3.10 GEOLOGY/SOILS/SEISMIC/TOPOGRAPHY

The information in this section is based on the *Geotechnical Final Report* (January 2010) and *Geotechnical Memorandum* for the northern portion of the Study Area (Department of Transportation Division of Engineer Service, Geotechnical Service, May 2010).

3.10.1 REGULATORY SETTING

For geologic and topographic features, the key Federal law is the Historic Sites Act of 1935, which establishes a national registry of natural landmarks and protects "outstanding examples of major geological features." Topographic and geologic features are also protected under the California Environmental Quality Act.

This section also discusses geology, soils, and seismic concerns as they relate to public safety and project design. Earthquakes are prime considerations in the design and retrofit of structures. The California Department of Transportation's (Caltrans) Office of Earthquake Engineering is responsible for assessing the seismic hazard for Caltrans projects. The current policy is to use the anticipated Maximum Credible Earthquake (MCE), from young faults in and near California. The MCE is defined as the largest earthquake that can be expected to occur on a fault over a particular period of time.

3.10.2 AFFECTED ENVIRONMENT

3.10.2.1 GEOLOGY/TOPOGRAPHY

The Study Area is located at the north end of the Peninsular Ranges physiographic province in the central and south-central coastal plain area of the Los Angeles Basin. The Los Angeles Basin is an alluviated coastal plain of low relief that slopes gradually seaward toward the south, southwest, and west. The basin is bordered on the north by the Santa Monica Mountains, Elysian Repetto, and Puente Hills, and is bordered on the east and southeast by the Santa Ana Mountains and San Joaquin Hills. The relatively flat surface of the Los Angeles Basin is interrupted by a locally trending northwest alignment of low hills and mesas that extend from Newport Beach on the south to Beverly Hills on the north. With the exception of embankments associated with the existing freeways and the embankments and levees of the Los Angeles River, the Study Area is relatively flat, with elevations ranging from approximately seven feet above mean sea level at the south end, to approximately 165 feet above mean sea level at the north end.

The northern portion of the Study Area will encounter older surficial sediments (Qoa) consisting of remnants of older weakly consolidated alluvial deposits of gravel, sand, and silt.

SURFICIAL AND SUBSURFACE SOILS. The vast majority of the surficial soils in the immediate vicinity of the Study Area consist of sand, sandy and fine-sand loam, silty loam, clay loam, clay, and gravel. The area within the northern portion of the project limits consists mainly of alluvial gravel, sand, and clay deposits with some cobbles.

The area in the vicinity of the Study Area is underlain by sandy alluvial soils containing silts, clays, and gravels deposited by the Los Angeles River, the San Gabriel River, and the Rio Hondo River. The recent deposits overlie older alluvium in some areas and overlie older bedrock in other areas. The depth to bedrock beneath the Study Area ranges from approximately 80 to 200 feet.

Artificial fill consisting primarily of fine sand and silt overlies older deposits at the southerly end of the Study Area south of Shoemaker Bridge in the city of Long Beach.

EXPANSIVE AND COLLAPSIBLE SOILS. Expansive soils are fine-grained soils (clay) that can undergo a substantial increase in volume with an increase in water content and a substantial decrease in volume with a decrease in water content. Changes in the water content of an expansive soil can result in severe distress to structures constructed upon the soil. No laboratory data is available regarding the expansion potential of site soils; however, based on review of the existing bridge Logs of Test Borings (LOTBs) for sites within the project area, the soils consist generally of coarse-grained materials that are not highly expansive, but some fine-grained soils susceptible to high degrees of expansion do exist.

Collapsible soils are characterized by having metastable soil structures that are susceptible to collapse upon saturation. Collapse typically occurs in relatively dry granular soils in arid climates or under dry conditions. Naturally occurring unsaturated sandy and silty alluvium and compacted granular fill materials with moisture content below optimum are considered collapsible. Since no laboratory data is available regarding the collapsibility of soils in the area, it is not known if collapsible soils are present; however, the area is not known from existing mapping to have collapsible soils.

OIL AND GAS RESOURCES. Oil and gas resources can be a concern from a geologic standpoint because of the potential for land subsidence to occur in areas where extraction of these resources occurs. The Study Area traverses four oil fields. The Bandini field is located near the city of Commerce. The Dominguez, Long Beach, and Wilmington fields are located near the city of Long Beach. The Wilmington is the largest oil field in the Los Angeles Basin. Oil is extracted from reservoirs in semi- and unconsolidated Pliocene- and Miocene-age sandstone strata.

There are numerous active, abandoned, and plugged oil wells in the immediate vicinity of the southern part of the Study Area where it crosses the Wilmington field. The majority of these wells are located on the west side of the Los Angeles River, from the south end of the Study Area north to the Shoemaker Bridge in the city of Long Beach. As discussed in Section 3.4, Utilities and Emergency Services, there are two active oil extraction operations (Oxy Oil and Long Beach Gas & Oil) adjacent to Interstate 710 (I-710) in the city of Long Beach. There are only a few scattered wells in the vicinity of the Study Area where it crosses the other three oil fields.

Land subsidence due to oil extraction in the Wilmington-Long Beach Harbor area of the Wilmington field began in the 1940s. The center of the subsidence area is located approximately one mile west of the southern limits of the Study Area. The center of the subsidence area dropped 29 feet before it was halted by injection water in the oil reservoirs in the 1950s. The south end of the Study Area was also affected, with approximately 10 feet of subsidence. Ground surface elevation monitoring and water injection continues today to counteract the effects of oil extraction.

3.10.2.2 WATER

GROUNDWATER. The primary source of groundwater in the project area is rain and snow melt from the San Gabriel Mountains, which travels through washes and creeks into the San Gabriel and Rio Hondo Rivers where some of the water flow is diverted by infiltration into spreading ground basins along those rivers to the northeast of the Study Area. The 15-acre west basin of the Dominguez Gap spreading basins is located between the Los Angeles River and the I-710 Corridor, immediately north of the I-710/Interstate 405 (I-405) interchange.

The depth of groundwater in the Study Area ranges from 2.2 feet below the ground surface (bgs) to greater than 113 feet bgs. In general, the groundwater is shallow at the south end of the Study Area and deepens to the north. Groundwater levels in the project vicinity are influenced by seasonal fluctuations. Fluctuations in groundwater levels due to water district practices and long-term climatic conditions may lead to future changes in the water levels.

3.10.2.3 FAULTING AND SEISMICITY

The entire southern California region is seismically active due to the influence of several earthquake fault systems resulting from the interaction between the Pacific and North American crustal plates. An active fault is defined by the State of California as a “sufficiently active and well defined fault that has exhibited surface displacement within the last 11,000 years.” A potentially active fault is defined by the State as a “fault with a history of movement between 11,000 and 1.6 million years ago.”

The Study Area is located within a seismically active region that will be subjected to future seismic effects from earthquakes occurring along local or regional faults. Active faults within the

Study Area are shown in Figure 3.10-1. The sources listed in Table 3.10-1, and described below, are known primary seismic sources that are capable of producing seismic shaking that could be damaging to bridges and other structures and, therefore, would influence the seismic design of the I-710 Corridor Project. The distances in Table 3.10-1 are the closest distance from the Study Area to the surface trace of the fault or top of the rupture plane. The maximum earthquake magnitudes and other fault parameters shown in Table 3.10-1 are those currently being considered for seismic design of the I-710 Corridor Project.

Table 3.10-1 Potential Seismic Sources

Fault	Approximate Closest Distance to the Study Area[1] (miles)	Fault Type	Maximum Credible Earthquake Moment Magnitude[2]
Newport-Inglewood (Cherry Hill fault)	0	RLSS	7.5
Puente Hills blind thrust	2.63	R	7.3
Compton blind thrust	5.44	R	6.8
Palos Verdes	6.9	RLSS	7.3
Elsinore fault zone (Whittier Section)	10.5	RLSS	7.6
Upper Elysian Park blind thrust	6.53	R	6.4

Source: *I-710 Corridor Project Geotechnical Final Report*, January 2010.
1 Distance noted is the closest distance to the surface trace to the fault as measured from Caltrans (2009 ARS Online).
2 Maximum moment magnitude earthquake reported by Caltrans (2009 ARS Online).
3 This fault is a blind thrust fault that does not rupture the ground surface. The distance noted is the closest distance to the upper limit of the rupture plane in the subsurface calculated using the fault location from Shaw et al. (2002) and the depth to top of rupture plane from Wills et al. (2008).
4 This fault is a blind thrust fault that does not rupture the ground surface. The distance noted is the closest distance to the rupture plane in the subsurface calculated using the fault location provided in the Community Fault Model (2004) and the depth to top of rupture plane from Wills et al. (2008).
R = Reverse fault
RLSS = Right Lateral Strike-Slip fault

The Newport-Inglewood Fault Zone extends approximately 41 miles from Newport Mesa in the south to the Baldwin Hills in the north and consists of a series of northwest-trending faults and folds that form an alignment of hills in the western Los Angeles Basin. The Newport-Inglewood Fault Zone consists of several fault segments and branch faults, four of which are in the project area: the Cherry Hill, the Pickler, the Northeast Flank, and the Reservoir Hill. The Cherry Hill Fault crosses the Study Area near the I-710/I-405 intersection.

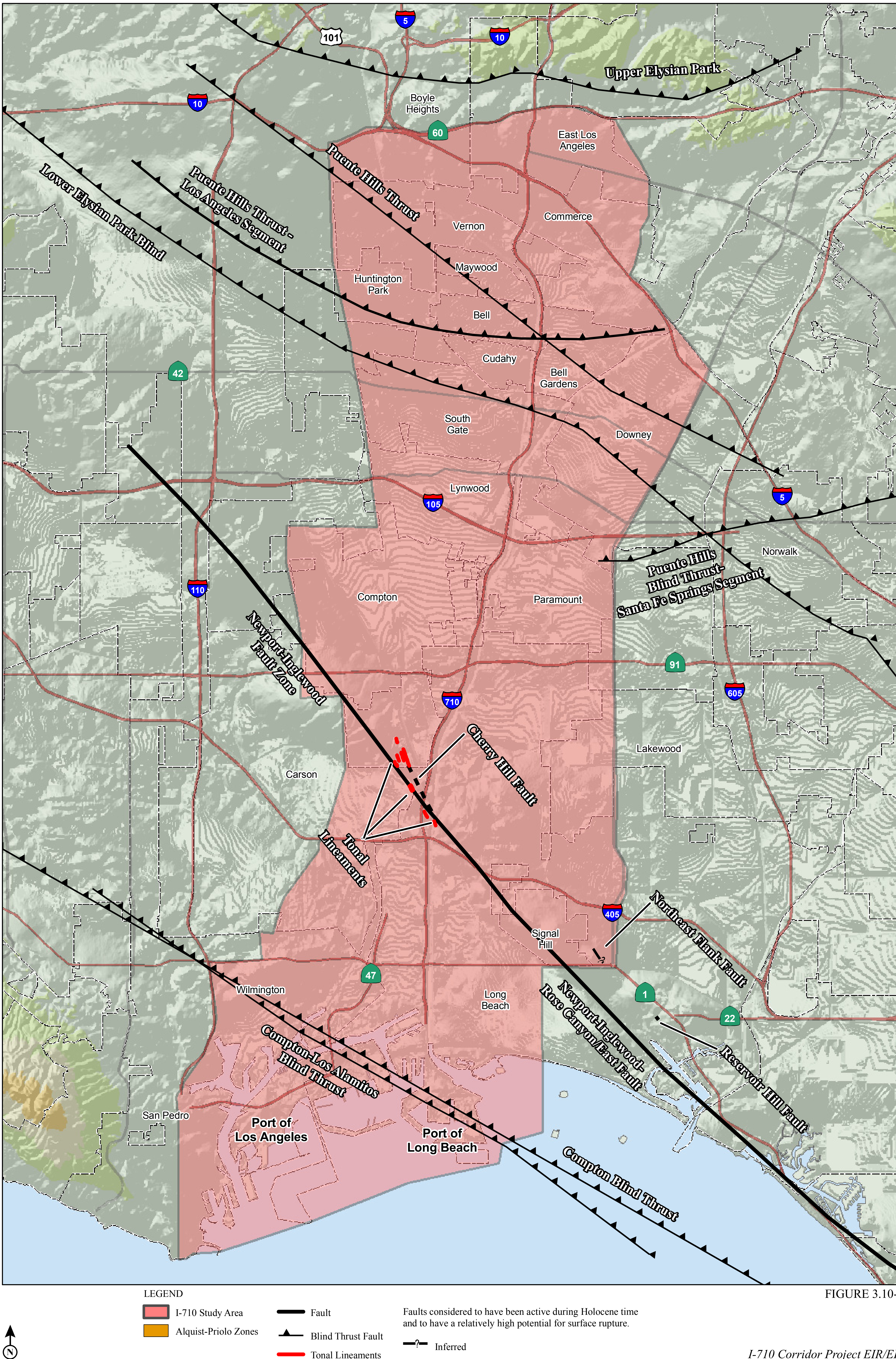

FIGURE 3.10-1

I-710 Corridor Project EIR/EIS

Fault Zones

07-LA-710- PM 4.9/24.9
EA 249900

SOURCE: TBM (2007); URS (2010)

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The Puente Hills Fault is a northerly dipping blind thrust fault that extends for more than 25 miles from downtown Los Angeles east to Brea in northern Orange County. The fault consists of three distinct segments: Los Angeles, Santa Fe Springs, and Coyote Hills. An area of the Los Angeles segment trends beneath the Study Area, approximately 3.8 miles north of the I-710/ Interstate 105 (I-105) interchange. At its western end, the Santa Fe Springs segment is located approximately 1.8 miles east of the I-710/I-105 interchange.

The Compton Fault extends northwest-southeast for approximately 25 miles along the western edge of the Los Angeles basin. At its closest point, this fault is less than one mile southwest of the southern end of the Study Area. The Compton Fault is not officially considered active, but is currently being studied by the California Geologic Survey and Caltrans to determine if it should be classified as active based on recent studies.

The Palos Verdes Fault is a northwesterly trending fault that extends from Santa Monica Bay southeasterly across the Palos Verdes Peninsula and then offshore along the coast for approximately 46 miles. At its closest point, the Palos Verdes Fault is approximately four miles southwest of the south end of the Study Area.

3.10.2.4 LIQUEFACTION

Soil liquefaction occurs when saturated, loose soils lose their strength due to excess water within the soils. The space between soil particles is completely filled with water, which exerts pressure on the soil particles, influencing how tightly the soil particles are pressed together. Prior to an earthquake, the water pressure is relatively low. However, the shaking caused by an earthquake can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. When liquefaction occurs, the strength of the soil decreases and the ability of the soil to support building and bridge foundations are reduced. Liquefied soils also exert pressure on retaining walls, which can cause them to tilt or slide.

The primary factors affecting the possibility of liquefaction in a soil deposit are: (1) intensity and duration of earthquake shaking, (2) soil type and relative density, (3) overburden pressures, and (4) depth to groundwater. Soils most susceptible to liquefaction are clean, loose, uniformly graded, and fine-grained sands and nonplastic silts that are saturated. Silty sands have also been proven to be susceptible to liquefaction.

With the exception of the northernmost 0.8 mile of the Study Area and portions of some proposed on-ramp/off-ramp/transitions on the east side of the Los Angeles River between Ocean Blvd. and I-405, the entire Study Area is located in an area identified as having the potential for liquefaction. Based on subsurface soil conditions and groundwater elevation, the majority of the Study Area has been preliminarily designated as having a low, moderate, or high potential for liquefaction. During the last two major earthquakes in the Southern California area, liquefaction did not occur within the limits of the northern portion of the Study Area. In addition, based on a regional study conducted by the United States Geological Survey, the relative liquefaction susceptibility along this portion of the Study Area is considered to be low to very low.

3.10.2.5 LANDSLIDES

Landslides are rock, earth, or debris flows on slopes due to gravity. They can occur on any terrain given the right conditions of soil, moisture, and angle of slope.

3.10.3 ENVIRONMENTAL CONSEQUENCES

3.10.3.1 PERMANENT IMPACTS

BUILD ALTERNATIVES. The roadway, structures, and other features of the I-710 Corridor Project build alternatives could be impacted by ground motion and liquefaction and possible ground rupture (deformation), to some degree. Design and construction of the proposed project to current highway and structure design standards, including applicable seismic standards, would minimize the potential impacts on the build alternatives.

The primary geologic and geotechnical constraints affecting the design and construction of any of the build alternatives include:

- Moderate to high ground accelerations due to the presence of nearby active faults and fault zones, including the Newport-Inglewood (Cherry Hills Fault), Puente Hills, Compton, and Palos Verdes Faults.
- Fault rupture associated with the Cherry Hill segment of the Newport-Inglewood Fault Zone.
- Liquefaction and seismically induced settlement in areas of shallow groundwater and loose alluvial soils. Most of the Study Area is within an area identified as having the potential for liquefaction.
- Earthquake-induced slope instability associated with liquefaction in areas of moderate to high liquefaction potential and near slopes such as the Los Angeles River.

FAULTING/SEISMICITY. Moderate to severe seismic shaking is likely to occur in the Study Area during the life of the I-710 Corridor improvements under all build alternatives. The Study Area is in the seismically active southern California region and within the influence area of several fault systems that are considered active. In general, the project facilities can be designed to accommodate the expected ground accelerations through compliance with applicable building and seismic codes. As a result, the potential for structural damage can be substantially reduced or avoided through seismic engineering design.

LIQUEFACTION. Impacts to the facilities and structures under the build alternatives due to liquefaction and seismically induced settlement can be substantially reduced based on design and construction, consistent with the recommendations of the detailed geotechnical investigations prepared during final design.

LANDSLIDES. With the exception of the freeway embankment and embankments and levees of the Los Angeles River, the topography in the Study Area is relatively flat with no natural slopes. Earthquake-induced slope instability is not a major factor in the design or operation of the I-710 Corridor Project, except in areas where there is a potential for liquefaction, as described previously.

NO BUILD ALTERNATIVE. Under Alternative 1, the permanent impacts discussed above for the build alternatives would occur for the I-710 Corridor Project itself, but earthquake and seismic safety concerns would be issues that would be analyzed as part of the environmental and engineering studies for the other transportation improvement projects included in Alternative 1.

3.10.3.2 PUBLIC HEALTH CONSIDERATIONS

The primary public health consideration related to geology is seismic safety. All new and modified bridge structures included in the build alternatives would be designed and constructed in accordance with Caltrans' latest seismic design criteria, thus minimizing public health risk concerns associated with structure collapses during an earthquake.

3.10.4 AVOIDANCE, MINIMIZATION AND/OR MITIGATION MEASURES

While implementation of standard design will reduce the I-710 Corridor Project's risk for geologic hazards such as soil erosion and slope instability, Measure GEO-1 listed below will also reduce potential impacts to liquefaction, seismic shaking, surface fault rupture, slope instability, and erosion. The following measure would apply to all build alternatives.

GEO-1 Prior to completion of final design, the California Department of Transportation (Caltrans) will prepare a design-level geotechnical report. This report will document soil-related constraints and hazards such as slope instability, settlement liquefaction, or related secondary seismic impacts that may be present. The report shall also include:

- Evaluation of expansive soils and recommendations regarding construction procedures and/or design criteria to minimize the effect of these soils on development of the project.

- Identification of potential liquefiable areas within the project limits and recommendations for mitigation.
- Demonstration that the design of all proposed retaining walls is geotechnically suitable for project area soils.

The Caltrans Project Engineer will incorporate the measures recommended in the design level geotechnical report in the final design and project specifications. The Caltrans Residents Engineer will require the construction contractor to implement the measures recommended in the design-level geotechnical report as included in the project specifications.