5.5 GEOLOGY AND SOILS

This section describes the existing geology and soils conditions for the project area, potential environmental impacts, recommended mitigation measures to help reduce or avoid impacts and the level of significance of project impacts after mitigation.

5.5.1 EXISTING CONDITIONS

5.5.1.1 Regional Setting

The project area is located in northeastern Orange County, near the northern end of the Peninsular Ranges physiographic province of southern California. The Los Angeles Basin, a geologically complex area, is situated west and northwest of the project area at the convergence of the Peninsular Ranges, which include the Santa Ana Mountains and Puente/Chino Hills, and the Transverse Ranges, which include the San Gabriel and Santa Monica Mountains. The Peninsular Ranges and Transverse Ranges are tectonically active regions, with high rates of uplift, folding, and sedimentation. This deformation is primarily driven by north-south compression associated with interaction of the North American Plate and the Pacific Plate. This convergence has caused folding and faulting in the rock units and overlying sediments in the region and resulted in the formation of large strike-slip faults of regional significance. The most prominent fault is the San Andreas Fault, approximately 30 miles northeast of the project area.

5.5.1.2 Local Setting

Specifically, the project area is located in Santa Ana Canyon, a narrow canyon between the Puente/Chino Hills to the north and the Santa Ana Mountains to the south. The Upper Santa Ana River (USAR) Valley lies to the east and the Los Angeles Basin to the west. The canyon was cut by the Santa Ana River (SAR) which flows westerly from the USAR Valley to the Los Angeles Basin. The flow of the SAR is controlled by Prado Dam which lies approximately 2.25 miles east of the project area. The floodplain of the SAR is irregular and consists of a meandering active channel and a broader floodplain comprising several levels of terraces. The width of the floodplain is about 900 feet. The Puente Hills rise to approximately 1,000 feet above mean sea level (amsl) immediately to the north. The Santa Ana Mountains rise to over 5,000 feet a few miles to the south at “Saddle Back” Mountain (Santiago and Modjeska peaks).

5.5.1.3 Site Conditions

The Santa Ana Canyon floodplain is underlain by non-indurated (i.e. “unconsolidated”) river sediments (“fluvial” deposits) deposited within the Quaternary time period (about the past 100 thousand years). These deposits are predominantly sand and gravel with some lenses of finer deposits (silts) and cobbles. Boulders are present but make up a relatively small percentage of the deposits. The non-indurated Quaternary-age fluvial deposits overlie deformed Tertiary-age (approximately 5 to 40 million years old) bedrock. The Tertiary rocks are transected by the Whittier fault with the younger rocks on the north side of the fault dipping at moderate angles to the north, and older rocks on the south dipping to the west.

The project area includes the SAR, its floodplain, and the SAR’s northern and southern bank levees between Gypsum Canyon Road Bridge and the Orange/Riverside/San Bernardino County boundaries. The topography of the project area is generally flat, dipping gently to the west. The elevation of the project area ranges from approximately 420 feet amsl at the eastern end of the project area in Green River Golf Club to approximately 375 feet amsl at the western end, at Gypsum Canyon Road Bridge.

5.5.1.4 Soils

Soil data for the project area was obtained from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Geospatial Data Gateway and Web Soil Survey (USDA-NRCS 2014a). The NRCS provides official soil series descriptions that define specific soil series and serve as specifications for identifying and classifying soils. Figure 5.5-1 (Project Area Soils Map), depicts the soil map units found within the project area and Table 5.5-1, shows the soil map units covering at least 1 percent area within the project area.

TABLE 5.5-1
SOIL DATA FOR THE PROJECT AREA

Map Unit Symbol	Map Unit Name	Acres	Percent
142	Cieneba sandy loam, 30 to 75 percent slopes, eroded	1.4	0.34%
152	Exchequer-rock outcrop complex, 30 to 75 percent slopes	0.9	0.21%
163	Metz loamy sand	108.8	26.07%
165	Mocho sandy loam, 0 to 2 percent slopes	47.6	11.40%
167	Mocho loam, 2 to 9 percent slopes	6.9	1.65%
191	Riverwash	212.9	51.00%
192	Rock outcrop-cieneba complex, 30 to 75 percent slopes	2.4	0.58%
194	San Emigdio fine sandy loam, 0 to 2 percent slopes	2.6	0.61%
198	Soboba cobbly loamy sand, 0 to 15 percent slopes	22.6	5.41%
202	Soper gravelly loam, 30 to 50 percent slopes	11.4	2.72%
	TOTAL	**417.5**	**100.00%**

Source: USDA-NRCS (2014a) and AECOM (2015).

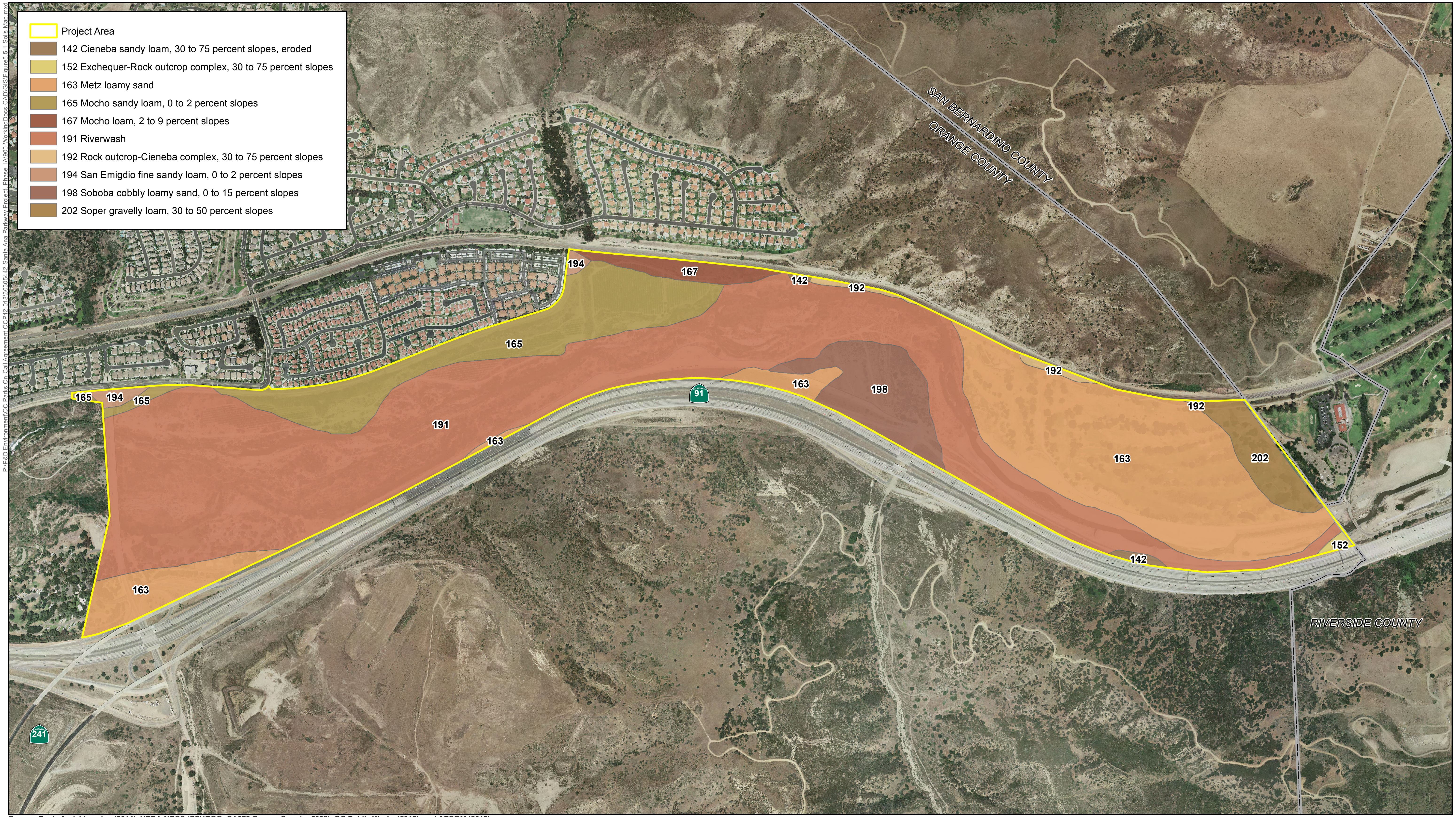
As shown in Figure 5.5-1 and Table 5.5-1, the majority of the project area (i.e., approximately 90 percent) is comprised of Riverwash, Metz sandy loam, or Mocho sandy loam.

5.5.1.5 Faulting and Seismicity

<u>Faults</u>[1]

The fault of most importance to the project area is the Whittier fault, which crosses through the project area.[2] Other faults of significance are the Chino fault and the Elsinore fault, both of which lie to the east. The Whittier, Elsinore, and Chino faults are believed to be related and merge toward the southeast. The convergence is characterized by a very complex branching and braided fault pattern which is largely covered by alluvium of the SAR floodplain and by landslides in the northeast Santa Ana Mountains (e.g. the Green River landslide). It should be noted that published geologic maps show little

[1] Note: *Fault* - A fracture or a zone of fractures along which there has been displacement of the sides relative to one another parallel to the fracture.
[2] Earth Mechanics, Inc. (2010).



Source: Eagle Aerial Imaging (2014), USDA-NRCS (SSURGO; CA678 Orange County; 2008), OC Public Works (2015), and AECOM (2015).

Scale 1 : 10,800
1" = 900 feet

0 450 900 1,800 2,700 Feet

Figure 5.5-1
Project Area Soils Map

agreement on the exact location of the Whittier fault (Earth Mechanics, Inc. 2010). Other published maps (for example, Weber 1977) show several faults in the convergence zone of the Whittier and Elsinore faults. Although these faults are young, they are generally not considered to be active seismogenic (earthquake generating) structures. However, these faults could possibly suffer displacements during a major earthquake on the Whittier, Chino, or Elsinore fault. The Scully Hill fault, just north of the project area, is one of these faults.

The Whittier-Elsinore fault system extends from the Los Angeles basin area to Mexico, a distance of more than 160 miles. The Whittier segment extends along the western margin of the Puente Hills for a distance of about 25 miles. The Whittier fault is predominantly a strike-slip fault as shown by the right-lateral shift of canyons across the fault but the fault may also have a component of reverse displacement. Prehistoric fault ruptures documented in trenches along the Glen Ivy segment of the Elsinore fault suggest a recurrence interval on the order of 250 years for earthquakes of magnitude 6 to 7 (Earth Mechanics, Inc. 2010). Slip rates estimated for the Elsinore fault by Millman and Rockwell (1986) range from 2.6 to 9.3 millimeters per year (mm/yr). The slip rate on the Glen Ivy segment is estimated to be 5.3 to 5.9 mm/yr. An average slip rate of 5.0 to 5.5 mm/yr seems to be a reasonable value for seismic hazard analyses. Slip rates on the Whittier fault are significantly less, about 3 mm/yr (Gath 1995). The apparent 2 mm/yr difference between the northern part of the Whittier-Elsinore fault system and the southern part could be partly accounted for by plastic deformation (folding) and/or partly by slip on the Chino-Avenue fault (Earth Mechanics, Inc. 2010).

Fault rupture hazards refer to impacts in the immediate vicinity of faults where the surface effect of a fault’s movement can cause direct, visible damage and offset. Fault rupture hazards occur when regional earth movements change the surface configuration of the earth in response to an earthquake. These vertical or horizontal changes in the earth can damage structures, utilities, and transportation corridors. Fault rupture/displacement may also alter natural drainage and groundwater flow direction. The Alquist-Priolo Earthquake Fault Zoning Act[3] was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The Earthquake Fault Zones map for the Prado Dam Quadrangle identifies an active fault and earthquake fault zone north of the project area, north of the Villa Del Rio neighborhood and the Burlington Northern Santa Fe (BNSF) railroad (CDC 2010). The portion of the fault closest to the project site is indicated by a long dashed line and dotted line with query (“?”) which indicates where the fault is approximately located and where the fault is concealed with additional uncertainty, respectively.

Seismicity

Seismicity is the frequency or magnitude of earthquake activity in a given location. Ground shaking (i.e., cyclic earth movements) results from sudden motions in the earth (earthquake) caused by the abrupt release of slowly accumulated strain energy. Earthquakes occur primarily along faults in areas undergoing active deformation. The motion of each earthquake is characterized by a unique set of body, longitudinal, and transverse waves. These waves can cause damage to structures, utilities, and transportation corridors; cause landslides, rockfalls, and embankment failures; and induce liquefaction failure in certain cohesionless soils (liquefaction is described later, in Section 5.5.1.6, Geohazards).

The proposed project area is located in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is

[3] The Alquist-Priolo Earthquake Fault Zoning Act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. This act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards. The Seismic Hazards Mapping Act, passed in 1990, addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically-induced landslides.

indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest crustal shortening of between 5 and 9 mm/yr across the greater Los Angeles area (Argus et al. 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the Los Angeles region. Earthquakes occur primarily as loose clusters along the Newport-Inglewood Structural Zone, the southern margin of the Santa Monica Mountains, the margin between the Santa Susana-San Fernando Valley and the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area.

Although the historical earthquakes occur in proximity to known faults, they are difficult to directly associate with mapped faults. Part of this difficulty is due to the fact that the basin is underlain by several poorly known subsurface thrust faults, generally referred to as blind thrust faults. Ward (1994) estimated that about 40 percent of seismic moment cannot be associated with known faults.

The largest historical earthquake within the Los Angeles Basin was the 1933 Long Beach event which had a moment magnitude (MW) of about 6.4 (or local magnitude [ML] of about 6.3). This earthquake did not rupture the surface but is believed to have been associated with the Newport-Inglewood Structural Zone (NISZ), a major strike-slip fault in the Los Angeles Basin (Benioff 1938). The association was based on abundant ground failures along the NISZ trend but no unequivocal surface rupture was identified. Reevaluation of the seismicity data by Hauksson and Gross (1991) relocated the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

Other major earthquakes in the region include the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred in the San Fernando Valley region. The 1994 earthquake had a MW of about 6.7 (or surface-wave magnitude [MS] of about 6.8, or ML=6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1.2 or 1.9 miles to 14 miles (Hauksson et al 2008). The causative fault was never identified with certainty. The event may have occurred on an eastern extension of the Oakridge fault (Yeats and Huftile 1995), a southerly dipping feature fault bounding the Ventura Basin and the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (MW=6.7, MS=6.4, ML=6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9.3 miles under the San Gabriel Mountains. Several mapped surface faults were involved such as the Sylmar fault, Tujunga fault, and Lakeview fault. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly from the San Fernando Valley, along the base of the San Gabriel Mountains on the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The 1987 Whittier earthquake (ML=5.9, MW=5.9) occurred on a subsurface fault dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer 1999, Shaw et al. 2002). This event did not rupture the ground surface.

Another significant earthquake in the region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al. 1987, Fumal et al. 1993, Weldon et al. 2004) postulated that the earthquake did not occur in the Capistrano area, but rather was a large (MW>7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the Los Angeles region was reported by the Portola expedition as they camped near the SAR in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (i.e. 1992 Landers event).

Whittier-Elsinore Seismicity

In general, the rate of historical seismicity has been low along the Whittier-Elsinore fault system. Small earthquakes are common along the southern part of the Elsinore fault and appear to form a crude alignment just east of the zone. This suggests either that the parallel faults to the east of the fault are active, or that the Elsinore fault dips easterly.

The largest earthquake reported for the Elsinore fault zone in historical time was a magnitude 6.0 earthquake in 1910. This event is believed to have been centered in the Temescal Valley/Glen Ivy Springs area south of the project area (Weber 1977). Speculations have been made in the literature that a large earthquake occurring in 1812 may have been associated with the Elsinore fault but recent investigations postulate that this event occurred on the San Andreas fault near Wrightwood (Earth Mechanics, Inc. 2010).

Small events (less than magnitude 5.0) were reported at the northern end of the Whittier fault system near Whittier in 1929 and 1976. The 1987 Whittier Narrows earthquake (ML=5.9, MW=5.9) was not on the Whittier fault, but occurred at depth below the Puente Hills and the San Gabriel Valley on a subsurface blind thrust fault of the Puente Hills blind thrust fault system (Shaw and Shearer 1999).

On July 29, 2008, a 5.4 magnitude earthquake occurred at a depth of about 9.3 miles below the Puente/Chino Hills. The earthquake focal mechanism indicated a mixture of strike-slip and thrust faulting on a west-southwest striking (N71ºW) plane dipping 62 degrees to the northeast suggesting that the event may have ruptured a portion of the Whittier fault (Shao and Hauksson 2009).

Estimates of the maximum earthquake likely on the Whittier fault are generally in the 7.0 magnitude range. The size of the maximum event would be controlled by the connections between the Whittier fault and the Elsinore fault. The greater length of the interconnected fault system would generate larger earthquakes. Caltrans considers the two connected and estimates a maximum earthquake of 7.6 (Earth Mechanics, Inc. 2010). The California Geological Survey model does not link the faults and estimates a maximum earthquake of only 6.8.

5.5.1.6 Geohazards

Each of the following types of geohazards can cause damage to structures, utilities, and roadways. Hazards discussed below include settlement, liquefaction, lateral spreading, subsidence, erosion, and expansive soils.

<u>Seismically-induced Settlement</u>

Strong ground shaking can cause the densification of soils, resulting in local or regional dynamic settlement of the ground surface. During strong ground shaking, soil grains may become more tightly packed due to the collapse of voids or pore spaces. Because the soil becomes more dense, it settles downward, removing support from the foundations of buildings; unsupported, the building foundations may break apart and the overlying structure may be damaged or even collapse. This type of failure typically occurs in loose, granular, cohesionless soil and can occur in either wet or dry conditions.

Liquefaction

Liquefaction is the phenomenon whereby strong, cyclic ground motions during an earthquake transform a soil mass into a liquid state. The process involves densification and pore pressure increases in a saturated soil mass. The occurrence of liquefaction is dependent upon the strength and duration of ground shaking, the depth to saturated soil, and local soil properties. It most readily occurs in loose, cohesionless, granular soil with a shallow groundwater table. Liquefaction can result in damage to or collapse of structures if the soils that support a building's foundation liquefy and no longer support the foundation of the building.

According to the Seismic Hazard Zones Map Prado Dam Quadrangle (USGS 2012b) and Black Star Canyon Quadrangle (USGS 2012a), the project area is located within a mapped Liquefaction Zone of Required Investigation.

Lateral Spreading

Lateral spreading, which is related to liquefaction, can occur on gentle slopes (typically 0.3 to 5 percent) where the surface soils are underlain by loose sands and a shallow water table. During an earthquake, the underlying loose sands can undergo liquefaction, leaving the surface layer unsupported. The surface layer can move downslope toward an unsupported area such as a stream bank or artificial cut. Under lateral spreading, the surface layer may sink into the liquefied layer, move downslope, rotate, or disintegrate, causing major damage to structures on the surface layer.

Subsidence

Subsidence is a general term for the slow, long-term regional lowering of the ground surface with respect to sea level. It can be caused by natural forces such as the consolidation of recently deposited sediments or by man-induced changes such as the withdrawal of oil field fluids or the dewatering of an aquifer. Subsidence occurs as a gradual change over a considerable distance (miles); less commonly, it can occur in discrete zones.

Soil Erosion

Erosion is the wearing away of the land surface by wind or water. Erosion occurs naturally from weather or runoff, but can be intensified by land clearing practices.

Expansive Soils

Expansive soils are primarily clay-rich soils subject to changes in volume with changes in moisture content. The resultant shrinking and swelling of soils can cause damage to fixed structures, utilities, and roadways by causing stresses to their foundations.

5.5.2 THRESHOLDS OF SIGNIFICANCE

Based upon the thresholds contained in Appendix G of the California Environmental Quality Act (CEQA) Guidelines, implementation of the project would result in a significant impact on the environment related to geology and soils if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning map issued by the State Geologist for the area or based on other substantial evidence of a known fault.
    - Strong seismic ground shaking.
    - Seismic-related ground failure, including liquefaction.
- Result in substantial soil erosion or the loss of topsoil.
- Be located on geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on-or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.
- Be located on expansive soil as defined in Table 18-1-B of the Uniform Building Code (1994) creating substantial risks to life or property.

5.5.3 METHODOLOGY RELATED TO GEOLOGY AND SOILS

The assessment of potential impacts concerning geology and soils is based on data collected from the State Geologist, NRCS, County of Orange, City of Yorba Linda, and a geotechnical memorandum prepared by Earth Mechanics, Inc. These resources were used to assess the level of geologic and seismic hazards to which the project area is subject.

5.5.4 POTENTIAL IMPACTS

5.5.4.1 Faulting and Seismicity

<u>Expose People or Structures to Substantial Adverse Effects as it Relates to Fault Rupture, Strong Seismic Shaking, Seismic-Related Ground Failure, and Seismically-Induced Settlement</u>

As discussed previously, the Earthquake Fault Zones map for the Prado Dam Quadrangle identifies an active fault and earthquake fault zone north of the project area, north of the Villa Del Rio neighborhood and the BNSF railroad. The portion of the fault closest to the project site is indicated by a long dashed line and dotted line with query (“?”) which indicates where the fault is approximately located and where the fault is concealed with additional uncertainty, respectively. The Yorba Linda General Plan identifies the Whittier fault and fault zone in the same general area as indicated on the Earthquake Fault Zones map for the Prado Dam Quadrangle. However, a geotechnical memorandum prepared by Earth Mechanics, Inc. (2010), identifies the Whittier Fault as crossing through the project area and having the potential for fault rupture. The memorandum notes that published geologic maps show little agreement on the exact location of the Whittier fault. For example, some maps indicate one location of the fault while others show several faults in the convergence zone of the Whittier and Elsinore faults. Regardless, there is the possibility of ground displacement during a major earthquake on the Whittier, Chino, or Elsinore fault.

However, the proposed project involves improvements to the connectivity of the existing SAR Class I Bikeway and Riding and Hiking Trail within the SAR Parkway. Implementation of the proposed project would include: new trails and bikeways on the north and south banks of the SAR; three non-vehicular bridges, two of which are to provide connections to the north and south sides of the SAR; a staging area adjacent to La Palma Avenue consisting of benches, picnic tables, bicycle racks, hitching rails, a corral, off-street parking, shade structure, and restrooms; and other associated amenities, including trailheads, turn-outs and vista points, fencing, and signage and interpretive boards. The intent of the Alquist-Priolo Act is to insure public safety by prohibiting the siting of most structures for human occupancy across traces of active faults that constitute a potential hazard to structures from surface faulting or fault creep. The proposed project does not include structures intended for permanent human occupancy and does not introduce a new land use to the project area that would result in the exposure of people to fault rupture hazards beyond those existing without the project.

The proposed project is located in the seismically active southern California region and would be subject to strong seismic shaking. The geotechnical memorandum prepared by Earth Mechanics, Inc., identifies the Whittier Fault as crossing through the project area. Estimates of the maximum earthquake likely to occur on the Whittier fault are generally in the 7.0 magnitude range. Other faults of significance to the project area are the Chino fault and Elsinore fault, which are located east of the project area. Large earthquakes on the Whittier, Chino, or Elsinore faults could generate strong seismic-related ground shaking within the project area. Therefore, in the absence of proper geotechnical design, constructed features of the proposed project, such as the proposed bridges, could be impacted by seismic activity and a potentially significant impact related to strong seismic ground shaking could occur.

Additionally, as discussed previously, according the California Geological Survey's Seismic Hazards Report's Seismic Hazard Maps for the project area (Prado Dam Quadrangle [USGS 2012b] and Black Star Canyon Quadrangle [USGS 2012a]), the majority of the project area occurs within an area delineated as having the potential for liquefaction. The mapping indicates the historic occurrence of liquefaction or presence of local geological, geotechnical, and groundwater conditions in the vicinity of the project area that have the potential for ground displacement. Likewise, because soils within the project area may contain loose, granular, cohesionless soils, strong ground shaking could result in the compaction and downward movement of soil grains in the presence of voids or pore spaces. Therefore, a potentially significant impact related to seismically-induced settlement and seismic-related ground failure, including liquefaction, could occur.

It should be noted the County of Orange regulates projects under the requirements of the California Building Code (CBC), which requires structures be designed to withstand potential seismic activity. Further, the proposed project would be required by the County as a Standard Condition of Approval to submit a geotechnical report prior to the issuance of a grading permit to the Manager, Subdivision and Grading, for approval. The site-specific geotechnical report is included as Mitigation Measures G-1 and would include detailed analyses and recommendations for all potential seismic-related impacts and geohazards associated with the proposed project.

5.5.4.2 Geohazards: Liquefaction, Lateral Spreading, Subsidence, Erosion, and Expansive Soils

Liquefaction and Lateral Spreading

As discussed above, according to the California Geological Survey's Seismic Hazards Report's Seismic Hazard Maps for the project area, the majority of the project area occurs within an area delineated as having the potential for liquefaction. The mapping indicates the historic occurrence of liquefaction or presence of local geological, geotechnical, and groundwater conditions in the vicinity of the project area that have the potential for ground displacement. Therefore, a potentially significant impact related to liquefaction and lateral spreading, which is related to liquefaction, could occur.

Subsidence

As defined previously, subsidence is a general term for the slow, long-term regional lowering of the ground surface with respect to sea level. Subsidence of the land surface often occurs as a result of extraction of underground fluids such as petroleum or groundwater. Temporary dewatering of groundwater may be required within the immediate vicinity of the proposed bridge columns/abutments; however, this temporary dewatering would not be sufficient to cause regional lowering of the ground surface. Therefore, impacts related to subsidence would be less than significant.

Soil Erosion and Loss of Topsoil

Soils throughout the project area are sensitive to disturbance during construction activities. Demolition, excavation, grading, and general ground-disturbing activities associated with the proposed project could expose soils to short-term erosion from wind and water.

As described in Section 5.8 (Hydrology and Water Quality) of this Draft EIR, the proposed project would be required to adhere to the requirements of a construction-related National Pollutant Discharge Elimination System (NPDES) permit, which would specify best management practices (BMPs) to prevent erosion and loss of topsoil. Adherence to the requirements of this permit would reduce impacts related to erosion and loss of topsoil to a level that would be less than significant.

Expansive Soils

As described previously, expansive soils are primarily clay-rich soils subject to changes in volume with changes in moisture content. The resultant shrinking and swelling of such soils can cause damage to fixed structures, utilities, and roadways by causing stresses to their foundations. As shown in Table 5.5-1, a number of the soils mapped within the project area contain loam and could be subject to moisture-related shrinking and swelling. Therefore, a potentially significant impact related to expansive soils could occur.

5.5.5 MITIGATION MEASURES

The following mitigation measure was developed to avoid or minimize the potential impacts related to seismic shaking, seismic-related ground failure, seismically-induced settlement, liquefaction, lateral spreading, and expansive soils.

G-1 A site specific, design-level geotechnical investigation shall be prepared for the proposed project prior to the issuance of a grading permit. The investigation shall be conducted by a Certified Engineering Geologist or Licensed Geotechnical Engineer to assess detailed seismic, geologic, and soil conditions for all components of the proposed project. The geotechnical investigation shall include a seismic evaluation of potential maximum ground motion at the site, an evaluation of liquefaction potential, slope stability, expansive and compressible soils, and other structural characteristics and shall conform to the County Grading Manual. All geotechnical recommendations identified in the investigation shall subsequently be incorporated into the design of the proposed project, as approved by the Orange County Public Works Chief Engineer or their designee.

5.5.6 LEVEL OF SIGNIFICANCE AFTER MITIGATION

Implementation of Mitigation Measures G-1 would reduce potential impacts related to seismic shaking, seismic-related ground failure, seismically-induced settlement, liquefaction, lateral spreading, and expansive soils to less than significant levels.