DIRECTORS FASANA AND MOLINA MOTION

ROUTE 710 NORTH EXTENSION PROJECT NEXT STEPS

Matters to be considered by the Board of Directors usually are first considered in a Committee and then forwarded to the full Board of Directors for their consideration. This item, Route 710 North Extension Project Next Steps, was removed from the Measure R Project Delivery Committee Meeting Agenda at the discretion of the Chairperson of the Board. I am now placing this item on the agenda of the regular Board of Director's meeting for our consideration.

I therefore move that the Board of Directors approve staff's recommendations in the attached report to:

A. Receive and file the Final Geotechnical Summary Report for the Route 710 Tunnel Technical Study shown in Attachment A;

B. Direct the Chief Executive Officer (CEO) to utilize the Transportation Planning Bench and/or advertise and procure consultant services to prepare a robust scoping document, Alternative Analysis and the appropriate environmental documents to determine the full range of new transportation options to (1) improve mobility, safety and congestion, (2) address community concerns and (3) augment planning efforts;

C. Authorize the CEO to execute a Funding Agreement with Caltrans and others should additional funds become available; and

D. Remove from further consideration Zone 1, Zone 2, Zone 4 and Zone 5 from the five-zone study area.

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MEASURE R PROJECT DELIVERY COMMITTEE
APRIL 15, 2010

SUBJECT: ROUTE 710 NORTH EXTENSION PROJECT NEXT STEPS

ACTION: APPROVE RECOMMENDATIONS

RECOMMENDATIONS

A. Receive and file the Final Geotechnical Summary Report for the Route 710 Tunnel Technical Study shown in Attachment A;

B. Direct the Chief Executive Officer (CEO) to utilize the Transportation Planning Bench and/or advertise and procure consultant services to prepare a robust scoping document, Alternatives Analysis and the appropriate environmental documents to determine the full range of new transportation options to (1) improve mobility, safety and congestion, (2) address community concerns and (3) augment planning efforts; and

C. Authorize the Chief Executive Officer to execute a Funding Agreement with Caltrans and others should additional funds become available.

ISSUE

For decades, planning has been underway to extend Route 710 from its northerly terminus at Valley Boulevard, in Los Angeles, to Interstate Route 210 in Pasadena to improve mobility. To date, only at-grade highway improvements and tunneling have been studied. Of late, Metro, in conjunction with Caltrans, conducted technical studies to assess the feasibility of tunneling to close the gap between the two freeways.

Over the years, outreach and consensus building have become crucial components in the transportation planning process. In addition, Metro has expanded its bus and rail transit services, as well as other motorized and non-motorized transportation options, and invested in signal synchronization and transportation demand management programs to provide a more balanced multi-modal system throughout the County. While much has been accomplished, in terms of identifying and addressing potential challenges associated with highway improvements and tunnel concepts for Route 710, the next steps need to reflect the current transportation planning context as well as new and emerging environmental challenges such as reducing Greenhouse Gas Emissions.

POLICY IMPLICATIONS

This action is consistent with planning efforts set forth in the Long Range Transportation Plan and the Board's commitment to improve mobility and address environmental and community impacts.

ALTERNATIVES

There are three alternatives to be considered. First, the Board could decide that there is enough information contained in the Final Route 710 Geotechnical Study to proceed to the next steps in the Project which lead to environmental clearance and preliminary engineering. This would mean updating the purpose and need for the project and identifying new strategies for further consideration. Staff recommends this option because it is more comprehensive and it may result in a program of improvements that are acceptable to communities that currently oppose closing the gap.

Second, the Board could decide to rescope the project and conduct a series of discrete studies related to community questions stopping short of an Environmental Document. This is not recommended and would stop short of addressing the host of community questions that were raised during the Geotechnical Study.

Lastly, the Board could decide to take no further action. However, given previous actions taken by the voters of Los Angeles County, through Measure R, and the Board to make congestion relief a priority, this alternative is not recommended.

FINANCIAL IMPACT

The funding in the amount of $2,000,000 is proposed in the FY11 budget in Cost Center No. 4710, Project No. 460315, for a project phase total of $59 million. Since this is a multi-year project, it will be the responsibility of the Chief Planning Officer and the Cost Center Manager to budget the appropriate expenditures in future years.

Impact on Bus and Rail Operating and Capital Budget

The funding for this project will be from Measure R Highway Funds (20%) and will have no impact on bus and rail operating and capital budgets.

BACKGROUND

In June 2006, staff completed the Route 710 Tunnel Technical Feasibility Assessment of extending the 710 Freeway from its current terminus at Valley Boulevard in Los Angeles to the 210 Freeway in Pasadena. The objective of the assessment was to determine whether a tunnel is technically, operationally and financially feasible, and to identify potential environmental impacts. The assessment considered a myriad of tunnel alternatives with construction costs ranging from approximately $2.3 billion to $3.6 billion (2006 dollars). The assessment concluded that a tunnel concept was feasible from a physical and environmental perspective, despite environmental impacts that would have to be mitigated. Moreover, no insurmountable environmental issues that would preclude further consideration of a tunnel alternative were identified. Immediately following completion of the technical assessment, staff conducted an extensive outreach program to inform communities of the assessment findings and obtain their feedback. Community comments on the technical feasibility assessment were collected, responded to and attached to the report.

After legislation was introduced by Congressman Adam Schiff, District 29, mandating that a route neutral approach be used to determine if a tunnel option was feasible, Caltrans initiated a Geotechnical Study to further evaluate the physical and environmental nature of a route neutral study area. The five-zone study area includes portions of the San Gabriel Valley, the southern San Rafael Hills, the Elysian Hills, and the Repetto Hills areas of the Los Angeles-Pasadena region. The Study included an assessment of geological conditions followed by exploratory borings and geophysical surveys used to determine soil and rock conditions, geological formation and the potential for tunneling. Also, consultant services were procured to develop a community facilitation program to mirror the progress of the Geotechnical Study and to keep the public informed of major study milestones and findings. The community participation framework included input from the Route 710 Tunnel Steering Committee, which represented communities potentially affected by the construction of a tunnel through the study area, as well as a Technical Advisory Committee, which was comprised of engineers and environmental professionals from participating public agencies and communities involved in the study. The public outreach process also included community meetings, presentations to stakeholder advisory groups, briefings to elected officials and/or representatives and the establishment of a study information newsletter and website. Public comments on the geotechnical study were collected, responded to and appended to the final report.

The final report on the Geotechnical Study concluded that it is feasible to construct a tunnel in any of the five zones using current available tunneling technologies, despite challenges that may need to be addressed during design and/or construction phases.

NEXT STEPS

Upon Board approval, staff will develop a statement of work for the Request for Proposal (RFP) for consultant services needed for the scoping document, alternatives analysis, environmental documents and community outreach program. It is anticipated that the RFP will be released in the Summer of 2010 and that the contract will be awarded in the Fall of 2010. Staff will return to the Board for contract award approval.

ATTACHMENT

A. Final Geotechnical Summary Report –Route 710 Tunnel Technical Study

Prepared by:

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Executive Summary

Introduction

The California Department of Transportation (Caltrans) and the Los Angeles County Metropolitan Transportation Authority (Metro) have proposed tunnels for extending State Route (SR) 710 within the area shown in Figure 1-1. The intent of this extension is to alleviate traffic congestion within the area, with a secondary benefit of improving air quality. In 2006, Metro performed a feasibility assessment of a tunnel to connect SR-710 at Valley Boulevard to Interstate (I) 210. In 2008, Caltrans retained a team led by CH2M HILL to evaluate the geologic conditions within the study area shown in Figure 1-1. This Geotechnical Summary Report presents the results of the 2008 study.

Caltrans Geotechnical Services and the CH2M HILL team jointly conducted the study, including planning of the exploration program, conducting field exploration, and evaluation of geotechnical data. CH2M HILL, Earth Mechanics, Inc. (EMI), Jacobs Associates (JA), and ILF comprise the CH2M HILL team.

Based on requests from local communities, Congressman Adam Schiff, District 29, introduced legislation mandating that a route-neutral approach be used for the SR-710 Tunnel Technical Study. Route-neutral means that all routes receive equal attention and no route for the tunnel is favored over another. It also requires that all practical routes for extending SR-710 be considered. As part of the route-neutral concept, Caltrans, along with the CH2M HILL team, identified five study zones as shown in Figure 1-2, representing the potential corridors for extending SR-710. The study area has been defined as the area bound by I-10 to the south, SR-2 to the west, I-210 to the north, and I-605 to the east.

The purpose of this geotechnical study is to determine the geologic, groundwater, and seismic conditions within the selected study zones to identify factors that affect the geotechnical feasibility of designing and constructing a tunnel. In addition, this information provides a basis for a comparison of the study zones with respect to tunneling.

For this study, the invert (bottom) of the tunnel along most of the zones is assumed to be about 200 feet below ground surface (bgs), except for the ends of the zones where the roadway would have to connect to existing freeways at the ground surface, and the diameter of the tunnel is assumed to be about 50 feet. Our understanding is that a detailed evaluation of the tunnel profile and tunnel configuration will be made during the environmental documentation phase in the future.

The following subsections of this Executive Summary provide a synopsis of the work that was carried out for this study.

Data Collection and Review

This task involved a comprehensive compilation and review of reports and publications from public and private files regarding the surface and subsurface conditions in the five zones. This collection and review task was performed to establish background information for the zones and to guide development of the field exploration program conducted for this phase of the study.

Data were compiled from public agencies including Caltrans, the United States Geological Survey (USGS), the California Geological Survey (CGS), the Southern California Earthquake Center (SCEC), the California Division of Oil and Geothermal Resources (CDOGR), the City of Los Angeles, the Los Angeles County Department of Public Works - Geotechnical and Materials Engineering Division (LACDPW), the California Department of Water Resources (CDWR), the Main San Gabriel Watermaster (MSGW), the Raymond Basin Management Board (RBMB), and the Dibblee Foundation. In addition, unpublished reports by other consultants were reviewed.

Historical and recent aerial photographs were examined to identify linear topographic and vegetation alignments that could be the surface expression of earthquake faults. Black and white photographs within the Fairchild Collection at Whittier College were the principal photographs utilized for the lineament analysis. Additional details regarding data collection and review are provided in Section 2 of this report.

Field Exploration Program

Field explorations were conducted to provide additional data for characterizing geologic and groundwater conditions within the tunnel study zones. Exploratory borings and geophysical surveys were completed to determine the characteristics of soil/rock units and to estimate the limits of the anticipated geologic formations within the study area.

The field investigation program included core borings, geological reconnaissance, and geophysical surveys. The locations of the borings and geophysical surveys were selected based on the site reconnaissance and review of available geotechnical and geological information. Twenty-five core borings, 17 seismic reflection lines, and 78 multichannel analysis of surface wave (MASW) tests were performed to characterize subsurface conditions. Table ES-1 presents a summary of the exploration program, including the previous borings available in each zone.

TABLE ES-1
Exploration Summary

Zone	Number of Previous Borings Available	Number of Borings in Current Study	Number of Seismic Reflection Lines	Number of Surface Wave Lines	Approximate Length of Zone (miles)
1	74	7	4	20	5.0 to 5.5
2	61	5	3	12	5.0 to 5.5
3	40	12	6	24	4.5 to 5.0
4	34	1	2	10	6.0 to 7.5
5	77	0	2	12	9.5 to 11.0

Caltrans Geotechnical Services and CH2M HILL completed the core borings. Caltrans completed 13 borings, and the remaining borings were completed by the CH2M HILL team. Representative samples of soil and rock core were obtained from each of the borings. Selected samples of soil and rock were tested in a laboratory to determine the properties of the different geologic materials encountered during this study. After completion of the drilling, all but three of the borings were converted to piezometers for monitoring groundwater levels.

In situ testing and downhole logging were completed in selected borings to determine the physical characteristics and engineering properties of the in-place soil/rock units. These tests/surveys included pressuremeter tests, caliper tests, acoustic televiewer (ATV), downhole compression and shear-wave velocity measurements, natural gamma, resistivity or conductivity logging, and packer tests. Additional details regarding the field exploration program are provided in Section 3 of this report.

Regional Geology, Faulting, and Seismicity

The SR-710 study area encompasses portions of the San Gabriel Valley, the southern San Rafael Hills, the Elysian Hills, and the Repetto Hills (Figure 4-1). These areas are within a transition zone between the northwest-southeast-trending Peninsular Ranges physiographic province to the south and the east-west-trending Transverse Ranges province to the north. A detailed description of the regional geology is presented in Section 4 of this report.

The study area is underlain by Quaternary-age alluvium (less than approximately 2 million years old), Tertiary-age sedimentary rocks (approximately 2 to 16 million years old), and ancient crystalline basement complex rocks (igneous and metamorphic rocks older than about 120 million years). Table ES-2 presents a generalized stratigraphic column of the geologic units within the study area.

TABLE ES-2
Study-Specific Stratigraphic Column

Geologic Unit/ Formation Name	Map Symbol	Geologic Epoch (Period)	Approximate Age (Years)	Generalized Description
Young Alluvium	Qa, Qg, Qal	Holocene (Quaternary)	0 to 11,000	Sand and gravel with scattered cobbles and boulders and layers/lenses of silt and clay; stream and fan deposits. Poorly defined, lenticular, discontinuous bedding.
Old Alluvium	Qae, Qalo, Qoa, Qof, Qt, Qvoa	Pleistocene (Quaternary)	11,000 to 2 million	Sand and gravel with scattered cobbles and boulders and layers/lenses of silt and clay stream and fan deposits. Poorly defined, lenticular, discontinuous bedding.
Fernando	Tfcg, Tfss, Tfsl, Tfs, Tfr	Pliocene (Tertiary)	2 to 5 million	Predominantly claystone, siltstone and mudstone, with some sandstone and conglomerate. Massive, marine deposits.

TABLE ES-2
Study-Specific Stratigraphic Column

Geologic Unit/ Formation Name	Map Symbol	Geologic Epoch (Period)	Approximate Age (Years)	Generalized Description
Puente (includes Monterey, Modelo, and Unnamed Shale)	Tpsl, Tpsh, Tpds, Tpss, Tpun, Tmy, Tmss, Tmsh, Tmlv	Late Miocene (Tertiary)	5 to 11 million	Claystone, siltstone, diatomaceous siltstone, mudstone, shale, and sandstone. Laminated to thinly bedded, locally thickly bedded. Marine deposits.
Topanga	Ttss, Ttcg, Ttsl, Ttqdc, Ttsc, Ttqdb	Middle Miocene (Tertiary)	11 to 16 million	Siltstone, mudstone, sandstone, and conglomerate, with local volcanic intrusions. Thinly to thickly bedded, marine deposits.
Basement Complex Rocks	Wqd, Wqg	Cretaceous and Pre Cretaceous	120 to 160+ million	Crystalline igneous rocks (diorite, quartz diorite, monzonite, foliated igneous rocks) and layered metamorphic rocks (gneiss).

Southern California is seismically active and crossed by a number of faults capable of producing significant earthquakes. Strong ground shaking is expected in the study area due to the regional seismicity. In addition, several active, potentially active, and inactive faults cross the study area. The active faults identified in the study area include the Raymond fault and the Alhambra Wash fault. The Raymond fault crosses Zones 2, 3, and 4 and is considered to be the most significant fault. The Alhambra Wash fault is projected to cross Zones 4 and 5. Potentially active faults in the study area are the Eagle Rock and San Rafael faults. Additional details regarding the regional geology, faulting, and seismicity are provided in Section 4 of this report.

Groundwater Conditions

Results of the literature reviews determined that Zones 1 through 5 straddle five separate groundwater basins of the South Coast Hydrologic Region:

- The Los Angeles River portion of Zone 1 located north of SR-110 and the broad valley located along Eagle Rock Boulevard (westernmost portion of Zone 2) are part of the San Fernando Valley Groundwater Basin.
- The portion of the Los Angeles River located south of SR-110, the Arroyo Seco, and all other drainages located in the eastern portions of Zones 1 and 2 and in the southwestern portion of Zone 3 are parts of the Coastal Plain of the Los Angeles Groundwater Basin – Central Sub-basin. A portion of Eagle Rock Basin is located in the northwest region of Zone 2.
- Zone 3 straddles three separate groundwater basins—the Central Sub-basin in the southwest, the San Gabriel Valley Groundwater Basin in the southeast, and the Raymond Groundwater Basin in the north.

- Zone 4 is located within two groundwater basins—the San Gabriel Valley Groundwater Basin in the south and the Raymond Groundwater Basin in the north.
- Zone 5 is located entirely within the San Gabriel Valley Groundwater Basin.

Groundwater levels vary considerably across the study area and occur as deep aquifers and as shallow perched zones. Several of the faults within the study area act as groundwater barriers with different levels on either side of the fault. A major part of the alluvium is an aquifer, and there will be a potential for inflows into tunnel excavations unless control measures are implemented. The underlying rock formations contain groundwater but are not aquifers. However, isolated bodies of groundwater might be encountered within faulted and/or fractured zones in the rock. Impact to groundwater should be kept minimal during tunnel construction and operation. Additional details regarding groundwater conditions are provided in Section 5 of this report.

Hazardous Materials

Hazardous materials present within the study zones are likely sources of soil and groundwater contamination. The potential for hazardous materials within the zones was evaluated using information from the Initial Site Assessments (ISAs) and an Environmental Site Assessment (ESA) performed for the study area.

The ISAs and the ESA identified several sites within the five study zones that have soil and groundwater contamination issues (see Figure 6-1).

The most significant contamination issues are the existence of the two National Priorities List (NPL) sites located within Zones 1, 4, and 5. These two NPL sites (also known as Superfund sites) are the San Fernando Valley Superfund Site (Zone 1) and the San Gabriel Valley Superfund Sites (Zones 4 and 5). The sites have known groundwater contamination.

Most of the groundwater contamination is due to chlorinated volatile organic compounds that are the result of past industrial activities in the area. Therefore, the potential of encountering the contaminated groundwater should be considered in tunnel design, and contamination containment should be part of the construction method.

In addition to the above NPL sites, a large number of small soil and groundwater contamination sites are identified in each zone. These sites are expected to be less important than the NPL sites for tunnel design and construction because of the small size of most sites and the depth of the tunnel. Additional details about hazardous materials are provided in Section 6 of this report.

Description of Zone Geologic Conditions

A summary of the geologic conditions determined for each zone in this preliminary evaluation is presented below. Additional details about the geologic conditions within Zones 1 through 5 are provided in Sections 7 through 11 of this report, respectively.

Zone 1 Geologic Conditions

Based on the results of this evaluation, the key geologic factors for this zone in terms of tunnel design and construction considerations (Plate 5) are:

- Subsurface conditions in most of this zone are fairly uniform, consisting mainly of weak sedimentary rocks of the Puente Formation. Typically, the formation in this zone consists mostly of sandstone, siltstone, and shale. Locally, there is a potential for encountering alluvium (or soil) near the northwestern and southeastern portions of the zone and beneath the Los Angeles River.
- Generally, the rock mass is only slightly fractured. Several inactive faults will likely be encountered; however, no active faults are mapped within this zone.
- Most of the rock is considered weak to moderately weak, although there is a potential for stronger cemented layers and concretions within the Puente Formation.
- The groundwater table within the alluvium is shallow (approximately 20 to 50 feet bgs) in parts of this zone. The rock mass is not expected to transmit large quantities of groundwater into the tunnel, except for possibly beneath the Los Angeles River and within isolated fractured zones. In this area, recharge from the river could lead to higher sustained groundwater inflows. High groundwater inflows are also expected in the saturated alluvium at the northwestern and southeastern portions of the zone.
- The water-bearing alluvial materials along the Los Angeles River in Zone 1 are considered to be susceptible to liquefaction in areas where groundwater is near the ground surface and loose, cohesionless soils occur.
- One Superfund site is located in the zone, which could be a source of contaminated soil and groundwater in the tunnel. This concern applies mainly to the northwestern portion of the zone.
- There is a relatively high potential of encountering naturally occurring gas (methane and/or hydrogen sulfide) in this zone because it is underlain by Puente Formation.

Zone 2 Geologic Conditions

Based on the results of this evaluation, the key geologic factors for this zone in terms of tunnel design and construction considerations (Plate 6) are:

- Subsurface conditions in this zone are fairly uniform, consisting mainly of weak sedimentary rocks of the Puente and Topanga Formations. The Puente Formation includes sandstone, siltstone, and shale and is found in the southeastern portion of the zone. Siltstone and sandstone of the Topanga Formation are expected in the northeastern portion (Plate 6). In addition, depending on the location of the tunnel, sandstones and conglomerates of the Fernando Formation may be encountered. Locally, alluvium (or soil) is expected near the northwestern and southeastern portions of the zone.

- Generally, the rock mass is slightly to moderately fractured. Several inactive faults will be encountered in this zone (Plate 1). The active Raymond fault crosses the zone at the northwestern end. The Raymond fault is capable of generating earthquakes in the range of earthquake moment magnitude (M_W) 6 to 6.7 and producing displacement of about 2 to 4 feet.
- Most of the rock is considered weak to moderately weak, although there is a potential for strongly cemented layers and/or concretions in the Puente and Topanga Formations. Additionally, cobbles and boulders can be expected in the northern portion of this zone, within the Topanga and Fernando Formation conglomerate and the alluvium.
- The Raymond fault is a groundwater barrier, and significant variations in groundwater levels can be expected on either side of the fault. Groundwater is shallow in alluvial valleys (approximately 20 feet bgs), but it is believed to be perched on top of bedrock. The rock mass generally has low permeability and, therefore, is not expected to transmit large quantities of groundwater into the tunnel.
- Some localized soil and groundwater contamination associated with two gas stations could result in hazardous materials being encountered in the northwestern end.
- Alluvial materials within the drainages that cross Zone 2 have been identified as potentially susceptible to liquefaction in areas where loose, cohesionless soils are below the groundwater table.
- There is a relatively high potential of encountering naturally occurring gas (methane and/or hydrogen sulfide) in this zone because a significant portion of the zone is underlain by Puente Formation.

Zone 3 Geologic Conditions

Based on the results of this evaluation, the key geologic factors for this zone in terms of tunnel design and construction considerations (Plate 7) are:

- Subsurface conditions in this zone vary at tunnel depth, including unconsolidated soil deposits (alluvium), weak sedimentary rocks (Puente, Fernando, and Topanga Formations), and strong igneous and metamorphic basement complex rocks (Wilson Quartz Diorite).
- Rock strength varies widely in this zone from the sedimentary rocks (which are very weak to weak) to the higher-strength igneous and metamorphic rocks. There is a potential for strongly cemented layers and/or concretions in the Puente and Topanga Formations. Additionally, cobbles and boulders can be expected in the northern portion of this zone within the Topanga Formation conglomerate and within the alluvium.
- The Raymond fault and San Rafael fault are groundwater barriers. Depth to groundwater varies from as shallow as 50 feet bgs near the Raymond fault to more than 100 feet in both the northern and the southern parts of the zone. Groundwater elevations vary by more than 100 feet on opposite sides of the San Rafael fault. Rock formations are not expected to transmit large quantities of groundwater into the tunnel. However, groundwater inflows are expected when tunneling in the saturated alluvium.

- There is one active, two potentially active, and several inactive faults in this zone. The Raymond fault is active and is capable of generating earthquakes in the range of M_W 6 to 6.7 and of producing displacement at the tunnel level of about 2 to 4 feet. The activity of the San Rafael and Eagle Rock faults are unknown; potentially active and inactive faults may act as groundwater barriers.
- Alluvial materials within the drainages that cross Zone 3 have been identified as potentially susceptible to liquefaction in areas where groundwater-saturated, loose, cohesionless soils are present.
- Two sites with minor soil contamination are located at the northern limits of this zone.
- There is a moderate potential of encountering naturally occurring gas (methane and/or hydrogen sulfide) in this zone because the southern portion of the zone is underlain by Puente Formation.

Zone 4 Geologic Conditions

Based on the results of this evaluation, the key geologic factors for this zone in terms of tunnel design and construction considerations (Plate 8) are:

- Subsurface conditions are fairly uniform in this zone at tunnel depth and consist mainly of Old Alluvium with a limited amount of sedimentary rocks (Fernando and Puente Formations) near the southern end of the zone. The majority of the tunnel is expected to be in the Old Alluvium. The Old Alluvium is generally expected to consist of uncemented coarse sand and gravel interbedded with sand, silt, and clay. The Fernando Formation is expected to consist of siltstone and claystone. The Puente Formation is expected to be composed of clayey siltstone and silty claystone (commonly called mudstone), as well as some sandstone.
- The Old Alluvium exhibits the strength characteristics of a soil with low cohesion (i.e., low undrained shear strength). Cobbles and boulders can be expected in the Old Alluvium. The Fernando and Puente Formations are expected to be moderately weak to weak rock. Strong cemented layers and concretions may be encountered locally in the Puente Formation.
- The active Raymond fault and Alhambra Wash fault cross this zone and could cause ground rupture during a large earthquake. Several inactive faults within the Tertiary-age rocks cross the southwestern portion of this zone.
- Most of the tunnel in this zone would be at or below the water table. Depth to groundwater varies; however, it could be as shallow as 100 feet below grade. The Raymond fault is a groundwater barrier. Historically, groundwater is shallowest on the north side of this fault. Groundwater inflows could occur while tunneling below the groundwater table in the saturated alluvium.
- Some of the alluvial materials within Zone 4 have been identified as potentially susceptible to liquefaction in areas where groundwater-saturated, loose, cohesionless soils are present.

- One Superfund site is located approximately at the southwestern end of this zone. The United States Environmental Protection Agency (USEPA) is currently evaluating the extent of the contamination and will subsequently complete a Record of Decision (ROD). Six other sites with various levels of soil contamination are also present in this zone close enough to impact the tunnel. Most of these sites are located in the vicinity of the northern end.
- There is a low potential for encountering naturally occurring gas in this zone due to the limited portion of the tunnel in the Puente Formation.

Zone 5 Geologic Conditions

Based on the results of this evaluation, the key geologic factors for this zone in terms of tunnel design and construction considerations (Plate 9) are:

- Subsurface conditions are fairly uniform in this zone at tunnel depth and consist mainly of Old Alluvium with a limited amount of sedimentary rocks (Fernando and Puente Formations) near the southern end of the zone. The Old Alluvium is generally expected to consist of uncemented, coarse sand and gravel interbedded with sand, silt, and clay. The Fernando Formation is expected to consist of siltstone and claystone. The Puente Formation is expected to be composed of clayey siltstone and silty claystone (commonly called mudstone), as well as some sandstone.
- The Old Alluvium exhibits the strength characteristics of a soil with low cohesion (i.e., low undrained shear strength). The Fernando and Puente Formations are expected to be moderately weak to weak rock. Cobbles and boulders can be expected in the Old Alluvium. Strong cemented layers and concretions may be encountered in the Puente Formation.
- The Alhambra Wash fault is considered active and projects into this zone. The inactive Workman Hill fault projects toward the western portion of the zone.
- Most of the tunnel in this zone would be at or below the groundwater table. Depth to groundwater varies with groundwater at surface grade in some locations. Groundwater inflows could occur when tunneling below the groundwater table in alluvium.
- The perennial Rio Hondo and San Gabriel River, as well as recharge lakes and deep (greater than 150 feet) gravel quarries, are located in the eastern portion of this zone.
- As a result of the shallow historically highest groundwater level, and, based on the composition of the shallow alluvial materials that occur along the eastern portion of Zone 5, potentially liquefiable conditions have been identified in general for the eastern half of the zone.
- One Superfund site is located in the south-central portion of the zone, which could be a source of soil and groundwater contamination in this zone. Seven other sites with various levels of soil and groundwater contamination are also present in this zone. Most of these sites are located near the eastern or central portion of Zone 5.
- There is a low potential for encountering naturally occurring gas in this zone due to the limited portion of the tunnel in the Puente Formation.

Geotechnical Considerations for Tunnel Design and Construction

Information collected during this study was interpreted relative to tunnel design and construction within each of the zones. Zones with similar geology/geotechnical conditions were grouped to provide similar tunnel design and construction considerations. Results of these reviews are summarized as follows:

Geologic Conditions in Zones 1 and 2

Tunnel excavations in Zones 1 and 2 will likely be in the Fernando, Puente, and Topanga Formations, depending on the location of the tunnel through the study zones. These formations consist of sedimentary rocks that all have similar characteristics. There is some inherent variability within these formations, such as occasional cemented layers and concretions within the sandstone.

Tunnel excavation in Zones 1 and 2 is feasible given the tunnel technology currently available, such as the tunnel boring machines (TBMs) used for the Northeast Interceptor Sewer Line (NEIS) project. Several other tunnels have been successfully constructed through these or similar formations in the Los Angeles area. The uniformity of geological conditions in Zones 1 and 2 will simplify construction planning. The potential impact of the cemented layers and concretions will need to be addressed in the selection/design of tunnel excavation equipment. These layers may reduce tunnel advance rates; however, properly designed tunneling equipment can successfully excavate these formations.

Geologic Conditions in Zone 3

Variable geologic conditions are anticipated within Zone 3. Alluvium (soil), low-strength rock, and high-strength rock are all expected to be encountered in this zone. The bedrock material is expected to consist of the weak rocks of the Fernando, Puente, and Topanga Formations, as well as stronger basement complex rocks and limited amounts of volcanic rocks. Strong cemented layers or concretions may be present in the sedimentary rock formations; cobbles and boulders may be encountered in the alluvium and conglomerate of the Topanga Formation in the northern portion of the zone.

A tunnel through Zone 3 will encounter varied geologic conditions, including several geologic formations with a wide range of strength and other physical properties. The basement complex rocks in the northern part of the alignment are stronger rocks that would likely require greater effort to excavate than the sedimentary rocks previously discussed.

Although Zone 3 exhibits the most variable geology of all the zones, excavation of a tunnel in this zone could be done with specialized tunneling machines adaptable to the expected range of anticipated geologic conditions or by using a flexible approach that allows methods to be changed to suit the geology. Due to the variability, the TBM could have a cutterhead with tools that could be changed to excavate either soil or rock. In addition, pressurized-face excavation methods would likely need to be used for face stability in the alluvium and fractured or crushed rock zones.

Geologic Conditions in Zones 4 and 5

Zones 4 and 5 consist mostly of alluvium with some weak sedimentary rocks of the Fernando and Puente Formations near the southern and western ends, respectively. There is some inherent variability within these formations, such as scattered cemented layers and concretions within the sandstone. The majority of the proposed tunnels in each of the zones will be excavated through the alluvium. The alluvium is generally expected to be uncemented, coarse sand and gravel interbedded with sand, silt, and clay with potential for cobbles and boulders.

Tunneling through alluvium involves a greater potential loss of ground at the tunnel face and surface settlement than tunneling through rock. Alluvium is the main formation in Zones 4 and 5. It is expected that the majority of the soil at tunnel depth will be saturated, which increases the potential for instability and surface settlement. Specialized TBMs with positive face control, using earth-pressure balance (EPB) or slurry methods, can control ground loss and surface settlement. The design of specialized TBMs and tunnel operations become more complex as the groundwater head increases. Tunneling machines for Zones 4 and 5 would need to be designed for the saturated alluvium, which contains cobbles and boulders, as well as the sedimentary rock at the southern (Zone 4) and western (Zone 5) portions of these zones.

Active and Inactive Faults

There are steeply dipping, inactive faults in all five zones. Tunneling across these faults is expected to include excavation in fractured rock, clay gouge, and variable groundwater conditions. The groundwater head can vary considerably across a fault if it is acting as a groundwater barrier. Therefore, the potential for groundwater inflows could be expected to vary dramatically across a fault zone. Fault zones are typically less than about 50 feet wide, but much wider zones with multiple branches (about 1,000 feet) are not uncommon. Additionally, a tunnel crossing a fault could encounter a wider zone of faulting if the tunnel were to cross the trend of the fault obliquely. A properly designed TBM can normally excavate these fault crossings without major difficulty, although the rate of excavation is normally less than the rate in better quality rock.

Depending on the location of a potential tunnel, the active Raymond fault may cross Zone 2 (if the tunnel is located within the northwest end of Zone 2) and may cross a potential tunnel in Zones 3 and 4. Similarly, the tunnel may cross the Alhambra Wash fault in Zones 4 and 5. Special considerations will need to be made for excavating through a fault and lining a tunnel in an active fault zone. An oversized tunnel could be excavated in the fault zone to accommodate fault offset (see Section 12.0). Such oversize excavations are typically employed through fault zones to accommodate offsets during fault rupture.

Additionally, tunnels through faults with clayey fault gouge can encounter squeezing conditions. Special provisions will be required to advance a TBM through the clayey zone. The tunnel will need to be designed to accommodate the expected fault displacements.

Contaminated Soil and Groundwater

The Superfund sites in Zones 1, 4, and 5 have the potential to impact tunnel construction and muck-disposal operations. In particular, plumes of contaminated groundwater and soil could be encountered during tunnel excavation. Although the severity of the hazardous conditions might be less in a tunnel than on the ground surface, handling hazardous materials in the confinement of a tunnel could be challenging. The contaminated soil, water, and vapors must be controlled to protect the workers and avoid contaminating adjacent areas. The contaminated soil and water must be handled properly and be transported to appropriate disposal sites.

Naturally Occurring Gas

Naturally occurring gas could be encountered in any of the formations discussed above; however, based on experience with other tunnels in Los Angeles, naturally occurring gas is most likely to be encountered within the Puente Formation. This formation is present in all five zones in different proportions. Appropriate precautions will be necessary in accordance with California Occupational Safety and Health Administration requirements for dealing with naturally occurring gasses during tunnel excavation.

Comparison of Zones

Key ground characteristics for tunneling, such as subsurface conditions, groundwater, contamination, faulting, and seismicity, and potential for gassy conditions, were compared between each zone and are summarized in Table ES-3. A more detailed comparison of the zones is provided in Section 13 of this report.

TABLE ES-3
Comparison of Zones

Zone	Approximate Length of Zone (miles)	Number of Geologic Formations	Predominant Geologic Formation(s)	Percent of Zone in each Formation	Number of Reported/ Mapped Faults	Number of Active Faults Crossing Zone	Potential for Gassy Conditions[a]	Percent of Zone under Superfund Sites
1	5.0 to 5.5	2	Puente Alluvium	80 to 90 10 to 20	5	0	H	5 to 10
2	5.0 to 5.5	4	Puente Topanga Fernando Alluvium	70 to 80 10 to 15 5 to 10 5 to 10	7	1 (NW end)	H	0
3	4.5 to 5.0	5	Topanga Alluvium Puente Fernando Diorite	30 to 40 10 to 20 20 to 30 5 to 10 10 to 20	7	1[b]	M	0
4	6.0 to 7.5	3	Alluvium Fernando Puente	70 to 80 10 to 15 10 to 15	5	2	L	5 to 15
5	9.5 to 11.0	3	Alluvium Fernando Puente	75 to 85 10 to 15 5 to 10	3	1	L	5 to 30

Notes:
[a] H-High, M-Moderate, L-Low
[b] Two potentially active faults cross Zone 3

A comparison of these geotechnical conditions was performed to identify the significance of each condition per zone. Each geotechnical condition has been categorized as design-, construction-, or operation-related. This classification is independent of the how significant the issue is; however, the classification assists in identifying the phase or phases of the project that each condition pertains to most. The results of this comparison analysis are provided in Section 13.8 of this report, and a memorandum regarding a detailed comparison of these conditions is presented in Attachment 1.

It should be recognized that these geotechnical conditions are routinely encountered in tunnel design, construction, and operation and can be successfully addressed, as discussed in Section 12 of this report. Preliminary concepts to mitigate these geotechnical conditions are described in Sections 7 through 11 of this report. A memorandum regarding detailed descriptions of the mitigation concepts is presented in Attachment 2.

Concluding Remarks

Information in this report provides a preliminary summary of geotechnical conditions within the five zones being considered for the SR-710 tunnel. Sections in this report contain detailed information about the geology, faults, seismicity, groundwater, contaminated materials, and potential for gassy conditions within each zone. This information provides a basis for evaluating the geotechnical feasibility of tunneling within each of the zones.

Based on the information collected and reviewed as part of the current geotechnical study, tunneling is considered to be geotechnically feasible in all five zones. Geotechnical feasibility implies that it is possible to construct a tunnel in the geologic formations expected, including the geotechnical conditions associated with these formations using currently available tunneling technologies. Section 12 discusses several tunnel projects and the construction technologies available for conditions similar to those present within the zones under consideration for this study.