SECTION 8

Site Conditions for Zone 2

8.1 General

Zone 2 is located entirely within the City of Los Angeles. As depicted in Plates 1 and 6, Zone 2 extends northwest from the northern terminus of I-710 to the SR-2/Verdugo Road intersection within the City of Los Angeles. Zone 2 is approximately 5.0 to 5.5 miles long and approximately 1.5 miles wide at its northwestern terminus. The delineation of Zone 2 anticipates a connection between the northern terminus of I-710 and SR-2.
The general location of Zone 2 is shown in Figure 8-1.

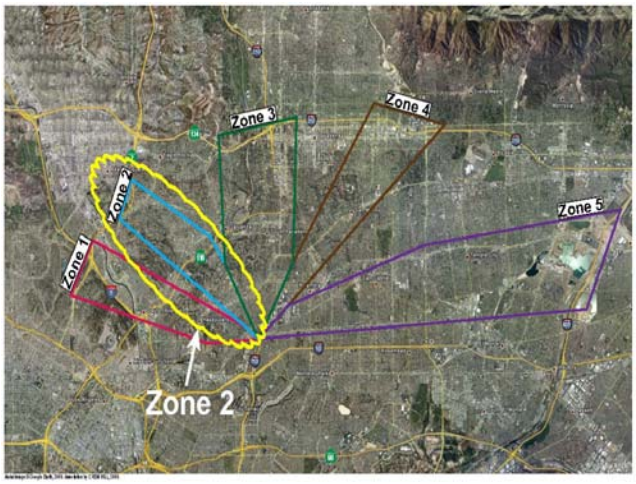

Figure 8-1. Zone 2 Location Map.

8.2 Existing Developments

Most of Zone 2 is densely populated and occupied predominantly by residential and small commercial developments. SR-110 crosses the central portion of the zone perpendicularly, following the configuration of Arroyo Seco. Other important surface roads from east to west that cross the zone include Alhambra Avenue, Mission Road, Monterey Road, Figueroa Street, Eagle Rock Road, and Verdugo Road. The Los Angeles–Pasadena Metro Line (Gold Line) runs from Union Station to Pasadena along Arroyo Seco, crossing Zone 2 through its middle portion. In addition, railroad tracks cross the eastern portion of the zone between Mission Road and Valley Boulevard.

The City of Los Angeles Avenue 45 sewer pipeline runs at an approximate depth of 10 to 50 feet bgs through the portions of Arroyo Seco located within Zone 2. In addition, several utility lines are located at shallow depths within the zone.

8.3 Zone Geology

8.3.1 Physiography

The regional physiographic conditions of the area surrounding Zone 2 is described in Section 4. Zone 2 is located in the Repetto Hills, a hilly region of topographically abrupt hills and narrow valleys within the City of Los Angeles. In general, the Repetto Hills consist of small rounded hills with gentle to very steep slopes. Mount Washington, with a maximum elevation of about 920 feet, is located in the west-central portion of the zone and represents the highest hill of the area. As a result, a portion of the western half of this zone is located on the northeast-facing slopes of Mount Washington, which, in turn, are surrounded

by relatively broad valleys located along Arroyo Seco, York Boulevard, and Eagle Rock Boulevard.

The floors of Arroyo Seco and York Boulevard valleys are at an approximate elevation of 500 feet above msl, and the elevation of the north-trending valley of Eagle Rock Boulevard is at up to 420 feet above msl. Unnamed high peaks in the south-central portion, immediately to the southeast of Arroyo Seco, reaching a maximum elevation of approximately 880 feet msl. The southeastern portion of Zone 2 is at an approximate elevation of 450 feet, a relatively flat area with gentle southwesterly slopes.

Several southwest-trending drainages cut through the Repetto Hills. The southwesterly draining Arroyo Seco represents the widest and most important topographic break through Zone 2, essentially dividing the zone into two equal portions. Arroyo Seco is a broad, flat floored valley that drains southerly and westerly from the San Gabriel and Verdugo mountain ranges in the north, along the eastern edge of the San Rafael Hills to the Los Angeles River just west of the Elysian Hills. Runoff in the Arroyo Seco channel is within a concrete-lined open aqueduct. Other southwest-flowing intermittent drainages perpendicularly dissect the Repetto Hills. One of the drainages is located along Eagle Rock Boulevard at the northwesternmost portion of the zone, whereas two other drainages are located along Mission Road and West Mission Road in the southeastern portion of the zone. These drainages consist of gently sloping floodplains/canyons. The topographic conditions for Zone 2 are shown in Plates 1 and 6.

8.3.2 Stratigraphy

There are four major geologic units present within Zone 2. These include the Topanga, Puente, and Fernando Formations, and Quaternary Alluvium (Plates 1 and 6). The general characteristics of these units are described in Section 4.1.2.

Quaternary alluvial materials occur within the dissecting drainages and topographically lower areas northwest of Arroyo Seco and in the southeasternmost portion of Zone 2. Alluvial materials are also anticipated at both portal locations. The alluvium is approximately 25 to 35 feet thick along Arroyo Seco and 5 to 30 feet thick at the northwestern portion of the zone. However, immediately east of the intersection of Eagle Rock Boulevard and York Boulevard, alluvium thickness changes abruptly from south to north from approximately 75 feet to slightly over 275 feet in a very short distance. The water-bearing young alluvium is considered to be susceptible to liquefaction (CDMG, 1998d). Liquefaction may affect shallow structures but is not expected to affect a deep tunnel.

As mapped by Lamar (1970), the Fernando Formation within Zone 2 in the Highland Park area comprises a fault-bounded block consisting of conglomerate, conglomeratic sandstone (Tfcg), and interbedded sandstone (Ttss). These rocks contrast sharply with the fine-grained massive claystone and siltstone typical of the Fernando Formation in the easternmost portion of the zone. The coarse-grained member is anticipated to be encountered only if the tunnel crosses the northern portion of the zone, west of Arroyo Seco.

The sandstone (Tpss), shale (Tpsh), and siltstone (Tpsl) units of the Puente Formation are anticipated to be encountered along different sections of a typical tunnel through Zone 2. The sandstone unit (Tpss) is exposed north of the Highland Park fault and between the Highland Park fault and Mount Washington. The shale unit (Tpsh) occurs predominantly in

the southern portion of the zone in the general vicinity of Arroyo Seco. Finally, the siltstone (Tpsl) unit crops out in the eastern portion of the zone.

The units of the Topanga Formation that have been identified within Zone 2 include siltstone (Ttsl), overlain by sandstone (Ttss). The sandstone unit (Ttss) crops out at the northwesternmost portion of Zone 2 in a fault block.

Boring R09-Z2B4 was excavated into the shales of the Puente Formation (Tpsh) and yielded rock core recovery between 103 and 120 percent between the depths of 135 and 245 feet and between 355 and 400 feet bgs. The core diameters varied locally from about 2 inches to 1.7 inches. However, the caliper log for this boring showed that the diameter of the borehole below a depth of 100 feet is roughly the same diameter of the drill bit used. Apparently the material was stretched during extraction of the core from the core barrel (necking). Expansion index testing performed on core material collected at this depth interval showed medium expansion potential.

A tunnel through the southern portion of Zone 2 should encounter the sandstone (Tpss), shale (Tpsh), and siltstone (Tpsl) units of the Puente Formation. A tunnel through the northern portion of Zone 2 would encounter the siltstone (Ttsl) and sandstone (Ttss) units of the Topanga Formation. However, within the northeastern portion of Zone 2, a tunnel would encounter the shale (Tpsh) and siltstone (Tpsl) units of the Puente Formation. A tunnel through the western half would encounter the siltstone (Ttsl) and sandstone (Tpsl) units of the Topanga Formation, along with sandstones (Tfss) and conglomerates (Tfcg) of the Fernando Formation.

8.3.3 Structural Geology

Zone 2 generally parallels the northwest-southeast trend of the major geologic faults and folds of the Repetto Hills. Faulting along the Elysian Park blind detachment fault has folded rocks, within the northwest-trending and southeast-plunging Elysian Park Anticline (Oskin et al., 2000). Uplift of this anticline has produced the Elysian and Repetto Hills. In addition, the highest topographic relief throughout Zone 2 corresponds approximately with the areal extent of the anticline and with the trends of secondary folds (Plates 1 and 6).

The northwest-trending and southeast-plunging axis of the Elysian Park Anticline runs approximately along the middle length of Zone 1. Consequently, Zone 2 (to the north of Zone 1) is within the northeastern limb of this major fold structure. Based on this structural location, bedding along this zone would be expected to dip predominantly toward the northeast. Such bedding orientations were confirmed with ATV logs for R-09-Z2B3 and R-09-Z2B4 where bedding dips in general to the north at approximately 10 and 70 degree angles, respectively. However, abrupt dip reversals from the expected and measured bedding orientations are common mainly due to fault-bounded blocks south of the Highland Park fault. Furthermore, due to tightly folded secondary folds associated with the Elysian Park Anticline, deviations from those expected bedding conditions, including overturned bedding, also occur in the area located south of the Highland Park fault and west of Arroyo Seco. Bedding in R-09-Z2B1 in the York Boulevard valley near the Raymond fault dips about 35 to 45 degrees in the upper 40 feet, similar to outcrops a short distance to the north and south, but the bedding abruptly became nearly vertical from 40 feet to the bottom of the boring. According to the ATV log for boring R-09-Z2B5 bedding under the alluvial

cover at that boring location dips 15 to 30 degrees in an east-southeast direction. In summary, bedding orientations and inclinations are highly variable, and their dips can be expected to range from 25 degrees to vertical.

Based on the ATV logs for the borings advanced within Zone 2, fracturing appears to be randomly oriented. However, data collected from the ATV log for boring R-09-Z2B5 indicated that a fracture set may exist between roughly 150 and 240 feet bgs.

8.4 Faulting

The geologic structure of most of the area is not only complicated but difficult to decipher because of the dense cover of paved streets, residential structures, commercial buildings and vegetation. Fourteen inactive faults are mapped (Lamar, 1970) within the limits of Zone 2 forming a complicated mosaic of intersecting faults and fault-bounded blocks. The largest of these faults corresponds to the trace of the northwest-trending Highland Park fault and dissects the middle of the entire length of Zone 2 (Plates 1 and 6). The Highland Park fault appears to terminate against the western continuation of the Raymond fault located along York Boulevard. The Highland Park fault is not considered by the CGS (2002b) and CDMG (1977) as active.

Among the other 13 inactive faults of the complicated fault mosaic mapped by Lamar (1970), 9 faults have been mapped in rocks of the Puente Formation located southwest of the Highland Park fault. In addition, the remaining four faults are mapped northeast of the Highland Park fault in rocks of the Fernando, Puente, and Topanga Formations. All of these fault traces are shorter and more discontinuous than the Highland Park fault. The orientation of the faults located southwest of the Highland Park fault varies from parallel, oblique, to perpendicular. Northeast of the same fault, the orientation is predominantly perpendicular to the Highland Park fault. The Highland Park fault and all other steeply dipping faults within Zone 2 might juxtapose various units of the Fernando, Puente, and Topanga Formations at the anticipated tunnel depth.

The active Raymond fault projects westerly from Raymond Hill into the valley along York Boulevard. However, the fault is poorly expressed in the surface morphology west of Arroyo Seco so the location is poorly known. Geophysical data collected during this investigation and previously by the USGS (personal communication, Mike Reimer, 2009) suggested faulting but was inconclusive. However, surface faulting was documented in fault trenches near Figueroa Avenue just west of Arroyo Seco. The aerial photograph lineament study revealed geomorphic features that suggest surface faulting along the edge of the hills north of York Boulevard.

The APEQFZ established by CDMG (1977) shows the Raymond fault extending westerly along the York Boulevard valley and terminating immediately before the northern limit of Zone 2. The presence of faulting is indicated by groundwater variations in wells at the Sparkletts plant near Lincoln Avenue and York Boulevard, where the thickness of alluvial materials varies abruptly by about 200 feet between two of the Sparkletts plant wells located within 40 feet of each other (approximately 120 feet south of Lincoln Avenue). Seismic-reflection line Z2-G1 (Appendix C.2) near the western end of Zone 2 indicates two faults, one north of York Boulevard and one to the south. All of these features provide compelling

evidence of a zone of active faulting within the York Boulevard valley extending as far west as about Eagle Rock Boulevard. At this time it is uncertain whether these features represent branches of the Raymond fault or whether they represent separate faults. The zone of faulting is expected to cross Zone 2 near the northwestern portal area.

8.5 Groundwater and Surface Water Conditions

Based on the information collected during this investigation, groundwater is under unconfined conditions within the granular and unconsolidated alluvial materials at approximate depths of 10 feet to 25 feet bgs along Arroyo Seco.

According to CDMG (1989d), the historical highest groundwater level at the northwesternmost portion of Zone 2 along the Eagle Rock Boulevard valley was at an approximate depth of 20 feet bgs in the central part of the valley.

No historical highest groundwater information is available for Arroyo Seco or other smaller drainages in the eastern portion of Zone 2. However, construction excavations underway during this investigation encountered groundwater about 5 feet deep on the north side of York Boulevard. Similar abrupt variations in ground water are reported at the Sparkletts water plant on the south side of the valley. Some of these groundwater variations appear to be due to faults that form barriers to groundwater flow. Groundwater depth varied from 10 to 48 feet bgs in the four piezometers installed as part of the current study in Zone 2.

Groundwater depths at 11 of the 12 surface wave soundings (Z2-S1 to Z2-S4 and Z2-S6 to Z2-S12) were estimated using simple seismic refraction analysis of MASW shot records with groundwater modeled in the 7- to 30-foot depth range. The MASW array was not long enough at Z2-S5 to interpret the approximate depth to groundwater.

The rocks of the Fernando, Puente, and Topanga Formations are considered non-water-bearing. Packer tests performed on the bedrock within Zone 2 confirm the very low permeability of these materials. However, localized fracture zones might have larger groundwater inflow potential than reported.

No major springs are known to occur in the upland bedrock areas within Zone 2. Although there are no large surface water recharge areas within the zone, normal inflow of water from the ground surface will occur during periods of rainfall.

8.6 Hazardous Materials

The ISAs and ESA identified eight open cases located within Zone 2. The locations of these sites are shown in Figure 6-1. No regional groundwater contamination sites (NPL site) were identified in Zone 2.

Eight sites with groundwater or soil contamination are located within Zone 2. Two of these sites, summarized below, are located in proximity (that is, less than 0.5 mile) to a portal zone for Zone 2:

- Chevron Station 9-0477, 4005 Eagle Rock Boulevard, Los Angeles, California (Map ID: 135/6). This site is located within 0.5 mile of the northwestern portal for

Zone 2. The site has groundwater impacted with MTBE. This site is considered to have a potential to impact the project because it is located within the western portal zone for Zone 2 and has impacted the groundwater.

- ARCO - Serrato, Rudy C., 5555 E Alhambra Avenue, Los Angeles, California (Map ID: 558/22). This site is located within 0.5 mile of the southeastern portal for Zone 2. The site has soil impacted with gasoline. This site is considered to have a potential to impact the project because it is located within the southeastern portal zone for Zone 2 and has impacted the soil.

The remaining six sites with localized soil or groundwater contamination were identified as being in the central portion of Zone 2 and are considered to have low potential impact to the project because they are located greater than 0.5 mile from a portal zone and are characterized with soil or groundwater contamination at a depth of less than 150 feet bgs. Additional detail for each of these sites, including the corresponding soil and/or groundwater contaminants, their corresponding concentrations, and depth of maximum concentration is included in the Environmental Screening Evaluation in Appendix F.

8.7 Potential for Naturally Occurring Gas

The Puente Formation is one of the more prolific petroleum sources in the Los Angeles Basin. However, no known oil and/or natural gas fields are located within Zone 2.

The Upper Reach of the NEIS tunnel excavated within the Puente Formation in Zone 1 experienced hydrogen sulfide and methane. Although the NEIS tunnel is located under the Los Angeles River in Zone 1, the similarity of geologic conditions suggests that gassy conditions could be encountered in Zone 2.

8.8 Geotechnical Considerations for Tunnel Design and Construction

8.8.1 Key Ground Characteristics

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

- Subsurface conditions are fairly uniform in this zone, 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 southern portion of the zone; siltstone and sandstone of the Topanga Formation is expected in the northern portion (Plate 6). In addition, depending on the location of the tunnel, sandstones and conglomerates of the Fernando Formation may also be encountered. Locally, alluvium (or soil) is expected near the portals.

- Rock is generally 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 and could be encountered within the portal area and/or the approach

excavation for the tunnel. The Raymond fault is capable of generating earthquakes in the range of M_W 6 to 6.7, and producing displacement at the tunnel level of about 2 to 4 feet.

- Most of the rock is considered very weak to weak, although there is a potential for stronger cemented layers and/or concretions in the Puente and Topanga formations.
- Groundwater is shallow in alluvial valleys (approximately 20 feet below grade) but it is believed to be ponded 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 except possibly in the saturated alluvium of the portal areas.
- Some minor soil and groundwater contamination, associated with two gas stations, could result in hazardous materials being encountered in the portal and tunnel approach excavations.
- CDMG (1999d) identifies the alluvial materials within the drainages that dissect Zone 2 as potentially susceptible to liquefaction in areas where the groundwater location is in loose cohesionless soils.
- There is a relatively high potential of encountering naturally occurring gas (methane and/or hydrogen sulfide) in this zone.

8.8.2 Preliminary Assessment of Tunneling Considerations

Information presented above and in previous sections of this report was used to perform a preliminary assessment of tunnel design and construction requirements, as summarized below.

A typical tunnel through the southern portion of Zone 2 would be excavated almost exclusively in sandstone (Tpss), shale (Tpsh) and siltstone (Tpsl) units of the Puente Formation. Except for the westernmost 6,000 feet where the tunnel will be in rocks of the siltstone (Ttsl) and sandstone (Ttss) members of the Topanga Formation. However, the eastern half (approximately) of a typical tunnel along the northern portion of Zone 2 is anticipated to be in the shale (Tpsh) and siltstone (Tpsl) units of the Puente Formation, whereas the western half would be in the siltstone (Ttsl) and in sandstone (Tpsl) units of the Topanga Formation and sandstones (Tfss) and conglomerates (Tfcg) of the Fernando Formation (Plate 6).

These formations have been encountered in previous tunnels completed in the Los Angeles area and can be excavated with modern tunneling equipment, as was the case for the conditions in Zone 1. The finer-grained portions of the Fernando, Topanga and Puente Formations are generally similar in terms of tunnel excavation and support requirements.

Similar to Zone 1, the uniformity of these formations (i.e., they are all weak sedimentary rock) will simplify construction activities and reduce the need for multiple excavation methods. As discussed for Zone 1, groundwater control methods will be required for the saturated alluvium present in the vicinity of the portals. In Zone 2, there appears to be less alluvium than in Zone 1; however, this may depend on the actual tunnel alignment, portal location, and tunnel depth. The need for special ground improvement measures or specialized tunneling machines for tunneling through saturated alluvium is the same as

discussed above for Zone 1. The support requirements and lining necessary for the formations in Zone 2 will be similar as those discussed for Zone 1 in Section 7.8.2.

Several steeply dipping inactive faults are located in Zone 2. Tunneling through these faults will require the excavation of fractured, poor-quality rock; control of groundwater; and may involve excavation of clay gouge formed by prior fault movements. Control of ground movements during tunnel construction will be necessary to avoid loss of ground, settlement, and tunneling delays. A trace of the active Raymond fault occurs at the northwestern portal and the approach excavation of the tunnel may cross this active fault. Appropriate measures should be taken during design to account for the crossing of a fault. As discussed previously for Zone 1, these faults could affect groundwater levels and inflow magnitudes into the tunnel. Additional characterization of these faults, groundwater conditions, and ground conditions will be needed to develop groundwater control strategies.

Naturally occurring gas could be encountered in this zone. Past experience in the Puente Formation suggests that gas could be present in the subsurface. Similar safety precautions and equipment would apply to this zone, as in Zone 1, for excavating in formations where there is a potential for noxious or flammable gases or soil and/or groundwater contamination.

Based on the information collected and reviewed in Zone 2, tunneling is feasible in this zone from the geotechnical standpoint. Subsurface conditions and other tunneling considerations discussed for this zone should be further evaluated in more detailed tunnel design studies.