# 2.10 Geology/Soils/Seismology/Topography

## 2.10.1 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 CEQA.

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. Structures are designed using the Department's Seismic Design Criteria (SDC). The SDC provides the minimum seismic requirements for highway bridges designed in California. A bridge's category and classification will determine its seismic performance level and which methods are used for estimating the seismic demands and structural capabilities. For more information, please see the Department's Division of Engineering Services, Office of Earthquake Engineering, Seismic Design Criteria.

## 2.10.2 Affected Environment

This section discusses the existing geologic and soils conditions within the project Study Area and provides an analysis of the potential impacts of the proposed project that are related to geology and soils. This section also addresses the potential for structural damage to project facilities due to the local geology underlying the project site, as well as slope stability, ground settlement, soils, grading, and seismic conditions. This section summarizes information provided in the Revised District Preliminary Geotechnical Report (Caltrans 2018b).

### 2.10.2.1 Local Geology, Topography, and Soils

The SR 55 project site is located in the southeastern edge of the Los Angeles Basin, just west of the Santa Ana Mountains. The Los Angeles Basin is a deep structural basin or trough which has been filled with a thick sequence of Tertiary and Quaternary-age (2 million years old and younger) marine and non-marine sediments. The upper, near-surface section of these sediments consists of stream-laid deposits that have been shed from the San Bernardino Mountains to the north and the nearby Santa Ana Mountains. These alluvial deposits overlie bedrock of the Fernando Formation.

The project alignment slopes gently downward toward the south, with elevations ranging from approximately 320 feet at the north end to 130 feet at the south end. Stormwater runoff in the area is collected into drainage devices that include the Newport Storm Drain and Buckeye Channel located on the east side of SR 55 near Meats Avenue, and the Santiago Creek, which transects the SR 55 between Chapman Avenue and La Veta Avenue in the City of Orange.

Geologic units underlying the project alignment underlain by old alluvial fan deposits and young alluvial fan deposits consisting generally of sand and silty sand with gravel, with scattered layers of silt and clay. Bedrock-like materials are exposed at the northerly end of the alignment. These sedimentary rocks consist of the Pliocene-age upper and lower members of the Fernando

Formation. The upper member consists of silty fine sandstone interbedded with siltstone. The lower member consists predominantly of siltstone.

Based on the as-built Log of Test Borings (LOTB), the near-subsurface soils along the project alignment consist mainly of sand, silty sand, and sandy silt from Main Street to Fairhaven Avenue and at Katella Avenue. The near-subsurface soils at Lincoln Avenue consist mainly of silty clay and sand with silt and gravel. Based on the available borings, the project site is underlain by man-made fill and alluvial deposits. The artificial fill is associated with construction of the freeway and expected to be relatively thin (5 feet or less) except at the interchanges where the embankment fill is generally up to 20 feet thick. Alluvial deposits underlying the fill are anticipated to consist of interbedded layers of sand, silty sand, silt, and clay.

The site is occupied by roadways in a well-developed area surrounded by mostly residential developments. Man-made features of engineering and construction significance include First Street overcrossing, 4th Street overcrossing, 17th Street overcrossing, Santa Clara overcrossing, Fairhaven Avenue overcrossing, Katella Avenue undercrossing, and Lincoln Avenue undercrossing. There are also existing retaining walls between 4th Street and 17th Street and soundwalls between 17th Street and Fairhaven Avenue and at the southbound SR 55 Katella Avenue on- and off-ramps. In addition, slopes associated with the interchanges exist at inclinations generally ranging from 1.5:1 to 2:1 (horizontal to vertical).

No natural features of geotechnical significance exist within the project limits.

#### 2.10.2.2 Geologic Hazards

Geological hazards relevant to the SR 55 project segment include seismic ground shaking, localized soil liquefaction, and seismic settlement. The following irrelevant geologic hazards for the SR 55 project segment are identified; however, they are not discussed further in this section:

<u>Tsunami and Seiches</u>

Seiches are large waves generated in enclosed bodies of waters, such as lakes, in response to ground shaking. Tsunamis are waves generated in large bodies of water as a result of fault displacement or major ground movement. No enclosed bodies of water are near the project site, and the Pacific Ocean is approximately 10.5 miles west of the southern terminus of the SR 55 project. As a result, potential risks to SR 55 related to tsunamis and seiches are negligible.

<u>Seismically Induced Landslides/Rock Falls</u>

The site is not located in an area susceptible the landslides and/or rock fall. Man-made slopes and existing embankments within the project limits were observed to be in good condition and appear to have performed satisfactorily. No signs of erosion or slope instability were noted. Existing embankments within the project limits were also observed to be in good condition, with no signs of excessive settlement.

#### 2.10.2.3 Faulting and Seismicity

No known active or potentially active faults have been mapped at the site, and the site is not located within an Alquist-Priolo Earthquake Fault Zone (Bryant and Hart 2007). The principal seismic hazard that could affect the site is ground shaking resulting from an earthquake occurring along one of several major active or potentially active faults in southern California. Major regional faults with surface expression in proximity to the site are shown on Figure 2.10-1, Regional Fault Map. A seismic analysis for the site following Caltrans Seismic Design Criteria (2013) and Geotechnical Services Design Manual (Caltrans 2012a and corresponding updates of December 2016). Distance of faults to the site along with the peak ground acceleration for each fault was estimated using the internet-based online tool by Caltrans (ARS Online, V.2.3.09; Caltrans 2017c). The estimated peak ground accelerations caused by three faults nearest to the site are summarized in Table 2.10-1.

**Table 2.10-1: Deterministic Peak Ground Acceleration**

| Fault | Maximum Magnitude | Fault Type | Distance, km (miles) | Peak Ground Acceleration |
|---|---|---|---|---|
| Northerly Segment (33.8349, -117.8358)<br>$Vs_{30}$ = 360 m/s (1,180 feet/s) | | | | |
| Peralta Hills | 6.1 | Reverse | 0.04 (0.03) | 0.56g |
| Puente Hills (Coyote Hills) | 6.8 | Reverse | 8.0 (5.0) | 0.40g |
| Yorba Linda (Seismicity) | 6.4 | Reverse | 4.6 (2.9) | 0.39g |
| Southerly Segment (33.7597, -117.8311)<br>$Vs_{30}$ = 300 m/s (985 feet/s) | | | | |
| San Joaquin Hills | 7.0 | Reverse | 8.1 (5.0) | 0.39g |
| Compton | 6.9 | Reverse | 16.6 (10.3) | 0.30g |
| Elsinore (Glen Ivy) | 7.7 | Strike Slip | 19.4 (12.1) | 0.23g |

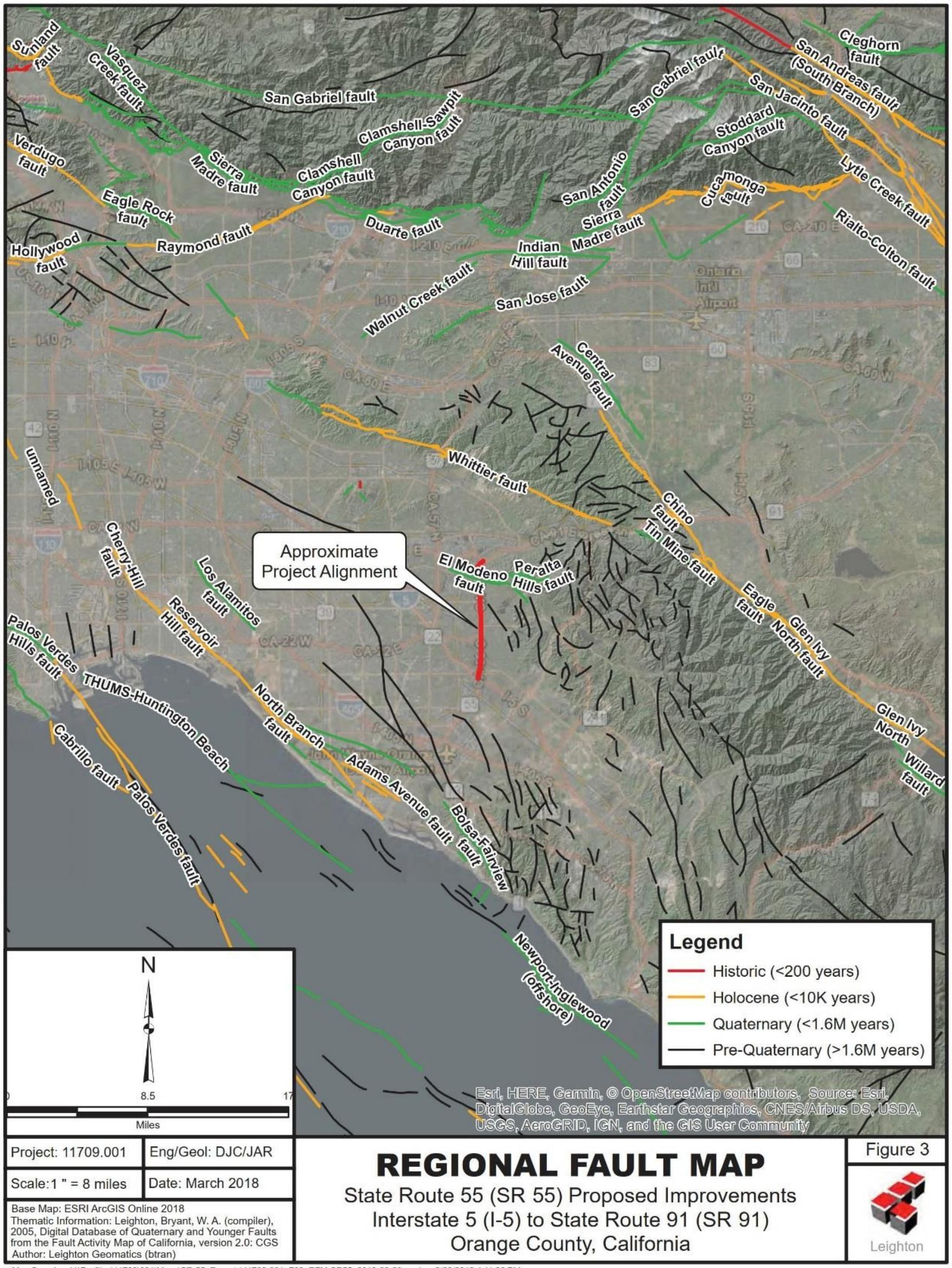
A probabilistic seismic analysis using Caltrans ARS online program and the U.S. Geological Survey (USGS) deaggregation online program were also performed. The peak ground acceleration for a return period of 975 years was calculated to be 0.53 gravity (g) and 0.50g for the northerly and southerly segment of the alignment, respectively, with a deaggregated moment magnitude (Mw) of 6.9.

### 2.10.2.4 Groundwater

Groundwater was not encountered in the as-built borings drilled for the original construction and subsequent widening of the interchanges along the project alignment except at First Street. At this location, groundwater was encountered at a depth of 70 feet below existing grade (elevation 74 feet) in the borings drilled in 1989 for the First Street Overcrossing Replacement project.

The historically high groundwater level for this area, according to the California Geologic Survey (CGS 2001, Plate 1.2), is on the order of 20 to 40 feet below the ground surface. As such, groundwater is not expected to adversely affect construction for the proposed project. Fluctuations of the groundwater level, localized zones of perched water, and an increase in soil moisture should be anticipated during and following the rainy seasons or periods of locally intense rainfall or stormwater runoff.

**Figure 2.10-1. Regional Fault Map**



#### 2.10.2.5 Liquefaction Potential and Seismic Settlement

Liquefaction is the loss of soil strength or stiffness due to a buildup of pore-water pressure during ground shaking. Liquefaction is associated primarily with loose (low density), saturated, fine- to medium-grained, cohesionless soils. Effects of liquefaction can include sand boils, excessive settlement, bearing capacity failures, and lateral spreading. The segment from SR 55/SR 22 interchange to Chapman Avenue is located within an area designated as potentially liquefiable on the California Seismic Hazard Zone Map (CGS 1998), as shown on Figure 2.10-2, Seismic Hazard Map. However, the proposed improvements for the Build Alternative are not located within this segment of SR 55. Shallow groundwater was not encountered in the as-built borings drilled for the original construction and subsequent widening of the interchanges along the project alignment. Additionally, sandy layers encountered in the borings drilled at the site were generally medium dense to dense. As such, based on the available information, liquefaction potential is not a design consideration for the project.

Seismically induced settlement consists of dry dynamic settlement (above groundwater) and liquefaction-induced settlement (below groundwater). This settlement occurs primarily within loose to moderately dense sandy soil due to reduction in volume during and shortly after an earthquake event. Based on the LOTB, sandy layers encountered in the borings drilled at the site were medium dense to dense. The seismically induced settlement is anticipated to be on the order of 1.0 inch.

#### 2.10.2.6 Contaminated Soils

As described in detail in Section 2.12, Hazardous Waste/Materials, aerially deposited lead (ADL) is generally encountered in unpaved areas (or formerly unpaved areas) adjacent to older roads, primarily as a result of lead deposition from historical vehicle emissions. Because the SR 55 alignment has been used during periods when leaded gasoline was still in use, the adjacent unpaved surficial soils may contain ADL.

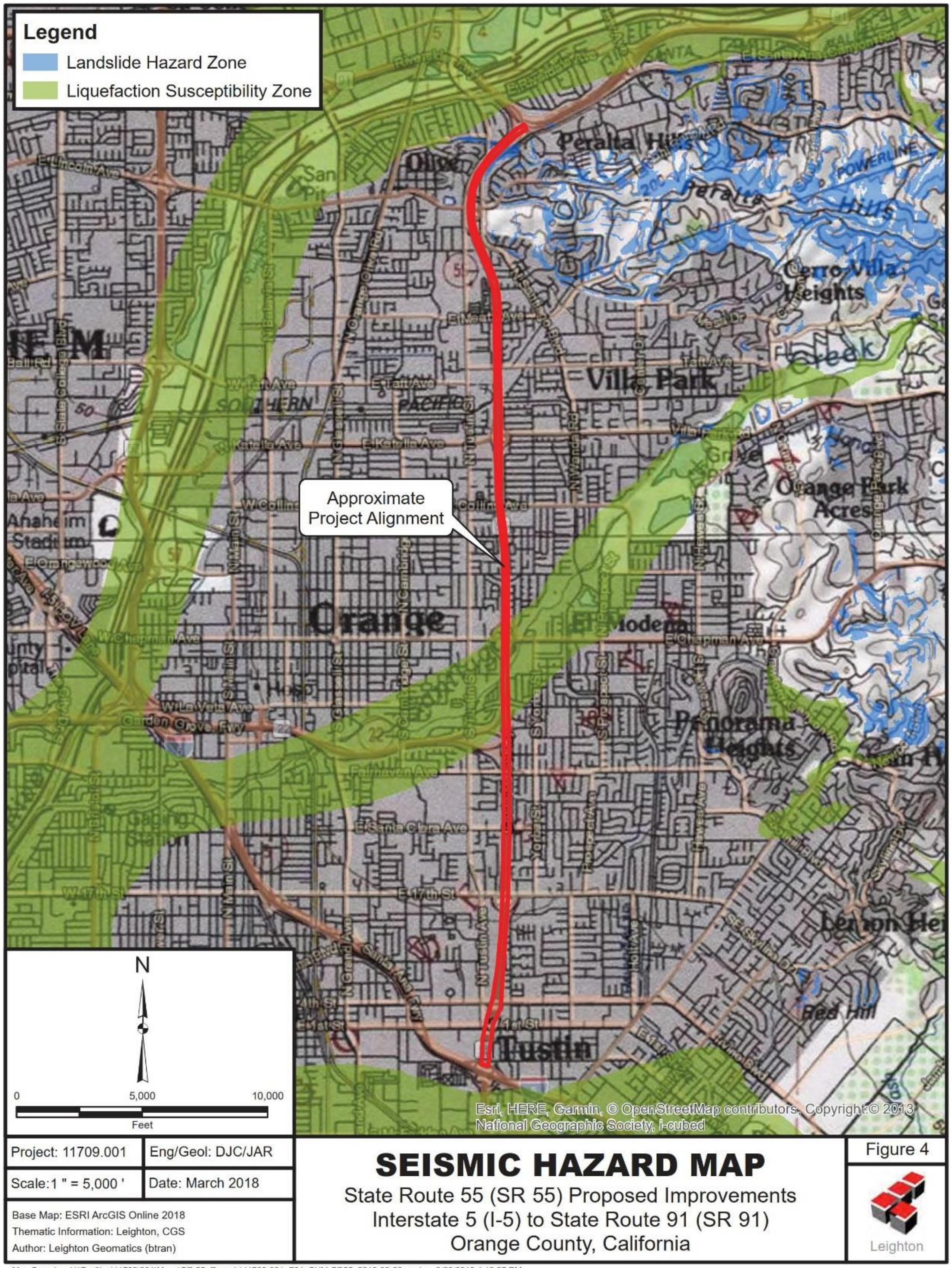
### 2.10.3 Environmental Consequences

#### 2.10.3.1 Temporary Impacts

Build Alternative

**Soil Erosion**: Construction of the Build Alternative would temporarily disturb soil outside the project footprint but within the freeway rights-of-way, around work areas, heavy equipment traffic areas, and material laydown areas. Construction activities at the TCEs outside the freeway right-of-way would also temporarily disturb soils. Excavated soil in the construction areas would be exposed; and, as a result, there would be an increased potential for soil erosion during construction compared to existing conditions. During a storm event, soil erosion could occur at an accelerated rate.

**Figure 2.10-2. Seismic Hazard Map**



During all construction activities for the Build Alternative, the construction contractor will be required to adhere to the requirements of the General Construction Permit and to implement erosion and sediment control BMPs specifically identified in the project SWPPP to keep sediment from moving off site into receiving waters and impacting water quality. Refer to Section 2.9, Water Quality and Stormwater Runoff, for additional discussion regarding construction-related water quality issues and mitigation, including BMPs.

**Ground Motion**: Construction activities could be affected by ground motion from seismic activities. Possible ground rupture, liquefaction, and slumping or slope failure could occur in areas with artificial fill if an earthquake were to occur during construction. Implementation of safe construction practices and compliance with Caltrans and the California Division of Occupational Safety and Health (Cal-OSHA) safety requirements would minimize the impacts to worker safety during construction activities.

**Hazardous Waste**: Disturbance of unpaved areas adjacent to the SR 55 mainline and ramps and the arterial streets within the project disturbance footprint could disturb ADL in the soils. Refer to Section 2.12, Hazardous Waste/Materials, for discussion of the potential effects associated with disturbance of soils containing ADL during construction of the Build Alternative and the project features addressing those potential effects.

No Build Alternative

Under the No Build Alternative, the temporary construction-related impacts discussed above for the Build Alternative would not occur because construction of project improvements on SR 55 would not occur under this alternative.

#### 2.10.3.2 Permanent Impacts

Build Alternative:

**Local Geology, Topography, and Soils**: The Build Alternative would not result in permanent substantive changes to the topography in the project area because the improvements would generally be constructed at or close to the same grade as the existing facility.

As discussed in Section 2.10.2.5, Liquefaction Potential and Seismic Settlement, shallow groundwater was not encountered in the as-built borings drilled for the original construction and subsequent widening of the interchanges along the project alignment. Additionally, sandy layers encountered in the borings drilled at the site were generally medium dense to dense. As such, based on the available information, liquefaction potential is not a design consideration for the project.

Seismically induced settlement consists of dry dynamic settlement (above groundwater) and liquefaction-induced settlement (below groundwater). This settlement occurs primarily within loose to moderately dense sandy soil due to reduction in volume during and shortly after an earthquake event. Based on the LOTB, sandy layers encountered in the borings drilled at the site were medium dense to dense. The seismically induced settlement is anticipated to be on the order of 1.0 inch. Design and construction of the proposed improvements would adhere to the Caltrans HDM (Caltrans 2016d) and other required standards, and recommendations from the Structure Foundation Report (March 2018) and the Geotechnical Design Report (May 2018), as included in Project Feature PF-GEO-1.

**PF-GEO-1** **Geotechnical Investigation**. During the Plans, Specifications, and Estimates (PS&E) phase, a detailed geotechnical investigation will be conducted by qualified geotechnical personnel to assess the geotechnical conditions at the project area. The geotechnical investigation will include exploratory borings to investigate site-specific soils and conditions and to collect samples of subsurface soils for laboratory testing. Those soil samples will be tested to evaluate liquefaction potential, collapsibility potential, stability, and corrosion potential. The project-specific findings and recommendations of the geotechnical investigation will be summarized in a Structure Foundation Report and a Geotechnical Design Report to be submitted to the California Department of Transportation (Caltrans) for review and approval. Those findings and recommendations will be incorporated in the final design of the Build Alternative.

Adherence to recommendations within these reports would substantially reduce the geologic risks to below a level of significance. In addition, surficial soils that are sandy can be susceptible to soil erosion produced by running water and accelerated erosion on steep slopes. The clayey surficial soils near in the northern portion of the project are expected to expand when wet, and crack upon drying. Cracking allows infiltration of water from storms and irrigation, ultimately causing loosening of the surficial soils. This results in an increase of soil erodibility.

Section 2.9, Water Quality and Stormwater Runoff, contains additional project features related to soil erosion, including BMPs; and Section 2.12, Hazardous Waste/Materials, contains additional project features related to hazardous wastes and materials. Implementation of these project features during construction would minimize direct and indirect effects from soil erosion.

**Faulting and Seismicity, and Groundwater:** Although liquefaction potential is not a design consideration for the project, seismically induced settlement could occur within sandy soil due to reduction in volume during and shortly after an earthquake event. The seismically-induced settlement is anticipated to be on the order of 1.0 inch, and any settlement would be minimized also through implementation of PF-GEO-1.

<u>No Build Alternative</u>

Under the No Build Alternative, the permanent impacts discussed above for the Build Alternative would not occur because none of the permanent SR 55 improvements provided in the Build Alternative would be implemented and operated under this alternative. No direct or secondary impacts on geology, topography, and soils would result from implementation of the No Build Alternative.

### 2.10.4 Avoidance, Minimization, and/or Mitigation Measures

The project will incorporate the project features outlined in Section 2.10.3.2, Permanent Impacts, to help avoid and/or minimize potential impacts. No additional avoidance, minimization, and/or mitigation measures other than the Standard Project Features are required.