Cost	
Subtotal Section 9	$0	x 10.00%	$0		
				Total Minor Items	**$0**

Section 11 - Mobilization

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Subtotal Sections 9 & 10	$0	x	10% Mobilization (includes 10% of Mob Cost)	$0	
				Total Structure Mobilization	**$0**
				Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 10.00%	$0		

Contingencies

Subtotal Section 9	$0				
Minor Items - Section 10	$0				
Sum	$0	x 35.00%	$0		
				Total Structure Additions	**$0**
				Subtotal for Sections 10, 11 & 12	**$0**
				Subtotal for Sections 1-5	**$13,447,000**
				TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

III. Freeway Tunnel & Ventilation Items

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Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

IV. LRT Items

Section 17 - LRT Items	Quantity	Unit	Unit Cost	Cost	Section Cost
10.01 Guideway: At-grade exclusive right-of-way	1850	Route FT	$480	$888,000	
10.03 Guideway: At-grade in mixed traffic	0	Route FT	$560	$0	
10.041 Guideway: Aerial Typical Span	21288	Route FT	$8,000	$170,304,000	
10.042 Guideway: Aerial Long Span LRT Bridge	0	Route FT	$10,000	$0	
10.081 Guideway: Double MSE Walls	800	Route FT	$2,600	$2,080,000	
10.082 Guideway: Retaining Walls	0	Route FT	$700	$0	
10.09 Track: Direct fixation	22088	Route FT	$720	$15,903,360	
10.10 Track: Embedded	1850	Route FT	$920	$1,702,000	
10.11 Track: Ballasted	0	Route FT	$460	$0	
10.112 Track: Switches No. 8 Diamond Double Crossover Fixed	5	EA	$980,000	$4,900,000	
10.122 Track: Switches No. 8 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	1	EA	$3,800,000	$3,800,000	
20.021 LRT Station Elevated Center Platform	2	EA	$15,000,000	$30,000,000	
20.0061 Automobile Parking Lot Structure Stall	0	EA	$23,000	$0	
20.07 Elevators/Escalators	42	EA	$250,000	$10,500,000	
30.03 Support Facility Heavy Maintenance	1	LS	$75,000,000	$75,000,000	
40.01 Demolition, Clearing Within Street	0	Route FT	$430	$0	
40.021 Site Utilities: Aerial/Tunnel Guideway	21288	Route FT	$210	$4,470,480	
40.022 Site Utilities: At-Grade Guideway within Street	1850	Route FT	$580	$1,073,000	
40.023 Site Utilities: Relocated 48" Water Line	0	Route FT	$270	$0	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route FT	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route FT	$70	$0	
40.051 Site structures: Retaining walls	0	Route FT	$180	$0	
40.052 Site structures: Sound Walls	0	Route FT	$380	$0	
40.061 Landscaping & Bike Path	0	Route FT	$340	$0	
40.062 Landscaping Street Scape, Urban Design Features	0	Route FT	$400	$0	
50.011 Train Controls: Signal Substation & Cables	23938	Route FT	$450	$10,772,100	
50.012 Train Controls: Ductbank & Pullboxes	23938	Route FT	$130	$3,111,940	
50.021 Traffic Signals: Major Intersection	4	EA	$300,000	$1,200,000	
50.022 Traffic Signals: Minor Intersection	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	23938	Route FT	$430	$10,293,340	
50.032 Traction Power: Building Installation	23938	Route FT	$52	$1,244,776	
50.041 Traction power distribution: Catenary OCS Pole	23938	Route FT	$220	$5,266,360	
50.042 Traction power distribution: Ductbank Pullboxes	23938	Route FT	$130	$3,111,940	
50.043 Traction power distribution: OCS Poles Foundations	23938	Route FT	$62	$1,484,156	
5.051 Communications: Communications Equipment Installation	23938	Route FT	$440	$10,532,720	
5.052 Communications: Ductbank & Pullboxes	23938	Route FT	$130	$3,111,940	
5.071 Fare Collection: Ticket Vending Machines	14	EA	$860,000	$12,040,000	
5.072 Central Control	1	EA	$2,400,000	$2,400,000	
70.01 LRT Vehicles	33	EA	$3,500,000	$115,500,000	
				Total LRT Section	**$500,690,112**

Section 18 - LRT Minor Items			Cost		Section Cost
Subtotal Section 17	$500,690,112	x 10.00%	$50,069,012		
				Total Minor Items	**$50,069,012**
				Total for Sections 17 & 18	**$550,759,124**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$500,690,112			
Minor Items - Section 18	$50,069,012			
Subtotal Sections 17 & 18	$550,759,124	x	10% Mobilization (includes 10% of Mob Cost)	$61,195,459

Total LRT Mobilization **$61,196,000**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$500,690,112			
Minor Items - Section 18	$50,069,012			
Sum	$550,759,124	x	10%	$55,075,913

Contingencies

Subtotal Section 17	$500,690,112			
Minor Items - Section 18	$50,069,012			
Sum	$550,759,124	x	35%	$192,765,694

Total LRT Additions **$247,841,607**

Sub Total for Sections 19 & 20 **$309,037,607**

Sub Total for Sections 17 & 18 **$550,759,124**

TOTAL LRT ITEMS SECTIONS 17-20 **$860,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

V. LRT Tunnel & Ventilation Items

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Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	1	LS	$13,484,891	$13,484,891	
Electrical	1	LS	$122,251,127	$122,251,127	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	3.67	MI	$126,000	$462,420	
Control Building	0	LS	$10,000,000	$0	
				Subtotal Tunnel Systems	**$136,198,438**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
Cut & Cover Station 1	1	EA	$110,000,000	$110,000,000	
Cut & Cover Station 2	1	EA	$110,000,000	$110,000,000	
Cut & Cover Station 3	1	EA	$110,000,000	$110,000,000	
Cut & Cover Station 4	1	EA	$110,000,000	$110,000,000	
Cut & Cover Tunnel	21,088	LF	$12,820	$270,348,160	
Instrumentation & Building Protection	0	LS	$0	$0	
Tunnel Cross Passages - Excavation, Support, Lining	0	EA	$0	$0	
Special Seismic Section	0	EA	$0	$0	
				Subtotal Tunnel	**$710,348,160**
				Section Total	**$846,546,598**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$136,198,438	x 5%	$6,809,922		
				Total Minor Items	**$6,809,922**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$136,198,438				
Minor Items - Section 22	$6,809,922				
Subtotal	$143,008,360	x 10%	$15,889,818		
				Total LRT Tunnel Mobilization	**$15,889,818**
				Total Sections 21-23	**$869,246,338**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$136,198,438				
Minor Items - Section 22	$6,809,922				
Sum	$143,008,360	x 5%	$7,151,000		
Contingencies					
Subtotal Section 21-23	$869,246,338				
Minor Items - Section 22	$6,809,922				
Sum	$876,056,260	x 35%	$306,620,000		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total LRT Tunnel Additions	**$313,771,000**
				Subtotal for Sections 22, 23 & 24	**$336,470,740**
				Subtotal for Section 21	**$846,546,598**
				TOTAL LRT TUNNEL ITEMS SECTIONS 21-24	**$1,184,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-4D

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$40,689,450	$40,689,450
R/W Acquisition (Commercial)	1	LS	$138,749,790	$138,749,790
Permanent R/W Easement (Tunnel)	0	LS		$0
Permanent Aerial Easement from UPRR	1	LS	$5,747,087	$5,747,087
Relocation Assistance	1	LS	$30,454,000	$30,454,000
Clearance/Demolition (Residential)	206,160	SF	$5	$1,030,800
Clearance/Demolition (Commercial)	1,294,646	SF	$7	$9,062,529
Title, Escrow, and Appraisal Fees (per parcel)	103	EA	$20,000	$2,060,000
			Total for Section 25	**$227,793,656**

Section 26 - Additions

Contingencies

Subtotal Section 25	$227,793,656				
Sum	$227,793,656	x	25%	$56,948,414	
				Total for Section 26	**$56,948,414**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$285,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE LRT-6

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$4,000,000
STRUCTURE ITEMS		$0
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$1,097,000,000
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$1,101,000,000
	SAY	$1,125,000,000
RIGHT OF WAY		$681,000,000
	SAY	$700,000,000
	TOTAL COST	$1,825,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

I. Roadway Items

Section 1 - Earthwork	**Quantity**		**Unit**		**Unit Cost**	**Cost**	**Section Cost**
Construction Site Management/SWPPP	1		LS		$2,000,000	$2,000,000	
Clearing and Grubbing	0.0		Acre		$20,000	$0	
Roadway Excavation	0		CY		$15	$0	
			%		**Unit Cost**	**Cost**	
Imported Borrow Due to Unsuitable On-Site Soil	0	x	40%	x	$20	$0	
Hazardous Waste Material/ADL	0	x	10%	x	$50	$0	
						Total Earthwork	**$2,000,000**

Section 2 - Structural Section	**Quantity**		**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Mainline Pvmt & Shldrs	0		SF	$20.00	$0	
Mainline AC Overlay	0		SF	$1.00	$0	
Curb and Gutter	0		LF	$20.00	$0	
Sidewalks	0		SF	$5.00	$0	
Mainline Re-Striping	0		LF	$0.50	$0	
			%		**Cost**	
Misc Pvmt Items & Removals (5% of Pvmt)	$0	x	5.00%		$0	
					Total Structural Section	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

I. Roadway Items (CONT.)

Section 3 - Drainage	**Rdwy Pvmt**		**%**		**Cost**	**Section Cost**
Onsite Drainage (20% of Pvmt)	0	x	20%		$0	
Utilities (15% of Pvmt)	0	x	15%		$0	
	Quantity		**Unit**	**Unit Cost**	**Cost**	
Offsite/Regional Drainage						
No conflict with Existing Drainage System	0		LS	NA	$0	
BMP						
1. BMPs (concrete-vault Austin Filters)	0		CF	$82	$0	
					Total Drainage Items	**$0**

Notes

1. Onsite Drainge Items include: Abn culvert, Removals (FES, Pipe, Inlet, Headwall, Concrete), Pipe or RCB culverts, new inlet, cap inlet, sand backfill, HMA, Minor conc, FES, CSP riser, RSP and fabrics, Misc items
2. Proposed light rail is entirely over existing roadway. Therefore there is no new impervious area and no treatment is required.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

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I. Roadway Items (CONT.)

Section 4 - Specialty Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0	Acre	$97,500	$0	
Modify Irrigation System*	0	Acre	$63,000	$0	
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	
Retaining Wall (H=20-30 FT)	0	LF	$3,850	$0	
Retaining Wall (H=30-40 FT)	0	LF	$5,000	$0	
Retaining Wall (H=40+ FT)	0	LF	$6,000	$0	
Soundwalls	0	LF	$400	$0	
Temporary Shoring	0	SF	$10	$0	
Wall Aesthetic Treatment	0	SF	$6	$0	
Concrete Barrier (Type 60D)	0	LF	$70	$0	
				Total Specialty Items	**$0**

Section 5 - Traffic Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
Fiber Optic & Twisted Pair Cable system	0.0	MI	$650,000	$0	
Signalized Intersections	0.0	EA	$270,000	$0	
	Rdwy Pvmt Cost	**%**		**Cost**	
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	$0 x	20%		$0	
Remove & Delineate Traffic Striping & Markings (7% of Rdwy Pvmt)	$0 x	7%		$0	
Micellaneous (20% Rdwy Pvmt) - Lighting, Call Box, CCTV, Elec Service for Irrigation, Overhead sign	$0 x	20%		$0	
Construction Staging (40% Rdwy Pvmt)	$0 x	40%		$0	
				Total Traffic Items	**$0**
				SUBTOTAL ROADWAY ITEMS SECTIONS 1-5	**$2,000,000**

*Unit Cost established by Caltrans during the Project Report phase to meet their expectations for landscaping scope of work.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

I. Roadway Items (CONT.)

Section 6 - Minor Items			**Cost**	**Section Cost**
Subtotal Sections 1-5	$2,000,000	x 15%	$300,000	
			Total Minor Items	**$300,000**

Section 7 - Mobilization			**Cost**	**Section Cost**
Subtotal Sections 1-5	$2,000,000			
Minor Items - Section 6	$300,000			
Subtotal Sections 1-6	$2,300,000	x 10% Mobilization (includes 10% of Mob Cost)	$255,556	
			Total Roadway Mobilization	**$256,000**

Section 8 - Additions			**Cost**	**Section Cost**
Supplemental				
Subtotal Sections 1-5	$2,000,000			
Minor Items - Section 6	$300,000			
Subtotal Sections 1-6	$2,300,000	x 10%	$230,000	
Contingencies				
Subtotal Sections 1-5	$2,000,000			
Minor Items - Section 6	$300,000			
Subtotal Sections 1-6	$2,300,000	x 35%	$805,000	
			Total Roadway Additions	**$1,035,000**
			Subtotal for Sections 6, 7 & 8	**$1,591,000**
			Subtotal for Sections 1-5	**$2,000,000**
			TOTAL ROADWAY ITEMS SECTIONS 1-8	**$4,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

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II. Structure Items

Section 9 - Structure Items

	Quantity	Unit	Unit Cost	Cost	Section Cost
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	SF	$300	$0	
	0	LF	$300	$0	
	0	LF	$300	$0	
				Total Structure Items	**$0**

Section 10 - Minor Items

			Cost	Section Cost
Subtotal Section 9	$0	x 10%	$0	
			Total Minor Items	**$0**

Section 11 - Mobilization

Subtotal Section 9	$0			
Minor Items - Section 10	$0			
Subtotal Sections 9 & 10	$0	x 10% Mobilization (includes 10% of Mob Cost)	$0	
			Total Structure Mobilization	**$0**
			Total Sections 9-11	**$0**

Section 12 - Additions

Supplemental

Subtotal Section 9	$0			
Minor Items - Section 10	$0			
Sum	$0	x 10%	$0	

Contingencies

Subtotal Section 9	$0			
Minor Items - Section 10	$0			
Sum	$0	x 35%	$0	
			Total Structure Additions	**$0**

Subtotal for Sections 10, 11 & 12	**$0**
Subtotal for Sections 1-5	**$2,000,000**
TOTAL STRUCTURE ITEMS SECTIONS 9-12	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

III. Freeway Tunnel & Ventilation Items

Section 13 - Freeway Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$50,883,000	$0	
Electrical	0	LS	$163,536,000	$0	
System and Instrumentation	0	LS	$28,454,000	$0	
Tunnel Drainage System	0.00	MI	$504,000	$0	
Control Building	0.00	LS	$15,000,000	$0	
				Subtotal Tunnel Systems	**$0**
Freeway Tunnel Items					
South Portal Development	0	LS	$139,311,000	$0	
North Portal Development	0	LS	$120,789,449	$0	
Northbound Tunnel Excavation	0	LF	$34,100	$0	
Southbound Tunnel Excavation	0	LF	$34,100	$0	
Pedestrian Cross Passages - Excav, Supp, Conc.	0	EA	$2,941,960	$0	
Instrumentation & Building Protection	0	LS	$8,596,000	$0	
Vehicle Cross Passages - Excav, Supp, Conc.	0	EA	$6,200,000	$0	
Vent Tube Cross Passages - Excav, Supp, Conc.	0	EA	$3,110,000	$0	
Special Seismic Section/Vault	0	EA	$29,609,147	$0	
Roadway Deck/Slab	0	EA	$2,770	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 14 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 15 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Subtotal	$0	x 10%	$0		
				Total Freeway Tunnel Mobilization	**$0**
				Total Sections 13-15	**$0**

Section 16 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 14	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 13-15	$0				
Minor Items - Section 14	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total Freeway Tunnel Additions	**$0**
				Subtotal for Sections 14, 15 & 16	**$0**
				Subtotal for Section 13	**$0**
				TOTAL FREEWAY TUNNEL ITEMS SECTIONS 13-16	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

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IV. LRT Items

Section 17 - LRT Items	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Section Cost**
10.01 Guideway: At-grade exclusive right-of-way	0	Route Foot (RF)	$480	$0	
10.03 Guideway: At-grade in mixed traffic	33800	Route Foot (RF)	$560	$18,928,000	
10.041 Guideway: Aerial Typical Span	7780	Route Foot (RF)	$8,000	$62,240,000	
10.042 Guideway: Aerial Long Span LRT Bridge	370	Route Foot (RF)	$10,000	$3,700,000	
Guideway: Tunnel Cut and Cover	0	Route Foot (RF)	$17,800	$0	
Guideway: Tunnel TBM	0	Route Foot (RF)	$20,000	$0	
10.081 Guideway: Double MSE Walls	2400	Route Foot (RF)	$2,600	$6,240,000	
10.082 Guideway: Retaining Walls	0	Route Foot (RF)	$700	$0	
10.09 Track: Direct fixation	10550	Route Foot (RF)	$720	$7,596,000	
10.10 Track: Embedded	33800	Route Foot (RF)	$920	$31,096,000	
10.11 Track: Ballasted	0	Route Foot (RF)	$460	$0	
Track: Switches No. 10 Diamond Double Crossover Fixed	2	EA	$980,000	$1,960,000	
Track: Switches No. 10 Diamond Single Crossover Fixed	0	EA	$580,000	$0	
20.011 At-grade station, Center Platform	6	EA	$3,800,000	$22,800,000	
At-grade station, Split Platform	0	EA	$5,200,000	$0	
20.021 LRT Station Elevated Center Platform	3	EA	$7,200,000	$21,600,000	
20.0061 Automobile Parking Lot Structure Stall	114	EA	$23,000	$2,622,000	
Automobile Surface Parking Lot Stall	1051	EA	$6,000	$6,306,000	
20.07 Elevators/Escalators	18	EA	$250,000	$4,500,000	
30.03 Support Facility Heavy Maintenance	1	LS	$75,000,000	$75,000,000	
40.01 Demolition, Clearing Within Street	44079	Route Foot (RF)	$430	$18,953,970	
40.021 Site Utilities: Aerial Guideway	7780	Route Foot (RF)	$210	$1,633,800	
40.022 Site Utilities: At-Grade Guideway within Street	33800	Route Foot (RF)	$580	$19,604,000	
40.023 Site Utilities: Relocated 81" storm Drain	2600	Route Foot (RF)	$270	$702,000	
40.031 Haz. Material: Remove Contaminated Soil In ROW	0	Route Foot (RF)	$160	$0	
40.04 Environmental Mitigation Within ROW	0	Route Foot (RF)	$70	$0	
40.051 Site structures: Retaining walls	0	Route Foot (RF)	$180	$0	
40.052 Site structures: Sound Walls	0	Route Foot (RF)	$380	$0	
40.061 Landscaping & Bike Path	4500	Route Foot (RF)	$340	$1,530,000	
40.062 Landscaping Street Scape, Urban Design Features	44079	Route Foot (RF)	$400	$17,631,600	
50.011 Train Controls: Signal Substation & Cables	44079	Route Foot (RF)	$450	$19,835,550	
50.012 Train Controls: Ductbank & Pullboxes	44079	Route Foot (RF)	$130	$5,730,270	
50.021 Traffic Signals: Major Intersection	0	EA	$300,000	$0	
Traffic Signals: Major Intersection Modification	13	EA	$200,000	$2,600,000	
50.022 Traffic Signals: Minor Intersection	36	EA	$150,000	$5,400,000	
Traffic Signals: Minor Intersection Modification	0	EA	$150,000	$0	
50.023 Traffic Signals: Aerial Intersection	0	EA	$60,000	$0	
50.023 Traffic Signals: Grade Crossings	0	EA	$250,000	$0	
50.031 Traction Power: Hardware Procurement	44079	Route Foot (RF)	$430	$18,953,970	
50.032 Traction Power: Building Installation	44079	Route Foot (RF)	$52	$2,292,108	
50.041 Traction power distribution: Catenary OCS Pole	44079	Route Foot (RF)	$220	$9,697,380	
50.042 Traction power distribution: Ductbank Pullboxes	44079	Route Foot (RF)	$130	$5,730,270	
50.043 Traction power distribution: OCS Poles Foundations	44079	Route Foot (RF)	$62	$2,732,898	
5.051 Communications: Communications Equipment Installation	44079	Route Foot (RF)	$440	$19,394,760	
5.052 Communications: Ductbank & Pullboxes	44079	Route Foot (RF)	$130	$5,730,270	
5.071 Fare Collection: Ticket Vending Machines, Total Corridor Length Times Cost Multiplier	16	EA	$860,000	$13,760,000	
5.072 Central Control	1	EA	$2,400,000	$2,400,000	
70.01 LRT Vehicles	57	EA	$3,500,000	$199,500,000	
				Total LRT Section	**$638,401,000**

Section 18 - LRT Minor Items			**Cost**		**Section Cost**
Subtotal Section 17	$638,401,000	x 10.00%	$63,840,100		
				Total Minor Items	**$63,841,000**
				Total for Sections 17 & 18	**$702,242,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

IV. LRT Items (CONT.)

Section 19 - LRT Mobilization

Subtotal Section 17	$638,401,000			
Minor Items - Section 18	$63,841,000			
Subtotal Sections 17 & 18	$702,242,000	x	10% Mobilization (includes 10% of Mob Cost)	$78,026,889

Total LRT Mobilization **$78,027,000**

Section 20 - LRT Additions

Supplemental

Subtotal Section 17	$638,401,000			
Minor Items - Section 18	$63,841,000			
Sum	$702,242,000	x	10%	$70,224,200

Contingencies

Subtotal Section 17	$638,401,000			
Minor Items - Section 18	$63,841,000			
Sum	$702,242,000	x	35%	$245,784,700

Total LRT Additions **$316,009,000**

Sub Total for Sections 19 & 20 **$394,036,000**

Sub Total for Sections 17 & 18 **$702,242,000**

TOTAL LRT ITEMS SECTIONS 17-20 **$1,097,000,000**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

V. LRT Tunnel & Ventilation Items

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Section 21 - LRT Tunnel & Ventilation Items	Quantity	Unit	Unit Cost	Cost	Section Cost
LRT Tunnel System Items					
Mechanical incl. Ventilation	0	LS	$11,082,315	$0	
Electrical	0	LS	$101,646,705	$0	
System and Instrumentation	0	LS	$0	$0	
Tunnel Drainage System	0.00	MI	$126,000	$0	
Control Building	0	LS	$10,000,000	$0	
			Subtotal LRT Tunnel Systems		**$0**
LRT Tunnel Items					
South Portal Development	0	LS	$0	$0	
Station 1 - Excavation, Support, Lining	0	LS	$0	$0	
Station 2/Crossover - Excavation, Support, Lining	0	LS	$0	$0	
Station 3 - Excavation, support, Lining	0	LS	$0	$0	
Station 4/Crossover - Excavation, Support, Lining	0	LS	$0	$0	
Northbound Tunnel Excavation	0	LF	$17,800	$0	
Southbound Tunnel Excavation	0	LF	$0	$0	
Instrumentation & Building Protection	0	LS	$0	$0	
Tunnel Cross Passages - Excavation, Support, Lining	0	EA	$0	$0	
Special Seismic Section	0	EA	$19,284	$0	
				Subtotal Tunnel	**$0**
				Section Total	**$0**

Section 22 - Minor Items			Cost		Section Cost
Subtotal Tunnel System Items	$0	x 5%	$0		
				Total Minor Items	**$0**

Section 23 - Mobilization					
Equipment Mobilization			$0		
General Mobilization / De-mobilization			$0		
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Subtotal	$0	x 10%	$0		
				Total LRT Tunnel Mobilization	**$0**
				Total Sections 21-23	**$0**

Section 24 - Additions					
Supplemental					
Tunnel System Subtotal	$0				
Minor Items - Section 22	$0				
Sum	$0	x 5%	$0		
Contingencies					
Subtotal Section 21-23	$0				
Minor Items - Section 22	$0				
Sum	$0	x 35%	$0		
Contingency for Special Seismic Section	$0	x 65%	$0		
				Total LRT Tunnel Additions	**$0**
				Subtotal for Sections 22, 23 & 24	**$0**
				Subtotal for Section 21	**$0**
				TOTAL LRT TUNNEL ITEMS SECTIONS 21-24	**$0**

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE LRT-6

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VI. Right of Way Items

Section 25 - Right of Way

	Quantity	Unit	Unit Cost	Cost
R/W Acquisition (Residential)	1	LS	$99,372,050	$99,372,050
R/W Acquisition (Commercial)	1	LS	$328,602,312	$328,602,312
Permanent R/W Easement (Tunnel)	1	LS	$10,019,633	$10,019,633
Permanent Aerial Easement	1	LS	$354,770	$354,770
Relocation Assistance	1	LS	$80,045,000	$80,045,000
Clearance/Demolition (Residential)	375,893	SF	$5	$1,879,465
Clearance/Demolition (Commercial)	2,805,498	SF	$7	$19,638,489
Title, Escrow, and Appraisal Fees (per parcel)	214	EA	$20,000	$4,280,000
			Total for Section 25	**$544,191,719**

Section 26 - Additions

Contingencies

Subtotal Section 25	$544,191,719			
Sum	$544,191,719	x	25%	$136,047,930
			Total for Section 26	**$136,047,930**

TOTAL RIGHT OF WAY ITEMS SECTION 25 & 26 **$681,000,000**

Assumptions:

Any property impacted in any way by the proposed alignment will require a full fee acquisition and is subject to all resulting relocation costs including damages, RAP and business goodwill where applicable as well as all applicable fees.

CONCEPTUAL COST ESTIMATE SUMMARY FOR ALTERNATIVE TSM/TDM

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PROJECT DESCRIPTION

STATE ROUTE 710 STUDY

ALTERNATIVE TSM/TDM

Proposed Improvement:

		Cost in 2012 $
ROADWAY ITEMS		$26,000,000
STRUCTURE ITEMS		$1,000,000
FREEWAY TUNNEL & VENTILATION ITEMS		$0
LRT ITEMS		$0
LRT TUNNEL & VENTILATION ITEMS		$0
SUBTOTAL CONSTRUCTION		$27,000,000
	SAY	$30,000,000
RIGHT OF WAY		$89,840,884
	SAY	$90,000,000
	TOTAL COST	$120,000,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR TSM/TDM ALTERNATIVES

ALTERNATIVE	I-1 W Broadway & Colorado Blvd Intersection Improvement				I-2 Eagle Rock Blvd & York Blvd Intersection				I-3 Eastern Ave and Huntington Dr Intersection Improvement			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				$794,000				$411,000				$178,000
Section 1 - Earthwork				$60,480				$67,095				$50,000
Construction Site Management/SWPPP	1	LS	$60,480	$60,480	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000
Clearing and Grubbing	0.00	Acre	$20,000	$0	0.12	Acre	$20,000	$2,400	0.00	Acre	$20,000	$0
Roadway Excavation	0	CY	$15	$0	667	CY	$15	$10,005	0	CY	$15	$0
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	$0	67	CY	$20	$1,340	0	CY	$20	$0
Hazardous Waste Material/ADL	0	CY	$50	$0	67	CY	$50	$3,350	0	CY	$50	$0
Section 2 - Structural Section				$176,400				$114,780				$22,680
Mainline Pvmt & Shldrs	14,000	SF	$12	$168,000	2,000	SF	$12	$24,000	1,800	SF	$12	$21,600
Mainline AC Overlay	0	SF	$1	$0	0	SF	$1	$0	0	SF	$1	$0
Curb and Gutter	0	LF	$20	$0	3,000	LF	$20	$60,000	0	LF	$20	$0
Sidewalks	0	SF	$6	$0	4,930	SF	$6	$29,580	0	SF	$6	$0
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$8,400	$8,400	1	LS	$1,200	$1,200	1	LS	$1,080	$1,080
Section 3 - Drainage & Utilities				$58,800				$8,400				$7,560
Onsite Drainage (20% of Pvmt)	1	LS	$33,600	$33,600	1	LS	$4,800	$4,800	1	LS	$4,320	$4,320
BMP	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Utilities (15% of Pvmt)	1	LS	$25,200	$25,200	1	LS	$3,600	$3,600	1	LS	$3,240	$3,240
Section 4 - Specialty Items				$0				$17,420				$0
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.12	Acre	$20,000	$2,300	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.24	Acre	$63,000	$15,120	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				$146,160				$20,880				$18,792
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$33,600	$33,600	1	LS	$4,800	$4,800	1	LS	$4,320	$4,320
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$11,760	$11,760	1	LS	$1,680	$1,680	1	LS	$1,512	$1,512
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$33,600	$33,600	1	LS	$4,800	$4,800	1	LS	$4,320	$4,320
Construction Staging (40% Rdwy Pvmt)	1	LS	$67,200	$67,200	1	LS	$9,600	$9,600	1	LS	$8,640	$8,640
Traffic Signals	0	EA	$100,000	$0	0	EA	$100,000	$0	0	EA	$100,000	$0
Section 6 - Minor Items				$66,300				$34,300				$14,900
Minor Items (15% of Rdwy Items)	1	LS	$66,300	$66,300	1	LS	$34,300	$34,300	1	LS	$14,900	$14,900
Section 7 - Mobilization				$56,500				$29,300				$12,700
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$56,500	$56,500	1	LS	$29,300	$29,300	1	LS	$12,700	$12,700
Section 8 - Additions				$228,800				$118,400				$51,300
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$50,900	$50,900	1	LS	$26,300	$26,300	1	LS	$11,400	$11,400
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$177,900	$177,900	1	LS	$92,100	$92,100	1	LS	$39,900	$39,900
STRUCTURE ITEMS				$0				$0				$0
Section 9 - Structure Items				$0				$0				$0
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				$0				$0				$0
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 11 - Mobilization				$0				$0				$0
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 12 - Additions				$0				$0				$0
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION				$794,000				$411,000				$178,000
RIGHT OF WAY				$0				$0				$0
Section 25 - Right of Way				$0				$0				$0
R/W Acquisition (Residential)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
R/W Acquisition (Commercial)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Permanent R/W Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Clearance/Demolition	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Title, Escrow, and Appraisal Fees (	0	EA	$0	$0	0	EA	$0	$0	0	EA	$0	$0
Section 26 - Additions				$0				$0				$0
ROW Contingency (25% of ROW C	1	LS	$0	$0	1	LS	$0	$0	1	LS	$0	$0
TOTAL				$794,000				$411,000				$178,000

ALTERNATIVE	I-4 SR-710 and Valley Blvd Intersection Improvement				I-5 SR-710 and Valley Blvd Intersection Improvement				I-6 Fremont and Columbia Ave Intersection Improvement			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				$516,000				$525,000				$2,205,000
Section 1 - Earthwork				$60,260				$67,550				$437,127
Construction Site Management/SWPPP	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000	1	LS	$127,949	$127,949
Clearing and Grubbing	0.08	Acre	$20,000	$1,610	0.17	Acre	$20,000	$3,440	0.61	Acre	$20,000	$12,266
Roadway Excavation	390	CY	$15	$5,850	833	CY	$15	$12,500	13,496	CY	$15	$202,440
Imported Borrow Due to Unsuitable On-Site Soil	40	CY	$20	$800	23	CY	$20	$460	1,350	CY	$20	$26,992
Hazardous Waste Material/ADL	40	CY	$50	$2,000	23	CY	$50	$1,150	1,350	CY	$50	$67,480
Section 2 - Structural Section				$116,700				$114,740				$399,309
Mainline Pvmt & Shldrs	7,500	SF	$12	$90,000	7,500	SF	$12	$90,000	26,715	SF	$12	$320,580
Mainline AC Overlay	0	SF	$1	$0	0	SF	$1	$0	0	SF	$1	$0
Curb and Gutter	500	LF	$20	$10,000	460	LF	$20	$9,200	1,425	LF	$20	$28,500
Sidewalks	2,000	SF	$6	$12,000	1,840	SF	$6	$11,040	5,700	SF	$6	$34,200
Mainline Re-Striping	200	LF	$1	$200	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$4,500	$4,500	1	LS	$4,500	$4,500	1	LS	$16,029	$16,029
Section 3 - Drainage & Utilities				$31,500				$31,500				$112,203
Onsite Drainage (20% of Pvmt)	1	LS	$18,000	$18,000	1	LS	$18,000	$18,000	1	LS	$64,116	$64,116
BMP	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Utilities (15% of Pvmt)	1	LS	$13,500	$13,500	1	LS	$13,500	$13,500	1	LS	$48,087	$48,087
Section 4 - Specialty Items				$0				$0				$0
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				$78,300				$78,300				$278,905
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$18,000	$18,000	1	LS	$18,000	$18,000	1	LS	$64,116	$64,116
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$6,300	$6,300	1	LS	$6,300	$6,300	1	LS	$22,441	$22,441
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$18,000	$18,000	1	LS	$18,000	$18,000	1	LS	$64,116	$64,116
Construction Staging (40% Rdwy Pvmt)	1	LS	$36,000	$36,000	1	LS	$36,000	$36,000	1	LS	$128,232	$128,232
Traffic Signals	0	EA	$100,000	$0	0	EA	$100,000	$0	0	EA	$100,000	$0
Section 6 - Minor Items				$43,100				$43,900				$184,200
Minor Items (15% of Rdwy Items)	1	LS	$43,100	$43,100	1	LS	$43,900	$43,900	1	LS	$184,200	$184,200
Section 7 - Mobilization				$36,700				$37,400				$156,900
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$36,700	$36,700	1	LS	$37,400	$37,400	1	LS	$156,900	$156,900
Section 8 - Additions				$148,500				$151,200				$635,400
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$33,000	$33,000	1	LS	$33,600	$33,600	1	LS	$141,200	$141,200
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$115,500	$115,500	1	LS	$117,600	$117,600	1	LS	$494,200	$494,200
STRUCTURE ITEMS				$0				$0				$0
Section 9 - Structure Items				$0				$0				$0
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				$0				$0				$0
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$0	$0
Section 11 - Mobilization				$0				$0				$0
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$0	$0
Section 12 - Additions				$0				$0				$0
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$0	$0
SUBTOTAL CONSTRUCTION				$516,000				$525,000				$2,205,000
RIGHT OF WAY				$2,556,577				$1,464,550				$11,830,730
Section 25 - Right of Way				$2,045,261				$1,171,640				$9,464,584
R/W Acquisition (Residential)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$8,606,494	$8,606,494
R/W Acquisition (Commercial)	1	LS	$1,731,350	$1,731,350	1	LS	$485,000	$485,000	0	LS	$0	$0
Permanent R/W Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	1	LS	$100,000	$100,000	1	LS	$600,000	$600,000	1	LS	$360,000	$360,000
Clearance/Demolition	1	LS	$193,911	$193,911	1	LS	$66,640	$66,640	1	LS	$258,090	$258,090
Title, Escrow, and Appraisal Fees (	1	EA	$20,000	$20,000	1	EA	$20,000	$20,000	12	EA	$20,000	$240,000
Section 26 - Additions				$511,315				$292,910				$2,366,146
ROW Contingency (25% of ROW C	1	LS	$511,315	$511,315	1	LS	$292,910	$292,910	1	LS	$2,366,146	$2,366,146
TOTAL				$3,073,000				$1,990,000				$14,036,000

ALTERNATIVE	I-7 Fair Oaks Ave and Mission St Intersection Improvement				I-8 Fair Oaks Ave and Monterey Dr Intersection Improvement				I-9 Fremont Ave and Monterey Dr Intersection Improvement			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				$180,000				$286,000				$198,000
Section 1 - Earthwork				$50,000				$58,049				$55,222
Construction Site Management/SWPPP	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000
Clearing and Grubbing	0.00	Acre	$20,000	$0	0.06	Acre	$20,000	$1,284	0.00	Acre	$20,000	$0
Roadway Excavation	0	CY	$15	$0	311	CY	$15	$4,665	261	CY	$15	$3,917
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	$0	30	CY	$20	$600	0	CY	$20	$0
Hazardous Waste Material/ADL	0	CY	$50	$0	30	CY	$50	$1,500	26	CY	$50	$1,306
Section 2 - Structural Section				$0				$46,600				$25,200
Mainline Pvmt & Shldrs	0	SF	$12	$0	3,000	SF	$12	$36,000	2,000	SF	$12	$24,000
Mainline AC Overlay	0	SF	$1	$0	0	SF	$1	$0	0	SF	$1	$0
Curb and Gutter	0	LF	$20	$0	200	LF	$20	$4,000	0	LF	$20	$0
Sidewalks	0	SF	$6	$0	800	SF	$6	$4,800	0	SF	$6	$0
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	0	LS	$0	$0	1	LS	$1,800	$1,800	1	LS	$1,200	$1,200
Section 3 - Drainage & Utilities				$0				$12,600				$8,400
Onsite Drainage (20% of Pvmt)	0	LS	$0	$0	1	LS	$7,200	$7,200	1	LS	$4,800	$4,800
BMP	0	LS	$0	$0	0	LS	$7,200	$0	0	LS	$0	$0
Utilities (15% of Pvmt)	0	LS	$0	$0	1	LS	$5,400	$5,400	1	LS	$3,600	$3,600
Section 4 - Specialty Items				$0				$10,304				$0
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.06	Acre	$97,500	$6,260	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.06	Acre	$63,000	$4,045	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				$50,000				$31,320				$20,880
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	0	LS	$0	$0	1	LS	$7,200	$7,200	1	LS	$4,800	$4,800
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	0	LS	$87,833	$0	1	LS	$2,520	$2,520	1	LS	$1,680	$1,680
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$0	$0	1	LS	$7,200	$7,200	1	LS	$4,800	$4,800
Construction Staging (40% Rdwy Pvmt)	1	LS	$0	$0	1	LS	$14,400	$14,400	1	LS	$9,600	$9,600
Traffic Signals	1	EA	$50,000	$50,000	0	EA	$100,000	$0	0	EA	$100,000	$0
Section 6 - Minor Items				$15,000				$23,900				$16,500
Minor Items (15% of Rdwy Items)	1	LS	$15,000	$15,000	1	LS	$23,900	$23,900	1	LS	$16,500	$16,500
Section 7 - Mobilization				$12,800				$20,400				$14,100
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$12,800	$12,800	1	LS	$20,400	$20,400	1	LS	$14,100	$14,100
Section 8 - Additions				$51,800				$82,300				$56,900
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$11,500	$11,500	1	LS	$18,300	$18,300	1	LS	$12,700	$12,700
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$40,300	$40,300	1	LS	$64,000	$64,000	1	LS	$44,200	$44,200
STRUCTURE ITEMS				$0				$0				$0
Section 9 - Structure Items				$0				$0				$0
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				$0				$0				$0
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 11 - Mobilization				$0				$0				$0
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 12 - Additions				$0				$0				$0
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION				$180,000				$286,000				$198,000
RIGHT OF WAY				$0				$13,024,821				$1,073,662
Section 25 - Right of Way				$0				$10,419,856				$858,929
R/W Acquisition (Residential)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
R/W Acquisition (Commercial)	0	LS	$0	$0	1	LS	$9,040,250	$9,040,250	1	LS	$696,750	$696,750
Permanent R/W Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	0	LS	$0	$0	1	LS	$720,000	$720,000	1	LS	$100,000	$100,000
Clearance/Demolition	0	LS	$0	$0	1	LS	$619,606	$619,606	1	LS	$42,179	$42,179
Title, Escrow, and Appraisal Fees (	0	EA	$0	$0	2	EA	$20,000	$40,000	1	EA	$20,000	$20,000
Section 26 - Additions				$0				$2,604,964				$214,732
ROW Contingency (25% of ROW C	1	LS	$0	$0	1	LS	$2,604,964	$2,604,964	1	LS	$214,732	$214,732
TOTAL				$180,000				$13,311,000				$1,272,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR TSM/TDM ALTERNATIVES

ALTERNATIVE	I-10 Fair Oaks Ave and Huntington Dr Intersection Improvement				I-11 Fremont Ave and Huntington Dr Intersection Improvement				I-12 Fremont Ave and Valley Blvd Intersection Improvement			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				$958,000				$1,090,000				$1,167,000
Section 1 - Earthwork				$68,855				$78,395				$83,194
Construction Site Management/SWPPP	1	LS	$66,855	$66,855	1	LS	$77,995	$77,995	1	LS	$79,154	$79,154
Clearing and Grubbing	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0
Roadway Excavation	100	CY	$15	$1,500	20	CY	$15	$300	202	CY	$15	$3,030
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	$0	0	CY	$20	$0	0	CY	$20	$0
Hazardous Waste Material/ADL	10	CY	$50	$500	2	CY	$50	$100	20	CY	$50	$1,010
Section 2 - Structural Section				$181,911				$223,652				$208,158
Mainline Pvmt & Shldrs	1,680	SF	$7	$11,760	430	SF	$7	$3,010	5,450	SF	$7	$38,150
Mainline AC Overlay	79,030	SF	$2	$158,060	92,710	SF	$2	$185,420	56,000	SF	$2	$112,000
Curb and Gutter	180	LF	$20	$3,600	270	LF	$20	$5,400	665	LF	$20	$13,300
Sidewalks	0	SF	$6	$0	3,400	SF	$6	$20,400	6,200	SF	$6	$37,200
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$8,491	$8,491	1	LS	$9,422	$9,422	1	LS	$7,508	$7,508
Section 3 - Drainage & Utilities				$84,437				$90,951				$127,553
Onsite Drainage (20% of Pvmt)	1	LS	$33,964	$33,964	1	LS	$37,686	$37,686	1	LS	$30,030	$30,030
BMP	1	LS	$25,000	$25,000	1	LS	$25,000	$25,000	1	LS	$75,000	$75,000
Utilites (15% of Pvmt)	1	LS	$25,473	$25,473	1	LS	$28,265	$28,265	1	LS	$22,523	$22,523
Section 4 - Specialty Items				$0				$0				$0
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				$197,743				$213,934				$230,631
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$33,964	$33,964	1	LS	$37,686	$37,686	1	LS	$30,030	$30,030
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$11,887	$11,887	1	LS	$13,190	$13,190	1	LS	$10,511	$10,511
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$33,964	$33,964	1	LS	$37,686	$37,686	1	LS	$30,030	$30,030
Construction Staging (40% Rdwy Pvmt)	1	LS	$67,928	$67,928	1	LS	$75,372	$75,372	1	LS	$60,060	$60,060
Traffic Signals	1	EA	$50,000	$50,000	1	EA	$50,000	$50,000	1	EA	$100,000	$100,000
Section 6 - Minor Items				$80,000				$91,100				$97,500
Minor Items (15% of Rdwy Items)	1	LS	$80,000	$80,000	1	LS	$91,100	$91,100	1	LS	$97,500	$97,500
Section 7 - Mobilization				$68,200				$77,600				$83,100
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$68,200	$68,200	1	LS	$77,600	$77,600	1	LS	$83,100	$83,100
Section 8 - Additions				$275,900				$314,300				$336,300
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$61,300	$61,300	1	LS	$69,900	$69,900	1	LS	$74,800	$74,800
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$214,600	$214,600	1	LS	$244,400	$244,400	1	LS	$261,500	$261,500
STRUCTURE ITEMS				$0				$0				$0
Section 9 - Structure Items				$0				$0				$0
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				$0				$0				$0
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 11 - Mobilization				$0				$0				$0
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 12 - Additions				$0				$0				$0
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION				$958,000				$1,090,000				$1,167,000
RIGHT OF WAY				$0				$0				$6,209,870
Section 25 - Right of Way				$0				$0				$4,967,896
R/W Acquisition (Residential)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$1,239,700	$1,239,700
R/W Acquisition (Commercial)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$2,096,050	$2,096,050
Permanent R/W Easement	0	LS	$0	$0	0	LS	$0	$0	1	LS	$31,329	$31,329
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	0	LS	$0	$0	0	LS	$0	$0	1	LS	$1,195,000	$1,195,000
Clearance/Demolition	0	LS	$0	$0	0	LS	$0	$0	1	LS	$285,817	$285,817
Title, Escrow, and Appraisal Fees (	0	EA	$0	$0	0	EA	$0	$0	6	EA	$20,000	$120,000
Section 26 - Additions				$0				$0				$1,241,974
ROW Contingency (25% of ROW C	1	LS	$0	$0	1	LS	$0	$0	1	LS	$1,241,974	$1,241,974
TOTAL				$958,000				$1,090,000				$7,377,000

ALTERNATIVE	I-13, I-14, I-15 Option A Huntington Dr and Garfield Ave Intersection			I-13, I-14, I-15 Option B Huntington Dr and Garfield Ave Intersection Improvement - Alt			I-13, I-14, I-15 Option C Huntington Dr and Garfield Ave Intersection Improvement - Alt C			
	QTY	Unit	Unit Cost	QTY	Unit	Unit Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS										$2,273,000
Section 1 - Earthwork										$167,770
Construction Site Management/SWPPP	1	LS	$76,533	1	LS	$198,010	1	LS	$131,770	$131,770
Clearing and Grubbing	0.00	Acre	$20,000	0.00	Acre	$20,000	0.00	Acre	$20,000	$0
Roadway Excavation	190	CY	$15	3,510	CY	$15	1,800	CY	$15	$27,000
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	0	CY	$20	0	CY	$20	$0
Hazardous Waste Material/ADL	19	CY	$50	351	CY	$50	180	CY	$50	$9,000
Section 2 - Structural Section										$394,278
Mainline Pvmt & Shldrs	5,160	SF	$7	9,200	SF	$7	12,500	SF	$7	$87,500
Mainline AC Overlay	64,822	SF	$2	175,000	SF	$2	82,630	SF	$2	$165,260
Curb and Gutter	755	LF	$20	2,935	LF	$20	2,370	LF	$20	$47,400
Sidewalks	7,365	SF	$6	18,405	SF	$6	13,580	SF	$6	$81,480
Mainline Re-Striping	0	LF	$1	0	LF	$1	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$8,288	1	LS	$20,720	1	LS	$12,638	$12,638
Section 3 - Drainage & Utilities										$163,466
Onsite Drainage (20% of Pvmt)	1	LS	$33,153	1	LS	$82,880	1	LS	$50,552	$50,552
BMP	1	LS	$25,000	1	LS	$75,000	1	LS	$75,000	$75,000
Utilites (15% of Pvmt)	1	LS	$24,865	1	LS	$62,160	1	LS	$37,914	$37,914
Section 4 - Specialty Items										$0
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	0.00	Acre	$97,500	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	0.00	Acre	$63,000	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	0	LF	$1,000	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	0	LF	$1,700	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	0	LF	$2,850	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	0	LS	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	0	SF	$10	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	0	SF	$6	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	0	LF	$70	0	LF	$70	$0
Section 5 - Traffic Items										$539,901
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$33,153	1	LS	$82,880	1	LS	$50,552	$50,552
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	0	MI	$650,000	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	0	EA	$20,000	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	0	EA	$25,000	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	0	EA	$2,500	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	0	EA	$35,000	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$11,603	1	LS	$29,008	1	LS	$17,693	$17,693
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$33,153	1	LS	$82,880	1	LS	$50,552	$50,552
Construction Staging (40% Rdwy Pvmt)	1	LS	$66,306	1	LS	$165,760	1	LS	$101,104	$101,104
Traffic Signals	1	EA	$220,000	1	EA	$210,000	1	EA	$320,000	$320,000
Section 6 - Minor Items										$189,900
Minor Items (15% of Rdwy Items)	1	LS	$114,200	1	LS	$249,500	1	LS	$189,900	$189,900
Section 7 - Mobilization										$161,800
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$97,300	1	LS	$212,600	1	LS	$161,800	$161,800
Section 8 - Additions										$655,000
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$87,600	1	LS	$191,300	1	LS	$145,600	$145,600
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$306,300	1	LS	$669,400	1	LS	$509,400	$509,400
STRUCTURE ITEMS										$0
Section 9 - Structure Items										$0
Structure - Bridge	0	SF	$200	0	SF	$200	0	SF	$200	$0
Section 10 - Minor Items										$0
Minor Items (10% of Structure Items)	0	LS	$0	0	LS	$0	0	LS	$0	$0
Section 11 - Mobilization										$0
Mobilization (10% of Strc & Minor Items)	0	LS	$0	0	LS	$0	0	LS	$0	$0
Section 12 - Additions										$0
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	0	LS	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	0	LS	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION										$2,273,000
RIGHT OF WAY										$1,686,885
Section 25 - Right of Way										$1,349,508
R/W Acquisition (Residential)	581	SF	$60	22,012	SF	$60	1	LS	$0	$0
R/W Acquisition (Commercial)	3,458	SF	$80	13,843	SF	$80	1	LS	$710,750	$710,750
Permanent R/W Easement							1	LS	$42,445	$42,445
Permanent Aerial Easement							0	LS	$0	$0
Relocation Assistance	1	LS	$31,150	1	LS	$242,816	1	LS	$450,000	$450,000
Clearance/Demolition	1	LS	$19,250	1	LS	$92,750	1	LS	$161,000	$86,313
Title, Escrow, and Appraisal Fees (	10	EA	$20,000	10	EA	$20,000	3	EA	$20,000	$60,000
Section 26 - Additions										$337,377
ROW Contingency (25% of ROW C	1	LS	$140,475	1	LS	$740,932	1	LS	$337,377	$337,377
TOTAL										$3,960,000

ALTERNATIVE	I-16 Garfield Ave and Mission Rd Intersection Improvement				I-17 Garfield Ave and Valley Blvd Intersection Improvement				I-18 San Gabriel Blvd and Huntington Dr Intersection Improvement			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				$1,076,000				$795,000				$232,000
Section 1 - Earthwork				$61,816				$53,000				$53,100
Construction Site Management/SWPPP	1	LS	$58,516	$58,516	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000
Clearing and Grubbing	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0
Roadway Excavation	165	CY	$15	$2,475	150	CY	$15	$2,250	155	CY	$15	$2,325
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	$0	0	CY	$20	$0	0	CY	$20	$0
Hazardous Waste Material/ADL	17	CY	$50	$825	15	CY	$50	$750	16	CY	$50	$775
Section 2 - Structural Section				$169,030				$126,584				$24,375
Mainline Pvmt & Shldrs	4,410	SF	$7	$30,870	4,000	SF	$7	$28,000	2,500	SF	$7	$17,500
Mainline AC Overlay	50,265	SF	$2	$100,530	32,240	SF	$2	$64,480	0	SF	$2	$0
Curb and Gutter	425	LF	$20	$8,500	460	LF	$20	$9,200	300	LF	$20	$6,000
Sidewalks	3,760	SF	$6	$22,560	3,380	SF	$6	$20,280	0	SF	$6	$0
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$6,570	$6,570	1	LS	$4,624	$4,624	1	LS	$875	$875
Section 3 - Drainage & Utilities				$70,990				$82,368				$6,125
Onsite Drainage (20% of Pvmt)	1	LS	$26,280	$26,280	1	LS	$18,496	$18,496	1	LS	$3,500	$3,500
BMP	1	LS	$25,000	$25,000	1	LS	$50,000	$50,000	0	LS	$0	$0
Utilites (15% of Pvmt)	1	LS	$19,710	$19,710	1	LS	$13,872	$13,872	1	LS	$2,625	$2,625
Section 4 - Specialty Items				$0				$0				$0
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				$234,318				$180,458				$45,225
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$26,280	$26,280	1	LS	$18,496	$18,496	1	LS	$3,500	$3,500
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$9,198	$9,198	1	LS	$6,474	$6,474	1	LS	$1,225	$1,225
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$26,280	$26,280	1	LS	$18,496	$18,496	1	LS	$3,500	$3,500
Construction Staging (40% Rdwy Pvmt)	1	LS	$52,560	$52,560	1	LS	$36,992	$36,992	1	LS	$7,000	$7,000
Traffic Signals	1	EA	$120,000	$120,000	1	EA	$100,000	$100,000	1	EA	$30,000	$30,000
Section 6 - Minor Items				$152,500				$66,400				$19,400
Minor Items (15% of Rdwy Items)	1	LS	$152,500	$152,500	1	LS	$66,400	$66,400	1	LS	$19,400	$19,400
Section 7 - Mobilization				$76,600				$56,600				$16,500
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$76,600	$76,600	1	LS	$56,600	$56,600	1	LS	$16,500	$16,500
Section 8 - Additions				$310,000				$229,000				$66,800
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$68,900	$68,900	1	LS	$50,900	$50,900	1	LS	$14,900	$14,900
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$241,100	$241,100	1	LS	$178,100	$178,100	1	LS	$51,900	$51,900
STRUCTURE ITEMS				$634,000				$0				$0
Section 9 - Structure Items				$480,000				$0				$0
Structure - Bridge	2400	SF	$200	$480,000	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				$48,000				$0				$0
Minor Items (10% of Structure Items)	1	LS	$48,000	$48,000	0	LS	$0	$0	0	LS	$0	$0
Section 11 - Mobilization				$52,800				$0				$0
Mobilization (10% of Strc & Minor Items)	1	LS	$52,800	$52,800	0	LS	$0	$0	0	LS	$0	$0
Section 12 - Additions				$52,800				$0				$0
Supplemental (10% of Str Cost & Minor Items)	1	LS	$52,800	$52,800	0	LS	$0	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	1	LS	$184,800	$184,800	0	LS	$0	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION				$1,710,000				$795,000				$232,000
RIGHT OF WAY				$963,400				$4,490,515				$0
Section 25 - Right of Way				$770,720				$3,592,412				$0
R/W Acquisition (Residential)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
R/W Acquisition (Commercial)	0	LS	$0	$0	1	LS	$2,121,700	$2,121,700	0	LS	$0	$0
Permanent R/W Easement	1	LS	$218,838	$218,838	1	LS	$52,715	$52,715	0	LS	$0	$0
Permanent Aerial Easement	1	LS	$491,882	$491,882	1	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	0	LS	$0	$0	1	LS	$1,050,000	$1,050,000	0	LS	$0	$0
Clearance/Demolition	0	LS	$0	$0	1	LS	$287,997	$287,997	0	LS	$0	$0
Title, Escrow, and Appraisal Fees (	3	EA	$20,000	$60,000	4	EA	$20,000	$80,000	0	EA	$0	$0
Section 26 - Additions				$192,680				$898,103				$0
ROW Contingency (25% of ROW C	1	LS	$192,680	$192,680	1	LS	$898,103	$898,103	1	LS	$0	$0
TOTAL				$2,674,000				$5,286,000				$232,000

CONCEPTUAL COST ESTIMATE SUMMARY FOR TSM/TDM ALTERNATIVES

ALTERNATIVE	I-19 San Gabriel Blvd and Mission Rd Intersection Improvement				I-20 Rosemead Blvd and Mission Dr Intersection Improvement				L-1 Figueroa St from Colorado Blvd to SR-134 NB ON and Off-Ramps			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				**$543,000**				**$726,000**				**$490,000**
Section 1 - Earthwork				**$81,398**				**$78,288**				**$55,604**
Construction Site Management/SWPPP	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000	1	LS	$50,000	$50,000
Clearing and Grubbing	0.25	Acre	$20,000	$4,968	0.22	Acre	$20,000	$4,448	0.04	Acre	$20,000	$894
Roadway Excavation	1,202	CY	$15	$18,030	1,076	CY	$15	$16,140	216	CY	$15	$3,240
Imported Borrow Due to Unsuitable On-Site Soil	120	CY	$20	$2,400	110	CY	$20	$2,200	21	CY	$20	$420
Hazardous Waste Material/ADL	120	CY	$50	$6,000	110	CY	$50	$5,500	21	CY	$50	$1,050
Section 2 - Structural Section				**$124,527**				**$162,069**				**$14,333**
Mainline Pvmt & Shldrs	10,820	SF	$7	$75,740	9,688	SF	$12	$116,256	1,950	SF	$7	$13,650
Mainline AC Overlay	0	SF	$2	$0	0	SF	$2	$0	0	SF	$2	$0
Curb and Gutter	900	LF	$20	$18,000	800	LF	$20	$16,000	0	LF	$20	$0
Sidewalks	4,500	SF	$6	$27,000	4,000	SF	$6	$24,000	0	SF	$6	$0
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$3,787	$3,787	1	LS	$5,813	$5,813	1	LS	$683	$683
Section 3 - Drainage & Utilities				**$26,509**				**$40,690**				**$4,778**
Onsite Drainage (20% of Pvmt)	1	LS	$15,148	$15,148	1	LS	$23,251	$23,251	1	LS	$2,730	$2,730
BMP	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Utilites (15% of Pvmt)	1	LS	$11,361	$11,361	1	LS	$17,438	$17,438	1	LS	$2,048	$2,048
Section 4 - Specialty Items				**$0**				**$21,684**				**$0**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.22	Acre	$97,500	$21,684	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				**$69,681**				**$101,143**				**$197,540**
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$15,148	$15,148	1	LS	$23,251	$23,251	1	LS	$2,730	$2,730
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$9,089	$9,089	1	LS	$8,138	$8,138	1	LS	$186,620	$186,620
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$15,148	$15,148	1	LS	$23,251	$23,251	1	LS	$2,730	$2,730
Construction Staging (40% Rdwy Pvmt)	1	LS	$30,296	$30,296	1	LS	$46,502	$46,502	1	LS	$5,460	$5,460
Traffic Signals	0	EA	$30,000	$0	0	EA	$30,000	$0	0	EA	$100,000	$0
Section 6 - Minor Items				**$45,400**				**$60,600**				**$40,900**
Minor Items (15% of Rdwy Items)	1	LS	$45,400	$45,400	1	LS	$60,600	$60,600	1	LS	$40,900	$40,900
Section 7 - Mobilization				**$38,700**				**$51,700**				**$34,800**
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$38,700	$38,700	1	LS	$51,700	$51,700	1	LS	$34,800	$34,800
Section 8 - Additions				**$156,500**				**$209,100**				**$141,100**
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$34,800	$34,800	1	LS	$46,500	$46,500	1	LS	$31,400	$31,400
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$121,700	$121,700	1	LS	$162,600	$162,600	1	LS	$109,700	$109,700
STRUCTURE ITEMS				**$0**				**$0**				**$0**
Section 9 - Structure Items				**$0**				**$0**				**$0**
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				**$0**				**$0**				**$0**
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 11 - Mobilization				**$0**				**$0**				**$0**
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 12 - Additions				**$0**				**$0**				**$0**
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION				**$543,000**				**$726,000**				**$490,000**
RIGHT OF WAY				**$17,973,749**				**$4,272,350**				**$0**
Section 25 - Right of Way				**$14,378,999**				**$3,417,880**				**$0**
R/W Acquisition (Residential)	0	LS	$0	$0	1	LS	$409,750	$409,750	0	LS	$0	$0
R/W Acquisition (Commercial)	1	LS	$7,126,250	$7,126,250	1	LS	$1,198,000	$1,198,000	0	LS	$0	$0
Permanent R/W Easement	0	LS	$0	$0	1	LS	$275,465	$275,465	0	LS	$0	$0
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	1	LS	$6,630,000	$6,630,000	1	LS	$750,000	$750,000	0	LS	$0	$0
Clearance/Demolition	1	LS	$522,749	$522,749	1	LS	$724,665	$724,665	0	LS	$0	$0
Title, Escrow, and Appraisal Fees (	5	EA	$20,000	$100,000	3	EA	$20,000	$60,000	0	EA	$0	$0
Section 26 - Additions				**$3,594,750**				**$854,470**				**$0**
ROW Contingency (25% of ROW C	1	LS	$3,594,750	$3,594,750	1	LS	$854,470	$854,470	1	LS	$0	$0
TOTAL				**$18,517,000**				**$4,999,000**				**$490,000**

ALTERNATIVE	L-2A Fremont Ave from Huntington Dr to Alhambra Rd				L-2B Fremont Ave from Poplar Blvd to Commonwealth Ave				L-2C Fremont Ave from Mission Rd to Valley Blvd			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				**$968,000**				**$1,101,000**				**$1,777,000**
Section 1 - Earthwork				**$73,256**				**$74,744**				**$136,615**
Construction Site Management/SWPPP	1	LS	$73,256	$73,256	1	LS	$72,344	$72,344	1	LS	$122,815	$122,815
Clearing and Grubbing	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0
Roadway Excavation	0	CY	$15	$0	120	CY	$15	$1,800	690	CY	$15	$10,350
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	$0	0	CY	$20	$0	0	CY	$20	$0
Hazardous Waste Material/ADL	0	CY	$50	$0	12	CY	$50	$600	69	CY	$50	$3,450
Section 2 - Structural Section				**$199,080**				**$214,920**				**$363,111**
Mainline Pvmt & Shldrs	0	SF	$7	$0	3,200	SF	$7	$22,400	18,660	SF	$7	$130,620
Mainline AC Overlay	94,800	SF	$2	$189,600	70,000	SF	$2	$140,000	52,000	SF	$2	$104,000
Curb and Gutter	0	LF	$20	$0	660	LF	$20	$13,200	2,340	LF	$20	$46,800
Sidewalks	0	SF	$6	$0	5,200	SF	$6	$31,200	11,660	SF	$6	$69,960
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$9,480	$9,480	1	LS	$8,120	$8,120	1	LS	$11,731	$11,731
Section 3 - Drainage & Utilities				**$91,360**				**$81,840**				**$157,117**
Onsite Drainage (20% of Pvmt)	1	LS	$37,920	$37,920	1	LS	$32,480	$32,480	1	LS	$46,924	$46,924
BMP	1	LS	$25,000	$25,000	1	LS	$25,000	$25,000	1	LS	$75,000	$75,000
Utilites (15% of Pvmt)	1	LS	$28,440	$28,440	1	LS	$24,360	$24,360	1	LS	$35,193	$35,193
Section 4 - Specialty Items				**$0**				**$0**				**$0**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				**$174,952**				**$241,288**				**$304,119**
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$37,920	$37,920	1	LS	$32,480	$32,480	1	LS	$46,924	$46,924
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$13,272	$13,272	1	LS	$11,368	$11,368	1	LS	$16,423	$16,423
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$37,920	$37,920	1	LS	$32,480	$32,480	1	LS	$46,924	$46,924
Construction Staging (40% Rdwy Pvmt)	1	LS	$75,840	$75,840	1	LS	$64,960	$64,960	1	LS	$93,848	$93,848
Traffic Signals	1	EA	$10,000	$10,000	1	EA	$100,000	$100,000	1	EA	$100,000	$100,000
Section 6 - Minor Items				**$80,800**				**$92,000**				**$177,200**
Minor Items (15% of Rdwy Items)	1	LS	$80,800	$80,800	1	LS	$92,000	$92,000	1	LS	$177,200	$177,200
Section 7 - Mobilization				**$68,900**				**$78,400**				**$126,500**
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$68,900	$68,900	1	LS	$78,400	$78,400	1	LS	$126,500	$126,500
Section 8 - Additions				**$278,900**				**$317,200**				**$512,300**
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$62,000	$62,000	1	LS	$70,500	$70,500	1	LS	$113,900	$113,900
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$216,900	$216,900	1	LS	$246,700	$246,700	1	LS	$398,400	$398,400
STRUCTURE ITEMS				**$0**				**$0**				**$291,000**
Section 9 - Structure Items				**$0**				**$0**				**$220,000**
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	1100	SF	$200	$220,000
Section 10 - Minor Items				**$0**				**$0**				**$22,000**
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$22,000	$22,000
Section 11 - Mobilization				**$0**				**$0**				**$24,200**
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$24,200	$24,200
Section 12 - Additions				**$0**				**$0**				**$24,200**
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$24,200	$24,200
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	1	LS	$84,700	$84,700
SUBTOTAL CONSTRUCTION				**$968,000**				**$1,101,000**				**$2,068,000**
RIGHT OF WAY				**$0**				**$6,084,243**				**$11,015,874**
Section 25 - Right of Way				**$0**				**$4,867,394**				**$8,812,699**
R/W Acquisition (Residential)	0	LS	$0	$0	1	LS	$1,912,900	$1,912,900	1	LS	$4,165,425	$4,165,425
R/W Acquisition (Commercial)	0	LS	$0	$0	1	LS	$2,014,500	$2,014,500	1	LS	$2,096,050	$2,096,050
Permanent R/W Easement	0	LS	$0	$0	1	LS	$17,850	$17,850	1	LS	$151,240	$151,240
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$95,012
Relocation Assistance	0	LS	$0	$0	1	LS	$490,000	$490,000	1	LS	$1,605,000	$1,605,000
Clearance/Demolition	0	LS	$0	$0	1	LS	$292,144	$292,144	1	LS	$399,972	$399,972
Title, Escrow, and Appraisal Fees (	0	EA	$0	$0	7	EA	$20,000	$140,000	15	EA	$20,000	$300,000
Section 26 - Additions				**$0**				**$1,216,849**				**$2,203,175**
ROW Contingency (25% of ROW C	1	LS	$0	$0	1	LS	$1,216,849	$1,216,849	1	LS	$2,203,175	$2,203,175
TOTAL				**$968,000**				**$7,186,000**				**$13,084,000**

ALTERNATIVE	L-3 Altantic Blvd from I-10 to Glendon Way				L-4 Garfield Ave from Valley Blvd to Glendon Way				L-5 Rosemead Blvd from Valley Blvd to Lower Azusa Rd			
	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost	QTY	Unit	Unit Cost	Cost
ROADWAY ITEMS				**$1,011,000**				**$996,000**				**$776,000**
Section 1 - Earthwork				**$82,716**				**$74,284**				**$56,800**
Construction Site Management/SWPPP	1	LS	$76,116	$76,116	1	LS	$74,284	$74,284	1	LS	$56,600	$56,600
Clearing and Grubbing	0.00	Acre	$20,000	$0	0.00	Acre	$20,000	$0	0.01	Acre	$20,000	$200
Roadway Excavation	330	CY	$15	$4,950	0	CY	$15	$0	0	CY	$15	$0
Imported Borrow Due to Unsuitable On-Site Soil	0	CY	$20	$0	0	CY	$20	$0	0	CY	$20	$0
Hazardous Waste Material/ADL	33	CY	$50	$1,650	0	CY	$50	$0	0	CY	$50	$0
Section 2 - Structural Section				**$200,232**				**$205,420**				**$204,250**
Mainline Pvmt & Shldrs	5,300	SF	$7	$37,100	0	SF	$7	$0	15,000	SF	$7	$105,000
Mainline AC Overlay	76,370	SF	$2	$152,740	94,000	SF	$2	$188,000	0	SF	$2	$0
Curb and Gutter	0	LF	$20	$0	260	LF	$20	$5,200	3,500	LF	$20	$70,000
Sidewalks	150	SF	$6	$900	470	SF	$6	$2,820	4,000	SF	$6	$24,000
Mainline Re-Striping	0	LF	$1	$0	0	LF	$1	$0	0	LF	$1	$0
Misc Pvmt Items & Removals (5% of Pvmt)	1	LS	$9,492	$9,492	1	LS	$9,400	$9,400	1	LS	$5,250	$5,250
Section 3 - Drainage & Utilities				**$104,412**				**$90,800**				**$36,750**
Onsite Drainage (20% of Pvmt)	1	LS	$37,968	$37,968	1	LS	$37,600	$37,600	1	LS	$21,000	$21,000
BMP	1	LS	$37,968	$37,968	1	LS	$25,000	$25,000	0	LS	$0	$0
Utilites (15% of Pvmt)	1	LS	$28,476	$28,476	1	LS	$28,200	$28,200	1	LS	$15,750	$15,750
Section 4 - Specialty Items				**$0**				**$0**				**$0**
Highway Planting* (includes planting, irrigation, and 3-year plant establishment)	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0	0.00	Acre	$97,500	$0
Modify Irrigation System*	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0	0.00	Acre	$63,000	$0
Retaining Wall (H=0-10 FT)	0	LF	$1,000	$0	0	LF	$1,000	$0	0	LF	$1,000	$0
Retaining Wall (H=10-15 FT)	0	LF	$1,700	$0	0	LF	$1,700	$0	0	LF	$1,700	$0
Retaining Wall (H=15-20 FT)	0	LF	$2,850	$0	0	LF	$2,850	$0	0	LF	$2,850	$0
Soundwalls (50% of Retaining Wall)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Temporary Shoring	0	SF	$10	$0	0	SF	$10	$0	0	SF	$10	$0
Wall Aesthetic Treatment	0	SF	$6	$0	0	SF	$6	$0	0	SF	$6	$0
Concrete Barrier (Type 60D)	0	LF	$70	$0	0	LF	$70	$0	0	LF	$70	$0
Section 5 - Traffic Items				**$175,161**				**$183,560**				**$134,000**
Misc. Traffic Items (20% of Rdwy Pvmt) - Loop Detectors, Ramp Metering, Count sta, Traffic control system, TMP)	1	LS	$37,968	$37,968	1	LS	$37,600	$37,600	1	LS	$21,000	$21,000
Fiber Optic & Twisted Pair Cable system	0	MI	$650,000	$0	0	MI	$650,000	$0	0	MI	$650,000	$0
Transit Signal Priority	0	EA	$20,000	$0	0	EA	$20,000	$0	0	EA	$20,000	$0
Install CCTV at Intersections	0	EA	$25,000	$0	0	EA	$25,000	$0	0	EA	$25,000	$0
Arterial Speed Data Collection	0	EA	$2,500	$0	0	EA	$2,500	$0	0	EA	$2,500	$0
Install Arterial CMS	0	EA	$35,000	$0	0	EA	$35,000	$0	0	EA	$35,000	$0
Remove & Delineate Traffic Striping & Markings	1	LS	$13,289	$13,289	1	LS	$13,160	$13,160	1	LS	$50,000	$50,000
Misc. (20% Rdwy Pvmt)- Lighting, Call Box, CCTV, Elec Service for Irrig., Overhead sign	1	LS	$37,968	$37,968	1	LS	$37,600	$37,600	1	LS	$21,000	$21,000
Construction Staging (40% Rdwy Pvmt)	1	LS	$75,936	$75,936	1	LS	$75,200	$75,200	1	LS	$42,000	$42,000
Traffic Signals	1	EA	$10,000	$10,000	1	EA	$20,000	$20,000	0	EA	$20,000	$0
Section 6 - Minor Items				**$84,400**				**$83,200**				**$64,800**
Minor Items (15% of Rdwy Items)	1	LS	$84,400	$84,400	1	LS	$83,200	$83,200	1	LS	$64,800	$64,800
Section 7 - Mobilization				**$71,900**				**$70,900**				**$55,200**
Mobilization (10% of Rdwy & Minor Items) (Inc 10% of mob cost)	1	LS	$71,900	$71,900	1	LS	$70,900	$70,900	1	LS	$55,200	$55,200
Section 8 - Additions				**$291,200**				**$286,900**				**$223,600**
Supplemental (10% of Rdwy cost & Minor Items)	1	LS	$64,700	$64,700	1	LS	$63,800	$63,800	1	LS	$49,700	$49,700
Contingencies (35% of Rdwy cost & Minor Items)	1	LS	$226,500	$226,500	1	LS	$223,100	$223,100	1	LS	$173,900	$173,900
STRUCTURE ITEMS				**$0**				**$0**				**$0**
Section 9 - Structure Items				**$0**				**$0**				**$0**
Structure - Bridge	0	SF	$200	$0	0	SF	$200	$0	0	SF	$200	$0
Section 10 - Minor Items				**$0**				**$0**				**$0**
Minor Items (10% of Structure Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 11 - Mobilization				**$0**				**$0**				**$0**
Mobilization (10% of Strc & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Section 12 - Additions				**$0**				**$0**				**$0**
Supplemental (10% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Contingencies (35% of Str Cost & Minor Items)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
SUBTOTAL CONSTRUCTION				**$1,011,000**				**$996,000**				**$776,000**
RIGHT OF WAY				**$0**				**$2,786,628**				**$0**
Section 25 - Right of Way				**$0**				**$2,229,302**				**$0**
R/W Acquisition (Residential)	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
R/W Acquisition (Commercial)	0	LS	$0	$0	1	LS	$1,972,700	$1,972,700	0	LS	$0	$0
Permanent R/W Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Permanent Aerial Easement	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Relocation Assistance	0	LS	$0	$0	0	LS	$0	$0	0	LS	$0	$0
Clearance/Demolition	0	LS	$0	$0	1	LS	$216,602	$216,602	0	LS	$0	$0
Title, Escrow, and Appraisal Fees (	0	EA	$0	$0	2	EA	$20,000	$40,000	0	EA	$0	$0
Section 26 - Additions				**$0**				**$557,326**				**$0**
ROW Contingency (25% of ROW C	1	LS	$0	$0	1	LS	$557,326	$557,326	1	LS	$0	$0
TOTAL				**$1,011,000**				**$3,783,000**				**$776,000**

Appendix C
SR 710 Drainage and Stormwater Treatment Technical Memorandum

SR-710 Conceptual Study for Drainage and Stormwater Treatment

PREPARED FOR: Metro

PREPARED BY: CH2M HILL

DATE: October 10, 2012

The purpose of this technical memorandum is to document the conceptual offsite drainage, pump stations, and stormwater treatment strategies and assumptions for the State Route 710 (SR-710) project. This process is part of the alternative analysis to develop conceptual costs for each alternative. For this conceptual study, onsite drainage systems, such as inlets and small diameter pipes, were not considered to be substantially different among the alternatives, and their cost was assumed to be a percentage of roadway paving cost, based on historic cost data. Therefore, onsite drainage was not discussed in this technical memo.

1. Offsite Drainage

Based on the Los Angeles County Hydrology Manual (2006), the 50-year 24-hour rainfall depth varies from 6.4 inches per year in the southern portion of the project (near I-10 interchange) to 8.1 inches per year in the northern portion (near I-210 interchange). Using the manual's intensity-duration-frequency (IDF) equation, the 25-year and 50-year rainfall intensity for the project can be derived and listed below. To obtain a better estimate, 3 zones (South, Middle, and North) were proposed in the calculations, as shown in Table 1.

TABLE 1
Design Rainfall Intensity

Rainfall Intensity (in/hr)				
Return year	T_c	South	Middle	North
50-yr	5 min	3.82	4.47	4.83
50-yr	10 min	2.76	3.23	3.49
25-yr	5 min	3.35	3.93	4.24
25-yr	10 min	2.42	2.84	3.06

T_c – Time of Concentration

Potential project conflicts with regional (offsite) drainage systems were identified using the Los Angeles County Department of Public Works (LACDPW) design-construction plan online map. Each potential conflict site was investigated by comparing the layouts and profiles of the drainage systems with the alternative alignments. If a conflict was identified, a conceptual plan and associated cost were developed to mitigate the impact. Because the as-builts were based on the National Geodetic Vertical Datum of 1929 (NGVD 29), a 2.5 ft adjustment was applied when comparing elevations between proposed alignments and as-builts.

Alternative F-2:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 155+00 to 170+00; Dorchester Ave. Storm Drain (20 ft x 14 ft reinforced concrete channel [RCC]) – The fill of the proposed alignment will be on top of the channel. The portion affected by the new roadway will be removed and replaced with a double 10 ft x 14 ft reinforced concrete box (RCB). The total length affected is 760 ft.
- Sta. 170+00 to 180+00; Dorchester Ave. Storm Drain (double 10 ft x 12 ft RCB) – Alignment has 80 ft horizontal clearance from existing drainage system. No conflict.
- Sta.430+00 to 435+00; Eagle Rock Blvd. Drain (108″ reinforced concrete pipe [RCP]) – Alignment is above grade. No conflict.

Alternative F-5:
The following regional Drainage Systems have been reviewed for potential conflicts.

- Sta. 155+00 to 170+00; Dorchester Ave. Storm Drain (20 ft x14 ft RCC) – The fill of the proposed alignment will be on top of the channel. The portion affected by the new roadway will be removed and replaced with a double 10 ft x 14 ft RCB. The total length affected is 760 ft.
- Sta. 170+00 to 180+00; Dorchester Ave. Storm Drain (double 10 ft x 12 ft RCB) – Alignment has 80 ft horizontal clearance from existing drainage system. No conflict.
- Sta. 220+00 to 225+00; Laguna Canyon Drain (48″ RCP) – Alignment is proposed on top of the existing drainage system, but there is 10 ft of vertical clearance. No conflict.

Alternative F-6:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 155+00 to 170+00; Dorchester Ave. Storm Drain (20 ft x14 ft RCC) – Alignment follows original roadway. No conflict.
- Sta. 170+00 to 180+00; Dorchester Ave. Storm Drain (double 10 ft x 12 ft RCB) – Alignment is above grade. No conflict.
- Sta. 290+00 to 300+00; MTD 689 (18″ to 36″ RCP) – Alignment passes below the drainage system. The affected drainage system will be removed and a new drainage system will be installed with the new bridge. Assume there will be at least 16.5 ft vertical clearance from the roadway, and 2 ft from the grade. The total lengths affected are 210 ft of 36″ RCP, 60 ft of 24″ RCP, and 60 ft of 18″ RCP.
- Sta. 340+00 to 345+00; South Pasadena Drain (33″ to 51″ RCP) – Alignment passes below the drainage system. The affected drainage system will be removed and a new drainage system will be installed with the new bridge. There will be a minor adjustment of the original drainage system alignment to accommodate the vertical clearance requirement from the roadway. Assume there will be at least 16.5 ft vertical clearance from the roadway, and 2 ft from the grade. The total lengths affected are 460 ft of 33″ RCP and 300 ft of 51″ RCP.
- Sta. 430+00 to 435+00; Del Mar Pump Station – Alignment passes through the pump station, so the station will be removed. The new grading will not require a pump station at this location.

Alternative F-7:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 155+00 to 170+00; Dorchester Ave. Storm Drain (20 ft x 14 ft RCC) – The fill of the proposed alignment will be on top of the channel. The portion affected by the new roadway will be removed and replaced with a double 10 ft x 14 ft RCB. The total length affected is 760 ft.
- Sta. 170+00 to 180+00; Dorchester Ave. Storm Drain (double 10 ft x 12 ft RCB) – Alignment has 80 ft horizontal clearance from existing drainage system. No conflict.
- Sta. 430+00 to 435+00; Del Mar Pump Station – Alignment passes through the existing pump station, so this station will be removed. The new grading will not require a pump station at this location.

Alternative H-2:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 47+00 to 62+00; Dorchester Ave. Storm Drain (20 ft x 14 ft RCC) – Alignment is 25 ft away from storm drain system. No conflict.
- Sta. 62+00 to 80+00; Dorchester Ave. Storm Drain (double 10 ft x 12 ft RCB) – Profile of alignment is higher than existing ground. No conflict.
- Sta. 80+00 to 87+00; Dorchester Ave. Storm Drain (10 ft x 13.25 ft RCB)– Alignment is 50 ft away from storm drain system. No conflict.
- Sta. 100+00 to 104+00 and Sta. 26+00 to 30+00 (Connector 2 line); Laguna Wash Storm Drain (10.75 ft x 12 ft RCB) – Proposed alignment is at existing ground level. No conflict.
- Sta. 106+00 to 116+00; Alhambra Storm Drain (24″ to 33″ RCP) – Alignment is at existing ground level. No conflict.
- Sta. 122+00 to 126+30; Laguna Wash Storm Drain (12 ft x 8 ft RCB) – Alignment is at existing ground level. No conflict.
- Sta. 140+00; Alhambra Storm Drain (30″ RCP) – Alignment is below existing ground, but finished pipe cover is greater than 3 ft. No conflict.
- Sta. 165+70; Northwest Alhambra Storm Drain (30″ RCP) – Alignment is below existing ground, but finished pipe cover is greater than 3 ft. No conflict.
- Sta. 215+83 to 219+35, between Freemont Ave. and Windsor Pl.; MTD689 (18″ RCP) – The proposed grade is about 5 ft below existing ground, where an existing 18″ RCP pipe would not have enough pipe cover. A solution is to replace the existing pipe with a new 18″ RCP and lower the invert elevation. Estimated pipe length is 300 ft.
- Sta. 225+70 to 234+30; MTD689 (33″ RCP) – Alignment is at existing ground level. No conflict.
- Sta. 250+30, and Sta. 266+35 to 272+30; South Pasadena Storm Drain (30″ RCP) – Profile of alignment is higher than existing ground. No conflict.
- Sta. 288+50 to 289+90; Arroyo Seco Channel – Proposed alignment is a bridge. No conflict.
- Sta. 320+00 to 332+00; Los Angeles Storm Drain (42″ and 51″ RCP) – Alignment is at existing ground level. No conflict.
- Sta. 368+70; Pasadena Storm Drain (45″ RCP) – Alignment is at existing ground level. No conflict.

Alternative H-6:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 69+00 to 85+00; Dorchester Ave. Storm Drain (double 10 ft x 12 ft RCB) – Profile of alignment is higher than existing ground. No conflict.
- Sta. 220+00, Sta. 225+00, and Sta. 235+00 to 246+00; South Pasadena Storm Drain (27″ to 60″ RCP) – Alignment is at existing ground level. No conflict.
- Sta. 320+00 to 336+00 A-2 line; Pasadena Storm Drain (24″ RCP) – Alignment is at existing ground level. No conflict.

Alternative LRT-4A:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 47+00 to 55+00; County Storm Drain (7.1 ft x 8.5 ft RCB) – Alignment is above ground. No conflict.
- Sta. 75+00 to 96+00; Caltrans 22 ft x 11 ft RCC – Alignment is near the existing channel. Assume the columns of the elevated tracks will be located outside of the channel, each column is 200 ft apart, and 30 ft RCC will be removed and replaced in kind for each column footing. The total length of replaced channel is 330 ft.
- Sta. 155+00 to 159+00; Dorchester Ave. (20 ft x 14 ft RCC) – Storm Drain is 15 ft away from proposed column. No conflict.
- Sta. 175+00 to 186+00; Dorchester Ave. (double 10 ft x 12 ft RCB) – Storm Drain is 120 ft away from proposed LRT tunnel. No conflict.
- Sta. 176+00 to 412+00 – Proposed LRT tunnel is about 60 ft below existing ground. No conflict.

Alternative LRT-4B:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 47+00 to 55+00; County Storm Drain (7.1 ft x 8.5 ft RCB) – Alignment is above ground. No conflict.
- Sta. 75+00 to 96+00; Caltrans 22 ft x 11 ft RCC – Alignment is near the existing channel. Assume the columns of the elevated tracks will be located outside of the channel, each column is 200 ft apart, and 30 ft RCC will be removed and replaced in kind for each column footing. The total length of replaced channel is 330 ft.
- Sta. 153+00 to 242+75 – Proposed LRT is about 25 ft above existing ground. No conflict.
- Sta. 263+90 to 264+50; between Pepper St. and Teagarden Ln.; Alhambra Storm Drain (24″ RCP) – Proposed LRT descends below grade nearby. This portion of pipe needs to be relocated to avoid the conflict. Estimated 24″ RCP length is 100 ft.
- Sta. 281+50 to 412+00 – Proposed LRT tunnel is about 60 ft below existing ground. No conflict.

Alternative LRT-4D:
The following regional drainage systems have been reviewed for potential conflicts.

- Sta. 71+00 to 79+00; County Storm Drain (7.1 ft x 8.5 ft RCB) – Alignment is above ground. No conflict.
- Sta. 99+00 to 120+00; Caltrans 22 ft x 11 ft RCC – Alignment is near the existing channel. Assume the columns of the elevated tracks will be located outside of the

channel, each column is 200 ft apart, and 30 ft RCC will be removed and replaced in kind for each column footing. The total length of replaced channel is 330 ft.
- Sta. 290+50 to 463+24 – Proposed LRT tunnel is about 30 ft below existing ground. No conflict.

Alternative LRT-6:
The proposed LRT alignment is either higher than existing ground or at existing ground level. No conflicts.

Alternatives BRT-1, BRT-6, BRT-6A, and TSM/TDM:
These proposed alignments are at grade, so there is no conflict with existing drainage systems.

2. Pump Stations

For each pump station, the cost includes electrical cost, but not right-of-way acquisition. To be conservative in pump sizing, storage detention was not considered in this phase.

Alternative F-2:

- **South Stormwater Pump Station near Station 160+00**
  This pump station will be located at approximate Station 160+00, about 200 feet outside the South Portal entrance. The actual location of the pump station will be outside the northbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 22.7 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the total dynamic head (TDH) is estimated about 30 ft.

  This station will be constructed within the cut and cover excavation area, outside the tunnel boring. A pump room will be constructed adjacent to the northbound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a smaller sump pump to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  This station will have 3 main pumps (2 duty and one stand-by) with each pump capable of handling 5,100 gpm at 30 ft TDH, with 75 hp motor and variable frequency drives (VFDs). The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 30 ft TDH with a 10 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

- **Low Point Pump Station near Station 232+50**
  This Low Point Pump Station will be constructed at the tunnel low point. The pump station will pump water that collects in a wetwell to a local stormwater drain system. Inlets located along the lower side of both the northbound and the southbound tunnel roadways will collect road runoff and convey it into a steel

pipe running beneath the lower roadway within the tunnel. Stormwater will be collected a short distance inside the tunnel and conveyed to the stormwater pump stations. Therefore, the tunnel roadways will normally generate little or no runoff, except during periods of tunnel washing or tunnel fire suppression system (FSS) testing. The tunnel drainpipe will also convey the minor amounts of tunnel seepage (generated on a continuous basis), draining it to the sump. Among the possible water sources, the design flow will be the FSS (fire sprinklers and fire hydrant). Assume 2 fire zones can go off at the same time. Per NFPA 13, using maximum fire zone of 5,000 sq ft and 0.30 gpm/sqft for Extra Hazard Group 1, the maximum fire sprinkler water flow rate will be 3,000 gpm, plus another 1,000 gpm for fire hydrant. So the total maximum flow is estimated at 4,000 gpm.

The pump station wetwell is assumed to have a minimum storage capacity (no extra storage for the fire water) due to the space limitations. The station will have 3 main pumps (2 duty and one stand-by) with each pump capable of handling 2,500 gpm at 220 ft TDH, with 200 hp motor and VFDs. These main pumps will be horizontal end suction centrifugal pumps. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 220 ft TDH with a 50 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

Alternative F-5:

- **South Stormwater Pump Station near Station 160+00**
  This pump station will be located at approximate Station 160+00, about 200 feet outside the South Portal entrance. The actual location of the pump station will be between the northbound and southbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 34.3 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the TDH is estimated about 90 ft.

  This station will be constructed within the cut and cover excavation area, outside the tunnel boring. A pump room will be constructed between the northbound and southbound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a smaller sump pump to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  The station will have 3 main pumps (2 duty and one stand-by) with each pump capable of handling 8,000 gpm at 90 ft TDH, with 250 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 90 ft TDH with a 25 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

- **North Stormwater Pump Station near Station 413+00**
  This pump station will be located at approximate Station 413+00, about 200 feet outside the North Portal entrance. The actual location of the pump station will be

outside the northbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 8.4 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the TDH is estimated about 90 ft.

This station will be constructed within the cut and cover excavation area, outside the tunnel boring. A pump room will be constructed outside of the northbound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a smaller sump pump to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

The station will have 2 main pumps (1 duty and one stand-by) with each pump capable of handling 4,000 gpm at 90 ft TDH, with 150 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 90 ft TDH with a 25 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

- **Low Point Pump Station at Station 219+50**
  This Low Point Pump Station will be constructed at the tunnel invert (low point). The approach and design concept of this pump station will be similar to the one in Alternative F-2.

Alternative F-6:

- **Stormwater Pump Station #1 near Station 204+20**
  This pump station will be located at approximate Station 204+20. The actual location of the pump station will be outside of the northbound or southbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 137.1 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the TDH is estimated about 100 ft.

  This station will be constructed within the cut and cover excavation area. A pump room will be constructed outside of the northbound or south bound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a pair smaller sump pumps to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  The station will have 6 main pumps (5 duty and one stand-by) with each pump capable of handling 12,500 gpm at 90 ft TDH, with 450 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 100 ft TDH with a 30 hp motor. The system is equipped with 2 backup power generators. The pump station will be equipped with communication systems.

- **Stormwater Pump Station #2 near Station 300+00**
  This pump station will be located at approximate Station 300+00. The actual location of the pump station will be outside of the northbound or southbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 124.4 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the TDH is estimated about 60 ft.

  This station will be constructed within the cut and cover excavation area. A pump room will be constructed outside of the northbound or south bound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a pair smaller sump pumps to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  The station will have 6 main pumps (5 duty and one stand-by) with each pump capable of handling 12,000 gpm at 60 ft TDH, with 250 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 75 ft TDH with a 20 hp motor. The system is equipped with 2 backup power generators. The pump station will be equipped with communication systems.

- **Stormwater Pump Station #3 near Station 344+00**
  This pump station will be located at approximate Station 344+00. The actual location of the pump station will be outside of the northbound or southbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 50.0 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the total dynamic head is estimated about 45 ft.

  This station will be constructed within the cut and cover excavation area. A pump room will be constructed outside of the northbound or south bound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a pair smaller sump pumps to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  The station will have 3 main pumps (2 duty and one stand-by) with each pump capable of handling 12,000 gpm at 45 ft TDH, with 200 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 55 ft TDH with a 15 hp motor. The system is equipped with 1 backup power generator. The pump station will be equipped with communication systems.

Alternative F-7:

- **South Stormwater Pump Station near Station 160+00**
  This pump station will be located at approximate Station 16+00, about 200 feet outside the South Portal entrance. The actual location of the pump station will be outside of the southbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 29.5 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the total dynamic head is estimated about 44 ft.

  This station will be constructed within the cut and cover excavation area, outside the tunnel boring. A pump room will be constructed outside of the southbound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a smaller sump pump to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  The station will have 3 main pumps (2 duty and one stand-by) with each pump capable of handling 7,000 gpm at 45 ft TDH, with 125 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 60 ft TDH with a 25 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

- **North Stormwater Pump Station at Station 506+80**
  This pump station will be located at approximate Station 506+80, about 200 feet outside the North Portal entrance. The actual location of the pump station will be outside the northbound or southbound traffic lanes. Pump station design is to convey the peak flow of 50-year storm flow from the contributing area. The peak flow is estimated to be 40.0 cfs. It is assumed that the stormwater can be discharged to a local drainage system and the TDH is estimated about 80 ft.

  This station will be constructed within the cut and cover excavation area, outside the tunnel boring. A pump room will be constructed outside of the northbound traffic lanes for maintenance access to the pump station and appurtenance equipment. The wetwell will include bar screens and a recessed area for a smaller sump pump to drain the wetwell during periods of dry weather. Vertical turbine pumps were used as the basis for the pump station design; however, other pump types may be feasible. Wet wells were assumed to rectangular.

  The station will have 3 main pumps (2 duty and one stand-by) with each pump capable of handling 9,200 gpm at 80 ft TDH, with 250 hp motor and VFDs. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 600 gpm at 95 ft TDH with a 25 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

- **Low Point Pump Station near Station 218+00**
  This Low Point Pump Station will be constructed at the tunnel invert (low point). The approach and design concept of this pump station will be similar to the one in Alternative F-2.

Alternative LRT-4A:

- **Low Point Pump Station at Station 191+89**
  This Low Point Pump Station will be constructed at the tunnel invert (low point). The pump station will pump water that collects in a wetwell to a local stormwater drain system. Inlets located along the side of both the northbound and the southbound tunnel tracks will collect road runoff and convey it into a steel pipe running beneath the track within the tunnel. Stormwater will be collected a short distance inside the tunnel and conveyed to the pump station. Therefore, the tunnel roadways will normally generate little or no runoff, except during periods of tunnel washing or FSS testing. The tunnel drainpipe will also convey the minor amounts of tunnel seepage (generated on a continuous basis), draining it to the sump. Among the possible water sources, the design flow will be the FSS (fire sprinklers and fire hydrant). Assume 2 fire zones can go off at the same time. Per NFPA 13, using maximum fire zone of 5,000 sq ft and density of 0.15 gpm/sqft for Ordinary Hazard Group 3, the maximum fire sprinkler water flow rate will be 1,500 gpm, plus another 1,000 gpm for fire hydrant. So the total maximum flow is estimated at 2,500 gpm.

  To be conservative, storage detention was not considered in the cost estimate. The pump station wetwell is assumed to have a minimum storage capacity (no extra storage for the fire water) due to the space limitations. The station will have 2 main pumps (1 duty and 1 stand-by) with each pump capable of handling 2,500 gpm at 125 ft TDH, with 125 hp motor and VFDs. These main pumps will be horizontal end suction centrifugal pumps. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 100 gpm at 125 ft TDH with a 7.5 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

Alternative LRT-4B:

- **Low Point Pump Station at Station 286+00**
  This Low Point Pump Station will be constructed at the tunnel invert (low point). The approach and design concept of this pump station will be similar to the one in Alternative LRT-4B.

Alternative LRT- 4D:

- **Low Point Pump Station near Station 290+38**
  This Low Point Pump Station will be constructed at the tunnel invert (low point). The pump station will pump water that collects in a wetwell to a local stormwater drain system. Inlets located along the side of both the northbound and the southbound tunnel tracks will collect road runoff and convey it into a steel pipe running beneath the track within the tunnel. Stormwater will be collected a short distance inside the tunnel and conveyed to the pump station. Therefore, the

tunnel roadways will normally generate little or no runoff, except during periods of tunnel washing or FSS testing. The tunnel drainpipe will also convey the minor amounts of tunnel seepage (generated on a continuous basis), draining it to the sump. The biggest and design water source will be the FSS (fire sprinklers and fire hydrant). Assume 2 fire zones can go off at the same time. Per NFPA 13, using maximum fire zone of 5,000 sq ft and density of 0.15 gpm/sqft for Ordinary Hazard Group 3, the maximum fire sprinkler water flow rate will be 1,500 gpm, plus another 1,000 gpm for fire hydrant. So the total maximum flow is estimated at 2,500 gpm.

To be conservative, storage detention was not considered in the cost estimate. The pump station wetwell is assumed to have a minimum storage capacity (no extra storage for the fire water) due to the space limitations. The station will have 2 main pumps (1 duty and 1 stand-by) with each pump capable of handling 2,500 gpm at 75 ft TDH, with 75 hp motor and VFDs. These main pumps will be horizontal end suction centrifugal pumps. The sump pumps (one duty and one stand-by) will be submersible type with each pump sized for 100 gpm at 75 ft TDH with a 5 hp motor. The system is equipped with a backup power generator. The pump station will be equipped with communication systems.

Alternatives LRT-6, BRT-1, BRT-6, BRT-6A, H-2, H-6, and TSM/TDM:
These options have no tunnel and have no pump station.

3. Stormwater Treatment

A stormwater quality analysis has been conducted to develop a conceptual treatment strategy for the project. The first step of the analysis is to perform a watershed water quality investigation to identify the receiving waters that the project is tributary to, as well as the 303(d) listed impairments. Information obtained from this investigation was used in developing a conceptual Best Management Practice (BMP) treatment strategy, followed by a determination of preliminary costs for treatment BMPs.

Receiving Waters

The project study area is located within the California Regional Water Quality Control Board (RWQCB), Los Angeles Region. The site is tributary to three Hydrologic Sub Areas (HSAs): undefined (412.10), Eagle Rock (412.25) and Pasadena (412.31). Flows from the project site eventually drain south to the Los Angeles River.

Impaired Waters

The most recent Clean Water Act Section 303(d) list of impaired water bodies for California was approved by the USEPA on October 11, 2011. Arroyo Seco, Los Angeles River, and Rio Hondo are all identified as impaired water bodies. Table 2 describes the impairments, and also whether the pollutant is considered a Targeted Design Constituent (TDC).

TABLE 2
Impaired Waters

Water Body	Pollutant	TDC	Status
Arroyo Seco Reach 1 (LA River to West Holly Ave)	Benthic-Macroinvertebrate Bioassessments	N/A	TMDL Required
Arroyo Seco Reach 1 (LA River to West Holly Ave)	Coliform Bacteria	N/A	TMDL Required
Arroyo Seco Reach 1 (LA River to West Holly Ave)	Trash	N/A	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 2	Ammonia	Nitrogen	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 2	Coliform Bacteria	N/A	TMDL Required
Los Angeles River Reach 2	Copper	Copper	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 2	Lead	Lead	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 2	Nutrients (Algae)	Phosphorus	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 2	Oil	N/A	TMDL Required
Los Angeles River Reach 2	Trash	N/A	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Ammonia	Nitrogen	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Cadmium	N/A	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Coliform Bacteria	N/A	TMDL Required
Los Angeles River Reach 1	Dissolved Copper	Dissolved Copper	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Cyanide	N/A	TMDL Required
Los Angeles River Reach 1	Diazinon	N/A	TMDL Required
Los Angeles River Reach 1	Lead	Lead	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Nutrients (Algae)	Phosphorus	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	pH	N/A	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Trash	N/A	Being Addressed by EPA-Approved TMDLs
Los Angeles River Reach 1	Dissolved Zinc	Dissolved Zinc	Being Addressed by EPA-Approved TMDLs
Los Angeles River Estuary	Chlordane (sediment)	N/A	TMDL Required
Los Angeles River Estuary	DDT (sediment)	N/A	TMDL Required

TABLE 2
Impaired Waters

Water Body	Pollutant	TDC	Status
Los Angeles River Estuary	PCBs (sediment)	N/A	TMDL Required
Los Angeles River Estuary	Sediment Toxicity	N/A	TMDL Required
Los Angeles River Estuary	Trash	N/A	Being Addressed by EPA-Approved TMDLs
Rio Hondo Reach 1	Coliform Bacteria	N/A	TMDL Required
Rio Hondo Reach 1	Copper	Copper	Being Addressed by EPA-Approved TMDLs
Rio Hondo Reach 1	Lead	Lead	Being Addressed by EPA-Approved TMDLs
Rio Hondo Reach 1	pH	N/A	Being Addressed by EPA-Approved TMDLs
Rio Hondo Reach 1	Toxicity	N/A	TMDL Required
Rio Hondo Reach 1	Trash	N/A	Being Addressed by EPA-Approved TMDLs
Rio Hondo Reach 1	Zinc	Zinc	Being Addressed by EPA-Approved TMDLs
San Pedro Bay Near-Shore/Offshore Zones	Chlordane	N/A	TMDL Required
San Pedro Bay Near-Shore/Offshore Zones	DDT (tissue & sediment)	N/A	TMDL Required
San Pedro Bay Near-Shore/Offshore Zones	PCBs	N/A	TMDL Required
San Pedro Bay Near-Shore/Offshore Zones	Sediment Toxicity	N/A	TMDL Required

EPA – United States Environmental Protection Agency
HSA – hydrologic sub area
N/A – not applicable

Treatment Strategy

The project consists of various alternatives, including freeway (F-2, F-5, F-6, and F-7), highway (H-2 and H-6), LRT (LRT-4A, LRT-4B, LRT-4D, and LRT-6), BRT (BRT-1, BRT-6, and BRT-6A), and TSM/TDM. The freeway and highway alternatives will be within Caltrans right-of-way, and will need to comply with the Caltrans Project Planning and Design Guide (PPDG). The LRT and BRT alternatives are subject to Standard Urban Storm Water Mitigation Plan (SUSMP) requirements of the Los Angeles County Department of Public Works. The existing SUSMP (2002) addresses the current Municipal Separate Storm Sewer System (MS4) National Pollution Discharge Elimination System (NPDES) permit (No. 01-182) from the Los Angeles Regional Water Quality Control Board issued in 2001. An updated Tentative Los Angeles County MS4 permit (No. CAS004001) has been developed reflecting technical progress in stormwater quality BMPs, but has not yet been finalized.

For all alternatives, treatment BMPs will be implemented to the maximum extent practicable. Given the draft status of the new Los Angeles County MS4 permit, and also for consistency in cost analysis, all alternatives were analyzed following the Caltrans PPDG. The TDC approach set forth in the Caltrans PPDG was used to determine the treatment strategy for the potential treatment BMPs. A TDC is a pollutant that has been identified during Caltrans runoff characterization studies as one that (1) is draining with a load or concentration that commonly exceeds allowable standards, and (2) is considered treatable by currently available Caltrans-approved treatment BMPs. According to the PPDG, a project must consider treatment to target a TDC when an affected water body within the project limits is on the 303(d) list for one or more of these constituents.

Based on the water body impairments identified for the project, the priority pollutants designated as TDCs are: phosphorus, nitrogen, total copper, dissolved copper, lead, zinc, and dissolved zinc. The BMP selection will be dependent on infiltration capacity and site-specific determination of feasibility. Infiltration devices, being the approved treatment BMP capable of treating all the TDCs, are generally the first treatment BMP to be considered. However, infiltration devices are dependent on having appropriate soil conditions, and most of the project area is located in Hydrologic Soil Group (HSG) D, which is not appropriate for infiltration. Only Alternative F-2 is located in both HSG C and D. Although infiltration devices are the preferred treatment BMPs, they are likely not appropriate for the project.

Based on the TDCs identified for the project, the treatment BMPs should be proposed based on BMP Selection Matrix D of the PPDG. Matrix D identifies two tiers of BMPs when the infiltration category is less than 20%. Tier 1 contains wet basins, Austin filters (both earthen and concrete), and Delaware filters. Tier 2 contains biofiltration strips, biofiltration swales, and unlined detention. The preference is for Tier 1 BMPs, followed by Tier 2 BMPs when Tier 1 BMPs are not feasible. From the Tier 1 BMPs, wet basins will likely be eliminated because no permanent source of water is available for any of the sites. Austin filters are prioritized above Delaware filters because they are more cost-effective and do not have vector issues. Gross Solids Removal Devices (GSRDs) should also be considered for the project because the downstream waterbodies are impaired for trash. Based on a preliminary analysis of site feasibility, the combination of Treatment BMPs for the project may include media filters, biofiltration strips, biofiltration swales, detention basins, and GSRDs. Final selection of BMPs will be made during final design, based on a site-specific determination of feasibility. BMPs along the LRT and BRT alternatives may also include other BMPs approved for use by the Los Angeles County MS4 permit.

- **Freeway and Highway Alternatives**
  For the freeway and highway alternatives, it was assumed that the project will treat all of the impervious area outside the tunnel, including existing roadway surfaces. It is assumed that the tunnel portion of the roadway will not be treated.

- **LRT Alternatives**
  For the LRT alternatives, all new impervious areas outside the tunnel (including aerial, at-grade, and transitional alignments; and maintenance yards) are assumed to be treated. It is assumed that the tunnel portion of the roadway will not be treated. Alternative LRT-6 does not introduce any new impervious surface; therefore, no treatment is proposed.

- **BRT and TSM/TDM Alternatives**
  For the BRT and TSM/TDM alternatives, only new impervious area is assumed to be treated. These alternatives mostly follow existing roadway, and only the small fraction of new impervious surface is proposed to be treated.

The assumption of tributary area to be treated for each alternative is based on a conceptual treatment strategy. A site-specific determination of feasibility will be made during final design, which may change the actual tributary area to be treated.

Water Quality Volume

The Water Quality Volume (WQV) for the design storm was calculated for each alternative as the Runoff Coefficient x Water Quality Depth (0.75”) x Tributary Area. The WQV is based on sizing criteria from the Los Angeles Regional Water Quality Control Board (LARWQCB). A water quality event of 0.75 inch has been set by the LARWQCB for the Los Angeles area.

Cost Estimate

A conceptual cost for treatment BMPs was determined for each alternative. The BMP cost was calculated using the unit cost per volume of the design storm derived from the Caltrans BMP Retrofit Pilot Program (Caltrans, 2004). The costs in that report represent 1999 dollars, so those unit costs were doubled to account for increased construction costs and represent 2012 dollars.

More recent cost estimates were checked to confirm the validity of this approach. BMP costs derived from this method compared favorably with the Best Engineering Estimate System (BEES) that was prepared for several treatment BMPs located in the I-5 North Corridor within Caltrans District 7. Thus, it was determined that doubling the unit costs from the Caltrans BMP Retrofit Pilot Program was a reasonable estimate to determine BMP costs.

To be conservative, a unit cost of \$82/ft^3 representing concrete-vault Austin filters was used to estimate conceptual BMP cost for each alternative. While final BMP selection may consist of other BMPs, a blanket unit cost of \$82/ft^3 was multiplied by the WQV to obtain the conceptual BMP cost for each alternative. The cost does not include right-of-way acquisition.